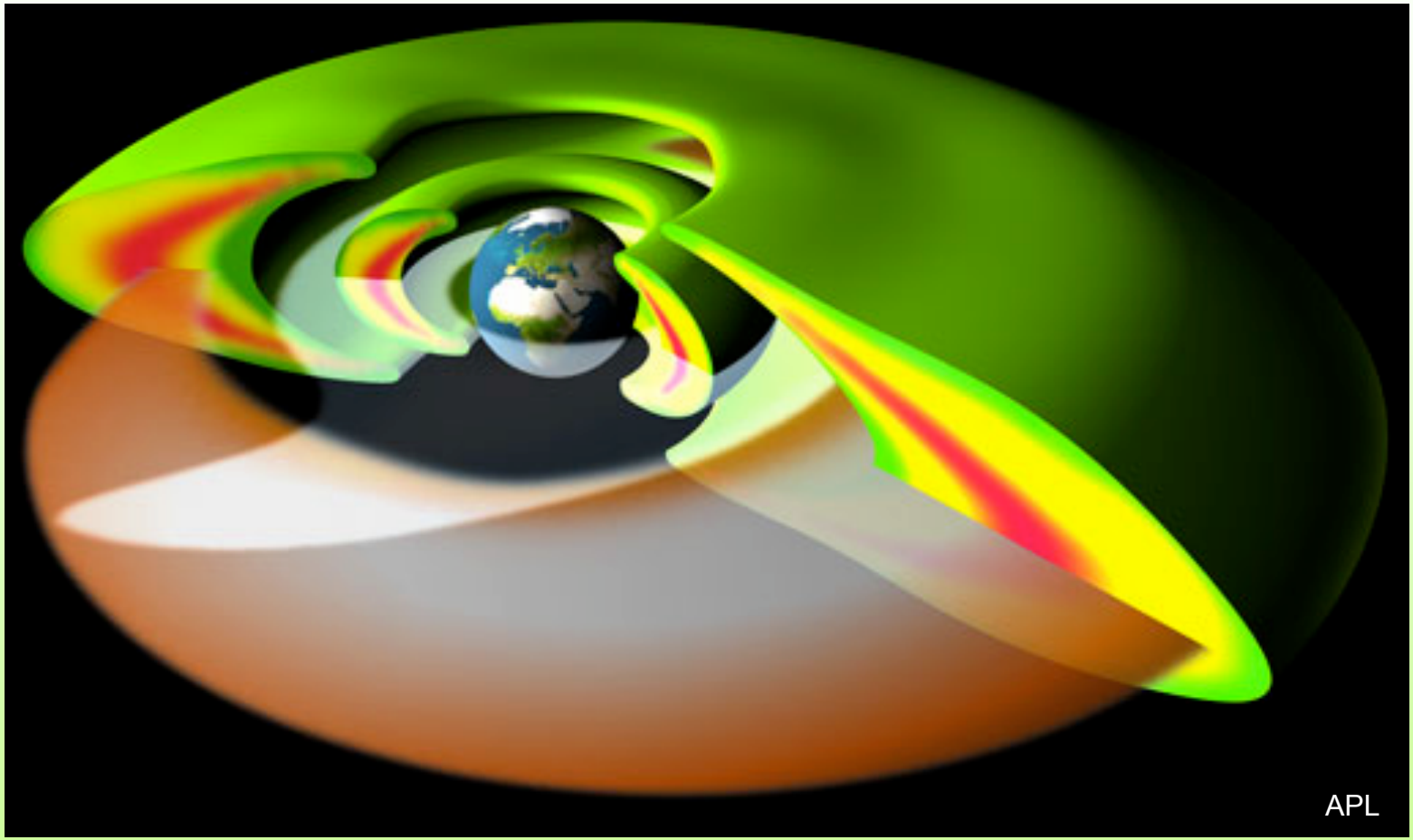
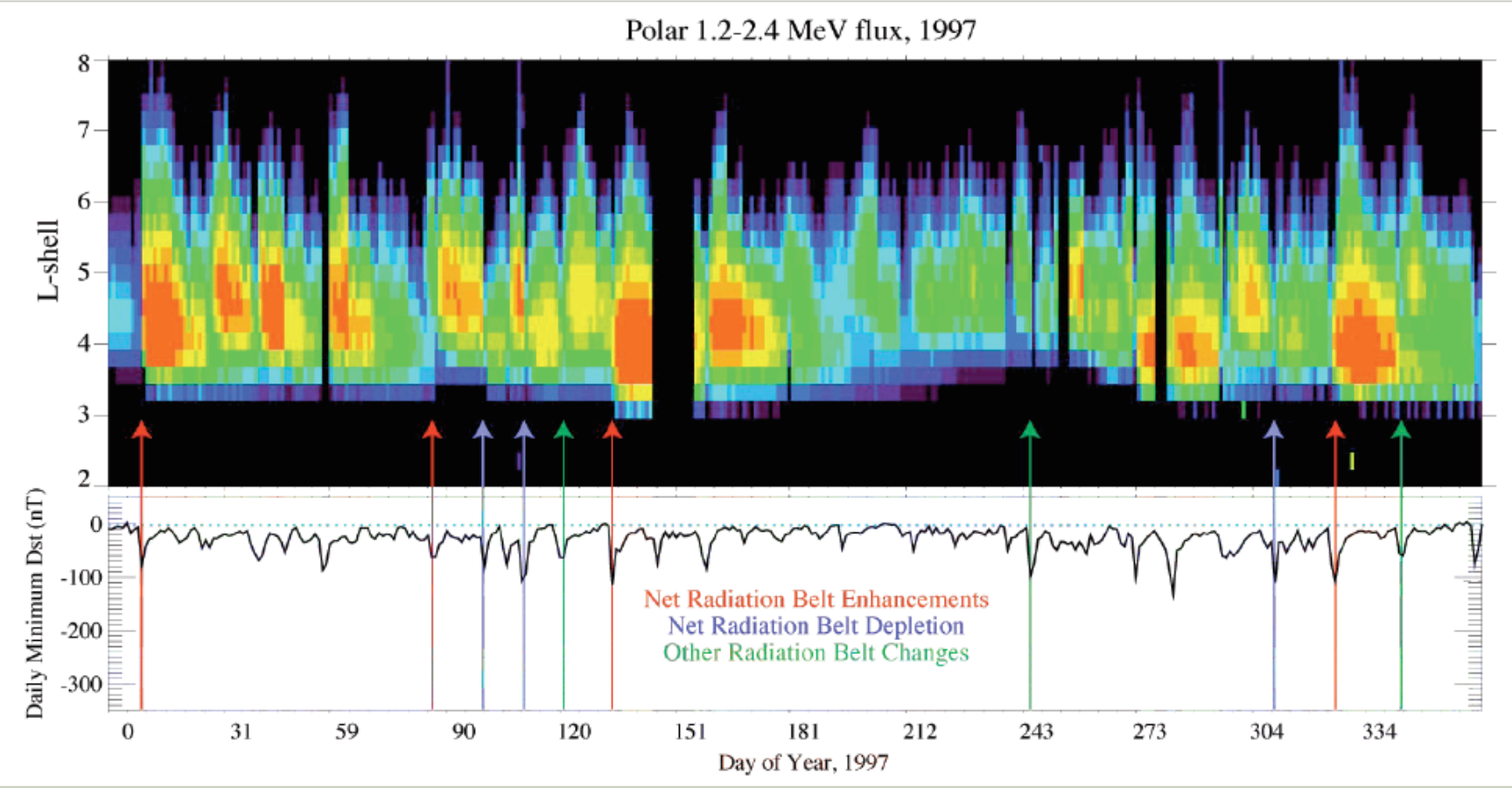
2007 GEM student tutorial

Radiation Belt Part II



Chia-Lin Huang, Boston University, MA

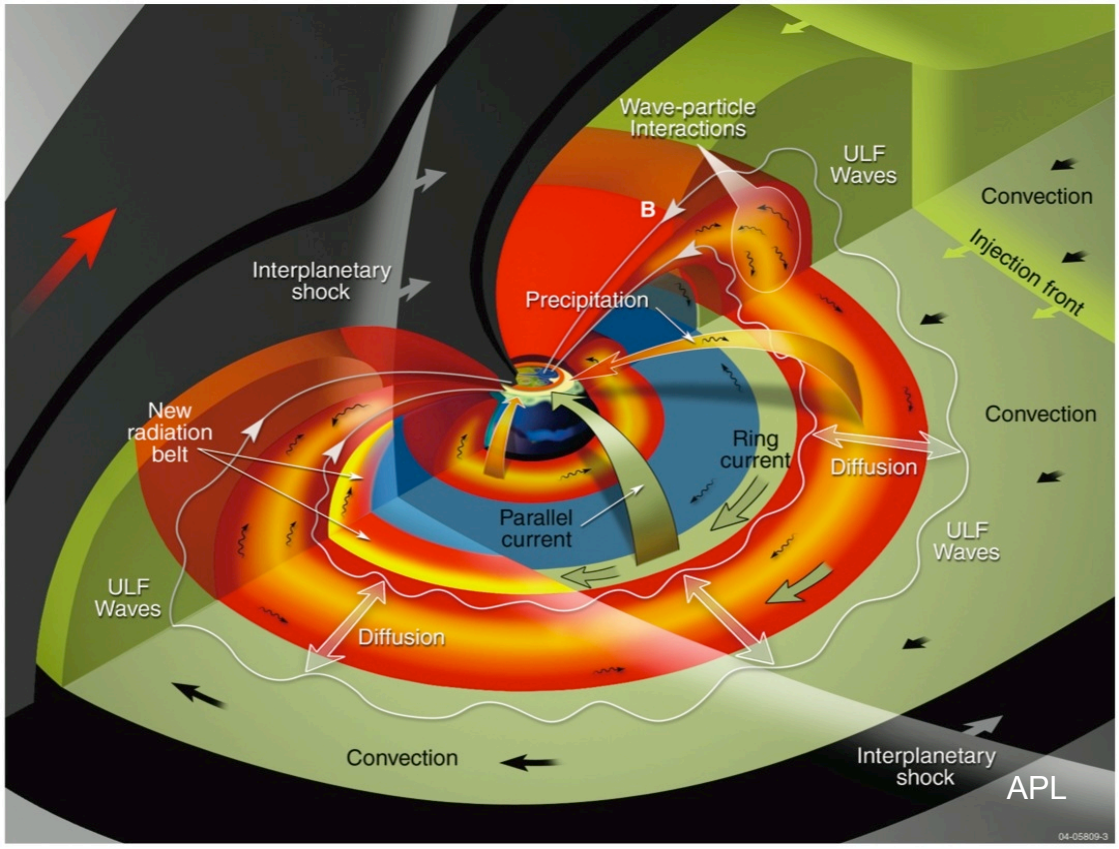
Highly structured and dynamic outer electron belt



Geoff Reeves

Outstanding questions

- Which physical processes produce radiation belt enhancement events?
- What are the dominant mechanisms for relativistic electron loss?
- How does the inner magnetospheric plasma environment control radiation belt acceleration/loss?



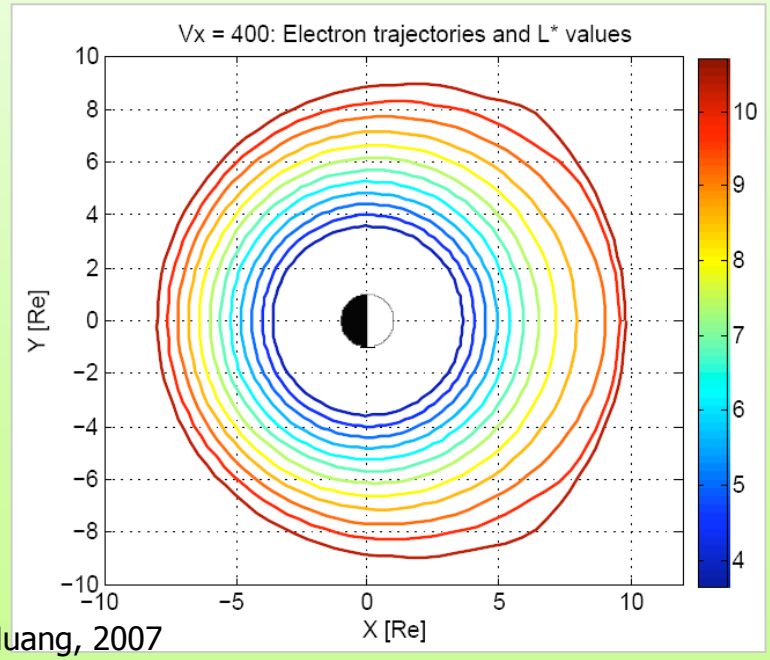
Outline

- What are they talking about?
- What are they fighting for?
- Why is it so hard?
- What would help?

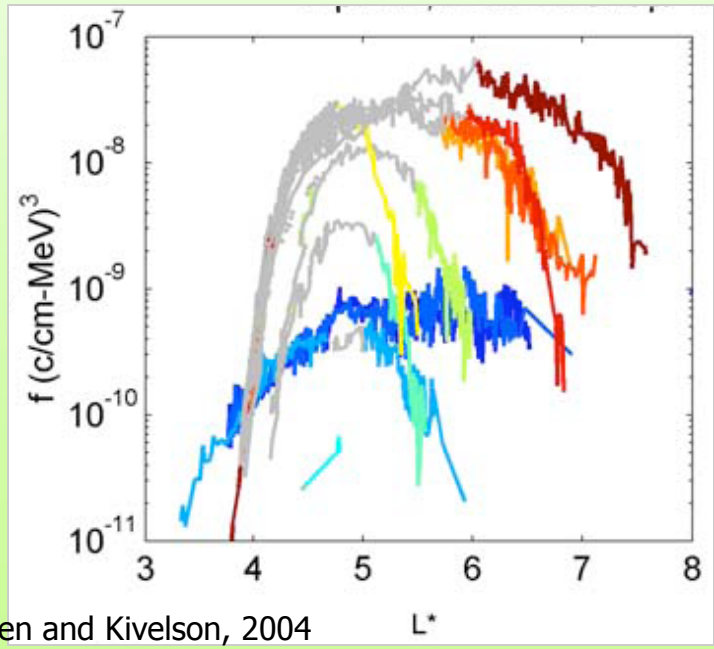
- Breakout sessions
- Student sponsored tutorial

What are they talking about? (1)

- Adiabatic and non-adiabatic processes **Need B-model!**
- L shell (L and L*) **Need B-model!**
- Phase space density (PSD) **Need B-model!**



Huang, 2007



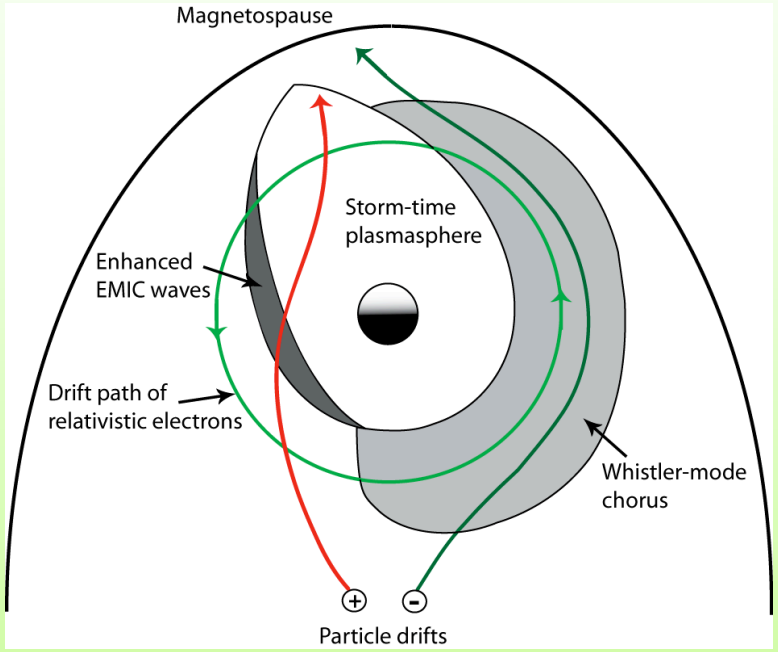
Green and Kivelson, 2004

What are they talking about? (2)

- Waves in the magnetosphere

  Need B and E-models!

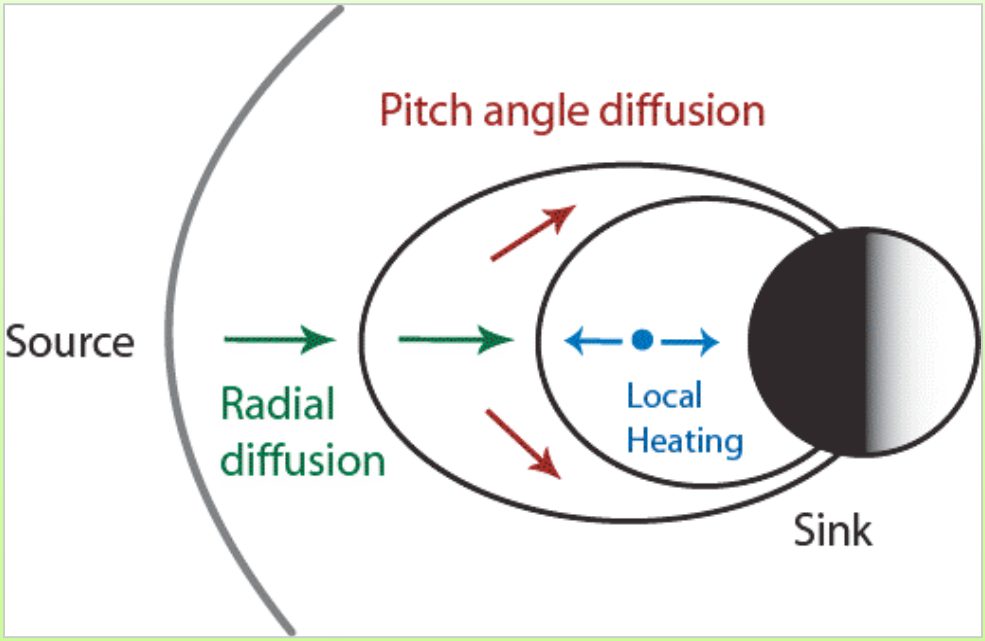
  - Local stochastic acceleration
    - Local heating, break 1st or 2nd invariant
  - ULF wave resonant
    - Radial diffusion, break 3rd invariant
  - VLF waves
    - Pitch angle diffusion, break 1st or 2nd invariant



After Summers et al., 1998

What are they talking about? (3)

- **Diffusion theory**: time evolution of a distribution of particles whose trajectories are disturbed by innumerable small, random changes.
  - Has to break one or more invariants
  - Has to remove the adiabatic motions

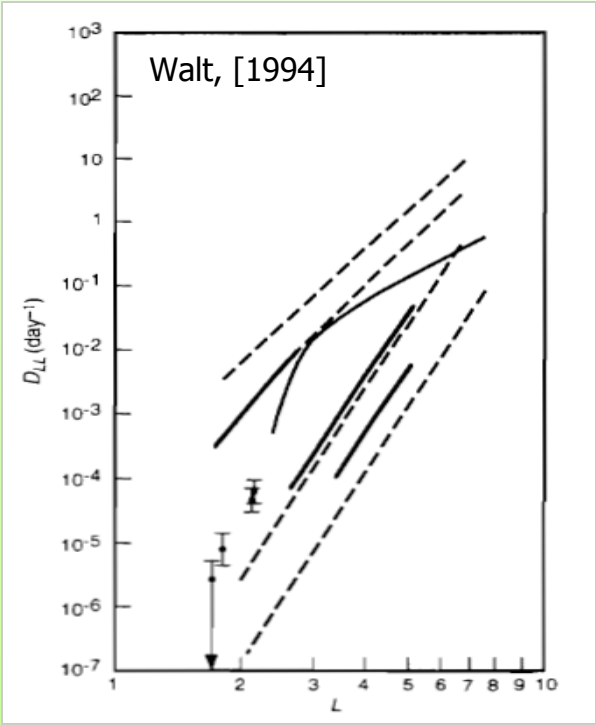


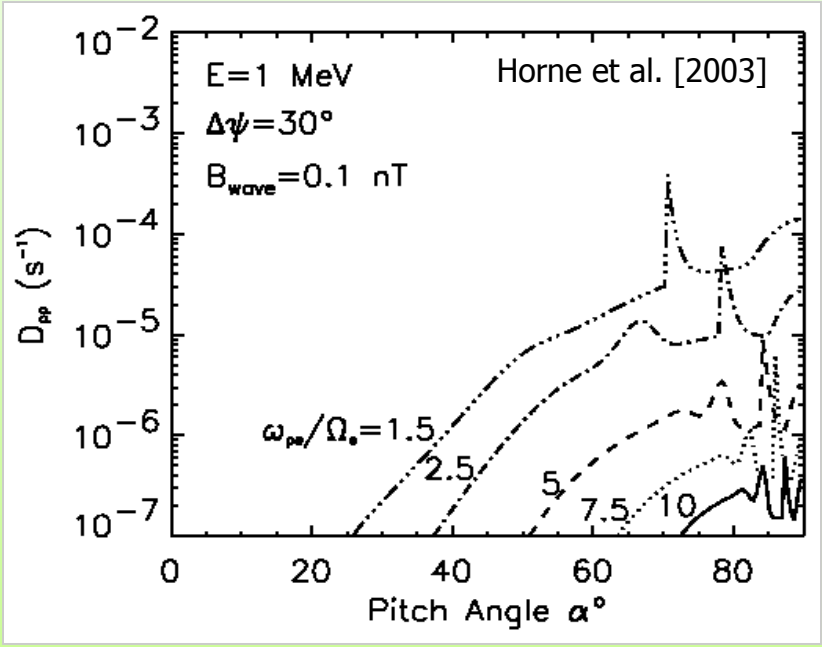
More on diffusion matters

- Diffusion coefficients
  - Radial diffusion (D_{LL})
  - Pitch angle diffusion ($D_{\alpha\alpha}$)

$$\frac{\partial f}{\partial t} = \frac{\partial}{\partial L}\left[D_{LL} \frac{1}{L^2} \frac{\partial}{\partial L}\left(L^2 f\right)\right], \quad D_{LL} = \frac{\left\langle (\Delta L)^2 \right\rangle}{2}$$

$$\frac{\partial f}{\partial t} = \frac{1}{\sin\alpha} \frac{\partial}{\partial \alpha}\left[D_{\alpha\alpha} \sin\alpha \frac{\partial f}{\partial \alpha}\right]$$

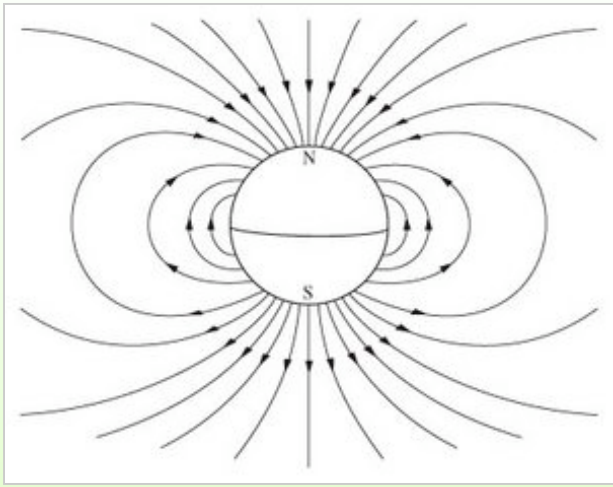




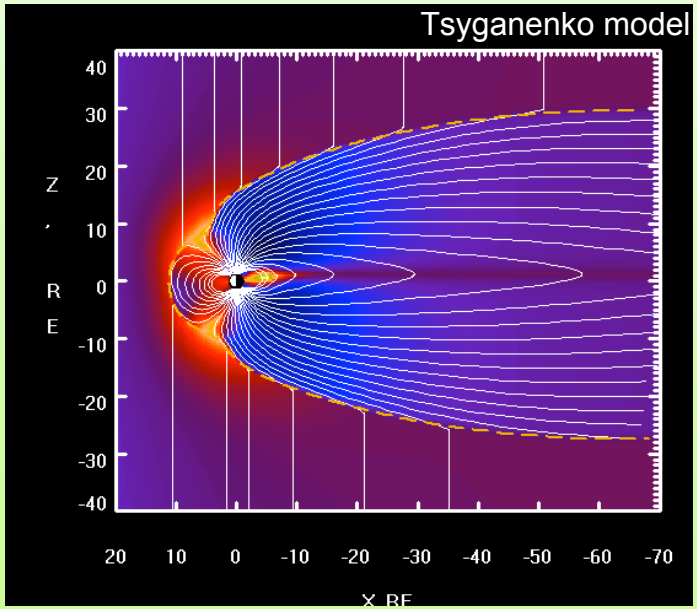
Importance of B and E field models

- VERY IMPORTANT!!!
- Field models determine almost everything
- Model validation

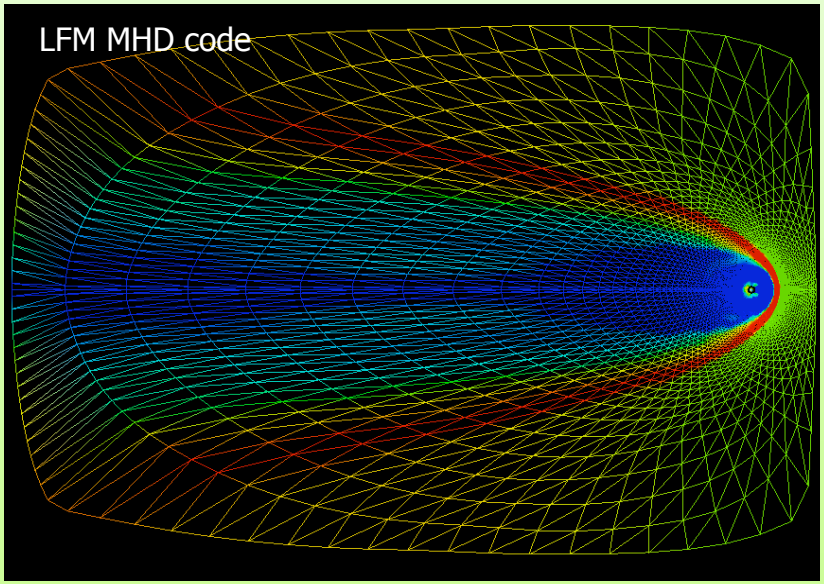
Dipole field



Empirical model



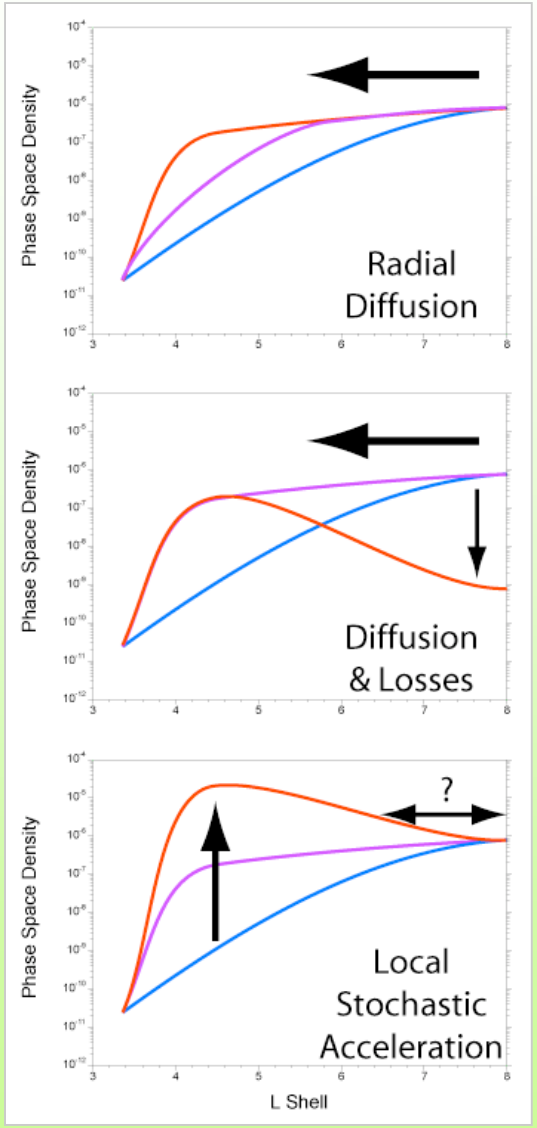
Global MHD simulation



What are they fighting for?

Balance between everything…

- Particle acceleration mechanisms
  - Internal and external heating mechanisms
  - Shock acceleration
  - Substorm injection
  - Recirculation, Jovian source, Cusp diffusion, SEP event
- Loss
  - Pitch angle diffusion
  - Coulomb collision
  - Magnetopause shadowing
- Transport
- No-so-perfect field models



Geoff Reeves

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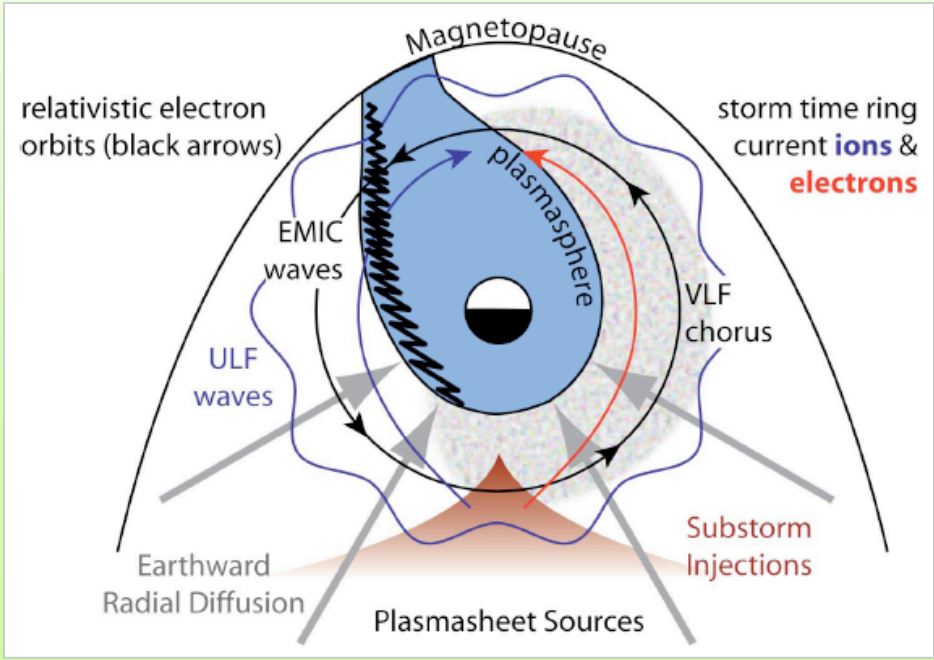


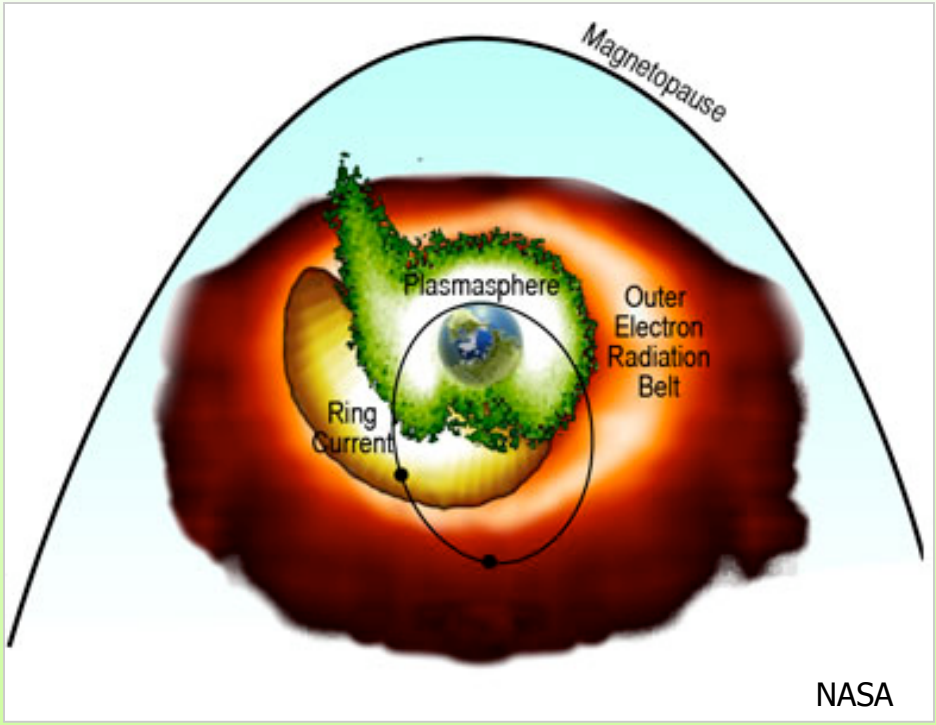
Reeves, 2007

Why is it so hard?

- Observational difficulties
  - Lack of measurements
  - Energetic particles are hard to measure
  - Converting particle flux to PSD is tricky
    - Because of not-so-perfect magnetic field model
- Modeling difficulties
  - Not-so-perfect magnetic and electric field model
    - Field configurations and wave fields
  - Limited understanding of wave-particle interactions
  - Limited computational resource

What would help?

- Better understanding of
  - Inner magnetospheric structure and dynamics
  - Wave-particle interactions
- Multi-spacecraft mission
  - **R**adiation **B**elt **S**torm **P**robes (RBSP)
  - **D**emonstration **S**cience E**x**periments (DSX)
- Physics-based Modeling
  - Include all physical processes



Space Radiation Climatology

- Goal: produce data-assimilative models of the magnetically trapped plasmas and radiation belts.
- IM tutorial talk: Friday morning by **Paul O'Brien**, Aerospace, title: "Space Radiation Climatology: A New Paradigm for Inner Magnetosphere Simulation and Data Analysis"
- Four breakout sessions on Thursday and Friday
  - Intro to focus group
  - Radiation Belt Data and Simulations
  - Ring Current/Plasmasphere Data and Simulations
  - Strategy and planning session

Student sponsored tutorial talk

- **Harlan Spence**, Boston University
- Title: Radiation Belt Redux: Science Objectives of the RBSP Mission
- Tuesday morning