Breakthrough in the Lifetime of Microchannel Plate PMTs*

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The charged particle identification in the PANDA experiment will be done with DIRC detectors. Since their focal planes will be placed inside the magnetic field of up to 2 Tesla microchannel-plate (MCP) PMTs are the favored photon sensors. These devices show very promising properties except that aging was a serious issue until very recently. Due to ion backflow the photo cathode (PC) gets damaged and the quantum efficiency (QE) drops rapidly. Just 3 years ago the best MCP-PMTs were unusable after $<$200 mC/cm^2 integrated anode charge [1], while for the PANDA DIRCs at least 5 C/cm^2 are needed.

With novel techniques the manufacturers recently succeeded in significantly increasing the lifetime of MCP-PMTs. This was accomplished by reducing the ion backflow either with a protection film (Hamamatsu R10754X) between the two MCPs or by applying an atomic layer deposition (ALD) technique to coat the micro pores and reduce the outgassing of the MCP glass (PHOTONIS XP85112, and now also Hamamatsu), but also by using a modified PC (BINP).

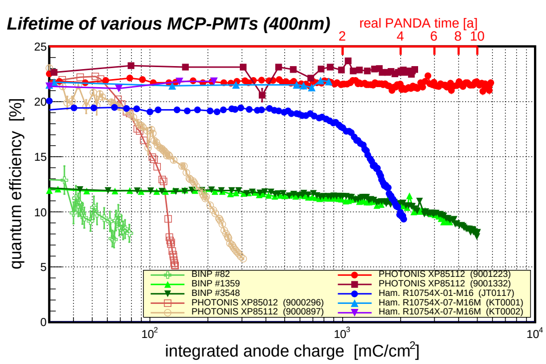

Figure 1: QE at 400 nm for old (open) and latest (solid dots) MCP-PMTs versus the integrated anode charge.

Our group is doing a long-term comparative measurement of the lifetime of the most recent MCP-PMTs by permanently illuminating the sensors with a single photon rate comparable to that expected at PANDA [2]. Gain, dark rate and QE (spectral and as a function of the PC surface) are measured in irregular intervals as a function of the integrated anode charge. A compilation of the QE of all tubes investigated are displayed in Fig. 1. While the QE of older models (open dots) drop to less than half the original value after $<$200 mC/cm^2 the situation for the most recent models (solid dots) is very different. Especially the ALD coated PHOTONIS XP85112 has meanwhile accumulated an anode charge of 5.9 C/cm^2 with only minor QE degradations. This corresponds to over 10 years of PANDA running.

We have also measured the spatial distribution of the QE at the PC surface for all MCP-PMTs. For the Hamamatsu R10754X (with protection film) and the BINP MCP-PMTs we observe that the QE starts degrading from the corners and the rims of the PC [3] and proceeds to the inner regions afterwards. In Fig. 2 a QE chart of the ALD coated PHOTONIS XP85112 is shown. For this tube we observe only moderate QE degradations of 1-2% up to 5.1 C/cm^2. Beyond this charge the sensor shows more QE damage, but still at a tolerable level. At 5.9 C/cm^2 a clear step emerges around x = 0 mm. This stems from the fact that the right half of the PC (x $>$ 0 mm) was covered during the illumination process.

These new results can be considered as a breakthrough in the lifetime of MCP-PMTs and will have implications also on other experiments.

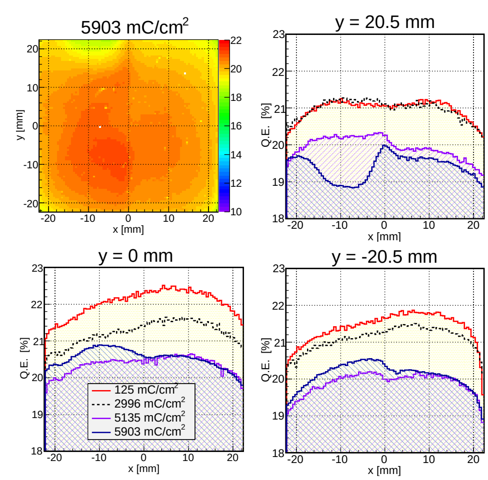

Figure 2: QE at 372 nm as a function of the PC surface for the PHOTONIS XP85112 (9001223) MCP-PMT. Upper left: 2-dim. QE chart (in % [color level]); other plots: QE x-projections at different y-positions and anode charges.

References

[1] A. Lehmann et al., GSI Scientific Report 2010, p. 106
[2] A. Lehmann et al., Nucl. Instr. and Meth. A 718 (2013) 535
[3] A. Lehmann et al., J. Instr. 9 (2014) C02009

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