High Resolution Electron Wave Measurements at Mars

By:

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Introduction and Background

Winningham et al. 2005 reported measurements of ultra low frequency waves at Mars based on fluctuations in the electron fluxes observed by the Electron Spectrometer (ELS) on the ESA Mars Express (MEX) spacecraft. These results were based on a 4 second data cadence. ELS data modes have been reprogrammed and 1 second complete spectra and 1/32 second fixed energy data are now available and will be reported in this paper.

In the prior work Fourier transforms of the integrated flux showed peaks in the 0.01 to 0.02 Hz range. No magnetometer data is available on MEX but comparison to MGS typical B field values shows these frequencies to be consistent with ion cyclotron oscillations of O^+ in the sheath.

Introduction and Background *cont*.

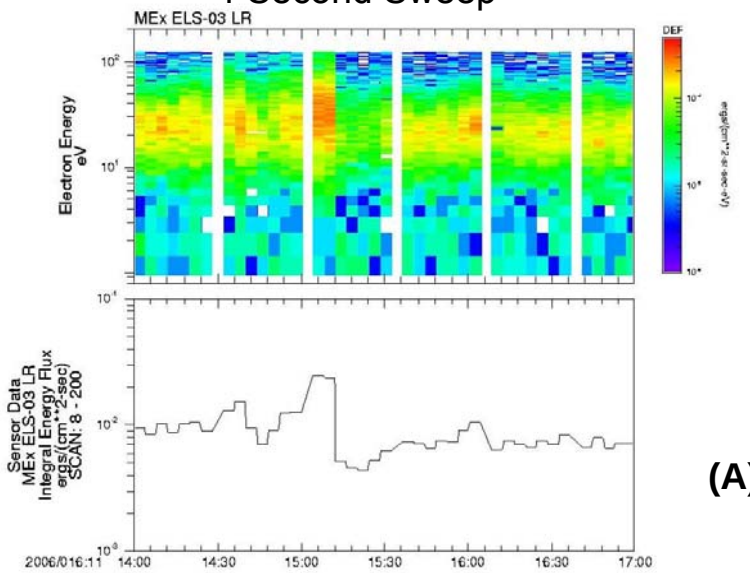
In brief, the wave power was observed to be greatest at the nose of the Martian shock and to decrease as one moves to the boundary with the ionosphere and with distance downtail in the sheath.

In this presentation we will extend this power spectral analysis to higher frequencies, further defining the wave environment of Mars.

We will also show data demonstrating further how widespread the waves are in the sheath.

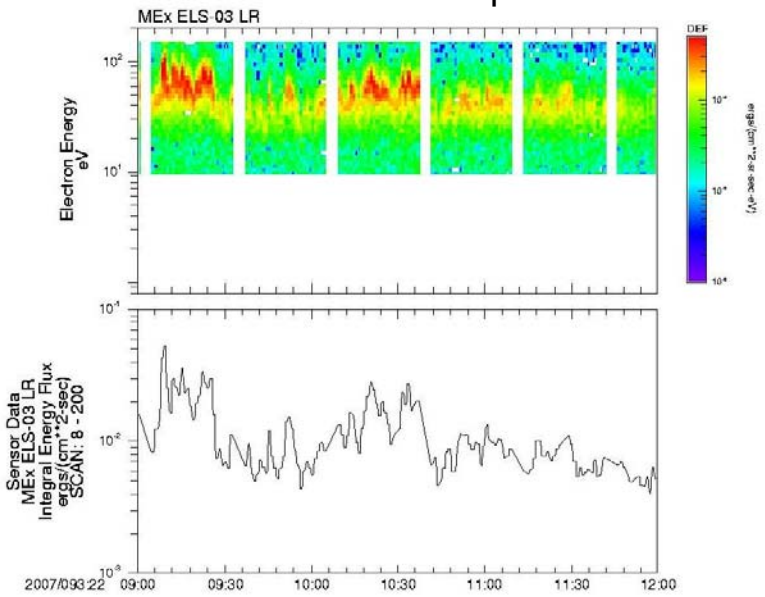
Examples of Different Temporal Resolution

4 Second Sweep



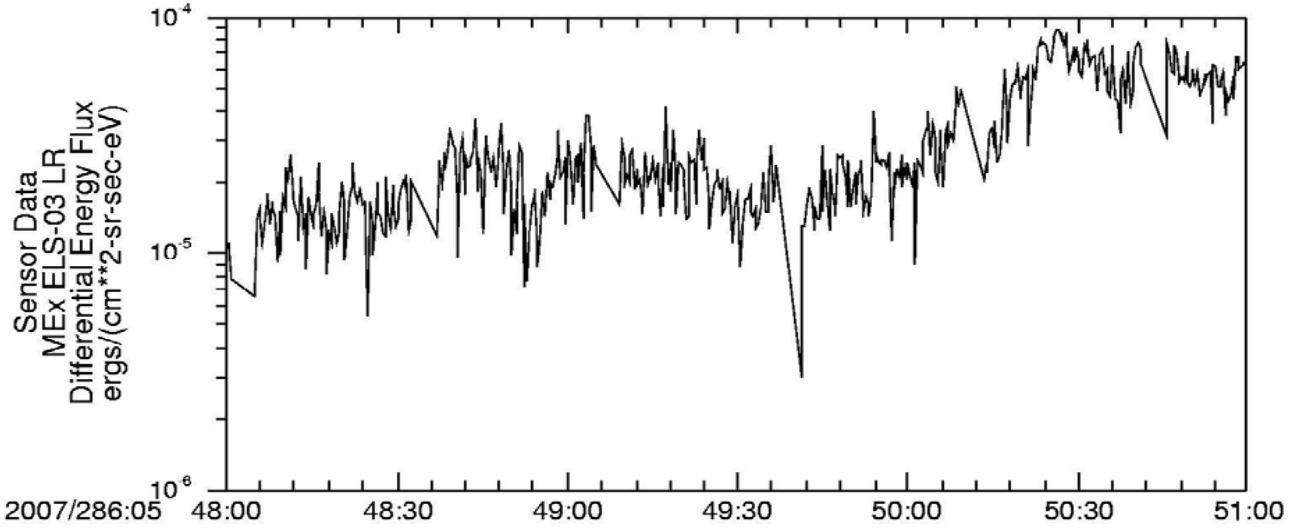
(A)

1 Second Sweep



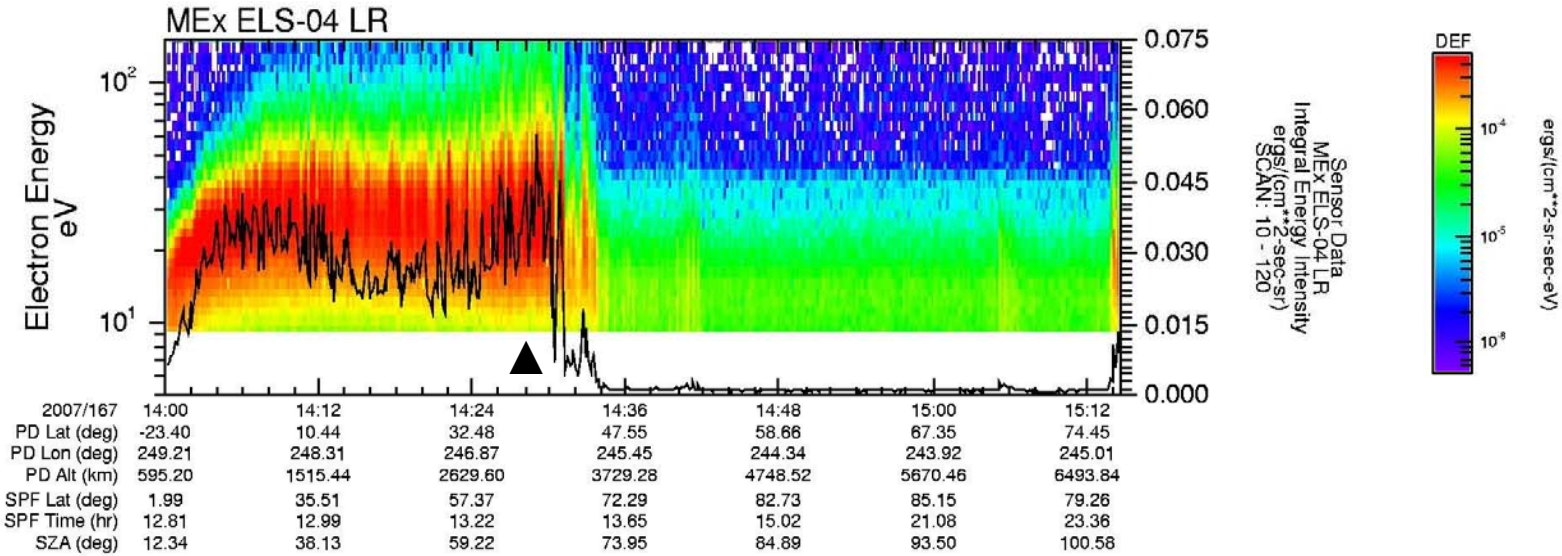
(B)

Single Energy Step



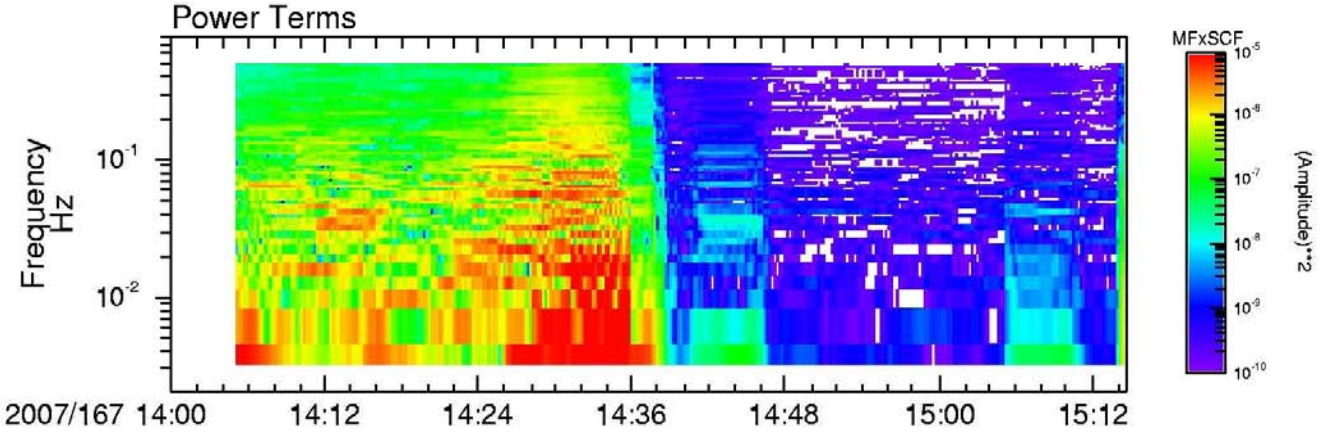
(C)

Mars Magnetosheath and Solar Wind

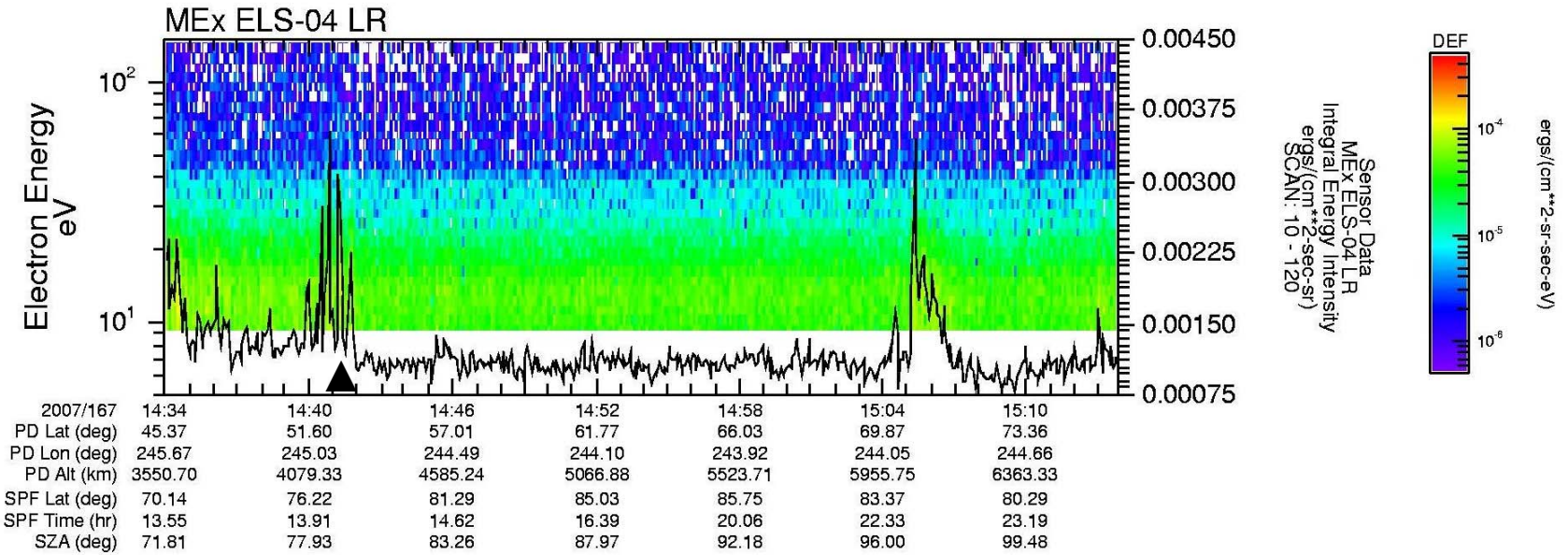


2007/167	14:00	14:12	14:24	14:36	14:48	15:00	15:12
PD Lat (deg)	-23.40	10.44	32.48	47.55	58.66	67.35	74.45
PD Lon (deg)	249.21	248.31	246.87	245.45	244.34	243.92	245.01
PD Alt (km)	595.20	1515.44	2629.60	3729.28	4748.52	5670.46	6493.84
SPF Lat (deg)	1.99	35.51	57.37	72.29	82.73	85.15	79.26
SPF Time (hr)	12.81	12.99	13.22	13.65	15.02	21.08	23.36
SZA (deg)	12.34	38.13	59.22	73.95	84.89	93.50	100.58

Mars Magnetosheath and Solar Wind Power

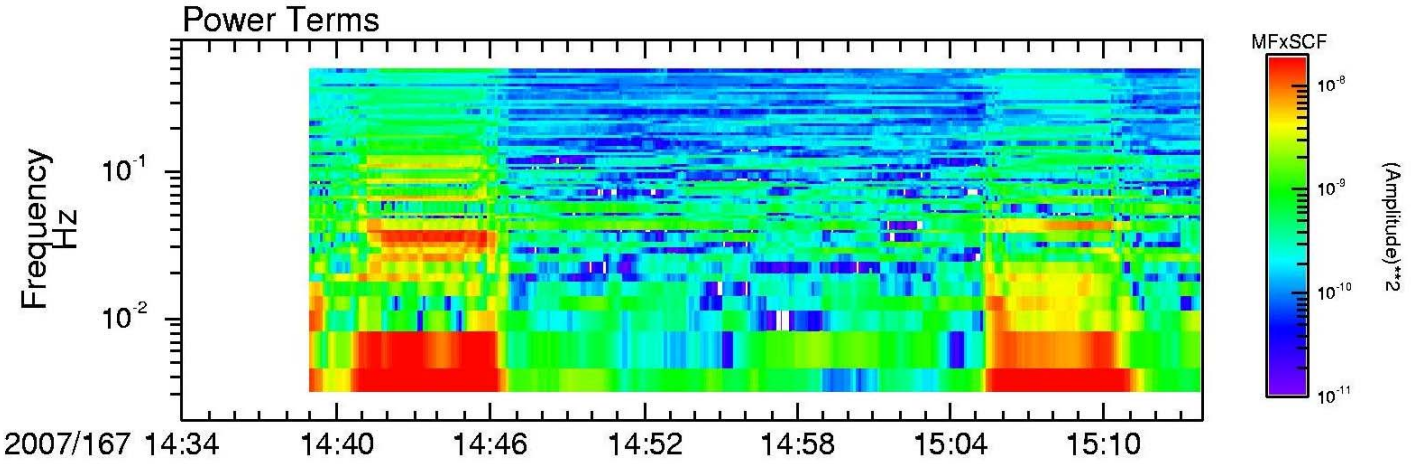


Solar Wind

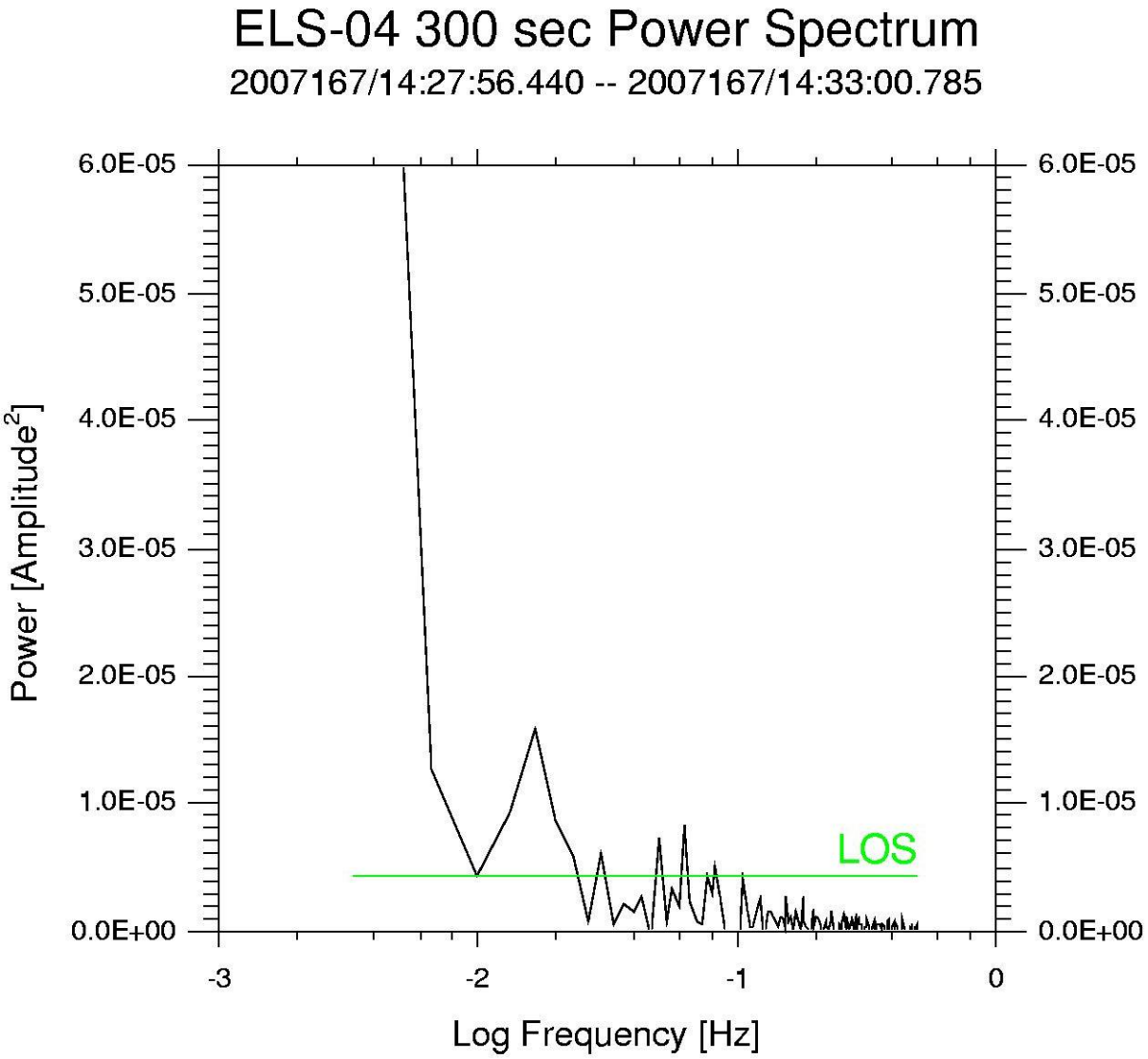


2007/167	14:34	14:40	14:46	14:52	14:58	15:04	15:10
PD Lat (deg)	45.37	51.60	57.01	61.77	66.03	69.87	73.36
PD Lon (deg)	245.67	245.03	244.49	244.10	243.92	244.05	244.66
PD Alt (km)	3550.70	4079.33	4585.24	5066.88	5523.71	5955.75	6363.33
SPF Lat (deg)	70.14	76.22	81.29	85.03	85.75	83.37	80.29
SPF Time (hr)	13.55	13.91	14.62	16.39	20.06	22.33	23.19
SZA (deg)	71.81	77.93	83.26	87.97	92.18	96.00	99.48

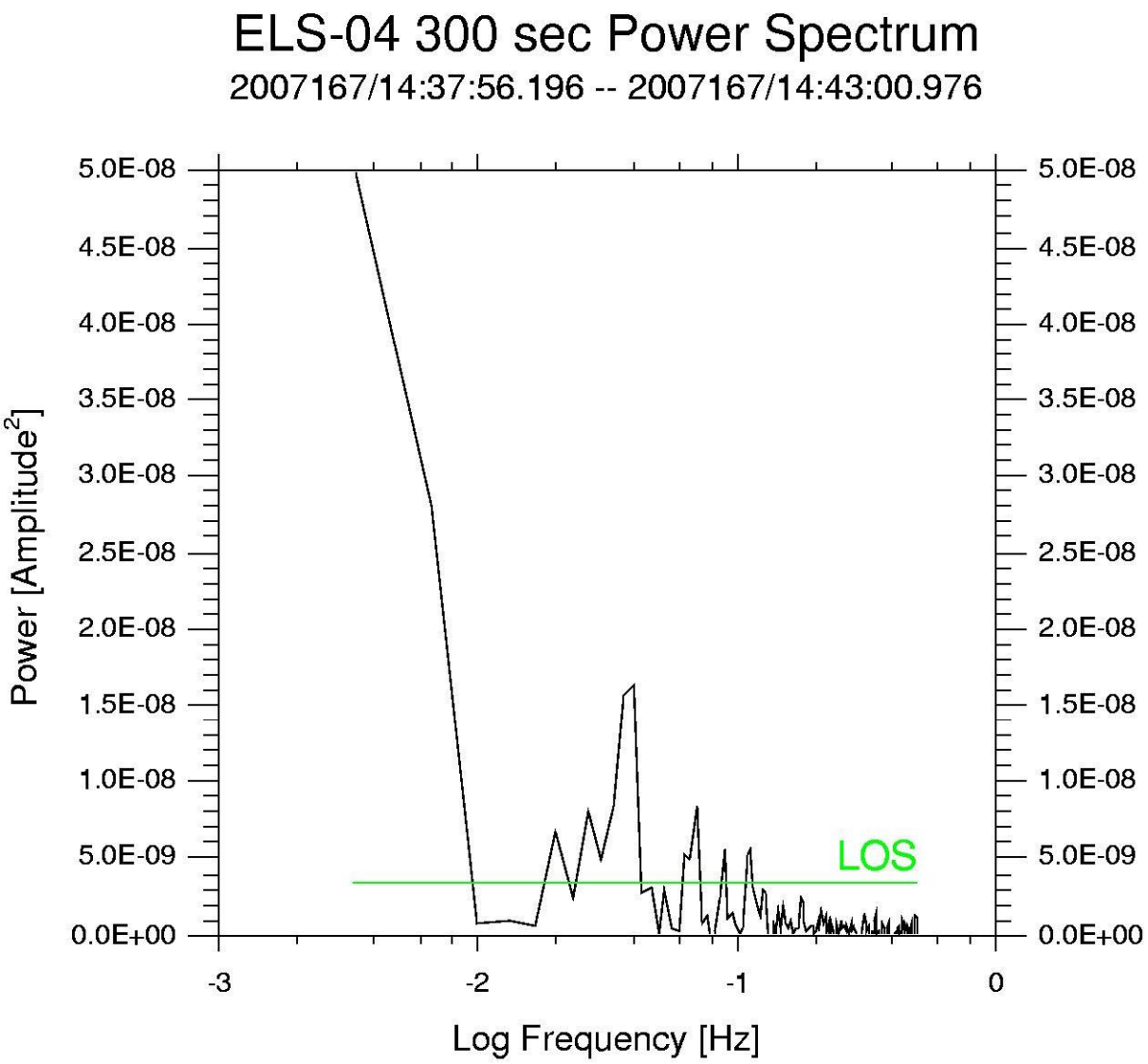
Solar Wind Power



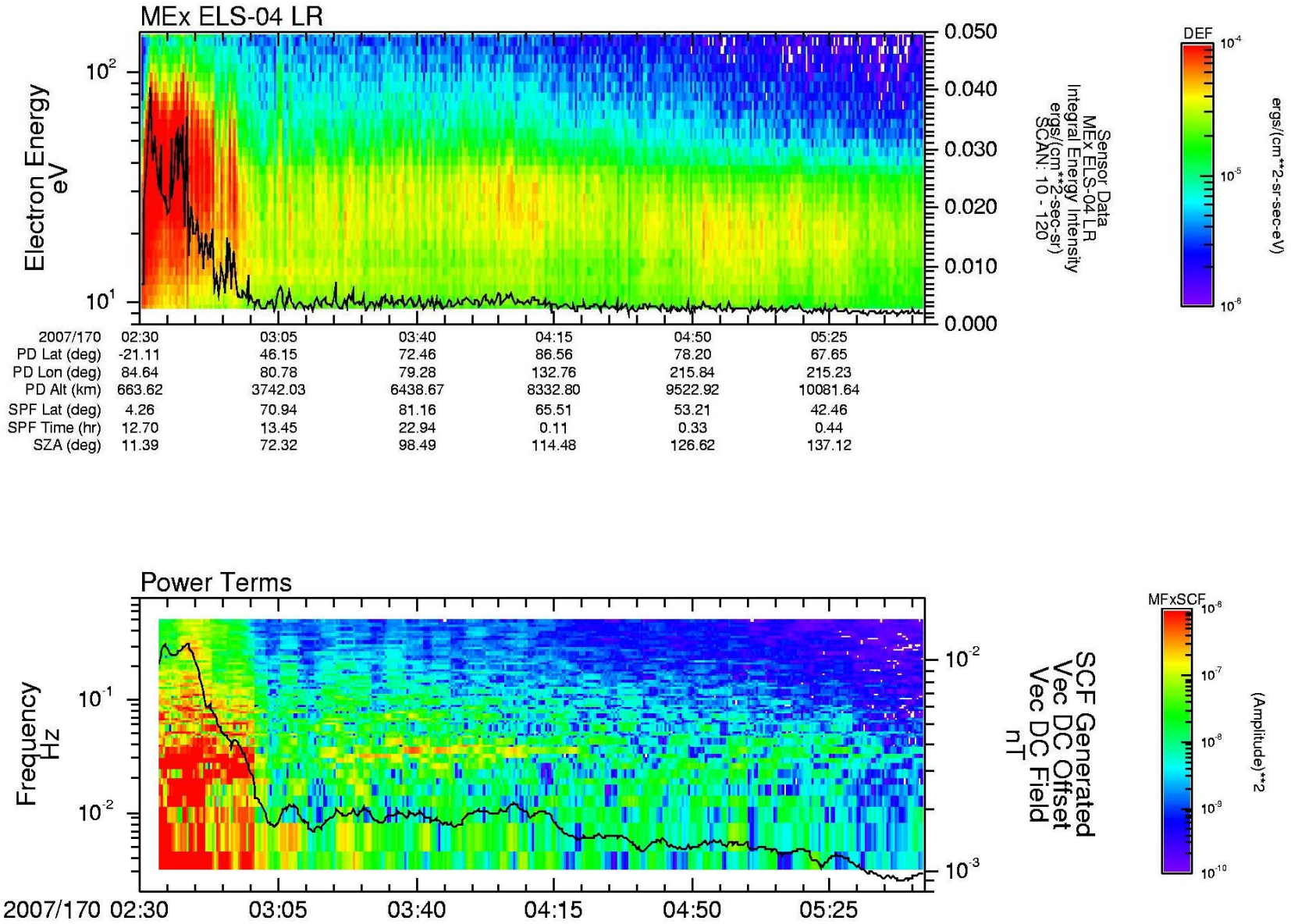
Sheath Shocked Power Spectrum



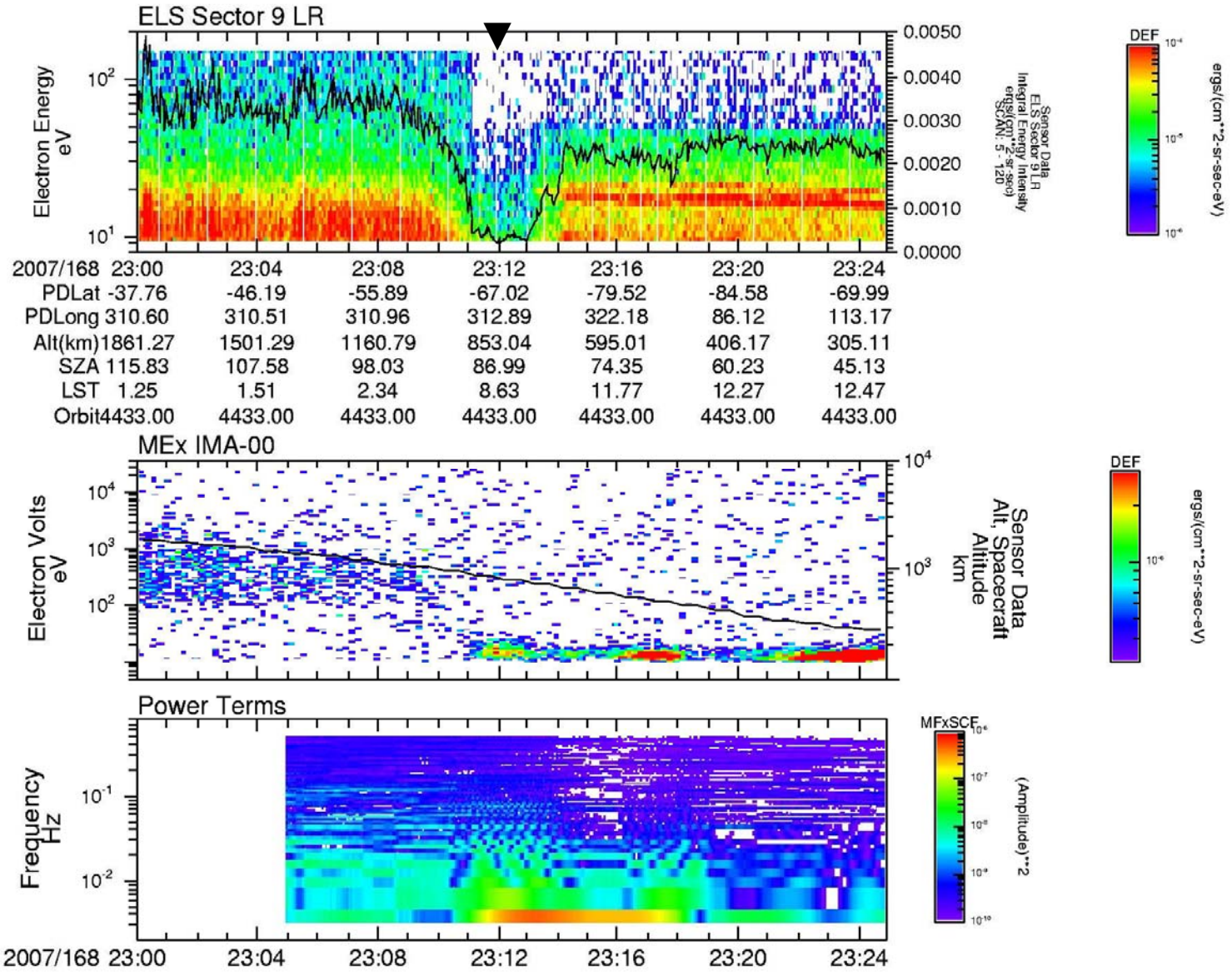
Upstream of the Mars Shock



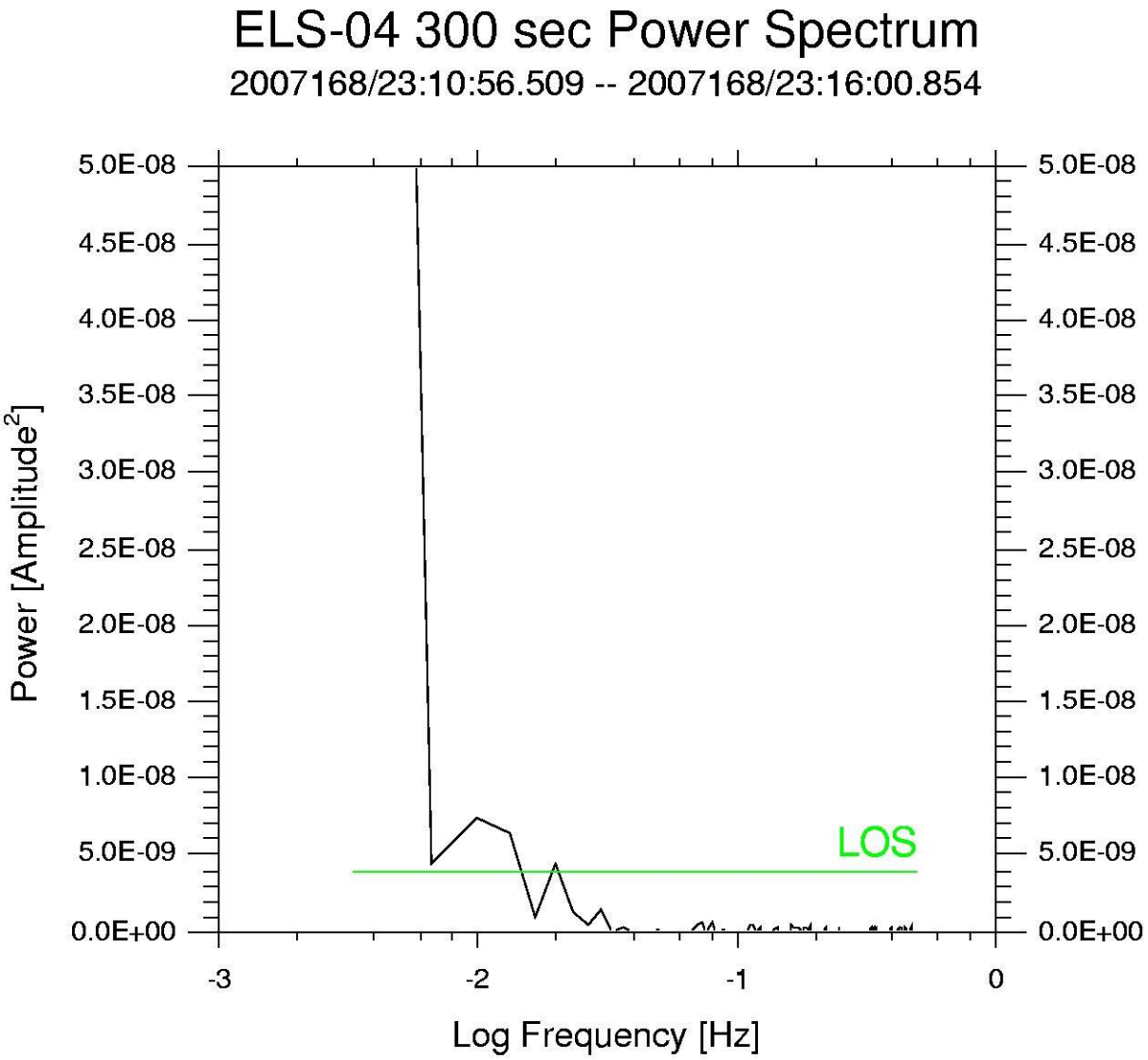
Example of Continuous Waves from Dayside to Nightside



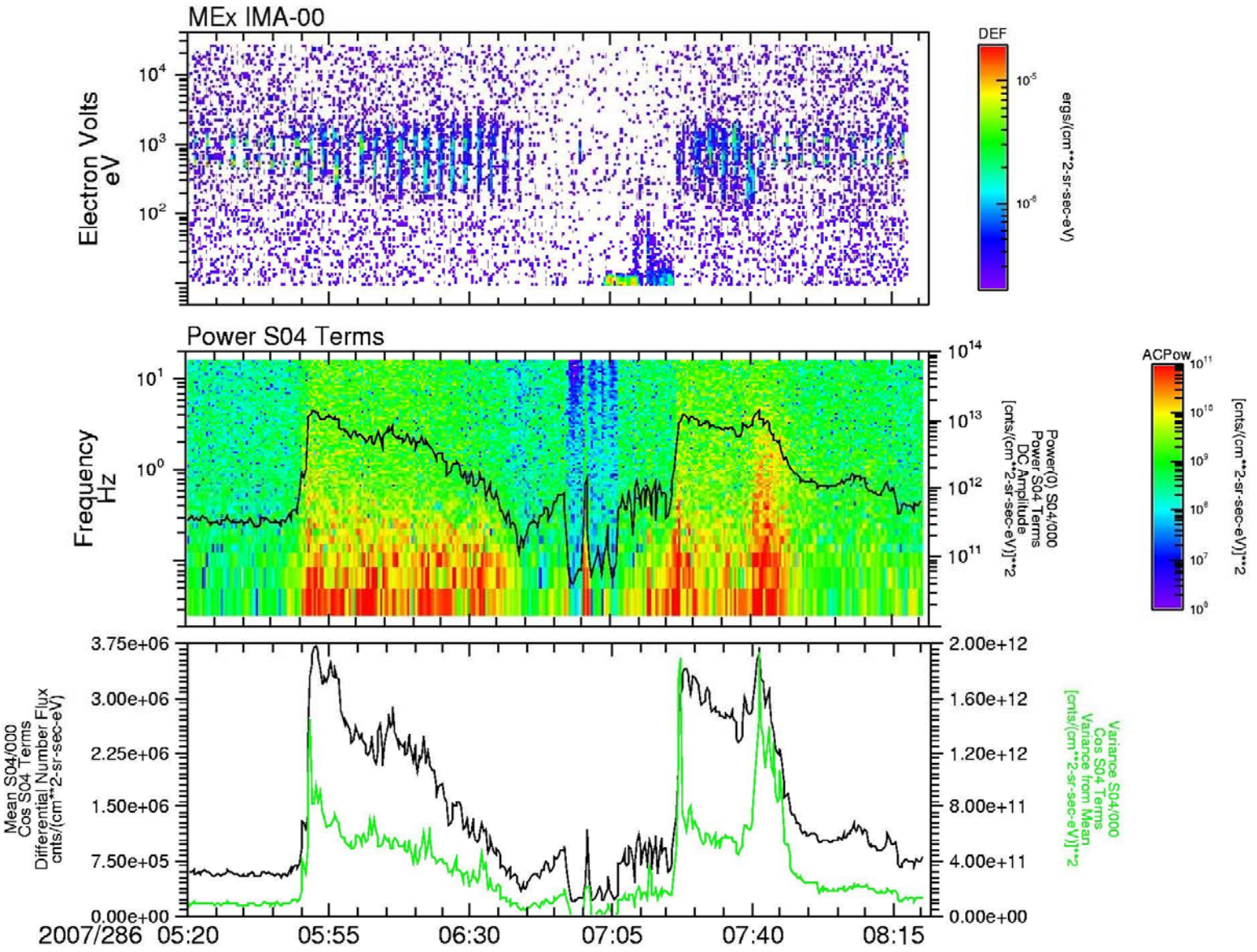
Magnetosheath / Ionosphere Boundary – Background Case



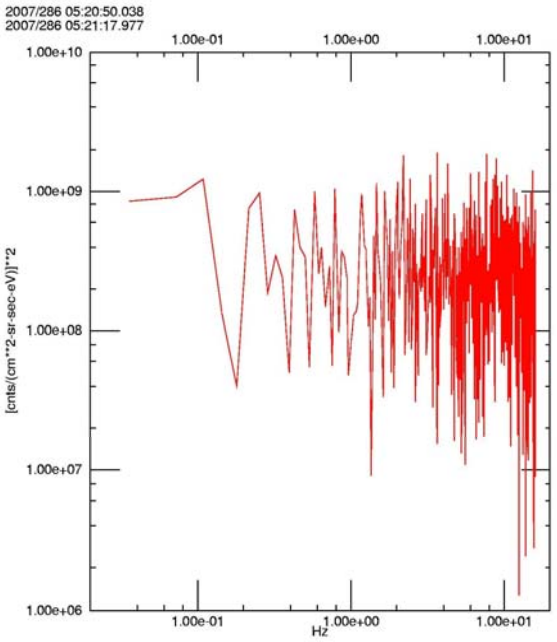
Background Boundary Power Spectrum



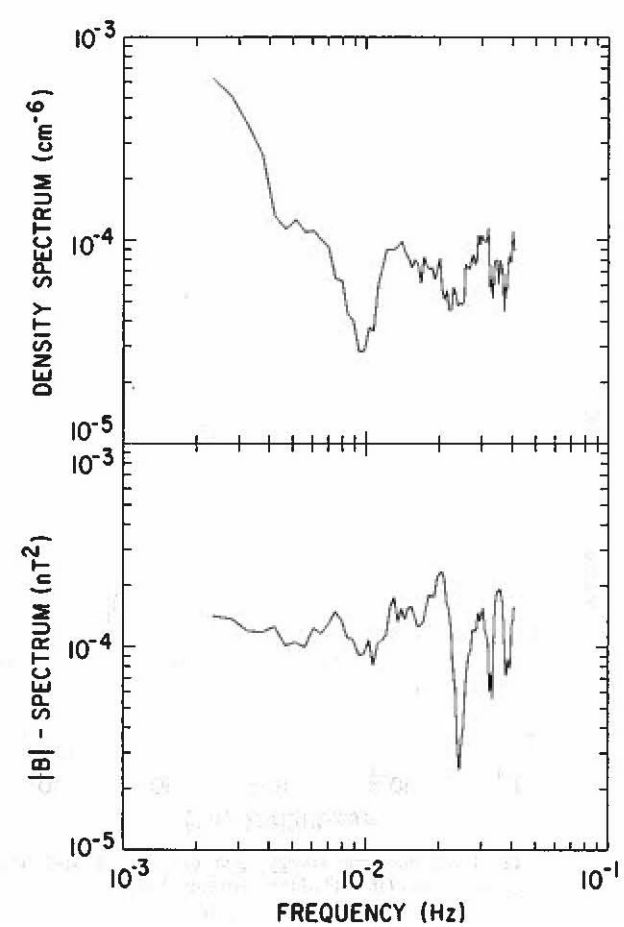
Single Energy Frequency Analysis



Solar Wind



Solar Wind Post Shock



Shocked Electrons

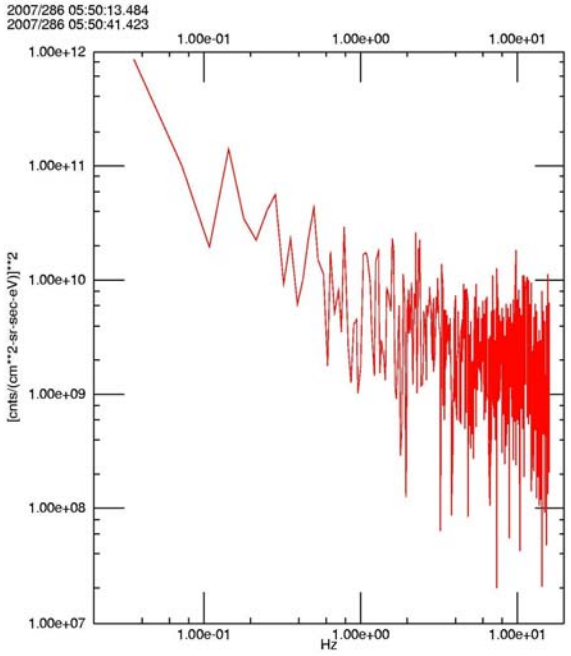


Figure 12 from Viñas *et al.,* **JGR**, 3762-3774, 1984.

Conclusion

The higher temporal resolution data presented in this paper confirms the earlier findings of Winningham, et al. 2005, concerning fluctuations in electron fluxes at Mars. In the highest frequency range observed (0.02 to 10 Hz) the spectrum is power law from the lower limit of 0.02 Hz to ~ 0.5 Hz. Above ~0.5 Hz to the upper limit of ~10Hz the spectrum flattens. Similar results have been observed in interplanetary shocks but ~10x lower in frequency. The 1 sec resolution data improves the spectral resolution below ~0.5 Hz. Peaks (and harmonics) are observed around 0.025 Hz in the Martian magnetosheath. If we assume the peaks are due to O^+ then B is ~26nT, which is in reasonable agreement with MGS sheath field value.

Conclusion cont.

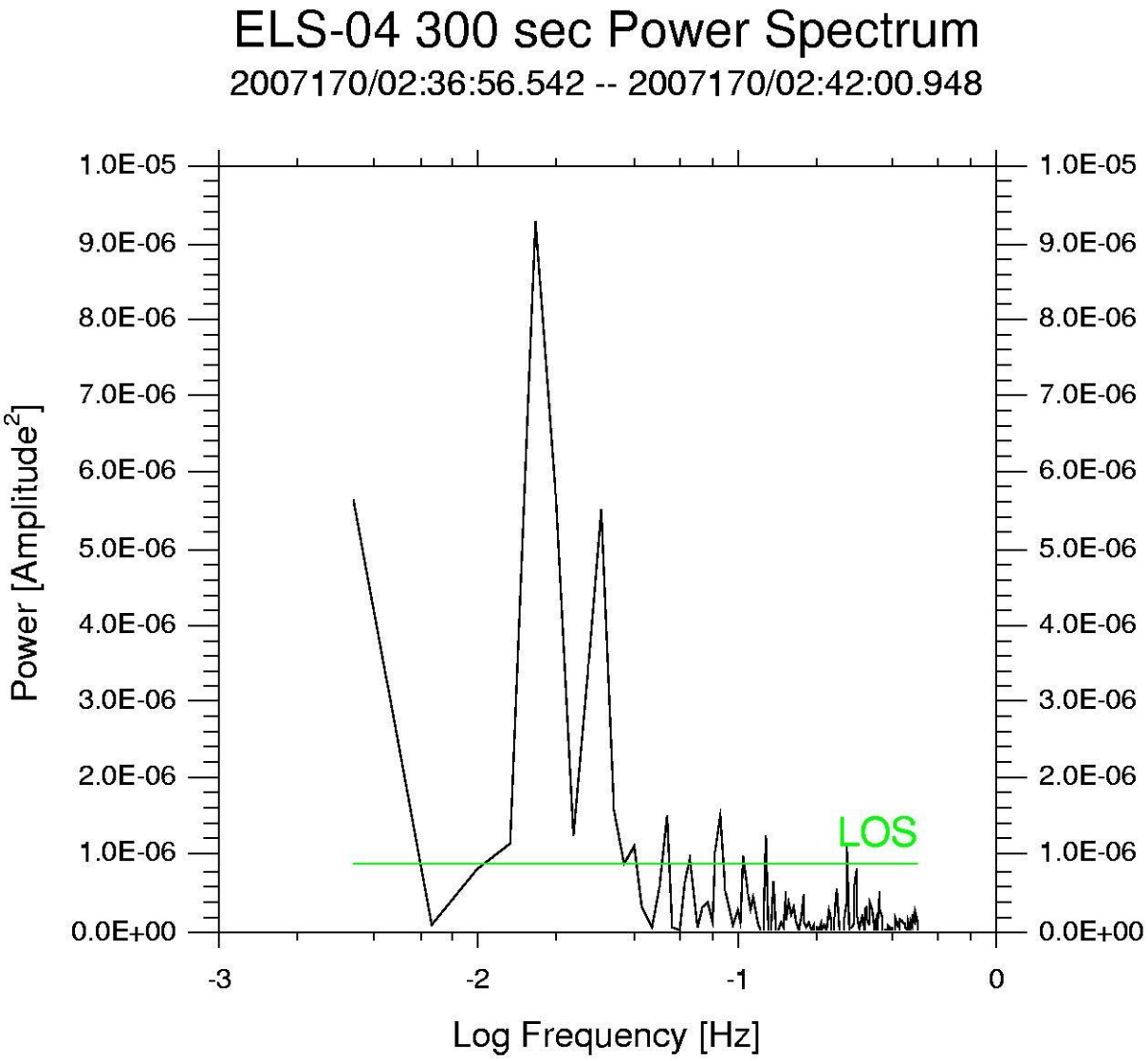
Sporadic, isolated bursts of electron fluctuations are seen upstream from Mars with a primary peak around 0.04 Hz. If we assume these are due to H^+ then B is ~ 3nT, which is within the range typical interplanetary B value.

Data have been presented for a pass extending from the dayside ionospheric boundary to ~ 3 R_M downstream in the sheath. Waves are continuously observed including very long (>10 min) period oscillations.

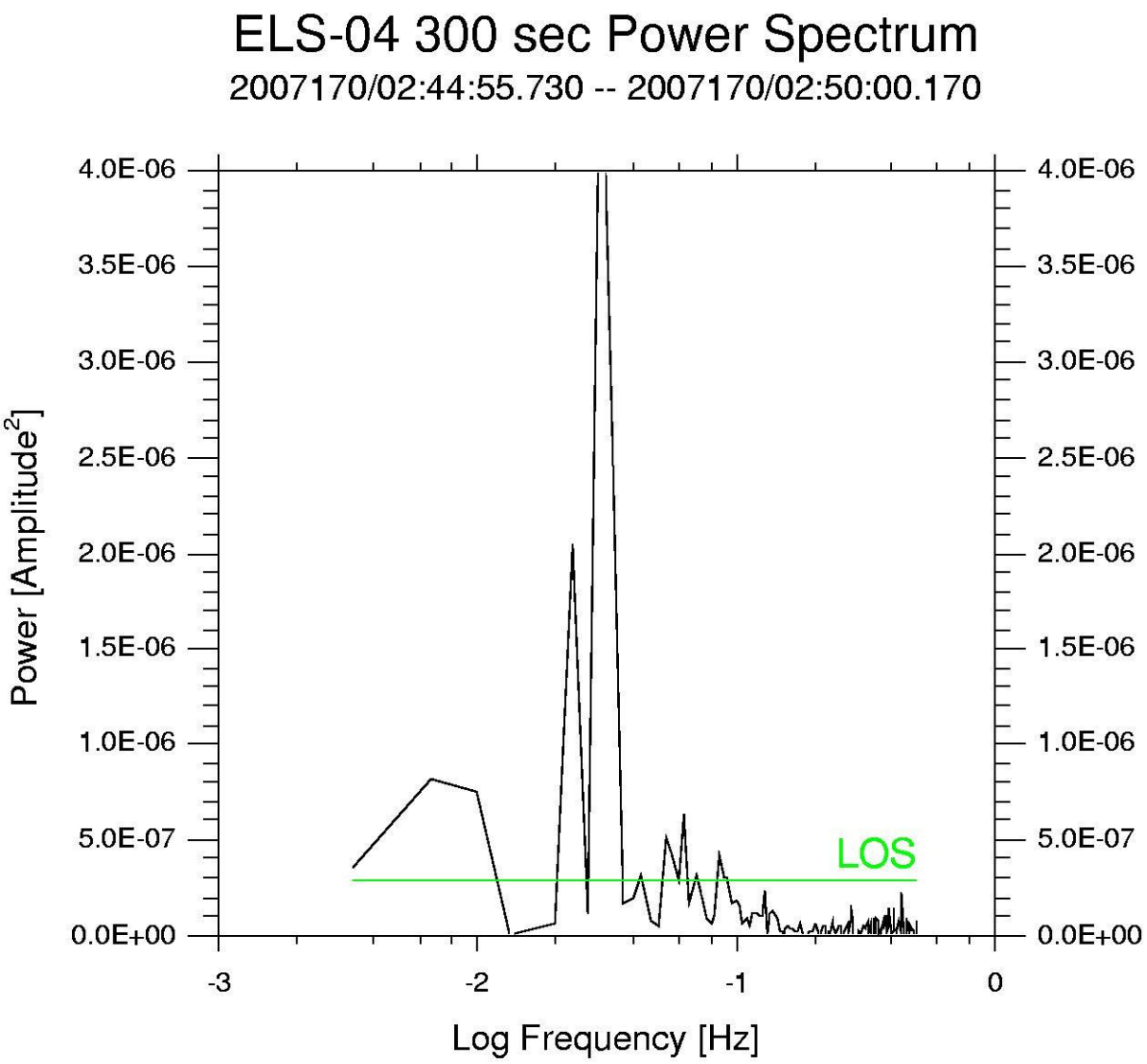
The results presented are consistent with ion cyclotron waves. However neither MGS nor MEX can definitively determine the true physical nature of these fluctuations due to incomplete data sets. Resolution will have to wait for a future mission with complete 3D electron and ion, mass resolved spectra with high time resolution (30 or more per sec) in conjunction with commensurate 3D, DC, and AC measurements in the 0.001 to ~100 Hz range.

Backup Slides

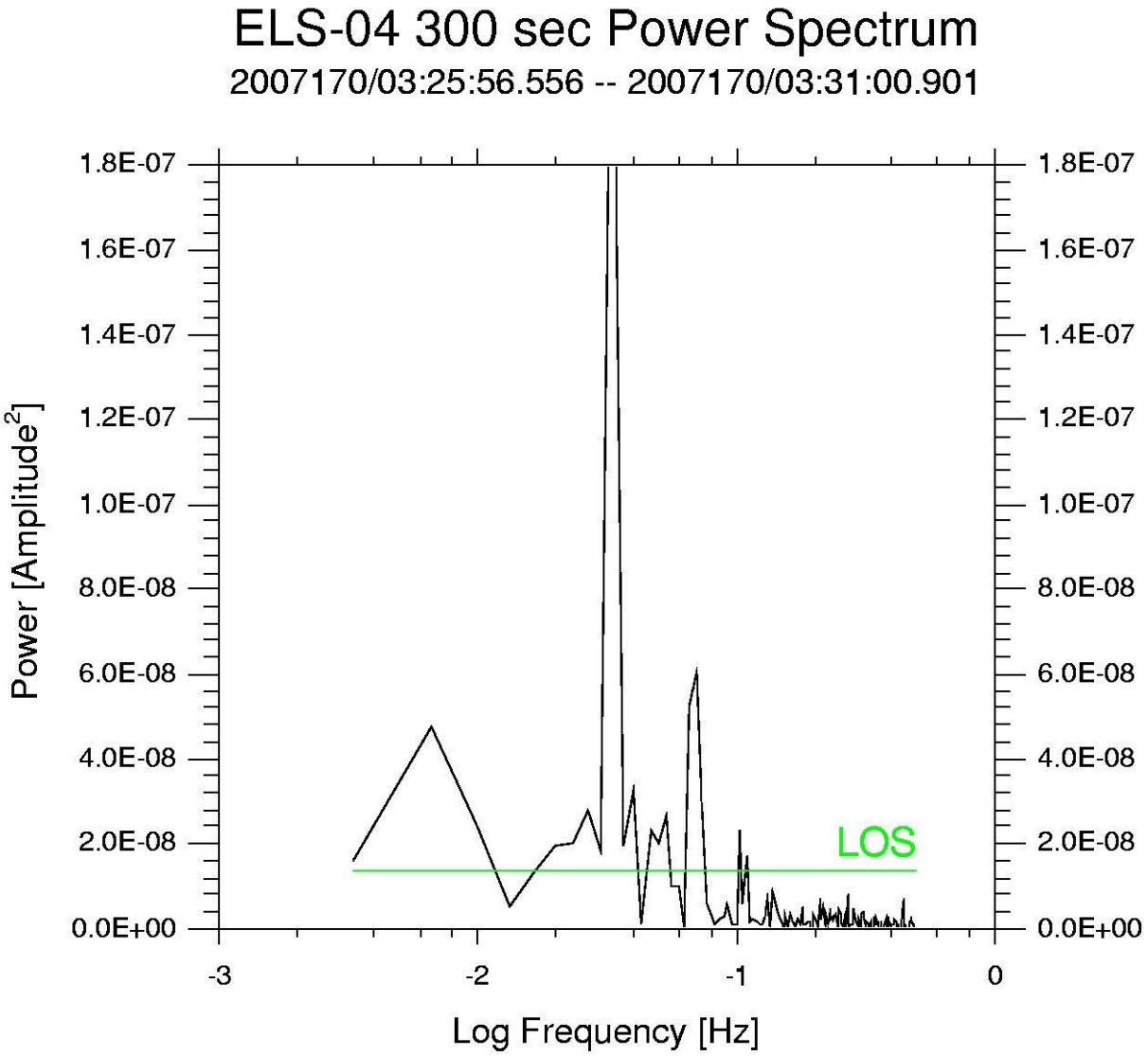
Dayside Sheath



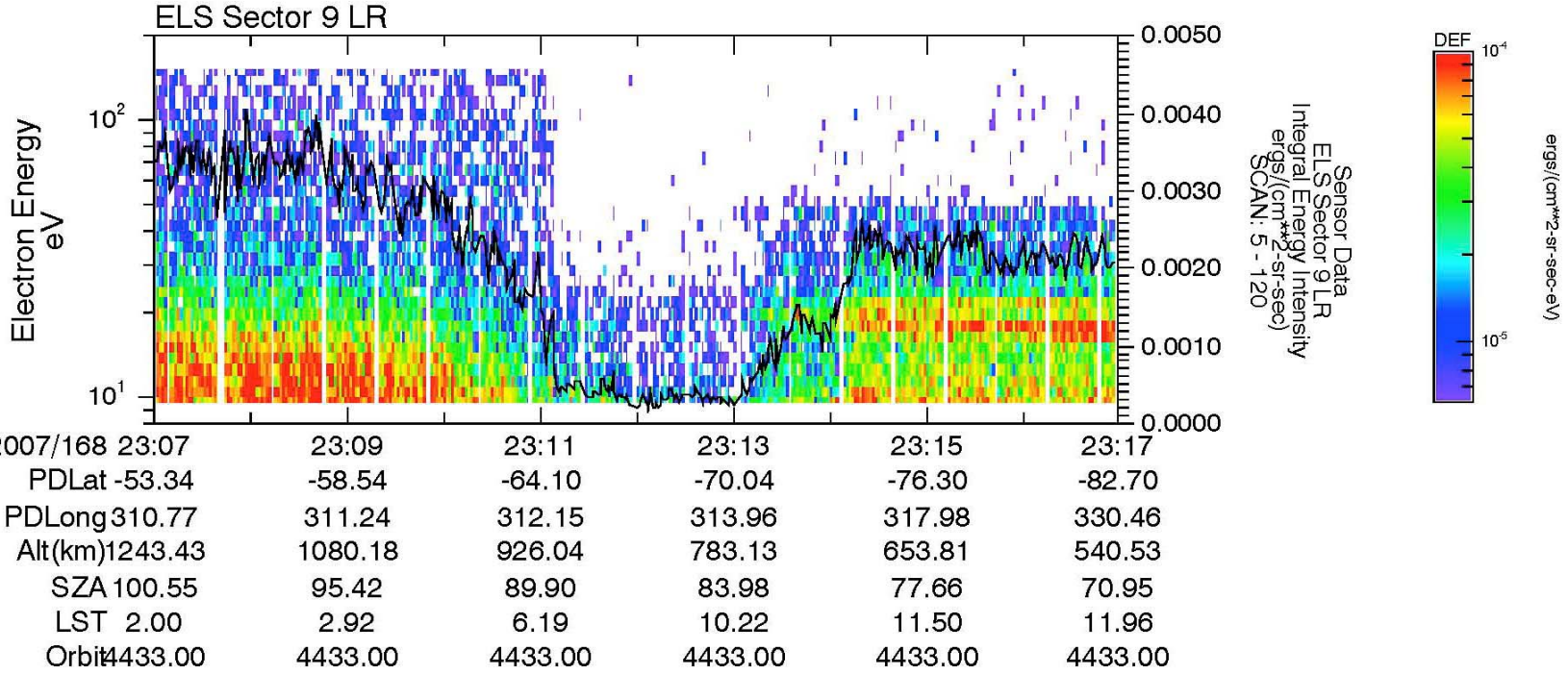
Polar Sheath



Downstream Sheath



Background Case Enlarged



2007/168	23:07	23:09	23:11	23:13	23:15	23:17
PDLat	-53.34	-58.54	-64.10	-70.04	-76.30	-82.70
PDLong	310.77	311.24	312.15	313.96	317.98	330.46
Alt(km)	1243.43	1080.18	926.04	783.13	653.81	540.53
SZA	100.55	95.42	89.90	83.98	77.66	70.95
LST	2.00	2.92	6.19	10.22	11.50	11.96
Orbit	4433.00	4433.00	4433.00	4433.00	4433.00	4433.00