JEM-EUSO - the highest energy cosmic rays balloon tests, Mini-EUSO at ISS, further plans

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Joint Experiment Missions - Extreme Universe Space Observatory

- Poland in JEM-EUSO since 2008
- New method of observation Extensive Air Showers induced by Cosmic Rays of the highest energy: measurements from space
- Polish hardware contribution: HVPS subsystem
- Polish PI: Jacek Szabelski PhD
- 16 Countries, 84 Organizations, 306 Members

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Cosmic Rays physics issues



We need higher statistic

JEM-EUSO

Observation principle



Detection of UHECR induced showers through the fluorescence light generated in the atmosphere EUSO wavelenght range: 290nm -400 nm



Figure: UV fluorescence spectrum (N_2)

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JEM-EUSO

EUSO detector

Photodetector module

- 36 Multi-Anode Photomultiplier Tubes (MAPMTs)
- Each MAPMT contais 64 anodes gives in total 2304 pixels
- Detector is working in single photon countig mode, returns number of photo-electrons (p-e) every 2.5µs from each of 2304 pixels
- Powered by HVPS designed and produced in Łódź





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HVPS

Designed and produced in Łódź

- high efficiency
- low power consumption
- ultra fast HV switches dedicated to reduced MAPMT efficiency in case of very bright signals result: MAPMT dynamics 0 1E6 p-e/ $2.5\mu s$





EUSO Balloon

24/25 August 2014, Timmins, Canada







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JEM-EUSO

EUSO – SPB

Extreme Universe Space Observatory – Super Pressure Balloon

- Start on April 2017 r. from Wanaka Airport, New Zealand
- 12 days of flight at 33 km altitiude



Source: www.nasa.gov



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EUSO – SPB2

Scientific objectives:

- measure, for the first time, EAS Cherenkov light from high altitude
- measure, for the first time, the evolution of nearly horizontal EAS developing at high altitude
- characterize the background for upwardgoing showers
- EUSO-SPB2 will serve as a pathfinder for the more ambitious space-based measurements by the Probe Of Extreme Multi-Messenger Astrophysics (POEMMA), selected by NASA for an in-depth probe mission concept study in preparation for the next decade



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EUSO-TA

- Ground based detector located in front of the Telescope Array (TA) Fluorescence detector in Black Rock Mesa, Utah, USA
- In operation since February 2015
- Detector is triggered by the fluorescence detectors of TA
- It is used to test the EUSO technology and study its response to cosmic rays and artificial sources
- Up to now 5 observation campaigns have been performed for a total of 48 observation nights





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Mini – EUSO

- Will be placed inside the ISS in the Russian Zvezda module
- Launch planned for July 2019
- Studying a variety of atmospheric events such as transient luminous events (TLEs) and meteors
- Searching for strange quark matter and bioluminescece
- Pathfinder for future JEM-EUSO missions



Source: Advances in Space Research, 2018, 62.10: 2954-2965

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K-EUSO



Source: PoS (2017): 412

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POEMMA



UHECR stereo observation mode

Neutrino stereo observation mode

arXiv:1708.07599 (2017)

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Timeline of EUSO experiments

- EUSO-TA 2013 –
- EUSO Balloon 2014
- TUS 2016
- EUSO-SPB 2017
- Mini-EUSO 2019
- EUSO-SPB2 2020 2022
- K-EUSO 2023+
- POEMMA 2028+



Summarize

- Our group is well recognized in the JEM-EUSO Collaboration
- We provide hardware: HVPS subsystems for MAPMTs
- We participate in tests, shifts, data analysis and simulations
- The 25th International JEM-EUSO Collaboration Meeting will be held in Łódź on the 10-14th June 2019