JEM-EUSO-RD

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JEM-EUSO (Extreme Universe Space Observatory at the Japanese Experiment Module of the International Space Station), 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 to be placed on the International Space Station (ISS), which uses the whole Earth as a detector. It will observe, from an altitude of ~ 400 km, the fluorescence tracks produced at (330÷400) nm by 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, new, intermediate configurations for a similar instrument to be placed on the Russian segment of the ISS (KLYPVE, K-EUSO) – based on new mirror optics concept - are being studied and in the phase of agreements between the Russian Space Agency Roscosmos, the Japanese Space Agency JAXA and the European Space Agencies.
Meanwhile, different pathfinder experiments, to test the JEM-EUSO instrumental concept, have been developed, 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 at the Telescope Array site in Utah. A third 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 late 2017 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.
A new, long duration balloon flight (EUSO-SPB) carried by a super pressure balloon developed by NASA, is going to be launched in Spring 2017 from New Zealand to look for and measure EAS at the top of the Atmosphere (about 40 km altitude). 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.
The LNF JEM-EUSO group is responsible (in collaboration with the SPCM LNF 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 and for EUSO-TA, EUSO-Balloon, Mini-EUSO and EUSO-SPB. 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 2016, the activity has been mainly dedicated to

- the continuation and implementation of the engineering project of the FS structure according to different launch vehicle configurations;
- the progress and development of the Mini-EUSO instrument, its science

objectives, and mission definition;
- contributions to EUSO-Balloon analysis and EUSO-TA operations.

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

Recent publications

1. *Experimental Astronomy – Volume 40, Issue 1, November 2015 Special Issue on The JEM-EUSO Mission. A. Haungs, G. Medina-Tanco, A. Santangelo Editors. Papers included:*

   J.H. Adams Jr. et al (The JEM-EUSO Collaboration):

   - The JEM-EUSO mission: An introduction
   - The JEM-EUSO instrument
   - The atmospheric monitoring system of the JEM-EUSO instrument
   - The Infrared Camera onboard JEM-EUSO
   - Calibration aspects of the JEM-EUSO mission
   - JEM-EUSO observational technique and exposure
   - JEM-EUSO observation in cloudy conditions
   - Performances of JEM-EUSO: angular reconstruction
   - Performances of JEM–EUSO: energy and Xmax reconstruction
   - Ultra high energy photons and neutrinos with JEM-EUSO
   - Science of atmospheric phenomena with JEM-EUSO
   - JEM-EUSO: Meteor and nuclearite observations
   - The EUSO-Balloon pathfinder
   - Ground-based tests of JEM-EUSO components at the Telescope Array site, "EUSO-TA"
   - Space experiment TUS on board the Lomonosov satellite as pathfinder of JEM-EUSO

2. G. Abdellaoui et al.: "Cosmic Ray Oriented Performance Studies for the JEM-EUSO First Level Trigger" (*subm. to Nuclear Instruments and Methods A*)
3. G. Abdellaoui et al. :"Meteor Studies in the Framework of the JEM-EUSO Program", *http://dx.doi.org/10.1016/j.pss.2016.12.001 (Planetary and Space Science, in press)*
4. S. Mackovjak et al.: "Ultra-violet imaging of night time Earth from stratosphere by "EUSO-Balloon" – a pathfinder mission towards space-based ultra-high energy cosmic ray observation", *subm. to Astroparticle Physics*
5. T. Fujii et al.: "Detection of ultra-high energy cosmic ray showers with a single pixel fluorescence telescope", Astrop. Phys. 74 (2016) 64–72