Rapid Prototype Plastic Scintillators for Mixed Field Borehole Detectors

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1. Motivations

This poster reports on the exposure of **cast scintillator, produced in-house**, to gamma ray sources. Rapid manufacture allows **fast-prototyping** of novel geometries for deployment in a limited borehole volume.

The **low-cost scintillator** will be deployed in **mixed-field neutron-gamma borehole detectors**, measuring the response of a borehole formation to a pulsed neutron generator (PNG). Sealed sources in common use such as AmBe or Cf-252 constantly emit neutrons, and are a security concern [1]. PNGs introduce timing information from neutron pulses, and can be turned off when not in use [2].

2. Compton Scattering in Plastic Scintillators

- Co-60 and Cs-137 gamma sources below [3]

Isotope	Gamma Energies / keV	Compton Electron Energies / keV
Cs-137	662	478
Co-60	1170, 1330	960, 1116

- Compton scattered electron energy inferred by equation below [4]

$$\frac{1}{E'} - \frac{1}{E} = \frac{(1-\cos\theta)}{m_o c^2}$$

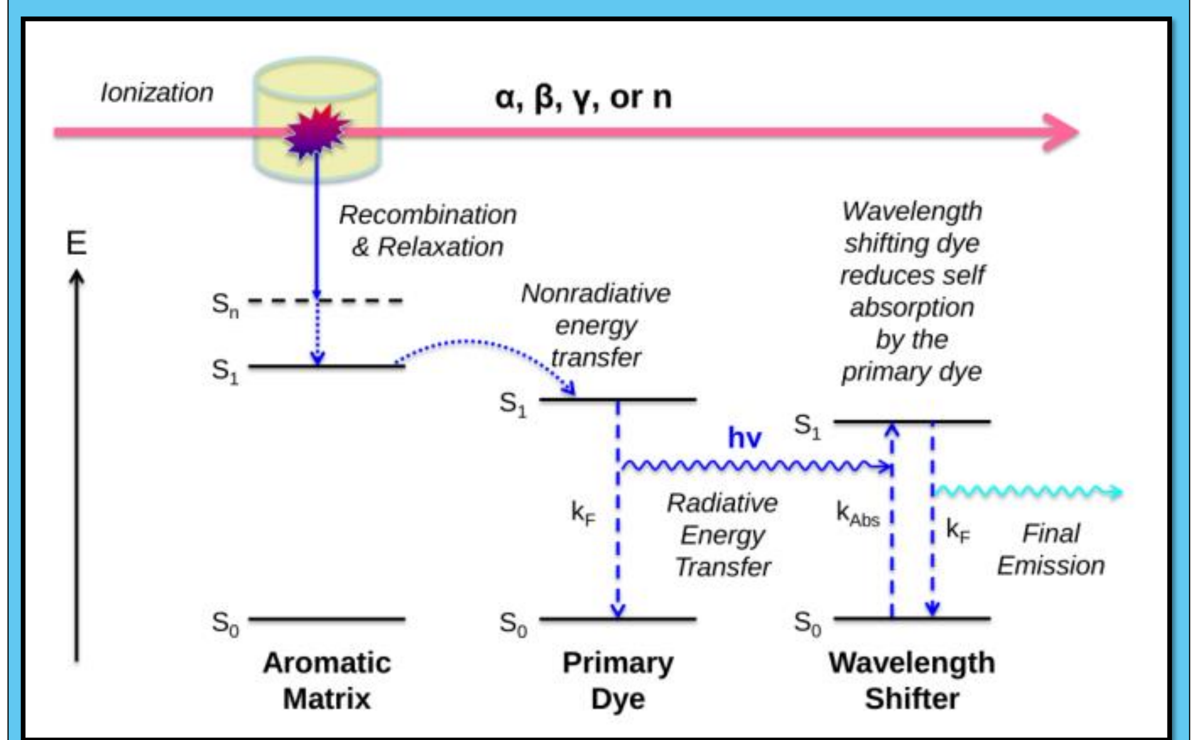

Figure 1: Organic scintillation process [5], the Compton scattered electron will induce ionization

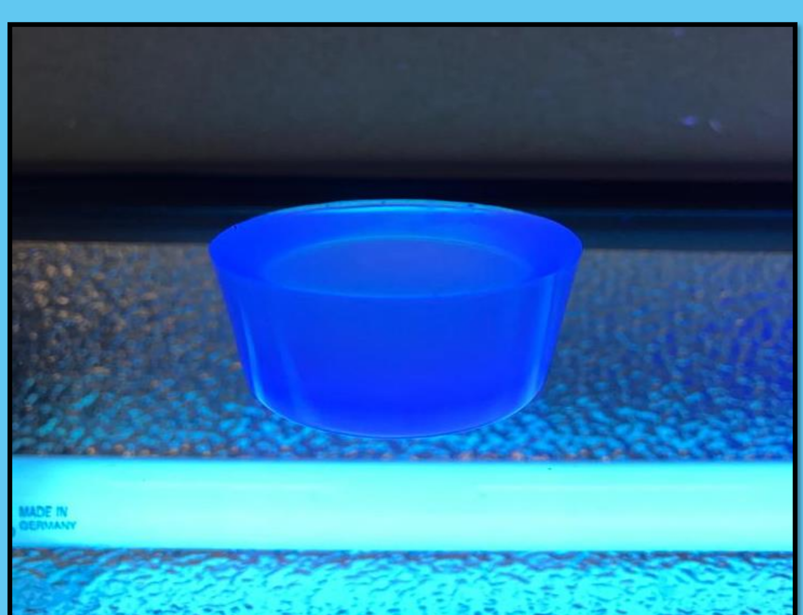

Figure 2: Prepared scintillator under UV illumination

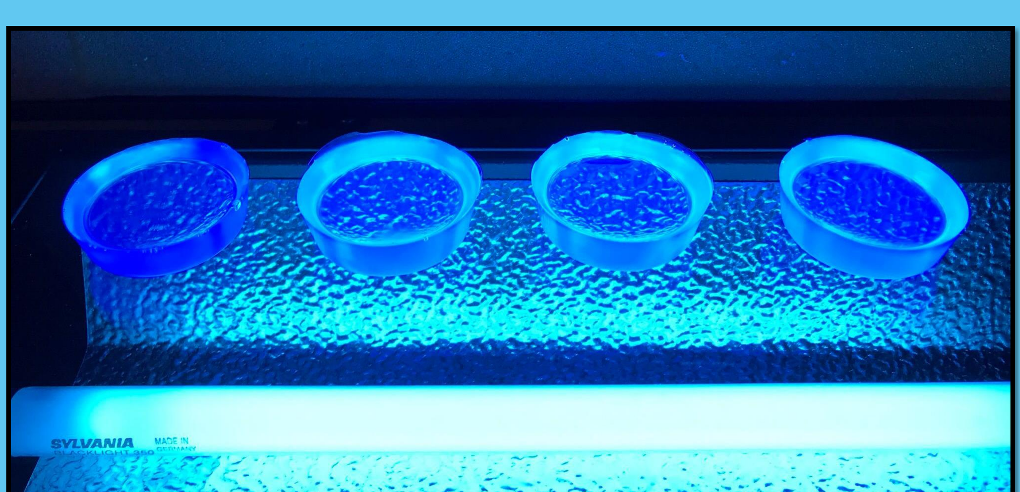

Figure 3: Scintillators with different dopant concentrations were cast in a 24 hour period

3. Methods

- Scintillator samples of approximately 25 cm^3
- Coupled to photomultiplier tube (PMT) in dark box as in Fig 4
- Assembly then exposed to **Cs-137 and Co-60** gamma ray sources
- All scintillation attributed to gammas – βs shielded
- Exposure time of 20 minutes
- Data recorded with **Multichannel Analyzer** (MCA)

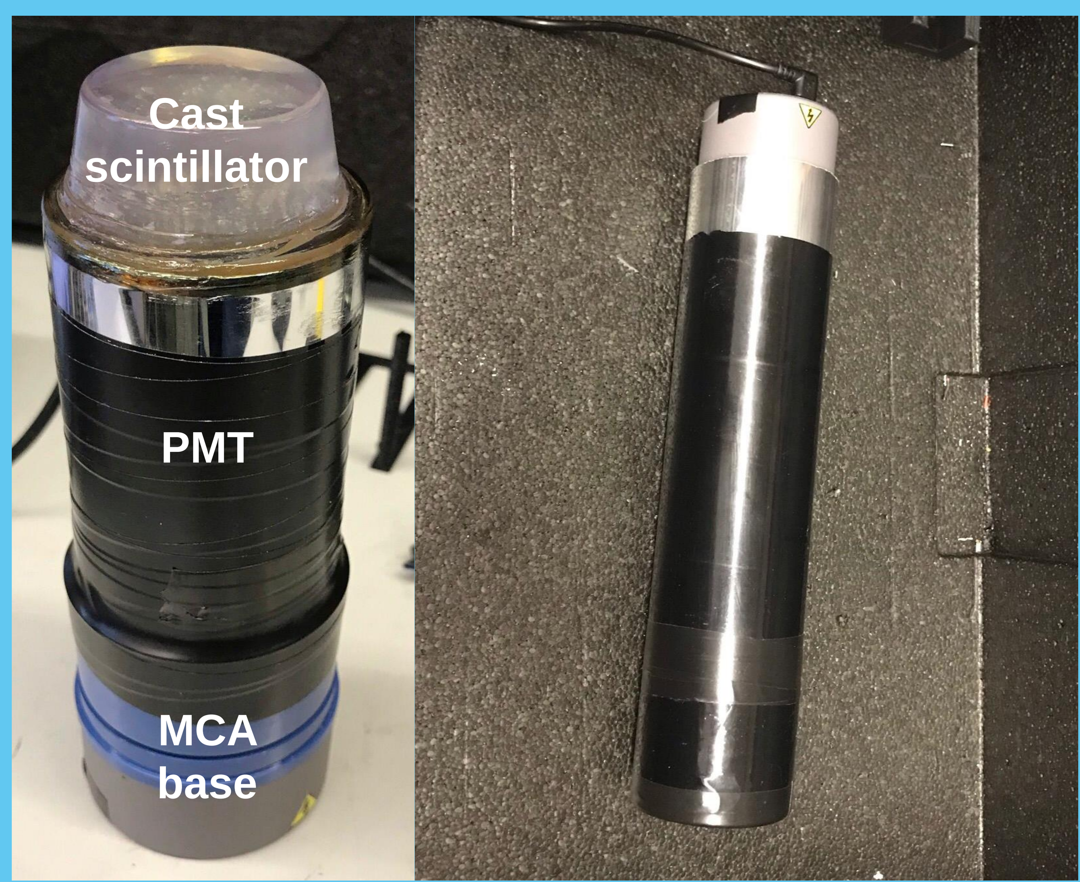

Figure 4: Sample coupled directly to PMT face (left) placed in light tight assembly (right)

4. Results

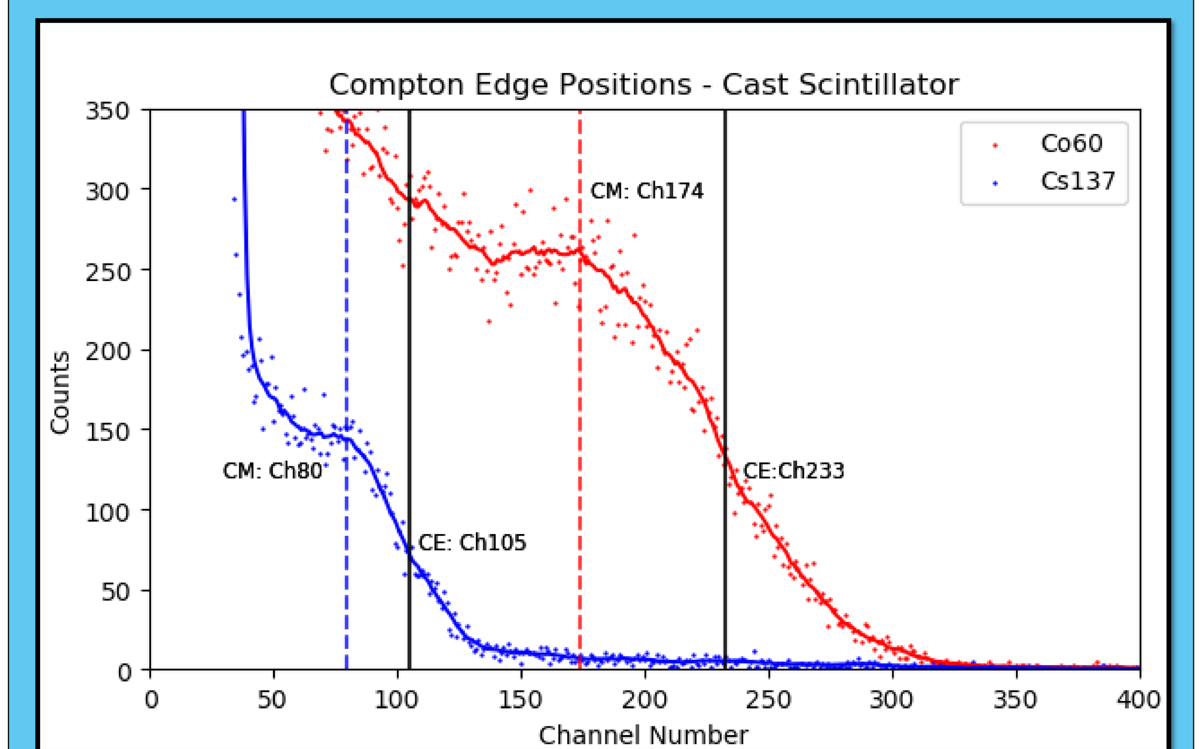

Figure 5: Comparison of 20 minute exposures to Cs-137 (19.6kBq) and Co-60 (20.9kBq) with CM and CE marked – moving average used for edge location

- Compton Edge (CE) selected at half-Compton maximum (CM) – though more precise schemes exist as discussed in [6]

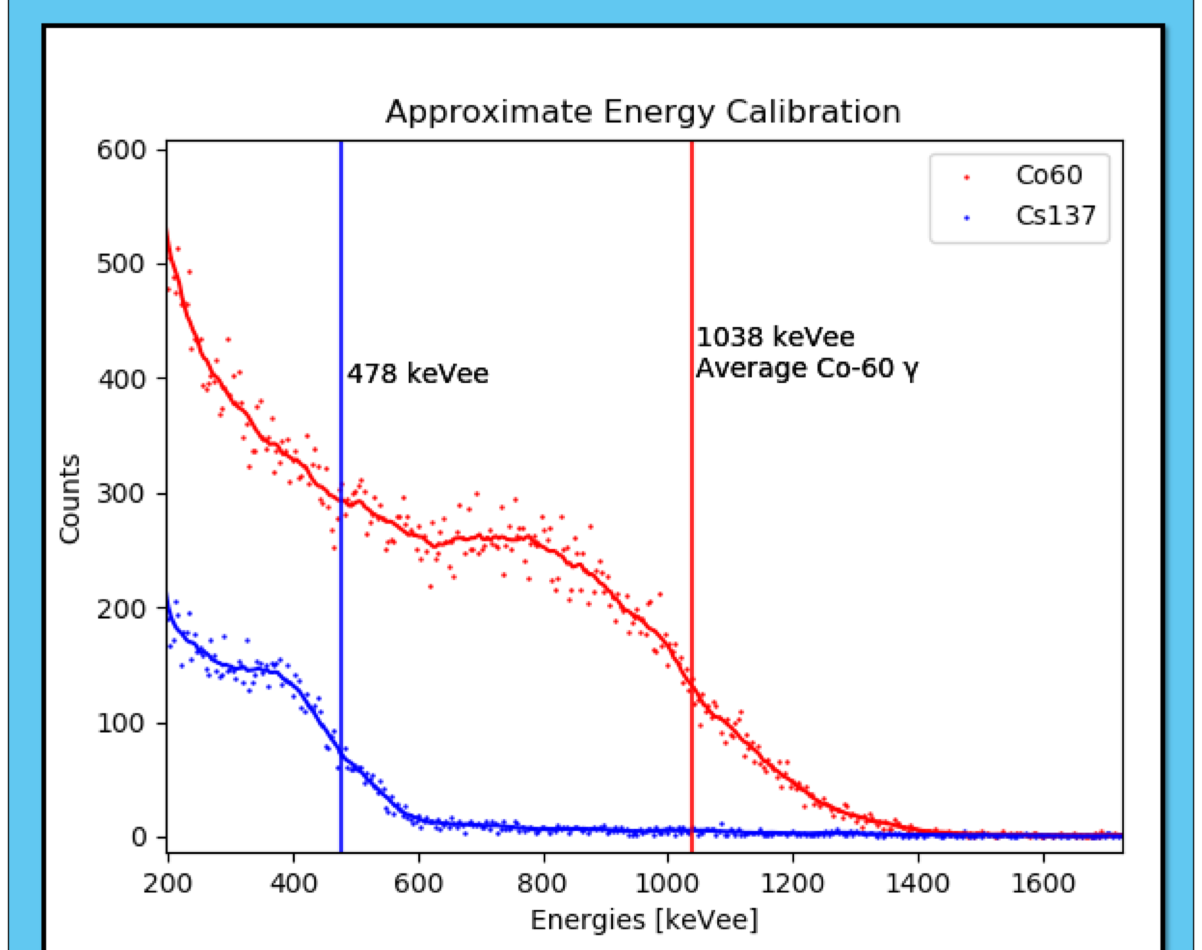

Figure 6: Approximate calibration of channel number to energy – poor discrimination of Co-60 gammas

5. Discussion

- Calibrate channels vs energy with three known gamma energies
- However, no discrimination between two Co-60 gammas – average energy used
- Poor energy resolution is expected of plastic scintillators – low Z, no full-energy peak
- This scintillator will be deployed in boreholes to detect neutron inelastic/capture gammas

6. Borehole Detectors & Thermal Neutron Detection

- Borehole "interrogated" by neutron flux
- Thermal neutrons indicate H and Cl content
- Inelastic and capture gammas indicate elemental composition
- Foils manufactured using mixture of Boron Nitride and Zinc Sulfide powder

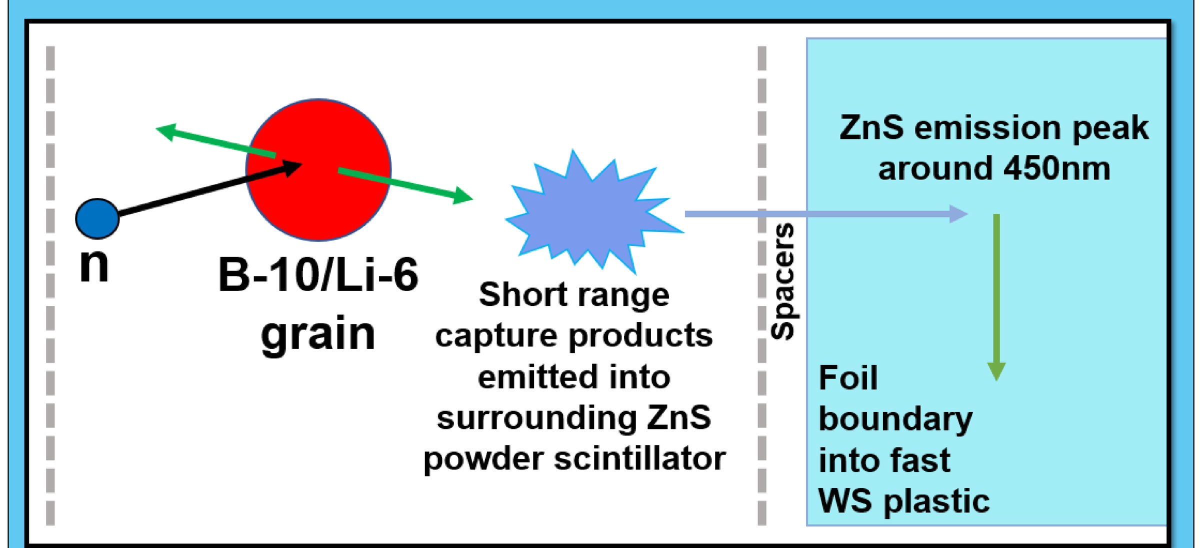

Figure 7: Capture foils coupled to wavelength shifter provide a convenient, low-cost method of thermal neutron detection

- BN:ZnS foils [7], coupled to wavelength shifter as in Fig 7

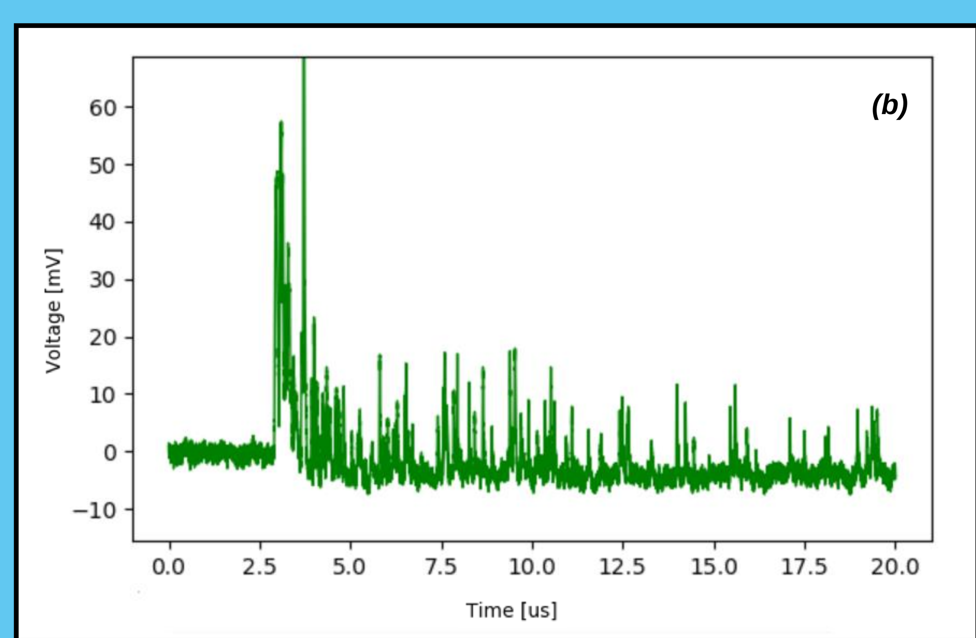

Figure 8: (a) Testing of thermal neutron foils on PMT face, (b) A typical neutron pulse from the BN:ZnS foils – ZnS decay time of several microseconds

References

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[6] Hawkes, N.P., Adams, J.M., Bond, D.S., Croft, S., Jarvis, O.N., Watkins, N.,. Nucl.Instrum. Methods A476, 190–194 (2002)

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