Gamma-Gamma Angular Correlation Measurements With GRIFFIN

Andrew MacLean
University of Guelph
GRIFFIN is a new high-efficiency gamma-ray spectrometer for decay spectroscopy with low-energy (30 keV) radioactive ion beams from TRIUMF-ISAC.
Gamma-Gamma Angular Correlation Measurements With GRIFFIN

\[ W(\theta) = 1 + \sum_{k=\text{even}}^{2L} a_k P_k(\cos\theta) \]

The \( a_k \) are coefficients are dependent on the nuclear spins, mixing ratios and multipolarities and \( P_k(\cos\theta) \) are the Legendre polynomials.

In the GRIFFIN geometry there are 51 distinct opening angles between HPGe crystals. Solid angle effects are treated through Geant4 simulated templates

\[ \delta = -10 \quad \delta = 0.2 \quad \delta = 1.0 \]

For mixed transitions, e.g., M1/E2, these correlation depend strongly on the mixing ratio, \( \delta \).
The first in-beam measurement was to investigate a $0^+\rightarrow 2^+\rightarrow 0^+$ cascade between the 1333-1039 keV gamma-rays following $^{66}$Ga beta decay.

The distinct $0^+\rightarrow 2^+\rightarrow 0^+$ template yields a $X^2/v = 0.96$ when compared to experimental data, while all other spin sequences yield $X^2/v > 100$. 
$^{66}$Ga Radioactive Beam Experimental Data

![Data](image)

**Data**

\[ 1^+ \rightarrow 2^+ \rightarrow 0^+ \text{ template (} \delta = -0.08 \) \]

\[ X^2/v = 0.92 \]

\[ 833-1039 \text{ keV} \]

**Normalized Counts**

\[ 2^+ \rightarrow 2^+ \rightarrow 0^+ \; \delta = -2.1(2) \]

\[ 2752-1039 \text{ keV} \]

\[ X^2/v = 0.86 \]

\[ 833-1039 \text{ keV} \]

\[ \cos(\theta) \]

\[ \tan(\delta) \]

66Zn

![Diagram](image)

**Nuclear Spins Legend**

- $0^+ \rightarrow 2^+ \rightarrow 0^+$
- $1^+ \rightarrow 2^+ \rightarrow 0^+$
- $2^+ \rightarrow 2^+ \rightarrow 0^+$
- $3^+ \rightarrow 2^+ \rightarrow 0^+$
- $4^+ \rightarrow 2^+ \rightarrow 0^+$

**Table**

<table>
<thead>
<tr>
<th>Cascade</th>
<th>[1]</th>
<th>[2]</th>
<th>$\delta$ (This work)</th>
</tr>
</thead>
<tbody>
<tr>
<td>833-1039 keV</td>
<td>-1.9(3)</td>
<td>-1.6(2)</td>
<td>-2.1(2)</td>
</tr>
<tr>
<td>2752-1039 keV</td>
<td>-0.09(3)</td>
<td>-0.12(2)</td>
<td>-0.08(3)</td>
</tr>
</tbody>
</table>


With techniques demonstrated a preliminary experiment was performed with a radioactive $^{62}$Ga beam to resolve a recently disputed spin assignment to the 2.34 MeV excited state in $^{62}$Zn.

In comparison to a previous experiment at TRIUMF, the high efficiency of GRIFFIN provided two orders of magnitude more statistics with half the number of decays using the $8\pi$ array.
With a beam rate of 1250 ions per second and a beta branch of 191 ppm to the 2.34 MeV state, the measurement favoured the assignment of this state as a $0^+$. A higher statistic experiment will be run with GRIFFIN to make a definitive spin assignment for this state.

GRIFFIN at ISAC-I is a powerful new facility for gamma-gamma angular correlation measurements to establish nuclear spins and transition mixing ratios in decay spectroscopy with radioactive ion beams.