The Compton Spectrometer and Imager

Carolyn Kierans - Goddard Space Flight Center
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**The Compton Spectrometer and Imager**

**COSI** is balloon-borne γ-ray telescope designed to
- investigate the origin of Galactic positrons,
- perform polarization measurements of astrophysical sources,
- and study stellar nuclear line emissions.

12 germanium detectors
The Compton Spectrometer and Imager

**COSI** is balloon-borne γ-ray telescope designed to

- investigate the origin of Galactic positrons,
- perform polarization measurements of astrophysical sources,
- and study stellar nuclear line emissions.

**Energy range:** 0.2–5 MeV
**Energy resolution:** 0.6% at 511 keV
**Angular resolution:** 6º at 511 keV
**Field of view:** 25% of sky

12 germanium detectors
The Crab and Cyg X1 detected as COSI drifts North towards the equator.

COSI detects GRB 160530A.

COSI launches from Wanaka, New Zealand on Super Pressure Balloon, May 16, 2016.

After 46 days aloft, COSI makes a gentle landing in southern Peru.

COSI detects Cen A at southern latitudes.

COSI detects Centaurus A.

Lowell et al, 2017a
Lowell et al, 2017b
COSI 2016 Galactic Exposure Map

Credit: C.-L. Chiu
GRB 160530A

Real-time alert
(GCN19473, Tomsick+)
• also detected by AstroSat/CZTI, INTEGRAL/ACS, and Konus-Wind

Polarization analysis:
• ML-approach (Krawczynski+ 2011)
• 90% confidence upper limit: <46%
• Best fit: $16^{+27}_{-16}$ %

A. Lowell Thesis UC Berkeley
Spectral Analysis Pipeline & Detector Effects Engine

- Spectral analysis pipeline that is compatible with XSPEC
- No detection of polarization (only 25 ks of exposure)

C. Sleator+ 2019
C. Sleator Thesis UC Berkeley
Detection of Galactic Positron Annihilation

Background estimation for spectral line analysis:
- COMPTEL Data Space (Knödlseder+ 1996)

GC Background Subtracted Spectrum

511 keV line - 7.2σ
positronium- 3σ

511 keV Angular Distribution around GC

FWHM = 33±2°

C. Kierans+ submitted to ApJ
arXiv:1912.00110
C. Kierans Thesis UC Berkeley
The Future of COSI

COSI-2 to launch from Wanaka, NZ Spring 2020

COSI-SMEX
• proposal for satellite submitted 2019
• finer strip pitch detectors give better angular resolution: $\times 2$ at 511 keV
Follow COSI in 2020!

Learn more about COSI and follow our blog at cosi.ssl.berkeley.edu
COSI 2016 Launch from Wanaka, NZ

Credit: Bill Rodman/NASA Wallops
**COSI Instrument**

- Evacuated anodized aluminum cryostat
- Sunpower Cryotel cryocooler
  - GeD operating temp \( \sim 85K \)
- Cesium iodide anti-coincidence shields
  - significant background reduction
  - FOV \( \sim 25\% \)
COSI 2016 Wanaka Campaign

Total suspended weight: 4500 lbs
COSI 2016 Full Flight Spectrum

Strong background from the atmosphere and instrument activation.

GC/Background ~5% @ 511 keV
**Galactic 511 keV with COSI**

**GC Background Subtracted Spectrum**

511 keV line - 7.2σ
positronium - 3σ

Flux measurement

\[
(3.9 \pm 0.4) \times 10^{-3} \, \gamma/\text{cm}^2/\text{s}
\]

\[
F(E) = A \exp \left( -\frac{(E - \mu)^2}{2\sigma^2} \right) + B F_{oPs}(E)
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Gaussian Fit</td>
<td>( \mu ) 511.8±0.3 keV</td>
</tr>
<tr>
<td></td>
<td>( \sigma ) 2.5±0.3 keV</td>
</tr>
<tr>
<td></td>
<td>( A ) 403±57 cts/keV</td>
</tr>
<tr>
<td>o-Ps Fit</td>
<td>( B ) 12±4 cts/keV</td>
</tr>
<tr>
<td>( \chi^2/\text{d.o.f.} )</td>
<td>193.0/196</td>
</tr>
<tr>
<td>511 keV line counts</td>
<td>2560±300 cts</td>
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<tr>
<td>o-Ps continuum counts</td>
<td>5110±1700 cts</td>
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<tr>
<td>( f_{oPs} )</td>
<td>0.76±0.12</td>
</tr>
</tbody>
</table>

CK et al. submitted to ApJ
Galactic 511 keV with COSI

511 keV Angular Distribution around GC

- COSI Flight Data
- Gaussian Fit
- Skinner Bulge (scaled)

FWHM = 33±2°

Twice as broad as SPI bulge models

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<thead>
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<th>Parameter</th>
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<tr>
<td>Gaussian Fit μ</td>
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<tr>
<td>σ</td>
<td>14.0±0.7°</td>
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<tr>
<td>A</td>
<td>89±0.6 cts</td>
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<td>χ²/d.o.f.</td>
<td>52.1/52</td>
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<tr>
<td>FWHM</td>
<td>33±2°</td>
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</table>

CK et al. submitted to ApJ