The HADES-Prototype Photon Detector with Improved CsI-Converter ◇

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The quantum efficiency (QE) of the CsI photon converter is of crucial importance for the Ring Imaging CHerenkov detector (RICH) of the HADES spectrometer [1]. Recently we succeeded in producing CsI layers of enhanced QE using a special substrate material called "RSG" [2]. Measurements on small samples performed in our lab and in collaboration with the PTB at the BESSY synchrotron in Berlin showed a QE enhancement by almost a factor of 2 compared to conventional substrate materials. However, those results had to be scaled up to large area converters ($A \simeq 50 \times 50\,\mathrm{cm}^2$) and stable operation of the HADES-RICH photon detector [1,3] with this type of converter had to be confirmed.

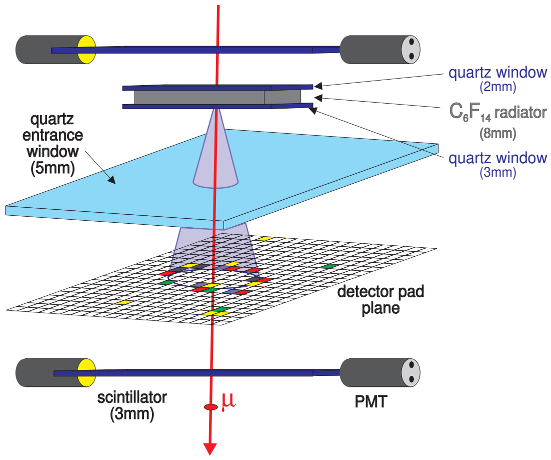

Fig. 1: Setup for QE measurements, of CsI using cosmic muons and a liquid Cherenkov radiator as calibrated light source. Position sensitive scintillation detectors serve as trigger devices. The ring images are a good filter for calibrating the efficiency of a large area position sensitive photon detector.

Therefore, we set up a cosmic muon experiment at our lab to study the performance and the VUV-photon detection efficiency of the prototype photon detector (see fig. 1). Above its quartz entrance window a L = 8 mm thick liquid C_6F_{14} radiator ($A = 2 \times 18\,\mathrm{cm}^2$) was mounted inside a gas tight box sealed to the window and flushed with purified nitrogen. Cosmic muons ($\beta \simeq 1$) passing the radiator produce Cherenkov light emitted into a cone with aperture $cos\Theta_C = \frac{1}{\beta n}$ and resulting in a ring image on the detector plane. Position sensitive scintillation counters mounted 40cm above and below the detector provide an event trigger and determine the incident angle of the muons with an accuracy of 50mrad. The photon detector is a single step multi wire proportional chamber (MWPC) with charge sensitive cathode pad readout (6144 pads of size $A = 6 \times 6\,\mathrm{mm}^2$). The pad plane is formed by a conventional PCB board covered with the RSG substrate and the CsI converter on top. VUV-photons ($160\mathrm{nm} < \lambda < 220\mathrm{nm}$) passing through the quartz entrance window and the detector gas (CH_4, 1 bar) release photo electrons from the converter. These drift to the anode wires where they start a gas amplification avalanche. The charge signal induced onto the pads is read out. On average a cluster of $\bar{p} = 3.7$ pads per photon is detected.

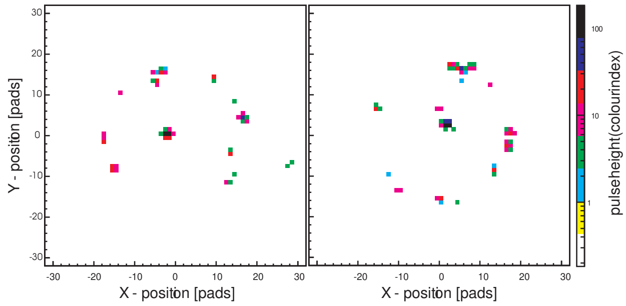

Fig. 2: Typical ring images produced by single cosmic muons passing the radiator. The central clusters indicate the impact position of the particles in the detector.

Fig. 2 shows two typical ring images produced by single muons vertically passing the radiator. Clusters along the ring induced by single Cherenkov photons are clearly separated and a mean number of 7.2 clusters per ring was measured. Taking into account a background of 1.1 clusters per event in the region of interest due to muons missing the radiator, the mean number of detected photons per muon is $\bar{n} = 6.1$. During the whole experiment the detector could be operated stable at a mean visible gain $g \simeq 10^5$ deduced from a pulse height analysis of clusters produced by single photons. This corresponds to a single electron detection efficiency of $\epsilon_{se} > 95\%$. The number of Cherenkov photons dN_γ per unit frequency produced by a single muon traversing the radiator can be calculated according to:

$$dN_\gamma = \frac{e^2}{\hbar c^2} \cdot L \cdot sin^2\Theta_C \cdot d\omega$$

Taking into account the CsI-QE from [2], the measured transparency of the radiator, the entrance window and the gases, the single electron efficiency of the detector and statistical considerations a mean number $\bar{n} = 6.2$ of detected photons per ring is calculated. Although the relative errors of this calculation are in the order of 20% the agreement confirms the QE-enhancement of CsI on RSG substrate [2].

From this experiment we conclude that stable operation of the HADES prototype photon detector with improved converter material is feasible meeting all HADES requirements.

References

[1] Proposal for a High-Acceptance Di-Electron Spectrometer (HADES Collab.); GSI, INTERNAL-REPORT (1994).
[2] C. Erbe *et al.*, this report, p. 99
[3] R. Gernhäuser *et al.*, Nucl. Instr. Meth. **A371** (1996) 300-304

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