Estimation of the capabilities of the SPHERE-3 Cherenkov telescope to determine the parameters of the primary cosmic particles.

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CORSIKA calculations on the Lomonosov-2 supercomputer of the MSU

EAS Cherenkov light database: Access on demand

1 nuclear, 1 energy, 1 atmosphere, 6 zenith angles $(5 - 30^{\circ}) \Rightarrow 600$ EAS Energy: 5, 10, 30 [100] PeV

interaction model	nuclei	atmosphere models	EAS events	angle grid	Altitude, 455 m +
QGSJET01	p, He, N, Al, Si, Fe	4	27 770	1.0°	500, 1000,
QGSJETII-04	p, He, N, Al, Si, Fe	4	27 224	1.0°	2000
QGSJETII-04	p, He, N, Fe	4	28 800	0.2°	500, 1000,
Sibyll 2.3	p, He, N, Fe	5	36 900	0.2°	1500

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SPHERE-3: Trigger

Task: to distinguish events in a continuous signal flow.

- 1. Threshold trigger
- 2. Neural network as a 2nd trigger:



p, 10 PeV, 15º, atm1, QGSJET-II, 500 m





SPHERE-3: Axis location by reflected Cherenkov light



SPHERE-3: Axis direction by direct Cherenkov light

The hole mask in the mirror



By geometric center of image (ML)Feature engineering:2.00°Linear regression model:0.64°Neural network MLP:0.44°

2.00°±0.8° 0.64°±0.31° 0.44°±0.26° Separate direct light detector



By image maximum: 0.20° By center of mass: 0.32°





SPHERE-3: Energy estimation by reflected Cherenkov light



SPHERE: Mass separation method. Reflected light

The shape of the Cherenkov Light lateral distribution function is used as a measure of the primary mass.



SPHERE: Mass separation method. Reflected light

10 PeV, 15°, amt1, QGSJET-II, 1000 m



Iron as nitrogen: 32%

SPHERE-3: Mass separation method. Direct light

Separate 400 cm² direct light detector



SPHERE-3: Mass separation method. Reflected + direct

Double detection geometry H=500m: Reflected: R < 180 m Direct light: r 100-200 m

Classification errors

р	p-N	N-Fe	Fe
0.22	0.15	0.19	0.14

Poster #9. Cherkesova O.



SPHERE-3 EAS reconstruction: Direct & Reflected light methods

EAS parameter accuracy	Reflected light	Direct light	Reflected + Direct				
Axis, m	5-10 ± 3	_	_				
Direction, °	1.3-1.7 ± 0.8	0.2 ± 0.2					
Energy	15-20%	-	-				
Mass Classification errors							
p as N: Fe as N:	30% 28%	25% 24%	15% 19%				

Summary

- SPHERE-3 will record both reflected and direct Cherenkov light.
- The design of the SPHERE-3 telescope will be optimized to determine the mass composition of primary cosmic rays.
- Direct light mass estimation by direct light is more accurate than by reflected light.
- Double detection allow a more accurate estimation of the primary particles mass.
- General procedure will convert the partial estimates of the primary parameters into a self-consistent parameter set.
- EAS Cherenkov light distribution database is open to colleagues.

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Thank you for your attention!

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