E13-2007-61

A. Andronic[1], V. Babkin, S. Chernenko, C. Garabatos[1],
V. Golovatyuk, S. Razin, F. Uhlig[1], H. K. Soltveit[2],
Yu. Zanevsky, V. Zryuev

# RESEARCH AND DEVELOPMENT OF FAST **TRD** READOUT CHAMBERS

Submitted to «Приборы и техника эксперимента»

[1]GSI, Darmstadt, Germany
[2]University of Heidelberg, Germany

Андроник А. и др. E13-2007-61
Разработка и исследование быстрых детекторов
переходного излучения

Для создания детектора переходного излучения для эксперимента CBM, планируемого на ускорителе FAIR, разработаны несколько прототипов быстрых многопроволочных пропорциональных камер и детекторов на основе GEM. Детекторы испытаны на пучке вторичных протонов ускорителя GSI. Эксперимент показал, что прототипы полностью удовлетворяют требованиям, предъявляемым для их использования в качестве детекторов переходного излучения для эксперимента CBM в условиях больших загрузок.

Работа выполнена в Лаборатории высоких энергий им. В. И. Векслера и А. М. Балдина ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 2007

Andronic A. et al. E13-2007-61
Research and Development of Fast TRD Readout Chambers

Several fast multiwire proportional chambers and GEM based detectors were constructed in the frame of R&D for Transition Radiation Detector for CBM experiment planned at FAIR. The results of experiments with a beam of secondary protons at GSI let us conclude that the multiwire proportional chamber–type detector meets all requirement to the Transition Radiation Detector of CBM high rate environment experiment.

The investigation has been performed at the Veksler and Baldin Laboratory of High Energies, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna, 2007

We present the results of R&D obtained for fast Transition Radiation Detector (TRD) prototypes for the Compressed Baryonic Matter (CBM) experiment planned at FAIR. The TRD will provide electron identification and tracking of all charged particles. Because of the high rate environment and high particles multiplicities expected in the CBM experiment a fast readout detector has to be used and carefully optimized.

Several multiwire proportional chambers (MWPC) and GEM based detectors with a sensitive area of $\sim 10 \times 10$ cm$^2$ were constructed at the JINR and tested with the beam [1–3] to study a rate capability, position resolution and operational stability. The measurements are performed at GSI with a beam of secondary protons having 1–2 GeV/c momentum. The setup used for the beam test was composed of two scintillator counters to define the beam and trigger as well as two silicon strip detectors with 50 $\mu$m strip pitch in both directions. The triple GEM detector with a drift gap of 3 mm, 3 mm induction gap and 2 mm pitch of PCB readout plane was used during this test as a reference detector [1]. The beam rate was chosen by varying the extraction time of the primary beam from 0.5 to 10 s. The beam spot size derived from the silicon strip detectors data was 23.5 mm in *X* direction and 14.5 mm in *Y* direction.

To choose for a good detector performance up to the rates of $\sim 400$ kHz/cm$^2$, the multiwire 6 mm thick proportional chamber was used which had anode wires of 20 $\mu$m diameter and the wire pitch of 2 mm. For an efficient absorption of Transition Radiation (TR), the counting gas was 85% Xe–15% $CO_2$. The chamber readout board consisted of 2 rows of $5 \times 20$ mm$^2$ pads (8 pads in the row). The pad induced signals were amplified with a 16-channel ASIC preamplifier/shaper (designed in 0.35 $\mu$m CMOS technology) [4] and sampled with a 25 MHz ADC (8 bit, nonlinear). An example of an average pulse height sampled by ADC is shown in Fig. 1 for MWPC (the left panel) and for the GEM based chamber (the right panel).

An example of the instantaneous rate of particles traversing the chambers at every triggered event is shown in Fig. 2. Figure 3 illustrates the beam intensity spectra. The pile-up events were taken into account and rejected during the data analysis. The low intensity events corresponded to the first triggers in the spill and to the triggers in-between spills.

To study the detector rate capability, the amplitude of the total charge induced in the detector was determined by summing up all the pad signal amplitudes in the MPWC and the strip signal amplitudes in the triple GEM detector. The amplitude spectra for MWPC and GEM are presented in Fig. 4. The line is the result of

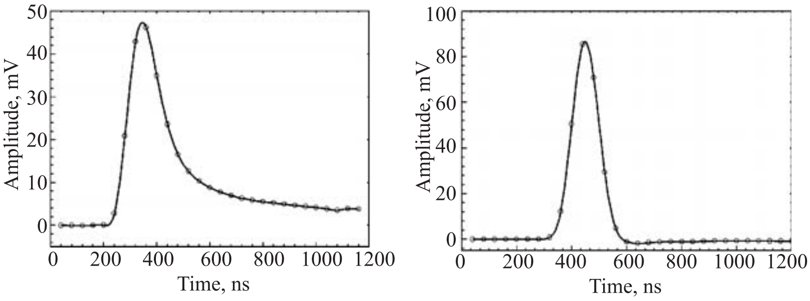


Fig. 1. Average signals sampled by ADC for MWPC (left panel) and triple GEM detector (right panel). The line is the result of spline interpolation

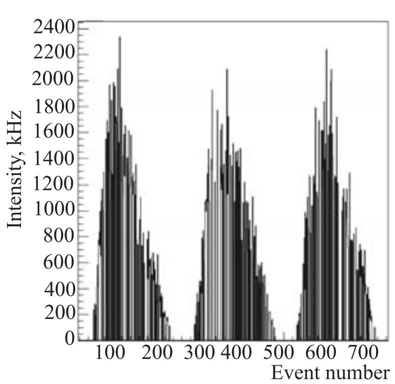


Fig. 2. Instantaneous rates for triggered events for 3 beam spills

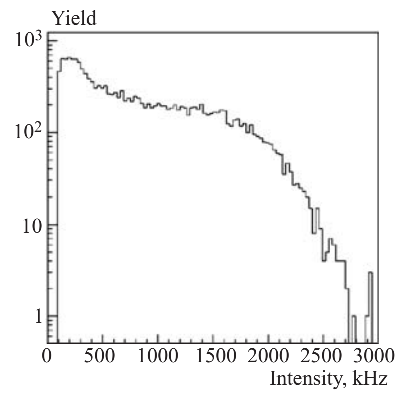


Fig. 3. The beam intensity spectra

Landau fit. The most probable amplitude value defined by the fit was used then in the rate dependence analysis as the average signal amplitude.

Figure 5 shows the rate dependence of the average signal amplitude for the MWPC and triple GEM detector. It is seen that the MWPC with anode potential of +1900 V (amplification factor is about $6{\cdot}10^3$) shows practically no degradation of the signal amplitudes up to the rate of $\sim$360 kHz/cm$^2$.

Taking into account the high spatial resolution ($<$ 200 $\mu$m) [5] and the operational stability of the multiwire proportional chamber type detector as well as the results obtained on its rate capability in our research we believe that the above detector meets all requirements to the Transition Radiation Detector of CBM project.

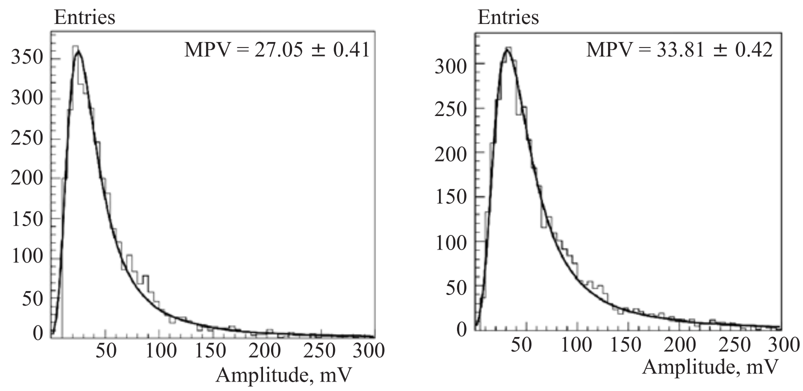


Fig. 4. Pulse height spectra for MWPC (left panel) and 3-stage GEM detector (right panel)

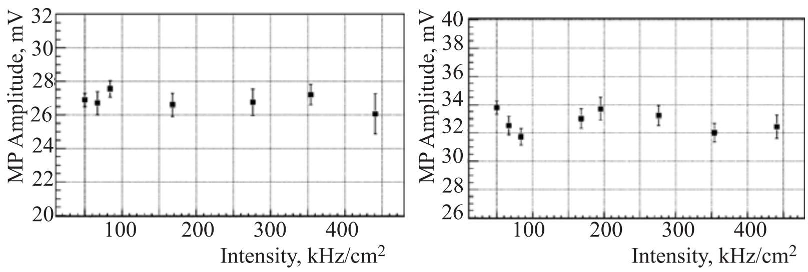


Fig. 5. Rate dependence of the average signal amplitude for the MWPC (left panel) and triple GEM detector (right panel)

Another double GEM detector was constructed and tested with $^{55}$Fe source at JINR. It had one-dimensional readout board with the strips of 0.6 mm pitch and 10 cm long. The drift gap was 10 mm and induction gap – 2 mm. The detector operated with gas mixture of 85%Ar + 15%$CO_2$. The amplification factor of the detector was about $3 \cdot 10^3$. The signal was readout to DAQ from the strips via the same 16-channels preamplifier/shaper [4]. The detector pulse shape can be described in terms of induced current due to the moving charge cluster. The total induced current should be constant. The strip closest to the centre of the cluster will get the main fraction of the total current and the rest part of the total current will spread out between the adjacent strips. The distribution of the number of fired strips is shown in Fig. 6. It is seen that mostly 3 adjacent strips are fired.

During the test the detector was irradiated with the $^{55}$Fe gamma source having 80 $\mu$m slit collimator. The coordinates of gamma conversion points into the detector were determined by using the centre of gravity method for the fired strips. The plot of gamma conversion point coordinates is shown in Fig. 7. Without taking the slit collimator size into account a Gaussian fit of the data let us to conclude that the spatial resolution should not be worse than $\sim$110 $\mu$m.

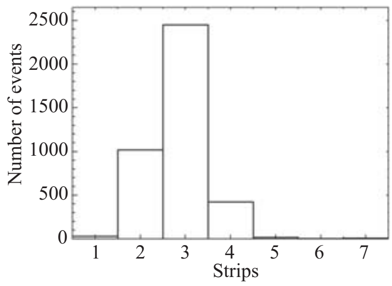


Fig. 6. Distribution of strip numbers fired in double GEM detector

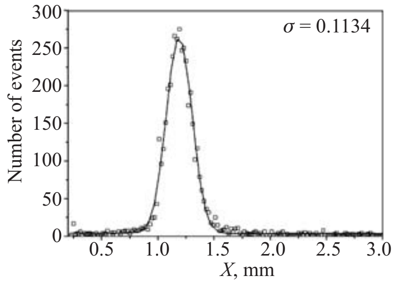


Fig. 7. Spatial resolution of double GEM detector

**Acknowledgements.** This work was partially supported by INTAS grant No. 03-54-4169. We would like to express our gratitude for the help to P. Braun-Munzinger, M. Petrovici, M. Petris, P. Senger, R. Simon, C. Schmidt, J. Wessels.

## REFERENCES


1. *Andronic A. et al.* High Rate Performance of Fast Gaseous Detectors. GSI Annual Report. 2004/2005-1.

2. *Andronic A. et al.* Electron/Pion Identification with Fast TRD Prototypes. GSI Annual Report 2006.

3. *Petrovici M. et al.* High Efficiency Transition Radiaition Detector for High Counting Rate Environment. GSI Annual Report 2006.

4. *Soltveit H. K., Rusanov I., Stachel J.* Fast TRD Pre-Amplifier Shaper for the CBM Experiment. GSI Annual Report 2005. P. 72.

5. *Petrovici M. et al.* Fast TRD–R&D Status. // CBM Collaboration Meeting, 22 September 2006, Strasbourg, France.


Received on April 23, 2007.

Корректор *Т. Е. Попеко*

Подписано в печать 2.07.2007.
Формат $60 \times 90/16$. Бумага офсетная. Печать офсетная.
Усл. печ. л. 0,43. Уч.-изд. л. 0,61. Тираж 325 экз. Заказ № 55821.

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