Exploiting the $8\pi$ spectrometer to probe nuclear matter and drive innovative applications at SFU and TRIUMF

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The $8\pi$ $\gamma$-ray spectrometer

- Collaboration between Chalk River and Canadian Universities.
- Funded in 1984 by a joint AECL and NSERC grant.
- Becomes operational in 1986.
- 1986—1997 at TASCC as a high-spin spectrometer.
- 1997—2000 at the 88” Cyclotron as a high-spin spectrometer.
- 2000—2013 at TRIUMF ISAC I as a decay spectrometer.
- In January 2014 moved to SFU.
The designed $8\pi$ configuration

- $8\pi = 4\pi + 4\pi$

- The inside $4\pi$ shell:
  - $\gamma$-ray sum-energy and multiplicity calorimeter,
  - comprised of 72 high-efficiency, low-resolution, BGO detectors.

- The outside $4\pi$ shell:
  - high-resolution, low-Compton background measurement of $\gamma$-ray spectra,
  - comprised of 20 Compton-Suppressed Spectrometers (CSS),
  - each CSS is comprised of a high-resolution HpGe, a BGO shield and a BGO back-catcher.
TIGRESS 90° clovers summed: $^{60}\text{Co}$ source spectra illustrating effect of **add back** and **Compton suppression**.
The $8\pi$ at SFU detector inventory

- 25 HpGe (20—30% efficiency),
- 21 BGO shields,
- 21 BGO back-catchers,
- 12 BGO filter pentagons,
- 62 BGO filter hexagons, 20 of them in 6-element clusters.
Use of the $8\pi$ for $\gamma$-ray detection at SFU and TRIUMF

- **Nuclear structure far from stability:**
  - trap-assisted decay spectroscopy at TITAN at TRIUMF,
  - spontaneous fission studies at SFU using the Twin Ionisation Chamber for Fission Fragment Investigations (TIFFIN) detector,
  - decay spectroscopy at SFU for fission fragments produced using the deuterium-tritium neutron generator.

- **Neutron activation analysis analysis at SFU:**
  - activity concentration of $(n,2n)$ and $(n,\gamma)$ reaction products following fast and thermal neutron irradiation using the SFU deuterium-tritium neutron generator.

- **Environmental monitoring at SFU:**
  - activity concentration of $^{134}\text{Cs}$ from the Fukushima accident using a coincidence method for detection of 604-keV/795-keV decay-pair in environmental samples.
8π Spectrometer at TRIUMF-ISAC
The $8\pi$ at SFU installation tasks

- Installation of the $8\pi$ frame for compatibility with the SFU neutron-generator pneumatic transport system.
- Rebuilding of the $8\pi$ to its original design for $\gamma$-ray calorimetry.
- Operation of the $8\pi$ using the SFU digital Data Acquisition System (DAQ).
- Capacity development at SFU for $8\pi$ detector maintenance and development.
Fitting in the $8\pi$: the CAD model
The $8\pi$ move
The $8\pi$ move
The $8\pi$ move
The $8\pi$ move
The $8\pi$ move
The $8\pi$ move
The $8\pi$ move
$8\pi$ BGO hexagons
$8\pi$ BGO hexagons
$8\pi$ BGO pentagons
$8\pi$ BGO pentagons
$8\pi$ Compton Suppressed Spectrometers
The $8\pi$ HpGe annealing station
100MHz 14-bit Digital Data Acquisition System
60Co, pentagon test

Energy [arb.]

Counts

Entries  40872

ch. 721

8π BGO pentagon digital DAQ test
$8\pi$ HpGe digital DAQ test

60Co

Charge

Counts

Entries  67494

K. Starosta (SFU)
$8\pi$ HpGe digital DAQ test

![Graph showing counts vs. charge for 60Co with entries 67494 and charge range from 2500 to 2900.]
$8\pi$ HpGe digital DAQ timing

Point of intersection = t₀

<table>
<thead>
<tr>
<th>Waveform</th>
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<tbody>
<tr>
<td>Entries</td>
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<tr>
<td>Mean</td>
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<td>RMS</td>
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$8\pi$ HpGe $\gamma - \gamma$ digital DAQ timing test
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