Particle emission in the β-decay of ^{8}He

AARHUS
UNIVERSITY
DEPARTMENT OF PHYSICS AND ASTRONOMY

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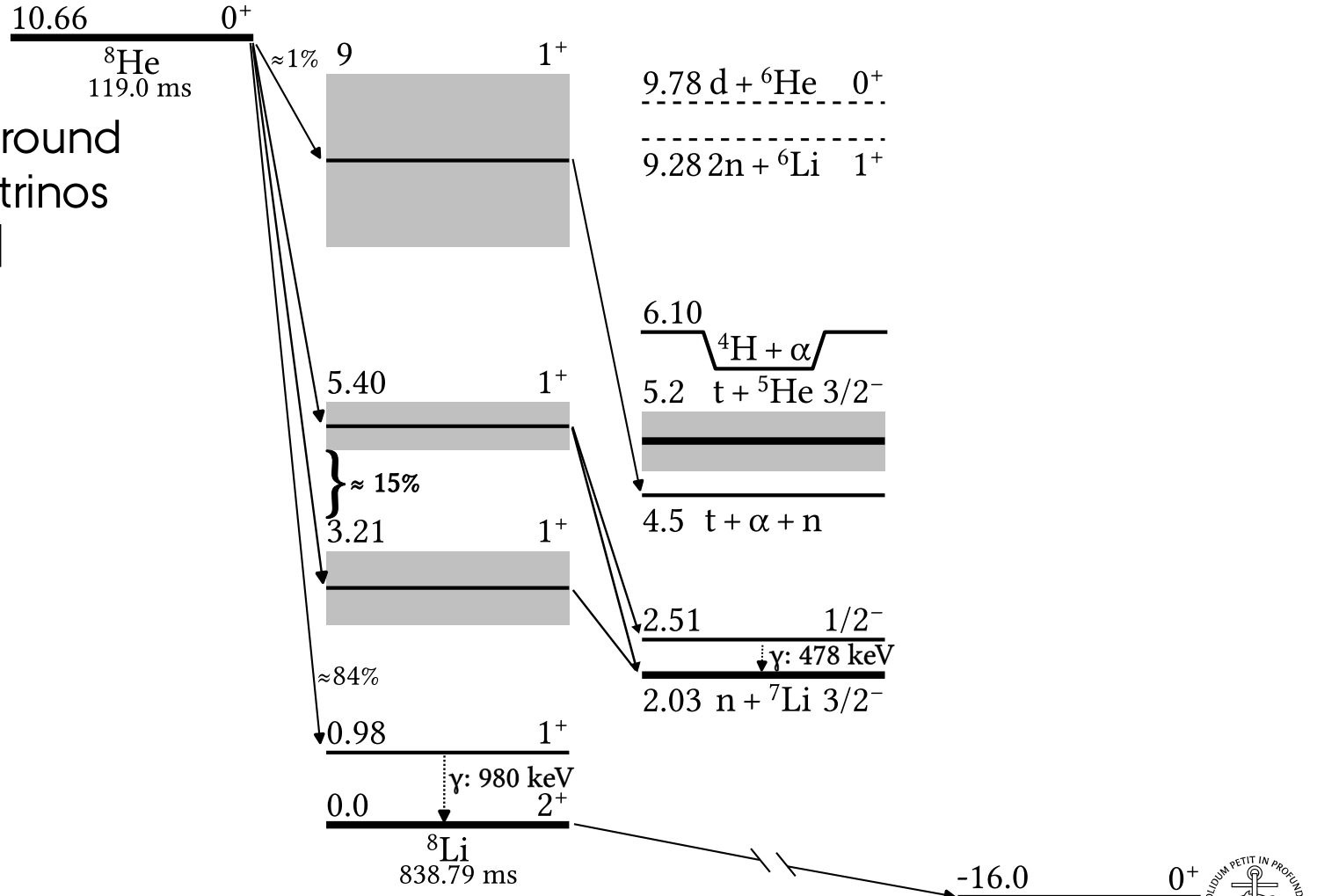
JEPPE SCHULTZ NIELSEN
PHD STUDENT

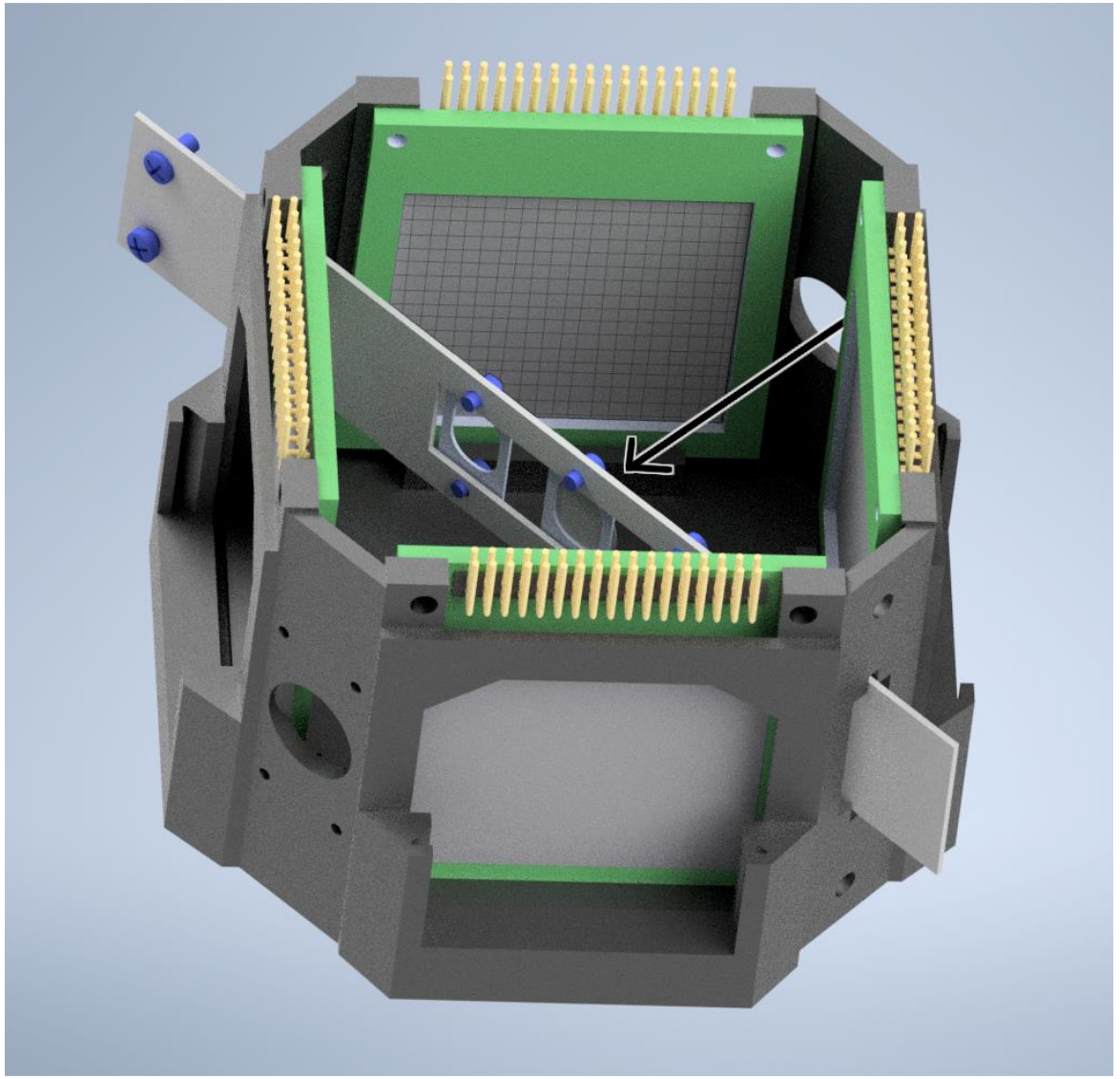
MOTIVATION AND PHYSICS

- ^{8}He and ^{9}Li cosmogenic background significant in detecting antineutrinos by inverse β-decay reaction [1]
  - $\bar{\nu}_e + p \rightarrow e^+ + n$
  - $^{8}He \rightarrow {}^{7}Li + \bar{\nu}_e + e^- + n$
- Small quantum systems
  - Three body decay
- Earlier measurements
  - T. Björnstad [2]
  - M. J. G. Borge [3, 4]
  - Z. Janas (unpublished)



EXPERIMENTAL SETUP

- ^{8}He beam @40 keV produced at ISOLDE and collected in carbon foil
- 4 double sided silicon strip detectors
  - Alphas, tritons, ^{7}Li



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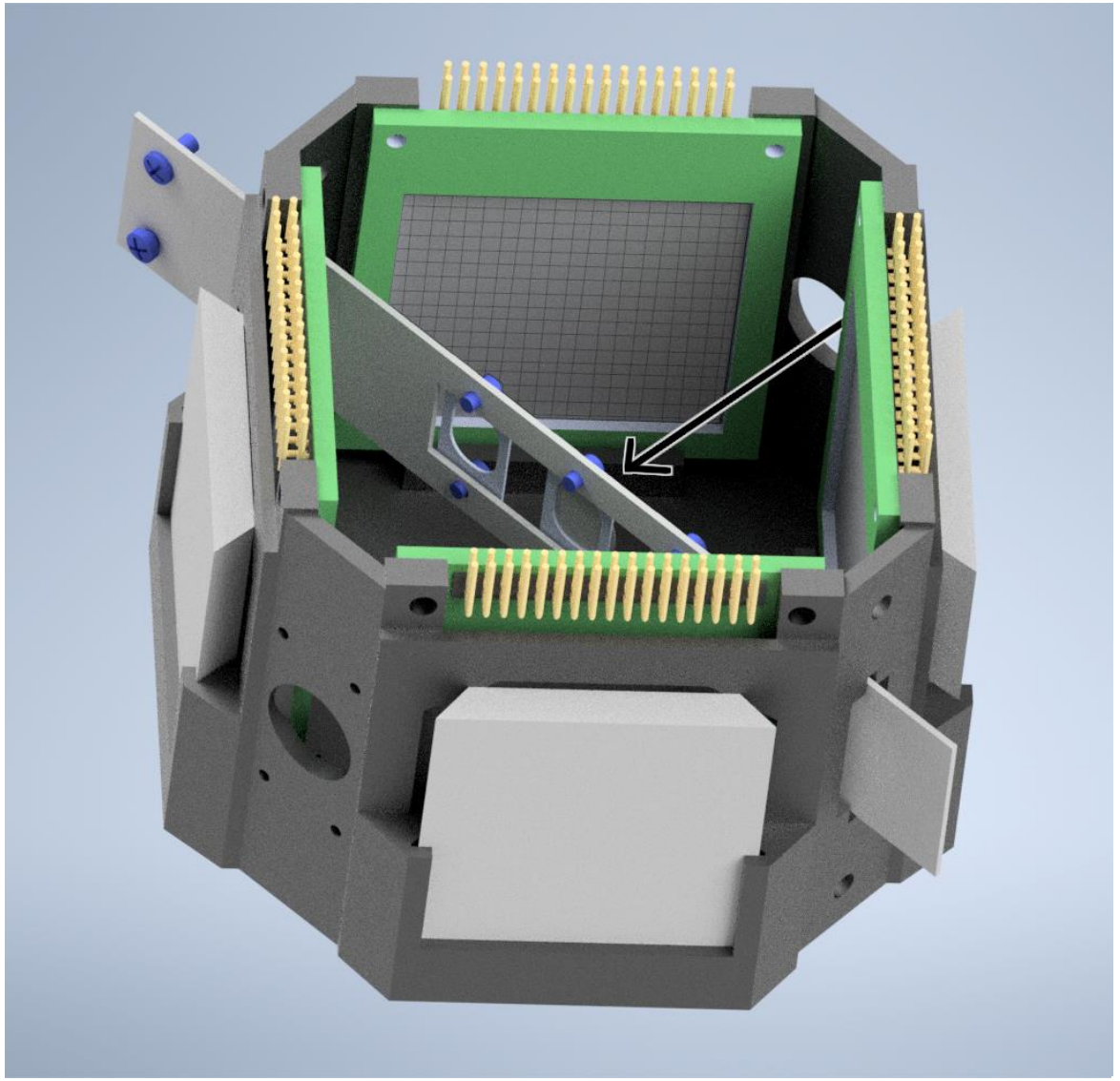

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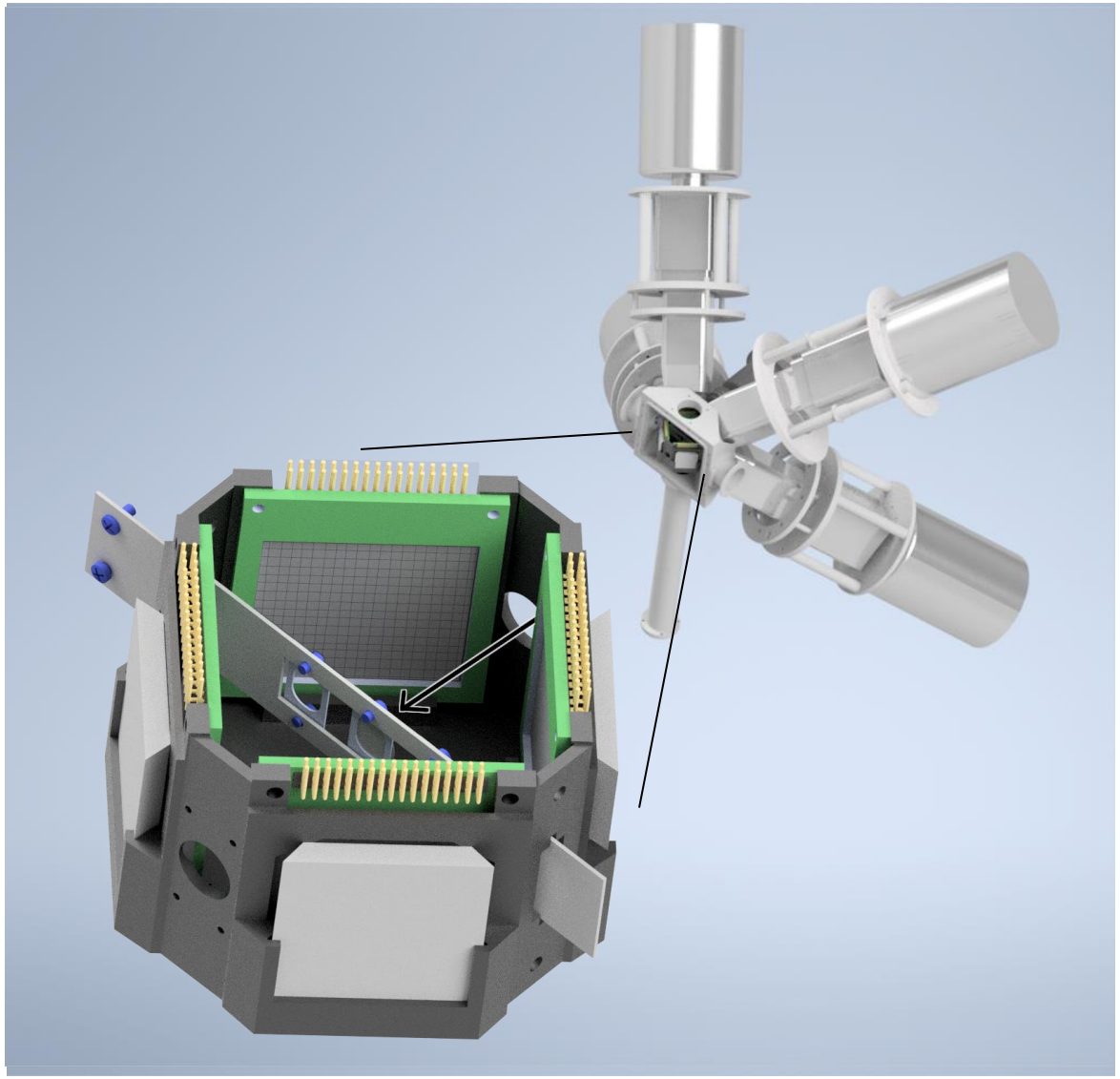

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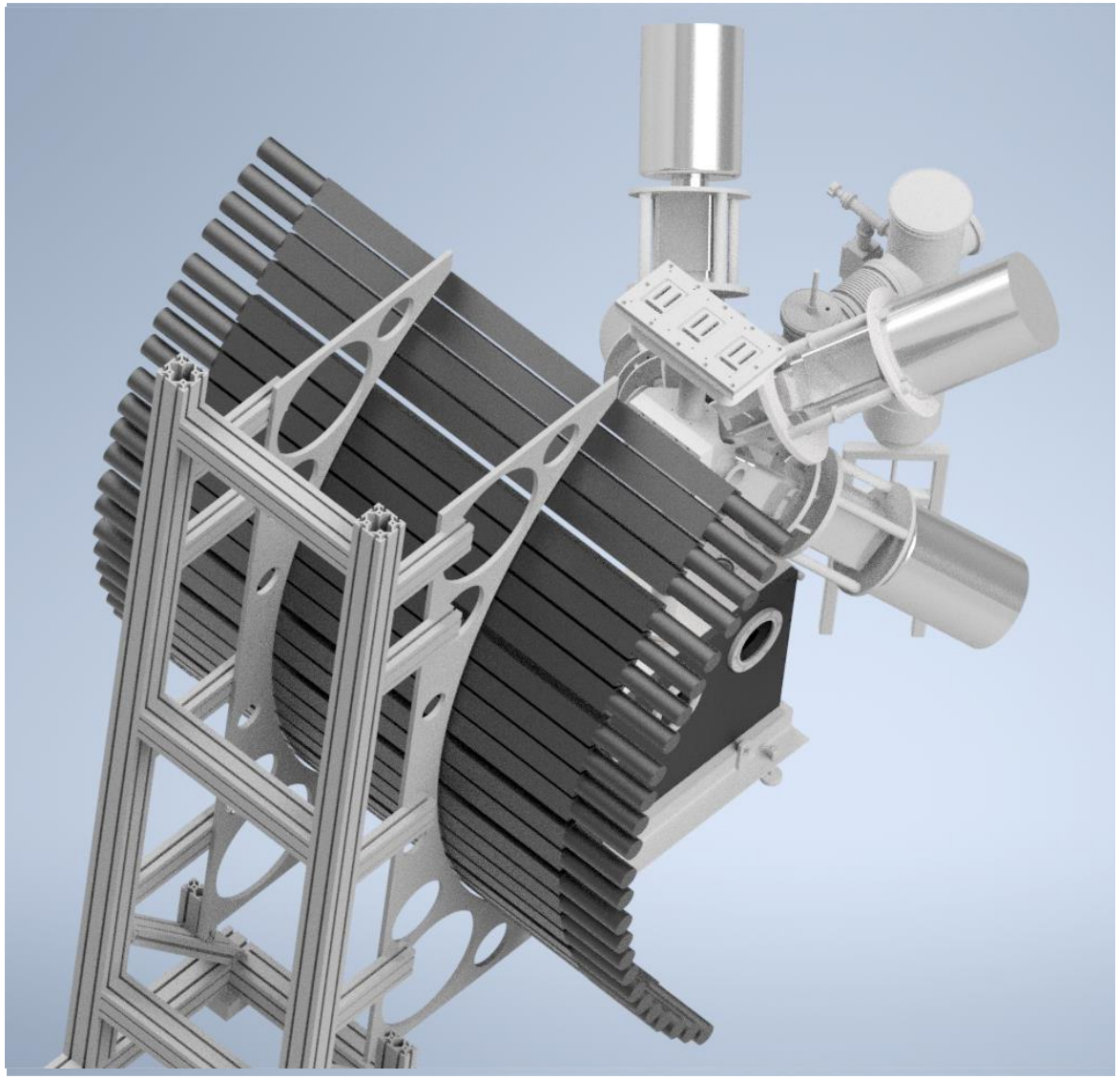
- 20 INDIE scintillator bars for TOF stop
  - Neutrons



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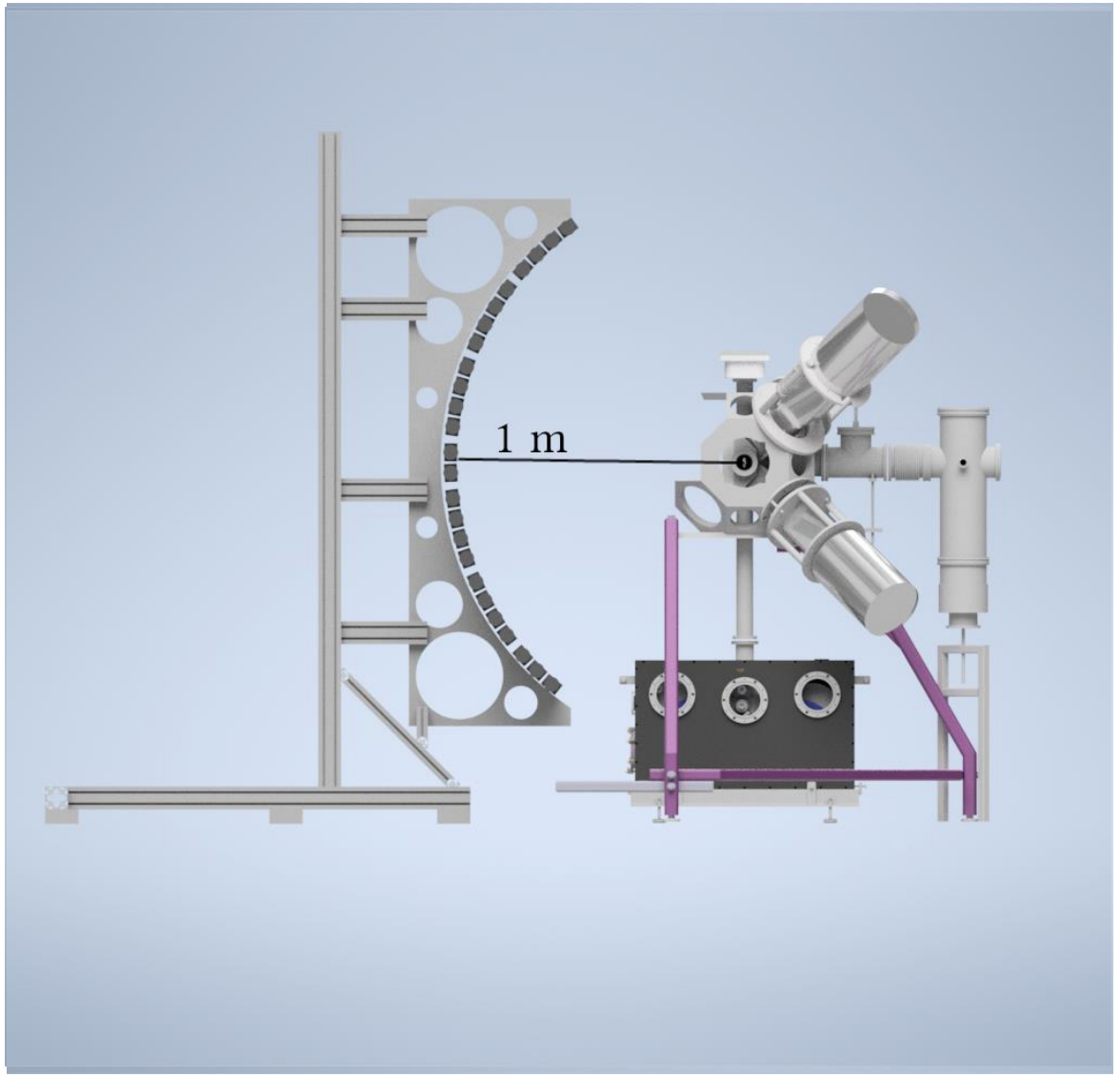
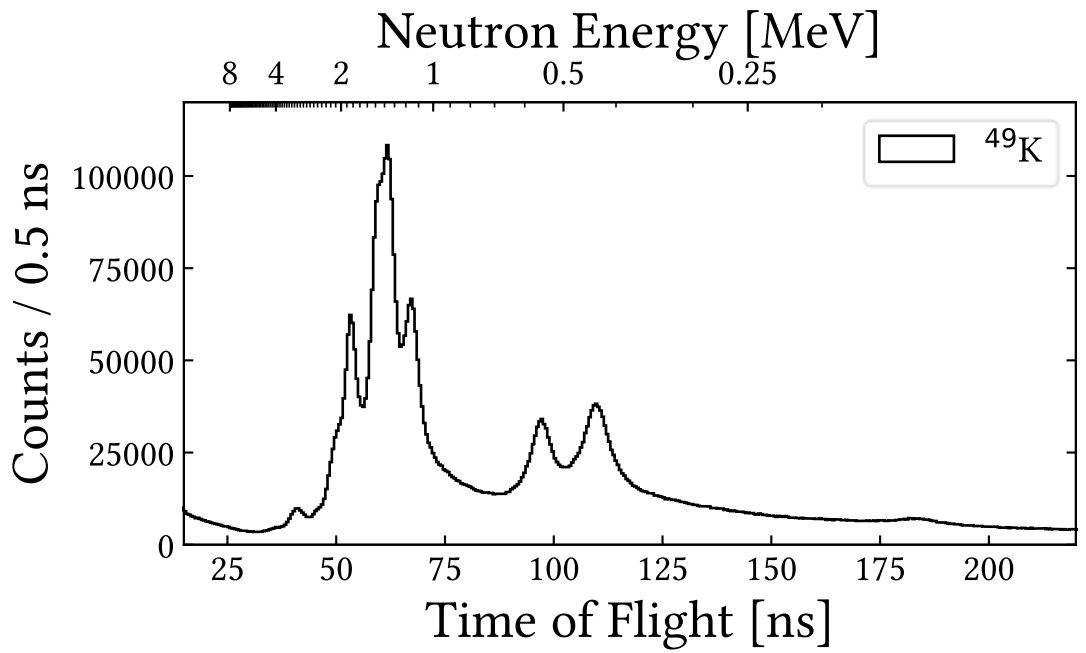
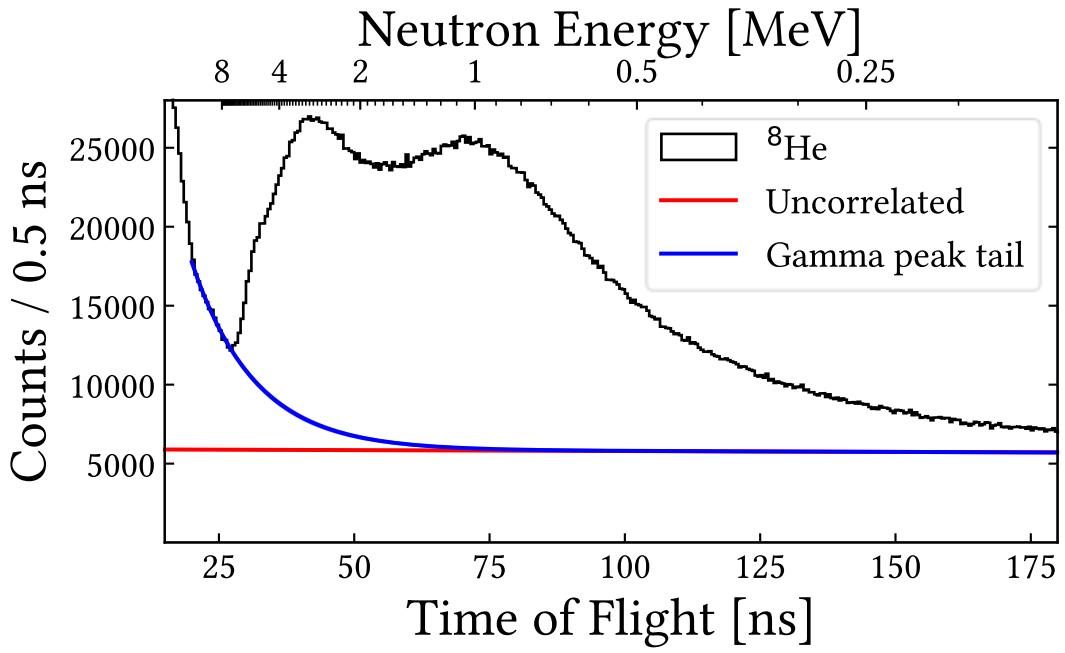


NEUTRON TIME-OF-FLIGHT SPECTRUM

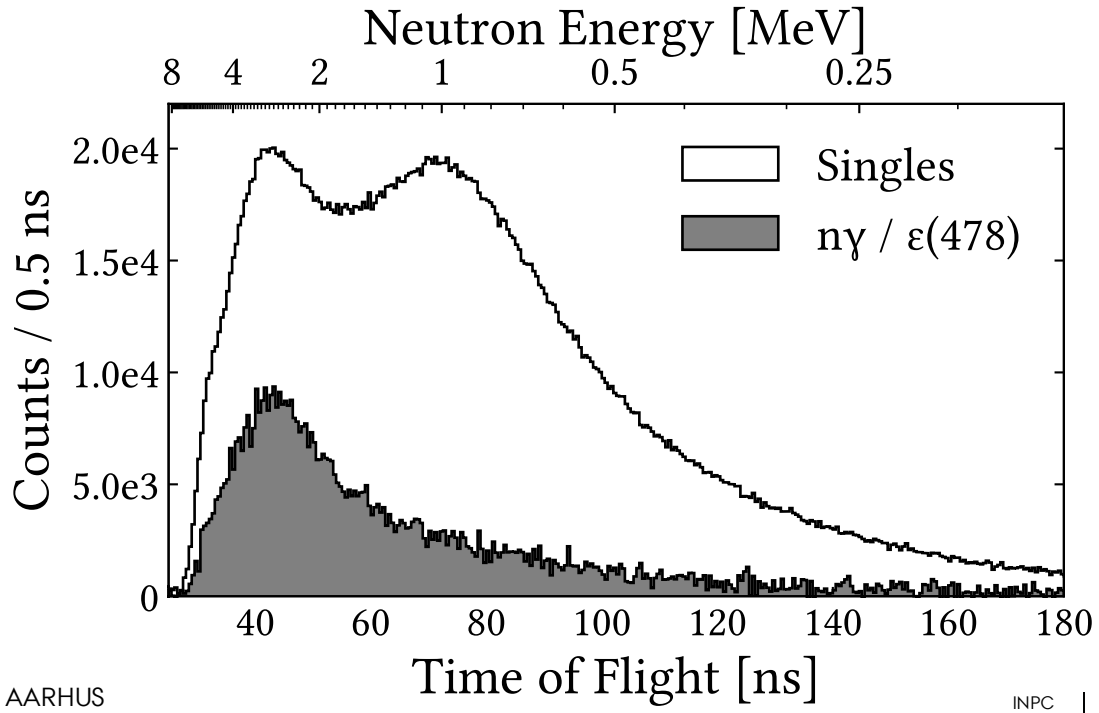
- Timing algorithms: DCFD [5] for SiPMs, polyCFD [6] for INDiE
- Low n-branching ratio gives signal/background-ratio challenges



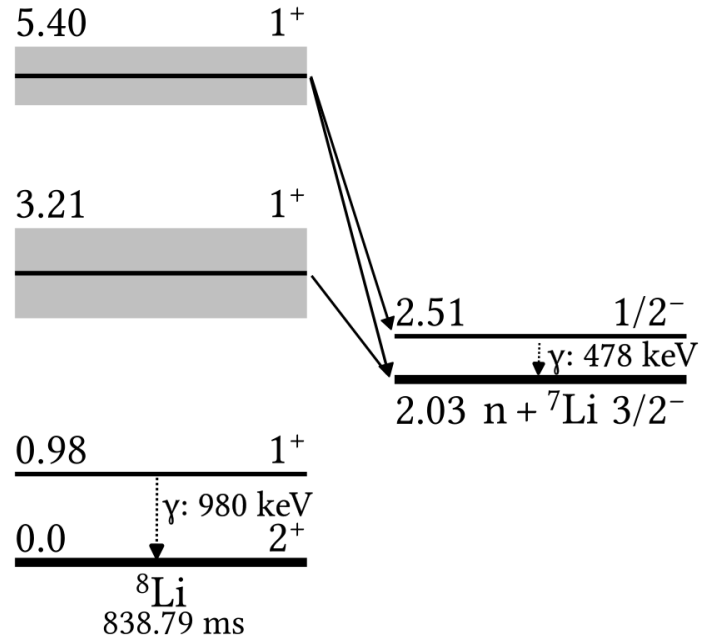


NEUTRON-GAMMA COINCIDENCES

- ^{7}Li 1st excited state (1/2- 478 keV) also populated
- N(478)/N(980)=6.5(1)%
- Assuming BR(980)=84(1)%, we get BR(nγ)≈5.5(1)%

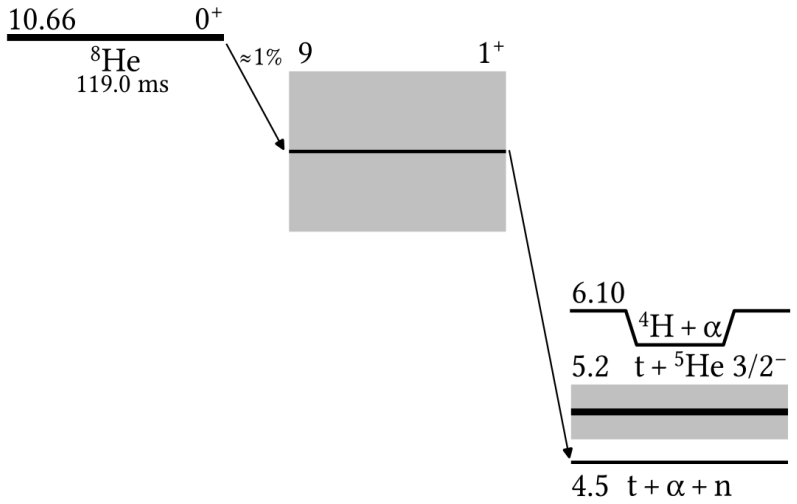


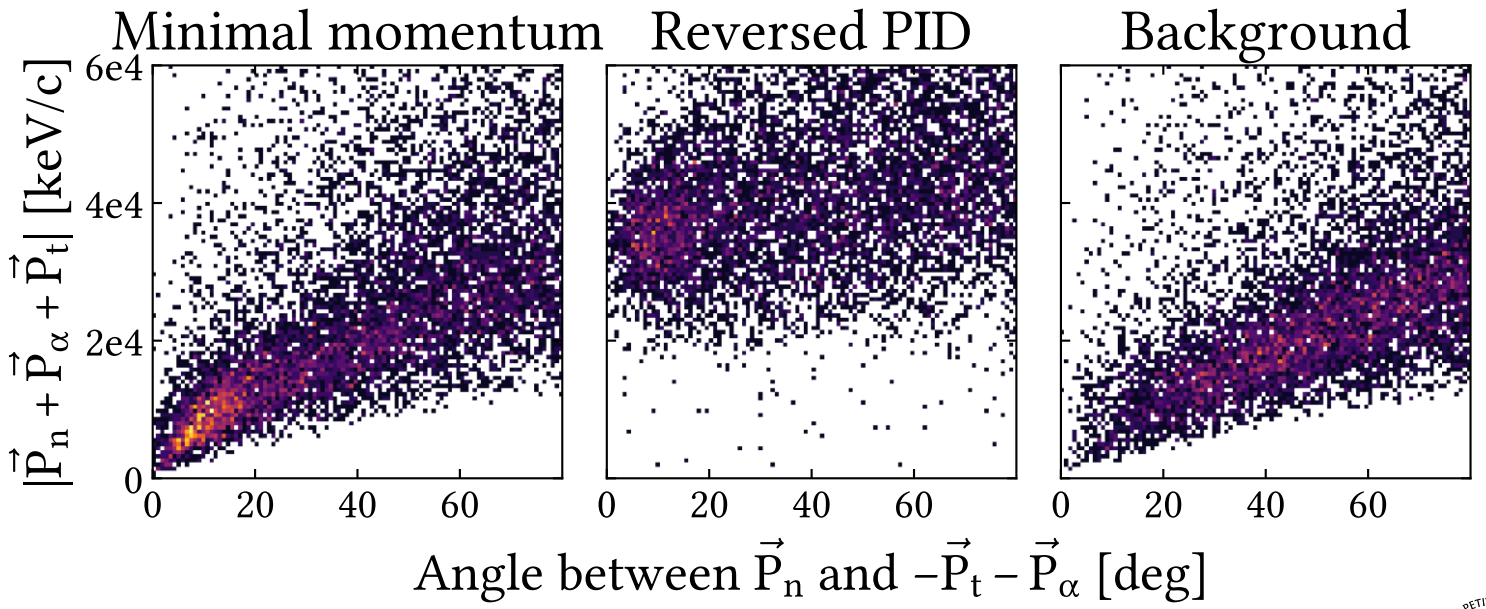
Effeciency at 478 keV: 5.71(8)%



THREE BODY BREAKUP IDENTIFICATION

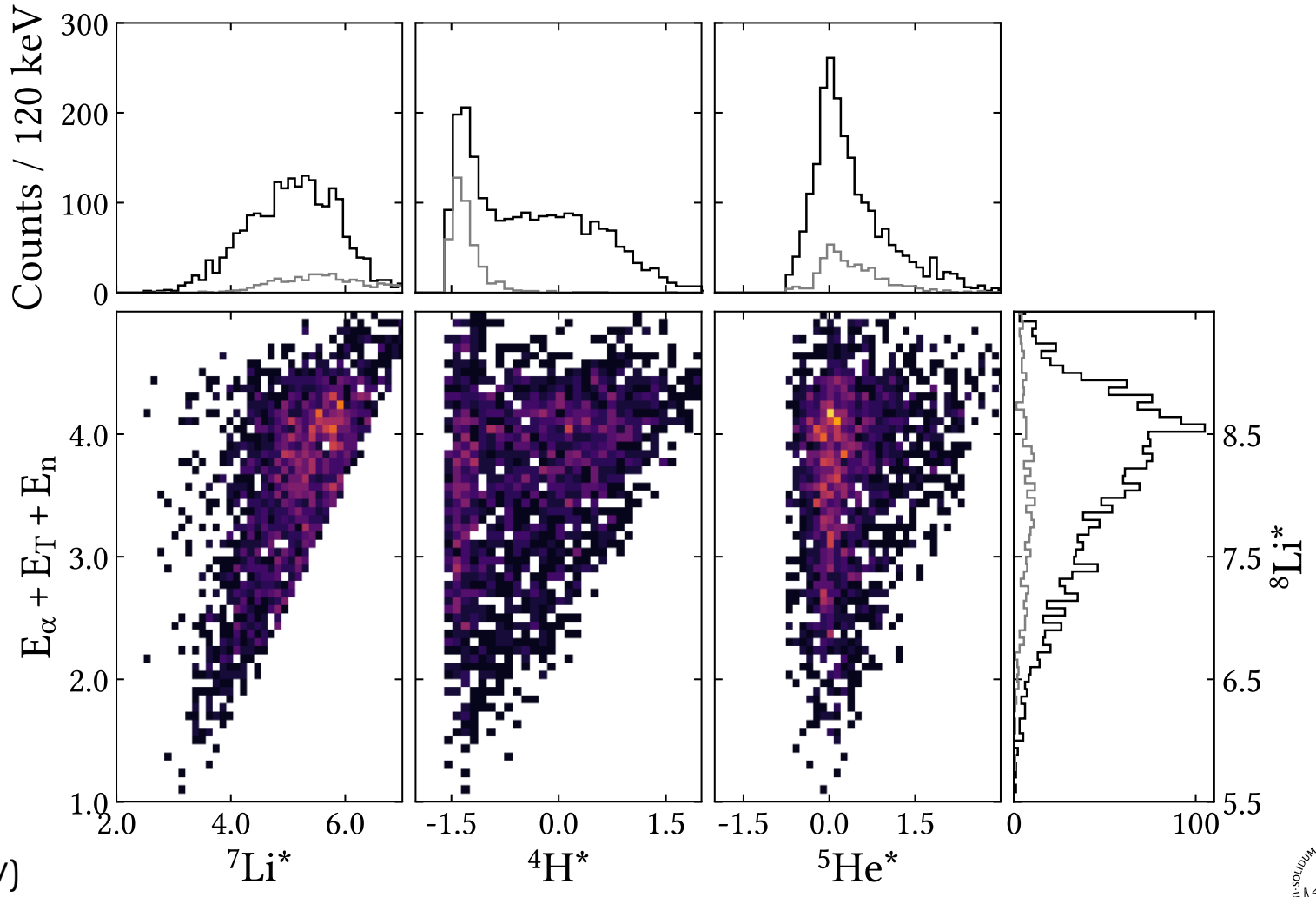
- Energy too low for dE-E particle identification with DSSDs
- For events with two DSSD hits and a neutron, do PID such that sum momentum is minimal
- Very significant background from ^{8}Li → 2α





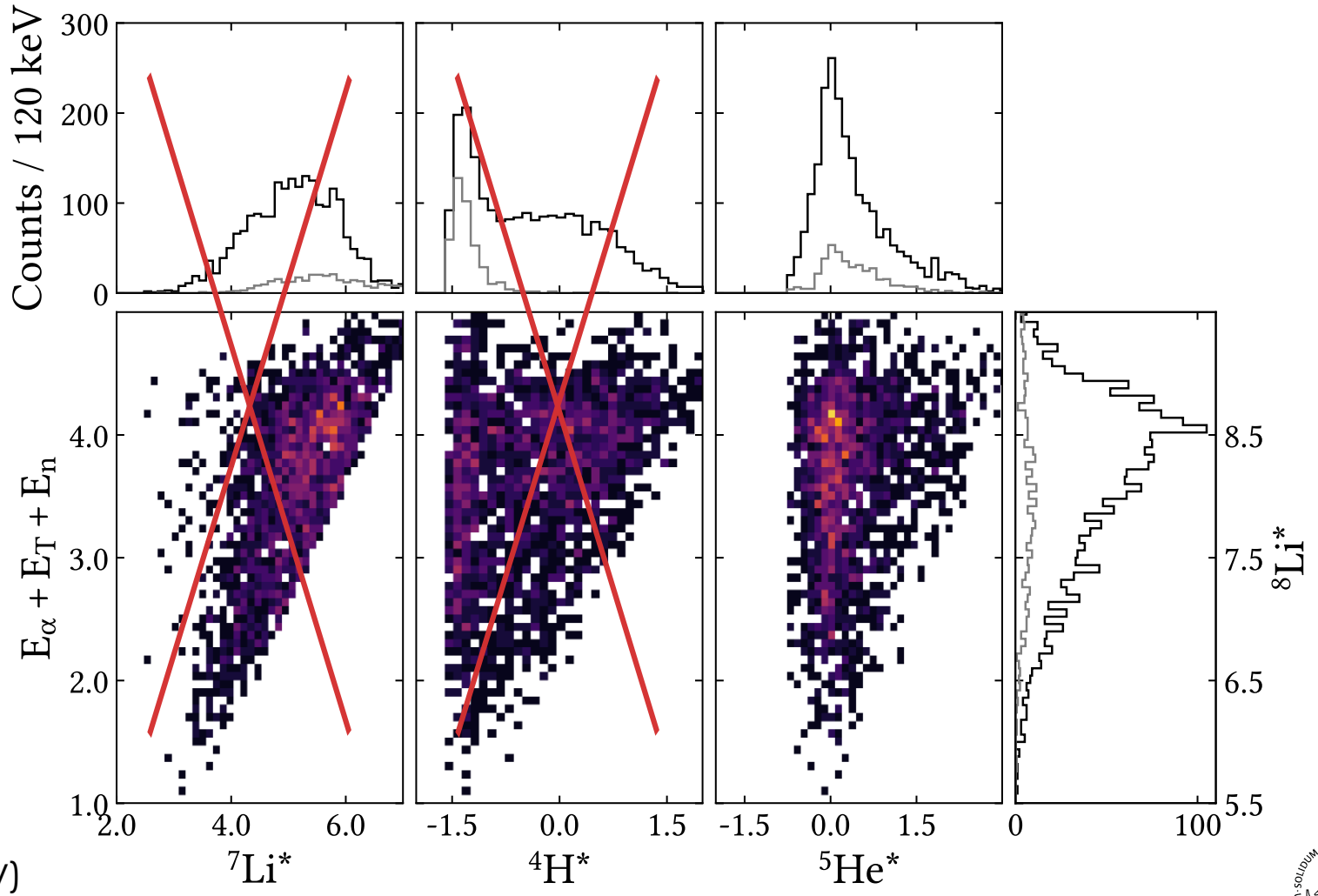
THREE BODY BREAKUP SPECTRA

- Analyze decay as sequential through different resonances
- Excitation in ^{8}Li vs excitation in resonance



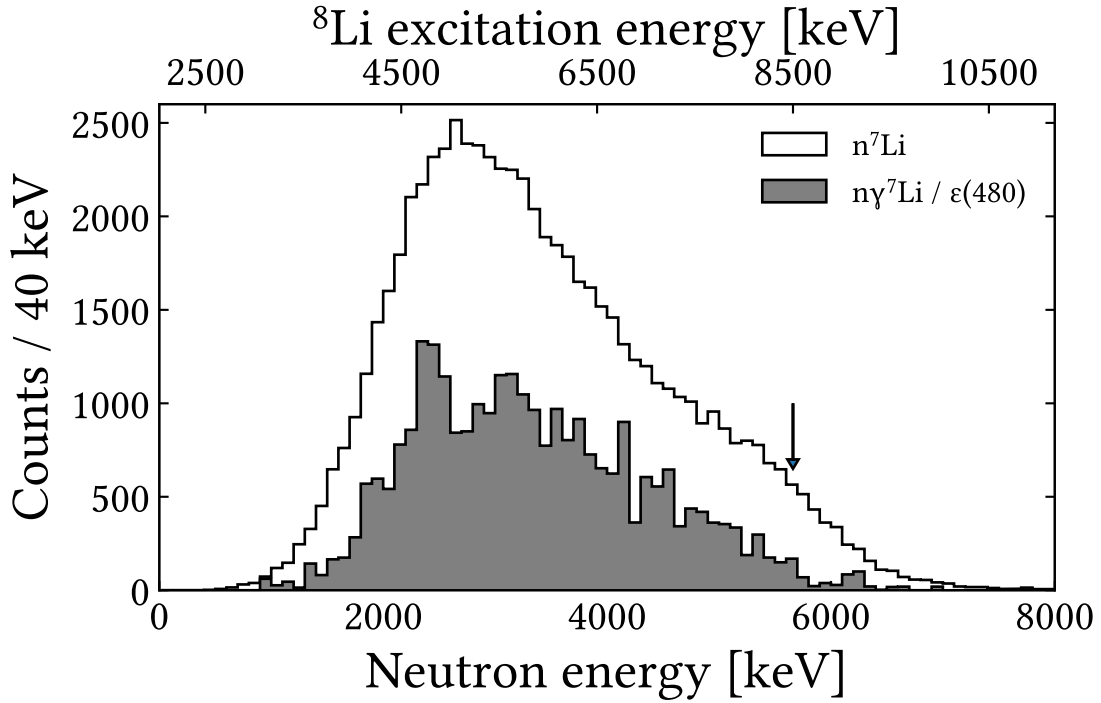
THREE BODY BREAKUP SPECTRA

- Analyze decay as sequential through different resonances
- Excitation in ^{8}Li vs excitation in resonance
- Qualitatively, only ^{5}He has structure
- Simulation will clear up



EMISSION OF HIGH ENERGY NEUTRONS

- Gate on 7Li with momentum conservation
- State also seems to decay with neutron emission



OUTLOOK

- Still work to be done determining response and acceptance of the setup
- Upper limit on 2n-branch
- R-matrix fit
- Thanks to IS659 collaborators and thank you for listening!

[1] Liangjian Wen et al. "Measuring cosmogenic 9Li background in a reactor neutrino experiment". Nucl. Instrum. Methods Phys. Res. 564.1 (Aug. 2006)
[2] T. Björnstad et al. “The decay of 8He”. Nuclear Physics A 366.3 (1981)
[3] M. J. G. Borge et al. “Beta-delayed triton emission in the decay of 8He", Nuclear Physics A 460.3 (1986)
[4] M. J. G. Borge et al. “Study of charged particles emitted in the -decay of 6,8He”. Nuclear Physics A 560.2 (1993)
[5] XIA LLC "Pixie-16 User Manual version 3.04" (January 2019)
[6] C. R. Thornsberry "Proton Transfer Reactions Studied Using the Versatile Array of Neutron Detectors at Low Energy (VANDLE)". Ph.D. thesis, University of Tennessee (2018)

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