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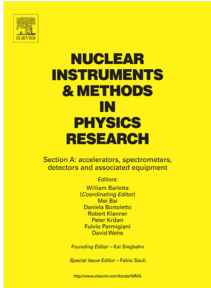

Enhanced UV light detection using a p-terphenyl wavelength shifter

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Enhanced UV light detection using a p-terphenyl wavelength shifter

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Abstract

UV-glass photomultiplier tubes (PMTs) have poor photon detection efficiency for wavelengths below 300 nm due to the opaqueness of the window material. Costly quartz PMTs could be used to enhance the efficiency below 300 nm. A less expensive solution that dramatically improves this efficiency is the application of a thin film of a p-terphenyl (PT) wavelength shifter on UV-glass PMTs. This improvement was quantified for Photonis XP4500B PMTs for wavelengths between 200 nm and 400 nm. The gain factor ranges up to 5.4 ± 0.5 at a wavelength of 215 nm, with a material load of 110 ± 10 μg/cm^2 (894 nm). The wavelength shifter was found to be fully transparent for wavelengths greater than 300 nm. The resulting gain in detection efficiency, when used in a typical Čerenkov counter, was estimated to be of the order of 40%. Consistent coating quality was assured by a rapid gain testing procedure using narrow-band UV LEDs. Based on these results, 200 Photonis XP4500B PMTs were treated with PT for the upgraded low-threshold Čerenkov counter (LTCC) to be used in the CEBAF Large Acceptance Spectrometer upgraded detector (CLAS12) at the Thomas Jefferson National Accelerator Facility.

1. Introduction

During the 6 GeV maximum electron beam energy era of Jefferson Lab, a Čerenkov Counter [1] (CC) has been used in several experiments in Hall B for electron/pion discrimination as part of the CLAS detector data acquisition trigger and particle identification systems. The CC has been refurbished to be used as a LTCC for pion/kaon discrimination in the new detector [2] for the 12 GeV upgrade of Jefferson Lab. Pions in the momentum region of interest produce significantly less Čerenkov photons compared to electrons. Hence, a significant increase in the light-collection efficiency was essential in the CC upgrade.

The number density of Čerenkov photons with a wavelength λ for a particle with velocity v and charge ze passing through a unit of length of a radiator can be written as [3],

$$\frac{d^2n}{dx d\lambda} = \frac{2\pi z^2 \alpha}{\lambda^2} \sin^2 \theta_C(v), \qquad (1)$$

with the fine structure constant α and the Čerenkov cone half-angle θ_C. Due to the λ^{-2} dependence of this distribution, a good sensitivity to photons in the UV region is required in order to maximize the efficiency of a Čerenkov detector.

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