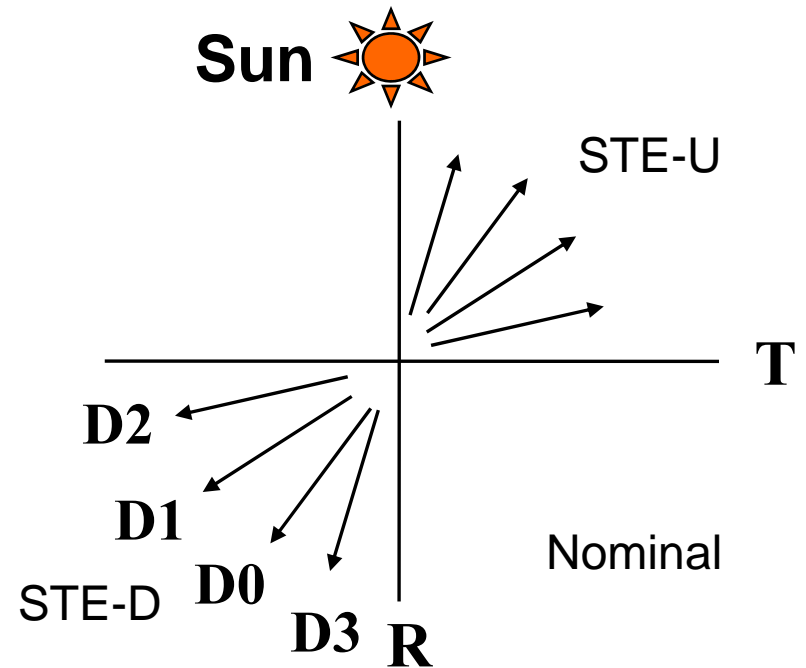


# **STEREO/STE Detections of Terrestrial ENAs and Anomalous ENAs**

**Linghua Wang, Bob Lin, John Sample, George Parks,  
and Janet Luhmann**

**SSL, UC Berkeley**

# ✦ STE



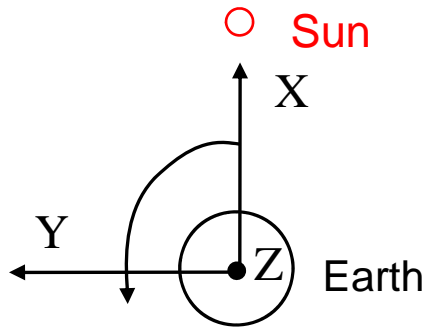
**The Suprathermal Electron (STE) instrument is much more sensitive than previous sensors at energies below 20 keV.**

**STE utilizes small (0.09 cm<sup>2</sup>) solid state detectors. It is able to detect electrons, ions, energetic neutral atoms (ENAs) and X-rays.**

# Outline

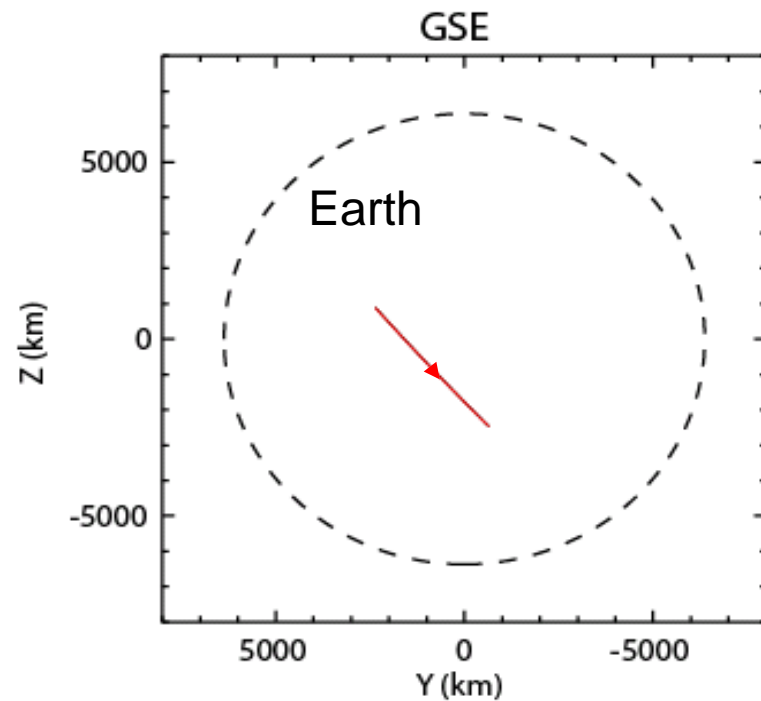
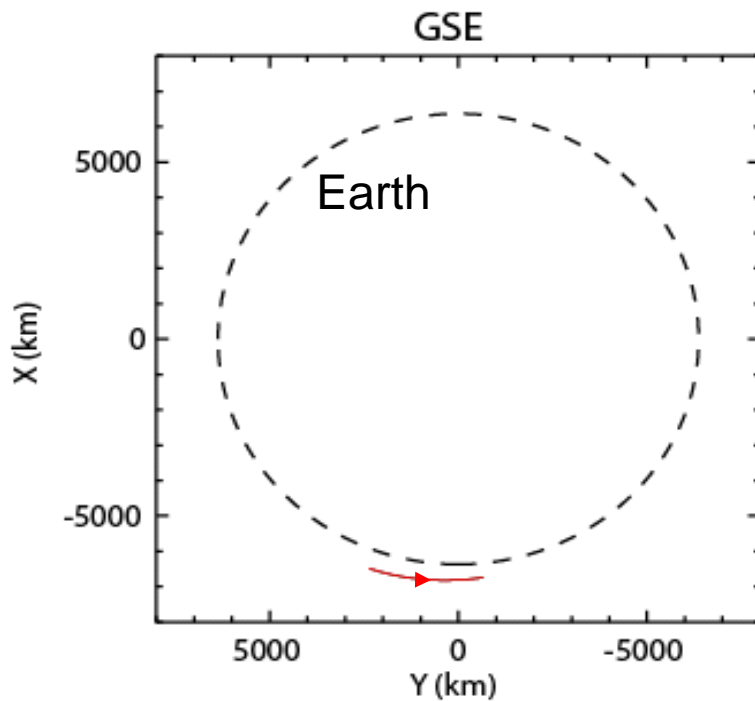
- 1. STEREO/STE observations of Terrestrial ENAs (first detection of quiet-time ring current ENAs from low Earth orbit)**
- 2. STE observations of anomalous ENAs during 2007 January (spectrum, source)**

# 1. STE observations of terrestrial ENAs

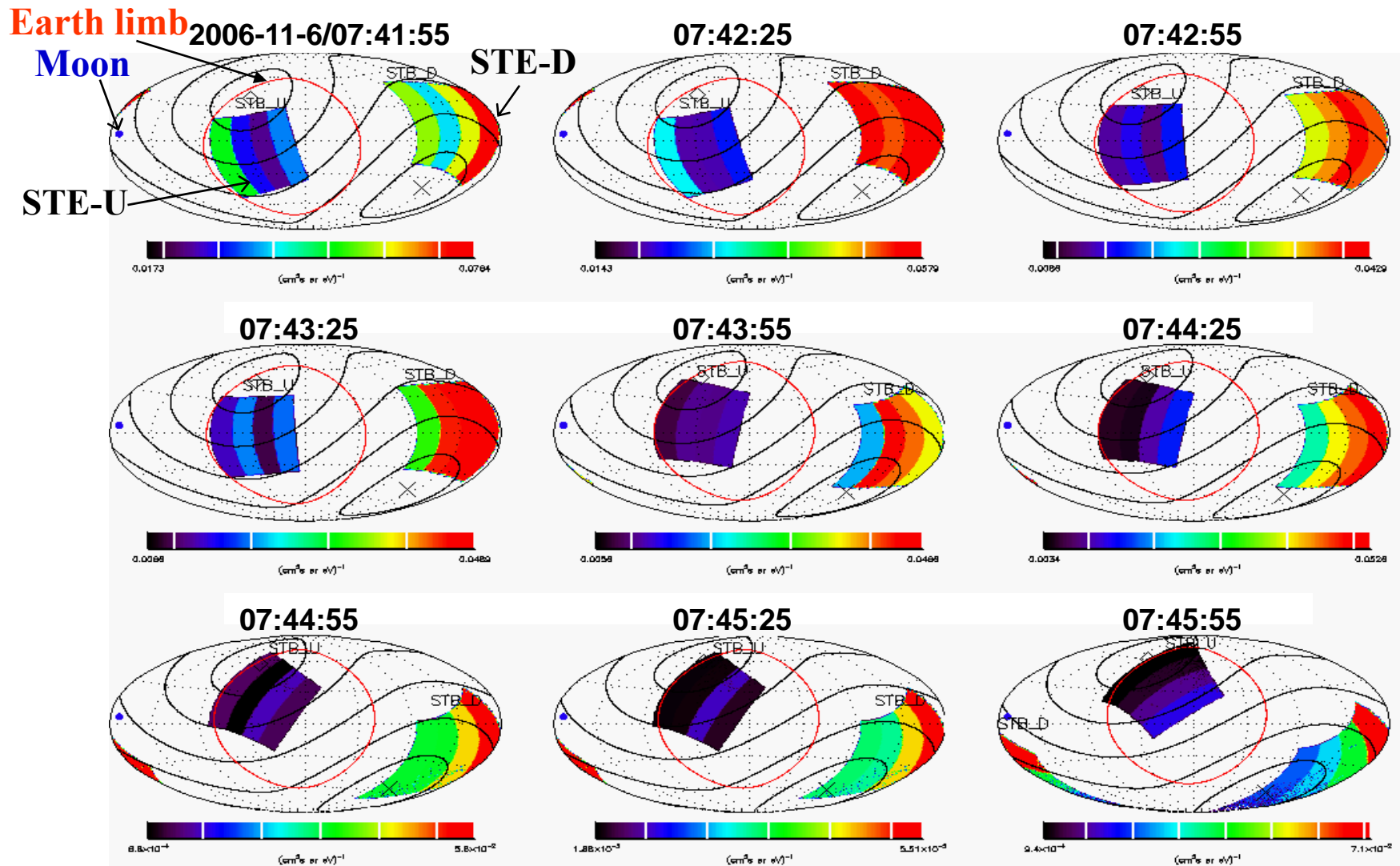


**2006 November 6**

**STEREO B ~0742 – 0750 UT**



# STEREO B/STE angular flux distribution in terms of source direction at 13 keV in a spacecraft-centered GSE coordinate



**Not charged particles**

**Not galactic X-rays**

➡ **STE-D saw energetic neutral atoms coming from a source behind the Earth, likely the magnetosphere ring currents.**

**The activity of ring currents was quiet during this day.**

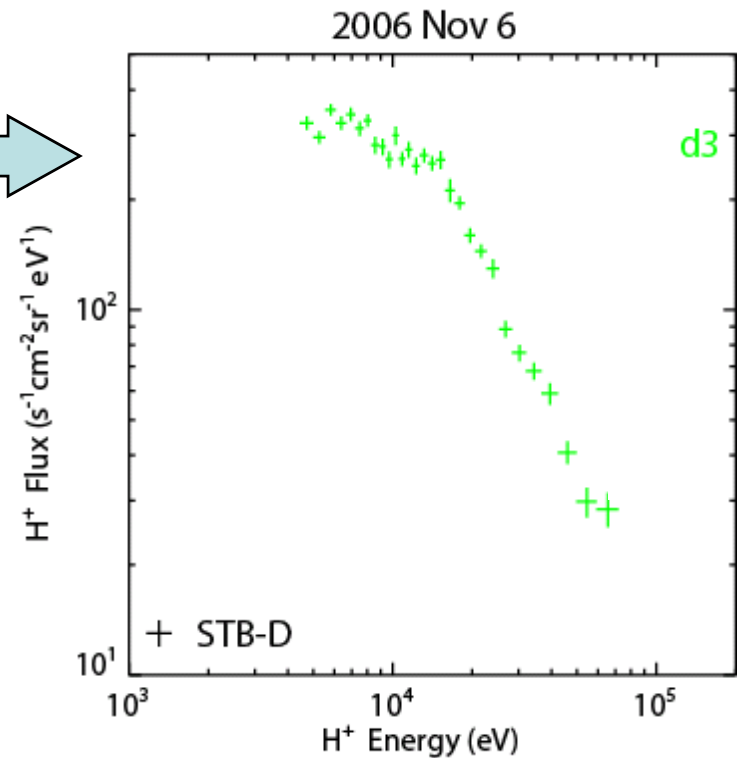
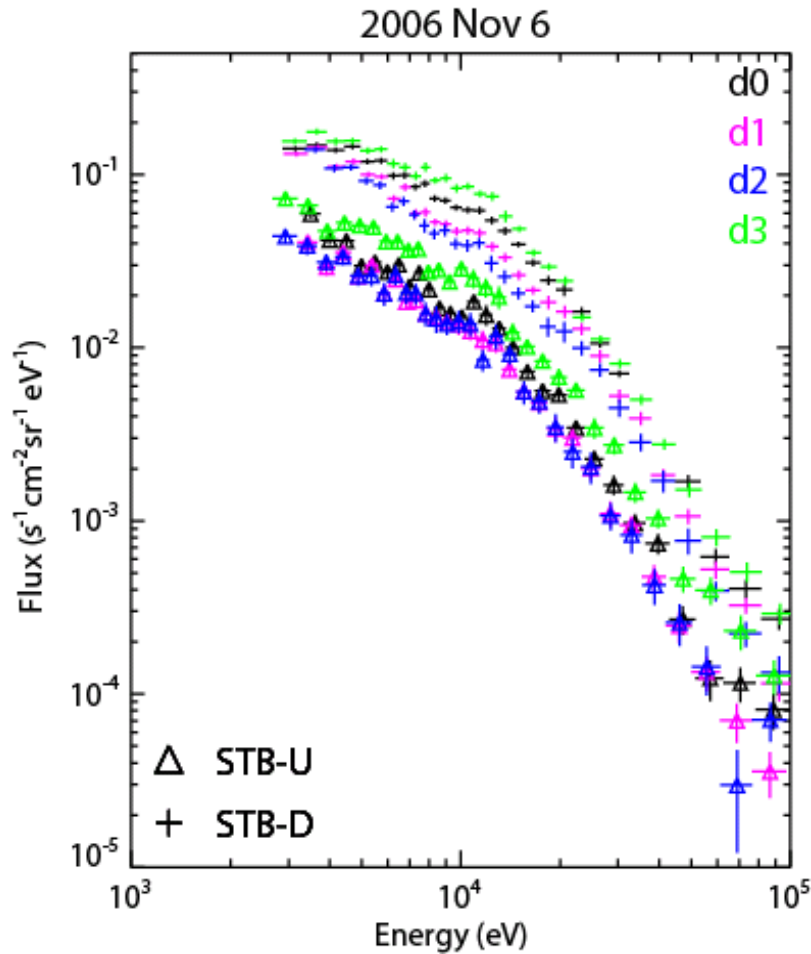
➡ **First detection of ENAs from the quiet-time ring currents from low Earth orbit**

# Estimate of source protons in the quiet-time ring current

$$j_{\text{ENA}} = j_p \times \sigma_{\text{pH}} \times n_{\text{H}} \times L$$

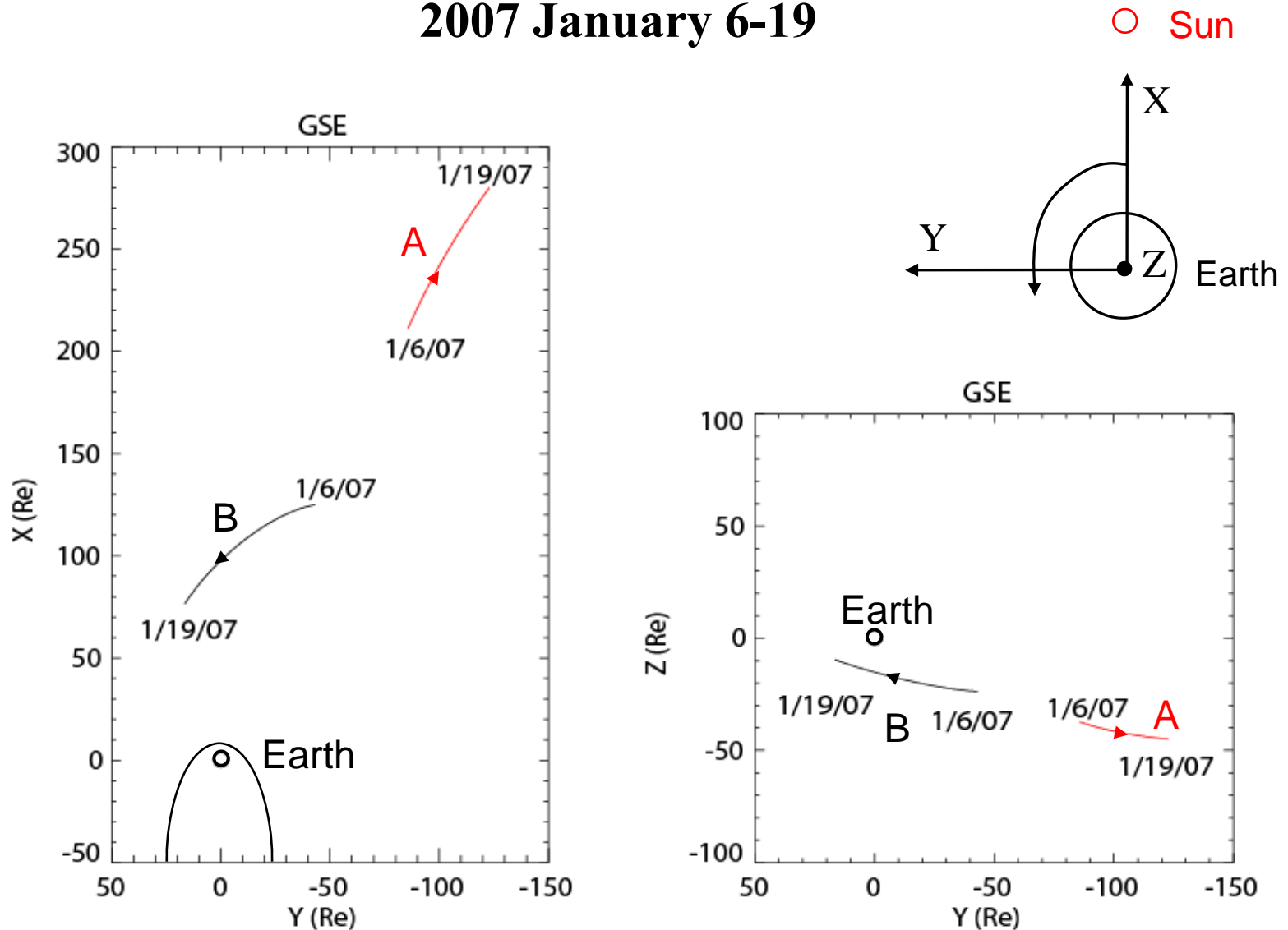
$$n_{\text{H}} = 150 \text{ cm}^{-3} \text{ ( at } \sim 4 R_{\text{E}} \text{ )}$$

$$L = 5 R_{\text{E}}$$



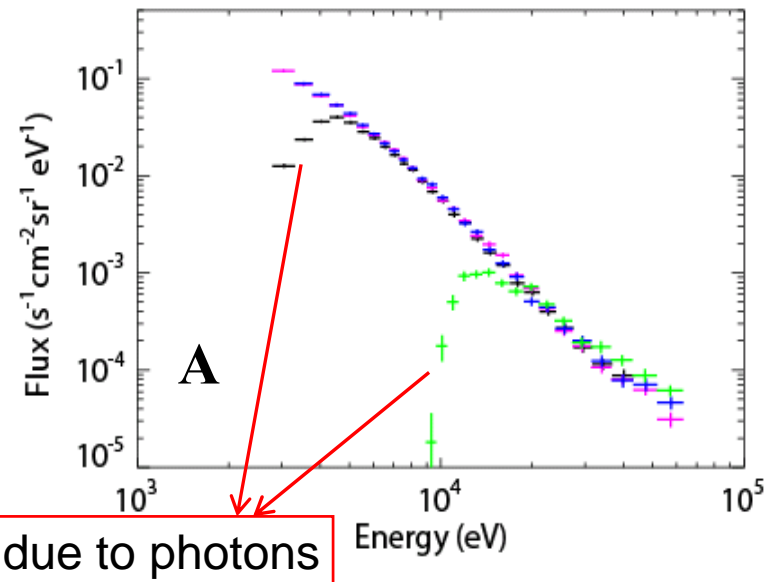
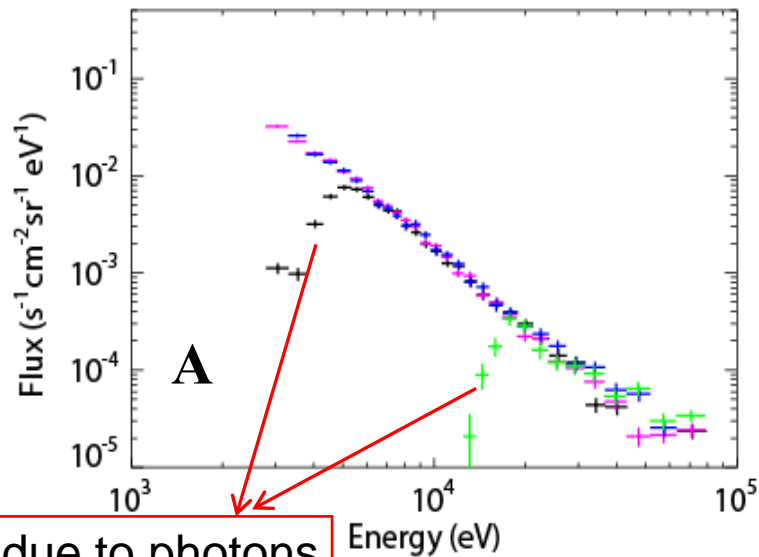
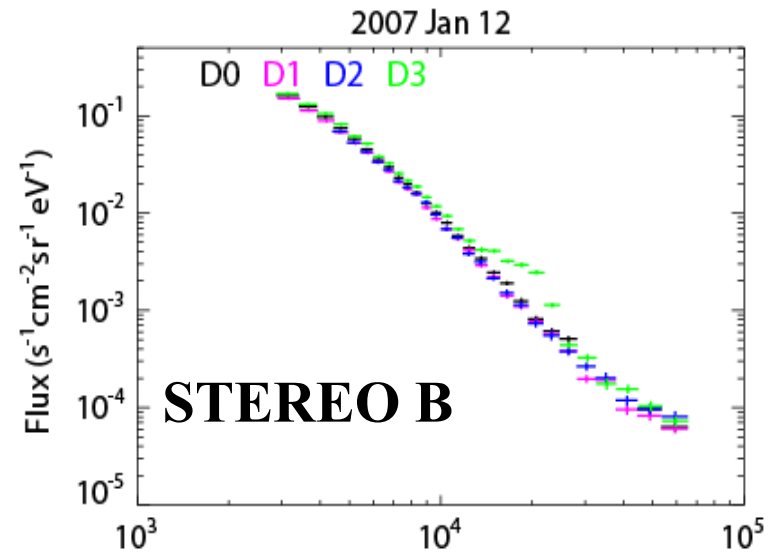
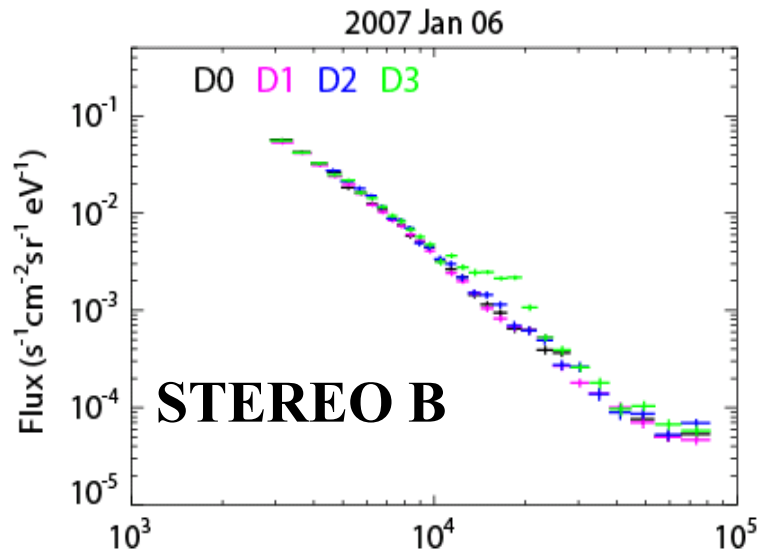
## 2. STE detections of anomalous ENAs

2007 January 6-19

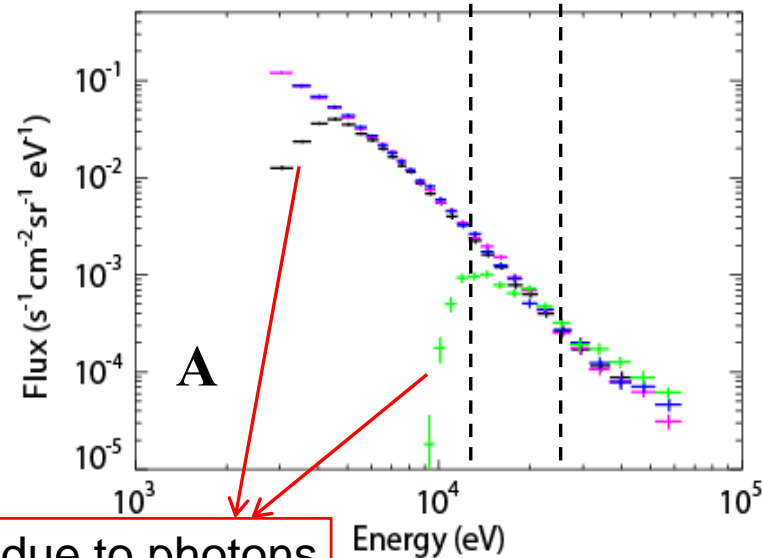
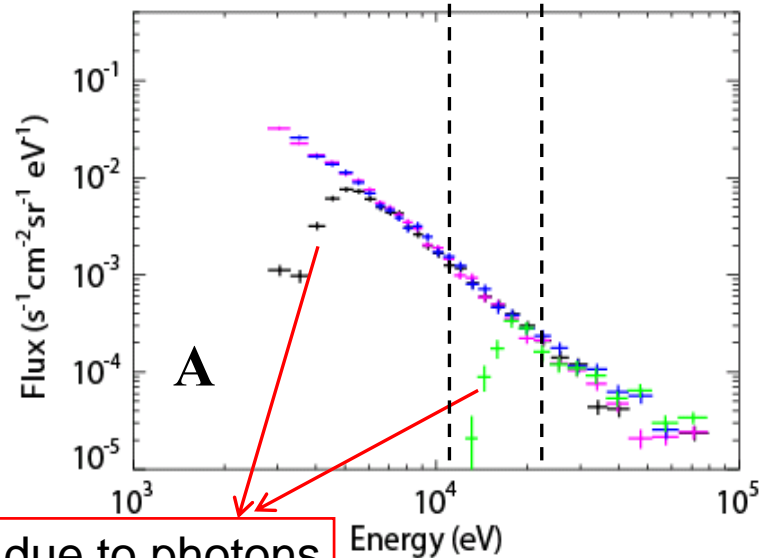
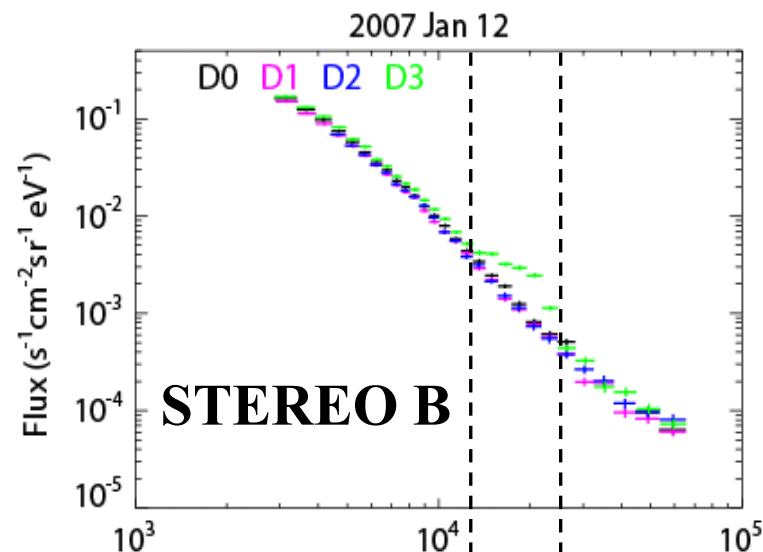
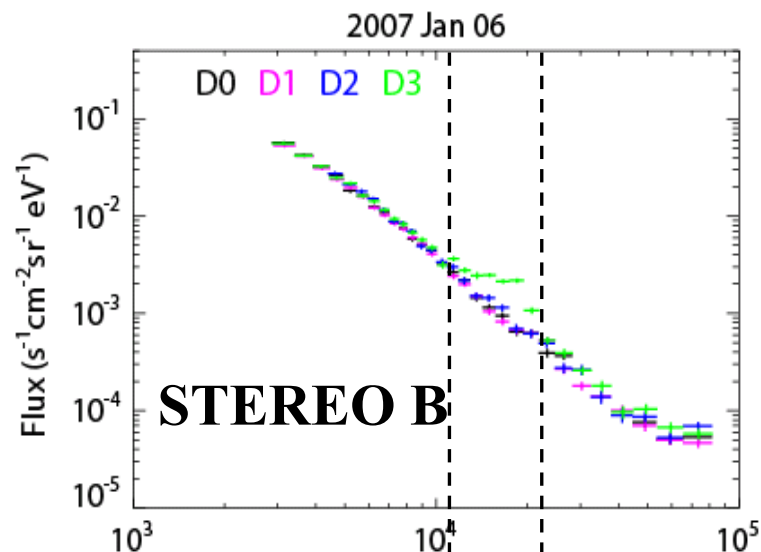




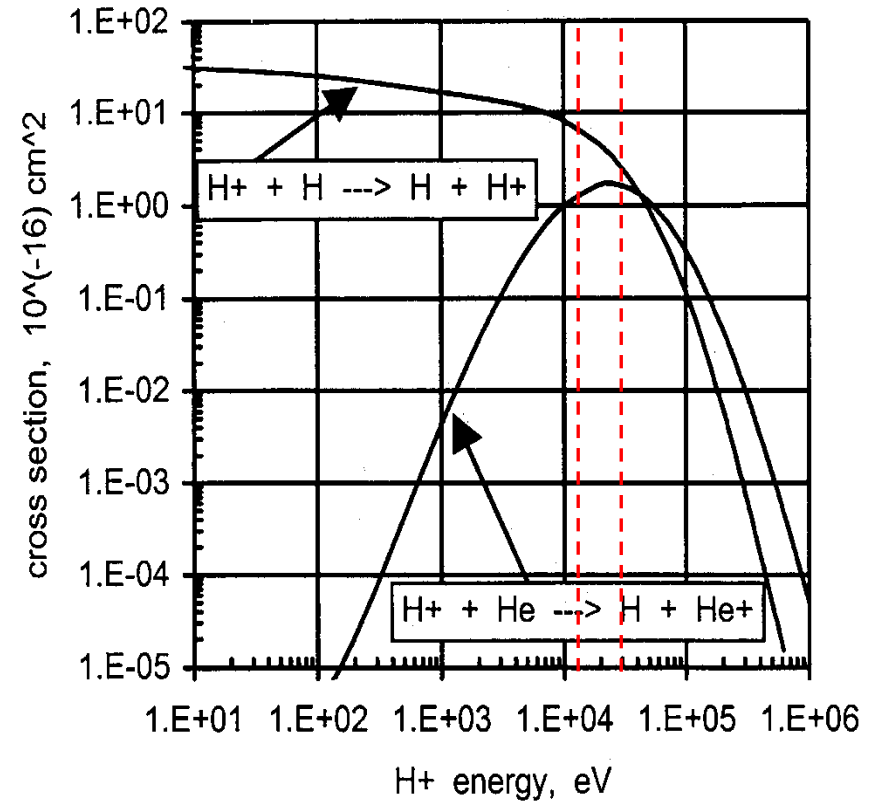
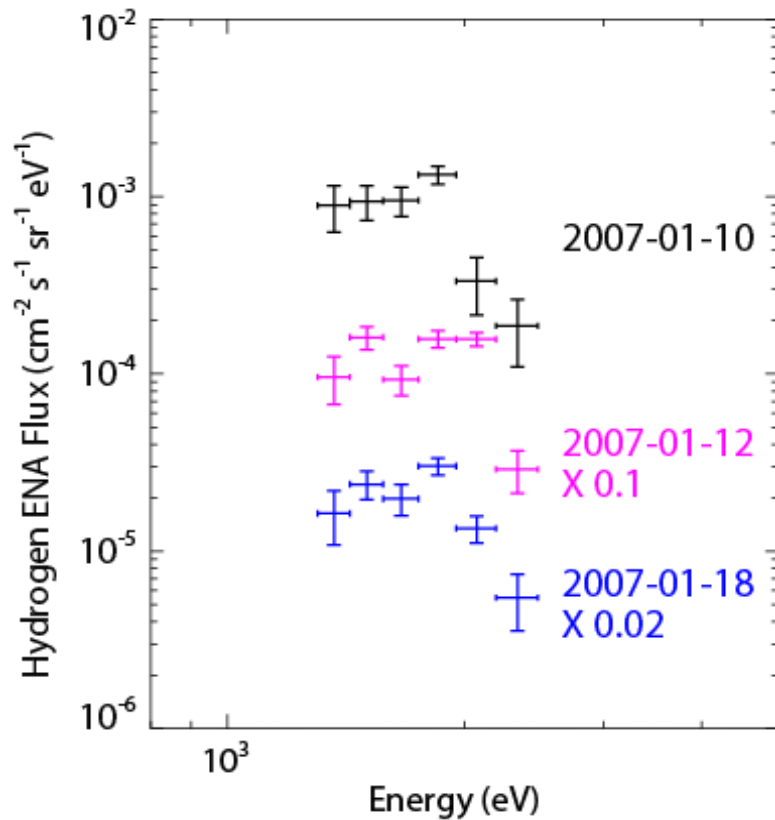
# Energy Spectrum (A : bottom; B: top)



Only D3 on B (probably also D3 on A??) saw the source.



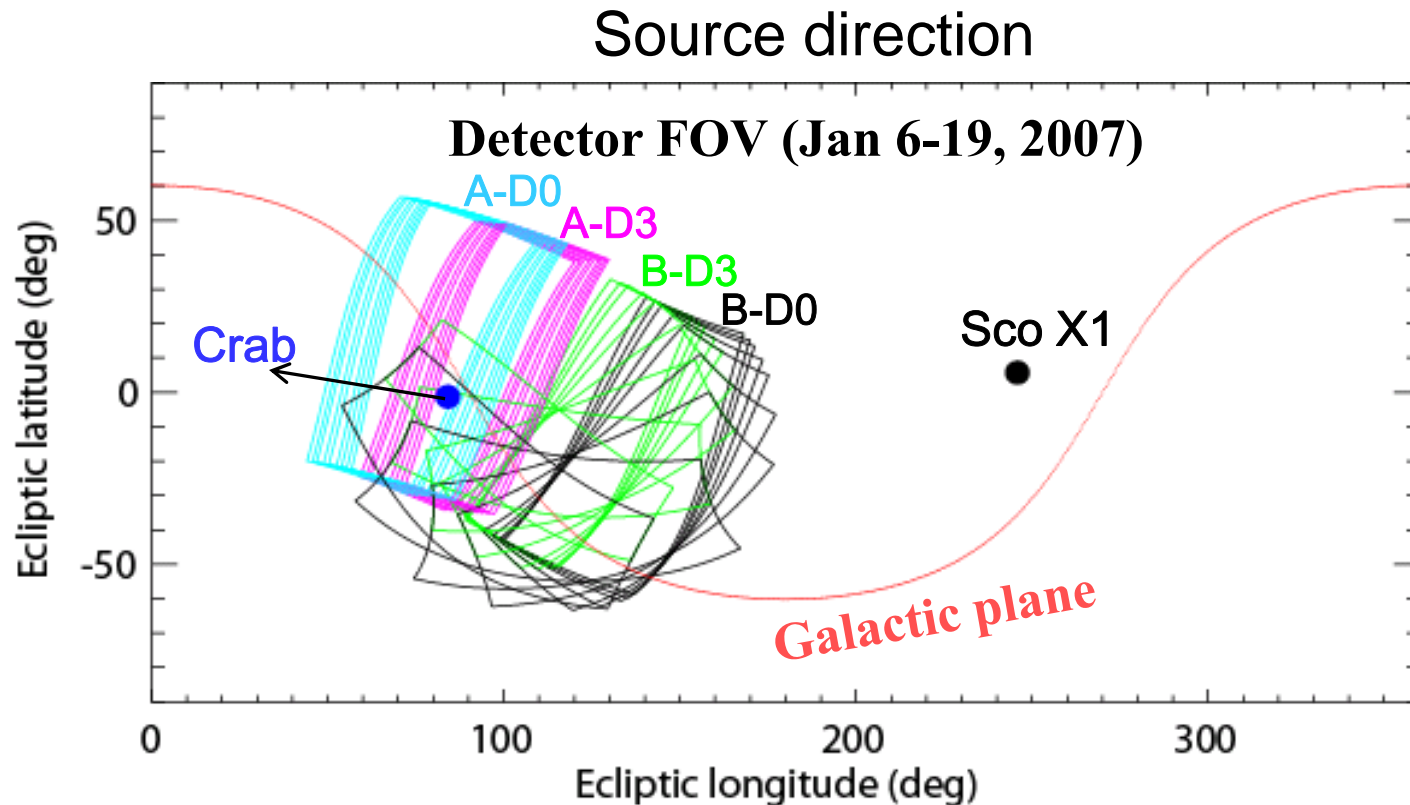
## 2.1 Background-subtracted spectrum



- Higher flux and different spectral shape, compared with the detector response to galactic X-ray sources like Sco X-1 and Crab.  $\Rightarrow$  Not X-rays
- The spectrum is similar to the cross section curve of  $\text{H}^+ + \text{He}$   $\Rightarrow$  ENAs from charge exchange of interstellar helium with energetic ions

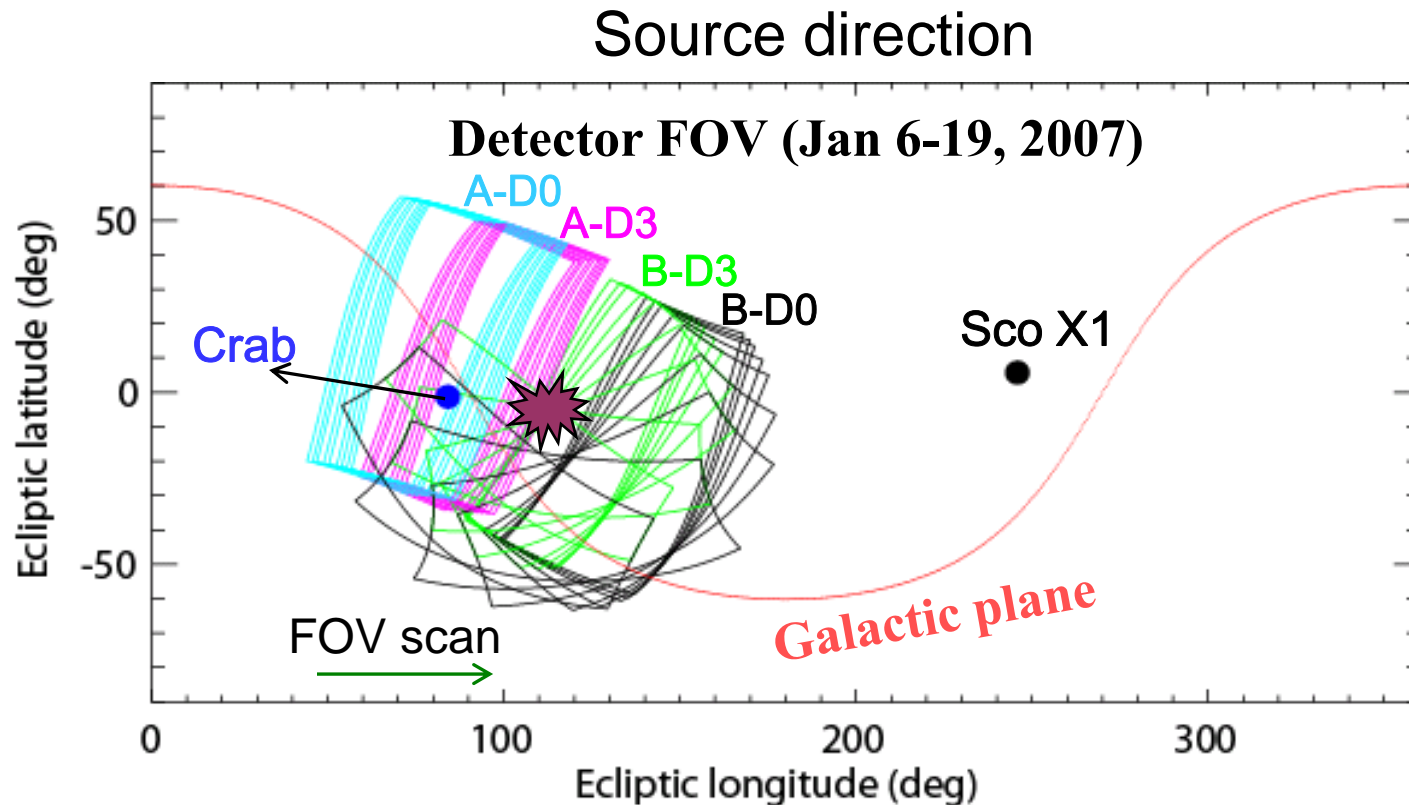
## 2.2 Source location estimate

- Distant source (e.g. Heliosheath)



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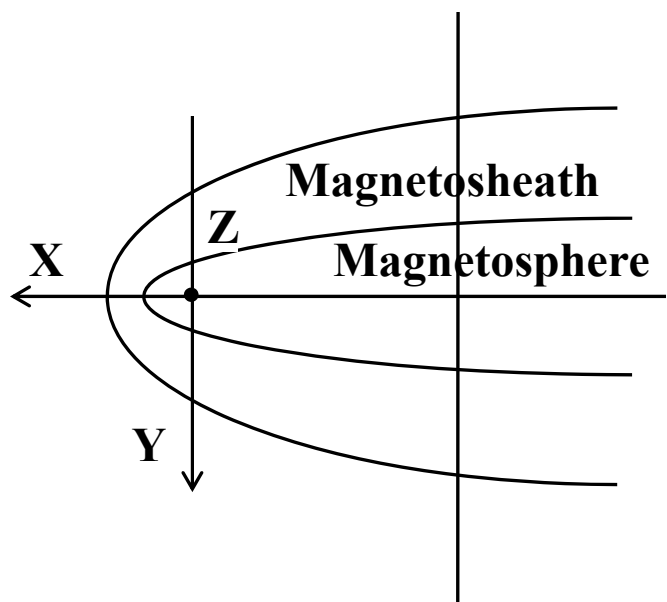


Away from Galactic X-ray sources

A transient (< 1 month) source ← Never see this source again

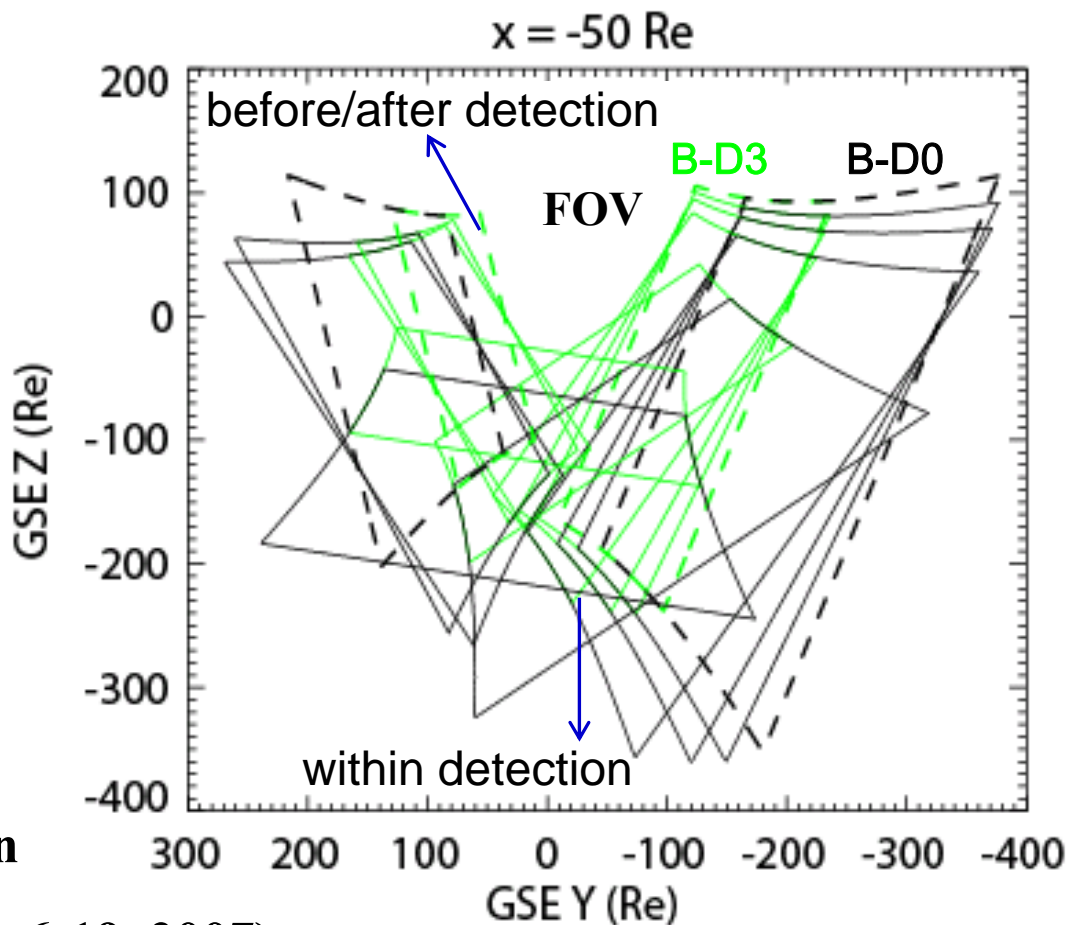
## • Close source

The Earth's magnetosphere/magnetosheath is a possible source of energetic ions.



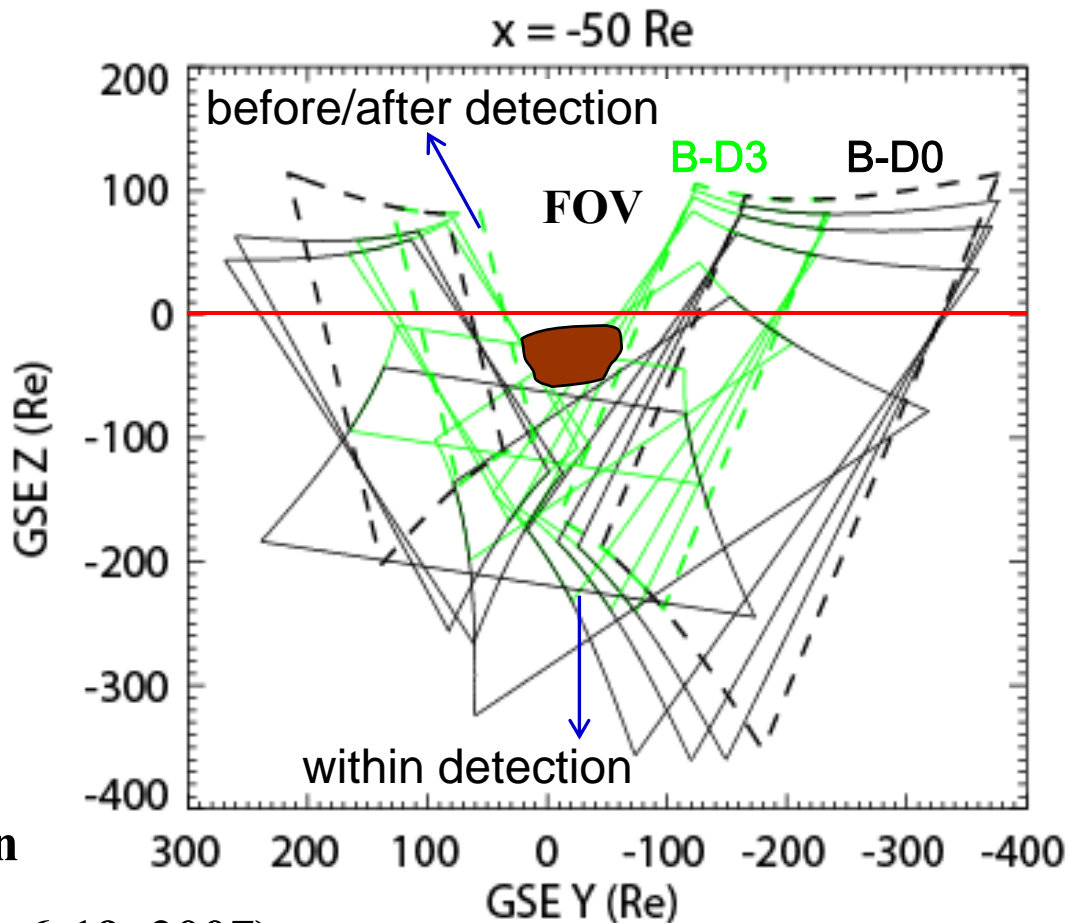
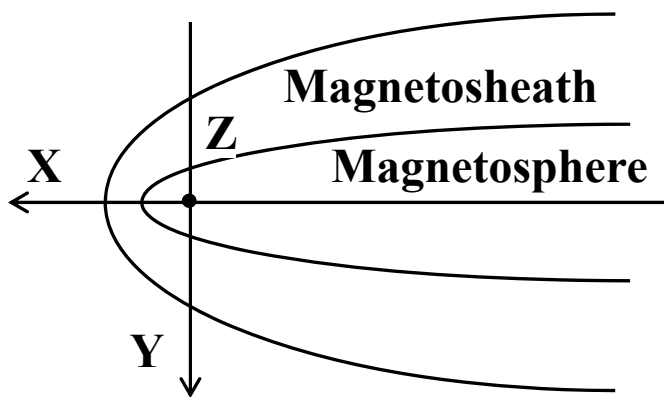
---- FOV before/after detection

— FOV within detection (Jan 6-19, 2007)



## • Close source

The Earth's magnetosphere/magnetosheath is a possible source of energetic ions.



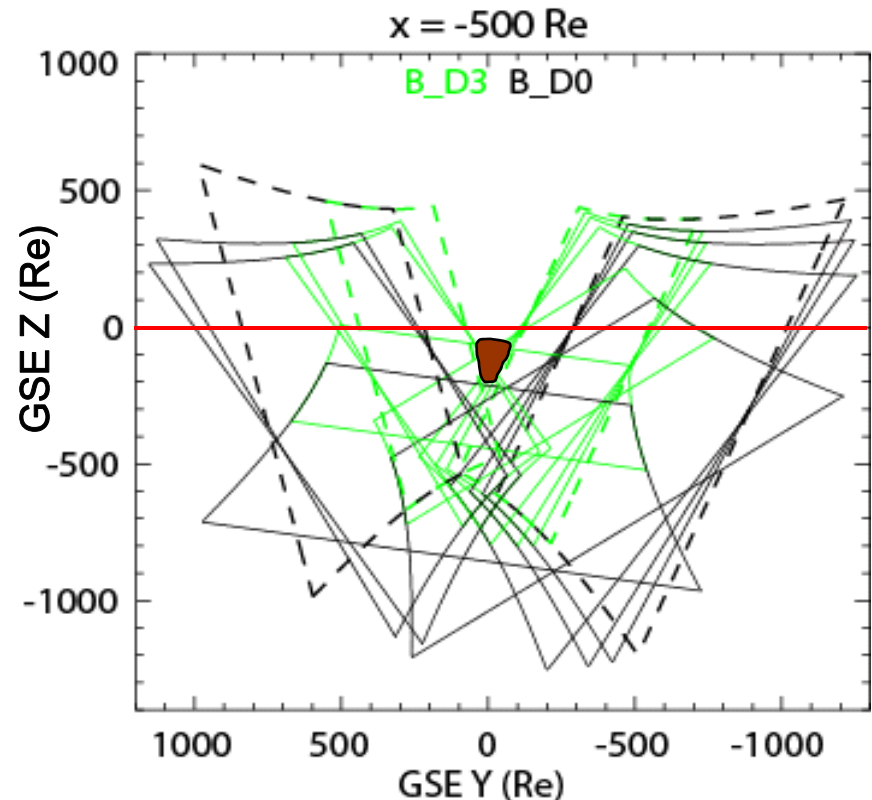
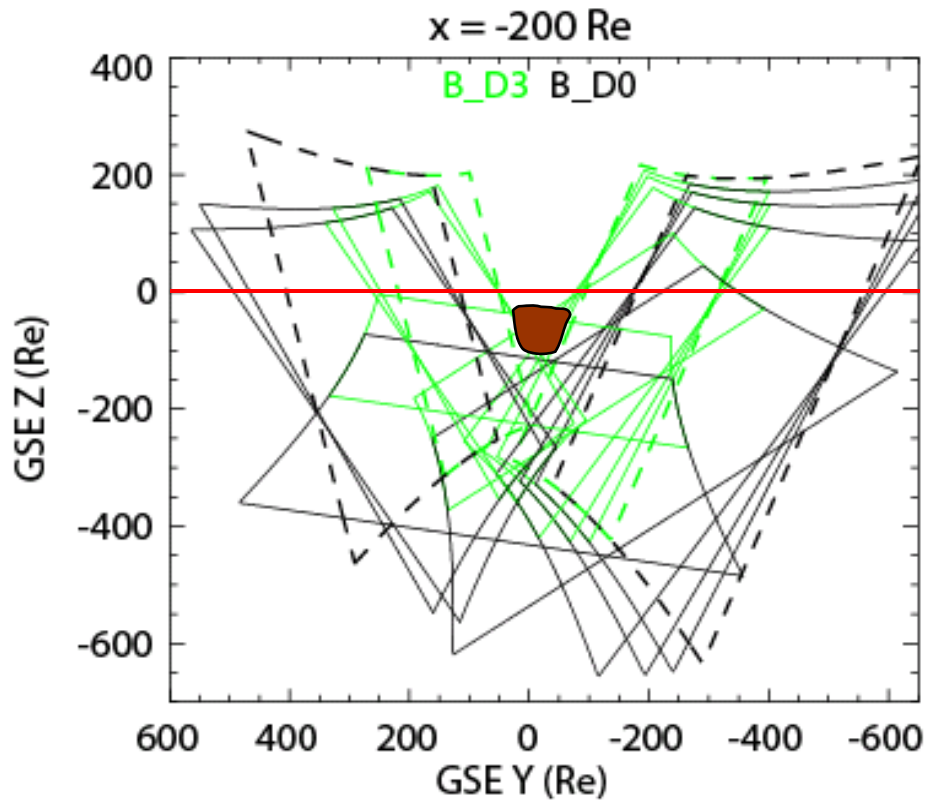
---- FOV before/after detection

— FOV within detection (Jan 6-19, 2007)



- **Close source**

**Source is located  $\sim 10s-100s R_E$  south from the ecliptic plane**



**After January 2007, the Earth's magnetosphere began outside the FOV of STE-D on STEREO B.**



# Conclusions

1. **STE observed terrestrial energetic neutral atoms. The source is likely magnetospheric protons in quiet-time ring currents.**
2. **STE detected anomalous ENAs in January 6-19, 2007.**
  - **Their spectra imply a charge exchange between He and energetic ions.**
  - **If the source is faraway, it must be transient (< 1 month).**

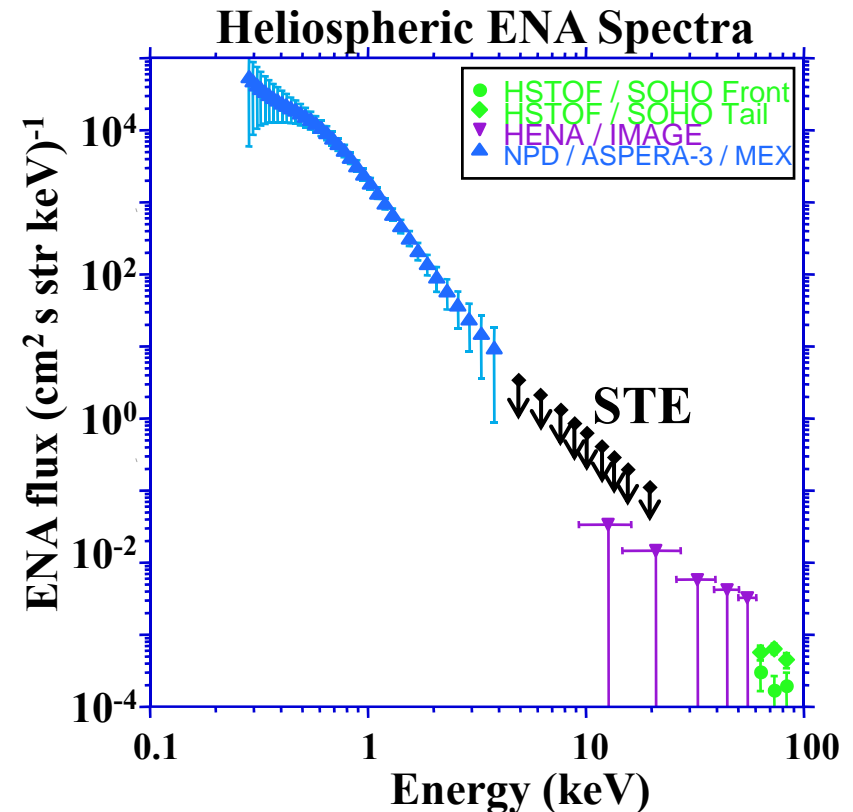
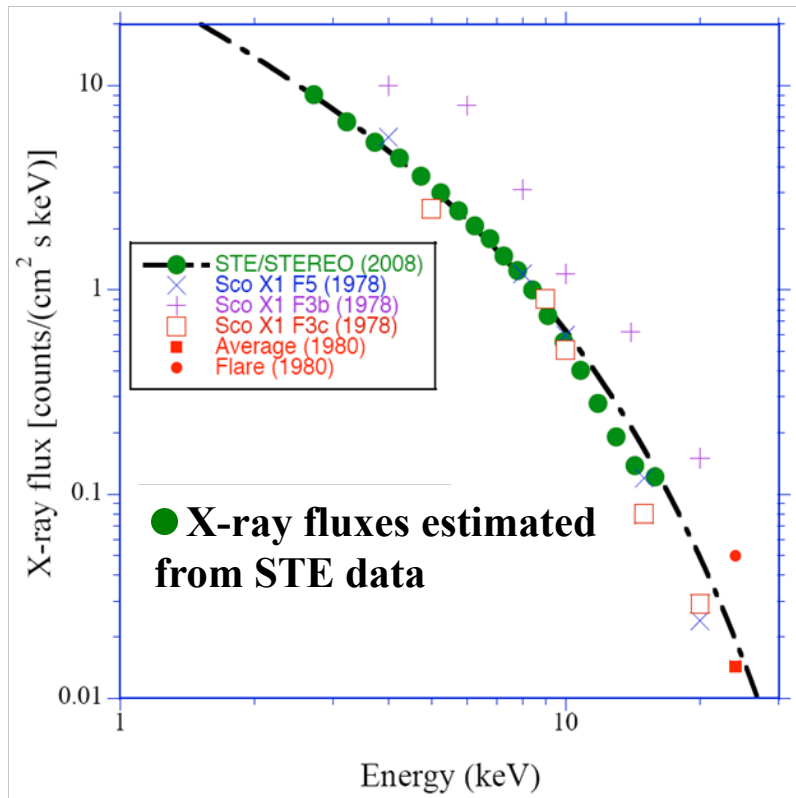
If the source is close, it is probably located south in the Earth's magnetosphere/magnetosheath,  $\sim 10s-100s R_E$  from the ecliptic plane.

More slides...

# STE detections of X-rays and heliospheric ENAs

- In the direction of heliosphere nose, STE measurements are likely dominated by X-rays from Sco-X1.

- In other directions (heliosphere flanks and tail), STE doesn't see heliospheric ENAs. → the upper limit (↕) of heliospheric ENA detection in those directions.



# STEREO B/STE angular flux distribution in terms of source direction at 13 keV in a spacecraft-centered GSE coordinate

