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PLANNED INVESTIGATION OF ENERGETIC PARTICLE POPULATIONS (~20–500 keV) IN THE CLOSE MARTIAN ENVIRONMENT

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ABSTRACT

Energetic particle observations made by the Irish SLED instrument on the Phobos 2 spacecraft in 1989 have revealed the presence, within the overall energy range < 30 keV- > 3.2 MeV, of variously located energetic particle populations in the close Marian environment. The signatures of characteristic boundaries have also been recorded for the first time in energetic particles in the distant Martian magnetotail. The new SLED-II instrument on the Mars-94 Mission is designed to study in detail, with 4π measurement capability, these and other energetic particle phenomena at Mars, while operating, over an extended period, at low altitudes above the planet.

THE MARS-94 MISSION

Within the past twenty years the Space Research Institute of the USSR Academy of Sciences has mounted several major missions to investigate planet Mars. These include MARS 2-3 (1971); MARS 4-7 (1974) and, more recently, the Phobos Mission to Mars and its Moons (1988). Now, for the next 15 to 20 years, the investigation of Mars has been specifically defined to constitute the main goal of ongoing Solar System Studies, and the Mars program has been formally entered in the list of National Scientific and Technological Programs adopted by the Soviet Government. The MARS-94 Mission is the first stage in the implementation of this program. The mission profile involves a launch to Mars of two identical spacecraft, the first in October 1994 the second, probably, in 1996. At the present stage of planning, each is to include an orbiter; a balloon; two meteorological stations; two penetrators and a Martian rover for surface studies.

The mission sequence envisaged requires spacecraft insertion into an Earth satellite orbit, followed by transfer into an interplanetary trajectory, with an Earth to Mars flight time of 315 days. Separation from the spacecraft of the small stations and penetrators will take place three to five days before planet approach. Retardation and insertion of the first spacecraft into its initial orbit about the planet will take place in September 1995. Astrophysical studies and measurements in the interplanetary medium along the cruise trajectory will be carried out before descent orbit formation - Orbit 1 (Hp = 500km, T = 0.5 day); Orbit 2 (Hp = 300km, T = 0.5 day); Orbit 3, (Hp = 300km, T = 0.5 day).

Next, balloon entry into the Martian atmosphere and the landing of a small Martian Rover will ensue, followed by the formation of orbit 4 (Hp = 500km, T = 0.5 day) and, finally, formation of the main operation orbit for remote sensing of Mars., Orbit 5 (Hp = 200-300km, T = 0.5 days) Related orbit parameters include; inclination to the Martian equator 70°-80°; initial percenter latitude 40°; percenter latitude range over one year 40°-70°-40°. A similar scenario will be adopted for the second spacecraft. For details see a description published by the Space Research Centre at Moscow, 1991 /1/.

SLED II OBJECTIVES

The pioneering detection 1989 by the Irish SLED instrument aboard the Phobos Mission of populations of energetic particles in the range 30-200 keV in the close Martian environment /2/, /3/, immediately resulted in a decision to fly a further energetic particle detector SLED-II on the Mars-94 mission. See also the results of later studies identifying the presence of variously located populations of energetic particles near Mars (range <30 keV - > 3.2 MeV); also the identification in energetic particles of various characteristic boundaries (bow shock and magnetopause with, between them, the magnetosheath) in the direction of the distant Martian magnetotail /3/, /4/.

The new SLED-II instrument is designed to investigate in depth, using increased measurement capability, the nature of the energetic particle fluxes recorded close to the planet. The purpose of the present paper is to describe SLED-II. Fig. 1 shows the position of SLED-II on the Mars-94 spacecraft.

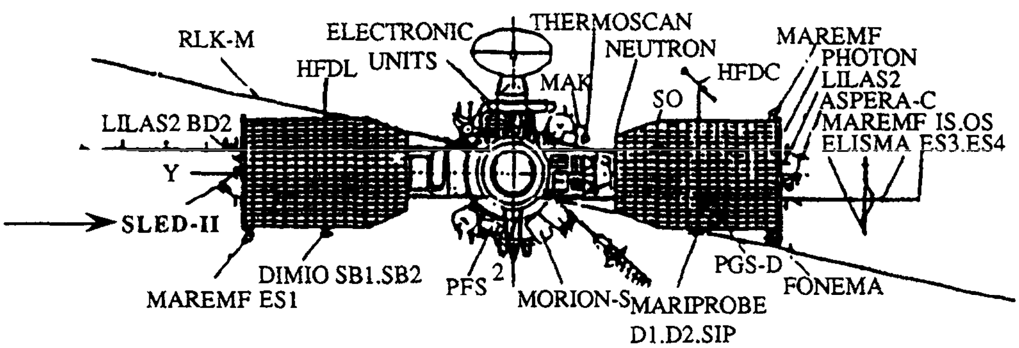

Fig. 1; The Mars - 94 spacecraft, showing the location of SLED II

SLED II, for which the mass allocation for the first SLED was increased from 1.55 kg to 3.1 kg, but with the necessity this time to accommodate a dedicated data processing unit within the instrument, will exploit the uniquely low perimartii of the Mars-94 Mission (down to at least 200 km, as compared with 580 km in the case of the Phobos Mission) and an expected dwell time of at least one year in working orbit 5 (as against the execution of only four close elliptical orbits during the Phobos Mission) to monitor, over an extended time period, the behaviour of particle populations with energies >30 keV in the close Martian environment.

More detailed objectives include

1. Investigation of the possible quasi trapping of energetic particles in the magnetosphere
2. Investigation of the dynamical properties of particles in the magnetosphere (bulk velocity) to provide an indication of their composition.
3. Use of the particle measurements as a probe of magnetic field topology in the Martian environment.
4. Study of the interaction of energetic particles with the bow shock; the magnetopause; the plasma sheet and other possible boundaries.
5. Study of the distribution of energetic particles within the magnetosphere.
6. Study of ion and electron acceleration at the bow shock and in regions within the magnetosphere.

Further, during the Cruise Phase, SLED II will monitor the interplanetary flux of low energy cosmic rays along its trajectory. Measurements made within the ecliptic plane during this part of the mission will be partly contemporaneous with out of the ecliptic particle measurements made aboard the Ulysses spacecraft, and interesting insights into the propagation and acceleration of solar cosmic rays in interplanetary space can resultingly be derived.

THE SLED II INSTRUMENT

Fig. 2 shows a schematic diagram of the SLED-II instrument.

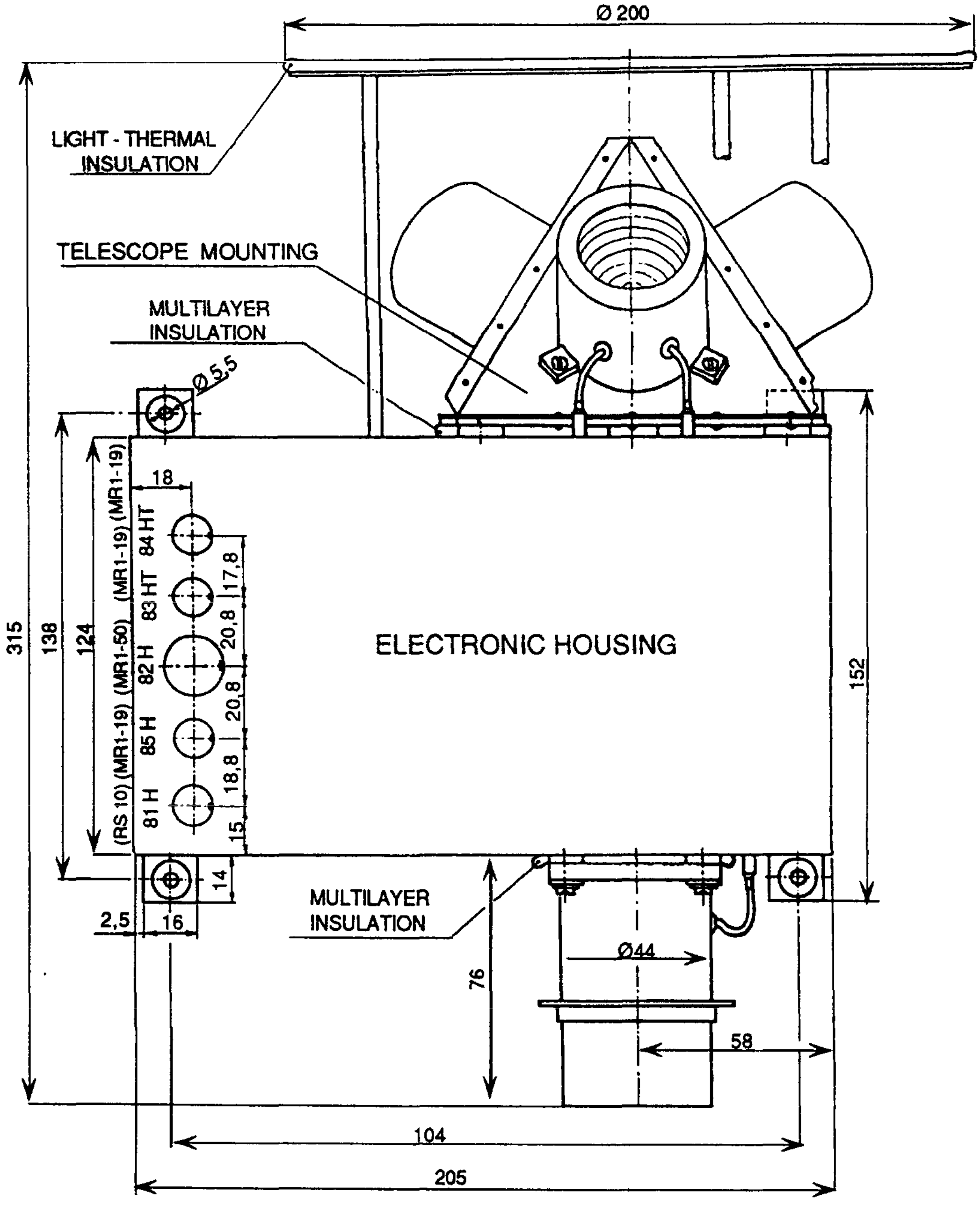

Fig. 2; Schematic diagram of the SLED-II instrument

Each ion telescope consists of an aperture followed by a detector mount housing two solid state detectors; a front detector of 150 µm thickness and area 50 mm^2, and a back (veto) detector of 300 µm thickness and area 100 mm^2. A broom magnet inserted in the aperture deflects incoming electrons < 500 keV, thus providing clean ion measurements in the range between approximately 20-500 keV. The electron telescope is similar to the ion telescope, except that the front detector thickness is 300 μm. However, instead of a broom magnet, a foil is used to prevent ions of below about 500 keV from reaching the front detector. The geometric factor of each telescope is 0.3 cm^2 ster and the field of view for each telescope is a cone with opening angle 30°.

The pulses registered in the detectors are transmitted to the instrument electronics which consist of three standard parts, namely analog electronics; digital electronics and a data processing unit equipped with an interface to the spacecraft. Each detector is coupled to an analog line consisting of one charge sensitive amplifier; one pulse amplifier and two discriminators. A 10 channel pulse height analyser is also provided to cover the energy range from approximately 20-500 keV. Two channels are assigned to energies > 200 keV. The design of the data processing unit is based on an NSC 800 microprocessor and a 16 kByte buffer memory is employed. The system features reconfigurable hardware memory management, as well as the capability to correct soft errors in the system memory after launch.

The SLED-II measurements are designed to provide intensities, energy spectra and anistropies (streaming directions) of ion and electron fluxes as a function of time and location. The total cycle of measurements, including five spectra, corresponds to approximately 1 kbit (one frame). The instrument has three modes of operation, with three corresponding data rates. These are designated as follows, "Monitoring Mode": 2 minutes/frame, 1.5 M bit/48 hours; "Nominal Cruise Mode": 1 minute/frame, 2.9 M bit/48 hours and "Orbit Mode": 10 seconds/frame, 17.3 M bit/48 hours. The latter mode will be used when the spacecraft is close to Mars.

CONCLUSION

The success of the first SLED instrument on the Phobos `Mission to Mars and its Moons in detecting populations of energetic particles in the approximate range 30-200 keV in the close neighbourhood of Mars, has prompted the flying on the forthcoming Mars-94 mission, of a detector with increased measurement capability, to investigate in depth the behaviour of these particles. Four π coverage for ions using four independent telescopes looking into the apices of a tetrahedron and 1 independent electron telescope looking in the anti-solar direction will be provided.

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