CAMMICE Science Report

May 5, 2006

CEPs: A Probable Source of Outer Radiation Belt Charged Particles

Jiasheng Chen* and *Theodore A. Fritz

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.

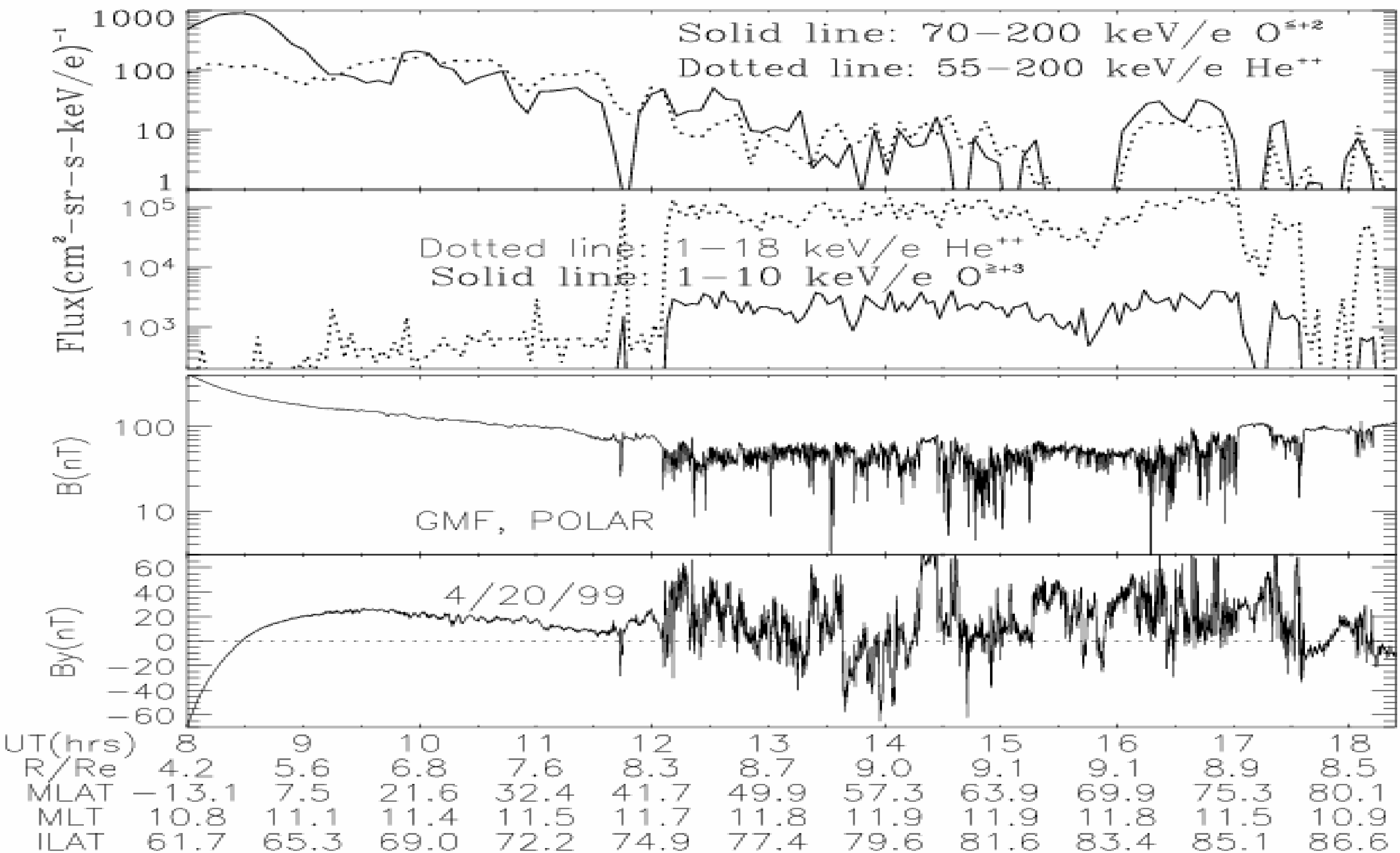
2. J. Chen, T. A. Fritz, and R. B. Sheldon, 2005. Multiple spacecraft observations of energetic ions during a high solar wind pressure event, J. Geophys. Res., 110, A11212, doi:10.1029/2005JA011043

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.

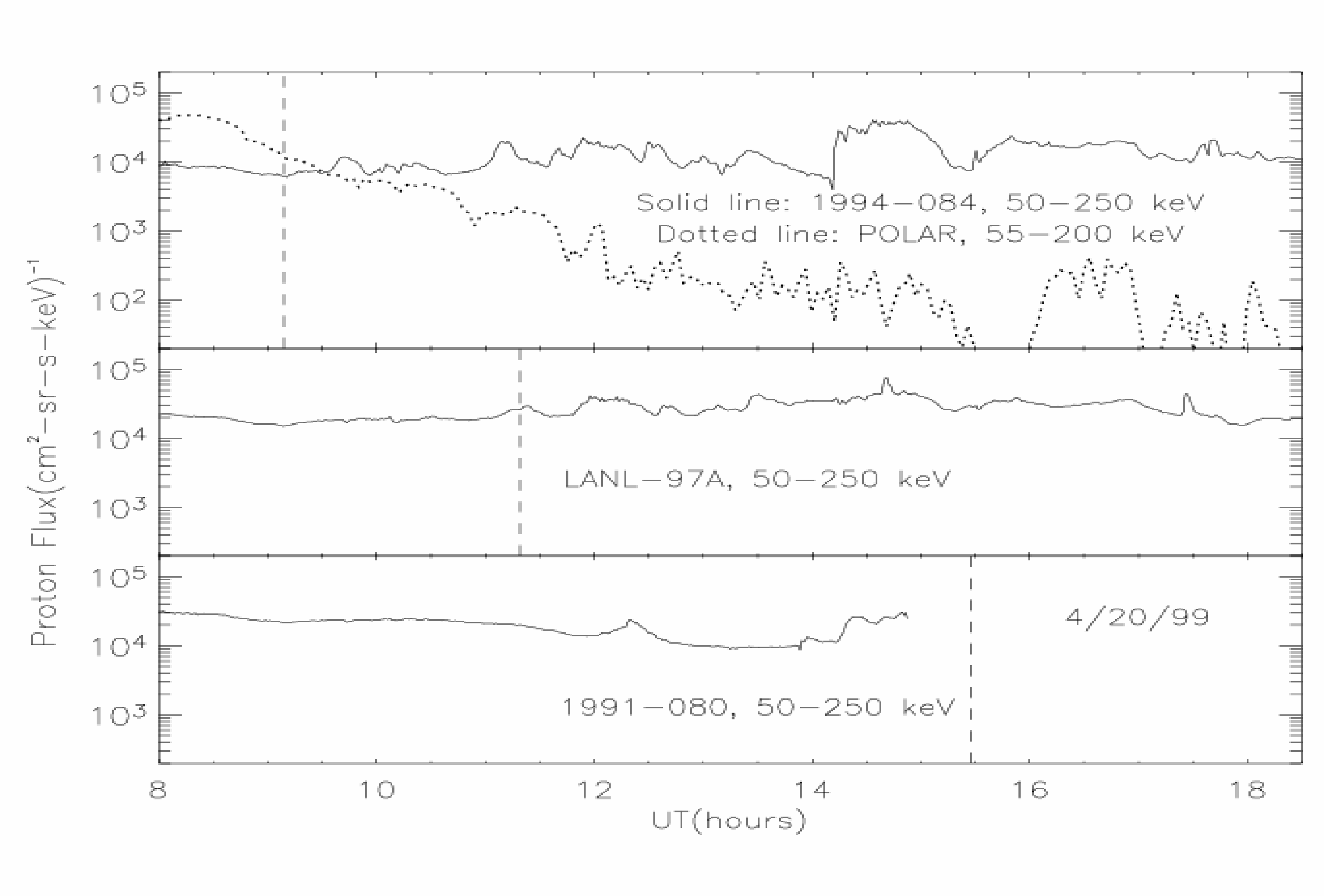
Definition of the cusp energetic particle (CEP) event:

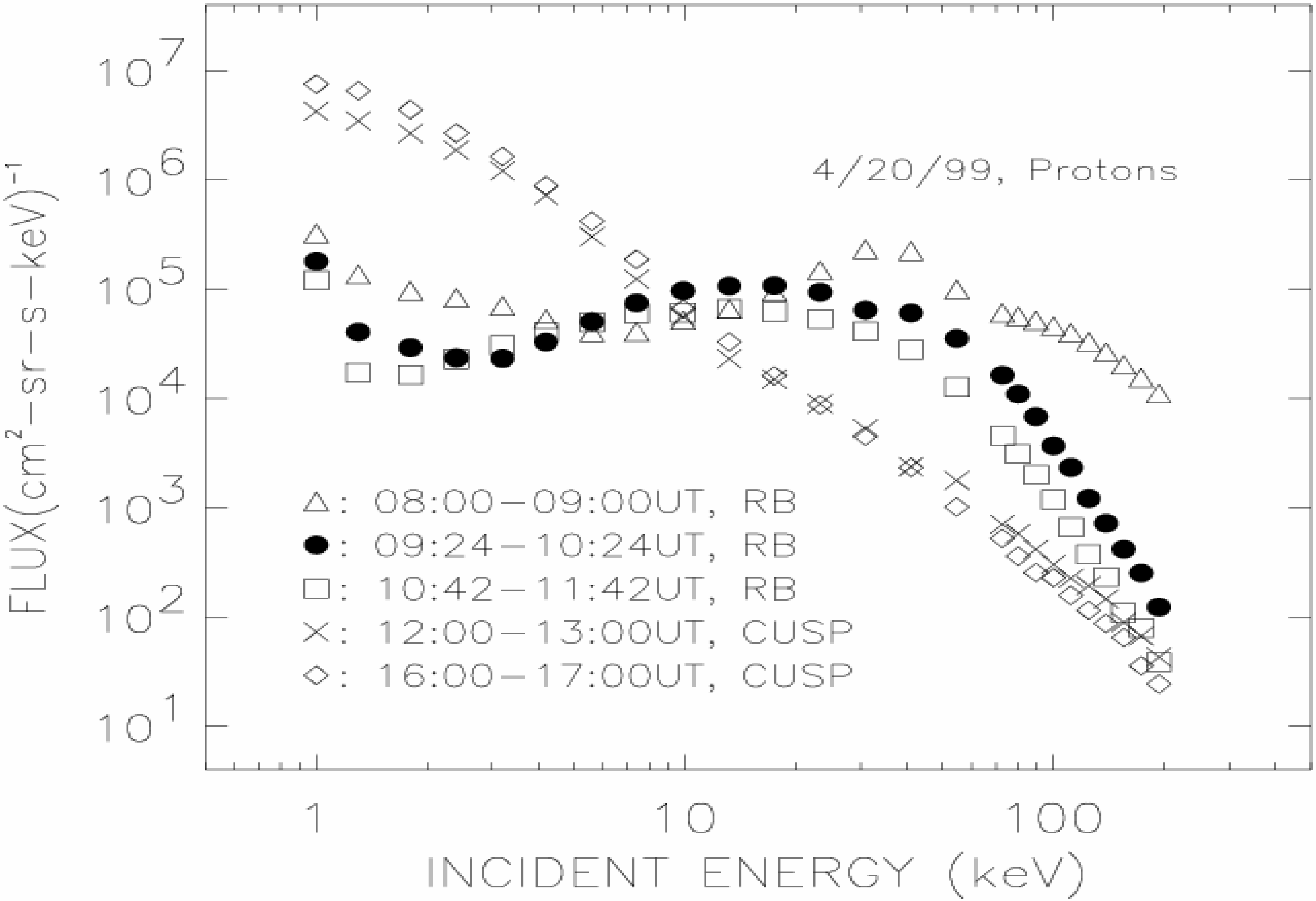
- 1. A decrease in |**B**| in the dayside cusp;
- 2. a more than one order of magnitude increase in intensity for the 1-10 keV ions;
- 3. a more than three sigma increase above background for > 40 keV ion intensity.



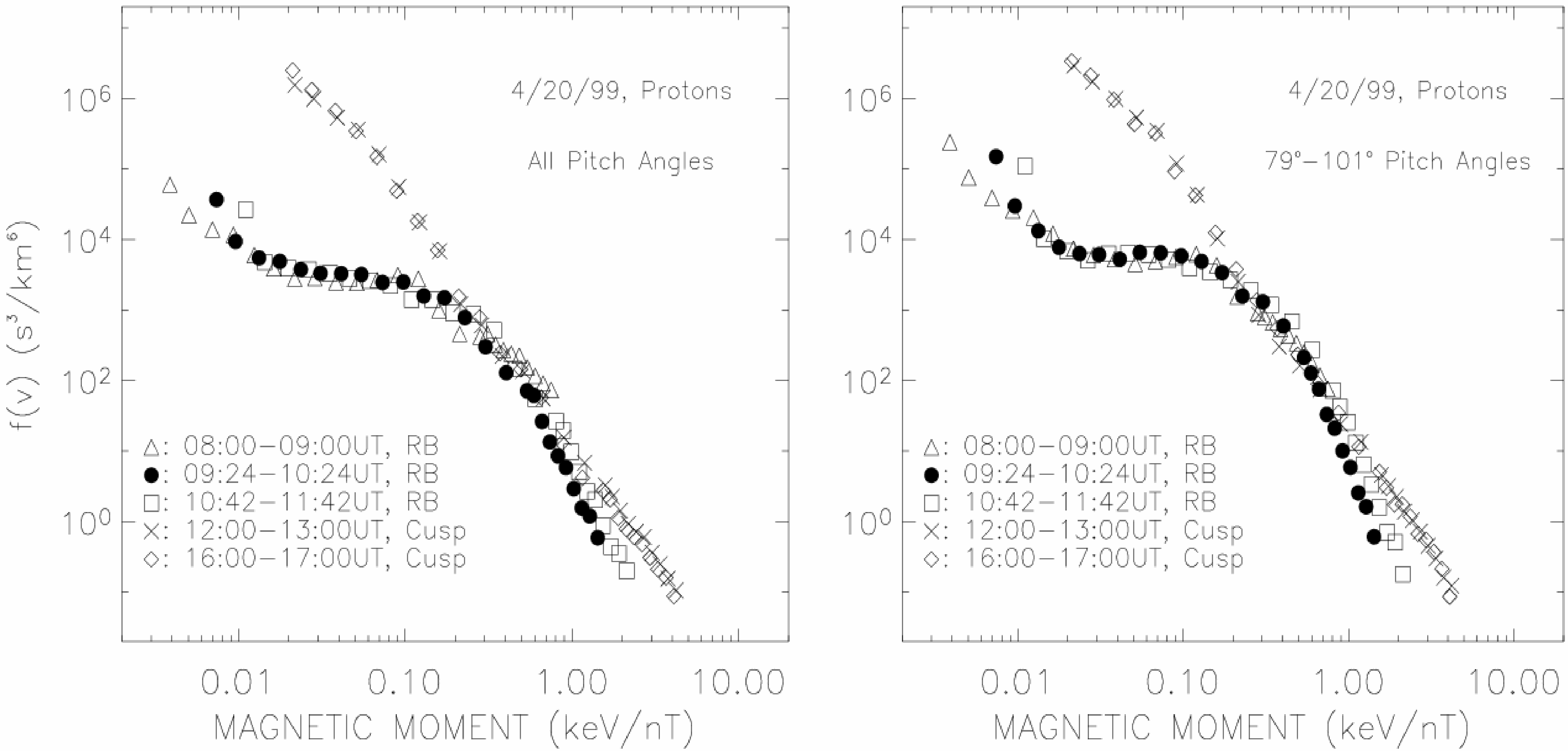
Solid line: 70-200 keV/e O≥+2
Dotted line: 55-200 keV/e He++
Dotted line: 1-18 keV/e He++
Solid line: 1-10 keV/e O≥+3
Flux(cm²-sr-s-keV/e)⁻¹
1000
100
10
1
10⁵
10⁴
10³
B(nT)
100
10
GMF, POLAR
By(nT)
4/20/99
60
40
20
0
-20
-40
-60
UT(hrs) 8 9 10 11 12 13 14 15 16 17 18
R/Re 4.2 5.6 6.8 7.6 8.3 8.7 9.0 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

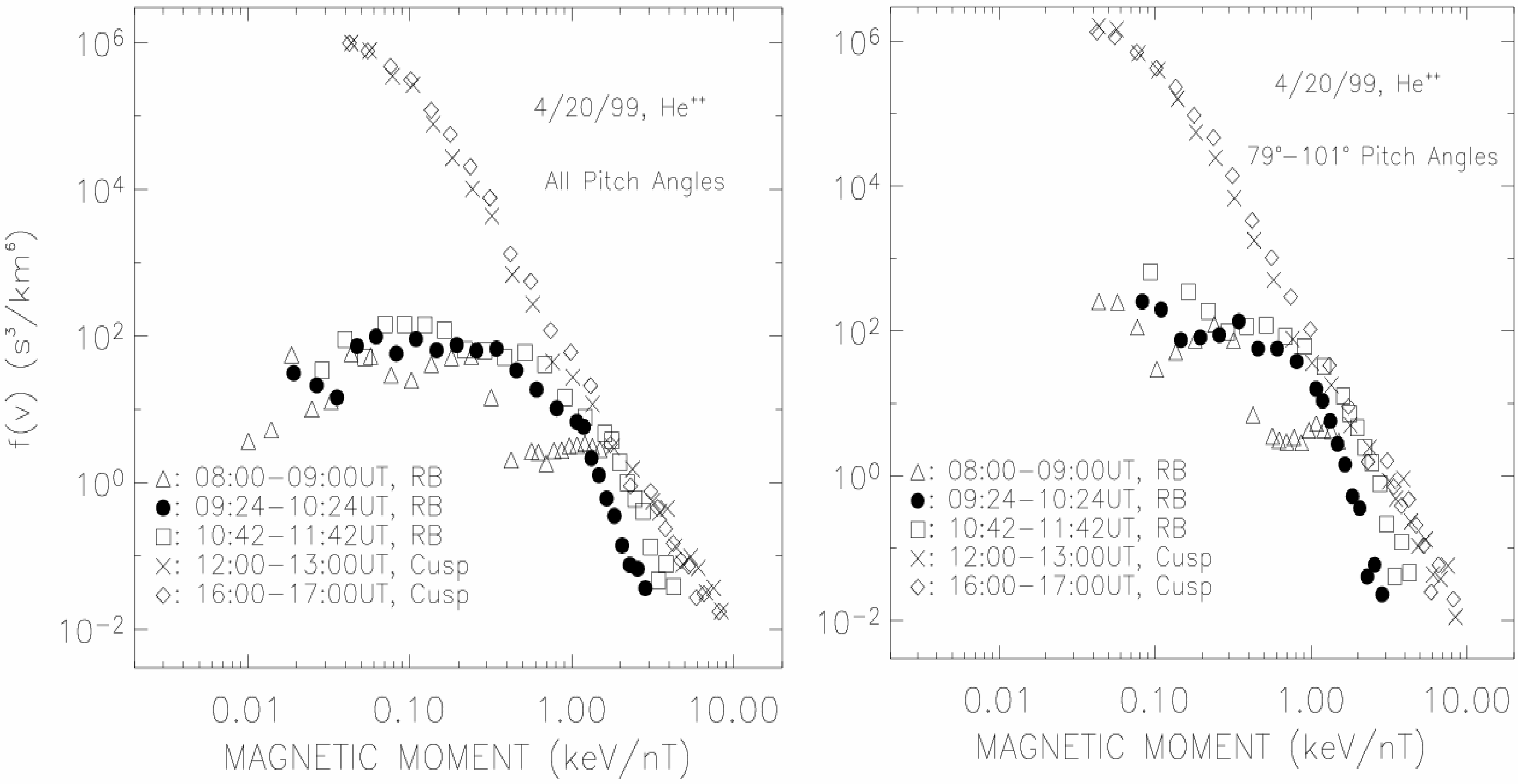



4/20/99, Protons
FLUX(cm²-sr-s-keV)⁻¹
10⁷
10⁶
10⁵
10⁴
10³
10²
10¹
△: 08:00-09:00UT, RB
●: 09:24-10:24UT, RB
□: 10:42-11:42UT, RB
×: 12:00-13:00UT, CUSP
◇: 16:00-17:00UT, CUSP
1
10
100
INCIDENT ENERGY (keV)

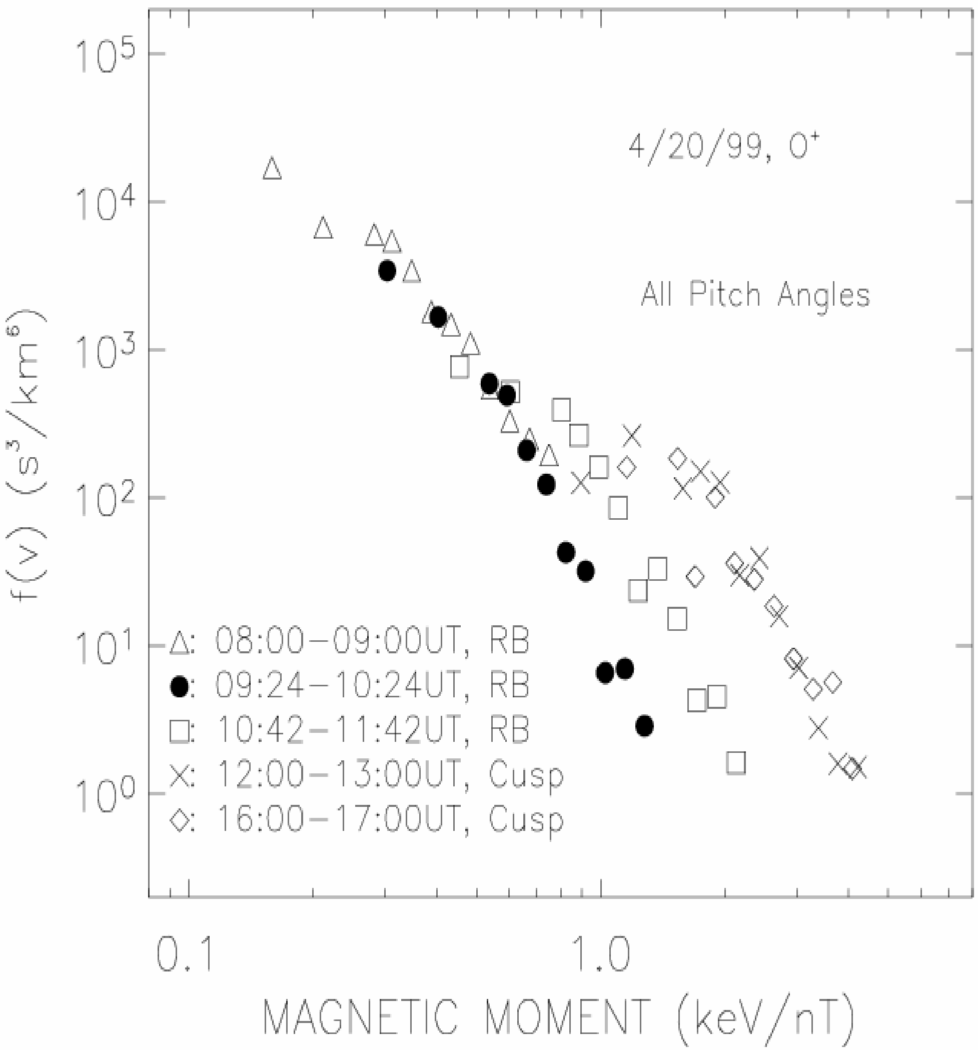
Proton magnetic moment spectra

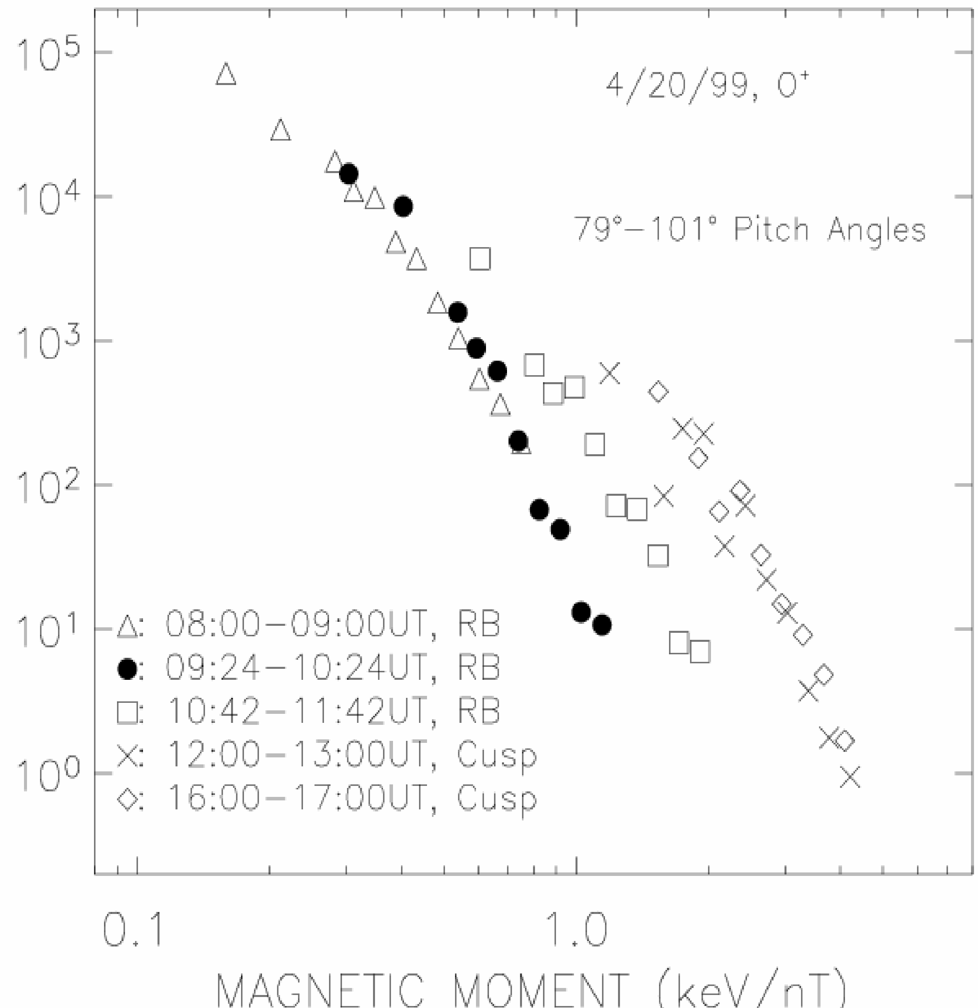


He^{++} magnetic moment spectra



O^+ magnetic moment spectra



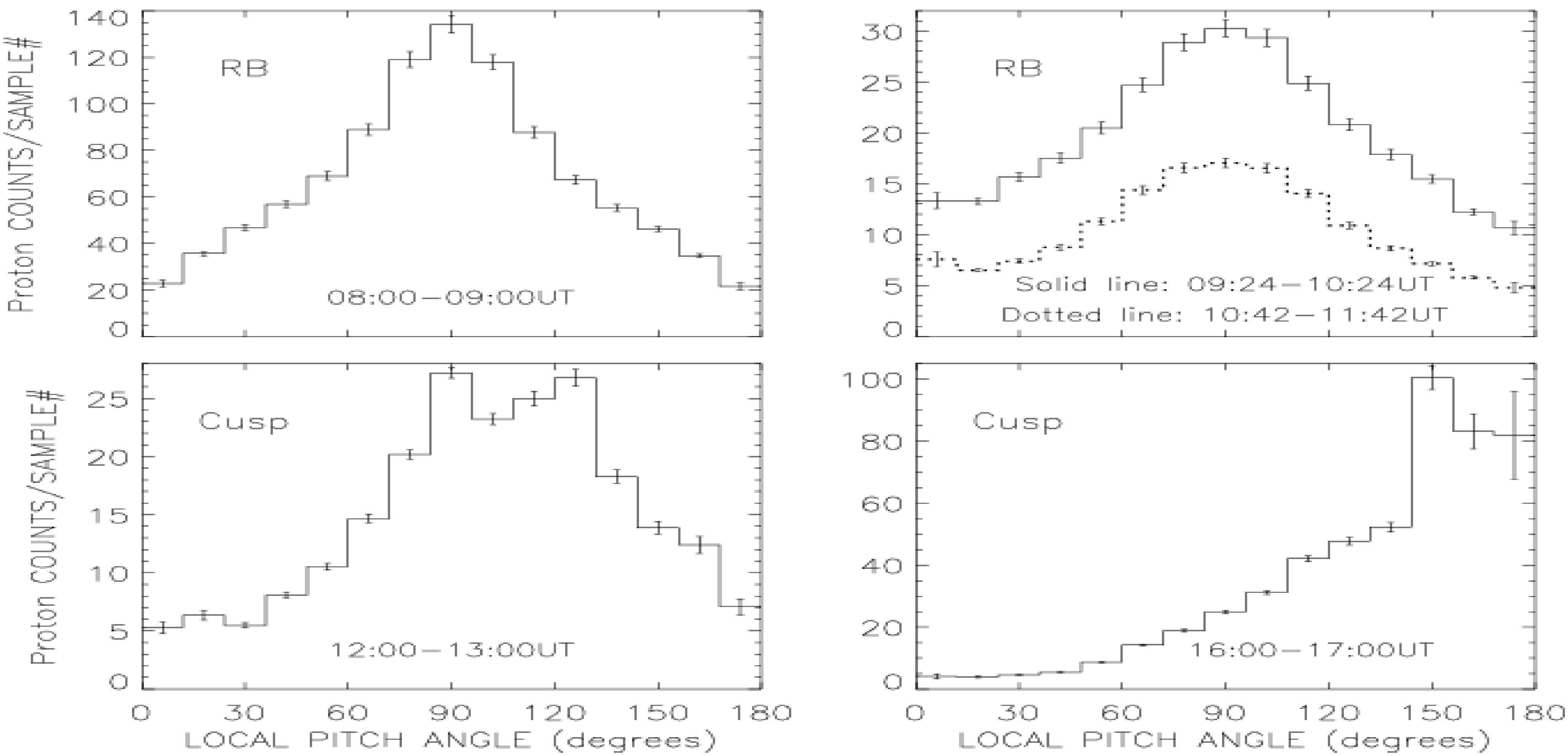


Conclusions – Part I

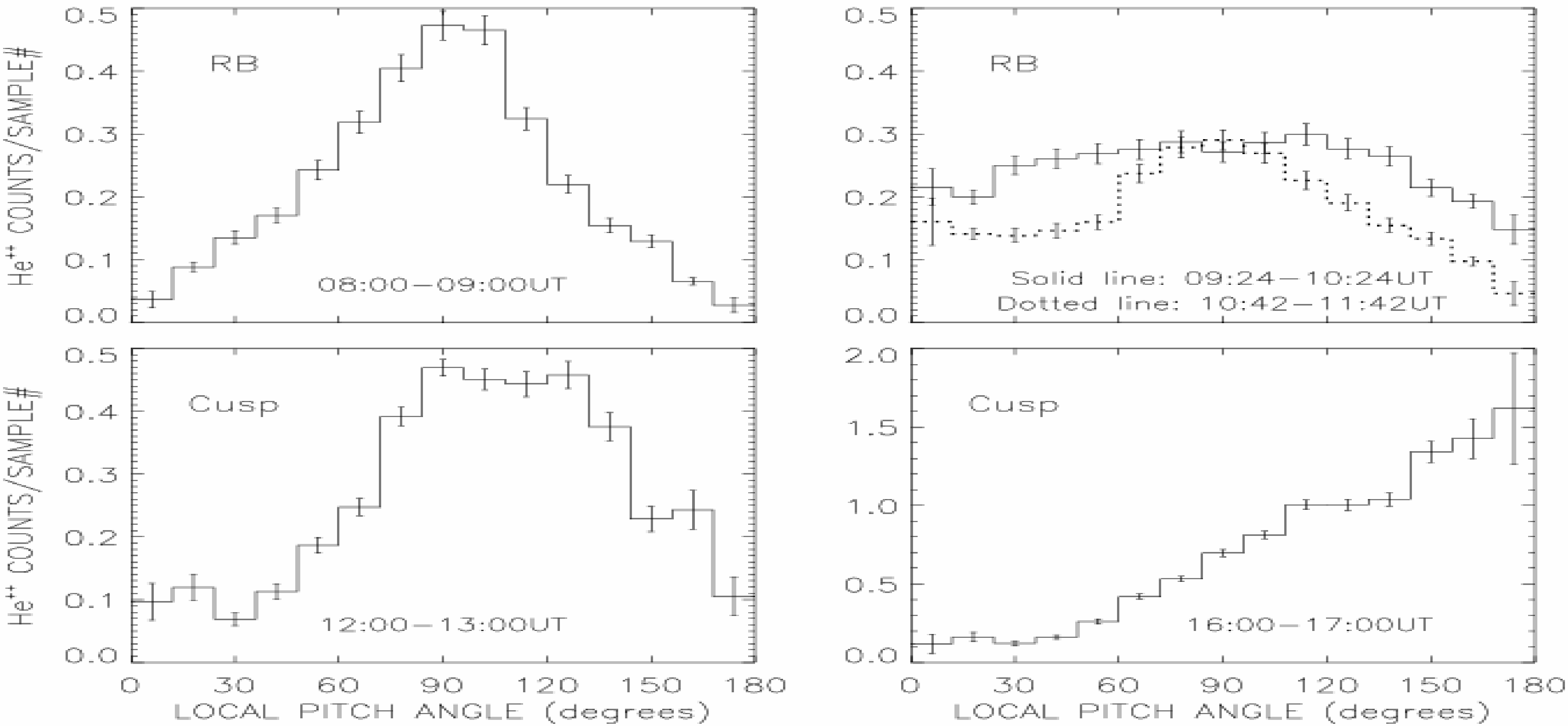
•This analysis demonstrates that the outer radiation belt cannot be the source of the particles in the cusps due to the fact that the phase space density at a given magnetic moment in the cusp is larger than [in one case equal to] the phase space density in the outer radiation belts.

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

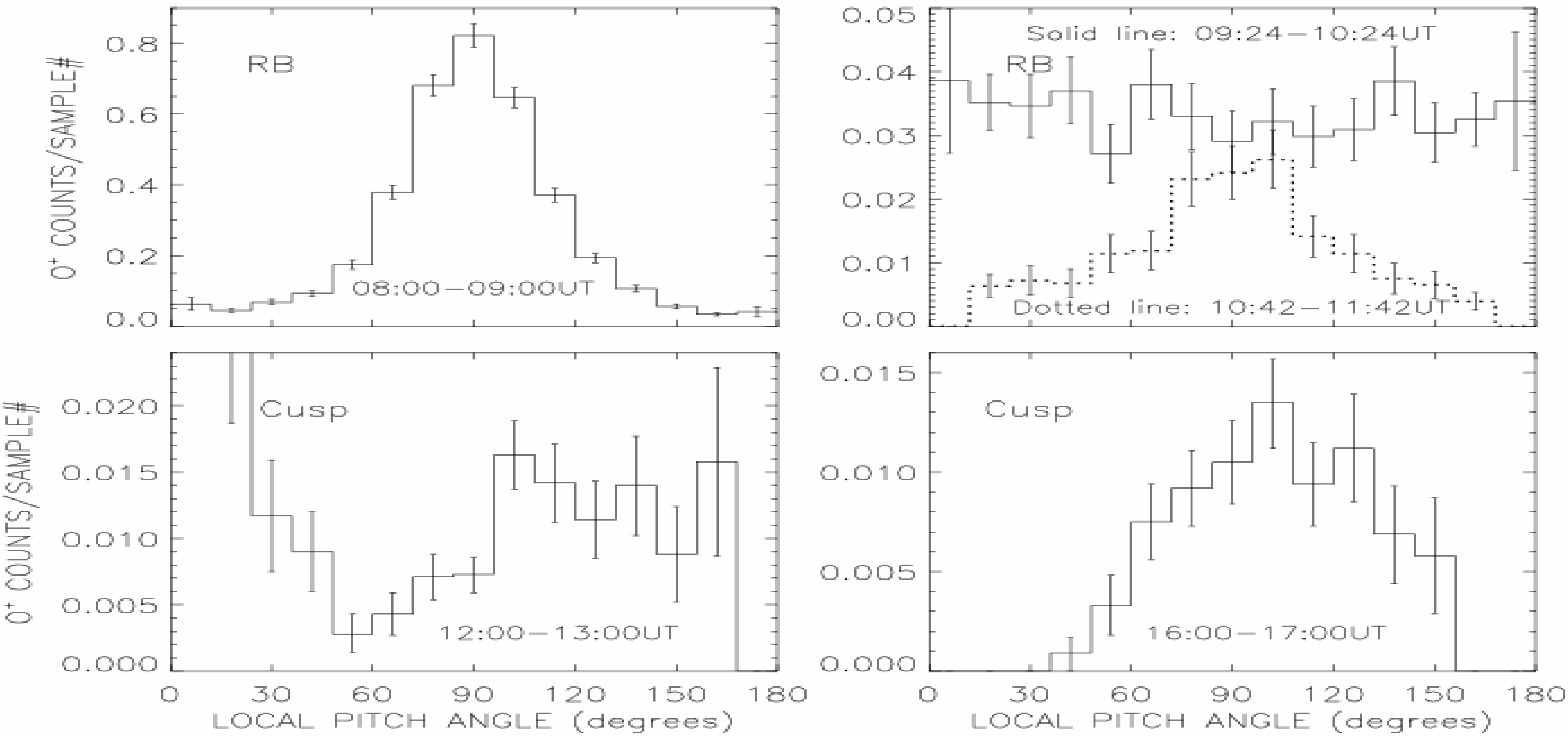
Proton pitch angle distributions



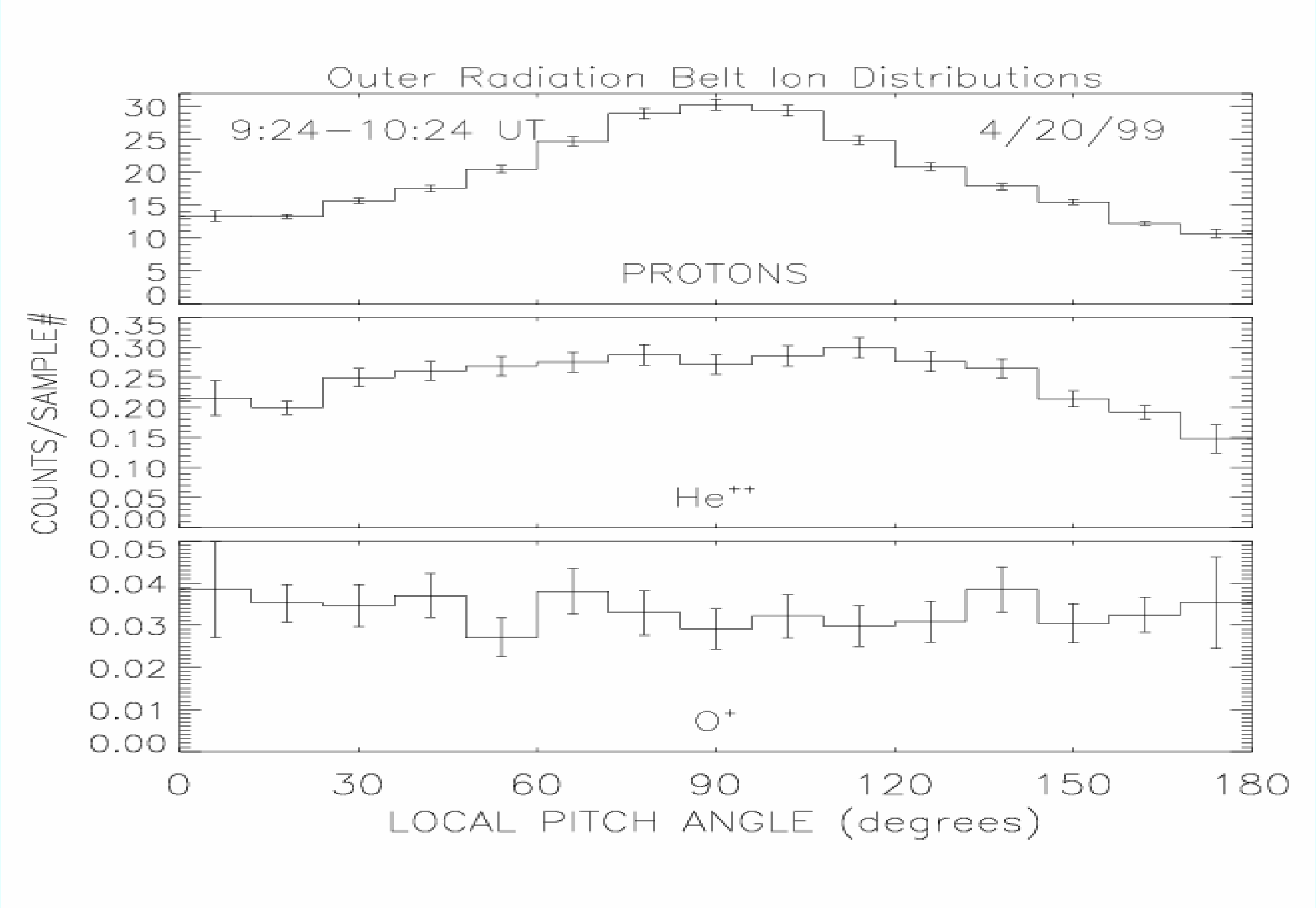
He^{++} pitch angle distributions



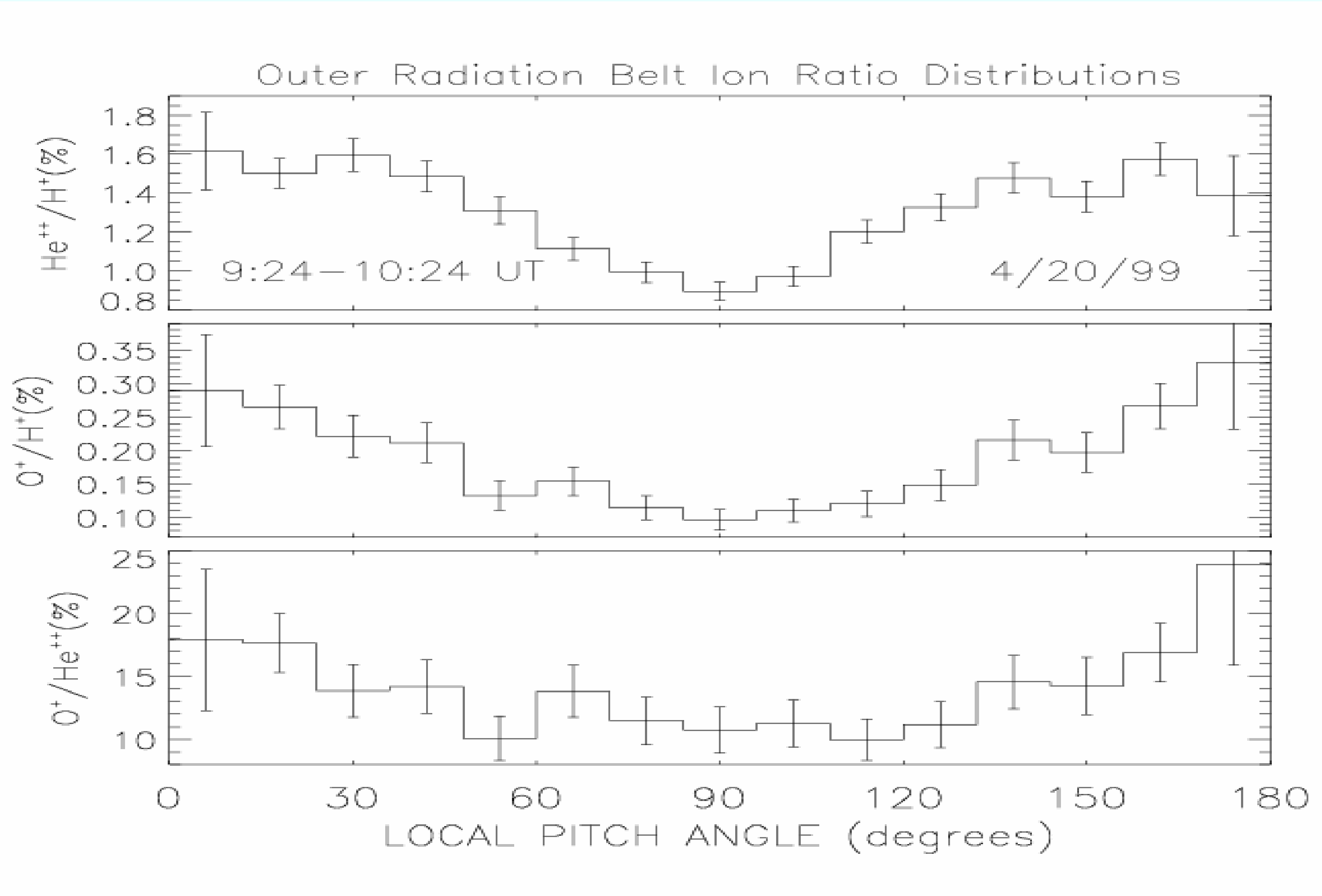
O$^+$ pitch angle distributions



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 (PSD) in the Outer Radiation Belt (ORB) 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.

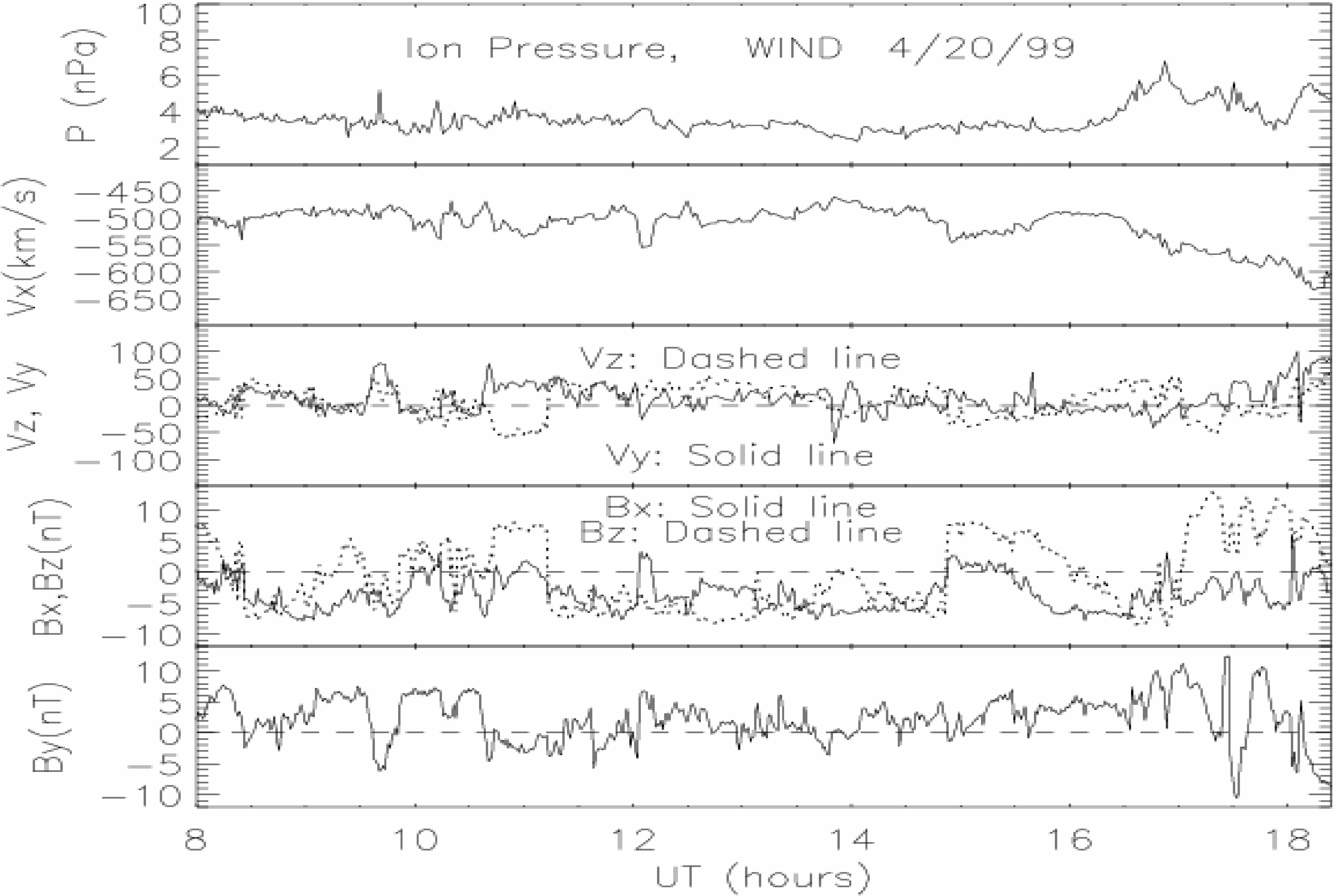
3. Both He^{++} and O^{+} PSDs in the cusp are significantly higher than those in the ORB at a given magnetic moment.

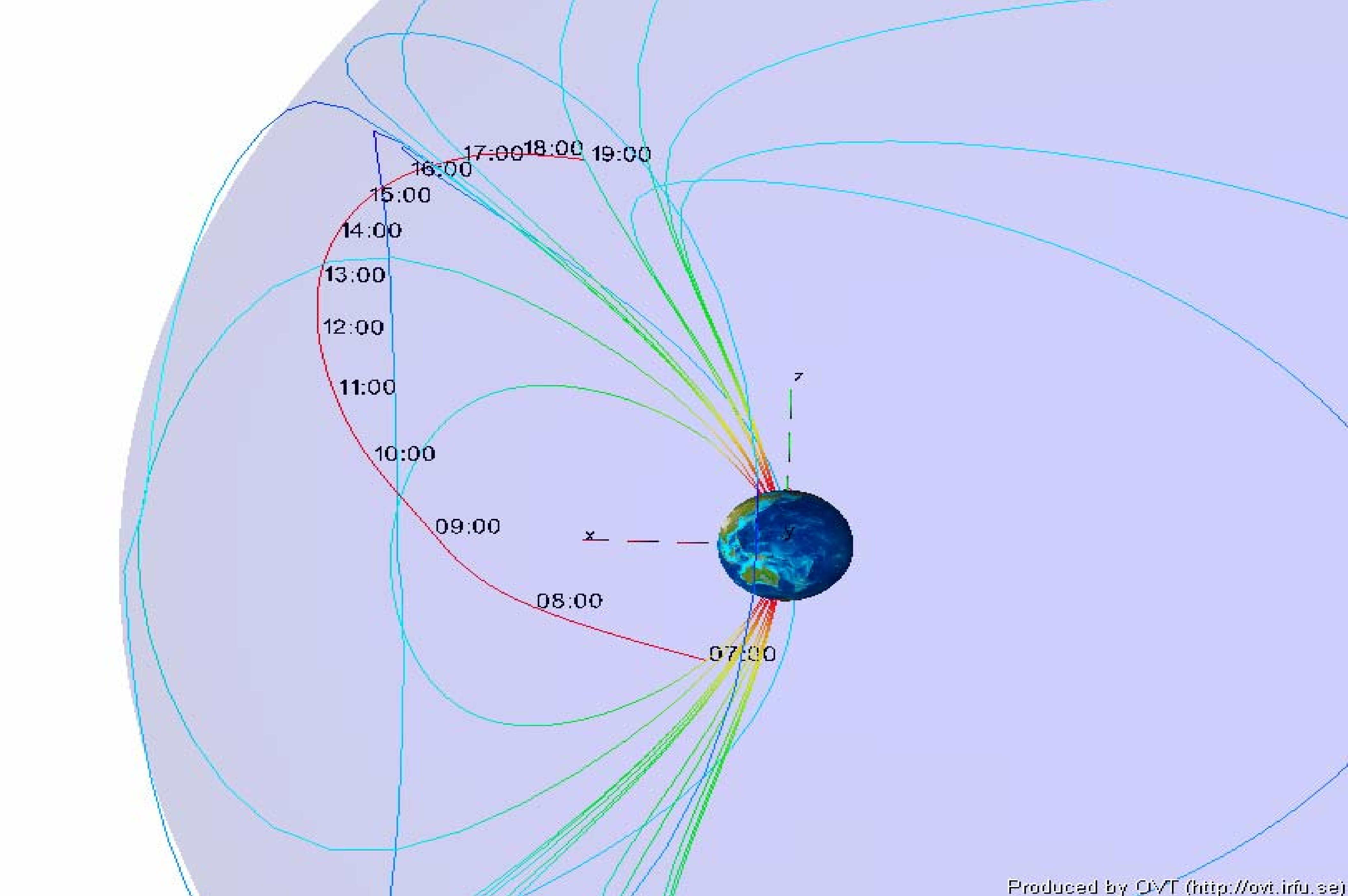
4. Different types of ion pitch angle distributions have been observed in the dayside ORB at the same time and location for different ion species. For example, protons peaked at 90^{o}; He^{++} isotropic; and O^{+} isotropic/butterfly are observed at the same time/location.

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 potentially an 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)



17:00
18:00
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z
x
y
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