Author(s): Grigoryev, V. A.; Kaplin, V. A.; Karavicheva, T. L.; Kurepin, A. B.; Maklyaev, E. F.; Melikyan, Yu. A.; Serebryakov, D. V.; Trzaska, Wladyslaw; Tykmanov, E. M.

Title: Study of the Planacon XP85012 photomultiplier characteristics for its use in a Cherenkov detector

Year: 2016

Version:

Please cite the original version:

Grigoryev, V. A., Kaplin, V. A., Karavicheva, T. L., Kurepin, A. B., Maklyaev, E. F., Melikyan, Y. A., Serebryakov, D. V., Trzaska, W., & Tykmanov, E. M. (2016). Study of the Planacon XP85012 photomultiplier characteristics for its use in a Cherenkov detector. In I. Arkhangelskaja, & P. Buzhan (Eds.), ICPPA-2015 : International Conference on Particle Physics and Astrophysics, 5–10 October 2015, Moscow, Russia. Institute of Physics Publishing Ltd.. Journal of Physics: Conference Series, 675. https://doi.org/10.1088/1742-6596/675/4/042016

Study of the Planacon XP85012 photomultiplier characteristics for its use in a Cherenkov detector

2016 J. Phys.: Conf. Ser. 675 042016

(http://iopscience.iop.org/1742-6596/675/4/042016)

Journal of Physics: Conference Series **675** (2016) 042016 doi:10.1088/1742-6596/675/4/042016

Study of the Planacon XP85012 photomultiplier characteristics for its use in a Cherenkov detector

V A Grigoryev[1], V A Kaplin[1,4], T L Karavicheva[2], A B Kurepin[2], E F Maklyaev[1], Yu A Melikyan[1], D V Serebryakov[2], W H Trzaska[3] and E M Tykmanov[1]
[1] National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, Moscow, 115409, Russia
[2] Institute for Nuclear Research of the Russian Academy of Sciences, V-312, 60-letiya Oktyabrya prospect 7a, Moscow, 117312, Russia
[3] University of Jyväskylä, P.O. Box 35, FI-40351 Jyväskylä, Finland

E-mail: kaplinv@mail.ru

Abstract. Main properties of the multi-anode microchannel plate photomultiplier to be used in a Cherenkov detector are discussed. The laboratory test results obtained using irradiation of the MCP-PMT photocathode by picosecond optical laser pulses with different intensities (from single photon regime to the PMT saturation conditions) are presented.

1. Introduction

In fast scintillation and Cherenkov detectors operating in high magnetic fields fine-mesh vacuum phototubes were used in the latest devices [1] due to their capability to operate in magnetic fields up to about 0.5 T. The future experiments demand higher fields combined with much smaller dimensions (length) of the photosensors. The MCP based PMTs were not used not only because of their high price, but also because of their arbitrary small photocathode area and poor ratio of the photocathode area to the total area of the entrance window.

The new Planacon XP85012 photomultiplier has a large area photocathode (53 x 53 mm^2) having the overall face area of 59 x 59 mm^2 and 28 mm thickness only [2]. The PMT is characterized by a multi-anode structure (8 x 8 anodes array), which provides not only for good coordinate resolution, but also for good time resolution (typically 35 ps) due to small sizes of the anodes. At the same time, in large area Cherenkov detectors there is no reason to take signals from each anode independently because it brings to an enormous number of electronic channels. The anodes should be reasonably united. We made our studies of the PMT timing properties combining up to 16 anodes into a single electronic channel. Besides this, the PMT has a separate positive output uniting all 64 anodes which also can be used.

Our measurements were done using a picosecond laser (405 nm) with the pulses duration of 30 ps, pre-amplifier ORTEC VT120 (x20 gain), LECROY WR 620Zi oscilloscope and standard NIM and CAMAC modules. For precise measurements we used also constant fraction discriminator (Canberra 454) and time-to-amplitude converter (Canberra 2145).

[4] To whom any correspondence should be addressed.

2. Amplitude measurements

Figure 1 shows the PMT signals waveforms detected by different number of electrically interconnected anodes (1, 2 and 4). One can see that the anodes interconnection brings to pulses' broadening. However, the leading edge of the pulses remains practically constant.

Figure 2 shows the dependence of the PMT amplitude versus the intensity of the light pulses. It is linear in the dynamic range more than 1:100 which is enough in most experimental cases. Cherenkov detector module based on the XP85012 multianode microchannel plate photomultiplier is going to be used as a basic element of the FIT detector. The first testing procedures carried out under laboratory conditions showed that the photomultiplier is suitable for the use in the FIT detector [3].

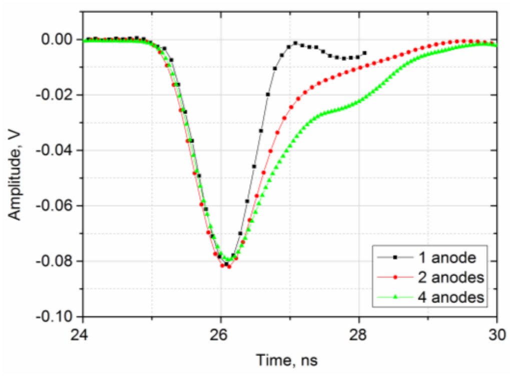

Figure 1. Signal waveforms from different number of the PMT anodes (1, 2 and 4), interconnected electrically.

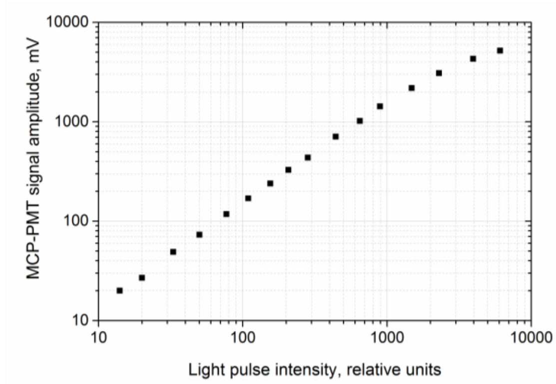

Figure 2. Dependence of the PMT signal amplitude (detected by 16 anodes) on the laser pulses' intensity (U_b = 1300 V, A_{MIP} = 50 mV).

Single photoelectron amplitude spectra are presented in figure 3 being measured with 1, 4 and 16 anodes. The amplitude resolution is much better in the case of 16 anodes which can be explained by a more complete electrons collection from the multichannel plate.

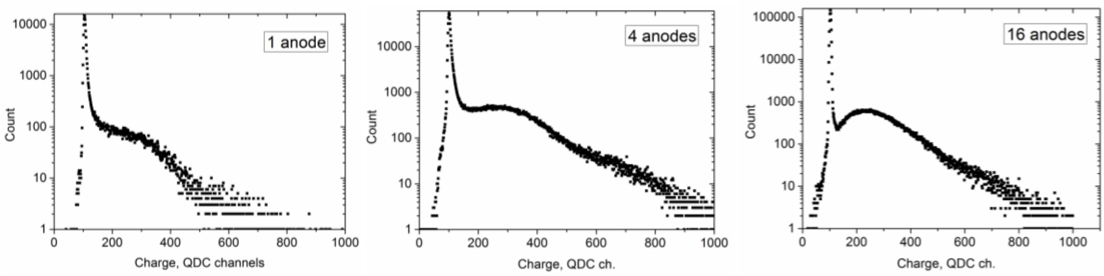

Figure 3. Single photoelectron amplitude spectra measured by 1, 4 and 16 interconnected anodes.

3. Timing measurements

Figure 4 shows the transit time spread for single photoelectron signals. The resulting time resolution values for signals detected by only one anode (50 ps sigma) corresponds to analogous results (35-40 ps) published elsewhere after certain corrections for the laser pulse duration and the timing properties of the analog electronics used. The time resolution obtained for several interconnected anodes is 1.5-2.0 times worse. As the leading edge of the signal from the interconnected anodes is not changed, we suppose that the time resolution worsening arises due to increased capacity of the anode and due to the decrease in the signal-to-noise ratio for this case.

A set of measurements of time resolution at different light pulse intensities up to 100 photoelectrons coming from the PMT's photocathode was done. Time resolution was measured with

Journal of Physics: Conference Series **675** (2016) 042016 doi:10.1088/1742-6596/675/4/042016

LeCroy WR 620 Zi digital oscilloscope for 1, 4 and 16 interconnected anodes with individual anodes' readout at different levels of the discriminator's thresholds. The same procedure was done for 16 interconnected anodes in the case of the common output readout. The summary of the results obtained for optimum levels of the discriminator's thresholds is shown in figure 5. As one can see, in all cases the resolution is better than 25 ps.

The time resolution measured by the NIM and CAMAC electronic circuits versus the amplitude of the light pulse is given in figure 6.

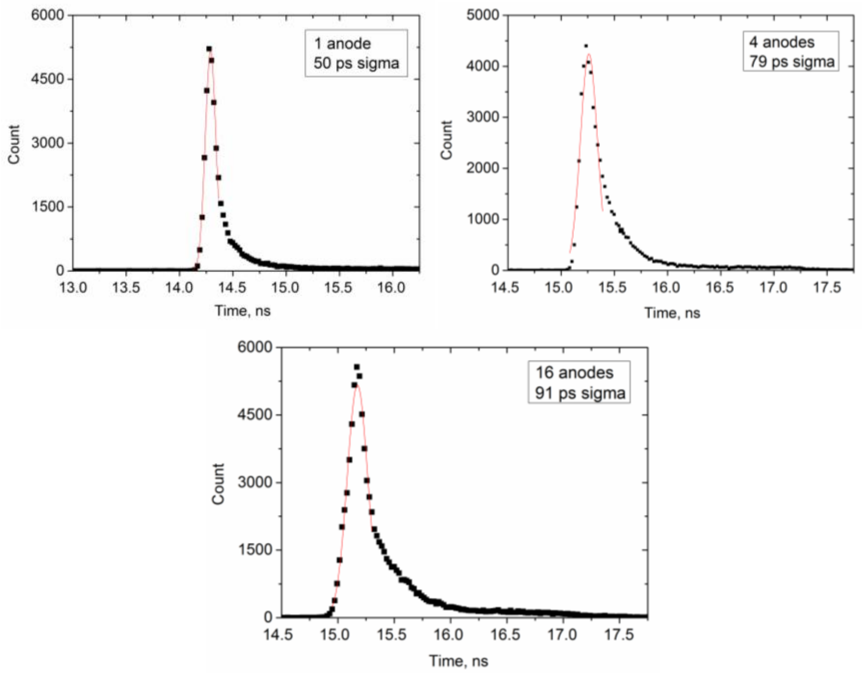

Figure 4. Time distribution spectra for single photon light pulses measured by 1, 4 and 16 interconnected anodes.

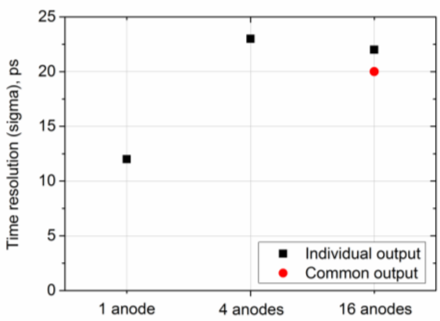

Figure 5. Summary of the time resolution measurements under the detection of 100 photoelectrons light pulses with different number of interconnected anodes for individual and common outputs. The measurements were carried out with LeCroy WR 620Zi digital oscilloscope.

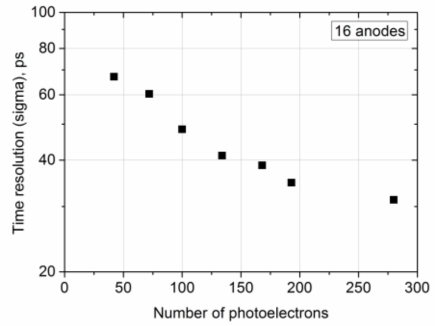

Figure 6. Time resolution as a function of light pulse intensity measured by the analog electronic circuit.

4. Cross-talks in the XP85012 PMT

As it was mentioned above, the PMT of this type offers the possibility to pick up a signal from a common output which unites all anode outputs. Anyhow the presence of this additional output leads to a strong cross-talk arising between individual anode's outputs during registration of a real signal. Figure 7 gives an example of such a cross talk: left picture represents a pulse from a common output (bottom waveform) and from 16 interconnected individual outputs (top waveform) during a real signal detection by these 16 interconnected adjacent channels only. Right picture shows pulses from the same combination of outputs while the whole area of the photocathode is illuminated except of the region with the 16 adjacent anodes under study. This cross talk may be a serious problem when registering simultaneously a number of particles by different groups of interconnected anodes.

The possible way out is to take a signal only from a common output, which is not sensitive to the cross-talks of such type. The other solution under consideration is to make a PMT without the common output by modernizing the PMT's voltage divider and power supply circuits PCB.

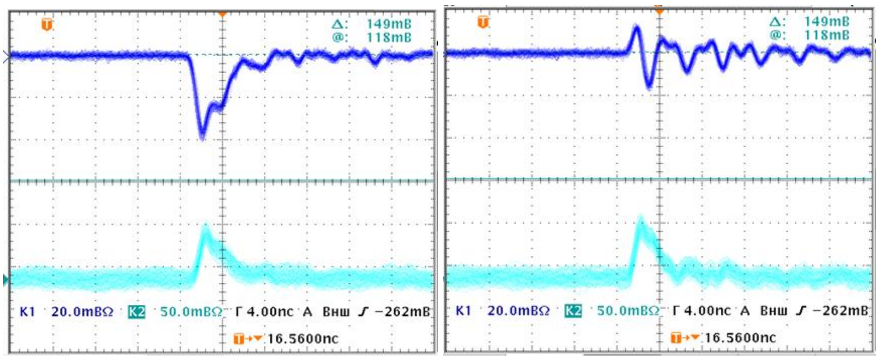

Figure 7. Waveform curves from 16 interconnected individual outputs (top curves) and from the common output (bottom curves). Please, refer to the text above for more detailed description.

5. Conclusion

The Planacon XP85012 MCP-PMT is a good candidate for its application to a Cherenkov detector for collider experiments because of its capability to operate at high magnetic fields, relatively large (53x53 mm^2) photocathode area along with compact total dimensions and reasonable price. Special measurements carried out with analog and digital electronics show the possibility to achieve acceptable amplitude dynamic range (1:100) and time resolution: up to 25 ps in case of direct measurements with digital electronics and up to 50 ps in case of measurements with full analog electronics circuit at 100 ph.e. illumination level.

The cross-talk problem constrains the use of the MCP-PMT in default electronic configuration: even in the case of a few particles simultaneous detection with the device, it would be impossible to use the individual outputs for timing purposes. The possible way out – the common output channel removal from the PMT's PCB – is going to be tested by us in the nearest future.

Acknowledgments

This work was performed within the framework of the Fundamental Research and Particle Physics Center supported by NRNU MEPhI Academic Excellence Project (contract № 02.a03.21.0005, 27.08.2013) and Russian state grant RFMEFI61014X0003.

References

[1] Ikematsu K *et al*. 1998 *Nucl. Instrum. Meth.* A **411** 238-48
[2] Yurevich V I 2013 *Physics of Particles and Nuclei Letters* **10** 258-68
[3] Abelev B *et al.* CERN-LHCC-2013-019 / LHCC-TDR-015