The project of a ground-based wide-angle EAS Cherenkov light imaging detector for PCR mass composition study in the 1-1000 PeV energy range

Dmitry Chernov
and
Elena Bonvech, Vladimir Galkin, Vladimir Ivanov, Timofey Kolodkin, Natalia Ovcharenko, Olga Cherkesova, Dmitriy Podgrudkov, Maxim Ziva, Tatyana Roganova, Elena Entina

Task

To solve the problem of the chemical composition of cosmic rays in the region of 1-1000 PeV, it is proposed to develop and create a new wide-angle 40-60 degrees Cherenkov light detector with an angular resolution of 0.2-0.4 degrees. The chemical composition is estimated using the Cherenkov light angular distribution.

The aim of this work: significant reduction of the pixels count in the photodetector matrix compared to the traditional design of Cherenkov telescopes, which will reduce the costs and ease manufacturing of the detector.

Experimental scheme of the detector

Aperture +/- 28 degrees

Angular resolution 0.2 - 0.4 degrees

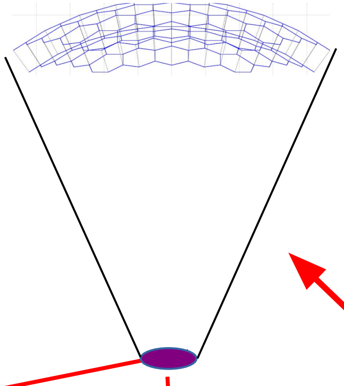
Focal length 1.2-1.5 m

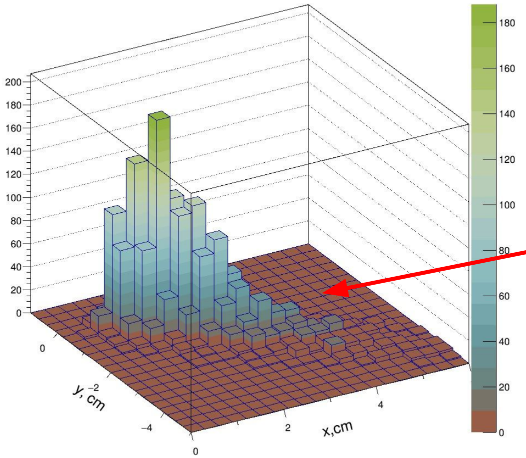
Telescope diameter 1.5 - 2 m

Pixels in the camera - 259 or 427

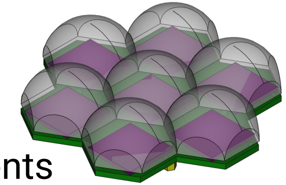
Luminosity - 0.02 m^2

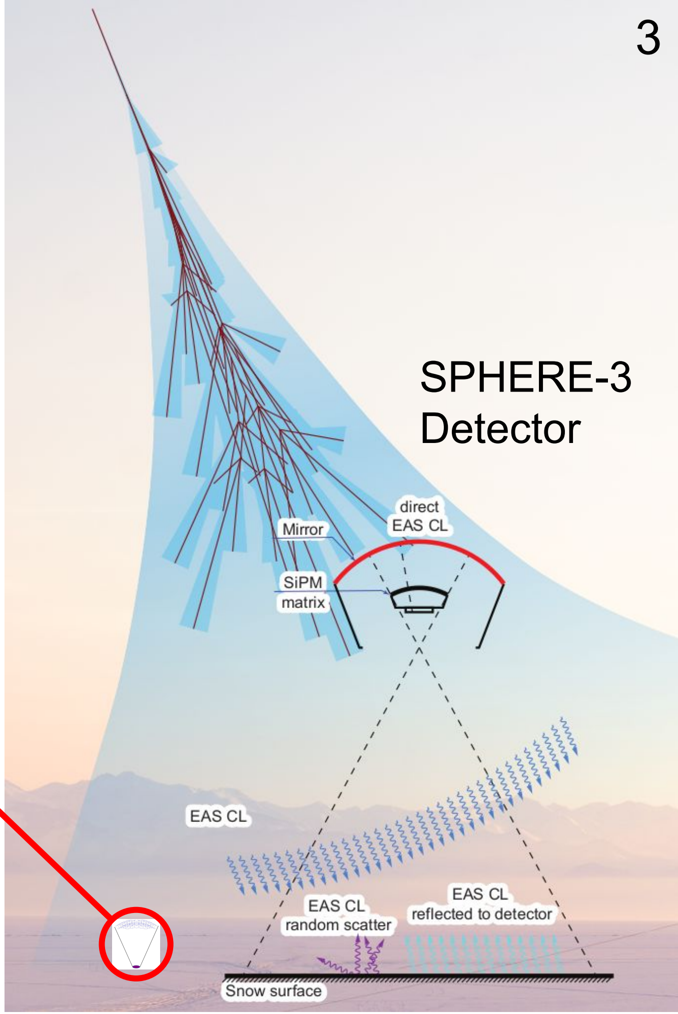
37-61 lens system



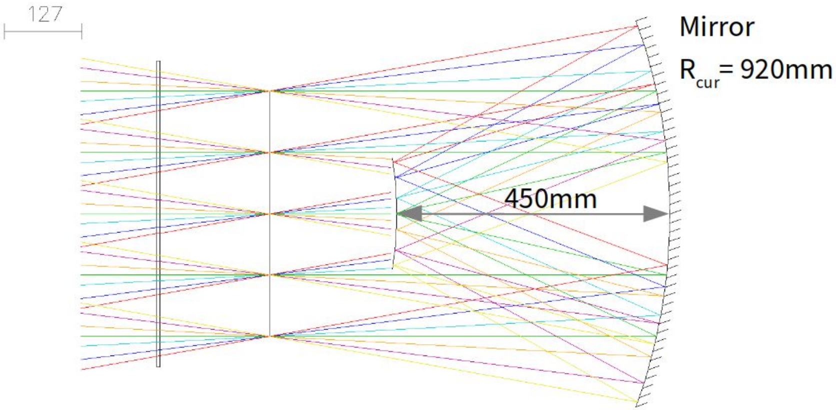


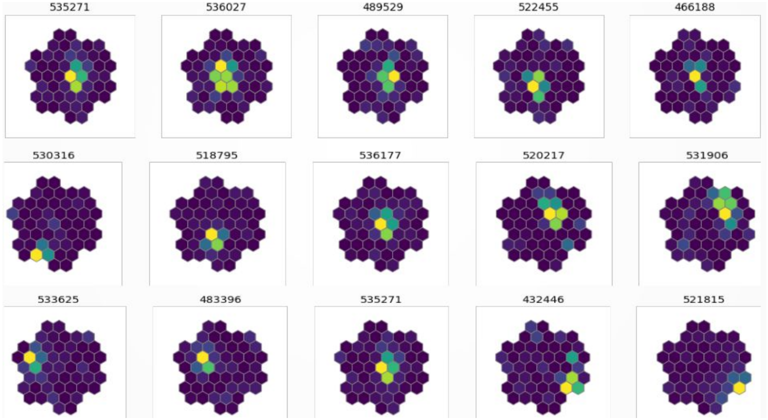
one of SiPM segments

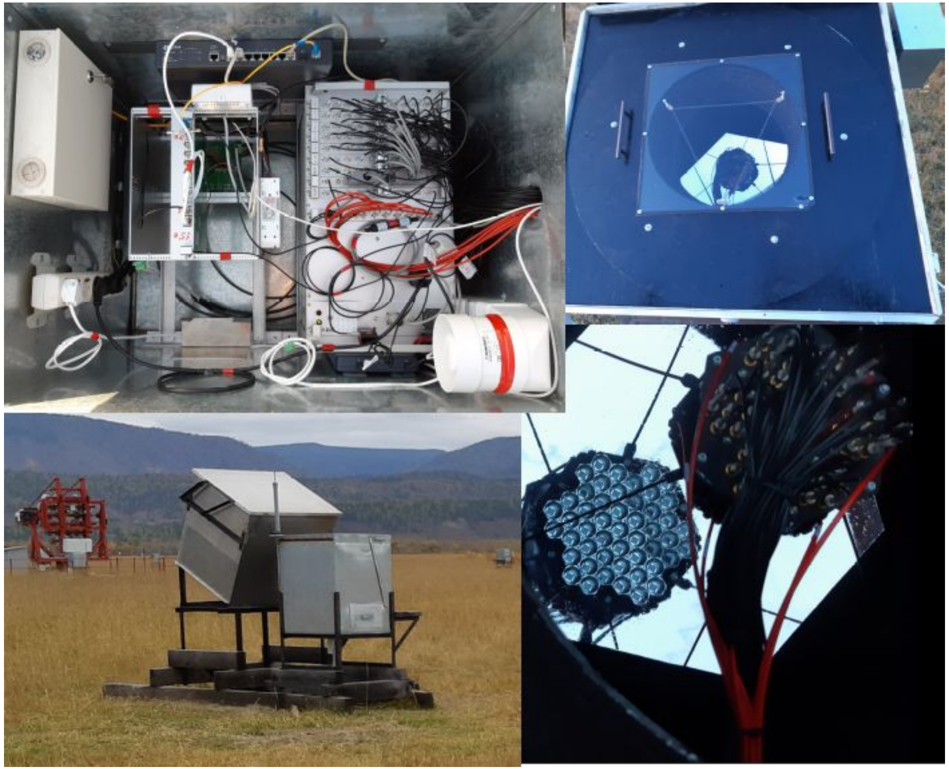




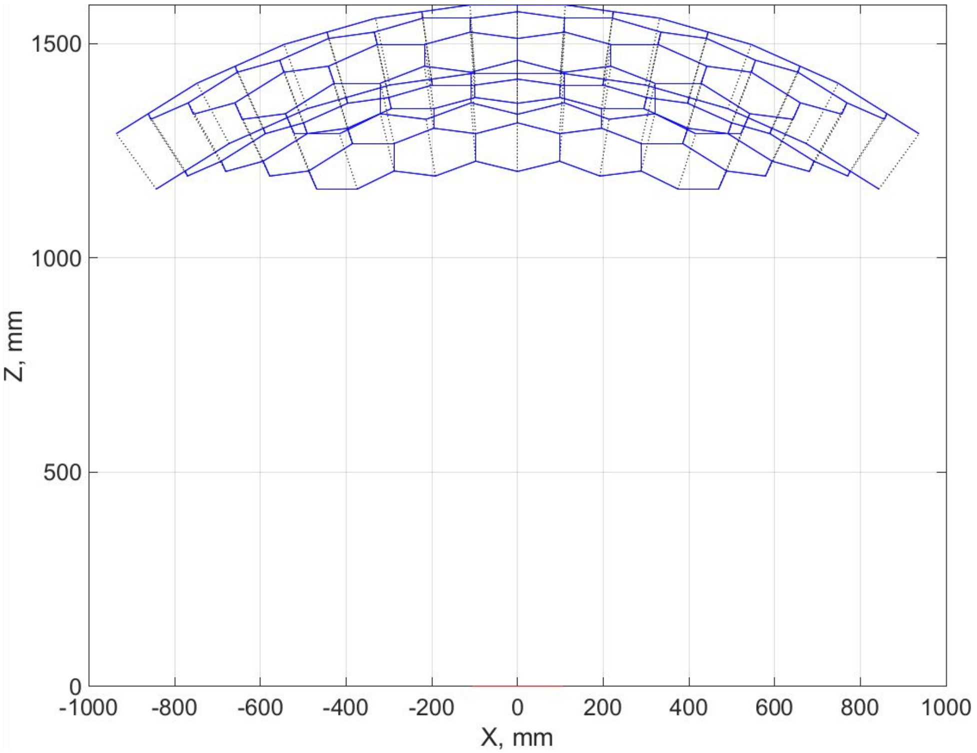
An example of using the SiPM matrix on the SIT telescope at the TAIGA astrophysical complex

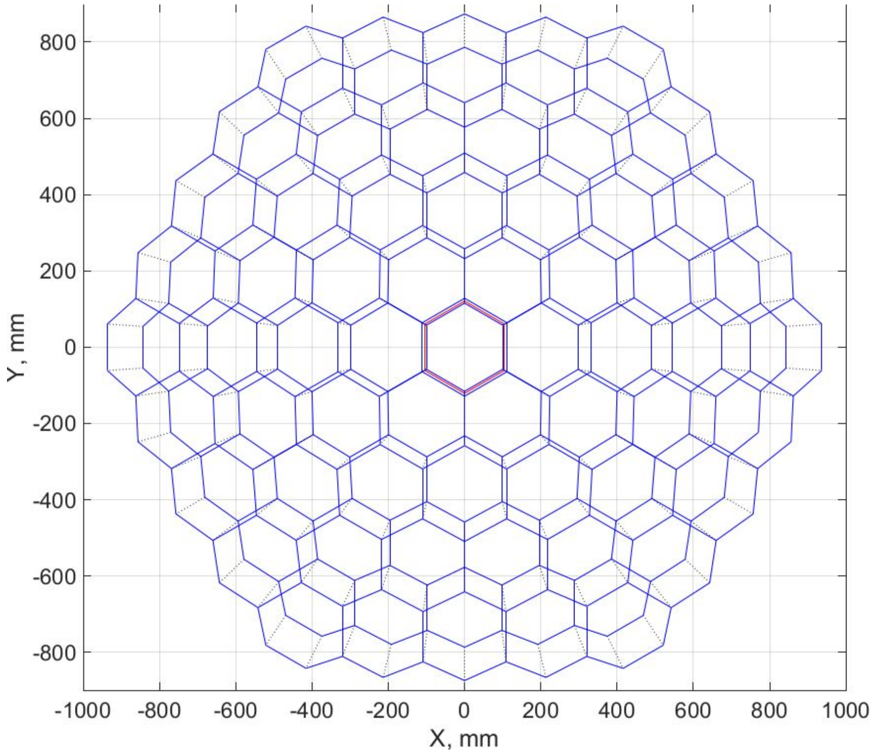




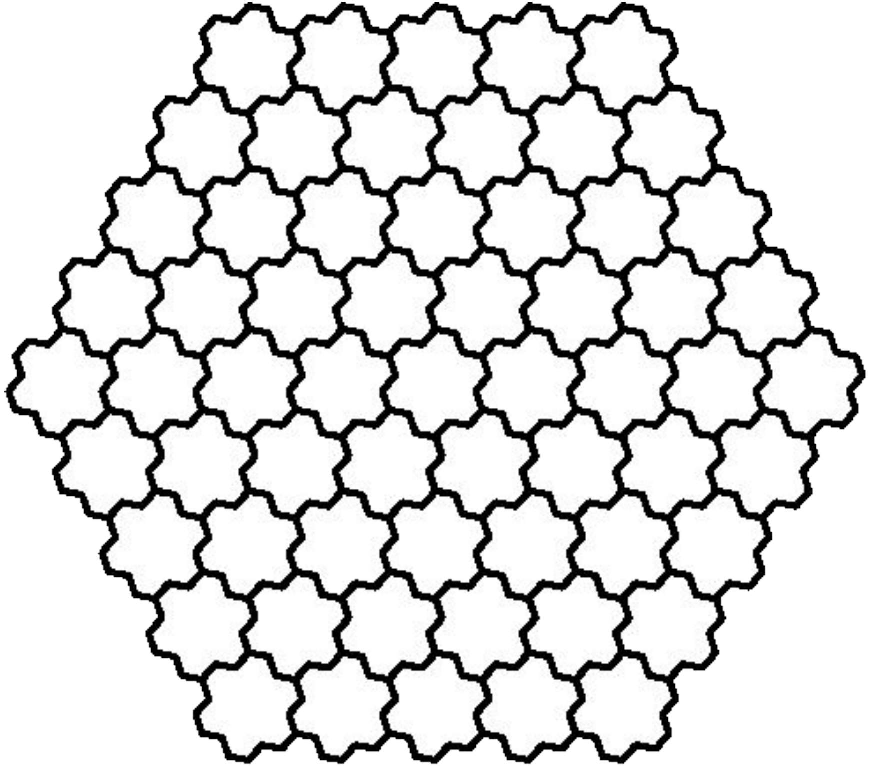


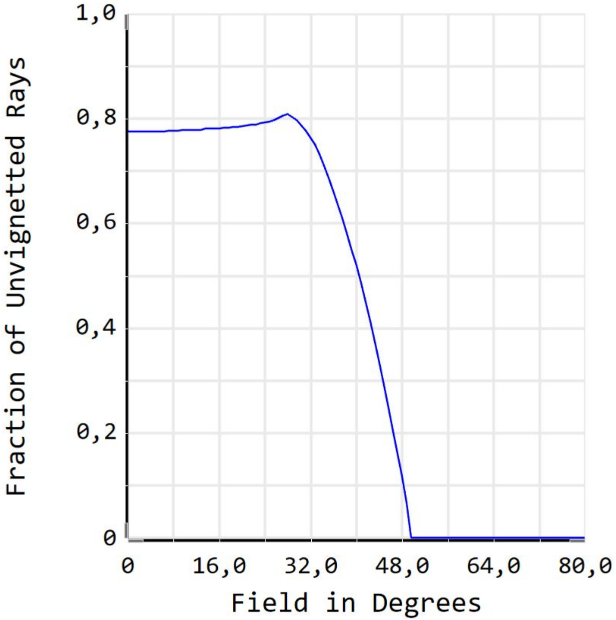
3D view of the lens arrangement



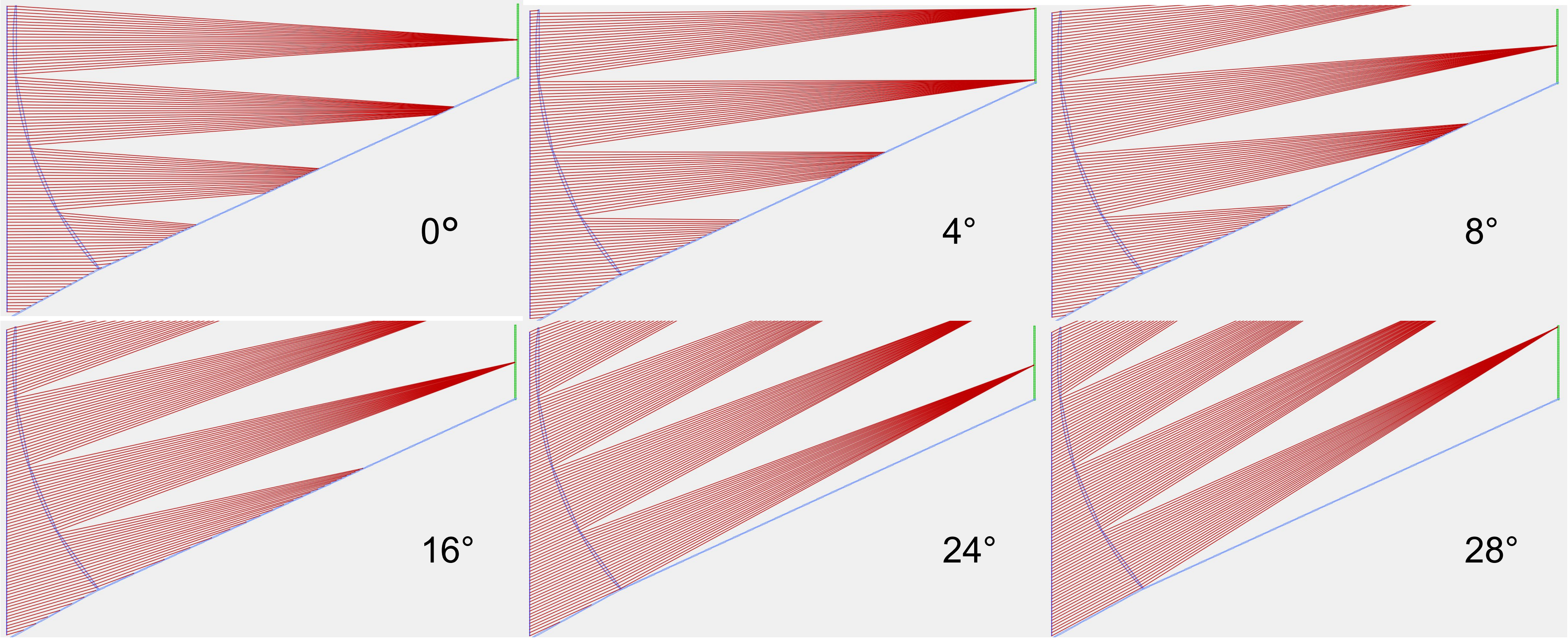


Optical modules layout in the camera

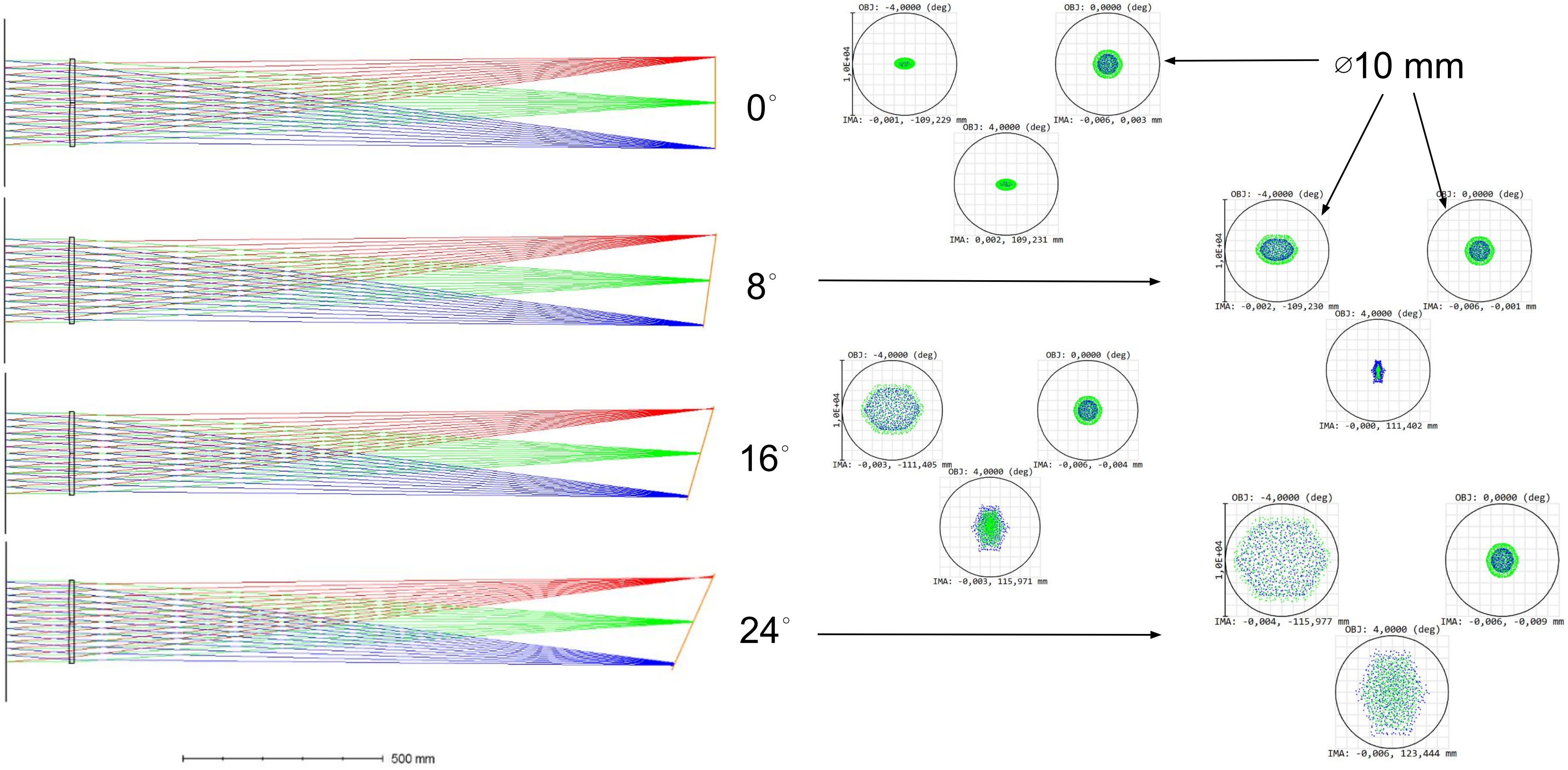




Examples of beam paths at different angles

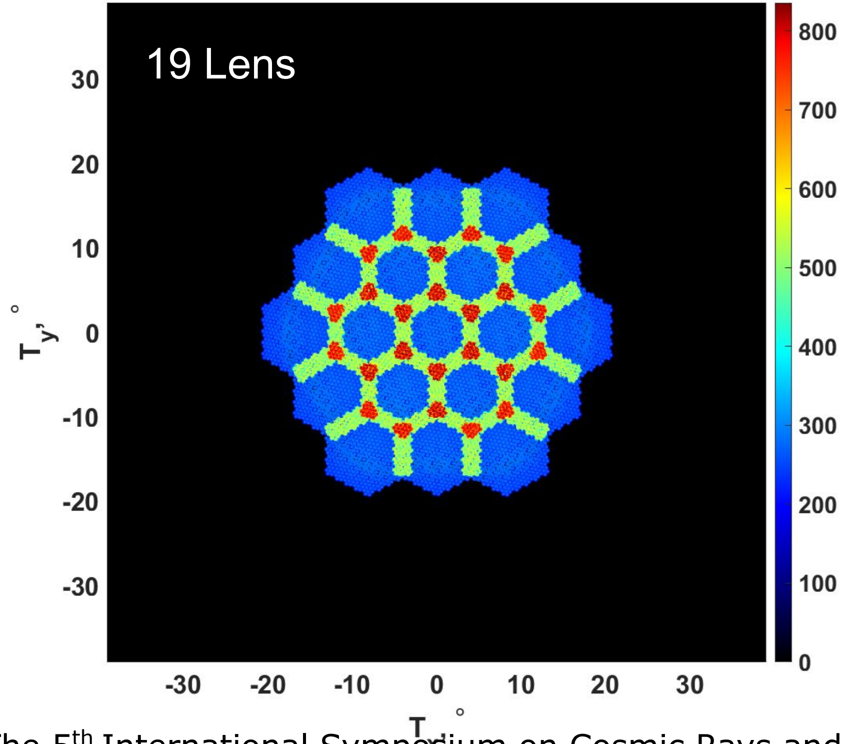


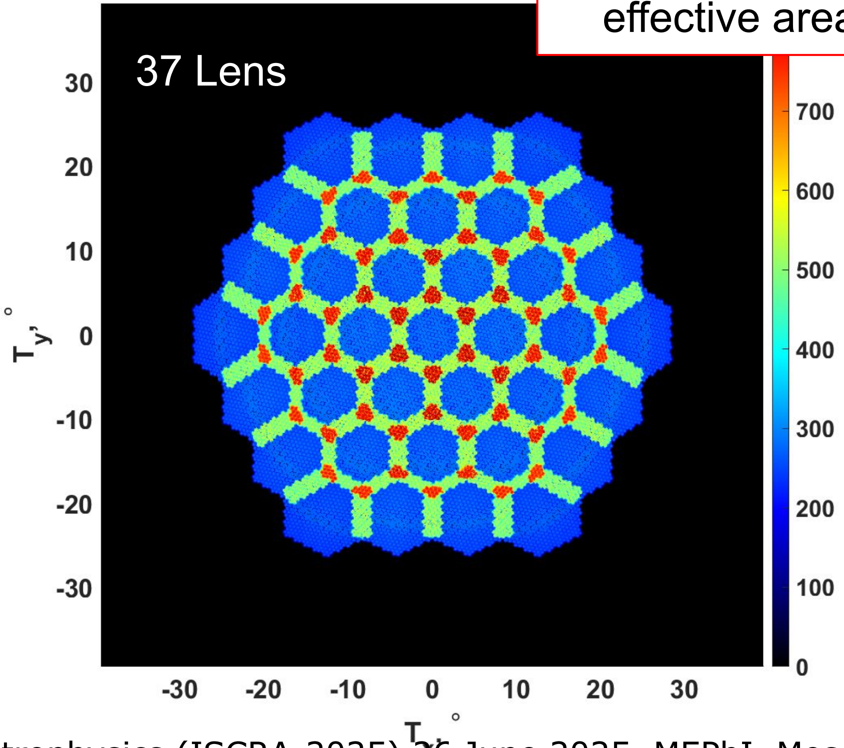
Optical properties for different groups of lenses



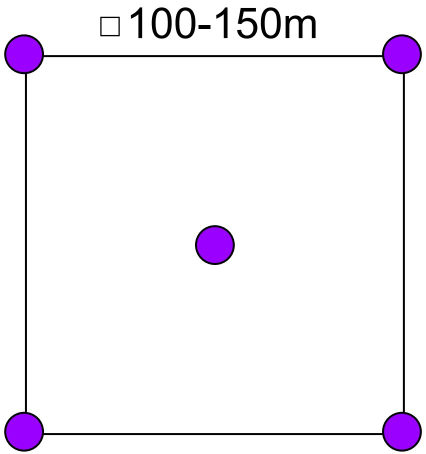
Effective area in cm^2 for each direction (lower estimation).

SIT had 367 cm^2 effective area

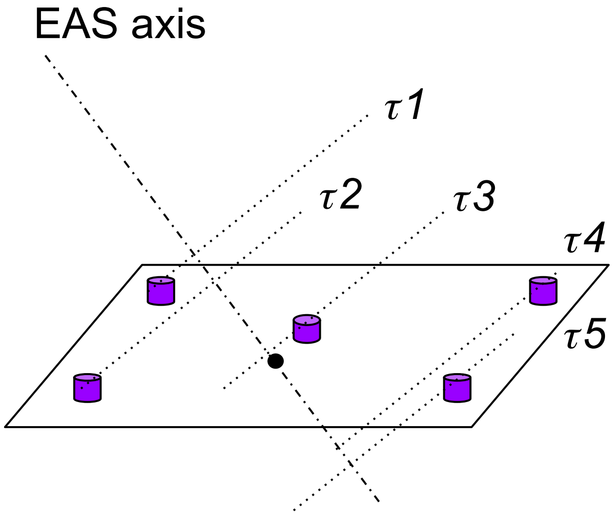




Installation of several detectors



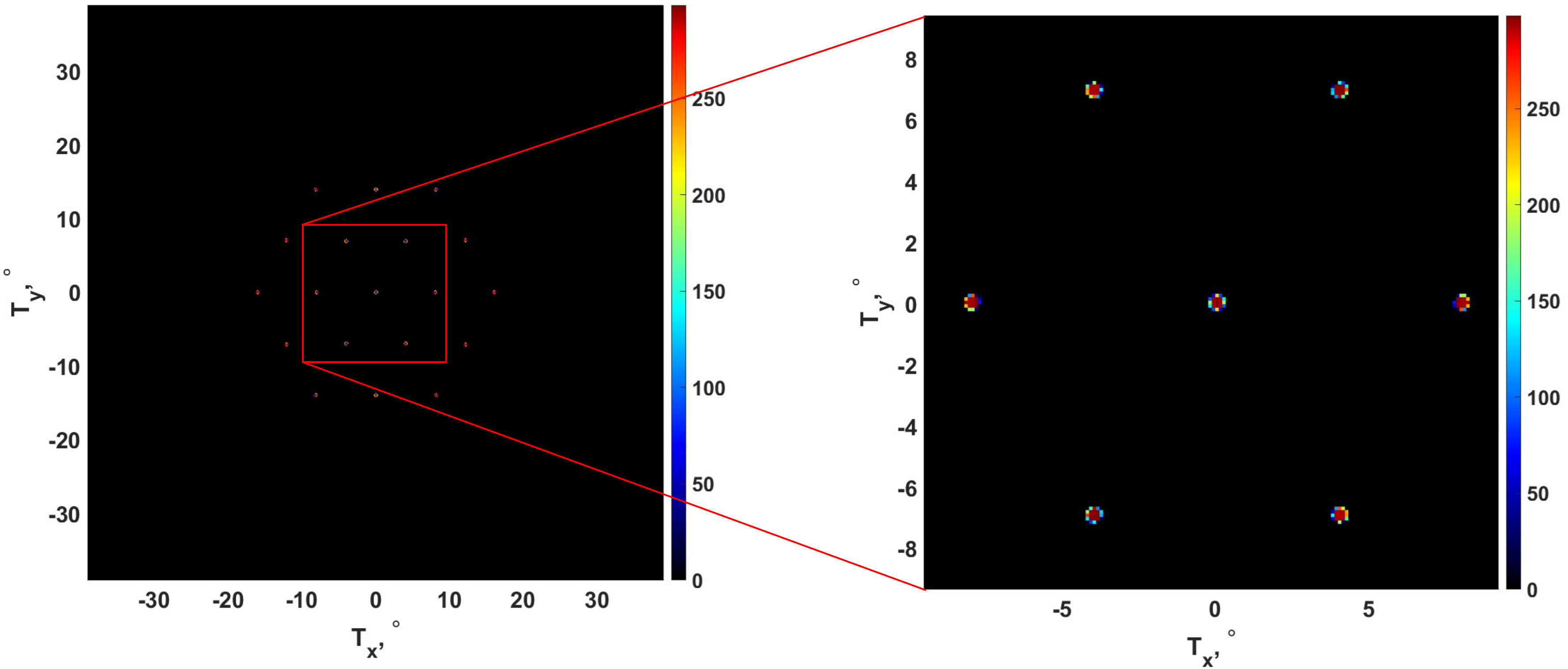
Minimum configuration



Measuring the direction of arrival of an EAS by the time of arrival of the Cherenkov light front

Background estimation

Field of view of one (central) pixel



Background estimation

Since the useful signal is usually formed by only one lens and the background signal is collected by all detector lenses simultaneously, it is necessary to estimate the signal/background ratio.

Sky background (from SIT telemetry)	3×10^{11} photoelectrons/m^2 × steradian
Photon flux per 0.5 degree cell in 100 ns	< 6 photoelectrons
SiPM quantum efficiency	33%
Background fluctuation	1-2 photoelectrons (NB: cross-talks!)

Even with 10 pixels triggered in one 1 PeV event on 100 m distance from EAS axis, the average signal level in the pixels will be 10 times higher than the background.

Conclusion

1. A design for a wide-angle ground base detector with high angular resolution for PCR mass composition study above 1 PeV energy is proposed.
2. The optical parameters of the proposed detector meet the requirements for angular resolution.
3. Evaluation of the influence of the background of the starry sky shows the possibility of registering EAS events from particles with an energy of 1 PeV.

Thank you for
your attention!