Performance of Stilbene Bars Coupled to Silicon Photomultipliers Using Different Reflectors
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Objective
Analyze stilbene crystals coupled to silicon photomultipliers (SiPMs) with various reflectors coating the stilbene to potentially increase the performance of neutron scatter cameras.

Motivation
- Increased need for systems that can detect and image special nuclear material (SNM)
- SNM has the characteristic of emitting both neutrons and gamma rays.
- Neutron scatter cameras work by measuring neutron time of flight (TOF) and deposited energy to reconstruct the event.
- Most neutron scatter cameras such as the dual particle imager (DPI) shown in Figure 1 use diffuse reflectors.

Diffuse and Specular Reflection

- Specular reflectors scatter incident light at the same angle relative to the normal of the surface.
- Specular reflectors tested: Mylar and 3M SFP D50F.
- Diffuse reflectors have some probability of reflecting incident light at any angle.
- Diffuse reflectors tested: PTFE (Teflon tape).

Digitized Pulses

- SiPMs have a standard and fast output.
- Standard output: Used for timing resolution, pulse shape discrimination (PSD) and energy resolution.
- Fast output: Better timing resolution, no PSD, and worse energy resolution.

Signal to Noise Ratio (SNR)

- Determining the SNR for the various reflectors.
- Measured the stilbene coated with each reflector with a Cs-137 source.
- The signal was chosen to be the Compton Edge of the Cs-137 spectrum while the noise was chosen to be the average root mean square of the baseline of the pulses making up the pulse height distributions (PHDs).

Table 1: Measured average SNR values

<table>
<thead>
<tr>
<th>Reflector</th>
<th>Average SNR</th>
<th>No Reflector</th>
<th>108 ± 10</th>
<th>3M SFP</th>
<th>170 ± 10</th>
<th>D50F</th>
<th>161 ± 3</th>
<th>Mylar</th>
<th>161 ± 3</th>
<th>PTFE</th>
<th>258 ± 2</th>
</tr>
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</table>

Time Resolution

- A coincident measurement was setup using a Na-22 source.
- Determining the start time of a pulse.
- Multiply the amplitude of each pulse by some fraction (F).
- Linearly interpolate between existing points to find the time at which that value occurs.

Table 4: Measured FP and FN rates

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<td>D50F</td>
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Conclusions

- How well gamma-rays and neutrons can be discriminated is a strong function of the SNR.
- While time resolution significantly increases by 32% for standard outputs and 40% for fast outputs when using a specular reflector, the misclassification rate increases by nearly a factor of 10.
- This work demonstrates that diffuse reflectors are optimal for neutron scatter cameras.

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