Suprathermal particle composition

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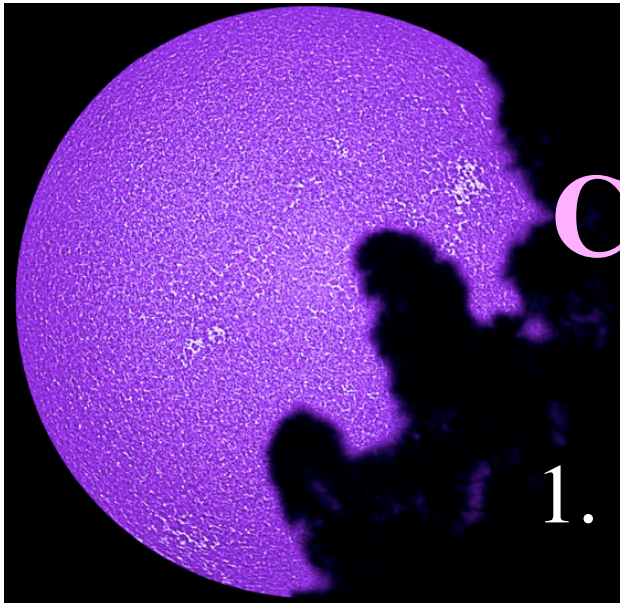
Thanks to J. Gilbert, S. Lepri



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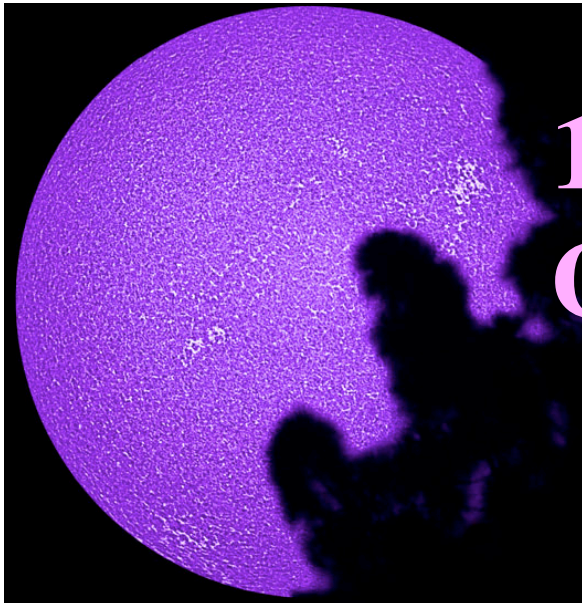
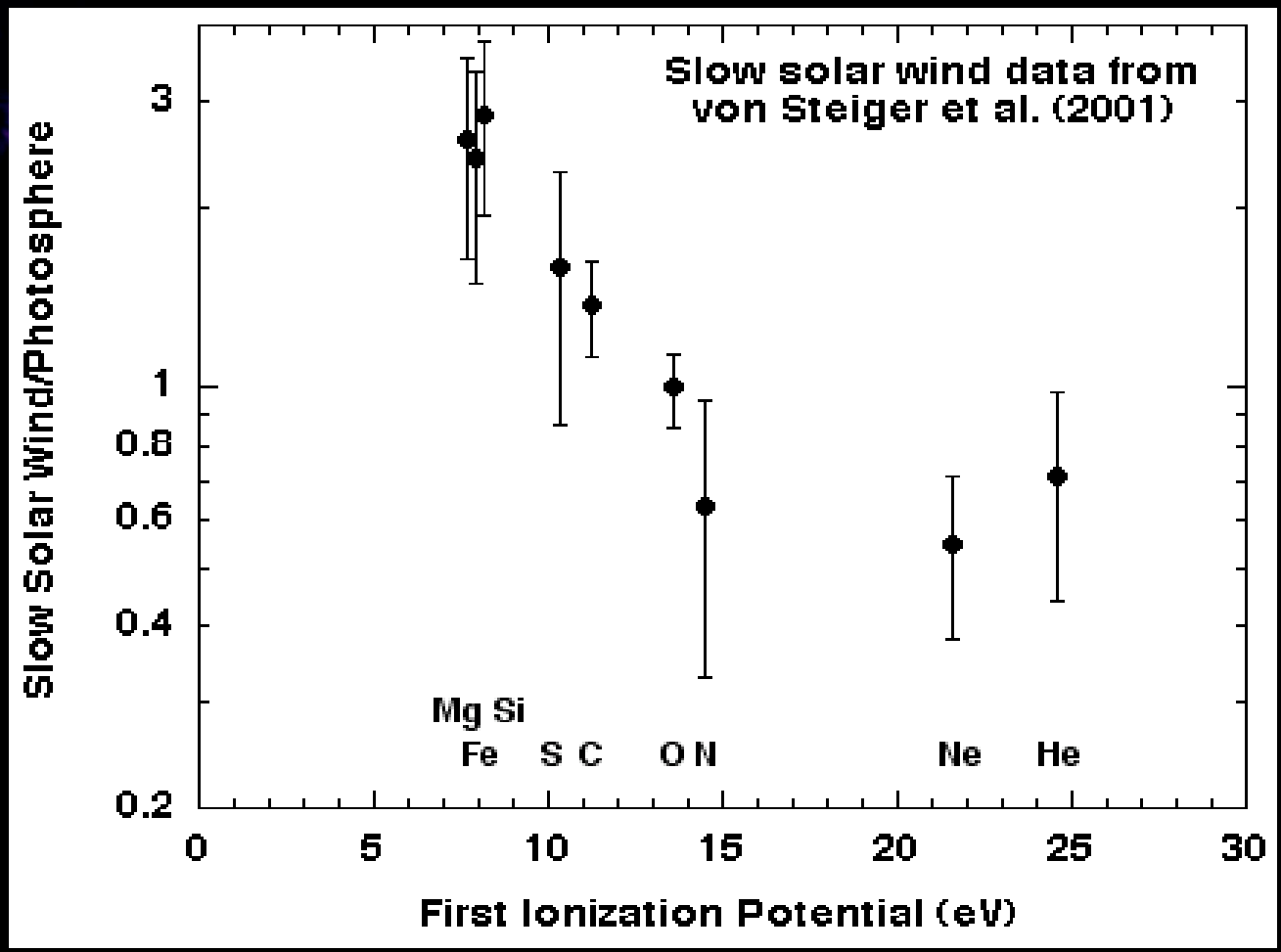
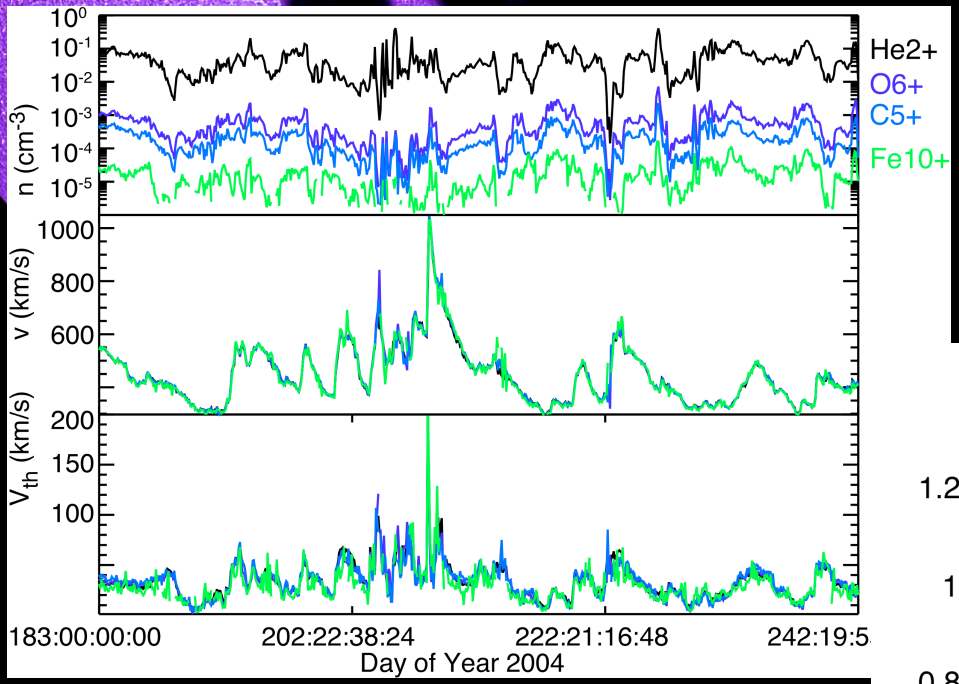


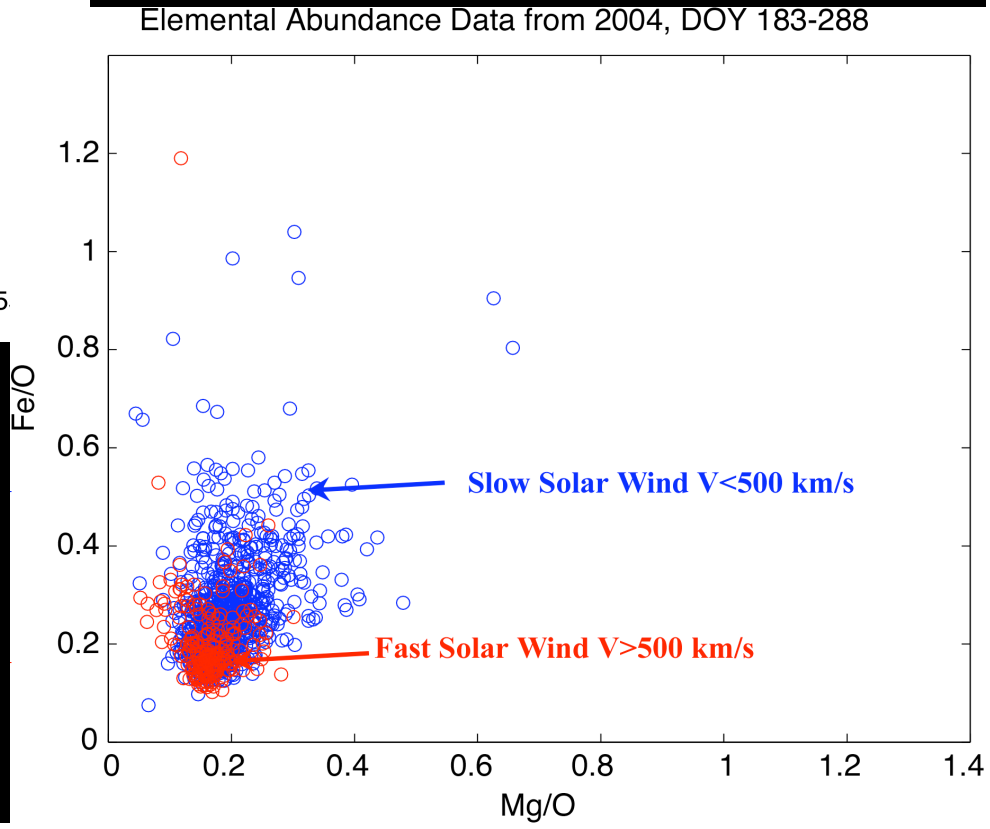
1) Notes on Solar Wind Composition

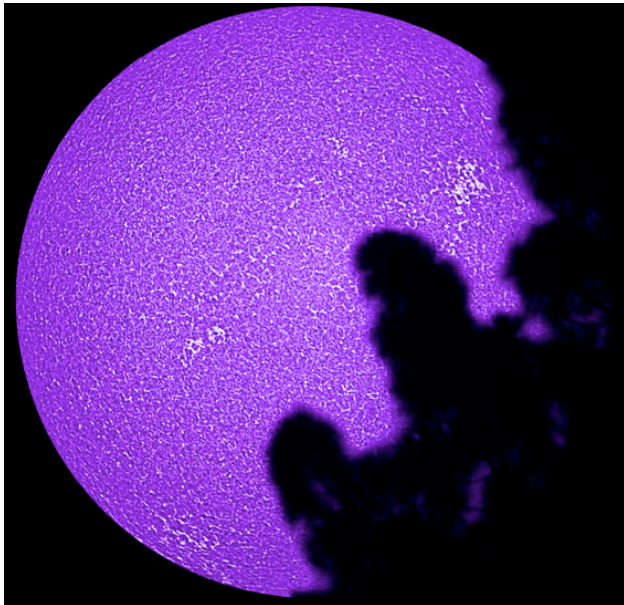
Slow solar wind

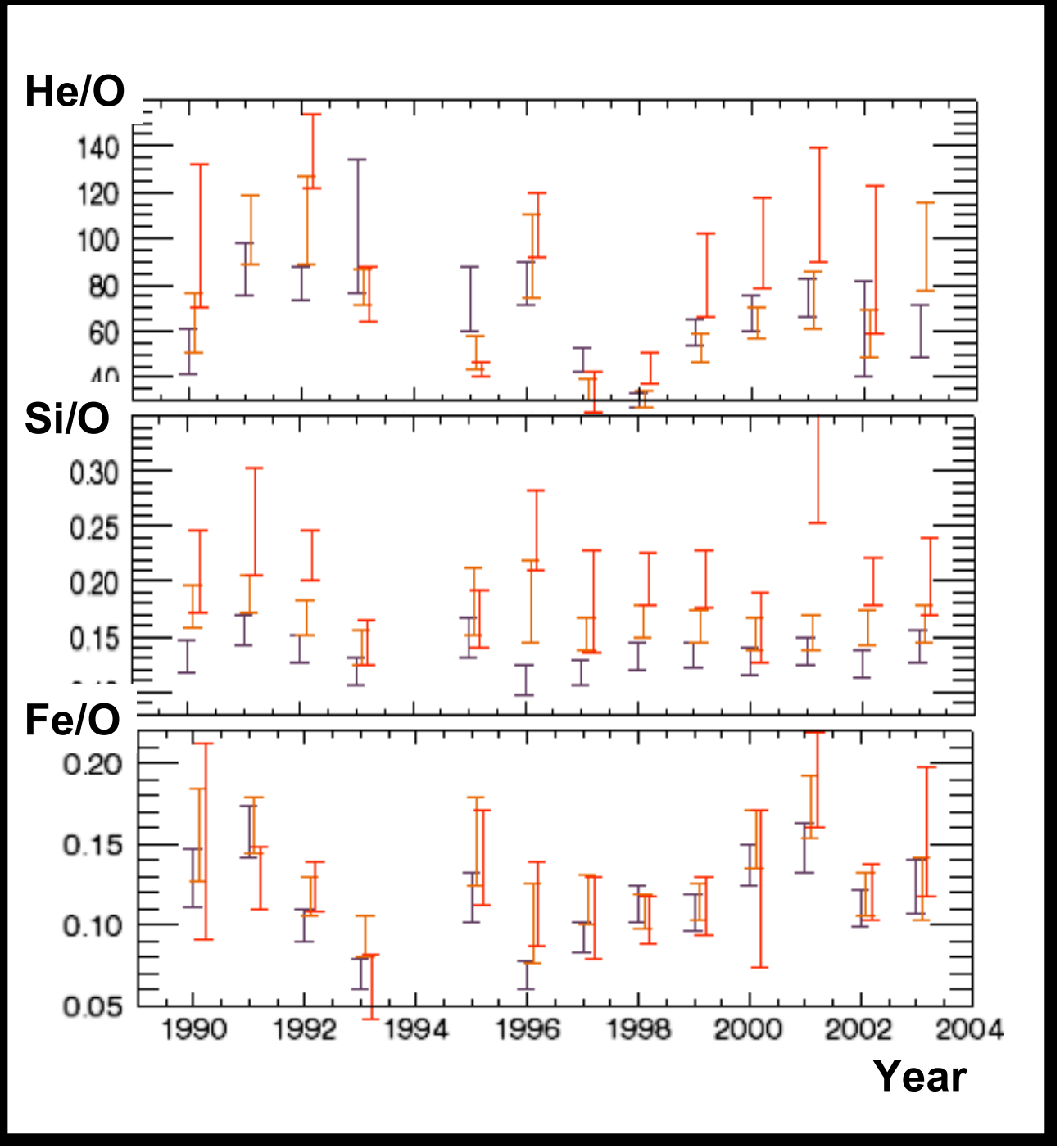


Solar wind variability







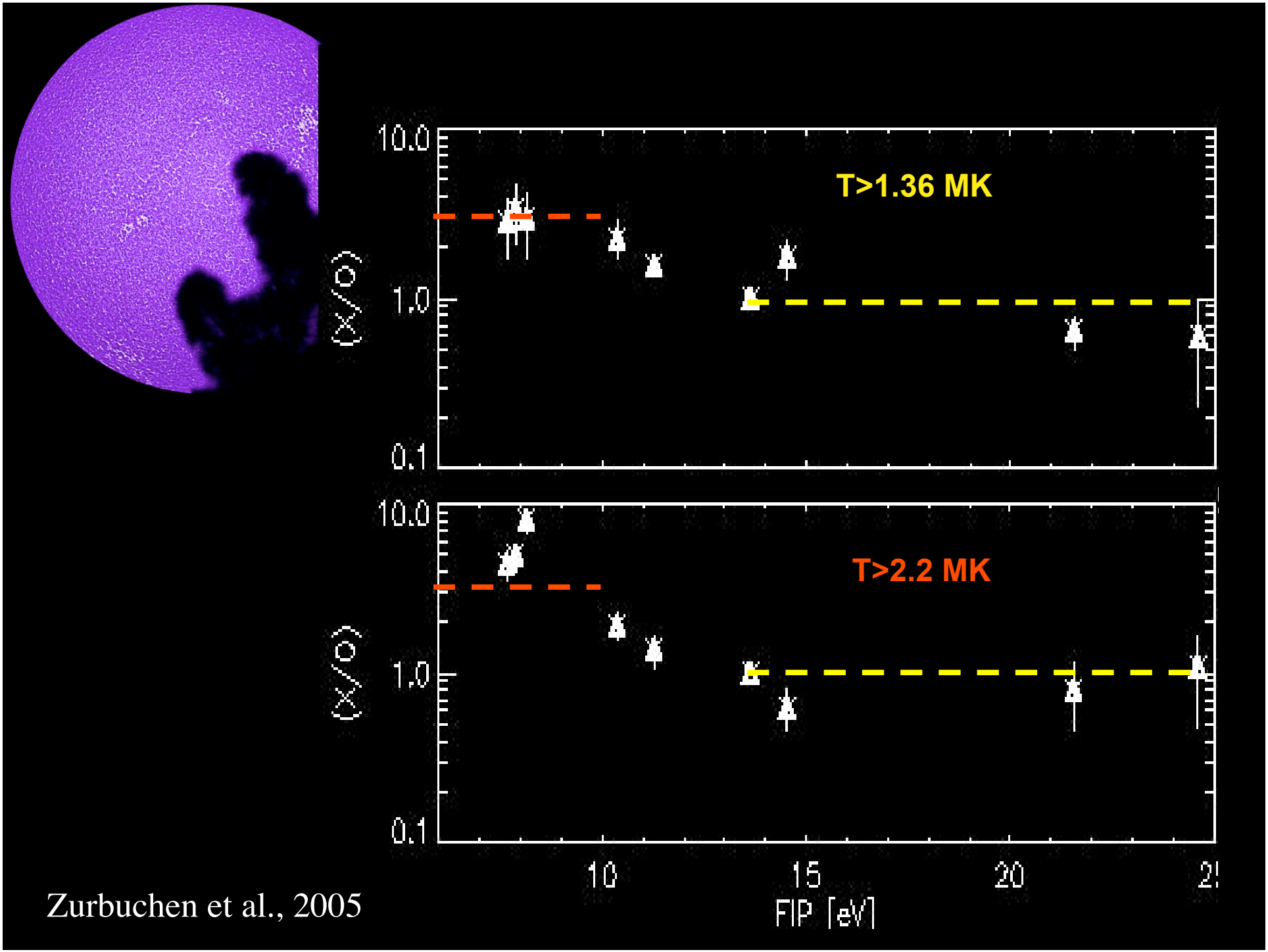


1.36 MK<Tf<1.6 MK

1.60MK<Tf<1.85MK

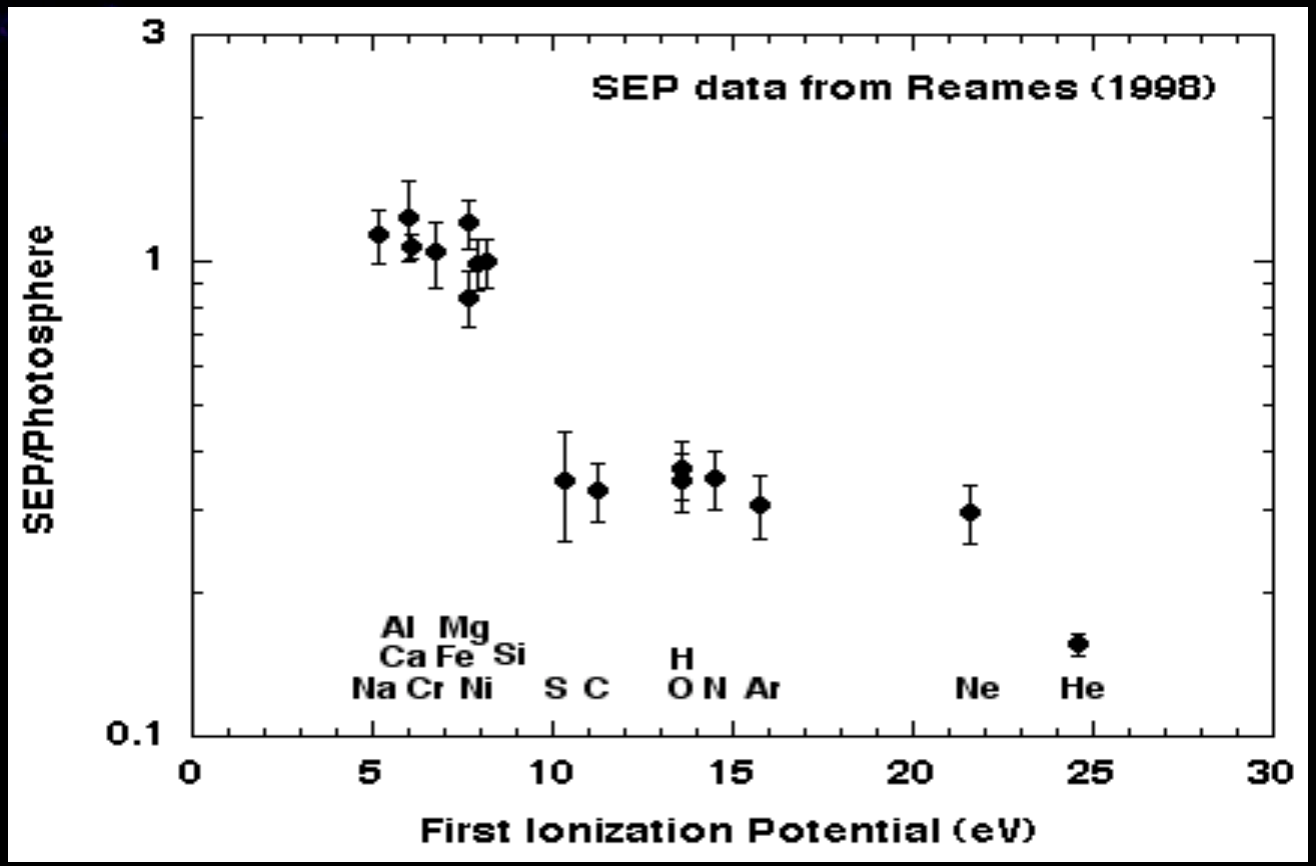
1.85MK<Tf

Zurbuchen et al., 2005



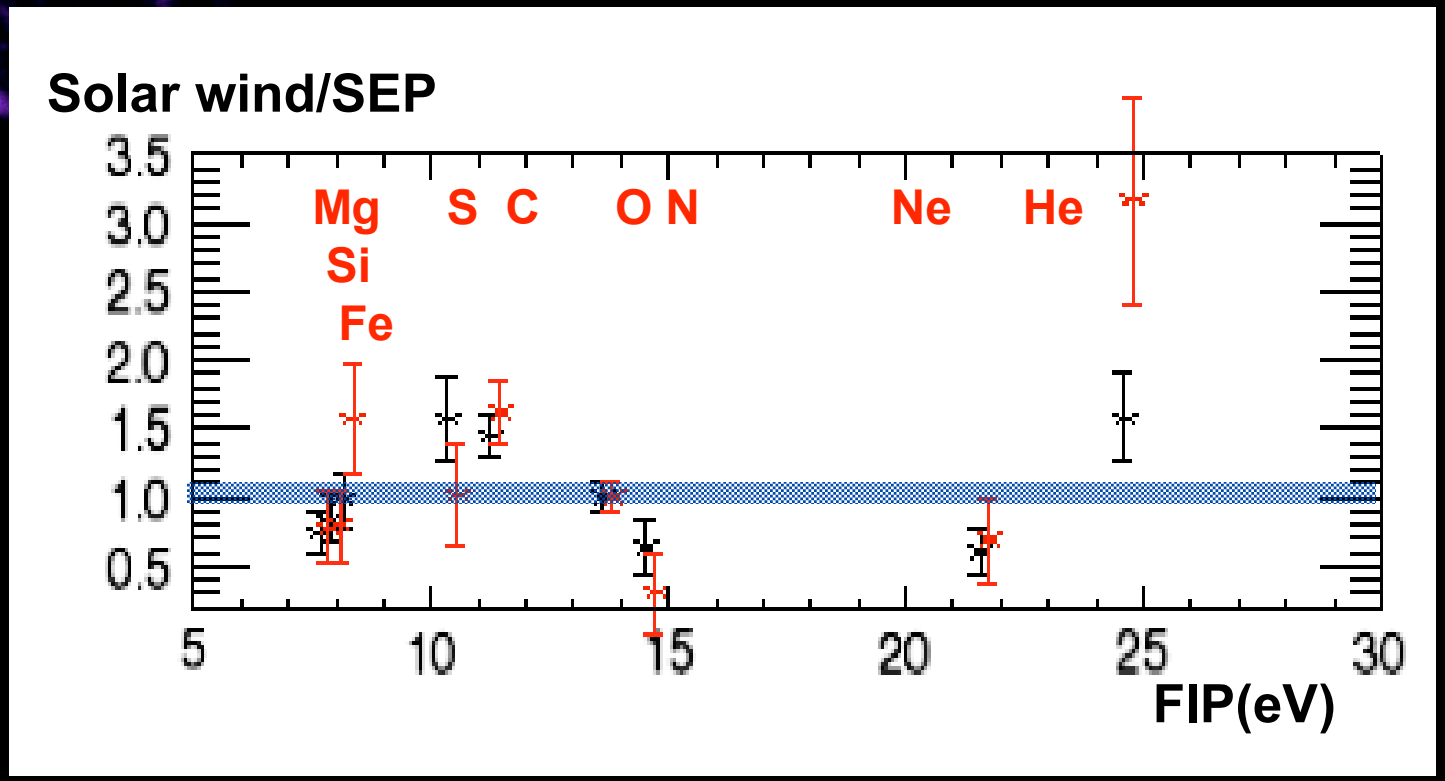
Zurbuchen et al., 2005

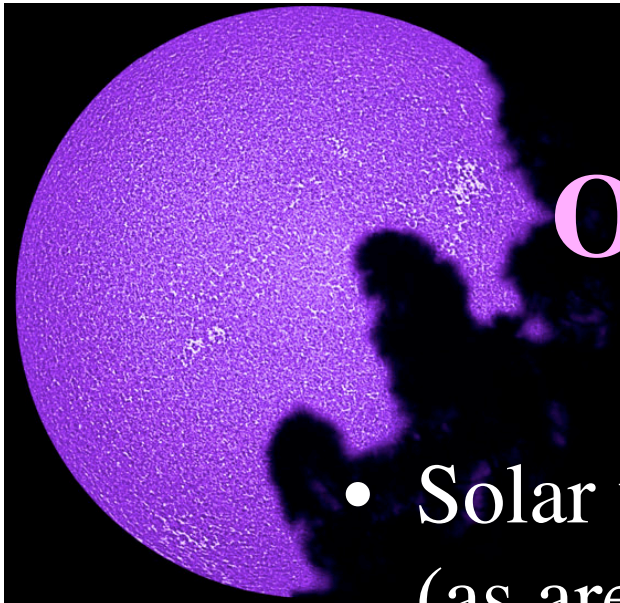
SEP comparison ?



For Discussion, see Mewaldt et al., 2003

High Tf and slow solar wind compared with SEPs

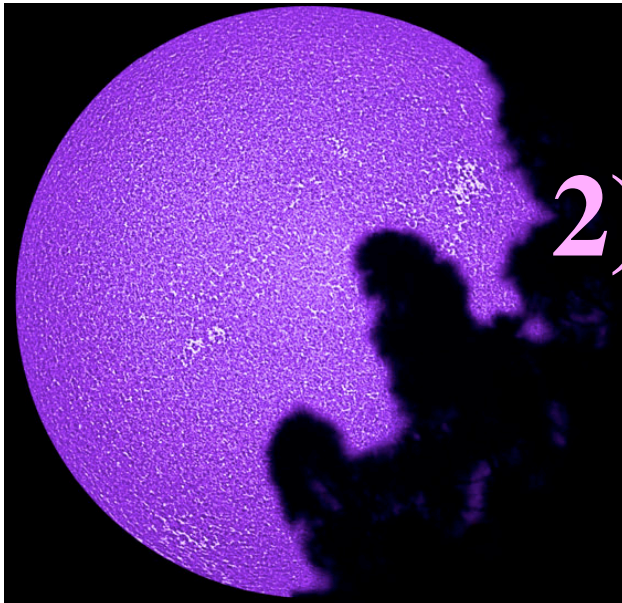




Observations

- Solar wind composition is very variable (as are SEPs)
- Variability appears to be systematic with Tf

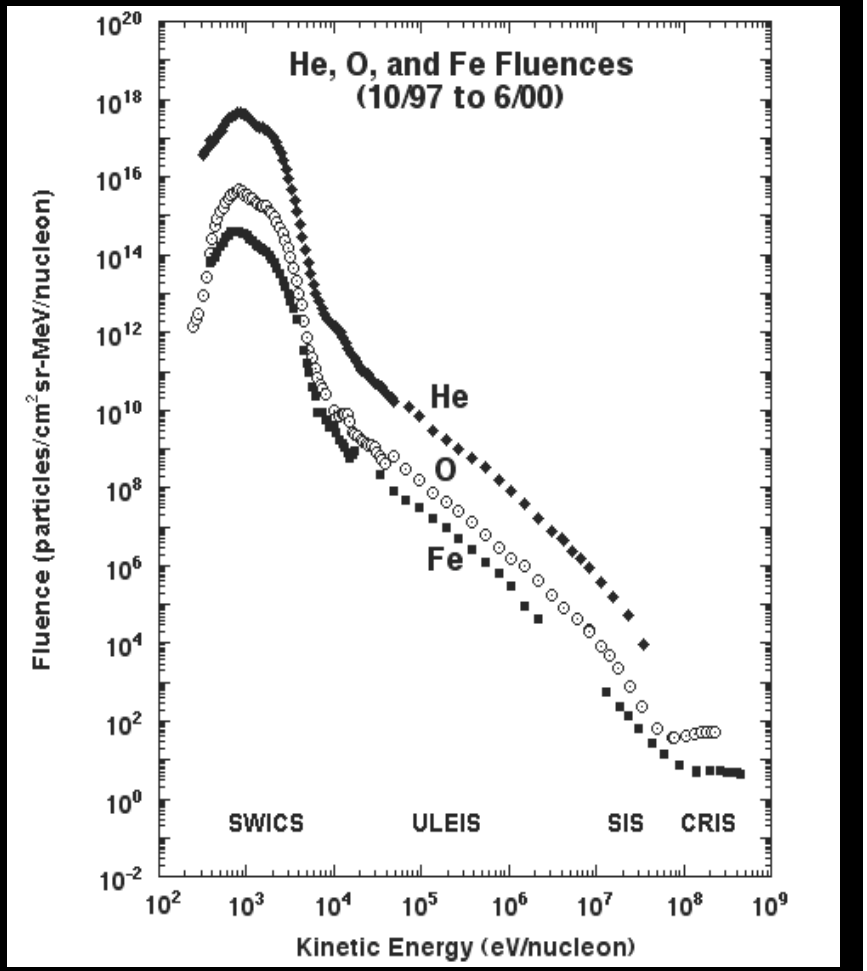
- If gradual SEPs are from solar wind – what particles does it pick out?



2) Suprathermals

Solar wind distribution

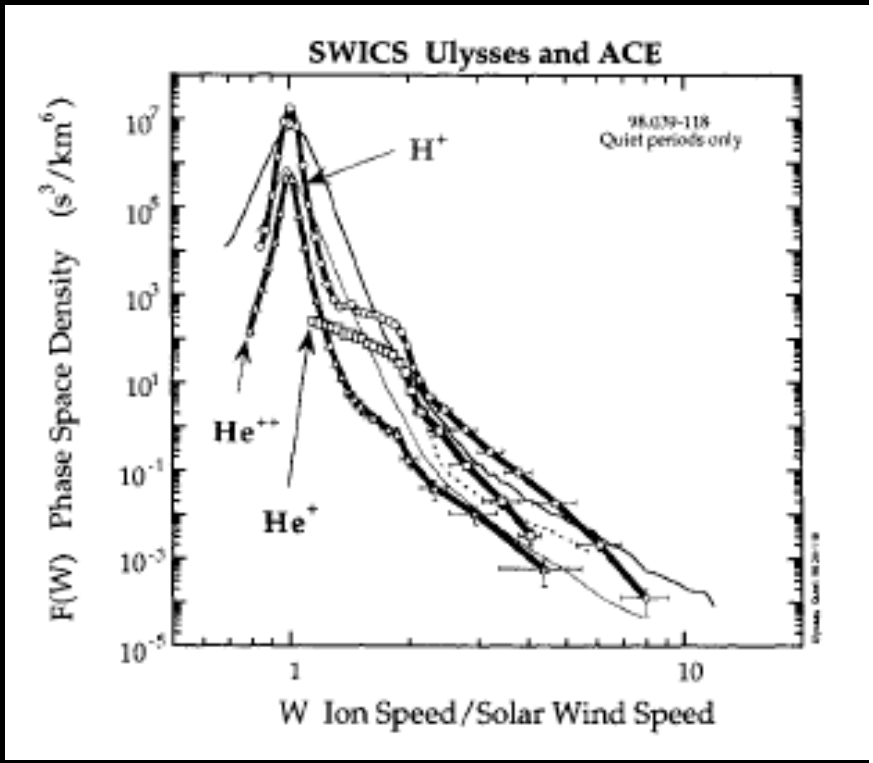
- Suprathermal particles: 5 – 100 keV/q
- Important link between solar wind and SEPs.



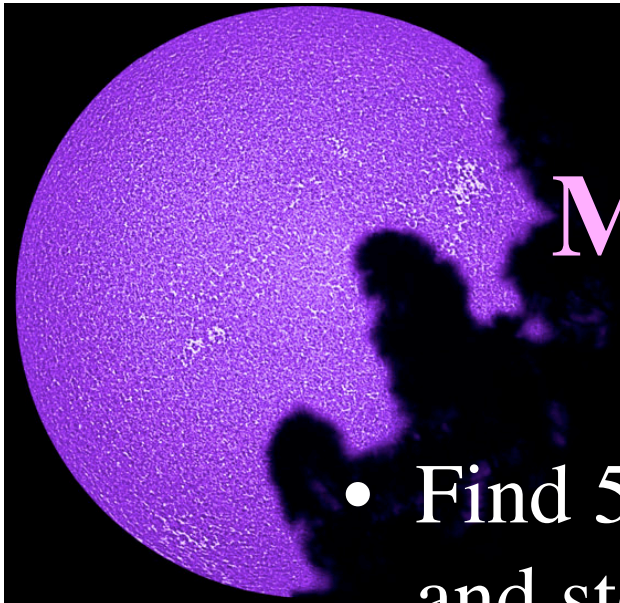
Mewaldt et al., 20002

Solar wind vs pickup ions

- For H and He
  - Pickup ion source is strong at high heliocentric distance
- Suprathermal characteristic "universal"

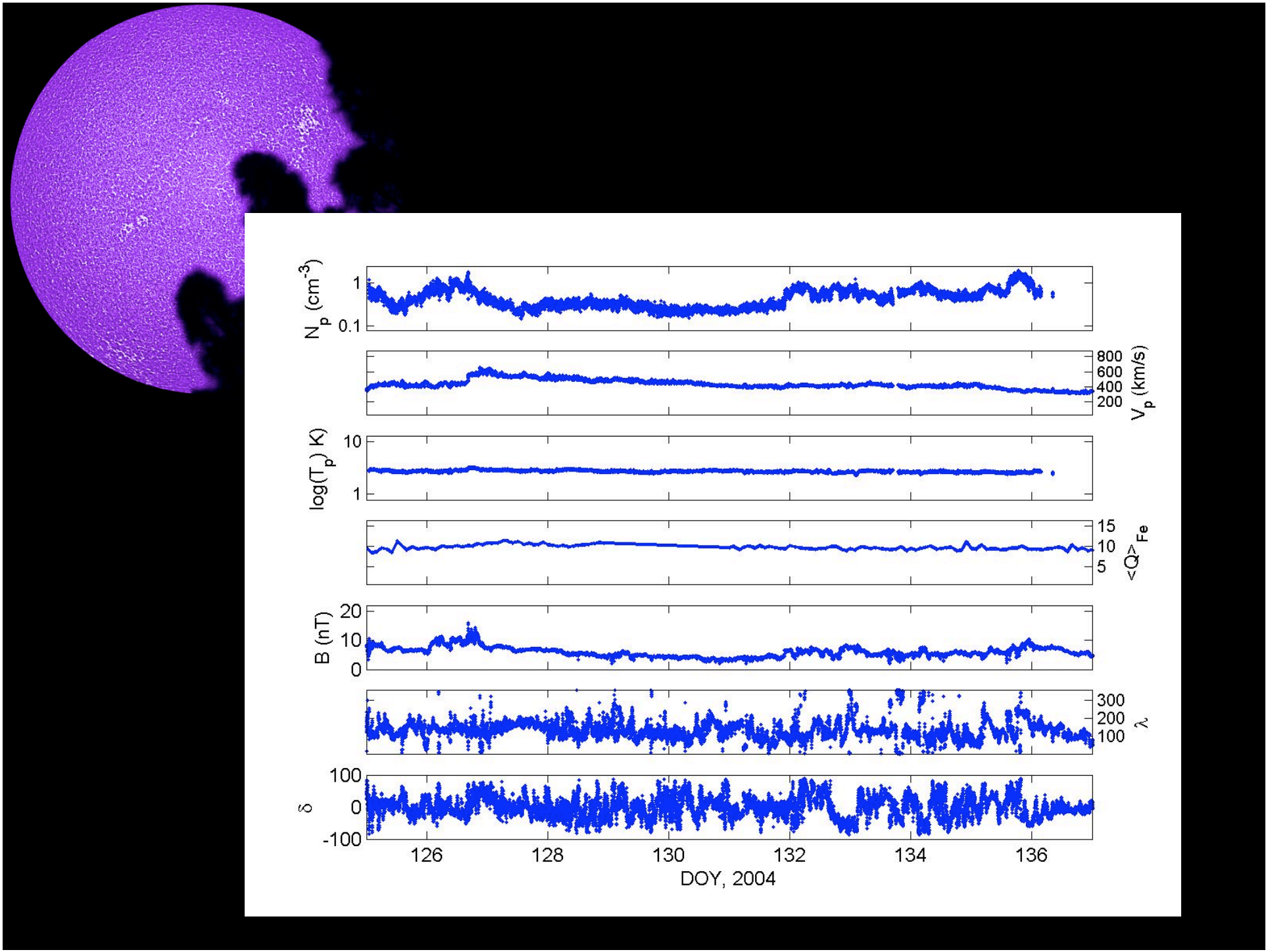


Gloeckler et al., 2000



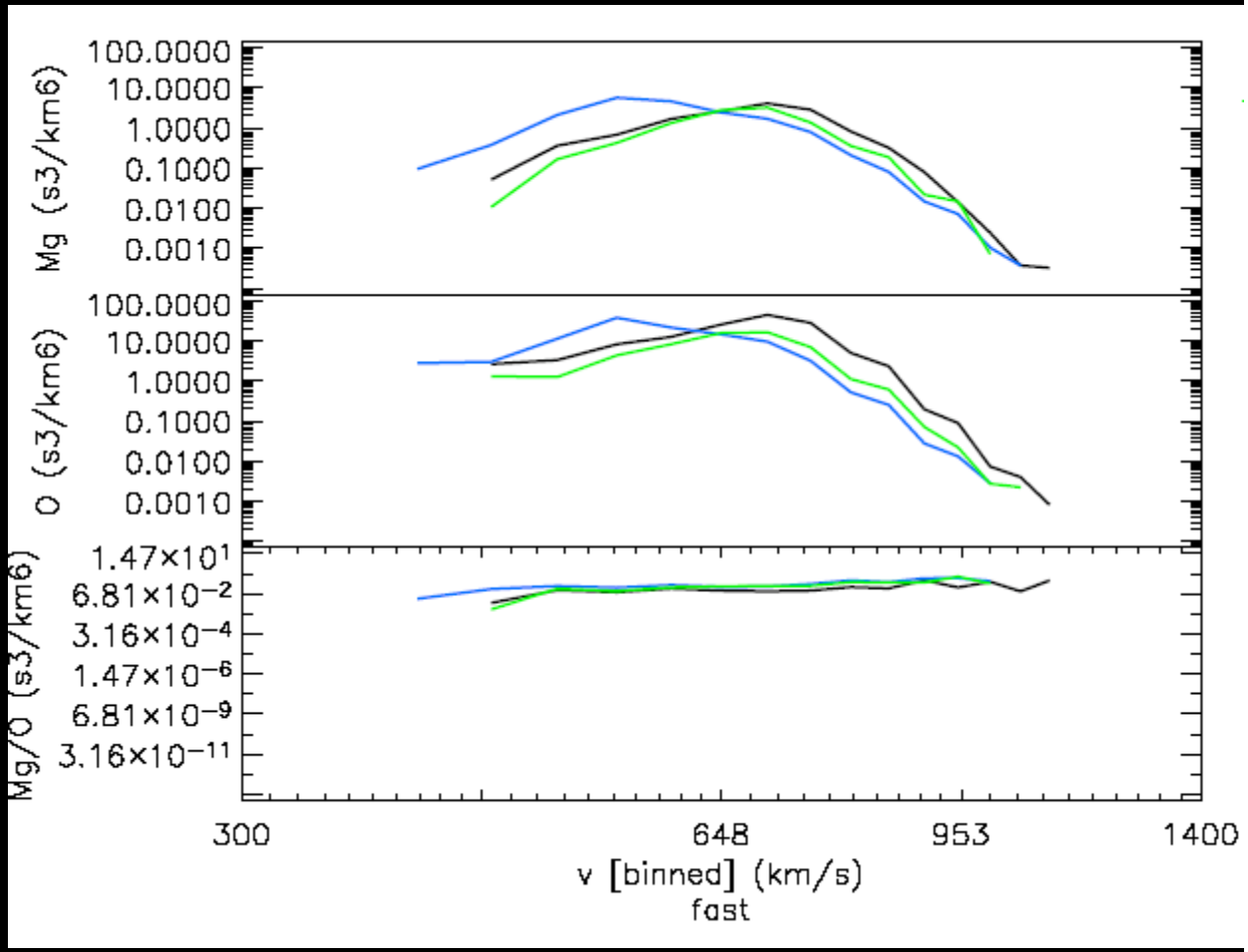
Methodology

- Find 5 or 10 day intervals of fast, slow and storm periods with rather “constant” composition
- Determine distribution functions for each of these intervals
- Calculate average compositions and ionic charge states

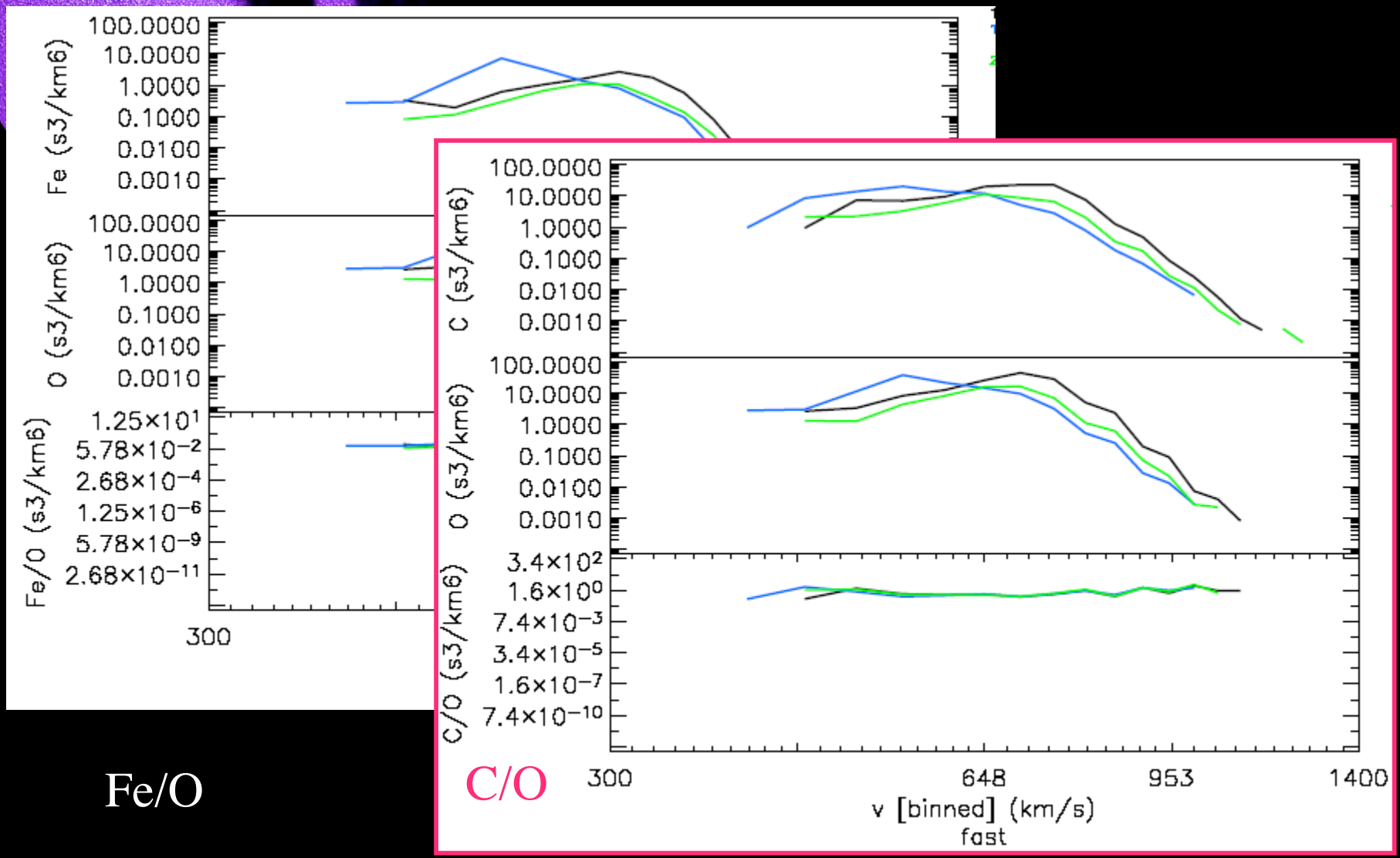

N_p (cm^{-3})
1
0.1
V_p (km/s)
800
600
400
200
log(T_p) K)
10
1
<Q>$_{Fe}$
15
10
5
B (nT)
20
10
0
λ
300
200
100
δ
100
0
-100
126
128
130
132
134
136
DOY, 2004

Fast wind

- Used 10 day averages
- Few supra-thermals
- Mg/O relatively constant



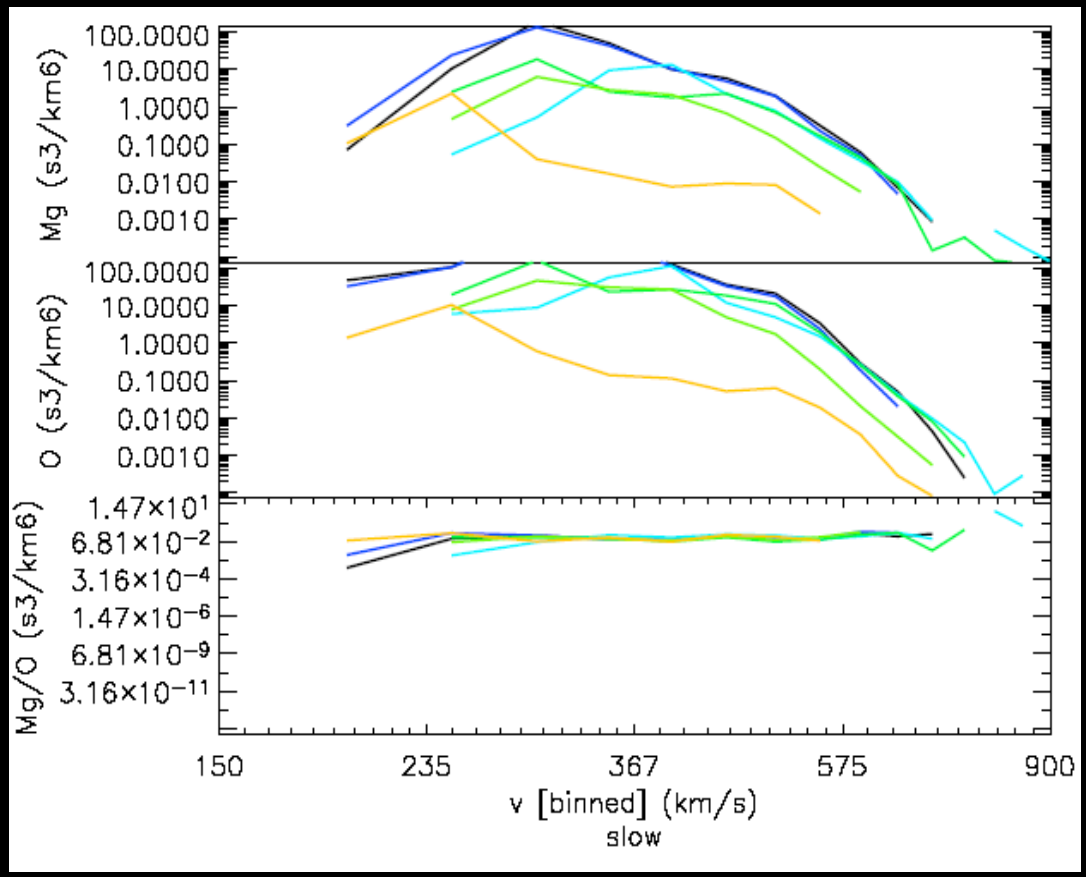
Fast, 2


Fe (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
O (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
Fe/O (s3/km6)
1.25×10^1
5.78×10^-2
2.68×10^-4
1.25×10^-6
5.78×10^-9
2.68×10^-11
300
C (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
O (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
C/O (s3/km6)
3.4×10^2
1.6×10^0
7.4×10^-3
3.4×10^-5
1.6×10^-7
7.4×10^-10
300
648
953
1400
v [binned] (km/s)
fast

Fe/O

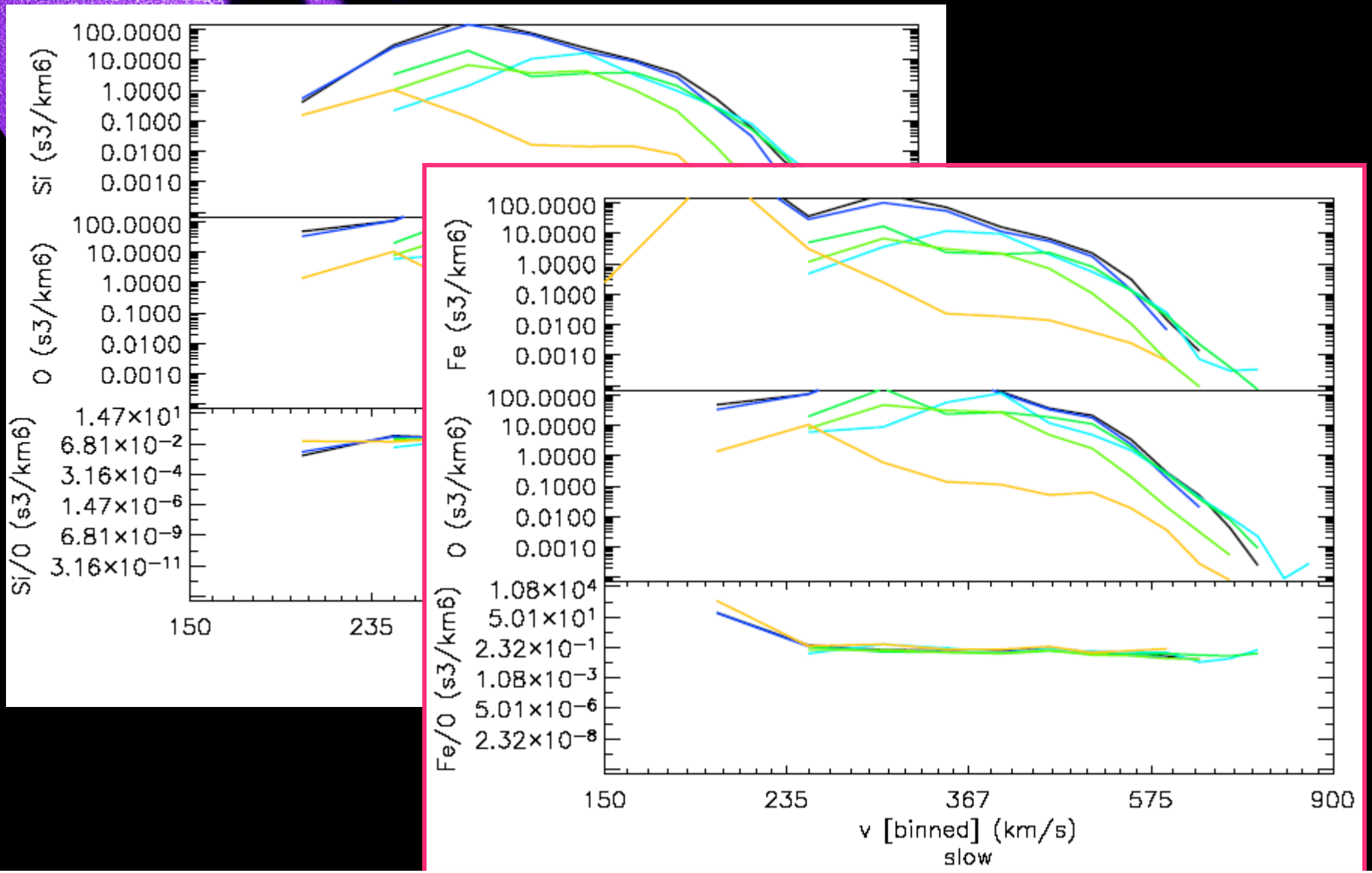
C/O

Slow solar wind



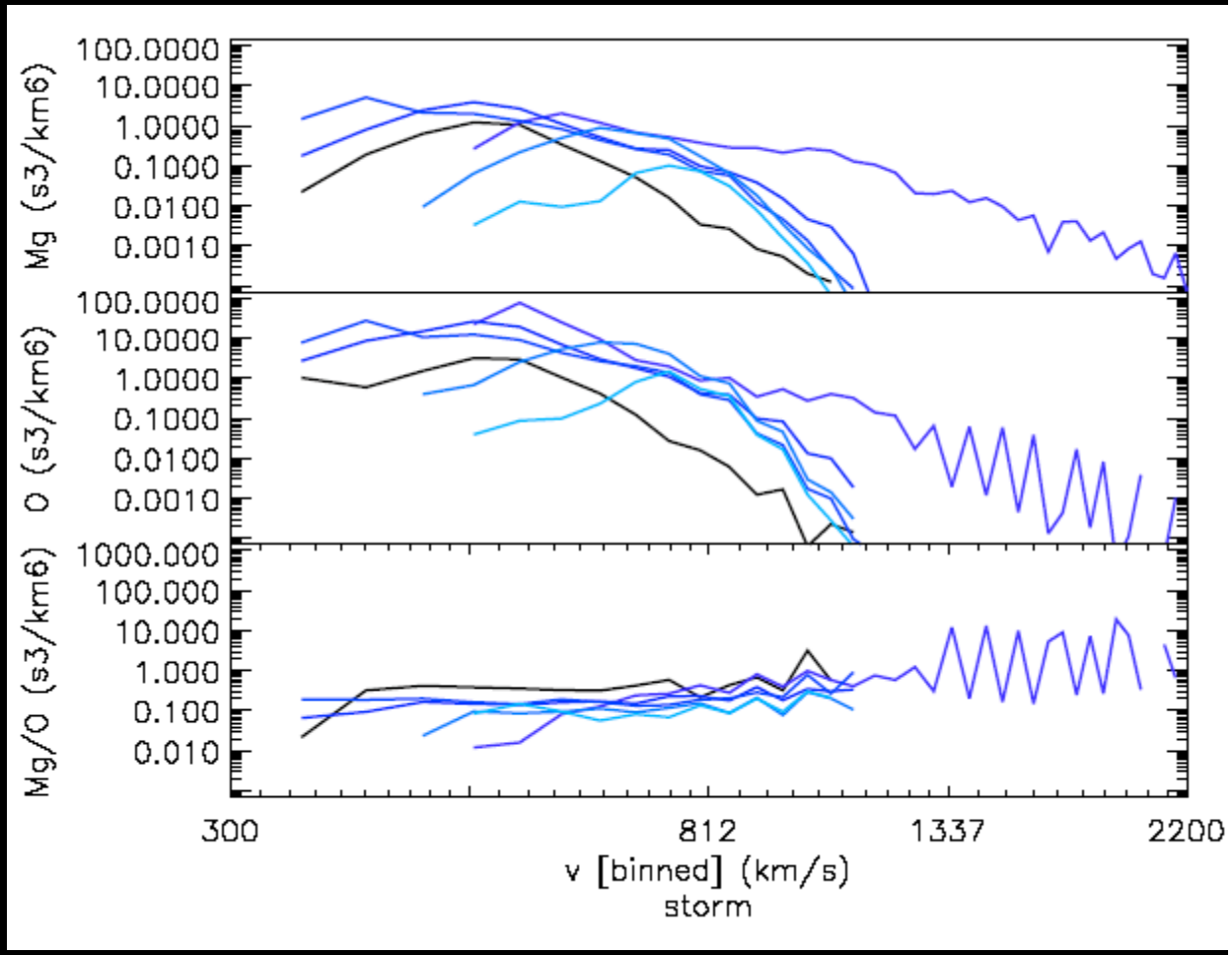
- Suprathermal characteristics
- Slight dependence in Mg/O

Slow, 2

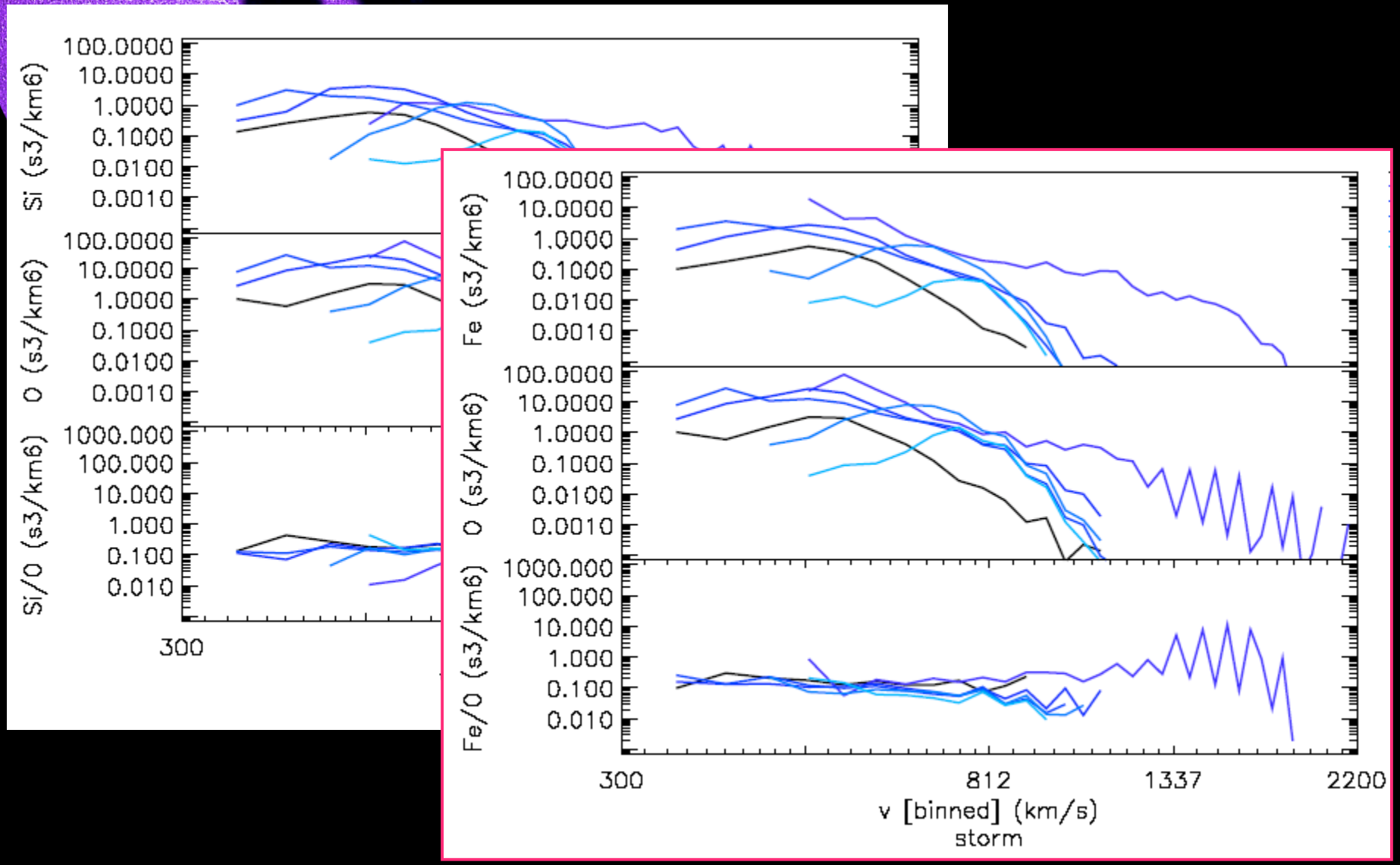

Si (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
O (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
Si/O (s3/km6)
1.47×10^1
6.81×10^-2
3.16×10^-4
1.47×10^-6
6.81×10^-9
3.16×10^-11
150
235
Fe (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
O (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
Fe/O (s3/km6)
1.08×10^4
5.01×10^1
2.32×10^-1
1.08×10^-3
5.01×10^-6
2.32×10^-8
150
235
367
575
900
v [binned] (km/s)
slow

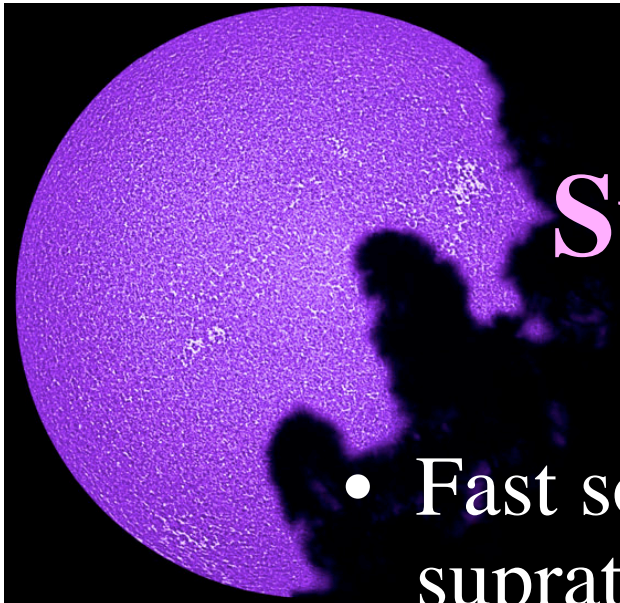
Storm times

- Has suprathermal character
- Mg/O increases with energy



Storms, 2


Si (s3/km6)
O (s3/km6)
Si/O (s3/km6)
Fe (s3/km6)
O (s3/km6)
Fe/O (s3/km6)
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
1000.000
100.000
10.000
1.000
0.100
0.010
300
812
1337
2200
v [binned] (km/s)
storm



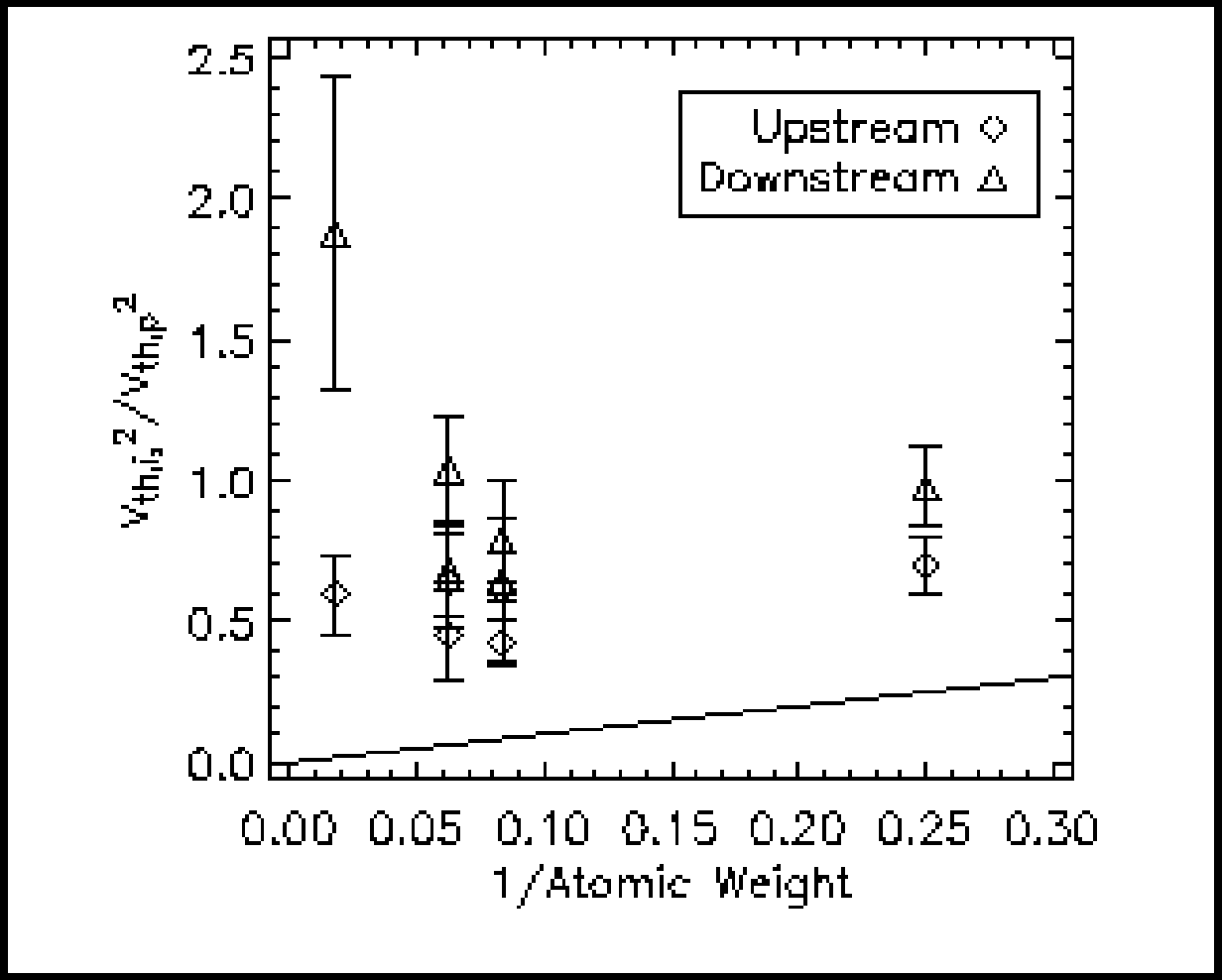
Suprathermals

- Fast solar wind does not exhibit strong suprathermal behavior, slow does.
- Slow and slow solar wind do not show systematic energy dependence of composition
- Storm times show familiar fractionation patterns – become more Fe, Si rich at high energy

Shock heating

Lowest energy

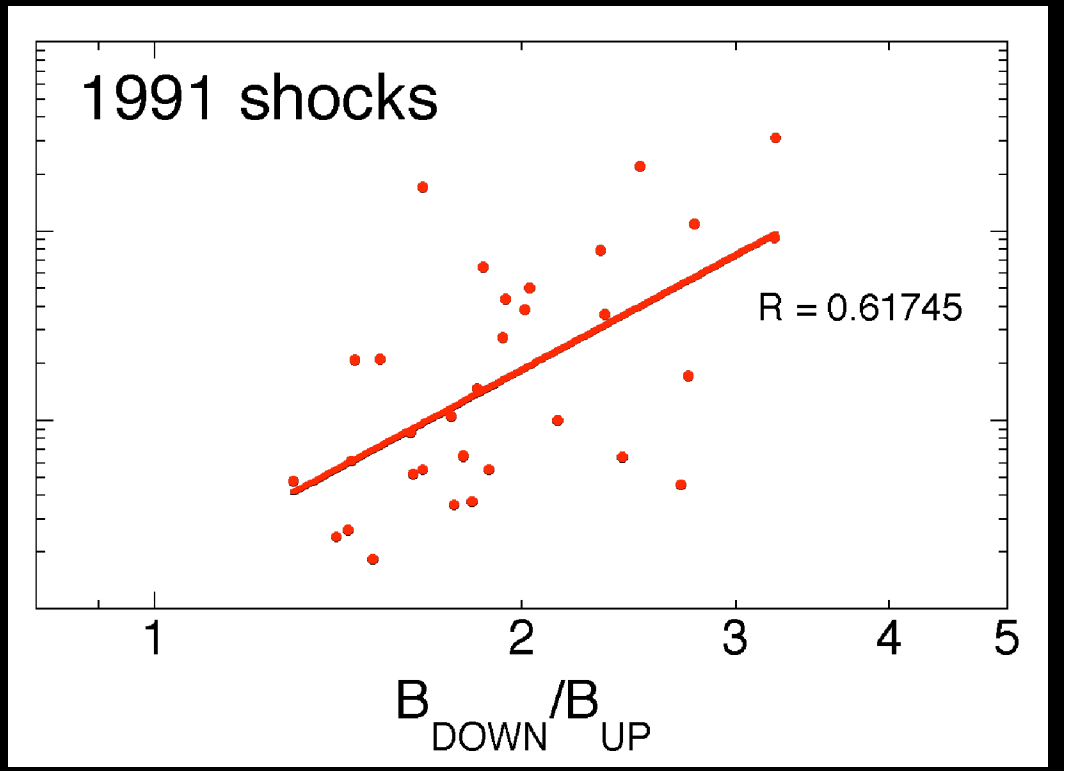
- We never start in equilibrium!



Korreck et al., 2005

Shock effects

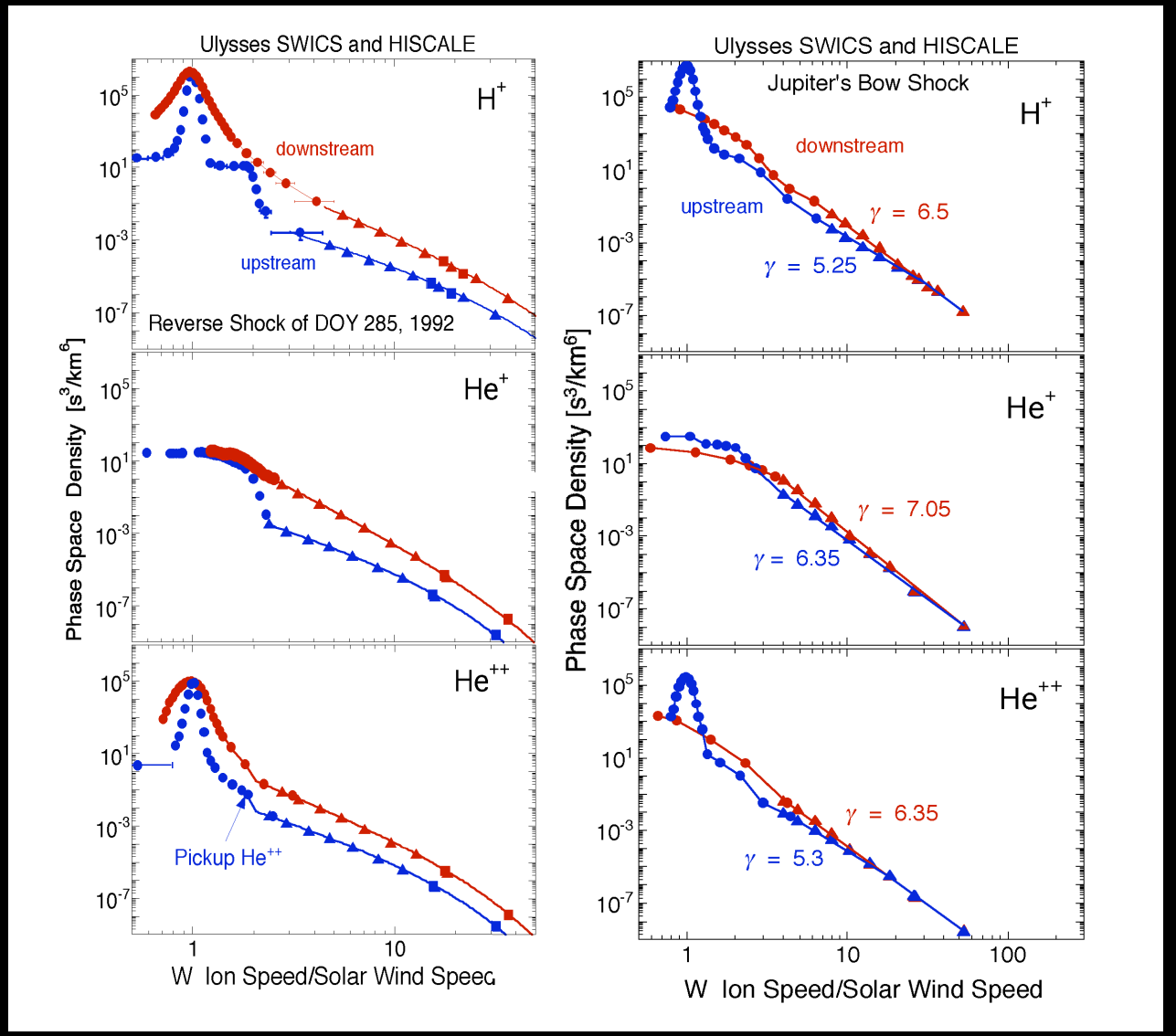
- Acceleration efficiency in 6-60 keV protons



Gloeckler et al., 2005

Shock heating

- Mostly at low energies
- Spectral shapes approx. unchanged.



Summary

- Quiet time solar wind from 1 AU to 5 AU
  - Harder spectrum for larger heliosph. Dist.