The results of the development of the setup of SPHERE-3 for studying the composition of the PCR in the field of 1-1000 PEV. The status of 2025.

#37

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and
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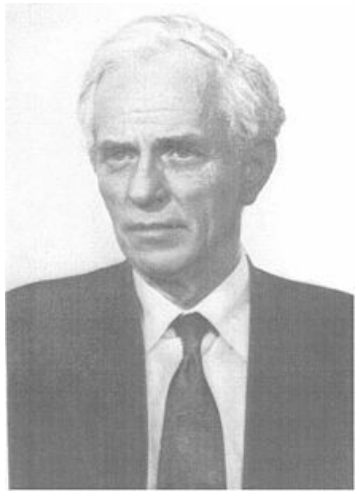
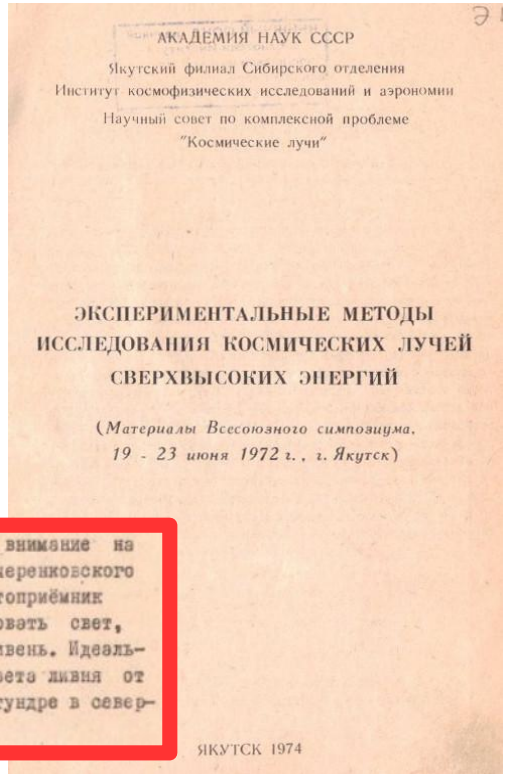
On the method of reflected Cherenkov light investigation

In 1972, A.E. Chudakov proposed installing two photomultipliers and two electron-optical converters with identical fields of view of 45 degrees on the aircraft. All four devices were to observe the snow-covered surface of the Earth from a height of about 10 km.



Целью настоящей заметки является обратить внимание на возможность прямого измерения полного потока черенковского света, создаваемого ливнем. Для этого надо светоприёмник расположить на большой высоте, чтобы регистрировать свет, отраженный от поверхности, на которую падает ливень. Идеальные условия в смысле отражения черенковского света ливня от поверхности земли можно ожидать в заснеженной тундре в северных районах СССР.



АКАДЕМИЯ НАУК СССР

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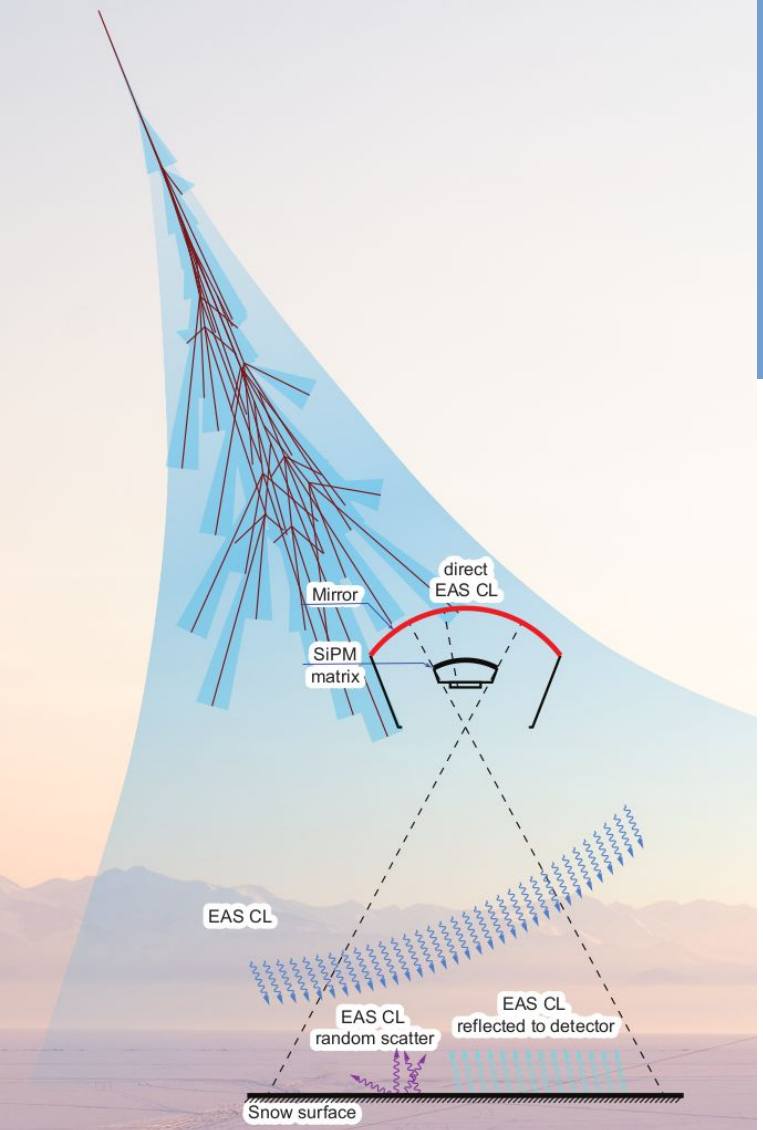
Институт космофизических исследований и аэрономии
Научный совет по комплексной проблеме
"Космические лучи"

ЭКСПЕРИМЕНТАЛЬНЫЕ МЕТОДЫ ИССЛЕДОВАНИЯ КОСМИЧЕСКИХ ЛУЧЕЙ СВЕРХВЫСОКИХ ЭНЕРГИЙ

(*Материалы Всесоюзного симпозиума, 19 - 23 июня 1972 г., г. Якутск*)

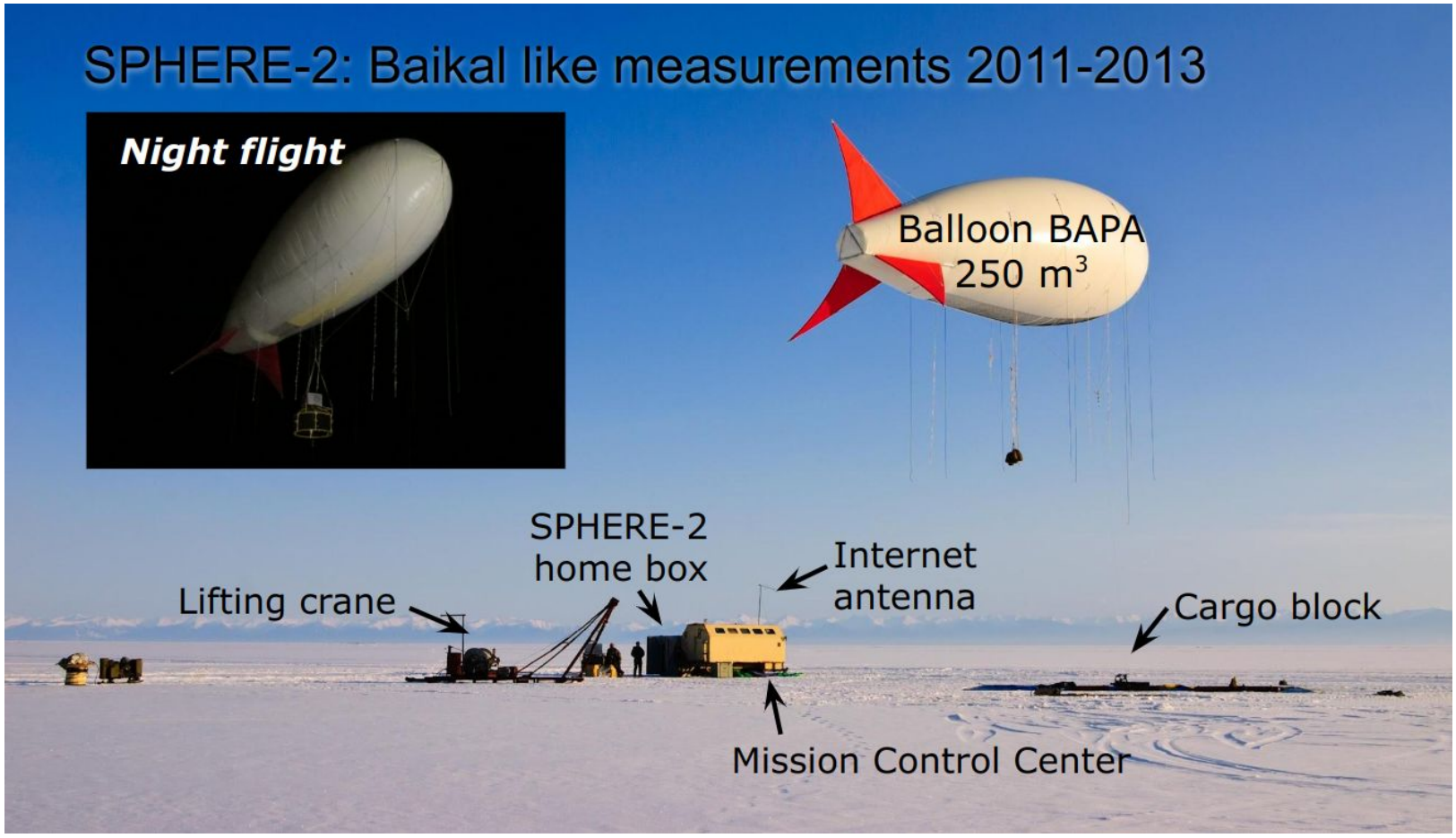
ЯКУТСК 1974

Experimental scheme of the SPHERE project



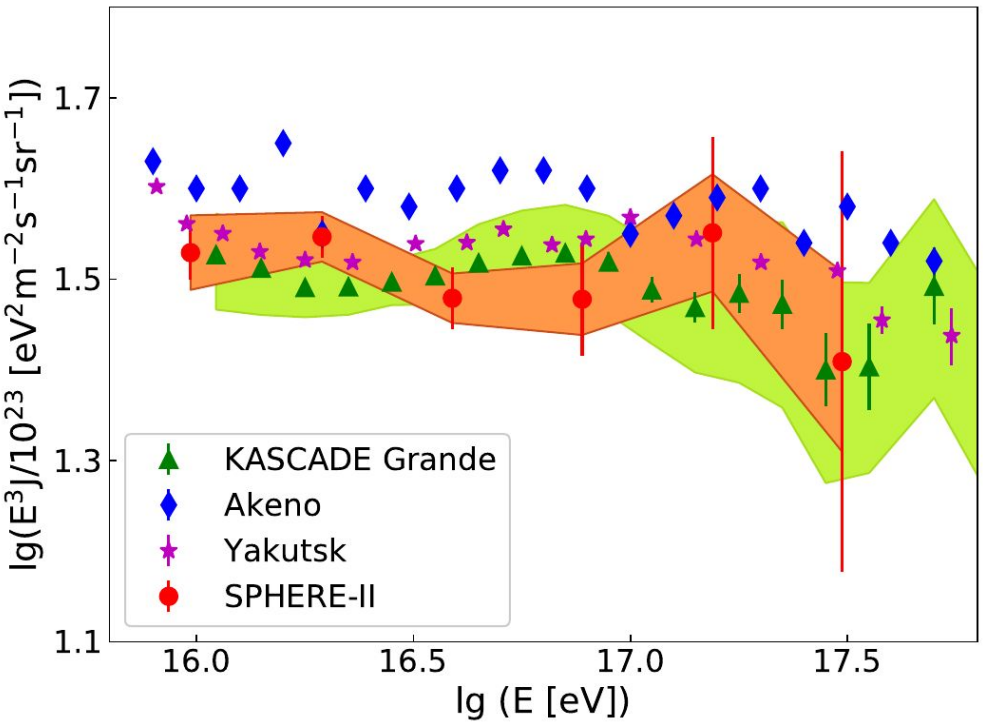
The setup rises above the snow-covered surface of the earth and records the reflected Cherenkov light of the EAS. The measured signal is proportional to the total flow of Cherenkov light of the EAS and the energy of the primary cosmic particle.

It is possible to record the direct flow of Cherenkov light if a wide-angle lens or a coding mask with a luminosity of about 100 cm^2 is installed on the mirror.

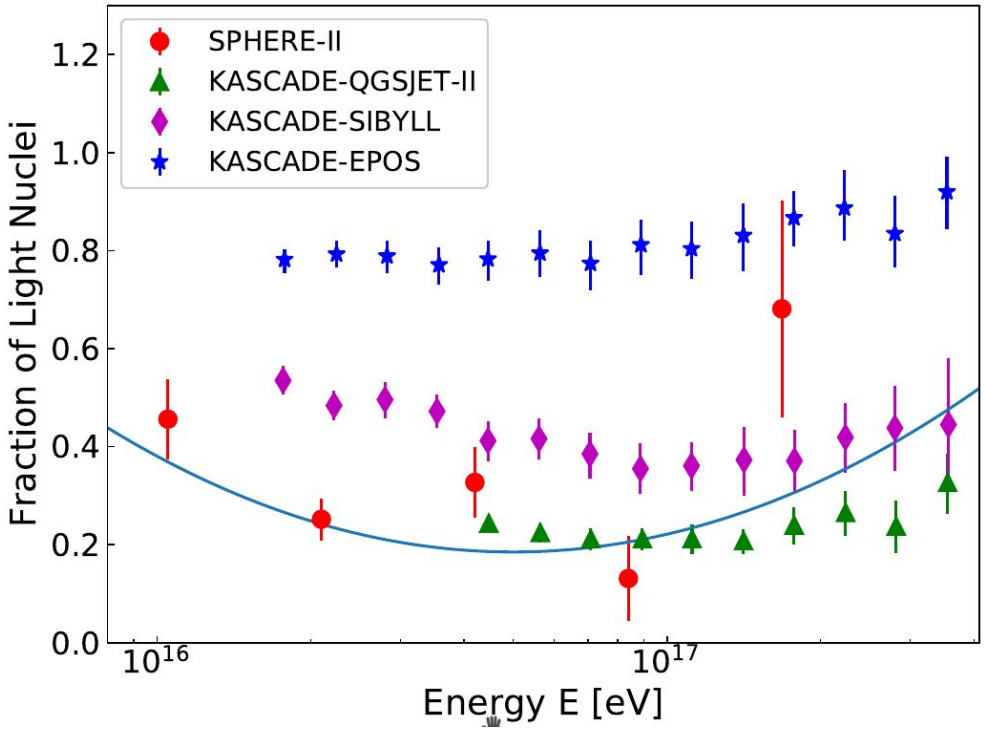


The experiment with the SPHERE-2 setup was carried out in the period 2008-2013 by SINP MSU and FIAN with the support of INR RAS near the neutrino telescope NT-200

SPHERE-2 detector results

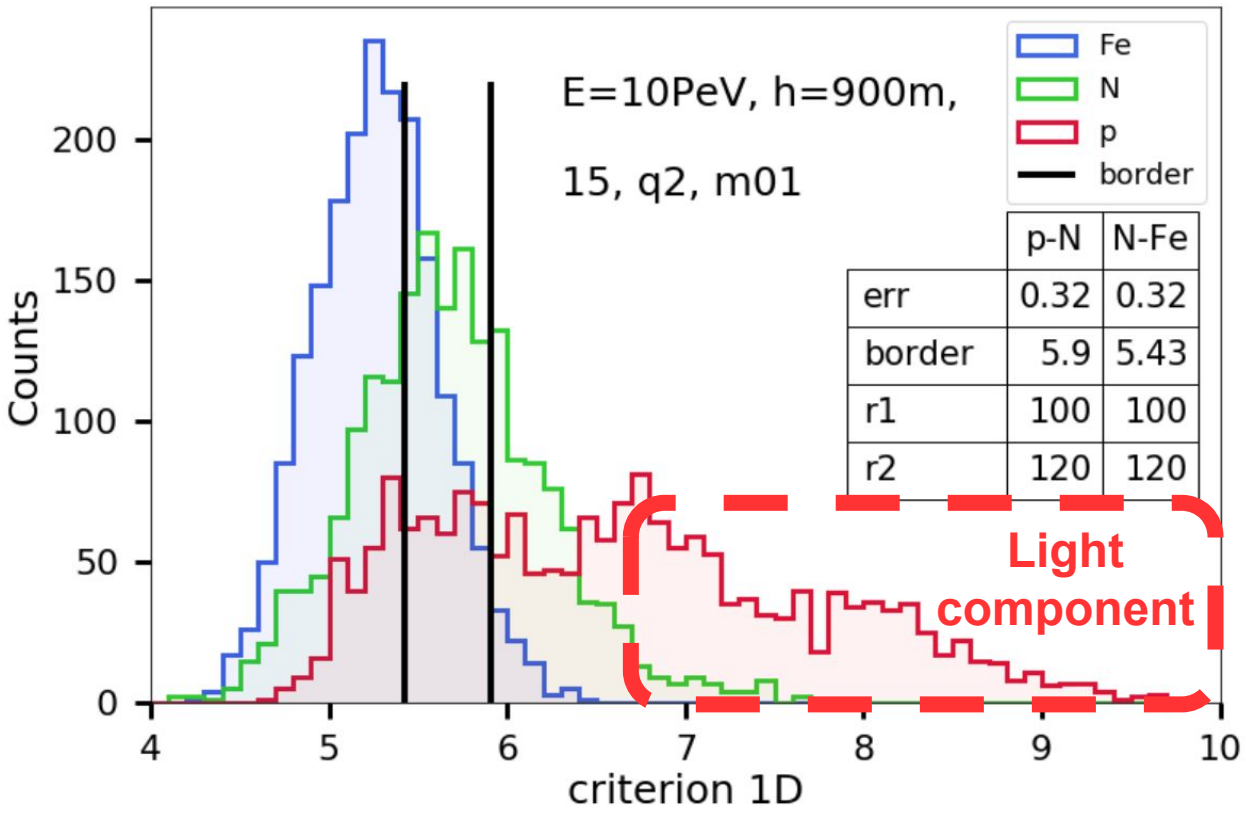


Energy spectrum

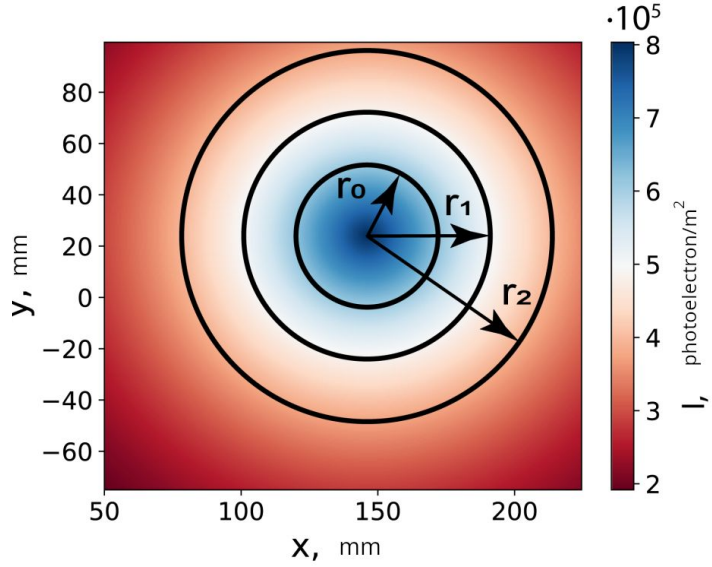


Mass composition for light nuclei

Method for estimation the PCR composition using reflected Cherenkov light

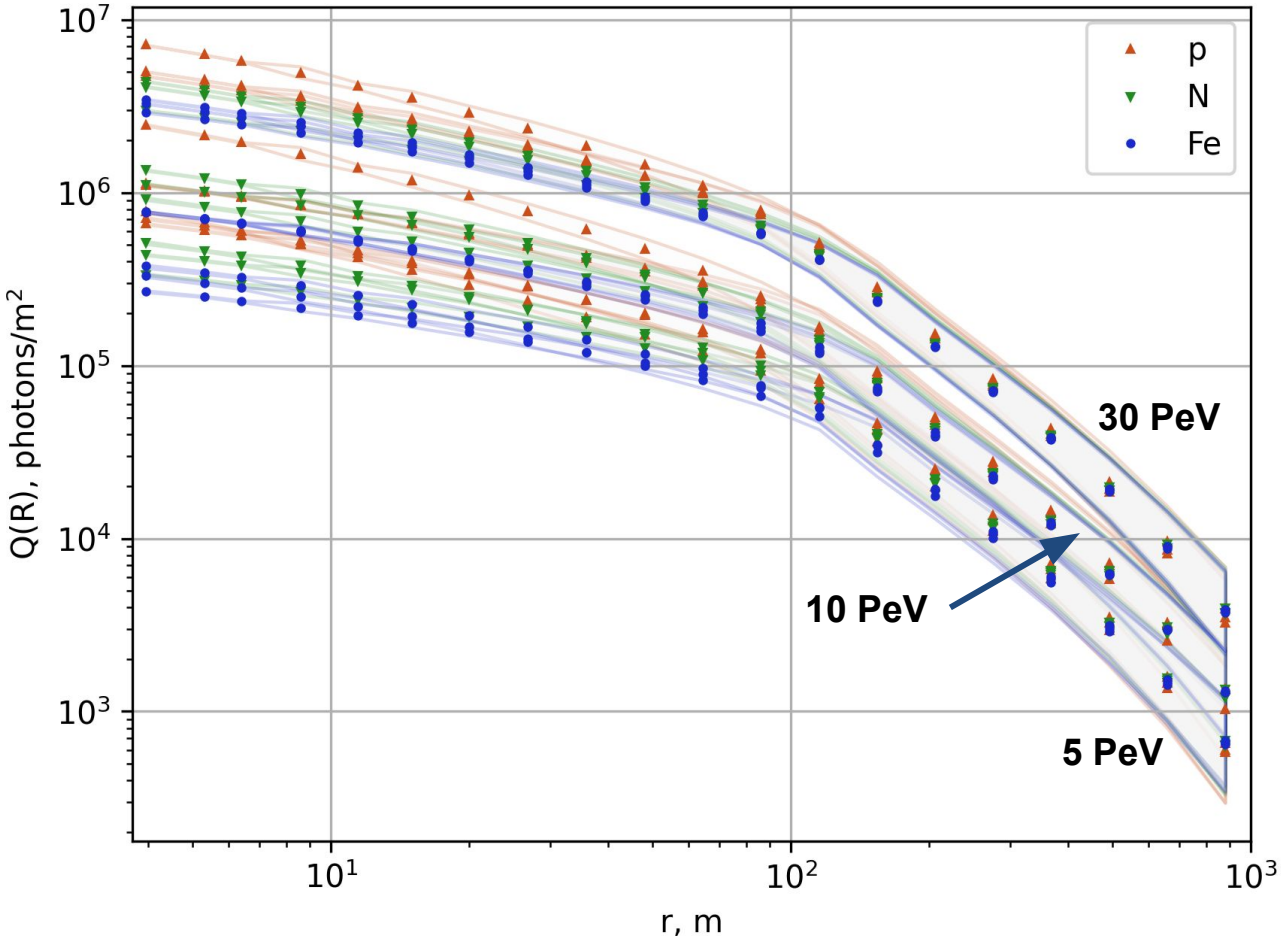


	p-N	N-Fe
err	0.32	0.32
border	5.9	5.43
r1	100	100
r2	120	120



$$cri_1 = \frac{\int_0^{r1} F_{LDF} dr}{\int_{r1}^{r2} F_{LDF} dr}$$

LDF model from vertical EAS

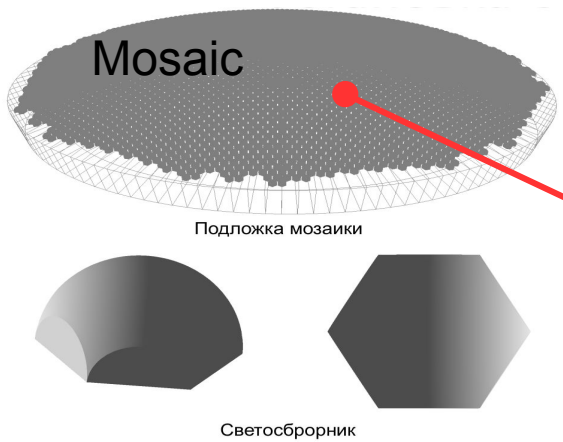


A set of individual events from p, N and Fe primary particle obtained using the CORSIKA simulation for energies of 5, 10 and 30 PeV.

The Cherenkov light is collected on the observation surface on a 2.5x2.5m grid.

The lines show the limits of the data spread in different grid cells.

Construction of the SPHERE-3 detector



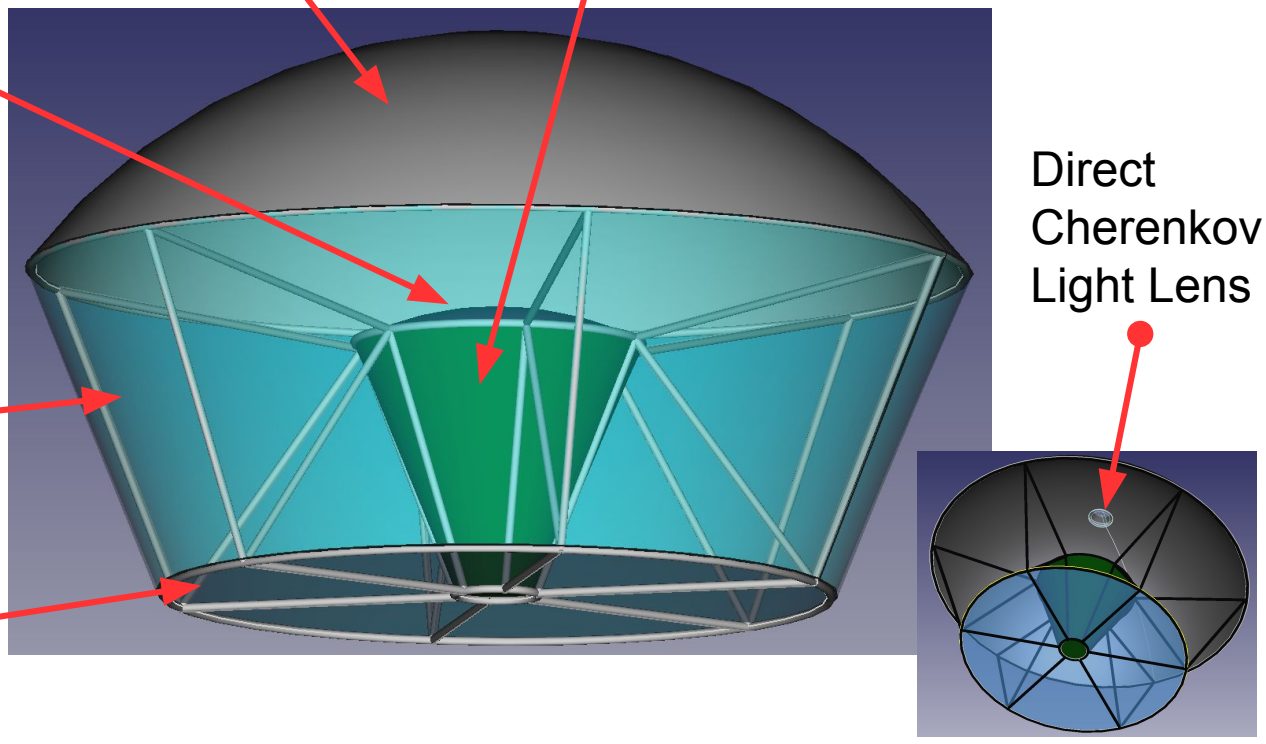
Mirror

Measuring equipment

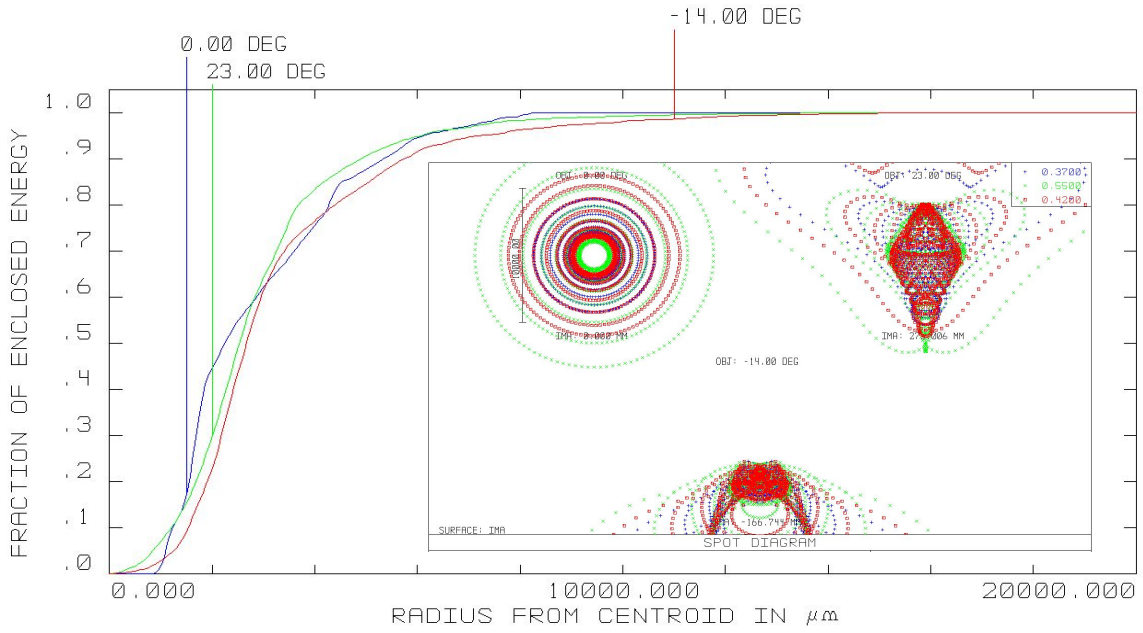
Direct Cherenkov Light Lens

Lens hood

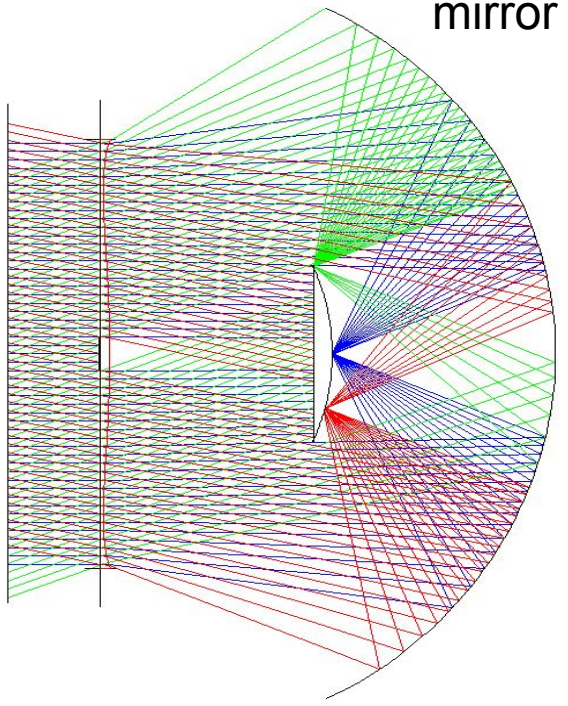
Corrective lens



Preliminary version of the optical system of the SPHERE-3 detector



Aspherical mirror



Spot shape optimization
Mosaic diameter 550 mm
S_{eff}~1.13м^2

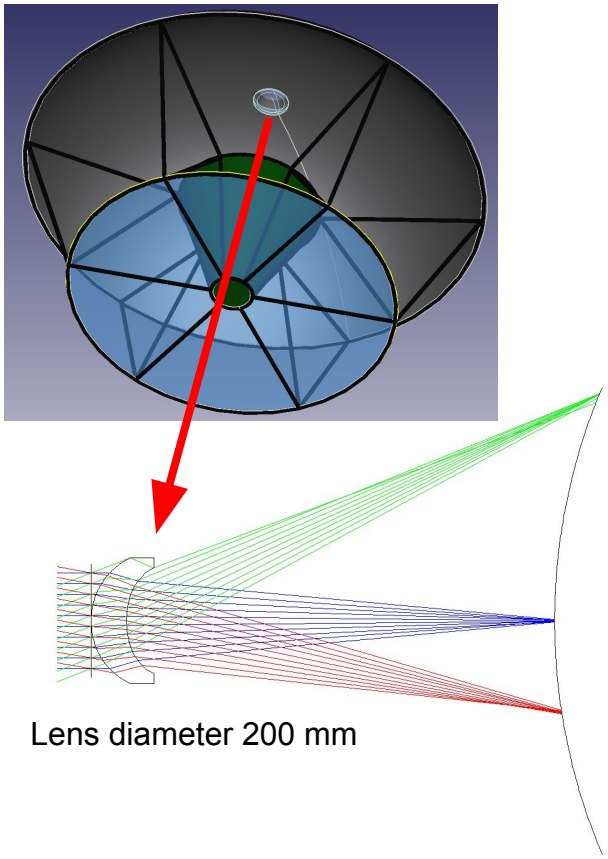
Mirror diameter 2160 мм
Diameter of the diaphragm 1320 mm

Characteristics of the designed detectors

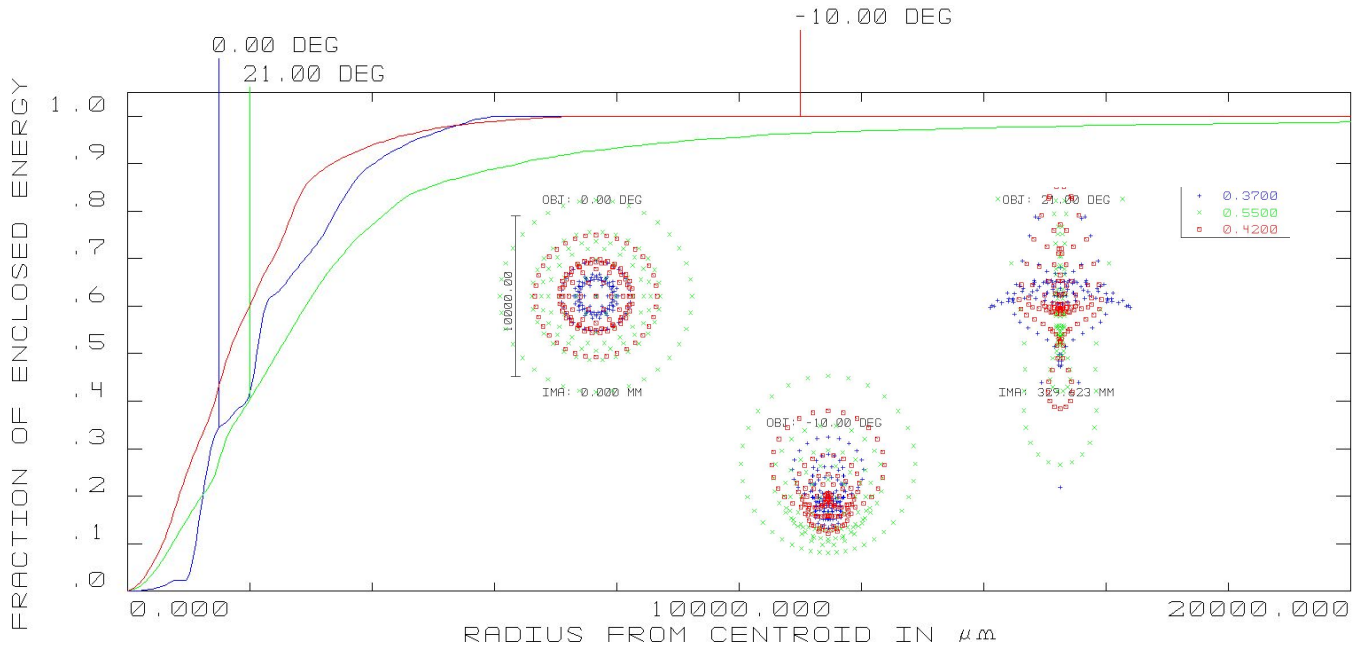
Parameter	SPHERE-2	Prototype	SPHERE-3
Effective sensitive area of optics (aperture entrance window), m^2	0,5	0,16*	1,13*
Mirror diameter, mm	1500	800*	2200*
Optical system viewing angle, degrees	±25	±23*	±23*
Number of mosaic elements	109	300*	2-3x10^3 *
Detector weight, kg	90	15*	100*
Detector height, m	up to 900 (balloon)	up to 500 (UAV)	up to 2000 (UAV)

* - preliminary

One way to register direct Cherenkov light



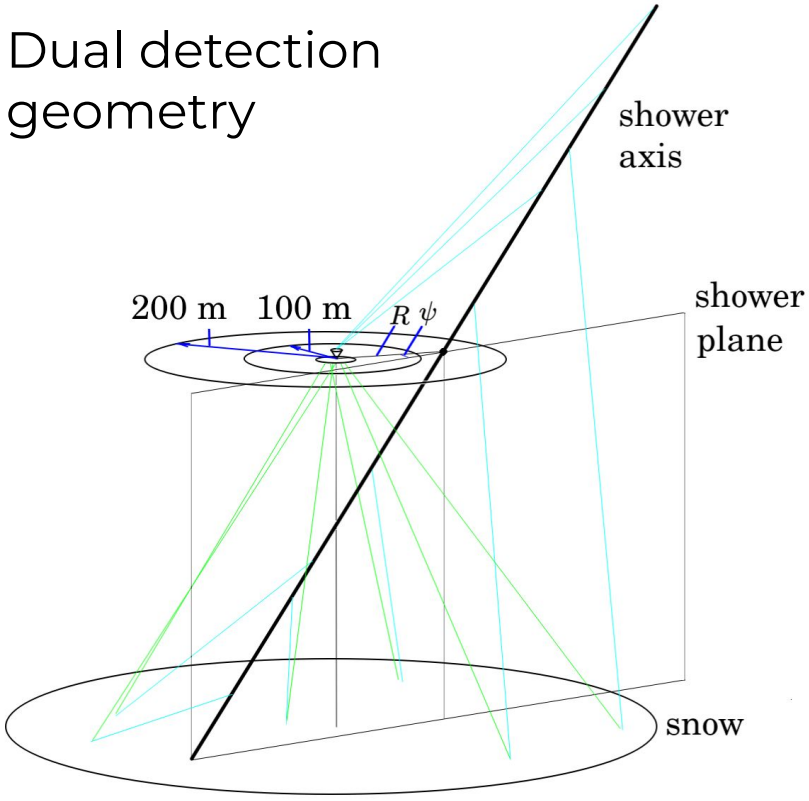
Lens diameter 200 mm

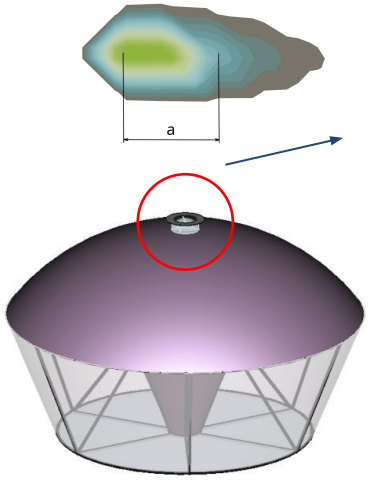


Development and modification of the method for estimating the mass of a primary particle with simultaneous registration of EAS by direct and reflected light detectors of the SPHERE-3 facility

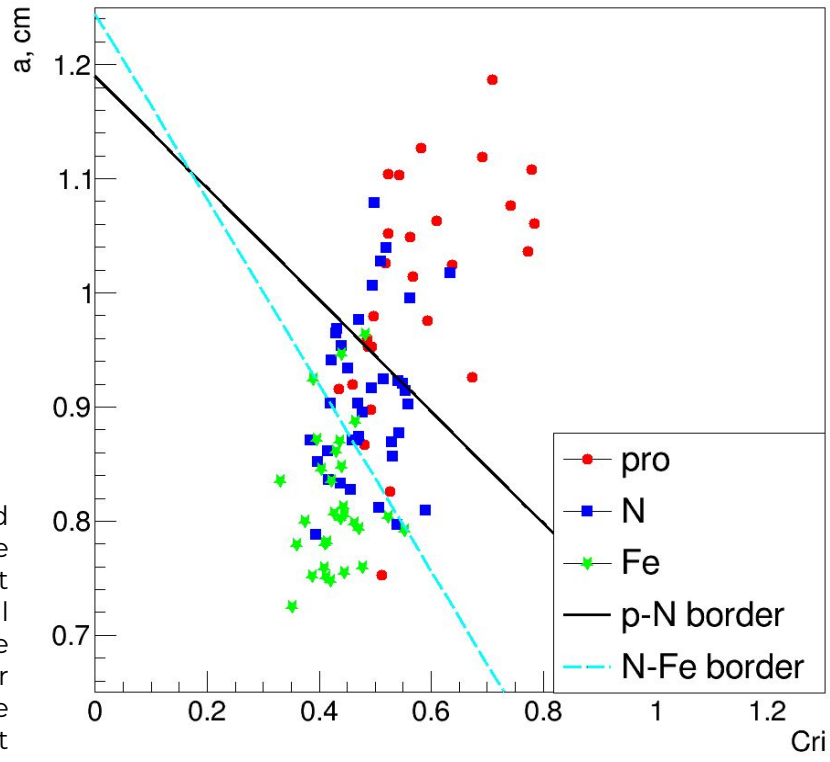
Poster presentation ID: #9, O. Cherkesova

Dual detection geometry





Every event was concerned as a point in 2D feature space: **a** for the direct light and the ratio of the integral over the inner circle of the image to the integral over the outer ring for the reflected light



Development and modification of the method for estimating the mass of a primary particle with simultaneous registration of EAS by direct and reflected light detectors of the SPHERE-3 facility

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Energy	10 PeV		30 PeV	
Incline	15°	20°	15°	20°
p	0.25	0.27	0.31	0.30
p-N	0.26	0.28	0.26	0.28
N-Fe	0.23	0.23	0.23	0.28
Fe	0.24	0.24	0.23	0.28

Preliminary results of the mass estimation using the length of the major axis

Here p - probability of proton misclassification, p-N – probability to take N for proton, N-Fe – probability to take N for Fe, Fe – probability of Fe misclassification.

p	p-N	N-Fe	Fe
0.22	**0.15**	**0.19**	**0.14**

Preliminary results of the mass estimation using dual classification

p	p-N	N-Fe	Fe
0.32	0.32	0.31	0.33

Preliminary results of the mass estimation using ratio of integrals of reflected light

Conclusion

- Work is underway to improve the method for the detection of the reflected Cherenkov light
- A preliminary design of the detector and optical system for the SPHERE-3 detector and its prototype has been developed.
- High sensitivity of the direct Cherenkov light to the primary mass was demonstrated.
- Method of the primary mass estimation using the data of both detectors was created

Acknowledgments

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rscf.ru/project/23-72-00006/

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Thank you for your attention!