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PTFE reflectance measurements, modeling and simulation for Xenon detectors

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Liquid/gaseous Xenon detectors are extensively used in rare-event searches such as a double beta decay and dark matter experiments [1]. The response of these detectors is strongly dependent on the reflectance of the inner surfaces surrounding the active volume. Maximizing the reflectance of these surfaces is therefore paramount to increase the sensibility of the detector, especially in large detectors where the light is reflected multiple times before being detected.

The leading experiments for dark matter detection (LUX and XENON) and neutrino-less double beta decay (EXO and NEXT) [2] all use polytetrafluoroethylene (PTFE) surrounding the active volume of their detectors. This material was chosen due to its large reflectance, about 100% in the visible spectrum [3]. However, in spite of being already in use in xenon detectors, its optical properties for the Xenon scintillation light (in the VUV, $\lambda\approx175$ nm) have not been accurately studied.

Here we report on measurements of the reflectance distributions of PTFE for Xenon scintillation light performed with a purposely built angle resolution system [4]. The reflectance distributions thus obtained are described using a physical model comprised of diffuse and specular components[5]. These measurements were performed for different PTFE samples, showing that the reflectance is dependent on the manufacturing process and finishing of the surface – for the tested samples the hemispherical reflectance varied from 50% to 75% [6]. It is therefore necessary to characterize the reflectance of the specific PTFE used in each detector.

These results were obtained for a gas/PTFE interface. Although no measurements were performed using a liquid-Xenon/PTFE interface, we developed a model to estimate the expected change in reflectance for both the specular and diffuse components when the gas is replaced by the liquid [7]. This allowed us to estimate the hemispherical reflectance in liquid to be roughly 15% larger than in a gaseous interface.

GEANT4 has become the simulation tool of choice for rare event detectors, but the reflectance models available in this package do not agree, in many ways, with our own and other published results. We adapted the reflectance model developed during our measurements so that it can be used directly in GEANT4, and we intend that it becomes part of the standard GEANT4 distribution in the near future.

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