

Use of Hybrid & MHD Models in Addressing TADMAC's Objectives

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Outline

- A Few Words on Transport at the Dayside Magnetopause and Cusp (TADMAC) Res. Area & Objectives
- Bow Shock Processes
- Magnetic Reconnection in the Magnetosheath
- Reconnection at the Dayside Magnetopause and Consequences



TADMAC Objective

- **Understand Transport Processes at Dayside Magnetopause and Cusp**

Major Topics of Study

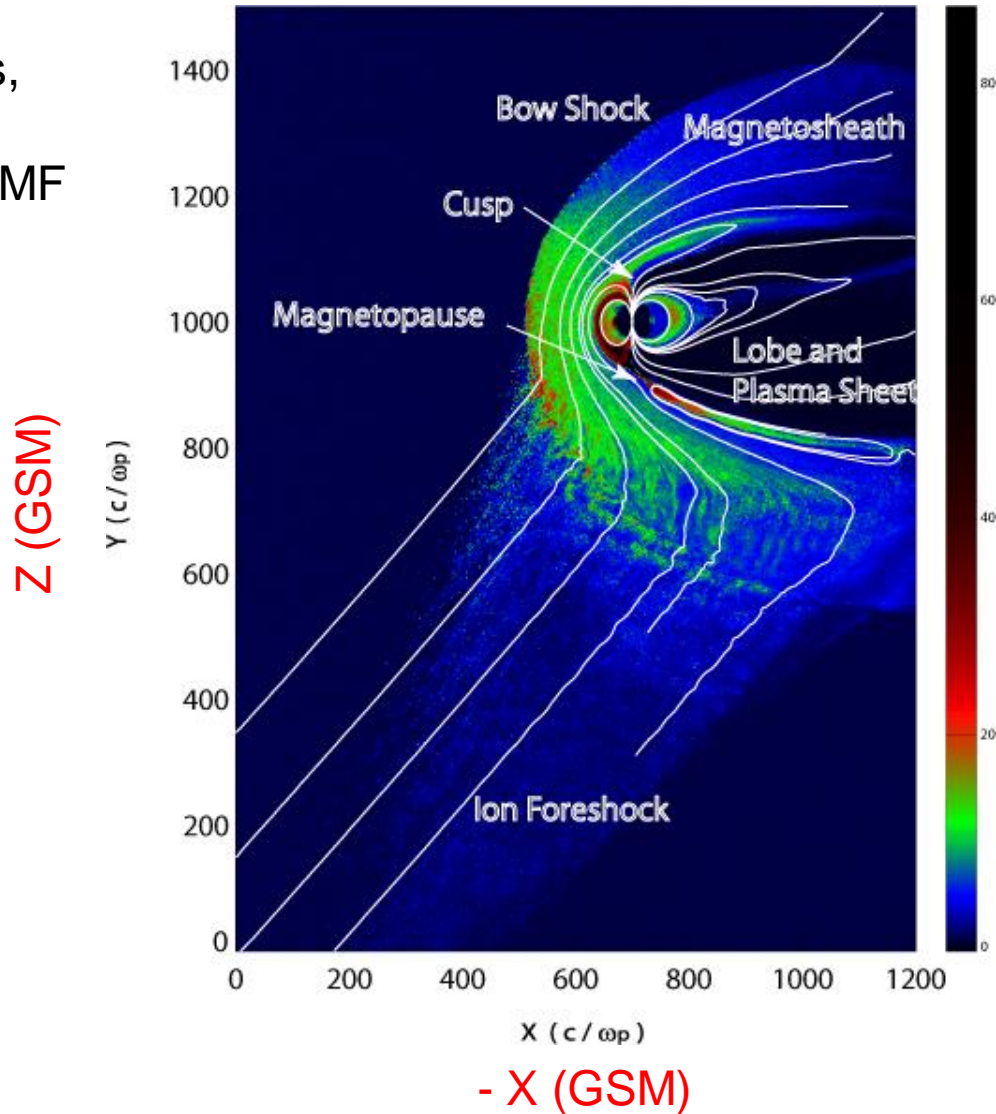
- Bow shock and magnetosheath & their impacts on transport processes
- Reconnection (and diffusive processes) at the magnetopause
- Transport and energization processes in the cusp & ionospheric signatures



Bow Shock Processes

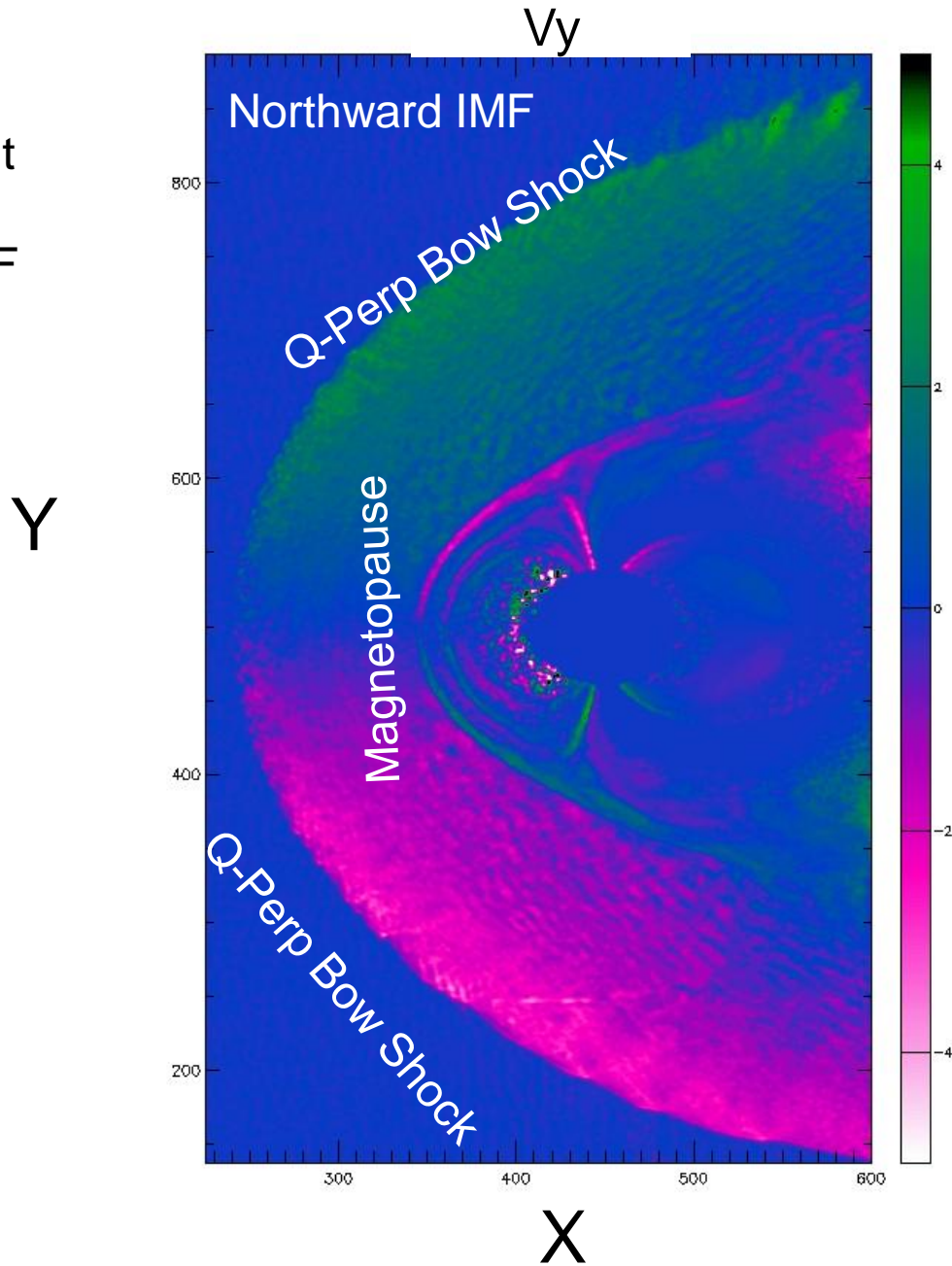
Ion Temperature & Field Lines
Noon-Midnight Meridian

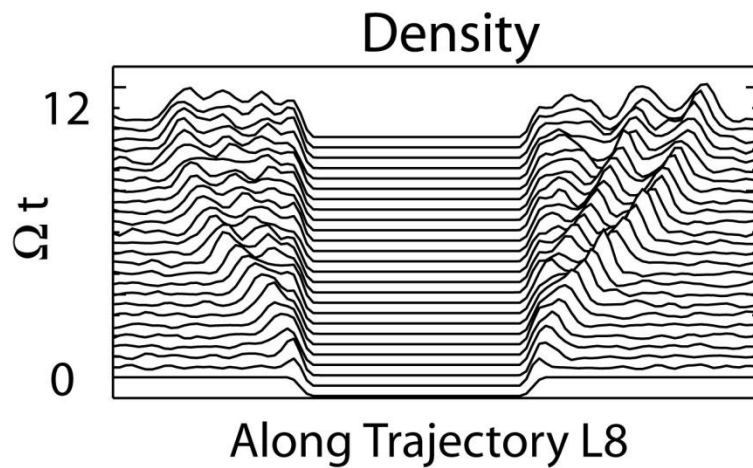
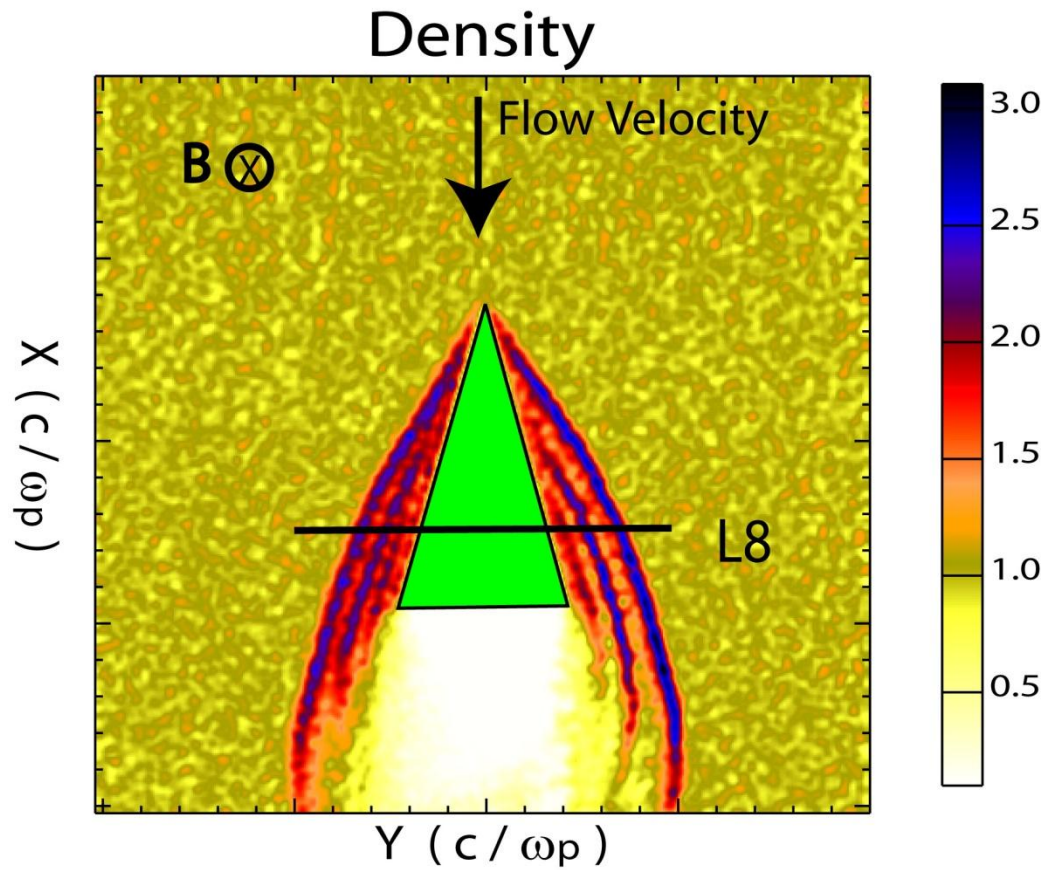
Hybrid (PIC ions,
fluid electrons)
simulation, 45° IMF

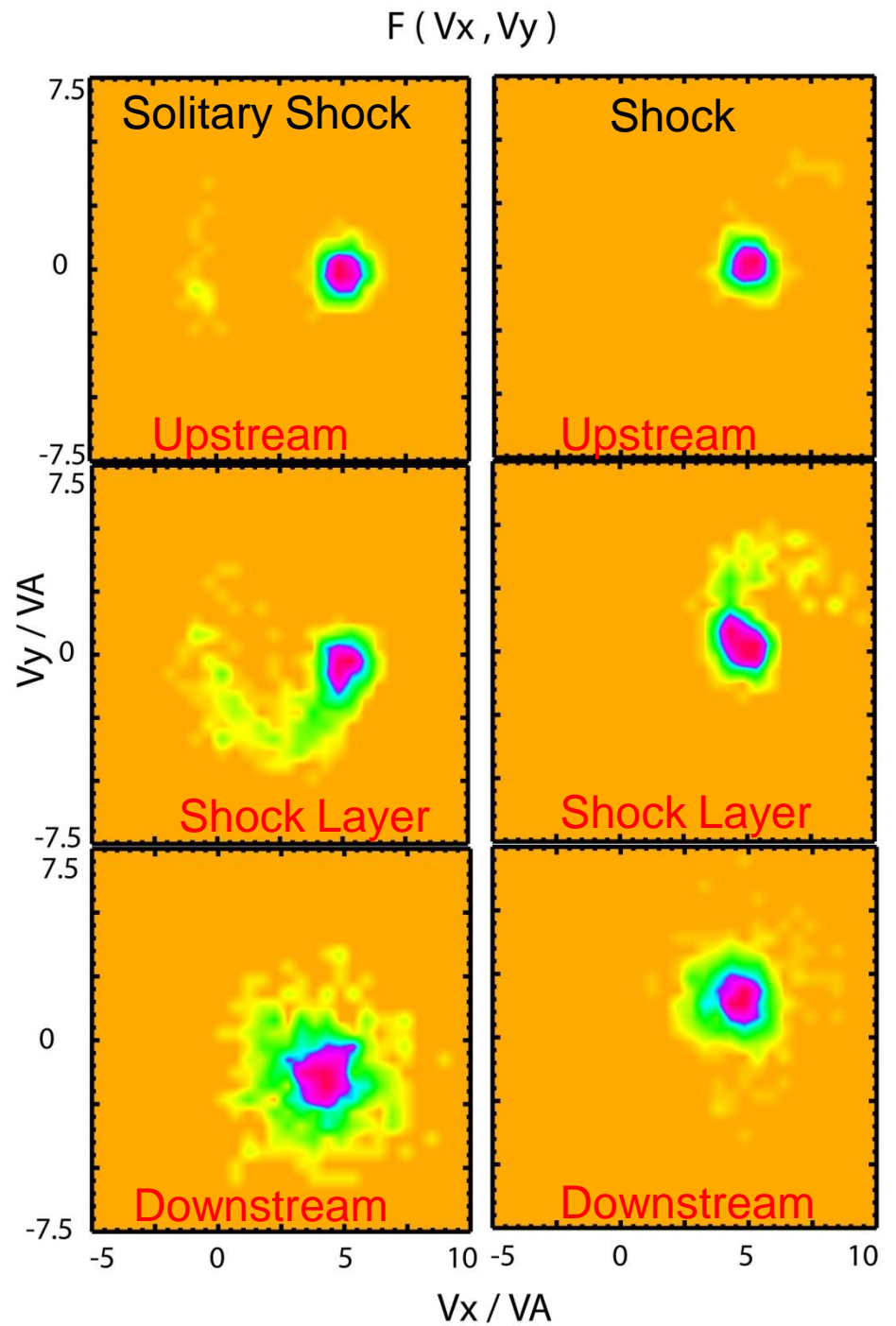
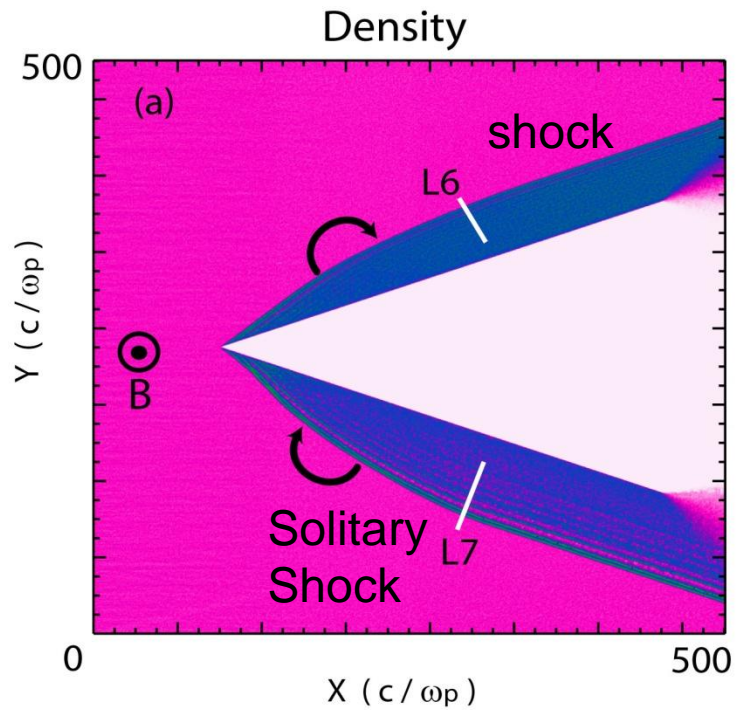


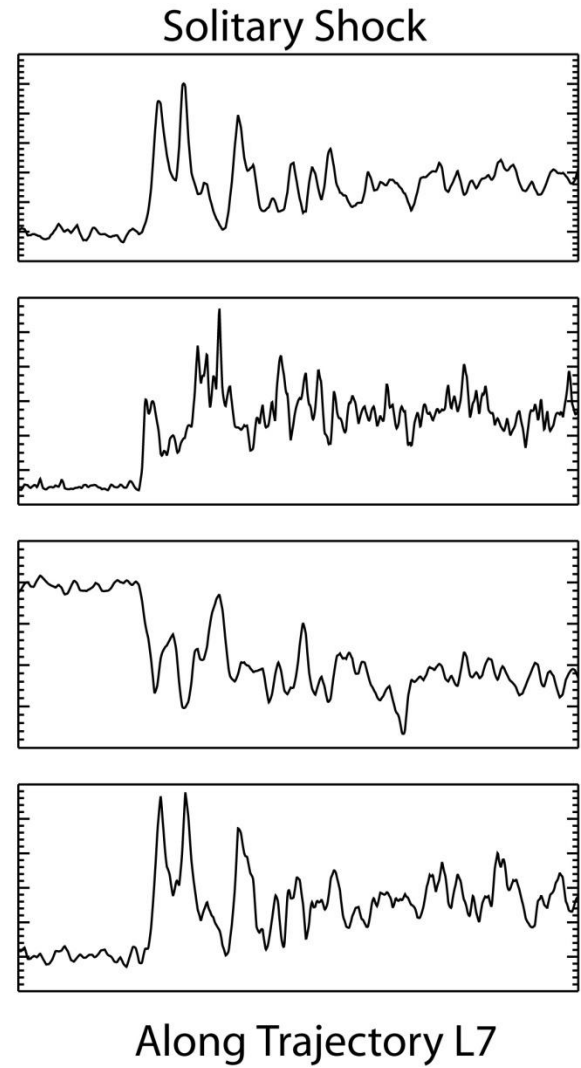
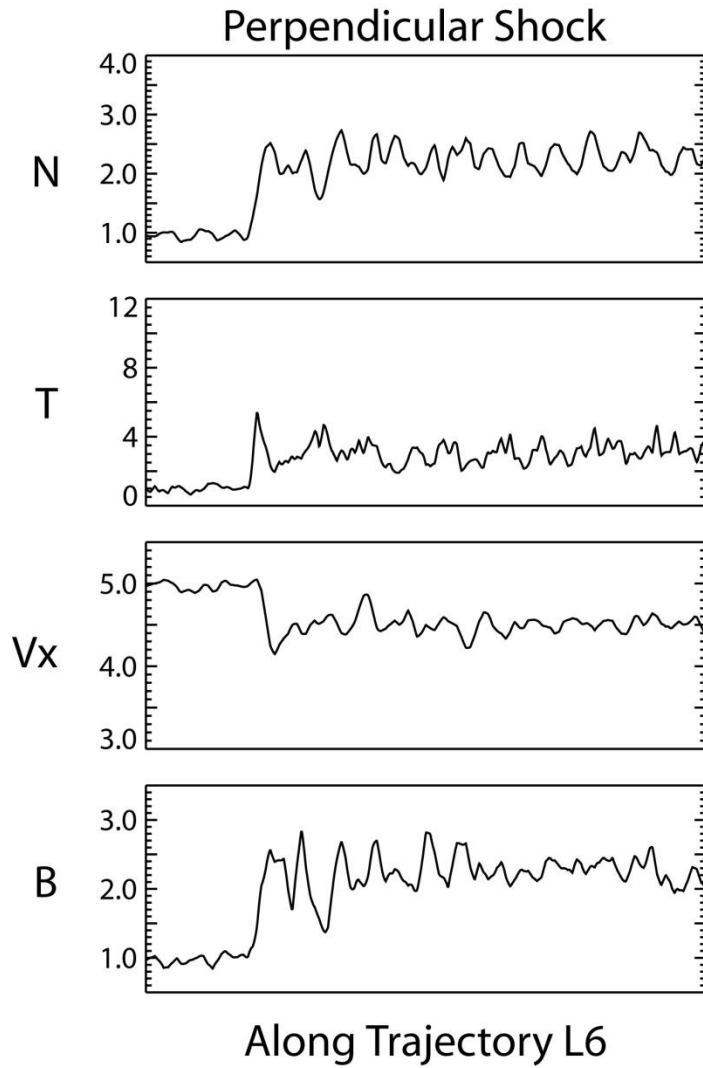
Waves Impinging on the Magnetopause

Noon-Midnight
Meridian
Northward IMF

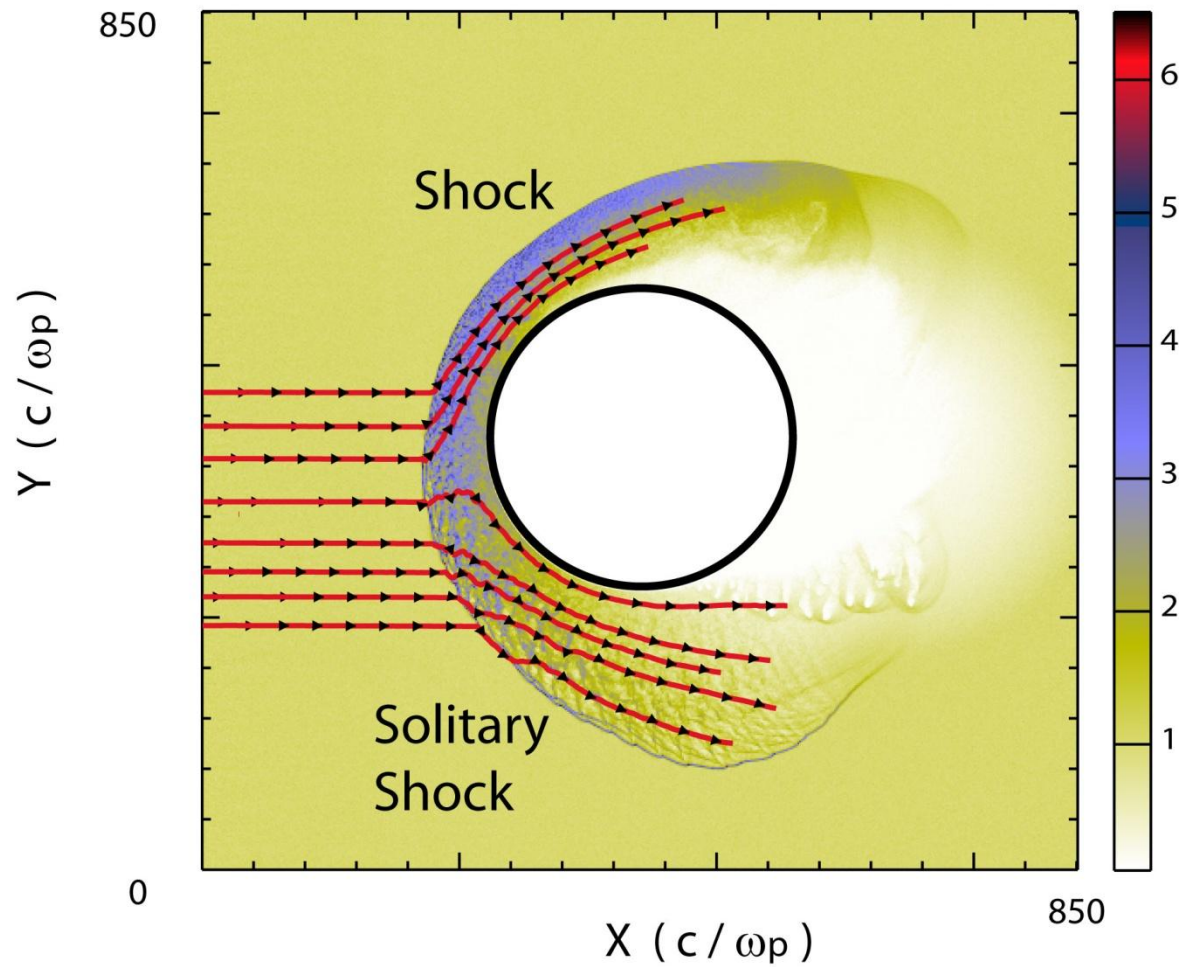




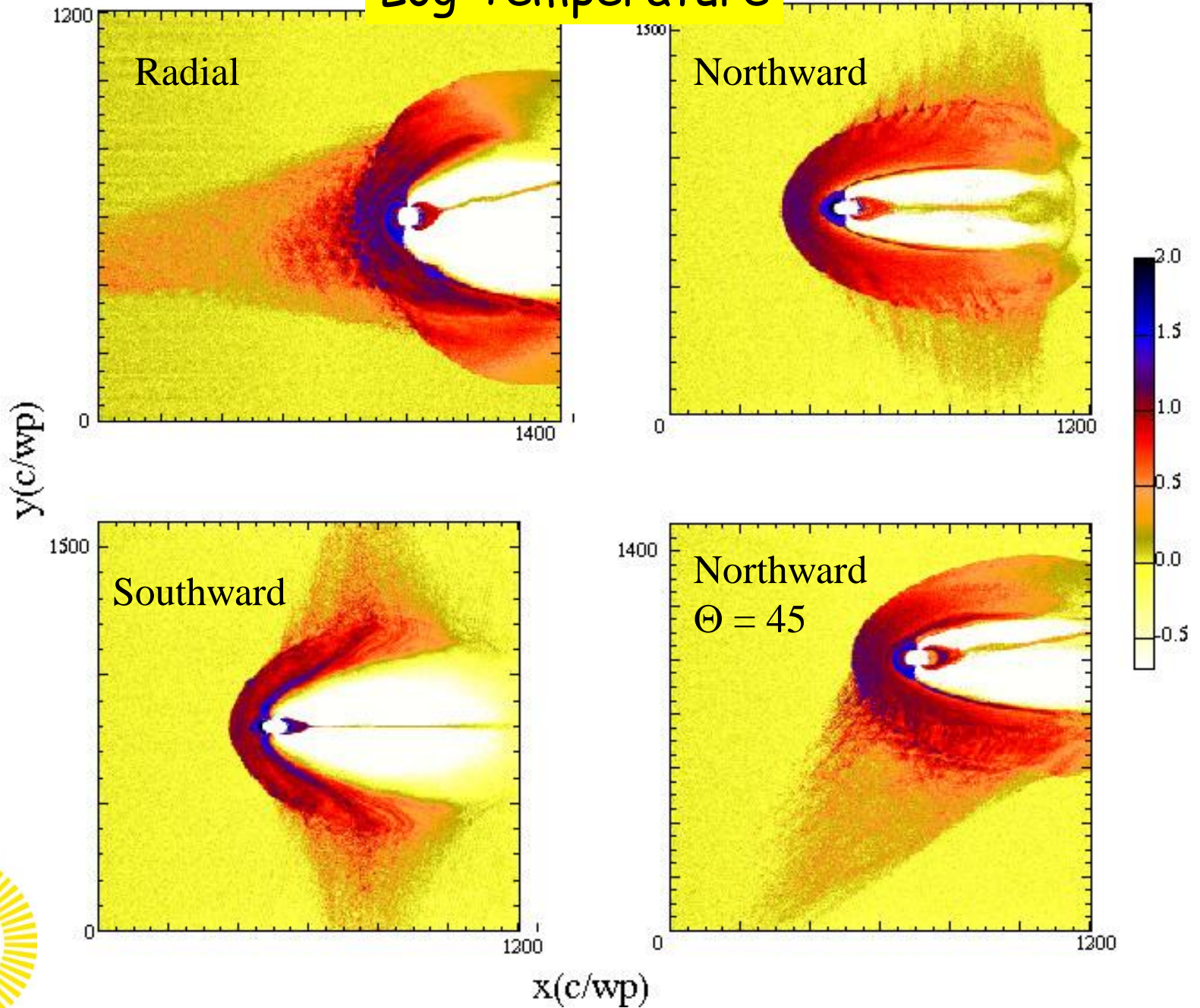




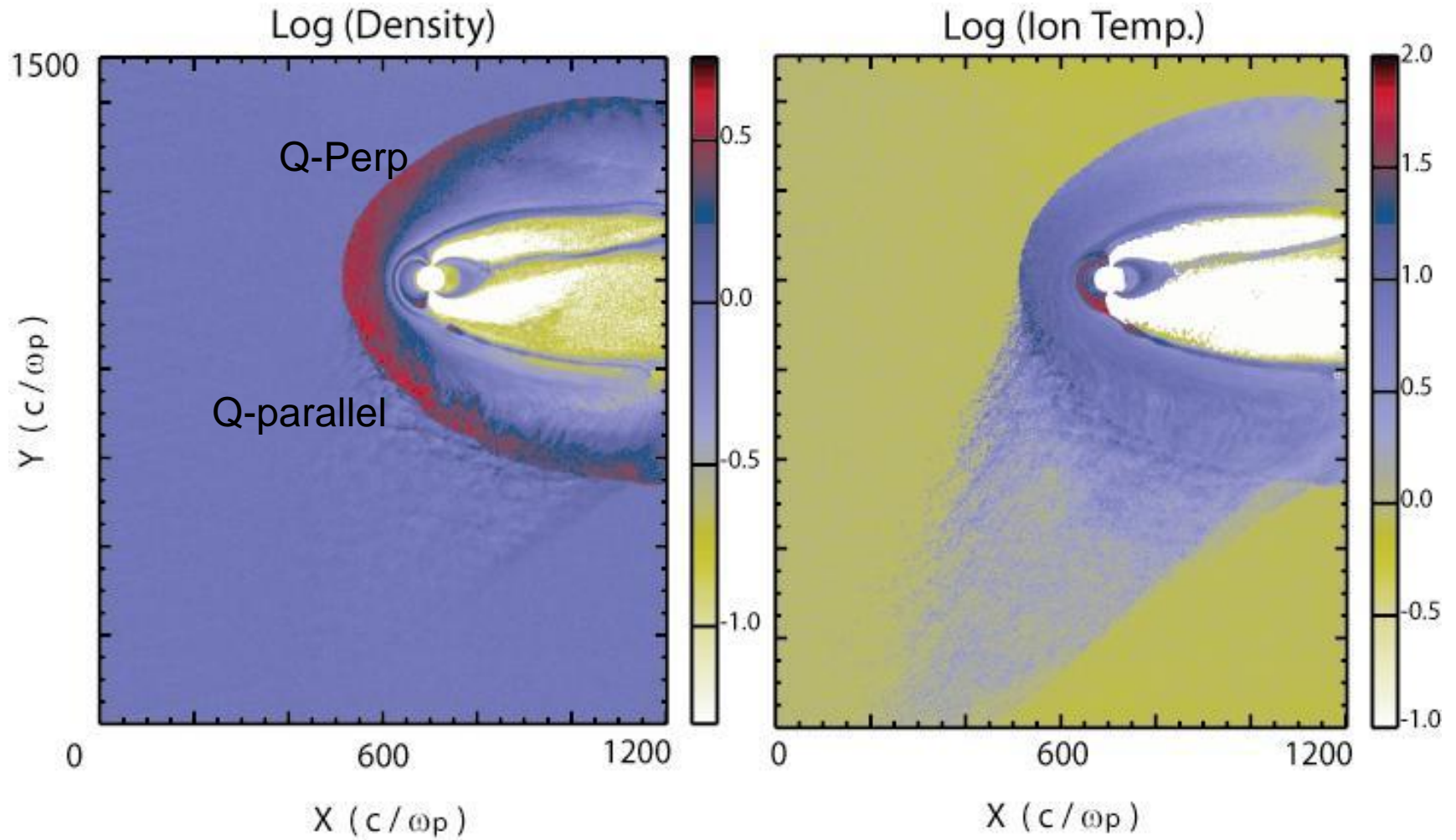
Density

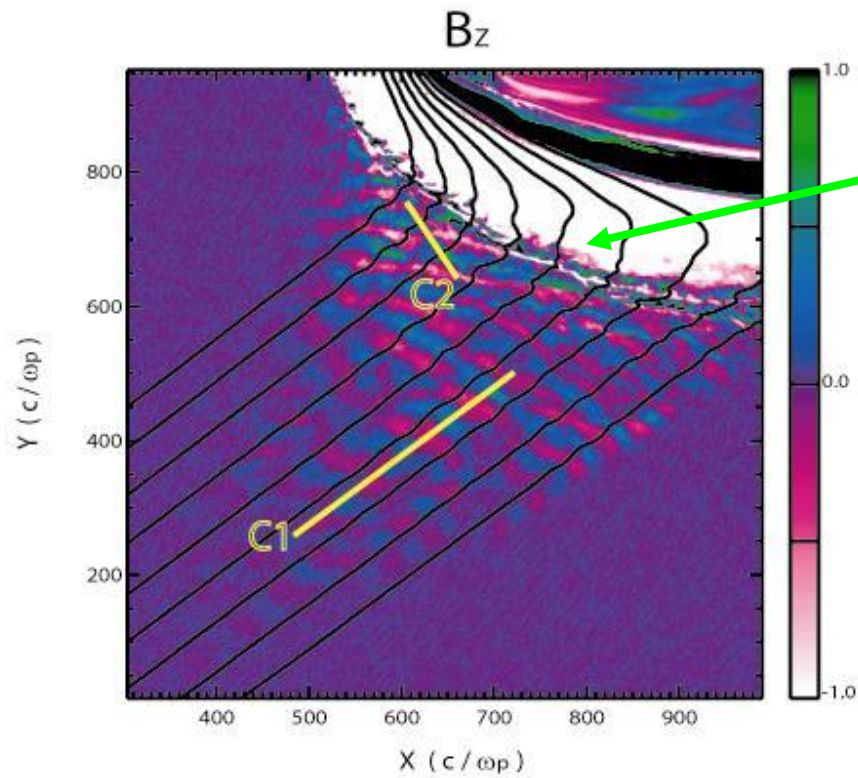


Log Temperature



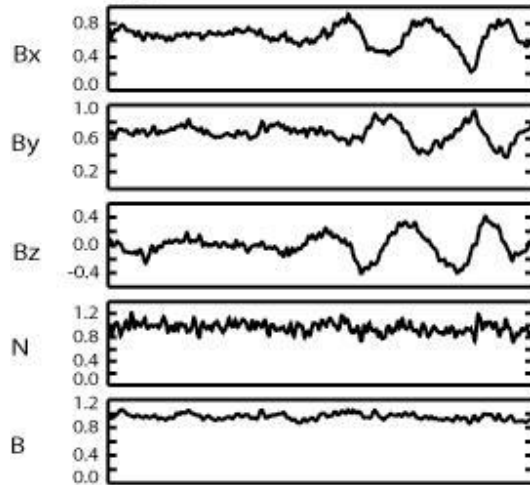
IMF at 45°



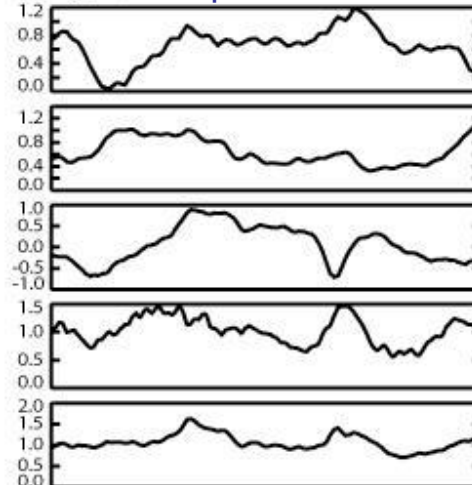


Q-Parallel Shock

C1 Sinusoidal waves

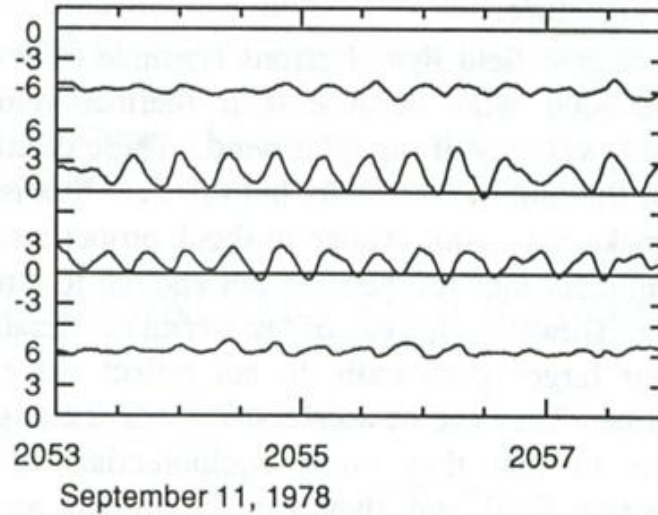


C2 Compressional waves (needed for q-par shock)



30 sec. ULF waves in the foreshock

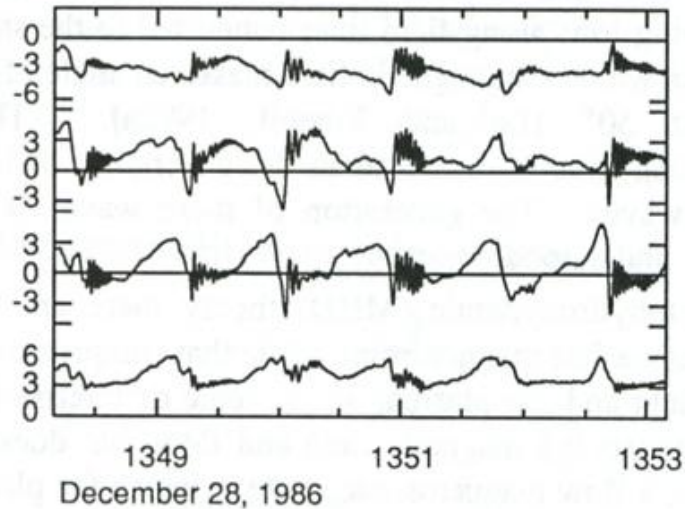
Sinusoidal Waves



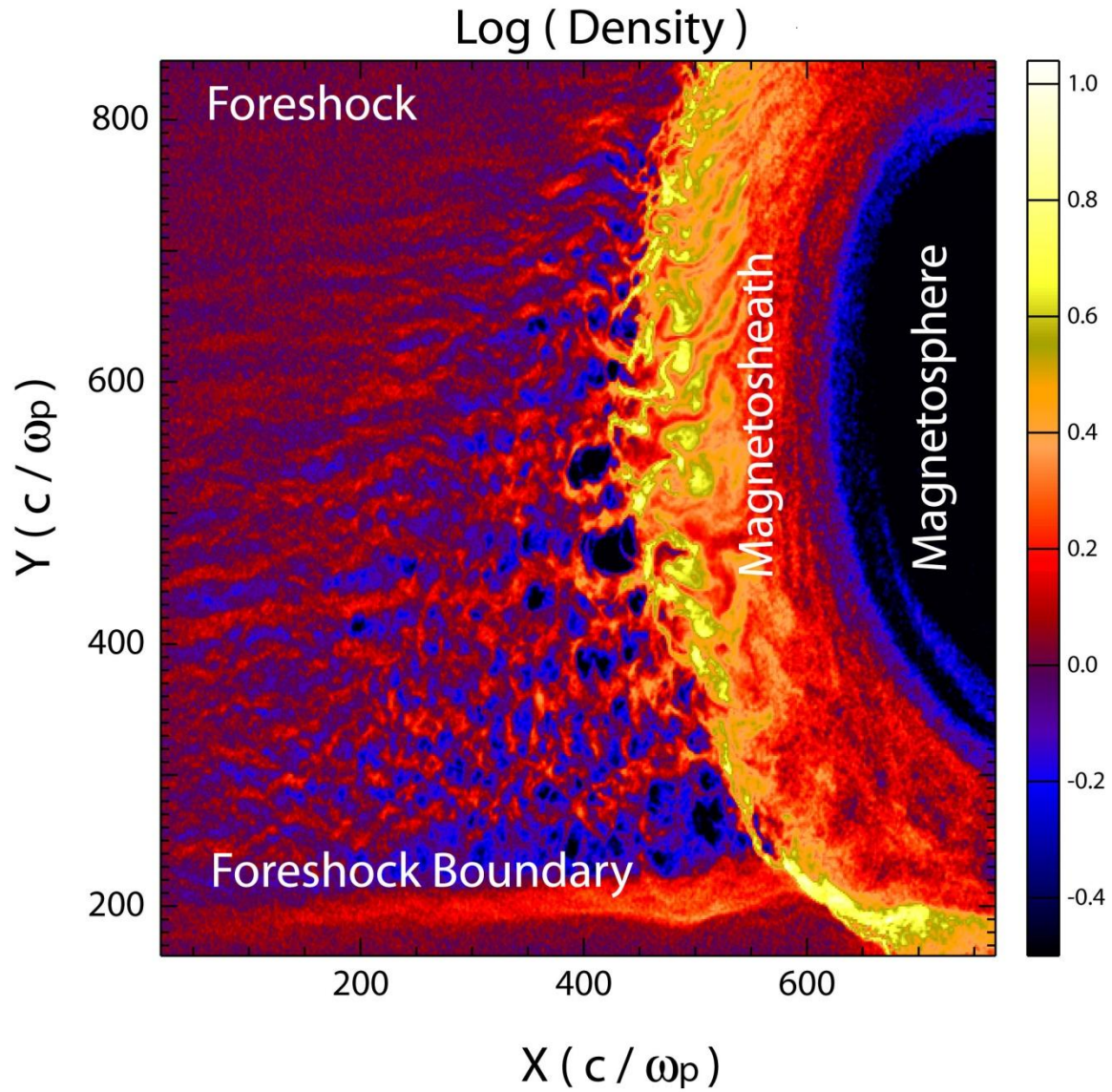
From Russell, 1994

Left handed sinusoidal waves reported by Eastwood et al. [2003]

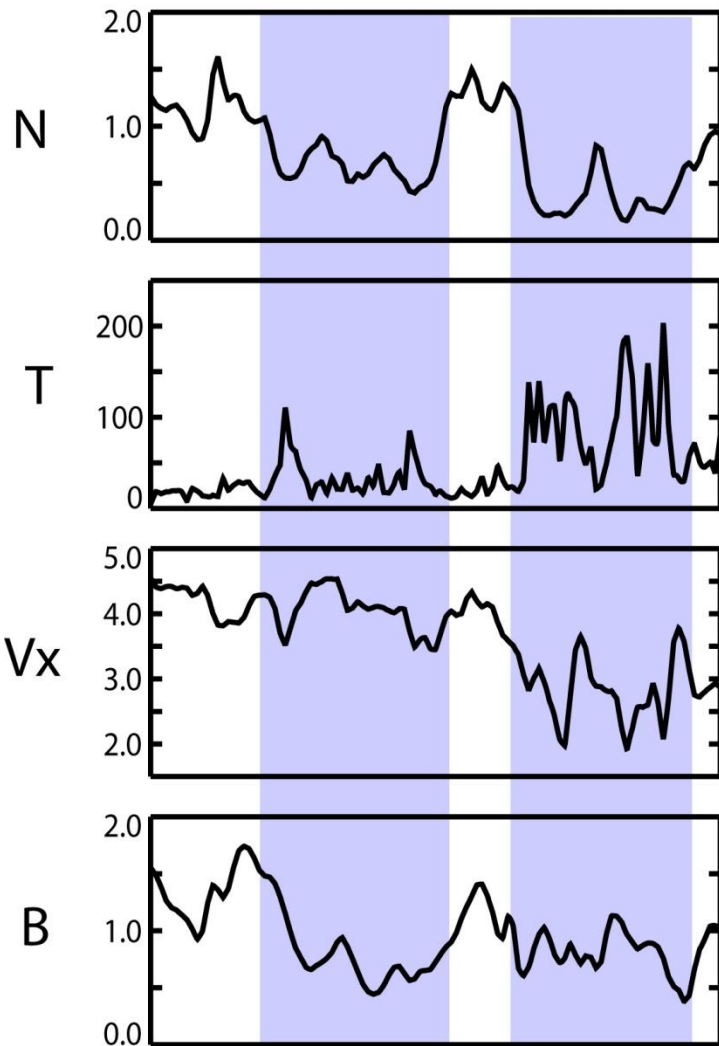
Shocklets and Discrete Wave Packets



Radial IMF

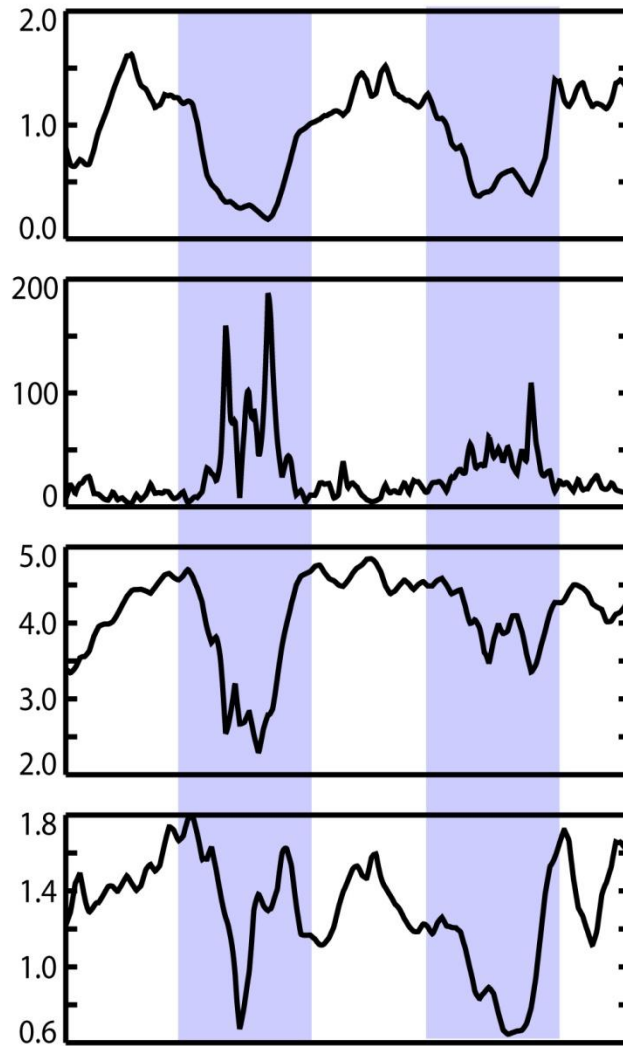


Radial Cut



110 c/ω_p along X

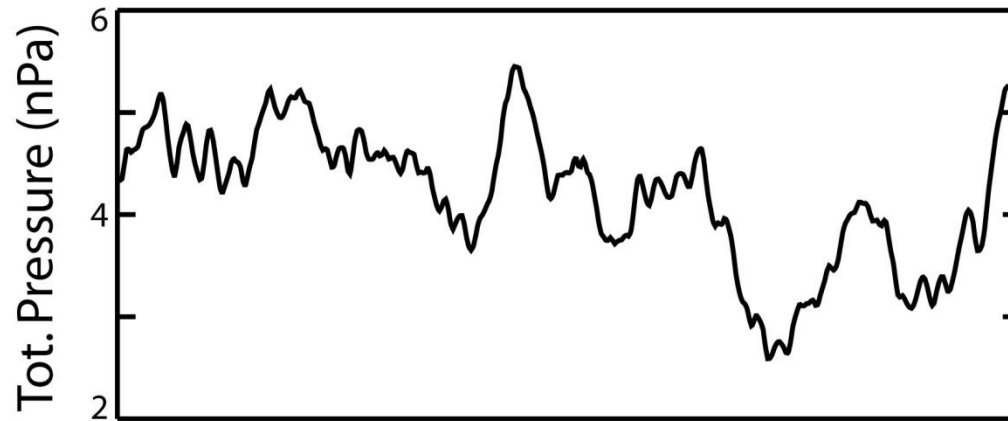
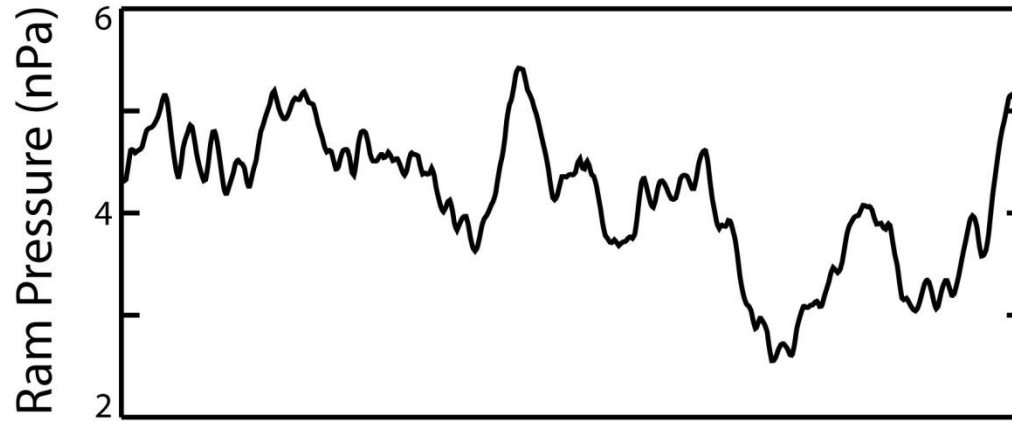
Vertical Cut



120 c/ω_p along Y



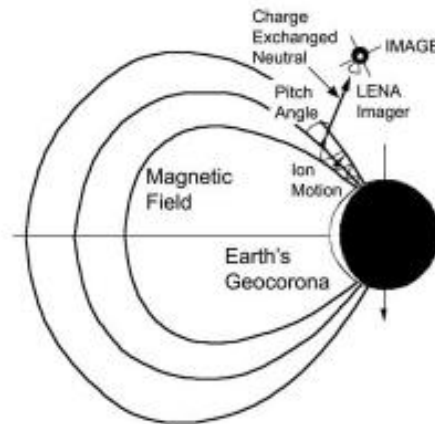
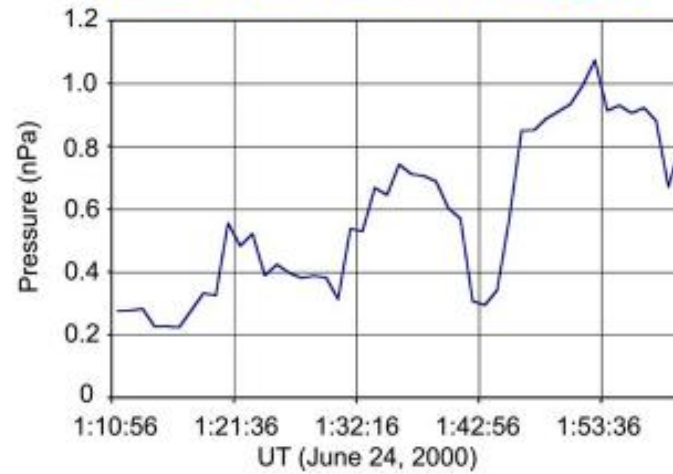
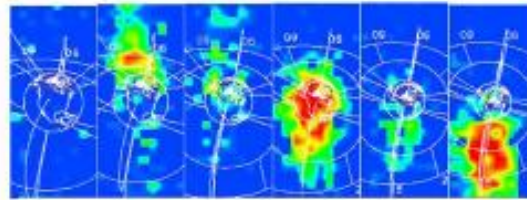
Pressure Variations in Foreshock



Along a radial cut



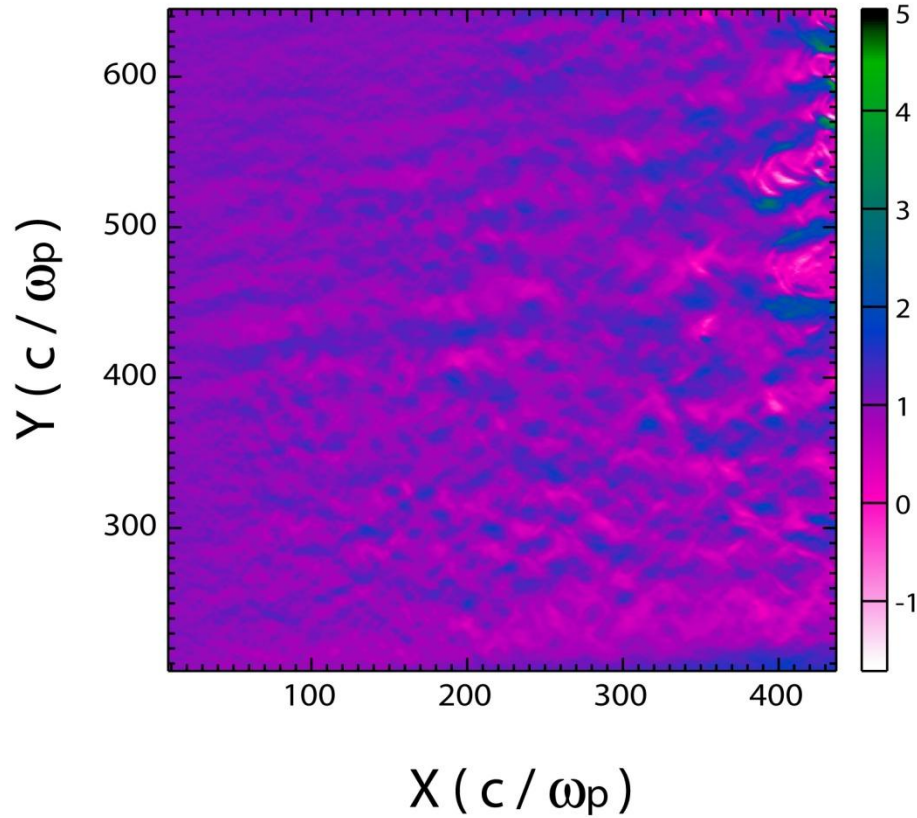
From:
Fuselier et al. 2003
Burch 2003



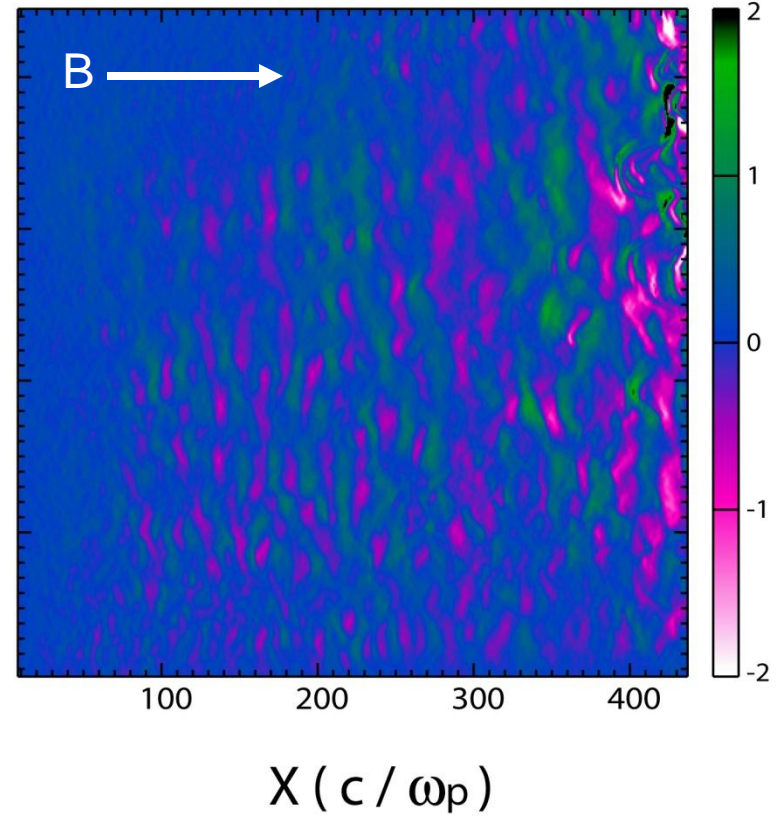
Radial IMF Foreshock

Fast Linearly Polarized Oblique

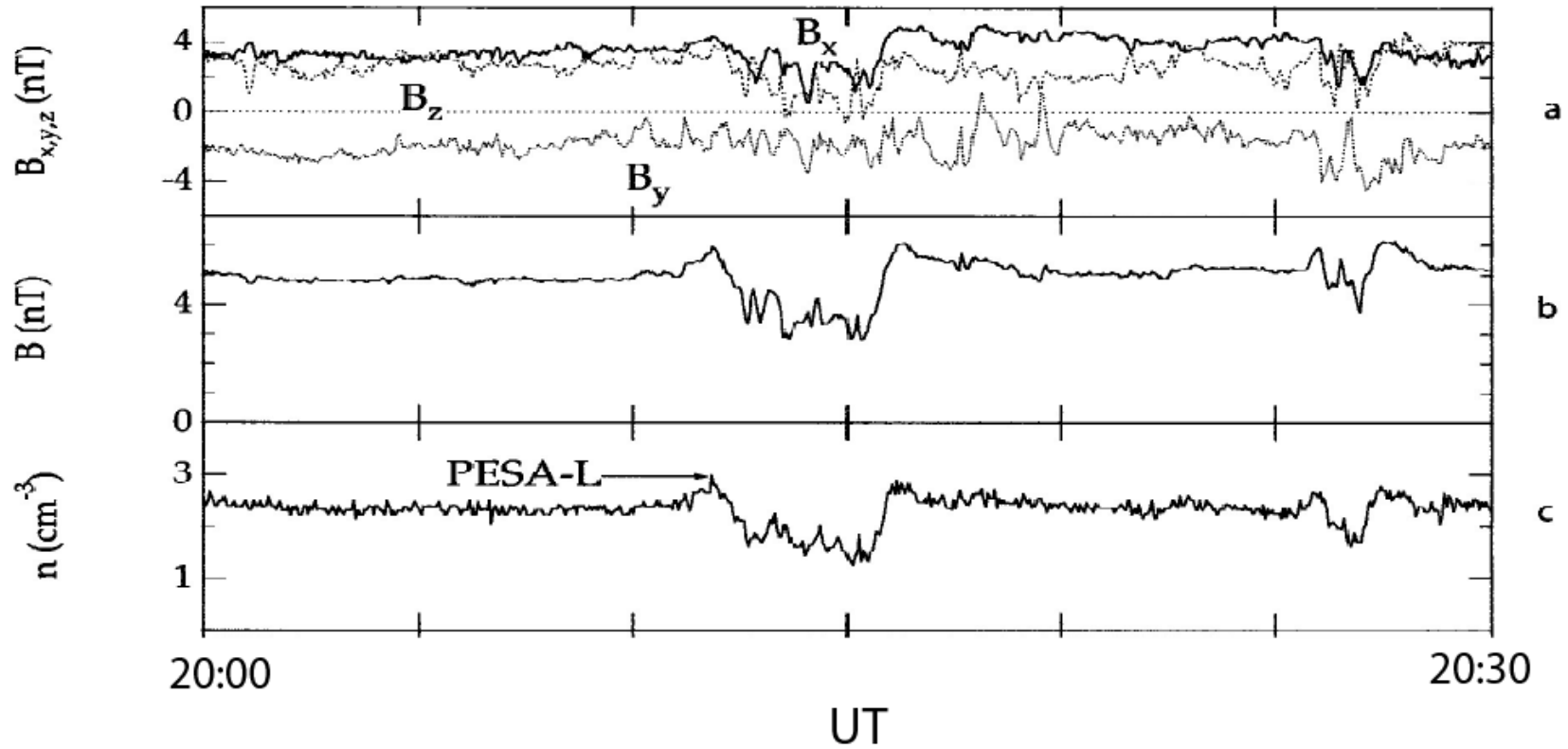
B_x



Right or Left hand Polarized
Sinusoidal
 B_y



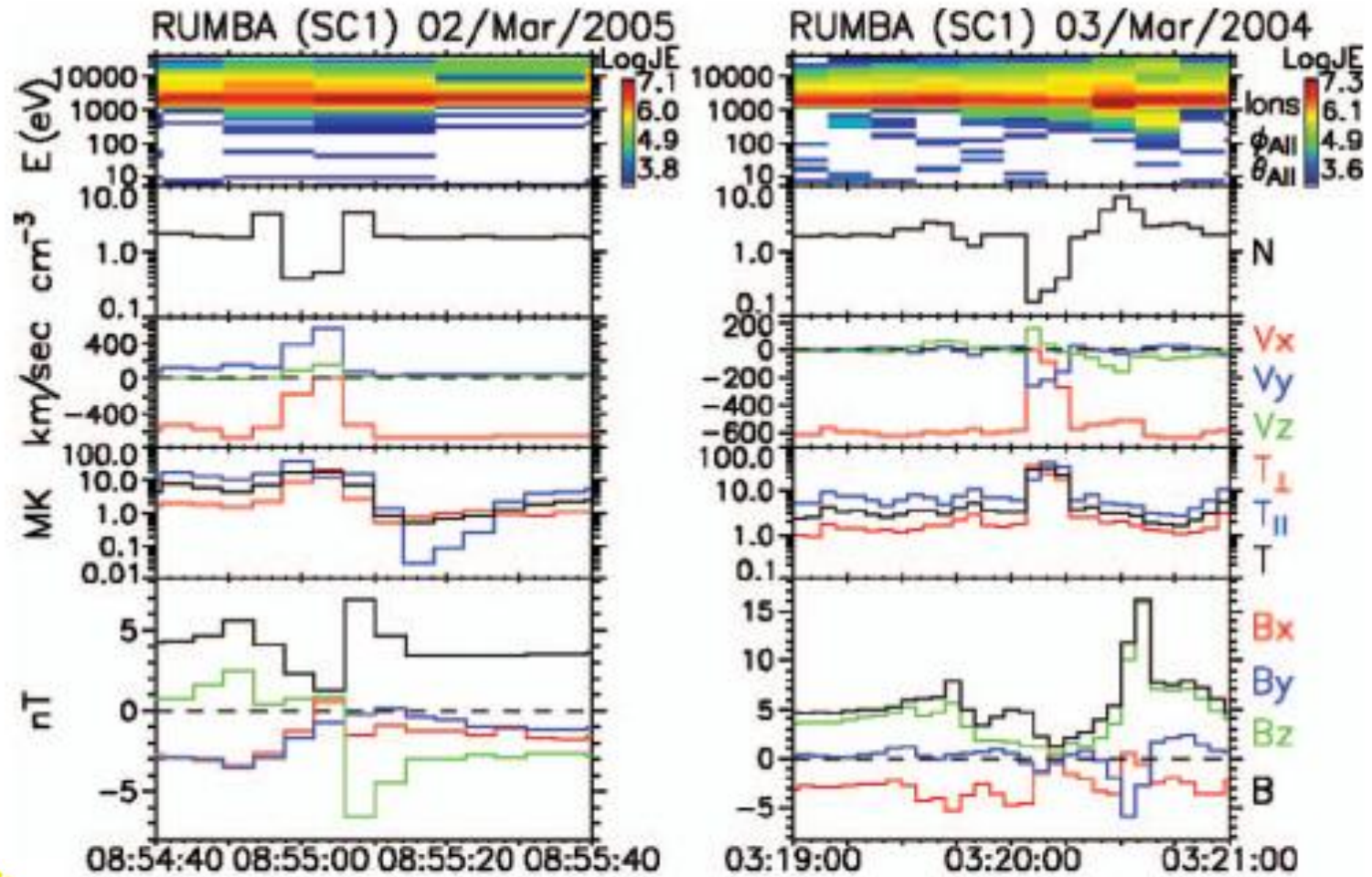
Foreshock Cavities



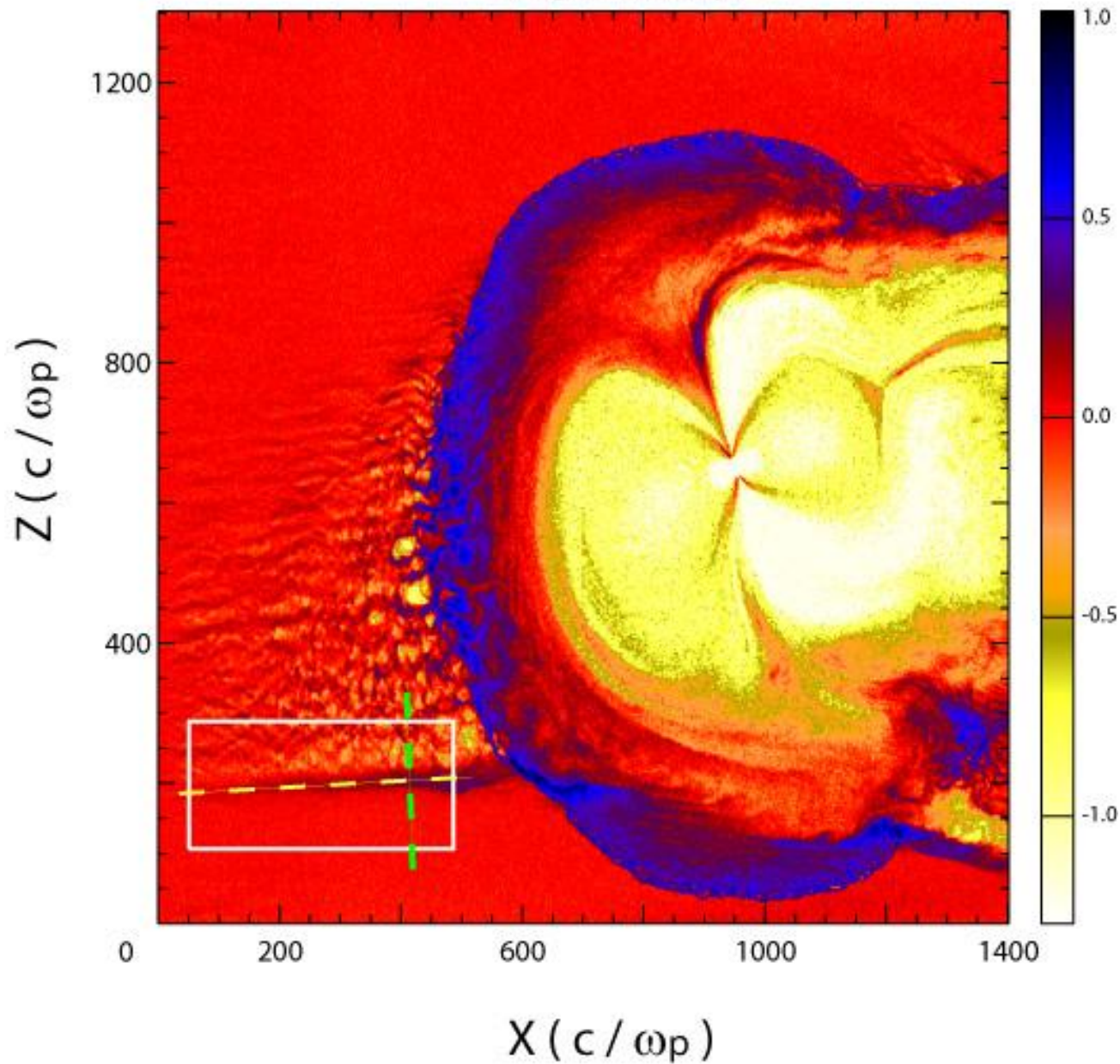
Sibeck et al., 2002

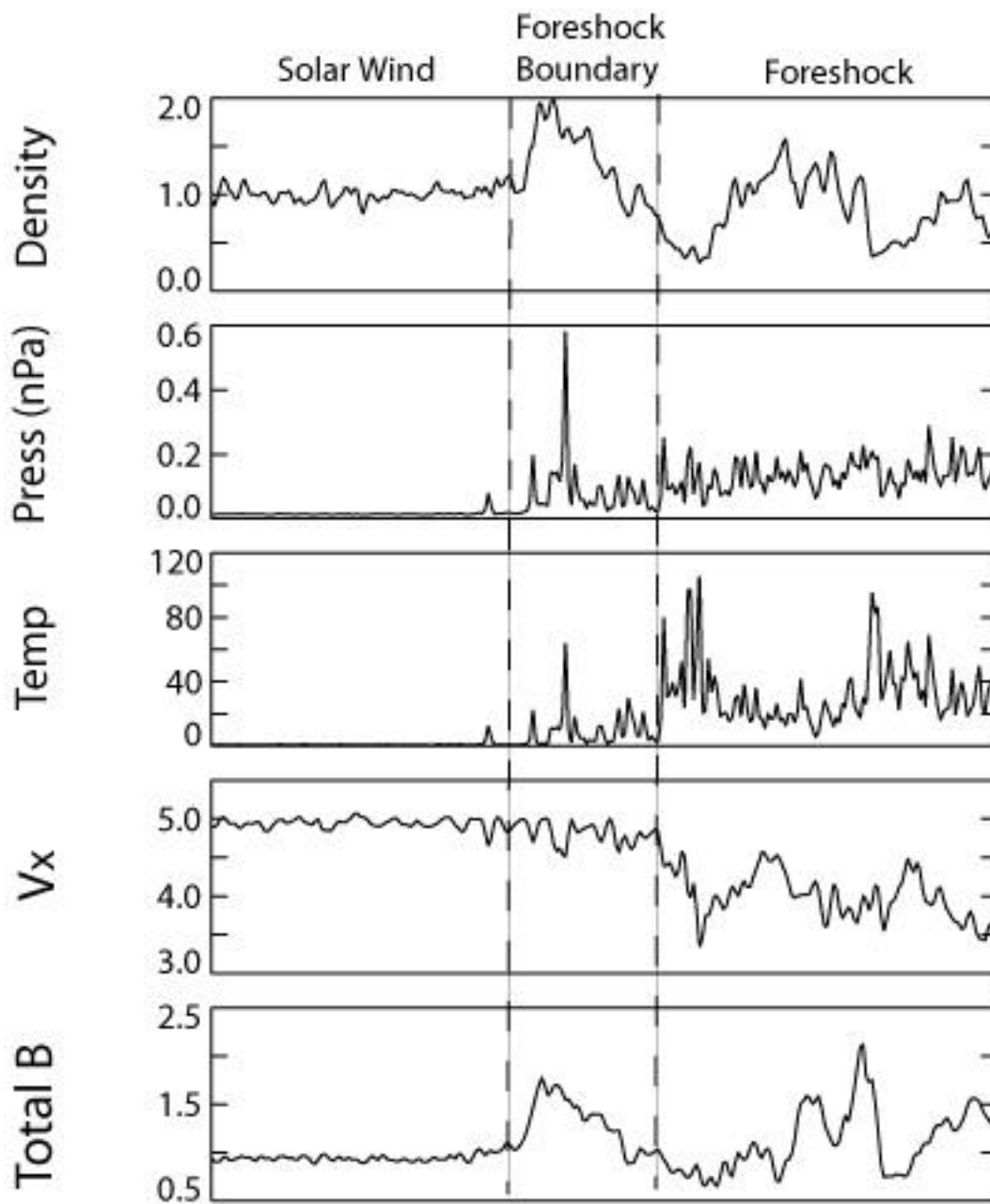


Density Holes in Foreshock (Parks et al. 2006)

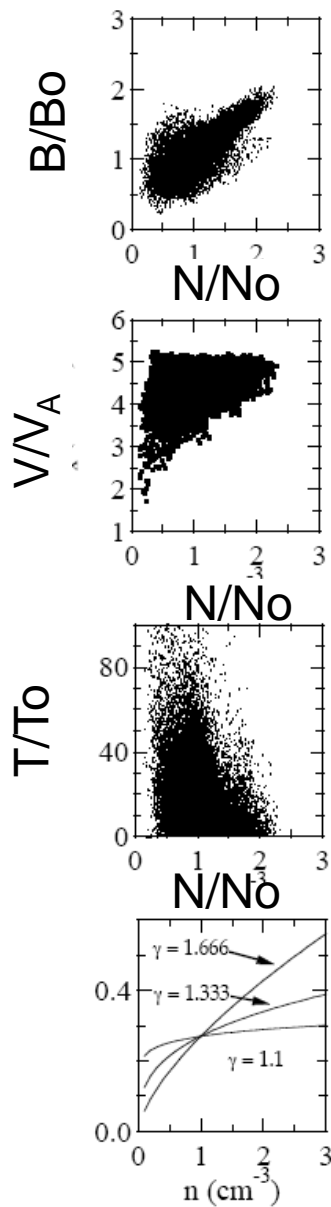


Log (Density)

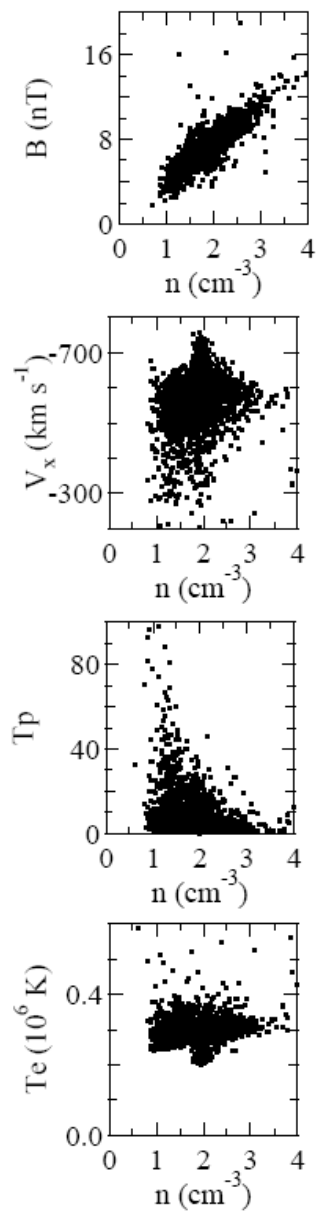




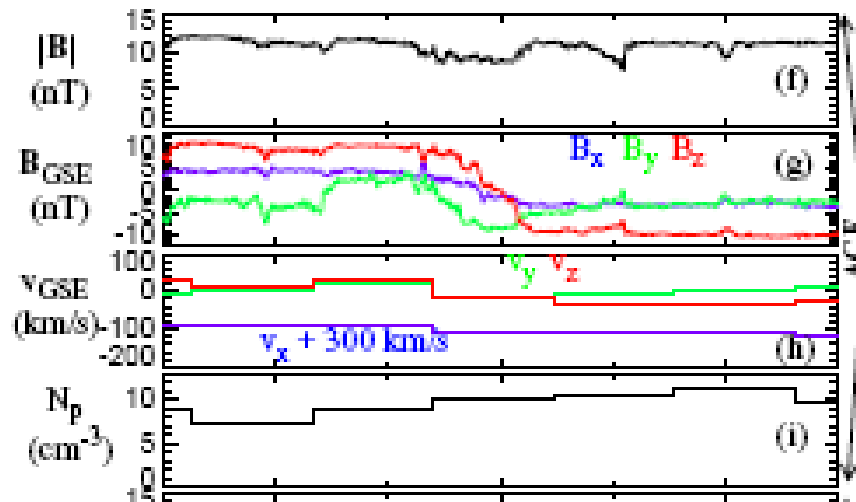
Simulation



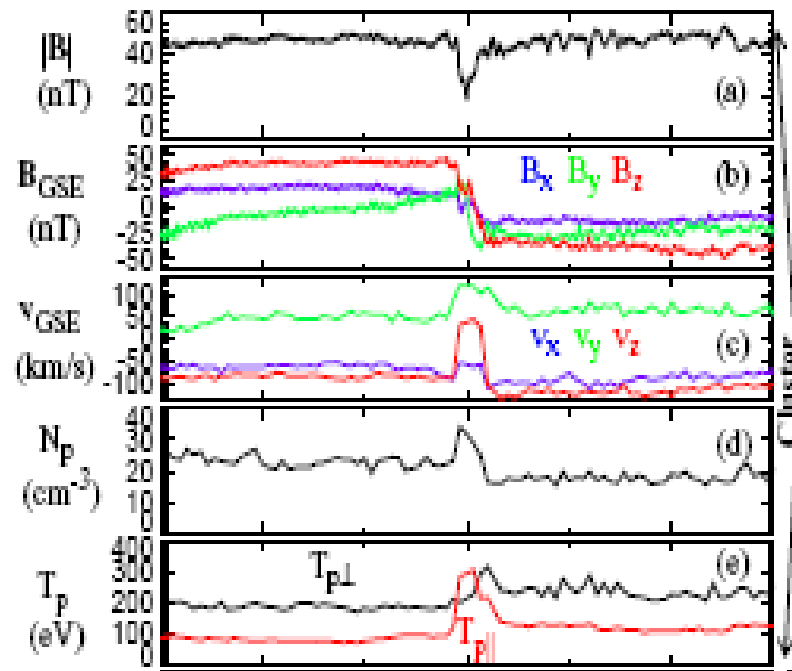
AMPTE/IRM



Reconnection in Magnetosheath



RD in Solar Wind
Width ~ 260 ion skin depth



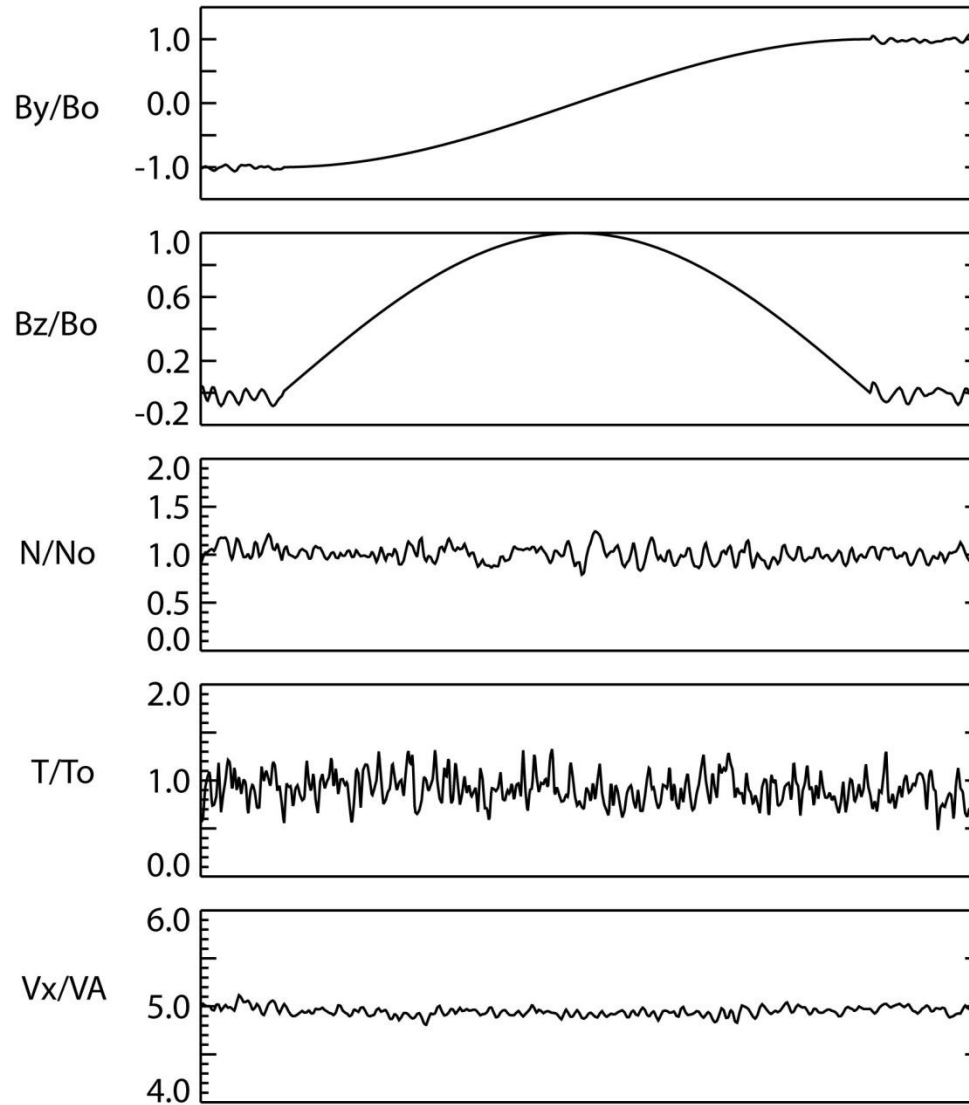
Compressed and Reconnected RD
in Magnetosheath

Phan et al. (2007)



Hybrid Simulation

Initial RD Width 260 Ion Skin Depth

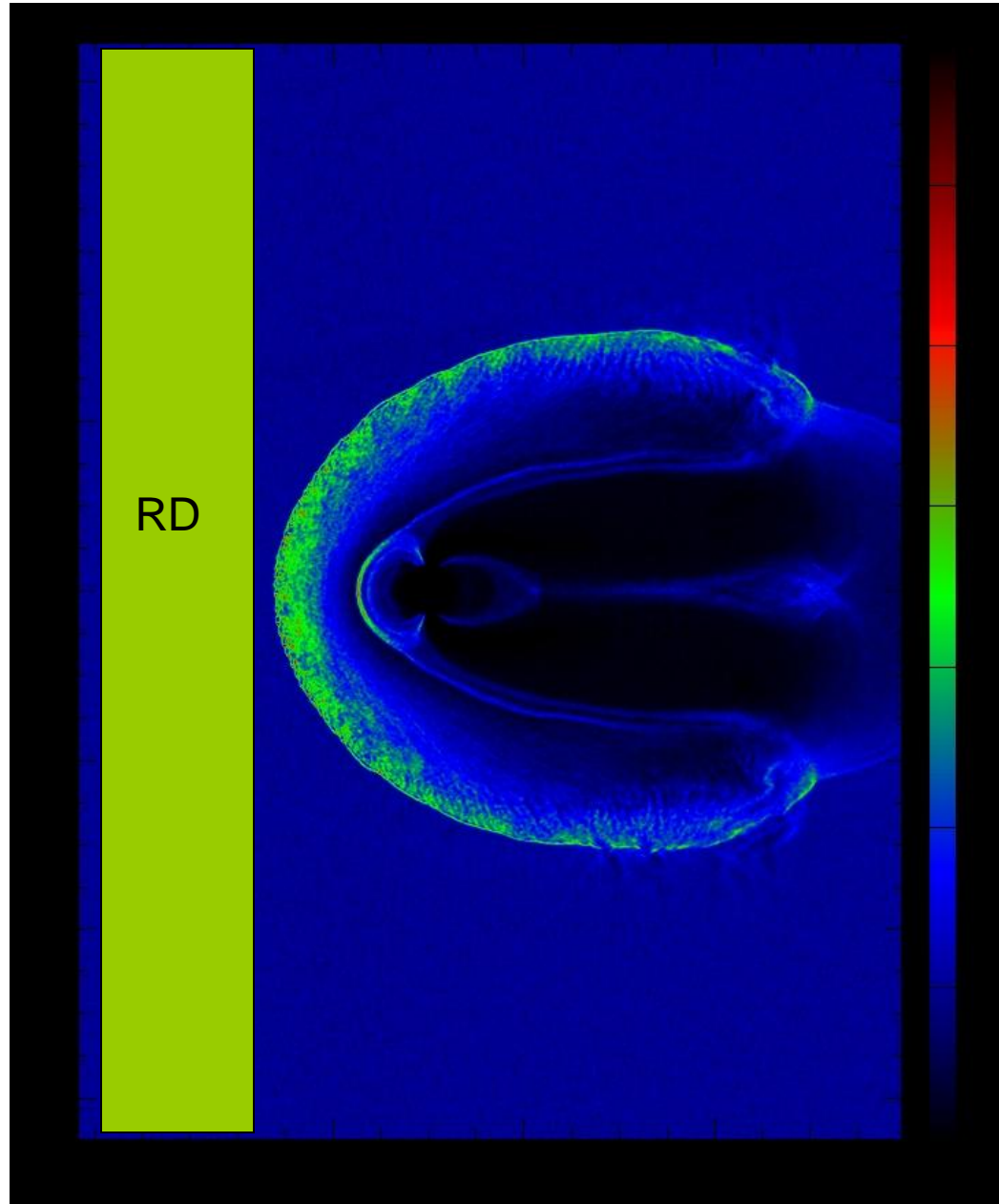


x: 24 / y: 1338

x: 370 / y: 1338



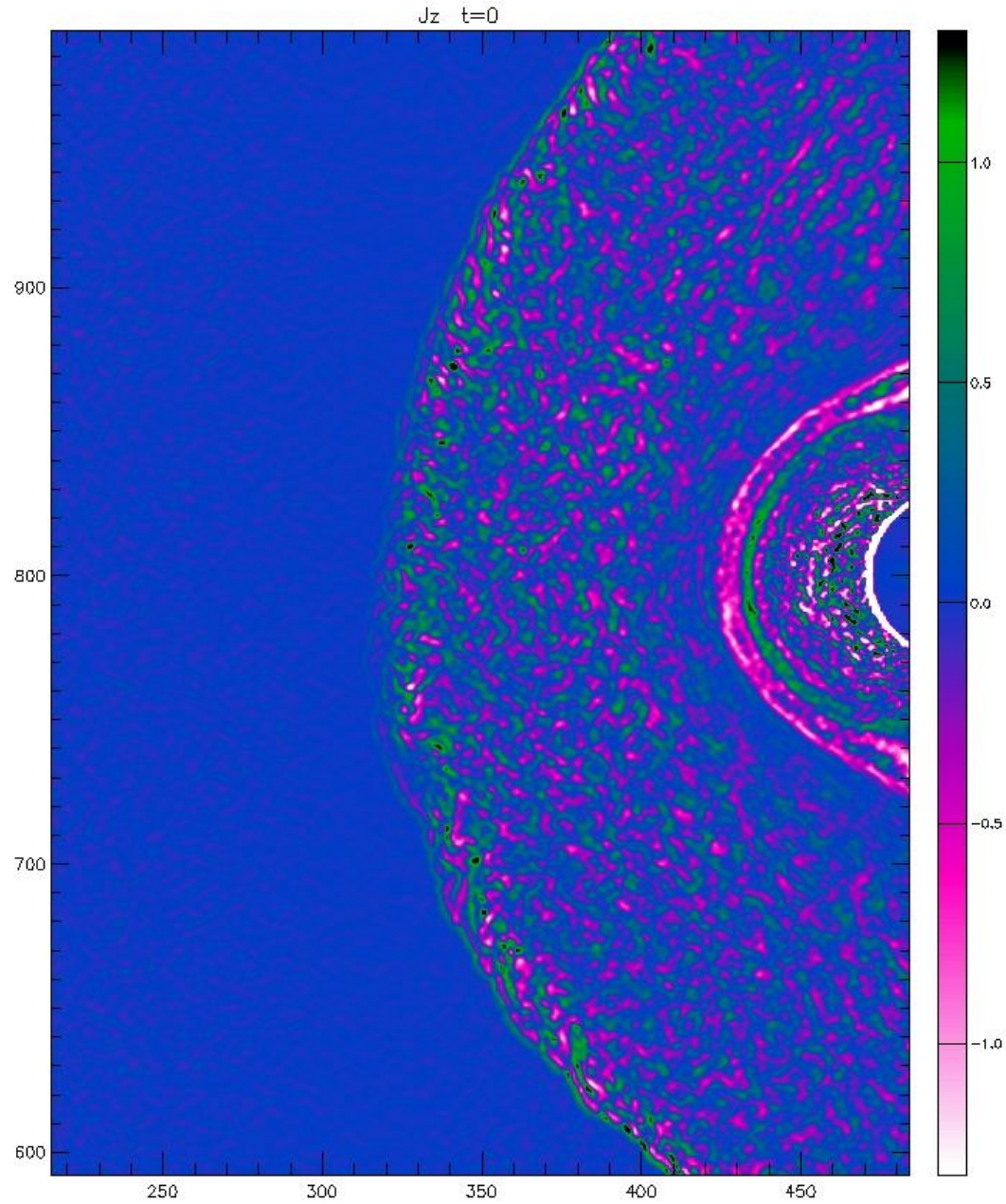
Density (Noon-Midnight Meridian)



RD

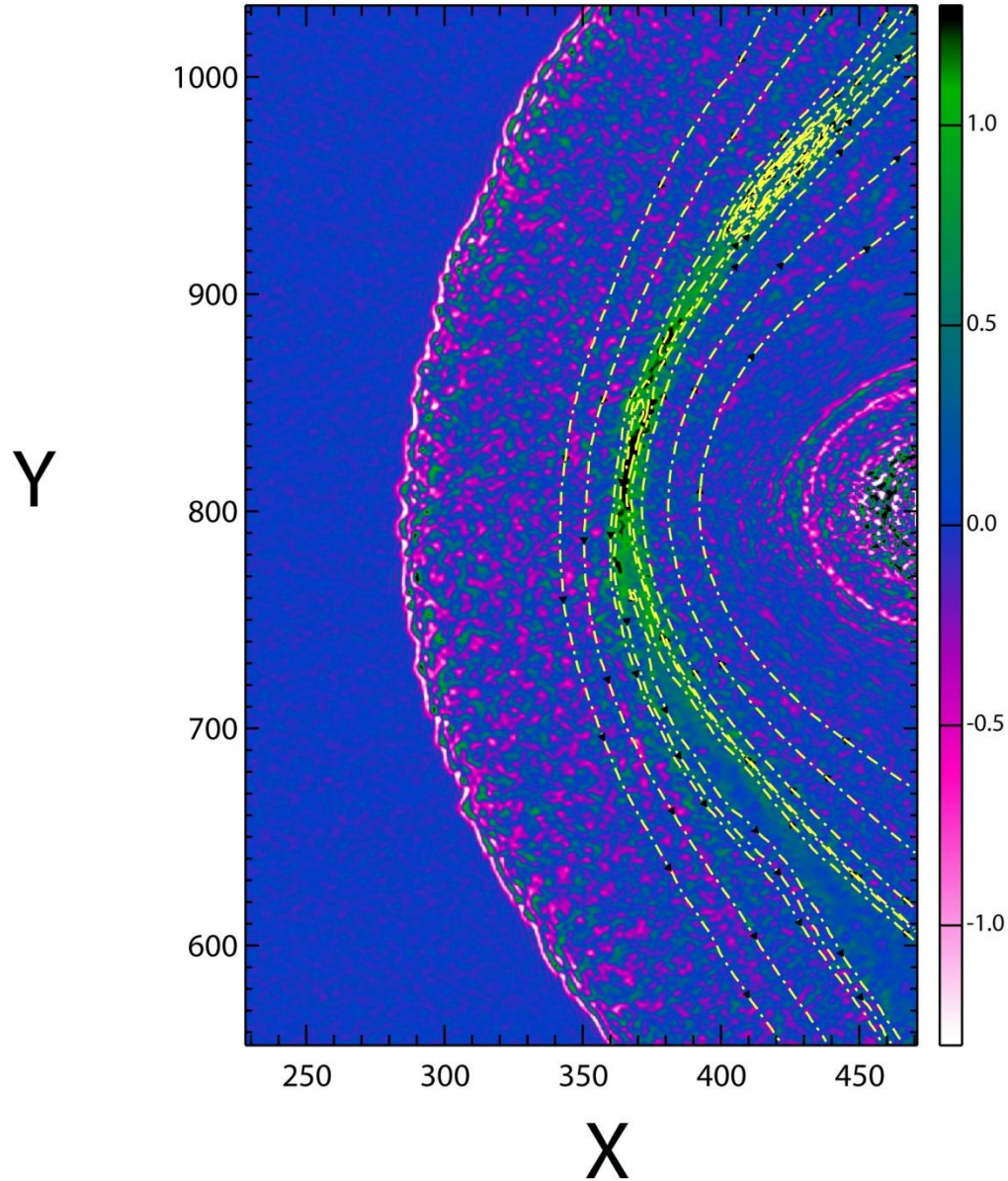


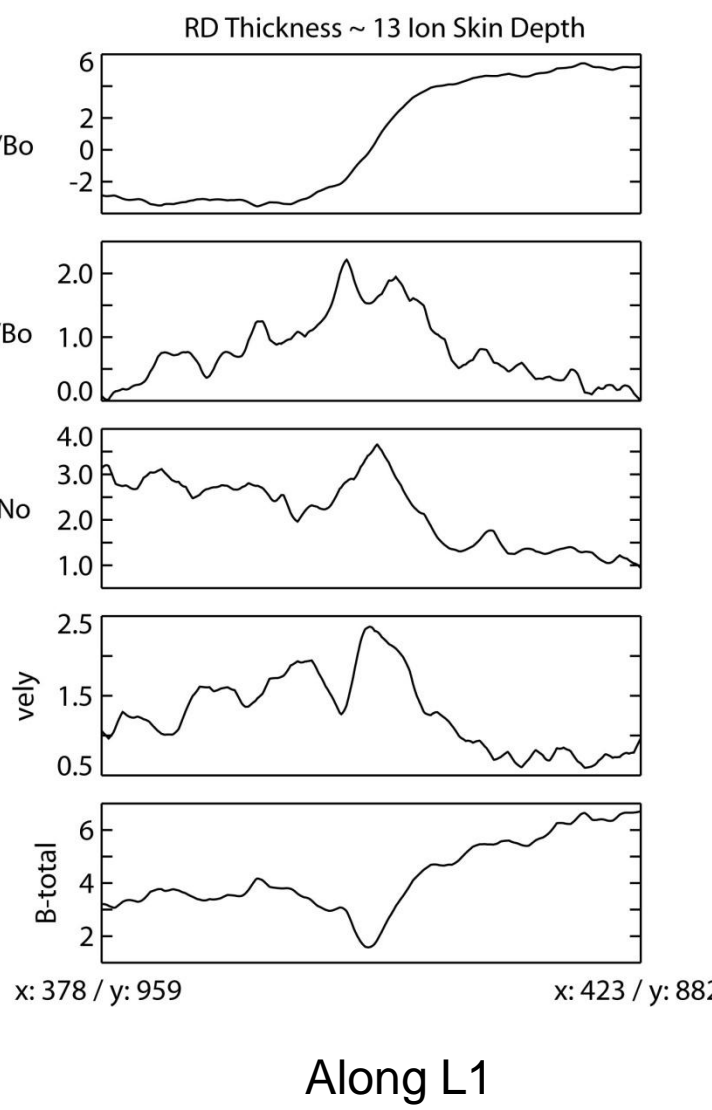
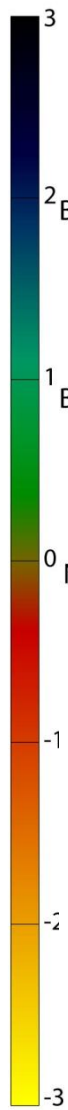
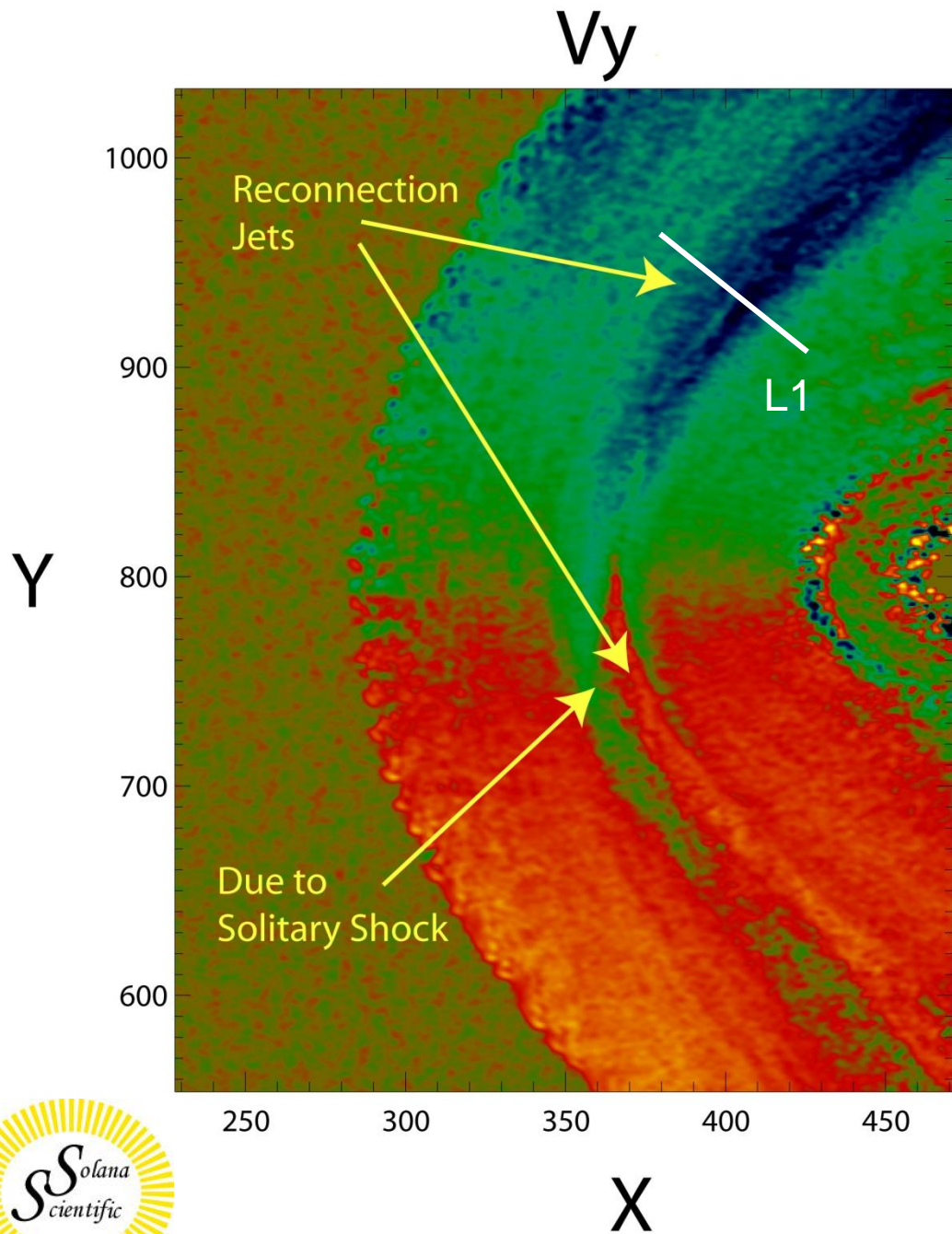
Current Density (zoomed on dayside)



Current Density & Field Lines

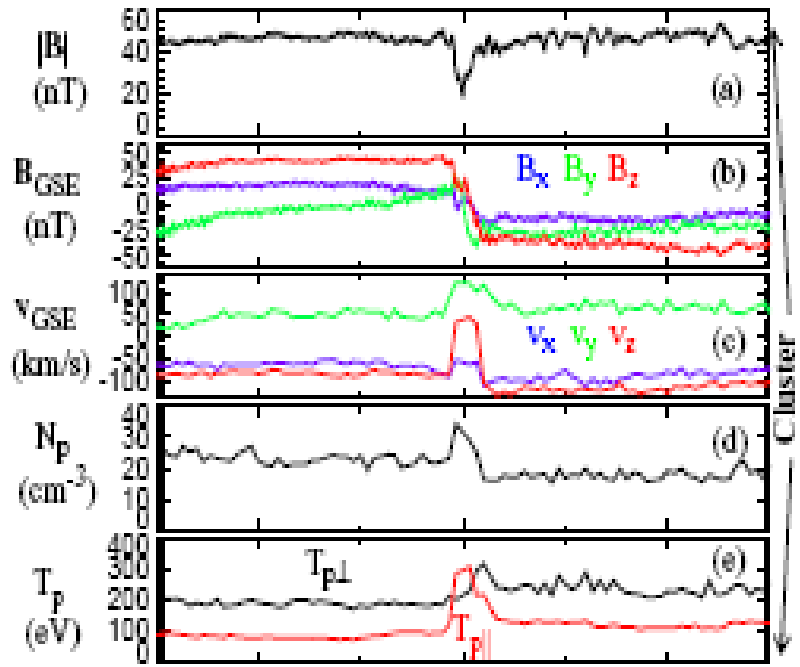
J_z





Cluster

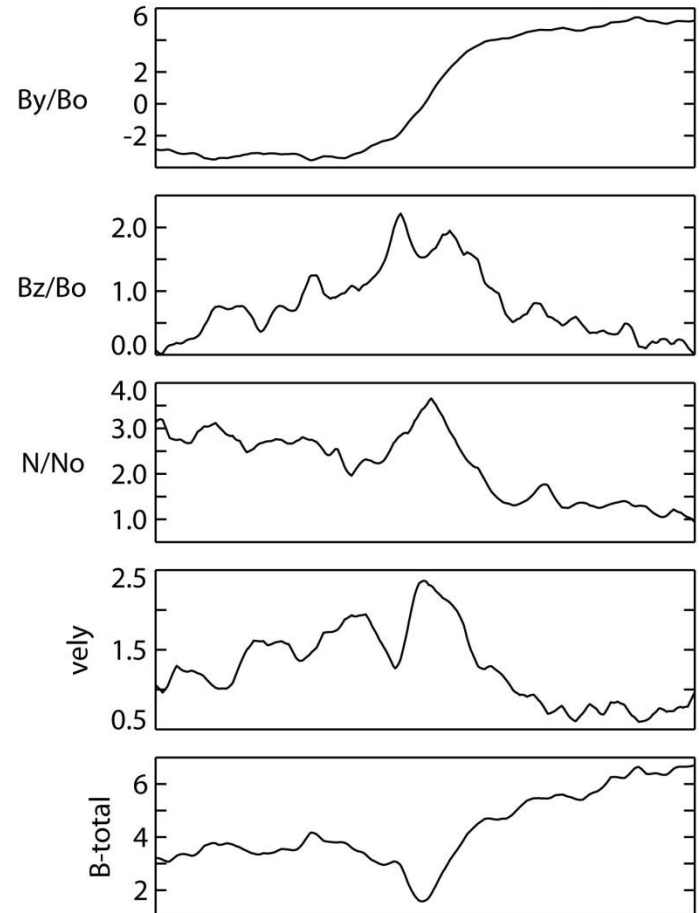
RD Thickness ~ 10 Ion Skin Depth



Phan et al. (2007)

Simulation

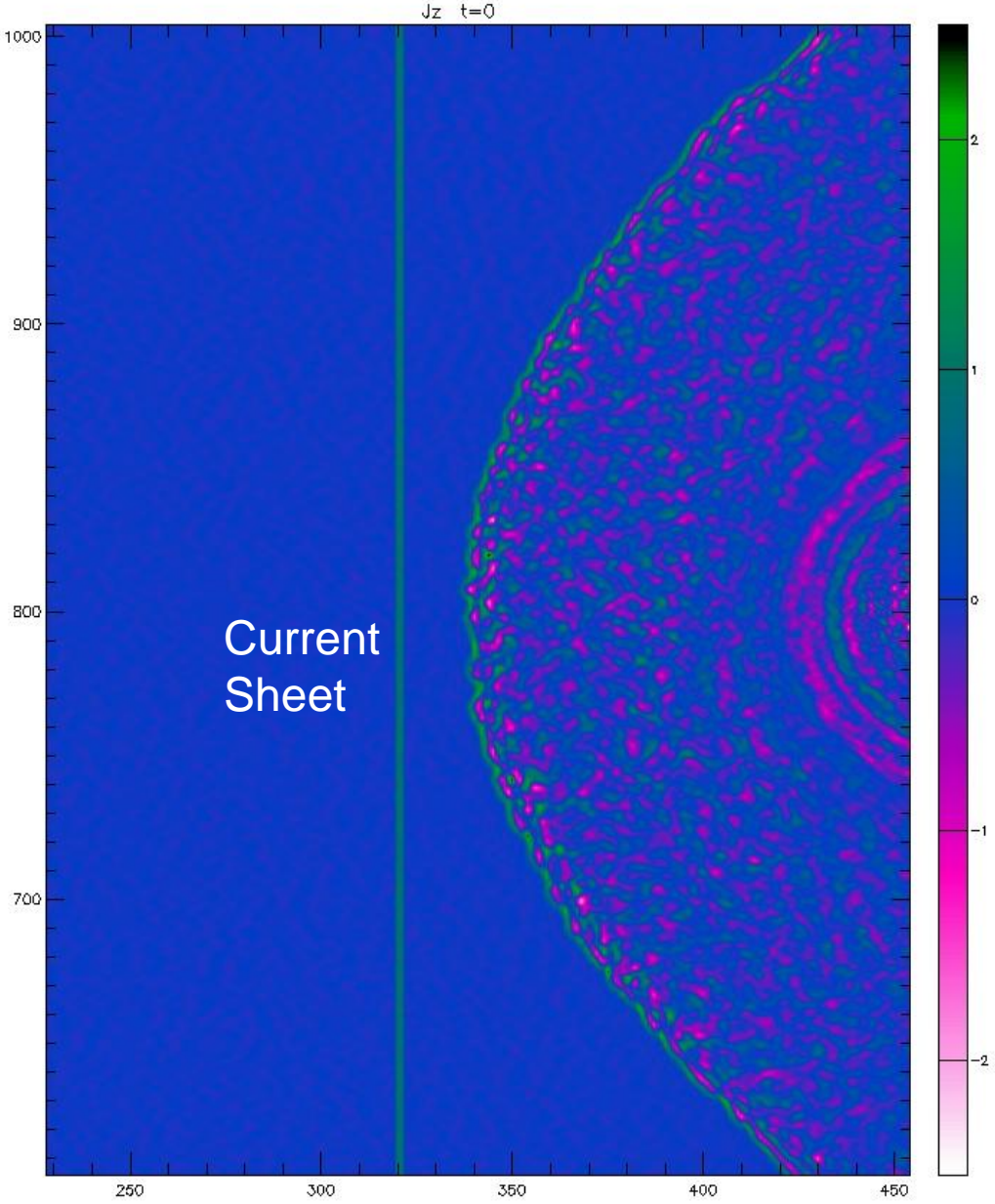
RD Thickness ~ 13 Ion Skin Depth



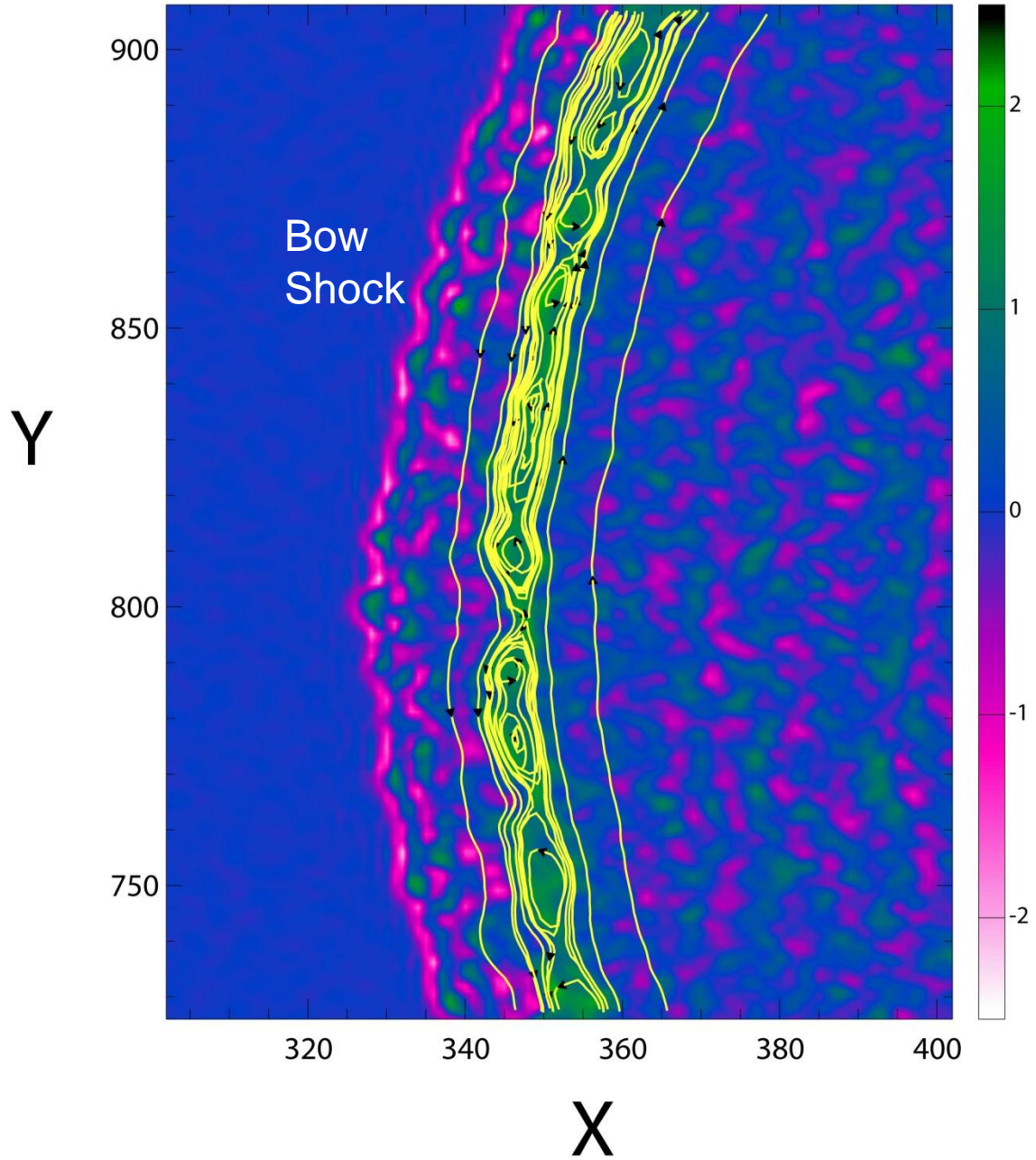
x: 378 / y: 959

x: 423 / y: 882

Current Density (Thin RD)



Jz



Bow
Shock

Y

900

850

800

750

320

340

360

380

400

X

2

1

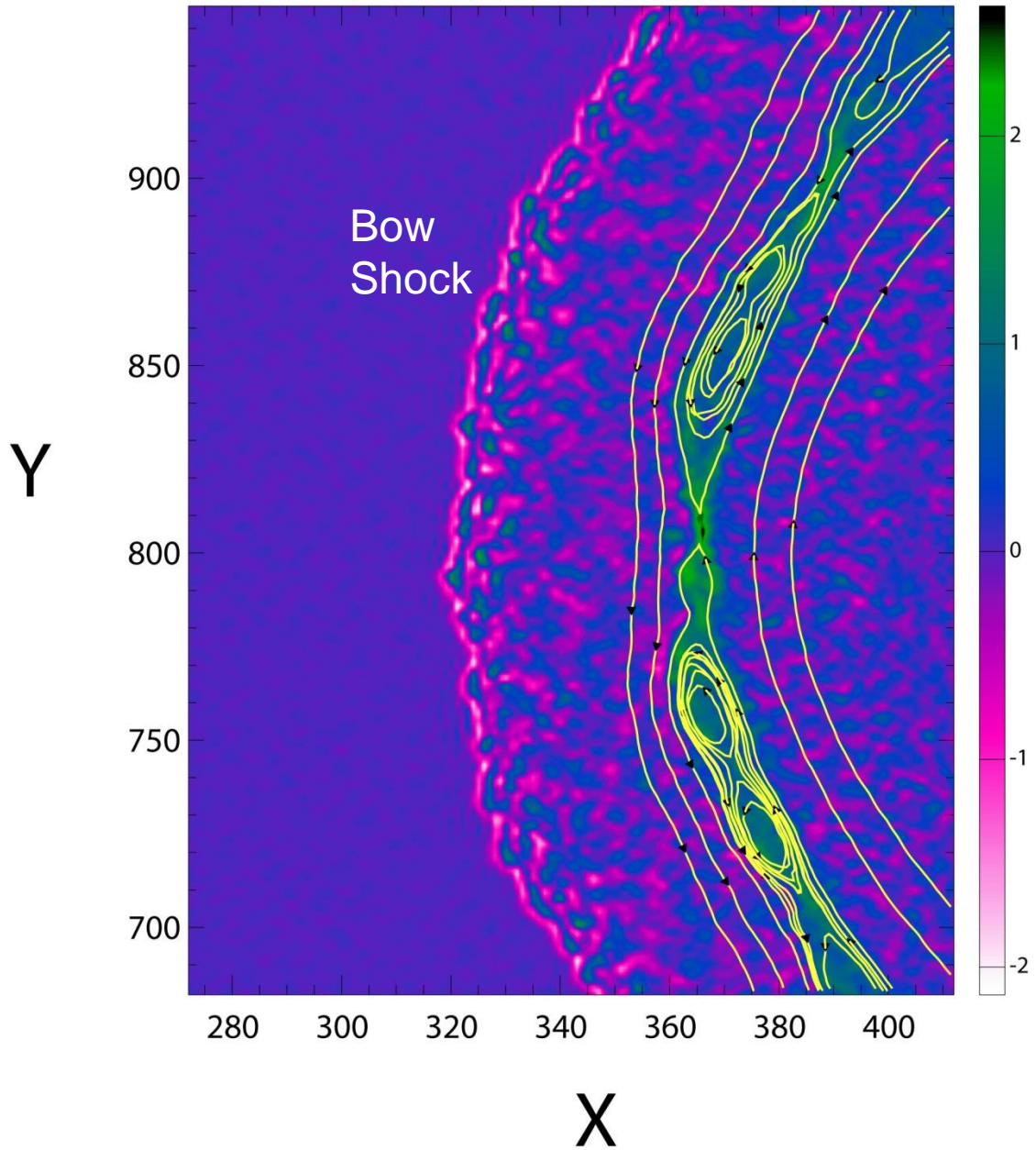
0

-1

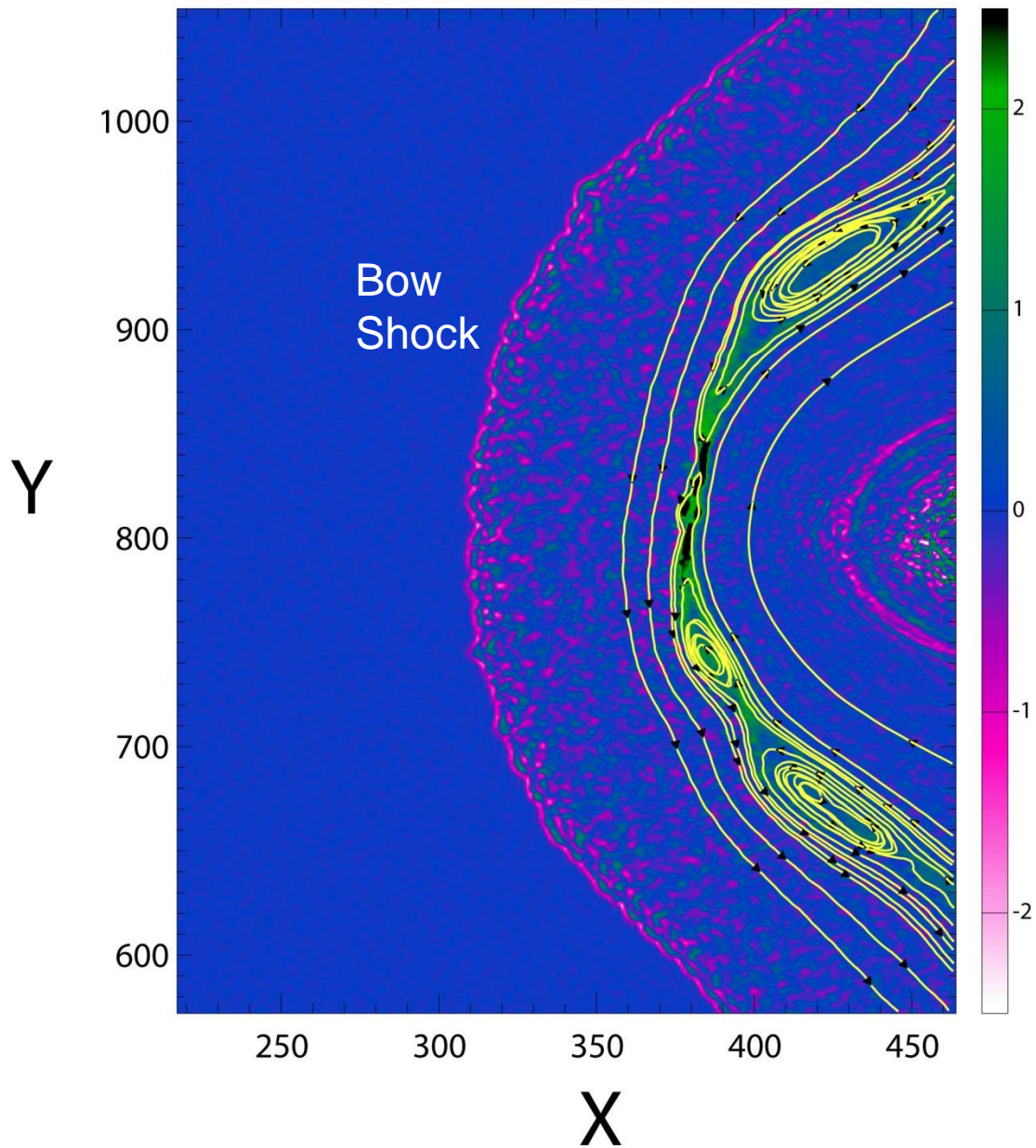
-2



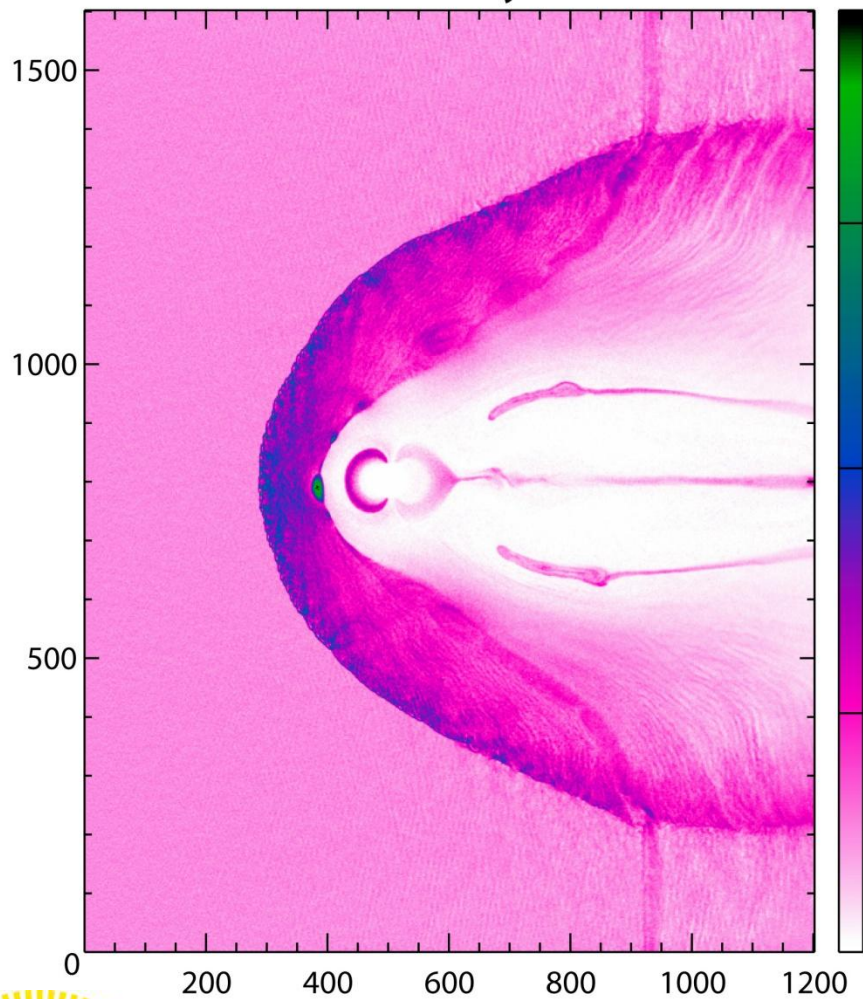
Jz



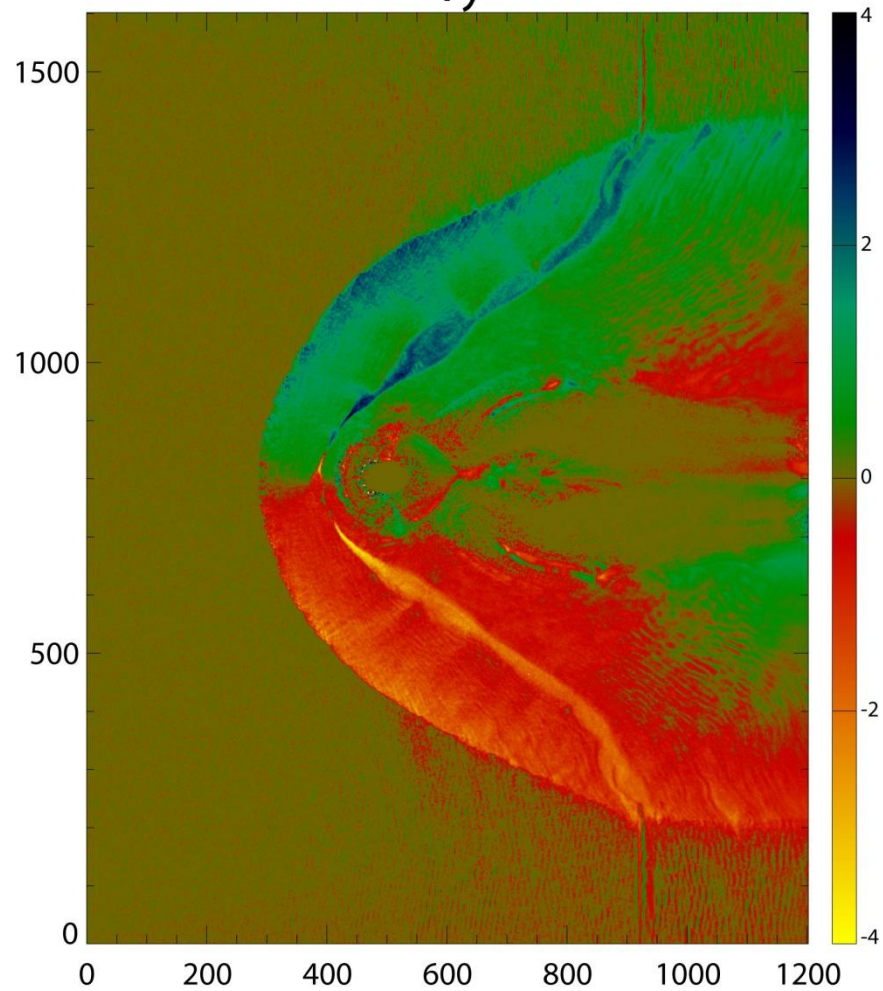
Jz



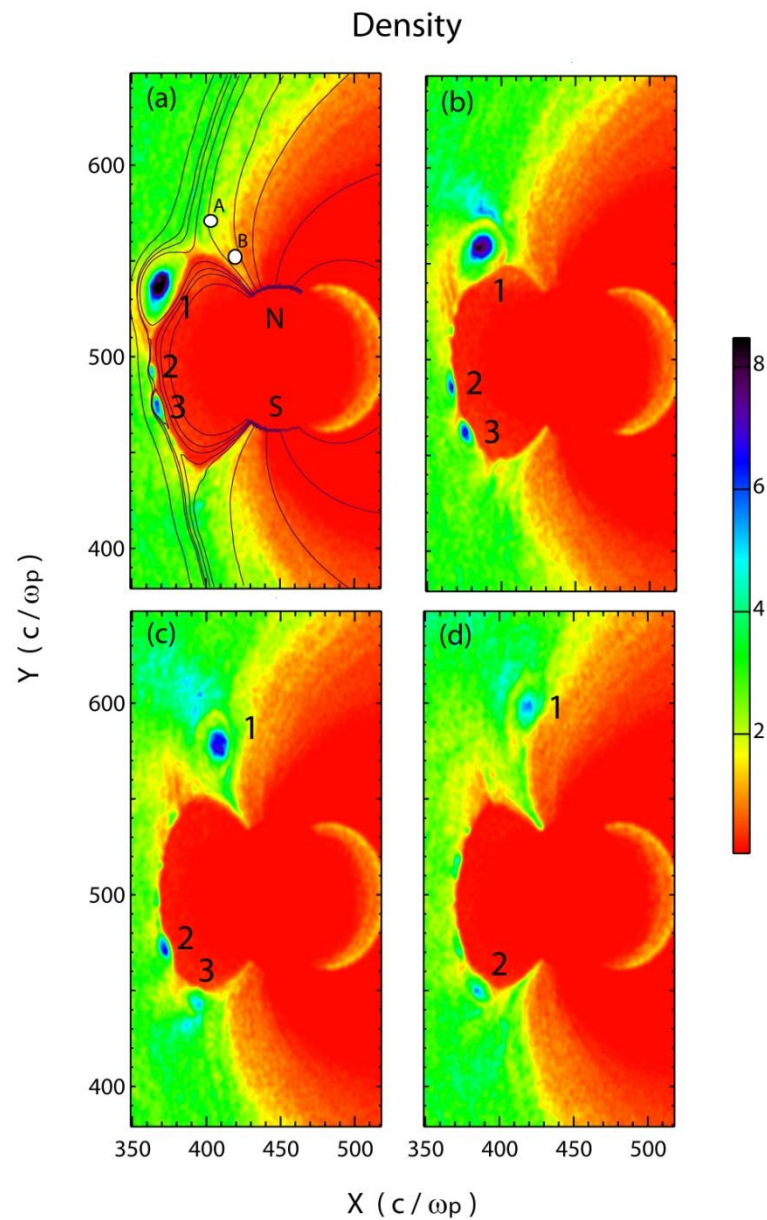
Density



V_y

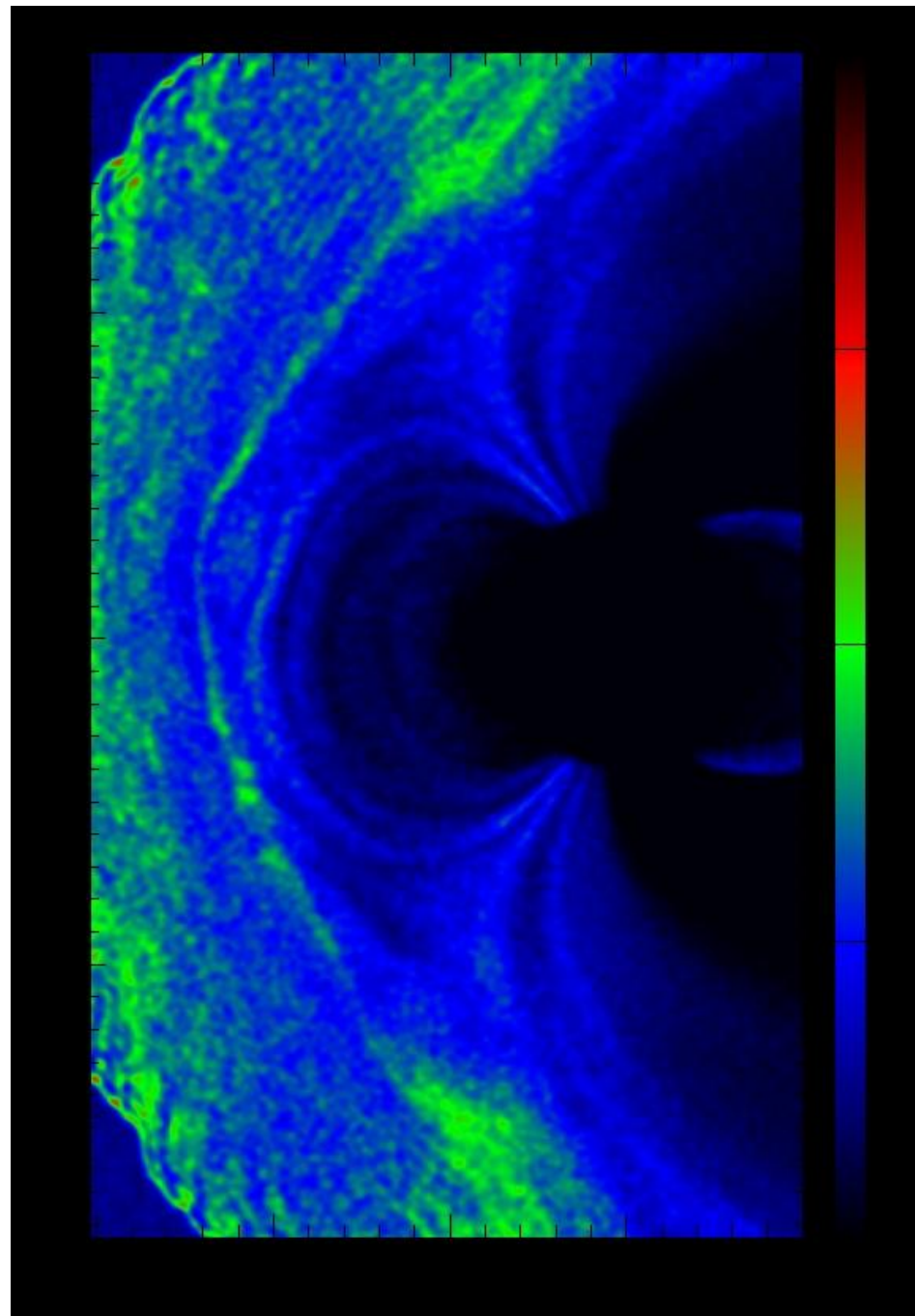


Magnetopause During Southward IMF



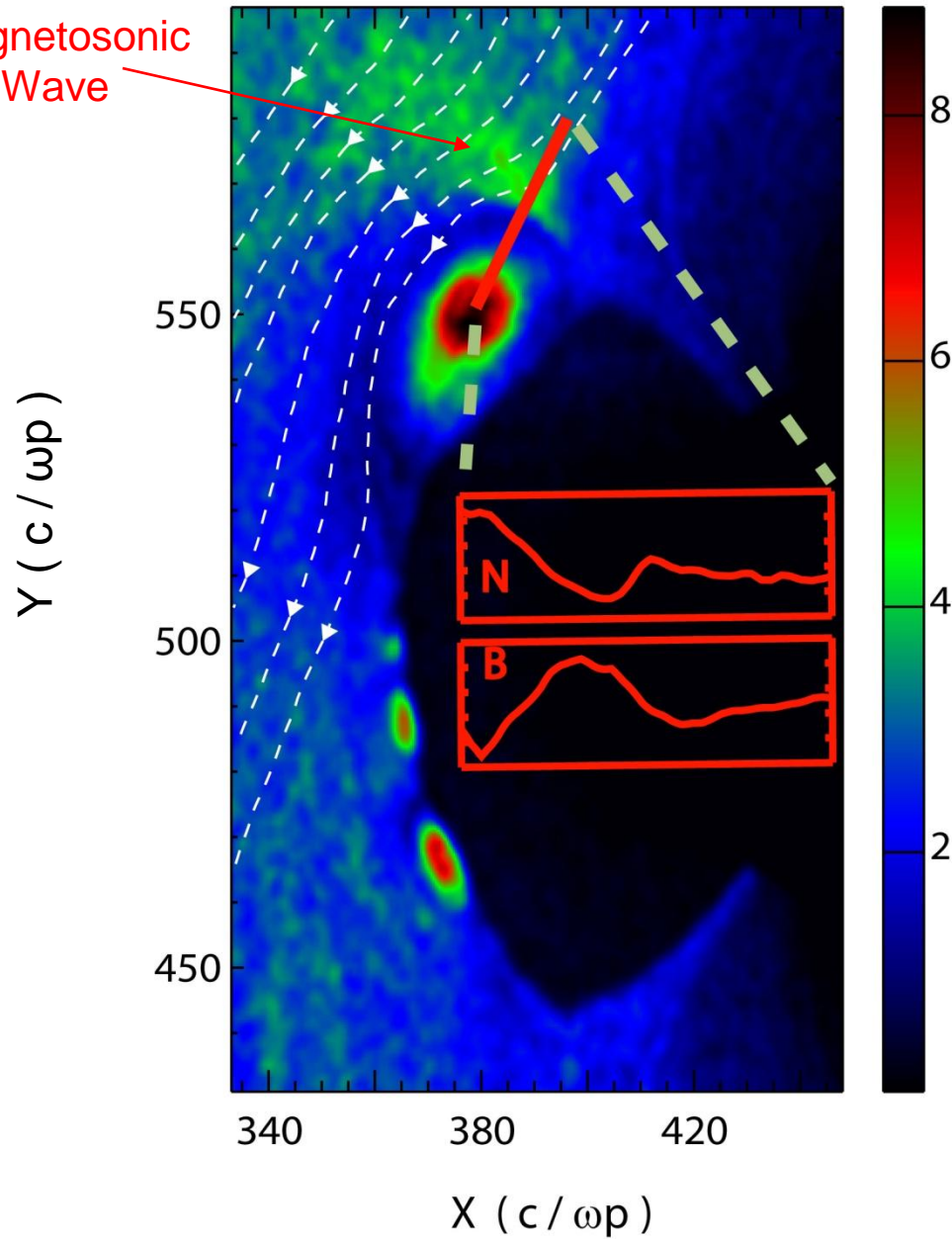
Density

No Dipole Tilt

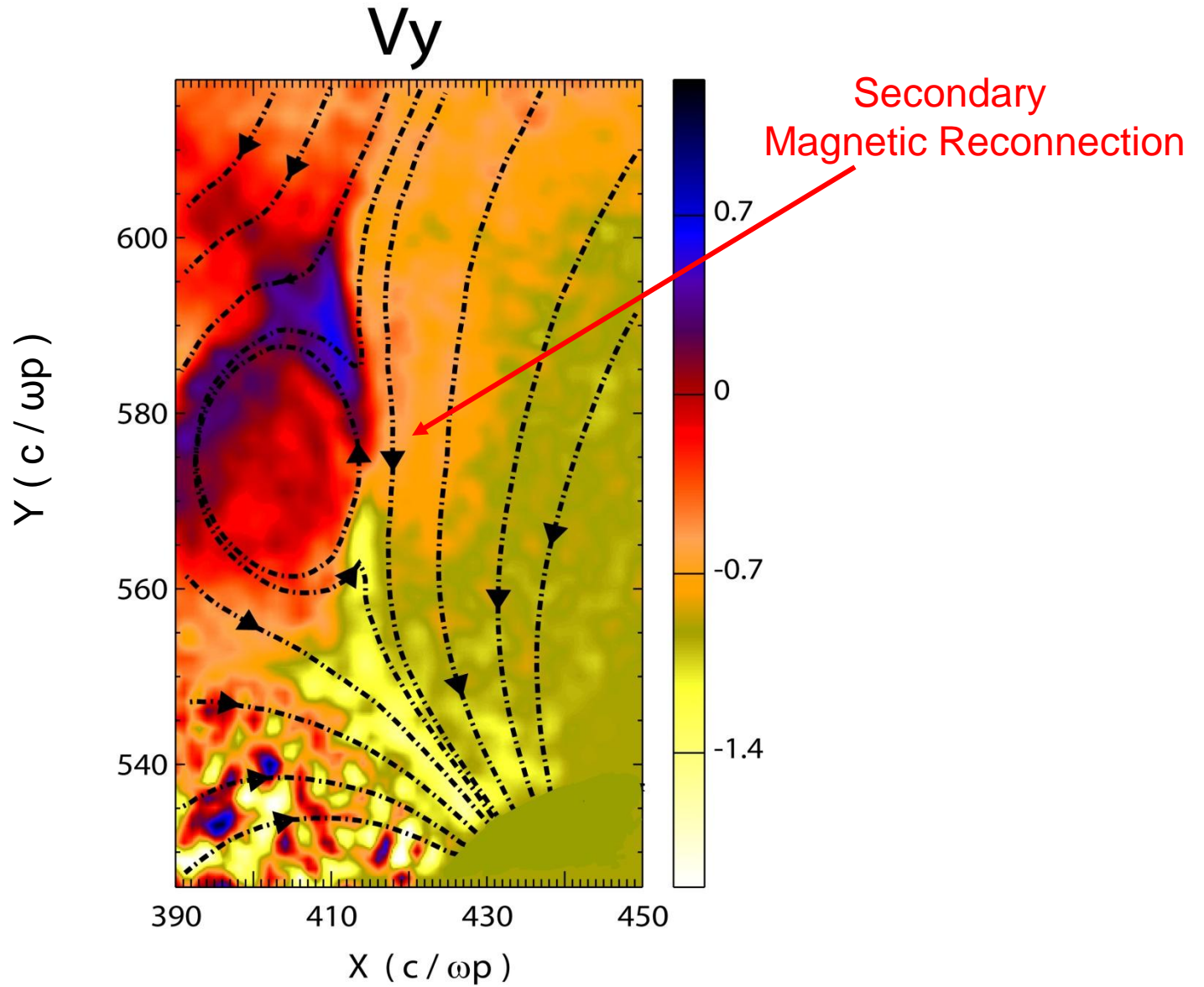


Density

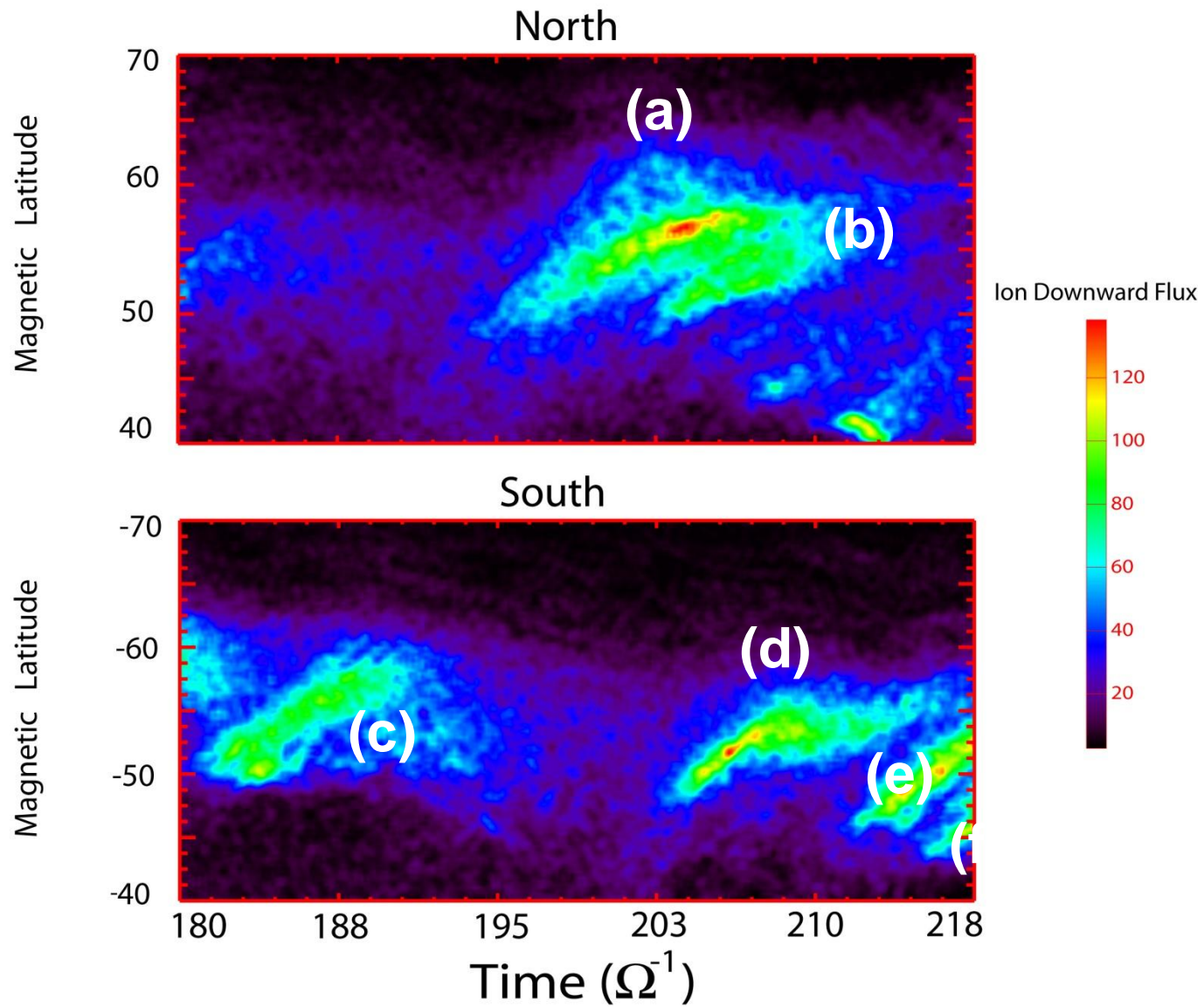
Slow Magnetosonic
Bow Wave



FTE in the Cusp

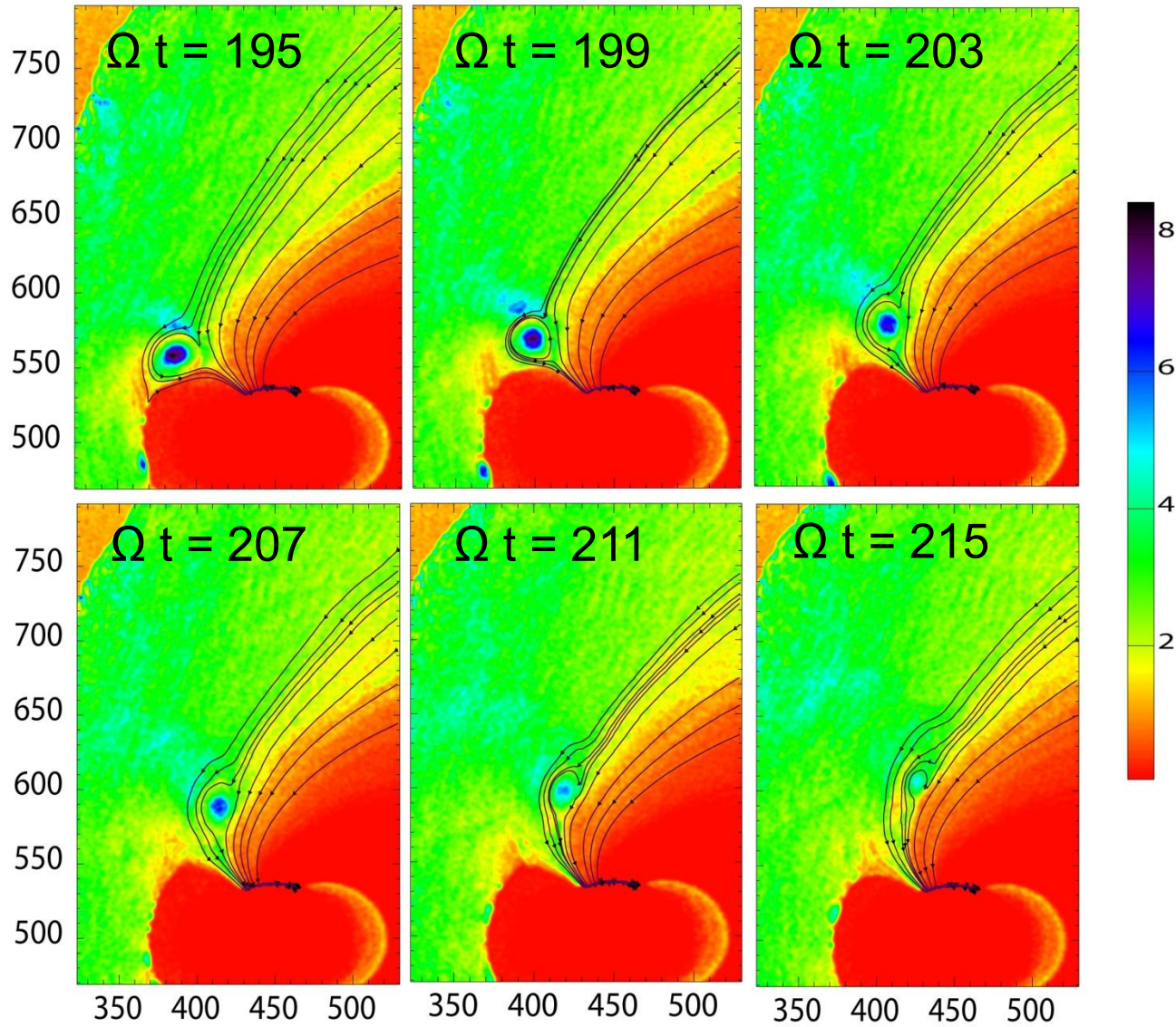


Downward Flux of 0.25 keV Ions at Low Altitude



Density

Y

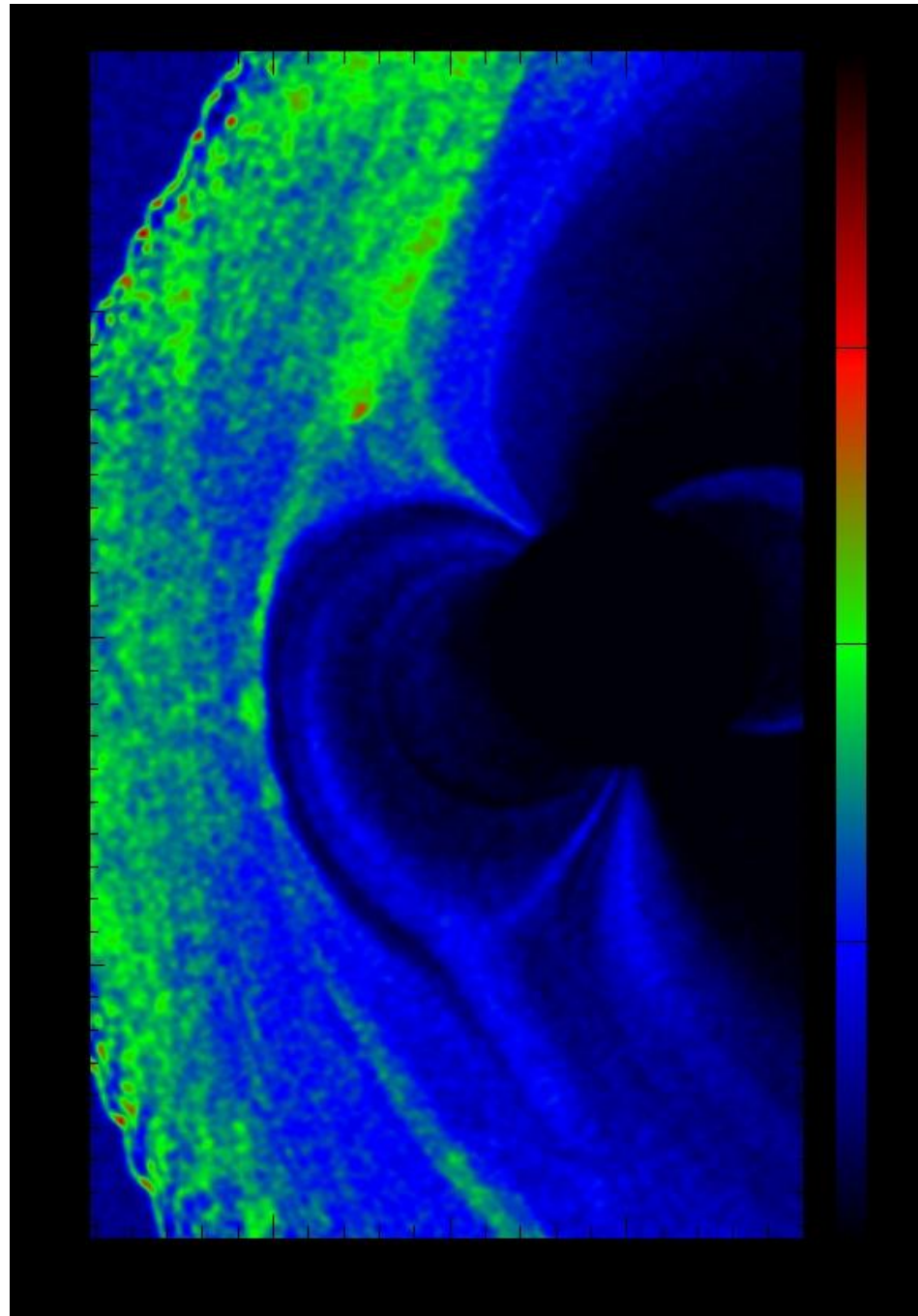


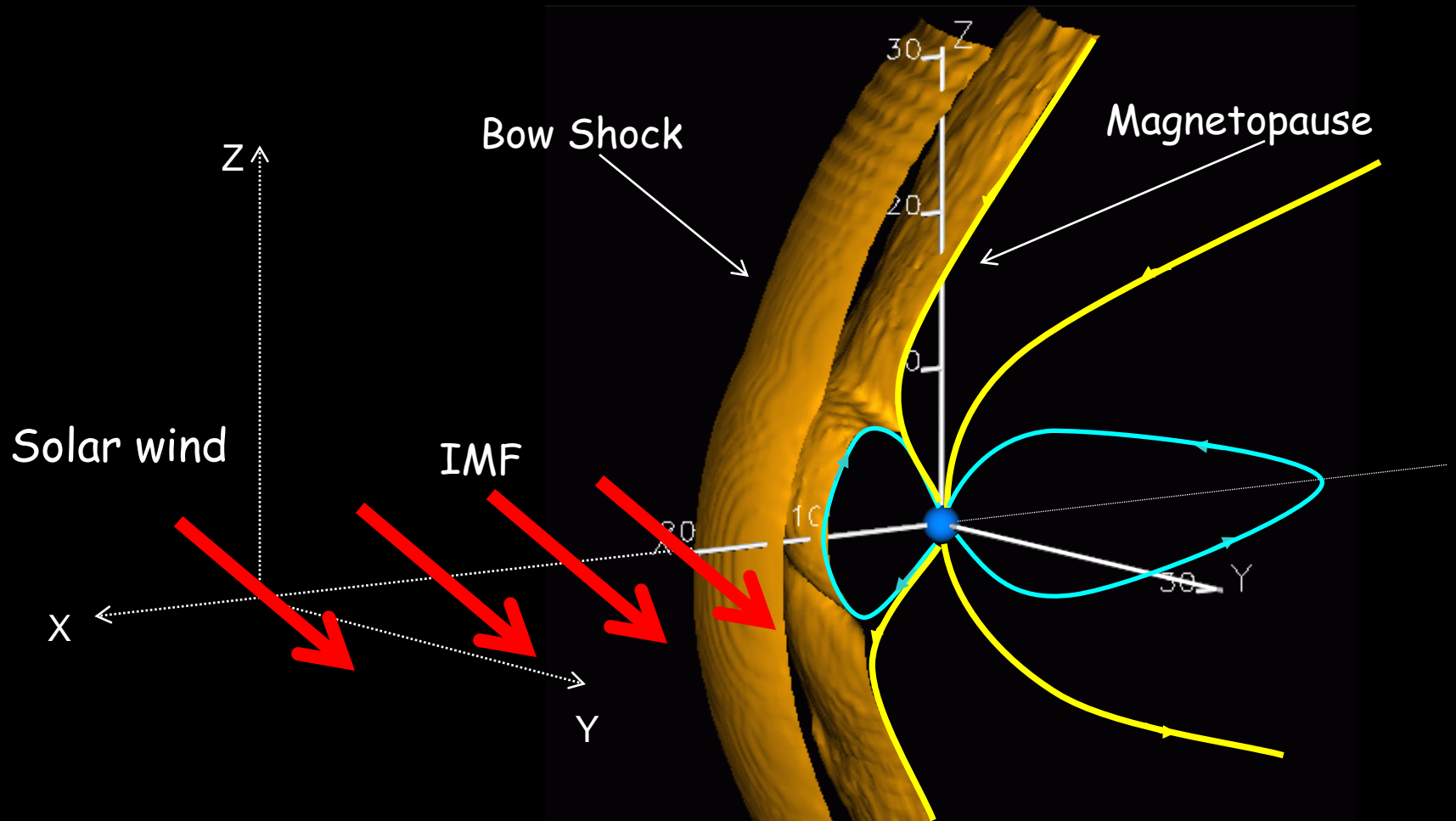
X

Solana
Scientific

Density

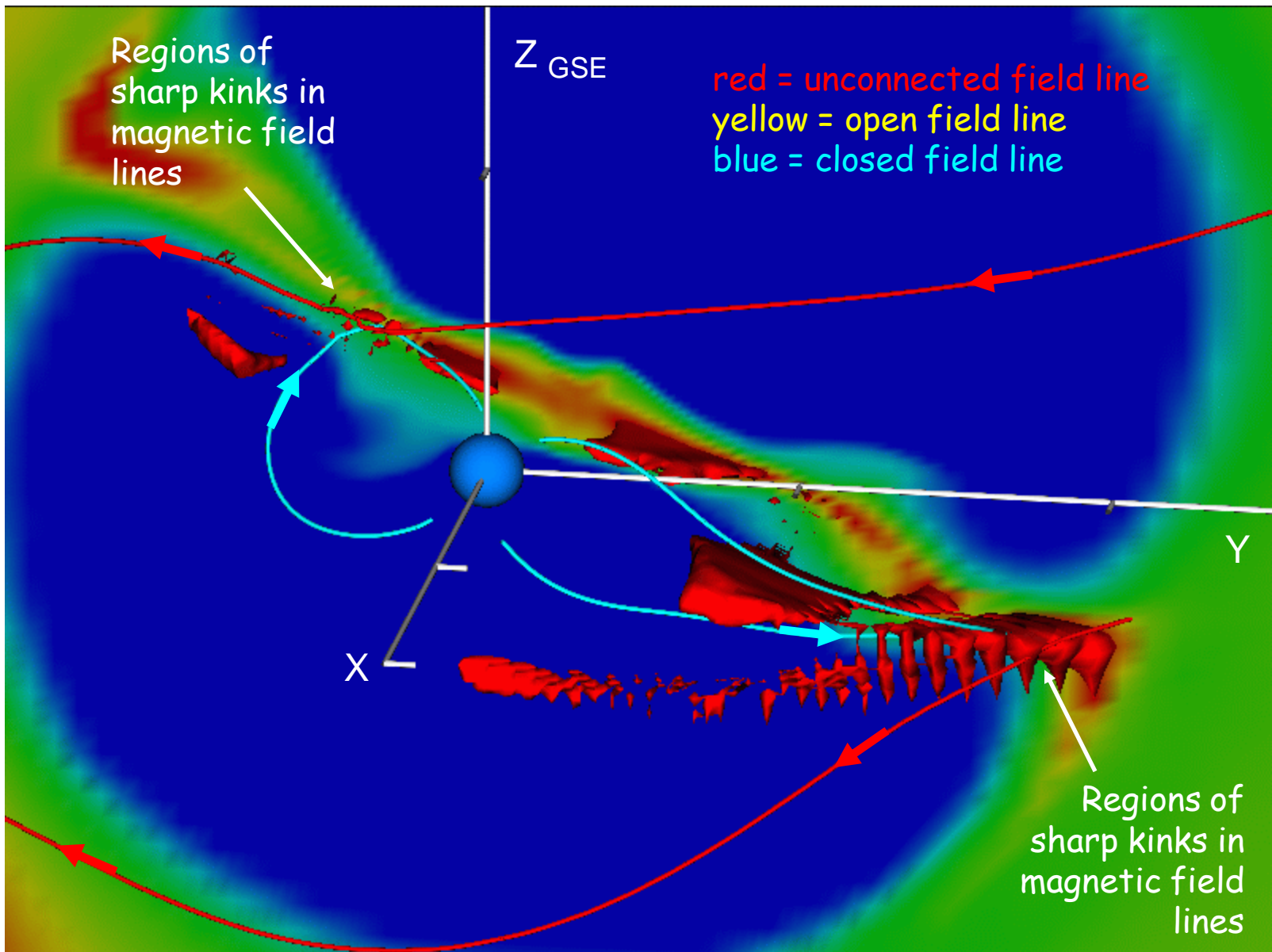
20° Dipole Tilt

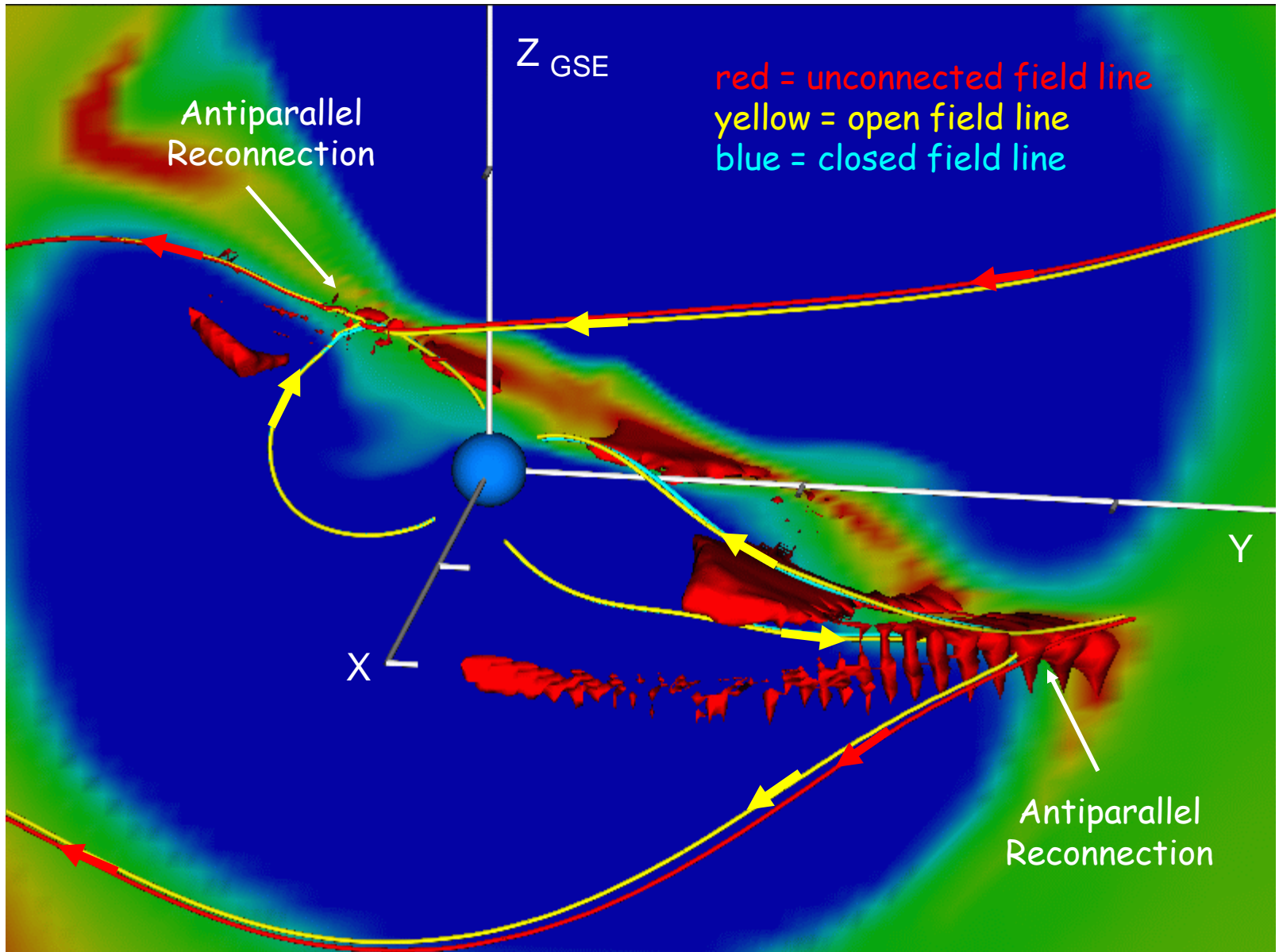


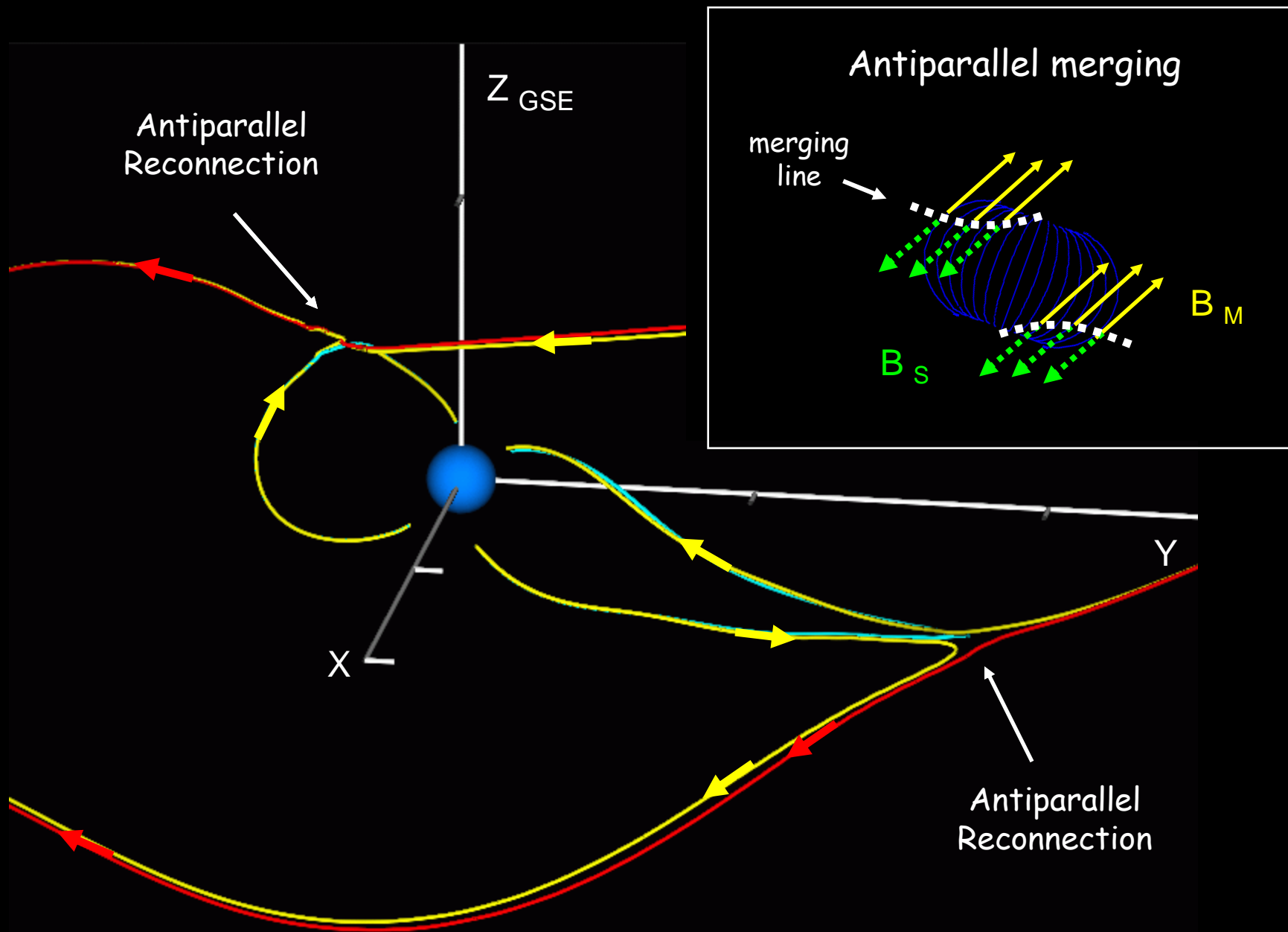


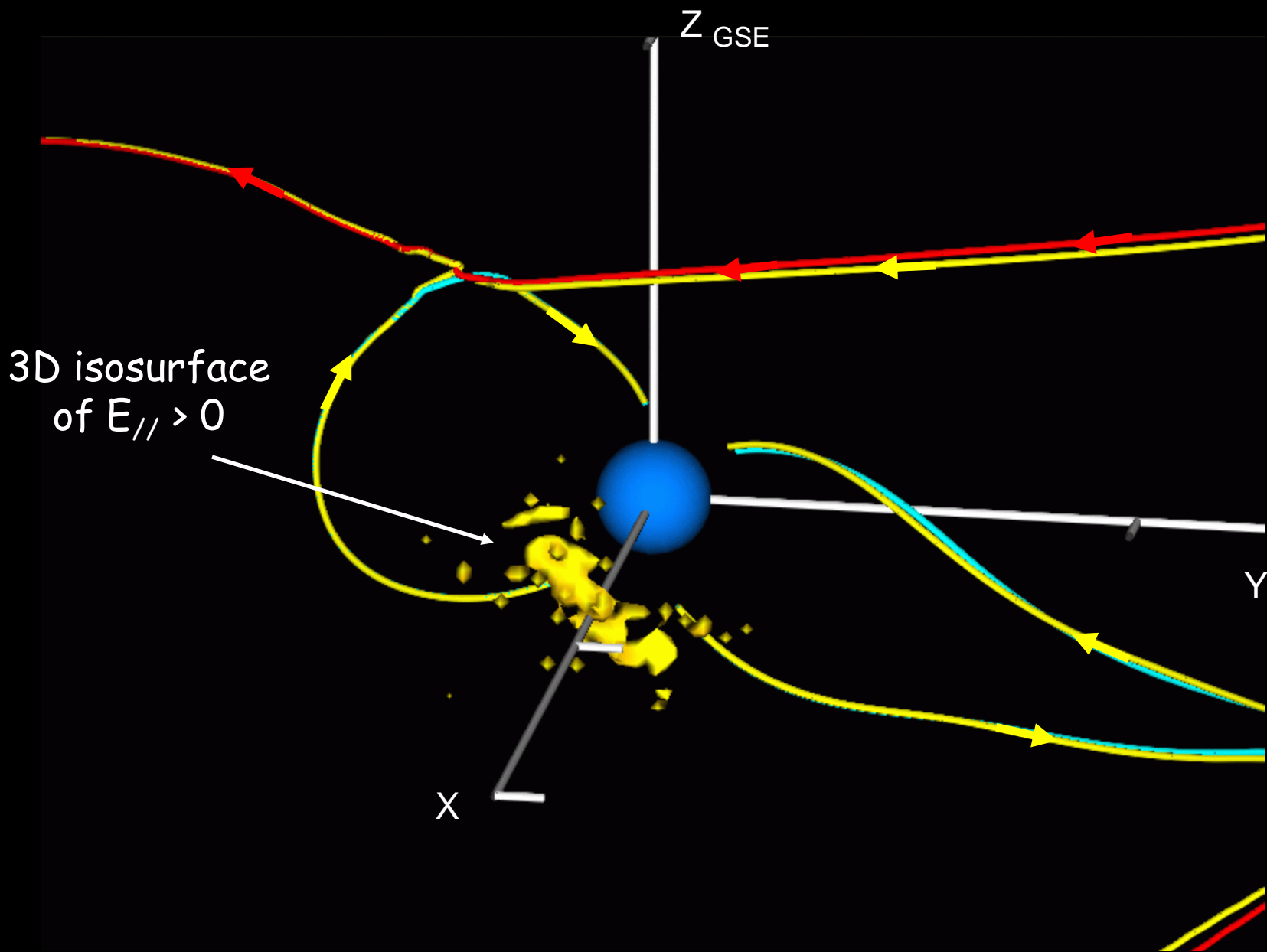
Question:

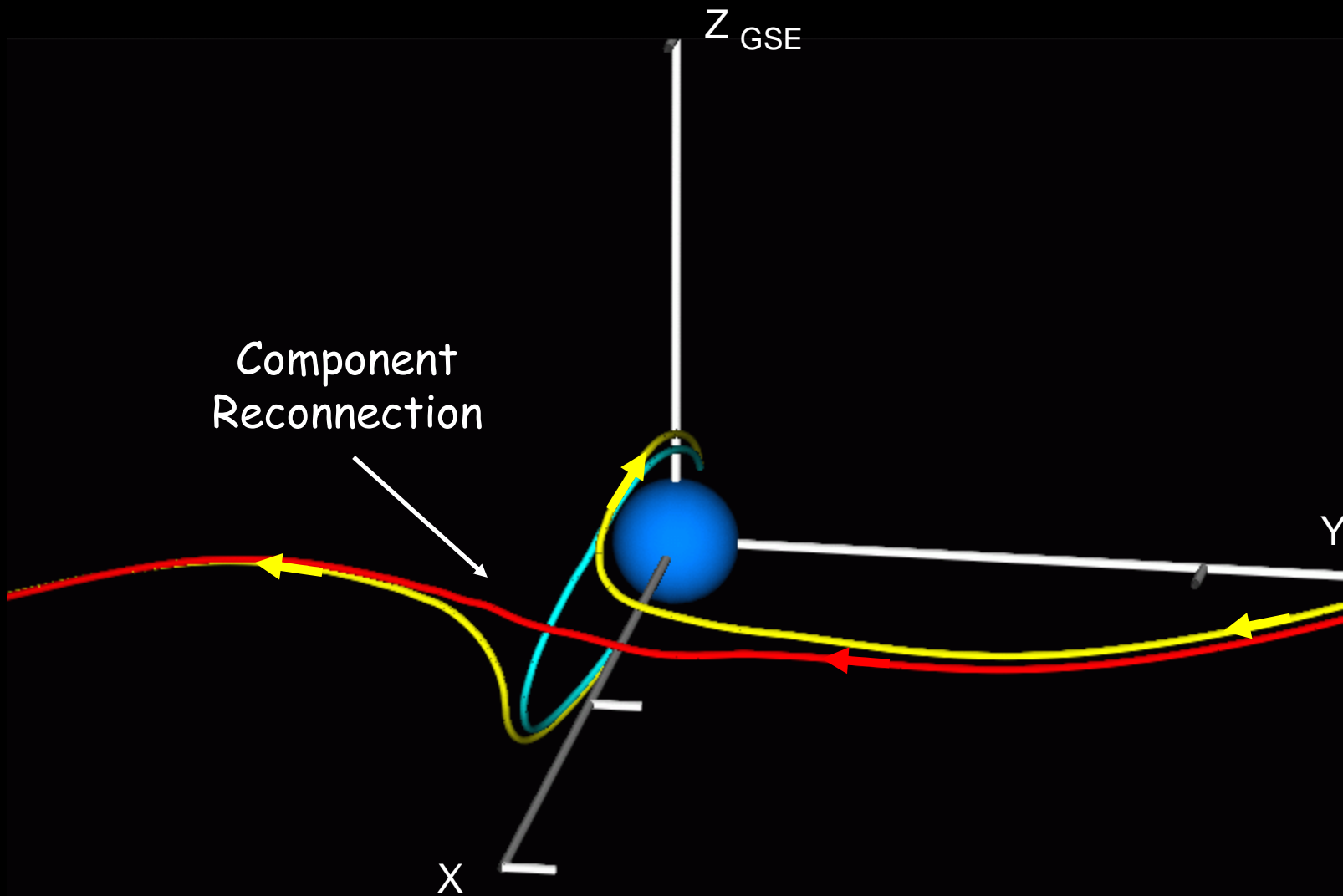
Given a set of solar wind conditions where is (are) the location(s) of merging (= magnetic reconnection) of the IMF with the geomagnetic field?

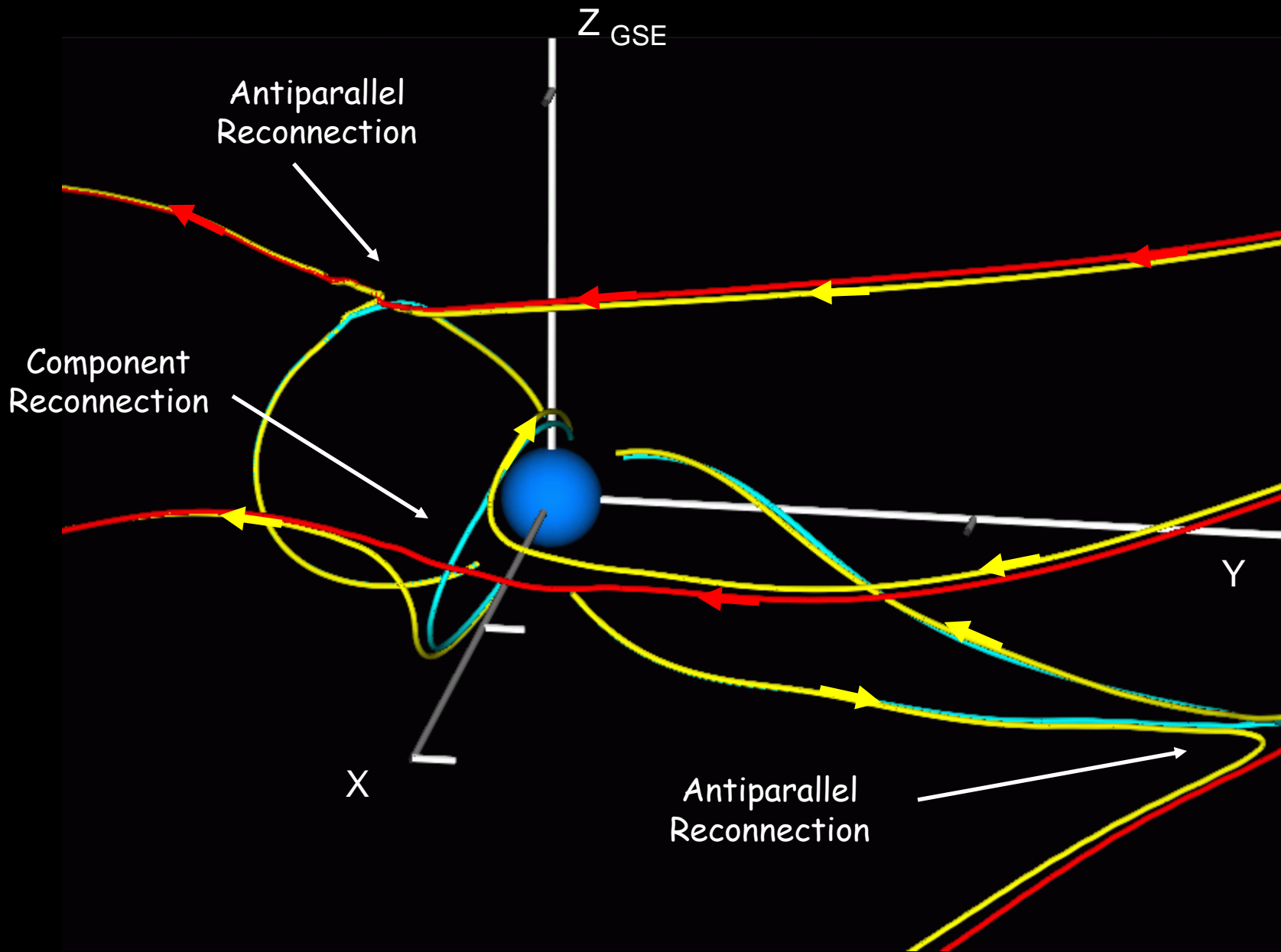












Summary

- Global structure and morphology of foreshock and bow shock are more complex than previously thought. Important questions remain to be addressed through modeling and observations.
- Interaction of solar wind discontinuities with the bow shock lead to a variety of processes including magnetic reconnection in the sheath. The internal structure of discontinuities modify the reconnection process and provide an opportunity to understand it in “isolation”.
- During southward IMF, time dependent reconnection leads to the formation of FTEs with a variety of sizes and plasma content. Interaction of FTEs with the cusp leads to their disintegration and plasma injection into the cusp with ionospheric signatures similar to PMAFs.
- Both anti-parallel and component merging operate at the magnetopause. However, when and where they occur remain open questions.