Photon Detector Performance for the HADES RICH ◇

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In the dilepton spectrometer HADES [1], presently under construction, e^+e^--pairs produced in heavy ion collisions will be investigated for projectile energies up to E = 2 A·GeV at the heavy ion accelerator facility GSI (Darmstadt). A fast Ring Imaging CHerenkov (RICH) detector surrounding the target is designed to act as a hadron blind trigger device. A detailed description of the whole HADES project and its detector components is given in [1]. We have assembled a photon detector with quartz entrance window and A = 48 × 48 cm^2 active area, which, although rectangular, is similar in size to one segment of the HADES RICH. The device consists of a MWPC with a $d = 3.8\,mm$ wide field gap and a pad cathode. The anode wires (20μm gold plated tungsten, 3 mm spacing) are fixed at $h = 1.2\,mm$ above the cathode pad plane. The asymmetric field configuration results in an enhanced charge fraction induced onto the cathode, which was measured to $\varepsilon_{coup} = 0.77$. The cathode plane, segmented into $6 \times 6\,mm^2$ pads, is realized as a printed circuit board with additional chemical deposition of thin Ni/Au layers. On top of those a thin CsI layer (d=500nm) is evaporated applying the technique described in ref. [3].

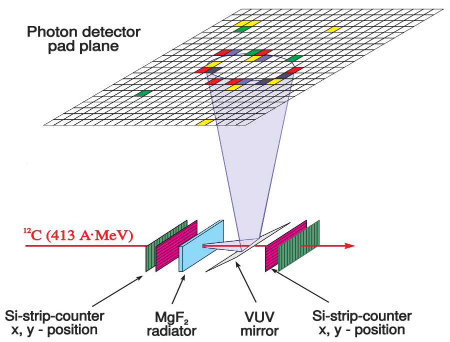

Fig. 1: Experimental setup to detect Cherenkov rings produced by ^{12}C particles passing a 2mm MgF_2 radiator. Silicon strip detectors serve for ion tracking and ring center determination.

The 6144 cathode pads are individually connected to the read out electronics on the rear side of the circuit board. The device was installed at GSI, Darmstadt, to detect Cherenkov photons produced by $E_{kin} \simeq 413$ A·MeV ^{12}C-ions passing a $l_{rad} = 2\,mm$ MgF_2 radiator. Expected intensities and radii of the Cherenkov rings were similar to those in the HADES RICH. The setup, schematically shown in Fig.1, was contained in a light tight aluminum box continuously flushed by purified nitrogen. The detector was operated at U_A=2550V with pure CH_4 at normal conditions, corresponding to a mean visible gain $g = 1.2 \cdot 10^5$. A variation of the beam position revealed a homogeneous efficiency across the whole detector area. In Fig.2 two typical Cherenkov rings produced by single ^{12}C-ions are displayed in an expanded view (25×25 pads) of the pad plane. With the threshold of the pad readout set to $s \simeq 6000e^-$, a single photo electron detection efficiency of $\varepsilon_{se} = 95\,\%$ was reached, while the ring pattern is not severely affected by random hits due to noisy electronics and charged particle background.

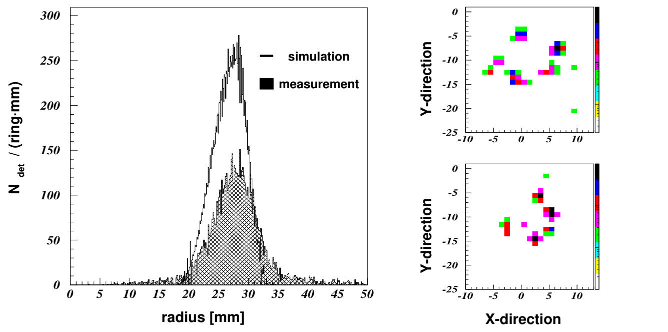

Fig. 2: Right side: Sample Cherenkov rings of single incident carbon projectiles (grey scale indicates pulse height). Left side: Radial photon distribution obtained for 1700 rings (hatched area) in comparison to a simulation.

The hatched curve in Fig.2 displays a normalized radial distribution of photon hits with the ring centers deduced from the tracks of the impinging ions. Photon hit positions were obtained from a center of gravity analysis around every local pulse height maximum including the multiple hit clusters. The expected radial distribution is shown for comparison. The calculation took into account all optical properties either measured or given by the supplier, and the CsI quantum efficiency QE(λ) as reported in [2] [4] as 'RD26 average'. While the mean ring radius and the shape of the measured distribution is reproduced by the calculation, the total photon yield $\langle N_{det} \rangle \simeq 8.2\,\frac{photons}{ring}$ is a factor of 1.9 lower than expected. We attribute this discrepancy to a reduced effective quantum efficiency of the CsI photon converter within the accessible wavelength region ($\lambda >$ 165nm). This result matches perfectly with recent precision measurements of CsI QE performed together with PTB [5]. For the setup in this measurement we obtain from a standard analysis [6] a figure of merit of $N_0 \simeq 23$. When using a C_4F_{10} radiator and assuming a reduced CsI - quantum efficiency as deduced above, a figure of merit $N_0 \geq 66$ will be achieved in the HADES RICH. This value, just at the lower edge of the demanded specifications makes further investigations and improvements in preparation and handling of the photo cathode inevitable.

References

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