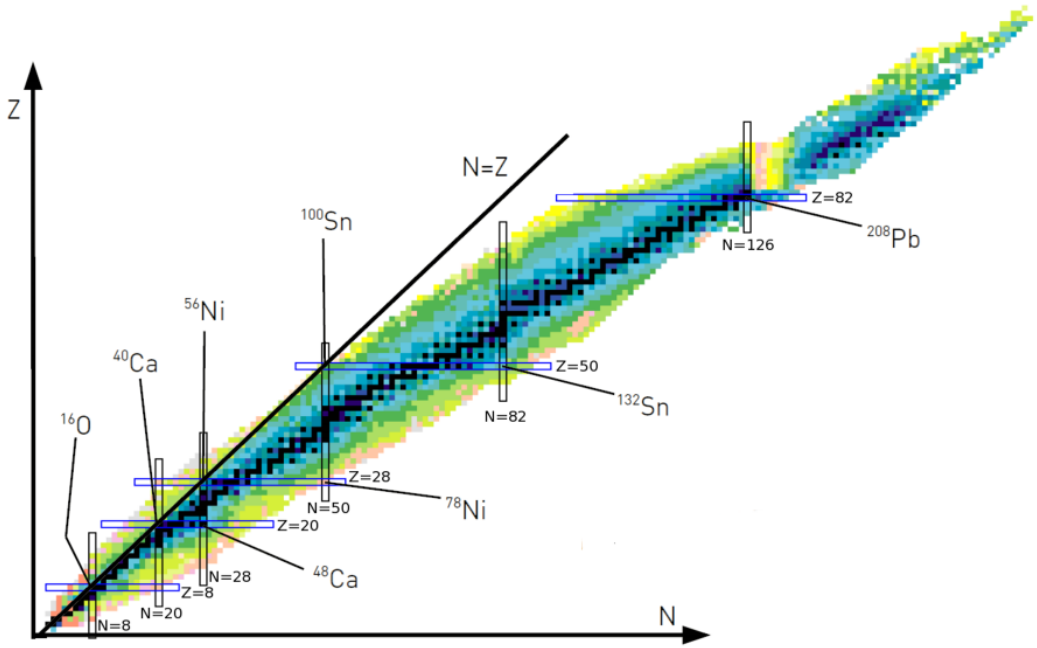
Exploring Mirror Asymmetry with ^{55}Ni and ^{55}Co.

Heinz Asch

Department of Physics, Simon Fraser University
for TIP/TIGRESS collaboration

Motivation


Z
N
N=Z
^{100}Sn
^{56}Ni
^{40}Ca
^{16}O
^{48}Ca
^{78}Ni
^{132}Sn
^{208}Pb
Z=82
N=126
Z=50
N=82
Z=28
N=50
Z=20
N=28
Z=8
N=20
N=8

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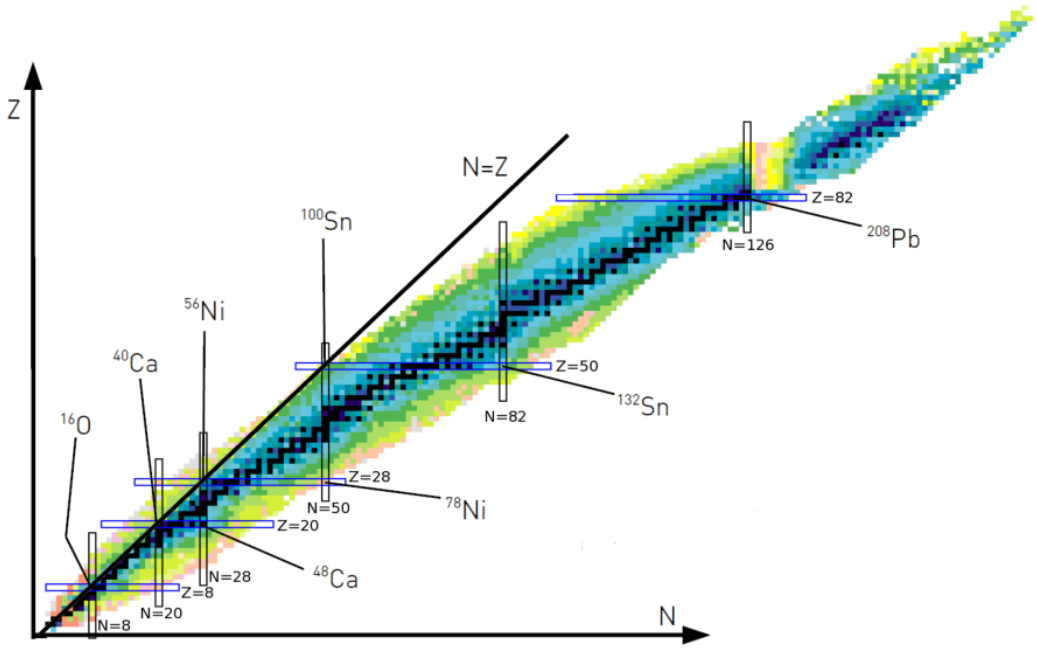

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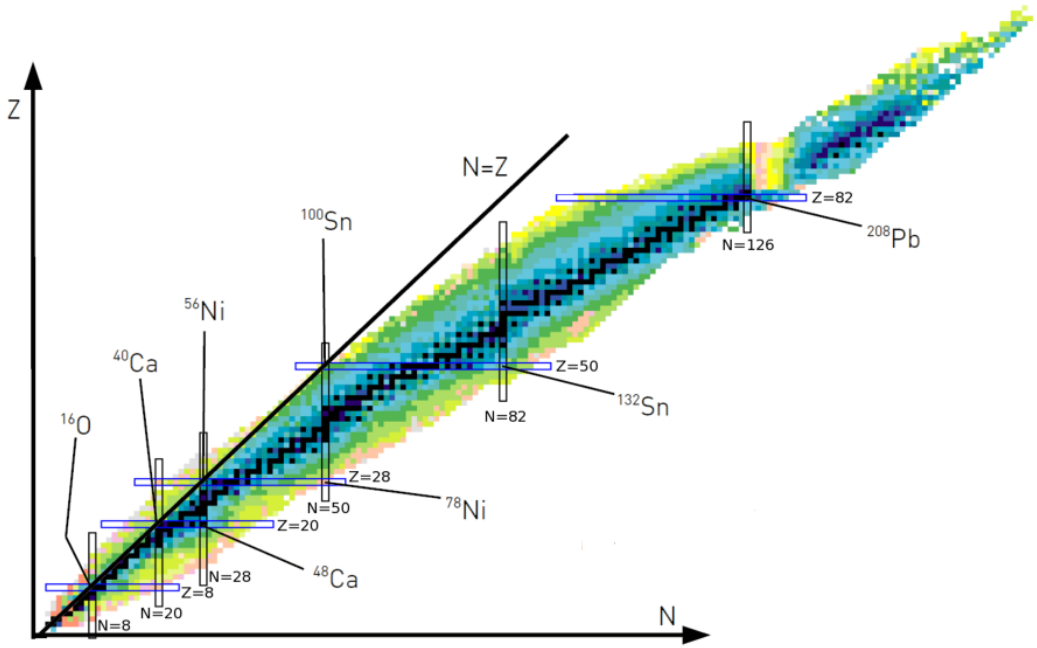

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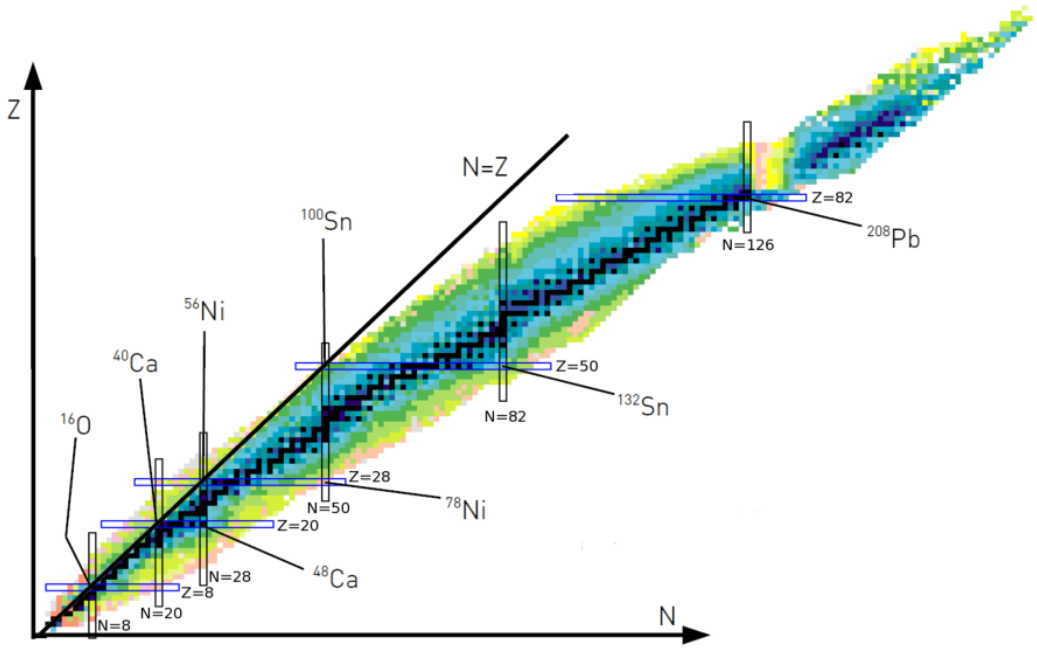

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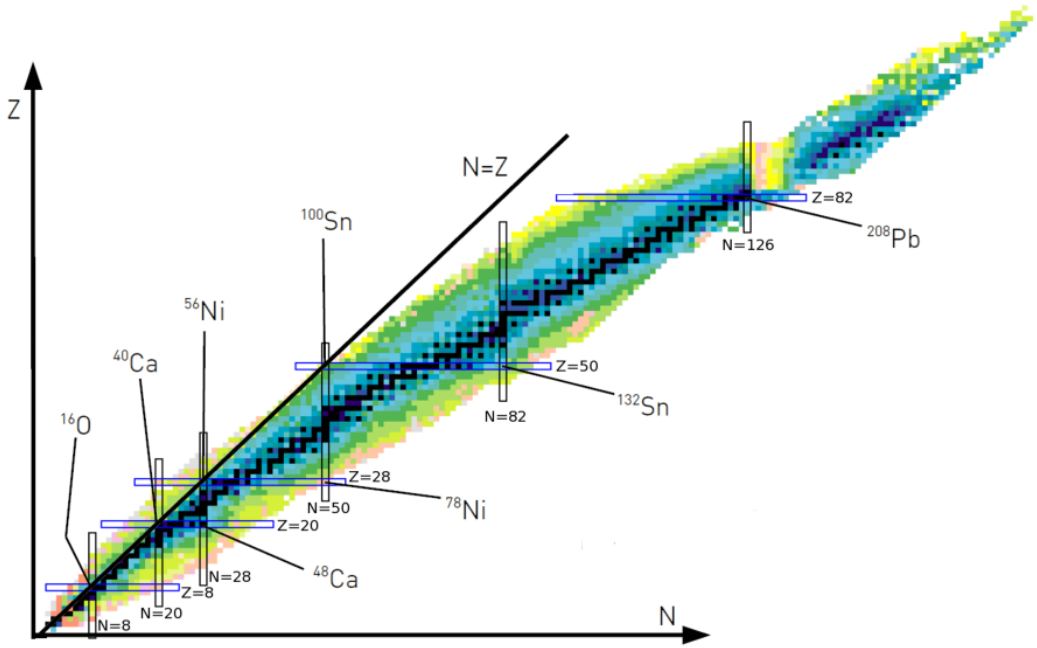

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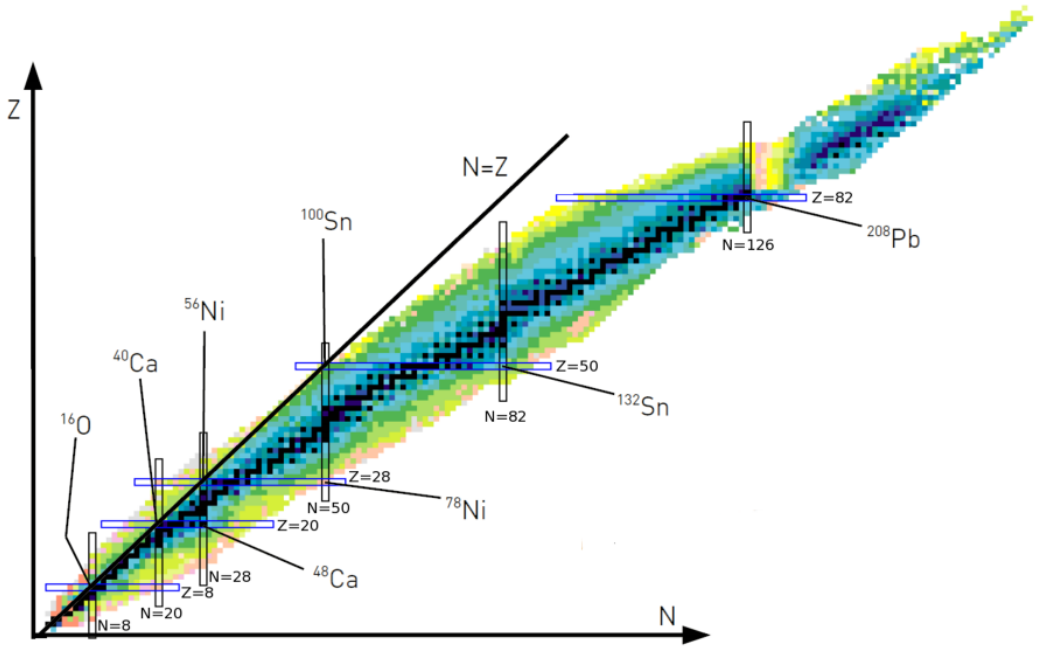

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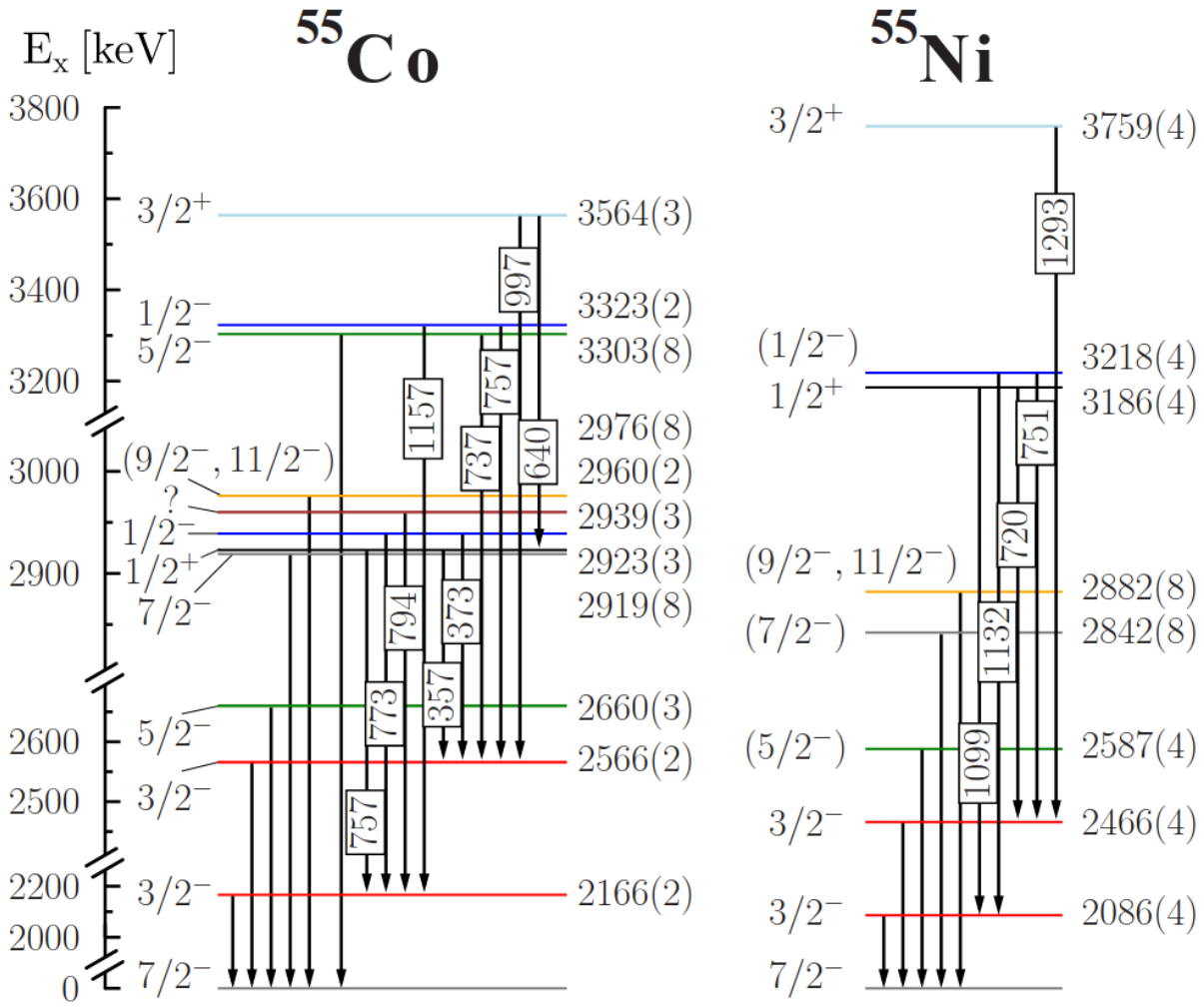
  - Isospin-nonconserving interactions break this mirror symmetry.

Mirror Asymmetry



Spieker et al., Physical Review C, 2019

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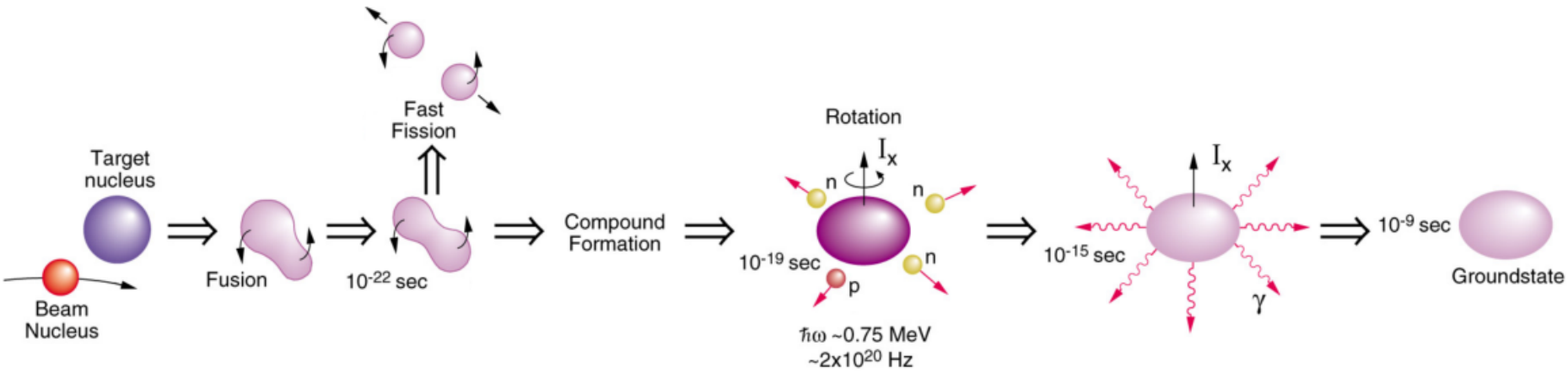
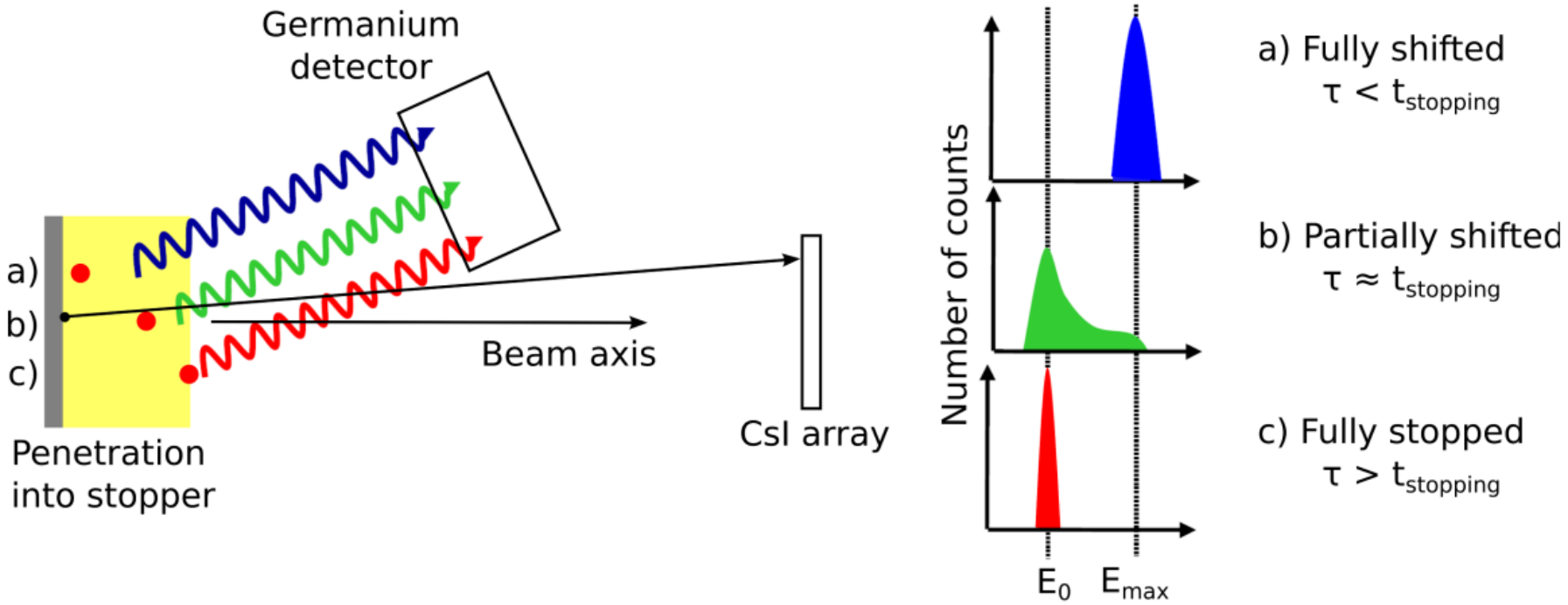
- Electromagnetic transition rates in ^{55}Ni and ^{55}Co will be measured and compared using Doppler-Shift lifetime measurements implemented using TIP and TIGRESS facilities.

Fusion Evaporation



Doppler-Shift Attenuation Method



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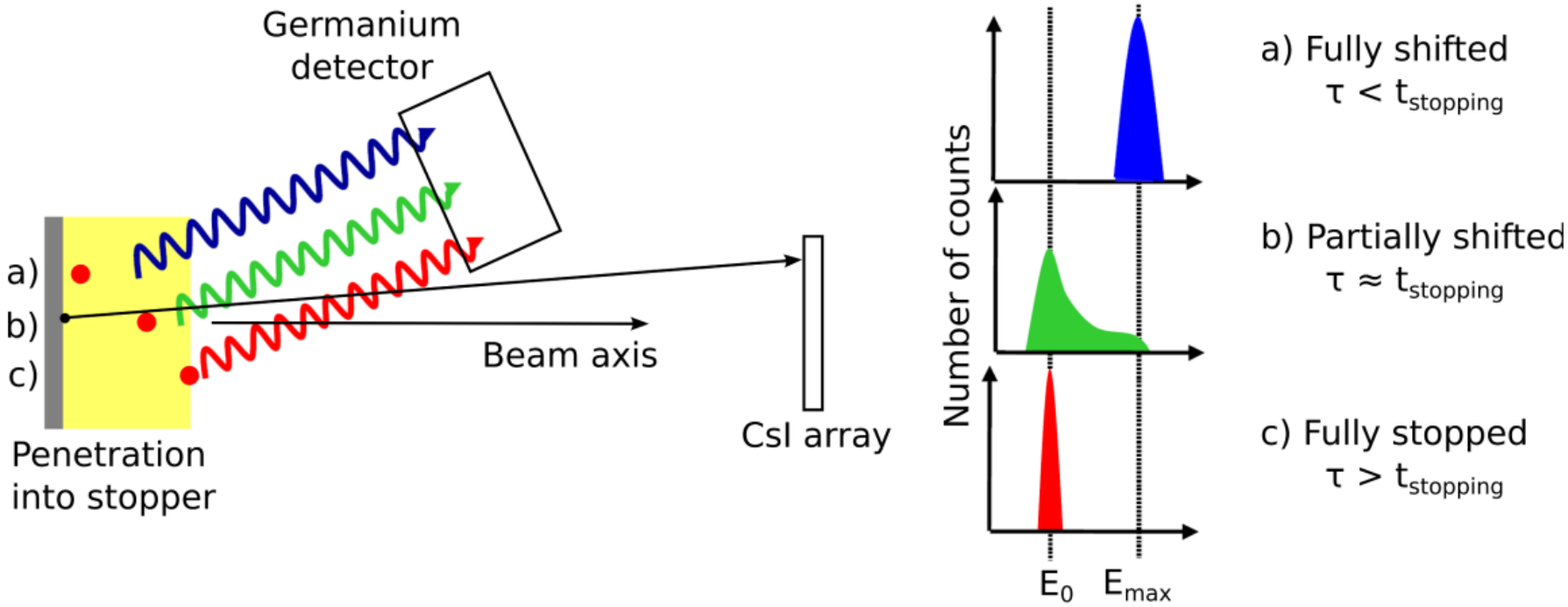

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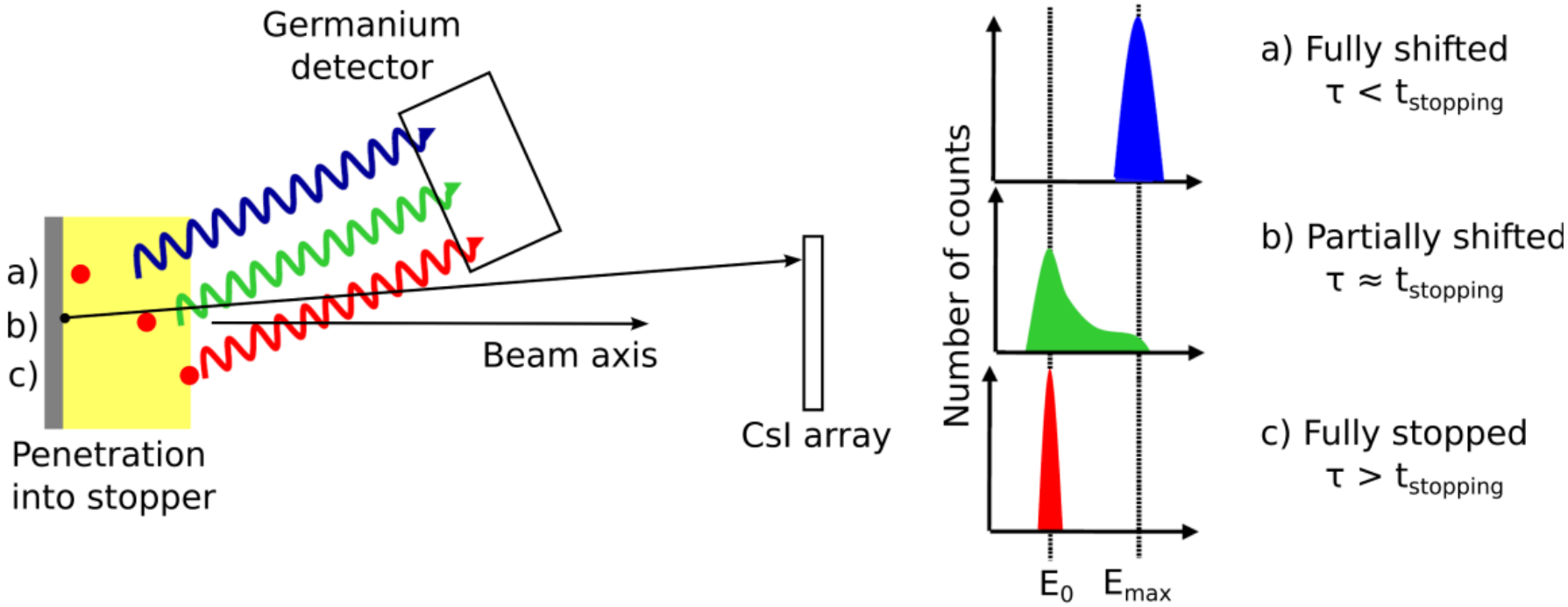

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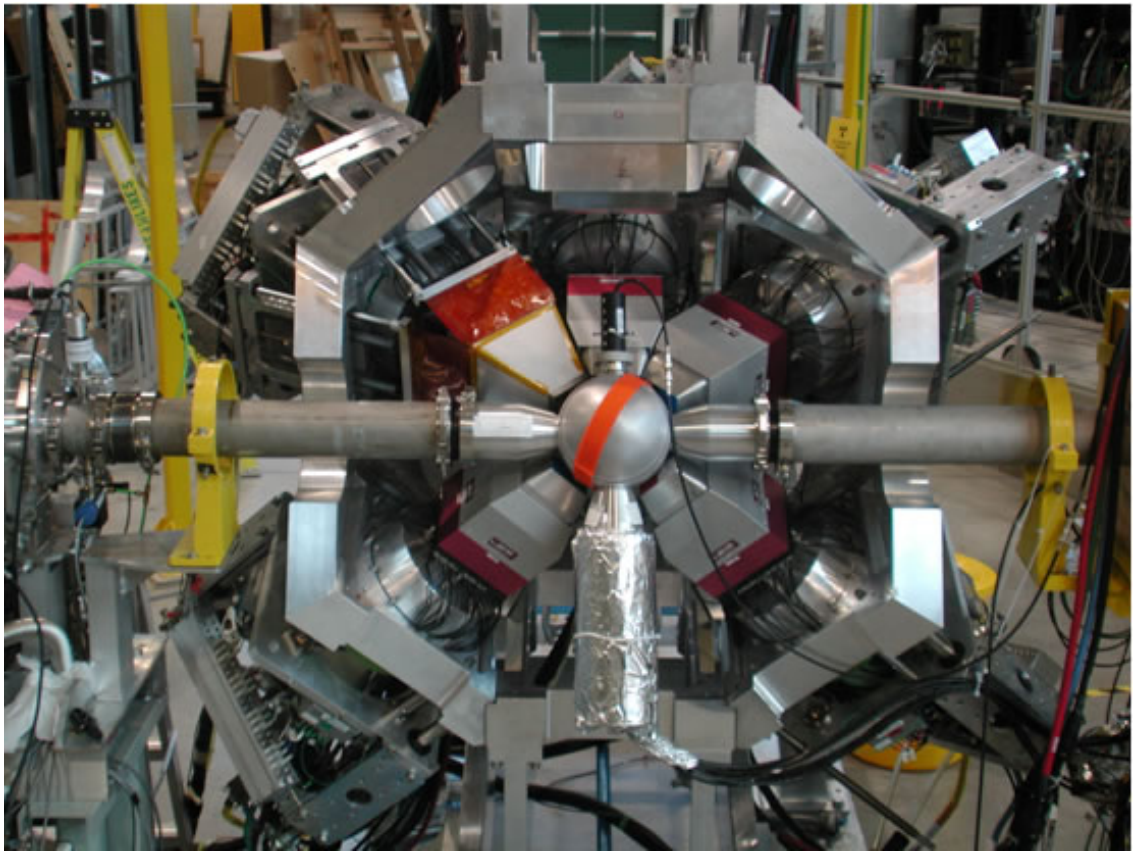
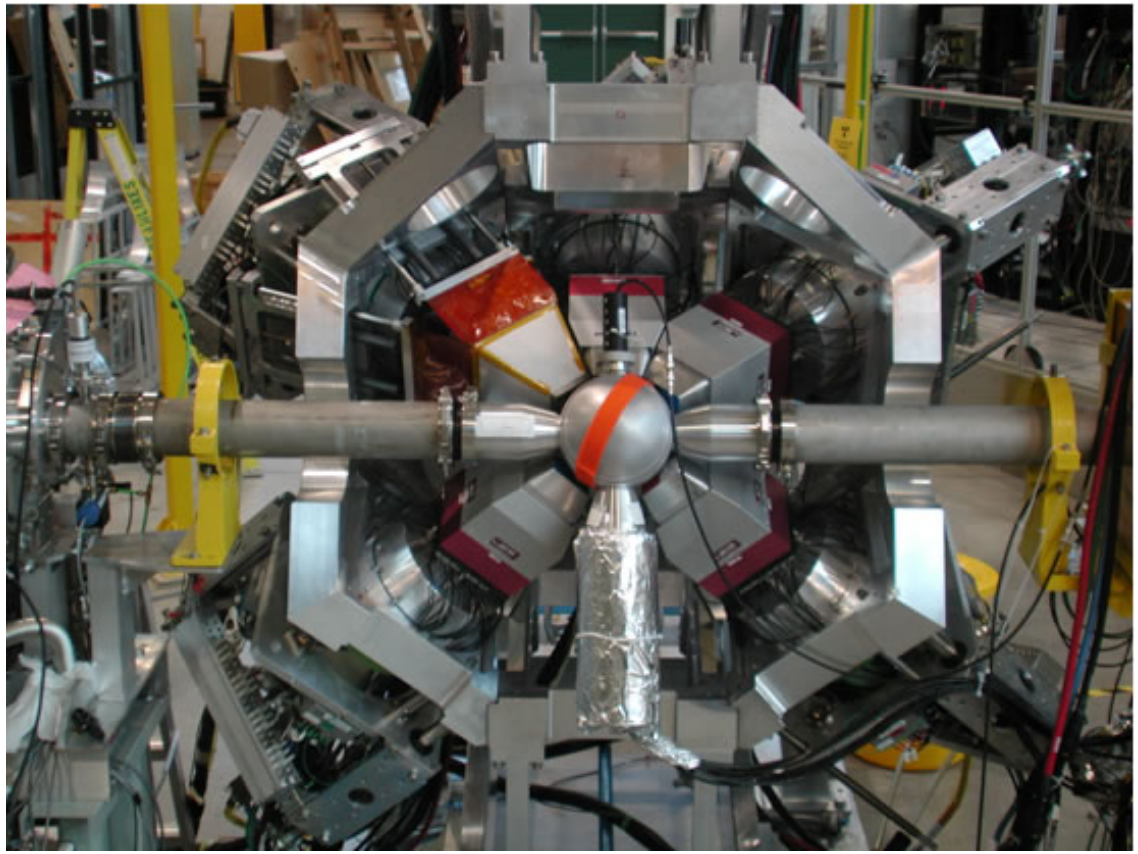
- Nucleus of interest recoils into target backing to slow.
- Higher density backing for shorter lifetimes or higher velocities.



- State-of-the art gamma-ray spectrometer.



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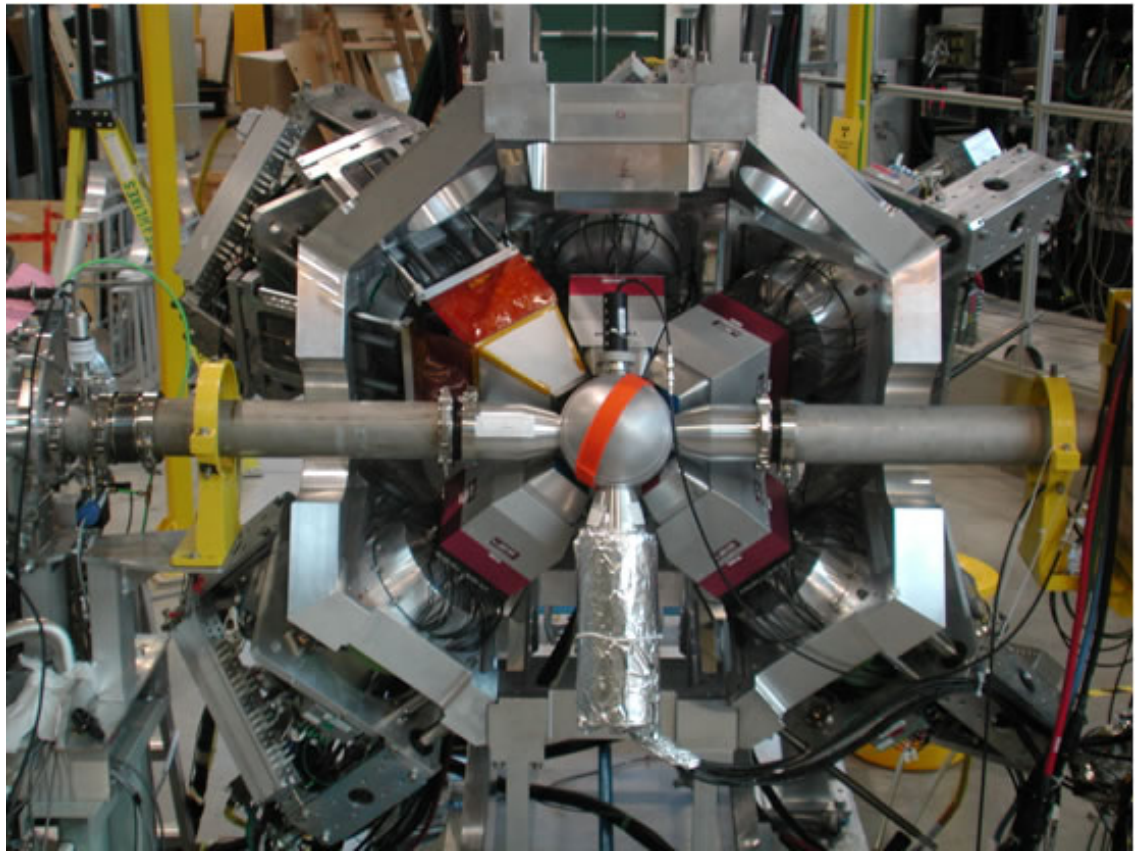

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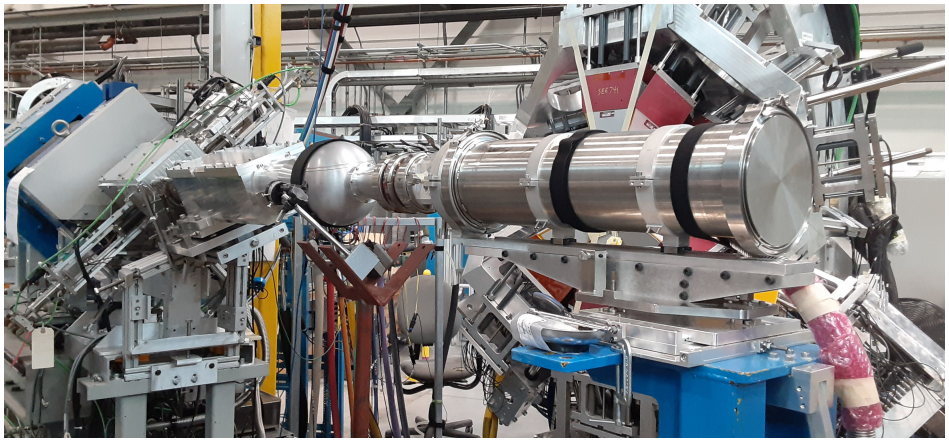
- Operational with auxiliary detectors: SPICE, SHARC, BAMBINO, DESCANT, and TIP.

TIGRESS Integrated Plunger



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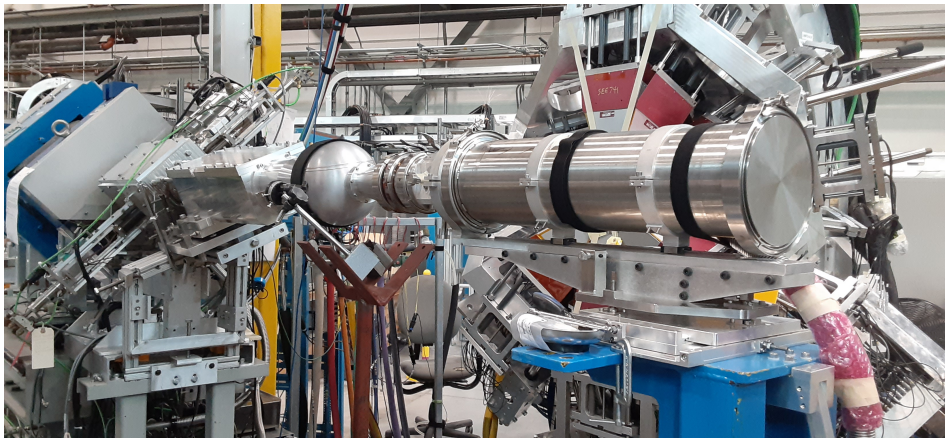

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  - Uses 2mm and 5mm apertures and a scintillating phosphor target for tuning.

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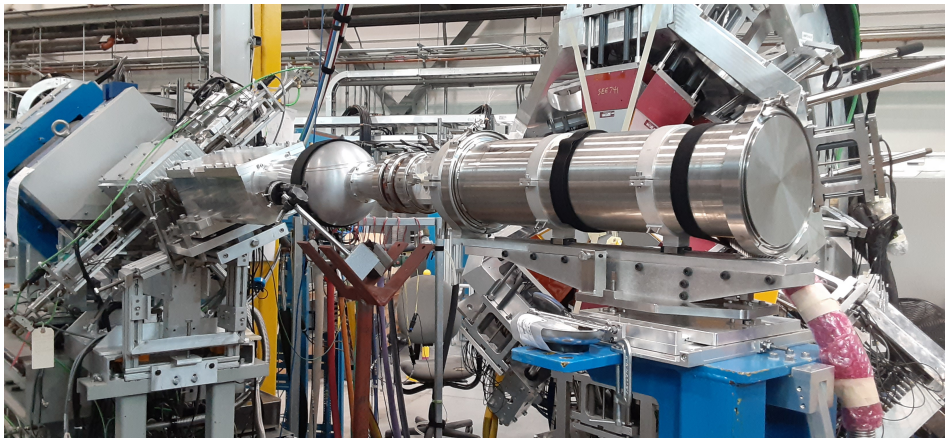

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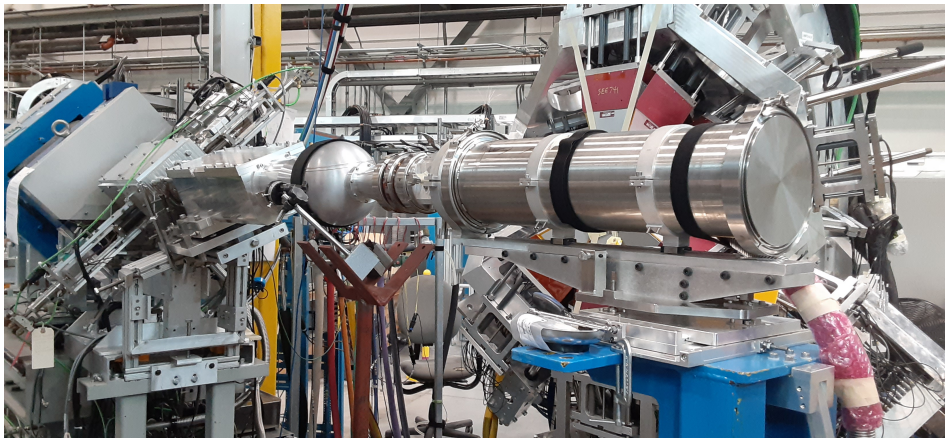

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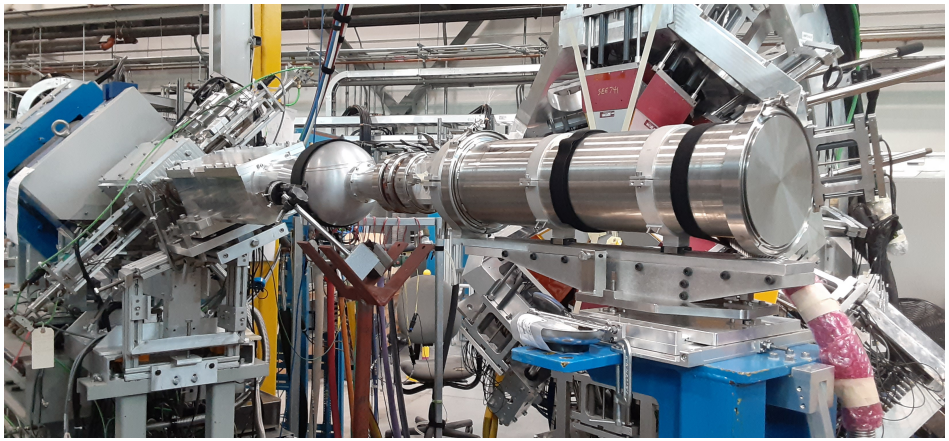

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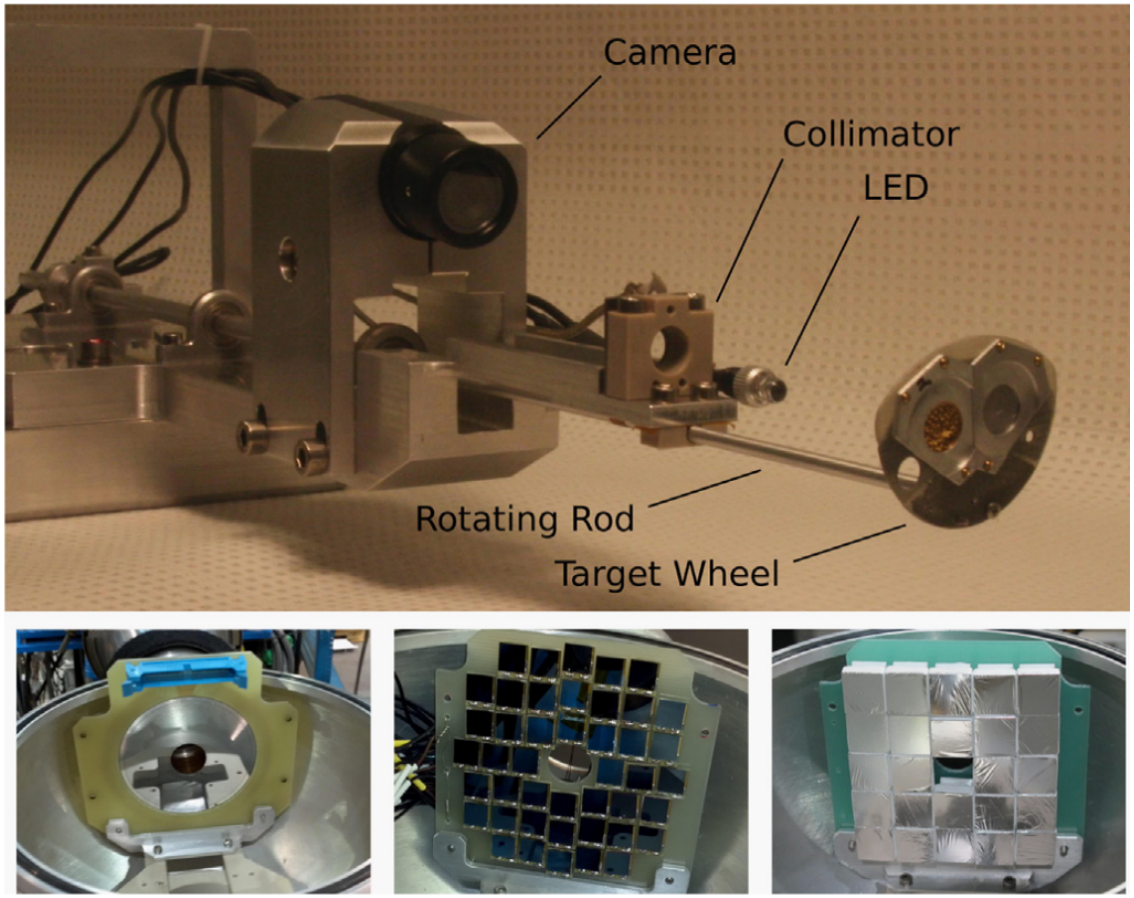
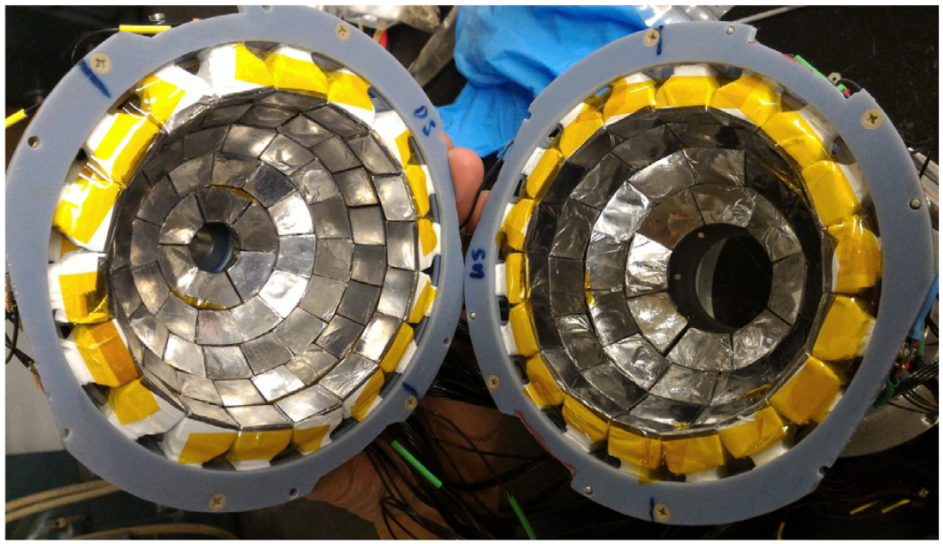
- RDM Plunger
  - Uses a capacitance feedback loop to actively monitor and control the size of the target/stopper gap for recoil in-flight decay.

Target Wheel and TIP Accessories



- Top: target wheel.
- Bottom: the S3-type annular silicon detector (left), the silicon PIN diode wall (middle), and the CsI(Tl) scintillator wall (right)

Cesium Iodide Ball



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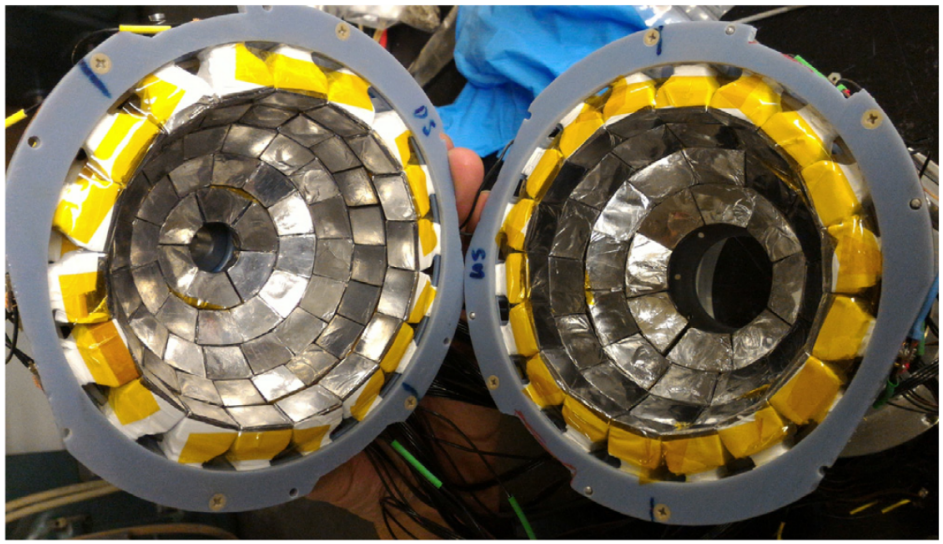

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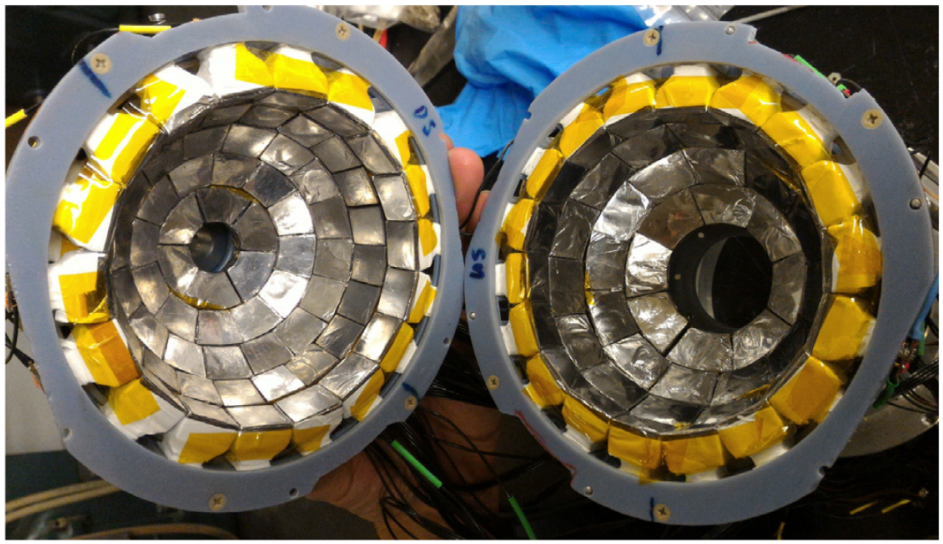

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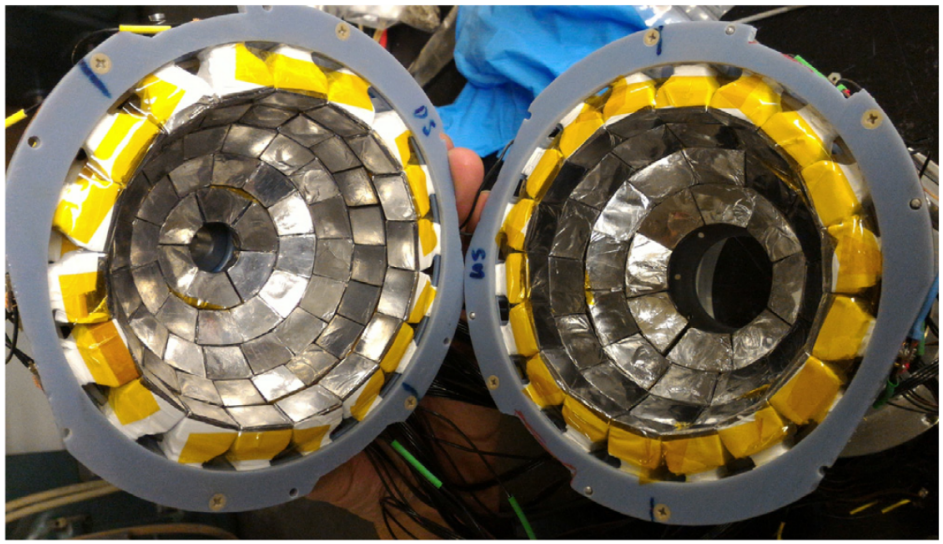

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- Products tend to be Lorentz boosted toward forward angles.

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  - Lifetimes via DSAM

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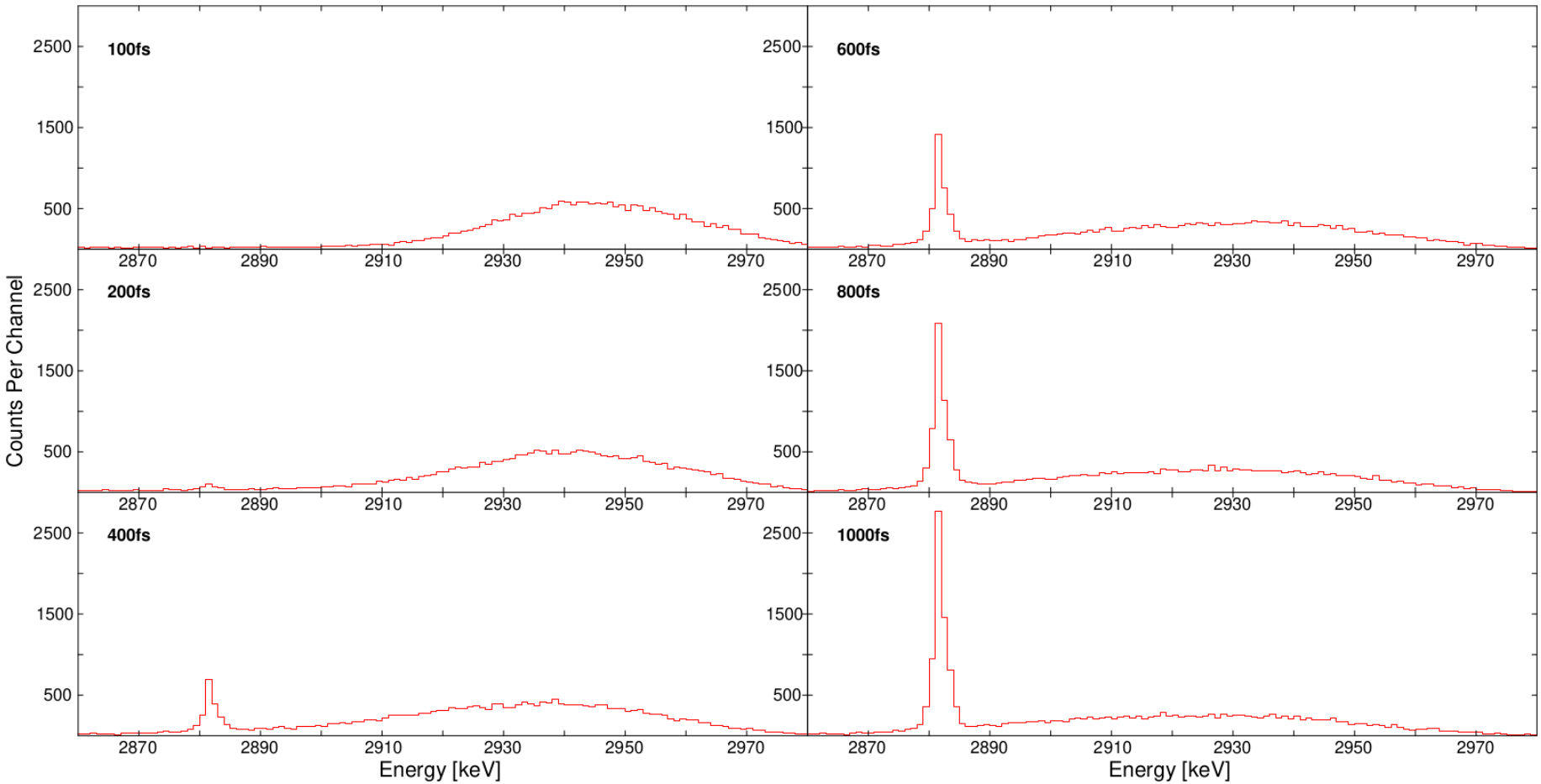
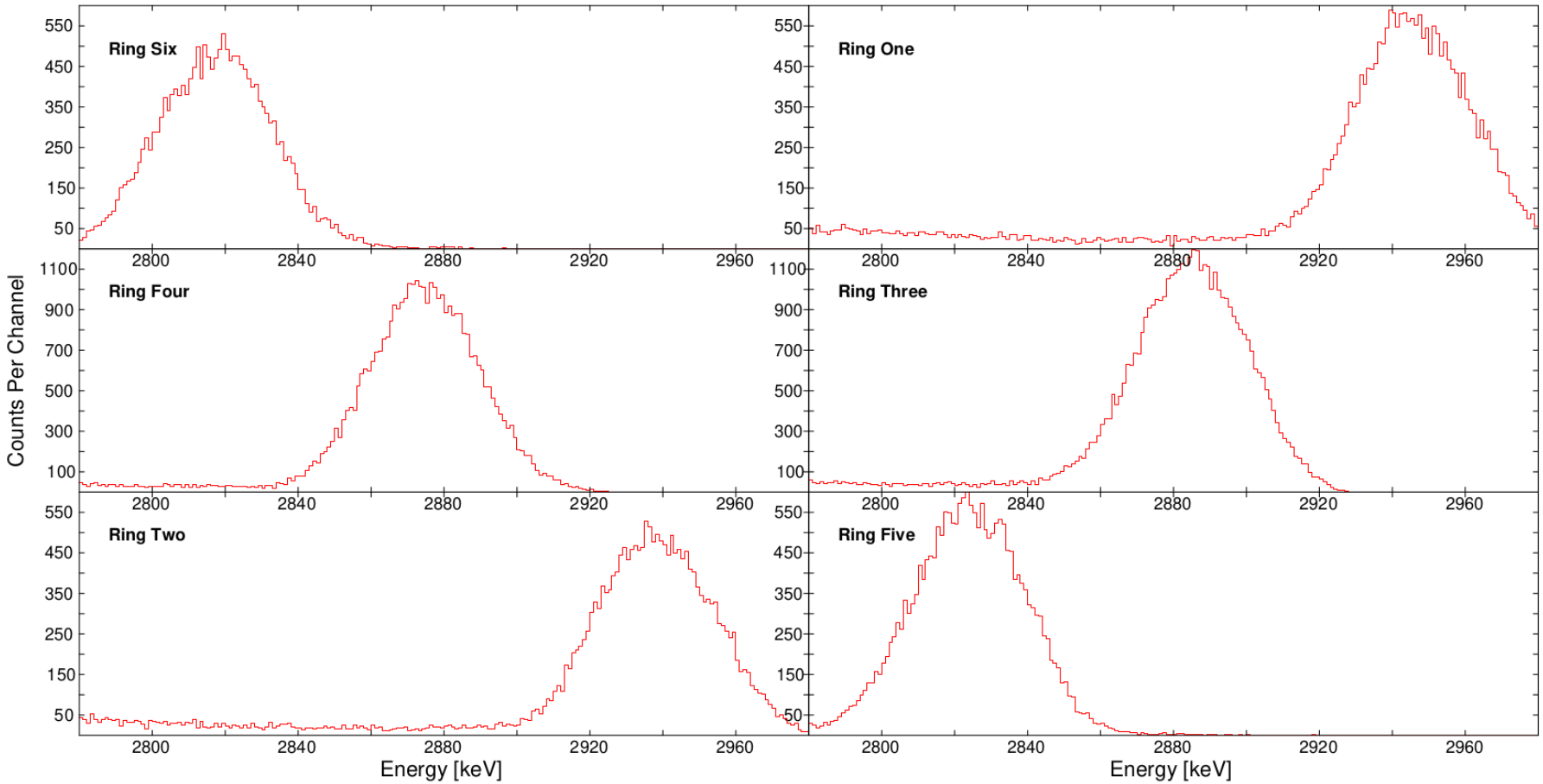
- Simulation parameters:
  - Projectile: ^{20}Na at 100 *MeV*
  - Target: ^{40}Ca with 1.91 mg/cm^2 (1.23 μm) thickness
  - Backing: ^{197}Au with 28.76 mg/cm^2 (14.9 μm) thickness
  - Reaction products: α, p, and 2882 *keV* γ-ray
  - Lifetime varied: 10, 20, 50, 100, 200, 400, 600, 800, 1000 *fs*
  - Q Values: 11.788 *MeV* for formation, and net -3.968 *MeV* for evaporation
  - Quality of simulation statistics improve with longer run times.

Line Shapes for Varying Lifetimes



Centroid Change with Ring Number



$$E_d = E_o \frac{\sqrt{1-\beta^2}}{1-\beta\cos\theta} \tag{1}$$

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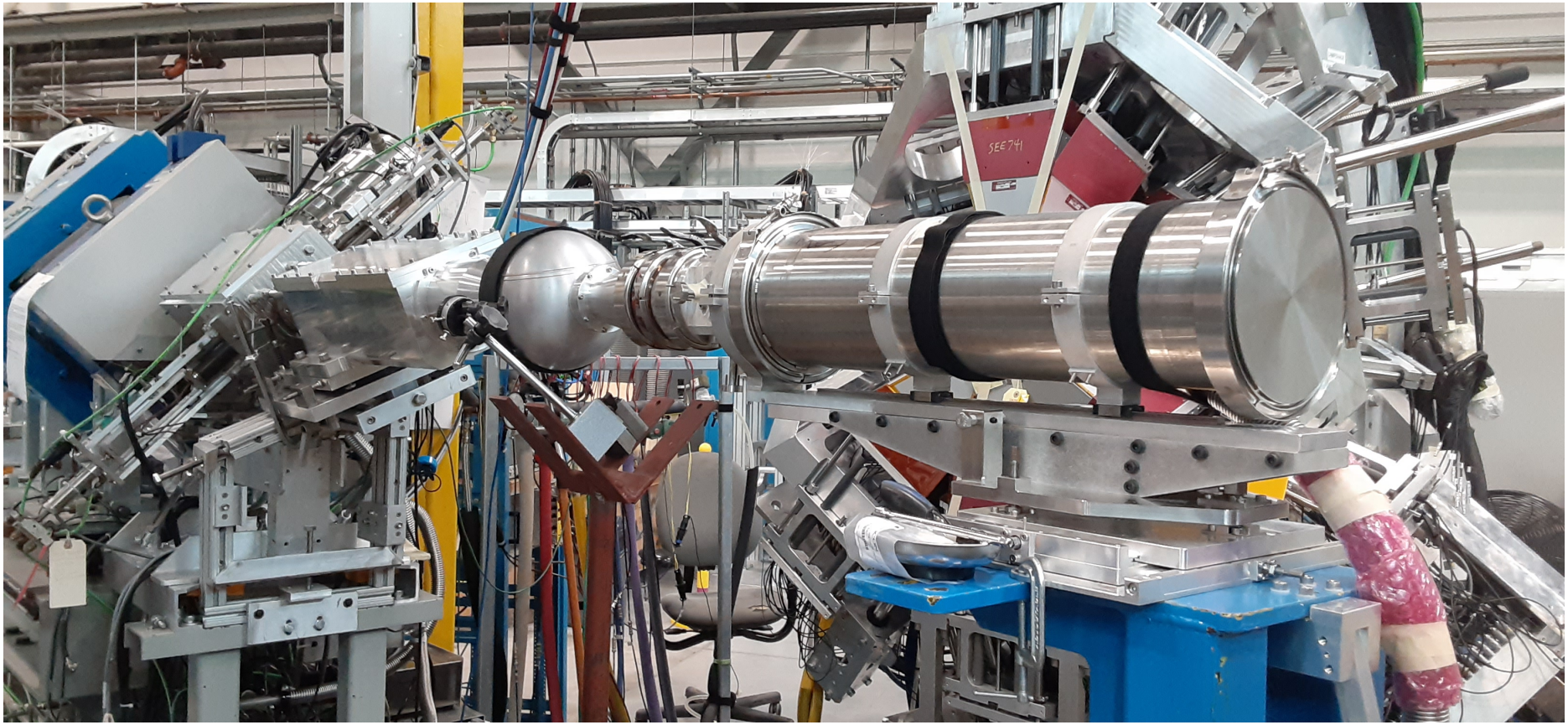
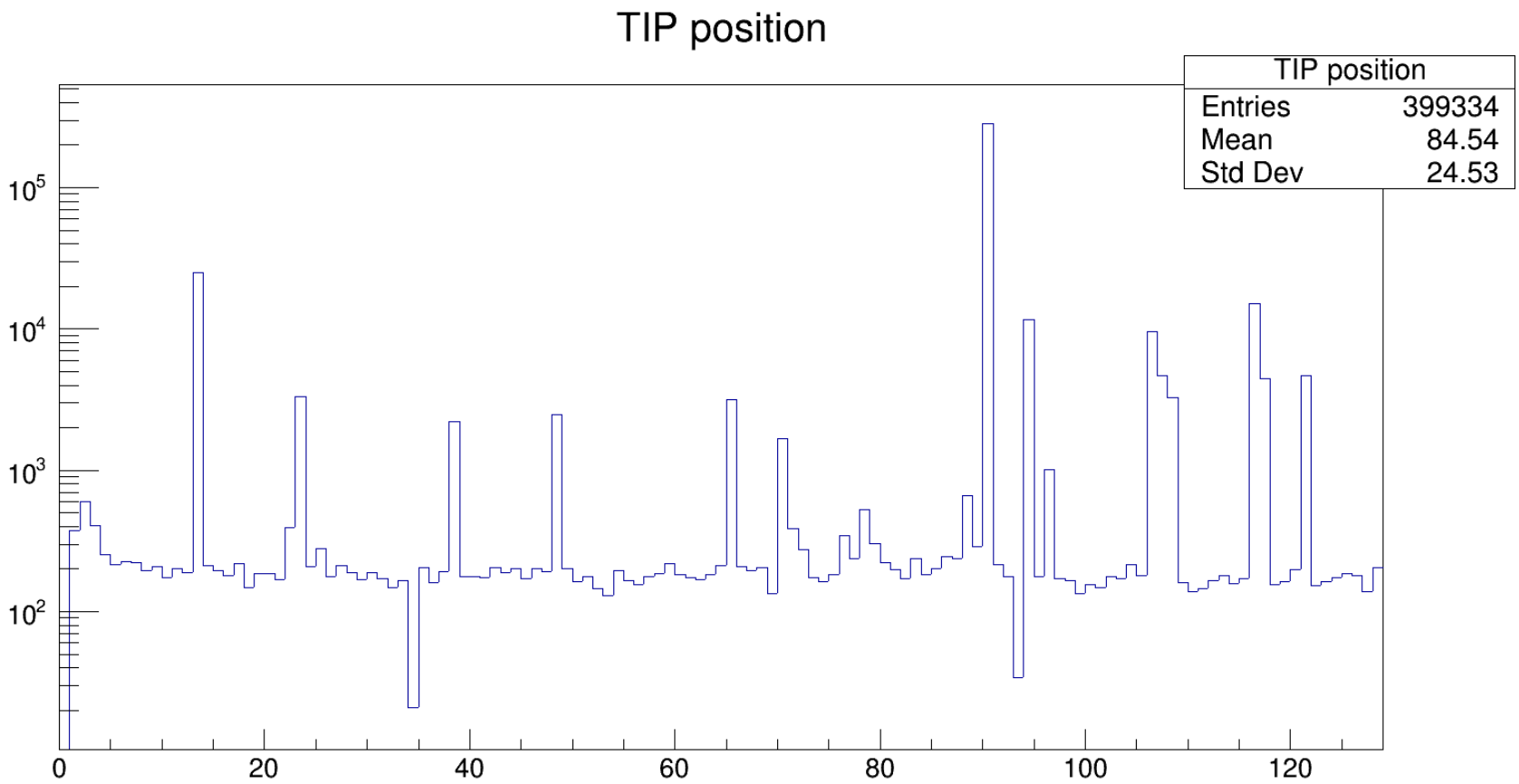
- TIP was aligned with the beam line and TIGRESS.
- Production of high quality ^{40}Ca targets has been initiated.

TIP Alignment




TIP position
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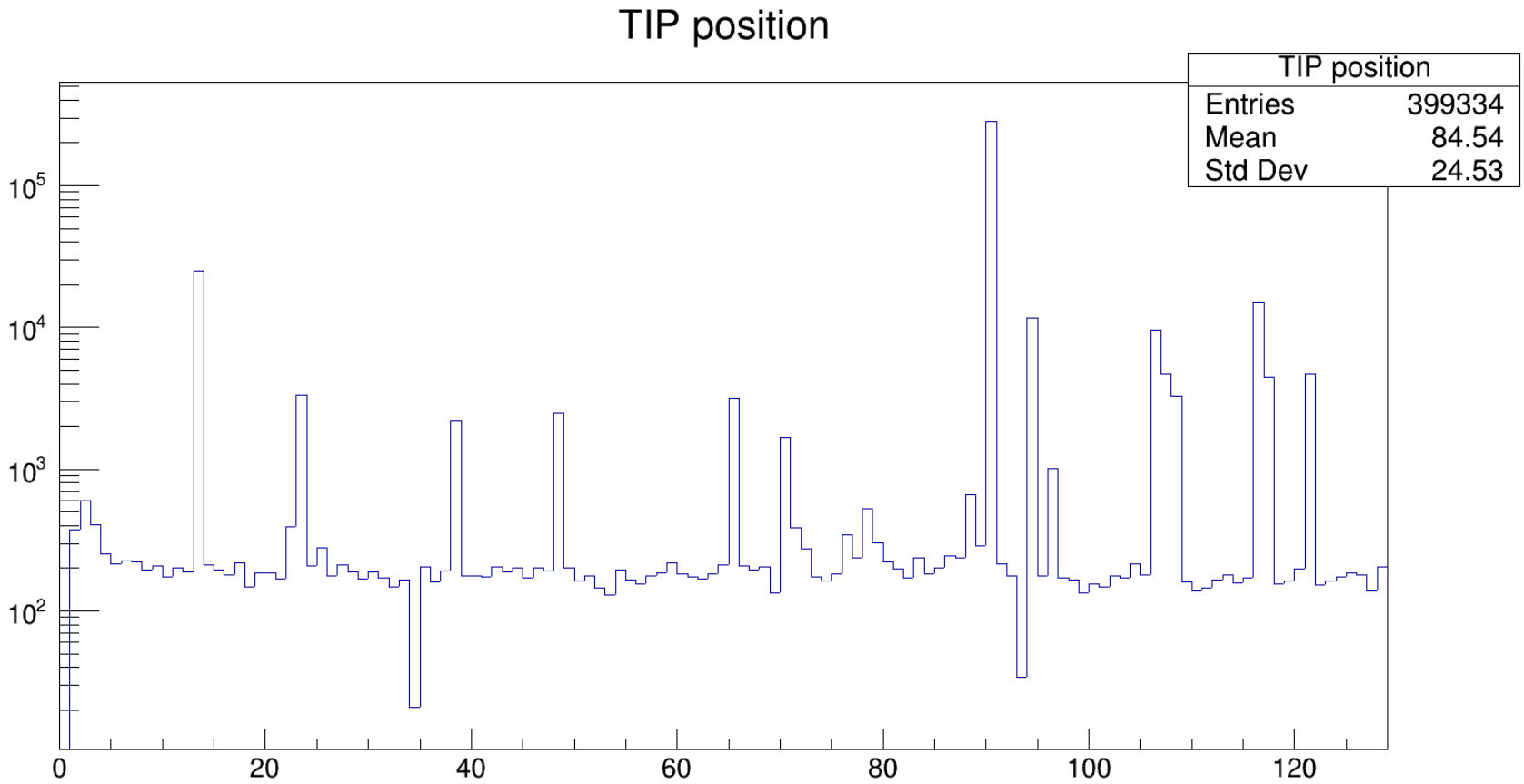
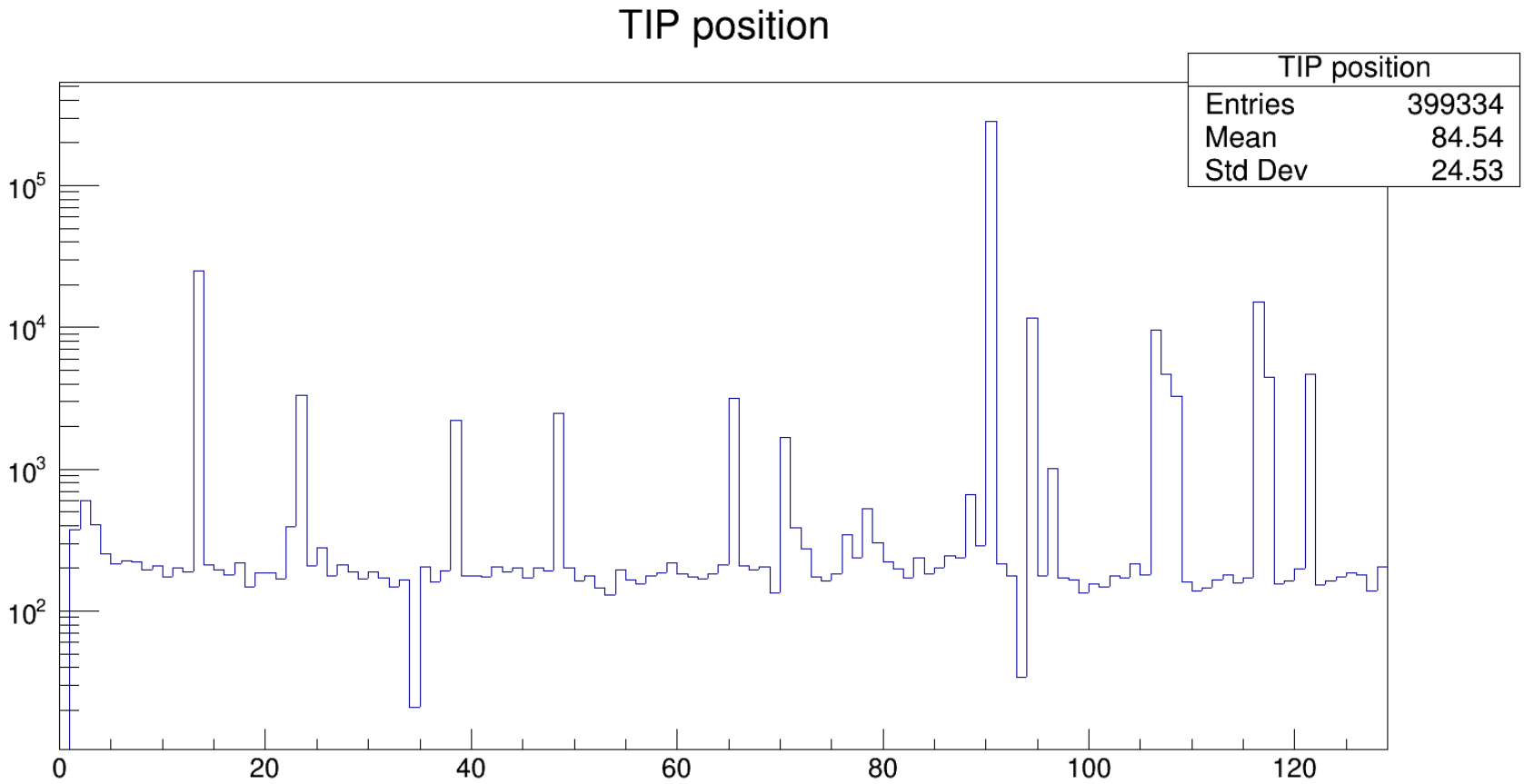
Entries 399334
Mean 84.54
Std Dev 24.53
10^5
10^4
10^3
10^2
0
20
40
60
80
100
120



- Absorber foils prevent using sources; cosmic rays used instead.

Cosmic Ray test of the CsI Ball



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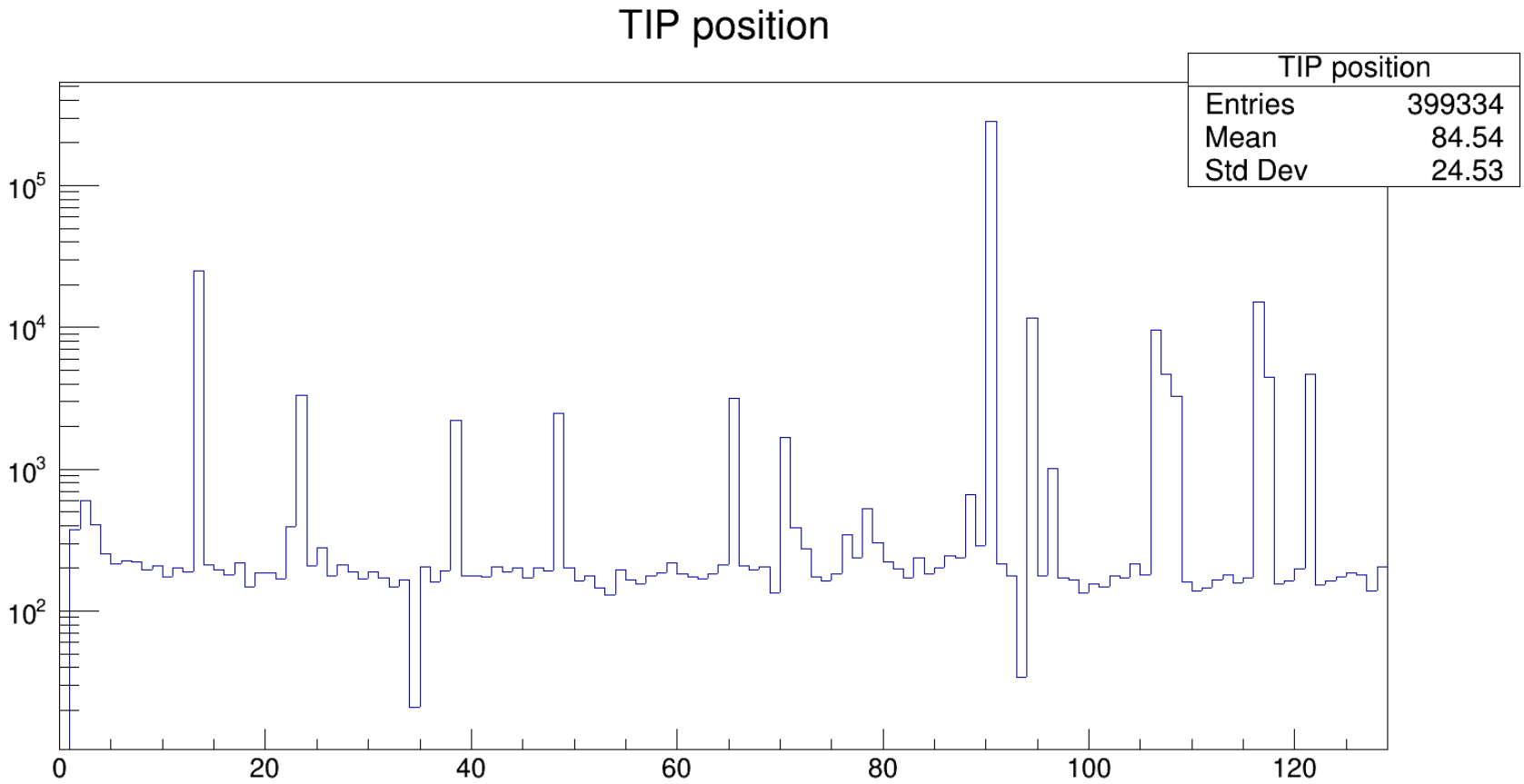
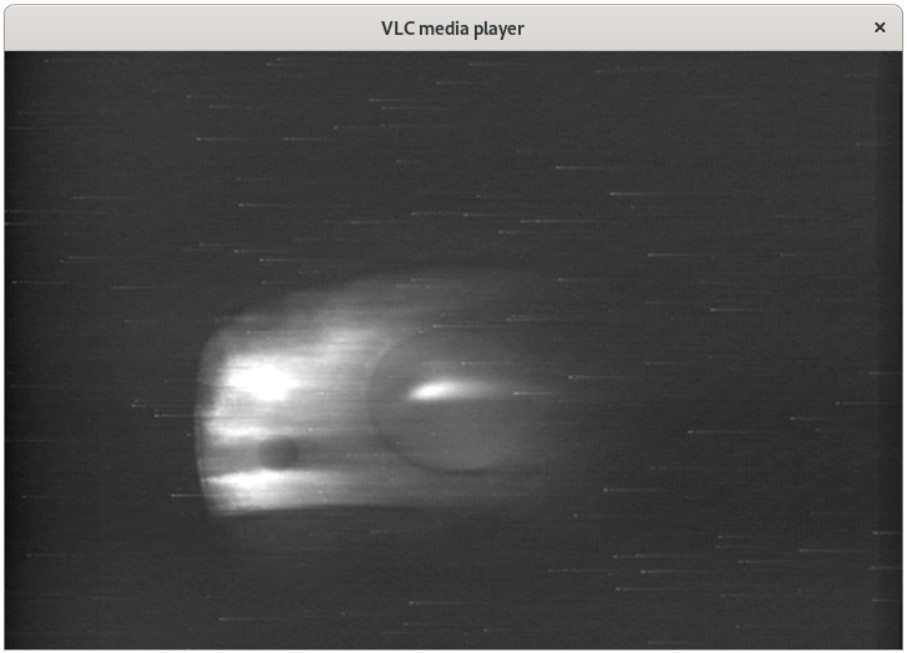
- Roughly 20 mV peak-to-peak noise with -70 V bias.

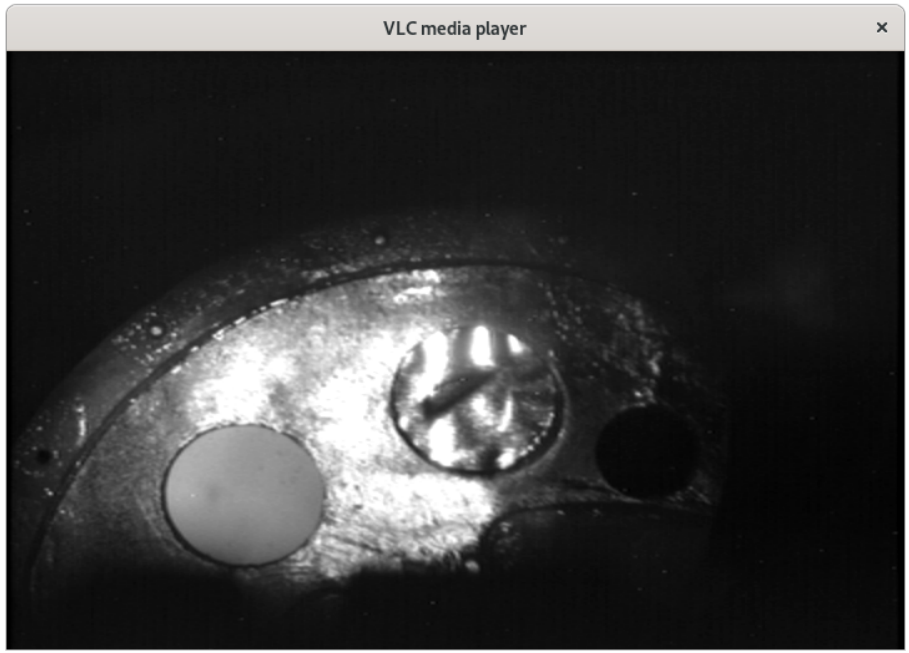
Cosmic Ray test of the CsI Ball



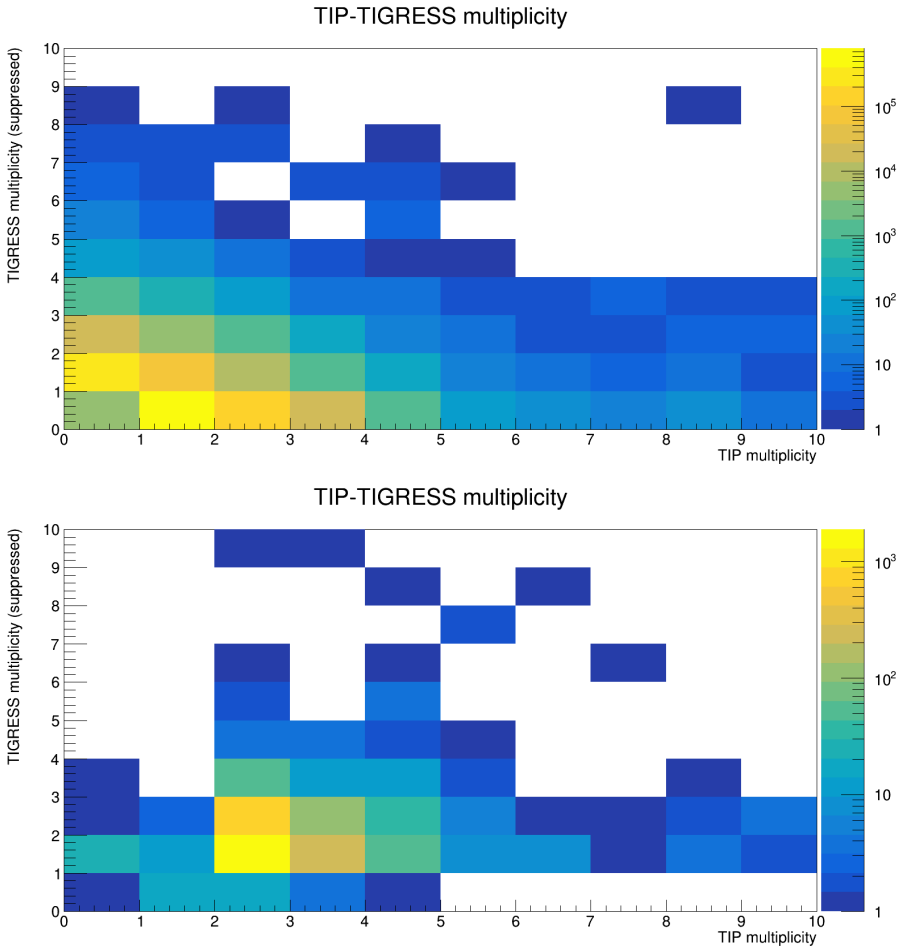
- Absorber foils prevent using sources; cosmic rays used instead.
- Roughly 20 mV peak-to-peak noise with -70 V bias.
- 126 detectors operational with detector 34 missing while detector 93 is undercounting.

^{20}Ne beam delivery to TIP



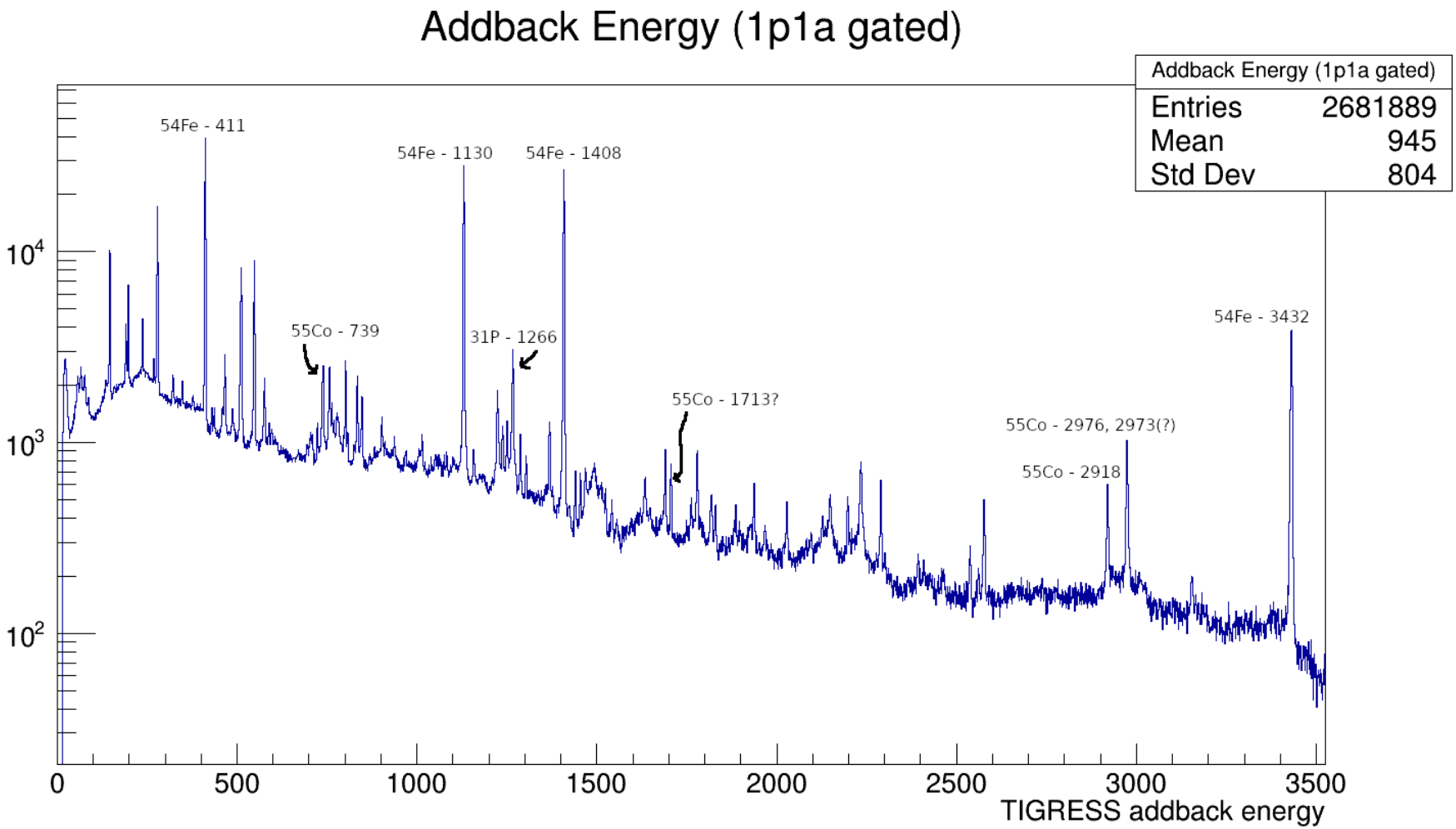


TIP/TIGRESS real time event selection



- All (top) and TIP-TIP-Ge-Ge (bottom) events.

Identification of Reaction Channels



- Calcium target is critical to exploring $N = Z$ nuclei:
  - Heaviest stable $N = Z$ target.
  - Allows for exploring heavy $N = Z$ nuclei.
  - Extremely vulnerable to oxidization.
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Calcium Target Making

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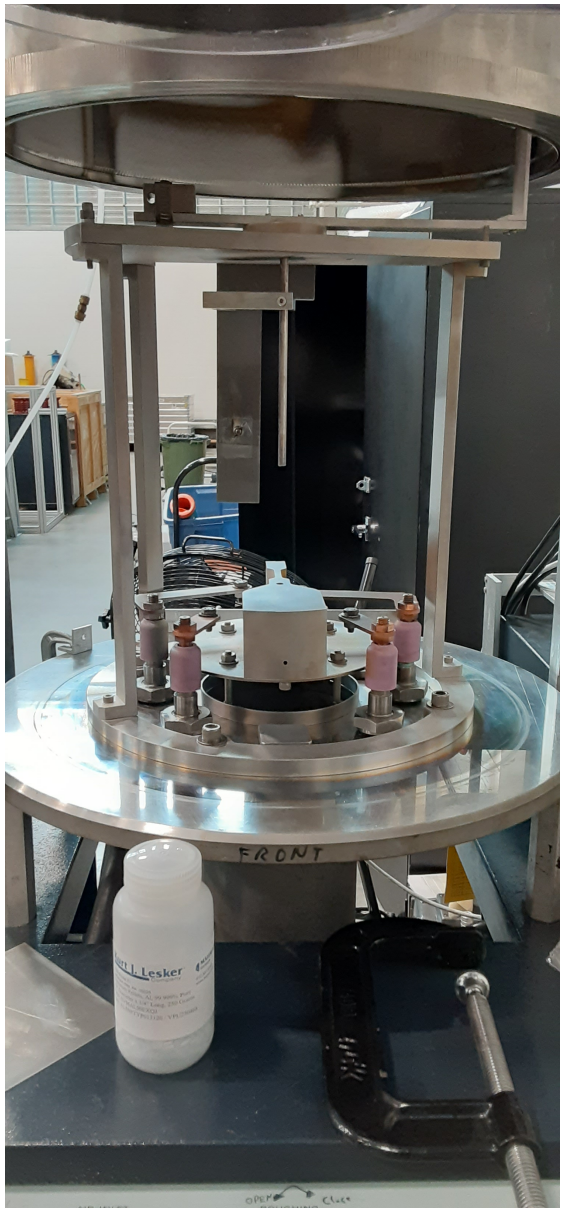
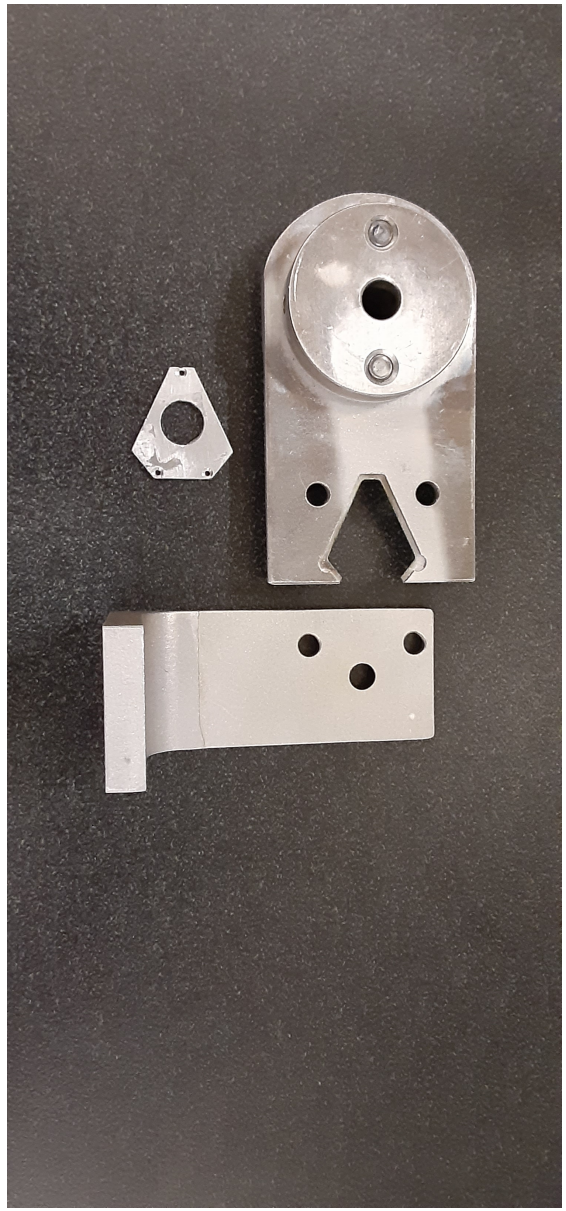
- Target production is a delicate process:
  - Begin by manually rolling a gold foil (9.4 mg/cm^2 for this experiment).
  - Epoxy the foil to a target frame.
  - Evaporate a thin adhesive layer onto the foil ($\sim$ 0.1 mg/cm^2).
  - Evaporate the calcium ($\sim$ 0.15mg/cm^2).
  - Protect the calcium with a layer of gold ($\sim$ 0.25 mg/cm^2).
  - Quickly affix the target to the wheel, cable the diagnostic tools, and secure everything in the beam line.

Evaporation Chamber Exterior

Evaporation Chamber Interior





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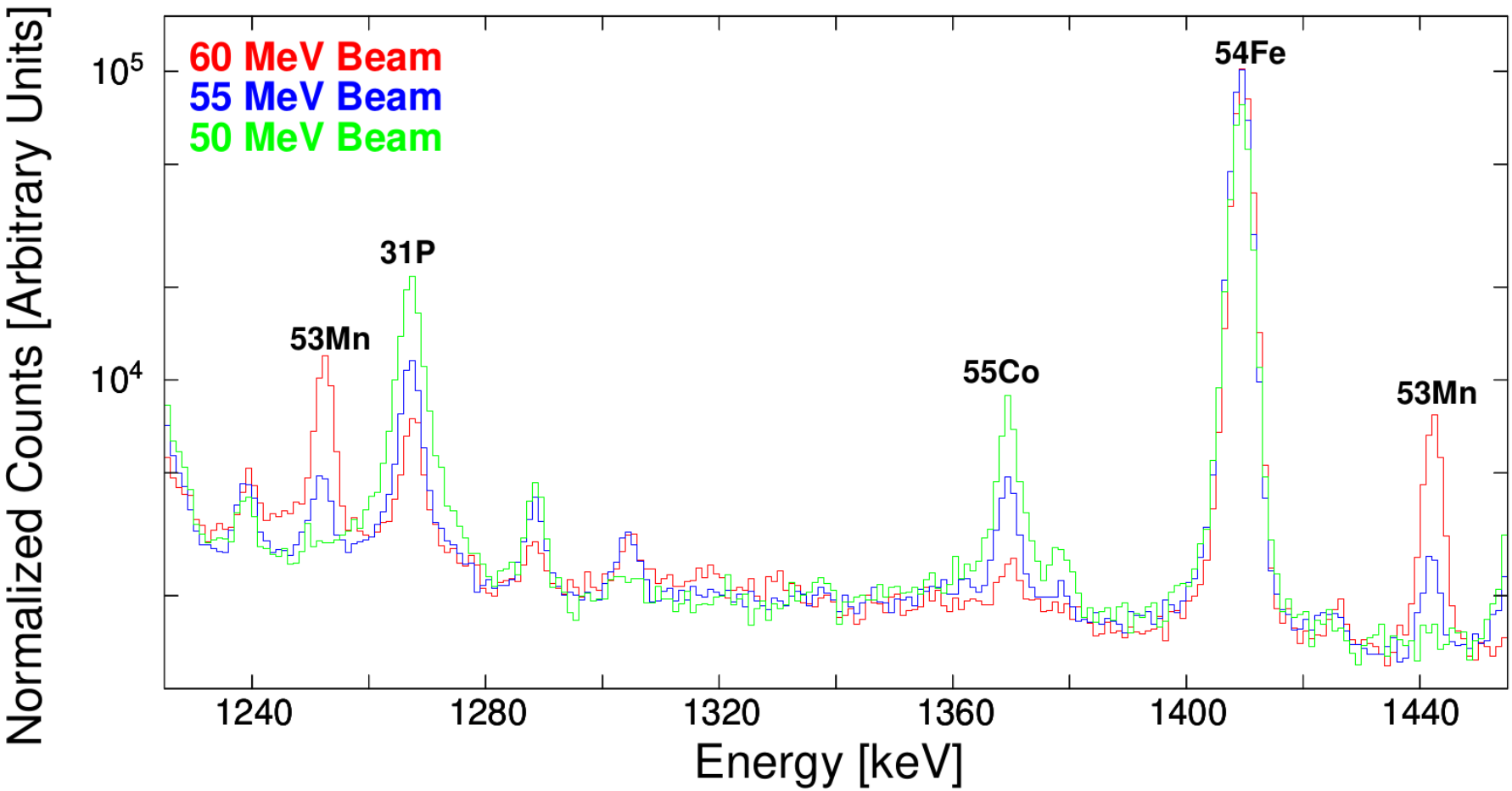
- Results were:
  - 1.3% at ^{20}Ne beam energy of 60 MeV
  - 2.3% at ^{20}Ne beam energy of 55 MeV
  - 5.1% at ^{20}Ne beam energy of 50 MeV

Beam energy dependence



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- R. J. Coleman[6], E. Kasanda[6], L. Schmidt[6]

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