Early Results from ASPERA-3 on Mars Express

Analyzer of Space Plasmas and Energetic Atoms

Presenter: James R. Sharber

Mars Aeronomy Workshop
Aug. 18, 2004

Highlights

On the Mars dayside we show evidence of accelerated heavy ions (e.g. O+) at low altitudes (~300 km).

We have evidence of direct solar wind electron and ion penetration to low altitudes in restricted regions of the Mars dayside (“cusps”).

As MEX approaches Mars, electrons show a ramp-up, shocked sheath region, and a clear transition region to the ionospheric photoelectron population.

On the nightside of Mars there is evidence of electron acceleration to several hundreds of eV with characteristics similar to those of suprathermal bursts observed at Earth. At times concurrent ions (O+, O_2+) are observed.

ASPERA-3
Analyzer of Space Plasmas and Energetic Atoms

Rickard Lundin, P. I.
Stanislav Barabash, Co-P.I.

Swedish Institute of Space Physics + 14 teams from Finland, France, Japan, Germany, Ireland, Italy, Russia, Switzerland, UK, and USA

***Question*:** **Is the solar wind erosion the prime reason for the present lack of water on Mars?**

***Objective*:** **To measure solar wind scavenging: The slow escape of volatiles (atmosphere, hydrosphere) from Mars.**

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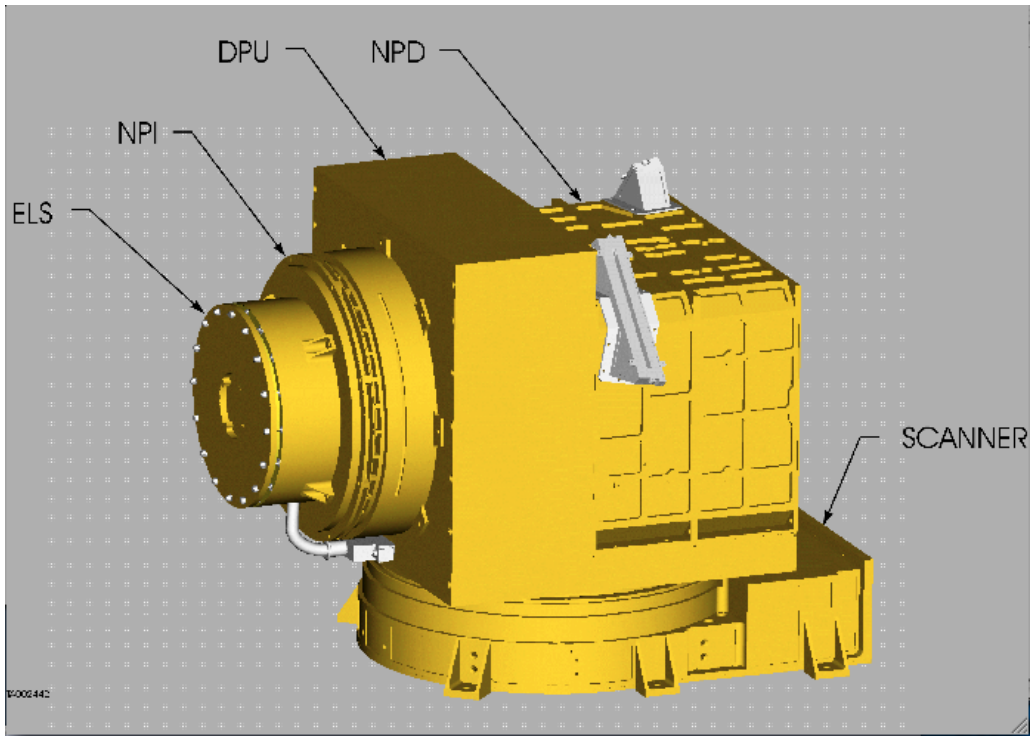
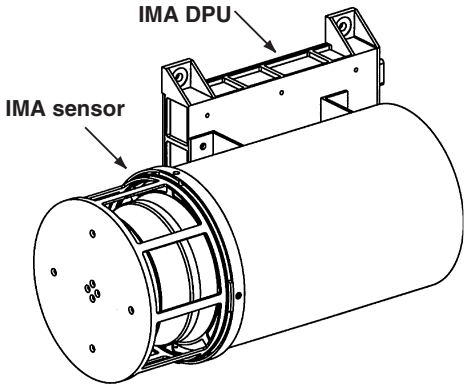
ASPERA Instrumentation



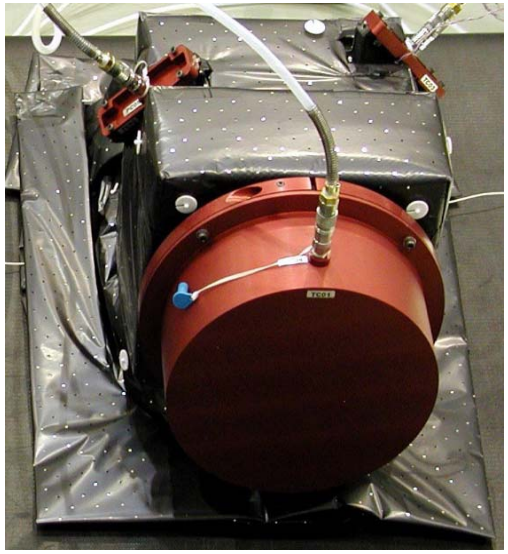


Ion Mass Analyzer (IMA)

Main Unit:

- Neutral particle imagers (NPI, NPD)
- Electron spectrometer (ELS)
- Data processing unit (DPU)
- Mechanical scanner

Instrumentation



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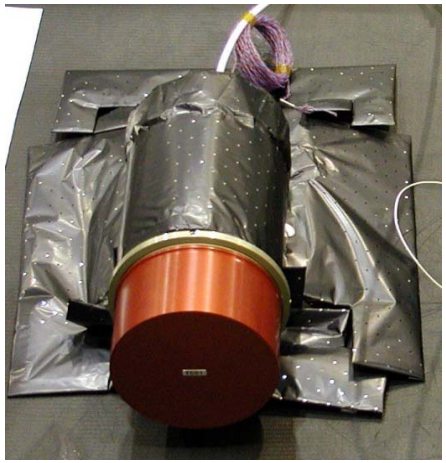
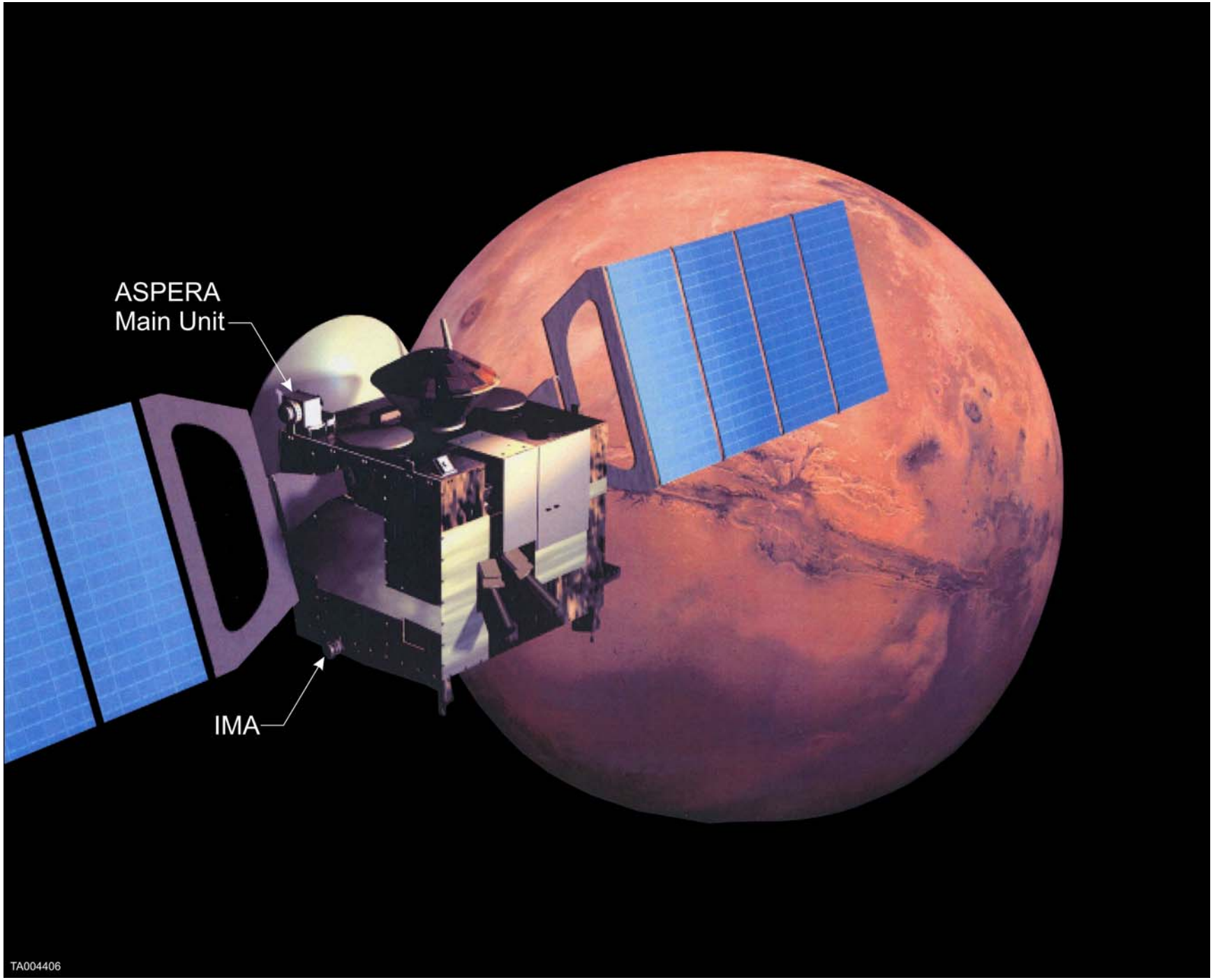
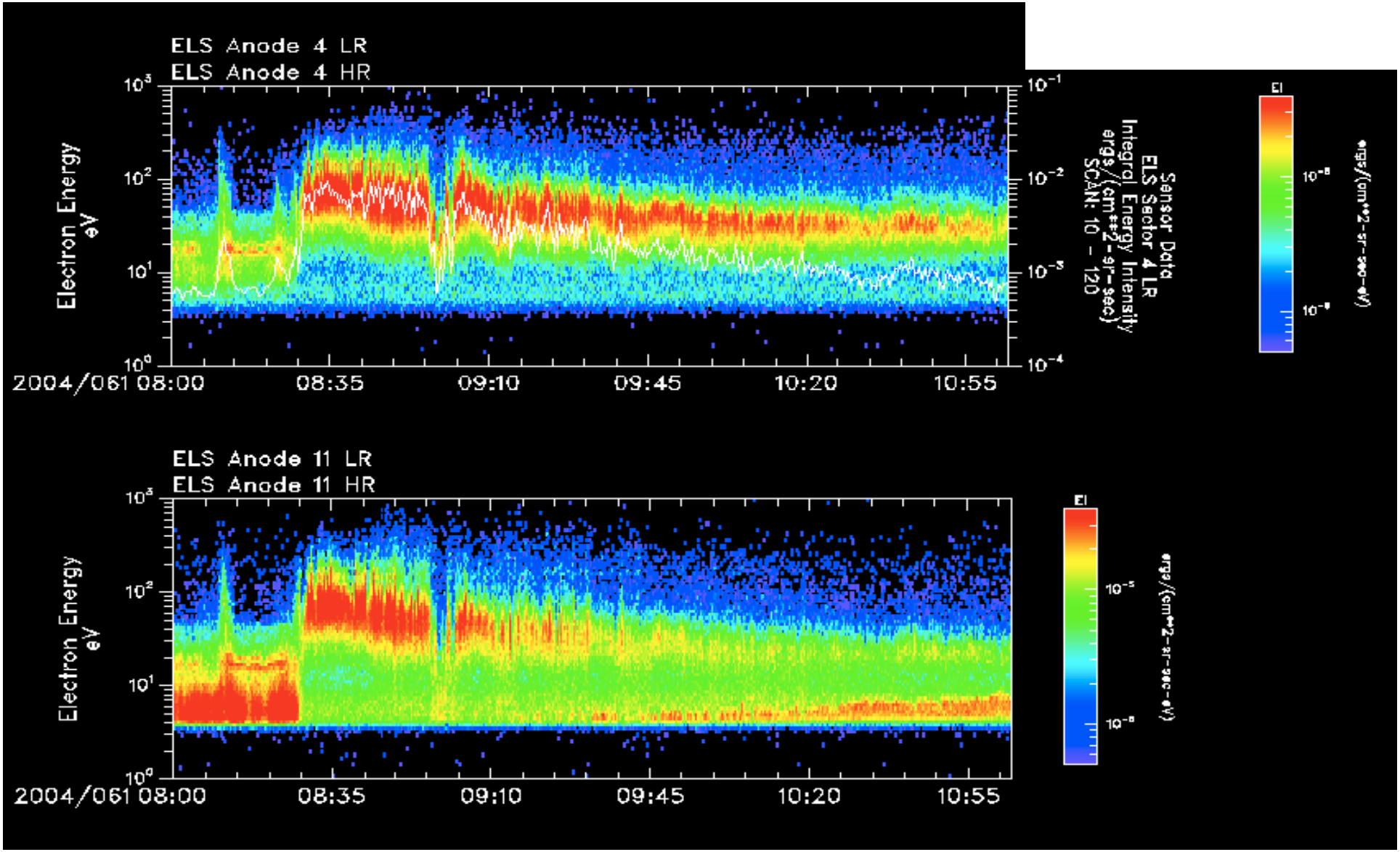


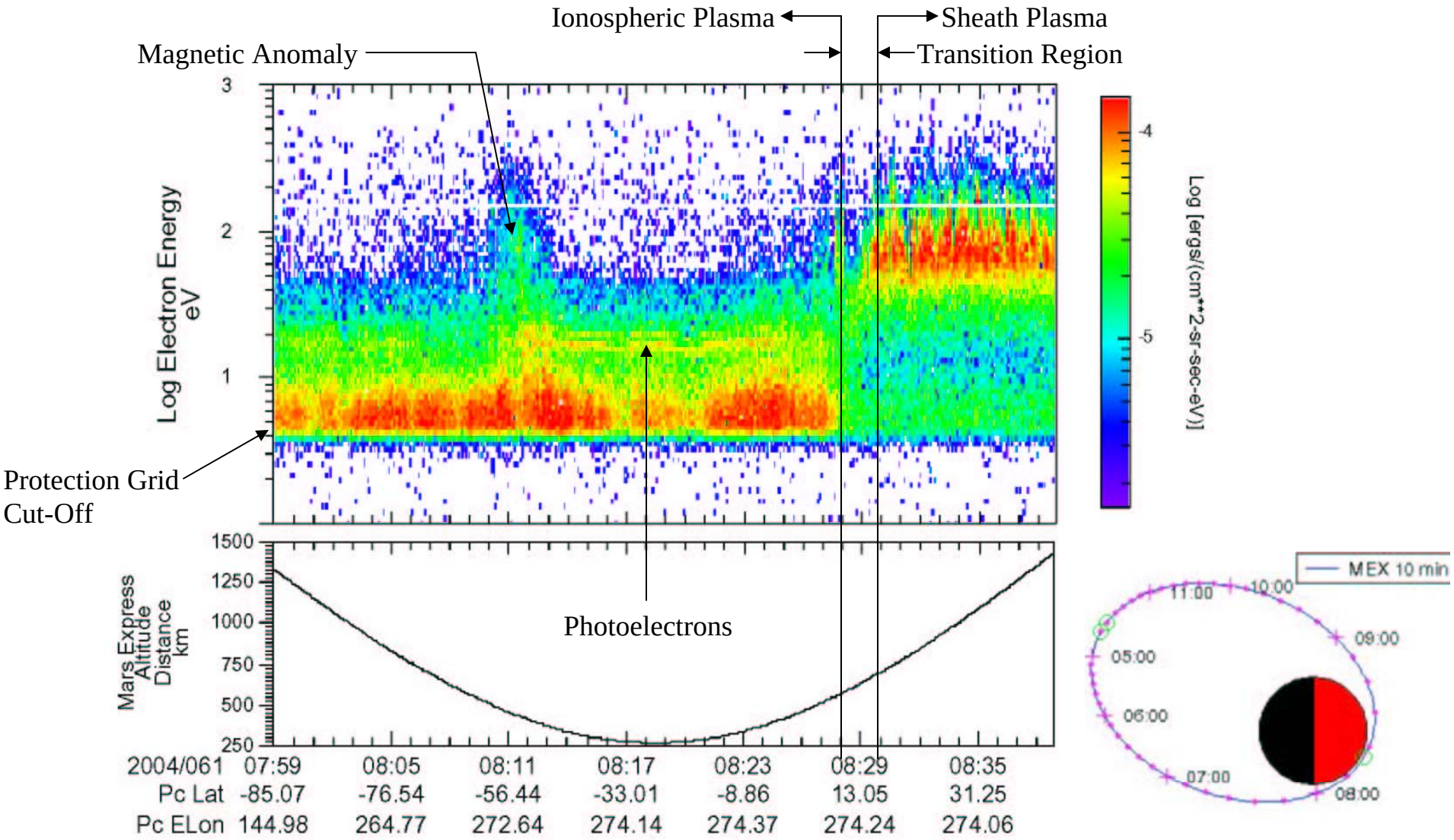
- **Ion Mass Analyzer**


ASPERA
Main Unit
IMA
TA004406

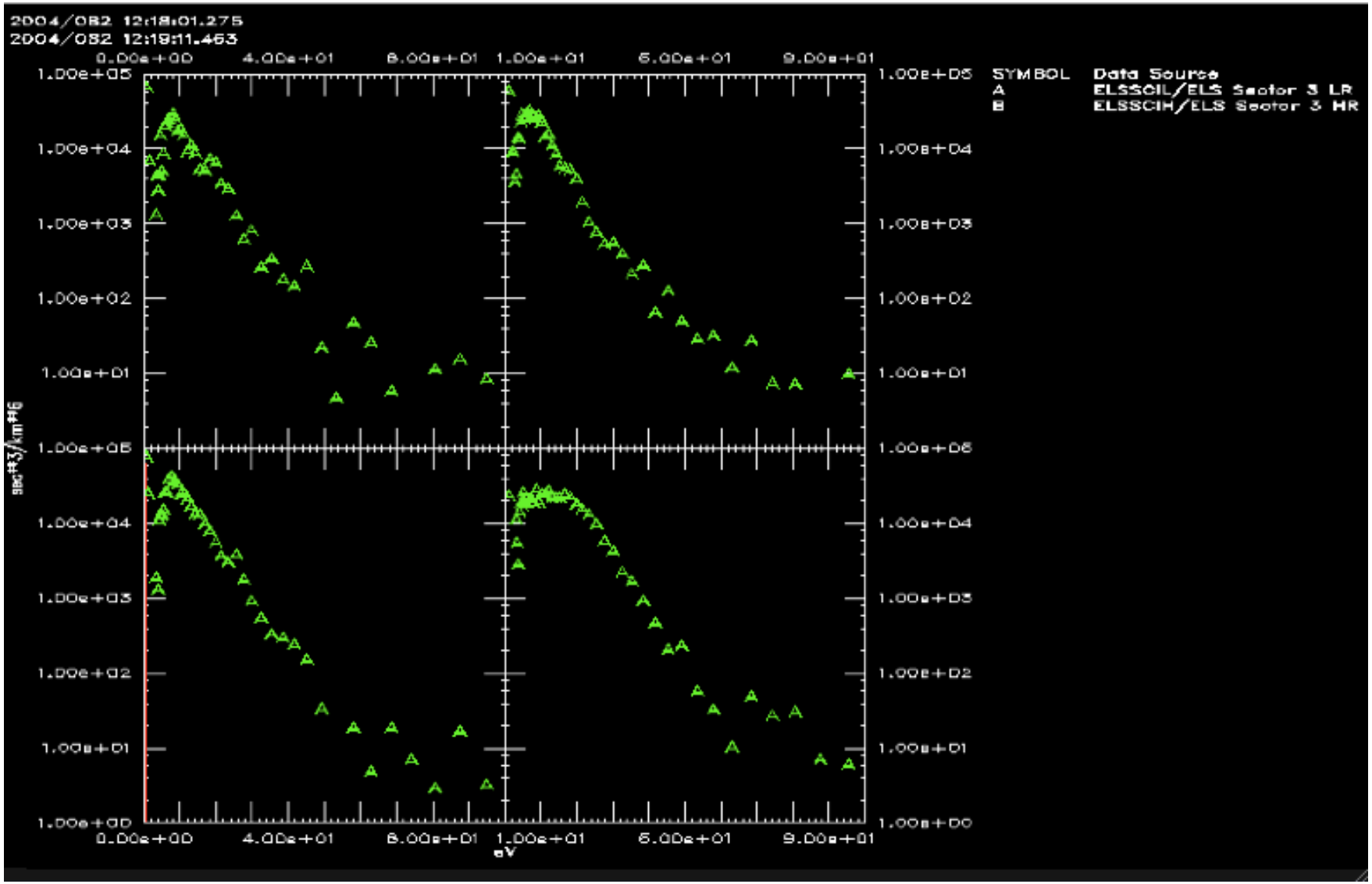
Electron Spectrometer (ELS)
Mar 1, 2004



Electrons in the Mars Ionosphere



ELS Spectra - Mar 22, 2004



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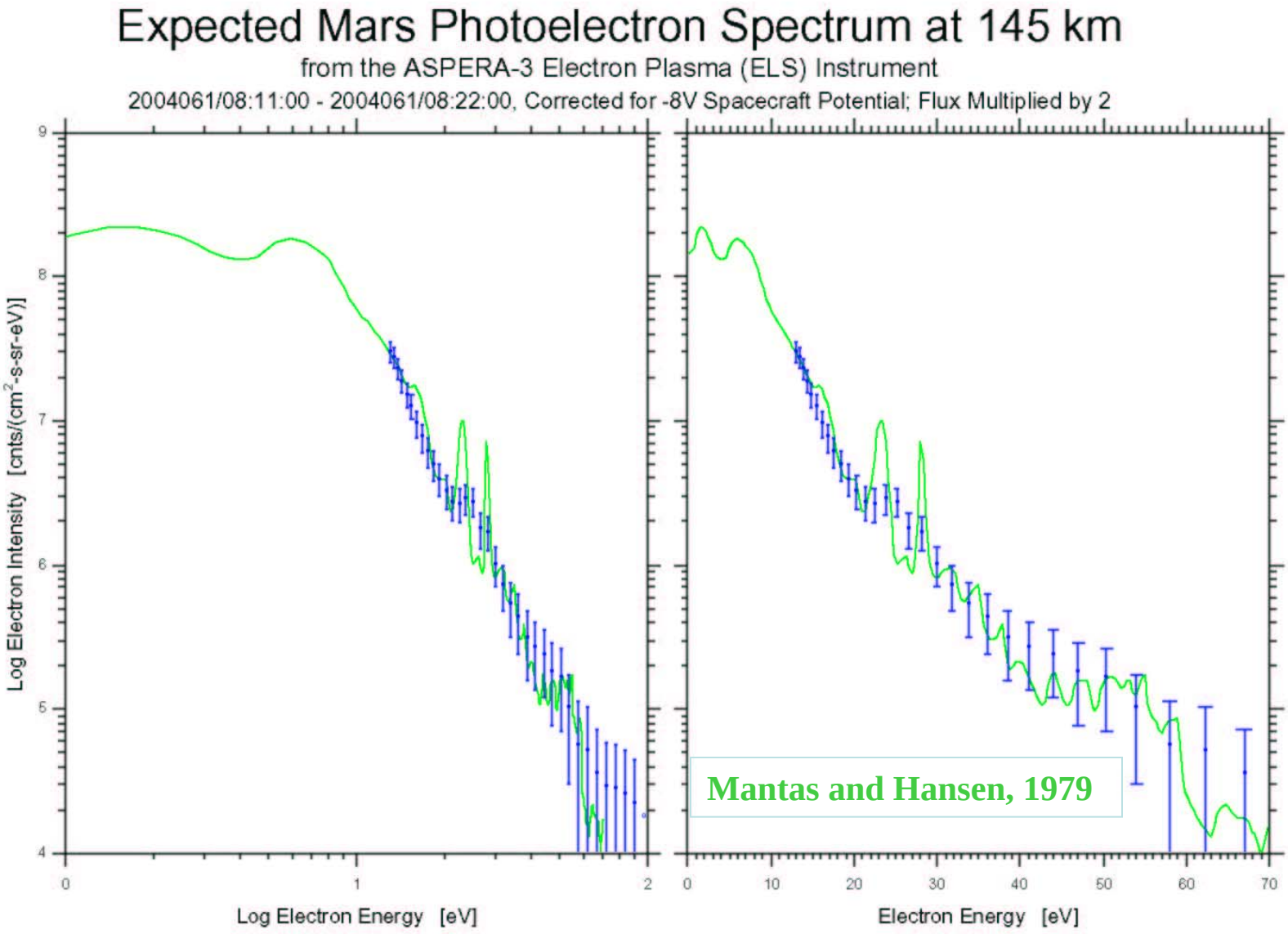
Transition Region

The magnetosheath has an inner boundary consistent with Crider mechanism.

In the transition region magnetic field lines must be long enough that the photoelectrons suffer significant atmospheric degradation, which would not occur in a vertically stratified non-magnetized model.

As MEX moves further down in altitude, we are reach a region where the mass density along the path becomes significantly less, enabling a measurement of the photoelectron peaks near their production altitude.



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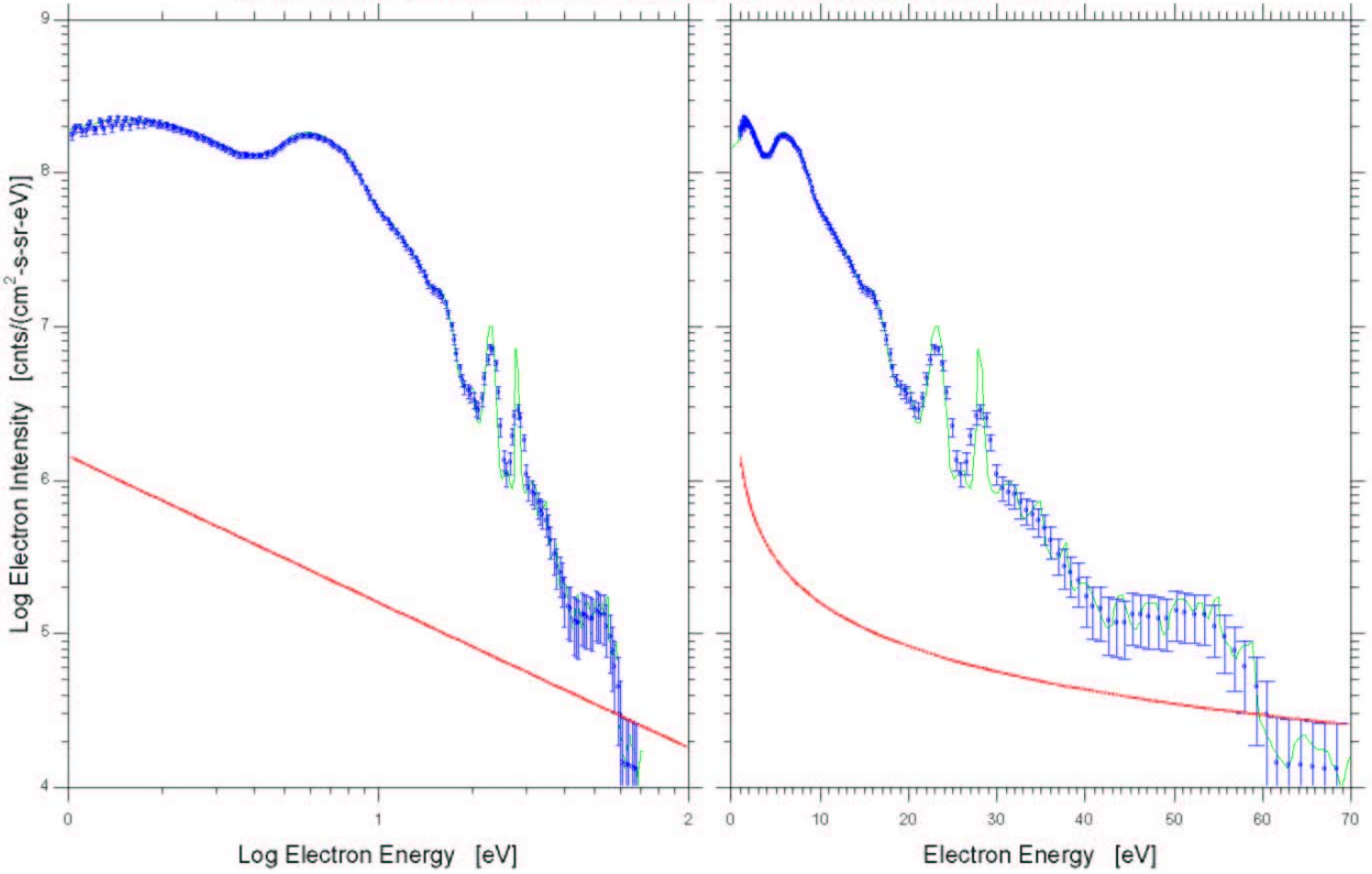
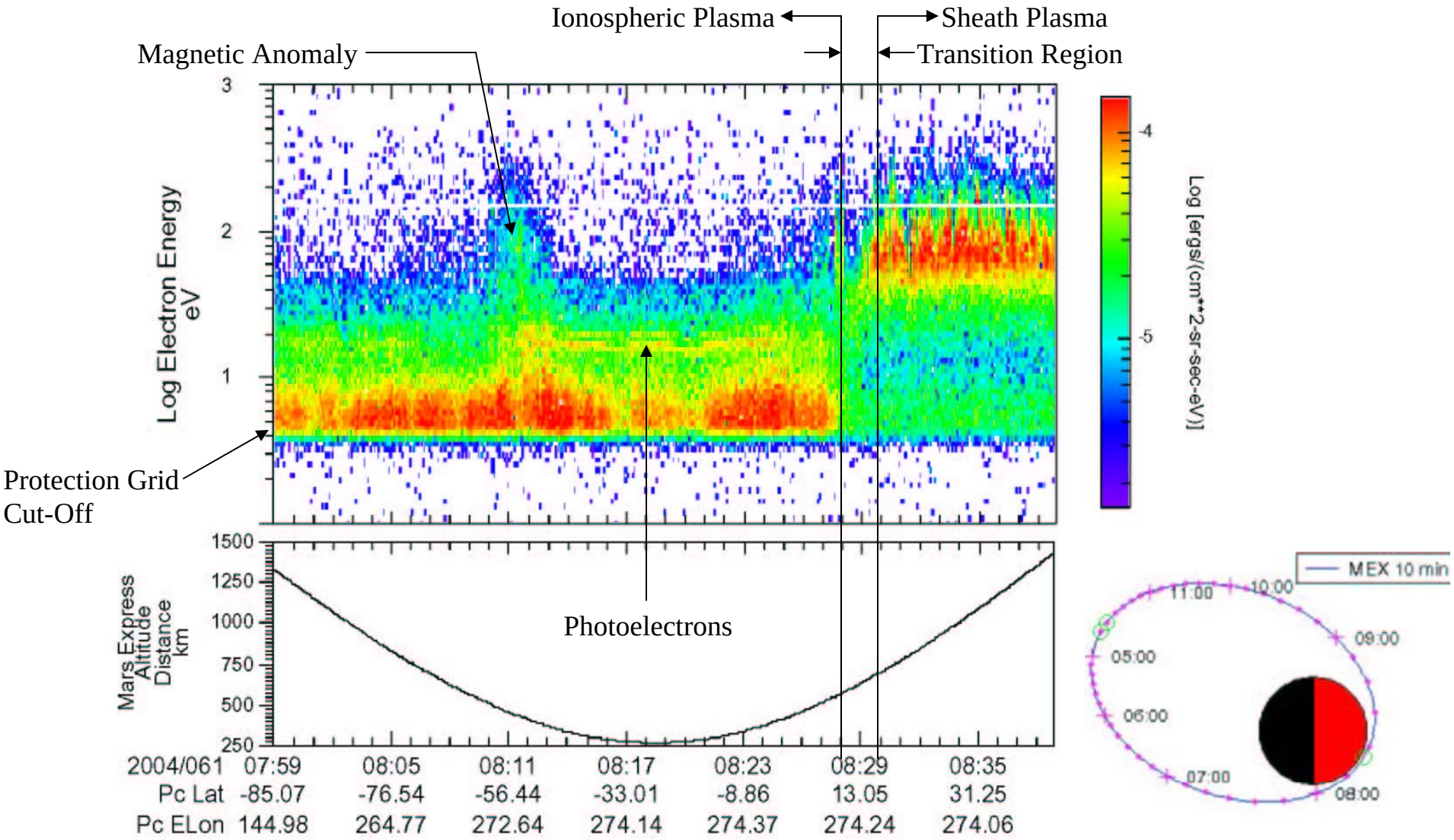
Expected Mars Photoelectron Spectrum at 145 km

from the ASPERA-3 Electron Plasma (ELS) Instrument

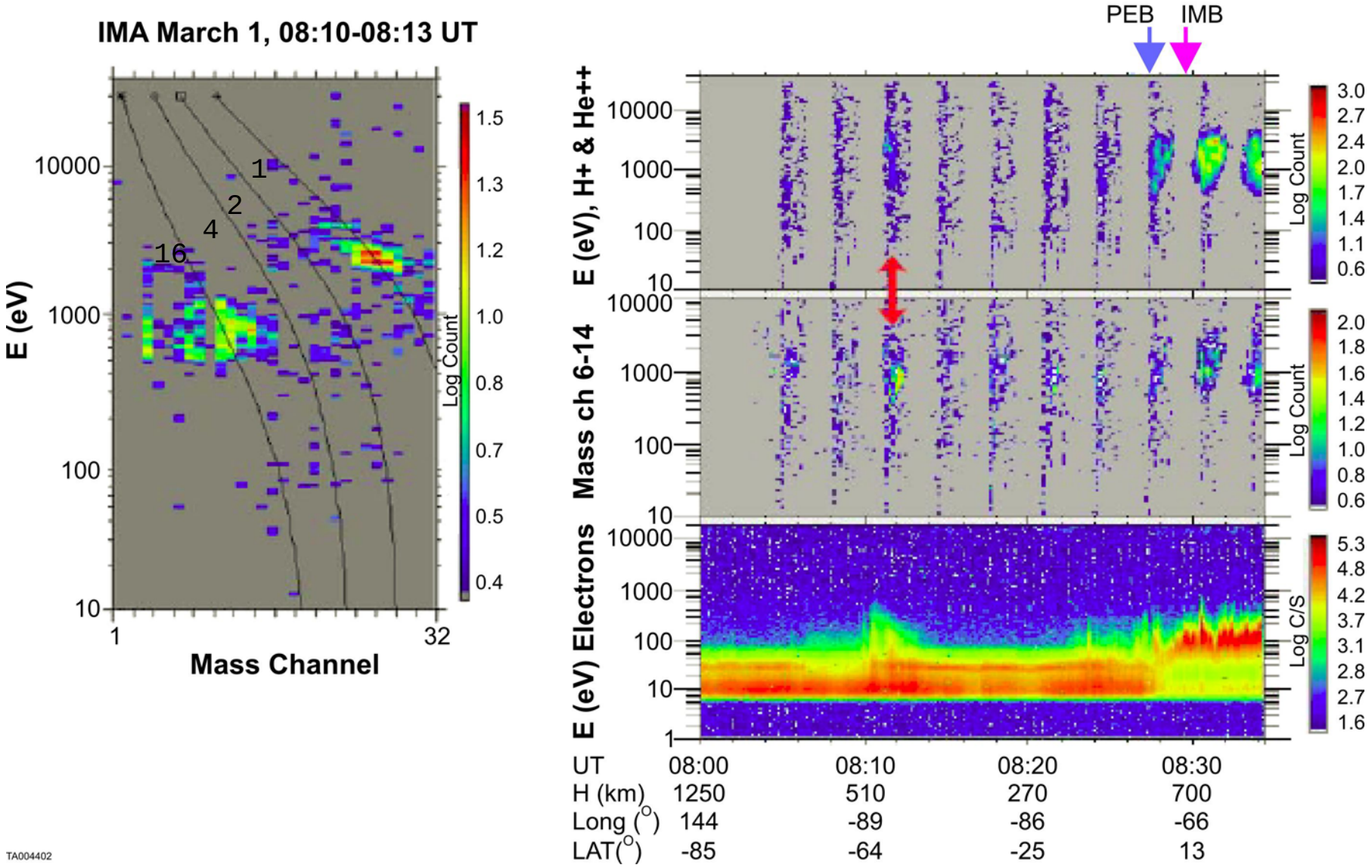
Instrument Response, Instrument Threshold (2 count), and Poisson Errors



Electrons in the Mars Ionosphere



ASPERA-IMA, ELS 1 March 2004



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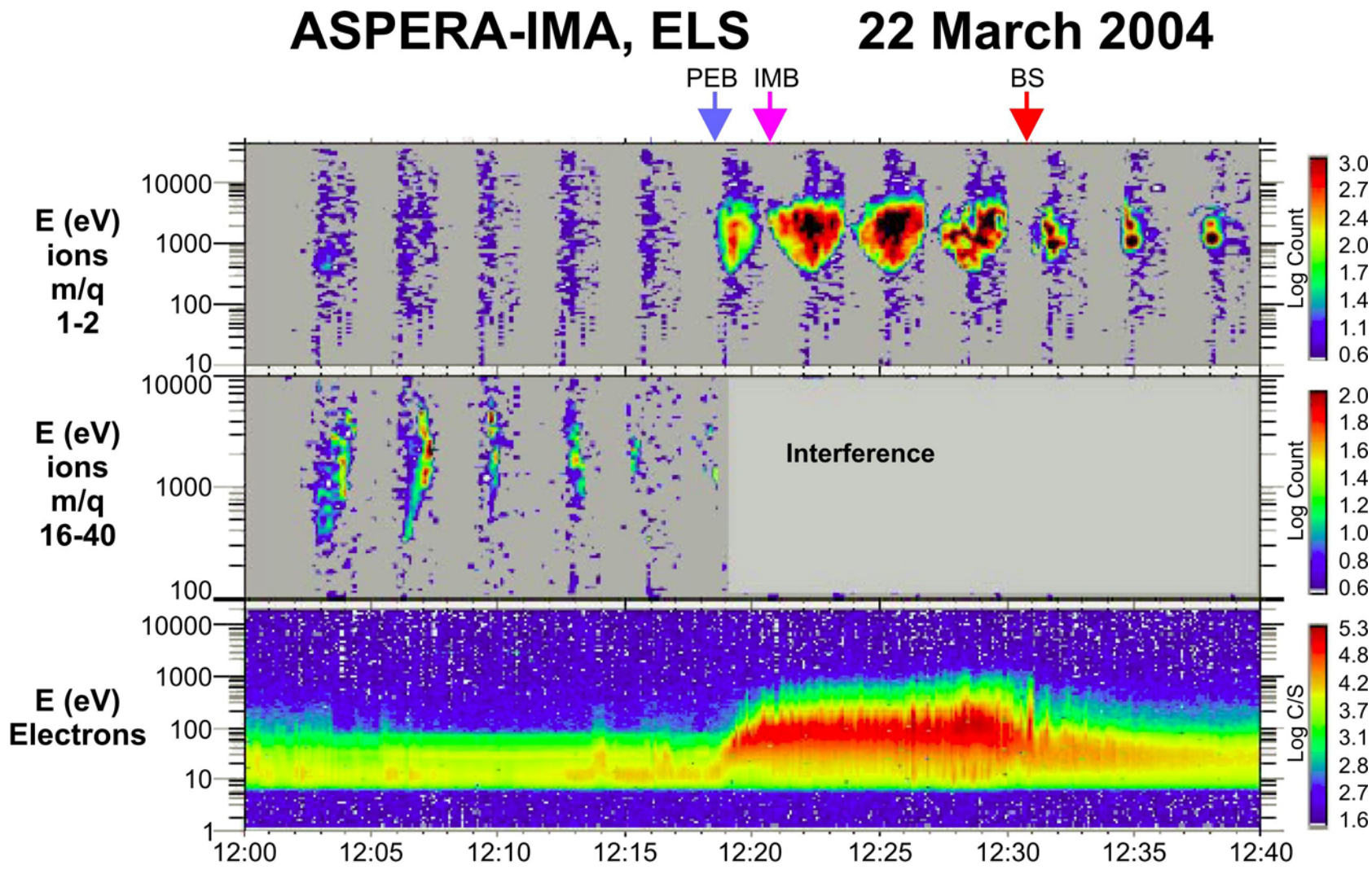
ASPERA-IMA, ELS 22 March 2004
PEB
IMB
BS
E (eV) ions m/q 1-2
E (eV) ions m/q 16-40
E (eV) Electrons
Interference
Log Count
Log Count
Log C/S
10000
1000
100
10
1
3.0
2.7
2.4
2.0
1.7
1.4
1.1
0.6
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
5.3
4.8
4.2
3.7
3.1
2.8
2.7
1.6
12:00 12:05 12:10 12:15 12:20 12:25 12:30 12:35 12:40
X_RM_MSD 0.21 0.53 0.81 1.03 1.17 1.25 1.27 1.24 1.19
Y_RM_MSD -0.57 -0.51 -0.42 -0.29 -0.14 0.02 0.17 0.33 0.42
Z_RM_MSD -0.99 -0.81 -0.57 -0.29 0.01 0.32 0.61 0.88 1.12
ALTITUDE_KM 544 340 272 374 611 985 1427 1902 2378
LONG_DEG 38.92 45.66 47.16 47.47 47.37 47.31 46.81 46.55 46.40
LAT_DEG -75.38 -56.98 -38.87 -16.92 1.21 16.74 29.85 40.33 49.21
TA004401

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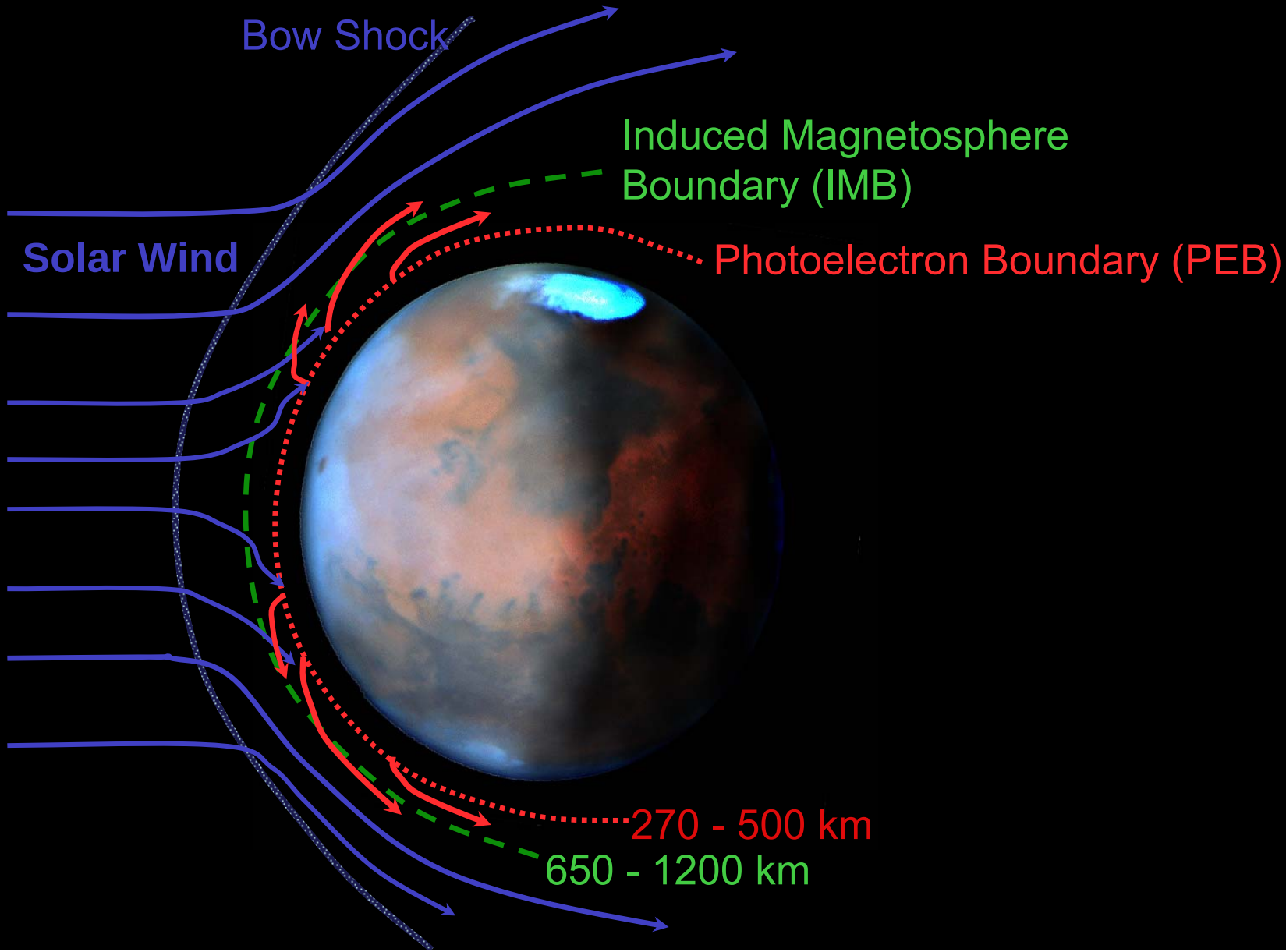
ASPERA-3 New Findings - Escape

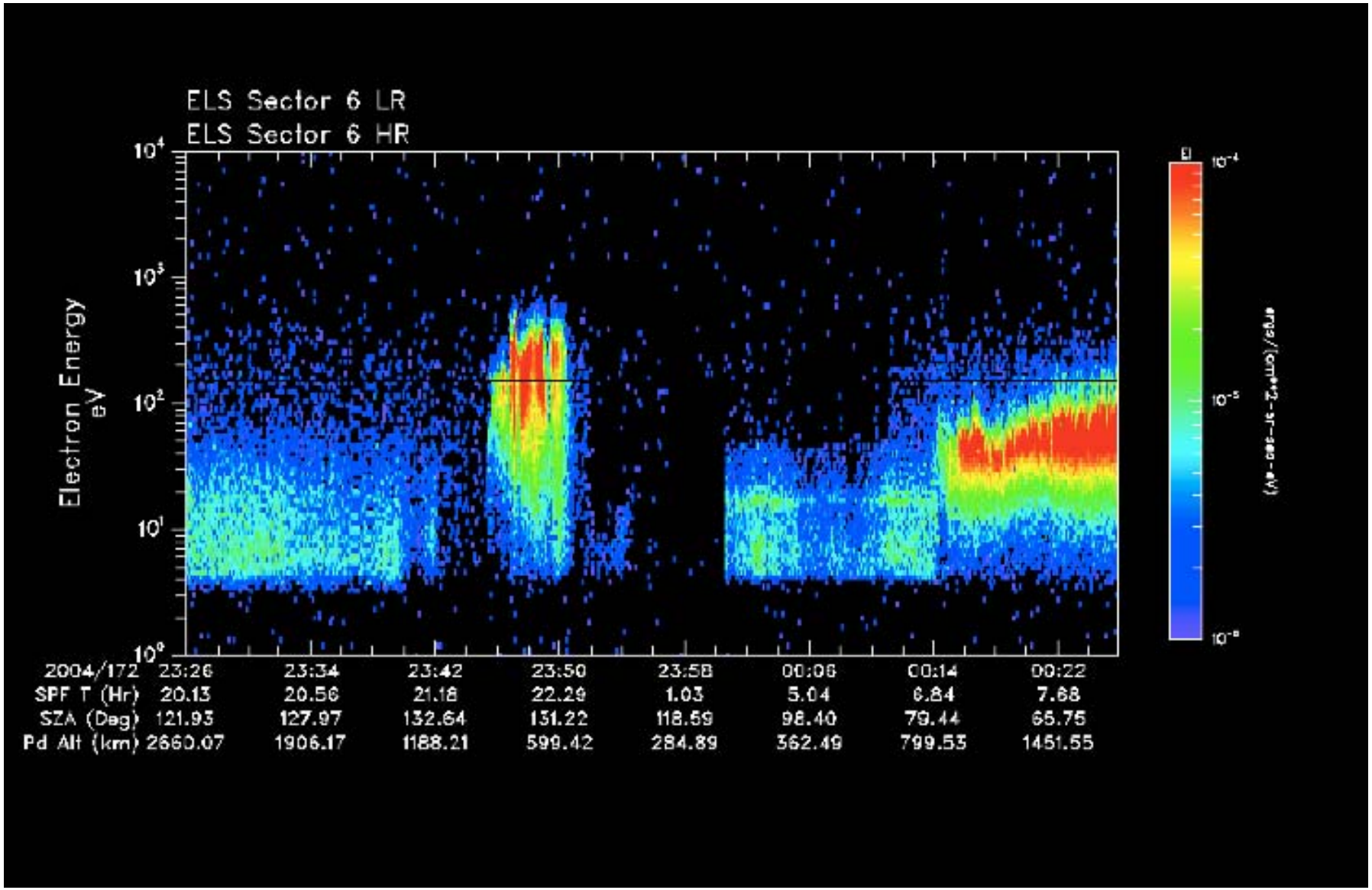
Presented by R. Lundin at EGS, Spring 2004

1. **The Solar wind** may protrude very deep into the atmosphere - down to pericenter altitudes ≈270 km
2. Acceleration processes responsible for the erosion of atmosphere - **the planetary wind** - start as low as ≈270 km above the surface of Mars.
3. Accelerated/outflowing O^+ may reach **several keV at 300 km** altitude.
4. The planetary wind also contains **molecular species** (e.g. CO_2^+ and O_2^+), consistent with acceleration processes reaching low altitudes.
5. Statistical results on dayside magnetosphere boundaries (Photoelectron Boundary and Induced Magnetosphere Boundary)

Atmospheric Outflow from Mars



Electron Acceleration - Nightside



Summary

The neutral atom imagers are in operation but are still in commissioning phase.

Several study areas are continuing with the in-situ instrumentation:

Photoelectron spectrum: work in progress to determine our ability to measure the identifying peaks in order to use ELS as a remote sensor of atmospheric properties at distant locations along the magnetic field line.

Characteristics and dynamics of the various plasma regions and the locations of their boundaries will continue with the objective of further specifying the nature and causes of the escape of ions from the atmosphere.

Comparison of particle observations with magnetic anomaly locations will continue in an effort to determine the effect of the anomalies on entry of particle populations into the Mars atmosphere and outflow of planetary atmospheric constituents.