Elargissement thermique des faisceaux alignés dans le pré-choc terrestre

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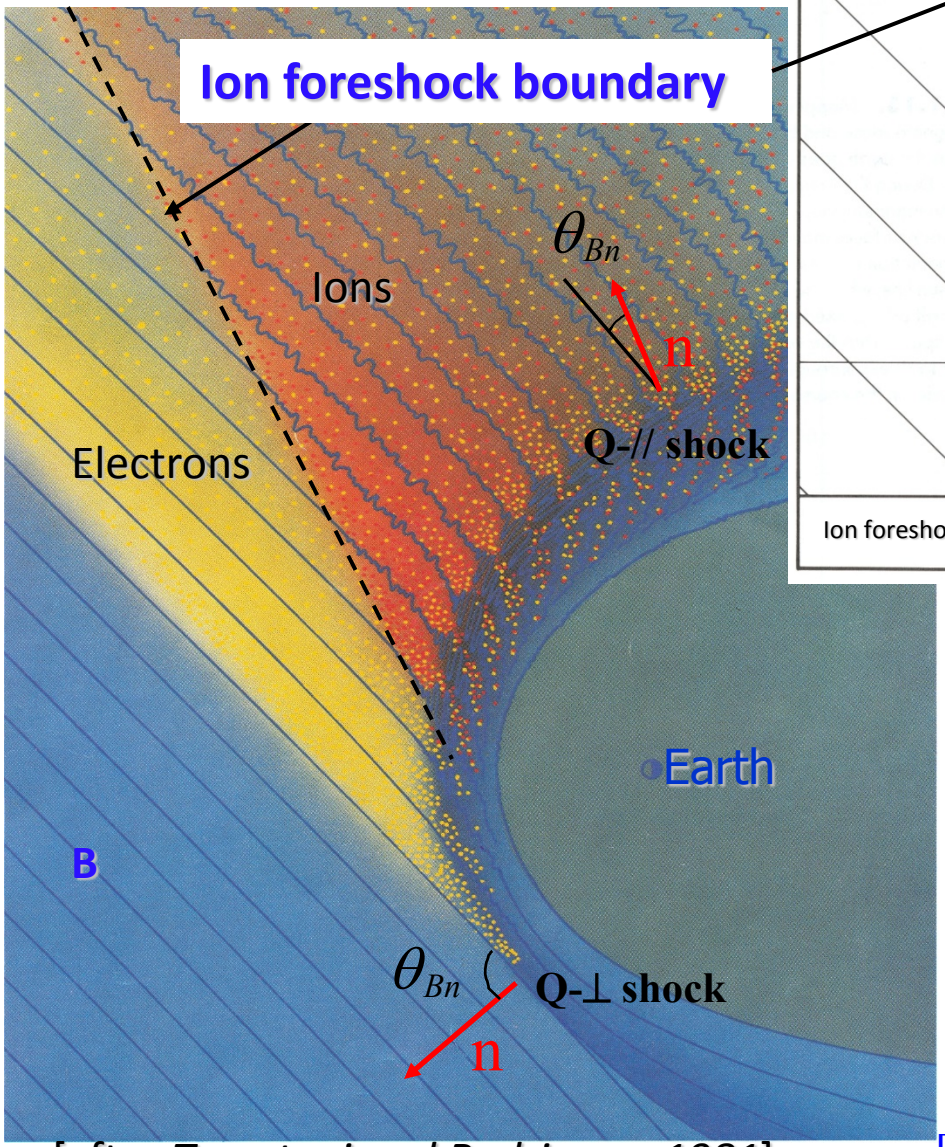
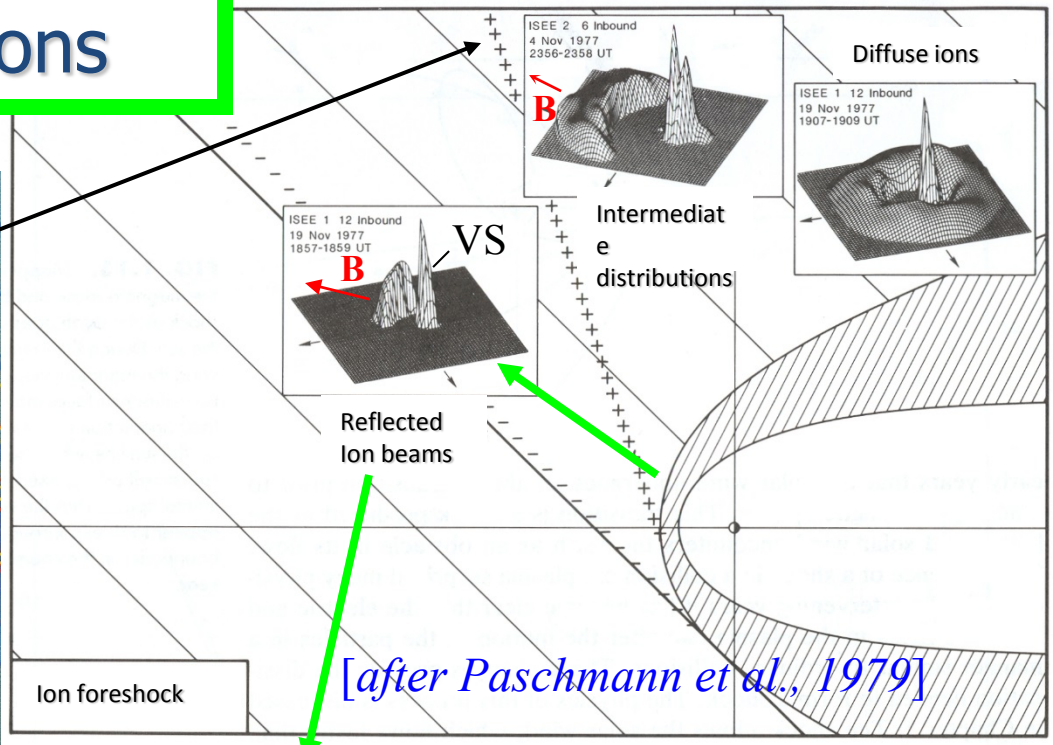
Résumé

L'élargissement thermique des faisceaux alignes d'ions observés en amont de l'onde de choc terrestre est étudié pour la première fois de manière exhaustive a partir des mesures de l'expérience CLUSTER/CIS. Ces élargissements thermiques sont tirés de l'analyse des fonctions de distributions des ions. Typiquement, les fonctions de distributions réduites f(Vpara) et f(Vperp) exhibent un profil quasi-maxwellien. Un fit maxwellien est alors utilisé pour déduire les températures parallèle et perpendiculaire des faisceaux. Les résultats obtenus montrent d'une part que les températures parallèles et perpendiculaire sont fortement corrélées avec la vitesse (ou la température) du vent solaire. D'autre part, plus le faisceau d'ion est rapide, plus il est chaud. Toutefois, c'est dans la direction perpendiculaire au champ magnétique que les élargissement sont les plus importants. L'analyse quantitative fournit des éléments primordiaux pour un quelconque mécanisme de production des faisceaux du pré-choc terrestre. L'anisotropie thermique observée pourrait relever d'un effet de turbulence afvénique (transverse) au niveau du choc.

Ion distributions

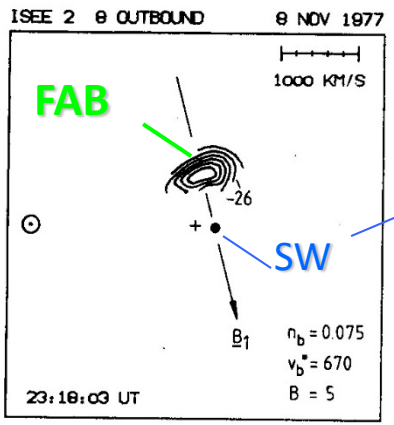


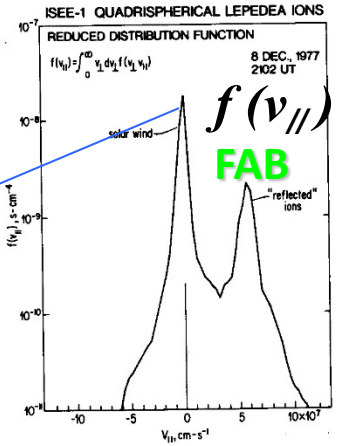
[after *Tsurutani and Rodriguez, 1981*]



[*after Paschmann et al., 1979*]

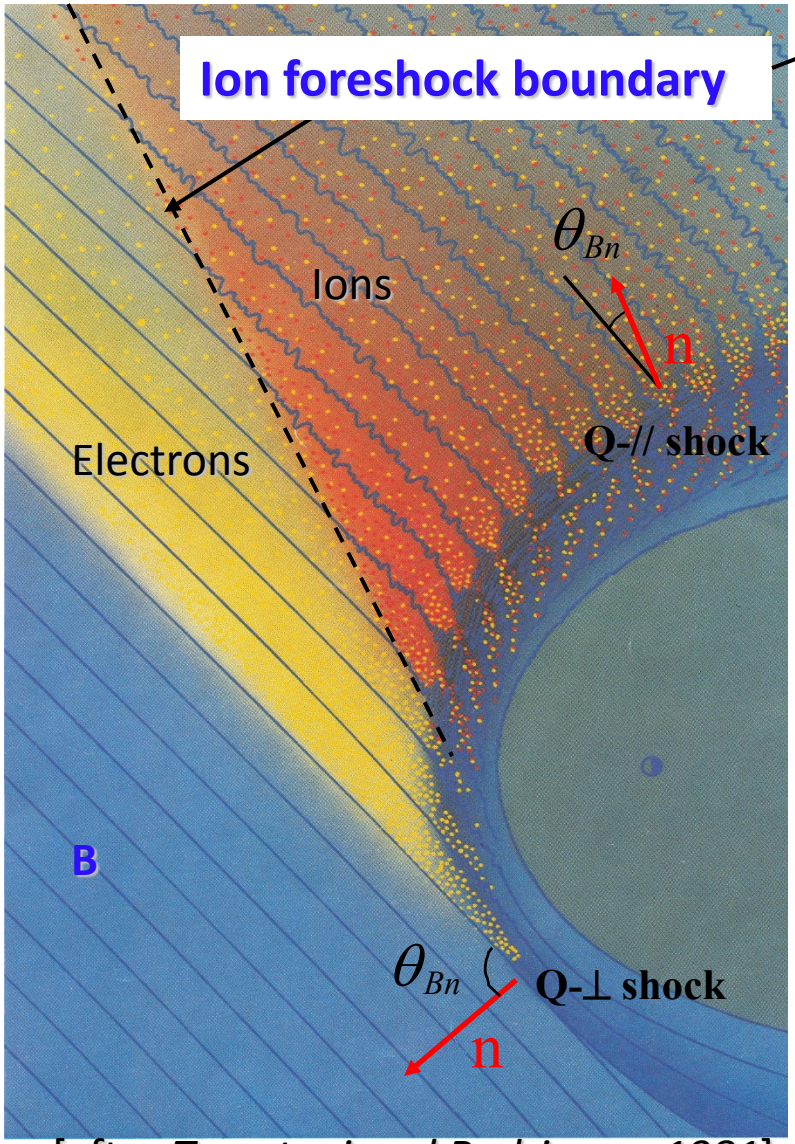
Field-aligned beams (FABs)





[*Paschmann et al., 1981*] [*Sentman et al., 1981*]

Ion distributions



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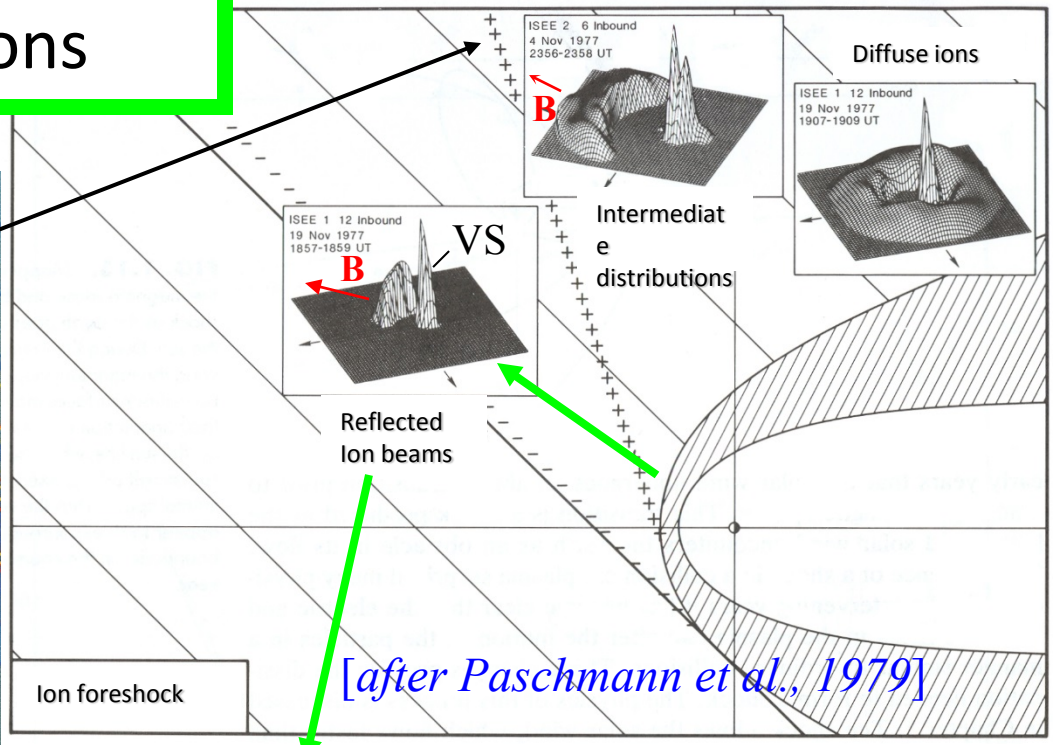
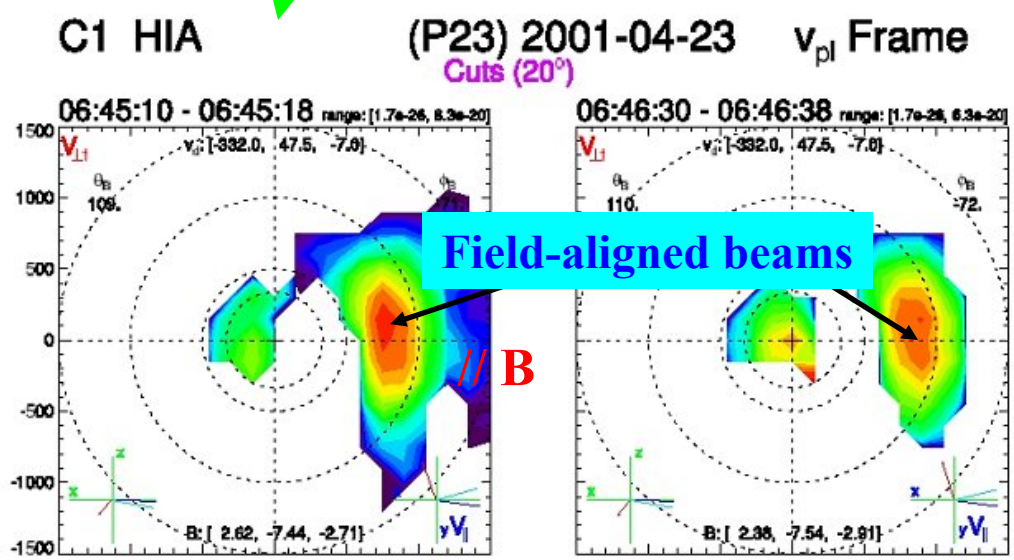


[*after Paschmann et al., 1979*]

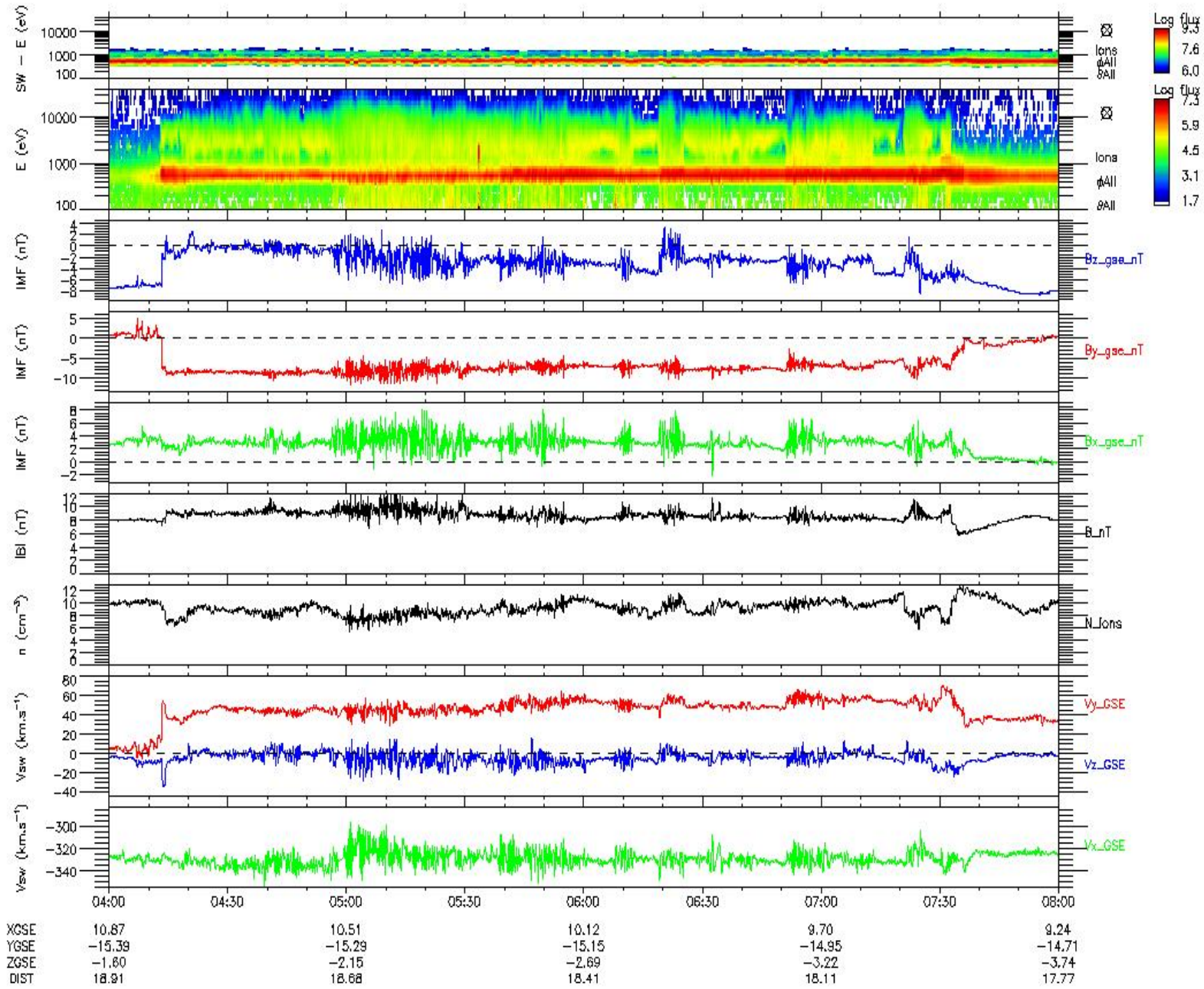


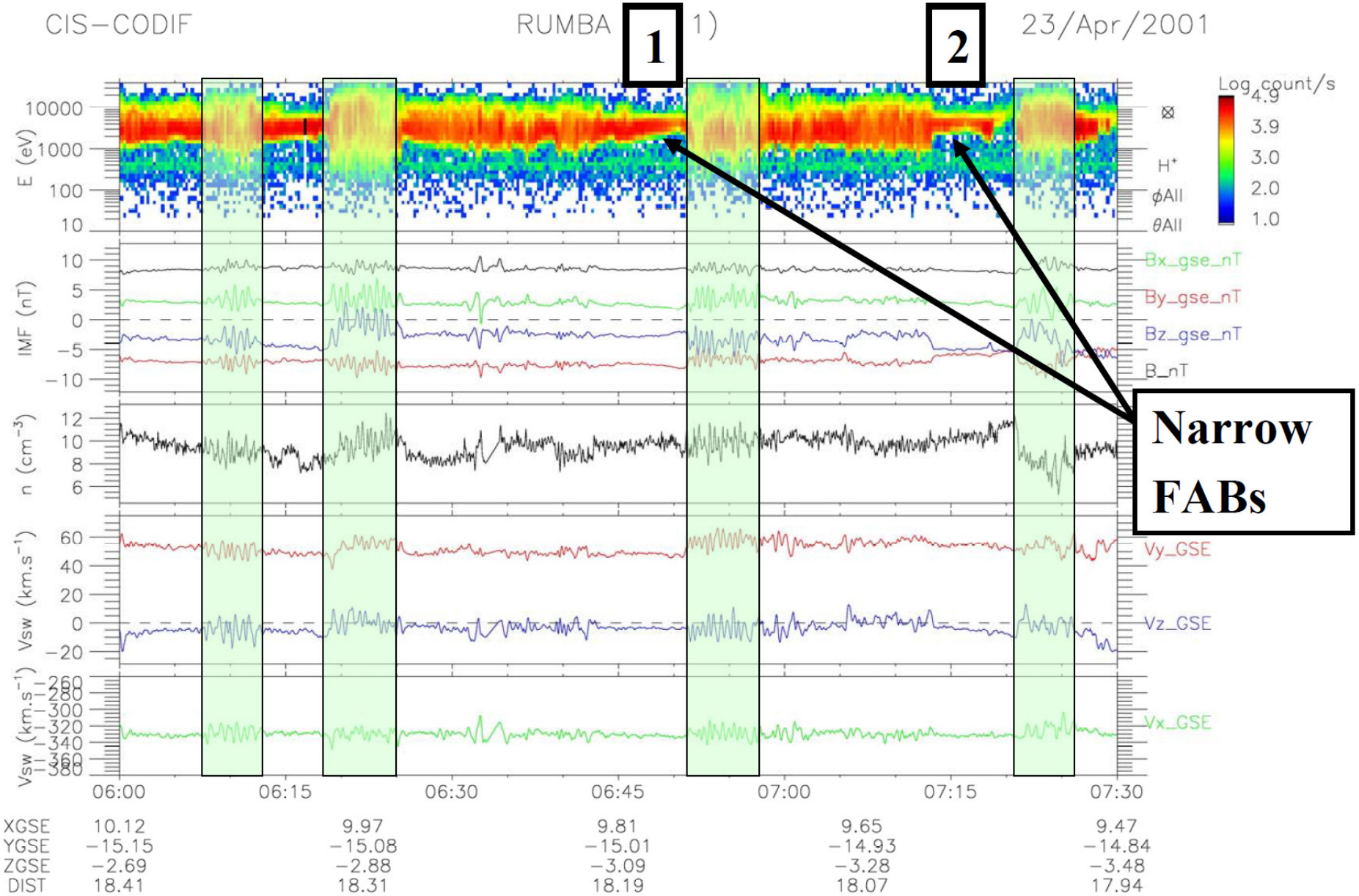
Cluster

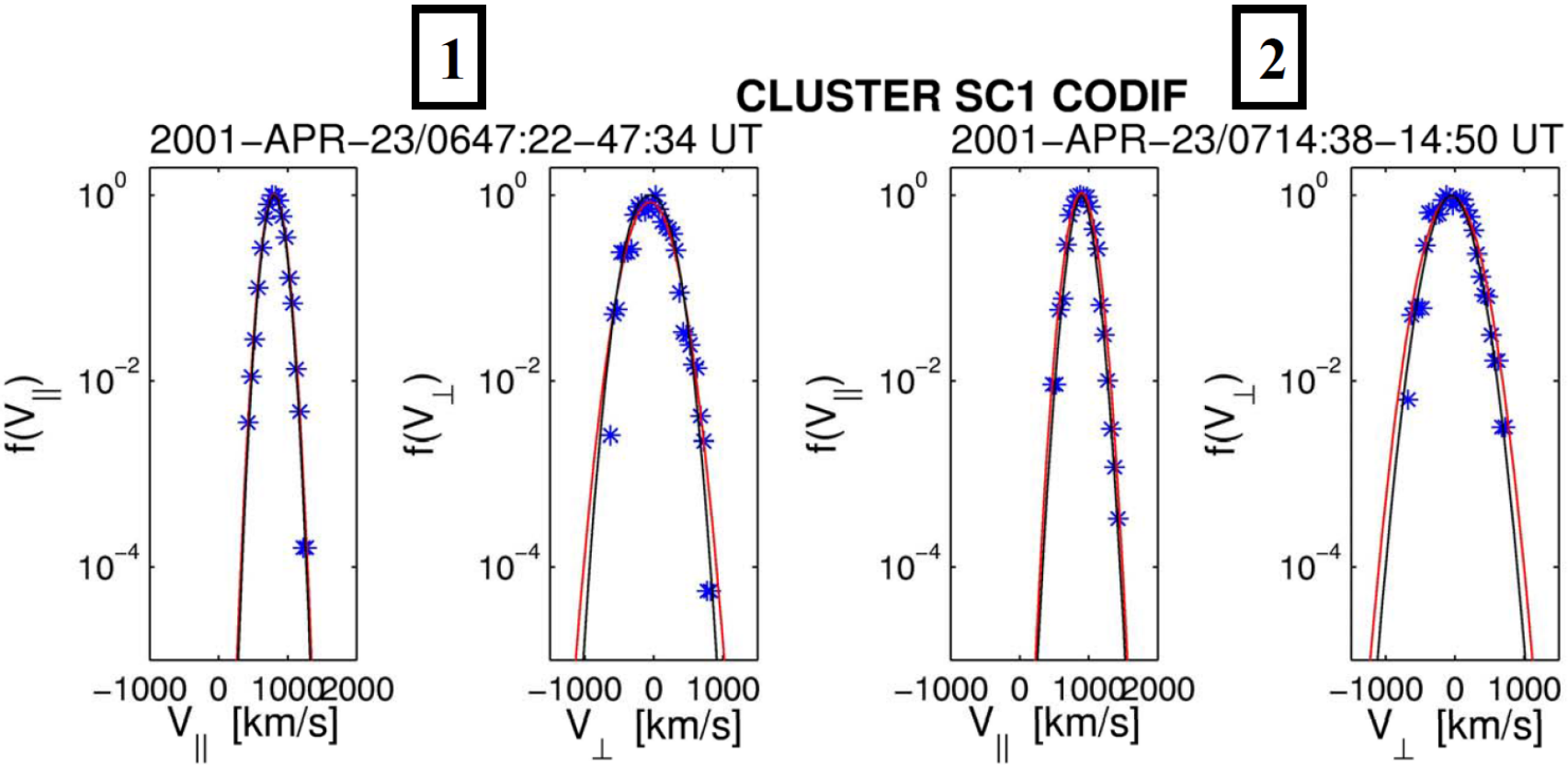
Mark Wilber, private communication

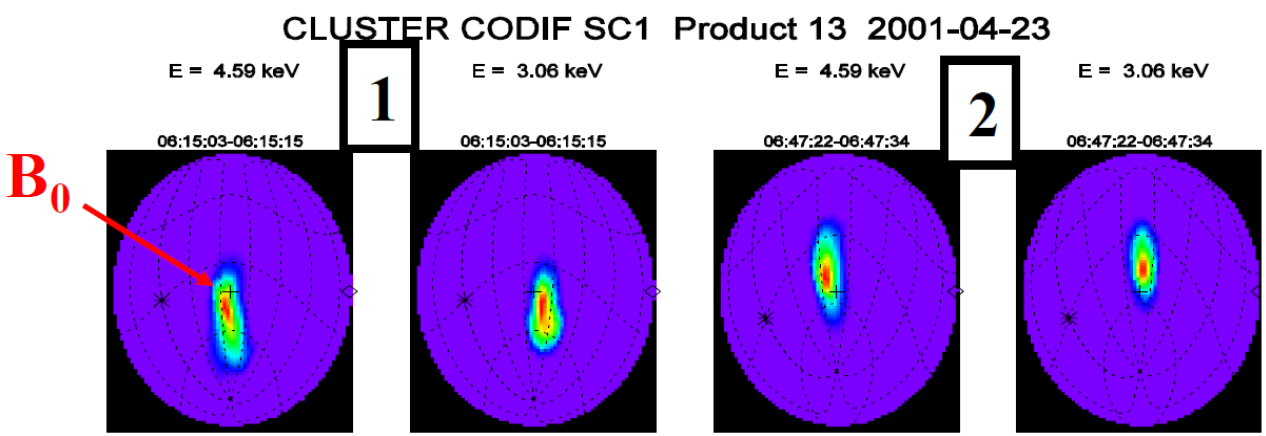
FAB Thermal Energy

- Not Investigated before.
- Relevance: Understanding the FAB production mechanism
- Parameters controlling the FAB thermal energy?
- What is the underlying mechanism for FAB thermal width?


CIS-HIA
RUMBA (SC 1)
23/Apr/2001
SW - E (eV)
E (eV)
Ions
φAll
θAll
Log flux
IMF (nT)
Bz_gse_nT
By_gse_nT
Bx_gse_nT
|B| (nT)
B_nT
n (cm⁻³)
N_Ions
Vsw (km.s⁻¹)
Vy_GSE
Vz_GSE
Vx_GSE
04:00
04:30
05:00
05:30
06:00
06:30
07:00
07:30
08:00
XGSE 10.87 10.51 10.12 9.70 9.24
YGSE −15.39 −15.29 −15.15 −14.95 −14.71
ZGSE −1.60 −2.15 −2.69 −3.22 −3.74
DIST 18.91 18.68 18.41 18.11 17.77


CIS−CODIF
RUMBA 1)
23/Apr/2001
1
2
Narrow FABs
E (eV)
10000
1000
100
10
Log count/s
4.9
3.9
3.0
2.0
1.0
H+
φAll
θAll
IMF (nT)
Bx_gse_nT
By_gse_nT
Bz_gse_nT
B_nT
n (cm−3)
Vsw (km.s−1)
Vy_GSE
Vz_GSE
Vx_GSE
06:00
06:15
06:30
06:45
07:00
07:15
07:30
XGSE 10.12 9.97 9.81 9.65 9.47
YGSE −15.15 −15.08 −15.01 −14.93 −14.84
ZGSE −2.69 −2.88 −3.09 −3.28 −3.48
DIST 18.41 18.31 18.19 18.07 17.94

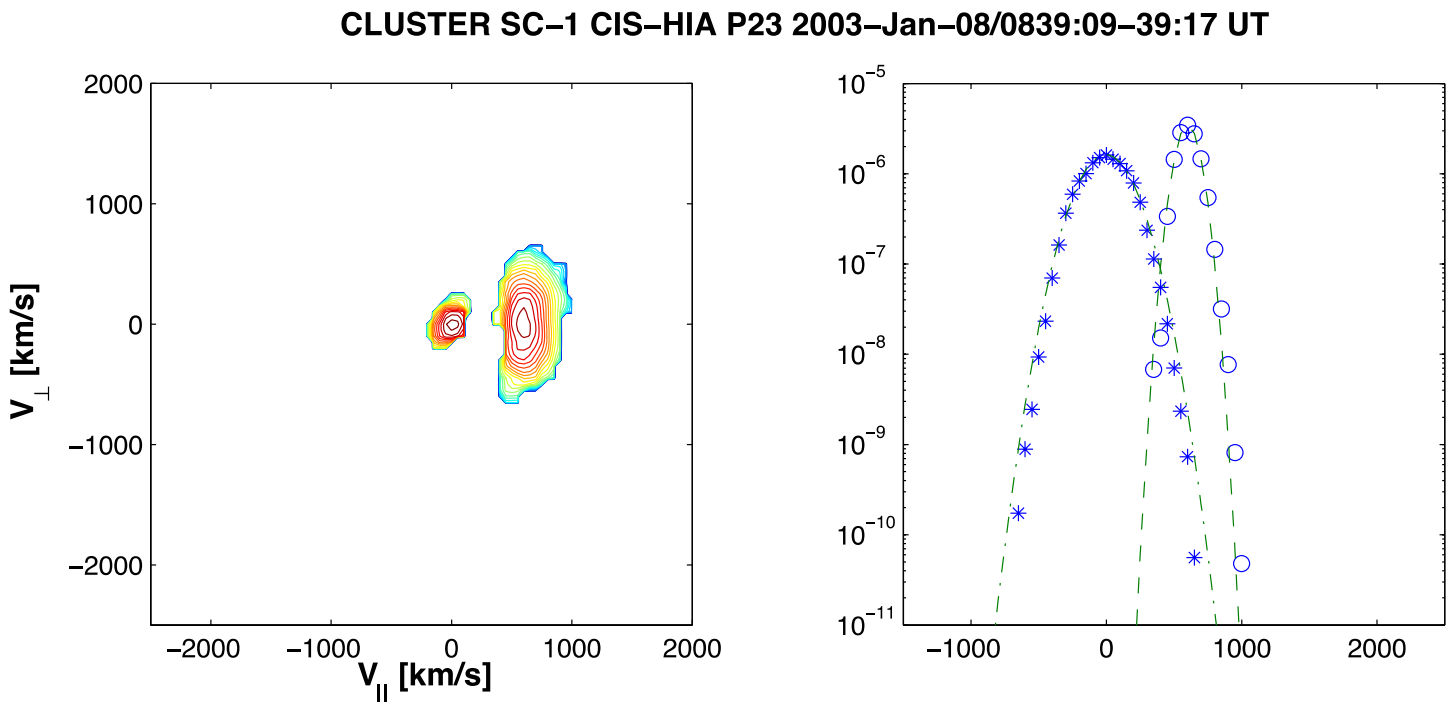




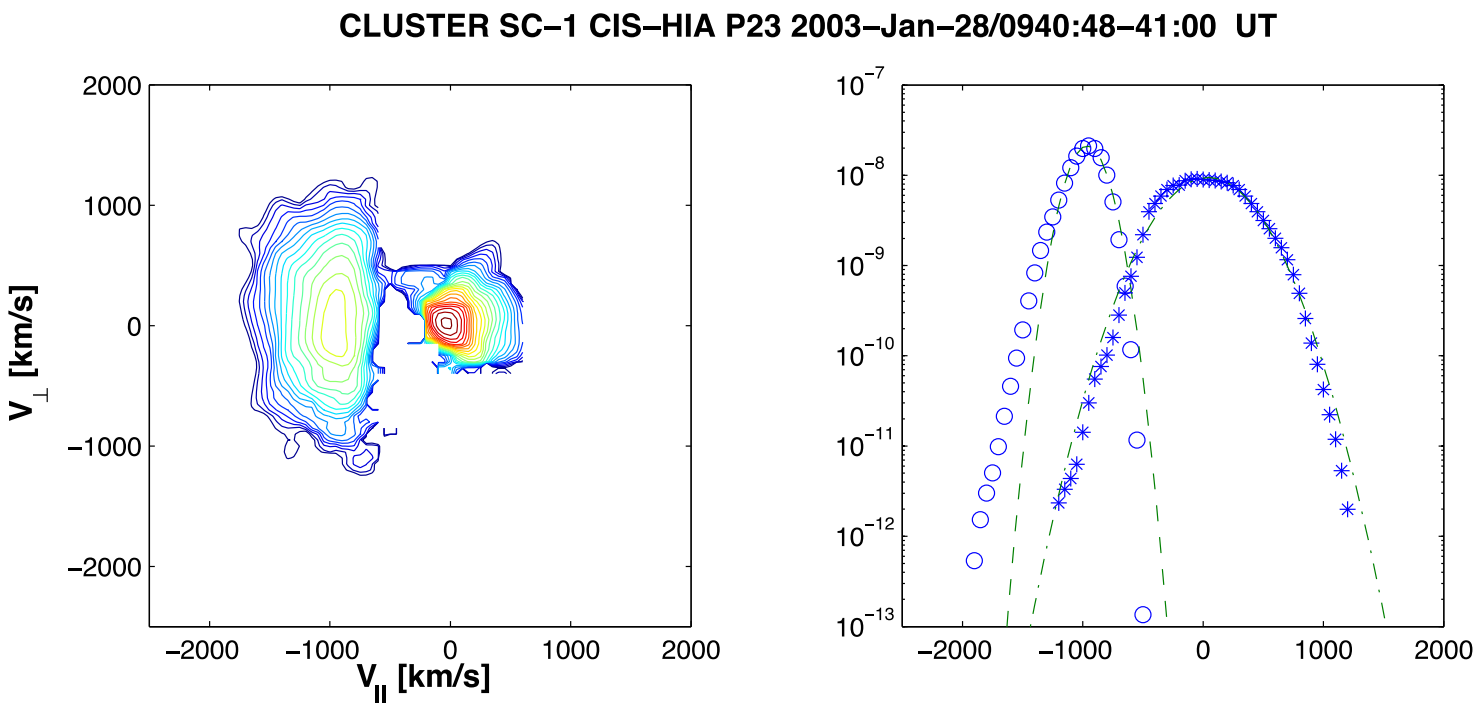
Maxwellian Fits

Field-aligned Protons

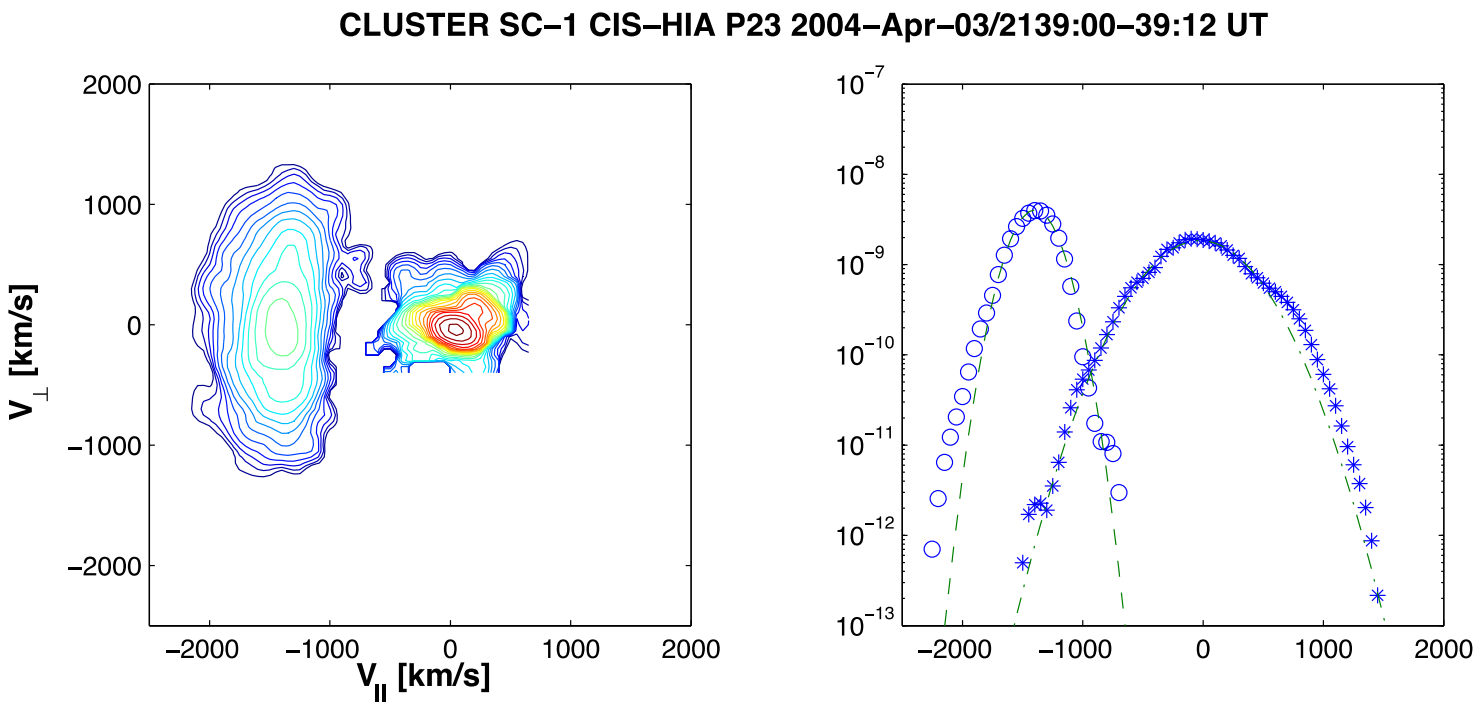
Slow solar wind (Vsw < 300 km/s)



Typical Solar Wind (Vsw ~ 420 km/s)

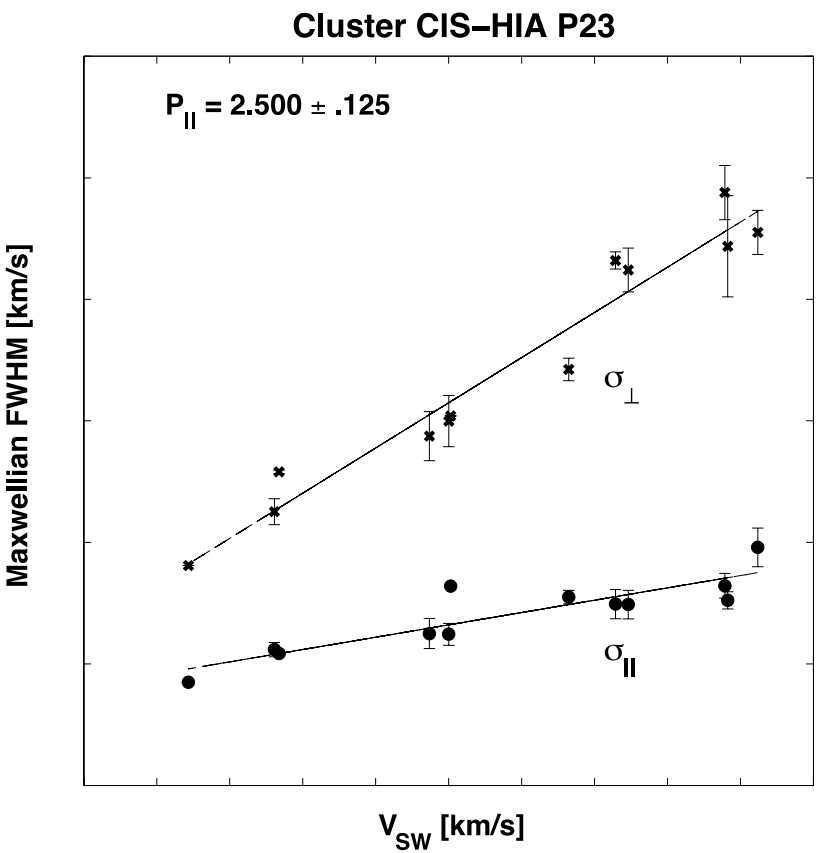


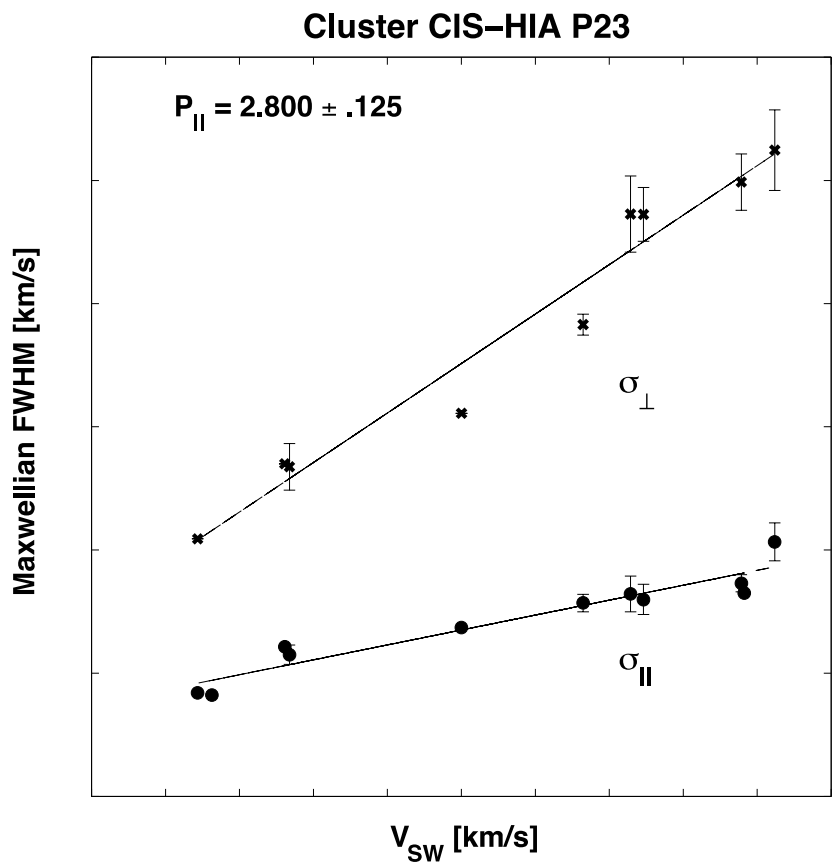
Fast Solar Wind (Vsw > 550 km/s)



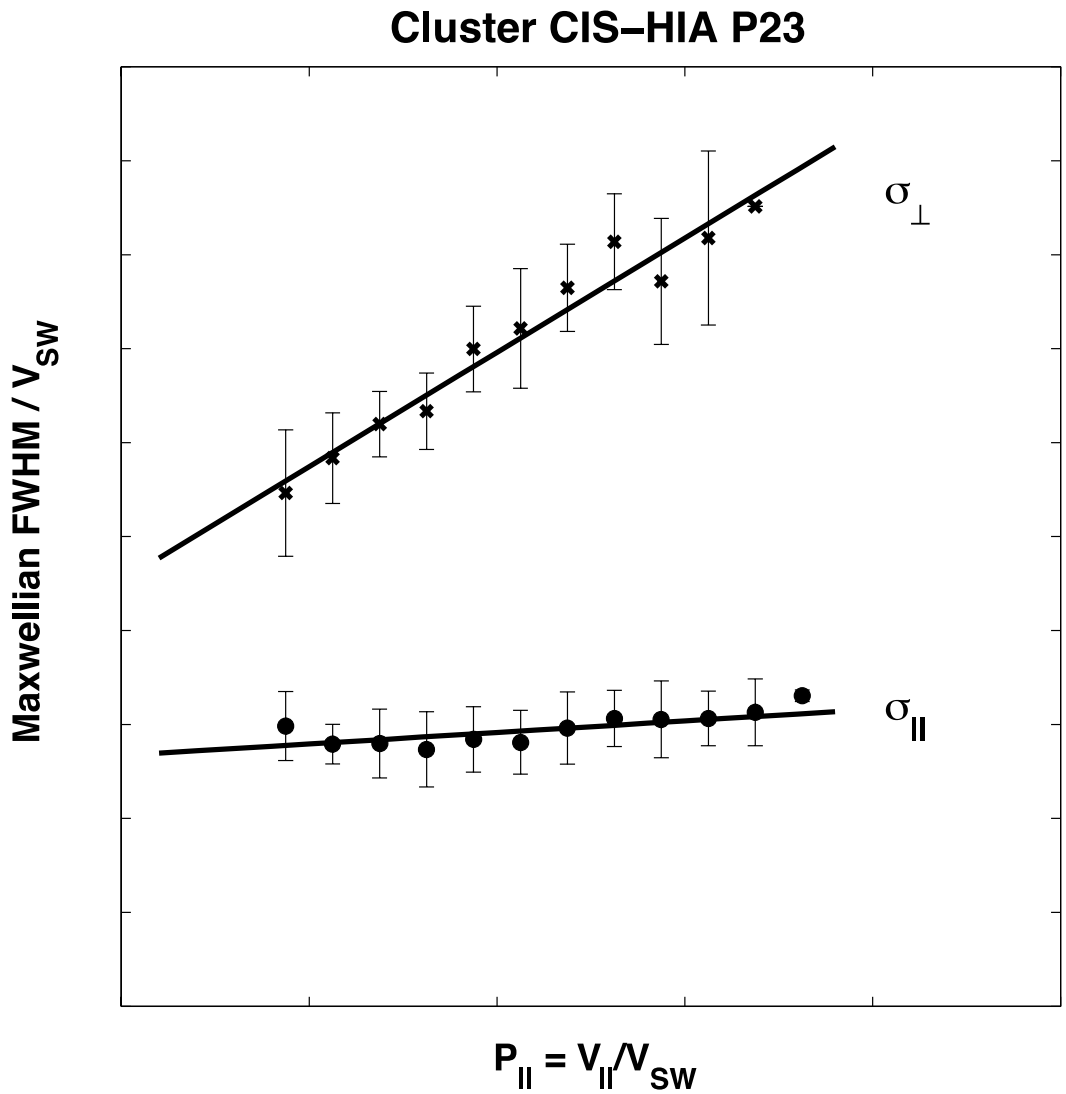
Correlation with SW speed

$$f_{Bulk}(v) = Ce^{-\left(\frac{v - v0}{\sigma\sqrt{2}}\right)^2}$$





Correlation with the Beam Speed



Discussion

- Strong constraints on FAB production mechanisms
- Current mechanisms fail to account for the observations:
  - Reflection: Thermal width ~ SW temperature
  - Leakage: Different correlations
  - Pitch angle scattering at the ramp: Faster beams are cooler.
- A possible mechanism: Alfven turbulence at the shock (?).