JEM-EUSO

A. Franceschi, A. Marini (Assoc.), T. Napolitano, M. Ricci (Resp. Naz.),
F. Ronga (Assoc.), B. Spataro (Assoc.)

JEM-EUSO (Joint experiment Missions for Extreme Universe Space Observatory), is 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 $10^{20}eV$. JEM-EUSO is a new type of observatory, based on a large UV telescope originally conceived to be placed on the International Space Station (ISS), which uses the whole Earth as a detector. The main driving idea is the observation of the fluorescence tracks (in the $330 - 400$ nm range) produced by the Extensive Air Showers (EAS) originated by UHE primaries which traverse the Earth's atmosphere at ultra-relativistic speed. The main scientific objectives, the instrument and the observational principle of JEM-EUSO have been described in detail in previous reports. Presently, an intermediate configuration based on a new mirror optics concept for a similar, re-scaled instrument to be placed in 2022 on the Russian segment of the ISS (KLYPVE, K-EUSO) is in the prototyping phase after approval by the the Russian Space Agencies Roscosmos and RSC Energia. In the longer term planning, a new conceptual design study (POEMMA, Probe Of Extreme Multi-Messenger Astrophysics), conducted by US Institutions and members of the JEM-EUSO Collaboration, has been selected in the study phase by NASA for a mission to observe both the fluorescence and the Cherenkov radiation from UHECRs to search also for cosmogenic tau neutrinos (CTNs) as well as Ultra-High Energy Neutrinos (UHEN) of other flavors.

In order to test the JEM-EUSO instrumental concept, different pathfinder experiments have been developed in the last years. The first, EUSO-Balloon managed by CNES, France - successfully flew on board a stratospheric balloon in August 2014 from Canada; a second, EUSO-TA on ground, is in operation since 2013 at the Telescope Array site in Utah. A second balloon flight (EUSO-SPB1) carried by a super pressure balloon developed by NASA, was launched in April 2017 from Wanaka, New Zealand. The flight was planned for an ultra-long duration (more than 30 days) but, due to a leak developed in the balloon, it terminated prematurely after 12 days of operation. Nevertheless, the data collected showed that the instrument performed well as expected; the analysis is in progress and preliminary results have been presented at international conferences and workshops. Another pathfinder, Mini-EUSO, approved by Roscosmos (under the name UV-Atmosphere) and by the Italian Space Agency, ASI, will be placed inside the ISS in 2019 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. All these pathfinders are based on the basic modular unit of the instrument, the Photo Detector Module (PDM) covered with 36 Hamamatsu Multi Anode Photo Multiplier Tubes (MAPMT), 64 pixel each. In the path towards the mission POEMMA, a new ultra-long duration super pressure balloon flight, EUSO-SPB2, has been approved by NASA for a launch in 2021-2022 from the same base of EUSO-SPB1 in Wanaka, New Zealand. The mission, with a duoble telescope instrument based on Schmidt mirror technology, has the main goal of observing both UHE CRs and neutrinos. The LNF JEM-EUSO group is responsible, in collaboration with the SPCM (Mechanical Design and Construction) Service) of the design, prototyping and production of the mechanical structures of the PDMs and of the study of the overall Focal Surface (FS) structure of the main

instrument. 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 and for EUSO-TA, EUSO-Balloon, Mini-EUSO and EUSO-SPB1. An implementation of the design and production - switching from metallic to plastic materials - has been obtained and carried out for the last versions produced with a 3D printer in service at SPCM LNF. The design of the container box (space qualified) and the system interfaces of Mini-EUSO have been produced for the Engineering Model and are in progress for the final Flight Model. Part of the integration work has been carried out in Rome area (collaboration between LNF and INFN Tor Vergata).

Members of the LNF group are involved in the JEM-EUSO Editor's Team of the Technical Reports and Design Reviews and in the JEM-EUSO Speaker's Bureau which manages and organizes the activities of the Collaboration related to publications and conferences. The group participates and contributes to the definition and assessment of the scientific objectives of the mission. In 2018, the activity has been mainly dedicated to:

- progress and development of the Mini-EUSO instrument, its science objectives, and mission definition. In particular, several phases of the test and integration of the Engineering Model of Mini-EUSO, shown in fig.1, have been carried out in the Frascati Laboratories;

- contributions to EUSO-SPB1 analysis and EUSO-TA operations;

- studies and assessment of space debris tracking and remediation;

- contributions to the definition and studies of science objectives of the POEMMA mission.

Scientific and technical contributions have been presented in several International Conferences and Workshops.

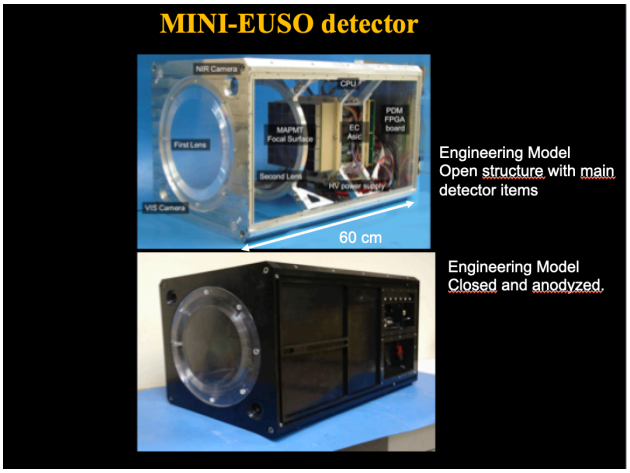

Figure 1: *Mini-EUSO Engineering/Qualification Model.*

References

1. A. Anzalone *et al.*, "Methods to Retrieve the Cloud-Top Height in theFrame of the JEM-EUSO Mission"; IEEE Transactions on Geoscience and Remote Sensing, **57**, 304 (2019).

2. G. Abdellaoui *et al.*, "EUSO-TA: First results from a ground-based EUSO telescope"; Astrop. Phys., **102**, 98 (2018).

3. G. Abdellaoui *et al.*, "First observations of speed of light tracks by a fluorescence detector looking down on the atmosphere"; Journal of instrumentation, **13**, P05023 (2018).

4. The JEM-EUSO Collaboration: 4 contributions to the 42nd COSPAR Assembly Conference, Pasadena, CA (USA), 14-22 July 2018; including M.Ricci, "The JEM-EUSO program to study Ultra-High Energy Cosmic Rays from Space." (E1.5-0066-18)

5. JEM-EUSO Italian web site: http://jem-euso.roma2.infn.it