Global Storm-Time Depletion of the Outer Electron Belt*

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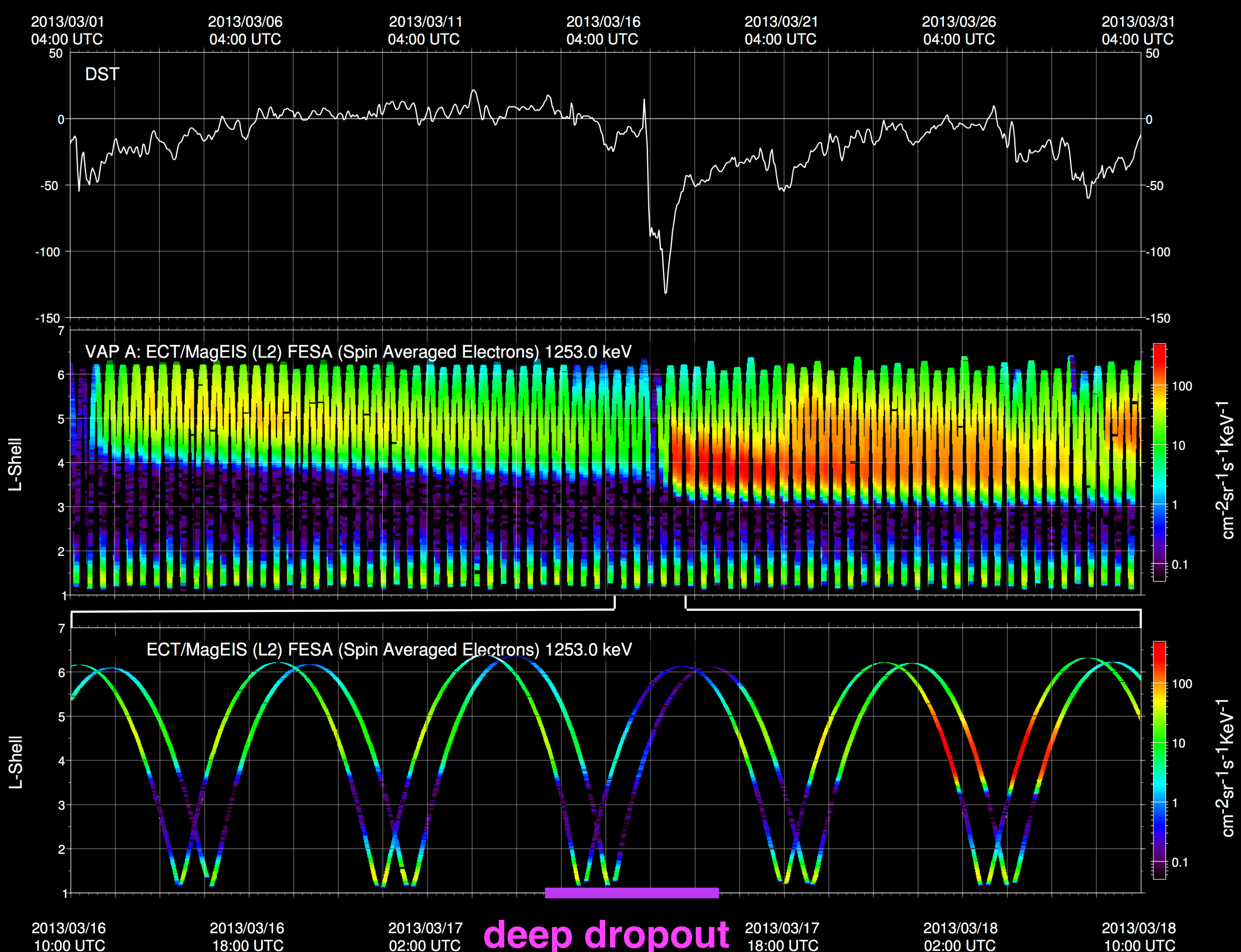
March 17, 2013 Storm



The storm main phase depleted the intensities of ≥1–6 MeV electrons by more than an order of magnitude over the entire radial extent of the outer belt.

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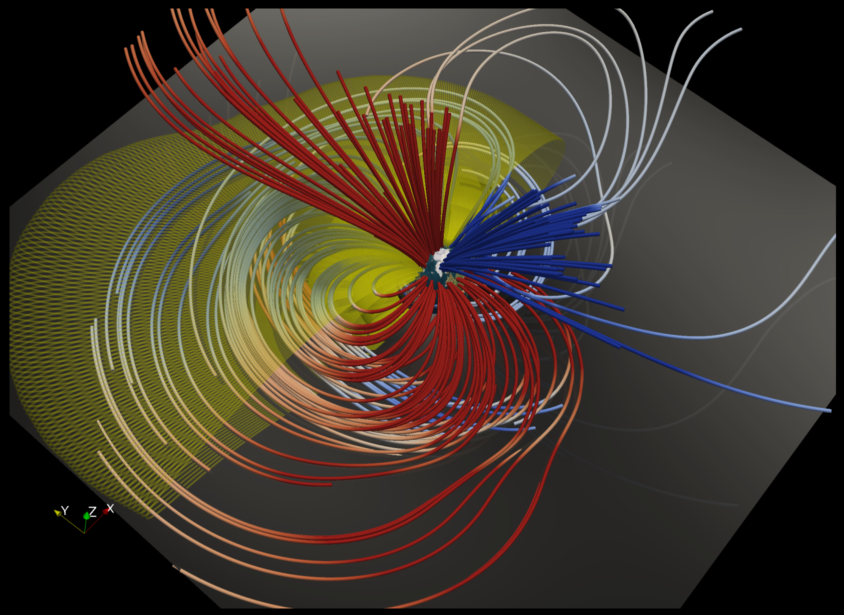
Long-Standing Science Questions

(1) Are the dropouts of radiation belt electrons observed during storm main phase adiabatic (i.e., reversible) or non-adiabatic (permanent)?

(2) What are the relative roles of local wave-particle interaction and global magnetopause losses in causing these dropouts?

Global 3D Test-Particle Simulations

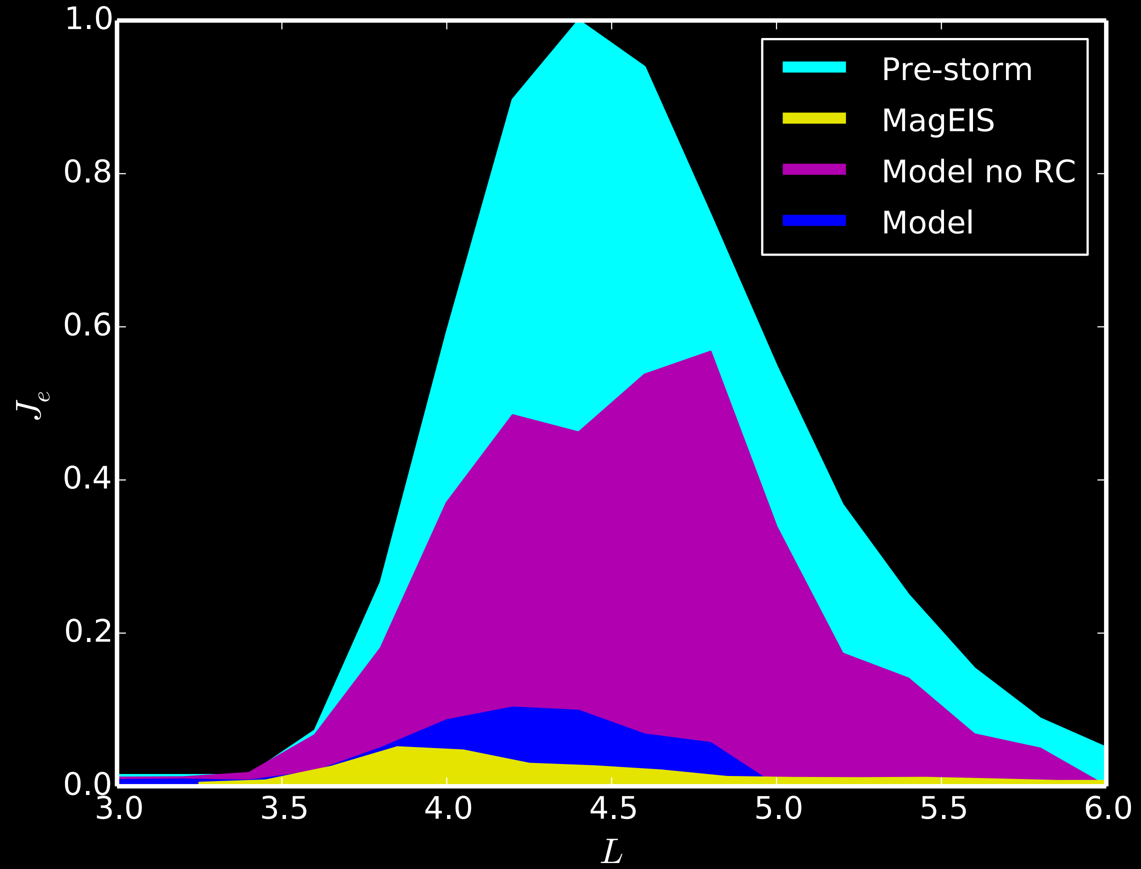


Provides accurate specification of:

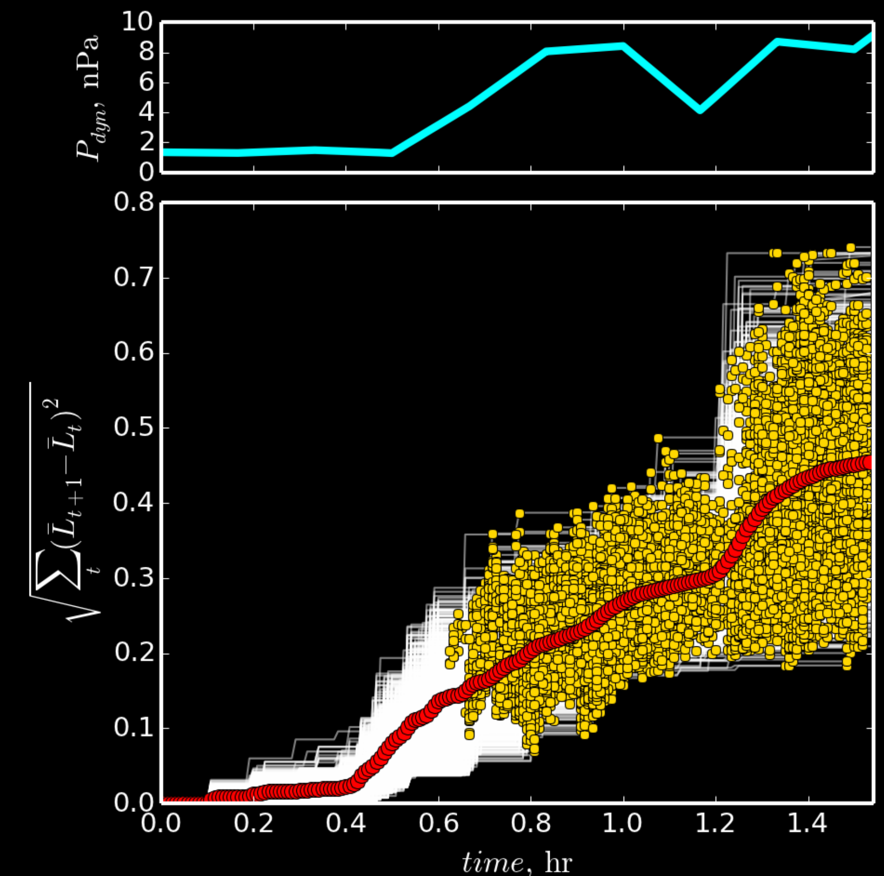
- Global configuration (e.g. magnetopause)
- Storm-time current systems
- Drift orbit bifurcations
- Large-scale quasi-adiabatic variations

Conclusions

Comparison with MagEIS



Radial Transport



1. Deep dropout of radiation belt intensities during storm main phase is produced by magnetopause losses.

2. Magnetopause losses are controlled by only two global processes. (a) Magnetospheric compressions lead to earthward expansion of the drift orbit bifurcation region. Bifurcations produce rapid radial transport leading to magnetopause losses. (b) Diamagnetic effect of storm-time ring current leads to strong field stretching on the nightside pushing electron drift orbits outward and increasing the losses. It also inhibit inward transport of radiation belt electrons; predominantly outward radial transport enhances the loss rates.

3. Losses involve strong radial transport that exceeds the rates of radial diffusion during disturbed geomagnetic conditions. Drift orbit bifurcations account for approximately 60% of the transport, the remaining 40% is attributed to large-scale inductive electric fields.

4. The fact that the main-phase dropouts are irreversible has an important implication: no correlation should be expected between the pre-storm and after-storm intensities of the outer radiation belt. Consequently, the state of the outer belt after the storm recovery is determined by the injections of “seed” electrons during storm main phase and the balance among their acceleration and loss mechanisms in the recovery phase.

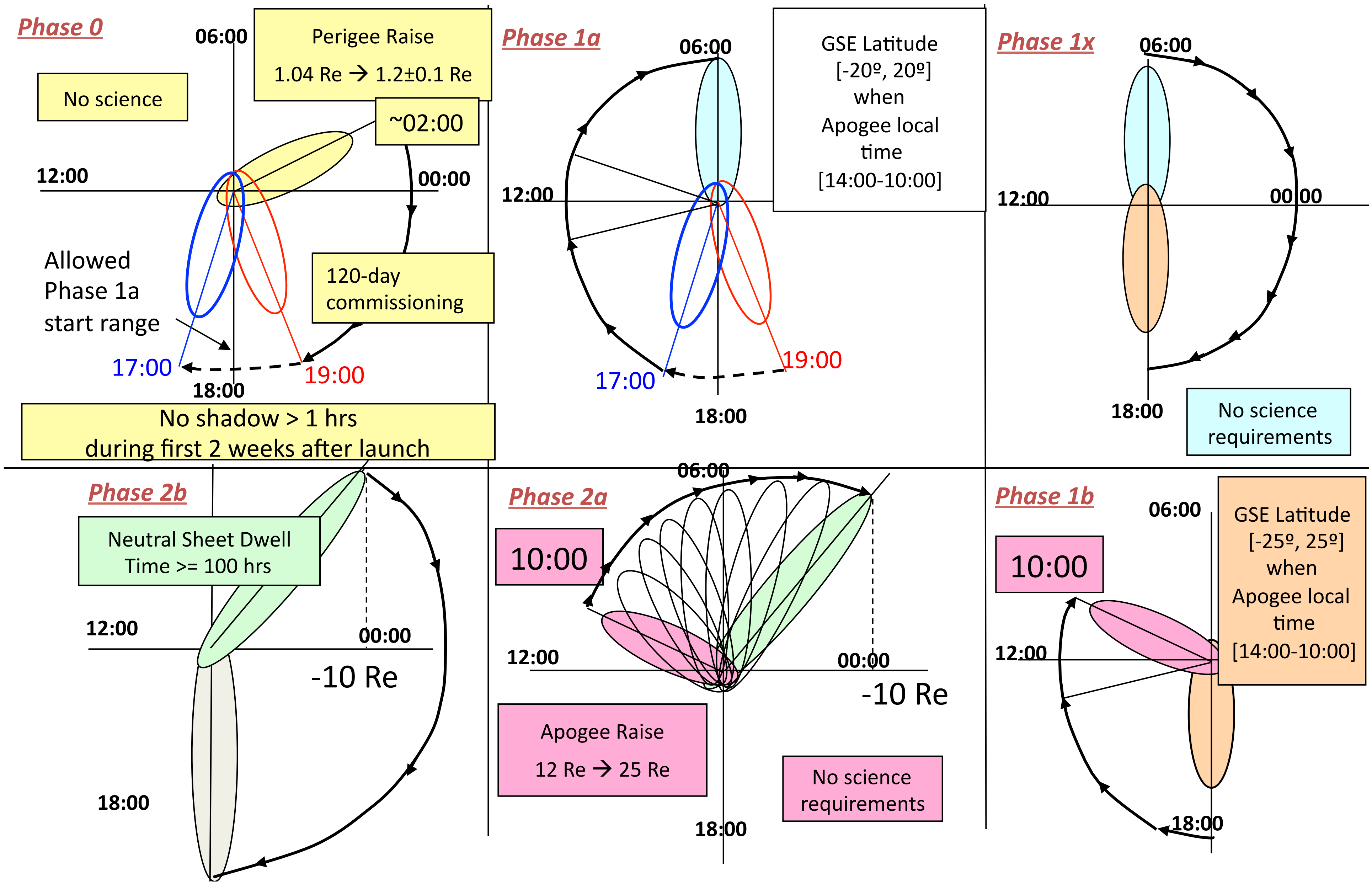
Supporting Observations of Radiation Belt Losses During The Van Allen Probes Extended Mission

- During early mission MMS will have period of 24 hours and the apogees at 12 Re on the dusk side around noon to dawn after commissioning
- MMS will spend significant time above the Van Allen Probes apogee, much of it just outside or skimming the magnetopause
  - From noon to morning MMS could measure the energetic electrons both headed towards the magnetopause and streaming along or upstream of the magnetopause during storm onsets and pressure pulses
  - The energetic radiation belt electrons lost to the magnetopause boundary should be easily observed by FEEPS in the presence of normal magnetosheath fluxes

- Low altitude missions such as FIREBIRD, AC6 etc. can provide measures of the precipitating electrons

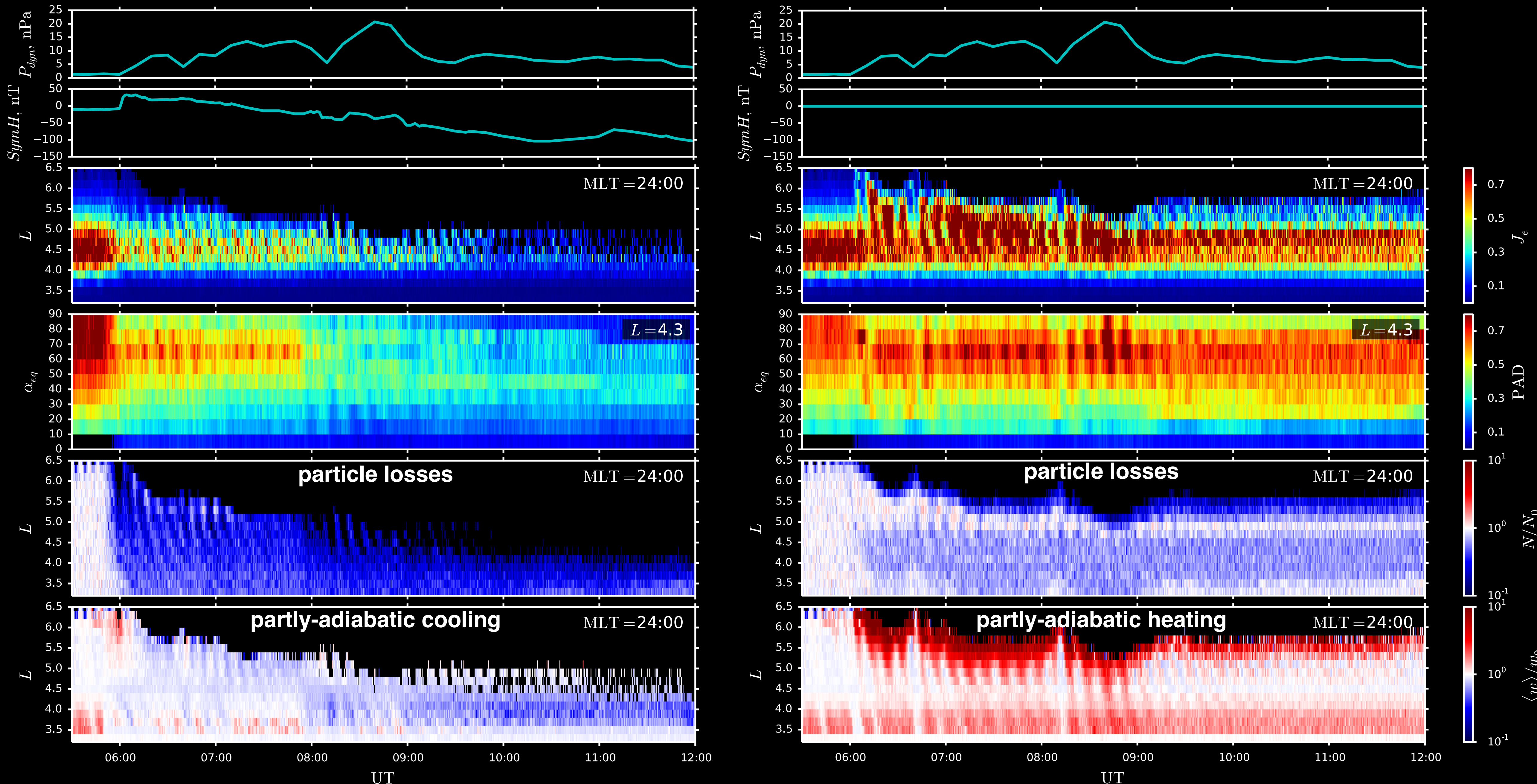
- Combining the Van Allen Probe observations with those of MMS, FIREBIRD, AC6, etc. can allow a more complete determination of the storm onset losses and how they are separated into their component parts.

Mission Phase Summary



Test-Particle Simulation Results

Full Model | No Ring Current



Simulation shows strong magnetopause losses starting after SSC and continuing thorough the entire simulation interval. Only 34% of particles remain in the system by the end of the simulation interval.

The role of storm-time ring current (RC) is addressed by adjusting TS07D model inputs throughout storm main phase.

Without RC the losses are not nearly as deep (85% of particles remain in the system at the end). Moreover, the magnetopause compressions produce partly-adiabatic particle energization as opposed to cooling in the case with RC.