University of Southampton

Observations and simulations of northward IMF magnetotail structure

ST2.7 – Global magnetospheric dynamics in simulations and observations

EGU2022 - Thursday 26/05/2022

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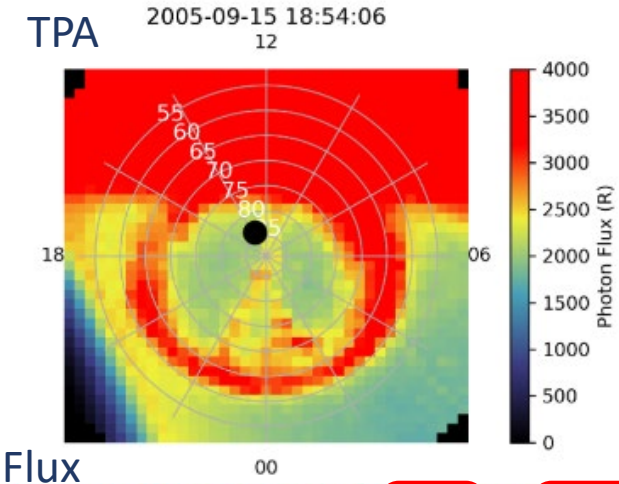
UKRI Science and Technology Facilities Council

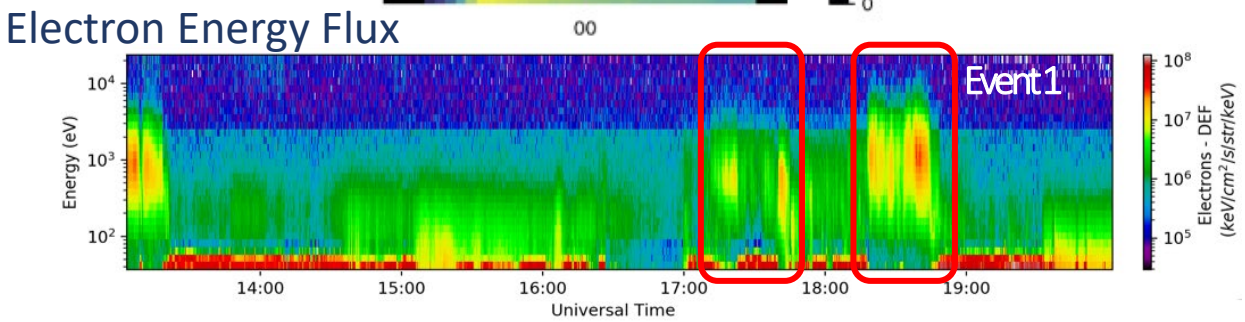
Northward IMF – Open questions

Observations

- What mechanism produces Transpolar Arcs?
- What leads to observations of uncharacteristically hot plasma in lobes?

Fryer et al 2021 - Published in JGR

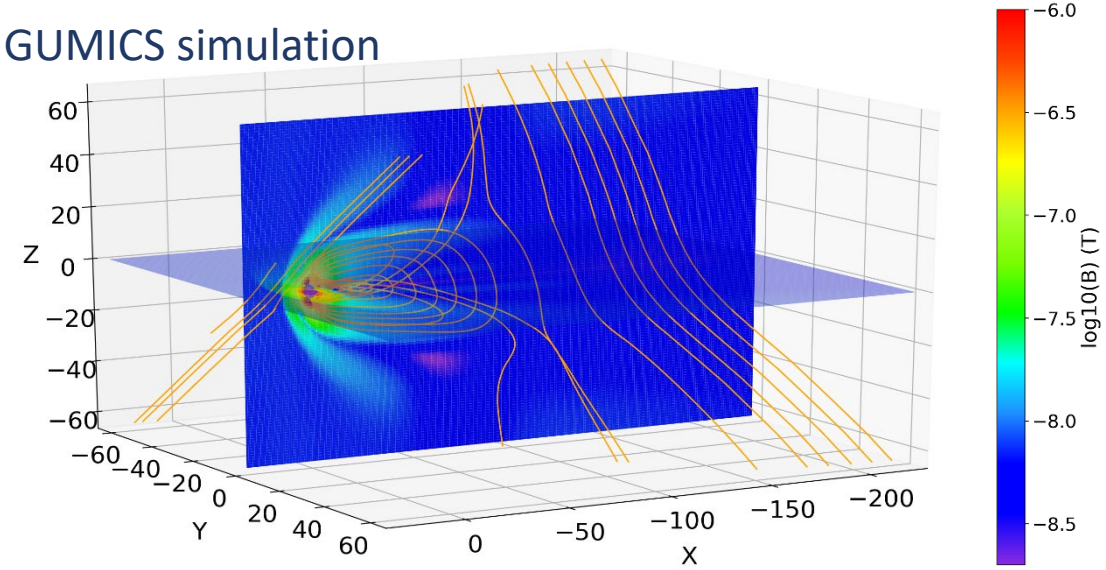




Simulations

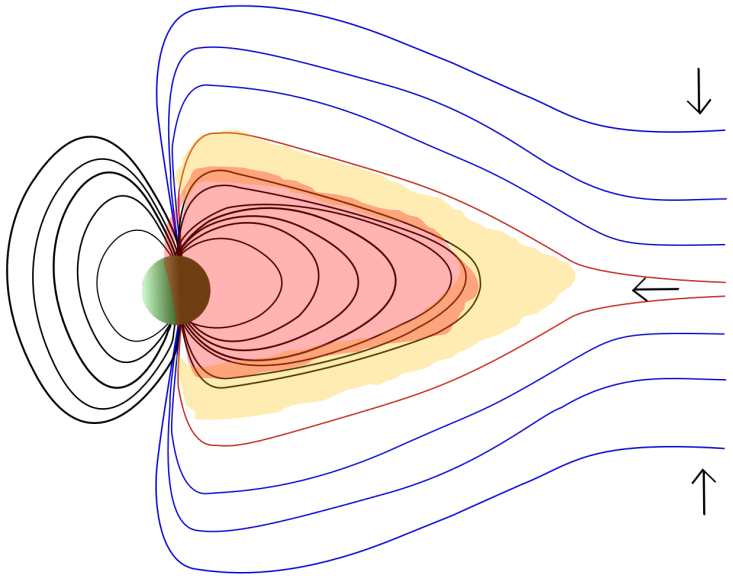
- What is the global configuration during Northward IMF?
- How does this relate to observations of TPAs and hot plasma populations?

Fryer et al 2022 – In prep



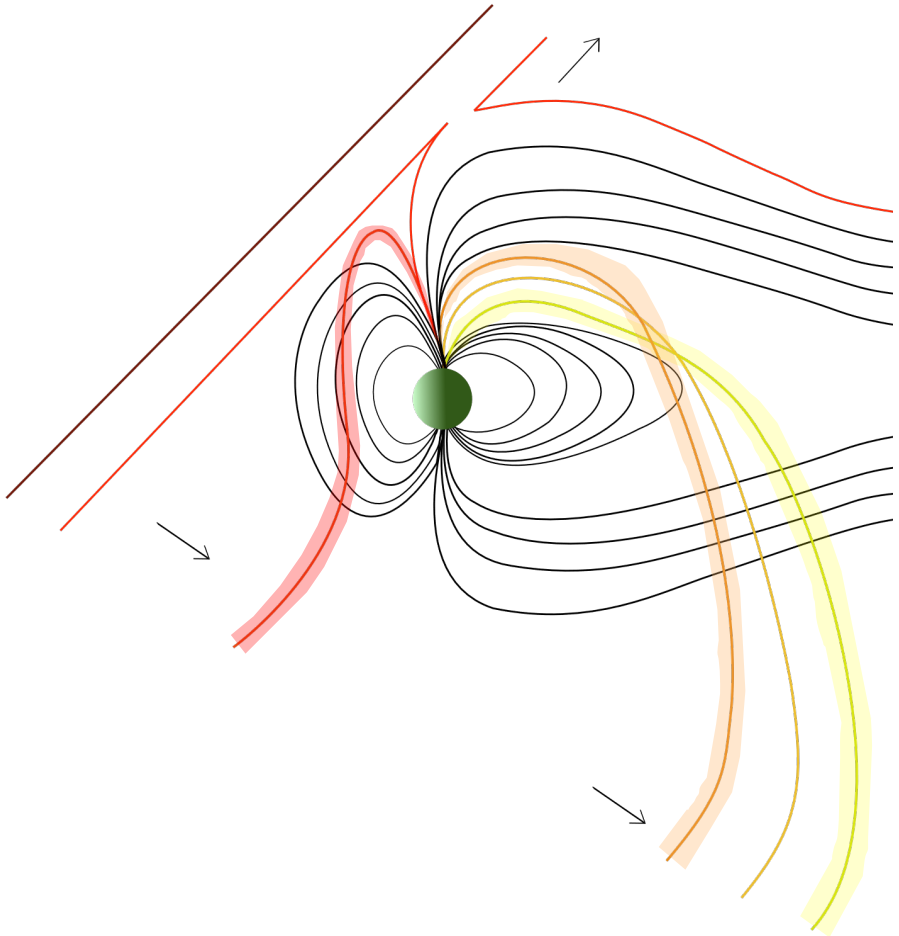
Current interpretations

Observations – closed



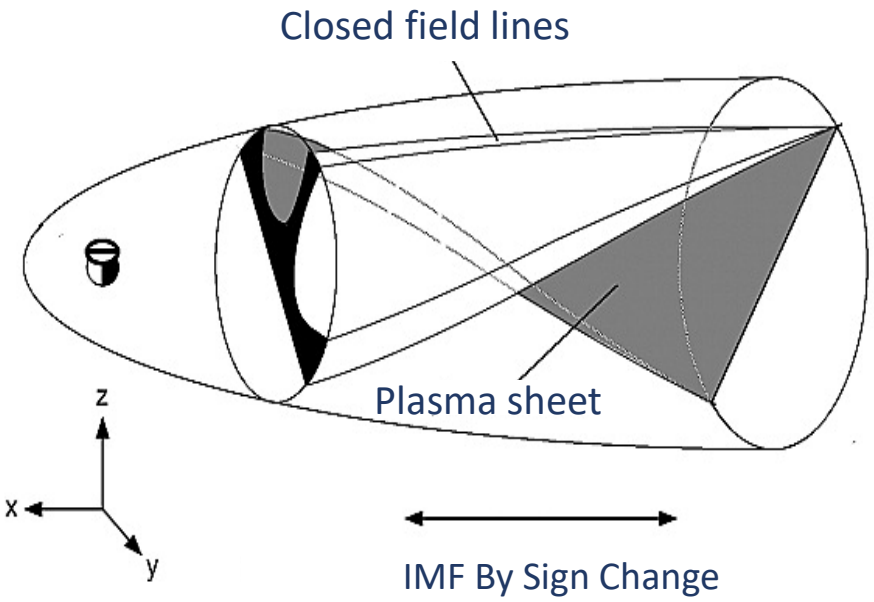
Milan et al 2005

Observations – open



Shi et al 2013

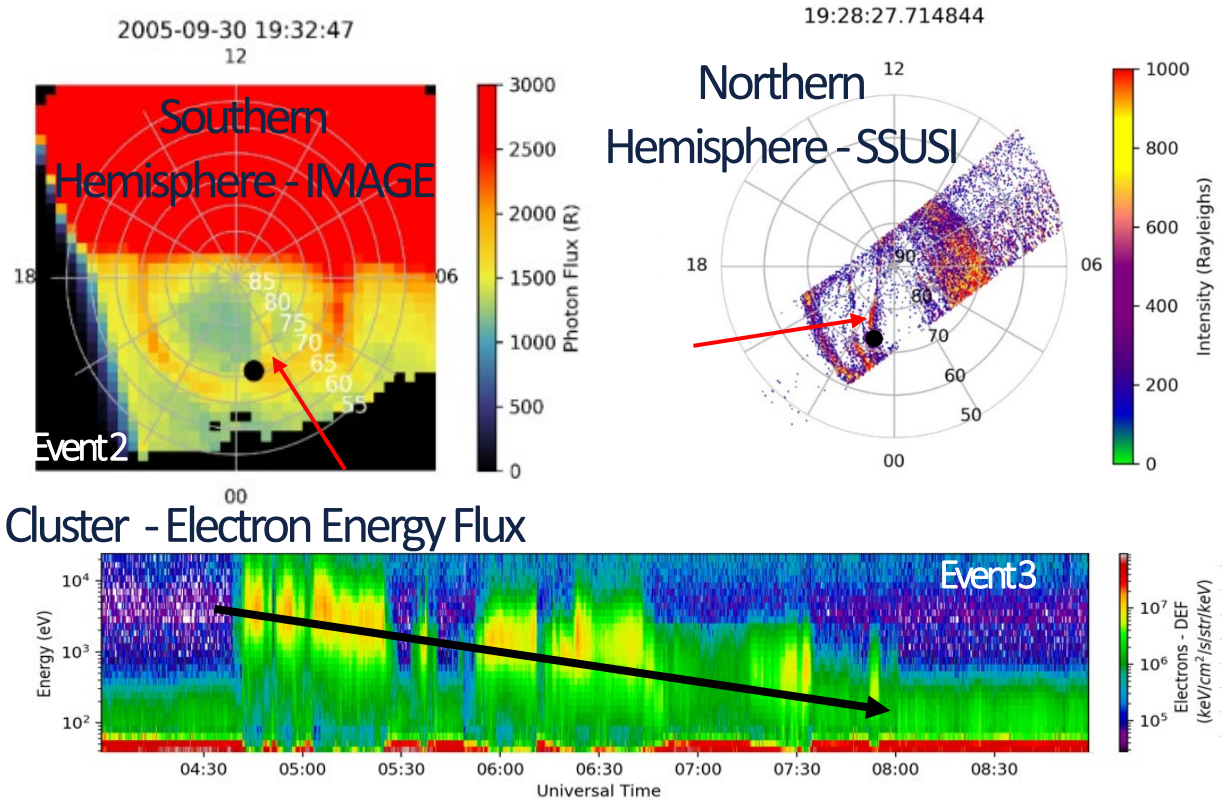
Simulations



Kullen et al 2002

Observational Case study results

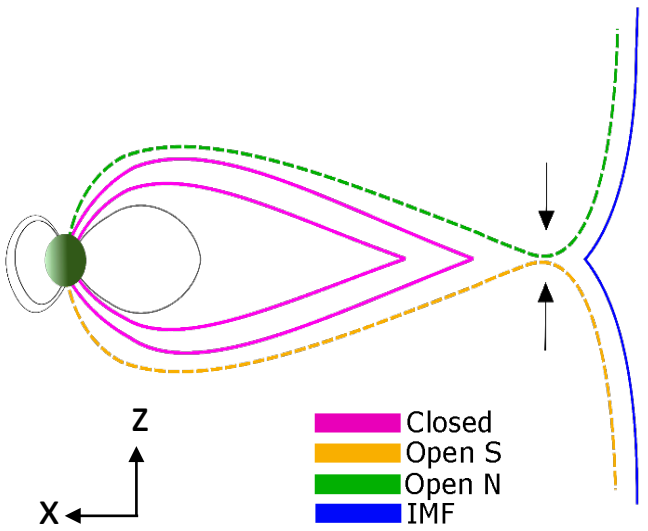
Fryer et al 2021 - Published in JGR



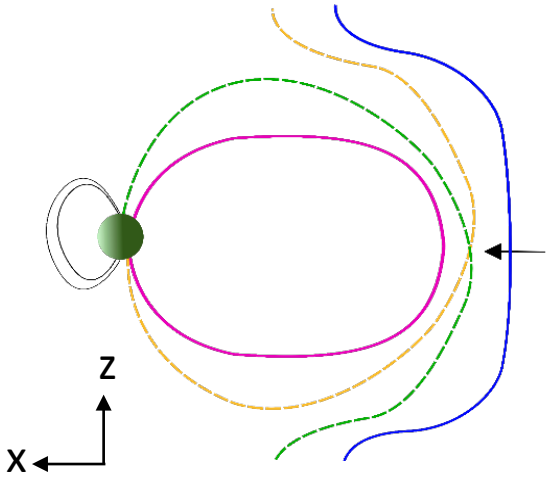
- Pitch angle distributions measured for all events compare well with observations of different “depths” of plasma sheet .
- Plasma energies measured in the lobe were comparable to simultaneous Double Star measurements in the plasma sheet.
- Observations of conjugate arcs indicated a closed field line topology (e.g Milan et al 2005 mechanism).
- Relationship between the plasma energy and the latitudinal footprint of spacecraft, agreed with tail reconnection mechanism.

GUMICs 3D Northward IMF simulations

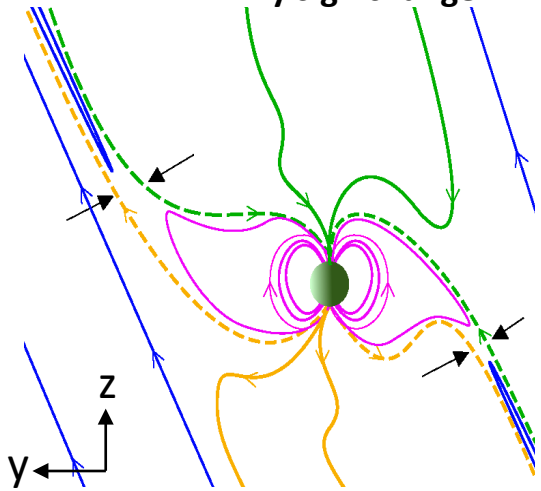
Proposed TPA reconnection configuration



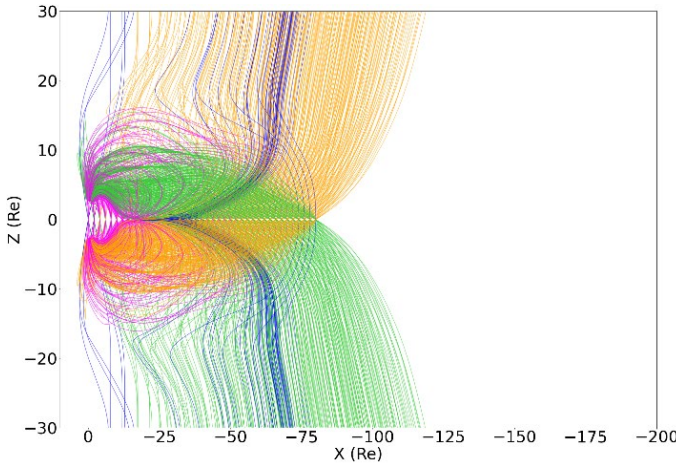
Purely Northward IMF – By sign change

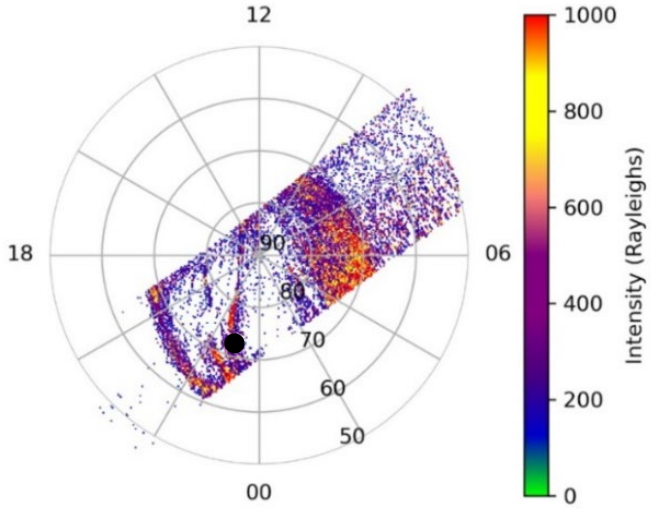


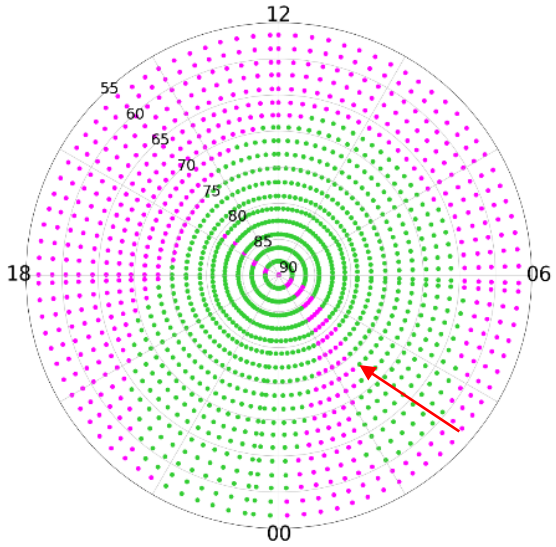
Initialised with southward IMF – By sign change

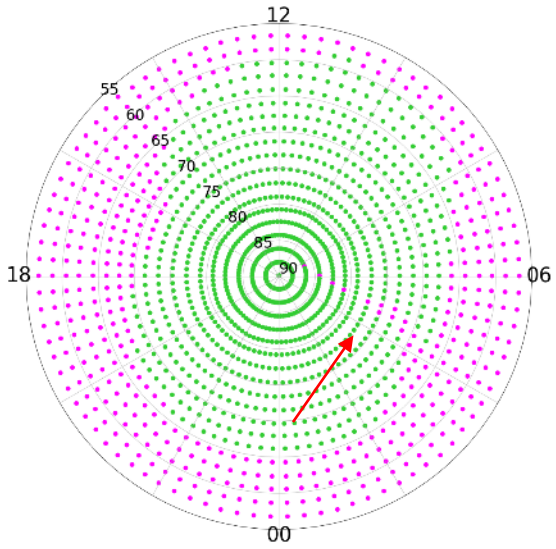


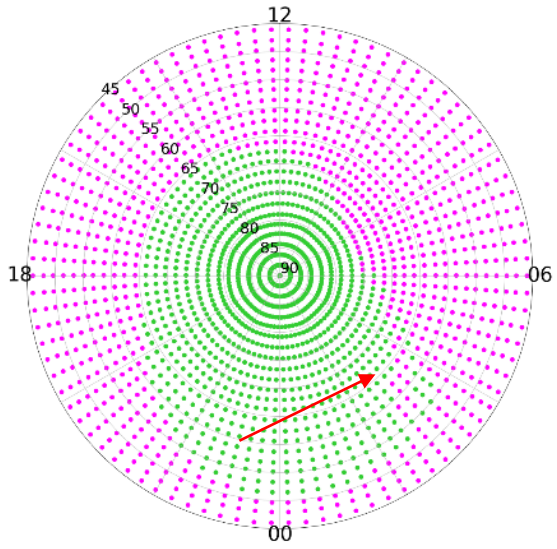
Purely Northward IMF – Pressure Pulse – By constant











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Supplementary material

Observations study – Fryer et al 2021
Cluster 20th issue JGR - doi:10.1029/2021JA029281

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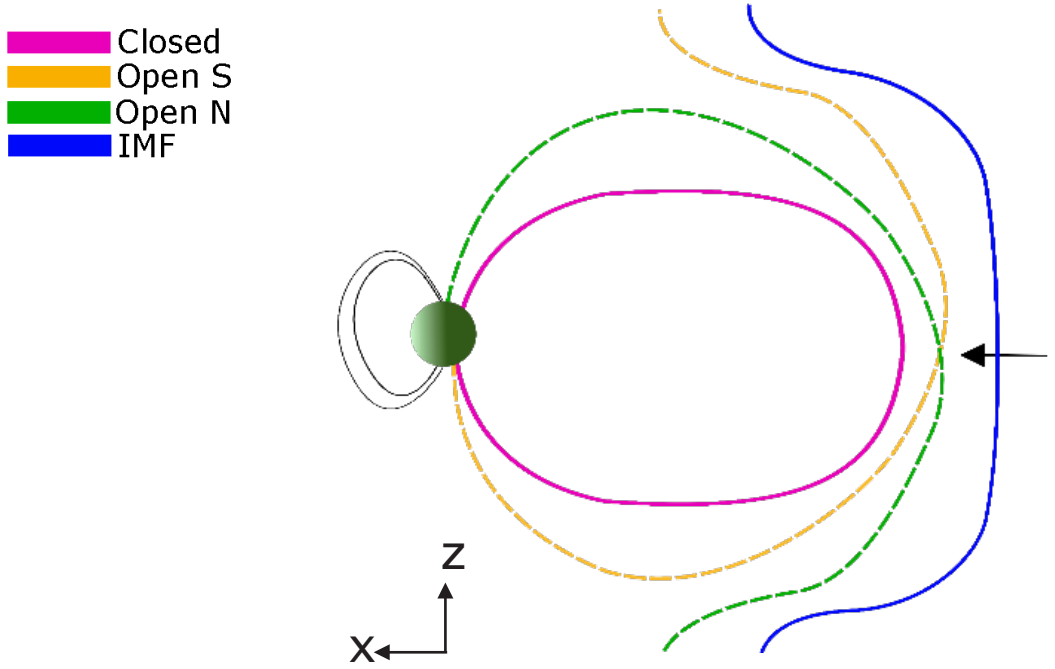
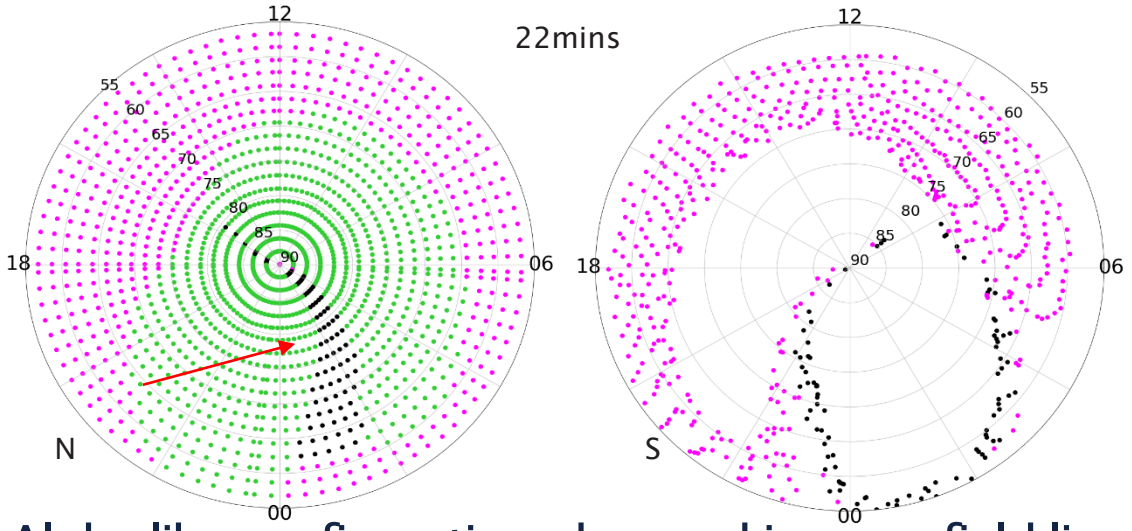
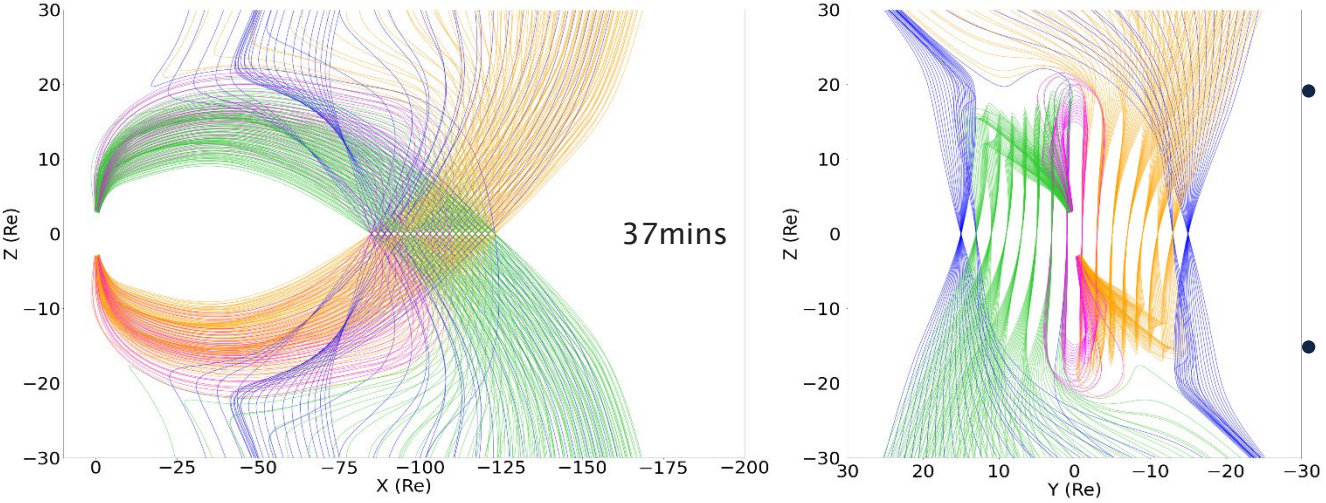
Purely northward IMF, B_y sign change

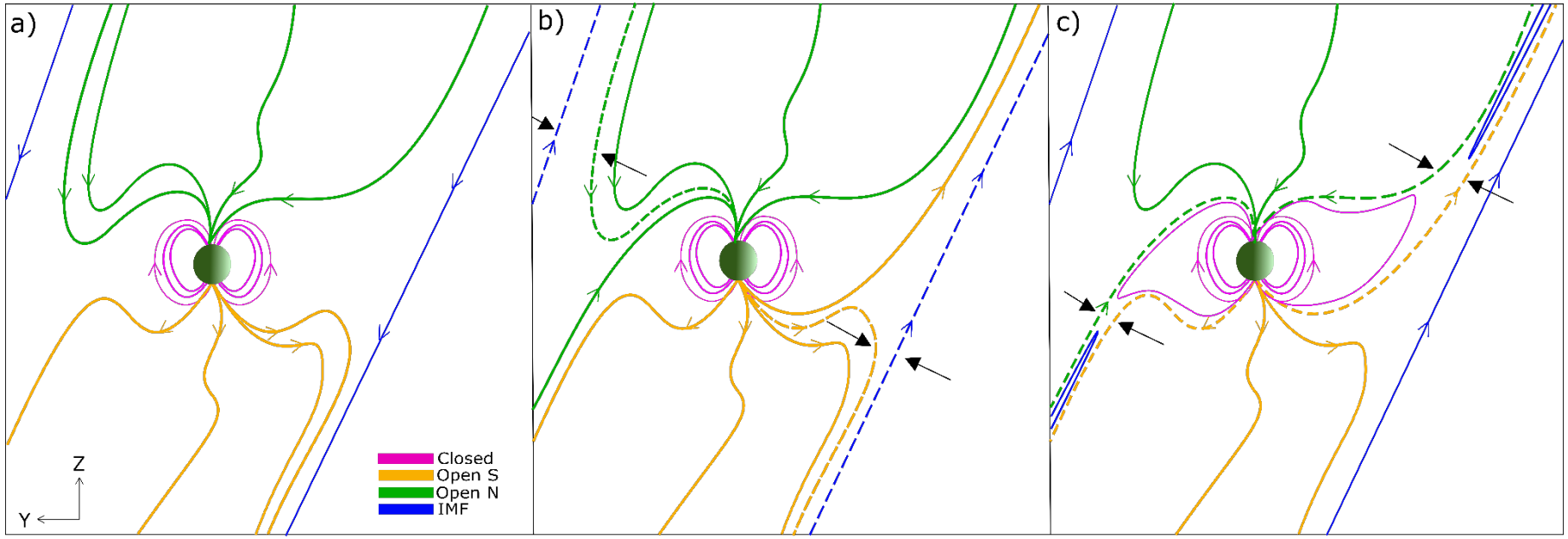


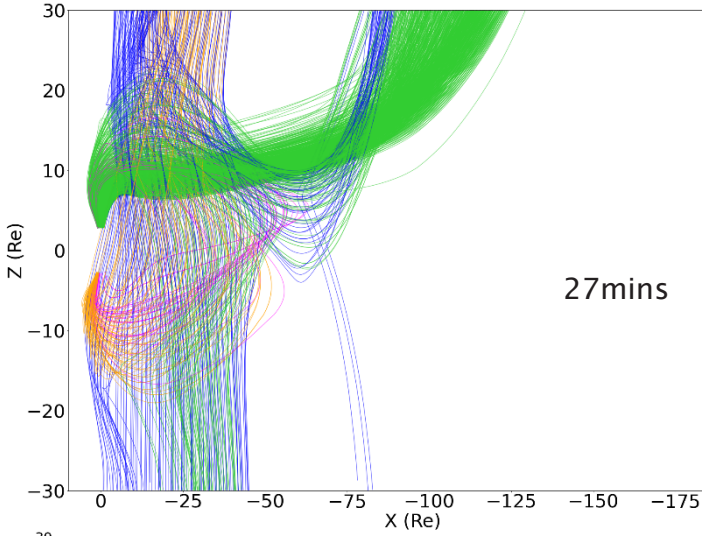


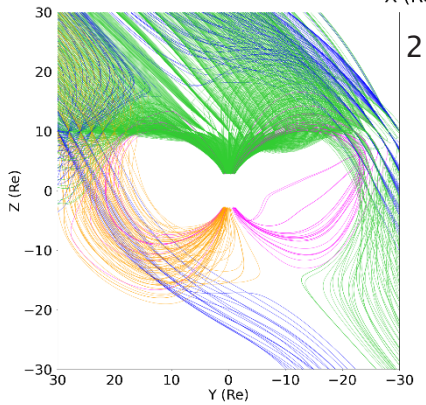


- Alpha-like configuration observed in open field line regions as a result of northward IMF initialization.
- B_y sign change causes field lines to rotate and oppositely connected N-open and S-open regions come into close contact.
- Four topologies meet in the mid-tail region, replicating magnetotail reconnection configurations, resulting in closed field lines being added to the tail.
- A large closed wedge protrudes into polar cap at the ionospheric boundary with some connection to the southern hemispheric protrusion (black traces above).

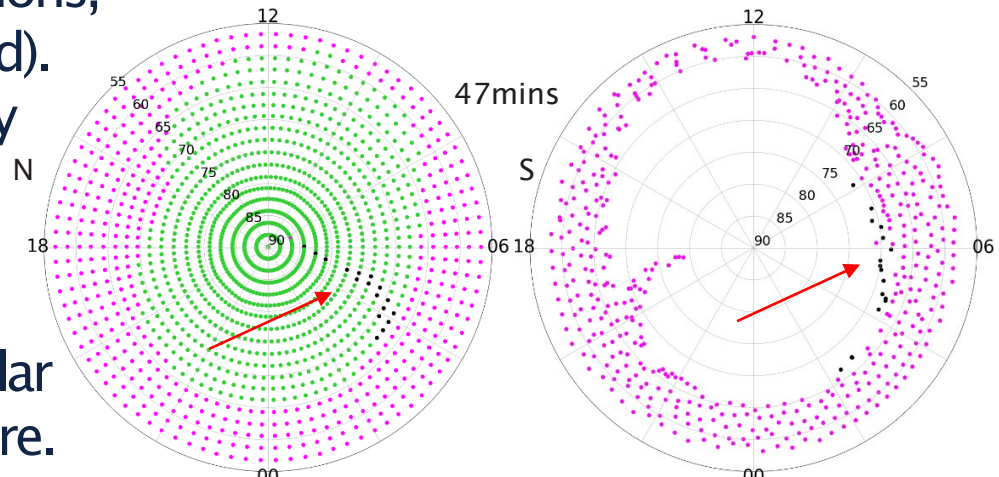
Southward IMF initialisation, with B_y sign change







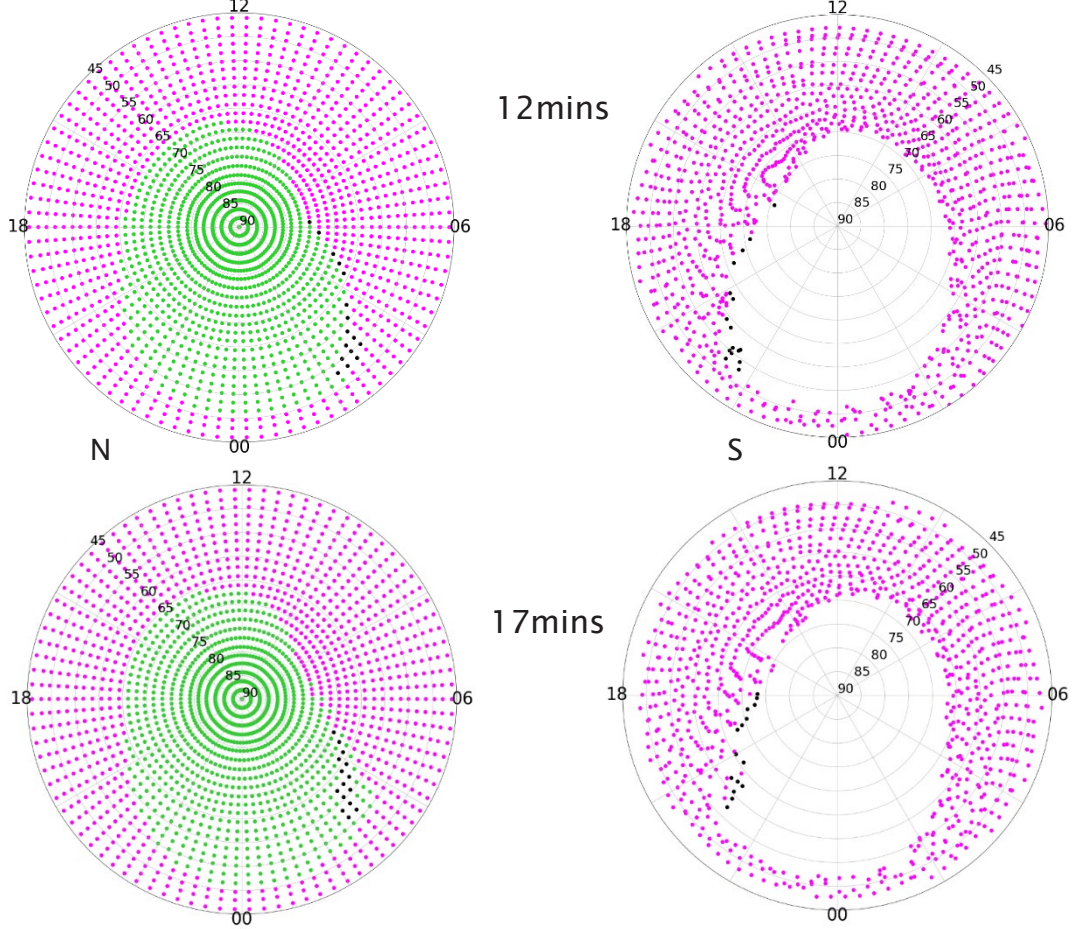
- Panel (a): Southward initialisation process forms two ‘typical’ open regions in the northern and southern hemispheres.
- Panel (b): Incoming Northward IMF then reconfigures the open regions, causing some to cross the X-axis (alpha-like, as previously observed).
- Panel (c): B_y sign change is introduced and allows for the oppositely directed open field lines to reconnect at high latitude and hence form two, distinct, closed field line populations (bifurcated tail).



- Right hand fig: Tracing protruding closed field lines in northern polar cap (black) shows non-conjugate protrusion in southern hemisphere.

Pressure pulse, constant B_y conditions

- A purely northward IMF initialisation results in alpha-like open field line regions in the mid-tail (as before).
- From 17 minutes after the pressure pulse hit the nose of the dayside magnetopause boundary, there is a single, large-scale wedge, that protrudes into the polar cap.
- We observe clear conjugacy between the north and south.
- The wedge is detached at the nightside boundary, which is not typically observed with TPAs.
- Currently still investigating what causes this in the simulation.



Closed
Open S
Open N
IMF