A Statistical Survey of the Distant Magnetotail using THEMIS/ARTEMIS: *Preliminary Results on Plasma Distribution and Transport*

Tim Stubbs, Yongli Wang, David Sibeck, Jan Merka, and Vassilis Angelopoulos

Fall 2011 THEMIS/ARTEMIS SWG Meeting
Annapolis, MD, September 14.

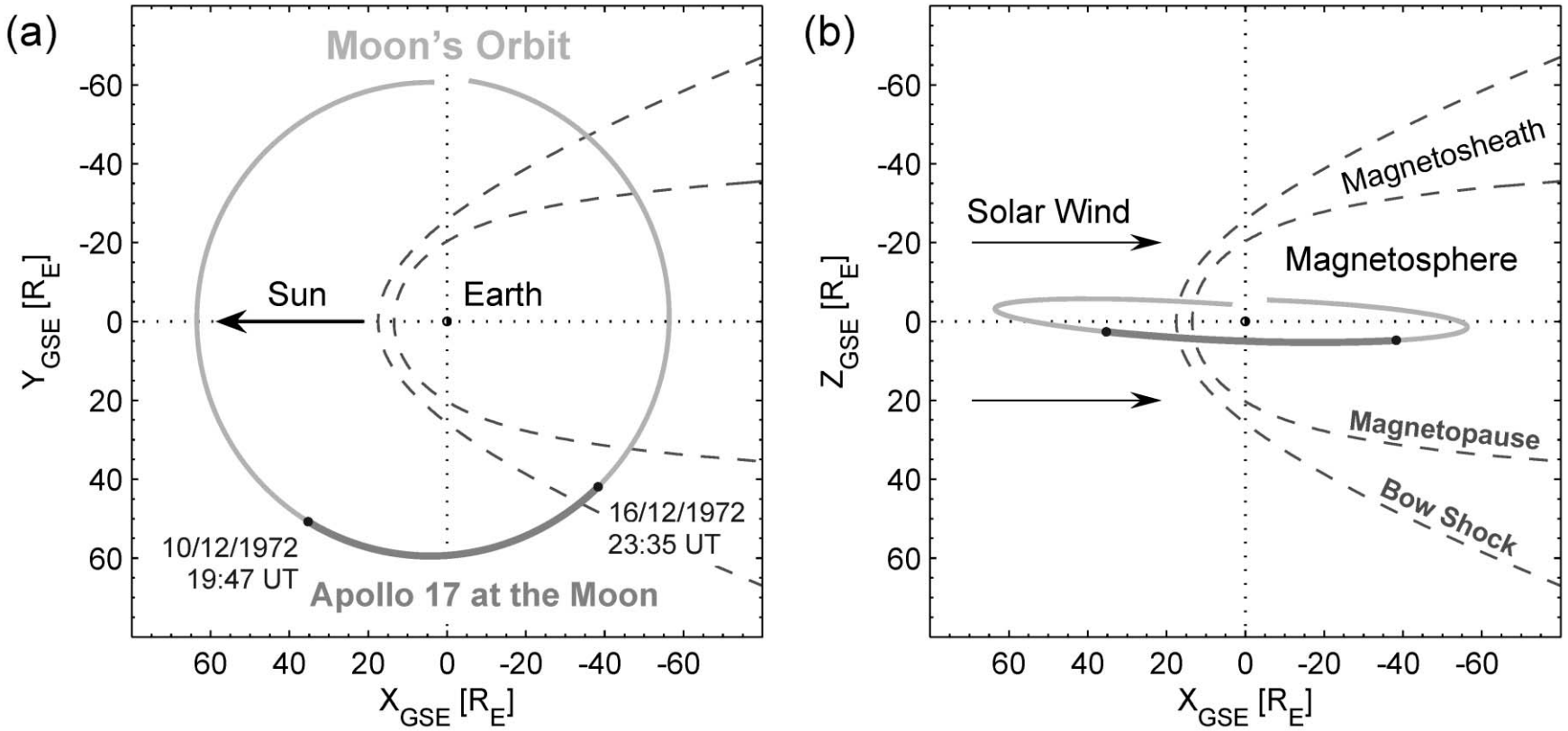
Motivation and Objectives

- Magnetosphere tailward of ~30 R_E remains relatively unexplored.
- A better characterization is critical to a more complete understanding of the processes taking place, and magnetosphere-solar wind coupling.
- Assess the magnetotail plasma encountered by the Moon to determine the effect on the lunar environment (e.g., surface charging, sputtering).
- Use THEMIS/ARTEMIS data to undertake a large-scale statistical survey.

Motivation and Objectives

- Working toward organizing various plasma moments by occurrence frequency and distance down the magnetotail – *PROGRESS REPORT*.
- Further sorting will be done to identify, e.g.:
  - different regions of the magnetotail, such as the tail lobes and plasma sheet.
  - The various physical processes taking place, such as reconnection.
- First step in constructing a comprehensive large-scale picture of the energization, distribution, and transport of plasma in the distant magnetotail.
- <u>See Wang et al. presentation at Fall AGU!</u>

The Moon in the Magnetotail

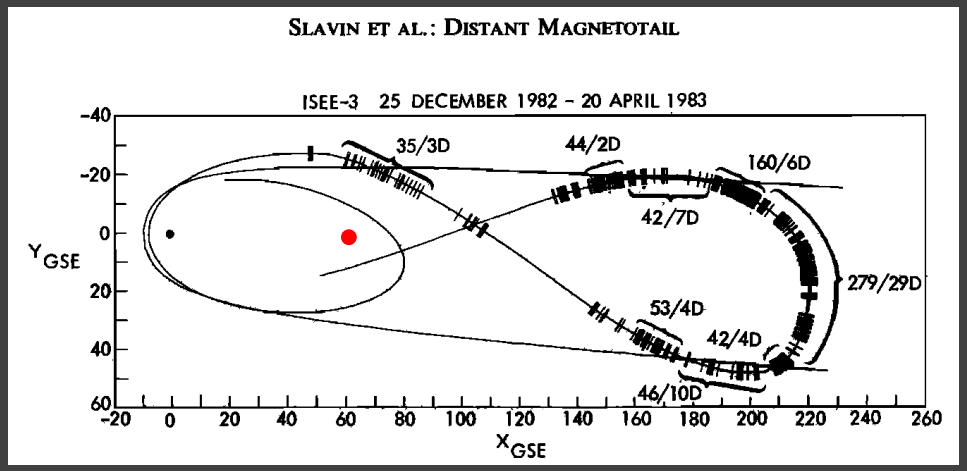


Orbit of the Moon during the Apollo 17 mission with predictions for *typical* magnetopause and bow shock locations.

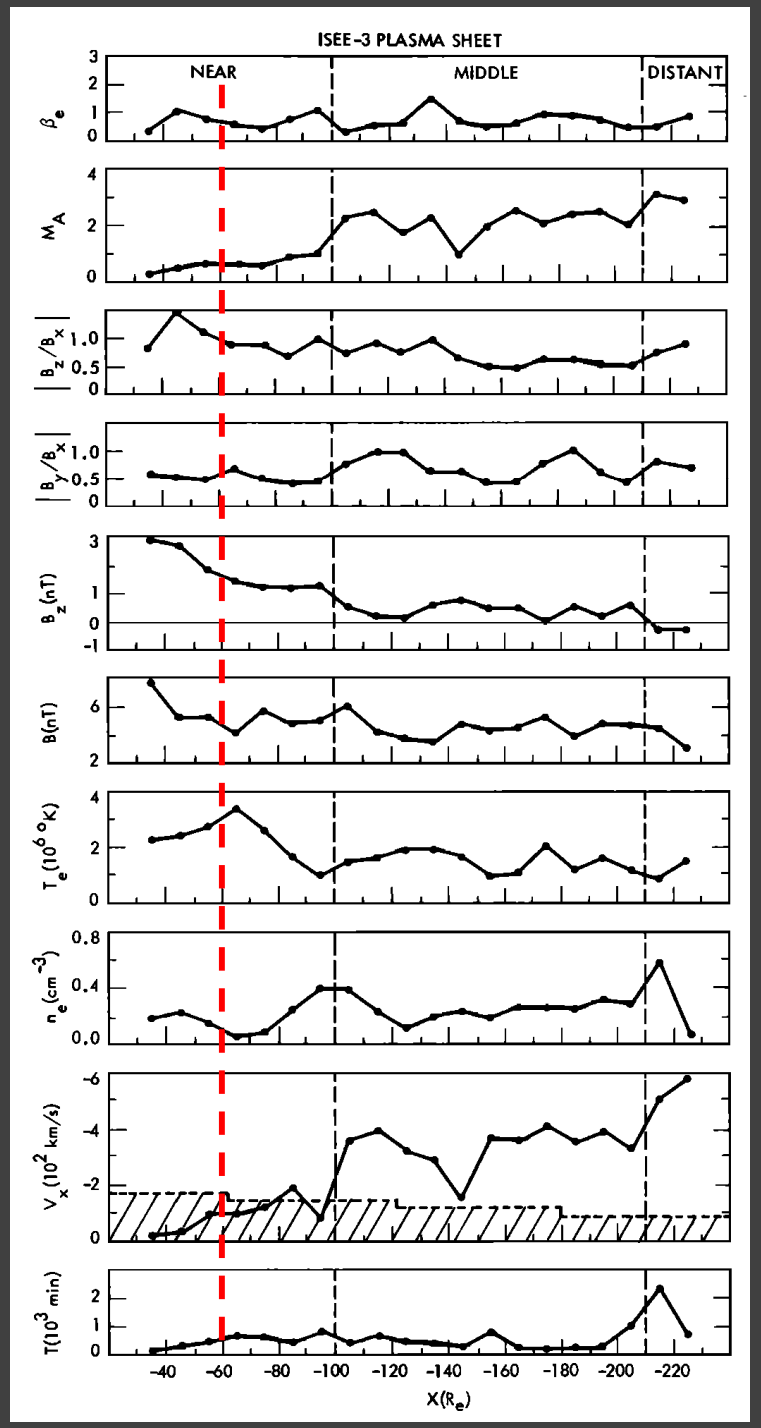
The Moon is ≈70% in the solar wind, **≈20% in the magnetotail,** and ≈10% in the magnetosheath.

Apollo missions did not experience the Moon in the magnetotail!

Previous Studies: ISEE-3 Slavin et al. (1985)

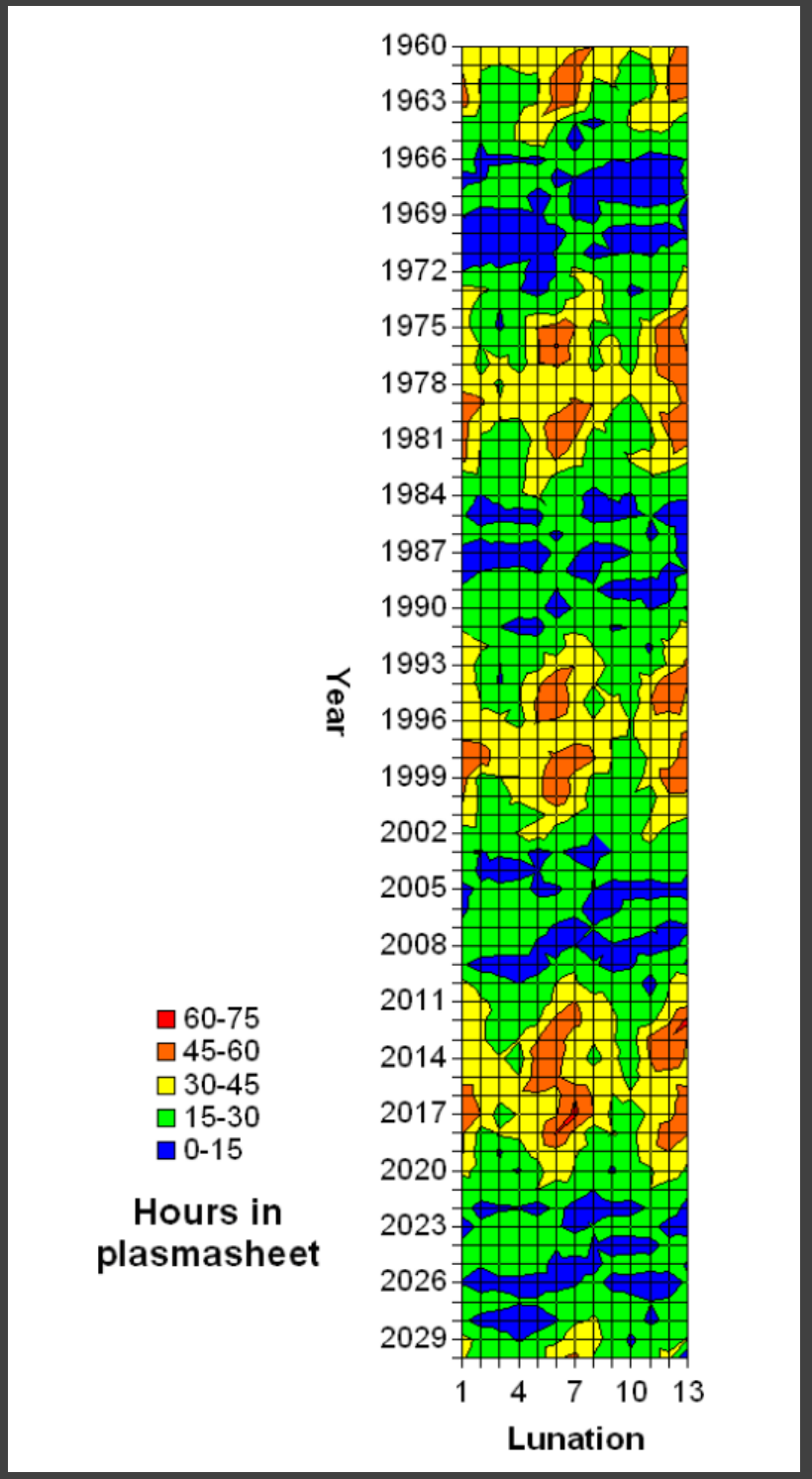


- Limited to electron moments and B-field data.
- Some ion properties could be inferred (e.g., ion temperature).
- Still some of the best published statistics of magnetotail plasma at lunar orbit ~ 60 R_E.



Previous Studies: T98 Hapgood (2007)

- Used Tsyganenko 1998 model to predict the exposure of the Moon to the plasma sheet.
- Large uncertainties.
- Does not account for the varying characteristics of the plasma sheet.
- **THEMIS-ARTEMIS data can be used to provide a much better picture of the variable magnetotail environment at lunar orbit.**

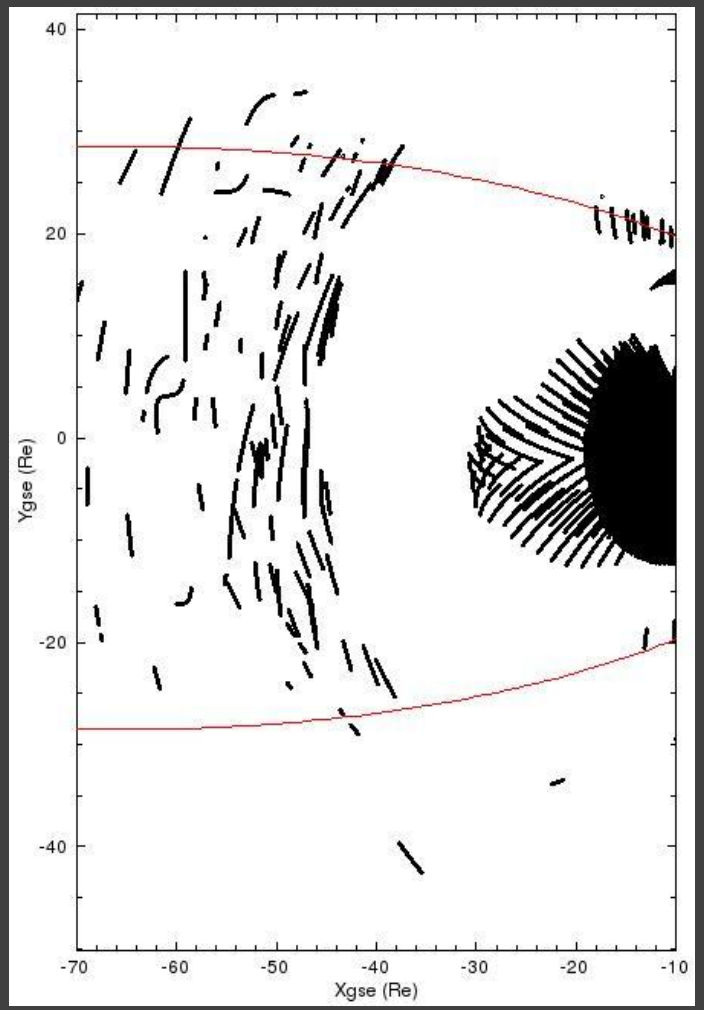


Identifying THEMIS-ARTEMIS in the Magnetotail

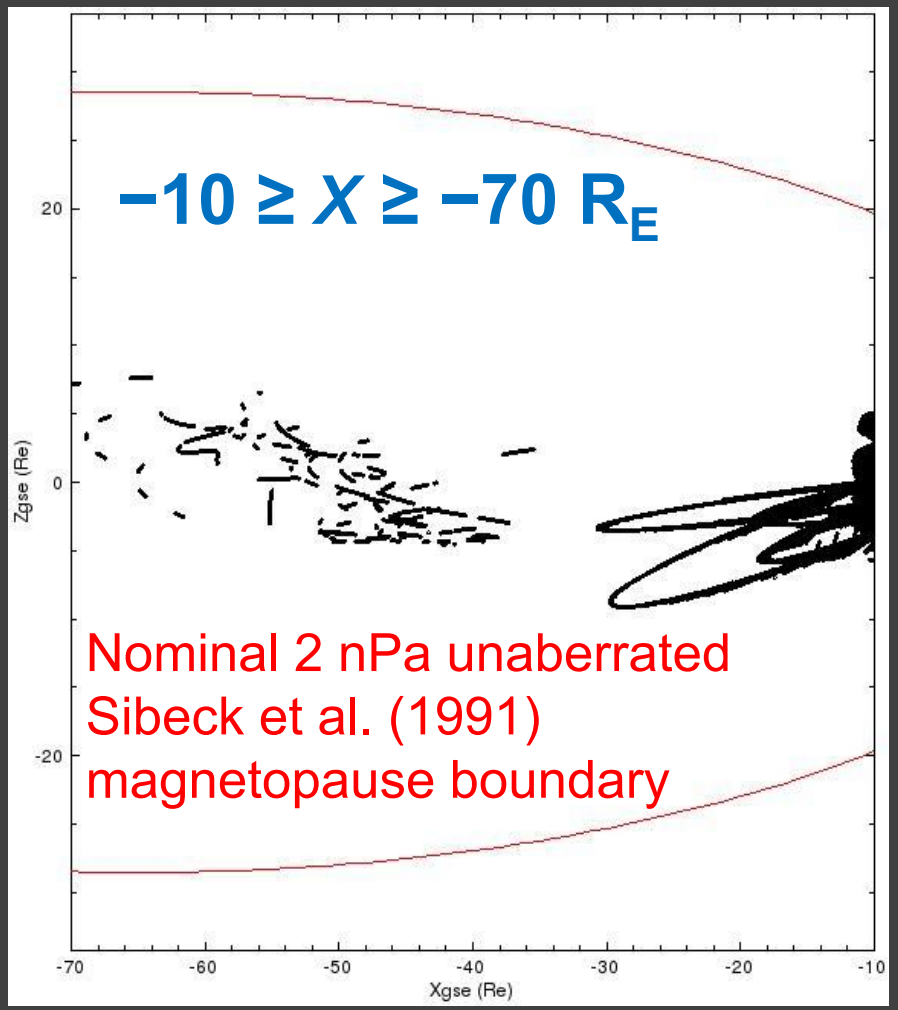
THEMIS A–E from 2007–2011 … spin resolution data (≈3 s)

Magnetopause crossings identified by comparison with high-res OMNI data (e.g., bulk flow, concentration, and B-field).

X-Y Plane



X-Z Plane

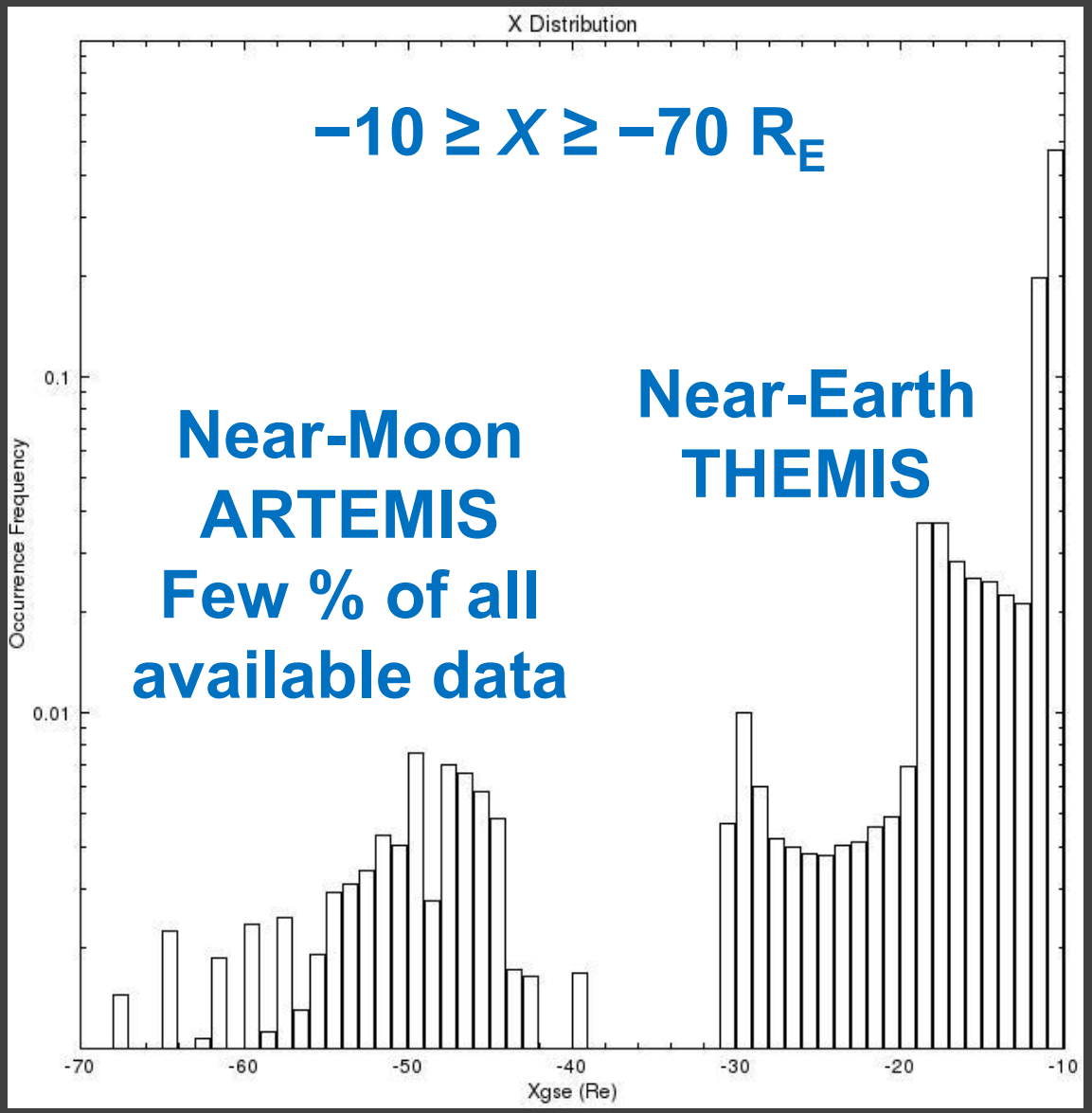


Distribution of Observations Down the Magnetotail

Only considered intervals for which the following data were available:

- B-field
- Ion moments. n, T_i and **V**
- Electron temperature T_e

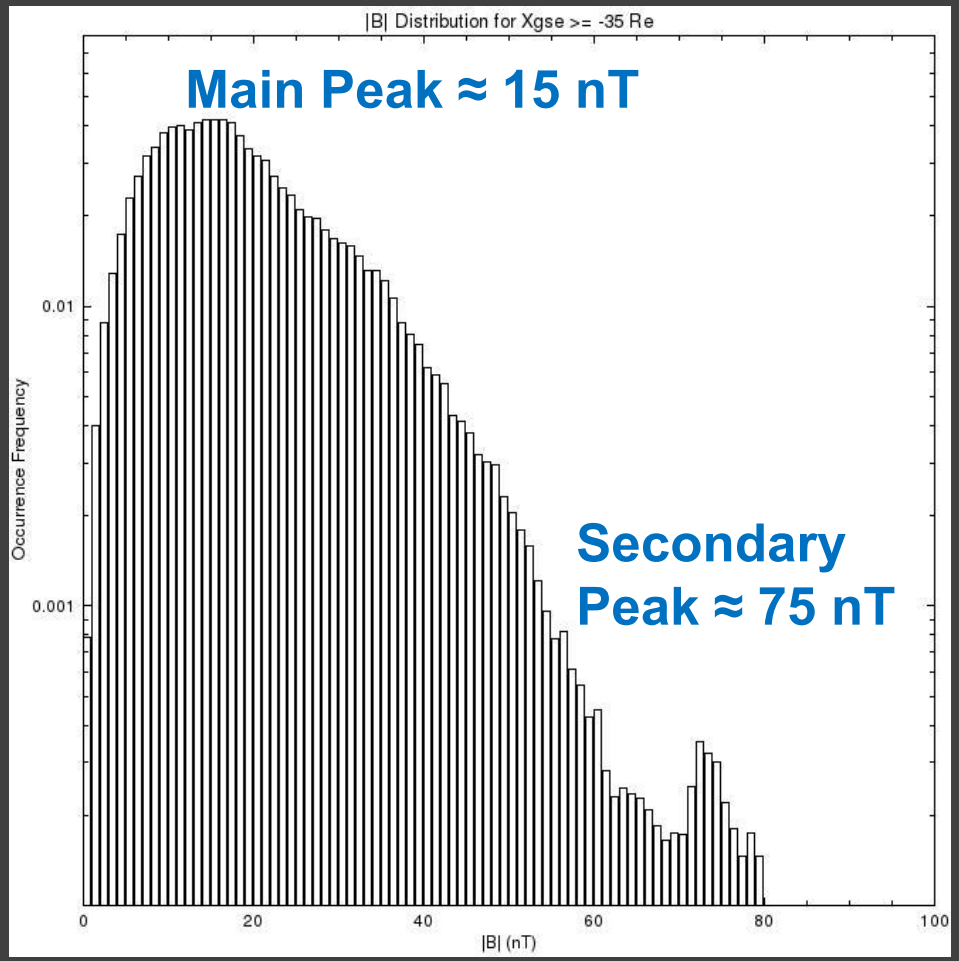
Almost 8 million data points!



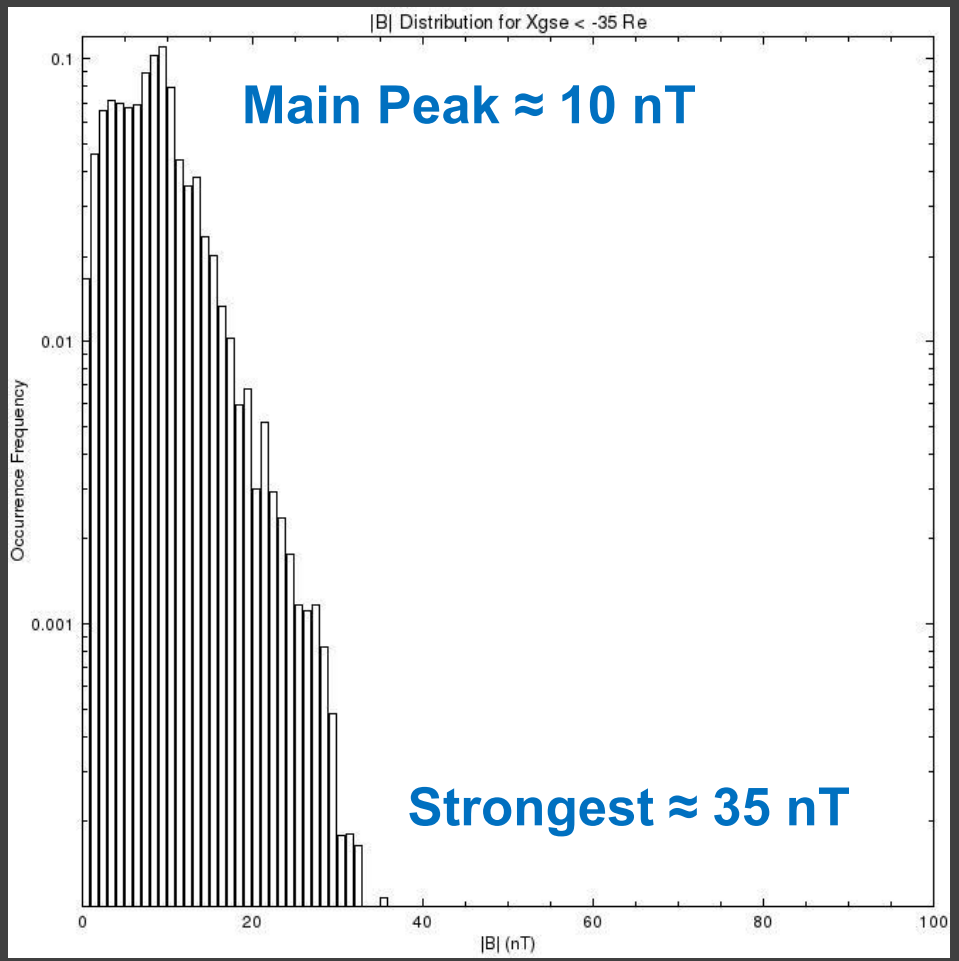
Includes intervals magnetically connected to the Moon

Distribution of B-field Magnitudes |B|

Near-Earth, $X \geq -35\ R_E$



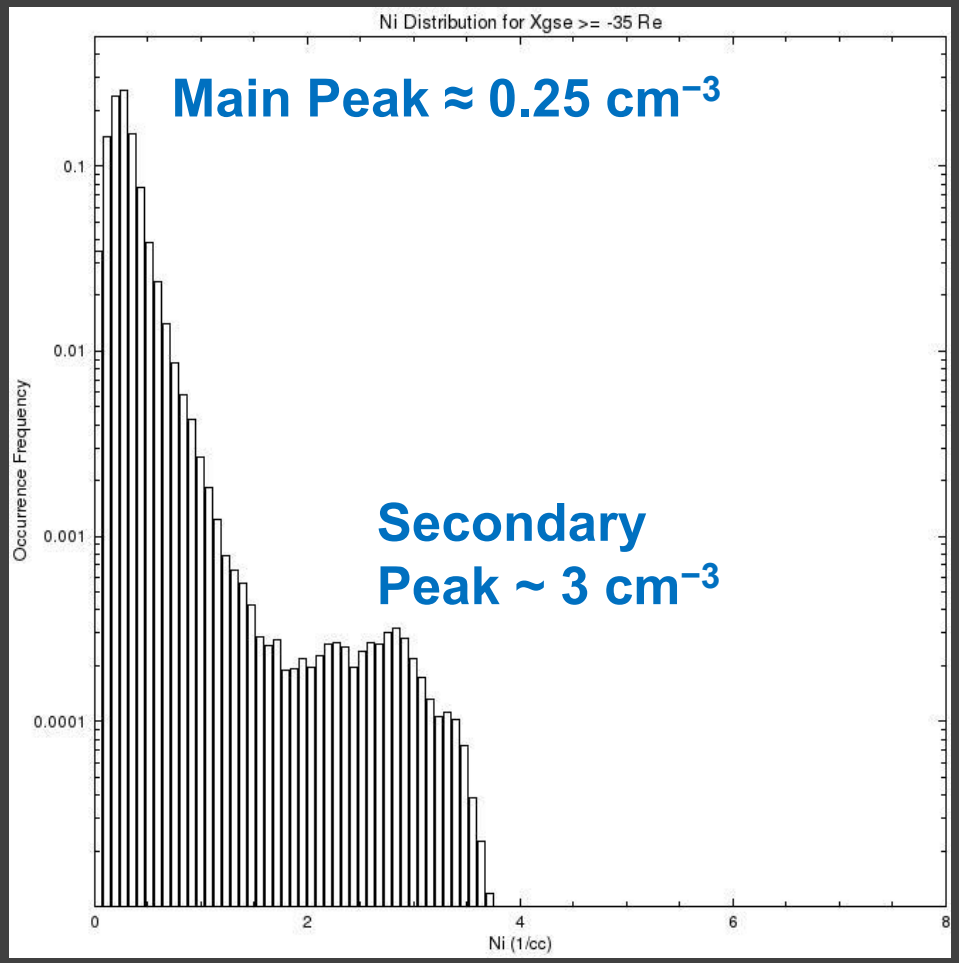
Near-Moon, $X < -35\ R_E$



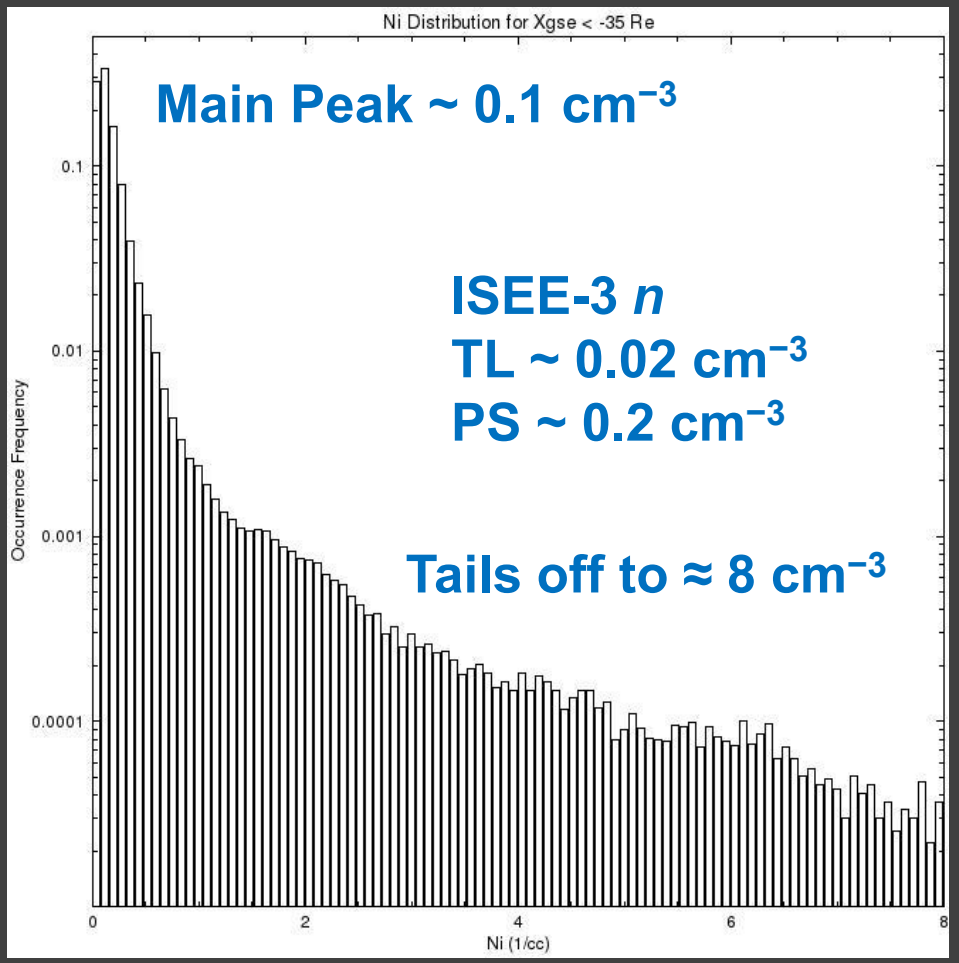
Indicative of morphology and substorm dynamics?

Distribution of Ion Concentrations *n*

Near-Earth, $X \geq -35\ R_E$



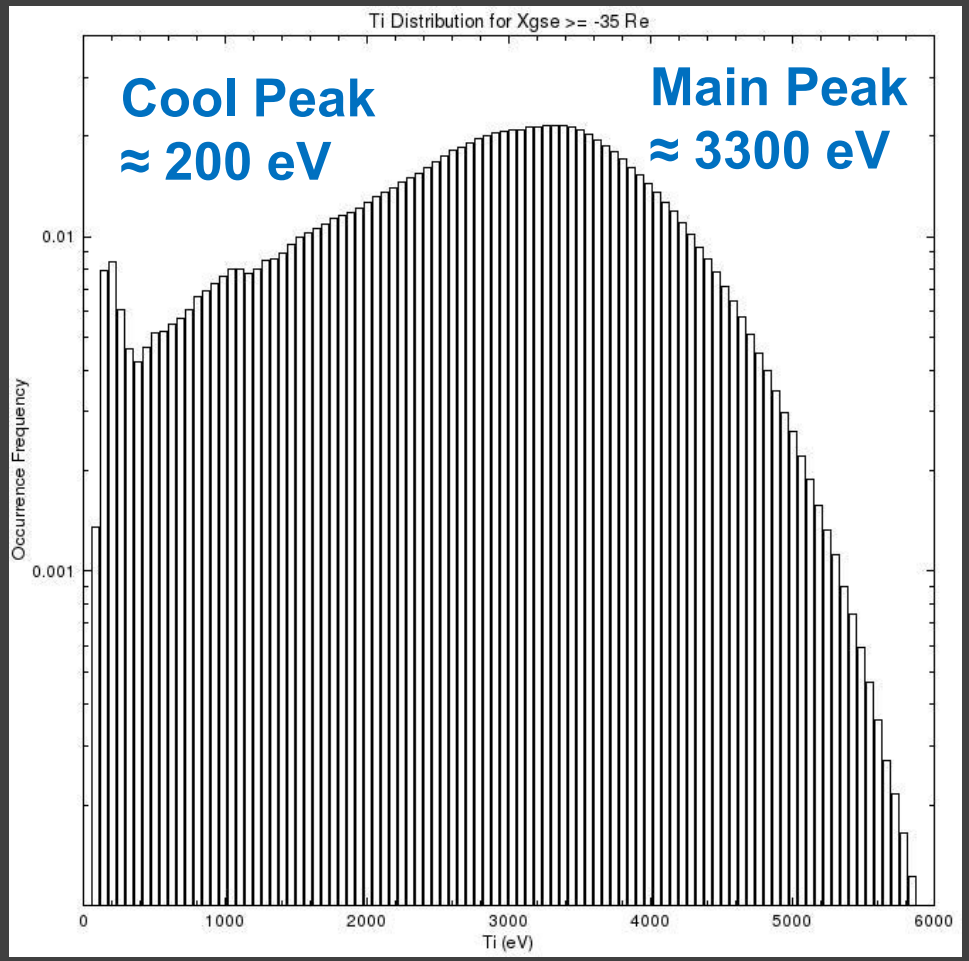
Near-Moon, $X < -35\ R_E$



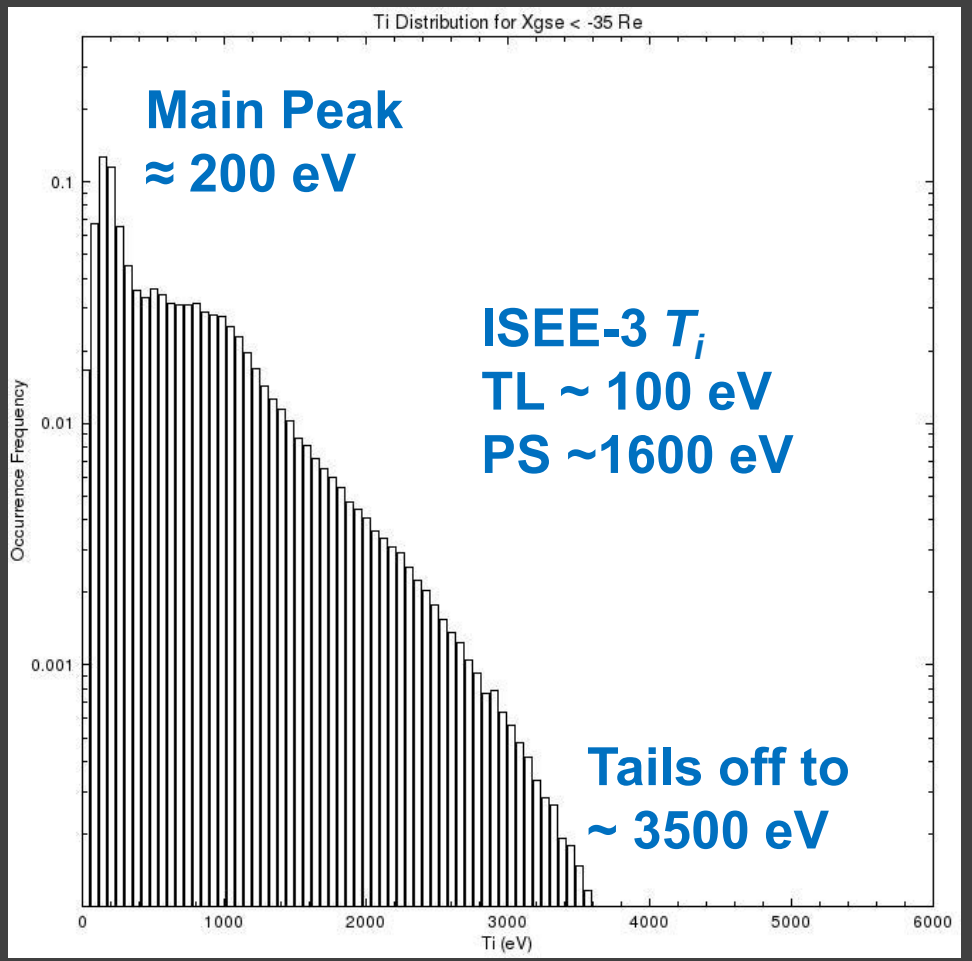
Spatial biases … Boundary layer with magnetosheath?

Distribution of Ion Temperatures T_i

Near-Earth, $X \geq -35\ R_E$



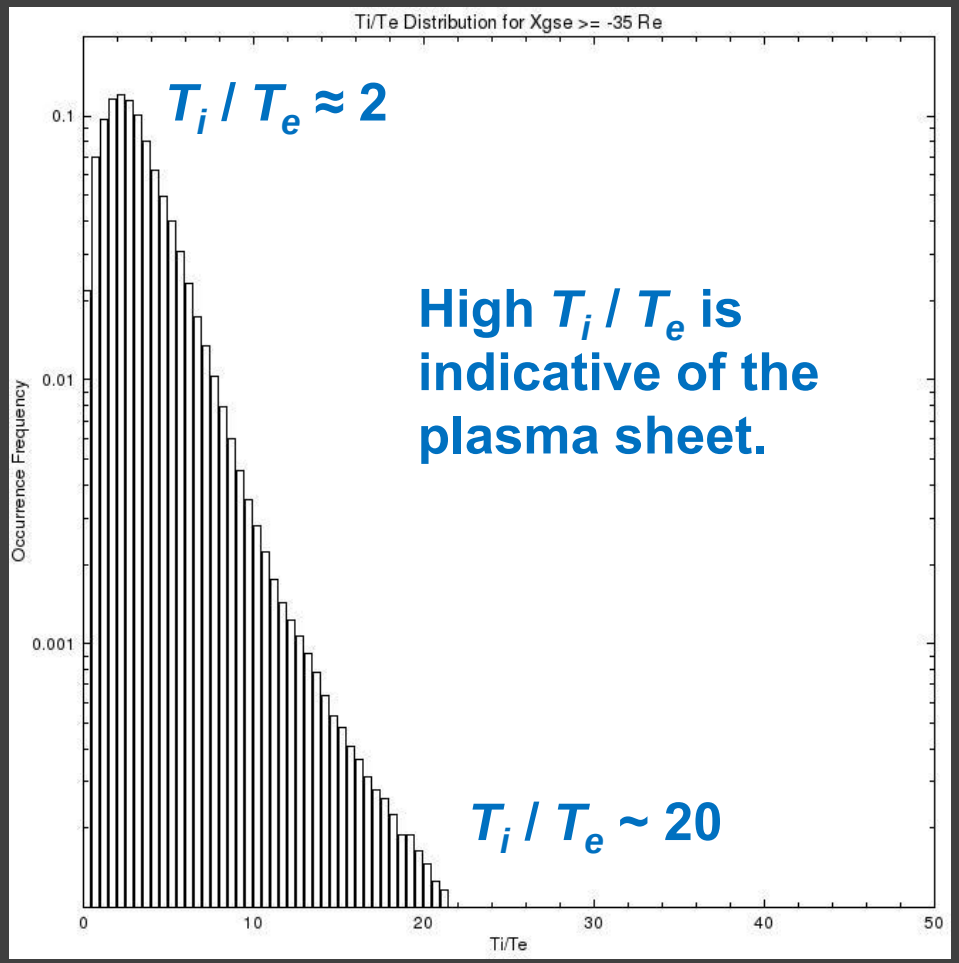
Near-Moon, $X < -35\ R_E$



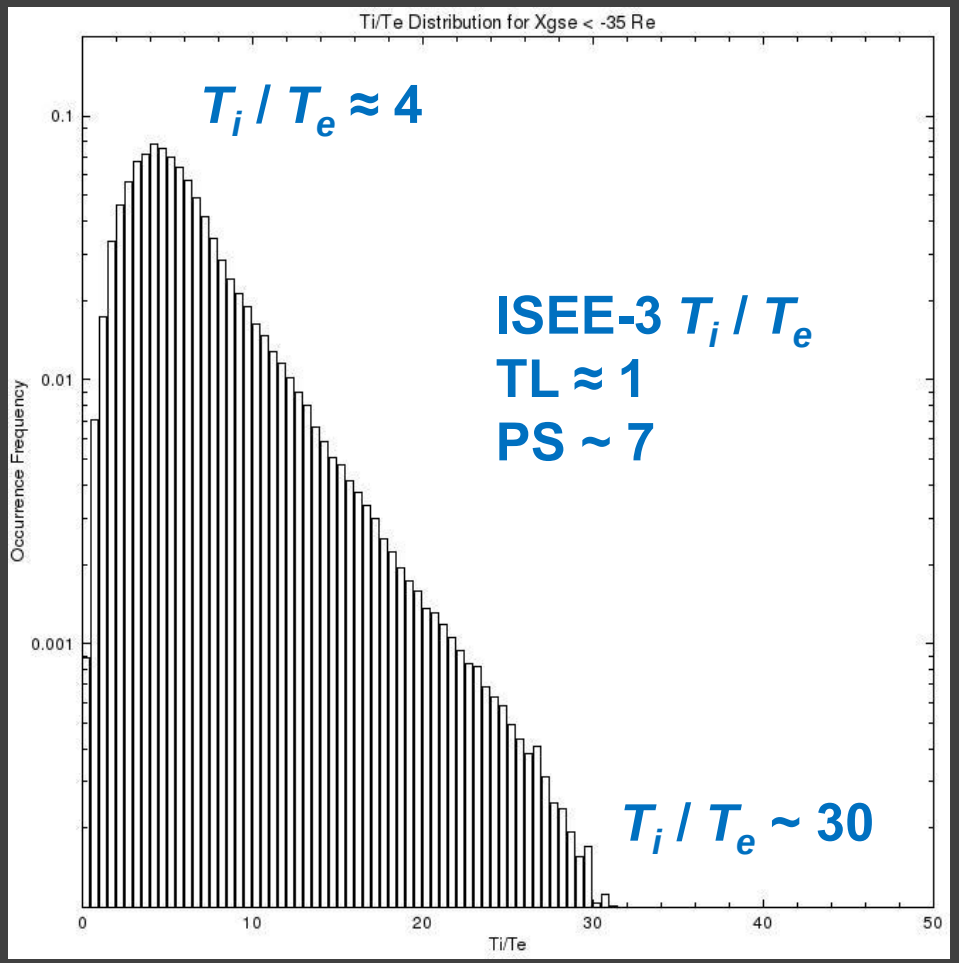
Indicative of plasma energization processes

Distribution of Ion-Electron Temperature Ratios T_i / T_e

Near-Earth, $X \geq -35\ R_E$



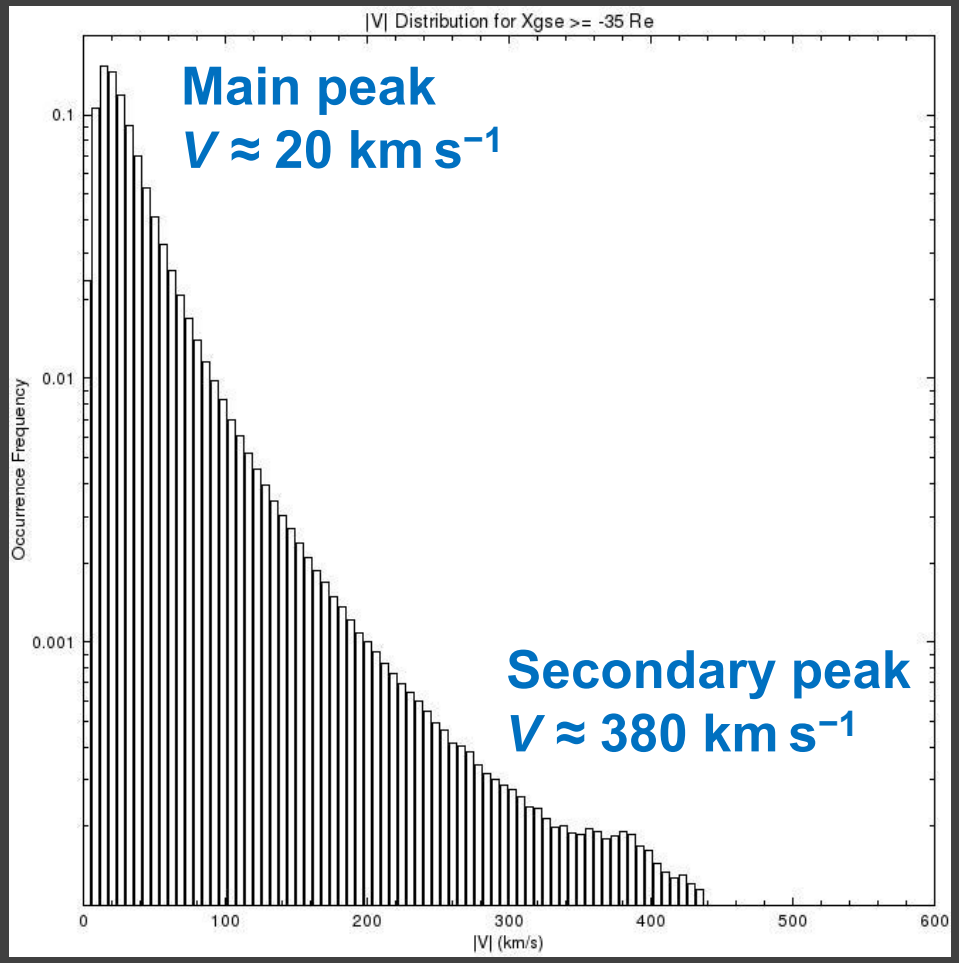
Near-Moon, $X < -35\ R_E$



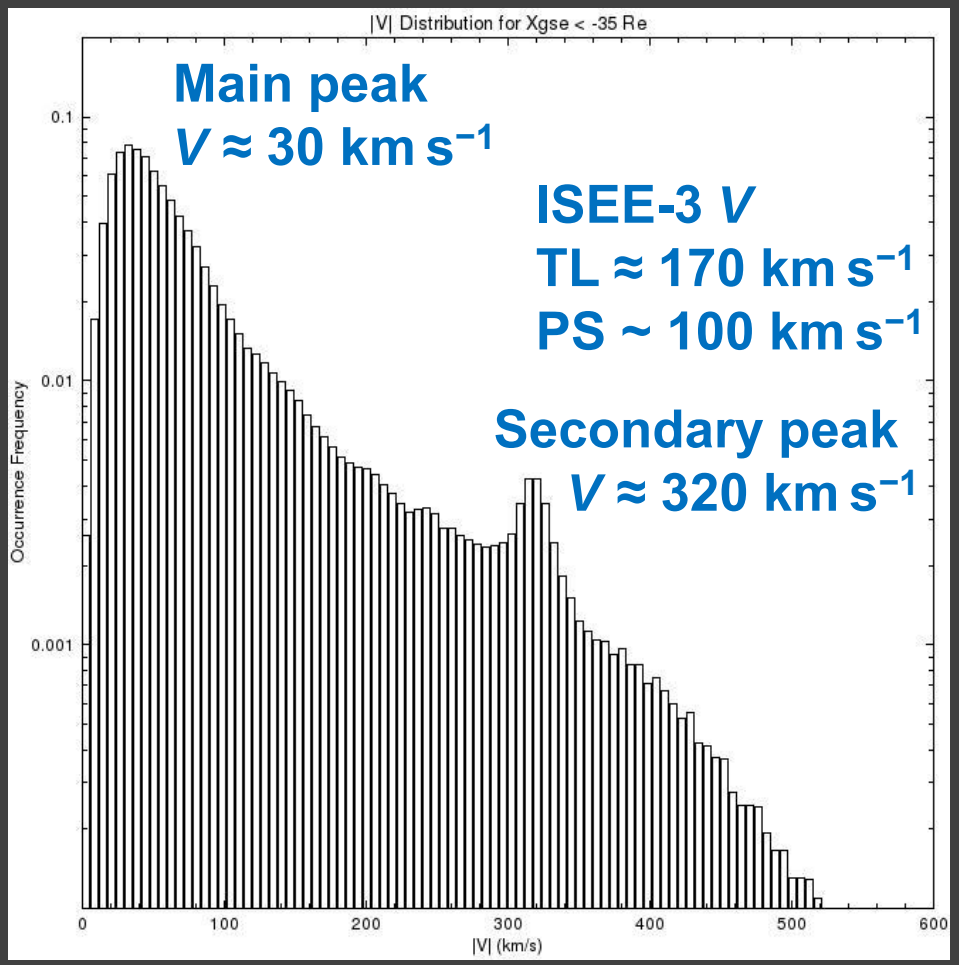
Indicative of plasma shock processes

Distribution of Bulk Flow Speed *V*

Near-Earth, $X \geq -35\ R_E$

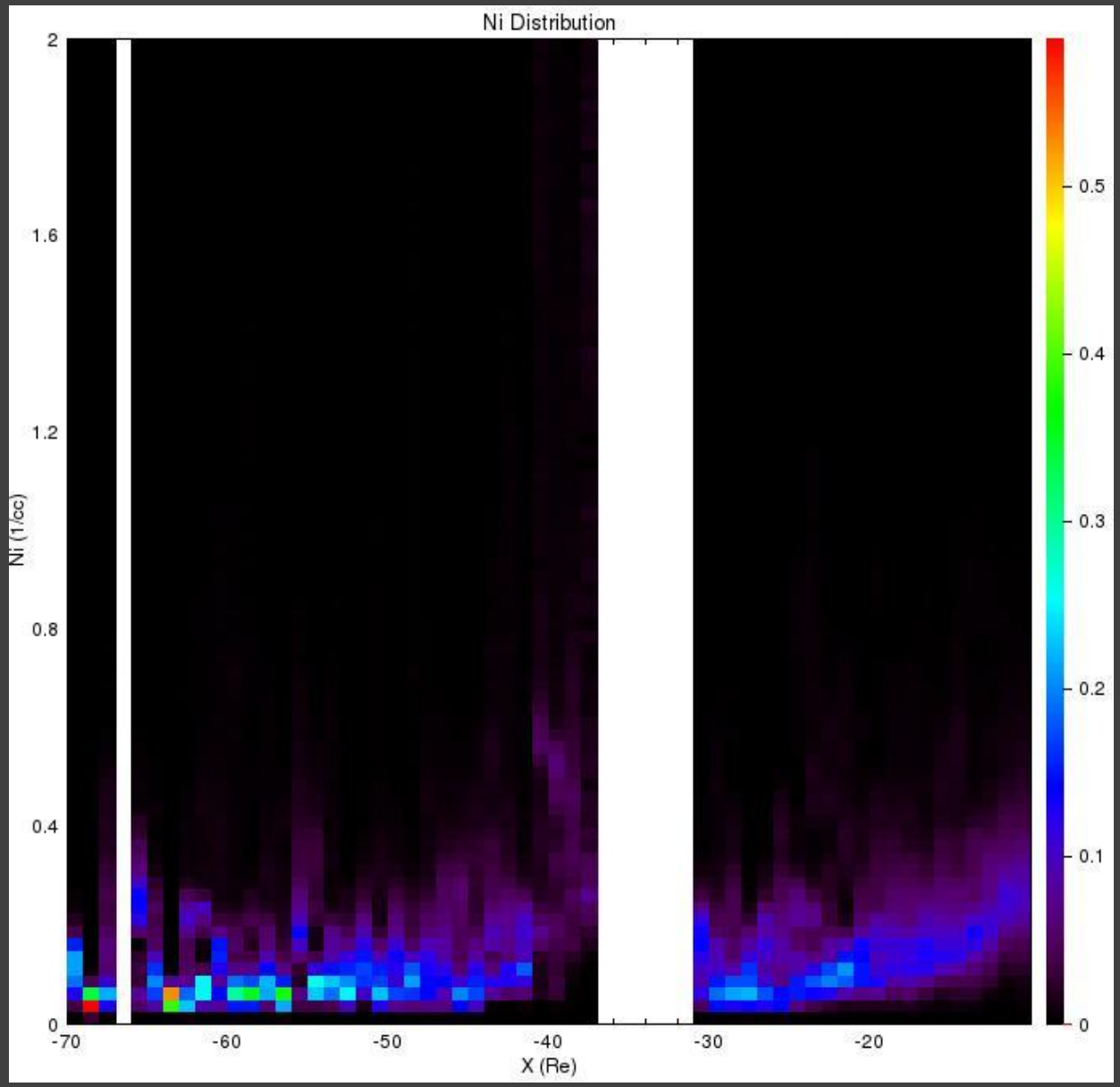


Near-Moon, $X < -35\ R_E$



If sonic Mach # > 1, then could form solar wind-like wakes?

Occurrence Frequency of Ion Concentration as a Function of Distance Down the Magnetotail



Summary

- Prepared database of THEMIS-ARTEMIS observations and identified magnetotail traversals.
- Found significant differences between near-Earth and near-Moon magnetotail environment.
- Further sorting will be done to identify:
  - different regions of the magnetotail.
  - various physical processes.
  - Dependence on solar wind conditions.
- Ready to start cranking out results ...
- <u>See Wang et al. presentation at Fall AGU!</u>