Fast Neutron Detector Modeling

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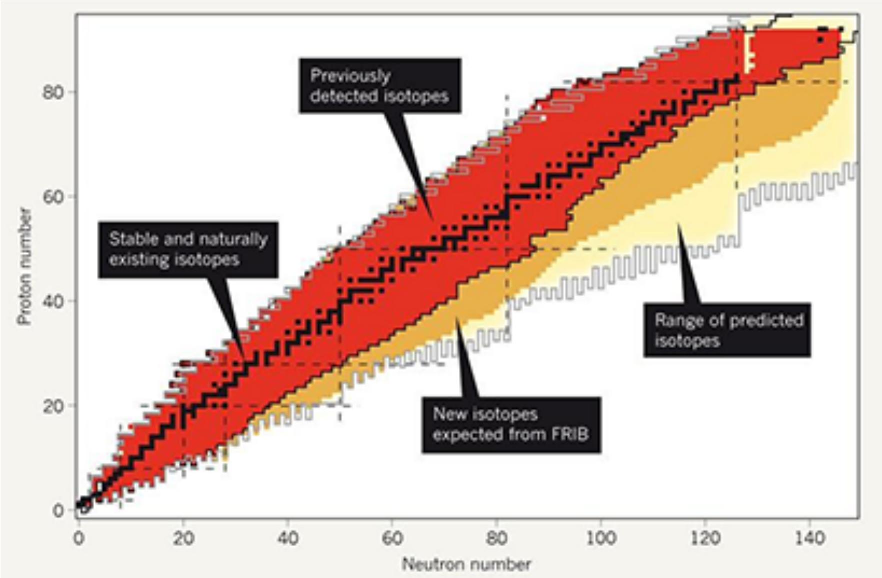
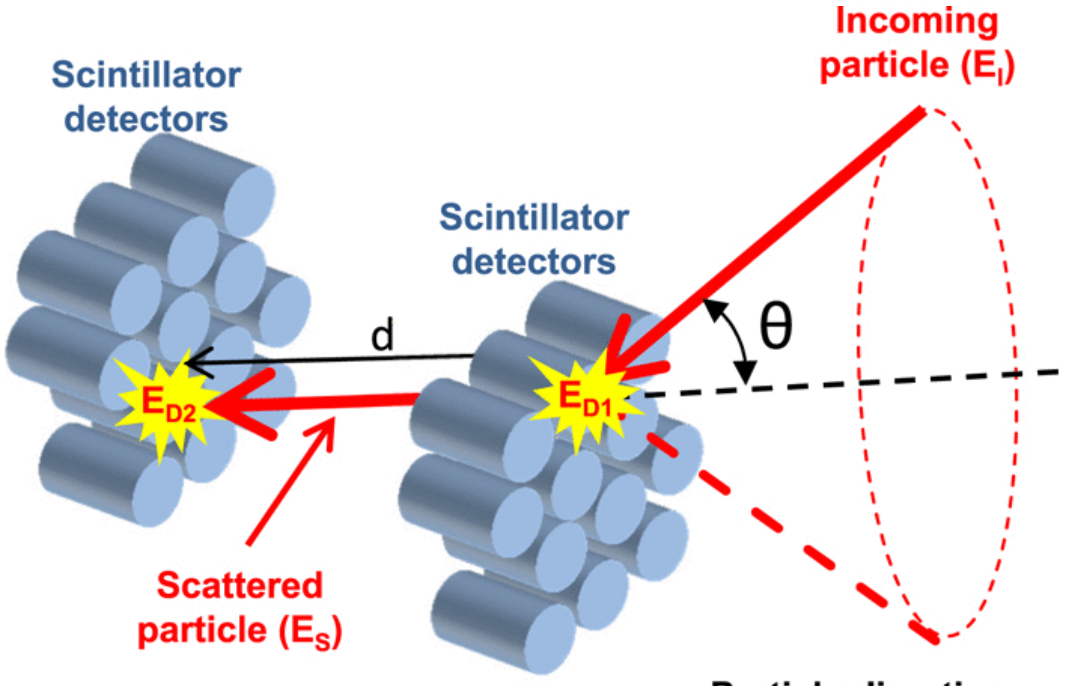
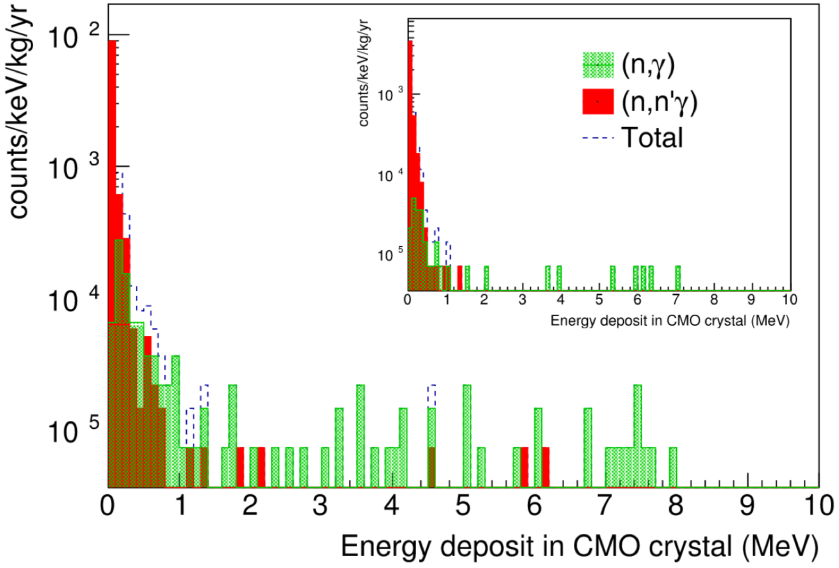
Fast neutrons: from new physics to warheads

- Fast neutron detection is a flexible and powerful tool
  - Neutron decay/emission from exotic nuclear systems (e.g. at the Facility for Rare Isotope Beams)
  - Fission-spectrum neutrons for detecting SNM (e.g. Single Volume Scatter Camera)
  - Neutron background in underground rare event experiments (or reactor monitoring)





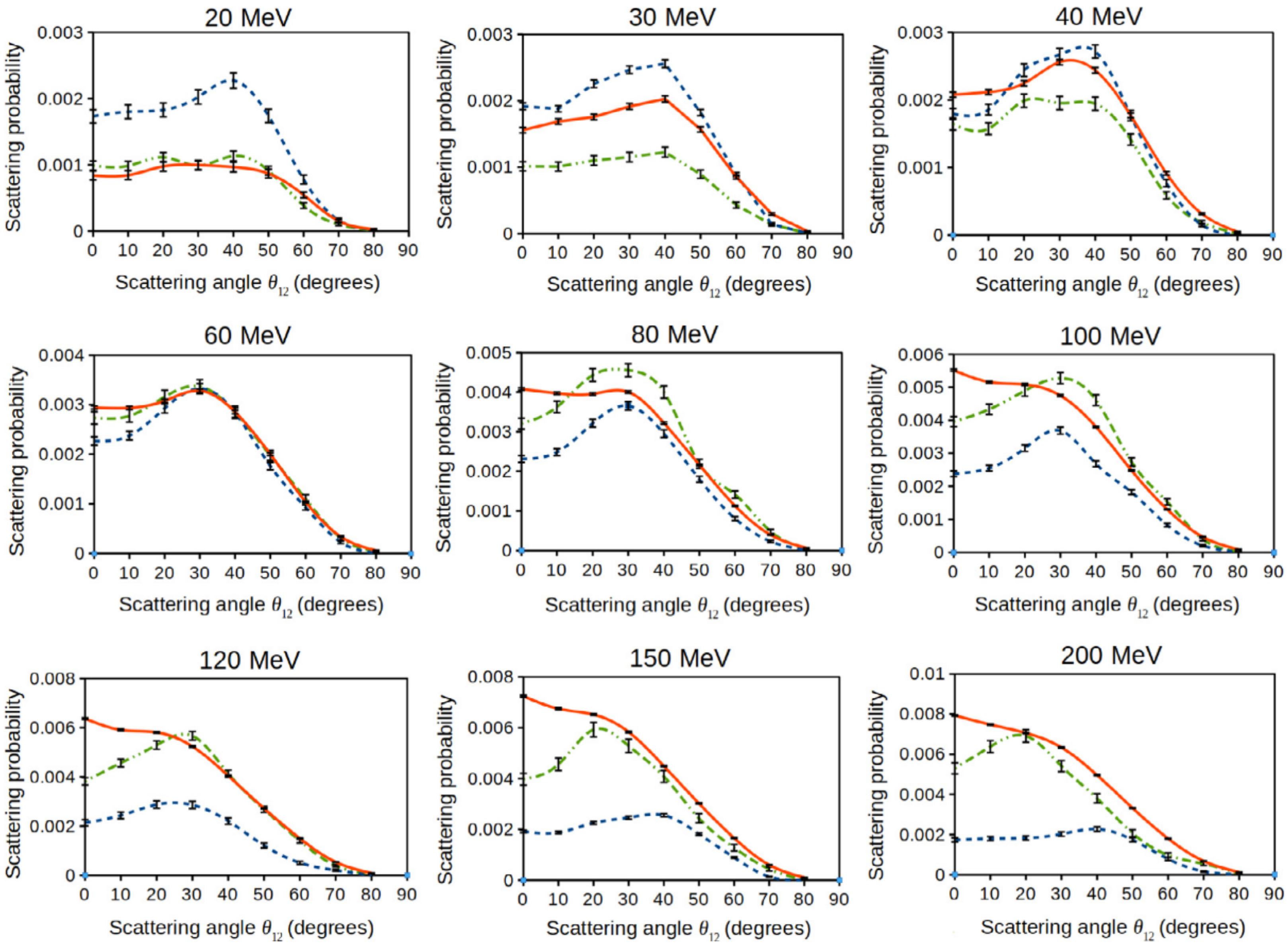
Particle direction constrained to cone surface



Goldsmith, et al. RSI. 87, 083307 (2016).
Bae, et al. Astroparticle Phys., 114 (2020).
https://frib.msu.edu/science/nuclearscience/structure.html

Data needs for fast neutron detection modeling

- In each application, modeling is vital
  - Light response
  - Detection efficiency
  - Multiplicity
  - Threshold
- Two specific areas where data are needed: ***scintillator characteristics and nuclear reaction cross sections***



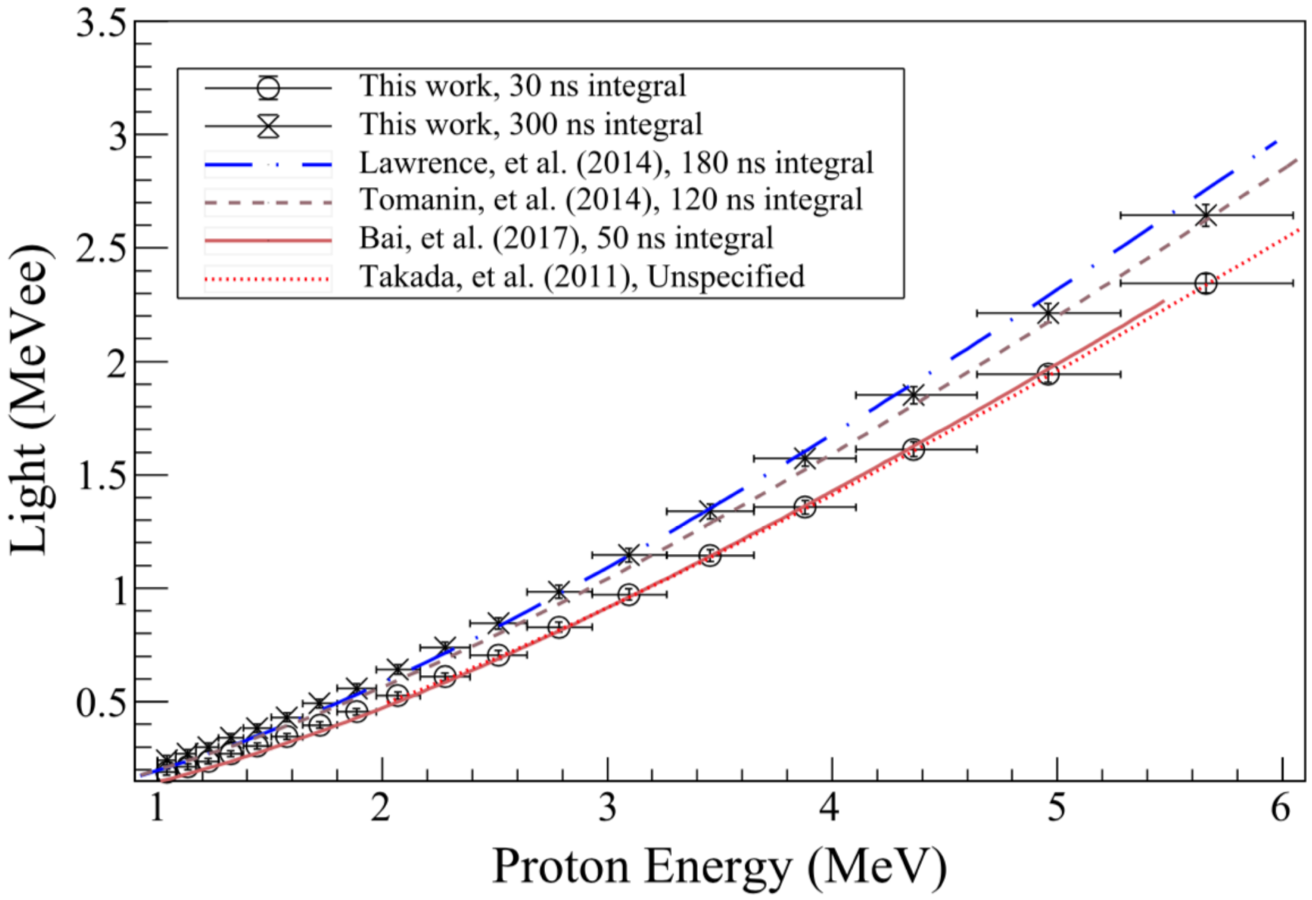
Rogers, et al. NIM A 943 (2019).

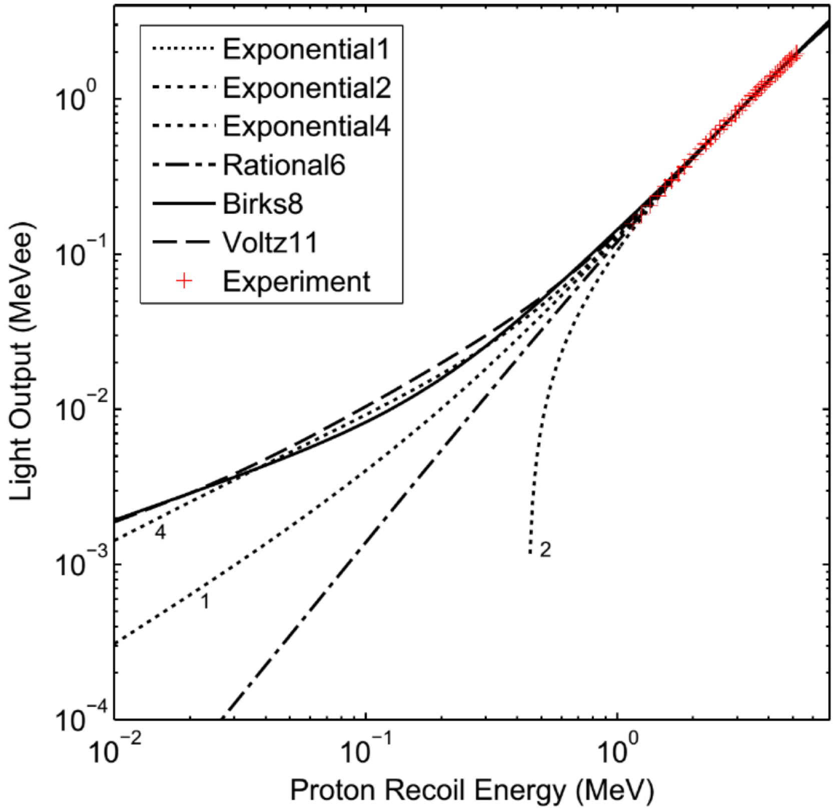
Data need: scintillator characterization

- Neutron detection is indirect, so characteristics of detection medium have impact on detector modeling
  - **Proton light yield**: critical step to translate from detected scintillation light to recoil particle energy
  - **Emission/absorption spectra/light attenuation length**: impacts detection efficiency and threshold behavior
  - **Carbon light yield:** distorts proton light response
- Central evaluated database of organic scintillator characteristics
  - Analogous to scintillator.lbl.gov for inorganic scintillators

Proton light yield

- Literature measurements plagued by inconsistency
- Underlying physics not well understood, especially at low energies: ergo data vital!

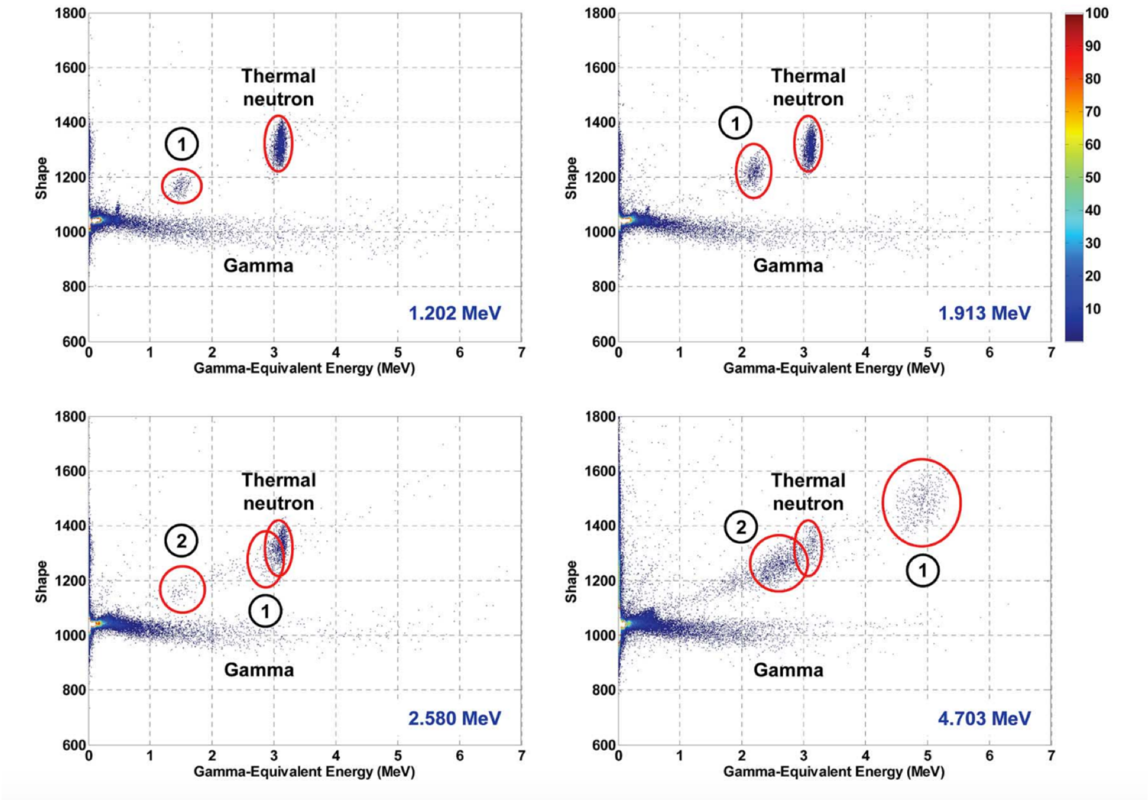




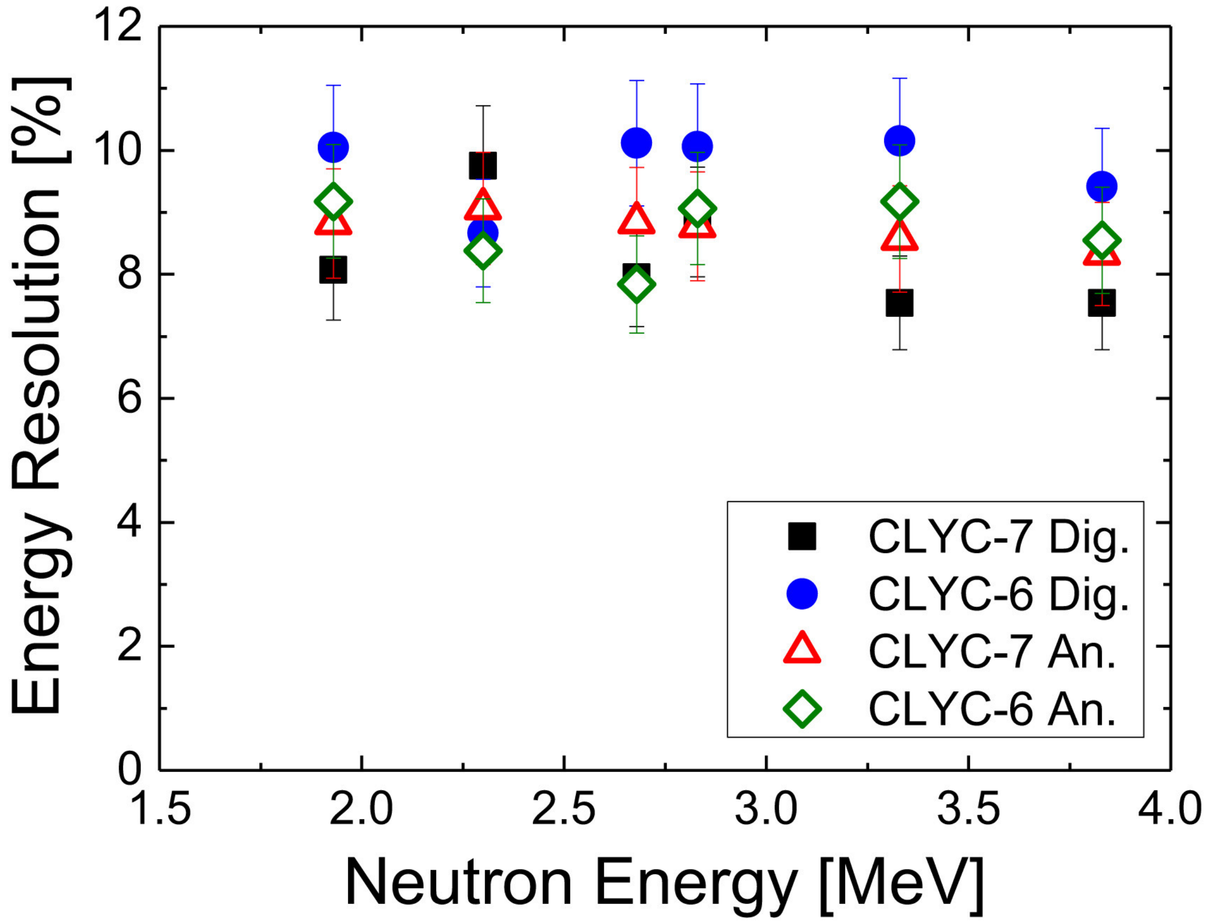
Brown, et al. Journal of Applied Physics 124, 045101 (2018).
Norsworthy, et al. NIM A 842 (2017).

Data need: nuclear reaction data

- For organic scintillators: n + C inelastic scattering at E > 20 MeV, other reaction channels
- For inorganic scintillators: (n,p) and (n,n'γ) as fast neutron detection mechanisms
  - Enables multimodal detection capability for basic physics and national security applications



M. Smith, et al. IEEE TNS 60 (2013).
Norsworthy, et al. NIM A 842 (2017).



Questions?

- Fast neutron detector modeling impacts overall effort to meet nuclear data needs
- Thank you to:
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