Investigations of Background and Compton Suppression Shields for GRIFFIN

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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.

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*See A.B. Garnsworthy (M2-2)*

*In-vacuum moving tape collector system*
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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 $\gamma$-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 $\gamma$-ray** : add energies.

  - If energy measured in a scintillator, **veto** any HPGe event in coincidence.
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.
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.

![Graph showing different energy thresholds with blue=59 keV, red=30 keV]
Environmental Background

- $^{40}\text{K}$ 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.
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, \(\sim 12\) kHz in the full GRIFFIN array without shielding
- Expecting 0.1 mHz for \(\sim 0.01\) 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 to the closer proximity of GRIFFIN to the ISAC production targets.
- **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
- $\beta$-$\gamma$ 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
- **GRiffin** array (16 clovers) will count \(~12\) kHz of background triggers without suppression shields, limiting experiments to isotopes with beam intensities \(\geq 0.1\) 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**.

TRIUMF

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Merci!

Thank you!