OAK RIDGE National Laboratory

Detector Modeling for Associated Particle Imaging

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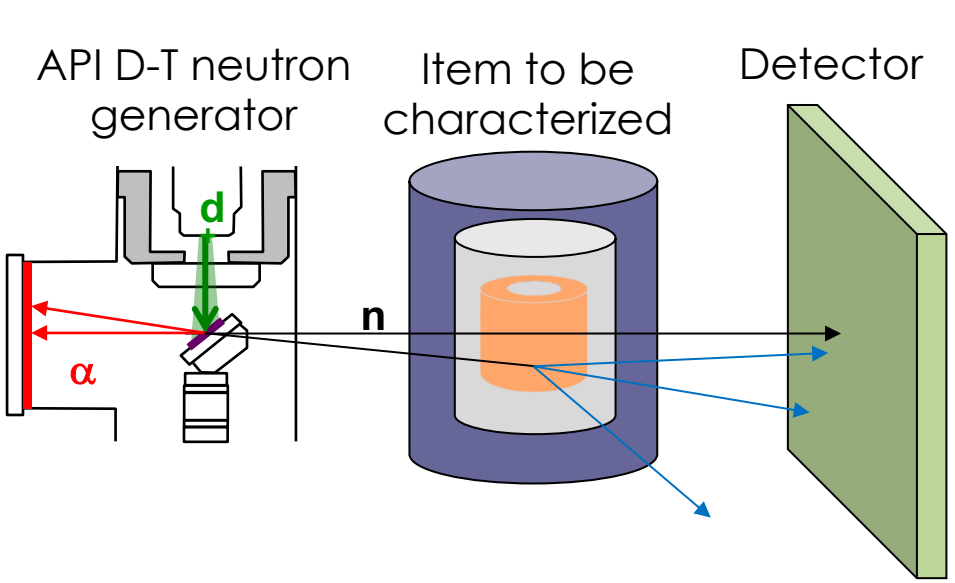
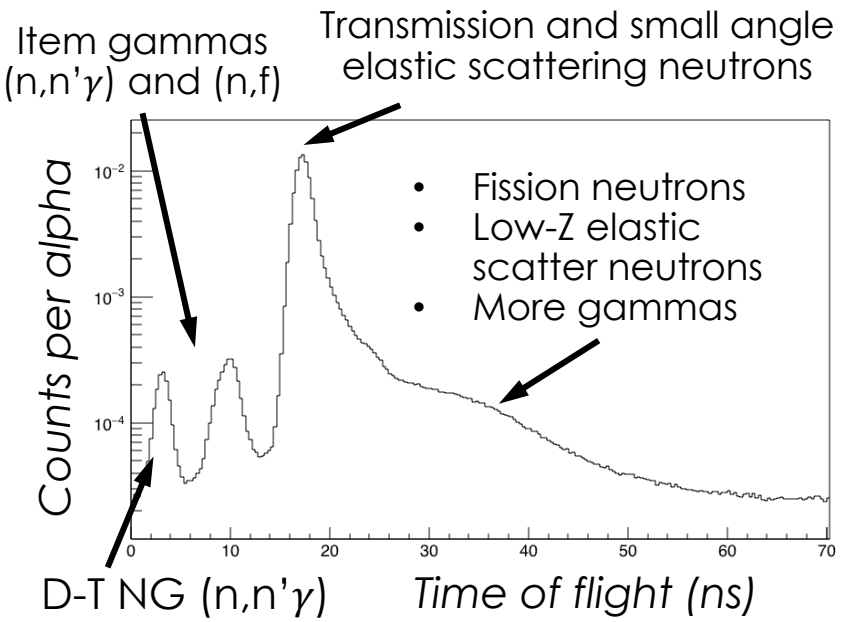
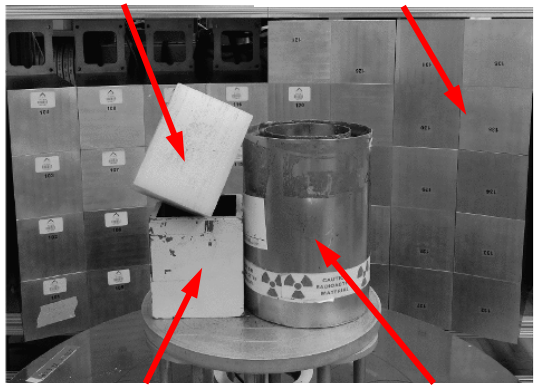
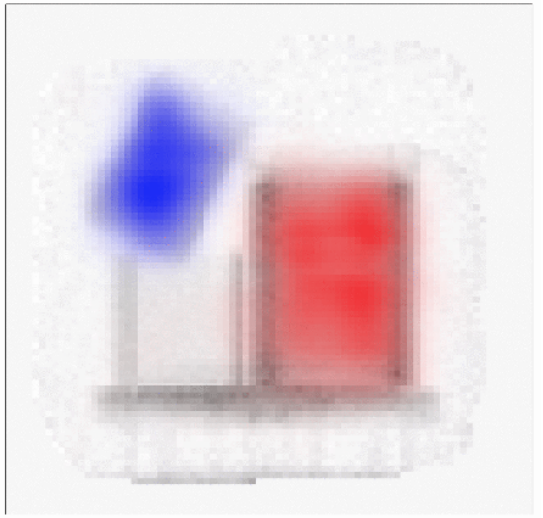
Associated Particle Imaging



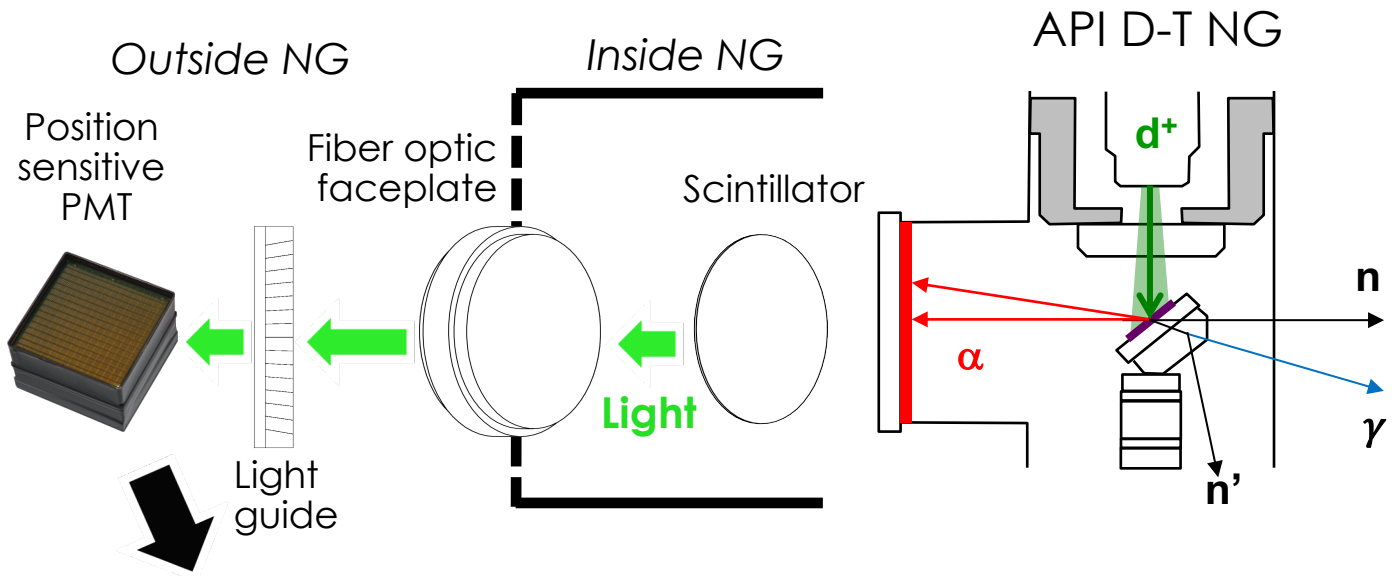






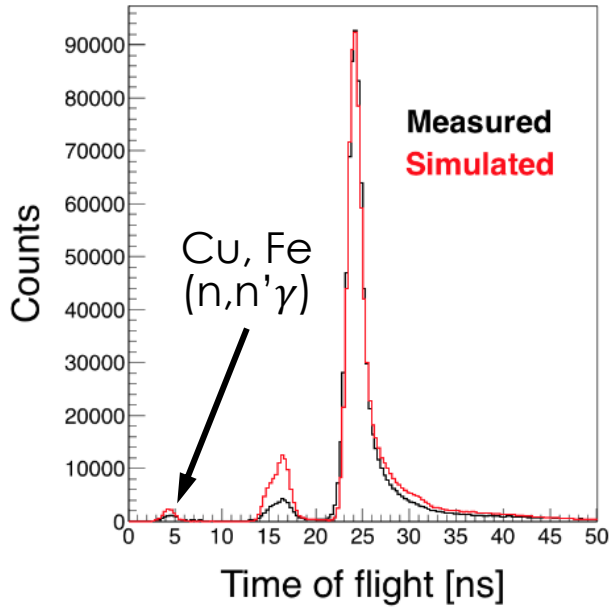
- Source neutron emission time and direction identified with alpha detection
- Time-of-flight measurement with directional information improves transmission contrast by reducing background from scatter
- Material characterization (low-Z, fissionable, etc.) made possible with alpha detection

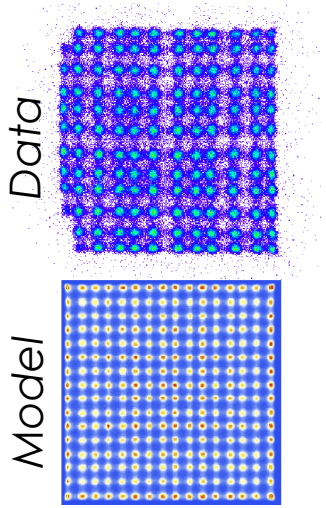
Neutron Source and Alpha Detector Modeling



Not shown

1. Item
2. Detector
3. Data acquisition



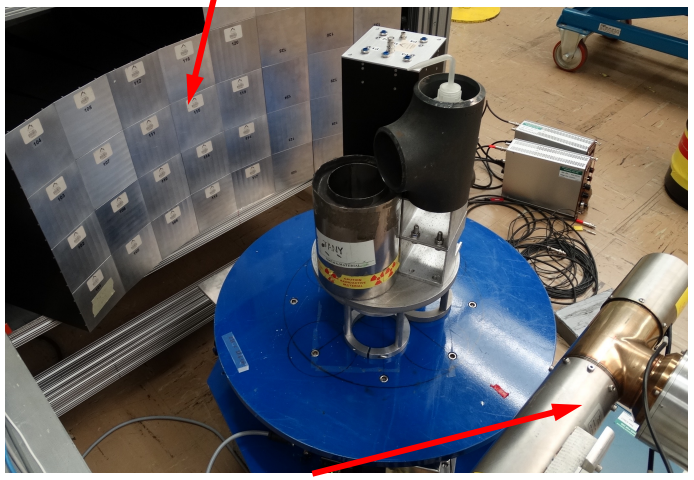


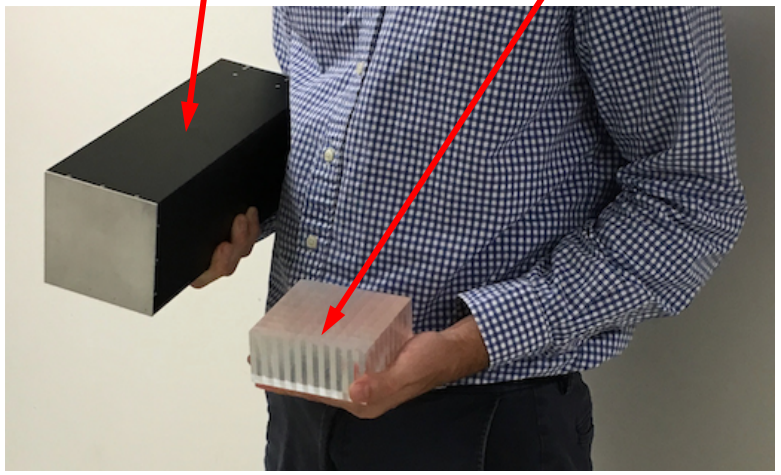
- Geant4 used to model light transport and design light guides (**no known data needs**)
- Modeling of alpha transport, photosensor/readout response, and angular resolution of 14 MeV neutron unneeded (**for now**)

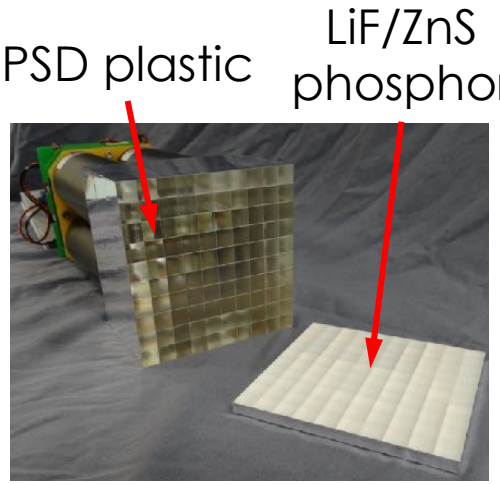
- Inelastic scatter gammas from copper and steel in NG are 50% higher in G4 model and spectrum is harder
- Neutron interactions within the NG widen the neutron cones and increase scatter background

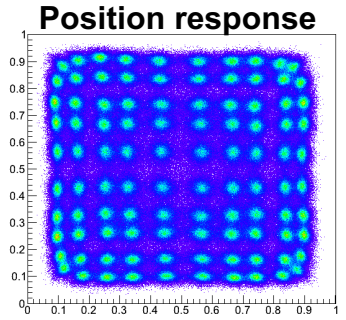
➢ **Potential need to improve nonelastic data for Cu and Fe for modeling performance**

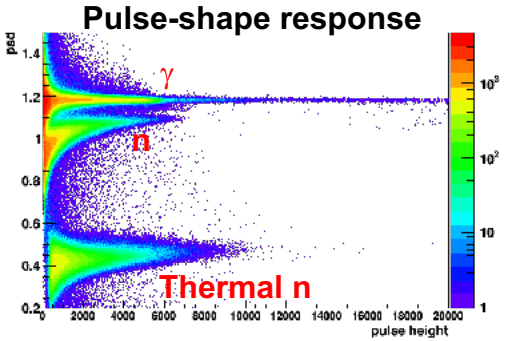
Detector Modeling









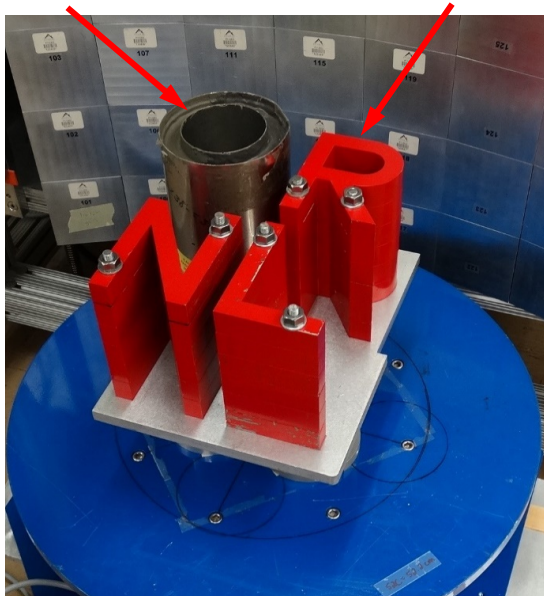


- Detector design relies on light transport and measurement calibration involves matching light output and thresholds until efficiency is accurately modeled (**no known data needs**)
- Neutron interactions in the detector materials contribute to scatter background that affects image reconstruction performance, especially when the background terms are estimated with a model

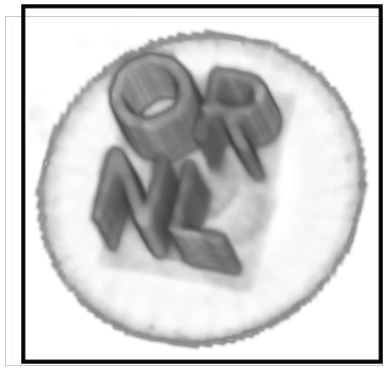
➢ **Potential need to improve nonelastic data for Al, C, etc. for modeling performance**

Item Modeling

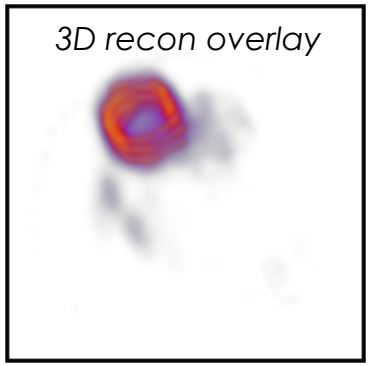
DU Steel

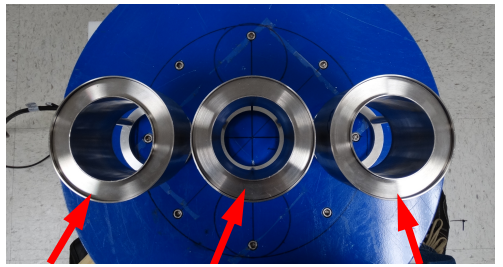


Transmission

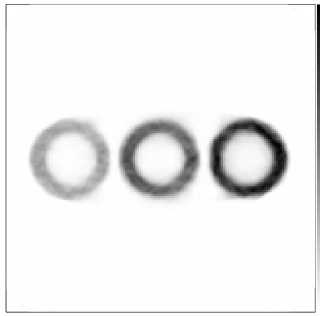


Doubles

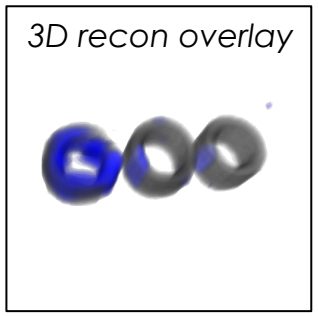




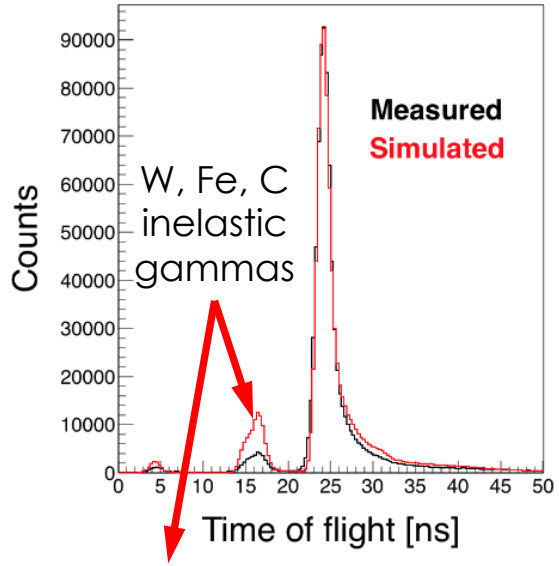
HDPE Steel Tungsten



Transmission



^{1}H elastic



Inelastic gamma overestimates:

- Tungsten: 1.90
- Steel: 2.84
- HDPE: 2.55

- Image reconstruction involves neutrons and gammas at various numbers, scatter angles, and energies, so **accurate final state models** are important for predicting performance
- Modeling is used currently to extract signal from background but should be used to understand absolute values in images (not just relative contrast)