Development and characterization of a test stand for Compact High Energy Camera (CHEC-S) mass test

Master Thesis

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Outline

Introductory information

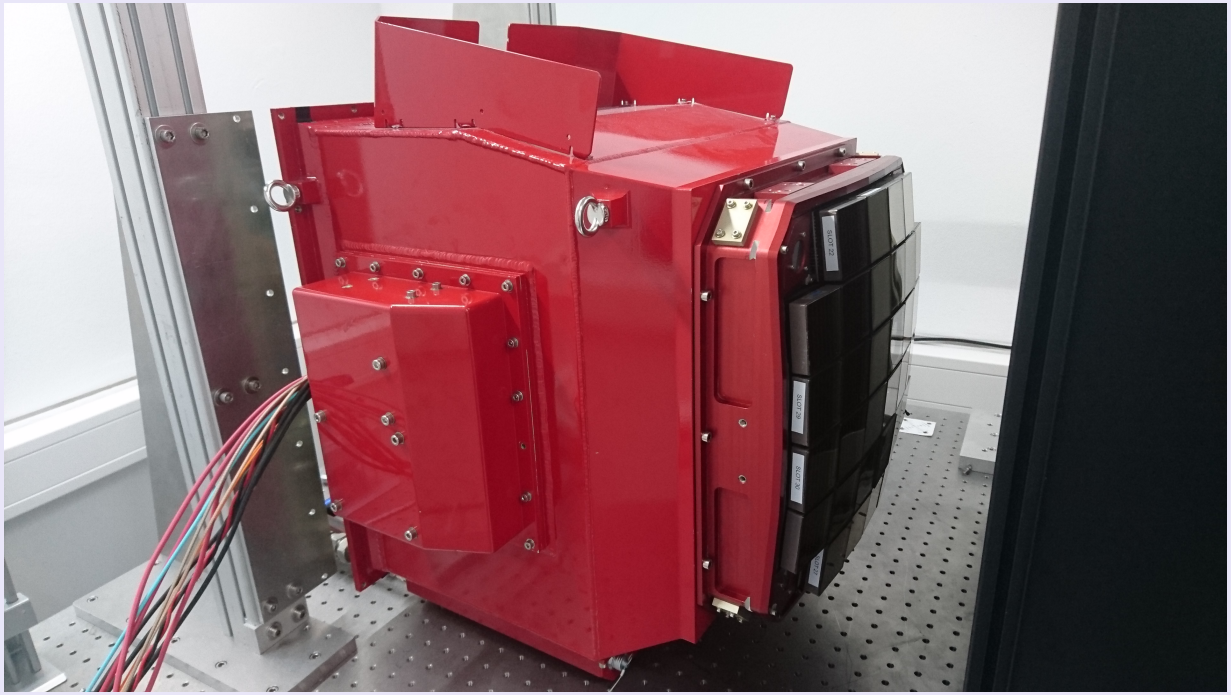

Figure: CHEC-S camera in Heidelberg at the MPIK

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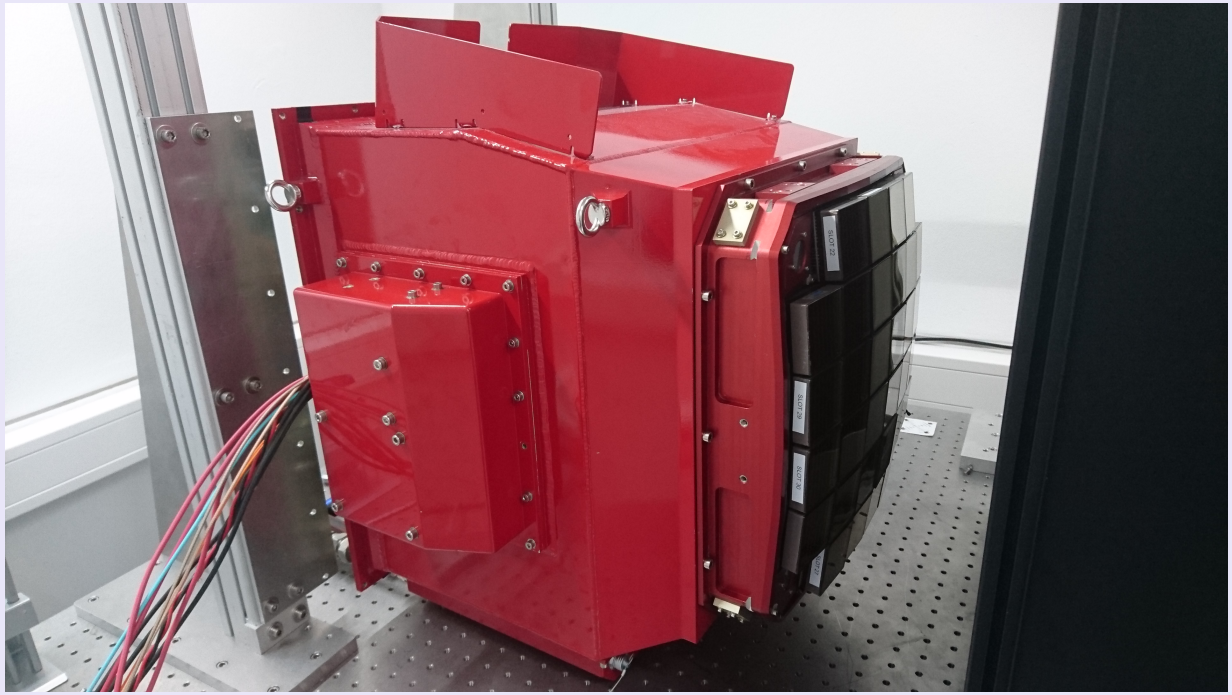

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Goal of my work:

- ☛ test-setup for the **C**ompact **H**igh **E**nergy **C**amera (CHEC-S) of the small size telescopes of CTA

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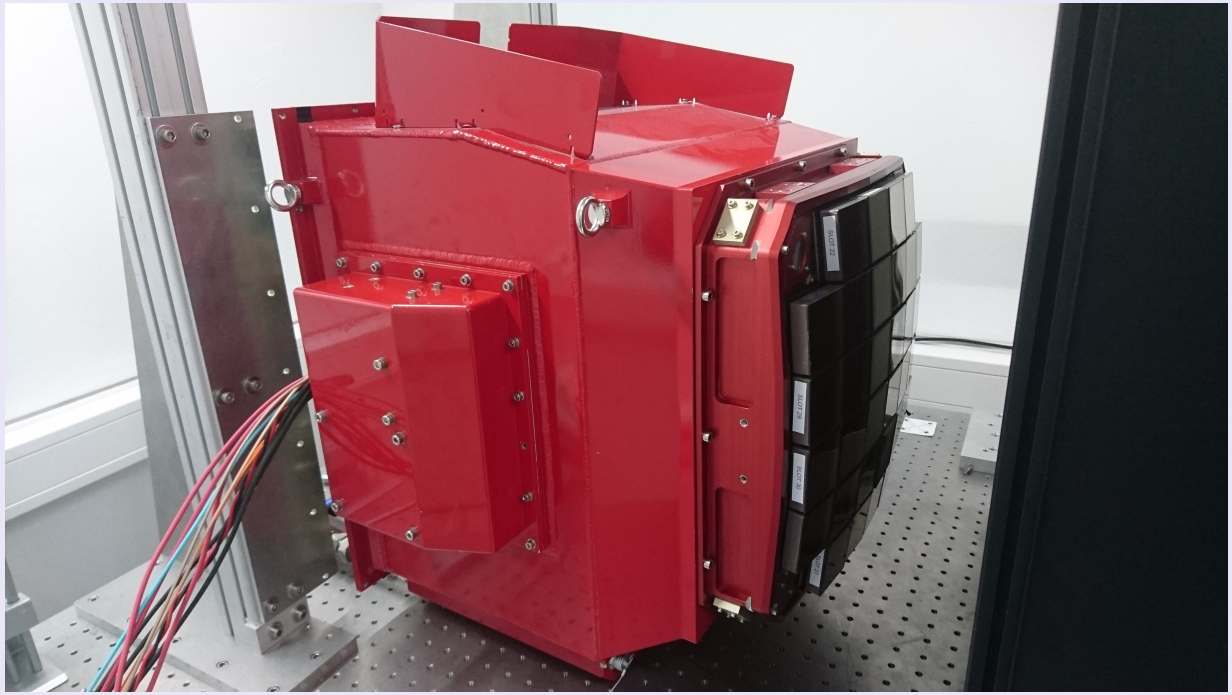

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Goal of my work:

- ☛ test-setup for the **C**ompact **H**igh **E**nergy **C**amera (CHEC-S) of the small size telescopes of CTA
- ☛ Characterization of this test-setup

Cherenkov Telescope Array

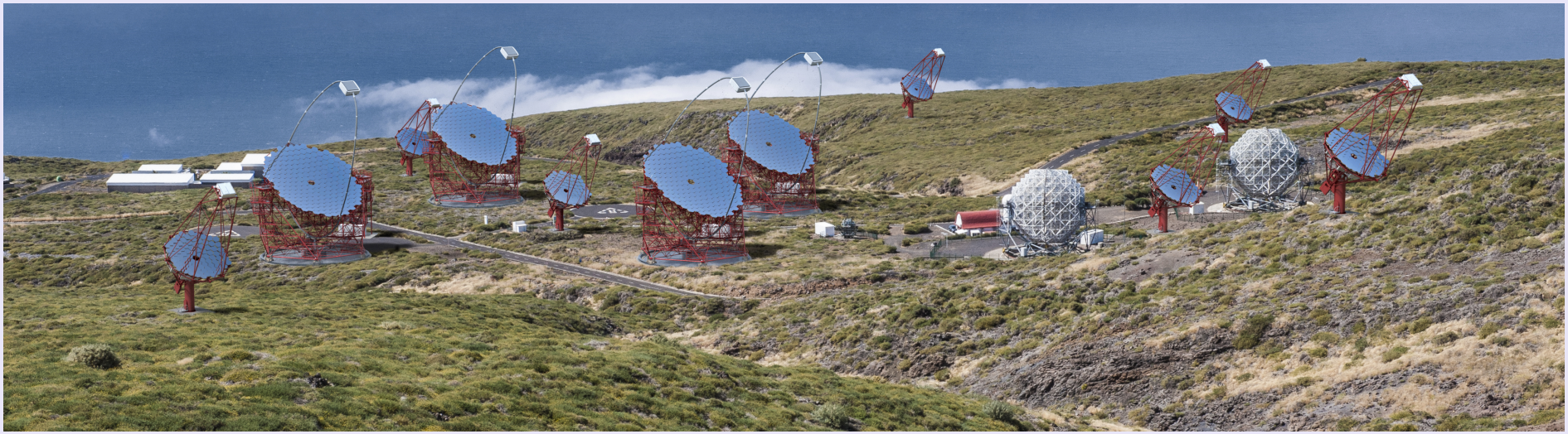


Figure: Northern Hemisphere Array Rendering, Credit: Gabriel Pérez Diaz, IAC, SMM
`https://www.flickr.com/photos/cta_observatory/32835056736/in/album-72157671319679034/`

- northern hemisphere: La Palma, Canary Islands
- southern hemisphere: Paranal, Chile

- energy range 20 GeV to 300 TeV

  → 8 LSTs
  → 40 MSTs
  → 70 SSTs

Cherenkov Telescope Array

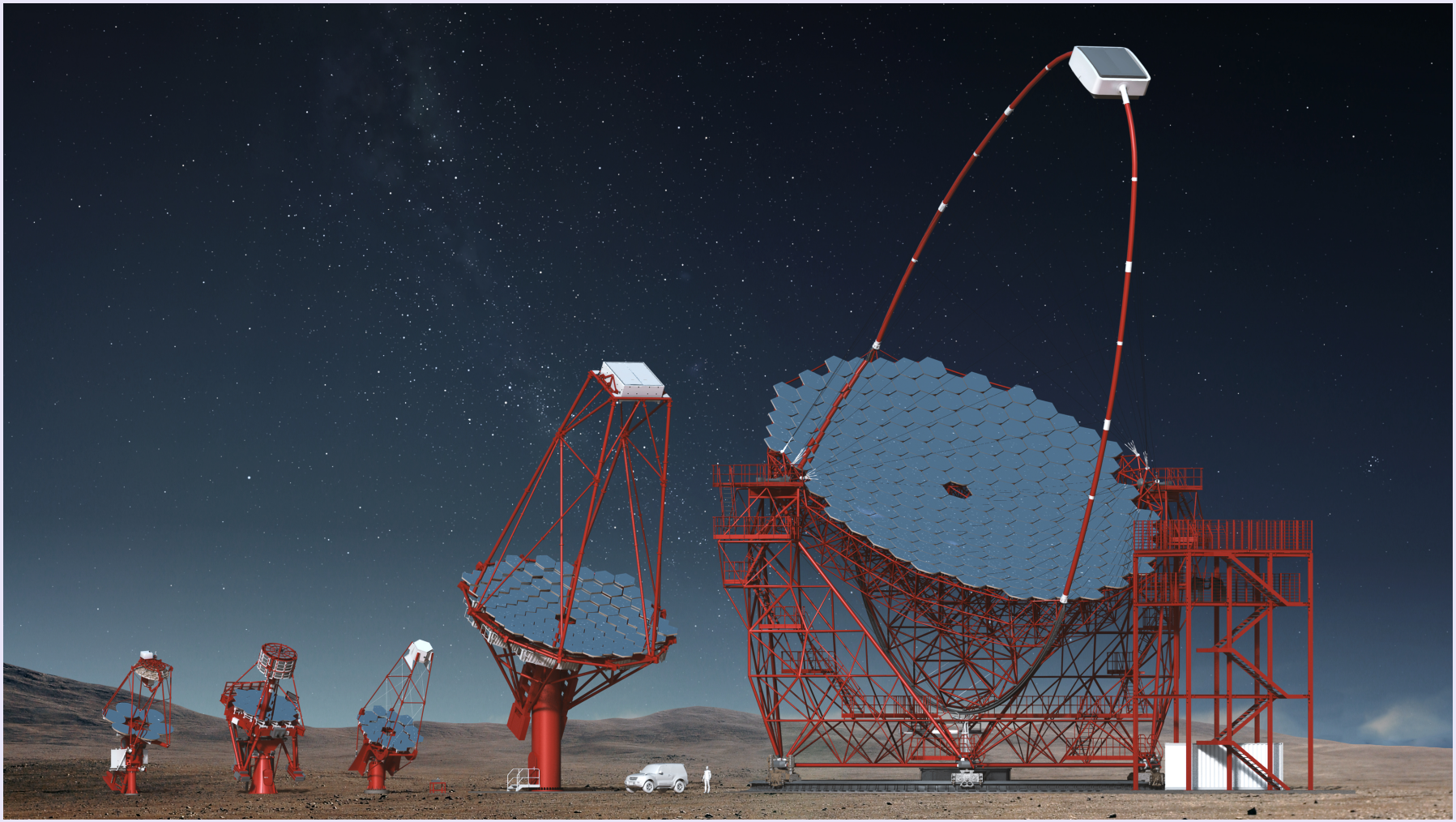


Figure: Credit: G. Pérez, IAC, SMM
`https://www.flickr.com/photos/cta_observatory/30329828142/in/album-72157671319679034/`

Small Size Telescopes

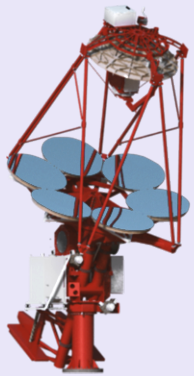


Figure: Rendering Credit: G. Pérez, IAC, SMM, `https://www.flickr.com/photos/cta_observatory/35640194511/in/album-72157672713462861/`

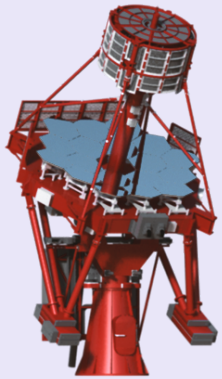


Figure: Rendering Credit: G. Pérez, IAC, SMM, `https://www.flickr.com/photos/cta_observatory/35640193441/in/photostream/`

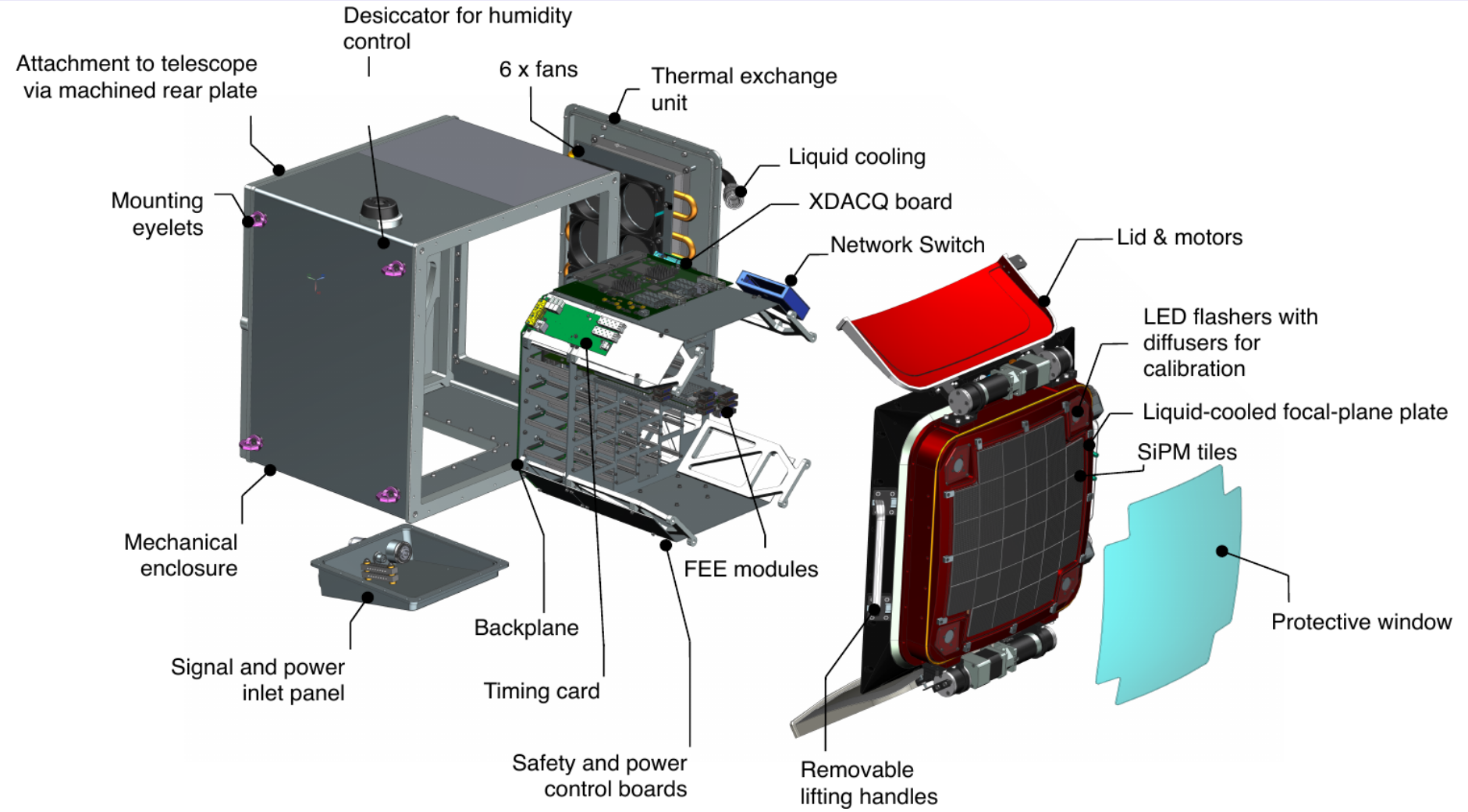
GCT:

- Effective collecting area: 6 m^2
- Telescope mass: 7.8 tons
- Field of view: 9.2°
- Focal length: 2.28 m

ASTRI:

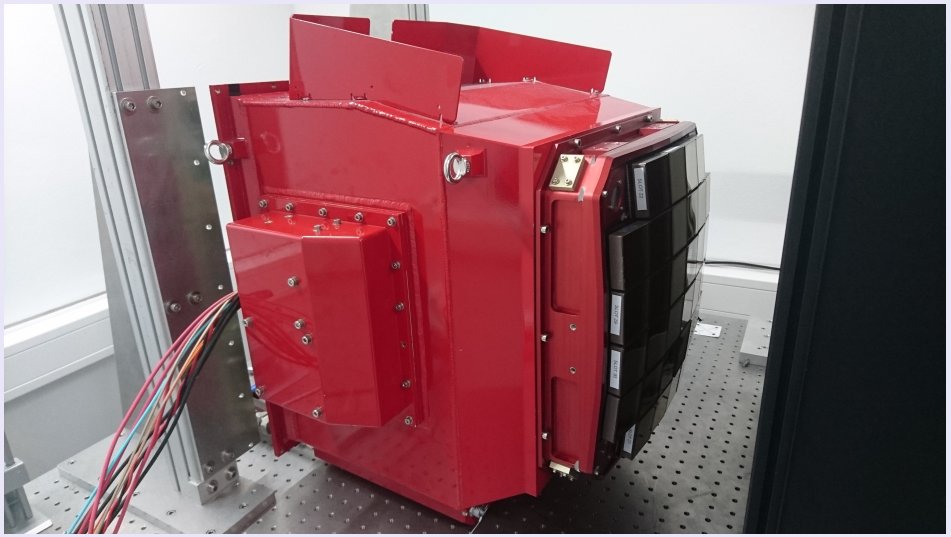
- Effective collecting area: 6 m^2
- Telescope mass: 20 tons
- Field of view: 9.6°
- Focal length: 2.15 m

Compact High Energy Camera with silicon Photomultiplier



CHEC-S

- Camera mass: 45 kg
- Camera diameter: 0.35 m
- Camera number of channels: 2048
- Readout window length: 96 ns
- Data rate at 600 Hz: 3 $\frac{\text{Gb}}{\text{s}}$



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Silicon Photomultiplier (SiPMs) in comparison to multi anode Photomultiplier (MAPMs):

\+ much more robust

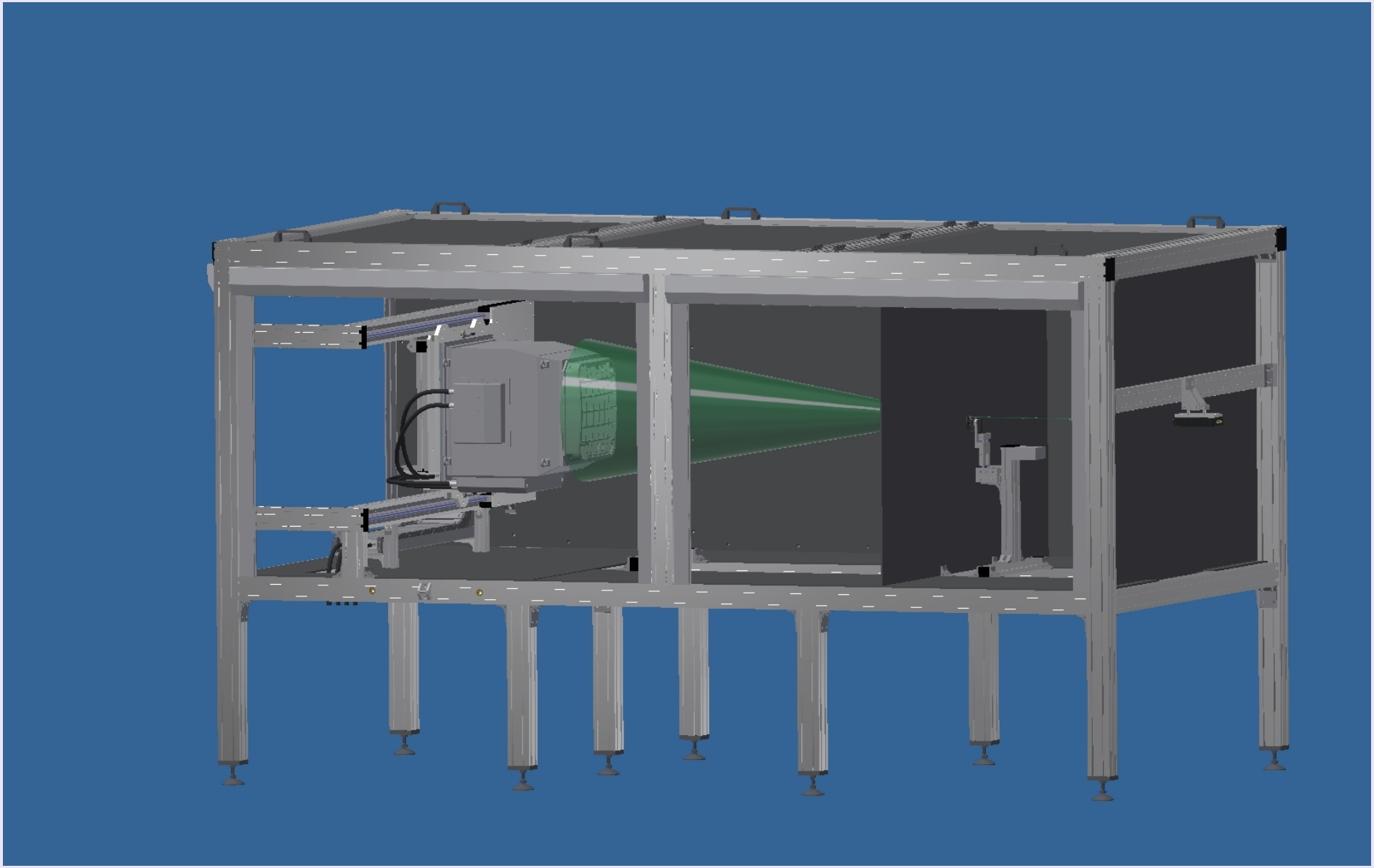
\- much higher dark count rate

Requirements for the test-setup

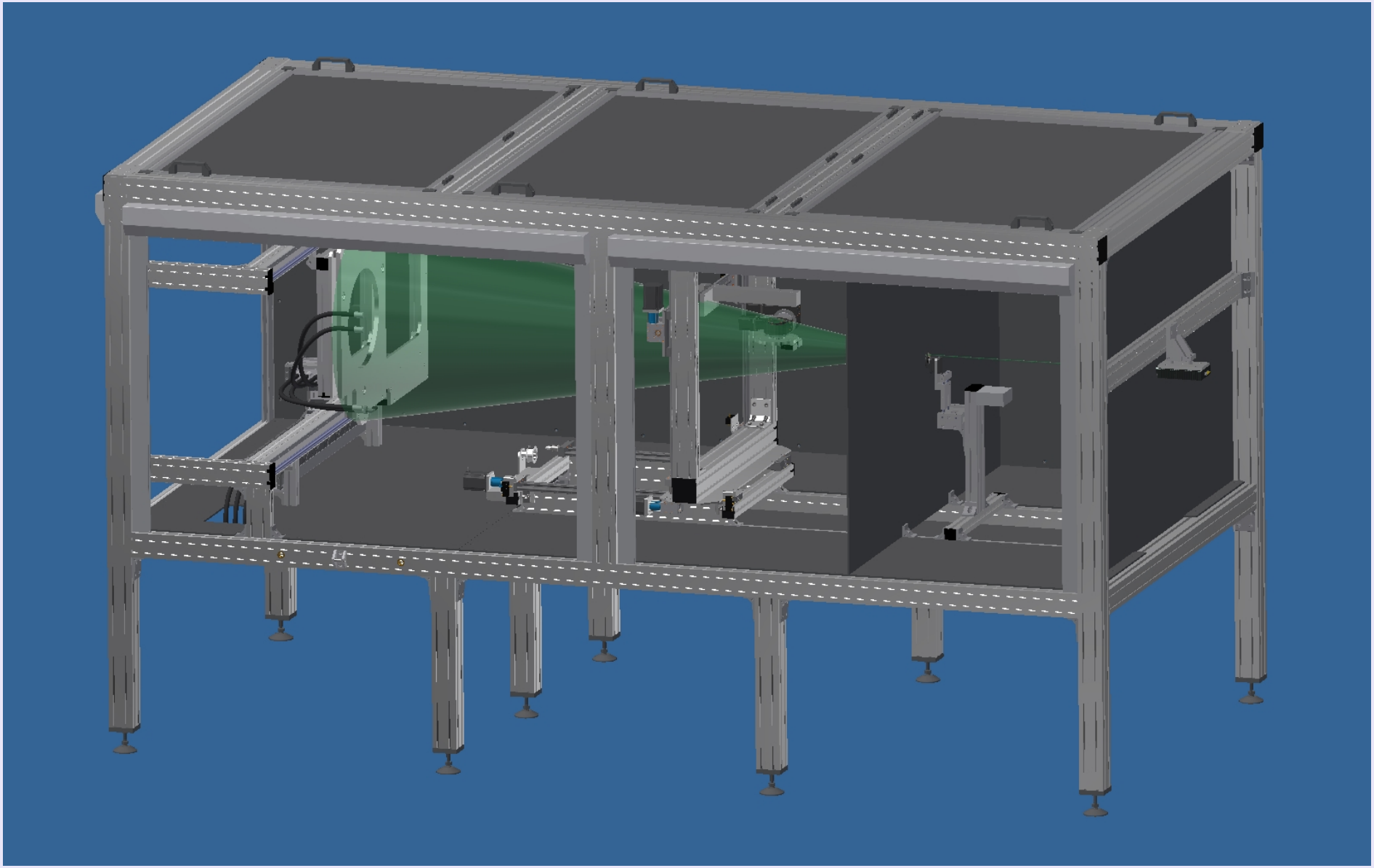
To test the whole camera, the following parts play an important role:

- because of very faint pulses:
  - $\rightarrow$ light-tight box
- to simulate these pulses:
  - $\rightarrow$ class 3B laser: $\lambda = 405\,\text{nm}$, $P_P = 2000\,\text{mW}$, $f = 40\,\text{MHz}$, $t = 40 - 3000\,\text{ps}$
- to use the whole range of the camera:
  - $\rightarrow$ filter wheel: has 4096 positions, whereas 0 means no attenuation and 4095 maximum attenuation
- spread the laser beam to the whole camera surface:
  - $\rightarrow$ diffuser

Test stand with camera



Test stand with 5-axis scanner



5-axis-scanner

Since we do not have the camera yet, we built a 5-axis-scanner with a photodiode to move to the exact position of each pixel and measure the intensity.

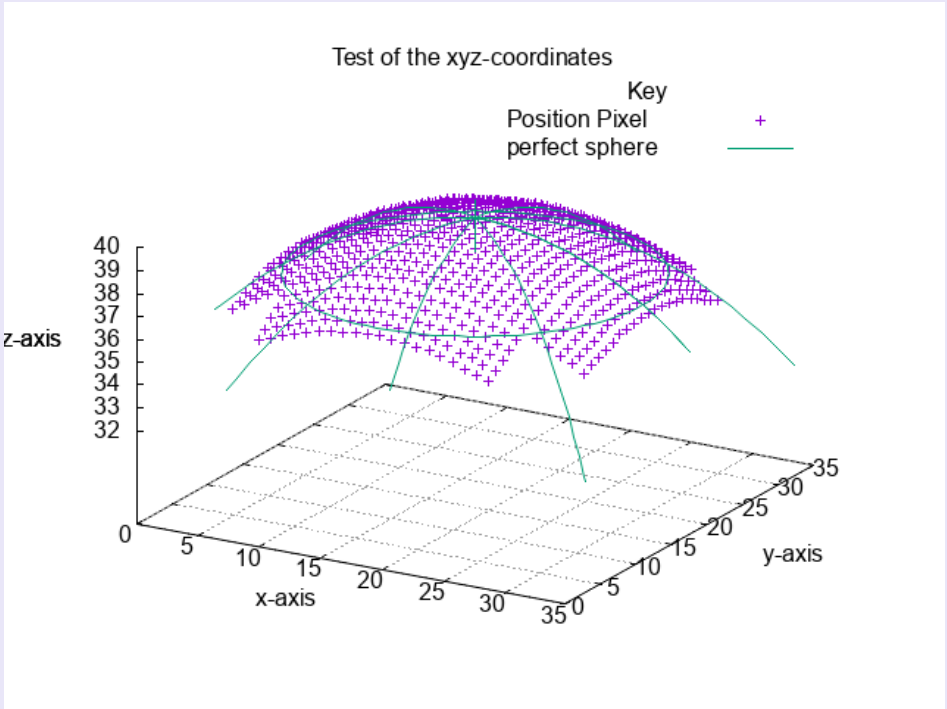


Figure: The surface of the camera is a sphere, the SiPMs are plane, all pixel of the same SiPM have the same azimuth and elevation angle

Outlook

The current status is:

- the test-setup has been built
- scanner & program for moving the steppers is ready
- photodiode readout is working
- diffuser & filter wheel are built-in

Characterization of the box still has to be done:

→ What is the dark current in the box if laser is off?

→ How stable is the laser in time and temperature?

→ What is the maximum attenuation with the filter wheel?

→ How does the light field after the diffuser look like? Is it homogeneous?

Bibliography

- CTA website, `https://www.cta-observatory.org/`
- M. K. Daniel, R. J. White, D. Berge, et al., 'A Compact High Energy Camera for the Cherenkov Telescope Array', (10 Jul 2013), arXiv:1307.2807v1
- G. Pareschi, G. Agnetta, L. A. Antonelli, et al., 'The dual-mirror Small Size Telescope for the Cherenkov Telescope Array', (18 Jul 2013), arXiv: 1307.4962v1
- R. White, H. Schoorlemmer, 'A Compact High Energy Camera (CHEC) for the Gamma-ray Cherenkov Telescope of the Cherenkov Telescope Array', (18 Sep 2017), arXiv: 1709.15799v1