E13-2005-87

I. Golutvin, N. Gorbunov, V. Khabarov,
P. Moissenz, S. Movchan, V. Perelygin, S. Sergeev,
D. Smolin, A. Zarubin

STUDY OF THE **CSC** ANODE SELF-TRIGGER ABILITY WITH **P3 ME1/1** PROTOTYPE

Submitted to «Nuclear Instruments and Methods A»

Голутвин И. и др. E13-2005-87

Изучение возможности триггирования при использовании
анодных сигналов от катодно-стриповой камеры
с помощью прототипа ME1/1 P3

Изучалось влияние высоких фоновых загрузок на свойства анодного триггера катодно-стриповой камеры (КСК). Исследования проводились на P3-прототипе КСК мюонной станции ME1/1 эксперимента CMS (ЦЕРН). Работа была проведена на установке гамма-излучения (GIF, ЦЕРН). P3 был установлен на канале мюонных пучков X5c и находился в поле излучения источника ^{137}Cs. Представлены результаты по временному разрешению КСК и эффективности регистрации треков мюонов в зависимости от интенсивности фона гамма-излучения.

Работа выполнена в Лаборатории физики частиц ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 2005

Golutvin I. et al. E13-2005-87

Study of the CSC Anode Self-trigger Ability
with P3 ME1/1 Prototype

The influence of the high background rates on the Cathode Strip Chamber (CSC) anode trigger has been studied. The investigation has been made with P3 prototype of the CSC of the 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 the X5c muon beam line in the background field of the ^{137}Cs source. The CSC timing resolution and track registration efficiency as a function of the gamma rate are presented.

The investigation has been performed at the Laboratory of Particle Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna, 2005

INTRODUCTION

The Cathode Strip Chambers (CSCs) are the coordinate detectors of the end-cap muon stations in 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 CSC chambers to provide precise position information as well as high rejection power against backgrounds.

Anode layers hits are used for track search. A low coincidence level, typically two layers, is used to establish timing, whereas a higher coincidence level, typically four layers, is used to establish the existence of muon track segment [1, 2].

The study of a possibility of an unambiguous bunch crossing identification for LHC beam has been made with P2 ME1/1 CSC prototype at CERN [3]. The analysis of the anode timing spectra has shown that the 1st, the 2nd and even the 3rd signals out of six layers could be used for BX identification. The goal of this work is to study CSC BX and track registration efficiency at high background rates.

1. P3 AND READ-OUT ELECTRONICS PARAMETERS

P3 is a full-scale prototype of the ME1/1 CSC [4]. It has been designed and assembled at JINR, Dubna. P3 is a unit of six identical proportional chambers of trapezoidal shape, layers, with cathode strip read-out (Fig. 1). Each layer is formed by two cathode electrodes with a gap of 5.6 mm and anode wire electrode in the middle. The anode wire diameter is 30 μm; wire spacing, 2.5 mm. The gas mixture is Ar/CO2/CF4 ($30:50:20$). The operating anode–cathode high voltage is 2.9 kV.

The prototype has been supplied with anode read-out electronics based on four-channel MSD-2 preamplifier (LABEN) [5] and MVL407 comparator. The main parameters of this chip are presented in Table 1. The electronics reads out four anode wire groups in each layer. This corresponds to 430 cm^2 of CSC sensitive area.

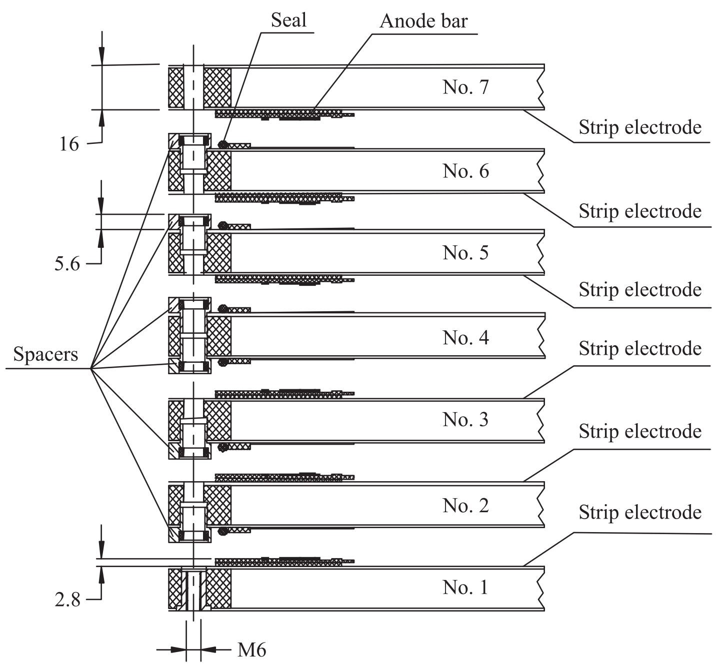

Fig. 1. P3 cross-section

Table 1. **MSD-2 specification**

Chip parameters	$C_{det} = 0$ pF	$C_{det} = 100$ pF
Equivalent input noise, r.m.s.	15 nA	50 nA
Gain	35 mV/μA	25 mV/μA
Rise time	3 ns	8 ns
Bandwidth	35 MHz	20 MHz
Input resistance	120 Ω	120 Ω
Crosstalk	4% max	4% max
Power consumption per channel	15 mW	15 mW

2. EXPERIMENTAL LAY-OUT

P3 has been installed at Gamma Irradiation Facility (GIF) [6] at CERN SPS X5c muon beam line. It has been turned to 10° (see Fig. 2) to correspond to ME1/1 CSC lay-out at 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 $2 \cdot 10^6$ γ/cm^2·s on P3 surface) to 10^4. Trigger counters S1–S3 separate the muon beam.

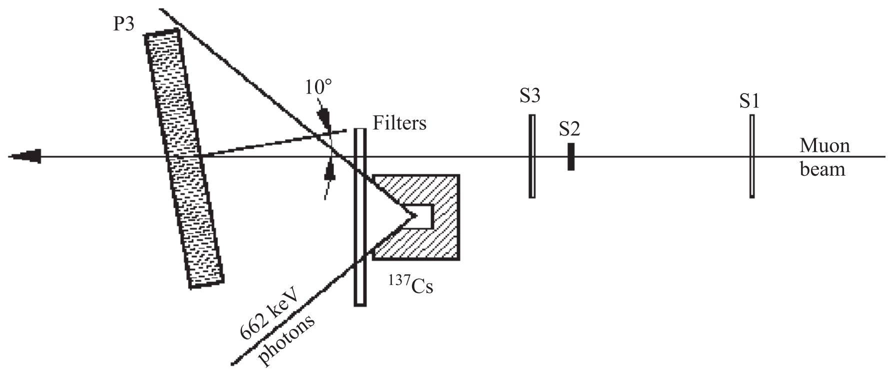

Fig. 2. Experiment lay-out (top view)

3. RESULTS

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

Figure 4 shows the time spectra for six subsequent anode signals. The corresponding spectrum width (99% of events) for the first output signal of six layers (1/6) is 10.5 ns. The same values for:

2nd signal — 12 ns;

3rd signal — 14 ns;

4th signal — 16.5 ns;

5th signal — 22.5 ns;

6th signal — 26.5 ns.

BX at 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 $1/6 \div 5/6$ inside the 25-ns strobe.

For CMS particle track identification, the criterion 4/6 is chosen. Figure 5 shows the CSC registration efficiency taken as 4/6 majority coincidence ($\varepsilon =$

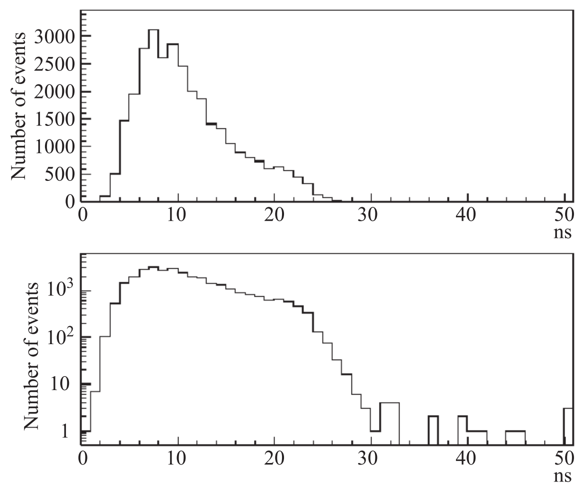

Fig. 3. P3 typical single layer time spectrum in linear and logarithmic scales

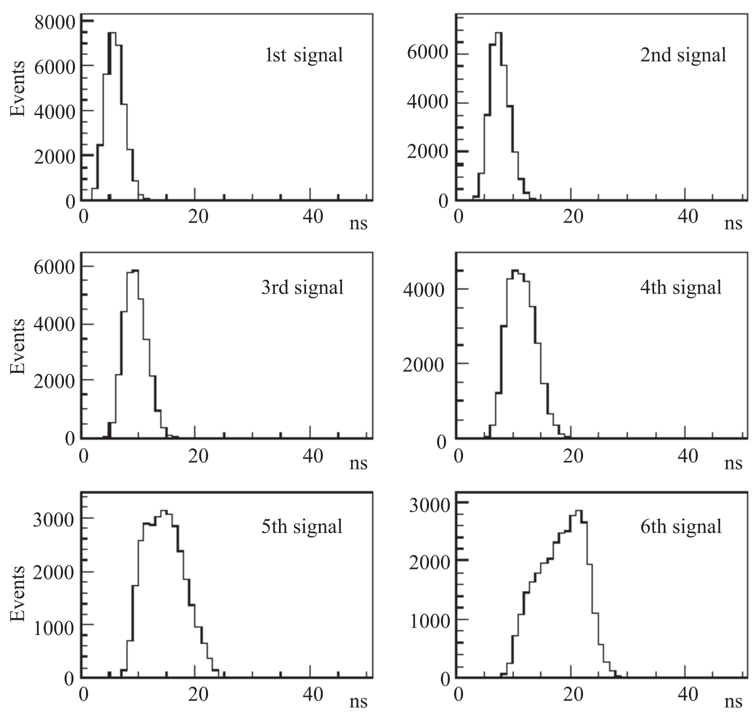

Fig. 4. The time spectra for six subsequent anode signals

$N_{4/6}/N_{\text{trigger}}$) vs. the strobe width. This scheme provides the identification of charged particles with 99% efficiency in the strobe of 25 ns.

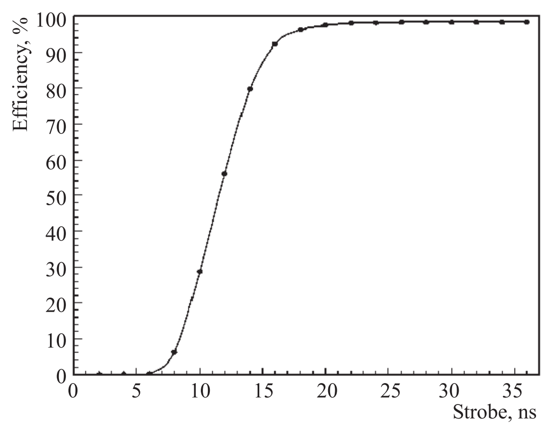

Fig. 5. CSC registration efficiency vs. strobe width for 4/6 majority scheme

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 $2 \cdot 10^5$ γ/cm^2·s).

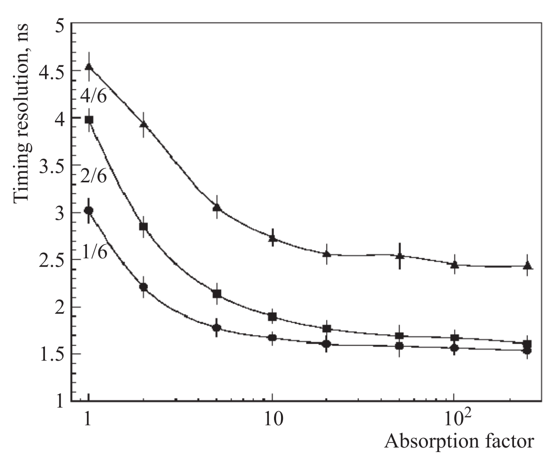

Fig. 6. CSC timing resolution for different majority coincidence options as a function of the absorption factor

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 widths of 25 and 50 ns. One can see that all the curves reach a plateau at absorption factor ~ 20 (10^5 γ/cm^2·s).

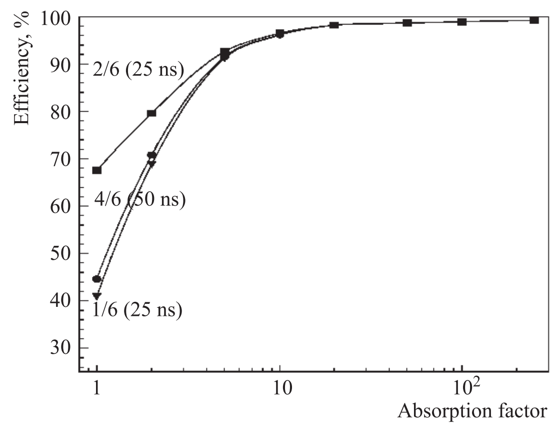

Fig. 7. The CSC efficiency vs. absorption factor for 25- and 50-ns strobe widths

CONCLUSIONS

The possibilities of the unambiguous BX and track registration efficiency have been studied with P3 ME1/1 CSC prototype.

The results show that without background the unambiguous BX identification with MSD-2 anode read-out electronics can be made by a majority coincidence scheme $1/6 \div 5/6$ within 25 ns. The CSC track registration efficiency (4/6 scheme) is about 99% within the 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 $2 \cdot 10^5$ γ/cm^2·s, no influence on CSC timing resolution is seen while track registration efficiency (4/6 scheme) degrades at a background rate higher than 10^5 γ/cm^2·s.

Acknowledgements. We would like to thank H. Reithler, G. Bencze, L. Gorn and GIF technical personnel for their kind attention and help.

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Received on June 17, 2005.

Редактор *Н. С. Скокова*

Подписано в печать 04.08.2005.
Формат $60 \times 90/16$. Бумага офсетная. Печать офсетная.
Усл. печ. л. 0,56. Уч.-изд. л. 0,81. Тираж 320 экз. Заказ № 54986.

Издательский отдел Объединенного института ядерных исследований
141980, г. Дубна, Московская обл., ул. Жолио-Кюри, 6.
E-mail: publish@pds.jinr.ru
www.jinr.ru/publish/