Письма в ЭЧАЯ. 2016. Т. 13, № 5(203). С. 848–851

МЕТОДИКА ФИЗИЧЕСКОГО ЭКСПЕРИМЕНТА

STATUS OF THE FRONT-END ELECTRONICS FOR THE TIME-OF-FLIGHT MEASUREMENTS IN THE MPD EXPERIMENT

V. A. Babkin, M. G. Buryakov[1], *V. M. Golovatyuk, S. V. Volgin, M. M. Rumyantsev*

Joint Institute for Nuclear Research, Dubna

The preamplifier based on the ASIC NINO for the Time-of-Flight system (TOF) of MPD/NICA was developed and tested. The signal is read from both sides of the strip of the Multigap Resistive Plate Chamber (MRPC). In total there are around 14000 channels of electronics. To measure the time of flight of secondary particles from collision of heavy ions on the NICA collider the Time-over-Threshold (ToT) method is used. According to the bench tests, the preamplifier board showed stable work and good time resolution < 10 ps for one channel. It was also tested at the test beam facility of the Nuclotron. The time resolution of the TOF detector which used the described preamplifier was reached ~ 42 ps.

PACS: 84.30.Le

INTRODUCTION

A conceptual design of the MultiPurpose Detector (MPD) is proposed for a study of hot and dense baryonic matter in collisions of heavy ions over the atomic mass range $A = 1{-}197$ at the centre-of-mass energy of up to $\sqrt{S_{NN}} = 11$ GeV (for Au^{79+}). The MPD experiment is designed to work at the constructing accelerator complex for heavy ions — the Nuclotron-based Ion Collider fAcility (NICA) which is designed to reach the required parameters with an average luminosity of $L = 10^{27}$ cm$^{-2} \cdot$ s^{-1}.

MPD is designed as a 4π-spectrometer capable of detecting charged hadrons, electrons and photons in heavy-ion collisions. MPD has two main identification subsystems. One of the subsystems is based on the Time Projection Chamber and the other one is a high-performance time-of-flight (TOF) detector.

Overall time resolution of the TOF has to be better than 100 ps. As an active detector for the TOF we use the Multigap Resistive Plate Chambers (MRPC) with a long strip readout.

The TOF system represents a barrel with two end caps. At the first stage it will consist of 14 modules with total number of FEE channels of 13440 [1].

[1]E-mail: bmg@jinr.ru

FRONT-END ELECTRONICS FOR THE TOF MPD

For the front-end electronics we use the preamplifier-discriminator based on ASIC NINO developed for the TOF ALICE. Since each detector has 24 strips it was decided to have a 24-channel amplifier. The 8-channel NINO ASIC has been designed for low-level input signals based on 0.25 μm CMOS technology [2]. The NINO chips are used in other applications such as the RICH detector at NA62 at CERN for R7400 PMT readout [3], the TOF system in PET Gundacker [4], Multianode Micro-Channel Plate (MCP) PMT, TORCH time-of-flight detector [5].

The NINO and multihit TDC HPTDC also developed for ALICE are used to perform time-over-threshold (ToT) measurements. A threshold value of the preamplifier can be set by the potentiometers and by the remote source. The NINO has an output pulse stretcher that can be set to suit input requirements of the HPTDC.

The front-end prototype (Fig. 1) has been developed at the Laboratory of High Energy Physics. The board has 24 channels based on 8-ch NINO ASIC. The board is specially adapted for the MRPC with long strips. It has matched impedance between the preamplifier and the chamber, preventing reflections in cable. Reflection of the signal is the main source of the error in reconstruction of charge of the signal in the ToT method.

Fig. 1. 24-ch NINO based front-end board with Molex's CXP connector as an output

The differential input was designed to have 55 Ω impedance that is equal to the MRPC output. In order to protect the channels of ASIC when the high voltage is applied to the detector, we put 1 MΩ resistors on each input. The Molex CXP (InfiniBand) connector system as an output provides 100 Ω transmission line with good electrical characteristics. The low dropout linear regulator (LDO) is installed on the board to eliminate additional measurement error. Also, LDO allows avoiding a jitter of controlling stages and provides more accurate measurement. The board can operate with the voltage in the range from 3.3 to 6 V.

The principal diagram of the FEE board is presented in Fig. 2. The active area of the MRPC is 600 × 300 mm. It has 24 readout electrodes each 10 mm wide and 600 mm long (strips). The differential analog signal is transmitted from readout electrodes by the

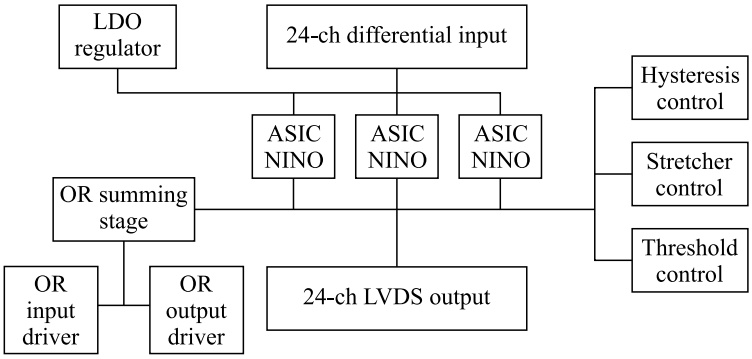

Fig. 2. Block diagram of the TOF preamplifier board based on the NINO chips

twisted pair cable to the front-end electronics. The signal is read out from both ends of the strip. It provides better time resolution and determination of the coordinate of a particle along the strip. The discriminated LVDS signal goes through the Molex cable to a special 72-channel VME64x time-to-digital converter TDC72VHL based on a High Performance TDC ASIC (HPTDC). Time-sampling of the TDC72VHL is less than 25 ps [6]. Then the data is collected on the PC for the future analysis.

Dependence of the width of the LVDS pulse on the electrical charge has been measured. Time resolution was measured with an electrical pulse coupled through a 1 nF capacitor. The pulse is split between two channels on the NINO board, one output with added cable delay. The magnitude of the difference is measured (Fig. 3) between the reference front edge and the front edge of the second channel — the sigma is over 10.39 ps. Since two signals are equal, the timing resolution of one channel is $10.39/\sqrt{2} = 7.34$ ps.

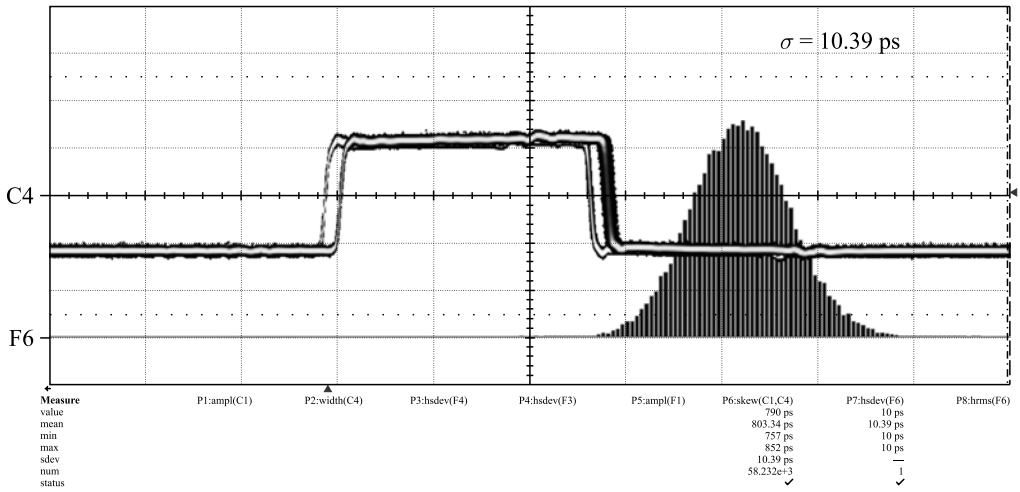

Fig. 3. Time distribution between two FEE board channels

CONCLUSIONS

The MRPC with preamplifier boards has been tested on a cosmic stand and also at the "Test beam MPD" facility during the Nuclotron run. The MRPC was tested on the beam of deuterons with energy of 3.5 GeV/A. Time resolution of 42 ps was reached (Fig. 4) after time-over-threshold correction. The detector provided an efficiency of about 99% at high voltage (12 kV) [7].

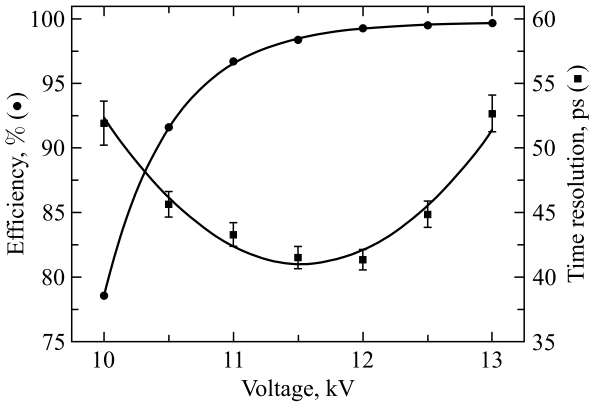

Fig. 4. Voltage dependence of the time resolution and efficiency

A further increase in voltage causes an increase of the number of streamers and deterioration in time resolution. Influence of the threshold of discrimination on the resolution and efficiency is not significant. Time resolution of the detector does not change due to the position of the particle tracks along the strip.

REFERENCES

1. MPD NICA Technical Design Report of the Time of Flight System (TOF). http://nica.jinr.ru/files/TDR_MPD/.
2. *Anghinolfi F. et al.* NINO: An Ultra-Fast and Low-Power Front-End Amplifier/Discriminator ASIC Designed for the Multigap Resistive Plate Chamber // Nucl. Instr. Meth. A. 2004. V. 533. P. 183–187.
3. *Marinova E.* The NA62 RICH Detector // Nucl. Phys. B. Proc. Suppl. 2011. V. 215. P. 125–127.
4. *Gundacker S. et al.* SiPM Photodetectors for Highest Time Resolution in PET // PoS (PhotoDet2012) 016. 2012.
5. *Gao R. et al.* Development of Precision Time-of-Flight Electronics for LHCb TORCH // J. Instr. 2014. V. 9. P. C02025.
6. *Christiansen J.* High Performance Time to Digital Converter. Version 2.2. 2004. http://tdc.web.cern.ch/TDC/hptdc/docs/hptdc_manual_ver2.2.pdf (7).
7. *Babkin V. et al.* Triple-Stack Multigap Resistive Plate Chamber with Strip Readout // Nucl. Instr. Meth. A. 2015. http://dx.doi.org/10.1016/j.nima.2015.11.060.