Ground Calibration for GEMS XPI

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GEMS

- Polarization measurements allow us to study:
  - Scattering
  - Magnetic fields
  - Strong gravity

- GEMS will use polarimetry to study these processes in black holes, neutron stars and SNR
What XPI will measure

- Polarization of X-rays
- Photoelectron is ejected in direction of X-ray E-field
- Photoelectron makes a track of electrons which is imaged by the TPC
- Initial direction of photoelectron gives the polarization of the X-ray
TPC Design and Requirements

- The GEMS TPC detectors need to detect 1% polarization with $1.8 \times 10^6$ counts.
- 2 - 10 keV energy response
- Energy resolution of 1 keV in the 2 - 10 keV band
- ~10 arcmin angular resolution
Calibration Requirements

- X-ray beams (100% and 0% polarization) at multiple energies will be scanned across the detector window.
- Polarized beams rotated with respect to the detector to produce range of polarization angles.
- Pulse height to energy conversion factor must be measured.
- Must be tested in flight conditions.
Calibration Facility

- X-ray beamline with 2-axis translation + 1 rotational axis
- X-rays generated by commercial medical X-ray tubes chosen to be cylindrically symmetric for low intrinsic polarization
- Helium filled beamline to improve transmission at low energies
100% Polarized Sources

- X-ray beam Bragg scattered at near 45 deg angle to produce 100% polarized beam
- Crystals selected that match the Bragg angle of the required X-ray energies

<table>
<thead>
<tr>
<th>Energy (keV)</th>
<th>Target and Line</th>
<th>Crystal Material</th>
<th>2d Spacing (Angstrom)</th>
<th>E at 45° keV</th>
<th>Bragg Order</th>
<th>Bragg Angle</th>
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</thead>
<tbody>
<tr>
<td>2.70</td>
<td>Rh-La</td>
<td>Ge (111)</td>
<td>6.532</td>
<td>2.68</td>
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<td>44.7</td>
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<tr>
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<td>Ag-La</td>
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<td>Ti-Ka</td>
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<td>44.9</td>
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</tbody>
</table>
0% Polarized Sources

- Cylindrically symmetric X-ray tube with circular filament
- Tube centered on beam line
- Low intrinsic polarization removed by continuous rotation to produce 0% net polarization
GEMS is required to find the energy of incident X-rays in addition to the polarization.

For a given energy, a pulse height distribution will be produced.

The relation between pulse height and energy will be extrapolated from the measurements with tubes at different energies.