Regional variation in neutron/gamma pulse-shape discrimination within an organic scintillator

Patrick Collins-Price and Prof. Malcolm Joyce
New Engineering Building, Lancaster University, Lancaster, LA1 4YW
Correspondence to: p.collins-price@lancaster.ac.uk

Motivation and Objectives

- Nuclear safeguarding and special nuclear material (SNM) assay require effective means of identifying gamma and neutron events in a mixed field environment
- Established systems use pulse-shape discrimination (PSD) with fast-response organic scintillators to plot events into neutron and gamma plumes, with their degree of separation characterised by a figure of merit (FoM)
- FoM is observed to be worse for events where PSD parameter values are small\(^1\); a possible cause is variation in the PSD response within different regions of the scintillator, which is currently not well understood
- Novel examination of how pulse shape varies within a scintillator will allow improved PSD FoM and inform studies seeking to exploit detector geometry\(^2\)-\(^4\) or extract interaction position from pulse shape

1. Multi-anode photomultiplier tube (MAPMT) – H13700\(^5\)

- High quantum and collection efficiencies (33%, 80% typical)
- Low crosstalk (mean 2.8% perpendicular, 0.4% diagonal)
- 256 3x3 mm anodes

2. Anger logic readout circuit – SIB71256\(^6\)

- Anode charge divided across resistive network
- 256 anode outputs reduced to 4 Anger logic outputs
- Anger logic gives coordinate information
- Separate last dynode output

3. Novel application of MAPMT (H13700) with continuous organic scintillator (EJ-276)

- H13700's 256 anodes would allow a very granular view of light behaviour within the scintillator
- Multiple anodes allow separate readings of the same event at different positions within a continuous scintillator
  - PSD FoM
  - Peak amplitude
  - Rise/die-away times
- Anger logic resistive network yields coordinate information

4. Current and future research methodology using Vertilon sensor-interface boards (SIBs)

- Anger logic readout SIB71256
  - Lead-polyethylene collimator with 1x1 pixel (3x3 mm) aperture controls interaction location
  - Cs-137 gamma calibration source
  - CF-252 mixed-field source
  - Calibrate detector energy channels
  - Position aperture at known coordinate position
  - Measure and compare PSD response across detector regions
  - Perform mixed-field PSD using last dynode output

- Custom manual selection SIB
  - Lead-polyethylene collimator with 1x1 pixel (3x3 mm) aperture controls interaction location
  - CF-252 mixed-field source
  - Position aperture at known coordinate position
  - Measure and compare PSD response across detector regions
  - Repeat for different interaction locations

References:

\(^5\) Hamamatsu flat panel type multianode PMT assembly – H13700
\(^6\) Vertilon SIB71256