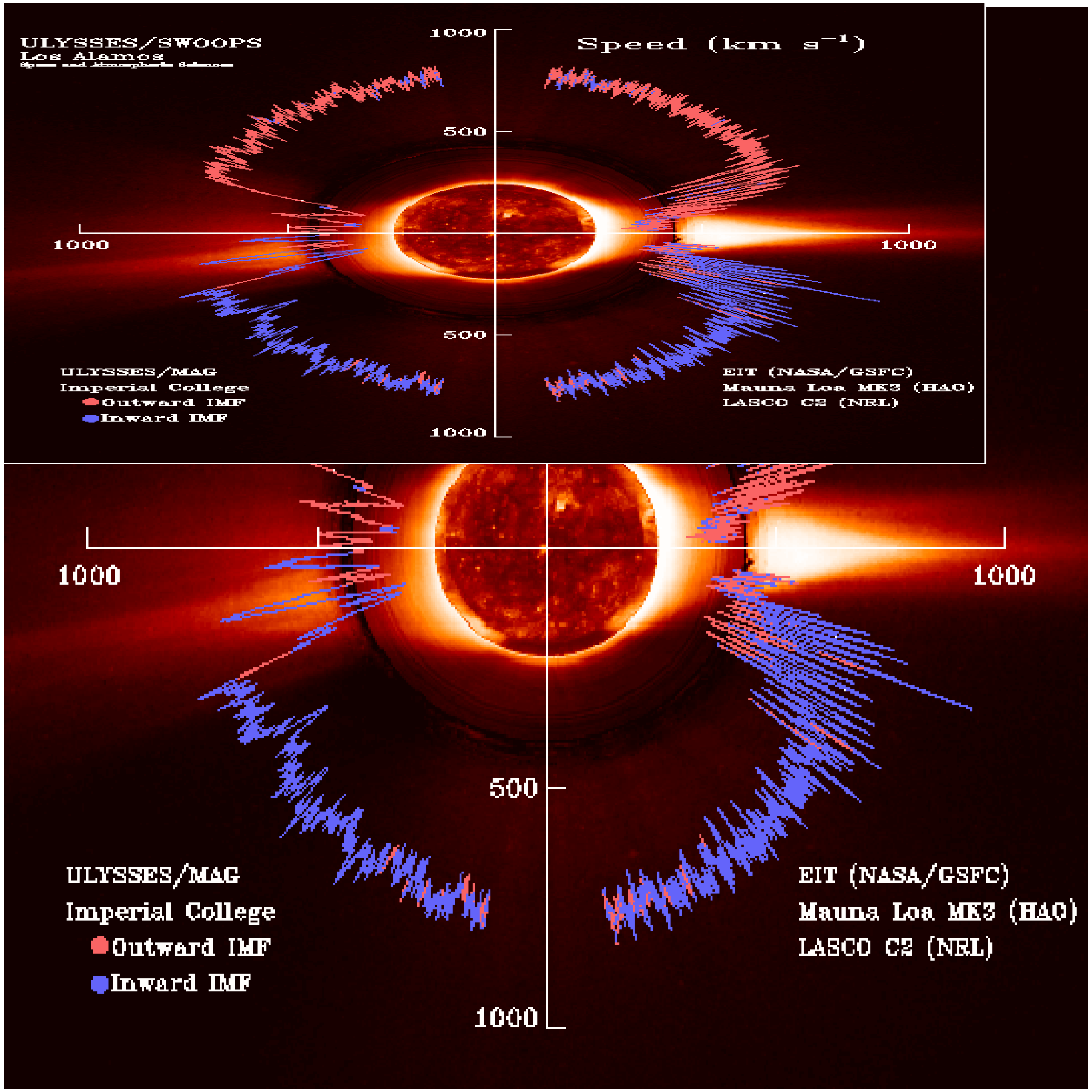
Solar-C Plan-A for the Study of the Acceleration of the Solar Wind

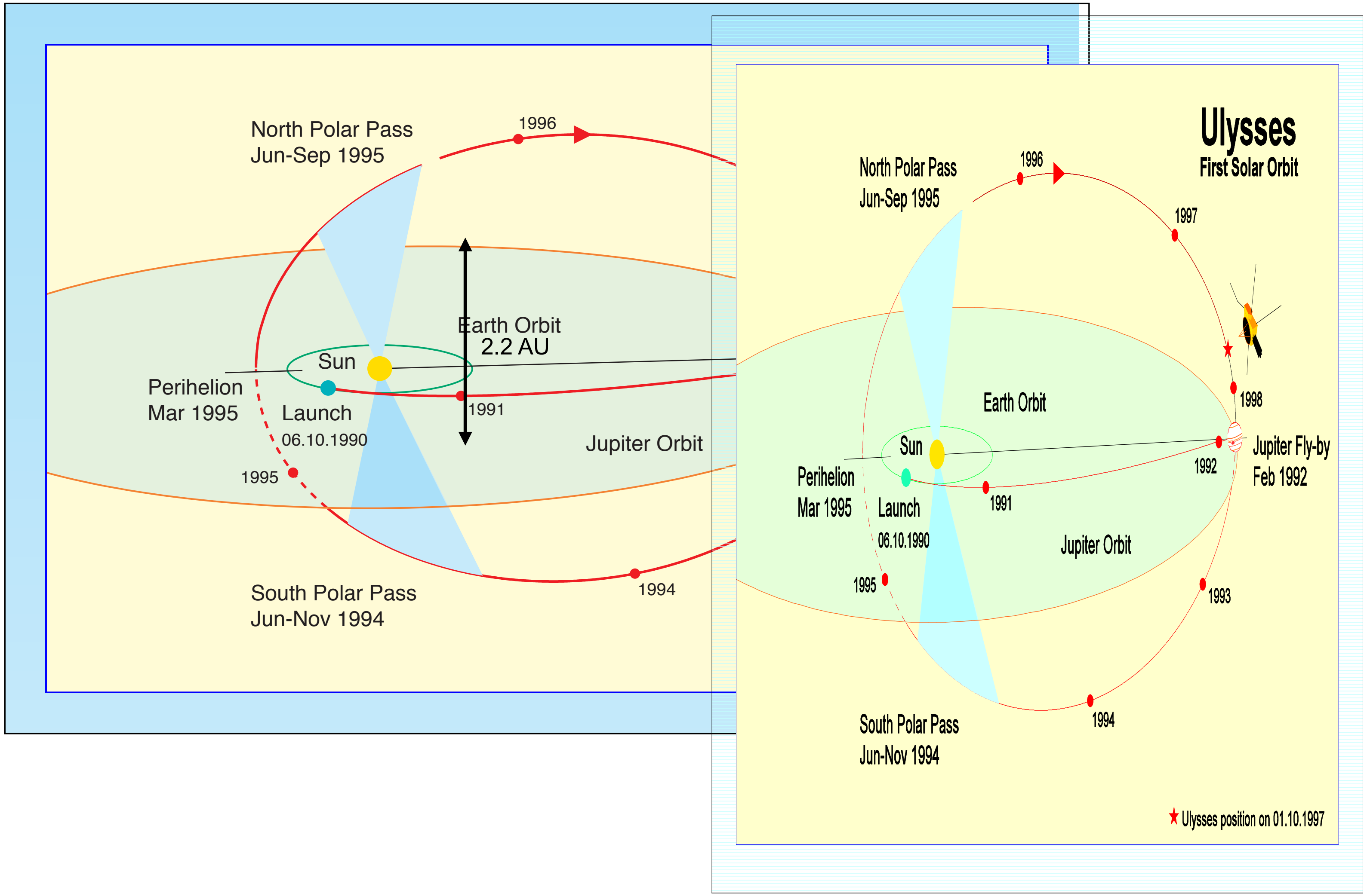
Takashi Sakurai (NAOJ)

acceleration of the solar wind

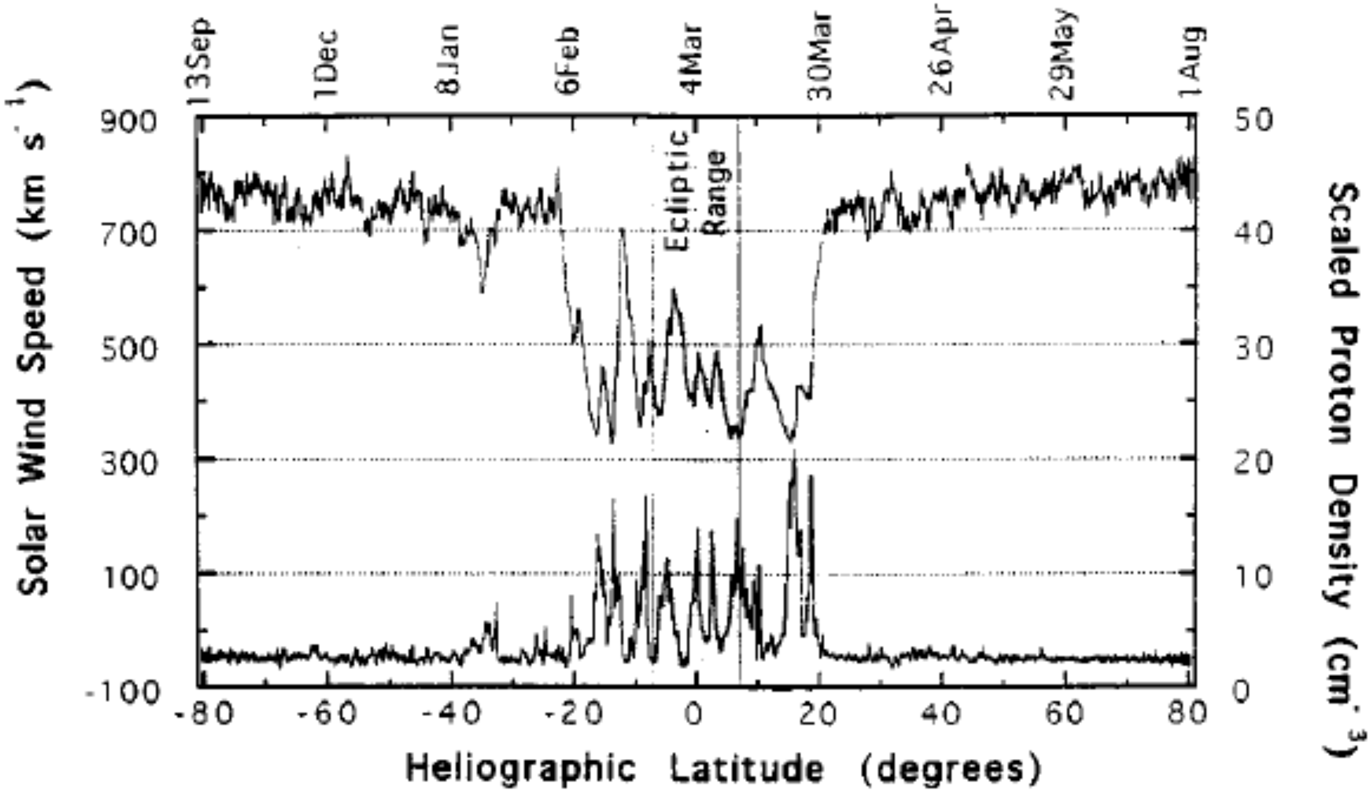
- reconnection (jets)
  - imaging of polar regions + B plus in-situ measurements
- low-frequency (MHD) waves
  - spectroscopy of polar regions (+B) plus in-situ measurements
- high-frequency waves with plasma-kinetic effects
  - in-situ measurements and ??

http://swoops.lanl.gov/index.html




North Polar Pass
Jun-Sep 1995
1996
Earth Orbit
2.2 AU
Sun
Perihelion
Mar 1995
Launch
06.10.1990
1991
Jupiter Orbit
1995
South Polar Pass
Jun-Nov 1994
1994
Ulysses
First Solar Orbit
North Polar Pass
Jun-Sep 1995
1996
1997
1998
Earth Orbit
Sun
Jupiter Fly-by
Feb 1992
1992
Perihelion
Mar 1995
Launch
06.10.1990
1991
Jupiter Orbit
1995
1993
South Polar Pass
Jun-Nov 1994
1994
Ulysses position on 01.10.1997

(Feldman et al. 1996)

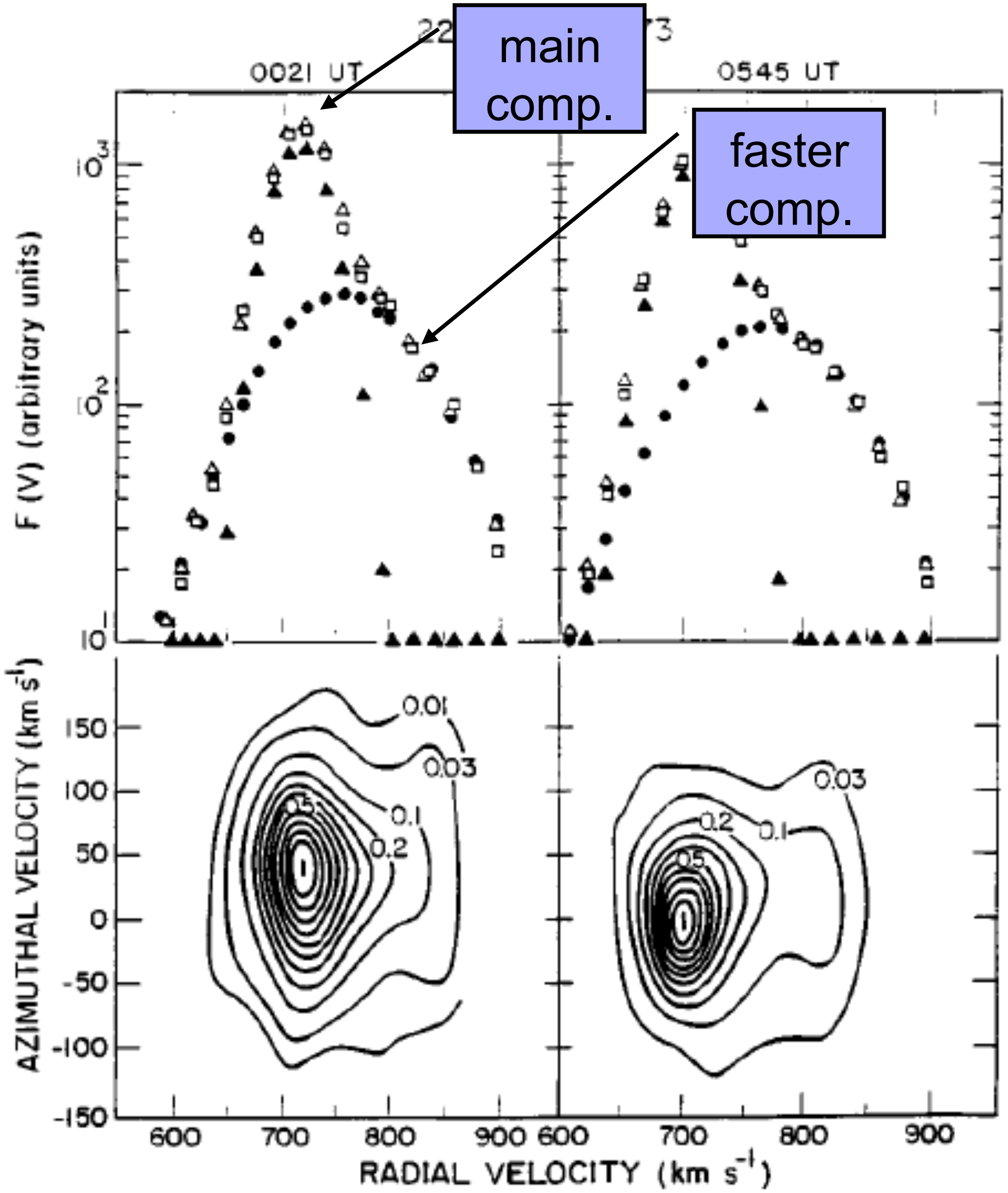


- fast wind: smooth, stable
  - superposition of many events if driven by jets
- slow wind: variable

proton distribution function in fast wind

- often non-Maxwellian (two-component)
- remnant of reconnection jet?

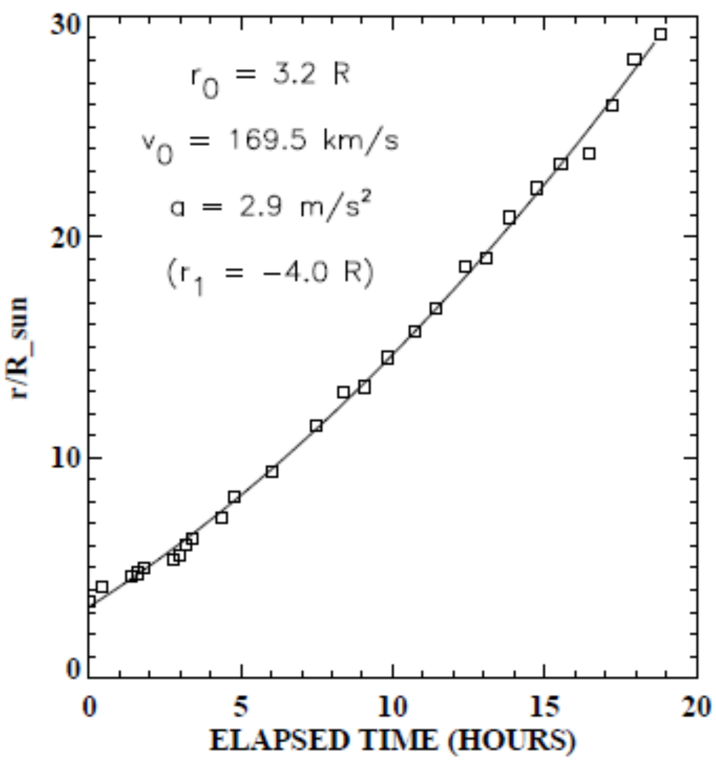
(Feldman et al. 1996)

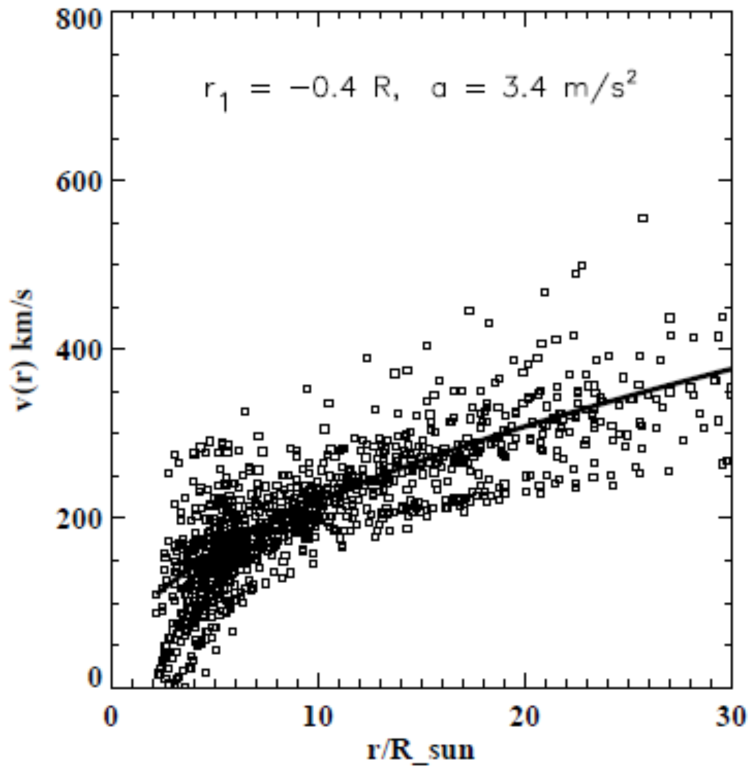


Plan A : 1 AU and inclination~45°

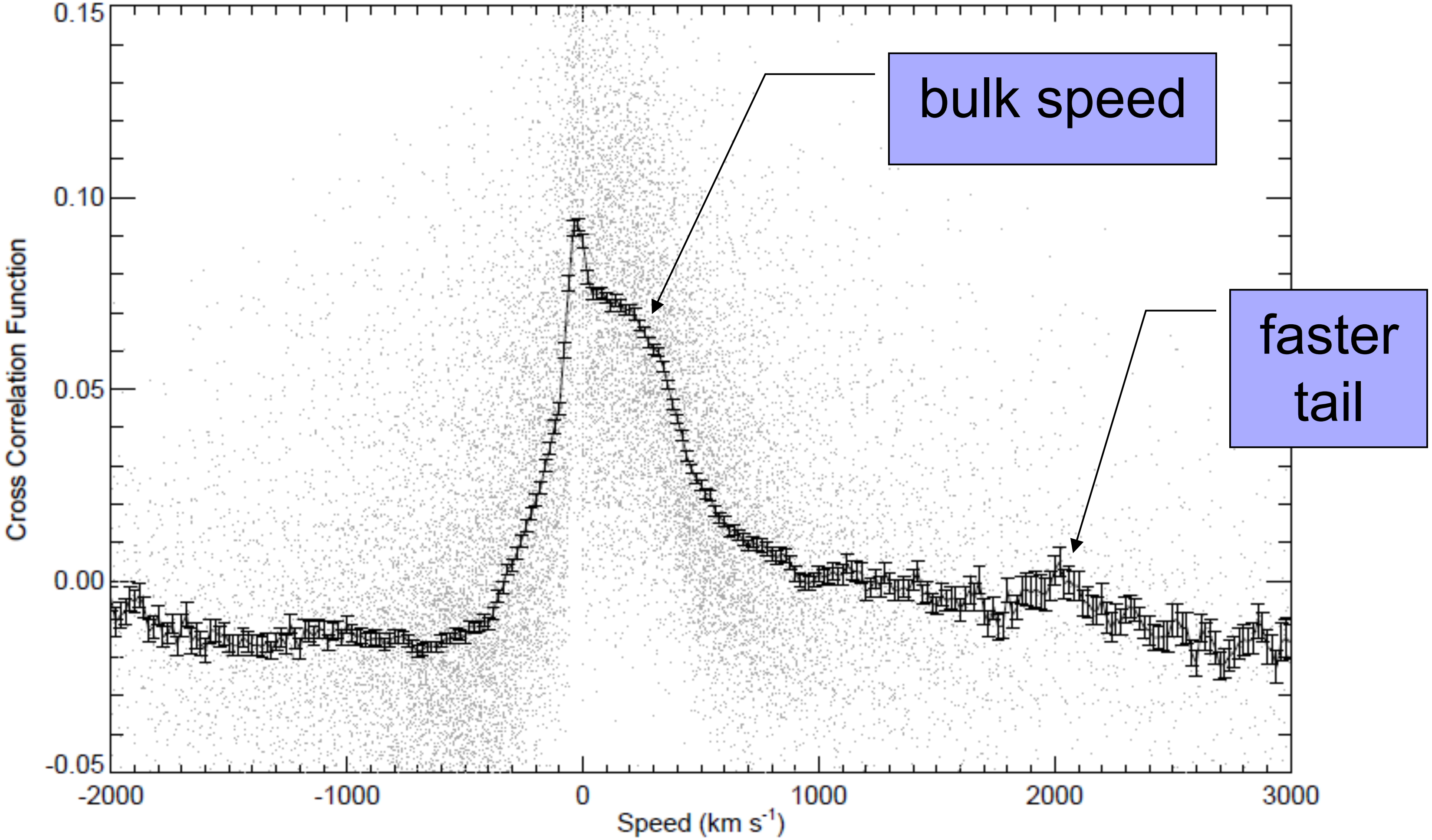
- interplanetary structures decay and dissolve into the solar wind
- At 1 AU and both incl.=0° (near-earth satellites) and incl.≠0° (Solar-C) will give better 3D structure
- (but may not be a very strong point,,,)

outflows seen in LASCO images





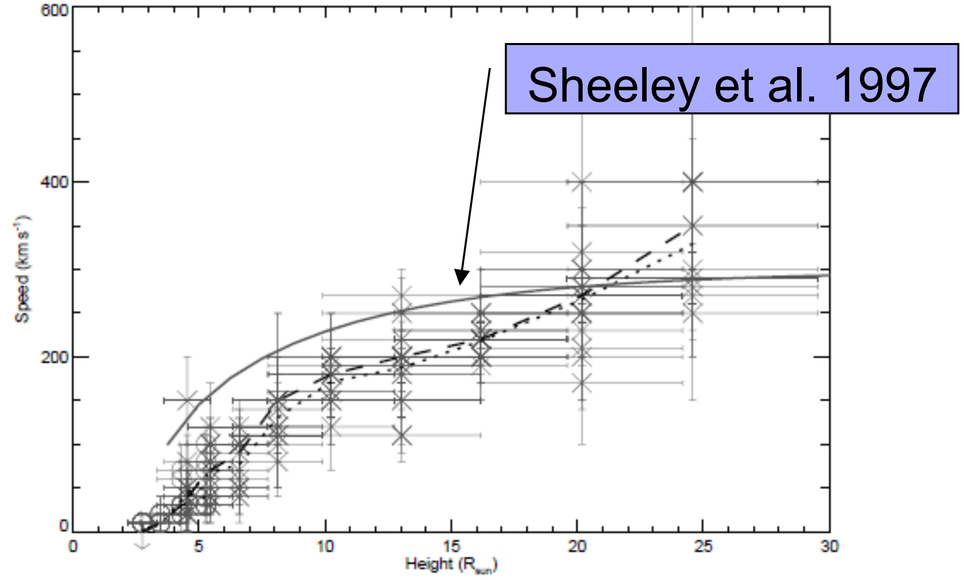
feature tracking (Sheeley et al. 1997)

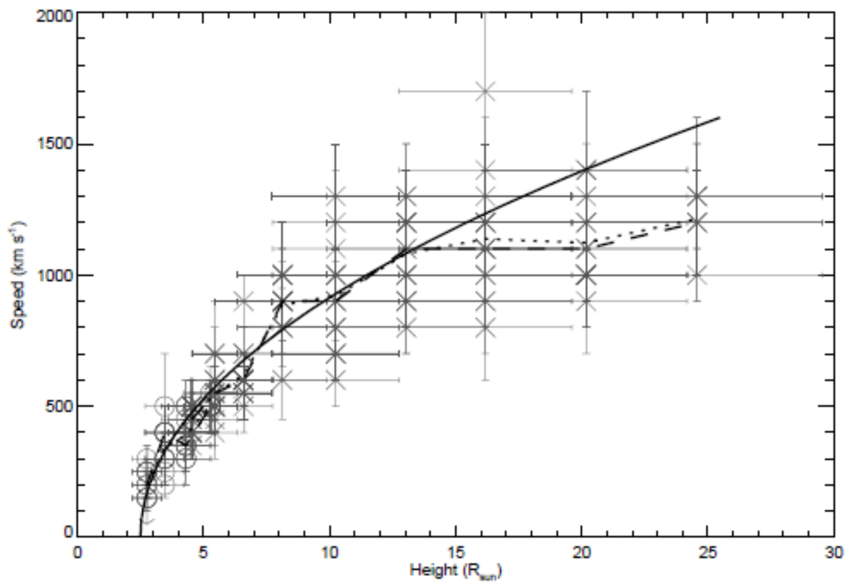


cross correlation (Tappin et al. 1999)

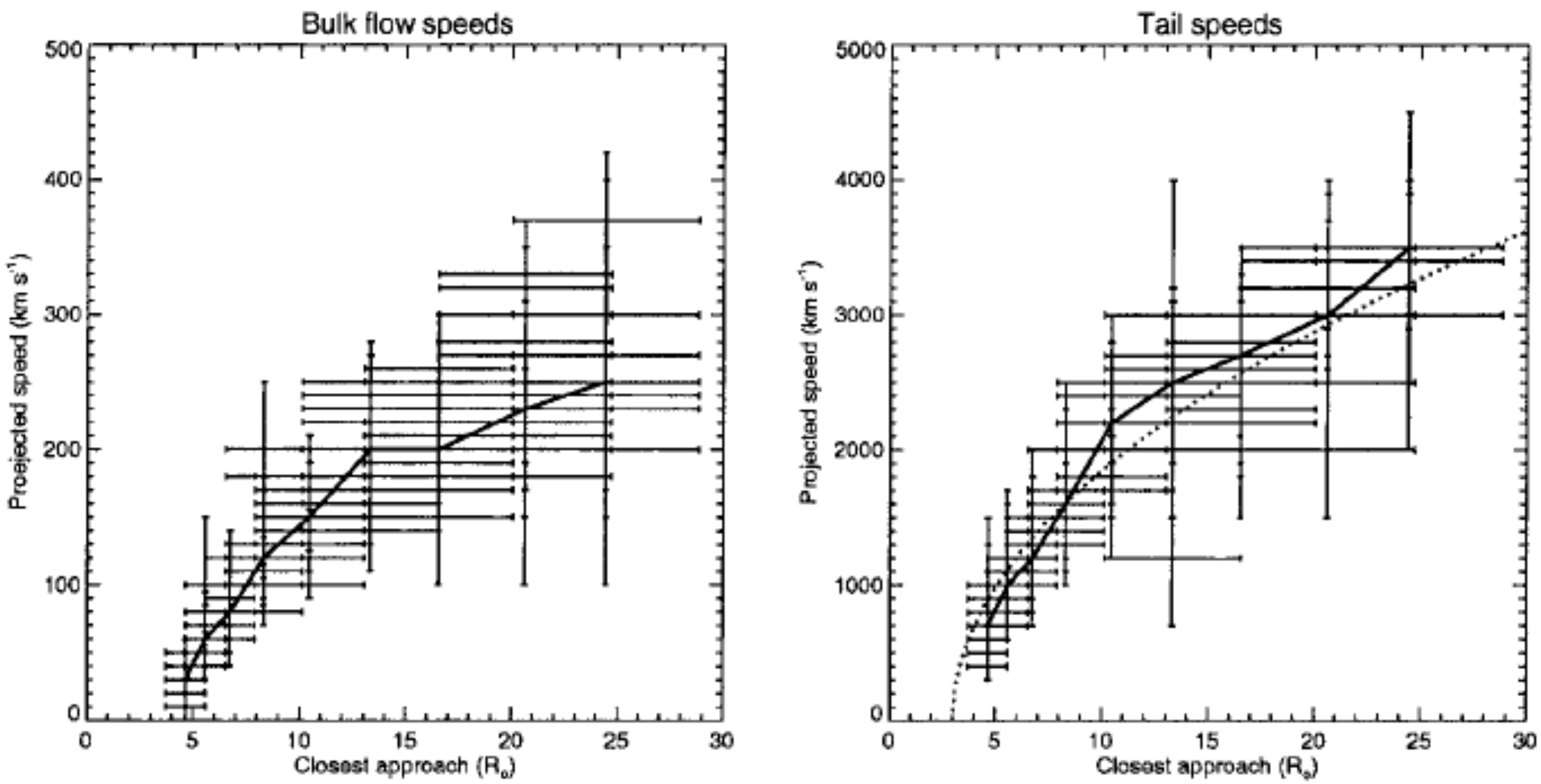
equatorial slow wind

- bulk speed
  ~300 km/s @ 30Rsun
- tail speed
  > 1000 km/s
  - source unknown





polar wind (Tappin et al. 2001)



same as equatorial wind:
contamination from foreground slow wind (?)

Interplanetary Scintillation Observations

- slow wind

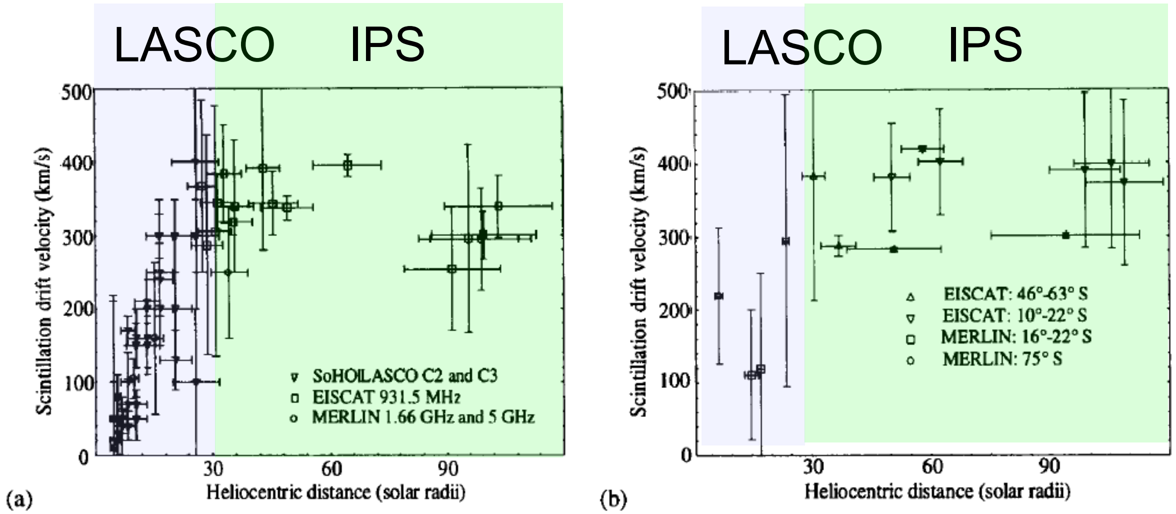


Figure 2: (a) LASCO, MERLIN and EISCAT measurements of slow wind velocity between 4 R and 100 R, May 1999 and (b) MERLIN and EISCAT measurements of slow wind velocity between 7 R and 110 R, May 2000.

- fast wind

(Breen et al. 2002)

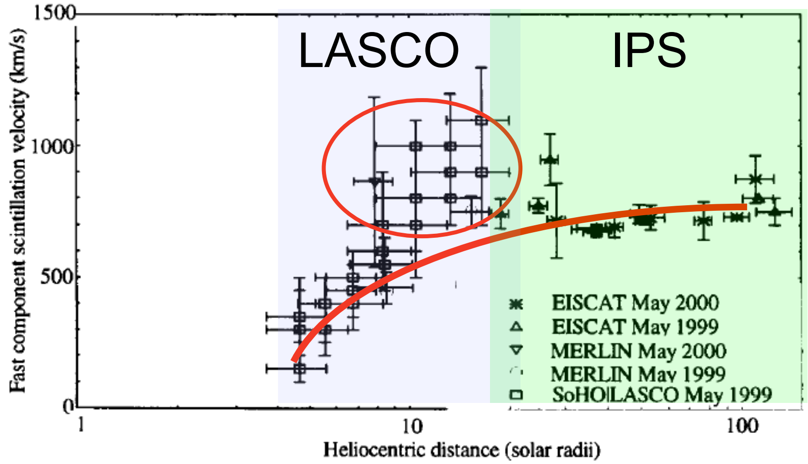
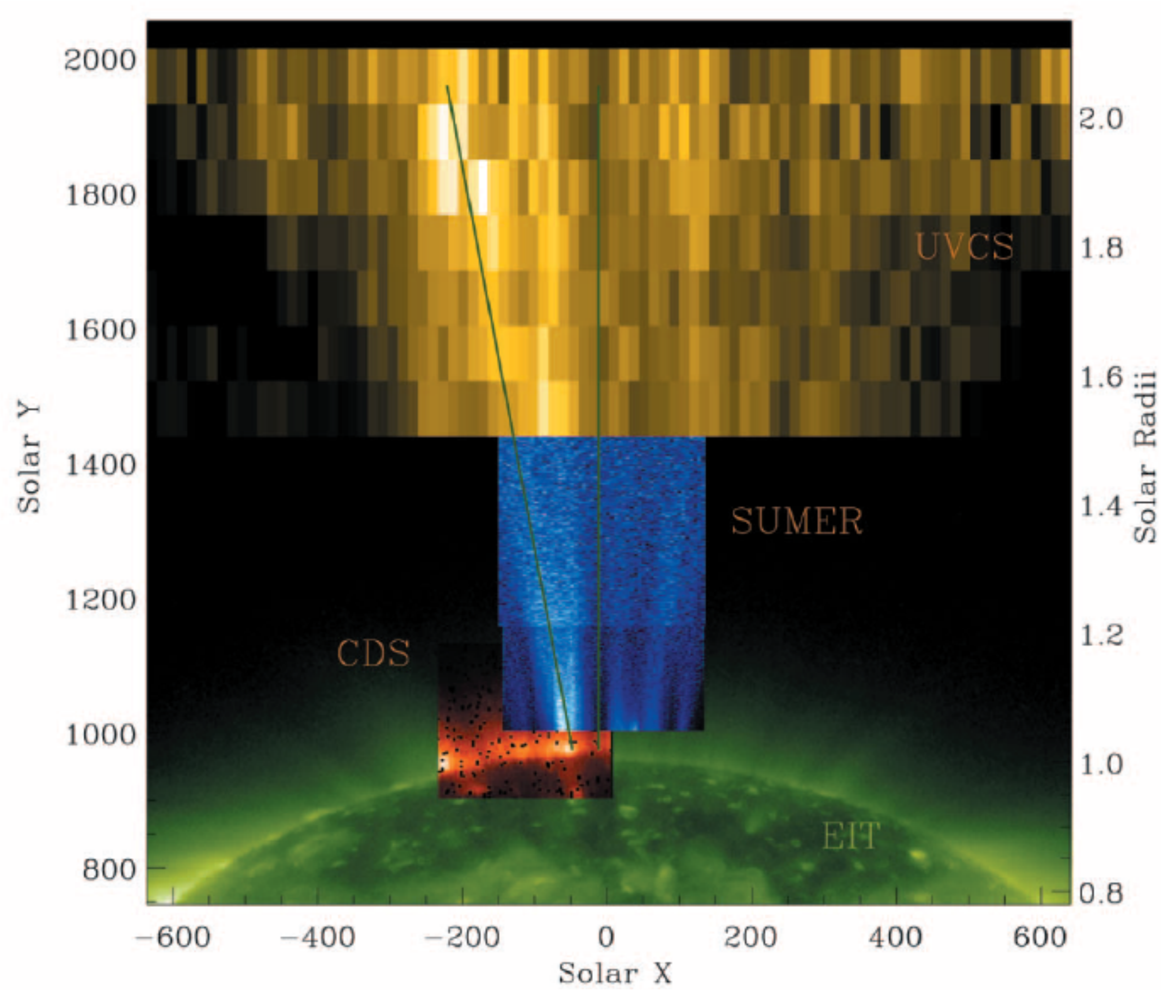


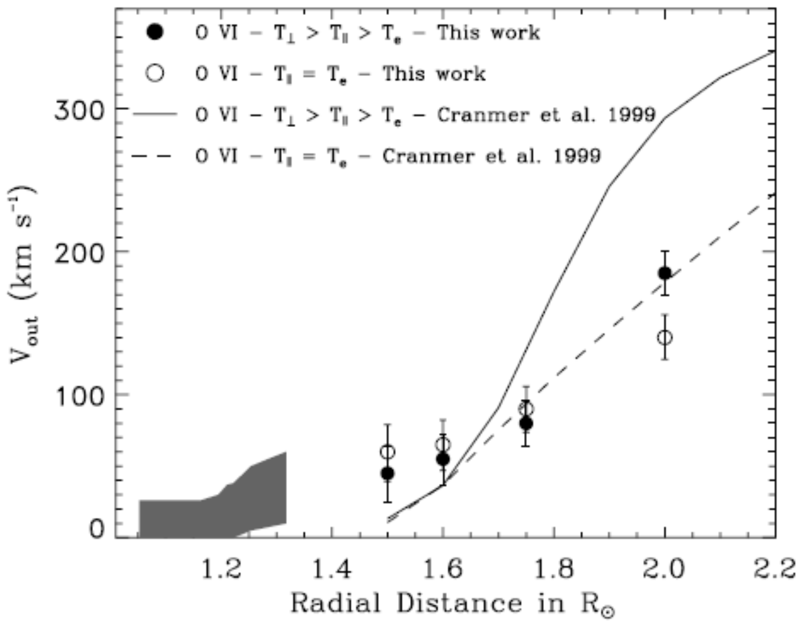
Figure 3: LASCO, MERLIN and EISCAT measurements of fast-component velocities between 4 and 100 R during May 1999 and 2000

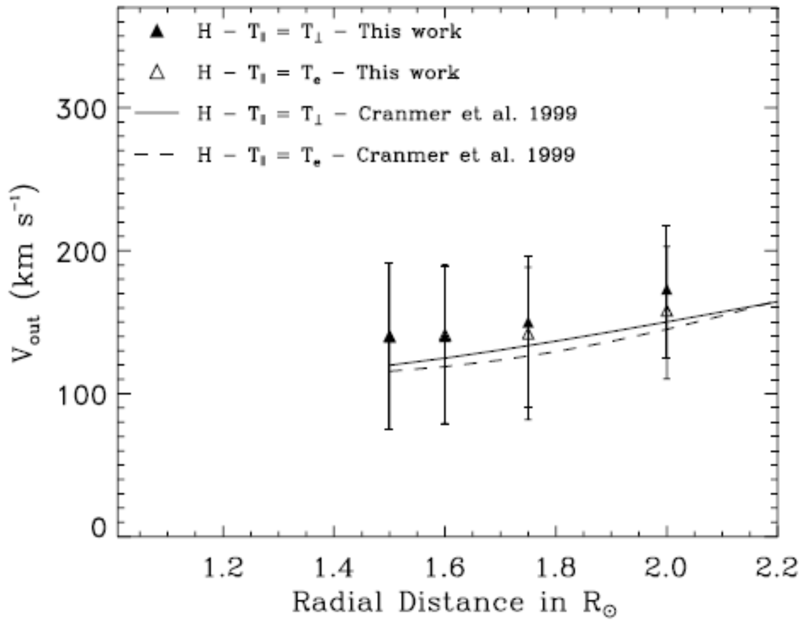
plume vs. inter-plume regions



Teriaca et al. 2003

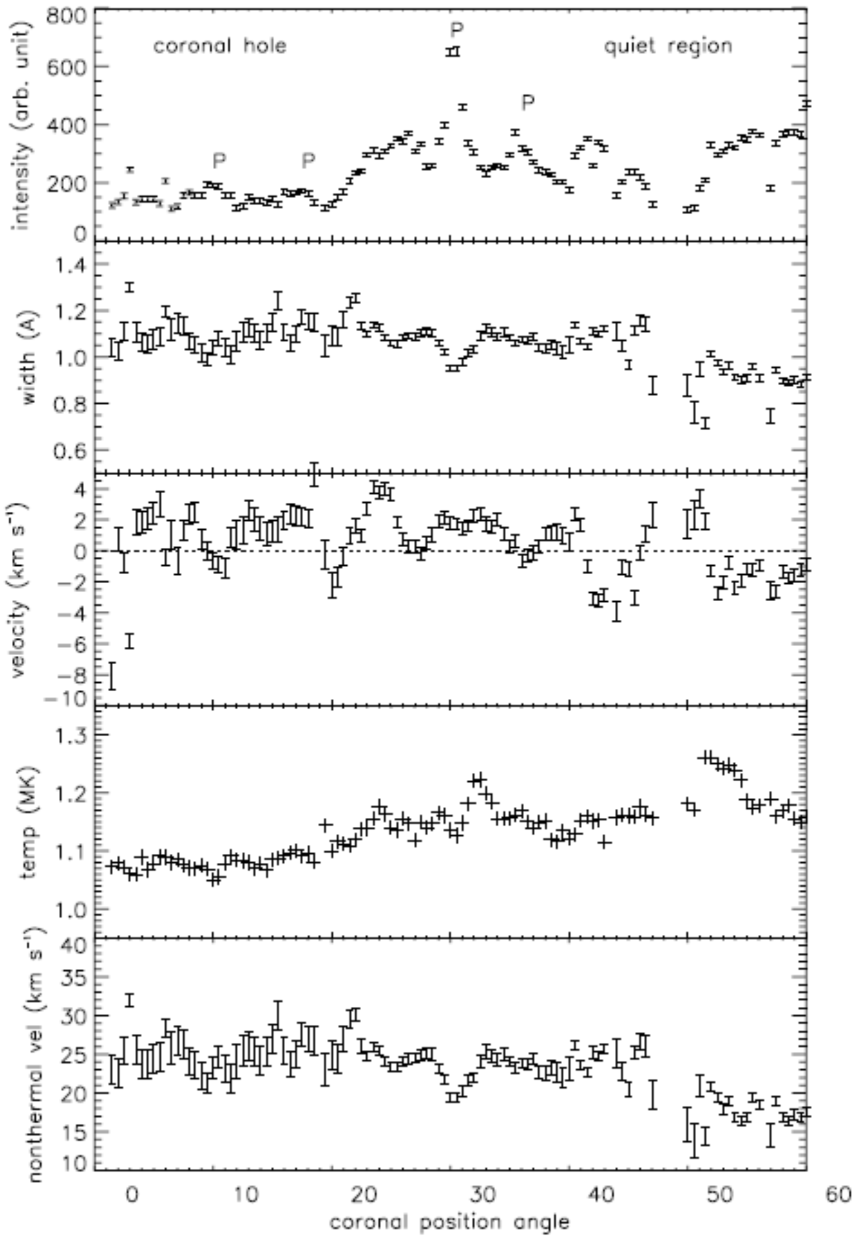
Doppler dimming => V(inter-plume)
V(plume)=0





- Fe X non-thermal line width (r=1.04Rsun)

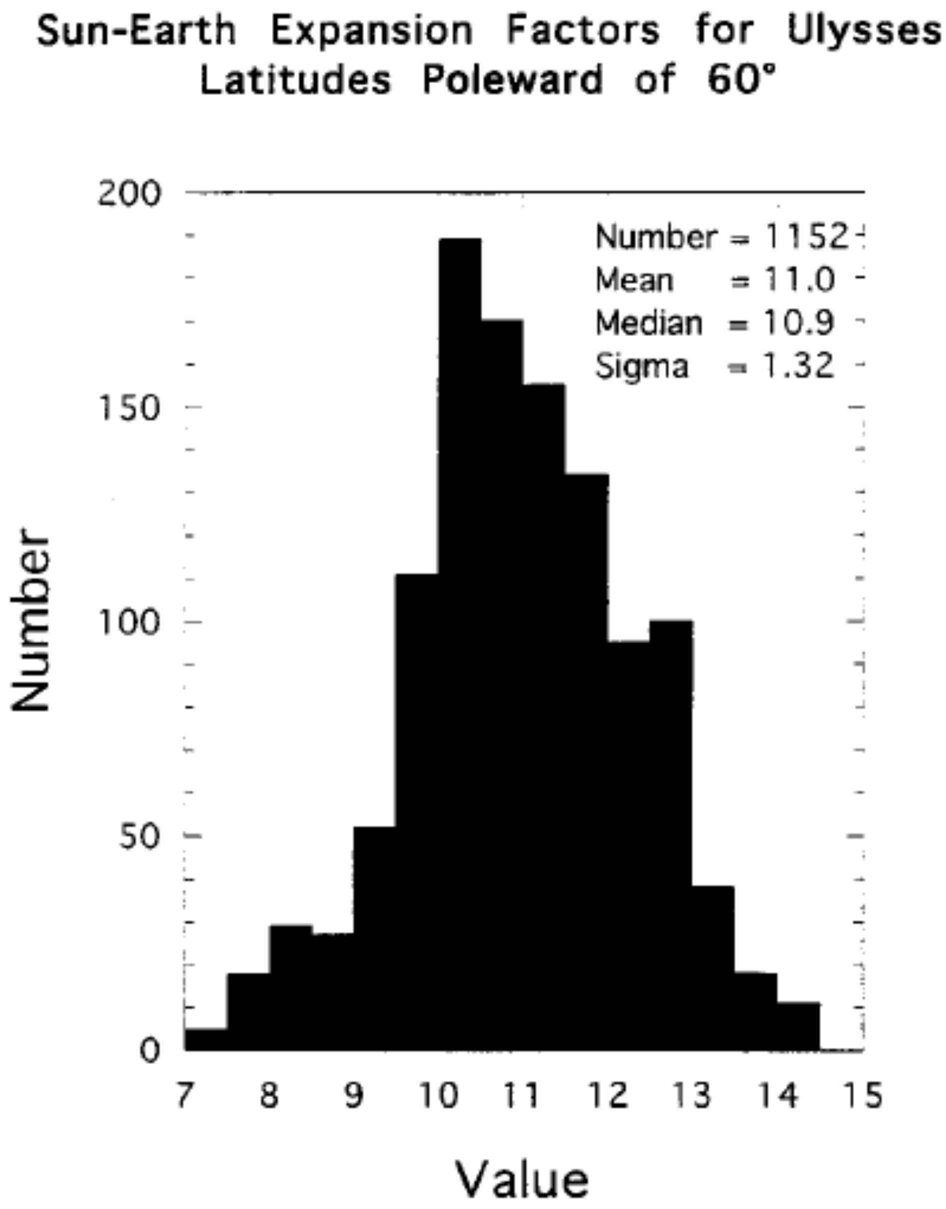
QS< CH(plume) <CH(interplume)



Raju et al. 2000

magnetic expansion factor
~ 10
(assuming source-surface model)

(Feldman et al. 1996)



very broad line width of ions (SOHO/UVCS)

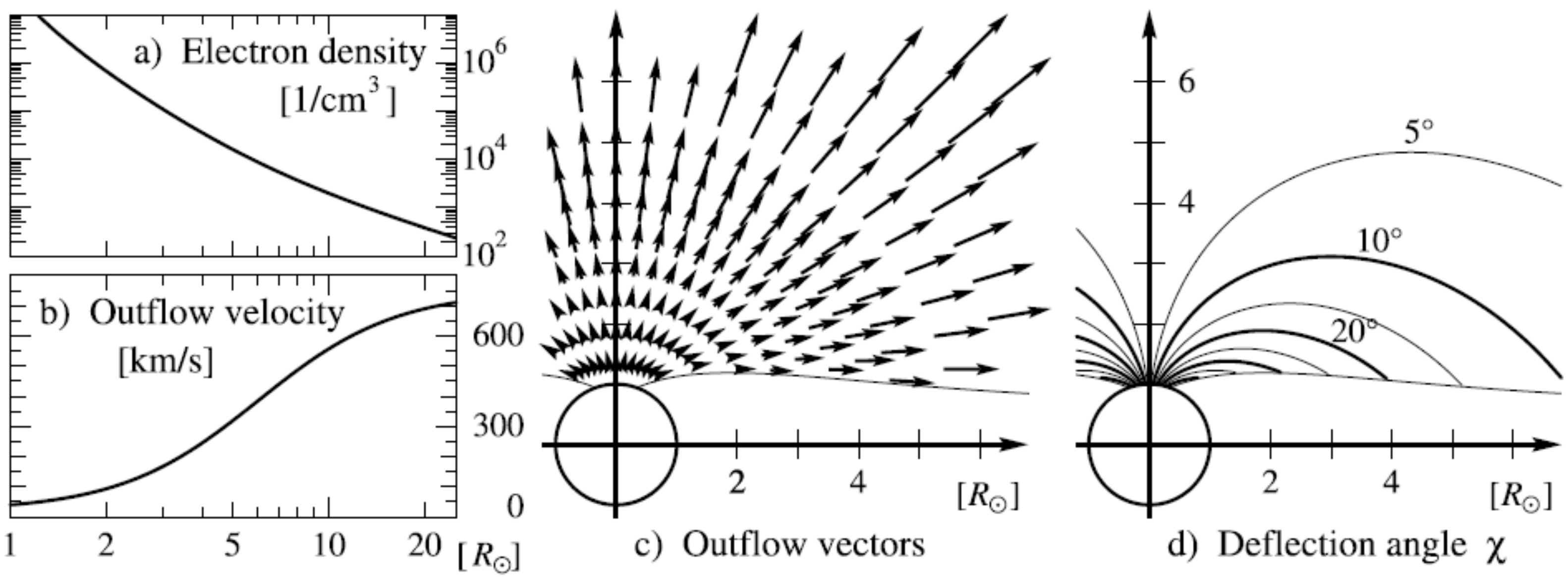
EMPIRICAL CORONAL HOLE MODEL OF CRANMER ET AL. (1999)

	H I Lyα		O VI $\lambda 1032$	
R ($R_\odot$)	$T_\perp$ (MK)	w (km s^{-1})	$T_\perp$ (MK)	w (km s^{-1})
1.5	1.9	...	7	11
2.0	2.5	150	64	179
2.5	3.2	186	120	320
3.0	3.3	219	160	420

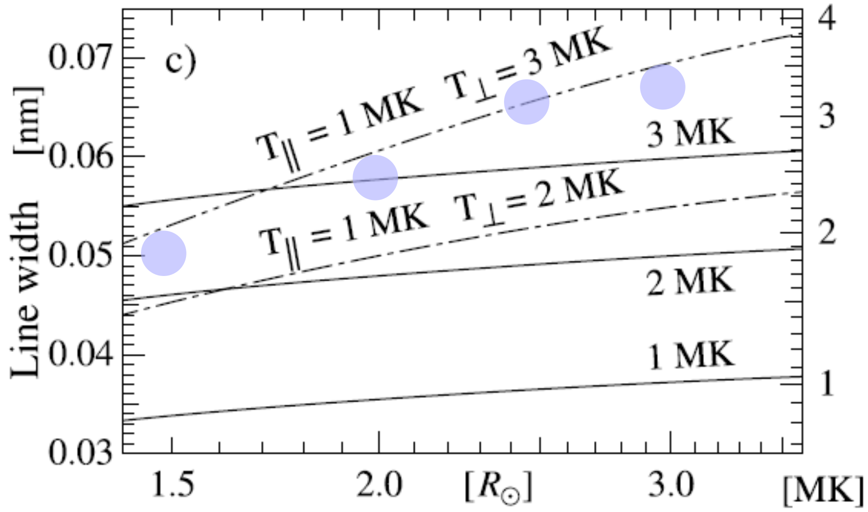
line broadening by resonant scattering + anisotropic temperature

➔ no need to assume 100MK ion temperature

(A.Nakagawa ApJ 2007)

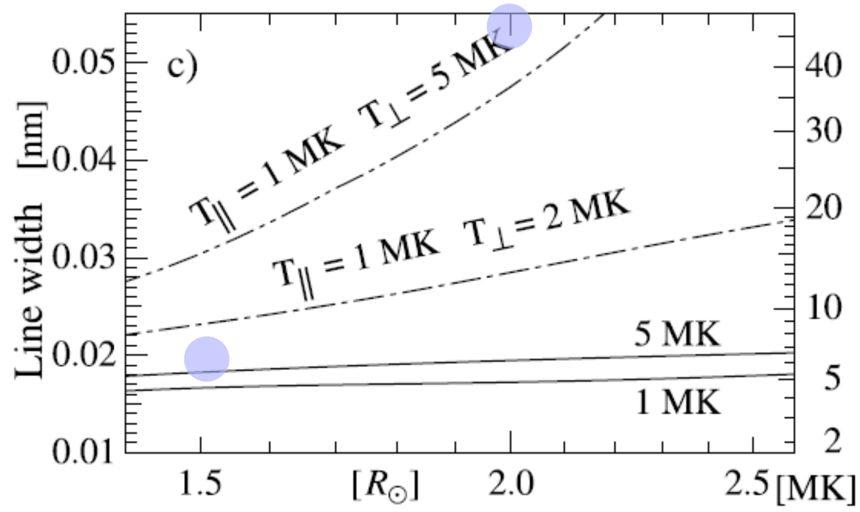


Ly α



c)
Line width [nm]
0.07
0.06
0.05
0.04
0.03
$T_\parallel = 1$ MK $T_\perp = 3$ MK
3 MK
$T_\parallel = 1$ MK $T_\perp = 2$ MK
2 MK
1 MK
4
3
2
1
1.5
2.0
[$R_\odot$]
3.0
[MK]

O VI



c)
Line width [nm]
0.05
0.04
0.03
0.02
0.01
$T_\parallel = 1$ MK $T_\perp = 5$ MK
$T_\parallel = 1$ MK $T_\perp = 2$ MK
5 MK
1 MK
40
30
20
10
5
2
1.5
[$R_\odot$]
2.0
2.5
[MK]

Solar-C Plan-A for Solar Wind study

- magnetometer and particle detectors
- LASCO-like coronagraph
  - to measure the near-Sun flow speed
- X/XUV imager
  - to identify jet-like source events
- magnetograph
- EIS-like EUV spectrometer?
  - dynamics of the source region

- Ulysses
  - flux-gate magnetometer: 2.4kg
    - 5m boom
  - ion analyzer:4.1kg
  - electron analyzer: 2.6kg
    - spin modulation