JEM-EUSO experiment for extreme energy cosmic rays observation

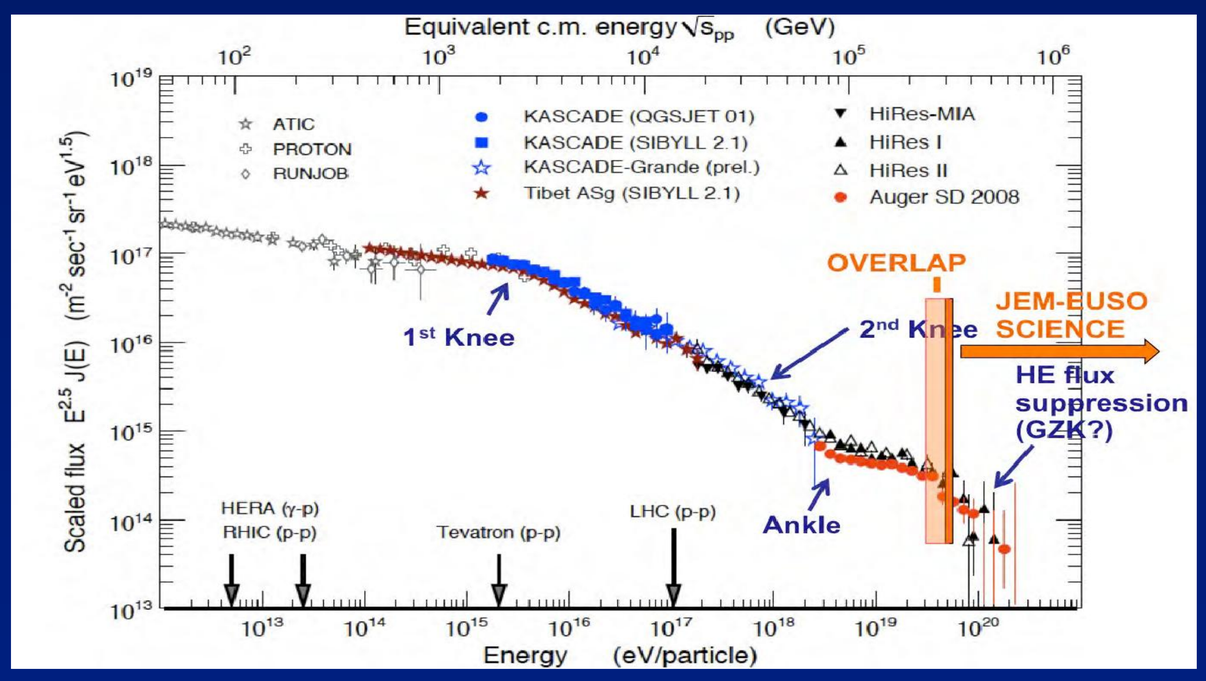
B.Pastirčák, K.Kudela and P.Bobík for the JEM-EUSO collaboration
INSTITUTE OF EXPERIMENTAL PHYSICS, SAS, Košice

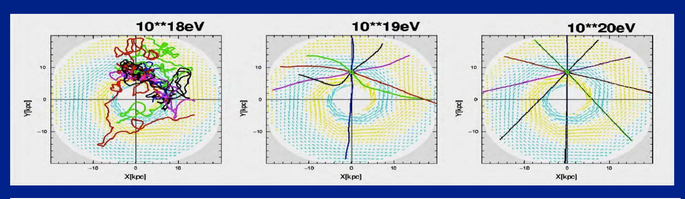
EXTREME UNIVERSE RESEARCH

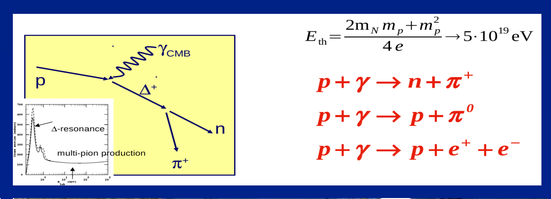
The astrophysical origin of the extreme energy cosmic rays (EECRs) and the physical mechanism of their acceleration to very high energies are of great interest. The highest observed cosmics rays energy is about **3×10^{20} eV** - exceeds 10^8 times CERN LHC energy scale – is above so called **GZK cuttof**, which is due to interactions of cosmic rays with the cosmic microwave background. The registration of EECRs at the earth implies that the sources are up to several tens Mpc far. Possible EECRs sources are supernovas, pulsars, gamma ray bursts, active galactic nuclei and recent collisions of radiogalaxies. But most of these candidates are incapable of accelerating particles beyond 10^{20} eV by any known acceleration mechanism.

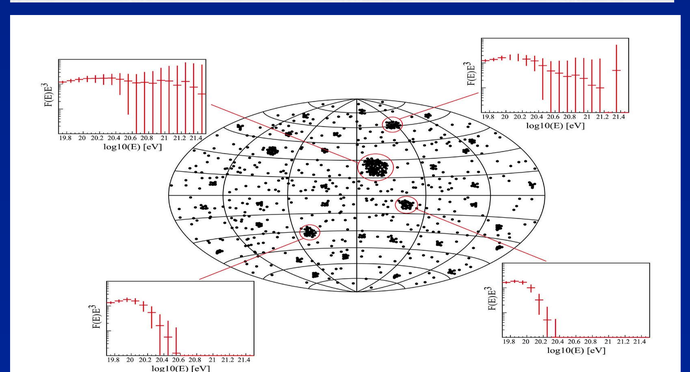
Low energy charged particles are bent by magnetic field in intergalactic and galactic space. The directional information of their origin is lost. The highest energy particles are barely bent, so retain the information of the direction to the origin.

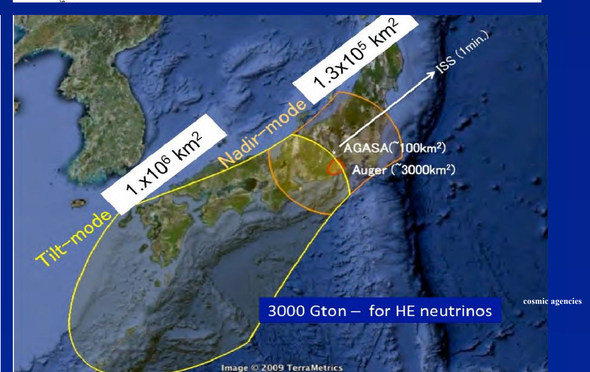
Very large area for observation is necessary to observe the rare EECRs events. Ground based observatories have nearly reached the maximum extent possible on earth. Space observatory makes a giant leap in the area size observed. JEM-EUSO mission explores the origin EECRs and explores the limits of the fundamental physics, through the observations of their arrival directions and energies.









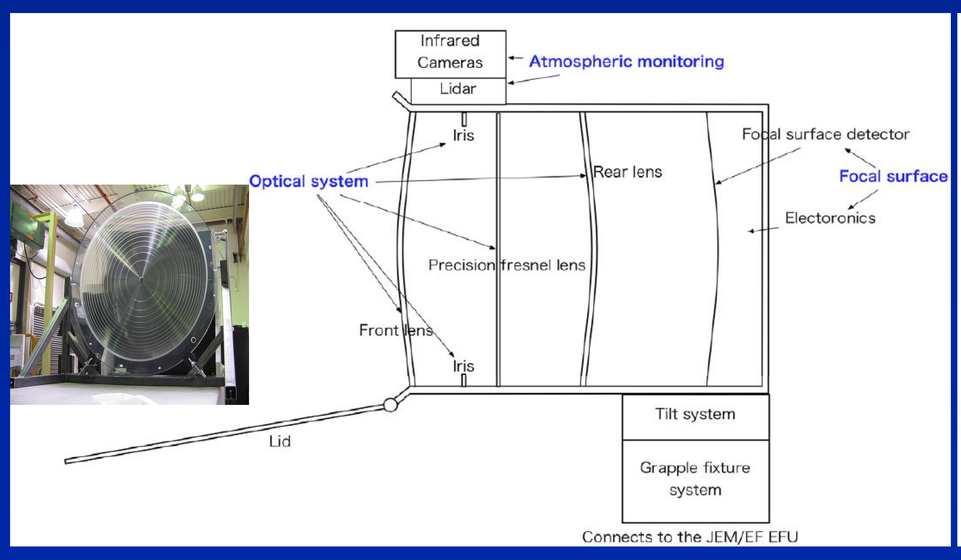


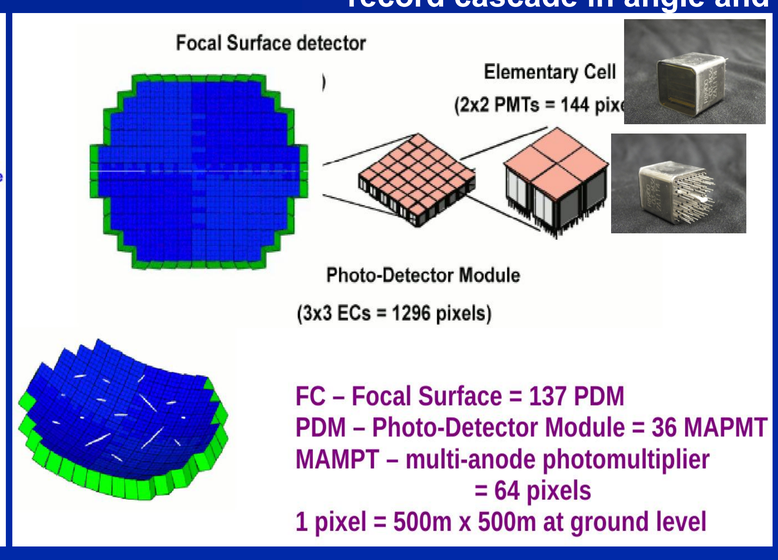
JEM-EUSO EXPERIMENT

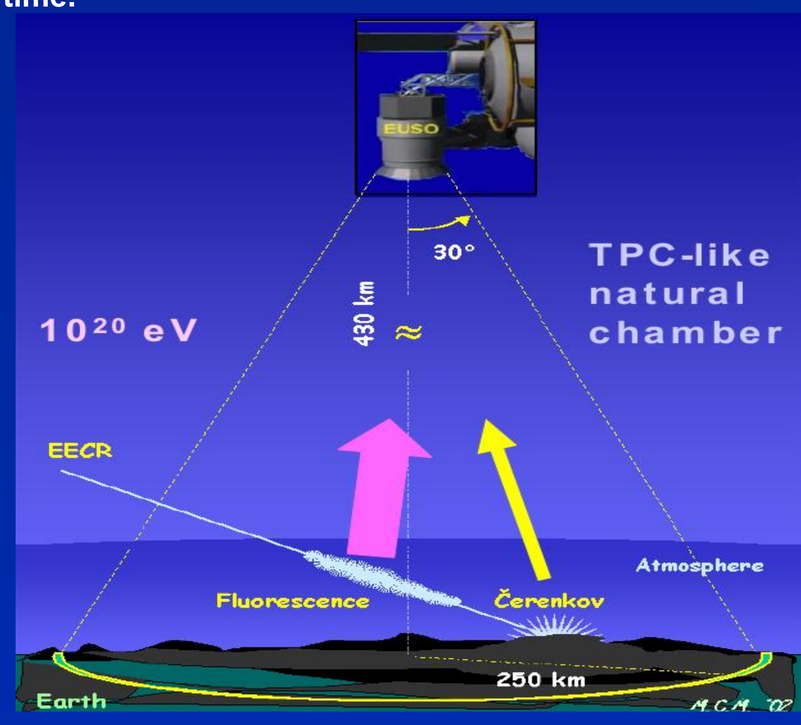
is common project of cosmic agencies JAXA, NASA, ESA, Roskosmos and 13 collaborating countries (77 institutions, over 250 researchers). The leading country is Japan, which provides the basic infrastructure including a vehicle HII-B, a spaceship HTV and the position for detector emplacement onboard the ISS Japanese Experimental Module Kibo. Minimum 3 years of operation starting from January 2017.

JEM-EUSO would measure the energy spectra of cosmic rays up to 10^{21} eV and would search for direction to their sources. It would observe extensive air showers (EAS) generated in the atmosphere by high energy cosmic ray primary particle. By observing from space the fluorescence and Cherenkov light emitted by EAS, the species, energy and direction of the primary could be well determined. Due to altitude of 400 km the instantaneous aperture of the telescope will exceed significantly the aperture of the largest ground EECRs detector Auger.

Technically JEM-EUSO is a large telescope with a diameter 2.5 m with fast UV camera. Camera takes 400000 frames/s. It defines the basic time unit of detector operation (GTU). Telescope on Focal Surface consists of more than 300000 pixels. It implies 500mx500m resolution at the ground. These allow to record cascade in angle and time.







OUR CONTRIBUTION

In Slovakia the Institute of Experimental Physics is participating in JEM-EUSO experiment preparation. We are responsible for several tasks. The main are:

1) **The estimation of the UV background on the night side of the Earth**

Sources of the backgound are reflections from sky (Moon, stars, planets), man made lights, lightnings, airglow, aurora, meteorites.

2) **The determination of the JEM-EUSO operational effiiciency**

fraction of time when monitoring UV compared to full time on orbit. Above mentioned UV background sources together with ISS operation schedule had to be taken into account in the model of JEM-EUSO operational efficiency

3) **The fake trigger event simulations and analysis**

The goal of the trigger system is to detect the occurrence of scientifically valuable signal among very huge background noise detected by JEM-EUSO. The UV background registered by JEM-EUSO is randomly distributed. We study if these random processes produce fake pattern, which could be mistakenly interpreted as EECRs events. We are simulating huge amount of measurements on PDM with only detector noise. To distinguish between such simulated fake events and real ECCRSs events and find the probabillity of registration fake event we are applying and developing pattern recognition methods.

$I_{Allowed}$ [ph/(m² ns sr)]	$I_{SUN} > 109.18°$	I_{MOON} only [%	Cities only [%	I_{SUN} + I_{MOON} [%]	I_{SUN} + I_{BG} + I_{MOON} [%	I_{SUN} + I_{BG} + I_{MOON} + Cities [%]
1		50.00	90.14	17.83	0.00	0.00
10		50.11	90.14	17.85	0.00	0.00
100		51.14	90.18	18.14	0.00	0.00
300		53.45	90.18	18.72	0.00	0.00
500		55.92	90.26	19.25	0.00	0.00
1000	34.84	62.06	90.26	20.41	19.25	17.46
1500		**68.08**	**91.06**	**21.43**	**20.41**	**18.51**
5000		89.73	95.97	26.73	26.07	23.61
10000		97.85	98.81	32.69	32.20	29.15
15000		99.99	100.00	34.83	34.80	31.55
30000		100.00	100.00	34.84	34.84	31.58

Level		Rate of signals/triggers at PDM level	Rate of signals/triggers at FS level
1st level trigger (PDM)	Photon trigger	~9.2×10^8 Hz	~1.4×10^{11} Hz
	Counting trigger	~7.1×10^5 Hz	~1.1×10^8 Hz
	Persistency trigger	~7 Hz	~10^3 Hz
2nd level trigger (PDM cluster)		~6.7×10^{-4} Hz	~0.1 Hz
Expected rate of cosmic ray events		~6.7×10^{-6} Hz	~10^{-3} Hz