Light Output Characterization for Small Stilbene Detectors

A. P. Panter[1*], C. A. Meert[1], S. D. Clarke[1], S. A. Pozzi[1]
[1]Department of Nuclear Engineering and Radiological Sciences, University of Michigan, Ann Arbor, MI
Sara Pozzi, pozzisa@umich.edu *Presenting Author, panteran@umich.edu
Consortium for Monitoring, Technology, and Verification (MTV)

Introduction and Motivation

- Small organic scintillators like stilbene show promise as detectors in photon active interrogation; the small volume reduces efficiency, reducing the effects of photon pile-up (Fig. 1)
- The detector light output (LO) function is essential to simulate organic scintillator energy response, but must be determined empirically
- Validation of simulation methods for small detectors can extrapolate results beyond physically available detector setups

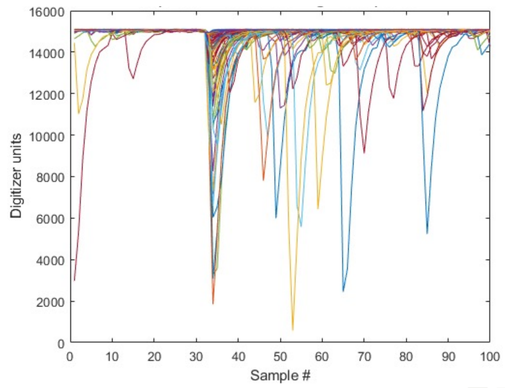

Fig. 1: *Example pile-up pulses in stilbene during DU interrogation. These pulses are rejected as they would be falsely attributed as neutrons*

Mission Relevance

- Improving detection capabilities in photonuclear applications will enable better characterization of photofission signals and source terms
- **Expected Impact**: Enable investigation of complex parameter spaces, such as inspection scenarios, at lower expense

Technical Approach

- ^{252}Cf time-of-flight (TOF) measurements were taken with stilbene at 30 cm, and Birks' Equation for LO was fitted to the data (Fig. 2)
  - $L(E) = \int_0^E \frac{S}{1+kB*(\frac{dE}{dx}(E'))}\,dE'$
- ^{137}Cs and ^{252}Cf were measured with a 6mm stilbene cube coupled to a PMT (Fig. 3L)
- Measurements were simulated in MCNPX-PoliMi, and the LO histogram was generated using MPPost (Fig. 3R)

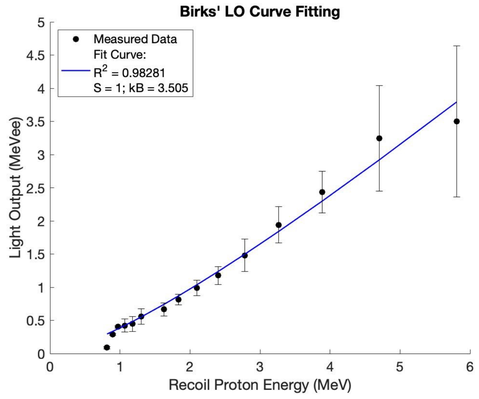

Fig. 2: *Stilbene TOF data with fitted Birks' Equation*

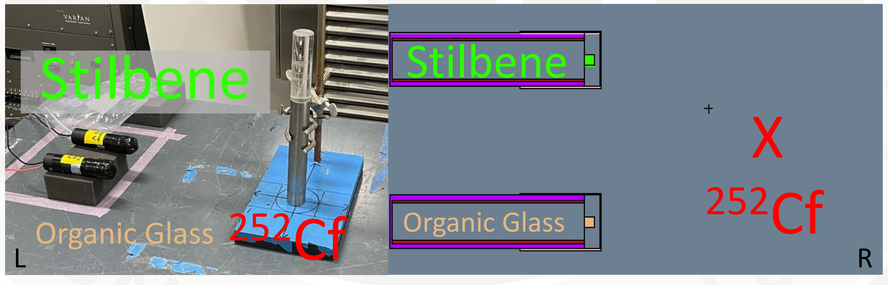

Fig. 3: *^{252}Cf measurement setup (Left). MCNP cutaway of measurement simulation model (Right). Organic glass detector results not analyzed in this work.*

Results

- ^{137}Cs Compton edge is much sharper in simulation, indicating energy resolution is not modeled (Fig. 4L)
- Electron escape bins some higher-energy photon depositions as lower energy, so the harder simulated ^{137}Cs spectrum indicates electron escape is not modeled
- These effects are expected from simulations of this kind

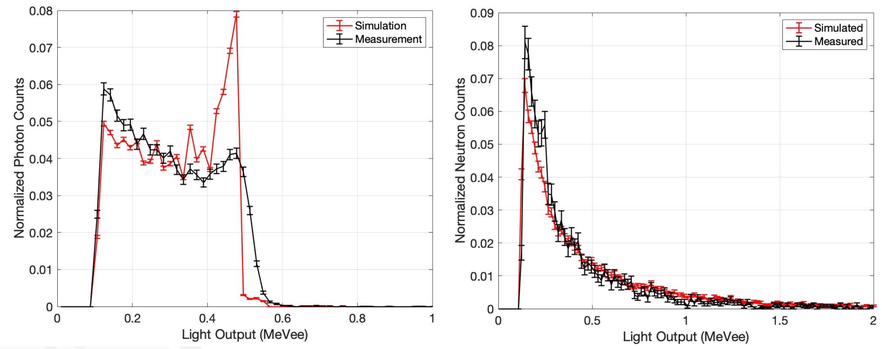

Fig. 4: *^{137}Cs normalized photon spectra (Left). ^{252}Cf normalized neutron spectra (Right).*

- ^{252}Cf neutron spectra shapes agree somewhat, with simulation indicating more counts in the tail (Fig. 4R)
  - Promising, but shape differences indicate a new LO function is required

Conclusion

- Electron escape must be modeled when simulating small detectors, whereas the effect is negligible in larger detectors
- LO function development for small detectors poses the challenge of obtaining sufficient counts with long counting time or higher source strength

Next Steps

- Implement energy resolution and electron escape corrections
- Analyze TOF with better statistics to obtain a higher-fidelity LO function

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