Observational Evidence of two Types of Field-Aligned Beams in the Foreshock Region

K. Meziane[1], M. Wilber[2], A. M. Hamza[1], C. Mazelle[3], H. Kucharek[4], H. Reme[3], A. Balogh[5]

[1] *University of New-Brunswick, Fredericton*

[2] *Space Sciences Laboratory, Berkeley*

[3] *Centre d'Etude Spatiale Des Rayonnements, Toulouse*

[4] *University of New-Hampshire, Durham*

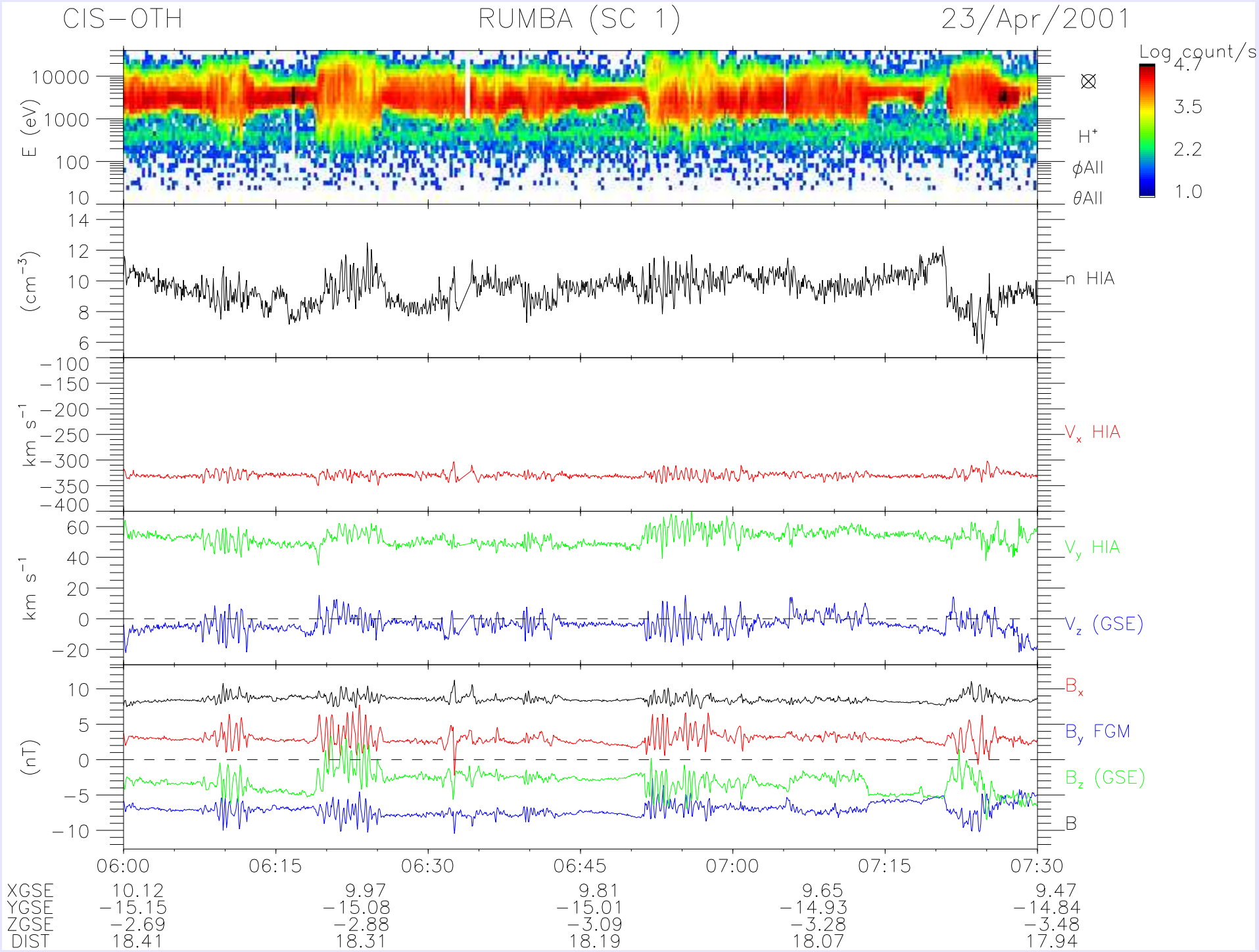
[5] *Imperial College, London*

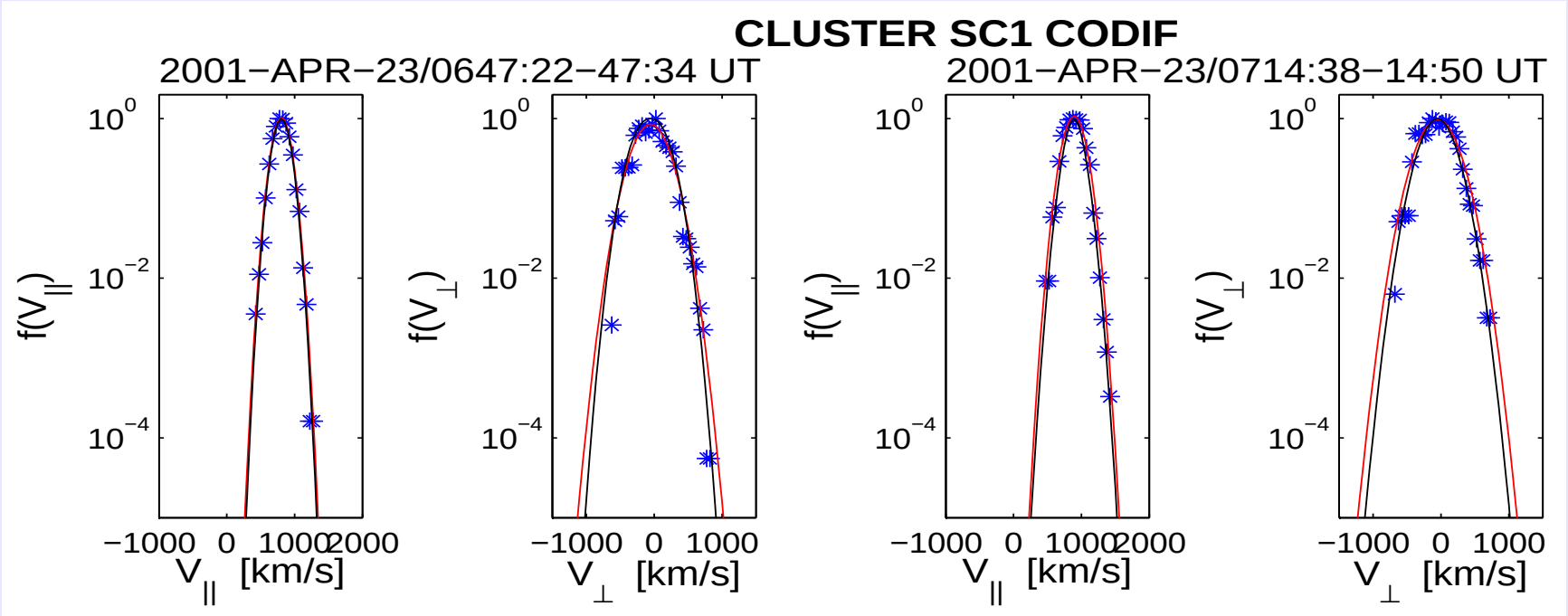
ABSTRACT- A significant number of Field-Aligned Beams (FABs) observed upstream of the Earth's bow shock by the Cluster-CIS experiment are examined in detail. In agreement with previous established results, no ULF waves are present in association with these FABs. The detailed analysis of parallel and perpendicular reduced distribution functions clearly indicates that the FABs could be classified into two types. In a first type, the reduced distribution function is remarkably well fit by a maxwellian functional form. The associated parallel temperature is typically in the order of ~150 km/s, independent of the angle θ_{Bn} between the local shock normal and the magnetic field direction, in agreement with recent results [*Wilber et al.*, 2005].

In the second class of FABs, the peak and the lower energy part of the parallel reduced distribution could be satisfactory fitted by a maxwellian, but a high energy tail appears is present, which extends to parallel velocities $V_{||}$ up to $5V_{SW}$ and beyond. We used a strech exponential functional to fit the tail and found that an exponent in the range 1.2-1.5. Perpendicular reduced distributions exhibited a similar tail distributions. Moreover, the three-dimensional angular distributions of these FABs indicate that the protons associated with the high energy tail do not propagate along the magnetic field direction, in contrast to protons associated with the peak of the distribution. Using multispacecraft observations as well some geometrical arguments, we show that FABs with high energy tail are usually located downstream from the Maxwellian FABs.

We will present results from an on-going analysis to determine whether the FABs with tails originate from Maxwellian FABs as the result of wave particle interactions, or from a distinct source at the shock. These observations provide new quantitative insights of FABs and introduce constraints on models involving shock production mechanism.

CLUSTER OBSERVATIONS



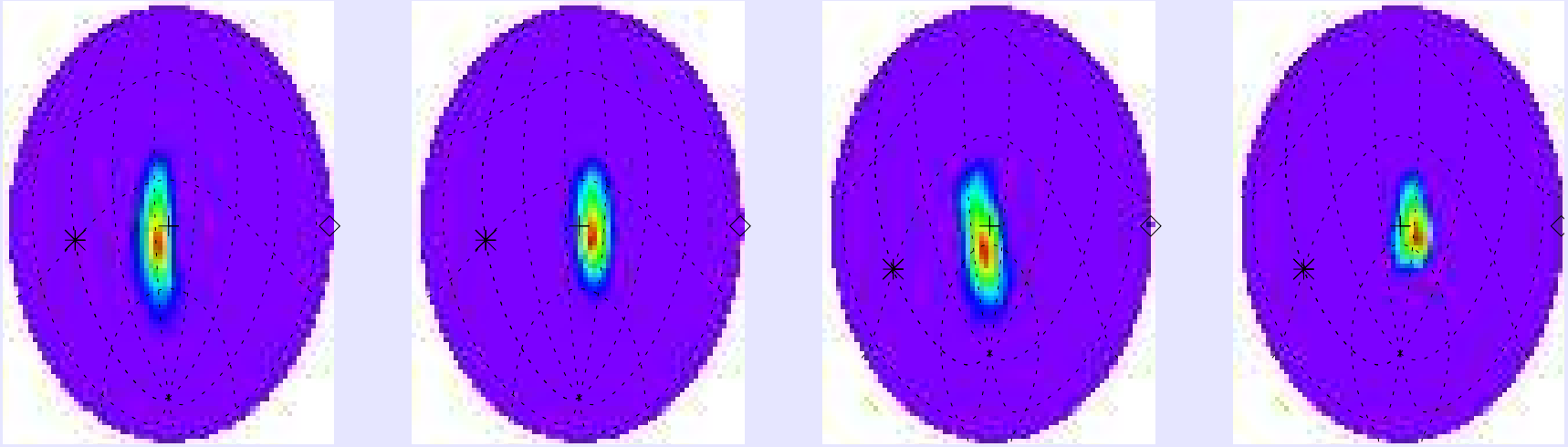


Maxwellian FABs

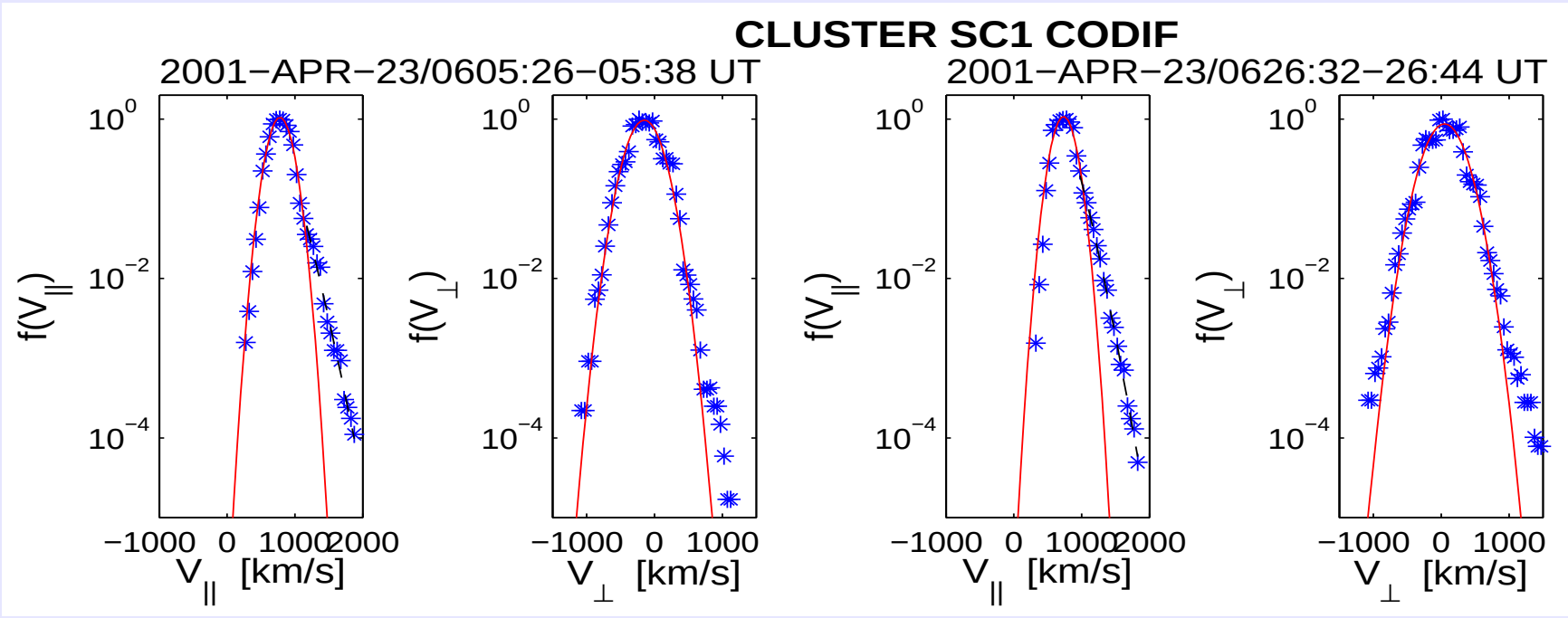
CLUSTER CODIF SC1 Product 13 2001-04-23

E = 5.68 keV | E = 3.05 keV | E = 5.68 keV | E = 3.05 keV

06:47:22-06:47:34 | 06:47:22-06:47:34 | 07:14:38-07:14:50 | 07:14:38-07:14:50

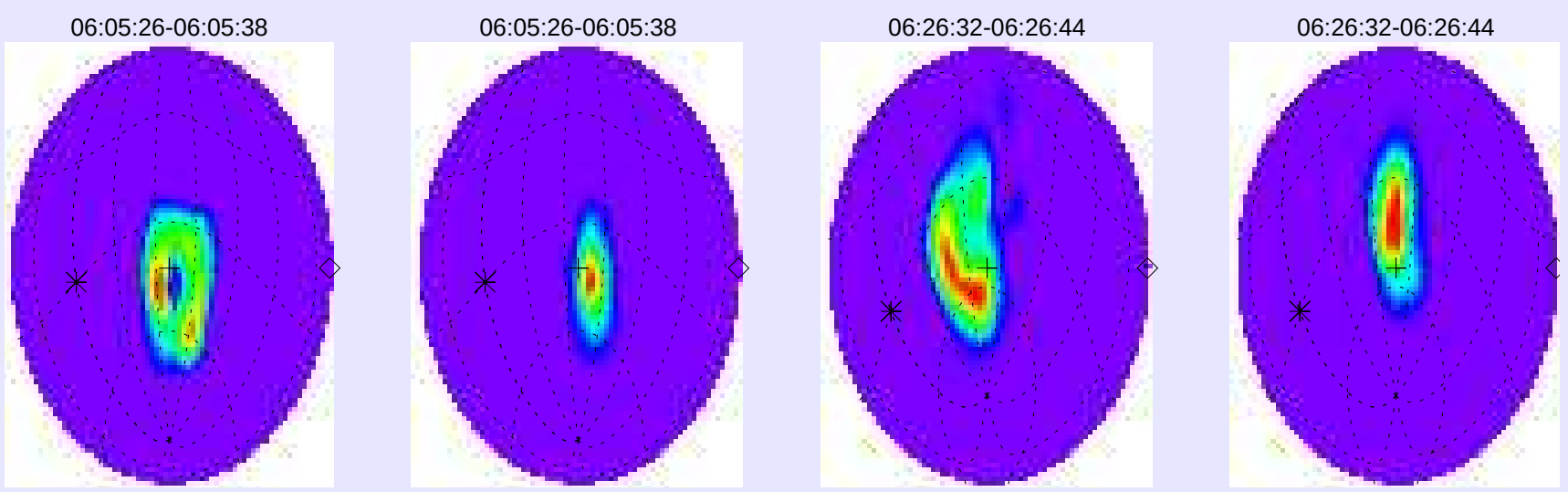


Angular Distribution



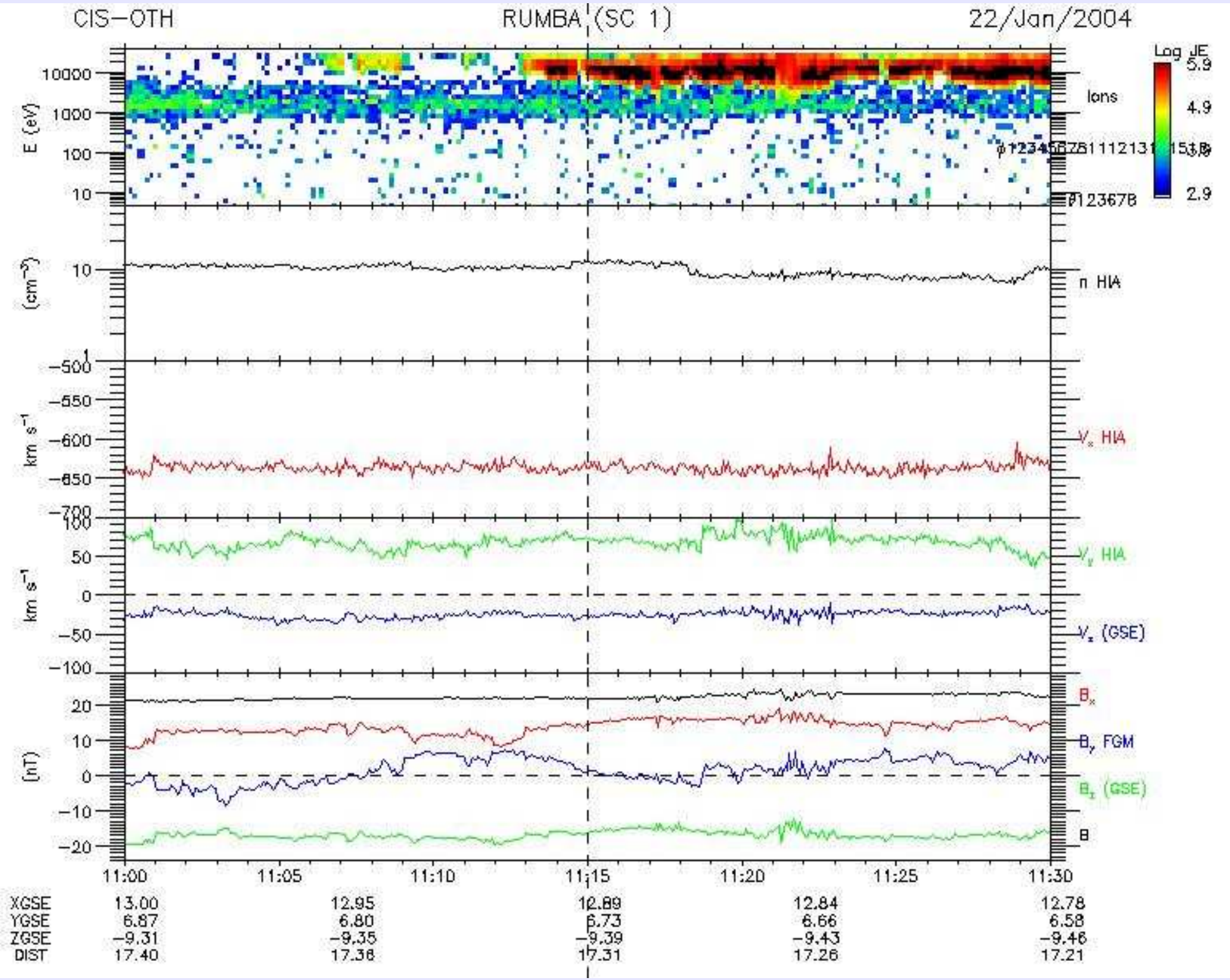
FABs with Energetic Tail

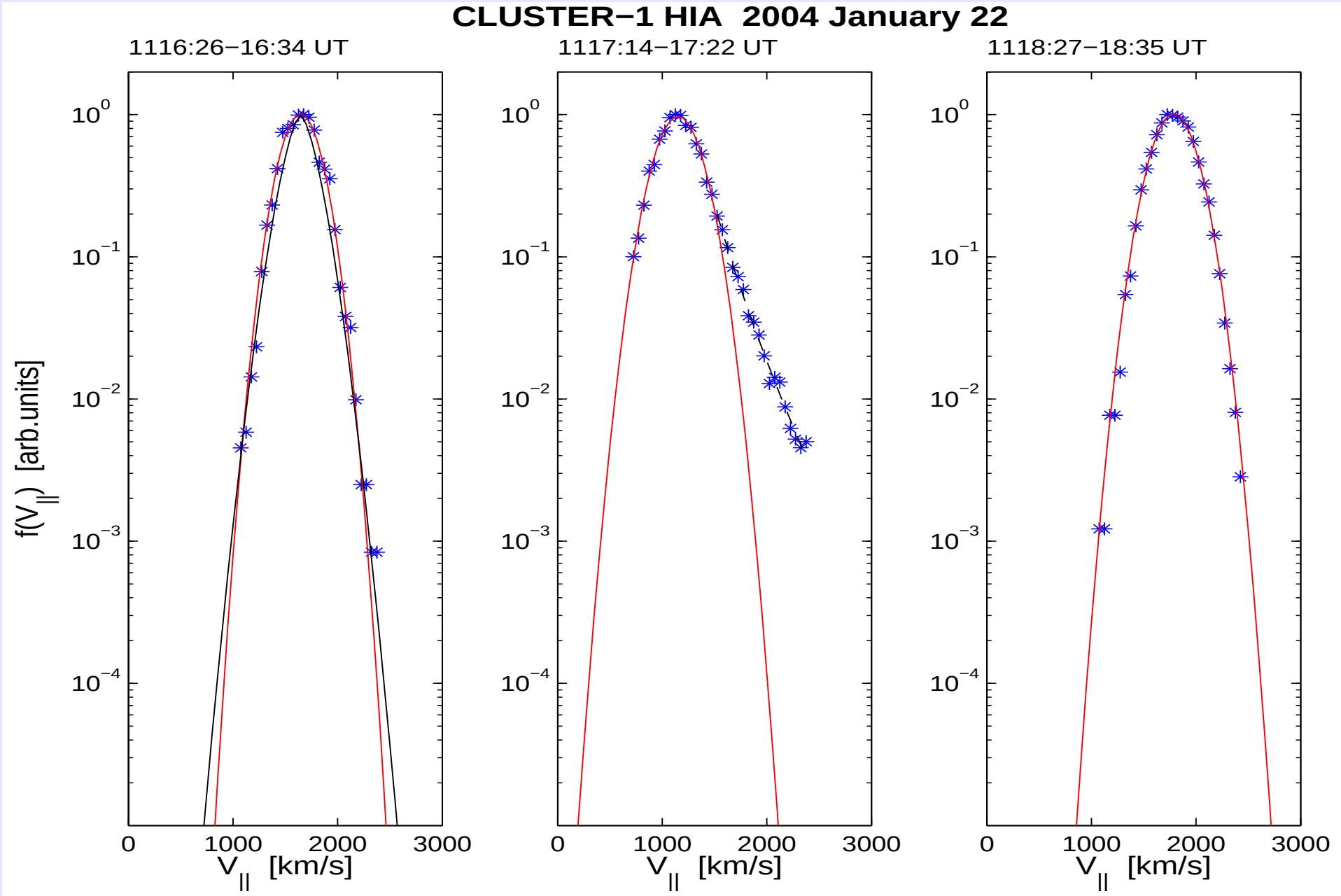
CLUSTER CODIF SC1 Product 13 2001-04-23



Low Energy (Along ***B***)

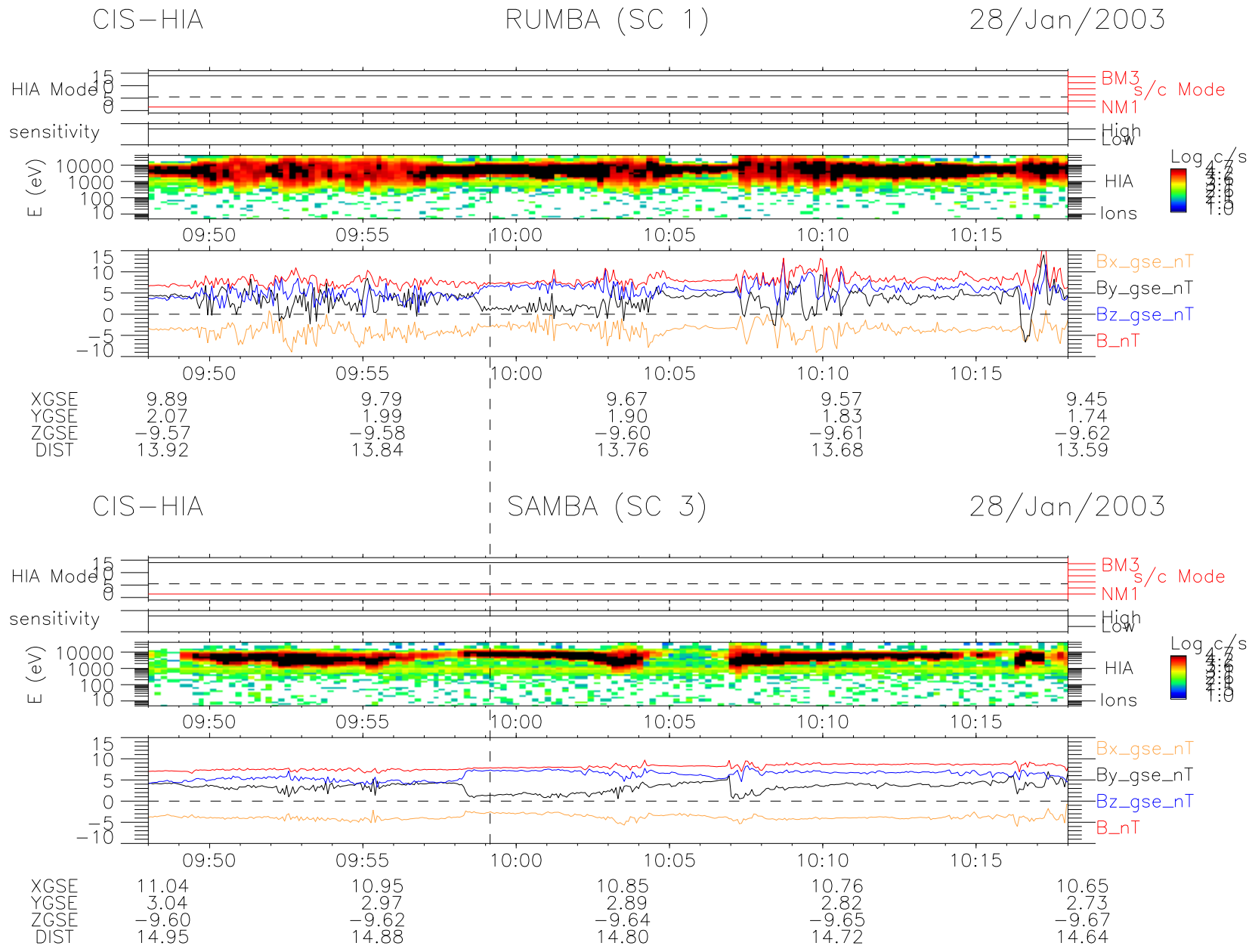
High Energy Not (along ***B***)

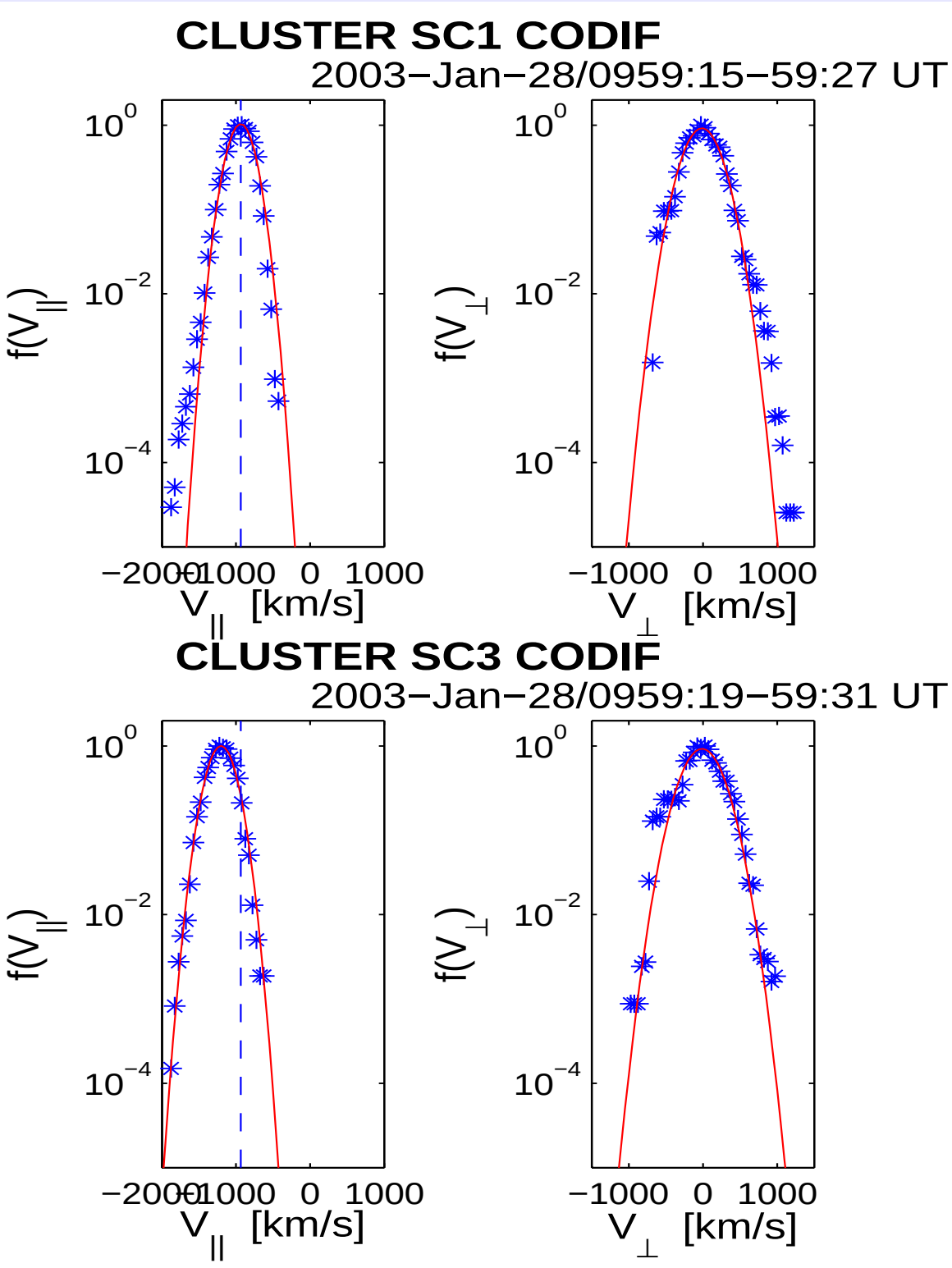

CIS–OTH
RUMBA (SC 1)
22/Jan/2004
E (eV)
10000
1000
100
10
Ions
Log JE
5.9
4.9
2.9
n HIA
(cm⁻³)
10
1
V_x HIA
km s⁻¹
−500
−550
−600
−650
−700
V_y HIA
100
50
0
V_z (GSE)
−50
−100
B_x
B_y FGM
B_z (GSE)
B
(nT)
20
10
0
−10
−20
11:00
11:05
11:10
11:15
11:20
11:25
11:30
XGSE 13.00 12.95 12.89 12.84 12.78
YGSE 6.87 6.80 6.73 6.66 6.58
ZGSE −9.31 −9.35 −9.39 −9.43 −9.46
DIST 17.40 17.36 17.31 17.26 17.21



θ_{Bn} [Maxwellian Beams] > θ_{Bn} [Tailed Beams]

MULTISPACECRAFT OBSERVATIONS





Beam Speed $V \sim 1/\cos\theta_{Bn}$

$\Delta V/\Delta\theta_{Bn} = V\tan\theta_{Bn}$

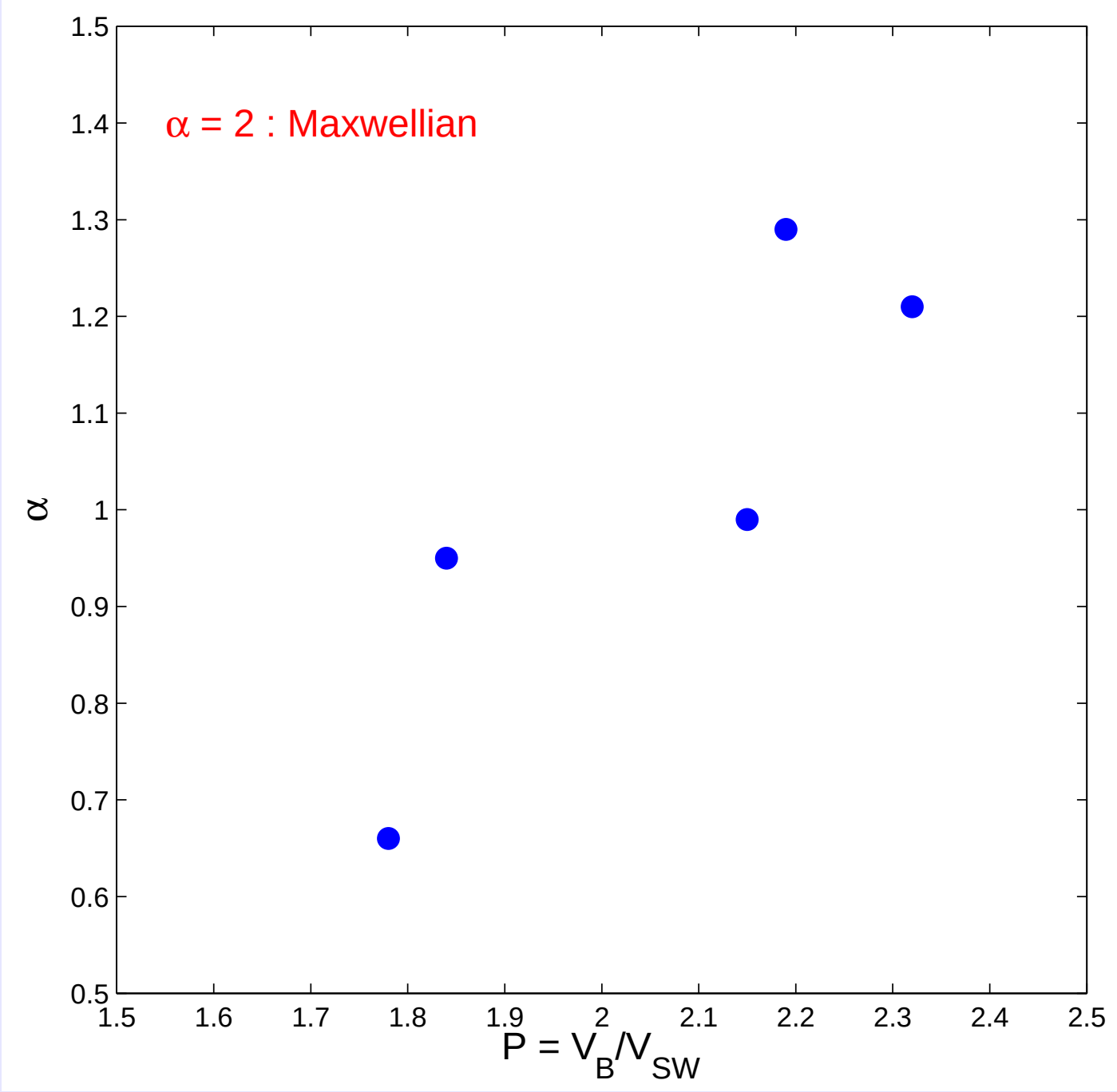
- SC#3 Downstream from SC#1:
- $\Delta V = V_{SC3} - V_{SC1} = 265\ \mathrm{km/s}$

  [Consistent with Geometry: $\Delta\theta_{Bn} \sim 10^{o}$]

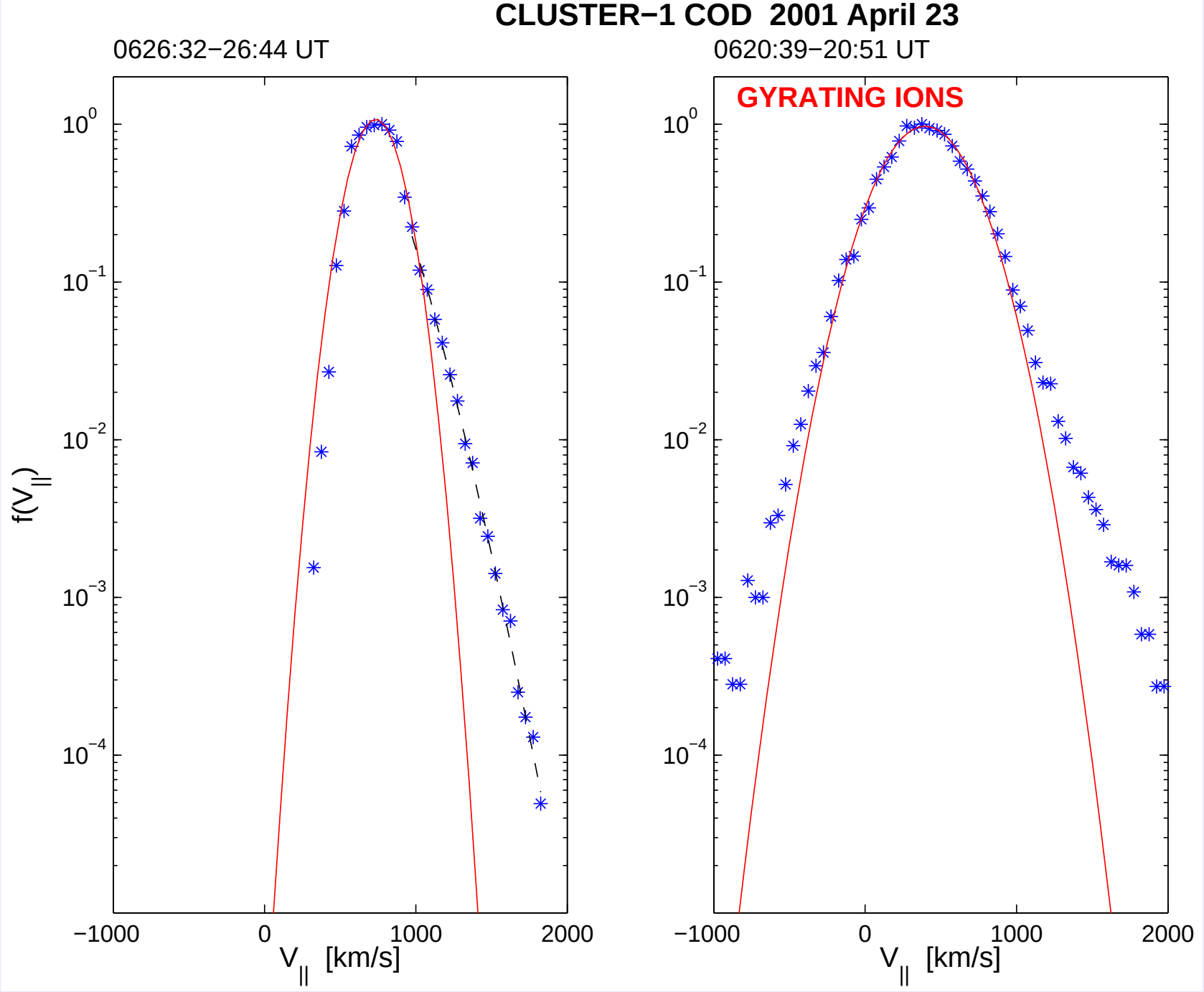
Maxwellian FABs ALWAYS Upstream of FABs with Tail.

Fitting the Beam Tail: $f(v_{||}) = Aexp[-(\beta v_{||})^{\alpha}]$

Developed High Energy Tail for Oblique Shock Region ?



TAIL = Remote Sensing Downstream Distribution – Larmor Radius Effect ?



SUMMARY

Observational Evidence of Two Classes of Field-Aligned Beams Upstream of the Bow Shock:

Class I: Gaussian Fit of reduced distribution functions

Class II: Guassian Fit of the Peak and Low energy of reduced distribution

+ High Energy Tail

No ULF Waves are observed with the FABs with Tail.

The high energy FAB Tail is associated with Gyrating ions.

Maxwellian FABs are ALWAYS observed upstream of the ones with tails.

Developed Tail for lower θ_{Bn}?