Investigating Upgrades to SoLiD by Comparing Wavelength Shifting Strips and Fibres

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Objectives

This project aims to determine whether wavelength shifting strips of dimensions 50 mm wide and 3 mm thick are a suitable alternative to the existing wavelength shifting fibres used in SoLid at present. Additionally variations on the strips are considered, including acrylic strips dip-coated in wavelength shifting paint and commercially available through-doped acrylic. The coating process sought to be refined to at least an extent sufficient to provide a proof of concept for the strips.

Materials & Methods

The acrylic strips were coated in wavelength shifting paint to create up to six layers of the coating by either dip coating and drawing the coating across the surface, with varying permutations tested.

These were the set up with a plastic scintillator cube from the existing SoLid detector in a manner that emulates the proposed detector design, and optically bonded to photomultiplier tubes.

An analogous test is done using the currently used wavelength shifting fibres set up to emulate the existing design, and then pulse height histograms of each are plotted and compared to determine which of the two has a higher light yield.

The best treatment method for the strips in preliminary testing proved to be annealing and subsequent dip coating. The results are for these strips.

References

[1] P Venkataramaiah, K Gopala, A Basavaraju, S S Suryanarayana, and H Sanjeeviah. A simple relation for the fermi function. *Journal of Physics G: Nuclear Physics*, 11(3):359, 1985.

Motivations

The current design of SoLid leaves it susceptible to background noise from bismuth and polonium decay (BiPo noise).

Part of a proposed redesign of SoLid to combat this uses larger wavelength shifting strips as opposed to the existing fibres and rearranges the geometry of the detector so that the detector's sensitivity to this noise is reduced, while the larger capturing area of the the strips (200mm wide as opposed to the fibres 3mm width) should also theoretically increase light yield and energy resolution.

Additionally, the new geometry should also remove the need to individually wrap the cubes, reducing cost and manpower needed to construct the detector.

Detector Designs

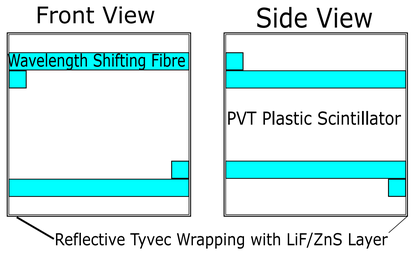

Figure 1: Diagram of the proposed detector design

The current detector design has the two scintillator components next to each other with the same fibres sensitive to both. Since BiPo noise manifests as two signals in the ^{6}LiF/ZnS layer and the anti-neutrino signals are one signal from each scintillator, the two cannot be distinguished.

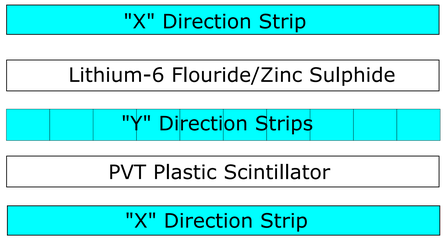

Figure 2: Diagram of the proposed detector design

The proposed detector design separates the two scintillating layers to allow different pairs of strips to detect light from each, thereby allowing the background signal and the antineutrino signal to be distinguished, as well a soding away with the wrapping of individual cubes in tyvec.

Fractional Light Yield Results

Setting up the strips and fibres in a manner that emulates the respective detector structures that they will be used in, the following results were obtained:

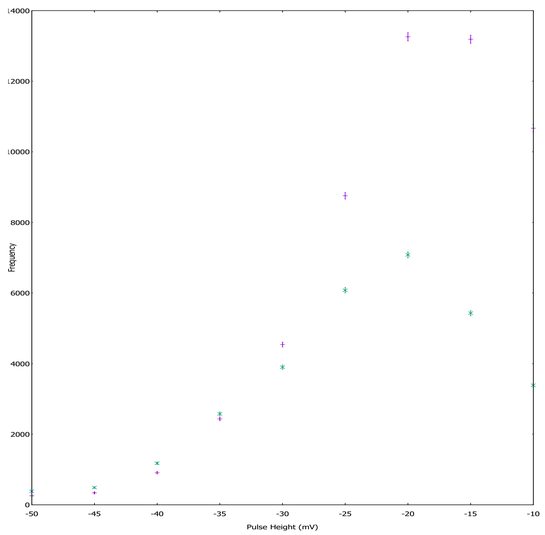

Figure 3: figure
Pulse Height of Signals With a Sr90 Source (Tube 1)

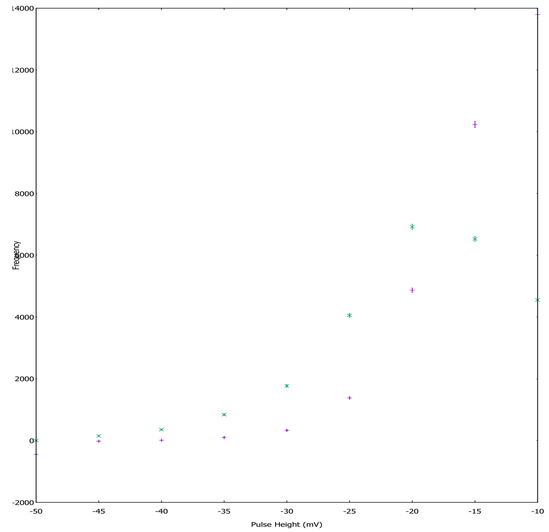

Figure 4: Pulse Height of Signals With a Co60 Source (Tube 1)

These data are fitted with an approximation to the respective energy spectra of the radiation for the specified sources. As can be seen, the strip spectrum does appear to peak somewhat higher than the fibre spectrum.

Conclusion

These data appear to indicate that the strips do seem to give a somewhat better light yield than the fibres, however the difference is not large especially large. That said the comparatively crude nature of the strip coating method compared to the quality of the wavelength shifting fibres does tend to suggest that as the strips tested here can at least hold their own, with some refinement to the strips they could in principle out perform the fibres with some additional development. These conclusions are at best tentative.

Future Research

Fitting this to a beta radiation spectrum is the next step, but this proved non trivial although approximations do exist [1]
Future work should compare attenuating properties of strips vs fibres, refine the coating/production method for the strips and take measurements with lower thresholds that account for the varying sensitivity of the PMTs used.

Contact Information

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