Heliospheric current sheet and Solar Energetic Particle propagation

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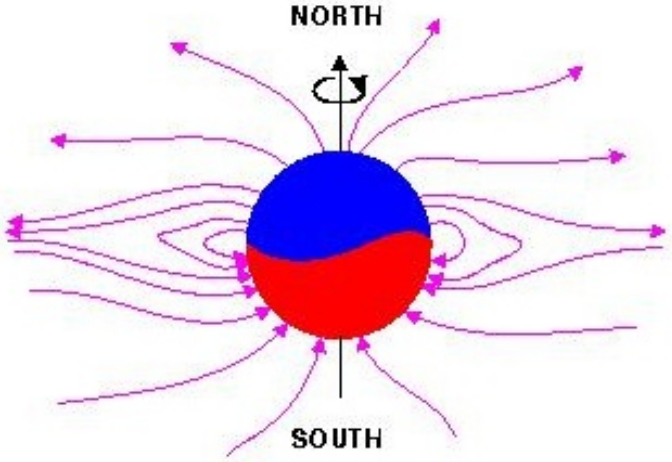
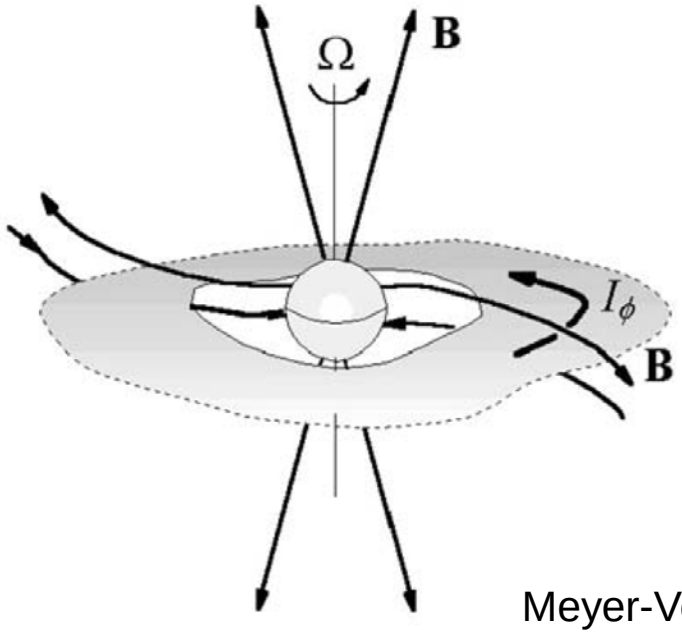
The Heliospheric Current Sheet (HCS)

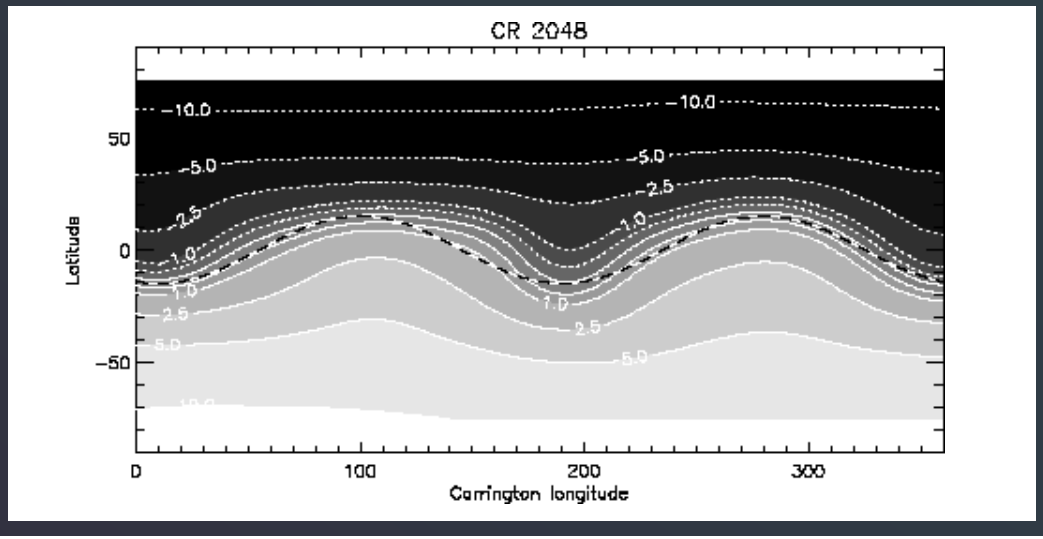


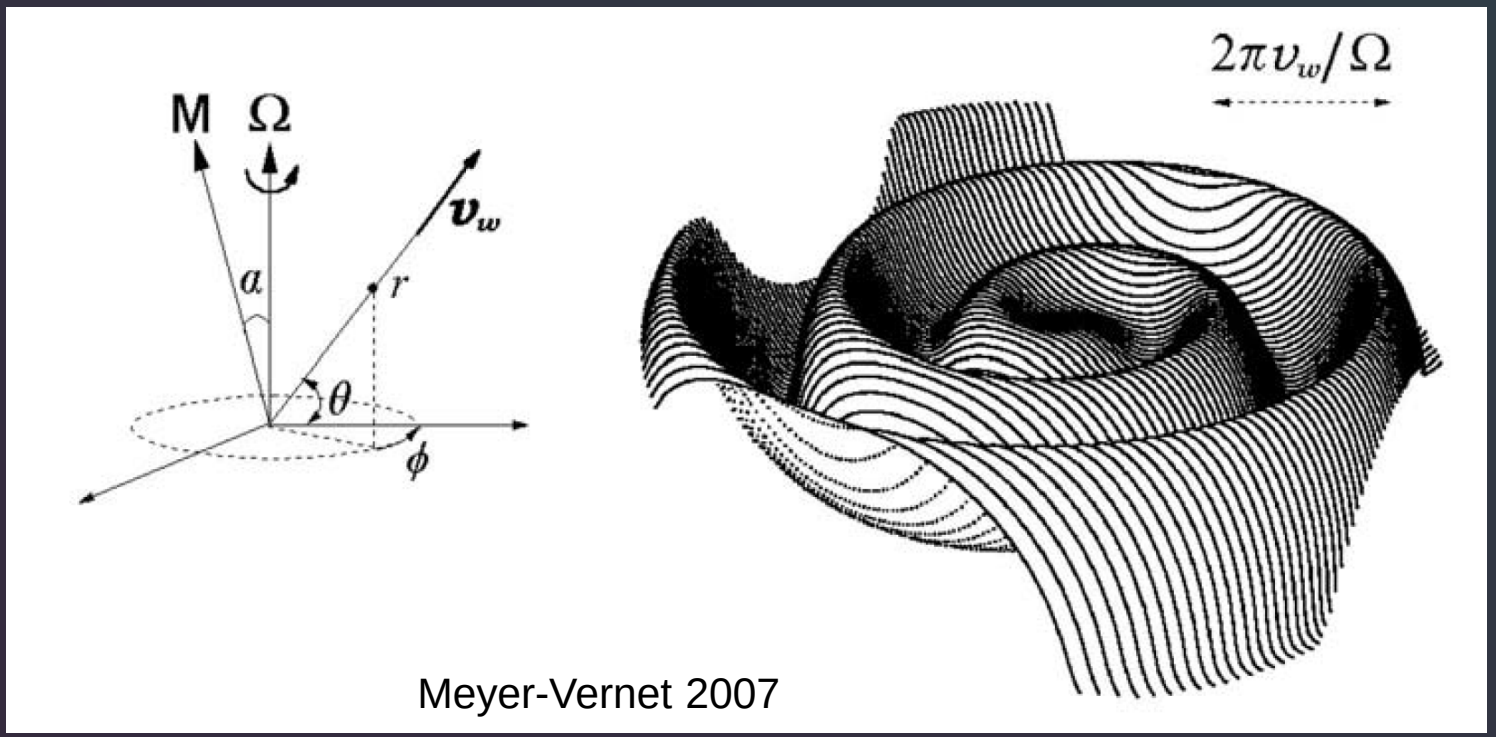
CORONAL MAGNETIC FIELD LINES AT
SOLAR MINIMUM ACTIVITY



Meyer-Vernet
2007

Wavy heliospheric current sheet



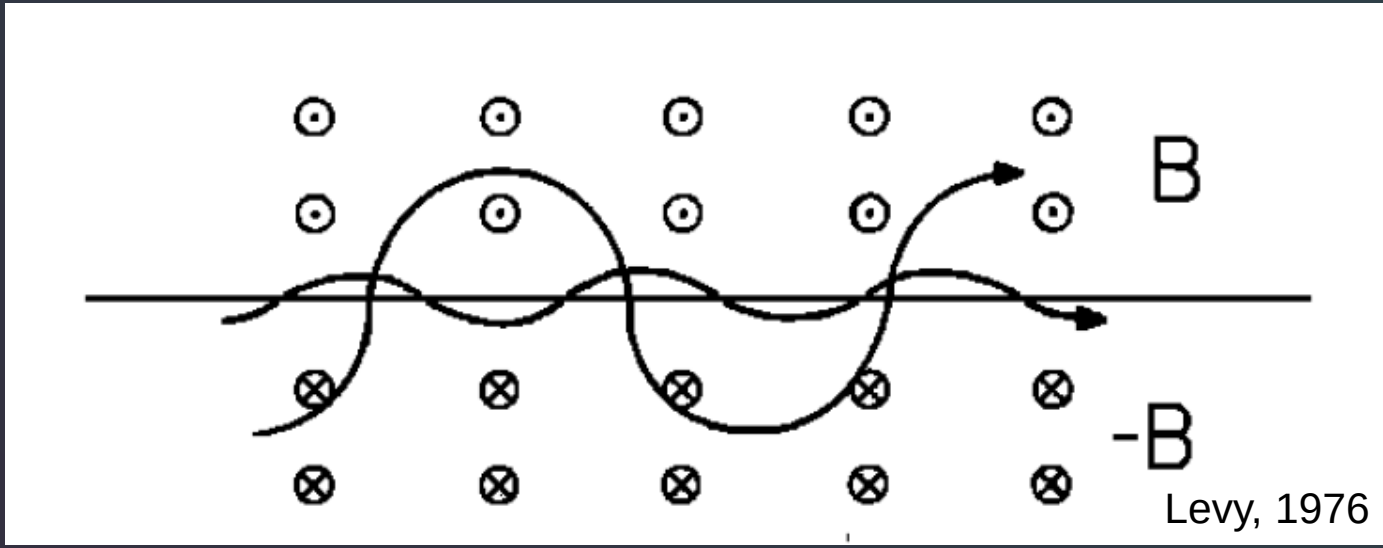


Meyer-Vernet 2007

This work:

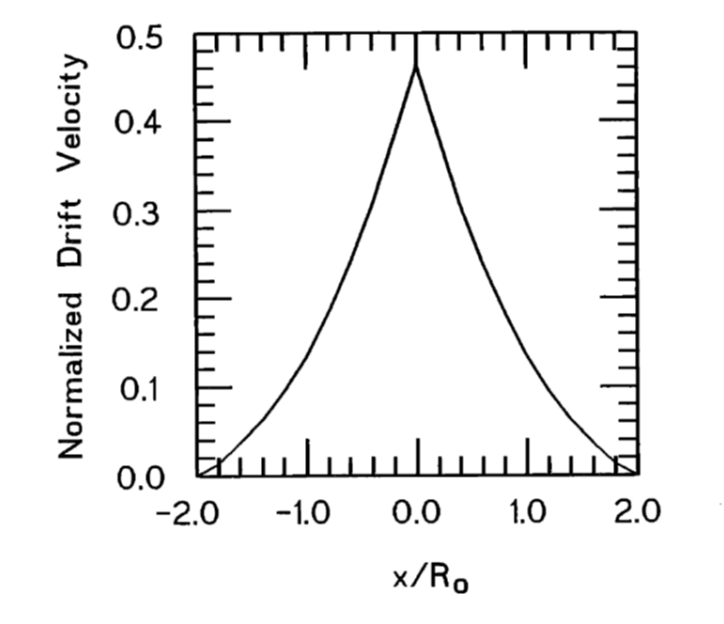
- Study the influence of the Heliospheric Current Sheet (HCS) on the propagation of Solar Energetic Particles (SEPs)
- Source locations of SEPs are often close to HCS
- The influence of HCS on (higher energy) Galactic Cosmic Rays (GCRs) is well studied

Current sheet drift

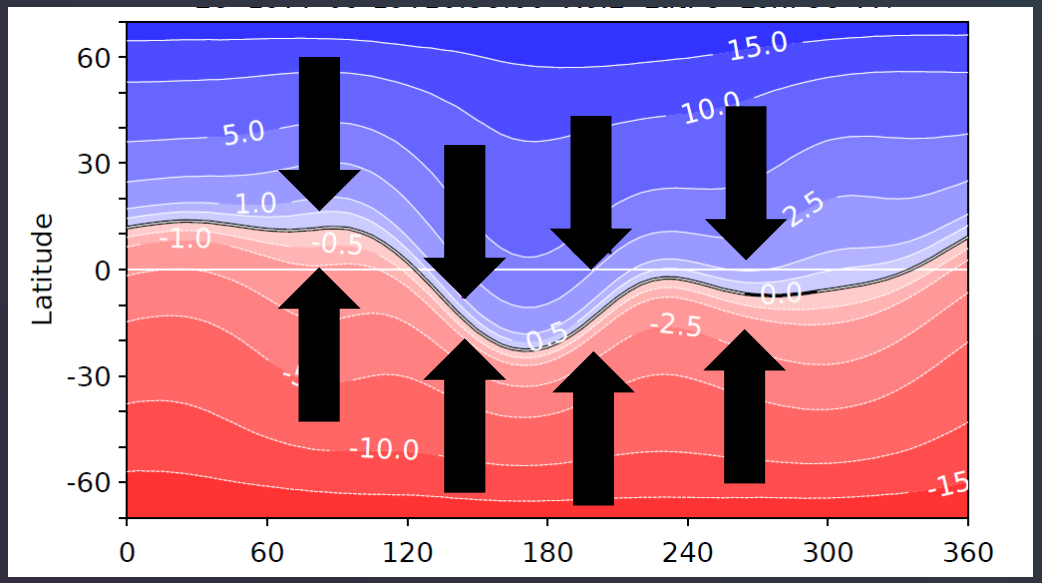


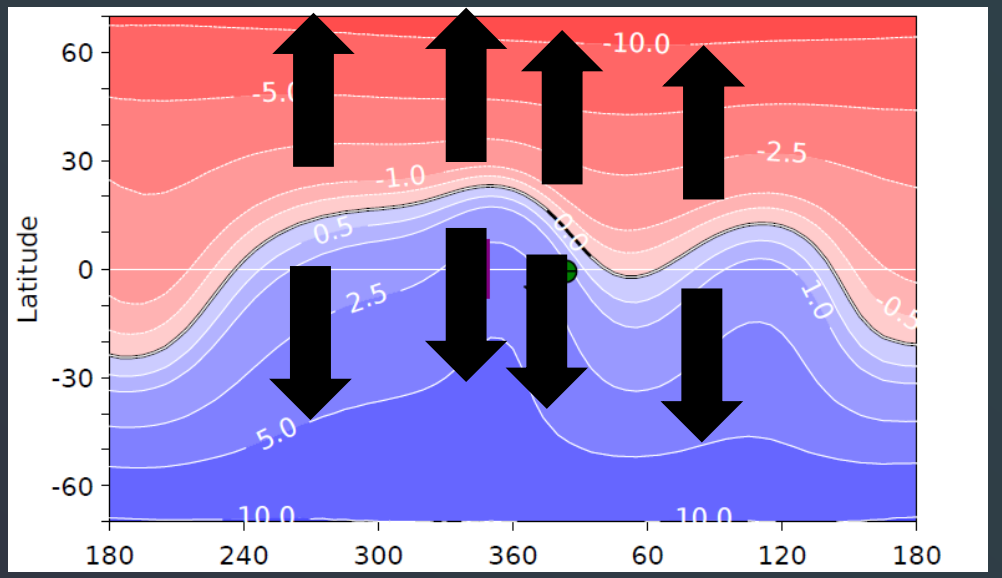
Levy, 1976

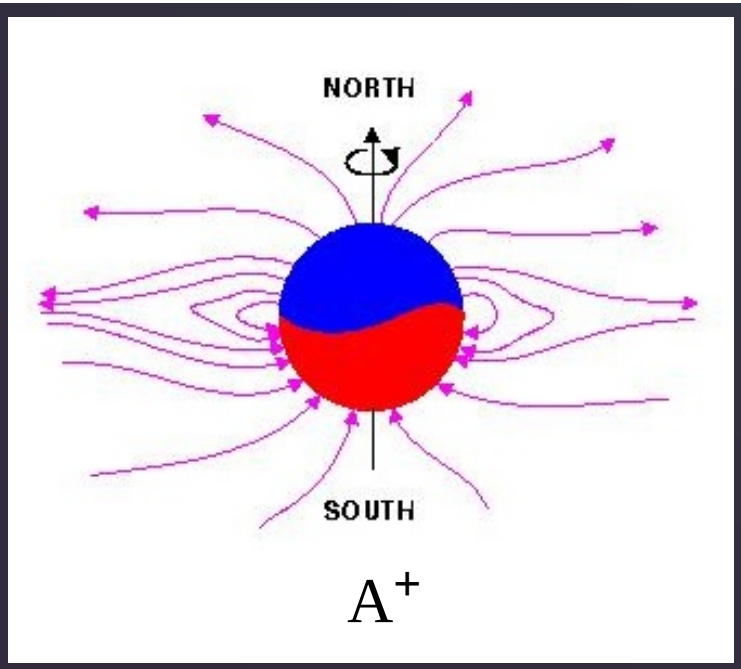
- Burger (1985) calculated the expected drift velocity, averaged over an isotropic population

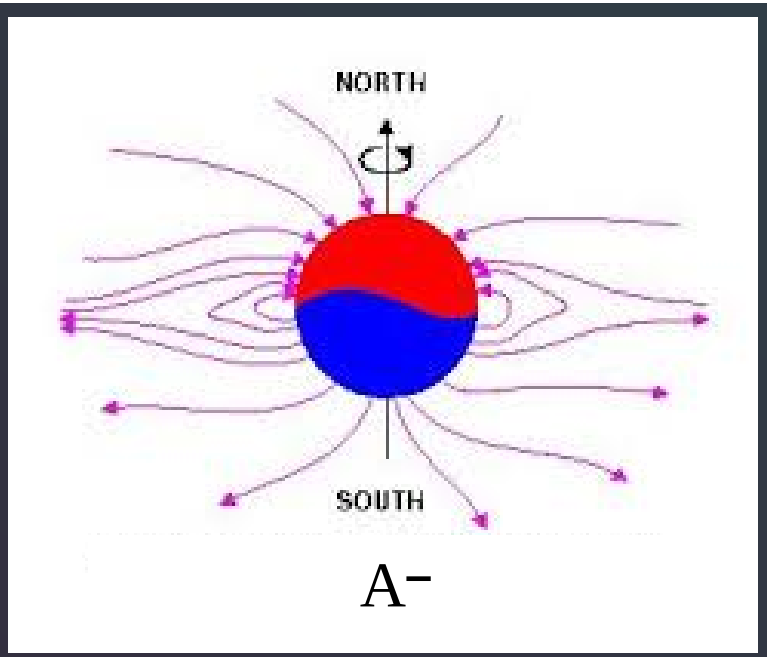


Heliospheric polarity configurations and particle propagation

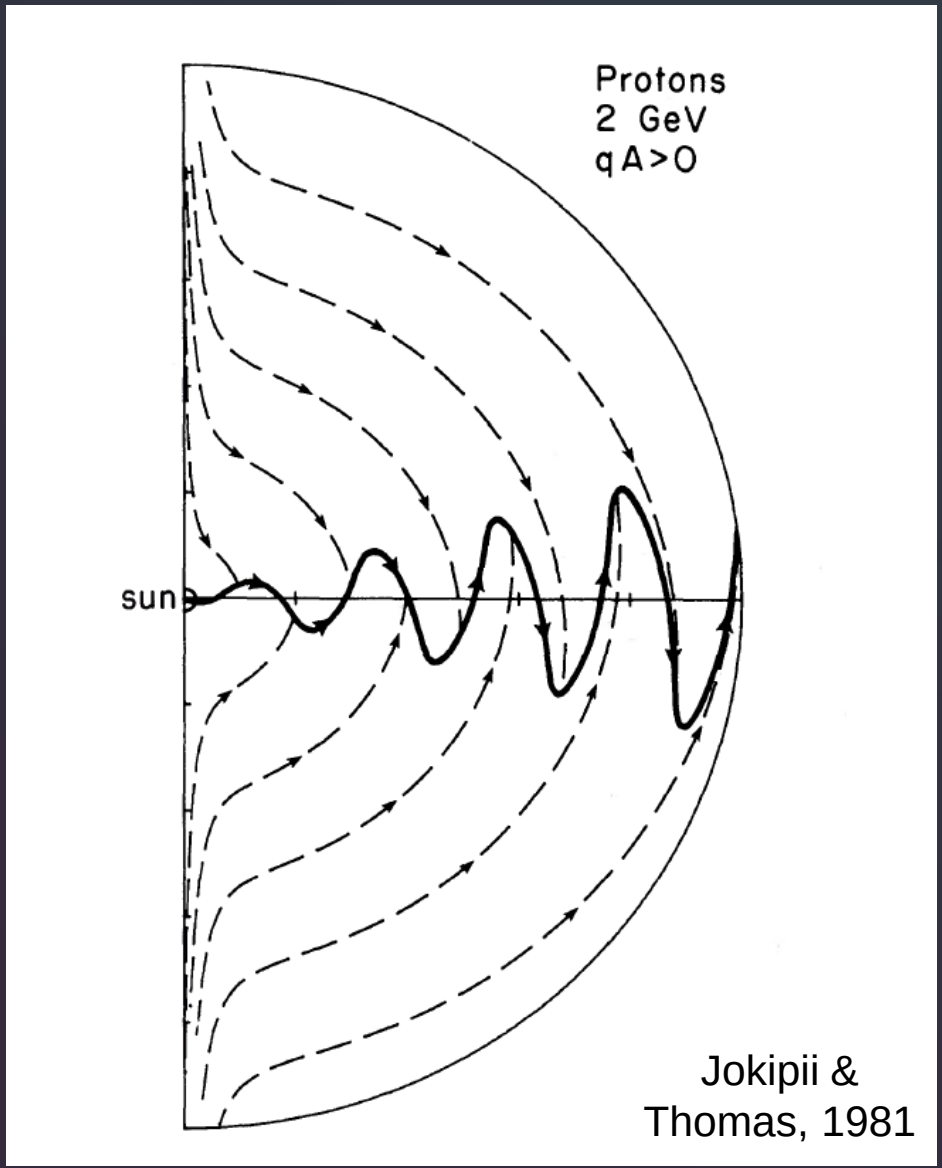








Patterns of GCR propagation



- During A+ times, protons enter the heliosphere from the poles then move outwards along HCS
- During A- times they drift in along the HCS and exit via the poles

Model SEPs in wavy HCS

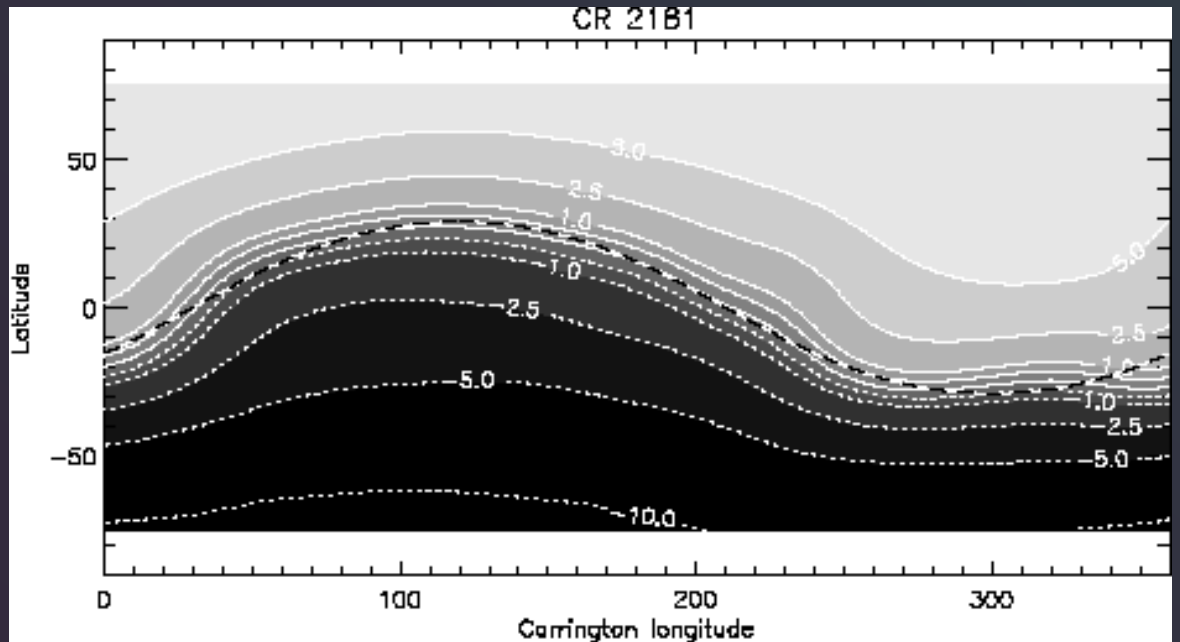
- Propagate SEPs using test particle model, with an analytic expression for HCS

$$\mathbf{B} = S(\delta')\mathbf{B}_{\mathrm{Parker}}$$

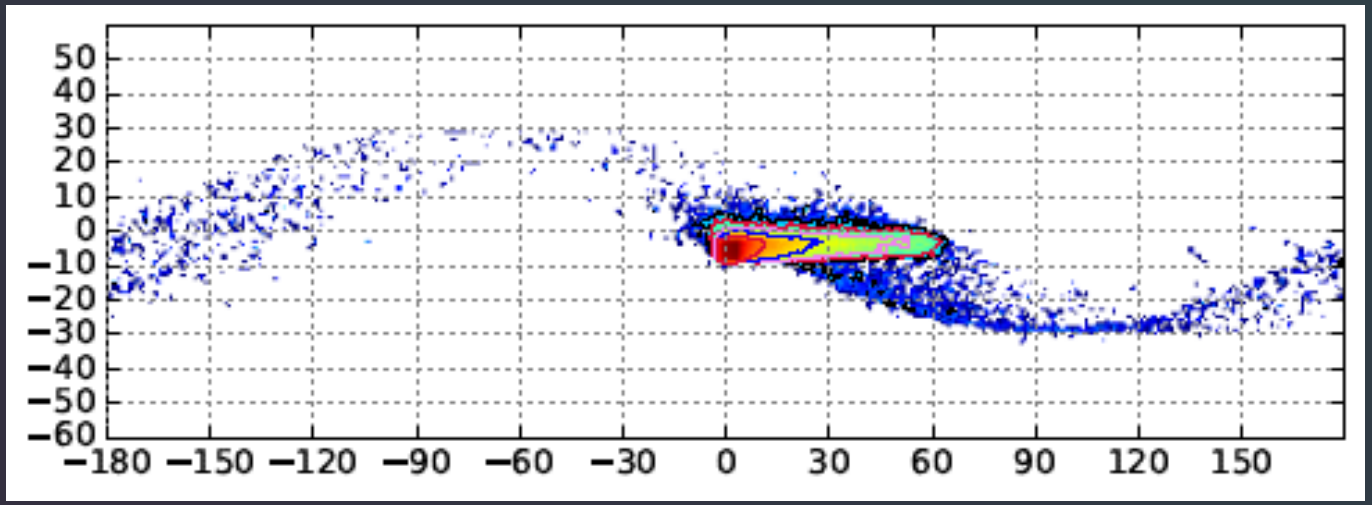
$$S(\delta') = A\left(-1 + 2\,\mathcal{S}\left(\tfrac{1}{2} + \frac{2\delta'}{l_{\mathrm{HCS}}}\right)\right)$$

$$\delta' = 90^\circ - \theta'$$

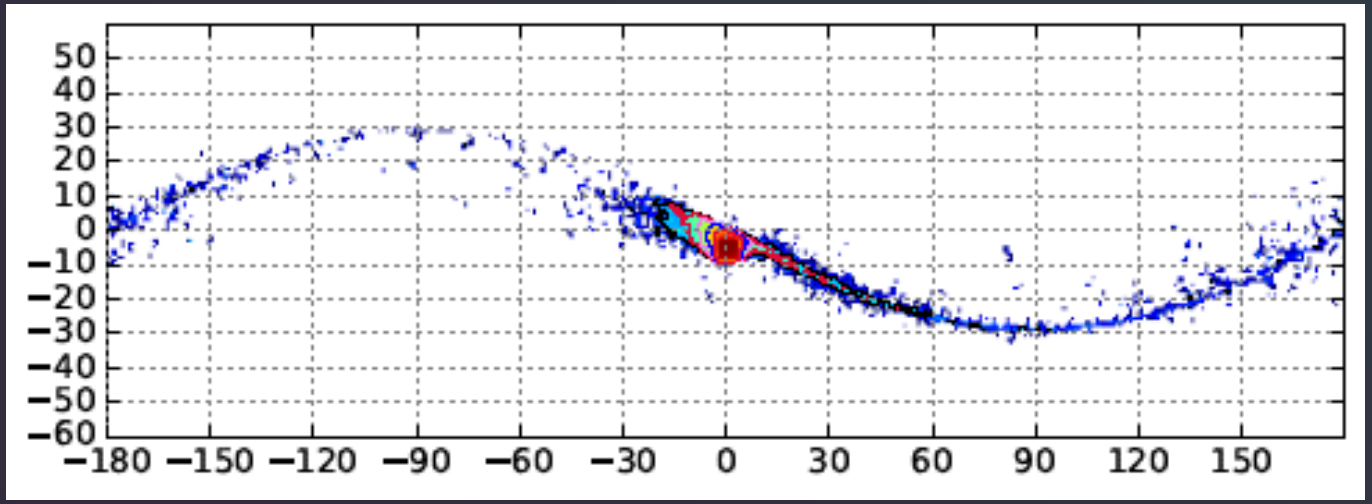
$$\cos\theta' = \cos\theta_{\mathrm{s}}\cos\alpha_{\mathrm{nl}} + \sin\theta_{\mathrm{s}}\sin\alpha_{\mathrm{nl}}\sin\left(n_{\mathrm{nl}}(\phi_{\mathrm{s}} - \Phi_{\mathrm{nl}}(t))\right)$$



Maps of SEP crossings of 1 AU sphere

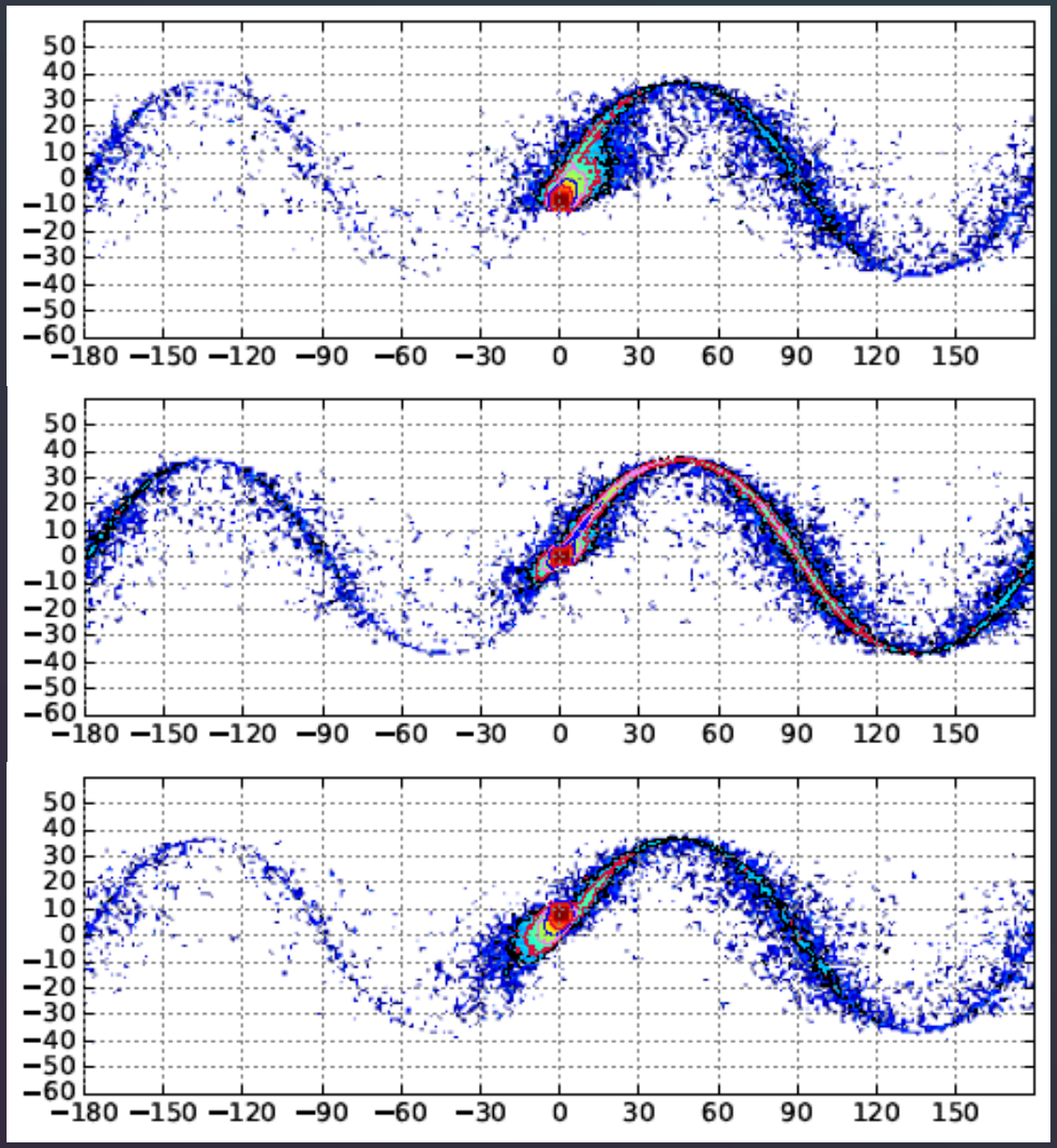


With corotation



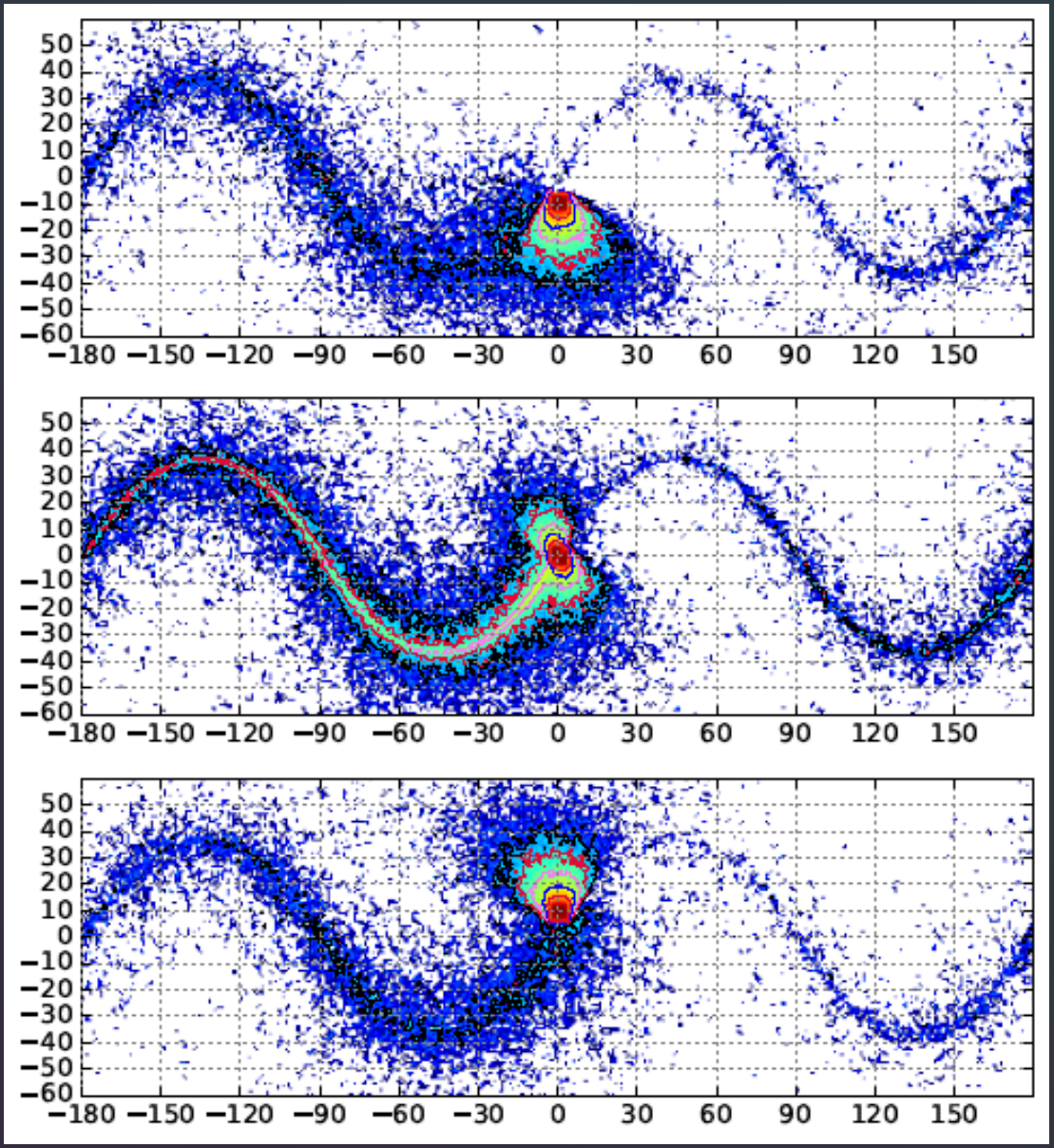
Corotation subtracted

A+ polarity simulations

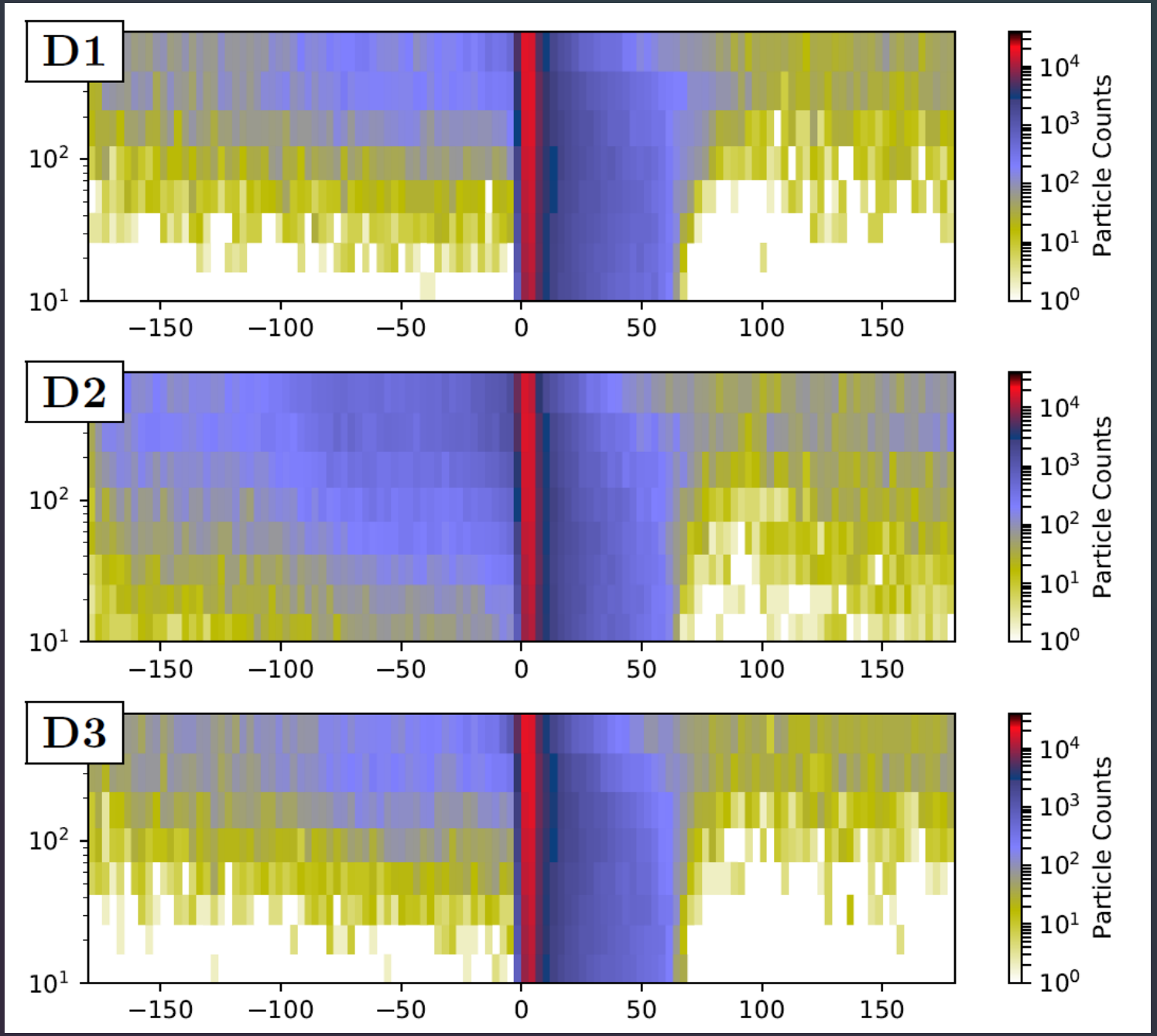


Battarbee et al, 2018

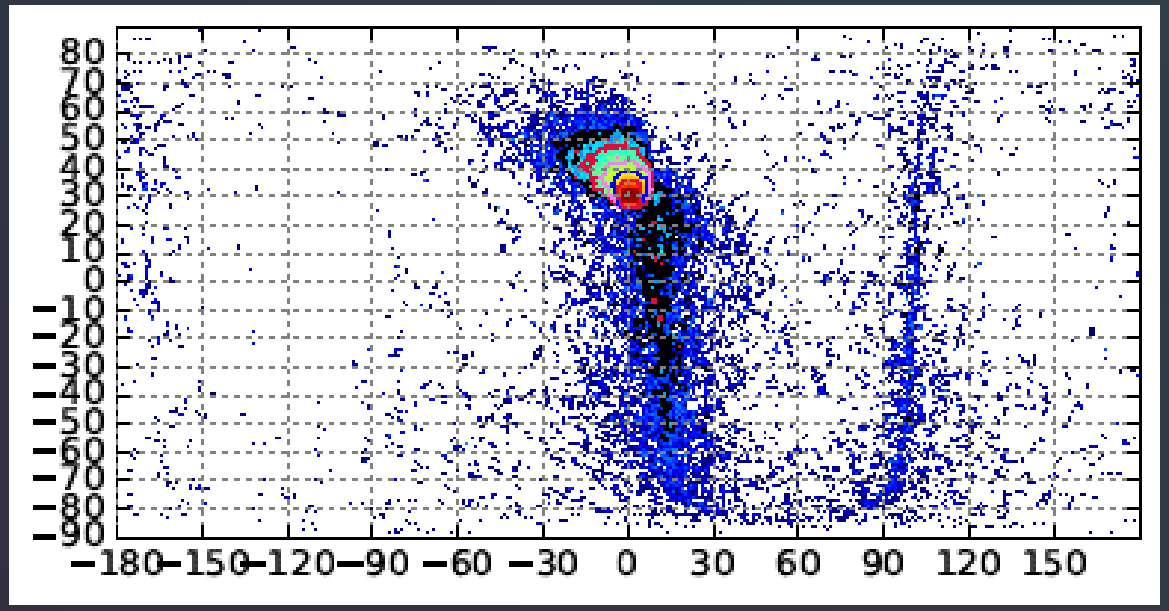
A– polarity simulations



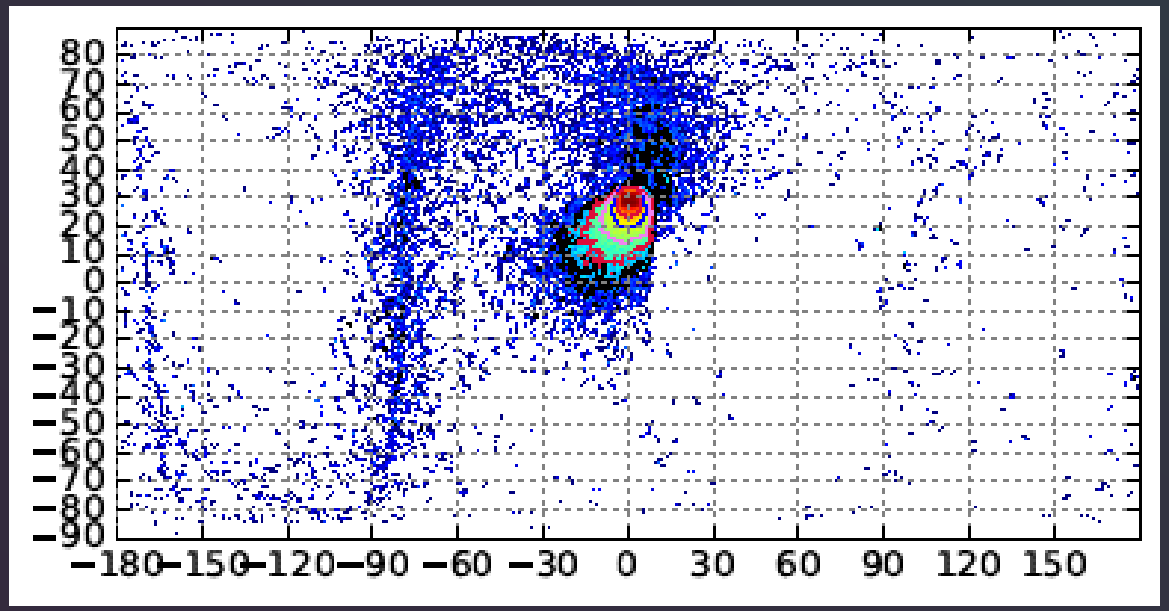
Energy spectrograms



Highly inclined HCS



A^+



A^-

Conclusions

- Our simulations show that SEPs can experience efficient current sheet drift and therefore transport in longitude
- Direction of HCS drift is opposite during A+ and A- times and the SEP spatial distribution near the HCS quite different, for tilt angle 30-40°
- For highly inclined HCS differences between A+ and A- are not so marked