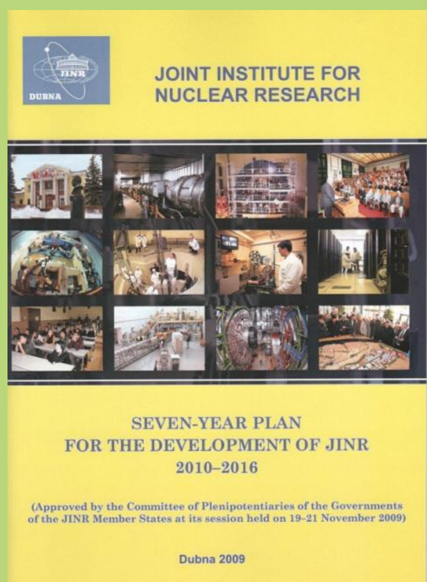
Progress of implementation of the Seven-Year Plan for the Development of JINR (2010–2016) in the main fields of research

(low- and intermediate-energy nuclear physics, nuclear physics with neutrons, and condensed matter physics)

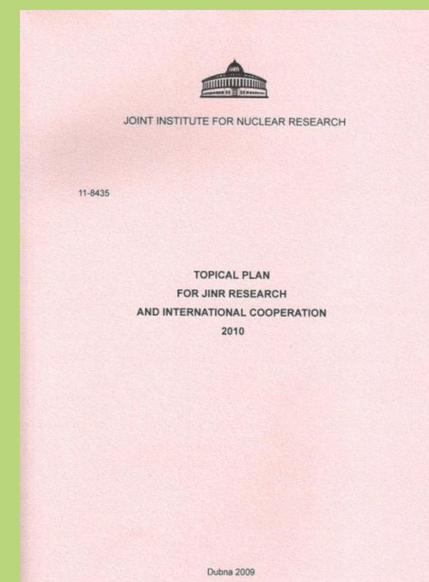


http://www.jinr.ru/7yearplan/Seven_Year_Plan-eng_fin.pdf

N. Russakovich

JINR SCIENTIFIC COUNCIL

108th Session, 23 September 2010



http://wwwinfo.jinr.ru/plan/ptp-2010/title_a0.htm

Facilities in use

- Accelerator Complex of Ion Beams (status to be reported by FLNR Director S.Dmitriev)
- IBR-2M and spectrometers (to be reported by FLNP Director A.Belushkin)
- IREN neutron source
- DLNP Phasotron
- External facilities (ILL and Tver reactors, COSY, PSI, LSM,…)

Research topics (I)

- **Synthesis and Properties of Nuclei at the Stability Limits** (Yu.Oganessian, M.Itkis, 03-5-1094-2010/2014)
- **Non-Accelerator Neutrino Physics and Astrophysics** (V. Brudanin, & A. Kovalik, 03-2-1100-2010/2012)
- **Physics of Light Mesons (** D.Mzhavia , 03-2-1101-2010/2012)
- **Nuclear Physics with Neutrons - Fundamental and Applied Investigations** (V. Shvetsov & Yu.Kopatch, 03-4-1036-2001/2010)

Research topics (2)

- **Investigations of Nanosystems and Novel Materials by Neutron Scattering Methods**

  (V. Aksenov, A. Balagurov & D. Kozlenko, 04-4-1069-2009/2011)
- **Research on the Biological Action of Heavy Charged Particles**
  with Different Energy (E.Krasavin & G.Timoshenko, 04-9-1077-2009/2011)

Theoretical support

- **Nuclear Structure and Dynamics** (V.Voronov & A.Vdovin, 01-3-1071-2009/2013)
- **Theory of Condensed Matter and New Materials** (N.Plakida, V.Osipov & J. Brankov, 01-3-1072-2009/2013)

Applied research

- **Improvement of the JINR Phasotron and Design of Cyclotrons for Fundamental and Applied Research** (L.Onischenko, M.Kazarinov & G.Karamysheva, 03-2-1102-2010/2012)
- **Radiation Effects and Physical Bases of Nanotechnology, Radioanalytical and Radioisotope Investigations on FLNR Accelerators** (S. Dmitriev & P.Apel, 04-5-1076-2009/2011)
- **Medical and Biological Researches with the JINR Hadron Beams** (G.V. Mitsyn, 04-2-1103-2010/2012)

IT & Computing

- **Information, Computer and Network Support of JINR's Activity** (V.Ivanov, V.Korenkov & P.V. Zrelov, 05-6-1048-2003/2010)
- **Mathematical Support of Experimental and Theoretical Studies Conducted by JINR** (V.Ivanov, Gh. Adam & P.Zrelov, 05-6-1060-2005/2010)

↓

13 “themes” having 6 to 15 “year milestones” each

Nuclear Physics

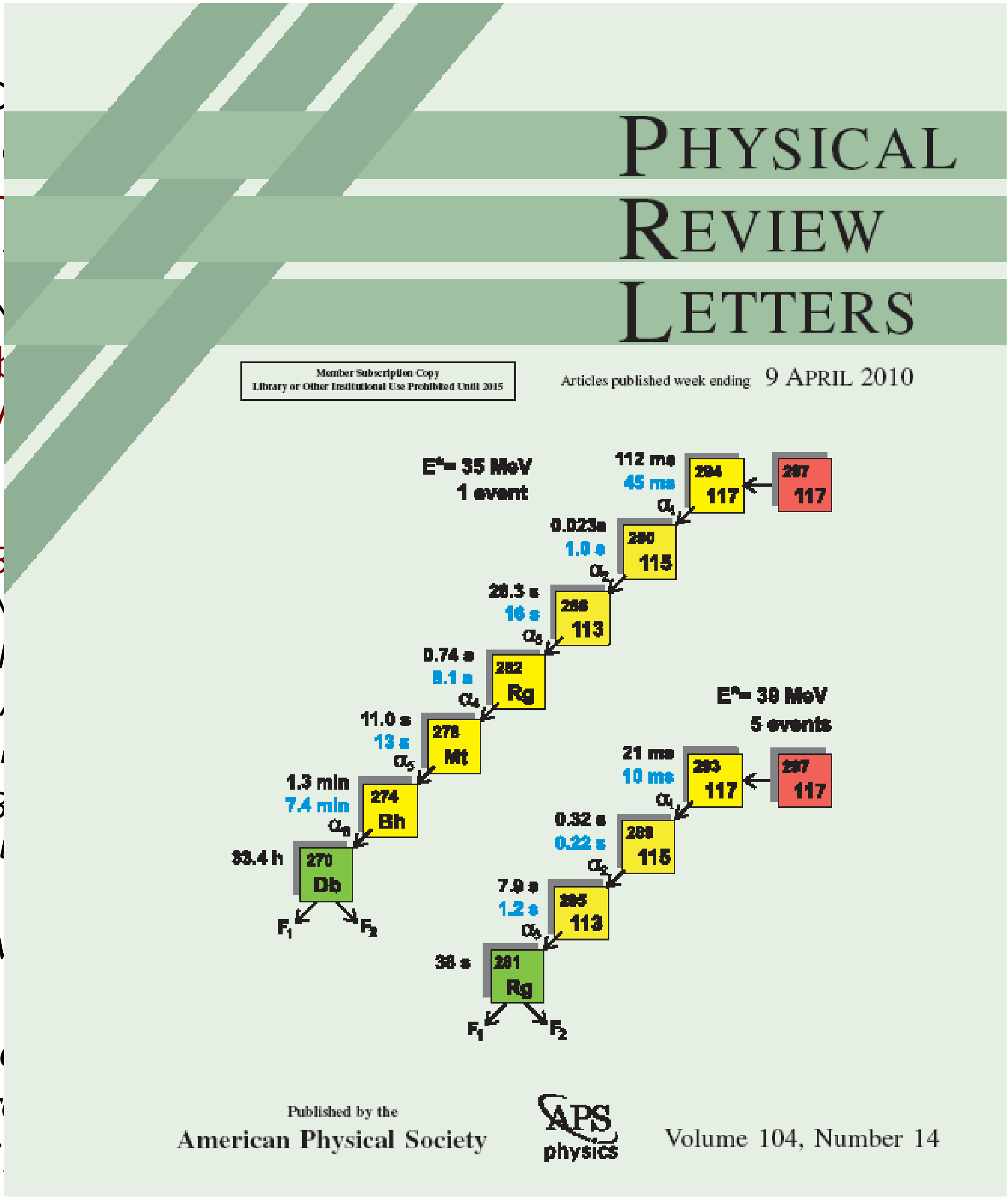
Synthesis of a new element with atomic number Z=117

Yu. Ts. Oganessian,[1)] F. Sh. Abdullin,[1)] P. D
M. E. Bennett,[3)] S N. Dmitriev,[1)] J. G. Ezol
M. G. Itkis,[1)] Yu. V. Lobanov,[1)] A. N. Mezen
A.N. Polyakov,[1)] C. E. Porter,[2)] A. V. Rama
M. A. Ryabinin,[6)] K. P. Rykaczewski,[2)] R. N
I.V. Shirokovsky,[1)] M. A. Stoyer,[5)] V. G. Sub
Yu. S. Tsyganov,[1)] V. K. Utyonkov,[1)] A. A. V
and P. A. Wilk[5)]

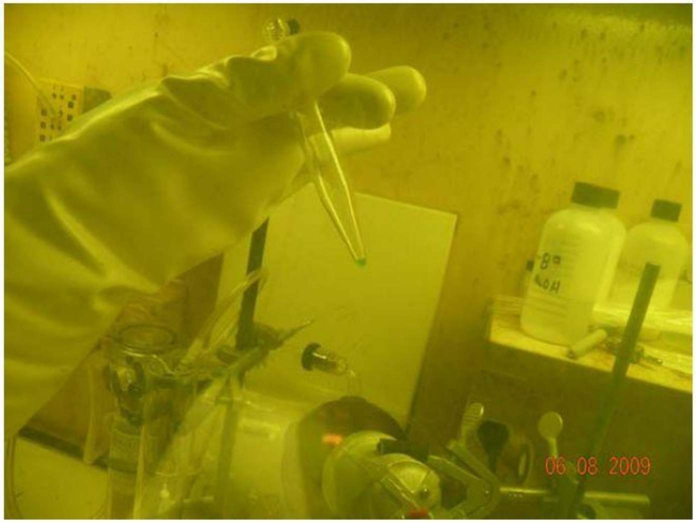
1 Joint Institute for Nuclear Research, RU-14198
2 Oak Ridge National Laboratory, Oak Ridge, TN
3 University of Nevada Las Vegas, Las Vegas, N
4 Vanderbilt University, Nashville, TN 37235, USA
5 Lawrence Livermore National Laboratory, Liver
6 Research Institute of Atomic Reactors, RU-433

(Dated: Apri

The discovery of a new chemical element w
^{293}117 and ^{294}117 were produced in fusion
involving eleven new nuclei were identified
The measured decay properties show a str
validating the concept of the long sought i



Scientific Collaboration and Material Transfer Agreement
between the
UT-Battelle, LLC, the Management and Operating Contractor
for Oak-Ridge National Laboratory, Oak Ridge, TN, USA
and
the FLNR JINR, Dubna, Russia

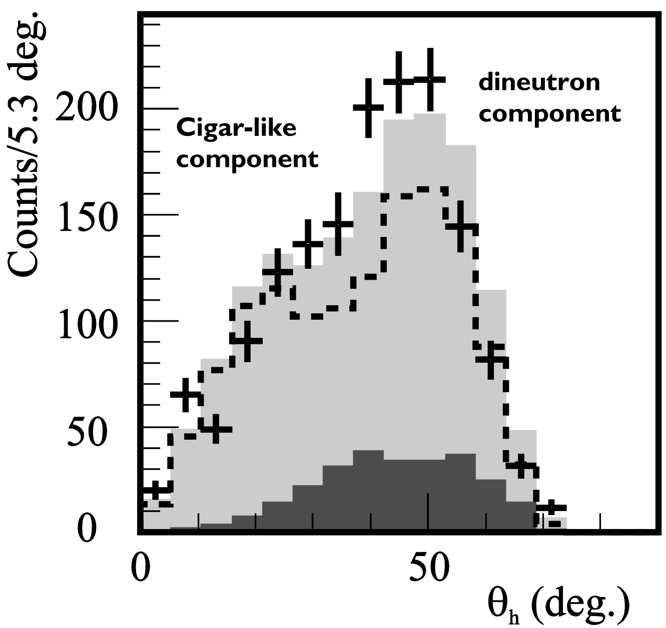


$Bk(NO_3)_3$Product

The purified product contained 22.2 mg of ^{249}Bk, approximately 1.7 ng of ^{252}Cf, and no other detectable impurities.

New agreement between ORNL and JINR is signed for the next 5 years.
This will allow to continue synthesis of superheavy with exotic targets, and, especially, to study their chemical properties.

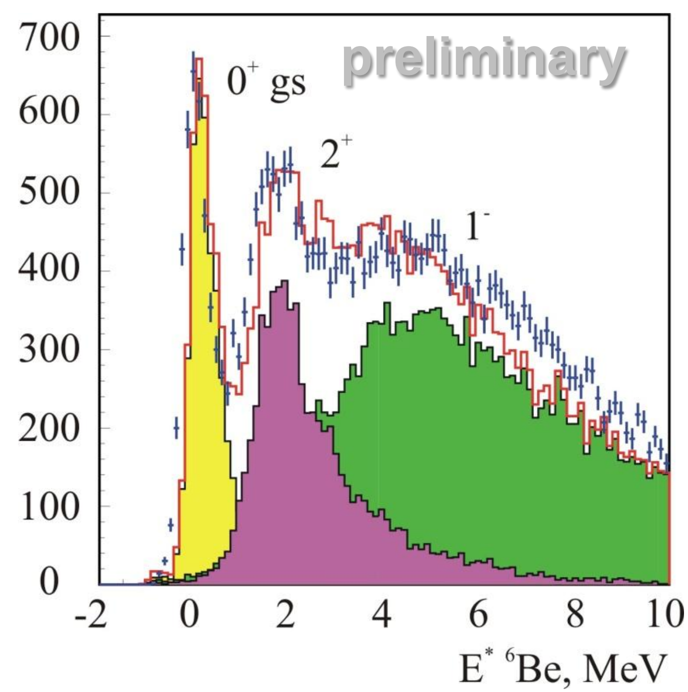
Structure of light exotic nuclei near and beyond the drip-lines



The direct experimental manifestation of the dineutron and cigar-like components of the ^{6}He WF was observed in the reaction of quasifree scattering $^{4}He(^{6}He,2\alpha)2n$.

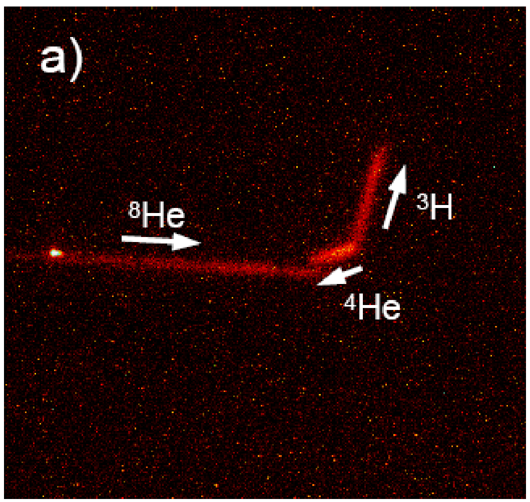
NPA 840 (2010) 1-18

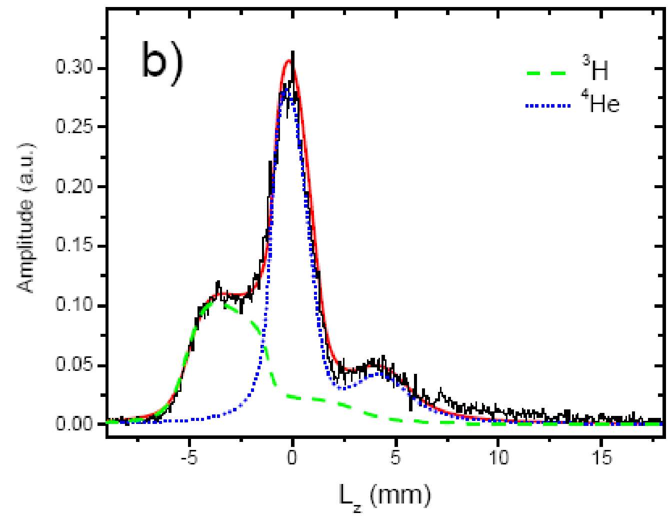
For the first time the isovector soft-dipole mode of excitation (1^{-}) was discovered in the spectrum of unbound proton-rich nuclear system ^{6}Be obtained in the reaction $^{6}Li+p$



Test of the Optical Time Projection Chamber at the ACCULINNA facility

The image of the Beta-delayed triton decay of ^8He obtained with the use of OTPC





^{4}He:

$L = (18 \pm 2)$ mm
$E = (1000 \pm 50)$ keV
$\Theta = (84 \pm 5)^\circ$
$\varphi = (200 \pm 5)^\circ$

^{3}H:

$L = (35 \pm 3)$ mm
$E = (640 \pm 40)$ keV
$\Theta = (98 \pm 5)^\circ$
$\varphi = (77 \pm 5)^\circ$

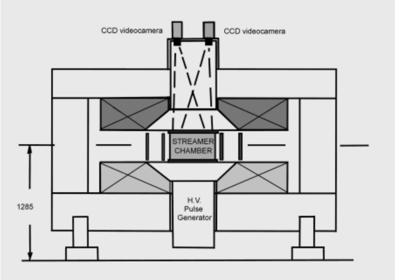
n:

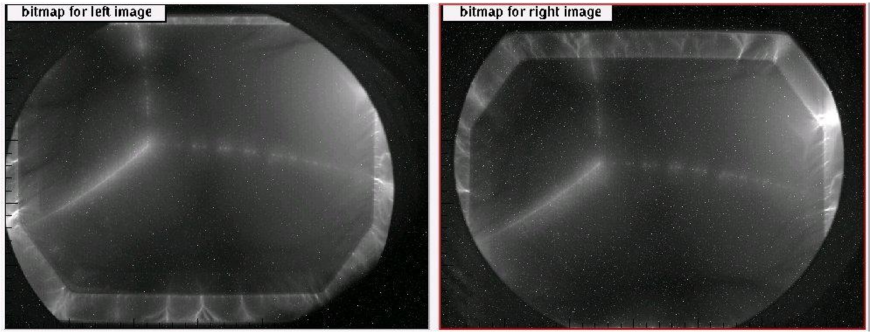
$E = (2.7 \pm 0.4)$ MeV

$Q = (4.3 \pm 0.4)$ MeV

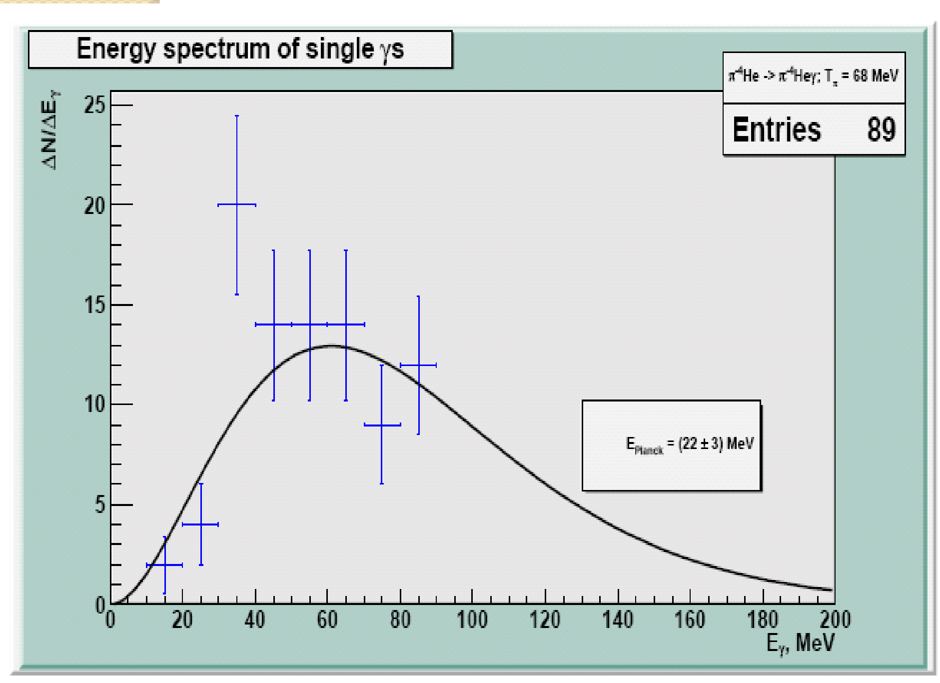
APPB, V. 41, N2 (2010) 449-456

PAINUC - pion interactions with light nuclei





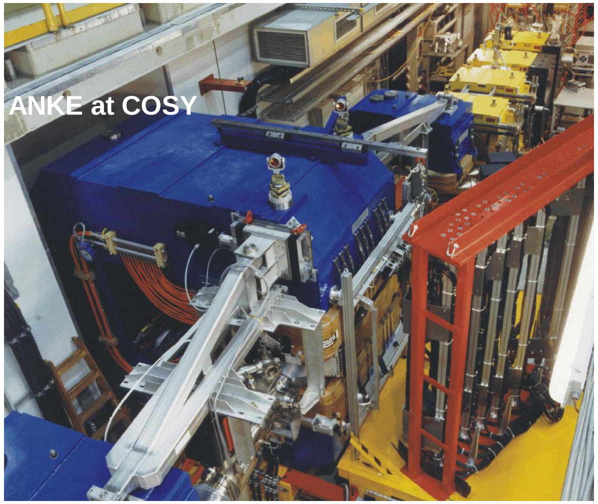
The JINR-INFN (Italy) experiment PAINUC has observed single γ-quantum production in "elastic" $\pi^{-}\,{}^{4}He \rightarrow \pi^{-}\,{}^{4}He\,\gamma$ interaction at 106 MeV.



Preliminary results at 68 MeV also reveal single γ-production.

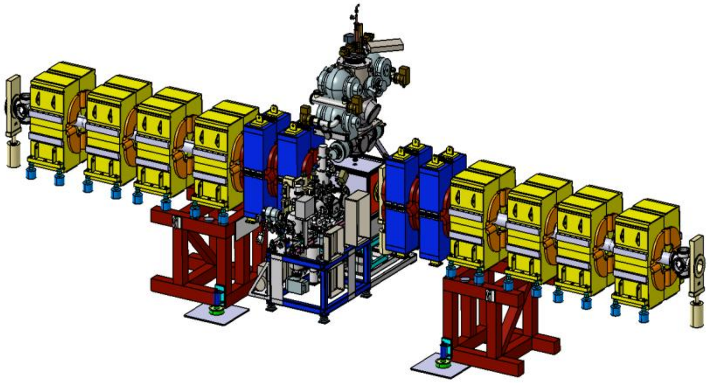
If the excited ${}^{4}He$ nucleus is a Planck radiator, one obtains a Planck temperature $E_{Planck} = 22 \pm 3$ MeV

SPRING



Study of *NN*-interaction dynamics at intermediate energies with the **ANKE** setup at **COSY** in Jülich

Preparations for experiment PAX at GSI ai to study the spin structure of the nucleon in double-polarized *p*↑*p*↑ interactions.



current stage: study of spin filtering (method of the beam polarization) with COSY.

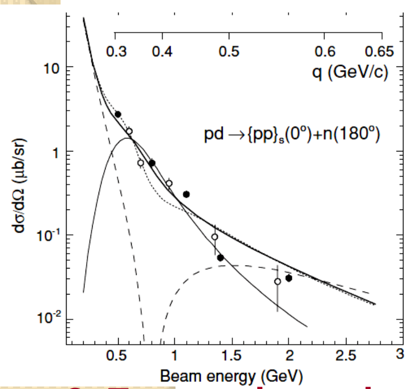
Summer 2010: installation of the equipment in the beam line
Autumn 2010: commissioning and measurements

SPRING project - results of 2010

1. Deuteron breakup pd→$(pp)_s$n with forward emission of a fast $^1S_0$ diproton

S.Dymov et al., Phys.Rev. C81 (2010) 044001

Energy dependence of the differential cross section



Energy and angular dependences have been measured in the 0.5-2.0 GeV proton beam energy range

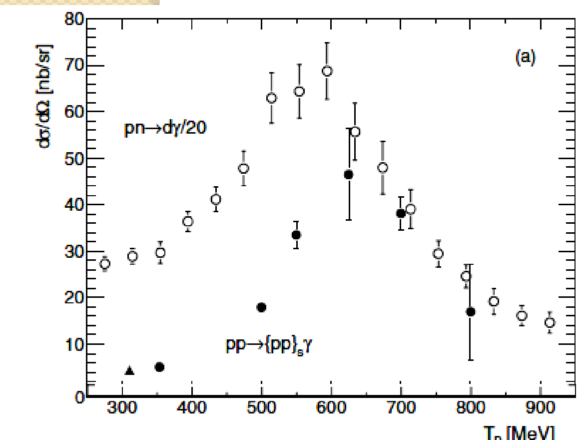
The main conclusion from the fulfilled extensive experimental measurements:

in order to describe the data, rather soft NN-potential, like CD-Bonn, should be used, together with the ONE+SS+Δ model.

2. Energy dependence of hard bremsstrahlung production in proton–proton collisions in the Δ(1232) region

D.Tsirkov et al., J. Phys. G: Nucl. Part. Phys. **37** (2010) 105005

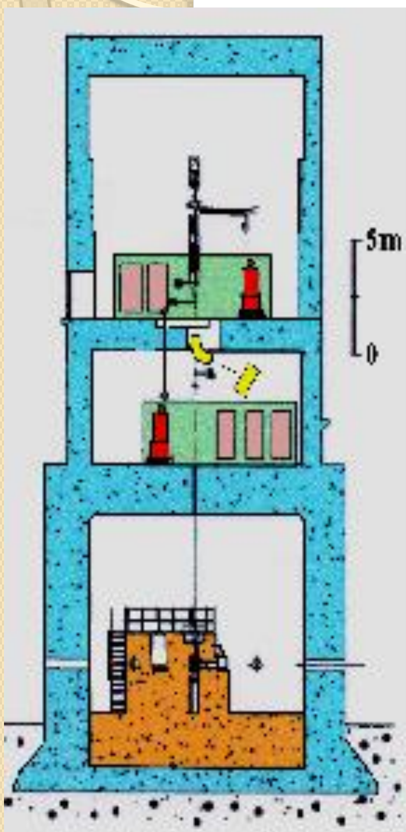
The diproton photodisintegration has been studied via inverse process pp→$\{pp\}_s\gamma$ at 0.35-0.8 GeV.



Differential cross section of pp→$\{pp\}_s\gamma$ (full circles – ANKE data, triangle at 310 MeV – CELSIUS-WASA) and, for comparison, of well studied pn→dγ, divided by 20 (MAMI data).

Energy dependence is found to be consistent with excitation of Δ(1232) in intermediate state in spite of its main contribution is suppressed due to selection rules.

IREN Development



- IREN facility operated 470 hours in 2010 (plan for 2010 – 700 hours);
- New 3-electrode electron gun was designed and manufactured;
- Purchase of the Toshiba E3730A klystron is in progress;
- Experimental and educational program at IREN started

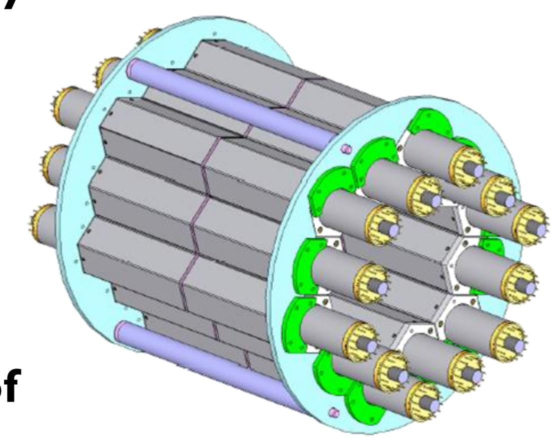
IREN instrumentation

Construction of multisectional gamma-quantum and neutron detector for measurements of capture, transmission and fission cross sections, alpha coefficient for reactor and constructional materials.

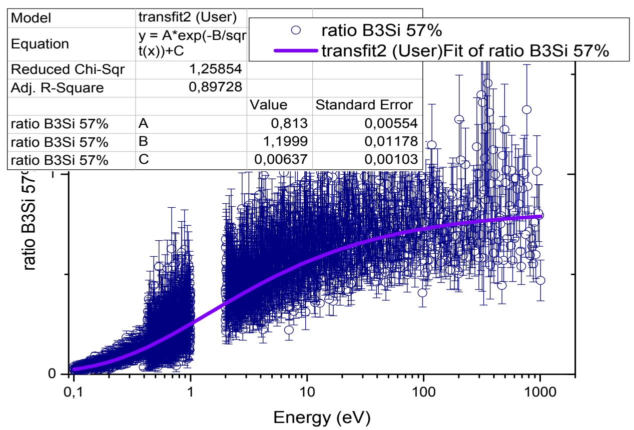
The multisectional detector "Romashka" is being constructed in collaboration with the Institute for Scintillation Materials (Kharkov, Ukraine).

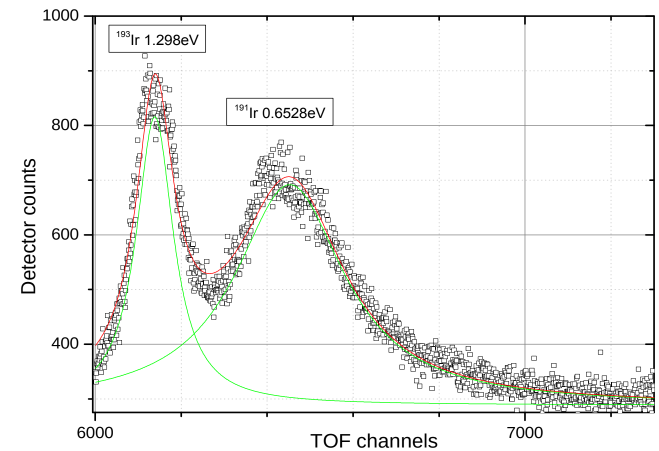
Current status (September, 2010):

- **Optimization of the detector geometry has been performed, which includes the possibility of mounting two HPGe detectors.**
- **Mechanical structure has been designed.**
- **A set of digital electronics for 16 channels (extendable to 32) has been ordered (will be ready in October-November).**
- **The construction of the first stage of the detector (6 crystals) is expected by the end of 2010.**



Experiments at IREN





Analysis of the boron content in ceramics by neutron transmission at IREN

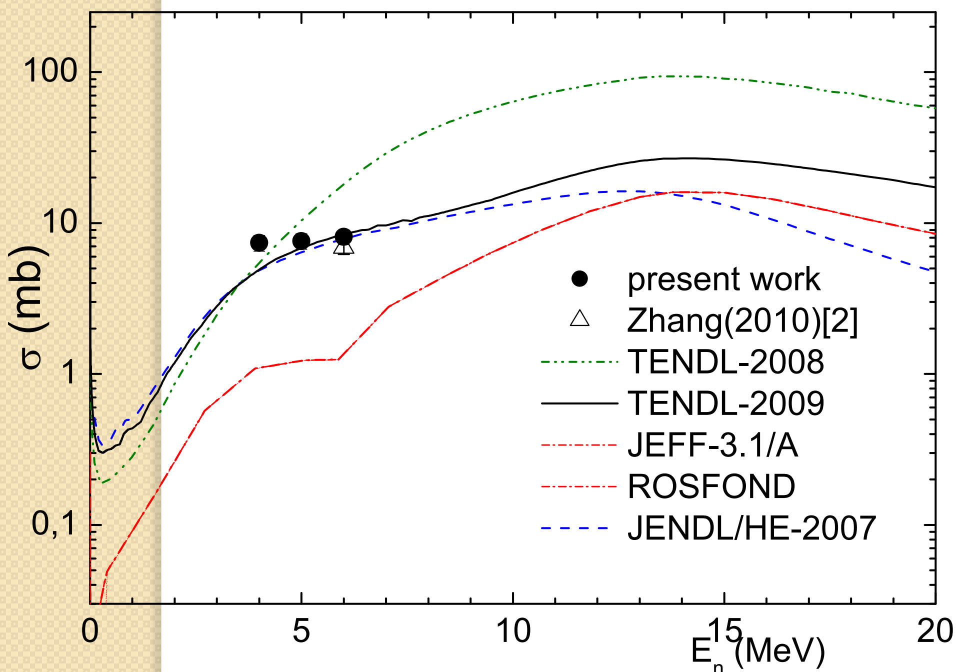
Sample	$n_B \cdot \sigma_B^{th} \cdot x$	$n_B \cdot 10^{21}$, см$^{-3}$	Boron mass in sample, г	Weight fraction in the sample, %
Amorphous boron 45% + phosphatic matrix	7.54(5)	24,6(2)	1,25(1)	27.5(2)
Amorphous boron 69% + phosphatic matrix	9.46(9)	24,1(2)	1,56(2)	34.7(3)
Boron silicide (B_3Si) 57% + phosphatic matrix	6.72(6)	21,9(2)	1,11(1)	21.1(2)

Analysis of the Platinum group elements content in the geological sample by Neutron Resonance Capture Analysis

Element \Sample	**S-1**	**S-2**
Os	**21.0 ± 6.5**	**19.5 ± 5.5**
Ir	**13.7 ± 3.9**	**13.0 ± 3.9**
Pt	**13.0 ± 3.9**	**14.3 ± 3.9**
Au	**0.059 ± 0.018**	**0.017 ± 0.006**
Ru	**4.3 ±1.3**	**3.9 ± 1.3**

Investigations of properties of atomic nuclei

Cooperation with China within Nuclear Data program



Cross sections of the 67Zn(n,alpha)64Ni reaction compared with existing data: Evaluated Nuclear Data File (ENDF) Database, v. Feb. 23 2010 Guohui Zhang et. al.

Eur. Phys. J. A, 43, 1 (2010).

Experiments with ultracold neutrons in ILL

Nuclear Instruments and Methods in Physics Research A 611 (2009) 314–317

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Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

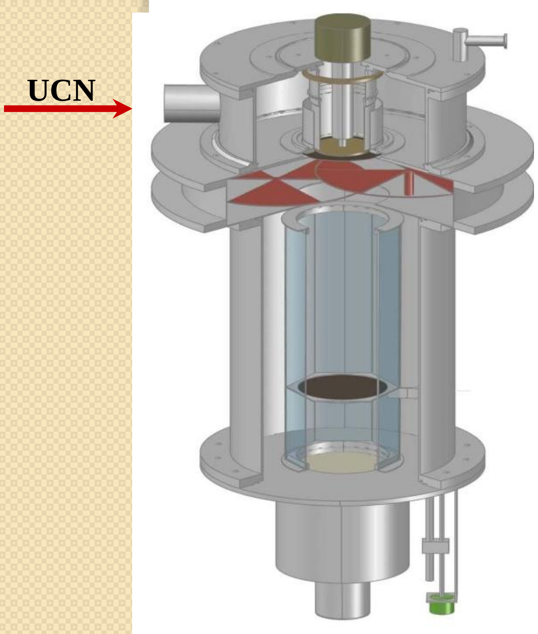
New test of the weak equivalence principle for neutrons

A.I. Frank [a,*], P. Geltenbort [b], M. Jentschel [b], G.V. Kulin [a], D.V. Kustov [a,c], V.G. Nosov [d], A.N. Strepetov [d]

[a] Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Moscow, Russia
[b] Institut Laue-Langevin, Grenoble, France
[c] Institute for Nuclear Research, Kiev, Ukraine
[d] Russian Research Centre Kurchatov Institute, Moscow, Russia

2007 -2009:

$$1-\frac{m_g a_n}{m_n g} = (1.8 \pm 2.1)\cdot 10^{-3}$$

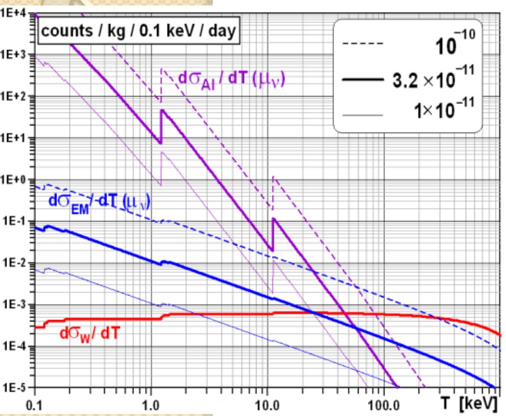


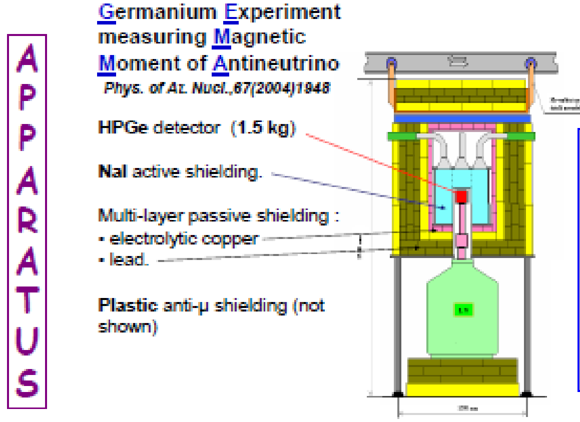
Scheduled beam time for the test of new spectrometer
27 October – 17 December 2010

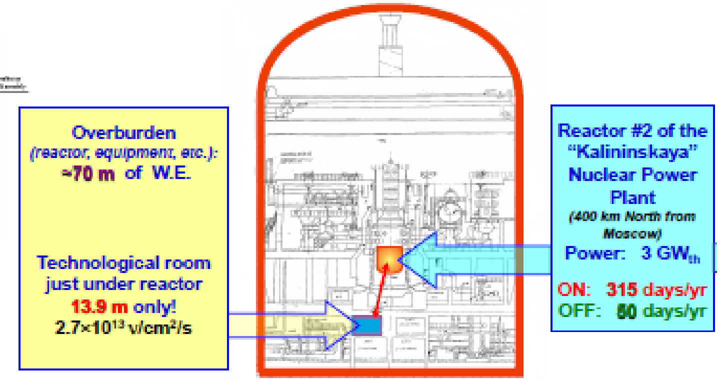
Estimated precision 10^{-4} will be reached probably during 2011

Non-Accelerator Neutrino Physics and Astrophysics

Search for Neutrino Magnetic Moment (GEMMA)

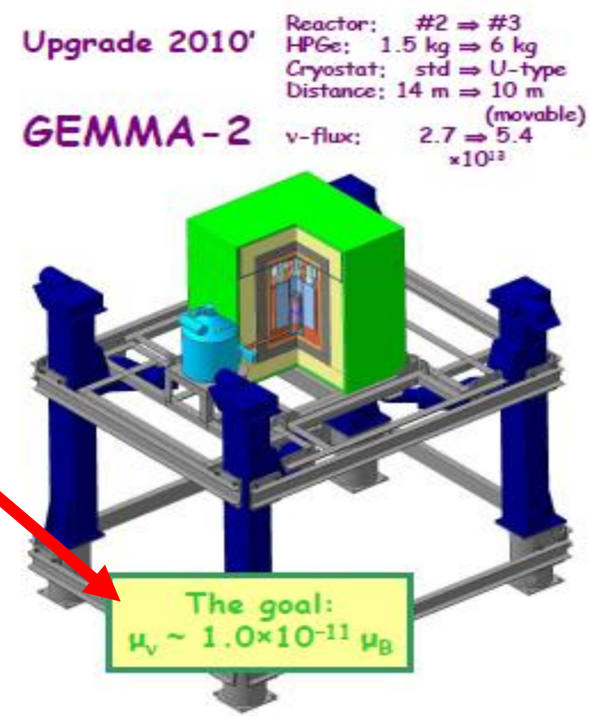




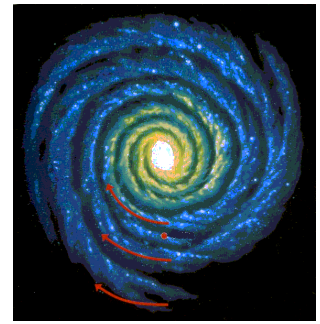


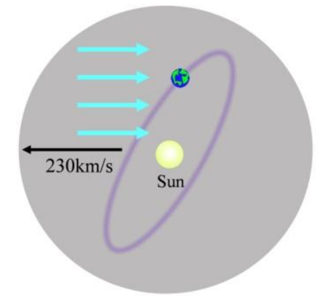
PRESENT:

- *TEXONO (Taiwan, 2006):* $\mu_\nu < 7.4 \times 10^{-11}\ \mu_B$
- *GEMMA phase I (2006):* $\mu_\nu < 5.8 \times 10^{-11}\ \mu_B$
- *BOREXINO (2008)* $\mu_\nu < 5.4 \times 10^{-11}\ \mu_B$
- *GEMMA phase I+II (2009):* $\mu_\nu < 3.2 \times 10^{-11}\ \mu_B$

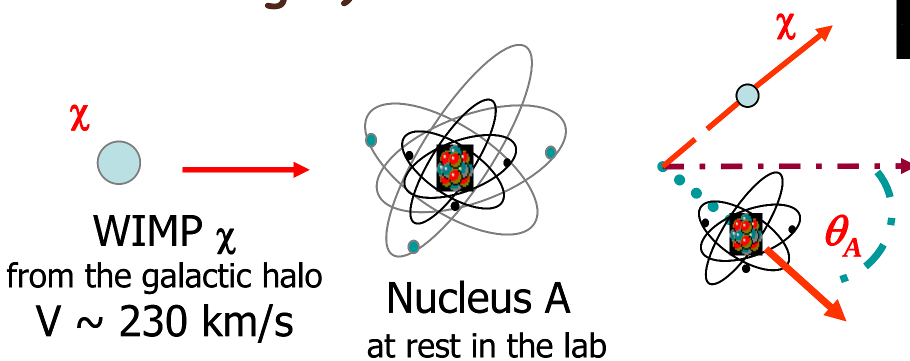


Search for Cold Dark Matter (EDELWEISS)





EDELWEISS-II experiment search for events of WIMP-nucleon scattering (with Ge as the target)



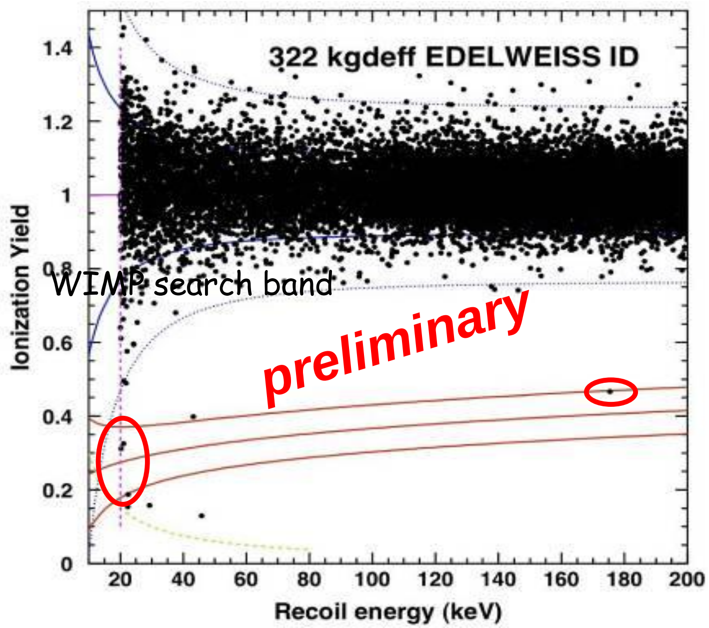
$$E_R = E_\chi \frac{4 M_A M_\chi}{(M_A + M_\chi)^2} \cos^2\theta_A$$

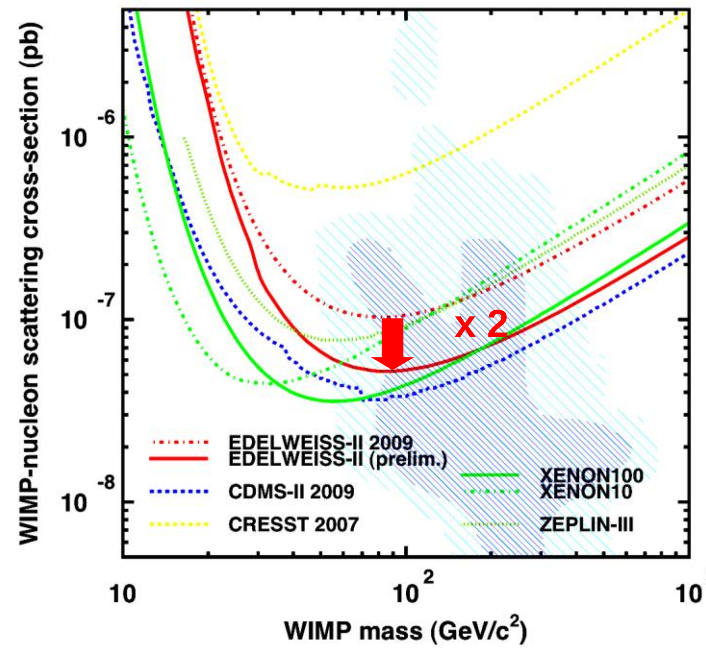
- Main experimental challenges are:

event rate is ultra small (below of 1 per 100 kg of matter per day);

energy deposition is tiny (below of 100 keV)

EDELWEISS results





3 evts near threshold + 1 evt at 175 keV in the NRB

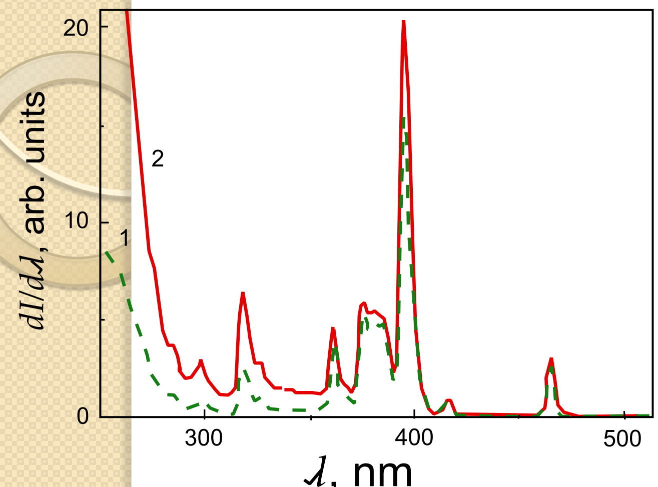
Best limit: σ_{SI}(W-N) ≤ 5.0x10^{-8} pb (5.0x10^{-44} cm^2) at M_{WIMP} = 80 GeV (90%CL)

→ new unknown background starts to appear?

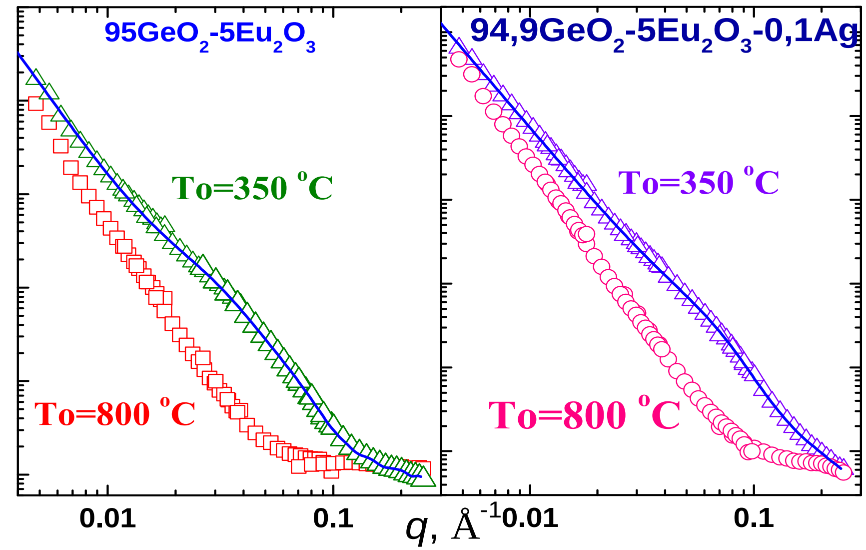
Condensed Matter

Nanosystem GeO_2-Eu_2O_3-Ag:

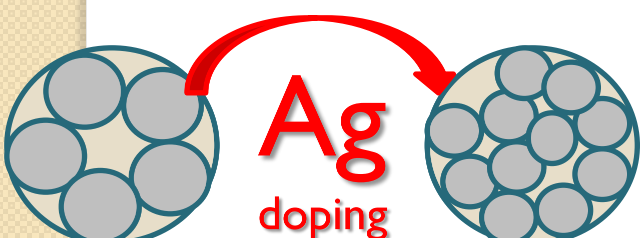
Luminescence control by nanoclusters formation



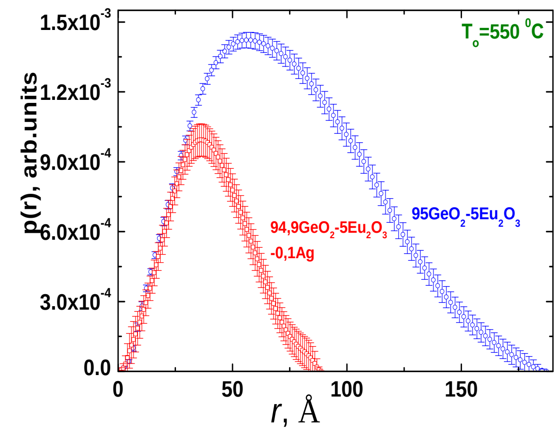
Spectra of luminescence excitation of Eu^{3+} ions in 95,0GeO_2-5Eu_2O_3 (1) and 94,9GeO_2-5Eu_2O_3-0,1Ag (2)



SANS curves at different annealing temperatures (measured at GKSS, Germany)



Decrease of the nanoclusters size in about 2 times

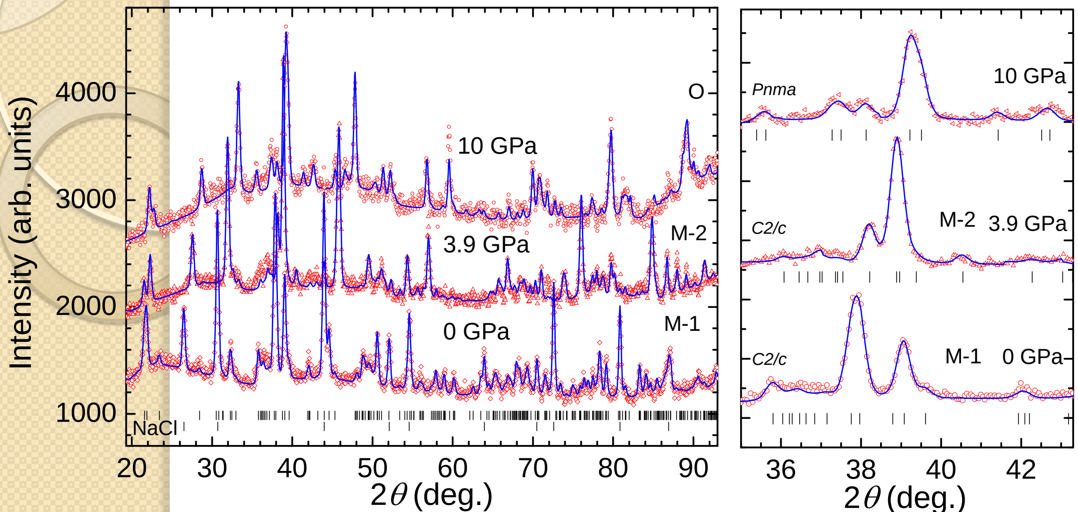


Cluster size distribution functions

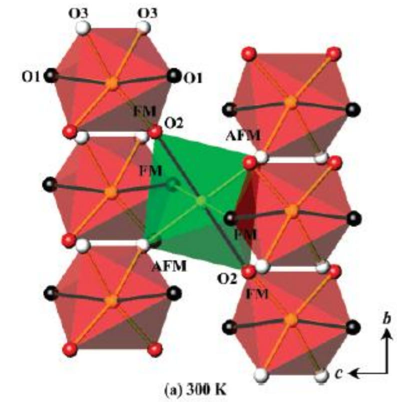
An increase in the intensity of luminescence excitation lines $^7F_0 \rightarrow {}^5L_6$ (λ~395 nm) and $^7F_0 \rightarrow {}^5H_6$ (λ~318 nm) of Eu^{3+}

A.V.Belushkin et al., Adv. Nat. Sci.: Nanosci. Nanotechnol. (2010)

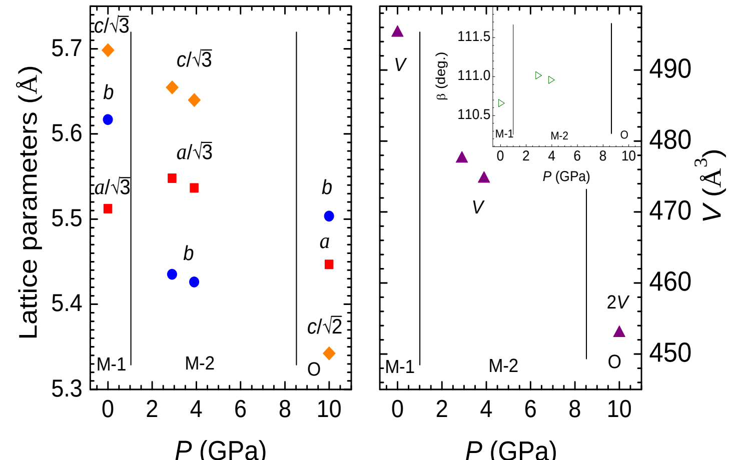
Structural and magnetic phase transitions in multiferroic $BiMnO_3$ in wide range of thermodynamic parameters (pressure, temperature)



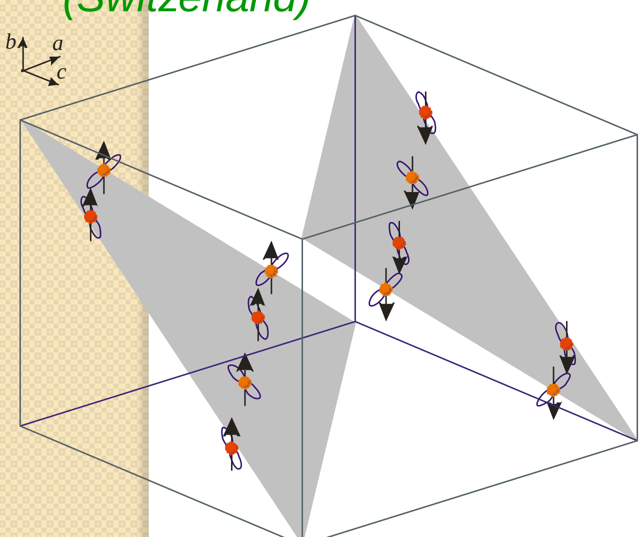
Neutron diffraction patterns of $BiMnO_3$ at elevated pressures and ambient temperature, measured at PSI (Switzerland)

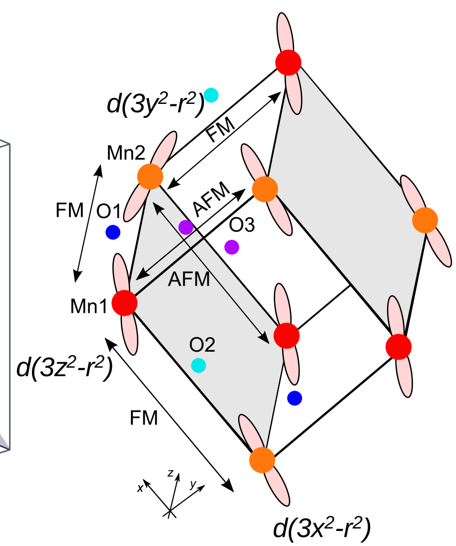


Monoclinic crystal structure of $BiMnO_3$ at high pressure



Lattice parameters and unit cell volume as functions of pressure in monoclinic (M1,M2) and orthorhombic (O) phases of $BiMnO_3$



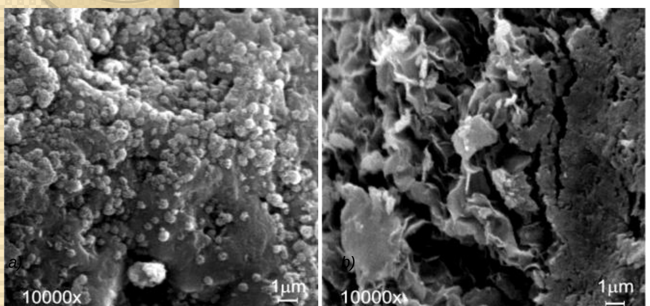


Arrangement of Mn magnetic moments in AFM high pressure phase of $BiMnO_3$ (left) and relevant order of e_g orbitals of Mn ions (right)

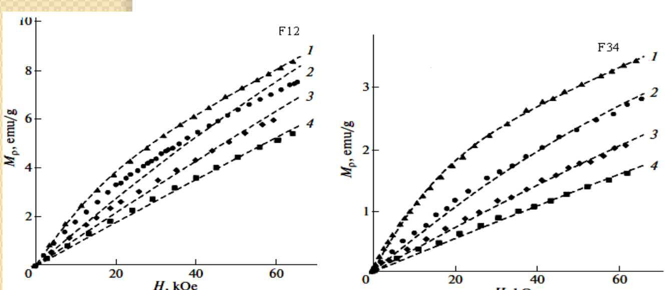
D.P.Kozlenko et al., Phys. Rev. B (2010)

Structural and magnetic investigations of biogenic ferrihydrite nanoparticles

Analysis of magnetic properties, morphology and structure of ferrihydrite particles produced in vivo by *Klebsiella oxytoca* bacteria.

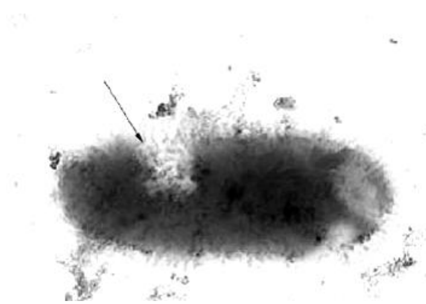


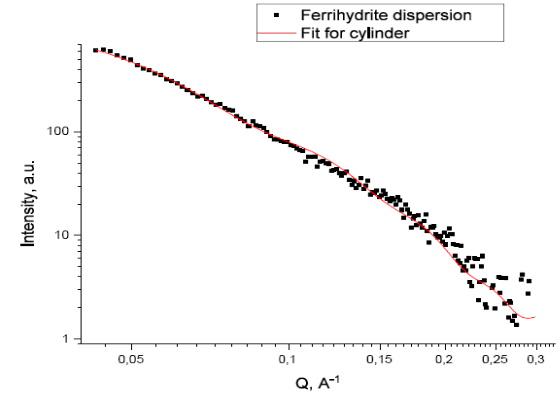
SEM images of two samples containing ferrihydrite nanoparticles obtained by means of two different methods; sample Fe12 *(a)* and sample Fe34 *(b)*.



Magnetization curves of Fe12 and Fe34 powders at different temperature experimental values T= 4.2K (1); 12K (2); 22K (3) and 33K (4). Lines represent the results of the calculations

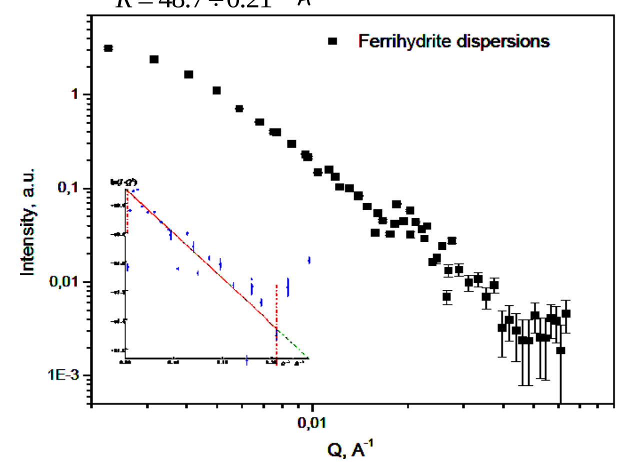
The micrograph of a *Klebsiella oxytoca* bacterium in a 15th day culture.





SAXS data from biogenic ferrihydrite (F12) dispersion sample, measured at IMC (Czech Republic). The parameters obtained from this fit are the cylinder radius R; and height L

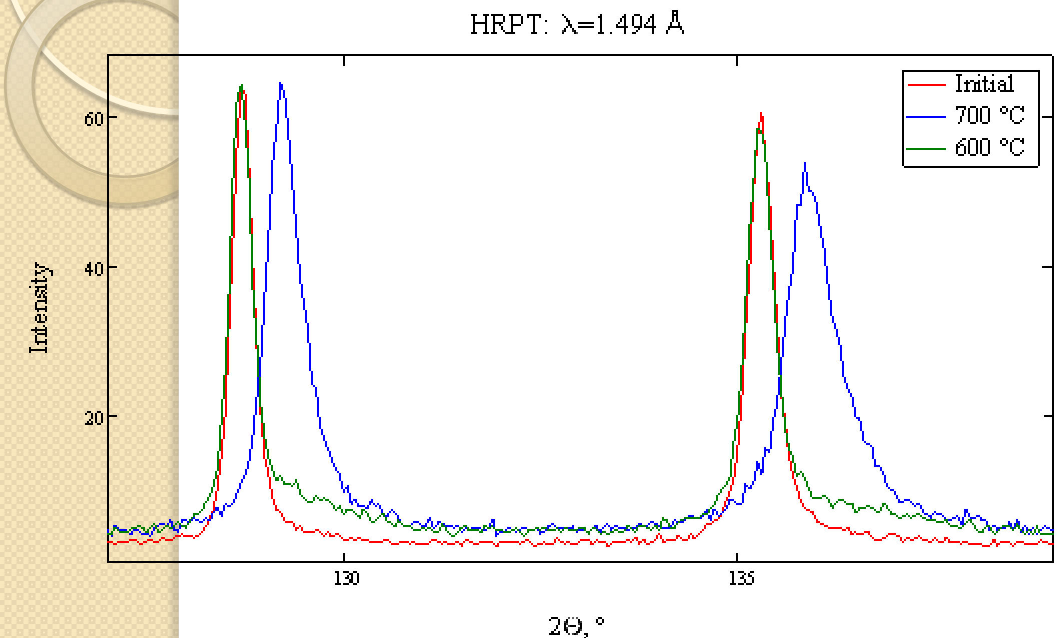
$R = 48.7 \div 0.21$ Å $\qquad L = 21 \div 0.41$ Å



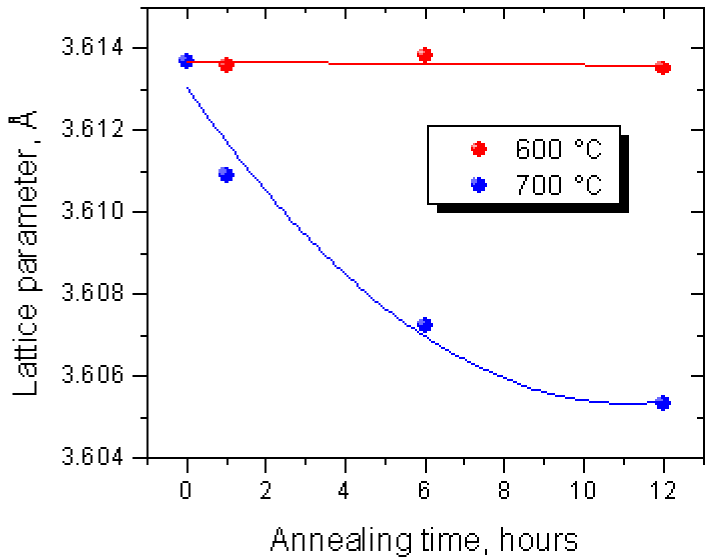
SANS data from biogenic ferrihydrite (F12) dispersion sample, measured at BNC (Hungary).

M. Balasoiu, et al., *Romanian Journal of Physics* Vol.55, Issues 7-8, 2010

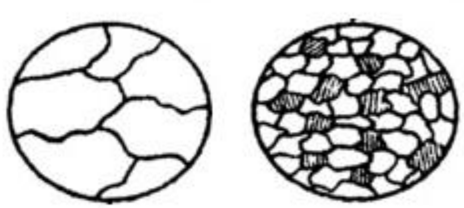
Structural and mechanical properties of the steel 40 X4G18F ($Fe_{0.748}Mn_{0.179}V_{0.013}Cr_{0.042}C_{0.018}$) modified by heat treatment



Comparison of neutron diffraction patterns for 40X4G18F steel samples aged at 600°C и 700°C, measured at PSI (Switzerland).



The lattice parameter dependence for 40X4G18F steel vs. quenching time at two temperatures: 600°C и 700°C.



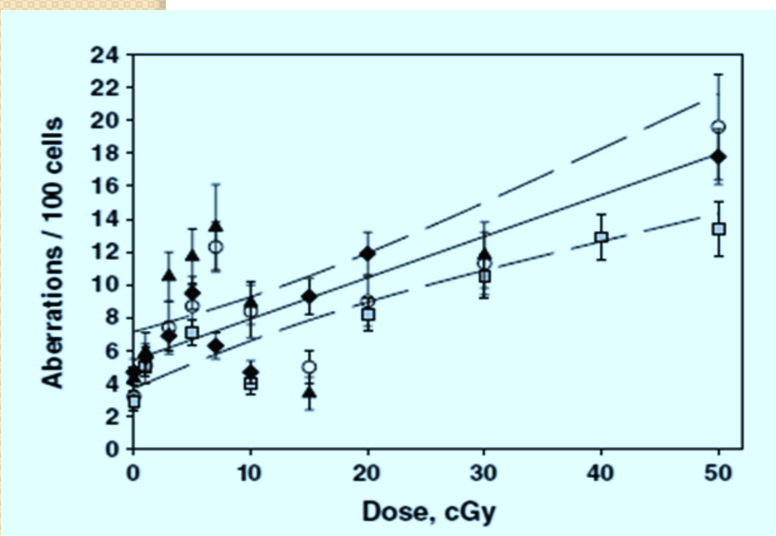
Formation of nanoparticles on quenching

Heat treatment	Reinforced nanoparticls VC, nm	Hardness HB, Kgf/mm^2	Microstrain, 10^{-4}
Quenching	-	221	4.08
Quenching+ aging 600°C, 12h	3÷5	313	5.44
Quenching+ aging 700°C, 12h	9÷10	282	14.45

Radiobiology

LRB low dose-irradiation research

Aberrant chromosomes in a metaphase of irradiated human lymphocytes

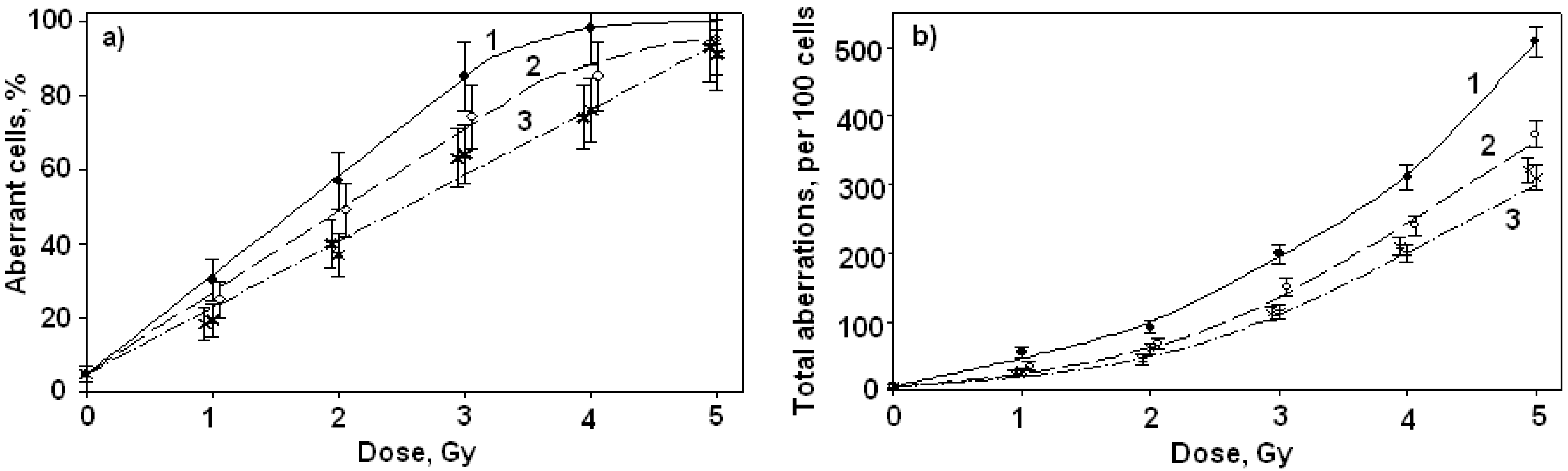


The frequency of chromosomal aberrations induced by γ-irradiation in lymphocytes of three donors.

- The health risks of low doses of ionizing radiation cannot be estimated in humans by epidemiological studies. The Laboratory's cellular-level research can help resolve this problem. At the LRB, chromosomal damage in human blood lymphocytes and mammary tumor carcinoma cells exposed to γ rays, 250 keV X-rays, and carbon ions (195 MeV/n, LET 16,6 keV/μm) are studied.
- A complex non-linear dose dependence of chromosome damage induced by all types of ionizing radiation was found in normal and cancer cells. It is characterized by hyper-radiosensitivity at very low doses with a peak around 5–7 cGy. For this reason, the LNT hypothesis of radiation-induced cancer should be reexamined for the low doses.
- The study of mechanisms underlying hyper-radiosensitivity at low doses has shown that non-DNA targeted effects are responsible for the excess of chromosome aberrations in this dose range. In particular, the radiation-induced generation of highly mutagenic reactive oxygen species in the mitochondrial electron transport chain may be the key process .
- The cycle of papers entitled "Cytogenetic Effects of Low-Dose Ionizing Radiation" won the 2010 JINR First Prize for applied research.

Chromosome aberrations in human cells

In 2010th the effectiveness of 155 MeV therapeutic beam protons (DLNP) is evaluated against chromosome aberrations in human blood lymphocytes.



The dose dependence of the frequency of cells with chromosome aberrations (a) and the total amount of aberrations (b) after irradiation with protons in the Bragg peak region:

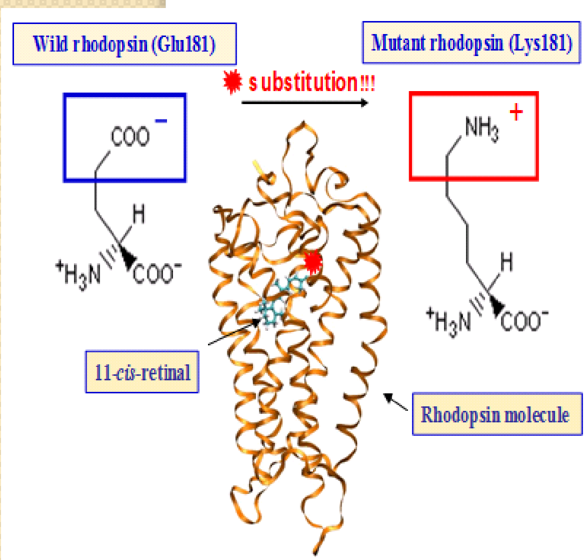
1 – a curve calculated taking into account the contribution of the radiosensitive G_2 fraction of dividing cells;

2 – non-dividing cell effects;

3 – irradiation of cells of normal tissues with 155 MeV protons and gamma rays.

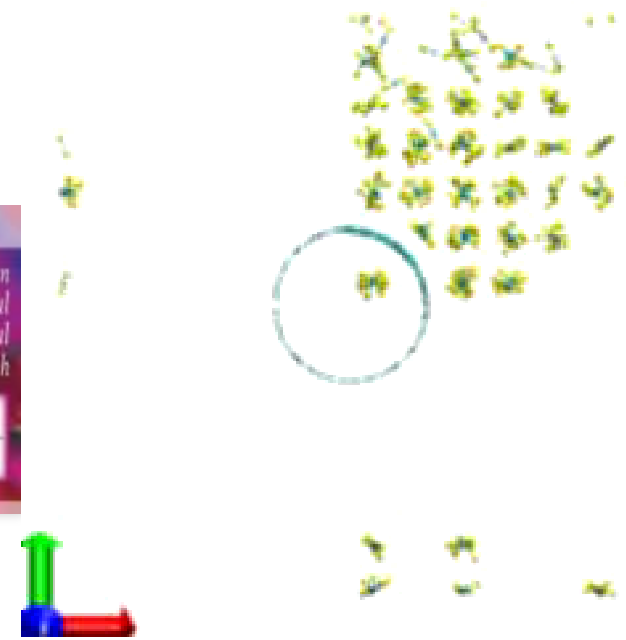
LRB Molecular Dynamics Research

- In 2010th during two months (May – July) prof. Kholmurodov (head of CMM division of LRB) was invited as visiting professor of Keio University (Japan). In this period he delivered lectures for students and researches on MD simulation of bio- and nano-structures using high performance computations. He also completed and published together with Japanese colleagues three papers in the international scientific journals (Natural Science, The Open Chemical Physics Journal, Advances in Bioscience and Biotechnology).
- Every two years, the LRB organizes the Japan – Russia International workshop "Molecular Simulation Studies in Material and Biological Sciences" (MSSMBS) – a unique meeting held in Russia which is specialized in MD modeling. Another workshop to be held on the next week.
- In according to Seven-Year Plan the LRB performs MD simulations at different international computing centers, including the Central Information and Computing Complex (CICC) of JINR; RIKEN Integrated Cluster of MDGRAPE Clusters (RICC, Japan); and Computing Cluster at the Yasuoka Laboratory (Keio University, Japan); and develops software in collaboration with the Daresbury Laboratory (UK).
- Since this July, the LRB has been licensed to use a general-purpose Amber ver.11 MD package supporting acceleration on modern GPU/CUDA hardware.



MD-simulated snapshot of the visual pigment rhodopsin with the E181K mutation associated with retinitis pigmentosa

Proceedings of the MSSMBS'04/06/08 workshops



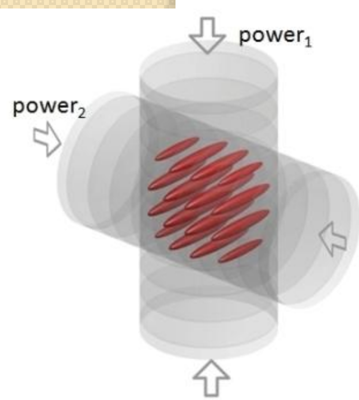
Self-assembly of a CS_2 solvent around a carbon nanotube (CNT)

Theory

Confinement-induced Resonances in Low-dimensional Quantum Systems

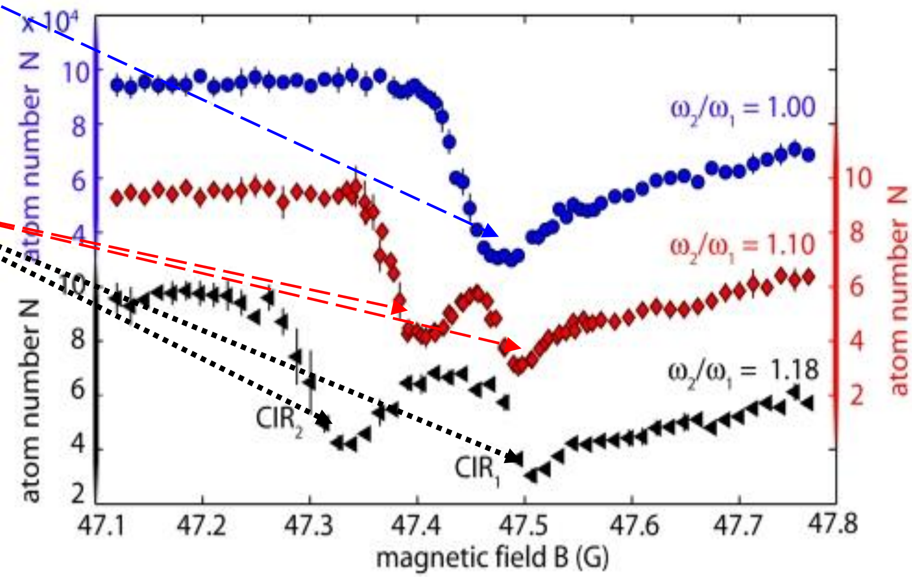
E. Haller, M. Mark, R. Hart, J. Danzl, L. Reichsollner, and H.-C. Nagerl (Univ. Innsbruck)
V. Melezhik (JINR Dubna), P. Schmelcher (Univ. Hamburg)

In experiment performed in Innsbruck in collaboration with theoreticians from JINR and Hamburg, properties of ultracold gases were studied by measuring the atom loss in a 2D lattice formed by two laser beams with frequences ω1 and ω2.



When s-wave atom-atom scattering length approaches the length scale of the transversal confinement, atom-atom scattering is substantially modified. It was detected by characteristic minimum of the number of atoms (confinement-induced resonance) in the 1D tubes

A **splitting of the confinement-induced resonance** **was theoretically predicted and found in experiment upon introducing an anisotropy** $\omega_1 \neq \omega_2$



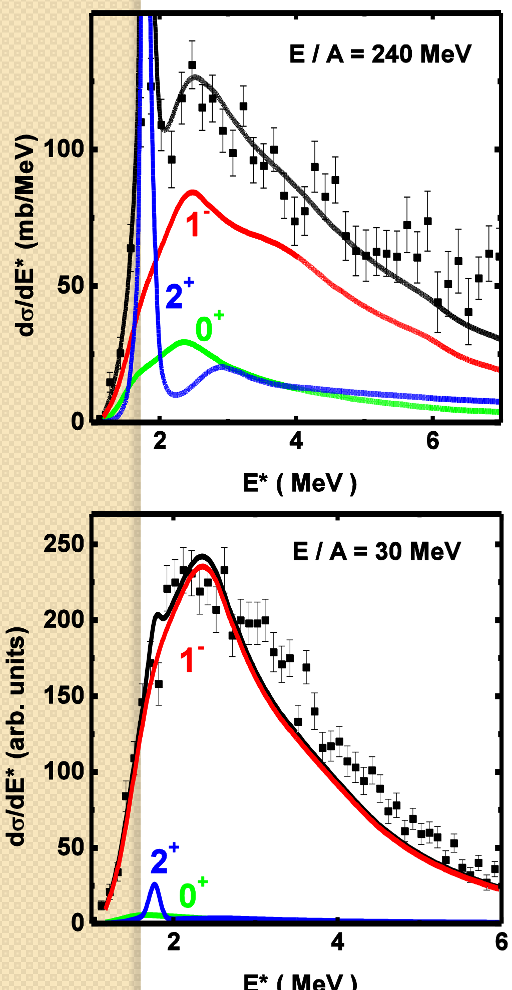
Phys. Rev. Lett. 104 (2010)

Halo formation and breakup: lessons and open questions

S.N. Ershov, L.V. Grigorenko, J.S. Vaagen and M.V. Zhukov

$^{6}He + ^{208}Pb \longrightarrow ^{4}He+n+n+X$

J. Phys. G, 37 (2010)



The microscopic four-body distorted wave theory for two-neutron halo breakup reactions leading to low-lying halo excitations was developed, which accounts for both elastic and inelastic breakup. The Coulomb and nuclear dissociation is included in a consistent way.

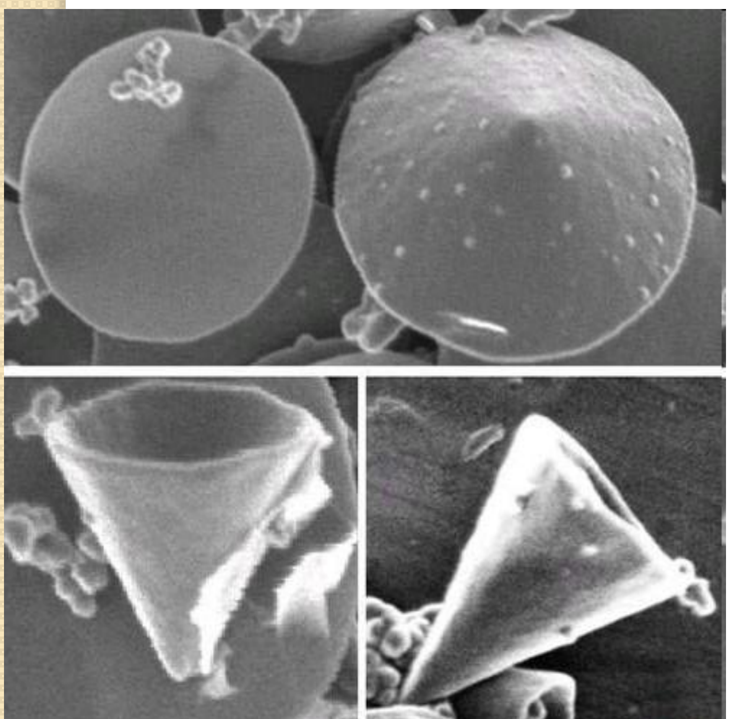
The calculations describe the experimental data for fragment correlations near breakup threshold rather well.

Theory now provides correlation cross sections from fully inclusive (spectrum) to fully exclusive.

Electronic Properties of Disclinated Flexible Membrane: Application to Graphene

E.A. Kochetov, V.A. Osipov, and R. Pincak

J. Phys.: Condens. Matter 22 (2010)



- The principally new model was formulated and applied to study the structure of the low energy electronic states of flexible graphene membrane with a topological defect.

SEM images of a carbon disk (top left image) and free-standing hollow carbon nanocones

Logarithmic Two-point Correlators in the Abelian Sandpile Model

V S Poghosyan, S Y Grigorev, V B Priezzhev and P Ruelle

***J. Stat. Mech.* (2010) P07025**

The detailed calculations of the asymptotics of two-site correlation functions for height variables in the two-dimensional Abelian sandpile model are presented. By using combinatorial methods for the enumeration of spanning trees, the well-known result for the correlation of minimal heights $h1 = h2 = 1$was extended to height values $h = 2, 3, 4$:

$$\langle h1\ h2 \rangle \sim (c \log r + d)/r^4.$$

These results confirm the dominant logarithmic behaviour for large *r*, predicted by logarithmic conformal field theory.

Algebraic form of entanglement criterion for a pair of mixed qubit states

A generic mixed 2-level quantum system (qubit) state is described by the 15-parameter density matrix

$$\varrho = \frac{1}{4}\left(\mathrm{I}_2 \otimes \mathrm{I}_2 + \vec{a}\cdot\vec{\sigma} \otimes \mathrm{I}_2 + \mathrm{I}_2 \otimes \vec{b}\cdot\vec{\sigma} + c_{ij}\,\sigma_i \otimes \sigma_j\right)$$

The separability conditions have been formulated in terms of inequalities

$$0 \le C_2 \le 1,$$
$$0 \le 3C_2 - 2C_3 \le 1,$$
$$0 \le (1-3C_2)^2 + 8C_3 - 12C_4 \le 1.$$

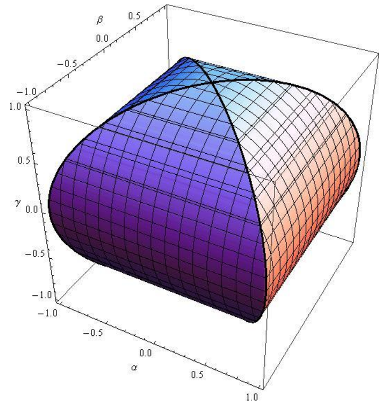
$$0 \le C_2 \le 1,$$
$$0 \le 3C_2 - 2C_3 - 4\,\det(C) \le 1,$$
$$0 \le (1-3C_2)^2 + 8C_3 - 12C_4 + 16\,\det(M) \le 1.$$

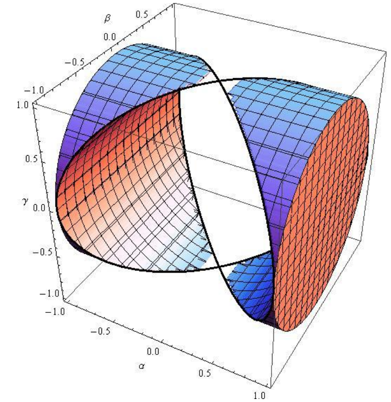
where C_2 C_3 and C_4 are Casimir invariants of SU(4) group, and

$M = \varrho - \varrho_1 \otimes \varrho_2$ - Schlienz & Mahler matrix composed of the single qubit density matrices

Example:

Separability domain





Entanglement domain

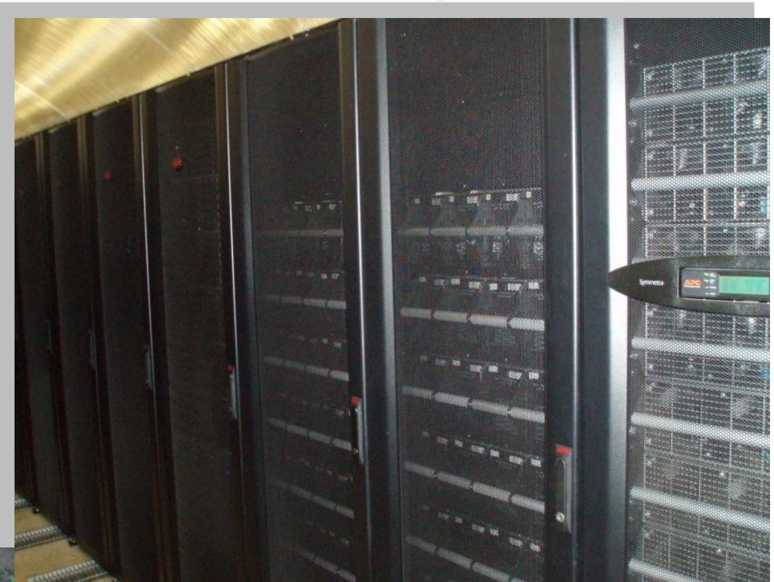
V.Gerdt, A.Khvedelidze, Yu.Palii. J.Math. Sciences 168, 3 (2010) 368-378

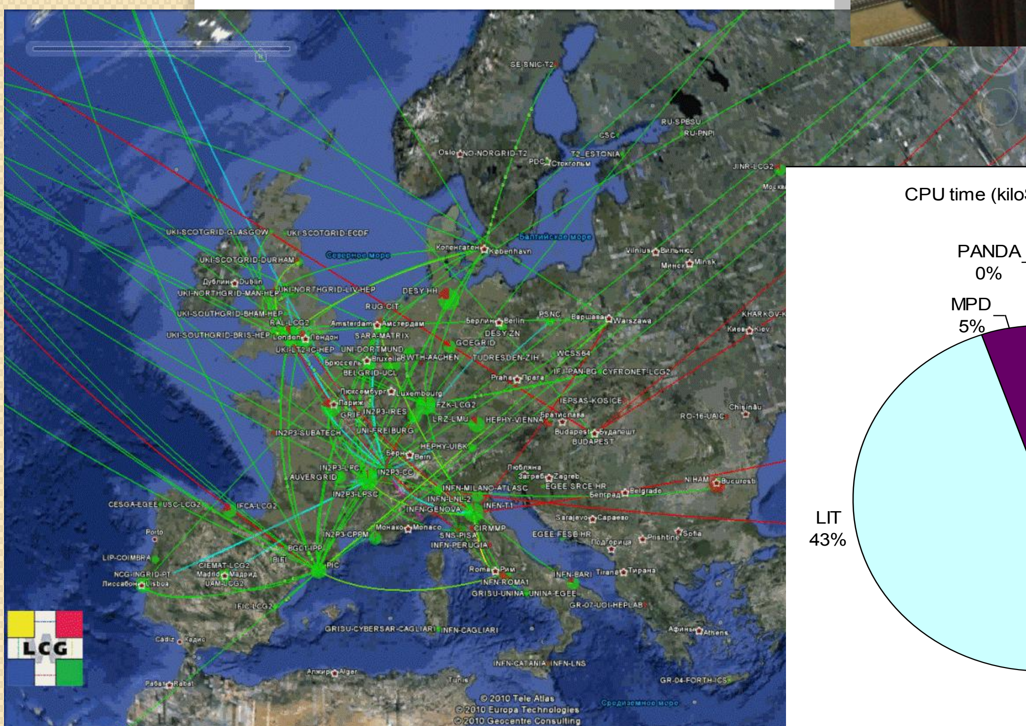
Information Technologies

JINR Central Information and Computing Complex

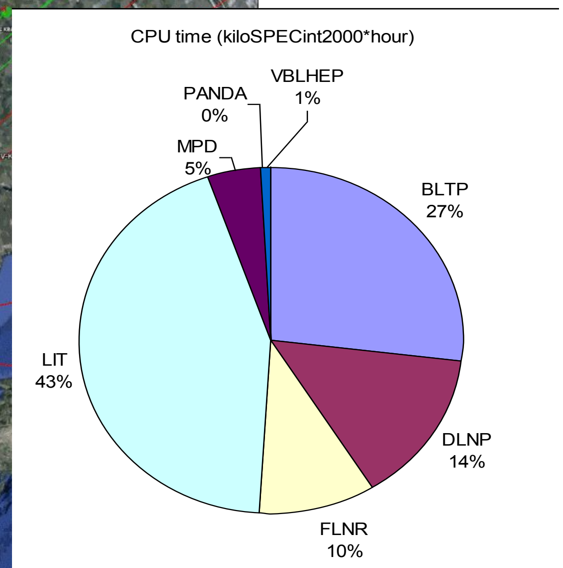
In 2010, the CICC performance equals 2800 kSI2K and the disk storage capacity 1068 TB

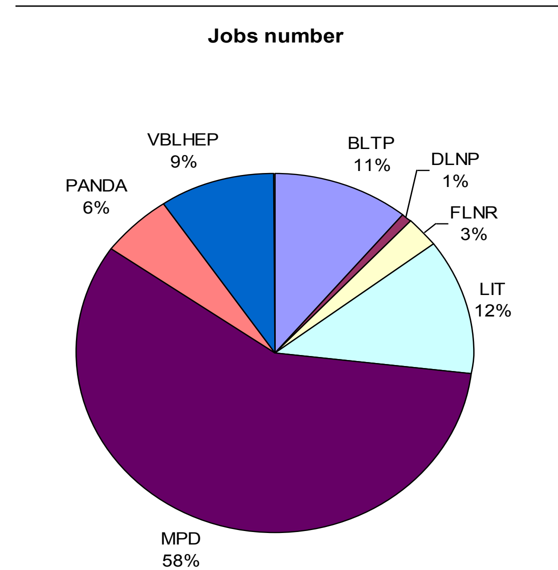
(Plans at the end of 2010 – 2500 kSI2K and 1200 TB)



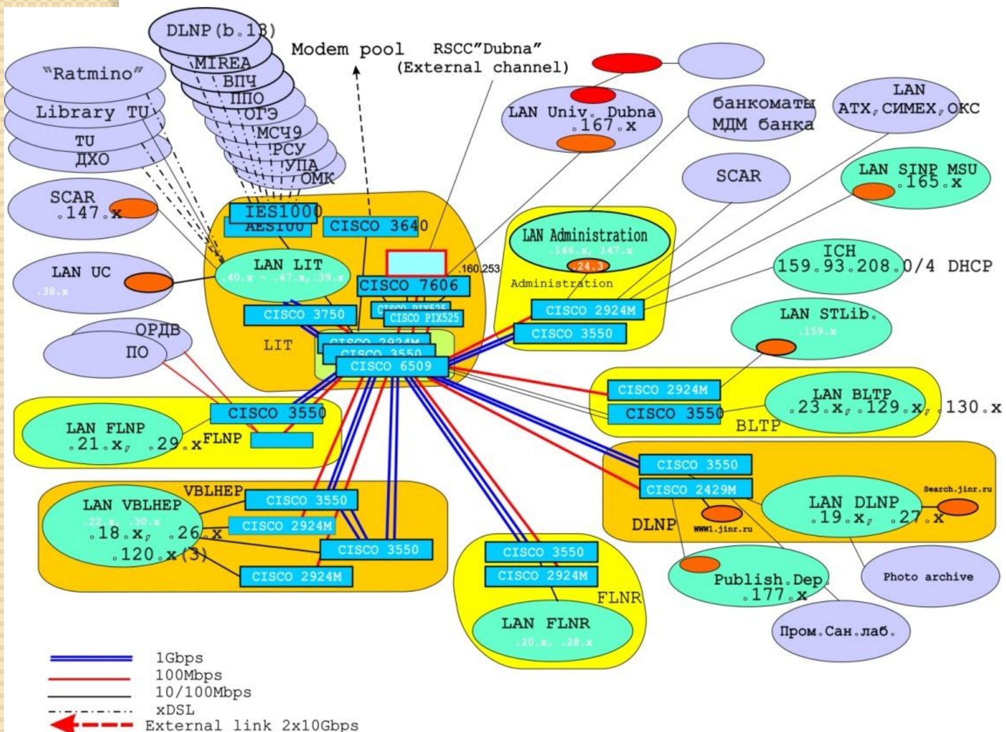


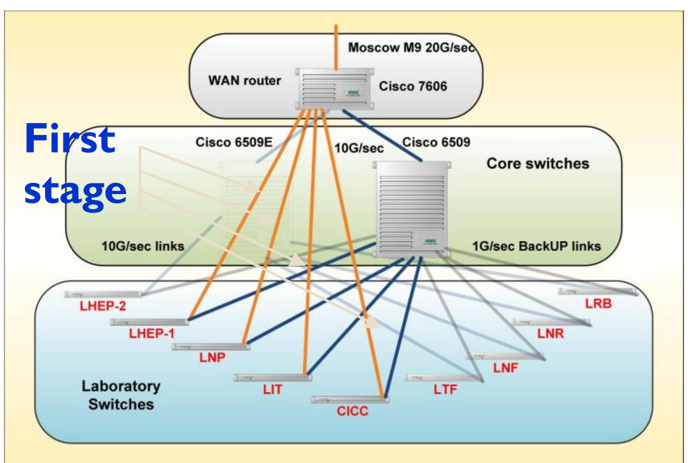
CICC CPU Statistics for batch jobs for Jan-Aug 2010





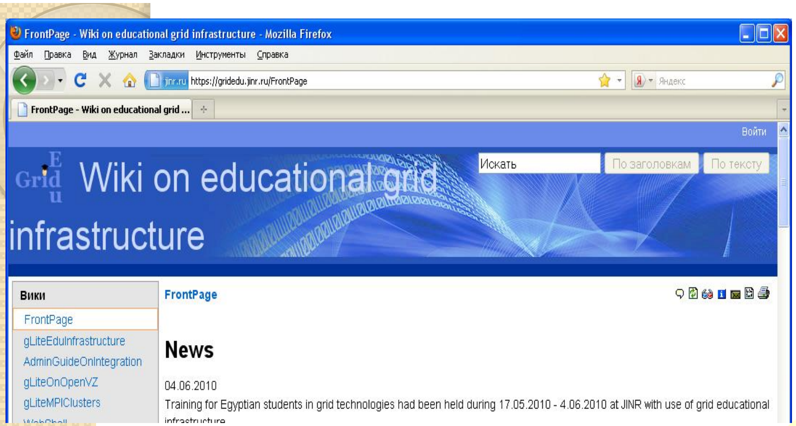
JINR Local Area Network Backbone (LAN)

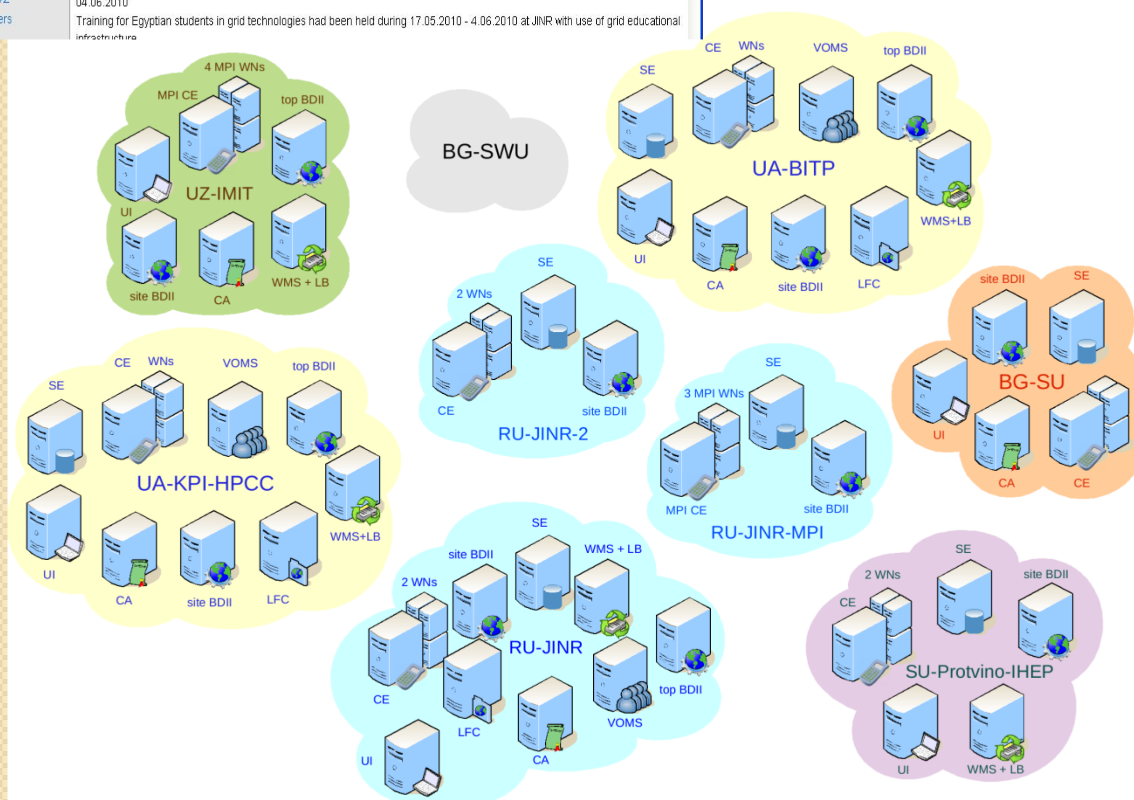




- Comprises 6891 computers and nodes,
  - Users – 3696 ,
  - IP – 8199 ,
  - Remote VPN users (Lanpolis, Contact, TelecomMPK) - 1298 ;
  - Electronic Libraries – 885;
  - AFS - 365
- High-speed transport (10 Gbps - 1Gbps) (Min. 100 Mbps to each PC);
- Controlled-access (Cisco FWM firewall module) at network entrance;
- General network authorization system involves many services (AFS, batch systems, Grid, JINR LAN remote access, etc.)
- Wireless access to the LAN within the JINR territory;
- Currently the JINR network infrastructure has direct communication line with CERN – 10 Gbps; RBnet - 10 Gbps; RASnet - 10 Gbps; RadioMSU - 10 Gbps; GEANT - 10 Gbps; GLORIAD - 1 Gbps; Moscow - 20 Gbps.

Grid-infrastructure for training and education





that consists of three grid sites located at JINR and one site in each of the following organisations:

- Institute of High-Energy Physics - IHEP (Protvino),
- Institute of Mathematics and Information Technologies AS of Republic of Uzbekistan - IMIT (Tashkhent, Uzbekistan),
- Sofia University "St. Kliment Ohridski" - SU (Sofia, Bulgaria),
- Bogolyubov Institute for Theoretical Physics - BITP (Kiev, Ukraine),
- National Technical University of Ukraine "Kyiv Polytechnic Institute" - KPI (Kiev, Ukraine).

Protocol of cooperation with Moldova, Romania

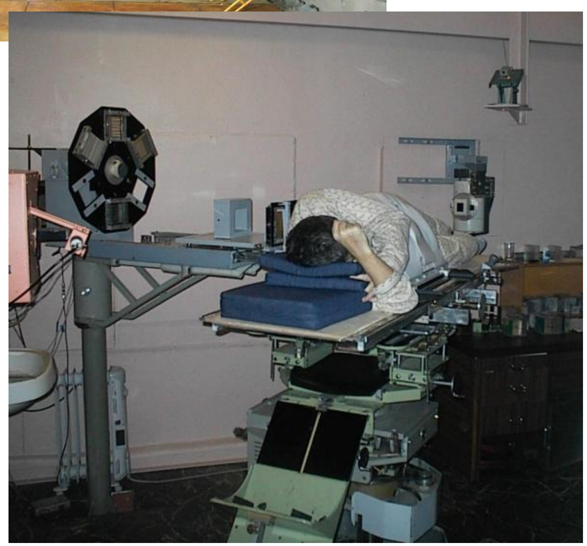
The Fourth International Conference "Distributed Computing and Grid-technologies in Science and Education" – GRID'2010

- 252 participants from 21 countries: Armenia, Belarus, Bulgaria, Hungary, Germany, Greece, Georgia, Iceland, Kazakhstan, Moldova, Myanmar, Poland, Russia, Romania, USA, Uzbekistan, Ukraine, France, Czechia, Switzerland, Sweden as well as from CERN and JINR.
- 56 universities and research centers of Russia.
- 8 sections: WLCG - worldwide Grid for processing data from LHC at CERN, Grid-applications, Grid in business, distributed computing and Grid-technologies in education, GridHHC – Grid of the national nanotechnology network, methods and algorithms for distributed computing, Grid-infrastructure and "cloud" computing.
- Round tables on using grid-technologies in business and on training in grid-technologies and their application in education.
- 36 plenary talks, 78 sectional talks.

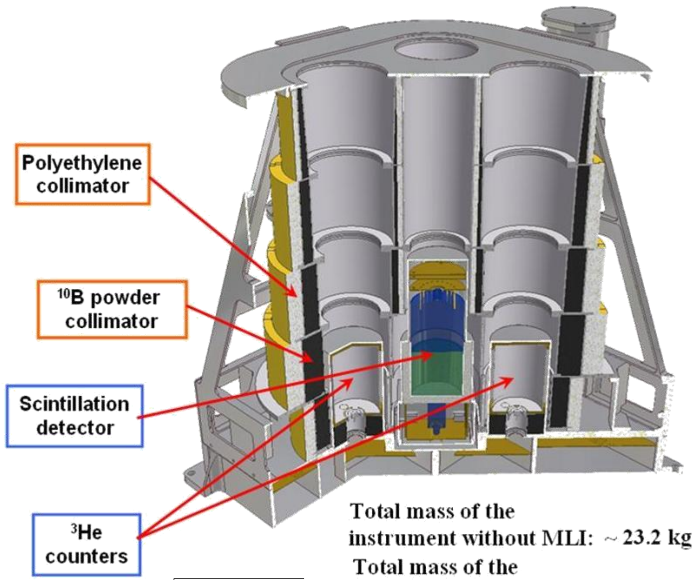
Applied research

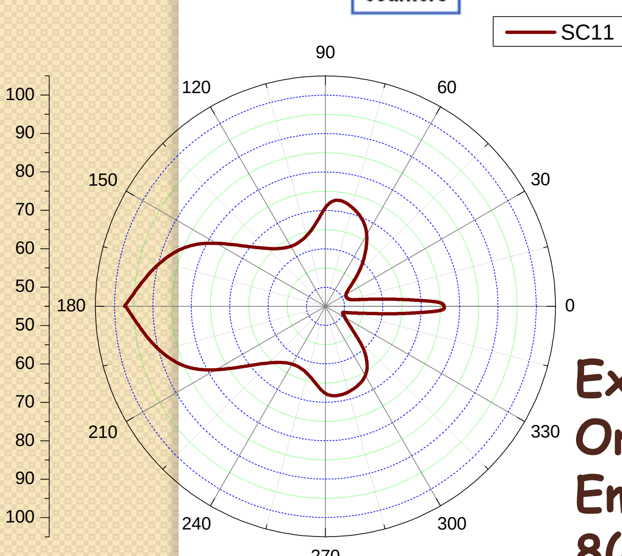
Proton therapy and development of medical technique

69 new patients were treated in 2010 on phasotron proton medical beams.
3412 dose fields were formed for patient treatment.
664 patients were treated since 2000.



Calibration of the angular response function of the Lunar Exploration Neutron Detector (LEND)





Experiment LEND of the NASA Lunar Reconnaissance Orbiter for High-Resolution Mapping of Neutron Emission of the Moon. Astrobiology. August 2008, 8(4): 793-804

Thank you!