

Study of ^{26}Al in the COSI 2016 superpressure balloon flight

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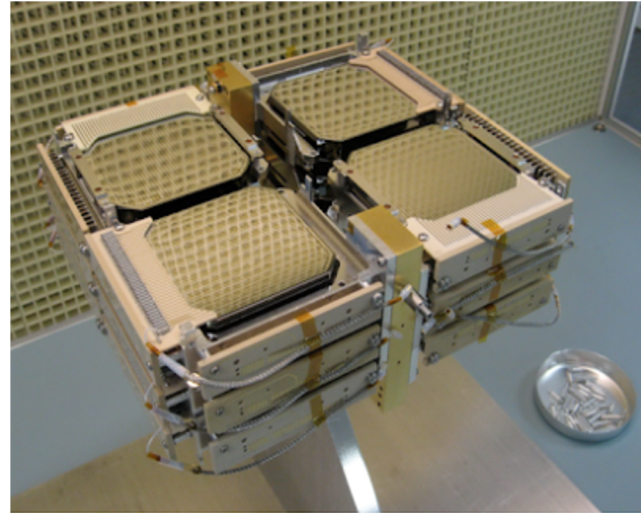
COSI Overview

Balloon-borne compact Compton telescope

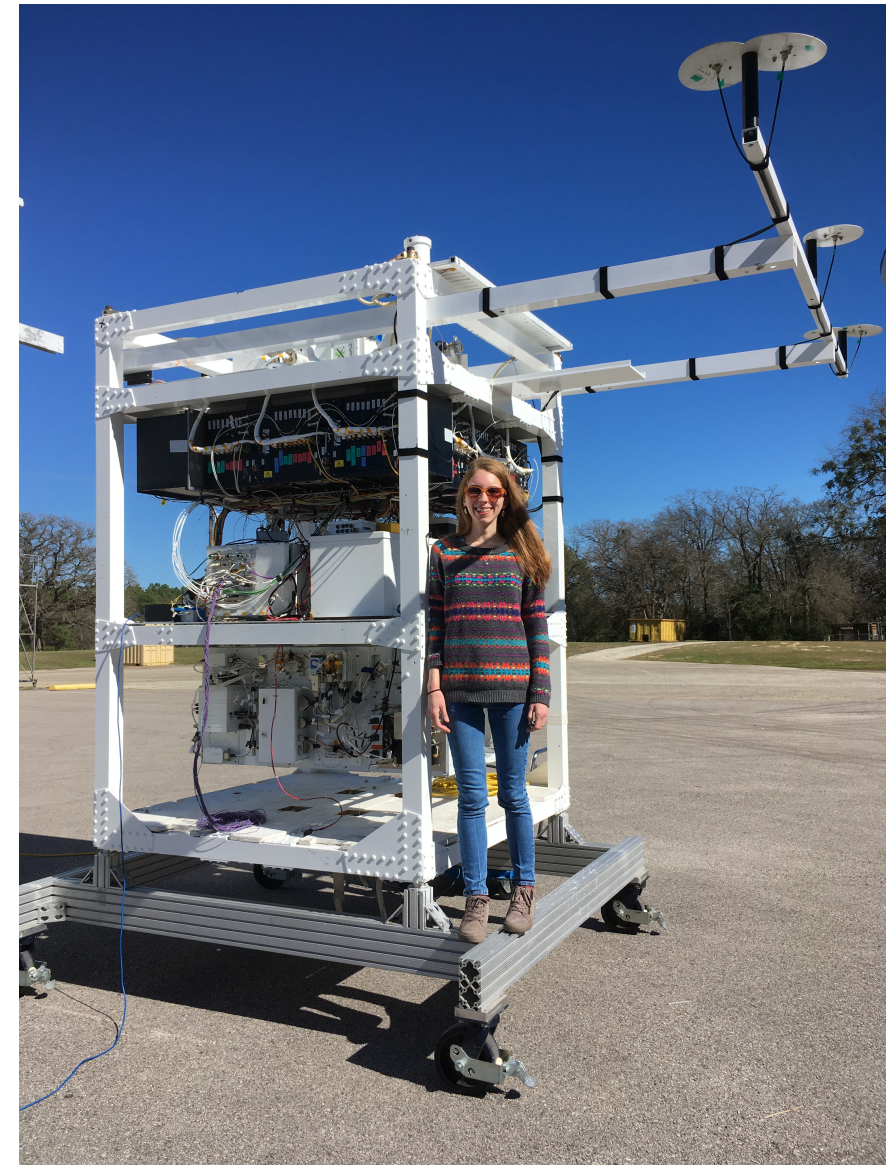
- Energy range: 0.2 - 5 MeV
- Energy resolution: $\sim 0.2\%$ FWHM at 1.8 MeV
- FOV: 25% of the sky ($\sim 1\pi$ steradian)

Science goals

- Study emission of nuclear lines (e.g. ^{26}Al)
- Map 511-keV electron-positron annihilation
- Measure polarization of compact objects, GRBs
- Multi-messenger astrophysics in the GW era



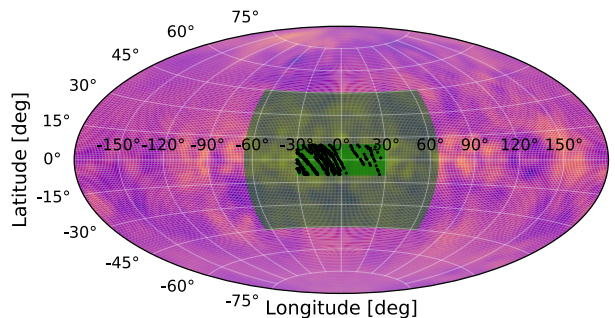
COSI's detector volume comprised of 12 high-purity germanium semiconductor detectors ($8 \times 8 \times 1.5 \text{ cm}^3$, 2-mm strip pitch)



The presenter with the COSI gondola at the Columbia Scientific Balloon Facility in Palestine, Texas, United States

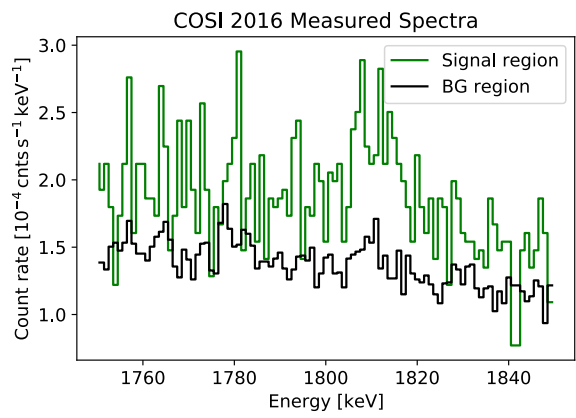
Search for 1809 keV signature of ^{26}Al in the 2016 flight

- NASA superpressure balloon flight**
- May 17 – July 2, 2016 (46 days)
 - Launched from Wanaka, New Zealand
 - Observation time in the signal region: ~156 ks
 - Observation time in the background region: ~1356 ks



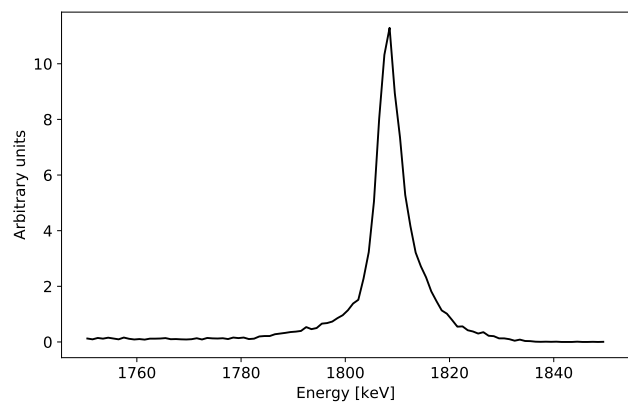
SPI A1-26 image¹ shows emission concentrated in the Inner Galaxy (I.G.) → choose the I.G. as the **signal region (green)** and the rest of the sky as the background region.

Black points: COSI exposures within the I.G.

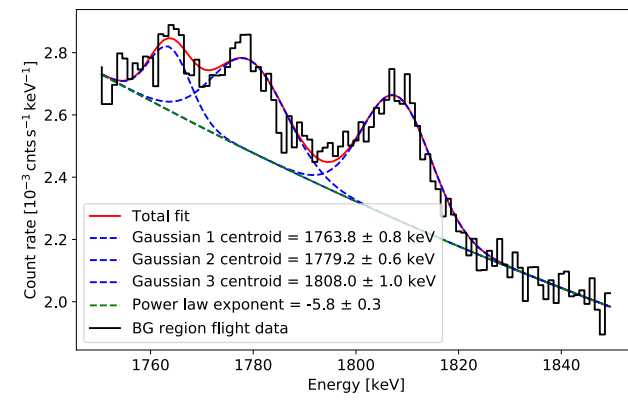


Search for ^{26}Al in the flight spectrum from the signal region:
 $(|l| \leq 30^\circ, |b| \leq 10^\circ)$

- Maximum likelihood search**
- Find sky amplitude α and BG amplitude β which best describe the flight data d_i in the signal region (left panel, bottom figure)
- $$\text{Maximize } \mathcal{L}(d|m) = \prod_{i=1}^N \frac{m_i^{d_i} e^{-m_i}}{d_i!}, \text{ where } m_i = \alpha s_i + \beta b_i$$
- 100 1-keV energy bins i spanning 1750–1850 keV

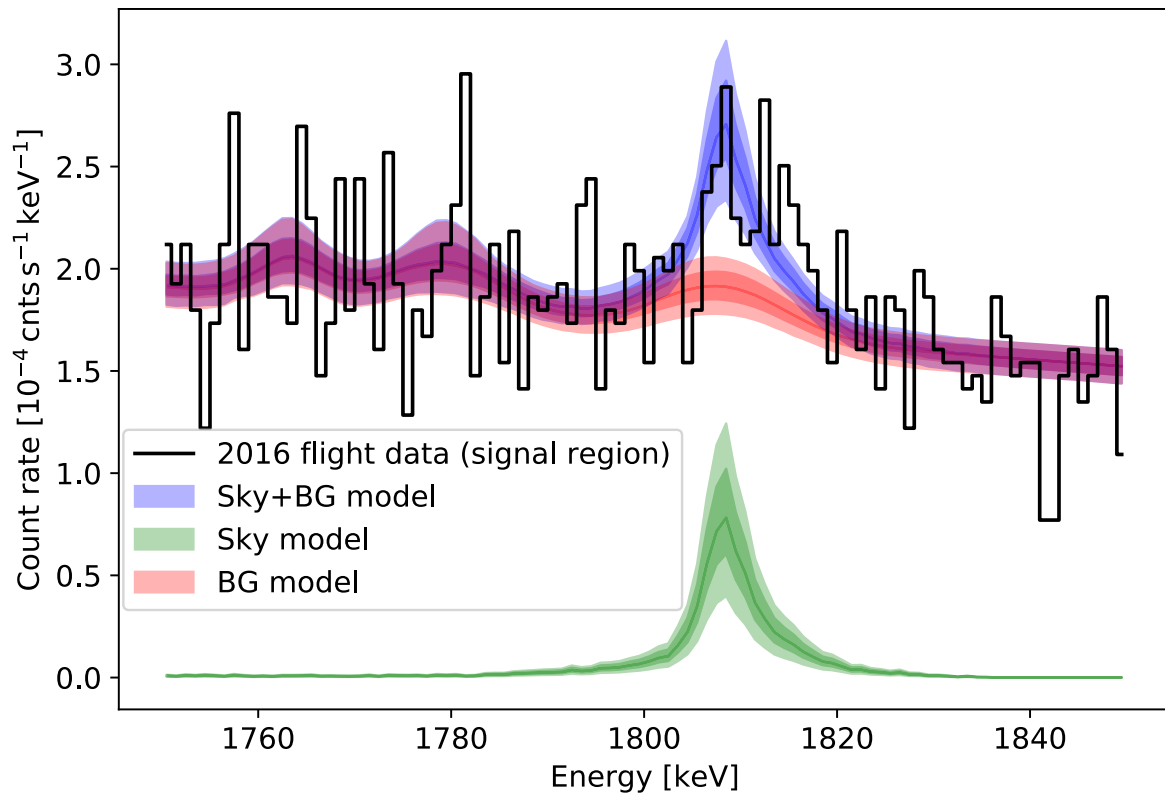


Sky model s_i
 Spectral response to the expected signal over 50 flights



BG model b_i
 Inferred from the data in the background region, fit with a power law + 3 Gaussians

Results



- Sky model (^{26}Al) contribution to the flight data in the signal region, with fitted sky amplitude $\alpha = 1.1^{+0.3}_{-0.3}$
- Measurement significance: 3.7σ above background
- Line centroid: $1811.3 \pm 1.9 \text{ keV}$
- Rate: $6.8 \times 10^{-4} \text{ cnts s}^{-1}$

Measured flux = $(17.0 \pm 4.9) \times 10^{-4} \text{ ph cm}^{-2} \text{ s}^{-1}$

Signal region is broadened by $35^\circ \rightarrow$ integrate SPI¹ and COMPTEL² 1.8 MeV maps for flux comparison:

SPI: $7.3 \times 10^{-4} \text{ ph cm}^{-2} \text{ s}^{-1}$

COMPTEL: $8.2 \times 10^{-4} \text{ ph cm}^{-2} \text{ s}^{-1}$

Take home messages

- **COSI finds an excess at 1.8 MeV consistent at the 2σ level with expectations from Al-26**
- Instrumental and atmospheric background simulations are being used to validate the results
- Investigations ongoing: using different template maps (COMPTEL, SPI), image reconstruction, model fitting

References

- 1 L. Bouchet, E. Jourdain and J.-P. Roques, *The galactic ^{26}Al emission map as revealed by INTEGRAL SPI*, *The Astrophysical Journal* **801** (2015) 142.
- 2 S. Plüschke, R. Diehl, V. Schönfelder, H. Bloemen, W. Hermsen, K. Bennett et al., *The COMPTEL 1.809 MeV survey*, *arXiv preprint astro-ph/0104047* (2001).

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