Investigation of wavelength shifter properties of p-terphenyl and TPB

P. Koczoń[1], C. Höhne[1], M. van Stenis[2], A. Braem[2], and C. Joram[2]
[1]GSI, Darmstadt, Germany; [2]CERN, Geneva, Switzerland

Abstract: Wavelength shifter materials like p-Terphenyl and Tetra Phenyl Butadiene (TPB) of thicknesses between 65 and 250 μg/cm^2 have been studied in order to improve the quantum efficiency (QE) of a photomultiplier in the UV range. The best result has been obtained for p-Terphenyl of 100 μg/cm^2 thickness. In this case the quantum efficiency integrated over a broad range of photon energies up to 6.2 eV shows a gain of a factor 1.6 compared to an uncovered photomultiplier.

Introduction

The rate of photons from Cherenkov radiation per energy bin is constant (dN/dE = const) therefore the bulk of the photons is produced in the UV and far UV region. The quantum efficiency of standard photomultipliers with glass windows reaches only 25% around 400 nm and drops down essentially to 0% below 250 nm. The aim of this work

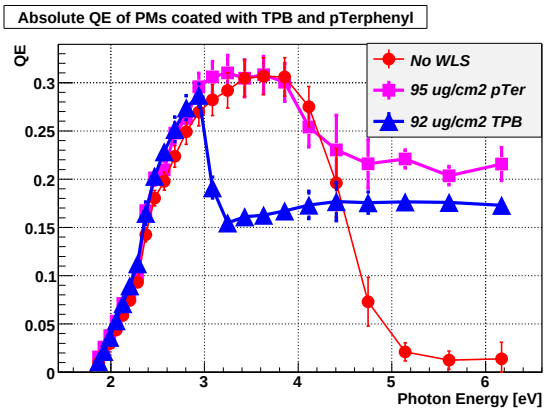

Figure 1: Quantum efficiency versus photon energy for the uncoated PMT (Photonis XP3102) and with TPB and p-Terphenyl coating.

was to reinvestigate the potential of the quantum efficiency improvement in the UV region using wavelength shifting substances on top of the glass window.

Technical details

Two of such wavelength shifter substances have been evaporated in vacuum with well controlled thickness on the entrance windows of several Photonis XP3102 photomultipliers. The quantum efficiency of those photomultipliers was measured in a wavelength range from 200 to 650 nm in a monochromator by comparison to an absolutely calibrated photodiode [1].

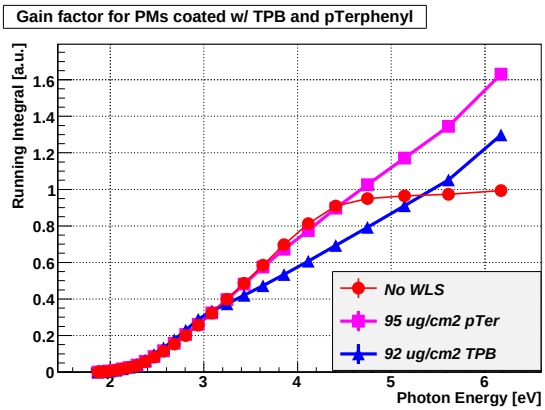

Figure 2: Gain of quantum efficiency obtained by integration of the QE curves from Fig. 1.

Results

Fig. 1 shows the improvement of the quantum efficiency as a function of photon energy for 95 μg/cm^2 p-Terphenyl and 100 μg/cm^2 TPB evaporated on the entrance window of the PMT compared to the quantum efficiency of an untreated PMT. TPB improves the efficiency for highest energies (around 5 eV=246 nm) moderately but deteriorates it in the visible region by a factor of 2. For p-Terphenyl we observe a clear improvement of QE in the UV and no change in the visible range. In order to quantify the overall QE improvement all curves have been integrated over the whole energy range. Running integrals are presented in Fig.2 and compared to the integral of the pure PMT (which is normalised to 1 at 6 eV). The value of the running integral for TPB lies below the reference PMT between 3.2 and 5.3 eV and finally reaches a gain of 30% only. The result for p-Terphenyl clearly shows a gain of 60 % above the uncovered PMT. Extrapolating to the far UV one can expect still higher gain values.

In order to investigate possible ageing processes of the wavelength shifter film in the radiator gas of the future RICH detector of CBM at FAIR the photomultipliers with an evaporated p-Terphenyl layer have been stored in CO_2 atmosphere and will be remeasured to monitor their performance every 6 - 12 months.

References

[1] A. Braem et al., NIM A 504 (2003) Pages 19-23