JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Radiation belt flux dropout event study with global MHD and test particle simulations

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Particle Interactions w/ Mesoscale Flows

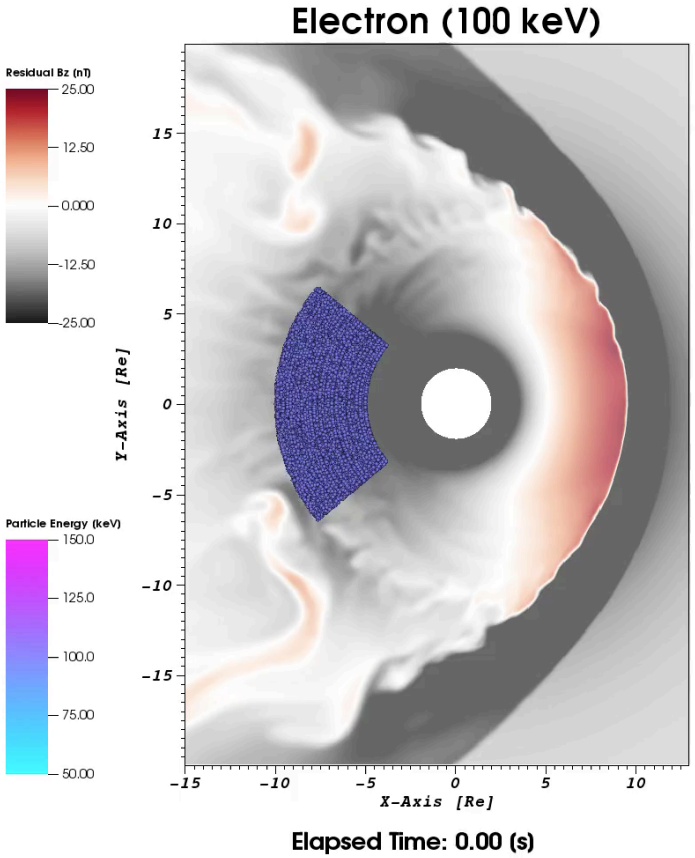
Magnetopause permeability

Two magnetopause shadows?

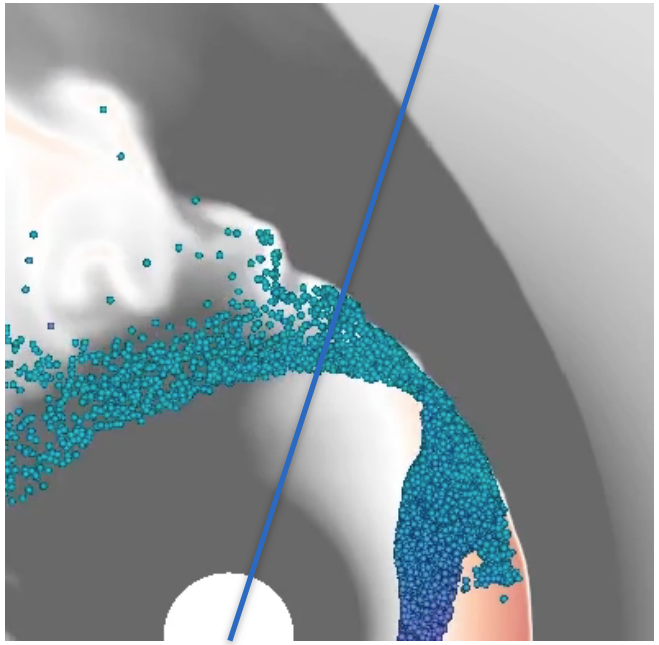
- MMS observations of energetic electrons in the day/dusk-side magnetosheath (Cohen+ 2016)
- Counter-intuitive to MP shadow picture

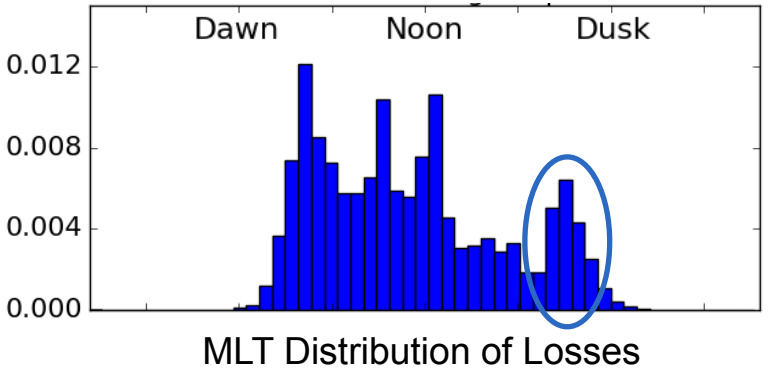
Magnetopause isn't a static border

- MP is a dynamic and active participant in regulating transport
- KH vortices at dusk flanks facilitate access to the MP/sheath



Sorathia+ 2017

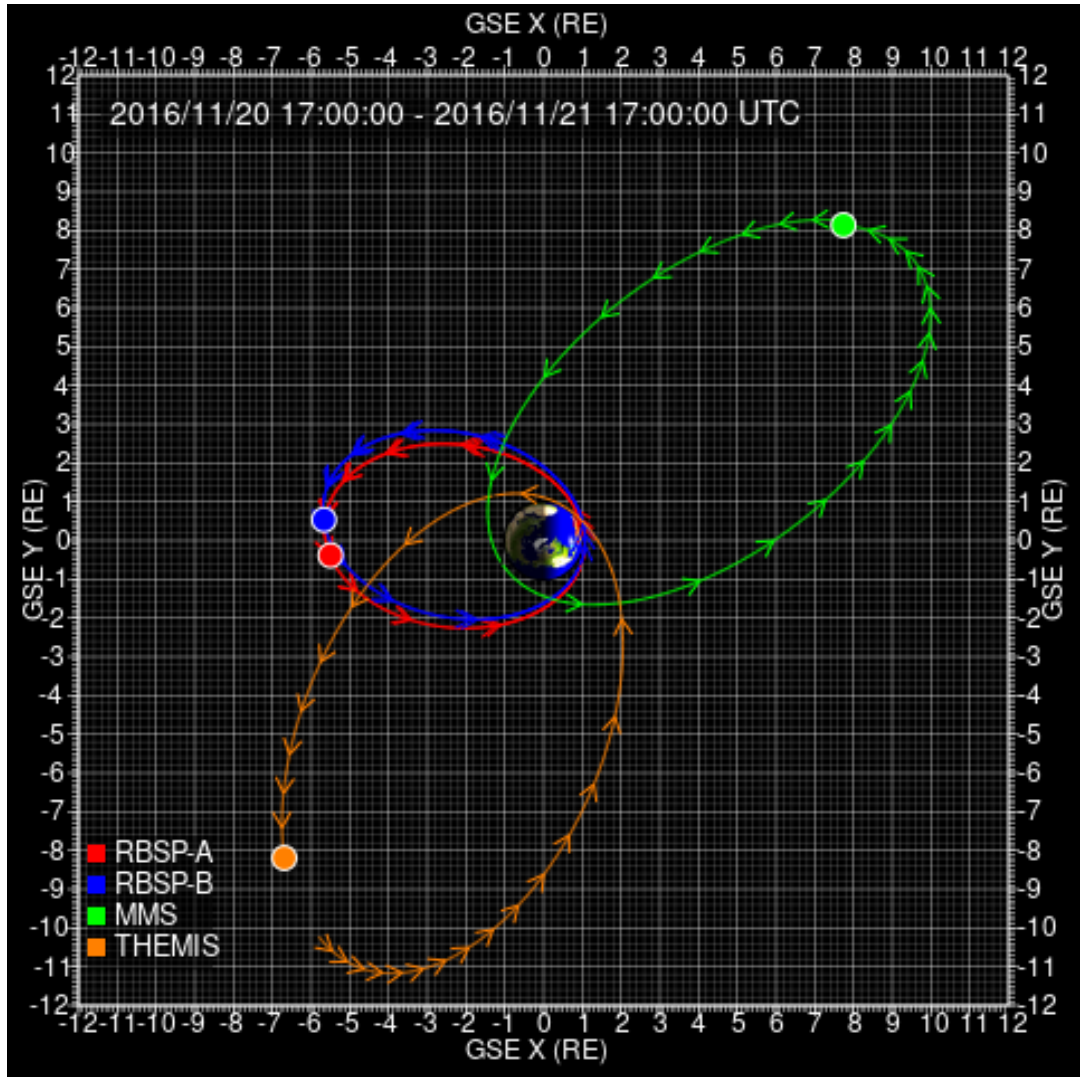


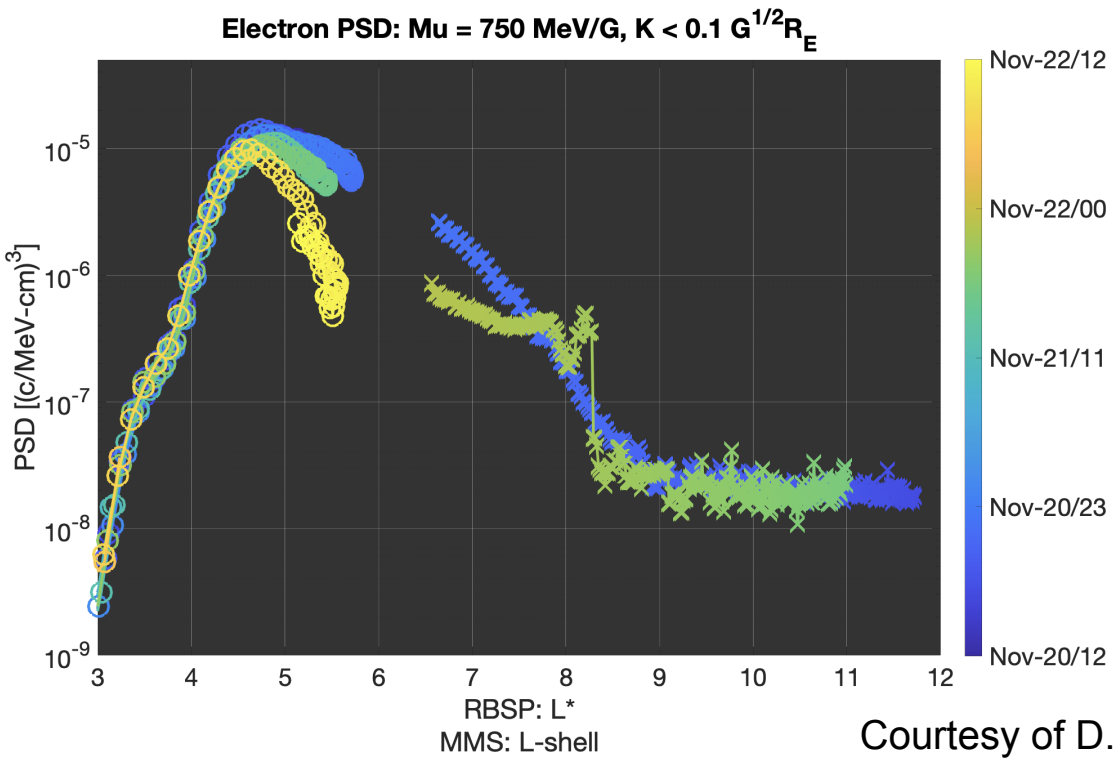


MLT Distribution of Losses

Energetic electron escape

November 2016 drop out event





Courtesy of D. Turner

- MMS observed energetic electrons in the magnetosheath (~65 keV)
- Occurred during a corresponding flux dropout event observed by he Van Allen Probes
- Goal:
  - Look at global variation in particle losses(latitude/ MLT) and help quantify total electron loss

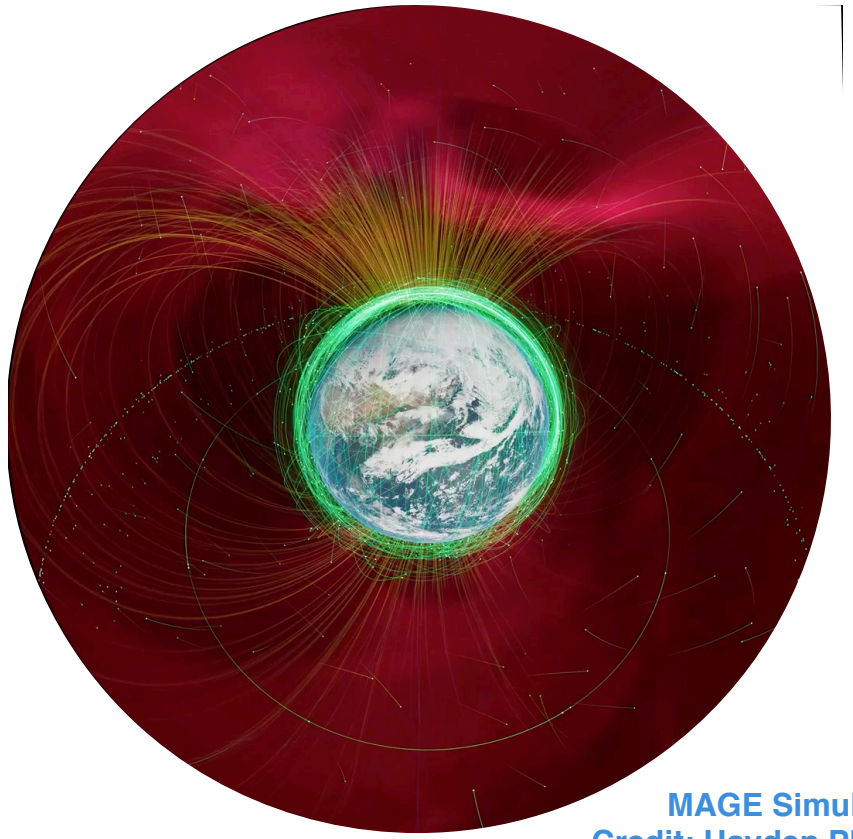
Mesoscale Modeling of the Outer Belt

Requirements and Our Approach

Our modeling approach (recent and ongoing work)

- Global geospace (MAGE) + electron test particle (CHIMP)
- Seed & evolve RB electrons in high-res global MHD
  - MHD informs where to create TPs and they move
- Model WPI as stochastic "kicks" in v-space
  - Wave power & diffusion on resonant surface
- Inform WPI via wave model
  - Empirical or connected to dynamic model quantities

MAGE
Multiscale Atmosphere-Geospace Environment



MAGE Simulation
Credit: Hayden Planetarium
"Worlds Beyond Earth"

What do we want to capture?

- Plasmasheet injections
- ULF waves & boundary dynamics (e.g. KHI)
- Relativistic electron dynamics
- Inner magnetosphere waves & WPI
- Changing plasmapause boundary/plumes

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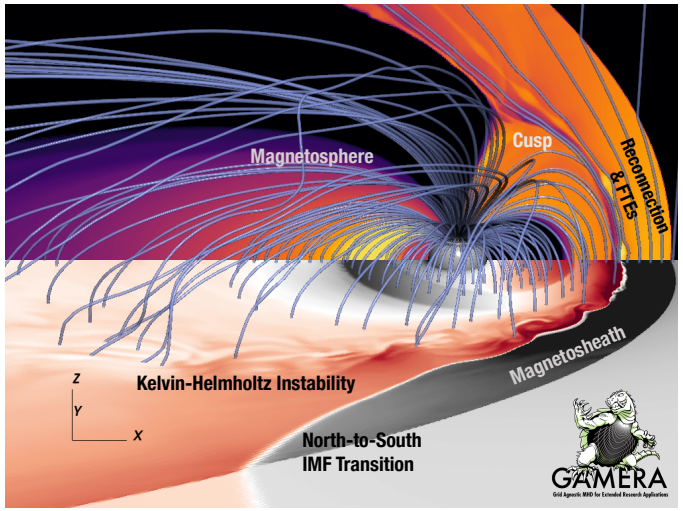
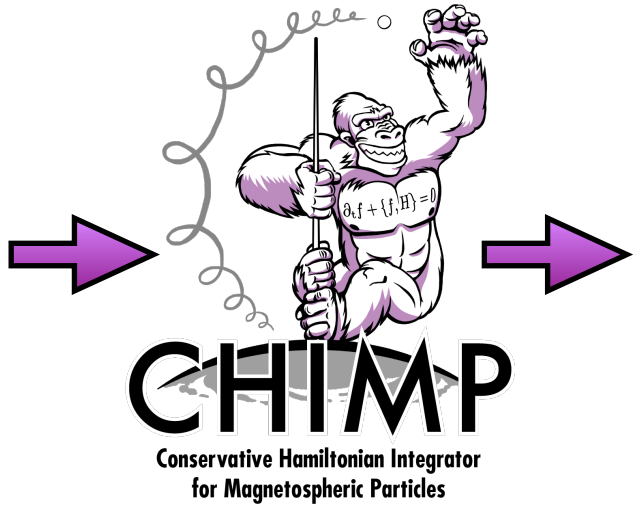
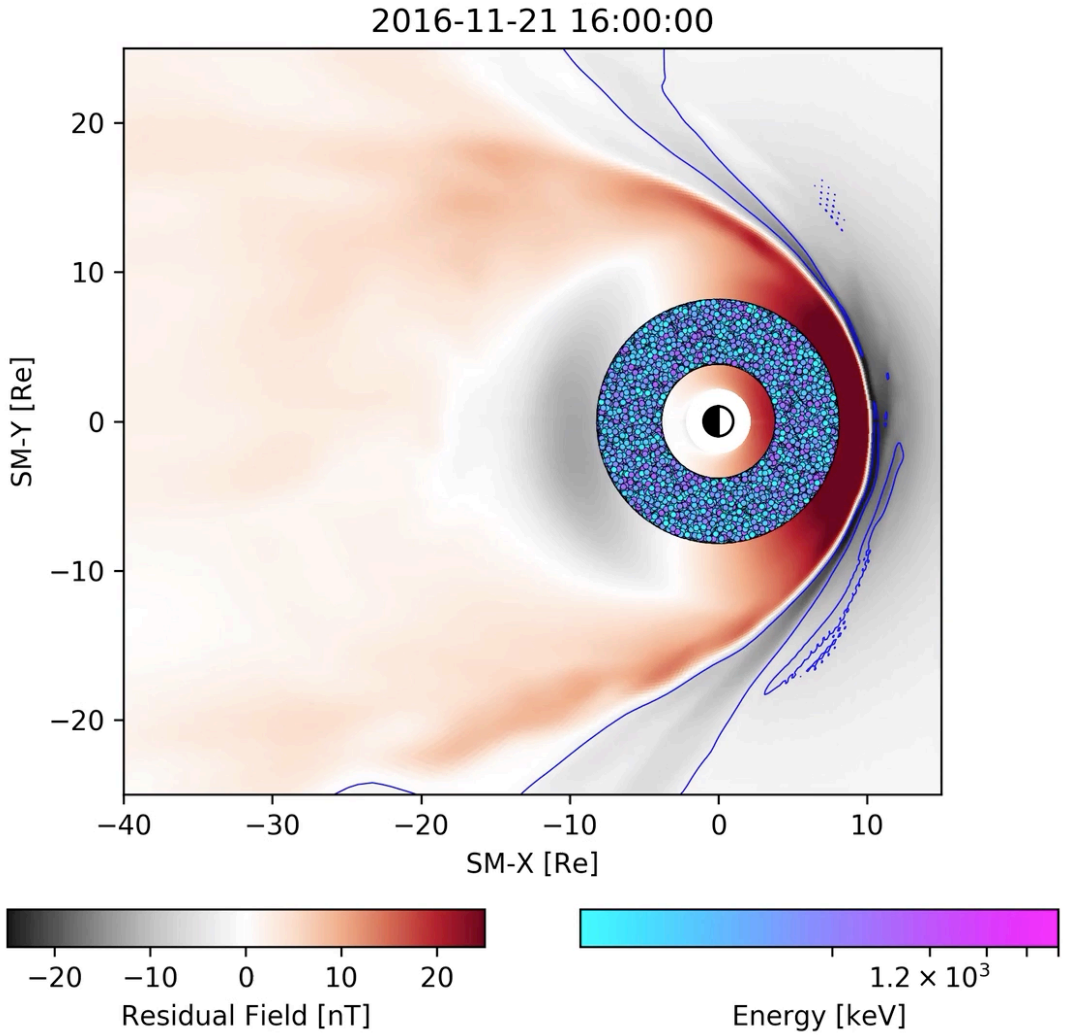
Methodology

civspace.jhuapl.edu/gamera

CHIMP + Gamera: Particle tracing in high-resolution MHD







Unweighted Electron TP's initialized in RB on Nov. 21, 2016 before dropout event

- GAMERA
  - Reinvention of the high-heritage LFM MHD code
  - High-order scheme solved on a warper spherical grid
  - Driven with solar wind from OMNI
- CHIMP
  - Evolve **electron** test particles (TPs) in 3D MHD-generated fields
  - Initial RB consists of over 400k TPs with energies from 100 keV - 1 MeV at an output cadence of ~0.2 s

Methodology

CHIMP + Gamera: TP Weighting and PSD Calculation

Weighting

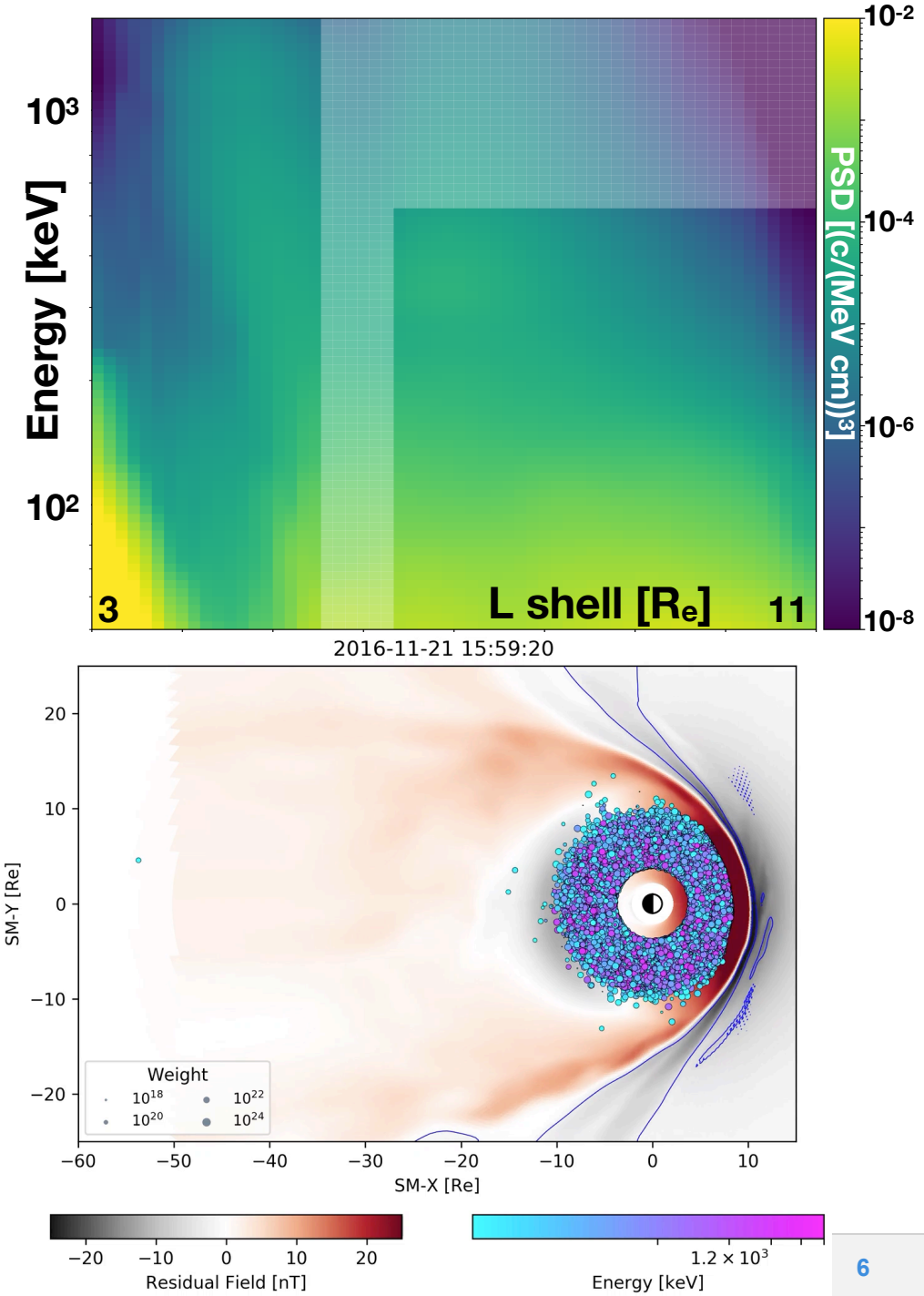
- Assign each created TP a weight (correlating to # real particles)
- Weights are selected to match pre-event RBSP and MMS data
  - Averaged over observations on 11/21/2016 up until event
  - Grey shaded area = interpolated/extrapolated

Phase space density

- Work in discretized 4D phase space, **X** = (L,φ,K,α_{eq})
- use particle trajectories to calculate evolved PSD(**X**,t)

Example (right)

- Evolution of initial radiation belt population
- Marker area ~ log(wgt)
- Marker position @ field-line projection to equator

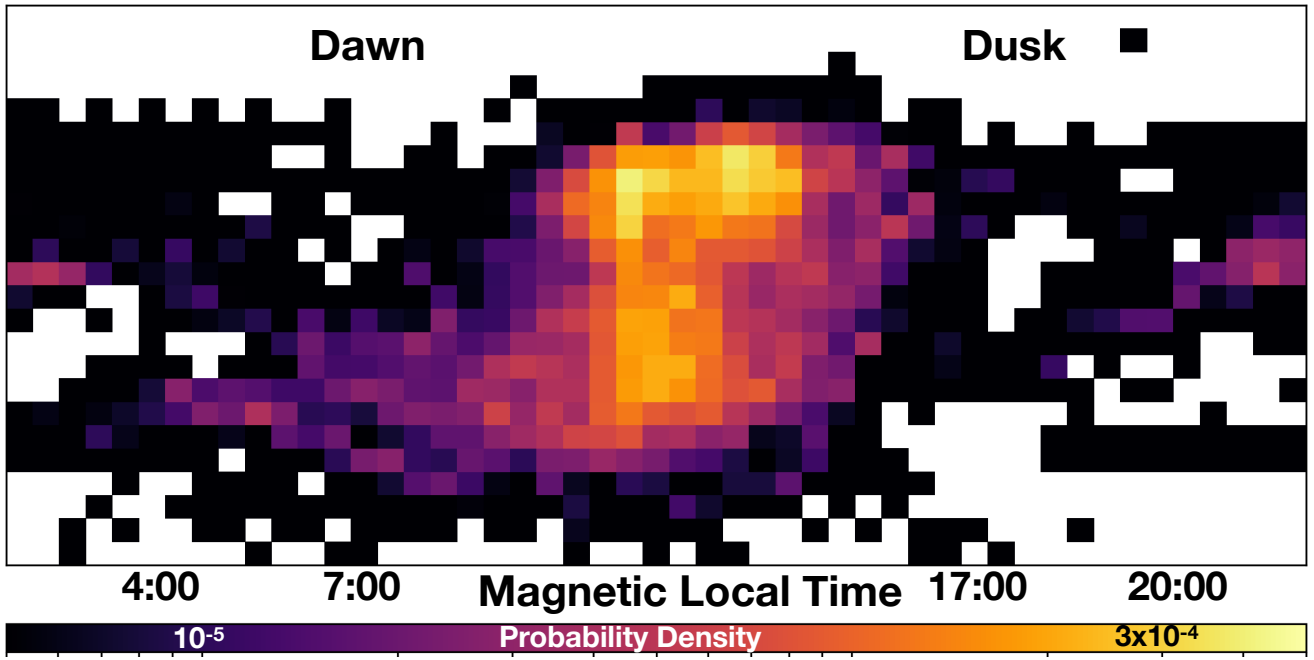


Flux Dropout and Magnetopause Loss

Preliminary results from test particle simulations

- Over two hour period, a quarter of the initial radiation belt is lost

- Electron escape through the magnetopause for realistic event and particle weighting
  - Captures better latitudinal loss variation



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