

## Mini-EUSO

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Mini-EUSO is part of the JEM-EUSO International Program (Joint Experiment Missions for Extreme Universe Space Observatory), a mission concept devoted to the observation and study from space of the cosmic rays at the highest energies (UHECRs, Ultra High Energy Cosmic Rays) above  $10^{19} \text{ eV}$ . The main scientific objectives, the instrumentation and the observational principle of JEM-EUSO have been described in detail in previous reports. Mini-EUSO, approved by the Russian Space Agency Roscosmos (under the name UV-Atmosphere) and by the Italian Space Agency, ASI, has been conceived to study and measure the UV emissions from Earth and to perform studies of atmospheric phenomena, observation of meteors, strange quark matter search and space debris tracking. It will map the Earth in the UV spectrum for the first time from space. The instrument is a compact telescope with dimensions  $(37 \times 37 \times 62) \text{ cm}^3$  and 30 kg weight. It consists of two main subsystem: Optics and Photo Detector Module (PDM). Mini-EUSO optics consists of two PMMA Fresnel lenses (25 cm diameter, one of them double sided) which focuses light onto the Focal Surface (FS) with a large field of view (44 deg). Mini-EUSO total FS observable area on Earth correspond to  $263 \times 263 \text{ km}^2$ . The FS consists of an array of 36 Hamamatsu 64 channels Multi-Anode Photomultipliers (MAPMT) divided into 9 Elementary Cells, for a total of 2304 pixels. The spatial resolution per pixel is 0.8 deg, or  $\simeq 5.5 \times 5.5 \text{ km}^2$ . The instrument is complemented with two ancillary cameras, one in the visible (400 - 780 nm) and the other in the near infrared (1500 - 1600 nm) range. An array of  $8 \times 8$  SiPMs (Silicon Photomultipliers by Hamamatsu) has been placed on top of the FS for R&D purposes.

Mini-EUSO has been successfully launched to the International Space Station (ISS) on August 22, 2019 by a Soyuz MS-14 spacecraft and placed in the Russian module Zvezda at the internal UV window (fig. 1 and fig. 2). It is in operation and taking data since October 2019. Astronauts Luca Parmitano and Oleg Skripochka have operated on the instrument in several successive observation sessions. Part (about one tenth) of the data has been so far transmitted to ground by telemetry, while the entire set of data available (about 25 TBytes stored in 50 USB sticks)) will be brought by Skripochka in April in his returning mission to Earth. First, preliminary results, have shown the good functioning of the instrument and its potentialities in fulfilling the scientific objectives. In particular, several ELVES (Emission of Light and Very low frequency perturbations due to Electromagnetic pulse Sources), a particular class of lightnings, and meteors have been observed, together with other atmospheric phenomena like the TLE's (Transient Luminous Events). Preliminary UV mapping of Earth has started and is in progress.

In the preparation of the mission and of the flight instrument, the LNF group has played a key role, through the Mechanical Design and Construction Service (SPCM), responsible of the design, test, prototyping and production of all the mechanical structures and containers and of the overall FS of the Engineering/Qualification and Flight Model of Mini-EUSO (as shown in fig.3). Engineering studies have been carried out, including 3D CAD design of the structure, finite element model calculations, vibration mode studies related to the launch vehicle parameters. First assembled prototypes of PDMs have been produced for testing purposes. An implementation of the design and production - switching from metallic to plastic materials - has been obtained and



Figure 1: *Launch of Soyuz MS-14.*



Figure 2: *Mini-EUSO in the ISS at the UV window.*

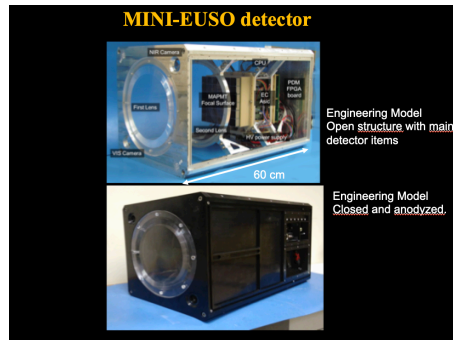


Figure 3: *Mini-EUSO Engineering/Qualification Model.*

carried out for the last versions produced with a 3D printer in service at SPCM LNF. Finally, part of the integration work has been carried out in Rome area in close collaboration with the Rome-Tor Vergata group). In particular, final vibration and thermo-vacuum tests have been performed outside to qualify the instrument according to space certifications required, and then approved, by Roscosmos-Energia Agencies. Data analysis has started just after receiving the first data by telemetry. In the references are listed the news appeared in the LNF, INFN and ASI web pages, related to the Mini-EUSO mission.

## References

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5. Science News, "Cosmic ray scope to look down", Science 16 August 2019 Vol 365 Issue 6454, p. 626
6. M. Casolino *et al.*, "Mini-EUSO experiment to study UV emission of terrestrial and astrophysical origin onboard of the International Space Station"; Proc. 36th International Cosmic Ray Conference - ICRC2019 - July 24th - August 1st, 2019 Madison, WI, U.S.A. <http://pos.sissa.it/>
7. JEM-EUSO Italian web site: <http://jem-euso.roma2.infn.it>