Cherenkov photon detection with WLS coated MAPMTs

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The performance of wavelength shifting (WLS) films on the front windows of MAPMTs installed in the CBM RICH prototype camera was studied during the beam test campaign in 2012 [1]. Three types of MAPMTs were coated with WLS films of approximately 200 nm thickness, which has been shown to be the optimium thickness for the respective MAPMTs with UV-extended front window [2].

The WLS films were evaluated by first measuring Cherenkov rings on an array of two by two MAPMTs with WLS films, then cleaning these MAPMTs, and measuring a second time on the same MAPMTs without WLS coverage. A correction for variations of the refractive index due to temperature and pressure changes during the cleaning process was done by using the data recorded by the gas system [3].

The analysis shows an increased hit multiplicity, i.e. photoelectrons per electron ring after ring finding and ring fitting [4], for WLS coated MAPMTs. Figure 1 depicts the hit multiplicity distribution for coated and uncoated MAPMTs of the H8500D-03 type. When comparing different MAPMT types, the following result is obtained (see Table 1): The gain with WLS films is 21.2 % for H10966A-103 (size 2", SBA photocathode, UV-extended window), 18.2 % for H8500D-03 (size 2", BA photocathode, UV-extended window), and 18.0 % for R11265-103-M16 (size 1", SBA photocathode, UV-extended window). This hierarchy is also seen in full Monte Carlo simulations using the measured wavelength dependent quantum efficiency (*QE*) for the different MAPMT types. The larger gain in hit multiplicity of the H10966A-103 compared to the H8500D-03 type can be understood when considering that, in the case of SBA photocathodes, the UV photons are shifted to a wavelength range with higher *QE* when compared to BA photocathodes. The comparison between both SBA MAPMT types, H10966A-103 and R11265-103-M16, reveals that the thinner front glass of the 1" R11265-103-M16 is more UV transparent than the thicker glass of the 2" H10966A-103 and thus makes the use of WLS films less effective.

When using WLS films on the MAPMTs, in principle two effects can lead to a decrease of the ring sharpness. First, due to the isotropic fluorescence of WLS films, the majority of wavelength shifted photons pass the MAPMT front window under a more inclined angle than without WLS film. Since the window has a certain thickness, the photon will thus enter the photocathode at a different position compared to the point of incidence on the window surface and the ring sharpness is therefore expected to decrease. Second, since chromatic dispersion is more pronounced in the UV range, the enhanced UV sensitivity with WLS coating may lead to a decrease in ring sharpness. Here, the ring sharpness is quantified by the parameter *dR*, which is defined as RMS of the distribution of the distance between each hit and the circular ring fit.

For H8500D-03 MAPMTs, the parameter *dR* has a value of 2.73 mm with WLS films and 2.42 mm without. The difference of ≈ 0.3 mm is small compared to the absolute value of *dR*. Given the pixel size of 6.125 mm and the resulting spatial resolution of the MAPMTs under test of $(6.125/\sqrt{12})$ mm $= 1.8$ mm, the effect on the ring sharpness is not significant.

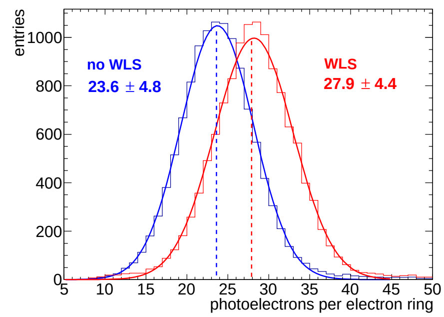

Figure 1: Number of photoelectrons per electron ring on H8500D-03 MAPMTs with WLS film in comparison to the same MAPMTs after film removal. Numbers show mean and sigma of gaussian fits to the distributions.

Table 1: Hit multiplicity gain due to WLS films on different MAPMT types in data and simulation.

MAPMT type	hit multiplicity gain data	hit multiplicity gain MC
H10966A-103	(21.2 ± 1.4) %	(23.1 ± 4.8) %
H8500D-03	(18.2 ± 1.5) %	(18.3 ± 4.7) %
R11265-103-M16	(18.0 ± 1.4) %	(14.8 ± 3.9) %

References

[1] S. Reinecke et al., CBM Progress Report 2012, p. 30

[2] T. Schweizer et al., CBM Progress Report 2012, p. 34

[3] L. Kochenda et al., CBM Progress Report 2012, p. 36

[4] S. Lebedev and C. Höhne, CBM Progress Report 2012, p. 37

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