JEM-EUSO on ISS explores the origin of the highest energy particles in the Universe

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JEM-EUSO observational capabilities for different UHE primaries

A Guzmán[a] , A Santangelo[a], E Iwotschkin[a], T Mernik[a], J Bayer[a], K Shinozaki[a], F Fenu[b], M Bertaina[b], G Medina-Tanco[c], AV Olinto[d], L Wiencke[e]

[a]Insitute für Astronomie und Astrophysik, Univeristät Tübingen, Germany
[b]Dipartimento di Fisica, Universita' di Torino, Italy
[c]Insituto de Ciencias Nucleares, UNAM, México
[e]Department of Physics, Colorado School of Mines, USA
[d]Kavil Insitute for Cosmological Physics, University of Chicago, USA

for the JEM-EUSO Collaboration

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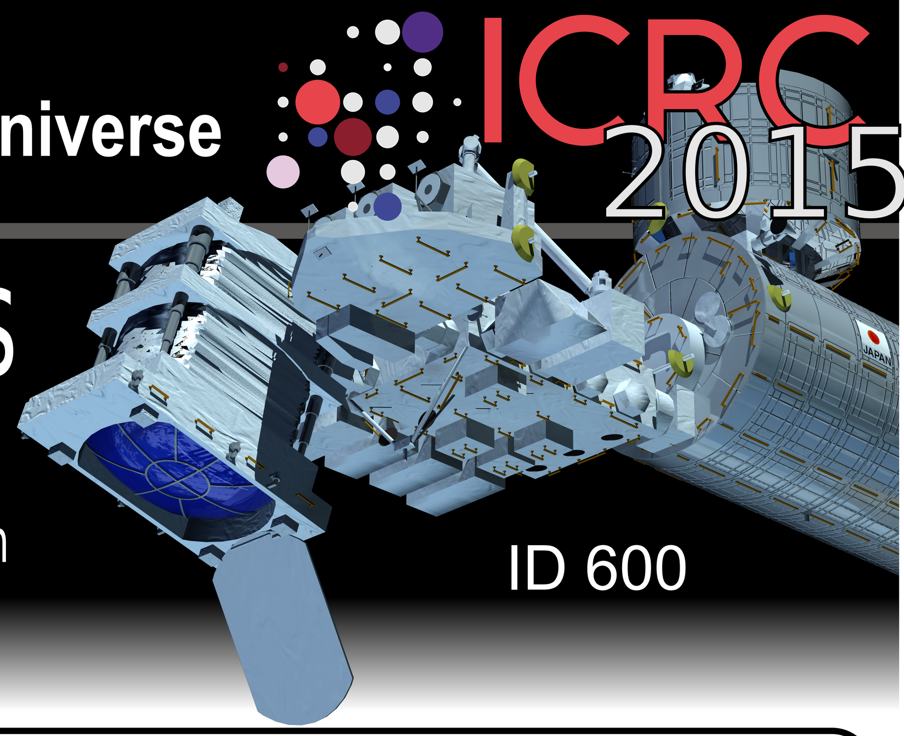

ABSTRACT

Cosmic rays with energies exceeding 1 EeV, usually defined as Ultra High Energy Cosmic Rays (UHECRs), allow the possibility to study physics at energies well beyond man made accelerators. State of the art UHECR detectors have reached unprecedented exposures and have pioneered the field of Extreme Energy Cosmic Rays (EECR), cosmic rays with energies exceeding 50 EeV.
The EECR flux is extremely small, of the order of 1 particle per square kilometer per century. The next generation of UHECR and EECR detectors are expected to increase the exposure by at least one order of magnitude. The JEM-EUSO mission, currently designed to be hosted onboard the JEM module of the ISS, consists of a ultra wide field of view UV-telescope orbiting the earth at an altitude of about 400 km. JEM-EUSO will look for fluorescent UV tracks produced by Extensive Air Showers (EAS) on the night side of the earth. According to the most recent studies, the JEM-EUSO mission, can be transported onto the ISS by using the SpaceX's Dragon spacecraft. In this work we present preliminary studies on the angular and energy reconstruction performances for different types of primaries (protons, iron nuclei and gamma rays). We compare our results with previously published results for the JEM-EUSO mission in a different configuration, and find a slight improvement.

The SpaceX Dragon configuration of the JEM-EUSO mission

The planned Extreme Universe Space Observatory on the Japanese Experiment Module (JEM-EUSO), is a downward looking telescope designed to detect the ultraviolet photons produced by extended air showers in the Earth's atmosphere . JEM-EUSO is equipped with three Fresnel lenses that focus the UV photons onto the focal surface (FS) detector. This FS detector is made of 137 individual photo-detector modules (PDMs), and each PDM is formed by 36 multi-anode photo-multiplier tubes (MAPMT). Each MAPMT has $8 \times 8 = 64$ pixels. An operation height of 400km, combined with JEM-EUSO's super wide angle field of view (FoV), will provide unprecedented exposure to (EECR). The expected value of the viewing angle is $\sim \pm 30°$.
Originally planned to be delivered to the ISS with the japanese HTV, the SpaceX Dragon space-craft is also studied as a suitable carrier. Although changing the delivery spacecraft does not affect the principle of operation, the specifics of the detector have to be fine-tuned to match the payload constrains of the spacecraft. Particularly the shape of and consequently the optics of the telescope differ from one option to the other. This modification is illustrated in Fig. 1. We can see that the dragon option offers an almost circular focal surface layout, whilst conserving the sensitive area.

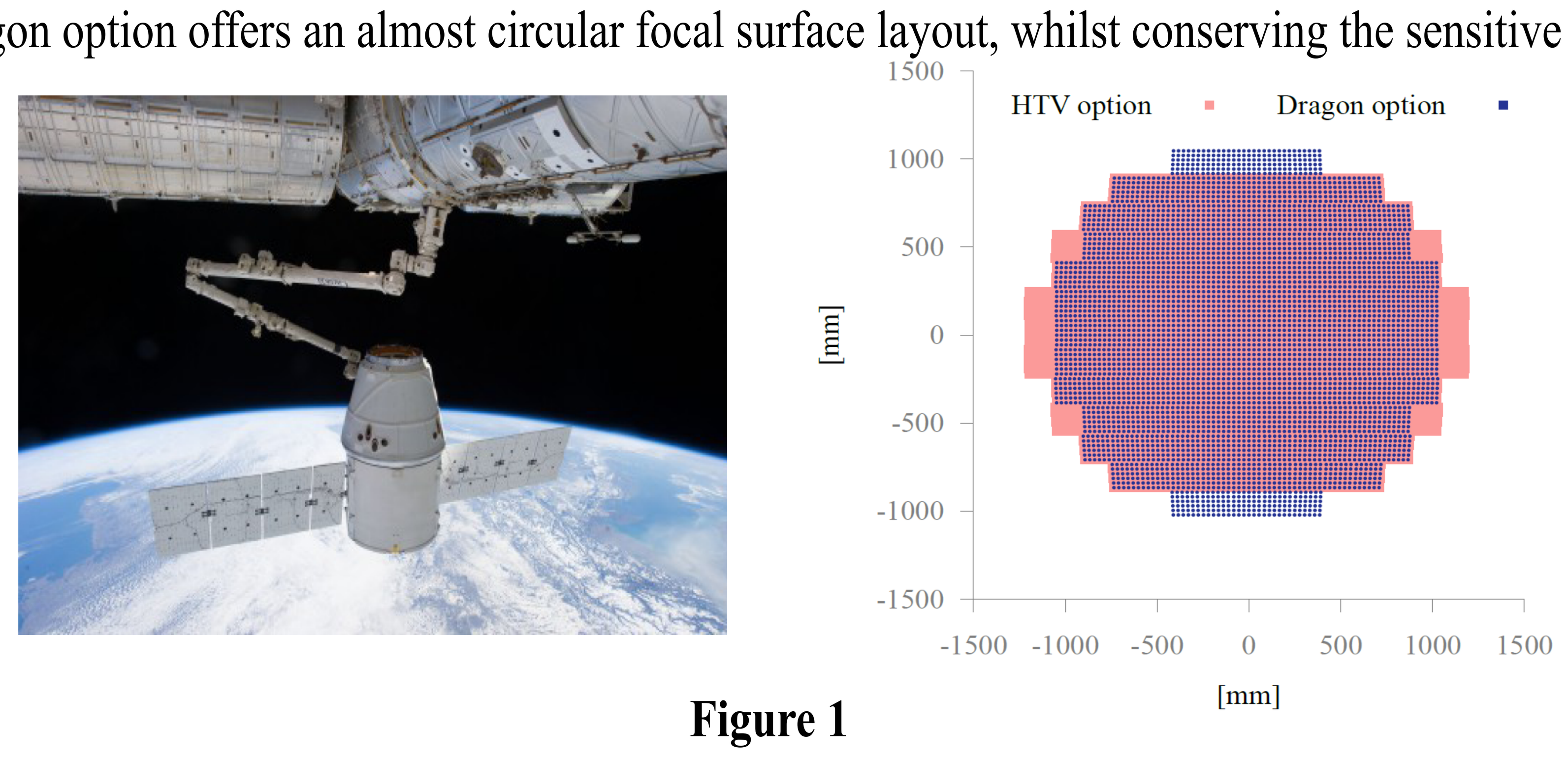

Figure 1

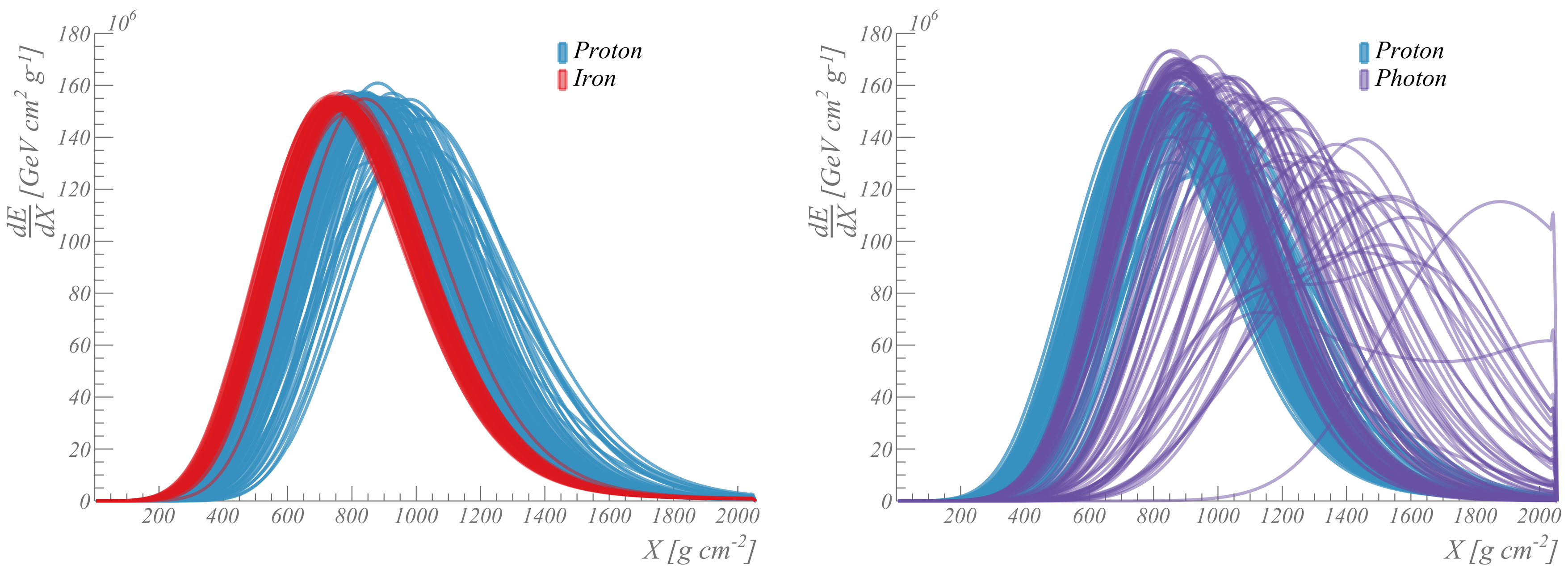

Figure 2

Simulation of different primaries within the JEM-EUSO mission

The chemical composition of UHECR and EECR is still not completely settled by current experiments. It is illustrative to show the behavior of the future JEM-EUSO mission with two representative hadronic primaries, protons and iron nuclei. For each primary, we simulated events with energies of 50EeV and 100EeV, and with zenith angles of $\Theta = 30°, 45°, 60°$ and $75°$. For each angle and energy combinations we simulated 1000 events using CONEX. Going into more "exotic" pimaries at these energies, we simulated a similar sample with photons as primaries with 100EeV with same zenith angles. An example of the simulated longitudinal profiles is shown in Fig. 2 . These shower simulations were then objected into EUSO Simulation and Analysis Software (ESAF) to simulate the detector's response.

Angular resolution

We proceeded to reconstruct the simulated showers using the ESAF. We added an update to the pattern recognition algorithm PWISE-R. The newer version performs a second iteration over the pixels activated, adding more pixels for the direction reconstruction module.
The error in the reconstructed arrival direction (γ) is taken as the angle between the simulated arrival direction vector Ω^{Simu} and its reconstructed counterpart Ω^{Reco}, i.e. $\gamma = acos(\Omega True \cdot \Omega Reco)$. We define the angular resolution as the value where the cumulative distribution of the reconstruction's error reaches 68%.

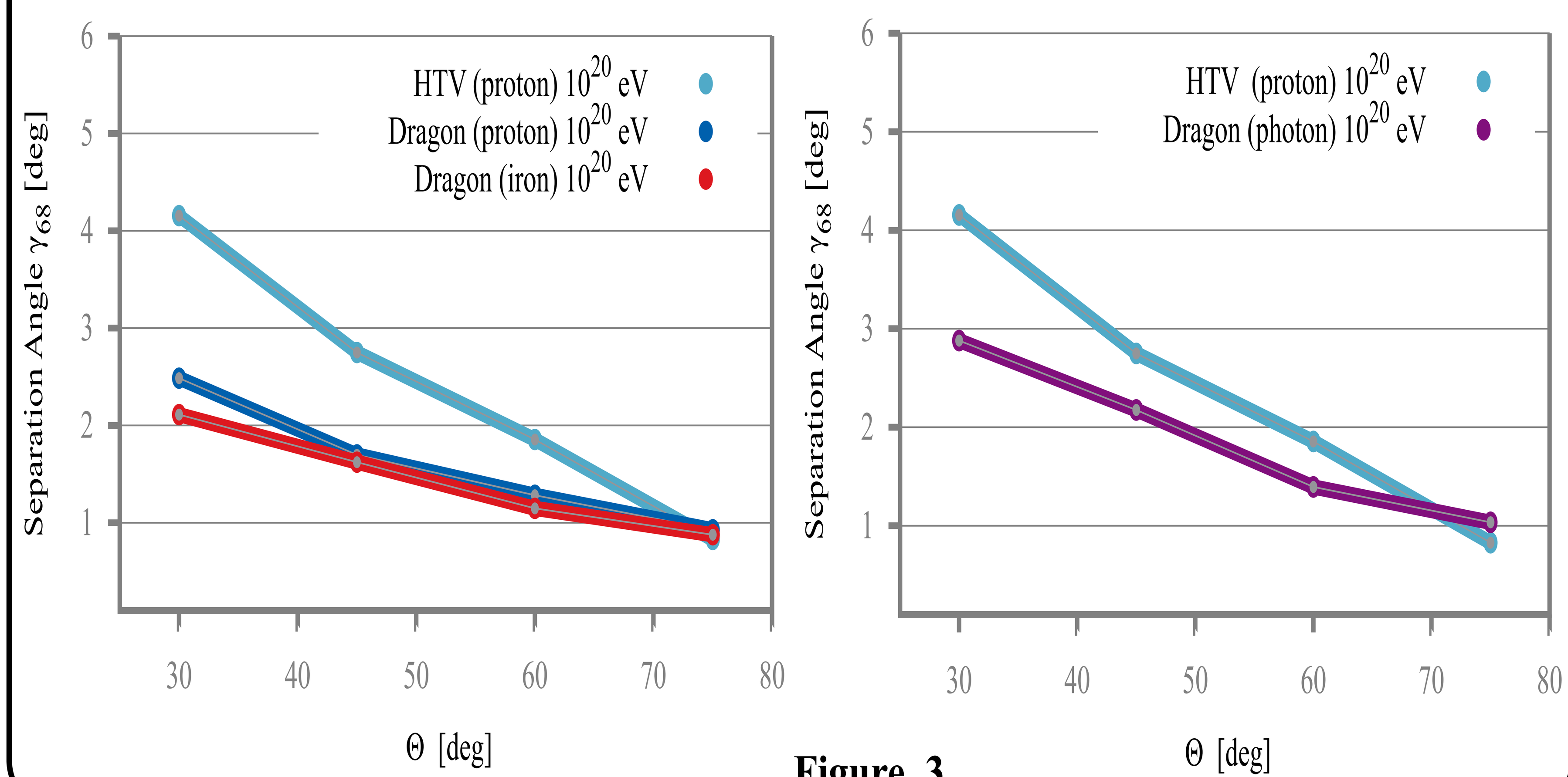

Figure 3

Energy Reconstruction

The longitudinal profile reconstruction available inside ESAF has only been optimized for parametrized proton showers. Nevertheless, we conducted a first blind test on our set of hybrid-simulated EAS applying the reconstruction module "as it is". We define the error in the energy reconstruction as $\Delta E = (E^{Reco} - E^{Simu}) / E^{Simu}$, where E^{Simu} and E^{Reco} are the simulated and reconstructed energies respectively.

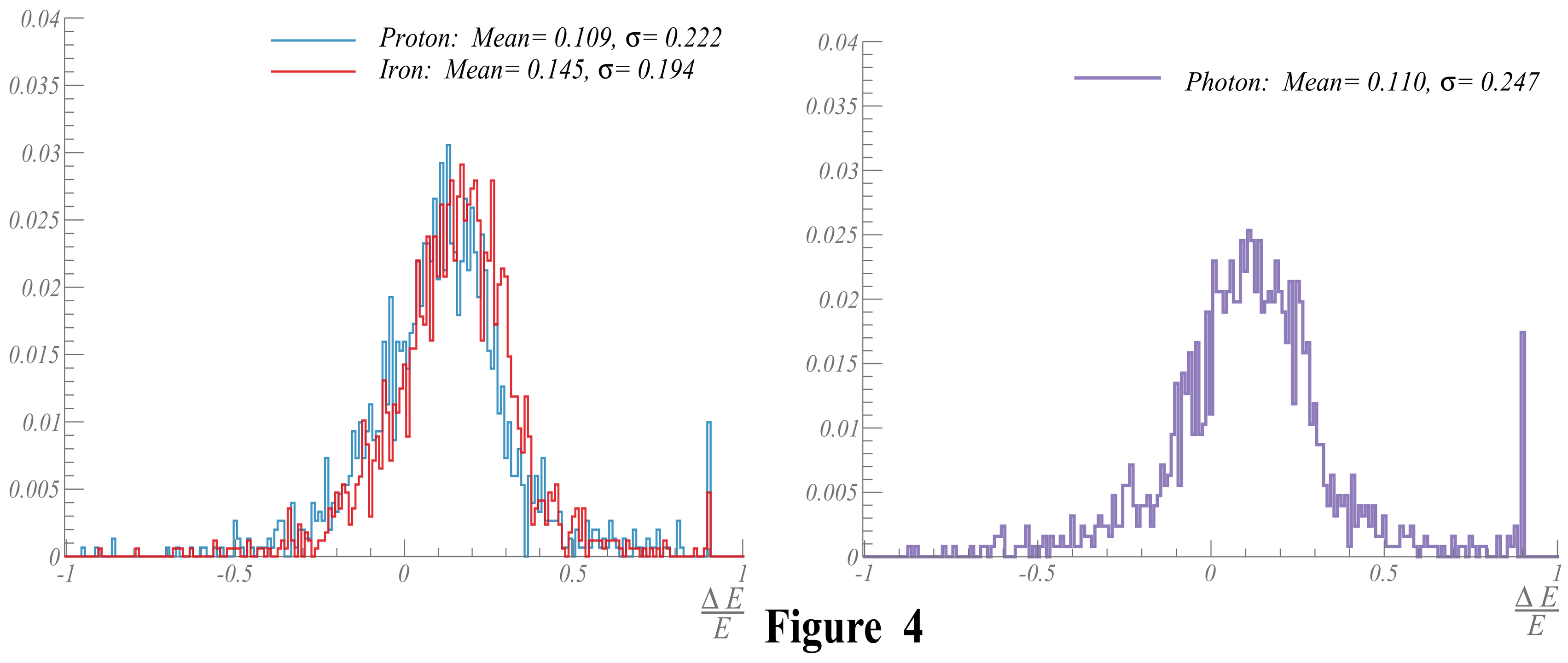

Figure 4

JEM-EUSO Collaboration 16 Countries, 93 Institutes, 355 People

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