IL NUOVO CIMENTO **41 C** (2018) 67
DOI 10.1393/ncc/i2018-18067-x

Colloquia: IFAE 2017

The EUSO mission to study UHECR from space: Status and perspectives

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received 21 April 2018

Summary. — The EUSO Collaboration has been studying a detector to be installed on the International Space Station which will observe ultra-high-energy cosmic rays (UHECR) from space for the first time. The observation of UHECR from space offers several advantages such as large field of view, uniform observation of both celestial hemispheres, uniform detector response. For these reasons, space-based observatories are complementary to the ground-based detectors. The EUSO Collaboration already built two pathfinders to test high-performance electronics and optical systems to meet the science requirements and the constraints (mass, power, hardness, ...) of space-borne detectors. Second-generation pathfinders, EUSO-SPB and Mini-EUSO, are currently under development. EUSO-SPB is a NASA Super Pressure Balloon payload scheduled to fly from New Zealand in Spring 2017 for a flight duration which may reach 100 days. The main scientific objective is the first observation and measurements of UHECR generated air showers by looking down from near space with a fluorescence detector. Mini-EUSO telescope (a joint ASI-Roscosmos mission) will be placed on the Russian Module of the International Space Station in 2019. Its science objectives are the study of UV emission of natural, astronomical and artificial origin and of atmospheric phenomena. In this contribution, we will also report on the status and perspectives of the future EUSO mission.

1. – The EUSO project

EUSO (Extreme Universe Space Observatory) is a new type of observatory which observes transient luminous phenomena occurring in the Earth's atmosphere looking at them from space [1]. EUSO aims to study the most energetic component of the cosmic rays spectrum, the so-called Extreme Energy Cosmic Rays (EECR). The telescope will observe fluorescence and Cherenkov Ultra Violet (UV) photons generated by Extensive Air Showers (EAS) created by EECR.

The idea of studying showers from space was suggested for the first time by John Linsley in the late 70s, since the observation from space has two advantages: the observed volume of atmosphere is far greater than that observable from the ground and it is possible to have full sky coverage.

The main objective of the EUSO is to study physics and astrophysics from $E > 5 \times 10^{19}$ eV, focusing at $E \sim 10^{20}$ eV and above, to:

- identificate EECR sources by high-statistics arrival direction analysis;
- measure the energy spectra of individual sources (spectral shape, flux, power);
- understand and constrain acceleration and emission mechanisms.

The instrument is planned to be attached to the International Space Station (ISS) for a 3 year long mission.

2. – The program

The EUSO Collaboration has developed several pathfinder missions to calibrate the detector response, test its performance in air and space, raise the Technological Readiness Level of some of the components and improve our knowledge of the various detectors.

- TA-EUSO: in 2014 a small telescope prototype was installed in the telescope array site in Utah (USA) to bring to maturity the technologies for EUSO. The telescope was composed by two Fresnel lenses of 1 meter of diameter and a Photo Detector Module (PDM) of 36 Multi-Anode PMT. This instrument is currently operational.
- EUSO-Balloon [2]: a similar prototype was launched from Timmins (CA) on a stratospherical balloon by the French Space Agency in 2014. This was mainly a technology demonstrator, but it allowed the Collaboration to perform trigger and background studies.
- EUSO-SPB: the EUSO-Balloon instrument was launche for a long-duration flight on a Super Pressure Balloon by NASA in April 2017. The main objectives of this mission were to do the first fluorescence observations of cosmic rays from above and to measure UV background light at night from space.
- Mini-EUSO [3]: a precursor on the ISS approved by Italian and Russian Space agencies. It will be launched in 2019 and it will bring one single EUSO PDM and two small Fresnel lenses (25 cm diameter) to ISS to perform UV background measurements. It is a key step for every mission in the UV range on ISS.
- K-EUSO foresees the installation of a bigger telescope on ISS in 2021–2022. This instrument will be equipped with Schmitd optics and could reach four times the exposure of the Pierre Auger Observatory.

REFERENCES

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