Carbon light yield of EJ-309 and EJ-204 organic scintillators

This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

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Introduction

Simultaneous measurement of the proton and carbon light yield over a continuous energy range

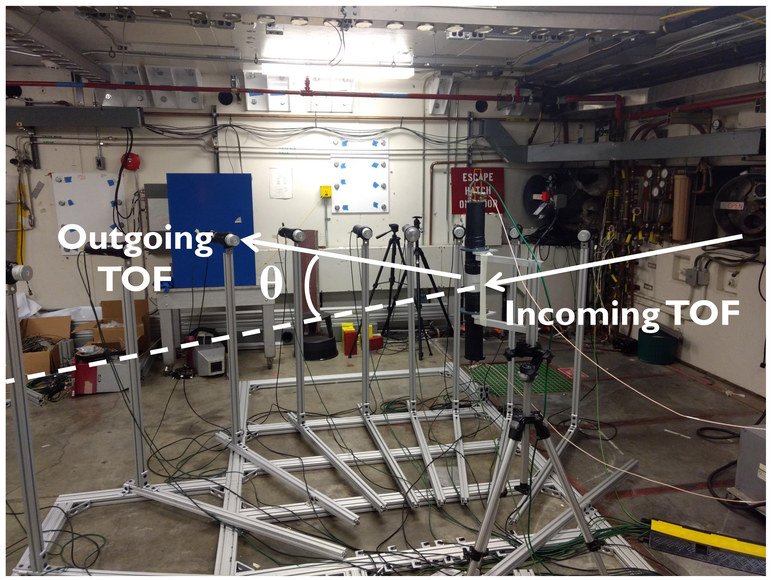
- Benchmark physics-based models of ionization quenching
- Accurate simulation of detector performance
- Inform design of new detection systems

EJ-309

EJ-204

Experimental setup

- 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/Carbon recoil energy obtained using kinematics
- Digital acquisition (CAEN V1730, 500 MS/s) recording full waveforms



Event selection

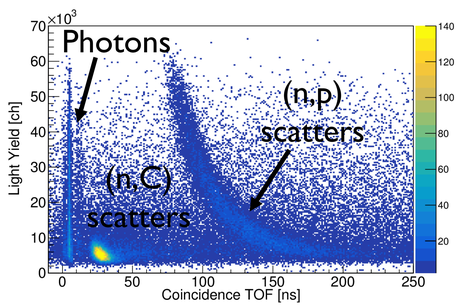


Fig. 1: Light vs Coincident TOF for a scatter cell at 30° forward scattering angle

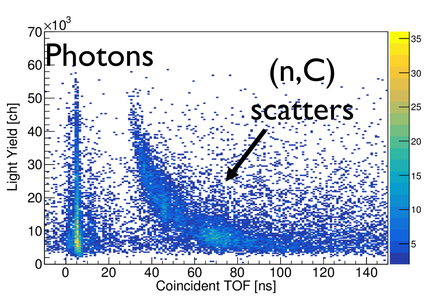


Fig. 2: Light vs Coincident TOF for a scatter cell at 130° backward scattering angle

- Incoming TOF
- Outgoing TOF
- Angle

} Over-constrained system to calculate particle recoil

Calibration

- Calibration using ^{241}Am 59.5 keV γ ray
- Electron light nonlinearity impact:
  - ➔ multiple scatters
  - ➔ cannot directly compare to light from ^{137}Cs
- Energy deposited in Geant4 simulation converted to light using measured electron light nonlinearity from Payne et al. [1]

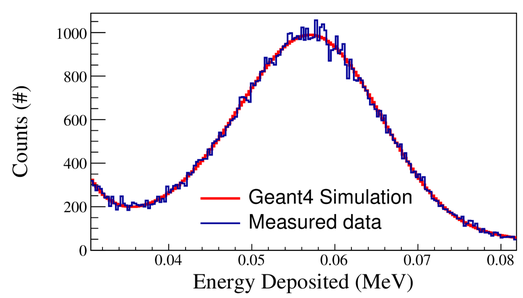


Fig. 7: Minimization between Geant4 modeled (red) and experimental (blue) ^{241}Am γ-ray spectrum

[1] Payne et al., IEEE TNS 58(6) (2011)

Results

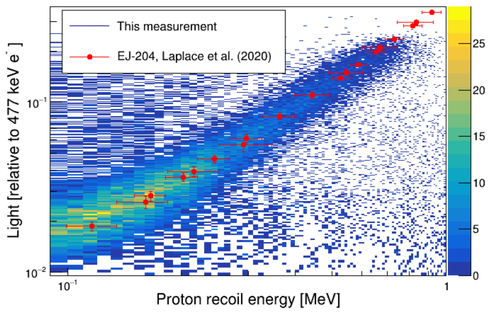


Fig. 3: EJ-204 proton light yield

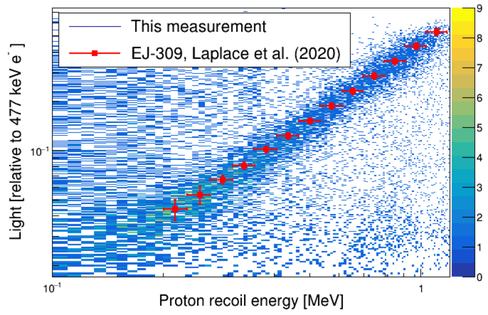


Fig. 4: EJ-309 proton light yield

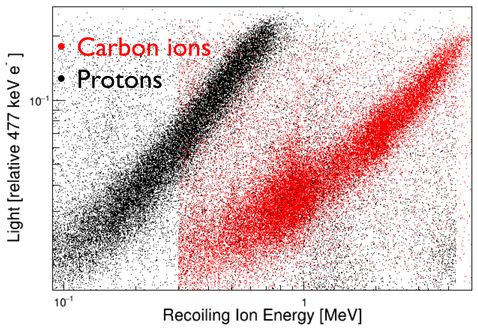


Fig. 5: EJ-204 proton and carbon light yield

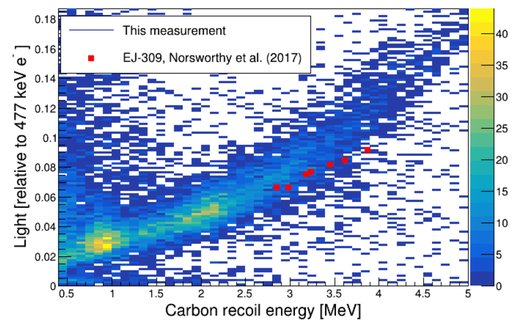


Fig. 6: EJ-309 carbon light yield

Rate dependent PMT response

- PMTs used for EJ-204 measurement presents a drift in the single photoelectron (PE) distribution between calibration and in-beam data. (H1949-51 PMT)
- Effect not observed for EJ-309 measurement (H13795-100)

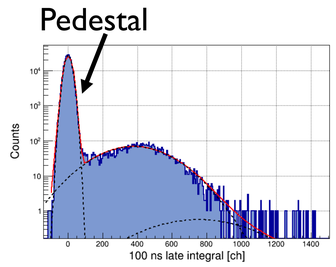


Fig. 8: PMT response to few photons during the calibration

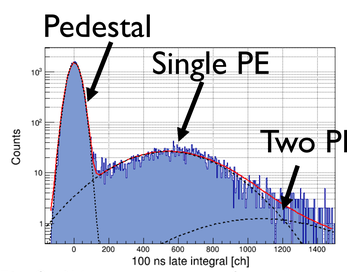


Fig. 9: PMT response to few photons during the in-beam measurement

Future work

- Proton/Carbon light yield binned using proton/carbon energy resolution
- Monte Carlo of systematic uncertainties
- PMT nonlinearity correction

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