Measurements of the solar wind acceleration region

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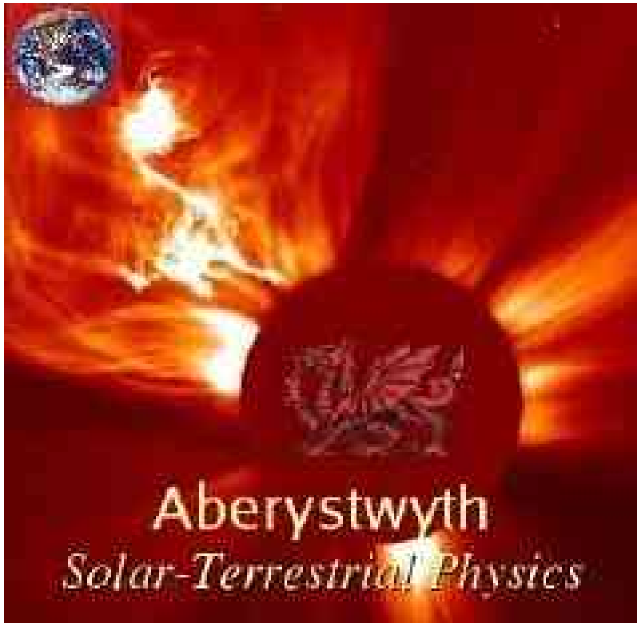
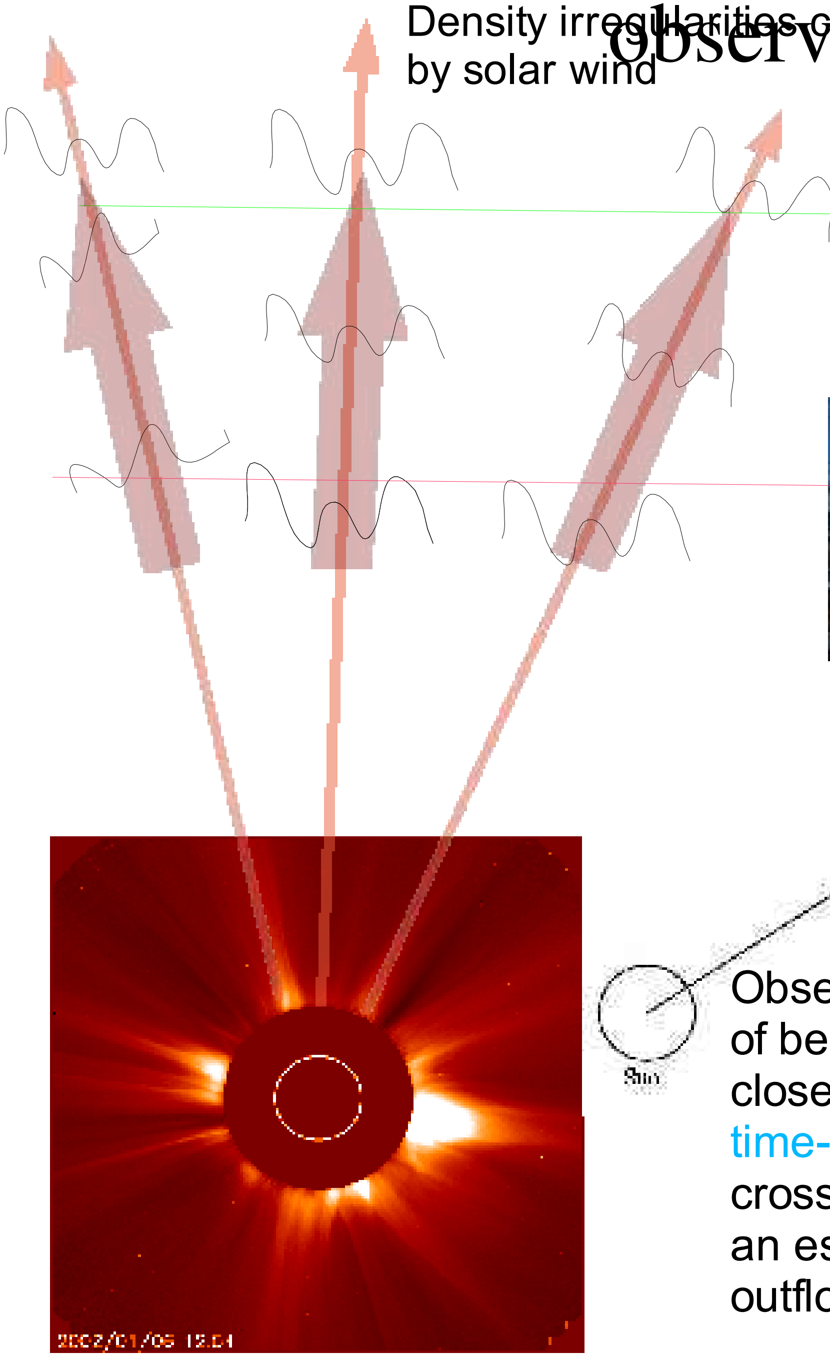
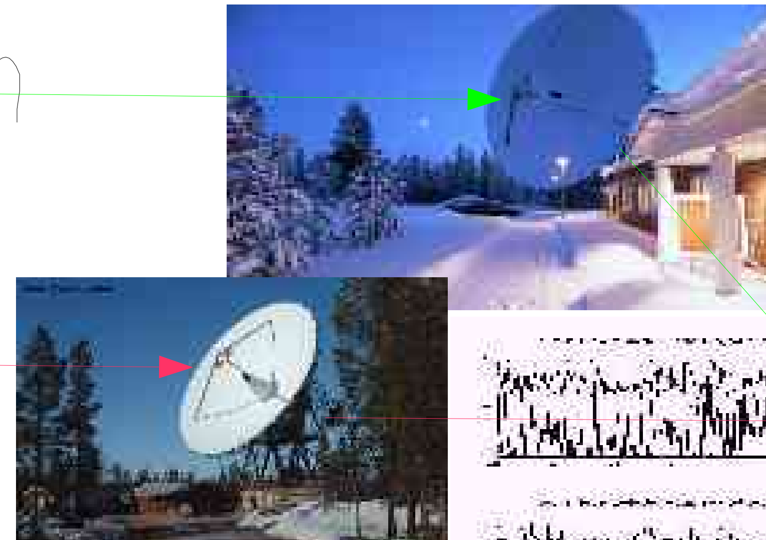


Remote-sensing techniques

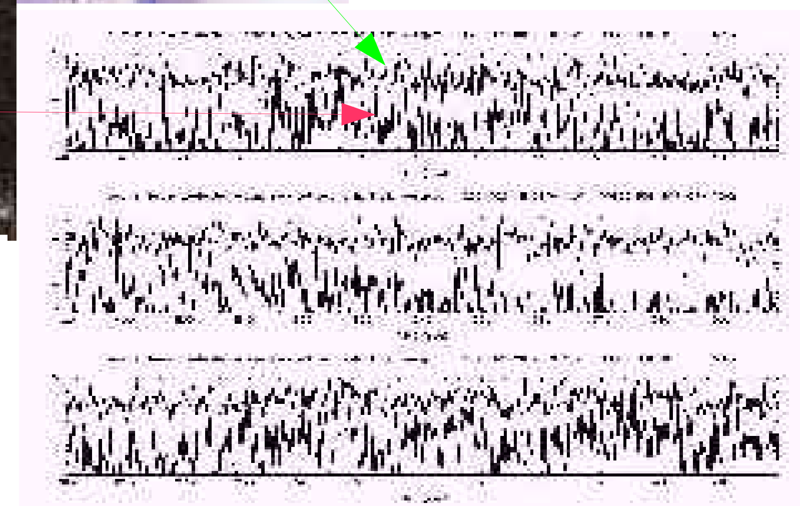
- Coronal observations (X-ray and UV)
  - Density, temperature, velocity estimates from spectra
  - Reliable measurements of true flow speeds (models permitting)
  - Restricted to close to Sun (inside 6 R)
- White-light measurements
  - Density estimates from white-light brightness
  - Velocity from speed of drifting features (assumed to be moving at background flow speed)
  - Path-integrated measurements off limb - velocities in plane of sky
- Radio (amplitude) Scintillation *or* Interplanetary Scintillation
  - Variation in apparent amplitude of compact astronomical radio sources when viewed through solar wind
  - Produced by variations in solar wind density (and thus refractive index) and subsequent interference
  - Uses turbulent-scale density irregularities in solar wind as flow tracers - assumes that their velocity is closely related to that of the background wind
- Radio (phase) Scintillation
  - Variation in phase of compact astronomical radio sources when viewed through solar wind
  - Produced by variations in solar wind density
  - Sensitive to density irregularities of scale of antenna separation

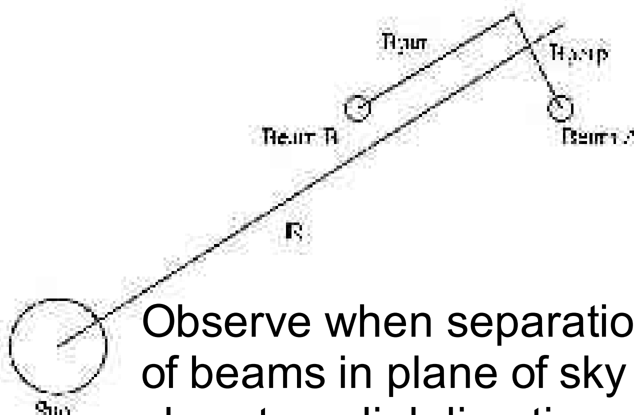
Multi-site Interplanetary Scintillation observations



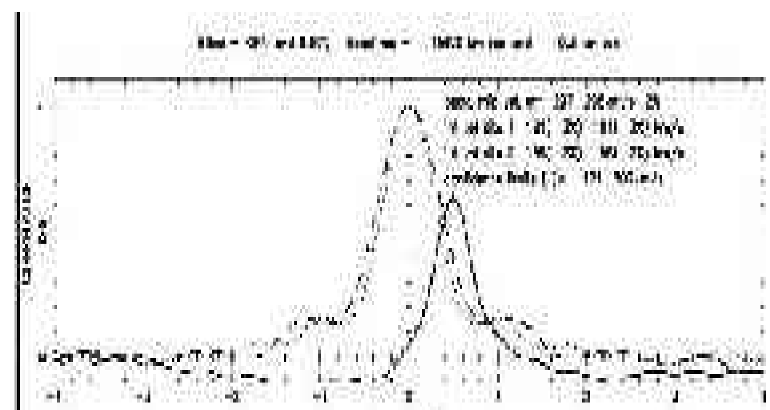


Scintillation patterns received at antennas

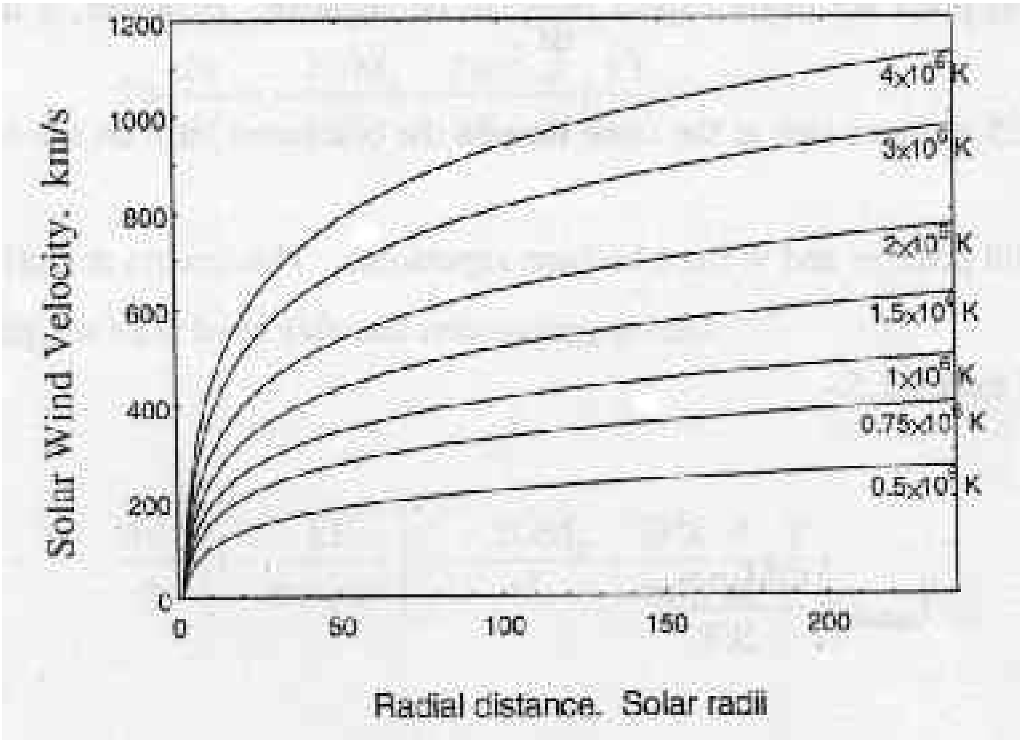




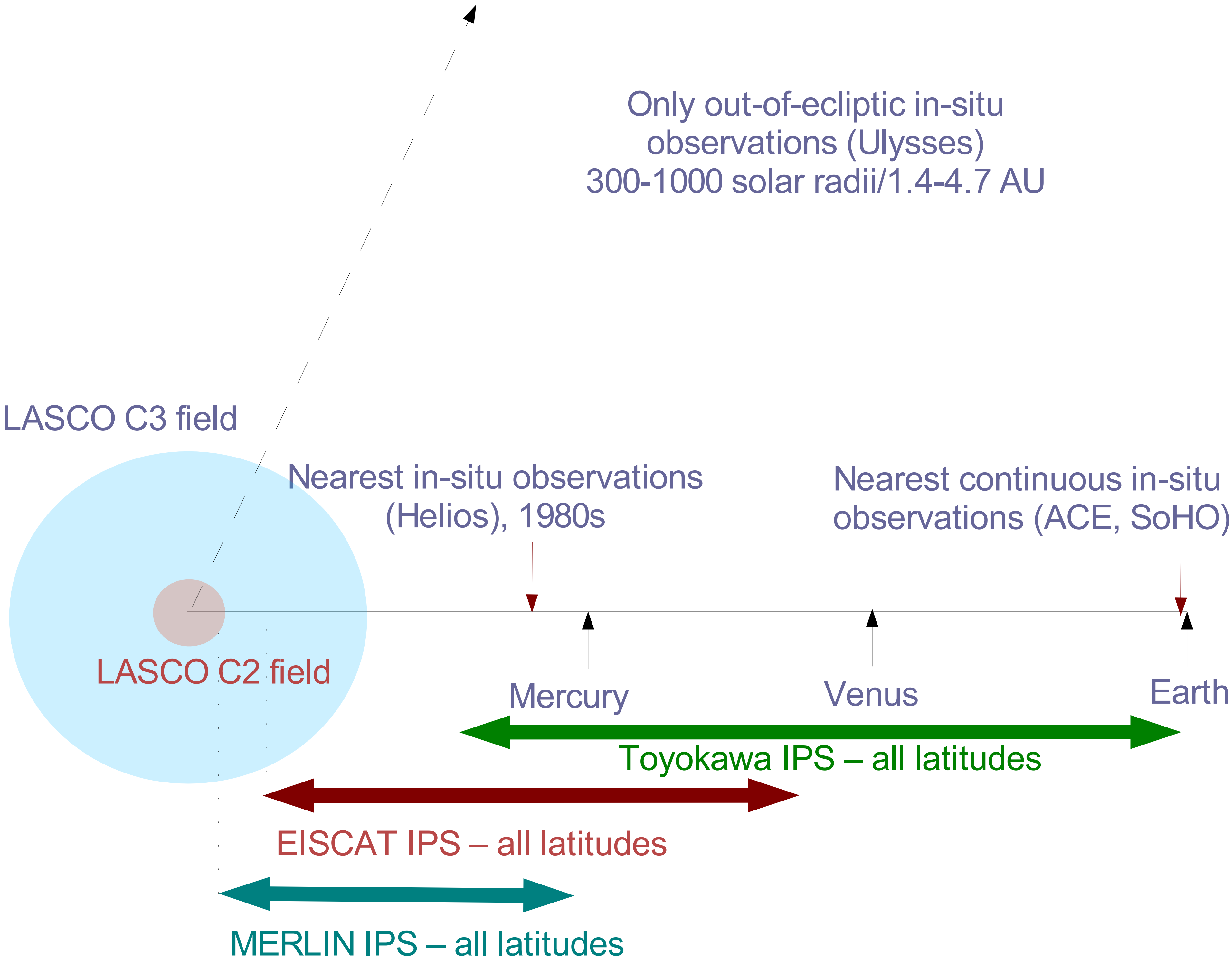
Observe when separation of beams in plane of sky is close to radial direction – time-lag for maximum cross-correlation provides an estimate of solar wind outflow speed



Parkers Acceleration curves



- Observations of the fast solar wind can't be explained by Parker expansion
- In-situ data from Helios showed that the fast wind can't be isothermal expansion
- So what ever is accelerating the Fast wind could be heating the corona



Only out-of-ecliptic in-situ
observations (Ulysses)
300-1000 solar radii/1.4-4.7 AU
LASCO C3 field
Nearest in-situ observations
(Helios), 1980s
Nearest continuous in-situ
observations (ACE, SoHO)
LASCO C2 field
Mercury
Venus
Earth
Toyokawa IPS – all latitudes
EISCAT IPS – all latitudes
MERLIN IPS – all latitudes

Remote-sensing

- Doesn't give exact measurement of solar wind

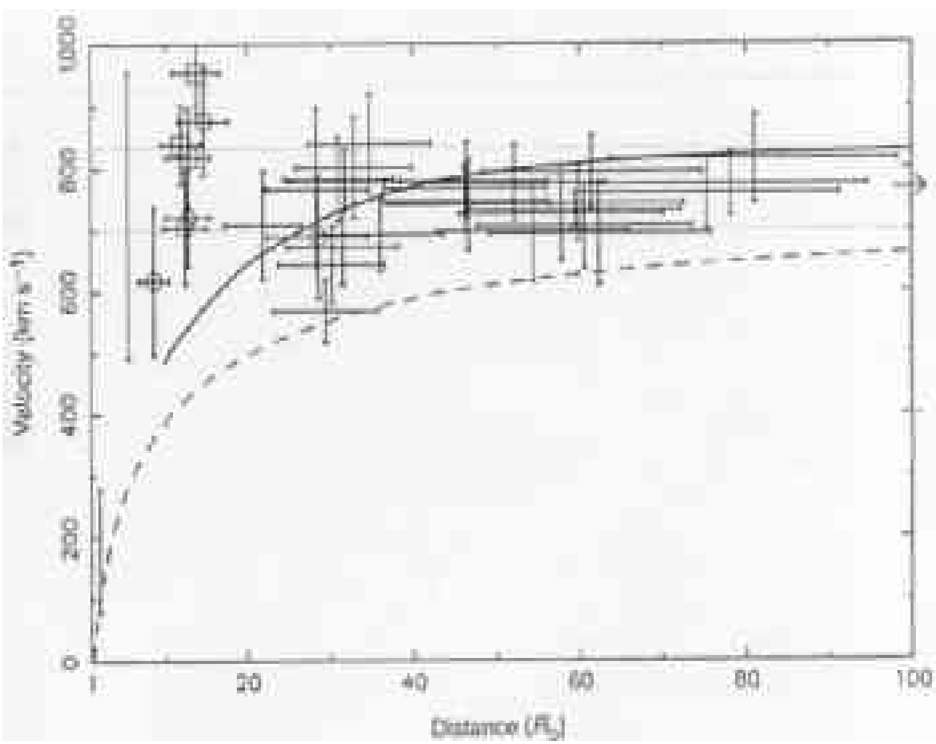
- Using different techniques observation of different scale sizes are possible

- LASCO white-light smallest scale size 10,000Km
- IPS approximate scale size 100Km

- Remote sensing can provide measurements of flow tracers of different scale sizes inside of the solar wind

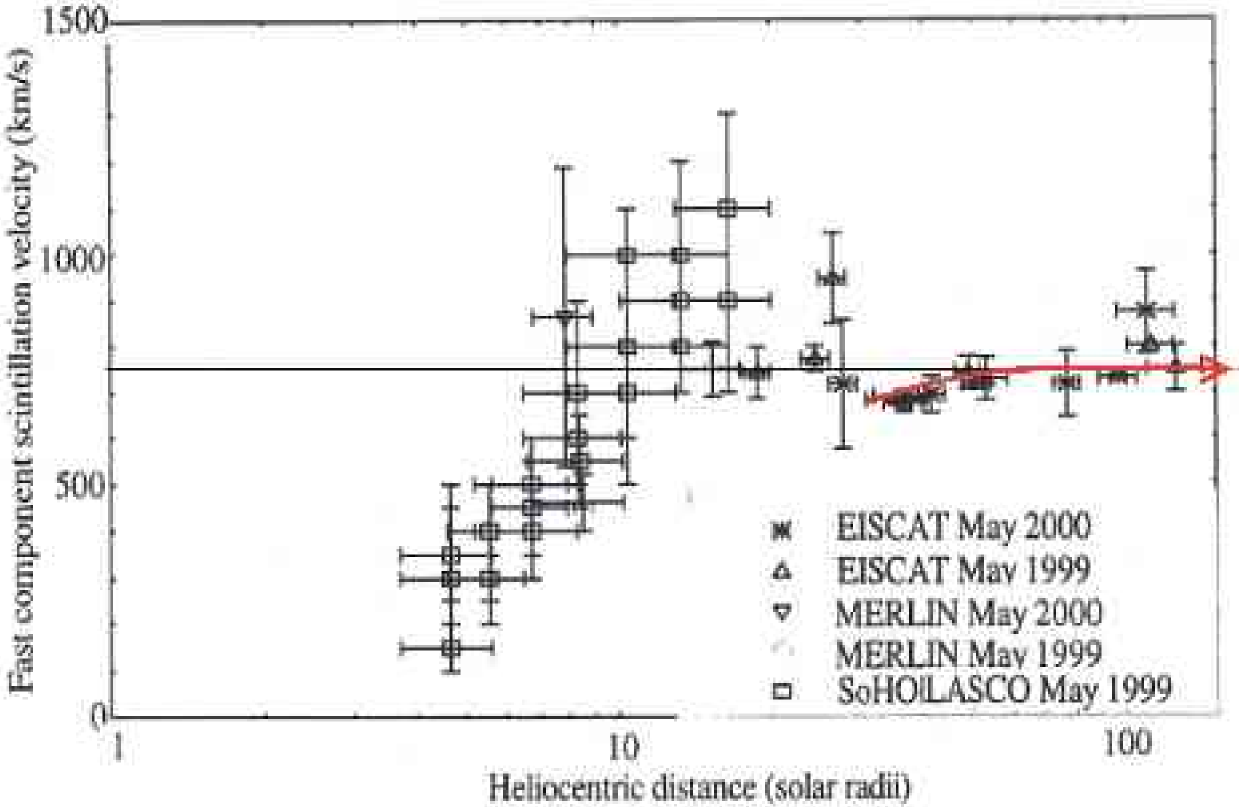
Fast Solar Wind Acceleration

- Grall et al, 1996 showed that the fast wind emanating from polar coronal holes is rapidly accelerated to its cruising velocity by 20R



- White-light observations by Kohl et al, 1998 showed that 50% of fast winds cruising velocity was reached by 5Rs with most of the acceleration over by 10Rs

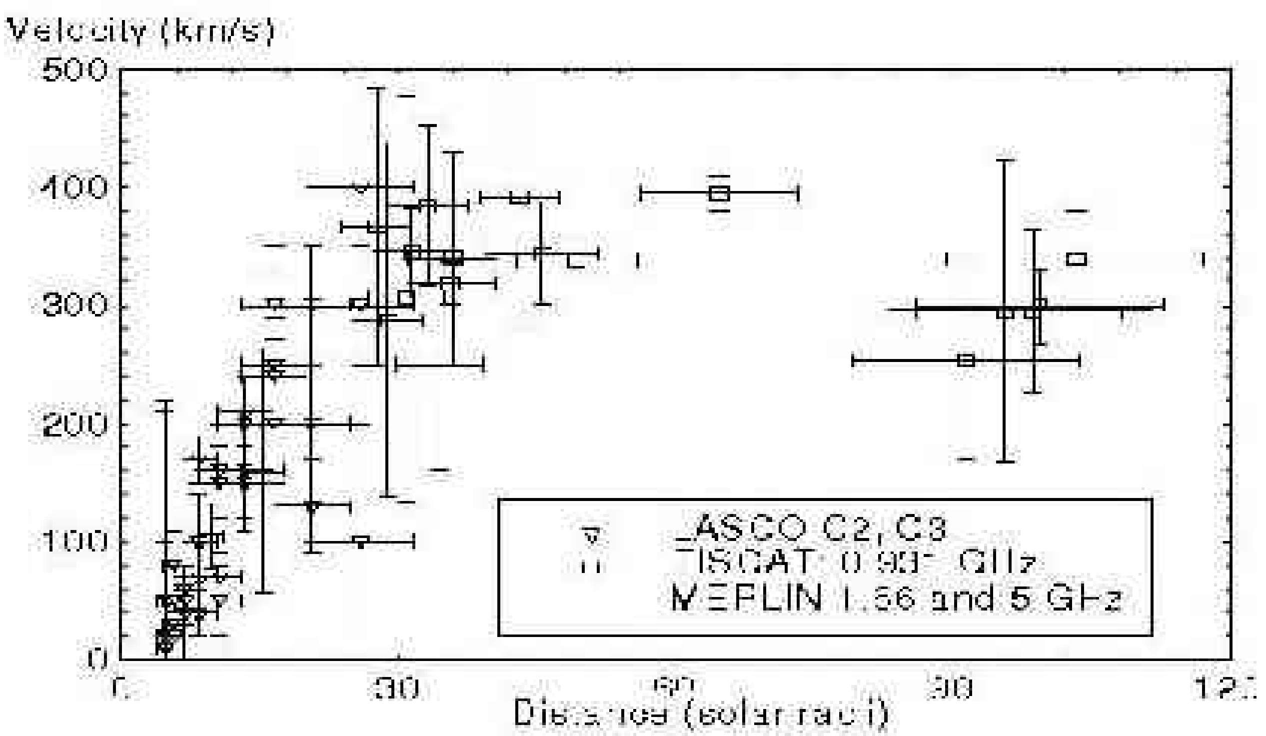
Klinglesmith



1500
1000
500
0
1
10
100
Fast component scintillation velocity (km/s)
Heliocentric distance (solar radii)
EISCAT May 2000
EISCAT May 1999
MERLIN May 2000
MERLIN May 1999
SoHO/LASCO May 1999

Slow Solar Wind Acceleration

- Breen et al 1996 showed that most of the slow winds acceleration was in between 5Rs-10Rs, with the slow wind continuing to accelerate out to 25Rs-30Rs



- Coles, 2004 Irregularities may be moving with respect to flow
- IPS measures V*wind* + V*wave*
- V*irregularity* can range from V*wind* to V*wind* + V*alfven*

- Comparing white-light and IPS observations V*wind* and V*wave* can be found
- By comparing with wave models details of wave interaction and dissipation can be had

Canals wave disspation

What IPS can do

- Track acceleration of fast and slow solar winds through regions inaccessible to other techniques
- Probe the large-scale structure of the solar wind and its evolution with distance from the Sun
- Provides upper limit on large-amplitude Alfvén wave activity in the fast solar wind