33-я Всероссийская конференция по космическим лучам
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Simulation for TUS experiment

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FOR THE TUS COLLABORATION .

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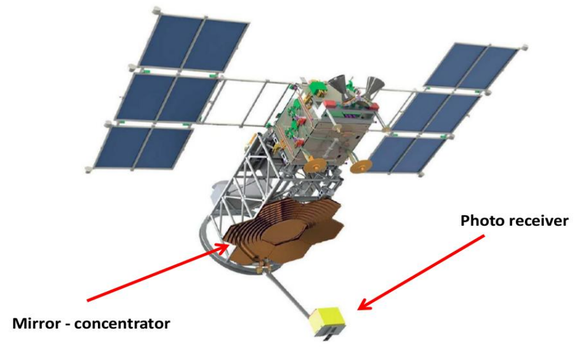
The main problems in UHECR:

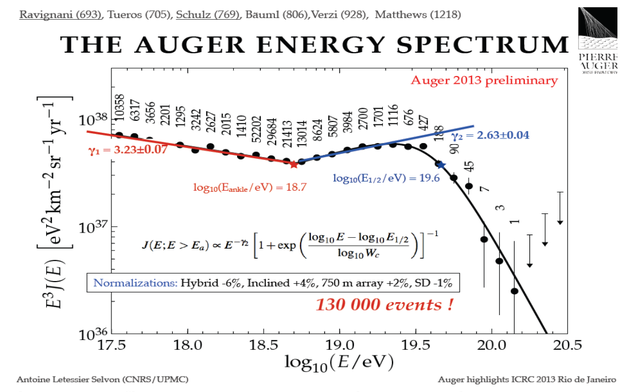
- **mass composition at 1 × 10^{18} – 1 × 10^{20} eV and origin of cutoff at E ~ 5 × 10^{19} eV (GZK cutoff ?)**
- **DETECTION OF UHE GZK NEUTRINOS.**
- **search for the UHECR sources.**

Detector TUS on-board Lomonosov satellite



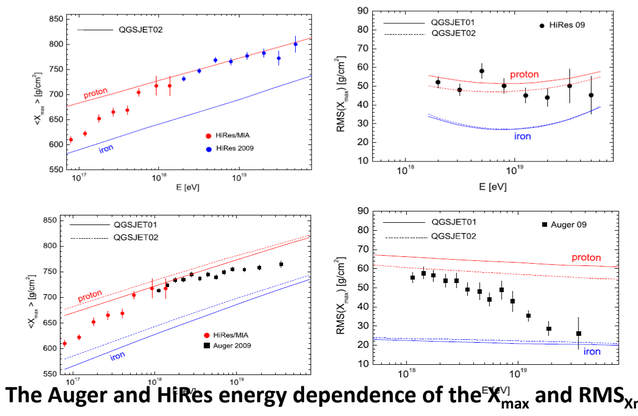
The TUS detector at the "Mikhail Lomonosov" satellite

Motivation



The UHECR flux measurements at the Auger detector presented at ICRC-2013.

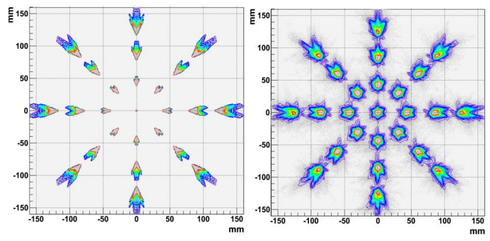
CRISIS 2009: MASS COMPOSITION



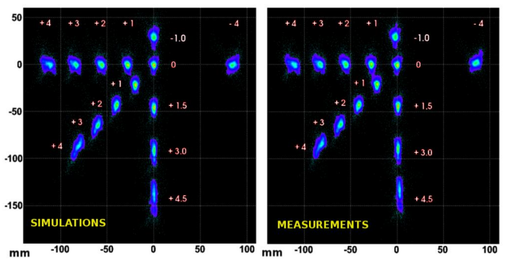
The Auger and HiRes energy dependence of the $X^{[EV]}_{max}$ and RMS_{Xmax} measurements

TUS optics measurement and simulation

The Fresnel mirror for TUS

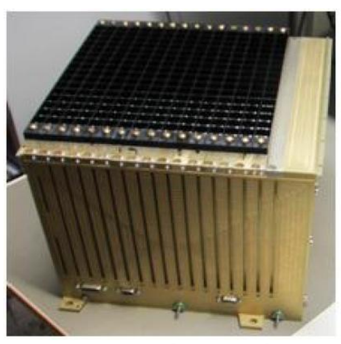


The PSF angular dependence of the Fresnel mirror (θ = 0°, 1.5°, 3.0°, 4.5°). Right panel: mirror 3D-model, Left panel: "ideal" mirror.

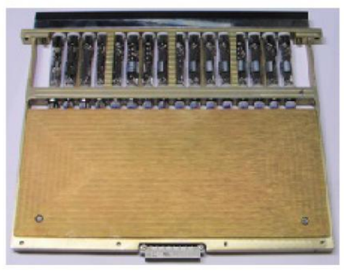


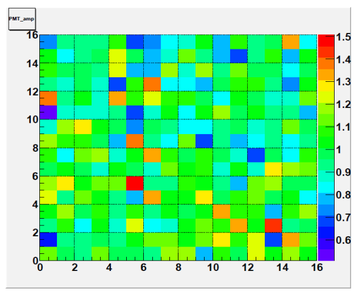
Spot point-by-point diagrams for lateral module Θ - angle between beam direction and the optical axis is indicated in white labels.

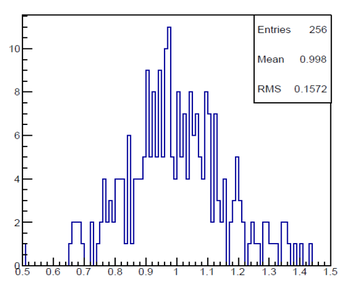
Photo detector measurement and simulation

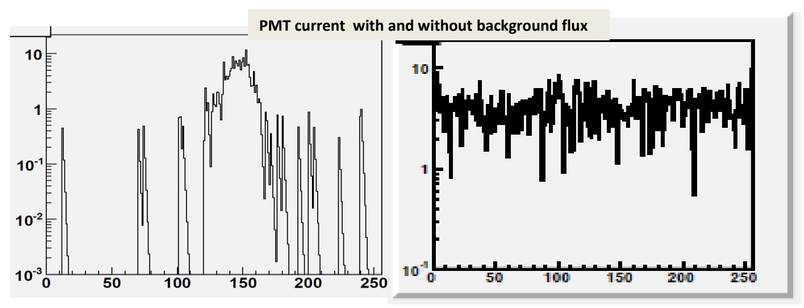


TUS photo detector is 16x16 PMTs



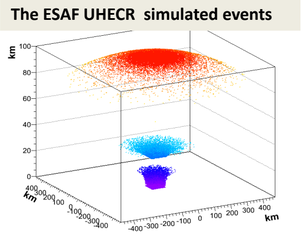




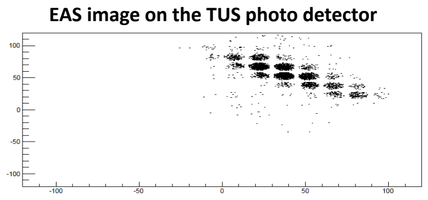


Events simulation

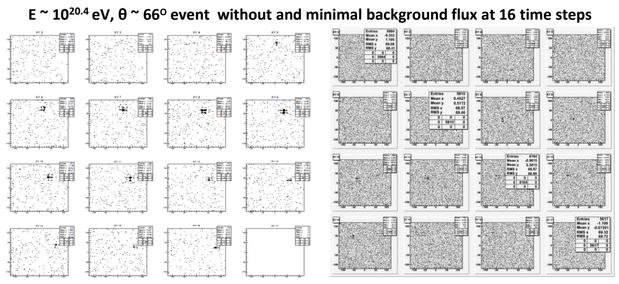
The ESAF UHECR simulated events



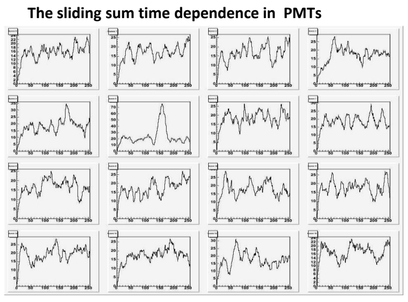
EAS image on the TUS photo detector



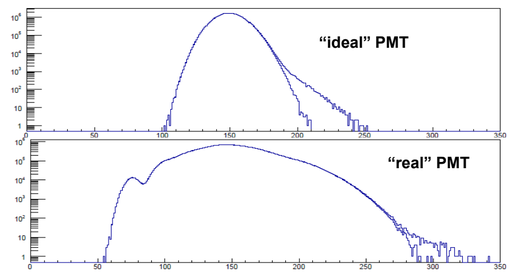
E ~ $10^{20.4}$ eV, θ ~ 66° event without and minimal background flux at 16 time steps



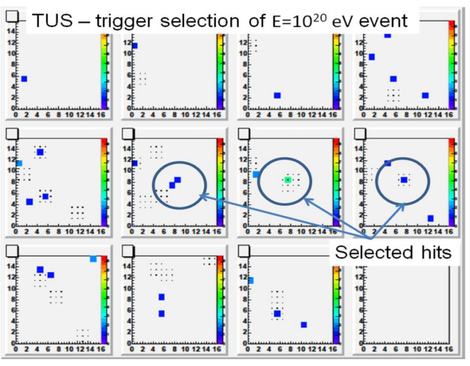
The sliding sum time dependence in PMTs



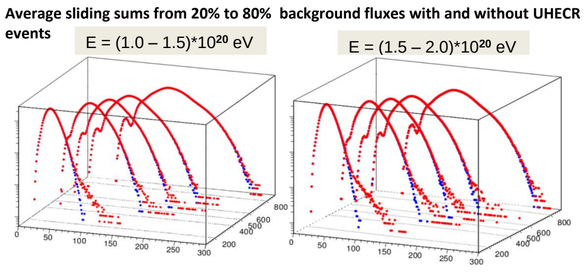
The sliding sum distribution in PMT clusters at I =0.8*I_o background flux for "ideal" and "real" PMTs



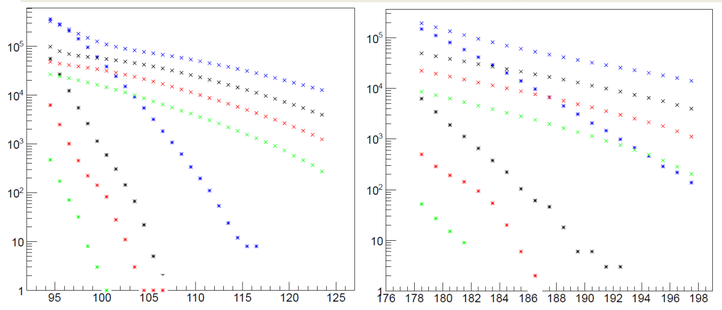
TUS trigger simulaion



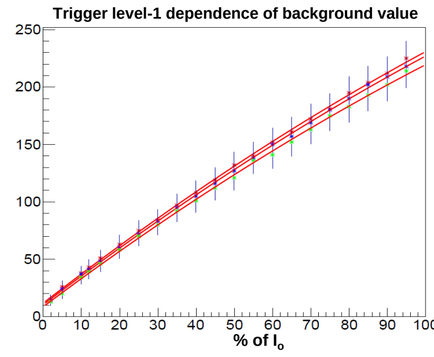
Average sliding sums from 20% to 80% background fluxes with and without UHECR events



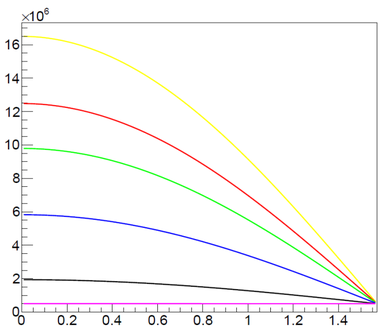
The TUS trigger rate at 40%(left) or 80%(right) background flux with and without UHECR events in (1.0 -1.5)*10^{20} eV energy range

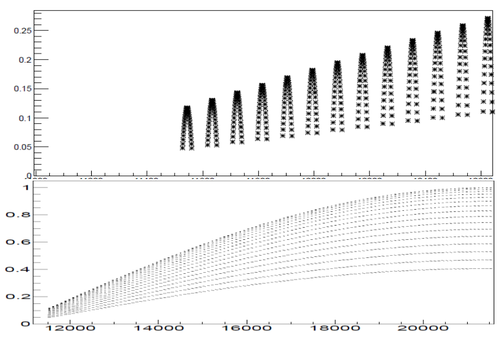


Trigger level-1 dependence of background value

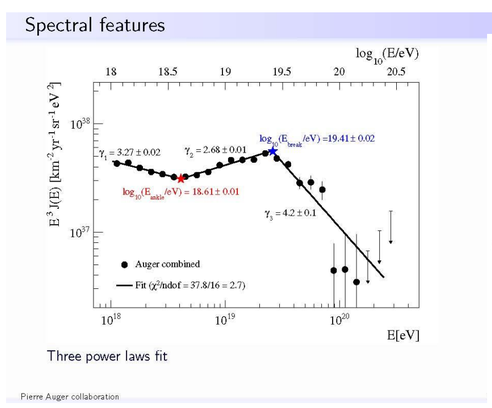


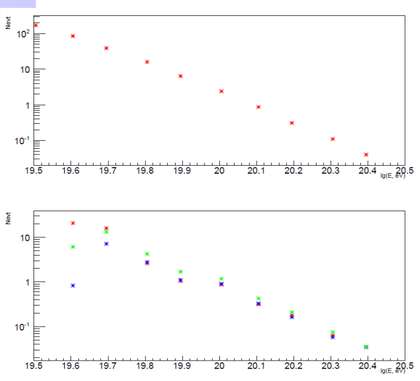
Expected statistics





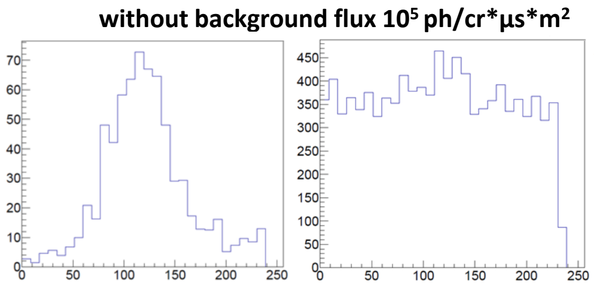
Expected TUS statistics for 5 years





Event reconstruction

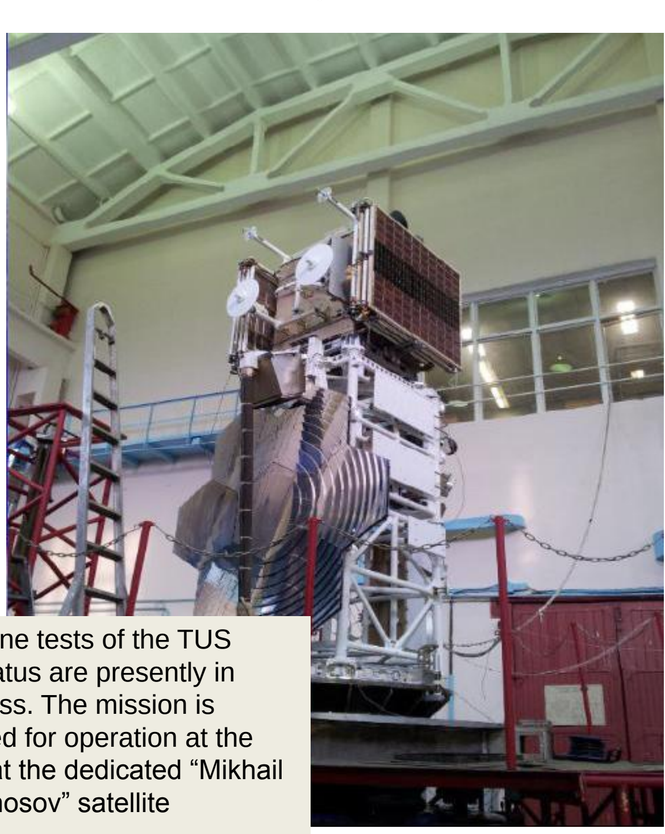
The UHECR E ~ $10^{20.4}$ eV, θ ~ 66° event with and without background flux 10^5 ph/cr*μs*m^2



Conclusion

The flight TUS copy was produced in 2012, assembled at the satellite and preflight tests were fulfilled in 2013. Combine tests of the TUS apparatus are presently in progress. The mission is planned for operation at the end of 2015 at the dedicated "Mikhail Lomonosov" satellite . TUS has been designed to operate for more than 3 years orbiting around the Earth every 90 minutes at altitude of 400-600 km and to take data in the most uncertain region **$E_o \geq 10^{20}$** eV.

TUSSIM program package was developed to simulate the TUS detector performance including the Fresnel mirror optical parameters, the photo detector and the FE and trigger electronics. Trigger efficiency is crucially dependent on the background level that is changed from ~0.2*10^6 to ~15*10^6 ph/(m²*s*sr) at moonless and full moon nights respectively. The preliminary TUS statistics is evaluated after 5 years of data collection from 500 km solar-sinchronized orbit taking into account the background light intensity change during the space flight.



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