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МЕТОДИКА ФИЗИЧЕСКОГО ЭКСПЕРИМЕНТА

# STUDY OF ANODE SELF-TRIGGER ABILITY OF ME1/1 CMS ENDCAP CATHODE STRIP CHAMBER

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The influence of the high background rates on the Cathode Strip Chamber (CSC) anode trigger ability has been studied. The investigation has been made with P3 prototype of the CSC of ME1/1 Endcap muon station of the CMS experiment (CERN). The work has been done at the Gamma Irradiation Facility (GIF, CERN). P3 has been installed at SPS X5c muon beam line in a background field of $^{137}$Cs source. The CSC timing resolution and track registration efficiency as a function of gamma rate are presented.

Изучалось влияние больших фоновых загрузок на свойства анодного триггера катодно-стриповой камеры (КСК). Исследования проводились с Р3-прототипом КСК мюонной станции МЕ1/1 эксперимента CMS (ЦЕРН). Работа была проведена на установке гамма-излучения (GIF, ЦЕРН). Прототип Р3 был установлен на мюонном пучке канала X5c и находился в поле излучения источника $^{137}$Cs. Представлены результаты по изучению временного разрешения КСК и эффективности регистрации треков мюонов в зависимости от интенсивности фона гамма-излучения.

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## INTRODUCTION

The Cathode Strip Chambers (CSCs) are the coordinate detectors of the Endcap muon stations in the CMS experiment (CERN) [1]. These chambers provide both the muon track coordinate measurements and bunch crossing (BX) identification. The CSC trigger uses the six-layer redundancy of the CSCs to provide precise position information as well as high rejection power against backgrounds.

Anode layers hits are used for track search. At a low coincidence level two layers of six are used to establish timing, while at a higher coincidence level four layers are used to establish the existence of muon track segment [1, 2].

The study of a possibility of an unambiguous BX identification for LHC beam has been made with P2 ME1/1 CSC prototype at CERN [3, 4]. It has been shown that the majority coincidence scheme option 3/6 (any three CSC layers of six coincide) provides the 25 ns anode spectrum width and so could be used for BX identification. The full-scale prototype of the ME1/1 CSC has been designed and assembled at JINR, Dubna [5, 6]. The goal of this work is to study BX and track registration efficiency at high background rates with this prototype.

## 1. P3 AND READOUT ELECTRONICS PARAMETERS

P3 is ME1/1 CSC full-scale prototype. It is a unit of six identical proportional chambers, layers, with cathode strip readout (Fig. 1). Each layer is formed by two cathode electrodes with gap of 5.6 mm having anode wires electrode in the middle. The anode wire diameter is 30 $\mu$m, wire spacing is 2.5 mm. The gas mixture is $\mathrm{Ar} + \mathrm{CO_2} + \mathrm{CF_4}$ (30:50:20). The operating anode-cathode high voltage is 2.9 kV.

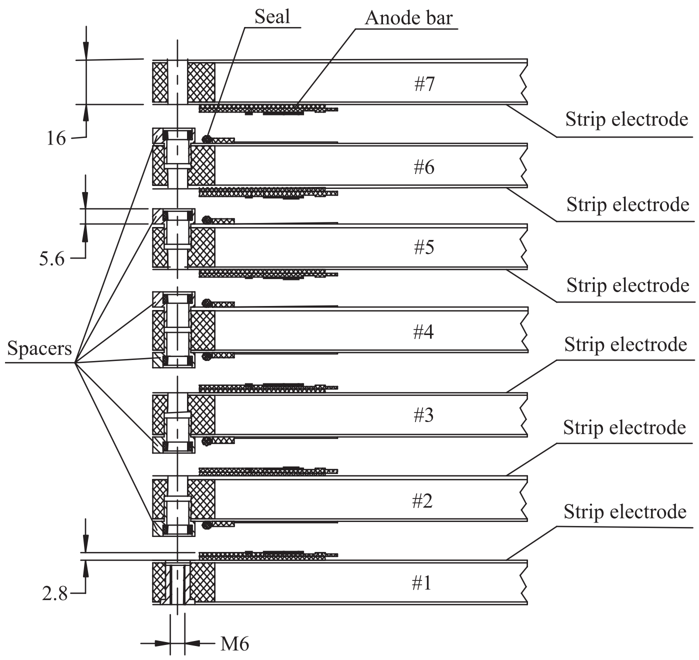


Fig. 1. P3 cross section

The prototype has been instrumented with anode readout electronics based on 4-channel MSD-2 preamplifier (LABEN) [7] and MVL407 comparator. The main parameters of this chip are presented in the table. The electronics reads out four anode wire groups in each of the six layers. This corresponds to 430 cm$^2$ of CSC sensitive area.

**MSD-2 specification**

| Chip parameters | $C_{\mathrm{det}} = 0$ pF | $C_{\mathrm{det}} = 100$ pF |
|---|---|---|
| Equivalent input noise, r.m.s., nA | 15 | 50 |
| Gain, mV/$\mu$A | 35 | 25 |
| Rise time, ns | 3 | 8 |
| Band width, MHz | 35 | 20 |
| Input resistance, $\Omega$ | 120 | 120 |
| Crosstalk, % max | 4 | 4 |
| Power consumption per channel, mW | 15 | 15 |

## 2. EXPERIMENTAL LAYOUT

P3 has been installed at the Gamma Irradiation Facility (GIF) [8] at CERN SPS X5c muon beam line. It has been turned through $10^\circ$ (see Fig. 2) to correspond to ME1/1 CSC layout at the CMS experiment. The $^{137}$Cs radioactive source (740 GBq) provides 662 keV gamma background. A combination of filters is used to change the absorption factor from 1 (about $2 \cdot 10^6\ \gamma/(\mathrm{cm}^2 \cdot \mathrm{s})$ on P3 surface) to $10^4$. Trigger counters S1–S3 separate the muon beam.

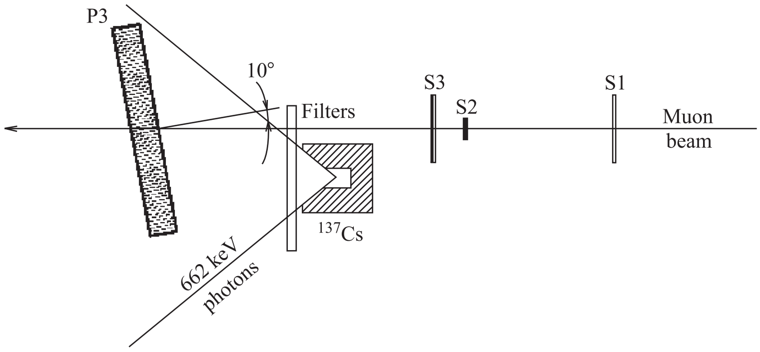


Fig. 2. Experiment layout (top view)

## 3. RESULTS

**3.1. Without Background.** Figure 3 shows the time spectrum of one CSC layer for muons. The width of the spectrum (99% of events) is equal to 25 ns.

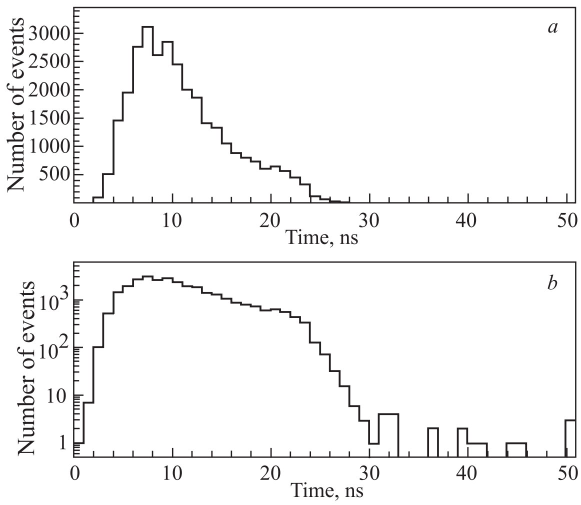


Fig. 3. P3 typical single layer time spectrum in linear (*a*) and logarithmic (*b*) scales

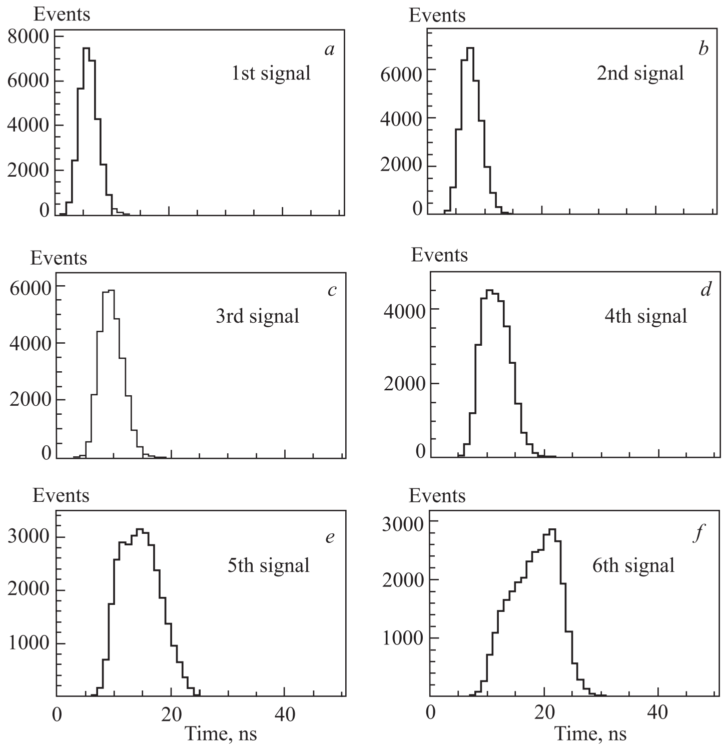


Fig. 4. The time spectra for 1st–6th anode signals

Figure 4 shows the time spectra for 1st–6th anode signals coming from any of the six layers. The spectra have been obtained with the majority coincidence scheme. For the first output signal (1/6) the spectrum width (99% of events) is 10.5 ns.

The same value for the 2nd signal is 12 ns; for the 3rd signal, 14 ns; for the 4th signal, 16.5 ns; for the 5th signal, 22.5 ns; for the 6th signal, 26.5 ns.

BX at the LHC will occur every 25 ns. For CMS unambiguous BX identification the criterion 2/6 (two out of six) is chosen. This means that majority coincidence of anode signals from any two of six CSC layers takes place. One can see that at a level of 99% efficiency we can work with majority coincidence 1/6–5/6 inside 25 ns strobe.

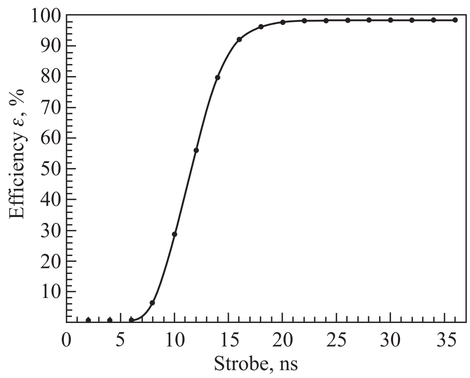


Fig. 5. CSC registration efficiency vs. strobe width for 4/6 majority scheme

For CMS particle track identification the criterion 4/6 is chosen. Figure 5 shows the CSC registration efficiency taken as 4/6 majority coincidence ($\varepsilon = N_{4/6}/N_{\rm trigger}$) vs. the strobe width. This scheme provides the identification of charged particles with 99% efficiency in the strobe of 25 ns.

**3.2. With the Background.** The study of the background influence on muon track registration efficiency and BX identification has been made with $^{137}$Cs radioactive source. Figure 6 illustrates the influence of the background rate on the CSC timing resolution for the majority coincidence options 1/6, 2/6, and 4/6. One can see a significant growth of the time spectra width at the absorption factor smaller than 10 (background rate higher than $2 \cdot 10^5\ \gamma/(\mathrm{cm}^2 \cdot \mathrm{s})$).

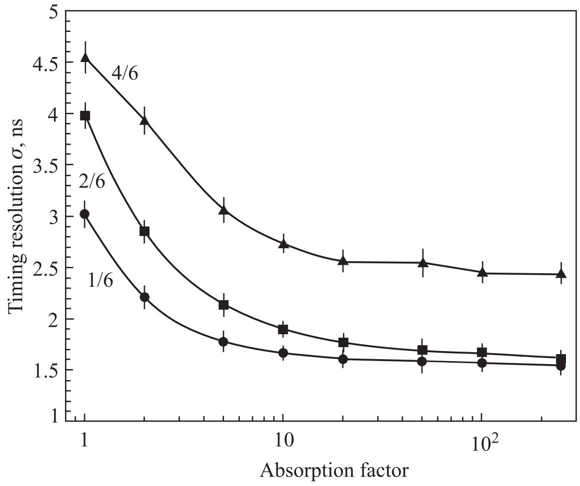


Fig. 6. CSC timing resolution for different majority coincidence options as a function of the absorption factor

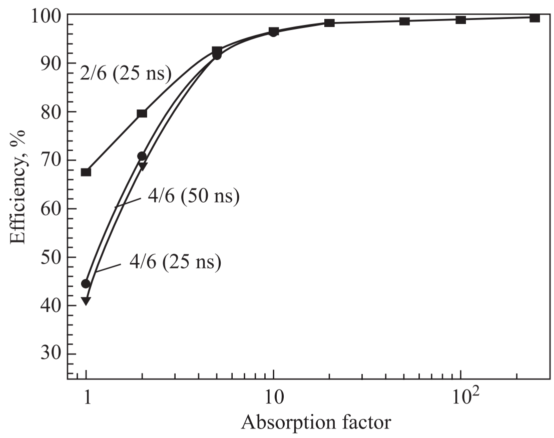


Fig. 7. The CSC efficiency vs. absorption factor for 25 and 50 ns strobe widths

The CSC efficiencies with the majority coincidence options 2/6 and 4/6 as a function of the absorption factor are shown in Fig. 7. For 4/6 coincidence two curves are presented: with the strobe width of 25 and 50 ns. One can see that all the curves reach a plateau at absorption factor $\sim 20$ ($10^5\ \gamma/(\mathrm{cm}^2 \cdot \mathrm{s})$).

## CONCLUSION

The possibilities of unambiguous BX and track registration efficiency have been studied with the six-layer ME1/1 CSC prototype.

The results show that without background the unambiguous BX identification with MSD-2 anode readout electronics can be made by majority coincidence scheme 1/6–5/6 within 25 ns. The CSC track registration efficiency (4/6 scheme) is about 99% within 25 ns strobe.

The influence of the high gamma background rate on BX and track registration efficiency of P3 prototype has been studied with $^{137}$Cs radioactive source. For BX identification at background rates smaller than $2 \cdot 10^5\ \gamma/(\mathrm{cm}^2 \cdot \mathrm{s})$ no influence on CSC timing resolution is seen while track registration efficiency (4/6 scheme) degrades at background rate higher than $10^5\ \gamma/(\mathrm{cm}^2 \cdot \mathrm{s})$.

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