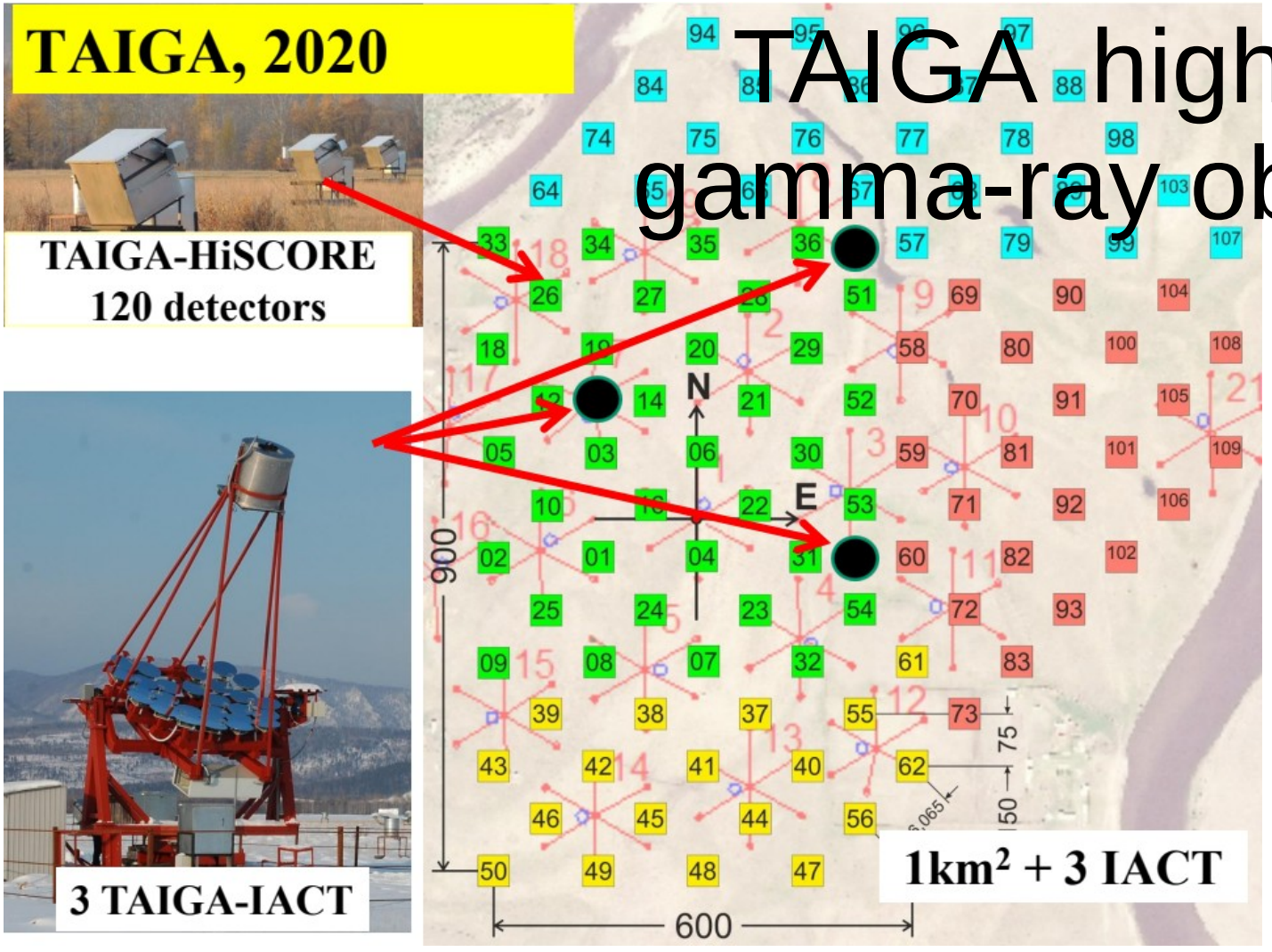
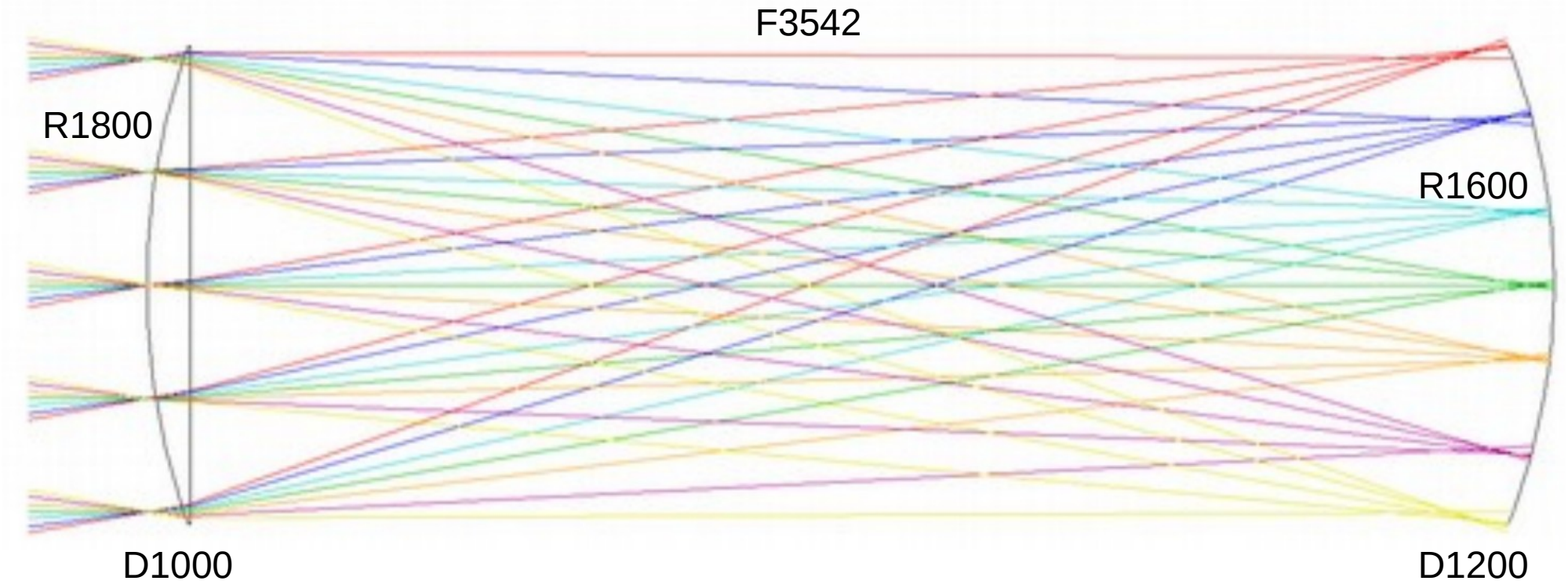
Optical system with SiPM-based camera for the TAIGA hybrid installation

Dmitry Chernov, Andrey Grinyuk
for TAIGA collaboration

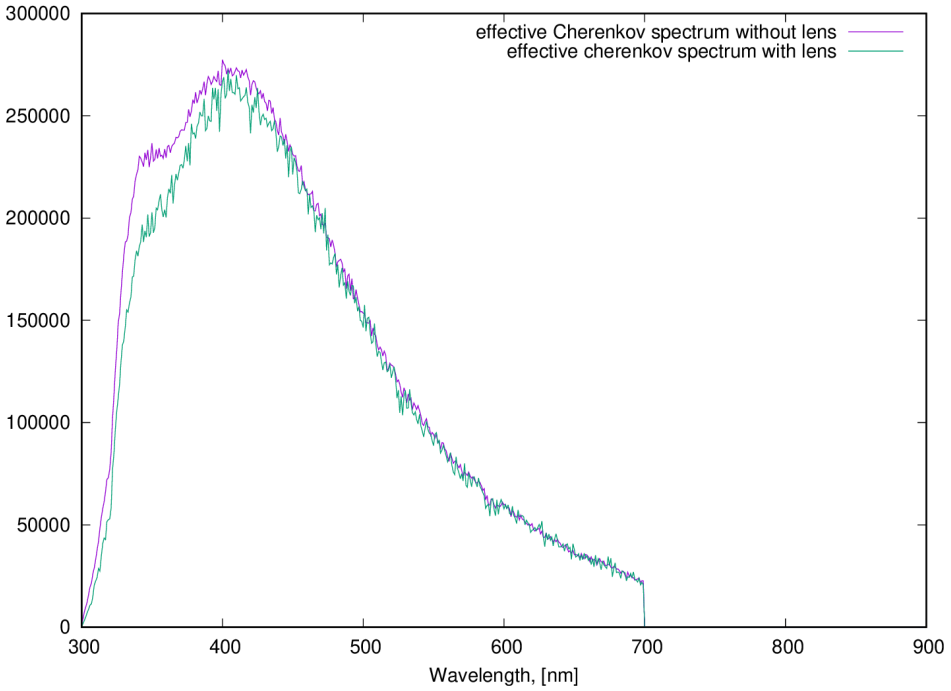
TAIGA high energy gamma-ray observatory



Proposed optical scheme of small wide angle SiPM telescope



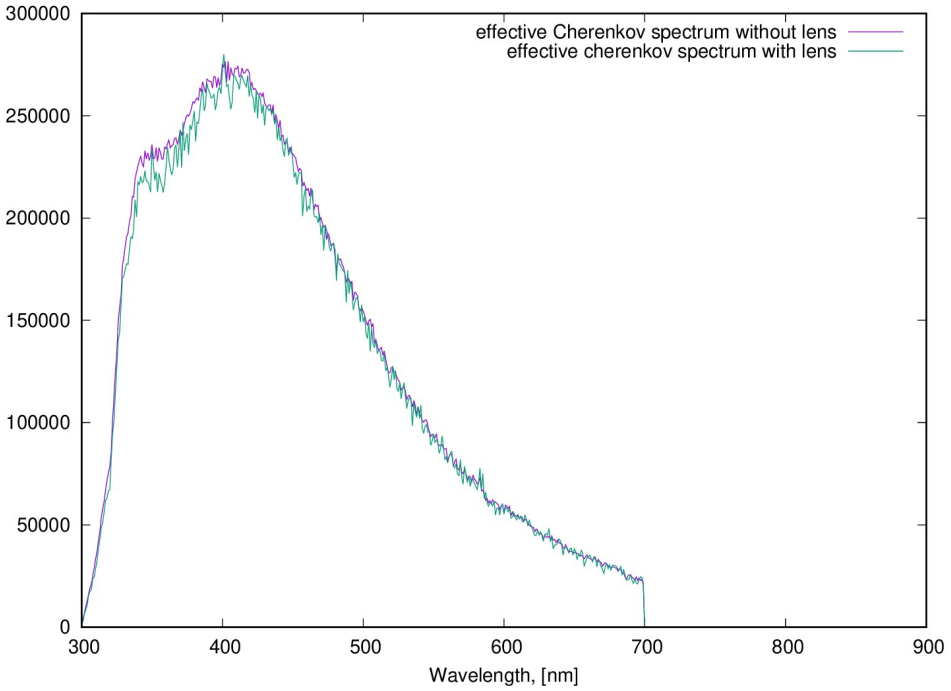
Effective Cherenkov spectrum



Spectrum of Cherenkov photons
taken from CORSIKA output files
and convoluted with atmospheric absorption
and SiPM quantum efficiency

With simple lens, 45 mm thickness in the center

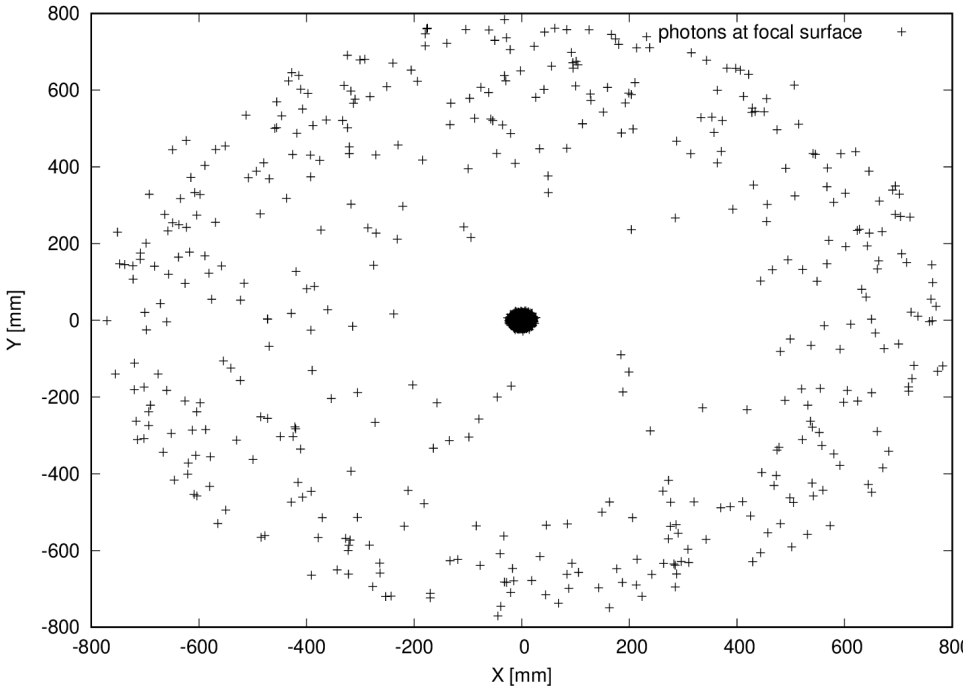
Effective Cherenkov spectrum



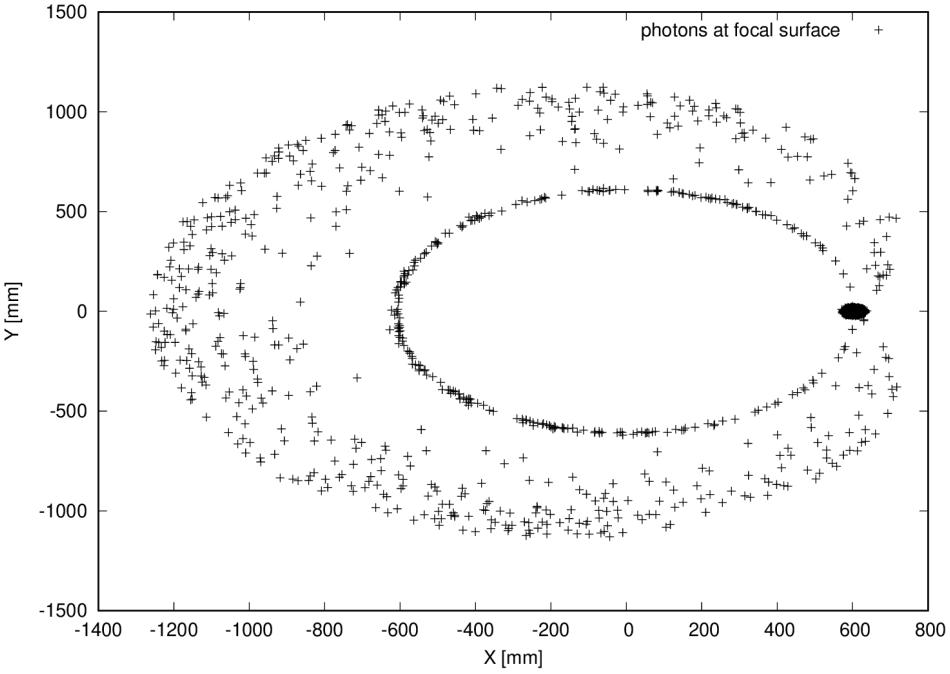
Spectrum of Cherenkov photons
taken from CORSIKA output files
and convoluted with atmospheric absorption
and SiPM quantum efficiency

With Fresnel lens, 5 mm maximum thickness

Parasitic reflections on Fresnel lens



On-axis



10° off-axis

Focal point and radial distribution

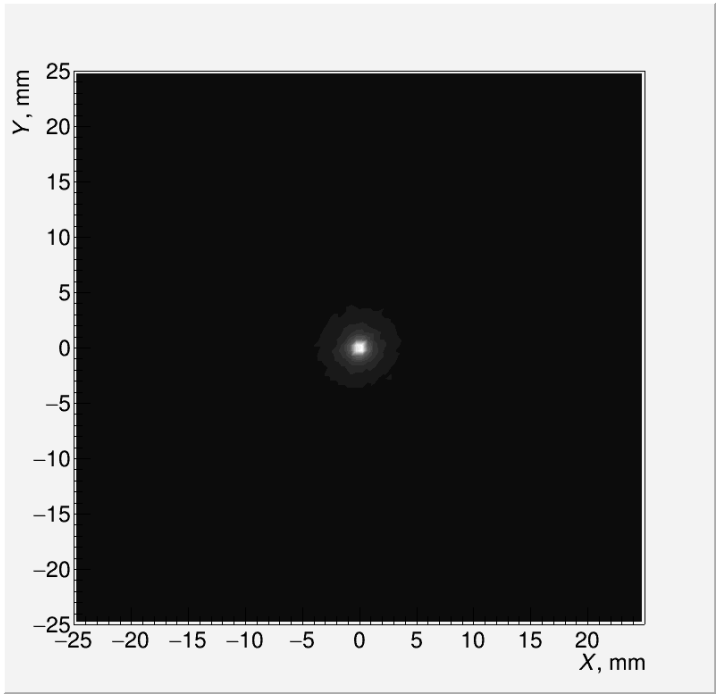
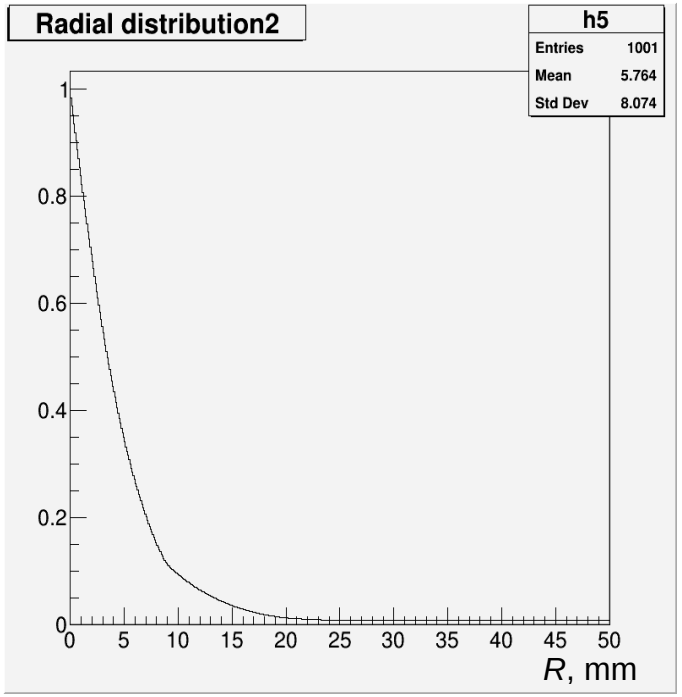


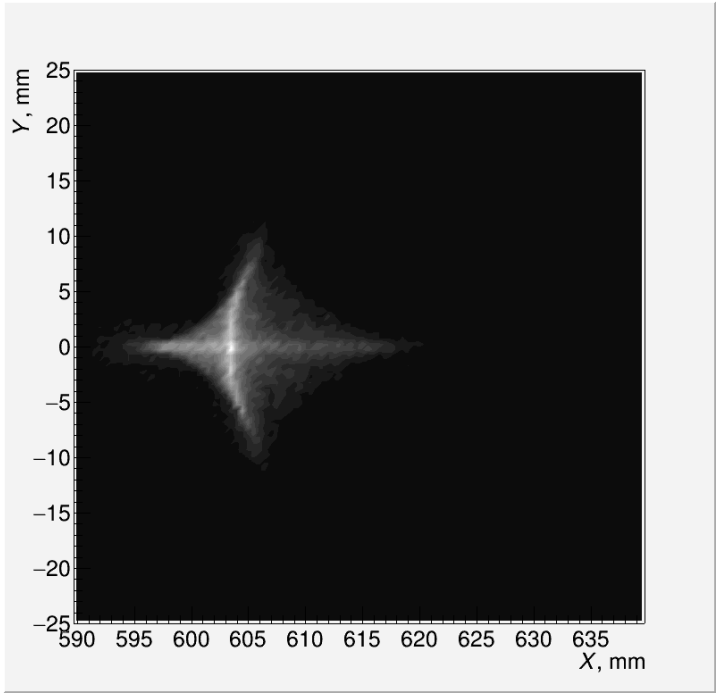
Image of focal point

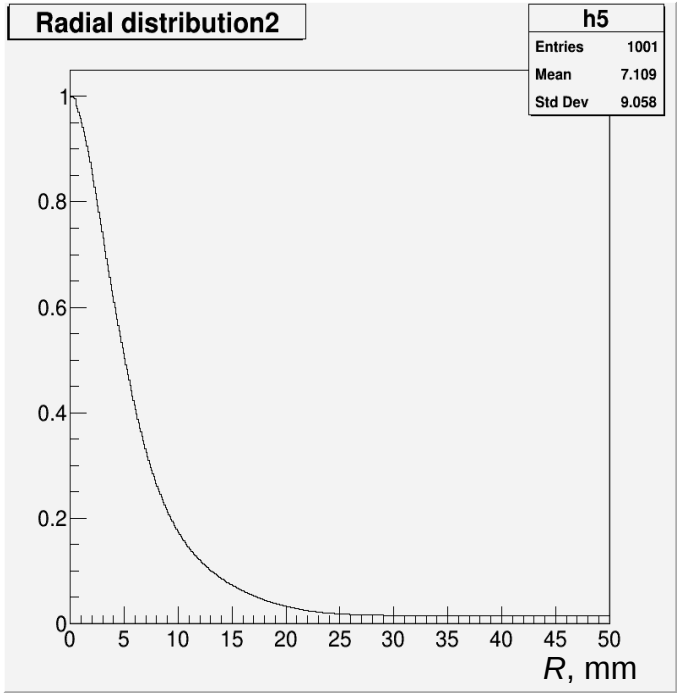


Light outside of circle of given radius

Fresnel lens,
D800, on axis

Focal point and radial distribution





Fresnel lens,
D800, 10° off-axis

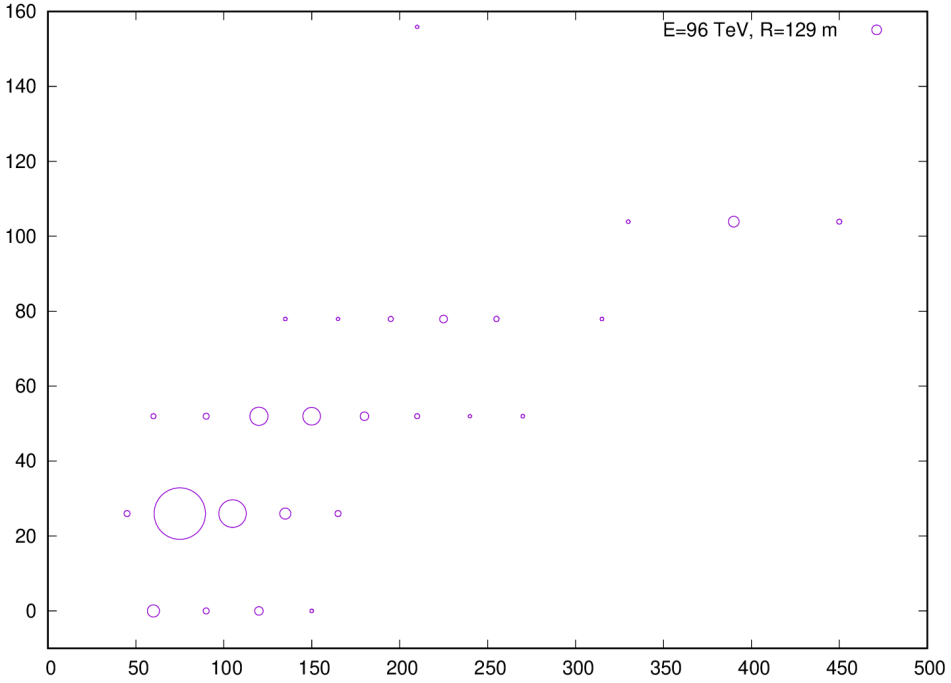
Image of focal point

Light outside of circle of given radius

Summary table

Lens type	R80, 0°, [mm]	R80, 8°, [mm]	R80, 10°, [mm]	Pass, 0°	Pass, 10°	reflection, 0°	reflect, 10°
Simple convex-planar, D800	7.7	7.8	8.6	0.800	0.781	0	0
Fresnel, D800	7.2	8.2	9.4	0.891	0.886	0.9%	2.0%
Fresnel, D1000	11.1	13.4	14.8	0.890	0.884	1.3%	2.9%
Fresnel lens, 2 zones, D800	7.3	7.9	8.9	0.823	0.814	0.7%	1.8%
Fresnel, D800, flat focal	7.2	14.8	20.5	0.892	0.888	0.9%	2.0%
Fresnel, D1000, flat focal	11.1	22.9	30.4	0.892	0.884	1.4%	2.8%

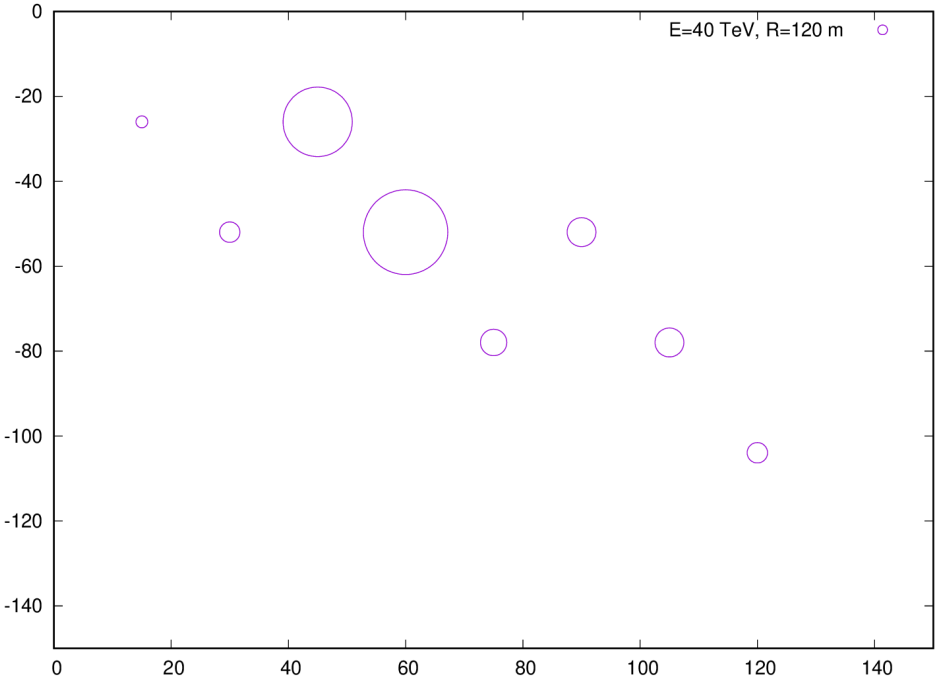
Examples of simulated events (without background)



Primary gamma

Area of the circles proportional to number of photoelectrons

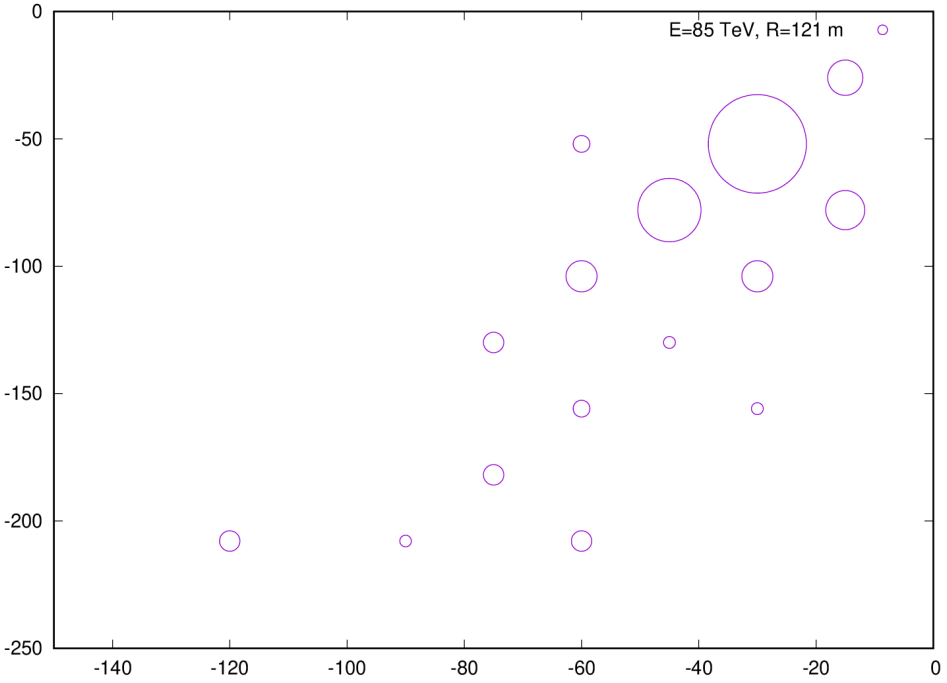
Examples of simulated events (without background)



Primary gamma

Area of the circles proportional to number of photoelectrons

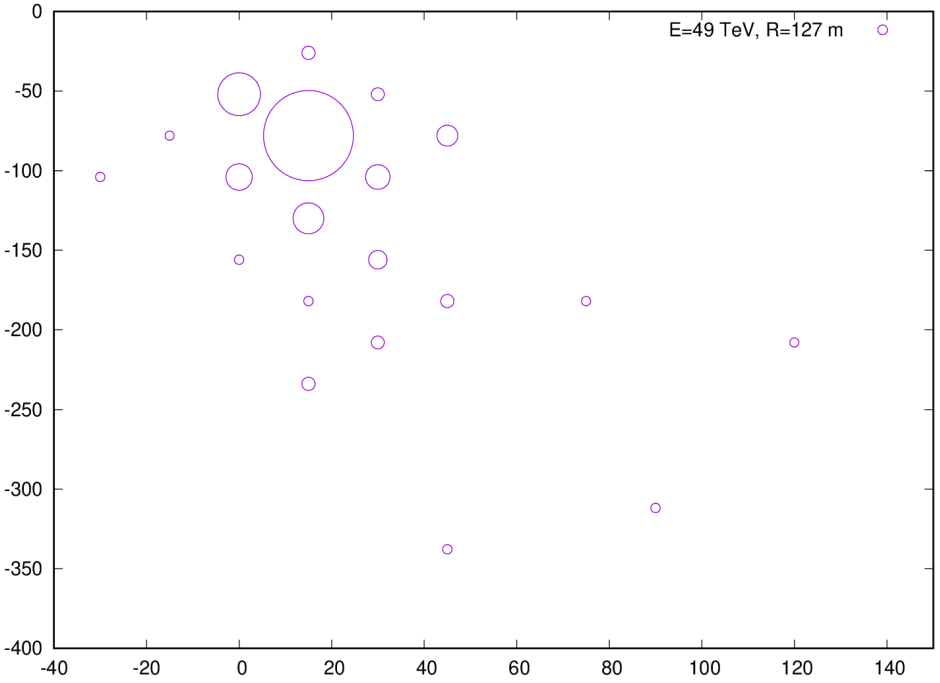
Examples of simulated events (without background)



Primary gamma

Area of the circles proportional to number of photoelectrons

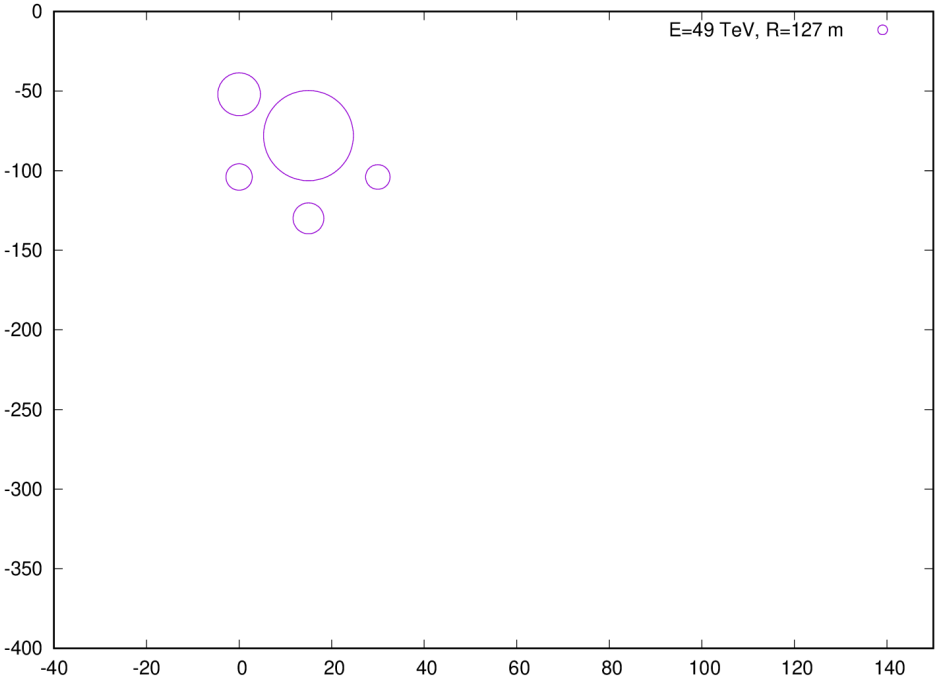
Examples of simulated events (without background)



Primary gamma

Area of the circles proportional to number of photoelectrons

Examples of simulated events (without background)



Primary gamma

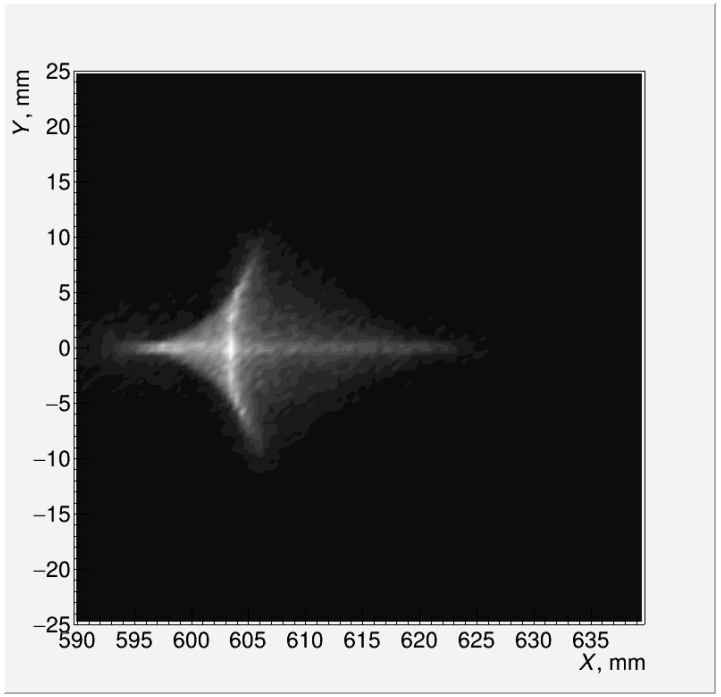
Area of the circles proportional to number of photoelectrons

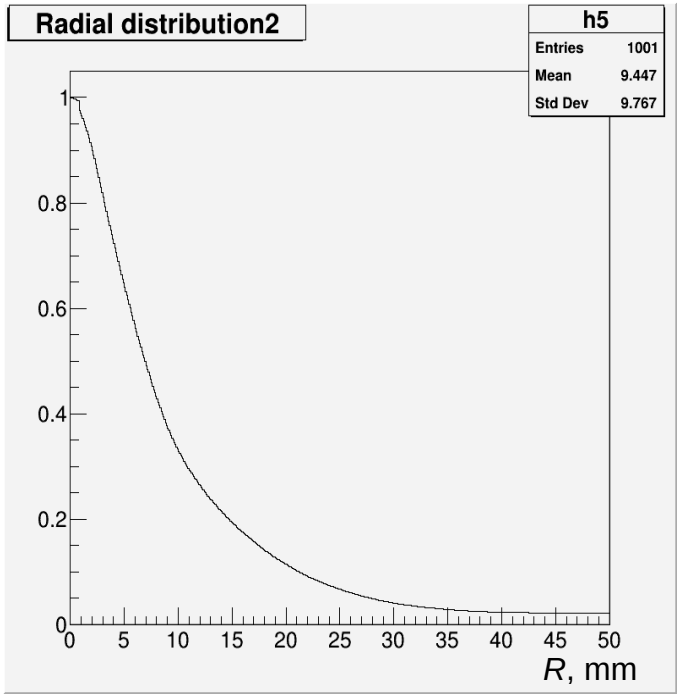
Previous event but with image cleaning >5 photoelectrons

Conclusions

- Thin Fresnel lens can be a preferred alternative to any thick lens.
- Blackening of vertical ridges of Fresnel lens may be useful but not absolutely necessary.
- Curved focal surface provides significant benefits for wide angle telescopes.
- It is possible to find image broadening along different axes depending on the position on the camera and use it to correct event reconstruction.

Focal point and radial distribution



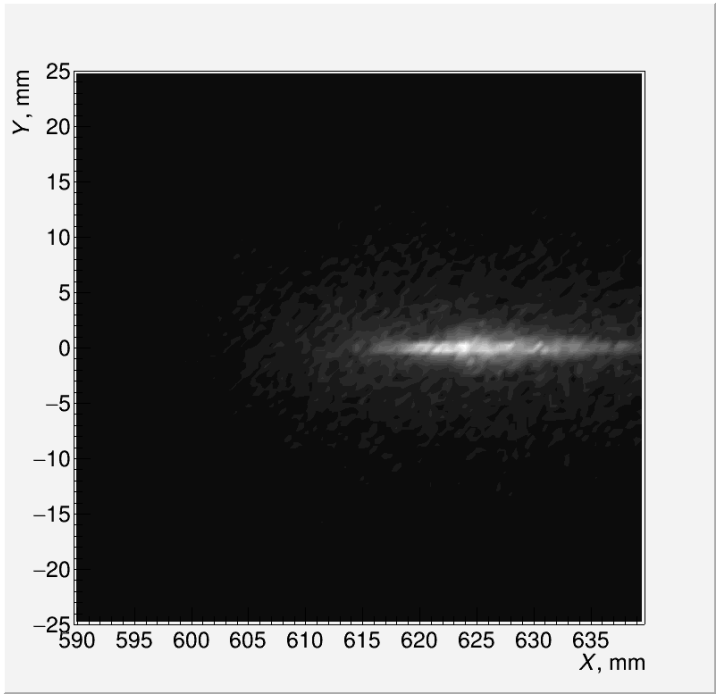


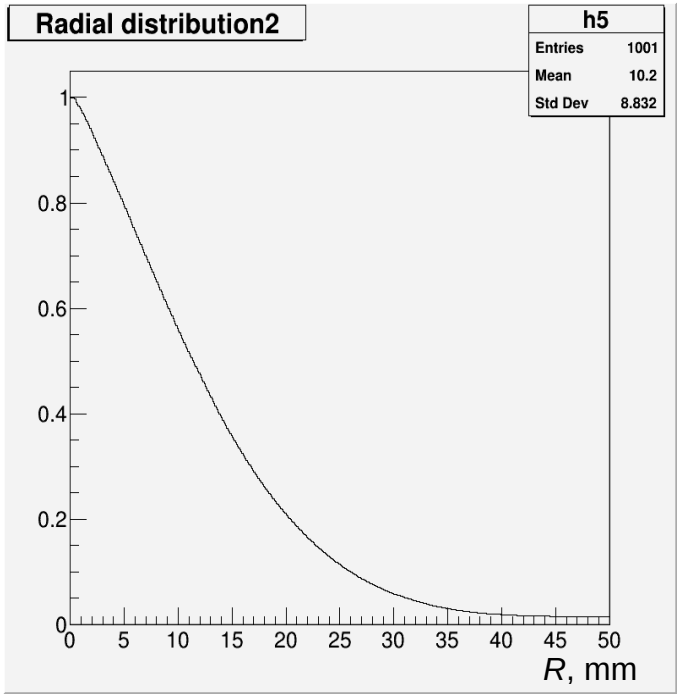
Fresnel lens,
D1000, 10° off-axis

Image of focal point

Light outside of circle of given radius

Focal point and radial distribution





Fresnel lens,
D800, 10° off-axis
flat focal surface

Image of focal point

Light outside of circle of given radius