In situ and Ground-based Space Plasma Investigations

Louis J. Lanzerotti, Center for Solar-Terrestrial Research, NJIT, Newark, NJ 07102
ljl@adm.njit.edu; 973-596-5343

Spacecraft Investigations

Ground-based Antarctic Investigations

Editor

NJIT

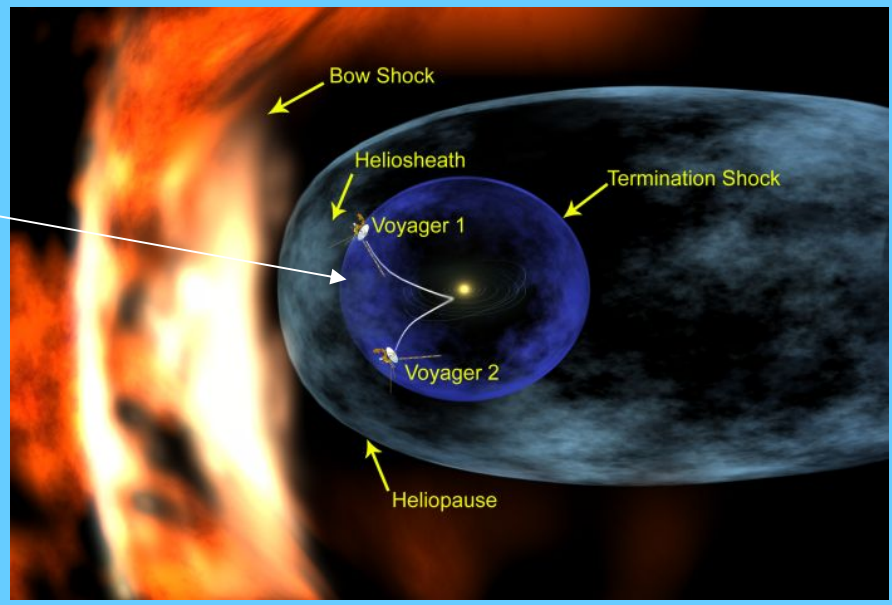
Overview of Talk

- Summary of some instrument/data involvements
- Recent results on studies of low energy ions in the heliosphere: 1 – 5 AU

Spacecraft investigations – Co-I or PI for low energy particle measurements on several spacecraft

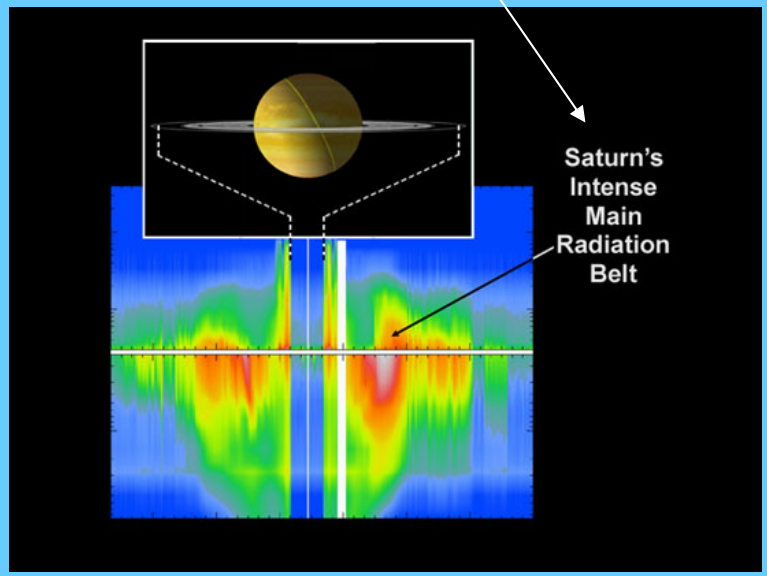
Voyager

Encounter of the heliosphere termination shock(?)



Cassini

Studies of Saturn's magnetosphere



Ulysses

Interplanetary Studies over the solar poles (2 AU) and to aphelion at 5 AU

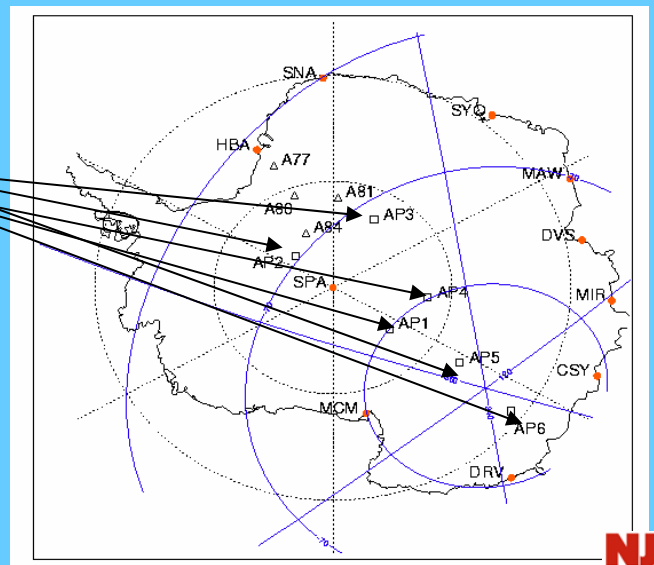
ACE spacecraft

1 AU in ecliptic upstream from Earth
Particle instrument is Ulysses backup instrument

Ground-based measurements in the Antarctic – Studies of the ionosphere and space

Instrumentation at South Pole and McMurdo Stations

And at six remote automatic observatories

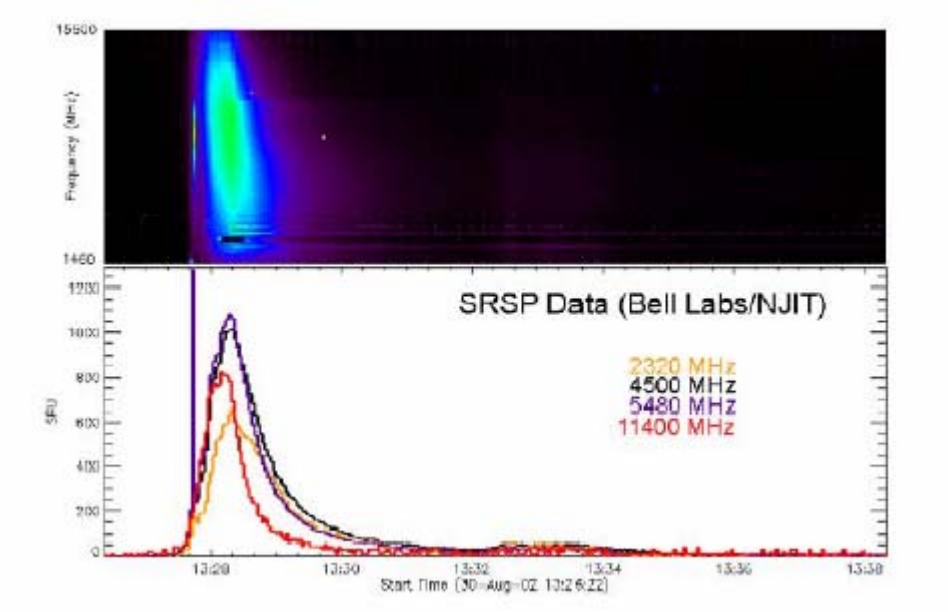


Magnetometers
Riometers
VLF
All-sky cameras

NJIT, Maryland, Stanford, Siena, UCB

NJIT

Solar Radio Telescope in New Jersey (Professor Dale Gary, NJIT)



Solar radio burst event
30 August 2002

Ion Distribution Functions at 1 and 5 AU Following October/November 2003 Solar Events

L. J. Lanzerotti[1,2], C. Denker[1], C. G. Maclennan[2]

1. Center for Solar-Terrestrial Research, New Jersey Institute of Technology, Newark, NJ 07102 USA

ljl@adm.njit.edu; cdenker@njit.edu

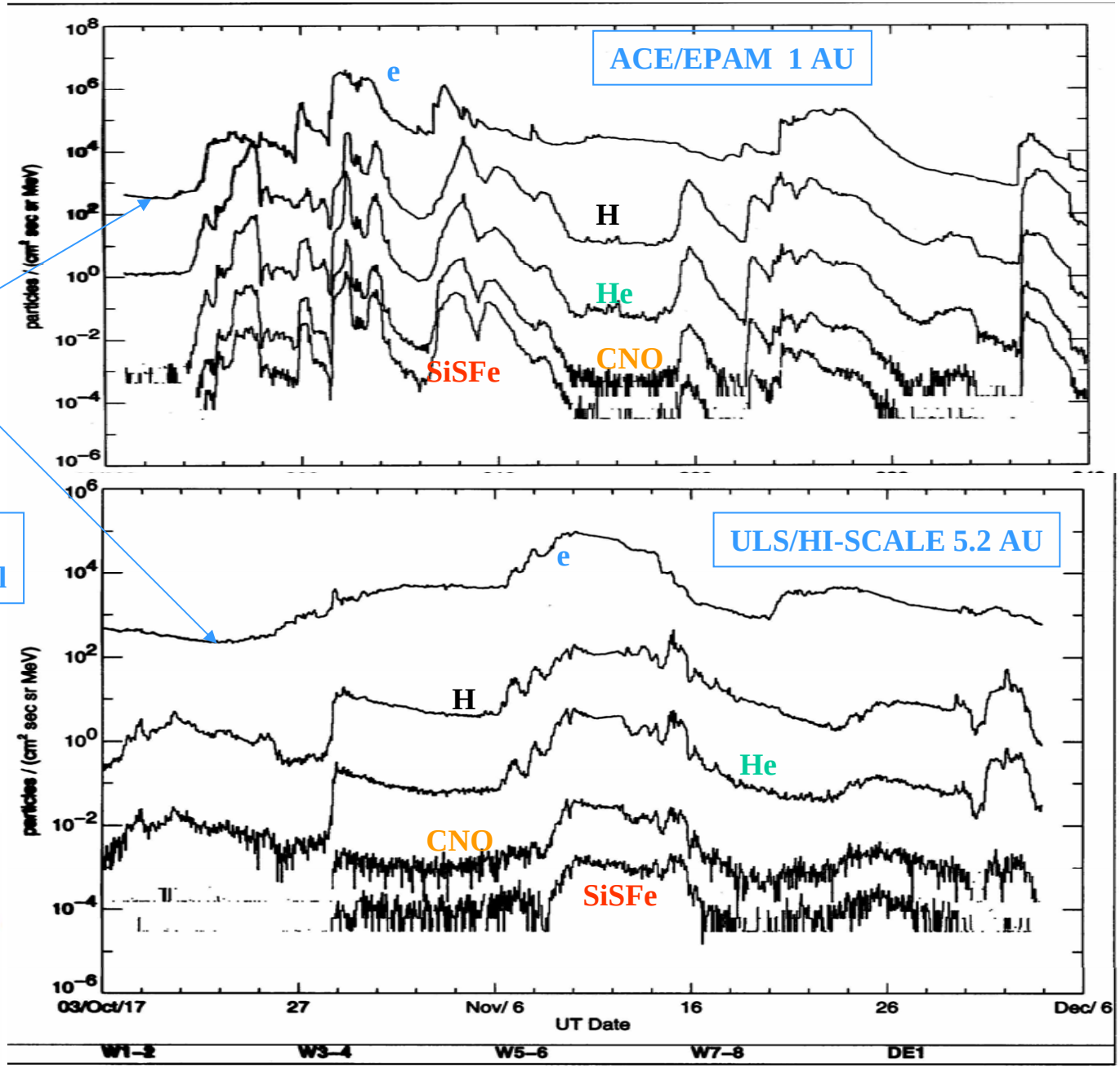
2. Bell Laboratories, Lucent Technologies, Murray Hill, NJ 07974 USA.

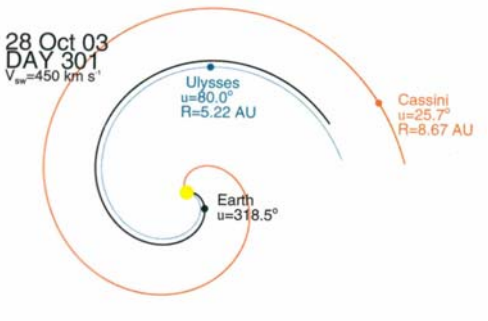
ljl@lucent.com; cgm@lucent.com

October-November 2003 Events

~ 50 keV electrons

H, He, CNO, SiSFe
Ions ~ 0.5 – 10 MeV/nucl





NJIT

ION DISTRIBUTION FUNCTIONS:

Gloeckler et al., *ApJ*, **230**, L191, 1979:

Their study of co-rotating interaction region (CIR) related acceleration at **1AU** (ecliptic plane) concluded that:

"[a] **statistical mechanism [is the] dominate accelerating process…in CIR"**

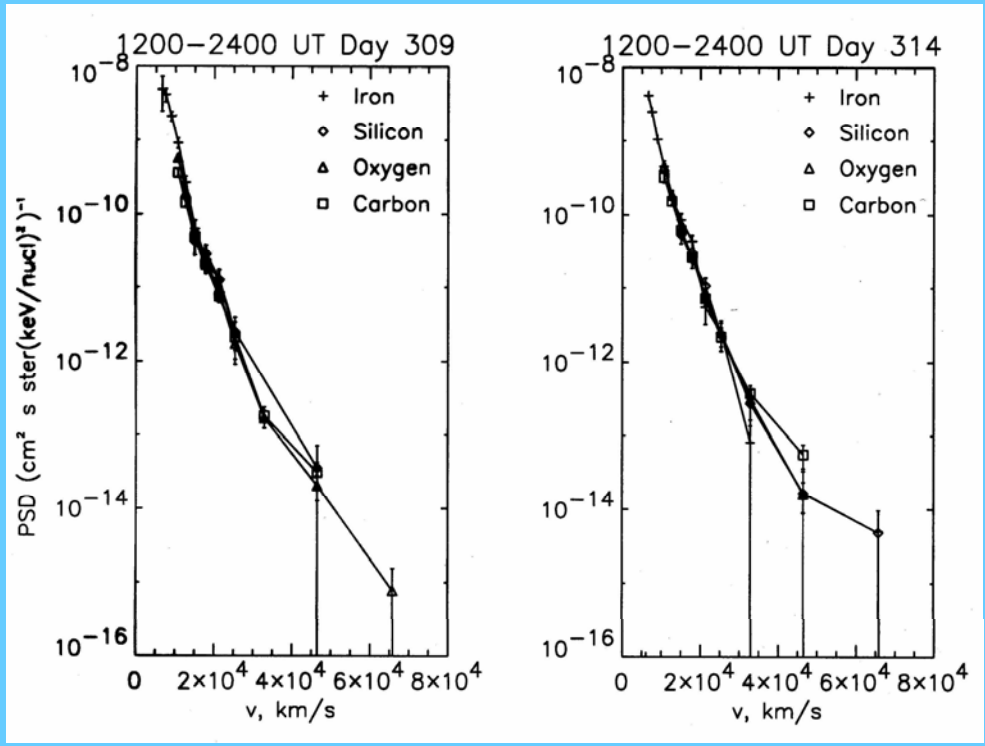
From this, Gloecker et al. concluded that:

particle diffusion in momentum space implies a power law in velocity space

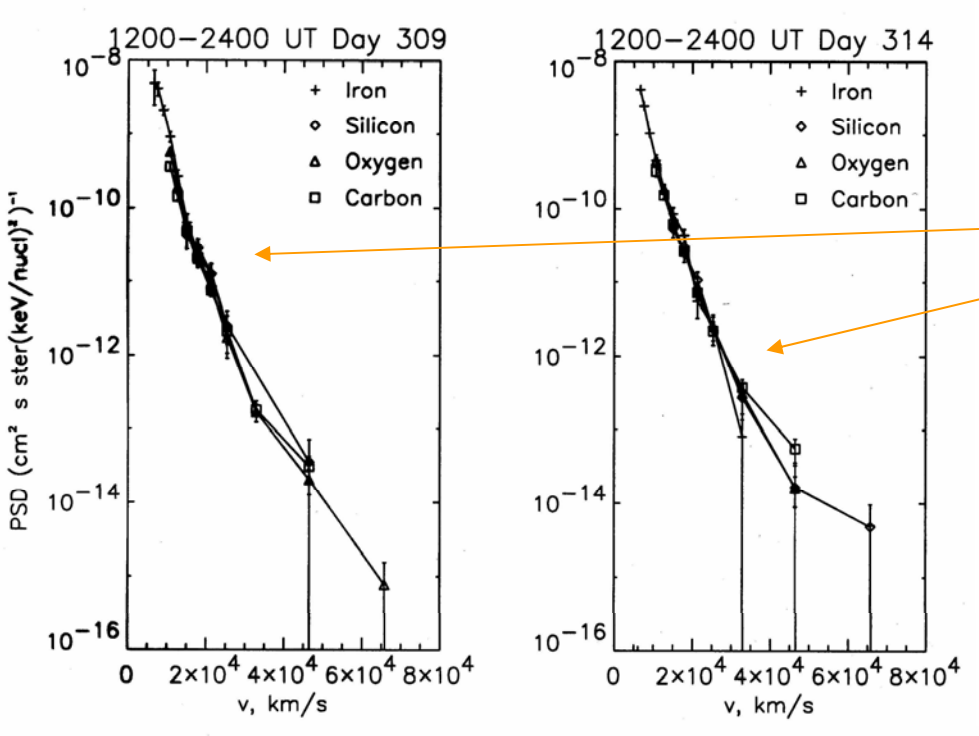
1992: ULYSSES at ~5 AU, ~ 19°S

Distribution functions examined for ions during CIR acceleration

(Lanzerotti and Maclennan, *The High Latitude Heliosphere*,
Ed. R. G. Marsden, Kluwer, 335, 1995)



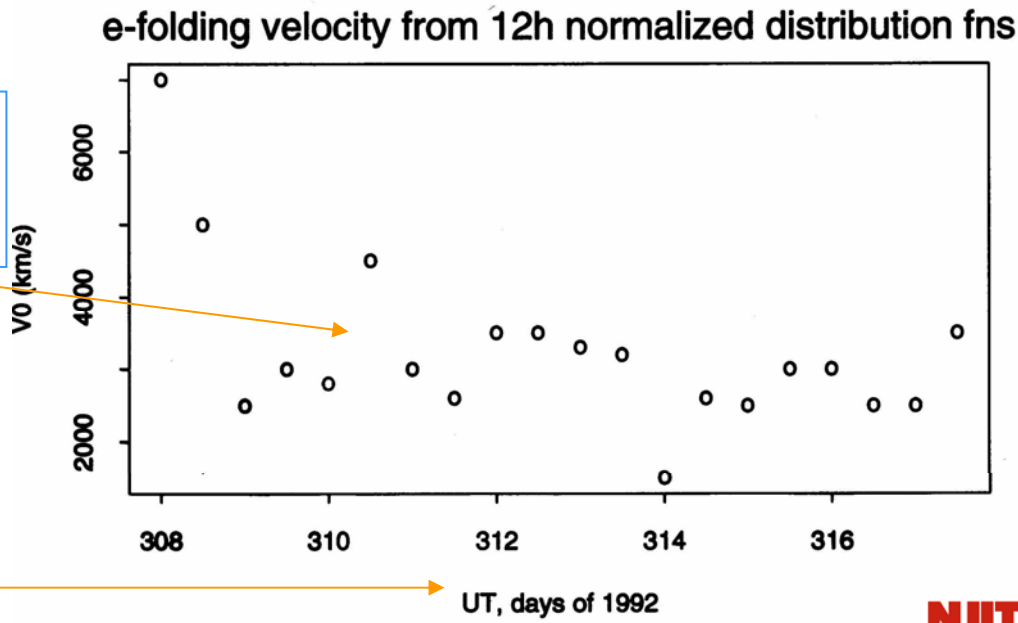
1992: ULYSSES at ~5 AU, ~ 19°S



Ion distributions at 5 AU during CIR events, 1992

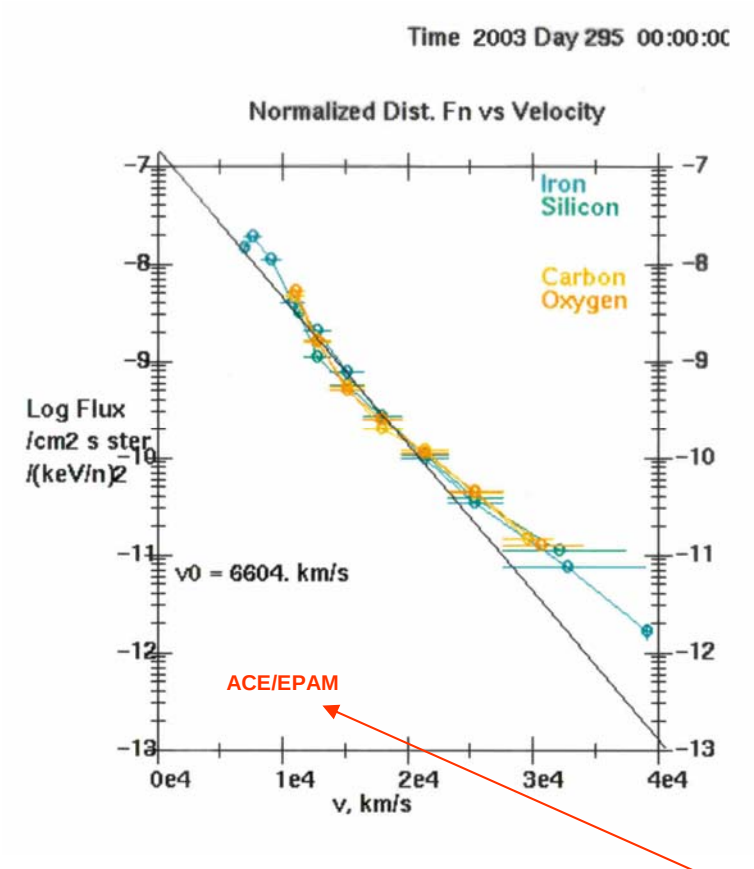
PSD α $e^{-v/vo}$ (at lower velocities)

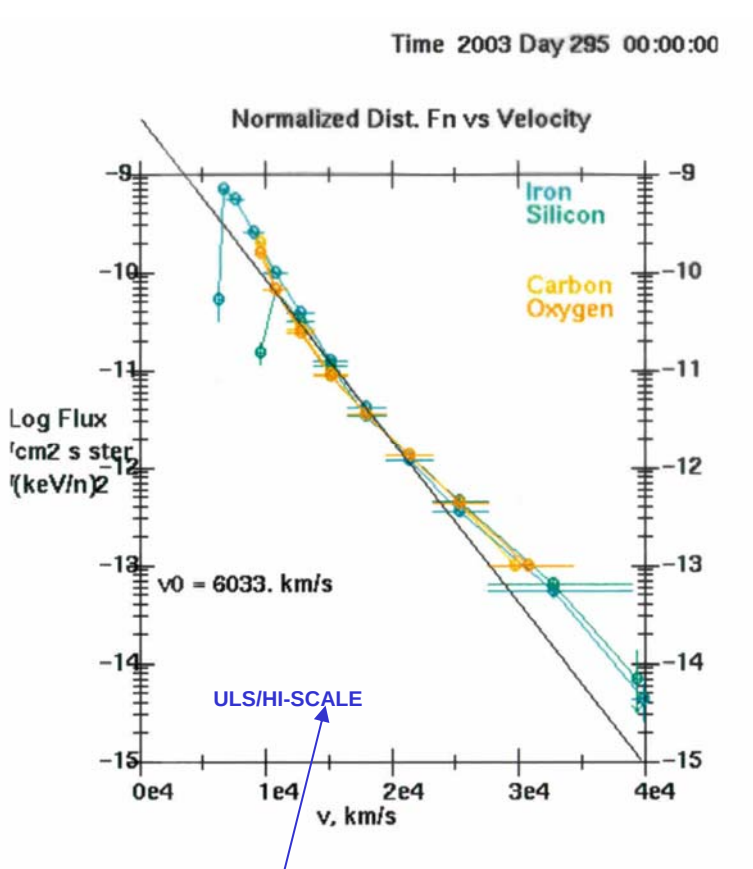
ULS (5 AU) CIR-related v_o ~ same as found by Gloeckler et al. (1 AU)



Entire CIR interval

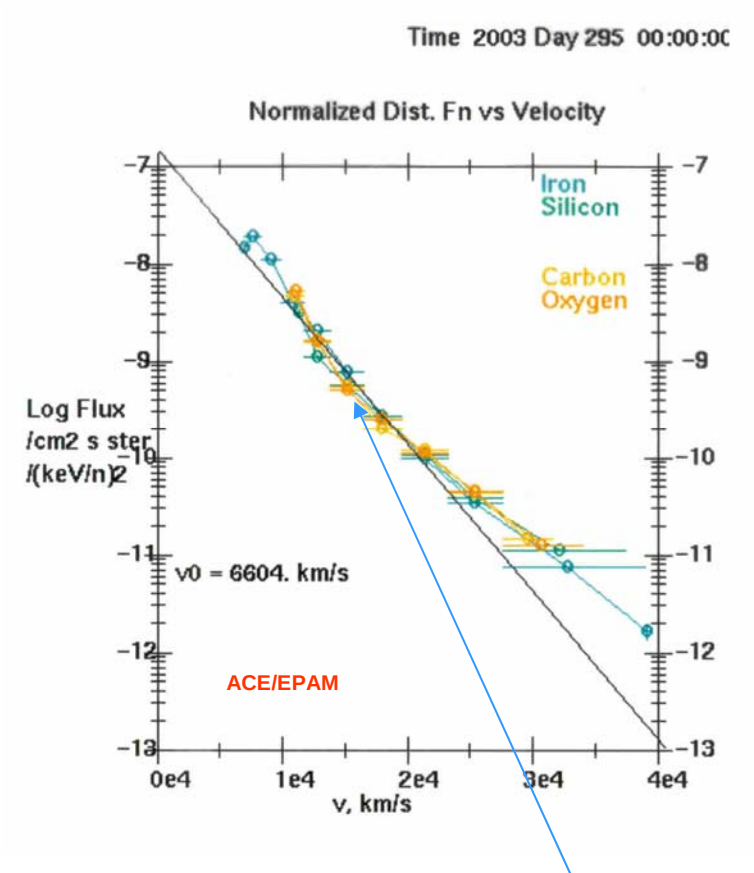
October-November 2003 events: traveling shocks: 1 AU and 5 AU

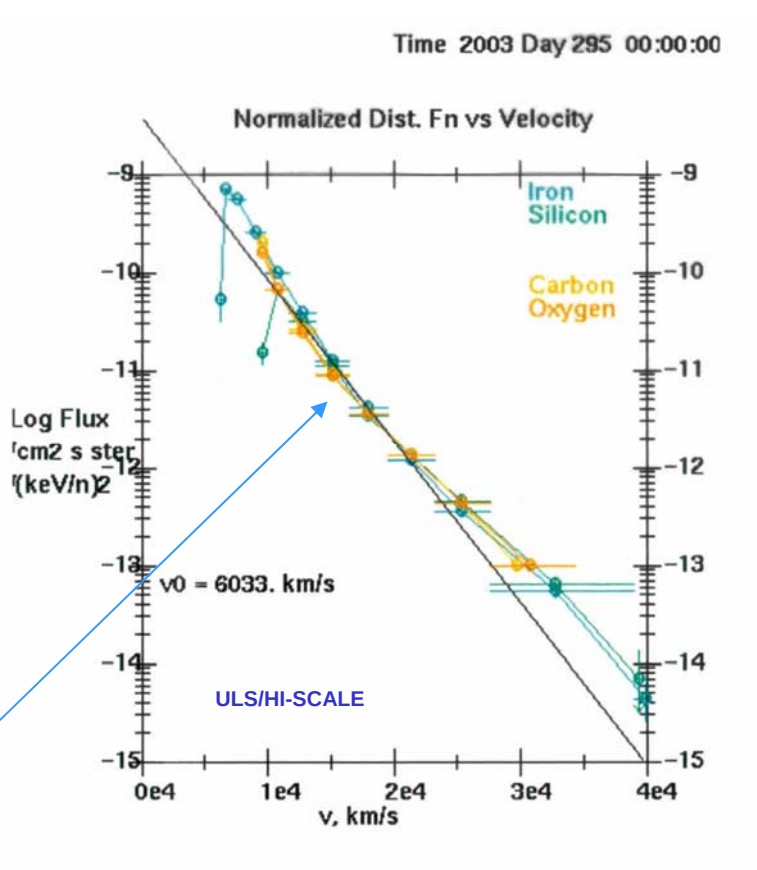




Entire time interval Day 295-315, 2003. 1 AU. 5 AU.
V_o ~ same, both locations

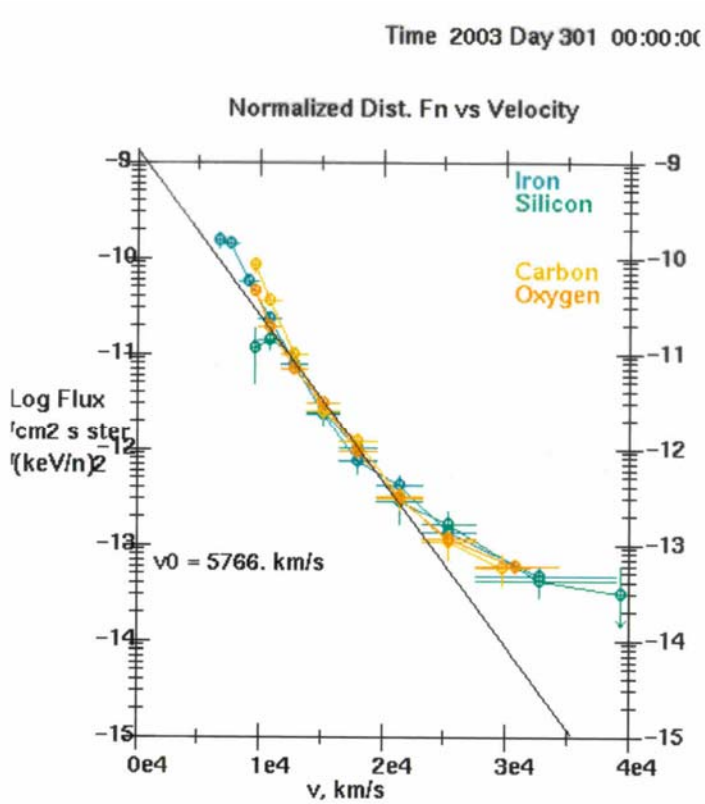
October-November 2003 events: traveling shocks: 1 AU and 5 AU

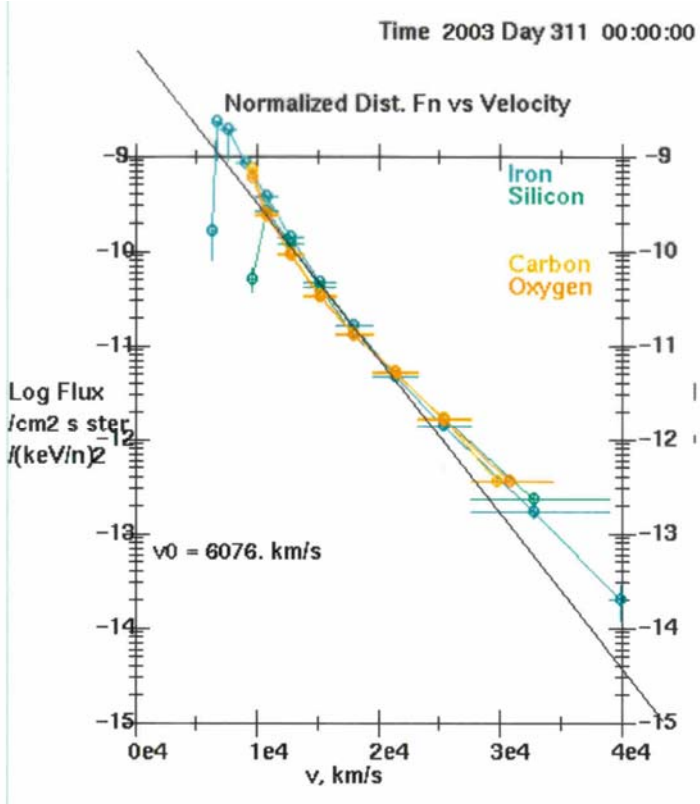




Linear fit to velocity range 1 – 2.5 × 10^4 km/s (capture more 'local' acceleration)

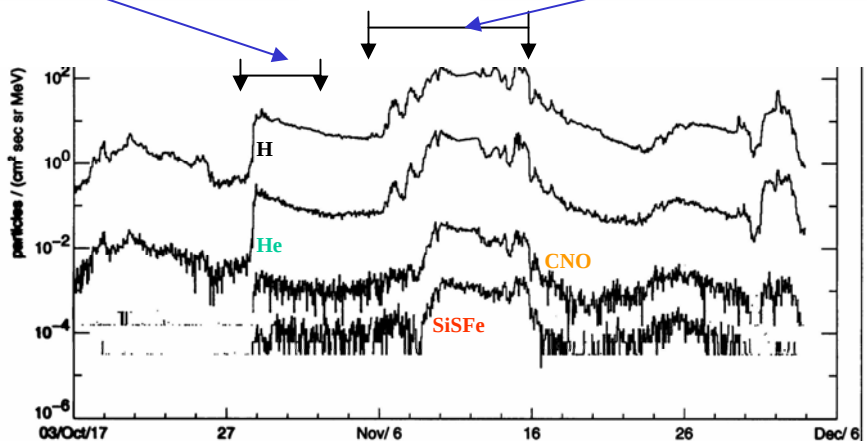
ULYSSES/HI-SCALE, 5 AU: October-November Events





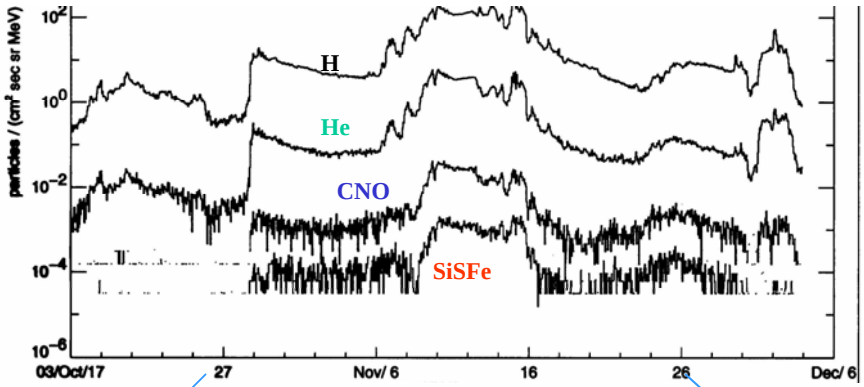
Days 301-307, 2003

Days 311-320, 2003

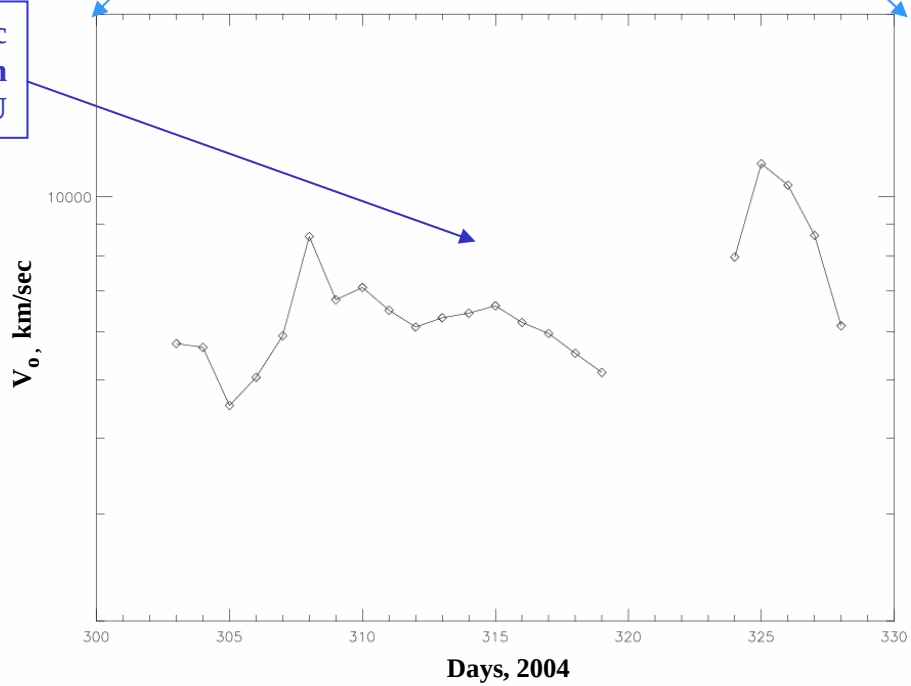


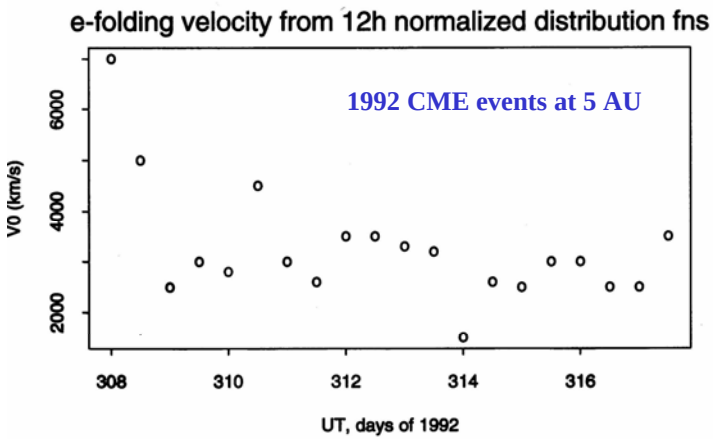
October-November 2003 events

Ulysses Ion Fluxes



Daily values of characteristic velocities from normalized ion distribution functions at 5 AU





Normalized Ion Distribution Functions: Results – Findings

- Characterize normalized ion distribution functions as $\alpha\, e^{-v/v_o}$
- Fits to distribution functions over range $1 - 2.5 \times 10^4$ km/s (to capture more 'local' acceleration)
- Find v_o order 2000 to 3500 km/s in CIR environments at 1 AU (Gloeckler et al., 1979); at 5.2 AU and ~20°S heliolatitude (Lanzerotti and Maclennan, 1995)
- Following intense solar activity and CMEs (October-November 2003 events):
  1 AU: $v_o \sim 6000$km/s
  5.2 AU, ~ 0° heliolatitude: $v_o \sim 6000$ km/s

Normalized Ion Distribution Functions: Results – Findings

- Characterize normalized ion distribution functions as $\alpha\ e^{-v/v_o}$
- Fits to distribution functions over range $1 - 2.5 \times 10^4$ km/s (to capture more 'local' acceleration)
- Find v_o order 2000 to 3500 km/s in CIR environments at 1 AU (Gloeckler et al., 1979); at 5.2 AU and ~20°S heliolatitude (Lanzerotti and Maclennan, 1995)
- Following intense solar activity and CMEs (October-November 2003 events):
  1 AU: $v_o \sim 6000$km/s
  5.2 AU, ~ 0° heliolatitude: $v_o \sim 6000$ km/s

- Flux difference between 1 and 5 AU order factor 70
- v_o following CIRs order 1/2 v_o following solar activity and CMEs in heliosphere between 1 and 5 AU
- Implies relatively fewer particles accelerated to higher energies in activity/CMEs compared to CIRs
- No strong evidence for interplanetary acceleration between 1 and 5 AU