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Comparative scintillation performance of EJ-276, EJ-309, and a novel organic glass

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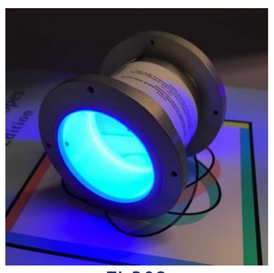
Organic Scintillators with Pulse Shape Discrimination


EJ-309


EJ-276


Organic glass

A new organic glass scintillator developed by Sandia National Laboratories was characterized in terms of its:

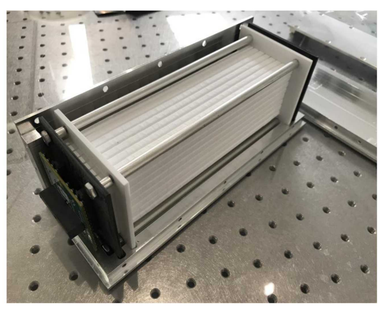
- Relative electron light output,
- Relative proton light yield, and
- Pulse shape discrimination (PSD) performance

and compared to commercially available competitors: EJ-309 (liquid) and EJ-276 (plastic)

Impact and Applications

Organic scintillators with PSD are useful for:

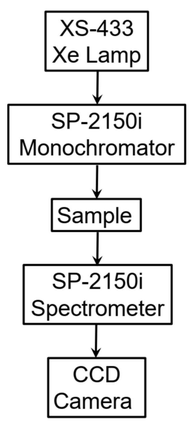
- Basic and applied nuclear physics,
- Homeland security, and
- Proliferation detection.


Optically-segmented single volumce scatter camera prototype at University of Hawaii (photo credit: N. Kaneshige)

Electron Light Output

Emission spectra measurements

<4% impact of disparate emission spectra and photocathode QE



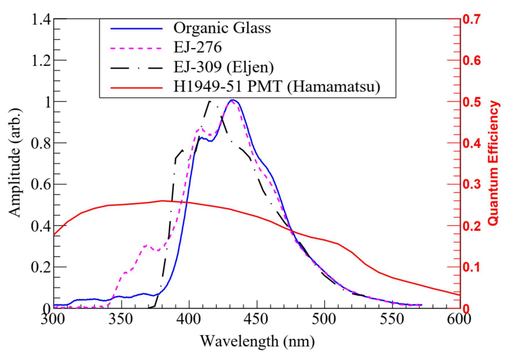


Fig. 1: Emission spectra for EJ-309, EJ-276 and the organic glass. The PMT quantum efficiency (QE) is given on the secondary ordinate axis.

^{137}Cs spectrum measurement

- Same scintillator size and bias voltage using the same H1949-51 PMT
- Compton edge determined by minimization of measured gamma-ray spectrum and Geant4 simulated energy deposited spectrum convolved with a resolution function

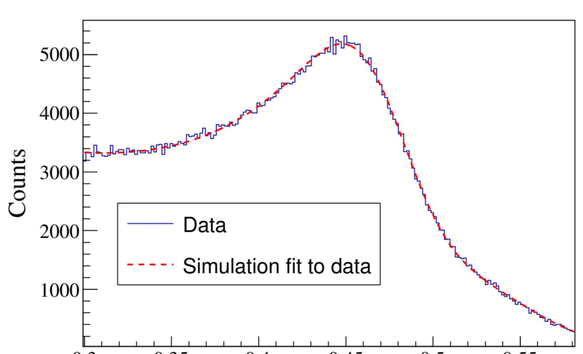


Fig. 2: Result of the minimization of a measured ^{137}Cs spectrum and a Geant4 simulated spectrum convolved with a resolution function for EJ-309.

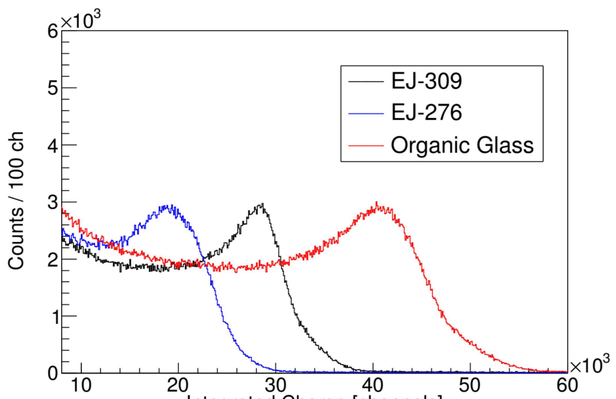
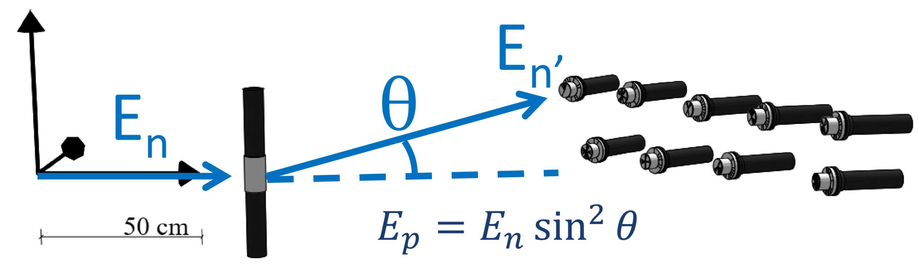


Fig. 3: Comparison of the pulse integral spectra obtained using a ^{137}Cs source for the three different materials

Proton Light Yield

- Pulsed ^{9}Be(d,n) beam at LBNL 88-Inch Cyclotron
- Dual PMT to reject dark current
- Coincidence between in-beam scintillator of interest and one of 11 out-of-beam PSD-capable scintillators
- Proton recoil energy obtained using kinematics
- Digital acquisition (CAEN V1730, 500 MS/s) recording full waveforms



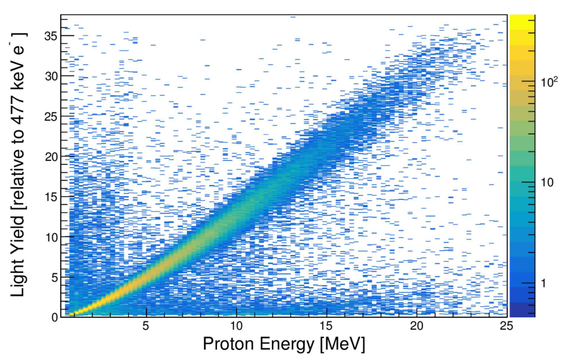


Fig. 4: Continuous proton light yield for the organic glass

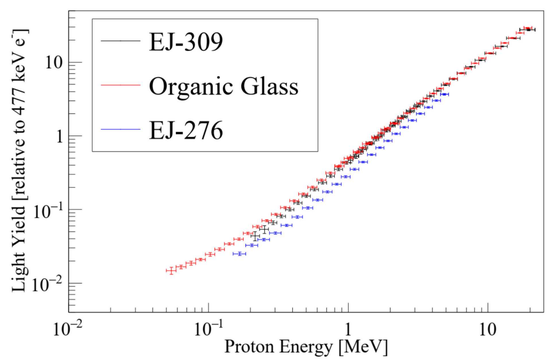


Fig. 5: Proton light yield results. The organic glass and EJ-309 outperform EJ-276

PSD Performance

PSD performance evaluated using figure-of-merit (FOM) and receiver operating characteristic (ROC) curves as function of proton recoil energy

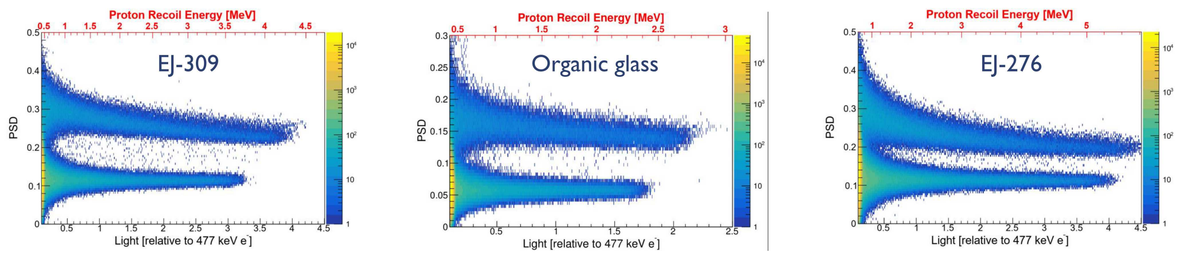


Fig. 6: Tail-to-total ratio as function of the light output (bottom x-axis) and proton recoil energy (top x-axis)

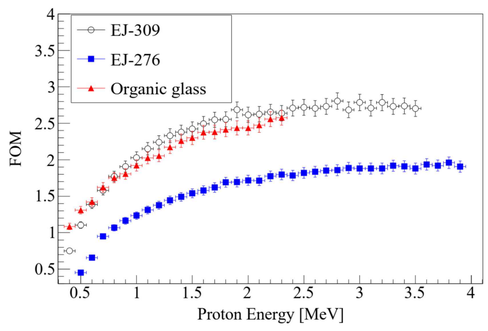


Fig. 7: Neutron/γ separation quantified using FOM as function of the proton recoil energy

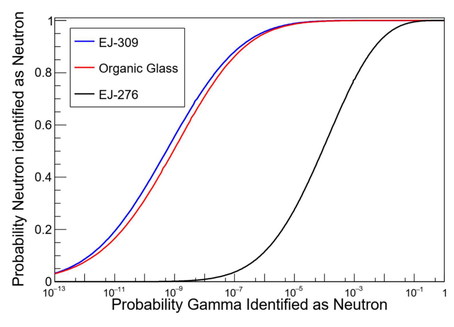


Fig. 8: ROC curves for 650 ± 50 keV proton recoils

Summary

The organic glass:

- is brighter than both EJ-309 and EJ-276
- has a similar proton light yield to EJ-309 but outperforms EJ-276
- has a similar PSD performance to EJ-309 but outperforms EJ-276
- is well poised to replace current state-of-the-art PSD-capable scintillators in select neutron detection applications

Acknowledgments

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