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Comparison of Stilbene neutron detection performance to EJ-309

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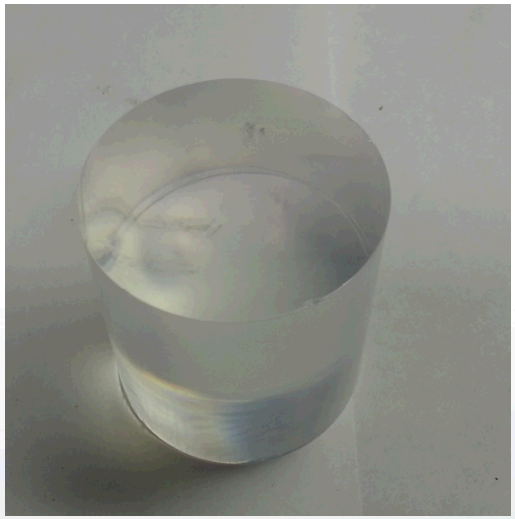
Outline

- **Stilbene 2”x2” crystals obtained from InradOptics (http://inradoptics.com/)**

- **Crystal properties under evaluation:**
  - Light yield
  - PSD
  - Durability (physical, temperature)

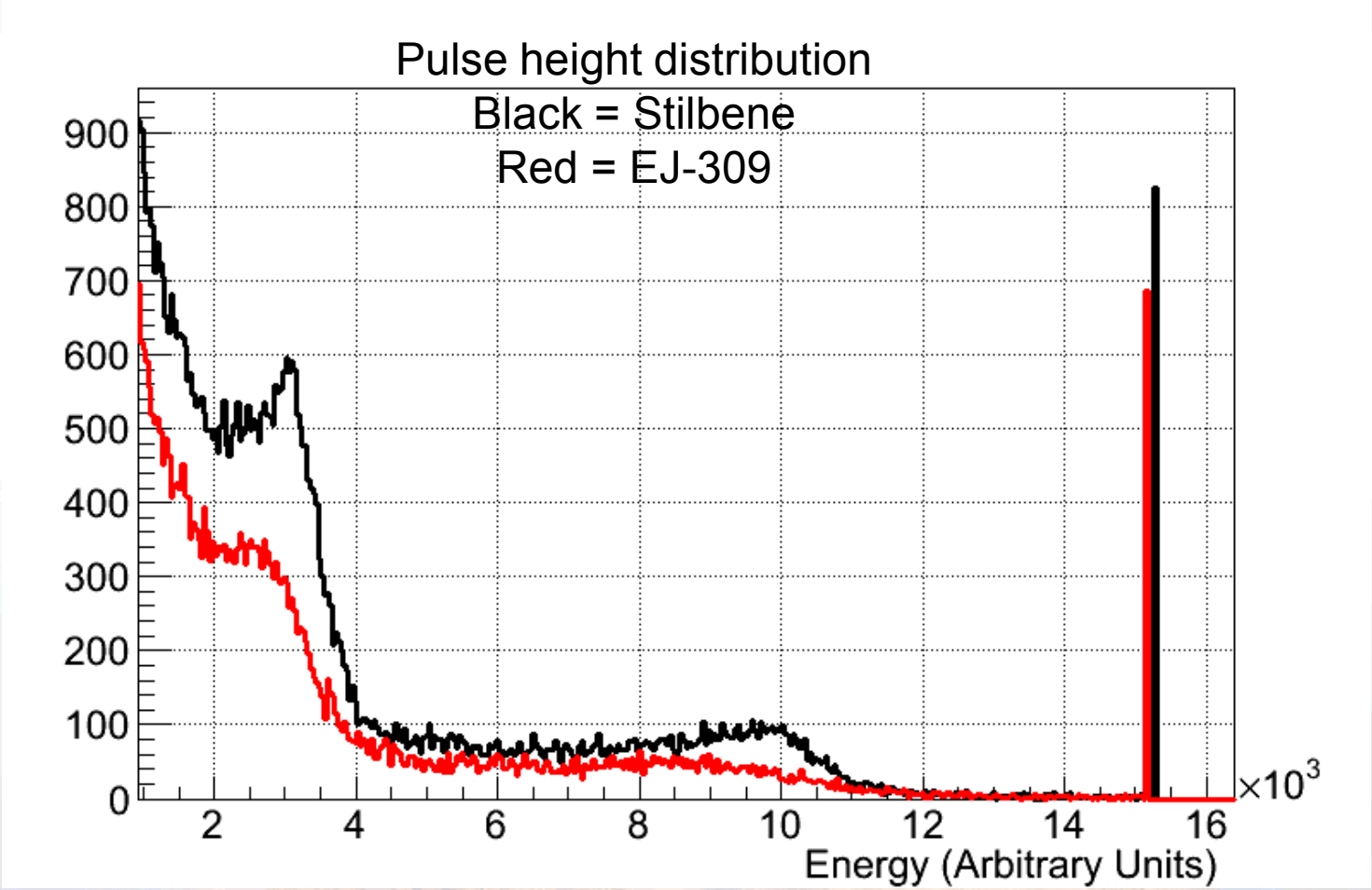
- **Current focus on PSD with comparison to current standard EJ-309 liquid scintillator 2” cells.**



Testing Setup

- **Struck 3316, 250 MHz, 14 bit digitizer (http://www.struck.de/sis3316.html)**
  - PSD may be further improved using 500 MHz digitizers, but one was not readily available for this round of testing.
- **Two Hamamatsu PMT H1949-51 used, one for each cell to be tested simultaneously.**
- **PMT biasing gain matched the two detectors based on peak heights to avoid clipping.**
- **Sources placed equidistant from cells.**

Na-22 Energy Calibration



Stilbene seems to have superior energy resolution.

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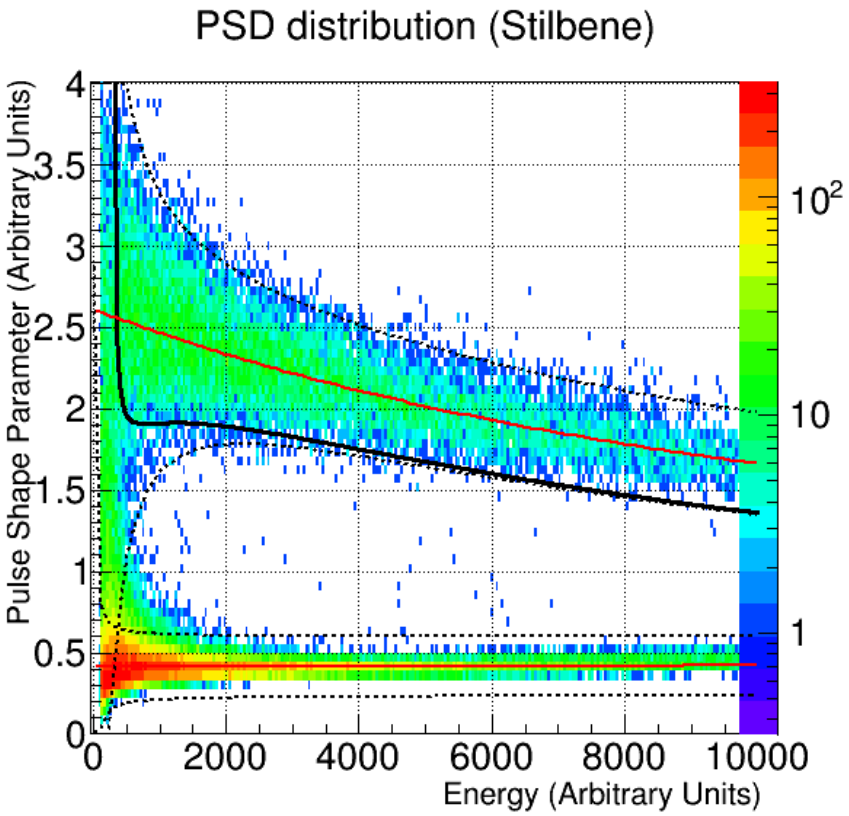
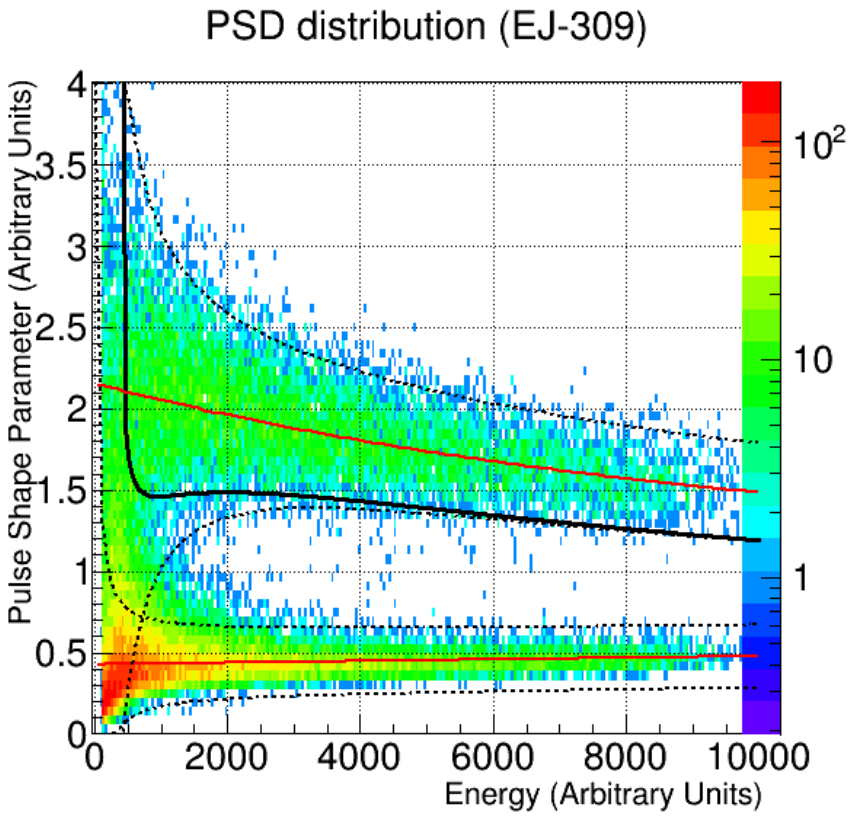
AmBe PSD Characterization

Lines are indicating gamma and neutron means (solid red) and 2 sigma limits (dotted black) from Gaussian fits, and neutron cuts (solid black).





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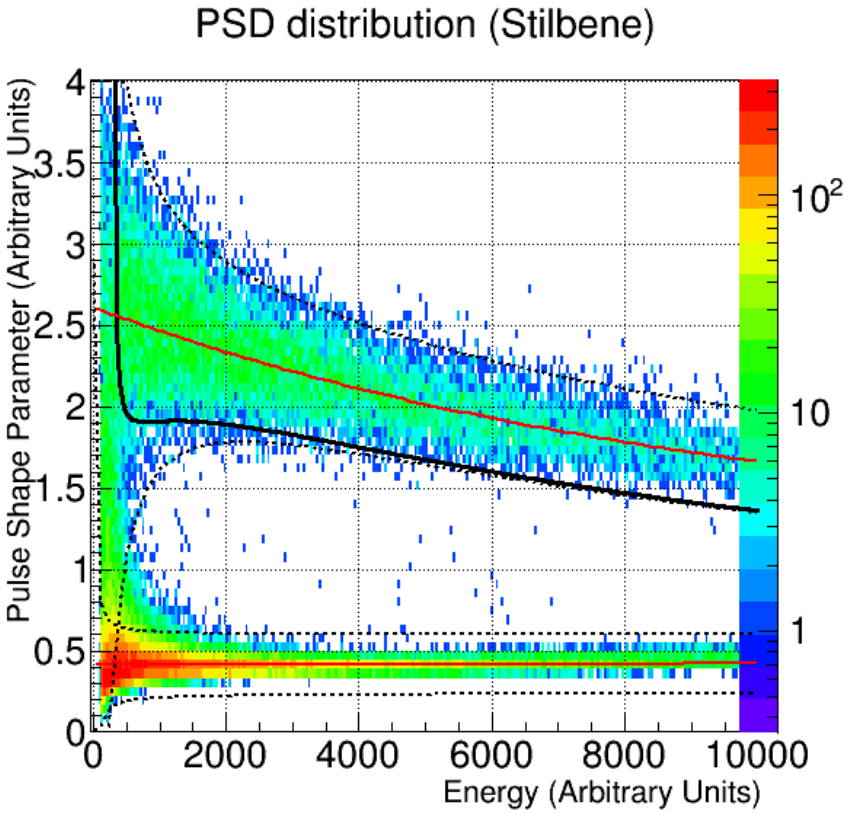
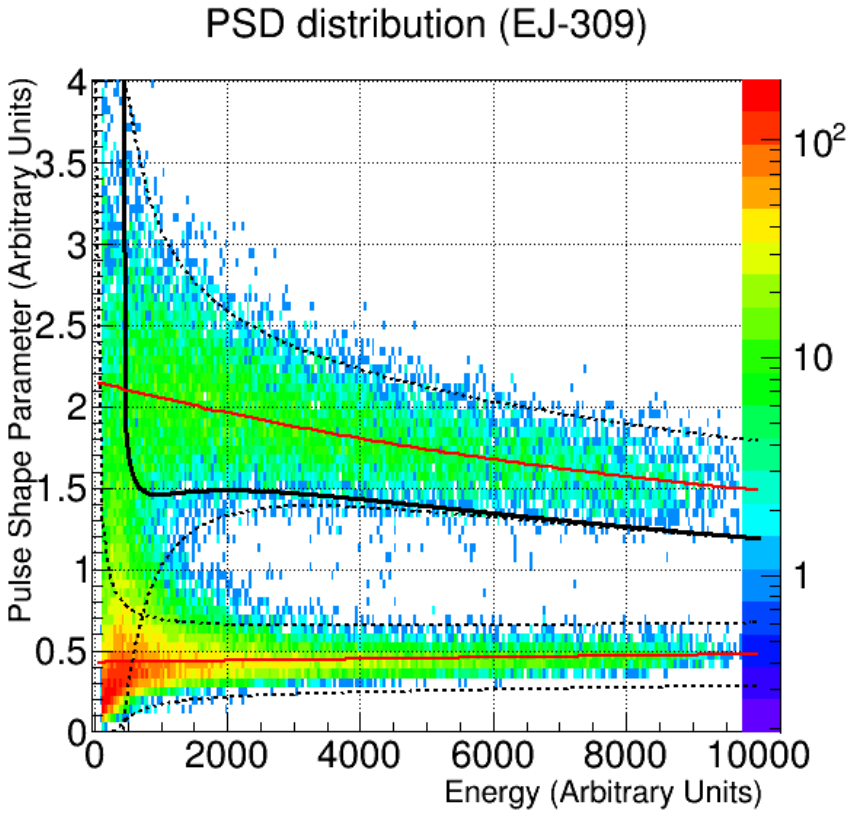
AmBe PSD Characterization

Bayesian probability of being a neutron or a gamma is defined:

$$Prob\_n = \frac{Ln}{Lg+Ln+Lo} = \frac{Gaus\_n(amp,psd)}{Gaus\_g(amp,psd)+Gaus\_n(amp,psd)+Lo}$$





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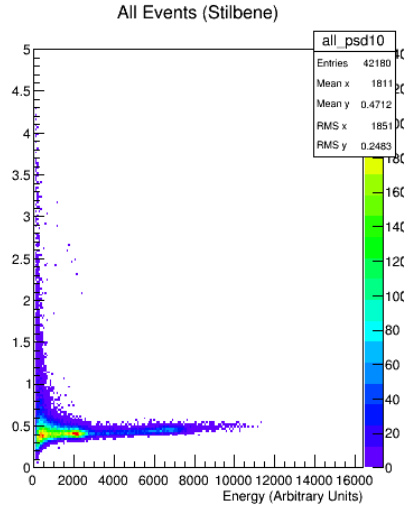
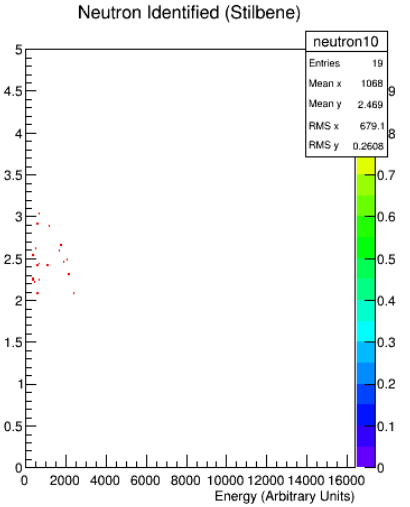
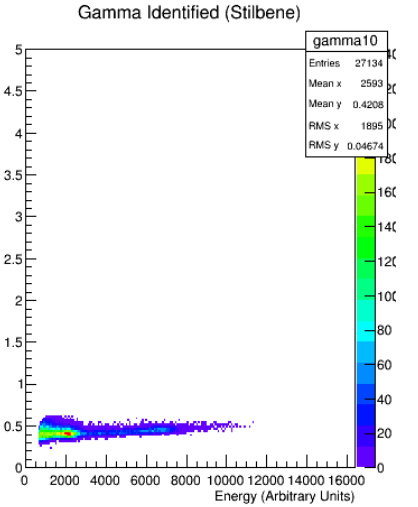
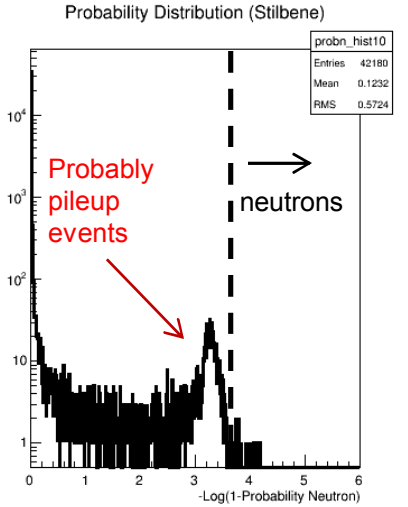
^{22}Na PSD Distributions

Stilbene

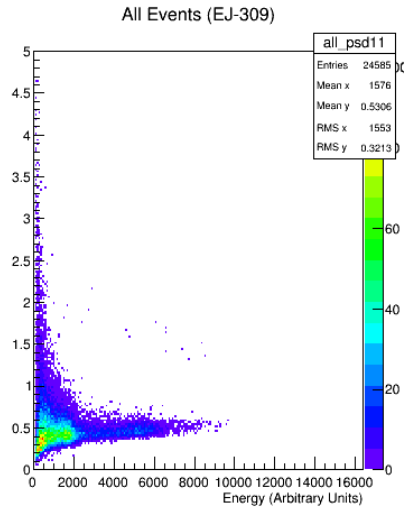


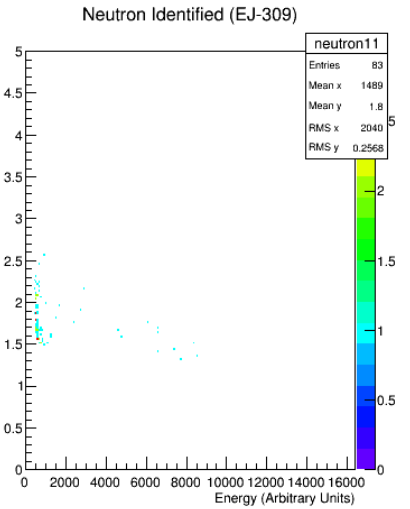


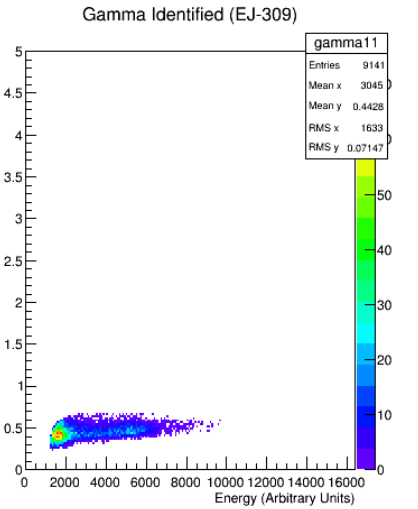


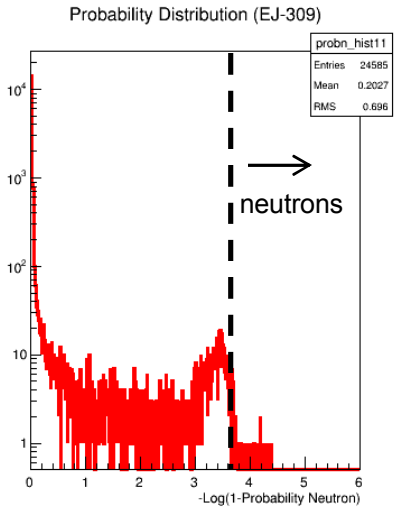


EJ-309









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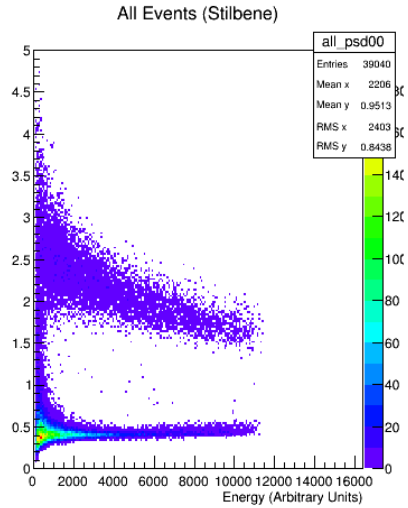
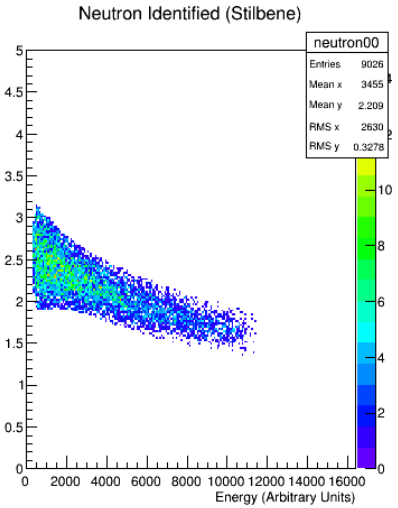
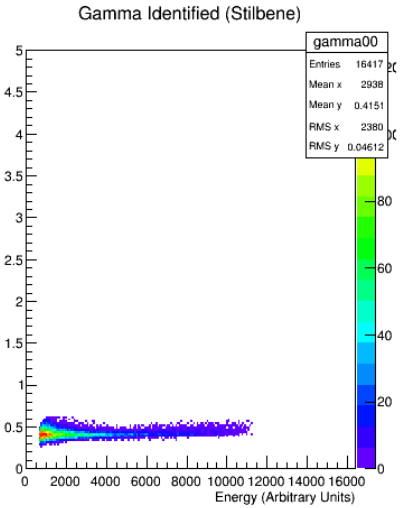
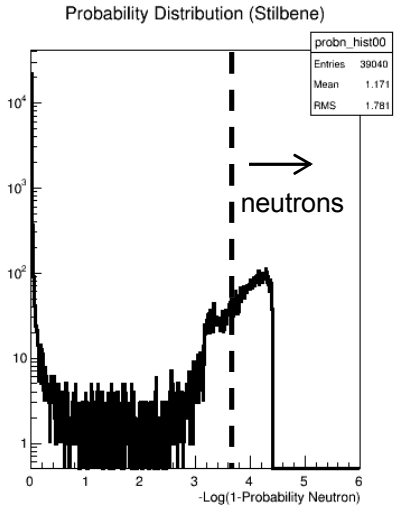
Cf-252 PSD Particle Identification

Stilbene

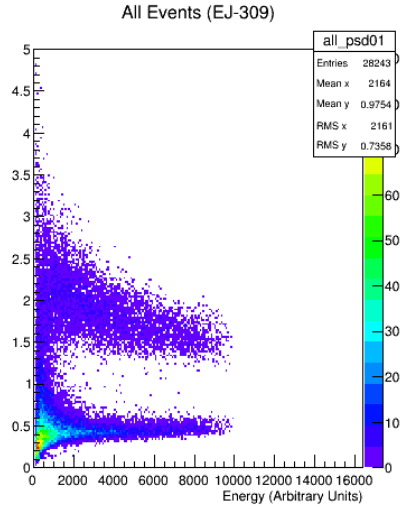


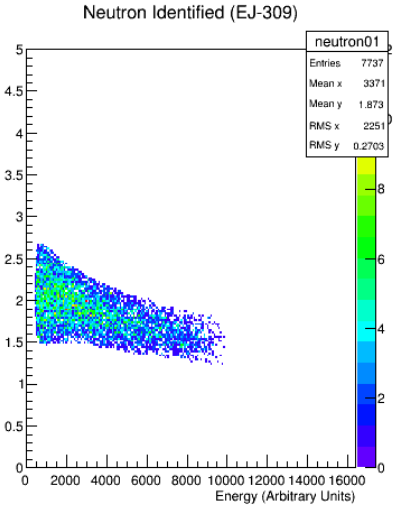


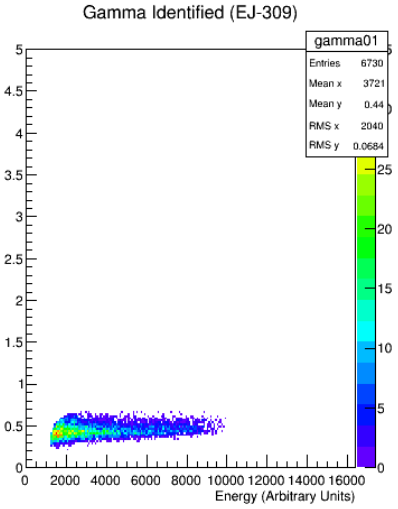




EJ-309







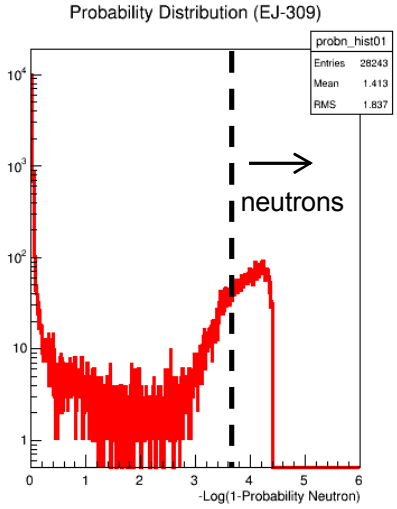


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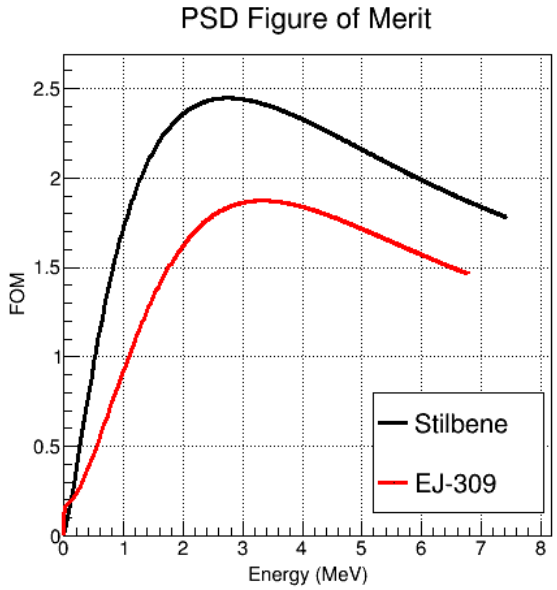
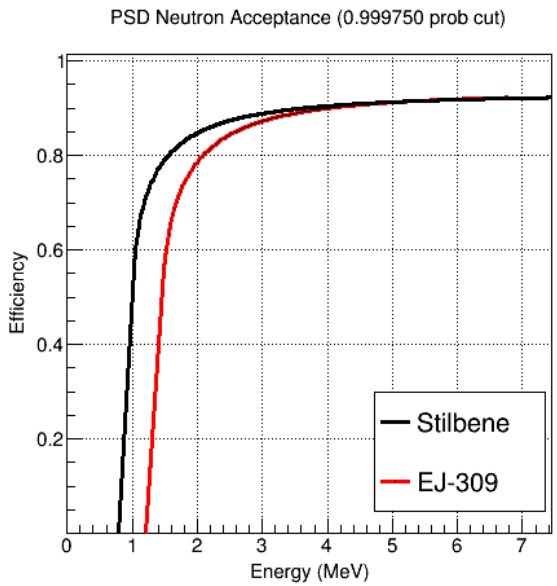
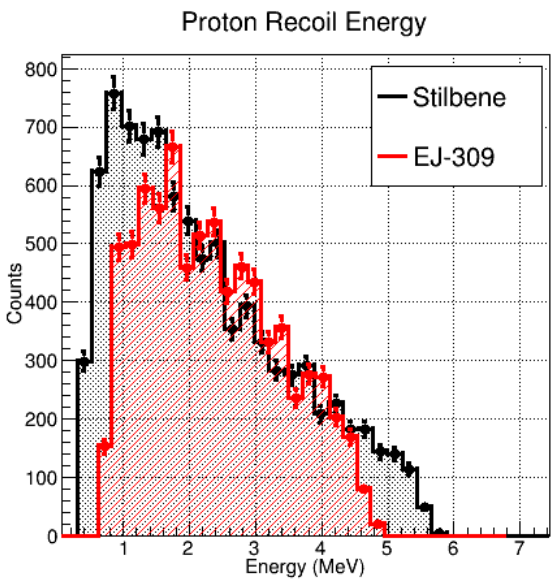
Figure-of-Merit and Neutron Efficiency

Functional fits used to characterize figure of merit (FOM) and Neutron Acceptance (efficiency given probability cut)

$$FOM = \frac{Mean_n - Mean_g}{FWHM_n + FWHM_g}$$







Neutron Identification (16.7% increase)
Stilbene (50% @ ~1 MeV): 9,026 events
EJ-309 (50% @ ~1.5 MeV): 7,737 events

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Summary

- **Stilbene appears to have superior PSD and energy resolution.**
- **Increased neutron detection efficiency (~17% improvement) gained from lower threshold while maintaining a high degree of gamma rejection.**
  - Higher proton quenching leads to smaller improvement than initially hoped.
- **Very low gamma energy thresholds achievable (~20 keV).**

References

Light Yield Function extracted from:

Franca T. Kuchnir and Frank J. Lynch, “Time Dependence of Scintillators and the Effect on Pulse Shape Discrimination”, Nuclear Science, IEEE Transactions on (Volume 15, Issue 3) June 1968. pp 107-113.