

# THE BETA-DECAY OF $^8\text{He}$

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6 May 2026

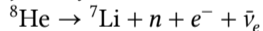
# MOTIVATION

- Antineutrino detectors

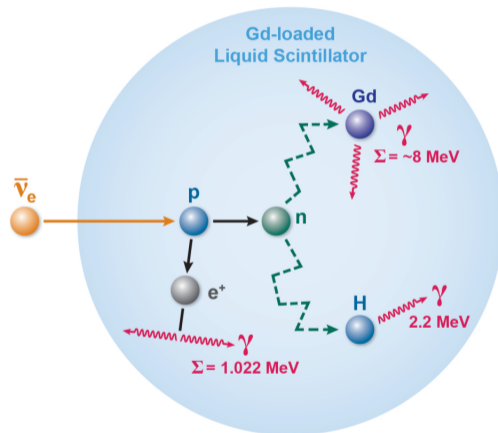
- ▶ Inverse  $\beta$ -decay reaction:

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

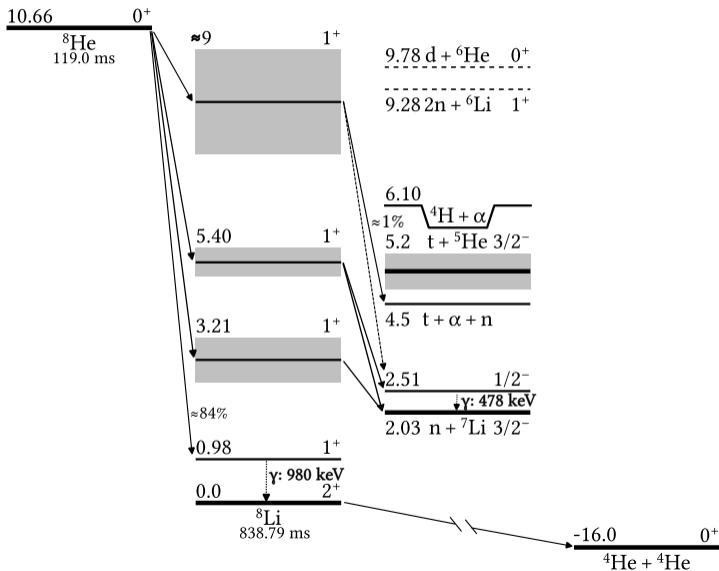
- ▶  $\beta$ -delayed neutron emission:



- Few-body interactions

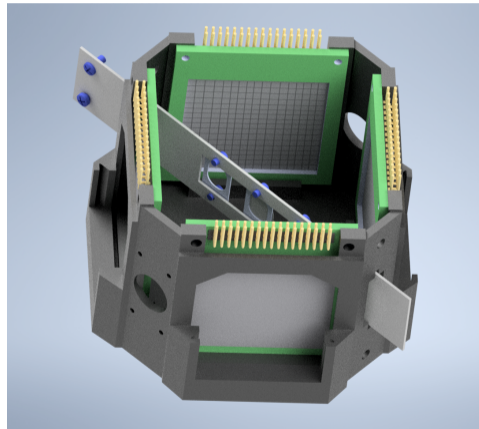


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${}^8\text{He}$ 

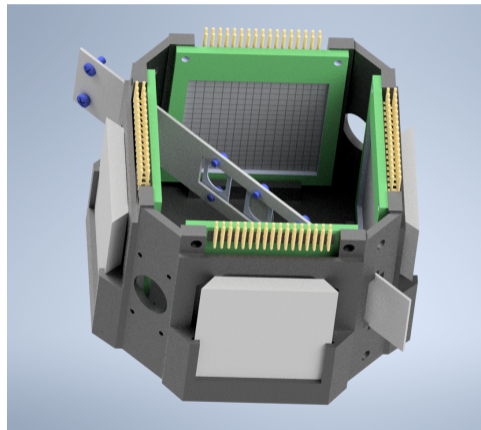
# SETUP

- 4 DSSDs
  - ▶ Heavy charged particles



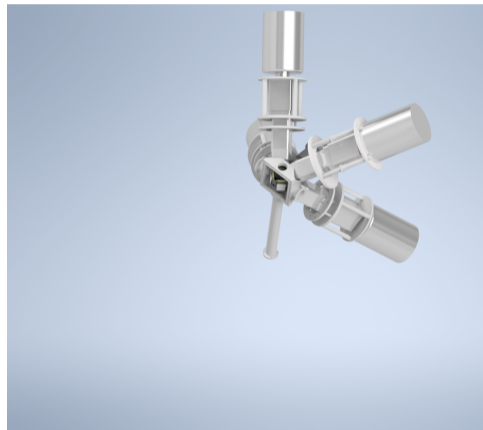
# SETUP

- 4 DSSDs
  - ▶ Heavy charged particles
- 4 plastic scintillators with SiPMs
  - ▶ Betas (neutron TOF start)



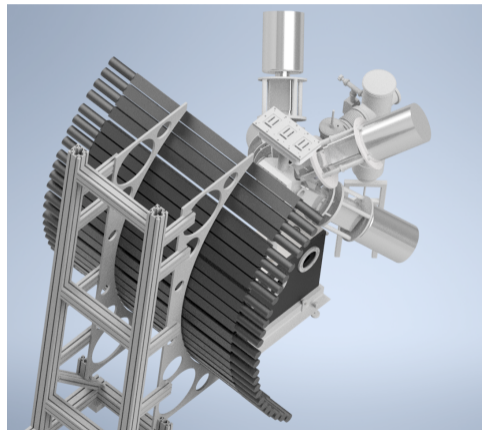
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- 4 DSSDs
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- 4 IDS HPGe Clover detectors
  - ▶ Gammas



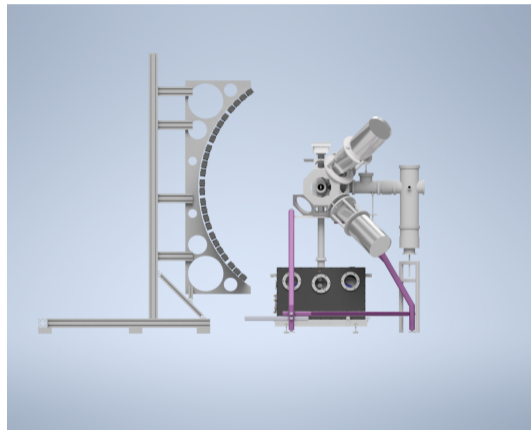
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- 20 INDiE scintillator bars
  - ▶ Neutron TOF stop

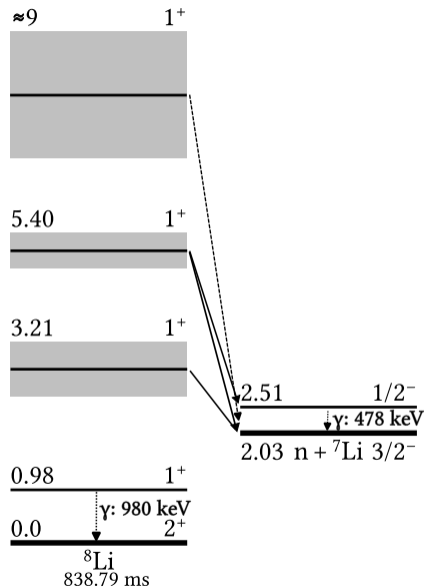
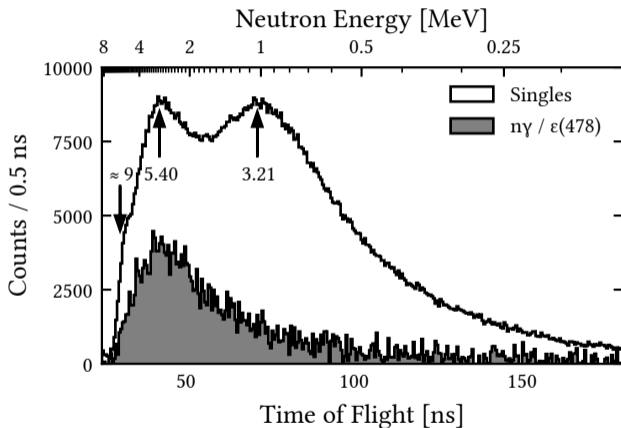


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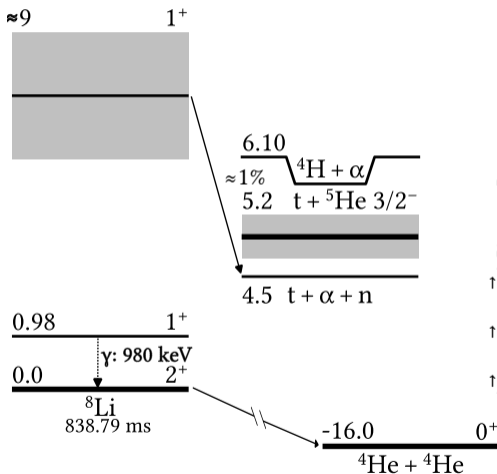
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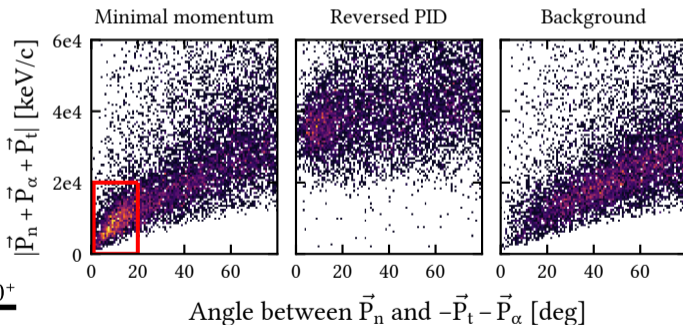
## NEUTRON TOF SPECTRA



# THREE-BODY BREAKUP PARTICLE IDENTIFICATION

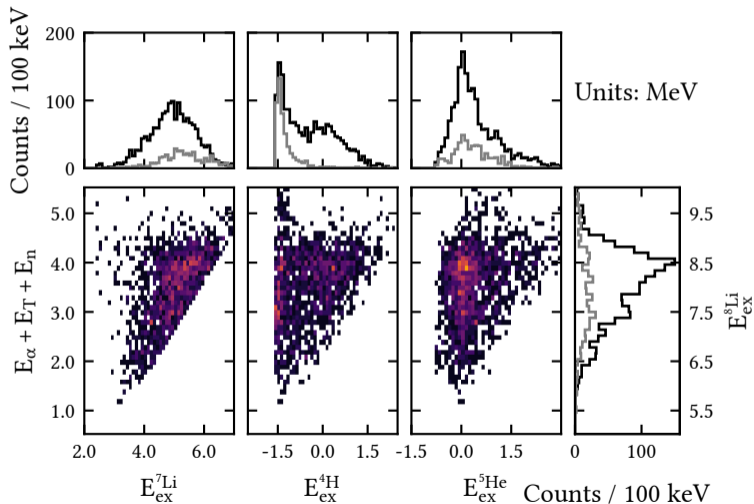


- Particle ID through momentum conservation
- Significant background from  $\alpha + \alpha + x$

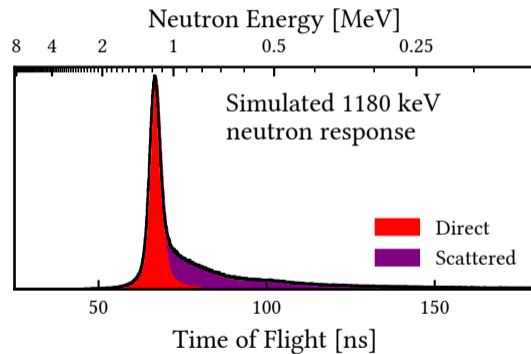
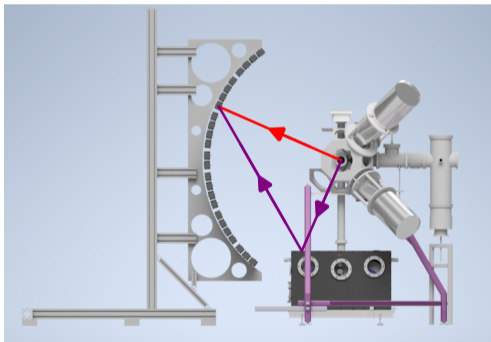


# THREE-BODY BREAKUP

- Decay mechanism?

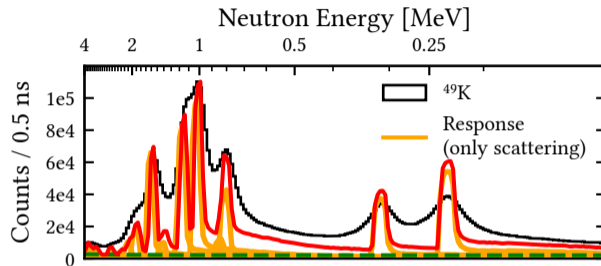


# NEUTRON SCATTERING



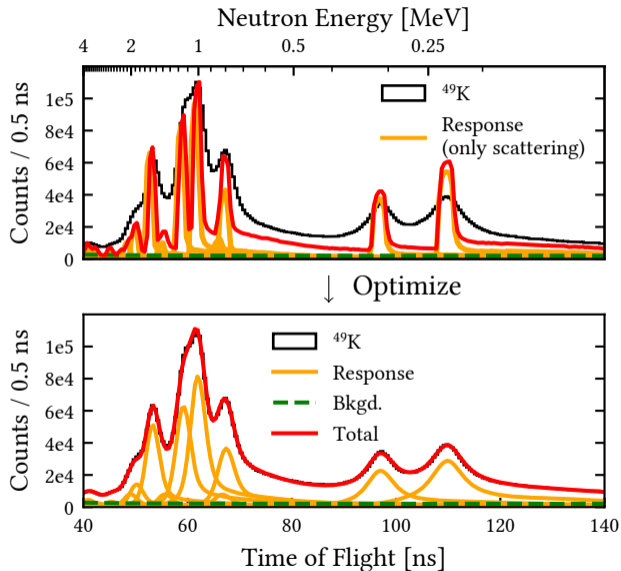
# NEUTRON RESPONSE

- Simulate scattering using GEANT4



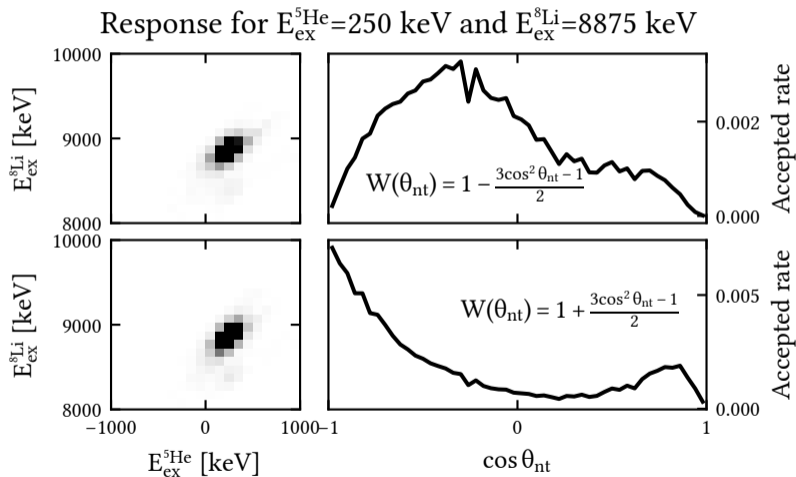
# NEUTRON RESPONSE

- Simulate scattering using GEANT4
- Optimize simulation parameters using  $^{49}\text{K}$  measurement: ADC thresholds, timing resolution...

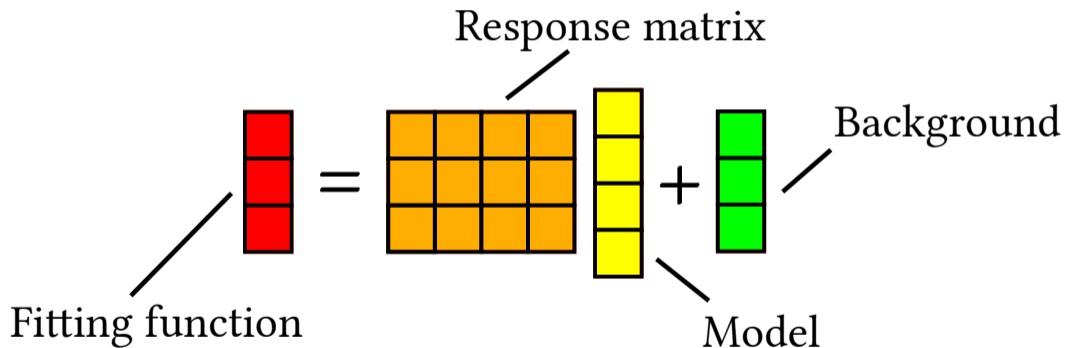


## THREE-BODY BREAKUP RESPONSE

- Kinematics constrained by  $E_{8\text{Li}}$ ,  $E_{5\text{He}}$  and  $\theta_{\text{nt}}$
- Simulate with  $W(\theta_{\text{nt}}) = 1 \pm \frac{3 \cos^2 \theta_{\text{nt}} - 1}{2}$



## FOLDING



# THREE-BODY R-MATRIX

- R-matrix theory assumes two-particle final states

$$w_c(E) = C^2 f_\beta P_c(E) \left| \sum_{\lambda\mu} g_{\lambda GT} \gamma_{\mu c} A_{\lambda\mu} \right|^2 \quad (1)$$

$$(A^{-1})_{\lambda\mu} = (E_\lambda - E) \delta_{\lambda\mu} - \sum_c [S_c(E) - B_c + iP_c(E)] \gamma_{\lambda c} \gamma_{\mu c} \quad (2)$$

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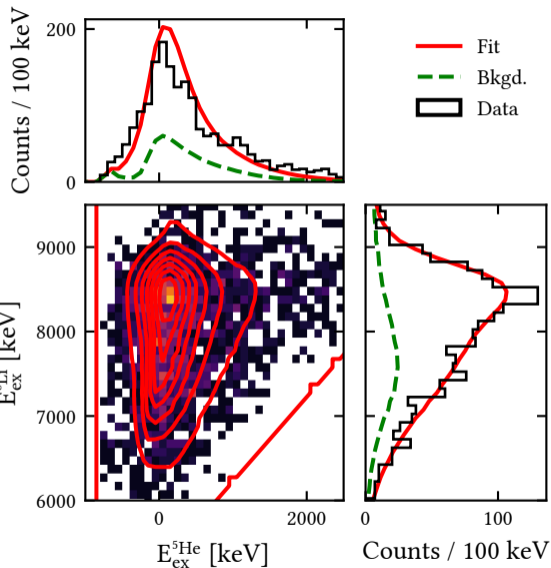
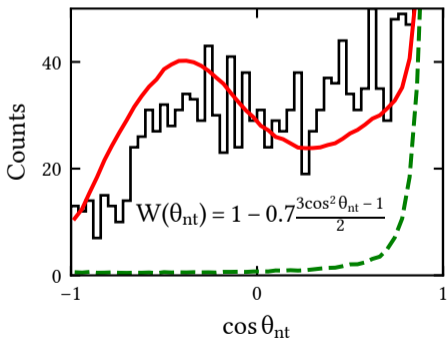
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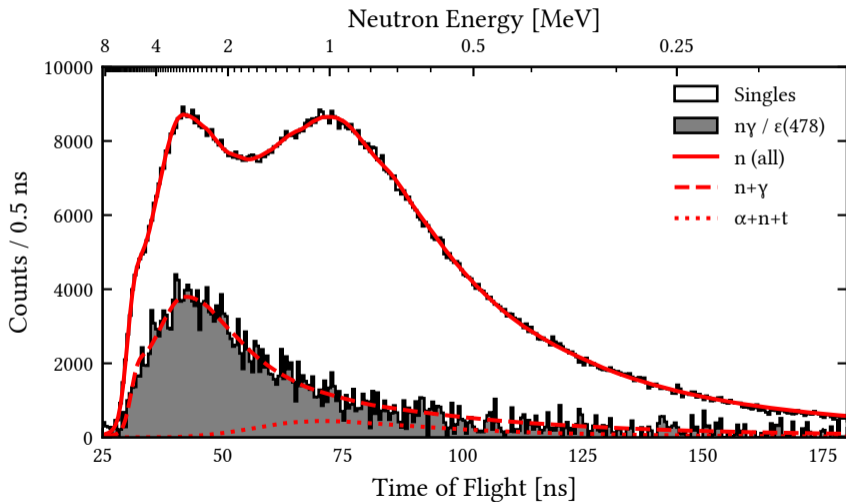
- Model  ${}^5\text{He}$  as a continuous spectrum of long lived states

$$\gamma_{\mu c} \rightarrow \gamma_{\mu c} \rho(E') \quad \sum_c \rightarrow \sum_c \int dE'$$

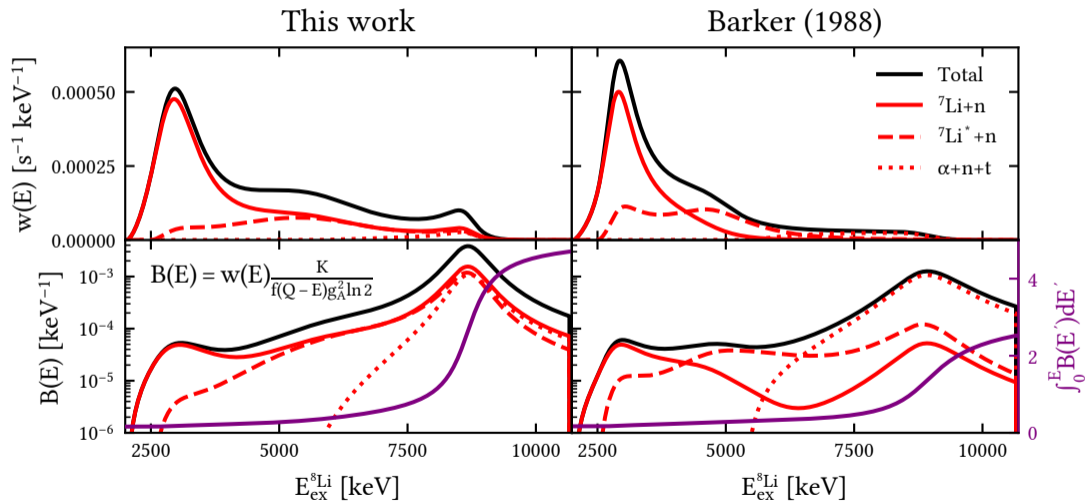
## R-MATRIX FIT: THREE-BODY



## R-MATRIX FIT: NEUTRONS



## BETA STRENGTH



# CONCLUSION

- Experiment sensitive to every branch in  $^8\text{He}$
- Simulate detector response
- R-matrix fit

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