The SST-1M project: *Past, Present and Future*

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cta — cherenkov telescope array

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ABSTRACT

The SST-1M project, run by a Consortium of institutes from Czech Republic, Poland and Switzerland, has been proposed as a solution for implementing the small-size telescope array of the southern site of the Cherenkov Telescope Array. The technology is a pathfinder for efficient production of cost-effective imaging air Cherenkov telescopes. We report on the main system features, the performance validation, the operation campaign carried out in 2018 and the future installation at the Ondrejov Observatory in Czech Republic.

The SST-1M telescope [1]

Optics	Focal Length	5600 ± 5 mm
	f/D	1,4
	Dish diameter	4 m
	Mirror Area (*)	9.42 m^2
	Mirror Effective Area (*)	6.47 m^2
	Hexagonal Mirror facets	780 ± 3 mm
	Mirror PSF D_{80} (requirement)	$0.082°$ (8.1 mm)
	Mirror PSF D_{80} (measured)	$0.028°$ (2.7 mm)
	Telescope PSF D_{80} (required)	$0.25°$ (24.4 mm)
	Telescope PSF D_{80} (measured) On-Axis	$0.082°$ (8 mm)
Camera	Camera dimensione (R/thickness)	810 mm / 900 mm
	Total pixel number	1296
	Pixel linear size	23.4 mm
	Pixel angular size	$0.24°$
	FoV	$8.9°$
	PDE@470 nm, 8% X-talk (LCT/LVR)	23% / 54%
	Sampling frequency	250 MHz
	Maximum trigger rate (80/200 ns window)	12.5 / 5 MHz
	Maximum readout rate (80/200 ns window)	22.6 / 9.4 kHz
	Time Spread RMS	< 0.25 ns
Structure & Drive	Telescope height pointing horizontally	$4908 + 400$ mm
	Telescope height pointing vertically	$9828 + 400$ mm
	Telescope length pointing horizontally	9098 mm
	Telescope width	3310 mm
	Elevation range	$-16° - 97° (\pm 1°)$
	Azimuth range	$\pm 280° (\pm 1°)$
	Max, Min speed	1, 4000 rpm
	Gear ratio	2800
	Oscillation modes	2.8 / 3.4 / 3.8 Hz
	Total Weight	**8.6 t**

Tab 1: Key characteristics of the SST-1M telescope

Fig. 1: SST-1M telescope in IFJ-PAN Krakow
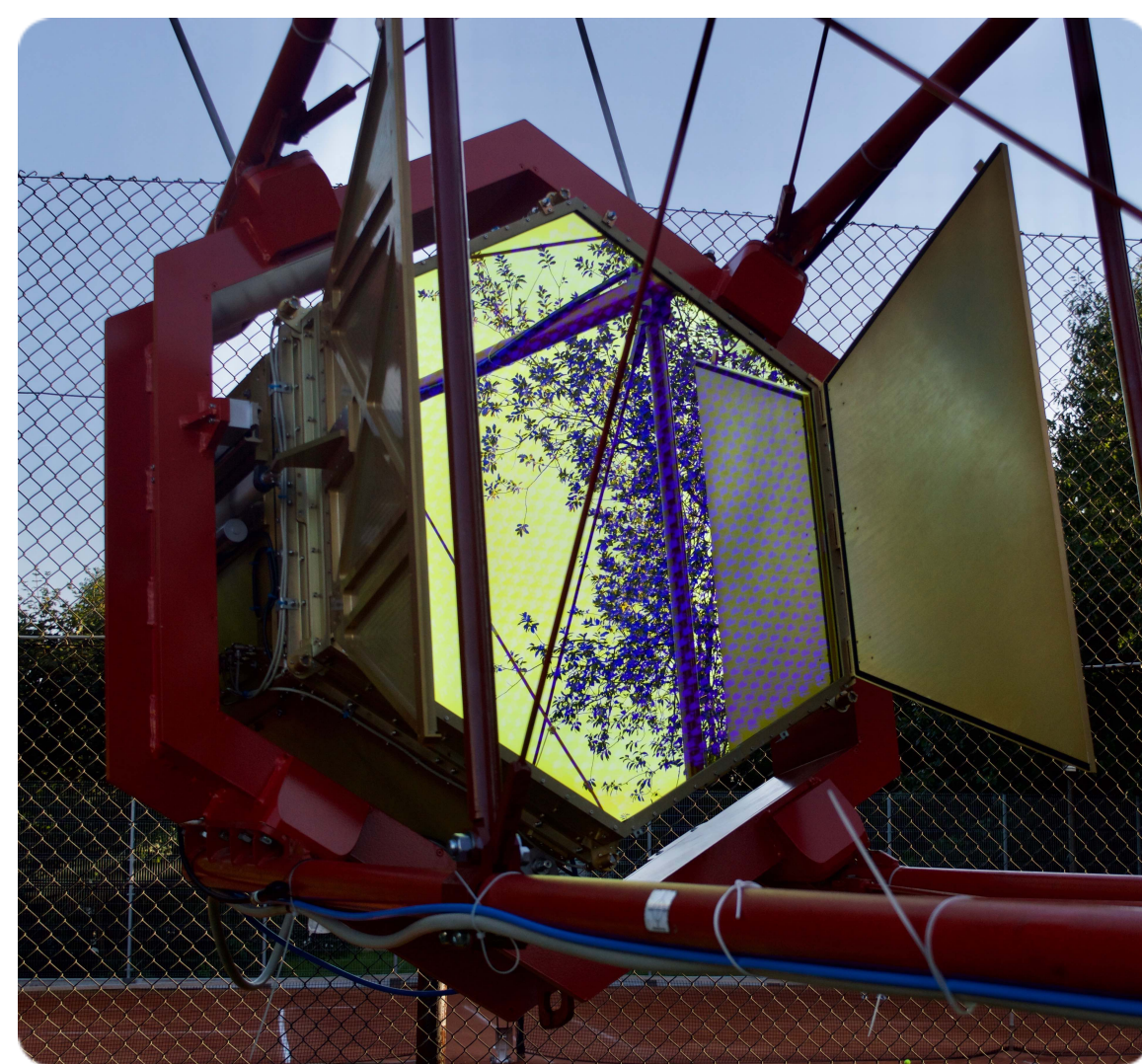
Fig. 2: SST-1M camera assembled at University of Geneva

High-performance SiPM camera [2] developed at UNIGE-DPNC in collaboration with Poland

Featuring hexagonal SiPM from Hamamatsu coupled to a hollow light-guide, the SST-1M pixels are readout by a custom front-end electronics and connected to a fully digital readout.
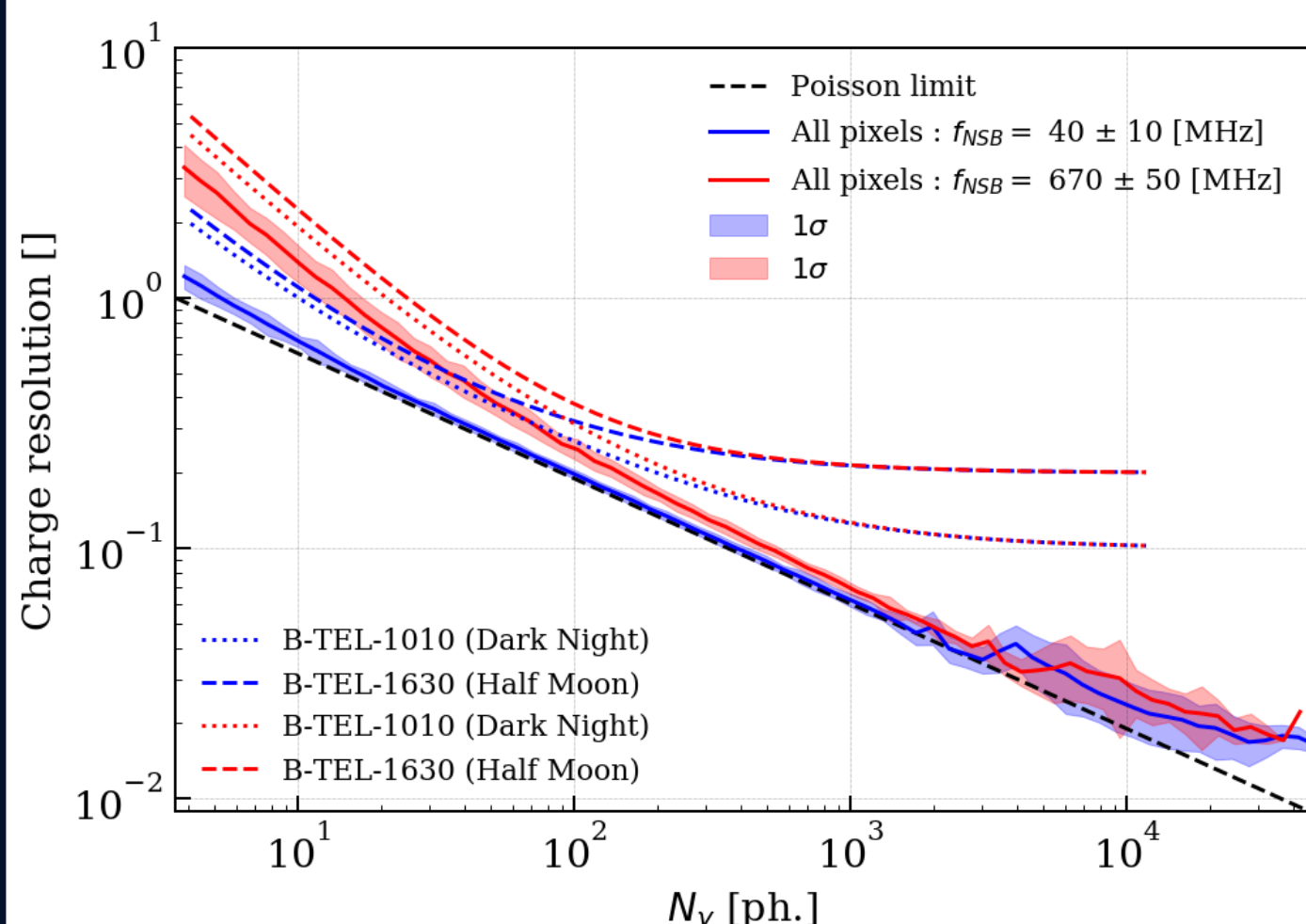
Fig. 3: Charge resolution as function of true photons in different NSB conditions [3]
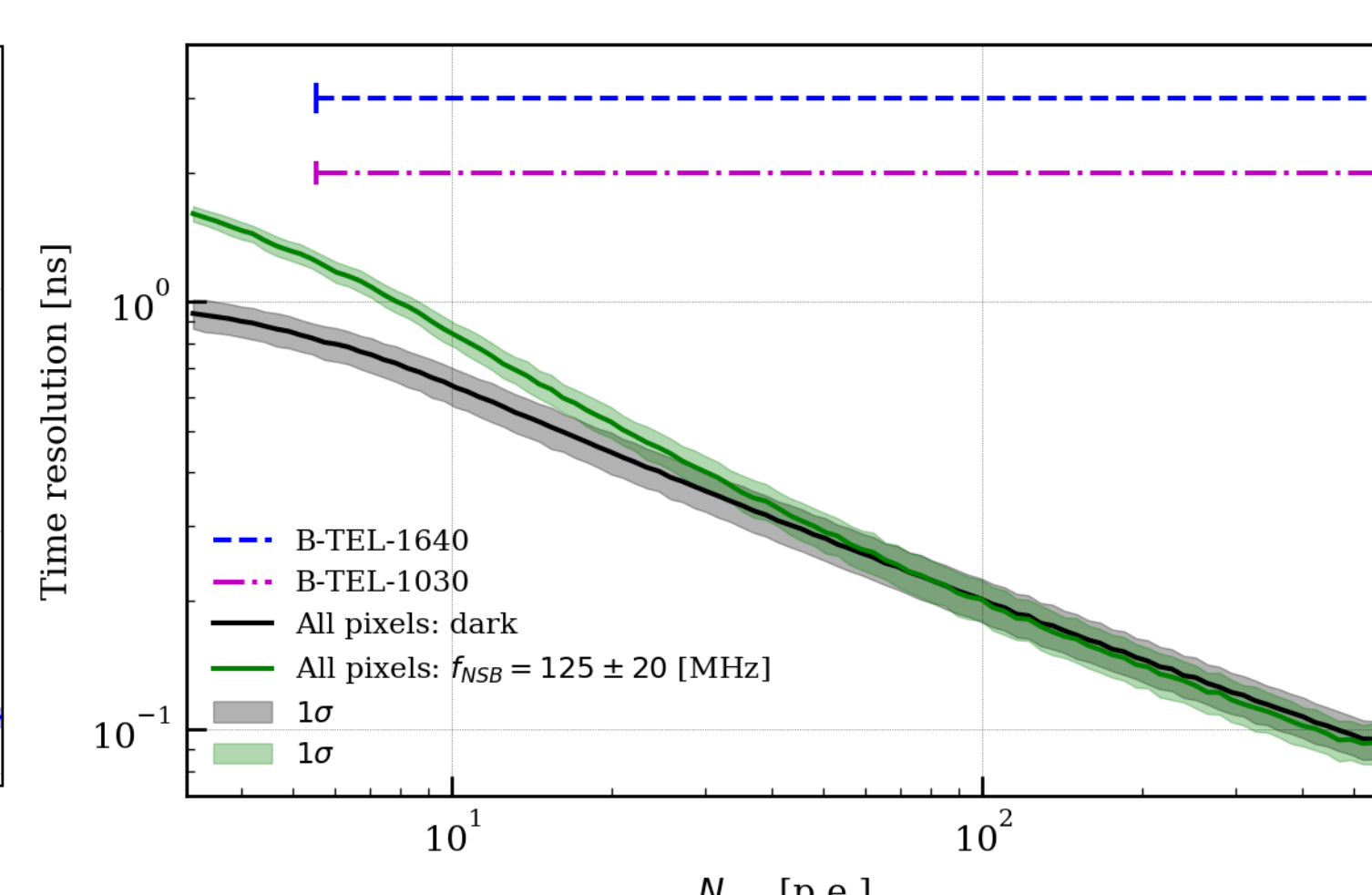
Fig. 4: Time resolution as function of number of photo-election in different NSB conditions [3]

Telescope control and file writing software [4] developed at UNIGE-ASTRO

Built around the Alma control software (ACS) and OPC-UA communication layers, the SST-1M control software allows to control the telescope entirely remotely. Observation and calibration procedures are implemented through the telescope master and can be easily altered through a flexible scheduler.

SST-1M observations in Krakow

Despite the large light pollution at the site (~1 GHz/pixel of NSB in commercial district of Krakow), important work was carried out on commissioning and data/simulation validation on the pointing and on the point spread function of the optical system, the trigger response and the overall performance. Simulation work assessed that a 5σ detection of Crab Nebula should be possible for 50h observation [5].
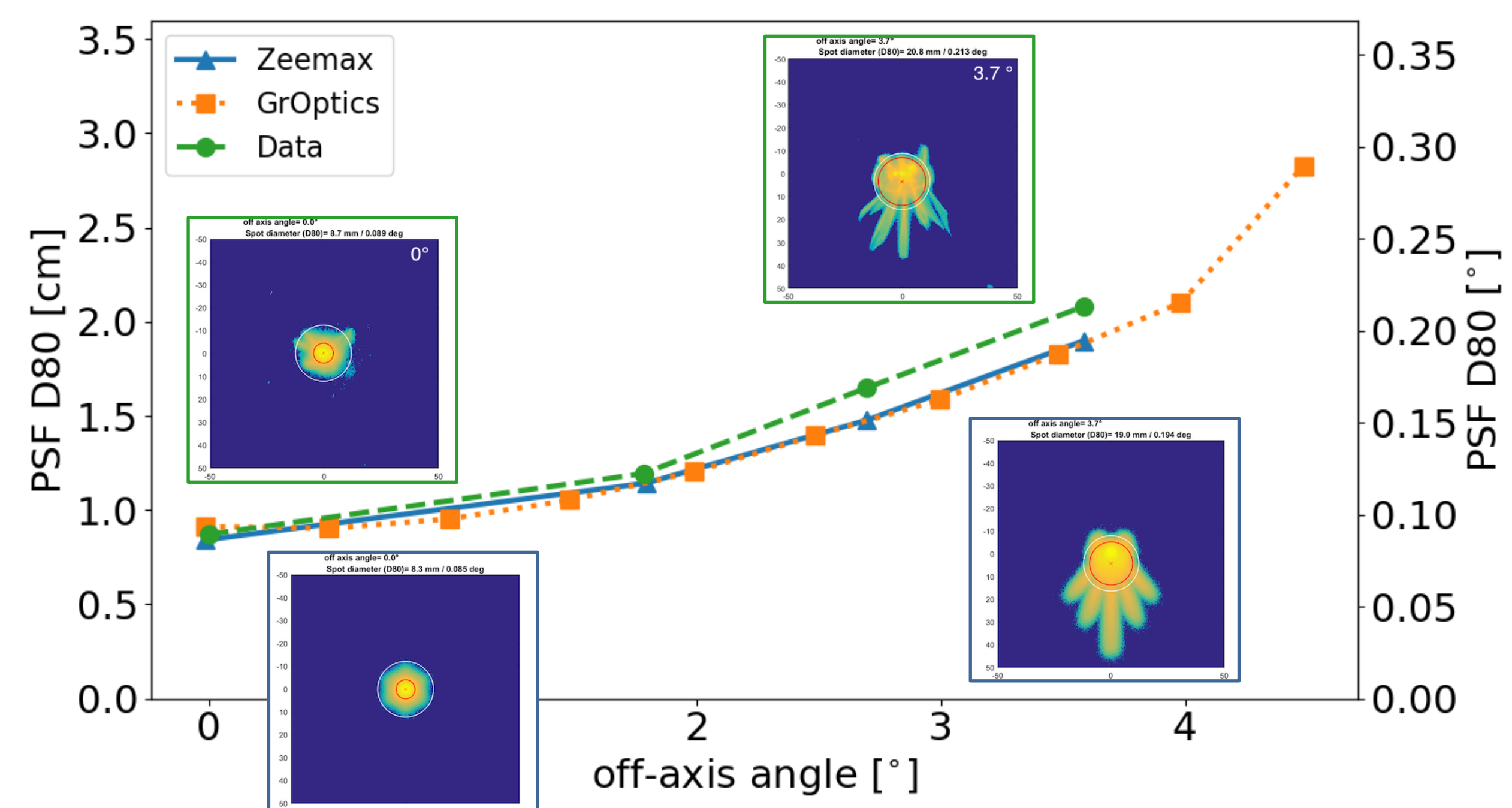

Fig. 5: Optics validation: comparison between data and simulation for the telescope PSF vs. off-axis angle

	Energy threshold [TeV]	Crab event rate [mHz]	Proton event rate [Hz]
All triggered	2.692	5.722	8.957
After cleaning	3.641	2.447	2.678
Quality cuts	5.009	1.237	1.558
g/h separation	4.966	1.174	0.605

Tab 2: Expected event rates for the full telescope FoV and energy thresholds for Crab observation in Krakow [5]
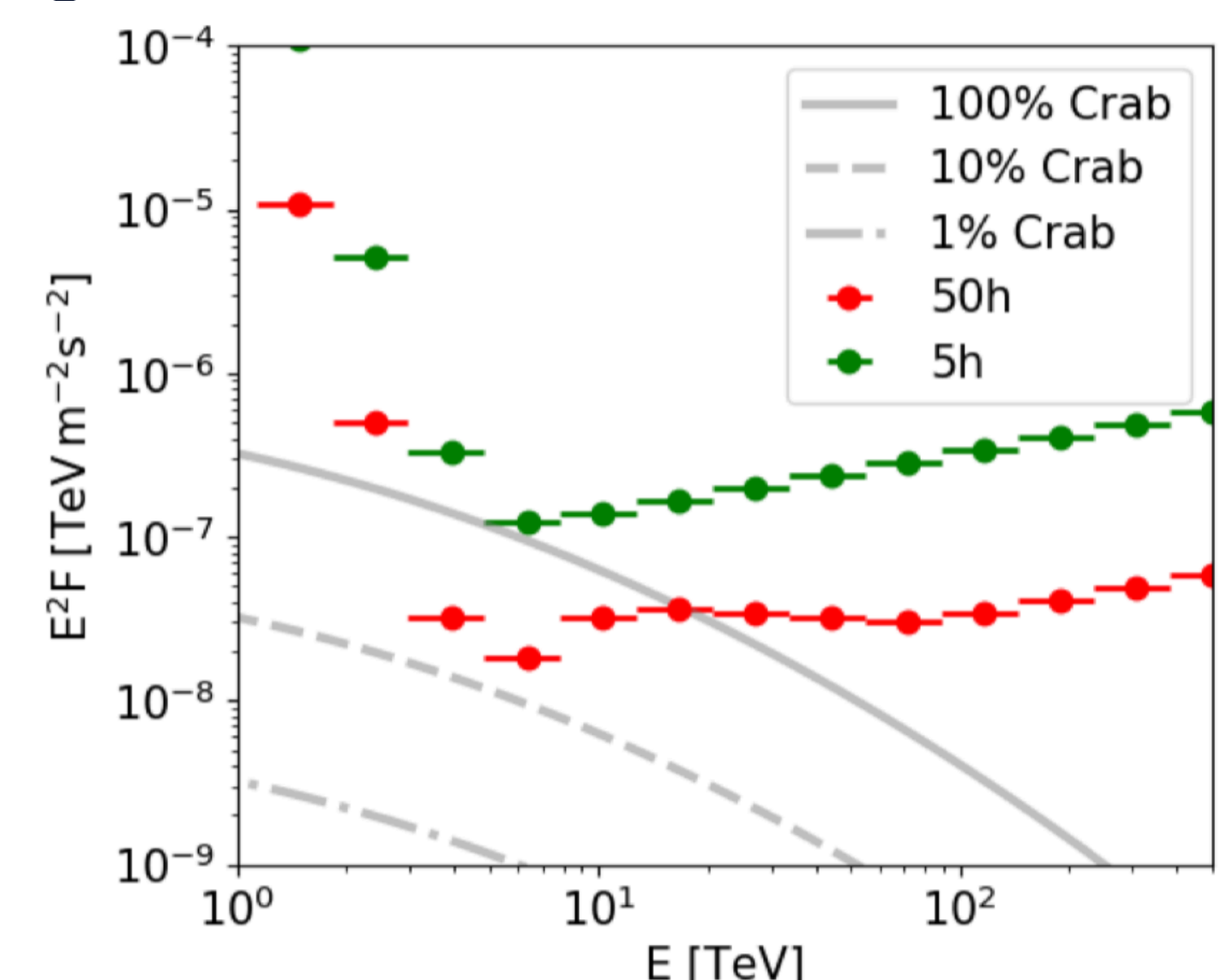

Fig. 6: Differential sensitivity of SST-1M prototype in Krakow in mono regime [5].

Future of SST-1M

Two telescopes will be installed at the Ondrejov observatory, 40 km from Prague, by the end of 2021. To be operated in stereo with 150 m distance. We will observe Crab Nebula and monitor blazars.

150 m

References:
[1] M. Heller et al., *The SST-1M project for the Cherenkov Telescope Array*, PoS, ICRC 2019
[2] M. Heller et al., *An innovative silicon photomultiplier digitising camera for gamma-ray astronomy*, Eur. Phys. J. C, 2017
[3] C. Alispach et al., *Large scale characterisation and calibration stagy of a SiPM-based camera for gamma-ray astronomy*, JINST, Vol. 15, 2020
[4] V. Sliusar et al., *Control software for the SST-1M Small-Size Telescope prototype for the Cherenkov Telescope Array*, PoS, ICRC 2017
[5] J. Jurysek et al., *Monte Carlo study of a single SST-1M prototype for the Cherenkov Telescope Array*, PoS, ICRC 2019

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