CAMMICE Science Report

March 31, 2006

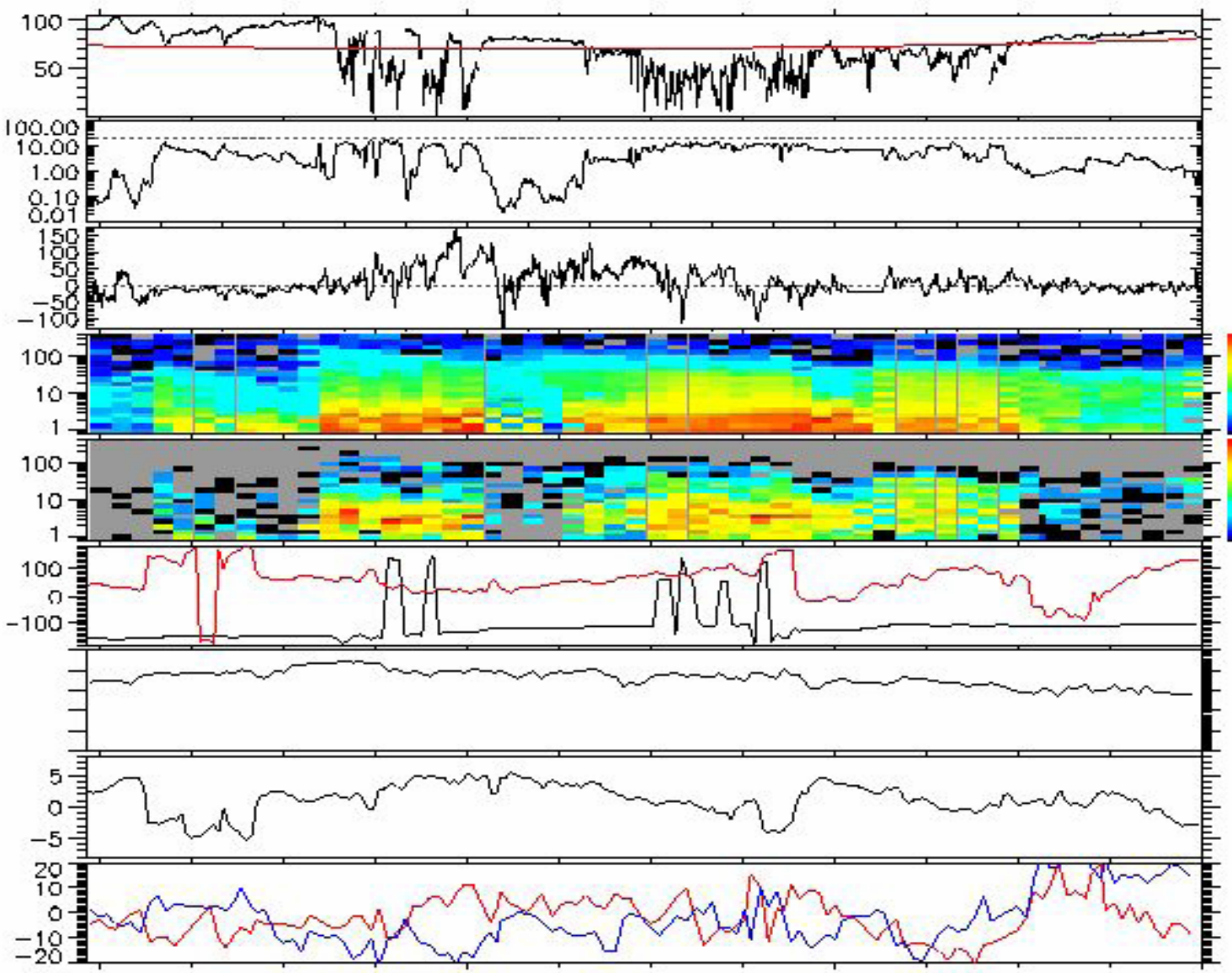
There will be two sections to the report:

1. A discussion on the inter-comparison of the responses of the MICS, Hydra, and TIMAS sensors as it pertains to our attempt to understand the Cusp Diamagnetic Cavities and the apparently lack of energy balance in them. Discussion with be led by my graduate student, Jon Niehof

2. A presentation of a recently published paper on a comparison of the particle fluxes in the cusp and in the radiation belts and the implications by Jiasheng Chen

T. Fritz

August 27, 1996 is an example of a CDC demonstrating a lack of energy balance throughout the cavity



T96 |B| at POLAR

WIND SWE
Vy GSE
VZ GSE

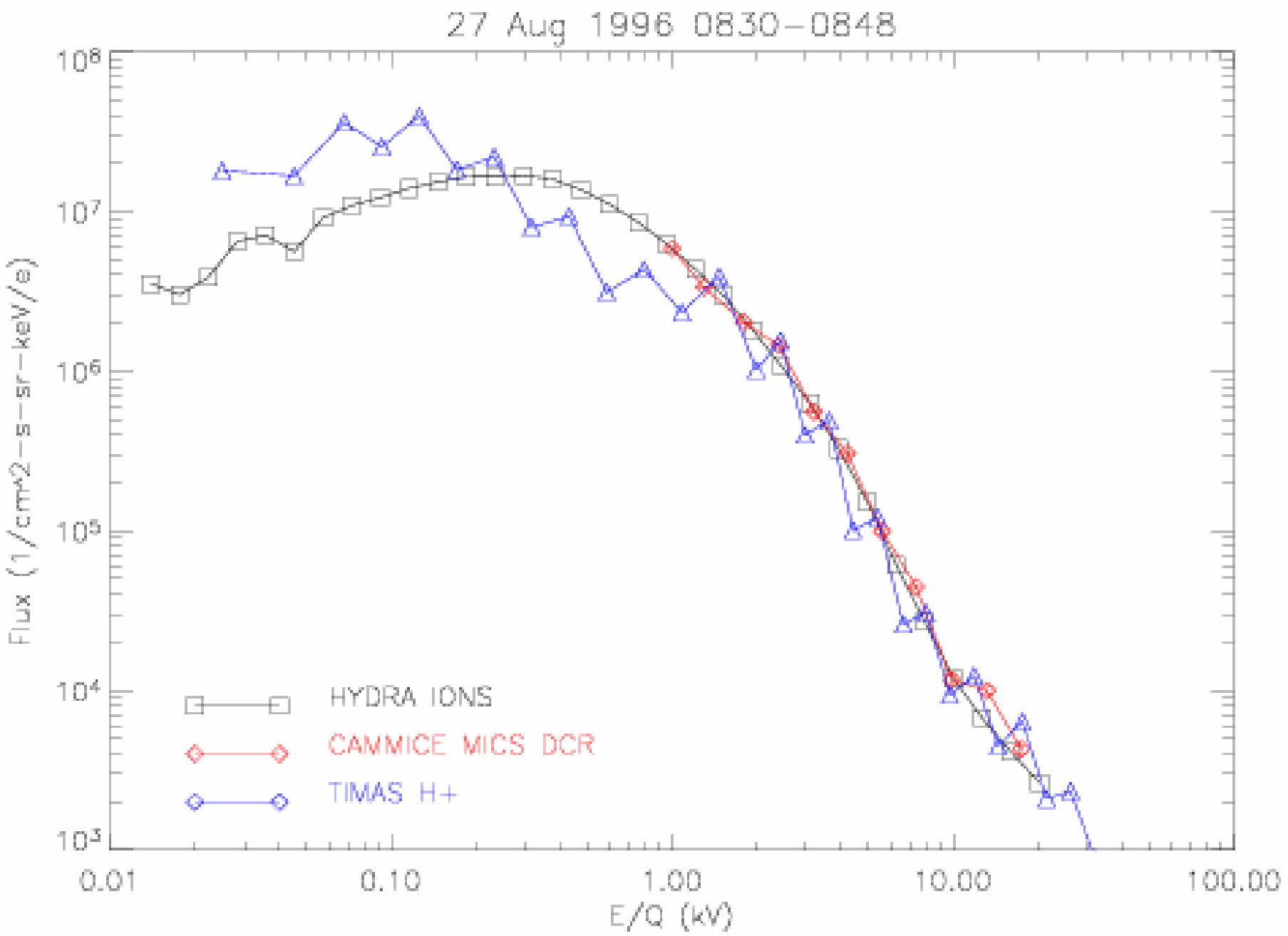
BACKGROUND

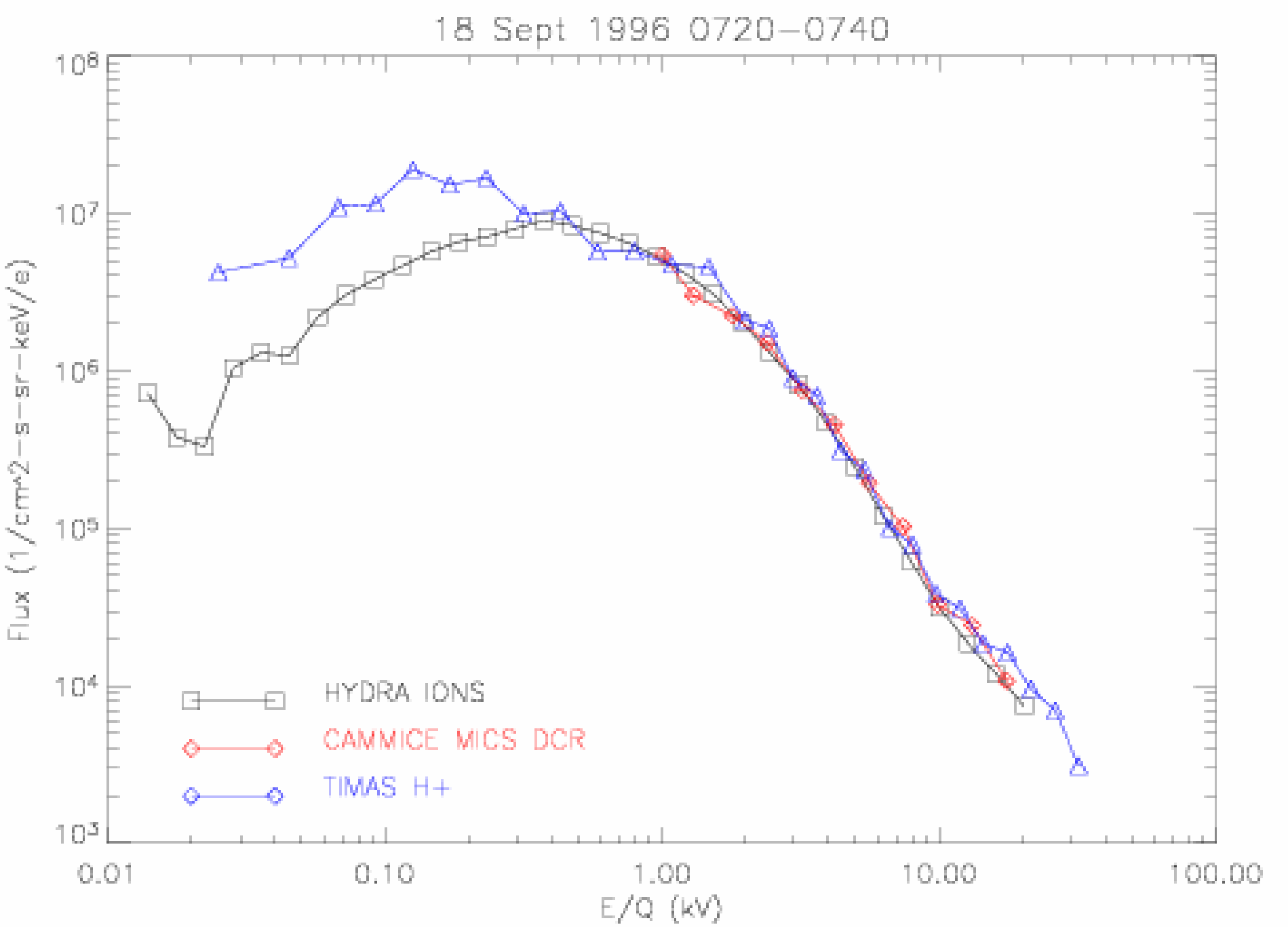
In attempt to understand this the lack of a measured energy balance the first question to be address was whether the “missing” energy density could be in the form of composition.

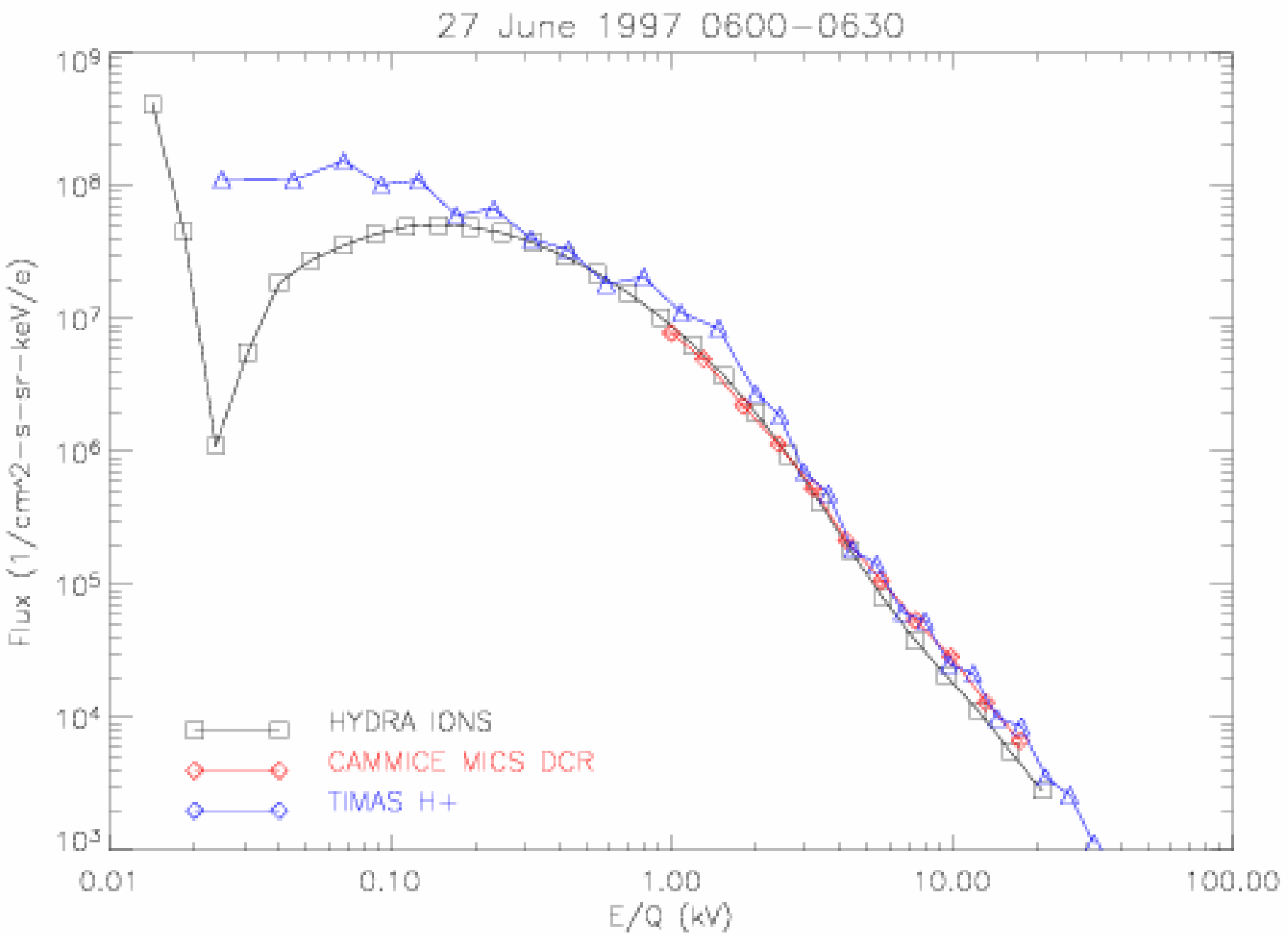
The responses of each of the plasma and energetic particle measuring instruments on Polar have been used and we have had some trouble in the agreement of the response of these instruments.

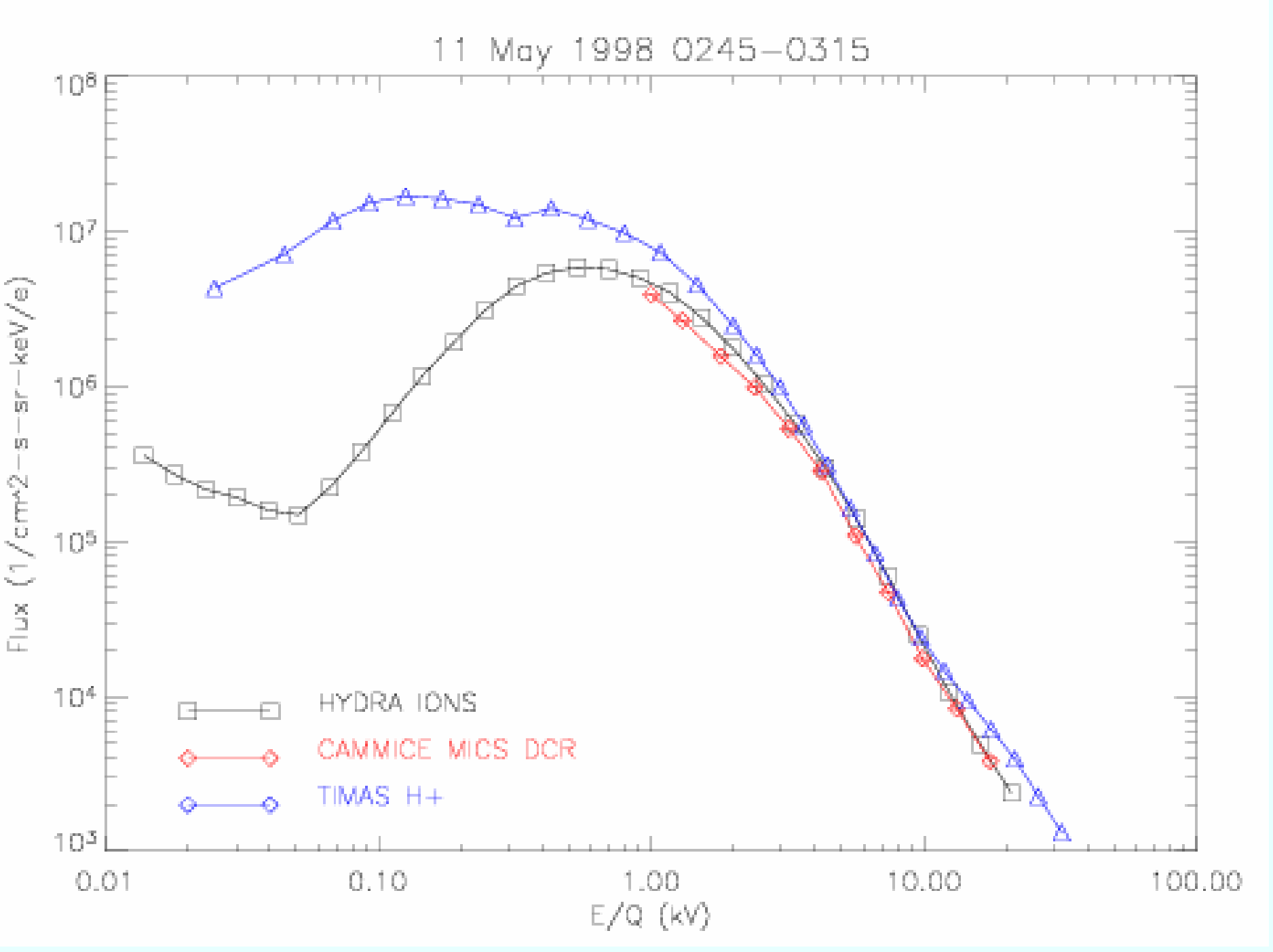
We would like to present this for discussion here.

As a post script to this study we have concluded that it is highly unlikely that composition is the answer to the missing energy density and we are pursuing the problem from the point of view of “force balance” rather than a balance of energy density in the particles and fields.


27 Aug 1996 0830-0848
Flux (1/cm^2-s-sr-keV/e)
10^8
10^7
10^6
10^5
10^4
10^3
0.01
0.10
1.00
10.00
100.00
E/Q (kV)
HYDRA IONS
CANMICE MICS DCR
TIMAS H+


18 Sept 1996 0720-0740
Flux (1/cm^2-s-sr-keV/e)
E/Q (kV)
HYDRA IONS
CAMMICE MICS DCR
TIMAS H+


27 June 1997 0600-0630
Flux (1/cm^2-s-sr-keV/e)
E/Q (kV)
HYDRA IONS
CAMMICE MICS DCR
TIMAS H+


11 May 1998 0245-0315
Flux (1/cm^2-s-sr-keV/e)
10^8
10^7
10^6
10^5
10^4
10^3
0.01
0.10
1.00
10.00
100.00
E/Q (kV)
HYDRA IONS
CAMMICE MICS DCR
TIMAS H+

CEPs: A Probable Source of Outer Radiation Belt Charged Particles

Theodore A. Fritz **and** ***Jiasheng Chen***

In cooperation with: ***J. F. Fennell, J. Roeder, K. Kudela, V. N. Lutsenko, F. Mozer, J. Niehof , G. L. Siscoe, J. S. Pickett, C. T. Russell***, and ***R. B. Sheldon***

References:

1. J. Chen, T. A. Fritz, and R. B. Sheldon, 2005. Comparison of energetic ions in cusp and outer radiation belt, J. Geophys. Res., 110, A12219, doi:10.1029/2004JA010718.

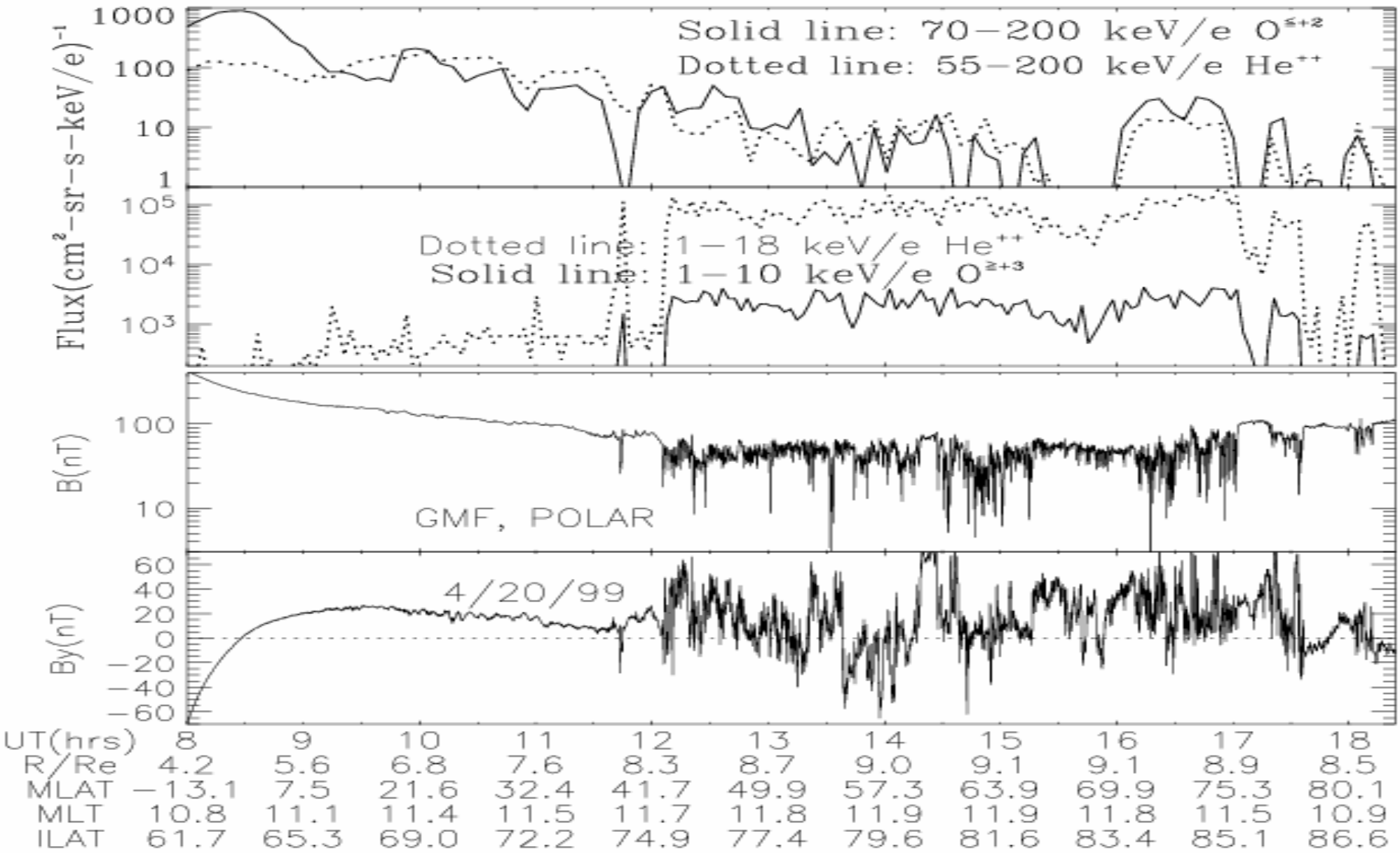
2. J. Chen, T. A. Fritz, and R. B. Sheldon, 2005. Multiple spacecraft observations of energetic ions during a high solar wind pressure event, J. Geophys. Res., 110, A11212, doi:10.1029/2005JA011043

CAMMICE measures H^{+}, He^{++}, O^{+}, and O^{+6} in which the high charge state ions originate in the solar wind and the O^{+} ions originate in the ionosphere.

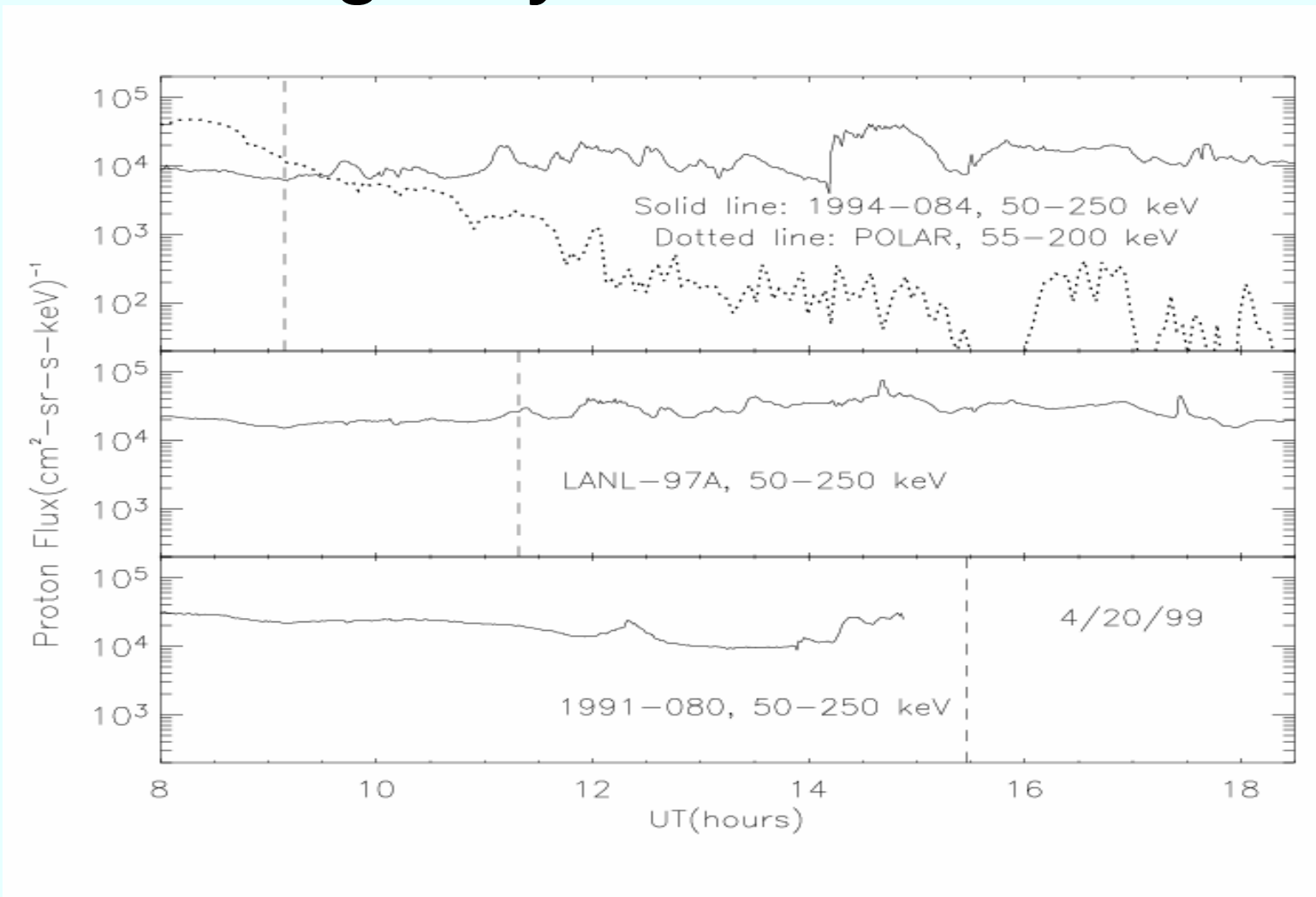
A comparison of the phase space densities at constant magnetic moment measured by Polar in the radiation belts and in the cusp will be presented to demonstrate the proposition contained in the title.

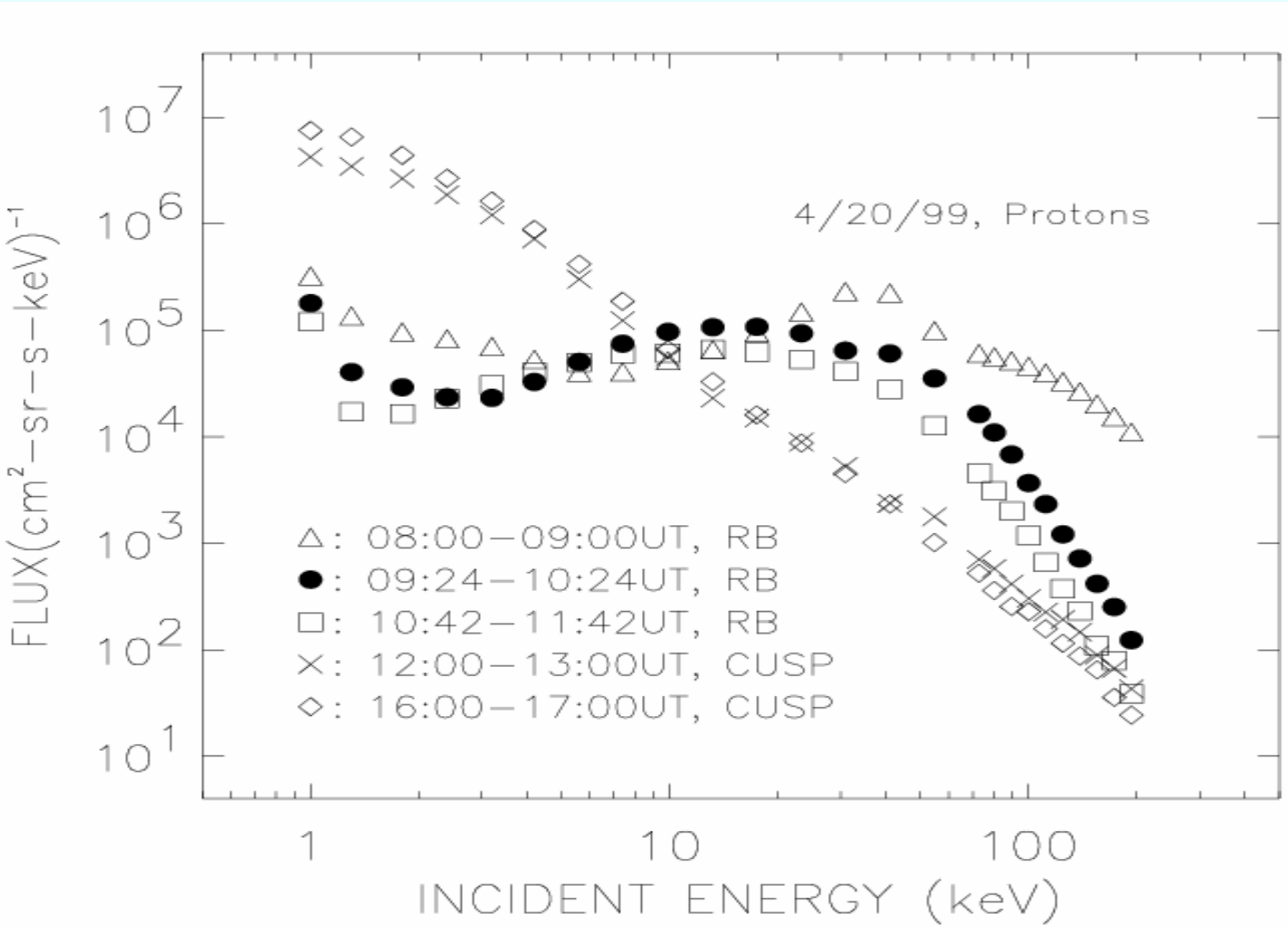
Definition of the cusp energetic particle (CEP) event:

- 1. A decrease in |**B**| in the dayside cusp;
- 2. a more than one order of magnitude increase in intensity for the 1-10 keV ions;
- 3. a more than three sigma increase above background for > 40 keV ion intensity.

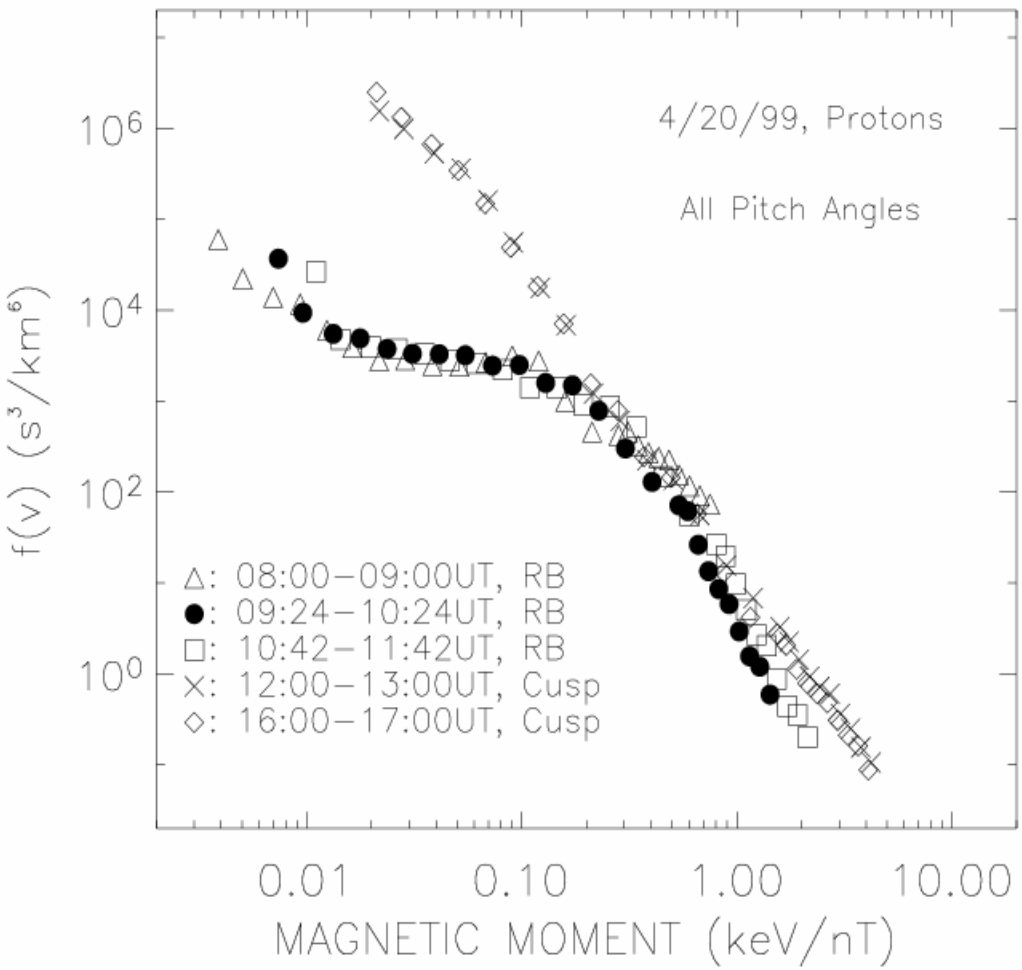

Solid line: 70–200 keV/e O^{+2}
Dotted line: 55–200 keV/e He^{++}
Dotted line: 1–18 keV/e He^{++}
Solid line: 1–10 keV/e O^{+3}
Flux(cm^2-sr-s-keV/e)$^{-1}$
1000
100
10
1
10^5
10^4
10^3
B(nT)
100
10
GMF, POLAR
4/20/99
By(nT)
60
40
20
0
−20
−40
−60
UT(hrs) 8 9 10 11 12 13 14 15 16 17 18
R/Re 4.2 5.6 6.8 7.6 8.3 8.7 9.0 9.1 9.1 8.9 8.5
MLAT −13.1 7.5 21.6 32.4 41.7 49.9 57.3 63.9 69.9 75.3 80.1
MLT 10.8 11.1 11.4 11.5 11.7 11.8 11.9 11.9 11.8 11.5 10.9
ILAT 61.7 65.3 69.0 72.2 74.9 77.4 79.6 81.6 83.4 85.1 86.6

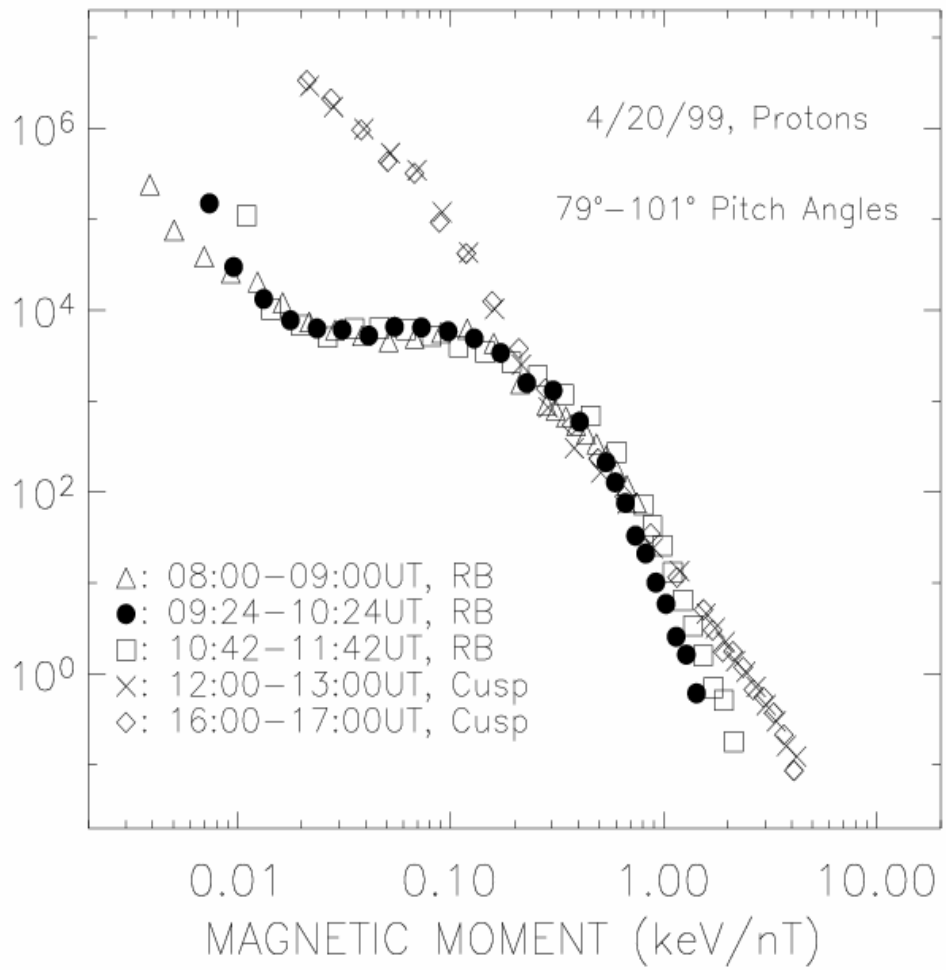
Simultaneous observations by Polar and three geosynchronous satellites



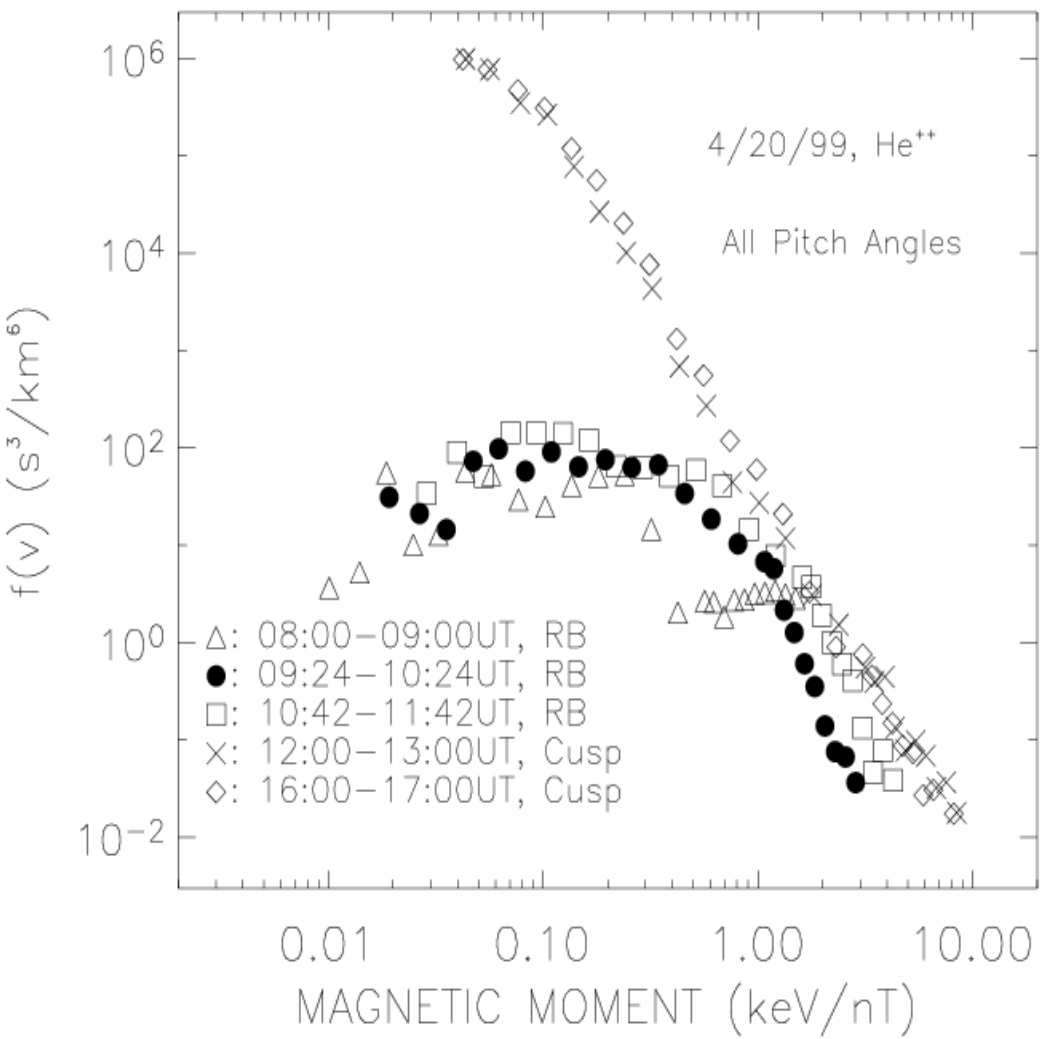

4/20/99, Protons
△: 08:00–09:00UT, RB
●: 09:24–10:24UT, RB
□: 10:42–11:42UT, RB
×: 12:00–13:00UT, CUSP
◇: 16:00–17:00UT, CUSP
FLUX(cm²–sr–s–keV)⁻¹
INCIDENT ENERGY (keV)
10⁷
10⁶
10⁵
10⁴
10³
10²
10¹
1
10
100

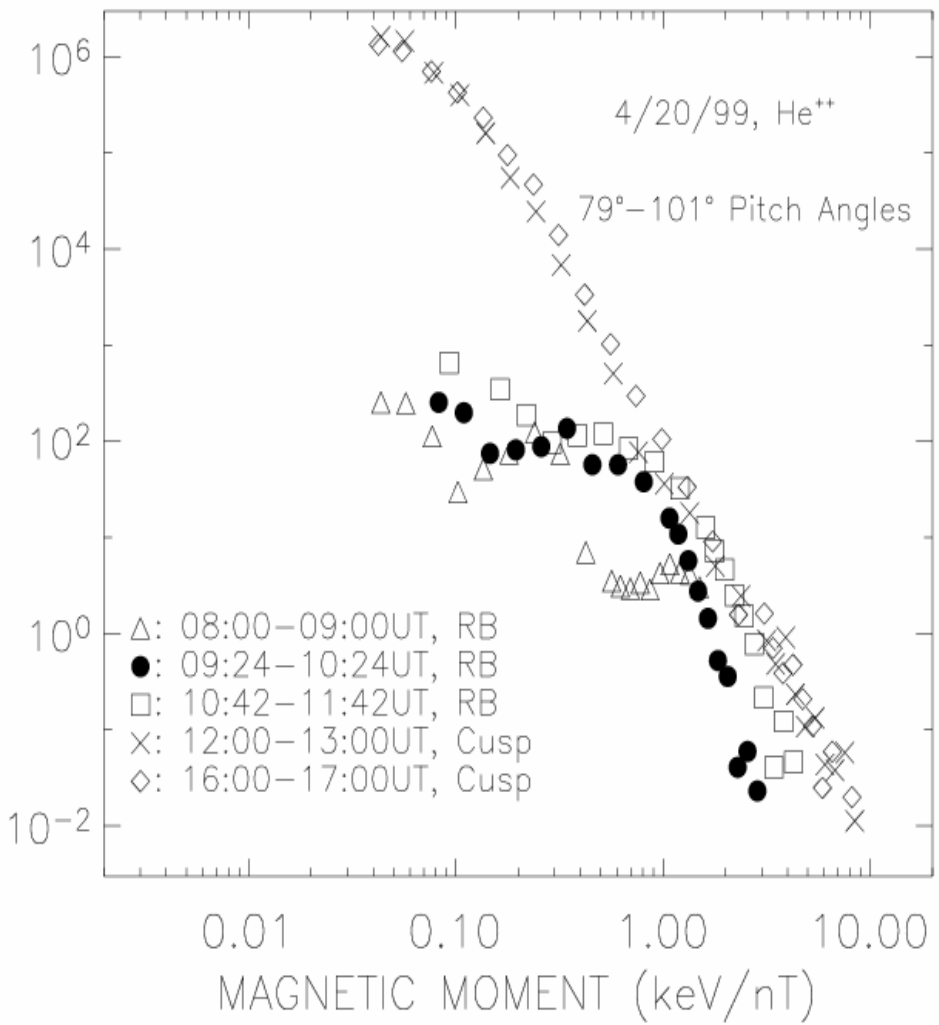
Proton magnetic moment spectra



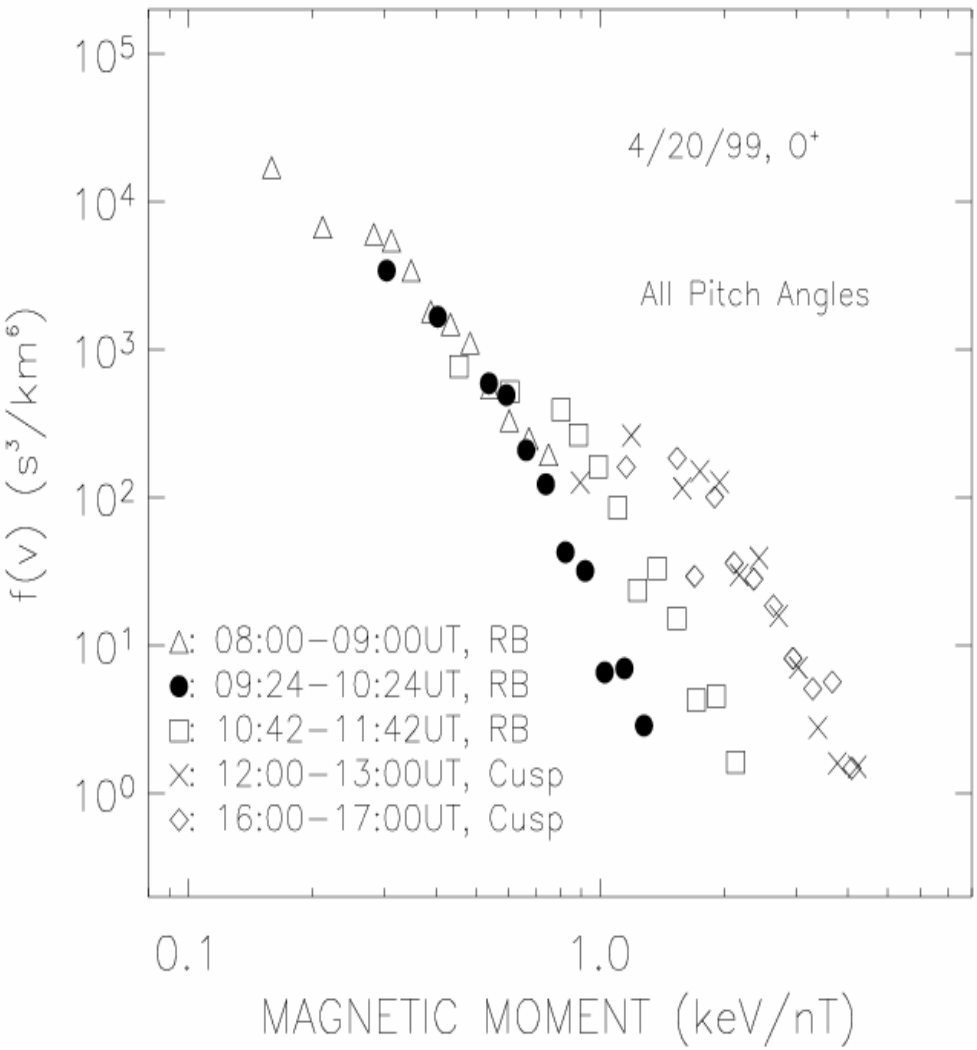


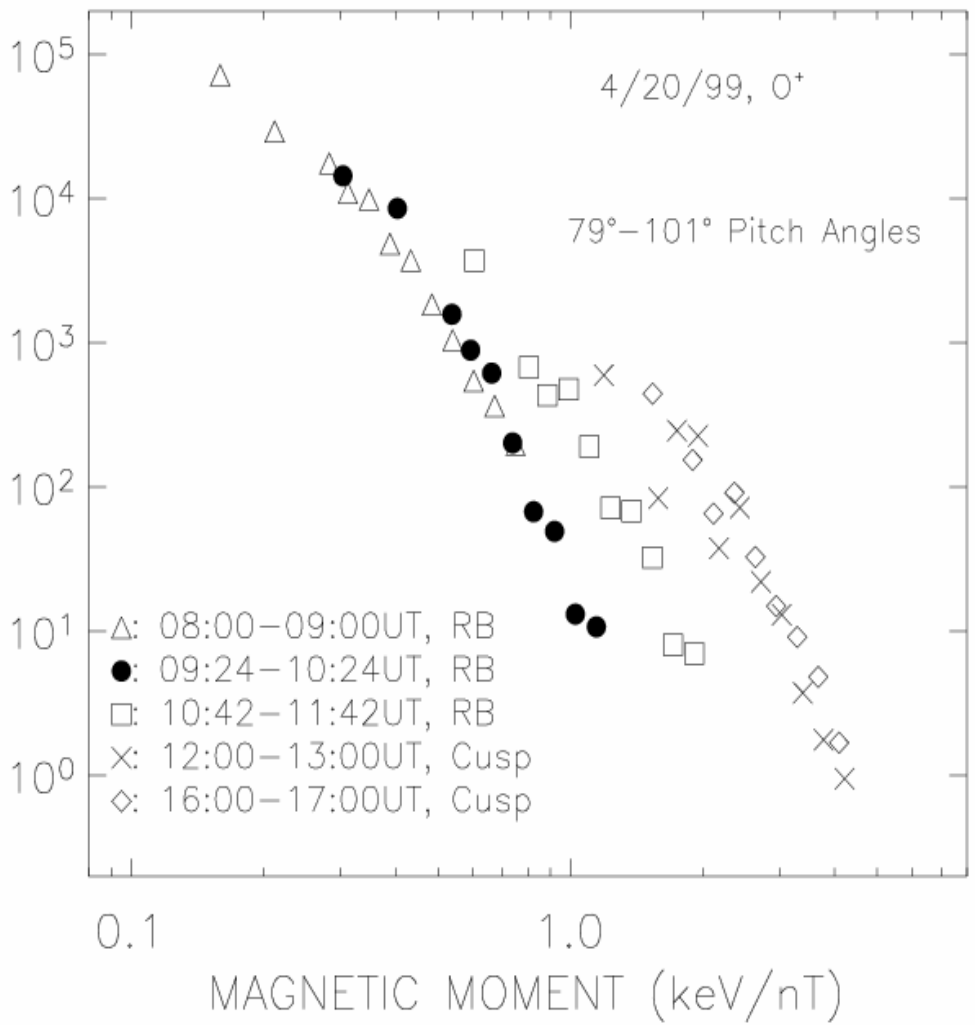
He^{++} magnetic moment spectra





O^+ magnetic moment spectra



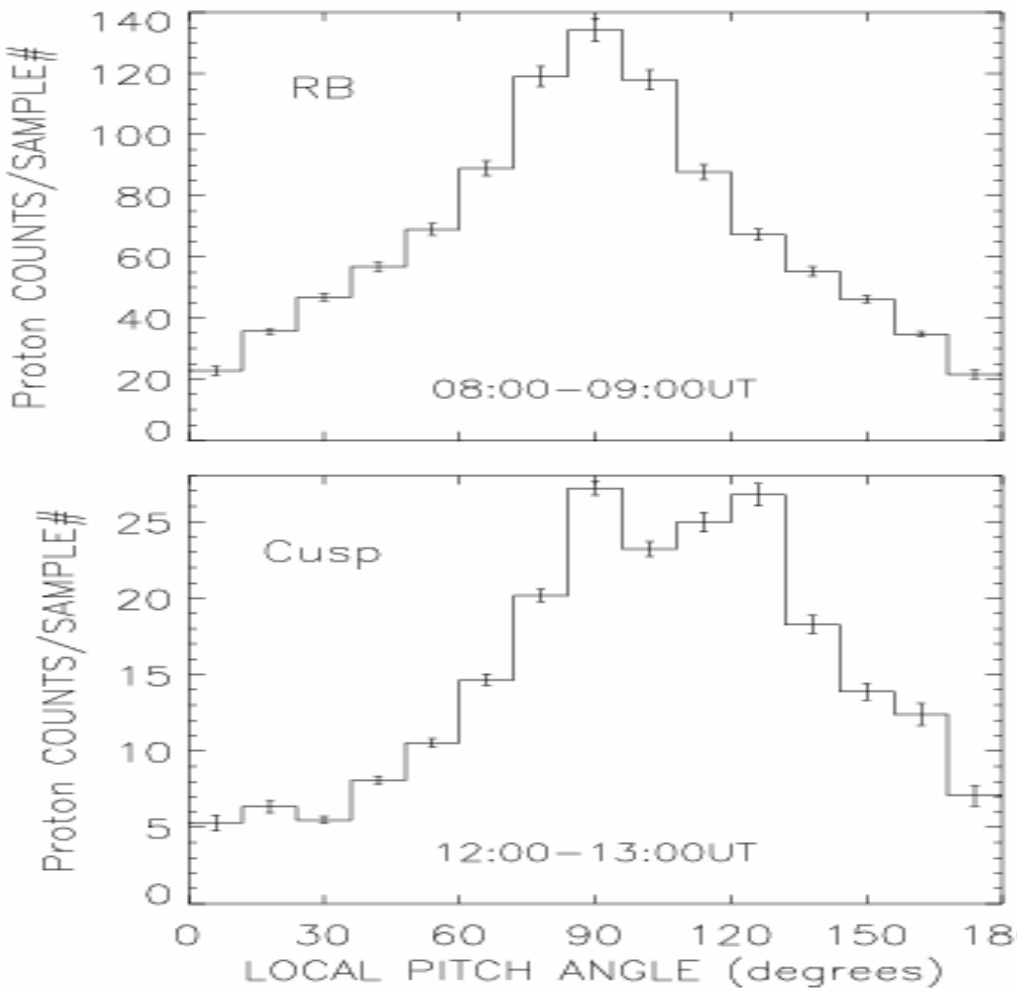


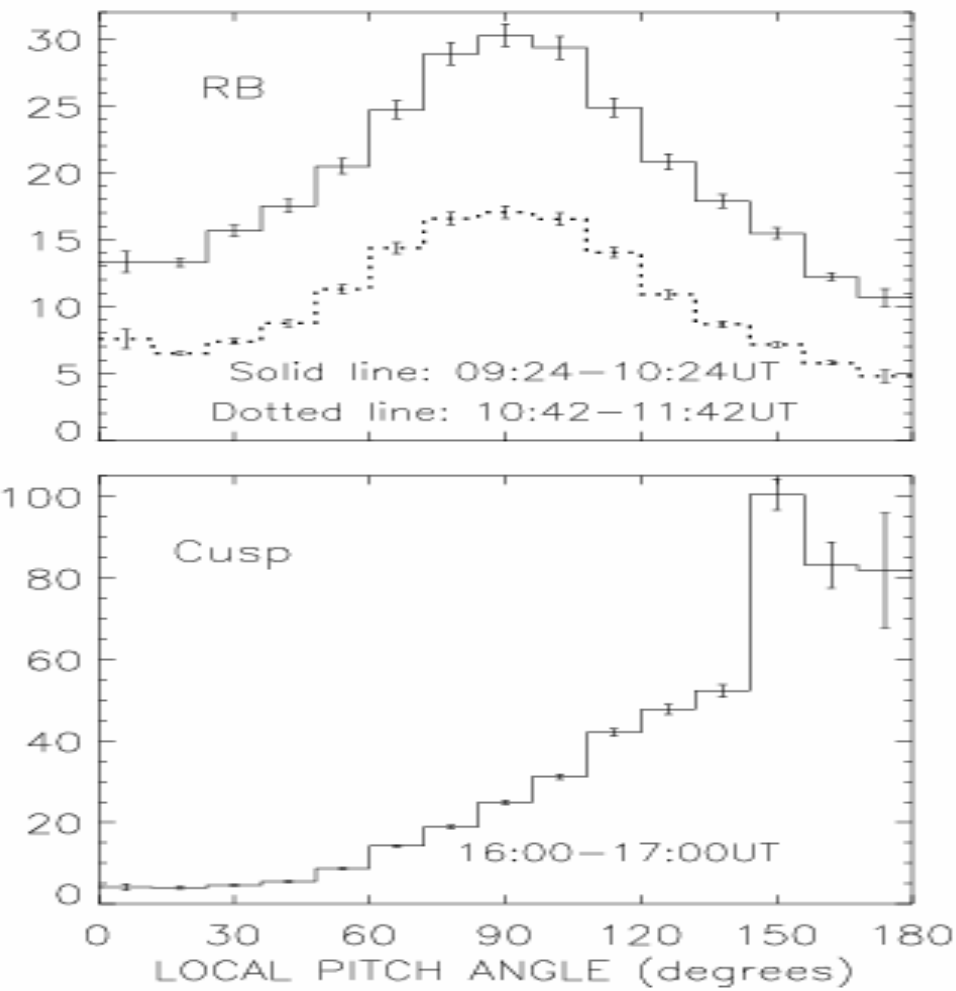
Conclusions – Part I

•This analysis demonstrates that the outer radiation belt cannot be the source of the particles in the cusps due to the fact that the phase space density at a given magnetic moment in the cusp is larger than [in one case equal to] the phase space density in the outer radiation belts.

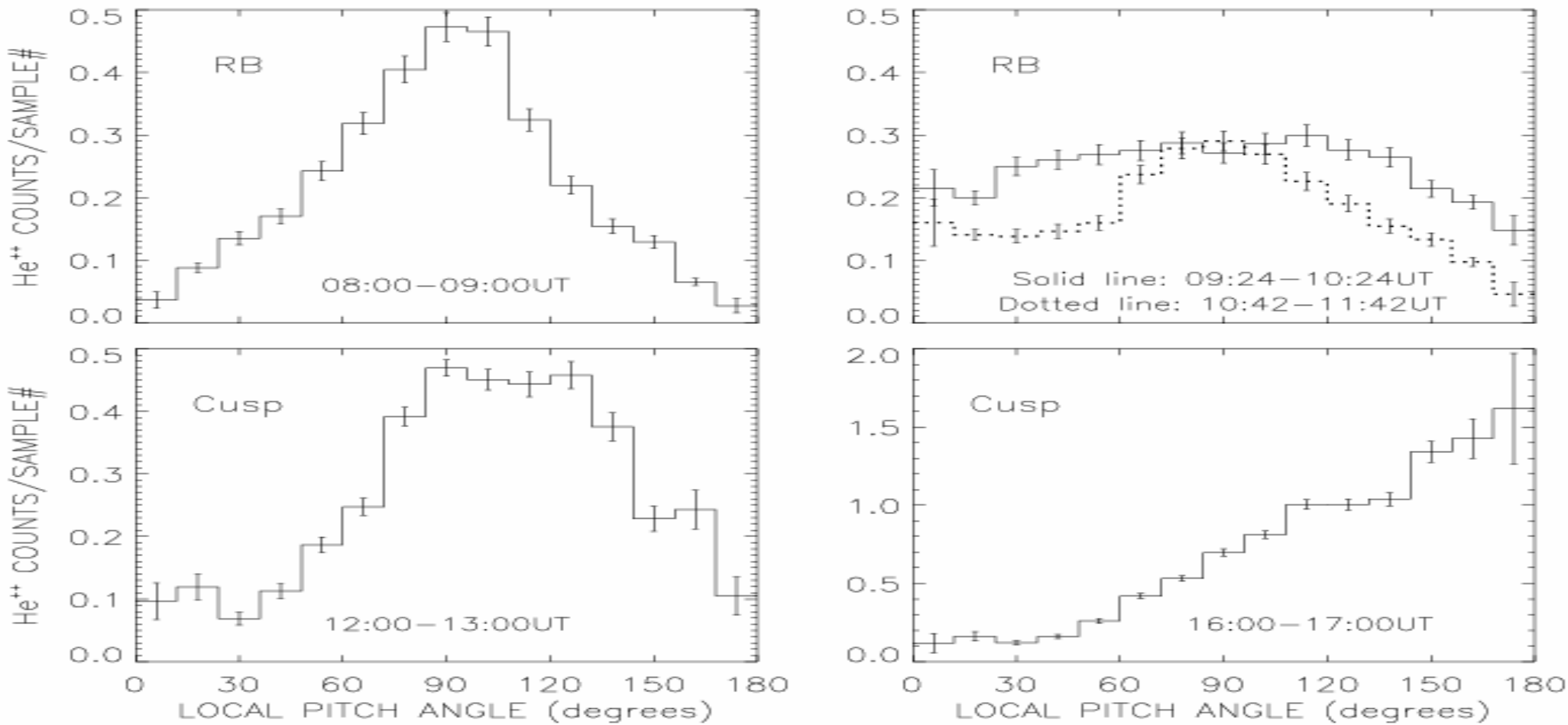
•The positive gradient (or increase) of the phase space density points in the direction from the radiation belts to the cusp.

Proton pitch angle distributions

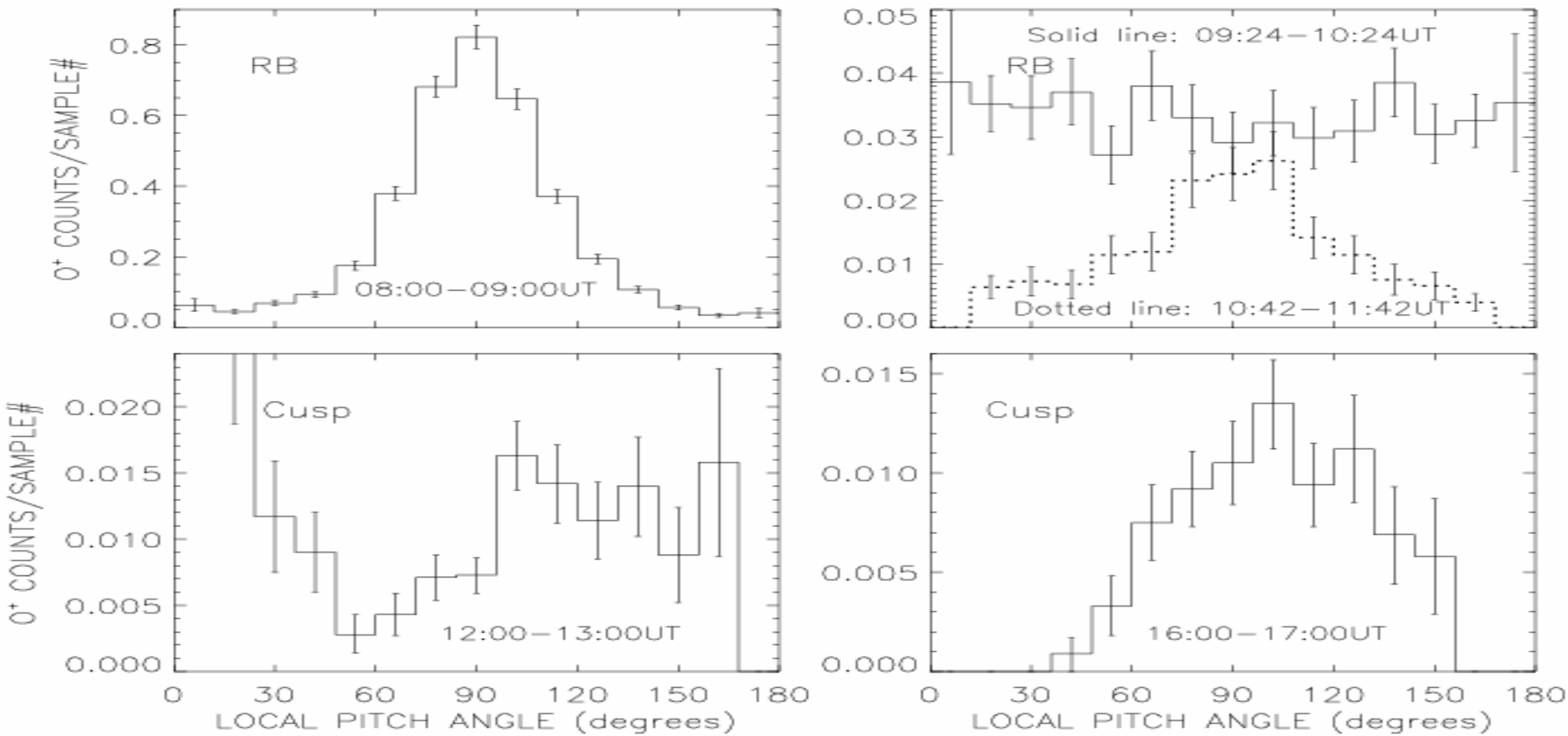




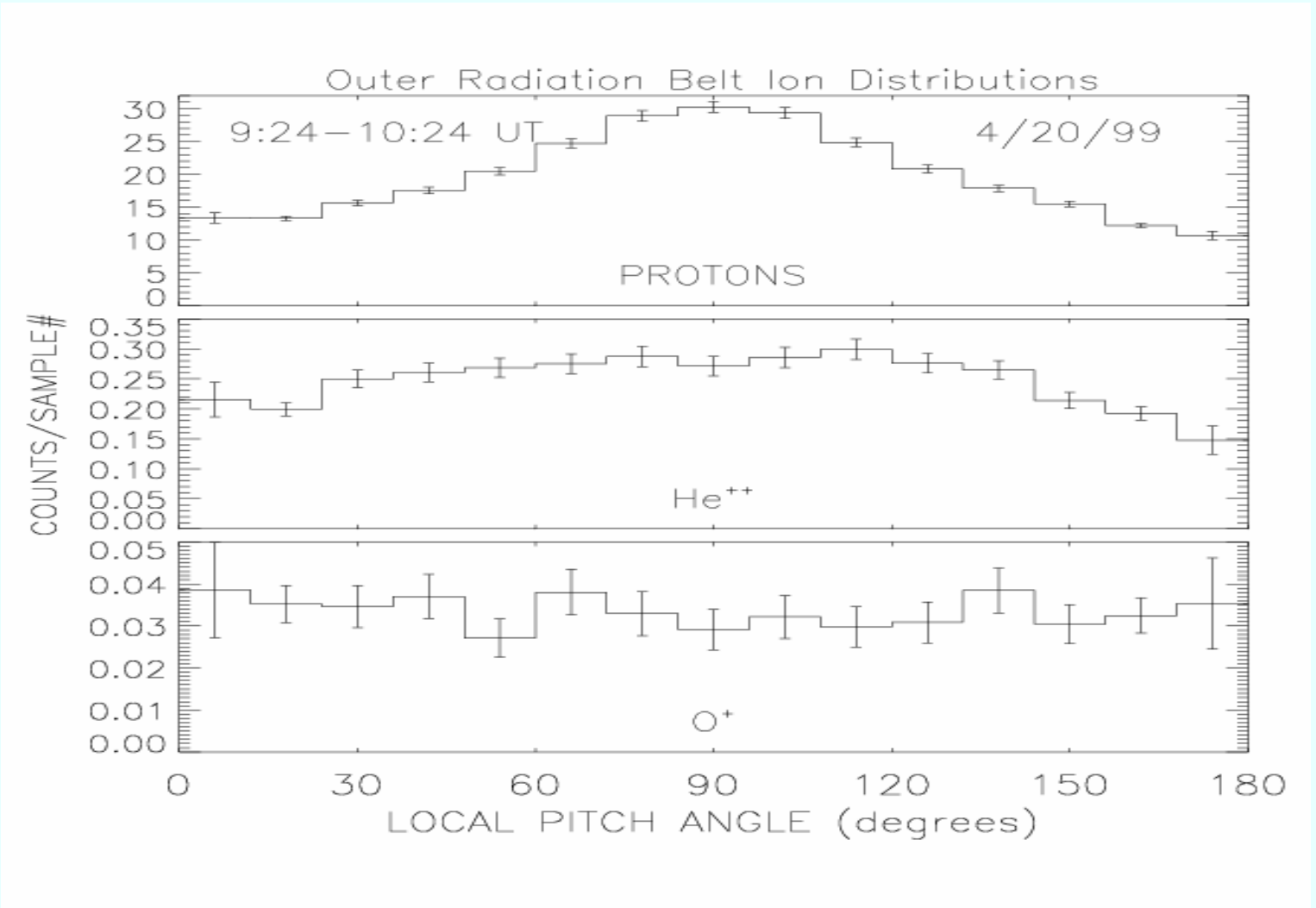
He^{++} pitch angle distributions



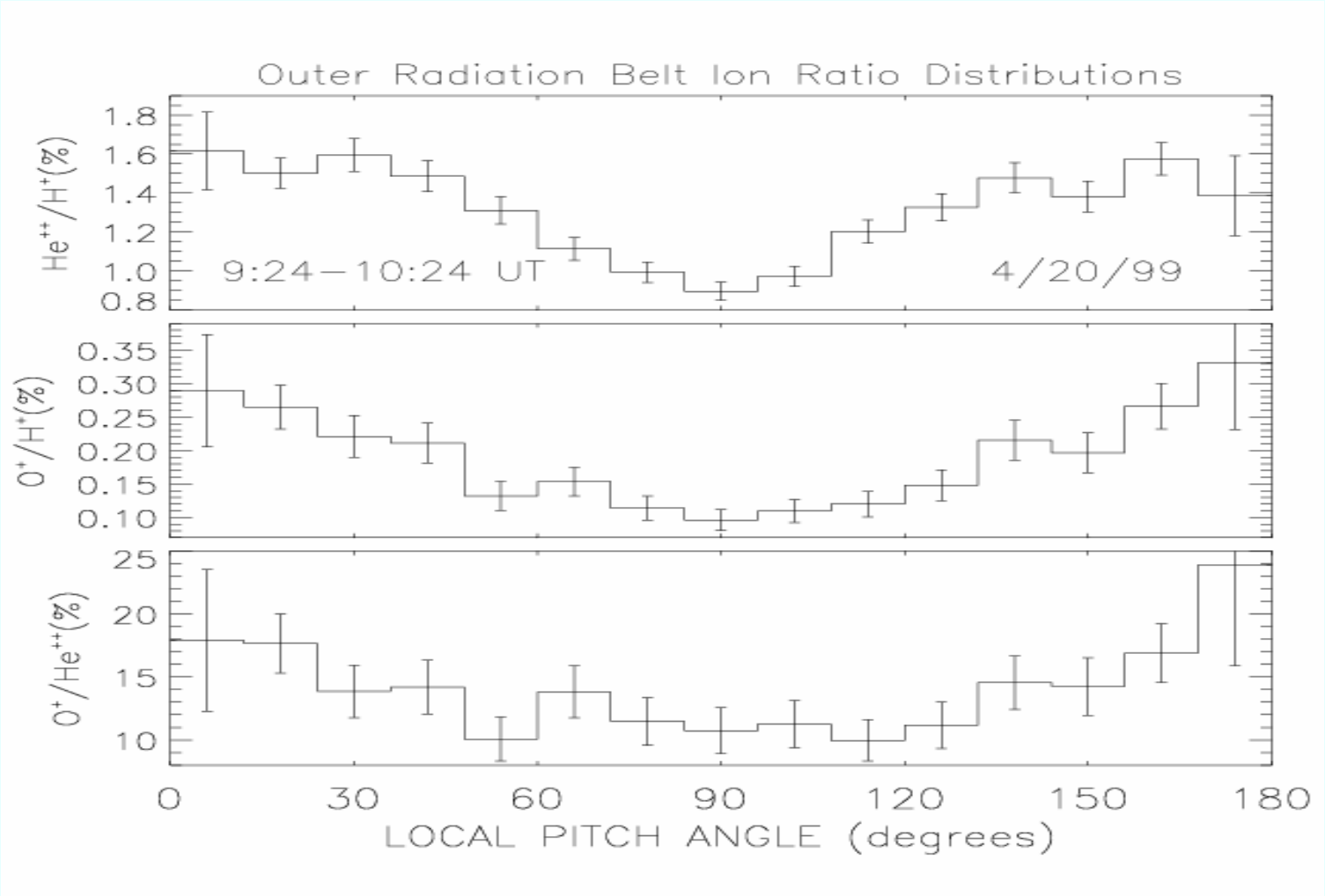
O^+ pitch angle distributions



Dayside outer radiation belt Ion pitch angle distributions



Dayside outer radiation belt
Ion Ratio pitch angle distributions



Conclusions – Part II

•Different pitch angle distributions for different particle species at the same time and location have been observed by CAMMICE in the dayside outer radiation belt.

• The pitch angle distributions of the major ion species (**H^+, He^{++}, and O^+**) reveals a second population introduced in the field aligned direction in the dayside outer radiation belt.

Summary

1. The proton Phase Space Density in the Outer Radiation Belt are organized by the magnetic moment and are independent of the solar wind conditions.

2. At a given magnetic moment in the dayside ORB, the PSD of the He^{++} and O^{+} ions increase with increasing latitude and altitude.

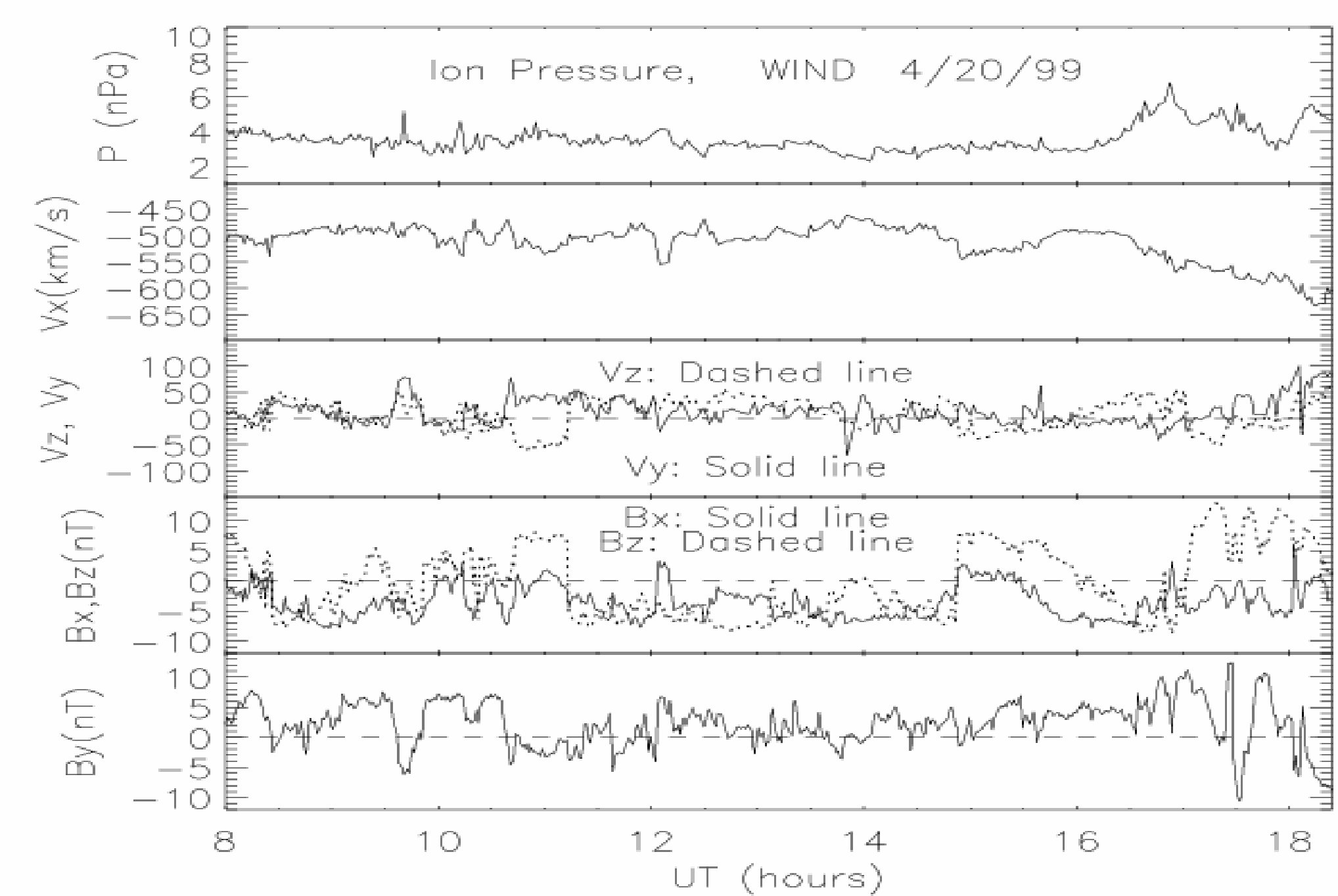
3. Both He^{++} and O^{+} PSDs in the cusp are significantly higher than those in the ORB at a given magnetic moment.

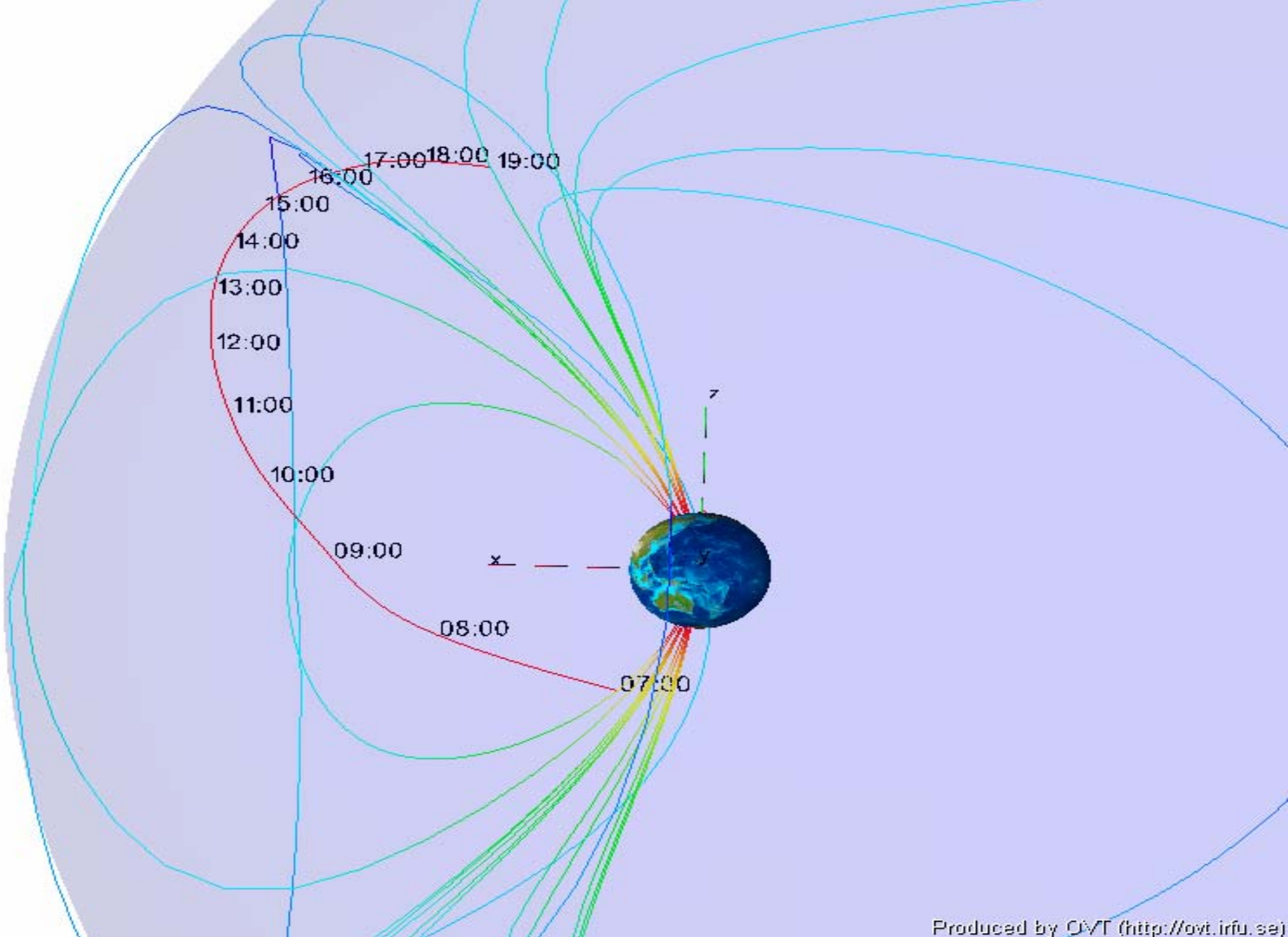
4. Different types of ion pitch angle distributions have been observed in the dayside ORB at the same time and location for different ion species: Proton peaked at 90^{o}; He^{++}, isotropic; and O^{+}, isotropic/butterfly.

5. New ion sources come from both parallel and anti-parallel field directions. Such directions may be connected magnetically to the equatorward edges of the southern and northern cusps.

6. These observational facts suggest that the CEPs are a potentially additional source of the charged particles in the ORB.

Backup Slides


Ion Pressure, WIND 4/20/99
P (nPa)
Vx(km/s)
Vz: Dashed line
Vy: Solid line
Vz, Vy
Bx: Solid line
Bz: Dashed line
Bx,Bz(nT)
By(nT)
UT (hours)


19:00
18:00
17:00
16:00
15:00
14:00
13:00
12:00
11:00
10:00
09:00
08:00
07:00
z
x
y
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