ANNUAL REPORT

JOINT INSTITUTE FOR NUCLEAR RESEARCH

Joint Institute for Nuclear Research

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INTRODUCTION

Ratification of the Agreement between the RF Government and JINR by the State Duma and the Council of Federation of the RF Federal Assembly at the end of 1999 and signing of the federal law «On Ratification of the Agreement between the Government of the Russian Federation and the Joint Institute for Nuclear Research on the Location and Terms of Activity of the Joint Institute for Nuclear Research in the Russian Federation» by President of Russia V.V.Putin on 2 January 2000 with its coming into force on 6 January 2000 are the particularly important events for the Institute. The existence and development of the Institute on the Russian territory have been officially guaranteed in compliance with recognized international legal norms.

Stable operation and further development of the basic facilities was ensured at the Institute in the past year. A system for slow beam extraction from the superconducting accelerator of relativistic nuclei Nuclotron became a prominent achievement of the JINR Laboratory of High Energies. It was for the first time that a beam of accelerated particles was extracted and sent to physical facilities with the aid of superconducting magnetic elements.

In December a unique cryogenic moderator based on solid methane was tested at the reactor IBR-2. The tests were carried out with the most powerful neutron flux as compared with similar facilities in the United States and Japan. All design modes of operation were tried. The cold neutron flux turned out to be 3–4 times higher than that from the currently best cold neutron source at ISIS (UK). All this opens up new avenues for the study of complex-structure compounds, which is particularly important for biology, polymer physics, materials science, pharmacology.

Important results have been obtained in several fields. The following are the most significant of them.

A general approach to the description of partial spontaneous breaking of extended supersymmetries has been developed by JINR theorists. New interesting models with this property were constructed, examples of superparticles with initial supersymmetry breaking were given. These results allow a better insight into the symmetry structure of supersymmetrical extended objects.

A.D.Sakharov's idea that gravitation can be induced by vacuum polarization effects has been further developed. A similar mechanism is shown to be responsible for other long-range forces as well. A model is built for illustration. It is free of ultra-violet divergences and the Einstein and Maxwell actions are entirely induced by quantum effects of supermassive constituent fields.

An isotope of element 114 has been synthesized in the experiment with the gas-filled separator at the cyclotron U400 at the Flerov Laboratory of Nuclear Reactions. Another isotope of this element with a different mass was produced in a parallel experiment with the separator VASSILISSA. Six heaviest isotopes of elements 112, 110, and 108 were identified among decay products in those experiments.

Within the SFERA collaboration, spectra of cumulative $K^{\pm}$ mesons have been measured to an accuracy of 10% in the cumulative number range from 0.9 to 1.35 in the deuterium fragmentation reaction at the deuteron beam from the JINR synchrophasotron. The K^{-}-meson spectra in the cumulative region are sensitive to the distribution of quarks in deuterium for the configuration where internucleon distances are smaller or comparable with the nucleon size.

Neutron generation processes in lead targets and uranium-lead assemblies exposed to a proton beam from the synchrophasotron have been experimentally studied. Space and mass distributions of nuclear fragments were investigated with activation track tomography. This allows further measurement of the power increase coefficient of electronuclear facilities to be planned.

JINR specialists participated in successful research within the framework of joint experiments at the accelerators of IHEP (Protvino), CERN, DESY, BNL, and FNAL.

The first modules for the central part of the ATLAS calorimeter were assembled at JINR and delivered to CERN.

A special «clean zone» has been built at JINR for mass production of modules for honeycomb drift chambers from materials supplied by DESY. The chamber mass production programme for the HERA-B collaboration, is fulfilled.

The yield of dimesoatoms in nickel and platinum targets was measured in the first two runs of the joint JINR–CERN experiment DIRAC carried out at CERN for model-free verification of quantum chromodynamics by analysing measured lifetimes of $\pi^+\pi^-$ atoms. Observation of a Coulomb increase in the pion pair yield in the relative momentum range below 5 MeV/c and recording of the Λ-hyperon decay peak in the $\pi^-\rho$ pair spectrum demonstrate good potentialities of the setup.

Recently computer networks have grown very important in preparing and carrying out experiments. By the recommendation of the 85th session of the Scientific Council, the Computation Complex of the Institute, including computer networks and computer infrastructure means, has been ranked as a basic facility of JINR.

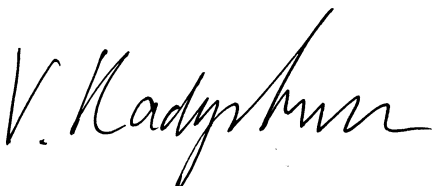
Reforms concerning basic facilities, infrastructure, and staff policy have continued at the Institute in accordance with the programme approved by the Committee of Plenipotentiaries two years ago. New departments were established, management of basic facilities was centralized, dedicated financing of first-priority research is practised. The Directorate made a lot of efforts to increase the salary. In 1999 it was increased, on the average, by two-fold.

Signing of the Agreement between BMBF (Germany) and JINR for another three-year period became an important event in the last year.

In 1999 the largest international meeting was the Bogoliubov Conference «Problems of Theoretical and Mathematical Physics». It began at Moscow State University, continued in Dubna, and finally moved to Kiev. Eminent scientists from many countries participated in the Conference.

A Jubilee Conference was carried out in Dubna on 17 December to celebrate the 50th anniversary of the synchrocyclotron of the Laboratory of Nuclear Problems. Venedikt Petrovich Dzhelepov, who was the first director of LNP, held this post for 33 years, and then became its honorary director, played a particularly important role in construction, development, and subsequent upgrading of the synchrocyclotron. Paying tribute to late V.P.Dzhelepov, the JINR Directorate decided to ask the Committee of Plenipotentiaries to name the Laboratory of Nuclear Problems after him.

The year 1999 is marked by another significant event. The first Honorary Doctors of JINR A.M.Baldin, A.A.Logunov, A.Hrynkiewicz (Poland), and H.Schopper (Germany) were given their diplomas at the 86th session of the Scientific Council for their outstanding service to JINR in developing priority fields of science and technology, training and educating young scientists.



V.G.Kadyshevsky
Director
Joint Institute for Nuclear Research

GOVERNING AND ADVISORY BODIES OF JINR

ACTIVITIES OF JINR GOVERNING AND ADVISORY BODIES

MEETING OF THE JINR COMMITTEE OF PLENIPOTENTIARIES

A regular meeting of the Committee of Plenipotentiaries (CP) of the Governments of the JINR Member States was held in Dubna on 11–12 March 1999. It was chaired by Professor R.Mach (Czech Republic).

Based on the report on implementing the JINR Scientific Council's recommendations and CP's decisions concerning the reform programme of JINR, on JINR's activity in 1998, and on plans for 1999–2001, presented by JINR Director V.G.Kadyshevsky, the Committee of Plenipotentiaries decided:

1. To approve the JINR Directorate's activities on implementing the reform programme of JINR; to emphasize that all initiatives of the JINR Directorate aimed at centralizing management of the basic facilities have proved to be correct.

2. To approve the recommendations of the 84th and 85th sessions of the JINR Scientific Council and the Topical Plan of Research and International Cooperation for 1999.

3. To approve the «Scientific Programme of JINR for the years 1999–2001».

4. Taking into account the recommendations of the 85th session of the Scientific Council, to commission the JINR Directorate to give first-priority financing in 1999 to:

— completion of the Nuclotron beam extraction system and external beam lines; continuation of the Nuclotron operation; experimental search for quark and gluon degrees of freedom in nuclei and spin effects at the LHE accelerator complex, also at the accelerators of other centres: SPS and LHC (CERN), RHIC (BNL), COSY (Julich), and CELSIUS (Uppsala); participation in the preparation of the HADES experiment at GSI (Darmstadt);

— construction of IREN with a realistic schedule and an agreed financial envelope with a view to its completion as rapidly as possible;

— upgrade of the IBR-2 reactor, with a view to securing the long-term future of this facility; development of instrumentation and data acquisition equipment for spectrometers at the reactor; continuation of the spectrometers' exploitation;

— synthesis of heavy nuclei near the region $Z=114$ using the Gas-Filled Recoil Separator and the upgraded VASSILISSA set-up; study of the fusion-fission reactions for weakly excited superheavy nuclei; study of the structure of light exotic nuclei and neutron correlations in them; research with beams of stable and radioactive ions using the FOBOS and MULTI detectors and the High Resolution Beam Line;

— continued participation in frontier particle physics experiments, amongst others at accelerators of IHEP (Protvino), CERN, DESY, BNL and FNAL; accelerator system R&D for the LHC (CERN) and linear colliders (TESLA);

— theoretical studies in particle physics and quantum field theory, nuclear physics, and condensed matter physics, also with a view to supporting experiments in these fields;

— further development of telecommunication links and computing and networking infrastructure at JINR.

The CP approved the recommendation of the Scientific Council concerning continuation with first priority of the JINR Educational Programme, aimed at increasing the inflow of young scientists to JINR and providing special-purposed training of specialists for the Member States.

Based on the report «Observation of the decay of the superheavy element with $Z=114$», presented by the Scientific Leader of the Flerov Laboratory of Nuclear Reactions Yu.Ts.Oganessian, the Committee of Plenipotentiaries acknowledged the results of the successful experiments on synthesis of the superheavy element with number 114, carried out by FLNP in collaboration with the Lawrence Livermore National Laboratory (USA), and congratulated JINR and its partners on this outstanding achievement that crowned 35 years' international collaboration in this field.

The Committee of Plenipotentiaries believes that advancing over this line of investigation is of importance for scientific priority of JINR. In this connection the CP recommended that the JINR Directorate should give maximum support to the experiments on synthesis of superheavy elements and noted with satisfaction the relevant help from the Ministry of Atomic Industry and Ministry of Science of the Russian Federation.

Based on the report presented by JINR Administrative Director A.I.Lebedev, the Committee of Plenipotentiaries took note of the information on the implementation of the JINR budget in 1997, approved the JINR budget of new structure for 1999 with the total expenditure US$37.5 million and the scale of the Member States' contributions to the 1999 budget proportional to the UN scale.

The CP fixed the 2000 budget estimate amounting to US$37.5 million.

Based on the information of the Chairman of the Finance Committee Professor S.Dubnička, the CP approved the Protocol of the Finance Committee meeting held on 11–12 February 1999 and the report of the Joint Institute for Nuclear Research on the implementation of the 1998 budget. The sanctions against those Member States whose debts exceed the sum of contributions for two years, as stipulated in Paragraph 5, Section IV, CP Minutes of 12–13 March 1998, were prolonged.

On hearing and discussing the report presented by A.Hrynkiewicz, Chairman of the CP Standing Commission for Improvement of the Scientific and Financial Policy of JINR and Its Structure, the Committee of Plenipotentiaries supported the guidelines, proposed by the Commission, for reforming JINR, improving its scientific and financial policy and developing a new method to define contributions, and charged the JINR Directorate to follow them. The Standing Commission was dismissed as it had fulfilled all the missions assigned.

On hearing the proposal and comments of the Plenipotentiary of the Government of the Russian Federation V.V.Rumyantsev, the CP decided to add Paragraph 1.3.11 to Chapter 1, Section 3 of «JINR Staff Regulations», worded as follows: «The Institute recognizes the right of the staff members from the host country of the Institute to settle labour disputes in compliance with the laws of the host country and labour contracts concluded with the staff members».

Based on the information of JINR Vice-Director A.N.Sissakian about restructuring of the JINR Member States' debts, the CP decided to support the initiative of the JINR Directorate to restructure the debts of the JINR Member States to the JINR budget and recommended that in 1999 the JINR Directorate should agree with the Governments of the JINR Member States on the terms and procedure for restructuring the debts.

Based on the information of JINR Director V.G.Kadyshevsky, the CP decided to approve the amendment to the current JINR Charter, Article 17, para 1 «i», Article 24, para 1, and Article 25, para 2 «f», consisting in withdrawal of the words «Administrative Director», as proposed by the JINR Directorate.

Based on the information of the head for the JINR Labour and Wages Department N.A.Ivanov, the CP decided to approve the List of grades of representatives of JINR Member States in JINR representative bodies and of JINR officials who enjoy the privileges and immunities stipulated by the Budapest Convention. This List shall be corrected, when necessary, on application from the Member States to the JINR Directorate with subsequent notification of the Member States.

On hearing the information of JINR Director V.G.Kadyshevsky about 1999 N.N.Bogoliubov Prize awarding, the CP congratulated Prof. V.G.Bar'yakhtar (Ukraine) and Prof. I.R.Prigojine (Belgium) on their being awarded the N.N.Bogoliubov Prize for outstanding achievements in theoretical physics.

On hearing and discussing the information of JINR Vice-Director A.N.Sissakian about introduction of honorary titles of JINR, the CP decided to approve the Regulations defining the titles «Honorary Doctor of JINR» and «Honorary Staff Member of JINR», and the «Honorary Diploma of JINR» .

SESSIONS OF THE JINR SCIENTIFIC COUNCIL

The 85th session of the JINR Scientific Council, chaired by JINR Director V.G.Kadyshevsky, took place in Dubna on 14–16 January 1999.

At the session, Director V.G.Kadyshevsky presented a report on implementation of the recommendations of the 83rd and 84th sessions of the Scientific Council concerning the reform programme of JINR and gave comments on the proposed JINR Scientific Programme for the years 1999–2001.

A 1998 highlight scientific report «Observation of the decay of the superheavy element with $Z=114$ » was presented by FLNR Director Yu.Ts.Oganessian.

Progress of JINR's reforms (1st stage) in the fields of basic facilities and infrastructure was reported by Chief Engineer I.N.Meshkov and by Administrative Director A.I.Lebedev. Vice-Director A.N.Sissakian informed the Council about the results of the internal re-examination of JINR research activities and projects conducted in 1998 as part of the preparation for the reform (2nd stage) in the scientific domain.

Recommendations of the JINR Programme Advisory Committees were presented by their Chairpersons: H.Lauter (PAC for Condensed Matter Physics), P.Spillantini (PAC for Particle Physics), and Ch.Briançon (PAC for Nuclear Physics).

At this session, the Council continued consideration of JINR's longer-range plans of research, which started at the 81st session. Two reports were offered: «Perspectives of nuclear power engineering in the 21st century including accelerator-driven reactors» by V.I.Subbotin and «Dubna Electron Accelerator Complex based on NIKHEF's AmPS» by I.N.Meshkov.

The following scientific reports were also included in the agenda: «Radioactive beams at JINR» by Yu.Ts.Oganessian and «Measurements of neutron yields and of radioactive isotope transmutation cross-sections in collisions of relativistic ions with heavy nuclei» by R.Brandt.

Information on the resumption of the experimental programme at the YePI electron synchrotron (Yerevan) was presented by H.Vartapetian.

The Council approved the Jury's recommendations on the 1998 JINR prizes.

The awarding of the 1998 B.Pontecorvo Prize took place at the session. The prize went to Professor V.M.Lobashev (INR, Moscow) for his experimental research in the field of weak interaction physics.

The Scientific Council took note of the reports presented by the JINR Directorate on implementation of the recommendations of the Scientific Council, approved by the Committee of Plenipotentiaries, concerning the reform programme of JINR.

The Scientific Council reiterated its support of the JINR Directorate's decision concerning the centralized management of the JINR basic facilities, which at present are IBR-2, Nuclotron, U400, U400M, computing infrastructure, and IREN, as an important element of the reforms. It took note, with satisfaction, of the close correspondence (about 90%) between the actual and planned running time achieved for the facilities in 1998, which has resulted in a significant scientific output.

The Scientific Council endorsed the results of the internal re-examination of JINR research activities and projects conducted in 1998 as part of the preparation for the reforms in the scientific domain, undertaken by the Directorate with the help of two specially established Internal Review Boards and generalized by the PACs at the November 1998 meetings. The Scientific Council recommended the activity of the JINR Review Boards to be extended in 1999.

The Scientific Council approved the first proposals presented by the JINR Directorate in the re-examination process, in particular optimization of the Scientific Programme, while preserving all the nine fields of its activities, active search of new non-budgetary sources, and obtaining a reasonable balance between the fundamental and applied research at JINR.

The Scientific Council highly appreciated the results of the experiments on the synthesis of the superheavy element with $Z=114$ carried out by the Flerov Laboratory of Nuclear Reactions in collaboration with the Lawrence Livermore National Laboratory (USA), and unanimously congratulated JINR and its partners on this outstanding achievement which crowned 35 years of international research efforts.

Because of the unstable financing of JINR, the Scientific Council addressed a letter to the Prime Minister of the Russian Federation Ye.Primakov, in which a serious concern about the future of JINR as well as high appreciation of the Prime Minister's personal assistance in resolving the problems of the Institute in 1998 was expressed.

The Scientific Council expressed its serious concern about the unsatisfactory situation with the development of the JINR basic facilities. The delays in the realization of IBR-2 modernization programme, of the IREN project and of the Nuclotron beam extraction system construction created a real danger for the implementation of the research programme. The Council strongly recommended that the JINR Directorate should make all possible efforts

for finding ways of providing the necessary support of these activities in 1999.

The Scientific Council strongly recommended that JINR telecommunication links, computing and networking infrastructure should be considered as a basic facility receiving the necessary annual funding for continuous and reliable operation.

The Scientific Council took note, with satisfaction, of the progress in the implementation of the 1998–2000 Scientific Programme based on a rolling three-year plan of activities and approved the general lines of the proposed «JINR Scientific Programme for the years 1999–2001».

The Scientific Council endorsed the following priority activities in 1999:

— completion of the Nuclotron beam extraction system and of external beam lines; continuation of the Nuclotron exploitation; experimental studies of quark and gluon degrees of freedom in nuclei and of spin effects at the LHE accelerator complex, also at the accelerators of other centres: SPS and LHC (CERN), RHIC (BNL), COSY (Jülich) and CELSIUS (Uppsala); participation in the preparation of the HADES experiment at GSI (Darmstadt);
— construction of IREN, with a realistic schedule and an agreed financial envelope, with a view to its completion as rapidly as possible;
— upgrade of the IBR-2 reactor, with a view to securing the long-term future of this facility; development of instrumentation and data acquisition equipment for spectrometers at the reactor; continuation of the spectrometers' exploitation;
— synthesis of heavy nuclei near the region $Z = 114$ using the Gas Filled Recoil separator and the upgraded VASSILISSA set-up; study of the fusion-fission reaction for weakly excited superheavy nuclei; study of the structure of light exotic nuclei and neutron correlations in them; research with beams of stable and radioactive ions using the FOBOS and MULTI detectors and the High Resolution Beam Line;
— continued participation in frontier particle physics experiments, amongst others at accelerators of IHEP (Protvino), CERN, DESY, BNL and FNAL; accelerator system R&D for the LHC (CERN) and linear colliders (TESLA);
— theoretical studies in particle physics and quantum field theory, nuclear physics, and condensed matter physics, also with a view to supporting experimental work in these fields;
— further development of JINR's telecommunication links and of JINR's computing and networking infrastructure.

The Scientific Council also recommended continuation with first priority of the JINR Educational Programme aimed at a higher inflow of young scientists to JINR and special-purpose training of specialists for the Member States.

The Scientific Council took note of and concurred, after due discussion, with the recommendations made by the PACs at the November 1998 meetings and presented by their Chairpersons.

PAC for Condensed Matter Physics. The Scientific Council endorsed the recommendations of the PAC for Condensed Matter Physics:

— 16% of the budget from the Member States arriving as cash-flow at JINR be immediately dedicated to Condensed Matter Physics after salary payments thus contributing to the refurbishment of the IBR-2 reactor.
— the reactor power be reduced from 2 to 1.5 MW and the number of annual cycles be reduced from 10 to 8. This emergency scenario should be revised as soon as the budget situation allows it;
— the idea to implement a «Dubna Electron Complex» based on the AmPS machine must be presented in more detail.

PAC for Particle Physics. The Scientific Council agreed with the PAC for Particle Physics that the list of projects proposed for execution by the JINR Internal Review Board was scientifically sound and could be accomplished within the nominal budget of the Institute. However, in view of the uncertain financial situation of JINR, the PAC would identify a list of core projects that should be supported with highest priority in case of further budget reductions. As a guideline, the list of core projects would focus on

(a) projects to which JINR has made particularly strong intellectual and financial investments which need to be protected;

(b) projects which are essential for the long-term scientific future of JINR.

PAC for Nuclear Physics. The Scientific Council agreed with the PAC for Nuclear Physics that the highest priority should be given to the completion of the IREN facility and to the development of the Radioactive Ion Beam project.

The Scientific Council called for a detailed Radioactive Ion Beam project to be presented at the next meeting of the PAC for Nuclear Physics.

The following experiments, highly ranked by the PAC, should be continued with the best possible financing: search for superheavy elements, properties of nuclei far from the stability line, AnCor, NEMO, TGV and DUBTO.

The Scientific Council invited the Directorate to consider the possibility of allocating funds for beam time at

the Phasotron for a limited number of already accepted experiments in order to complete them in good conditions in the forthcoming 2–3 years.

The Scientific Council expressed its great interest in the new ideas of safe production of energy using subcritical assemblies and methods of waste transmutation. It recommended that JINR Laboratories should continue some R&D activity in these directions supported from extrabudgetary sources.

The Scientific Council was informed of the JINR Directorate's initiative on the possible establishment of an Electron Accelerator Complex based on NIKHEF's AmPS. Since many questions were raised during the general discussion, the Scientific Council strongly suggested that the project should be presented at a joint meeting of the three PACs to be organized by the PAC for Condensed Matter Physics and should get their recommendations.

The Scientific Council elected by ballot:

- V.Brudanin, A.Kurilin and E.Syresin as Deputy Directors of the Laboratory of Nuclear Problems,
- D.Kazakov and V.Voronov as Deputy Directors of the Bogoliubov Laboratory of Theoretical Physics

until the completion of the current terms of office of their Laboratory Directors.

The 86th session of the JINR Scientific Council, chaired by JINR Director V.G.Kadyshevsky, took place in Dubna on 3–4 June 1999.

At the session, Director V.G.Kadyshevsky informed the Council about the decisions taken by the JINR Committee of Plenipotentiaries at its March 1999 meeting.

LHE Director A.I.Malakhov reported on the status, new possibilities and perspectives of the Nuclotron. A scientific report «Fundamental and Applied Aspects of Relativistic Nuclear Physics» was delivered by LHE Scientific Leader A.M.Baldin.

Recommendations of the JINR Programme Advisory Committees were presented by their Chairpersons: P.Spillantini (PAC for Particle Physics), Ch.Briançon (PAC for Nuclear Physics), and H.Lauter (PAC for Condensed Matter Physics). A proposal concerning changes in the memberships of the PACs was presented by JINR Vice-Director A.N.Sissakian.

The status of activities on a synchrotron radiation source was reported by JINR Chief Engineer I.N.Meshkov.

The Scientific Council congratulated Professors A.M.Baldin, A.Hrynkiewicz, A.A.Logunov and H.Schopper on their being awarded the title «Honorary Doctor of JINR».

The session also included awarding of diplomas to the 1998 JINR prizewinners and a special scientific seminar dedicated to the 10th anniversary of the Laboratory of Particle Physics.

The Scientific Council took note of the information, presented by the Director of JINR, about the decisions taken by the JINR Committee of Plenipotentiaries at its March 1999 meeting, in particular of:

— the approval of the JINR Directorate's activity on implementing the reform programme of the Institute;
— the approval of the «JINR Scientific Programme for the years 1999–2001» based on the recommendations of this Council and the PACs;
— the amendments to the JINR Charter and JINR Staff Regulations;
— the introduction of honorary titles of JINR.

The Scientific Council appreciated the steps taken so far by the JINR Directorate within the reform programme in the areas of basic facilities, infrastructure, and personnel policy. It looks forward to being informed at the next sessions about the progress of these reforms and about the Directorate's new scientific research proposals.

The Scientific Council took note of the report «Nuclotron: status, new possibilities and perspectives» presented by LHE Director A.I.Malakhov.

The Scientific Council endorsed the spirit of the joint recommendations taken on 26 April 1999 by the PACs for Condensed Matter Physics, Nuclear Physics and Particle Physics on a synchrotron light source in Dubna.

The Scientific Council recommended that a decision on DELSY should be taken only after the scientific, technical, and resource aspects of the project had been fully studied and documented. The decision should take into consideration the impact of DELSY on the existing facilities and on-going projects of JINR. Ample consideration should also be given to its impact on the long-term scientific direction of the Institute.

The Scientific Council took note of and concurred with the recommendations made by the PACs at the April 1999 meetings and presented by their Chairpersons.

Particle physics issues. The Scientific Council endorsed the recommendations of the PAC for optimizing the JINR research programme in particle and relativistic nuclear physics, and invited the JINR Directorate to propose a list of core projects that should be supported with high priority.

The Scientific Council joined the PAC in congratulating the Directorates of JINR, LPP and LHE on the establishment of the first JINR PC Farm. The Scientific Council agreed with the PAC that, in view of the rich data soon to be available at RHIC, at the Fermilab Tevatron, and later at the LHC, the potential of the Farm needed to be complemented by adequate bandwidth of international network connections. The Scientific Council reiterated its recommendation that the JINR Directorate should take

urgent measures to improve the external connectivity of the Institute.

Nuclear physics issues. The Scientific Council congratulated the Flerov Laboratory of Nuclear Reactions on the results of experiments on the synthesis of two isotopes of the new element with $Z=114$. The Scientific Council strongly recommended the continuation of the programme with high priority.

The Scientific Council recognized the high scientific and technical interest of the Dubna Radioactive Ion Beams (DRIBs) project dedicated to the production of intense beams of unstable nuclei. The Scientific Council strongly recommended that the DRIBs project should be approved and be given the status of a JINR all-Institute project, and that its necessary funding in the next three-year period should be secured.

The Scientific Council asked the JINR Directorate to make a clear decision on whether the IREN project should be completed on a reasonable schedule or should be cancelled. The Scientific Council gave strong support to this project in the past, and has no basis to reverse its earlier recommendations.

The Scientific Council wished to emphasize that nuclear physics with neutrons at the JINR site would come to an end if the IREN project were terminated.

The Scientific Council concurred with a beam allocation of up to 1,000 hours per year for the next two years, financed by the JINR budget, for experiments at the Phasotron.

Condensed matter physics issues. The Scientific Council recommended adequate funding, including refurbishment, of the IBR-2 reactor to ensure its continuing operation.

The reduced power of the reactor from 2 to 1.5 MW and the reduced number of cycles from 10 to 8 should be reversed as soon as the budget situation allows it.

Upon proposal by the JINR Directorate and on recommendations of the PACs, the Scientific Council re-appointed the following Chairpersons of the PACs for a term of one year:

- Ch.Briançon — PAC for Nuclear Physics,
- H.Lauter — PAC for Condensed Matter Physics,

and appointed S.Dubnička as Chairperson of the PAC for Particle Physics for a term of one year.

Upon proposal by the JINR Directorate, the Scientific Council appointed the following new members of the PAC for Particle Physics:

- J.Nassalski (INS, Warsaw, Poland),
- H.-D.Trines (DESY, Hamburg, Germany),
- T.Virdee (CERN, Geneva, Switzerland).

The Scientific Council extended the current mandates of the PACs until January 2001 and looks forward to a rotation of the PAC membership as stipulated by the Regulation for the JINR PACs.

After due consideration, the Scientific Council agreed to postpone the election of the Director of the Frank Laboratory of Neutron Physics (FLNP) until June 2000.

Upon proposal by the JINR Directorate and with the endorsement of the Scientific Council, V.Aksenov has been appointed Acting Director of FLNP for a term of one year.

In view of the absence of nominations for candidates, the Scientific Council agreed to postpone the election of the Director of the Laboratory of Computing Techniques and Automation (LCTA) until June 2000.

Upon proposal by the JINR Directorate and with the endorsement of the Scientific Council, R.Pose has been appointed Acting Director of LCTA for a term of one year.

The Scientific Council followed with interest the reports presented at the seminar on the occasion of the 10th anniversary of the Laboratory of Particle Physics.

The Scientific Council noted with satisfaction that, since its foundation, this Laboratory has acquired a leading position in particle physics research. Involvement of JINR member-state institutions in the scientific activity of LPP permits concentration of intellectual and material resources, resulting in a significant contribution to international research projects.

The Scientific Council congratulated the staff of the Laboratory of Particle Physics on the 10th anniversary of its establishment and wished them further successful activity.

MEETING OF THE FINANCE COMMITTEE

A regular meeting of the JINR Finance Committee was held in Dubna on 25–26 February 1999. It was chaired by S.Dubnička (Slovak Republic).

The Finance Committee heard a report «On implementation of the recommendations of the JINR Scientific Council and CP concerning the reform programme of JINR; results of 1998 and plans for 1999–2001» presented by JINR Director V.G.Kadyshevsky. The Committee approved JINR's activity on implementation of the research and international collaboration plan in 1998.

Based on the information given by V.G.Drozhenko, the Finance Committee approved the work of the Control Commission, which met on 3 July 1998, and recommended that the Committee of Plenipotentiaries (CP) approve the report on the implementation of the JINR budget in 1997.

The Finance Committee asked the Plenipotentiary of Russia to inspect the financial and management activity of JINR in 1998. For examining the inspection results, it is recommended to set up a control commission consisting of representatives of Belarus, Georgia, and Russia.

Note was taken of a report, presented by the JINR Directorate, on implementing the Finance Committee's decisions of 12–13 February 1998 and the Control Commission's recommendations of 3 July 1998.

A report on the implementation of the JINR budget in 1998, on the draft budget for 1999, and on the budget estimates for 2000 was presented by JINR Administrative Director A.I.Lebedev. The Finance Committee recommended that the CP take note of the information on the implementation of the JINR budget in 1998, approve the 1999 JINR budget with the total expenditure US$37.5 million; support the recommendation of the 85th session of the JINR Scientific Council that JINR computing and networking infrastructure be considered as a basic facility receiving the necessary annual funding; approve the main part of the Member States' contributions for 1999 to be proportional to the UN scale and approve the contribution scale for 1999; fix the 2000 budget estimate amounting to US$37.5 million, which may be corrected for inflation and US$/rouble exchange rate fluctuations; support the initiative of the JINR Directorate on restructuring in 1999 the debts of JINR Member States to the JINR budget; consider the effect of sanctions, stipulated in Paragraph 5, Section IV, CP Minutes of 12–13 March 1998, against those Member States whose debts exceed the sum of contributions for two years.

The Finance Committee supported the proposals of the 4th meeting of the CP Standing Commission for Improvement of the Scientific and Financial Policy of JINR and Its Structure and recommended that the JINR Directorate should seek to implement them.

MEETINGS OF THE JINR PROGRAMME ADVISORY COMMITTEES

The 11th meeting of the Programme Advisory Committee for Particle Physics, 16–17 April 1999. Chairperson: Prof. P.Spillantini.

The PAC for Particle Physics was informed by Chairperson P.Spillantini about implementation of the recommendations of the PAC's 10th meeting. It was also informed by Vice-Director A.N.Sissakian about the resolution of the 85th session of the JINR Scientific Council, decisions of the March 1999 meeting of the JINR Committee of Plenipotentiaries, and the Directorate's further steps towards reforming JINR.

The PAC congratulated the Directorates of JINR, LPP and LHE on the establishment of the first JINR PC Farm, which opens new possibilities for making JINR a «cluster centre» with modern computing facilities for data analysis.

The PAC reiterated its invitation to the JINR Internal Review Board for Particle Physics and Relativistic Nuclear Physics to propose a list of core projects that should be supported with highest priority in case of further budget reductions.

The PAC endorsed the plan of the Nuclotron development, presented by LHE Director A.I.Malakhov.

The PAC took note of the report «Status of JINR's research in accelerator physics and engineering», presented by Chief Engineer I.N.Meshkov. The Committee welcomes the policy of the JINR Directorate aimed at consolidation of specialists in accelerator physics and engineering, as well as the plan to centralize management of the basic facilities and their servicing subdivisions.

The PAC took note of the report «Current situation with the transfer of NIKHEF's AmPS accelerator to Dubna», presented by Chief Engineer I.N.Meshkov. The Committee made a number of statements and recommendations concerning the Dubna ELectron SYnchrotron proposal (DELSY), given in an appendix to the recommendations of this PAC meeting.

The PAC took note of the status report on JINR's participation in the CMS project. The Committee was pleased to note that the involvement of JINR Member States in this activity through the RDMS (Russia and Dubna Member States) part of the collaboration had given them an opportunity to play leading roles and to contribute significantly to the preparation of the hadron and electromagnetic calorimeters, and of the muon detector.

The PAC took note of the status report on JINR's participation in the ATLAS project and was particularly impressed with the outstanding progress made in this activity despite considerable delays in financing from the Russian Fund for the LHC.

GOVERNING AND ADVISORY BODIES OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

COMMITTEE OF PLENIPOTENTIARIES OF THE JINR MEMBER STATES

Armenia	H.A.Vartapetian	Moldova	V.A.Moskalenko
Azerbaijan	N.A.Guliev	Mongolia	Ts.Ganzog
Belarus	V.A.Gaisenok	Poland	A.Hrynkiewicz
Bulgaria	G.Kaschiev	Romania	I.Vâță
Cuba	D.Codorniu	Russia	M.P.Kirpichnikov
Czech Republic	R.Mach	Slovak Republic	S.Dubnička
Georgia	N.S.Amaglobeli	Ukraine	I.I.Zalyubovsky
Kazakhstan	V.N.Okolovich	Uzbekistan	B.S.Yuldashev
D.P.Republic of Korea	Li Je Sen	Vietnam	Nguen Van Hieu

Finance Committee

One delegate
from each Member State

SCIENTIFIC COUNCIL

Chairman: V.G.Kadyshevsky

Scientific Secretary: V.M.Zhabitsky

N.S.Amaglobeli	Georgia	A.A.Logunov	Russia	S.K.Rahmanov	Belarus
W.Andrejtscheff	Bulgaria	L.Masperi	Brazil	Š.Šaro	Slovak Republic
Ts.Baatar	Mongolia	M.Mateev	Bulgaria	H.Schopper	Switzerland
A.Budzanowski	Poland	V.A.Matveev	Russia	N.M.Shumeiko	Belarus
N.A.Chernoplekov	Russia	R.Mir-Kasimov	Azerbaijan	A.N.Sissakian	Russia
Choi Jae Gon	D.P.Republic of Korea	V.A.Moskalenko	Moldova	A.N.Skrinsky	Russia
M.Della Negra	Switzerland	T.M.Muminov	Uzbekistan	R.Sosnowski	Poland
C.Détraz	France	Nguyen Van Hieu	Vietnam	P.Spillantini	Italy
F.Dydak	Switzerland	V.N.Okolovich	Kazakhstan	A.N.Tavkhelidze	Georgia
J.Ganzorig	Mongolia	Yu.A.Osipian	Russia	G.Trilling	USA
A.Hrynkiewicz	Poland	V.V.Papoyan	Armenia	I.N.Vishnevsky	Ukraine
J.Janik	Poland	M.Petrovici	Romania	I.Wilhelm	Czech Republic
N.Kroo	Hungary	B.Peyaud	France	B.S.Yuldashev	Uzbekistan
F.Lehar	France	G.Piragino	Italy	G.M.Zinovjev	Ukraine

Programme Advisory Committee for Particle Physics

Chairperson: S.Dubnička (Slovak Republic)
Scientific Secretary: R.Ya.Zulkarneev

Programme Advisory Committee for Nuclear Physics

Chairperson: Ch.Briançon (France)
Scientific Secretary: N.K.Skobelev

Programme Advisory Committee for Condensed Matter Physics

Chairperson: H.Lauter (France)
Scientific Secretary: S.I.Tyutyunnikov

INTERNAL ORGANIZATION OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

DIRECTORATE
Director V.G.Kadyshevsky
Vice-Director A.N.Sissakian
Vice-Director Ts.Vylov
Chief Scientific Secretary V.M.Zhabitsky
Chief Engineer I.N.Meshkov

Bogoliubov Laboratory of Theoretical Physics

Director
A.T.Filippov

Research in
- symmetry properties of elementary particles
- field theory structures
- interactions of elementary particles
- theory of atomic nuclei
- theory of condensed matter

Laboratory of High Energies

Director
A.I.Malakhov

Research in
- structure of nucleons
- strong interactions of particles
- resonance phenomena in particle interactions
- electromagnetic interactions
- relativistic nuclear physics
- particle acceleration techniques
- interactions of multicharged ions in a wide energy range

Laboratory of Nuclear Problems

Director
N.A.Russakovich

Research in
- strong, weak and electromagnetic interactions of particles, particle structure
- search for new particles
- nuclear structure
- nuclear spectroscopy
- mesoatomic and mesomolecular processes
- particle acceleration techniques
- radiobiology

Flerov Laboratory of Nuclear Reactions

Director
M.G.Itkis

Research in
- properties of heavy elements, fusion and fission of complex nuclei, cluster radioactivity, reactions on an isomer hafnium target
- reactions with beams of radioactive nuclei, structure of neutron-rich light nuclei, non-equilibrium processes
- interactions of heavy ions with condensed matter
- particle acceleration techniques

Frank Laboratory of Neutron Physics

Director
V.L.Aksenov

Research in
- nuclei by neutron spectroscopy methods
- fundamental properties of neutrons
- atomic structure and dynamics of solids and liquids
- high-temperature superconductivity
- reactions on light nuclei
- materials by neutron scattering, neutron activation analysis and neutron radiography methods
- dynamic characteristics of the pulsed reactor IBR-2

Laboratory of Computing Techniques and Automation

Director
R.Pose

Research in
- development of information and computation infrastructure of JINR
- development of interfaces with international computer networks and information systems
- nonlinear problems of computing and mathematical physics for development of methods, algorithms and software
- automation of experimental facilities
- film data processing

Laboratory of Particle Physics

Director
V.D.Kekelidze

Research in
- experimental investigations in elementary particle physics at external accelerators to study particle structure and interaction laws
- development of instruments and methods for investigation of elementary particles
- development of methods and systems for acceleration of particles to super-high energies

Division of Radiation and Radiobiological Research

Leader
E.A.Krasavin

Research in
- radiation fields
- genetic effect of ionizing radiation
- radiation monitoring

University Centre

Director
S.P.Ivanova

Central services

- central scientific and information departments
- administrative and economic units
- manufacturing units

The PAC recommended that JINR continue to participate in the very important programmes of CMS and ATLAS.

The PAC took note of the status reports on JINR's participation in the NOMAD project and recommended continuation of this activity in 2000 with first priority.

The PAC took note of the proposal on LHE's participation in the NA49 project and recommended approval of this activity with first priority until 2002.

The PAC took note of the proposal on JINR's participation in the ALICE project and recommended approval of this activity with first priority until 2005.

The PAC took note of the proposal on the ELECTRONICS project and recommended it to be integrated into the research activity «Study of multiple production in 4π-geometry and construction of the SPHERE spectrometer. First-line experiments at the Nuclotron».

The PAC took note of the reports presented on JINR's participation in the DELPHI experiment, also on LHE's participation in the HADES and CERES/NA45 projects, and recommended continuation of these activities with first priority until 2002.

The PAC took note of the report «Nonlinear problems of computational and mathematical physics: algorithms, software and investigations» and recommended continuation of this activity in 2000 with first priority.

The PAC took note of the status report on the MINOS project, presented by S.Wojcicki, and of the information on the workshop «Spin effects in QCD and future experiments», presented by A.V.Efremov.

The PAC expressed its gratitude to Professor P.Spillantini for his valuable work as Chairperson of the PAC for Particle Physics and recommended that the JINR Scientific Council should appoint Professor S.Dubnička as Chairperson of this PAC for a term of one year.

The 10th meeting of the Programme Advisory Committee for Nuclear Physics, 19–20 April 1999. Chairperson: Prof. Ch.Briançon.

The PAC was informed by Chairperson Ch.Briançon about implementation of the previous PAC recommendations, also by JINR Chief Scientific Secretary V.M.Zhabitsky about the resolution of the 85th session of the JINR Scientific Council (January 1999) and the decisions of the Committee of Plenipotentiaries (March 1999).

The PAC took note of the Topical Plan of Research and International Cooperation for 1999 and of the JINR Scientific Programme for the years 1999–2001.

The PAC made the following recommendations concerning the fields of research.

Heavy-ion physics. The PAC congratulated FLNR on the synthesis of two isotopes of the new element $Z=114$ in the reactions $^{48}\mathrm{Ca} + {}^{244,242}\mathrm{Pu}$, and recommended continuation of this programme with highest priority and securing in 1999 and in 2000 at least 5,500 running hours of the U400 accelerator for these experiments.

The PAC recognized the high scientific and technical level of the presented project «Dubna Radioactive Ion Beams (DRIBs)», its exciting perspectives for the study of nuclear structure and nuclear dynamics, and its international competitiveness. The PAC recommended to accept this project for realization, to give it the status of an all-Institute project, to provide its necessary funding in the next three-year period and to discuss the first series of experiments.

Nuclear physics with neutrons. The PAC noted that the funds necessary in 1998 to maintain the IREN project could not be allocated. The achievement of the project is now foreseen by the Directorate for mid-2002, and the needs for 1999 are estimated to be more than 500 k$. The PAC's concern for the future of IREN remains. If this project cannot be realized as now planned, as a consequence, the research programme in nuclear physics with neutrons will irremediably come to an end at JINR site with the outphasing of the IBR-30 facility.

The PAC heard the presentation of a REGATA project aimed to study the atmospheric deposition of heavy metals by nuclear and related analytical techniques, and endorsed approval of this project.

Low- and intermediate-energy physics. The PAC heard a report explaining the conditions of the Phasotron's exploitation and noted that the beam time recommended for each experiment should respect the total limit of about 1,000 hrs/year financed by the JINR budget.

The PAC was also presented with reports on the research programmes at the Phasotron: activities in mu-catalysis and at YASNAPP-2, studies of two-photon emission in pp-reactions at intermediate energies, investigations of muon properties and interactions, and the status of the DUBTO experiment to study pion interactions with light nuclei using the streamer chamber technique.

As for the μSR-part, the PAC considered it as a separate programme, inviting a dedicated proposal to be submitted at the next meeting which should clarify also the articulation to the corresponding PSI-experiments. Concerning the DUBTO experiment, prepared and supported financially within the JINR–INFN (Italy) Agreement, the PAC noted its good position for starting and data taking.

JINR basic facilities. The PAC was satisfied to learn that the running time of the U400 and U400M cyclotrons was sufficient to meet the experimental requirements and recommended adequate beam time to be allocated for both machines in view of the exciting and top-level scien-

tific programme. The PAC supported the upgrade of the U400 by improving the injection line.

The PAC noted that the DRIBs project had been developed very fast and should be continued accordingly, to be competitive in view of the upcoming ISOL-RIB facilities worldwide.

Projects under consideration. Concerning the status of the preparation of the DELSY project presented at the meeting, the PAC noted that the information available was insufficient to evaluate the interest of the project for nuclear physics and to identify the corresponding user community. However, the PAC is concerned about the possible adverse effects that the project may have on the human and financial resources of JINR, on the approved programme and on the long-term future of the JINR basic science. The PAC therefore urged the Directorate to identify funds outside the Institute's budget for both the implementation and the running cost of the project, if adopted.

The PAC took note of the positron cooler project LEPTA and of the positronium experiments it may allow. The PAC invited for its next meeting a technical note on the project and a detailed description of dedicated experiments.

JINR networking. The PAC appreciated that the networking and telecommunication links were going to be considered as a basic facility of JINR with the first-priority financing status. The completion of the ATM backbone represents an important achievement. Attention must also be paid to the improvement of network links and renewal of the computing facilities at the JINR Laboratories.

The PAC approved the activities of LCTA to ensure as much as possible the effective utilization of the JINR network for scientific purposes.

The connection to abroad remains at critical point. The PAC suggested different ways of solving this problem, including renting of a commercial telecommunication channel.

Miscellaneous. The PAC gave its high appreciation of the JINR Educational Programme, conducted on the basis of the University Centre as a first-priority activity, and recommended that the JINR Directorate assist in further improvement of the equipment for educational process with the purpose of extending the fields of specialized training.

The PAC was presented with two scientific reports: «Results of the muonium-antimuonium conversion investigation» and «Fabri-Perot neutron interferometer and fundamental neutron optical experiments». It took note of the interesting results obtained in these two important experiments.

The 10th meeting of the PAC for Condensed Matter Physics, 25–26 April 1999. Chairperson: Dr H.Lauter.

The PAC took note of the information about the recommendations of the 85th session of the JINR Scientific Council (January 1999) and the decisions of the Committee of Plenipotentiaries (March 1999), presented by JINR Chief Scientific Secretary V.M.Zhabitsky.

The PAC took note of the reports, presented by V.D.Ananyev, on the present situation with the IBR-2 reactor and the cold moderator. The PAC recommmended that the exploitation of IBR-2 should be adequately financed to ensure a full use of the cycles and that a special reward fund be established for the reactor's personnel.

The PAC supported the JINR Directorate in finding the complete financing for the reactor refurbishment by seeking a possible assistance from the Russian Ministry of Atomic Energy to provide additional funding of the reactor and through the Directorate's efforts to ensure availability of the maximum possible inflows into the JINR budget.

The PAC took note of the report by A.V.Belushkin «Instrumentation on the new cold moderator» and recommended working out the instrumentation optimized to be used on the cryogenic moderator taking into account its start-up in 1999 and tests. The PAC welcomed a proposal for this project to be presented at its next meeting.

The PAC took note of the «Status report about activity at DN-12 diffractometer» given by B.N.Savenko, and appreciated the upgrade work done for this instrument which allows an increase in pressure and temperature range available for experiments using elastic and inelastic neutron scattering. The PAC recommended considering the possibility of relocating DN-12 within the instrument reshuffling around the cold moderator.

The PAC took note of the scientific report «Investigation of biological objects via small angle neutron scattering and synchrotron radiation» by V.I.Gordely and recommended, in particular, construction of a SANS instrument for lower Q-values ($Q \approx 10^{-3} \cdot E^{-3}$).

The PAC took note of the scientific report «Interaction of high-energy heavy ions with matter. New experimental methods and results» by V.F.Reutov and recommended that the FLNR Directorate support this activity.

The PAC thanked Professor I.N.Meshkov for his presentation about the «Status of activities on a Synchrotron Radiation Source at JINR» and made the following statements and recommendations.

It seems that the specifications of the AmPS accelerator and synchrotron radiation source can be optimized by the JINR experts to meet the requirements for the research in condensed matter physics, biology and chemistry.

The scientific case has still to be worked out, and the user community has to be identified. The outcome will probably redefine the layout of the radiation source within its possibilities. A workshop will be very helpful for these tasks.

The transport of the AmPS facilities and further related activities should be performed only if non-budgetary funds have been obtained within this year.

These constraints are necessary because it seems that JINR cannot fulfil its obligations with respect to the development and refurbishment of the basic facilities. In general, no budgetary resources from the Member States, German and Hungarian contributions should be used directly or indirectly for this project.

The 11th meeting of the PAC for Condensed Matter Physics, 12–13 November. Chairperson: Dr H.Lauter.

The PAC took note of the information on the Resolution of the 86th session of the JINR Scientific Council, presented by V.M.Zhabitsky.

The PAC took note of the report «IBR-2 operation and preliminary results of the cold moderator tests» presented by V.D. Ananyev. The PAC was satisfied with the first successful test of the cryogenic moderator which allowed the intensity for long wavelength neutrons to be increased at least by a factor of 10.

The PAC took note of the information, presented by I.N.Meshkov, on the current situation with the IBR-2 reactor refurbishment. The Committee was pleased that the JINR Directorate had provided the financing of the refurbishment work in 1999. It was shown that for the following years an average 600 k$ per year was needed to accomplish the refurbishment. It was unlikely, noted the PAC members, that JINR's financial situation would improve over the next years. In view of this, they signed a letter to the Russian Minister for Atomic Energy and Minister of Science and Technology, appealing to them to join the efforts and help materially and financially to support the modernization of the IBR-2.

The PAC took note of the presentation by A.V.Belushkin about the implementation of the PAC previous recommendations concerning the instrumentation around the cold moderator. It was decided to discuss, at the next PAC meeting, the first proposal of relocating spectrometers on the cold moderator as well as how the associated higher demand of multi-detectors and neutron guides could be satisfied.

The PAC took note of the report «Prospects for biological investigation at IBR-2», presented by V.I.Gordely, and supported the following aspects of this activity:

— development of the YuMO spectrometer to match the requirements given by the new cryogenic moderator;
— the mentioned new SANS spectrometer should be presented in detailed form at the next PAC meeting;
— further development of the biochemical laboratory for the needs of users.

The PAC took note of the «Status report on the activity at the spectrometer of polarized neutrons (SPN)» presented by Yu.V.Nikitenko. The PAC appreciated the fruitful collaboration with different organizations in many countries. The project for relocating the SPN on the new cryogenic moderator should be presented in detail at the next PAC meeting. The PAC supported the demand of a qualified technical personnel for the SPN complex and for SANS with polarized neutrons.

The PAC followed with interest the scientific reports given by A.Yu.Didyk, N.A.Koltovaya and V.F.Klepikov, covering aspects of radiation material science and radiobiology, and recommended continuation of these activities.

The PAC appreciated the scientific report «Perspective trends in physics of magnetism and materials with electron correlation» presented by A.L.Kuzemsky. The PAC invited further reports on this subject relevant to investigations with neutrons and supported the collaboration between FLNP and BLTP.

The PAC took note of the information, presented by I.N.Meshkov, about the international workshop «JINR Synchrotron Radiation Source: Prospects of Research» held in Dubna on 1–3 November 1999, which was organized according to the joint recommendations of the three JINR PACs held in April 1999.

At this meeting, the PAC insistently repeated item 5 of the «Joint Recommendations» that no further steps with respect to realization of the DELSY project should be taken until outside funding has been secured.

The 11th meeting of the Programme Advisory Committee for Nuclear Physics, 19–20 November 1999. Chairperson: Prof. Ch.Briançon.

The PAC was informed about the recommendations of the previous PAC meeting and their implementation, also about the Resolution of the 86th session of the JINR Scientific Council (June 1999). The PAC noted with satisfaction that the Scientific Council concurred with its recommendations on giving the Dubna Radioactive Ion Beams (DRIBs) project the status of an all-Institute JINR project and on financial support for the IREN project. The PAC recognized the difficult task of the JINR Directorate to manage the Institute in the present difficult financial conditions and appreciated that in 1999 the basic facilities were kept operational for many important experiments.

The PAC considered and approved the JINR scientific programme in nuclear physics for the years 2000–2002. The PAC made the following recommendations concerning the fields of research.

Heavy-ion physics. The PAC heard a report on the current status of the Dubna Radioactive Ion Beams project and noted a realistic chance for exceeding the initially anticipated parameters of performance, appreciated that the details of the project were developed in parallel with the realization of the running scientific programme at FLNR, also emphasized the inclusion into the project of the low-energy fission fragment section. For the successful realization of the FLNR scientific programme during 2000–2002, the PAC recommended the adequate funds to be provided, with the full allocation of the requested beam time of 6,000 hrs at U400 and 4,000 hrs at U400M, also continuation of the on-going upgrades of the FLNR cyclotron complex and further development of instrumentation.

Nuclear physics with neutrons. The PAC recognized some success in the development of the IREN project, which was achieved in 1999, and stated that in order to accomplish the project an allocation of 600 k$ in 2000 and a significant increase of funding during 2001–2002 were strongly requested. Additional efforts should be made for improving the manpower. The PAC also recommended a detailed technical plan for the implementation of the IREN project in the framework of the new schedule to be prepared and presented at the next session. The PAC recommended the extension of the theme «Construction of the IREN facility» until the end of 2004, retaining the implementation of the IREN neutron source in 2002. The PAC learned with satisfaction about the interesting programme of investigations performed successfully under the theme «Investigations of the fundamental properties of neutron and nucleus» and recommended extension of this theme for one year, until the end of 2000.

Low- and intermediate-energy physics. The PAC appreciated the top quality of the investigations on weak and electromagnetic interaction at low energies and on symmetries and dynamics of lepton, hadron and nucleus interactions at intermediate energies. The PAC approved this programme of investigations. The PAC recommended continuation of the programme of experiments within the LESI project in view of its importance for astrophysics. The PAC heard the reports on the themes expiring in 1999 «Development of the cyclotron method for high-current beam acceleration» and «Dynamics of interaction of leptons, hadrons and nuclei» and recommended their extension for one more year. The PAC took note with interest of the proposal to search for massless Goldstone-bosons (familons) in muon-decay (FAMILON project), however the information presented was considered insufficient for making some reasonable recommendations. The PAC approved the experiments planned within the MU-CATALYSIS project. For these experiments, 600 hrs of beam time per year are recommended or more, subject to financial arrangements with RIKEN. The PAC considered the LEPTA proposal and stated that the project was still under review by external experts and that technical aspects are discussed at regularly organized workshops. The PAC looks forward, for its next meeting, to obtaining a report with the results of the required feasibility studies and to a discussion of the scientific programme. The PAC got acquainted with the first steps on the searching for dibaryon resonances in the framework of the DIBARYON programme and recommended that the LNP Directorate support the fast realization of this experiment. The PAC took note of the μSR-part of the project «Investigation of muon properties and muon interactions with matter». The PAC considers that this type of activities should be continued at LNP and that the group constitutes a valuable link to the international community active in this field; also, 200 hrs/year at the Phasotron could be recommended for the project.

Remarks on the DELSY project. The PAC heard the information about the workshop «JINR Synchrotron Radiation Source: Prospects of Research» (Dubna, 1–3 November 1999) and about the project preparation. The PAC noted that no substantial new information had been presented about the importance and interest of the project for the nuclear physics field, and that the corresponding user community had not been identified yet. The PAC reiterated that the scientific programme and technical aspects resulting from this workshop and the subsequent ones should be refereed by a panel of outside experts. The PAC reaffirmed that no further steps towards the realization of the DELSY project should be taken until outside funding had been secured.

JINR networking and computing. The PAC recognized the progress achieved in the access to the external communication links. At the same time, this progress has no adequate effect on the real network operation for the JINR users. The PAC suggested that the network system, being one of the JINR basic facilities, should need an adequate treatment as regards the mode and amount of financing. The regular money allocated for each year would enable a systematic procedure to be undertaken on modernization, maintenance and operation of the network.

The PAC considered the written report on the theme expiring in 1999 «Nonlinear problems of computational and mathematical physics: algorithms, software, and investigations» and recommended extension of this theme over the year 2000 as a first-priority activity.

The 12th meeting of the Programme Advisory Committee for Particle Physics, 26–27 November 1999. Chairperson: Prof. S.Dubnička.

The PAC for Particle Physics heard a report about implementation of the recommendations of its previous meeting as well as was informed by Vice-Director A.N.Sissakian about the Resolution of the 86th session of the JINR Scientific Council and about the Directorate's further steps towards reforming JINR.

The Committee appreciated the efforts of the JINR Directorate and of the JINR Internal Board for Review of Research Activities to further develop a plan for optimization of the JINR Scientific Programme in Particle and Relativistic Nuclear Physics and endorsed the main lines of this programme proposed for the years 2000–2002.

The PAC was pleased to learn about the completion of construction of the Nuclotron beam slow extraction system and looked forward to a successful test run in December 1999.

The Committee followed with interest the information given by Prof. T.Hallman on the start-up of the new powerful collider RHIC at BNL and the first experiments planned with JINR physicists' participation. The PAC took note of the reports on the projects HERA-B, D0, CDF, DISK, STAR, MARUSYA and LHC-TESLA-CLIC, approved for completion in 1999, and recommended extension of these first-priority activities until the end of 2002. The Committee also recommended that the activities on 5 experimental projects, approved for completion in 1999, be closed.

The PAC continues to be concerned about the potential impact of the DELSY initiative on the JINR infrastructure and existing scientific programme and recommended that the JINR Directorate fully assess this impact before proceeding further with this project.

On the basis of previous recommendations and of the list of projects proposed for execution by the JINR Internal Board, the PAC recommended that first priority be given to 19 projects of the JINR Programme of Particle Physics and Relativistic Nuclear Physics for the years 2000–2002.

PRIZES AND GRANTS

The 1999 B.Pontecorvo Prize was awarded to Professor R.Davis (USA) in recognition of his outstanding achievements in developing the chlorine-argon method for solar neutrino detection.

The N.N.Bogoliubov Prize of the Joint Institute for Nuclear Research for 1999 was awarded to Academician V.G.Bar'yakhtar (Ukraine) and to Professor I.R.Prigogine, Nobel Prize winner (Belgium), for their important contribution to theoretical physics.

PRIZEWINNERS OF JINR'S ANNUAL COMPETITION FOR BEST RESEARCH – 1999

Theoretical physics research

First Prize

«Integrable systems with extended supersymmetry».
Authors: E.A.Ivanov, S.O.Krivonos, A.S.Sorin.

Second Prizes

1. «Self-similar potentials of quantum mechanics».
Author: V.P.Spiridonov.

2. «Prediction of existence of a long-lived superheavy nucleus with $Z=114$ and of the stability island».
Authors: F.A.Gareev, B.N.Kalinkin, A.Sobiczewski.

Experimental physics research

First Prize

«Fission of heavy and superheavy nuclei near and below the Coulomb barrier».
Authors: M.G.Itkis, E.M.Kozulin, N.A.Kondratiev, L.Krupa, I.V.Pokrovsky, E.V.Prokhorova, A.Ya.Rusanov, G.G.Chubarian, F.Hanappe, L.Stuttge.

Second Prizes

1. «Large investigation of the angular anisotropy of fragment formation in the resonance neutron induced fission of aligned ^{235}U nuclei and the role of JK-channels».
Authors: A.A.Bogdzel, J.Kliman, Yu.N.Kopach, A.B.Popov, W.I.Furman, N.N.Gonin, L.K.Kozlovsky, D.I.Tambovtsev, A.L.Barabanov.

2. «The study of spin effects in polarized deuteron fragmentation into cumulative hadrons».
Authors: L.S.Azhgirey, L.S.Zolin, A.Yu.Isupov, V.P.Ladygin, A.G.Litvinenko, A.I.Malakhov, V.N.Penev, Yu.K.Pilipenko, S.G.Reznikov, P.A.Rukoyatkin.

Encouraging Prize

«Mutagenic action of radiation with different linear energy transfer on mammalian and human cells».
Authors: R.D.Govorun, I.V.Koshlan, N.A.Koshlan, E.A.Krasavin, M.V.Repin, T.A.Fadeeva, N.L.Shmakova.

Physics instruments and methods

First Prize

«Fragment separator COMBAS».
Authors: A.G.Artyukh, P.G.Bondarenko, G.F.Gridnev, M.Grushezki, F.Koscielniak, Yu.G.Teterev, L.A.Rubinskaya, Yu.P.Severgin, A.G.Semchenkov, Yu.M.Sereda.

Second Prizes

1. «Design of silicon planar detectors for application in experiments by high radiation flux».
Authors: I.A.Golutvin, N.I.Zamyatin, E.V.Zubarev, N.M.Lustov, S.V.Sergeev, A.E.Cheremukhin, S.A.Golubkov, N.N.Egorov, Yu.F.Kozlov, A.I.Sidorov.

2. «System for registration, acquisition, processing and analysis of data in the EXCHARM experiment».
Authors: A.N.Aleev, V.P.Balandin, I.M.Geshkov,

I.M.Ivanchenko, N.N.Karpenko, D.A.Kirillov, Z.I.Kozhenkova, I.G.Kosarev, N.A.Kuzmin, Yu.K.Potrebenikov.

Applied physics research

First Prize

«Hydrodynamic and heat regimes of two-phase cryogenic flows: experimental and theoretical base and practical application».
Author: Yu.P.Filippov.

Second Prize

«Irradiation facility at the IBR-2 reactor».
Authors: V.V.Golikov, L.B.Golovanov, S.M.Golubykh, E.N.Kulagin, V.V.Kukhtin, C.Leroy, V.I.Luschikov, V.F.Minashkin, H.Oberlack, A.P.Cheplakov.

Special encouraging prize

Information and Biographical Reference Book «Joint Institute for Nuclear Research».
Author: M.G.Shafranova.

GRANTS

In 1999, a number of scientific projects developed by JINR staff members received grants of the Soros Foundation, INTAS Foundation, and of the International Centre for Science and Technology. Seventy-four projects were financed by the Russian Foundation for Basic Research. Twenty-nine staff members of JINR were awarded state grants by the Presidium of the Russian Academy of Sciences.

INTERNATIONAL RELATIONS AND SCIENTIFIC COLLABORATION

COLLABORATION IN SCIENCE AND TECHNOLOGY

The international collaboration of the Joint Institute for Nuclear Research in science and technology in 1999 is described by the following facts:

- Joint investigations on 33 first-priority and 15 second-priority research topics were carried out with scientific centres of the Member States, with international and national institutions of other countries.
- 2,522 JINR scientists and engineers went on various missions within collaborative projects and for participation in external scientific meetings and conferences.
- 772 scientists and engineers came to JINR for joint work and consultations.
- 597 scientists and engineers came to JINR to participate in workshops, conferences and schools.
- 15 international conferences, 18 workshops, and 12 other scientific meetings were organized by JINR.
- 20 fellows worked at the Laboratories of JINR.

The international collaboration of JINR is also characterized by agreements and contracts, joint experiments at basic facilities of physics research centres, scientific results, joint publications, delivery of equipment and technologies to the interested parties, etc.

On 14 January, the JINR Directorate received Professor R.Kamermans, Counsellor to the Minister of Education, Science, and Culture of the Netherlands. Issues of collaboration, including the proposal of creation in Dubna of a synchrotron radiation source based on NIKHEF's AmPS accelerator, were under consideration. Participating in the meeting were V.G.Kadyshevsky, A.N.Sissakian, I.N.Meshkov, A.S.Vodopyanov.

On 15 January, the JINR Directorate had talks with the Vice-Minister for Science of Ukraine B.V.Grinev, Corresponding Member of the National Academy of Sciences. Participating in the talks were JINR Director V.G.Kadyshevsky, Vice-Director A.N.Sissakian, Administrative Director A.I.Lebedev, member of the JINR Scientific Council G.M.Zinovjev (Ukraine), and others. The participants exchanged their opinions on the various aspects of the collaboration. On behalf of the Government of Ukraine, the Vice-Minister officially signed the Charter of the Joint Institute.

From 24–27 January, JINR Vice-Director A.N.Sissakian was on a working visit to Armenia. At Yerevan State University he met with Academician E.V.Chubaryan, YeSU Vice-Rector, Academician Yu.S.Chilingaryan, Dean of the Physics Department, Heads of the Chairs and Professors of the University and discussed with them issues of collaboration in research and educational programmes.

The results of the joint YePI–JINR experiment on deuteron photo-disintegration performed at the YePI accelerator in 1998 and future plans were on the agenda of the discussion with YePI Director R.L.Mkrtchyan.

In the course of his visit, A.N.Sissakian also had meetings with Sh.L.Karamanukyan, First Vice-Minister for Foreign Affairs of Armenia, Academician F.T.Sarkisyan, President of Armenia's National Academy of Sciences, V.Asaturyan, General Secretary of the UNESCO National Committee, and other scientists and statesmen.

Meeting with Prime Minister of Armenia A.P.Darbinyan on 27 January, A.N.Sissakian informed him on JINR's on-going research and some problems of the collaboration, needing support of the Government of Armenia. A.P.Darbinyan highly appreciated JINR's activities and the collaborative achievements.

Director of the Moscow Office of the French National Centre for Scientific Research A.Sempere visited the Joint Institute from 27–29 January. He met with JINR Director V.G.Kadyshevsky, Vice-Directors A.N.Sissakian and Ts.Vylov, Chief Scientific Secretary V.M.Zhabitsky, Assistant Director P.N.Bogolubov, and visited the Institute's Laboratories.

The 9th annual meeting of the Joint Steering Committee for the implementation of the Agreement on Cooperation between the Federal Ministry for Education, Research and Technologies (BMBF, Germany) and JINR took place in Jülich from 4–5 February. The delegations were headed by JINR Director V.G.Kadyshevsky and Councellor of the Ministry H.-F.Wagner, Co-chairman of the Committee. A comprehensive presentation of JINR's research programme, on-going reforms, results and prospects of the collaboration between the Joint Institute and German scientific centres was made by JINR Vice-Director A.N.Sissakian, Co-chairman of the Committee. The participants discussed in detail the various aspects of the collaboration.

A decision to prolong the term of the BMBF–JINR Agreement for three more years (2000–2002) was the major outcome of the meeting. The German Government approved the prolongation, a respective document to be finalized by the end of the year.

Plans of the two collaborating parties for 1999 found their reflection in the official protocol of the meeting.

From 6–10 February, JINR Director V.G.Kadyshevsky and Vice-Director A.N.Sissakian stayed in Brussels. During the visit the JINR leaders met with ISIPC Deputy Director I.Antoniou, INTAS Coordinator in Charge R.Vardapetian, and others.

On 9 February, at the NATO Headquarters, V.G.Kadyshevsky and A.N.Sissakian were received by Professors A.Jubert and W.Kaffenberger, Programme Advisors of the NATO Department of Science. Possibilities of joint activity in scientific programmes purposed to unite scientists of the West and the East were touched upon in the discussion.

Minister Plenipotentiary of the Embassy of the Republic of Poland in Russia T.Turowski and Councellor of the Embassy J.Sieniawski stayed at JINR on 17 February. The mission followed after the Minister for Foreign Affairs of Poland B.Gieremek had visited Moscow from 27–28 January and discussed issues of collaboration between Poland and Russia with members of the RF Government.

The guests had a meeting with the JINR Directorate and the Polish employees of the Institute, got acquainted with the Flerov Laboratory of Nuclear Reactions. Issues of further participation of Poland in JINR's activity were the focus of the discussions.

On 23 February, in Moscow, M.P.Kirpichnikov, Minister for Science and Technologies and Plenipotentiary of Russia to JINR, met with JINR Director V.G.Kadyshevsky and Vice-Director A.N.Sissakian. The JINR leaders informed the Minister on the preparation for the meetings of the Finance Committee (25–26 February) and the Committee of Plenipotentiaries of the Institute's Member States (11–12 March). Information on the major scientific results and future plans, the development of cooperation, the status of consideration by the State Duma of the Agreement between the RF Government and JINR, and some other questions were also presented at the meeting.

The Minister highly appreciated the results of JINR's activity, congratulated the staff on the discovery of the element of the Periodic Table with atomic number 114 and wished them further success in research. M.P.Kirpichnikov noted that the Ministry of Science and other governmental agencies would support JINR.

Academician A.N.Tavkhelidze, President of Georgia's National Academy of Sciences, stayed at JINR from 23–24 February. He discussed with the JINR Directorate some collaboration issues and the programme to commemorate the 90th anniversary of N.N.Bogoliubov's birth (1909–1992).

A representative delegation from CERN, including the newly appointed Director for Research R.Cashmore, Coordinator for Collaboration with CERN Non-Member States J.Ellis, Coordinator for Collaboration with Russia and the CIS Countries N.Koulberg, stayed at JINR on 28 February and 1 March. The guests visited the Laboratory of Nuclear Problems, the Laboratory of Particle Physics, and the JINR Experimental Workshop. JINR Director V.G.Kadyshevsky, Vice-Director A.N.Sissakian, Chief Engineer I.N.Meshkov, LPP Director V.D.Kekelidze, and other scientists acquainted them with the Institute's on-going research, major achievements and problems of the collaboration. A wide range of issues of mutual interest were touched upon in the discussions.

In March, JINR Director V.G.Kadyshevsky and Vice-Director A.N.Sissakian were on a short visit to the USA. At the Fermi National Accelerator Laboratory (FNAL, Batavia) they got acquainted with the status of upgrades of the D0 and CDF large detectors to be commissioned for the second long-term run in May 2000. The JINR leaders got acquainted with the on-going research within the MINOS project and some other collaborative programmes. A FNAL–JINR Protocol on VLHC Magnet Systems (to be designed at LHE, JINR) was signed during the visit. V.G.Kadyshevsky and A.N.Sissakian had discussions with FNAL Assistant Directors B.Christmann and R.Rubinstein, and with some other leading scientists of the Laboratory.

The programme of the visit also included their acquaintance with the preparations under way for the STAR experiment at the RHIC new relativistic nuclei accelerator of Brookhaven National Laboratory (BNL) to be commissioned in June 1999. V.G.Kadyshevsky and A.N.Sissakian met with BNL Director J.Marburger, RHIC Director S.Ozaki, and other scientists. A JINR–

BNL Collaboration Agreement on the STAR Experiment was signed at the meeting. Possible participation of JINR in activities at BNL's reactor, including production at the JINR Experimental Workshop of some elements for the upgrade of the reactor, aimed to treat cancer diseases and solve some medico-biological tasks, was touched upon in the discussions.

The JINR leaders also visited the Dowling College of the National Aviation Centre in Brookhaven and the International Career Centre in New York. Issues of cooperation in educational programmes were under consideration.

On 14–15 April, JINR was visited by Regional Coordinator of IAEA Department for Technical Cooperation J.Sabol. He made a tour of JINR divisions and met with Vice-Director A.N.Sissakian. Issues of cooperation, including organization of IAEA courses and training of specialists at JINR through IAEA, were touched upon in the discussions. Participating in the meeting were JINR UC Director S.P.Ivanova and DRRR Deputy Leader V.E.Aleinikov.

On 20–22 April, JINR was visited by Dr M.Della Negra, Spokesperson of the CMS Collaboration (LHC, CERN). He was received by JINR Director V.G.Kadyshevsky, Vice-Director A.N.Sissakian, and LPP Deputy Director I.A.Golutvin. The guest got acquainted with the activities of the Dubna group participating in the CMS project and made a tour of the Laboratory of Particle Physics.

On 3–4 May in Geneva, V.G.Kadyshevsky and A.N.Sissakian held a number of meetings with the CERN Directorate and spokespersons of the collaborations in which JINR teams are involved. They had talks with CERN Director General L.Maiani and Director for Research R.Cashmore. A wide range of collaboration issues, including a symposium «LHC Physics and Detectors» to be held in Dubna in 2000, and organization of a series of exhibitions «Science Bringing Nations Together» during 1999–2000, were discussed.

On 5–6 May in Brussels, V.G.Kadyshevsky and A.N.Sissakian met with Director of the International Solvay Institutes for Physics and Chemistry, Nobel Prize Laureate I.R.Prigogine, his Deputy I.Antoniou (Greece), Physics Department Dean of Brussels Free University and Director of the High Energy Physics Institute J.Lemann, Professor of the University Ph.Lambert, and others.

Issues of cooperation in scientific and educational programmes, including joint projects within the EC Framework 5 and possibilities of extending partnership of European countries in JINR's research programmes, were considered.

A joint JINR–CERN poster exhibition was held from 3–12 May at the Palais des Nations of the European Office of the United Nations Organization in Geneva.

The inauguration of the exhibition was attended by representatives of diplomatic missions accredited to Geneva, JINR and CERN Directorates, leaders of scientific collaborations, public figures and journalists.

The participants were welcomed by R.Ricupero, Secretary-General of the UN Commission for Trade and Development, who highly evaluated the great contribution of JINR and CERN to world science and the humanistic role of these organizations in bringing nations together to advance scientific researches in the world. On behalf of the national missions located in Geneva, all those present at the opening of the exhibition were welcomed by V.Sidorov, Permanent Representative of the Russian Federation to the UN Office. The participants were also addressed by V.G.Kadyshevsky, JINR Director, and L.Maiani, CERN Director-General. They shared their experience in creation and collaboration of the two international organizations, which during the time of the Cold War and political confrontation continued their fruitful cooperation for the benefit of humanity. Messages of congratulation from V.F.Petrovsky, Undersecretary of UN, Director General of UNOG, and Academician M.P.Kirpichnikov, Minister of Science and Technologies of the Russian Federation, the Plenipotentiary of Russia to JINR, observer of the Russian Federation to CERN, were announced.

On 12 May, the Joint Institute was visited by Ambassador of the Slovak Republic to Russia J.Furdik, Chairman of the Slovak State Committee for Metrology, Standardization and Certification D.Podgorski, First Secretary of the Embassy and Counsellor for Economics J.Sandtner, Attaché for Culture and Science M.Adam, and Second Secretary of the Embassy V.Borecki. The guests were received by JINR Director V.G.Kadyshevsky, Vice-Directors A.N.Sissakian and Ts.Vylov, Assistant Director P.N.Bogolubov, FLNR Director M.G.Itkis, FLNR Deputy Director S.N.Dmitriev, and Group Head of the Slovak employees at JINR J.Kliman.

A wide range of collaboration issues, including the construction of the Slovak cyclotron complex with the assistance of JINR, were on the agenda of the meeting. The guests visited the Flerov Laboratory of Nuclear Reactions, got acquainted with its experimental facilities, and met with the Slovak staff members and students working on graduation theses.

On 31 May in Moscow, Executive Director of the International Science and Technology Centre A.Gérard and JINR Vice-Director A.N.Sissakian signed an Agreement on Cooperation in the Ion Sources Project to be realized with support of ISTC and RIKEN (Japan). The status of

collaboration between JINR and ISTC and its prospects were discussed at the meeting. Participating in the discussions were ISTC Deputy Executive Director Sh.Ueta, Senior Manager Yu.Malakhov, Senior Technology Implementation Manager M.Sakamoto, JINR Group Head G.D.Shirkov, and others.

The first meeting of the Coordination Committee for Cooperation between JINR and Research Centres of Poland took place in Dubna from 5–8 June. About 20 Polish scientists and specialists, representatives of virtually all the institutes and universities collaborating with JINR, executives of the Polish State Agency for Atomic Energy, as well as members of the Directorates of JINR and the Laboratories, leaders of the major research programmes attended the meeting. Minister Plenipotentiary of the Embassy of Poland T.Turowski joined its final sitting.

Reports at the meeting were delivered by Plenipotentiary of Poland to JINR A.Hrynkiewicz, JINR Director V.G.Kadyshevsky, Vice-Director A.N.Sissakian, Directors of the JINR Laboratories, Polish leading scientists — employees of JINR, and others.

Guided by the scientific argumentation, the participants of the meeting have considered it to be expedient for Poland to keep its membership in JINR.

JINR Vice-Director A.N.Sissakian was on a visit to CERN in July. A wide range of collaborative issues were discussed at the meeting with CERN Director- General L.Maiani on 29 July. Among other matters it was decided that an International Symposium «LHC Physics and Detectors» would be held in Dubna through 28–30 July 2000.

Ways of promoting efficiency of the cooperation, especially taking into account that CERN and JINR have some common Member States (Bulgaria, Czech Republic, Poland, Slovak Republic), were on the agenda of the discussions.

A meeting «Particle Physics in Central Europe between CERN and JINR: Responsibility, Problems and Prospects», involving representatives of the CERN and JINR Directorates, as well as of a number of their Member States, was agreed upon to take place in 2000.

Issues related to the organization in 2000 of a series of joint exhibitions «Science Bringing Nations Together» were under discussion at the meeting too. Such an exhibition is expected to open in Brussels in spring.

A.N.Sissakian held meetings with R.Cashmore, J.Allaby, N.Koulberg, E.Lillestol, members of CERN's Directorate and collaboration coordinators, as well as with the spokespersons and participants of the ATLAS, CMS, ALICE, COMPASS and other experiments.

On 12 August in Moscow, JINR Director V.G.Kadyshevsky, Vice-Director A.N.Sissakian, and FLNR Scientific Leader Yu.Ts.Oganessian met with the RF Minister of Atomic Energy E.O.Adamov. The JINR leaders informed him on the status of cooperation with scientific centres and enterprises of the RF Ministry for Atomic Energy (Minatom). An understanding to prolong till the year 2003 the term of the Agreement on Science and Technology Cooperation between JINR and Minatom was reached at the meeting.

The participants discussed in detail possibilities of Minatom's support of the programme on synthesis and studies of new superheavy elements at FLNR. Issues of mutual interest related to the development of oncological and radiobiological activities at JINR's Phasotron in collaboration with the RF Ministry of Public Health, research at the IBR-2 reactor, and others were also considered.

Professors W.Gudowski (Stockholm), K.Broeders (Karlsruhe), E.Gonzalez-Romero (Madrid), and S.Taczanowski (Cracow), experts in application of electronuclear methods in power engineering, stayed in Dubna in August. They got acquainted in detail with the on-going research under way at JINR in this field, and visited LNP, LHE, LCTA and FLNP. Issues of cooperation in this promising area of nuclear power engineering were discussed with Vice-Director A.N.Sissakian.

On 5–9 September, JINR was visited by Professor G.Kaschiev, Chairman of the Committee on the Use of Atomic Energy for Peaceful Purposes of Bulgaria and Plenipotentiary of this country to JINR. He had discussions with JINR Director V.G.Kadyshevsky, Vice-Directors A.N.Sissakian and Ts.Vylov, made a tour of JINR Laboratories, met with the Bulgarian employees of the Institute.

Following the invitation of the JINR Directorate, the Chairman of the State Duma of the Russian Federation (Speaker of Parliament) G.N.Seleznev visited Dubna on 16 September. He was accompanied by the State Duma deputies A.A.Polyakov, A.V.Korovnikov, RF Vice-Minister of Science and Technologies V.N.Alimpiev, and others. The guests got acquainted with the on-going research programmes and basic facilities at the Flerov Laboratory of Nuclear Reactions and the Laboratory of High Energies, also with an exhibition specially prepared for the visit in the Cultural Centre «Mir».

In the Cultural Centre «Mir», G.N.Selesnev met with representatives of the JINR international staff and of the town enterprises and institutions. At this meeting, conducted by JINR Vice-Director A.N.Sissakian, the high-ranking guest was welcomed by JINR Director V.G.Kadyshevsky and Dubna Mayor V.E.Prokh.

The State Duma Chairman informed the participants on the status of parliamentary work on the Agreement between the Government of the Russian Federation and JINR.

A meeting of the JINR Directorate and the leaders of the Moscow Institute of Radioengineering, Electronics and Automation (MIREA) took place in Dubna on 21 September. At the meeting, MIREA was represented by Rector A.S.Sigov, Vice-Rector A.A.Berzin, EOT Faculty Dean A.G.Vasiliev, and Director of the Dubna branch M.N.Omelyanenko; the JINR Directorate, by Vice-Director A.N.Sissakian, Chief Engineer I.N.Meshkov, Division Leader V.V.Katrasev, and UC Director S.P.Ivanova. A wide range of issues on cooperation in scientific and educational programmes, including the development of training in engineering sciences using JINR facilities, were the focus of attention in the discussions.

CERN Director-General L.Maiani visited Dubna on 28 September. At JINR he met with Vice-Director A.N.Sissakian and leaders of the Laboratories of Particle Physics, High Energies, and Nuclear Problems — V.D.Kekelidze, I.N.Ivanov, A.I.Malakhov, and A.S.Kurilin.

At the Laboratory of Nuclear Problems, Professor L.Maiani got acquainted with the assembly of the hadron calorimeter modules for the ATLAS facility. At the Laboratory of Particle Physics, he visited the area for serial production of pokalon-C chamber modules and also other subunits of the Laboratory involved in the design and construction of electronics for the LHC large detectors. At the Laboratory of Theoretical Physics, he saw a photo exhibition dedicated to the 90th anniversary of the birth of Academician N.N.Bogoliubov (1909–1992).

L.Maiani gave his high appreciation of the status and perspectives of the CERN–JINR collaboration and underlined the powerful scientific and technical potential of the Joint Institute which represents an important part of the world scientific community.

A delegation of deputies of the National Assembly and leaders of a number of institutes and organizations of the Slovak Republic stayed at JINR on 30 September. The visit was connected with the Slovak Cyclotron Complex being constructed with participation of Russia and JINR. The guests had talks with the Directorates of the Joint Institute and of the Flerov Laboratory of Nuclear Reactions, got acquainted with FLNR's facilities. They also met with the Slovak employees of JINR and heard a report of the Slovak students having special-purpose training at the JINR University Centre to be able to work at the complex.

A meeting of the Joint Committee on Collaboration between the National Institute for Nuclear and Particle Physics (IN2P3, Paris) and JINR took place at the National Centre for Scientific Research (CNRS) in Paris on 29 October. A wide range of collaborative issues, including the results obtained in 1999 and plans for 2000, were on the agenda of the discussions. At the talks IN2P3 was represented by Director J.-J.Aubert, Vice-Director B.Haas, International Relations Department Head E.Perret; JINR, by Director V.G.Kadyshevsky, Vice-Directors A.N.Sissakian and Ts.Vylov, Assistant Director for International Relations P.N.Bogolubov.

On 2 November at the Embassy of Germany in Moscow, JINR Director V.G.Kadyshevsky signed the Agreement on Cooperation between the Federal Ministry for Education, Research and Technologies (BMBF, Germany) and JINR, defining the participation of Germany in the JINR research programme for the next three years (2000–2002). On behalf of the Government of Germany the BMBF Directorate signed the Agreement on 15 October.

On 5 November, JINR Director V.G.Kadyshevsky and Vice-Directors A.N.Sissakian and Ts.Vylov received J.Stamenov, Director of the Institute for Nuclear Research and Nuclear Energy (Sofia, Bulgaria). Issues of cooperaton in research and educational programmes were considered at the meeting.

A delegation of the Islam Republic of Iran (IRI), including R.Aghazadeh, IRI Vice-President and President of the Atomic Energy Organization of Iran (AEOI), M.Safari, IRI Ambassador to Russia, and members of the Parliament, visited the Joint Institute on 17 November. They were received by JINR Director V.G.Kadyshevsky, Vice-Directors A.N.Sissakian and Ts.Vylov, Chief Engineer I.N.Meshkov. A tour of the Flerov Laboratory of Nuclear Reactions was organized for the guests.

A.Battur, Minister of Education of Mongolia, Chairman of the Committee for Atomic Energy and the Committee for UNESCO Affairs, stayed at JINR on 20 November. He was accompanied by Mrs Sarantuyaa, Counsellor of the Embassy of Mongolia in the Russian Federation, Mr Baasanjav, Agency Deputy Head of the Ministry, representatives of the Mongolian group at JINR. They were received by JINR Director V.G.Kadyshevsky, Vice-Director A.N.Sissakian, Assistant Director for International Relations P.N.Bogolubov, and DRRR Head E.A.Krasavin. Various aspects of the cooperation between physicists of Mongolia and JINR were on the agenda of the meeting. The guests visited the Flerov Laboratory of Nuclear Reactions and the International University «Dubna».

A meeting of the CERN–JINR Cooperation Committee, co-chaired by Professors J.Allaby and A.N.Sissakian, was held in Geneva on 2 December. Participating in the meeting were representatives of the JINR and CERN Directorates, spokespersons of the joint experiments, and the collaboration coordinators. The participants were presented with 15 reports covering the major research directions and a review presentation by A.N.Sissakian. J.Allaby summed up the results of the meeting.

The participants expressed their hope that the cooperation in the joint experiments will be successfully continued in 2000.

It was noted that CERN Director-General L.Maiani and Director for Research R.Cashmore gave high appreciation of the status of the JINR–CERN cooperation during their visit to Dubna in 1999.

In the course of his visit to Geneva, JINR Vice-Director A.N.Sissakian had meetings with CERN Director for Research C.Detraz, the collaboration coordinators J.Allaby and N.Koulberg, as well as with the spokespersons of the joint experiments. At the meeting JINR was also represented by Chief Scientific Secretary V.M.Zhabitsky, LPP Director V.D.Kekelidze, and Professors A.S.Vodopyanov, L.L.Nemenov, N.M.Shumeiko (Belarus), A.S.Kurilin, M.Mateev (Bulgaria).

CONFERENCES AND MEETINGS HELD BY JINR

The 3rd Scientific Conference for Young Scientists and Specialists organized by JINR's Association of Young Scientists and Specialists (AYSS) was held in Dubna from 15–19 February. For five days about 140 participants from JINR Laboratories, Moscow State University, Dubna University, Tver University, Tula University, Belarusian State University, and other universities and scientific centres attended lectures given by V.G.Kadyshevsky, A.N.Sissakian, I.N.Meshkov (JINR Directorate), A.A.Baldin, A.I.Malakhov (LHE), V.G.Egorov, V.A.Karnaukhov (LNP), Yu.Ts.Oganessian, A.V.Eremin, S.N.Dmitriev, S.I.Sidorchuk (FLNR), V.S.Shakhmatov, and V.N.Shvetsov (FLNP).

Young scientists presented about 110 scientific talks in the sections «Solid State Physics», «Particle Physics», «Application of Mathematical Methods in Scientific Research», «Fields and Particles», «Particle Acceleration Techniques and Accelerator Engineering», «Nuclear Reactions», «Application of Information Technologies in Scientific Research», «Relativistic Nuclear Physics», «Automation of Physics Experiment», and others.

The VIII International Seminar on Interaction of Neutrons with Nuclei was organized at the Frank Laboratory of Neutron Physics from 25–28 May. The Seminar was devoted to the problems of nuclear physics with neutrons and included studies of fundamental properties of neutron, theoretical and methodical aspects of nuclear physics with neutrons, reactions on fast neutrons, physics of ultracold neutrons, neutron optics, fission of nuclei, etc. Specialists from JINR as well as from China, Russia, the USA, France, South Korea attended the Seminar.

The 2nd International Conference «Non-Accelerator New Physics» (NANP-99) took place in Dubna from 28 June to 3 July. Among its participants were representatives of scientific collaborations in France, Germany, Italy, Japan, Poland, Russia, Ukraine, and the USA. The present status and perspectives of search of new physics beyond the Standard Model in non-accelerator experiments were discussed at the Conference. It was organized by JINR, the Russian Foundation of Basic Research, the Institute of Nuclear Research of the Russian Academy of Sciences, and Prague Technical University.

From 30 July to 8 August in Belarus, Gomel hosted an International School-Seminar «Actual Problems of Particle Physics». It was attended by leading and young scientists from a number of JINR Member-State research centres and other countries. A large delegation of JINR took part in the School-Seminar, whose co-chairmen were V.A.Gaisenok, Plenipotentiary of Belarus to JINR, and A.N.Sissakian, JINR Vice-Director. Professor A.N.Sissakian delivered a lecture on the JINR scientific programme, visited research centres in Gomel, and met with leading scientists and research organizers of Belarus.

The VII European School of High-Energy Physics was held from 22 August to 3 September in Casta-Papiernička, Slovak Republic. Its organizers — CERN, JINR, the Slovak Ministry of Education, the Institute of Physics of the Slovak Academy of Sciences — invited leading theoretical physicists to lecture from Great Britain, the USA, and France. The lecturers from JINR were A.N.Sissakian, D.Yu.Bardin, S.M.Bilenky. The School's students were young experimental physicists from 40 countries of the world.

The Organizing Committee of the joint CERN–JINR schools summed up the results of the 1999 school and planned to hold the next school in 2000 in Portugal.

August 1999 marked the 90th anniversary of the birth of Academician Nikolai Nikolaevich Bogoliubov (1909–1992), an outstanding scientist in the field of mathematics, mechanics and physics. An International Conference «Problems of Theoretical and Mathematical Physics», dedicated to the memory of N.N.Bogoliubov,

was held from 27 September – 6 October 1999. Its scientific and memorial sessions were successively held in Moscow, Dubna and Kyiv — the cities in Russia and Ukraine where N.N.Bogoliubov left his remarkable heritage as a teacher and a founder of new scientific schools and research directions.

The subject of the Conference covered those fields of knowledge to which N.N.Bogoliubov made fundamental contributions and initiated new lines of research: mathematics and nonlinear mechanics, quantum field theory, elementary particle physics, statistical physics and kinetics, and nuclear physics. More than 200 scientists from many countries of the world attended the Conference.

During the opening of the Conference at Moscow State University (MSU) on 27 September, the participants were addressed by President of RAS Yu.S.Osipov, Rector of MSU V.A.Sadovnichy, and JINR Director V.G.Kadyshevsky. The first day of the Conference included ceremonies of awarding prizes. The N.N.Bogoliubov Gold Medal of the Russian Academy of Sciences for 1999 went to Academician V.S.Vladimirov, and the N.N.Bogoliubov Prize of the Joint Institute for Nuclear Research for 1999 was awarded to Professor I.R.Prigogine, Nobel Prize winner, Director of the International Solvay Institutes of Physics and Chemistry (Brussels), and to Academician V.G.Bar'yakhtar, Institute of Mathematics of NASU (Kyiv).

On the following day, 28 September, the Conference was continued at the Steklov Mathematical Institute of RAS.

On 29 September, the Conference participants paid tribute to the memory of N.N.Bogoliubov by laying flowers on his tomb in the Novodevichy Cemetry in Moscow. Afterwards, the participants moved to Dubna, where Conference sessions were continued at the Bogoliubov Laboratory of Theoretical Physics till 2 October. Of great interest were reminiscences by N.N.Bogoliubov's brothers — A.N.Bogoliubov (Kyiv) and M.N.Bogoliubov (St. Petersburg).

The opening of the Kyiv part of the Conference was held on 4 October in the Main Conference Hall of the National Academy of Sciences of Ukraine. The participants were welcomed by B.E.Paton, President of NASU, A.G.Sitenko, Director of the Bogoliubov Institute of Theoretical Physics and V.G.Kadyshevsky, JINR Director.

On 5 and 6 October, sessions were continued at the Bogoliubov Institute for Theoretical Physics of NASU and the Institute of Mathematics of NASU, where more than 70 talks were given.

The Bogoliubov Conference, at which 42 plenary talks and more than 150 original contributions at parallel sessions were presented, was closed on 6 October in Kyiv — the scientific «cradle» of the outstanding scholar of the 20th century N.N.Bogoliubov.

A scientific conference «JINR Synchrocyclotron: 50 Years» was held in Dubna from 16–17 December. It was opened at the Laboratory of Nuclear Problems by its Director N.A.Russakovich. JINR Vice-Director A.N.Sissakian addressed the participants with a speech of greetings.

The Laboratory's veterans spoke about the first experiments with Synchrocyclotron beams, which marked the beginning of a new nuclear physics field, high-energy physics, in the USSR. Some of the talks dealt with the conversion of the accelerator; international cooperation of scientists who worked at the Laboratory was highly acknowledged. Guests from Russia, Romania, Slovakia also spoke at the conference.

On 17 December a ceremonial meeting of the JINR scientific community was held in the Cultural Centre «Mir», where JINR Director V.G.Kadyshevsky and JINR Chief Engineer I.N.Meshkov addressed the audience with their greetings. The meeting was followed by a festive concert.

Words of congratulation on the anniversary of the Institute's basic facility came from Chairman of the State Duma of the Federal Assembly of the Russian Federation G.N.Seleznev, Minister for Atomic Energy E.O.Adamov, First Vice-Minister of Science and Technology G.V.Kozlov, and from representatives of many research centres in JINR Member States.

PARTICIPATION OF JINR IN INTERNATIONAL AND NATIONAL CONFERENCES

In 1999, scientists of the Joint Institute for Nuclear Research took part in 196 international and national conferences.

The largest delegation of JINR attended the following conferences: Egyptian-Russian Workshop on Cyclotrons (Egypt, Cairo), 1999 Particle Accelerator Conference (PAC'99) (USA, New York), 6th International Seminar «Neutron Scattering Investigations in Condensed Matter» and the 3rd Polish Seminar on Neutron Scattering (a joint seminar) (Poland, Poznan), 14th Inter-

national Workshop on ECR Ion Sources (Switzerland, Geneva), 14th International Conference on Ultra-Relativistic Nucleus-Nucleus Collisions (Italy, Turin), 5th Workshop on Polarized Protons at High Energies (Germany, Hamburg), Workshop on Electron Cooling and Related Topics (ECOOL'99) (Sweden, Uppsala), Summer School on Particle Physics (Italy, Trieste), XV Particles and Nuclei International Conference (PANIC-99) (Sweden, Uppsala), NEMO Collaboration Meeting (Czech Republic, Prague), 2nd International Conference on Fission and Properties of Neutron-Rich Nuclei (UK, St. Andrews), 7th Summer School on Neutron Scattering («Neutron Scattering in Next Millennium») (Switzerland, Zuoz), International Summer School «Particle Production Spanning MeV and TeV Energies» (Netherlands, Nijmegen), VI International Wigner Symposium (Turkey, Istanbul), 3rd International Conference «Modern Problems of Nuclear Physics» (Uzbekistan, Bukhara), 2nd European Conference on Neutron Scattering (Hungary, Budapest), International Workshop «Symmetry and Spin» (PRAHA-SPIN'99) (Czech Republic, Prague), VI All-Russian Workshop on the Optics and Optimization of Particle Beams (Russia, Saratov), International Workshop on Hadron Physics (Portugal, Coimbra), 5th International Conference on Positron Sensitive Detectors (UK, London), Conference «Internet Service for Science» (Russia, Novorossiysk), 1st International Conference on Chemistry and Physics of the Transactinide Elements (TAN-99) (Germany, Seeheim), XIII International School on Nuclear Physics, Neutron Physics and Nuclear Energy (Bulgaria, Varna), International Workshop on Polarized Sources and Targets 1999 (Germany, Erlangen), 7th International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS'99) (Italy, Trieste), International Conference «Textures and Physical Properties of Rocks» (Germany, Gottingen), International School «Selected Topics on Quantum Field Theory and Quantum Statistics» (Georgia, Tbilisi), 1999 Atlas Muon Workshop (Israel, Eilat), East-European Meeting on Synchrotron Radiation and Free Electron Lasers (EESRFEL' 99) (Poland, Cracow), 2nd Conference on Nuclear and Particle Physics (NUPPAC'99) (Egypt, Cairo), Workshop «Laser Spectroscopy on the Radioactive Nuclear Beams» (Poland, Poznan), Workshop «Relativistic Nuclear Physics from Hundreds of MeV to TeV» (Slovak Republic, Stara Lesna), V International School-Seminar on Actual Problems of Particle Physics (Belarus, Gomel), VII European School of High-Energy Physics (Slovak Republic, Casta-Papiernička), Bogoliubov Conference «Problems of Theoretical and Mathematical Physics» (Ukraine, Kyiv).

Development of JINR's international collaboration and relations during the years 1965-1999

		1965	1975	1985	1990	1995	1998	1999
1.	Number of visits to JINR by specialists from its Member States (excluding participants in JINR conferences)	203	1026	1469	1050	299	285	361
2.	Number of visits by JINR specialists to Member States	171	474	600	778	682	626	692
3.	Number of conferences and meetings organized by JINR	19	42	49	44	52	47	48
4.	Number of visits to international conferences and research centres of non-Member States	69	131	119	437	1451	1659	1830
5.	Number of visits of scientists from non-Member States	27	226	144	563	1036	792	659
6.	Number of JINR fellows		11	3	16	28	29	20

CONFERENCES AND MEETINGS HELD BY JINR IN 1999

Title	Site	Date
85th Session of the JINR Scientific Council	Dubna	14–16 January
Workshop of the Polarized Target Users	Dubna	16 January
21st Workshop on the IHEP–JINR Neutrino Detector and the NOMAD Experiment	Dubna	19–21 January
Workshop «Space Charge Effects for the Formation of Intensive Low-Energy Particle Beams»	Dubna	15–17 February
III Scientific Conference for Young Scientists and Specialists	Dubna	15–19 February
Meeting of the JINR Finance Committee	Dubna	25–27 February
Meeting of the Committee of Plenipotentiaries of the JINR Member States	Dubna	11–13 March
III Workshop «Nucleation Theory and Its Application»	Dubna	4–27 April
Meeting of the Programme Advisory Committee for Particle Physics	Dubna	16–17 April
Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	19–20 April
International Conference on Nuclear Spectroscopy «Nuclear Shells: 50 Years»	Dubna	21–24 April
Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	25–26 April
17th EMU01/12 Collaboration Workshop on Prospects for the Use of Photoemulsions in Experiments with the Nuclotron Beams of Relativistic Nuclei	Dubna	18–20 May
Workshop «Laser Spectroscopy on Radioactive Nuclear Beams»	Poland Poznan	24–27 May
VII International Seminar on Interaction of Neutrons with Nuclei	Dubna	25–28 May
BAIKAL Collaboration Workshop	Dubna	26–30 May
86th Session of the JINR Scientific Council	Dubna	3–4 June
III Scientific School for Young Scientists and Specialists	Lipnya (an island in the Moscow Sea)	5–7 June
Meeting of the JINR–Poland's Institutes Cooperation Council	Dubna	7–9 June
International School «Symmetries and Integrable Systems»	Dubna	8–11 June
Workshop «Relativistic Nuclear Physics from Hundreds of MeV to TeV»	Slovak Republic Stara Lesna	14–18 June

Title	Site	Date
Workshop «Cooperative Methods in Nuclei and Other Mesoscopic Systems»	Dubna	14–24 June
Meeting of the Control Commission of the JINR Finance Committee	Dubna	24–25 June
II Workshop «Non-Accelerator New Physics»	Dubna	28 June – 3 July
Workshop «Diffraction at Colliders»	Dubna	3–6 July
V International Symposium «Dubna-Deuteron» («Dubna-Deuteron' 99»)	Dubna	6–10 July
Workshop «Supersymmetries and Quantum Symmetries»	Dubna	27–31 July
Workshop «Quantum Gravity and Superstrings»	Dubna	2–10 August
V International School-Seminar on Actual Problems of Particle Physics	Belarus Gomel	30 July – 8 August
VII European School of High Energy Physics (a JINR–CERN school)	Slovak Republic Casta-Papiernička	22 August – 4 September
International Workshop «Science, Philosophy, Religion»	Dubna	9–11 September
IAEA Courses on Radiation Safety	Dubna	13 September – 12 November
International School for Young Scientists «Problems of Particle Acceleration»	Dubna (Ratmino)	14–22 September
Workshop «Physical Variables in Gauge Theories»	Dubna	21–25 September
3rd Scientific Seminar in Memory of V.P.Sarantsev	Dubna	22–23 September
Bogoliubov Conference «Problems of Theoretical and Mathematical Physics»	Dubna	27 September – 6 October
II International Seminar «Neutron Scattering at High Pressure»	Dubna	29 September – 2 October
Workshop «Fermions and the Structure of the QCD Vacuum»	Dubna	5–9 October
EXCHARM Collaboration Workshop	Dubna	19–21 October
International Conference «Naukograds: Dialogue between Science and Education»	Dubna	20–22 October
International Workshop «Electronuclear Technology and Transmutation of Radioactive Waste at the LHE Accelerator Complex»	Dubna	26–29 October
Workshop «JINR Synchrotron Radiation Source: the Prospects of Research»	Dubna	1–3 November

Title	Site	Date
Workshop «Monitoring of Natural and Man-Made Radionuclides and Heavy Metal Waste in Environment»	Dubna	2–5 November
Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	12–13 November
Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	18–20 November
Meeting of the Programme Advisory Committee for Particle Physics	Dubna	26–27 November
BAIKAL Collaboration Workshop	Dubna	30 November – 3 December
International Conference «JINR (LNP) Synchrocyclotron: 50 Years»	Dubna	16–17 December

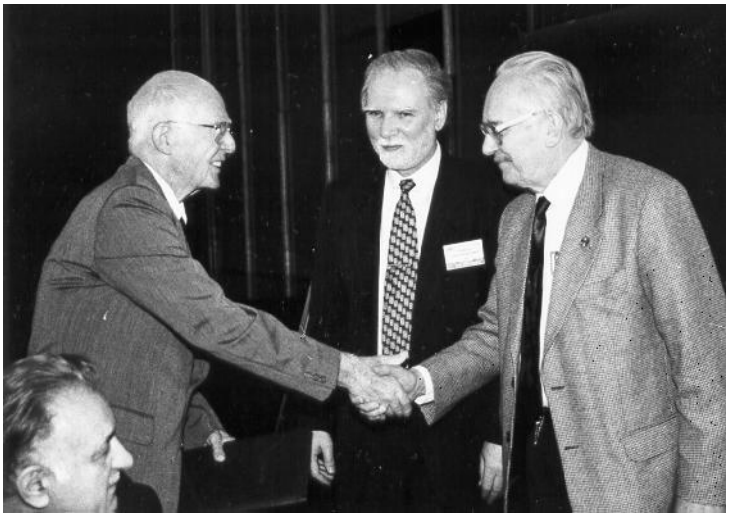
The Joint Institute for Nuclear Research is an international intergovernmental sientific research organization, the activities of which are based on principles of openness for participation to all interested states and of their equal, mutually beneficil collaboration.

Dubna, 3–4 June. The 86th session of the JINR Scientific Council

Dubna, 11–12 March. Meeting of the Committee of Plenipotentiaries of the JINR Member States

Dubna, 4 June.
Director of the Institute V.G.Kadyshevsky
presents a Diploma «Honorary Doctor of JINR»
to Professor H.Schopper (Germany)

Professor R.Davis (USA)(left),
the winner of JINR's 1999 B.Pontecorvo Prize



Dubna, 17 February.
Visit to JINR of the
Minister Plenipotentiary
of the Embassy of the Republic
of Poland in Russia
T.Turowski (second from right)

USA, March.
Signing of the JINR–BNL Agreement
on the STAR experiment.
In the photograph (left to right):
A.N.Sissakian, V.G.Kadyshevsky,
Yu.A.Panebratsev (JINR),
J.Marburger, T.Hallman,
S.Ozaki (BNL)

Dubna, 30 April.
Inauguration of an exhibition
of modern Mongolian painting
at the JINR Scientists' Club

Dubna, 21–24 April. International Conference on Nuclear Physics «Nuclear Shells — 50 Years»

Dubna, 12 May.
JINR's guest — Ambassador
of the Slovak Republic to Russia
J.Furdik (first from right),
at the meeting with the Slovak students
at the JINR University Centre

Dubna, 25–28 May. Participants of the VII International Seminar
on Interaction of Neutrons with Nuclei on a trip in the neighbouring forest

Geneva, 3–12 May. JINR-CERN poster exhibition «Science Bringing Nations Together» at the Palais des Nations of the European Office of the United Nations Organization

CERN, 3 May.
Meeting of the JINR and CERN Leaders.
In the photo:
JINR Vice-Director A.N.Sissakian,
JINR Director V.G.Kadyshevsky
and CERN Director-General
L.Maiani

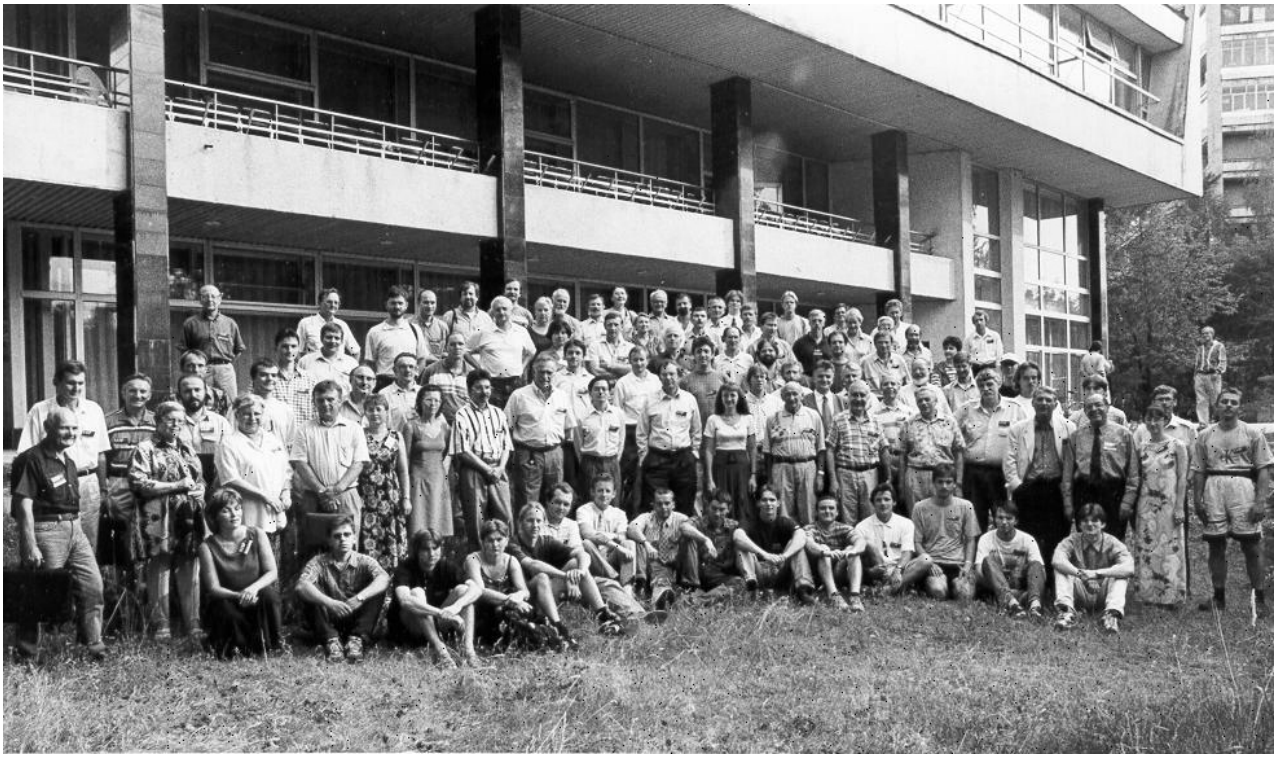
Dubna, 5 September.
Professor G.Kaschiev (second from right),
Chairman of the Committee
on the Use of Atomic Energy
for Peaceful Purposes of Bulgaria
and Plenipotentiary of this country to JINR,
tours the Frank Laboratory of Neutron Physics

Dubna, 16 September. Guest of JINR — G.N.Seleznev (centre),
Chairman of the State Duma of the Russian Federation's Federal Assembly, tours the Laboratory of High Energies

Dubna, 27 July. Participants of the Workshop «Supersymmetries and Quantum Symmetries»

Dubna, 3 June. Inauguration of a monument
to Academician Georgy N.Flerov (1913-1990)

Dubna, 28 June. Participants of the International Conference
«Non-Accelerator New Physics»

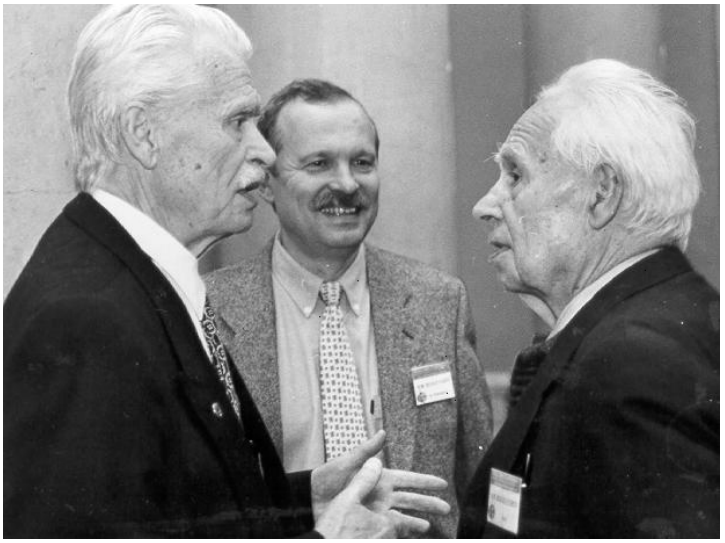


Dubna, 15–19 February. The 3rd Scientific Conference
for Young Scientists and Specialists

Dubna, 5–8 June. Meeting of the Coordination Committee
for Cooperation between JINR and Research Centres of Poland


БОГОЛЮБОВ

Moscow-Dubna-Kyiv,
27 September – 6 October.
International Conference
«Problems of Theoretical
and Mathematical Physics»,
dedicated to the 90th anniversary
of the birth of Academician
N.N.Bogoliubov (1909–1992)



Dubna. During his stay in Dubna on 20 November, JINR's guest — Professor A.Battur (right), Minister of Education and Chairman of the Atomic Energy Commission of Mongolia, visited the International University «Dubna»

Dubna. A delegation of the Islamic Republic of Iran (IRI) headed by R.Aghazadeh, Vice-President of IRI and President of the Atomic Energy Organization, visited JINR on 17 November to get acquainted with the Institute's activities

Dubna, 26–27 November. Participants of the 12th meeting of the JINR Programme Advisory Committee for Particle Physics

RESEARCH AND EDUCATIONAL PROGRAMMES OF JINR

BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

At the Laboratory, studies are carried out on three first-priority themes approved at the 85th session of the Scientific Council: «Fields and Particles», «Theory of Nuclei and Other Finite Systems», and «Theory of Condensed Matter».

FIELDS AND PARTICLES

The theme «Fields and Particles» included a wide range of researches on problems of «pure theory» and of particle physics. The main activity was concentrated on the following directions:

— Quantum symmetries, supersymmetries, and integrable models, with applications to strings, gravity, and cosmology;
— Perturbative computations in gauge theories and various approaches to nonperturbative treatment;
— Standard model and its extension;
— Heavy flavours and B-physics;
— Spectroscopy of light flavours.

Note the growth of activity in the theory of superstrings, integrable models, and lattice gauge theories.

The theory of quantum matrix algebras became in recent years one of the most intensively developing topics in the mathematical theory of quantum groups. These algebras found their application in the description and investigation of quantum-mechanical and statistical integrable models, being, in fact, an adequate mathematical tool for formulation of the notion of integrability. The investigations carried out in this direction at BLTP resulted in the construction of a new family of quantum matrix algebras that includes all previously known quantum matrix algebras as particular cases [1]. For these algebras the problem of finding a special commutative subalgebra — the so-called spectrum of a quantum matrix — was solved in general. For the corresponding integrable models, the spectrum of the quantum matrix gives an involutive set of the integrals of motion. The techniques developed for calculations with quantum matrices was applied for investigation of the «zero modes» algebra of the chiral Wess–Zumino–Novikov–Witten mode [2].

The superfield models with 1/2 partial spontaneous breaking of the global $D=3$, $N=2$ supersymmetry were discussed, both within nonlinear and linear realizations of supersymmetry [3]. In the first approach, the manifestly $N=1$, $D=3$ supersymmetric superfield action of a $D=4$ supermembrane was derived for the first time, and its dual equivalence to the worldvolume action of an $N=2$ «space-time filling» D2 superbrane was demonstrated. In the second approach, the same partial breaking arises in the Abelian gauge model describing low-energy interactions of the real scalar field with $3D$ vector and fermion fields. The partial breaking of $N=1, D=10$ supersymmetry was treated from a similar standpoint within nonlinear realization [4] and that of $N=2, D=4$ within linear realization [5].

The multidimensional $N=4$ **supersymmetric quantum mechanics** (SUSY QM) was constructed by using the superfield approach. As a result, the component form of the classical and quantum Lagrangian and Hamiltonian was obtained. In the considered SUSY QM, both classical and quantum $N=4$ algebras include central charges, and it opens various possibilities for the partial supersymmetry breaking, including the fractional options [6].

A bound system composed of the Yang monopole coupled to an isospin particle by the SU(2) and Coulomb interaction was considered. A system like that is an example of **the Seiberg–Witten duality in quantum mechan-**

ics. The generalized Runge–Lenz vector and the SO(6) group of hidden symmetry were found. It was also shown that the group of hidden symmetry allows one to algebraically compute the spectrum of systems of that sort [7].

By carefully analysing the picture-dependence of the BRST cohomology, an infinite set of symmetry charges of **the closed $N = 2$ string** was identified [8]. The transformation laws of physical vertex operators were shown to coincide with the linearized nonlocal symmetries of the Plebanski equation (which is the effective field theory of a closed $N = 2$ string). Moreover, it was shown that the corresponding Ward identities are powerful enough to allow for a rederivation of the well-known vanishing theorem for tree-level correlation functions with more than three external legs. Holomorphic Chern–Simons–Witten theories defined on 6D manifolds with a complex structure were considered, and 4D conformal field theories connected with them were described [9]. All these models are solvable. Analogs of the Virasoro and affine Lie algebras, the local action of which on the fields of holomorphic Chern–Simons–Witten theories becomes nonlocal after pushing down to an action on the fields of solvable 4D conformal field theories, were described.

Tau-functions **of the N-soliton solutions** of the Kadomtsev–Petviashvili hierarchy of equations and of its B-type reduction were shown to describe fixed-temperature partition functions of the specific Coulomb plasmas on the plane with some boundaries. In this picture, coordinates of the charges coincide with the complex spectral variables of solitons, phase shifts (describing scattering of solitons) coincide with the Coulomb interaction potentials, and the hierarchy evolution «times» contributions correspond to external electric fields. This identification generates some new solvable lattice plasma models. A (1+1)-dimensional discrete-time chain associated with the three-term recurrence relation of the R_{II}-type and some of its similarity reductions were described [10].

Photon and fermion correlators were studied analytically and numerically in the quenched **lattice QED** within the Lorentz (or Landau) gauge. It was shown that zero-momentum modes (ZMM) as well as Dirac sheets (DS) play an important role in fixing the Lorentz gauge nonperturbatively. They spoil fermion and photon propagators, and the standard fermion mass estimate fails for the commonly employed Lorentz gauge fixing procedure. To resolve the problem, a new gauge fixing procedure — zero-momentum Lorentz gauge (ZML) — was proposed. Therefore, the Gribov ambiguity problem was finally resolved in quenched QED on the lattice in the (physical) Coulomb phase [11].

Sakharov's idea that gravitation can be induced by vacuum polarization effects was generalized. It was suggested that the same mechanism is responsible also for the origin of other long-range forces in Nature. As an example, an ultraviolet-finite model, where the Einstein and Maxwell actions are entirely induced by quantum effects of very massive constituent fields, was constructed. The gravitational and gauge fields appear here on equal footing, and, thus, the model is a unified theory of gravitation and electromagnetism. In the low-energy limit, **the induced Einstein–Maxwell gravitation** admits standard solutions and rotating charged black holes, in particular. It was shown that the Bekenstein–Hawking entropy of these black holes is described by the same statistical-mechanical formula as the entropy of a Schwarzschild black hole. This demonstrates that the mechanism of generation of the Bekenstein–Hawking entropy in induced gravitation is universal, and it does not depend on the angular momentum and the charge of a black hole [12].

In **supersymmetric gauge theories** with soft supersymmetry breaking, a powerful method of obtaining the renormalization-group equations for soft terms was proposed. The method is based on the Taylor expansion in the Grassmannian parameter and also allows one to derive the solutions of RG equations. New solutions for the soft terms in the Minimal Supersymmetric Standard Model, in SUSY GUTS, and in $N = 2$ Seiberg–Witten Models were obtained [13].

The structure functions of inelastic lepton–nucleon scattering processes were analyzed starting from the general principles of the theory expressed by the Jost–Lehmann–Dyson integral representation. A nonstandard scaling variable that leads to analytic moments of the structure functions was used, and the relation between these analytic moments and the operator product expansion was established [14].

The first estimation of **the proton transversity distribution** was done by using the azimuthal asymmetry in semiinclusive DIS recently measured on longitudinally (HERMES) and transversely (SMC) polarized targets and experimental data of DELPHI on the T-odd fragmentation function, responsible for the left–right asymmetry in the fragmentation of transversely polarized quarks. It was shown that the u-quark transversity distribution in a proton is close to the effective chiral quark soliton model, and the u contribution to the proton tensor charge is of order 1. On this basis, one can state that the proton transversity distribution could successfully be measured in future DIS experiments (e.g., in COMPASS) with a *longitudinally* polarized target together with measurement of ΔG [15].

The spin dynamics described by the properties of nonperturbative matrix elements in QCD was analyzed. In particular, the consistent description of the tensor polarization of vector mesons originating in the fragmentation of quarks and gluons was developed. New sum rules for T-odd fragmentation functions were derived. The notion of the T-odd fracture function describing single spin asymmetries in the polarized-particle fragmentation region was introduced. An interesting link between the spin structure of a nucleon and the Einstein equivalence principle was suggested [16].

A complete analysis of the helicity amplitudes in the small-angle process of double bremsstrahlung along one

direction in **electron–positron scattering at high energies** was carried out. The analytic expression for a correction up to the next-to-leading order for the quasielastic radiative tail of the deep–inelastic and Bhabha scattering process with an account of nonleading corrections was obtained [17].

It is shown that a homogeneous self-dual gluon field, in which «analytic confinement» is realized (i.e., the quark propagator is an entire analytic function in the momentum space), leads to **confinement in the sense of the Wilson criterion** — there arises a growing confining potential between heavy quarks. By using the recent development of the axial gauge representation for QCD, it was demonstrated that in the high-temperature limit, the effective potential of the background field under consideration has a minimum at the zero field strength, which means that at some critical temperature there should be a confinement-deconfinement phase transition. The geometrical gluon mass at finite temperature (finite extension) acting as an infrared regulator in the system plays an important role in the derivation of the above result [18].

A realistic nonlocal chiral $U(3)\times U(3)$ model with 't Hooft interaction was constructed to describe the mass spectrum of excited scalar, pseudoscalar, and vector mesons and their first radial excitations. This allowed us to interpret experimentally observed scalar, pseudoscalar, and vector meson states as members of quark-antiquark nonets in the energy interval from 400 MeV up to 1.7 GeV. It was shown that all the 19 scalar meson states can be considered as two nonets: a meson nonet of ground states and that of their first radial excitations plus one glueball with mass 1.5 GeV. The mass spectra and strong decay modes of excited scalar, pseudoscalar, and vector meson nonets were described. A quark model without unphysical $q\bar{q}$ thresholds (quark confinement) was proposed. The thresholds were eliminated by means of an infrared cut-off [19].

The relativistic Schrödinger-like wave equation suggested for the use in **hadron spectroscopy** was shown to approximately satisfy important constraints (such as the slope of meson Regge trajectories following from the relativistic string theory, the ratio between the contributions of anomalous and traceless parts of the QCD Hamiltonian to hadron masses) coming from more general field-theoretical approaches. This wave equation was then applied to evaluate characteristics of higher radial excitations of vector resonances (masses, scaling relations for leptonic and total widths) needed for comparison with new analyses of the nucleon form factors in the space-like and time-like region and the electron–positron annihilation cross sections [20].

A new **next-to-leading order QCD analysis** was given for the world data on inclusive polarized deep inelastic lepton-nucleon scattering that extended the old set of data on the final SMC results, the HERMES proton results, and very recent SLAC/E155 deuteron data. An excellent fit to the data was found, and the results for polarized parton densities were presented in different factorization schemes. These results are in good agreement with theoretical predictions. It was also found that the main effect of the newly incorporated data is a more accurate determination of the polarized gluon density [21].

A constrained instanton solution was suggested in the physical QCD vacuum described by large-scale vacuum field fluctuations. This solution decays exponentially at large distances. It is stable only if the interaction of an instanton with the background vacuum field is small, and additional constraints are introduced. The constrained instanton solution was explicitly constructed in the ansatz form, and the two-point vacuum correlator of gluon field strengths was calculated in the framework of the effective instanton vacuum model [22].

THEORY OF NUCLEI AND OTHER FINITE SYSTEMS

In 1999, investigations within the area «Theory of Nuclei and Other Finite Systems» were carried out in accordance with four projects, namely,

— Nuclear Structure under Extreme Conditions;
— Dynamics and Manifestation of Structure in Nuclear and Mesoscopic Systems;
— Few-Body Physics;
— Relativistic Nuclear Dynamics.

Let us start with the results in the field of **nuclear structure theory**.

The equations of the quasiparticle-phonon model using a phonon basis of an extended random phase approximation were generalized to include multipole particle–particle interactions. An effect of the new interactions on the ground state correlations and vibrational excitations was considered for the one highly degenerate shell model [23]. A renormalized random phase approximation (TRRPA) for finite Fermi systems at finite temperatures was evaluated with the use of the thermo field dynamics formalism. The TRRPA takes into account the Pauli principle in a more proper way than the usual thermal RPA, thus incorporating a new type of correlations in a thermal ground state. It was applied to the exactly solvable Lipkin model. Advantages of TRRPA are especially evident in the vicinity of the phase transition point. Moreover within TRRPA the phase transition occurs at lower temperature than in thermal Hartree–Fock and thermal random phase approximations [24]. The impact of the ratios of nuclear

matrix elements on the weak induced pseudoscalar coupling constant extracted from the relative observables in nuclear ordinary muon capture was investigated. It appeared that the value $g_P / g_A \leq 0$ obtained from the experimental data on γν-correlations in polarized muon capture by ^{28}Si can be explained by unexpectedly strong influence of velocity-dependent matrix elements [25]. A new mechanism of high angular-momentum states population in fission fragments, based on the quantum mechanical uncertainty relations between the orientation angles of the fragments and the angular-momentum content of their intrinsic states, was suggested. The angular momentum is «pumped» into the fragments by the forces responsible for their mutual orientation. Recent experimental measurements seem to be in favour of a new spin generation scheme [26]. Conditional asymmetric fission barriers were calculated on the basis of the rotating-liquid-drop model that takes into account short-range nuclear forces and the diffuseness of the nuclear surface. These calculations were performed for 15 nuclei in the range $Z^2 / A = 20 - 40$ for angular-momentum values from 0 to 70 $\hbar$. For any angular-momentum value, a direct comparison of theoretical mass distributions obtained within the statistical approach with available experimental data reveals reasonably good agreement in the interval $Z^2 / A = 20 - 30$ [27].

New approaches to describe **nucleus-nucleus collisions** were developed.

The role of the entrance channel in the fusion–fission reactions leading to nearly the same superheavy compound nucleus was studied in the framework of a dynamic model. It was shown that for the considered reactions, there is an energy window for the bombarding energy at which the capture cross section is large enough to have physical interest. This result puts strong limitations on the choice of the bombarding energy for a given reaction. The results of calculations showed that the ^{48}Ca + ^{244}Pu reaction is more favorable than ^{74,76}Ge + ^{208}Pb to produce the superheavy element $Z = 114$ [28]. The energy thresholds for complete fusion in relative distance and mass asymmetry degrees of freedom were estimated. The time-dependent transition between a diabatic interaction potential in the entrance channel and an adiabatic potential during the fusion process was microscopically investigated. A large hindrance was obtained for a motion to smaller elongations of near symmetric dinuclear systems. The comparison of the calculated energy thresholds for the complete fusion in different relevant collective variables showed that the dinuclear system prefers to evolve in the mass asymmetry coordinate by nucleon transfer to the compound nucleus [29].

The nuclear theory methods were applied in studying metallic clusters.

The orbital M1 collective mode was investigated for deformed single-charged metallic clusters in a microscopic self-consistent random phase approximation approach. The M1 strength appears to be fragmented over a large energy interval. It was concluded that in light clusters, the M1 mode has the character of a single-particle excitation. In heavy clusters the collective nature of the mode appears evident. The crucial role of the quadrupole field in promoting the M1 mode is confirmed [30].

Interesting results were obtained within the project **Few-Body Theory**.

The scattering length for the η-meson collision with deuteron was calculated on the basis of rigorous few-body equations for various $\eta - N$ input. The results strongly support the existence of a resonance or a quasi-bound state close to the $\eta - d$ threshold [31]. Recent measurements for electromagnetic production of pions were analyzed. It was demonstrated that they can be explained in a dynamical and unitary isobar models, together with a simple scaling assumption for the bare $\gamma^* N\Delta$ form factors. It appeared that the bare Δ is almost spherical and the electric E2 and Coulomb C2 quadrupole excitations of the physical Δ are nearly saturated by pion cloud contribution in $Q^2 \leq 4.0$ GeV^2. The results well agree with experimental data, but deviate strongly from the predictions of the perturbative QCD [32]. It was shown that the lifetimes of actual physical systems «two atoms + electron» ($\geq 10^6$ s) allow one to consider these systems as bound ones for any processes in gases. On the basis of the results of the previous study, a new class of diatomic negative molecular ions, having the states with anomalously large characteristic sizes, was predicted [33].

The following **relativistic effects in nuclear physics** were studied.

The structure of the ϕ photoproduction amplitude in the $\sqrt{s}$ ~ 2–5 GeV region was analyzed based on the Pomeron-exchange and meson-exchange mechanisms. The differences between competing mechanisms were shown to have profound effects on various spin density matrices which can be used to calculate both the cross sections and various single and double polarization observables. A definite isotopic effect was predicted — polarization observables of ϕ photoproduction on the proton and neutron targets can differ by a factor of 2 and more [34]. The influence of the nuclear shape on various characteristics of multifragmentation was first studied within an extension of the statistical microcanonical model of multifragmentation. Combined effects of the shape of decaying nuclei, the high angular momentum and the collective expansion velocity were demonstrated by comparing the results for a hot source formed in central Xe + Sn (50 A/MeV) collisions with experimental data [35]. The method for the model-free derivations of the evolution of the nucleon structure in the lightest nuclei was developed. It allows one to express a structure function $F_2^A(x)$ in terms of structure functions of nuclear fragments and three-dimensional momentum distributions. It was found that the effects from nucleon relative time, which naturally follow from a relativistic treatment of the two-nucleon

binding, play a decisive role in differences between structure functions of bound and free nucleons. The modification of the nucleon structure found for $A = 2$ serves as a priming for the modifications in the three- and four-nucleon systems and plays an important role in evolution of the bound nucleon structure [36].

New results were also obtained in **the Vavilov–Cherenkov radiation theory**.

Numerical analysis of the Tamm problem (the charge motion on a finite space interval with the velocity exceeding light velocity in medium) on the basis of the exact solution to a nondispersive medium showed that the Fourier components of electromagnetic field strengths had no well pronounced maximum at the Cherenkov angle in the case of a finite motion interval. When the interval increases from an infinitesimal value many maxima appear. For the charge motion on an infinite interval, there appears an infinite number of maxima of the same amplitude [37].

THEORY OF CONDENSED MATTER

Theoretical investigations in the «Theory of Condensed Matter» were performed in the framework of the following projects:

— Strongly correlated systems;
— Dynamic systems: chaos, integrability and self-organization;
— Disordered structures: glasses, topological defects, nanostructures and Josephson junction;
— Mesoscopic and coherent phenomena in quantum systems.

In the field of **strongly correlated systems** main attention was paid to studies of electronic spectra, charge, magnetic and superconducting phase transitions for models of novel materials belonging to a class of marginal electronic liquids (manganites, cuprates, vanadates, heavy fermions).

A new solution to the Periodic Anderson Model with two strongly correlated subsystems of d and f electrons was proposed by using a special form of canonical transformation. The corresponding 16 rank S-matrix is constructed by using, as its elements, the orthonormalized system of eigenfunctions of the localized Hamiltonian for different eigenvalues [38].

A phase diagram of half-doped perovskite manganites within the extended two-orbital double-exchange model was studied. The orbital degeneracy results in appearance of charge-ordered states for different antiferromagnetic states only for a large enough Coulomb interaction. The relevance of the results to the experimental data obtained in neutron scattering experiments at FLNP is also discussed [39].

In order to account for competition and interplay of localized and itinerant magnetic behavior in correlated many-body systems, the $d-f$ and Kondo–Heisenberg models were considered [40].

LDA and LDA+U electronic band structure calculations were performed for multiband effective models with strong Coulomb repulsion to interpret polarization dependent angle-resolved valence band photoemission measurements for different copper oxides [41].

In the field of the theory of **dynamic systems** the following results should be mentioned.

The theorem is proved that the upper critical dimension of the Abelian sandpile model is four [42].

The eigenvectors of the Hamiltonian of 1D quantum spin chains with an elliptic form of exchange were described via the solutions to the highly transcendental systems of Bethe-ansatz type which were explicitly presented for the first time in all subspaces of the corresponding Hilbert space [43].

The moduli space of self-dual Yang–Mills fields was described in terms of Čech and Dolbeault cohomology sets by using the correspondence between complex vector bundles over self-dual four-dimensional manifolds and holomorphic bundles over their twistor spaces [44].

In the investigations of **disordered structures**, the following main results were obtained.

A variant of a gauge theory is formulated to describe disclinations on Riemannian surfaces that may change both the Gaussian (intrinsic) and mean (extrinsic) curvatures under deformations. As an application, two special cases are considered: elastic membrane and elastic sphere. For a single disclination on an arbitrary elastic surface, a covariant generalization of the von Karman equations is derived. The model is suitable for description of the topological defects in membranes and layered structures [45].

By appropriate generalization of the Ginzburg–Landau theory based on admixture of s-wave (S) and d-wave (D) superconductors, a differential thermoelectric power (TEP) of the SND configuration in $Bi_xPb_{1-x}Sr_2CaCu_2O_y$ is considered. In addition to its strong dependence on the relative phase $\theta = \phi_s - \phi_d$ between the two superconductors, two major effects are shown to influence the behavior of the predicted TEP based on the chemical imbalance at the SD interface. The experimental conditions under which the predicted behavior of the induced differential TEP can be measured are discussed in detail [46]. To clarify the underlying microscopic transport mechanisms in exhibiting colossal magnetoresistance (CMR) in manganites, the substitution

effects in $La_{0.7}Ca_{0.3}Mn\,O_3$ were studied. An anomalous behavior of resistivity in $La_{0.7}Ca_{0.3}Mn_{0.96}Cu_{0.04}O_3$ due to Cu doping was found and attributed to the Cu induced weakening of the kinetic carrier energy and concomitant strengthening of potential barriers. In turn, CMR and magneto-TEP observed in $La_{0.6}Y_{0.1}Ca_{0.3}MnO_3$ suggest spin hopping transport mechanism (with magnetization dependent charge carrier localization length) dominated by strong magnetic fluctuations [47].

Mesoscopic and coherent phenomena in quantum systems were studied in the following papers.

A fermionic path integral approach is applied to analyze the phase transition in the two-dimensional Ising model with quenched site disorder. The log-log singularity in the specific heat near T_c for weak site dilution was obtained [48].

The shift of the ^{4}He excitation spectra, caused by the ^{4}He admixture, is evaluated by using the partition function in the form of a path integral. The excitation (neutron scattering) spectrum $E_p(\lambda,\rho_f,T)$ is found as a function of $^3\mathrm{He}-^4\mathrm{He}$ interaction λ, ^{3}He density ρ_f and temperature T. The largest influence of the ^{3}He admixture is noticed in the region of roton minimum of the ^{4}He spectrum due to the influence of the pure ^{3}He dispersion curve [49].

A new way of treating the dilute Bose gas with the strongly singular potential is developed. Using the reduced density matrix of the second order and a variation procedure, this way allows one to operate with singular potentials of the Lennard–Jones type [50].

A variational study of the ground-state energy of an exciton-phonon system spatially confined to a quantum well with a confinement potential in the form of a parabolic function was performed. An interpolation formula for the ground-state energy bound was obtained which corresponds to similar formulae for the free polaron or the free exciton-phonon system [51].

A mechanism for creating well-collimated beams of neutral particles by magnetic fields is suggested [52]. Theory of nonlinear spin dynamics in ferromagnets with electron-nuclear coupling is developed [53]. Transient effect of negative electric current in nonuniform semiconductors is predicted [54].

COMPUTER FACILITIES

The concept of development of the Laboratory's computer facilities is based on the idea of balanced development of the stocks of both servers and personal computers, all connected via the computer network with adequate performance.

The servers provide ready to use resources (software, processors, memory, disk space), and personal computers provide convenient access to these resources via the network; in addition personal computers are able to solve many less resource-demanding tasks right at the workplaces.

In 1999, 24 new personal computers with CPU Pentium II and III 300–450 MHz were installed on workplaces. The most powerful workstation Ultra 2 was equipped with the second processor Ultra SPARC 300 MHz. The system memory on this workstation was extended to 768 MB. Several disks were added to the cluster of Sun's computers, the total disk space available now is about 80 GB. New operating system Solaris 7 was introduced on two workstations. Among the new software available on workstations there is Star Office 5.1 which is capable to deal with the files in the format of Microsoft Office (Word, Exel, etc.). The renewed software includes Reduce 3.7, Netscape Communicator 4.7, Java Workshop 2, Java Studio 1.0, Acrobat 4, GNU CC 2.8.1. The publicly accessible archive of free software was created on thsun1.jinr.ru. Currently, the archive contains full mirrors of CTAN (tex-archive), CPAN (Perl archive), GNU software, Solaris public patches, Solaris freeware (binaries and sources), and other widely used software and documentation. The archive is equipped with the file search engine and available at http://thsun1.jinr.ru/file-archive.html. Among other new computer services available now at BLTP, there is the cache server (accelerator) at http://thsun1.jinr.ru:1081 which stores files requested from the E-print archive xxx.itep.ru. The cache server provides instant access to new publications on xxx.itep.ru which are automatically downloaded every morning. There is also a common proxy cache server http://thsun4.jinr.ru:3128 which stores all files requested from Internet and also automatically redirects requests sent to xxx.itep.ru to the accelerator http://thsun1.jinr.ru:1081. Protocols supported by the server are HTTP, FTP and Gopher. The Proxy Auto Configuration (PAC) script intended for automatic configuration of Internet Explorer and Netscape Communicator to use this proxy server is located at http://thsun1.jinr.ru/proxy.pac. BLTP continues to support local mirror of the Journal of High Energy Physics (JHEP) http://jhep.jinr.ru which got a larger disk space, system memory and new base software. Laboratory's WWW server base software was renewed also, improved access statistics becomes available.

MEETINGS, SCIENTIFIC COLLABORATION

In 1999, the Laboratory participated in the organization of 12 meetings, most of which were supported by UNESCO, the Russian Foundation for Basic Research (RFBR), the Heisenberg–Landau Programme (HLP), the Bogoliubov–Infeld Programme, and other scientific funds.

A great event was an International Conference «Problems of Theoretical and Mathematical Physics», dedicated to the 90th anniversary of the birth of Nikolai Nikolaevich Bogoliubov. The Conference was held from 27 September to 6 October, 1999. Its sessions were successively held in Moscow, Dubna, and Kyiv. The subject of the Conference covered those fields of knowledge to which N.N. Bogoliubov made a fundamental contribution: mathematics and nonlinear mechanics, quantum field theory, elementary particle physics, statistical physics and kinetics, and nuclear physics. More than 200 scientists from many countries attended the Conference.

The international school «Symmetries and Integrable Systems» was held at BLTP on June 8–11. It was jointly organized by the Laboratory and the Institute of Theoretical and Experimental Physics. Lecturers at the school were leading researchers of the following institutes: Institute of Theoretical and Experimental Physics, Moscow; Lebedev Physical Institute, Moscow; Steklov Mathematical Institute, Moscow; Bogoliubov Laboratory of Theoretical Physics, Bogoliubov Institute of Theoretical Physics, Kiev; Konstantinov Institute of Nuclear Physics, St.-Petersburg, and from others. Series of lectures on the modern subjects of theoretical and mathematical physics were given during the School. They were addressed to high-level and post-graduate students. Students from the Moscow Institute of Physics and Technology, Moscow State University, Kiev State University, JINR University Centre, Ural Technical University (Ekaterinburg), Moscow Engineering Physical Institute, and Ecole Polytechnique (Paris), took part in the school activities.

As in the last year, the workshops on selected topics of quantum field theory, mathematical physics, particle physics, nuclear theory, and theory of condensed matter were held at the BLTP. The Workshops «Nucleation Theory and Applications», «Collective Excitations in Nuclei and Other Finite Fermi Systems», «Supersymmetries and Quantum Symmetries», and «Quantum Gravity and Superstrings» became a tradition and were regularly held at the BLTP. NATO Advanced Research Workshop «Lattice Fermions and Structure of the Vacuum was held at the BLTP on October 5–9. This kind of meetings was organized in Russia for the first time.

In 1999, the collaboration was supported by grants of the plenipotentiaries of the Czech Republic, Poland, the Slovak Republic, Hungary, and the JINR Directorate; the collaboration with Polish theorists was based on the Bogoliubov–Infeld Programme.

Within the Heisenberg–Landau Programme, more than 70 papers were published jointly with the colleagues from German scientific centres, 33 joint projects and 7 meetings obtained financial support from the HLP.

Some studies were carried out in collaboration with scientists from Western Europe in the framework of the JINR–INFN, JINR–IN2P3 agreements and on the projects supported by INTAS, RFBR–DFG, RFBR–CNRS. Agreements between BLTP and CERN TH, ICTP are in force.

Of particular importance are the collaboration of BLTP with scientific and educational centres of Russia and training of specialists for these centres. At present, about 30 scientists from many regions of Russia (Moscow, St.Petersburg, Petrozavodsk, Tomsk, Novosibirsk, Vladivostok, etc.) are working at BLTP on a contract basis. At the laboratory, there are students and post-graduate students not only from the JINR University centre, but also from a number of Russian Universities; theorists of BLTP give lectures there.

REFERENCES

1. *Isaev A.P., Ogievetsky O.V., Pyatov P.N. — J.Phys. A: Math. Gen., 1999, v.32, p.L115.*
2. *Dubois-Violette M., Furlan P., Hadjiivanov L.K., Isaev A.P., Pyatov P.N., Todorov I.T. — hep-th/9910206.*
3. *Zupnik B.M. — Phys. Lett. B, 1999, v.461, p.203; Ivanov E.A., Krivonos S.O. — Phys. Lett. B, 1999, v.453, p.237.*
4. *Bellucci S., Ivanov E.A., Krivonos S.O. — Phys. Lett. B, 1999, v.600, p.348.*
5. *Ivanov E.A., Zupnik B.M. — Yad. Fiz., 1999, v.62, p.1110.*
6. *Donets E.E., Pashnev A.I., Juan Rosales J., Tsulaia M.M. — JINR Preprint E2-99-218, Dubna, 1999; hep-th/9907224; Phys. Rev. D (in press).*
7. *Mardoyan L.G., Sissakian A.N., Ter-Antonyan V.M. — Mod. Phys. Lett., 1999, v.14, p.1303.*
8. *Junemann K., Lechtenfeld O., Popov A.D. — Nucl. Phys. B, 1999, v.548, p.449.*
9. *Popov A.D. — Nucl.Phys. B, 1999, v.550, p.585.*

10. *Loutsenko I., Spiridonov V. — Nucl. Phys. B, 1999, v.538, p.731;*
Zhedanov A., Spiridonov V. — Uspekhi Mat. Nauk (Russ.Math.Surv.), 1999, v.54, p.173 (in Russian).
11. *Bogolubsky I.L., Mitrjushkin V.K., Muller-Preussker M., Peter P. — Phys. Lett. B, 1999, v.458, p.102;*
Bogolubsky I.L., Mitrjushkin V.K., Muller-Preussker M., Peter P., Zverev N.V. — JINR Preprint E2-99-288, Dubna, 1999;
Humboldt Univ. Preprint HUB-EP-99/51, Berlin, 1999.
12. *Frolov V.P., Fursaev D.V. — gr-qc/99070046; hep-th/9910006; to appear in Phys.Rev. D.*
13. *Kazakov D.I. — Phys. Lett. B, 1999, v.449, p.201.*
14. *Shirkov D.V., Solovtsov I.L. — Teor. Mat. Fiz., 1999, v.120, p.482 (in Russian).*
15. *Efremov A.V. — Proc. of Intern. Workshop «Praha-Spin99», Prague, September 5–12, 1999;*
Efremov A.V., Goke K., Polyakov M.V., Urbano D. — Ruhr-Univ Preprint, Ruhr, 1999.
16. *Schafer A., Teryaev O.V. — hep-ph/9908412, to appear in Phys.Rev. D;*
Schafer A., Szymanowski L., Teryaev O.V. — Phys. Lett. B, 1999, v.464, p.94.
17. *Kuraev E.A., Schiller A., Serbo V.G., Shaikhatdenov B.G. — hep-ph/9909220, Nucl.Phys. B (in press);*
Antonelli V., Kuraev E.A., Shaikhatdenov B.G . — JETP Lett., 1999, v.69, p.900; hep-ph/9905331, Preprint BICOCCA-FT-99-13, Nucl.Phys. B (in press).
18. *Efimov G.V., Kalloniatis A.G., Nedelko S.N. — Phys. Rev. D, 1999, v.59, p.014026.*
19. *Volkov M.K., Nagy M., Yudichev V.L. — Nuovo Cim. A, 1999, v.112, p.225;*
Volkov M.K., Ebert D., Yudichev V.L. — J. Phys. G, 1999, v.25, p.2025.
20. *Gerasimov S.B. — Czech. J. Phys., 1999, v. 49, p.65.*
21. *Leader E., Sidorov A.V., Stamenov D.B. — Phys. Lett. B, 1999, v.462, p.189.*
22. *Dorokhov A.E., Esaibegian S.V., Maximov A.E., Mikhailov S.V. — hep-ph/9903450, Eur. J. Phys. C (accepted).*
23. *Severyukhin A.P., Voronov V.V., Karadjov D. — JINR Preprint P4-99-121, Dubna, 1999, accepted to Izv. RAN, ser. fiz.*
24. *Vdovin A.I., Storozhenko A.N. — Eur. Phys. J. A, 1999, v.5, p.263.*
25. *Junker K., Kuz'min V.A., Ovchinnikova A.A., Tetereva T.V. — Preprint PSI-PR-99-14, Paul Scherrer Institut, CH - 5232 Villigen PSI, 1999, accepted to Phys.Rev. C.*
26. *Mikhailov I.N., Quentin P. — Phys. Lett. B, 1999, v.462, p.7.*
27. *Rusanov A.Ya., Pashkevich V.V., Itkis M.G. — Yad. Fiz., 1999, v.62, p.595.*
28. *Jolos R.V., Muminov A.I., Nasirov A.K. — Eur. Phys. J. A, 1999, v.4, p.245.*
29. *Diaz-Torres A., Antonenko N.V., Scheid W. — Nucl. Phys. A, 1999, v.652, p.61.*
30. *Nesterenko V.O., Kleinig W., et al. — Phys. Rev. Lett., 1999, v.83, p.57.*
31. *Shevchenko N.V., Belyaev V.B., et al. — LANL e-print nucl-th/9908035, 1999.*
32. *Drechsel D., Hanstein O., Kamalov S.S., Tiator L. — Nucl. Phys. A, 1999, v. 645, p.145.*
33. *Pen'kov F.M. — JETP, 1999, v.88, p.1079.*
34. *Titov A.I., Lee T.-S.H., Toki H., Streltsova O. — Phys. Rev. C, 1999, v.60, p.035205.*
35. *Le Fevre A., Ploszajczak M., Toneev V.D. — Phys. Rev. C, 1999, v.60, p.R051602.*
36. *Burov V.V., Molochkov A.V., Smirnov G.I. — Phys. Lett. B, 1999, v.466, p.1.*
37. *Afanasiev G.N., Kartavenko V.G., Stepanovsky Yu.P. — J. Phys. D: Appl. Phys., 1999, v.32, p.2029.*
38. *Moskalenko V.A., Perkins N.B. — Theor. Mat. Fiz., 1999, v.121, p.250.*
39. *Jackeli G., Perkins N.B., Plakida N.M. — cond-mat/9910391, Phys. Rev. B, submitted.*
40. *Kuzemsky A.L. — Physica A, 1999, v.267, p.131.*
41. *Hayn R., Rosner H., Yushankhai V., et al. — Phys. Rev. B., 1999, v.60, p.645.*
42. *Priezzhev V.B. — math-ph/9904054, J.Stat.Phys., 1999 (in press).*
43. *Inozemtsev V.I. — math-ph/9911022.*
44. *Ivanova T.A. — math-ph/9902015.*
45. *Kochetov E.A., Osipov V.A. — J. Phys. A: Math.Gen., 1999, v.32, p.1961.*
46. *Sergeenkov S., Ausloos M. — Phys. Rev. B, 1999, v.59, p.11974.*
47. *Sergeenkov S., et al. — Phys. Rev. B, 1999, v.60, p.12322;*
Sergeenkov S., et al. — JETP Lett., 1999, v.69, p.812; ibid v.70, p.136; ibid. v.70, p.465.
48. *Plechko V.N. — In: «Path Integrals from peV to TeV: 50 Years after Feynman's Paper», ed. by R. Casalbuoni et al. (World Scientific, Singapore, 1999), p.137; hep-th/9906107.*
49. *Baranov D., Yarunin V. — Physica A, 1999, v.269, p.222.*
50. *Cherny A.Yu., Shanenko A.A. — Phys. Rev. E, 1999, v.60, p.R5.*
51. *Gerlach B., Wüsthoff J., Smondyrev M.A. — Phys. Rev. B, 1999, v.60, p.16569.*
52. *Yukalov V.I., Yukalova E.P. — Phys. Lett. A, 1999, v.253, p.173.*
53. *Yukalov V.I. — Phys. Rev. A, 1999, v.60, p.721.*
54. *Yukalov V.I., Yukalova E.P., Singh M.R. — Phys. Rev. B, 1999, v.59, p.10111.*

LABORATORY OF HIGH ENERGIES

The scientific programme of the Laboratory of High Energies (LHE) at present is concentrated on investigations of interactions of relativistic nuclei in the energy region from a few hundred MeV to a few TeV per nucleon with the aim of searching for manifestations of quark - gluon degrees of freedom in nuclei, asymptotic laws for nuclear matter at high-energy collisions as well as on the studies of the spin structure of the lightest nuclei. The experiments along these lines are being carried out using beams of the Synchrophasotron–Nuclotron accelerator complex and of other accelerators: at CERN (SPS, LHC), BNL (RHIC) and also at the CELSIUS storage ring in Uppsala (Sweden). LHE also takes part in the HADES experiment at GSI (Darmstadt, Germany).

ACCELERATION COMPLEX DEVELOPMENT

In 1999, all elements of the system of slow extraction of a beam from the superconducting accelerator Nuclotron were made and installed in a ring of the Nuclotron. In the run of December 14-29, the complex test of the system of slow extraction of a beam was carried out, and were obtained circulation of a beam and an accelerated beam of protons. On 29 December, the beam of protons with the efficiency of ~10 % from the Nuclotron with an energy of 0.2 GeV was extracted.The creation and first-order commissioning of the system of slow extraction of a beam using the economic superconducting technology was completed. For the first time in the world, a beam of accelerated particles has been extracted into an experimental hall using superconducting magnetic elements (Fig.1).

The total running time of the Synchrophasotron was limited by 303 hours. In 1999, the users compensated the cost of the beam time. The dominant condition of the machine operation is the attraction of the users' resources. In spite of a continuous rise of the electricity cost, the number of users does increase. First of all, these are the polarized beam users. The interest in the traditional beams of light nuclei is still very great.

Project «Crystal-W» (on the theme of 0979). The work on preparation of the experimental investigations of new tungsten deflectors at the circulating nuclear beam of the Nuclotron was performed during this year. The tungsten and silicon deflectors were produced with the bending radius of 277 mm and at a thickness of 200 μm and 270 μm correspondingly. Smaller thickness of the tungsten crystal has to ensure its elastic bending [1-2].

A new experiment on the relativistic Pb ion deflection with a bent silicon crystal at the CERN-SPS was simulated in the frame of the co-operation with the project collaborator Dr. Konrad Elsener. The last experiment had shown that the background particle intensity registered at large angles to the straight beam direction changes with the crystal orientation relative to the beam. The original program was written, which calculates not only the Pb ion trajectories in the aligned crystal but also the inelastic interactions of ions with the crystal atoms. The FRITIOF model together with the statistical model of the nuclei multifragmentation is used for drawing of the inelastic interactions. The generated particles and nuclei fragments were observed up to their exit from the crystal. These particles can experience nuclear interactions with the crystal atoms, too. Three generations of particles produced in the inelastic interactions were considered. The simulation results allow explaining the dependence of the background intensity on the crystal orientation observed in the experiment. [3]

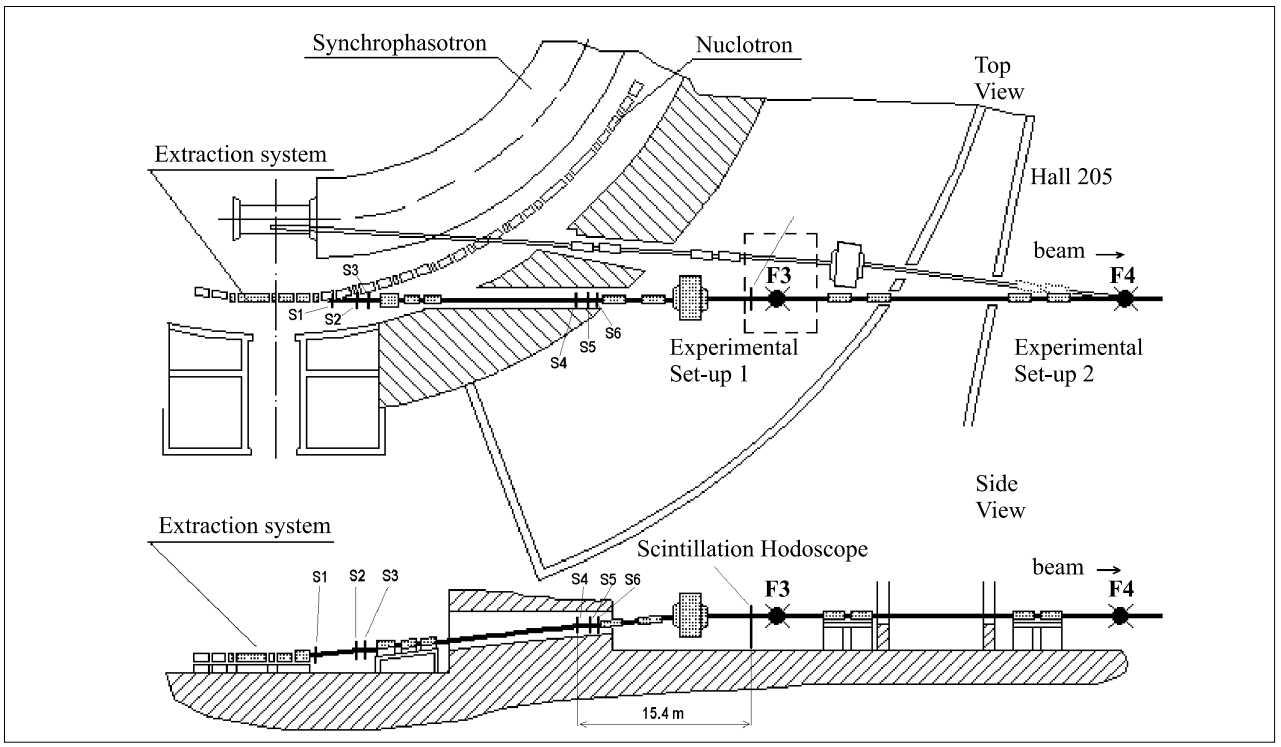


Fig.1. The plan of the transporting channel of a beam from the Nuclotron to experimental installations

EXPERIMENTS ON THE EXTRACTED BEAM OF THE NUCLOTRON

At the end of 1999 in the framework of the project «**SPHERE**», the run on a slow extracted beam of the superconducting accelerator Nuclotron was carried out for debugging the equipment intended for studying the narrow pp correlations in cumulative region.

In the run, the TOF hodoscope, the bending magnet, and the system of three monitor counters S4÷S6 (a scheme of experiment on fig.2) were used. The time-of-flight spectra of primary protons (Fig.3) were measured and used for diagnostics when the slow extracted beam system was under tuning.

The installation «STRELA» for investigation of the charge-exchange process at the deuteron-protons interaction is prepared.

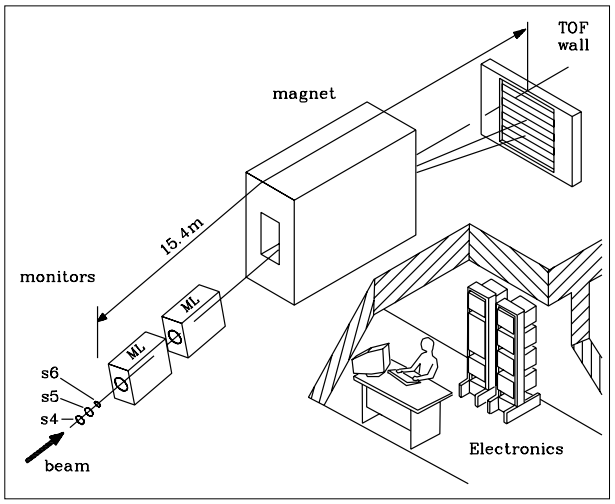


Fig.2. The set-up intended for the experiment on the study of pp correlations on a slow extracted beam line of the Nuclotron

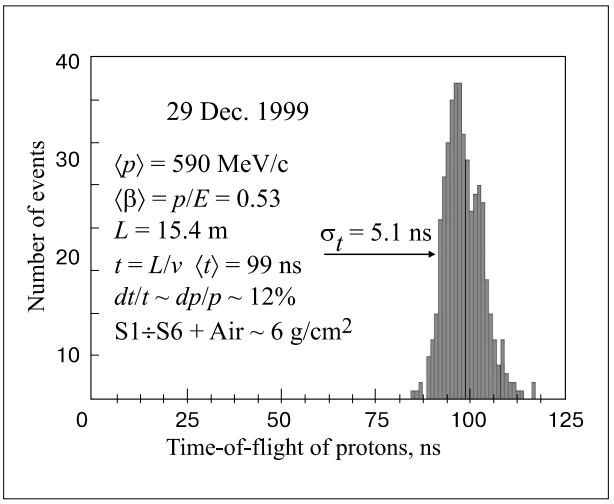


Fig.3. The time-of-flight spectrum obtained in the first run of the Nuclotron with the slow extracted beam system

Project «**SPHERE**». On the nonpolarized deuterons beam the inclusive spectra for $K^{\pm}$ in cumulative and noncumulative region were obtained with the accuracy of 10%. These data will be the most accurate (after off-line analysis and publication) in the world and will be unique obtained on one set-up for cumulative and noncumulative region. It is important to have the data for both regions (cumulative and noncumulative) in order to understand the reaction mechanism and the deuteron structure on small distances as it was outlined in a series of theoretical articles. These data were obtained due to the detection of the particles from the beam fragmentation. In used realization it is no background from the target walls, and kaons have rather big momentum (in our case from 2 to 2.5 GeV/c) and particles losses because of the decay are smaller than for target fragmentation.

In this run the dependence of cross section of beam deuteron fragmentation in «twice cumulative pions» on atomic mass of target nuclei has been measured for the reaction $d + A_t = \pi(0^\circ) + X$. The twice cumulative pions are the pions that cannot be produced in the reaction $p + p = \pi(0^\circ) + X$ as well as in the reaction $d + p = \pi(0^\circ) + X$. It is assumed that proton and deuteron in these reactions have the same momentum per nucleon. It means that high-momentum component in both deuteron and target nuclei are necessary. The target mass dependence in reaction is sensitive to the flucton distribution through the volume of the target nucleus. The preliminary data obtained for A_t = Be, C, Al, Cu, Pb are shown on Fig.4. From these data one can see that cross-section target mass dependence is the same for twice cumulative and cumulative pions production in the collisions with heavy ($A_t > 64$) nuclei. It means that flucton and nucleon distributions are the same also. For light nuclei ($A_t < 64$) the target mass dependence for cumulative and noncumulative region is different. It is a strong indication on different distribution of high momentum component and nucleon around the volume.

Delta-Sigma Set-Up. New results for the *np* spin-dependent total cross-section difference $\Delta\sigma_L(np)$ at the neutron beam kinetic energies of 1.59, 1.79, and 2.20 GeV are presented [4]. The measurements of the $\Delta\sigma_L(np)$ energy dependence were carried out at the Synchrophasotron of the Laboratory of High Energies of JINR, Dubna. A quasi-monochromatic neutron beam was produced by break-up of accelerated and extracted polarized deuterons.

The transmission of the neutron beam through a large proton polarized target has been measured. The values of $\Delta\sigma_L$ were measured as a difference between the *np* total cross sections for parallel and antiparallel beam and target polarizations, both oriented along direction of the beam momentum. The results at the two higher energies were obtained using four combinations of two opposite polarization directions for both the beam and the target. Only one target polarization direction was available at the energy of 1.59 GeV. Fast decrease of $\Delta\sigma_L(np)$ with increas-

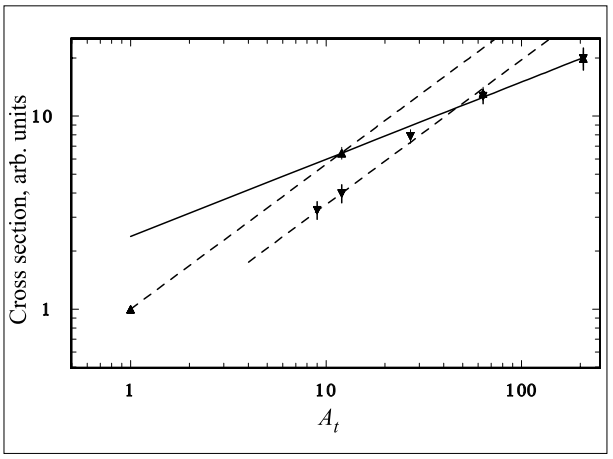


Fig.4. Experimental data on the target mass dependence of cross sections for twice cumulative production. The triangles with apex to up — these data (very preliminary), the triangles with apex to down — data from Yu.Anisimov et al., Yad.Fiz. (Rus.), 1997, v.60, p.1010 for cumulative pions production, solid line — $At_t^{0.4}$, dashed line — $At_t^{0.7}$

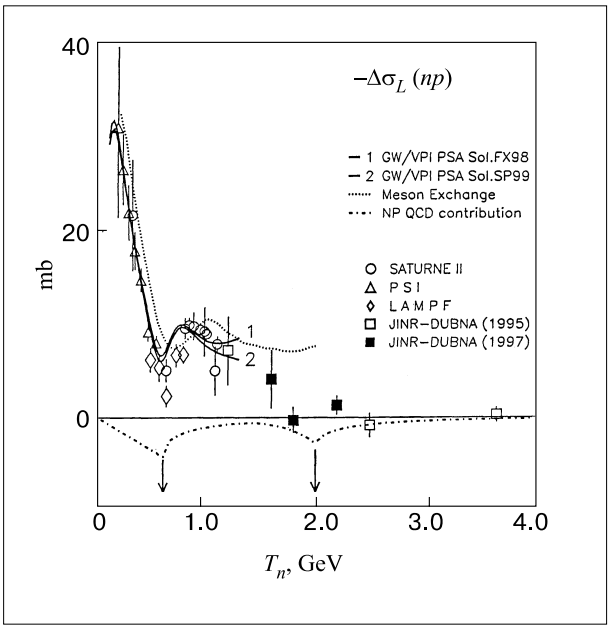


Fig.5. Energy dependence of the $-\Delta\sigma_L(np)$ value obtained using free neutron polarized beams

ing energy above 1.1 GeV, as it was first seen from our previous data, was confirmed. The new results are also compared with model predictions and with the phase shift analysis fits. The $\Delta\sigma_L$ quantities for isosinglet state $I = 0$ deduced from the measured values of $\Delta\sigma_L(np)$ and known $\Delta\sigma_L(np)$ data were given.

In November 1999, at the Synchrophasotron according to the demand of the groups of the Lebedev Physical Institute RAS (FIAN), for the first time there was carried out **an experiment on nuclear photoemulsion irradiation with the beam of the ^{3}H and ^{6}He nuclei**. The accelerator ran in the regime of acceleration of ^{6}Li, produced via a laser ion source at the ratio $Z/A = 1/2$. The ion intensity of ^{6}Li at the Synchrophasotron ring amounted to 10^8 ions per acceleration cycle at the value $pc/z = 5.34$ GeV. The secondary beam of ^{3}H and ^{6}He ions has been formed in the magnetic channel. During the total work time (16 hours) a beam of secondary nuclei was formed and its parameters were determined. Also the irradiation of three cassettes with nuclear photoemulsion was performed for further scanning and determination of physical parameters at the interaction of ^{6}He with photoemulsion nuclei at the momentum of 8 GeV/c. The expected statistics for interactions of helium-6 nuclei is over 100 events in the emulsion material. This experiment is the first stage in the investigation of the interactions of light relativistic nuclei, having an exotic structure, with emulsion nuclei. This research was initiated and supported by a large group from Russia and also by scientists from other countries (Egypt, China, Slovakia, etc.).

PREPARATION OF SOME EXPERIMENTS FOR RESEARCHES ON EXTRACTED BEAM OF THE NUCLOTRON

Project GIBS. Filmless readout should be used for the LHE streamer chamber to significantly increase statistics in the investigation of the behavior of isobars Δ and N in nuclear matter in the charge-exchange reactions of light nuclei on the nuclear targets. In 1999, all necessary technical efforts were made to reach the dedicated aim: TV cameras and readout cards were tuned and tested, TV stereosystem was designed and produced, the simplest first version computer codes for data recording and subsequent scanning were elaborated and tested. The complex test with model streamer chamber and two TV cameras was started as well. All elements of the proportional chamber readout electronics were tested in order to prepare apparatus for the hypernuclear experiments. Readout cards were tuned for four proportional chambers.

Project MARUSYA. The physical and methodical programmes have been developed. The simulation of operating condition of magnetic spectrometer and detectors has been carried-out. The possibility of registration and reliable indentification of particles with the momentum from 300 to 2000 MeV/c has been shown. All works concerning the reconstruction of experimental zone, creation of new radiation shield, creation of rotating magnetic spectrometer, mechanical positioning, connection and testing of the communications, preparation of the placement for electronics and DAQ have been accomplished.

The diagnostics system of the beams of the Nuclotron based on microchannel plates has been done and successfully tested in four beam runs.

The prototypes of monitoring system and scintillator TOF system have been done and tested on the beams of the Synchrophasotron. The Cherenkov threshold counter based on the silicon crystal has been done and tested.

THEORETICAL RESEARCH AND INTERPRETATION OF THE EXPERIMENTAL DATA

The A-dependence of z-scaling in inclusive hadron production $(\pi^{\pm}, K^{\pm}, \bar{p})$ in pA collisions at high transverse momentum is studied [5,6]. The concept of z-scaling based on the fundamental principles is developed for the description of processes of hadron production in pA collisions. The scaling function ψ of inclusive particle production is constructed (Fig.7). The independence of the function ψ of center-of-mass energy $\sqrt{s}$ and the angle of produced particle for different nuclei from D up to Pb is shown. The symmetry transformation, $z \to \alpha z$, $\psi \to \alpha\psi^{-1}$ is used to determine the A-dependence of transformation parameter α. The properties of z-scaling are used for the predicted spectra calculations of the $\pi^{\pm}$,

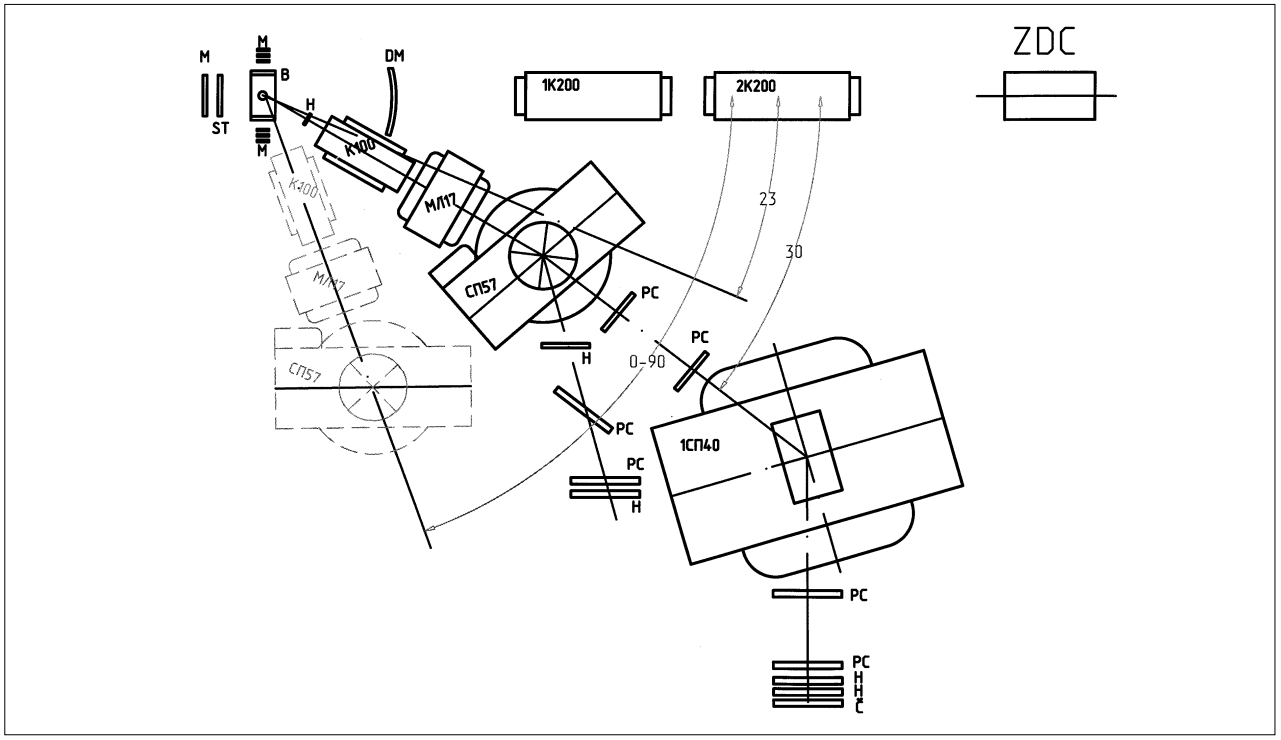


Fig.6. MARUSYA set-up

$K^{\pm}$, $\bar{p}$ hadron produced in pA collisions in the central range ($\eta = 0$) at RHIC energies.

In the framework of the impulse approximation, the connection between the effective cross section of the charge-exchange break-up of a fast deuteron $d + p \to (pp) + n$ with the production of two protons and the spin structure of the amplitude of the charge transfer reaction $n + p \to p + n$ was considered. Taking into account the Fermi statistics and the strong and Coulomb in-

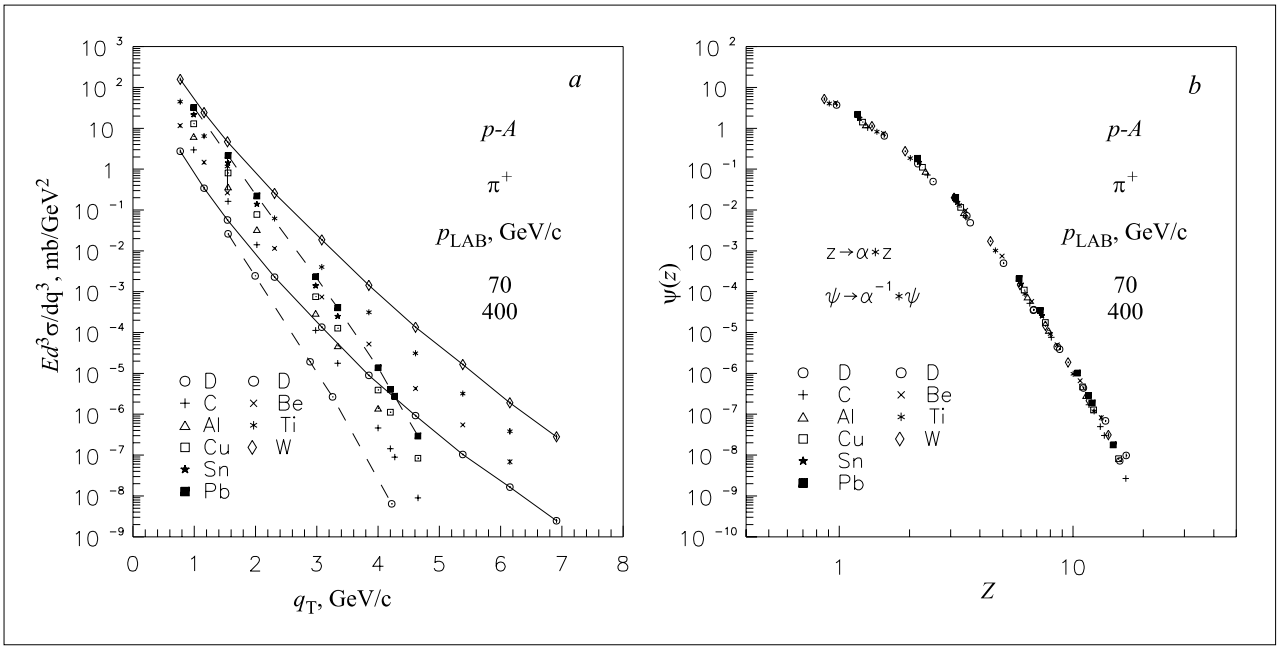


Fig.7. *a*) The inclusive cross section of $\pi^{\pm}$-mesons produced in central pA collisions at the incident proton momentum $p_{\text{lab}} = 70$, 400 GeV/c as a function of transverse momentum $q_{\perp}$; the solid and dashed lines are obtained by the fitting of the experimental data for nuclei D, W and D, Pb, respectively. Experimental data are obtained by Cronin's and Suliaev's groups at Fermilab (Batavia) and IHEP (Protvino); *b*) the corresponding z-presentation of the same data

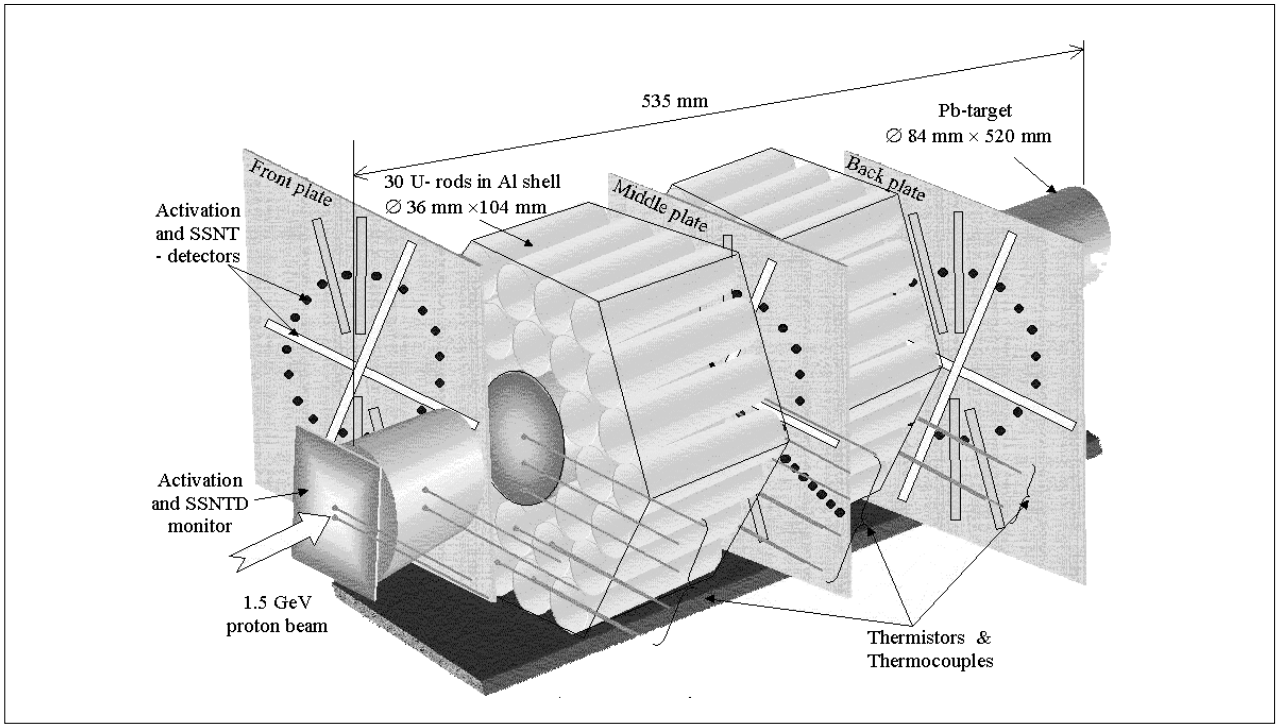


Fig.8. Flow diagram of the two-section model of the U/Pb assembly (scale 1:30) which includes a lead target and natural uranium blanket

teractions in the final state, the distribution of relative momenta of two protons, produced in the process $d + p \to (pp) + n$ in the forward direction, was found. It was shown that the study of this process in a beam of polarized deuterons on a polarized proton target allows one to separate two spin-dependent terms in the amplitude of the charge-transfer reaction $n + p \to p + n$ at the zero angle, one of which does not conserve and the other one conserves the projection of the nucleon spin onto the direction of momentum at the transition of the neutron into proton, and to determine the phase difference between these terms, too. The work has been fulfilled in connection with the programme of the experimental investigations at the Nuclotron of LHE [7].

In connection with the analysis of the spin correlations in the system of two identical particles with close momenta, the relations were derived, describing the angular correlations between the directions of the flight of the decay products of two identical unstable particles (resonances), — in particular, the angular correlations between the proton momenta at the decays of two Λ-particles into the channel $\Lambda \to p + \pi^-$, which is the ideal analyser of the Λ-particle spin. The possibility of using the data on the angular correlations in the ΛΛ-system for the experimental verification of the consequences of the quantum-mechanical coherence, connected with the violation of the «classical» Bell inequalities, has been considered.

Were obtained the new predictions of the cross-sections behaviour of the particles production in AA interactions at the ultra-relativistic energies [16].

APPLIED RESEARCH

The measurement of the temperature of the uranium sample irradiated with secondary neutrons, formed in a lead target, is carried out. The target was irradiated with a proton beam with an energy of 1.5 GeV and intensity of $3.9 \cdot 10^9$ p/c during 260 minutes. The thermometers on the basis of quartz resonators have fixed the changes of the uranium sample temperature, which correlated on time with beam intensity. The estimation of an average energy allocated in the sample using these data and thermo-physical model is made, it is equivalent to 3.1mW. This mean-

ing coincides with the quantity of an average energy of 3.4 ± 0.5 mW, determined with using the solid state track detector. The sensitivity of the measuring channel was 1 mK. The work was executed at the LHE of JINR.

In November 1999, on a proton beam of the Synchrophasotron the next session of irradiations of heavy targets was carried out. The basic task of a session is to expand a set of irradiated targets and a series of radioactive samples for measurement of transmutation sections. To traditionally used lead and uranium targets, the mercury target was added, and to radioactive isotopes of Np, I and Am, the isotope of Pu was added. The irradiations were done on a proton beam (with kinetic energies of 0.5 and 1.0 GeV) to obtained the additional information on a discrepancy of experimental estimations of a neutron yield depending on energy of a beam (C.Rubbia and M.Zucker). In the run, the methodical researches on monitoring of a primary beam including definition of intensity of a beam, its profile and other parameters were studied. In view of the complexity of reception of the satisfactory sizes of a beam on the Synchrophasotron at low energies (0.5 GeV) the recurrence of the measurements on Nuclotron is expedient.

R&D studies of the full-scale U/Pb assembly and its model are fulfilled in cooperation with specialists from VNIIAtomEnergoMash (Moscow). The model assembly consisting of the lead target and fissile blanket (see Fig.8.) is manufactured at the LHE workshop. This model assembly was exposed to the proton beam (Synchrophasotron, LHE, JINR) at the energy of 1.5 GeV in November 1999.

CO-OPERATION AT THE ACCELERATORS OF OTHER CENTRES

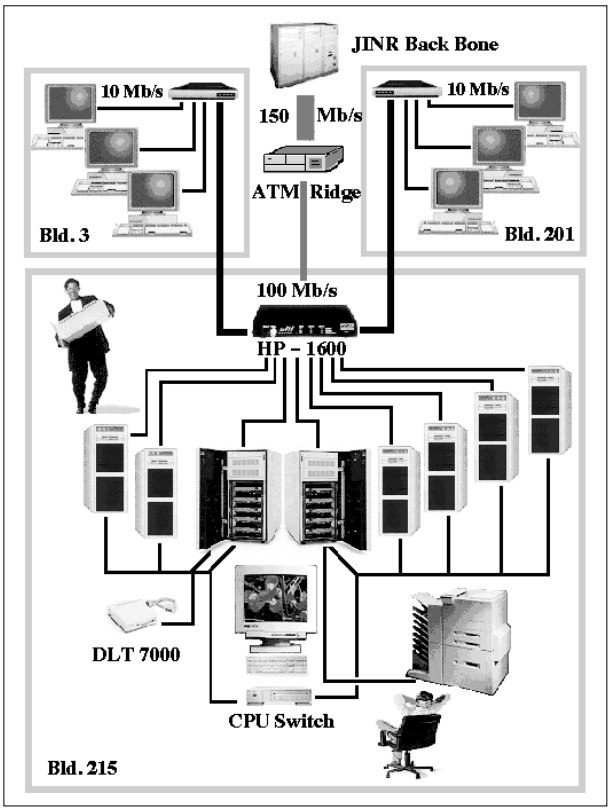
In 1999, the manufacturing and testing of gaseous and scintillator prototypes of the Shower Maximum Detector of the End-Cap Electromagnetic Calorimeter for STAR experiment were completed.

In 1999, the joint LHE-LPP and LCTA project for creation of personal computer complex (PCfarm) was developed (Fig.9). The complex includes 2 interactive computers with 4 CPU each (RS1 and RS2), 4 batch computers with 2 CPU Intel Pentium-400, tape drive (DLT 7000) for data input-output, optical channel for Fast Ethernet, 10 workstations (CPU type Celeron 333). The hard disk space on PCfarm is available about 160 Gb. Software for data analysis for STAR (STAF, ROOT4STAR) and NA45 (LHC++, IRIS Explorer, Objectivity) experiments were installed.

Realization of PCfarm project changes the situation in a radical way and opens for JINR physicists real possibility to make essential contribution to data analysis of relativistic nuclear physics experiments at BNL and CERN. The PCfarm allows performing the simulation of End-Cap Electromagnetic Calorimeter in the AgSTAR framework for the new design of the EEMC proposed by Indiana University group for the STAR experiment.

Simulation study of the basic characteristics of the EEMC such as deposited energy distributions, linearity of calorimeter responses, position and energy resolution has been performed. The relative linearity response for photons over an energy range of 2.5–40.0 GeV was found to be better than 1.5%. The energy resolution of the EEMC for photons $\sigma / E = 15.8/\sqrt{E}$ is close to the value from the project.

In 1999, upgrade of the CERES/NA45 set-up for improvement of an effective mass resolution near ρ/ω peak compared with natural width of ω-meson was completed. The first measurements of electron-positron pair produc-



tion in Pb-Au collisions at 40 GeV/nucleon were carried out.

The joint JINR-YerPI experiment on disintegration of the deuteron by polarized photons was carried out on the linearly polarized photon beam of the Yerevan Synchrotron [8]. The unique cryogenic set-up with the deuteron liquid target designed in LHE was used. New experimental data on asymmetry Σ of the process $\vec{\gamma} d \to np$ at the photon energy of $E_\gamma = 0.9$–1.7 GeV/c and an angle of protons near $\theta_{cm} = 90^\circ$ were obtained (Fig.10). The energy dependence of Σ significantly differs from asymptotic value $\Sigma = -1$ predicted by the quark counting rule.

HADES. Three modules of low-mass multilayer drift chambers (MDC-2) have been constructed and tested in the laboratory condition. A leakage of He-isobutan mixture from module is less than 15 cm^3 per min. An efficiency of the registration is about 99 %, plateau is ~ 200 v (with Sr^{90}). Two modules have been tested at GSI with a full set of readout electronics and integrated to the HADES spectrometer. The beam experiments in 1999 demonstrated stable operation of the drift chambers in a high intensive charged particle fluxes. Good correlation of the MDC's tracks information and TOF's data has been achieved.

The analogue readout electronics (FEE), based on the chip ASD-8, for drift chambers of the HADES spectrometer has been developed at LHE (JINR) in collaboration with GSI. This electronics has a high level of integration, high-rate capacity and low power dissipation. After mass-production about 2200 channels of the analogue readout electronics have been installed on two modules of MDC-2, which were integrated in the HADES set-up and used for testing and beam experiments. Special attention was paid to an improvement of noise immunity of the signal transport between the sense wires of MDC and the inputs of analogue electronics, which has to bridge the distance up to 40 cm. For the analogue monitoring of the drift chamber's behavior during the beam time we have designed and used the modified 16-chan. cards, which permit to check permanently an operation of MDC's modules.

We have developed (in collaboration with GSI) the program for track finding and the events' reconstructions in the HADES drift-chamber system. The fast and efficient algorithm for track finding in drift chambers (with high multiplicity) has been proposed. This algorithm allows one to select a real information about the tracks from ~1 million false combinations. The first tests of this program on the experimental data from 2 beam times have shown a high efficiency of this algorithm.

CMS Heavy Ion Programme. In the framework of LHE physicist's participation in the development of a Heavy Ion experiment programme of the CMS collaboration at LHC, a simulation of ultrarelativistic nucleus-nucleus collisions was continued [9]. An effect of parton jet quenching and parton shadowing on the charged multiplicity distributions over pseudorapidity was studied. It is shown that a distinctive feature of heavy ion collisions is a presence of a bump in a central pseudorapidity region in charged multiplicity distributions induced by a jet quenching effect in a dense nuclear matter (Fig.11). The similar behaviour is supported by calculations performed within the HIJING, VNI, and FRITIOF models. On the basis of a primary rescattering model it was demonstrated

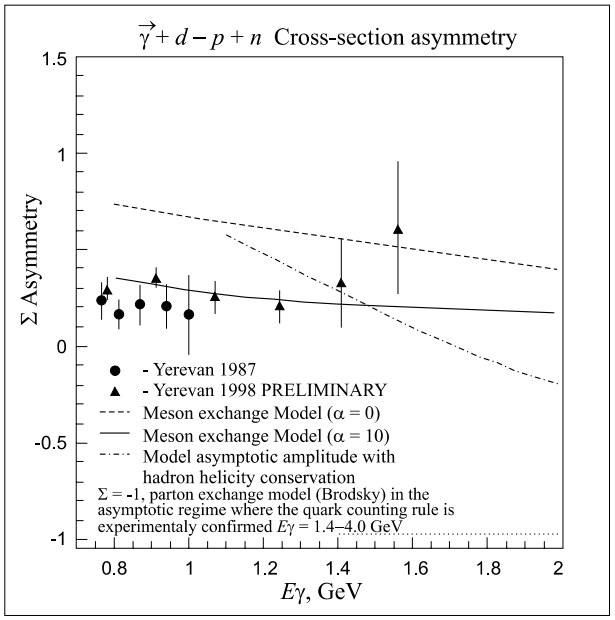


Fig.10. Dependence of the cross section asymmetry Σ of deuteron photodisintegration process on the photon energy E_γ at an angle $\theta_p = 90^\circ$ in the cms

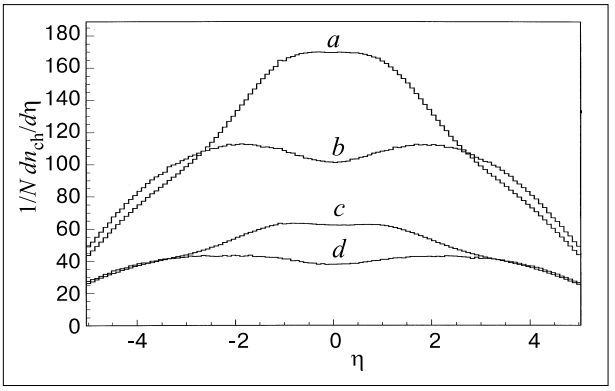


Fig.11. Distribution of a charged multiplicity over pseudorapidity for PbPb collisions at the LHC energy ($\sqrt{s} = 5$ TeV/nucl.) for the following scenario of nucleus-nucleus interactions: *a*) jet quenching (JQ), without parton shadowing (PS); *b*) no JQ, no PS; *c*) JQ and PS; *d*) PS, no JQ

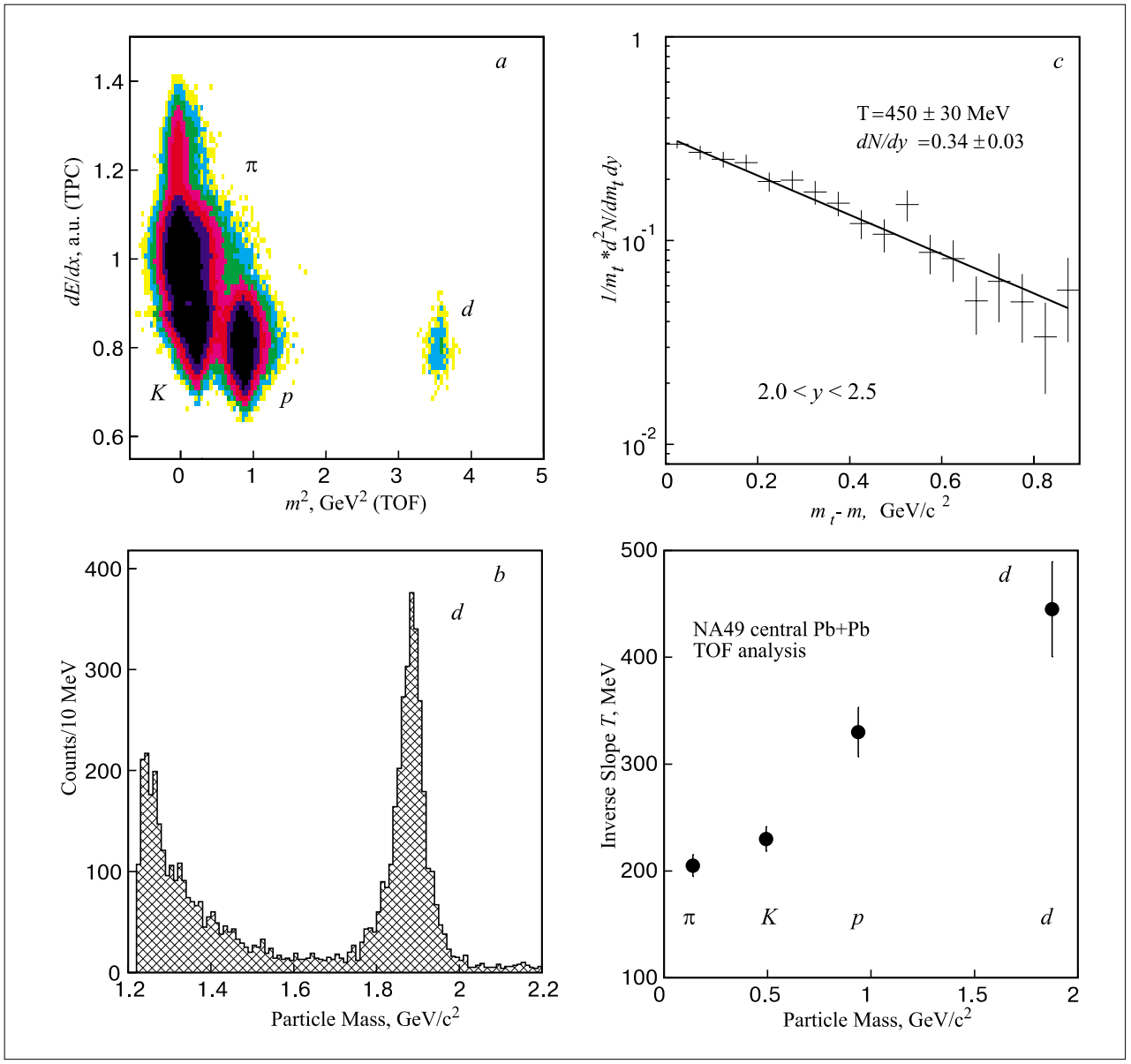


Fig.12. *a*) The particle identification by time-of-flight and *dE/dx* measurements and *b*) invariant mass distribution at p =3–10 GeV/c; *c*) transverse mass mt spectrum of deuterons in the central Pb+Pb collisions at 158 AgeV and *d*) inverse slope T of the transverse mass spectra for various hadron species in central Pb+Pb collisions at 158 AGeV

that parton rescattering leads to a central bump formation in the global variable distributions also.

Using the HIJING model of nucleus-nucleus interactions the influence of parton shadowing on the global variable distributions (total transverse energy and charged multiplicity) was investigated. In case of the interaction of nuclei at the energies of 5 TeV/nucleon, parton shadowing leads to a significant reduction of a minijet production (~ 4 times at the PbPb-collisions). This leads to the reduction of a total transverse energy flow and a charged multiplicity by a factor of 2.8 and 3.3, accordingly. The scale evolution on Q^2 of a nuclear structure function reduces the effect of a shadowing (2 times for PbPb-collisions). Our calculations have been done using various sets of nucleon structure functions within the framework of investigated parton shadowing models. One can conclude that the global variables are insensitive to a choice of a particular set of nucleon structure functions.

JINR has been actively taking part in the project **NA49** at CERN since 1994 and supplied the experiment by the 900-channel time-of-flight (TOF) detector as a main contribution. With its large acceptance and particle identification coverage the NA49 experiment can study

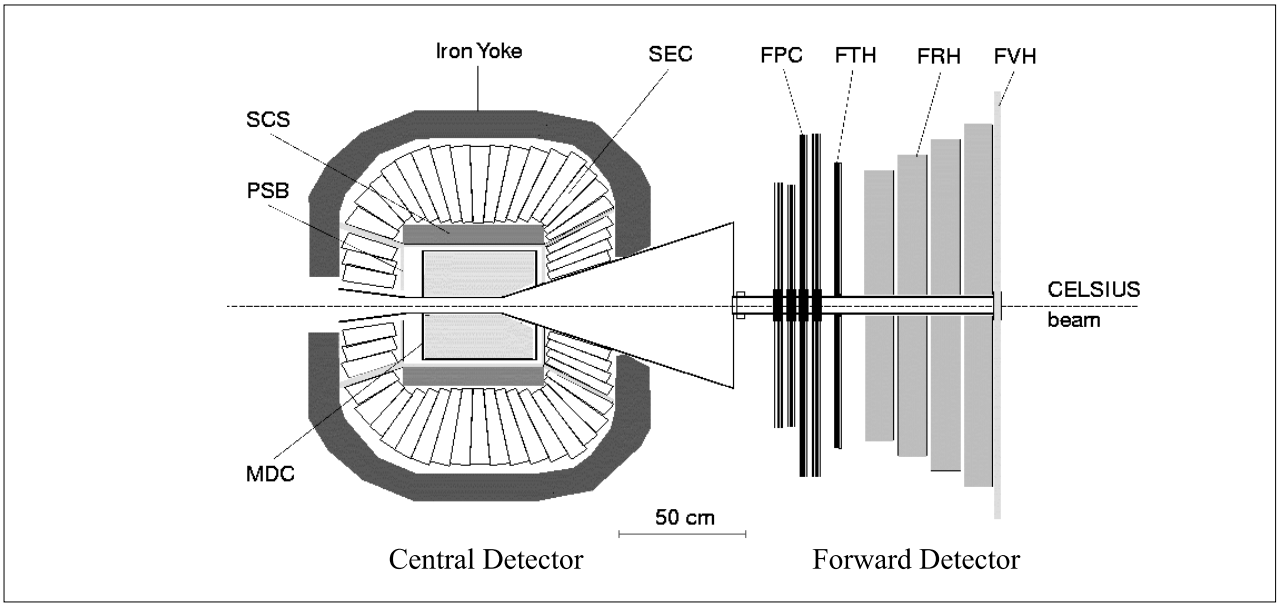


Fig.13. Layout of the WASA 4π-set-up

hadron production in a wide range of high-energy reactions.

Originally aimed at the examining of central Pb+Pb collisions for signatures of quark-gluon plasma formation, the scope of the experiment has been enhanced with the systematic study of impact parameter and system size and energy dependence as well as inclusion of more elementary p+p and p+A interactions. During the year 1999, the NA49 collaboration vigorously pursued this experimental programme and new vast data samples at the SPS with 158 GeV proton and 40 AGeV Pb ion beams, and with secondary 40 AGeV ion beams of C and Si have been obtained (about 4 million events in total).

Along with the maintenance of the Dubna TOF detector and data taking during the beam runs of the NA49, the physicists from the JINR group have been taking part in the data processing and the physics analysis. They are actively involved in the study of charged pions, kaons, protons and deuterons production as well as their antiparticles. The last activity is concerned with the studying of the deuteron production in central Pb+Pb collisions at 158 AGeV.

The sensitivity of light nucleus production to the space-time extent of the interaction region and collision dynamics makes their study very interesting. Light nucleus production enables one to study several topics, including the mechanism of composite particle production, freeze-out temperature, size of the interaction region, and collective expansion. Figure 12 represents some illustrative results of the deuteron analysis.

WASA Project. The main physics programme of the WASA/CELSIUS collaboration is based on studies of rare processes, in particular studies of rare decays of π^0 - and η-mesons. The experiments require a high quality beam in the CELSIUS storage ring, a pellet target system and a detector, that covers close to 4π steradian [10]. The main activity of our collaboration for 1999 was to put the new WASA 4π detector set-up «on the floor» in order to start the data taking in spring 2000.

In 1999, the different components of the central detector (CD) and the forward detector (FD) were installed in full and tested with beam: the minidrift chamber (MDC) with 1738 proportional straw counters [11], the electromagnetic calorimeter (SEC) comprising 1012 CsI modules [12], the superconducting solenoid (SCS), the plastic scintillator barrel (PSB), the forward tracker planes (FPC) and the others. Computer-controlled high-voltage systems for MDC and SEC are installed and tested. The systems have been developed and produced in Dubna. The necessary electronics hardware, the triggers, the data acquisition system [13] and Monte Carlo studies on selected decays are prepared in parallel. A method of global track recognition for CD was developed in Dubna/Uppsala and the programme codes are ready for verification.

In parallel to WASA 4π-set-up installation and test, we continue to analyze the data which had been taken in 1996-1998 [14,15].

CONFERENCES, MEETINGS

In 1999, with participation of the LHE there were organized some scientific conferences:

The 4th Workshop of the International Scientific Users' Committee for the Movable Polarized Target took place at the Laboratory of High Energies on 16 January. It was held within the framework of the agreement between five institutes of Russia, Ukraine, Italy, and France on the use of the polarized target as a basic facility of LHE. The Workshop programme included reports on the target's upgrades completed in 1998 and plans of its modernization in the current year, as well as on the results of the performed measurements and proposals of the new experiments.

An International Workshop «EMU01 Collaboration and Perspectives of Using Photoemulsions in Experiments with Beams of the Nuclotron Relativistic Nuclei» was organized by the Laboratory of High Energies on 18–20 May. Scientists from JINR, JINR Member States, Egypt, India, China, and Sweden took part in it. Issues of preparation of new experiments with the Nuclotron extracted beams and at other accelerators of the world (CERN, Brookhaven) by photoemulsion technique were discussed at the Workshop.

From 14–18 June an International Workshop «Relativistic Nuclear Physics: from Hundreds MeV to TeV» was held in Stara Lesna (Slovak Republic). It was organized by the Joint Institute for Nuclear Research (Dubna) and the Institute of Physics (Slovak Academy of Sciences). The programme covered a wide scope of research topics in relativistic nuclear physics and development of experimental instruments including:

— Investigations of interactions of relativistic nuclei on beams of the Synchrophasotron–Nuclotron accelerator complex;
— Development of the Laboratory of High Energies accelerator complex. Use of the Nuclotron beams to research into the nuclear structure;
— Experiments at other accelerators: CERN (SPS, LHC), HADES experiment at GSI (Darmstadt);
— Applied research.

International Workshop on «Modelling of Electronuclear Method of Energy Production and Studies of Nuclear Waste Transmutation Using LHE JINR Synchrophasotron/Nuclotron Beams» has been held on October 26-29, 1999 in Dubna. Academician A.M. Baldin — scientific leader of LHE JINR — was a chairman of the Organizing Committee. The programme of the Workshop included more than 90 reports on the following items: heat generation and energy needed to generate one neutron; power amplification coefficient (energetic gain); multiplication and balance of neutrons depending on the beam parameters, isotope and structural composition of the blanket; transmutation of radioactive wastes; optimal characteristics of multipurpose electronuclear installations as well as practical recommendations on the development of the prototype transmutation installation; testing and modernization of the computation methods and the computer programs used to perform modelling of electronuclear processes and installations.

REFERENCES

1. *Artemov A.S. et al. — JINR Rapid Communications, 1999, No. 2[94]-99, p.25.*
2. *Artemov A.S. et al. — JINR Communications P1-99-128, Dubna, 1999.*
3. *Biino C. et al. — Deflection of 33 TeV/c fully stripped Pb ions by means of a bent Si crystal. - to be published in Nucl. Instr. Meth. B.*
4. *Sharov V.I. et al. — JINR Rapid Communications, 1999, No.4[96]-99, p.5.*
5. *Zborovsky I. et al. — Phys.Rev., 1999, C59, p.2227.*
6. *Tokarev M.V. et al. — JINR preprint E2-99-113, Dubna, 1999.*
7. *Glagolev V.V., Lyuboshitz V.L. et al. — JINR Communications E1-99-280, Dubna, 1999.*
8. *Adamian F. et al. — Measurement of the cross section asymmetry of deuteron photodisintegration process by linearly polarized photons at the energy range E_γ = 0.9–1.7 GeV, Preprint YERPHI-1541(15)-99.*
9. *Savina M.V. et al. — Yad. Fiz, 1999, v. 62, No.12, p.1–3.*
10. *The WASA/CELSIUS collaboration. Dubna–Julich–Moscow–Novosibirsk–Tsukuba–Tubinen–Uppsala–*

Warsaw. The WASA Detector at CELSIUS. XVth Particles and Nuclei International Conference (PANIC), June 10-16, 1999, Uppsala, Sweden, p.593.

11. *Morosov B. et al. — For the WASA/CELSIUS collaboration. Dubna–Julich–Moscow–Novosibirsk– Tsukuba–Tubingen–Uppsala–Warsaw. A Mini Drift Chamber for the WASA Detector. XVth Particles and Nuclei International Conference (PANIC), June 10–16, 1999, Uppsala, Sweden, p.559.*
12. *Kupsc A. et al. — For the WASA/CELSIUS collaboration. Dubna–Julich–Moscow–Novosibirsk–Tsukuba–Tubingen–Uppsala–Warsaw. An Electromagnetic Calorimeter for the WASA Facility. XVth Particles and Nuclei International Conference (PANIC), June 10–16, 1999, Uppsala, Sweden, p.561.*
13. *Gustafsson L. et al. — For the WASA/CELSIUS collaboration. Dubna–Julich–Moscow–Novosibirsk–Tsukuba–Tubingen–Uppsala–Warsaw. The WASA Data Acquisition System. XVth Particles and Nuclei International Conference (PANIC), June 10–16, 1999, Uppsala, Sweden, p.593*
14. *Calen H. et al. — Phys. Lett., 1999, v.B458, p.190.*
15. *Betsch A. et al. — Phys. Lett., 1999, v.B446, p.179.*
16. *Malakhov A.I. — In: Proceedings of the 29 th Intern. Confer. on High Energy Physics, Vancouver, Canada, 23–29 July 1998, Editors Alan Astburg et al. Word Scientific, p.1497-1500.*

LABORATORY OF PARTICLE PHYSICS

In 1999, the activity of LPP was concentrated on the current experiments in the field of particle physics and preparation of new experiments, R&D of the particle detectors and different acceleration systems.

1. RESEARCH ACTIVITIES AT IHEP (Serpukhov)

A study of charmed baryon production in neutron–nucleus interactions is continued in the frame of the **OSCAR** theme at the **EXCHARM** set-up [1]. The EXCHARM experiment is an extension of the scientific programme being carried out at the U-70 accelerator in Protvino and aimed at:

— searching for exotic states in hadron reactions;

— studying of strange and charmed particle hadroproduction, including polarization phenomena;

— investigating of single and double ϕ-meson production characteristics and OZI rule violation.

A clear signal from the decay $\Lambda_c \to p\pi^+\pi^+\pi^-$ has been observed (about 5 standard deviations) in the Λ_c^+ mass region (see Fig.1). The (124 ± 20) events of double ϕ-meson production in neutron–carbon (nC) interactions have been observed. The calculated cross section of the double ϕ-meson production is

$$\sigma = (12.9 \pm 3.0_{\text{stat.}} \pm 1.3_{\text{syst.}})\ \mu\text{b/nucleon.}$$

The lower limit of the ratio of the cross section of the processes, suppressed by Okubo–Zweing–Iizuka (OZI) rule, to the total double ϕ-meson production cross section, measured in this experiment, was determined to be equal to 0.09 at 95 % CL [2].

Inclusive production cross sections of strange resonance $K^{*\pm}(892)$ have been measured in nC-interactions:

$$\sigma(nN \to K^*(892)^+ X) =$$
$$= (0.433 \pm 0.018_{\text{stat.}} \pm 0.016_{\text{syst.}})\ \mu\text{b/nucleon,}$$

$$\sigma(nN \to K^*(892)^- X) =$$
$$= (0.252 \pm 0.013_{\text{stat.}} \pm 0.017_{\text{syst.}})\ \mu\text{b/nucleon.}$$

Some parametrizations of invariant differential cross section have been considered and experimental values of their parameters have been obtained [3].

New precise measurements of spin density matrix element ρ_{00} of $K^*(892)^{\pm}$-mesons produced inclusively

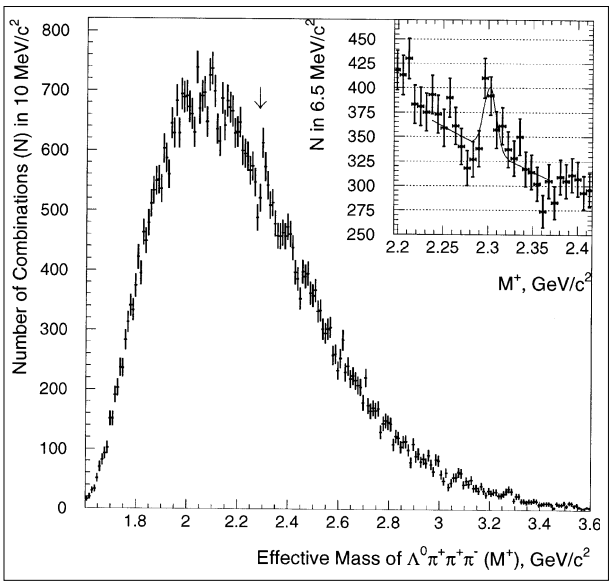


Fig.1. A signal from the decay $\Lambda_c^+ \to \Lambda^0\pi^+\pi^+\pi^-$ in the Λ_c^+ mass region

in neutron–carbon interactions have been carried out [4]. The values of ρ_{00} in the transversity frame are $0.424 \pm \pm 0.011_{\text{stat.}} \pm 0.018_{\text{syst.}}$ for $K^{*+}(892)$ and $0.393 \pm \pm 0.025_{\text{stat.}} \pm 0.018_{\text{syst.}}$ for $K^{*-}(892)$.

New precise data on polarization of Λ's produced in nC interactions in the kinematic range of $0.1 \le x_F \le 0.6$ and $0.2 \le p_t \le 1.2$ have been obtained [5]. The polarization has nearly linear dependence within all the range of $p_t \le 1$ GeV/c at fixed x_F. The polarization increases roughly linearly with the increasing of x_F at fixed p_t.

2. CO-OPERATION WITH CERN

The construction of the **NA48** detector has been completed for the precision measurement of the ε'/ε ratio in CP violating decays of K^0-mesons into $\pi^+\pi^-$ and $\pi^0\pi^0$. The value of ε'/ε has been measured from the data recorded in 1997 [6]:

$$\mathrm{Re}(\varepsilon'/\varepsilon) = (18.5 \pm 4.5_{\text{stat.}} \pm 5.8_{\text{syst.}}) \cdot 10^{-4}.$$

The JINR group has made a considerable contribution to the final data analysis, including the corrections and the systematical error estimation.

Totally 6864 events of the decay $K_L \to e^+e^-\gamma$ have been observed with an estimated background of 10 events [7]. The branching ratio is:

$$\Gamma(K_L \to e^+e^-\gamma)/\Gamma(K_L \to \text{all}) = \\ = (1.06 \pm 0.022_{\text{stat.}} \pm 0.020_{\text{syst.}}) \cdot 10^{-5}.$$

The parameter α_{K^*} describing the relative strength of the two amplitudes contributing to this decay through intermediate pseudoscalar or vector mesons, was measured to be

$$\alpha_{K^*} = -0.357 \pm 0.060.$$

A new precision measurement of the Ξ^0 mass has been carried out [8]:

$$m_{\Xi^0} = (1314.82 \pm 0.06_{\text{stat.}} \pm 0.20_{\text{syst.}})\ \text{MeV/c}^2.$$

The branching ratios of Ξ^0 radiative decays have been measured as:

$$\mathrm{Br}(\Xi^0 \to \Lambda\gamma) = (1.90 \pm 0.34_{\text{stat.}} \pm 0.19_{\text{syst.}}) \cdot 10^{-3},$$

$$\mathrm{Br}(\Xi^0 \to \Sigma^0\gamma) = (3.14 \pm 0.76_{\text{stat.}} \pm 0.32_{\text{syst.}}) \cdot 10^{-3}.$$

A study of the polarizaton of Λ-hyperons produced in inelastic pN reactions by the 450 GeV proton beam has been performed [9]. The Λ-hyperons were detected at a fixed angle of 4.2 mrad in the momentum range from 50 to 200 GeV/c. The polarization changed from -0.053 ± 0.034 to 0.298 ± 0.074 for a transverse momentum range of Λ between 0.028 GeV/c and 0.86 GeV/c. The Λ polarization is consistent with zero. Two events of light gluinos have been found through the appearance of $\eta \to 3\pi^0$ with a high transverse momentum [10].

The formalism for the space charge in ionization chambers and shower detectors has been developed identifying dimensionless parameters acceptable to describe a wide range under operating conditions [11]. The results of the computation have been compared with observations made during the operation of the NA48 calorimeter.

The 1999 experimental run has been carried out with the active participation of the JINR group and about $2{,}5 \cdot 10^6$ CP violating decays of $K_L^0 \to \pi^0\pi^0$ have been accumulated. The on-line physical data monitoring has been maintained by the JINR group. The first results based on the data obtained in 1998 have been received.

According to the JINR obligations on the **ATLAS** set-up, LPP participates in the construction of the Liquid Argon Hadronic End-Cap Calorimeter (LArHEC) and subsystems connected to it. The team from JINR is actively working in the following directions:

- production of front wheel serial modules of the hadronic calorimeter;
- investigations of radiation hardness of materials and electronics supposed for the ATLAS liquid argon calorimetry, study of possible liquid argon pollution due to the materials irradiation;
- participation in preparation of the ATLAS physics performance Technical Design Report, simulation, and analysis of the experimental data;
- design and construction of the liquid argon temperature measuring system;
- design and production of the certain part of the electronic chain which compensates capacity differences of the HEC calorimeter readout structure.

The absorber structure and stainless steel pieces for four serial HEC modules assembly were produced at the JINR Experimental Workshop. The first serial module was manufactured at JINR, shipped to CERN and checked at the SPS test beams of pions, electrons and muons.

A lot of work was done on the IBR-2 reactor at JINR to investigate properties of materials and electronics being exposed to the high neutron fluence up to the 10^{16} n/cm^2. The GaAs preamplifiers of the final design have shown stable performance in terms of the transfer function, rise time, and linearity for neutron fluences

up to $3 \cdot 10^{14}$ n/cm^2 and for gamma irradiation — up to 31 kGy. The pollution of the liquid argon due to the irradiation of materials, which are used to construct all the ATLAS liquid argon calorimeters, by neutrons with the fluence of about $1.5 \cdot 10^{16}$ n/cm^2 were mesuared by the apparatus specially built up at the IBR-2 reactor. Numerous runs have shown that liquid argon pollution is less than 2 ppm.

To study the top quark physics in the frame of ATLAS physics performance TDR preparation, the JINR team selected the process of single top quark production. The full simulation of the process in ATLAS detector has been done and the topology carefully studied. The criteria of the wanted signal identification were formulated. It was shown that the single top quark production process may be studied with a good statistical significance.

The preshapers were designed and the first set of electronics was produced. The performance was studied at the SPS test beam with 6 first serial modules. It has shown that the design and production of the preshapers are successful.

The main activity of LPP within Compact Muon Solenoid Project, **CMS**, was concentrated on the study, design, and integration of the CMS End-Cap detectors, where JINR has got a full responsibility in frame of Russia and Dubna Member States (RDMS) of the CMS Collaboration. The main task was optimization of separate sub-systems of the Forward Muon Station (ME1/1) in view of mass production. Analysis of the experimental data taken with the P4 ME1/1 Cathode Strip Chamber (CSC) prototype instrumented with front-end electronics based on the Minsk chips ASIC, was completed [12]. The results have confirmed that the performance of baseline CSC such as position and timing resolution, efficiency of Local Charge Trigger and track reconstruction, meets the CMS requirements. The simulation of the analog memory has shown that to provide a precise reconstruction of the pulse height maximum, the optimal number of pulse height measurements with a period of 50 ns should be equal to 6–8. Development of the robust method has increased the precision of the track reconstruction up to 40 mm by a factor of 1.5 in respect to the method of the least squares.

JINR co-ordinates the RDMS CMS Collaboration activity on the design and construction of the Hadron End-Cap (HE) calorimeter and is responsible for the HE absorber. A full-scale preproduction prototype of the HE calorimeter sector together with the HB sector prototype is installed on the «movable table» and tested at CERN H2 beam.

Manufacture of preseries Preshower strip-detector based on a new radiation resistive Si-detector topology developed by JINR in collaboration with RIMST, Zelenograd, and CERN has started. The radiation investigations of the full-scale detectors by irradiation with fast neutrons and 24 GeV protons are continued in collaboration with CERN. The Preshower prototype with 5×5 PWO crystals prototype of electromagnetic calorimeter is tested at the CERN H4 beam with electron energy range of 15–180 GeV.

The experimental test with «X-ray CSC prototype» has demonstrated successful operation of the Katod-1m and Anod-1m ASICs for the background rate of 1–10 MHz per channel. A full-scale mock-up of ME1/1 CSC equipped with a set of the cathode and anode readout electronics, cooling and low voltage systems, realistic layout of cables and services is worked out to study chamber integration issues.

The investigations on application of *pp*-collision events with the production of direct photons associated with a single hadron jet have been continued to calibrate the hadron calorimeters. It was shown that these events can be used for precise determination of the gluon component of the proton structure function in a region of very small x_F and a very large transfer momentum square. This range can be considered as a complementary one to that measured at HERA. Simulation of the trigger option for heavy ion collisions in the CMS is in progress.

The Common Muon and Proton Apparatus for Structure and Spectroscopy, **COMPASS (NA58)**, has been proposed to perform a series of experiments with the high energy muon and hadron beams. In 1999, within available resources, JINR has participated in construction of various COMPASS detectors which are under Dubna responsibilities defined in the Memorandum of Understanding. Modules of the Hadron Calorimeter (HCAL1), which is under full responsibility of JINR, have been constructed at Dubna and delivered to CERN for beam tests. The total number of the delivered modules is 500, 300 of them have been tested in 1999. The movable platform for HCAL1 is being designed in Romania under contract with JINR, and after inspection at CERN the construction of the platform has started.

Taking into account the 1998 results of the straw tube prototype tests, which have shown a high efficiency (≥ 99 %) and good precision of the tubes ($120 \div 150$ μm), drawings and production area have been prepared for mass production of straw drift chambers. These chambers (15 planes) will be included in the Straw Tracking Station placed within COMPASS spectrometer after the first magnet.

JINR experts take part in refurbishing the multiwire proportional chambers (MWPC) to be used in the Large Area Tracking Detector (LAT) placed within COMPASS before and after the second magnet. Chambers are tested with new electronics and new gas based on CF_4. The conceptual and technical design of the Muon detector (MW1), which is also under full responsibility of JINR, has been agreed upon with collaboration. Boxes and proportional tubes for two planes of tracking chambers were produced at JINR workshop and have passed inspections and tests at CERN. Amplifiers and discriminators for the MW1 read-out system have been also tested.

The Dubna group is taking part in the COMPASS optimization and preparations of the software. The group has contributed to:

— determination of the efficiency of registration and reconstruction of Λ- and $\bar{\Lambda}$-hyperons;
— determination of the efficiency of pattern recognition and reconstruction of primary and secondary vertices;
— background from K- and $\sum$-decays;
— optimization of the straw tracker;
— MC description of HCAL1 and analysis of the HCAL1 tests;
— development of the MC program COMGEANT and reconstruction program;
— development of algorithms for inclusive and semi-inclusive cross section calculations;
— optimization of LAT and positions of MWPC along the set-up.

3. CO-OPERATION WITH DESY

The Dubna group has taken an active part in data taking, data analysis and technical maintenance of the system of mini-Drift Vertex Chambers (DVC) of **HERMES** Spectrometer Front Tracking. The LPP group has performed the technical support of DVC, which provides the stable DVC operation conditions with high efficiency (98–99 %) and high spatial resolution (about 200 μm). The LPP physicists have participated in analysis of the 1996 and 1997 experimental data aimed at extracting the Q^2 dependence of the generalized Gerasimov–Drell–Hearn integral for proton in the resonance region and for the region $W^2 > 1.0$ GeV^2.

Spin asymmetries of semi-inclusive cross sections for the production of positively and negatively charged hadrons have been measured in deep-inelastic scattering of polarized ^{1}H and ^{3}He targets, in kinematical range $0.023 < x < 0.6$ and $1.0 < Q^2 < 10$ GeV^2 [13] (see Fig.2). Polarized quark distributions are extracted as a function of x for up- $(u + \bar{u})$ and down- $(d + \bar{d})$ flavours. The up-quark polarization is positive, the down-quark polarization is negative and the polarization of sea quarks is compatible with zero (see Fig.3). The isospin non-singlet combination is consistent with the prediction based on the Bjorken sum rule. The moments of the polarized quark distributions are compared to the predictions based on SU3 flavor symmetry and to the prediction from the lattice QCD, it is found to be in agreement.

Exclusive incoherent electroproduction of the $\rho^0(770)$ meson with ^{1}H, ^{2}H, ^{3}H, and ^{14}N targets has been studied by the HERMES experiment at squared four-momentum transfer $Q^2 > 0.4$ GeV^2 and positron energy loss ν from 9 to 20 GeV [14]. The ratio of the ^{14}N to ^{1}H cross sections per nucleon known as the nuclear transparency was found to decrease with increasing coherence length of quark-antiquark fluctuation of the virtual photon (see Fig.4). The data provide clear evidence of the interaction of the quark-antiquark fluctuations with the nuclear medium.

A measurement of the longitudinal spin asymmetry $A_\parallel$ in photoproduction of pairs of hadrons with high transverse momentum p_t has been done [15]. The data were accumulated by the HERMES experiment using the 27.5 GeV polarized positron beam and a polarized hydrogen target integral to the HERA storage ring. For h^+h^- pairs with $p_t^{h1} > 1.5$ GeV/c and $p_t^{h2} > 1.0$ GeV/c, the measured asymmetry is $A_\parallel = -0.28 \pm 0.12_{\text{stat.}} \pm 0.02_{\text{syst.}}$. This negative value is in contrast to the positive asymmetries typically measured in deep inelastic scattering from protons, and is interpreted to arize from a positive gluon polarization (see. Fig.5). The value of $\Delta G/G$ was determined in the leading order of QCD to be $0.41 \pm 0.18_{\text{stat.}} \pm 0.03_{\text{syst.}}$.

According to the JINR commitments, LPP participates in the construction of the Outer Tracker (OTR) of the **HERA-B** detector designed to search for CP-violation in exclusive B-decays, mainly, in the «gold plated» decay mode $B^0 \to J/\Psi K_S^0$. The LPP provides the following items and supports them in order to carry out the HERA-B experiment:

— construction, installation, and commissioning of parts of the OTR;
— participation in the assembly, maintenance, and operation of the OTR;
— contribution to the development and maintenance of the off-line reconstruction code, the calibration code and the detector-specific code for the slow control;
— participation in the physics analysis of the data.

A specialized mass production line was set at the LPP for manufacturing the honey-comb modules by using the materials and parts supplied from DESY, Germany. All information about every wire in the manufactured chamber (wire tension, high voltage test, etc.) including results of the module test at the set-up with radioactive source (dark current for wire group, wire noise, wire counting frequency, chamber efficiency) was inserted to the chamber quality data base. The direct access to this data base via Internet provides the transparency of mass production at Dubna for all participants of the HERA-B collaboration. In September 1999, the mass production program

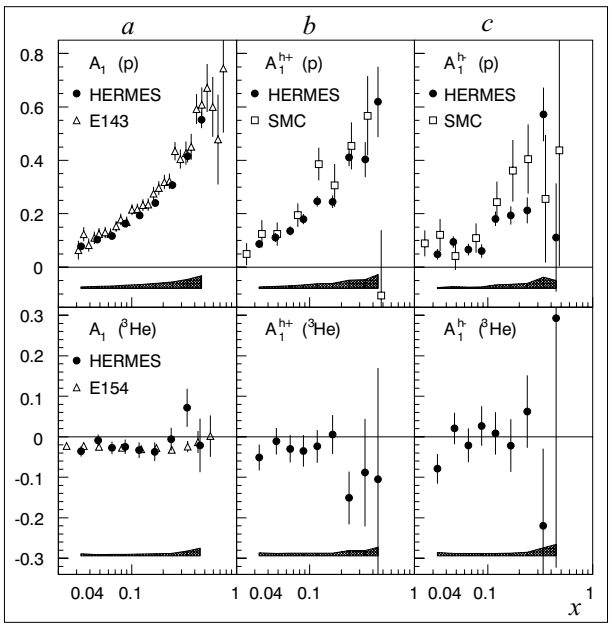


Fig.2. The inclusive (a) and semi-inclusive asymmetries for positively (b) and negatively (c) charged hadrons on the proton (top) and ^{3}He (bottom) target. The inclusive asymmetries are compared to SLAC results for g_1/F_1 (open triangles)

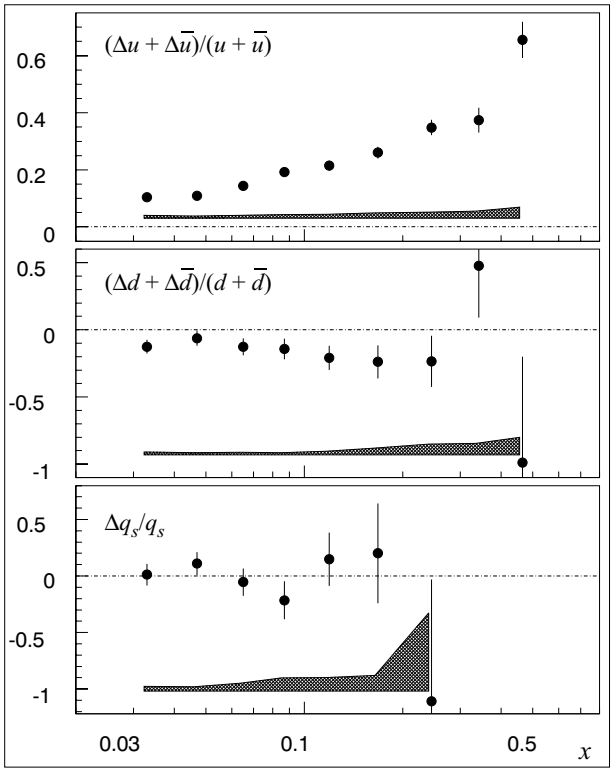


Fig.3. The flavor decomposition $(\Delta u(x)+\Delta\bar{u}(x))/((u(x)+\bar{u}(x)))$, $(\Delta d(x)=\Delta\bar{d}(x))/((d(x)+\bar{d}(x)))$ and $\Delta q_s(x)/q_s(x)$ of the quark polarization as function of x, derived from the HERMES inclusive and semi-inclusive asymmetries

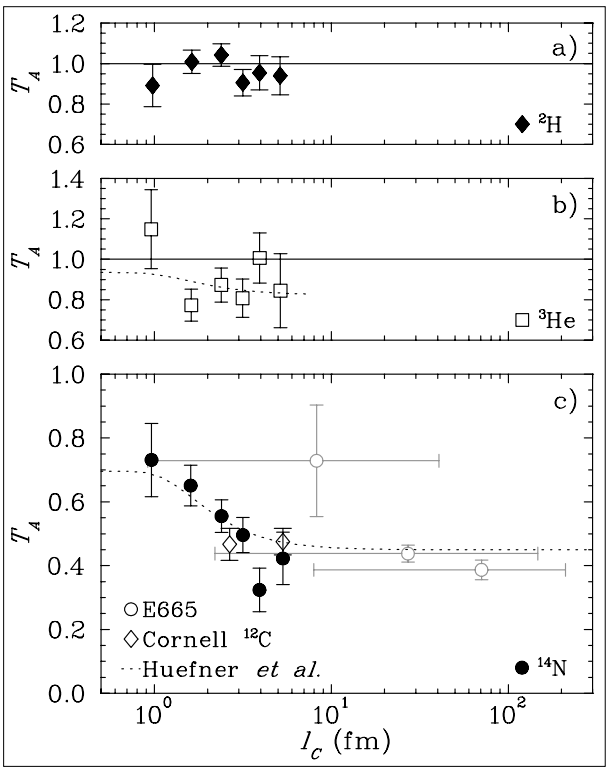


Fig.4. Nuclear transparency T_A as a function of l_c for (a) ^{2}H (filled diamond), (b) ^{3}H (open square) and (c) ^{14}N (filled circle) targets. The error bars include statistical and point-to-point systematical uncertainties added in quadrature

was completely fulfilled at the LPP. In total, about 300 modules have been manufactured and delivered from Dubna to DESY. This number of modules corresponds to about 40,000 channels or, respectively, to 30 % of the total number of the OTR channels. The final quality tests performed in Hamburg after the delivery of the chambers produced in Dubna have shown that the number of bad wires is less than 1 % (noisy channels — less than 0.3 %, dead channels — 0.6 %).

A strong team from Dubna consisting of physicists, engineers, and technicians also works at DESY. This group is responsible for the cabling of the OTR beginning from the drift tube modules inside the gas volumes to the TDC. For this task there were developed schemes of the OTR cable infrastructure including the labeling of all kinds of cables (signal, high voltage, low voltage, sharc) and electronic components (ASD, TDC, HV and LV boards, trigger link boards, sharc boards). A special graphical interface program has been developed to design the cabling schemes.

An overwhelming contribution to the OTR installation, testing and commissioning is carried out by the Dubna group. Their activity covers a wide field of tasks: from the beginning of the equipment preparation for the inner and outer superlayer frames, installation and connection of modules — to testing and debugging the readout elec-

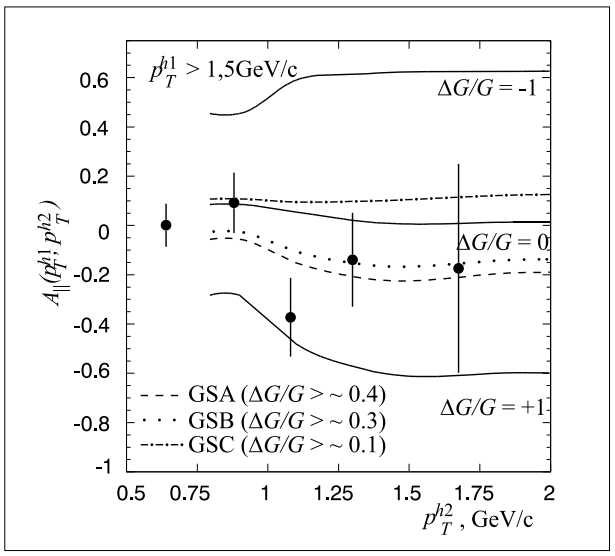


Fig.5. Comparison of asymmetry $A_{\|}$ with Monte Carlo predictions for high p_t hadron production measured at HERMES

tronics and DAQ programs. While finishing the OTR superlayers commissioning, the activity of Dubna physicists involved in this task will be focused on the OTR running and data analysis.

LPP participates in the upgrading of detectors for the **H1** experiment to investigate deep inelastic scattering of electrons on protons, specifically, in the software/hardware support of Forward Proton Spectrometer (FPS) operation and in the upgrading of the hadron Plug calorimeter. The upgrading of the Plug calorimeter includes the design of sensitive layers for the detector based on radiation hard scintillators readout by wave length shifting fibers and magnetic field resistant photo-multipliers, and manufacturing of selected readout analog and monitoring electronics.

The LPP takes an active part in physical analysis of deep-inelastic scattering processes on the base of experimental data from the FPS and hadron Plug calorimeter. Measurements of the transverse energy flow have been carried out for neutral current deep-inelastic scattering events produced in positron-proton collisions at HERA [16]. The kinematic range covers squared momentum transfers Q^2 from 3.2 to 2200 GeV^2, the Bjorken scaling variable x from $8\cdot10^{-5}$ to 0.11 and the hadronic mass W from 66 to 233 GeV. The transverse energy flow is measured in the hadronic centre-of-mass frame and is studied as a function of Q^2, x, W and pseudorapidity. A comparison is made with QCD based models. The behaviour of the mean transverse energy in the central pseudorapidity region and an interval corresponding to the photon fragmentation region are analysed as a function of Q^2 and W.

Deep-inelastic scattering events with a leading baryon have been detected by the H1 experiment at HERA using a forward proton spectrometer and a forward neutron calorimeter [17]. Semi-inclusive cross sections have been measured in the kinematic region $2 \le Q^2 \le 50$ GeV^2, $6\cdot10^{-5} \le x \le 6\cdot10^{-3}$ and baryon $p_T \le 200$ MeV. A Regge model of the leading baryon production which consists of the pion, pomeron and secondary reggeon exchanges gives an acceptable description of the both semi-inclusive cross sections in the region of $0.1 \le x_{IP} \le 0.3$. The leading neutron data are used to estimate the structure function of the pion at small x.

Measurements of the energy of the leading proton detected in the FPS Horizontal Roman Pots sensitive in the diffractive kinematic range ($x_{IP} \le 0.05$) and cross calibration of Horizontal Roman Pots in elastic ρ-meson photo-production events have been performed [18]. The final aim of the analysis is to measure the semi-inclusive diffractive structure function $F_2^{D(3)}$ and to study the vector meson ($\rho, \omega, \phi, J/\psi$) diffractive photo-production cross sections.

4. OTHER EXPERIMENTS

LPP takes part in the design and construction of the End-Cap Electro-Magnetic Calorimeter (EEMC) for the 4π-detector **STAR** for the collider RHIC at the Brookhaven National Laboratory. A model of the EEMC was manufactured and tested in the 27 GeV e-beam of the accelerator U-70 (Protvino). The results of tests have confirmed the requirements of the EEMC design. Setting up of the area to produce the scintillation plates by means of molding under pressure has been created at the Serpukhov Division of LPP, JINR. The LPP physicists together with the BLTP theoreticians have shown that, under operation conditions of the STAR detector a new opportunity is revealed to measure polarization of the particles produced in multi-particle processes. The Technical design and the full scale prototype of the PMT box for the Barrel EMC (BEMC) of the STAR detector have been done by the LPP physicists at the Wayne State University (USA).

The LPP specialists participate in construction of the low-noise neutrino detector **BOREXINO** located at the underground laboratory in Gran Sasso (Italy). The responsibilities shared by the JINR group are mainly concerned DAQ system, detector calibration and testing, cleaning and mounting of photo-multiplier tubes (PMT).

The 109 PMTs have been tested on the BOREXINO test facility and significantly improved during the test. The database containing all the PMT parameters has been created to provide parameters for the better MC simulations of the detector. On the base of the measurements the model of the PMT single electron response has been developed and succesfully integrated in the BOREXINO simulation code. The method of the fast HV tuning for the PMT has been also developed and tested.

5. ACCELERATION TECHNIQUES

According to the JINR obligations on the transverse oscillation damping system for **LHC**, assembling of the prototype of the wide band amplifier and of the full-scale kicker model has been completed in 1999. Tests of the system on frequency and energy were carried out on a specialized stand of LPP. Technical documentation for the prototype of the device has been developed and corrected on the basis of the obtained experience. Besides, the construction was completed by the elements necessary for the high precision positioning of the reper targets of the tuning system. Experimental studies aimed at the production of the NbN/Nb/NbN films with a higher first critical magnetic field were continued. Theoretical analysis of the influence of the surface smoothness of the working layer of superconducting cavities on the character of nonquadratic losses was continued.

The main direction of co-operation with DESY is developments for linear collider **TESLA** and studies in the field of free electron lasers (FEL) [19]. Conceptual projects have been developed for an X-ray laser on free electrons, which was integrated into the project of the linear collider, as well as for the second place of the collision of the linear collider to carry out experiments on colliding $\gamma\gamma$ and γe beams of high luminosity. Optimization of the parameters of the X-ray FEL has been done on the TESLA Test Facility (TTF). The schemes of the X-ray range FEL have been developed and tested on the LPP stand, they provide full coherence of the output radiation (regenerative FEL amplifier for the first phase and a two-cascade scheme for the second phase of the project).

A big amount of work was fulfilled on cryogenic supply of TTF and TESLA. Calibration of the first batch of thermometers has been carried out for the project TESLA in the range of 1.5–300 K with an accuracy of 0.01 K in the helium range of temperatures. The algorithm of processing the sensors calibration results has been improved that provides a higher precision in comparison with the earlier known methods. The behavior of the thermometers in the magnetic field up to 11 T was studied in the range from 1.5 K to 4.5 K. The metrological system for calibration of the RF sensors of void fraction of the two-phase cryogen flows has been modernized to extend its operational range till 1.5 K and calibrate RF-sensors. A prototype of the void fraction sensor has been manufactured with a relatively big inner diameter (about 70 mm) and with improved nonuniformity of the electric field in its sensitive element. This system has been delivered to CERN. The results of studies of the properties of the horizontal two-phase helium flows used as cryogen in superconducting cryogenic systems, have been systematized.

Studies on FELs for electron–positron colliders with a scheme of two-beam acceleration — **CLIC** — were carried out on the following main directions:

— development of the FEL generators and amplifiers of the millimeter range for high gradient supply of the accelerating structures of the electron–positron colliders;
— theoretical and experimental studies of the electron bunch dynamics in FEL, studies of the possibility to construct a group former for the beam driver of the two-beam accelerator;
— studies of the possibility of grouping the driver beam and transportation of the grouped beam captured by synchronous electromagnetic wave using the travelling wave tube (TWT) scheme.

The FEL generators have been studied theoretically and experimentally. Two new schemes of Bregg reflectors have been used — with the uniform structure of corrugated waveguide and with the corrugated waveguide with phase shift of π [20]. Numerical simulation has shown that it is possible to carry out a precision up-tuning of the output radiation frequency by means of the FEL having a Bregg reflector with a phase shifted by the corrugated waveguide. A new version of the RF-signal input device in the FEL amplifier with the efficiency of 60 % has been developed and manufactured. The work was fulfilled on the accelerator LIU-3000.

Numerical simulation was applied to study the dynamics of the banched beam in the FEL-generators with two types of the Bregg reflectors. Jointly with a group from the LNP the specialists from the LPP have developed Cherenkov radiators on the basis of the quartz aerogel having a very high quantum yield and big resource. While using these radiators there is a possibility preserved to control the electron beam current and radiation power at the FEL output. Preliminary experiments have been carried out to study the grouping of the beam in several types of the FEL generator.

It has been shown experimentally that the existing system with low phase velocity does not provide the TWT amplifier on the saturation regime. A new system with low phase velocity has been calculated, designed and

manufactured. Cold measurements of its characteristics have been done and the preparation is conducted for the experiments on the beam.

An experimental study of the model of **electron accelerator for radiation technologies** has been performed at LPP. It is a scaled model of 700 kV, 300 kW, high repetition rate accelerator. The parameters of the model are the following: electron energy — 200 kV, average beam power — 20 kW, peak current — 1 A, pulse duration — 10 μs, repetition rate — 18 kHz. The accelerator is designed as a vacuum diode with a special cathode under the sinusoidal high-frequency potential. The cathode voltage is formed by high-frequency $\lambda/4$ coaxial resonator with a spiral inner conductor. The resonance frequency of the coaxial resonator is equal to 18 kHz. Using the vacuum insulation allows one to increase significantly the resonator quality up to 140 and efficiency of the electrical power conversion into the power of the electron beam up to 97–98 %.

The experimental study and preliminary operation of the 200 keV model of the electron accelerator have been performed. The model has a high factor of safety. Dark currents of the cathode-anode system (without mosaic cold cathode) are detected at voltage exceeding 300 kV. The experimental experience obtained with the 200 keV accelerator model will be used to construct a full scale accelerator model with the energy of about 1 MW and output power of about 330–300 kW.

The **Accelerator Complex for hadron therapy** has been designed in collaboration of specialists from LPP, different Czech Institutes and Companies, and specialists from AccSyS Inc. (USA). The designed synchrotron meets special requirements which are defined by the «active» scanning of tumors (in particular, the «raster-scanning» technique). The synchrotron will work in the mode of slow (resonant) extraction of accelerated protons with the spill duration not less than 500 ms in all the range of the output energies from 60 MeV to 220 MeV. The step of the output energy variation must be not more than 0.4 MeV with the needed accuracy better than $\pm$ 40 keV. The FWHM-spot size at the patient should be less than 5 mm to realize the «raster scanning» technique. The intensity of the extracted beam should be about $6.25 \cdot 10^{10}$ protons in the case of 1 Hz repetition rate to provide the irradiation dose till 5 Gy in the volume of 1 litre per minute. The Proposal of the Comprehensive Oncology Centre based on the designed machine will be presented to the Czech Government for financial support to be included in the State budget for 2001.

REFERENCES

1. *Aleev A.N. et al. — Instrum. Exp. Tech., 1999, v.4, p.1.*
2. *Aleev A.N. et al. — JINR Rapid Communications, 1999, No.1[93]-99, p.14.*
3. *Aleev A.N. et al. — JINR Preprint P1-99-136, Dubna, 1999.*
4. *Aleev A.N. et al. — JINR Preprint E1-99-178, Dubna, 1999.*
5. *Aleev A.N. et al. — JINR Preprint E1-99-77, Dubna, 1999.*
6. *Fanti V. et al. — CERN-EP/99-114, 1999; hep-ex/9909022.*
7. *Fanti V. et al. — Phys. Lett., 1999, v.B458, p.553.*
8. *Fanti V. et al. — Print-99-036, 1999.*
9. *Fanti V. et al. — Eur. Phys. J., 1999, v.C6, p.265.*
10. *Fanti V. et al. — Phys. Lett., 1999, v.B446, p.117.*
11. *Palestini S. et al. — Nucl.Instrum.Meth., 1999, v.A421, p.75.*
12. *Golutvin I.A. et al. — JINR Rapid Communications, 1999, No.1[93]-99, p.48.*
13. *Ackerstaff K. et al. — Preprint DESY 99-048, Hamburg, 1999; hep-ex/9906035.*
14. *Ackerstaff K. et al. — Phys. Rev. Lett., 1999, v.82, p.3025.*
15. *Airapetian A. et al. — Preprint DESY 99-071, Hamburg, 1999; hep-ex/9907020.*
16. *Adloff C. et al. — Preprint DESY 99-091, Hamburg, 1999.*
17. *Kapichine M. (for the H1 Collaboration) — Talk Presented at the 7th International Workshop on Deep Inelastic Scattering, DIS'99, Zeuthen, Germany, April 1999; Proc. in Nucl.Phys. B (Proc.Suppl.), v.79, 1999.*
18. *Van Esch P. et al. — Preprint DESY 99-158, Hamburg, 1999.*
19. *Saldin E.L., Schneidmiller E.A., Yurkov M.V. — Nucl. Instrum. Meth., 1999, v.A429, p.197.*
    Faatz B. et al. — Nucl. Instrum. Meth., 1999, v.A429, p.424.
    Saldin E.L., Schneidmiller E.A., Ulyanov Yu.N., Yurkov M.V. — Fusion Engineering and Design, 1999, v.44, p.341.
20. *Filippov Yu.P. — Cryogenics, 1999, v.39, p.59–69.*

LABORATORY OF NUCLEAR PROBLEM

ELEMENTARY PARTICLE PHYSICS

A full sample of NOMAD (WA96 experiment at CERN) data corresponding to $\sim 1300\,000$ ν_μ charged current (CC) interactions was reconstructed and analyzed. The upper limit (at 90 % C.L.) on the probability of $\nu_\mu \to \nu_\tau$ oscillations was established to be $P(\nu_\mu \to \nu_\tau) < 4.2 \cdot 10^{-4}$. The corresponding limit on the oscillation amplitude is $\sin^2 2\theta < 8.4 \cdot 10^{-4}$ for large Δm^2 [1]. The previous limit from the E531 collaboration is improved by a factor of 6 (Fig.1). A new limit on the probability of $\nu_e \to \nu_\tau$ oscillations was obtained (at 90 % C.L.) to be $\sin^2 2\theta < 5{,}2 \cdot 10^{-2}$ for large Δm^2 [2]. This result improves the existing limit by a factor of more than 2 (Fig.2).

The collaboration memo of the JINR group on the study of Λ hyperon polarization in ν_μ CC interactions is accomplished and published in the NOMAD preprint database [3]. The statistics of the NOMAD Λ sample is ~ 15 times larger than the one of the previous neutrino experiments performed with bubble chambers.

There is a strong collaboration between the JINR and INR (Moscow) groups within the NOMAD experiment.

DELPHI is a general-purpose detector for physics at LEP on and above the Z^0, offering three-dimensional in-

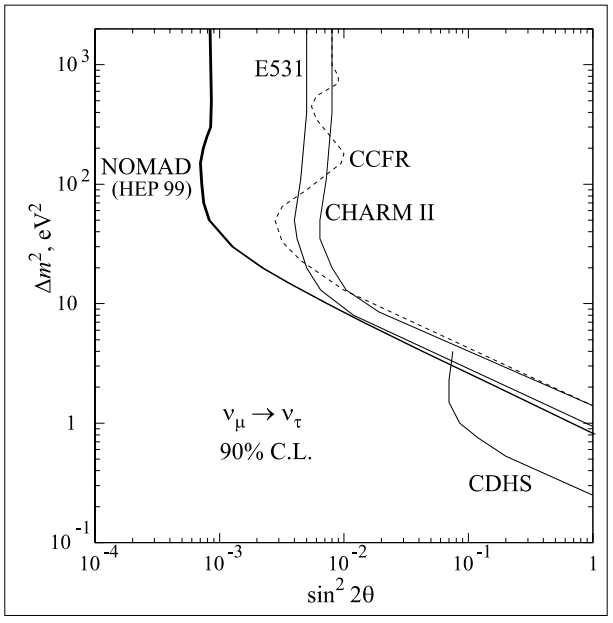


Fig.1. The $\Delta m^2 - \sin^2 2\theta$ plane for $\nu_\mu \to \nu_\tau$ oscillations. The region excluded by NOMAD at 90 % C.L. is shown together with the limits published by other experiments

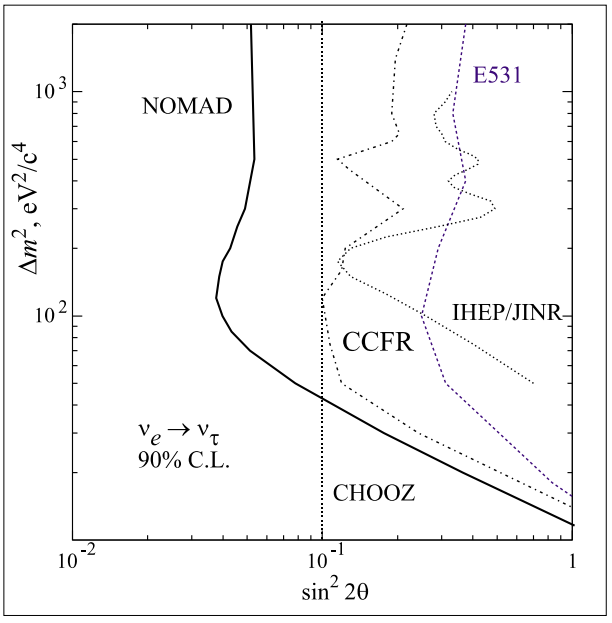


Fig.2. The $\Delta m^2 - \sin^2 2\theta$ plane for $\nu_e \to \nu_\tau$ oscillations. The region excluded by NOMAD at 90 % C.L. is shown together with the limits published by other experiments

formation on curvature and energy deposition with fine spatial granularity as well as identification of leptons and hadrons over most of the solid angle.

The large statistics (about $4.5 \cdot 10^6$ Z-boson decays) and high quality of the data allowed DELPHI to obtain a number of important results concerning electroweak theory, QCD, searches for new particles, b-quark physics and some others. At present most of the analyses based on the whole statistics of Z^0-data are finishing and final results are expected soon.

During the 1999 data taking period LEP has been routinely operating at the collision energies of up to 202 GeV. A total integrated luminosity of about 230 pb^{-1} was recorded by the DELPHI experiment. These new data allowed the exclusion limit on the mass of the Standard Model Higgs boson of about 106 GeV (at 95 % C.L.) to be set. Improvements between 3 and 6 GeV were reported on the mass limits for new particles, compared with the data obtained in 1998. The data are also being used for the high precision measurement of the W-boson mass and the tests of electroweak theory, QCD, two-photon and other physics. DELPHI results from running at Z-resonance and at LEP200 are summarized in about 250 papers. New results are regularly presented at the conferences.

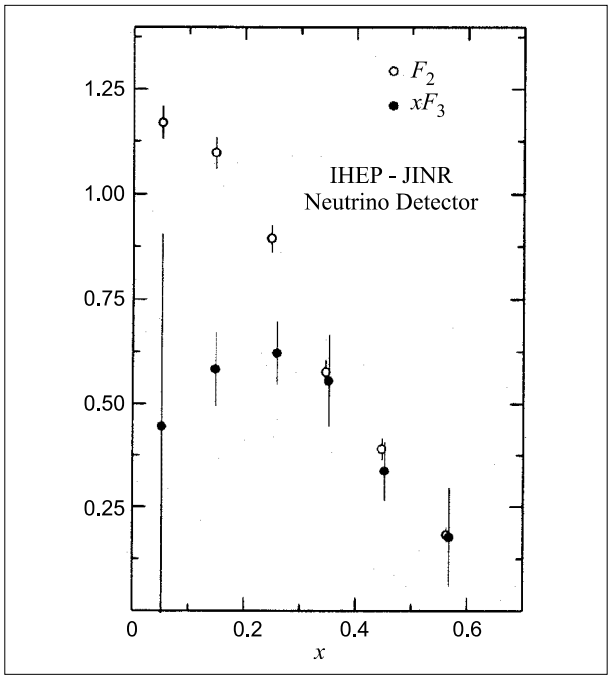


Fig.3. Structure functions $F_2(x)$ and $xF_3(x)$ measured with the Neutrino Detector

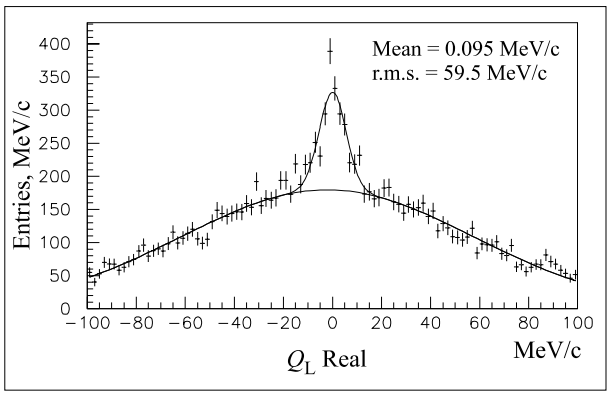


Fig.4. Distribution of $\pi^+\pi^-$ pairs over the longitudinal component of relative momentum in the c.m. frame

The main contributions of the JINR group in hardware concern the maintenance and running of the Hadron Calorimeter and the Surround Muon Chambers of DELPHI. In the area of physics analysis the Dubna people are working on the precision tests of the Electroweak theory from Z- and W-data, τ-lepton physics, tests of QCD and studies of multiparticle production dynamics at Z and higher energies, two-photon physics, etc.

The construction of the new neutrino beam with an average energy of 1.5 GeV at the U-70 accelerator (Protvino) was finished in 1999. The structure of the target of the IHEP–JINR Neutrino Detector was modified by removing aluminum plates.

The target part of this new set-up configuration consists only of liquid scintillator counters and drift chambers. It allows protons from elastic scattering of neutrinos on protons to be registered. During the first testing run with the new beam and the upgraded detector the on-line program was tuned and tested, performance of different detector components was checked after a long pause in operation (more than 3 years). The structure functions xF_3 and F_2 in low Q^2 were obtained on the basis of the experimental data collected in previous exposures on the Neutrino Detector (Fig.3) [4]. Under the assumption of validity of QCD in the region of low Q^2, the analysis of xF_3 yields $\Lambda_{\overline{MS}} = 411 \pm 200$ MeV. The corresponding value of the strong interaction constant $\alpha_S(M_Z) = 0.123^{+0.010}_{-0.013}$ agrees with the recent result of the CCFR collaboration and with the combined LEP/SLC result.

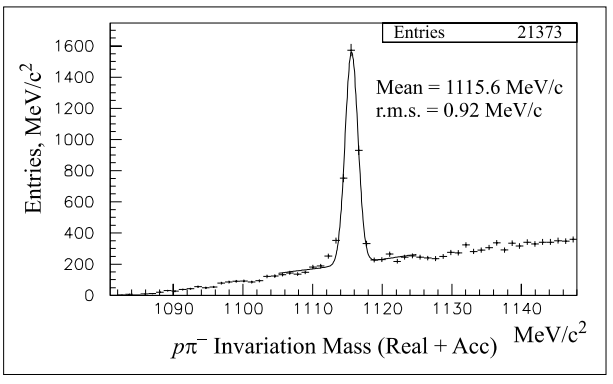


Fig.5. Effective mass distribution of $\pi^- p$ pairs

The collaboration with physicists from the Institute of High Energy Physics (IHEP) is decisive for this project.

In 1999, the DIRAC collaboration, aimed at the lifetime measurement of $\pi^+\pi^-$ atoms, achieved the following main results. The dedicated processor of the fourth-level trigger was developed. The map of the spectrometer magnet field was reconstructed with the accuracy of 0.4 %. The programs for determination of the set-up geometric constants and for event reconstruction were developed.

Experimental data for measurement of the dimesoatom yields on the targets of Ni and Pt were obtained during a 4-month data taking at the CERN PS accelerator. Performance of the set-up is demonstrated by the observation of the Coulomb enhancement in the yield of $\pi^+\pi^-$ pairs in the relative momentum range below 5 MeV/c (Fig.4) and by observation of a peak from Λ decay in the spectrum of the detected $\pi^- p$-pairs (Fig.5).

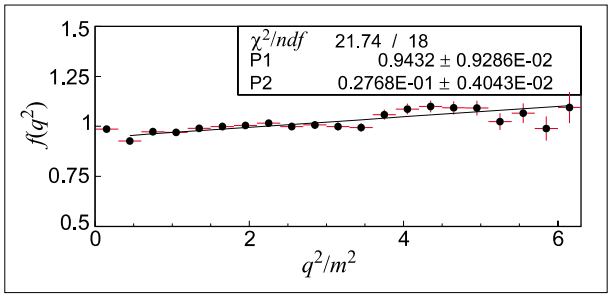


Fig.6. The dependence of the vector form factor of $K^+ \to \pi^0 e^+ \nu$ decay on q^2-momentum transferred to the lepton pair

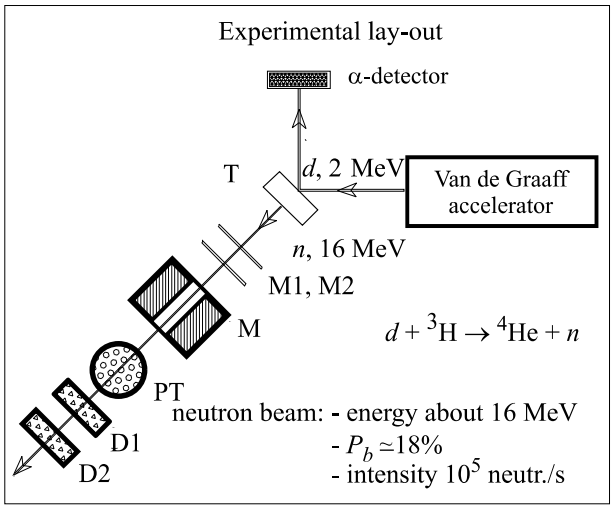


Fig.7. α-detector — the silicon detector for monitoring of the neutron beam; T — titanium-tritium target; M_1, M_2 — thin plastic scintillator detectors; M — magnet for neutron spin rotation; PT — polarized target; D_1, D_2 — liquid scintillation detectors

The estimated momentum resolution is $\sigma_p / p \approx 6.5 \cdot 10^{-3}$ and for the relative momentum $\sigma_q / q \approx 2.7$ MeV/c.

The processing of 25 % of new experimental data (about 14000 events) obtained with the HYPERON set-up allows new determination of the slope parameter of the vector form factor of the $K^+ \to \pi^0 \nu e^+$ decay: $\lambda_+ = 0.0277 \pm 0.0040$ [5]. This result (Fig.6) is in good agreement with the world average value and the accuracy of measurement is comparable with the accuracy achieved in the best experiments.

The experiment was carried out at IHEP (Protvino) with valuable contributions to the experiments from the scientific group of IHEP.

At the Nuclear Centre of Charles University (Prague) new measurements of spin-dependent total cross-section differences $\Delta\sigma_L$ and $\Delta\sigma_T$ were performed with the transmission method. For these experiments the frozen-spin polarized target was developed, which includes a stationary cryostat with a dilution refrigerator, a movable magnetic system and electronic equipment for providing dynamic polarization and NMR signal detection (Fig.7).

A polarized neutron beam is produced with the Charles University Van de Graaf electrostatic accelerator by means of the reaction ${}^3\mathrm{H}(dn){}^4\mathrm{He}$ with an initial deuteron energy of 1.82 MeV.

The physics results on the measurement of $\Delta\sigma_L$ and $\Delta\sigma_T$ obtained in Prague permit a new view at the earlier data in this energy range. Earlier, some experiments (Bonn, Erlangen) supported the hypothesis of the mini-

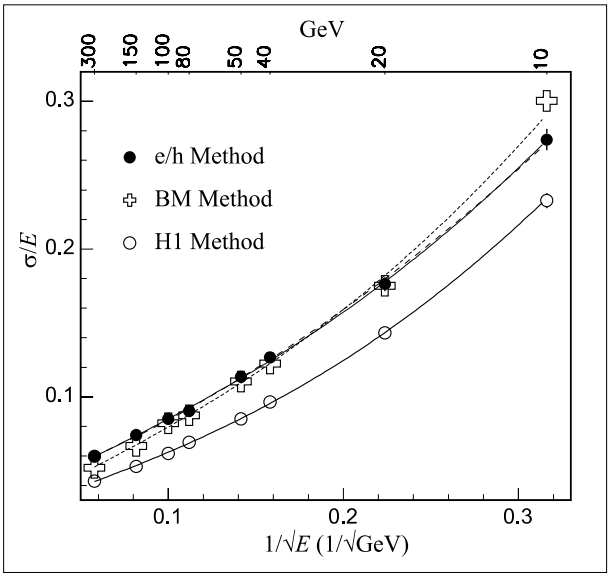


Fig.8. Energy resolutions (for 10, 20, 40, 50, 80, 100, 150 and 300 GeV pions and electrons) obtained with the e/h-method (●), the benchmark method (✙) and the cells weighting method (○)

mal value of the ${}^3S_1 - {}^3D_1$ mixing parameter (ε_1) in the range of 15 MeV. These results disprove it, which is in good accord not only with the other experimental data, but also with the model predictions [15].

In 1999, the main activities of the ATLAS TileCal-group were a) study of performance of combined calorimeter and the hadronic Tile calorimeter, b) production of modules of the Tile calorimeter, c) construction of optomechanical test benches for PTM and d) development of slow control.

The response to 10, 20, 40, 50, 80, 100, 150 and 300 GeV pions and electrons at an incident angle of 12° was investigated [6, 7] (Fig.8). The response of the ATLAS calorimeter system to single charged pions was investigated via full simulation [7]. Performance was estimated for the cases when energy and rapidity dependent and independent calibration parameters were applied. The best results were obtained with the energy and rapidity dependent parameters. The lateral and longitudinal profiles of hadronic showers detected by the prototype ATLAS Iron-Scintillator Tile Hadron Calorimeter were investigated [8]. The detailed experimental information about the electron and pion responses, the electron energy resolution and the e/h ratio as a function of incident energy E, impact point Z and incidence angle θ of the Module-0 of the Tile iron-scintillator barrel hadron calorimeter is obtained [9].

The main achievement in 1999 was the successful start of mass production of the ATLAS Barrel Hadron Calorimeter Modules and submodules at JINR [10]. In Dubna 110 submodules were manufactured. Nine Modules were sent to CERN in 1999. The expected average delivery cycle is 1 Module per 2 weeks. Module assembly is controlled by a special laser hardware and software complex which was developed at JINR and which allows measurement precision of 50 μm.

LNP started the construction of seven optomechanical test benches to be used for the detailed study of 10300 photomultipliers. This test bench will allow one to measure 24 photomultipliers at once.

The architecture of the Tile calorimeter control system (TCS) was elaborated including detailed functionality arrangement and data flow distributions. The pilot project for prototyping of final version of HV subsystem was started.

The main task of the JINR Muon ATLAS group in 1999 was to construct a site for full cycle production and test of Muon Chambers (MDT-chambers) at JINR.

To this end a lot of high-technology set-ups and tools were constructed. Their list consists of 1) two dust-free production areas with climate control; 2) full infrastructure for the production area (with cranes, compressors, vacuum pumps, gas pipes, computer network, etc.); 3) semiautomatic wiring line for mass-production of drift tube detectors (DDT); 4) full set of tools for DDT testing (with wire tension, tightness, HV-test) including X-ray set-up for wire position control inside the detector; 5) full set of tools for high-precision muon chamber assembling, which includes: large-scale high-precision granite table ($3.5\times2.5\times0.5\ \mathrm{m}^3$), set of precision tools for high-accuracy DDT positioning, computer-controlled pneumatic sag compensation mechanism and automatic glue machine.

Search for the flavor-changing neutral-current (FCNC) decays of B-mesons was performed by the CDF Collaboration with 88 pb^{-1} of Run I data from $p\bar{p}$-collisions at $\sqrt{s}=1.8$ TeV [11]. The best limits Br $(B^+ \to \mu^+\mu^- K^+) < 5.2\cdot10^{-6}$ and Br $(B^0 \to \mu^+\mu^- K^{*0}) < 4.0\cdot10^{-6}$ were found at 90 % C.L.

The oscillation frequency Δm_d of $B^0\bar{B}^0$ mixing was measured using the semileptonic decay $\bar{B}^0 \to l\bar{\nu}D^* + X$. The value obtained is $\Delta m_d = 0.516\,(\mathrm{stat.}) \pm 0.099^{+0.029}_{-0.035}\,(\mathrm{syst.})\ \mathrm{ps}^{-1}$ [12].

Silicon Vertex Trigger (SVT) is designed to reconstruct track parameters $P_\perp$ and ϕ with a sufficient speed and accuracy [13]. The SVT is aimed at tagging events containing secondary vertices from the b decay. The LNP group participates in the design and hardware implementation of the SVT [14]. The SVT operation time for most of events from $B \to \pi^+\pi^-$ decays in Run II was found to be between 8.6 and 10.8 μs. A new layer of silicon detector (L00) was proposed as an upgrade to CDF.

The main 1999 results of JINR cooperation with Fermilab on construction of the upgraded D0 detector (Fig.9) (forward/backward muon system) for Run II at the Tevatron Collider are the following:

a) A new type of a wire detector, called Mini-Drift Tubes (MDTs), is designed and tested. These Iarocci-type multiwire tubes with a metallic cathode are running in a proportional mode and are suitable for large-surface set-ups, like muon systems, in particular.

b) Mass production and testing of MDTs were developed practically on the basis of the domestic (Russian) technologies. Production of all 6500 detectors is accomplished at the JINR central workshop and 2/3 of this total amount are already shipped to Fermilab.

c) ASIC chips were developed, tested and produced for the D0 muon system in cooperation with Byelorussian institutes and industries. These chips include an 8-channel amplifier (D0M Ampl-8.3) and an 8-channel discriminator (D0M Disc-8.3). A total amount of channels produced is 52736, most of them are shipped to Fermilab.

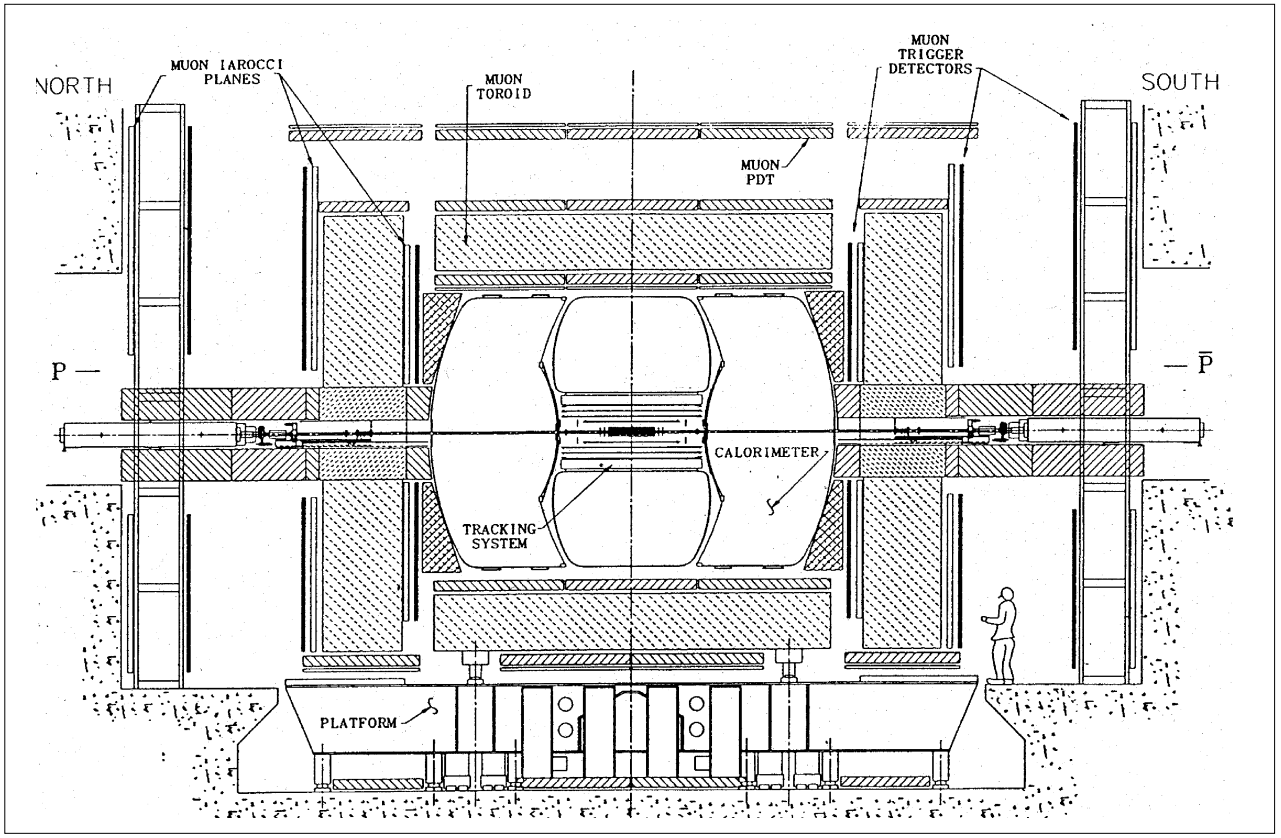


Fig.9. Shematic view of the D0 upgrade Detector

The D0 cooperation involves industries of 5 countries (Armenia, Byelorussia, Canada, Russia and USA). In Russia five enterprises, «Serp i Molot» (Moscow), «Agrisovgaz» (Maly Jaroslavets), «Savma» (Savelovo), «Himplast» (Dzerzhinsk) and «JINR Workshop» (Dubna), participated in technology development and mass production.

The JINR physicists are presently participating in assembly of the D0 muon system in Fermilab and in preparation for commissioning and running the detector. They also plan to participate in data analysis.

The «Muon Wall 1» detector of the COMPASS set-up is entirely the responsibility of JINR. The conceptual and technical design of the MW1 was agreed upon with the collaboration. Proportional tubes of the Iarocci type (as in Fermilab's D0 set-up) will be used as detectors. A production line was set-up at JINR. The detector consists of an aluminum profile with 8 cells 10 mm wide and a sensitive wire in the centre. This unit is covered by an ABS plastic envelope. In total, the COMPASS MW1 detector will use about 4 km of these tubes (1040 pieces).

These MW1 fabricated at the JINR Workshop have passed inspections and tests at JINR and at CERN in a test beam run. Amplifiers and discriminators for the MW1 read-out system have also been tested. Besides a design of the detector support frame and a preparation for its production in Russian industry is in progress. The mass production of MW1 tubes started.

A PCB design for MW1 digital readout electronics is in progress.

Multiwire proportional chambers (MWPC) to be used as Large Area Trackers in the Small Angle Spectrometer of the COMPASS. At the beginning of 1999, various prototype MWPC configurations (new fast CF_4-based gas mixtures, new front/end electronics, etc.) were tested. The final test was performed with the full-size chamber at CERN. The results obtained confirm the possibility of using MWPC with the new gas mixtures and new electronics together with a sufficiently large efficiency plateau and an acceptable working high-voltage potential.

During the second half of 1999, the certification of the almost full set of available Omega-spectrometer chambers was completed. The chambers were checked for gas tightness, the efficiency plateau was measured for each chamber, the leakage current was examined.

Precise measurement of the probability of the pion β decay allows a rigorous test of charged quark-lepton current universality, unitarity of the Cabbibo-Kobayashi-Maskawa mixing matrix and search for a possible manifestation of «new physics». The goal of the PIBETA experiment is to improve the accuracy from 4 % to 0.5 % at the first stage.

The data taking runs were successfully performed in 1999. The general duration of these runs exceeded 4 month. Dubna specialists took part in preparation of the set-up for the data taking and in the running of the set-up. The new electronics for anode wires of proportional chambers was developed at LNP. This electronics provides more reliable and efficient read-out of chamber information.

The μSR experiments with silicon carried out in 1999 were aimed at investigating the effect of impurities on the relaxation rate of the magnetic moment of the shallow acceptor centre.

The measurements were carried out in the temperature range 4–300 K with four silicon samples with different boron impurity ($7.4\cdot10^{13}-4.1\cdot10^{18}$ cm^{-3}), with two samples with gallium impurity ($1.1\cdot10^{15}, 1.1\cdot10^{18}$ cm^{-3}) and with two samples with arsenic impurity ($8.0\cdot10^{15}, 2.0\cdot10^{17}$ cm^{-3}). These measurements allow the constant of the hyperfine interaction of the muon magnetic moment with the electron shell in the acceptor centre (muonic atom μAl) as well as the type of temperature dependence of the relaxation rate of the magnetic moment of Al acceptor centre in silicon to be found.

The values of the hyperfine interaction constant $A_{\rm hf}/2\pi$ are close to 30 MHz for different samples except two samples with the highest concentration of boron impurity. For these samples the temperature dependence of the shift of the muon spin precession frequency is not yet studied completely. This does not allow the unambiguous determination of $A_{\rm hf}$. The temperature dependences of the relaxation rate of the magnetic moment of the acceptor centre (muonic atom) for the samples investigated are well approximated by the power function $\nu(T)=C\cdot T^q$ [16].

In 1999, the main objective of the analysis of the OBELIX data on the antiproton-proton annihilation at low energy into five pions $\bar{p}p\to\pi^+\pi^-\pi^+\pi^-\pi^0$ is the investigation of the 4π decay mode of the 0^+0^{++} scalar mesons $f^0(1300)$ and $f^0(1500)$, which proceeds mainly via $f^0\to\rho\rho$ and $f^0\to\sigma\sigma$. Due to the phase space available the two pion states in this reaction are limited by the low energy part of the $\pi\pi$ S- and P-waves. It is found that the $\pi^+\pi^-$ invariant mass and angular distributions are rather sensitive to the mass and width of the σ meson $f^0(400\div1200)$ in the Review of Particle Physics), and the particularities of their behavior can be well described only with using the small σ mass ($M_\sigma\approx500$ MeV/c^2).

Measurements of the double differential cross section for subthreshold K^+-production in pC-collisions at the spectrometer ANKE were carried out in the energy range from 2.0 GeV down to 1.0 GeV. This low value (1.0 GeV) is 580 MeV below the free NN threshold.

The kaon spectra are obtained at an angle of $\sim0^\circ$ [17] (Fig.10). A software package for the ANKE data processing, developed in Dubna, provides calibration of the spectrometer momentum scale with a relative accuracy not worse than $4\cdot10^{-3}$. The gained energy dependence of the differential cross section is significantly more sensitive to mechanisms of the deep subthreshold kaon production than the total cross section dependence measured earlier in Gatchina. In the middle of 1999, a deuterium cluster target developed in Münster was installed and tested in the beam conditions. The commissioning of the target and the detector system developed in Dubna provides starting an experiment on cumulative deuteron break-up by protons with the energy from 0.5 GeV up to 2.5 GeV.

The collaboration DUBTO has completed the experimental apparatus for studying pion interactions with light nuclei at low energies. The experimental set-up is based on the JINR streamer spectrometer STREAMER, serving

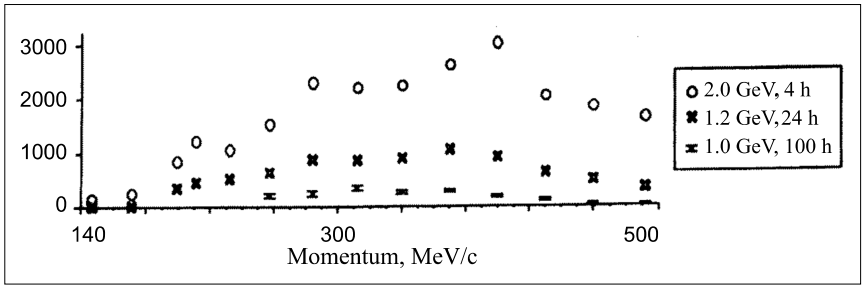


Fig.10. Preliminary results of the ANKE collaboration on the kaon spectra in the process $p+C\to K^++X$. The numbers in the frame denote the beam energy and time of the data taking

both as a vertex and track detector, and is equipped with CCD telecameras for recording the images of nuclear events occurring inside the gas volume of the streamer chamber. With the exception of the streamer chamber, no available apparatus can be used for measuring energies down to ~1 MeV of charged secondaries, such as protons and light nuclei, produced in reactions occurring inside gas targets. A 150-hour run was performed in November 1999, and video images (over 1000) of inelastic $\pi^+ - {}^4\mathrm{He}$ nuclear events were obtained; data processing is under way.

The purpose of the experiment DISTO is to measure the differential cross sections, as well as the spin observables P_Λ, P_{Σ^0}, A_γ, and $D_{\gamma\gamma}$, for the reactions $pp \to pK^+\Lambda$, $pp \to pK^+\Sigma^0$, and $pp \to pK^+\gamma^*$ at energies between the reaction thresholds and the maximum attainable energy at Saturne (about 2.9 GeV). The correlation between these observables and the N^* and γ^* resonances will also be determined [18]. The measurement of spin observables at Saturne provides a way to investigate the relationship between the fundamental QCD approach and the boson-exchange theories.

The Dubna group has undertaken investigation of the reaction $pp \to p\pi^+\Lambda K^0$, which, in case when both neutral particles decay via charged modes, requires registration of events with 6 charged particles and 2 secondary vertices. This problem is noticeably more complicated than registration of the main reaction $pp \to pK^+\Lambda$. No events involving K_S^0 decays have been found yet, most likely owing to the geometry of the DISTO apparatus. The registration of events with a Λ-decay in $pp \to p\pi^+\Lambda K^0$ permits estimating the number of events of this reaction that can be obtained by registering events with all strange particles decaying via the channels with charged particles. The results obtained are not final, and studies will be continued with more profound investigation of how well the simulation program describes the experimental data for the reactions at issue.

In 1999, the measurements of the astrophysical *S*-factor for the *dd*-reaction at very low deuteron collision energies with the liner plasma technique were performed under project LESI. The experiment was fulfilled at the high current generator of the High-Current Electronics Institute (Tomsk, Russia). It is worth stressing that investigation of nuclear reactions at ultralow collision energies (~ keV) with ordinary accelerators is unrealizable in practice due to a very low cross section of the processes under investigation ($\sigma \approx 10^{-43} \div 10^{-32}\,\mathrm{cm}^2$) and extremely low luminosity of beams of charged particles. The first measured values of the *S*-factor for the deuteron collision energies 1.8, 2.06, 2.27 keV are $S_{dd} = (53 \pm 16)$; (64 ± 30); (114 ± 68) b·keV, respectively. The ultralow *S*-factors do not disagree within experimental uncertainties with the values of the *S*-factor extrapolated from larger collision energies (7÷45 keV) (Fig.11). The corresponding *dd* cross sections described as a product of the barrier factor and the measured astrophysical *S*-factor are $\sigma_{dd}^n = (0{,}43 \pm 0{,}26); (0{,}98 \pm 0{,}46); (2{,}1 \pm 0{,}6) \cdot 10^{-32}\,\mathrm{cm}^2$, respectively [19].

The project has been performed in collaboration with High-Current Electronics Institute of RAN (Tomsk), Electrophysical Institute of RAN (Ekaterinburg) and Nuclear Physics Institute of Politechnical University (Tomsk).

In 1999, the research on μ-catalyzed nuclear fusion was continued to measure basic characteristics of the processes in a high-density mixture of hydrogen isotopes, including tritium. Two runs with a high-pressure hydrogen target were carried out at the JINR LNP Phasotron to investigate dependence of the cycle rate (neutron yield) on temperature (300–800 K), pressure (up to 1500 atm) and concentration of isotopes in the double (H/D) and triple (H/D/T) mixture. Processing of the experimental data is under way, which will make it possible to find the rate for formation of dtμ mesomolecules on DD and DT molecules and neutron multiplicities per muon as a function of temperature (300–800 K), pressure (800–1500 atm) and tritium concentration.

An additional *W* target (100 μm, 4 g) is installed in the mass separator unit of the ISOL complex YASNAPP-2, which allowed some five-fold increase in the yield of radioactive rare-earth isotopes. An $e-\gamma$-coincidence mode of operation is provided for the «minior-

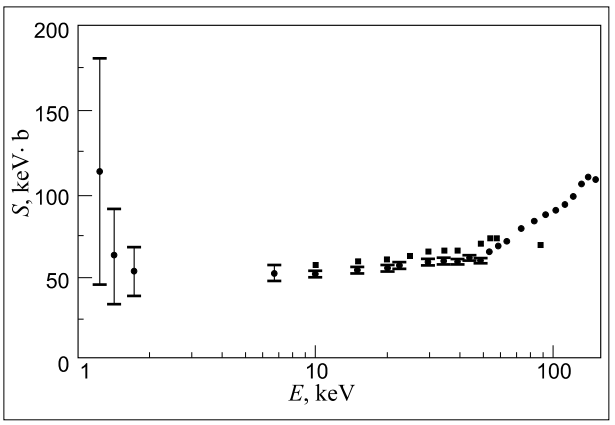


Fig.11. Dependence of the astrophysical *S* factor on the energy of *dd* interaction. Filled circles and squares — previous data, ♦ — results obtained

ange» spectrometer. A precision technique for determining γ-quantum energies is proposed on the basis of the delayed coincidence method and fiber optics. A quasi-differentiation method is introduced to eliminate Compton distribution in γ spectra measured by SCD [20].

Monopole excitations in transition nuclei (^{152}Gd) and strongly deformed nuclei (Dy isotopes with $A = 156$, 158, 160) were systematically searched for. A lot of E0 and E0+E2 transitions were observed [21]. A few new isomeric states are identified and studied in the ^{152}Eu and ^{156}Ho nuclei that are in the vicinity of the deformation jump ($N = 88$) [22].

The investigation of the ^{221}Fr ($T_{1/2} = 4.9$ min) α-decay is completed [23]. Populations of ^{217}At levels by the ^{221}Fr α decay and multipolarities of some γ transitions are found from the quantitative analysis of $\alpha - \gamma$ coincidences. The properties of ^{217}At levels agree with their interpretation as excitations related to shell-model states $\pi h^3_{9/2}$ and $\pi h^2_{9/2} f_{7/2}$. The investigation of the ^{209}Tl ($T_{1/2} = 22$ min)β decay is accomplished; the investigation of the ^{213}Bi (β^-, 46 min) ^{213}Po decay is under way. The probabilities for the β decay of ^{213}Bi to ^{213}Po levels are found. Investigation of $\gamma\gamma$ coincidences confirm the decay scheme.

Cadmium KLL and KLZ Auger spectra from the ^{111}In decay are studied with an ESA-50 electrostatic spectrometer [24]. Energies and relative intensities of all nine well-resolved KLL lines are found with a high accuracy. The intensity values are in very good agreement with the calculations by the relativistic model of intermediate coupling. On the other hand, the energies, especially their absolute values, differ from the results of widely used semiempirical calculations. The investigations allow the conclusion that more accurate theoretical calculations should be carried out for the complicated mechanism of interaction between two inner-shell vacancies.

The work done under the AnCor project (*Angular Correlations with Neutrinos*) was aimed at searching for scalar interaction in β decay and in μ capture.

In order to search for scalar interaction in a pure Fermi β decay of ^{18}Ne, a two-week experiment was carried out at the MP-Tandem accelerator (IPN, Orsay, France). The angular correlation between the neutrino and positron momenta was measured by means of high-precision γ spectroscopy via the Doppler shift of γ rays following the β decay. The data analysis is in progress.

A similar idea was used in the four-week experiment on μ capture at the muon beam of PSI (Villigen, Switzerland). The oxygen gas target at a pressure of 1 bar was irradiated by low-energy unpolarized muons. The 277 keV γ line following the OMC (Ordinary Muon Capture) by ^{16}O nuclei was measured very precisely with several independent HPGe detectors. The Doppler-broadened shape of this line is very sensitive to the possible admixture of Scalar Interaction (genuine and induced). Analysis of the line shape provided the correlation coefficient value $\alpha = +0.096 \pm 0.020$ (68 % C.L.), which corresponds to the presence of the scalar form factor at the level of 5–10 % (depending on the nuclear model used for the NME calculation).

After few years of operation exploitation of the NEMO–2 double-beta spectrometer, many new results on the $2\beta2\nu$ decay and upper limits for the $2\beta0\nu$ decay of several isotopes have been obtained. On the basis of this experience, a new NEMO–3 spectrometer is developed in order to replace the previous one and to search for *neutrinoless* double-beta decay of ^{100}Mo at the level of $T_{1/2} \cong 10^{25}$ years, which would correspond to the Majorana neutrino mass of 0.1 eV.

Initially, 10 kg of this enriched isotope were planned to be used as a source. Thanks to recent R&D made by our Moscow and American colleagues, several purification procedures are being applied now to ^{82}Se, ^{96}Zr, ^{100}Mo, ^{116}Cd, and ^{130}Te. All these isotopes will be measured *simultaneously*.

In 1999, the most of mechanical work on NEMO–3 was successfully finished in Dubna, now all of 20 sectors are being equipped with Geiger cells and plastic scintillators. Almost 2000 such scintillators (total mass about 7 tons) were produced by LNP JINR in 1996–1999, now this production is also finished. Three of 20 sectors are already installed in the Frejus tunnel (LSM, Modane, France), the rest will be finished (cabling, PMTs, front-end electronics, etc.) next spring.

The 5-year experiment with NEMO–3 is planned to start after few months of tests and tuning, at the end of next year, and this plan seems to be quite realistic.

The aim of the FASA project is the investigation of nuclear multifragmentation induced by relativistic light ions in heavy targets. In the case of a proton beam, thermal multifragmentation takes place. It is governed by the statistical laws, as the excitation energy of the target spectator is entirely thermal one. It is not the case in collisions of very heavy ions, when the collective degrees of freedom are also excited, and decay of hot nuclear system is influenced by the dynamic effects related to compression (followed by expansion), rotation and shape distortion. The evolution of the reaction mechanism from thermal to more complicated one was investigated by comparing the collisions of protons, ^{4}He and ^{12}C with Au. Figure 12 shows mean multiplicities of intermediate mass fragments (IMF, $2 < Z < 20$) as a function of the beam energy.

The saturation effect is observed for energies above 5 GeV for all the projectiles. This fact cannot be rendered by the traditional approach with the intranuclear cascade (first stage of collision) followed by the statistical multifragmentation model (SMM or EES). Considering an expansion phase between two parts of calculations, the excitation energies and the residual masses are empirically modified to obtain agreement with the measured IMF multiplicities. The mean excitation energy is found to be (400–500) MeV for the beam energies above 5 GeV. It is believed that the expansion is driven by the thermal pressure. It is larger for He- and C-induced collisions because of higher initial temperature. Therefore the expansion flow is visible in the kinetic energy spectra of IMF, they become harder (Fig.13). The estimation of the expansion velocity gives a value 0.1 c (on the system surface). The analysis of the data reveals very interesting information on the fragment space distribution inside the break-up volume: heavier fragments are formed predominantly in the interior of the nucleus. This conclusion is in contrast to the predictions of the Statistical Multifragmentation Model (Copenhagen version) [25].

The FASA collaboration includes scientists from Dubna, Kurchatov Institute, Institute for Nuclear Research (Moscow), H.Niewodniczanski Institute of Nuclear Physics (Cracow), TU-Darmstadt (Darmstadt), Iowa State University.

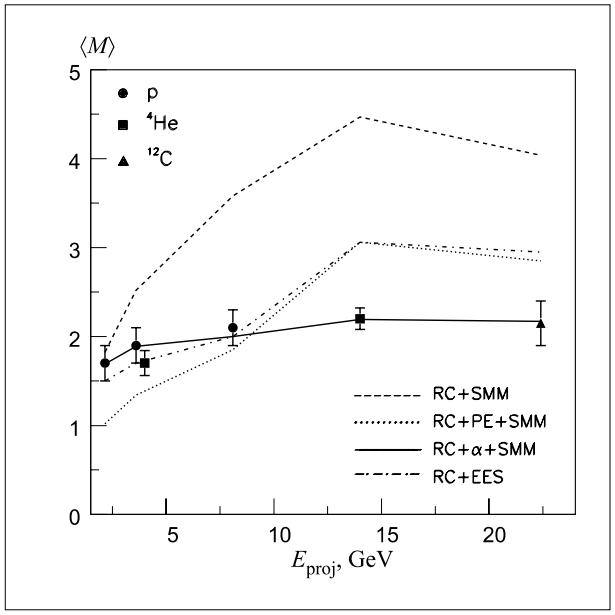


Fig.12. Mean IMF multiplicity as a function of the beam energy. The solid line is obtained with taking into account the additional energy and mass loss during the expansion of the system. Other lines are the calculations in traditional approaches (which are not adequate to the data)

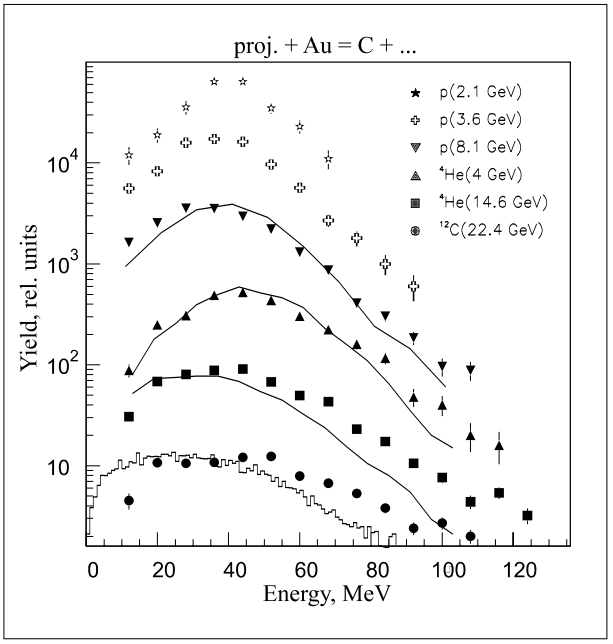


Fig.13. Energy spectra of outgoing carbon nuclei created in collisions of protons, ^{4}He and ^{12}C with the Au target. Lines show the spectra calculated in the combined model with account of the expansion stage of reaction. Calculations are made under the assumption of no flow in the system. Fitting the spectrum for proton collisions, model calculations disagree with the data obtained with He (14.6 GeV) and C (22.4 GeV) beams indicating the contribution of a collective flow

Neutralization of the beam space charge in the electron cooling system permits one to increase the quality of an electron beam and to decrease the cooling time. In the experiments on the JINR Test Bench the influence of the ion mass composition on the electron beam stability was found. The specially developed method of the ion mass composition determination in the neutralized electron beam was discovered. This method showed that the number quantity of hydrogen ions decreases with reducing cathode heating current of the electron gun. In this way the threshold of beam-drift instability increases and the electron beam becomes more stable. On the basis of the experimental data it is concluded that heavy ions are accumulated in the neutralized electron beam [26].

In the collaboration with the INOE2000 institute (Romania) a vacuum chamber of the LEPTA storage ring was designed and constructed (Fig.14). The first vacuum test was performed and a vacuum pressure of 10^{-8} Torr was obtained. The vacuum chamber was transported to JINR and was reassembled in LNP. The straight section of the magnetic system was made (Fig.15, pos.7) in 1999. The magnetic field was measured inside solenoids and a correction coil was developted. The coils allowed the quality of the magnetic field to be improved up to the necessary value $\Delta B/B<10^{-3}$. The positron source based on the radioactive ^{22}Na source and the positron trap for storage of positrons before the injection in the LEPTA ring were designed [27].

Participants in the research under the topic «Radiation treatment with JINR Phasotron beams» are the Laboratory of Nuclear Problems, of JINR, the Cancer Research Centre and the Medical Radiological Research Centre (MRRC) of the Russian Academy of Medical Sciences, the Institute of Atomic Energy and the Institute of Nuclear Physics (Poland), the Radiation Dosimetry Department of the Institute of Nuclear Physics and the Institute of Radiation Oncology (Czech Republic).

The main objective is to carry out medico-biological and clinical research on treatment of tumour patients on the basis of the many-room clinico-physical complex at the JINR LNP, to improve equipment and instruments, and to devise new methods for radiation treatment and diagnosis of tumour patients with medical hadron beams from the JINR Phasotron. The following results are obtained in 1999.

Clinical investigations on proton treatment of tumour patients with Phasotron beams are resumed after a long idle period. Irradiation of three patients with malig-

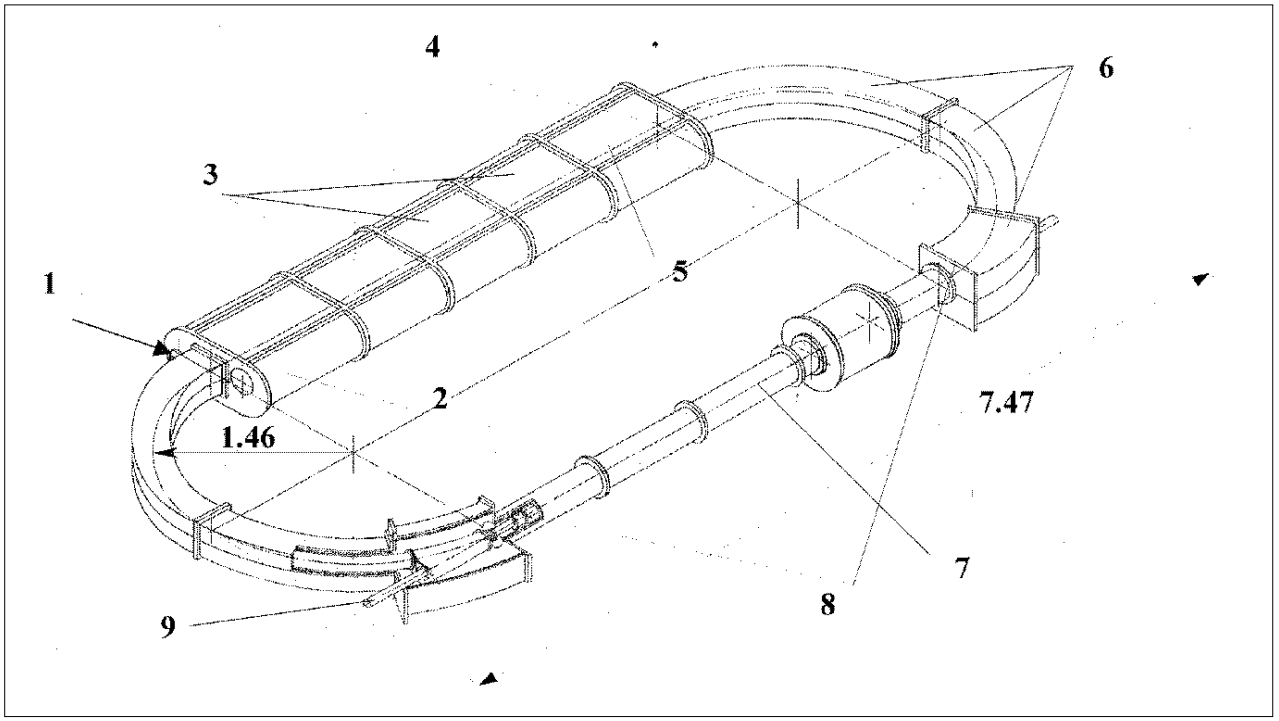


Fig.14. LEPTA Design (dimensions in meters): 1 — positron beam from injector, 2 — electron gun of the electron cooling system, 3 — septum, 4 — collector of electrons, 5 — injection kicker, 6 — toroidal solenoids, 7 — electron cooling section, 8 — pick-up stations of the diagnostic system, 9 — tubes for vacuum pumping and positronium beam extraction

nant head tumours was carried out in co-operation with radiology physicians from the MRRC (Obninsk). A new radiation treatment method was used, which required some preparation activities that resulted in highly conformal irradiation of guaranteed quality, namely,

— a beam of 150 MeV protons, uniform in the transverse section, was formed, which allowed homogeneous dose distribution inside the target volume;

— a multiplate collimator is designed and manufactured, which allows formation of a proton beam with the prescribed transverse profile matching the target profile;

— a method of calculating and manufacturing boluses (complex-shaped moderators) that allow the dose distribution maximum to be brought into coincidence with the tumour volume is devised and tested;

— treatment planning software is realized, which greatly increases the quality guarantee of the radiation treatment;

— systems of additional laser alignment and fixing of the patient in the chair are developed, manufactured and tested; they guarantee highly accurate (within 1 mm) reproducibility of the patient's position from session to session.

An important step forward in organization of clinical research on hadron therapy of tumour patients with LNP Phasotron beams is a special radiological 30-bed department opened in Medico-Sanitary Unit No.9 in Dubna. It will allow up to 150 patients per year to be treated with medical beams at JINR. The Russian Health Ministry has given an official permit for clinical research on hadron therapy of tumour patients at the JINR LNP medico-technical complex.

REFERENCES

1. *Astier P. et al., NOMAD Collab. — Phys. Lett. B, 1999, v.453, p.168.*
2. *Astier P. et al., NOMAD Collab. — Preprint CERN, CERN-EP/99-151, to be published in «Phys. Lett. B».*
3. *Bunyatov S. et al. — Polarization of Λ Hyperons Produced Inclusively in Neutrino Charged Current Interactions in the NOMAD Experiment, NOMAD note #99-017.*
4. *Sidorov A.V. et al. — Eur. Phys. J. C, 1999, v.10, p.405.*
5. *Blik A. et al. — JINR Communication P1-99-293, Dubna, 1999 (in Russian);*
   Flyagin V. — Workshop on Physics and Detectors for DAFNE'99, INFN, Frascati, Italy, 1999 (to be published).
6. *Ajaltouni Z. et al. — NIM A (in press).*
7. *Airapetian A. et al. — ATLAS Detector and Physics Performance Technical Design Report, v.1, CERN-LHCC-99-14; ATLAS-TDR-14, 1999, p.458, CERN;*
   Bosman M., Kultchitsky Y.A., Nessi M. — Charged Pion Energy Reconstruction in the ATLAS Barrel Calorimeter, ATL-COM-TILECAL-99-011, 1999, p.17, CERN, Switzerland.
8. *Amaral P. et al. — NIM A (in press).*
9. *Kultchitsky Y.A., Vinogradov V.B. — JINR Communication E1-99-12, Dubna, 1999.*
10. *Alikov A.M. et al. — JINR Communication E1-99-79, Dubna, 1999.*
11. *Affolder T. et al. — FERMILAB-PUB-99-138-E, submitted to «Phys. Rev. Lett.».*
12. *Affolder T. et al. — FERMILAB-PUB-99-210-E, submitted to «Phys. Rev. D».*
13. *Ashmanskas W. et al. — FERMILAB-CONF-99-236-E, submitted to «Nuovo Cim.».*
14. *Ashmanskas W. et al. — FERMILAB-CONF-99-158-E, Proc. of 6th International Workshop on New Computing Technics in Physics Research (AIHENP 99) Heraklion Crete, Greece, April 1999.*
15. *Plis Yu.A. — In: The Proc. of the 13th Int.Symp. on High Energy Spin Physics, World Scienific, 1999, p.430.*
16. *Mamedov T.N. et al. — J. Phys.: Condens. Matter, 1999, v.11, p.1;*
    Mamedov T.N. et al. — μ^{-}SR Investigations in Silicon, to be published in «Physica B».
17. *Barsov S. et al. — In: Proc. XV Particles and Nuclei Int. Conf., PANIC'99, Uppsala, Sweden.*
18. *DISTO Collab.: Balestra F. et al. — Spin Transfer in Exclusive Lambda Production from pp Collisions at 3.67 GeV/c, accepted for publication in «Phys. Rev. Lett.»;*
    DISTO Collab.: Balestra F. et al. — A Large Acceptance Multiparticle Spectrometer for 1–3 GeV Proton Beams, accepted for publication in Nucl. Instr. and Meth. A, 1999, v.426, p.385.
19. *Bystritsky V.M. et al. — JINR Preprint D15-99-163, Dubna, 1999, submitted to «Nuclear Physics».*

20. *Morozov V.A. et al. — JINR Preprint P6-99-3, Dubna, 1999, submitted to «PTE»;*
Morozov V.A., Morozova N.V. — JINR Preprint P6-99-4, Dubna, 1999, submitted to «PTE».
21. *Adam I. et al. — JINR Rapid Communications, 1999, No.2[94]-99, p.37;*
22. *Stegailov V.I. et al. — Czech. J. Phys., 1999, 49/S2, p.247.*
23. *Gromov K.Ja. et al. — Izvestija RAN, (phys.), 1999, v.63, p.860.*
24. *Kovalik A., Yakushev E.A., Filosofov V.D. et al. — J. Electron Spectrosc. and Relat. Phenom., 1999, v.105, p.219.*
25. *Karnaukov V.A. et al. — Acta Phys. Polonica B, 1999, v.30, p.429;*
Wagner P., Richert J., Karnaukhov V.A., Oeschler H. — Phys. Lett. B, 1999, v.460, p.31;
Oeschler H. et al. — In: Proc. of the Int. Workshop XXVII on Properties of Nucl. and Nucl. Exc., Hirschegg, 1999, p.116;
Karnaukhov V.A. — JINR Preprint P1-99-13, Dubna, 1999.
26. *Meshkov I. — Space Charge Effects in the Intense Electron Beam Related to the Electron Cooling System, Symposium SCHEF'99. Dubna, 1999, p.163;*
Meshkov I. et al. — Electron Cooling of Magnetized Positrons, Proc. Intern. Workshop ECOOL'99, Uppsala University, Sweden, 1999.
27. *Meshkov I. et al. — NIM A, 1999, v. 427, p.58.*

FLEROV LABORATORY OF NUCLEAR REACTIONS

The scientific activity of the FLNR in the field of heavy-ion physics traditionally has been developing in three main directions. It includes experiments on the synthesis of heavy and exotic nuclei using ion beams of stable and radioactive isotopes and studies of nuclear reactions, acceleration technology, heavy ion interaction with matter and applied research.

In 2000–2002 in the field of nuclear physics, we will continue to undertake these investigations, grouped in 11 projects within the framework of two topics and an all-Institute project:

— Synthesis of new nuclei and the study of nuclear properties and heavy ion reaction mechanisms (8 projects);
— Development of the FLNR cyclotron complex for producing intense beams of accelerated ions of stable isotopes (3 projects);
— Development of the U400 + U400 + MMT25 cyclotron-microtron complex for producing radioactive ion beams (DRIBs project).

These activities will be performed in wide international collaboration, using the accelerators of the Laboratory and other scientific centres.

Heavy Elements

A fundamental outcome of macro-microscopic theory is the prediction of an «island of stability» for the superheavy elements with $Z = 114$ and $N \approx 184$. This intriguing hypothesis, proposed more than 30 years ago and intensively developed during all this time, seems to have recently received an experimental confirmation at the FLNR.

The use of ^{48}Ca ions as projectiles in the production of the heaviest elements is of special interest. Their neutron excess makes it possible to gain access to compound nuclei whose neutron numbers are close to the predicted magic neutron numbers. The doubly magic structure ($Z = 20$, $N = 28$) of ^{48}Ca allows one to form relatively cold compound nuclei at energies close to the fusion barrier. In the $^{48}\mathrm{Ca} + ^{244}\mathrm{Pu}$ fusion reaction, isotopes of element 114 with a maximum neutron excess can be synthesized.

The production of an intense ion beam of the rare and extremely expensive isotope ^{48}Ca was the cornerstone in our attempts to synthesize superheavy elements. In order to achieve this goal, it was necessary to carry out a modernization of the U400 accelerator. Due to these improvements, an internal ^{48}Ca beam with an intensity of $1.5 \div 2.0$ pμA was produced at material consumption of about 0.3 mg h^{-1}. The average intensity of the ^{48}Ca beam on the target was about $4 \cdot 10^{12}$ pps.

The experiments on the synthesis of these nuclei were carried out using the Gas-Filled Recoil Separator. The target consisted of the enriched isotope ^{244}Pu (98.6 %). The projectile energy in the middle of the target was chosen to be 236 MeV, and the excitation energy of the compound nuclei should be in the range from 34 to 38.5 MeV. Under these conditions, two experiments were carried out. The total beam dose amounted to $9.8 \cdot 10^{18}$ ions.

In the first experiment [1], we detected one chain of sequential decays, which is shown in Fig. 1a. Such a scenario is expected for the decay of the superheavy nuclei of element 114. Considering the conditions of performing the experiment and the decay characteristics, the decay chain most probably refers to the isotope ^{289}114 produced in the 3n-evaporation channel. The observed event corresponds to a cross section of about 0.5 picobarn.

In the second experiment [2], carried out in June–October 1999, the total beam dose amounted to $1.1 \cdot 10^{19}$ ions. There two more α-decay sequences terminating in spontaneous fission were observed (Fig.1b).

The projectile energy corresponds to the excitation energy of the compound ^{292}114 nucleus equal to $E_x = 38 \pm 2$ MeV. At this energy, the most probable

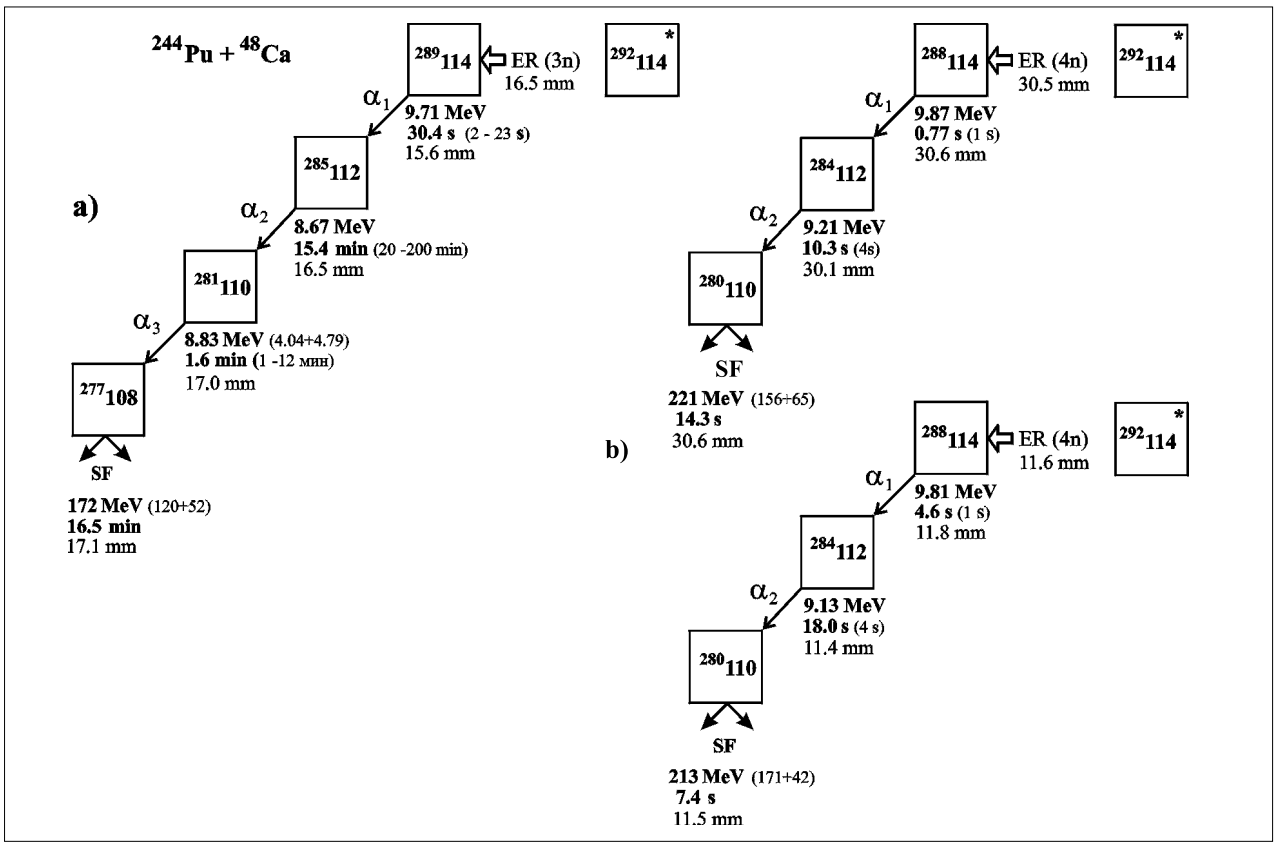


Fig.1. Sequential decay chains, obtained in the ^{48}Ca +^{242}Pu reaction. For the spontaneous fission fragments the values of the energies deposited in the front and side detector are indicated. For all the registered signals the position coordinates are also indicated

4n-evaporation channel leads to the formation of the isotope ^{288}114.

The isotope of element 114 with $N = 173$, namely ^{287}114, can be synthesized via the 3n-evaporation channel in the ^{48}Ca + ^{242}Pu reaction. It should predominantly undergo α-decay to the daughter nucleus ^{283}112 , which has been found in the ^{48}Ca + ^{238}U reaction.

The conditions of the experiment [3], performed in March and April 1999 at the VASSILISSA separator, were practically identical to the conditions under which the synthesis of the isotope ^{283}112 in a ^{48}Ca + ^{238}U reaction was performed. A rotating ^{242}Pu target 0.2 mg/cm^2 in thickness was bombarded by the 235 MeV ^{48}Ca beam. The total beam dose was $7.5 \cdot 10^{18}$ ions.

The most probable de-excitation channel of the compound nucleus of ^{290}114 ($E_x \approx 33.5$ MeV), corresponding to the emission of 3 neutrons, leads to the formation of the even-odd isotope ^{287}114 ($N = 173$). There two more α-decay sequences terminating in spontaneous fission with the half-life of $T_\alpha = 5.5^{+10}_{-2}$ s. were observed (Fig.2).

The production cross section of the new isotope of element 114 amounts to about 2 pb. Its half-life and decay sequence are shorter than those of the previously observed heavier isotope ^{289}114, formed in the reaction ^{48}Ca + ^{244}Pu through the 3n-evaporation channel and the intermediate even-even isotope ^{288}114 (Fig.1). Such a trend is expected, according to theory, with a decrease in the neutron number of the superheavy nucleus, or, in other words, with moving away from the closed $N = 184$ shell.

Summarizing the results of three experiments performed using a ^{48}Ca beam with a total beam dose of about $2.2 \cdot 10^{19}$, we came to the following conclusions.

The spontaneous fission events (TKE ~ 200 MeV) are related to the decay of heavier and considerably more long-lived nuclei ($T_{SF} = 10 \div 1000$ s). In the experiments with the ^{242,244}Pu targets ($Z_{CN} = 114$), they are the daughter nuclei of heavier products.

For the four events of sequential α-decays, terminated by spontaneous fission, the energies — Q_α and the decay half-lives — T_α obey the basic rule of Geiger–Nuttall (Fig.3). The energy values and decay probabilities imply the decays of nuclei with large atomic numbers ($Z = 110 \div 114$). According to the conditions of the experiment the parent nuclides are formed in the fusion reactions in the 3n- or 4n-evaporation channels. The cross

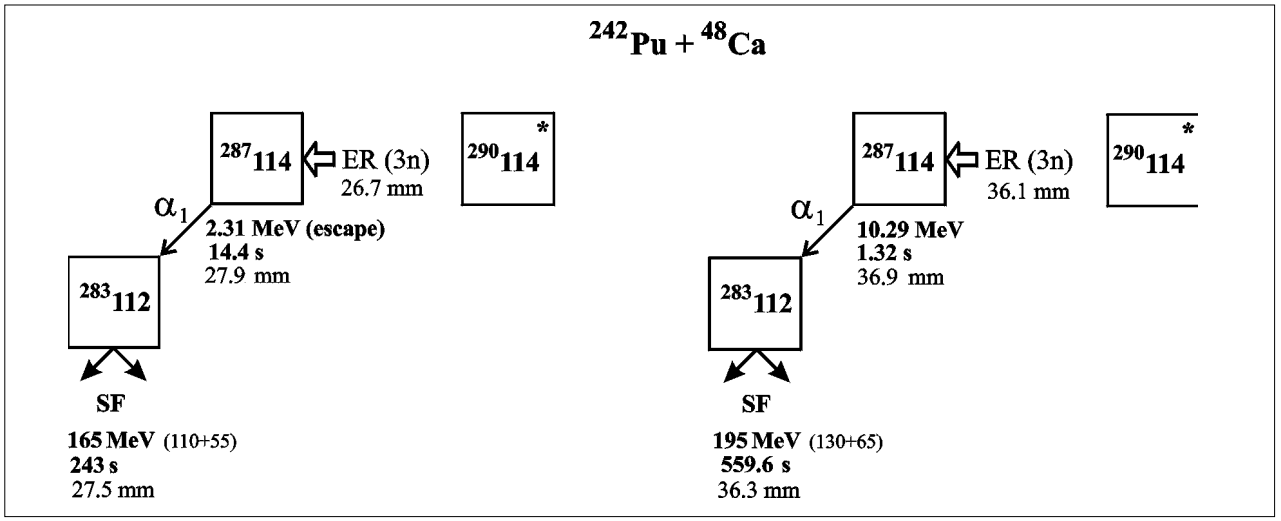


Fig.2. Sequential decays observed in the $^{48}Ca+^{242}Pu$ reaction

sections for these reaction channels amount to one or several pb.

During the period of 2000-2002, the investigations will be aimed at the synthesis of nuclei with Z ~110–116 in the ^{232}Th, $^{236,238}U$, ^{237}Np, $^{242,244}Pu$, $^{241,243}Am$, $^{246,248}Cm + ^{48}Ca$ reactions. It should be noted that even-odd and odd-odd isotopes, which can be produced in reactions with ^{237}Np, ^{243}Am or ^{249}Bk targets, may happen to be even more long-lived. Both facilities — VASSILISSA and the Gas-Filled Recoil Separator (GFRS) — will be used in these experiments.

In 2000, it is planned to continue the upgrading and reconstruction of the GFRS (electronic and detector systems) and the VASSILISSA facilities (improvements in the mass-resolution, electronic and detector systems [4]).

The experiments will be carried out in collaboration with LLNL (Livermore, USA), the GSI (Darmstadt, Germany), Comenius University (Bratislava, Slovakia), the University of Messina (Italy), RIKEN (Japan).

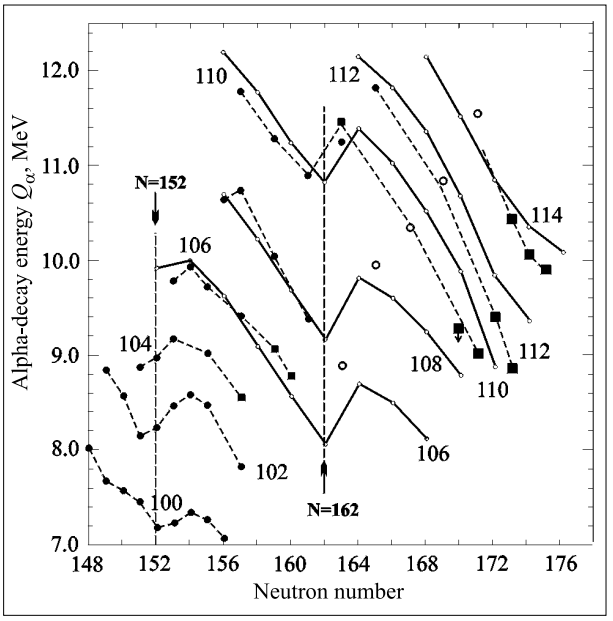


Fig.3. The α-decay energy — Q_α as a function of the number of neutrons for the isotopes with $Z = 100 \div 114$ (they are denoted in the Figure). The solid lines denote the calculated values, the filled points — the experimental values, the filled squares — the results obtained in ^{48}Ca-induced reactions, the open circles — the results by V.Ninov et al. ($^{86}Kr + ^{208}Pb$). The dashed lines through the experimental points are to guide the eye

Chemistry of Transactinides

The investigation of chemical properties of new elements is traditionally included into the FLNR research programs. A series of collaborative experiments were conducted at the FLNR together with scientists from Switzerland, Germany and Poland. New results on the properties of Rf , Db, and Sg were obtained [5].

The relatively long half-lives of the isotopes with $Z = 108 \div 114$, obtained in ^{48}Ca-induced reactions, open up new opportunities for the investigation of the chemical properties of these elements. A question arises as to whether these isotopes are homologues of the heavy metals Os ÷ Pb or not. It strongly depends on the relativistic effect of the heavy-atom electron structure, which influences their chemical properties. This question is fundamental for modern chemistry.

Element 108 (hassium) is expected to be a chemical homologue of Ru and Os. There are good prospects for selective separation of hassium from the transactinoid and actinoid elements with $Z < 108$ making use of the unique chemical group property of Ru, Os, and Hs, i.e., the capability to form very volatile stable tetroxides such

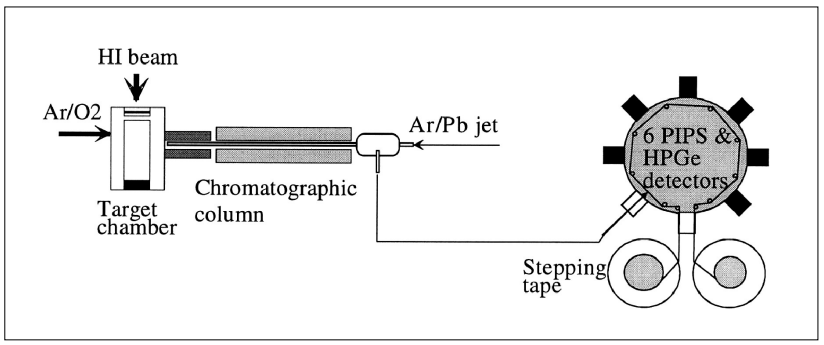


Fig.4. Shematic view of the upgraded set-up KIT

as $Os(Ru)O_4$. The final test experiments were made with the short-lived alpha-active $^{171-174}Os$ produced in the reaction $^{20}Ne + ^{158}Dy$ [6]. With the help of Ar/O_2 carrier gas, the thermalized recoil atoms were transported into a hot cell and then to a quartz chromatographic column (see Fig.4).

When the gas stream mixed with a Pb aerosol, OsO_4 fastened to the Pb particulates, which could be transported through a 10 m long capillary to a counting room within a few seconds. Here, the aerosol was repeatedly collected for 20 s by impact on a tape, which then was stepped. An overall yield (chemical conversion, transportation, deposition) of 50–60% was achieved.

Planned for 2000 are on-line chemical isolation and identification of heavy isotopes of the element with $Z = 112$ produced in $^{238}U(^{48}Ca, 3-4n)$ reactions and detection of the α-decay and spontaneous fission fragments in coincidence with neutrons.

Nuclear Fission

The interest in the study of the process of superheavy nucleus fission in reactions with heavy ions is connected first of all with a possibility of obtaining information, which is of great importance for the problem of synthesis, on the production cross section of compound nuclei at excitation energies of $\approx 15 \div 30$ MeV.

In this connection, experiments on the fission of superheavy nuclei in the reactions $^{208}Pb + ^{48}Ca \rightarrow ^{256}No$, $^{238}U + ^{48}Ca \rightarrow ^{286}112$, $^{244}Pu + ^{48}Ca \rightarrow ^{292}114$, $^{208}Pb + ^{86}Kr \rightarrow ^{294}118$ were carried out at FLNR JINR in 1999 [7,8]. The choice of the indicated reactions was undoubtedly inspired by the results of the recent experiments on the production of the nuclides $^{283}112$, $^{287}114$, $^{289}114$ at Dubna and $^{293}118$ at Berkeley in the same reactions.

The experiments were carried out on the extracted beam of ^{48}Ca and ^{86}Kr ions of the FLNR JINR U400 accelerator, using the time-of-flight spectrometer CORSET, the 24-module neutron spectrometer Demon and a 4π detector scintillation γ-quanta multiplicity spectrometer.

Figure 5 shows the TKE-M two-dimensional matrices for the studied reactions at the energy of ^{48}Ca ions $E_{lab} = 233$ MeV and ^{86}Kr ions $E_{lab} = 453$ MeV, which corresponds to the excitation energy $E^* \approx 33$ MeV of compound nuclei of ^{256}No, $^{286}112$ and $^{292}114$, and $E^* \approx 15$ MeV of compound nuclei of $^{294}118$. It is clearly seen that the form of the TKE-M matrix between the elastic scattering peaks changes drastically as one goes from ^{256}No to the superheavy nuclei. For ^{256}No, it is of a triangular form, which is characteristic of compound nucleus fission; and only at its edges, the contribution of events

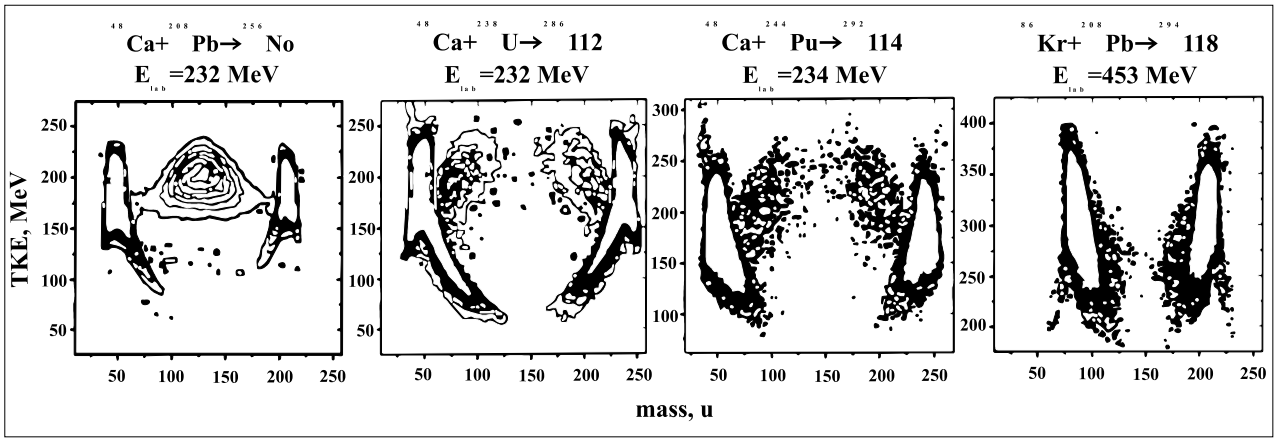


Fig. 5. Two-dimensional matrices TKE-Mass of the products of the indicated reactions

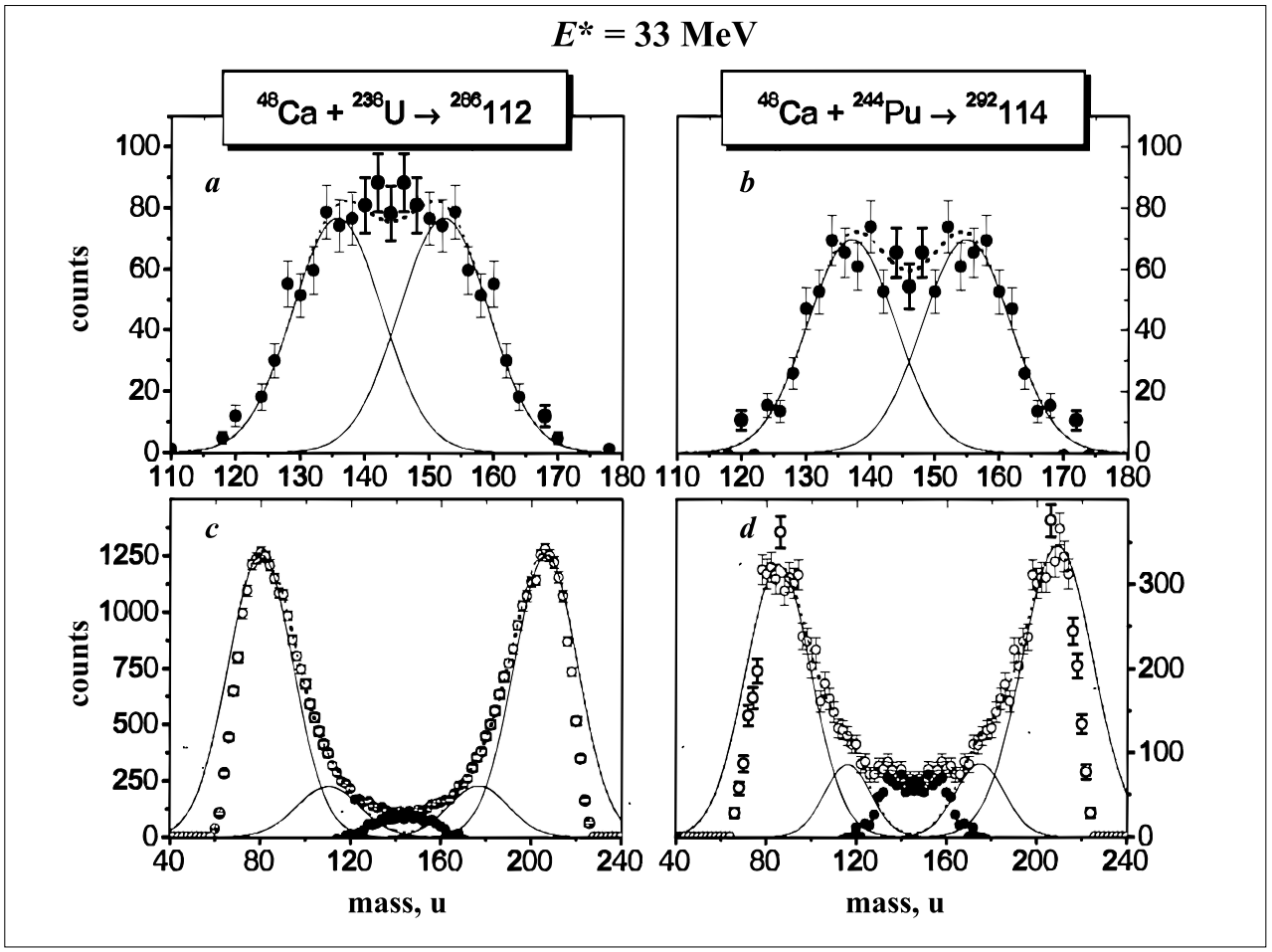


Fig.6. Bottom: mass distributions of the reaction products. Open circles show the experimental data; filled circles — the extracted components, corresponding to the compound nucleus (CN) fission. Top: the extracted components of CN fission and its description by a sum of two Gaussians

which can be considered as quasifission is seen. As one goes to the ^{286}112 nucleus, the quasifission process becomes distinctly dominant.

For the ^{292}114 nucleus, the picture again changes. It can be seen that the intensity of the quasifission peaks in relation to the yield of fragments in the symmetric mass region differs essentially from the similar ratio for the ^{286}112 nucleus. This tendency is seen more clearly from the lower part of Fig.6, which shows the yields Y(M) for two reactions ^{48}Ca + ^{238}U and ^{48}Ca + ^{244}Pu. Table 1 presents both the results obtained from the studied reactions with ^{48}Ca ions and from the reaction ^{86}Kr + ^{208}Pb.

In the case of the reaction ^{86}Kr + ^{208}Pb, in the symmetric fission region ($A/2 \pm 30$), the quasifission process is predominant, by which this reaction strongly differs from the reaction ^{48}Ca + ^{238}U and especially from ^{48}Ca + ^{244}Pu. There the contribution of the compound

Table 1. Cross sections and TKE

Reactions	E_{lab} (MeV)	E^* (MeV)	σ_{fis}	$\sigma_{fis}/\sigma_{cap}$, %	TKE, MeV
^{48}Ca + ^{208}Pb	230	33	350 mb	96	193
^{48}Ca + ^{238}U	232	33	6 mb	3	215
^{48}Ca + ^{244}Pu	233.5	33	4 mb	9	220
^{86}Kr + ^{208}Pb	486	28	~ 6 μb	$\leq 10^{-3}$	260
^{86}Kr + ^{208}Pb	453	15	≤ 500 nb	—	260

nucleus fission in the same region of fragment masses is dominant.

Measurements of subbarrier fusion-fission in the Pb,U, ^{244}Pu, ^{248}Ca + (^{48}Ca, ^{58}Fe, ^{64}Ni, ^{86}Kr) reactions and analysis of the low-energy fission dynamics using the 4π-array neutron multidetector «Demon» and the fission fragment trigger «Corset» will be continued. It is planned to continue the investigation of the influence of shell effects on the ^{252}Cf spontaneous fission dynamics.

The experiments will be carried out in collaboration with Vanderbilt University (Nashville, USA), INPN (Catania, Italy), ISN (Grenoble, France), University of Brussels (Belgium), University of Texas (USA), IP (Bratislava, Slovakia) and INP (Alma-Ata, Kazakhstan).

Formation and Decay of Hot Nuclei

At the recoil separator VASSILISSA, a de-excitation reaction of compound nuclei with excitation energies of up to 300 MeV and the evaporation of protons, α particles and up to 20 neutrons will be studied in reactions between ^{40}Ar and ^{40,48}Ca with ^{144,154}Sm targets. These experiments will allow obtaining data for complete fusion reactions leading to the heavy compound nuclei with $Z \geq 86$, and also obtaining new data on the fission barriers and fissility of nuclei with $Z \geq 90$. Investigations of deep subbarrier fusion using the reactions ^{12}C + ^{204,208}Pb have been planned.

The experiments will be carried out in collaboration with the GSI (Darmstadt, Germany), Comenius University (Bratislava, Slovakia), INPN (Catania, Italy), University of Messina (Italy), RIKEN (Japan).

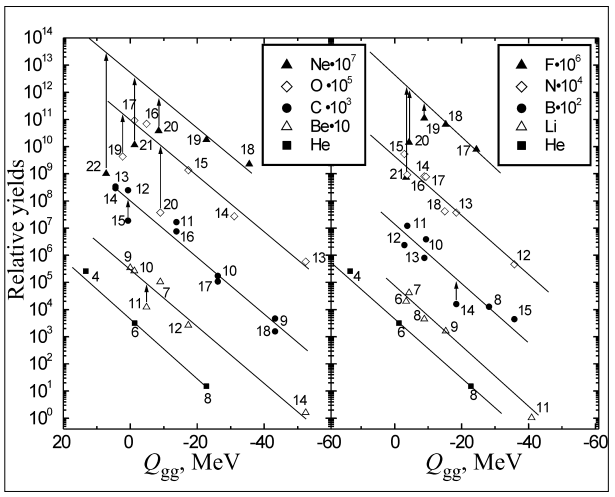


Fig.7. Isotopic yields of elements with $2 \leq Z \leq 10$ versus the Q_{gg} values. The arrows (for the isotopes O, F, and Ne) show a decrease in the yields of the isotopes as a possible consequence of the influence of the de-excitation effects. The numbers near the isotopes show the multiplied factors of the experimental yields

Fragment Separator COMBAS

In 1999, a number of experiments were carried out devoted to reaction mechanism study in nucleus-nucleus collisions at intermediate energies and determination of the intensity of secondary radioactive beams of nuclei. The inclusive yields of the isotopes with atomic numbers $2 \leq Z \leq 11$ produced in reactions between ^{18}O ($35A \cdot$ MeV) and ^{9}Be (light target) and ^{181}Ta (heavy target) were measured [9].

A simple exponential approximation realized by the Q_{gg} systematics discribes on the whole the yields of the isotopes produced in stripping nucleon reactions with large negative Q_{gg} values (Fig. 7). An exponential function drawn through the points corresponding to the neutron-rich isotopes ^{6}He and ^{8}He fits well the experimental data for the isotopes of each element. For the isotopes with $2 \leq Z \leq 10$, an exponential approximation is made by the shifting of the same exponent.

No evidence was found for any dramatic change in the reaction mechanism for peripheral reactions in comparison with that for the low energy range. The production rates of exotic nuclei of ^{9}Li, ^{11}Li, ^{11}Be, ^{12}Be, and ^{14}Be; which can be used as secondary radioactive beams of nuclei with haloes (Table 2) have also been determined.

Table 2. The production rates of halo-like isotopes of Li and Be from reactions of the 35 $A \cdot$ MeV ^{18}O on a ^{9}Be target (200-mg/cm^2). The primary beam current on the target was 10 μAe

Secondary beams (pps)				
^{9}Li	^{11}Li	^{11}Be	^{12}Be	^{14}Be
$5 \cdot 10^5$	$6 \cdot 10^3$	$3 \cdot 10^5$	$3 \cdot 10^5$	$5 \cdot 10^2$

In 2000–2002, using intermediate energy projectiles, the yield and properties of heavy oxygen isotopes will be studied in the reactions ^{36}S, ^{40}Ar($20 \div 60\ A \cdot$MeV) + ^{9}Be, Ta. A track focal plane detector based on a multilayer drift chamber will be constructed. Experiments will be carried out in collaboration with the GSI (Darmstadt, Germany) and Comenius University (Bratislava, Slovakia).

High Resolution Beam Line ACCULINNA

The ACCULINNA separator was designed and built for the realisation of a physics program dedicated to direct reaction study with radioactive ion beams. With primary beams of (32–34) $A \cdot$ MeV ^{7}Li and ^{11}B ions

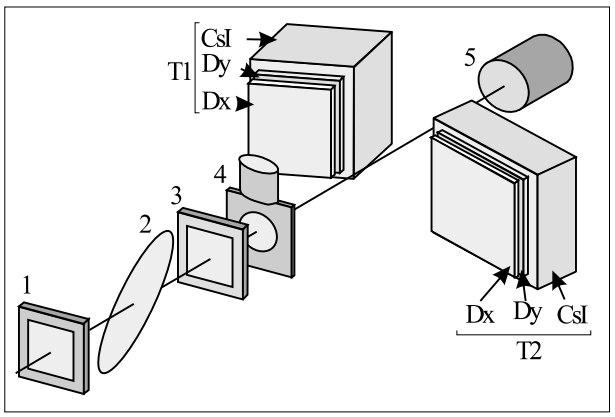


Fig.8. Detector array. Particle telescopes T1 and T2 each consisting of two 400 Si strip detectors, Dx and Dy, and one thick CsI crystal. Installed at the beam axis are the target (4), two multiwire proportional chambers (1 and 3) and plastic scintillation counters 2 and 5

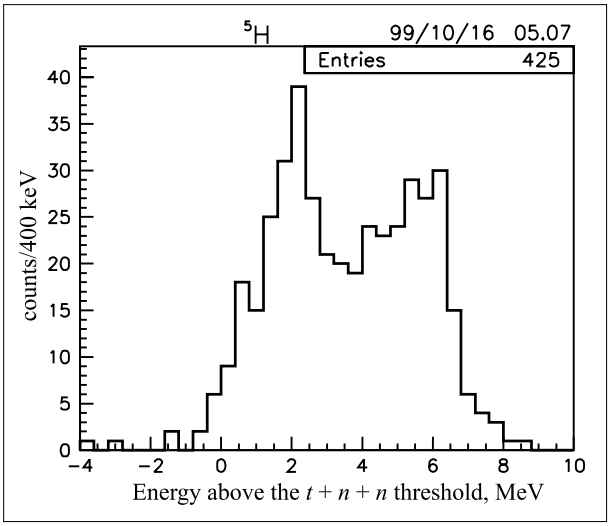


Fig.9. The energy spectrum of space-correlated two-proton pairs detected in the reaction $^6\mathrm{He} + p \rightarrow {}^3\mathrm{H} + 2p + n + n$ projectile energy of 36 A·MeV. The energy above the $t + n + n$ threshold is presented in the abscissa axis

delivered by the U-400M cyclotron we produced (20–30) A·MeV secondary beams of ^{6}He and ^{8}He nuclei focused on a physical target of 0.8 cm^2.

These secondary beams had intensities of 3×10^5 and 1×10^4, respectively, when the routinely produced primary beam intensity on a Be target was 4 pμA. The secondary beam energy spread was about 5 % (FWHM). Multiwire proportional chambers, installed on the beam path to the target, provided a resolution of 1.5 mm and 0.15 degrees, respectively, for the hitting position and inclination angle for an individual projectile. The experimental set-up used in our experiments is shown in Fig.8.

We concentrated our efforts on the transfer reactions occurring between ^{6}He and ^{8}He projectiles and helium and hydrogen target nuclei [10]. In the case of a ^{4}He target, these reactions could be two- and four-neutron transfer reactions for ^{6}He and ^{8}He, i.e., an exchange effect, which could be observed in the centre-of-mass frame as elastic scattering in the backward direction. The two-neutron transfer between ^{6}He and ^{1}H nuclei could also be a good test of predictions made on the basis of the three-body model of ^{6}He [11].

We carried out experiments aimed at observation of a 4n-exchange effect in the elastic scattering of 210 MeV nuclei of ^{8}He from helium target nuclei. In spite of rather low cross section limits achieved for the CM angles lying between 140 and 165 degrees, the 4n-transfer effect is not seen.

A series of experiments aimed at observation of the ^{5}H ground-state resonance yielded an unambiguous result. As one can see from Fig.9, the long-term puzzle of ^{5}He is solved. The ground-state resonance of ^{5}H was obtained in the reaction $^6\mathrm{He} + p \rightarrow {}^5\mathrm{H} + 2p$. A binary kinematics condition for this reaction is provided due to a two-proton virtual-state interaction. A resonant state which is about 2 MeV higher than the $t + n + n$ disintegration threshold could be revealed in the spectrum of the total energy of the correlated protons emitted in the reaction exit channel. The width of this peak is mainly due to the apparatus resolution. The real width of the ^{5}H ground-state resonance is estimated to be by about one order of magnitude of the peak width seen in Fig. 9. The rest of the count distribution shown in this figure is well understood in terms of the space volume that is obtained with a real detector array, which gives a limitation at the right side of the shown distribution.

Recently we have completed experiments in which the population of different resonant states of ^{7}He occurring in the one-neutron transfer on ^{6}He from deuterium was investigated. At present, the data are being analyzed with the aim to extract new information on the structure of the ^{7}He ground state p3/2 resonance and possible observation of another p1/2 resonant state in this nucleus.

Upgrade of ACCULINNA involving the extension of the ACCULINNA beam line with its exit from the cyclotron hall, installation of a liquid-tritium target, installation of neutron detectors were performed.

The work at ACCULINNA was performed in collaboration with the groups of GANIL (Caen, France) and YerPhI (Yerevan, Armenia). The part of the work related to ^{5}H and ^{7}He was carried out in collaboration with the groups of RIKEN (Saitama, Japan) and Kurcharov Institute (Moscow, Russia), GSI (Darmstadt, Germany) and Comenius University (Bratislava, Slovakia).

4π-Set-Up FOBOS

In the collaborative experiments (FLNR-Jyväskylä Accelerator Laboratory, Finland), carried out with the use of the detector modules of the FOBOS set-up, the decay of nuclear systems produced in the reaction $^{238}U + ^{40}Ar$ has been investigated [12]. For the first time ever, the fine structure has been revealed in the mass distribution of the fission fragments of the system $^{278}110$ with an initial excitation energy of 60 MeV. This structure manifests itself as separate peaks situated in the vicinity of the mass numbers A ~ 70, 100 and 130 characteristic of the magic nuclei (clusters) Ni, Zn, Sn, Sr.

Set-Up MULTI

In 1999, creation of the MULTI multimodule spectrometer has been completed. MULTI is designed for measuring the characteristics of nuclear reactions with stable and radioactive beams. The spectrometer includes multilayer scintillation and semiconductor (including epitaxial) detectors, position-sensitive proportional chambers, BGO-scintillation hodoscopes [13]. Its time and position resolution (~ 1 ns and not less than 1 mm, respectively) and capability to simultaneously register several particles providing measurement of their energies at the same time (the energy resolution is not worse than 1%) allow complicated correlation experiments to be carried out for the study of the breakup of exotic proton-rich nuclei of ^{8}B, ^{10}Ne, ^{20}Na, etc.

Using this spectrometer at the U-400M cyclotron, the cross sections have been measured for the interaction of ^{8}B with silicon and hydrogen targets.

The collaborative FLNR-GANIL experiments aimed at investigating the detecting characteristics of the MULTI set-up, have been continued. Using ^{36}S and ^{48}Ca beams, the masses and deformations have been measured for about 20 nuclides lying between the neutron shells $N = 20$ and $N = 28$ [14]. The deformation was measured with the use of the «clover»-detectors of the Eurogamm γ spectrometer.

DEVELOPMENT OF THE FLNR CYCLOTRON COMPLEX FOR PRODUCING INTENSE BEAMS OF ACCELERATED IONS OF STABLE AND RADIOACTIVE ISOTOPES

In 2000, emphasis will be put on the optimization of the U-400 + ECR-4M cyclotron, aiming at performing the experiments on superheavy element synthesis. The formation of a magnetic field in the accelerator central region for the optimization of the acceleration regime has been performed at the U-400M cyclotron, which resulted in a considerable increase in the ion beam intensity.

The U400M + U400 + MT25 Complex for Producing RIBs (the DRIBs project)

Any further development during 2000–2002 will be connected with the realization of the DRIBs project (production of radioactive ion beams at Dubna).

It is planned to do the work in 2 stages so that by the time of the first stage completion experiments with beams of radioactive nuclei could start and in parallel the work on completing the construction of the whole complex could be continued.

Stage I (Years of 2000–2001)

a) Production of radioactive nuclei of light elements using the U400M accelerator, separation and transport of a low energy beam into the U400 hall, injection, acceleration and extraction of the radioactive ion beams as well as channeling of the beam through the existing ion guides to physical facilities. The startup of the accelerating complex will begin with the production of radioactive beams of such ions as ^{6}He (13 MeV/n) and ^{8}He (8 MeV/n) with maximum intensity.

b) Generation of a beam of ^{238}U low energy fission fragments in the MT-25 Microtron hall.

c) Completion of technical projecting of the building and of all the devices linked with the production of low energy beams of fission fragments and production of accelerated ions at the U400 cyclotron.

Comparative parameters of He ion beams are presented in Table 3. It also contains the data on the ^{11}B beam ($T_{1/2} = 13.8$ s).

Stage II (Years of 2001-2002)

a) Production of low energy ion beams at the U400M accelerator and the MT-25 Microtron.

b) Production of beams of medium energy ions (fission fragments) in the ion guides of the U400 experimental hall.

It is planned to create additional working space between the existing buildings 101 and 131 of the FLNR for

Table 3. ^{6}He, ^{8}He and ^{11}Be beam intensities of the RIB facilities

		on-line	ISOL
		ACCULINA	DRIBs
^{6}He 808 ms	RIB	$1.5 \cdot 10^{6}$ pps 25 MeV/n	$9 \cdot 10^{9}$ pps 13 ÷ 8 MeV/n
	Primary beam Target	^{7}Li; 5 pμA 32 MeV/n Be	^{7}Li; 10 pμA 32 MeV/n Be
^{8}He 119 ms	RIB	$2 \cdot 10^{4}$ pps 28 MeV/n	$3 \cdot 10^{7}$ pps 6 ÷ 8 MeV/n
	Primary beam Target	^{11}B; 5 pμA 34 MeV/n Be	^{11}B; 10 pμA 34 MeV/n Be
^{11}Be 13,8 s	RIB	$9 \cdot 10^{4}$ pps 36 MeV/n	$2 \cdot 10^{8}$ pps 4 ÷ 16 MeV/n
	Primary beam Target	^{13}C; 3 pμA 42 MeV/n Be	^{13}C; 10 pμA 42 MeV/n Be

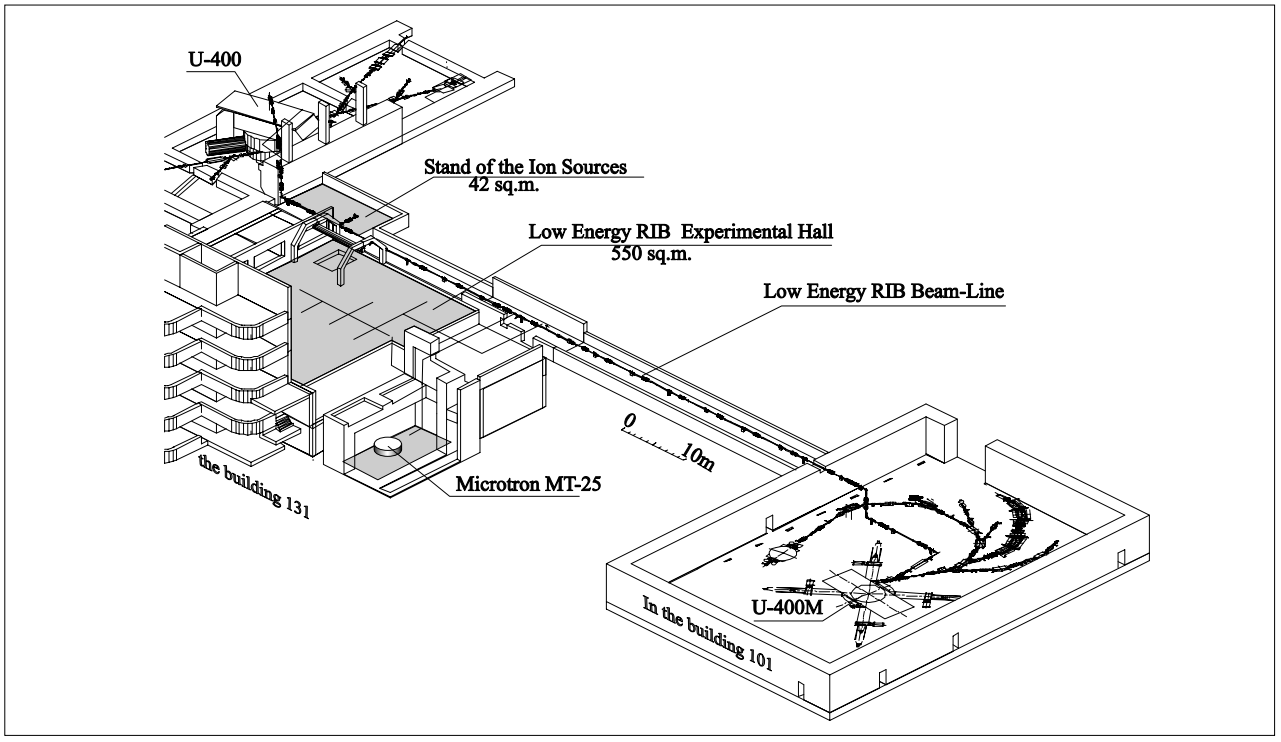


Fig.10. Schematic view of low energy beam transport channels of the DRIBs complex. The solid line — beams of radioactive ions generated at the U400M accelerator. The broken line — beams of fission fragments produced at the electron accelerator MT-25

creating additional possibilities for the study of the nuclear properties and decay characteristics of neutron-rich and proton-rich nuclei of light and medium masses, which are the products of direct reactions, fragmentation reactions, as well as fission in the ground and isomeric states.

The configuration of the transport channel is presented schematically in Fig.10.

The research program for the creation of the DRIBs project envisages wide cooperation of institutes and separate groups working with beams of radioactive nuclei in the field of physics and technology.

RADIATION EFFECTS AND MODIFICATION OF MATERIALS, RADIOANALYTICAL AND RADIOISOTOPIC INVESTIGATIONS

Investigation in the Field of Physics of Radiation Effects in Condensed Media

1. The phenomenon of the surface sputtering of monocrystalline tungsten, polycrystalline nickel and chromo-nickel alloys irradiated with high doses of Kr, Xe, and Bi ions has been studied.

2. In cooperation with the Oak Ridge Laboratory and the Institute of Transuranium Elements in Karlsruhe (Germany) the influence of high ionization density on the microstructure of spinelle $MgAl_2O_4$ irradiated with high-energy Kr and Xe ions in the energy range from 70 to 600 MeV has been studied.

3. A method of producing asymmetric track membranes has been developed. Membranes of this type look promising as permeable substrates for immobilization and study of the metabolism of cells and other biological objects.

4. R&D of thermo-sensitive membranes based on a PETP matrix with grafted N-isopropylacrylamide (NIPAAM) and a mixture of NIPAAM and acrylamide is in progress. The response of those membranes to temperature variations and their electric surface properties have been investigated.

5. New methods of the production of high selective track membranes with profiled pore channels for filtering disperse media of various nature have been developed. Based on the results of this investigation, an application has been submitted for an USA patent.

6. The recrystallization of an amorphous Si(a-Si) layer prepared by irradiation with 17 KeV He ions was studied after post-radiation annealing in the temperature range of 500-1000 °C.

7. The radiation damage in Si exposed to 245 MeV Kr has been investigated. An extremely high temperature (up to 1000 degrees C) stability of collecting radiation defects in the straggling zone of the bombarding ions has been found.

Production of Ultra-Pure Isotopes and Radioanalytical Methods for Environmental Studies

A procedure for radio-chemical extraction of ^{149}Tb and methods of producing the radio-isotopes $^{99}Tc(^{99}Mo)$ and ^{225}Ac have been developed.

In the framework of the project «Research in Nuclear Waste Transmutation», the distributions of relativistic particles and fast neutrons from massive Pb and U targets have been measured with the help of track detectors.

REFERENCES

1. *Oganessian Yu.Ts. et al. — Phys. Rev. Lett., 1999, v.83, p.3154.*
2. *Yu.Ts. Oganessian et al. — JINR Preprint E7-99-347, Dubna, 1999.*
3. *Oganessian Yu.Ts. et al. — Nature, 1999, v.400, p.242.*
4. *Malyshev O.N. et al. — Nucl. Instr. & Meth. A, 2000, v.440, p.86.*
5. *Dressler R. et al. — Phys. Rev. C, 1999, v.59, p.3433.*
6. *Yakushev A.B. et al. — On-Line Experiments with Short-Lived Osmium Isotopes as a Test of the Chemical Identification of the Element 108 – Hassium. In: Proc. of the 1st Internat. Conf. on Chemistry and Physics of the Transactinide Elements. Sept. 1999, Seeheim, Germany. Extended Abstracts, P-M-17.*
7. *Itkis M.G. et al. — Nucl. Phys. A, 1999, v.654, p.870.*
8. *Itkis M.G. et al. — JINR Preprint E15-99-248, Dubna, 1999.*
9. *ArtukhA. G. et al. — Nucl.Phys. A. (accepted for publication).*
10. *Ter-Akopian G.M. et al. — Phys. Lett. B, 1998, v.426, p.251.*
11. *Oganessian Yu.Ts. et al. — Phys. Rev. Lett. B, 1999, v.82, p.4996.*
12. *Pyatkov Yu.V. et al. — JINR, E7-99-253, Dubna, 1999.*
13. *Asaturjan R.A. et al. — Instr. Exp. Techn., 1999, v.42, p.342.*
14. *Reed A.T. et al. — Phys. Rev. C, 1999, v.60, p.024311.*

FRANK LABORATORY OF NEUTRON PHYSICS

In 1999, the FLNP scientific programme was covered by five research themes of the JINR Plan of Scientific Research and International Scientific and Technical Cooperation (PSRISTC) and it was aimed at obtaining new results in

— condensed matter physics (theme «Neutron Investigations of Structure and Dynamics of Condensed Matter», headed by V.L.Aksenov and A.M.Balagurov),
— neutron nuclear physics (theme «Study of the Fundamental Characteristics of Neutrons and Nuclei», headed by W.I.Furman and V.N.Shvetsov).

To effect scientific research, work was continued to develop, modernize, and construct the FLNP basic facilities:

— IBR-2 (theme «Development and Upgrading of the IBR-2 Complex», headed by V.D.Ananiev)
— IREN (theme «IREN Project», headed by W.I.Furman and I.N.Meshkov),
— the IBR-2 computation and spectrometry complex (theme «Development of the IBR-2 Spectrometer Complex and Computation Infrastructure», headed by A.V.Belushkin and V.I.Prihodko).

Also, FLNP took part in the JINR themes:

— «ATLAS. General-Purpose pp Experiment at the Large Hadron Collider in CERN» (headed by N.A.Russakovich),
— «Theoretical and Experimental Investigations of the Electronuclear Method of Energy Production and Radioactive Waste Transmutation)» (headed by A.N.Sissakian and I.V.Puzynin).

FLNP organized International seminars on interaction of neutrons with nuclei and on neutron investigations under high pressure.

CONDENSED MATTER PHYSICS

Experimental Investigations. In 1999 under theme -1031-, neutronography investigations in condensed matter physics were conducted at IBR-2 using four basic experimental techniques: diffraction, small-angle scattering, inelastic scattering, and polarized neutron optics. During the reported year there were eight reactor sessions. Beam-time on spectrometers was allocated according to experts recommendations on the basis of the submitted experimental proposals taking into account the existing long-term agreements for cooperation.

In 1999, the list of spectrometers operating in the user regime included 10 instruments: HRFD, DN-2, DN-12, SKAT, YuMO, SPN, REFLEX-P, KDSOG, NERA, and DIN.

A close type refrigerator-based cryostat to conduct experiments under simultaneous action of low temperatures, down to 12 K, and high pressures, up to 7 GPa, was put into operation. Filling of a two-axis position sensitive detector with a working gas mixture, 3 atm ^{3}He + 2.0 atm propane, was accomplished. The detector was installed in the diffractometer DN-2 and tested in the neutron beam. The modernization project of the DIN-2PI spectrometer was developed to raise the upper limit of initial working energies. Assemblying of the supporting systems of the thermostat TS3000 started and a pavilion for control systems of the thermostat was built to allow measurements of materials at 3000 K with DIN-2PI.

Diffraction. Structural changes in ammonium iodide, ND_4I, at high pressures up to 3 GPa and temperatures to 12 K were investigated. Dependence of lattice parameters and the deuterium position parameter on the pressure and temperature was established.

In order to determine magnetic structure of $(La_{1-y}Pr_y)_{0.7}Ca_{0.3}MnO_3$ series with giant isotopic effect, apparent in changing of transport condition with a substitution of ^{16}O with ^{17}O, experiments have been performed. Systematic structural data of temperature dependence of A-cation average radius have been obtained. The main purpose was to define structures of two samples with $y = 0.75$ and different amount of oxygen isotopes ^{17}O and ^{16}O [1]. HRFD experiment showed that these samples are identical in temperature diapason from 300 K to ^{16}O metal ferromagnetic transition temperature $T_{FM\ O\text{–}16}$. Thus, for the first time convincing evidence of existence of LPCM-75 isotopically different magnetic and transport properties at $T < T_{FM\ O\text{–}16}$ have been acquired.

Structural changes in samarium hexaboride, SmB6, at pressures up to 7GPa were investigated. At 4-5 GPa there was observed anysotropic broadening and splitting of diffraction peaks, which points to the existence of the structural phase transition to a lower symmetry phase in SmB_6 at pressures up to 7 GPa. Neutron diffraction investigations were conducted to study the effect of single axis elastic strain on the magnetic structure of terbium monocrystals. Decreasing of the wave vector of the helicoid magnetic structure under the action of a single axis strain by an order of 1 kbar was observed. (see Fig.1)

Small Angle Scattering. Purple membranes from the bacterium *Halobium Salinaris* were studied with the YuMo spectrometer. The observed conformational fast alterations occur within the first 10 min and are irreversible for hours suggesting strong interaction of guani-

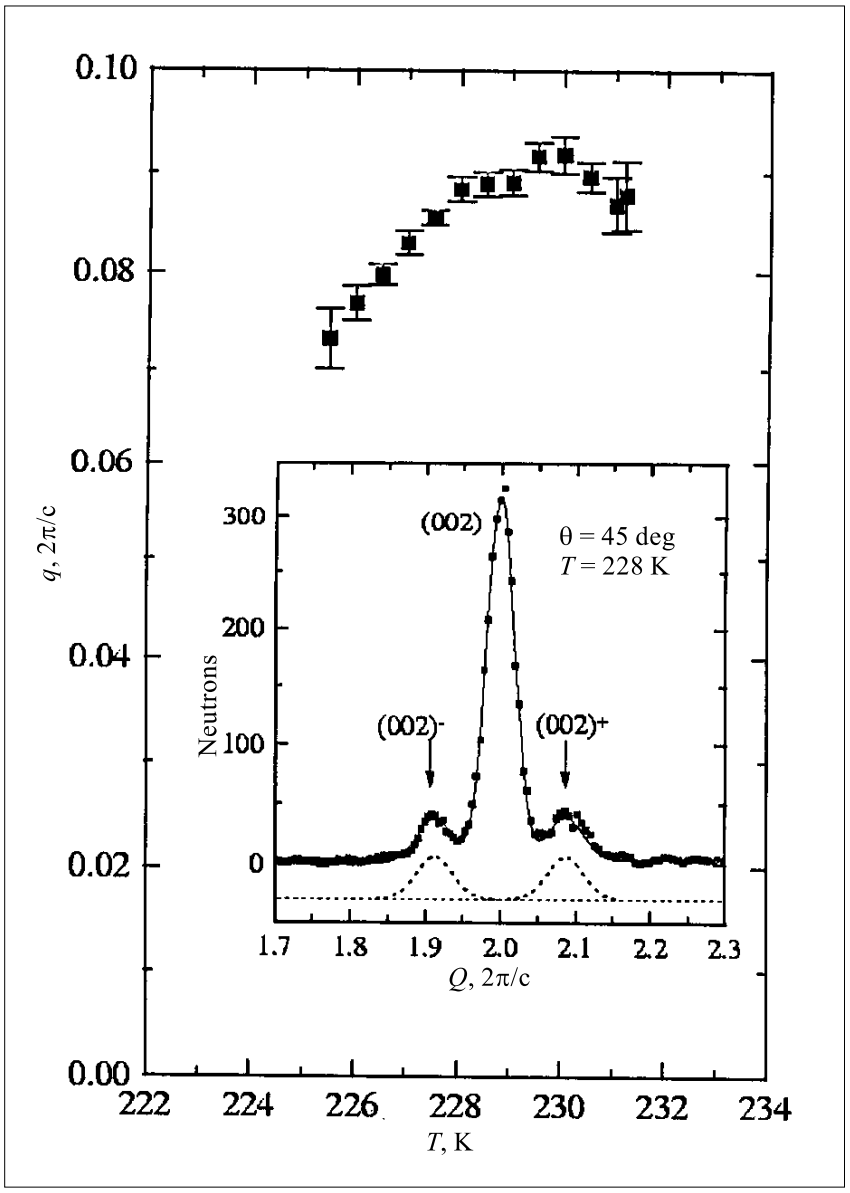


Fig.1. Temperature dependence of helicoid magnetic structure in Tb. Helicoid arrangement exists only in narrow temperature diapason from 225 to 231 K. A typical part of diffraction spectra are shown in the inset

dine hydrochloride with illumination-induced PM in the samples.

Polarized Neutron Optics Investigations. The magnetic field distribution inside thin $YBa_2Cu_3O_7$ films in the mixed state was studied by polarized neutron reflection. The experiments showed a peculiar behavior of flux-lines in the films under the action of an external magnetic field applied parallel to the film surface if the thickness of the film d is of the same order of magnitude or smaller than the magnetic penetration depth. Flux-line row transitions were observed. They extend the penetration of the magnetic flux occuring in the form of flux-lines to an appreciable range of external fields. The restricted geometry of the film does not only affect the flux-line arrangement inside the film but also the distribution of the magnetic field around the single flux-line core. This happens because on the film interface the normal component of screening currents around the core should vanish. We were able to verify the effect in our polarized neutron reflectometry experiment.

The atomic and magnetic structures of Fe/Cr superlattices were studied by means of polarized neutron reflectometry and complementary methods, such as X-ray diffraction, electron microscopy and Moessbauer spectroscopy.

Inelastic Neutron Scattering. Investigations with DIN-2PI of water solutions were aimed at revealing the influence of dissolved particles on the microdynamics of water molecules in the hydrate spheres of the particles. Hydrophobic hydration effects and their influence on diffuse mobility and rotation-vibrational dynamics of hydrate water molecules were investigated. A comparative analysis of two types of hydration was carried out and it was discovered that there existed a principal difference between them consisting in that, differently from ions (Li^+ or Cs^+), big apolar particles did not destroy the hydrogen bonds lattice in the surrounding water. Low frequency vibrational modes of atoms in the normal and superionic phases of lead fluoride (PbF_2) were investigated at $T = 293$ and 823K. The obtained data evidence in favour of a liquid-like state of anionic lattice in the superionic phase of PbF2, the nature of collective excitations in which is different from classical liquids.

NEUTRON NUCLEAR PHYSICS

The 1999 experimental research program in FLNP includes traditional research directions: experimental investigations of the fundamental properties of the neutron, studies of the processes of spatial parity violation in different nuclear reactions induced by neutrons, investigations of highly excited states of nuclei in reactions with resonance and fast neutrons, astrophysical aspects of neutron physics, experiments with ultracold neutrons. An extensive program of studies in resonance neutron induced fission completed in the main.

Applied research in the field of neutron activation analysis (NAA) by neutron detectors of different types and make were also conducted.

The main part of these investigations was carried out on seven neutron beams of the IBR-30 booster, beam 1 and 11 of the IBR-2 reactor and the experimental facility «Regata» for neutron activation analysis at IBR-2. At the same time, a number of investigations were conducted in collaboration with nuclear centers in Russia and other countries.

Experimental Researches. Combined investigations of parity-nonconserving (PNC) and parity- conserving (PC) interference[2] effects, that may extend essentially the possibilities of theoretical analysis of the experimental data on nuclear fission continued using ^{239}Pu. A new multilayer fission chamber containing 0.5 g of ^{239}Pu is made, the pulse height spectra of fission fragments are obtained using an isotope neutron source.

In the experiment to study angular correlations of fission fragments in the resonance neutron induced fission of an aligned ^{235}U nucleus in beam 5 of IBR-30, data taking completed. A combined data analysis of the $A2$ energy dependence and known data on total and spin-separated cross sections is performed[3].

Studies of fission modes and correlations with quantum states of compound nuclei continued on beam 2 of IBR-30. A method of precise measurements of the kinetic energy of fission fragments is developed and realized for actinide isotopes. The method employs a double ionization chamber with Frish grids.

Using the γ-ray spectrometers PARUS and ROMASHKA the pulse height and multiplicity spectra of ^{117}Sn, ^{235}U, ^{239}Pu are measured in a wide energy region. Relative yields of high-energy γ quanta are obtained for ^{117}Sn and also, α values ($\alpha = \sigma_\gamma / \sigma_f$) are derived from multiplicity spectra for all measured isotopes. An increase of multiplicity and decrease of α with increasing U and Pu sample thickness are first observed.

In the reported period an additional mechanism of UCN escape from traps was observed in experiments at ILL (Grenoble, France)[4]. It is associated with an approximately two-fold increase of UCN energy with the probability about 10^{-6} per collision for the stainless steel surface and lower for other studied materials (Cu, Be). The observed effect is not reduced to known UCN upscattering leading to an increase in neutron energy to about thermal.

Theoretical Researches. A new theory of nuclear fission induced by resonance neutrons is developed. It provides a new and sufficiently natural interpretation of A.Bohr's fission channels. A similar-based description of *P*-even and *P*-odd angular correlations of fission fragments is obtained. Part of the predicted new effects found confirmation in experiments performed in FLNP.

Methodical Researches. Construction work in the experimental pavilion completed with installing the UGRA spectrometer. A vacuum chamber, sample movement mechanism and two detector shielding blocks are assembled on the 250 m flight path in beam 6 of IBR-30. Assemblying of electric motors and signaling systems completed. A computer-aided control block is manufactured and the software is developed. The first experimental researches were done in 1999 using this unique facility to study neutron scattering in the resonance energy region.

To carry out investigations in paramagnetic neutron resonance and nuclear pseudomagnetism at the IBR-2 pulsed reactor, an experimental complex «Kolkhida» is being built to consist of a polarized neutron spectrometer and a polarized nuclear target.

Applied Researches. Application of instrumental neutron activation analysis (INAA) at the IBR-2 pulsed fast reactor is based on the use of the experimental set-up «Regata». In the reported period the activation analysis experience was mostly in pollution studies over some industrial areas of Russia (the South Ural, Tula, Moscow region) [5] and the JINR Member States (Poland, Romania). The application of neutron activation analysis with epithermal neutrons (ENAA) makes it possible to improve the selectivity and detection power of the method. The dominating part of air pollution studies is based on the use of the moss biomonitoring technique. It was applied to study air pollution by heavy metals and other trace elements in combination with atomic absorption spectrometry in the case of Pb, Cd, Cu, and Ni. The results are presented in the form of tables, diagrams, graphs and, using the geographical information system (GIS) technology, in the form of colored contour maps for each element.

In collaboration with the Russian Space Research Institute tests with a High Energy Neutron Detector (HEND) prototype to measure the energy dependence of the detector efficiency were completed in November. HEND will be launched on board the Mars Surveyor Orbiter 2001 in March 2001. In the year 2000, the test program of HEND will be carried out together with extensive MC calculations.

NEUTRON SOURCES

The IBR-2 Pulsed Reactor

In 1999, the IBR-2 reactor operated for physical experiments 1984 hours in 8 cycles, including three cycles with a cryogenic moderator.

Cryogenic Moderator (CM). The main achievement of the year is that CM is constructed and put into operation. A physical sturtup have been realized in period from 18 October to 17 December, 1999. The cryogenic moderator (CM) is made on solid methanium base. This CM is the third solid methanium moderator in the world.

All CM work regimes were tested. At $\lambda > 4$ Å and temperature equal to 30 K the gain was 10–20 times in comparison with the water moderator (see fig.2).

Modernization Project. In 1999 the modernization concept was sufficiently corrected. Work on engineering design of movable reflector MR-3 resumed and is planned to be completed by the end of the year.

The working plan of the production of TVELs for IBR-2 by the enterprise «Majak» is updated. Work on TVEL engineering project and specifications completed. Work to finish off the production technology of TVEL parts began.

Work on the IBR-2 modernization engineering project started.

The IREN Project

The Project Status. Following the recommendations of the JINR Committee of Plenipotentiaries (March 1993), the JINR Directorate adopted the decision, approved at the 76th Session of the JINR Scientific Council (June 1994), to construct a new modern source of resonance neutrons for investigations in fundamental and applied nuclear physics. The completion date (physical startup date) was the end of 1997. The IBR-30 analogous scheme, i.e., combination of a powerful linear electron accelerator and a subcritical multiplying target, was chosen for the new neutron source. The new IREN facility will permit the neutron energy resolution to be increased

by an order of magnitude at a double increase in luminosity.

Due to the lack of financing from the JINR budget, only 1044 K$ was invested in the IREN project by the end of 1998. In spite of insufficient and irregular financing of the project some progress was achieved.

For the linac, the first modulator M-350 created on the basis of an OLIVIN station with a SLAC klystron 5045 was successfully tested; designing and production of a RF feeder and accelerating tubes were partly realized as well as the designing of the focusing system and the vacuum system; practically all equipment for the latter system was shipped to JINR; an essential part of the full scale stand for testing of accelerating tubes was created in FLNP.

For the multiplying target, the technical project of the subcritical core and respective fuel elements was elaborated; all spare parts of fuel elements, including metallic plutonium rods, were manufactured; the technological design of fuel element production is practically completed; the contract for working out of a civil engineering project of the IREN installation and dismounting of the old IBR-30+LUE-40 booster is signed and its first stage is realized.

Above-mentioned results were mainly obtained from June 1994 to March 1996 when the financing of the project was on the level of ~ 40% of the scheduled amount. But in the next three years the rate of project implementation dropped, the key contracts were frozen or cancelled and so, the future of the project became questionable.

In this critical situation in March 1999, the JINR Directorate approved the revised working schedule of the IREN project with a new startup date in the year 2002 and found the possibility to allocate a special grant to save the project. The promised 250K$ to be paid by the end of 1999 will make it possible for the management of the IREN project to start negotiations with partners on the preparation of new contracts and prolongation of some old ones.

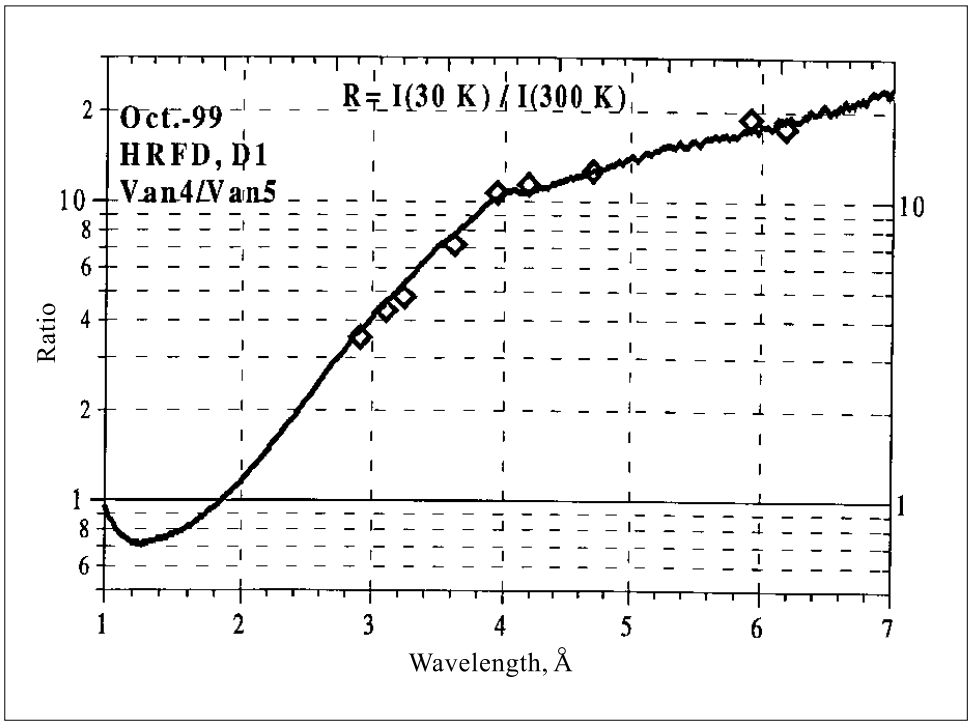


Fig.2. Wave length dependence of relative changing of neutron numbers for cryogenic and water moderators

DEVELOPMENT OF THE IBR-2 SPECTROMETER COMPLEX AND COMPUTATION INFRASTRUCTURE

In 1999, work was carried out to continue developing of the information and computation infrastructure of the IBR-2 complex:

— a high-rate network switch was purchased and installed in the second experimental hall of the IBR-2 reactor;

— the number of high-rate lines in the central network switch CISCO 5000 was increased;
— transition to twisted pairs in the experimental halls of IBR-2 to connect the spectrometers equipment to the network completed;
— the working place infrastructures of engineers and programmers were considerably improved.

The architecture and electronic modules of unified VME-based data acquisition and control systems for the IBR-2 spectrometers were developed. These systems are based on a limited but functionally complete set of identical (from hardware viewpoint) modules in which distinctions in parameters, functional capabilities, encoding as well as correction and preliminary data processing procedures are realized by means of microprograms, electronic tables, switches, etc. The main elements of technical solutions and software were tested in the structure of VME data acquisition systems operating at NSVR, SCAT, HERA-PR, EPSYLON, and HRFD spectrometers. In 1999, the first stage of VME equipment and software for data acquisition was put into operation on the YUMO spectrometer, and in December it is planned to complete work on PSD. Over the same period, unified VME-systems on the DN-2 (including PSD) and DN-12 spectrometers will be put into operation.

REFERENCES

1. *Balagurov A.M. et al. — Phys. Rev. B, 1999, v.60(1) p.383.*
2. *Alfimenkov V.P. et al. — Nucl. Phys.A.,1999, v.645, No.1, p.31.*
3. *Копач Ю.Н и др. — ЯФ, 1999, т.62, №5, с.900.*
4. *Несвижевский В.В. и др. — ЯФ,1999, т.62, №5., с.832.*
5. *Frontasyeva M.V. et al. — JINR, E14-98-392, Dubna, 1998, p. 14.*

LABORATORY OF COMPUTING TECHNIQUES AND AUTOMATION

In 1999, the research activity of the Laboratory of Computing Techniques and Automation covered two first- and two second-priority topics of the «Topical Plan for JINR Research and International Cooperation». The Laboratory staff participated in 18 more topics of the Topical Plan in collaboration with other JINR Laboratories. Main results of the investigations performed have been published in the well-known journals, proceedings of the scientific conferences and preprints. More than 100 scientific publications, conference reports and JINR preprints were published and presented in the year 1999.

NETWORKING, INFORMATION AND COMPUTING INFRASTRUCTURE AT JINR

JINR Local Area Network

In 1999, all JINR Laboratories put into operation the network equipment for the high-speed JINR backbone based on the ATM technology. Thus the ATM backbone of JINR LAN has been realized and is operating now. The JINR Computing & Networking Infrastructure is shown schematically on Fig.1. Systematic work on the LAN

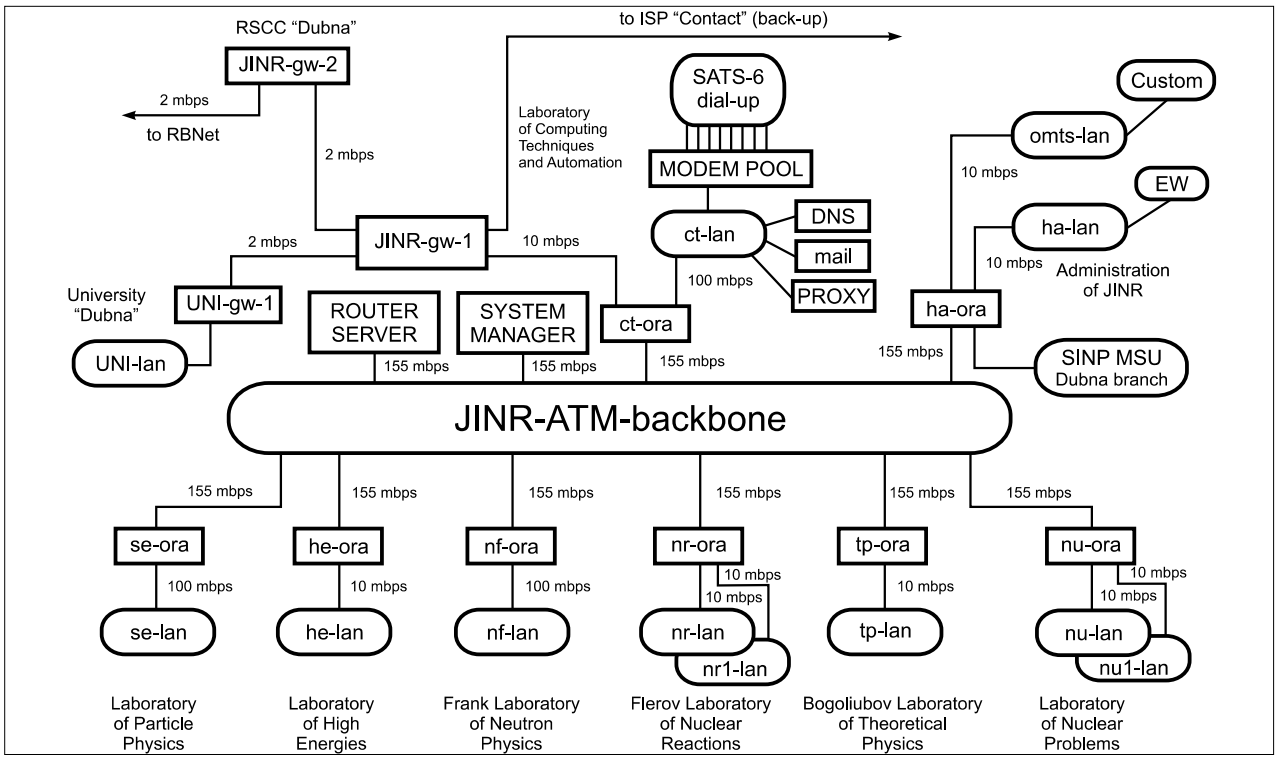


Fig.1. Scheme of JINR Computing & Networking Infrastructure

management was performed by the Network Operation Centre (http://noc.jinr.ru/). The rules for users of the JINR Computing & Networking Infrastructure have been worked out and approved by the JINR Directorate.

Telecommunication Systems

Since 1997, JINR has served as a RBNet node and uses RBNet facilities and DEMOS provider for external telecommunications. The main task of 1999 to increase the telecommunication channel capacity and throughput within the frames of the programme for National Computer Telecommunications Network was fulfilled.

The change-over to the worldwide channel RBNet was done. Today JINR uses fully the 2Mb/s channel to Moscow M9-IX, that means 1.5Mb/s for the Russian networks and other 512 kb/s of the granted capacity for the international networks using TELEGLOBE as a main RBNet partner. For this purpose an agreement has been signed with ROSNIIROS (the Russian Institute for Public Networks). If the operation of the channel shows its reliability and effectiveness, an increase in its throughput for JINR will be discussed.

The satellite computer communication link RADIO/MSU-DESY is expected to be used for cooperation with the nuclear physics centres CERN, DESY, etc., in the frames of the RUHEP community.

The channel of the CONTACT-DEMOS company is utilized as BACKUP for the reliable operation of the JINR's network. 256kb/s at 5% load has been agreed (Fig.2).

In 1999, a computer program was created for processing statistics of using the JINR external computer communication links. This allows one to analyze data in the interval of the requested dates sampling by subnetworks, subdivisions and leaders in the subdivisions, and to extract the main sites which they had the biggest traffic with.

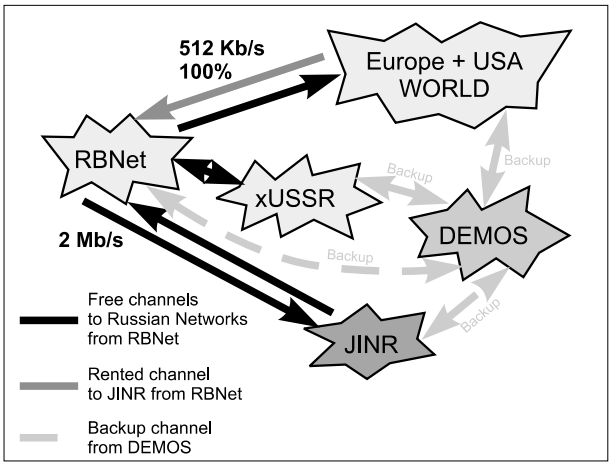


Fig.2. The current state of the JINR communication links

Computing Service

The table below shows the main JINR servers which are under LCTA maintenance:

Router	JINR – gw -1	CISCO AGS+
Provision of the JINR's backbone operation (ATM-backbone)	ATM ROUTER server	
	ATM System Manager	SUN SPARC 5
Domain Name Server (DNS), NEWS, MAIL-RELAY, Modem pool	JICOM	SUN SPARC 20
	JIMEX	SUN 1+
PROXY	PROXY	
MAIL-SERVER		SUN Ultra 10
FILE SERVER + MSS	DTMAIN	HP D370+
		ATL2640
Visualization and network monitoring server HP Open View	DTSERV	HP J282
Central Data Base server	DBSERV	DEC ALPHA 2100
Administrative Data Bases	ADM	
Computing servers	SPP	HP SPP-2000
	BCV	CONVEX 3840
WWW-servers	CV	CONVEX 220
	JICOM	SUN SPARC 20
Electronic library (JINR Library, Publish. Dept., Photo archive)	LIB	
	PD01	
General purpose servers	CV	CONVEX 220
	MAIN1, MAIN2	VAX 8800
FTP-servers	FAXE	
	CV	CONVEX 220
	DBSERV	DEC ALPHA 2100
Servers of applications	ULTRA	SUN ULTRA 1
	LINUX4U	
	NICE NT	

Below is given the relative intensity of the CONVEX, SPP200 computing servers and the modem pool used by the Institute laboratories during 11 months of the year 1999.

Load	BLTP	FLNR	FLNP	LHE	LCTA	LNP	LPP	Adm.	Other	Total
Convex C-3840	51 %	4 %	2 %	2 9 %	14 %	—	—	—	—	6389 h
Convex C-220	4,6 %	4,2 %	1,6 %	42,9 %	30,4 %	2,9 %	12,8 %	0,5 %	-	4462 h
SPP2000	51 %	1 %	9 %	6 %	8 %	2 %	20 %	-	3 %	34621 h
Modem pool	0,5 %	10,0 %	15,1 %	16,1 %	19,6 %	23,7 %	5,7 %	7,7 %	0,6 %	

Software Development

CMS Computing Support. During the last 3 years JINR was the only RDMS (Russia-Dubna Member States) CMS institute where the complete support of CMS computing has been organized. The software environment of the Sun CMS cluster at JINR is similar to the Sun CMS clusters at CERN. JINR specialists from several JINR Laboratories (LPP, LHE and LCTA) participating in the CMS experiment have had a full possibility to accomplish their studies for CMS at JINR, at Sun CMS cluster (a number of users — about 50 persons): simulation of set-up and processes, beam test data processing, etc. The SPP-2000 computer has been also widely used for the CMS activities as there exists the proper environment including CMSIM — the main CMS simulation program. Almost 6500 hours of the SPP-2000 processor time were used for CMS studies at JINR in 1999. The centralized archiving of working design documents (in particular, design drawings) has been organized for supporting RDMS CMS design activities of JINR, IHEP (Protvino), and HTTC (Minsk, Belarus). The further support of the official RMDS CMS www-server (http://sunct2.jinr.ru) was provided during the year: a lot of new documents on RDMS CMS activities have been located at the server.

The main points in Computing for LHC Experiments are:

— Design and development of computing configuration and software for Russian Regional Computing Centre for LHC experiments according to MONARC (Models of Networked Analysis at Regional Centres for LHC Experiments) Project requirements.

— Creation of software tools and environment for using LHC++ Library in design and development of software for teams of physicists participating in LHC experiments.

— Adaptation and support of LHC++ Library for PC-farm under LINUX platform.

— Technical and programming assistance while using the LHC++ Library for development of software for LHC experiments.

To provide information and computer support of the JINR participation in the experiments at the installations of CERN, DESY and BNL, adaptation of the technology for creation of object-oriented applications and data bases (GEANT4, Objectivity/BD, ROOT) was in progress in 1999. A program library LHC++ which is oriented on various types of OS and includes the components listed above (including OODBMS Objectivity/DB) has been received from IT CERN and installed at the JINR machines (SUN-cluster of the RDMS collaboration, two Windows NT stations).

Investigations for Paralleling of Computations. In 1999, the LCTA staff members performed experimental study of MPI-technology for paralleling of computations on a multiprocessor SPP-2000 computer. With the help of LCTA an all-purpose computer program GAMESS for modelling a molecular structure of a substance was successfully transferred to SPP. For the first time a problem of paralleling of computations in very large programs has been solved at JINR. At present the program is capable of using all the available SPP processors simultaneously. Another example is a paralleling of computations in the MICODE program. It should be noted that the work was done without specialized program packages. The available OS Unix only was used. Despite this circumstance, the speed of computations grows proportionally to the quantity of the processors used.

Maintenance of the JINR Program Library:

— New documents have been prepared and introduced in WWW. They include realization at JINR of electronic access to the texts of the program library CPCLIB (Belfast, Northern Ireland) and the Elsevier Publishing House (Amsterdam) for the readers of the CPC (Computer Physics Communications) journal;

— Maintenance of the NAG Library — information on the rules for work with the NAG Library at JINR have been prepared and introduced in WWW;

— Maintenance of CERNLIB on the JINR computer platforms;
— Filling the JINRLIB was in progress. Almost 25 computer programs have been tested on the platforms VAX, SPP, Convex and PC and provided with a doubled accuracy.

DATABASE and WWW SERVICE

A number of issues has been solved in the field of information management, namely:
— development and maintenance of the main information centre established for organizations of applied nuclear physics and fundamental properties of matter (project BAPHYS);
— creation of information retrieval systems based on applying the CORBA standard, WWW, languages of Java and C++ type;
— introduction of object-oriented systems for data base management of ORACLE8 and Objectivity/DB types.

External data bases (bibliographic, full text, factographic ones) which are of particular interest for the research under way at JINR, are as follows: data bases and documentation prepared by the collaborations ATLAS, CMS, etc.; PPDS (data base on elementary particle physics, Russian participants — IHEP, ITEP and JINR); HEP-SPIRES (data bases of electronic publications in HEP); unified base for CERN preprints and Los Alamos HEP collection; RPP (materials of Review of Particle Physics); INSPEC (bibliographic base on physics, electronics, computer technologies), etc.

One of the most important activities was the development of the system of WWW/FTP servers at Institute's subdivisions and the maintenance of the main WWW/FTP Server of JINR. In the framework of this activity a reference division Physics Information Servers and Data Bases was developed.

Among the activities related to the main JINR and LCTA servers (http://www.jinr.ru) (http://jicom.jinr.ru/LCTA), the following work should be noted: actualization of the divisions in accord with the main scientific results and the programs of JINR activities; information on conferences, schools and workshops held at JINR; News; updating the presentation about JINR and Dubna.

In 1999, the activities within the RFBR grant for electronic libraries and development of the information system for the JINR Library and Publishing Department included the following: introduction of a new system Liber Media to maintain the JINR Scientific Library and its readers, maintenance of the Library Web-site; formation of electronic collections with Web-interface to provide access to them (for bibliographic databases of the JINR Library, full-text publications of the JINR Publishing Department and photoarchive).

Finally, according to the plan and taking into account the requests of the JINR Board, the development of soft- and hardware tools has been carried out to provide work with administrative databases. Some of this work was performed together with STD AMS, JINR. This is particularly true for the following information systems: Topical plan for JINR research and international cooperation; Monitoring of the JINR Basic Facilities operation; Consolidated report on finances at JINR's subdivisions for the JINR Accounts Department; Law Information for the Public Library; Accounting of persons to be accounted at the JINR Accounts Department; Cash Accounting; JINR report to the Pension Provision Foundation; Consolidated register on salaries and wages of the JINR staff members including those working on short-term contracts.

COMPUTATIONAL PHYSICS

Monte-Carlo Simulation of Physics Processes. New more effective and simple modules of the programming complex have been designed for modelling nuclear physical processes in a substance exposed to high energy particles and nuclei [1]. The properties of various variants of the designed electronuclear installation "PLUTON" have been studied by way of mathematical experiments due to the type and the configuration of the reflector, the type of the fissionable substance and target [2]. Integral high-energy nuclon-nucleus cross sections for mathematical experiments with electronuclear facilities have been obtained. Parameterization of the integral cross sections σ_{el}, σ_{nonel}, σ_{tot} for the elastic, nonelastic and total proton- and neutron-nucleus interactions was considered at medium and high energies. On the basis of this parameterization a code was created for the interpolational calculations of the integral cross sections for arbitrary target nuclei at proton energies $E = 1$ MeV – 1 TeV and neutron energies $E = 12.5$ MeV – 1 TeV [3].

In collaboration with the Royal Technological Institute (Stokholm) and on the basis of the created data base, a precised version of "Electronic guide to cross-sections"

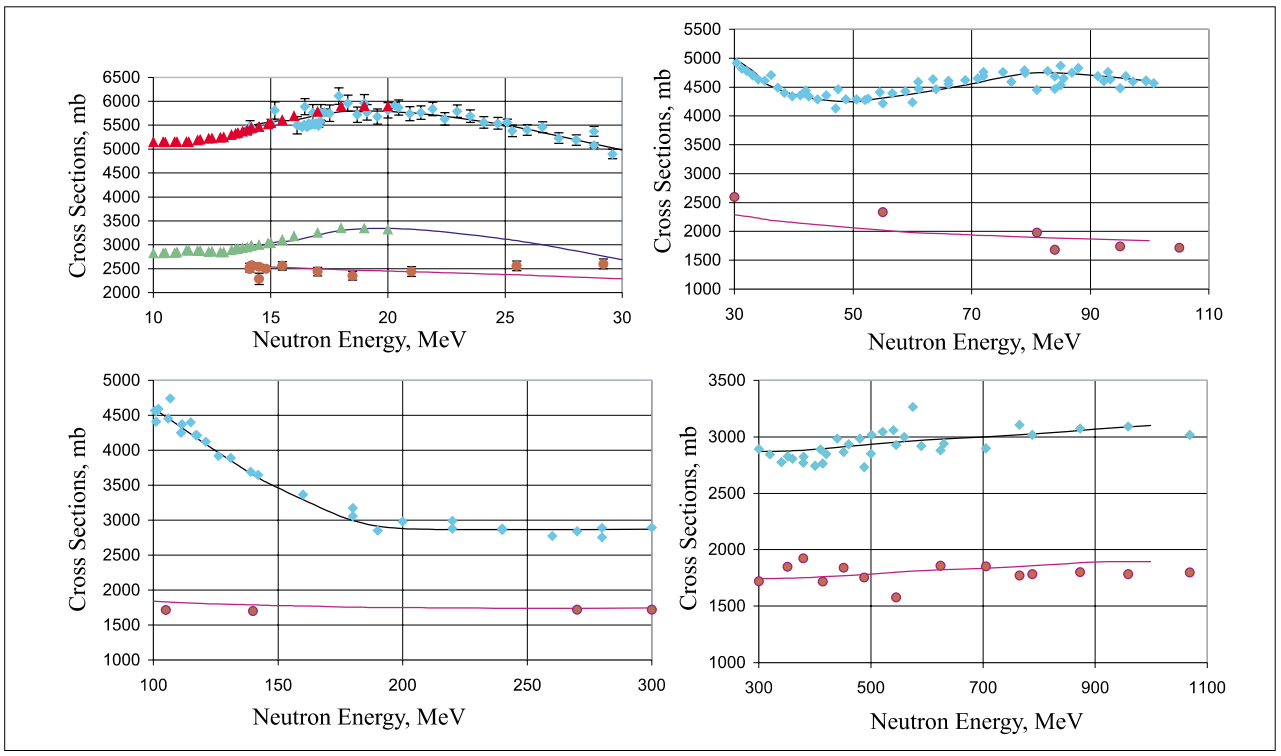


Fig.3 Cross sections for $n+^{207,2}$Pb. In the first figure the upper, intermediate and low curves are the calculated $\sigma_{tot}, \sigma_{el}, \sigma_{nonel}$. In other figures the upper and low curves are σ_{tot} and, σ_{nonel}. Points are experimental data

has been designed. It provides a way for calculating a cross section of pion- and nucleon-nucleus interactions for various values of mass and charge numbers of nuclei in the energy range of 10 MeV – 1000 GeV. The new version allows one to perform much more fast and precise computations of the electronuclear processes. Figure 3 shows how good the agreement is between the data of the guide and the experimental points [4] .

Modern Computational Tools in Experimental Data Simulation (Artificial Neural Networks and Cellular Automata). In the series of works [5] problems of data processing from Cherenkov detectors of the RICH type were considered. The main stages of data processing are expounded on the basis of the mathematical model of the RICH data. On the first stage of measurement clustering in order to obtain photon hits, two new methods of hit accuracy improving are described: numerical approximation method and the wavelet analysis method. The main efforts are focused on the approach of direct processing of raw RICH data, which is especially actual for the high granularity RICH detectors like CERES and COMPASS. The raw data approach is based on applying the robust technique at both stages of the further data analysis: for Cherenkov ring recognition and for particle identification. This technique is based on a least-square method with special recalculated weight functions depending not only on the distance of pads from the fitted circle but also on the signal amplitudes in pads. The proposed methods lead to a reliable parameter reconstruction from measurement and are then successfully used for the particle identification (Fig.4).

Modelling of Magnetic Systems and Particles Transportation. The problem of modelling the magnetic systems containing superconducting screens was considered (Fig.5). The nonlinear volume and boundary integral equations were proposed for a description of distribution of magnetization and surface currents. A special investigation was performed for digitization of equations and for solving nonlinear problems [6].

The experimental programmes of acceleration of the short-lived radioactive nuclei are widely realized in the world (CERN, GANIL, RIKEN, Gatchina, Dubna). The lifetime of isotopes varies from microseconds to hours. The process of diffusion of nuclei from the target is the slowest process while transporting the reaction products of interaction of the primary bundle with the target. The mathematical modelling of processes of diffusion from target and of processes of nuclei passage on the pipe is carried out to study and optimize the target characteristics for the FLNR experimental programmes. The dependence of diffusion time exit of the nuclei from a cylindrical target and of diffusion time of nuclei by the pipe [7] upon the geometrical sizes of a target is simulated. The

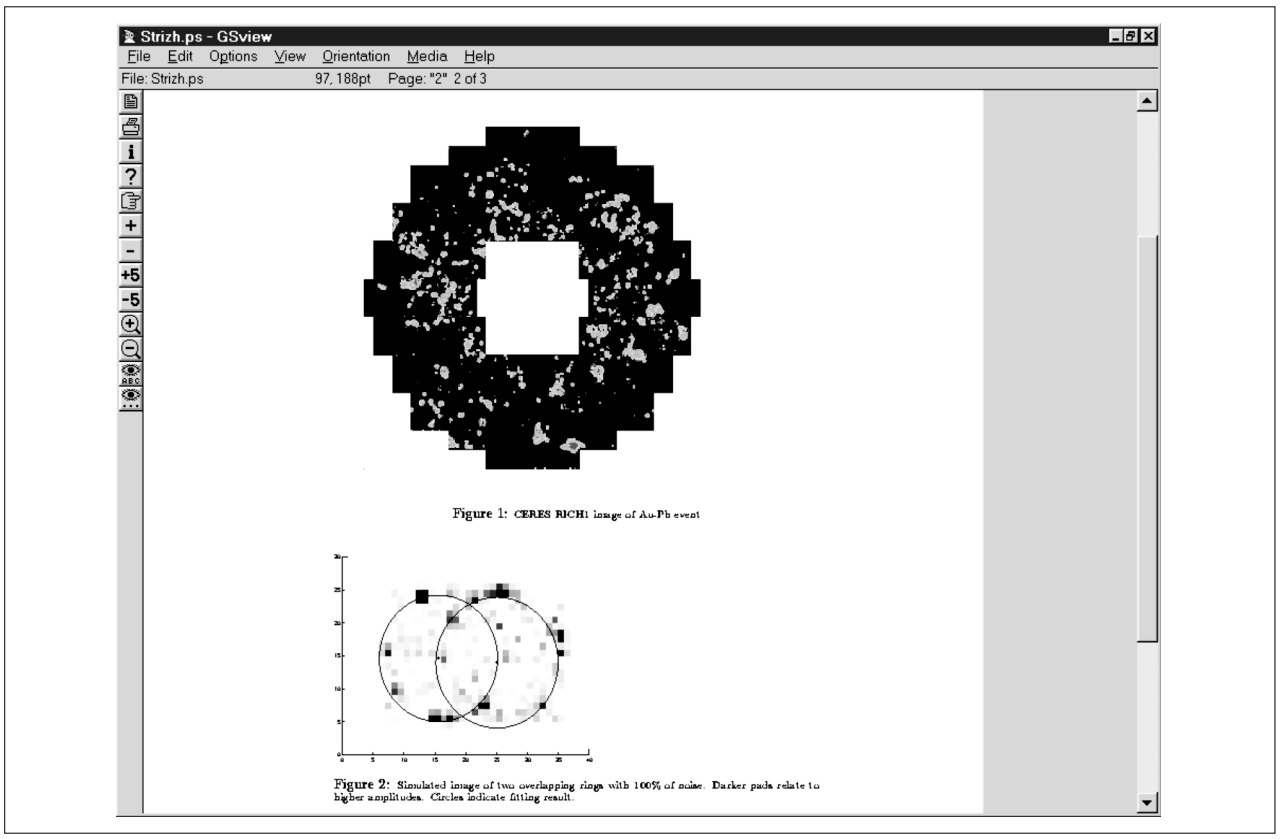


Fig. 4. CERES RICH image of Au-Pb event and simulated image of two overlapping rings with 100% of noise. Darker pads relate to higher amplitudes. Circles indicate a fitting result

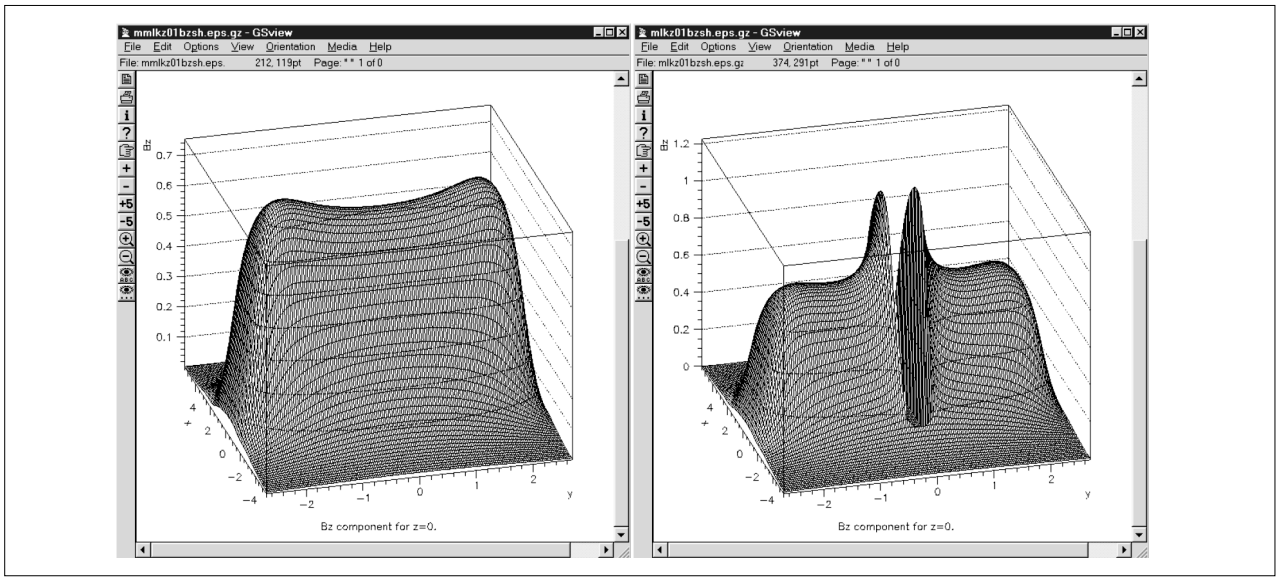


Fig.5. Numerical results for ALICE set-up magnetic system modelling without and with a superconducting screen

simple analytical formulae describing these dependences (associations) are constructed.

Methods and Software for Complex Physics System Calculations. A bicubic model for the local smoothing of functions related to pivot points (marks) of a searching surface has been constructed. Such an approach allows reducing the dimension of a matrix of normal equations more than twice. The algorithms constructed by using the offered model can be used both in applications and devel-

opment of global methods of smoothing and approximation of surfaces [8].

A numerical investigation of relativistic QCD equations for a bound-state problem with Coulomb and linear potentials was in progress. These models are described by three-dimensional relativistic equations with various generalizations of Coulomb and linear potentials in the momentum space. Algorithms and codes are developed for numerical investigations of these equations. The modified generalized continuous analog of Newton's method is used [9].

A process of division of a nuclear cluster into constituents was described on the base of an elastodynamic model. The issues of stability were studied, too [10] .

Numerical and analytical investigations for modelling the $\pi^+\pi^-$ atoms dynamics were performed together with physicists from LNP for the DIRAC set-up. These investigations are important for the experiments on the lifetime measurement for this system [11].

A discrete spectrum of the two-centre Coulomb problem of $\bar{p}He^+$ system was studied numerically. To solve this problem, a finite-difference scheme of fourth order and the continuous analog of Newton's method was applied. The algorithm for calculation of eigenvalues and eigenfunctions with optimization of the parameter of the fractional-rational transformation of the quasiradial variable to a finite interval was developed [12].

The integral boundary conditions for the time-dependent Shroedinger equation describing an atom with the laser interaction in dipole approximation was formulated. For numerical integration of the Shroedinger equation, these exact conditions may be used to replace diffuse absorbing potentials or mask functions. This method allows one to reduce substantially the size of the space domain where the integration is carried out numerically [13].

Computer algebra. Within the work on computer algebra, a number of new programs have been created which have no analogy due to the novelty of the algorithms embedded. Algorithms of the Dirac method for computation and separation of relations for dynamic systems of a polynomial type have been created and realized in the Maple system language [14]. Algorithms have been created of the most general methods for completion of nonlinear algebraic equations and linear differential equations to involution and realized in the Mathematica system language [15].

A computer program written in the C language for computations of cohomology of Li algebras and superalgebras of vector fields is far in excess of the best computer programs of analogous purpose ever written worldwide in the Reduce and Mathematica systems languages [16]

Software has been designed at LCTA which allows the users of the system REDUCE to use a large number of numerical routines written in C and FORTRAN in symbolic-numerical computations. A symbolic-numerical interface of the Standard LISP interpreter — GSL together with debugging and profiling tools of the dynamically loaded object modules for symbolic or numerical computations has been developed and realized [17].

Mathematical processing of experimental data in particle physics

In collaboration with LPP physicists work was done on creation of a system for registration, collection, processing and monitoring of data from the experiment EXCHARM. The work was awarded the Second JINR Prize of 1999 in the field of methodical and engineering research.

A synthesis of soft- and hard-ware platforms has been realized for modelling and processing the data taken from the particle physics experiments. Thanking the funds coming from RFFR (grant 98-07-90294), the local computer cluster RISC (Extended Integrated System of Computers) has been modernized. One of the basic properties of the local cluster — the process of its reconfiguration and scaling — allows one to move aside the state of their moral aging which is one of the main disadvantages of the alternative approaches. The local cluster RISC is applied as an instrumental and, what is of particular importance, effective purposeful tool for solving the problems of processing physical data. All mathematical processing of the experimental data obtained at the EXCHARM installation is carried out at this cluster [18]. The data banks — the results of mathematical processing of initial experimental information — have been generated and transferred to the EXCHARM collaboration participants for a further physical analysis.

The cluster RISC is also used for modeling (the inverse problem) the experiments on studying the processes with charmed and strange particles at the U-70 accelerator in Serpukhov. Thus, we have obtained and put into practice the typical high-efficient and promising solving in the area of computing the wide class of physical experiments.

APPLIED INVESTIGATIONS

A multifractal analysis of the images obtained by «Galileo» mission to Jupiter in 1997 has been performed at LCTA in cooperation with the Space Research Institute, RAS. The spectrum of Renyi dimensions Dq calculated for a given set of conditional colors shows the crack network on Europa surface to be multifractal. This supports the hypothesis that the cracks are produced by strong internal load, since the brittle fracture experiments on solids performed in terrestrial conditions give similar dimension spectra [19].

In collaboration with Salvay Institute (Brussels, Belgium) the following investigations were performed:

— A new application of the optical coherence tomography (OCT) for analysis of a skin microstructure has been recently developed. At present a compact system for imaging in real time of human tissues in vivo is under construction. The OCT database destined for storing and management of the information about patients, their lesions and tomograms have been worked out. It was developed in the framework of Microsoft Access 97 using Visual C++, Visual Basic and Quick Camera application [20] .

— The investigation of seismic processes as applied research is in progress. This processes are well known to be self-similar in both spatial and temporal behavior. At the same time, the Burridge-Knopoff (BK) model of earthquake fault dynamics, one of the basic models of theoretical seismicity, does not possess self-similarity. An extension of the BK model, based on the introduction of nonlinear terms for the interblock springs of the BK model, which results in the self-similarity of earth crust elastic properties being accounted for directly was presented. Phase space analysis of the model reveals the behavior of a system of randomly kicked coupled oscillators. The nonlinear stiffness terms cause synchronization of the collective motion and produce stronger seismic events [21].

INTERNATIONAL COOPERATION

In cooperation with CERN and Brookhaven National Laboratory the following work has been carried out:

1. Development of an object-oriented program environment (framework ROOT) for the solving of a wide class of scientific problems using workstations and personal computers;

2. Development and realization of an information model for acquisition, reconstruction and physical analysis of data for large experiments;

3. Promotion of up-to-date object-oriented technologies for experiment STAR.

A general model of the problem for reconstruction of the events obtained at the accelerators' experiments, has been completed. On its basis a library of base classes for the STAR experiment has been designed. The model was presented at the US HENP ROOT Users Workshop and at a meeting of the STAR Experiment Collaboration BNL (http://sol.star.bnl.gov/~fine/ Publications/ STARJuly99 Meeting/).

All the designed program products including the ROOT package and the software for the STAR experiment have been installed at JINR.

An automated system for administrating the computer complex in the research centre of Rossendorf (Germany) has been realized in the framework of cooperation and usage of some elements of the Java technology.

A protocol of cooperation with the University of Sofia in the area of application of such technologies has been signed.

In accordance with an agreement between JINR and the Research Centre Rossendorf, joint work was conducted on the project «Zentrale Nutzerdatenbank» (Users Data Bank). The purpose of the project is the creation of an automated system of administrating a computer complex by using WWW technologies as a tool of access via the Internet to the database ORACLE.

In frames of these activities a new concept of a computer program for registration of users and work groups on the NT platform has been worked out. This concept takes a unified approach (and a unified program code as an ideal) to registration of users on any POSIX — compatible platforms based on utilizing a centralized database for users and a unified (using the HTTP protocol) procedure for access to it.

A possibility was studied for a unified (standard) approach to the development of an automated procedure for registration of users within the POSIX specifications.

Within the cooperation with the Technical University of Cosice, Slovakia, a study has been conducted in the area of applying a wavelet transformation. A new promising tool has been developed for a description of denoised signals obtained by wavelet shrinking due to the criterion introduced [22]. An algorithm for a numerical solution of the inverse problem for two-dimensional Shroedinger equation has been worked out. The problem reduces to reconstruction of a symmetric five-diagonal M*N matrix with a given spectrum and given first N components for each of basic eigenvectors. But in difference with one-dimensional case all N components cannot be chosen arbitrary. It is stated that they must satisfy $(N-1)^2(M-1)$ additional conditions[23].

The investigation in the framework of «Agreement for co-operation in the field of Applied Mathematics and Mathematical and Computational Physics», concluded between JINR and the University of Cape Town (South Africa), and «Joint Research Project on Nonlinear Structures in Novel Magnetic Materials and Optical Transmission Lines», was continued. Numerical simulation and theoretical analysis of Nonlinear Schroedinger equation (NLS), has been performed. This equation finds a number of applications in the condensed matter and nonlinear optics models, superconduction theory; it describes, particularly, properties of optical telecommunications, magnetic materials to microwave fields, etc. Original results on existence and properties of NLS solitons were obtained (regions of existence, bifurcations, stability, bounding of solitons, etc.)[24].

REFERENCES

1. *Barashenkov V.S., Soloviev A.G., Sosnin A.N. — JINR, P2-99-125, Dubna, 1999.*
2. *Barashenkov V.S, Polyanski A., Puzynin I.V., Sissakian A.N. — JINR, E2-99-206, Dubna, 1999; presented at Prague conference.*
3. *Barashenkov V.S., Gudowski W., Polanski A. — JINR, E2-99-207, Dubna, 1999; subm. to III International Conference on Accelerator Driven Transmutation Technologies.*
4. *Barashenkov V.S., Gudowski W., Polanski A. — Reported at Prague conference, Praha, 1999.*
5. *Ososkov G. — Czech.J.Phys., 1999, v.49/S2, p.145;*
   Ososkov G., Shitov A. — Comp.Phys.Comm., 1999, v.119, p.1;
   Ososkov G. — Nuclear Ins.Meth., 1999, v.A433, p.274;
   Kolganova E.A., Ososkov G.A. — Czech. J. Phys., 1999, v.48/S2, p.169;
   Linka A., Ososkov G. et al. — Czech.J.Phys., 1999, v.49/S2, p.93, 161.
6. *Акишин П.Г. — ОИЯИ, Р5-99-312, Дубна 1999; напр. в ЖВМ и МФ.*
7. *Airapetyan M.G. et al. — JINR, P11-99-102, Dubna, 1999.*
8. *Dikoussar N.D., Török Cs. — JINR, P10-99-223, Dubna, 1999.*
9. *Amirkhanov I.V. et al. — JINR, P11-99-159, Dubna 1999 ; subm. to «Math. Modelling».*
10. *Bastrukov S.I., et al. — Phys. Nucl. Part., 1999, 30, N4, p. 992.*
11. *Amirkhanov I.V. et al. — Phys.Lett.B, 1999, v.452, p.152;*
    Afanasyev L., Voskresenskaya O. — Phys.Lett.B, 1999, v.453, p.302;
    Afanasyev L. et al. — J.Phys.G: Nucl.Part.Phys., 1999, v.25, p.B7-B10.
12. *Pavlov D.V., Puzynin I.V., Vinitsky S.I. — JINR, E4-99-141, Dubna, 1999; subm. to «Yadernaya Fizika».*
13. *Ermolaev A.M., Puzynin I.V. et al. — JINR, E11-99-156, Dubna, 1999; subm. to Phys.Rew. A.*
14. *Gerdt V.P., Gogilidze S.A. — In: «Computer Algebra in Scientific Computing», V.G.Ganzha, E.W.Mayr, E.V.Vorozhtsov (Eds.), Springer-Verlag, Berlin, 1999, p.139.*
15. *Gerdt V.P. et al. — In: «Computer Algebra in Scientific Computing», V.G.Ganzha, E.W.Mayr, E.V.Vorozhtsov (Eds.), Springer-Verlag, Berlin, 1999, p.147.*
16. *Kornyak V.V — In: "Computer Algebra in Scientific Computing", V.G.Ganzha, E.W.Mayr, E.V.Vorozhtsov (Eds.), Springer-Verlag, Berlin, 1999, p.241.*
17. *Raportirenko A.M. — JINR, P11-99-230, Dubna, 1999.*
18. *Алеев А.Н. и др. — ПТЭ, 1999, N4, с.1.;*
    Алеев А.Н. и др. — ОИЯИ, Р1-99-136, Дубна,1999;

Aleev A.N., et al. — JINR, E1-99-177, Dubna, 1999; Aleev A.N., et al. — JINR, E1-99-178, Dubna, 1999.

19. *Altaisky M.V. et. al. — JINR, P10-99-191, Dubna, 1999.*
20. *Akishina E.P. et al. — JINR, E10-99-150, Dubna,1999; subm. to «Computational Tools and Industrial Applications of Complexity».*
21. *Akishin P.G. et al. — Chaos, Solitons & Fractals, 2000, v.11 (1-3), p.207.*
22. *Török Cs., Bernhard H.P. — JINR, E5-99-221, Dubna, 1999.*
23. *Сердюкова С.И. Павлуш М. — Краткие сообщения ОИЯИ, 1999, No.3 [95]-99, p.5.*
24. *Barashenkov I.V., Zemlyanaya E.V. — Physica D, 1999, v.132, No.3, p.363; Phys. Rev. Lett., 1999, v.83, p.5568.*

DIVISION OF RADIATION AND RADIOBIOLOGICAL RESEARCH

In 1999, the main lines of the DRRR activity were concentrated on:

— neutron spectrometry and radiation monitoring;
— physical support of radiobiological experiments;
— theoretical modeling of ionizing radiation interaction with matter including interactions with biological structures and shielding calculations;
— investigations of peculiarities and mechanisms of point and structural mutation induction in pro- and eukaryotic cells by radiation with different linear energy transfer (LET);
— problem of low doses of radiation with different LET and sell recovery;
— investigation of «methylene blue — ^{211}At» complex therapy efficiency in melanoma cells.

RADIATION RESEARCHES

Radiation protection conceptual framework of the Cylab cyclotron complex (Slovakia) was developed. The course of feasible study of major radiation protection issues of the complex comprised not only radiation protection of the cyclotron, but also problems related to the safe use of many nuclear and medical technologies. Section of the request for proposal (RFP) of Cylab's design appertaining to radiation protection was prepared in the fullest detail. The radiation protection requirements needed for all nuclear and medical technologies to be used at the complex were specified. The following aspects of radiation protection were considered in all its bearings: criteria of radiation protection design, possible radiation sources, radiation shielding, radiation monitoring, waste management, possible radiation accidents and others.

Attention was given to the use of Monte Carlo method for shielding calculations, radiation detector response study and dosimetric applications. In particular, the depth-dose distribution from a ^{166}Ho skin patch to skin tissue was estimated by the electron-gamma transport simulation. This work was done in frame of collaboration with the INP (Czech Republic) and connected with radionuclide therapy of skin cancers. The neutron spectra of reference fields based on ^{252}Cf in polyethylene spherical moderators were calculated for real geometry. The physical support of the radiobiological experiments was continued [1,2].

Measurements of the neutron spectra generated by 1 GeV protons in the U + Pb + CH_2 assembling in a wide energy range were continued [3,4]. This work was done in collaboration with the LHE for estimation of radioactive waste transmutation cross section. The multisphere spectrometer and the code for neutron spectra unfolding by the statistical regularization method were used. Activation detector's technique for the estimation of the spatial neutron distribution around the assembling was applied. The data of the last experiments with proton energy of 1 and 1.5 GeV have been processed. As a result, the neutron spectra under different angles and estimation of the total neutron yields (for various energy groups) were obtained.

Measurements of the radon-gas concentration in air and water in environment and JINR dwellings were completed [5]. Measurements of radionuclides concentrations in soil near the Balakovo NPP as well as samples of soil and multiyear mosses from Yerevan environs were carried out.

Experimental study of radiation detector characteristics was continued [6]. In the neutron reference fields the characteristics of the personnel dosimeters being used by JINR and Czech Republic as well as the microdosimetric characteristics of the track etch detectors and the thermo-

luminescent detector responses were studied. The data of the LET measurements of the secondary particles generated by 1 GeV proton beams in CR-39 detectors have been processed [7].

RADIOBIOLOGICAL RESEARCH

A data analysis has been conducted on stable and unstable chromosomal aberrations in human blood lymphocytes, induced by scarce and densely ionizing types of radiation (γ rays, 1 GeV protons with LET ~ 0.218 keV/μm, ions ^{14}N with LET ~ 77 keV/μm) [8,9]. Possible mathematical approach has been taken up to compare the data obtained by FISH and standard metaphase methods. The obtained data may serve as evidence for suppositions about various radiosensitivities of different human chromosomes. They testify on a higher frequency of damage of chromosomes 1 and 2 in the human genome.

The question about possibility of extrapolation of the effects induced by high doses of irradiation to the range of low doses and also the problem of induction of adaptive response which is the increasing radioresistance of cells after irradiation with low doses to the following irradiation with higher dose, are the most important aspect of the biological effects of low doses of ionizing radiation. The dose-effect dependence of cytogenetic damage in the dose range 0.1–2 Gy of the single-dose irradiation with Chinese hamster and human melanoma cells in culture had been studied. The nonlinear dependences are shown for the induction of chromosome aberration with dose. The radiosensitivity of cells was maximal at the doses lower than 10 and 20 cGy for melanoma and Chinese hamster cells respectively. This hypersensitivity was followed by increased radioresistance and the reverse dose-effect dependence had taken place at appropriate dose range. It was supposed [10] that this phenomenon reflects induced radioresistance mechanisms at some level of damage and that induced repair processes are more effective and operates at lower doses in melanoma than in Chinese hamster cells. For verification of this hypothesis, a quantitative comparison of induction of adaptive response after double-dose irradiation of these two cell lines was carried out. It was shown that maximal adaptive response was induced at 1 cGy for melanoma cells and 20 cGy for Chinese hamster cells. It can be concluded that the same inducible repair processes are analogous in mechanisms and different in quantitative proportion for different cell types underlying on the base of nonlinear dose-effect curves and induction of the adaptive response.

A study of mutagenic action of ionizing radiation on mammalian cells was continued. Chinese hamster cells (line V79) were irradiated with 1 GeV protons at the LHE Synchrophasotron at doses of 1, 1.5, and 2.5 Gy. HPRT-mutant subclones were revealed and separated from the irradiated cells' culture, their cytogenetic analysis was conducted. An increase of the growth duration of mutants is obtained in comparison to the intact control.

In our earlier study of spontaneous and γ-induced mutants it was distinguished the group-I of mutants which did not differ essentially from the control in the chromosomal aberration level, and the group-II, which had the level of chromosomal damages about 1.5 to 2 times higher. Besides, in contrast to spontaneous mutants among γ-induced group-I mutants those were obtained which had a chromosomal aberration level about 2 times lower than in the control. No difference was observed in the yield of various types of chromosomal aberrations due to proton irradiation in comparison to γ-induced mutants. The obtained data testify that irradiation of mammalian cells with γ rays and high-energy protons may induce stable on cytogenetical parameter types of radiation-induced mutants.

Experiments on the determination of survival and oncogenic transformation regularities of fibroblast cells at the 580 MeV proton irradiation have been started. The curves of survival and frequency of oncogenic transformation for these cells were obtained.

A study of genetic control of checkpoint-regulation in yeast Saccharomyces cerevisiae was continued [11]. Checkpoint mechanisms cause the cell cycle to pause and allow DNA damage repair. In yeast several checkpoint-genes have been identified. Double-mutant strains have been constructed and their radiosensitivity was studied.

A special tester system for detection point mutations after radiation was used. The study of induction of base substitutions in haploid yeast strains by γ irradiation was finished [12]. The γ irradiation induces efficiently all types of the base substitutions. The dose dependence is linear, that differs from those of diploid strains that show linear-quadratic dependence. The base-substitutions spectrum in haploid yeast is the same as in diploid cells. Observation of base-substitution induction by heavy ion in yeast strain was begun. The first experiment with ^{4}He (LET = 20 kev/μm) showed relative biology effectiveness about 2. A study of frameshift induction mutations in yeast was started by using a special test-system based on the reversion tests with a 4-base insertion in the LYS2 gene or a +1T insertion of a stretch of 6T in HOM3 gene.

Studies of regularities in the formation of spontaneous and induced deletion mutations in E.coli bacterial cells were continued [13]. Dose dependence of formation frequency of tonB-trp deletion mutations at γ irradiation is obtained. A series of preliminary experiments has been

conducted on mastering the methods to study the induction process of deletion mutations with heavy ions.

Studies on the regularities of SOS-response in E.coli cells at the ultraviolet light action have been completed [14]. In particular, the influence of visible light (photoreactivation) on the character of kinetic and dose curves of SOS-induction in E.coli cells (uvrA) was investigated [15]. The analysis of these data along with the data obtained earlier concerning UV-induced SOS-response allowed concluding that different molecular events lie in the basis of SOS-system induction. In the region of the 0–2 J/m^2 dose the SOS-signal is most probably caused by gaps, generated in the process of the damaged DNA replication. In the region of 2–10 J/m^2 an interruption of DNA replication may be regarded as a SOS-inducing event. Studies of the influence of umuC-mutations on the SOS-response induced in E.coli cells with UV and γ rays have been finished. It is shown that in both cases the presence of this mutation leads to a 5-time growth of the SOS-induction level. The investigation of the SOS-response was continued on E.coli cells at the heavy ion action. In particular, kinetic curves of SOS-induction in irradiation of wild-type cells with different doses of γ rays and ^{4}He ions with LET = 20 KeV/μm were obtained.

The activities on computer simulation of genetic regulator system of SOS-response in E.coli bacteria have been concluded [16]. They resulted in a model and corresponding differential equations which describe the dynamics of genetic regulation and inducing signal for the regulator SOS-response system after the UV action. Dynamic curves of the SOS-response regulator components after UV irradiation, as well as dose dependence of maximum concentrations of genes recA and sulA production have been calculated and analyzed.

The combined effect of low-dose ionising radiation and chemical agents on seeds of higher plants (plantain Plantago Major) in the area of the Balakovo Nuclear Power Plant (NPP), Saratov region was studied [17]. The subjects of the studies were the antioxidant status, mitotic activity and chromosome material damage in meristem cells of plantain seedling apex. The data were analysed with the account of results in radionuclide and chemical contamination determination, and simulation of the gaseous flux exhaust of inert gases from NPP. The research demonstrated that the delay in sprouting and the number of not sprouted seeds in populations correlated with the chromosome damage yield in the first mitosis of meristem cells, in case the damage was large, both at the radiation action and at the effects of chemical agents. In these populations the level of chromosome aberrations was 3–4 times higher than the control level.The analysis of chromosome aberration yield and the quantity of proliferating cells in the apex in the first mitosis showed that the action of the ionising radiation lead to classical dependence of these values on the fixation time, while the combined action with chemical agents detained and arrested the cell division. The decrease in the mean values on the quantity of dividing cells in the apex was observed in populations subjected to the effect of radioactive fallout from NPP and chemical agents. These processes affected the normal growth of the plant root, studied in some populations. The study of the antioxidant status demonstrated its decrease by 2–3 times in populations situated mostly on the wind direction from NPP.

The analysis of the results in dose–effect relationship studies has been carried out on the cell and organism level, with the aim to obtain more precise data on the risk coefficient at low doses [18]. The results are represented by two contrasting groups of dose dependence on effect. Both types of dependence are described by the equation solutions of an assumed unified protective mechanism, which comprises two components: constitutive and adaptive or inducible ones. The latest data analysis of the downwards concave dependence curves shows a considerable underestimation of radiation risk in all types of cancer, except leukemia, for a number of critical groups in a population, at low doses comparing to the ICRP recommendations.

The series of experiments had been finished for the purpose of quantitative comparison between degrees of damage of normal Chinese hamster cells and human melanoma tumor cells in vitro treatment with free astatine-211 and ^{211}At-labelled methylene blue (MTB) [19]. The results of experiments confirmed our preliminary data that the efficiency of ^{211}At-labelled MTB on melanoma cells was one order higher than on Chinese hamster cells. Also it was shown the same efficiency of ^{211}At in ionic form for both cell lines.

This means that ^{211}At-MTB is selectively accumulated in pigmented tumor cell, which prove this compound to be clinically effective in radiotherapy of disseminated melanoma accompanied by minimal damage of normal tissues.

RADIATION PROTECTION

The radiation monitoring for occupational exposure at JINR nuclear facilities was carried out in 1999 by the automatic systems of radiation control (ASRC) and by portable instruments. The radiation field investigations in dwellings around the cyclotron U-400M were continued. The organizational and technical measures on radiation protection ensured inexceeding of planned doses.

The regular environmental monitoring of soil, plants (grass), water from the river basins in Dubna vicinity, water-supply system and water effluents of enterprises con-

firms that the environmental radiation pollution around JINR area remain constant during a long time and contains the natural radioactivity and products of global fallout only. Any contribution to radioactive pollution of the environment from the JINR nuclear facilities was not found.

In 1999, the Individual Dosimetry Service maintained dose control to 1816 persons, including 77 visitors, under individual monitoring. Their number decreased by 72 persons as compared with 1998. The yearly individual doses to the personnel did not exceed 21 mSv/yr. The highest values of the average individual dose per year among the JINR Laboratories are at FLNP and DRRR — 2 mSv/yr. The exceeding of the control levels of doses at the Laboratories and the dose limits was not observed in 1999 as well.

EDUCATIONAL ACTIVITY

The second run of the 9-weeks IAEA Regional post-graduate educational course on radiation protection was held in JINR in autumn 1999. The course was opened to 25 young specialists from the IAEA Member States in East Europe and West Asia region. The course was organized on the basis of DRRR and the University Centre. The course consisted of 125 lectures, 17 laboratory exercises, and 10 scientific visits. The main part of the lectures and all practices were given by the specialists from DRRR. As the course result the listeners were awarded by the IAEA certificates. Taking into account the high level of the course organization and experience accumulated in JINR it was proposed by the IAEA to prolong the effective cooperation in this field on the permanent basis.

REFERENCES

1. *Spurny F., Bamblevski V.P. — Radiation Measurements, 1999, v.31, № 1–6, p.413.*
2. *Timoshenko G.N., Bamblevski V.P., Krylov A.R. — JINR Preprint E16-99-47, Dubna, 1999.*
3. *Brandt R. et.al. — Radiation Measurements, 1999, v.31, № 1–6, p.537.*
4. *Brandt R. et.al. — Radiation Measurements 1999, v.31, № 1–6, p.497.*
5. *Timoshenko G.N., Merzlaykova N.N. — JINR Communication P16-99-328, Dubna, 1999.*
6. *Golovchenko A.N. et. al. — NIM B, 1999, v.159, p.233.*
7. *Spurny F., Vlcek B., Bamblevski V.P., Timoshenko G.N. — JINR Preprint E16-99-158, Dubna, 1999.*
8. *Govorun R.D. et. al. — In: «Fundamentals for the Assessment of Risks from Environmental Radiation», NATO Science Series, 2. Environmental Security, v.55, Kluwer Academic Publishers. Dordrecht / Boston / London, 1999, p.249.*
9. *Lukasova E. et. al. — In: «Fundamentals for the Assessment of Risks from Environmental Radiation», NATO Science Series, 2. Environmental Security, v.55, Kluwer Academic Publishers. Dordrecht / Boston / London, 1999, p.195.*
10. *Schmakova N.L. et.al. — Nucleonica, 1999, v.44, № 4 (in press).*
11. *Koltovaya N.A. et. al. — Current Genetics, 1999, v.35 (3–4), p.336.*
12. *Зюзиков Н.А. и др. — Радиационная биология. Радиоэкология. 1999, т.39, № 6, с.628.*
13. *Булах Ф.П., Борейко А.В., Красавин Е.А. — Третья научная конференция молодых ученых и специалистов ОИЯИ, Дубна, 1999, с.181.*
14. *Aksenov S.V. — JINR Preprint E19-99-74, Dubna, 1999.*
15. *О.В.Комова и др. — Препринт ОИЯИ Р19-99-40, Дубна, 1999.*
16. *Комова О.В. и др. — Радиационная биология. Радиоэкология (в печати).*
17. *Гришина И.В. и др. — Труды Третьей научной конференции молодых ученых и специалистов ОИЯИ. Дубна, 15–18 февраля 1999 г., с.182.*
18. *Komochkov M.M. — JINR Communication E19-99-295, Dubna, 1999.*
19. *Schmakova N.L. et. al. — Nuclear Medicine, 1999, v.20 (5), p.466.*

UNIVERSITY CENTRE

In 1999, the University Centre (UC) of JINR continued its activities within the first-priority topic «Organization, Maintenance, and Development of the University-Type Educational Process at JINR».

Students of the fourth through sixth years complete their university education at the UC in the following areas:

— nuclear physics;
— elementary particle physics;
— condensed matter physics;
— theoretical physics;
— technical physics;
— radiobiology.

In the spring semester (autumn semester in parentheses) of 1999, there were 80 (69) students from Russia and other JINR Member States at the UC, including 14 (13) students from Moscow State University (MSU), 19 (19) from Moscow Engineering Physics Institute (MEPI), 18 (18) from Moscow Institute of Physics and Technology (MIPT), and 29 (19) from other institutions of higher education.

30 diploma theses were defended by students of MSU, MEPI, MIPT, and other universities, as well as two Bachelor's theses by MIPT students. 44 JINR staff members participated in the education process as lecturers and instructors.

In 1998, a new form of tuition was introduced at the UC: the target training of specialists from the JINR Member States. This year, a second group of fifth-year students of Bratislava Technical University (Slovakia) began studying at the UC on the special programme of training specialists for the cyclotron complex in Slovakia. The students' curricula are individual and coordinated with the Dean's Office of the Faculty of Electrical Engineering and Information Technologies of Bratislava Technical University. The Plenipotentiary Representative of Slovakia allotted a special grant to the UC in 1999.

In the current academic year, the UC and the Laboratory of Theoretical Physics of JINR announced the enrollment of students in the programme of educating theoreticians in elementary particle physics.

In 1999, the N.N. Bogoliubov Scholarship was established at JINR for the most gifted UC students and post-graduates specializing in theoretical physics. The scholarship winners were paid this scholarship for half a year.

The JINR post-graduate studies continued to function in ten specialties of physics and mathematics:

01.04.16 — nuclear and elementary particle physics;
01.04.02 — theoretical physics;
01.01.20 — charged particle beam physics and accelerator techniques;
01.01.07 — computational mathematics;
01.04.07 — solid state physics;
01.04.01 — physics experiment techniques, instrument physics, and physics research automation;
01.04.23 — high energy physics;
05.13.11 — mathematical and software support of computers and computational complexes, systems, and networks;
05.13.16 — computer facilities, mathematical simulation, and mathematical methods in scientific research;
03.00.01 — radiobiology.

In the spring semester (autumn semester in parentheses), there were 46 (44) students at the JINR post-graduate studies. They were distributed over the JINR Labora-

tories as follows: 10 (9) post-graduates at the Laboratory of Theoretical Physics, 10 (9) at the Laboratory of Nuclear Problems, 2 (2) at the Laboratory of Nuclear Reactions, 6 (5) at the Laboratory of Neutron Physics, 3 (3) at the Laboratory of High Energies, 6 (6) at the Laboratory of Particle Physics, 4 (5) at the Laboratory of Computing Techniques and Automation, 4 (2) at the Division of Radiation and Radiobiological Research, and 1 (1) at the UC.

Five UC post-graduates have defended their doctoral theses (two of them did so this year) and work at JINR Laboratories.

In 1999, a lecture cycle under the general title «Modern Problems of Natural Sciences» for post-graduates continued at the UC. Given were lectures «Accelerators of Charged Particles and Colliders», by Prof. I.N.Meshkov, and «Neural Networks and Cell Automata in High-Energy Physics Experiments», by Dr I.V. Kisel.

On September 26–28, Prof. Robert Kragler, Head of the Computational Centre of the University of Applied Sciences in Ravensburg–Weingarten (Germany), visited Dubna at the invitation of JINR. It was his second visit to JINR. During his first visit, which took place in October 1998, he gave a course of lectures at the UC on the «Mathematica» computer system. This time, R. Kragler discussed with Assoc. Prof. S.P. Ivanova, Director of the UC, the prospects for the co-operation between the two educational institutions with regard to student and faculty exchange.

On June 1, a second group of UC post-graduates, who enrolled in the spring of 1996, had a ceremony of completing their studies. Out of 13 post-graduates who had fulfilled their post-graduate programmes, 12 remained at JINR for further work.

The JINR educational programme is being realized and developing in close co-operation with Russia's leading institutions of higher education. The geography of the co-operation between the UC and higher education institutions of Russia is not limited to Moscow. Rather, it extends over all Russia. The target tuition of students, which is a special feature of the UC, has also touched other higher education institutions of Russia.

The UC has agreements on co-operation in education with many higher education institutions of Russia and the JINR Member States. Among them are I.N. Ulyanov Chuvash State University, Far East State University (Vladivostok), and Omsk, Tbilisi, Tomsk, Tula, Tver, and Voronezh State Universities.

In 1999, groups of physics students from Tver State University are studying according to individual curricula and have practice at the Flerov Laboratory of Nuclear Reactions.

INTERNATIONAL CO-OPERATION

To keep up the traditional ties in education and staff training, the student exchange between the UC and universities of Eastern Europe goes on. It has become a tradition to receive student groups and individual students coming to Dubna with visits of acquaintance. Regularly held are summer courses, schools, and special seminars, which are attended by participants from Russia, countries of Western Europe, and CIS. Especially active in co-operation with the UC are universities of Poland, Slovakia, and the Czech Republic.

In May, a workshop on co-operation in education was held at the UC within the Bogoliubov–Infeld programme. A group of professors from the universities of Bialystok, Gdansk, Krakow, Lodz, and Lublin, and Szczecin Polytechnic discussed with the UC authorities the capabilities and areas of the JINR educational programme. The participants of the workshop were acquainted with the scientific programmes of all the JINR Laboratories and visited the basic facilities of JINR. Special attention was paid during discussions to the issues of co-operation with Polish institutes and universities.

The workshop resolution notes expedience of student group visit exchange, the scientific and lecture programmes of the visits to be prepared in advance; exchange of information on schools, seminars, and conferences for students, post-graduates, and specialists; and mutual participation in them. Specially emphasized is high efficiency of diploma research being performed at the JINR Laboratories and the UC under the supervision

by scientists of Polish universities and the JINR Laboratories.

In 1998, A. Kucharska, a student of the Faculty of Physics of Adam Mickiewicz University (Poznan, Poland), had a three-month pre-diploma practice at the Department of Nuclear Physics of the Laboratory of Neutron Physics; this year in May she defended with the «Excellent» grade her Master's thesis «Epithermal Neutron Activation Analysis of Biomonitor Moss Used for Studying Atmospheric Precipitation of Heavy Metals in the Copper Field of Poland». She has been given a recommendation for entering the post-graduate studies of the Ecological School of Zittau (Germany).

In September, the Fifth School of Young Scientists «Problems of Accelerating Charged Particles» was held in Ratmino. Its participants came from Russia, CIS countries, and Slovakia. The School was supported by the JINR Directorate, the UC, the Laboratory of Particle Physics, the Ministry of Science, the Russian Fund for Basic Research, Moscow Engineering Physics Institute, and the Centre of Fundamental Physics in Moscow. The School programme consisted of two parts: 1) Acceleration of heavy ions and their application in nuclear physics and nuclear reactions, and 2) Synchrotron and undulator radiation, and application of synchrotron radiation sources and free electron lasers in physics and adjacent areas of science and industry. The second part of the programme is connected with the training of specialists for the future synchrotron radiation source DELSY. The School participants attended a seminar dedicated to the memory of V.P. Sarantsev.

In October, a group of students of Adam Mickiewicz University (Poznan, Poland) and a group of students and post-graduates from Krakow and Lublin (Poand) visited JINR. Both groups were acquainted with the UC, Laboratory of Computing Techniques and Automation, Phasotron Research Department of the Laboratory of Nuclear Problems, and research performed at the medical beam; they have also visited the Laboratory of Theoretical Physics, Laboratory of Nuclear Reactions, and Division of Radiation and Radiobiological Research.

The student and post-graduate student exchange between JINR and Poland is supported within the Bogoliubov–Infeld programme (in its educational part), which is provided with special financing at the expense of the grant from the Plenipotentiary Representative of Poland at JINR.

Two UC post-graduate students participated in the 35th Winter School on Theoretical Physics «From Cosmology to Quantum Gravity», which took place on February 2–12, 1999, in Poland.

Within the co-operation between the International Atomic Energy Agency (IAEA) and JINR, a second IAEA nine-week regional course on radiation protection was conducted at the UC, which began on September 13. The make-up of the participants was determined by IAEA and its Member States and represented 11 countries of the region. The main aim of the course consisted in educating young specialists and managers for various spheres of the radiation safety infrastructure of these countries on the basis of international recommendations. The course was conducted on the basis of the UC and the Division of Radiation and Radiobiological Research of JINR. Within the course, its participants attended more than 130 lectures and performed 17 laboratory exercises.

25 young specialists of Armenia, Belarus, Bulgaria, Estonia, Georgia, Kazakhstan, Latvia, Lithuania, Moldova, Ukraine, and Uzbekistan attended the lecture course covering physics and biological fundamentals of radiation protection; radiation detection techniques; radiation magnitudes and units; external and internal irradiation monitoring; biological effects of ionizing radiation; radiation safety of personnel; medical irradiation; radiation protection principles; and engineering-related irradiation of population.

Scientific visits were arranged for the course participants to the basic facilities and the radiochemical laboratories of JINR, the Radiological Clinic and the Whole-Body Radiation Counter Laboratory of the Institute of Biophysics (Moscow), and the «Radon» Nuclear Waste Management Enterprise (Sergiyev Posad). The lectures at the course were given by more than 30 leading JINR scientists, and lecturers invited by IAEA.

Summing up the results of the course, Mr A. Bilbao, an IAEA officer and head of an IAEA Department, noted the high professional level of the course and its good organization. In his opinion, JINR's experience in conducting international courses like this, its good educational and organizational potentialities, the availability of highly qualified specialists in all the disciplines taught, and the Institute's unique variety of ionizing radiation sources make the ground for the co-operation between IAEA and JINR in educating specialists in radiation protection for Eastern Europe and Asia becoming permanent.

Within the frames of the programme of the German Service of Academic Exchanges (DAAD) «Leonard Euler Scholarships», a joint project of the UC and the Institute of Theoretical Physics of the University of Giessen (Germany) has been supported. Two UC post-graduates and one graduate student performing theoretical research in heavy ion physics are paid an additional scholarship during the current academic year and will have a month's practice at the University of Giessen.

For the second time, jointly with the Faculty of Physics and Inter-Faculty Centre for Matter Structure and New Materials of Moscow State University (MSU), the UC participated in the conduction of student academic practice in medical physics. For two weeks, 18 students of MSU and Voronezh State University, who had completed their fourth year, attended lectures, had academic practice, and were acquainted with the JINR Laboratories and basic facilities.

In September 1999, the second conference of the European Physics Society «Trends in Physics» was held in London, Great Britain. Assoc. Prof. S.P. Ivanova, Director of the UC, participated in this conference. The UC is a member of the European Physics Education Network (EUPEN).

In early October, the Director of the UC participated in the celebration of the 10th anniversary of friendship between the sister cities of Dubna and La Crosse (Wisconsin, the U.S.) as a member of the Dubna delegation. The negotiations with the rectorate of the University of Wisconsin – La Crosse (UWL) resulted in signing a new Agreement on Co-operation between UWL and the «Dubna» University. The documents were signed that regulate specific measures within the student exchange programme, which also includes the UC.

In the summer of 1999, 18 students of the Nuclear and Engineering Physics Faculties of Prague Technical University spent two weeks in Dubna. They visited the JINR Laboratories and basic facilities, and participated in the conference «New Physics in Non-Accelerator Experiments». The aim of this visit was to lay the foundation of the co-operation between Prague Technical University and the UC. One of the members of this student group, a student of the Department of Experimental Nuclear Physics, will begin studying at the UC in February 2000.

According to the agreement between Lund University (Sweden) and JINR, a UC post-graduate student participated for three months in the DELPHI experiment as a member of the Lund University team.

In May 1999, a UC student participated in the Third Pontecorvo School on Physics, which was held on Capri, Italy. Two UC students participated in the CERN Summer Student Programme.

In August, a UC student participated in a conference of the International Association of Physics Students (IAPS), which was held in Helsinki (Finland). Such conferences are held annually in different countries. Students of physics and chemistry attend these conferences and present there reports on their research. This year, the conference participants came from 38 countries, including Australia, CIS, Portugal, and the U.S. Russia was represented by 5 students.

Since 1999, the UC turns out and retrains workers and specialists, and raises their professional skills. The UC organizes and controls their training on the basis of the JINR Laboratories and divisions. Workers learn new and related specialties both individually and in groups. Altogether, 43 people were trained this year, out of whom 34 JINR staff members acquired professions that are within the jurisdiction of the National Technical Inspection. The qualifications of workers are improved by establishing on-the-job training courses and target training courses. 329 people completed such courses during this year.

92 JINR staff members completed the courses of raising the skills of the engineering and technical staff that were conducted at JINR and other educational institutions of Moscow, St. Petersburg, Obninsk, and Dmitrov.

On-the-job practice was organized at the JINR Laboratories and manufacturing divisions for 42 students of technical schools and colleges.

A branch of the courses of the tuition of entrants to Moscow Engineering Physics Institute (MEPI) was opened. In the academic year 1999–2000, 42 students (in two groups) attend these courses. In November, 30 students of these courses participated in the competition in physics and mathematics hosted by MEPI.

Regularly updated has been information at the UC Web site (http://uc.jinr.ru).

In 1999, the reports on the JINR educational programme were presented:

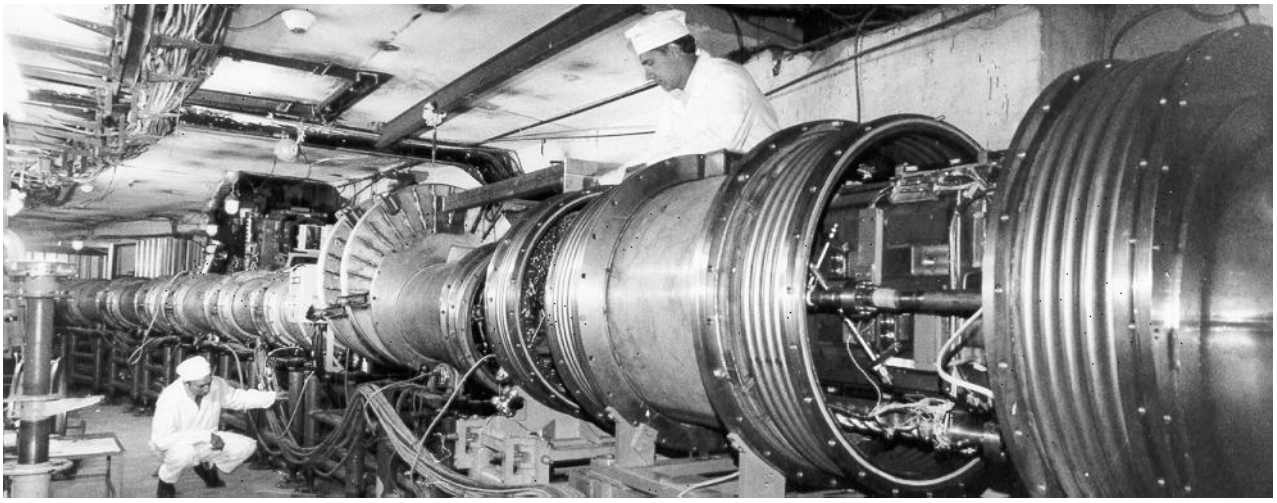
— at the conference of the European Physics Society «Trends in Physics», in the section of the development of physics education in Europe, in the report «Organization of Physics Education at an International Scientific Institute (JINR, Dubna)»;

— at the conference «Science Cities: a Dialogue between Science and Education», in the report «JINR as an Example of a Union of Science and Higher Education».

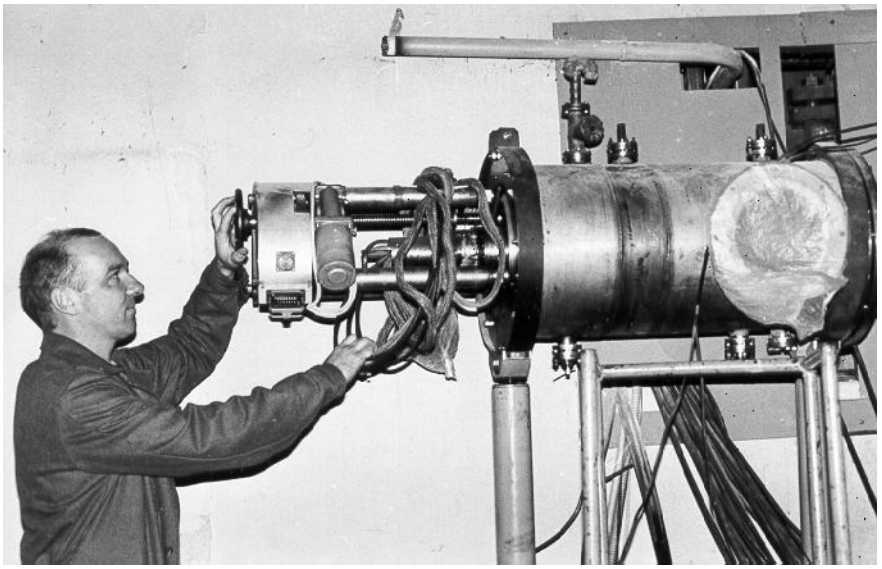
Theoretical research into the interaction between heavy ions and nuclei is performed at the UC (Adamian G., Antonenko N., Ivanova S., Scheid W. — Nucl. Phys. A, 1999, v.646, p.29; Shneidman T., Adamian G., Antonenko N., Ivanova S., Scheid W. — Nucl. Phys. A, in print).

JINR is developing as a large multidisciplinary international scientific centre incorporating basic research in the field of modern nuclear physics, development and application of high technologies, and university education in the relevant fields of knowledge.

Laboratory of High Energies.
Completion of the assembly
of the Nuclotron ring's area
with elements of the beam slow
extraction system

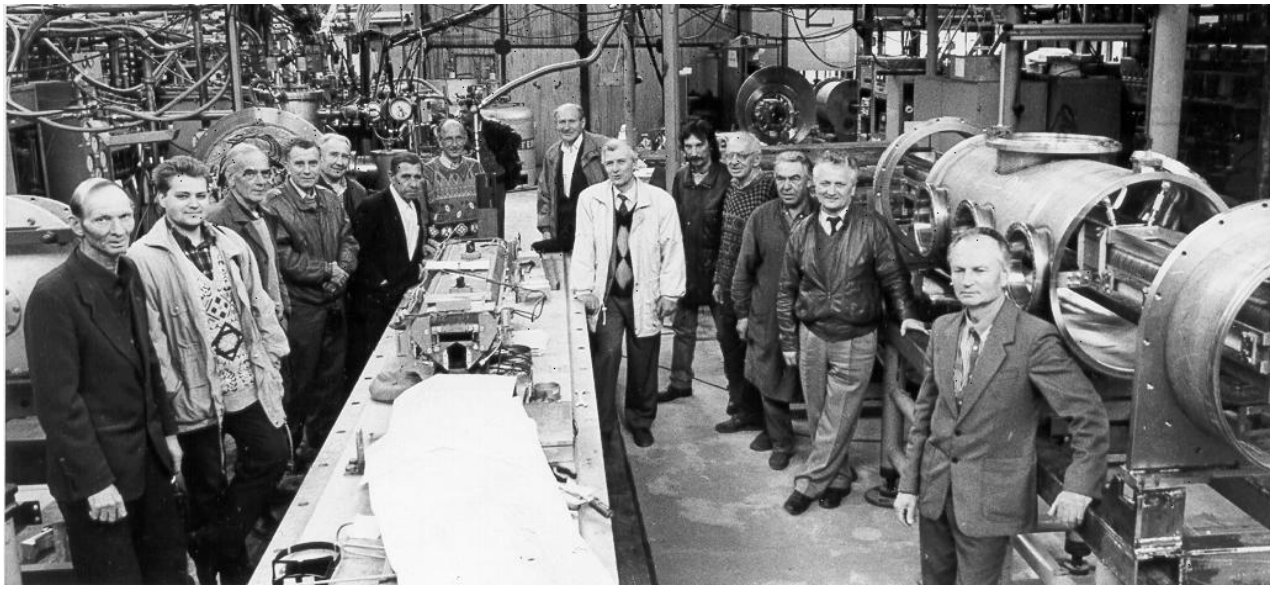


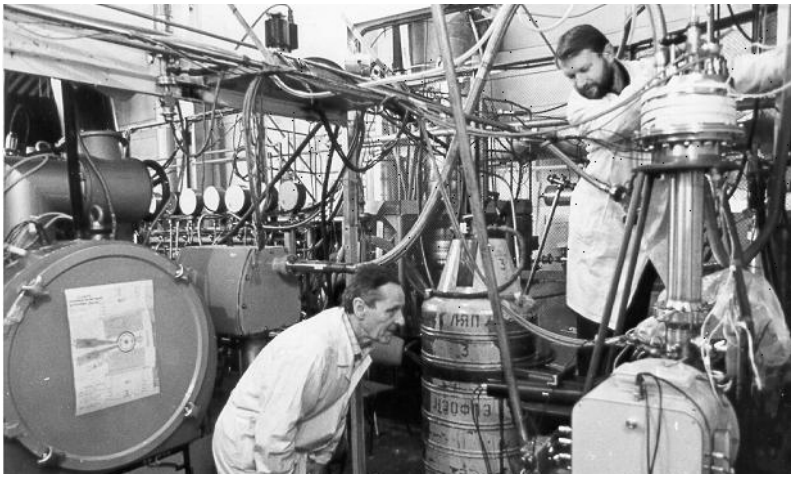
Laboratory of High Energies.
The Scintillation
Magnetic Spectrometer
of Moscow State University (MSU)
for joint JINR-MSU investigations
into the space-time structure
of hadron interactions



Laboratory of High Energies.
The central part of the MARUSYA
set-up — an instrument
for experimental research
of heavy-ion interactions at relativistic
and ultrarelativistic energies

Laboratory of High Energies.
A group of specialists
of the Laboratory — participants
of the construction of the Nuclotron
beam slow extraction system



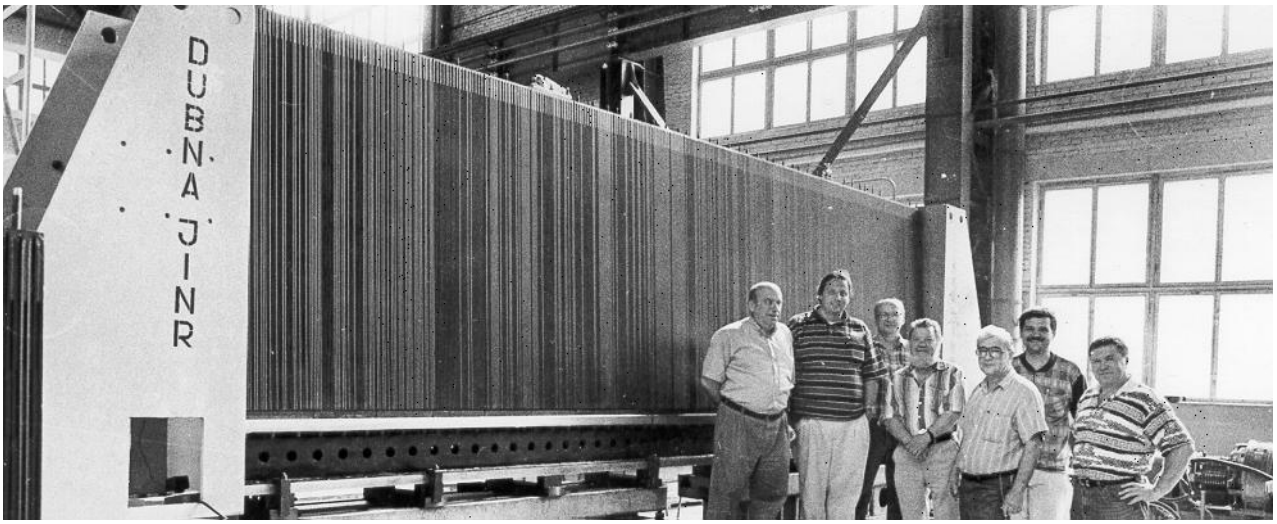


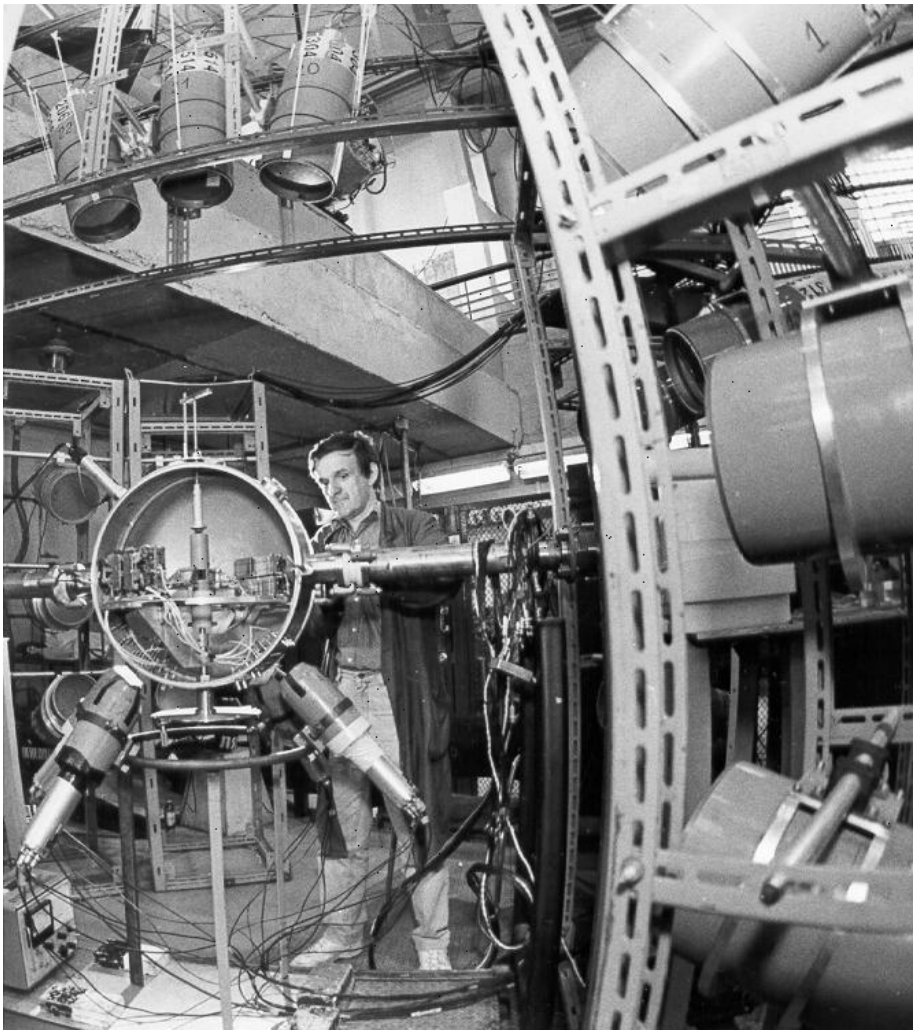
Laboratory of Nuclear Problems.
New equipment being assembled
for the -catalysis
experimental studies

Laboratory of Nuclear Problems. Tests of the cryogenic surgical apparatus developed at the Laboratory for surgical and cosmetic operation

Laboratory of Nuclear Problems. Commissioning of the aerogel production facility constructed by a group of engineers and physicists of Dubna and Bratislava (Slovakia)

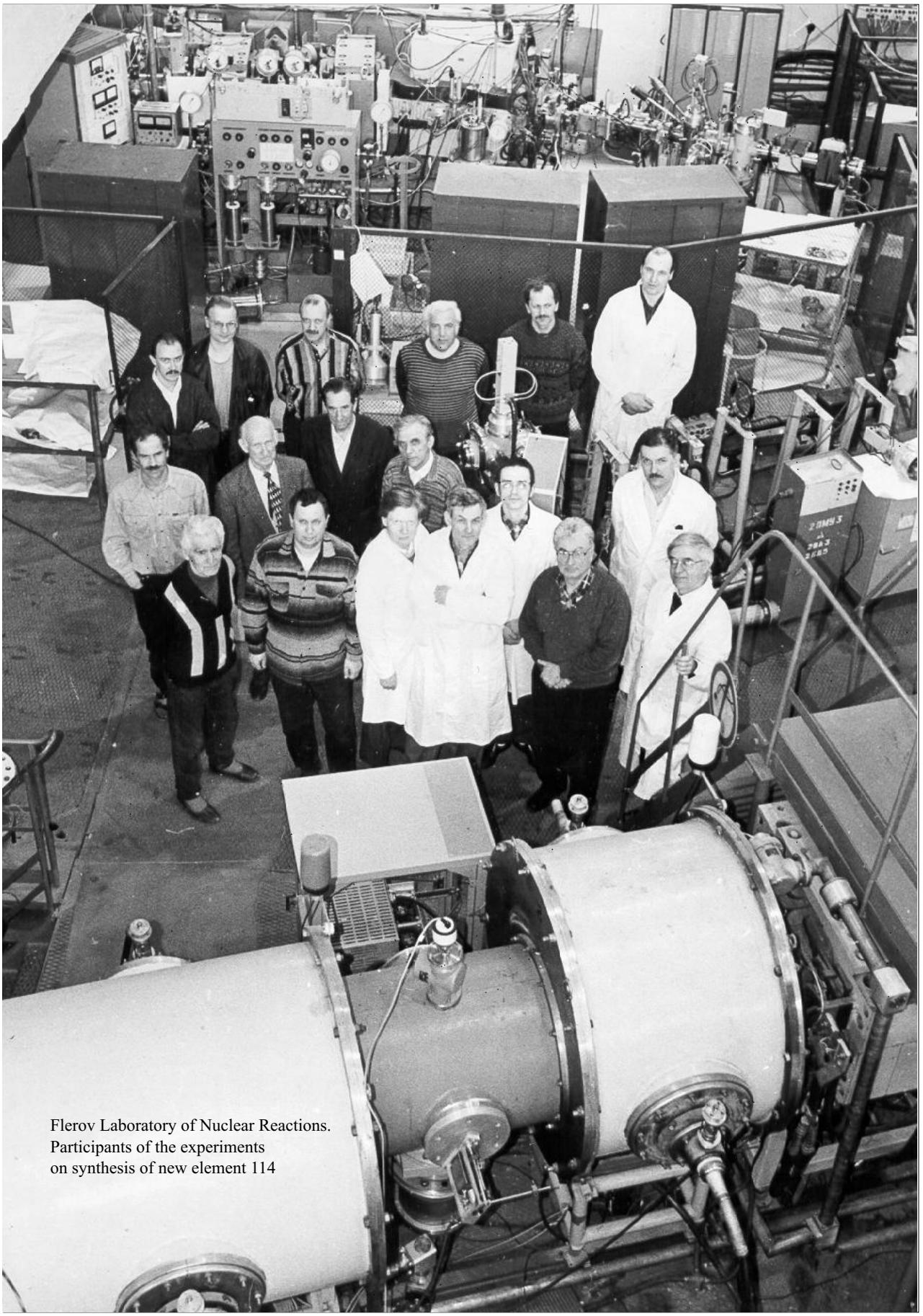
Laboratory of Nuclear Problems. A photograph to remember: assembled at JINR, the first serial module of the hadron tile-calorimeter for the ATLAS facility is ready to go to CERN



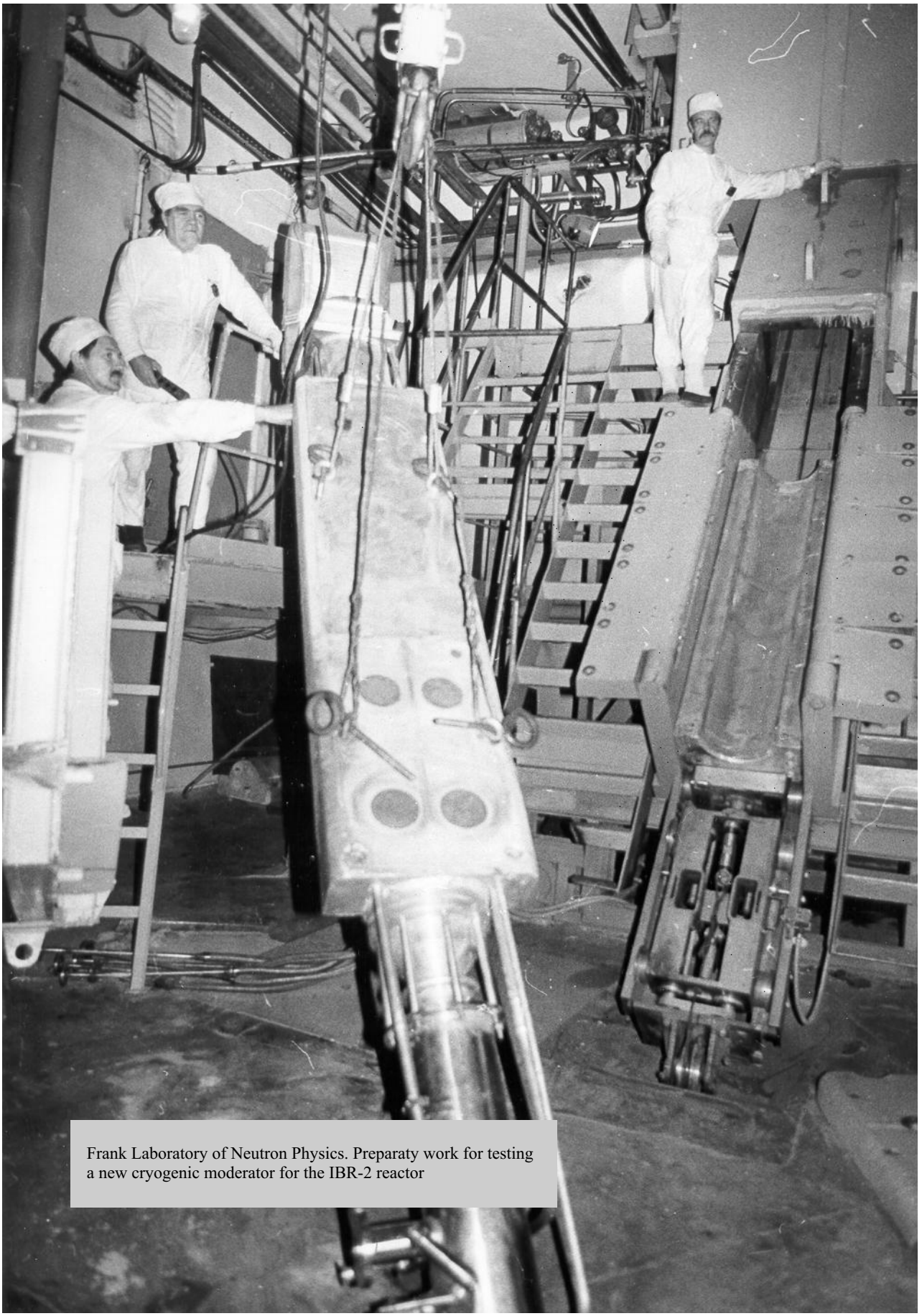


Flerov Laboratory
of Nuclear Reactions.
The CORSET spectrometer,
used to study the fission of heavy
and superheavy nuclei near
and below the Coulomb barrier

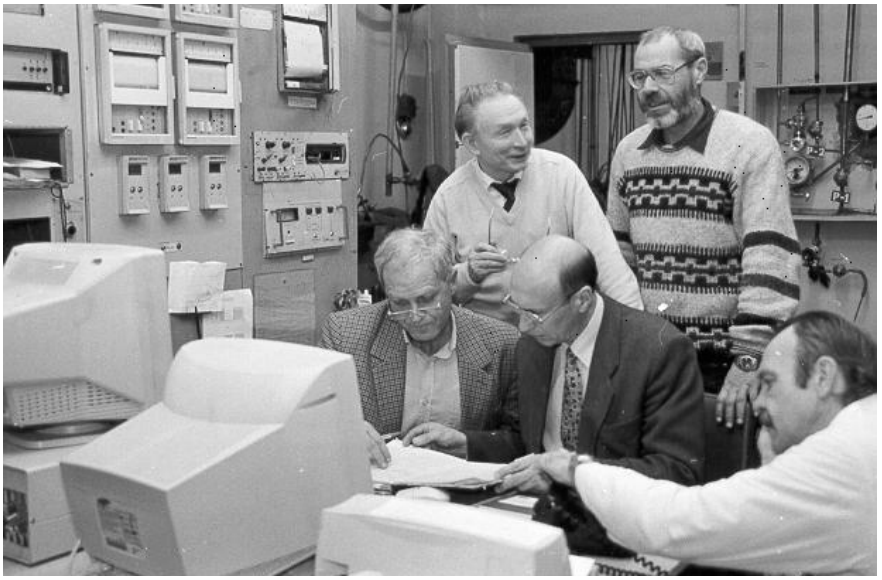
Flerov Laboratory
of Nuclear Reactions.
Participants of the experiments
on fission of superheavy compound
nuclei Z=112, 114, and 118 at ion
beams ^{48}Ca and ^{86}Kr



Flerov Laboratory of Nuclear Reactions.
Participants of the experiments
on synthesis of new element 114



Frank Laboratory of Neutron Physics. Preparaty work for testing a new cryogenic moderator for the IBR-2 reactor

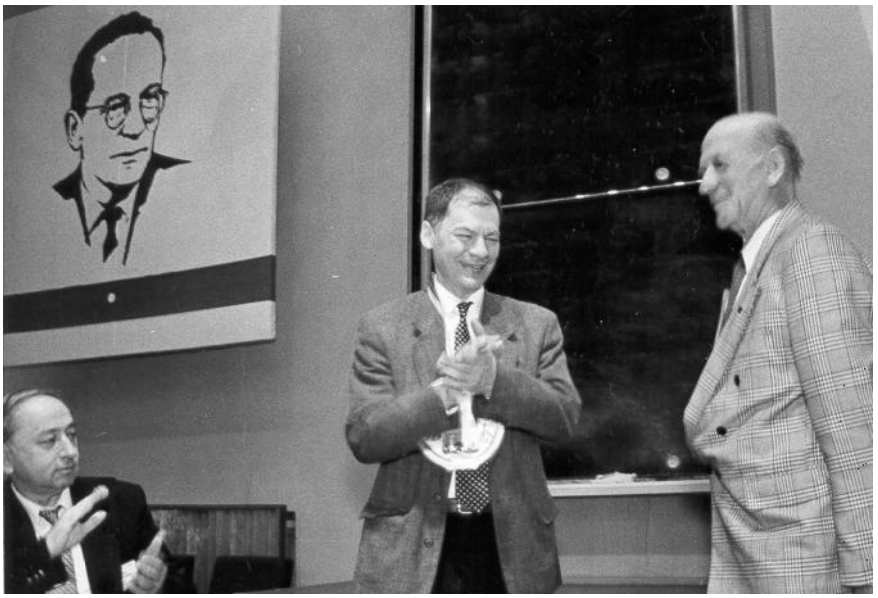


Frank Laboratory of Neutron Physics.
Control panel for testing
the cryogenic moderator
of the IBR-2 reactor

Frank Laboratory of Neutron Physics.
Adjustment of protective suits
for the IBR-2 personnel to dismantle
the reactor's old movable reflector
by controlled explosion technique

Frank Laboratory of Neutron Physics.
Assembling of the neutron chopper
in the FSD diffractometer purposed
for mechanical stress studies
in materials

Laboratory of Particle Physics. Visit by CERN Director-General L.Maiani (centre)



Laboratory of Particle Physics.
Director of LPP V.D.Kekelidze (centre)
accepts congratulations
on the Laboratory's 10th anniversary

Laboratory of Particle Physics.
Members of the JINR
Scientific Council get acquainted
with the Laboratory

Laboratory of Particle Physics. Participants of a meeting
of the Programme Advisory Committee for Particle Physics visiting the computer farm

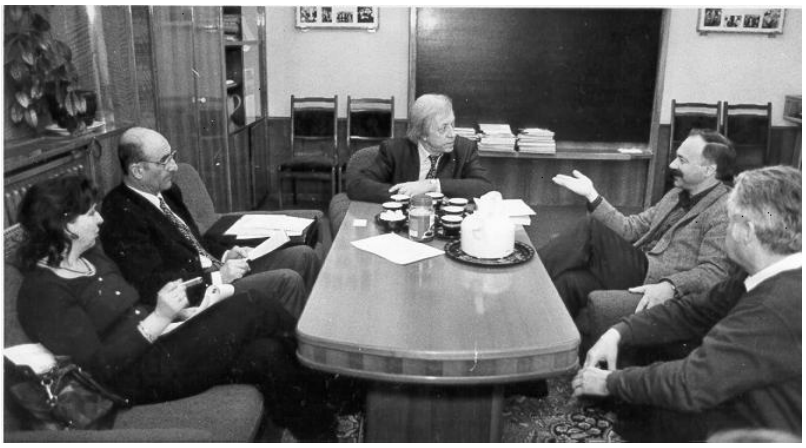
Dubna, 22 September. Participants of the 3rd Scientific Seminar
in Memory of Professor V.P.Sarantsev

JINR University Centre.
A group of students
of IAEA's Regional Training
Course on Radiation Protection

JINR Experimental Workshop.
CERN partners visit JINR.

Dubna. Unloading
of the first vehicle with elements
of the AmPS accelerator delivered
from NIKHEF
(Amsterdam, the Netherlands)

Laboratory of Nuclear Problems.
Work under way to construct
large scintillator counters
for the CDF spectrometry complex
upgrade programme
at the FNAL Tevatron (USA)



Bogoliubov Laboratory
of Theoretical Physics.
Guest of JINR — A.Sempere
(second from left),
Director of the Moscow Office
of the French National Centre
for Scientific Research

Laboratory of Computing Techniques and Automation.
University Professors of Poland visit the Laboratory

Dubna, 17 December.
Ceremonial meeting
of the JINR scientific community
to celebrate the 50th anniversary
of the commissioning of Dubna's first
basic facility — the Synchrocyclotron

CENTRAL SERVICES

PUBLISHING DEPARTMENT

In 1999, the Publishing Department published JINR communications and preprints of 381 titles. Issued were 123 official publications.

A total of 35 proceedings of various conferences, schools and workshops were issued. Among them are proceedings of the workshop «Actual Problems of Physics» (in two volumes), the III International Workshop «Classic and Quantum Integrable Systems», the International Workshop «Self-similar Systems», the XVII International Conference «HEACC-98», the VII International Seminar on Interacton of Neutrons with Nuclei (ISINN)». Published were also the annual reports of JINR for 1998 (in Russian and in English), the annual report of the Frank Laboratory of Neutron Physics for 1998, the report of the Bogoliubov Laboratory of Theoretical Physics for 1997–1998, the collections «The Laboratory of Nuclear Problems in 1996–2000», «JINR LHE Research Programme Proposals».

Published also were the booklets «N.N.Bogoliubov», dedicated to the 90th anniversary of the birth of the outstanding mathematician and physicist, and «V.I.Korogodin. Dedicated to the 70th Birthday». The monographs of the JINR scientists appeared: «An Introduction to Experimental Particle Physics» by A.L.Lyubimov and D.Kiss; «An Introduction to Irreversible Electrodynamics» by I.A.Shelaev.

In 1999, six issues of the journal «Physics of Elementary Particles and Atomic Nucleus» with 30 reviews, and six books «JINR Rapid Communications» with 35 articles, describing original scientific, technological, and applied results, were printed. Publication of the bulletin «JINR News» in the Russian and English languages was continued.

The Publishing Department sent 316 articles and reports by JINR scientists to journals and various conferences, symposia, workshops, schools, held both in the JINR Member States and in other countries. Papers by JINR scientists were published in the «Journal of Experimental and Theoretical Physics», «Theoretical and Mathematical Physics», «Instruments and Experimental Techniques», «Yadernaya Fizika», «Physics of Elementary Particles and Atomic Nucleus», «Physical Review», «Journal of Physics», «Physics Letters», «Nuclear Physics», «Nuclear Instruments and Methods», «European Physical Journal», etc.

Publications of the Joint Institute for Nuclear Research were sent to 44 countries of the world.

To keep readers of the Science and Technology Library up to date as to new publications received, there are bulletins of the Library and of the Intellectual Property Protection and Standardization Office printed by the Publishing Department. Traditionally, the «Bibliographic Index of Papers Published by JINR Staff Members in 1998» was issued.

The Publishing Department was also engaged in Xerox copying and book binding to fulfil numerous orders of JINR Laboratories. About 100,000 various forms were printed for processing of experimental information and for other purposes.

SCIENCE AND TECHNOLOGY LIBRARY

In 1999, the number of readers in the Science and Technology Library was 4,680. Ordered by readers, 1,506 publications were received via the interlibrary loan system. Over 282 Xerox copies of articles from foreign journals were received under the agreement with INTASS. A total of 8,514 books, periodicals, and preprints, about 5,807 of them being in foreign languages, were added to the Library stock from different sources. All these publications are registered in the central catalogue and the branch catalogues.

As of 1 January 2000, the Library stock amounted to over 421,822 copies, 186,380 of them in foreign languages. A total of 156 issues of the bulletins «Books», «Articles», «Preprints» with information on 20, 857 titles were published. The bulletins are distributed among about 200 JINR staff members and mailed at 50 outside addresses. The information bulletins and lists of conferences regularly appear in the WWW and INFOMAG (Moscow). Exhibitions of new books, preprints, periodicals were arranged with 7,800 titles displayed. Two subject exhibitions were held.

The «Bibliographic Index of Papers Published by JINR Staff Members in 1998» (1,668 titles) was prepared.

In 1999, in exchange for JINR publications printed by the Publishing Department, the Library received 5,565 publications from 30 countries, among them 475 from Russia, 198 from Great Britain, 820 from Germany, 632 from Italy, 719 from the United States, 371 from France, 97 from Switzerland, 1,589 from CERN, and 310 from Japan. In addition, the Library receives scientific journals and books (117 titles) from 31 countries and organizations.

INTELLECTUAL PROPERTY PROTECTION AND STANDARDIZATION OFFICE

In 1999, the Intellectual Property Protection Department was changed into the Intellectual Property Protection and Standardization Office, whose basic task was to provide JINR staff members with patent information and technical literature (standards).

The stock of the Standardization Office library includes over 8,000 copies of the State Standard, 632 copies of Specifications, about 800 copies of the All-Russian Standard, 69 copies of handbooks of radioelectronics, and about 1,000 copies of other technical books. In 1999, the library was additionally supplied with the State Standard List, Specifications List, information lists No. 4–12, and 50 copies of the State Standard on the request of various JINR departments.

To create a job certification database, the diskette-based general technical and organization procedure standards (group 1) were purchased with quarterly upgrading of databases for 2000 under the contract with VNIIKI. Selection of scientific and technical documents on the requested topics (nonferrous metals, vacuum technology, etc.) was carried out.

Guidance was provided for elaboration and preparation of technical documents at JINR. Earlier elaborated enterprise standards were revised to comply with the State Standard in force (collections «Abrasive Materials», «Mounting Hardware», «Nonferrous and Ferrous Metals», STP 4601-91).

In 1999, the Office received 72 patent bulletins of the Russian Federation with the information on pending and issued patents. They were analysed from the standpoint of JINR research topics. Based on this analysis, 12 issues of the bulletin «Patents» were published at JINR. The Office keeps 1,660 RF bulletins. The library stock of invention descriptions amounts to 360,000 items.

In 1999, nine applications were submitted for issuing patents to the authors as patent holders. The work with the applications included search for subjects of protection, formulation of the claim, and description of the invention.

Preparation of earlier unpublished inventions for publication was also carried out. Twelve inventions were prepared and submitted to the bulletin «Inventions» for publication.

Patent No. 2132727 for the invention «System for Decomposition of Toxic Compounds» by V.N.Samoilov and S.A.Korenev was issued to JINR.

EXPERIMENTAL WORKSHOP

In 1999, the Experimental Workshop manufactured products to an amount of over 8.5 million roubles on the order of the JINR Laboratories and other departments. These were mainly mechanical equipment, including:

- modules and submodules of the ATLAS Hadron Calorimeter,
- NEMO-3 shielding,
- polymerizers for production of scintillators,
- muon detectors for the D0 experiment,
- units of the U400M accelerator,
- units for upgrading of the polarized neutron spectrometer,
- a prototype kicker for ADT,
- cavity cooling system for the VINCI cyclotron,
- equipment for making the ALICE magnet.

Some of these items were manufactured in collaboration with the scientific centres of the JINR Member States, the United States, France, Yugoslavia, and CERN.

Many orders came from outside customers, among which the Scientific Production Centre «Aspect» with the equipment for monitoring of radioactive materials occupied a prominent place. There was an increase in orders from other enterprises in Dubna, e.g. Business Centre «Magistr», joint-stock company Tensor-Byte. Orders also came from enterprises of various industries in other towns.

ADMINISTRATIVE ACTIVITIES

FINANCIAL ACTIVITIES

The Committee of Plenipotentiaries of the Governments of the JINR Member States approved a budget of 37,500.0 thousand US dollars to cover research, construction of basic facilities, and other JINR activities in 1999. The actual annual receipts amounted to 19,255.0 thousand US dollars, or 51.3% of the annual allocations.

In 1999, the actual research expenditures of the Joint Institute for Nuclear Research amounted to 14,556.3 thousand US dollars (services of JINR managerial departments).

Actual expenditures were as follows:

	Item	Annual budget in thous. US dollars	Actual expenditures in 1999 in thous. US dollars	% of budget
I.	Research	13,567.3	7,089.3	52.3
II.	Basic facilities	6,829.5	2,891.5	42.3
III.	Infrastructure of the Laboratories	5,814.8	2,070.8	35.6
IV.	Infrastructure of the Institute	5,053.0	2,504.7	49.6
V.	On agreement with BMBF less JINR infrastructure and Directorate reserve fund expenditures	1,013.0		
VI.	On agreement with the Hungarian Academy of Sciences less JINR infrastructure and Directorate reserve fund expenditures	127.5		
VII.	Plenipotentiaries' grants, 8% of Member States' contributions	2,897.4		
VIII.	Directorate reserve fund, 5% of budget	1,867.5		
IX.	Savings from item IV for financing development of JINR computer network infrastructure	330.0		
	Total expenditures	37,500.0	14,556.3	38.8

STAFF

As of 1 January 2000, the total number of the staff members at the Joint Institute for Nuclear Research was 5,921 (without temporary staff).

Working at JINR are: academicians of RAS — A.M.Baldin and D.V.Shirkov; corresponding members of RAS — V.P.Dzhelepov, V.G.Kadyshevsky, I.N.Meshkov, Yu.Ts.Oganessian, academicians of other academies of sciences — V.L.Aksenov, I.A.Golutvin, A.V.Eremin, V.I.Korogodin, A.M.Petrosyants, A.G.Popeko, A.N.Sissakian, corresponding members of other academies of sciences — A.S.Vodopianov, I.Zvara, R.M.Mir-Kasimov, A.I.Titov, V.A.Khalkin; 239 doctors of science, 655 candidates of science, including 87 professors and 13 assistant professors.

In 1999, there were 543 people engaged and 659 people discharged because of engagement period expiry and for other reasons.

During the year the JINR staff members were awarded the titles of senior researcher — 4, junior researcher — 1.

In 1999, 27 scientists got a Candidate of Science degree and 13 got a Doctor of Science degree at JINR, among them 22 from JINR, 1 from the Republic of Azerbaijan, 2 from the Republic of Bulgaria, 3 from the Republic of Georgia, 1 from Egypt, 1 from the Republic of Kazakhstan, 1 from Mexico, 2 from Mongolia, 7 from the Russian Federation.

AWARDS

On the eve of the 70th anniversary of the Moscow region, by the decree of the President of the Russian Federation of 3 August 1999 the Order «For Services to the Motherland», IV grade, was awarded to Yu.Ts.Oganessian, Scientific Leader of the Flerov Laboratory of Nuclear Reactions, and the medal of the Order «For Services to the Motherland», II grade, to V.G.Zinov, head of a sector at the Laboratory of Nuclear Problems, for their great contribution to strengthening of the national economy, solution of social problems, and long conscientious work.

For the outstanding services to JINR in development of priority fields in science and technology and in education of scientists, the title «Honorary Doctor of JINR» is conferred upon A.M.Baldin, Scientific Leader of the Laboratory of High Energies (JINR); A.A.Logunov, Director of IHEP (Russia); A.Hrynkiewicz, Professor of the Institute of Nuclear Problems (Poland); H.Schopper, CERN; C.Detraz, Director of the National Institute of Nuclear Physics and Particle Physics.

On the occasion of the 50th anniversary of the synchrocyclotron of the Laboratory of Nuclear Problems and in recognition of the services to JINR, the great contribution to scientific and technological progress, and long fruitful work, the Honorary Diploma of JINR was awarded to L.M.Soroko, senior researcher; N.L.Zaplatin, leading researcher; V.B.Flyagin, chief researcher; S.M.Kirichenko, chief researcher; A.N.Sinaev, acting leading researcher; A.N.Budagov, acting chief researcher.

On the occasion of the 50th anniversary of the synchrocyclotron and in recognition of their services to JINR, the title «Honorary Staff Member of JINR» is awarded to the former JINR staff members who took part in the commissioning of the synchrocyclotron: A.T.Vasilenko, F.E. Gugnin, V.A.Kochkin, N.I.Semenov, V.F.Permyakov, N.T.Grekhov.

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