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Performance of the most recent microchannel-plate PMTs for the PANDA DIRC Detectors at FAIR

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PANDA is one of the main experiments at the FAIR facility at GSI which will study different aspects in QCD by, e.g., performing hadron spectroscopy, among others in searching for glueballs and exotic states, and by investigating hyperons. The PANDA experiment will use an antiproton beam in the momentum range of 1.5 to 15 $\mathrm{GeV/c}$ colliding with a stationary target. Due to antiproton-proton annihilations the production of exotic particles and states is directly possible. The PANDA detector consists of a target and forward spectrometer. Two DIRC detectors, a cylindrically shaped Barrel DIRC (BaD) around the interaction region and an Endcap Disc DIRC (EDD) covering the forward hemisphere, will be used for particle identification in particular for π/K separation up to 4 $\mathrm{GeV/c}$.
Since the focal planes of both DIRC detectors will reside in an $\sim$ 1 T magnetic field and because of other boundary conditions microchannel-plate photomultipliers (MCP-PMTs) are the only viable sensor candidates. Their advantageous properties in terms of excellent time resolution, moderate dark count rate and especially their favorable gain behavior inside magnetic fields make them most suitable for the PANDA DIRCs. During a planned PANDA operation time of $\sim$10 years at full luminosity the MCP-PMTs have to withstand $>$5 $\mathrm{C/cm^2}$ integrated anode charge without any QE losses. Previous aging problems of MCP-PMTs were recently solved by applying the ALD (atomic layer deposition) coating technique. For this matter an ultrathin layer of alumina or magnesia covers the MCP glass substrate leading to an increased MCP-PMT lifetime of up to a factor $\sim$100. The current status of these measurements will be presented. Furthermore the sensors have to be capable to detect single photons at very high rates [$\sim$0.2 MHz/cm^2 (BaD) and up to 1 MHz/cm^2 (EDD)].
To measure these and other performance parameters by surface scans a semi-automatic setup was built, consisting of a light tight and copper shielded box combined with a 3-axis stepper and a picosecond laser pulser. With the multihit capable, FPGA-based DiRICH/TRB (Trigger and readout Board) DAQ many parameters like time resolution, dark count rate, afterpulsing ratio, charge sharing crosstalk and electron recoil behavior, but also QE and gain homogeneity, can be simultaneously obtained as a function of the xy-position. This paper will present new insights to the performance parameters of several types of the very latest multi-anode MCP-PMTs. In particular properties like gain and internal parameters like charge cloud width and electron recoil distributions were investigated also inside the magnetic field. In addition the performance of new MCP-PMTs from Photonis with an anode layout of 3 $\times$100 pixels will be shown in this talk. Also recently observed side effects with the latest two ALD layer MCP-PMTs will be reviewed.

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