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Status of the TUS space experiment preparation

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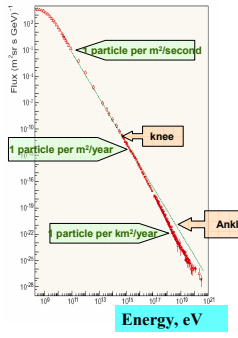
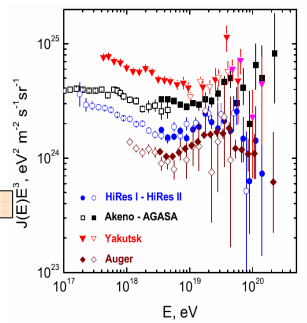
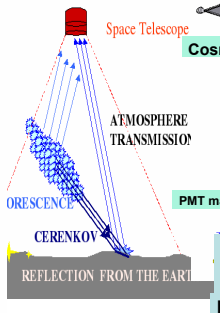
The TUS space project for investigation of Ultra High Energy Cosmic Rays (UHECR) by the measurement of Extensive Atmospheric Shower fluorescent radiation is in the construction stage. The main goal of the TUS mission is to search for cosmic ray particles beyond GZK energy limit, E=50 EeV. In comparison to ground based detectors TUS has an advantage of the all sky observation of primary particle arrival directions. The TUS experience of UHECR study from space will be important for future space detectors like the next JEM-EUSO mission for which the TUS space detector could be considered as a "pathfinder". UV sensor of the TUS detector was operated on board the Russian "Universitetsky-Tatiana" satellite. The JEM-EUSO UV sensor will be tested during the TUS data taking for atmospheric transient luminous events measurements by pinhole camera at the TUS apparatus. The technological TUS prototype is produced and their tests are in progress. The flight TUS detector has to be produced in 2010-2011. The mission is planned for operation at the end of 2011 at the dedicated "Mikhail Lomonosov" satellite.

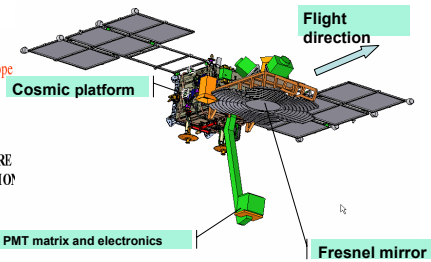
The TUS project task is the UHECR study. The optical (fluorescent and Cherenkov) radiation of Extensive Air Showers (EAS) generated by UHECR particles will be detected at the night side of the Earth atmosphere from the space platform at heights 400-500 km. It will make possible to measure the UHECR event **spectrum, composition and angular distribution at E > 5*10^{19} eV. There are two main parts of this detector: a modular Fresnel mirror and a matrix of PMTs with a corresponding DAQ electronics in its focal plane as a photoreceiver**

Ultra High Energy Cosmic Rays (UHECRs)





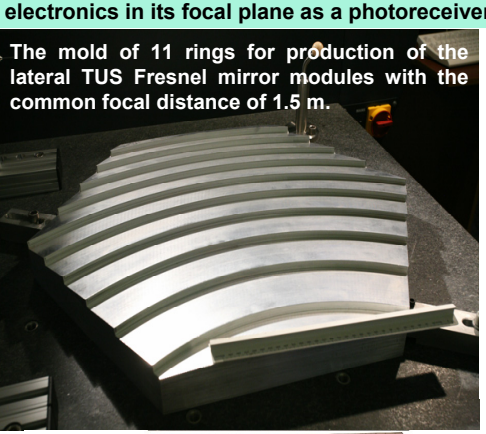




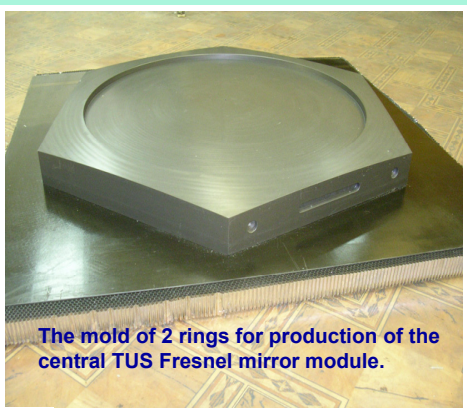
TUS detector is the Small Space Apparatus.

Mass < 60 kg. Power 65 W. Data rate 200 Mbytes/day, 1 EAS event *~80Kbytes*
FOV ±4,5 degree. Number of pixels 16x16 PMTs. Pixel:10 mrad (5,5x5,5 km). Mirror area 1,8 m^2. Focal distance 1,5 m

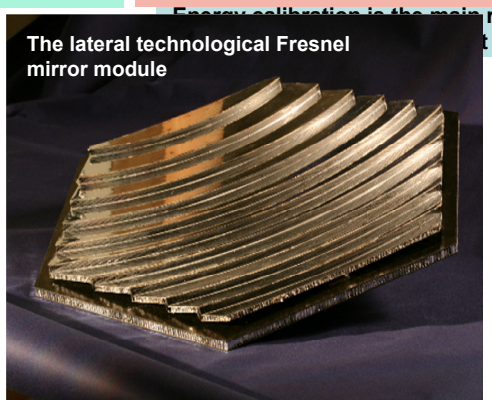
TUS Fresnel mirror production and tests



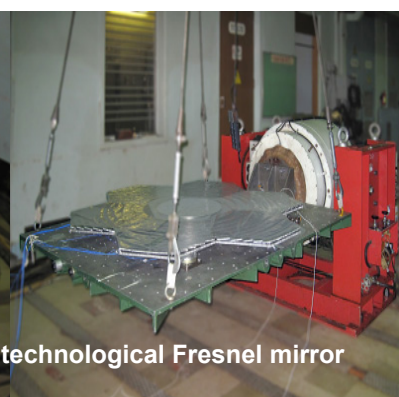
The mold of 11 rings for production of the lateral TUS Fresnel mirror modules with the common focal distance of 1.5 m.



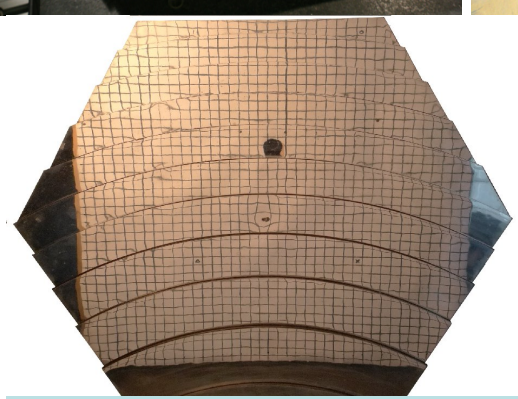
The mold of 2 rings for production of the central TUS Fresnel mirror module.



The lateral technological Fresnel mirror module

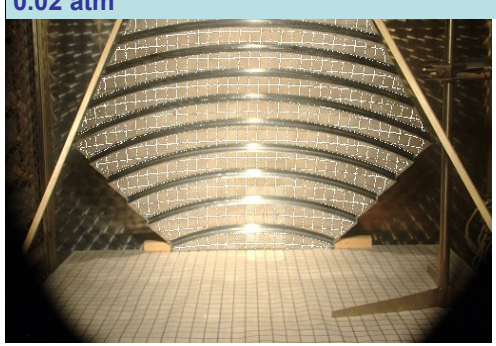


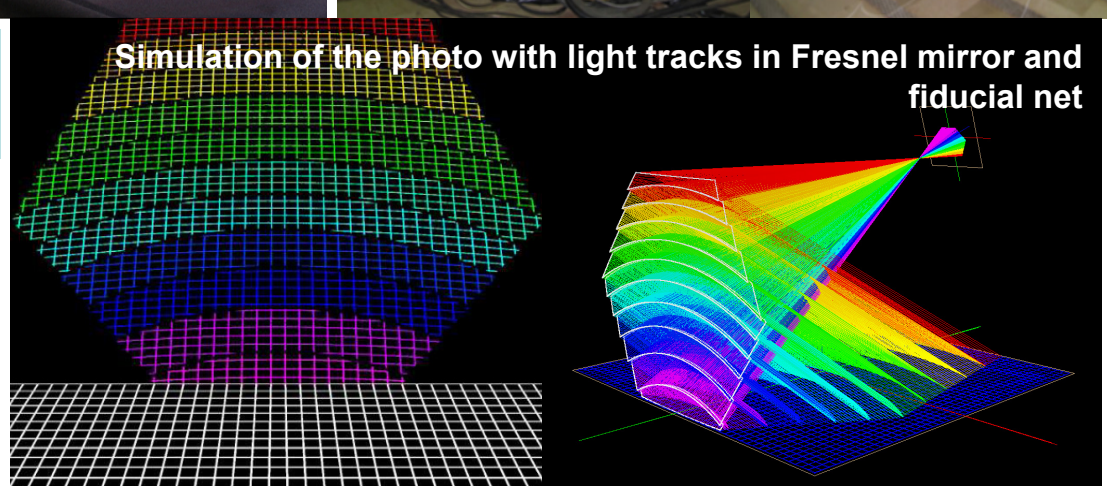
Space qualification test of the technological Fresnel mirror



Fiducial net reflection at the first mirror prototype

Fresnel mirror module and fiducial net reflection inside of thermovacuum camera at tests: T ≈ ±80°C and P = 1 – 0.02 atm

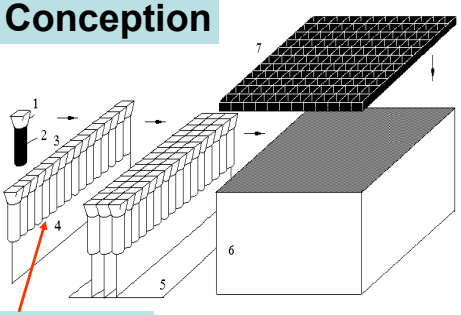




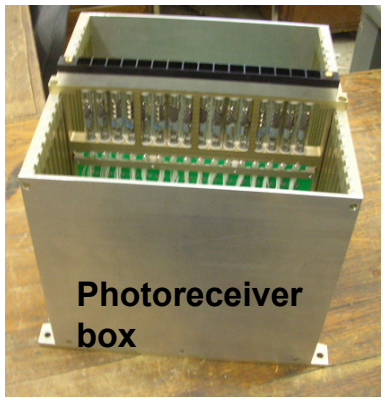
Simulation of the photo with light tracks in Fresnel mirror and fiducial net

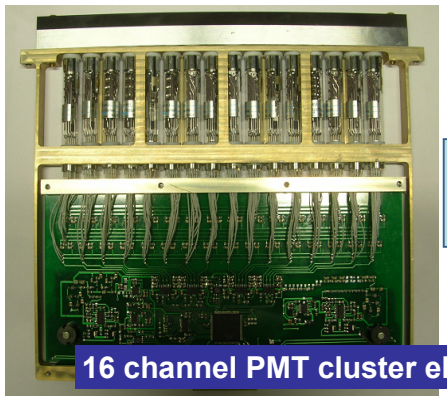
TUS photoreceiver and electonics production and tests

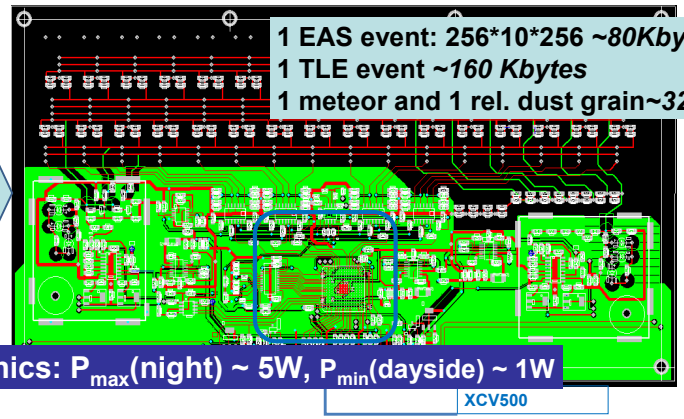
Conception



16 channel PMT cluster







1 EAS event: 256*10*256 ~*80Kbytes*
1 TLE event ~*160 Kbytes*
1 meteor and 1 rel. dust grain~*320 Kbytes*

16 channel PMT cluster electronics: P_{max}(night) ~ 5W, P_{min}(dayside) ~ 1W

XCV500

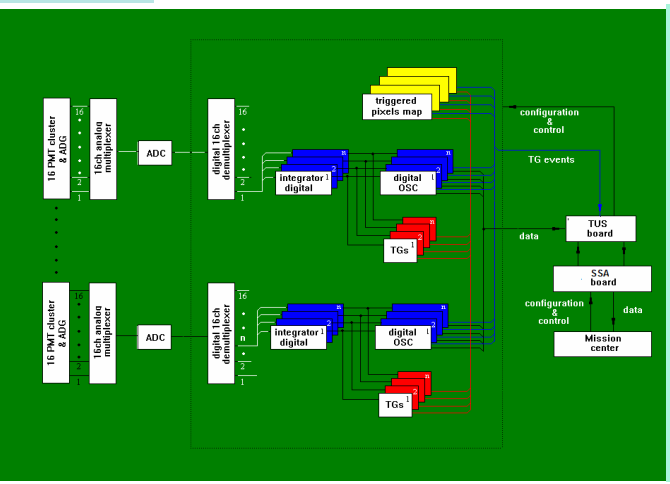


Photo detector and electronics consists of 256 pixels with the time resolution 0,8 μs and the spatial resolution 5.5x5.5 km. The digital integrators allow to use the same photo detector for study different phenomena in the atmosphere in wide time interval: ~100 μs (EAS) and 1 ms – 1 s (transient luminous events). That principle was tested during 2 years of "Universitetsky-Tatiana" mission.

Specification of TUS Pinhole Camera

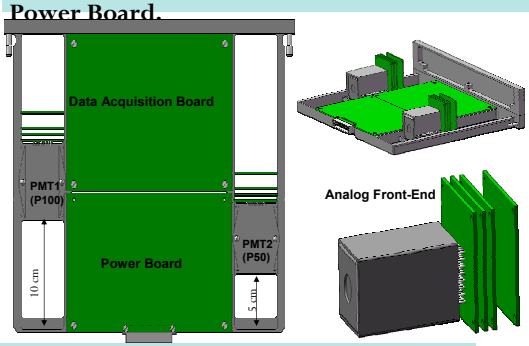
- TUS Pinhole camera consists of two telescopes by the focal length(FL).
  - P100 – FL:100mm, FOV: 72.4 x 72.4 km²
  - P50 – FL: 50 mm, FOV: 144.8 x 144.8 km²

  TUS will cover only .
- Pinhole camera is readout by two 64ch MAPMTs that is used for MTEL.
- Pinhole Size = Pixel size = 2mm.
- The event information -100 kbyte/event
  - Number of pixel : 64 ch x 2 PMTs
  - Dynamic range : 10bit
  - Duration time : 512ms
  - Sampling time : 10us ~ 0.512ms
  - Number of sample : 625
  - 64ch x 2 x 10bit x 625 = 100 kbyte/event
- The two pinhole cameras information – 30 Mbyte/day
  - TLE trigger will operate 1 event/min.
  - Average event number is 20 event/orbit, 15 orbits/day
  - 100kbyte x 20 x 15 = 30Mbyte/day
  - This is well inside of information volume available for

Design of TUS Pinhole camera

Power Consumption : ~ 5 Watt max.

The readout electronics consists of 3 parts ; Analog Front-End, Data Acquisition Board, Power Board.



The JEM-EUSO UV sensor will be tested during the TUS data taking for atmospheric transient luminous events measurements by pinhole camera

Conclusion:

The TUS detector production is at the conclusive phase. The technological prototype of the 7-module Fresnel mirror is produced and tested according to space qualification program. The flight TUS prototype production is in progress. A set of the program packages for TUS are producing including the event simulation with expected optical parameters, programs for on board data processing and off-line physical analysis. A special attention is given to measurements of the Fresnel mirror system for correct evaluation systematic uncertainties in data. The TUS mission is planned for operation at the end of 2011 at the dedicated "Mikhail Lomonosov" satellite.