Pulse-Shape Discrimination of Scintillators for α-Particles, ɣ-Particles, and Neutrons

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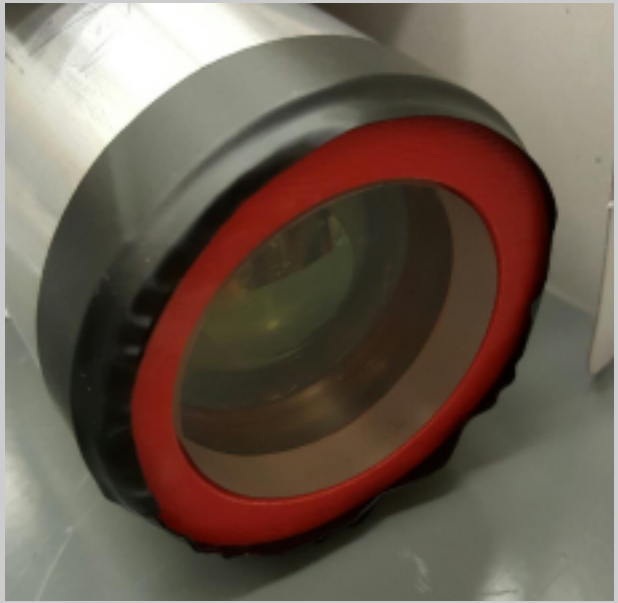
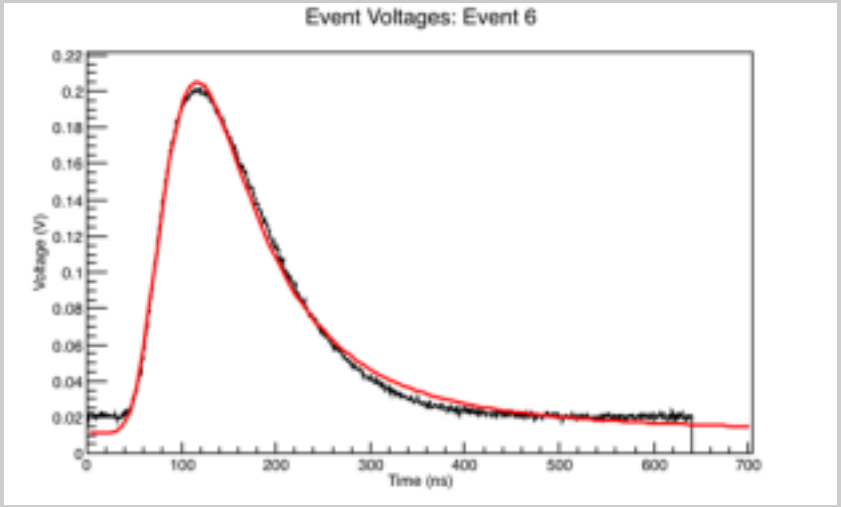
Motivation and Background

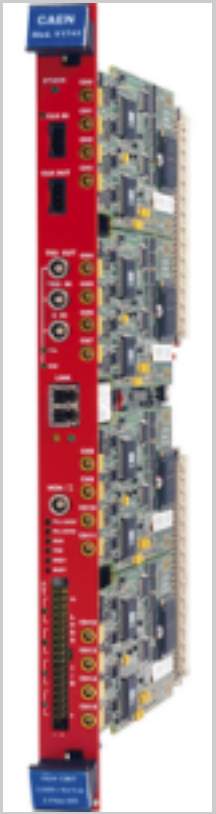
- Purpose: distinguish between signals from different particles
  - Pulse-shape discrimination (PSD)
- Scintillator: material which gives off photons when struck by a particle with high energy
  - Produce different shapes by particles stimulating different ratios of the fast and slow components
- Mitchell Institute Neutrino Experiment at Reactor (MIνER)
  - Coherent neutrino scattering
  - Background measurements



Methods of PSD

- Initially used simulated data
  - Test different forms of PSD:
    - Fit with different functions
    - Plot just the fall
    - Charge

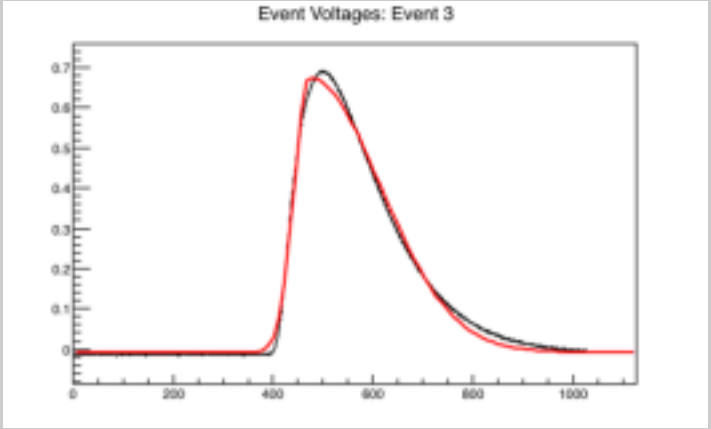




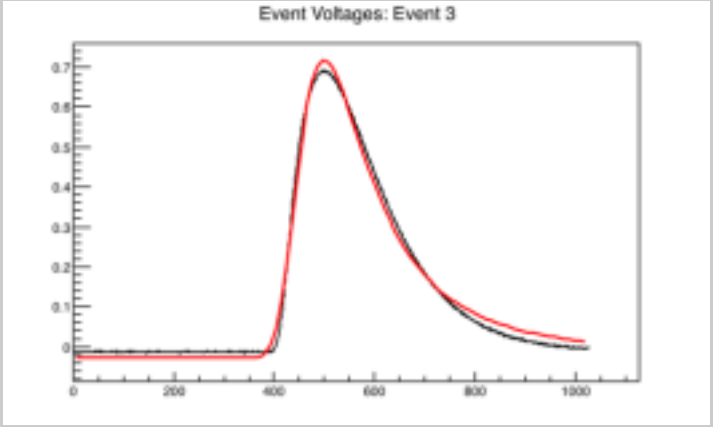
Fitting Functions

- Gauss
- Two Gauss
- Cauchy
- Landau

Two Gauss

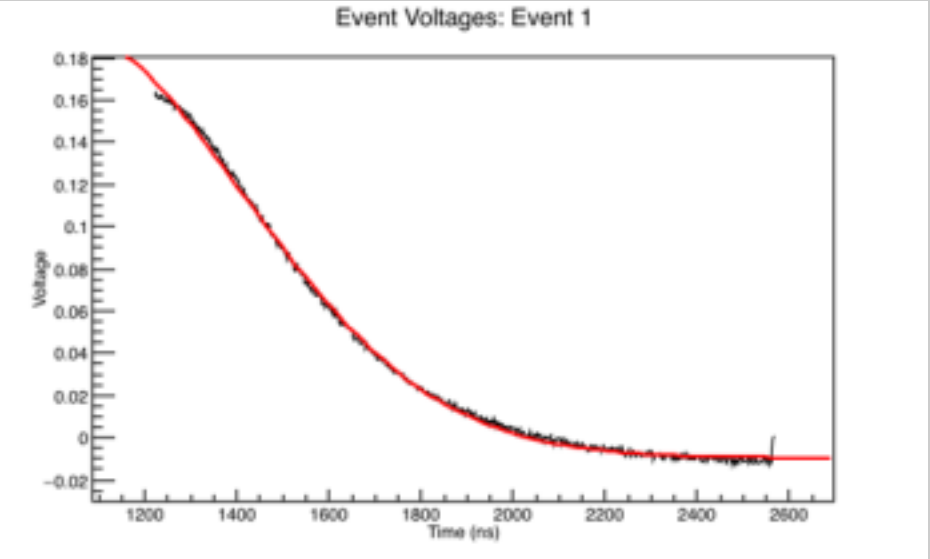


Landau



Plotting Half

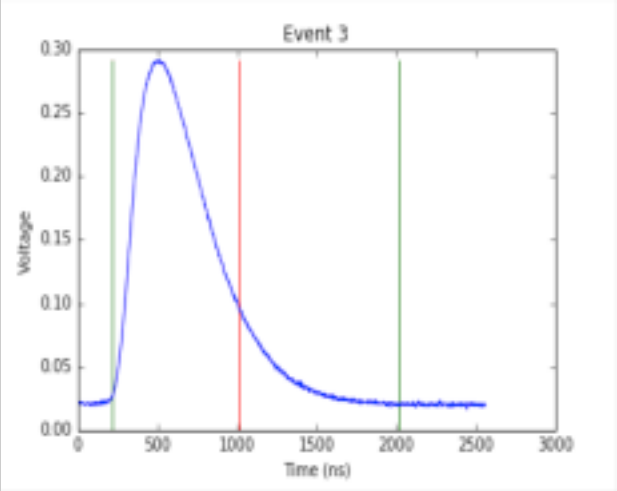
- Found maximum
- Graphed from that point
- Found that the fits were not always accurate
- Difficult to see separation

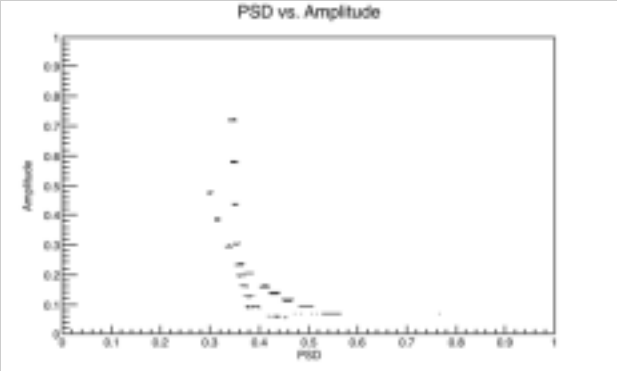


PSD Using Charge

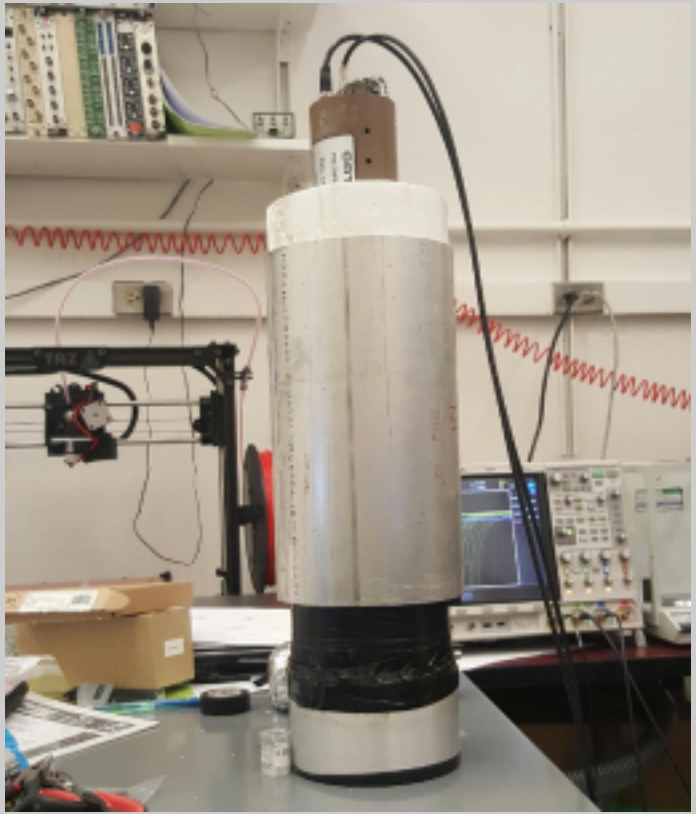
- Select a long window and a short window
- Integrate under the fit in those windows
- This is the charge
- Plot the parameters against PSD, defined as

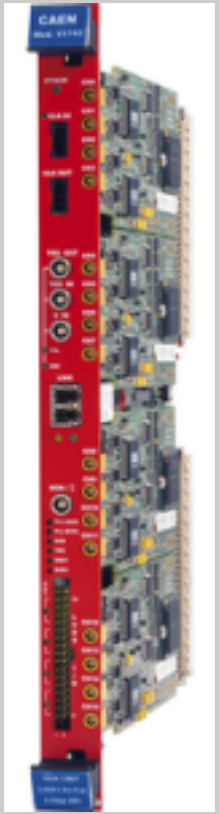
$$PSD = \frac{Q_L - Q_S}{Q_L}$$

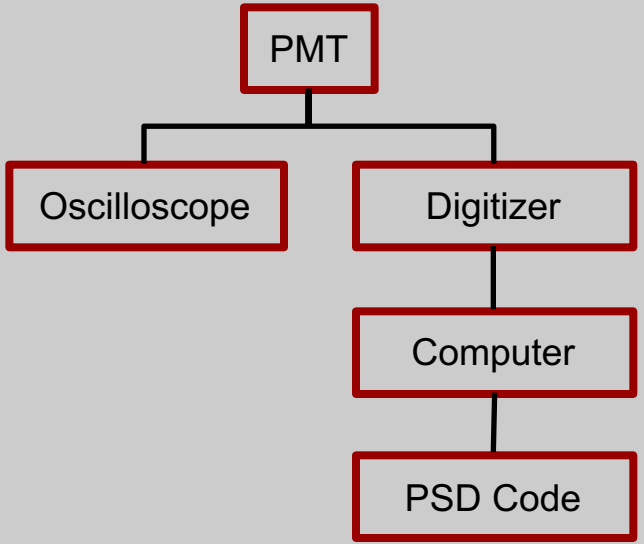




Experimental Setup

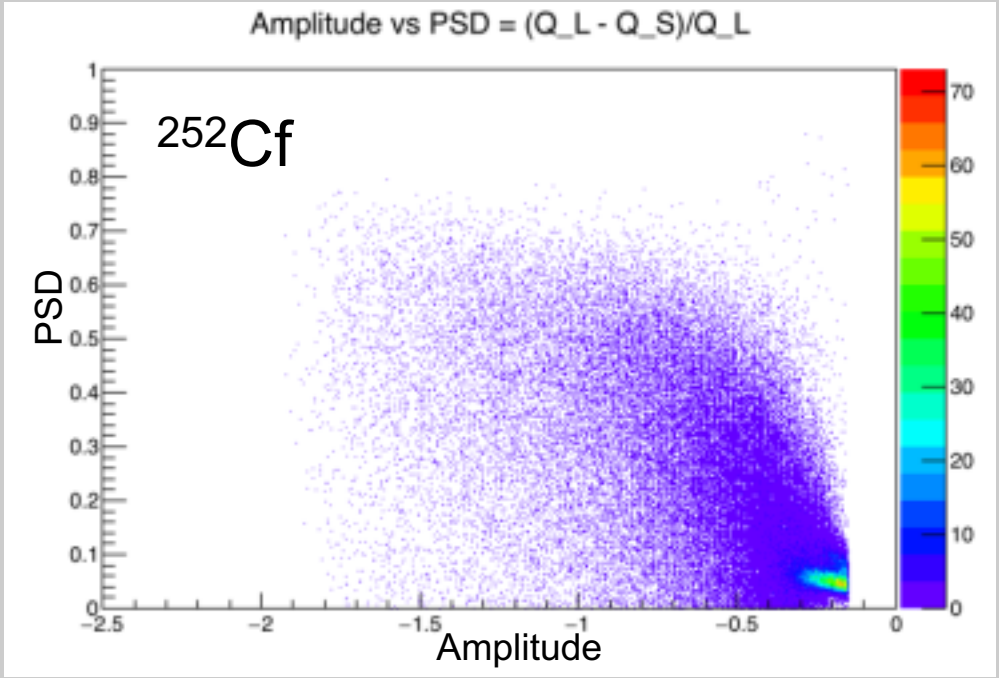






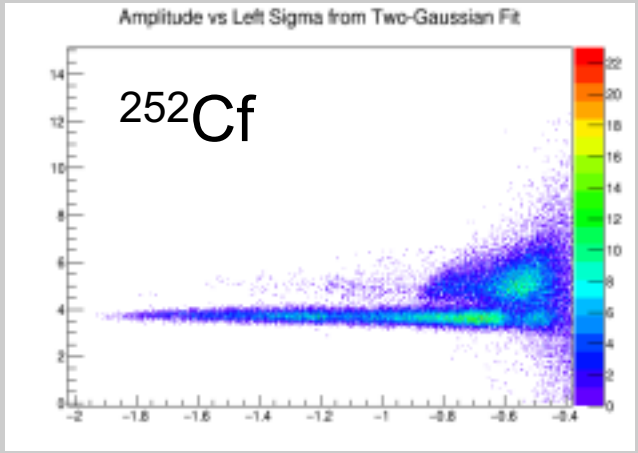
Amplitude and Charge against PSD

- Too difficult to see a separation

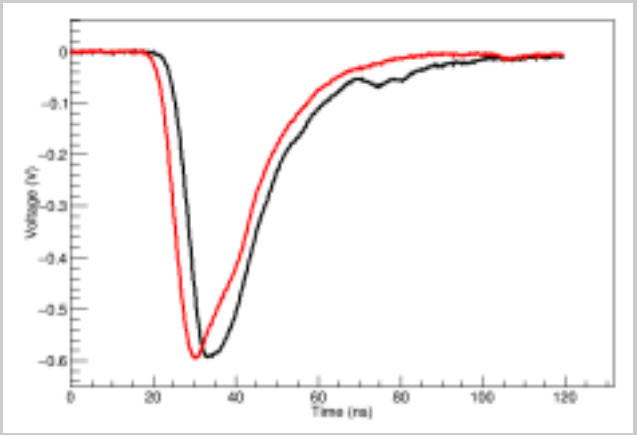


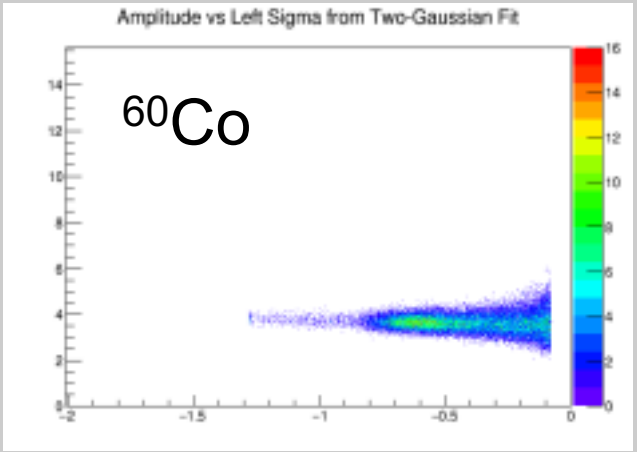
Amplitude vs. Sigma (Stilbene)

- Clear separation:



- Which is which?
  - Neutrons have a wider signal (i.e. bigger sigma)
  - ^{60}Co Test

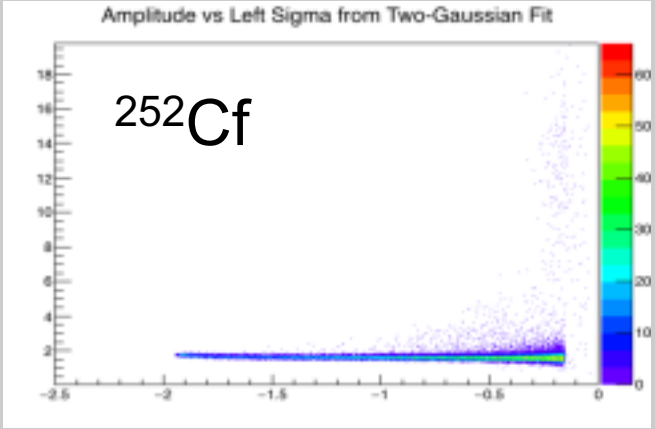


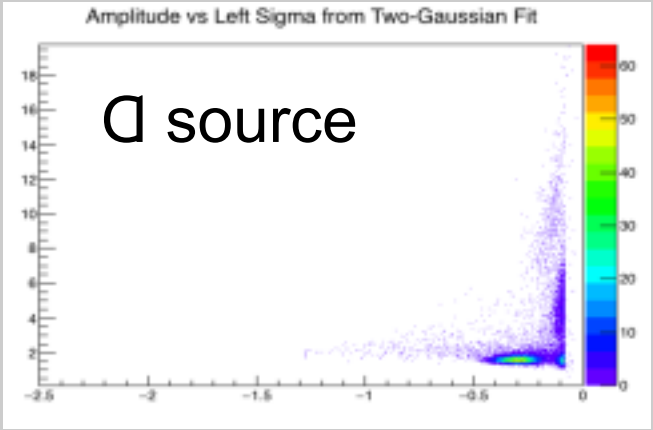


Amplitude vs. Sigma (Plastic)

- Test with scintillator with no PSD
  - No separation in ^{252}Cf test
  - α test gave data at same sigma

- MIνER will use same PMT, different scintillator
  - p-Terphenyl: best non-liquid scintillator for PSD
  - Difficult crystal to grow





Conclusions and Further Work

- Amplitude vs. Left Sigma gave best PSD for Stilbene
- Preliminary results showed a distinct separation of the ɣ-particles and neutrons of ^{252}Cf
- Methods will be further modified and applied with p-Terphenyl for MIνER

Thank you!

Questions?