Characterization of the Anisotropic Scintillation Response of Stilbene to Neutrons

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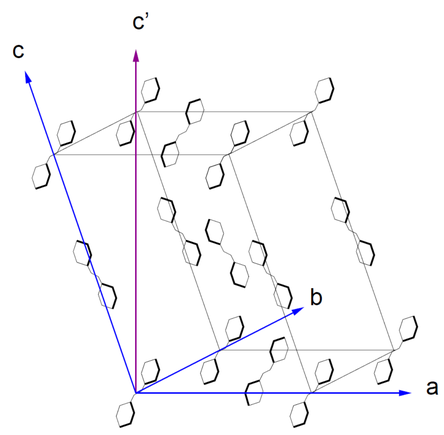
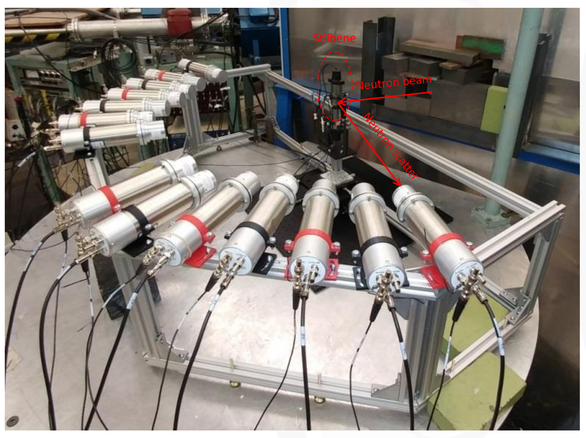
Introduction

- New crystal growth techniques have expanded the use of stilbene for radiation detection applications
  - Crystalline organic scintillator
  - Excellent PSD characteristics
- Stilbene has an anisotropic scintillation response to neutrons dependent on the proton recoil direction w.r.t. the crystalline axis



- **Research goals**:
  - Obtain a high precision light output characterization over a wide energy range (500 keV – 10 MeV)
  - Measure proton recoils over a full hemisphere of the crystal over this range
  - This will expand the current response characterization for stilbene from 2 energies to over 10 energies
- **Measurements presented here**: ratios of maximum to minimum light outputs at 6 distinct energies between 1.3 MeV and 10 MeV

Experiment Setup

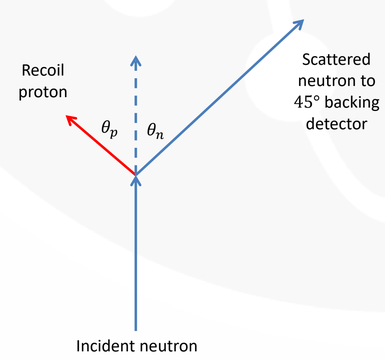


- Measure proton energy deposition in the stilbene using known neutron beam energies and n-p scatter kinematics:

$$E_p = E_n \sin^2 \theta$$

- Identify neutron scatter angle θ by backing detector that is triggered in coincidence with the stilbene

- 14 EJ-309 backing detectors
- Neutron beam: d(d,n) reaction using the tandem accelerator at TUNL
- Protons recoil at 90° relative to the scatter direction of the neutron (e.g. $\theta_n = \theta_p = 45°$, $\theta_n + \theta_p = 90°$)
- Rotate stilbene on rotational stage to change the direction of the proton recoils relative to the crystalline axes

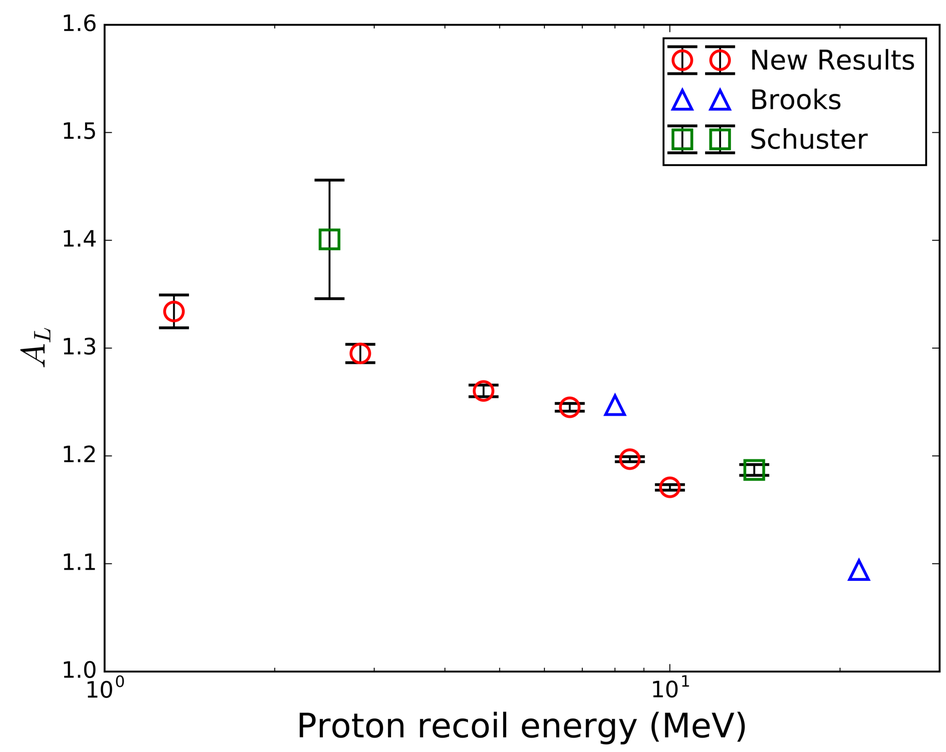


Measurements

- **Goal: measure light output along major axes (a, b, c')**
- 11.33 MeV neutron beam
- Proton recoil energy range: 1.3 MeV– 10 MeV
- Measured 3 separate 1cc stilbene crystals :
  (1) c' vertical, measurements in a-b plane
  (2) b vertical, measurements in a-c' plane
  (3) a vertical, measurements in b-c' plane
- Ratio of maximum light output to minimum light output for the b vertical crystal are presented here

Results

- Plot: ratio of maximum light output to minimum light output vs proton recoil energy (A_L = maximum light output / minimum light output)
- Red points are the result of our measurement, blue points were measured by Brooks[1], green points were measured by Schuster[2]



- Ratios follow the trend of decreasing anisotropy with increasing proton recoil energy
- Uncertainty in A_L is statistical (uncertainty was not provided by Brooks)
- While A_L values show agreement with Brooks' and Schuster's results, the maximum light output in our measurements are for proton recoils along the a-axis

	Brooks/Schuster	Our Work
Maximum LO	b-axis	a-axis
Minimum LO	c'-axis	c'-axis
Saddle	a-axis	b-axis

Conclusions and Future Work

- Measured the light output in the major axes planes using 3 stilbene crystals at 6 proton recoil energies
- Ratios of maximum to minimum light output are consistent with results published by previous authors
- Future work:
  - Compare light output between crystals (different crystals and different PMTs)
  - Return to TUNL and measure the scintillation response over a full hemisphere

References

1) F. D. Brooks and D. T. L. Jones, "Directional anisotropy in organic scintillation crystals," Nuclear Instruments and Methods, vol. 121, no. 1, pp. 69–76, 1974.
2) P. Schuster and E. Brubaker, "Characterization of the scintillation anisotropy in crystalline stilbene scintillator detector," Nuclear Instruments and Methods, vol. 859, pp. 95–101, 2016.

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