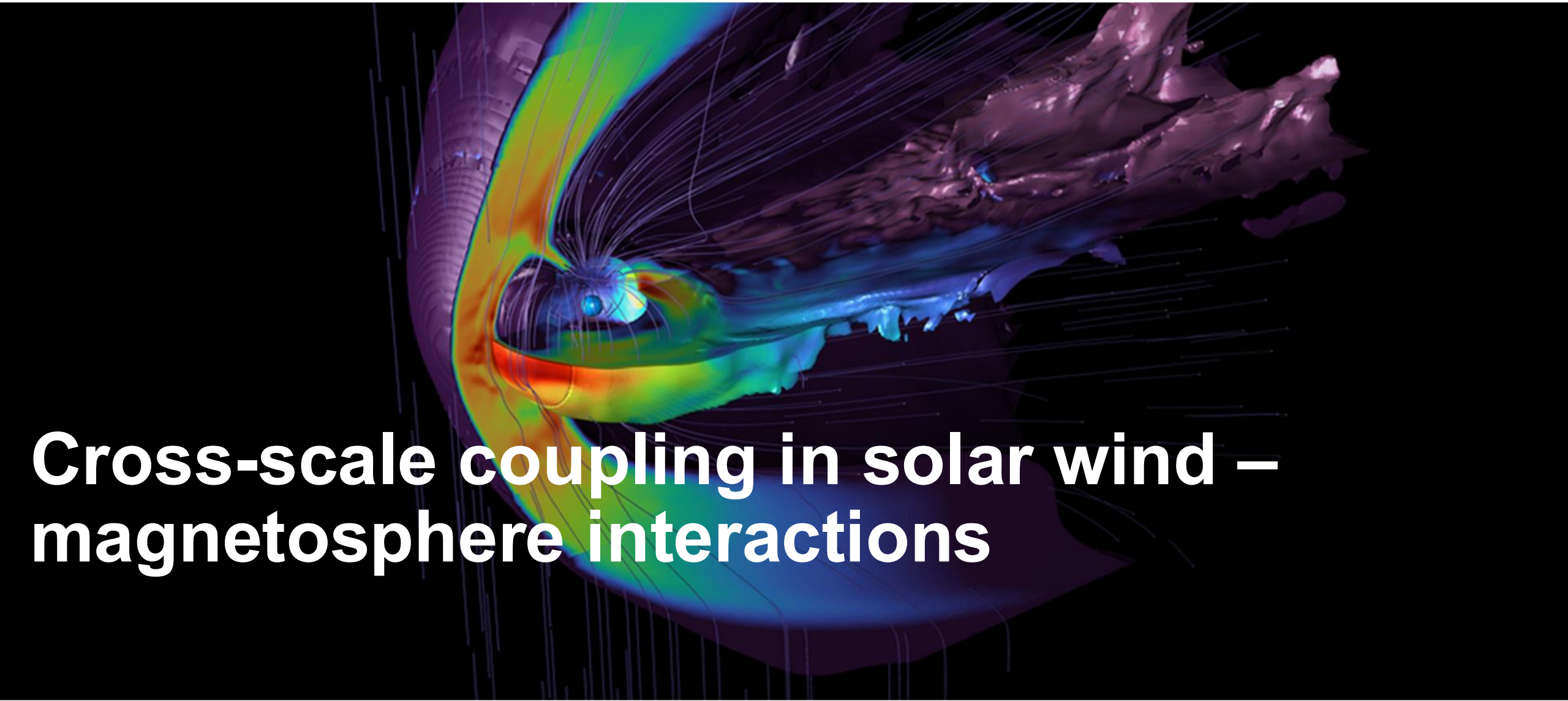
Mullard Space Science Laboratory

UCL



# Cross-scale coupling in solar wind – magnetosphere interactions

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CF

**Menti**

Magnetopause

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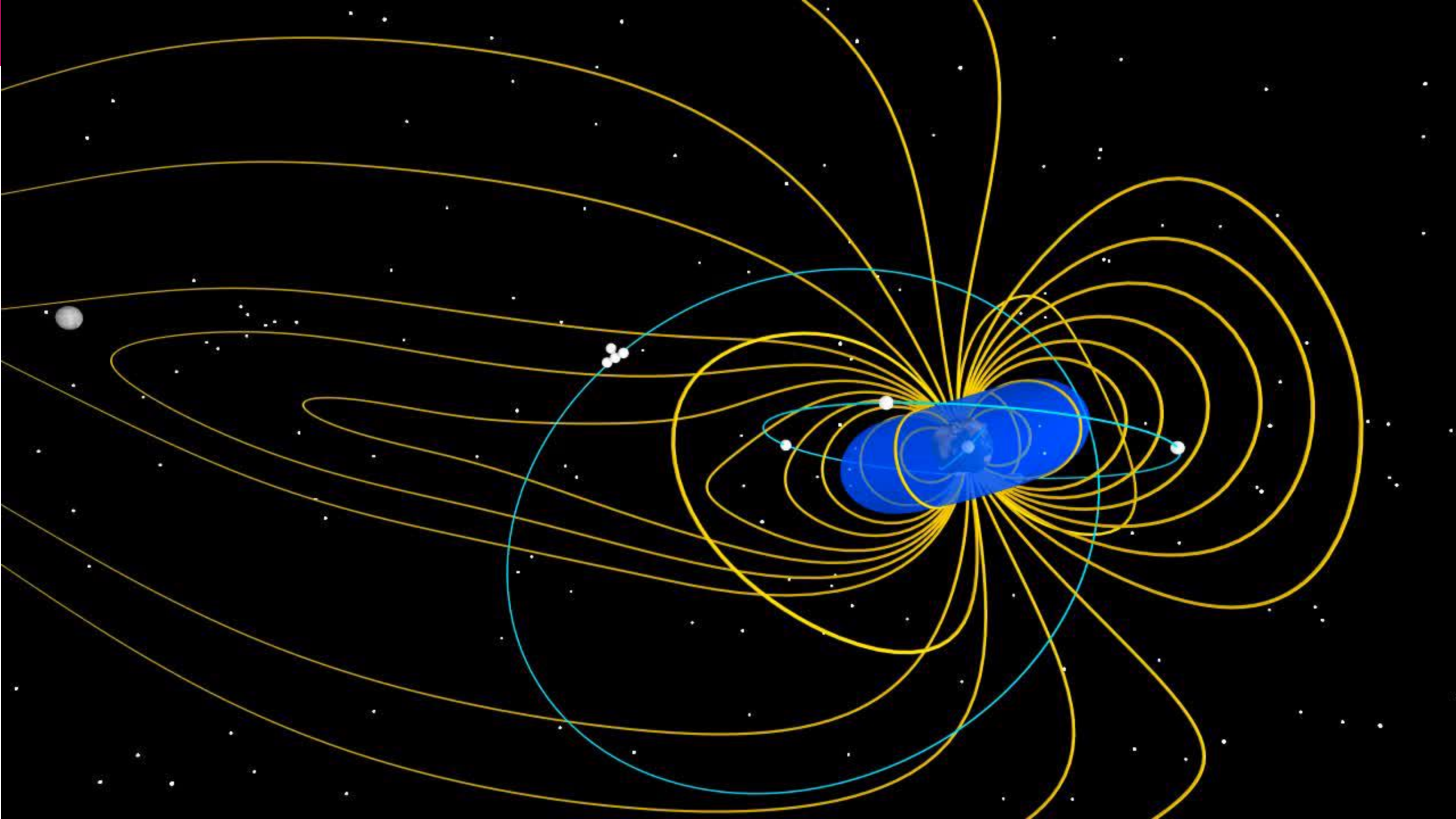

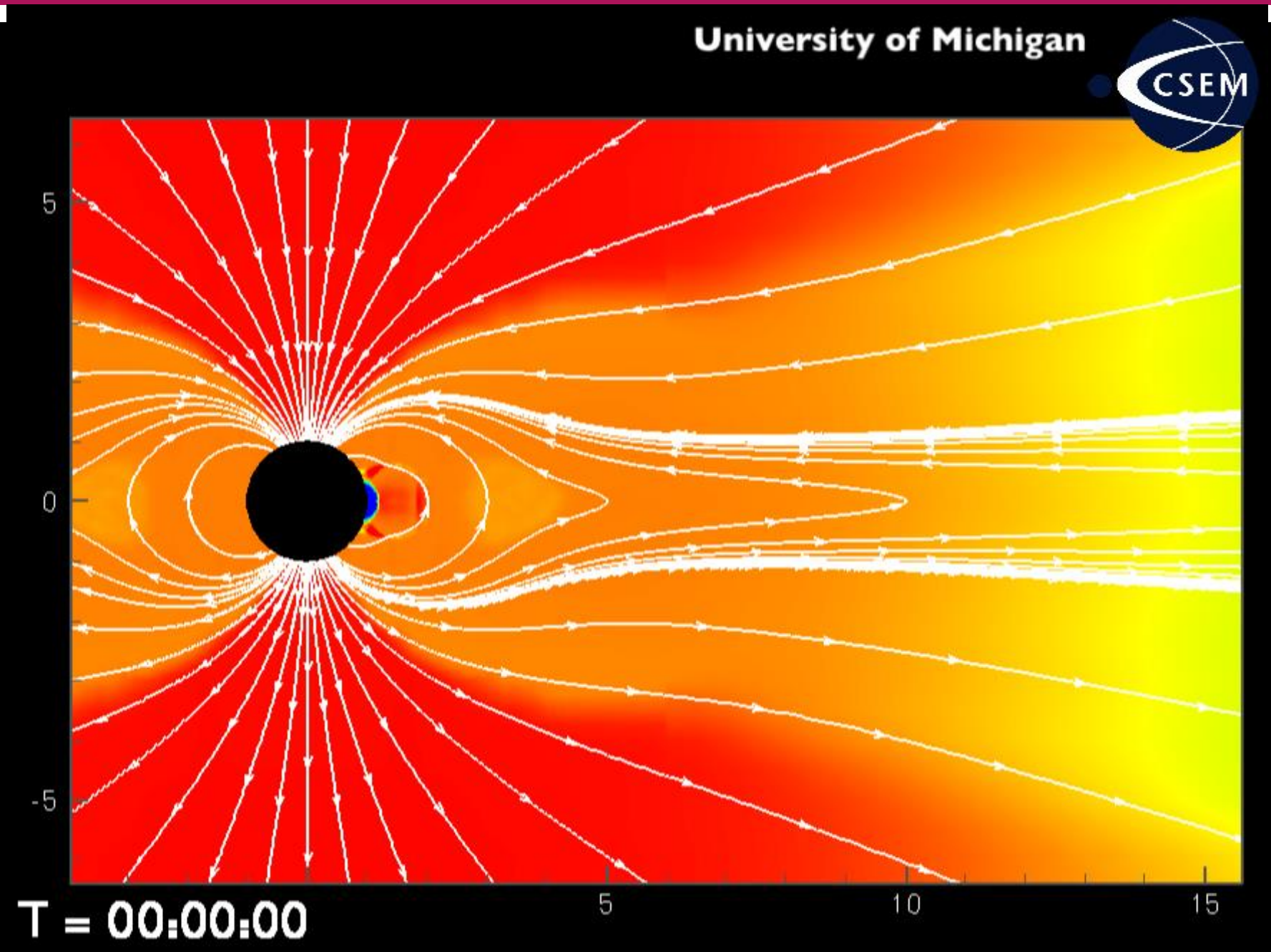
University of Michigan
CSEM
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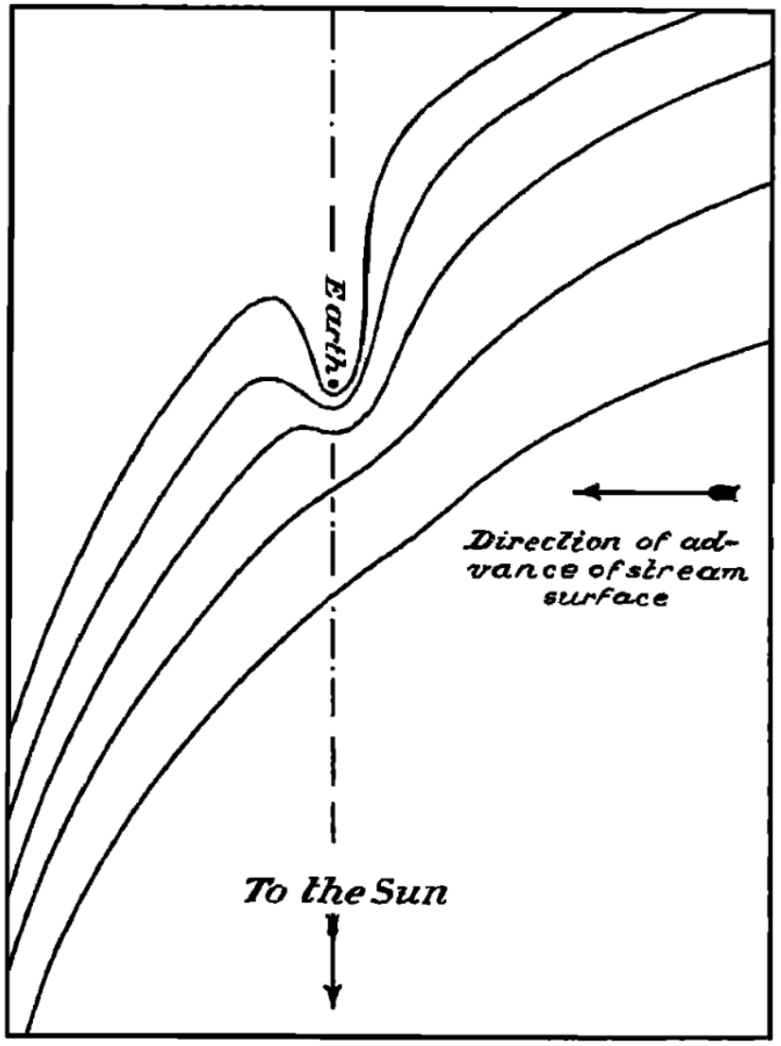
# Large-scale confinement (magnetopause)

Chapman & Ferraro (1931)



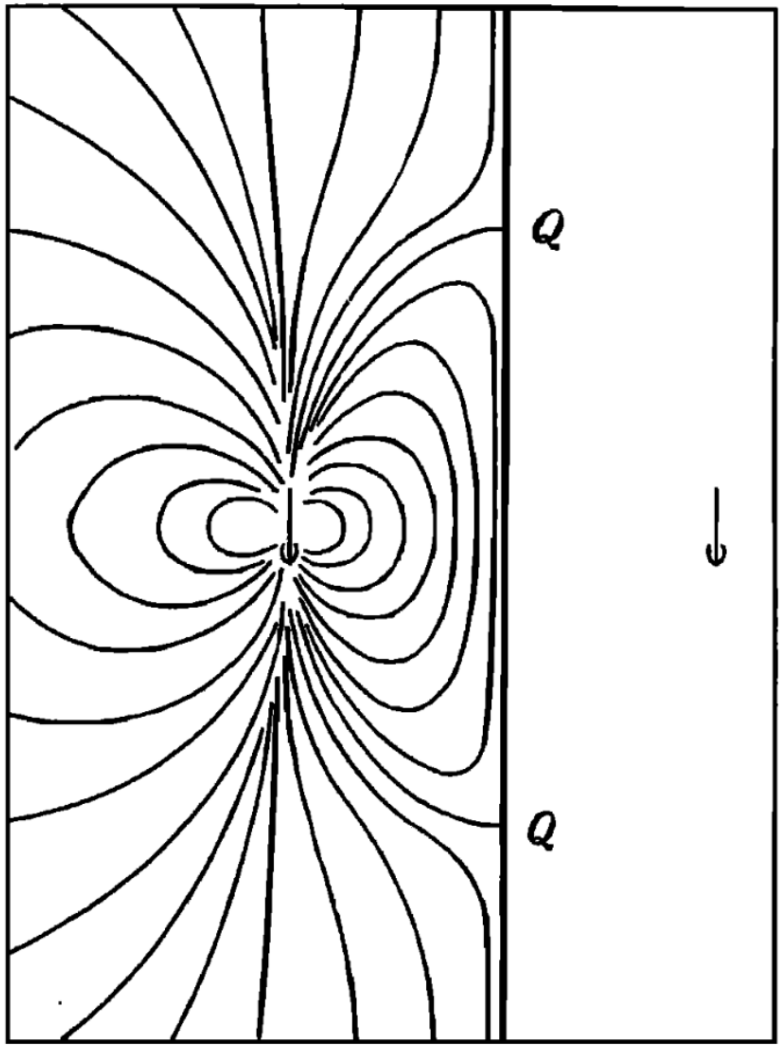




FIG. 4—Meridian section

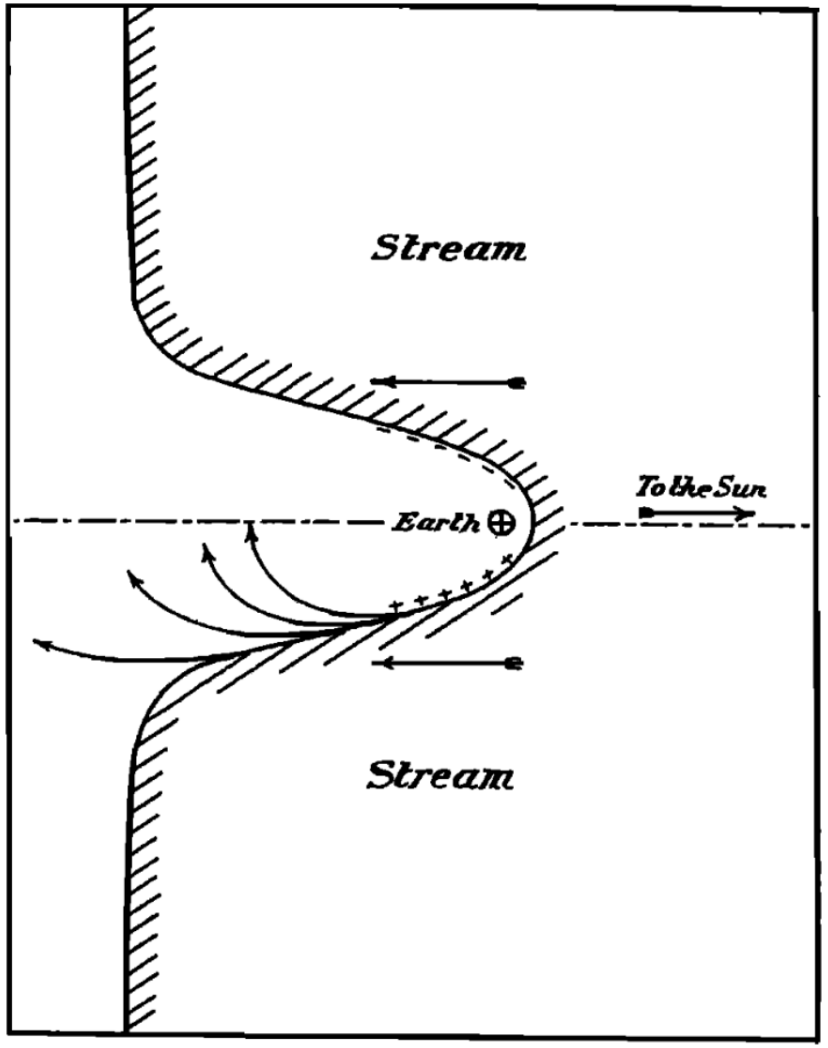
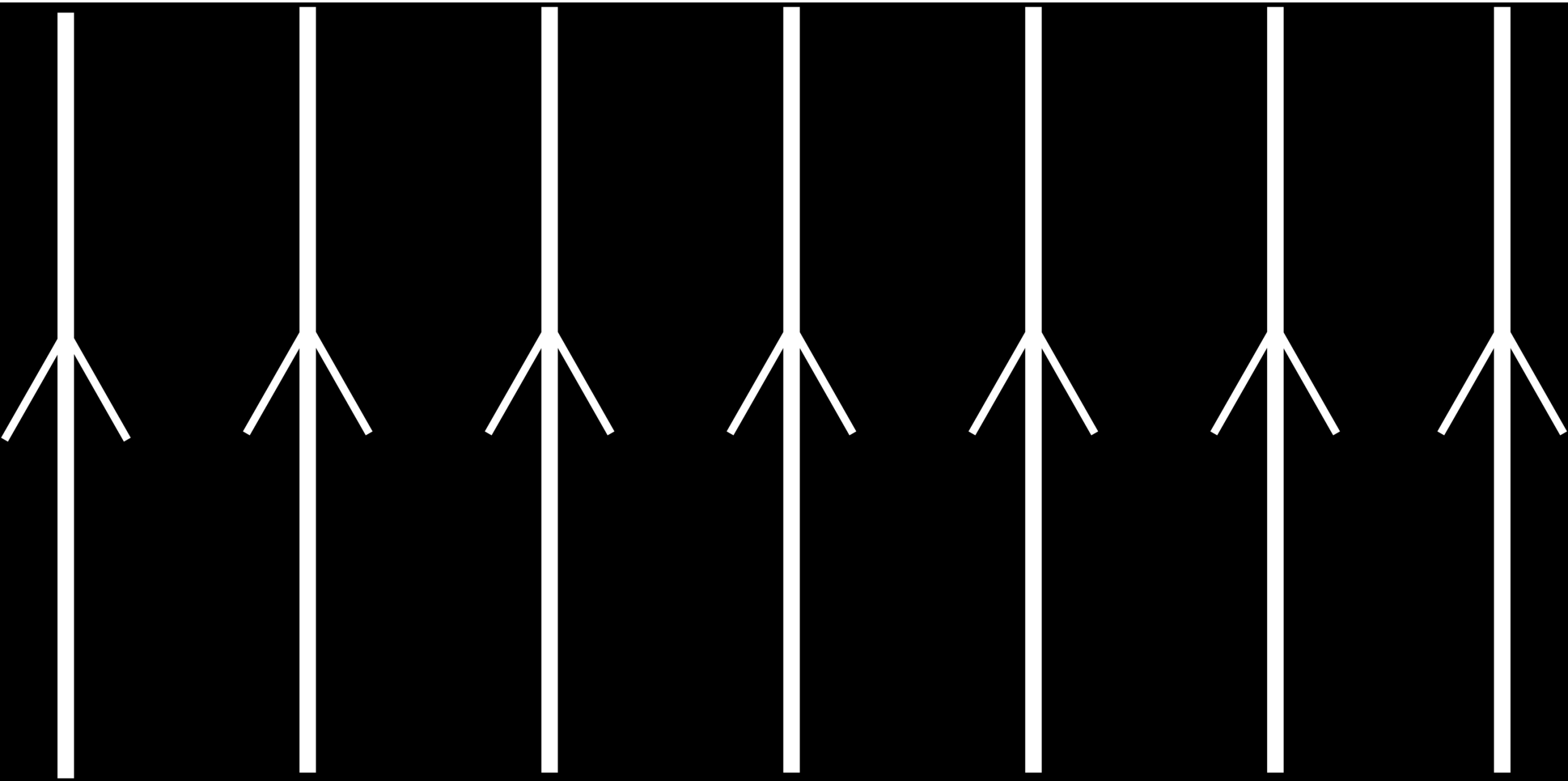
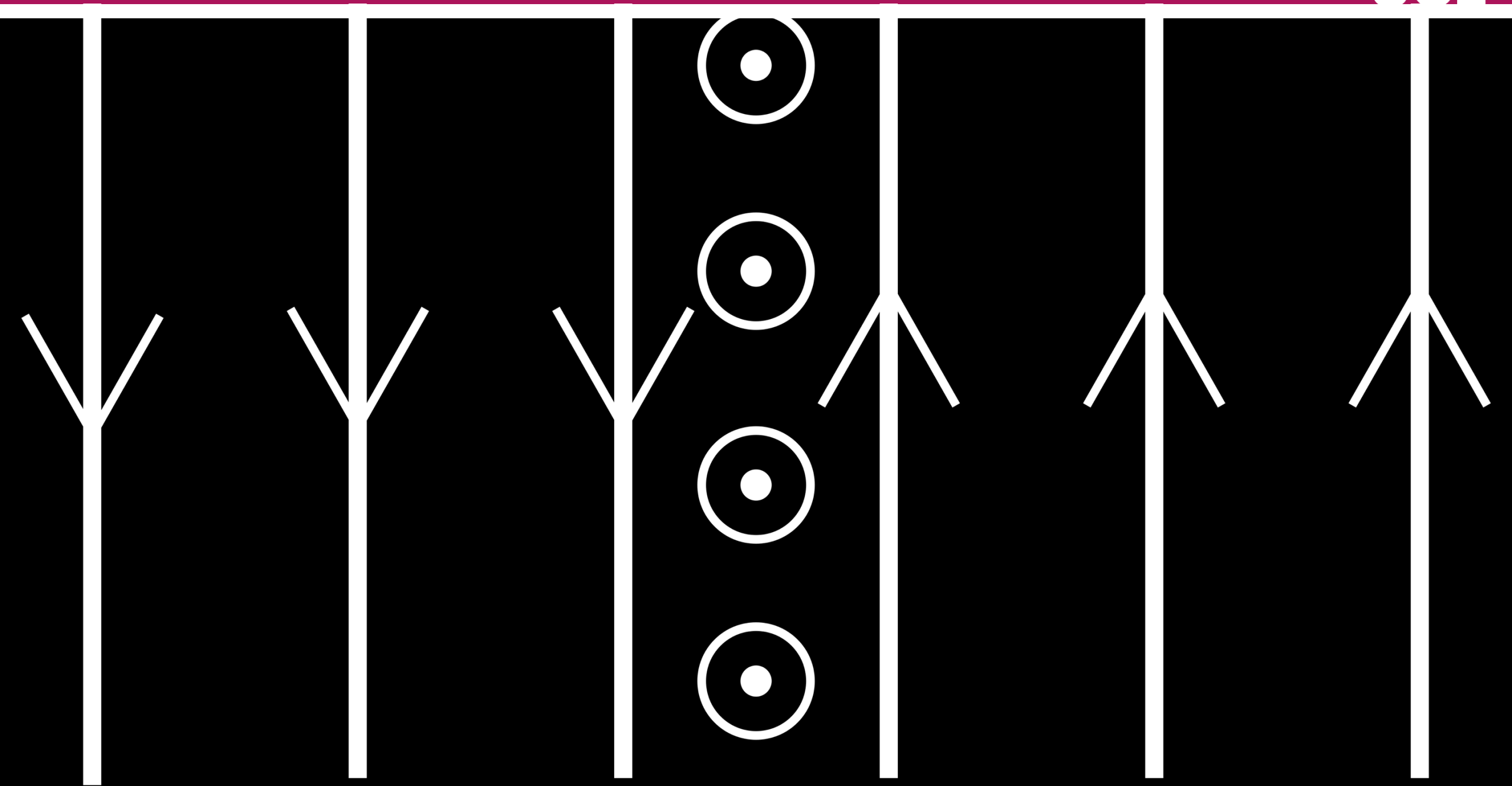
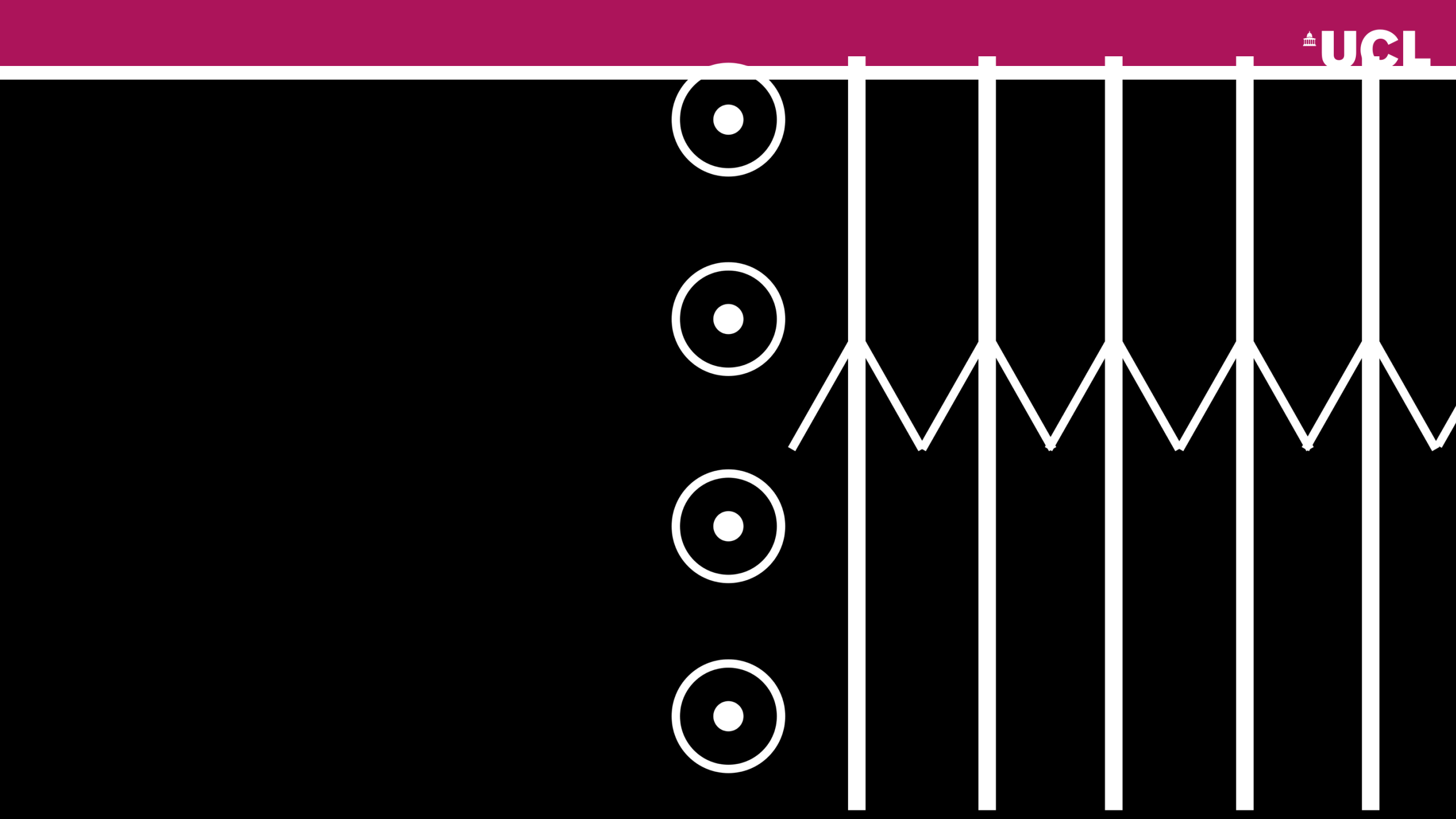



FIG. 5—Equatorial section







# Determining the boundary

$$\rho v^2$$

$$\frac{\left(2B_{dip}(r)\right)^2}{2\mu_0}$$

$$B_{dip} = \frac{\mu_0 M_E}{4\pi r^3}$$

$$r^6 = \frac{2\mu_0}{\rho v^2}\left(\frac{M_E}{4\pi}\right)^2$$

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Where is the nose of the magnetopause in Earth Radii?

Earth

Sun

CF

Menti

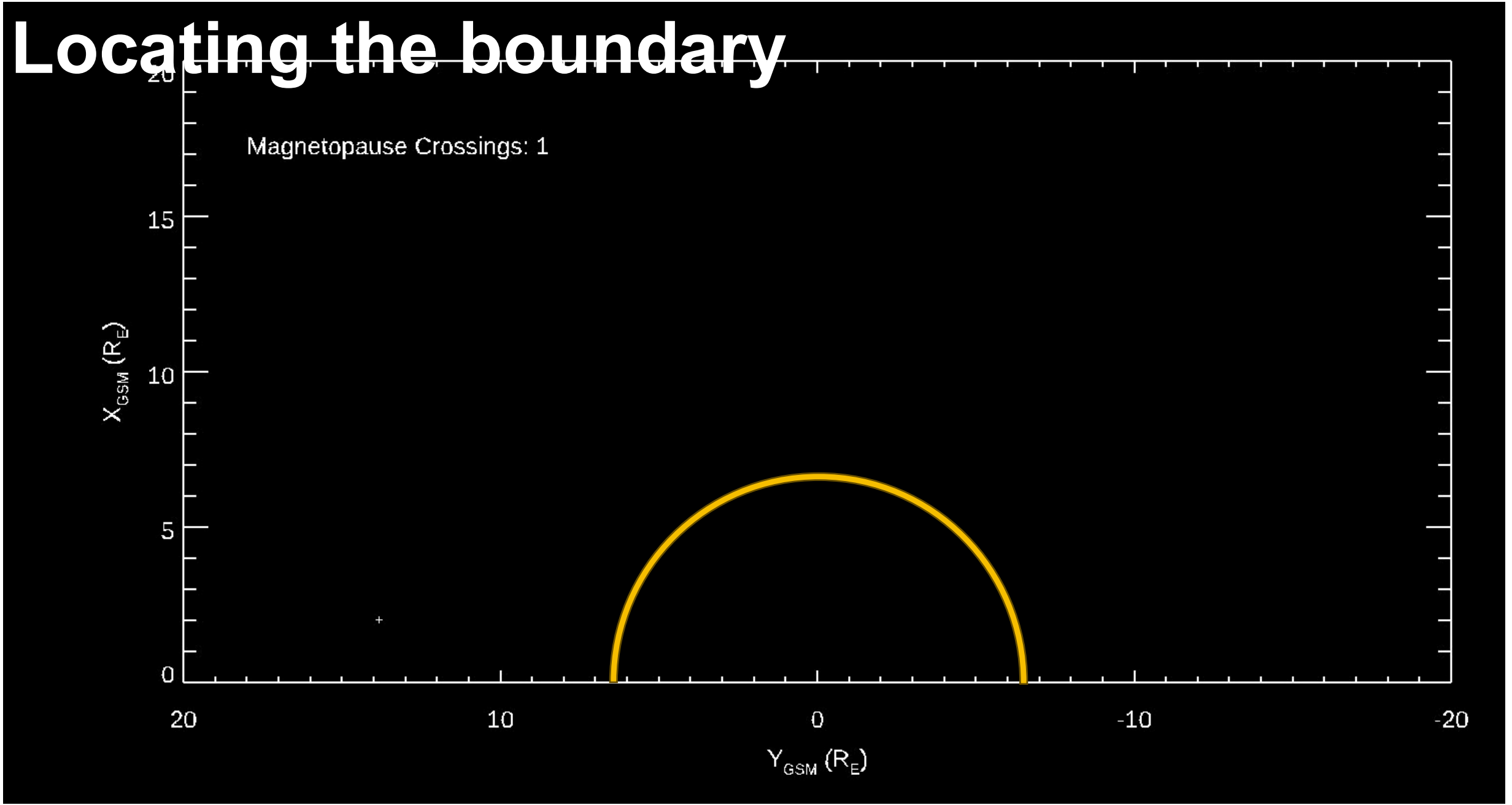
Magnetopause

Choose a slide to present

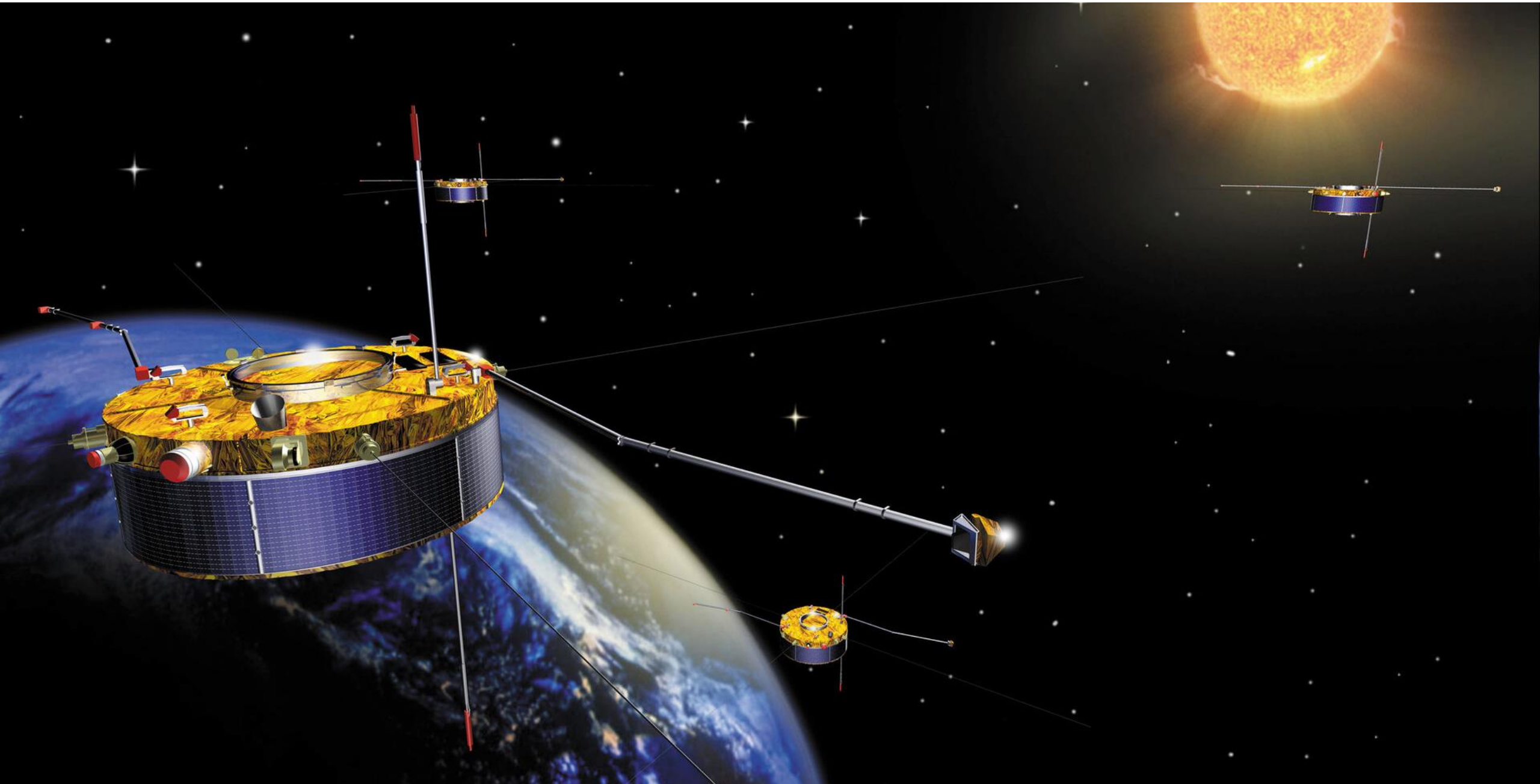
$$r^6 = \frac{2\mu_0}{\rho v^2}\left(\frac{M_E}{4\pi}\right)^2$$

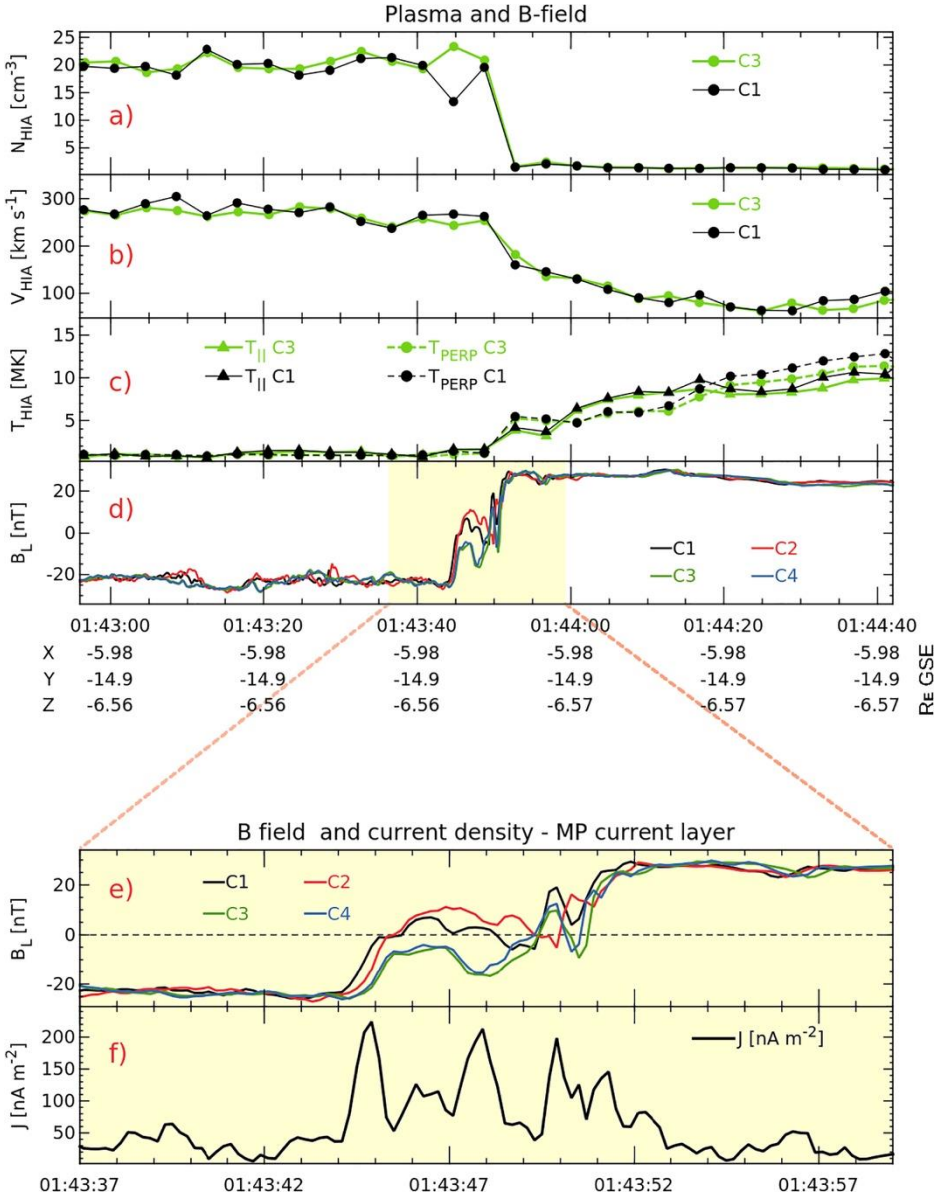
| | |
|---|---|
| $\mu_0$ | 4 $\pi$ x $10^{-7}$ |
| v | 500 km/s |
| n | 5 $cm^{-3}$ |
| $m_p$ | 1.67 x $10^{-27}$ kg |
| $M_E$ | 8.05 x $10^{22}$ A $m^2$ |
| $R_E$ | 6371 km |

# Locating the boundary

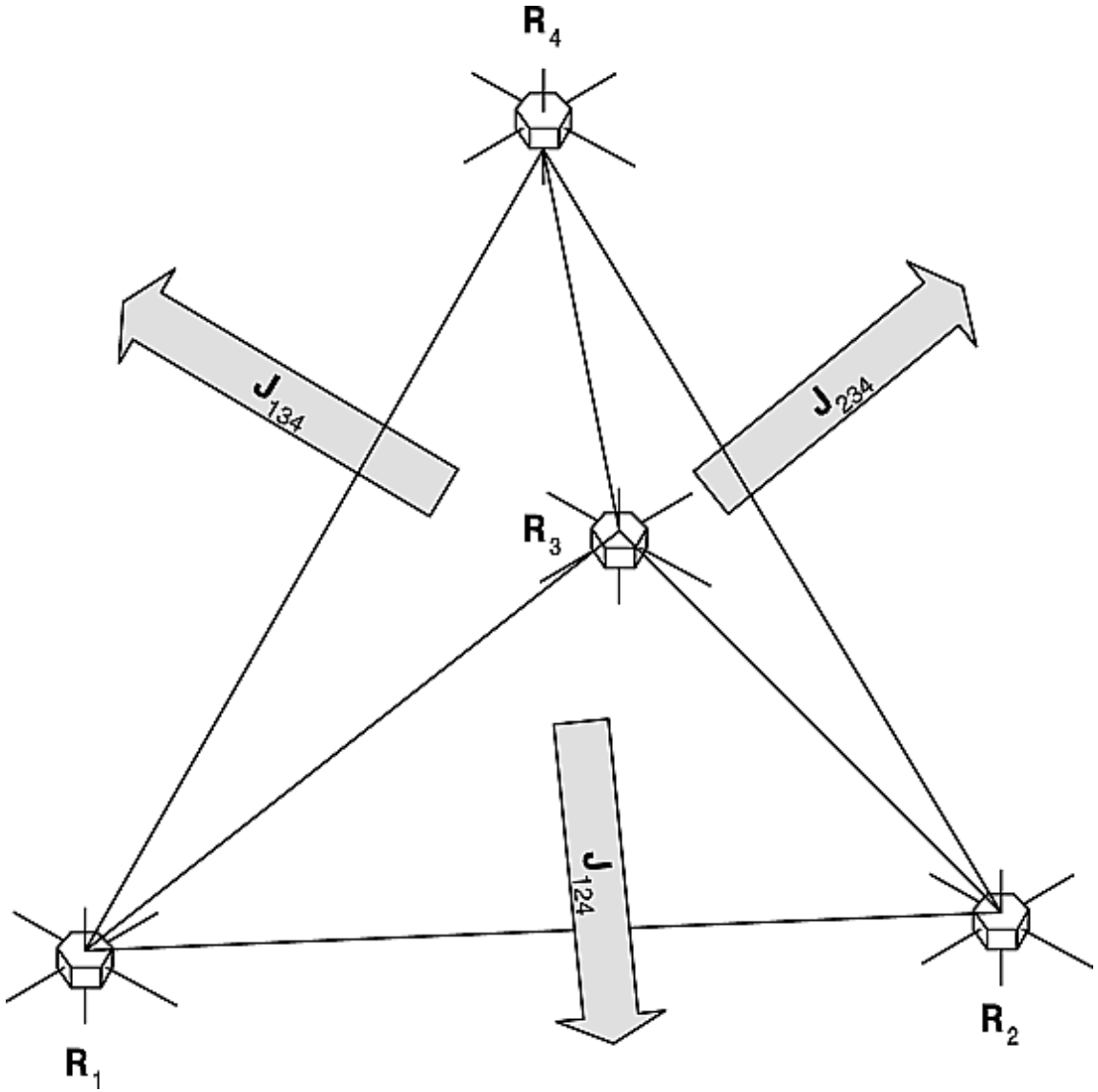



Staples et al. (2020)



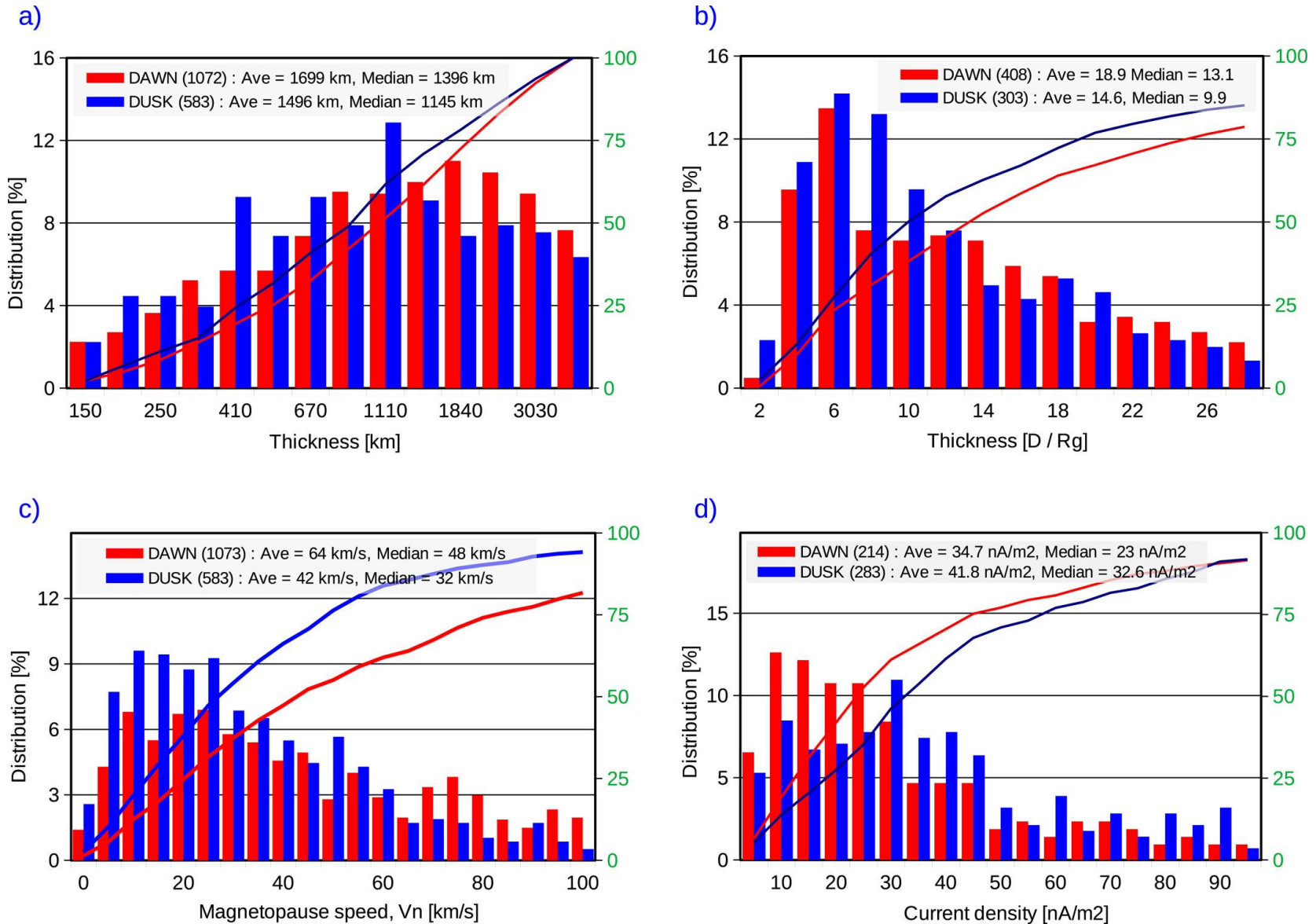



Haaland et al. (2014)



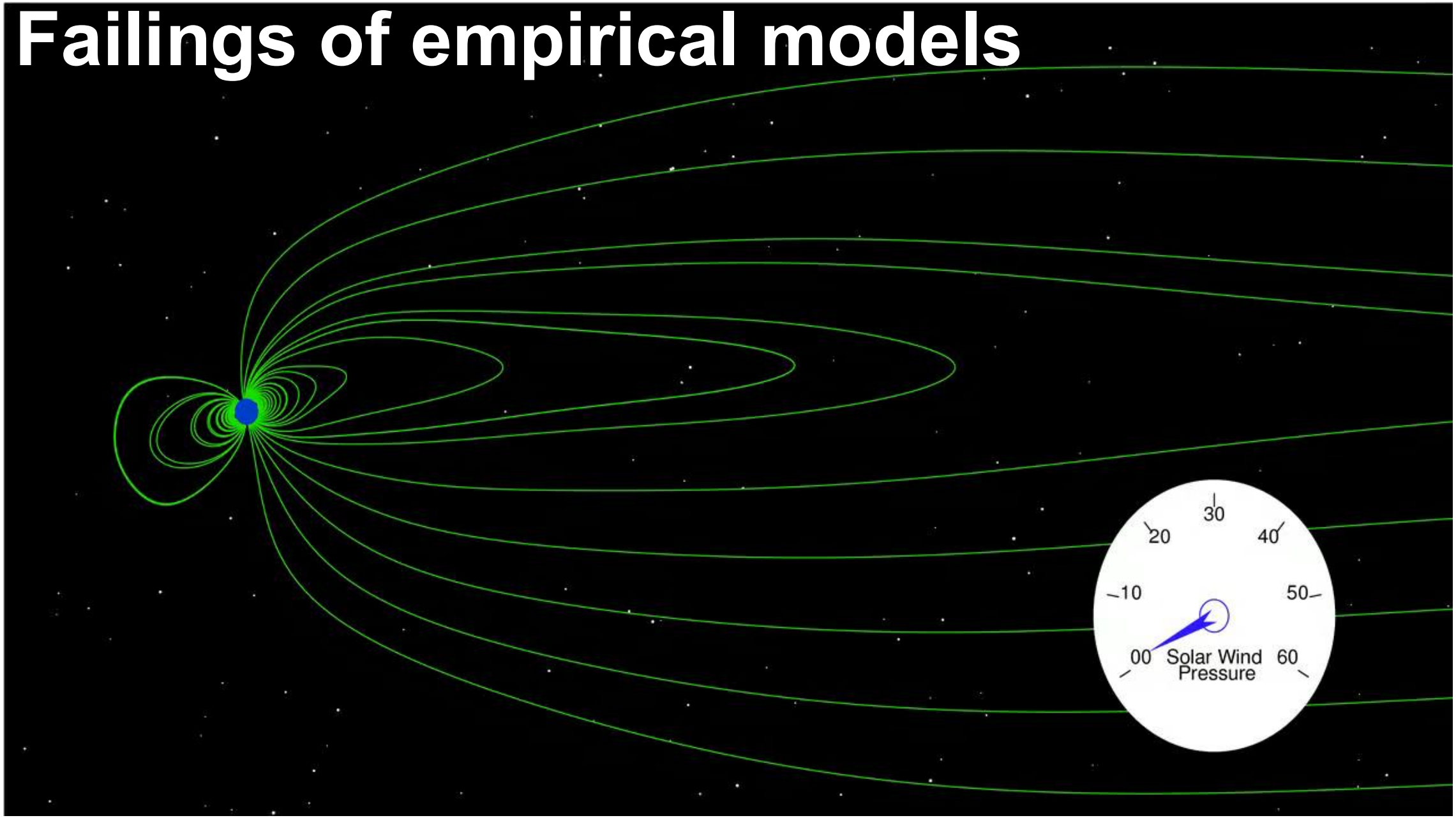

Dunlop et al. (2002)

# Spatial variations in the boundary

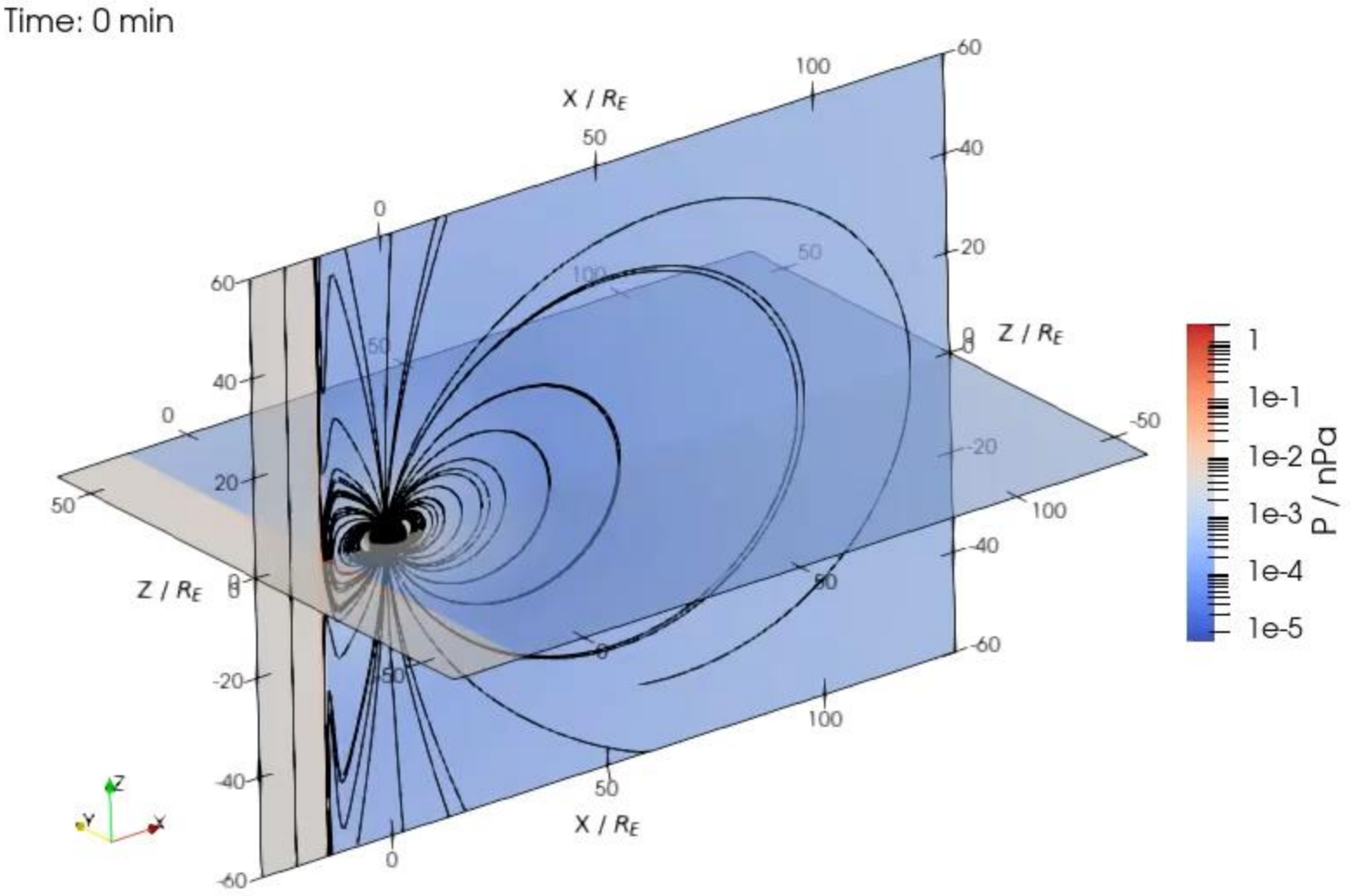


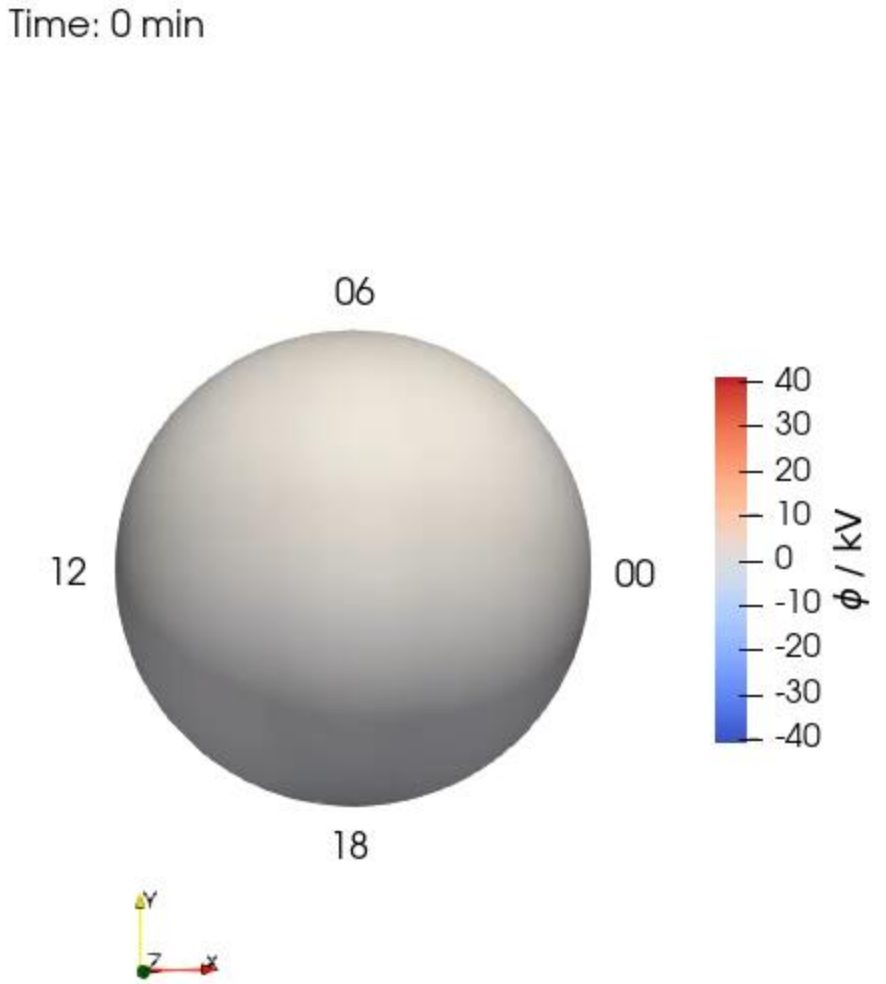

Haaland et al. (2014)

# Failings of empirical models



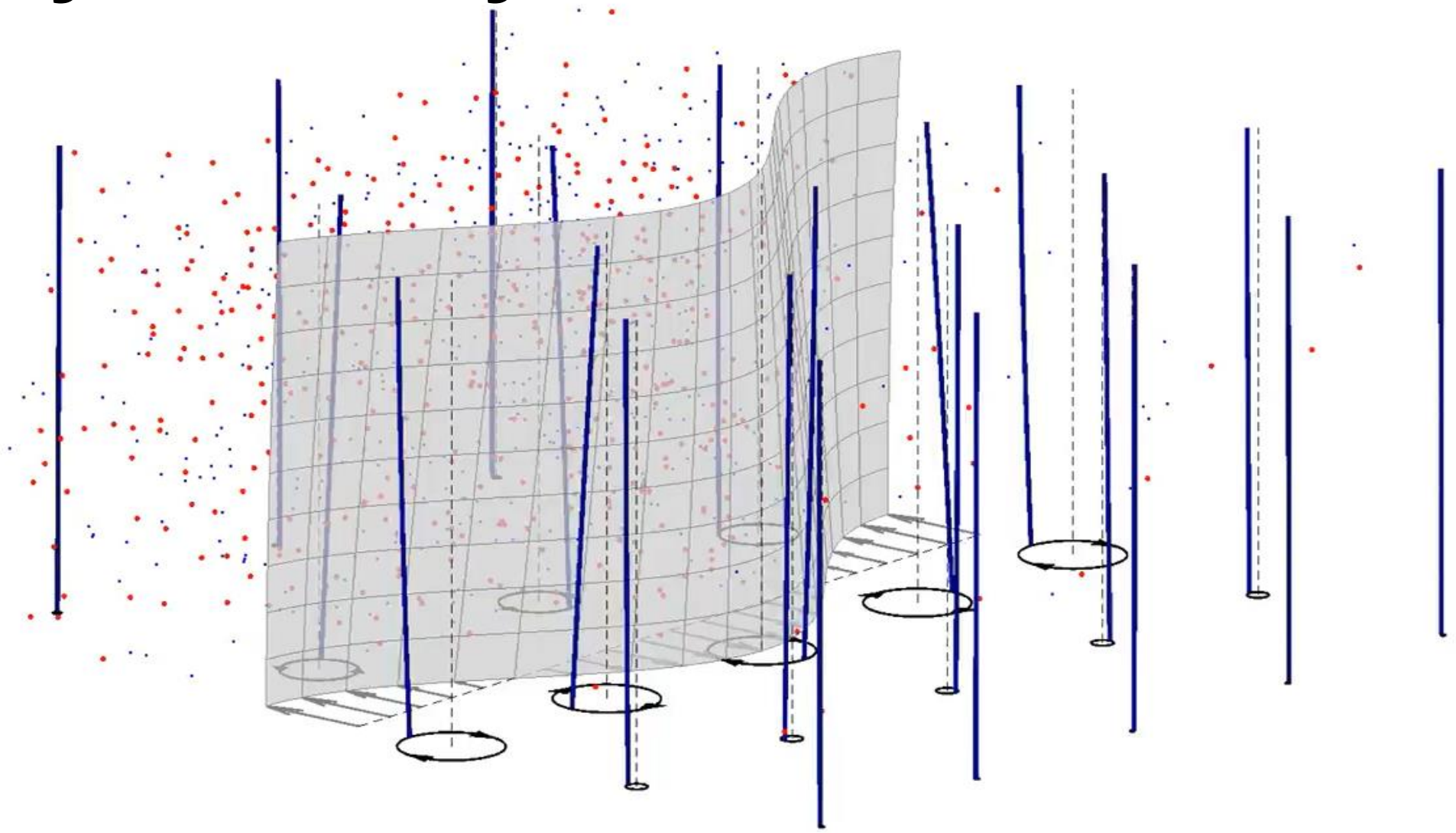
# Dynamics of change



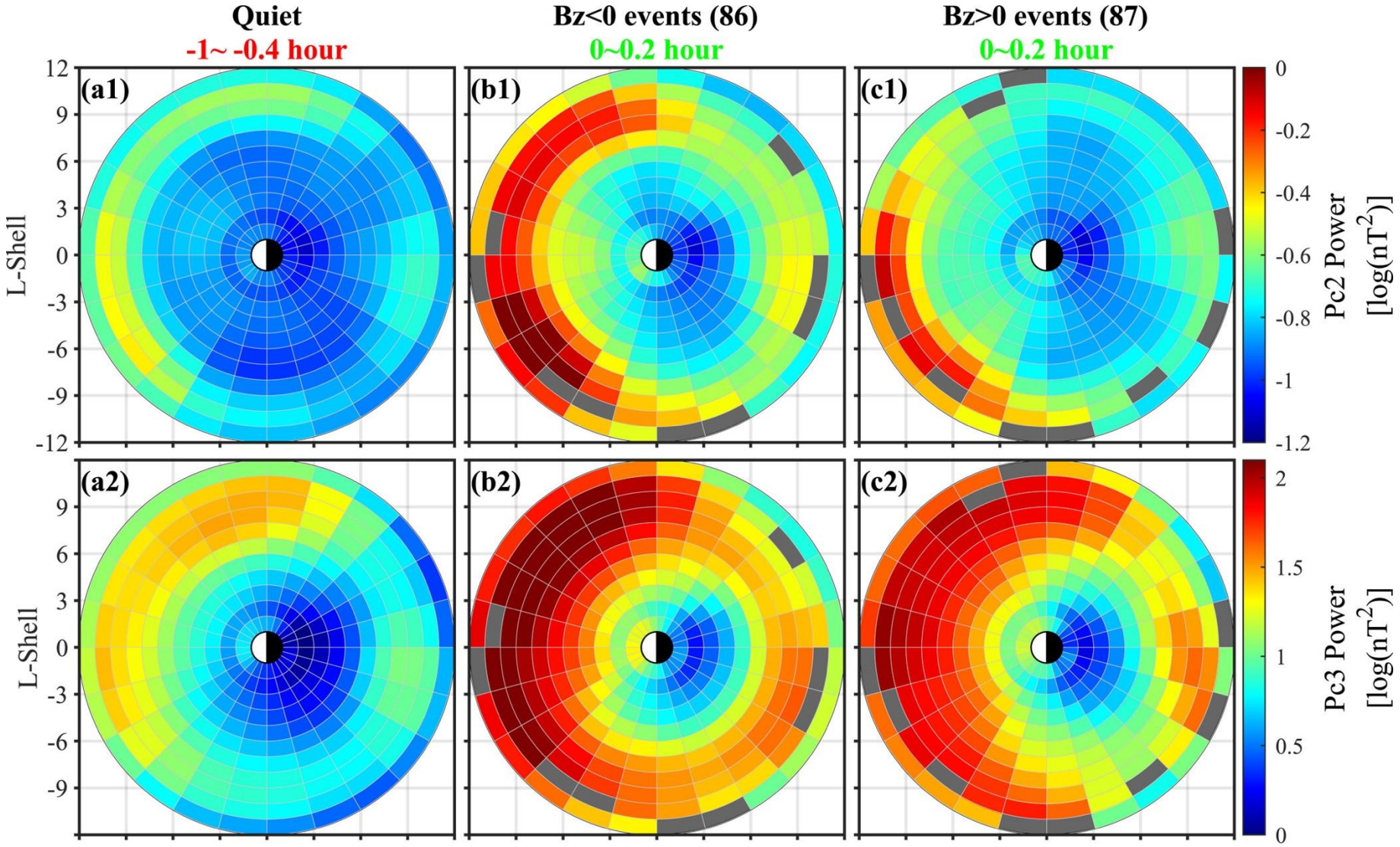




Courtesy: J. Eggington

# A wavy boundary

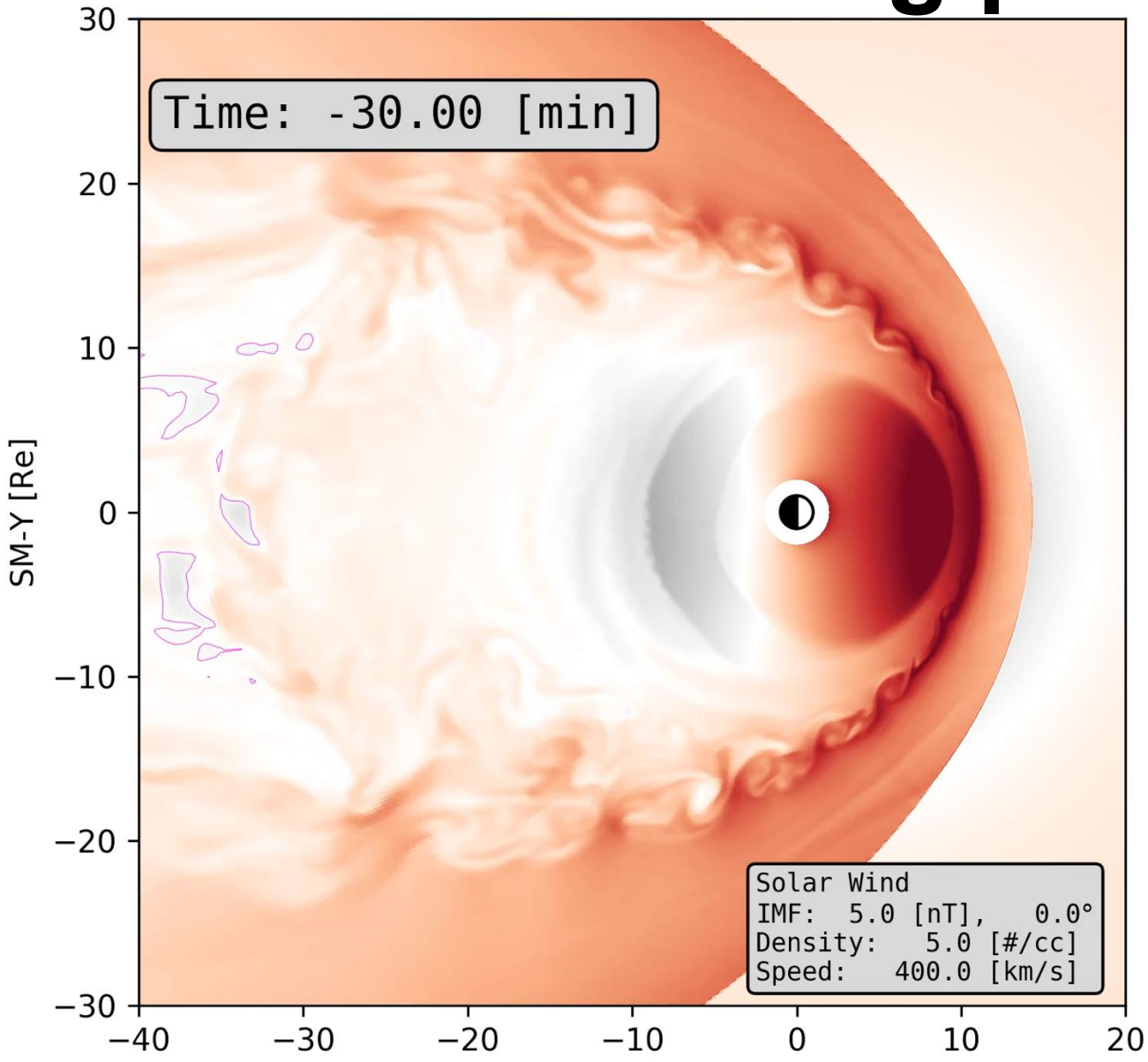


# Coupling to internal waves



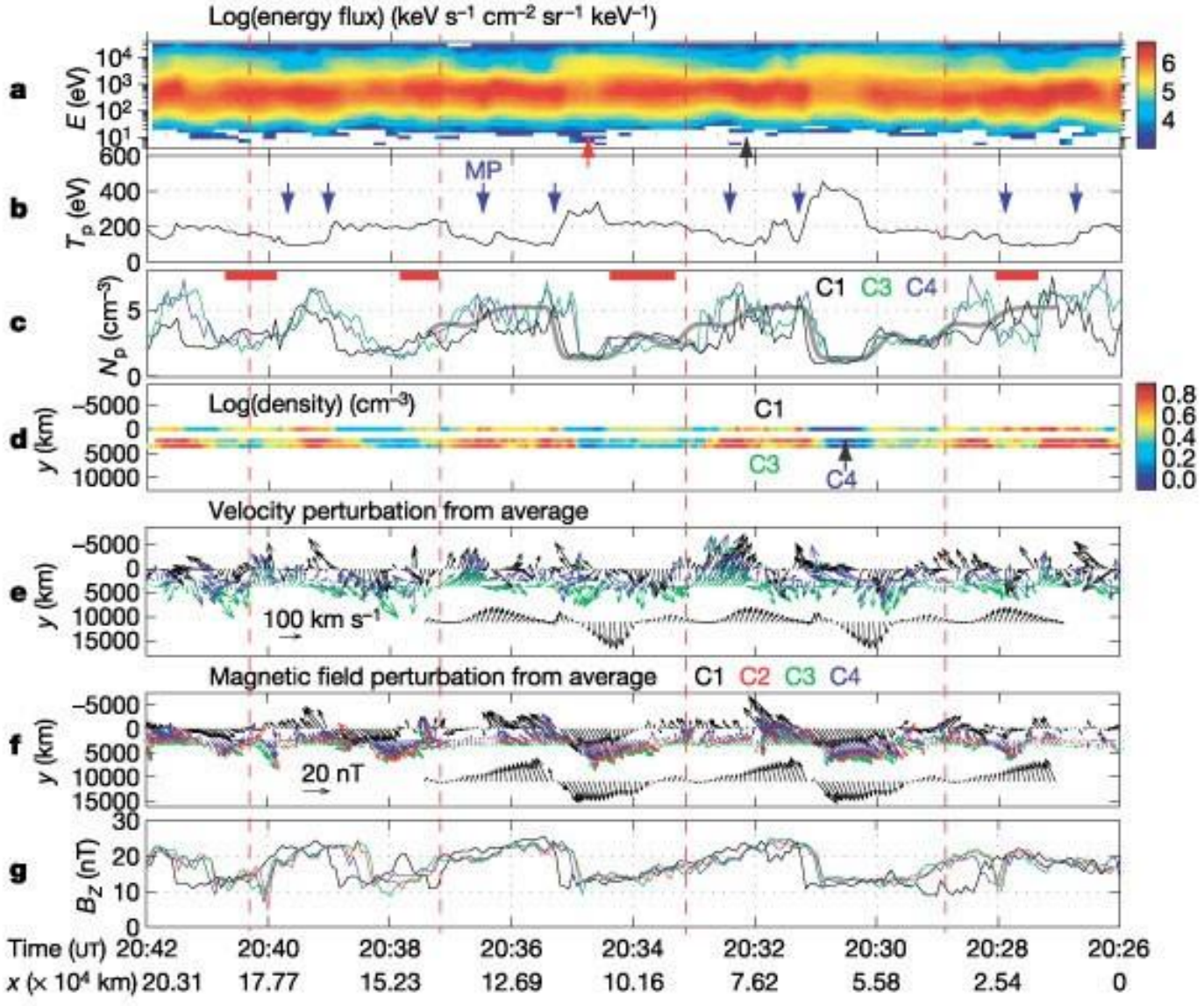

Xie et al. (2023)

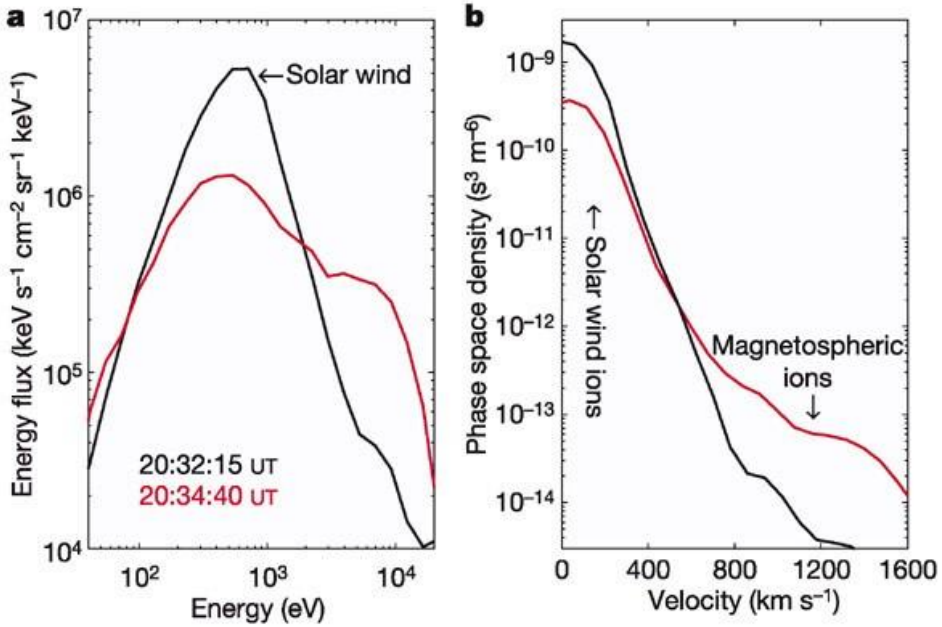
# Boundary waves from flowing plasma




Sorathia et al. (2020)

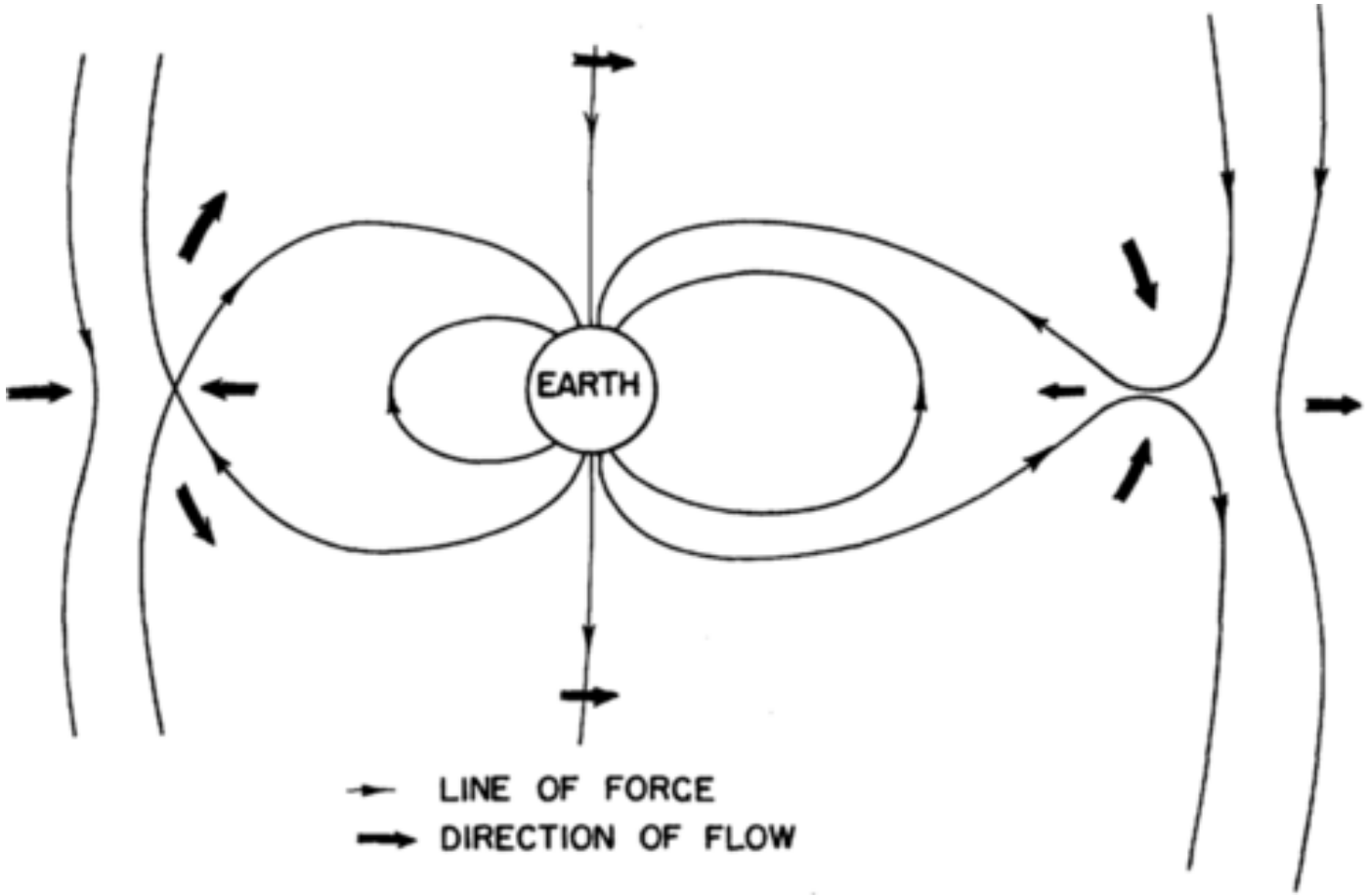
# Plasma intrusion from boundary waves

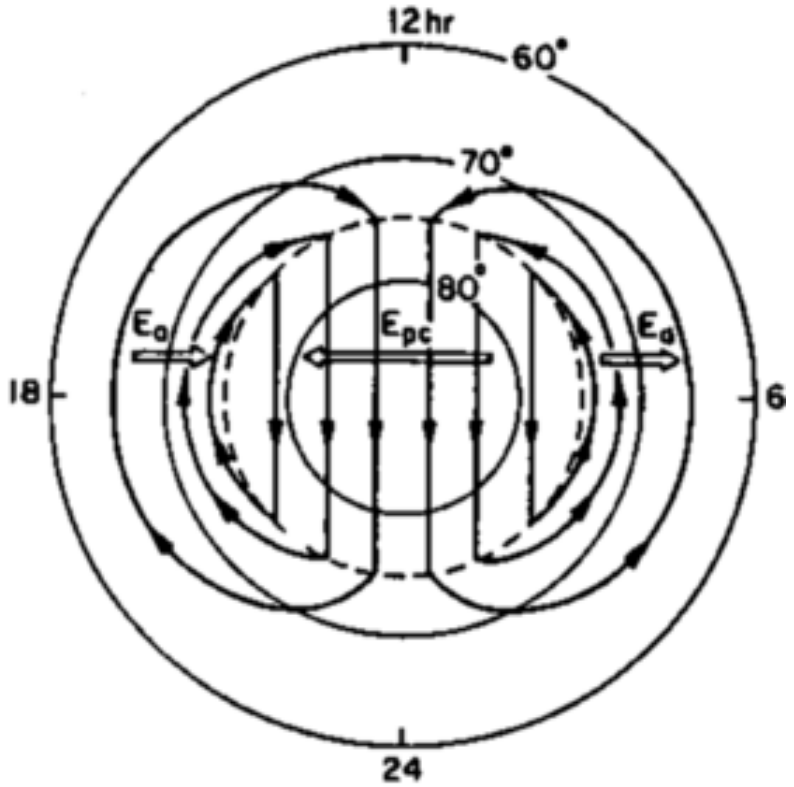



Hasegawa et al. (2004)

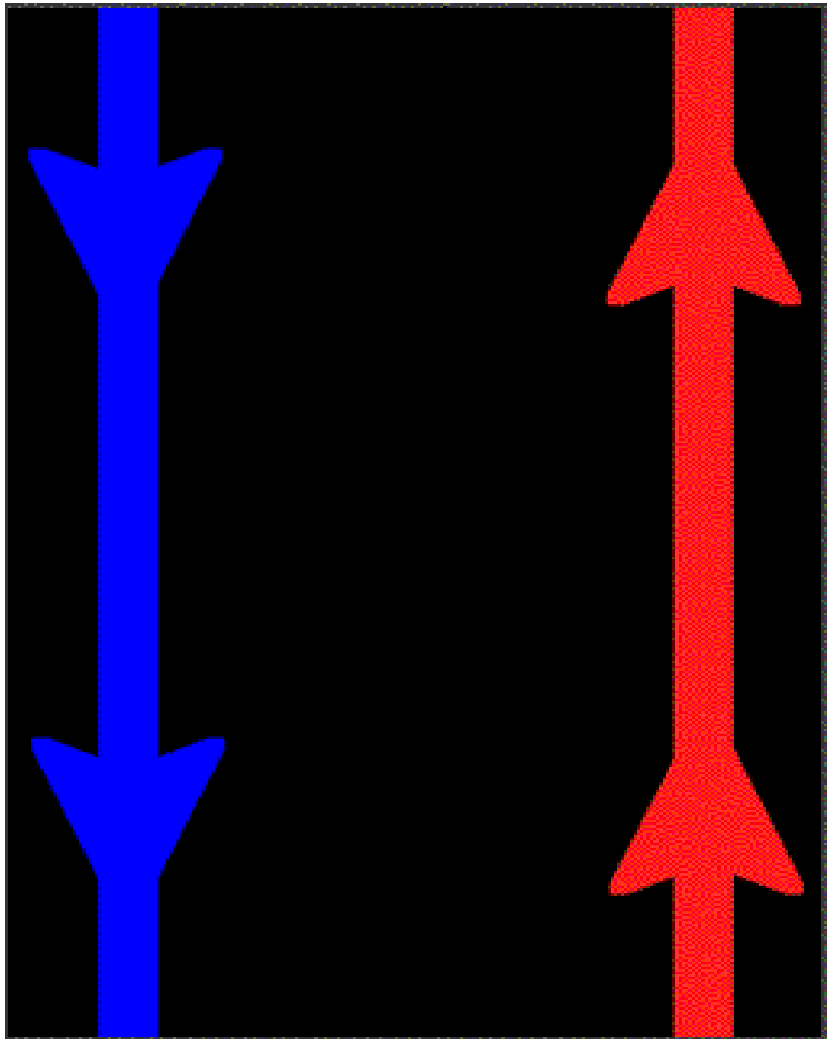
# Large-scale magnetic coupling

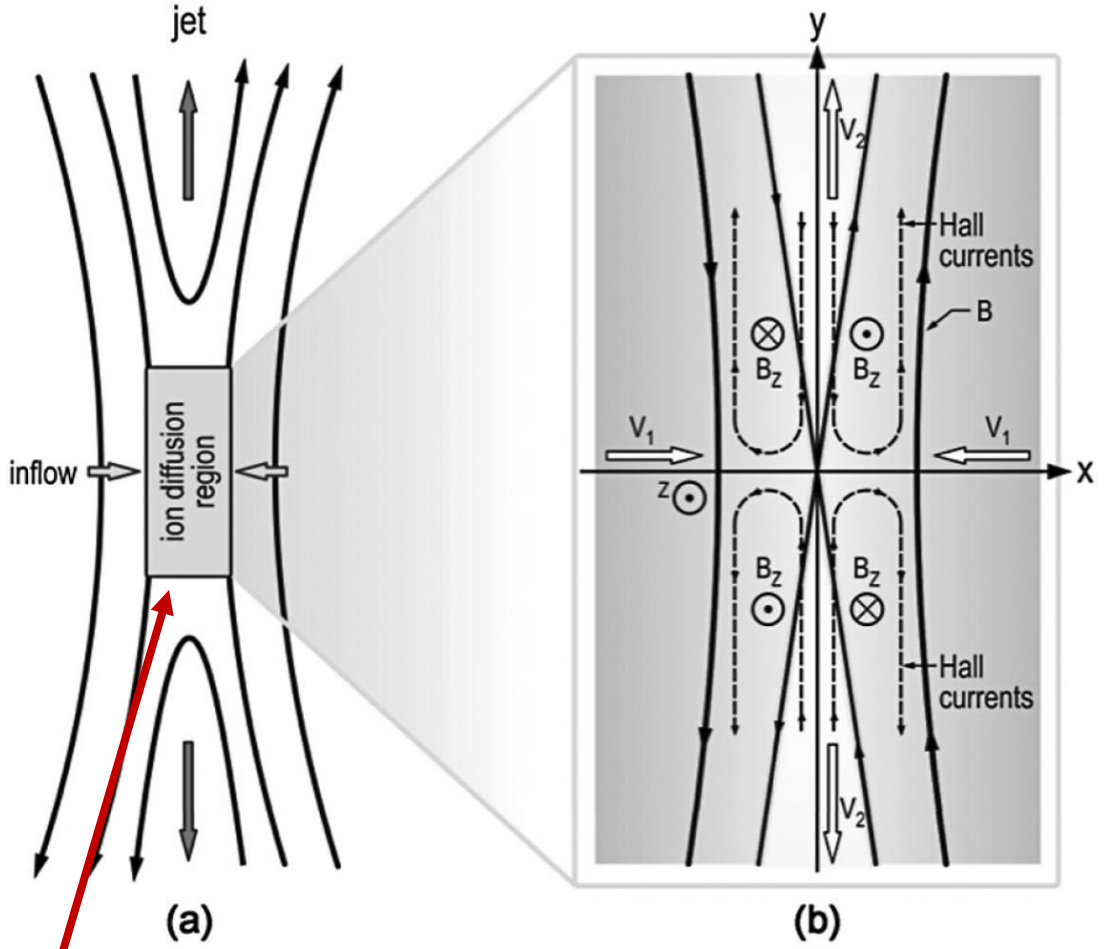



Dungey (1961)

# Small-scale physics of reconnection

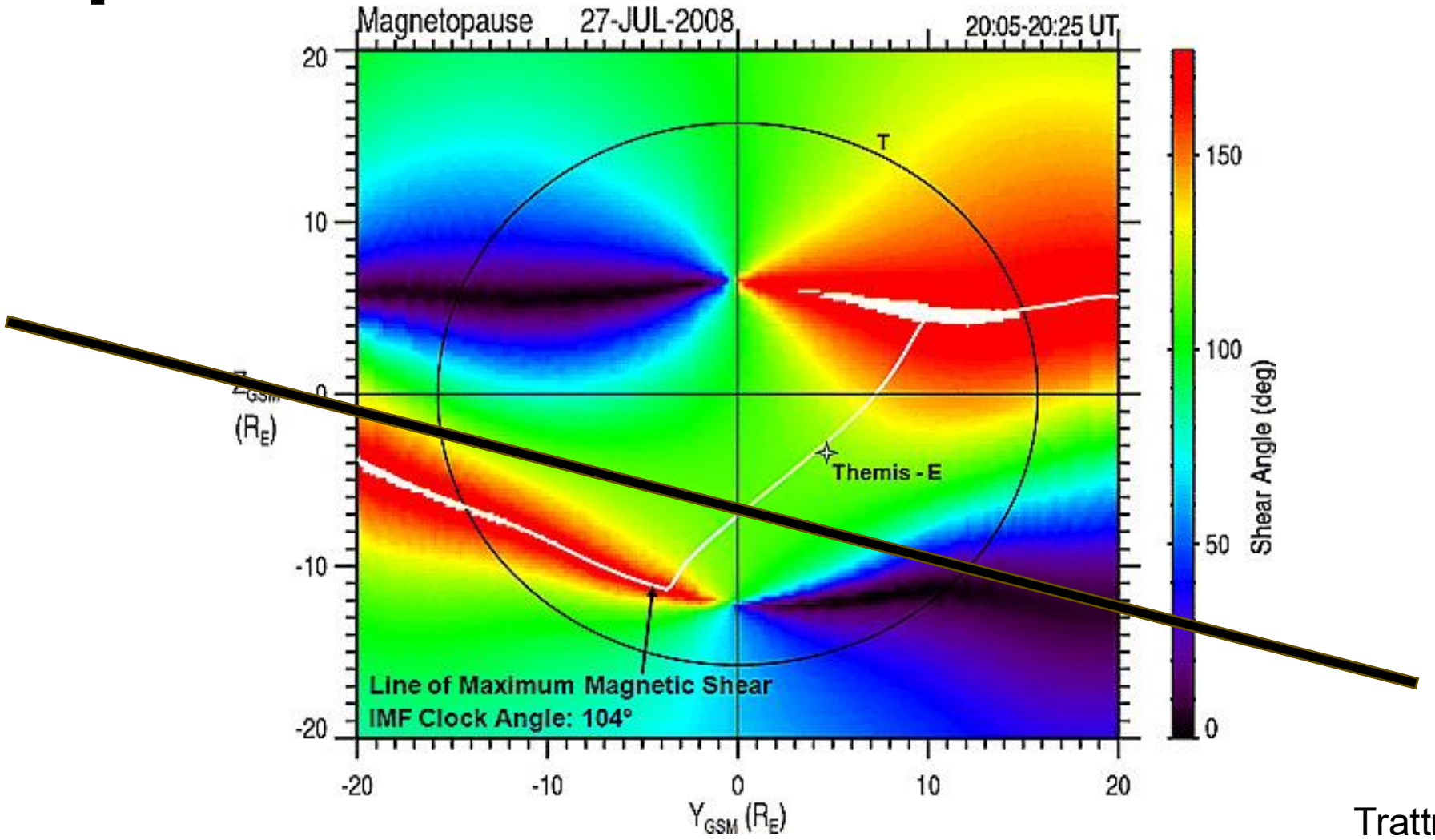





$$\frac{228}{\sqrt{n}[cm^{-3}]}\ [km]$$

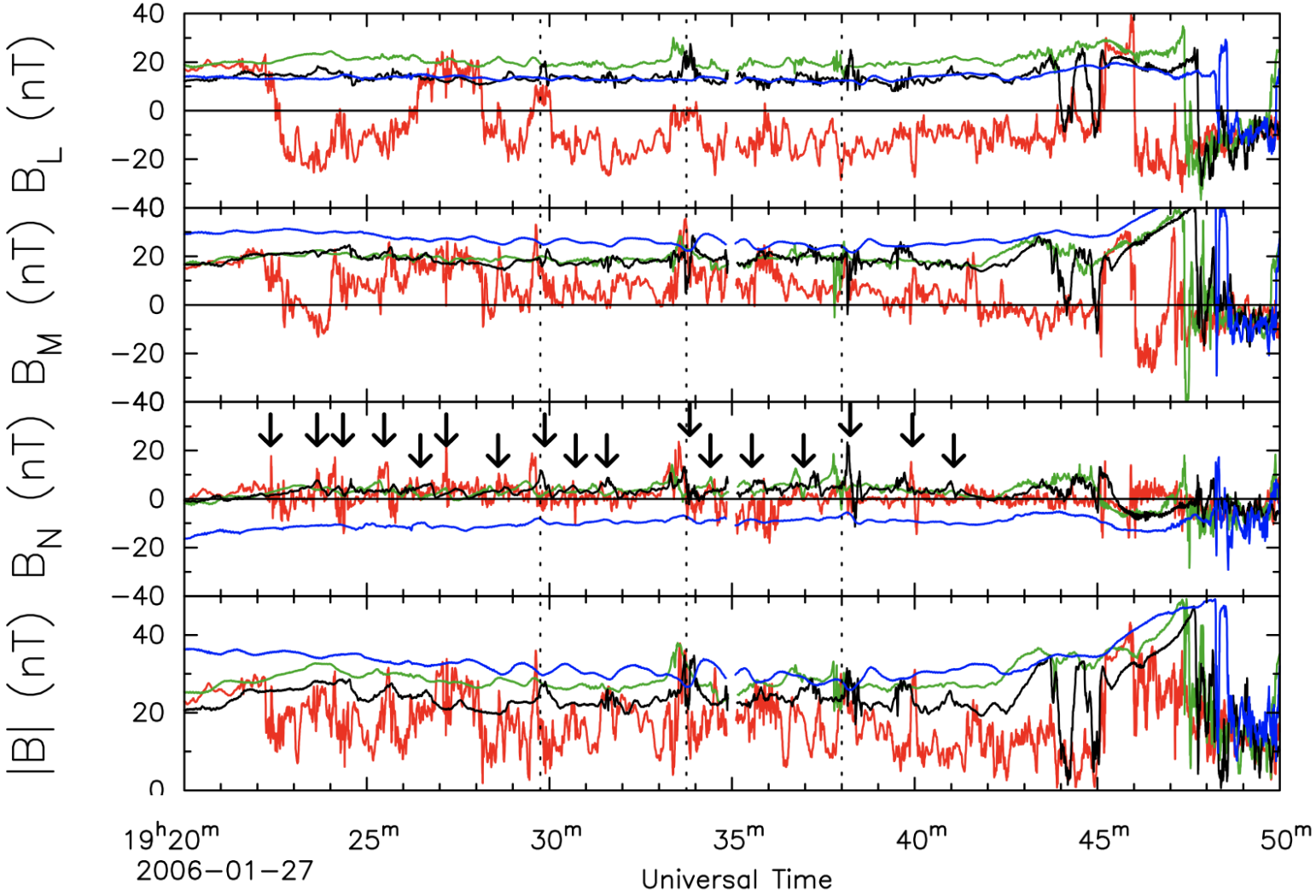
Burch et al (2015)

# Where can reconnection happen on the magnetopause?

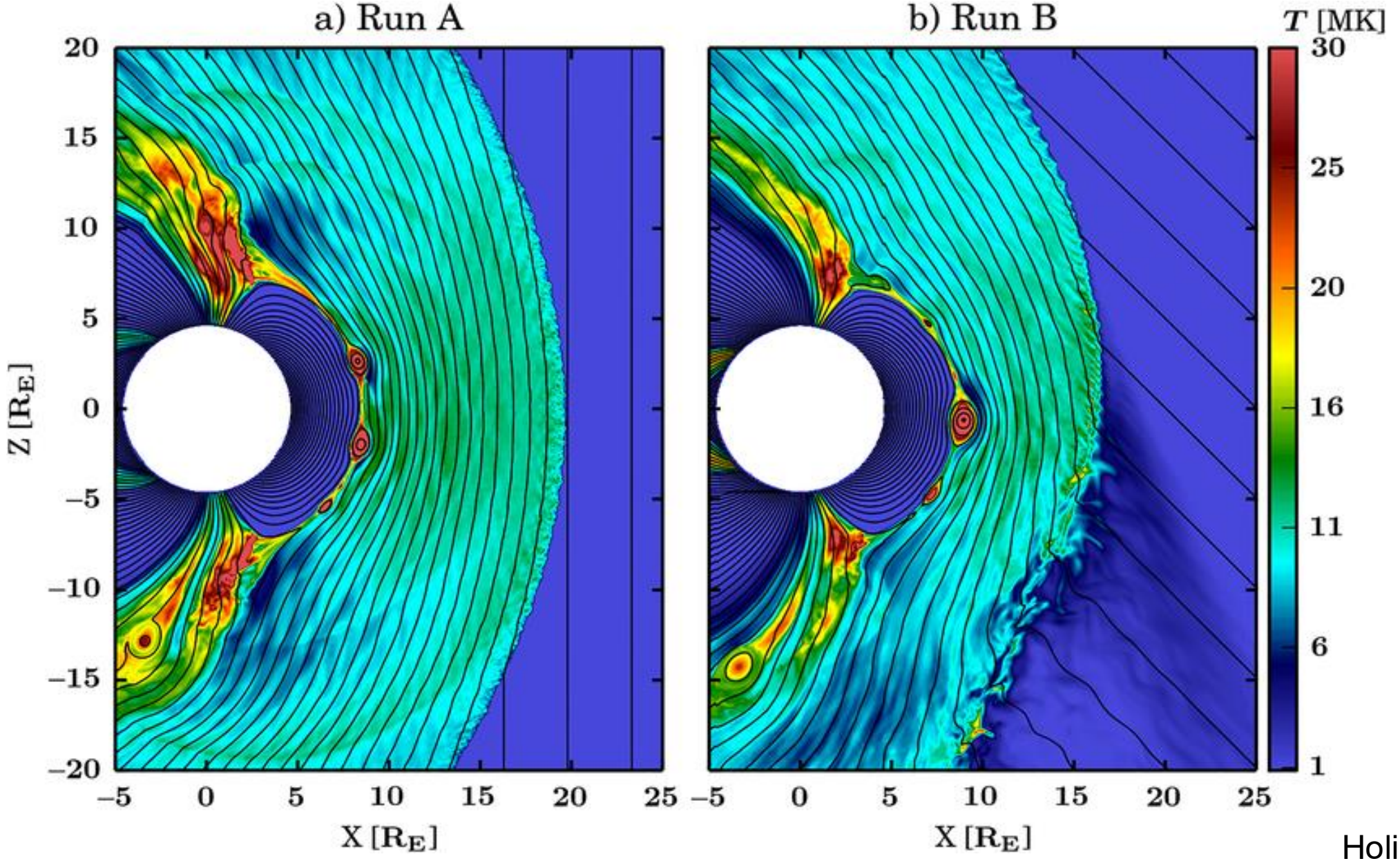



Trattner et al. (2012)

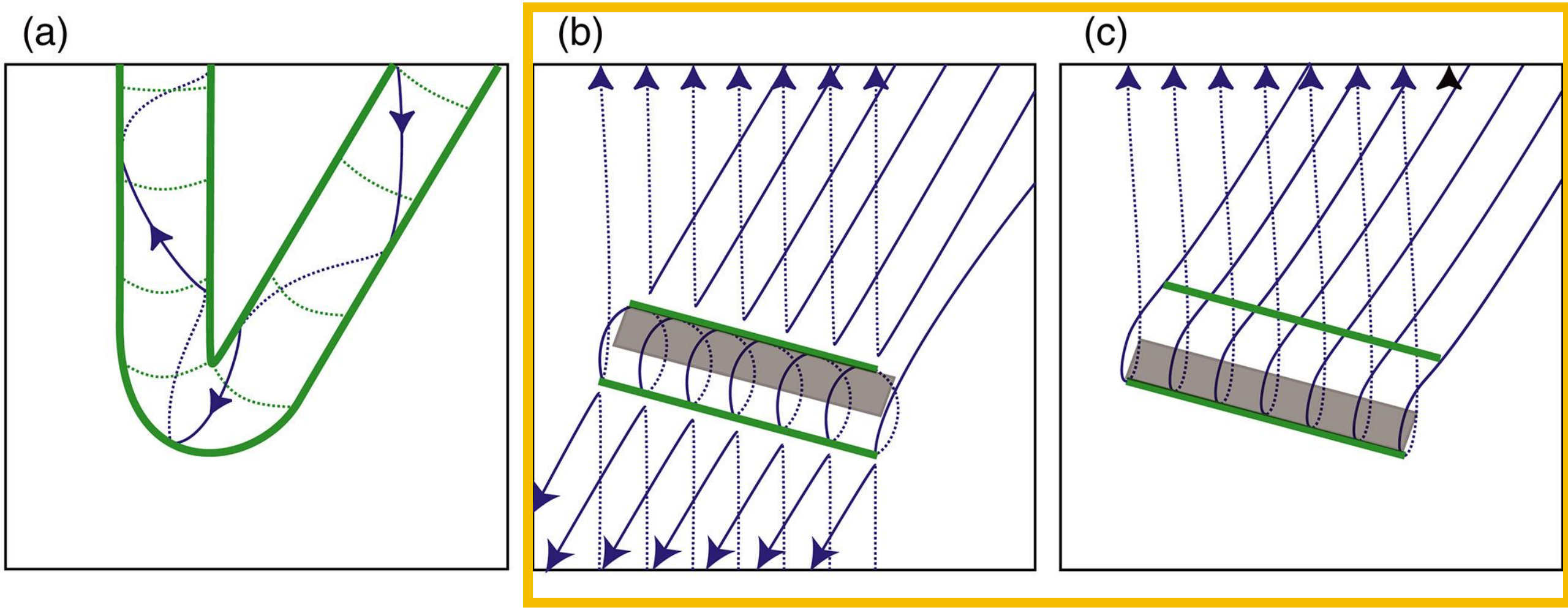
# Is reconnection steady?




Fear et al. (2008)




Holijoki et al. (2019)



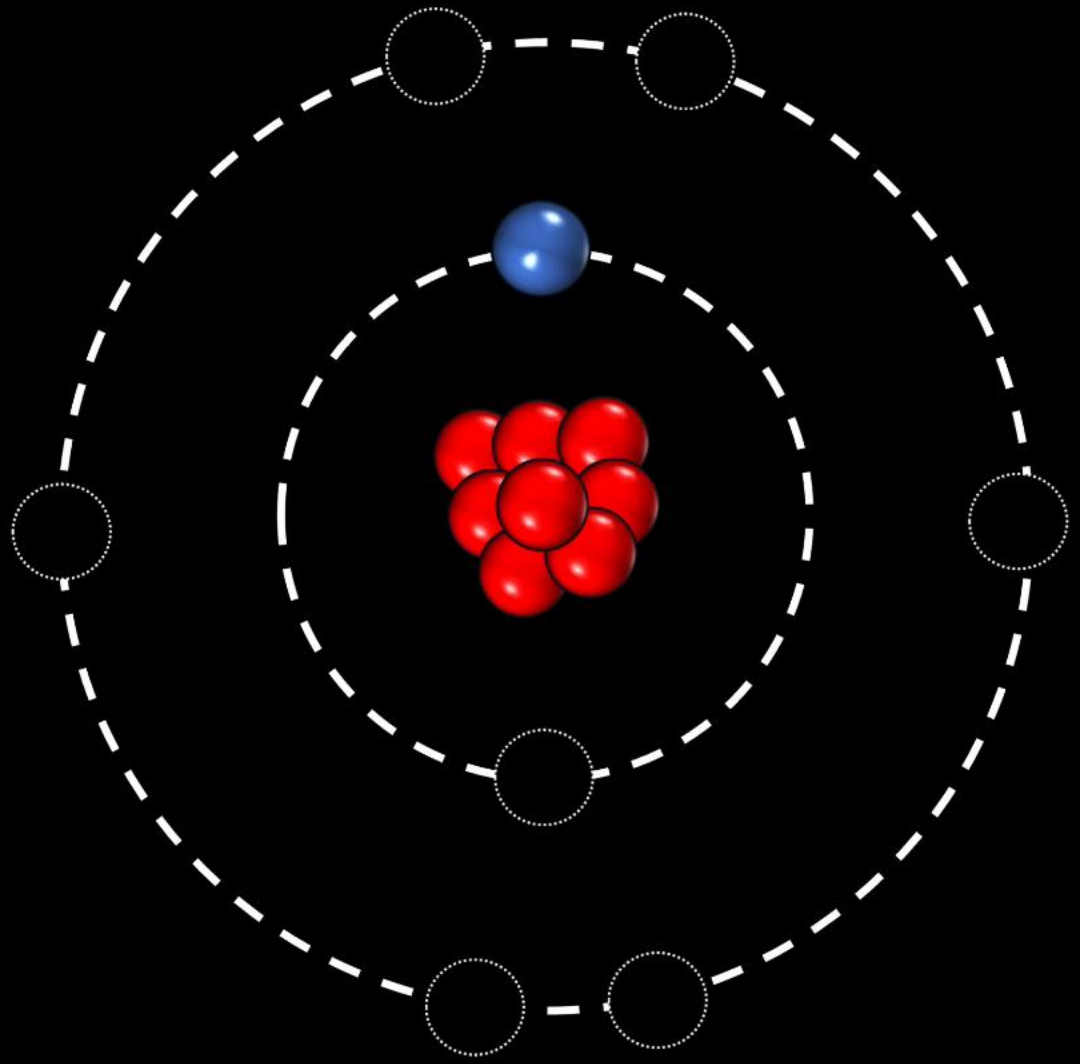

Fear et al (2017)

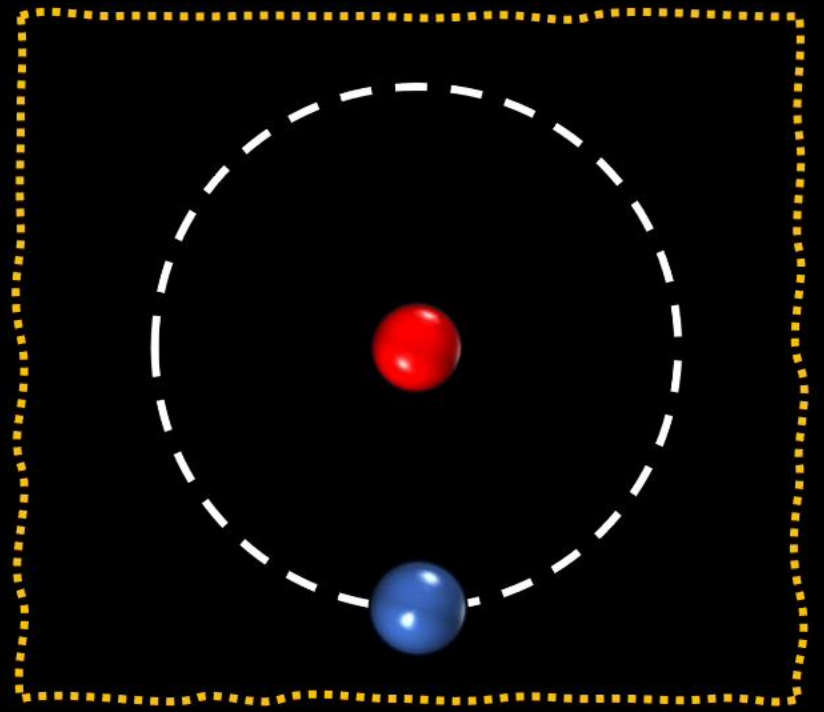
# What is SMILE?

- Next ESA/CAS mission to study Earth's magnetosphere
- Will image the inputs and outputs of MI coupling
- A cross-over between X-ray astronomy and heliophysics
- Objectives:
  i. *What are the fundamental modes of the dayside solar wind/ magnetosphere interaction?*
  ii. *What defines the substorm cycles?*
  iii. *How do CME-driven storms arise and what is their relationship to substorms?*

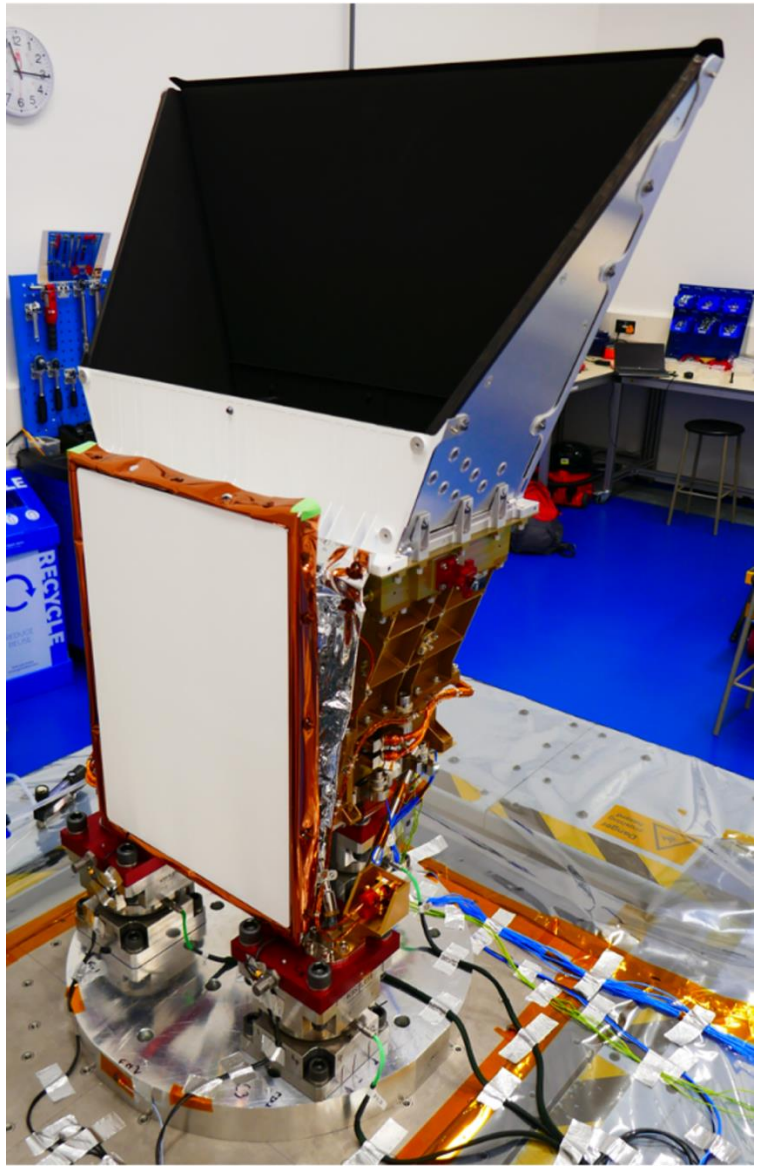
smile

IMAGING EARTH'S MAGNETIC ENVIRONMENT

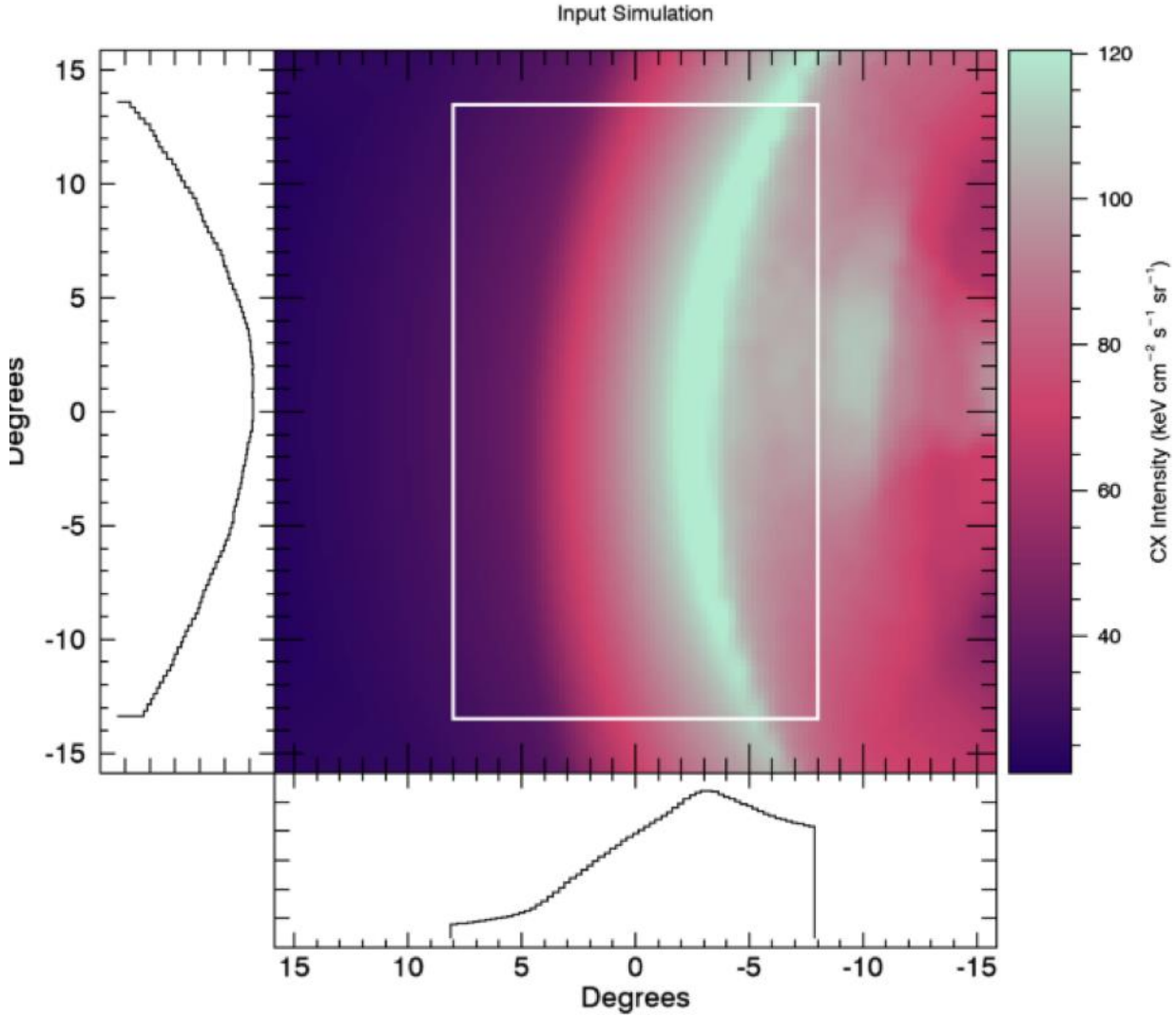





SXI TELESCOPE BAFFLE COVER
UNIVERSITY OF LEICESTER
REMOVE BEFORE FLIGHT


RECYCLE

# An unprecented global magnetosheath view



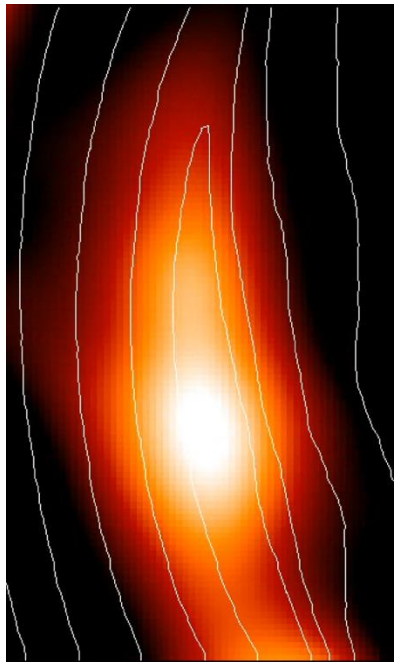



Image credit: Carter/Sembay/Forsyth

# Large scale driving leads to cross-scale coupling

- Interaction between incoming plasma and Earth's magnetic field creates a boundary – the magnetopause
- The magnetopause varies in location and thickness
- The magnetopause moves, transmitting energy into the magnetosphere via ULF waves
- The magnetopause breaks by KH instability and reconnection, allowing plasma entry into the magnetosphere at small to large scales
- Reconnection may be steady or vary on short time scales

*To be continued…*