Structure and Ion Composition of the Martian Wake Boundary Layer

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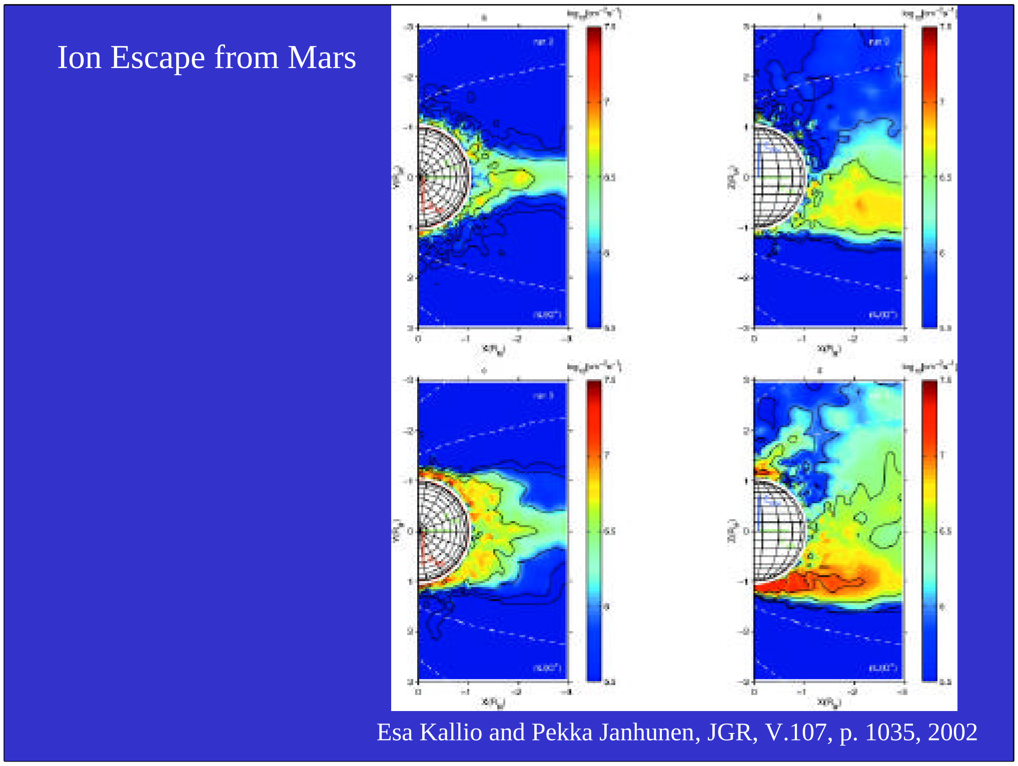
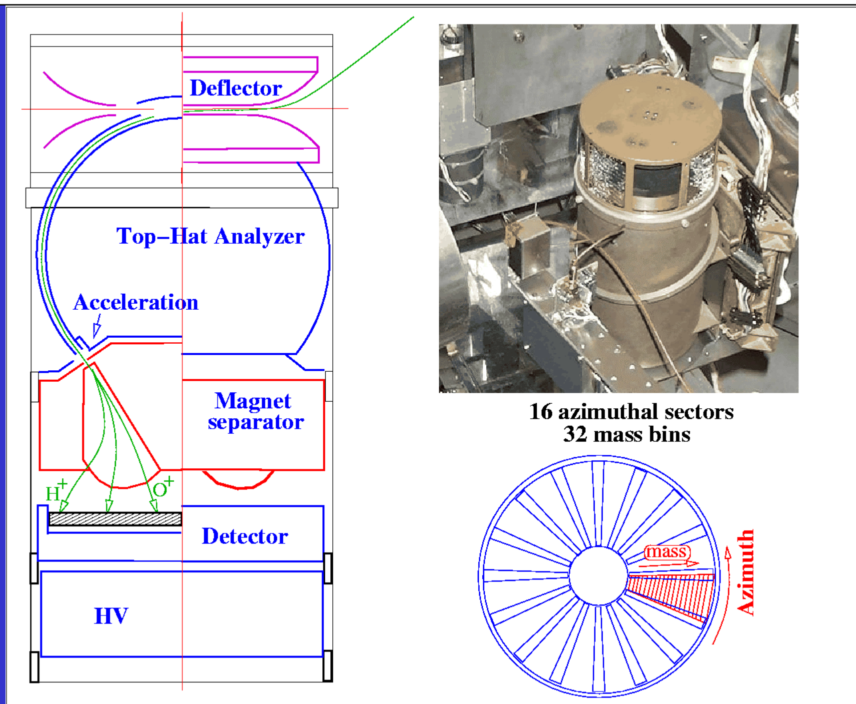


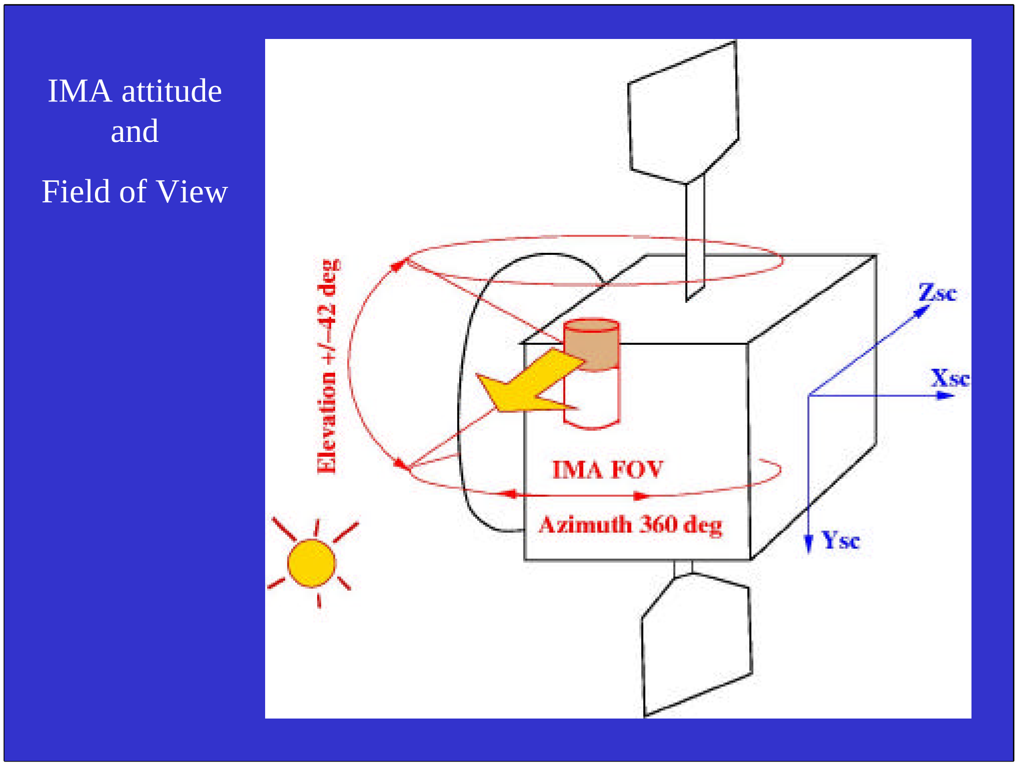
If you look the hybrid simulation of Kallio and Janhunnen you can see a significant flux of the the planetary ions (namely O+) behind the planet. It is worth to note that this flow is very anisotropic in respect to the IMF direction. With Mars-Express, after 15 years passed from Phobos mission we are restarting to study this ion outflow. This report mostly focuses on the statistical study of the data of the ion mass-analyzer IMA. This work is very preliminary because of:

1) We at at the begin of the road.
2) We have no magnetic field measurements, and even IMF direction.

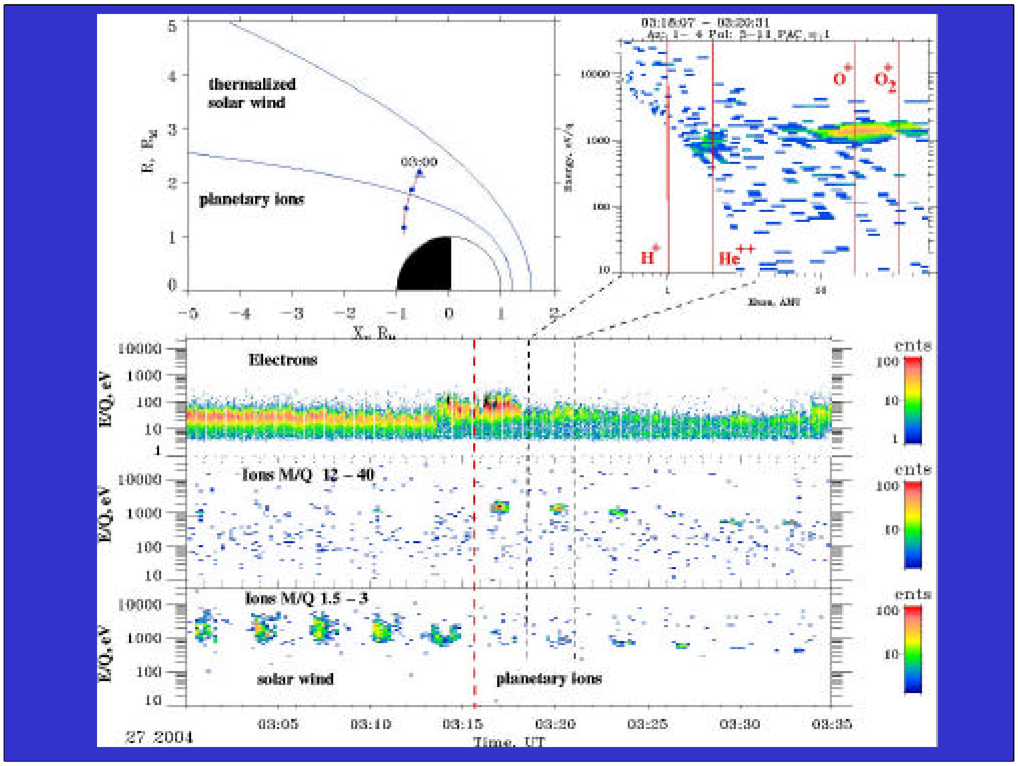


IMA mass–analyzer conceptual design

Several words about IMA design. It is standard top-hat electrostatic analyzer followed by 16 magnet sectors. Each sector allows to distinguish H+, He++ (or H2+), O+, O2+ (or any ions with M/Q greater than 30. Thus the analyzer has 360 deg. FOV divided in 16 azimuthal sectors. The entrance electrostatic scaner allows to sweep the view direction +/- 45 deg in the perpendicular plane.

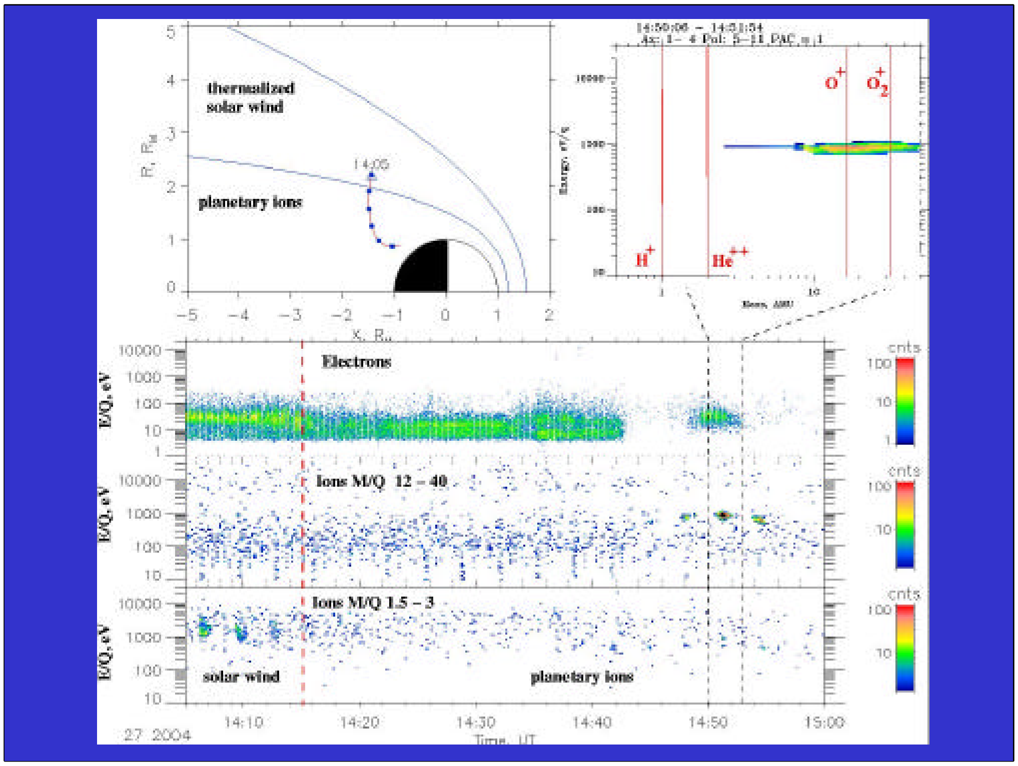


This figure shows IMA attitudes and standard MEX attitudes which it keeps along the most part of the orbit. IMA always sees the particles coming from the solar direction and at least +/- 45 deg around.



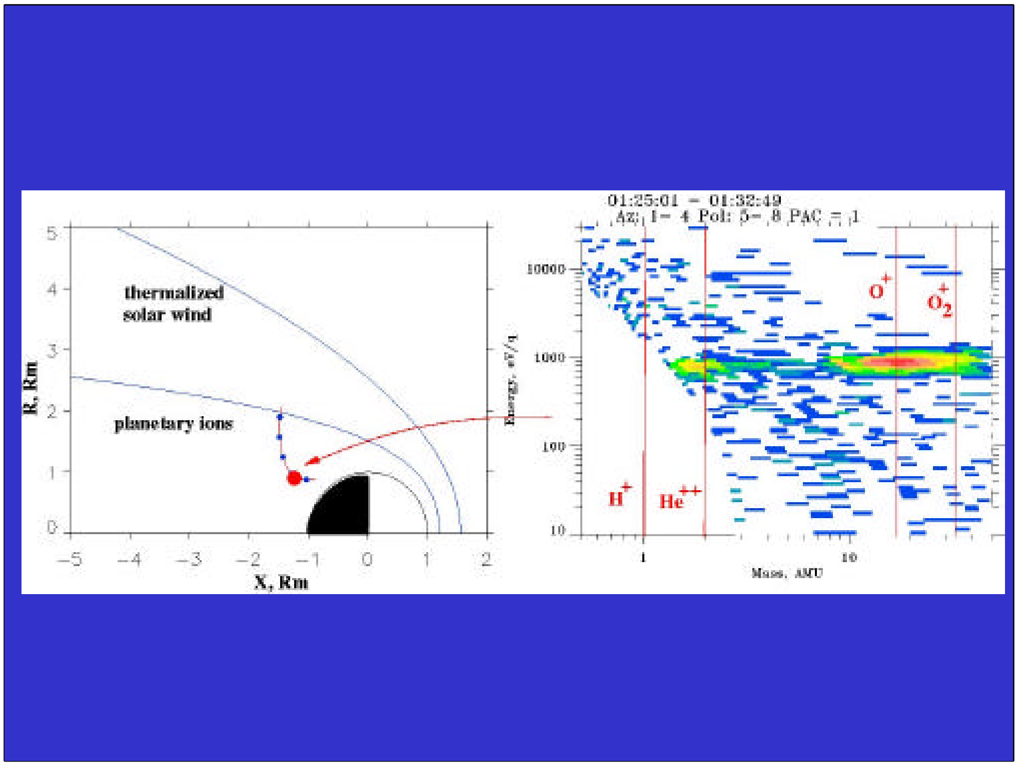
Let me show several examples of different behaviour of the planetary ions in the plasma wake of the Mars:

1) This figure shows the replacement of the solar wind flow with the planetary origin ions. Top left panel shows the spacecraft orbit. The shown boundary is the theoretical one indicating the boundary between magnetosheath flux and the region filled by the planetary ions. The E-T spectrogram on the bottom panel shoes that when MEX cross this boundary, the solar winf flow presented by He++ ions in the low spectrogram is replaced with heavy ions. The heavy ions demonstrates energy decreasing and decreasing of the intensity closer to the center of the planet. Also you can see the rest of the He++ ions. The energy-m/q spectra at the top-right of the figure shows that O+ ions are dominant, but O2+ ions also are seen with a little bit higher energy. One can see also the remains of the He++ at the smaller energy. Since the heavy ions are observed in the vicinity of the boundary, I call this event as “Boundary Layer”.

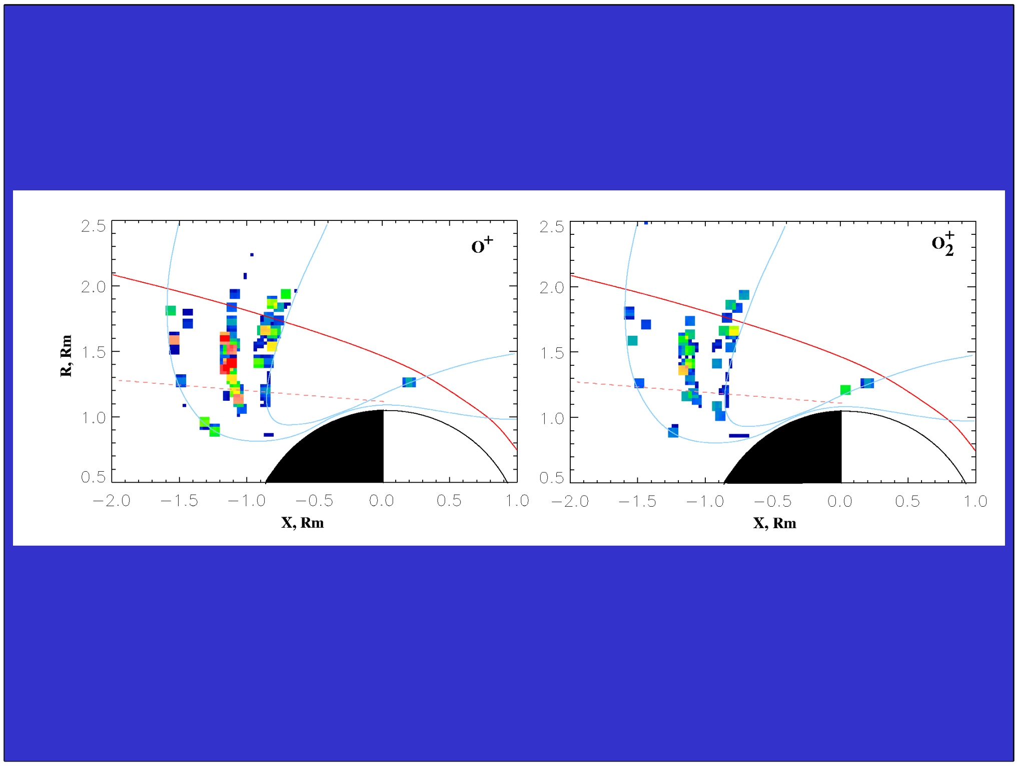


2) But the most of the orbits (about 70%) demonstrates absolutely different behaviour, shown in this figure. In this case the He++ ions disappear after the boundary cross. And there is no indication of the heavy planetary ions. Then complete absence of the electron flow indicates that MEX entered the planet shadow. End there you can see the burst of the

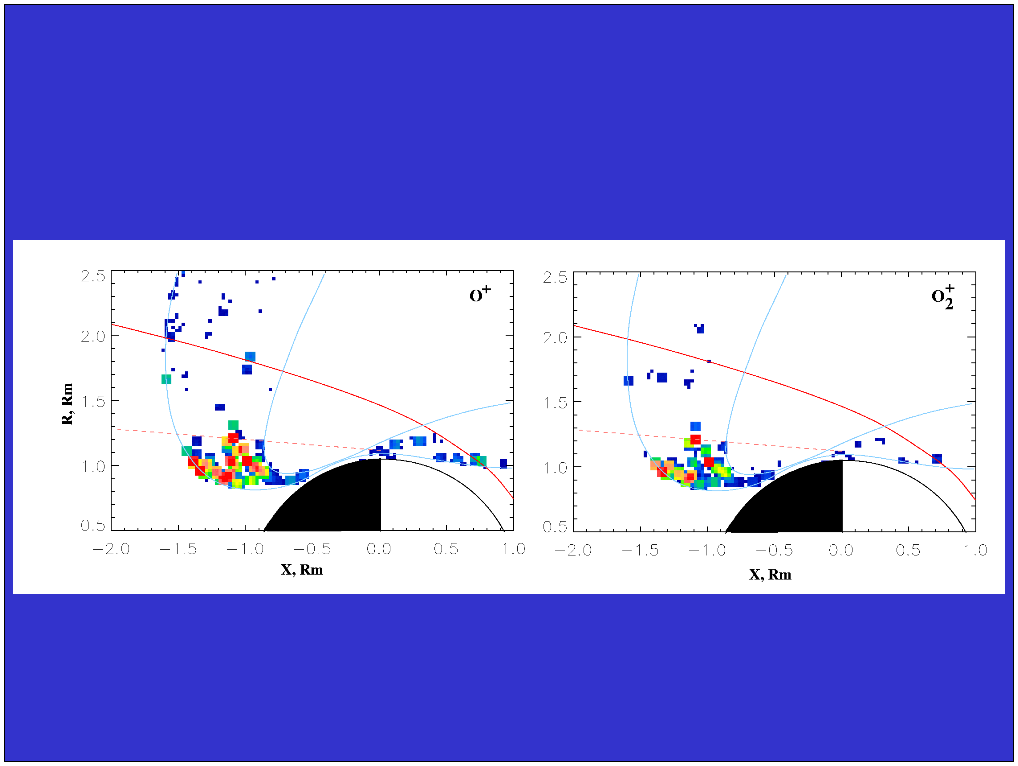
Electron flow and the burst of the heavy ions. Energy-M/Q spectra shows O+ and O2+ ions in this burst.



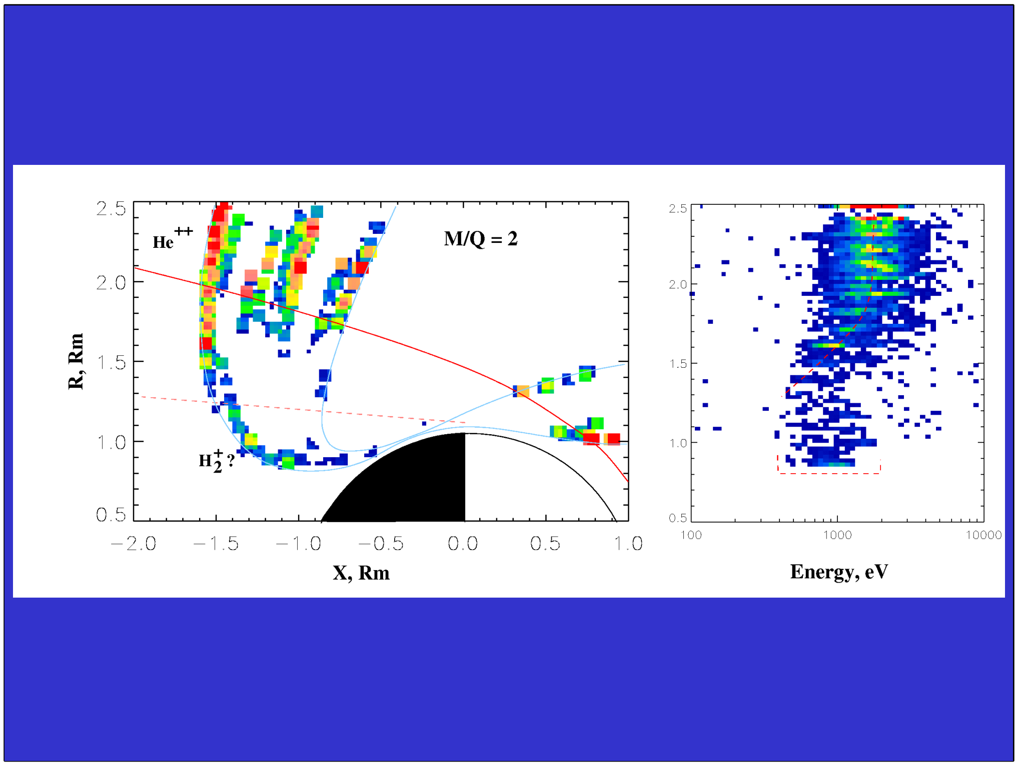
3) Sometimes such ions burst contain an essential number of ions with M/Q = 2. Since this event is registered in the planet shadow, I doubt that it is He++ from the solar wind. But we have now enough evidences in favor of H2+ now.



The spatial statistics of the “boundary layers” is shown in this figure. O+ (left panel) and O2+ (right panel) are seen everywhere between boundary and red dashed line. The color is indicates the average count rate in the given spatial pixel (0.1 X 0.1 Rm). Note that statistics is made for the **entire** orbit when the “boundary layer” has been registered.

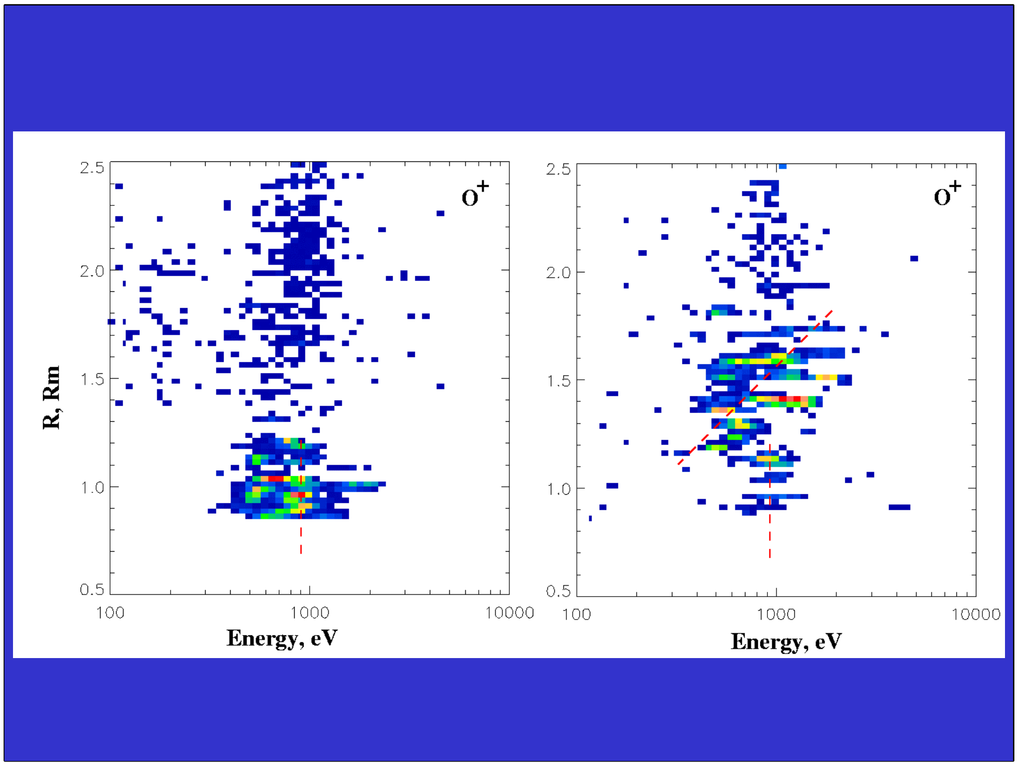


This slide shows the statistics of the heavy ions observed on the orbits containing the "busty events". As well as for the previous figure, the **entire** orbit has been taken into account. This is the reason why we can see some counts on the dayside. But the main count was registered on behind the planet, under the red dashed line. Since the intensity of the flux does not depend on the distance to the planet I do not believe that magnetic anomalies can play essential role here.

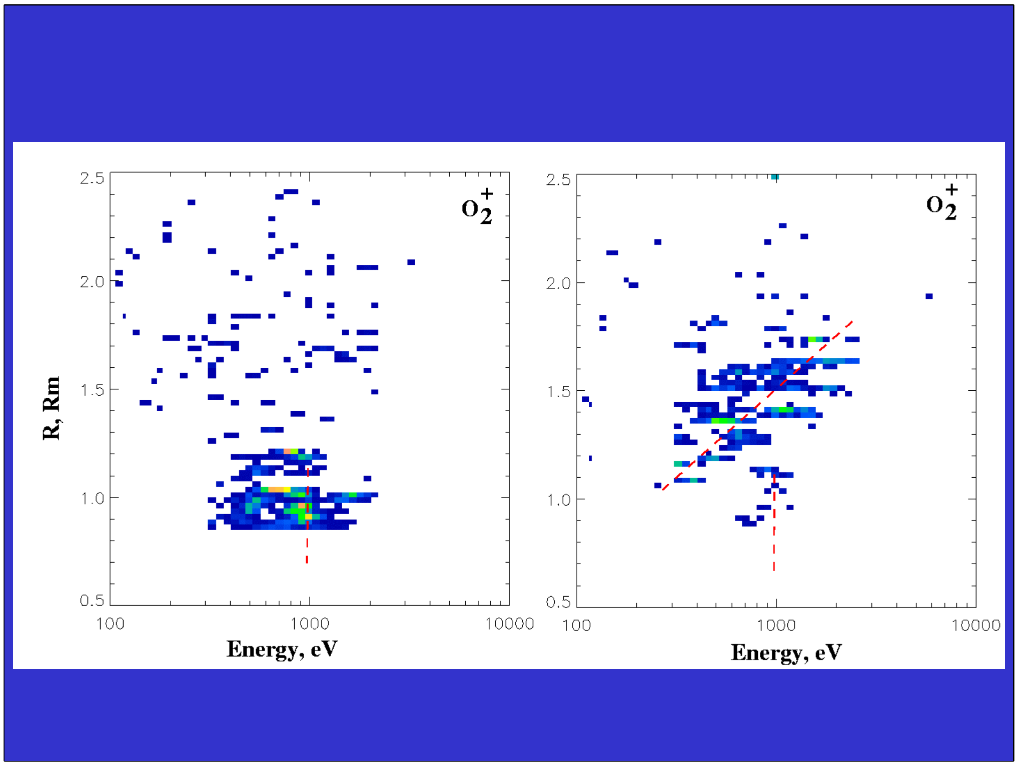


3) The spatial distribution of the M/Q = 2 is shown in this figure in the left panel. You can see the He++ in the magnetosheath, and some He++ ions in the “boundary layer”.

But on the several orbits mosly far from the planet the M/Q =2 are observd in the planet’s shadow. The color coded count rate of these ions in the frame Energy v. R is shown in the right panel. The “boundary layer” is seen as energy and intensity gradient until R = 1.3 Rm. Then for R < 1.0Rm an another population with energy about 900 eV is seen.



Similar “scatter plots” in the Energy v. R frame is shown foe O+ ions. The left panes shows statistics for “bursty” orbits. And right panel shows shows the statistics for “boundary layers”. Again ypu can easily distinguish two populations. One is a “boundary layer” with energy dispersion and another is a “bursty” population with spread around 900eV energy.



The same properties you can see even better in O2+ statistics.

Conlusions:

- There are two regimes of escaping planetary ions :

  - Planet shadow

  - Boundary Layer

  Perhaps it depends on IMF_{YZ} direction
- Ions M/Q =2 are seen in the planet shadow

To Do:

IMF reconstruction by MGS observations