Краткие сообщения ОИЯИ №2[65]-94 *JINR Rapid Communications No.2[65]-94*
УДК 539.1.074.6

SOME RESULTS OF MCP TIMING RESOLUTION MEASUREMENTS WITH MINIMUM IONIZING PARTICLES

A.A.Baldin[1], L.G.Efimov, G.A.Feofilov[2], S.N.Filippov[1], V.S.Pantuev[1], F.F.Valiev[2]

First results of the timing resolution tests done with 800 MeV/c pion and proton beams for the MCP-based detector are reported. Two chevron stacks of multichannel plate (MCP) detectors with dimensions 43×63 mm^2 were used together with the multipad readout anodes. The detectors were placed at 34 mm distance one from another along the beamline inside the vacuum chamber. The value 285 psec (FWHM) was obtained for the TOF spectra both for pions and protons.

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

Некоторые результаты измерений временного разрешения МКП для минимально ионизирующих частиц

А.А.Балдин и др.

Приводятся первые результаты измерений временного разрешения детектора на основе микроканальных пластин (МКП), полученные на пучках пионов и протонов с импульсом 800 МэВ/с. Использовались две сборки МКП детекторов с размерами 43×63 мм^2 совместно с многопадовой анодной системой. Детекторы располагались в вакуумной камере на расстоянии 34 мм по пучку. Для времяпролетного спектра получена ширина на полувысоте 285 псек как для пионов, так и для протонов.

Работа выполнена в Лаборатории высоких энергий, ОИЯИ.

1. Introduction

This work is aimed at the experimental investigation of the high timing features of MCP detectors that can be used in a wide range of experiments with MIPs. Results of the previous studies [1] of the efficiency of MCP detectors for the MIPs registration stimulated our proposals for the new type coordinate and time sensitive detectors [2]. Now the work is being carried

[1]INR, Institute for Nuclear Research, RAS, Moscow, Russia
[2]SPbSU, St. Petersburg State University, St. Petersburg, Russia

out on the design of the MCP Forward Multiplicity Detector of the future ALICE detector at the LHC [3]. Besides being used as charge particle multiplicity counter this MCP detector is supposed to be applied as Z-coordinate primary vertex detector and can be included into the First Trigger. The expected excellent timing characteristics of MCPs [4] were not sufficiently studied previously with minimum ionizing particles.

Below we describe briefly the MCP-based multipad detector prototype designed for the future LHC environment and give the details of timing resolution measurements done for a set of two detectors.

2. Detectors and Experimental Setup

Measurements were done at the KASPIY magnetic channel of the INR located at the Laboratory of High Energy, JINR, Dubna. Pions and protons with momentum 800 MeV/c, beam size $10 \times 10\ cm^2$ and intensity $10^2 - 10^3$ per spill were used as well as β-source.

We used rectangular MCPs with conventional parameters: material — (SiO_2) PbO, density 3.89 g/cm^3, sensitive area $43 \times 63\ mm^2$, thickness

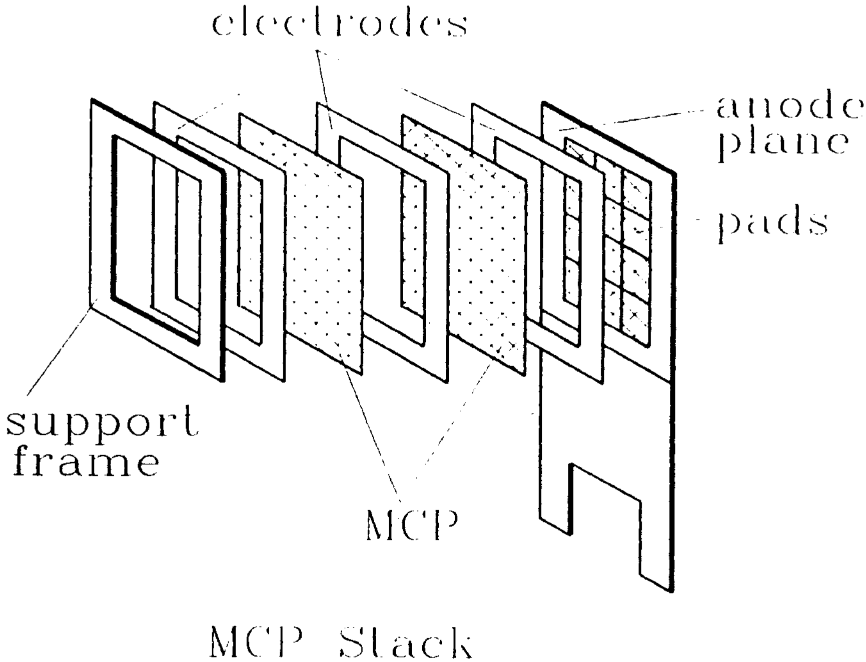

Fig.1. Artistic view of the MCP stack. The transmission lines are positioned on the backplane of the anode plate

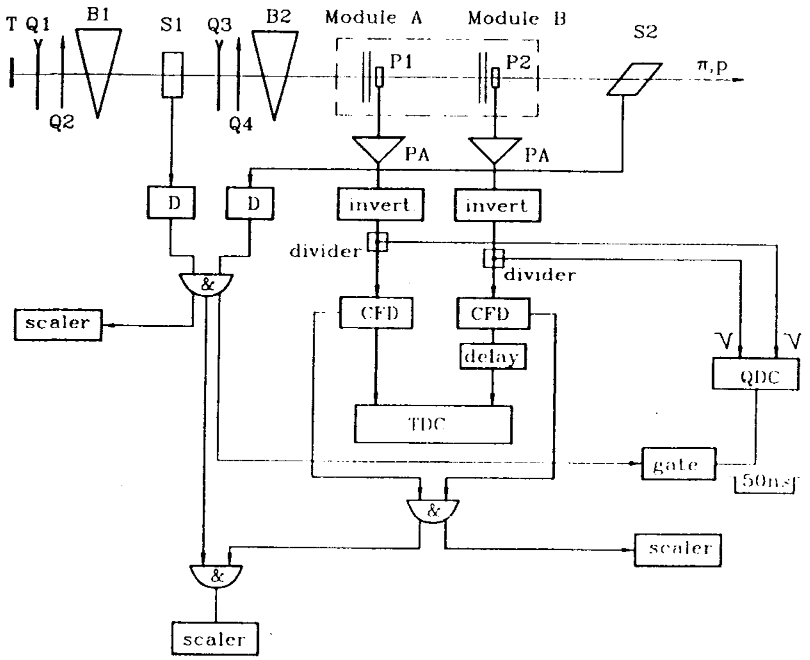

Fig.2. Schematic view of the channel and the block diagram of the electronics. T — target, Q1—Q3 — magnetic lenses, B1—B2 — magnetic dipoles, S1—S2 — scintillation counters, P1—P2 — pads, PA — current preamplifiers, D — discriminators, CFD — constant fraction discriminators, QDC — charge-to-digital converters, TDC — time-to-digital converter

770 μm, channel diameter 15 μm, channel pitch 17 μm, channel bias angle 7°, resistance $6.4 \cdot 10^8$ Ohm, gain $1.6 \cdot 10^4$ at $U = 1.14$ kV.

The general layout of one MCP-based large area multipad detector is given in Fig.1. It consists of two MCPs mounted in a chevron type stack and a special multipad readout anode combined with 50 Ohm transmission lines [5]. Pads have $13{\times}15$ mm^2 size arranged in 3×4 matrix. For technical reasons we have chosen rather large interplate distance 0.5 mm for each stack. The distance between last MCP plate and anode was 0.25 mm.

Two similar modules were mounted on the flange at the distance of 34 mm and placed into the vacuum chamber along the beam line. The vacuum chamber had two mylar $28{\times}16$cm^2 windows of 250 micron thickness. Operating pressure was $(1 \div 3) \cdot 10^{-6}$ Torr. An external high voltage divider was used for each detector. It supplies equal HV for MCPs in the stack, some potential between MCPs, and a collecting potential about 100 V between the last MCP and the anode.

Signals from the anode pads were enhanced by current preamplifiers with 3 nces rise time (resulted in 5 nsec rise time and 20 nsec duration after 30 meters of cable) and the gain about 40 (or 2 mV/μA).

The block diagram of the electronics used for measurements with beam particles is presented in Fig.2. We used one pad in the first module and one pad in the second one. Signal after preamplifier was splitted to two equal pulses by passive divider. One pulse was sent to QDC, another one after Constant Fraction Discriminator (CFD) was used as start/stop input for TDC and for coincidence measurements. Two identical plastic scintillator counters S1 and S2 having sizes 10×10 cm^2 were used for QDC gating. S1 was mounted in intermediate focal plane of the magnetic channel 7.2 meters upstream, S2 was positioned just behind the vacuum chamber.

3. Results and Discussion

Operating conditions of the MCP detectors were tested with a collimated β-source prior to measurements with beam particles.

In our case the applied voltage was 2.5 kV for the stack or 1.2 kV for one MCP plate and was restricted by ion feedback. All presented results were obtained at this voltage. The interplate voltage obtained after some adjustment was −100 V. It cleared the signal and suppressed the positive ion feedback in a wide range of the applied voltage. Nevertheless, as can be seen from Fig.3, where collected charge from one pad is shown, we are far from the saturation mode.

The test measurements of counting rate from β-source and noise versus applied HV are shown in Fig.4. The efficiency of registration of MIPs by this MCP detector was tested with particle beams by usual method of two- and three-fold coincidences between S1, P1 and P2 (See Fig.2). The measured dependence of the efficiency on HV is shown in Fig.5. The geometric factor + 25% was taken into account. It reflects an angular spread of particles in the beam about ± 70 mrad. Estimations of this geometric factor were made with the program code DECAY TURTLE. Within the errors we did not find the efficiency plateau: it grows steadily with HV reaching the value more than 80% at the maximum. This value is close to that from [1] and may be explained by the rather high CFD threshold and hence by some amount of amplitudes under the threshold.

The result of the timing resolution measurement is presented in Fig.6. Signals from two MCP detectors were used as start-stop inputs for TDC. The TDC channel width is 95 ± 5 psec. The timing resolution (for two detectors and electronics) is 3 TDC's channels that corresponds to FWHM = 285 psec.

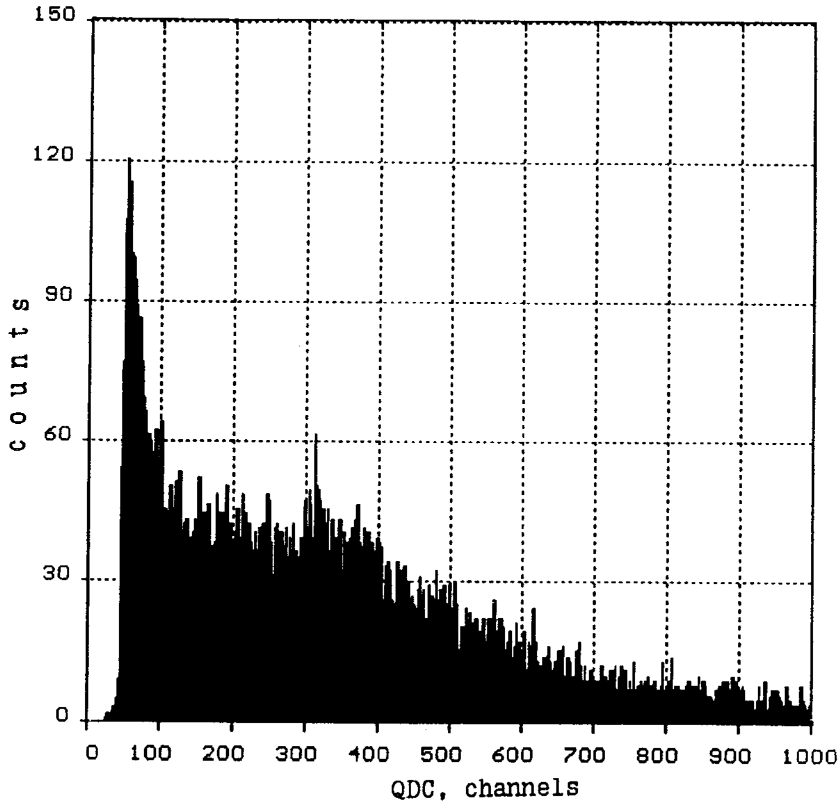

Fig.3. The pulse height spectrum from one pad of the MCP detector obtained with β-source

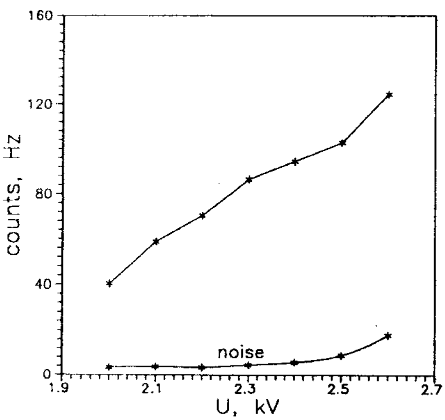

Fig.4. The counting and noise rates for one pad measured with β-source

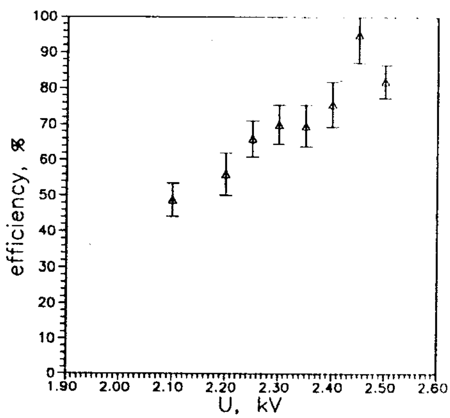

Fig.5. The efficiency vs. HV for one pad measured with pions and protons at 800 MeV/c

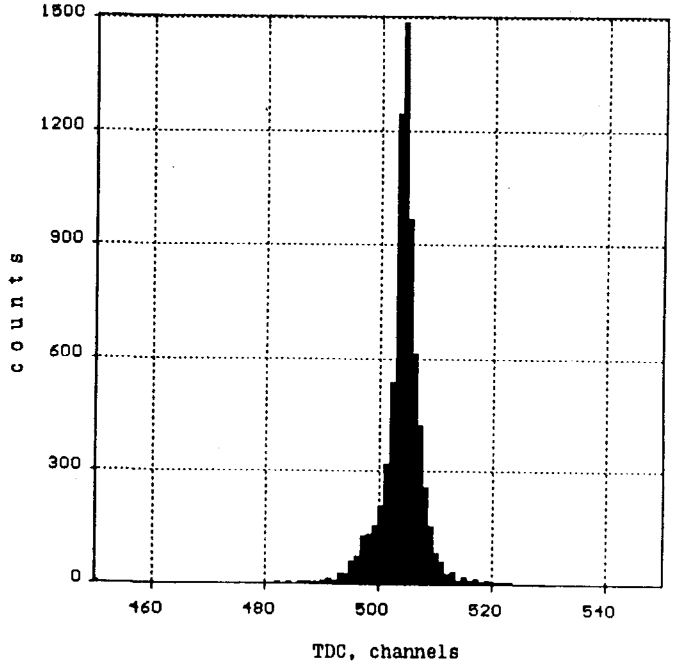

Fig.6. Time-of-flight spectrum for two pads measured with pion and proton beam at 800 MeV/c. The distance between pads is 34 mm. FWHM is 285 psec. The TDC channel width is 95 ± 5 psec

4. Conclusions

First results of the timing resolution tests at 800 MeV/c pion and proton beams for two MCP-based multipad detectors are reported. Two chevron stack of 43×63 mm^2 sensitive area MCPs were used together with the multipad readout anodes. The value FWHM = 285 psec was obtained for the TOF spectra both for pions and protons.

In order to improve further the timing resolution it is necessary to optimize the geometry of the detectors and exploit MCPs in saturation mode. The later is preferable for using MCP as a multiplicity detector [3] due to better signal to noise ratio and peaked signal electron pulse height attainable for this regime.

It would be useful also to test these detectors at lower pressure of ambient gas close to that of LHC, where the effect of ion feedback is negligible.

5. Acknowledgments

We would like to express sincere gratitude to a lot of people from JINR who helped us in the preparations of this work: to the engineering staff of the synchrophasotron for the possibility of our investigations with high quality particle beams, to L.B.Golovanov for his constant interest and support, to A.P.Tsvinev and A.Churkin for their help with the vacuum provision, to A.Semenov and Yu.Belikov who kindly lended us computer codes for data acquisition, to P.K.Manyakov for his useful consultations. Authors are grateful also to F.A.Tsimbal, S.Borozdin and O.I.Stolyarov (all from SPbSU) who participated in the multipad anode design.

References

1. Valiev F.F. et al. — JINR Rapid Communications, No.4[50]-91, Dubna, 1991, p.27.
2. Baldin A.A. et al. — NIM, 1992, A323, p.439.
3. ALICE Collaboration at CERN, CERN/LHCC/93-16, LHCC/I 4, 1 March 1993.
4. Oba K. et al. — IEEE Trans. Nucl. Sci., vol.NS-28, No.1, February 1981, p.705.
5. Borozdin S., Feofilov G., Stolyarov O., Tsimbal F., to be published elsewhere.

Received on July 18, 1994.