Quantum efficiency and gain homogeneity measurements of H8500 MAPMTs for the development of a CBM-RICH prototype camera

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The camera of the RICH detector in the CBM experiment is foreseen to consist of approximately 860 Hamamatsu H8500 multi-anode photomultiplier tubes (MAPMTs). A RICH prototype is currently being built. Knowing the MAPMT characteristics is crucial for understanding the expected detector performance. Gain homogeneity and spectral response in terms of quantum efficiency (QE), i.e. the number of generated electrons per incident photon, were measured at Bergische Universität Wuppertal.

The QE of a PMT is mainly determined by the materials of the photocathode and the window. MAPMTs with bialkali (BA) and superbialkali (SBA) photocathodes as well as borosilicate and UV glass windows were tested.

The QE was measured by operating the PMT as a photocell, i.e. shortening all dynodes and applying a voltage of $\approx$ -100 V between the photocathode and the dynode system. The photocathode was illuminated with monochromatic light from a deuterium and tungsten-halogen lamp in the wavelength range between 200 nm and 800 nm using a double grating monochromator. For spatially resolved measurements, the light was coupled to a light fibre connected to a x-y stage. The photocurrent was measured by a picoamperemeter, and the QE was determined using a calibrated photodiode as a reference.

Figure 1 (top) shows the wavelength-dependent QE for MAPMTs with different types of photocathode and window materials. The maximal QE is $\approx 35\%$ for SBA cathodes and $\approx 25\%$ for BA cathodes. UV glass windows are transparent down to the deep UV, resulting in a QE of $\approx 5-10\%$ at 200 nm, whereas borosilicate blocks the light below about 300 nm. Folding these QE curves with the $1/\lambda^2$-spectrum of Cherenkov light leads to 89.6% of detected Cherenkov photons for BA + UV glass and 83.2% for SBA + borosilicate when compared to SBA + UV glass which exhibits the maximal yield. As the difference of QE between SBA and BA cathode vanishes towards UV, and because of the $1/\lambda^2$ dependence of the Cherenkov spectrum, the benefit of using SBA instead of BA is just 10%.

Spatially resolved QE measurements reveal relative inhomogeneities of $\approx 25\%$ over the photocathode surface. A gradient from down right to top left as well as a circular structure are visible (Fig.1 bottom).

The gain was measured using a pulsed LED emitting at 470 nm. A voltage of -1000 V was applied between cathode and anode. The charges of the pulses were sampled by VME-based 100 MHz flash ADCs [1]. Using the x-y stage, MAPMTs were scanned with a resolution of $<$ 1mm. The average values of each MAPMT pixel normalized to the maximum are shown in Fig. 2 for a SBA (left) and a BA cathode (right). The ratio between minimal and maximal charge is 1:1.4 for SBA and 1:1.3 for BA, slightly better than stated by the manufacturer.

These results demonstrate that MAPMTs are suitable for the construction of the CBM-RICH detector. They will thus be implemented in prototype simulations [2].

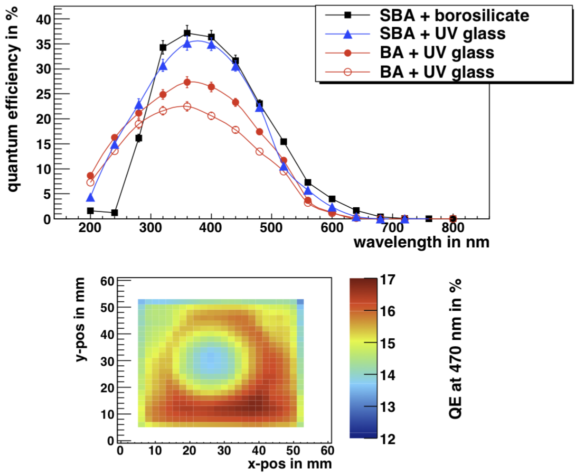

Figure 1: QE as function of wavelength for H8500 MAPMTs (top) and spatially resolved at 470 nm for a MAPMT with BA cathode and UV window (bottom)

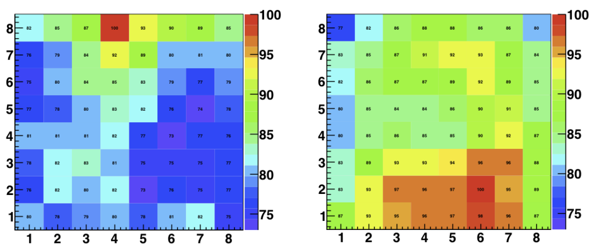

Figure 2: Normalized gain distribution (in % of the maximum) of a MAPMT with SBA (left) and BA cathode (right)

References

[1] K.-H. Becker *et al.*, *CBM Progress Report 2009*, Darmstadt 2010, p. 24

[2] D. Kresan and C. Höhne, *Design studies for a CBM-RICH prototype*, this report