

An astronaut in a white spacesuit is floating in space, with the Earth's horizon visible below. In the background, a large, bright solar flare or coronal mass ejection (CME) is visible, emitting a strong orange and yellow glow. The overall scene is set against the dark blue and black of space.

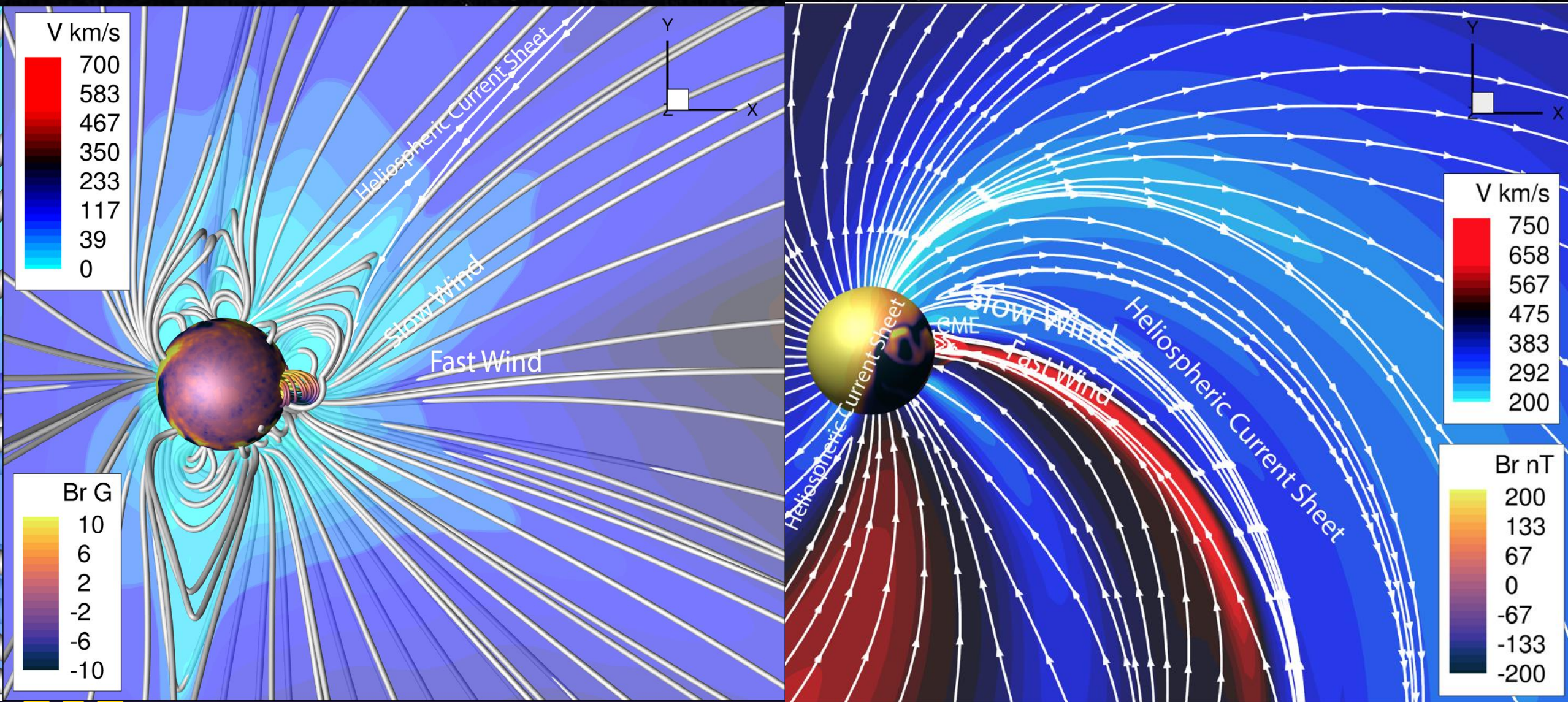
# Simulating Mesoscale CME Structures as Seen By PUNCH

Chip Manchester, Nishtha Sachdeva, Mojtaba Akhavan-Tafti

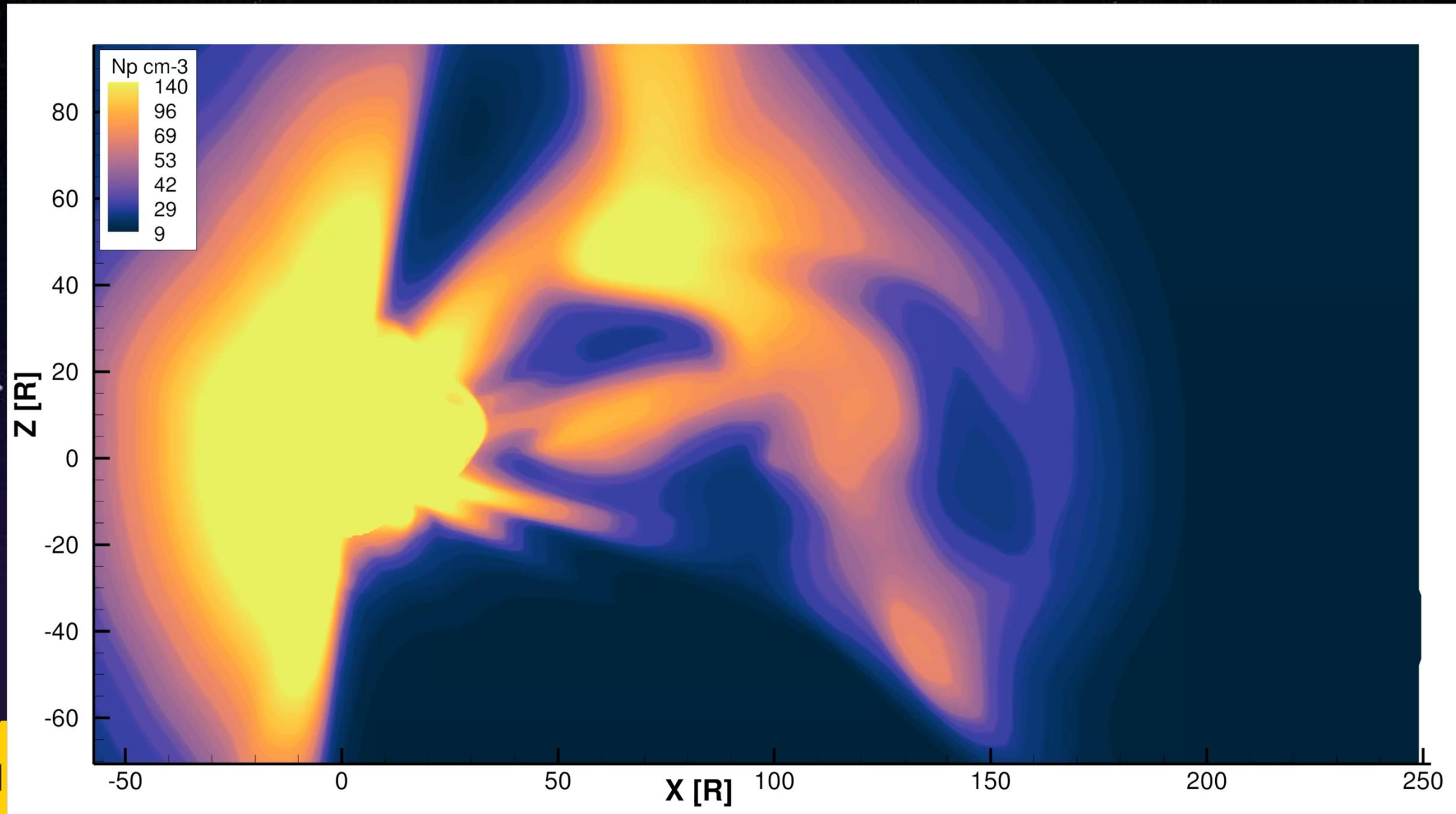


# CME CIR Interaction

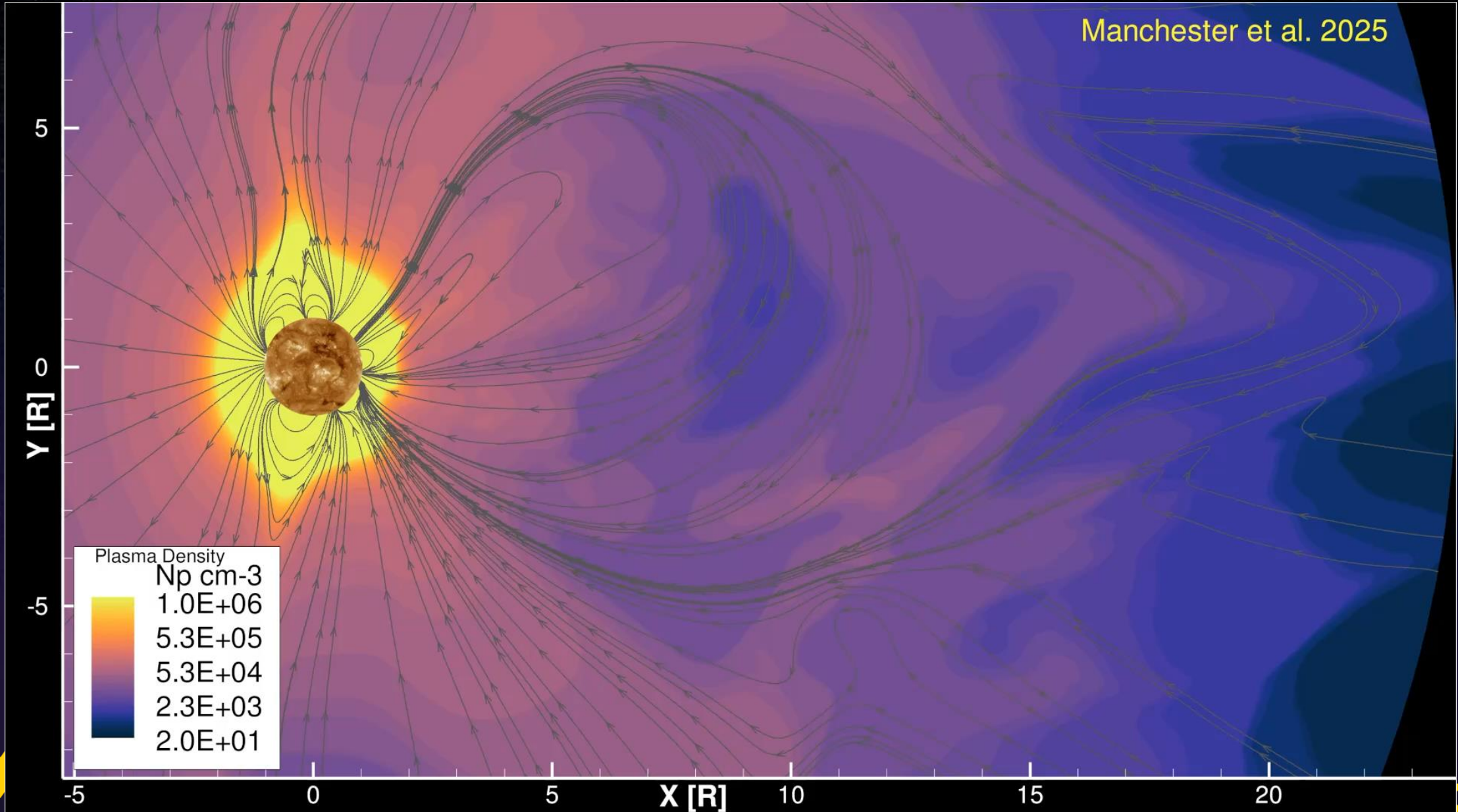
• Time =0 Polar View



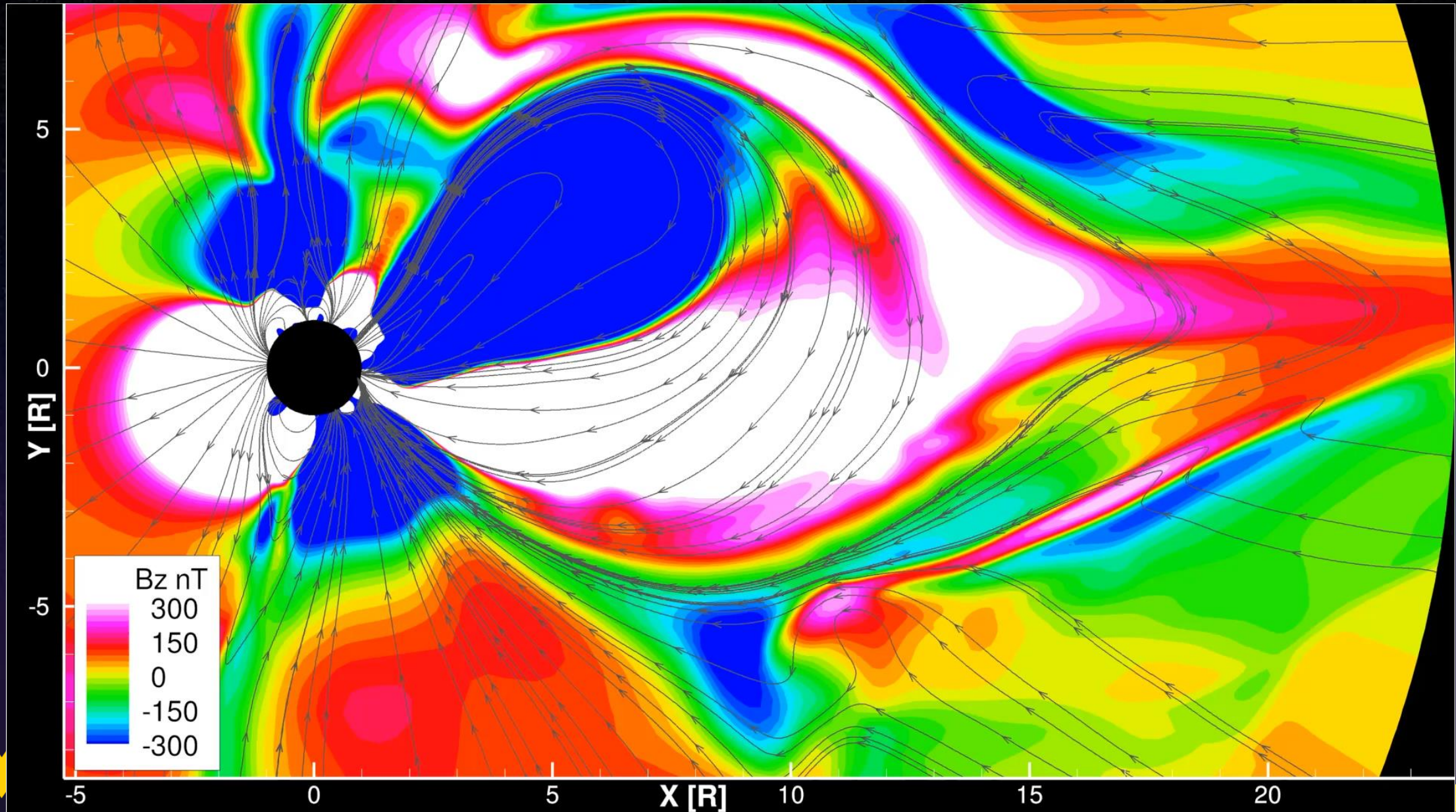
# Plasma Density on Vertical (xz) Cut Plane



# Plasma Density on the (xy) Equatorial Plane

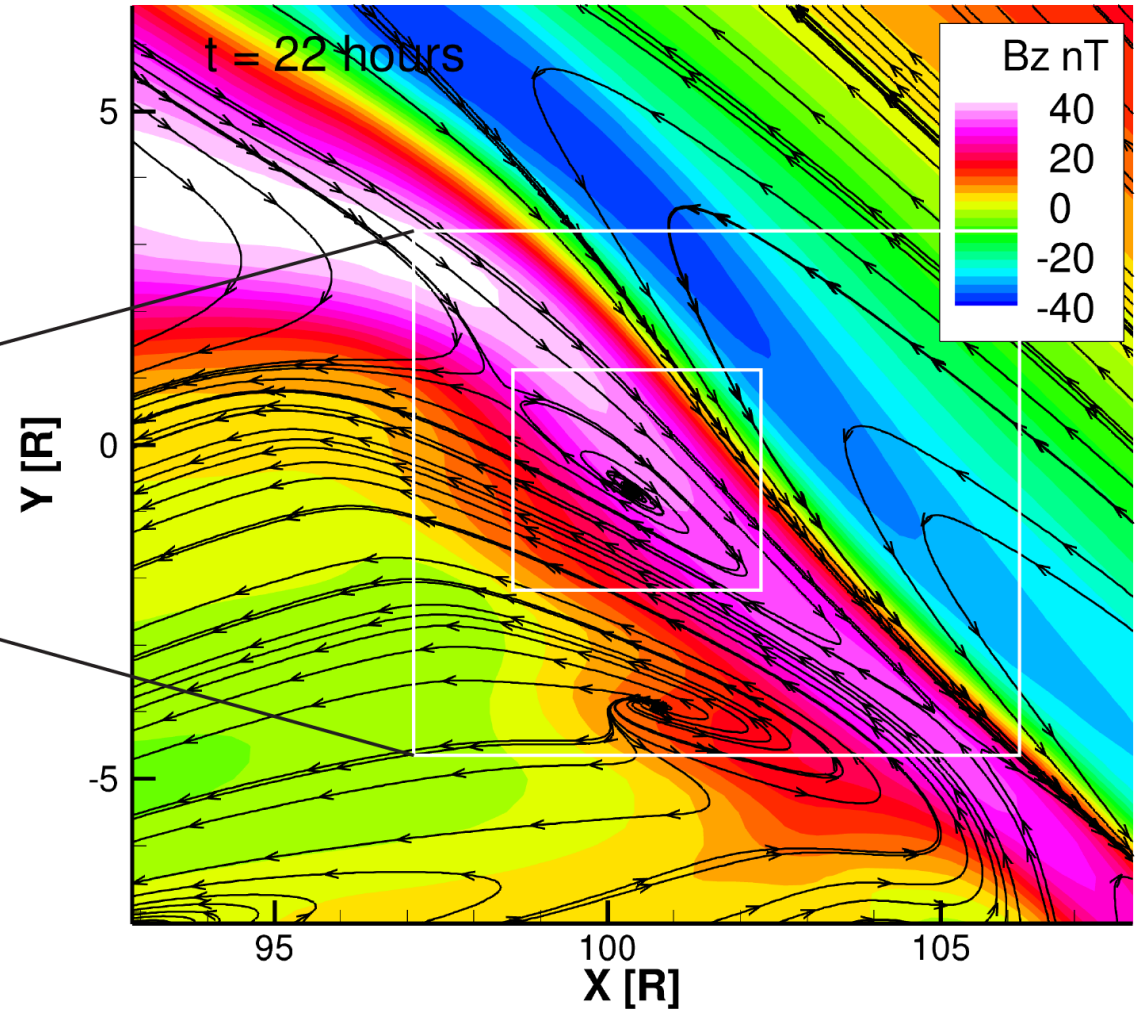
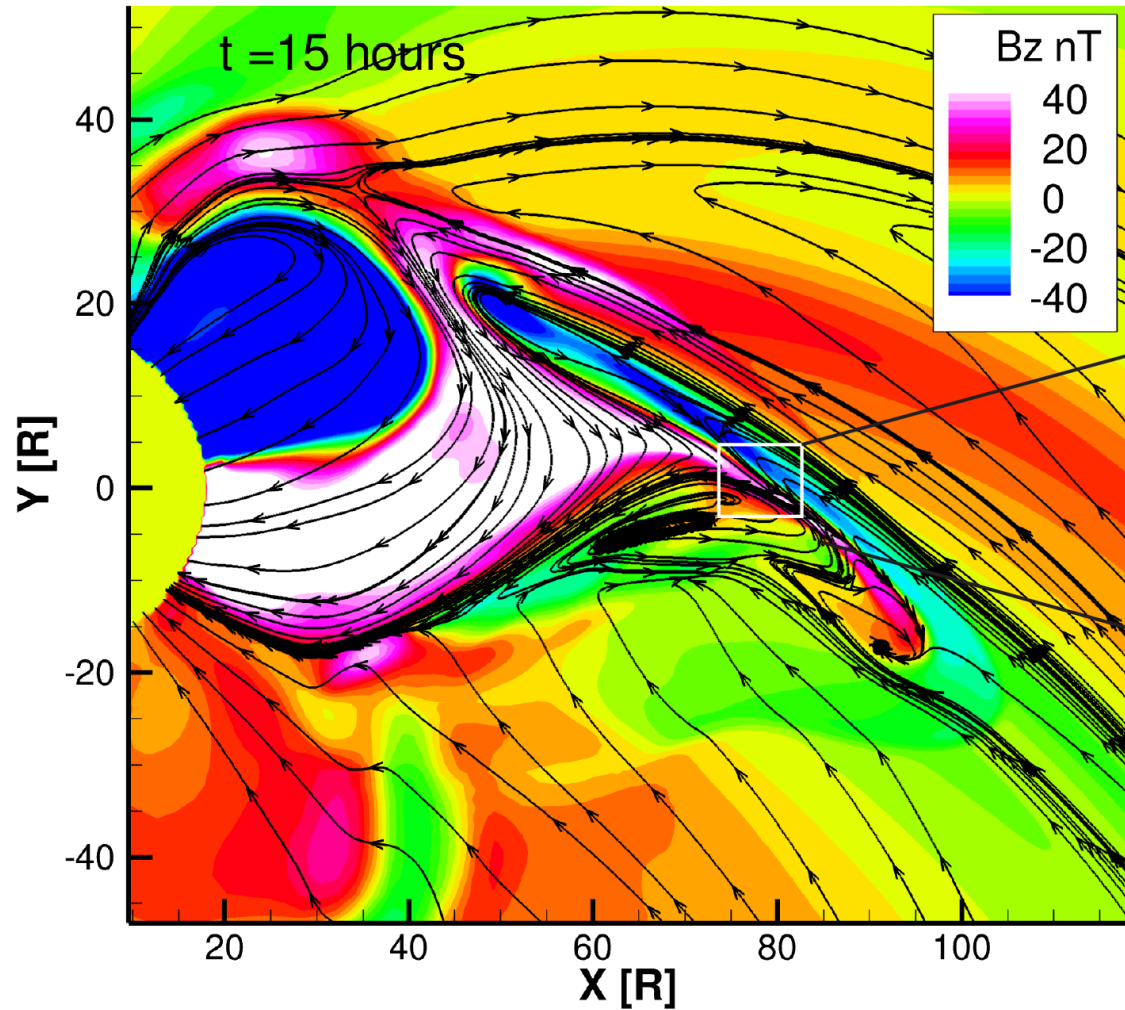


# Bz on the (xy) Equatorial Plane



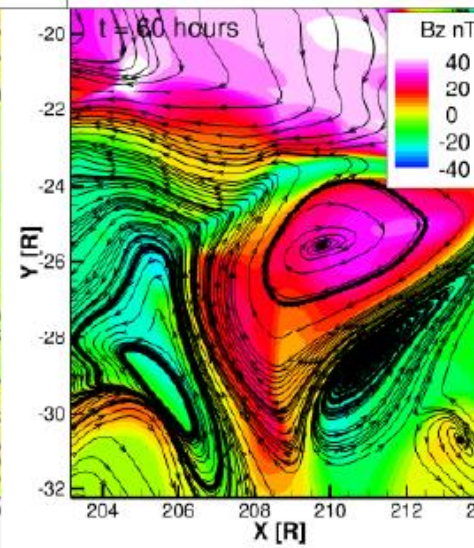
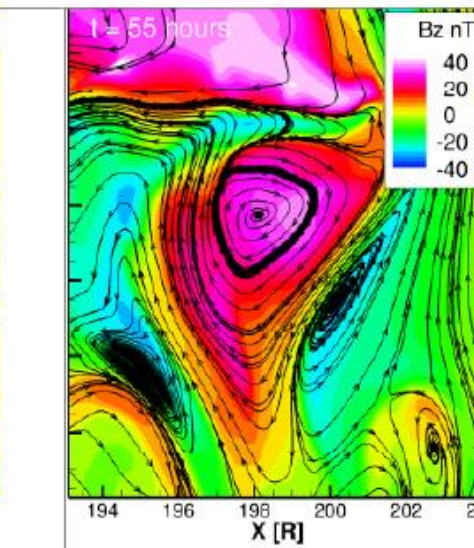
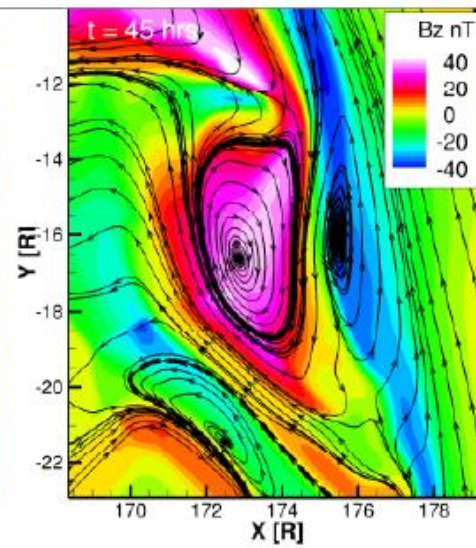
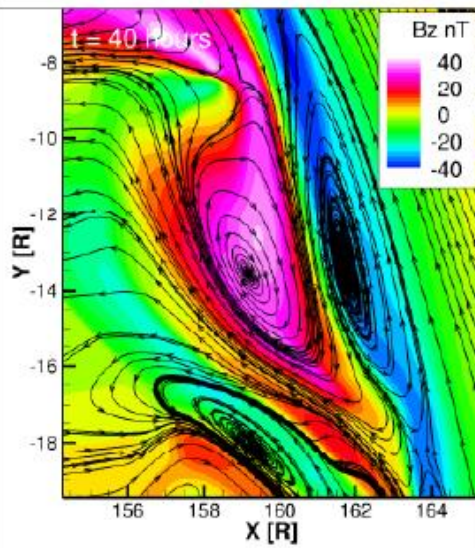
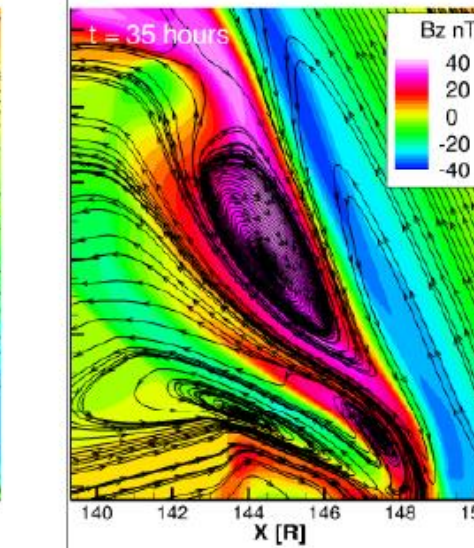
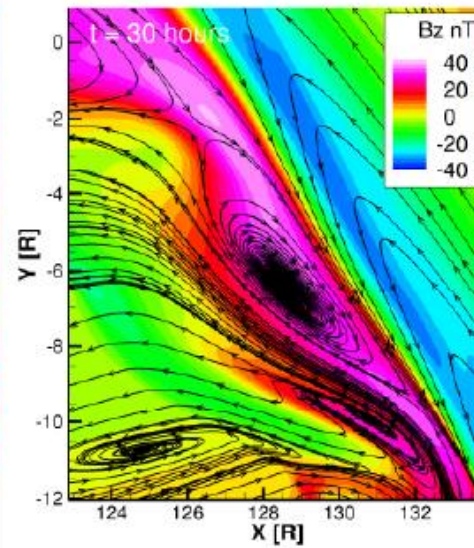
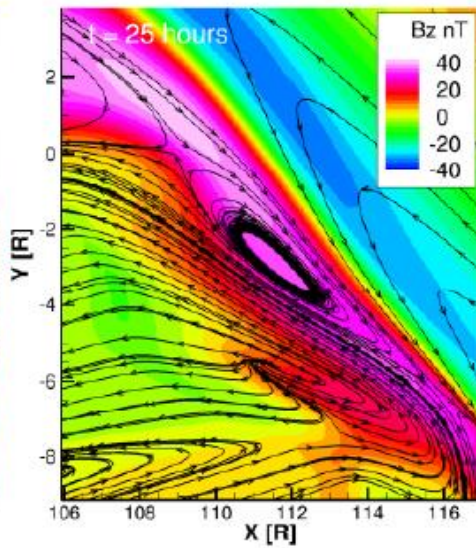
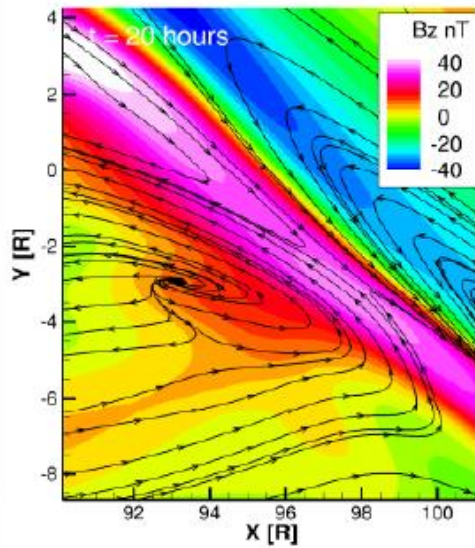
# CME-CIR Flux Rope Formation

t = 15 hours Current Sheet Formation t = 22 hour Flux Rope Formation



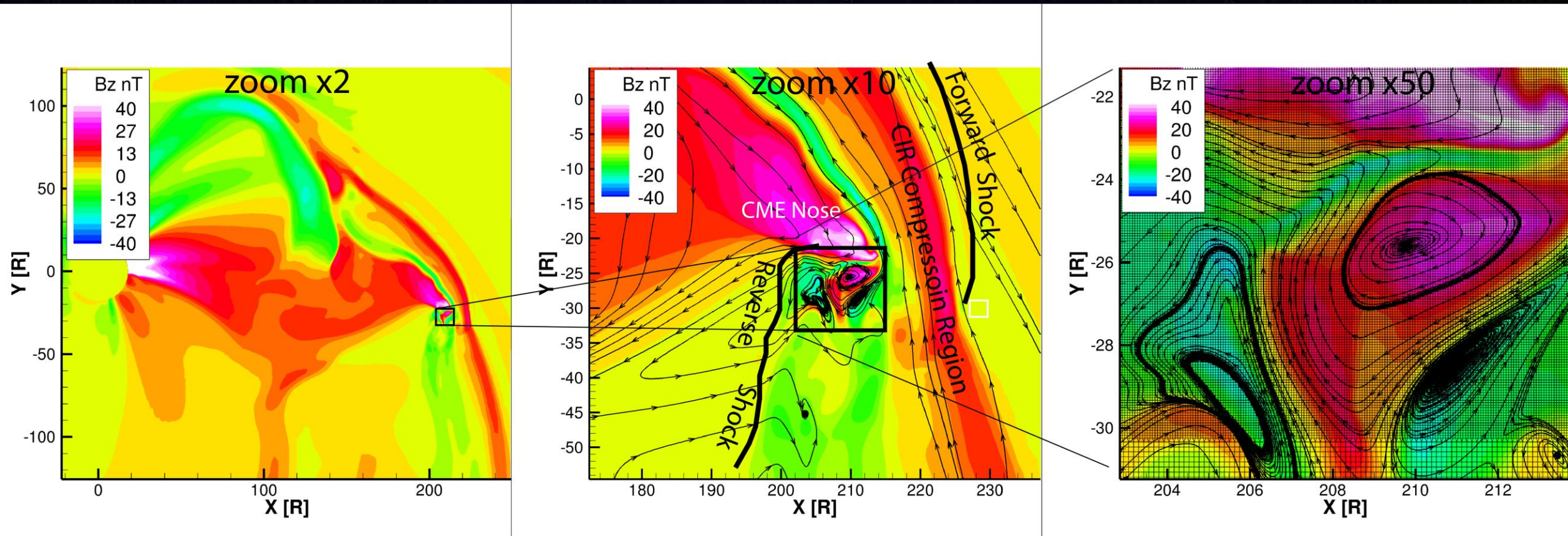
# CME-CIR Flux Rope Formation

Time = 20-60 hours Equatorial Plane



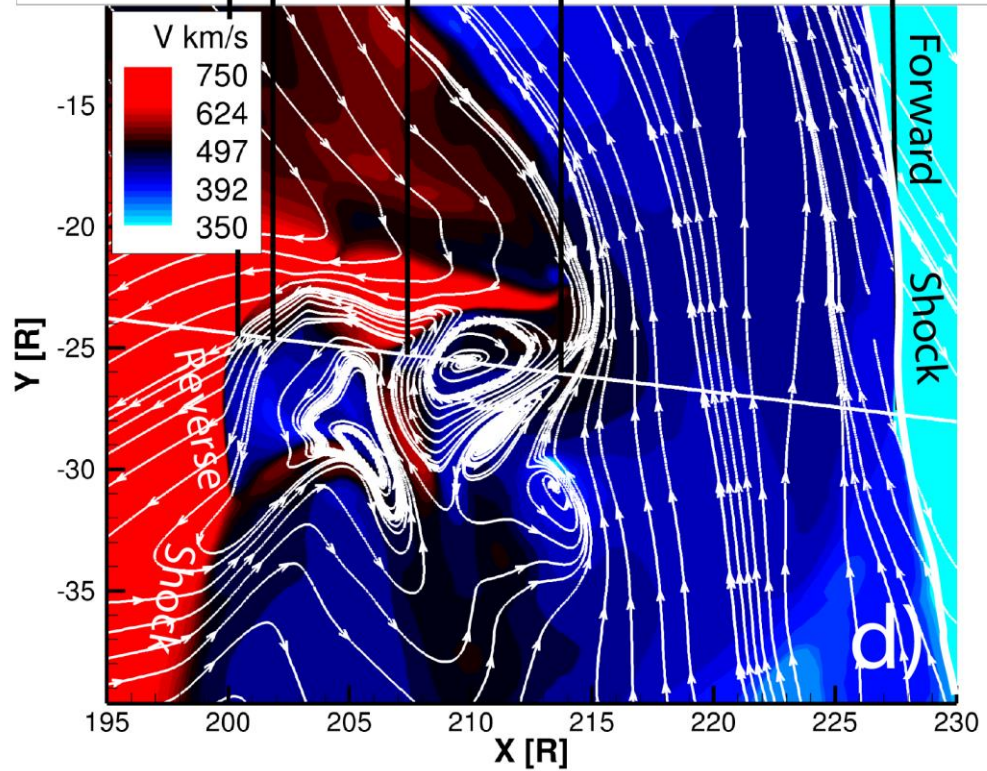
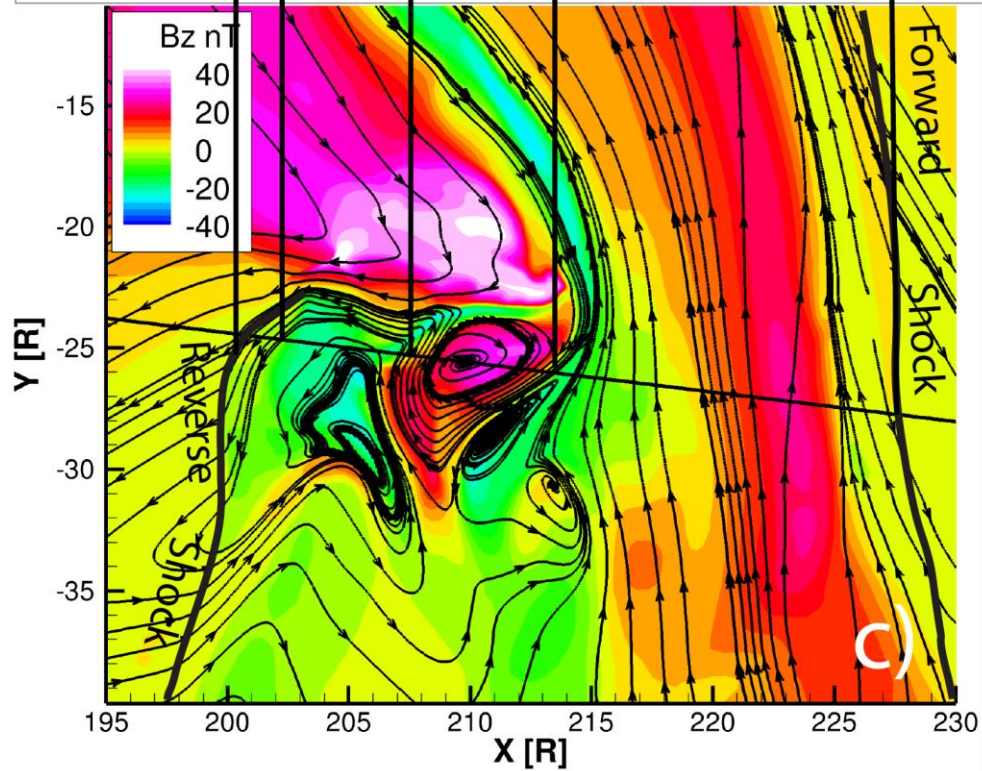
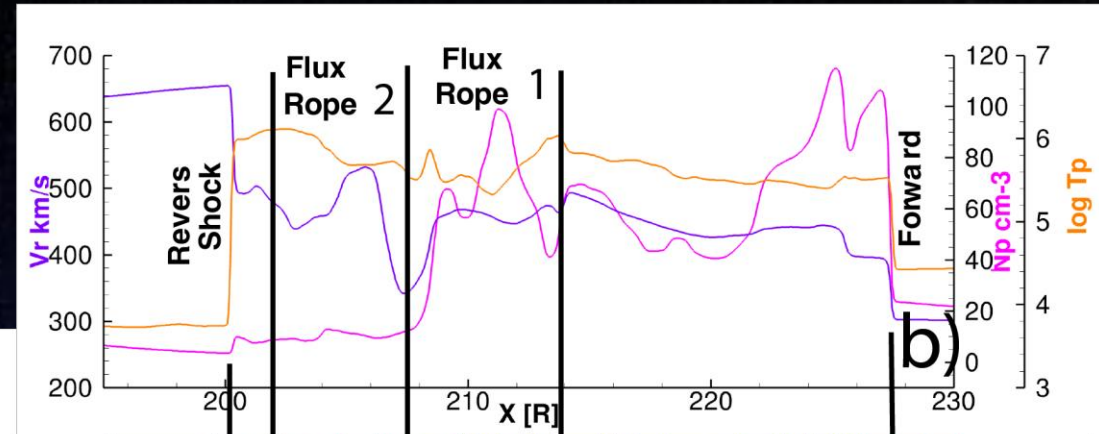
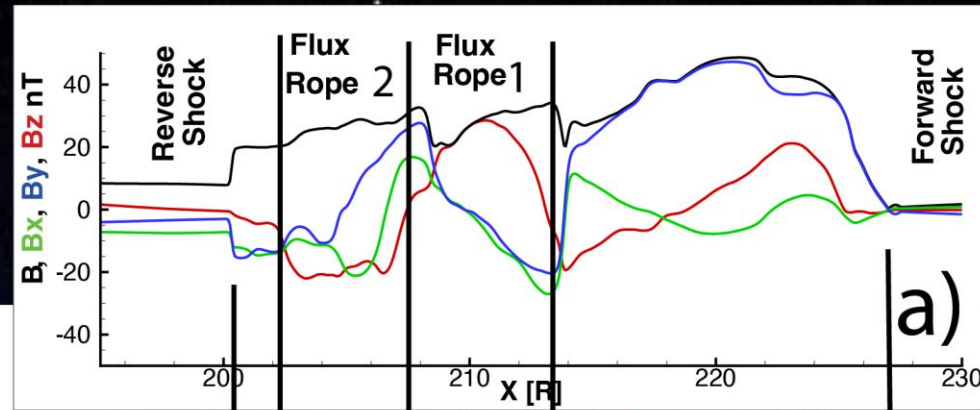
# Meso

- time = 60 minutes: Zoom in Bz on the Meridional plane



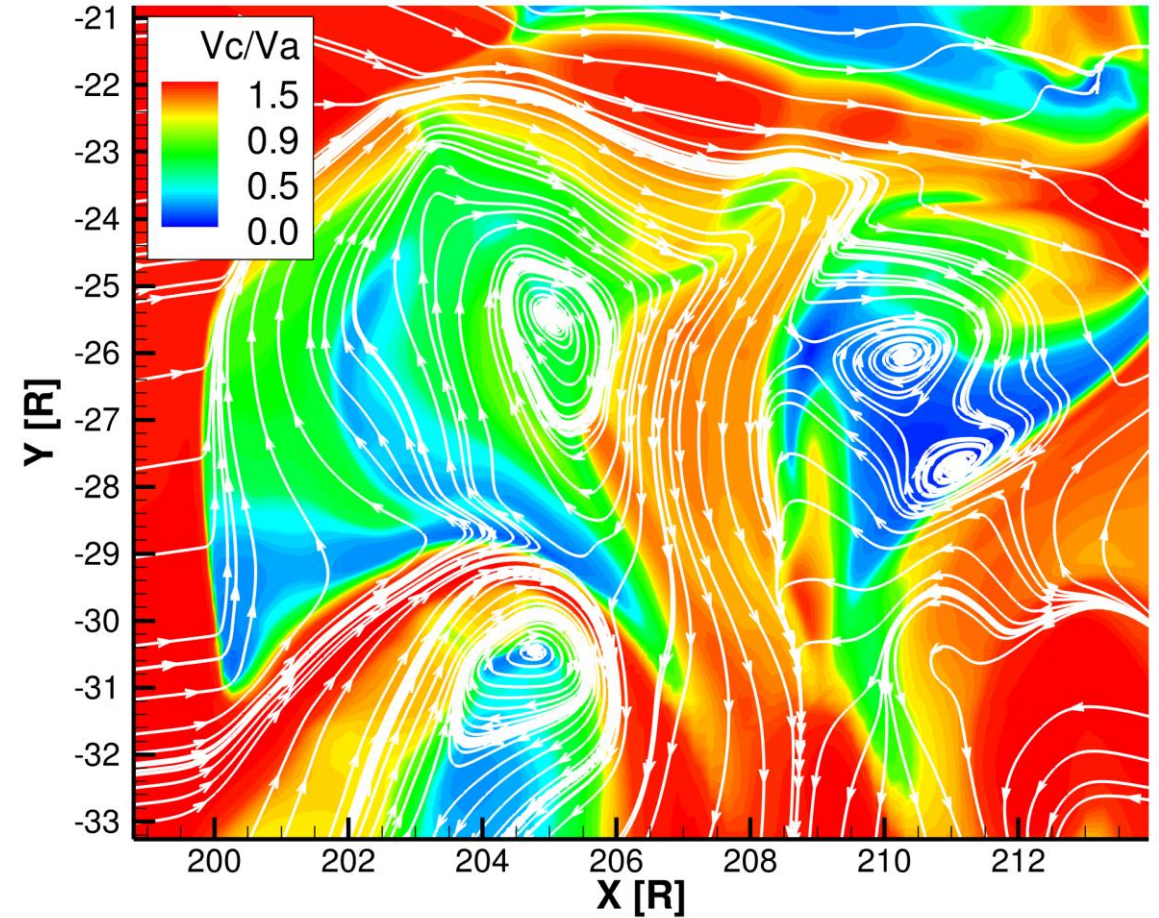
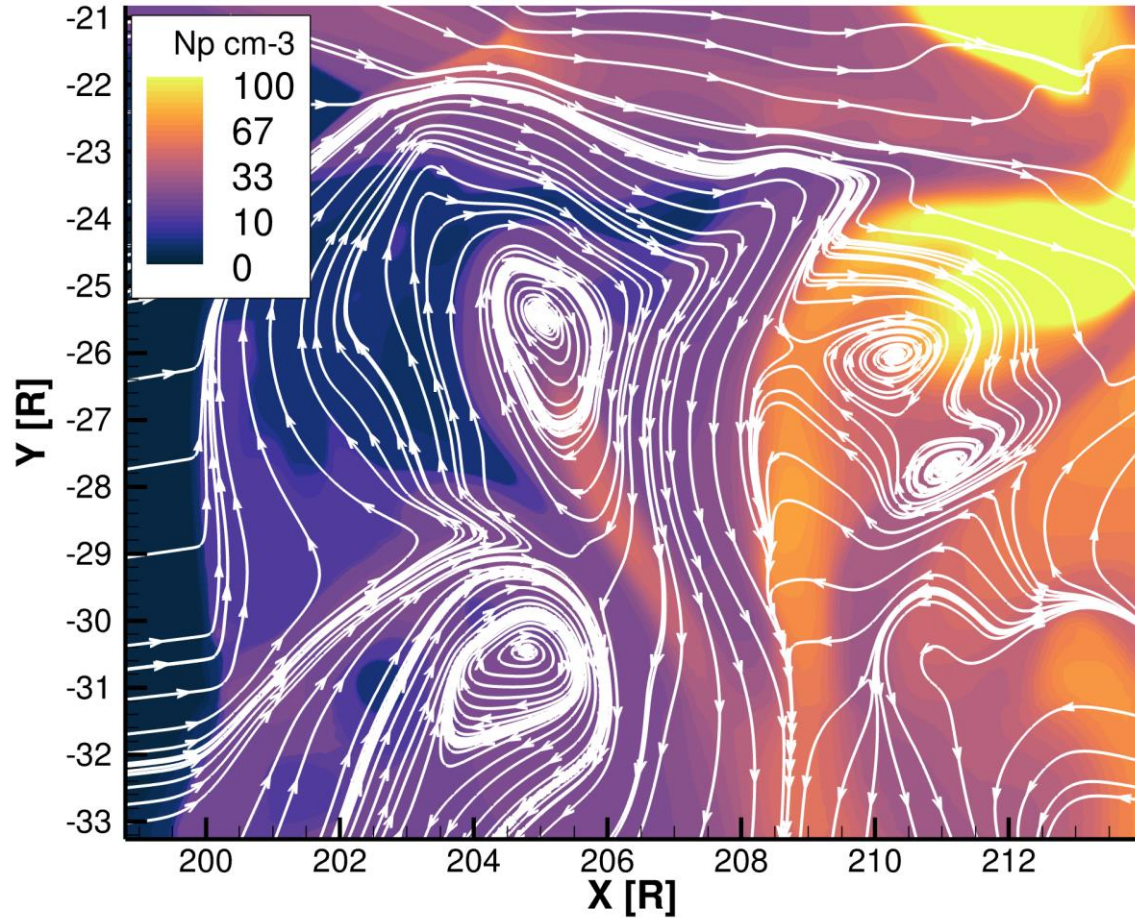
# Detailed Structure of Mesoscale Flux Ropes

- T = 60 hours Equatorial plane & Radial Line Extraction

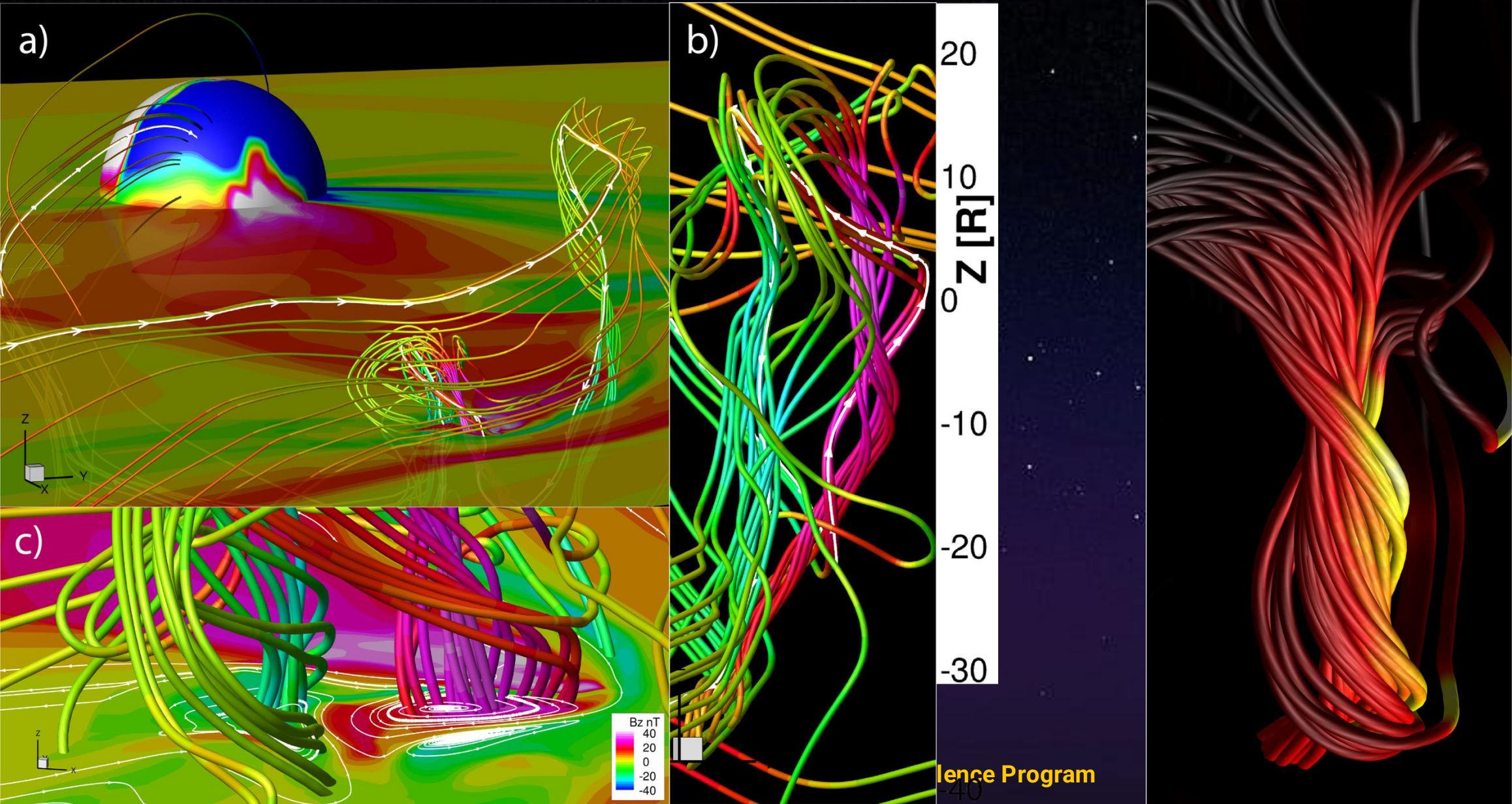


# Turbulent Flows of Mesoscale Flux Ropes

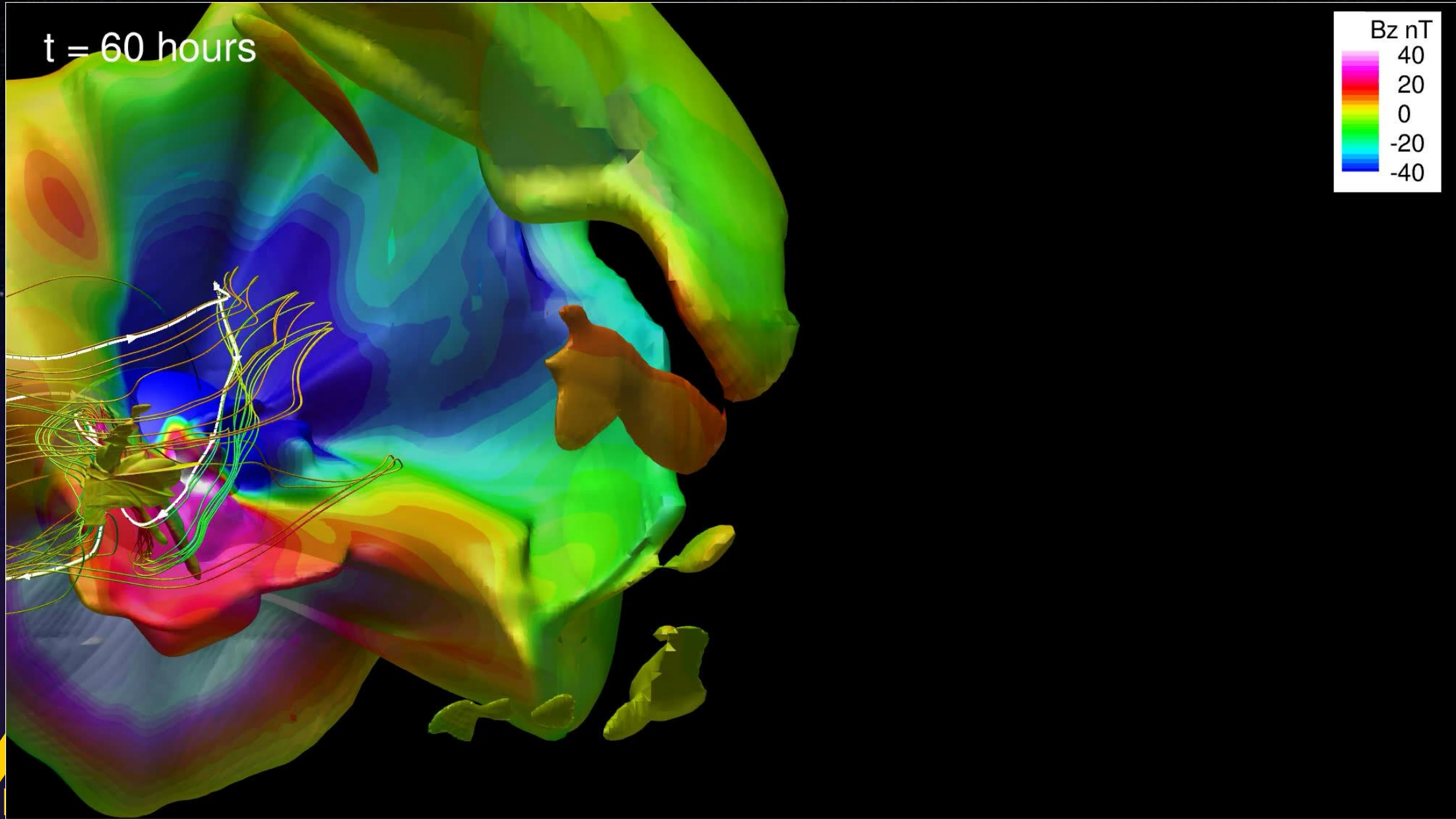
- T = 60 hours Equatorial plane



# 3D structure of Mesoscale Flux Ropes



# 3D structure of Mesoscale Flux Ropes



# SWIFT Mission at L1

# SWIFT Constellation

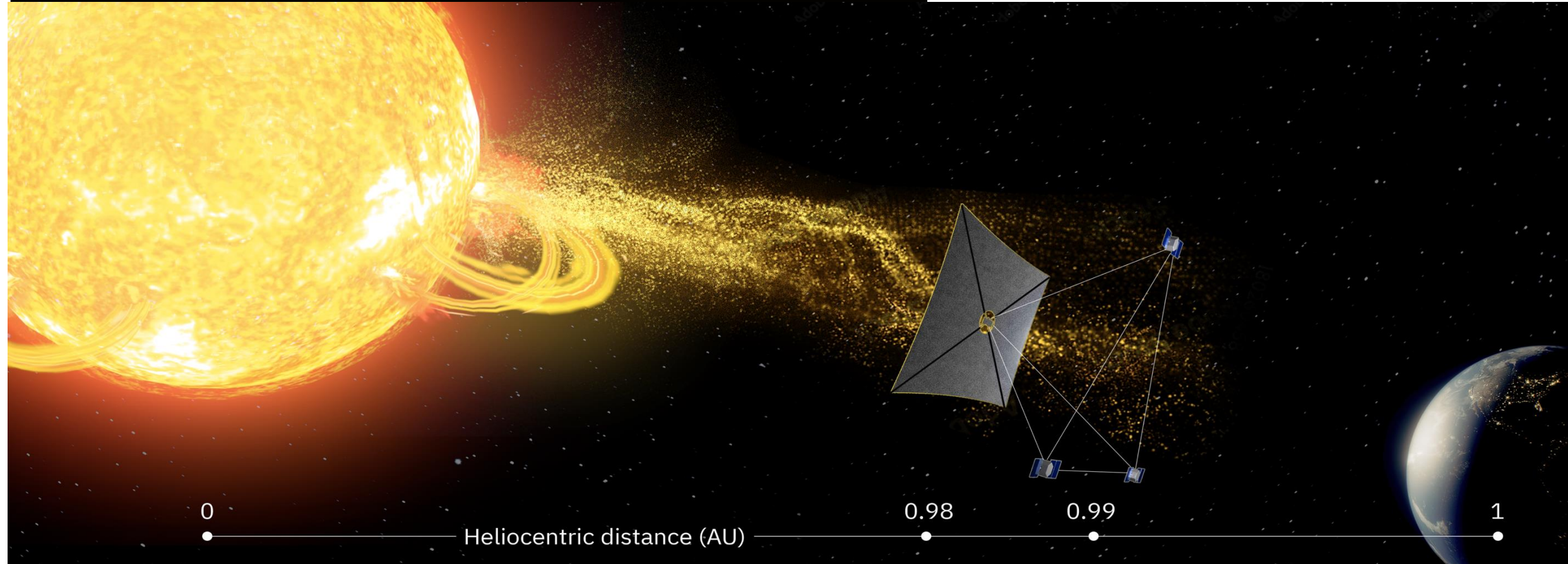
ROSES 2022 - B10. Heliophysics Flight Opportunities Studies (HFOS)

## SPACE WEATHER INVESTIGATION FRONTIER

### 1 "hub" @ sub-L1

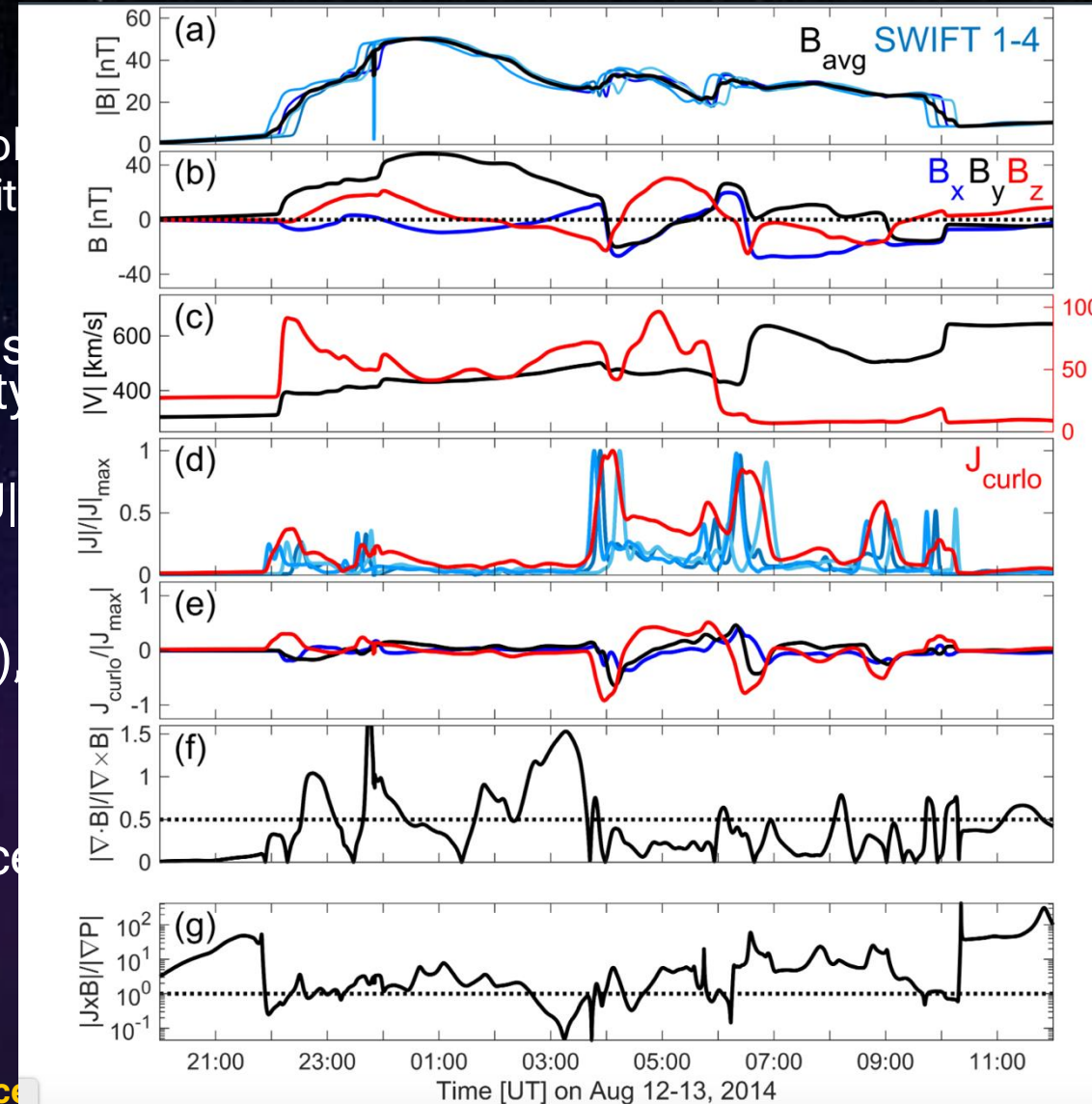
- Solar sail propulsion
- Lissajous orbit

### 3 identical "nodes" @ L1



# Time-Series Data and SWIFT Reconstruction

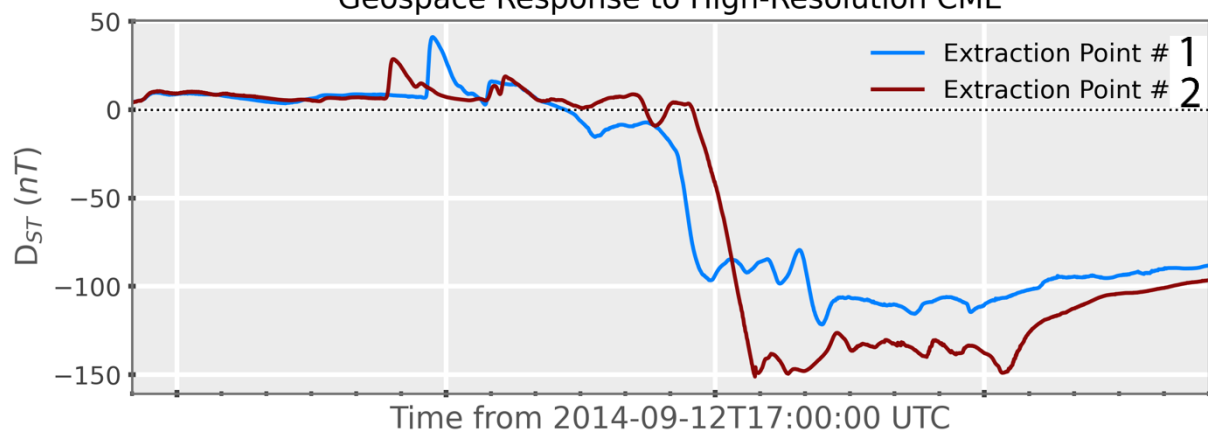
- Simulating CME-CIR Interaction with Super High Resolution
  - CR2154 at solar max. with current sheet passing over the pole
  - Fast CME originates in an AR very close to a coronal hole with no dense plasma ahead of the CME
  - Super high-resolution 1/16  $R_s$  grid total of 240 million cells
- Magnetic field magnitude ( $|B|$ ); (b) the field components from SWIFT 1, (c) plasma speed ( $|V|$ ) and proton density ( $n_p$ ) from SWIFT 1, (d) simulation total electric current density ( $|J|$ ) as well as the one evaluated from the SWIFT 1-4 magnetic field
- Data with the curlometer technique (Dunlop et al. 2002), (e) current density components, (f) the ratio of the magnetic field
- Divergence and curl, (g) the ratio between the total magnetic forces ( $|J \times B|$ ) and ion pressure gradient force ( $|\nabla P_i|$ ), and the
- BZ component extracted as a time series and along a correspondent spatial line shown in previous Figures.



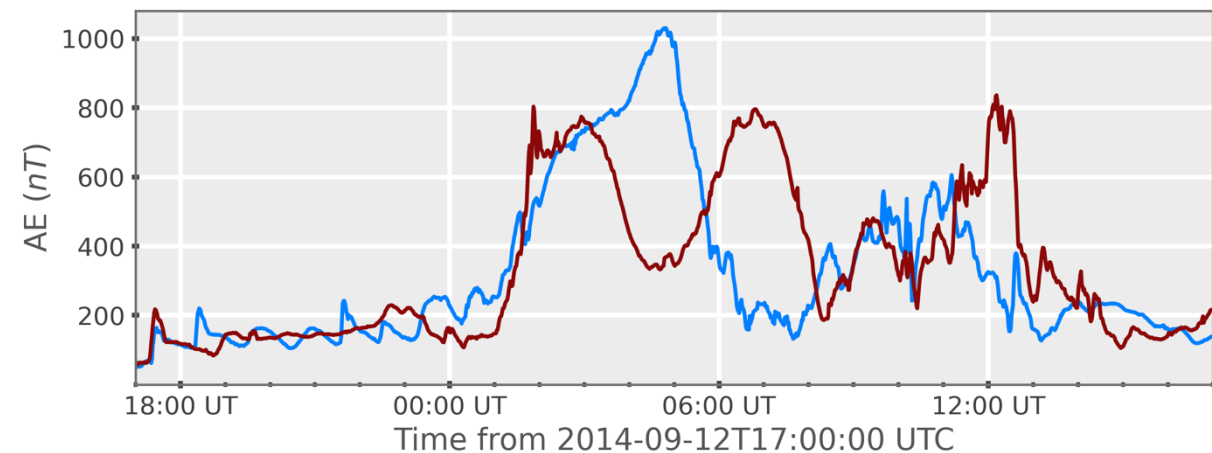
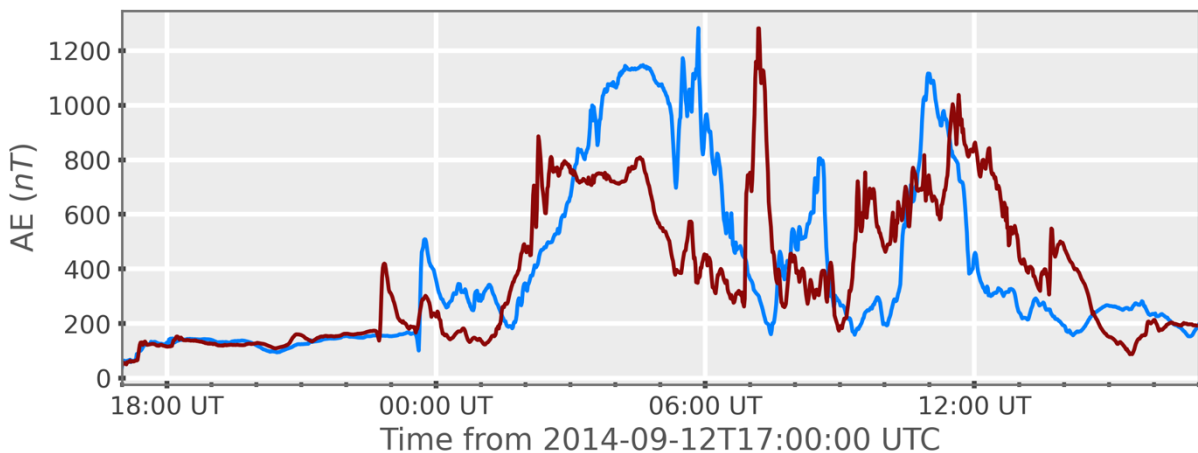
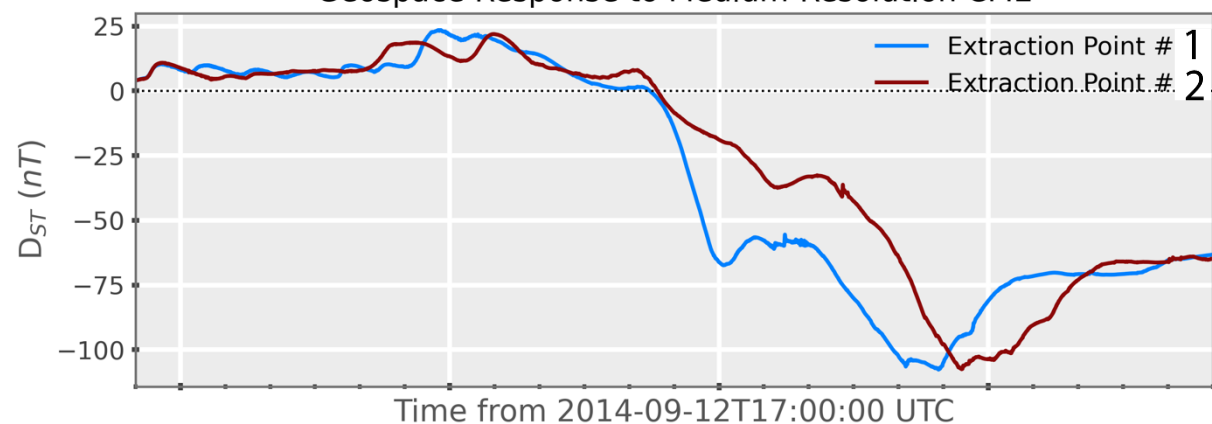
# Magnetospheric Response to Mesoscale Flux Ropes

• High-resolution CME (SW) Observation setup: GM-RIM-ADAM  
• CR field has little impact on Dst, storm onset occurs with mesoscale dry  
• High resolution minimum Dst of -150 nT, Medium resolution Dst of -110 nT

Geospace Response to High-Resolution CME



Geospace Response to Medium-Resolution CME



# Summary

- Simulation of CME-CIR Interaction with Medium to High Resolution
  - CR2154 at solar max. with current sheet passing over the poles
- Fast CME propagates directly into a low-density high-speed stream forming a protrusion extending up the backside of the CIR
- Strong reverse shock forms behind the flux rope cluster compressing and maintaining strong geoeffective magnetic fields
- Hi Res: Current sheet reconnection forms a cluster of mesoscale flux ropes  $|B| \sim 30\text{-}40$  nT, Dst down to -150
- Medium Resolution: MS Ropes are lost  $|B|$  falls to 10 nT Dst -110
- Magnetosphere Impact: two vastly different results at two points only 400 Re apart. The under sampling is such that we cannot tell the end-user the magnitude of the threat from a single L1 monitor.

# CME at 1 Hour After Initiation

- Time = 1 hour z=0 plane (HGI)

