Performance of the SST-1M telescope for the Cherenkov Telescope Array Observatory

R. Moderski[1], M. Chruślińska[2], A. Porcelli[3], E. Pueschel[4], P. Rozwadowski[2] and the SST-1M sub-consortium for the CTA Consortium[5]

[1]Nicolaus Copernicus Astronomical Center, Warsaw, Poland
[2]Astronomical Observatory, University of Warsaw, Poland
[3]DPNC, Universite de Geneve, Switzerland
[4]University College Dublin, Ireland
[5]see www.cta-observatory.org for full author & affiliation list

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ABSTRACT

The single mirror small-size telescope (SST-1M) is one of the telescope projects being proposed for the Cherenkov Telescope Array observatory by a sub-consortium of Polish and Swiss institutions. The SST-1M prototype structure is currently being constructed at the Institute of Nuclear Physics in Cracow, Poland, while the camera is being build at the University of Geneva, Switzerland. This prototype enables measurements of parameters having a decisive influence on the telescope performance. We present results of numerical simulations of the SST-1M performance based on such measurements. The telescope effective area, the expected trigger rates and the optical point spread function are calculated.

Introduction

The Cherenkov Telescope Array (CTA) observatory is an international initiative to build the next generation of ground-based very high energy gamma-ray instruments [1]. The single mirror small-size telescope (SST-1M) is one of the telescope projects proposed for the CTA by a consortium of Polish and Swiss institutions [2]. Its design is based on the Davies-Cotton concept. The prototype SST-1M telescope structure was installed at the Institute of Nuclear Physics in Cracow, Poland [3]. In parallel the SST-1M camera is being constructed at the University of Geneva [4]. This camera utilizes silicon photomultipliers and fully digital read-out and trigger electronics. The readout and trigger parts, called DigiCam, are developed in Poland [5].

Optical point spread function

The telescope optical point spread function (PSF) has been estimated using ray-tracing feature of the sim_telarray software [6] and taking into account measurements of the first 14 (out of 18) mirror facets delivered for the prototype. An average spot size D_{80} at twice the telescope focal length of 5.7±1.1 mm together with average focal length of the mirror facets 5.60±0.03 m have been measured. Results of the simulations of the PSF are presented in Fig. 1.

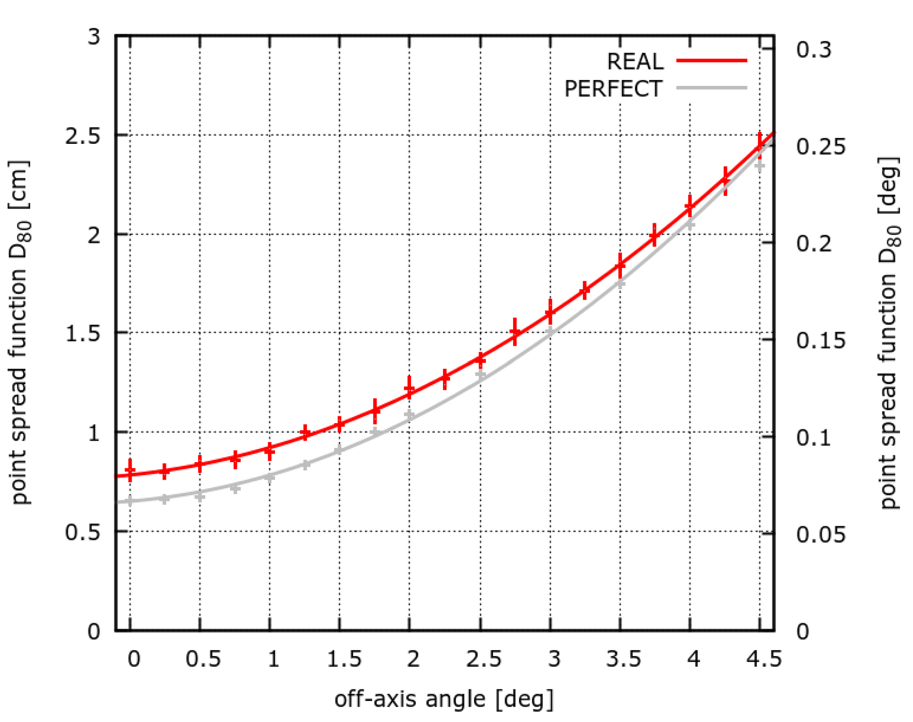

Fig. 1: Comparison of PSF dependence on off-axis angle for both perfect and real cases.

Night sky background trigger rate

In the CTA framework the so called "dark night" conditions correspond to the nigh sky background (NSB) level of 33.2 x 10^6 ph s^{-1} per pixel for the SST-1M telescope. Numerical simulations have been used to estimate the trigger thresholds necessary to lower the NSB trigger rate below 20 kHz – limit resulting from the SST-1M camera internal bandwidth. Results are presented in Fig. 2.

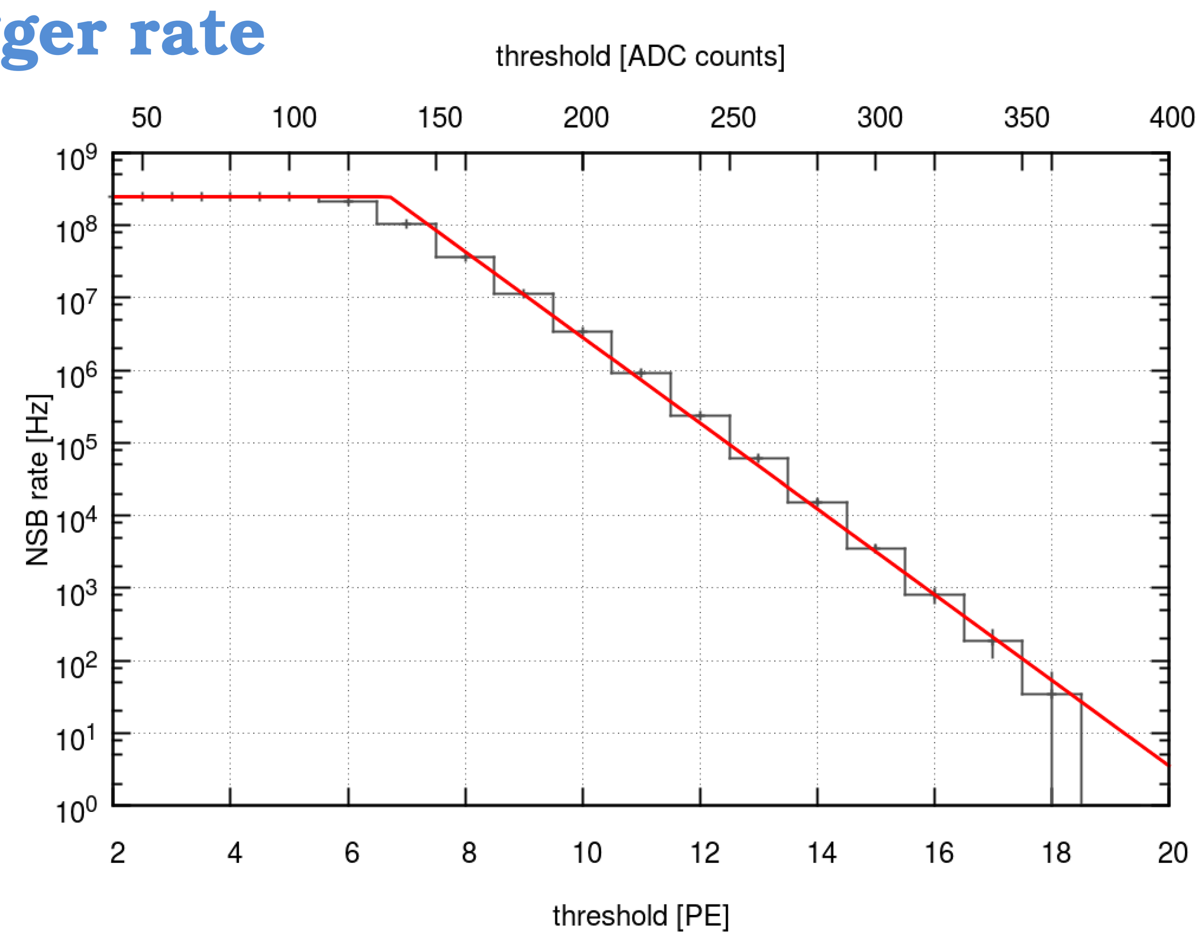

Fig. 2: Night sky background trigger rate as a function of trigger threshold for SST-1M telescope.

Effective area and gamma-rays rate

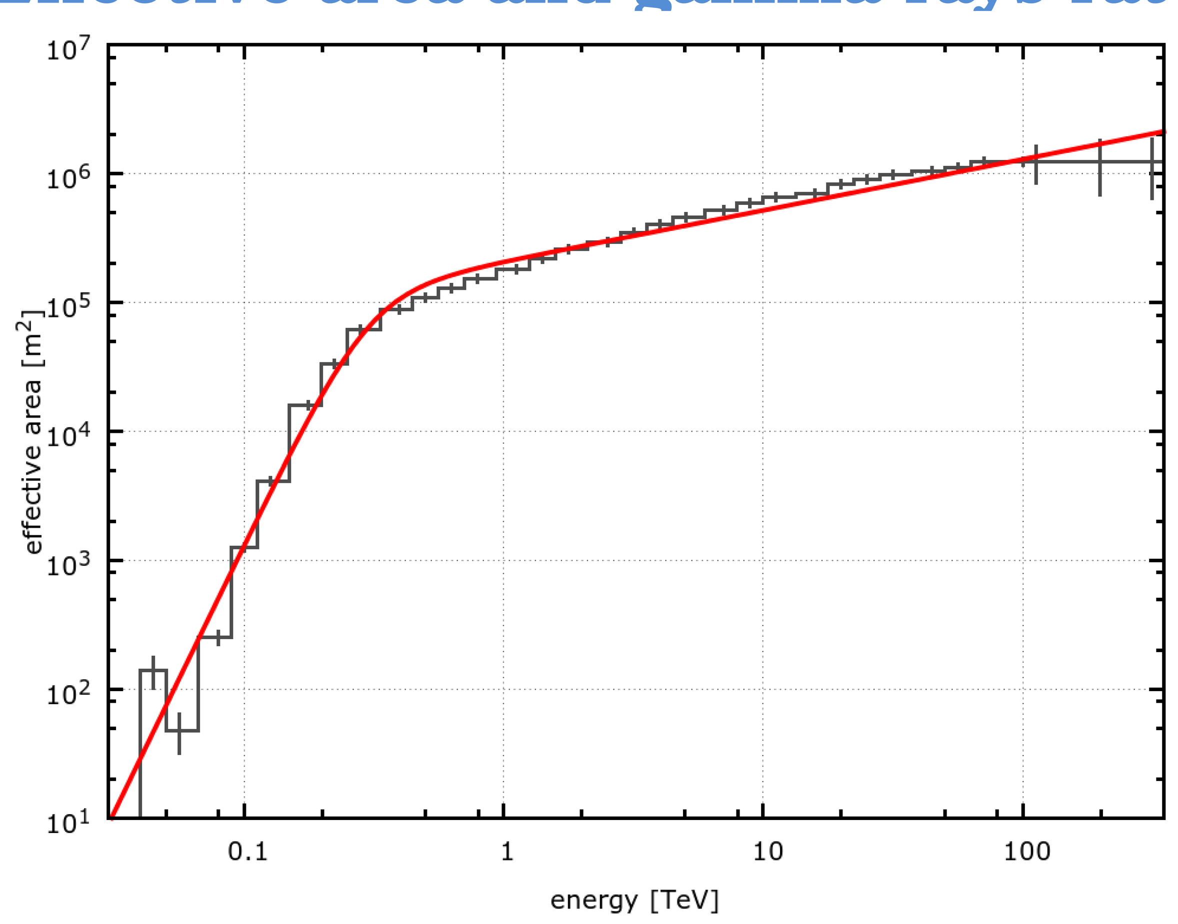

Fig. 3: SST-1M telescope effective area as a function of energy.

A total number of 1.6 x 10^7 gamma-ray showers within energy range 0.05-320 TeV has been simulated with CORSIKA software to estimate the effective area of the SST-1M telescope for a point-like gamma-ray source and trigger threshold of 17.2 PE. The result is presented in Fig. 3. To estimate the expected gamma-ray trigger rate the above effective area has been folded with a Crab-like source spectrum resulting in the total expected gamma-ray rate of 0.27 Hz.

Summary

Results show that a network of SST-1M telescopes is a valuable proposal for one of the sub-arrays of the small size telescopes for the CTA Observatory. In the near future SST-1M parameters estimated during presented studies will be used in a massive numerical simulations of the whole CTA array to determine the final performance characteristics of the SST-1M sub-system.

References

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