Profiling CsI detectors and using pulse shape discrimination to identify alpha particles, neutrons, and gamma rays

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Introduction

•Scintillator detectors play an important role in nuclear physics research
•CsI scintillators are important components of the new active target detector Texas Active Target (TextAT) that is being built at the Cyclotron Institute for experiments with rare isotope beams
•A p-terphenyl scintillator will be used for neutron background measurements in the MIvER experiment, which seeks to detect coherent neutrino scattering

Goals:

•Determine energy resolution and surface uniformity of 5x5 cm2 CsI (Tl) crystals produced by SCIONIX
•Develop a pulse shape discrimination (PSD) method with a waveform digitizer that will later be applied for n-γ PSD with the p-terphenyl scintillator for MIvER

Materials and methods

- 3D printed a plastic mask to place over the face of the CsI detector
- Measured the counts and energy of the alpha particles passing through each hole
  - Recorded means, sigmas
- Developed a variety of PSD techniques
- Tested these PSD techniques on simulated data with a digitizer and a detector emulator

Fig. 1: Setup of the CsI experiment.

Data Analysis and Results

- Resolution calculated by dividing the FWHM (sigma*2.3548) by the mean
- The PSD integration technique worked well with simulated data
  - Integrated pulse with a short window and a long window [1]
  - This gave charge (or Q) values for the formula $PSD = \frac{Q_L - Q_S}{Q_L}$

Fig 2: A photo of the CAEN V1743 digitizer used in developing pulse shape discrimination techniques [2]

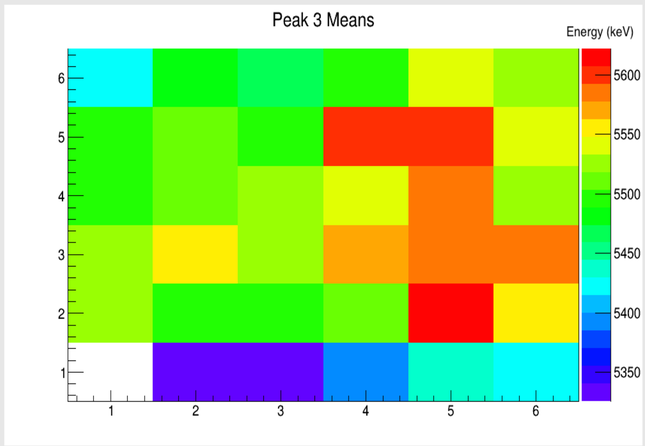

Fig. 3: A sample plot of one peak's means across the surface of the detector.

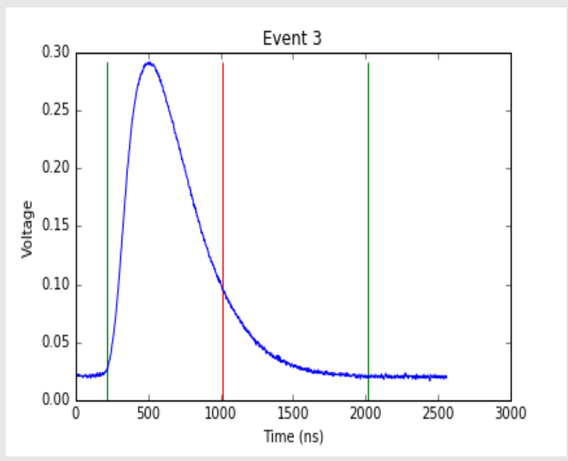

Fig. 4: A sample emulated waveform used to test our PSD techniques.

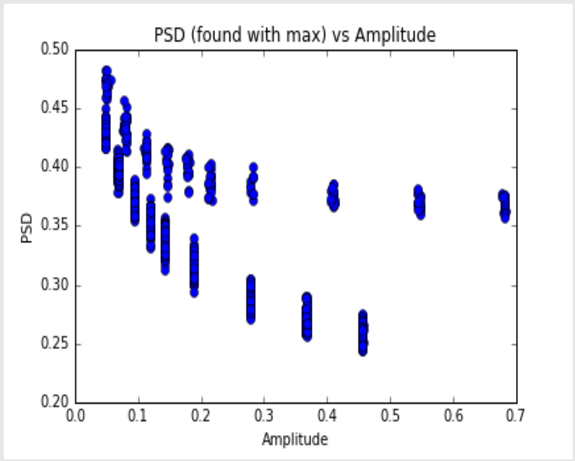

Fig. 5: A plot of the calculated PSD vs. amplitude (peak height) of simulated waveforms.

Conclusions

- Means vary across the surface of the CsI detector
- Resolution of the CsI is about 3%
- Pulse Shape discrimination techniques worked well in distinguishing waveforms of simulated data

References

[1] *Application Note AN2506: Digital Gamma Neutron discrimination with liquid scintillators*. CAEN. 2012.

[2] V1743. CAEN. 2016. http://www.caen.it/csite/CaenProd.jsp?idmod=801&parent=11

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Further information

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