

First ASPERA-3 Mars Encounter Results

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1.0 Introduction

ASPERA-3 contains an electron spectrometer (ELS), an ion mass spectrometer (IMA), a neutral particle imager (NPI), and a neutral particle detector (NPD). The United States supplied the ELS instrument and the anode detector of IMA. The ELS, NPI, and NPD instruments are mounted on a scanner platform that rotates through 180° and sits on the top of the spacecraft. The scanner movement allows a 3-dimensional view of the plasma, but has yet to be activated due to inadequate thermal conditions. The IMA unit is mounted on the bottom of the spacecraft and electrically scans in elevation to create its 3-dimensional view of plasma. This report covers the initial activations of ASPERA-3 while at Mars with emphasis on data from the ELS.

The Mars Express spacecraft was launched on June 1, 2003 and arrived at Mars on December 25, 2003 in an orbit plane that was parallel to the ecliptic plane. An orbital maneuver was performed to increase the spacecraft inclination so that the orbit became nearly perpendicular to the ecliptic plane and a polar orbit was achieved. On January 4, 2004, the orbit reduction was begun which increased the ellipticity of the orbit and lowered apogee from 190,000 km to 40,000 km. At the same time, the perigee became about 250 km. Mars Express final operational orbit is about 11,000 km for apogee and 300 km for perigee. These orbital characteristics were reached at the end of January.

SwRI® stores data from the ASPERA-3 experiment in IDFS™ format. Automatic transfers of telemetry are occurring from IRF to SwRI. ASPERA-3 data are being converted into IDFS files and are being archived at 129.162.154.22. ASPERA-3 data are available over the web at <http://mexdata.space.swri.edu>. At present, the mirror web site at IRF has not been established. ASPERA-3 IDFS data are available through SDDAS™. By inclusion of the node address 129.162.154.22 where ASPERA-3 IDFS data are stored, personal copies of SDDAS can access these data. SDDAS administration tools are available for updating the database for access to ASPERA-3 data.

The features of SDDAS and available ASPERA-3 data change daily. Local copies require a download of metadata in order to access the most current ASPERA-3 data. SDDAS tools are available in local copies of SDDAS to update metadata. This report utilizes presentations of ASPERA-3 generated from ASPERA-3 data stored in IDFS format under SDDAS.



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2.0 ELS Observations

During the period of orbital adjustment, ASPERA-3 observations were sparse. Initial observations from ELS were conducted in the magnetotail of Mars on orbit 19. Figure 1 shows an energy-time spectrogram of the energy flux carried by the electrons from this observation. ELS sectors 3 through 7 are shown on the left and sectors 8 through 12 are shown on the right. Sectors not shown have an elevated noise background most likely due to either the spacecraft itself or reflected solar ultraviolet radiation. The data from these sectors are currently under examination. When the scanner is activated, a determination of the extent of aspect dependence of the effect will be possible, and a scheme for elimination of the background will be formulated.

In the mode shown in Figure 1, every-other ELS sector is inactive. The data show the solar wind at 35 eV. It is most prevalent in ELS sector 3 at the top left panel of Figure 1. Order of magnitude fluctuations are seen in the energy flux as a function of time. These fluctuations are probably caused by eddy currents formed in the plasma as a result of having to divert around the planet.

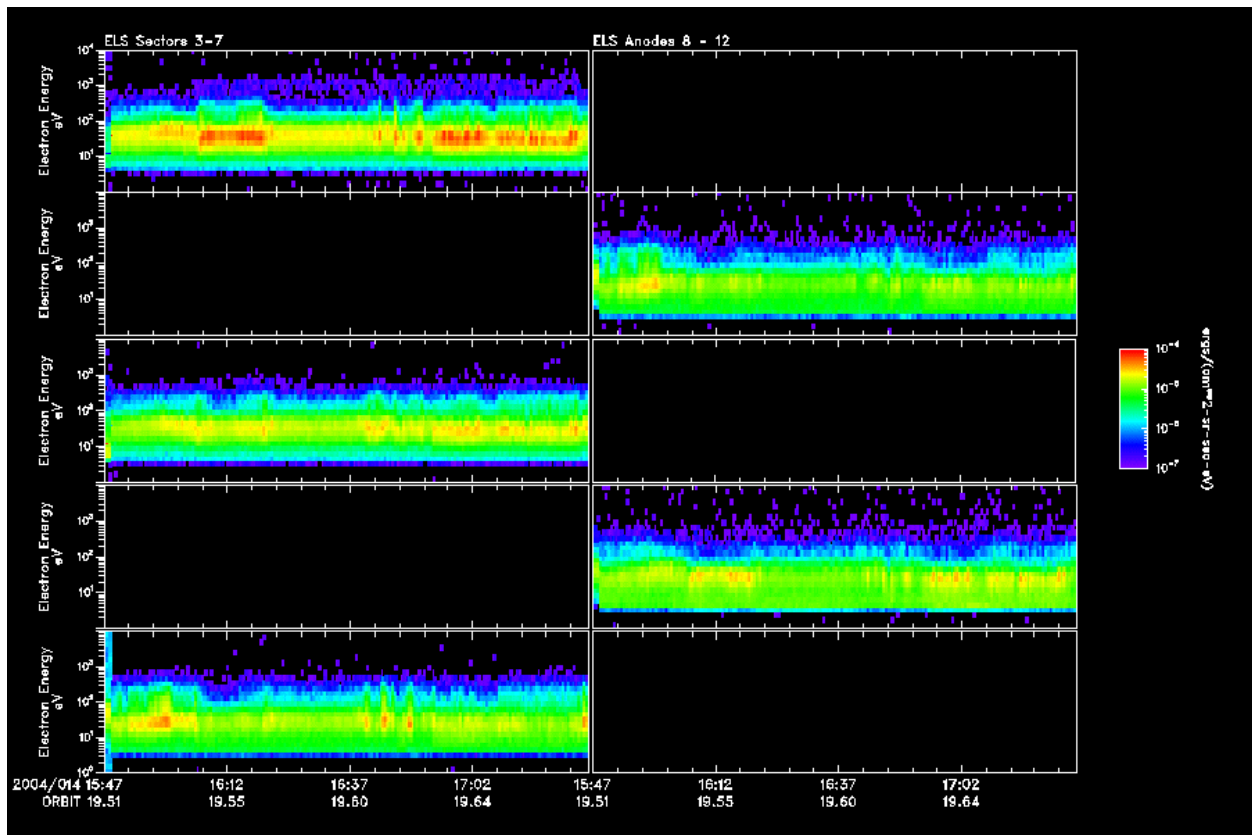


Figure 1. Electrons in the Magnetotail of Mars. These data were taken on orbit 19 which occurred on January 14, 2004. Energy-Time spectrograms in energy flux are shown for ELS sectors 3 through 12.



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The first observations of the Mars ionosphere by the ELS instrument are shown in Figure 2. The data presented in Figure 2 is in the same format and has the same flux scales as Figure 1. This spacecraft passed through the Mars ionosphere during perigee of the Mars Express orbit. At present, it is felt that ELS sees the Mars magnetic pile-up boundary between 6:12 UT and 6:15 UT, Mars ionosphere from 6:15 UT to 6:31 UT, and magnetic pile-up boundary again between 6:31 UT to 6:34 UT. The enhancements of energy flux at 6:20 UT and 6:24:30 UT are probably density fluctuations in the Mars ionospheric plasma because there seems to be about the same amount of flux intensity in all sectors. The enhancement at 6:27 UT may be an electron flow because there appears to be systematic differences between sectors.

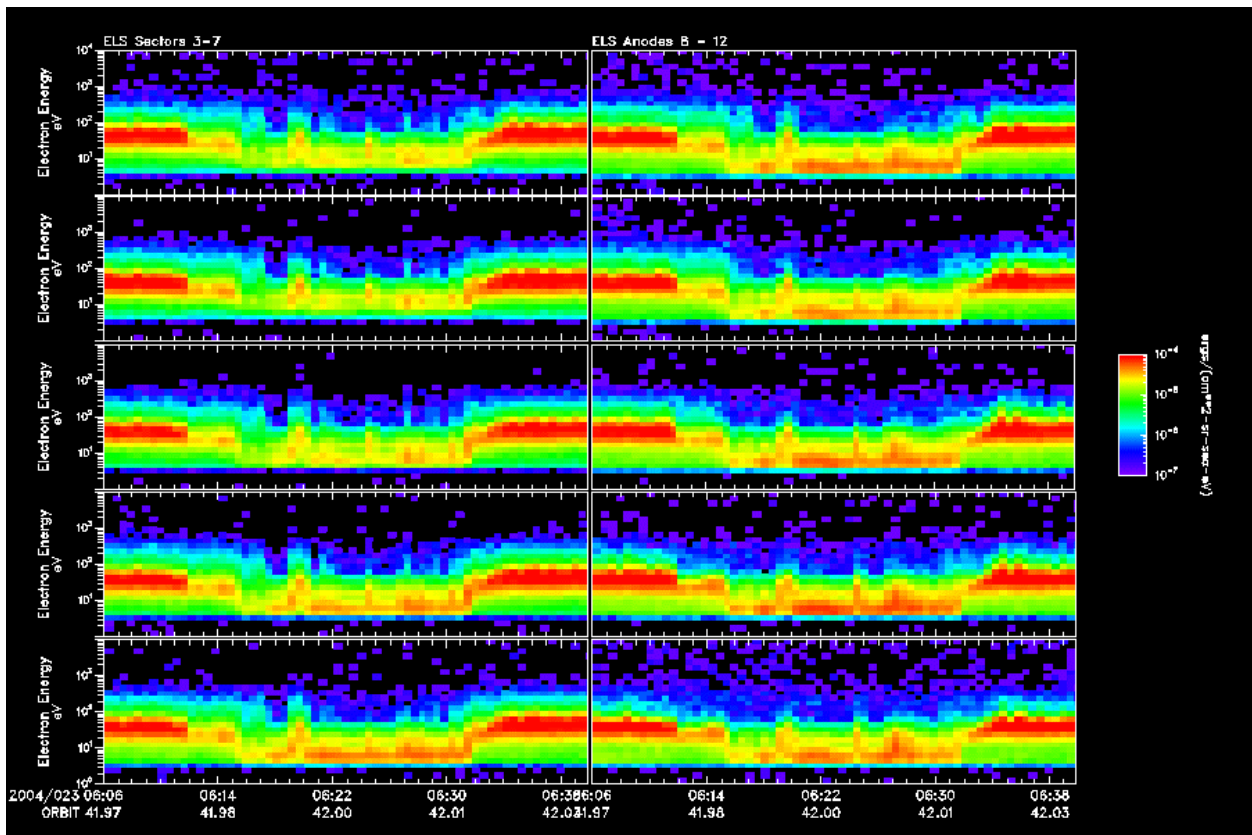


Figure 2. First Observations of Electrons in the Ionosphere of Mars by ELS. These data were taken during perigee on orbit 41/42 which occurred on January 23, 2004. The data are presented in the same format as the data shown in Figure 1.



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Figure 3 shows the electron spectra from ELS during the transition through the magnetic pile-up boundary and into the Martian ionosphere. These spectra are shown in number flux-energy between 5 eV and 1000 eV. Spectra from ELS sectors 3 through 12 are drawn on top of each other so that differences in sectors can be seen. Time runs from the upper left to the upper right, and then from the lower left to the lower right. The legend at the right indicates the symbol used to mark each sector's spectra.

Magnetosheath plasma is shown at the beginning of the spectral plots. The spectral peak at about 40 eV is at the solar wind energy, but the flux has been isotropized so that angular differences are not as great as they are in the solar wind. As the spacecraft enters the ionosphere, the electron spectra show a flux increase in plasma at 10 eV energies while the flux in the 40 eV region decreases. Below 100 eV, the spectral flux from sector 10 is the largest. This flux shows a distinct increase in Auger electrons at 100 eV in the third and fourth panel. Auger electrons are ejected from the inner shell of an atom and are more energetic than photoelectrons. Fluxes in sector 10 indicate that there is a preferential direction to ionization.

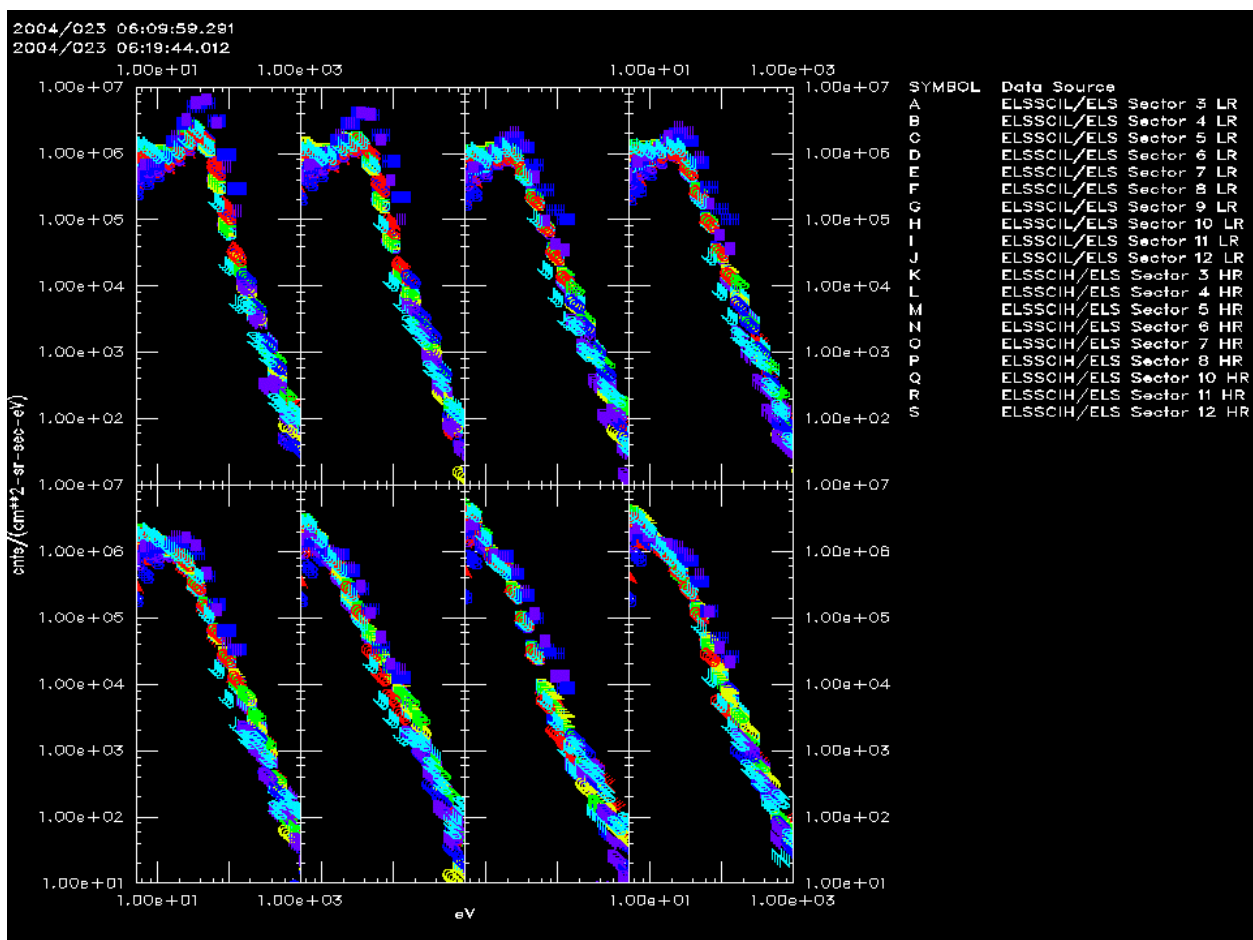


Figure 3. Spectra from the First Observation in the Martian Ionosphere by ELS. The number flux from sectors 3 through 12 are plotted on top of each other and these 8 spectra show the time progression as the spacecraft passes into the Martian ionosphere.



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The second observation on the Martian ionosphere by the ELS instrument was only about 16 hours later, yet there was less energy flux observed than during the first pass through the ionosphere, see Figure 4. The orbital parameters did not change substantially. Fluxes in sector 11 are the strongest. Through the Martian ionosphere, a higher intensity flux is observed at 20 eV. These are photoelectrons that are generated from ionization from the outer shell of the atom.

The lower intensities do not make the magnetic pile-up boundary as visible as in Figure 2. The transition into the ionosphere begins at 22:42 UT, but it is not clear if the plasma detected at the start of the pass is from within the pile-up boundary. In addition, a similar situation is seen as the spacecraft exits the ionospheric plasma. A gradual transition is difficult to see and there appears to be a feature at 23:06 UT that requires further investigation. This pass requires greater scrutiny in order to determine boundaries with more certainty.

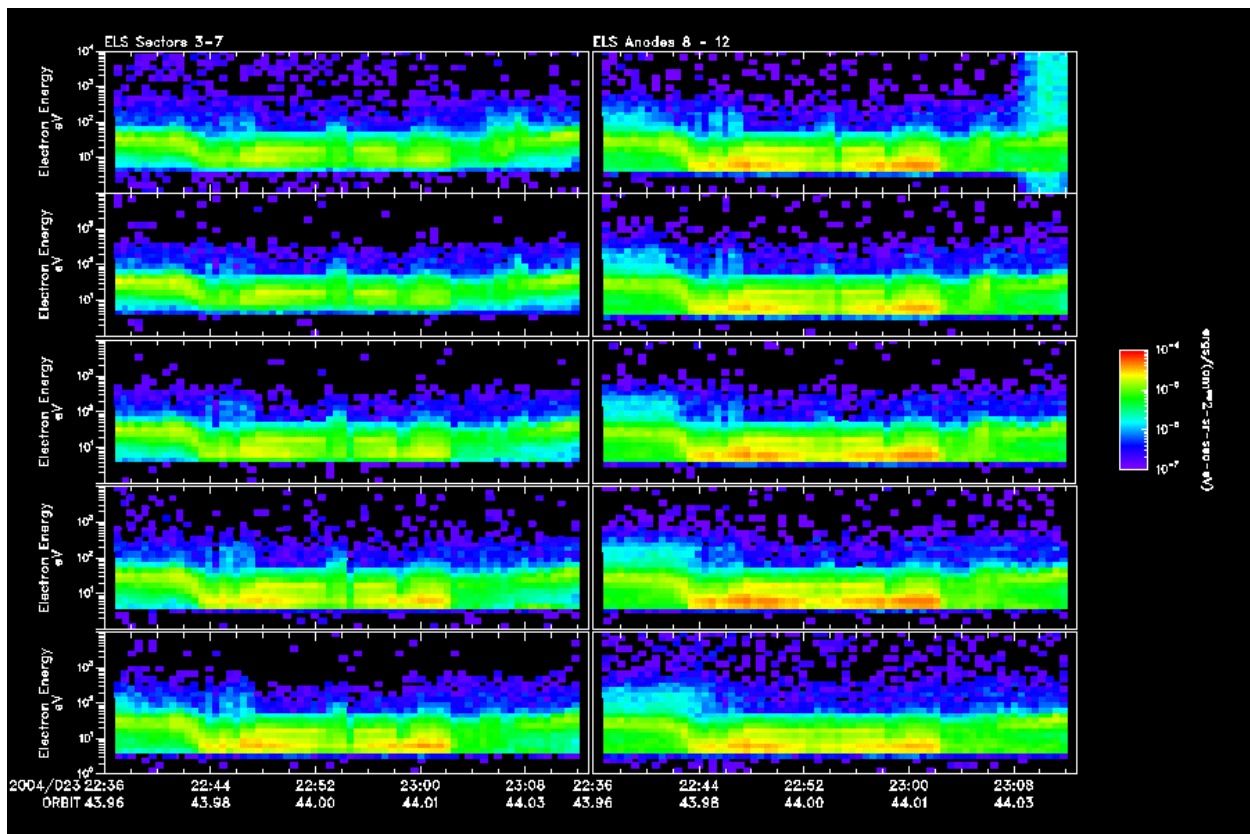


Figure 4. Second Observations in the Ionosphere of Mars by ELS. These data were taken during perigee on orbit 43/44 which occurred on January 23, 2004.



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Comparison of the spectra between the first pass in Figure 3 and that of the second pass shown in Figure 5 reveals that there is a different character to the plasma. For energies below 500 eV, the fluxes are less in Figure 5 than that shown in Figure 3. However, the Auger peaks in the spectrum at about 100 eV are stronger in spectra from Figure 5 than those shown in Figure 3. At the lower energies, fluxes from sectors 10 and 11 dominate. At high energies, fluxes from sector 12 dominate.

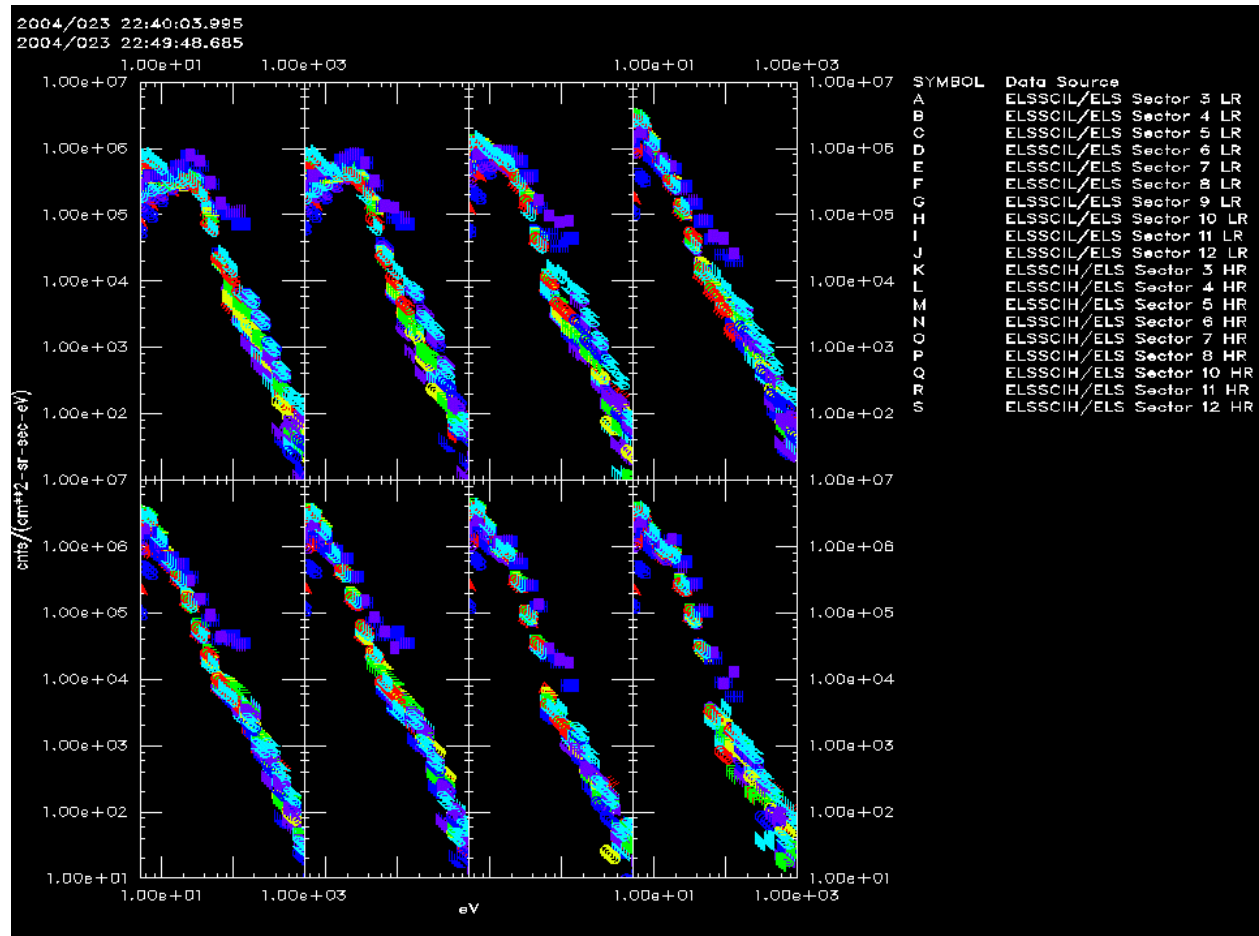


Figure 5. Spectra from the Second Observation in the Martian Ionosphere. These spectra show an increase in the Auger flux in the 100-200 eV regions.



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The Martian ionosphere was again observed on January 25, 2004 (Figure 6). The beginning of the data shows that the activation of ELS probably occurred within the Martian ionosphere. The feature between 14:52 UT and 14:56 UT is the largest energization seen to date in the Martian ionosphere. Photoelectron peaks at 20 eV are observed and are separated to a higher degree in some sectors. Photoelectron peaks are not visible from the beginning of the data to after the feature at 14:56 UT. From 14:56 UT until 15:06 UT (when the spacecraft leaves the influence of the ionosphere), the 20 eV photoelectron peaks show a gradual decrease in flux intensity.

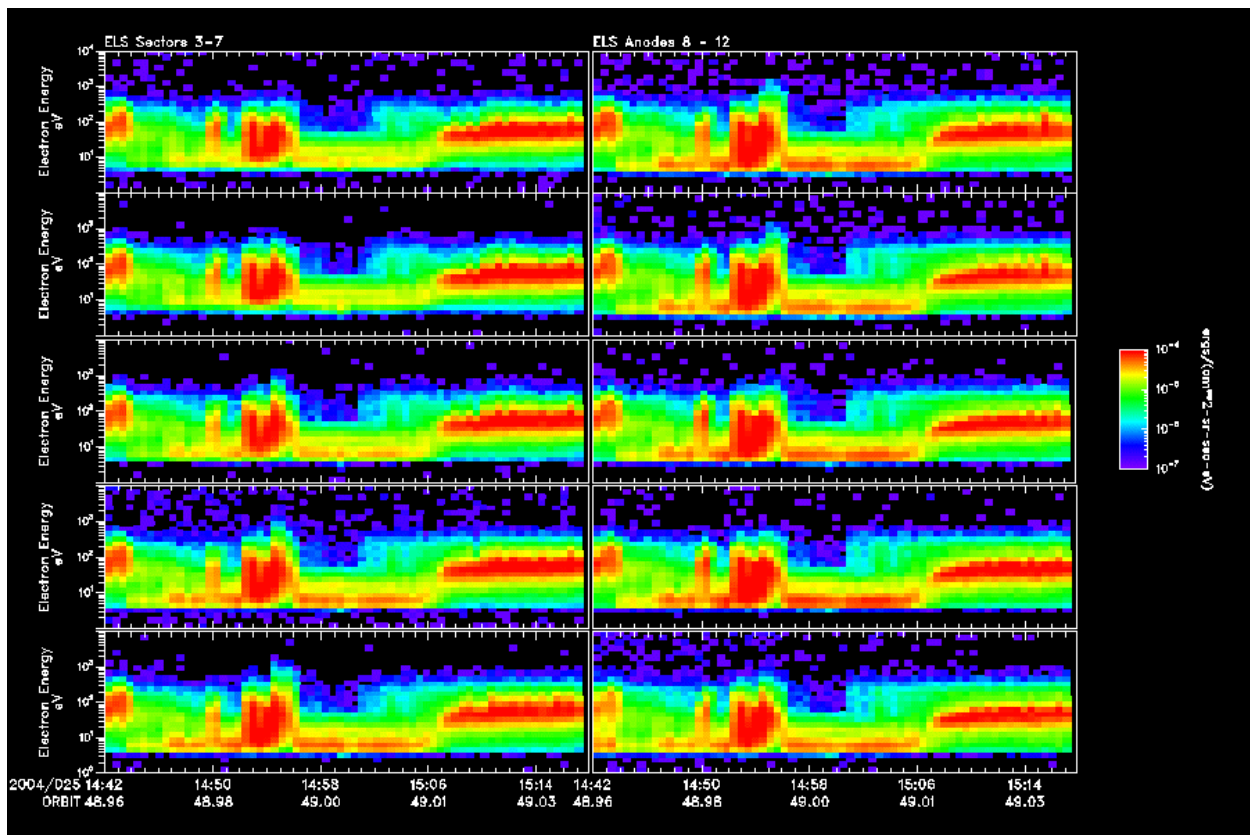


Figure 6. Third Observations of Electrons in the Ionosphere of Mars by ELS. These data were taken during perigee on orbit 48/49 which occurred on January 25, 2004.



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Spectra from this ionospheric pass are shown in Figure 7. These spectra are taken from 14:53 UT through 15:02 UT, through the intense electron feature. The spectra show that the flux at energies below 100 eV from sectors 10 and 11 dominate the plasma during the most intense portion of the energized electron region. During the same time, fluxes above 100 eV are dominated by fluxes from sectors 7 and 8. Photoelectron and Auger electron peaks dominate the spectra of sectors 10 and 11 after the end of the energization feature.

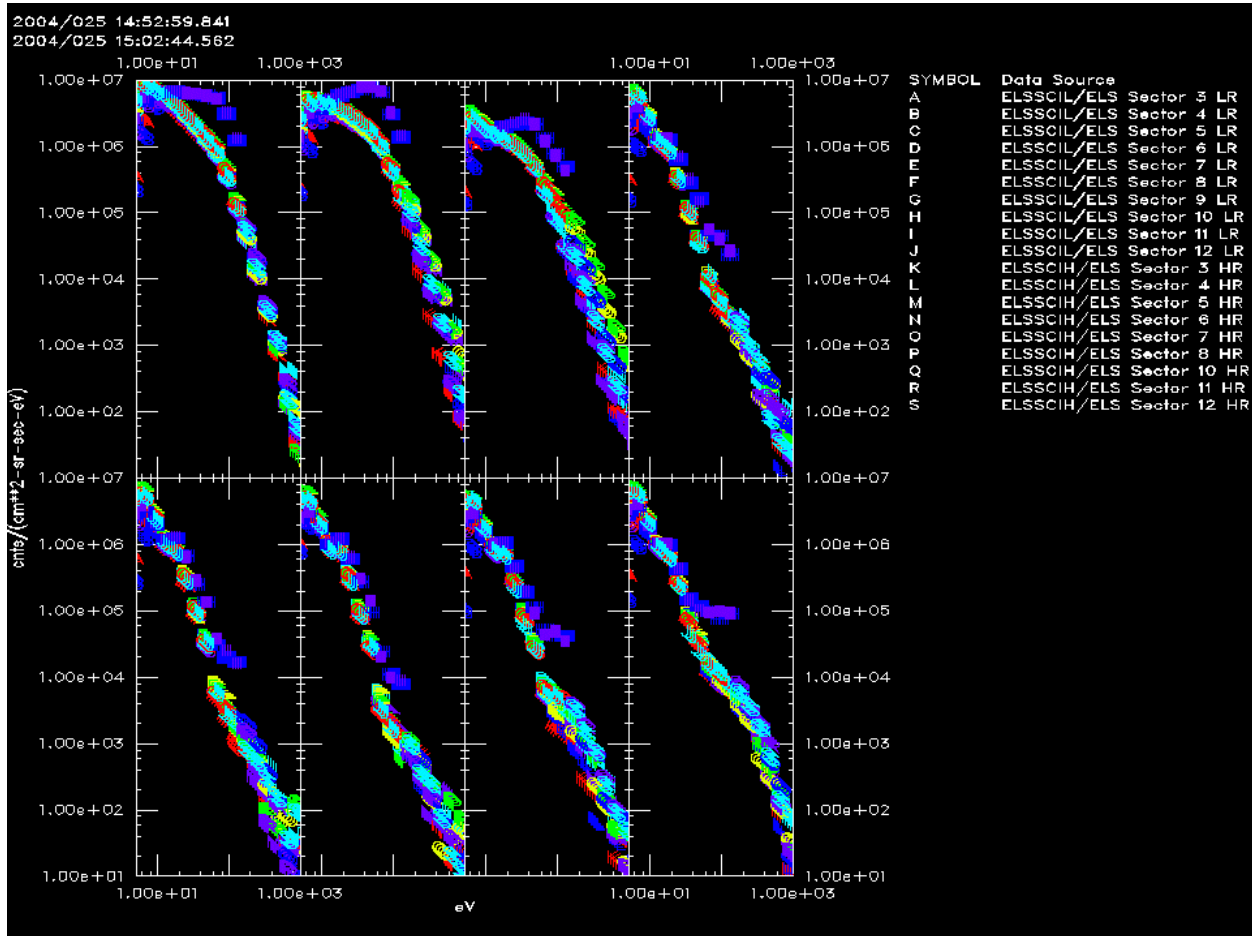


Figure 7. Spectra from the Third Observation in the Martian Ionosphere.



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3.0 IMA Observations

Observations of ions have currently focused on the region above the poles and in the tail region of Mars, examining the planetary ion wind. Figure 8 shows an example of IMA counts from January 29, 2004 for data from all IMA sectors. The data are shown in ring-time spectrogram format with raw counts coded with the scale at the right of the plot. Ring is a complicated function of ion mass and charge, but in general, H^+ appears at higher ring numbers. As time progresses, the ion energy and angle of acceptance are scanned. Shown in the plot is a complete energy scan for a given acceptance angle. Fluxes vary with energy and acceptance angle. Figure 8 shows H^+ in the Martian tail. H^+ is an indicator that the ions probably came from the solar wind and not the planet and we are observing the solar wind as it skirts around Mars.

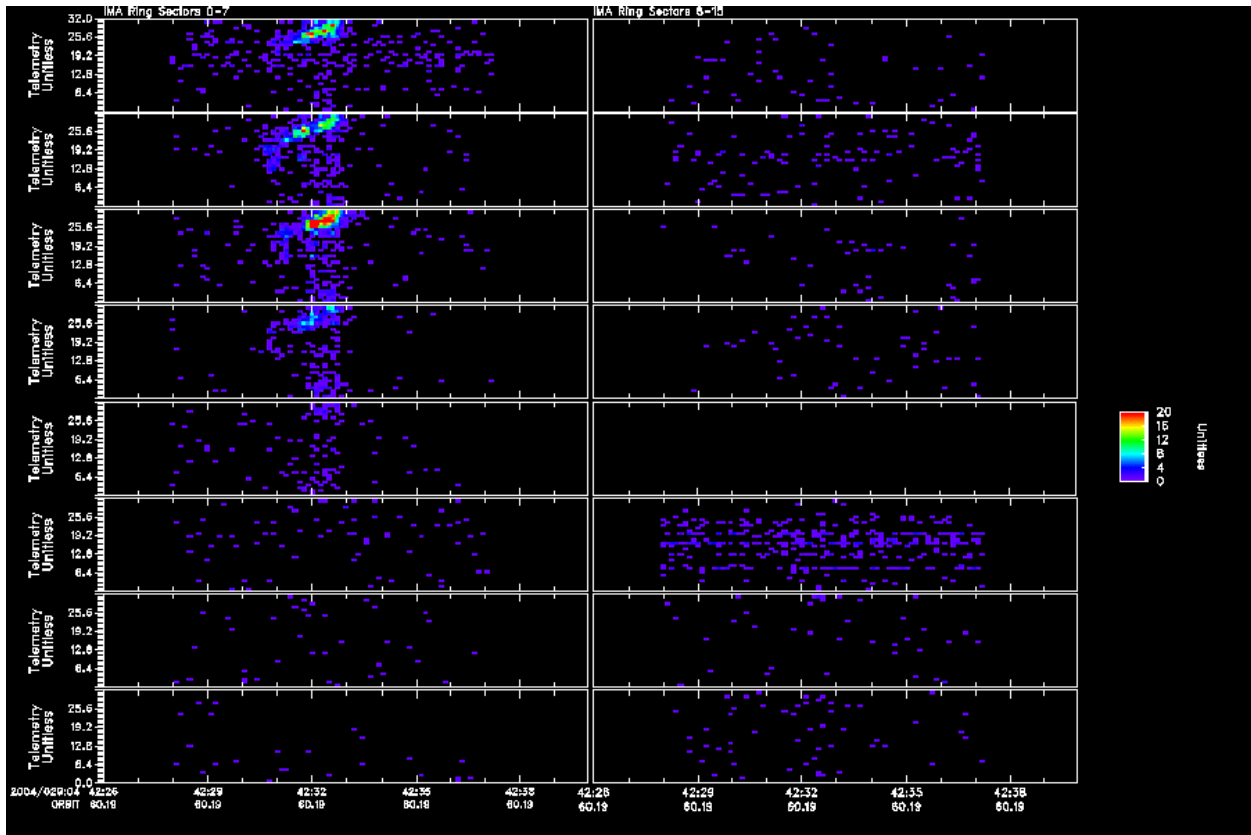


Figure 8. Ring-Time Spectrogram from IMA Observations in the Martian Tail. These data were taken on orbit 60 which occurred on January 29, 2004.



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IMA also detects additional ion species. Figure 9 shows a ring-time spectrogram where at 23:57 in sector 2, H^+ is seen at high ring number. At the same time, a weaker flux is seen at about ring 15. This could be He^{++} from the solar wind or O^+ from the planet. Further investigation needs to be pursued to determine this for certain. These observations occurred later in time than those of Figure 8, when the spacecraft was further down the tail of the Martian magnetosphere.

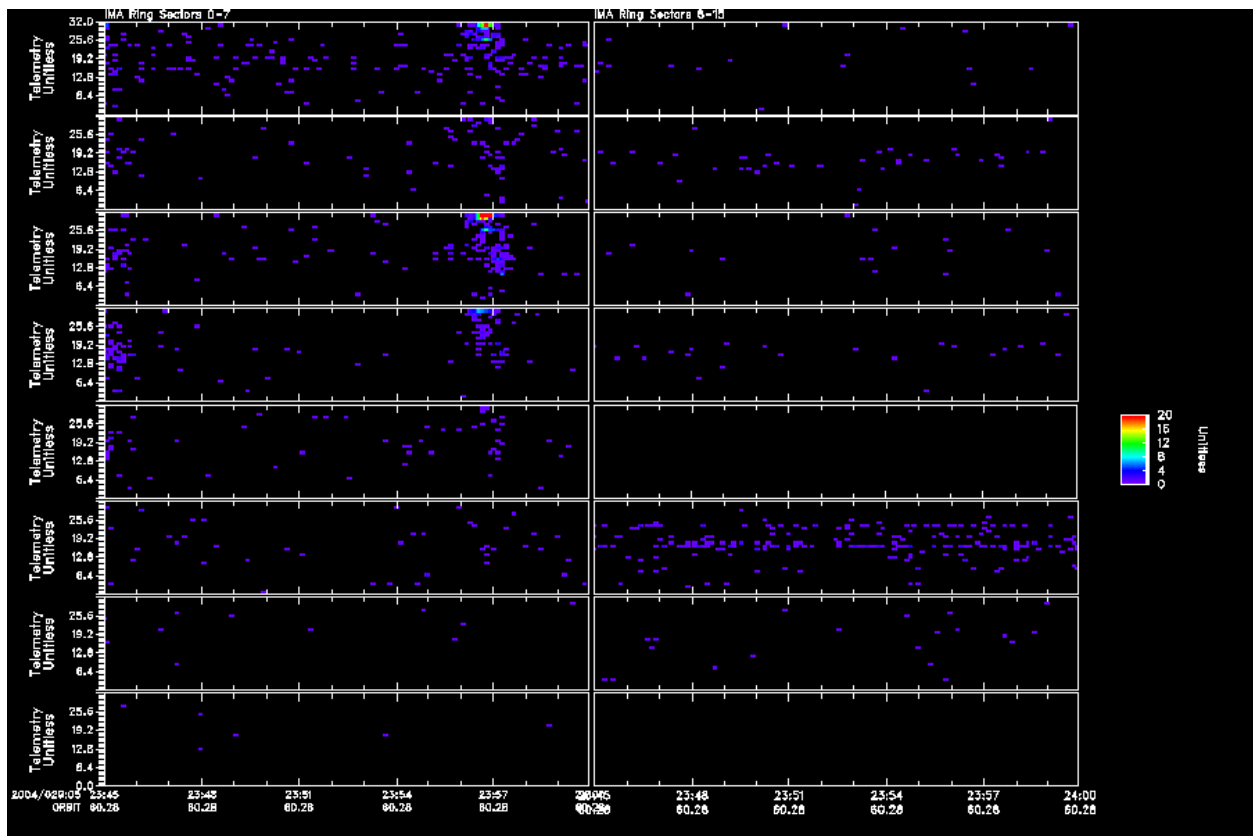


Figure 9. Ring-Time Spectrogram from IMA Tail Observations of Different Mass Ions Present Simultaneously. These data were taken on orbit 60 which occurred on January 29, 2004, similar to those shown in Figure 8, but when the spacecraft was further down the Martian magnetotail.

