

# Indications of plasma instabilities near Mars

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## **Abstract:**

We present observations of plasma oscillations seen on the nightside of Mars inside the induced magnetosphere boundary. The measurements were made using the electron spectrometer (ELS) and the ion mass analyzer (IMA), both of which are part of the ASPERA-3 instrument on Mars Express.

We have analysed data from orbits 2148 and 2510. For orbit 2148 we have surveyed the magnetosheath region, a part of the orbit when the spacecraft travelled along the induced magnetosphere boundary, and a region inside the induced magnetosphere. The measurements inside the induced magnetosphere are then compared to measurements in the same region during orbit 2510. In orbit 2510 the temporal resolution of the ion measurements was better, and oscillations could be seen in both ion and electron data.

Large amplitude plasma oscillations appear inside the induced magnetosphere. The period of the oscillations is about five minutes. The electron oscillations were similar during orbits 2148 and 2510, even though protons dominated the ion data during orbit 2148 and heavy planetary ions dominated orbit 2510.

A velocity shear has been detected in the ion data from orbit 2510. The oscillations could possibly be a result of the Kelvin-Helmholtz instability, but further studies are required to confirm this.

## **Acknowledgment:**

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# MEX Orbits 2148 and 2510

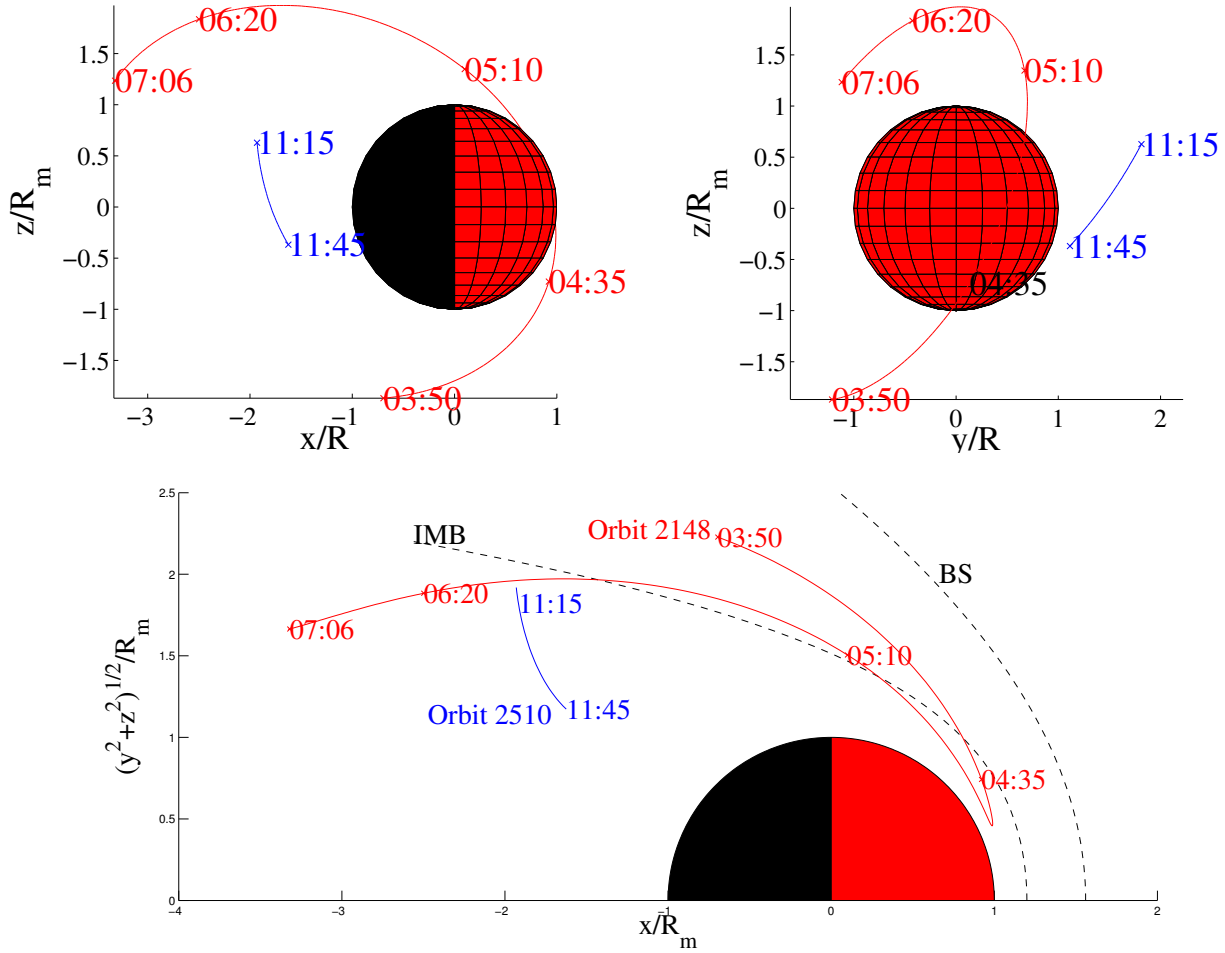


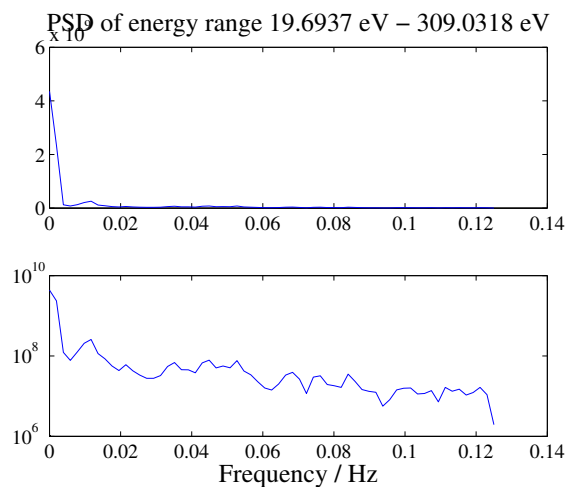
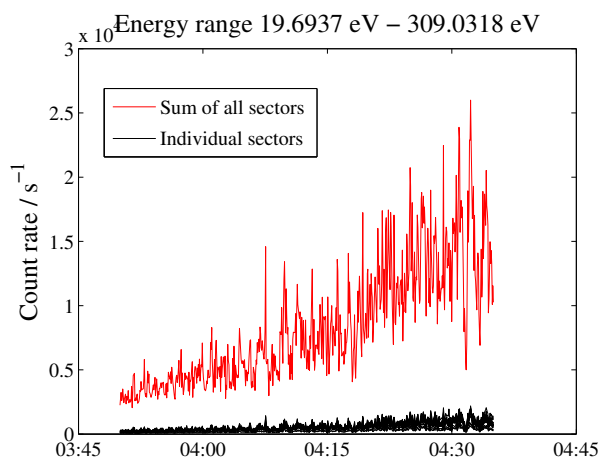
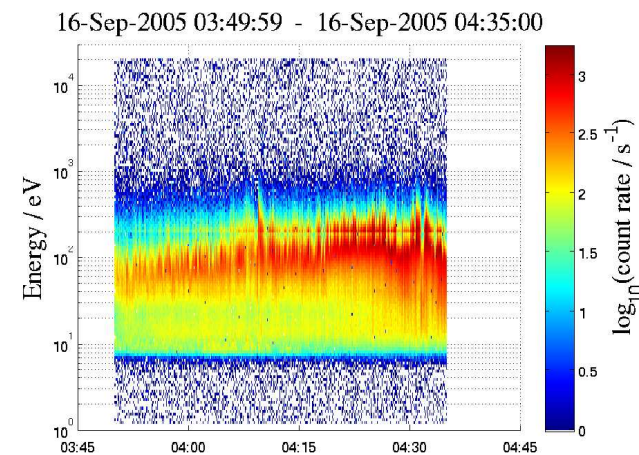
FIG. 1 The parts of orbits 2148 and 2510 that are studied here in the  $xz$ - and  $xy$ -planes (top left and right), and in a cylindrical coordinate system (bottom), with the bow shock (BS) and the induced magnetosphere boundary (IMB) shown.  $(y^2 + z^2)^{1/2}$  is the distance to the Mars-Sun line.

We have used data from the electron spectrometer (ELS) and the ion mass analyser (IMA) of the ASPERA-3 instrument.

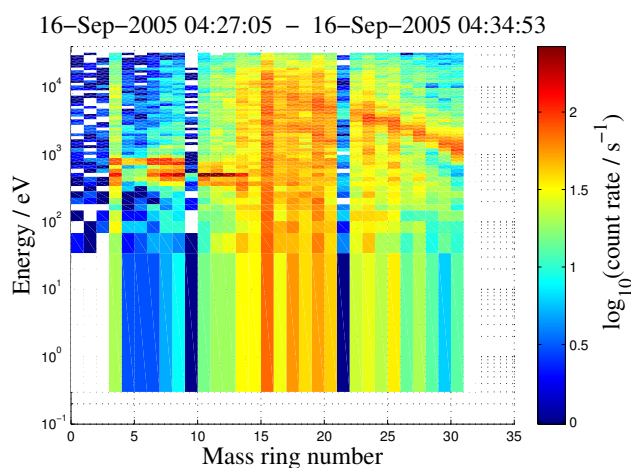
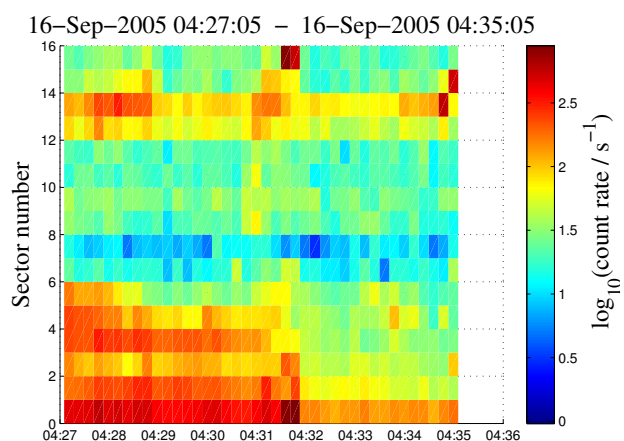
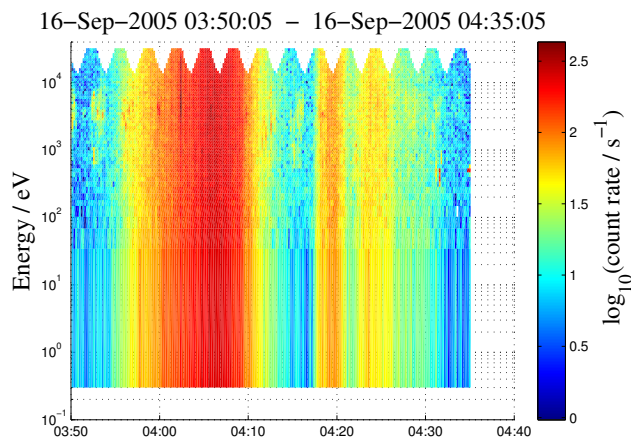
Parameter	ELS	IMA
Particles to be measured	electrons	ions
Energy, keV per charge	0.01-20	0.01-40
Energy resolution, $\Delta E/E$	0.07	0.07
Mass resolution	-	$m/q=1,2,4,8,16,>20$
Intrinsic field of view	$10 \times 360^\circ$	$90 \times 360^\circ$
Angular resolution, FWHM	$10 \times 22.5^\circ$	$4.5 \times 22.5^\circ$
G-factor / pixel, $\text{cm}^2 \text{ sr}$	$7 \cdot 10^{-5}$	$3.5 \cdot 10^{-4}$
Efficiency, %	incl. in G-factor	incl. in G-factor
Time resolution (full 3D), s	32	32
Mass, kg	0.3	2.2
Power, W	0.6	3.5

# In the magnetosheath

## Electrons



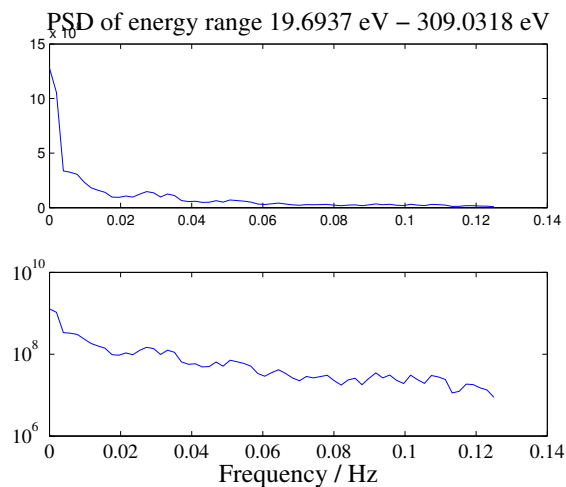
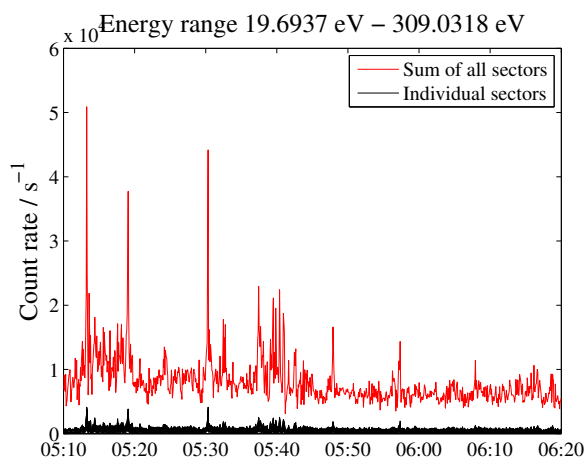
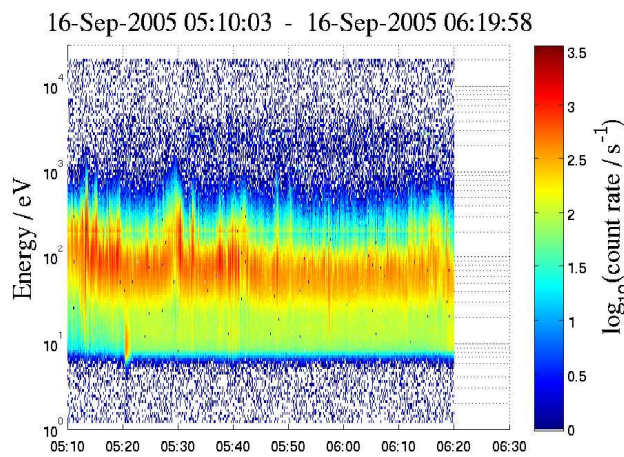
## Ions



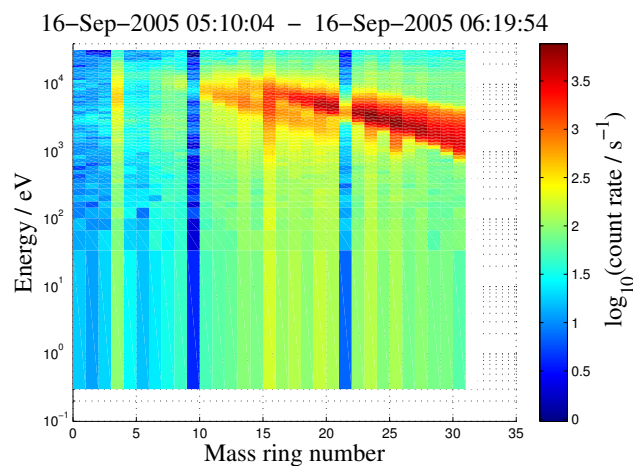
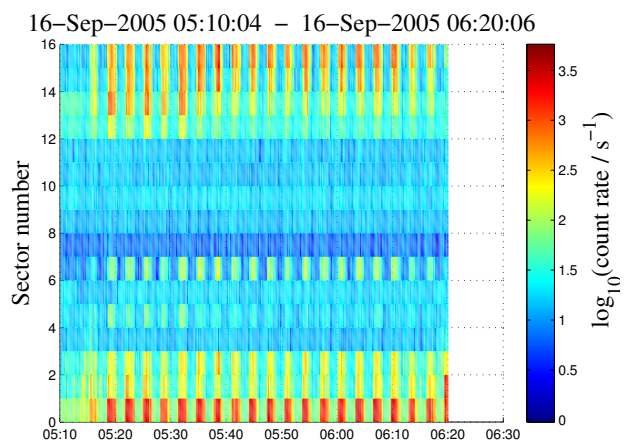
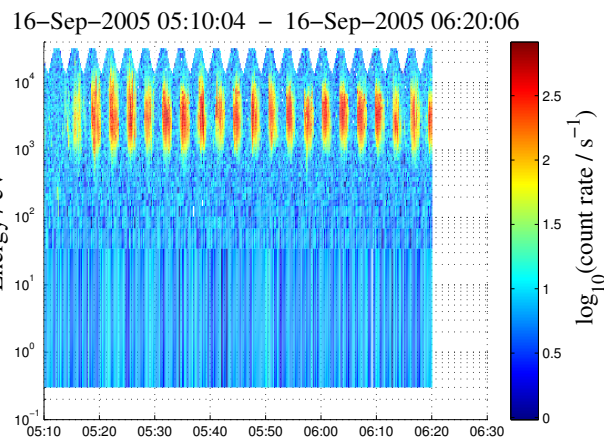
Some electron oscillations can be seen at about 0.01 Hz. Both protons and heavy ions are present. The ion composition (lower right panel) is taken from the last eight minutes of the period shown in the other panels.

# Along the induced magnetosphere boundary

## Electrons



## Ions

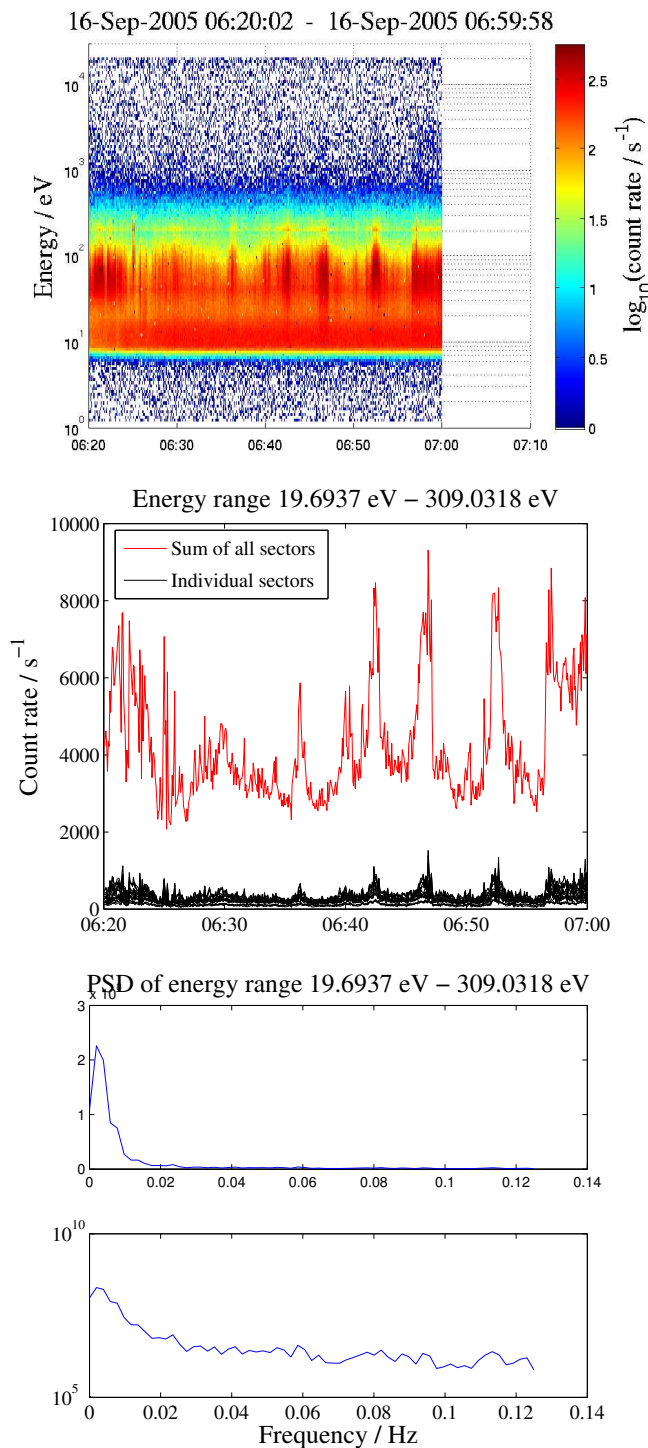


Some electron oscillations are present at low frequencies, but there is no clear peak in the spectrum. The ions that we see are mostly protons.

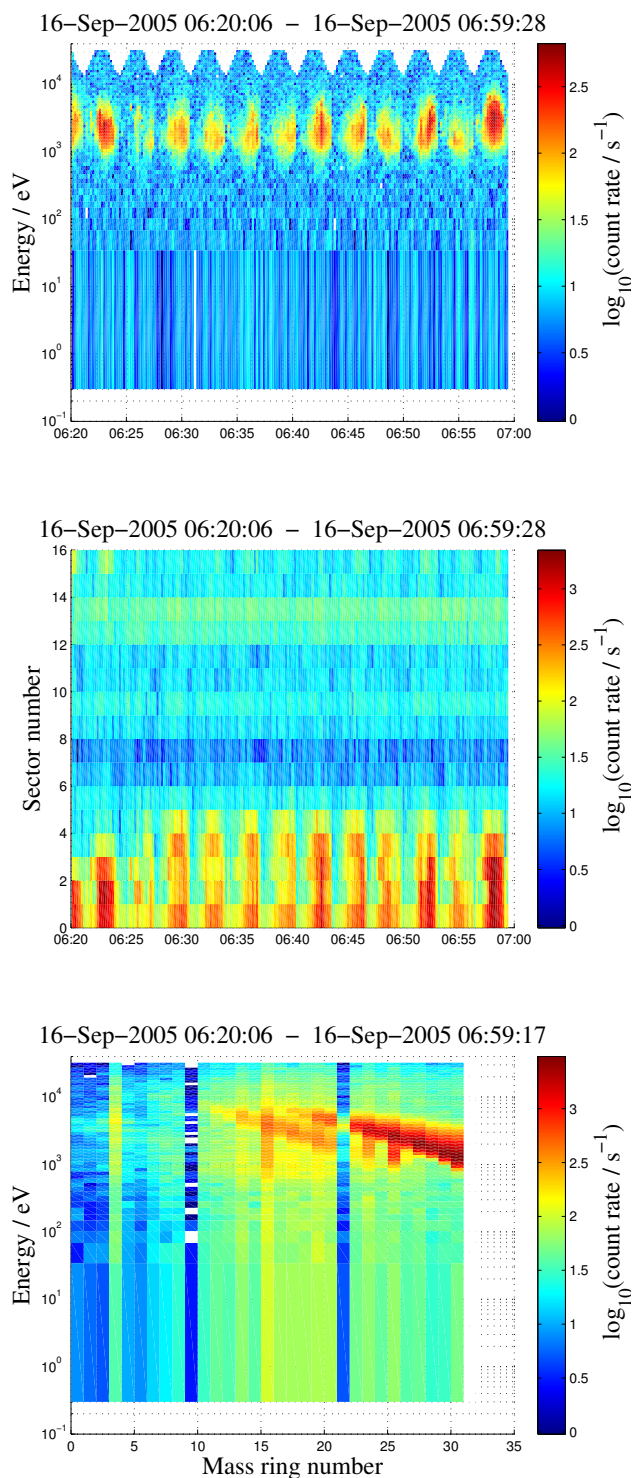


# In the induced magnetosphere: orbit 2148

## Electrons



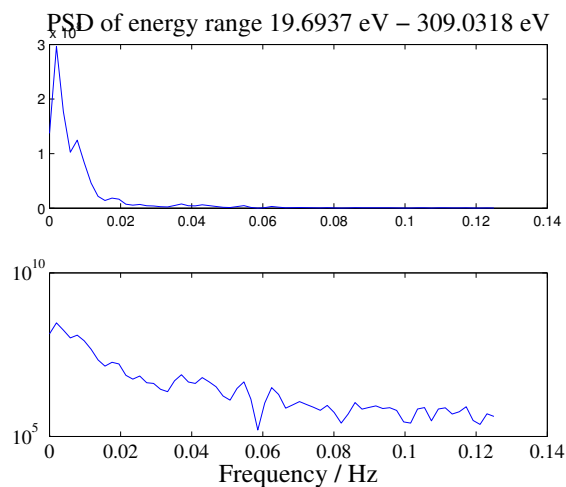
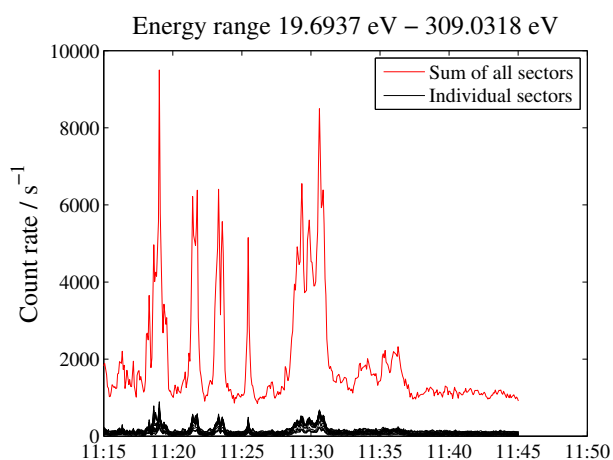
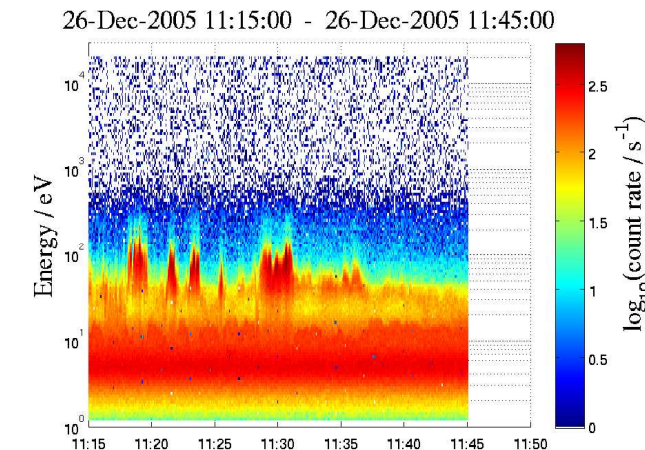
## Ions



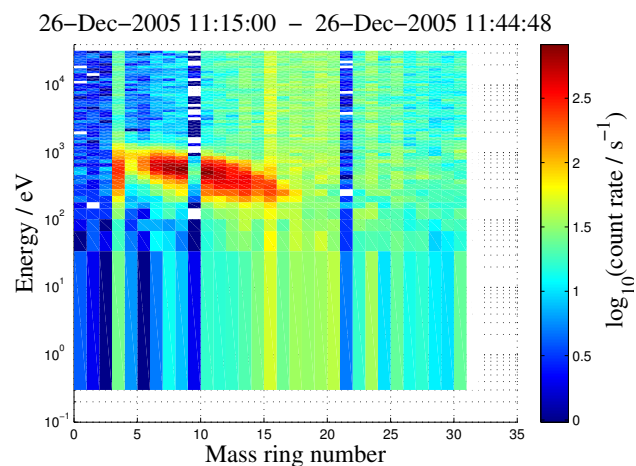
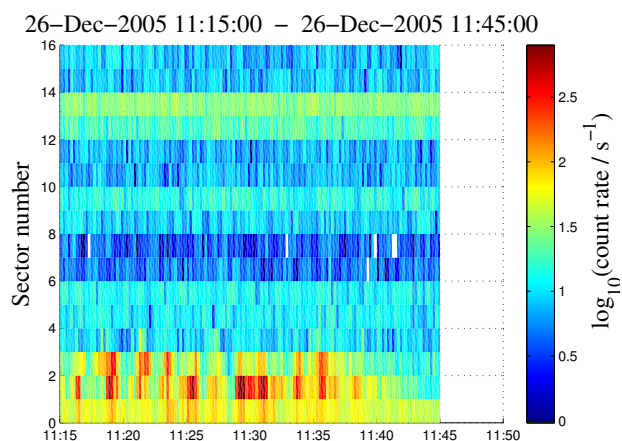
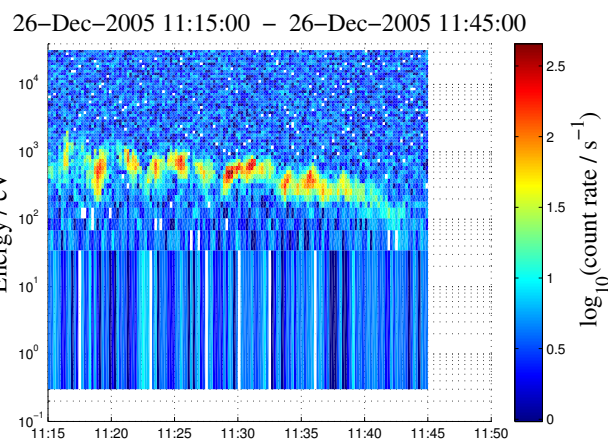
Here the relative amplitude of the oscillations is much higher than in the cases shown on the previous pages. The period of the oscillations is about five minutes. This could possibly be interpreted as clouds of higher plasma density drifting past the spacecraft. The ions are mostly protons.

# In the induced magnetosphere: orbit 2510

## Electrons

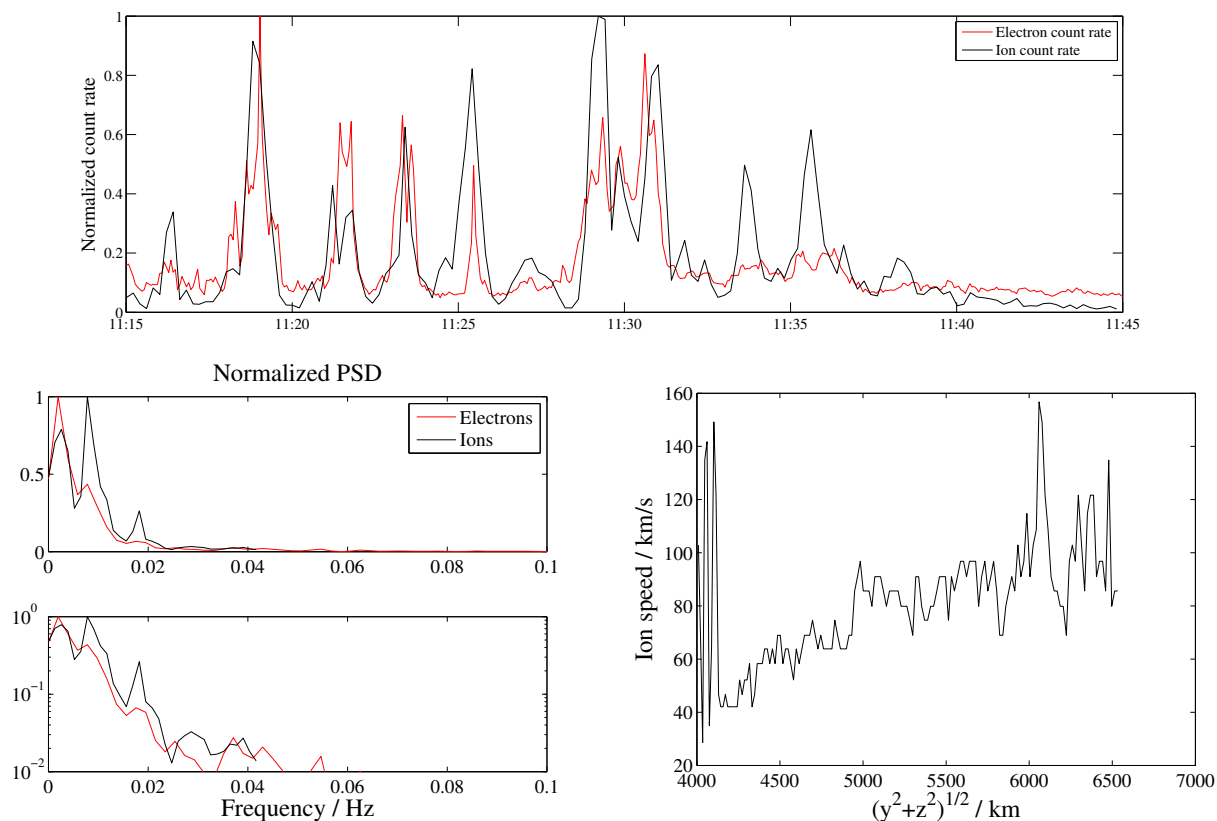


## Ions

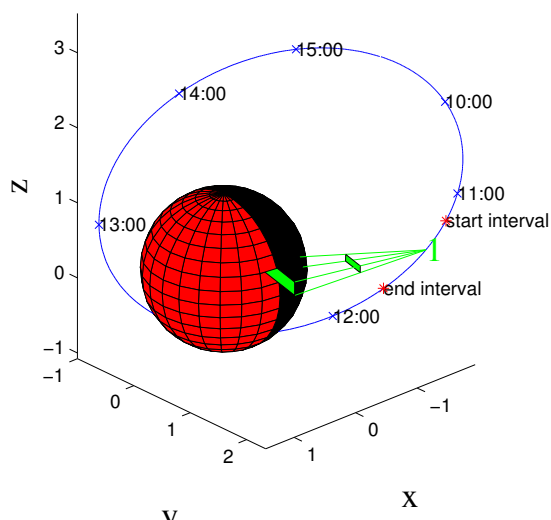


The oscillations were relatively stronger in this case. Heavy ions of planetary origin are seen. The ions come from a narrow range of incident angles. With the higher temporal resolution in this case we are also able to detect oscillations in the ion data.

## Further analysis of orbit 2510



orbit 2510 2005-12-26 11:28:15



Field of view of IMA sector 1, i.e., the sector dominating the ion count during this observation.

The peaks in count rate coincide for the ions and electrons. Peaks in the power spectral density are seen at the same frequencies for ions and electrons, but are more distinct in the ion data.

Assuming that the ions are  $\text{O}^+$  ions the ion flow speed has been calculated from the data and is shown as a function of the distance to the Mars-Sun line.

## Summary and Conclusions

- Plasma oscillations are seen inside the induced magnetosphere boundary.
- These oscillations have been seen both in the presence of protons and of heavy planetary ions.
- The planetary ions come from a narrow range of directions thus indicating that the oscillations are caused by a density structure that is carried along the direction of the plasma flow.
- The oscillations could possibly be a result of the Kelvin-Helmholtz instability, but further studies are required to confirm this.

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