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

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Introduction

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

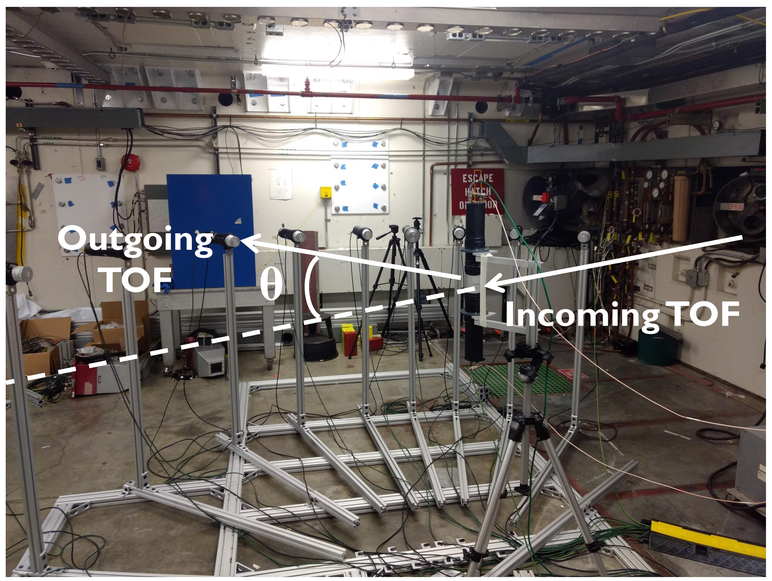
- Benchmark physics-based models of ionization quenching
- Accurate simulation of detector performance
- Inform design of new detection systems

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

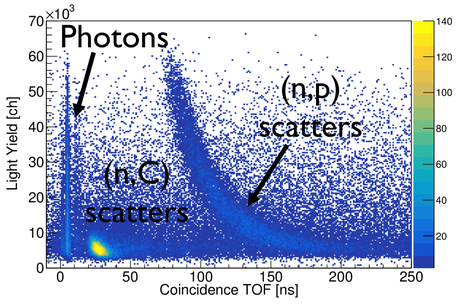


Fig. 1: Light vs Coincident TOF for a scatter cell at 30° forward scattering angle

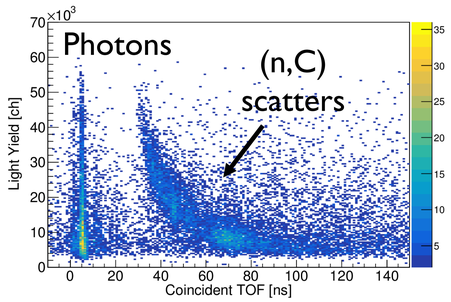


Fig. 2: Light vs Coincident TOF for a scatter cell at 130° backward scattering angle

- Incoming TOF
- Outgoing TOF
- Angle

} Over-constrained system to calculate particle recoil

Results

Fig. 3: EJ-309 proton and carbon light yields

Fig. 4: EJ-204 electron, proton and carbon light yields

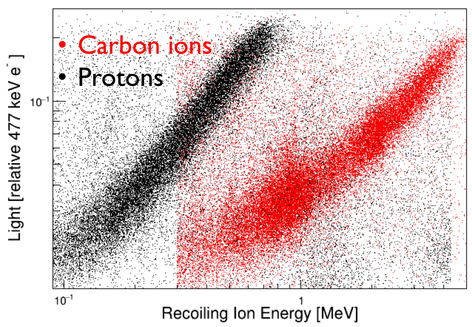


Fig. 5: EJ-204 proton and carbon light yield

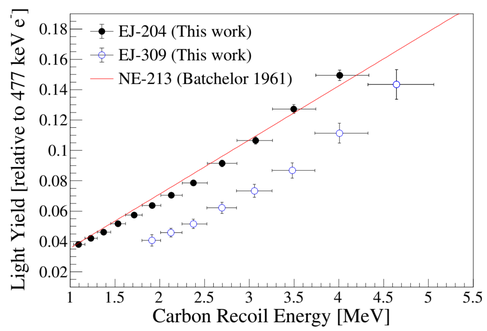


Fig. 6: Relative carbon light yields of EJ-309 and EJ-204

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]

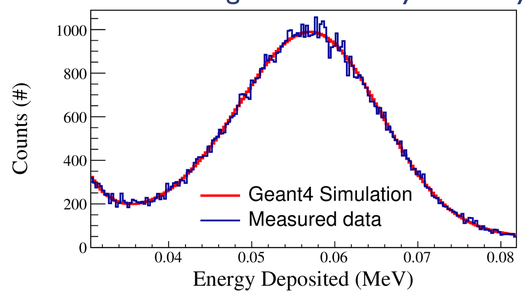


Fig. 7: Minimization between Geant4 modeled (red) and experimental (blue) ^{241}Am γ-ray spectrum

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

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)

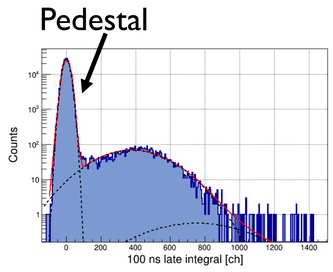


Fig. 8: PMT response to few photons during the calibration

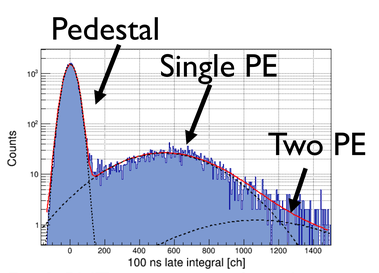


Fig. 9: PMT response to few photons during the in-beam measurement

Impact

- First continuous measurement of the carbon light yield
- First measurement of the EJ-204 carbon light yield
- Enables study of ionization quenching for stopping powers of recoil nuclei spanning several orders of magnitude
- Results published in Phys. Rev. C (July 2021)

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