DECEMBER 2006 SEP EVENTS:
Ulysses, STEREO & ACE OBSERVATIONS

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Objective

• Present unique energetic particle observations by Ulysses > 70°S during intense solar activity in December 2006

• Compare with previous high latitude measurements obtained close to solar max

• Compare with simultaneous in ecliptic observations by STEREO, ACE at 1 AU
Ulysses
Third Solar Orbit

North Polar Pass

2008
2002
Jupiter

Perihelion
Aug 2007

Earth Orbit

2003
2004
2005
2006

Aphelion
June 2004

South Polar Pass
Nov 2006-Apr 2007

★ Ulysses position on 07.02.2007
Unique Events of December 2006

All x-ray events associated with intense, metric type-II radio bursts, indicative of coronal shocks
Angular separation with X9.0 flare location

Ulysses footprint : 70 deg
ACE footprint : 135 deg
Velocity dispersion at Ulysses
Radiation belt pass
ULYSSES/ACE OBSERVATIONS

Electrons 175–315 keV

ACE/EPAM
ULYSSES/HI–SCALE
Near-isotropic angular distributions at the onset (Ulysses)
ULYSSES/STEREO-B OBSERVATIONS
How do SEPs reach high latitude?

• Field line connection?  (Smith et al. 2001) -
  Unlikely, since Ulysses in fast wind and AR in slow wind
• Accelerated by coronal shock? (Cliver et al. 1995)
  - Delay to ACE: 3.6 Hr (Dec 5)
  - Delay to Ulysses: 9.6 Hr
  - Coronal shock travel time: ~13 minutes
• Cross field diffusion? (Zhang 2003; Dalla et al. 2003) - possible, but no local evidence

Credit: NSO/Optical Solar Patrol Network Telescope
December 2006 SEP events

• Unique observation of a high latitude event in the history of Ulysses mission during a period of relatively quiet and stable conditions in the heliosphere

• Simple structure of the heliosphere and Ulysses in high-speed coronal hole flow exclude the possibility that low latitudes magnetic fields lines reached Ulysses

• EP released when the propagating coronal waves reached high latitude magnetic field lines connected to Ulysses/EP underwent perpendicular diffusion

• Rise-phase of the event at STEREO & ACE in response to the X9.0 flare faster than at Ulysses ⇒ more diffusive transport to high latitudes and to 3 AU than to STEREO, ACE

• ‘Reservoir effect’ observed late in the decay phase of the particle events