Analysis of 200,202Hg Coulomb Excitation Data

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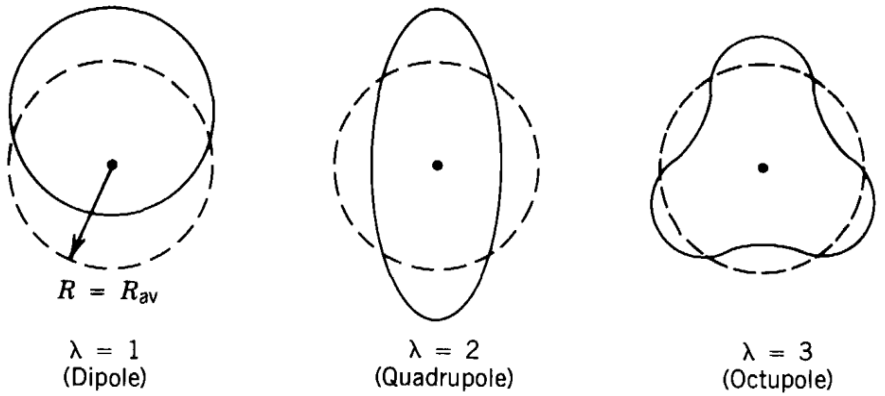
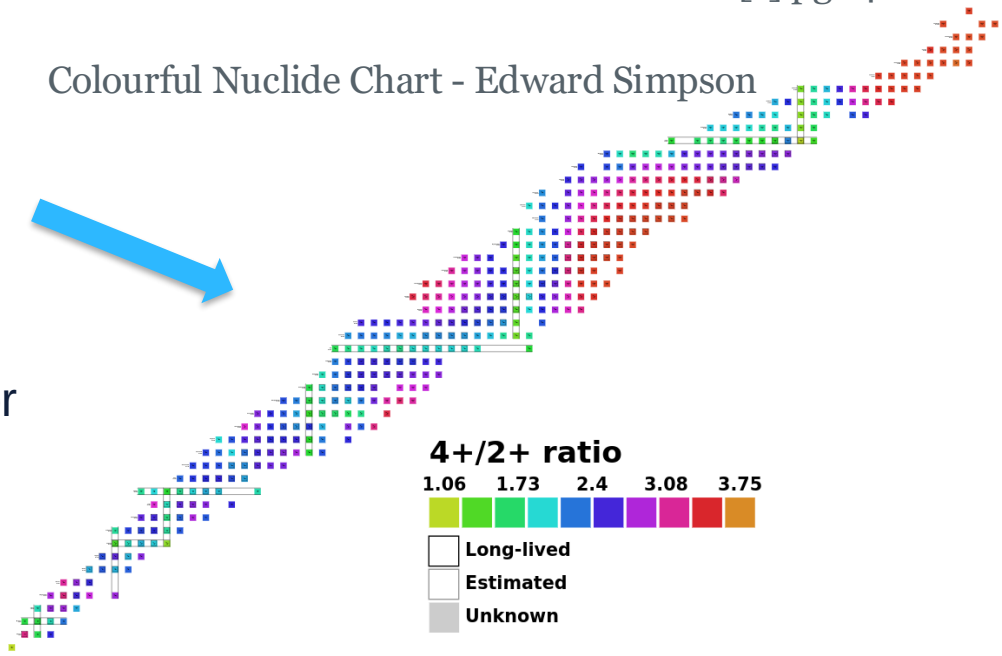
Project Motivation

- Collective behaviour arises when nucleons become a nucleus
- Nucleus excitations can be surface vibrations or rotations (coupling occurs too)
- Few nuclei are spherical (ratio of the first 4+ and 2+ state energies as indication)
- Measurables: Important tests for nuclear theory



Lowest three nuclear vibrational modes [1] pg 140

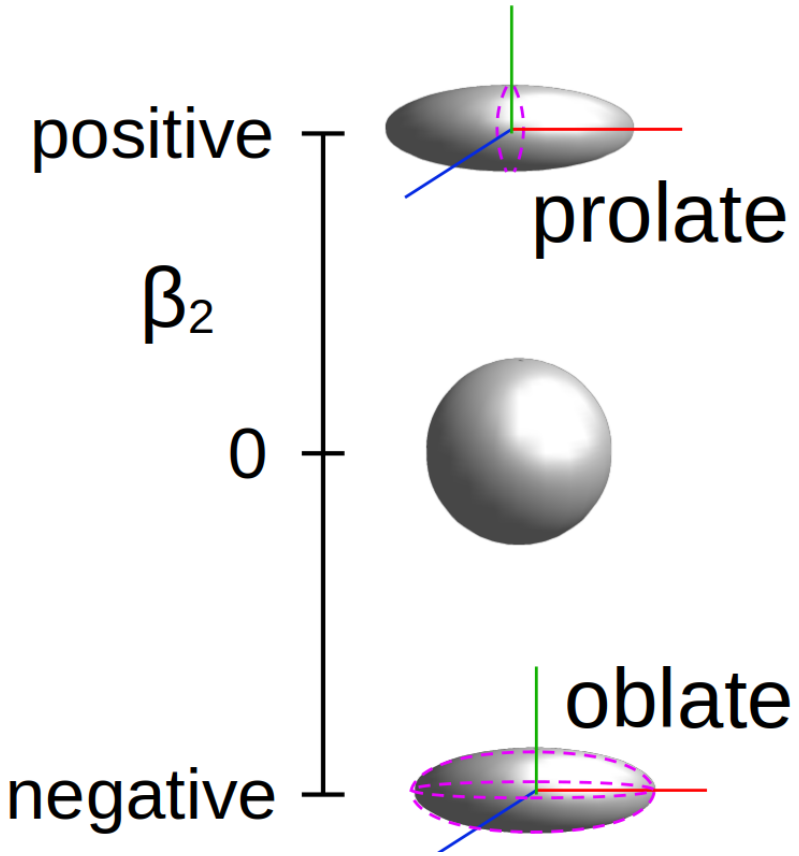
Colourful Nuclide Chart - Edward Simpson



[1] Krane, K.S. (1988) Introductory Nuclear Physics. Wiley John & Sons, New York.

Project Motivation

- Quadrupole deformation parameter β_2: one of the key parameters
- β_2 accessed via other key parameters
- Some nuclei don't fit this scale (triaxiality) if they deviate from rotor-like behaviour (second axis, γ)



Possible forms of nuclear deformation [2]

[2] Casten, R.F. (1990) Nuclear Structure from a Simple Perspective. Oxford University Press

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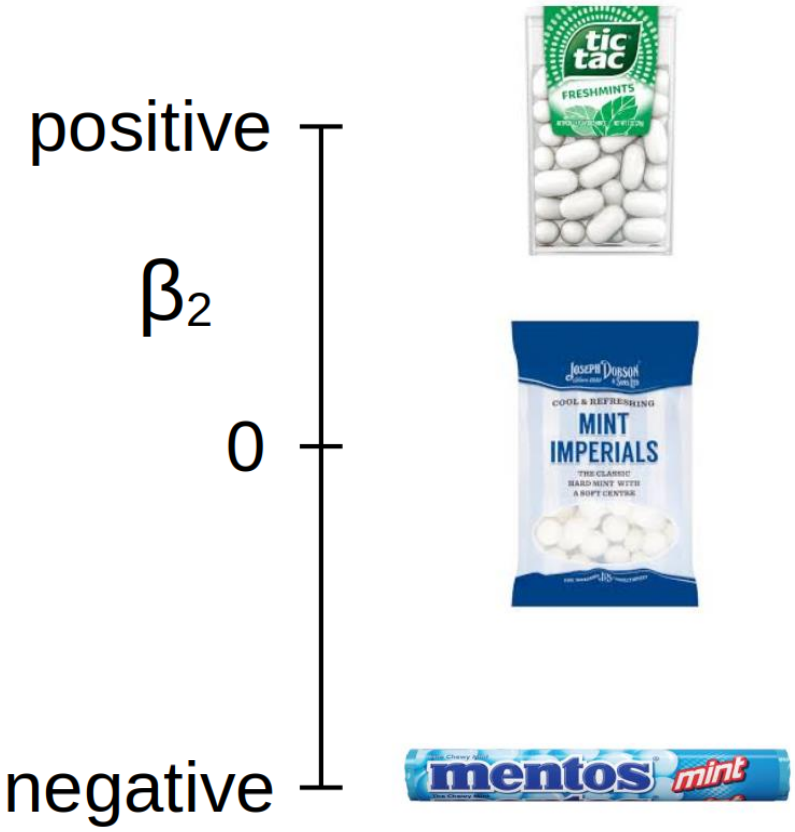

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Why 200,202Hg?

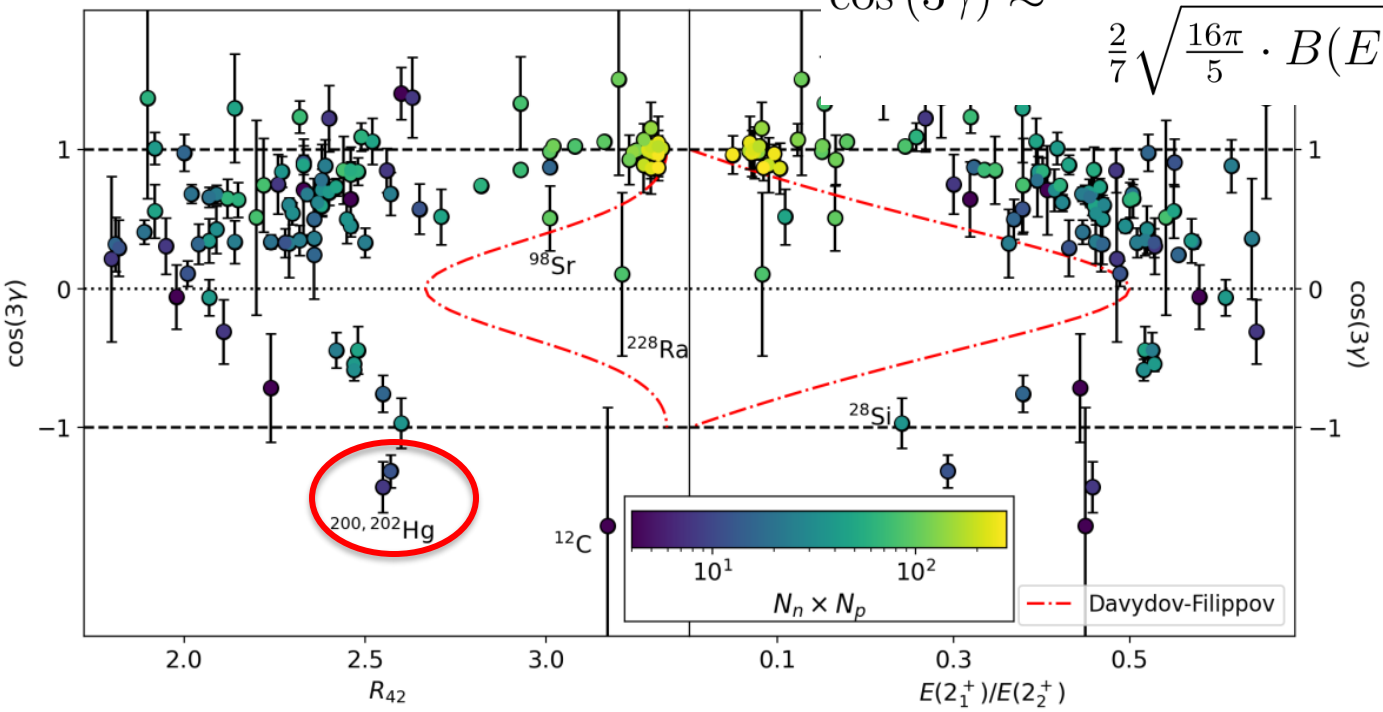
Project Motivation

- Previous measurement of even Hg isotope deformation A. Bockisch et al (1979)
- Unphysical result so *Coulomb excitation* experiment done at Argonne National Lab in December 2023

$$\cos(3\gamma) \approx -\frac{Q_s(2_1^+)}{\frac{2}{7}\sqrt{\frac{16\pi}{5}\cdot B(E2;0_1^+ \rightarrow 2_1^+)}}$$

Spectroscopic quadrupole moment

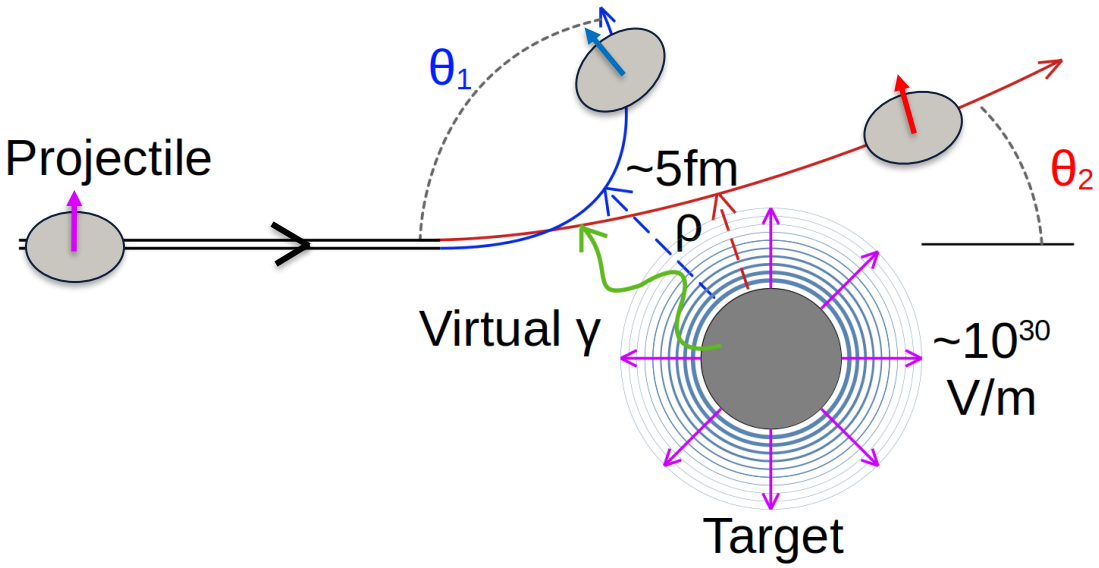
Quantitative measure of E2 transition strengths

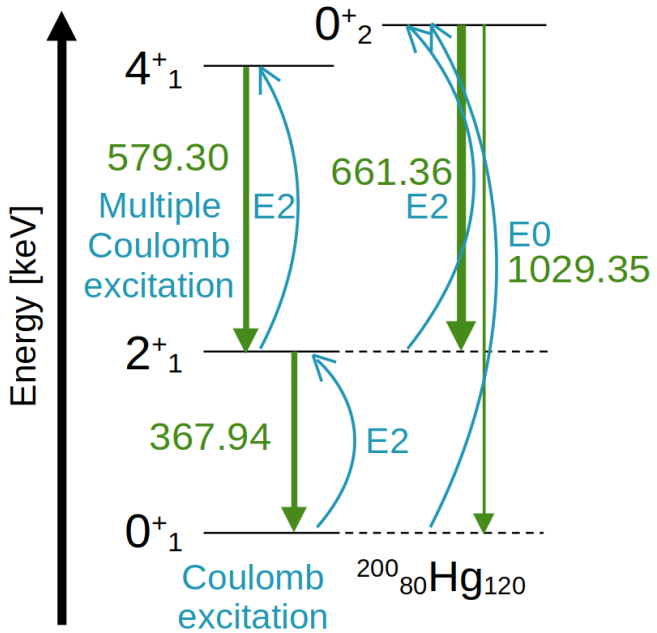


J. Henderson et al. ATLAS research proposal

What is Coulomb Excitation?

The Experiment





- Purely Electromagnetic interaction
- Projectile (and target) can be put in an excited state
- Electric transitions favoured
- Reorientation effect: sensitivity to quadrupole moment
- Inverse kinematics: projectile is the larger nucleus

What did we do?

The Experiment

- Beams: 200,202Hg @ 780MeV, 10ppA

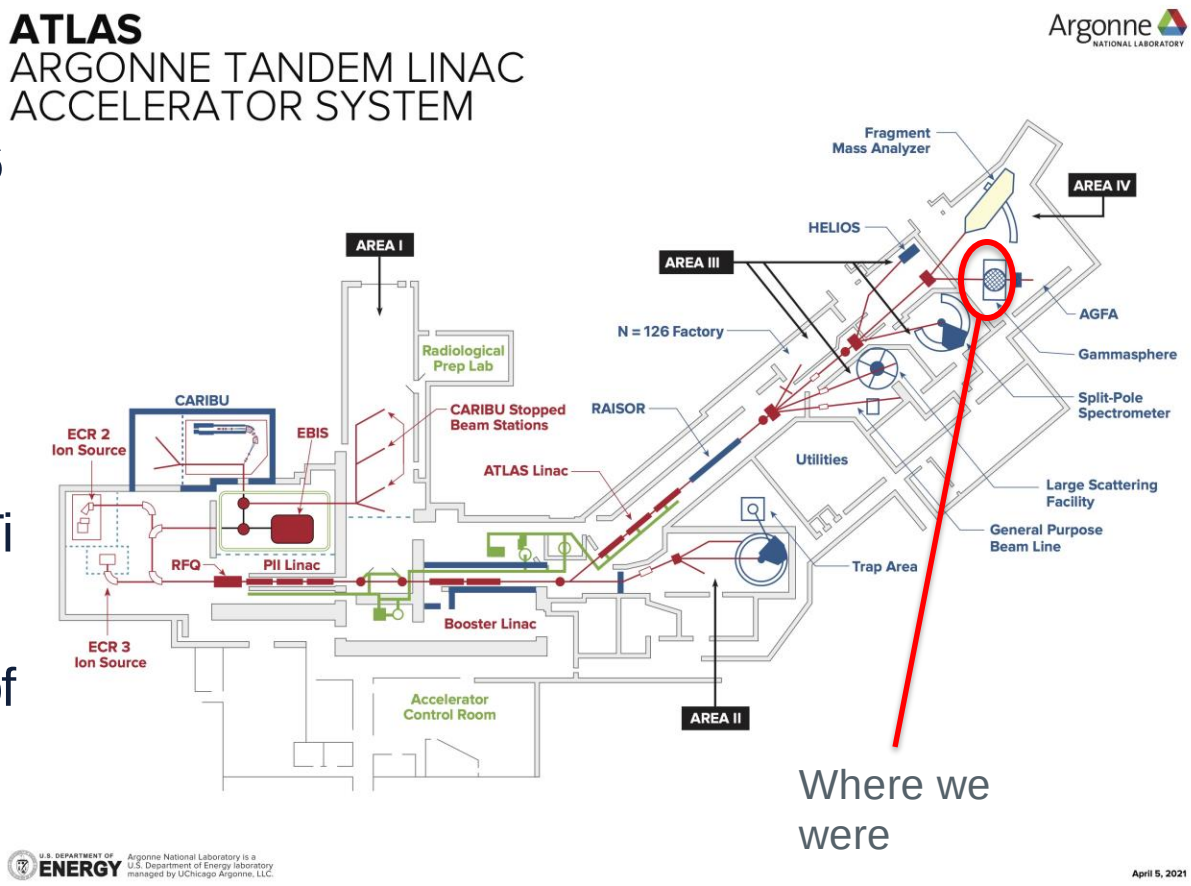
  (31+ charge, ~2x10^6 pps)
- Targets:

  780 mg/cm2 120Sn

  ~98% pure

  452 mg/cm2 natural Ti

- Took 11 to 19 hours of good data per beam-target setup



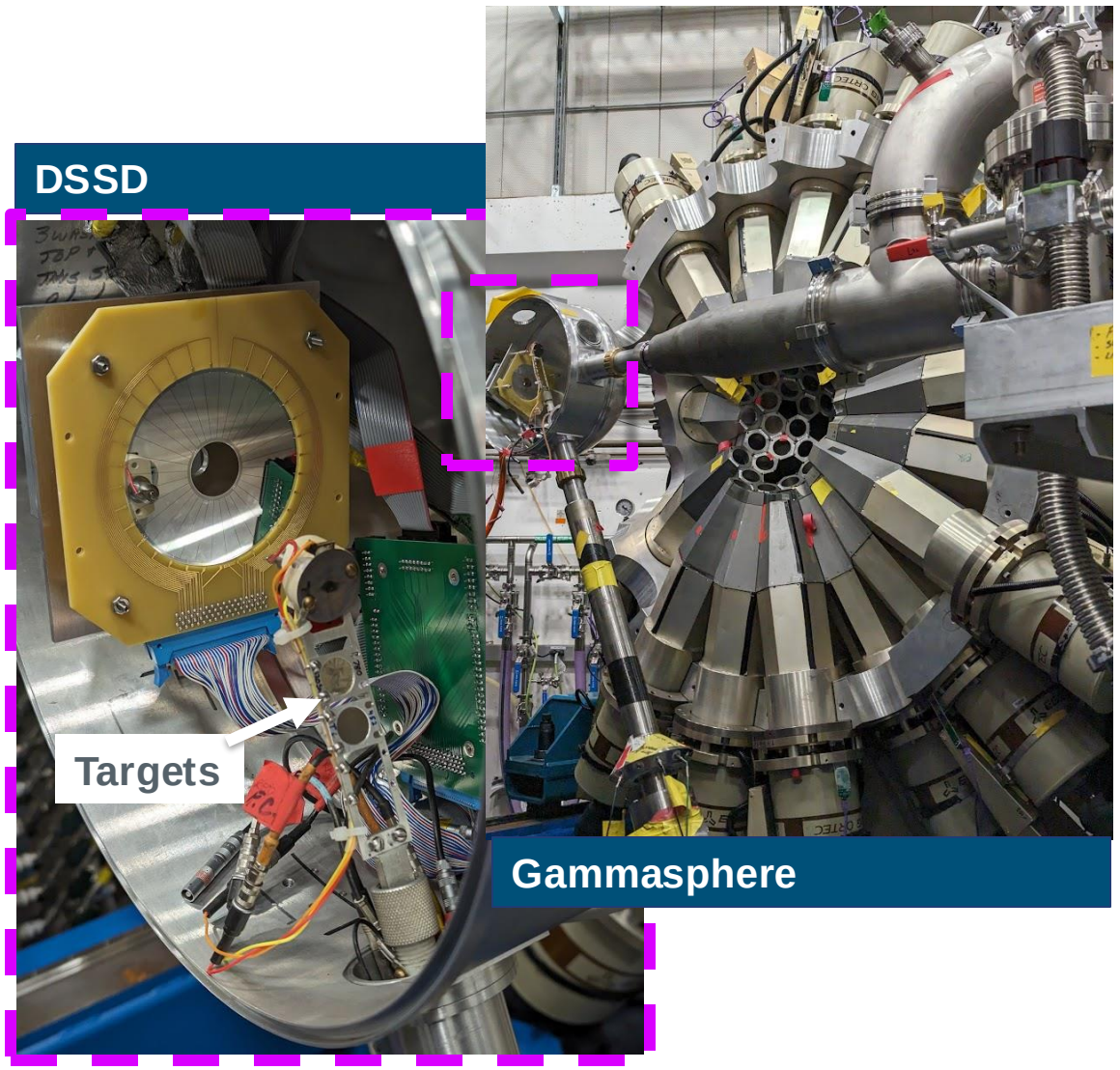
What data did we collect

The Experiment

Two primary devices:

- **Gammasphere**
  (HPGe array for γ-rays)
  position
  energy
  timestamp

- **Micron S3 Dual-sided Si Strip Detector**
  ring/sector #
  'energy'
  timestamp



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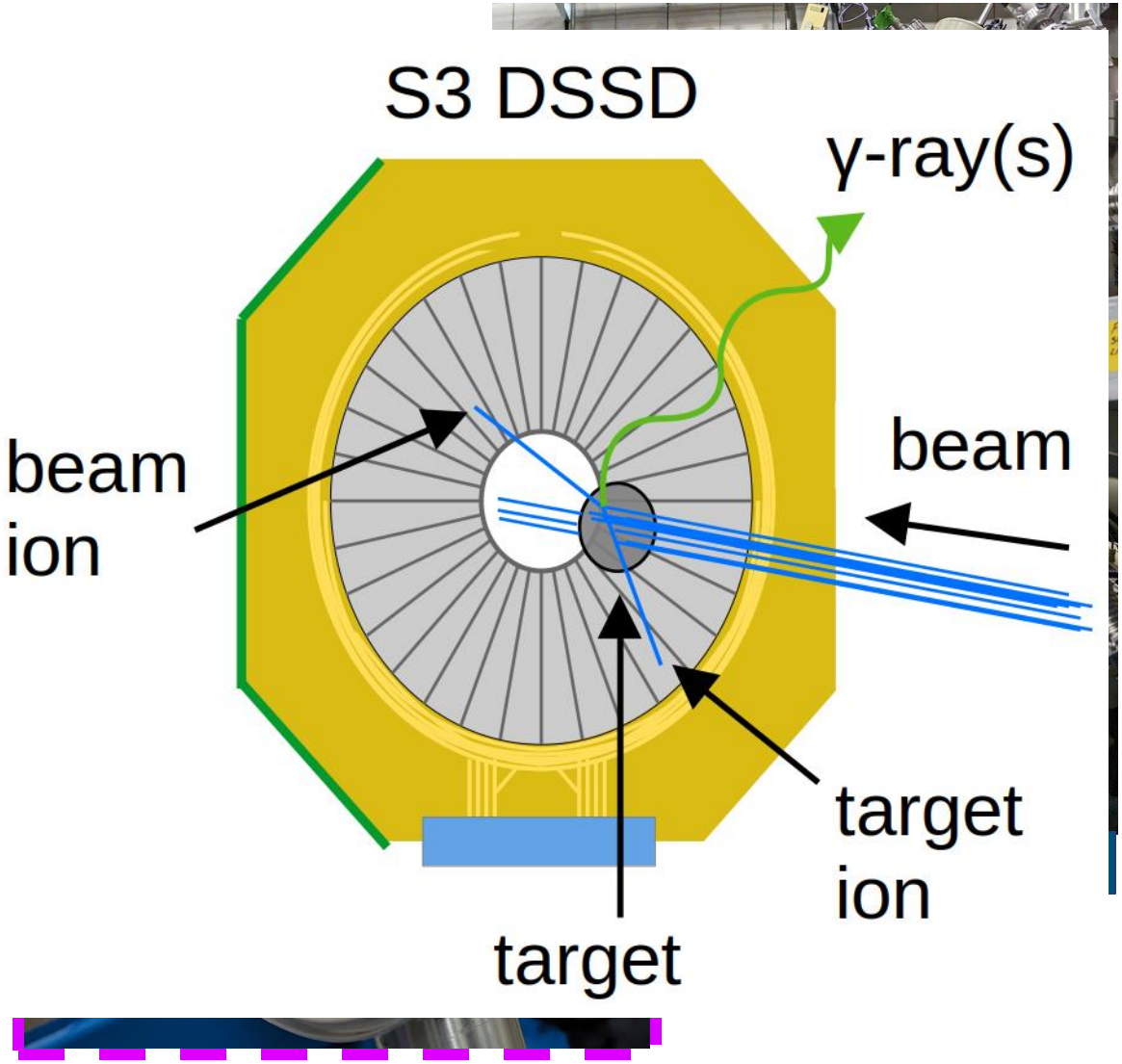
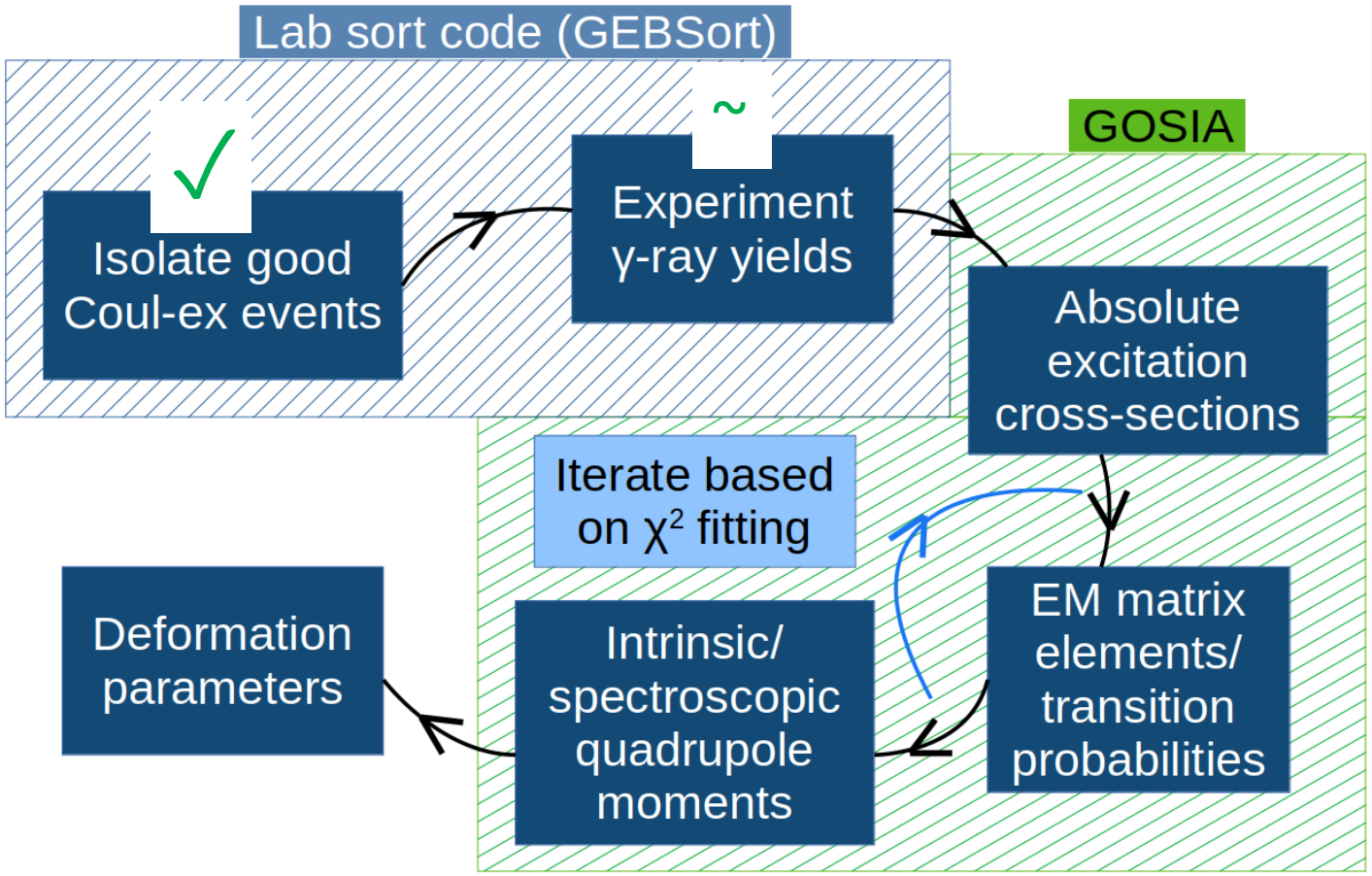


Analysis method

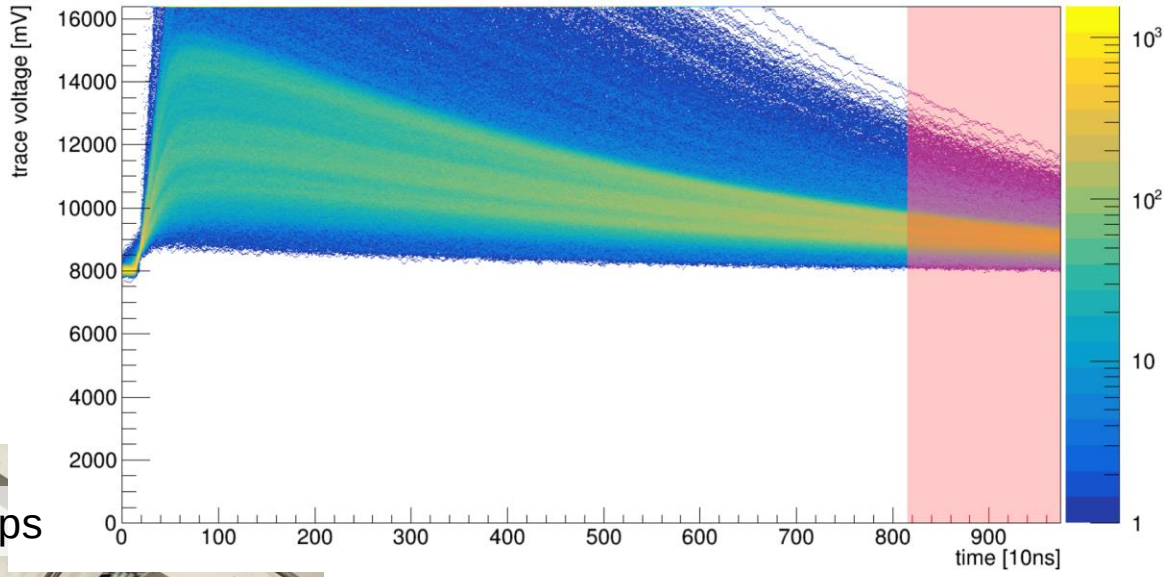
Preliminary Analysis

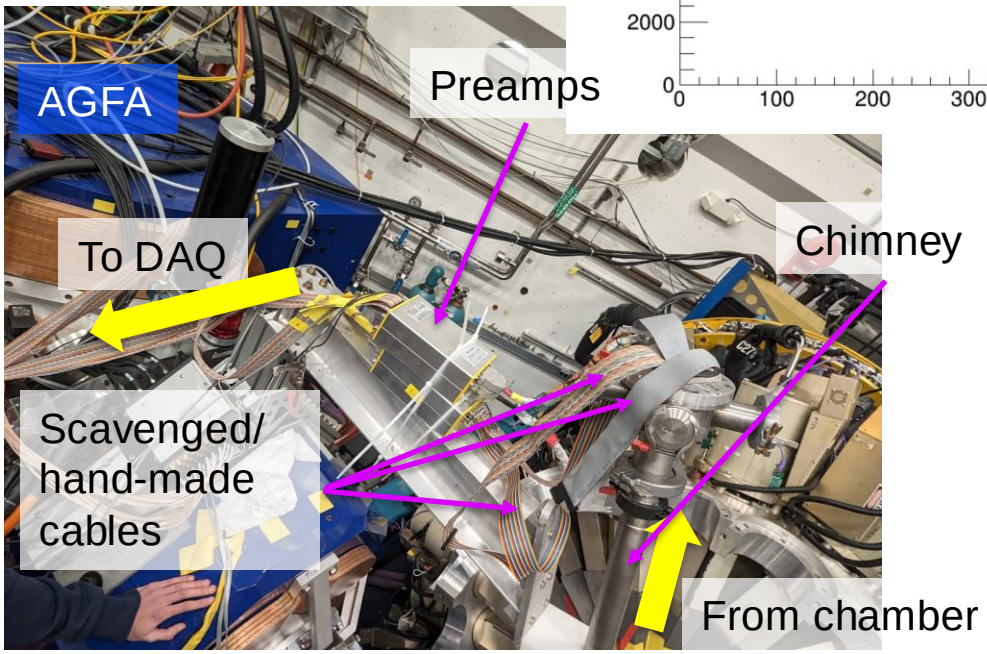


Current state: using DSSD data

Preliminary Analysis

- Experiment electronic setup had issues- missing equipment led to improvisation
- Result is non-standard analysis:

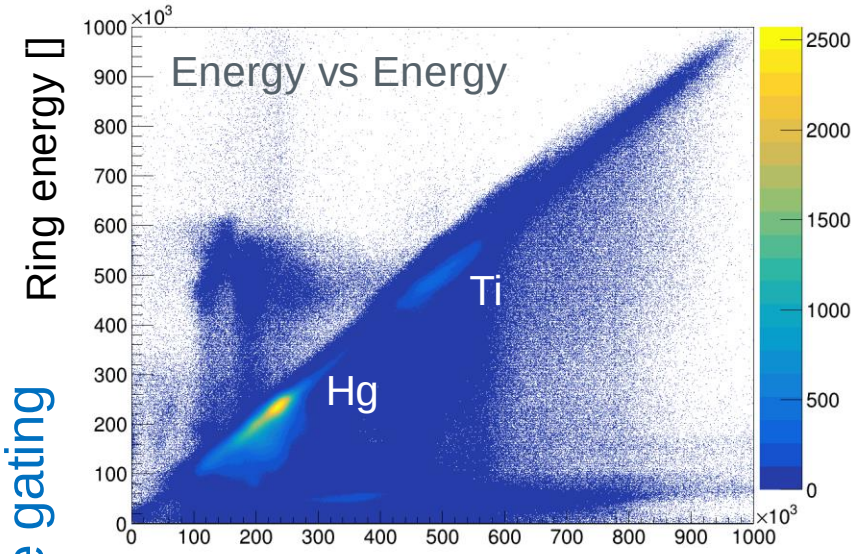


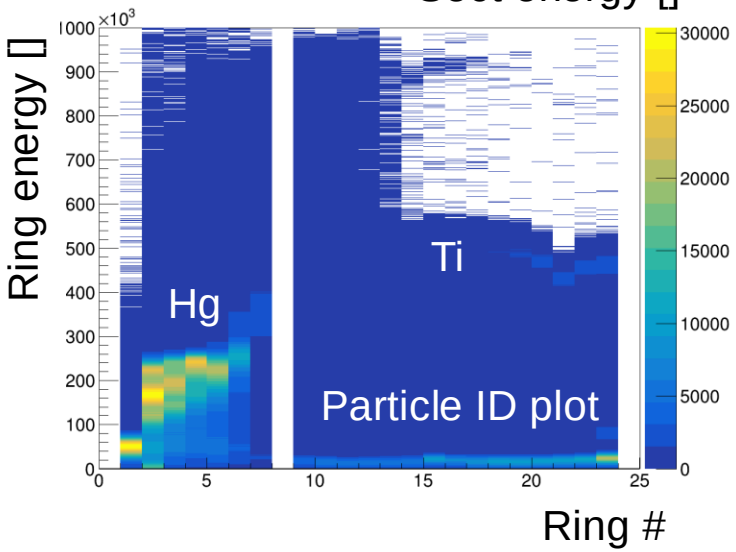


- DSSD signal traces. To get the 'energy' of a hit, its trace is integrated inside of the highlighted window
- Baseline of ~8V

Current State: DSSD hits

Before gating





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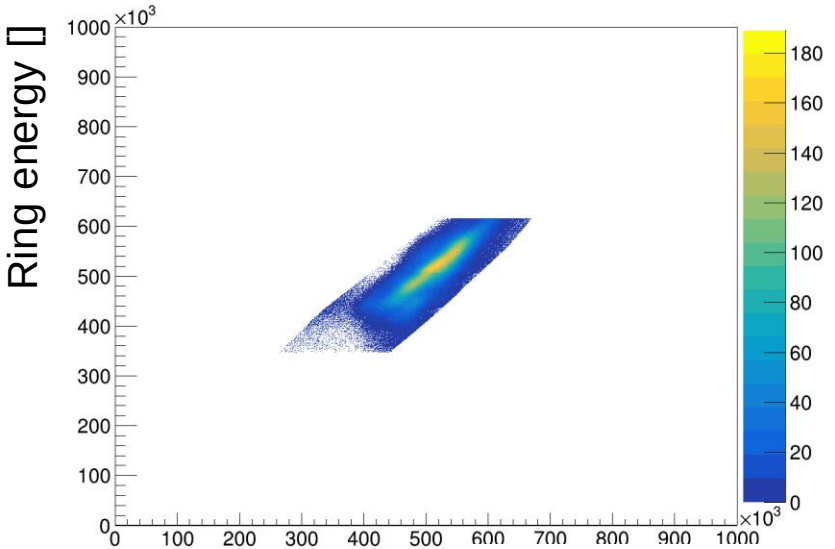

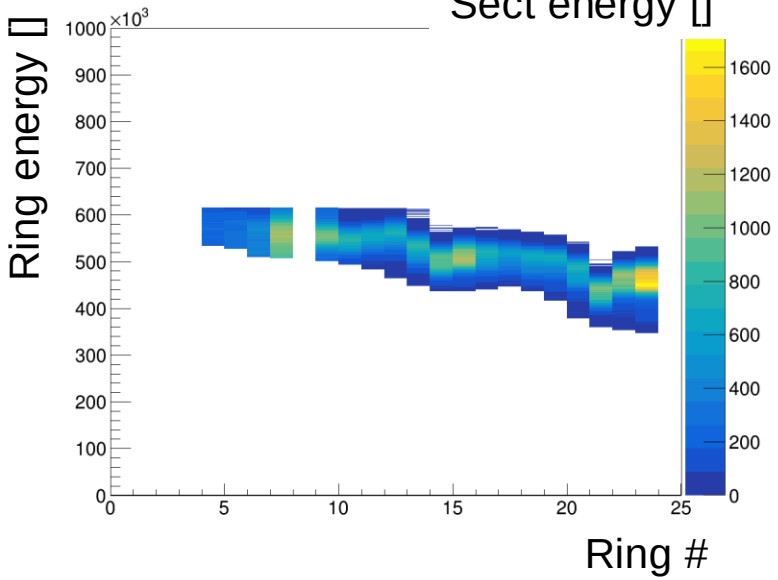

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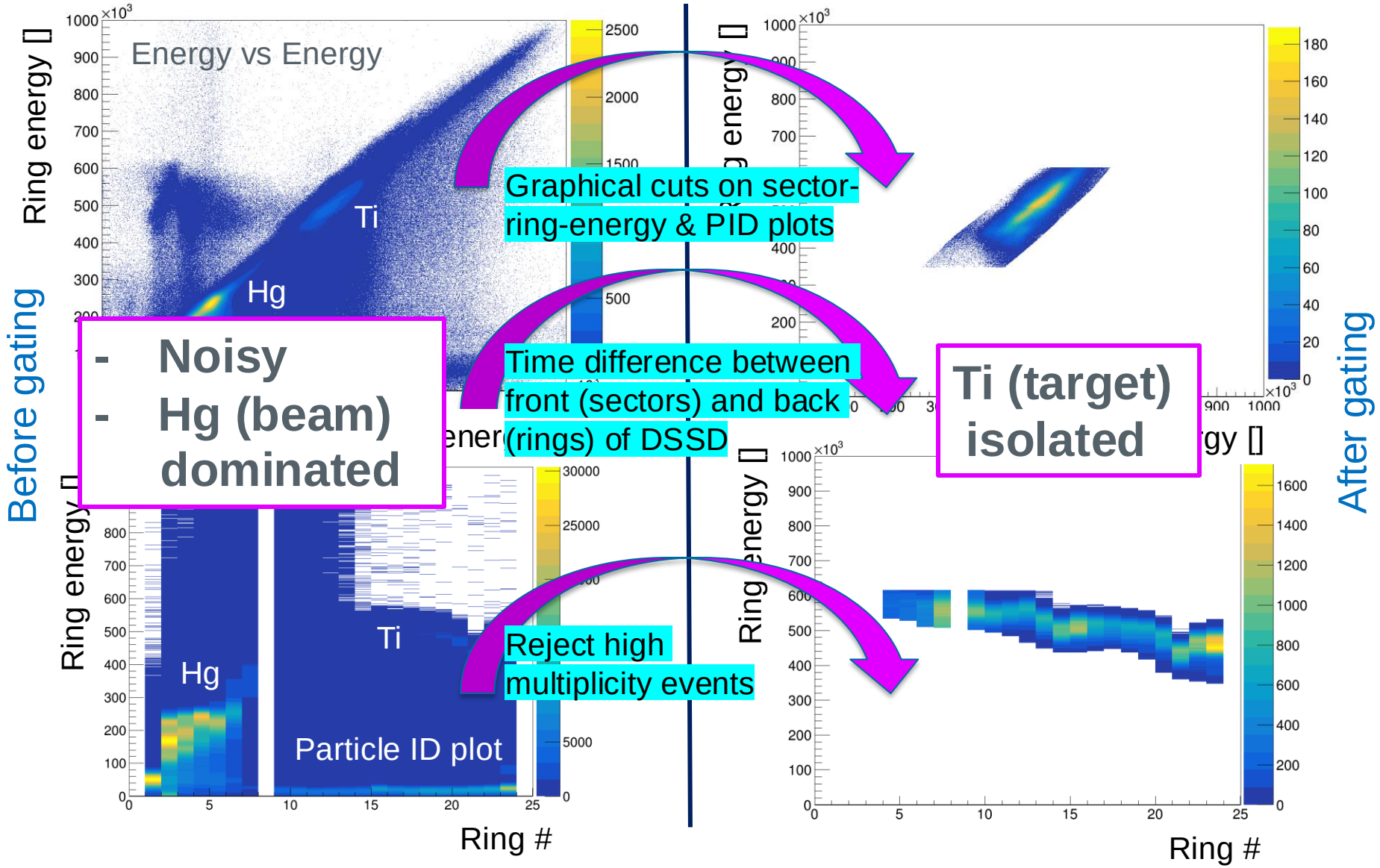
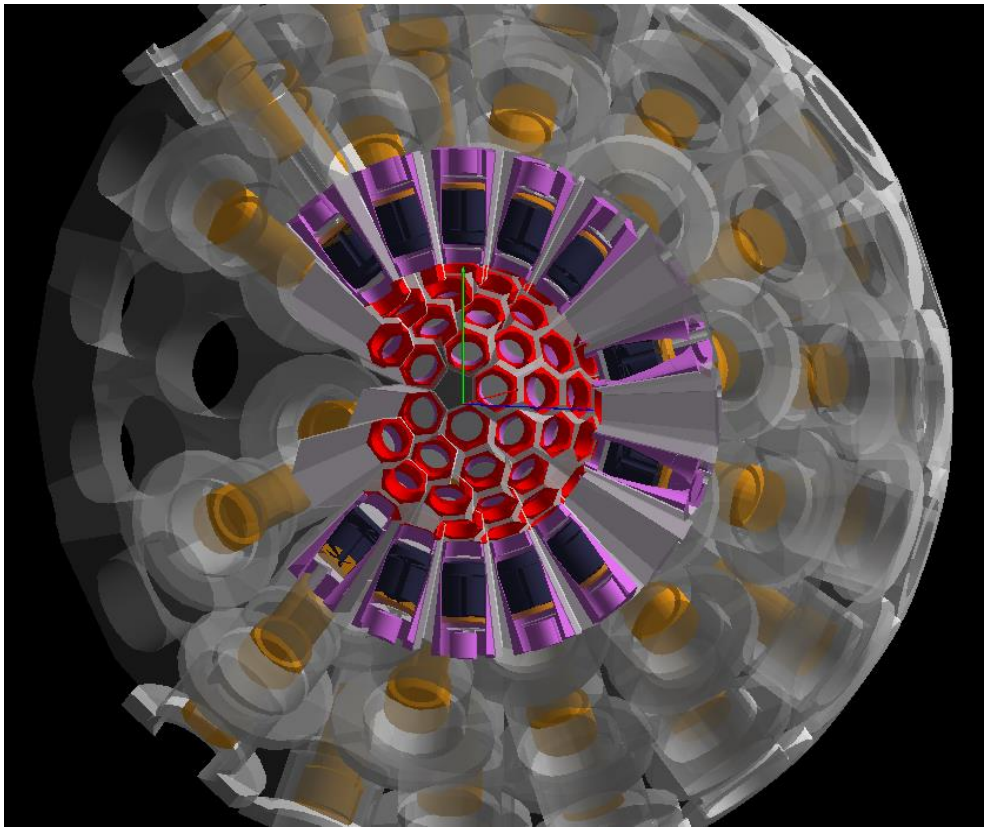


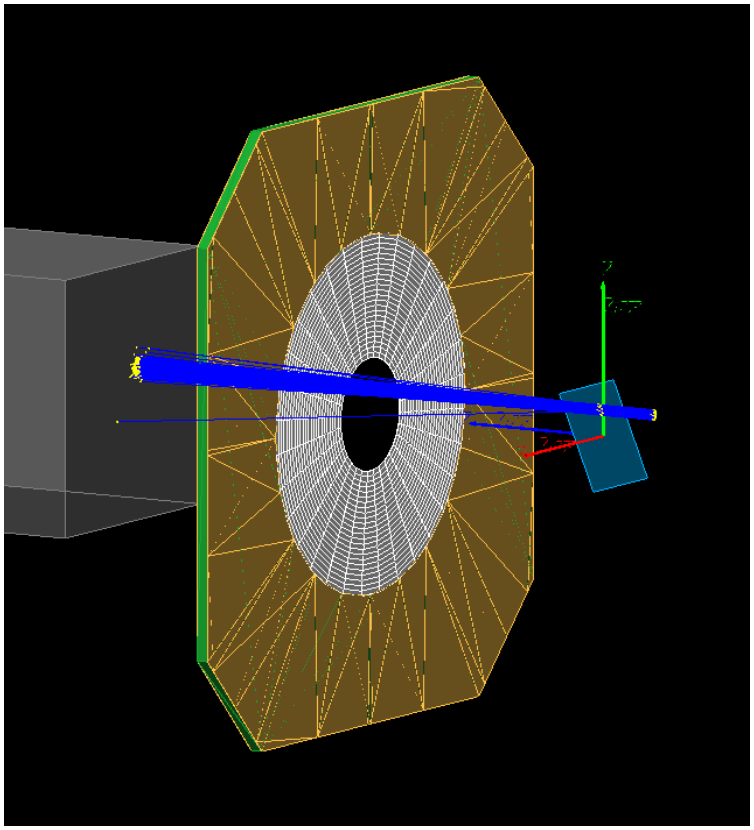
Current state: detector simulation

Geant4 simulations of detectors



Gammasphere HPGe γ-ray detector array

- Estimated absolute efficiency



S3 DSSD charged particle detector

- Estimated hit pattern/beam offset

Current state: detector simulation

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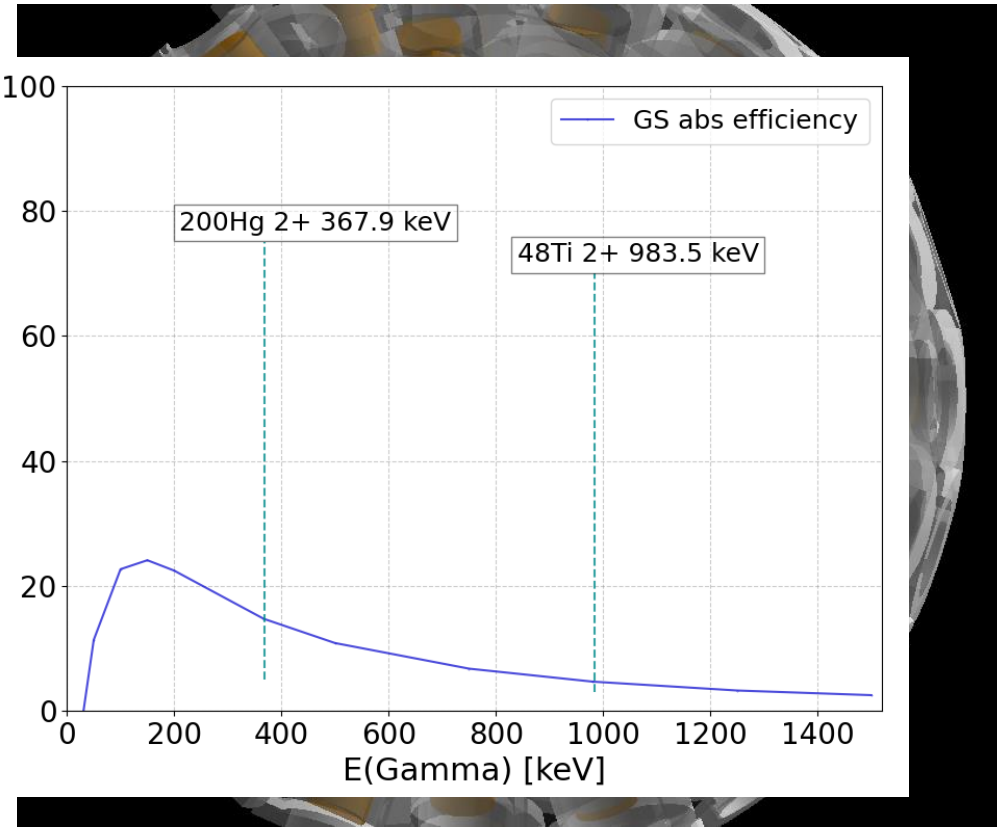

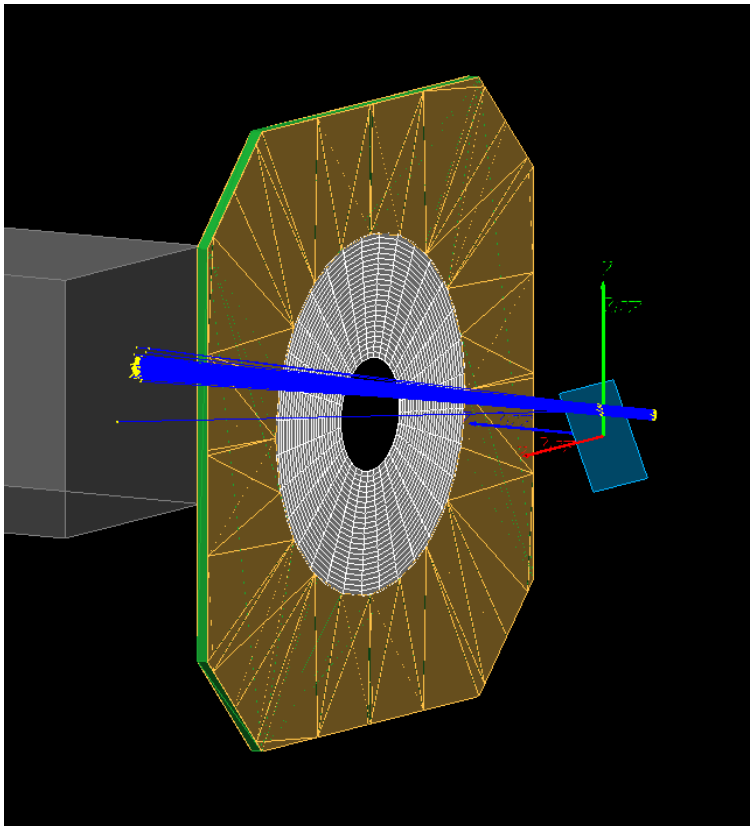

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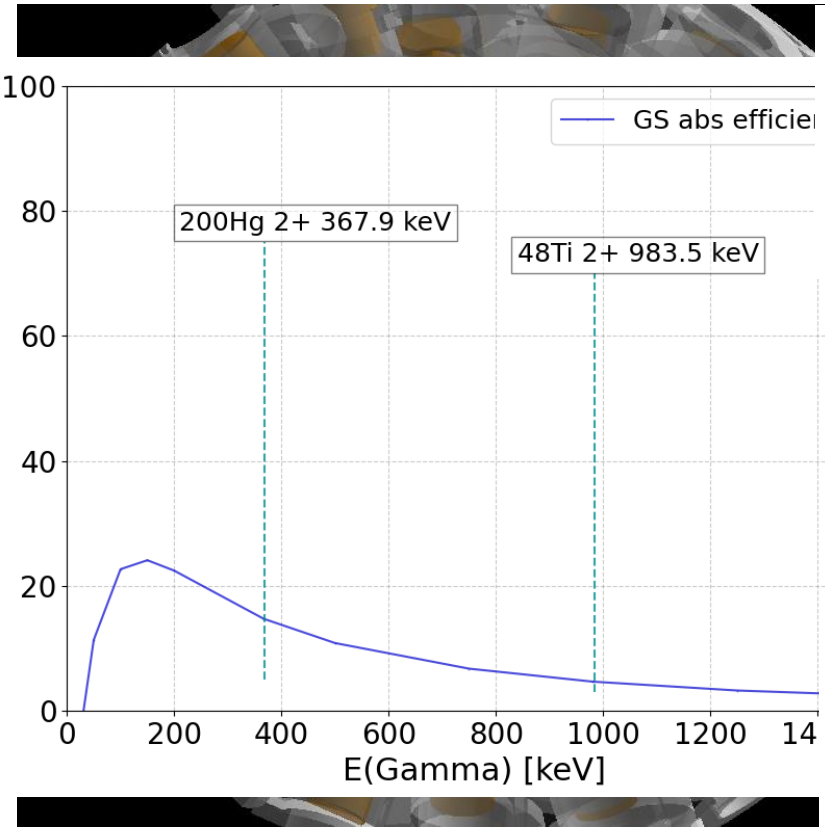

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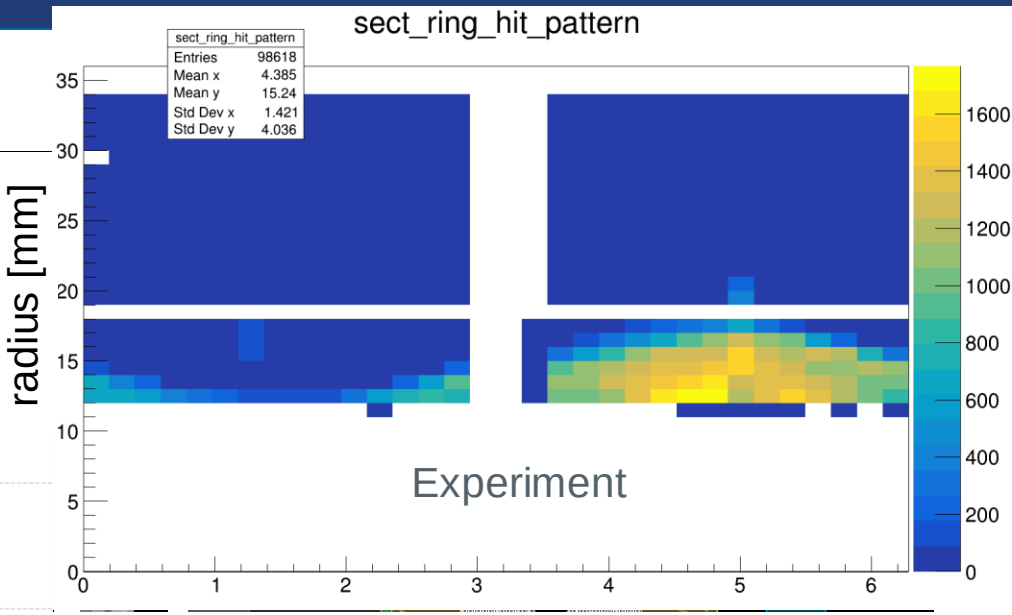
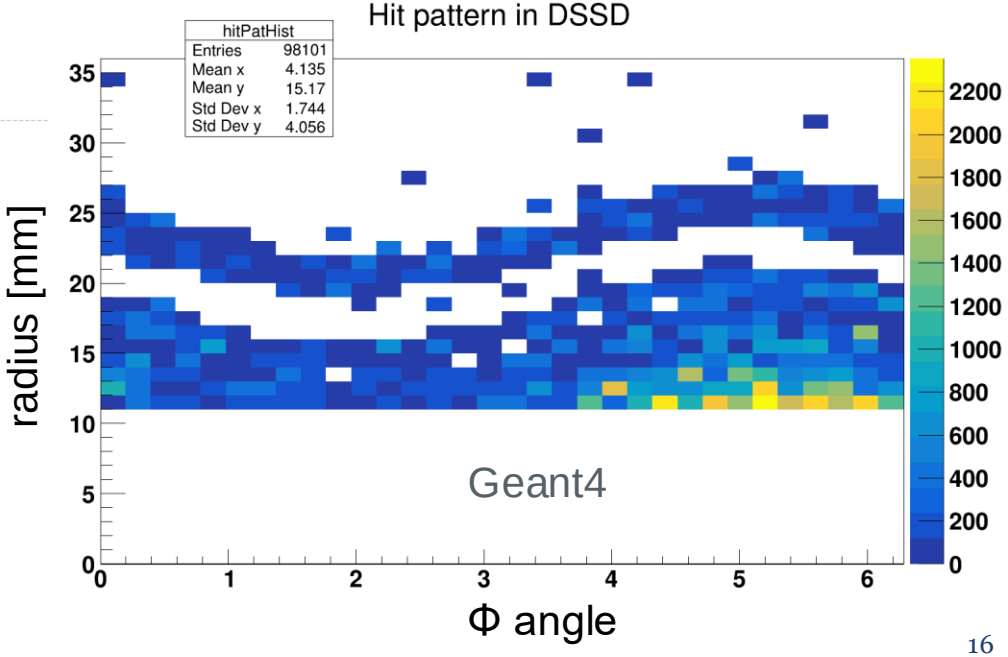
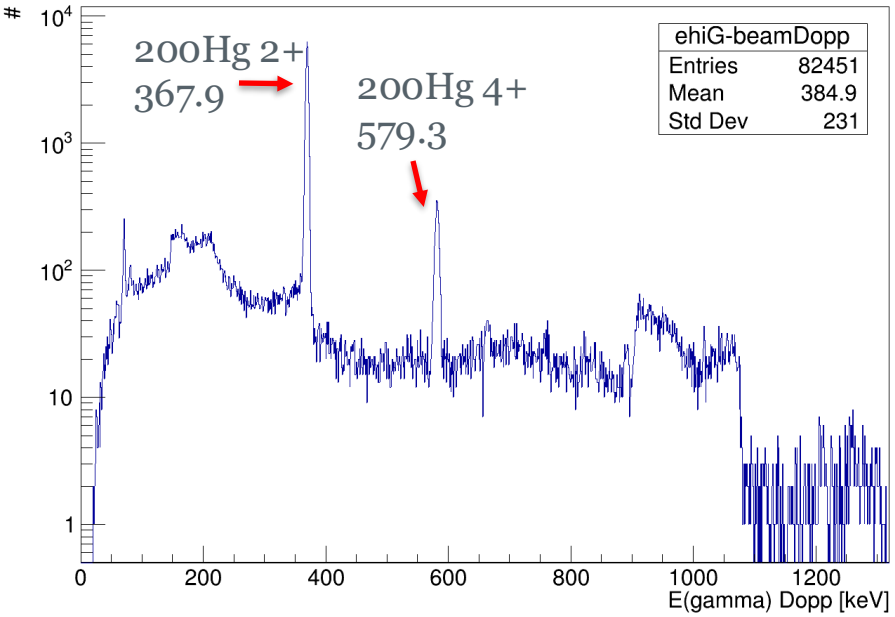




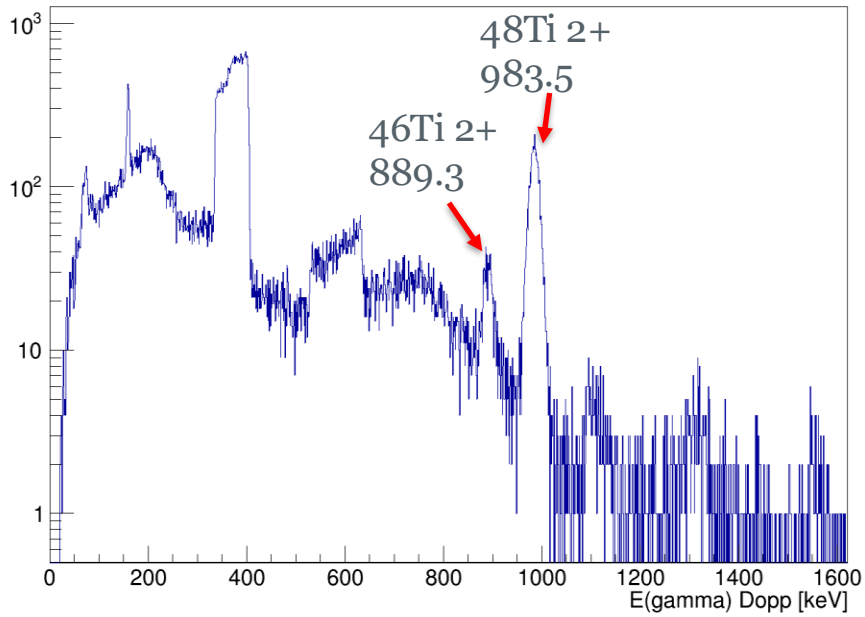
Current State: γ-ray data

Preliminary Analysis

Doppler corrected on **beam** kinematic solution



Doppler corrected on **target** kinematic solution



- Spectra are generated from all 200Hg + nat Ti runs, sum of 74 Gammasphere modules
- Centroid energies in keV from NNDC, NUDAT3
- Other peaks are visible on closer inspection

Summary / Future Work

- 200,202Hg Coulomb excitation experiment was carried out at Argonne National Lab
- Aim is to get new values of the deformation parameters, maybe resolve unphysical cos(3γ)

Next steps

- Create an input for GOSIA for 200,202Hg and iteratively improve it
- 72Se Coulomb excitation experiment @ ISOLDE, CERN

Acknowledgements

Thank you to the following collaborators:

J. Henderson[1], J. Heery[1], C. Müller-Gatermann[2], D. Seweryniak[2], D. T. Doherty[1], R. Russell[1], I. Tolstukhin[2], M. Siciliano[2], C. O'Shea[1], B. Kay[2], P. H. Regan[1,4], N. Sensharma[2], C. Y. Wu[3], A. Ertoprak[2], W. Reviol[2], R. S. Sidyu[5], D. Rhodes[6]

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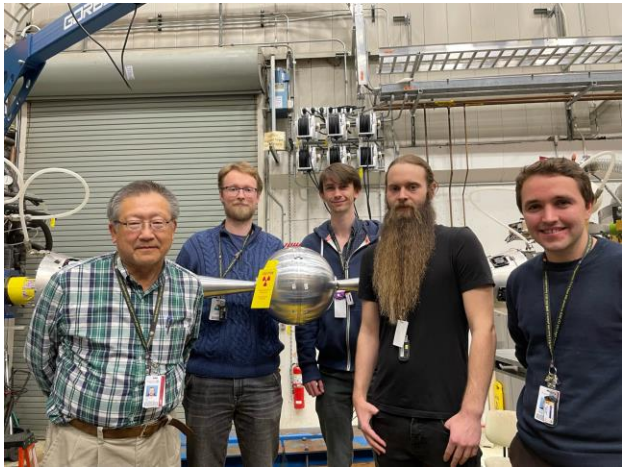
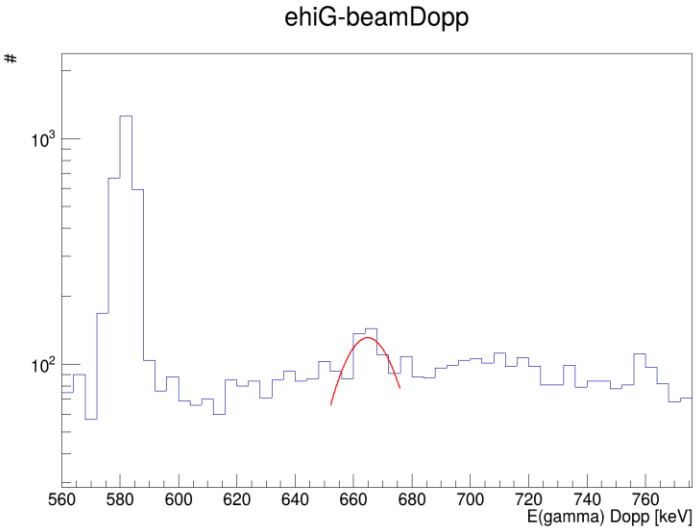
4 National Physical Laboratory, Teddington TW11 0LW, UK
5 School of Physics and Astronomy, University of Edinburgh, EH9 3JZ, UK
6 TRIUMF, 6095 Nurseries Road Vancouver, BC V6T 2A3 Canada

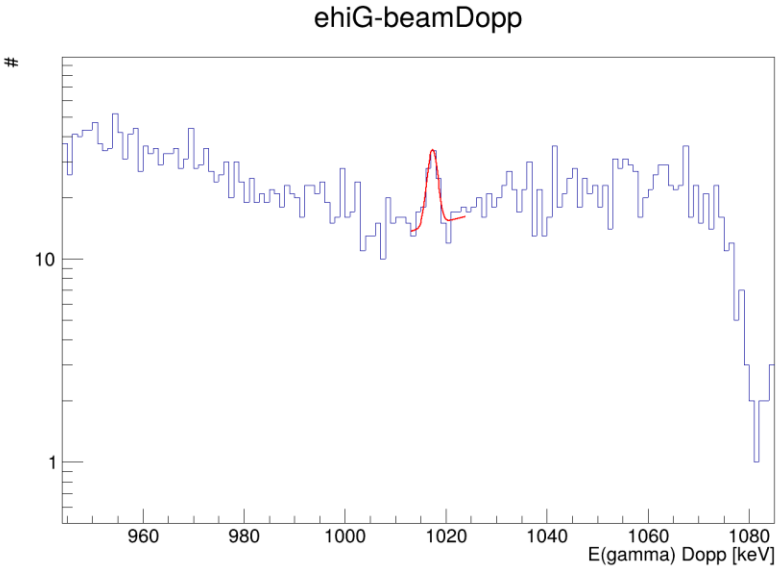
Also, the technical staff and beam operation team at ATLAS, Argonne National Laboratory



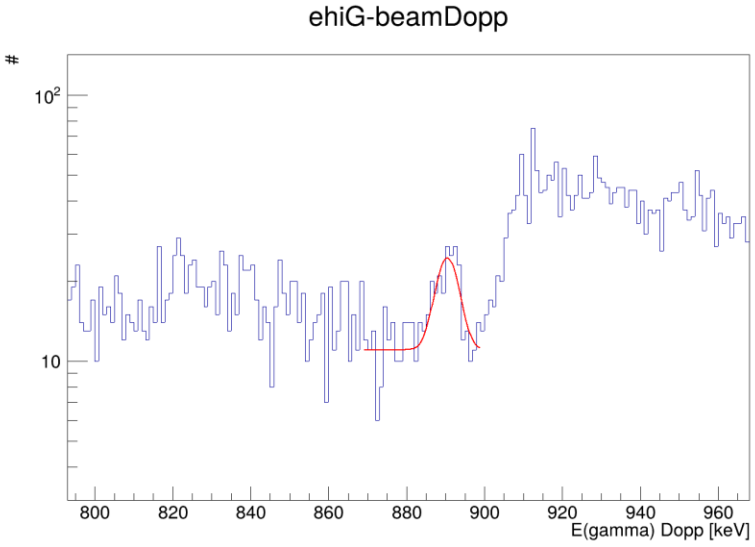
Extra γ-rays



2nd 0+ → 1st 2+: 661.36 keV
Fit: 664.8



2nd 0+ → 1st 0+: 1029.35
Fit: 1017.3



2nd 2+ → 1st 2+: 886.2 keV
Fit: 890.4