Improvements in Energy Resolution using a Stilbene Crystal in Conical Geometry

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Overview

- Stilbene fluoresces when ionizing radiation interacts with it making it a suitable radiation detector when coupled to a light-readout electronic device, such as a photo-multiplier tube (PMT).
- Due to the manufacturing process, the most common stilbene shape is a cylinder; one face is coupled to the PMT, while the remaining surfaces are covered with a reflective material to increase the light collected by the PMT.
- The purpose of this work is to demonstrate how a conical scintillator improves the light collection process and by extension, the detector performance in comparison to a cylinder of equal base diameter.

Background

- One critical component to detector performance is light-collection efficiency (LCE), which is defined as the fraction of light produced from a radiation interaction that is detected.
- The total LCE depends on several factors including the number of times optical photons reflector at a boundary prior to detection.
- On average, optical photons reflect less inside of a cone than a cylinder prior to detection and this is evident from Geant4 simulations reported here.
- Maximizing the LCE increases the pool of statistical information needed to resolve the energy deposited by the radiation interaction and the identity of the radiation particle.

Summary

- **We report an 8.7% improvement in energy resolution at 478 keVee light output, and a 21% in particle discrimination in the light output range from 0 to 100 keVee, by using the cone in place of a cylinder of equal base.**
- **Future work will include experiments that characterize the timing resolution of stilbene and PSD capable organic scintillators.**

Methods

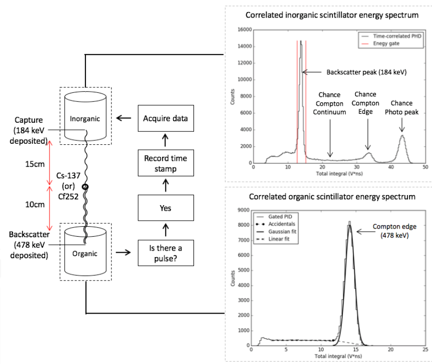

Figure.1: Compton coincidence technique (CCT) was used to obtain the energy resolution from the organic scintillators

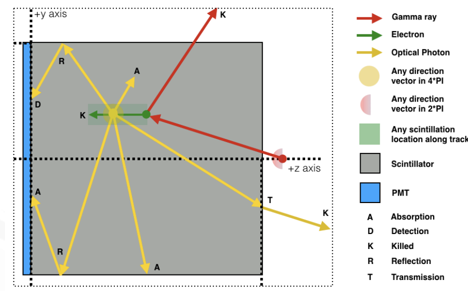

Figure.2: A graphical representation of the Geant4 model used to assess the optical photon reflection and time distribution profiles

Results

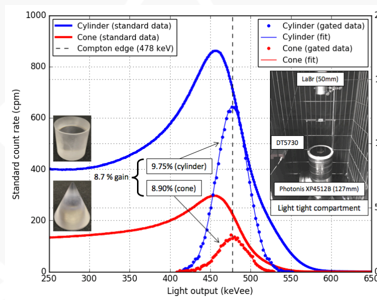

Figure.3: Calibrated energy spectrum with time and energy correlated counts from CCT

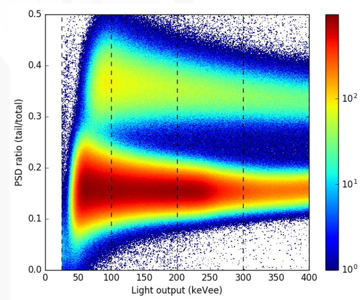

Figure.4: PSD (cylinder) ratio as a function of light output bins (threshold 25 keVee)

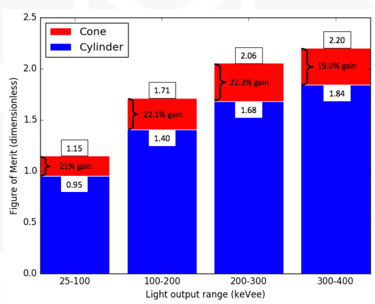

Figure.5: Figure of merit comparison as a function of light out bins

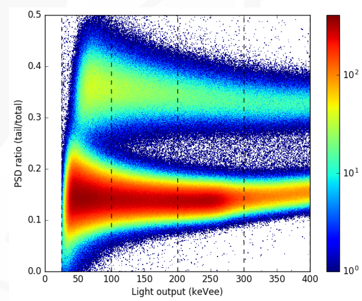

Figure.6: PSD (cone) ratio as a function of light output bins (threshold 25 keVee)

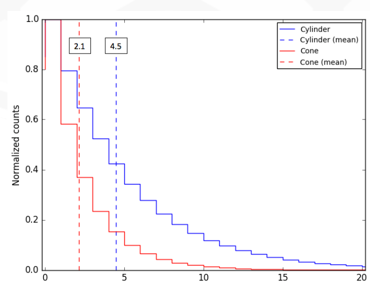

Figure.7: Geant4 simulation showing the number of times optical photons reflect prior to detection

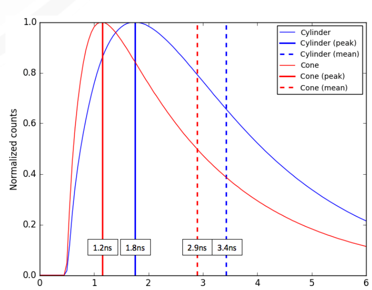

Figure.8: Geant4 simulation showing the detection time optical photons after the birth of the source particle (gamma ray)

Acknowledgements

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Idaho National Laboratory

National Nuclear Security Administration