TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

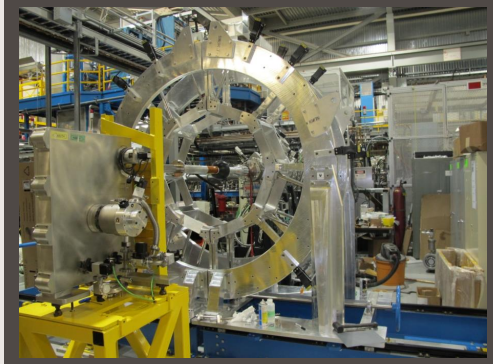
Investigations of Background and Compton Suppression Shields for GRIFFIN

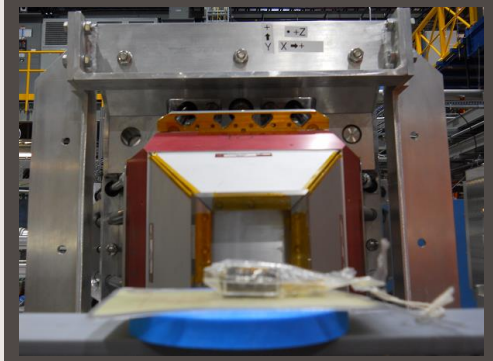
Nikita Bernier, UBC and TRIUMF
for the GRIFFIN collaboration

2014 Canadian Association of Physicists Congress

June 17th, 2014.

GRIFFIN

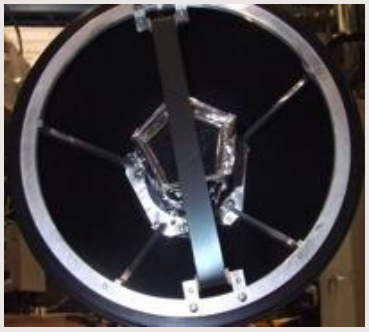




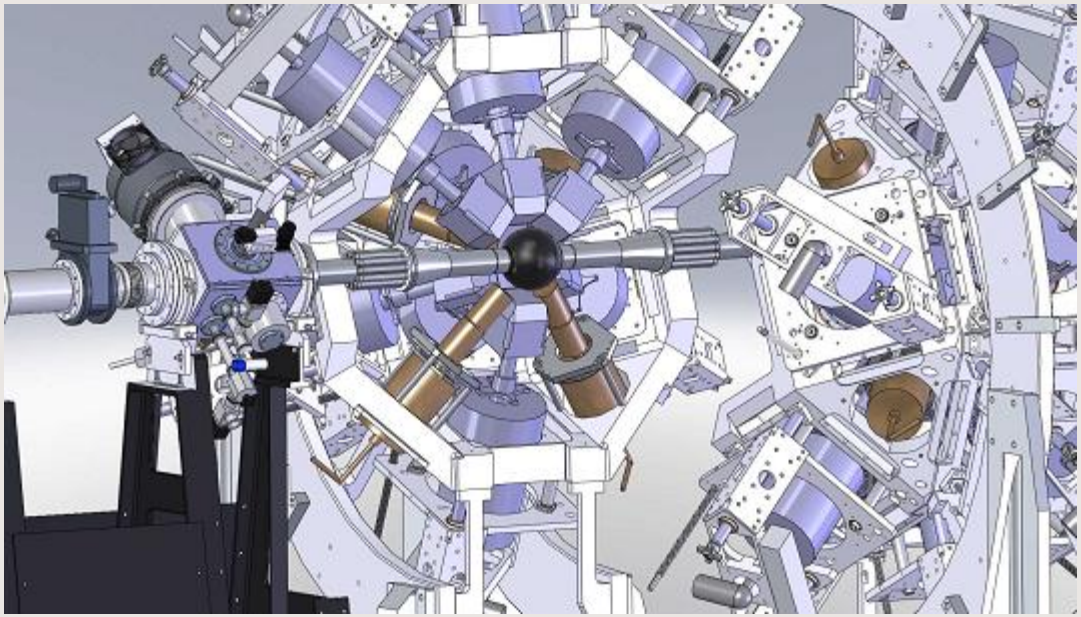
GRIFFIN Spectrometer

- **GRIFFIN** : Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei
  - 16 large-volume clover-type High Purity Ge [HPGe] detectors dedicated to **decay spectroscopy** research with the low-energy radioactive ion beams in ISAC-I at TRIUMF
  - Five sub-systems are combined to create a high-efficiency decay spectrometer for sensitive measurements.

TRIUMF ISAC



In-vacuum moving tape collector system



See A.B. Garnsworthy (M2-2)

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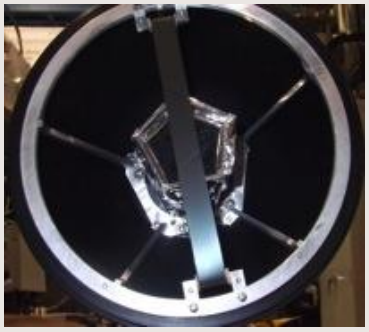

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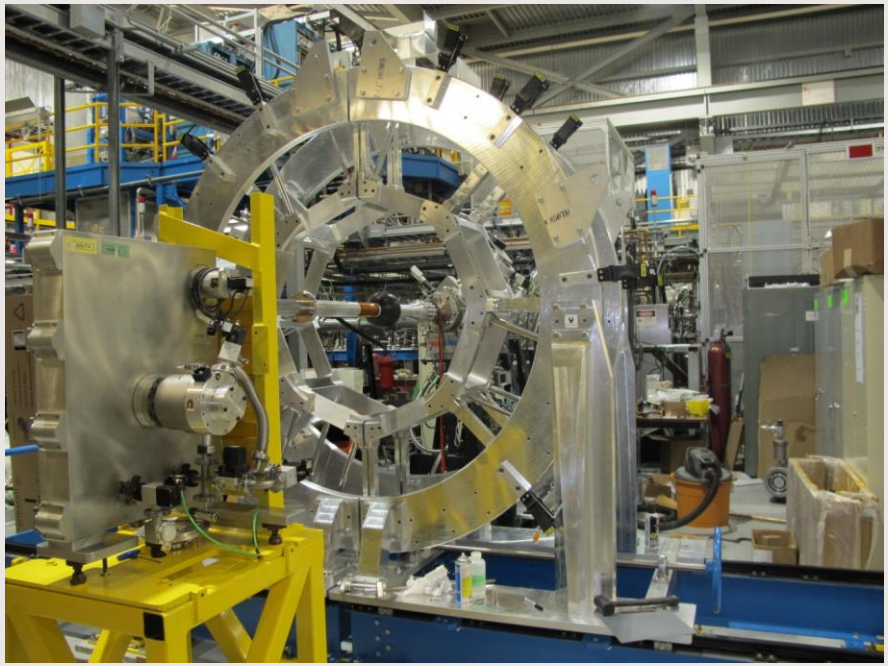


See A.B. Garnsworthy (M2-2)

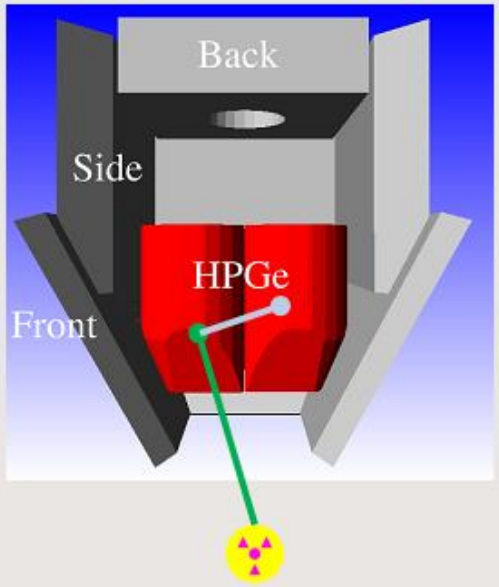
Suppression Shields

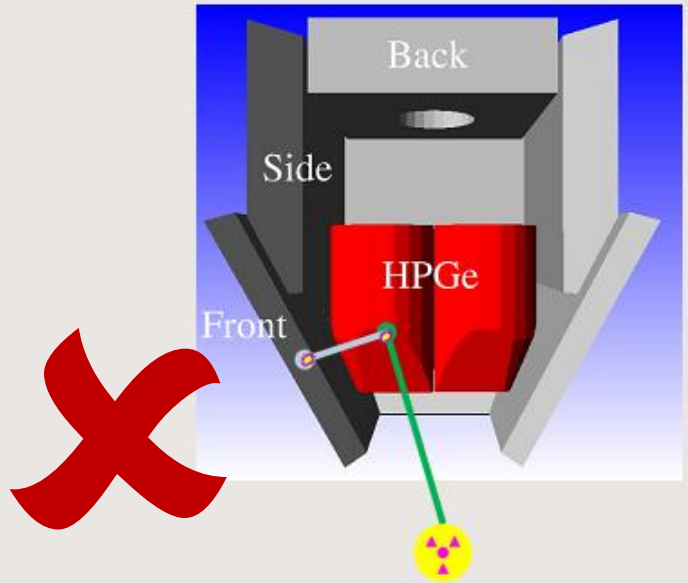
- The performance of a γ- ray spectrometer is determined primarily by
  - γ- ray energy resolution
  - total γ- ray photopeak detection efficiency
  - **photopeak-to-total ratio**, and
  - **suppression** of environmental background signals.

- Solutions for improved performance :
  - Significantly reduce **Compton scattering and escape peaks** [high rate] by placing HPGe detectors in close proximity and add energy loss in each crystal
  - Shield against the **radioactive background** [low rate] present in the experimental hall by surrounding HPGe with a high density scintillator.

Addback and Escape Suppression

- High probability that an incoming γ- ray **Compton scatters**, or an annihilation photon, will **escape** the detector
  - Results in a continuous spectrum of lost energy and escape peaks.



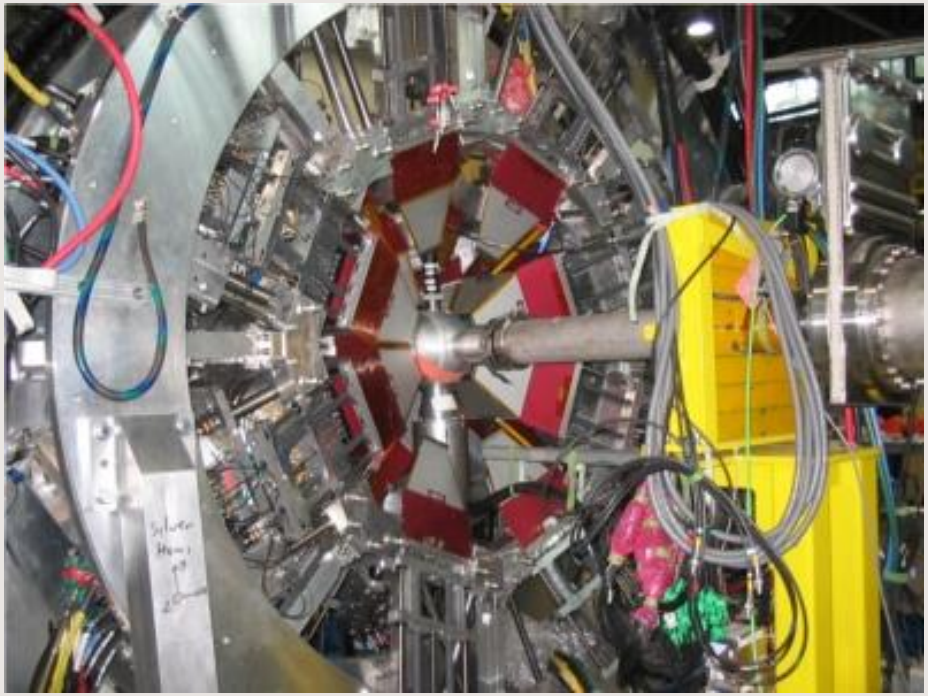


- If energy deposited in two crystals, treat as a **single incident γ-ray** : add energies.
- If energy measured in a scintillator, **veto** any HPGe event in coincidence.

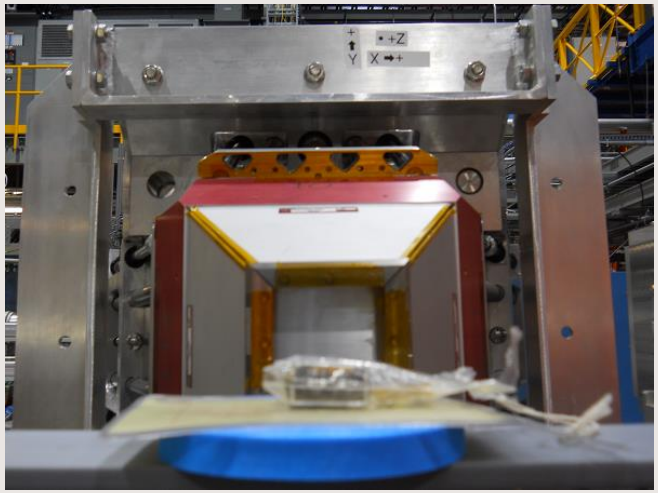
G. Hackman

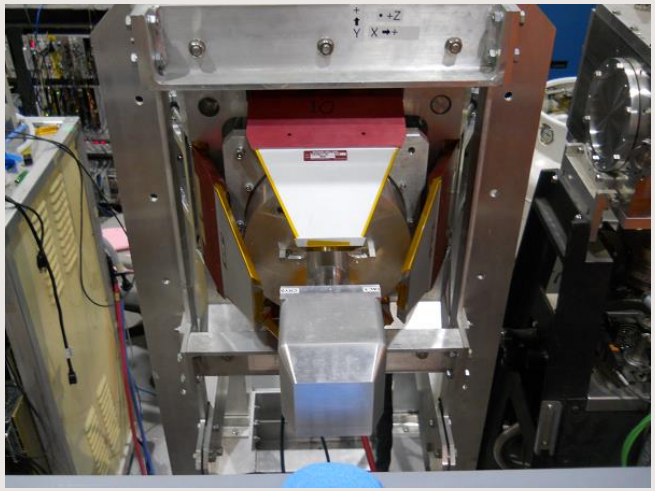
Experimental Setup

- **GRIFFIN** clover set up with **TIGRESS** shields
- 20 optically-isolated **scintillators** per shield for crystal specific Compton suppression
  - Retractable BGO front shields, BGO side shields and CsI back shields.



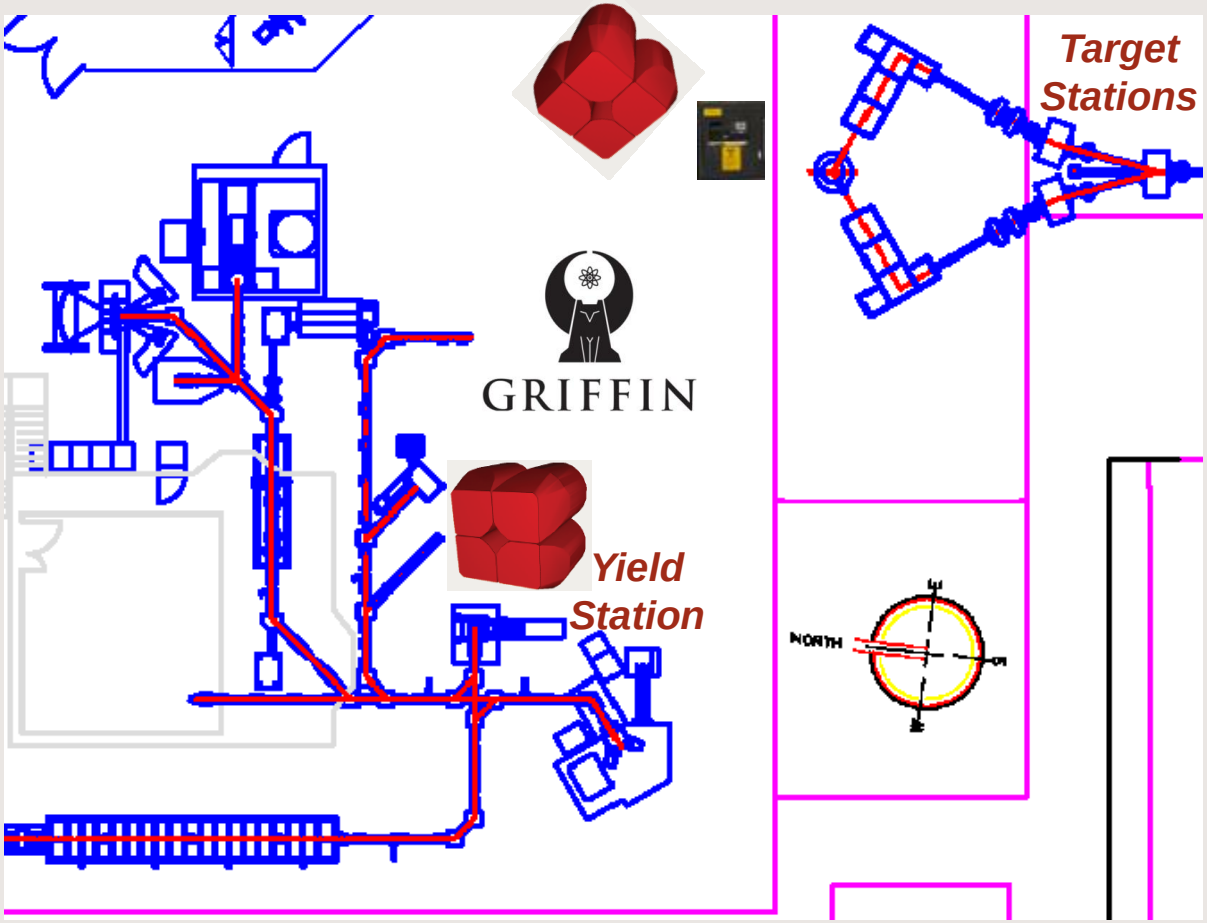
TIGRESS array in ISAC-II experimental hall

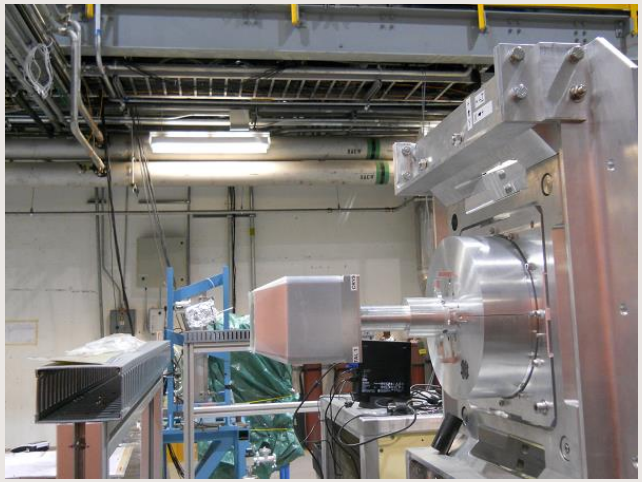




Background Characterization

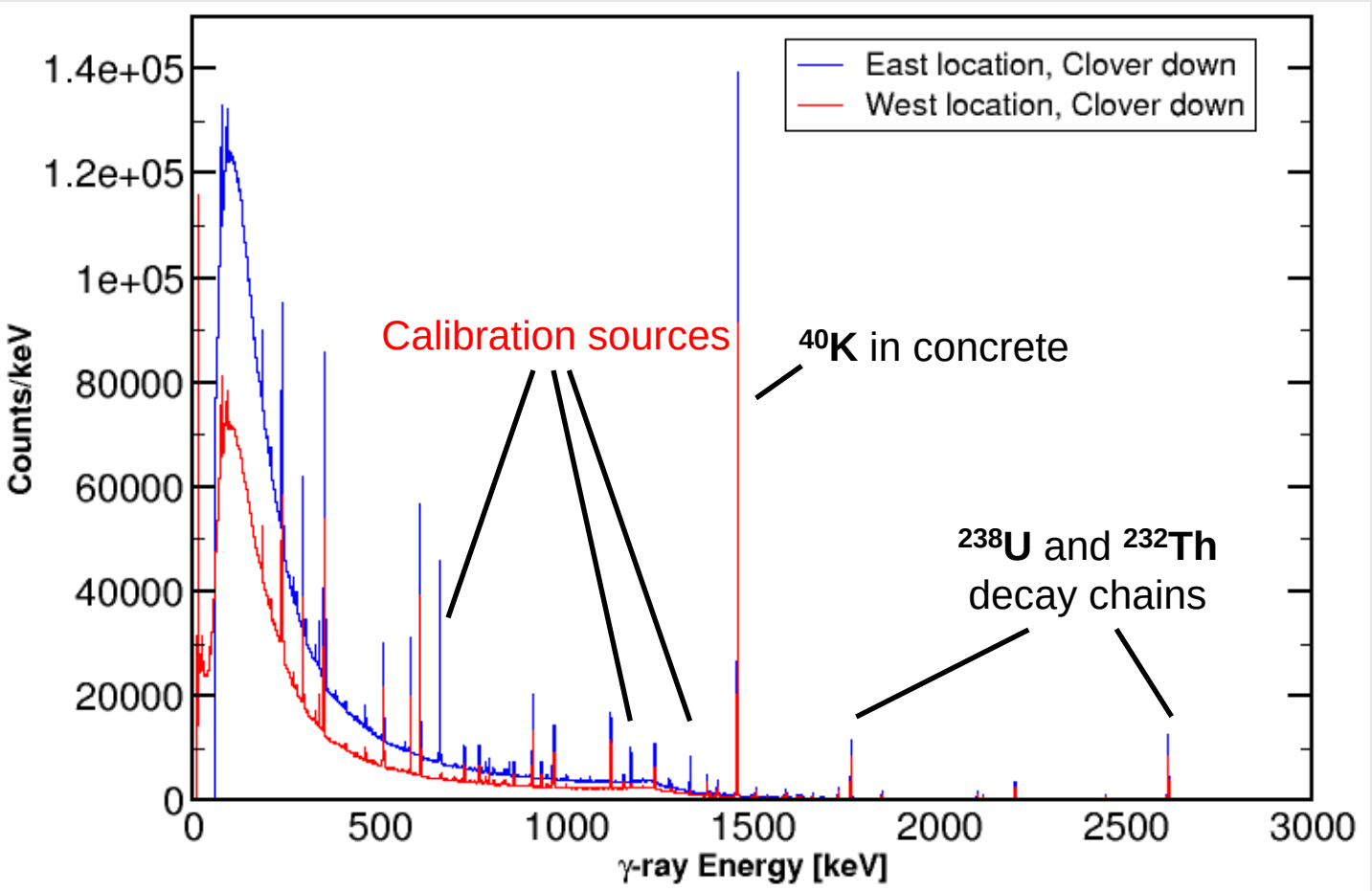
- Measurements taken with **GRIFFIN** clover in 2 locations in ISAC-I hall
  - **East** : closer to sources safe
  - **West** : closer to yield station.





Different Locations

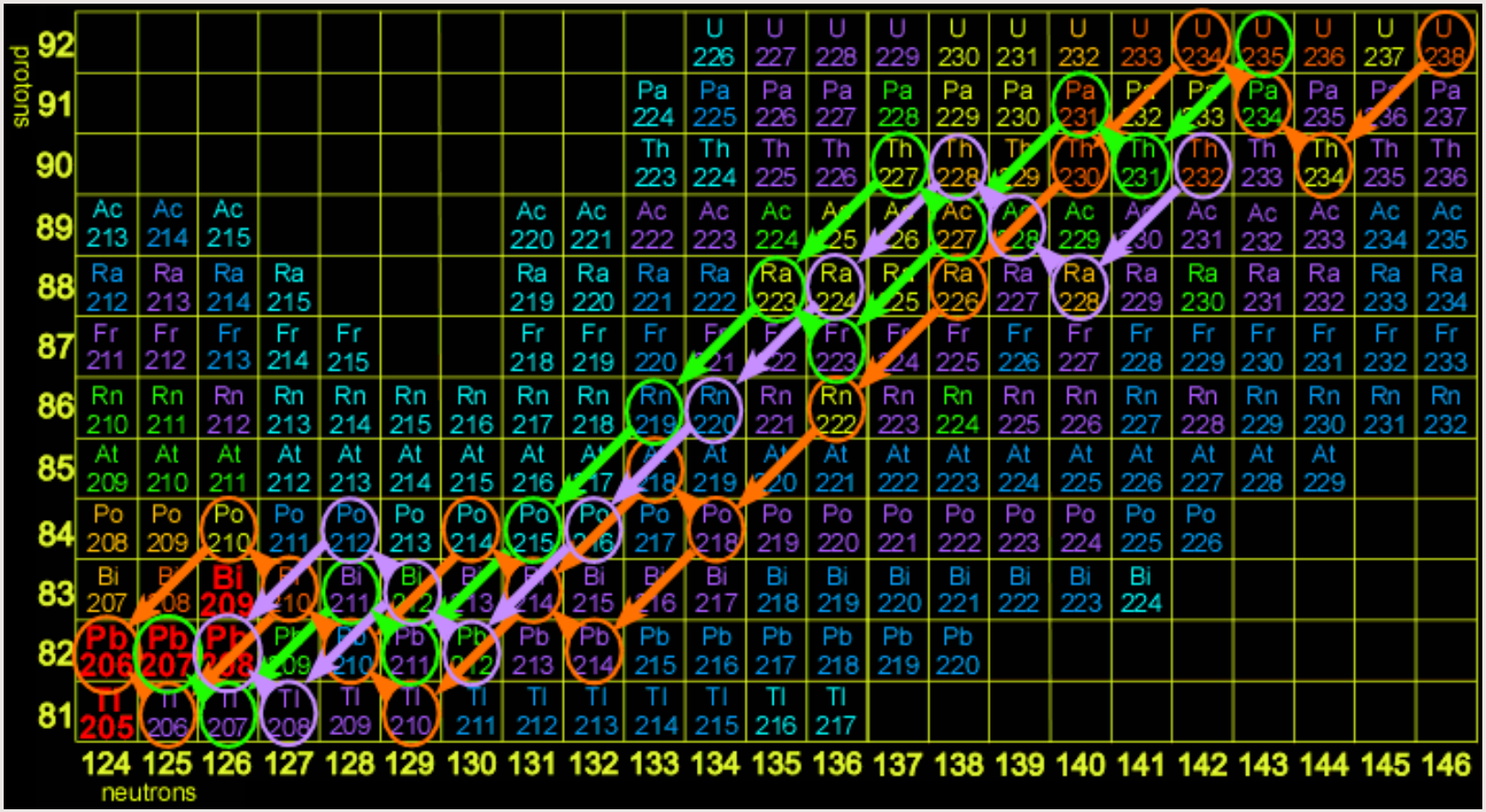
- Proton beam **off**, 48h
- East : **>**124 Hz/crystal, West : 102 Hz/crystal
- **>18%** difference between both locations.



! Different energy thresholds
Blue=59 keV
Red=30 keV

Environmental Background

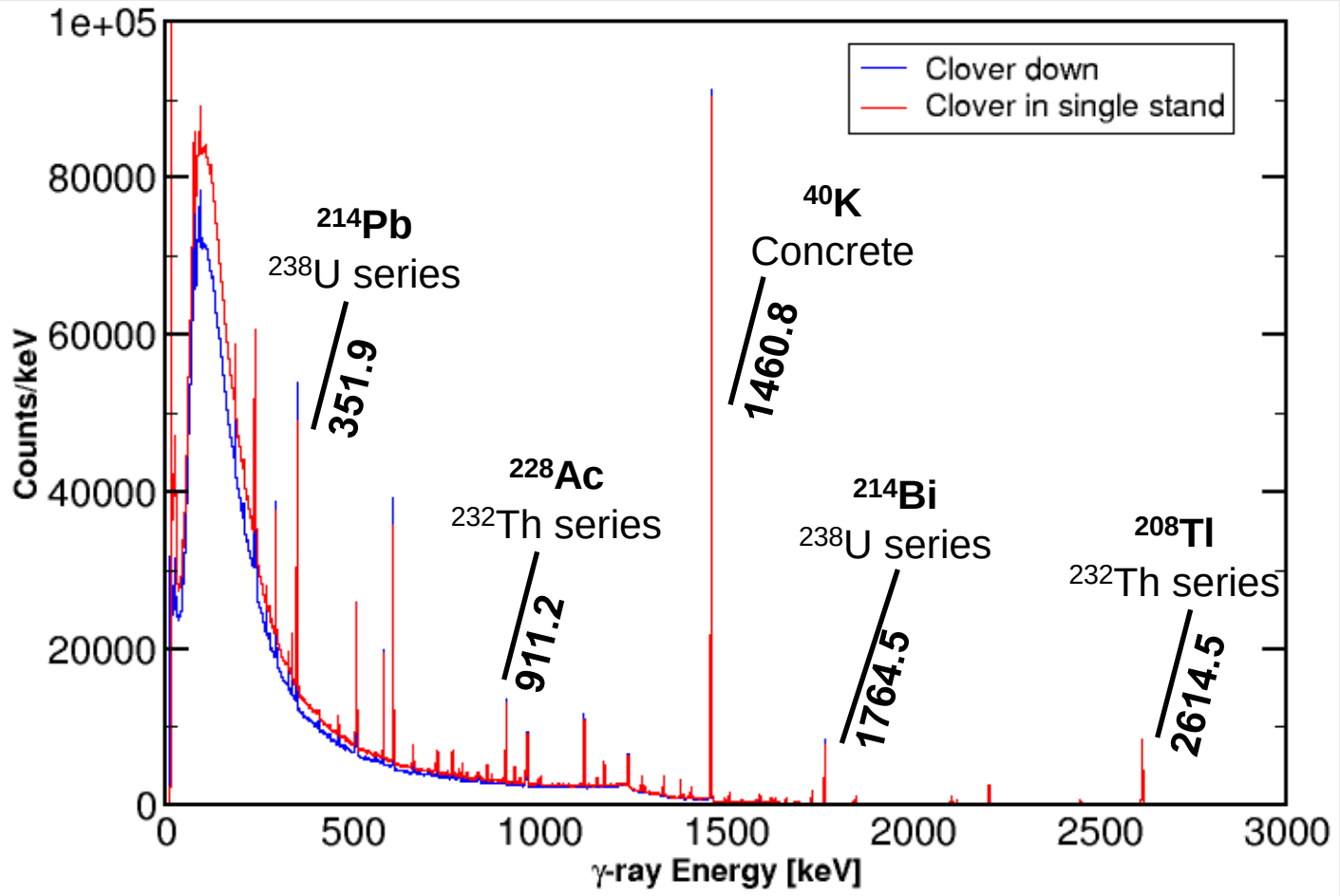
- ^{40}**K** and **U/Th** series decays and cosmic rays
- Activity generated by **high-energy neutrons** produced when the 500 MeV proton beam impinges on the high-power ISAC production targets located 2 stories below the ISAC-I experimental hall.



M. Brown

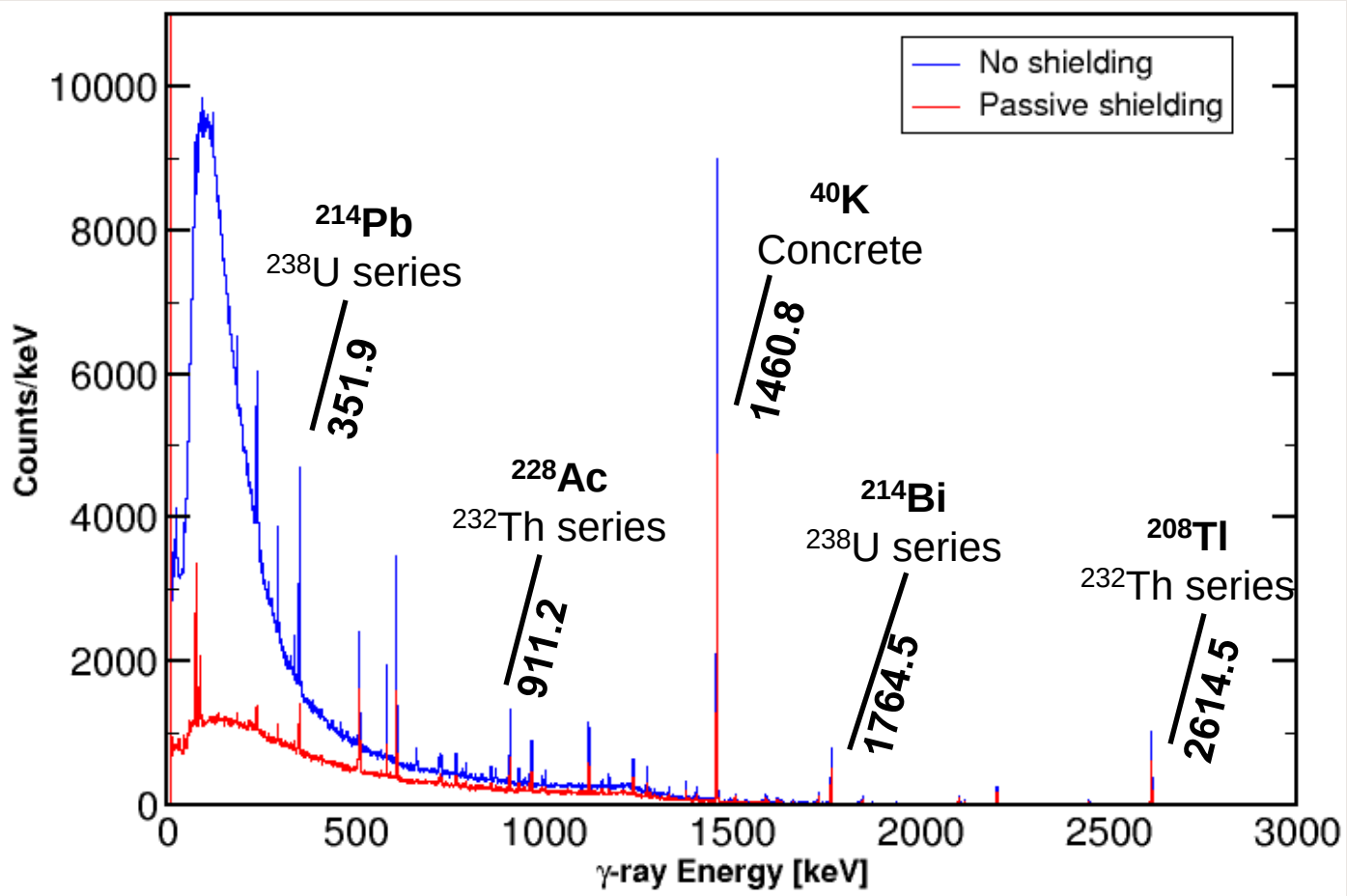
Different Orientations

- Proton beam **off**, 48h
- **Down** : 102 Hz/crystal, **Horizontal** : 87 Hz/crystal
- **14%** decrease with orientation.



Shielded Clover

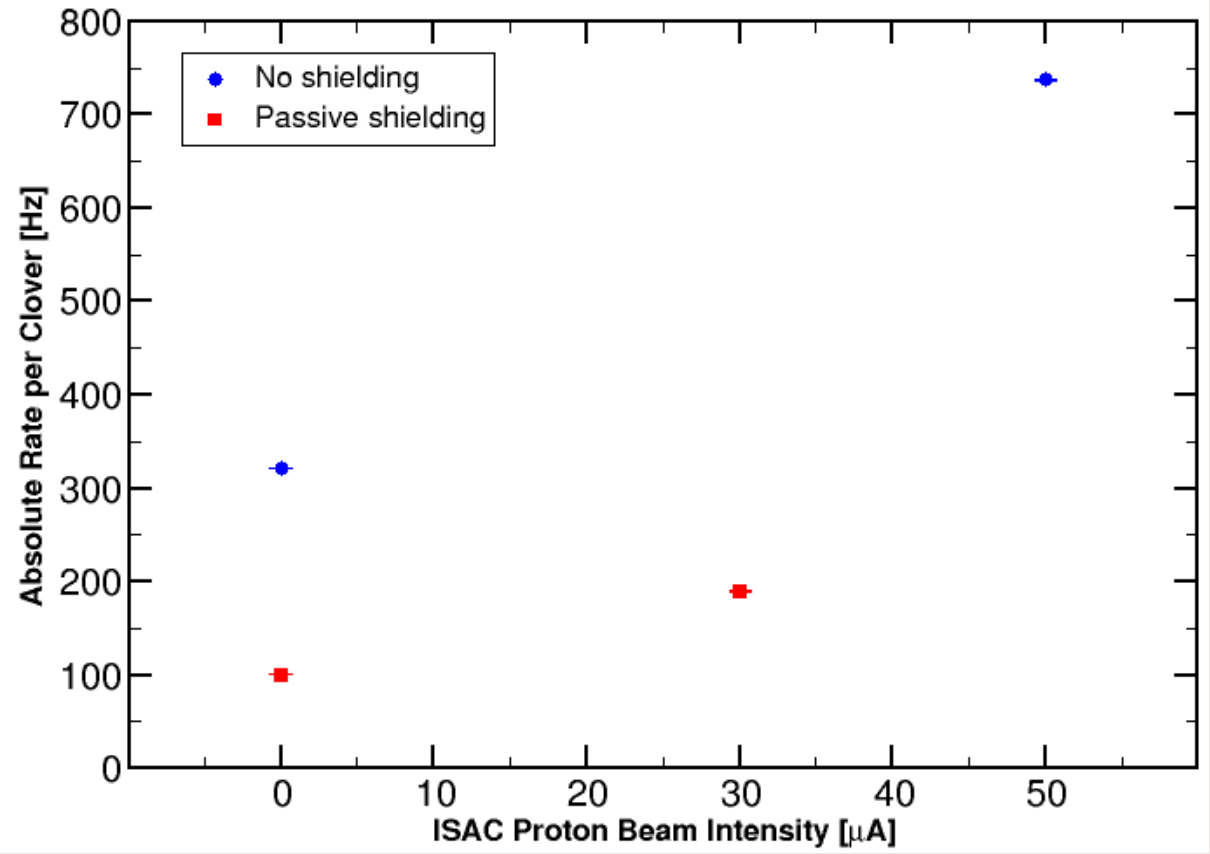
- Proton beam **off**, 2h
- **Passive** Shielding : 101 Hz/clover, **No** Shielding : 321 Hz/clover
- **69%** decrease with passive shielding only.



! 4 HPGe crystals summed without addback.

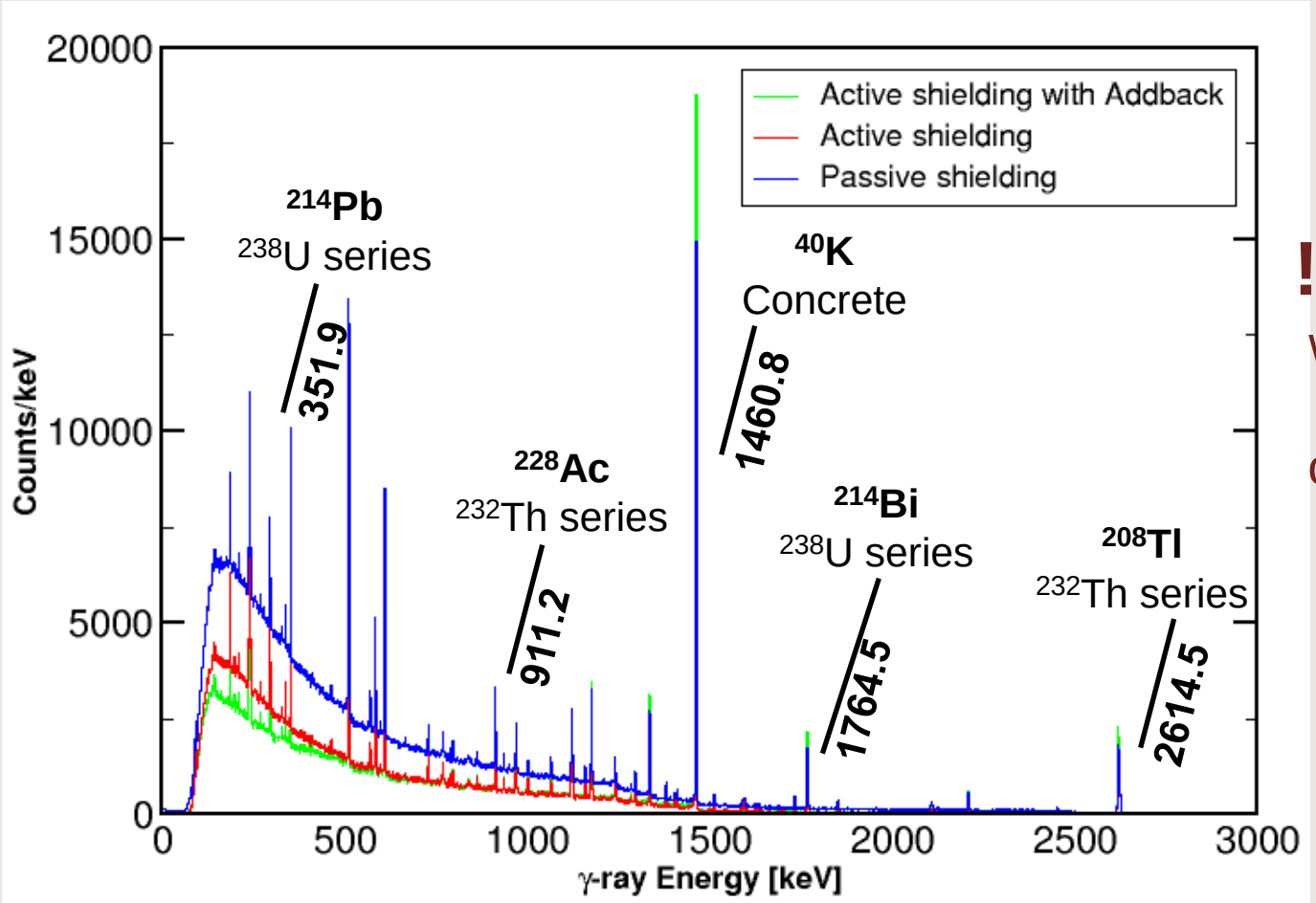
ISAC Proton Beam ON

- 737 Hz/clover, ~12 kHz in the full **GRIFFIN** array **without shielding**
- Expecting **0.1 mHz** for ~0.01 ions/s radioactive beams
- Background exceeding signal of interest by factor **10^8**.



Active Suppression

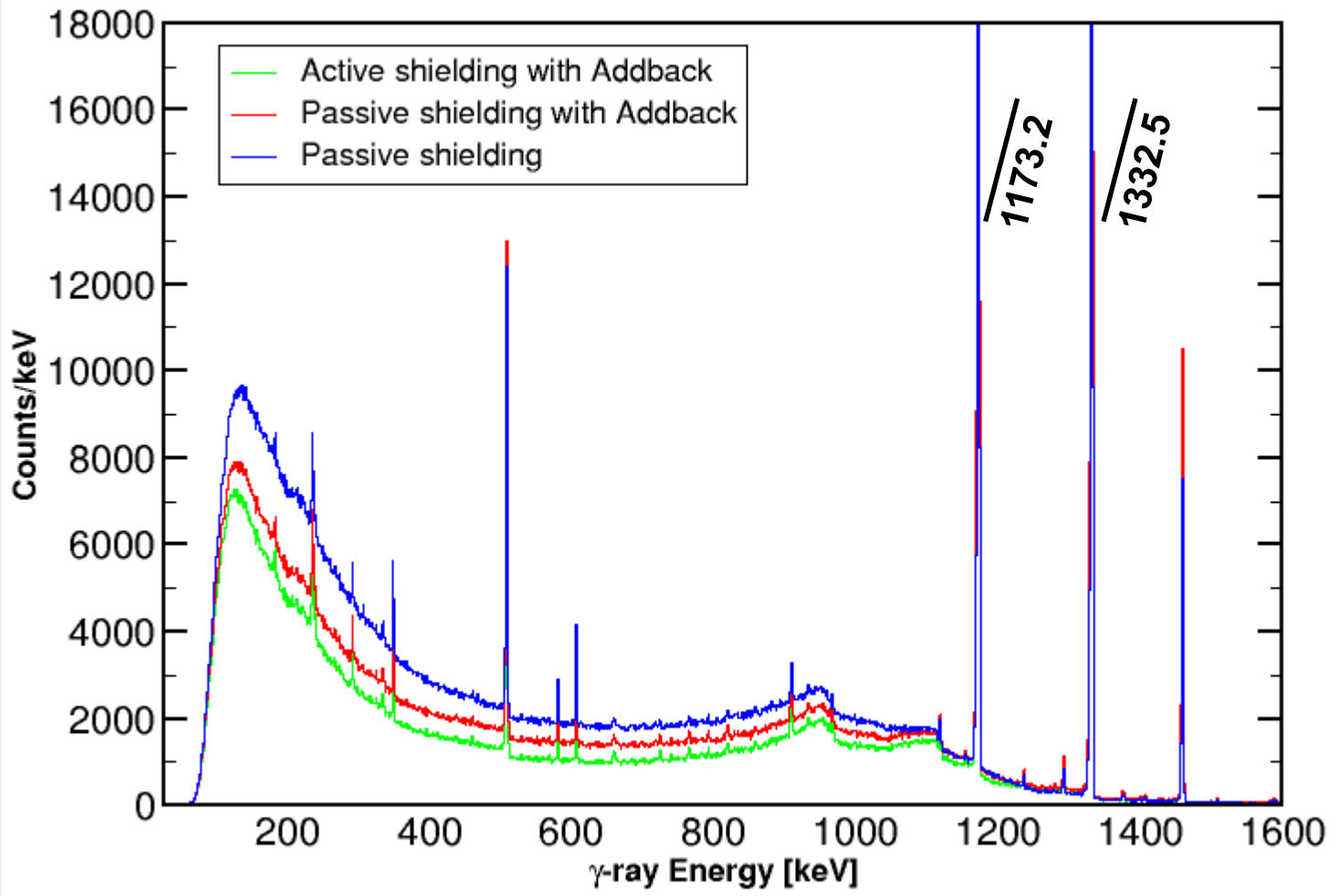
- **TIGRESS** clover in closed array, 24h
- **Passive** : 50 Hz/clover, local **active** : 23 Hz/clover
- Reduction of **GRIFFIN** background by a factor ***20***.



! Background rates will be moderately higher due the closer proximity of GRIFFIN to the ISAC production targets.

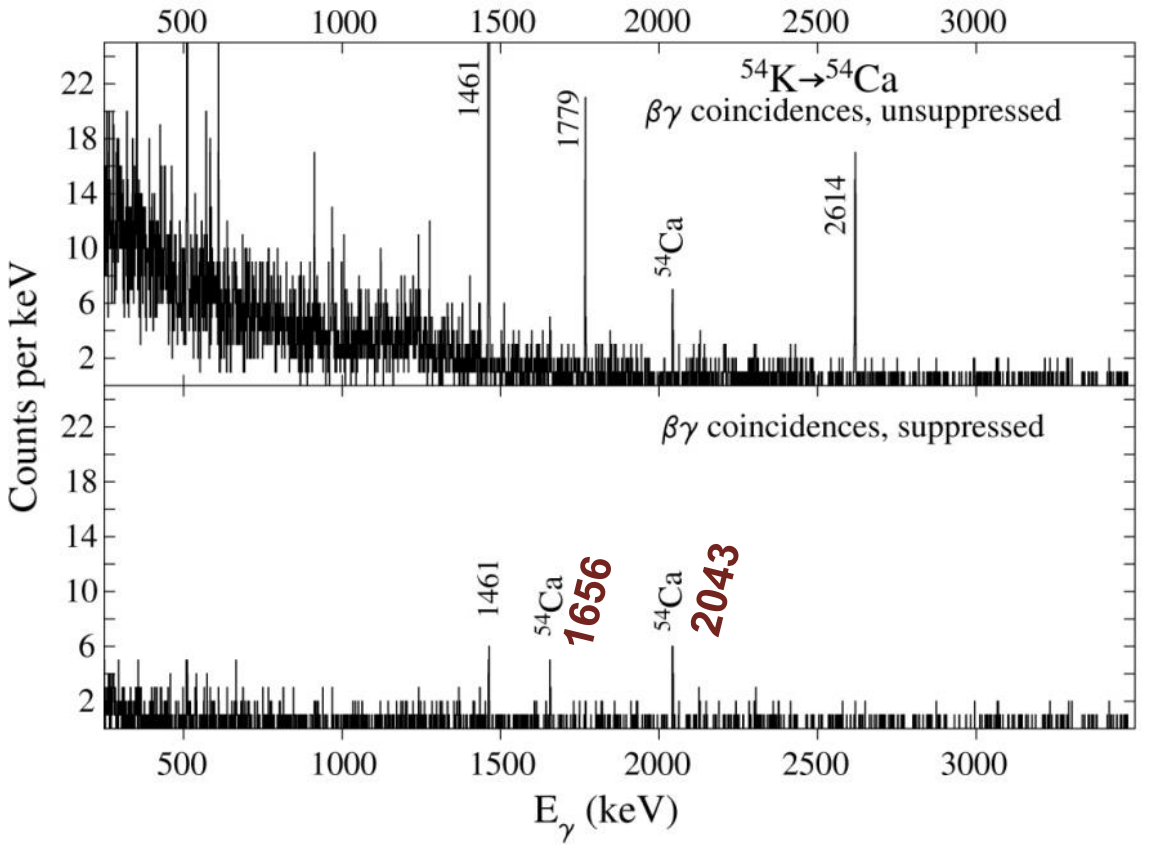
Peak-to-Total Ratios

- **TIGRESS** clover in closed array, 4h
- Improved ratios from **9.8%** to **11%** for a ^{60}Co source**.**



Example : Decay of ^{54}K to ^{54}Ca

- Simulation for a one week experiment using **GRIFFIN** at a beam rate of 0.01 ions/s using **TIGRESS** background measurements
- β-γ coincidence condition already suppresses by a factor **10^6**
- Impossible without the suppression shields !



Photopeaks from ^{40}K, Th series and neutron capture on **^{27}Al**

C.E. Svensson

Overview

- **GRIFFIN** array (16 clovers) will count **~12 kHz** of background triggers without suppression shields, limiting experiments to isotopes with beam intensities **≥ 0.1 ions/s**.

- Suppression shields will represent a **factor of 20** reduction in environmental background enabling an entire class of sensitive experiments down to beam intensities ~0.01 ions/s, approximately **200 additional exotic isotopes**.

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a place of mind
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PHYSICS ASTRONOMY

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Merci!
Thank you!

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