A Camera for the Small Sized Telescopes of the Cherenkov Telescope Array

cherenkov telescope array

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ABSTRACT

CTA will use three telescope sizes to efficiently detect cosmic gamma rays in the energy range from several tens of GeV to hundreds of TeV. The Small-Sized Telescopes (SSTs) will form the largest section of the array, covering an area of many square km on the CTA southern site in Paranal, Chile. The SSTs will provide unprecedented sensitivity to gamma rays above 1 TeV and the highest angular resolution of any instrument above the hard X-ray band. The SSTs will be a dual-mirror design with ~4 m primary reflector and equipped with a compact SiPM-based camera with full waveform readout from all 2048 channels.

Introduction

CTA has finalised the technology that will be used for the SSTs. The telescopes will be a dual-reflector, Schwarzschild-Couder, design, based on the ASTRI and CHEC prototype telescope structure and camera (Fig. 1, 2). The optical configuration leads to a large field of view and a small plate-scale (and consequently a compact, cost-efficient camera) (Fig. 3).

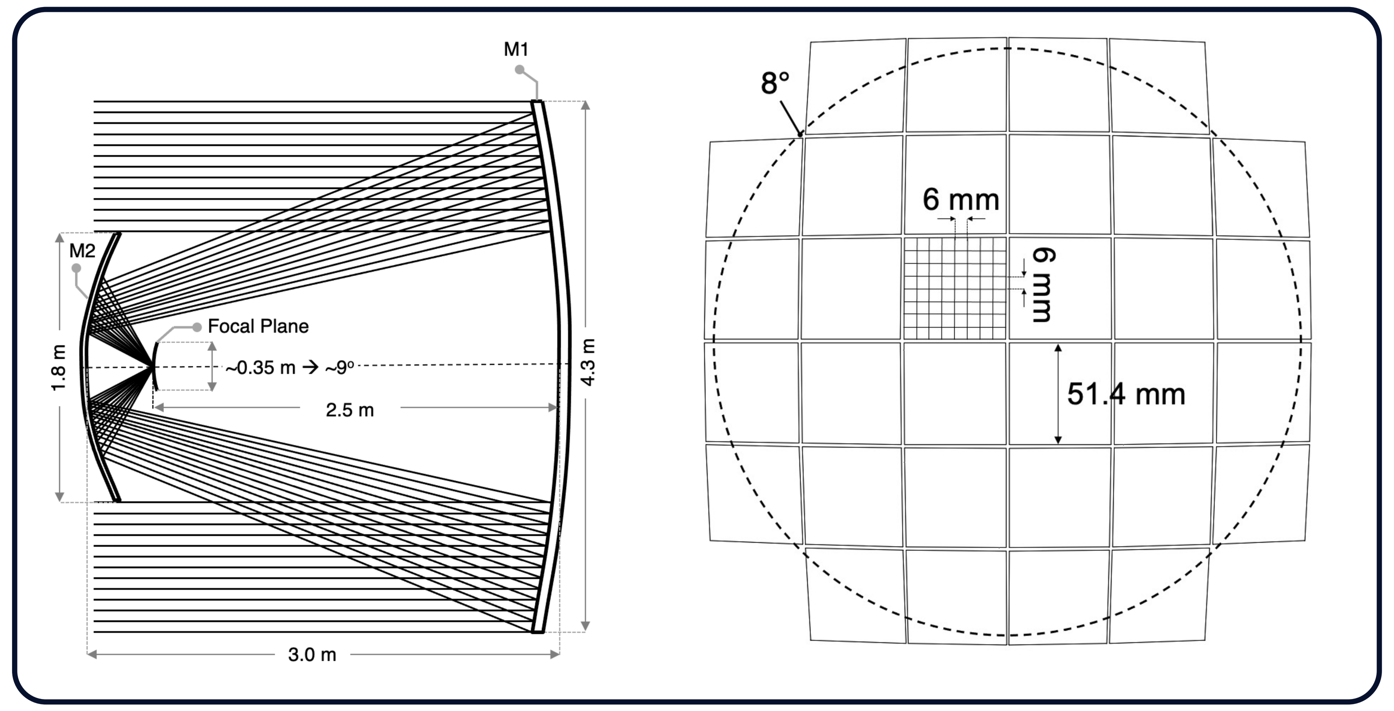

Fig. 3: Overview of the SST optical system and focal plane layout.

Fig. 1: The ASTRI-Horn prototype at the Catania Observatory.

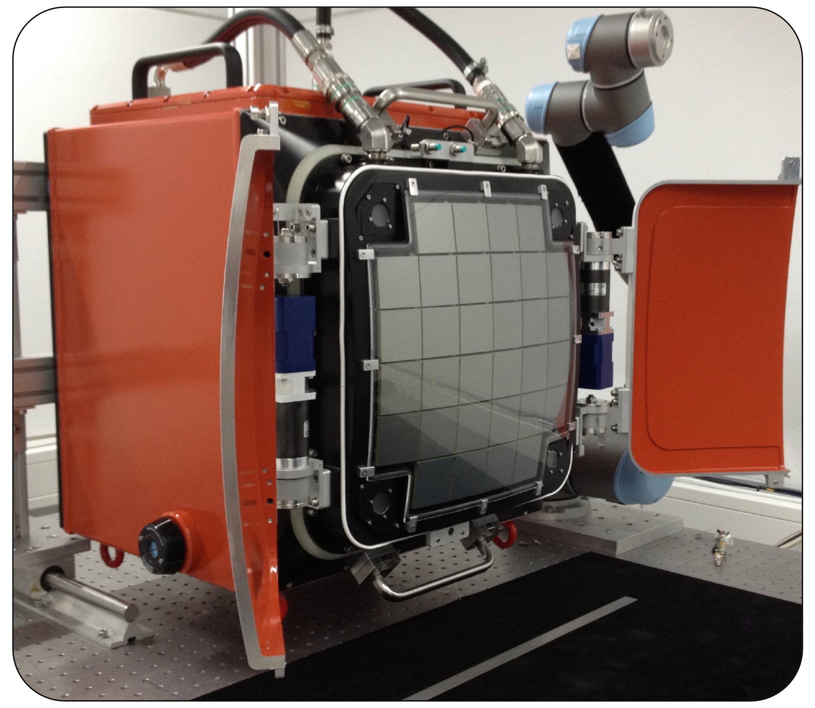

Fig. 2: The CHEC-S camera prototype undergoing laboratory tests.

Camera

The SST Camera (Fig. 4, 5) features 2048, 6 mm x 6 mm, SiPM pixels, implemented as 32 tiles arranged to approximate the curved focal plane and attached to electronics modules based on the TARGET ASICs for digitisation (at 1 GSa/s) and triggering. A backplane and timing board provide camera-level triggering with nanosecond precision and readout of 128 ns waveforms from all pixels on a 10 Gbps link. A door system & entrance window provide protection and minimise NSB transmission. LED flashers provide an internal calibration source. The camera is liquid cooled by an external chiller.

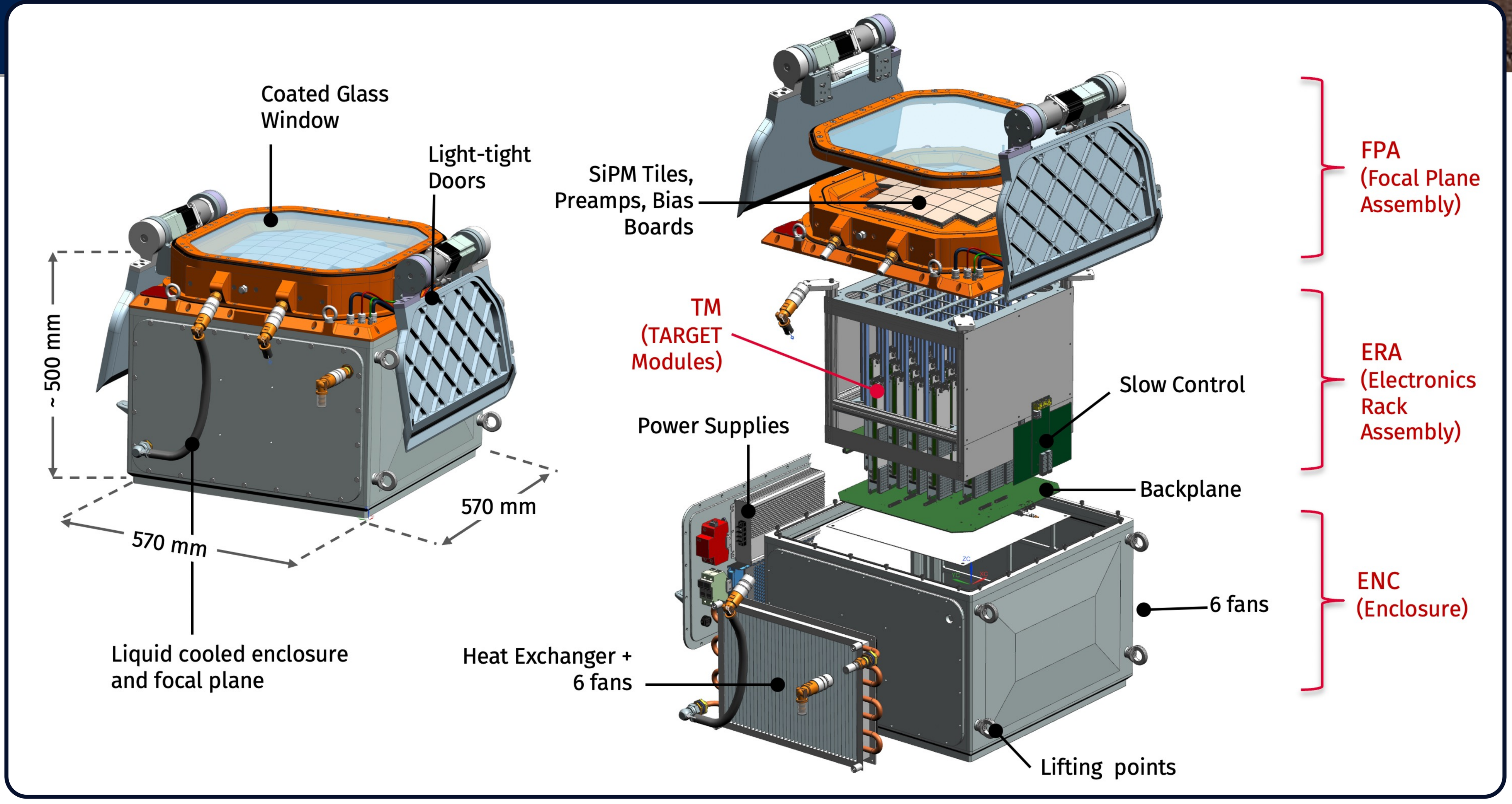

Fig. 4: An overview of the camera CAD indicating the major subsystems in red, integrated (left) and exploded (right).

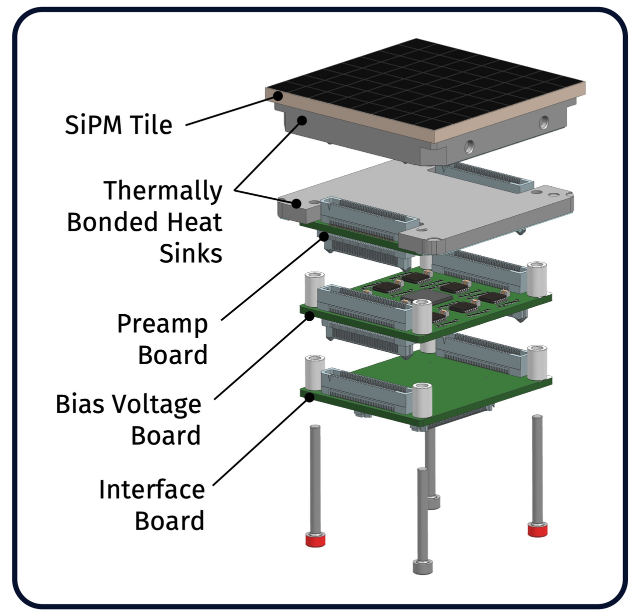

Fig. 5: CAD model of the SiPM and focal plane electronics. The 64-pixel custom Hamamatsu tile is thermally bonded to boards that supply per-pixel bias voltages and provide amplification. Behind these electronics sits the TARGET Modules that provide triggering and digitization.

On-Sky Verification

Preliminary verification of the SST concept was performed by installing CHEC-S on the ASTRI-Horn prototype in 2019. Over two observing campaigns the on-sky performance, interfaces, and camera installation procedure were investigated. Fig 6 shows a selection of Cherenkov images captured; comparison to simulations showed a good match, as did trigger rates vs. threshold for varying NSB conditions. The camera was also used for astrometry, using a second readout chain to reconstruct the pointing direction of the telescope.

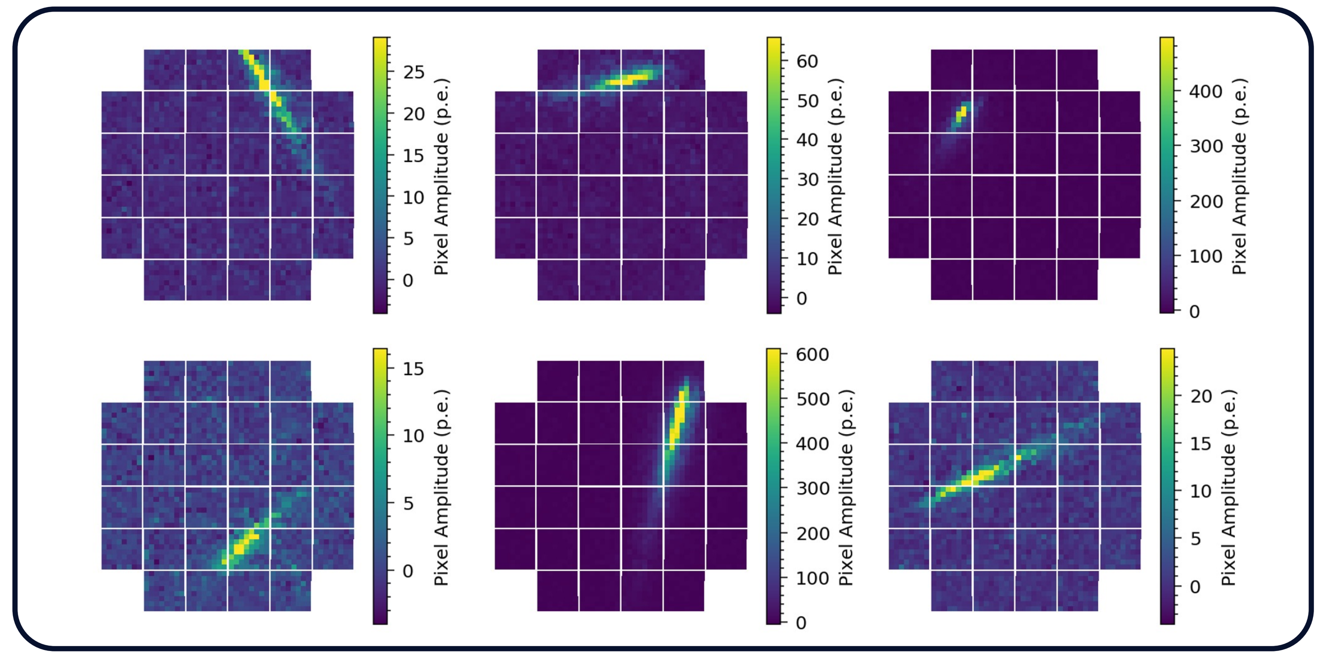

Fig. 6: Examples of Cherenkov images recorded with the CHEC-S camera installed on the ASTRI-Horn telescope.

ACKNOWLEDGEMENTS

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