

WG3 Session#3

Thursday PM:

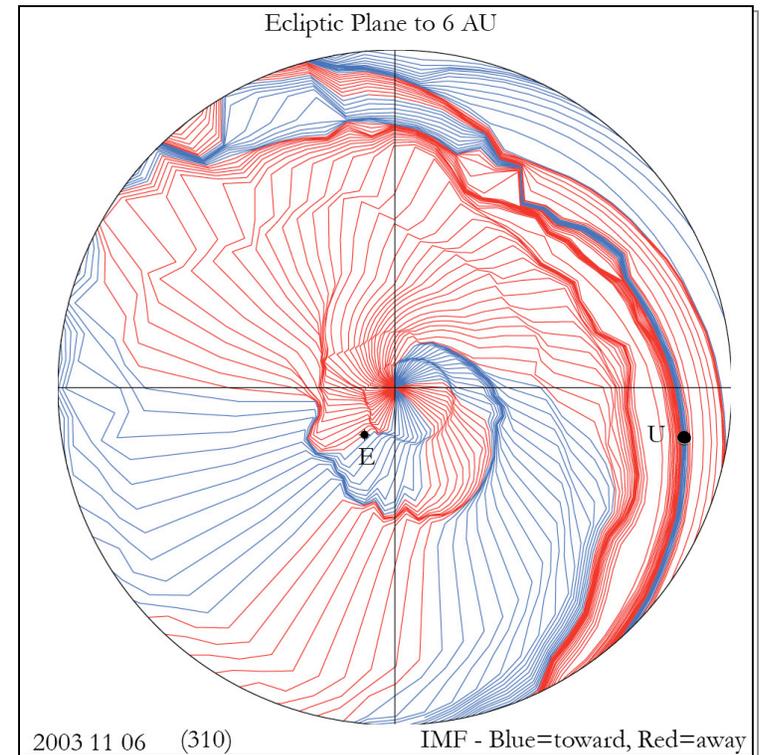
The Effects of the Sun in the Outer Heliosphere

This session focused on the global effects of the Sun as seen in the outer heliosphere.

The largest solar energetic particle events of cycle 23 e.g., the Halloween events of 2003, have been observed in the outer heliosphere at *Voyager* and have been modeled.

Invited Speakers:

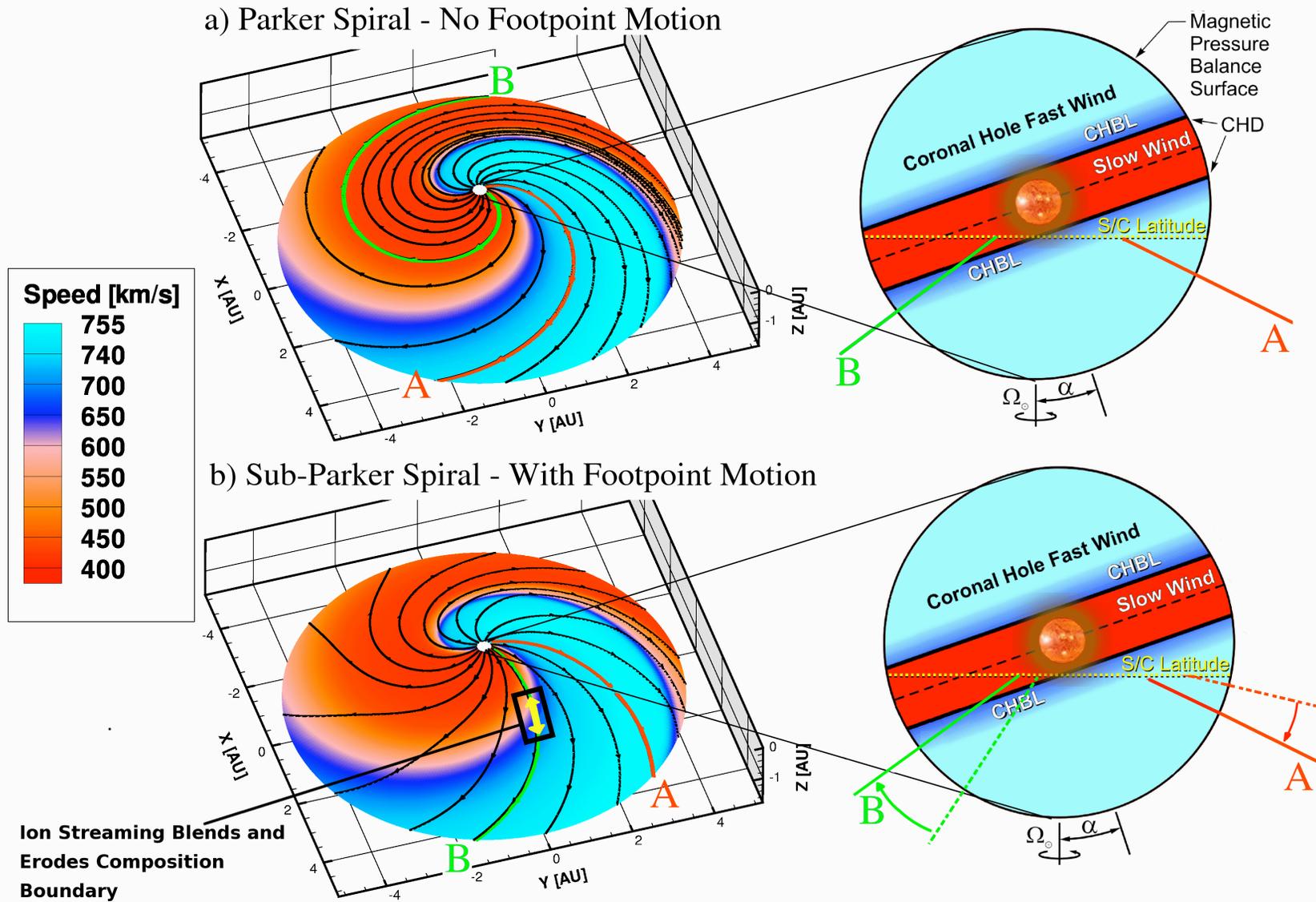
- **John Richardson**, *MIT*
- **Devrie Intrilligator**, *Carmel Research Center*
- **Trevor Sanderson**, *ESA*
- **Nathan Schwadron**, *Southwest Research Institute*



Voyager 1 crosses the Termination Shock

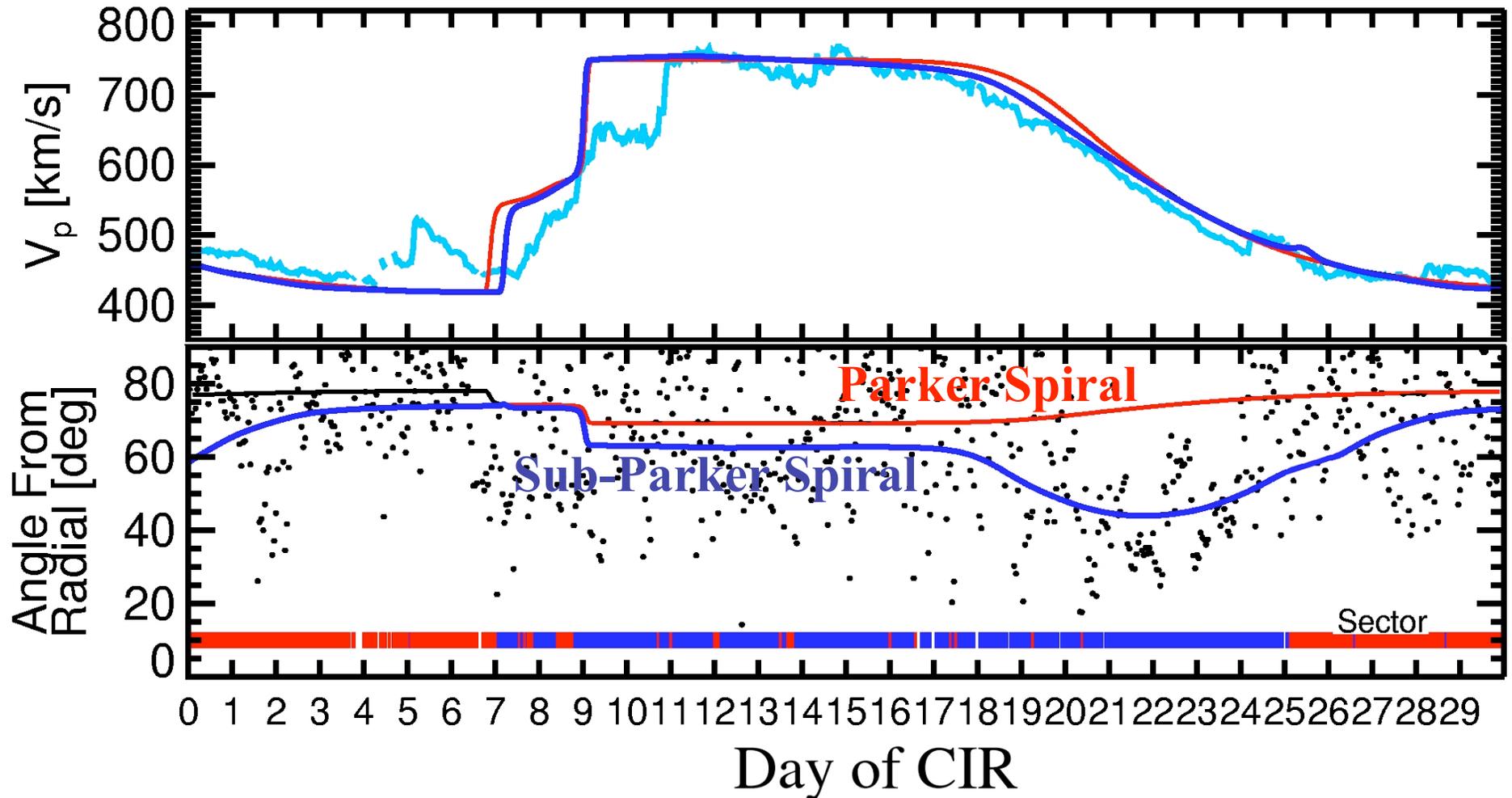
- In Dec. 2004, V1 clearly observed features of energetic particles and magnetic field indicating the crossing of the termination shock
- Magnetic field jumps by at least 2.5 to 4.
- Low-energy cosmic rays increase sharply by a factor of 50.
 - Not obviously similar to the predictions of diffusive shock acceleration
- High-energy cosmic rays (ACRs) do not show the “rollup” expected on the downstream of the shock
- Magnetic-field shows sector structure prior to crossing the shock, but since the crossing, the field has been of the same polarity (consistent with the opposite hemisphere than V1!)

Parker/Sub-Parker Spirals



Sub-Parker Spiral Observed

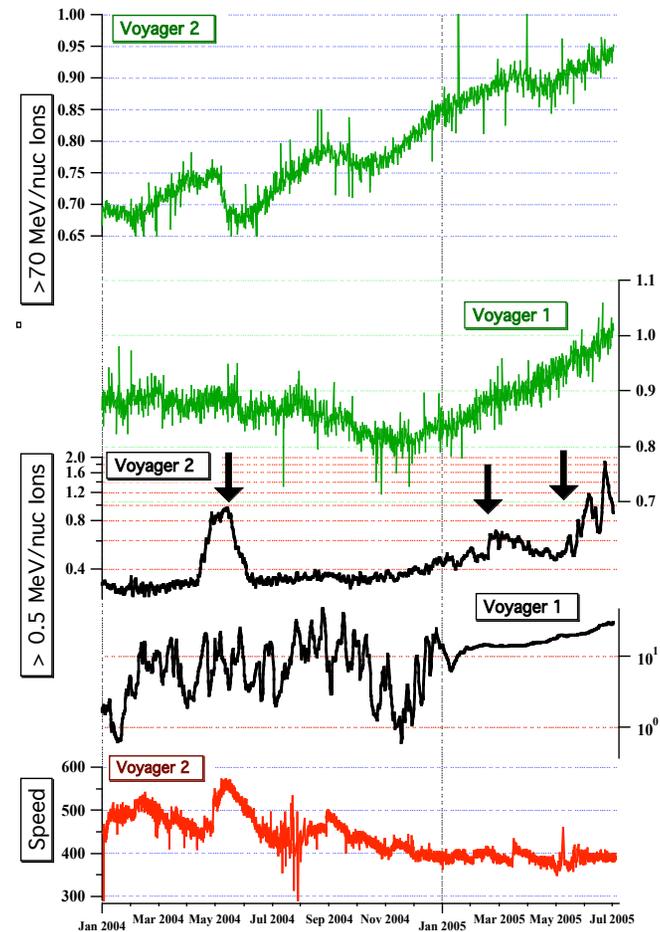
09/30/1992 to 11/03/1992



Schwadron et al., GRL 2005

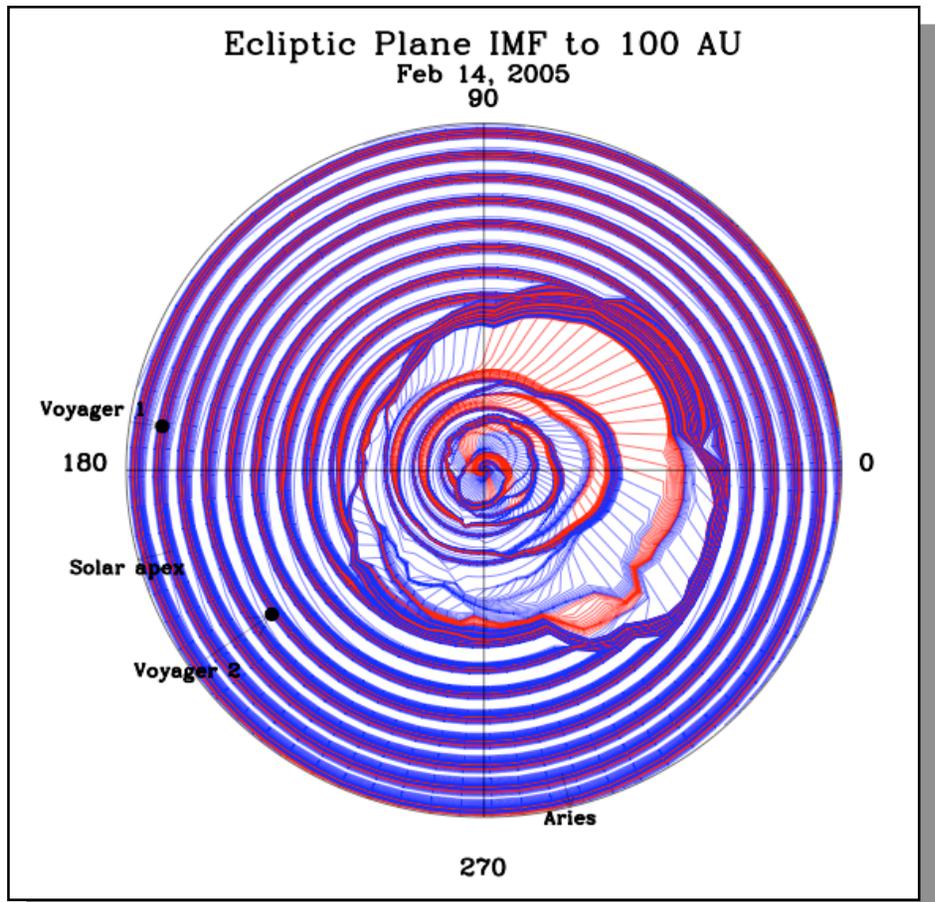
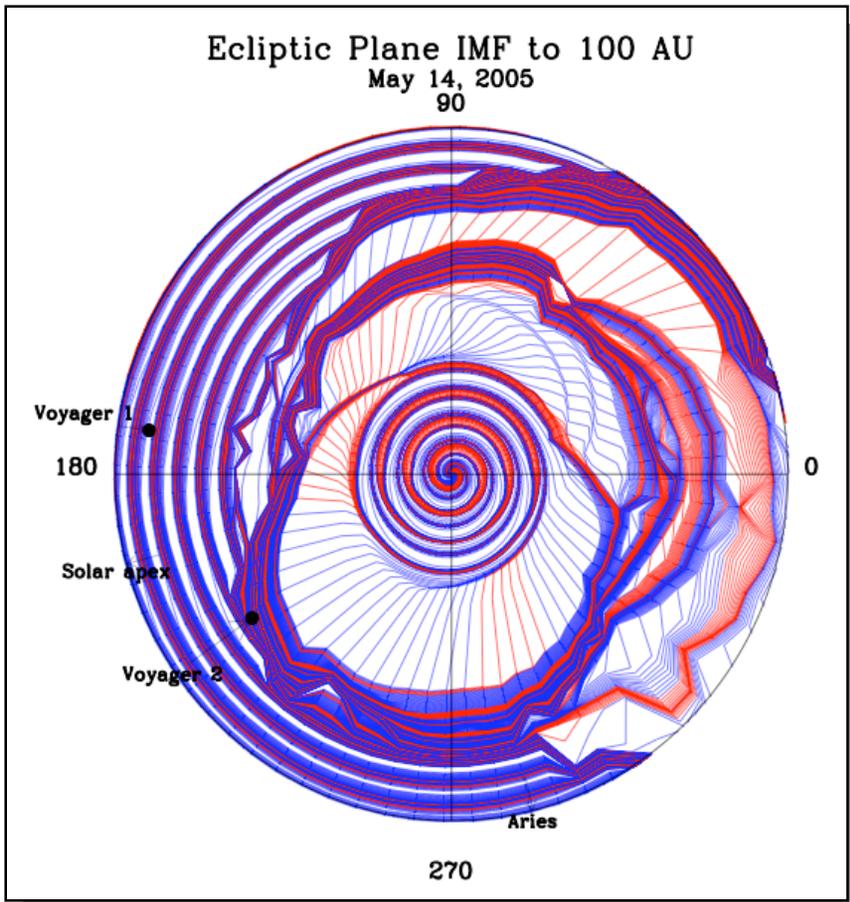
Halloween Events Seen in Voyager 2 Data

- Calculations by D. Intriligator et al. indicate that there is a good magnetic connection between energetic particles (modeled) from Halloween events and Voyager 2
- Increase in particles may be related to these solar storms



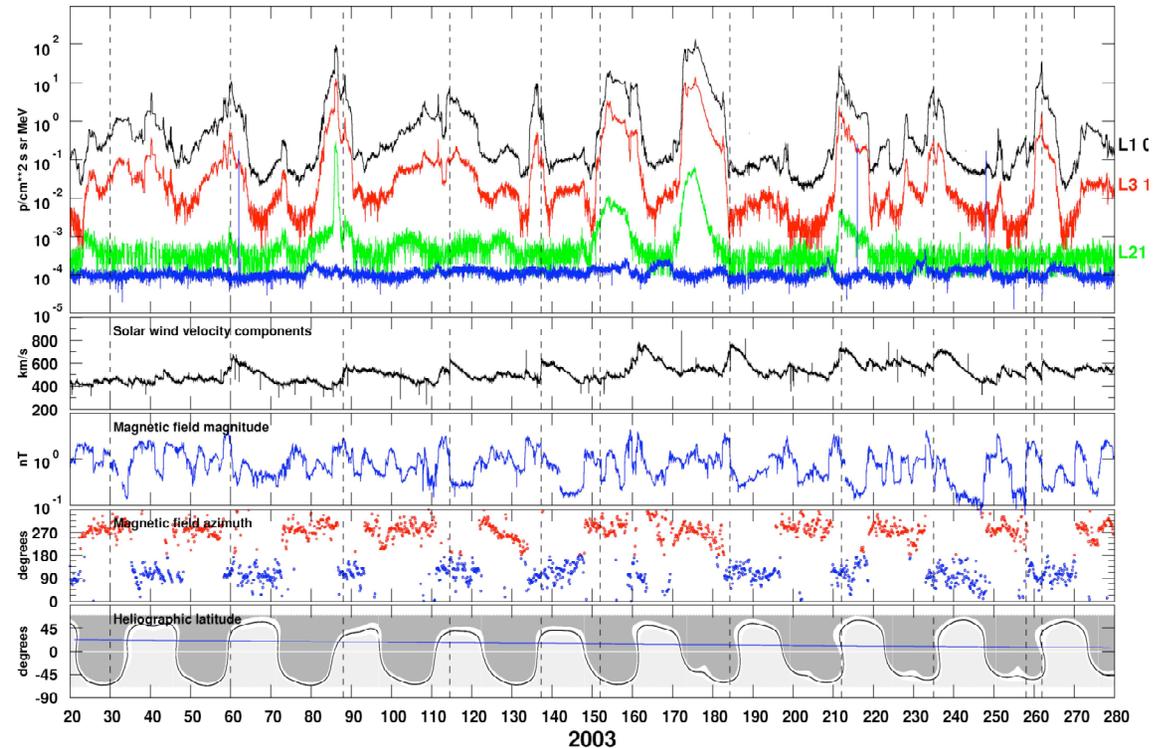
HAFv2 ecliptic plane IMF to 100 AU

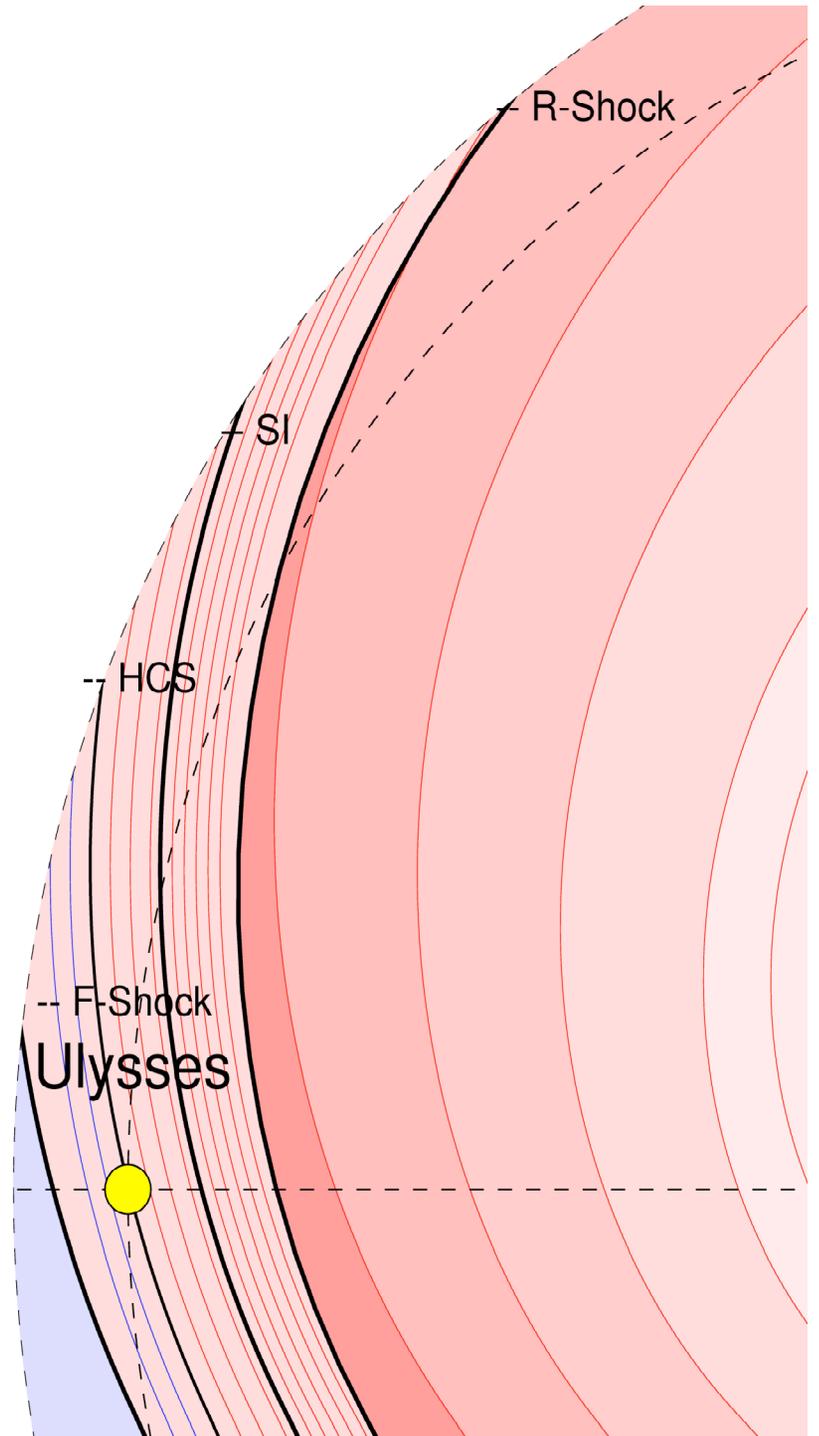
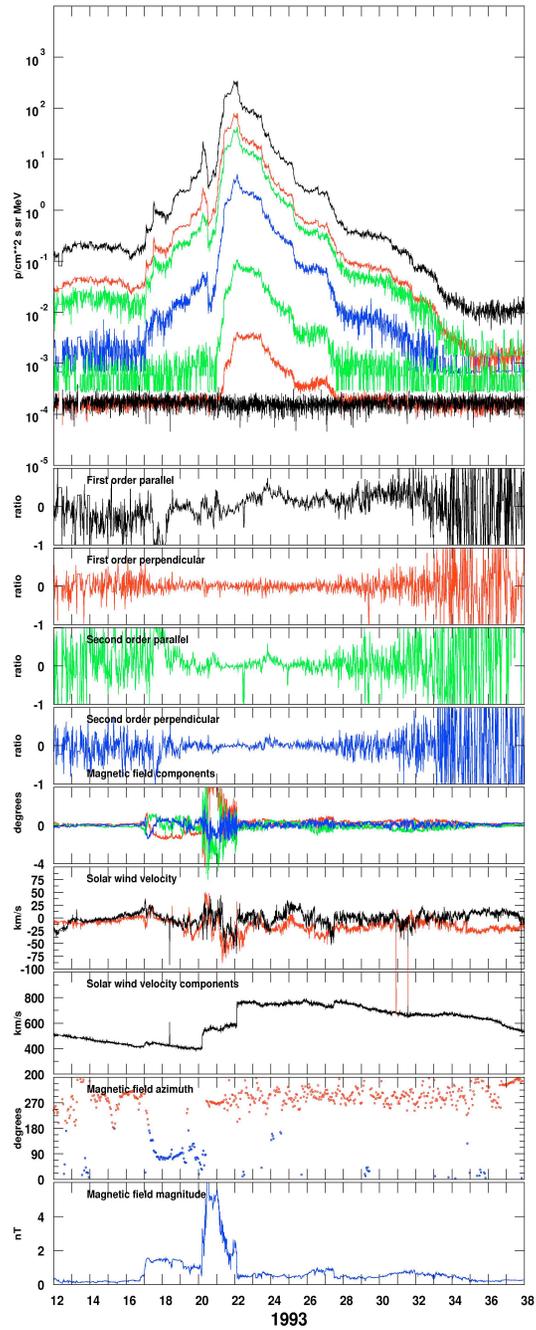
Halloween 2004 events - 5/05 & 2/05



CIRs seen in 2003

- T. Sanderson showed Ulysses data of CIRs during 2003
- About 2-4 per solar rotation
- Clear energetic-particle signatures associated with the CIRs





Finishing the Summary of Particle Acceleration Mechanisms

A new approach (applied to Flares?)

Len Fisk started with an equation for the evolution of the open magnetic field

$$\frac{\partial \mathbf{B}}{\partial t} = -\nabla \times \nabla \times (\kappa \mathbf{B}) + \nabla \times (\mathbf{U} \times \mathbf{B})$$

Which can be rewritten as

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times \left[(\mathbf{U}_{\kappa} + \mathbf{U}) \times \mathbf{B} \right]$$

$\nabla \cdot \mathbf{U}_{\kappa}$ Gives rise to an energy change in energetic particles

Mechanisms of Particle Acceleration

Challenges / Future Directions / Open Issues

- **Observational issues:**
 - How often are power laws observed?
 - How common are double power laws?
- **Theoretical Issues:**
 - Shock Acceleration: It is time to **put up or shut up** on the issue of 3He^{++} and electrons !! (otherwise, it is not relevant for solar flares)
 - What is the importance of magnetic geometry for CME-driven shocks?

Mechanisms of Particle Acceleration

Challenges / Future Directions / Open Issues

- Theoretical Issues (cont):
 - Stochastic Acceleration: Are power laws determined naturally from this mechanism under a wide variety of plasma conditions? If so, ***WHAT PHYSICAL PARAMETERS DETERMINE THEM??***
 - Direct Acceleration by Electric Fields: What is the role of turbulence? Do the accelerated particles give rise to plasma instabilities? (there is clearly a significant amount of energy in the energetic particles)

Are these mechanisms mutually exclusive??