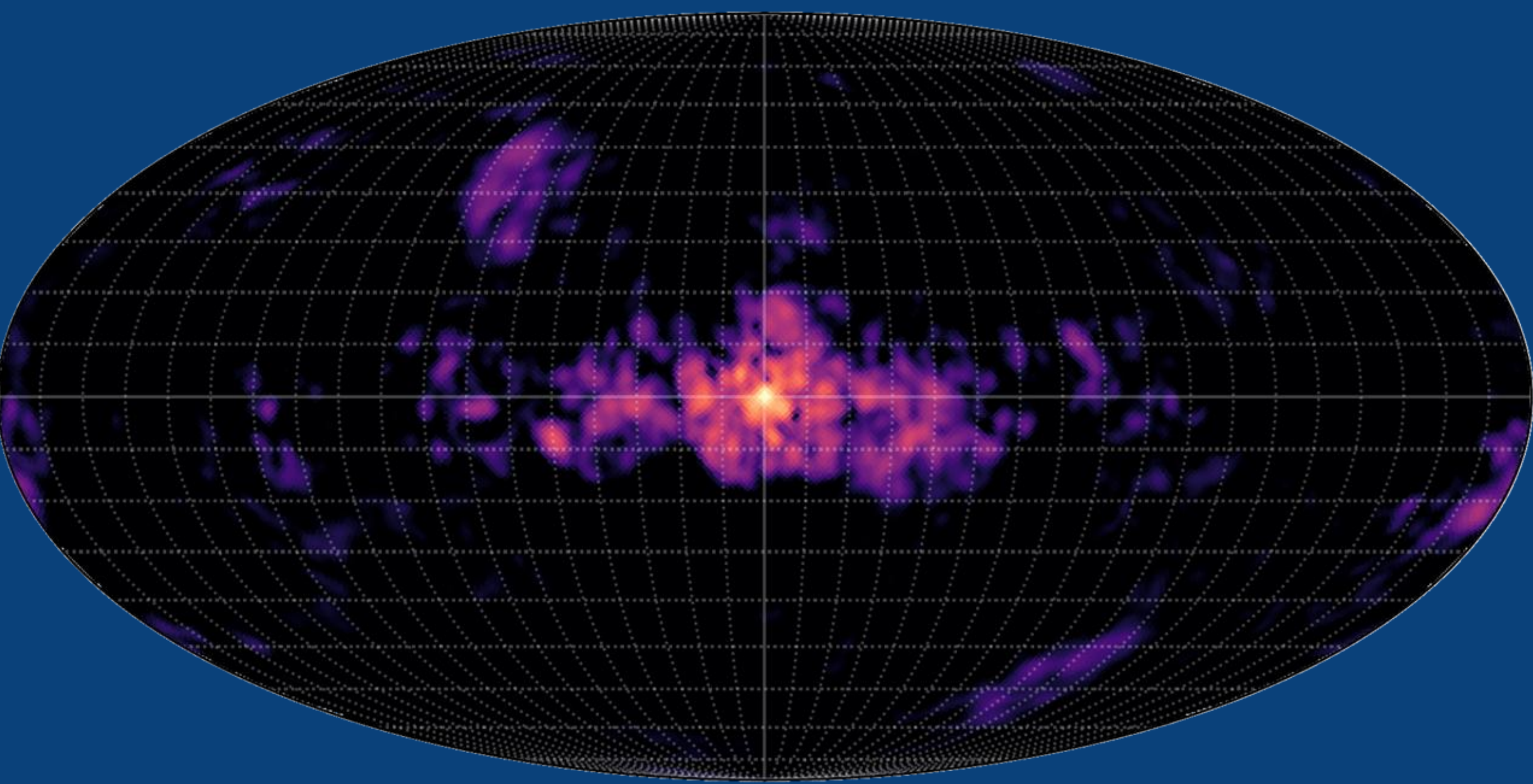
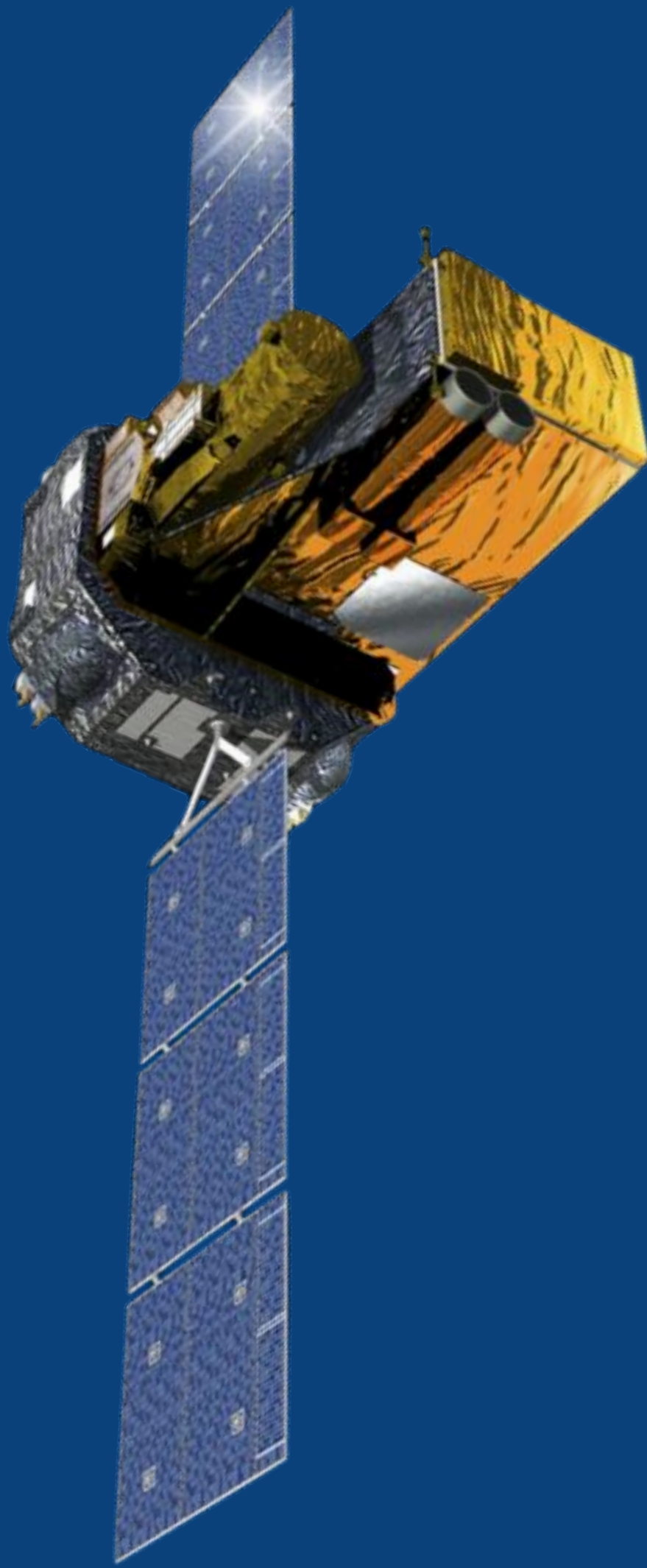




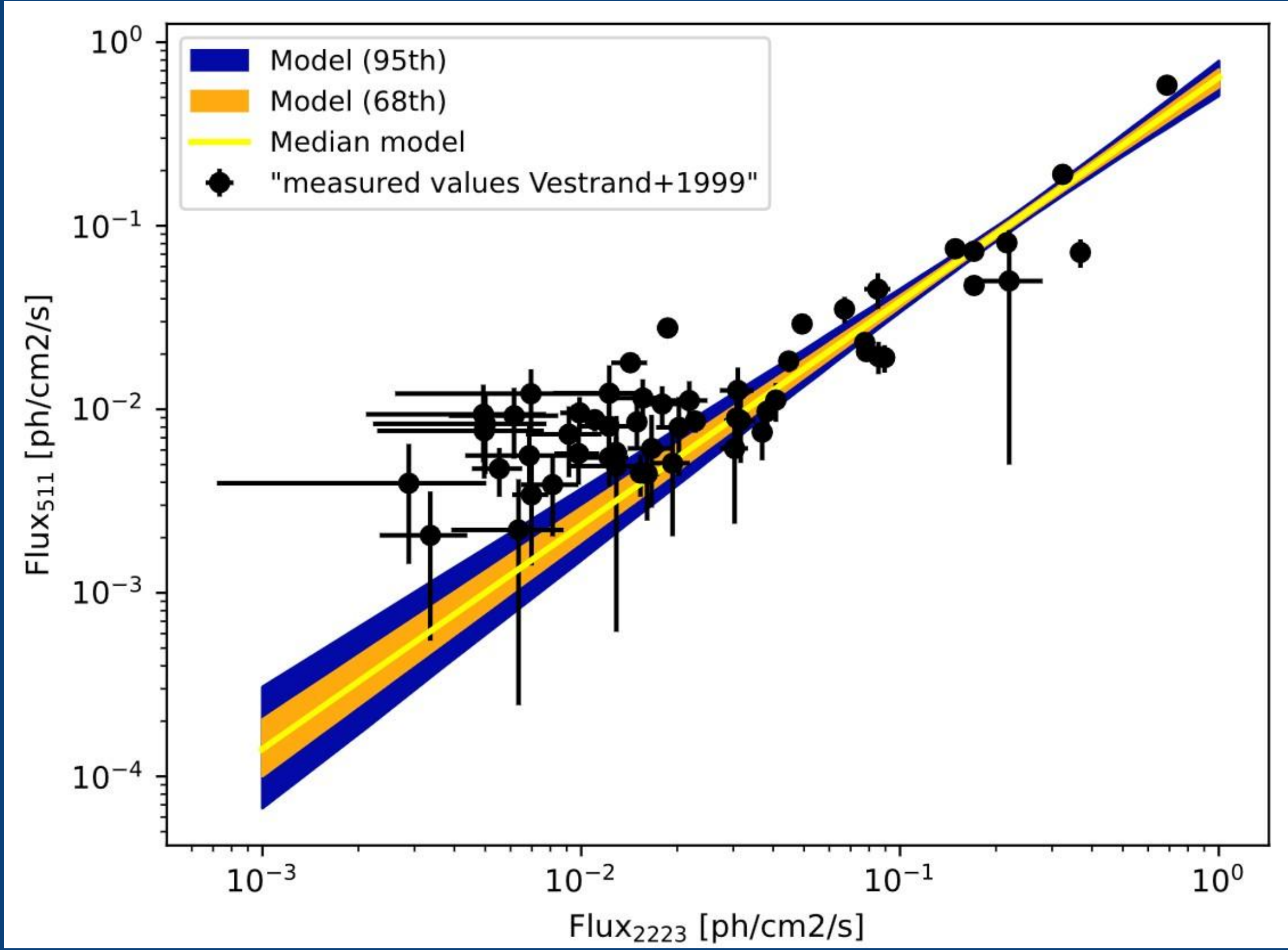
## Positron Puzzle



20 Years INTEGRAL/SPI 511 keV All-Sky map (Yoneda+ 2025)



## 511 keV – 2.223 MeV Correlation



Empirical scaling between prompt 511 keV and 2.223 MeV line flux (Mittal+ 2026)

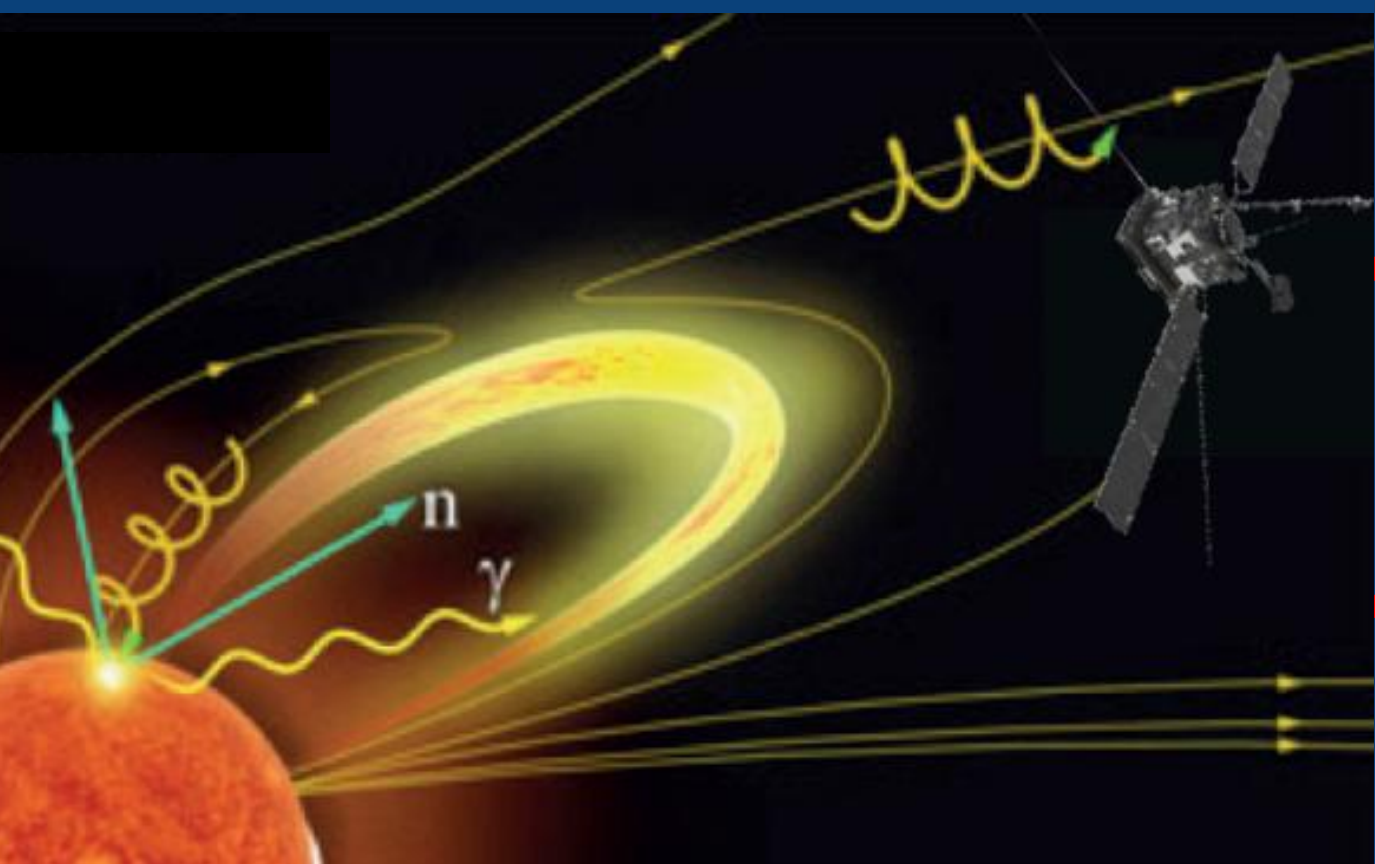
$$e^+ + e^- \rightarrow 2\gamma(511\text{keV})$$

$$F_{511} \propto (F_{2.223})^{1.22 \pm 0.07} \quad p + n \rightarrow d + \gamma(2.223\text{MeV})$$

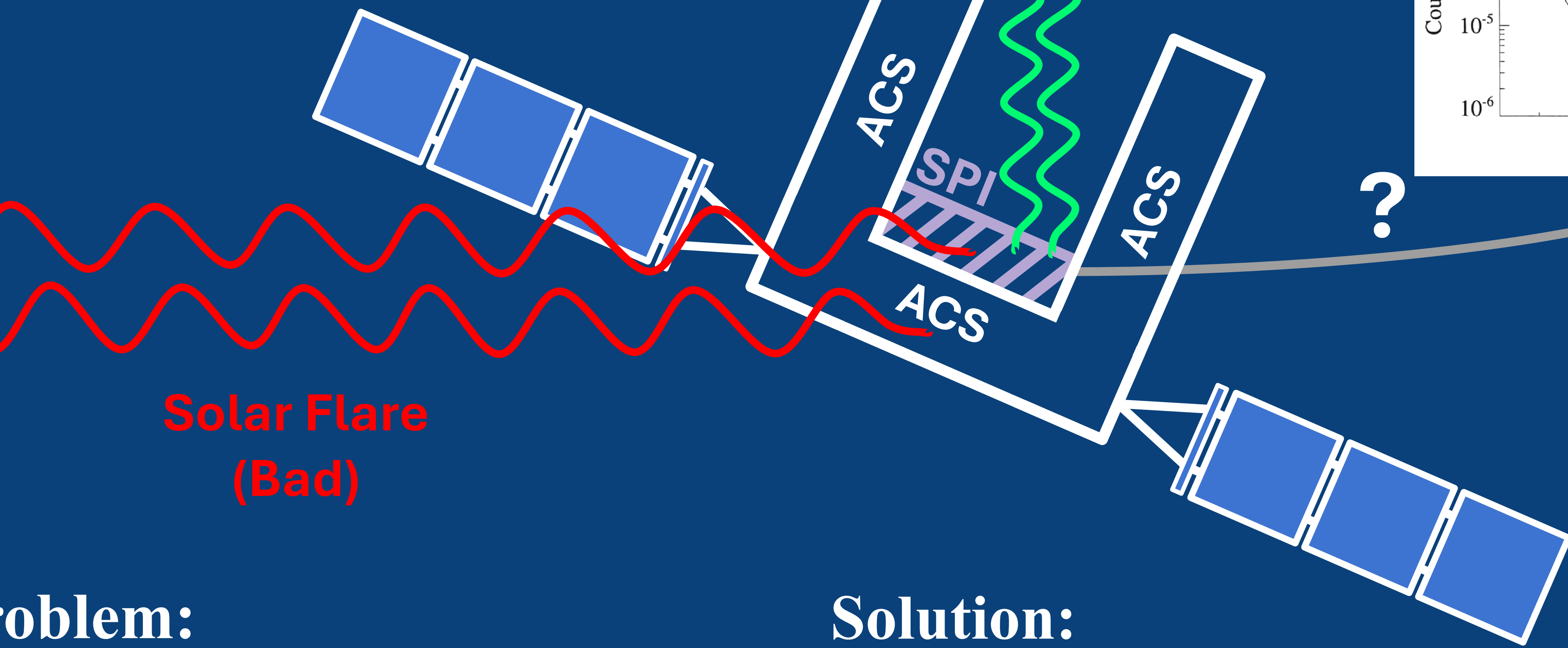
**Positron Puzzle:** 511 keV emission has an anomalous Bulge-to-Disk ratio (B/D ~ 1; Siegart+ 2016, 2023), which lacks a complete explanation to date.

**Why measure the 2.223 MeV line?**

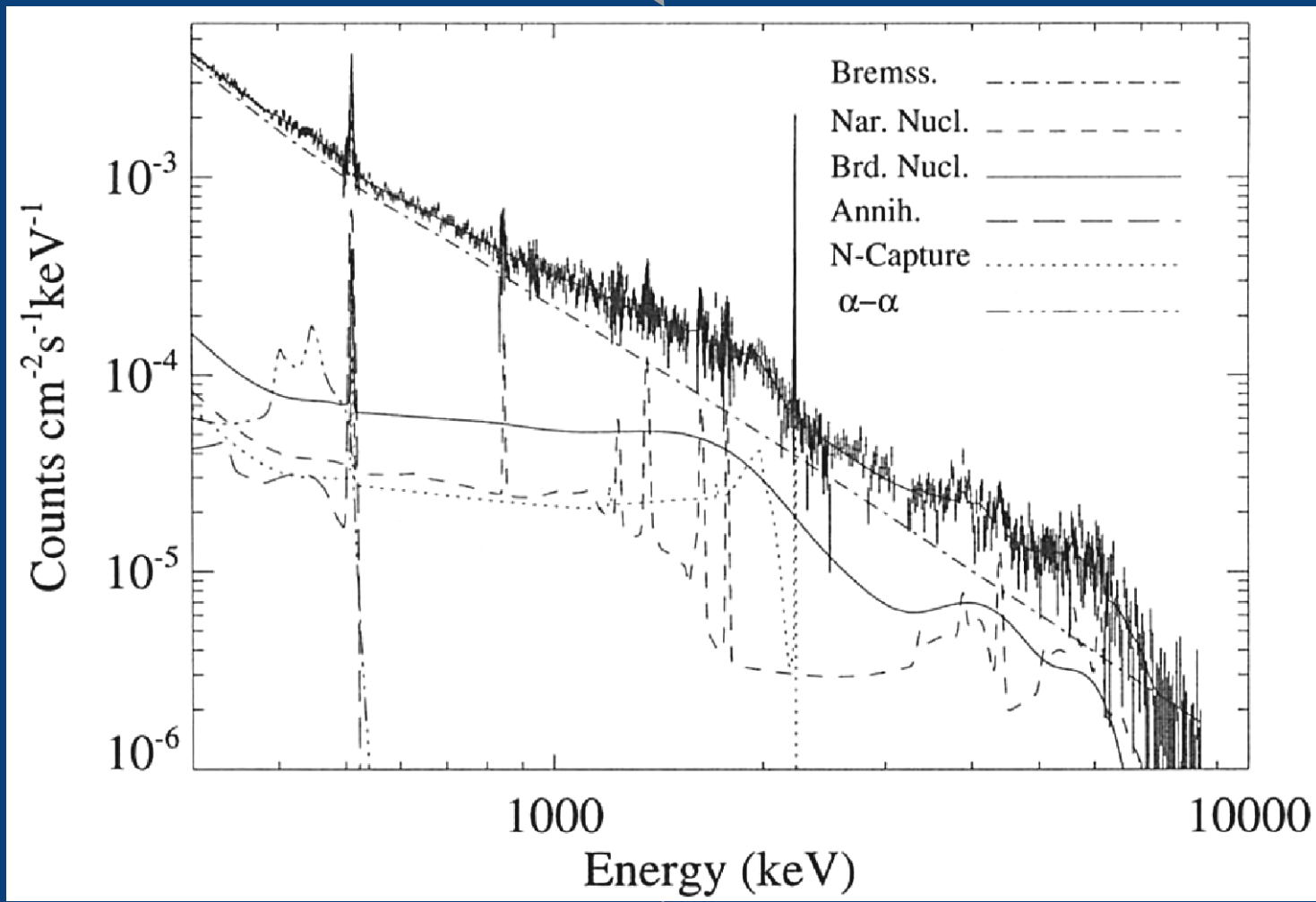
- **511 keV:** Positrons diffuse across kpc in the ISM → Source locations blurred.
- **2.223 MeV:** Photons map prompt reaction sites → No blurring of sources.



**Flaring Sun**



**Solar Flare (Bad)**



**Problem:**  
Solar Flares produce BG

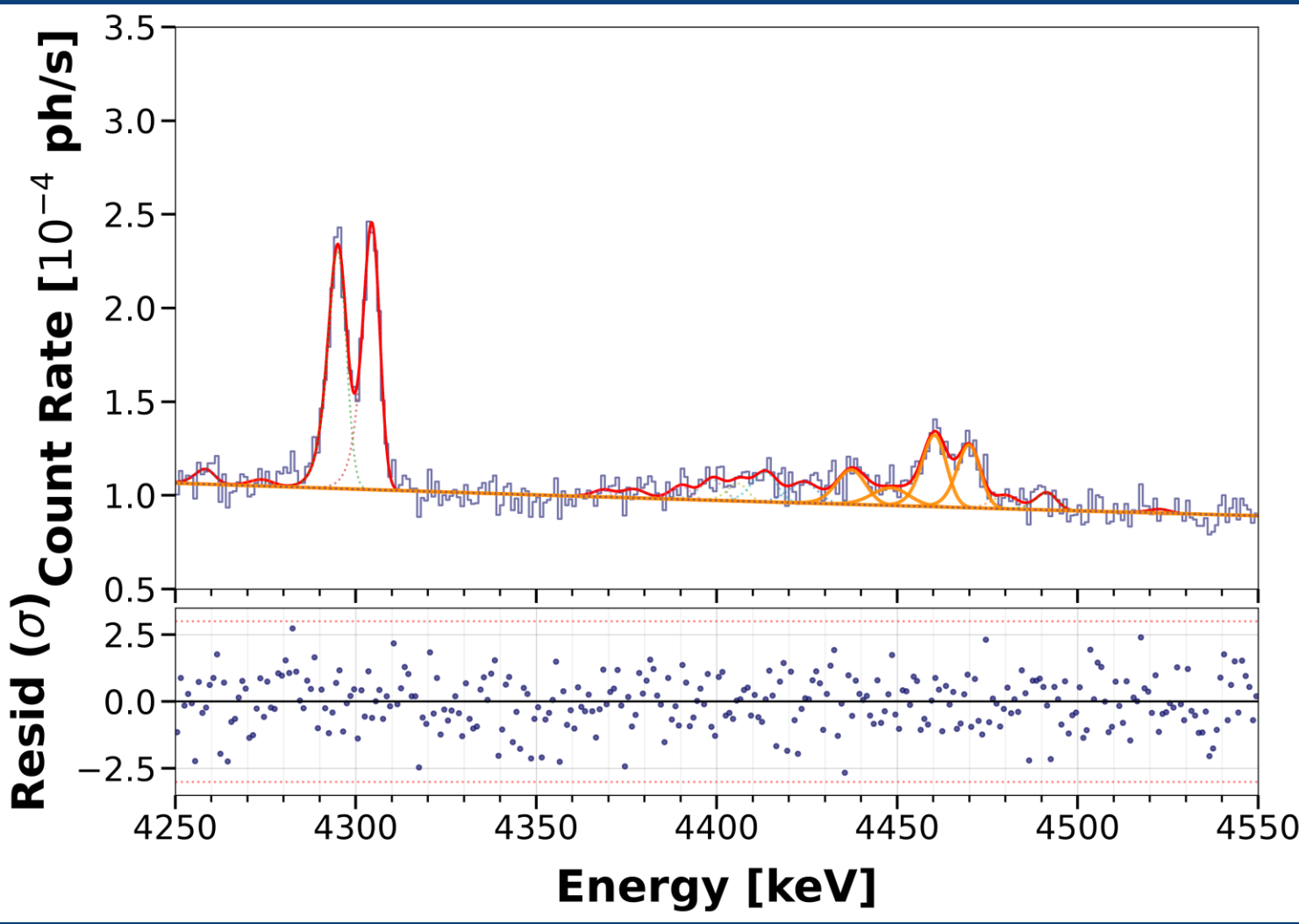
**Solution:**  
Solar Flare Filter

**SPI Testbeds**

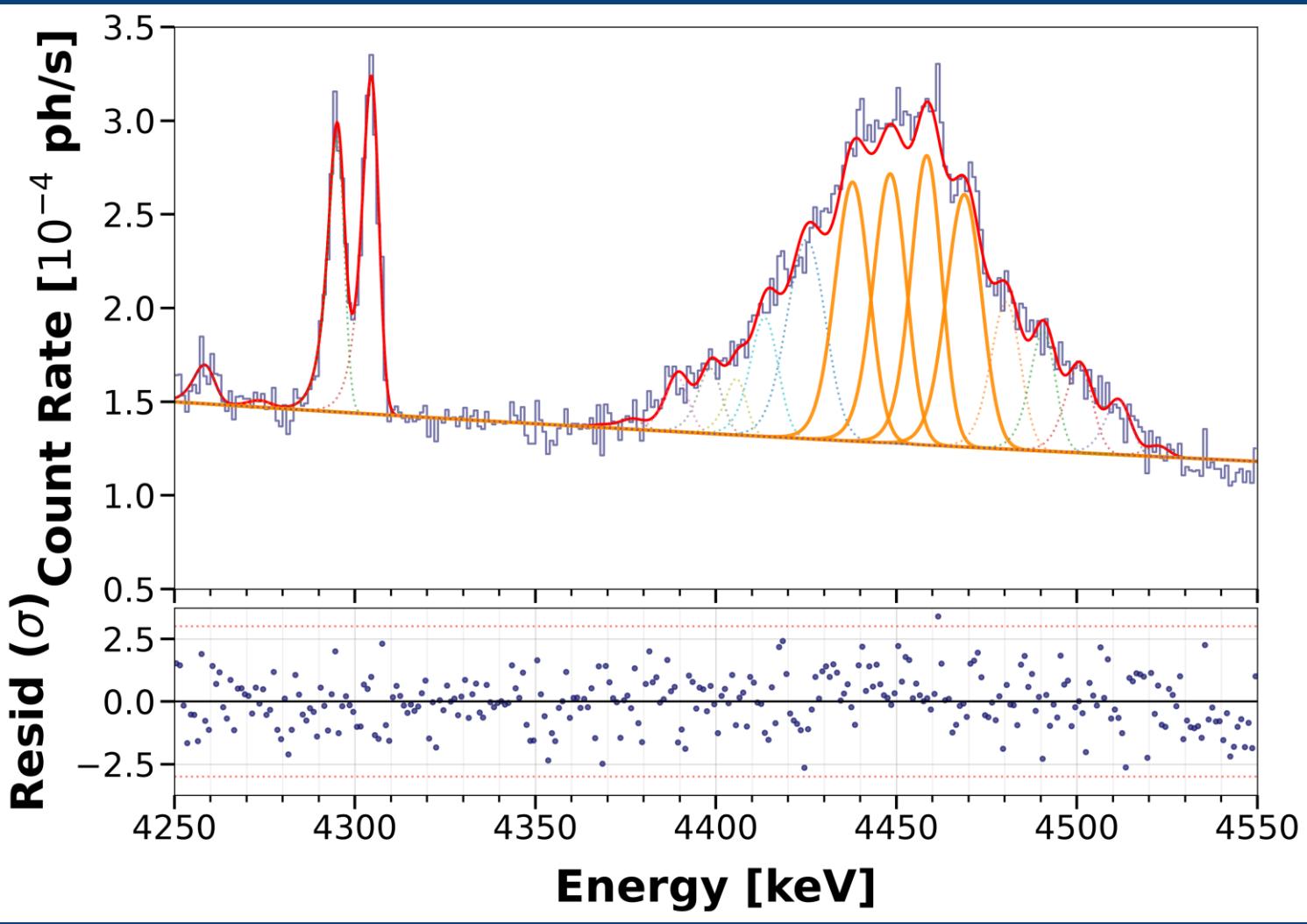
Galaxy →  $F_{2.223} \propto 10^{-3} F_{511}$

Glob. Clust. →  $F_{2.223} \geq F_{511}$

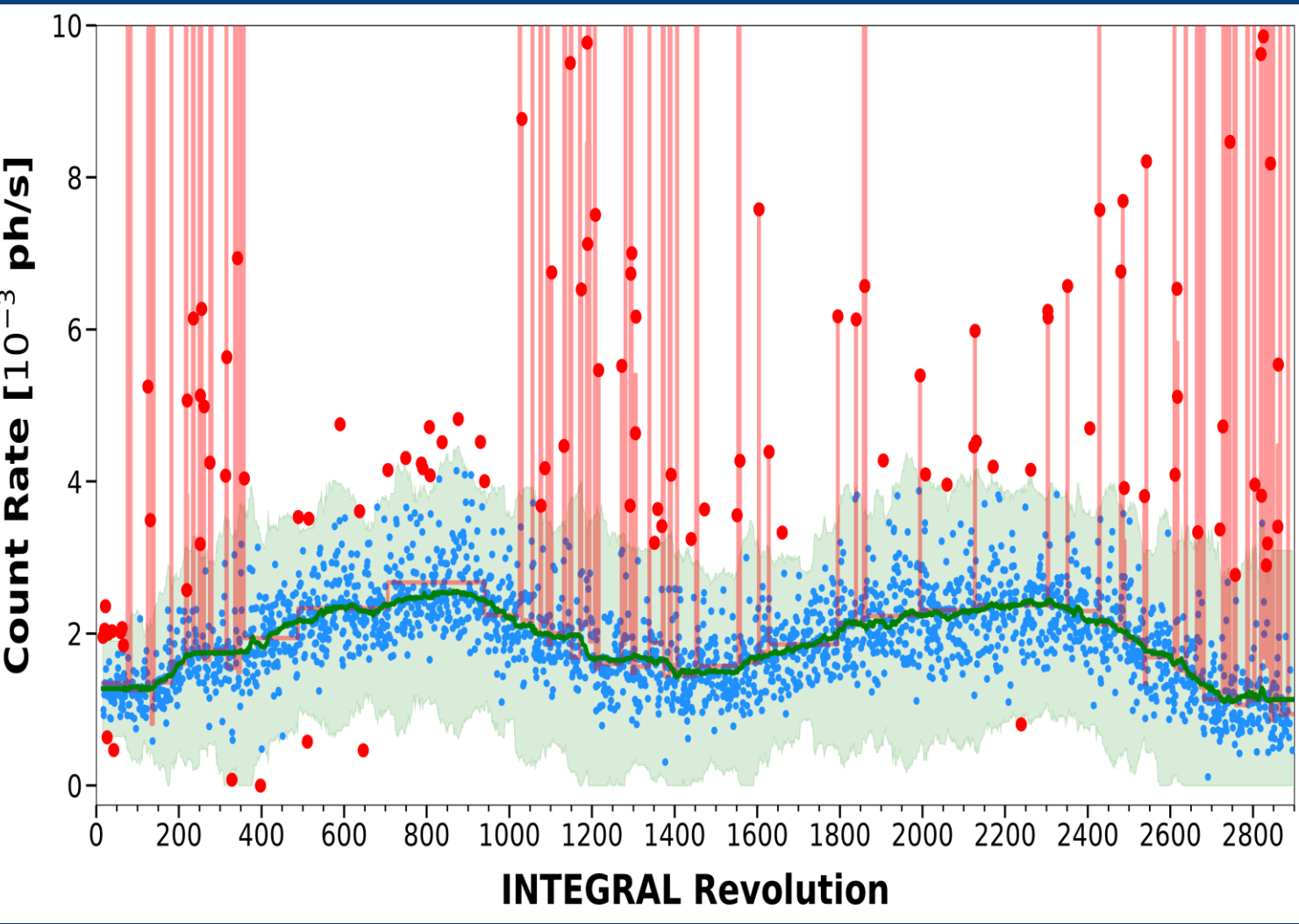
XRBs, Stellar-mass  
BH binaries



**No Flare**



**Flare**



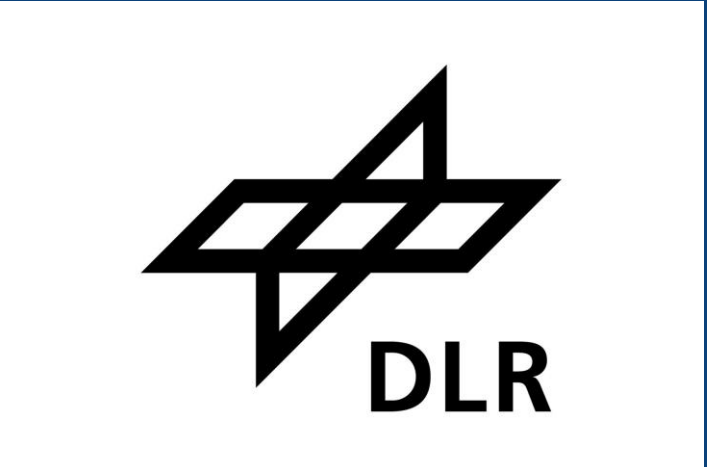
## Next Steps

Construct a 22-year solar flare-filtered INTEGRAL/SPI all-sky map to test if the 2.223 MeV emission traces the 511 keV Bulge excess or exhibits spatial deviations that motivate alternative explanations such as dark matter.

### References

- |                      |                             |
|----------------------|-----------------------------|
| Siegart+ 2016        | Müller+ 2020                |
| Siegart+ 2023        | ESA, sci.esa.int, Gaia 2018 |
| Mittal+ 2026         | Share & Murphy 2004         |
| Yoneda+ 2025         | Lin+ 2003                   |
| Murphy+ 2007         | Vestrand+ 1999              |
| Jean & Guessoum 2001 |                             |

### Acknowledgement



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