Calibrating MMS Electron Drift Instrument (EDI) Ambient Electron Flux Measurements and Characterizing 3D Electric Field Signatures of Magnetic Reconnection

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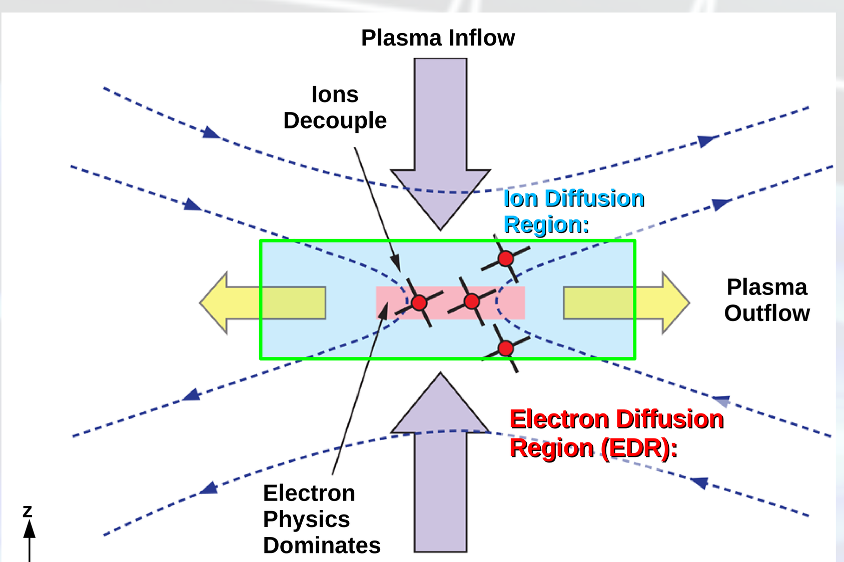
Background

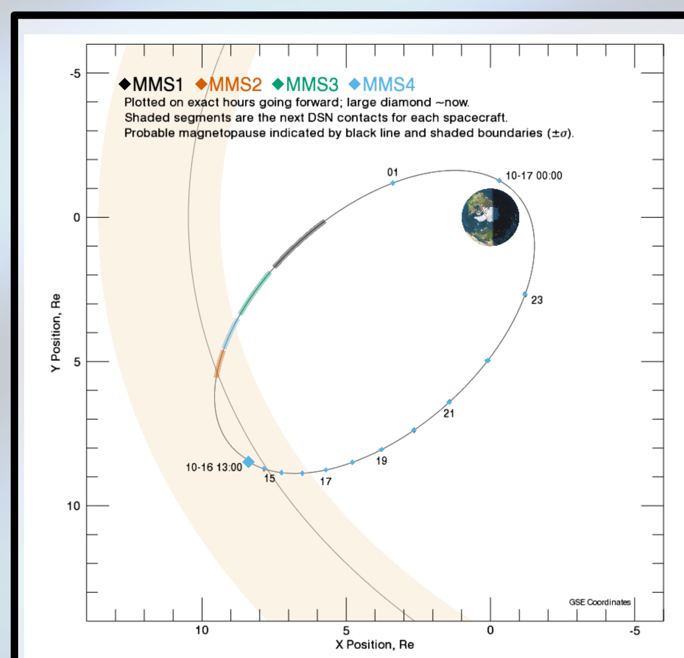
Motivation and Context

How can magnetic reconnection occur in a collisionless plasma? This outstanding mystery fueled the successful launch of NASA's Magnetospheric Multiscale (MMS) mission. The primary science goal of MMS is to reveal the small-scale, 3D structure and dynamics of the elusive electron diffusion region (EDR) believed to hold the key to the reconnection puzzle.



Cartoon of 2D reconnection.

The unprecedented time resolution of the 3D electric field measurements made by the FIELDS suite [1,2] and particle distributions caught by the Fast Plasma Investigation (FPI) [3] onboard the MMS spacecraft motivates a comprehensive study of the electric field signatures of magnetic reconnection and their implications for particle energization. The three-axis electric field measurements from the spin-plane and axial double probes (SDP and ADP), combined with high time resolution (~1 millisecond) ambient electron fluxes from EDI and ~30 millisecond full distribution functions from FPI, enable MMS to resolve electron-scale reconnection structures. Here, we present a case study of a candidate EDR crossing at the magnetopause and our initial efforts to interpret the data using PIC simulations and established reconnection studies [*e.g.* 4,5,6,7,8].



MMS Orbit: (GSE)

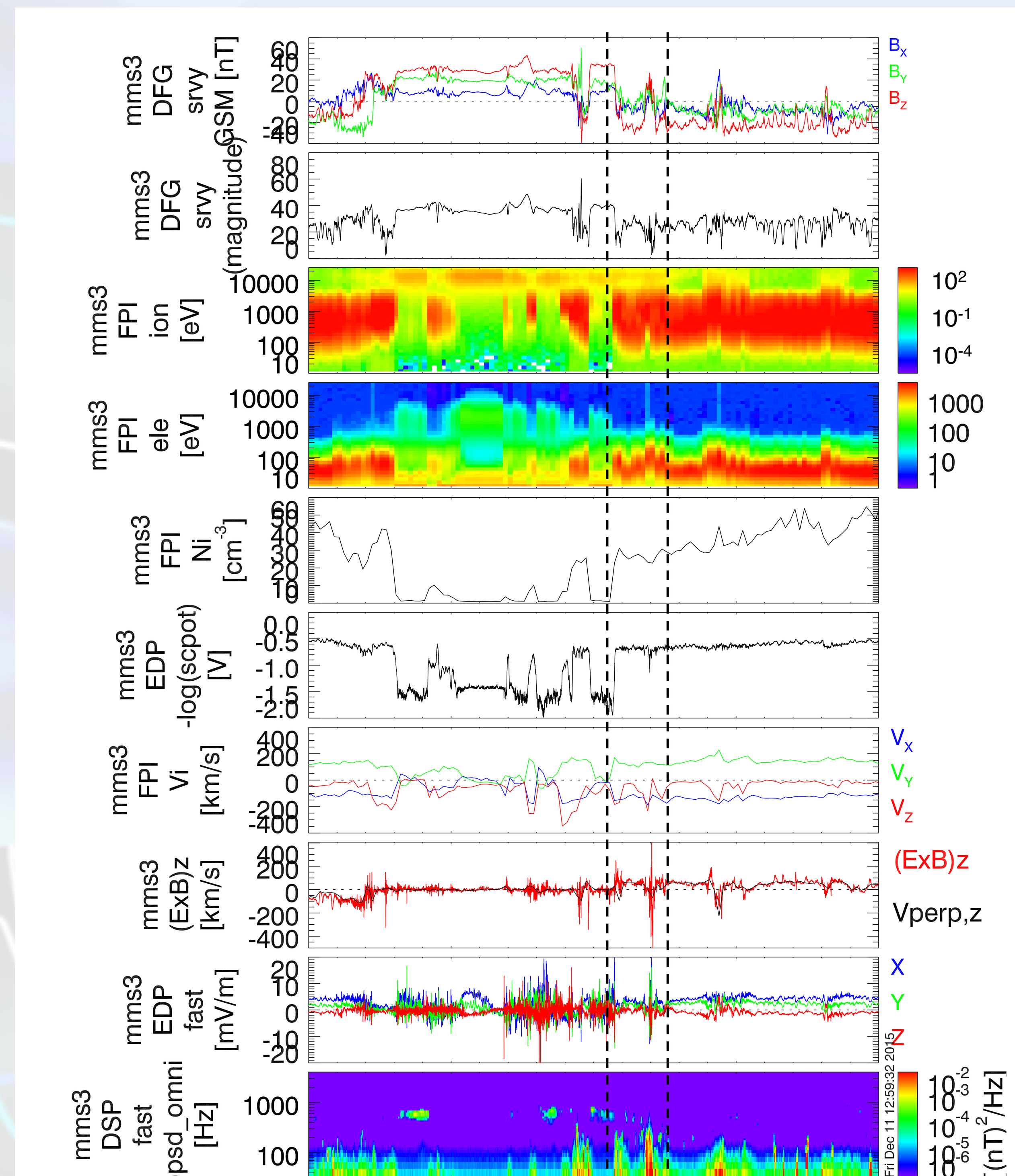
2015/10/16 – 13:00UT

PIC parameters:

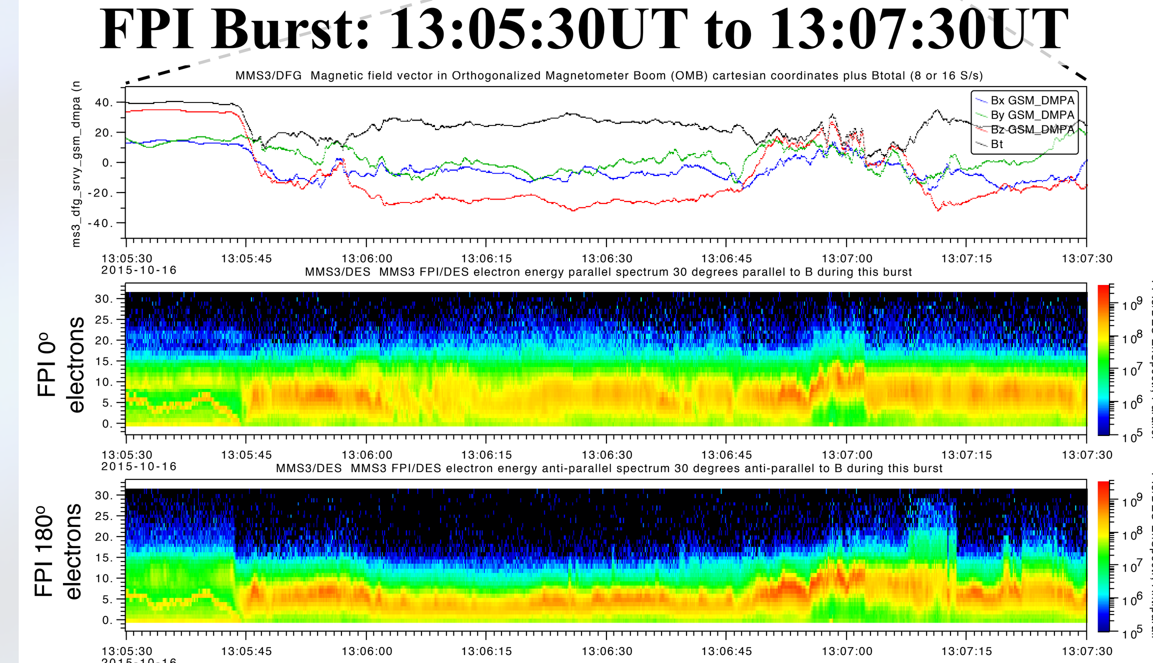
- 2.5D, asymmetric, collisionless, undriven, open boundaries
- antiparallel ($B_g = 0$)
- $m_i / m_e = 100$
- domain: $75 d_i \times 25 d_i$

Results

MMS3 10/16/2015: 12:55UT to 13:15UT

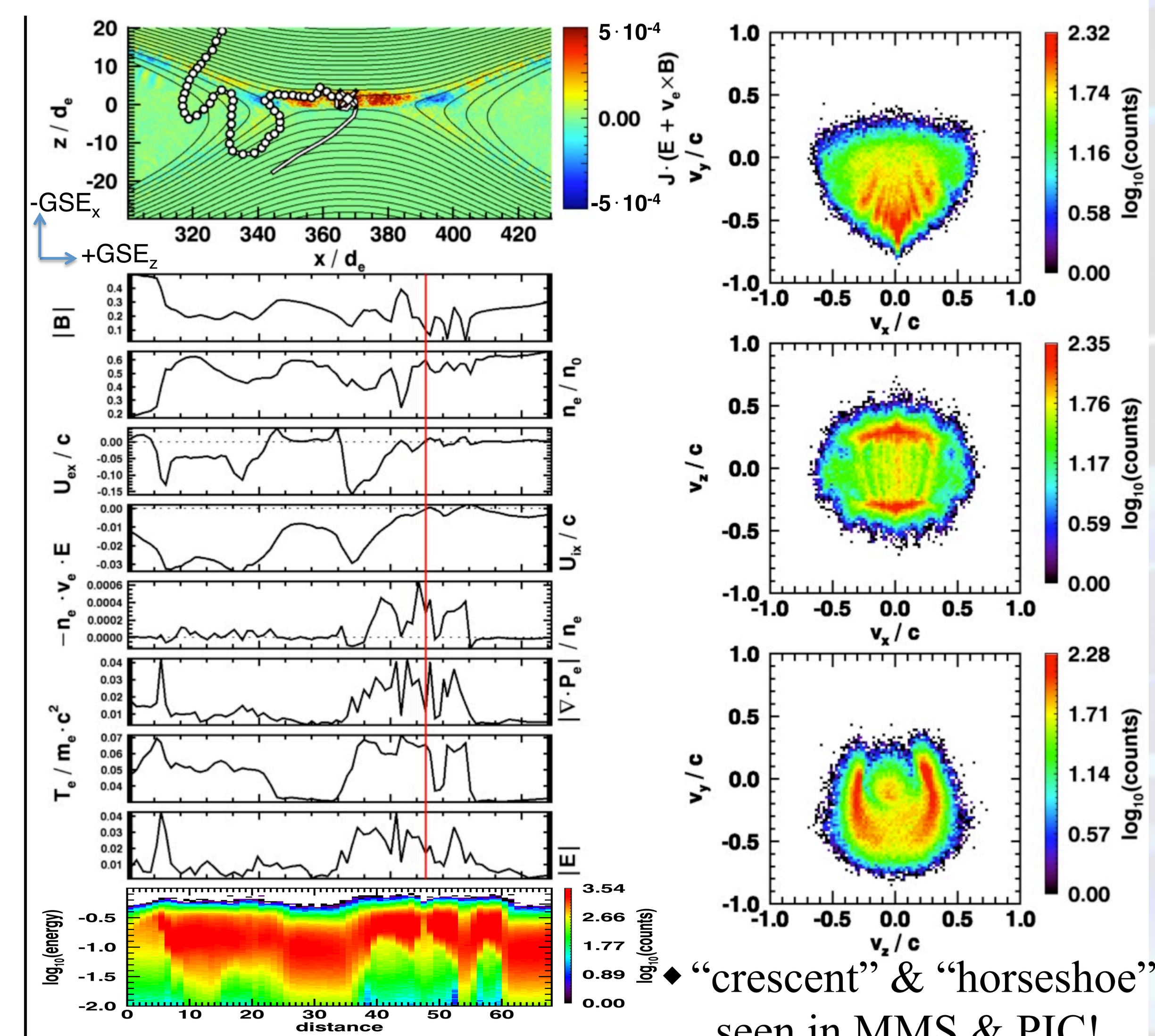


FPI Burst: 13:05:30UT to 13:07:30UT



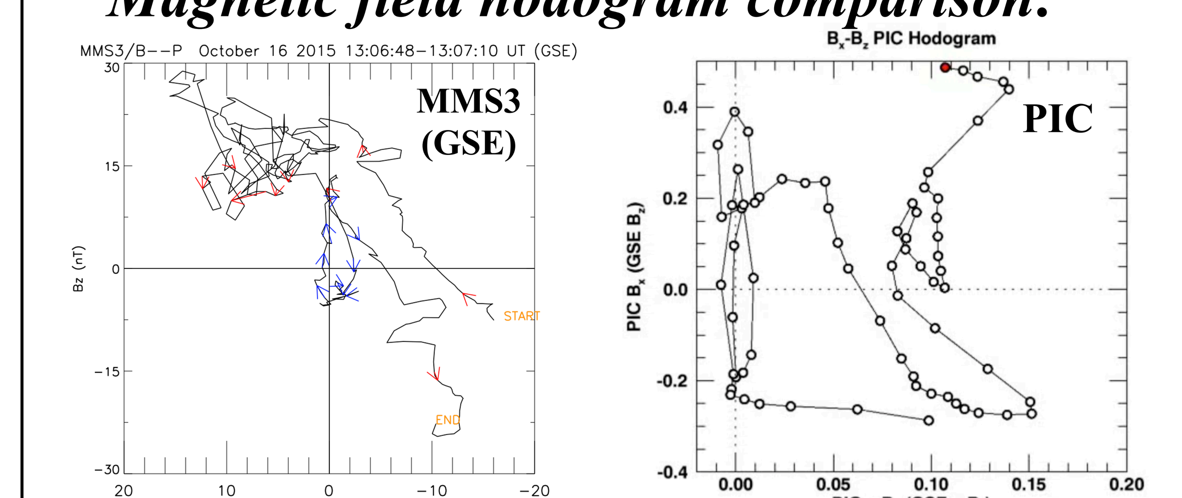
Field-line connectivity: 180° flux decreases *before* 0° flux, indicating that the reconnection X-line was north (+GSE$_Z$) of MMS.

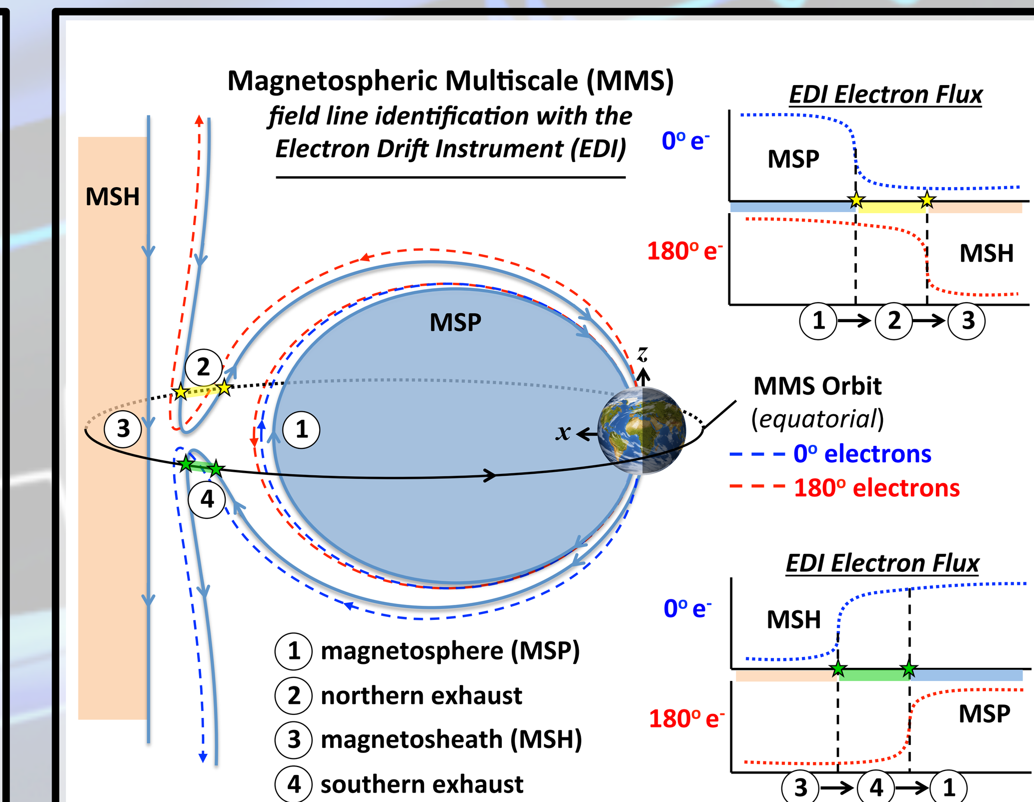
Asymmetric 2.5D Particle-in-Cell (PIC)



- "crescent" & "horseshoe" seen in MMS & PIC!

Magnetic field hodogram comparison:





Where is MMS?

- High to low e- flux: MSP to MSH
- Low to high e- flux: MSH to MSP

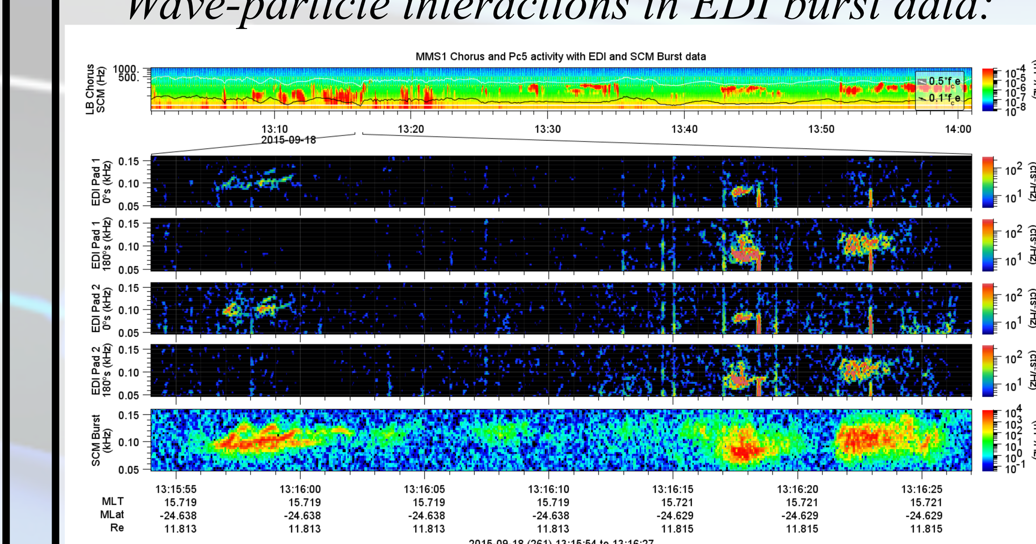
Case 1: 0° remaining: southern exhaust

Case 2: 180° remaining: northern exhaust

EDI GDU Ambient Calibration

- Relative and absolute calibration with FPI.

Wave-particle interactions in EDI burst data:



Conclusions

- **Candidate EDR encounter at the magnetopause: "crescent" structures found in MMS and PIC electron distributions in non-ideal region where $\mathbf{J} \cdot (\mathbf{E} + \mathbf{v}_e \times \mathbf{B}) \neq 0$.**
- Field-line connectivity inferred based on anisotropic 0° vs. 180° electron fluxes.
- PIC **B**-hodograms & non-ideal Ohm's law terms aid in orienting MMS trajectory.
- EDI burst-mode counts modulated by chorus and Pc5 wave activity.

References

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