The SPHERE Project

Antarctic Balloon-Borne Measurements Of Cosmic Rays Spectrum In Energy Range 1-100EeV

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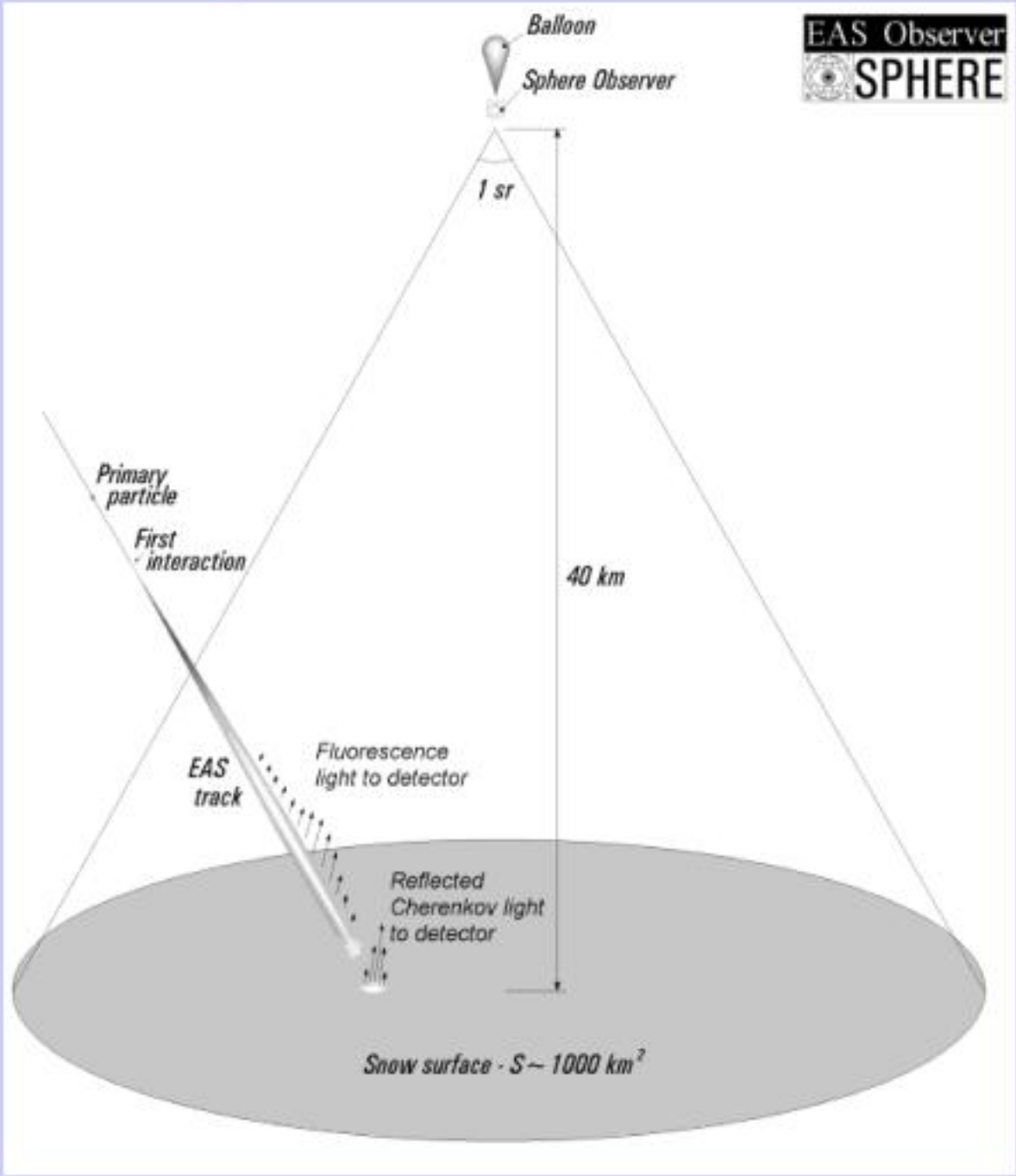
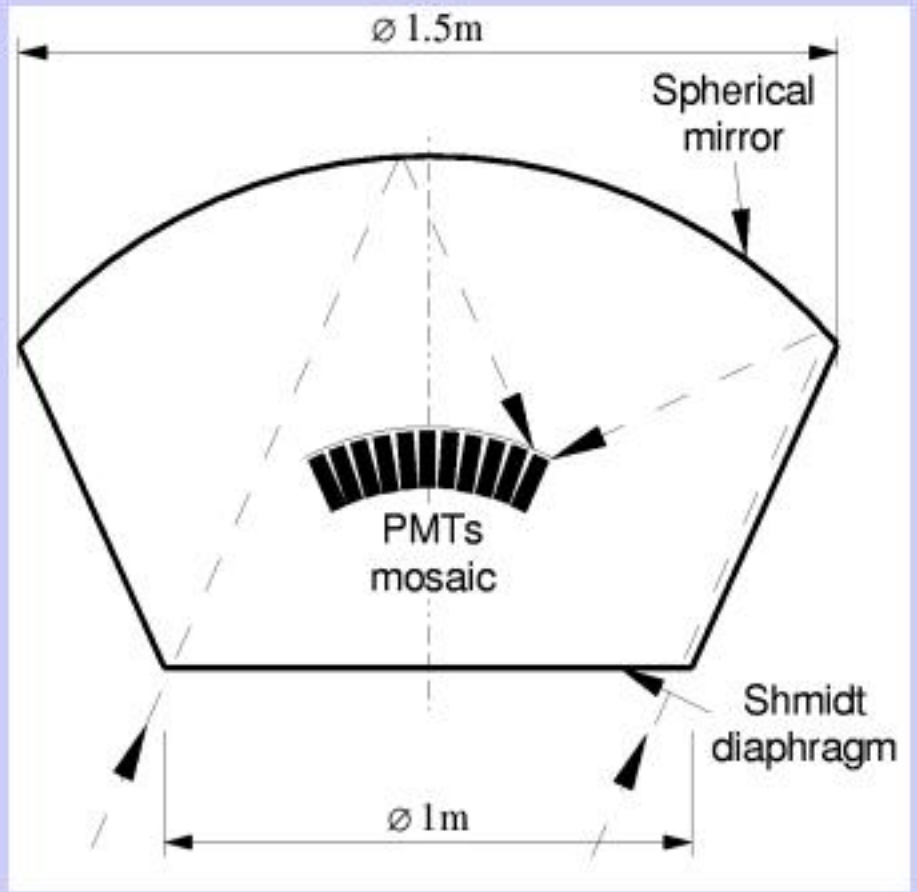
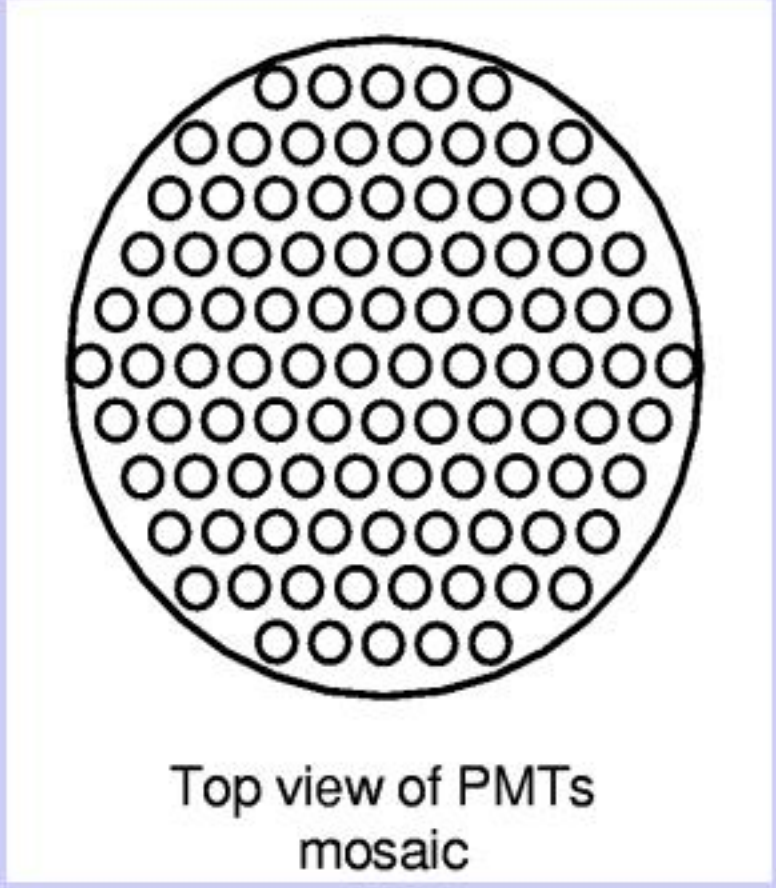
The SPHERE Project



Experiment configuration of long time antarctic flight.

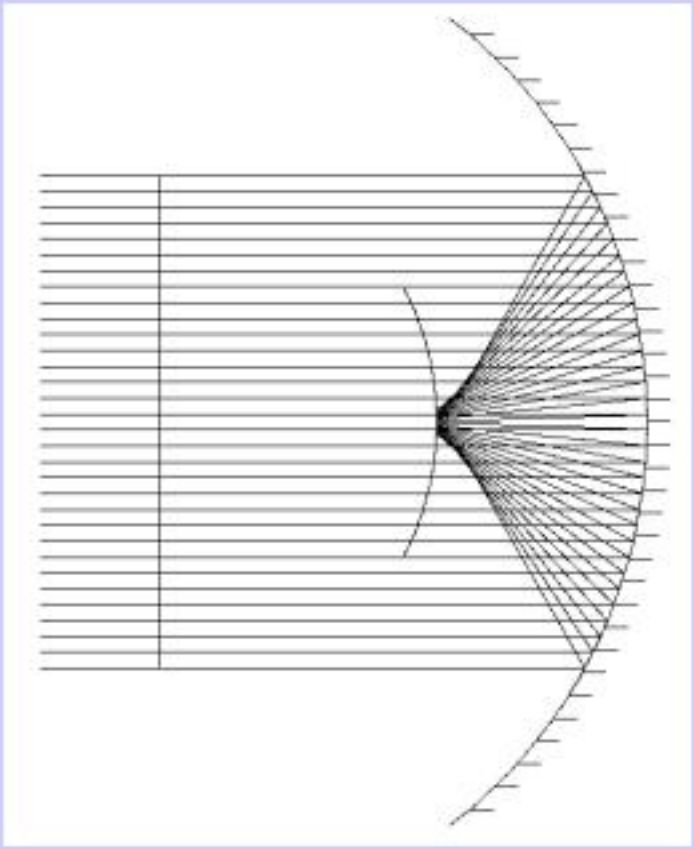




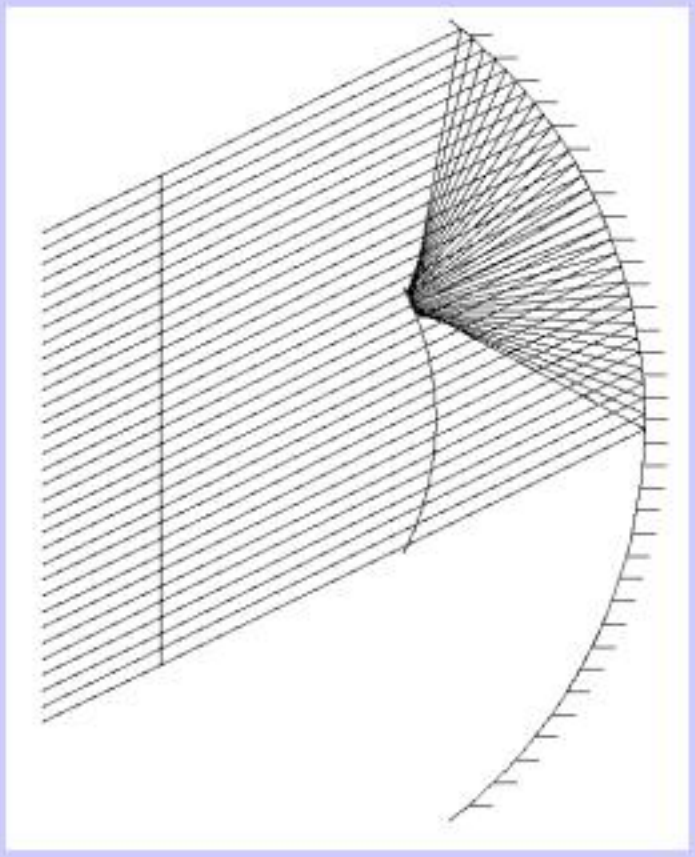
Scheme of optical system of SPHERE-2 detector.

Parameters of the optical part of SPHERE-2 detector.

- Spherical mirror diameter – 1500 mm
- Curvature radius – 940 mm
- Diaphragm window diameter – 920 mm
- PMT's retina diameter – 500 mm
- Retina curvature diameter – 526 mm
- Retina to mirror distance – 414 mm

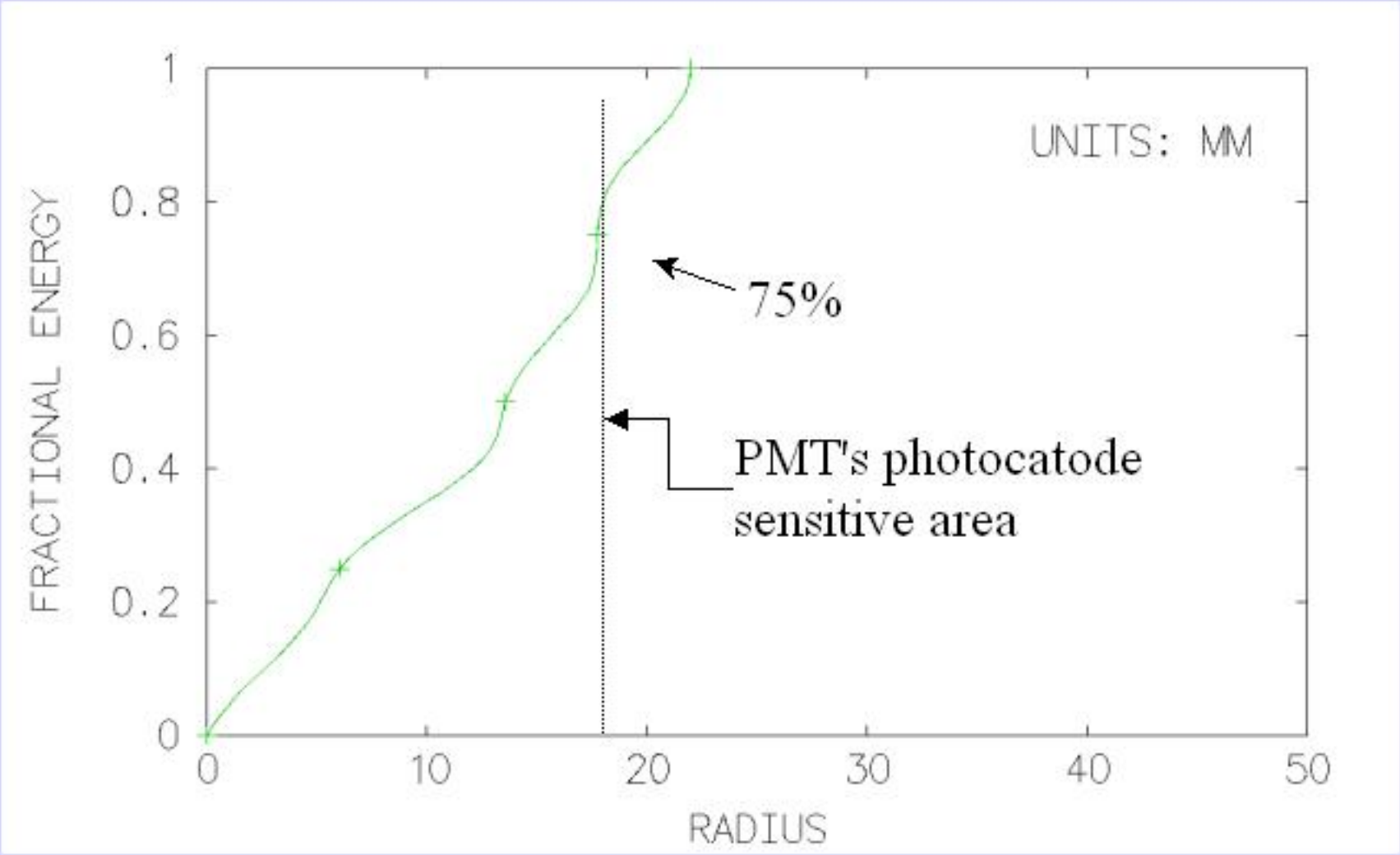


Paraxial optical beams



25 degree optical beams

Parameters of the optical part of SPHERE-2 detector.



Light radial energy distribution on focal surface.

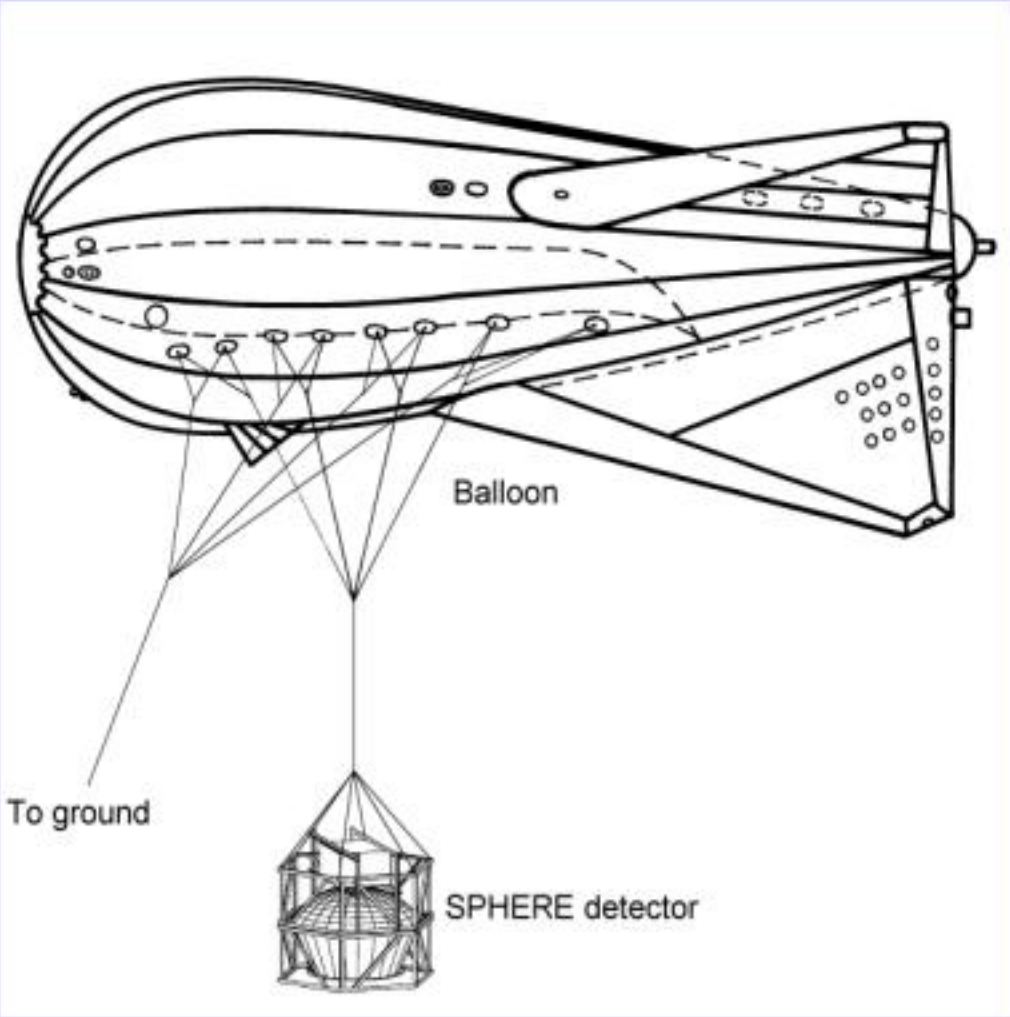
It is possible to estimate the values of starlight background PMTs pulses and PMTs pulses caused by the reflected Cherenkov light and by the amount of fluorescent light from the length of EAS track L≅1km in case of mirror with diaphragm area s=1m^2 and EAS energy E=10^{20}eV. L=1km corresponds to time interval ~3μs.

The mean value of PMTs pulse caused by starlight background will be **16 ph.-el.**

The mean value of PMTs pulse caused by fluorescent light near shower maximum will be **1300 ph.-el**.

The mean value of PMTs pulse caused by EAS Cherenkov light reflected from snow will be **5300 ph.-el**.

Configuration of SPHERE-1 experiment (the picture not for scale)



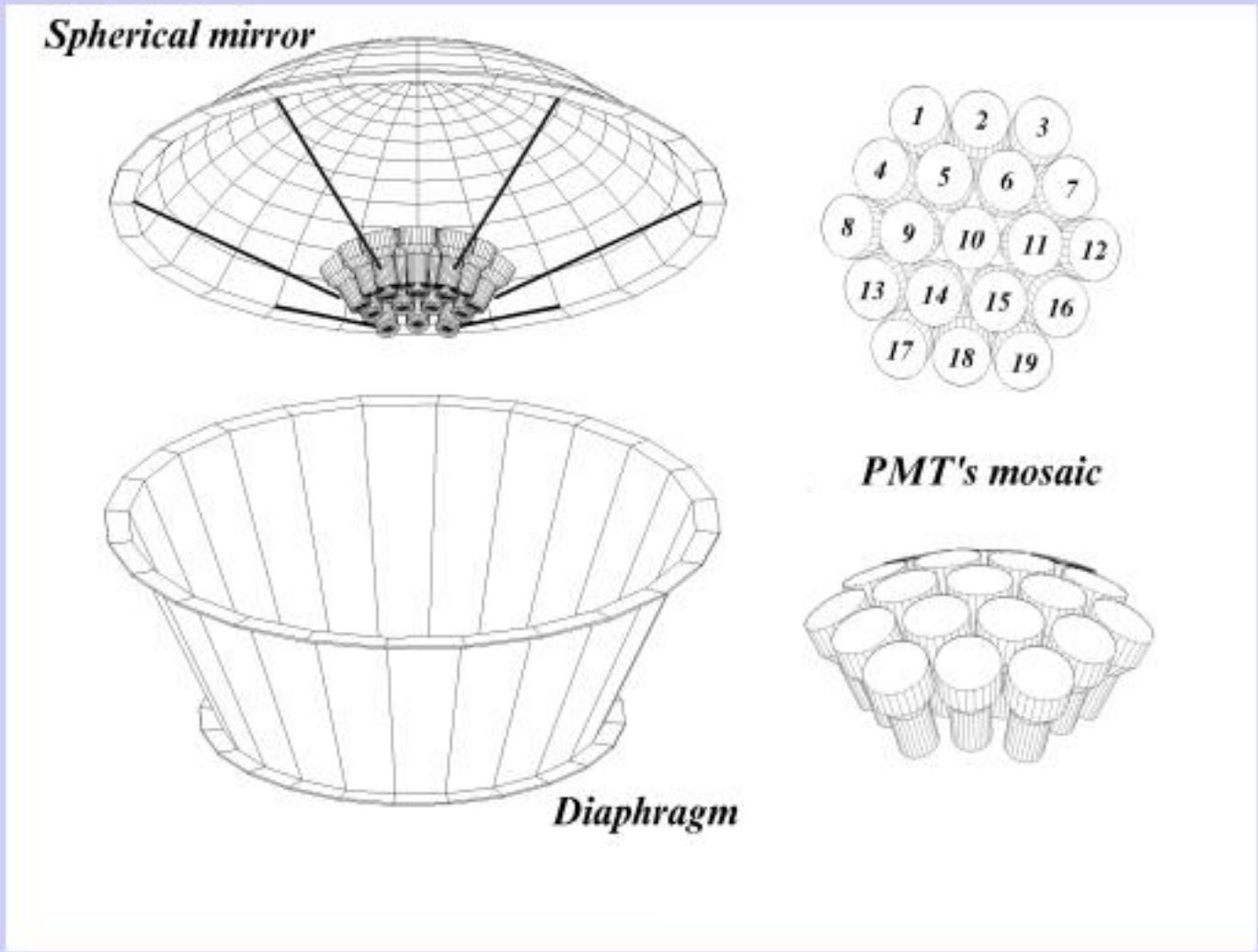
·Measurements place: 30 km from the Vol'sk city (N52°02′, E47°22′)

·Time: February 2000

·Altitude above snow surface: 1 km

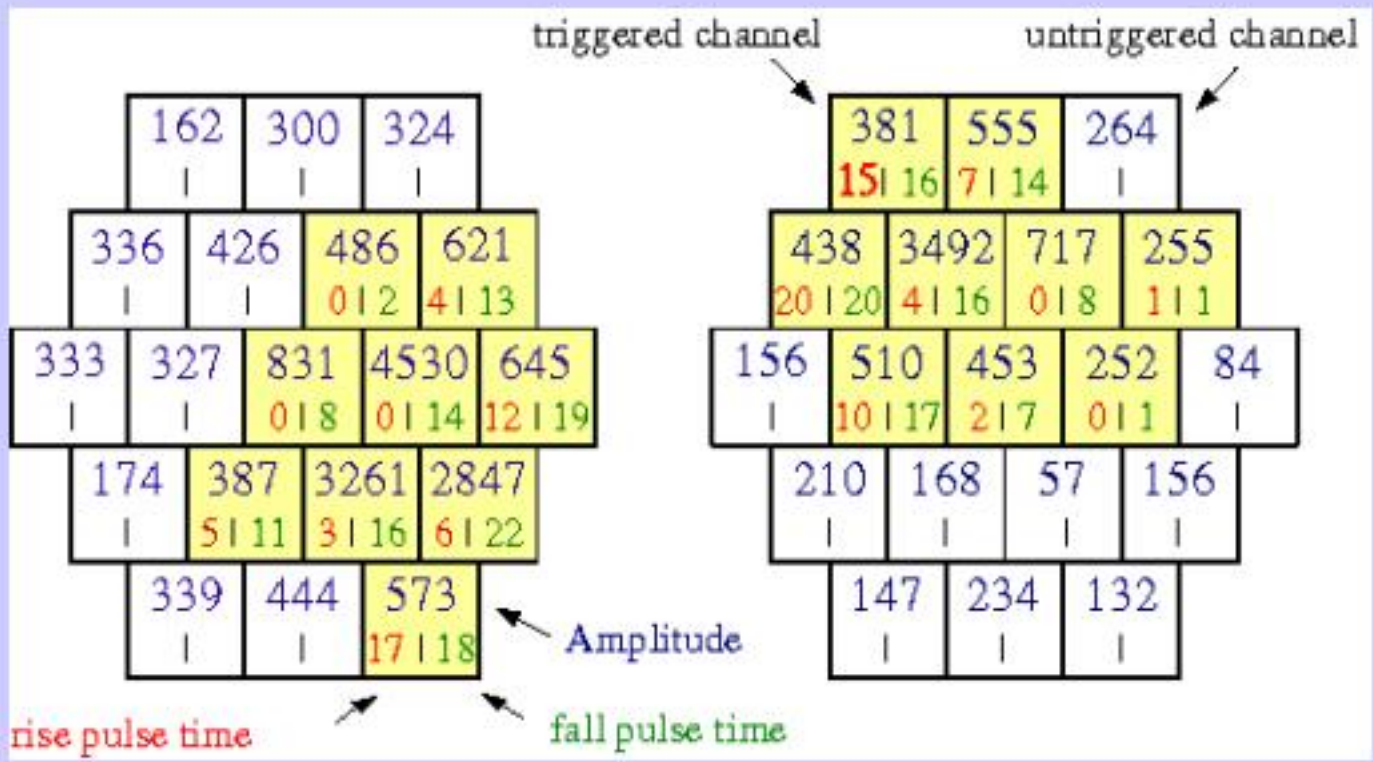
·Exposition time: 10 hours during clear moonless night.

·Registered cherenkov events: >700



Optical scheme of SPHERE-1 detector.

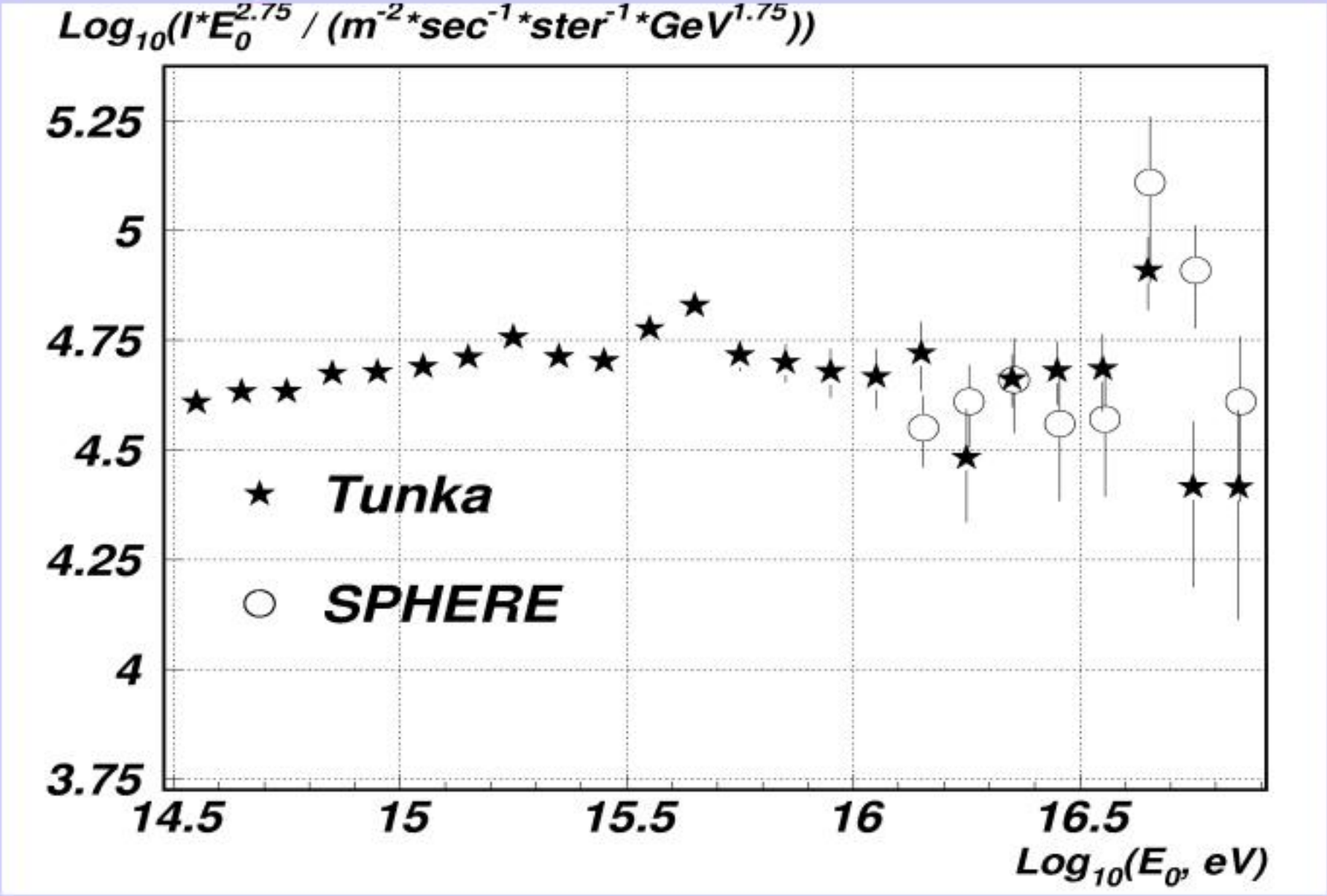
- Mirror diameter – 1200 mm
- Mirror curvature – 750 mm
- Diaphragm window- 800 mm



Example of two events measured during the flight.

Standard deviation of reconstructed EAS parameters.

Initial value Q, [quanta]	10^{12} (E~30PeV)			10^{13}(E~300Pev)		
Initial value ?, [degree]	8	36	60	8	36	60
Zenith angle						
$\sigma\theta$, [degree]	7	7	6	6	8	3
Lateral distr. function of Cherenkov light parameter						
σR_0, [m]	10	30	40	7	9	12
Shower core location						
$\sigma (X_0 , Y_0)$, [m]	5	7	10	2	2	3
$(\sigma Q)/Q$, [%]	10	10	10	8	9	6



Experimental spectra of ground-based Cherenkov array Tunka (data 2000 year) and SPHERE-1.

Conclusion

1. **Relatively simple detector SPHERE (mirror ~∅ 1.5m and mosaic ~100 PMT`s) for Antarctic balloon-borne measurements of the cosmic ray spectrum is presented. Practically there are no aerosols in Antarctic atmosphere. Antarctic sky is cloudless practically during all winter and the usefull part of operating time may to be ~100%.**
2. **Long time operating (up to 100 days) winter flight make it possible to measure the spectrum up to 10^{20}eV. It It will be possible to detect 15-20 events in the enrgy range E > 10^{20} eV.**
3. **On altitudes 30-40km the energy thresold will be ~10^{18} eV for Cherenkov light and ~ $4 \cdot 10^{18}$ eV for fluorescence light. It is possible to measure spectrum before the Greisen-Zatsepin-Kuzmin "cut off" and afterwards (the energy threshold of space detector EUSO will be ~ $4 \cdot 10^{19}$ eV).**

Conclusion

4.Accuracy of the energy measurements is high, due to two methods of measurements used - the measurement of the EAS fluorescence track in the atmosphere and full flux of the EAS Cherenkov light. It is possible to cross calibration both metods.

5.Using results of measurements of the balloon-borne detector SPHERE it is becomes possible to tie ground-based and stellite experiments.

6. In 2003 group of MSU and FIAN carried out the measurements of the light background in the region of Russian Antarctic station Novolazarevskaya and in 2004 we are planning to begin the first measurements of the energy spectrum. SPHERE – 1detector will be lifted to level 1 km by of fastened ballon.