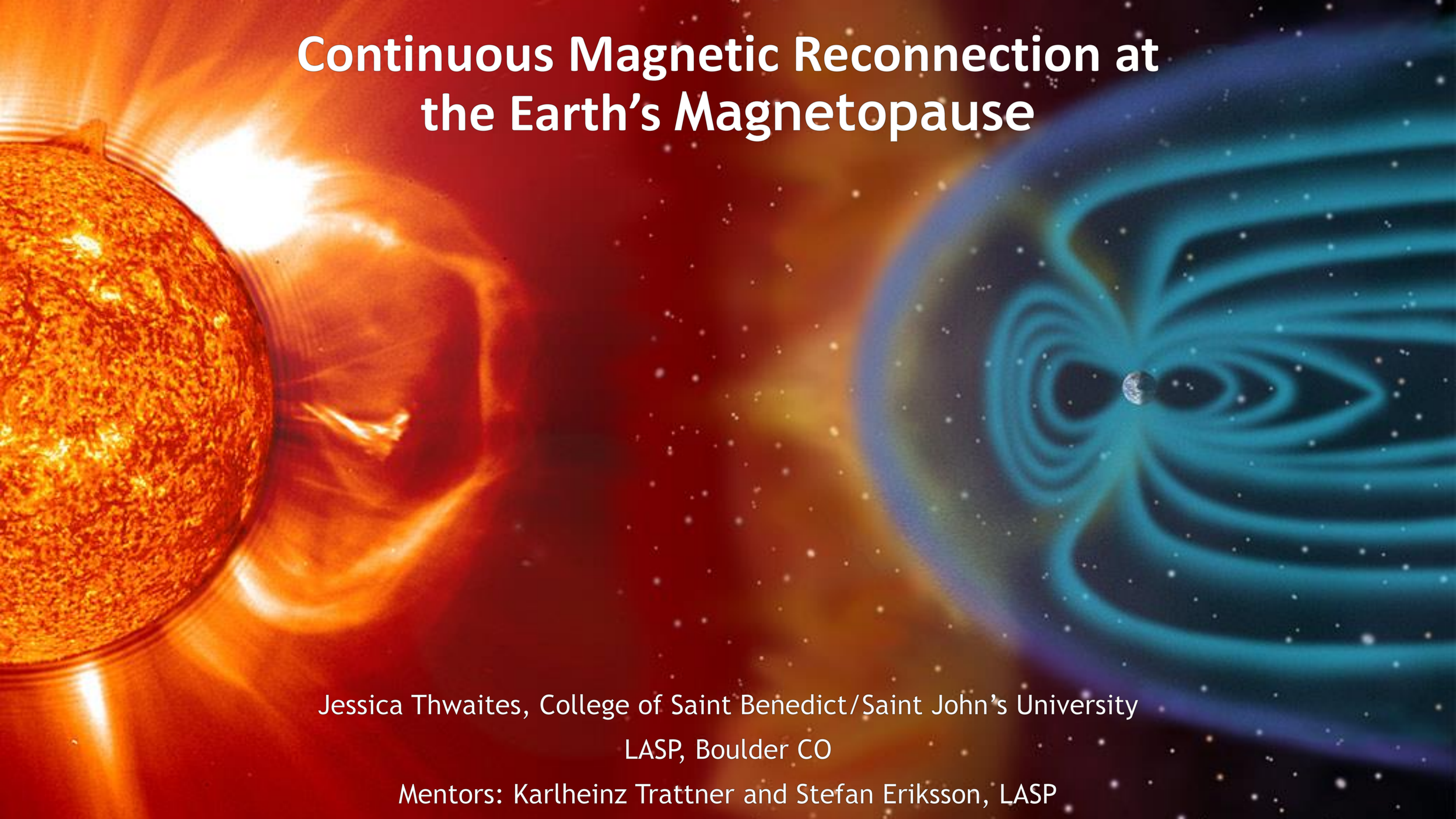

Continuous Magnetic Reconnection at the Earth’s Magnetopause

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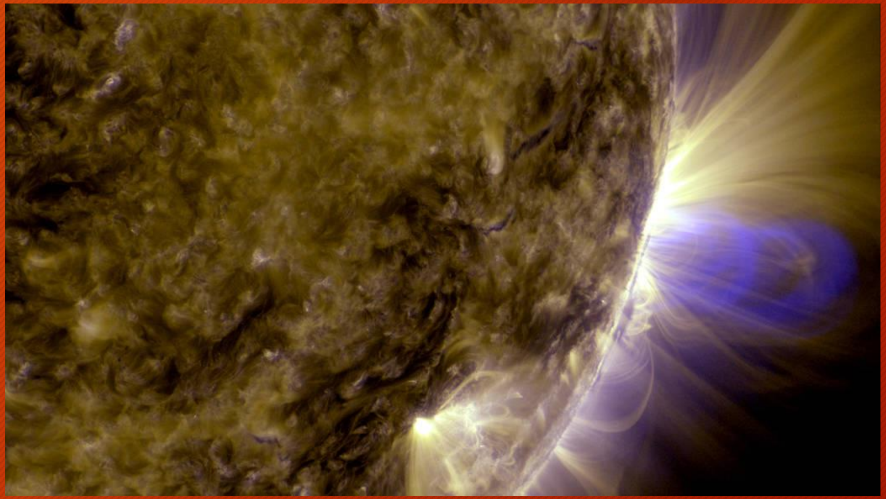
LASP, Boulder CO

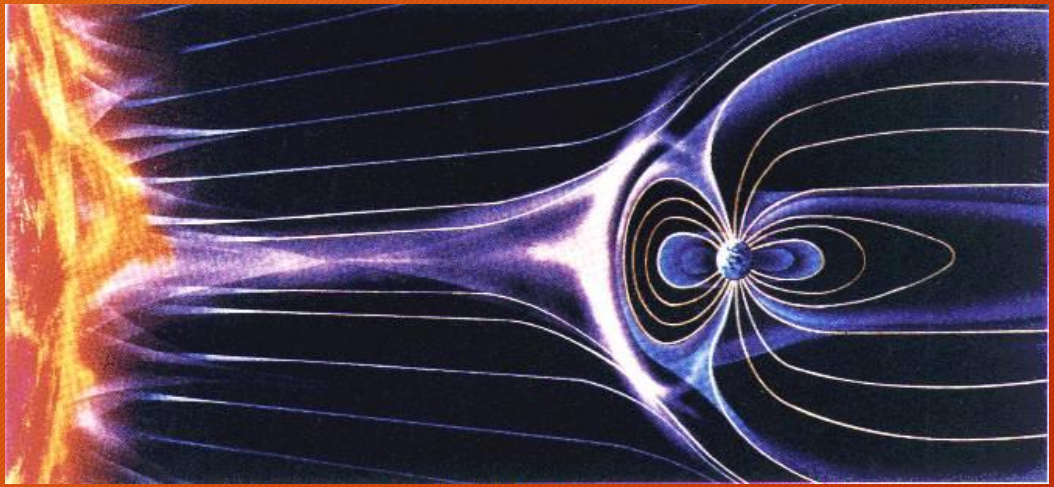
Mentors: Karlheinz Trattner and Stefan Eriksson, LASP

Why Study Magnetic Reconnection?

Fundamental Process

- Sun: Solar flares, Flare loops, CMEs
- Interplanetary Space
- Planetary Magnetosphere: solar wind plasma entry, causes Aurora

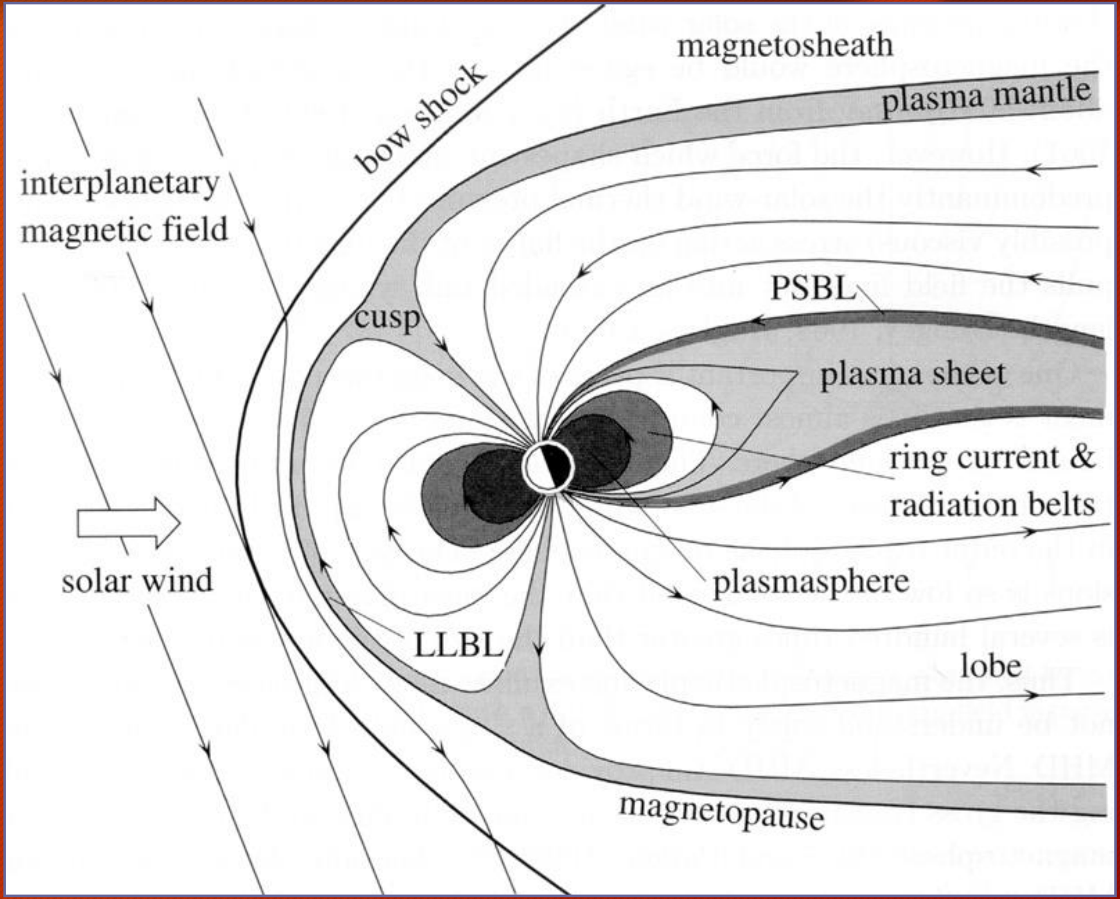




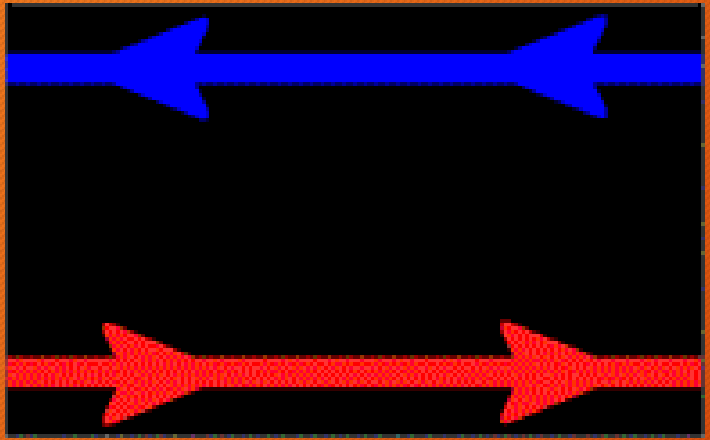
Ultimate goal of the project – observe magnetic reconnection by satellite *in situ* through predictions of reconnection site in model

Regions of the Geosphere

- Solar wind: made up of plasma particles (pressure causes field distortion)
- Bow shock: shock wave preceding Earth's magnetic field
- Magnetosheath: region of shocked plasma (higher density)
- Magnetopause: Boundary between solar wind/geosphere
- Cusp region: region with open field lines and direct solar wind access to upper atmosphere



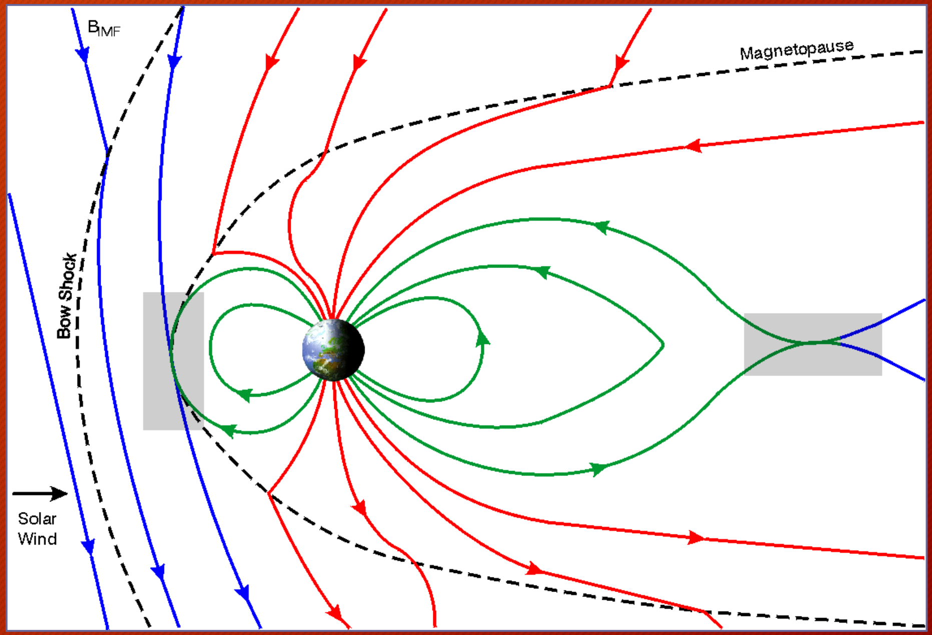
Magnetic Reconnection



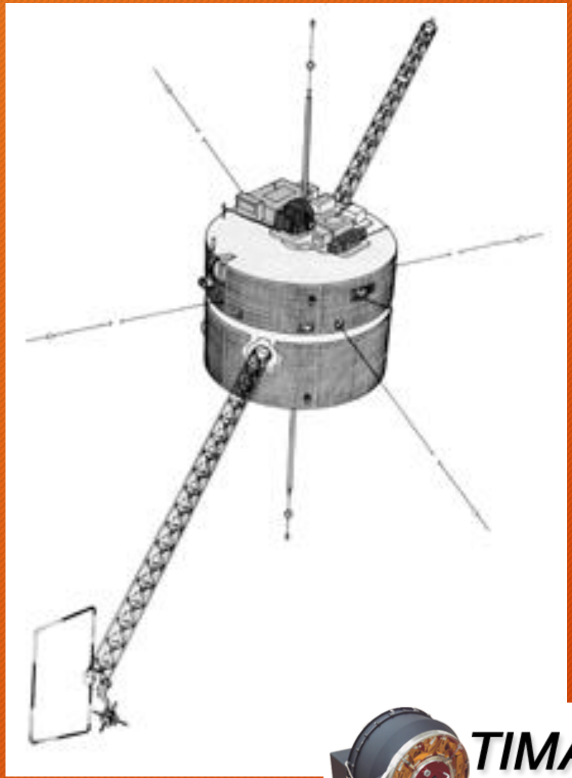
- Two antiparallel magnetized plasmas, separated by current sheet
- Occurs in a very small area (Diffusion Region)

At the Earth's Magnetopause:

- IMF reconnects with Earth's magnetic field across the magnetopause
- Southward IMF reconnects near equator
- Forms open field lines, which convect backwards to cusp



Instrument Overview



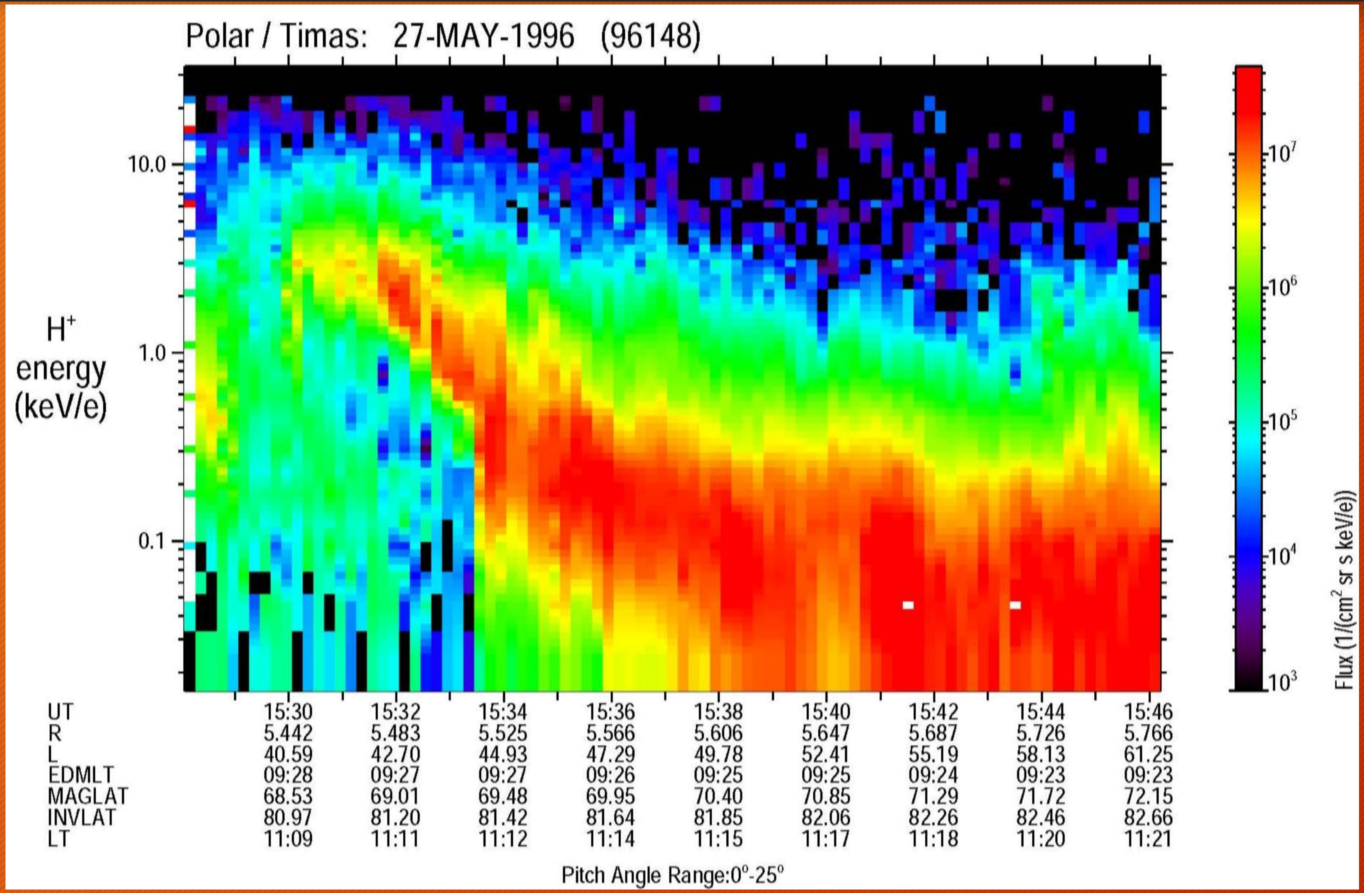
Polar –TIMAS instrument

- Measures 3D velocity distributions
- Focused on H+ data

Wind - SWE

- Outside geospheric influence
- Provides solar wind data

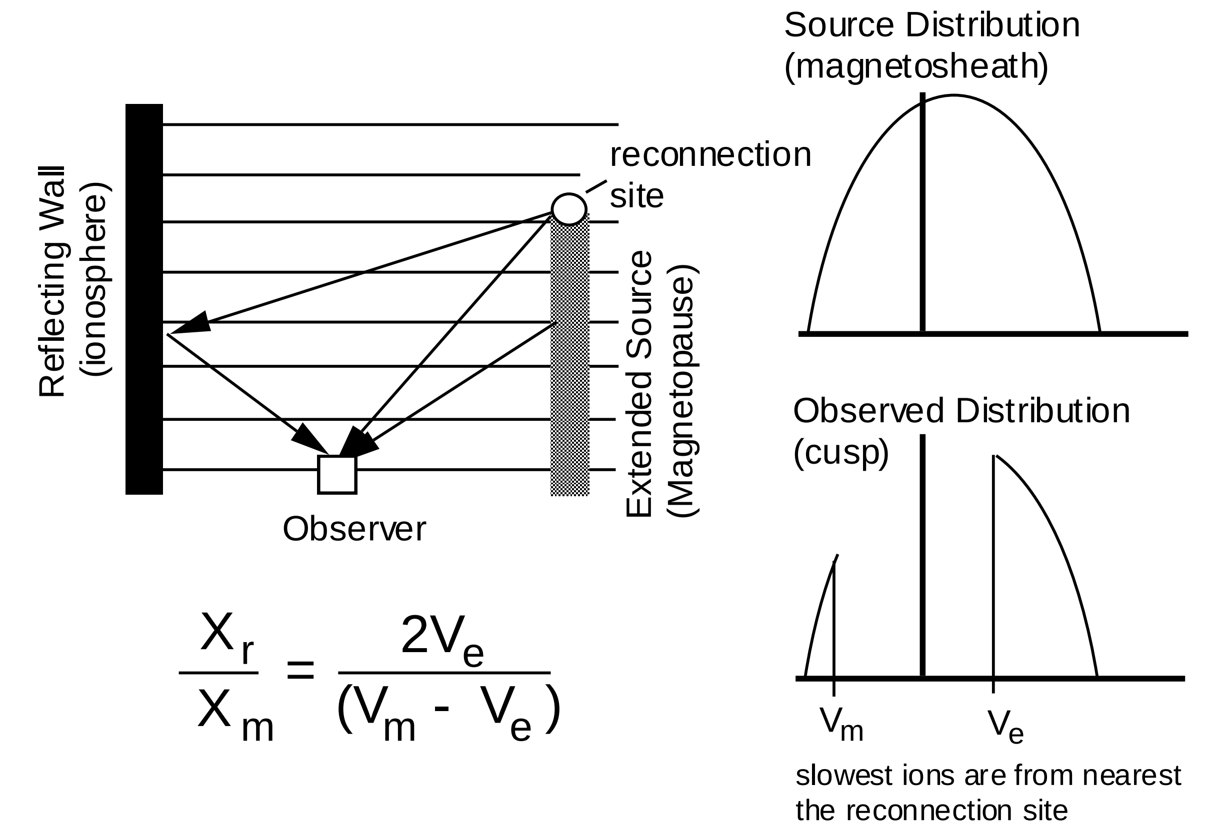
Magnetic Reconnection Observed in the Cusp



Color spectrogram produced by IDL program written by mentor

- Color spectrogram
- Measures energy and intensity (flux) of protons from solar wind in cusp with respect to time and latitude
- Latitude changes due to convection

Methodology to Determine Where Reconnection Occurs

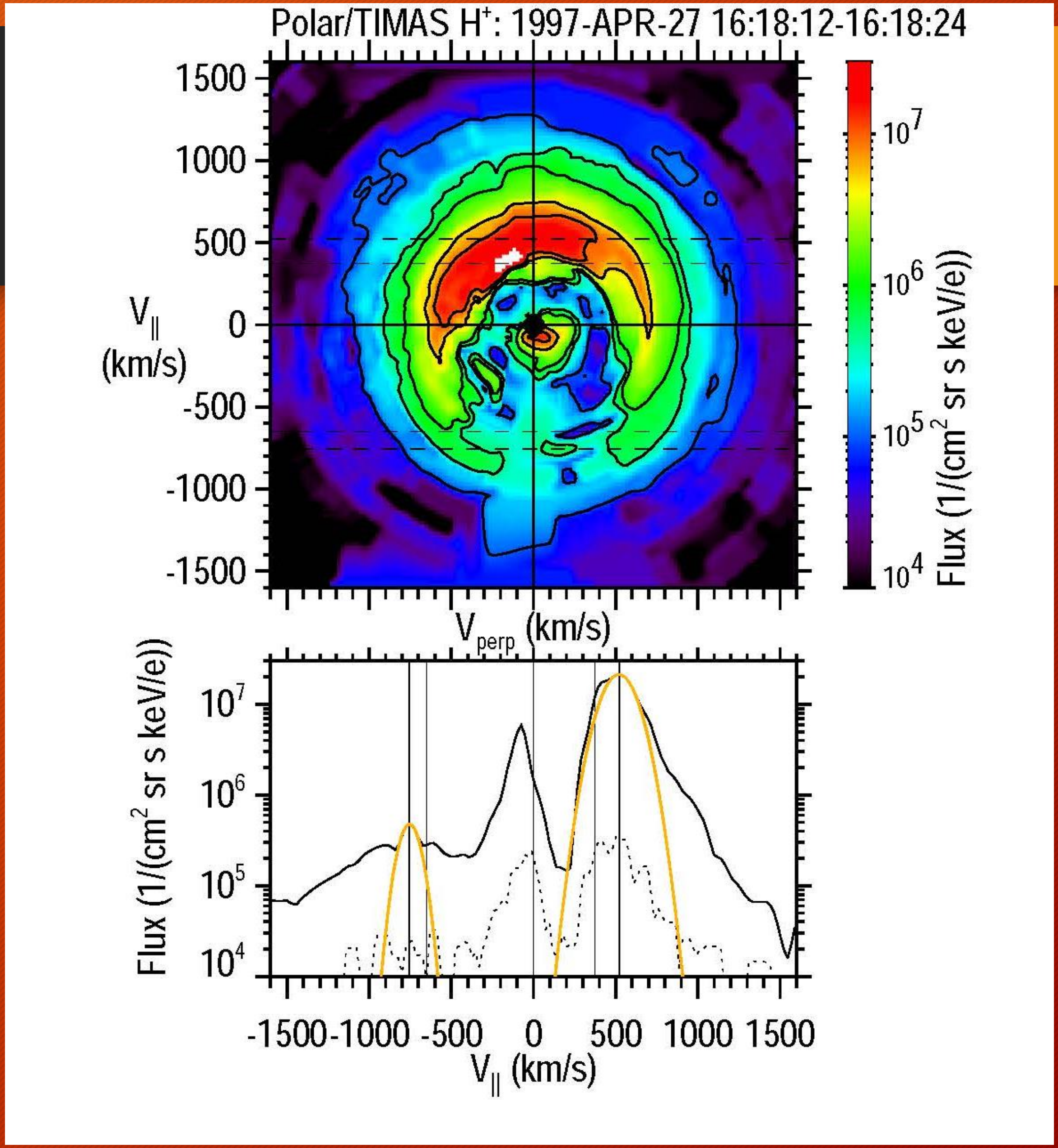


$$\frac{X_r}{X_m} = \frac{2V_e}{(V_m - V_e)}$$

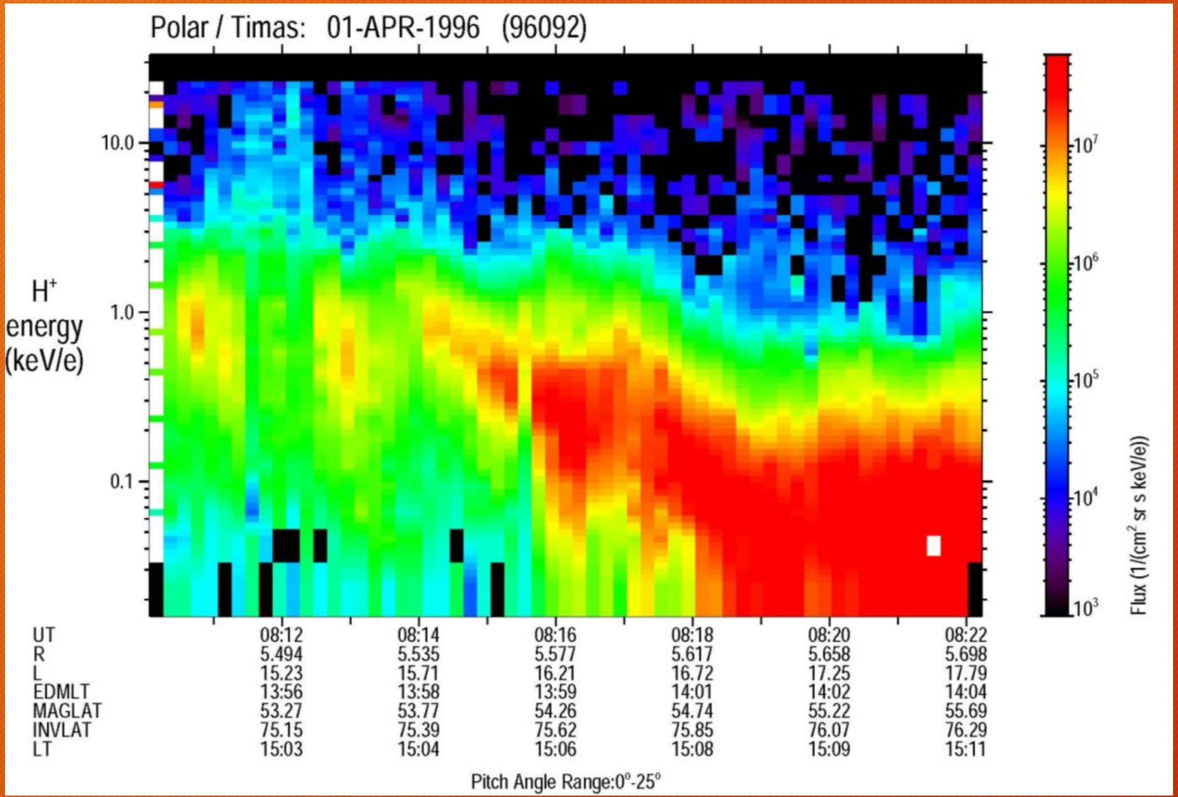
- Ions are reflected when they reach the ionosphere
- X_m = Distance to ionospheric mirror point, calculated using Tsyganenko 1996 model (known value)
- V_m = cutoff velocity of mirrored ions
- V_e = cutoff velocity of earthward propagating ions (precipitating)
- X_r = distance to reconnection point (Calculated by program)

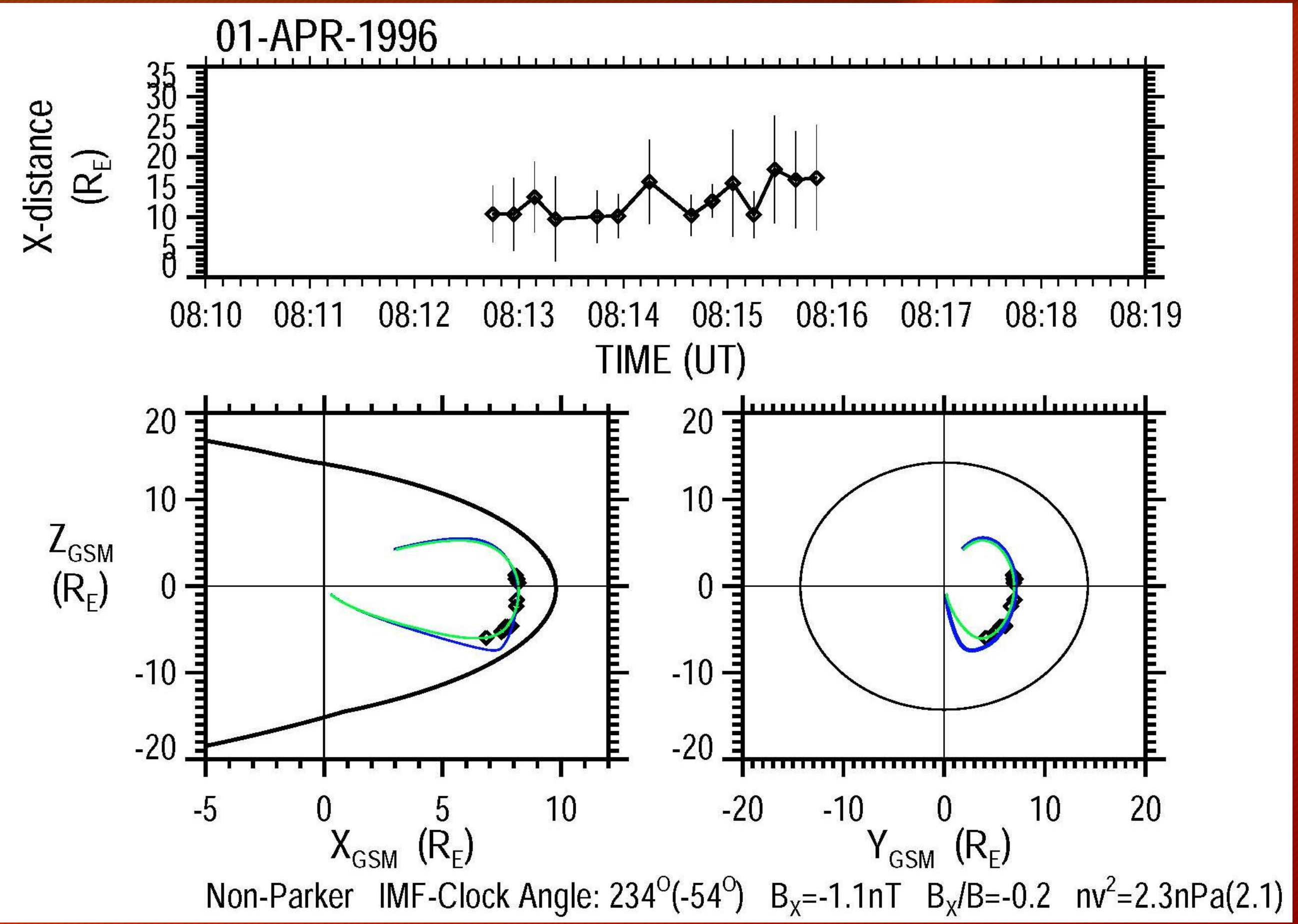
Fitting Distributions to Calculate Velocities

- TIMAS data presented in a field-aligned coordinate system
- Gaussian distributions fitted to TIMAS data
- Determine velocities in relationship and calculate distances

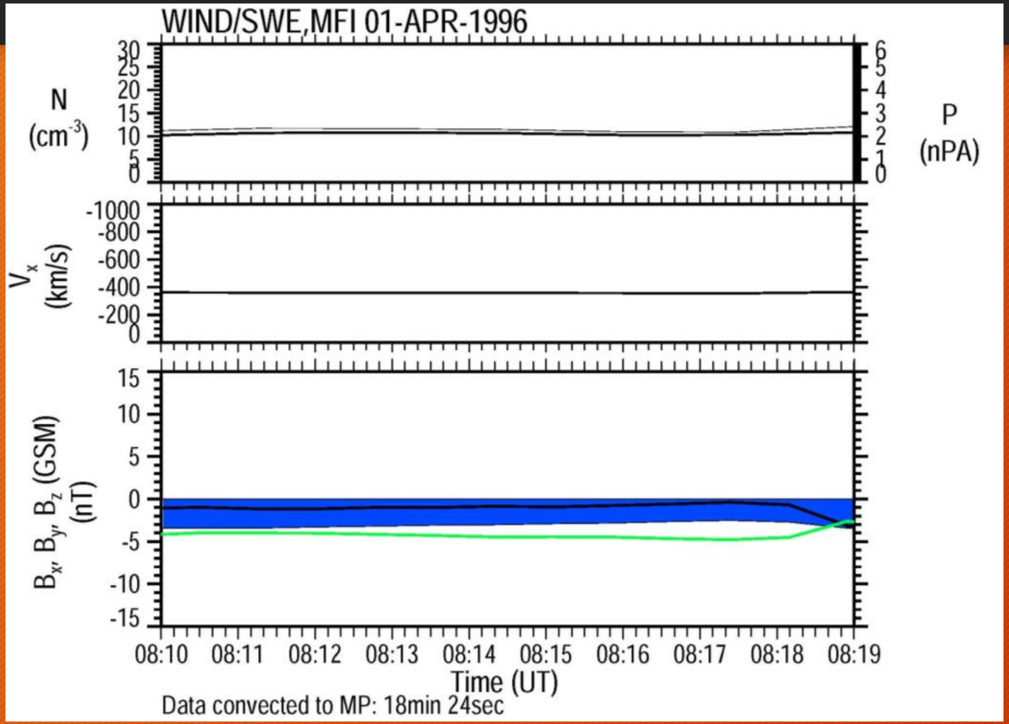


Reconnection Line





Maximum Magnetic Shear Model

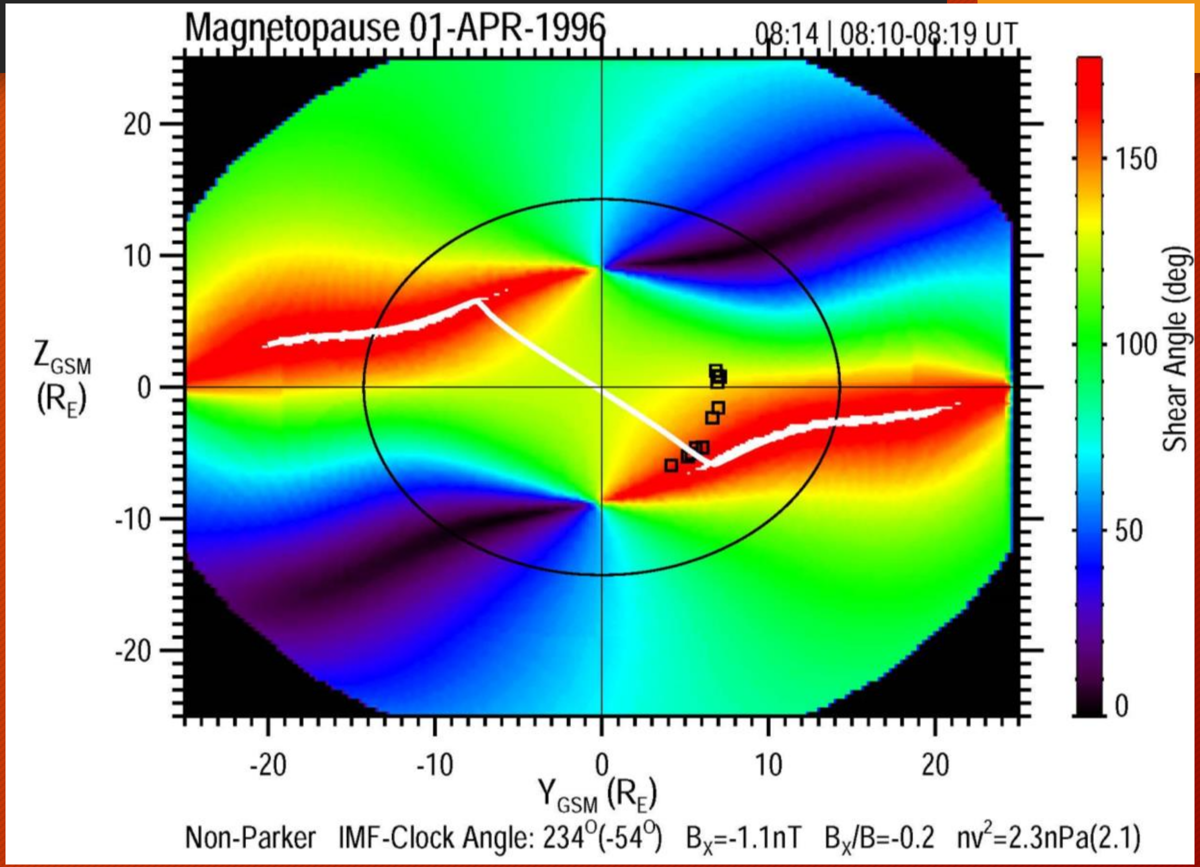


Solar Wind Conditions (Data from Wind/SWE)

Pressure

Velocity of solar wind particles

Magnetic field components (B_x = black line, B_y = green line, B_z = blue shaded)

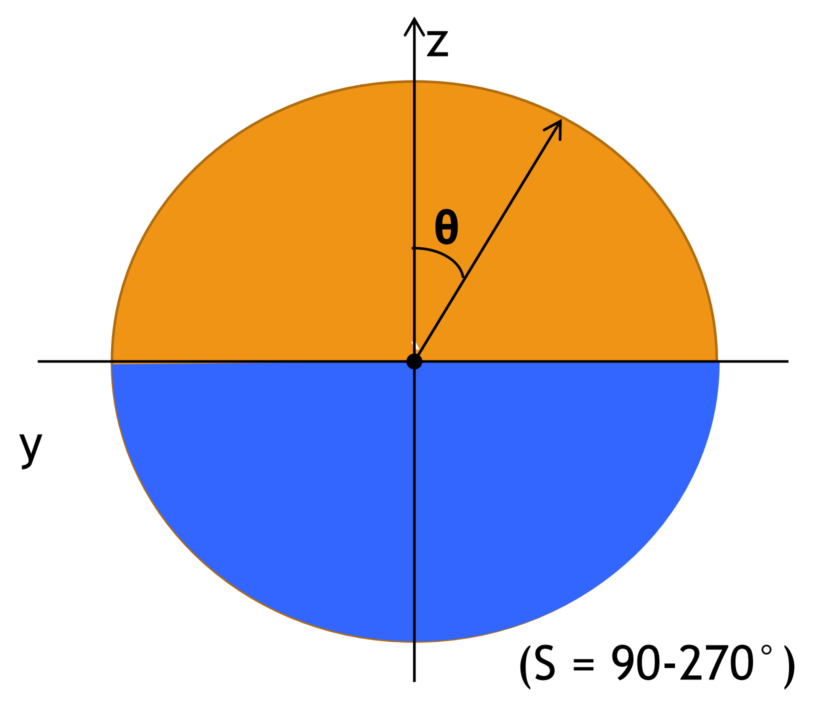


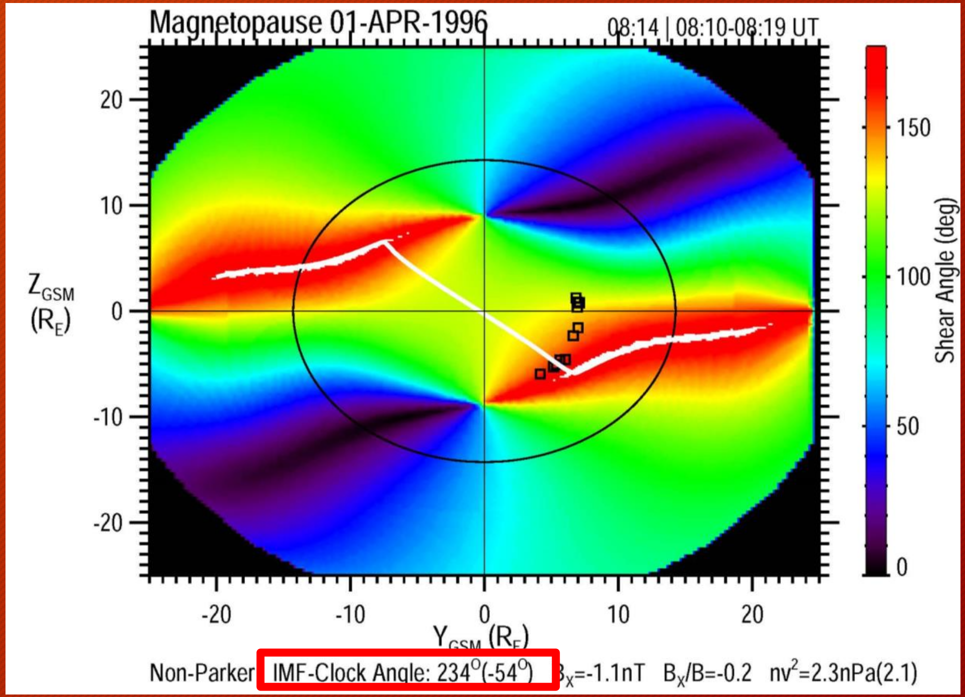
Shear angle plot:

Angle between solar wind magnetic field and earth's magnetic field lines

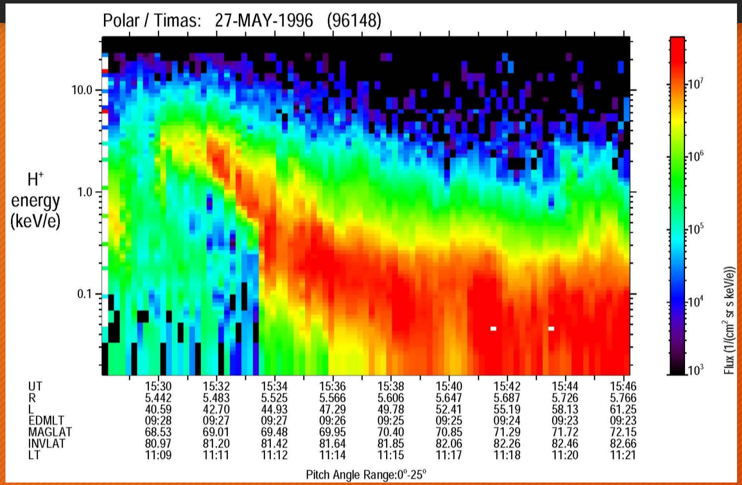
IMF Clock Angle

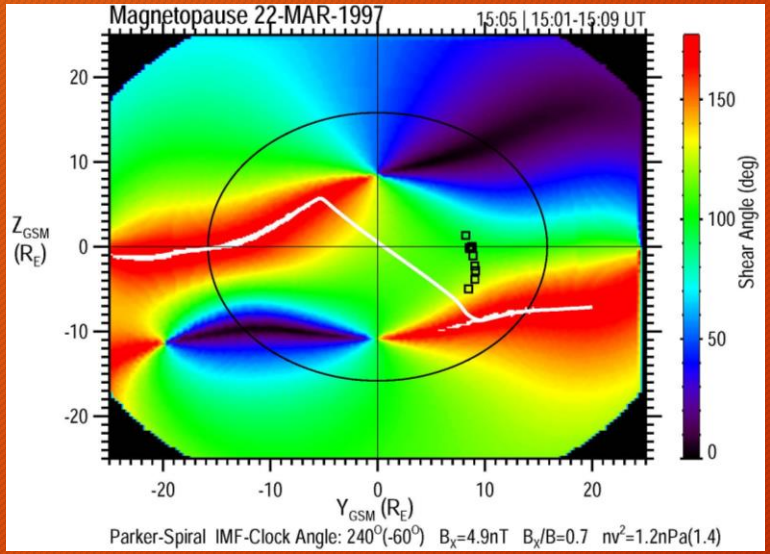
An organization parameter that allows us to characterize the solar wind with one parameter. It represents the angle of the incident IMF aligned to the dipole of the Earth.





Task 1: Smooth Single Dispersions





Objectives for This Summer

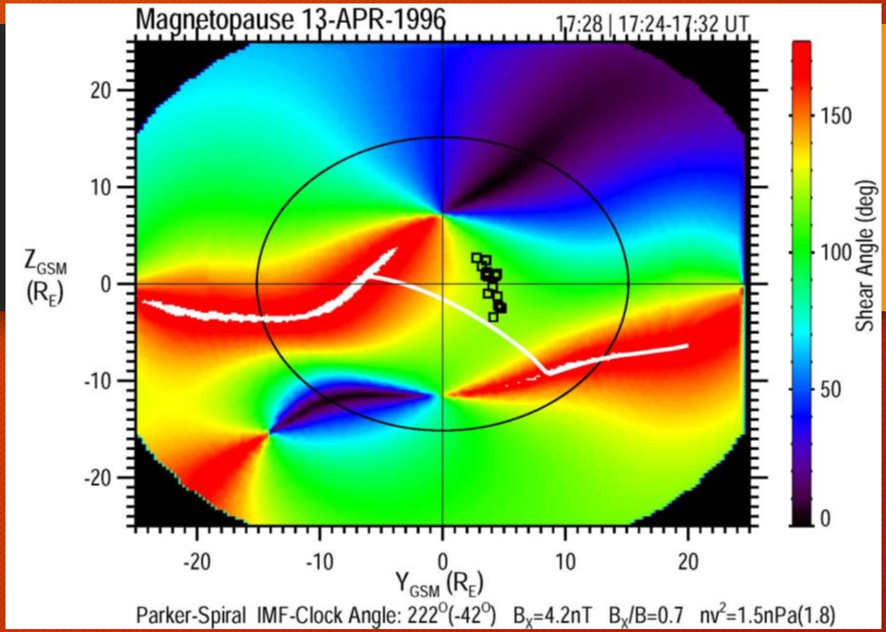
- Use data from POLAR satellite and IDL program written by mentor
- Analyze single dispersion events, which produce anomalies in shear angle plots
- 3 data sets – normal, large Bx, flank events

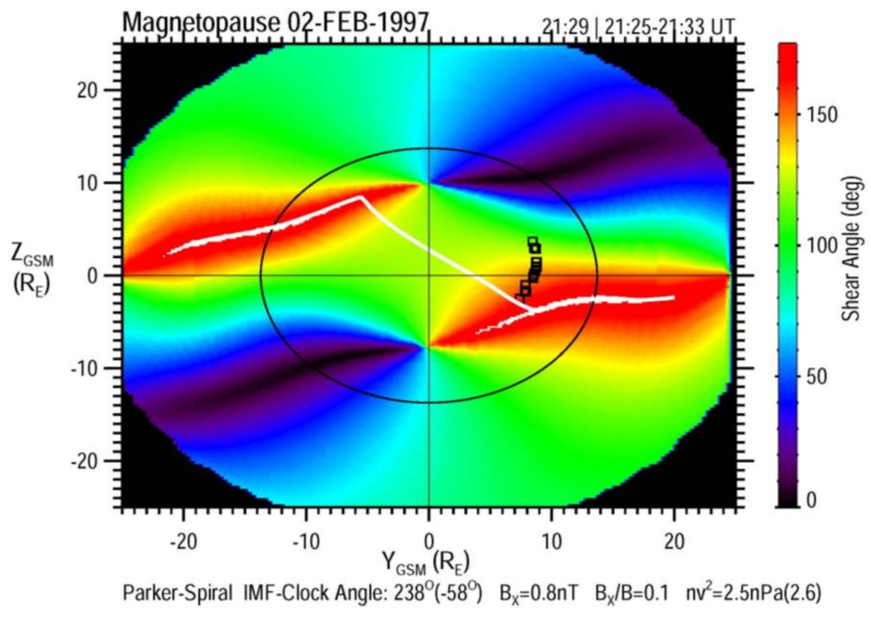
Last Summer

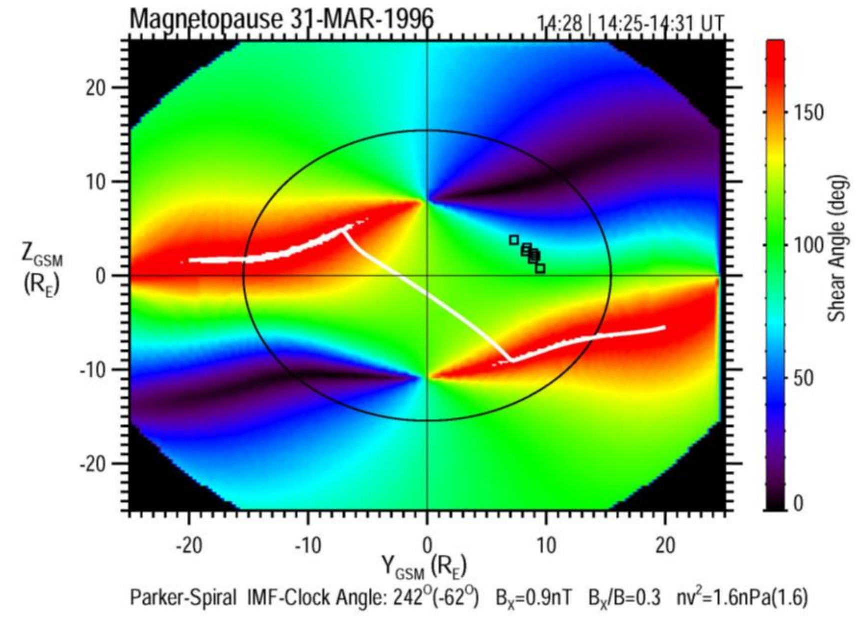
- Possess Clock angles between 220° and 270°
- Occur around spring equinox

Task I: Data and Trends

- 40 events analyzed
- Showed clock angles from 99° to 267°
- Almost all anomalies







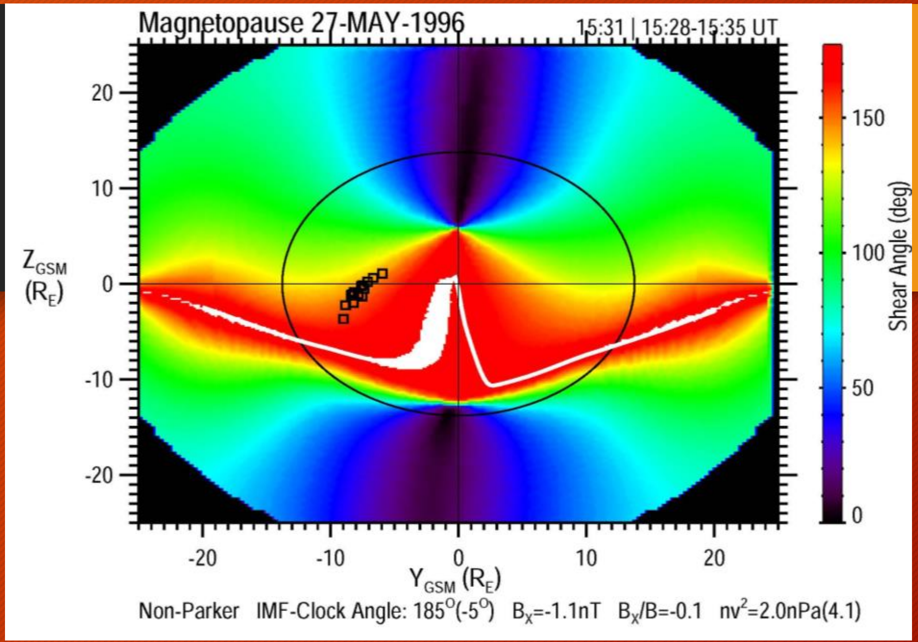
Task I: Trends

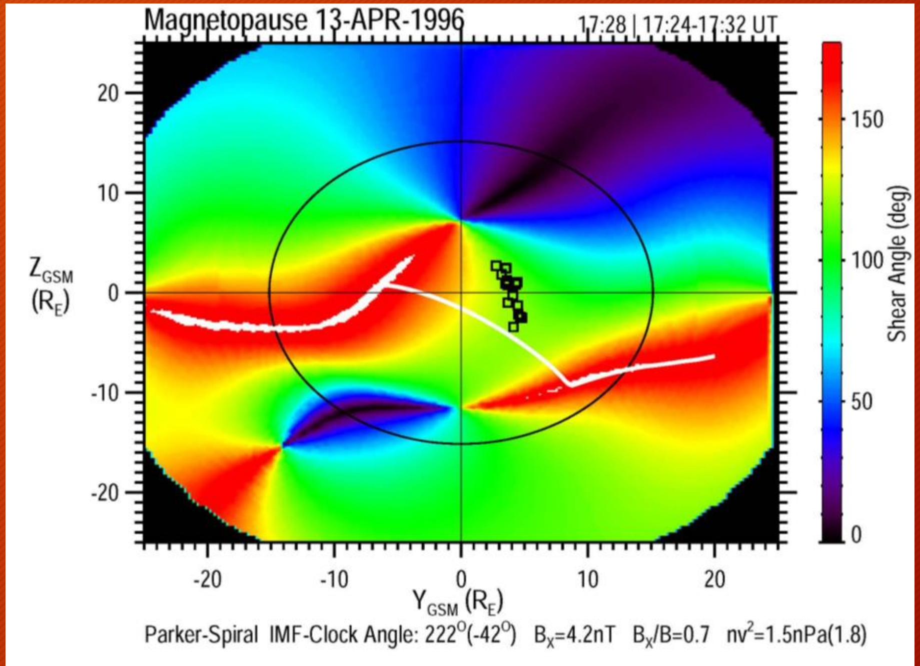
- Anomalies are very likely to occur when a smooth single dispersion is observed
- Occur all throughout year
- Spring Equinox - between 220° and 270° (Further investigation)

Month	Single	Large Bx	Flank	Total	220°-270°
January				0	-
February	2		3	5	2
March	9	1		10	8
April	5	2		7	3
May	1		1	2	0
June	3		1	4	3
July		1	2	3	0
August				0	-
September	2			2	0
October	2			2	0
November	1	1	2	4	0
December				0	-

Task I: Conclusions (2)

- Large Bx and Flank dispersions – higher uncertainty in model
- Large Bx equally likely to have anomalies, within 220°-270°
- Flank dispersions more likely to have anomalies, not within 220°- 270° range (Further investigation)

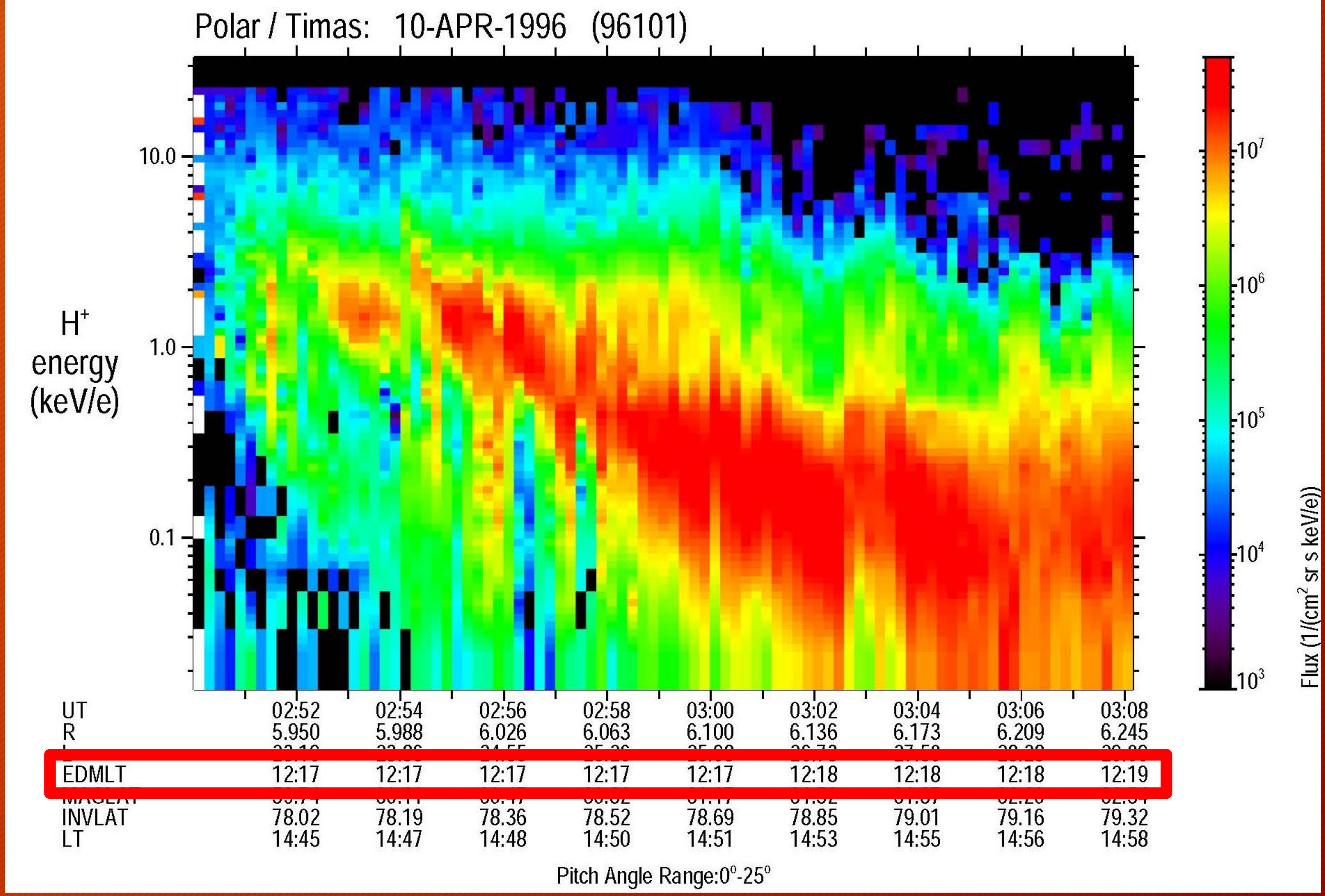




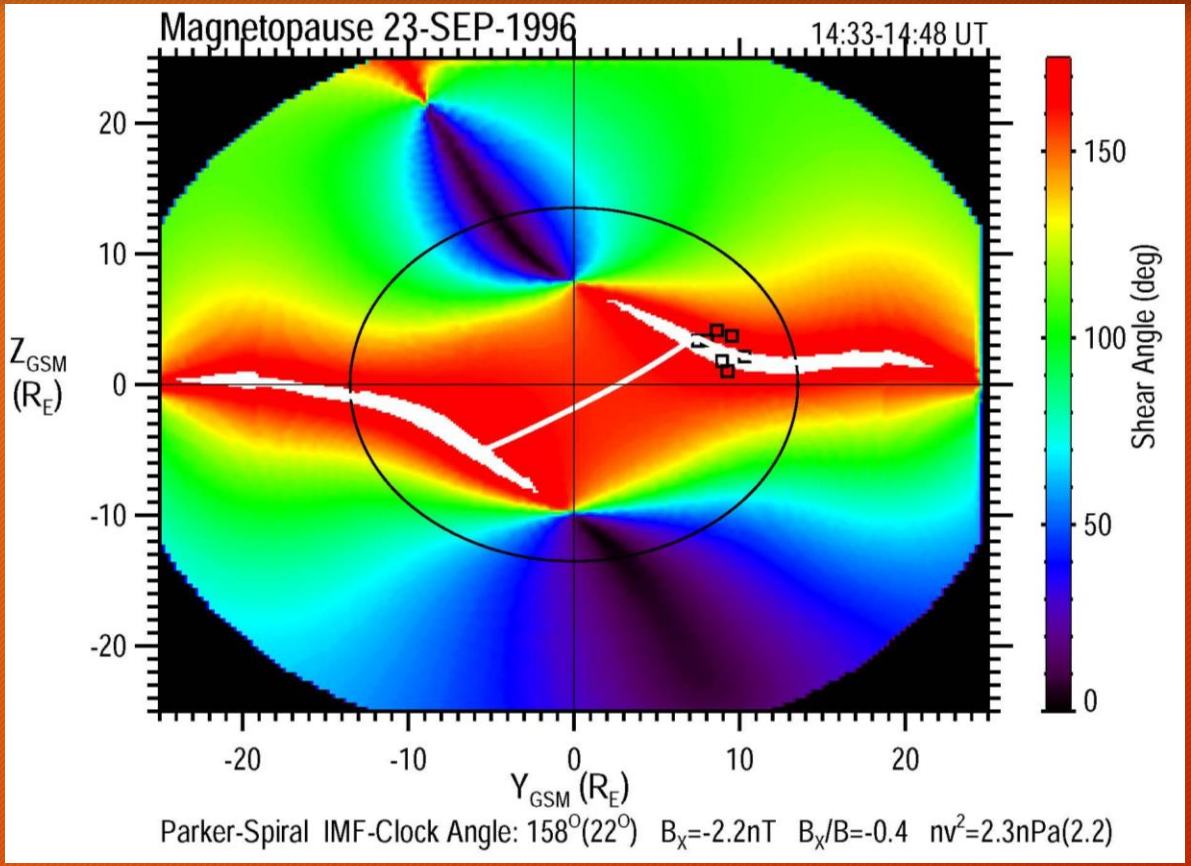
Task II: Local Noon

Objectives:

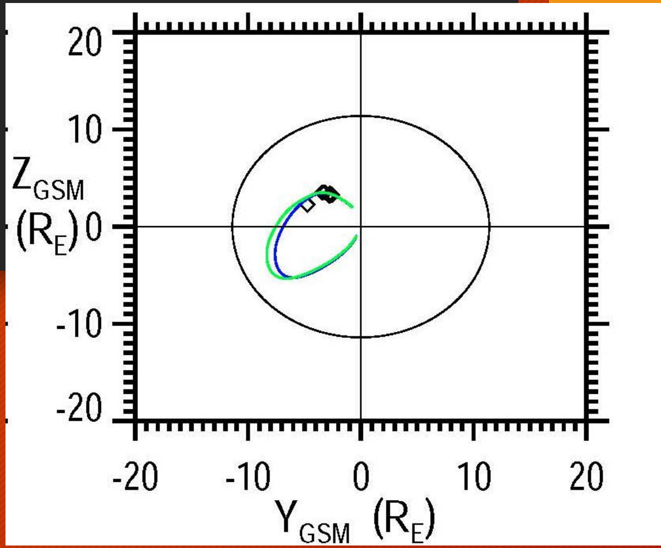
- Use same method to analyze events occurring near magnetic noon (10:00 – 14:00)
- Decrease uncertainty in model for these dispersions



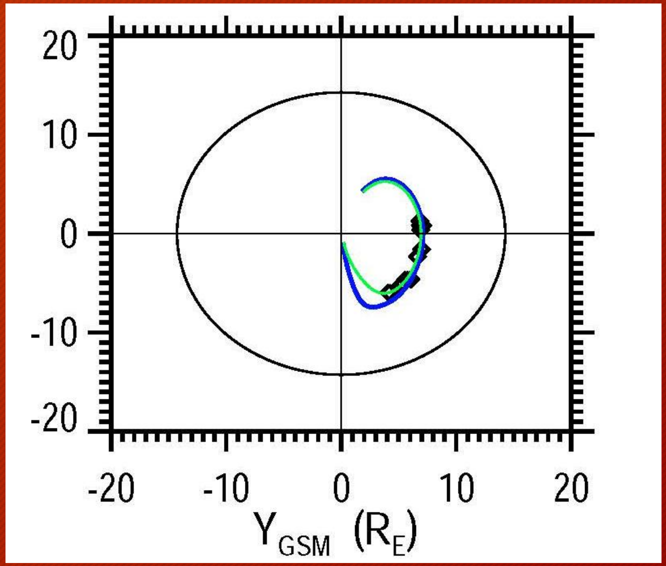
Why look at magnetic noon?



05 Apr 2004, 10:25



01 Apr 1996, 14:00



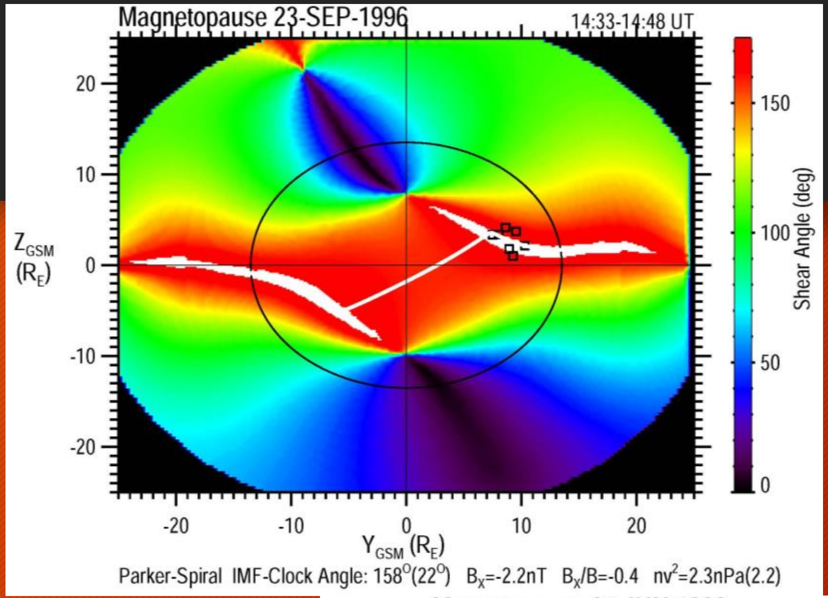
Task II: Conclusions

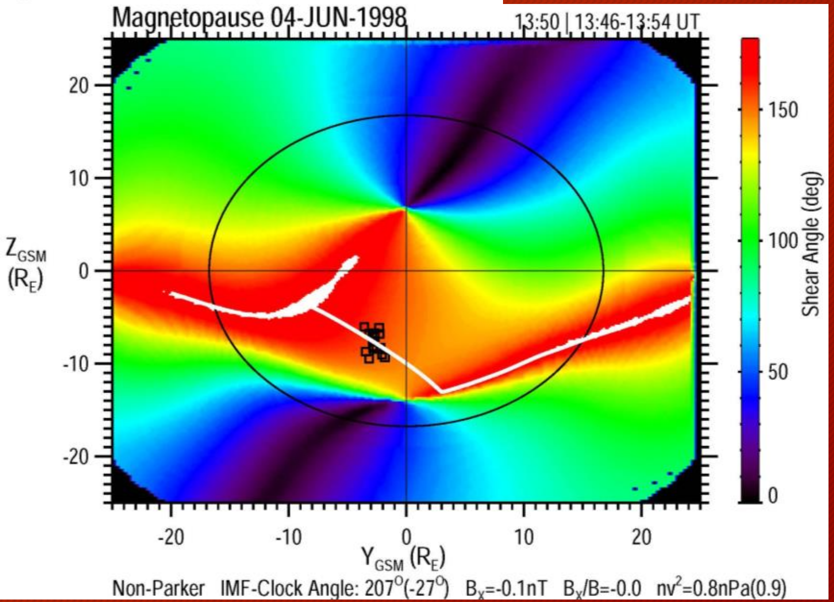
Month	90°-150°	151°-210°	211°-270°	Total
January	-	-	-	0
February	-	-	-	0
March	3	7	7	17
April	6	12	16	34
May	-	11	11	22
June	1	3	3	7
July	-	-	-	0
August	6	2	-	8
September	16	7	-	23
October	8	9	2	19
November	7	6	2	15
December	-	-	-	0
Total	**47**	**57**	**41**	145

- Local noon events more likely at high clock angles (211°-270°) early in year (March-June)
- More likely at low clock angles (90°-150°) later in year (August-November)
- Clock angle correlation may be due to tilt of Earth relative to incident solar wind
- Very concentrated around March-May and September-November (Further Investigation)

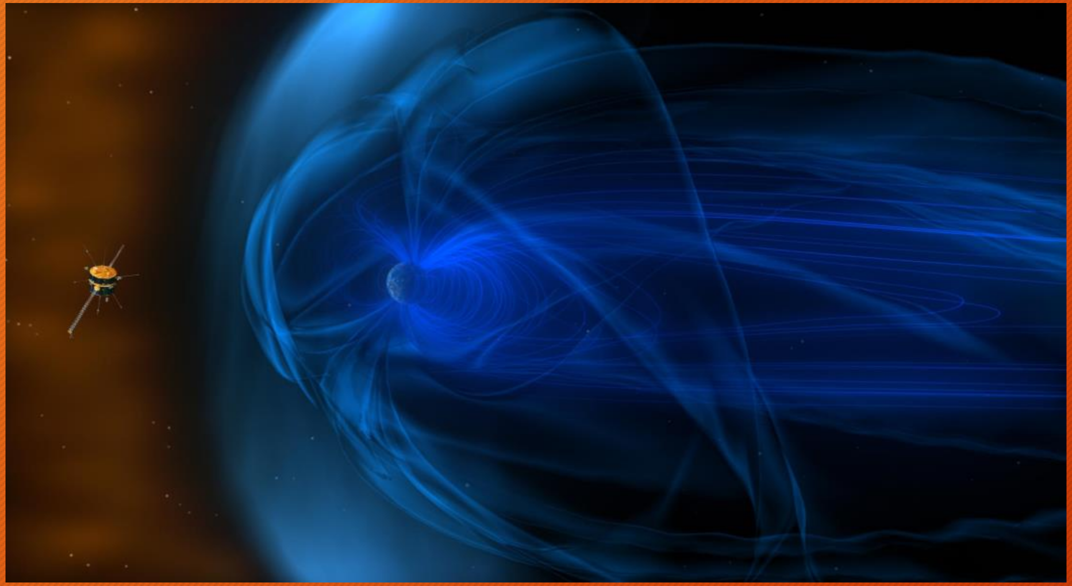
Task II: Conclusions (2)

- Produced many anomaly plots – most likely due to high degree of uncertainty
- Clock angles 150°-210° more likely to follow outer lines of model
- Other angles more likely to follow local noon reconnection line





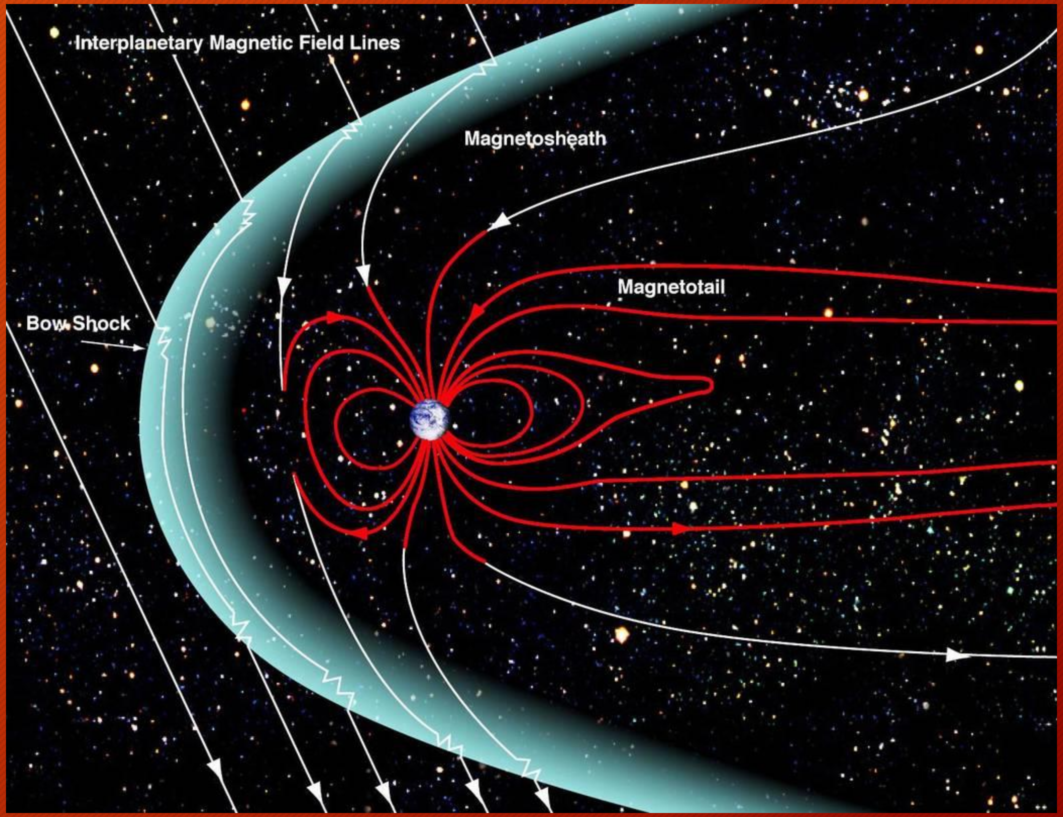
Further Investigation

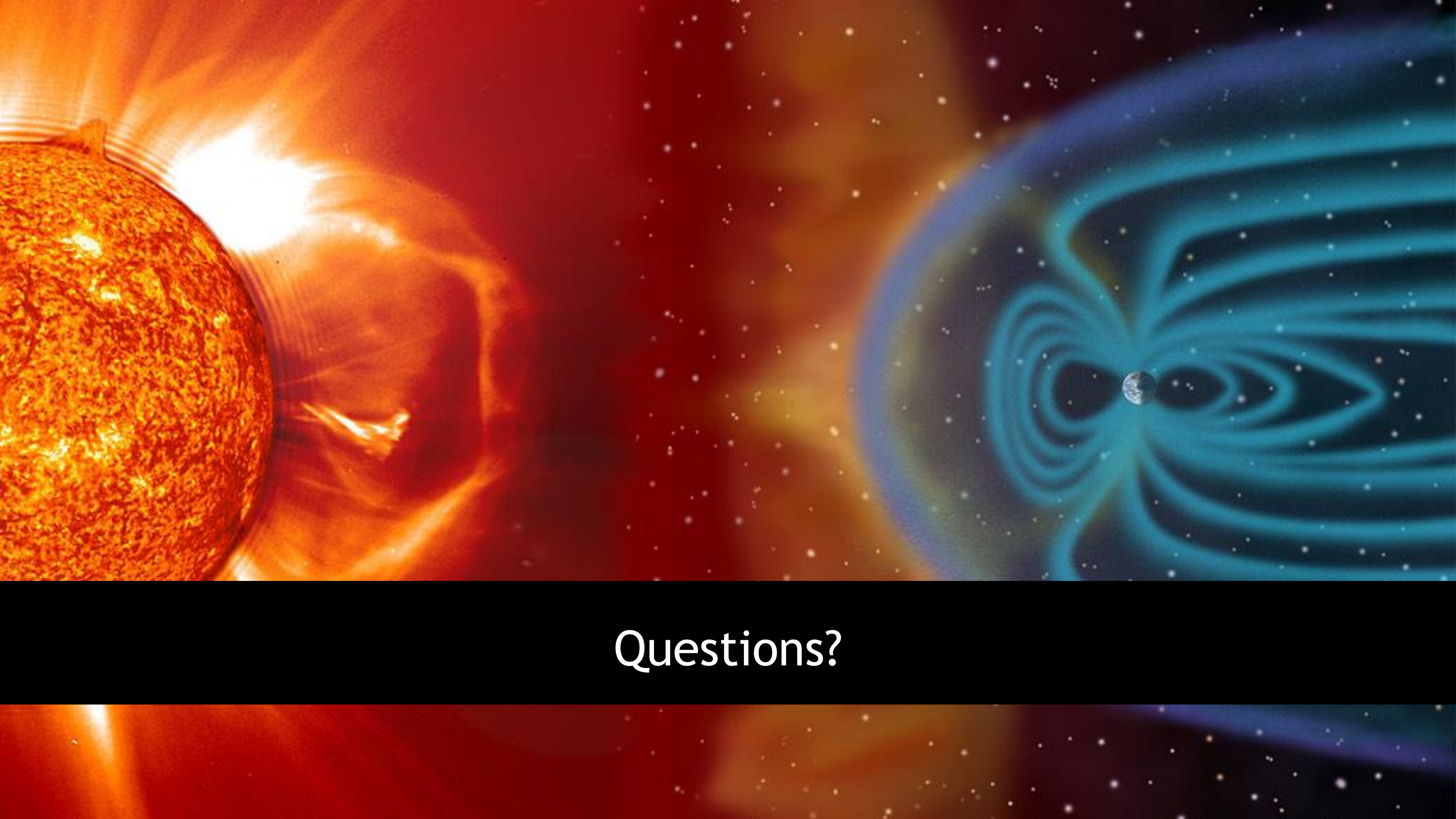


- Solar wind correlations
  - 220-270 degrees – anomalies
  - Spring – higher clock angle
  - Fall- lower clock angle
- Single Dispersion – most events March and April
- Local Noon – no events Dec-Feb, July

Final Thoughts

- Reconnection is a fundamental process
- Dominant mechanism for energy/mass/momentum transfer at magnetosheath/magnetosphere
- Purpose- study 2 cases with high uncertainty and incorporate into model
- Ultimate goal of observing reconnection *in situ*




Questions?

Acknowledgements and References

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All color spectrograms and plots were produced by an IDL program written by Dr. Trattner.

All other images courtesy of NASA.

Laboratory for Atmospheric and Space Physics
University of Colorado Boulder

1) Trattner, K.J., S. A. Fuselier, and S. M. Petrinec. “Location of the reconnection line for northward interplanetary magnetic field.” *J. Geophys. Res.* 109 (2004)

2) Kivelson, Margaret G. and Christopher T. Russell. *Introduction to Space Physics*. New York, Cambridge University Press. 1995.