# Simulation status and benchmarking with real data

UCGretina Geant4 GRETINA/GRETA Simulation Code
github.com/rileyle/UCGretina

4th AGATA-GRETINA/GRETA Tracking Arrays Collaboration Meeting
Argonne National Laboratory
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FRIB

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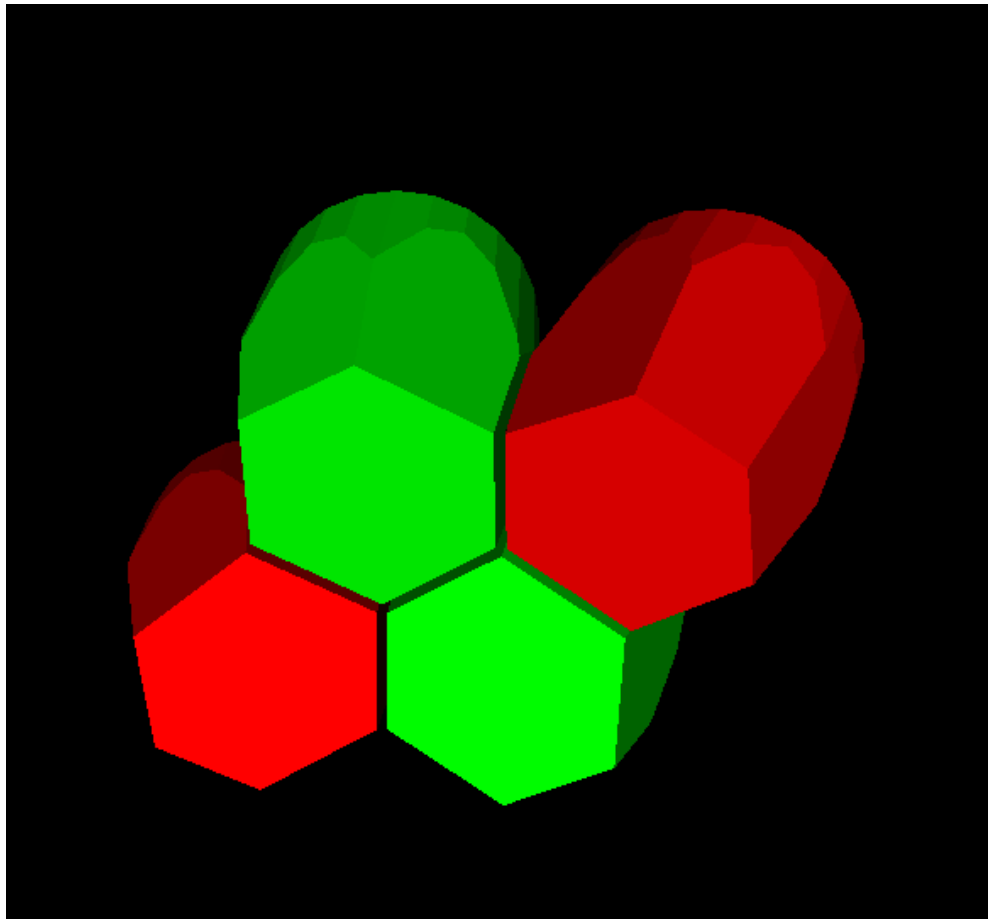
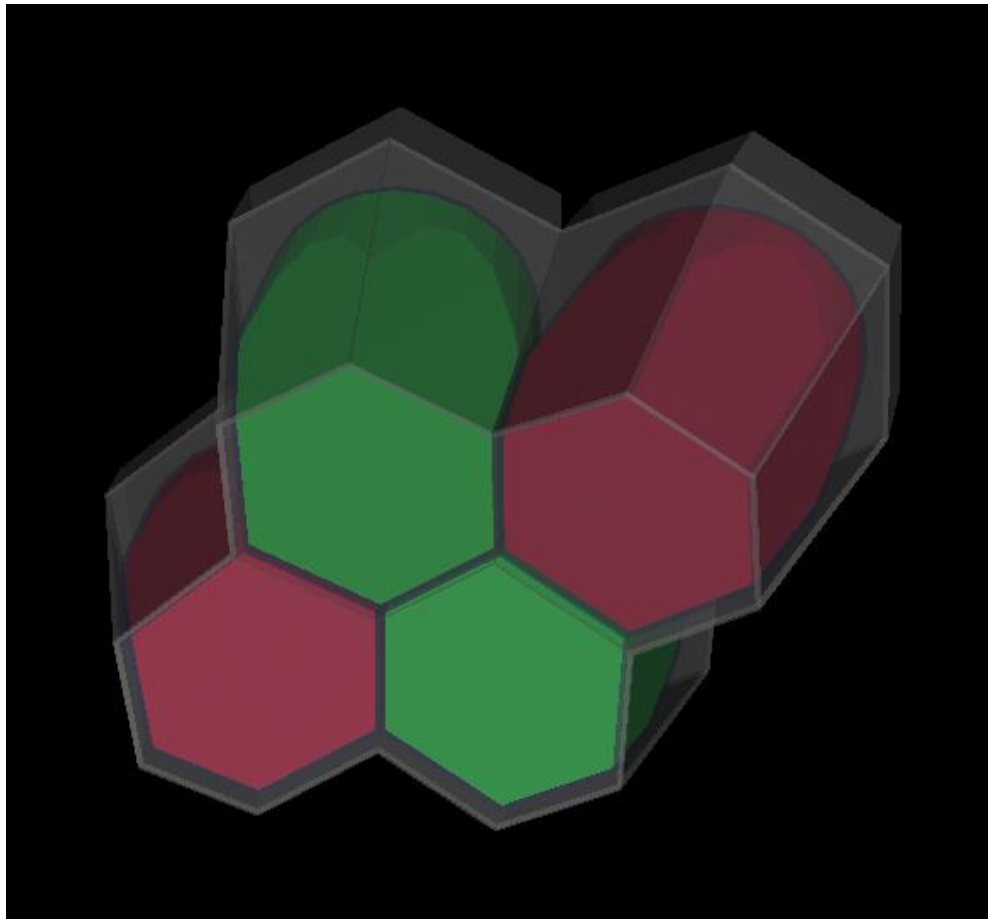
# GRETINA/GRETA Geometry

## adopted from the AGATA simulation code

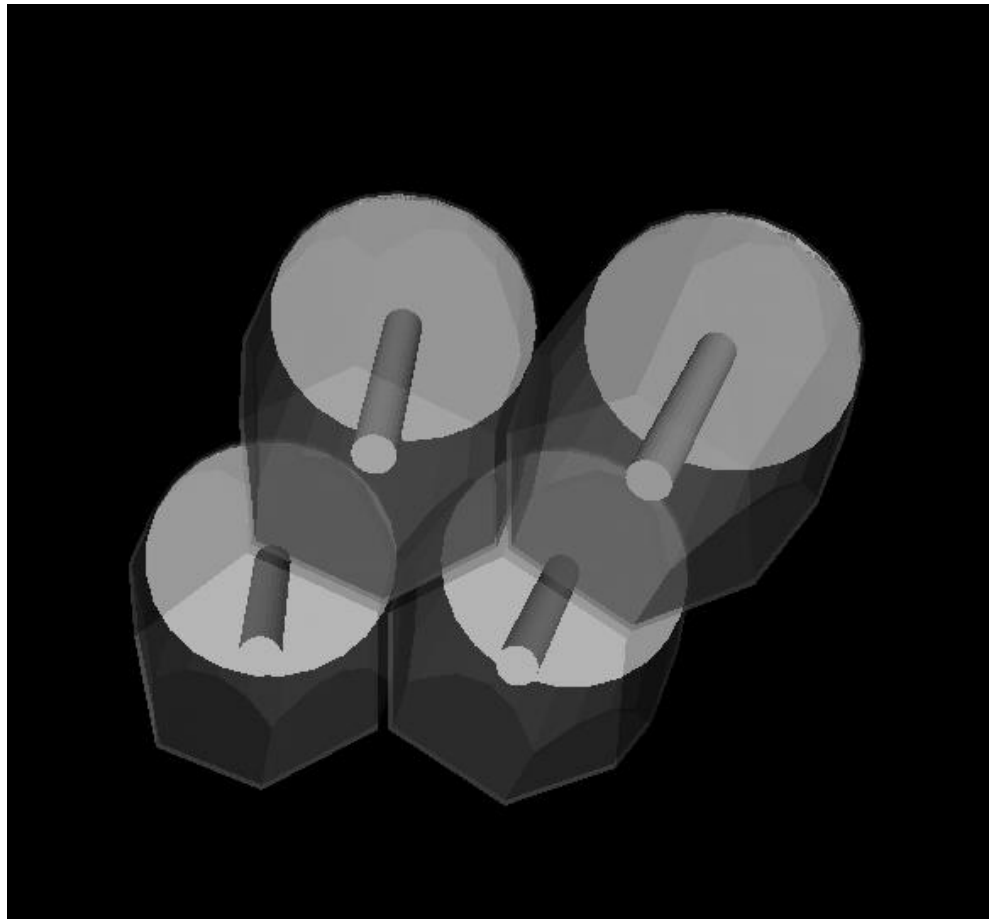


E. Farnea et al., NIMA 621, 331 (2010)

# GRETINA/GRETA Geometry



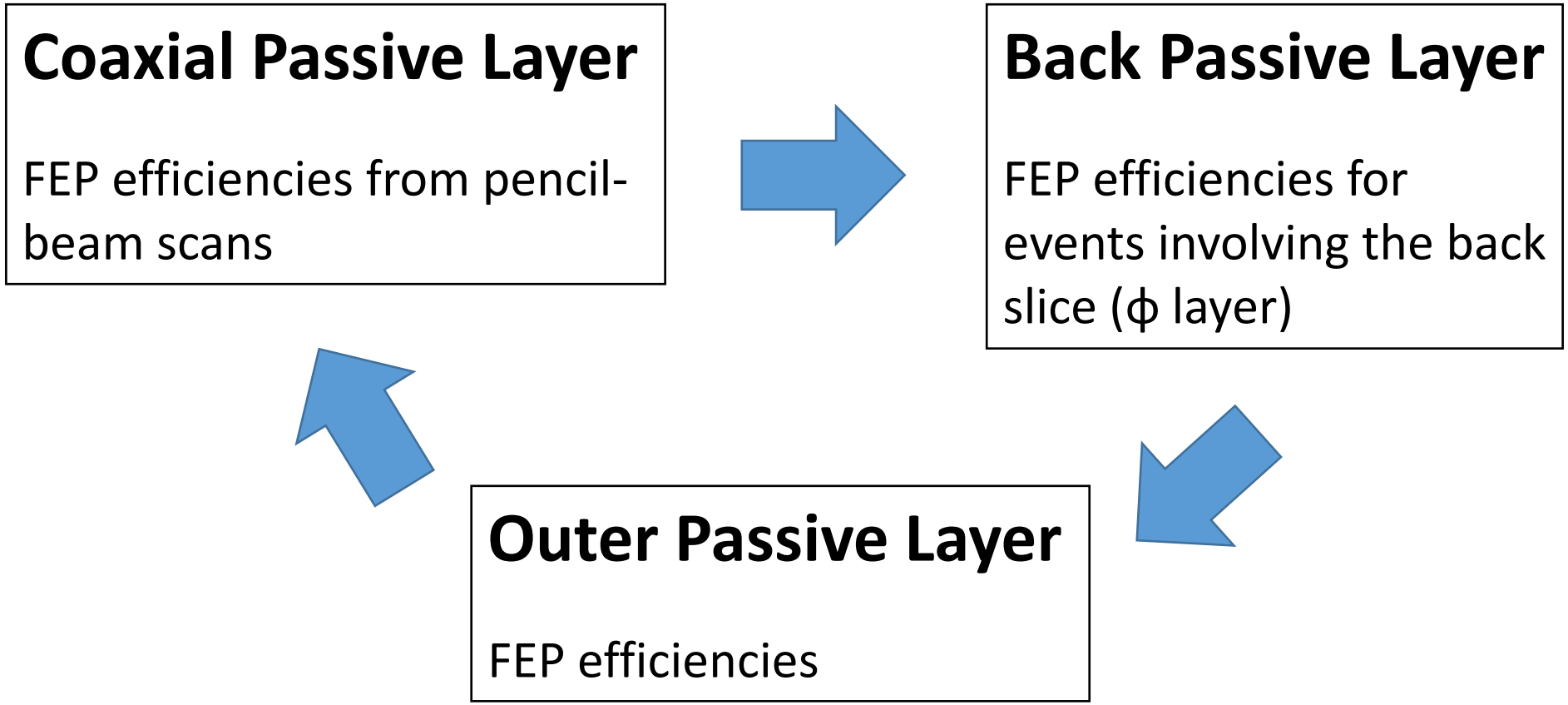
… with modified capsules and cryostat walls …



… and back, coaxial, and outer passive layers.

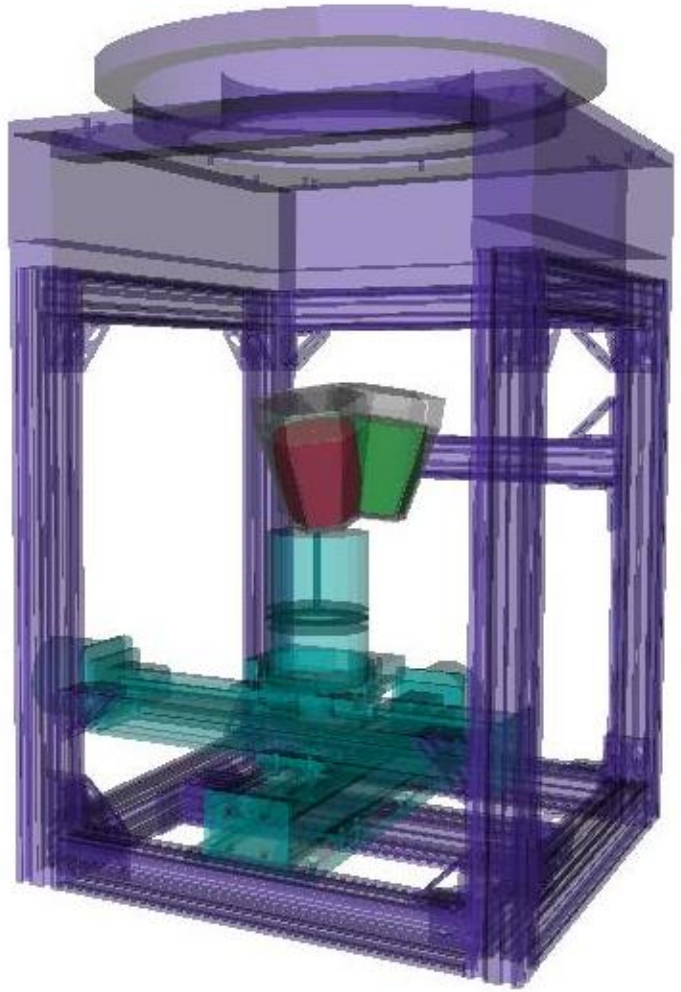
# GRETINA/GRETA Geometry

## constraining passive layers: Q4, Crystal 4



# GRETINA/GRETA Geometry

## constraining passive layers: Pencil-beam scans Q4, Crystal 4



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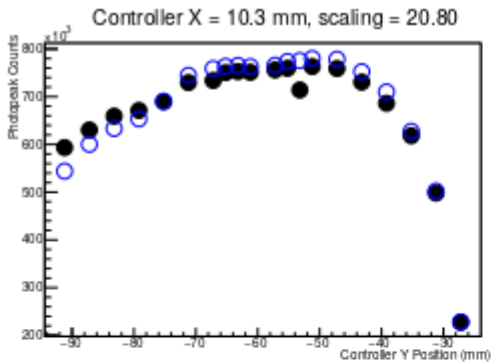
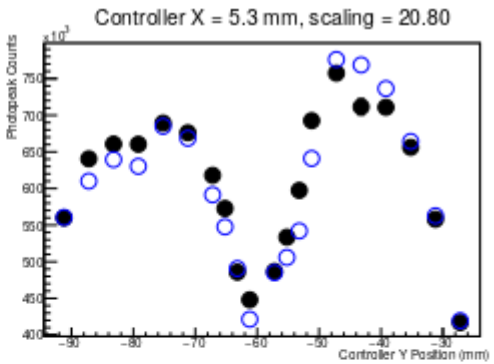
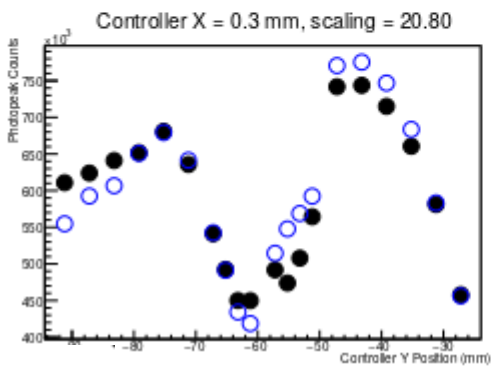
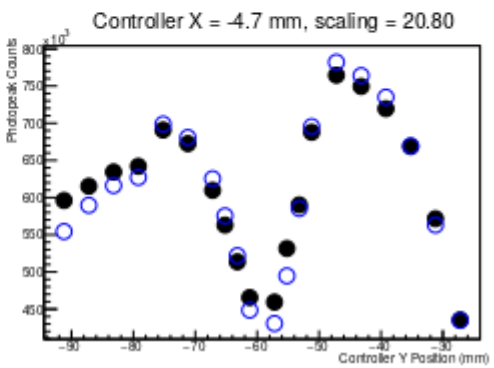
# GRETINA/GRETA Geometry

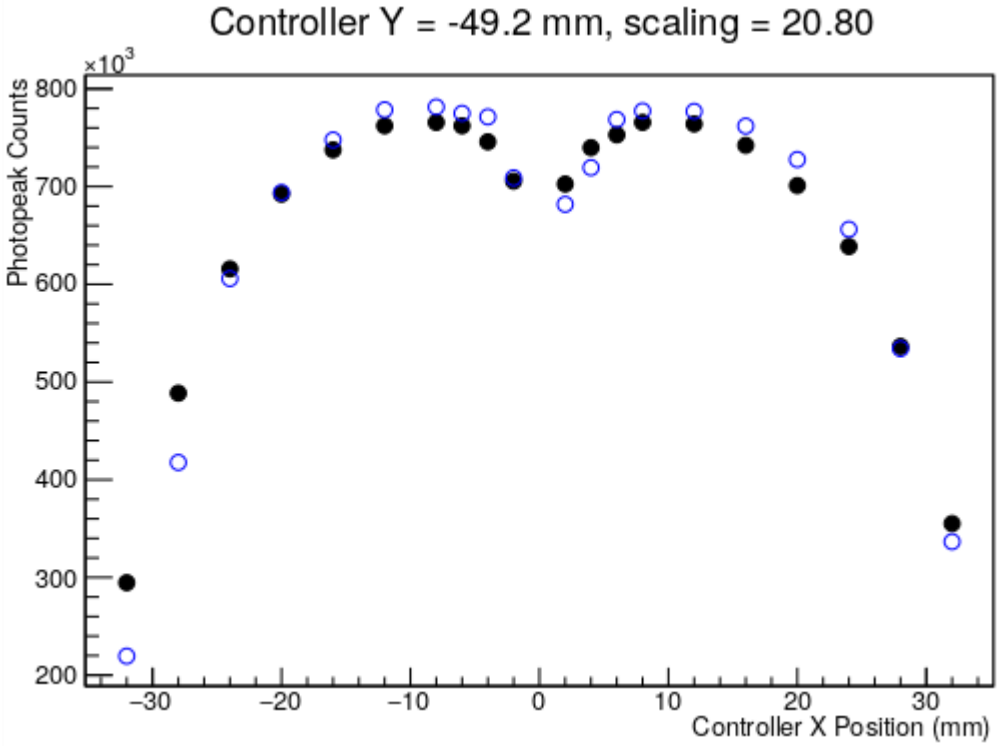
## constraining passive layers: Pencil-beam scans Q4, Crystal 4

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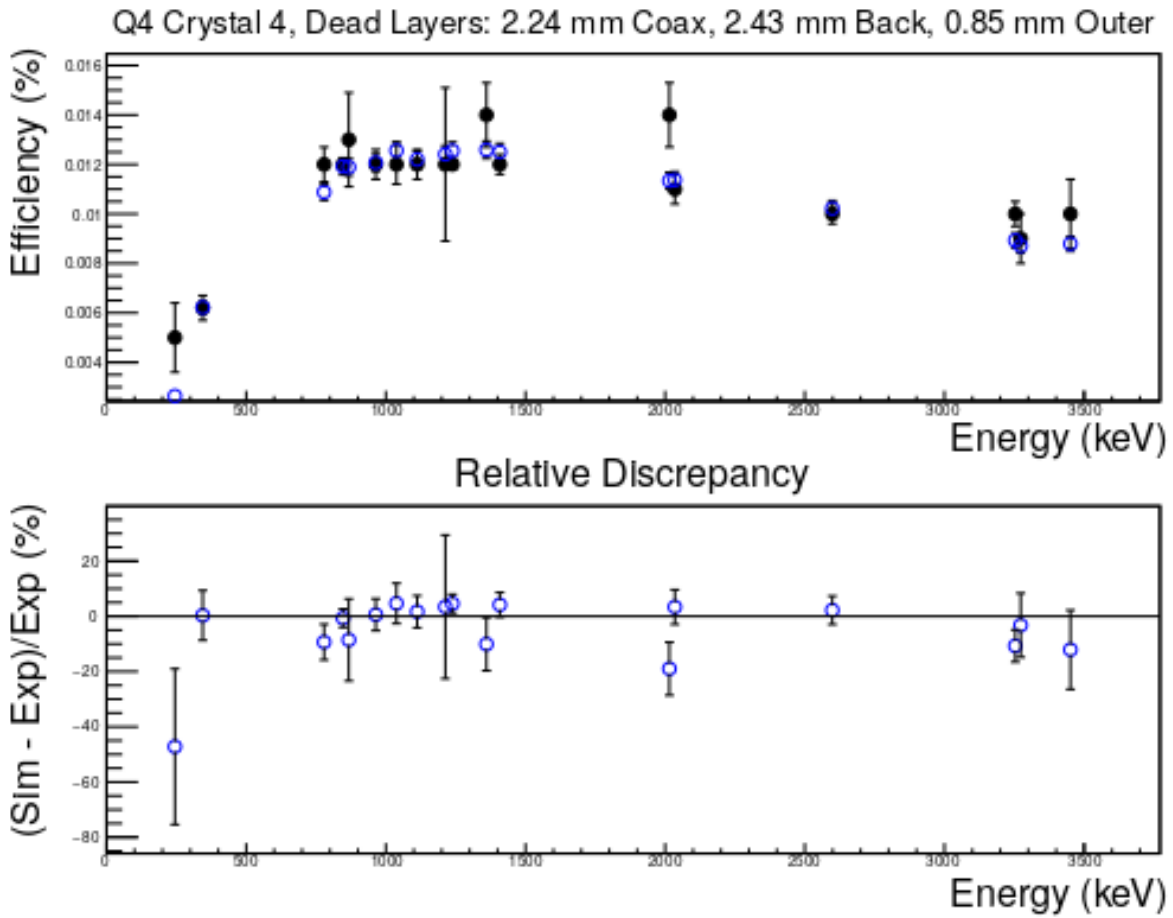
**Best-fit coaxial passive-layer thickness = 2.24(6) mm**

# GRETINA/GRETA Geometry

## constraining passive layers: back slice Q4, Crystal 4

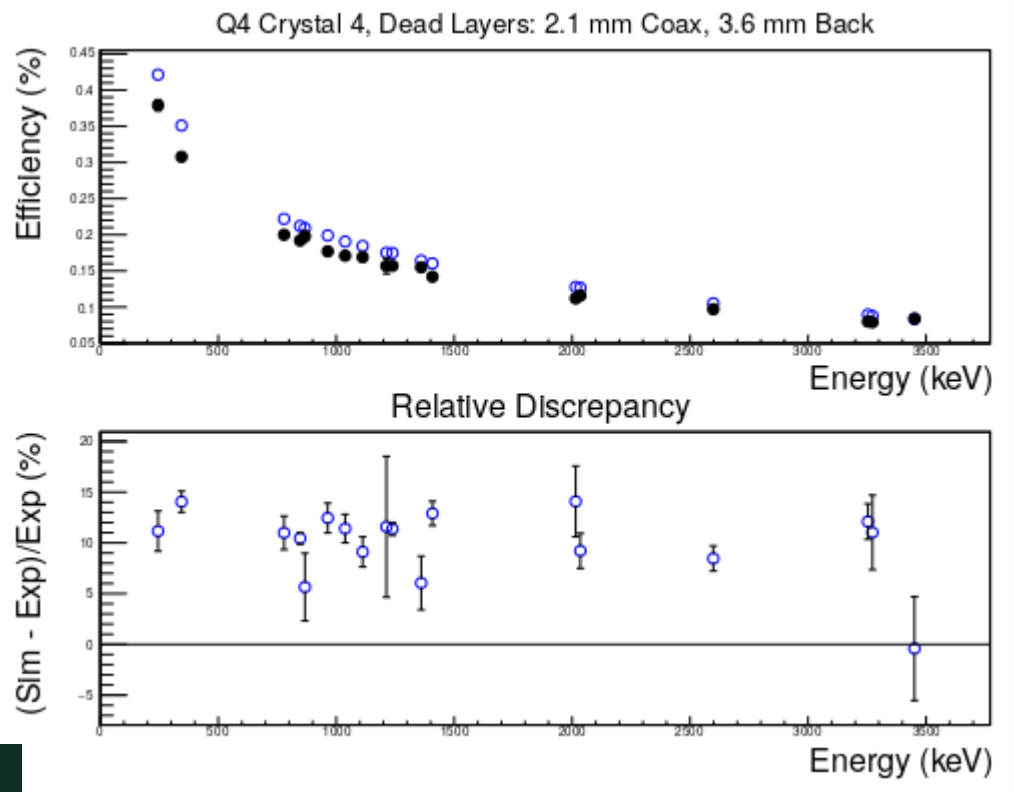


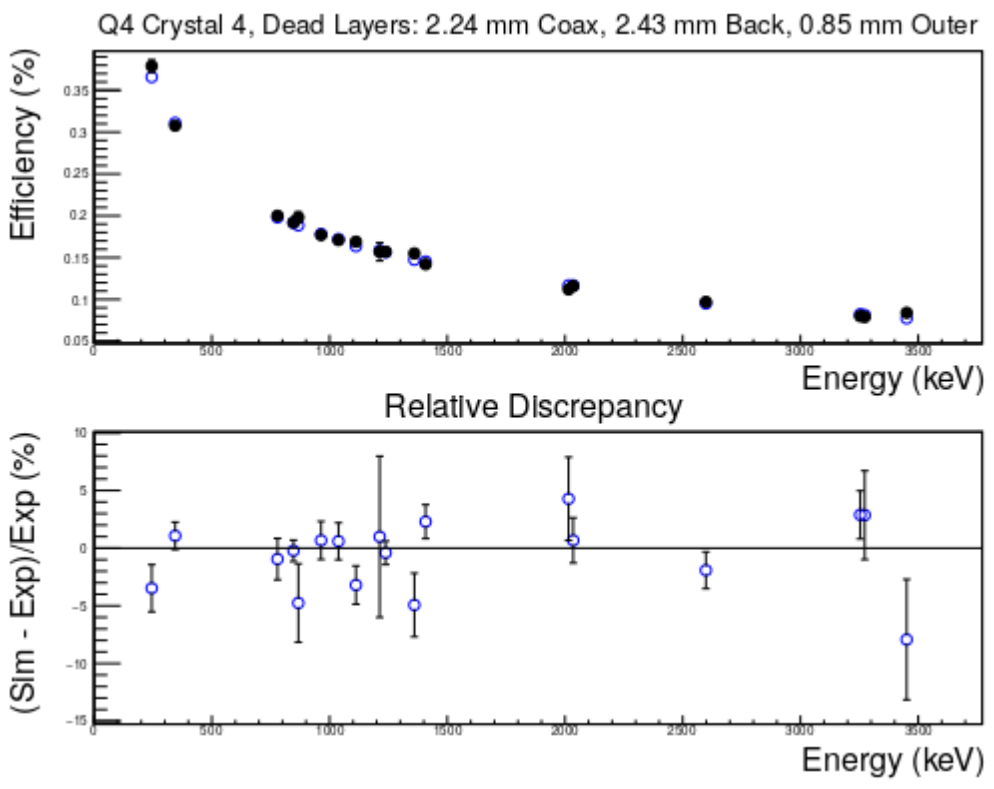

**Best-fit back passive-layer thickness = 2.43(12) mm**

NSCL

# GRETINA/GRETA Geometry

## constraining passive layers: Q4, xtal4 FEP efficiencies



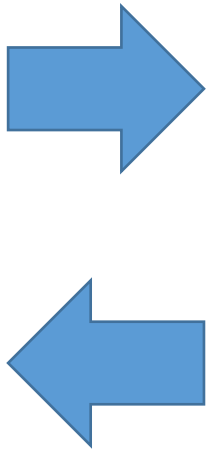




**Best-fit outer passive-layer thickness = 0.85(2) mm**

# GRETINA/GRETA Geometry
## constraining passive layers: 12 Quads

**Coaxial & Outer Dead Layers**

FEP efficiencies
(no pencil beam scans)

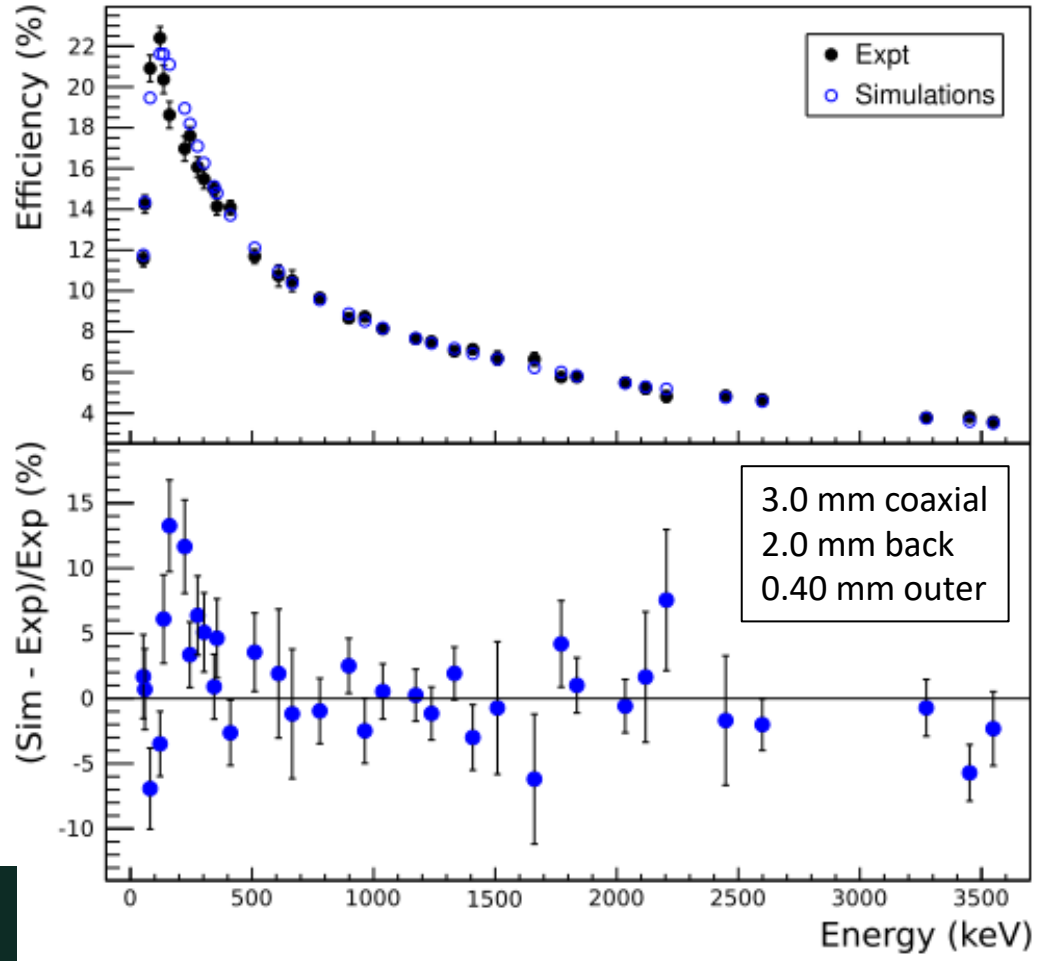


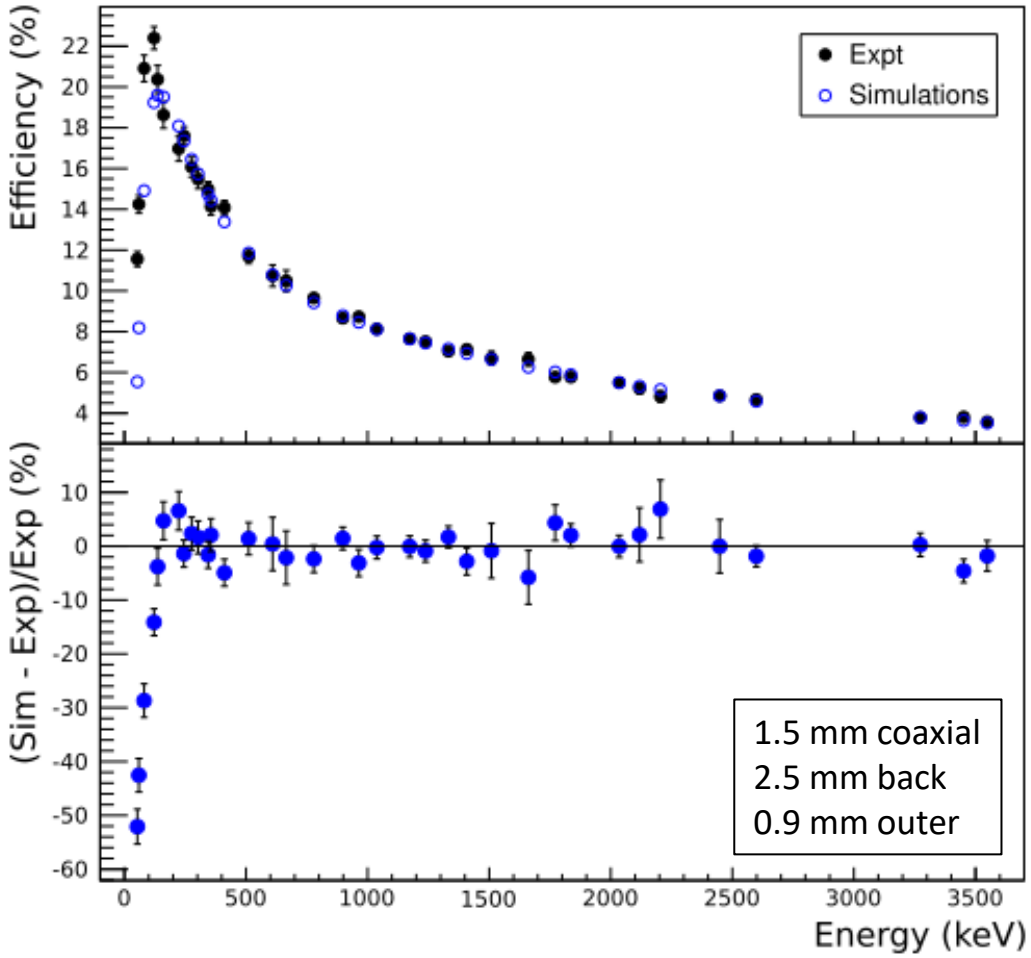
**Back Dead Layer**

FEP efficiencies for events involving the back slice (ϕ layer)

L. A. Riley *et al.*, NIMA 1003, 165305 (2021)

# Full-Energy Peak Efficiencies, 12 Quads

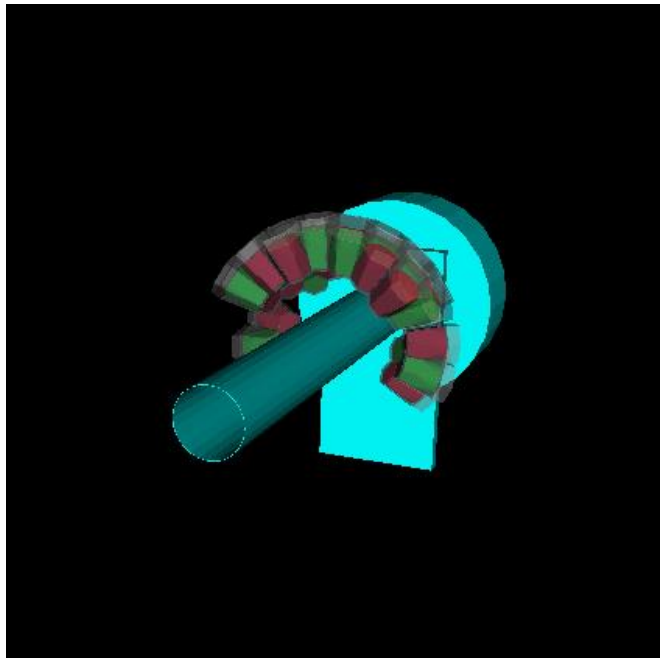


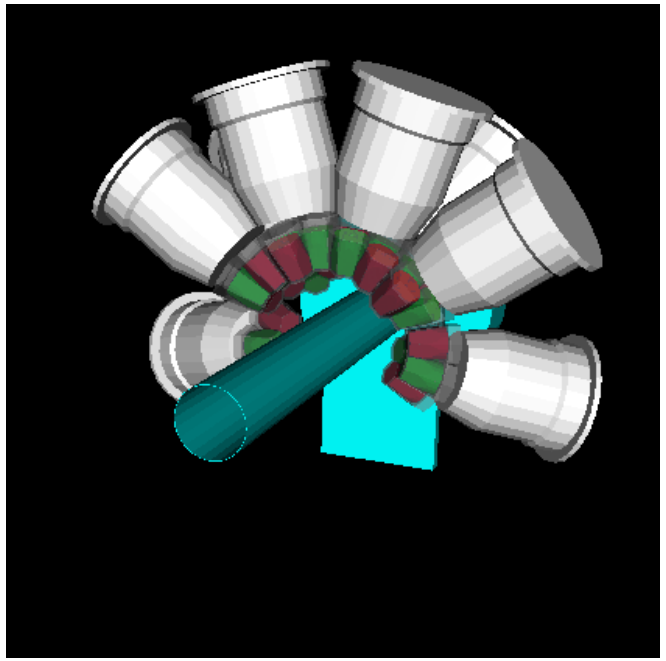



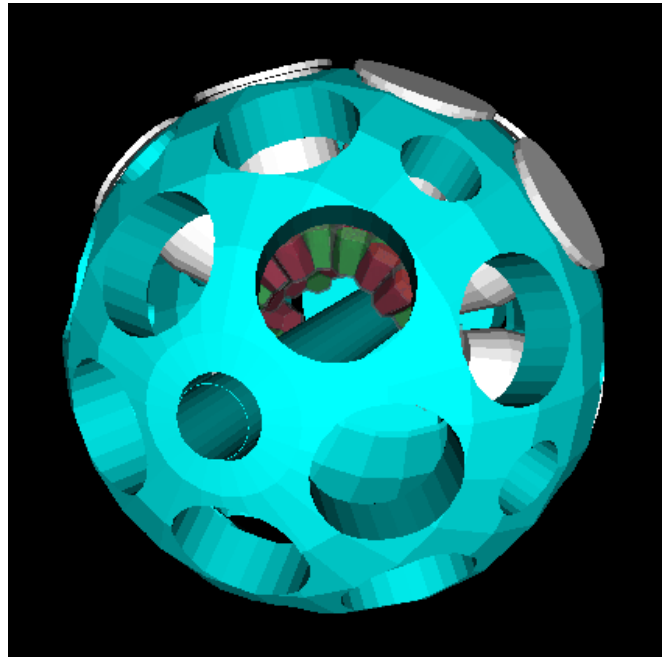

L. A. Riley *et al.*, NIMA 1003, 165305 (2021)

# GRETINA/GRETA Geometry

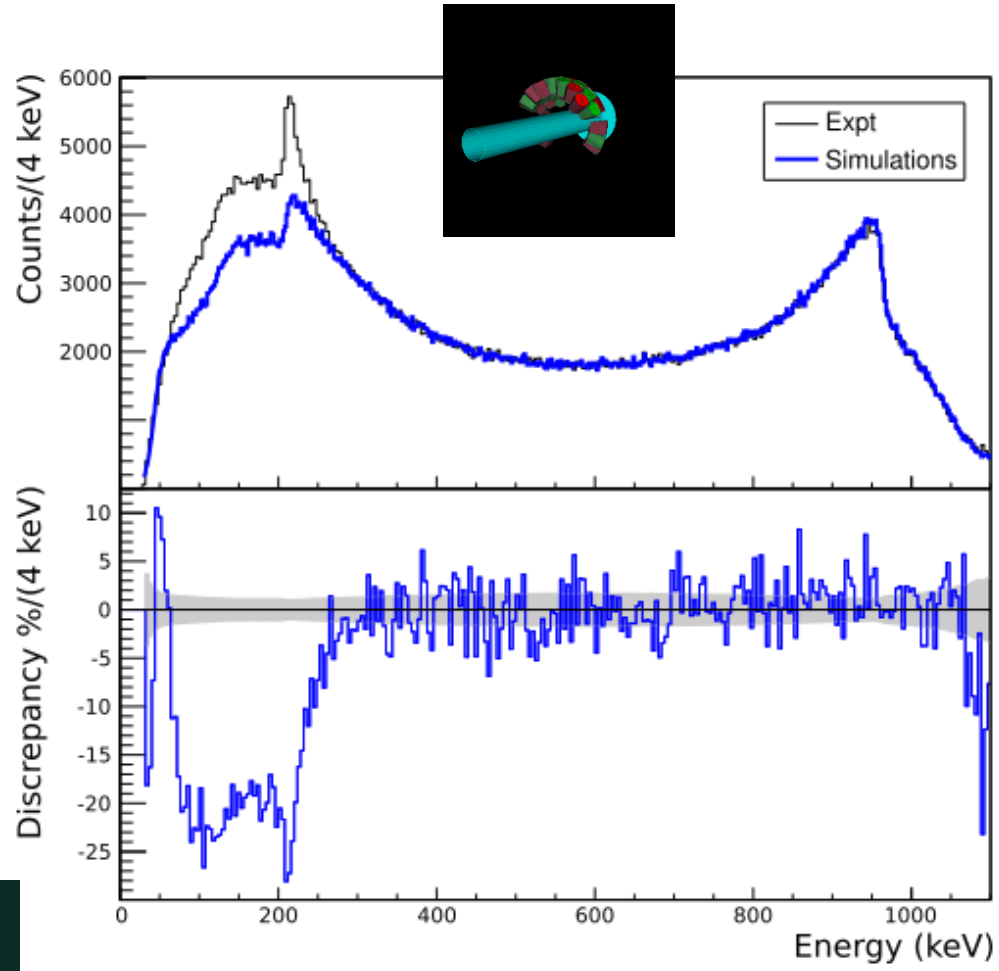
## … and additional passive material

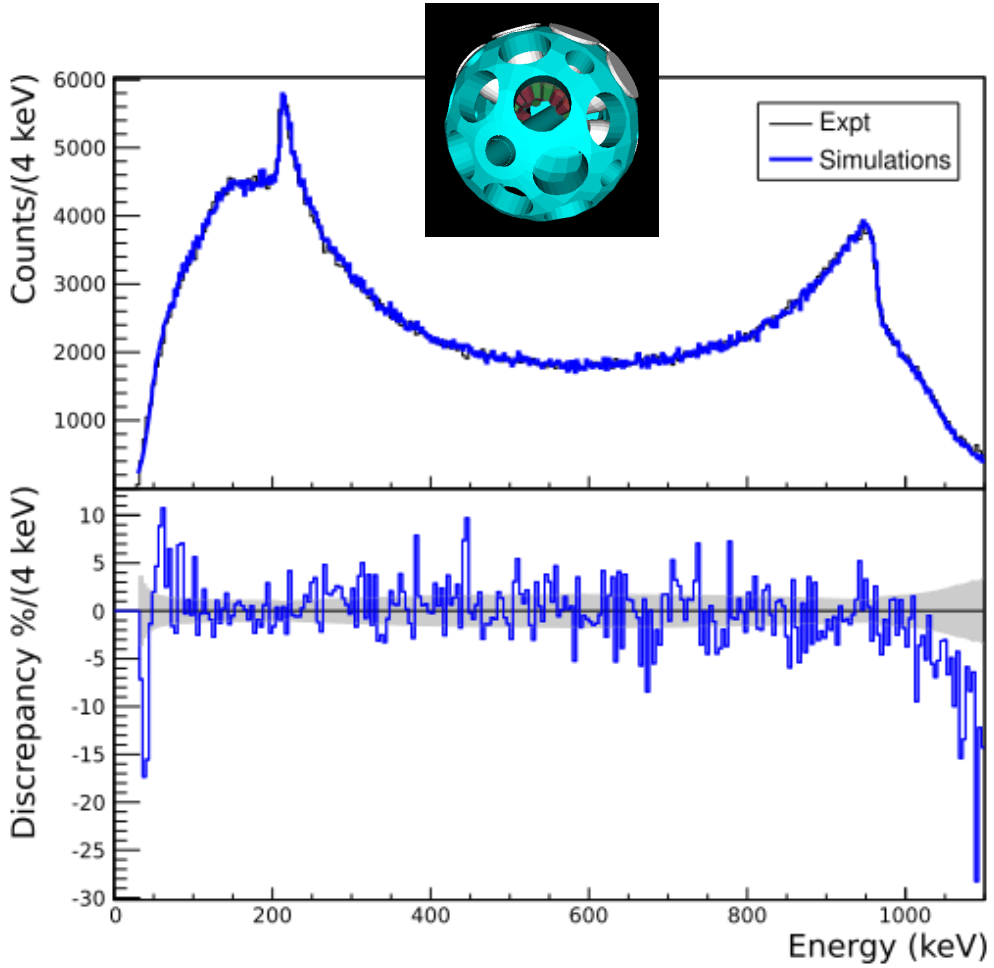






# LaBr-Gated $^{60}$Co: Compton Continuum

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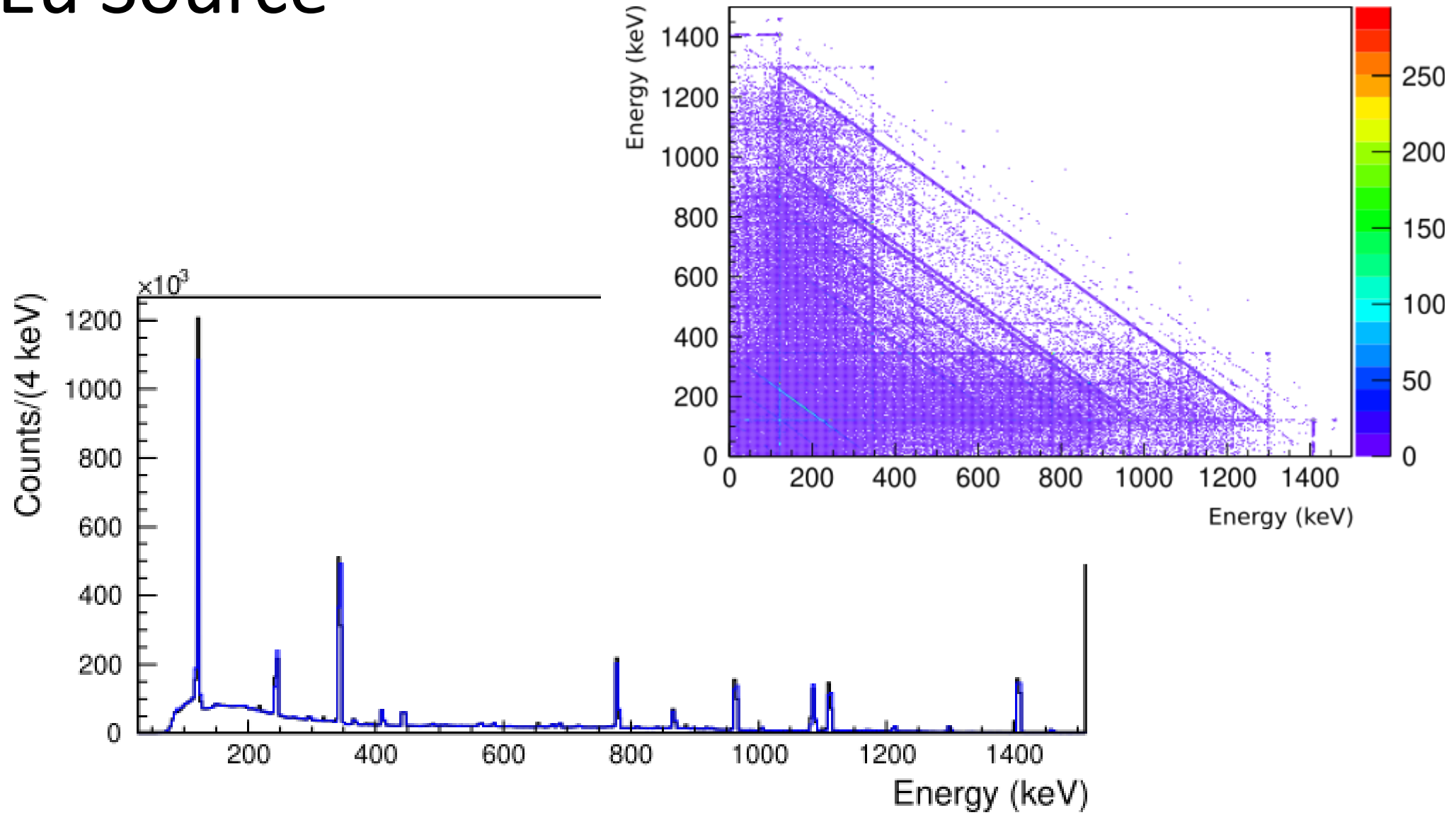
L. A. Riley *et al.*, NIMA 1003, 165305 (2021)

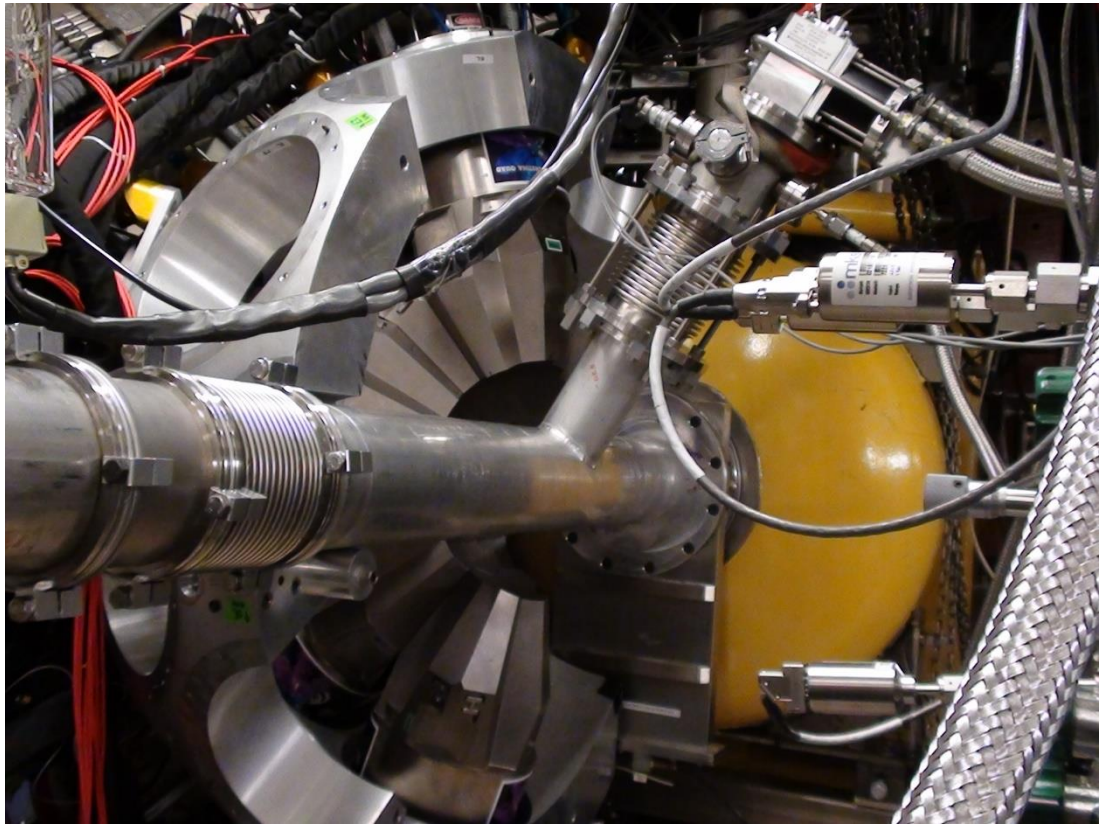
# $^{152}$Eu Source

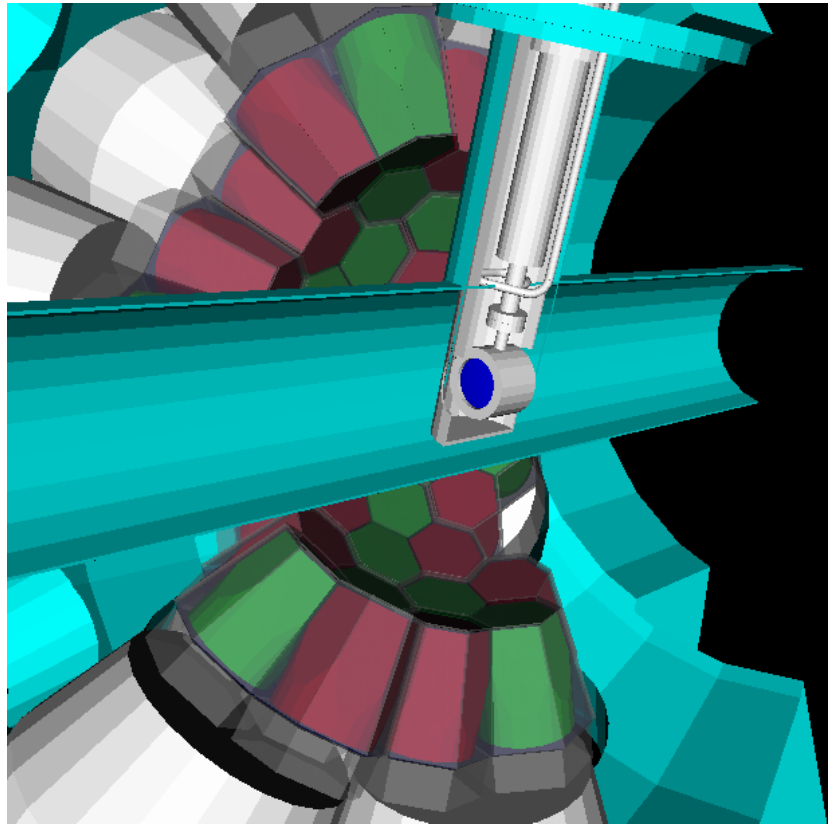



NSCL

# Liquid Hydrogen Target

## NSF-MRI PHY-0922615 (2009-2010)





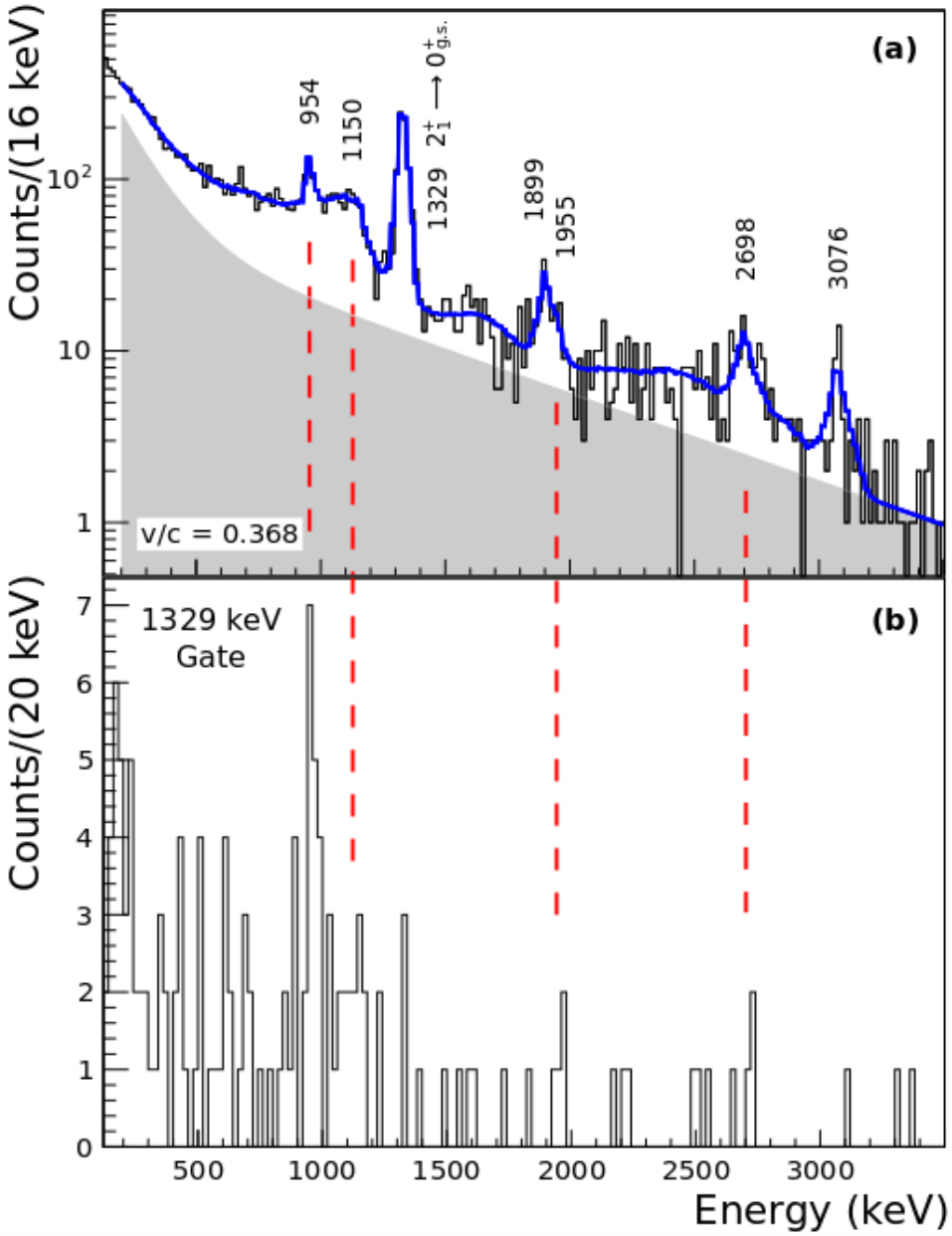
# In-beam

## Inverse-kinematics $^{44}$S(p,p’)

30 mm LH Target

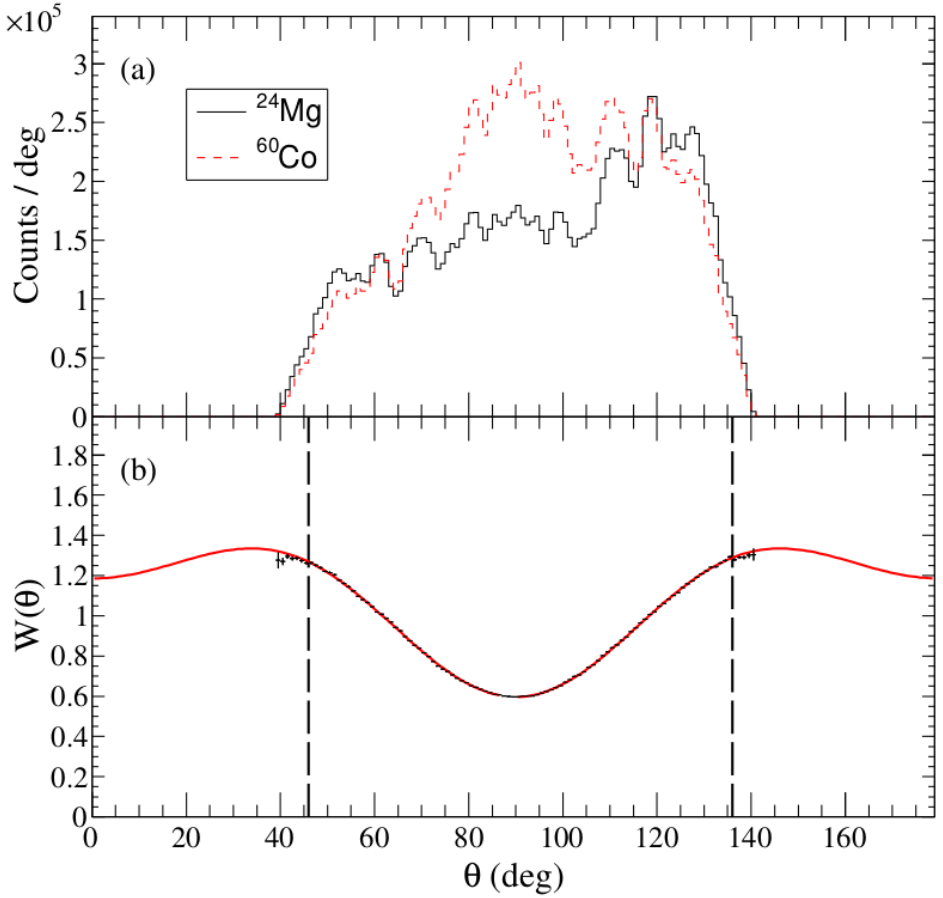
≈5×10$^{6}$ beam particles

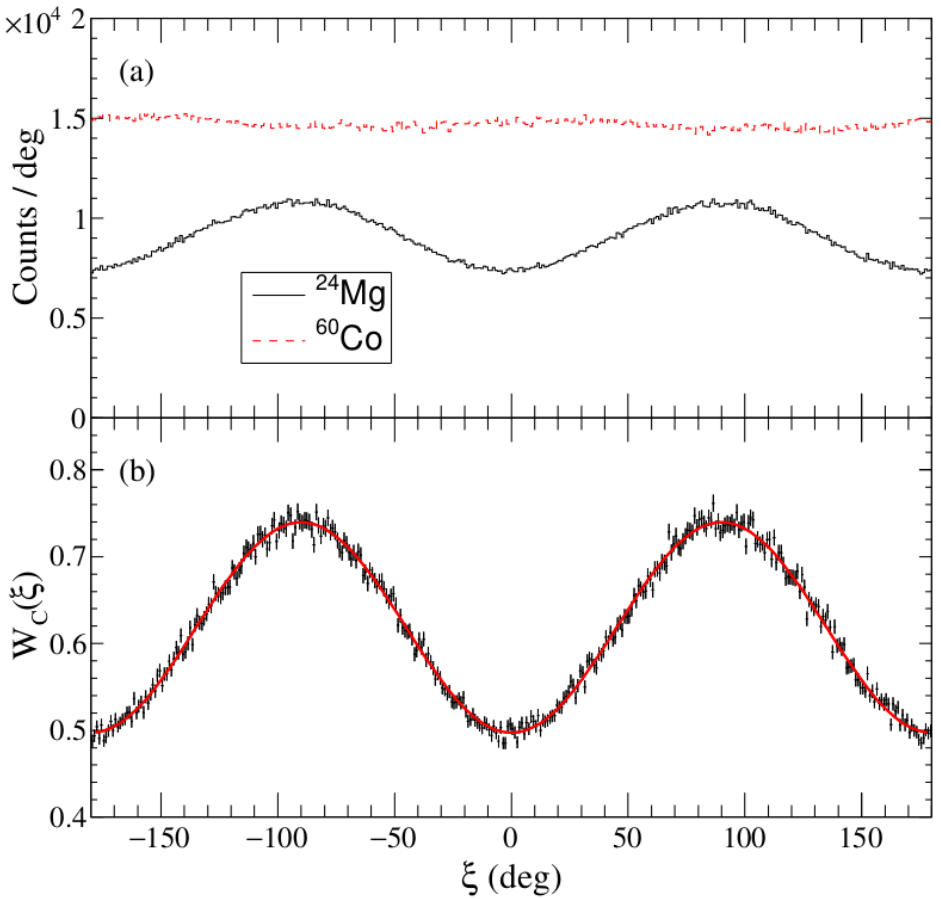
L.A. Riley et al., PRC**100**, 044312 (2019)



# Angular Distributions & Compton Polarimetry

## In Beam: Inverse-kinematics $^{24}$Mg(p,p')




C. Morse *et al.*, NIMA 1025, 166155 (2022)

# Geant4 γ Tracking Information → Simulated Data

- **Raw data:** "hits" depositing energy in active detector volumes
  - Primary particles (emitted γ rays)
  - Secondary particles (scattered electrons, scattered γ rays, pairs)

- **First pass:** consolidate secondary electrons with each Compton-scattering interaction

- **Second pass:** Consolidate multiple interaction points within each segment
  - User-specified "packing resolution" (6 mm?)
  - IP positions: barycenters of consolidated hits

# In Beam: Ion Tracking, Reactions, and γ Decay

- **Beam/Beam-Like Reaction Product** (GenericIon Class)
  - Tracked through the target
  - Incoming kinetic energy
    - Option 1: Mean KE and dp/p
    - Option 2: User-supplied incoming KE distribtution
  - Relativistic 2-body reaction kinematics
  - Alignment of beam-like reaction product (magnetic substate populations)
- **γ decay in flight**
  - Option 1: Single transition
  - Option 2: User-supplied partial level scheme (including level half-lives)

# Output

- **Decomposed γ-ray packets** (Mode 2 data, Type 1)
- **S800 physics data packets** (Type 9)
- **Emitted γ-ray packets** (Type 11)
  - Number of emitted γ rays
  - Full-energy flag (multiplicity 1, full energy in one crystal)
  - For each emitted γ:
    - Energy
    - Emission position (x, y, z)
    - Emission direction (theta, phi)
    - Source beta
- User sorting code must fold in thresholds, energy resolution, & position resolution

# Thank You!


Heather Crawford, Chris Morse, Chris Campbell, Mario Cromaz, Paul Fallon, Augusto Macchiavelli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Samantha Wildonger (UC `12), Michael Agiourgousis (UC `13), Ben Roberts (UC `13), Bryan Sadler (`14), Jonathan Kustina (UC `16), Sean Gregory (UC `17), Ethan Haldeman (UC `18), Leah Jarvis (UC `18), Chase Stine (UC `18), Esther Lawson-John (UC `20)

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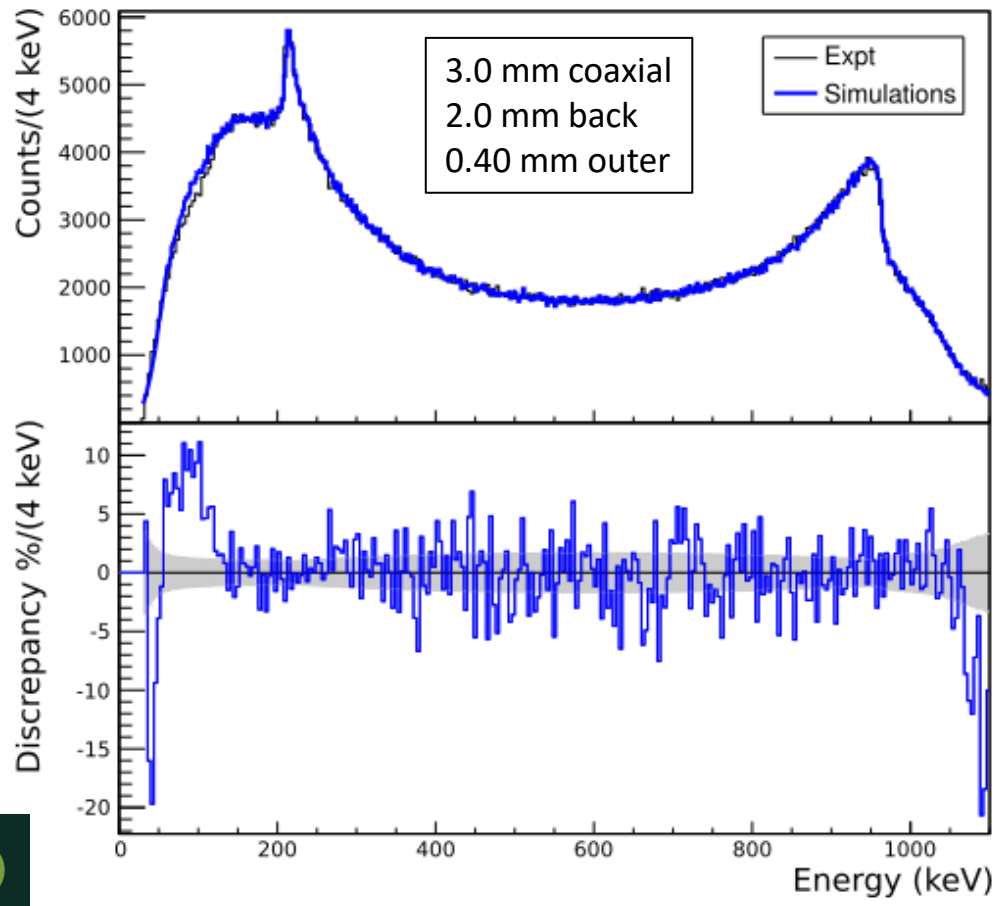
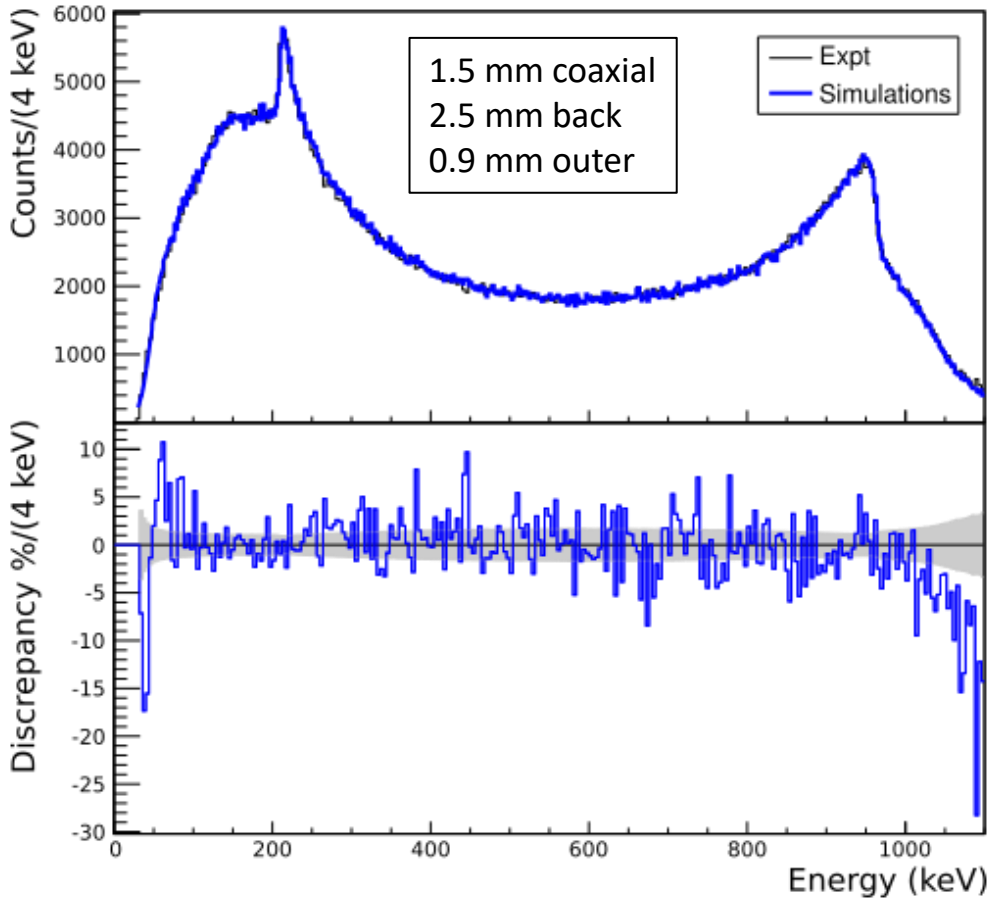
# LaBr-Gated $^{60}$Co: Compton Continuum

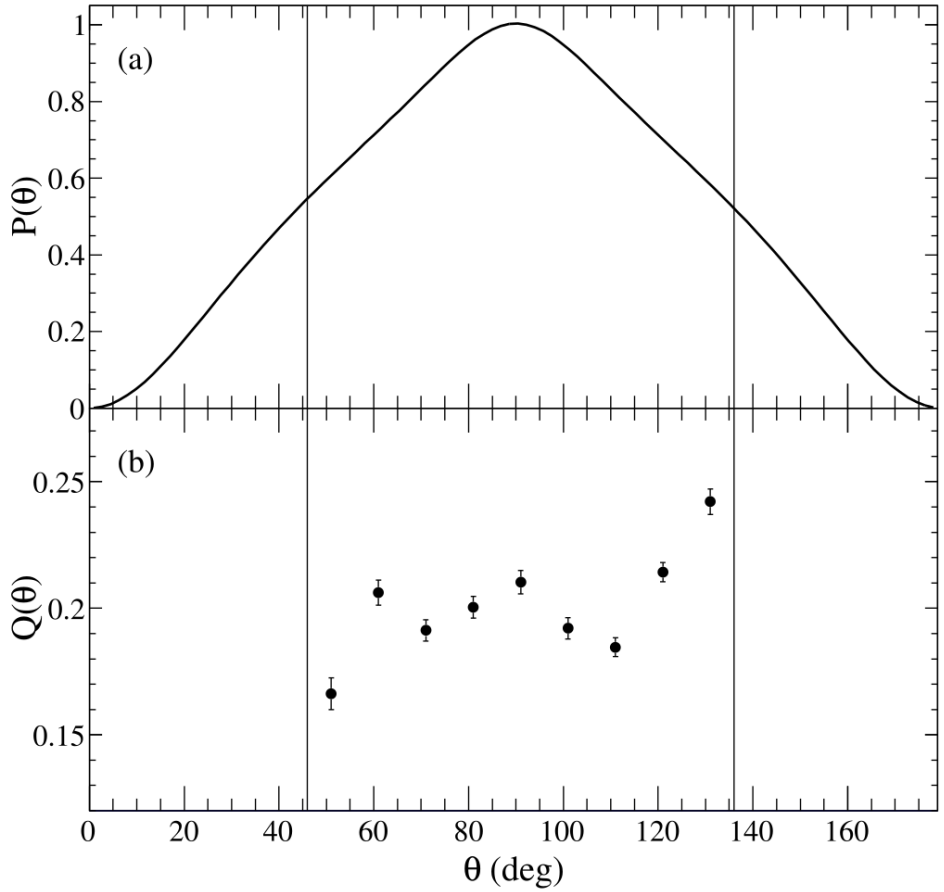


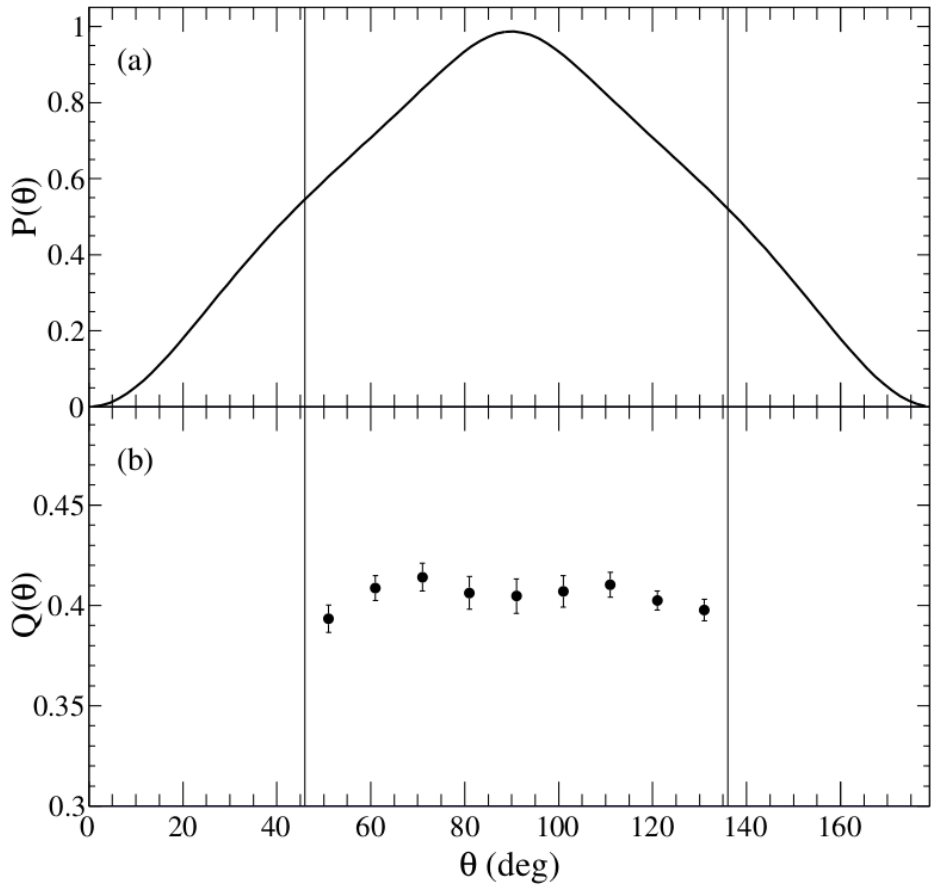




L. A. Riley *et al.*, NIMA 1003, 165305 (2021)

# Polarization Sensitivity

## In Beam: Inverse-kinematics $^{24}$Mg(p,p')




C. Morse *et al.*, NIMA 1025, 166155 (2022)