Ion Temperature Anisotropies across Magnetotail Reconnection Jets

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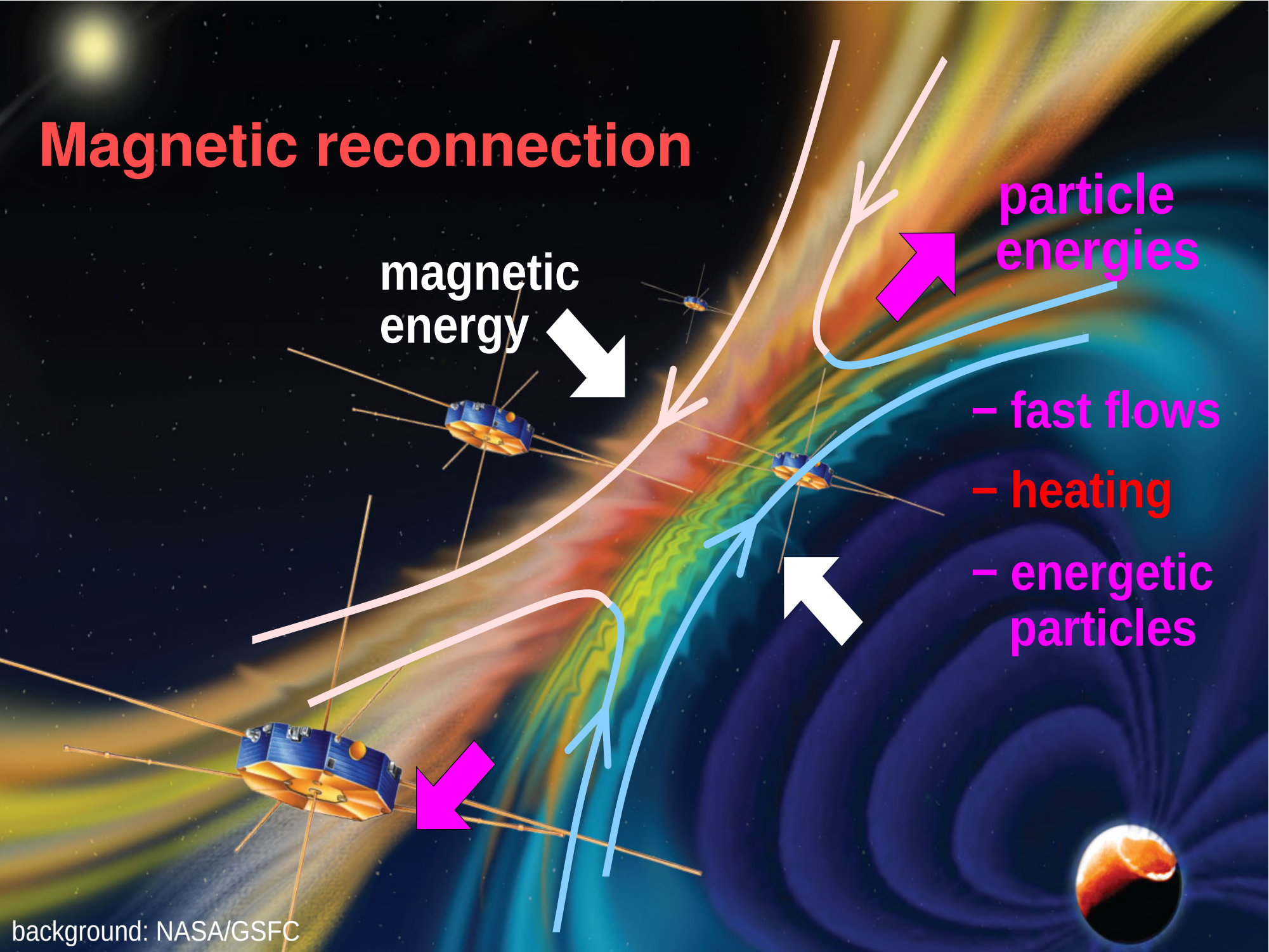
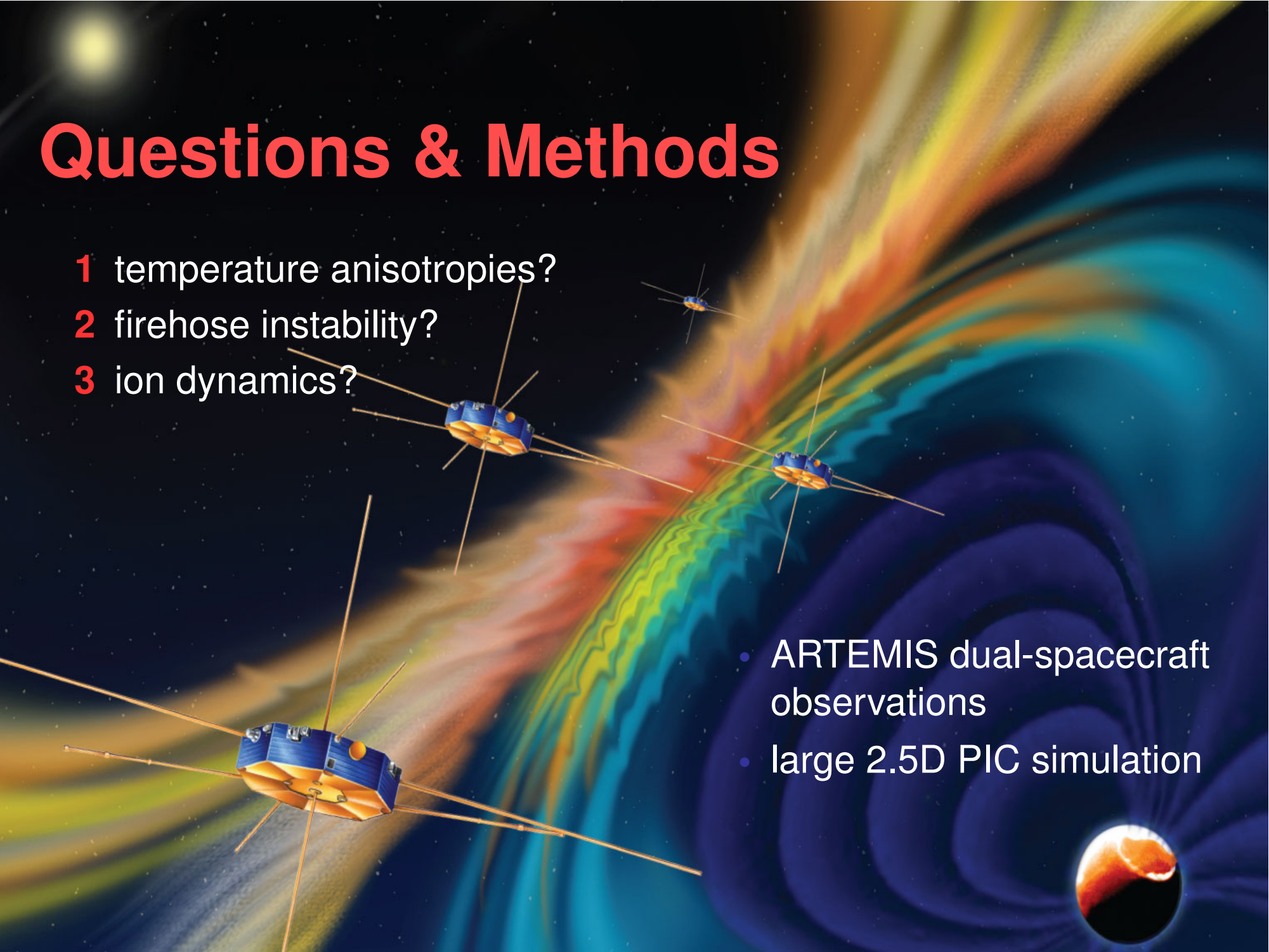
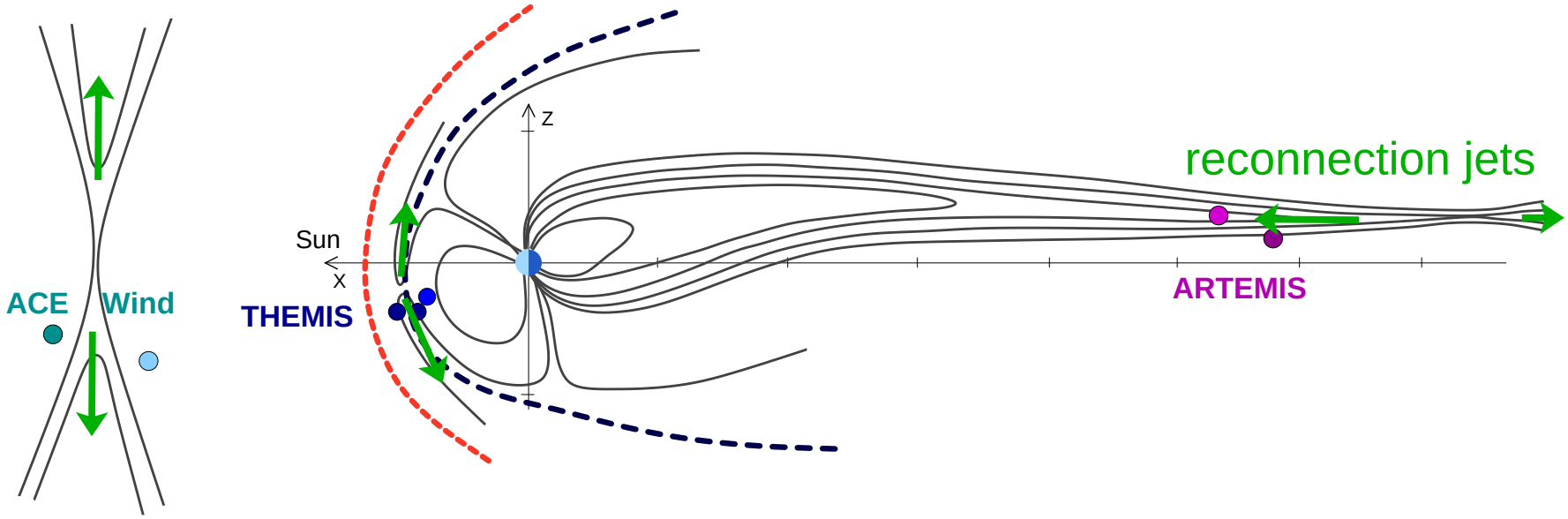

Magnetic reconnection
magnetic energy
particle energies
– fast flows
– heating
– energetic particles
background: NASA/GSFC


Questions & Methods
1 temperature anisotropies?
2 firehose instability?
3 ion dynamics?
• ARTEMIS dual-spacecraft observations
• large 2.5D PIC simulation

In situ observations: heating in different parameter regimes?

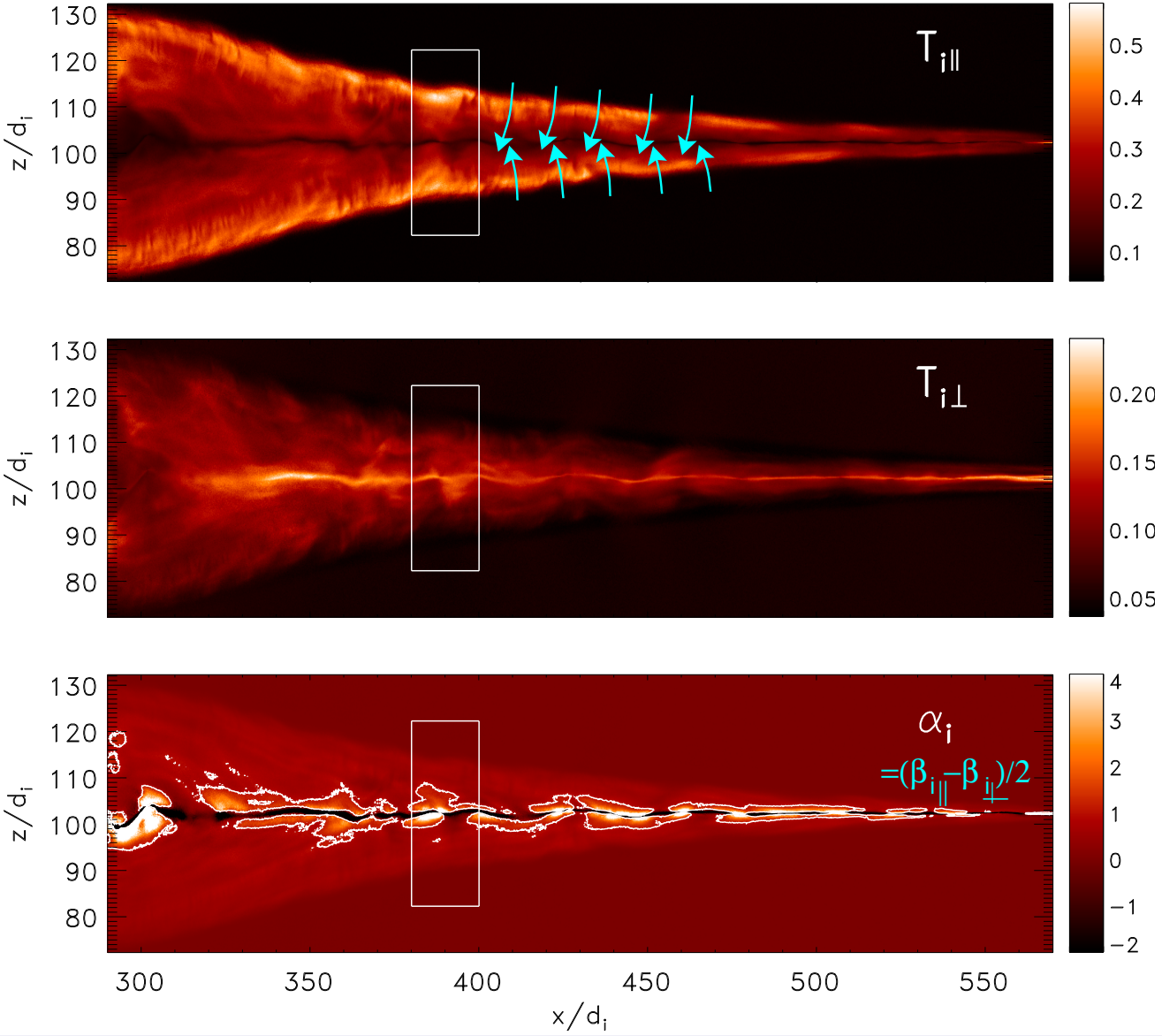
solar wind **magnetopause** **magnetotail**



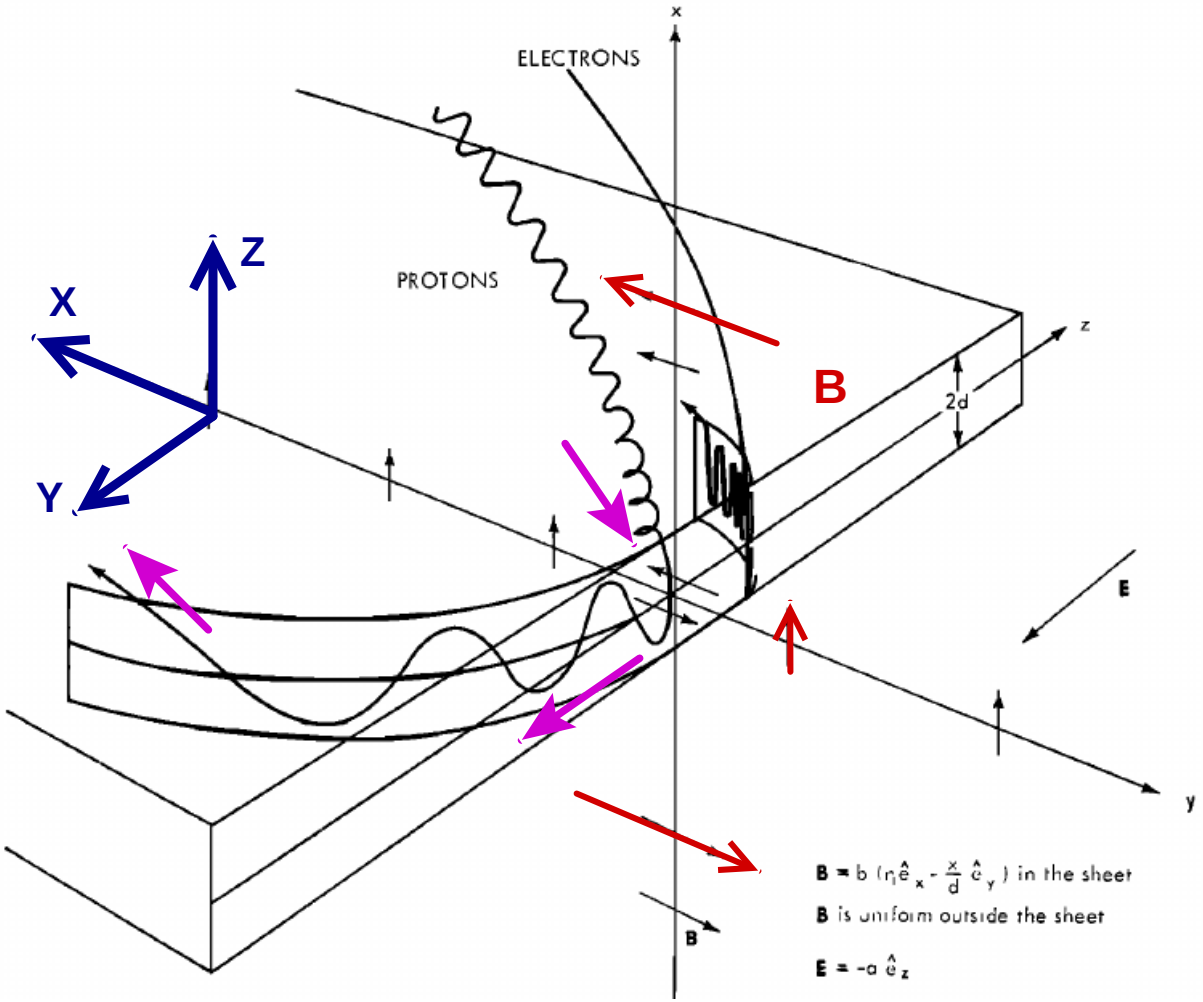
available magnetic energy per particle: $B_{in}^2/\mu_0 n_{in} = m_i \mathbf{V}_{A,in}{}^2$

$10^1 - 10^2$ eV **$10^2 - 10^4$ eV** **$10^4 - 10^5$ eV**

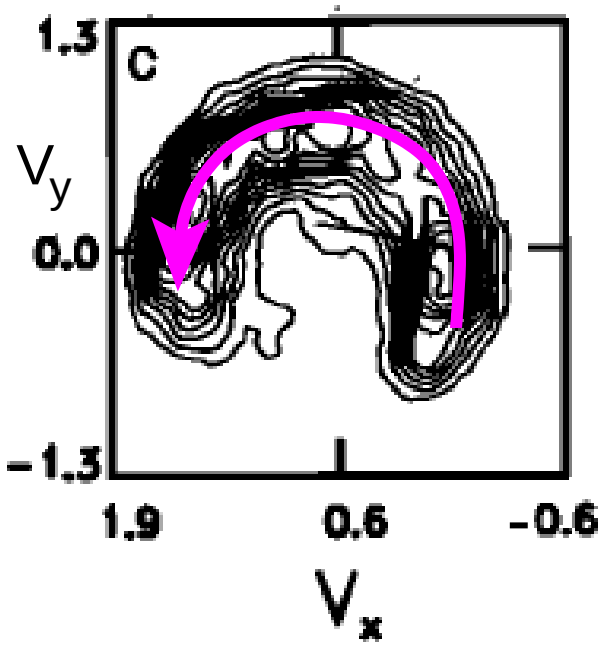
Anisotropy: firehose instability?



Ion dynamics: Speiser motion?



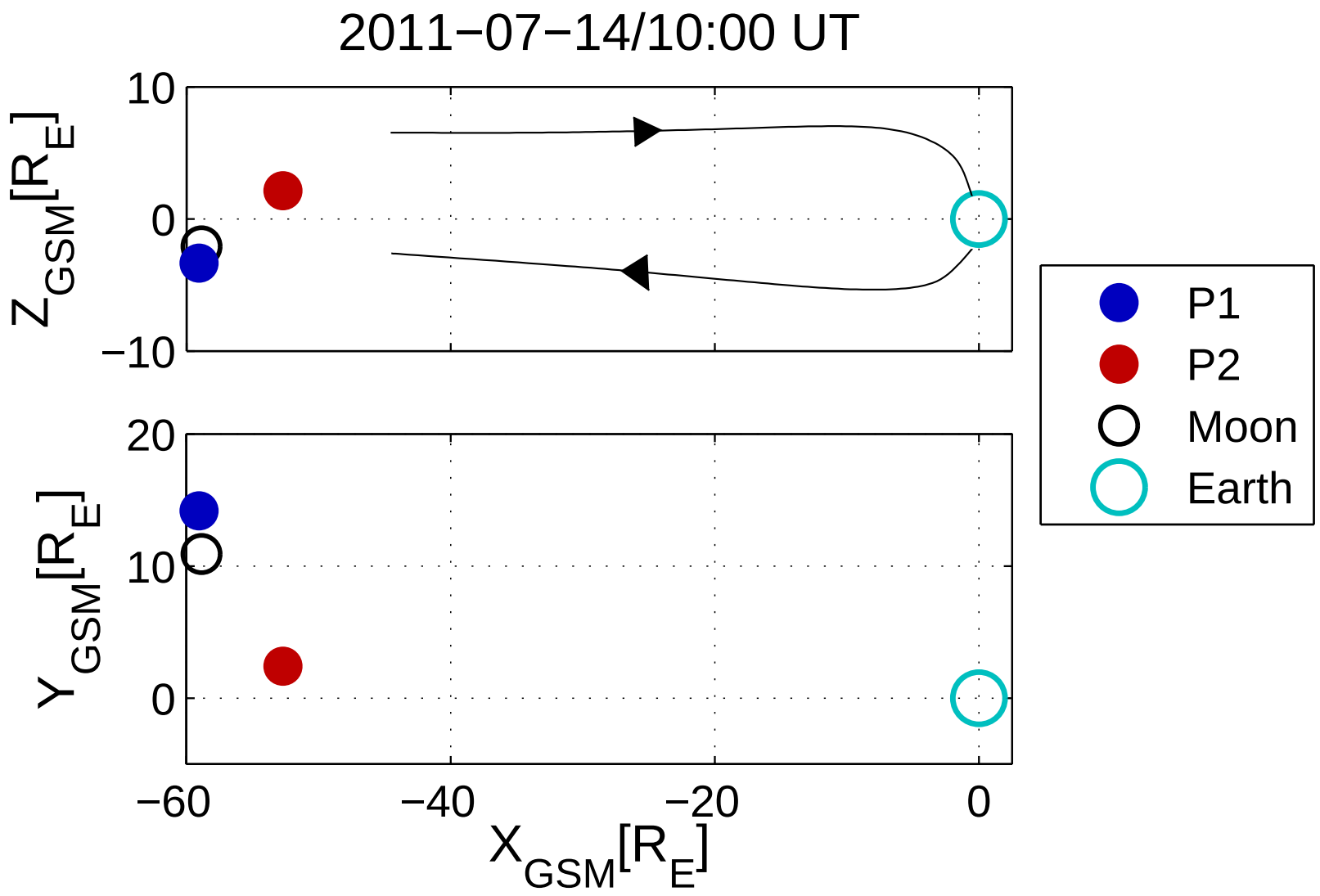
Speiser, JGR (1965)



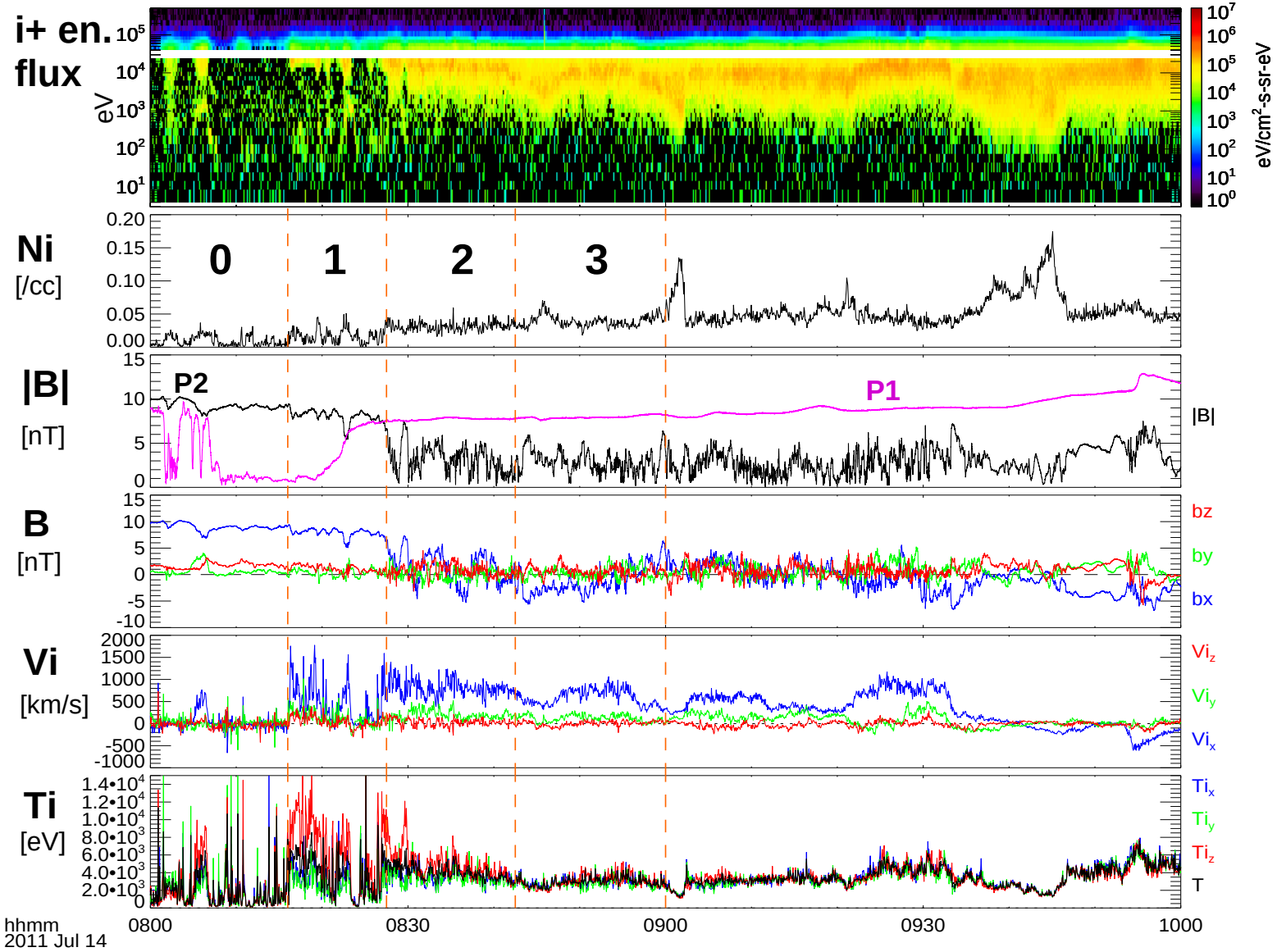
Simulation by

Lottermoser *et al.*, JGR (1998)

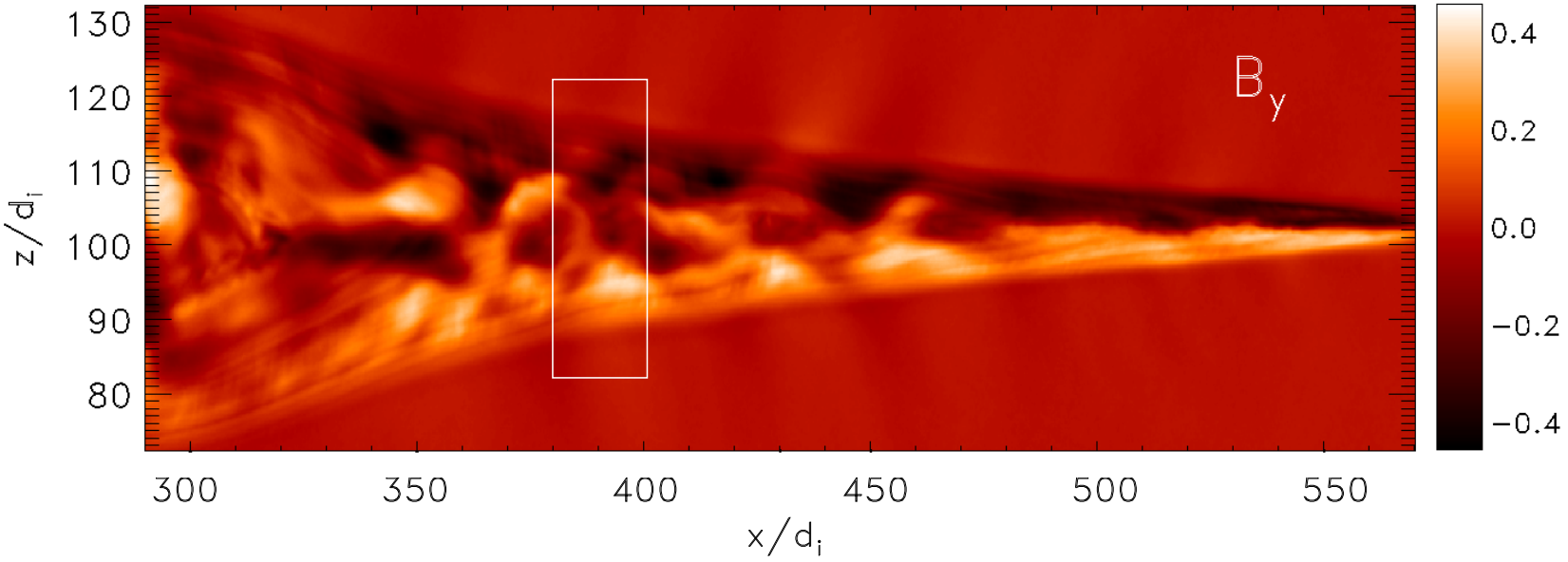
ARTEMIS observations: anti-parallel, symmetric



ARTEMIS observations: overview

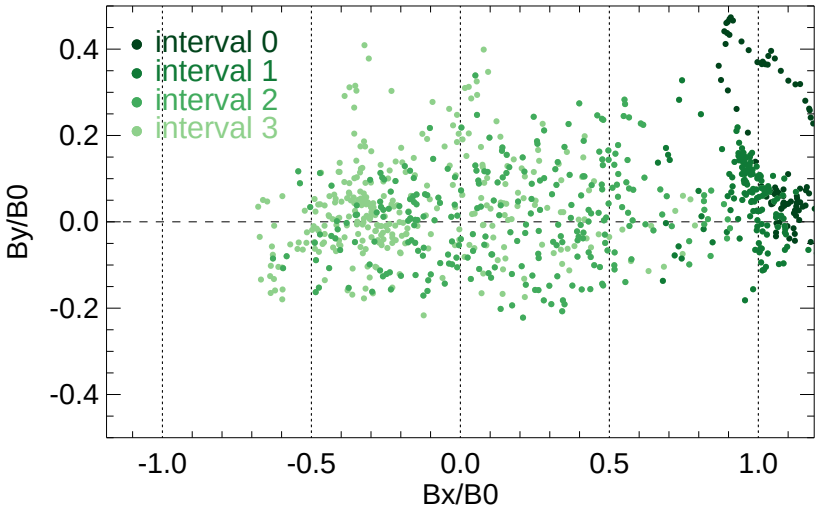


Where are we? → Hall magnetic field

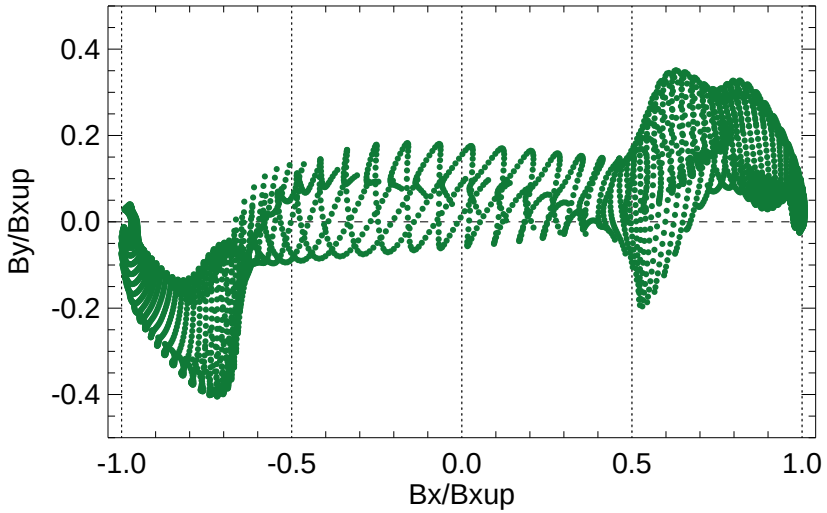


Hall magnetic field profiles: comparison

OBSERVATIONS

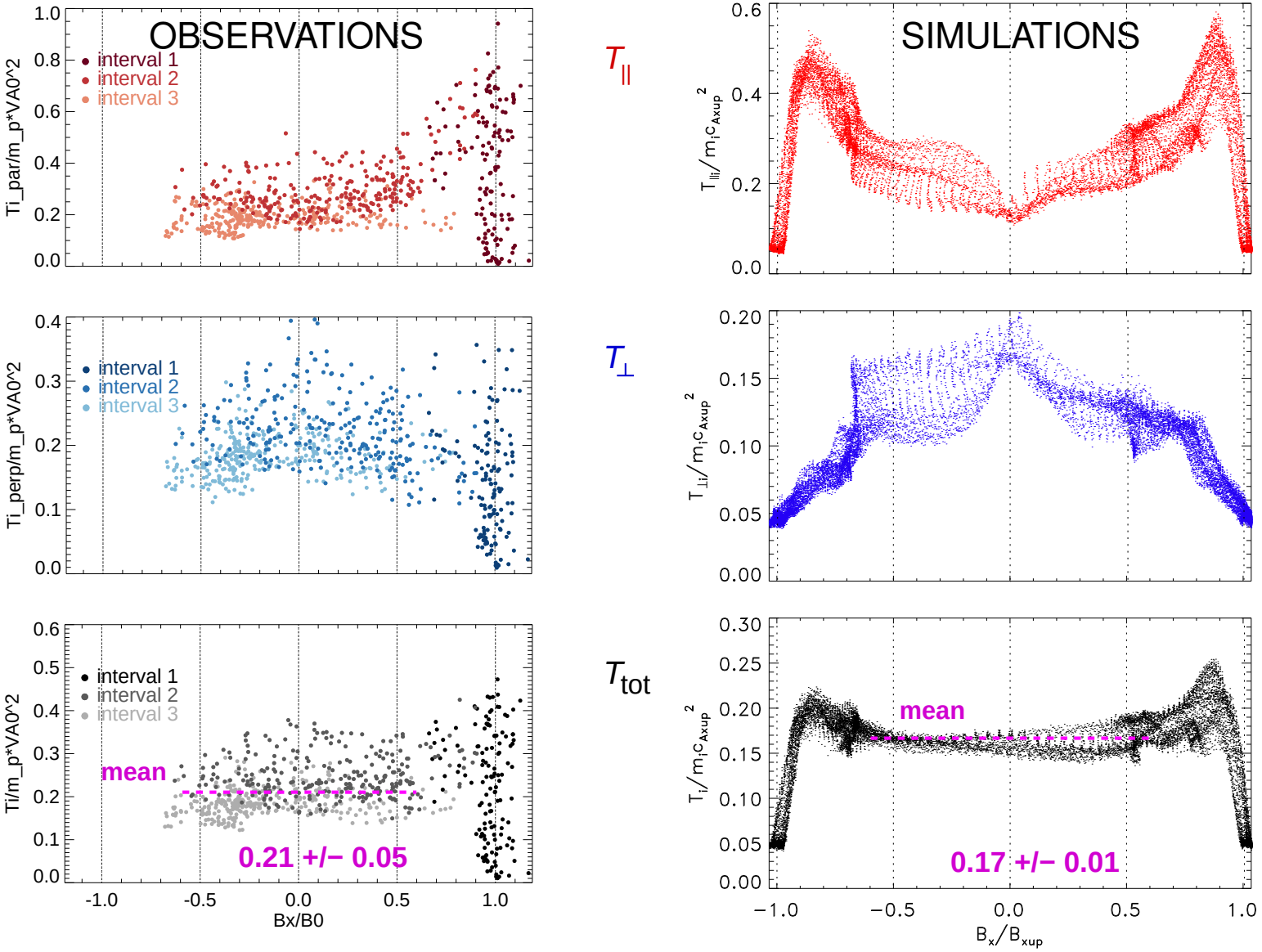


SIMULATIONS



→ we're **more than 100** d_i downstream

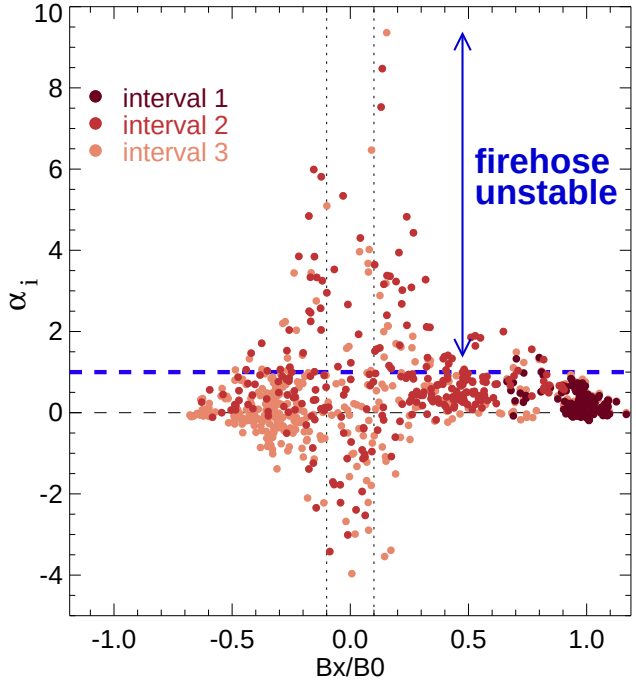
Temperature profiles: good agreement



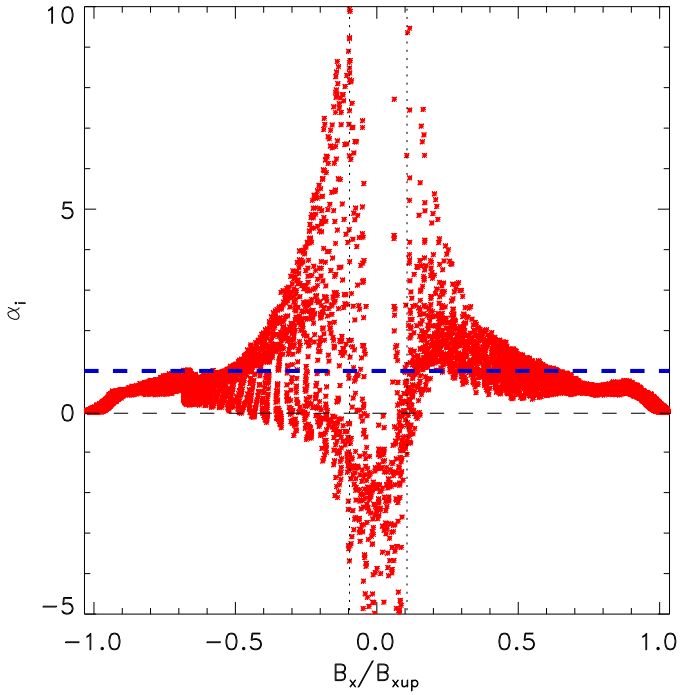
Firehose condition: good agreement

$$\alpha = \frac{1}{2}(\beta_{||} - \beta_{\perp}) > 1 \quad \text{is unstable}$$

OBSERVATIONS



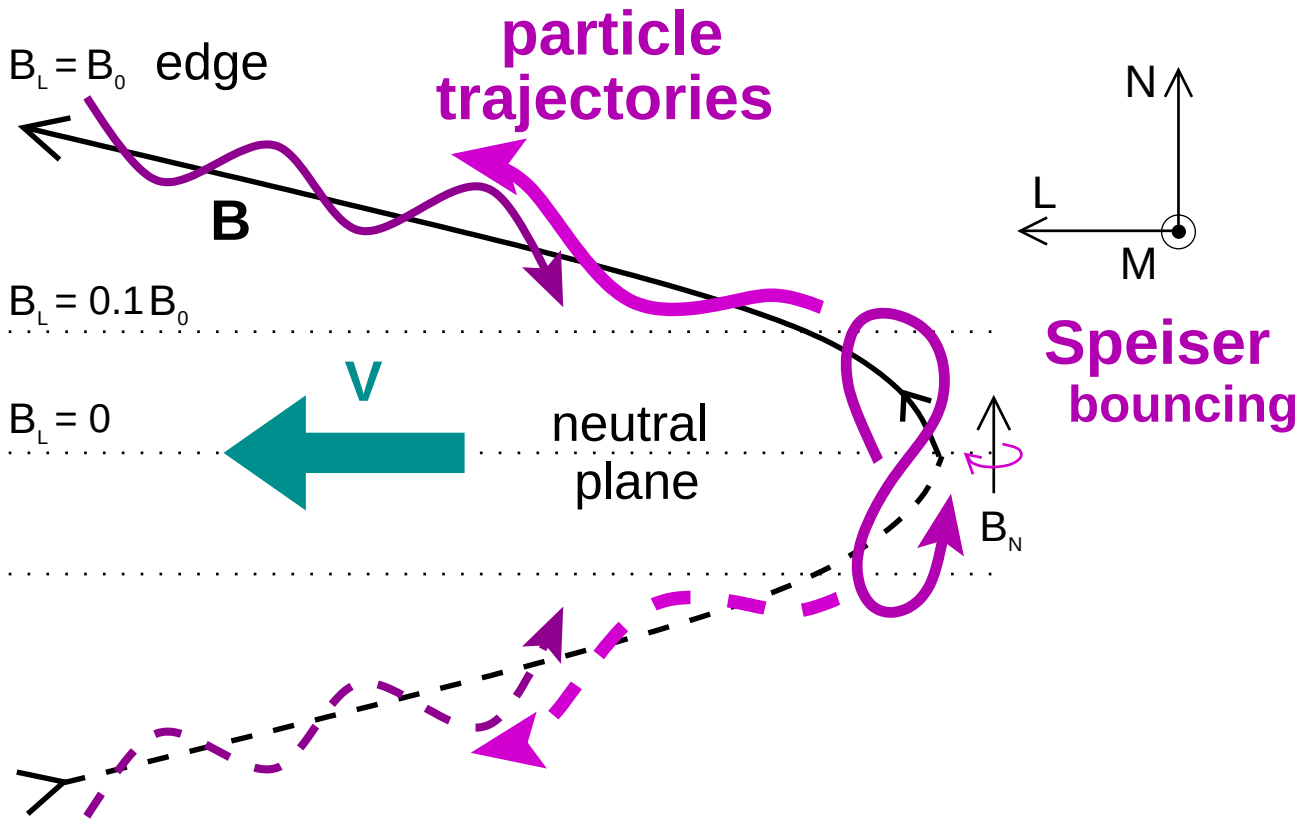
SIMULATIONS



→ firehose ***not fast enough*** to limit anisotropy

Ion dynamics: reconnection plane

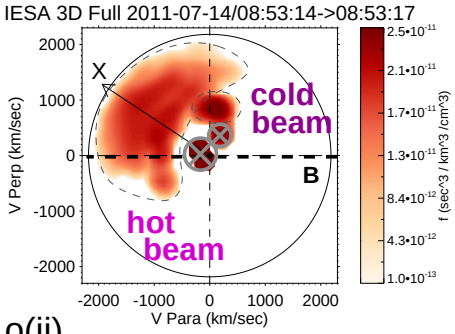
jet frame



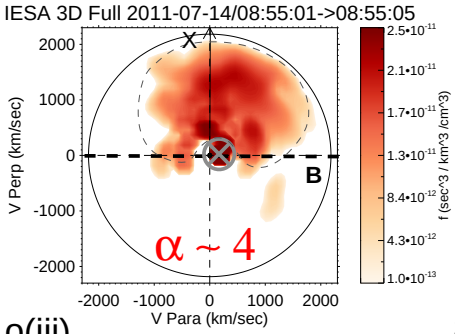
Ion dynamics: reconnection plane edge → mid-plane

OBSERVATIONS

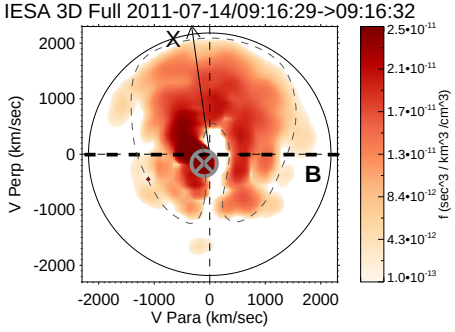
o(i)



o(ii)

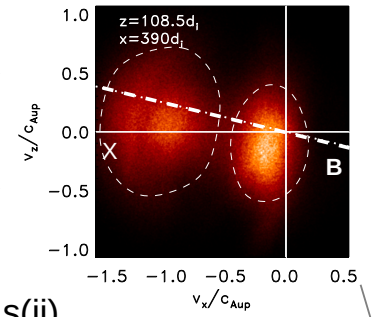


o(iii)

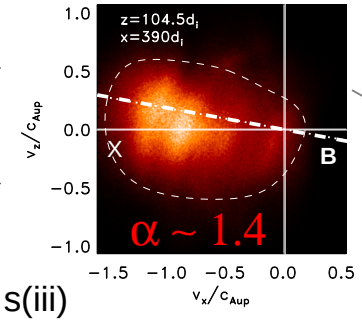


SIMULATIONS

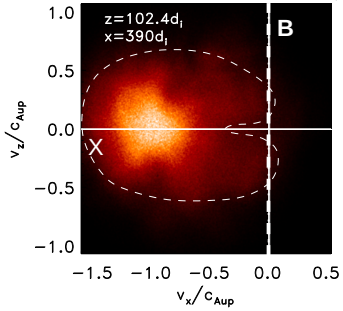
s(i)

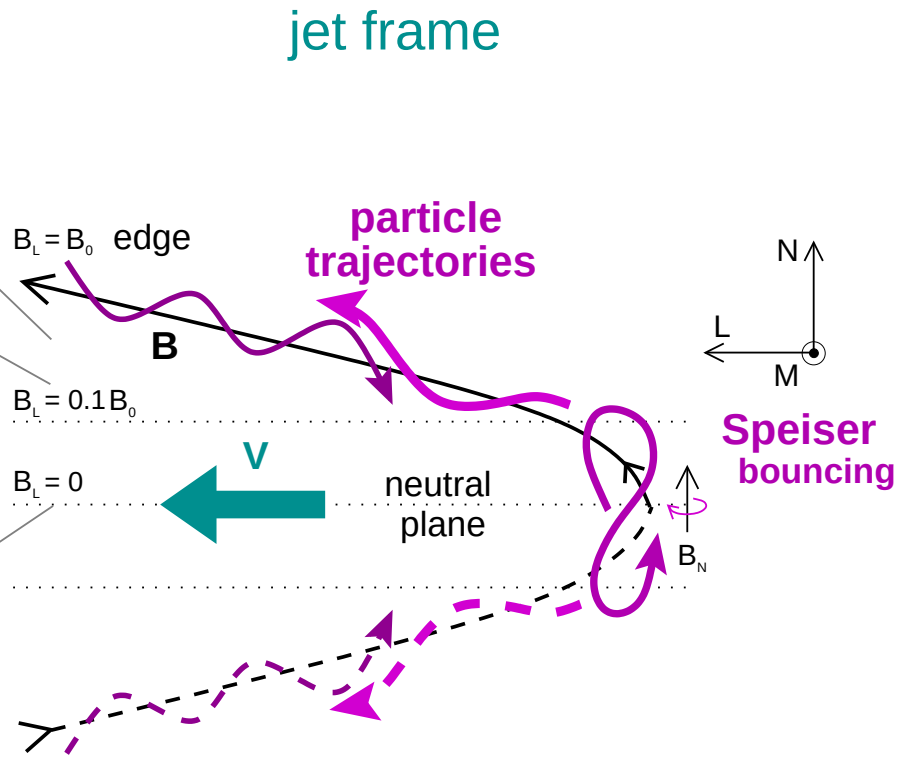


s(ii)



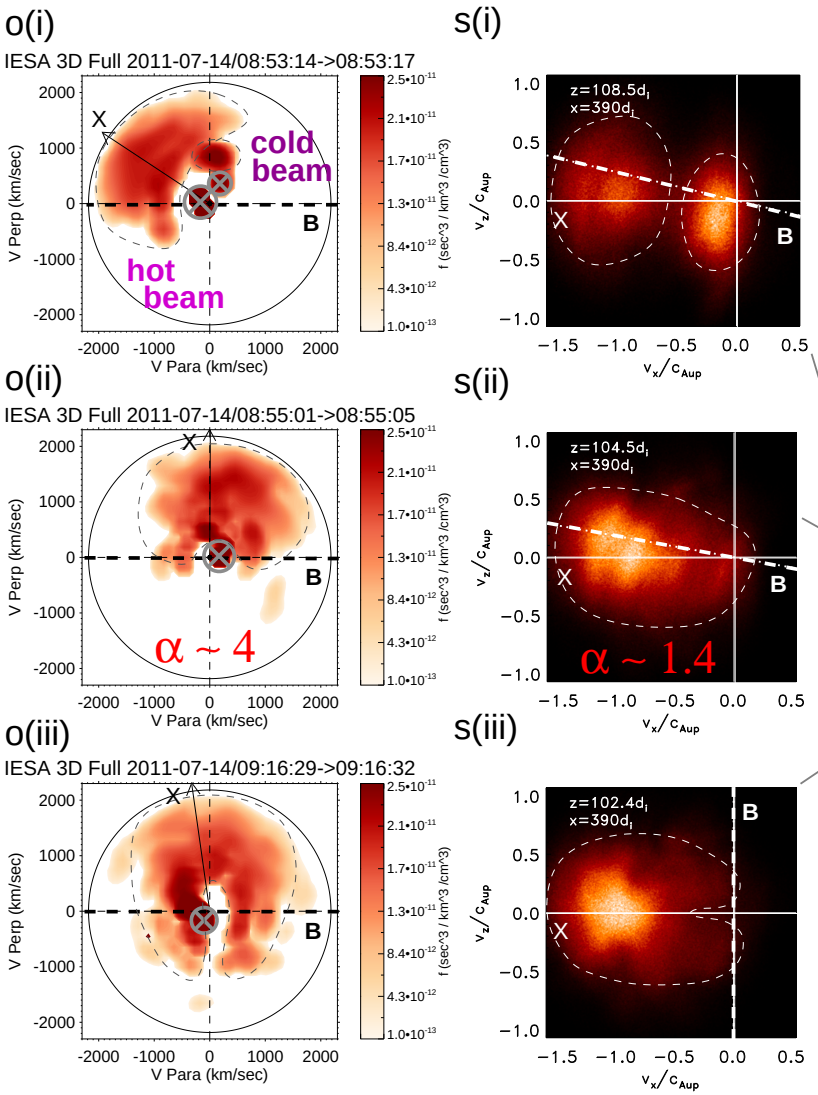
s(iii)

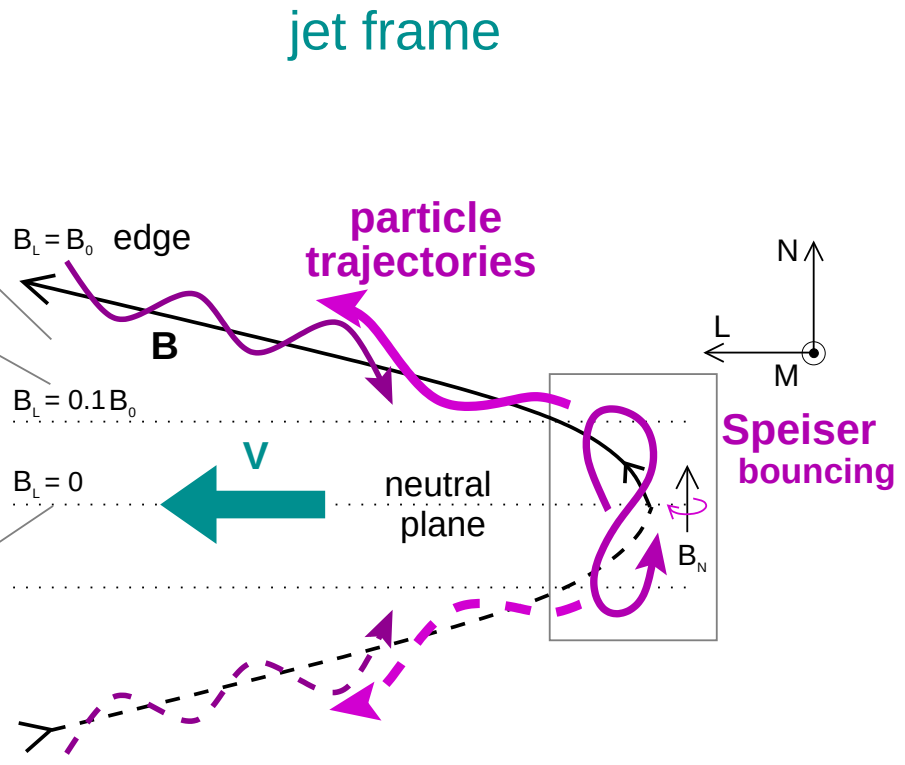




Ion dynamics: reconnection plane edge → mid-plane

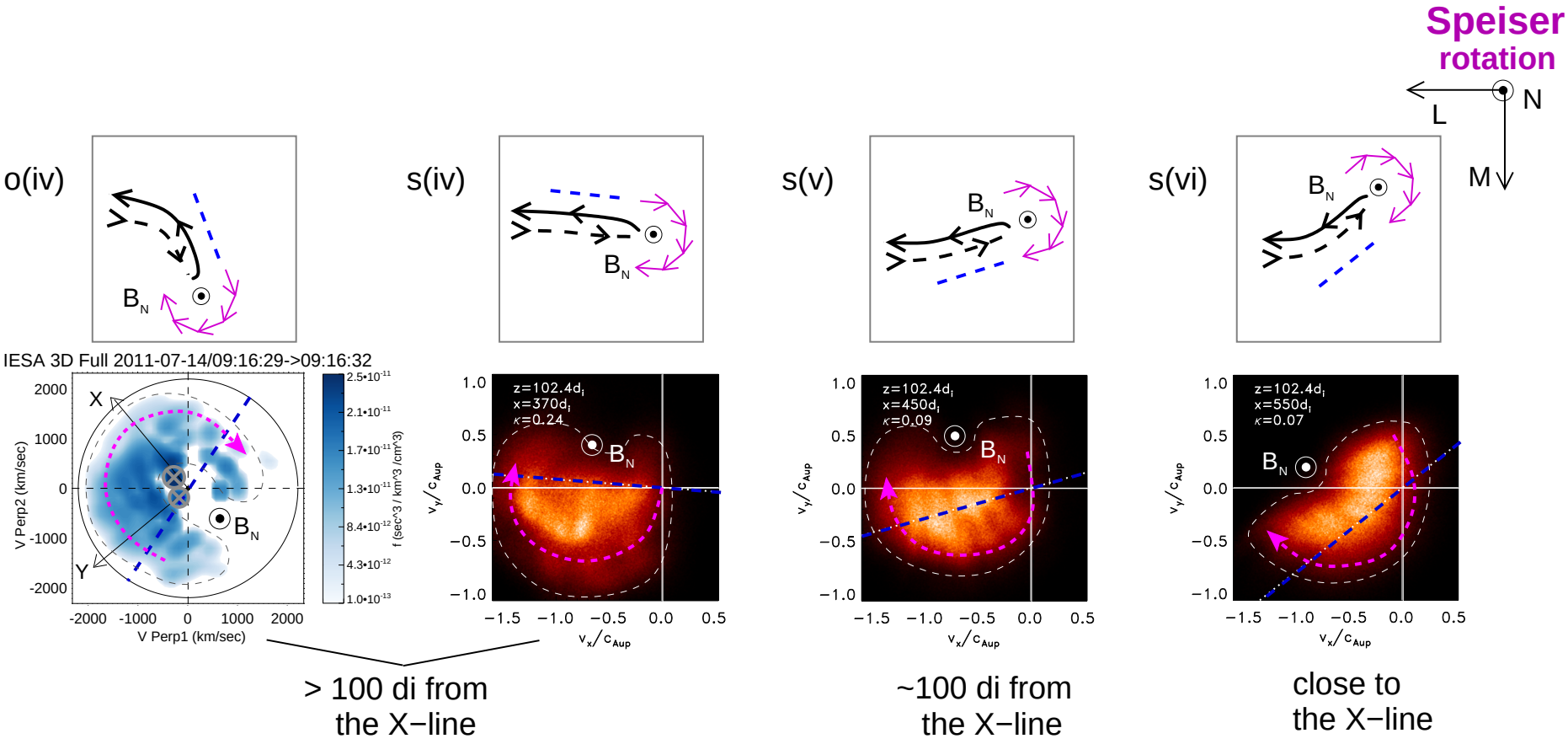
OBSERVATIONS SIMULATIONS



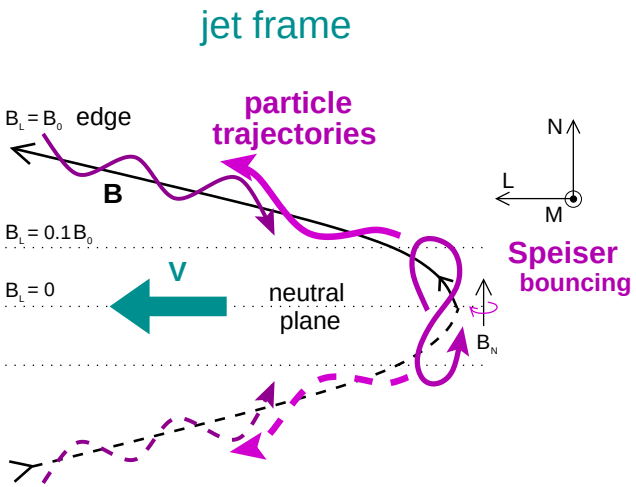


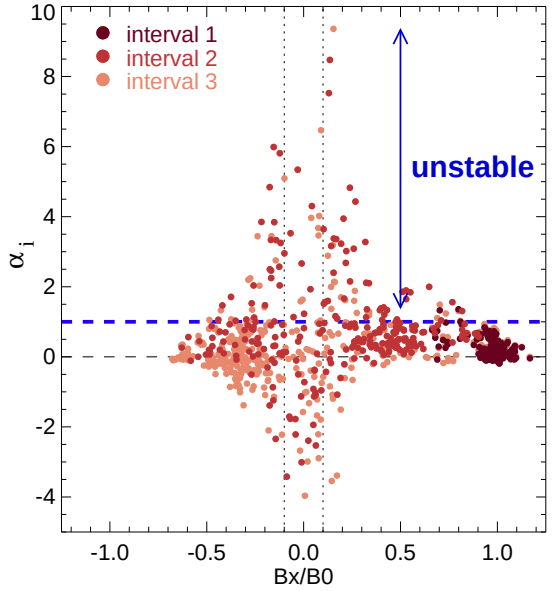
Ion dynamics: current sheet plane

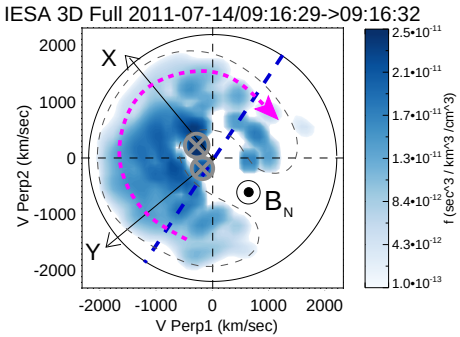
orientation of the loop defines the orientation of the Speiser-like distribution



Conclusions
on anisotropy and dynamics



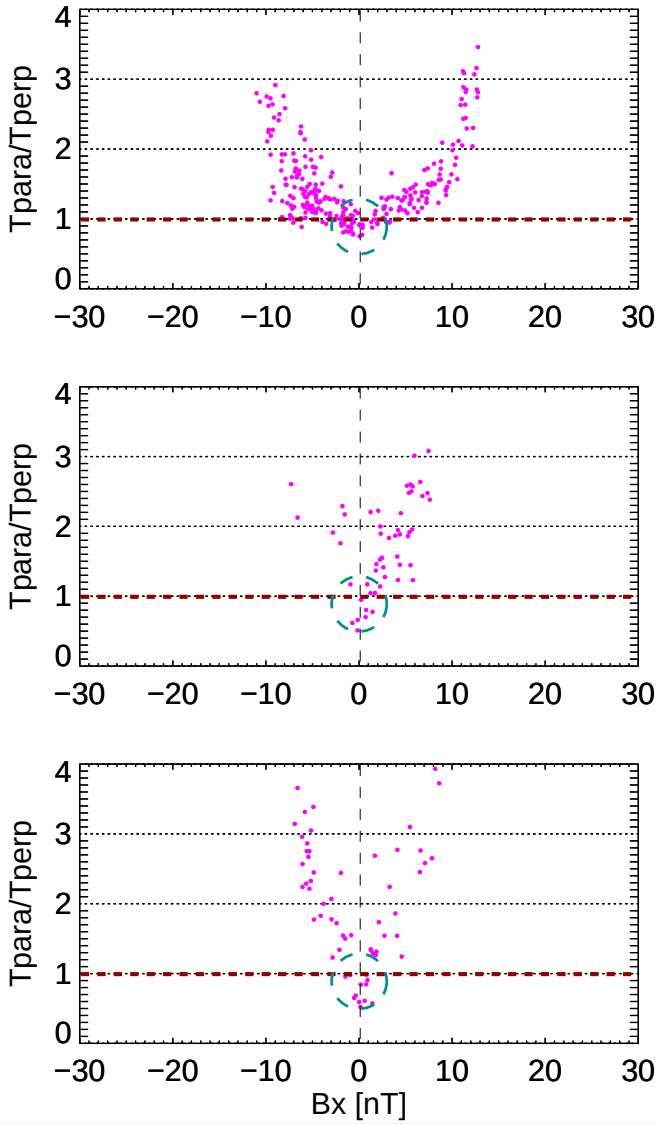




(1) varying anisotropies (2) firehose unstable (3) Speiser-like

Additional material

Other events: $T_{||}/T_{\perp}$ profiles



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