Commissioning a CTBT Coincidence Detector System Underground at SNOLAB

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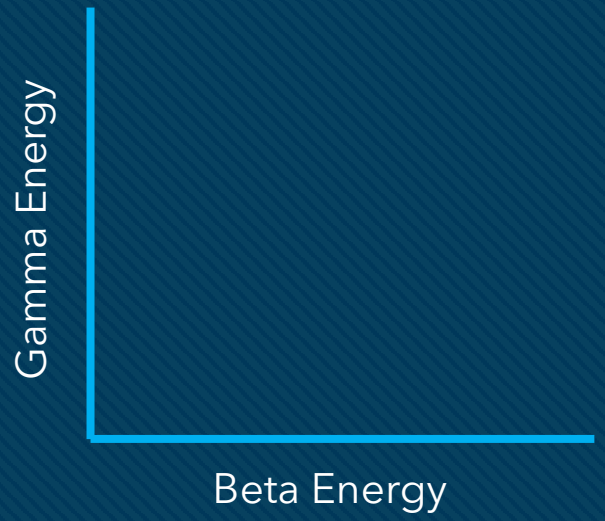
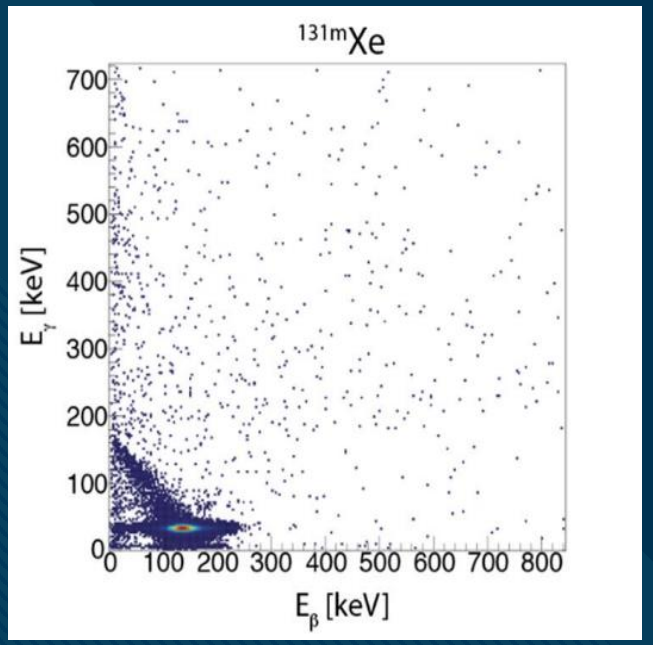
The Comprehensive Nuclear-Test-Ban Treaty (CTBT)

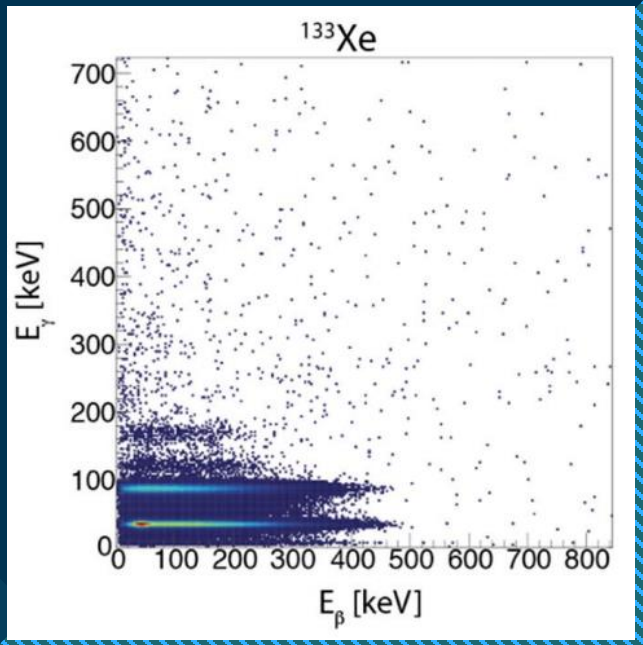
- UN General Assembly adopted treaty with basic obligations banning detonation of nuclear explosions
- Global radionuclide stations set up to monitor potential nuclear events
- Xenon radioisotopes are of interest, as possible products of nuclear detonations
- Proposed identification by beta-gamma coincidence detection

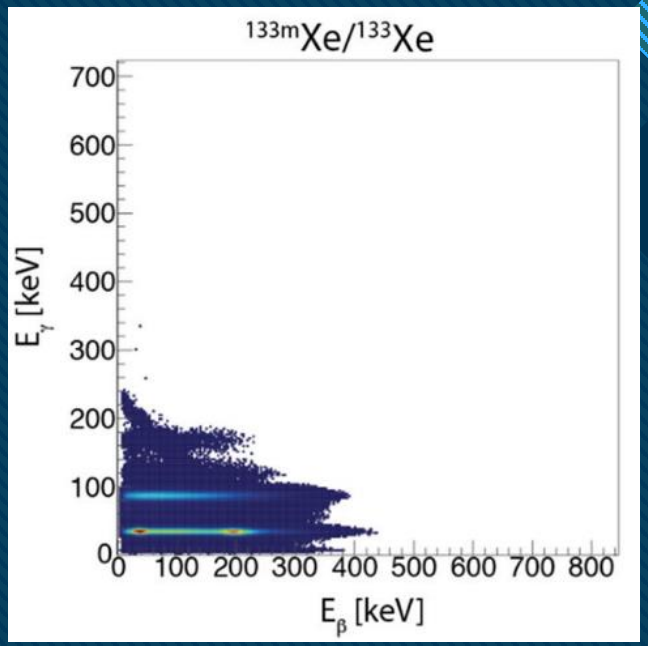
Radioxenon Isotopes

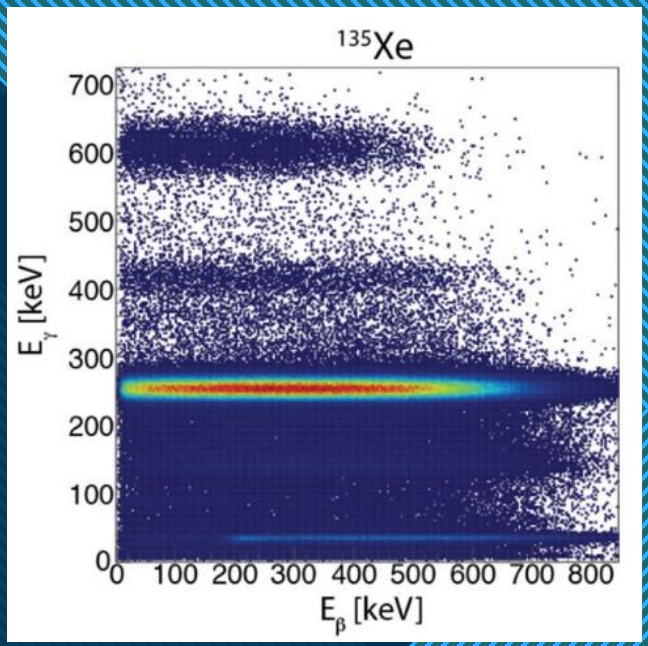
- Beta gamma coincidence detection
- Four different isotopes
- Distinguishing features:
  - Horizontal lines (broad beta spectrum)
  - Diagonal lines (Compton scattering)









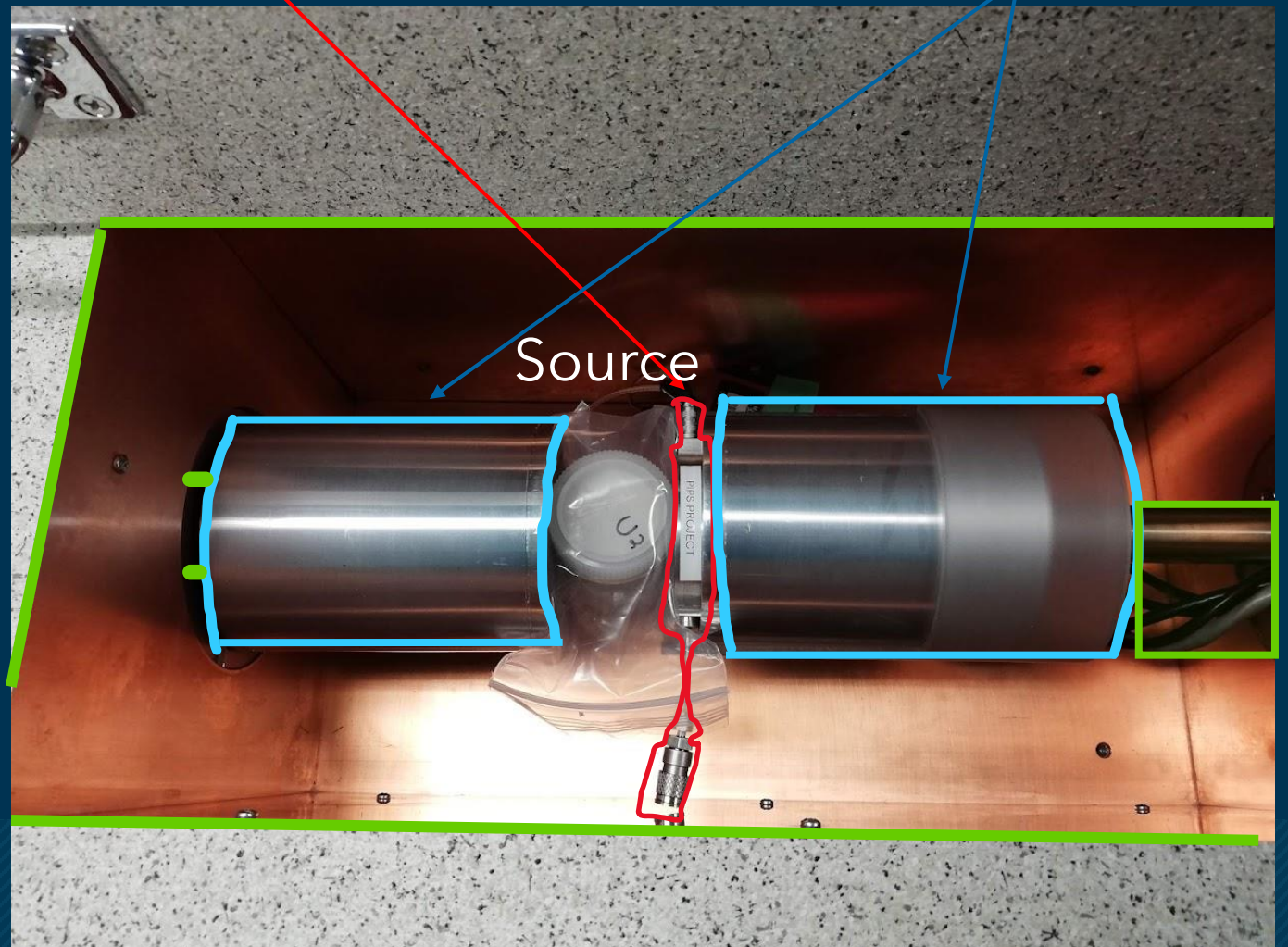


Cooper et al. 2019. Radioxenon net count calculations revisited

The CTBT System

Beta Detector (PIPS)

Gamma Detector(s) (HPGe)

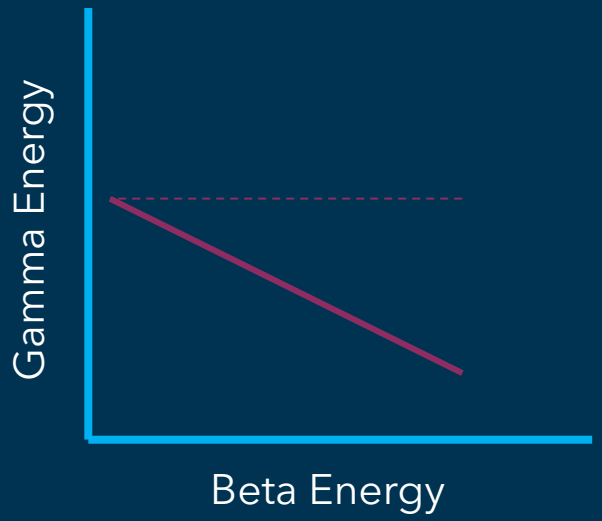


Housing and auxiliary

Lynx MCA
- Data
- Preamplifier

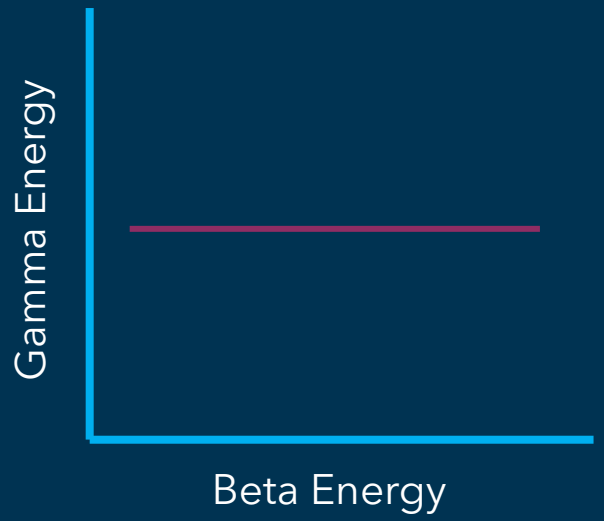
- Power
- Network/Ethernet
- Voltage
- LN2 (Liquid Nitrogen)

Key Coincidence Patterns



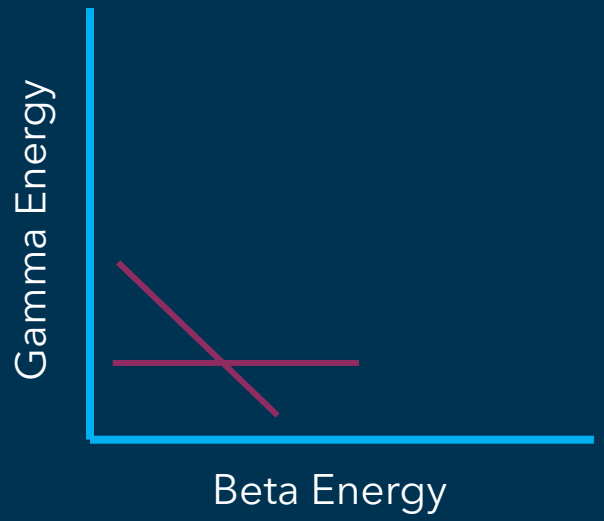
Compton Scattering

Co-60



Full 1st Gamma, Partial 2nd Gamma Energy Deposit

Na-22

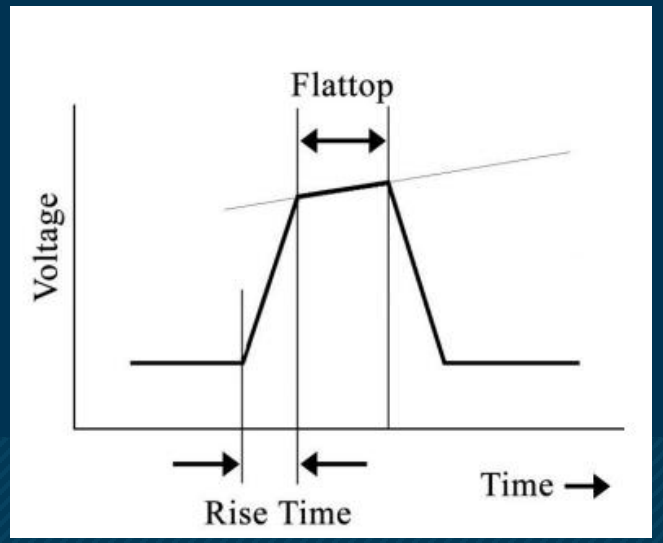


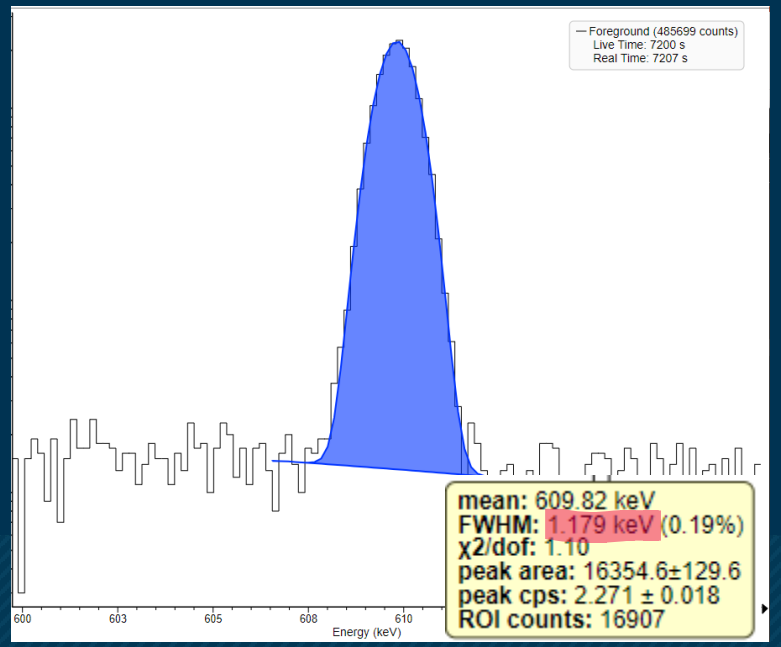
Full Beta, Full Gamma Energy Capture

Xe Isotopes

Gamma Detector (HPGe)

- HPGe gamma-gamma system already in use underground
- Optimizing Lynx MultiChannel Analyzer (MCA) pulse processing
  - Low FWHM values constitute accuracy

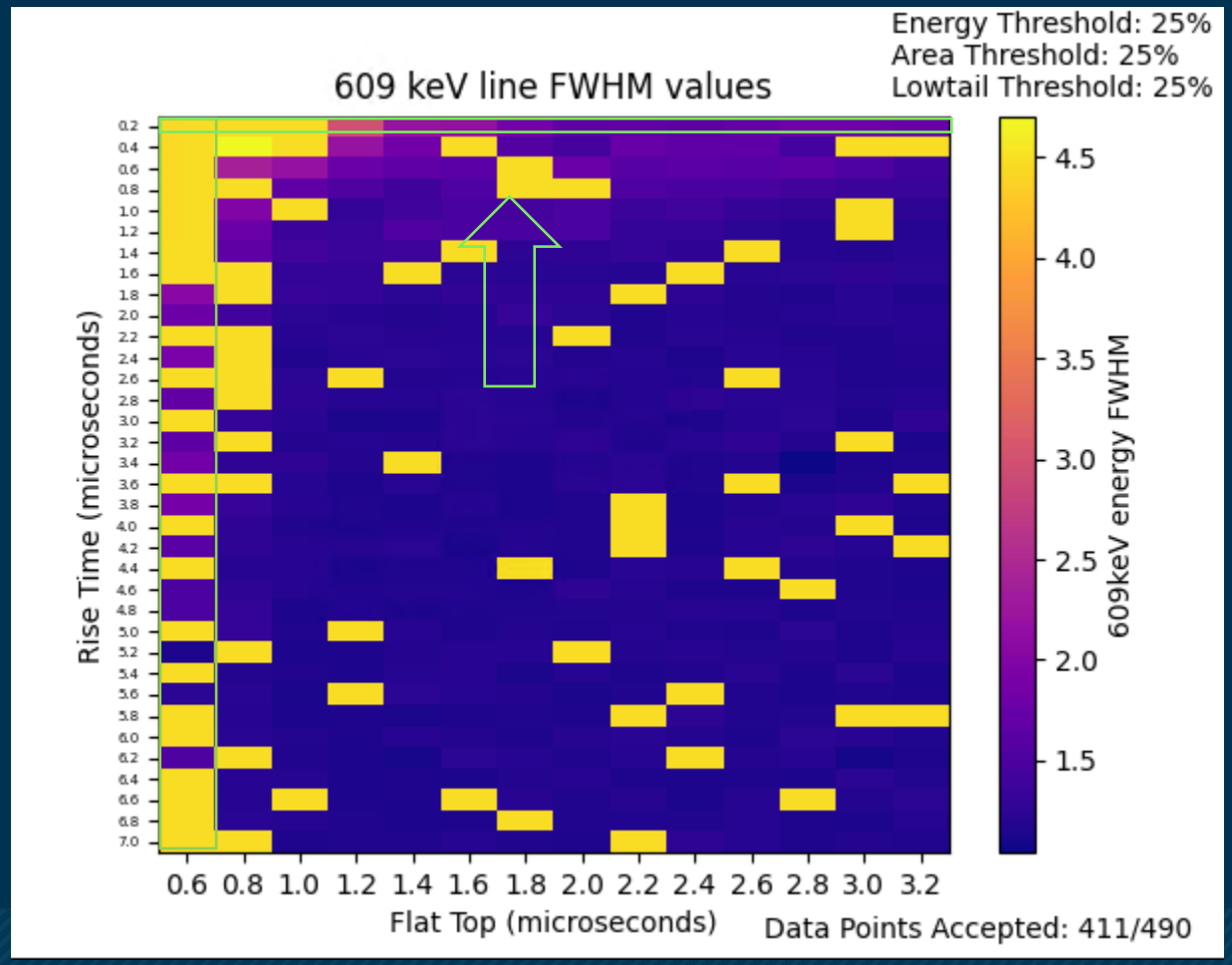




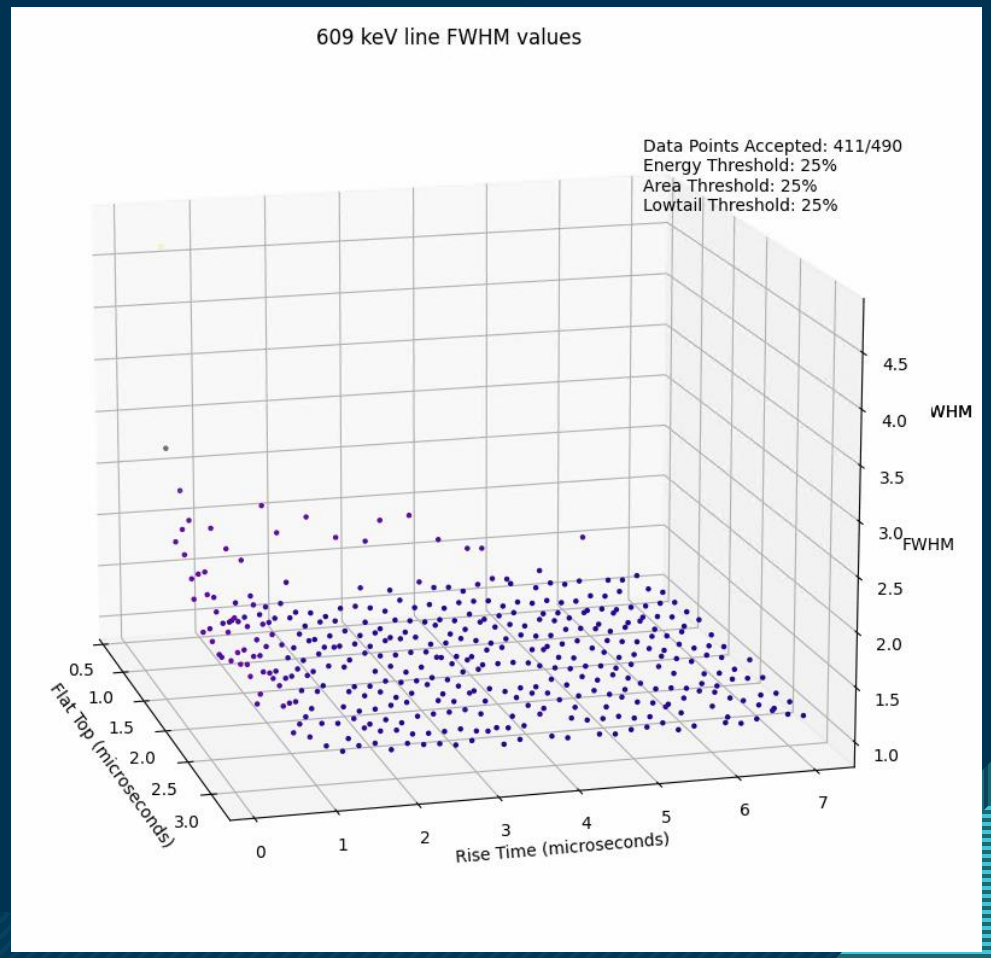
U238 609 keV FWHM Trend

Conclusion: Rise Time set to 4.0µs
Flat Top set to 1.8µs

Heatmap Representation



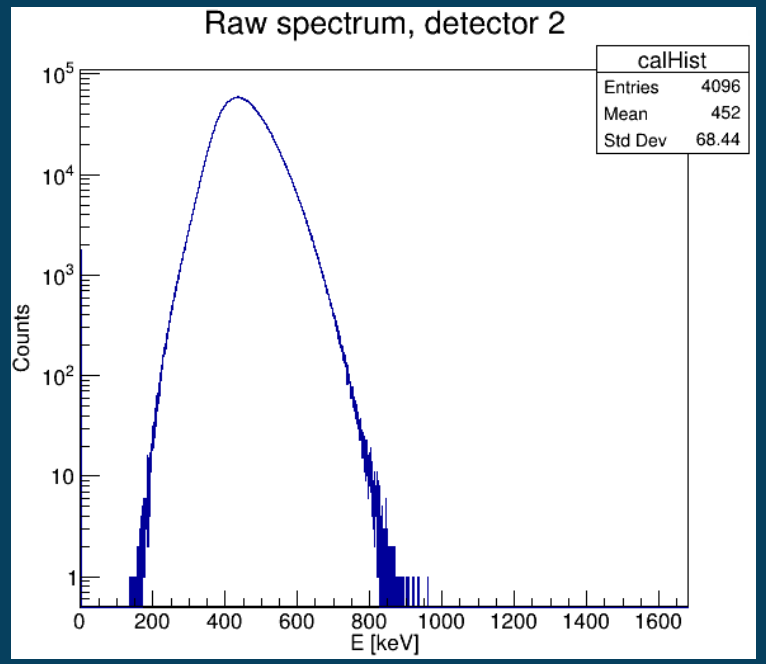
Scatter Representation



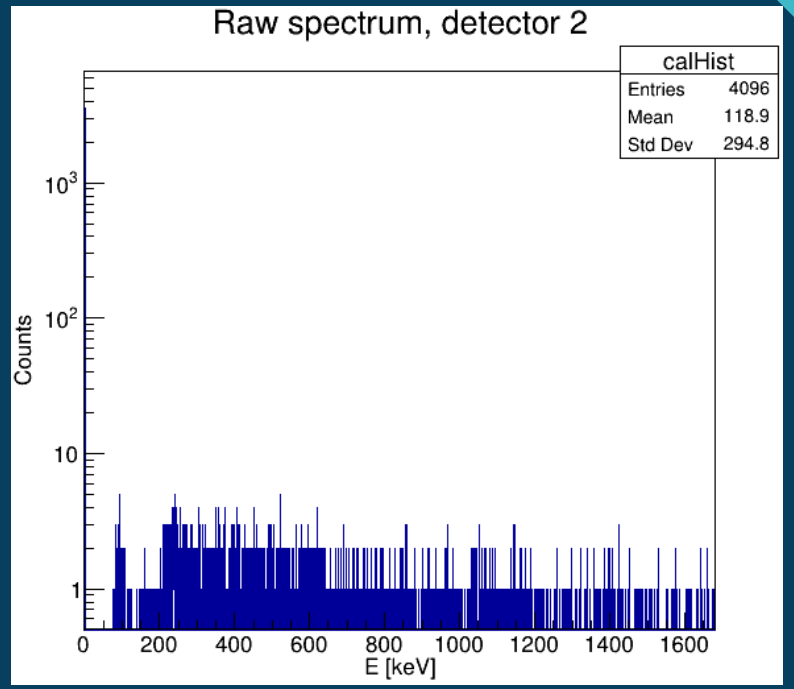
Beta Detector (PIPS)

- Provided by Health Canada following use in CTBT system development
- PIPS sensitive to electronic noise, reconfiguration necessary

U238 Beta Spectrum

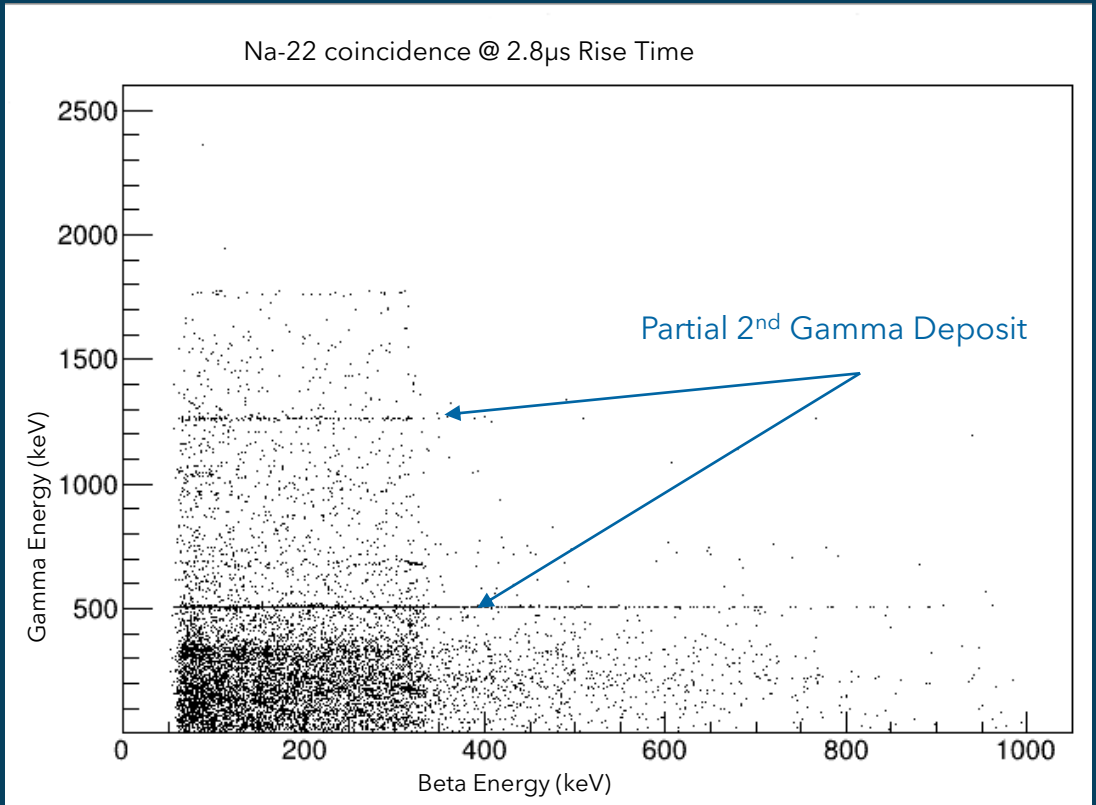


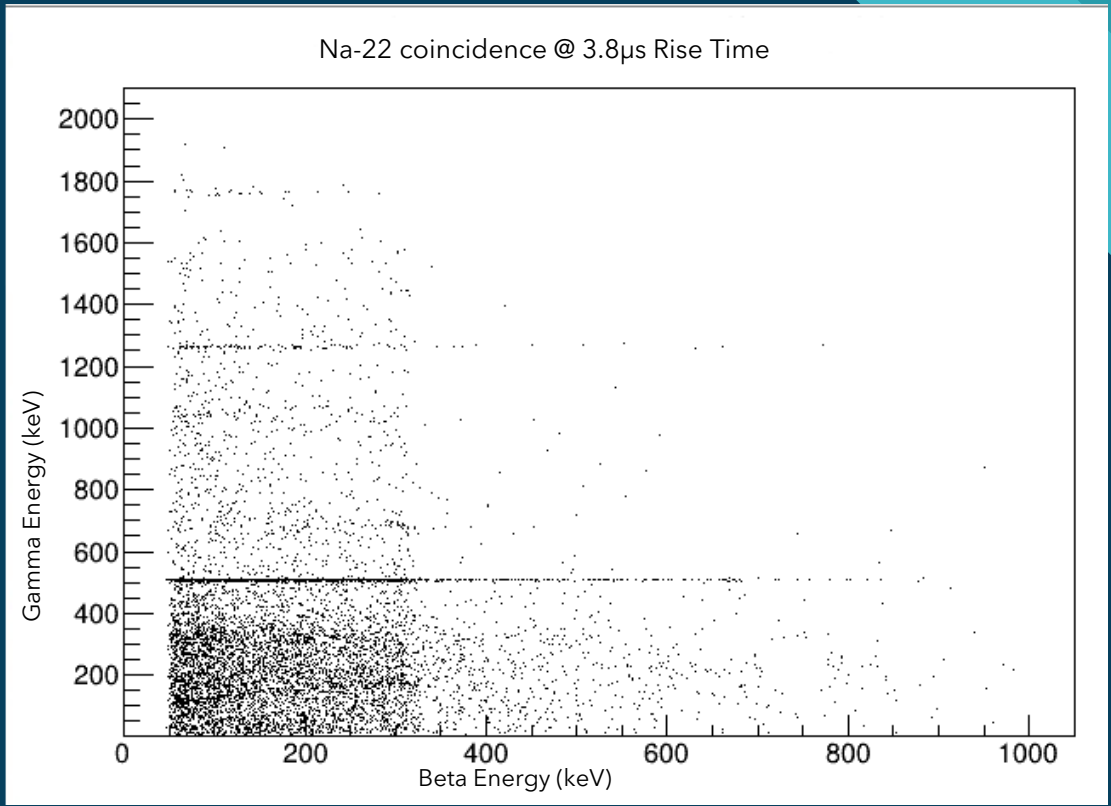
Rewiring/Isolation



Rise Time Adjustments

- Data runs of ~45 minutes of Na-22
- 511, 1275, and 1786 keV gamma lines well defined on both
- Take HC recommendation of “higher” rise time

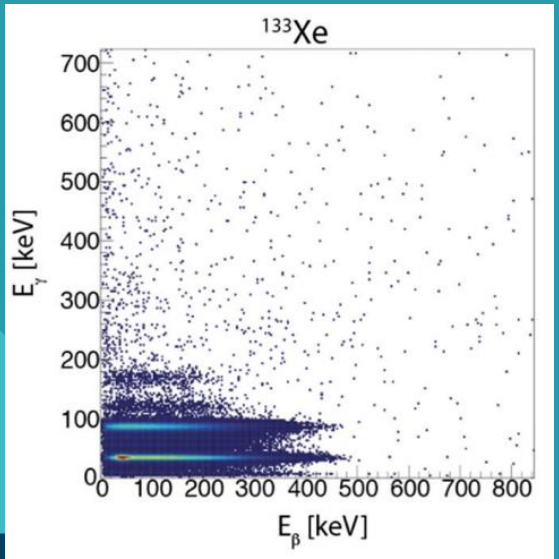


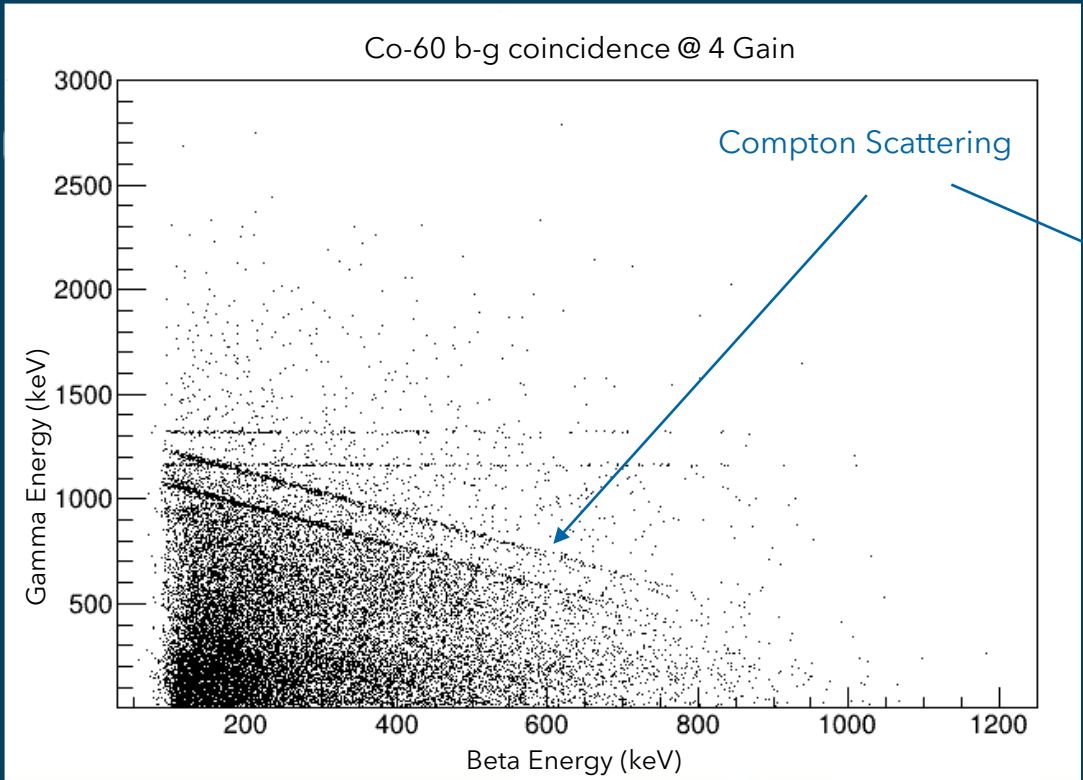


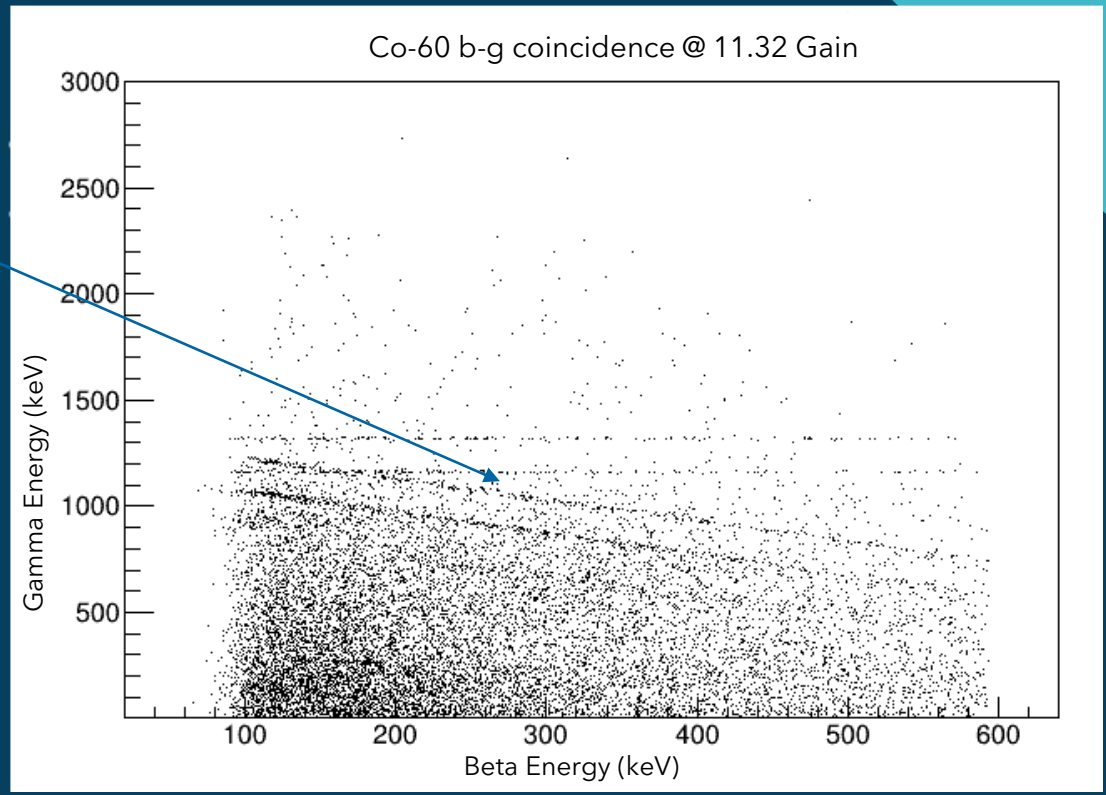
Gain

- Recommended gain setting by HC: 11.32

- Beta-gamma coincidence showed majority of beta counts at < 600 keV

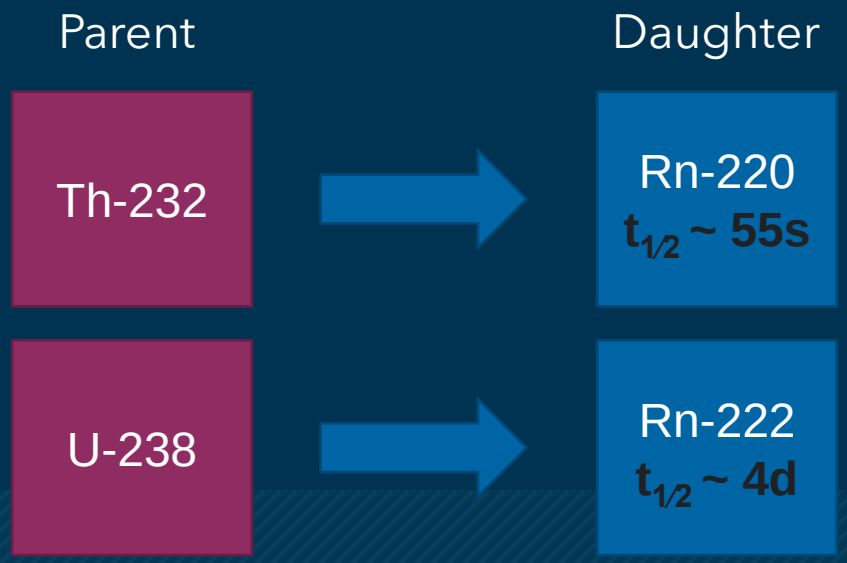






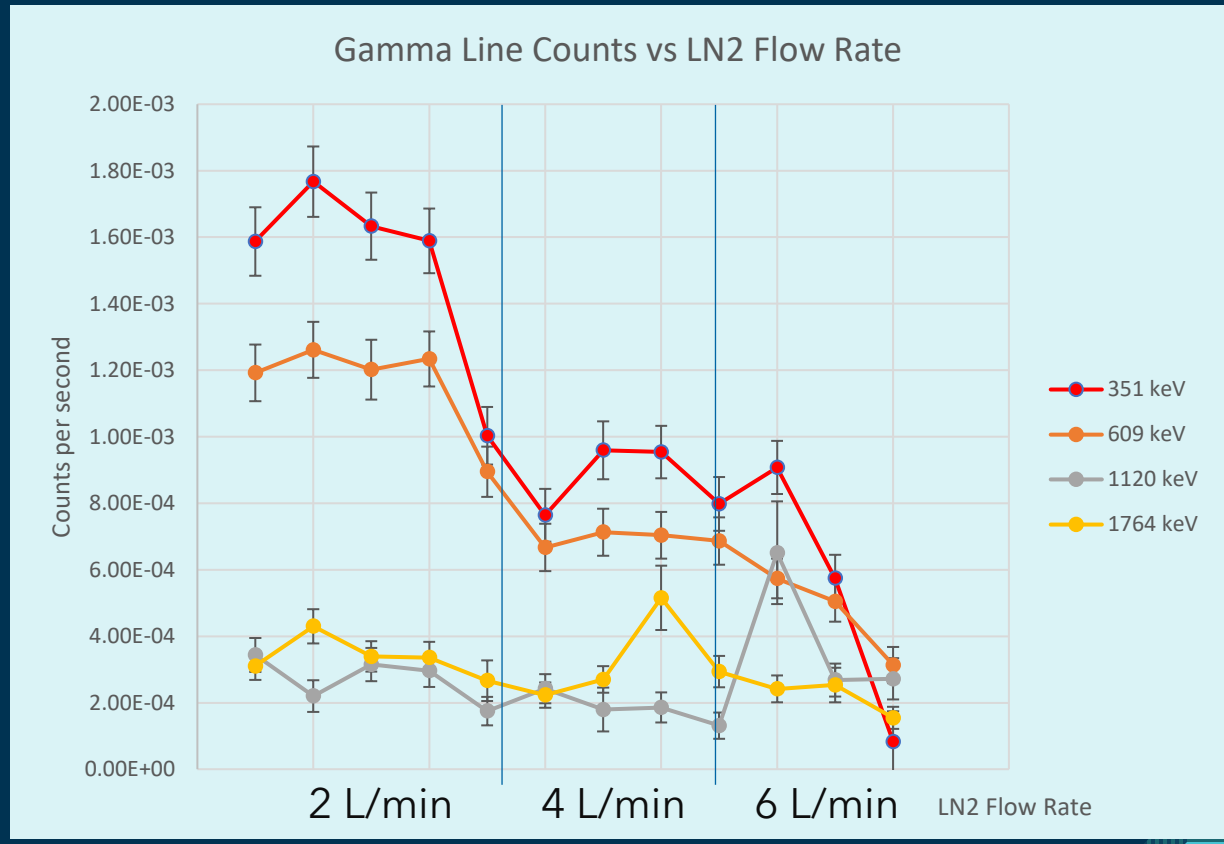
Underground Radon Rates

- Rocks and soil surrounding SNOLAB have trace amounts of U-238 and Th-232
- Decays lead to higher concentration of Rn gas underground
- Interferes with background gamma counts, purged via LN2



LN2 Purge Flow Rates

- Three LN2 rates tested against U-238 gamma lines
- Data ranging from three to seven days
- Lower energy lines saw more drastic decreases in counts per second
- Settled on 4 L/min



The Future

- Further optimization of beta detector settings
- A second PIPS detector has been installed
- Once up to standard, SNOLAB could become premier location for air sample analysis

Thank You!

Image References

Cooper et al. 2019. *Radioxenon net count calculations revisited* https://d-nb.info/1201957443/34