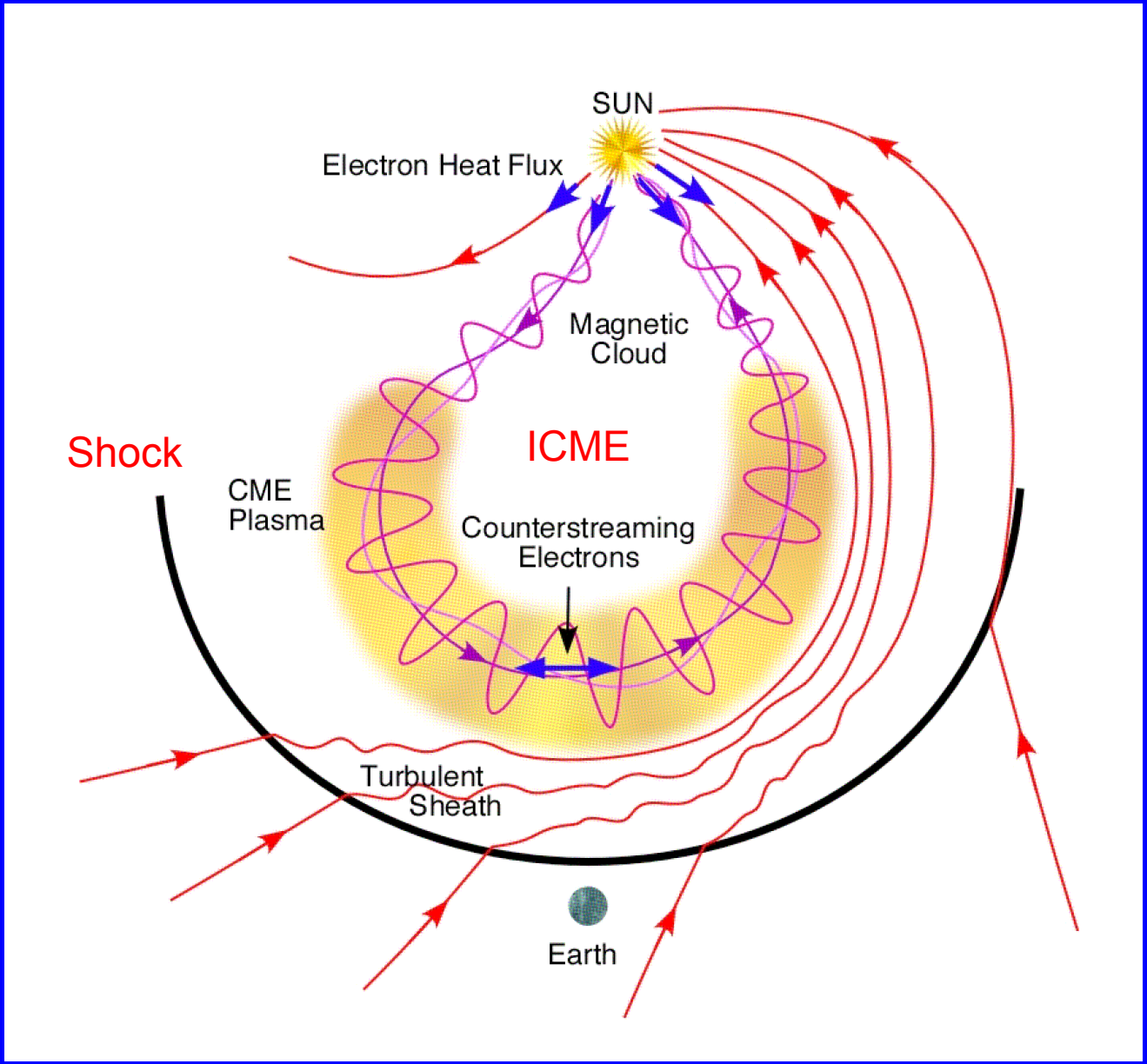
Interplanetary Coronal Mass Ejections During 1996 - 2007

Ian G. Richardson[1] and Hilary V. Cane[2],

Astroparticle Physics Laboratory,
NASA/Goddard Space Flight Center

[1]Also CRESST and Department of Astronomy, University of Maryland, College Park
[2]Also School of Mathematics and Physics, University of Tasmania



Interplanetary coronal mass ejection (ICME) driving an upstream shock.

***Zurbuchen & Richardson*, 2006**

Many signatures of ICMEs

e.g., *Zurbuchen and Richardson* [2006] list 23!

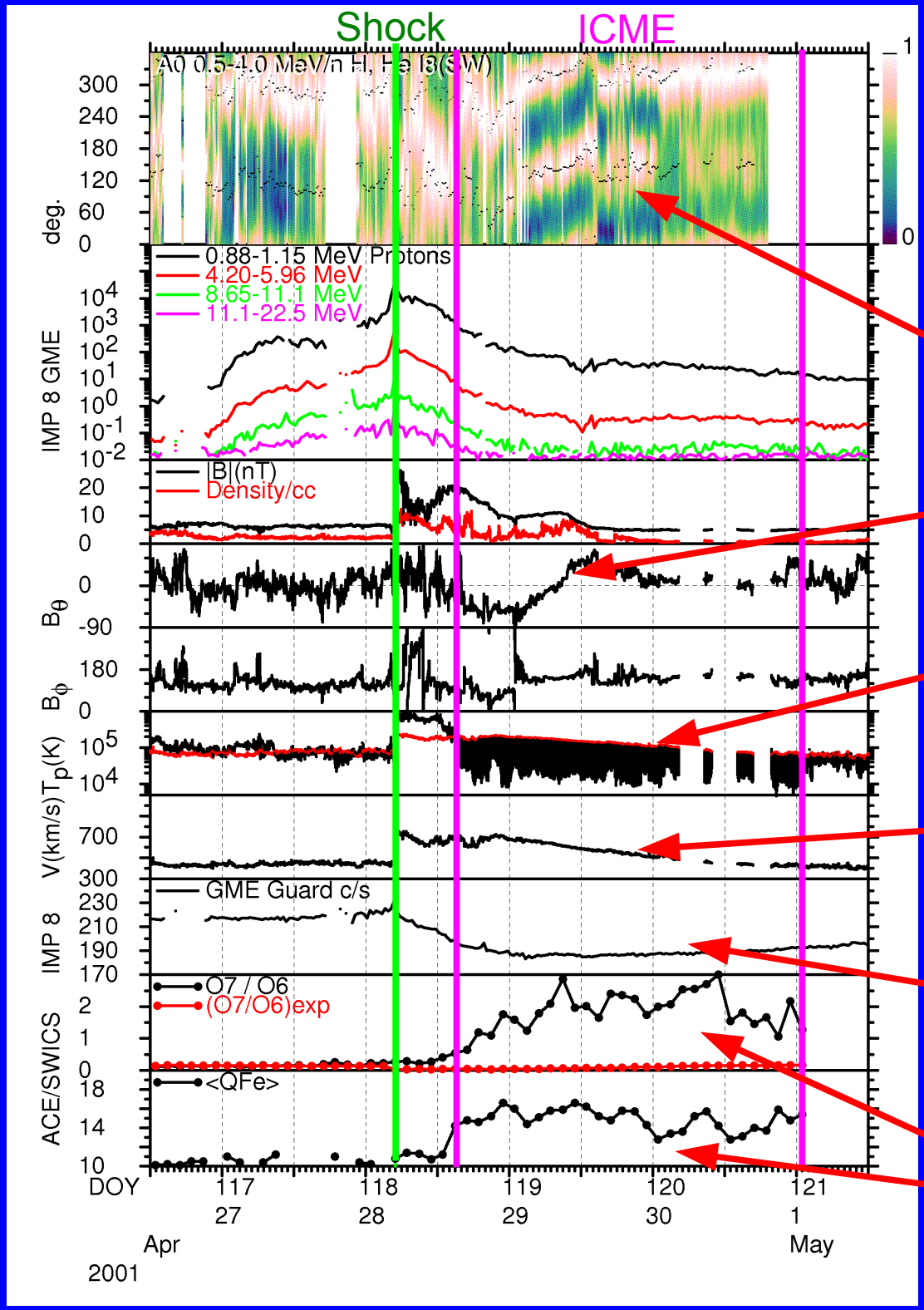
In recent studies, we have compiled a "comprehensive" list of ICMEs at Earth since 1996 based predominantly on anomalous features in solar wind plasma, field and composition measurements.

(Current list is is available on request from the authors.)

- We will:

- Summarize some of the properties of the ~300 ICMEs detected at 1 AU since 1996;

- Apply similar methods to Ulysses observations and obtain a preliminary ICME list (to add to others e.g., by *Reisenfeld and Gosling*, *Lui et al*., etc).



Example of an ICME at 1 AU preceded by a shock

ICME Signatures include:

Bidirectional 0.5-4 MeV ion flows;

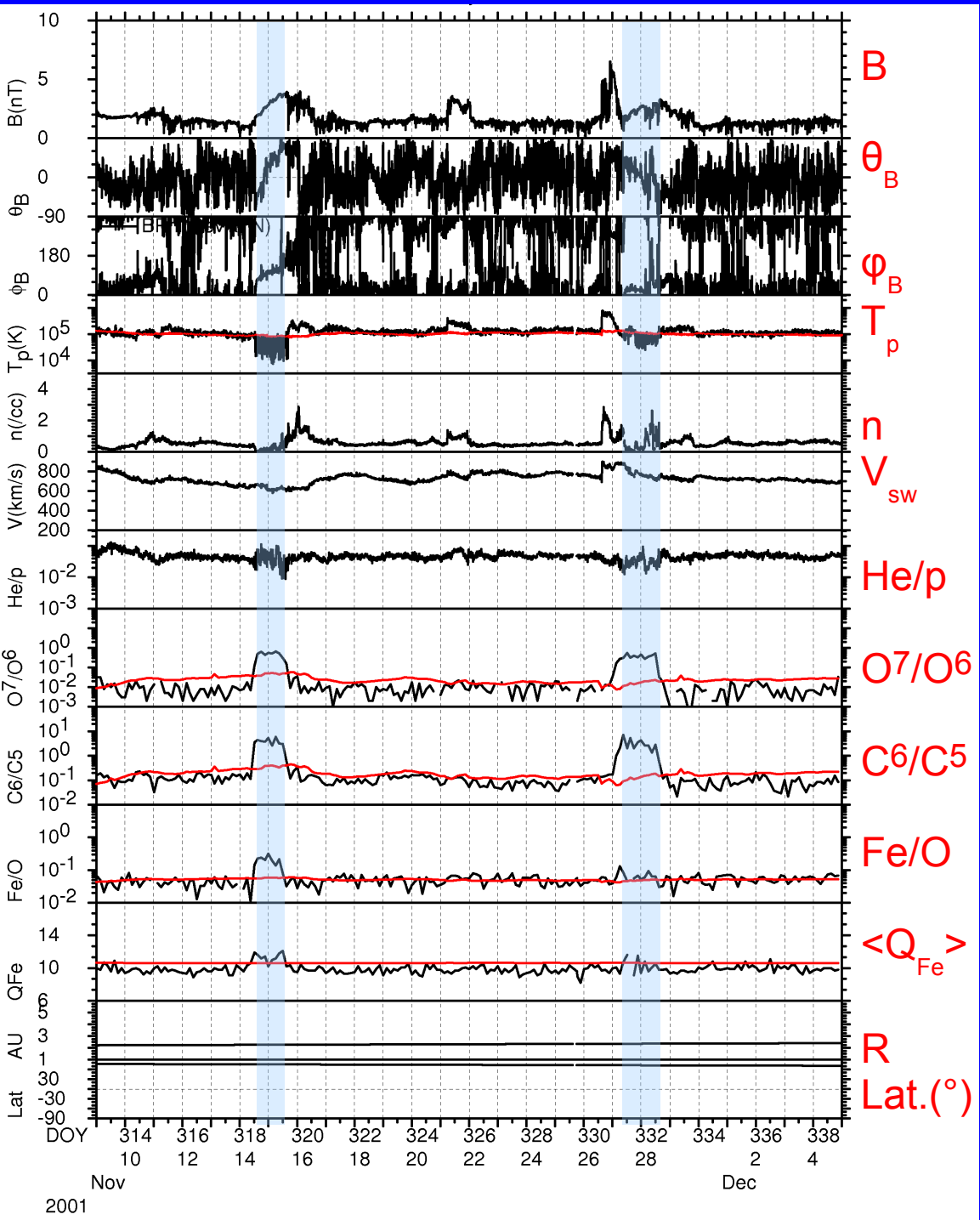
Organized magnetic field;

Low solar wind proton temperatures;

Declining V_{sw} profile;

Cosmic ray Forbush decrease;

Enhanced solar wind ion charge states (e.g., O, Fe)

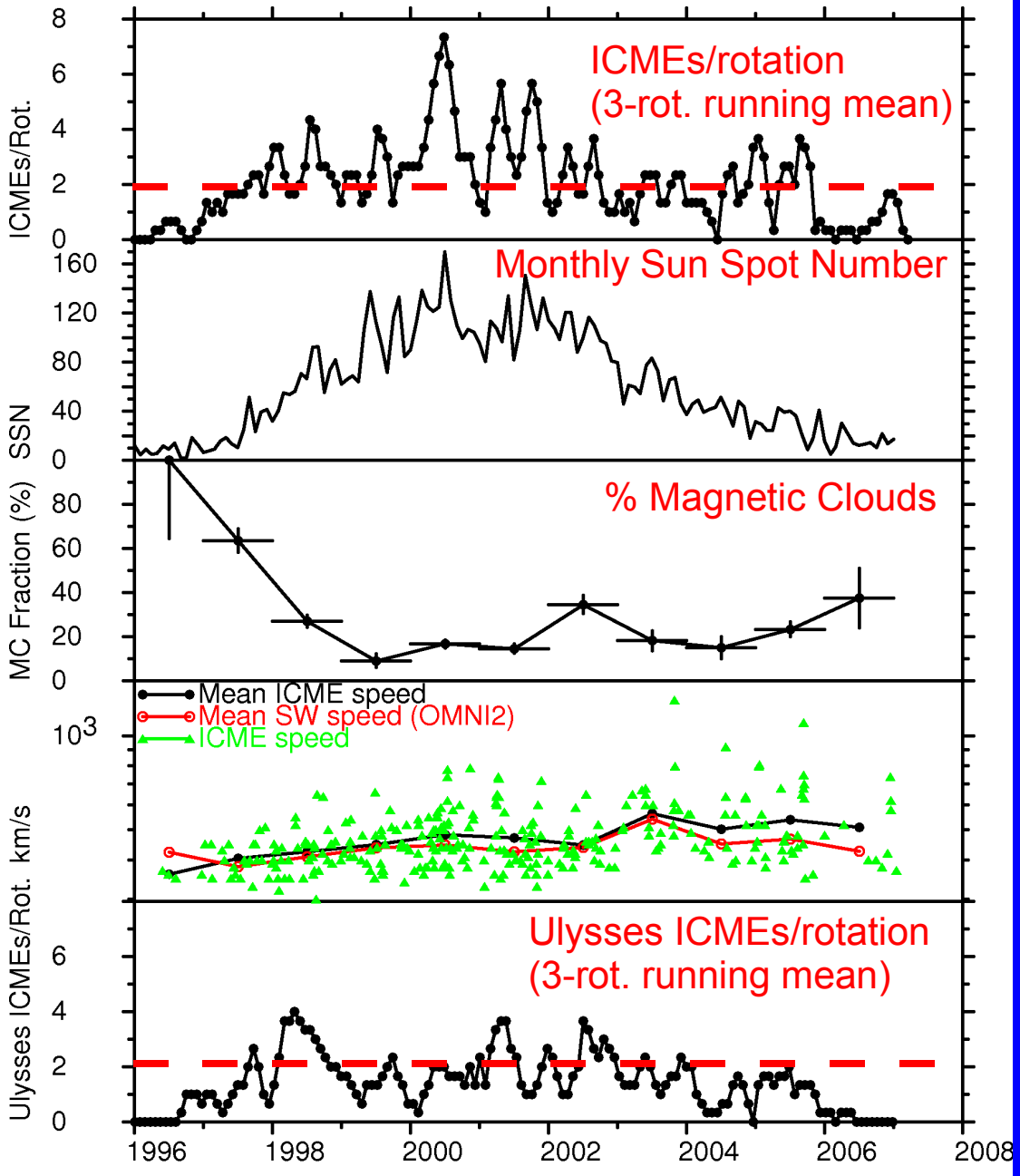


Ulysses: Solar Rotation interval in November-December, 2001 (~2 AU, ~80°N)

Two clear ICMEs in high-speed, high latitude solar wind.

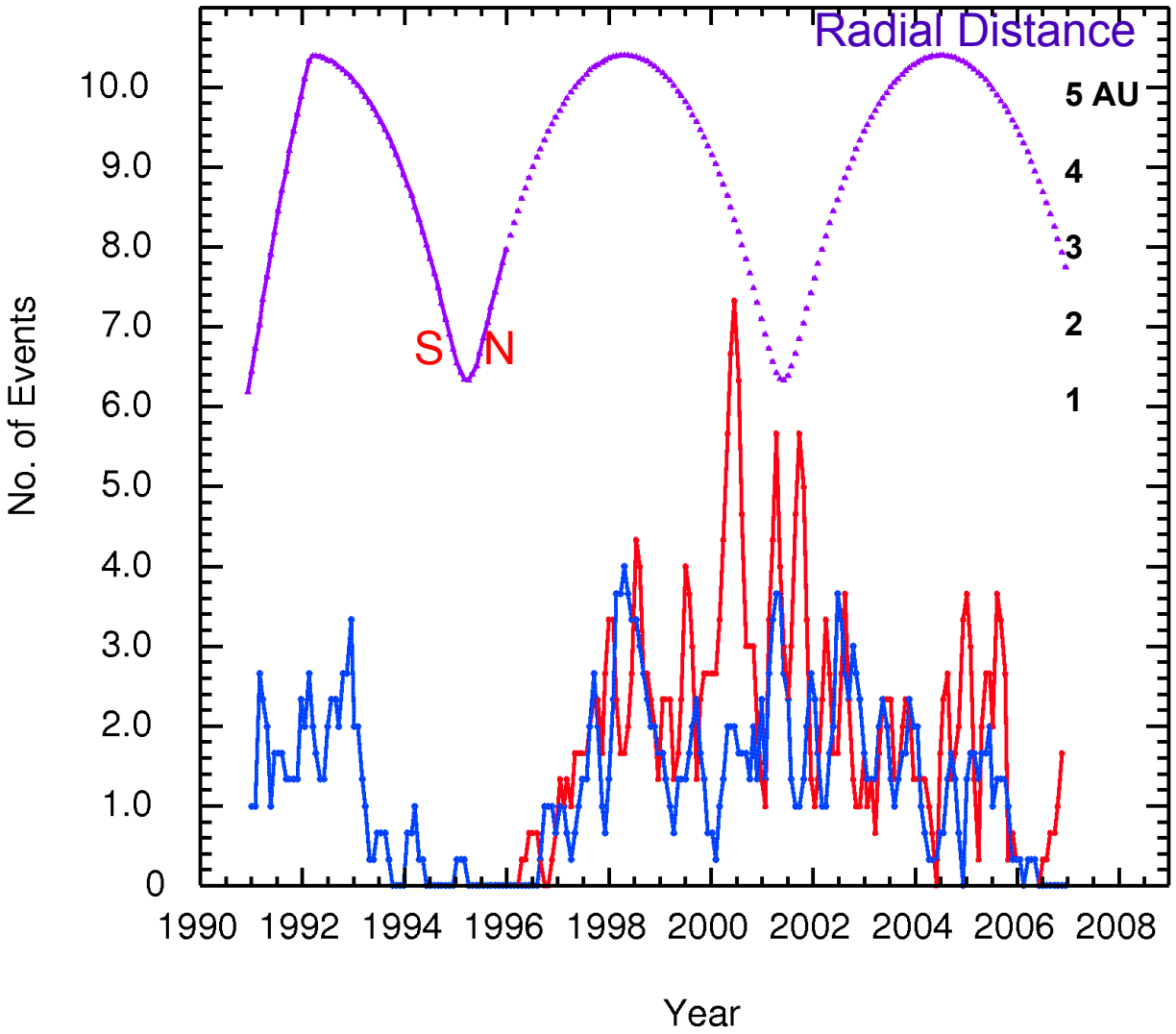
ICME signatures include: magnetic field, low proton temperatures, enhanced O^7/O^6, C^6/C^5, Fe/O, $\langle Q_{Fe} \rangle$.

ICME Properties, 1996-2007



- ICME rate has nearly returned to that during the previous solar minimum;
- ICME rate does not strictly follow the sunspot number;
- Increasing trend in fraction of magnetic clouds?
- Mean ICME speeds are highest during declining phase of this solar cycle.
- ICME rate at Ulysses is comparable to that at Earth (~2/rotation), despite the variations in s/c latitude.

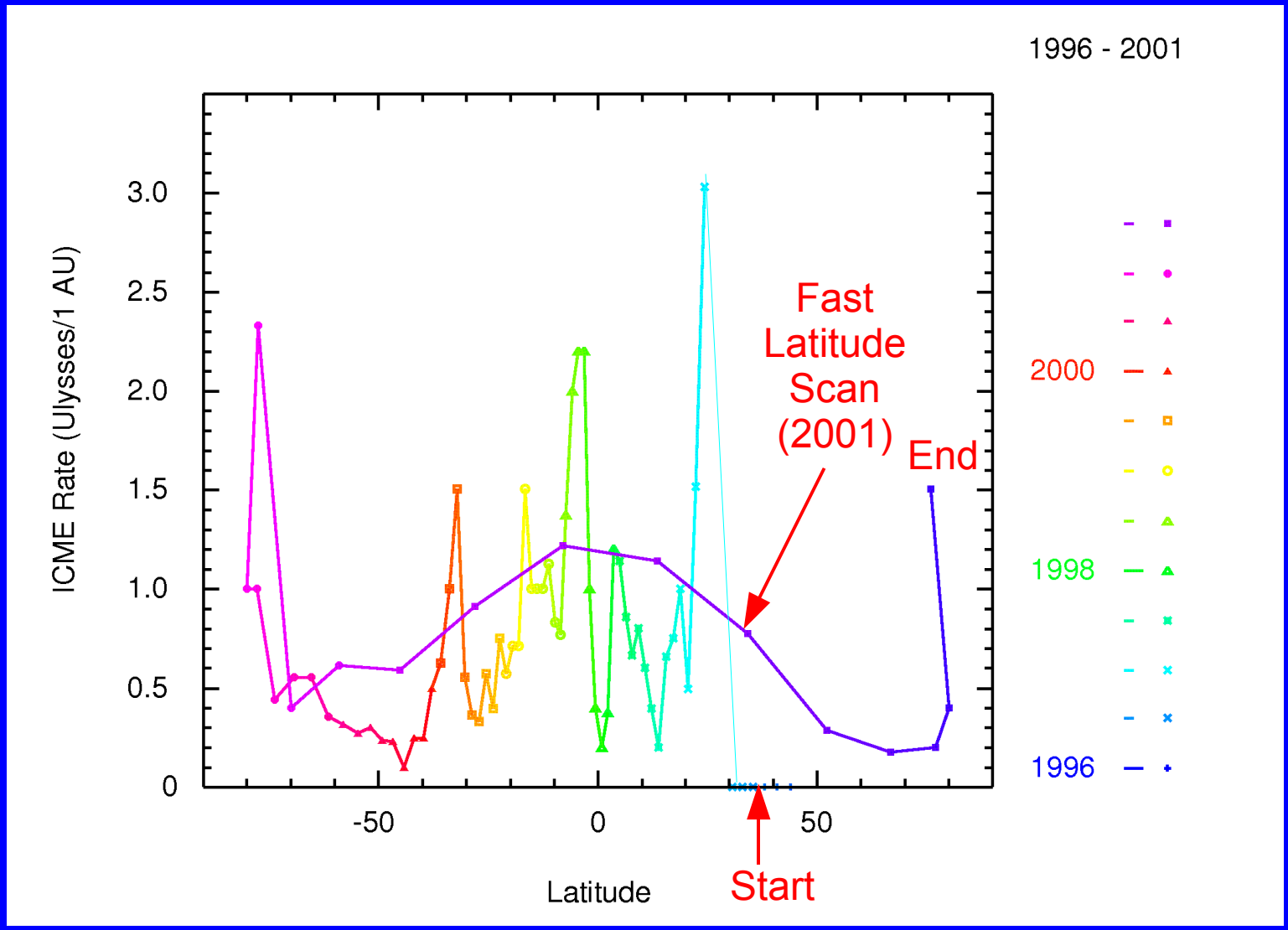
ICME Rates (3-Rotation Running Averages) at Ulysses and Earth



- No of ICMEs (Ulysses)
- No of ICMEs(1 AU)
- R+5AU

Similar rates (~2-3/rotation) at Ulysses and Earth (cf. Riley et al., ApJ, 2006)

Ratio Ulysses/1AU ICME Rates vs. Ulysses Latitude, 1996-2001



Similar rates at low latitudes <~40º

Separate population of high-latitude ICMEs?

(Related to high latitude CMEs at the Sun?)

Summary

- Around 300 ICMEs have been identified in the near-Earth solar wind since 1996;

- ICME rates at 1 AU are approaching those of the last solar minimum, and the fraction of MCs *may* be increasing again;

- Ulysses and 1 AU ICME rates are typically comparable (see also, *Riley et al*. [2006]);

- There is an indication of a high-latitude ICME population unrelated to those at low latitude.