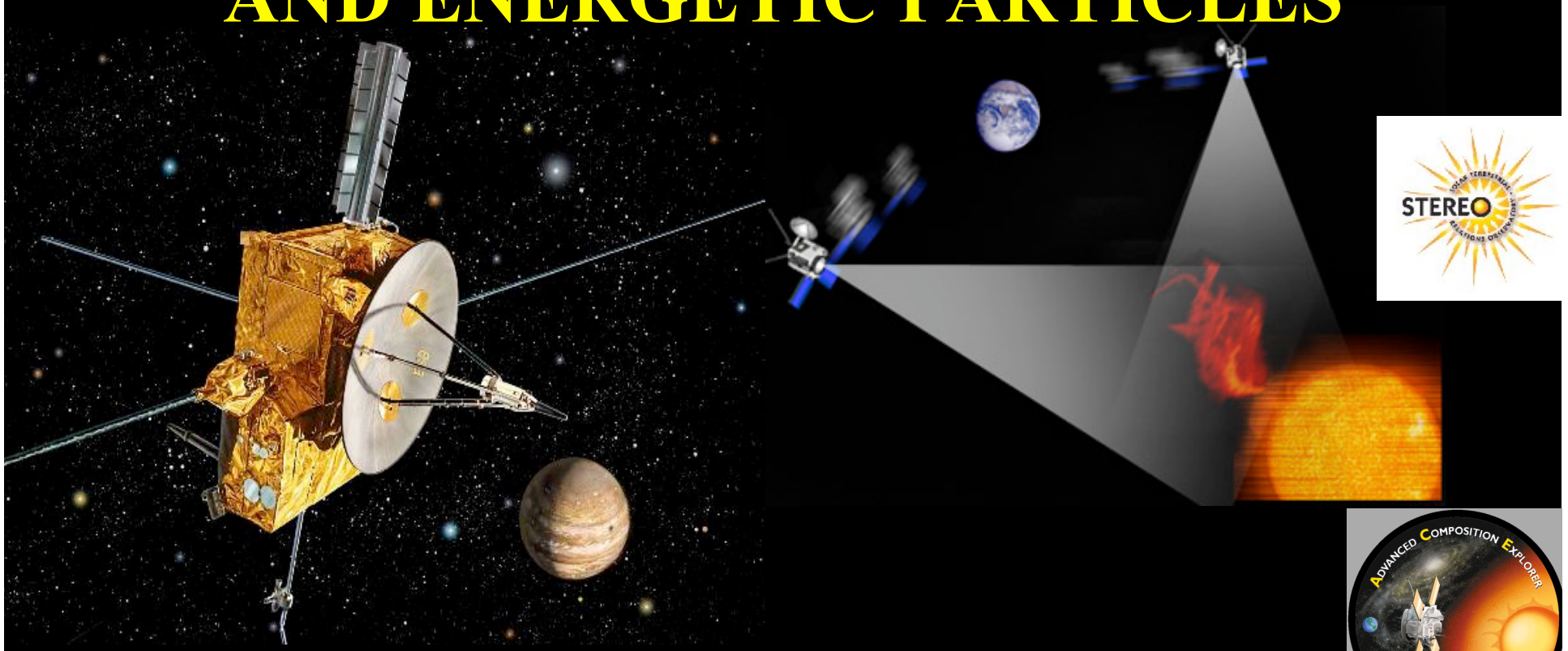
COROTATING INTERACTION REGIONS CORONAL MASS EJECTIONS AND ENERGETIC PARTICLES



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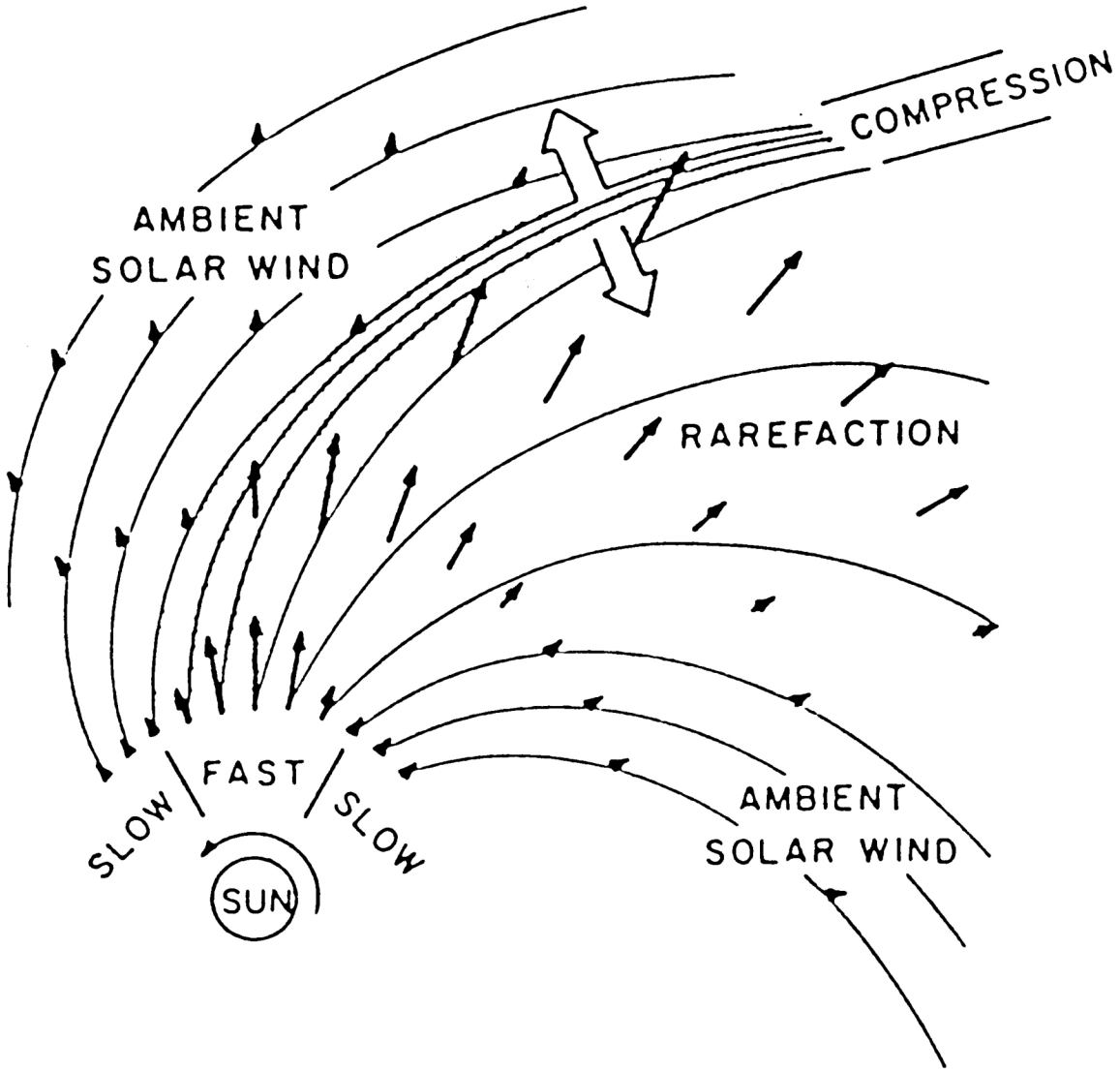
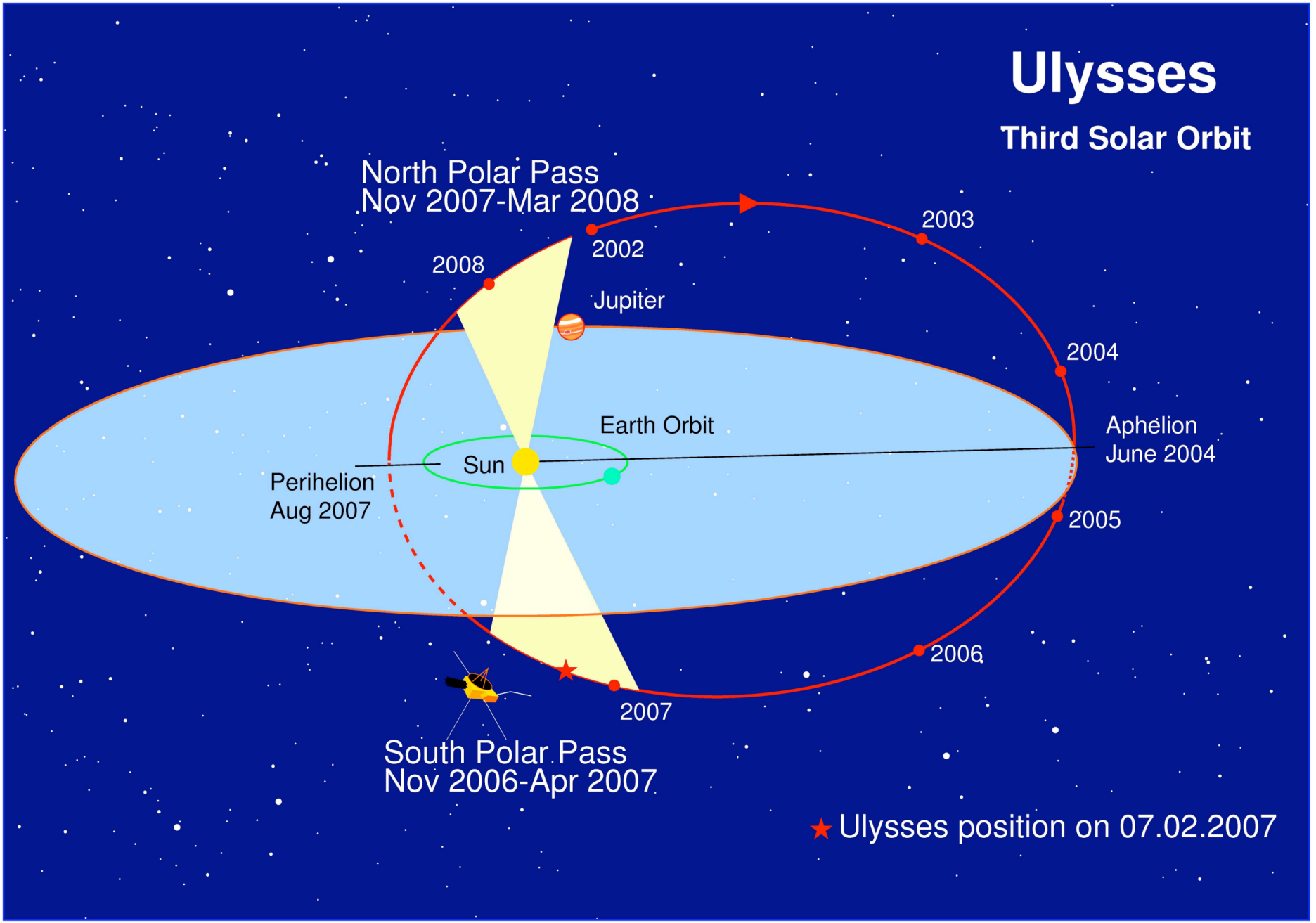
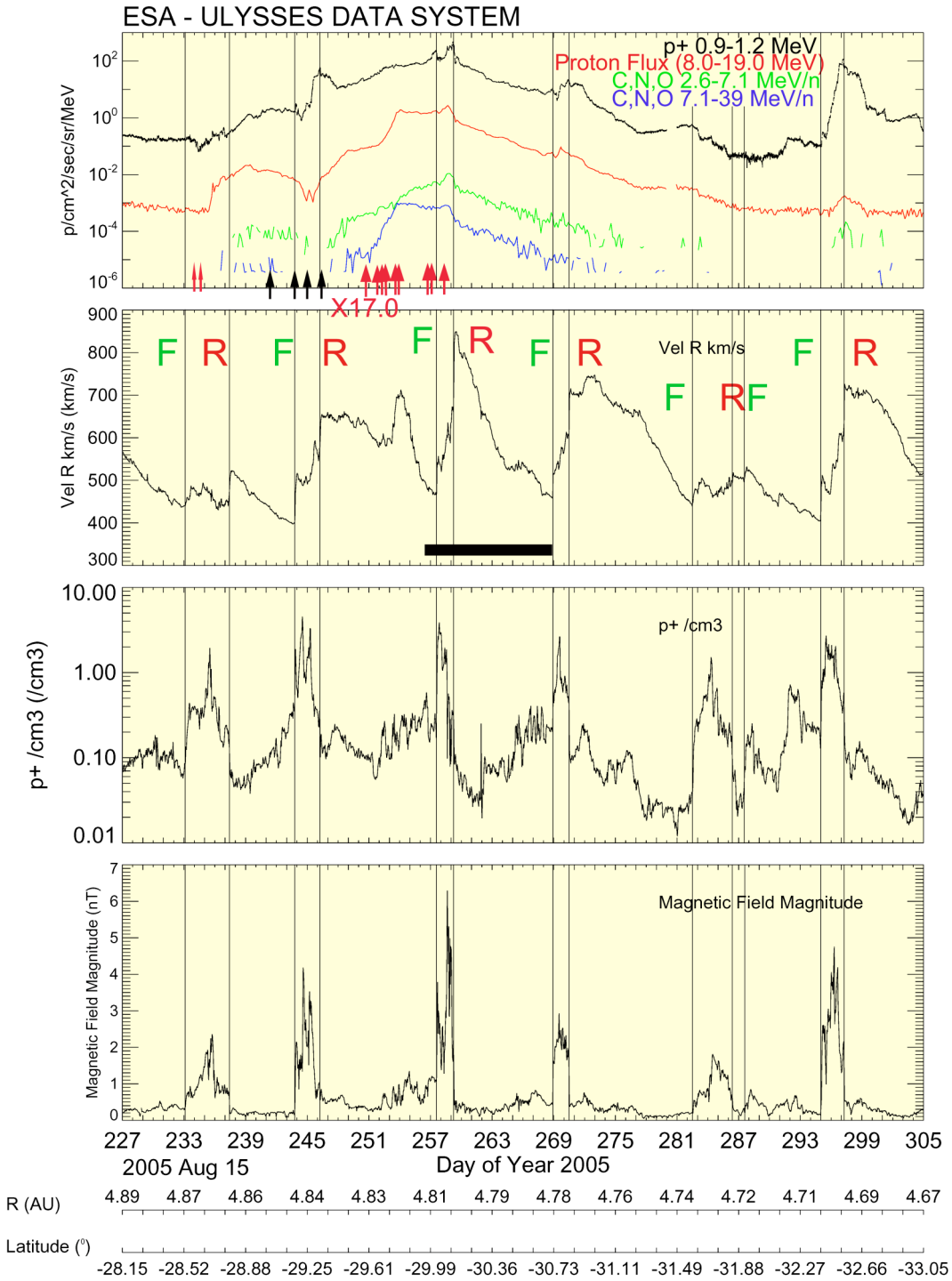
Corotating Interaction Region - CIR

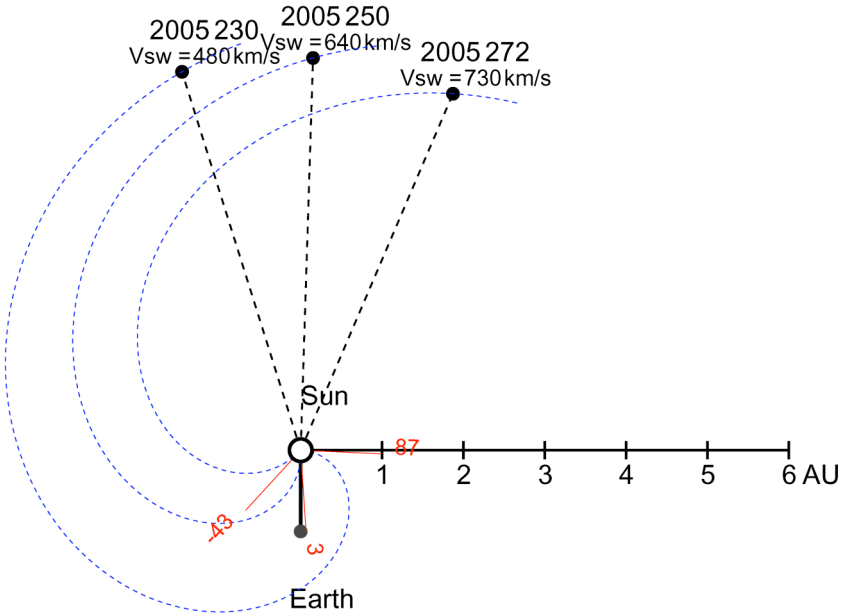


Objective (1)

- Study the effects of solar activity from a near-ecliptic vantage point ~5 AU from the Sun, CME-CIR interaction and the beginning of formation of GMIRs
- We present energetic particle measurements in the 1-20 MeV/n range by the COSPIN/LET instrument focusing in particular on the origin of the complex particle increases observed at the location of the spacecraft
- Composition analysis can provide useful clues in this regard, allowing distinction between particles accelerated in transient events associated with CMEs (i.e. SEPs) and particles accelerated at SIRs or CIRs
- Composition signatures during periods of CME/CIR combinations observed by ULS in Aug/Sept 2005

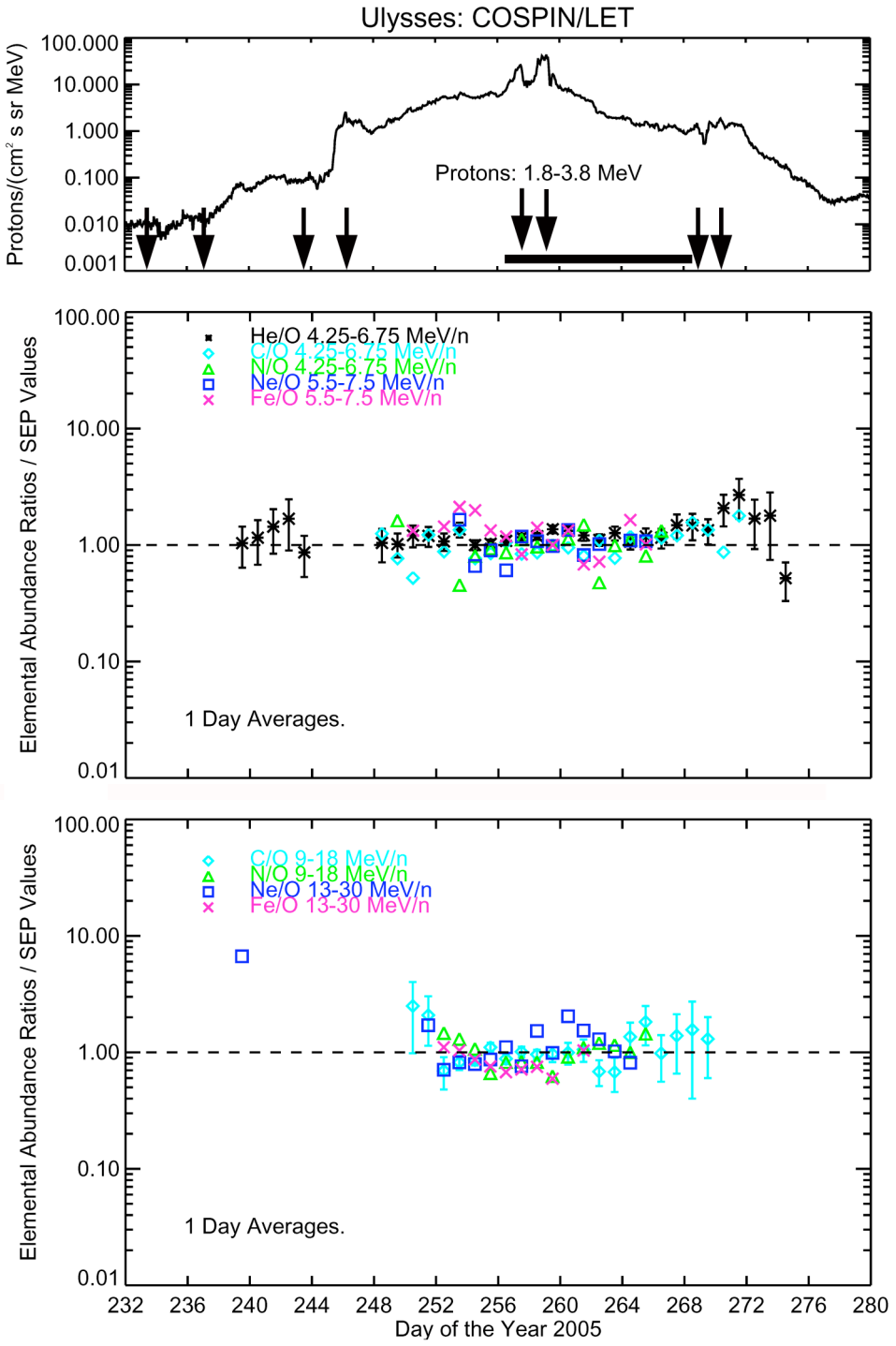

Ulysses
Third Solar Orbit
North Polar Pass
Nov 2007-Mar 2008
2002
2003
2004
2005
2006
2007
2008
Jupiter
Earth Orbit
Sun
Perihelion
Aug 2007
Aphelion
June 2004
South Polar Pass
Nov 2006-Apr 2007
Ulysses position on 07.02.2007


ESA - ULYSSES DATA SYSTEM
p+ 0.9-1.2 MeV
Proton Flux (8.0-19.0 MeV)
C,N,O 2.6-7.1 MeV/n
C,N,O 7.1-39 MeV/n
p/cm^2/sec/sr/MeV
X17.0
Vel R km/s
Vel R km/s (km/s)
F R F R F R F R F RF F R
p+ /cm3
p+ /cm3 (/cm3)
Magnetic Field Magnitude
Magnetic Field Magnitude (nT)
227 233 239 245 251 257 263 269 275 281 287 293 299 305
2005 Aug 15
Day of Year 2005
R (AU)
4.89 4.87 4.86 4.84 4.83 4.81 4.79 4.78 4.76 4.74 4.72 4.71 4.69 4.67
Latitude (°)
-28.15 -28.52 -28.88 -29.25 -29.61 -29.99 -30.36 -30.73 -31.11 -31.49 -31.88 -32.27 -32.66 -33.05


2005 230
Vsw = 480 km/s
2005 250
Vsw = 640 km/s
2005 272
Vsw = 730 km/s
Sun
87
43
3
1 2 3 4 5 6 AU
Earth

	CIR	SEP	CIR/SEP
He/O	159 ± 1	55.2 ± 3	**2.9 ± 0.2**
C/O	0.89 ± 0.04	0.48 ± 0.02	**1.9 ± 0.1**
N/O	0.14 ± 0.01	0.13 ± 0.01	1.1 ± 0.1
Ne/O	0.17 ± 0.02	0.15 ± 0.01	1.1 ± 0.2
Fe/O	0.097 ± 0.01	0.16 ± 0.02	0.6 ± 0.1

Mason and Sanderson (1999)



Aug/Sept 2005 events

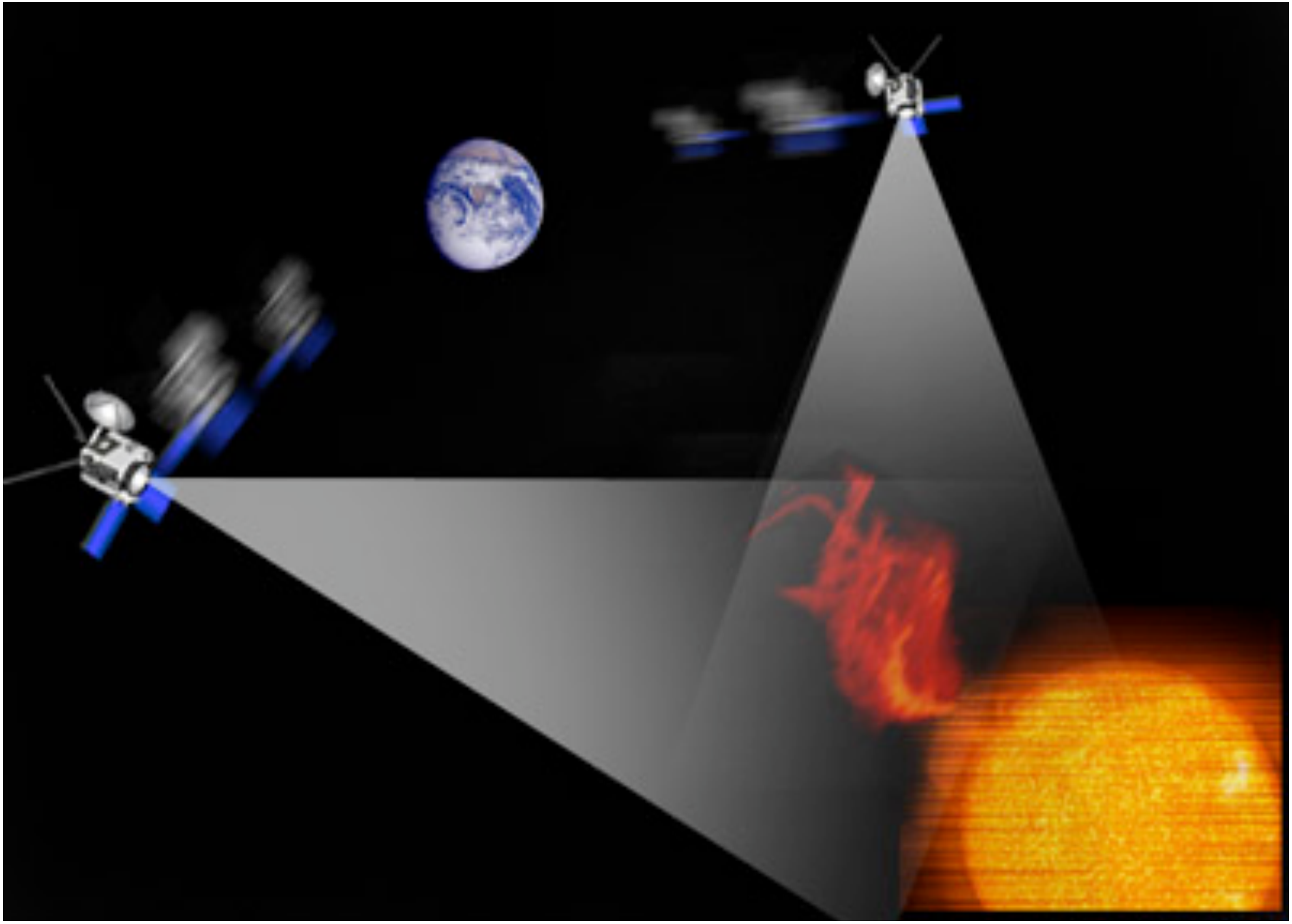
- ULS observes the arrival of a compound stream resulting from the merging of individual transient flows generated by a series of solar events in Aug/Sept 2005 and their interaction with the pre-existing pattern of SIRs in the ambient medium
- The EP intensities remained elevated at ULS for at least 20 days following the X17/3B flare/associated CME on Sept 7
- During the CIR/CME combination period: Composition analysis identifies the EPs as an SEP population ⇒ transient related
- In the trailing edge of the CME/CIR combination, following a recurrent FR shock: an enhanced He/O ratio observed ⇒ evidence of Reverse shock accelerated pickup He originating as interstellar neutrals
- Non-observation of a C enhancement by ULYSSES ⇒ bulk of the particles observed dominated by the ambient SEP population/CIR re-accelerated a pre-existing population of SEPs

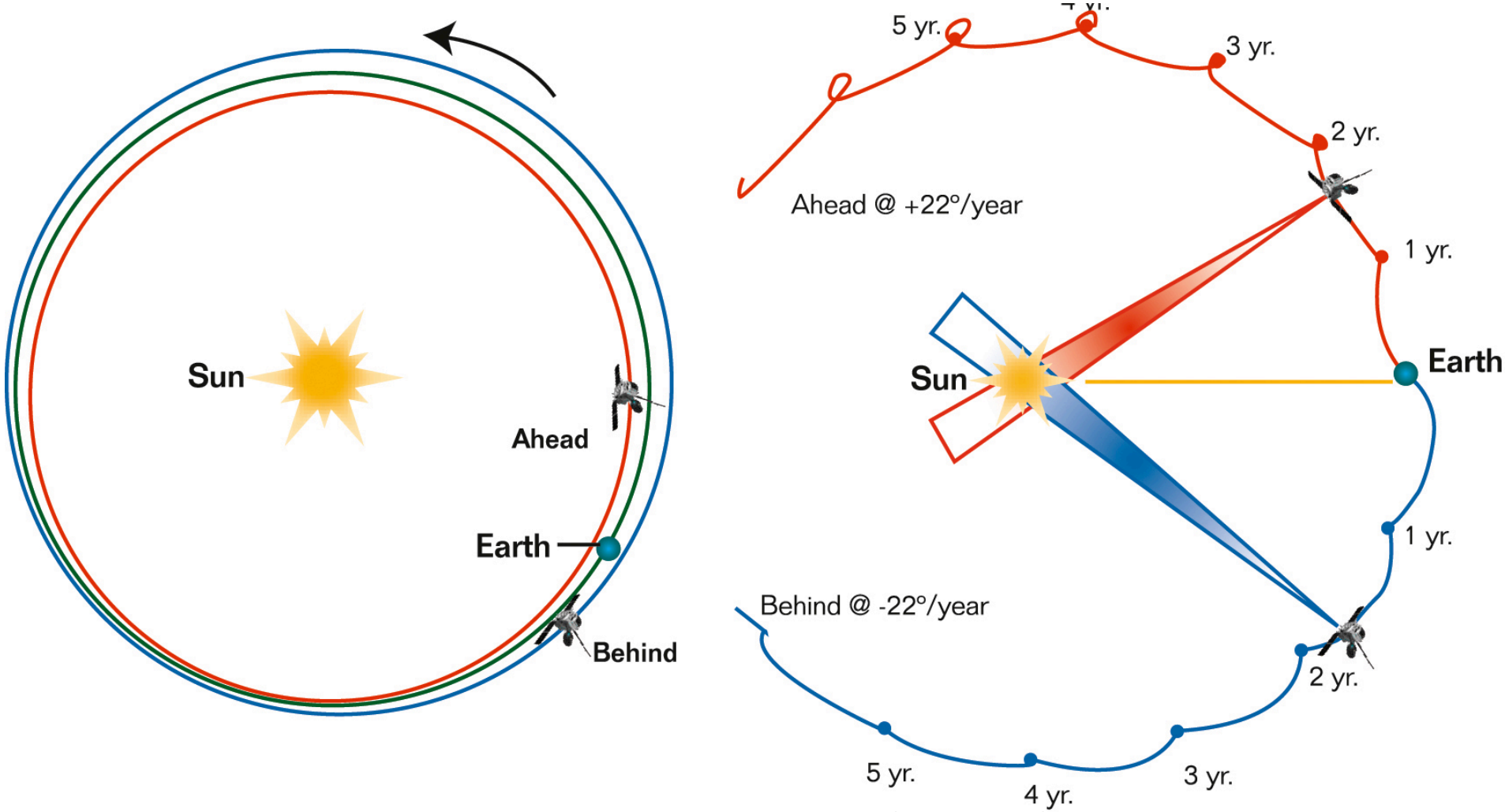
Objective (2)

•We present and compare multi-point plasma and energetic particle observations of the same CIR events by the twin **STEREO** spacecraft and the **ACE** spacecraft, during the recent unusually low solar activity minimum (CR 2067-2082)

•We present and discuss several cases where the presence of Interplanetary Coronal Mass Ejections (ICMEs) in the vicinity or embedded in the CIR is accompanied by significant changes in the CIR structure and in the associated energetic ions **(STEREO/SEPT).** (STEREO/PLASTIC, STEREO/MAG, ACE/SWEPAM complementary measurements used)

STEREO A & B twin spacecraft



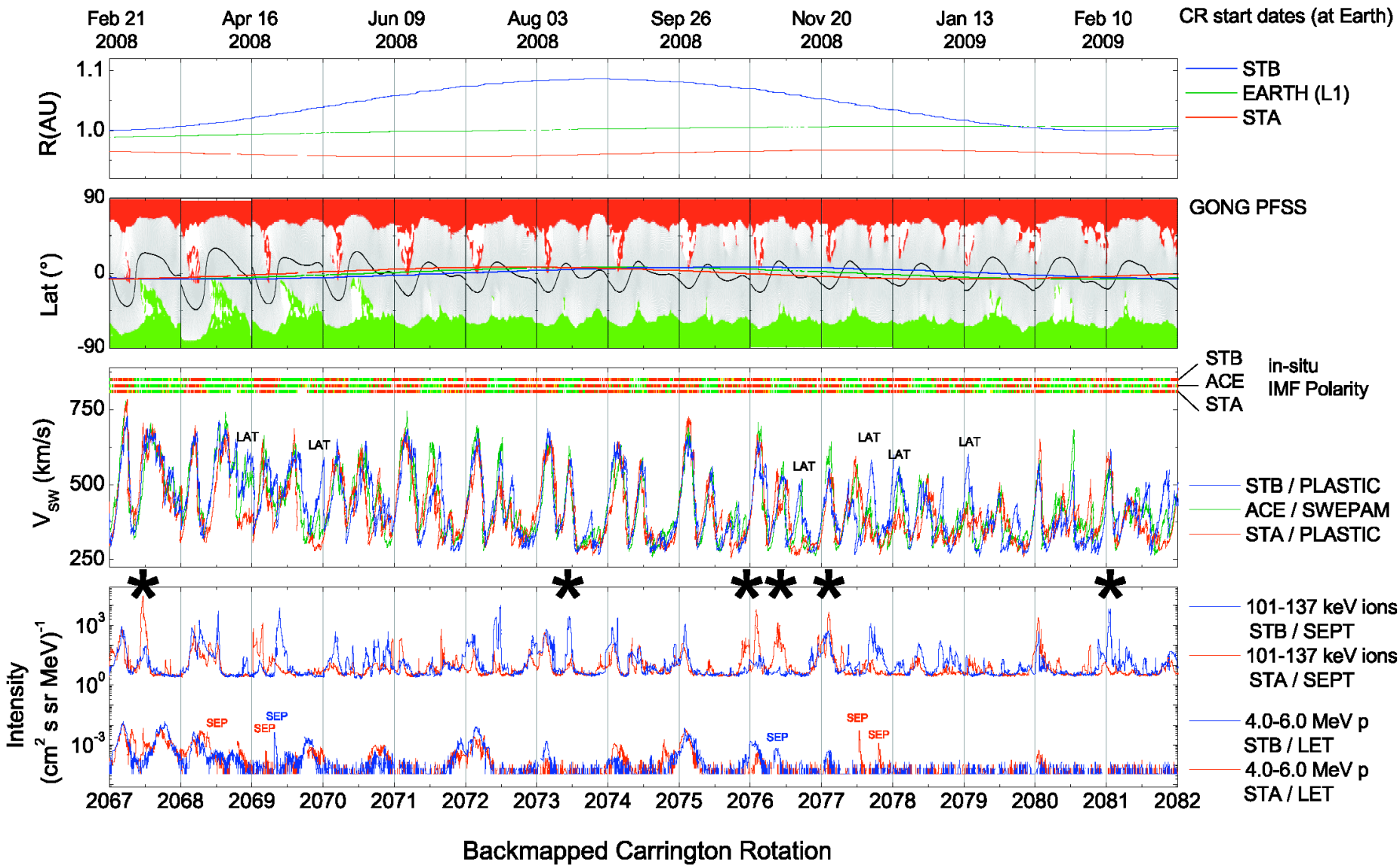


2008: 266, 2009: 260 sunspotless days

Period under study: Feb 21, 2008-Apr 5, 2009

Angular separation between STA-B: 46°-93°

Nominal Co-rotation times: 3.1-6.4 days



$$\Delta\phi = \frac{\Omega_s (r - r_o)}{Vsw}$$

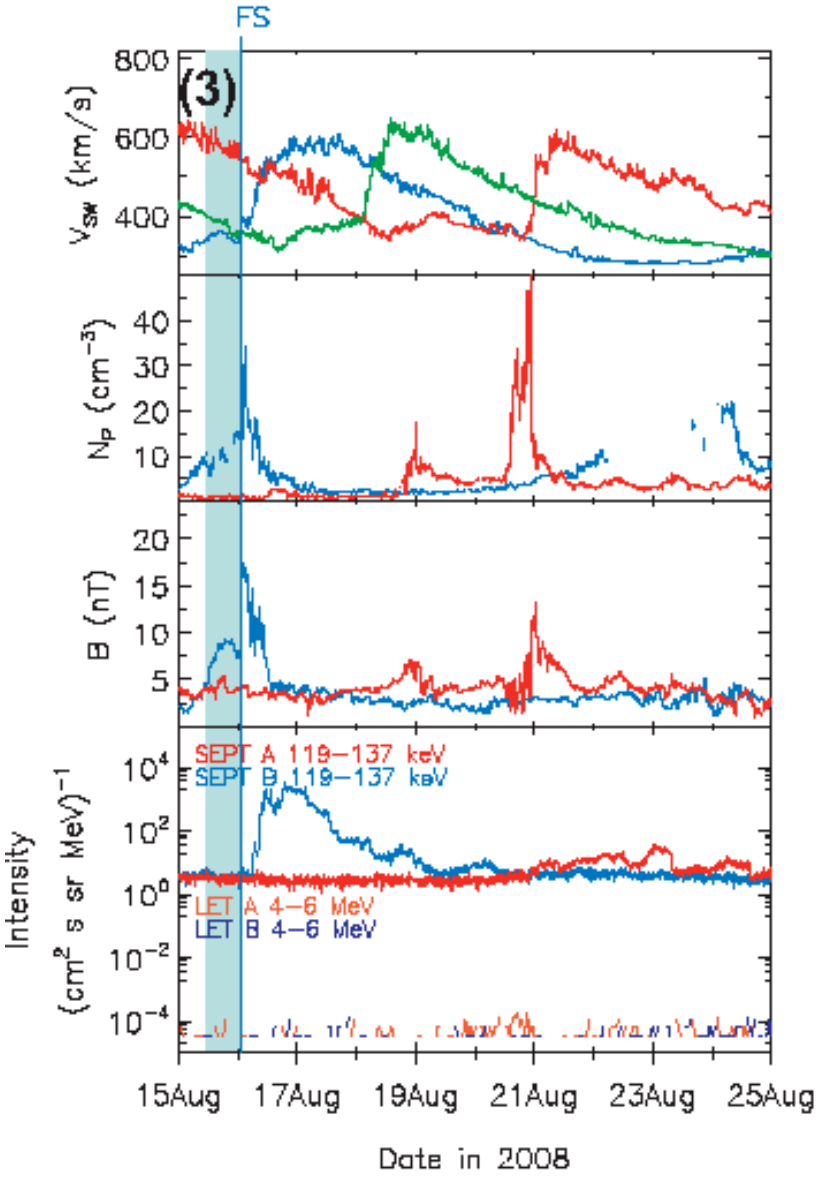
STEREO/SEPT

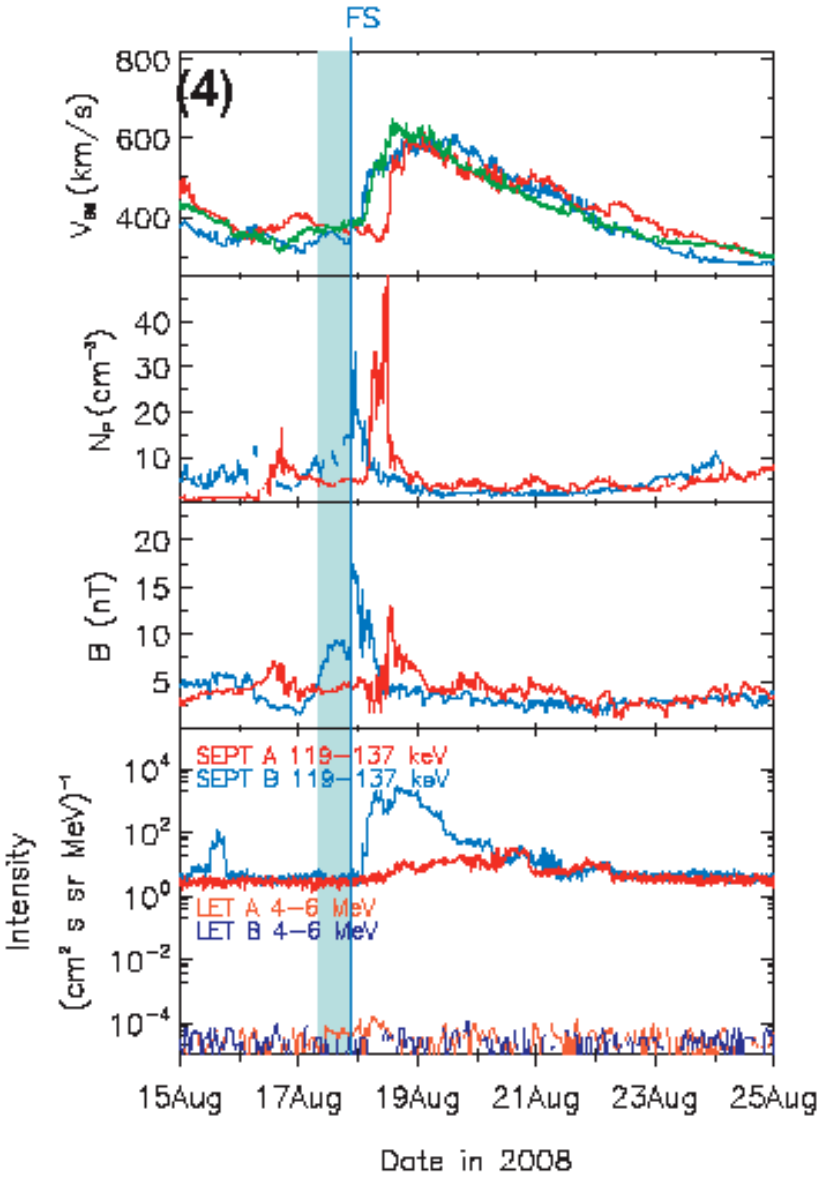
STA

STB

ACE

Aug 2008 CR 2073





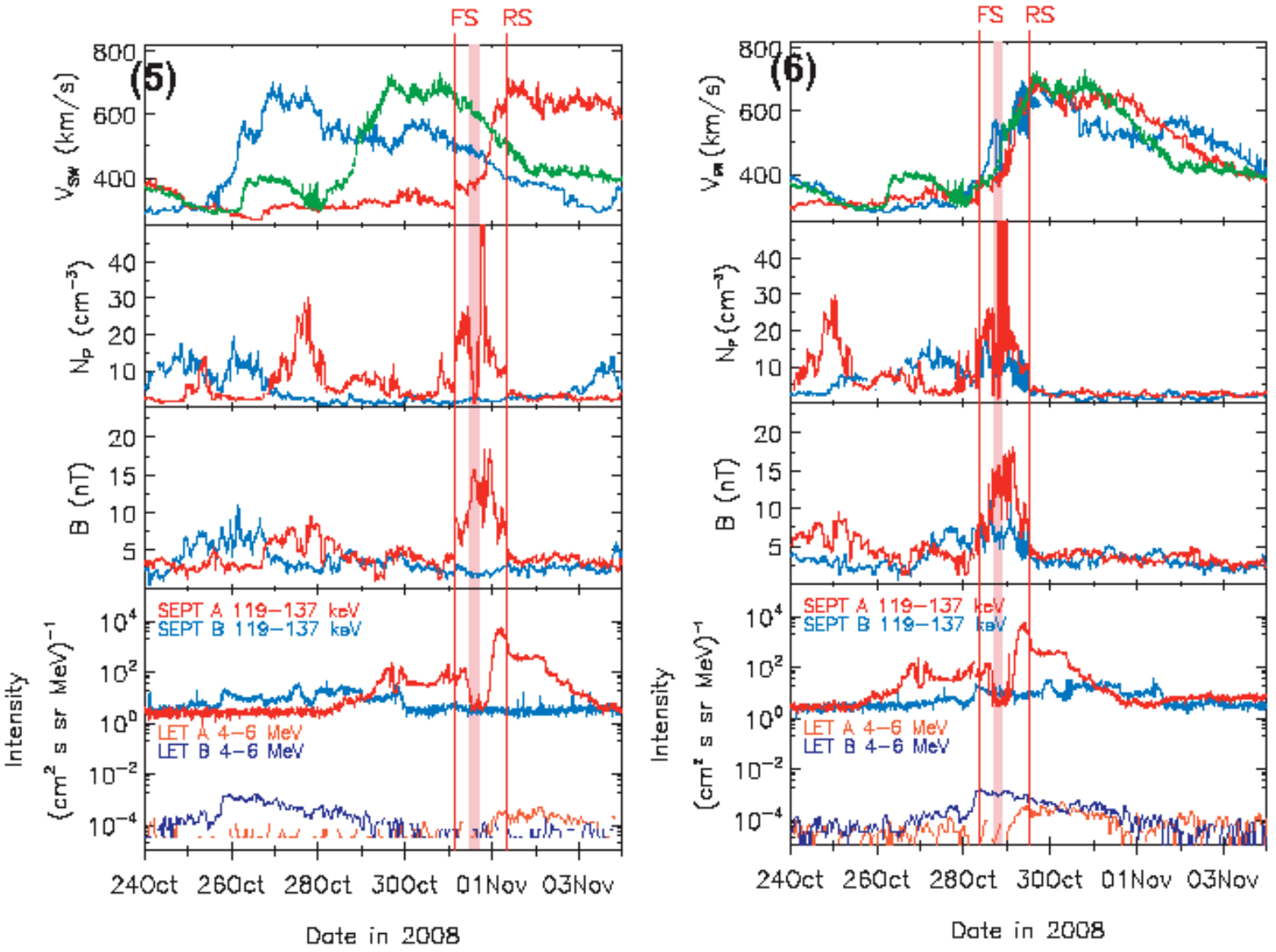
$$t_A - t_B = \frac{\phi_A - \phi_B}{\Omega_s} + \frac{r_A - r_B}{Vsw}$$

STA

STB

ACE

Oct/
Nov
2008
CR
2076

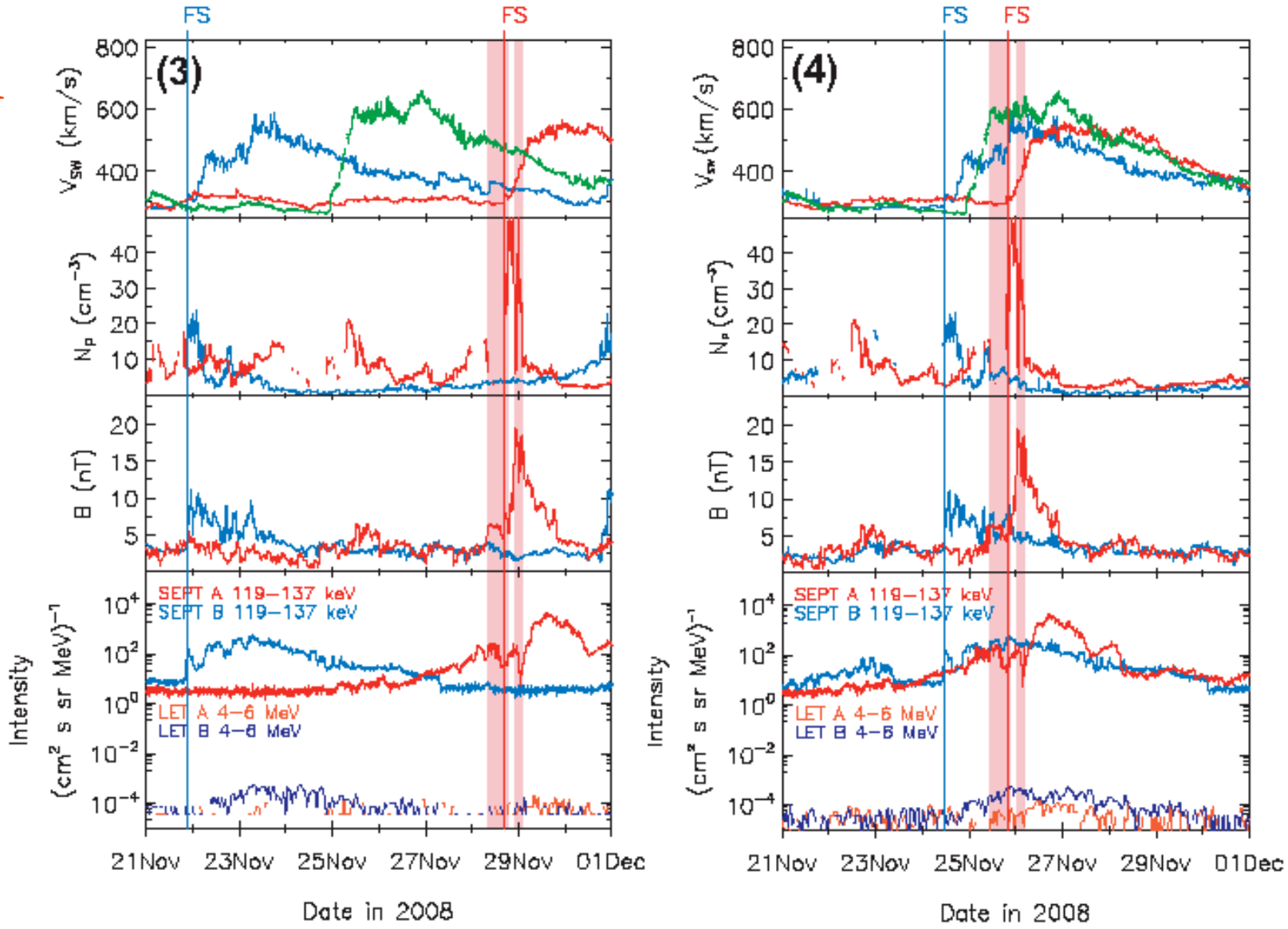


STA

STB

ACE

Nov 2008 CR 2077



ICME-CIR interactions at ~1 AU

- A source of temporal evolution of CIRs: presence of transient structures in the solar wind preceding the high-speed streams.

- Several cases where the presence of an ICME in the vicinity or embedded in the CIR for one s/c is accompanied by enhanced **CIR-ion acceleration** in 100-keV energy.

- During the ICME-CIR events showing enhanced hundred-keV ion acceleration, the several MeV ion fluxes remain unaffected and the higher intensities are normally measured by the outer s/c (STB)

  $\Rightarrow$ MeV protons come mainly from CIR-shocks located beyond the s/c, while at energies of hundred-keV particles are accelerated in the vicinity of the s/c (local phenomena important for the acceleration of ~100 keV ions)