Significantly improved lifetime of Microchannel Plate PMTs*

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The main particle identification devices of the PANDA experiment will be two DIRCs placed around (barrel) and downstream (disc) of the target. The preferred photon sensor option are microchannel plate (MCP) PMTs because they can be operated inside the 2 Tesla magnetic field of the solenoid. Furthermore, these multi-anode sensors are rather compact and show a superior time resolution which is typically $<$50 ps.

Until recently the major drawbacks of MCP-PMTs were serious shortcomings with their rate capability and in particular with aging effects. The main cause of aging are rest-gas ions in the tube being accelerated towards the photo cathode (PC), whose surface gets damaged by their impact and the quantum efficiency (QE) suffers. Although the rate capability issue was resolved already a few years ago, the aging remained a serious problem [1, 2].

In the latest generation of MCP-PMTs important counter measures were taken to seriously tackle the aging problem. These include a higher vacuum inside the tube and electron scrubbing of the MCP surfaces (PHOTONIS, BINP), an Al_2O_3 protection layer between the 2 MCPs (Hamamatsu R10754X), an ALD coating of the whole MCP capillaries to prevent outgassing of the glass substrate (PHOTONIS XP85112), and even a modified photo cathode (BINP). For further details see Ref. [3].

At the design luminosity of PANDA the anticipated photon rates at the DIRC focal planes range from a few hundred kHz for the barrel DIRC to several MHz at the disc DIRC. Integrated over the envisaged 10 years operation period of the PANDA experiment these rates accumulate to anode charges of $\approx$5 C/cm^2 for the barrel DIRC and even more for the disc DIRC. Since about 18 months we are simultaneously and permanently illuminating the most recent MCP-PMTs to study their aging. The single photon rate at the PCs is chosen to be comparable to that expected in the PANDA environment. The accumulated anode charge is determined by a permanent monitoring of the pulse heights. Every few days a wavelength scan of the QE is done for all illuminated MCP-PMTs. In addition, every few months a QE scan as a function of the PC surface is performed to identify critical regions where the QE may start to drop.

Currently, $>$4 C/cm^2 of integrated anode charge are accumulated. In Fig. 1 the behaviour of the quantum efficiency at a wavelength of 400 nm is compared for several MCP-PMTs. While the QE of the older models (open dots) dropped to 5% after typically $<$300 mC/cm^2 the results for the most recent models (solid dots) is very different. In particular, the ALD coated PHOTONIS XP85112 shows no obvious QE loss even at 4 C/cm^2 which corresponds to 8 years operation of the PANDA barrel DIRC.

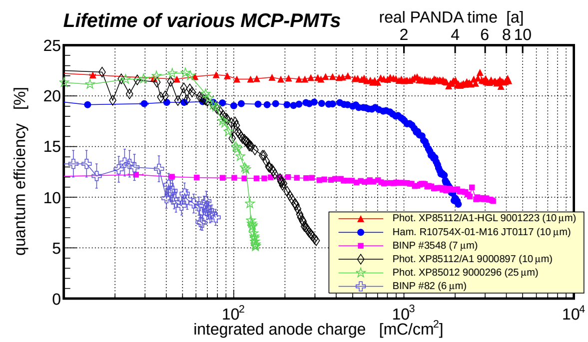

Figure 1: QE at 400 nm for old (open) and new generation (solid dots) MCP-PMTs as a function of the anode charge.

In Fig. 2 the QE is shown as a function of the PC surface. While the QE of all tubes was rather uniform across the PC at the beginning, it starts dropping from the corners and the rim of the PC after a long-term illumination. The figures show that after an integrated anode charge of $\approx$1.8 C/cm^2 for the Hamamatsu and of $\approx$3.4 C/cm^2 for the BINP MCP-PMT the PCs show clear signs of aging. The PHOTONIS XP85112 does not yet show such effects after $>$4 C/cm^2.

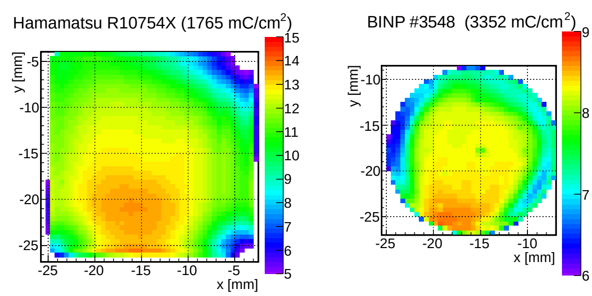

Figure 2: QE across the PC at 372 nm after long-term illumination. The plots scale with the actual dimensions of the PCs (22x22 mm^2 for R10754X [left] and 18 mm diameter for BINP #3548 [right]; the PHOTONIS XP85112 [not shown] has a much larger PC: 51x51 mm^2).

References

[1] A. Lehmann et al., GSI Scientific Report 2009, p. 7.
[2] A. Lehmann et al., GSI Scientific Report 2010, p. 106.
[3] A. Lehmann et al., Nucl. Instr. and Meth. A (2012), http://dx.doi.org/10.1016/j.nima.2012.11.109

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