Dutch Contributions to the Cherenkov Telescope Array (CTA)

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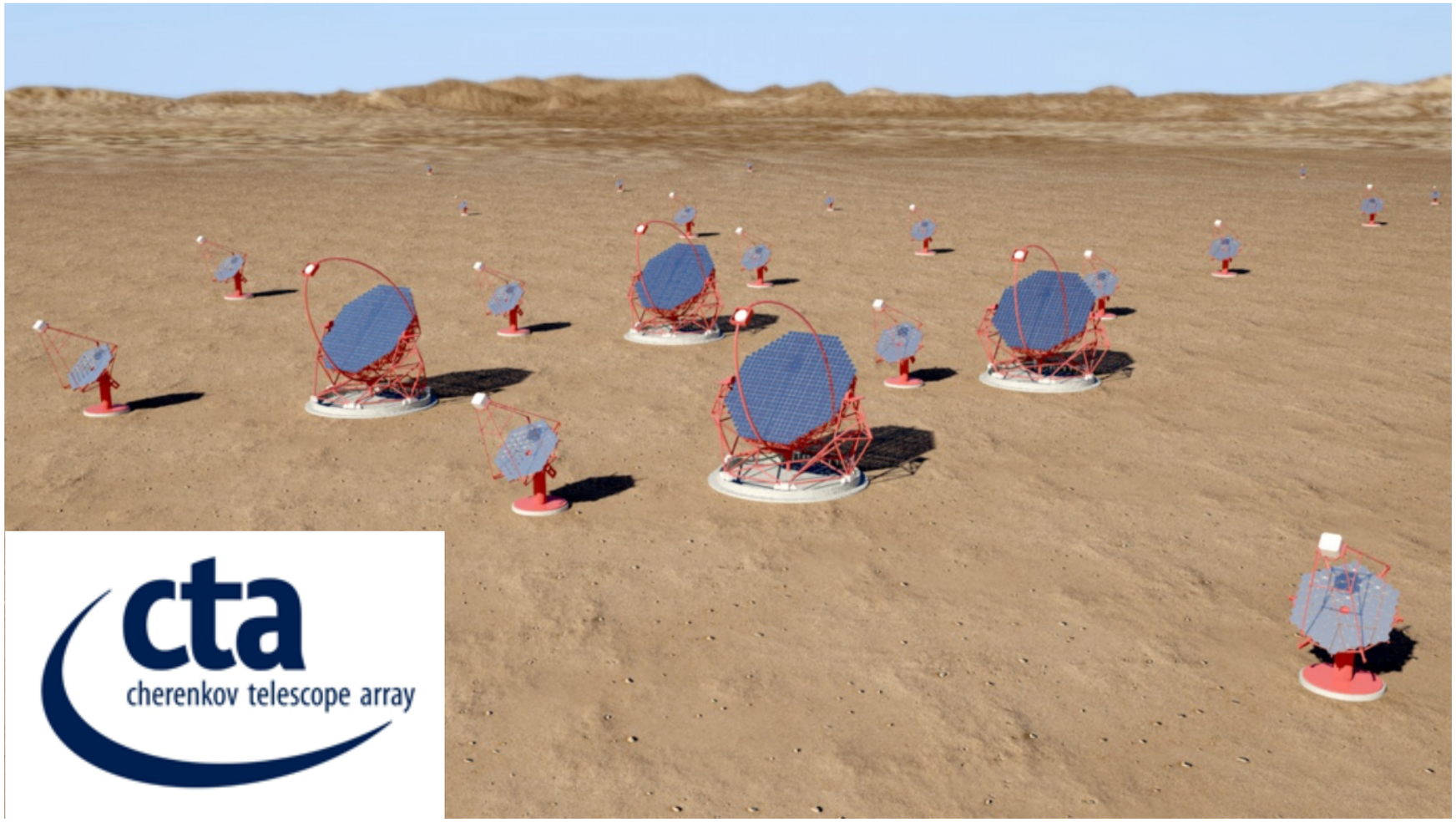
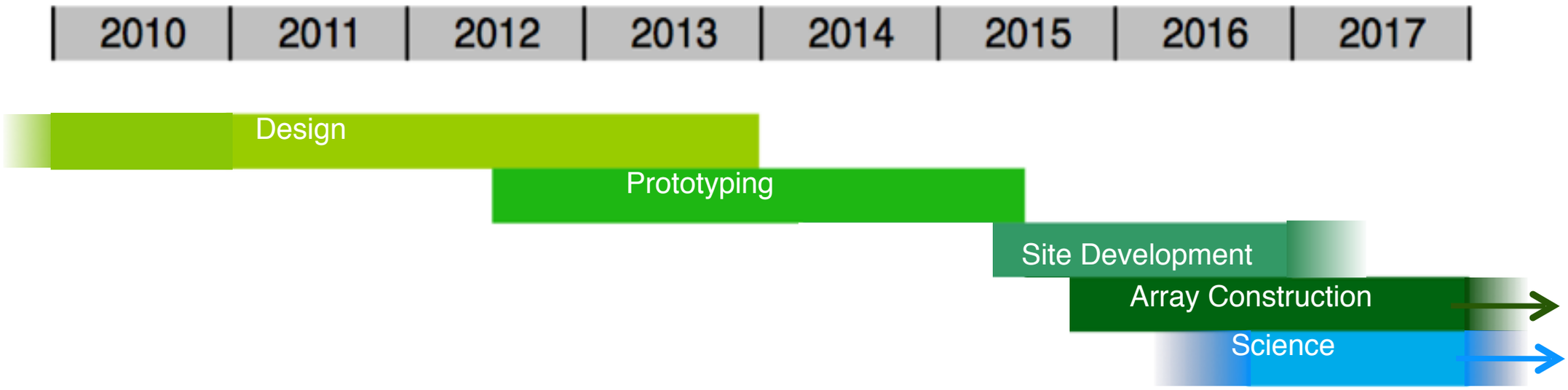
Big Science Day
Eindhoven, 15/10/2014

What is CTA?



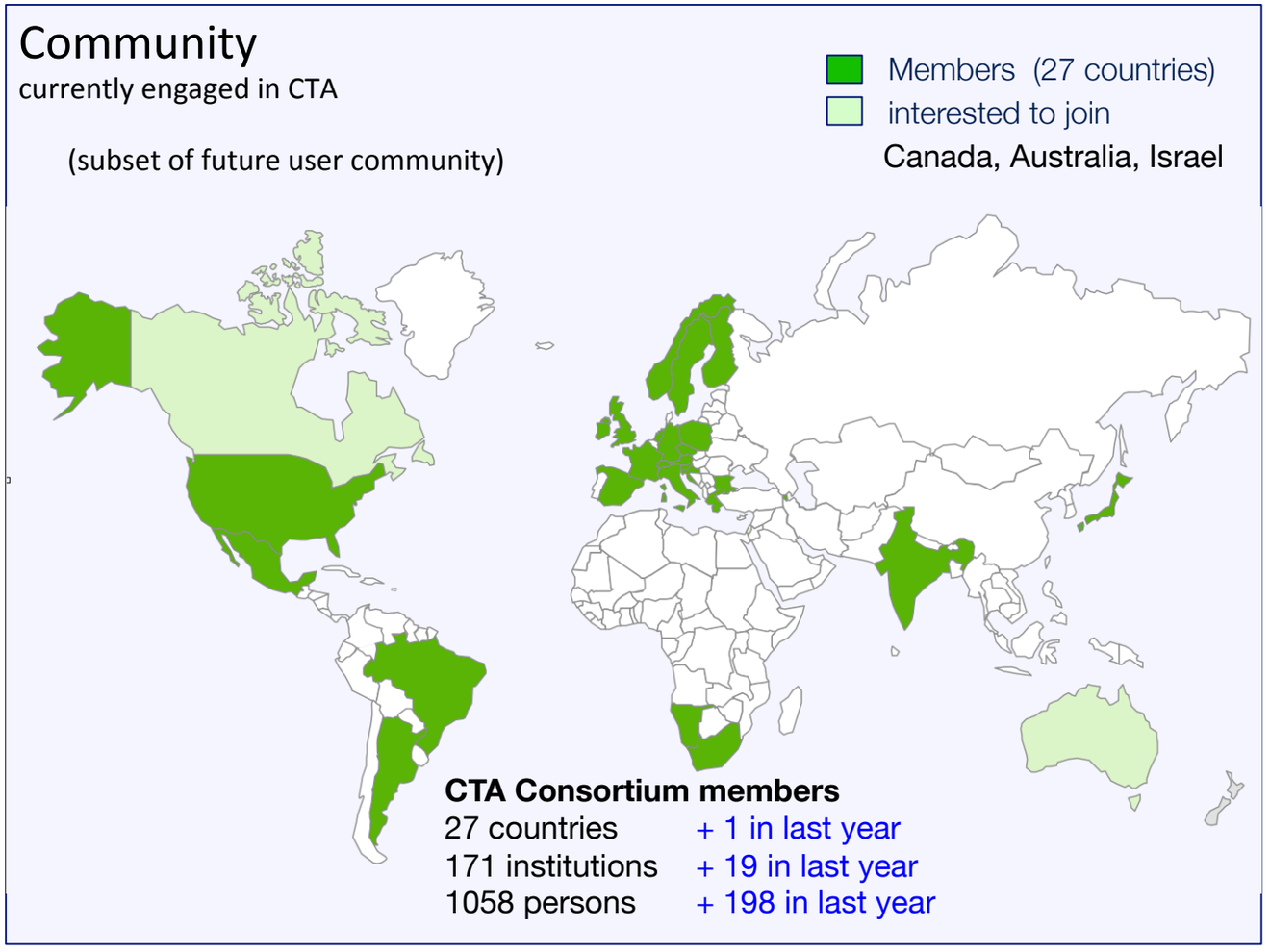
- CTA will be a ground-based observatory of *very high energy gamma-rays* (0.2-100 TeV)
- CTA will consists of an array of ~100 individual optical telescopes of various sizes
- Telescopes detect the Cherenkov light induced by gamma-rays entering the atmosphere
- CTA will consist of two observatories: CTA South and CTA North
  - CTA south: negotiations started with Namibia (Chili as back-up)
- CTA south will be operational by ~2020
- Total construction cost: 200 M€ per site

CTA time line



- Initial ideas for CTA: 2006
- Building on proven technology of current telescopes: H.E.S.S., MAGIC, Veritas
- Start of prototyping phase 2012
- 2014: announcement of preferred site Southern site: Namibia
- *April 2015: Critical design review*

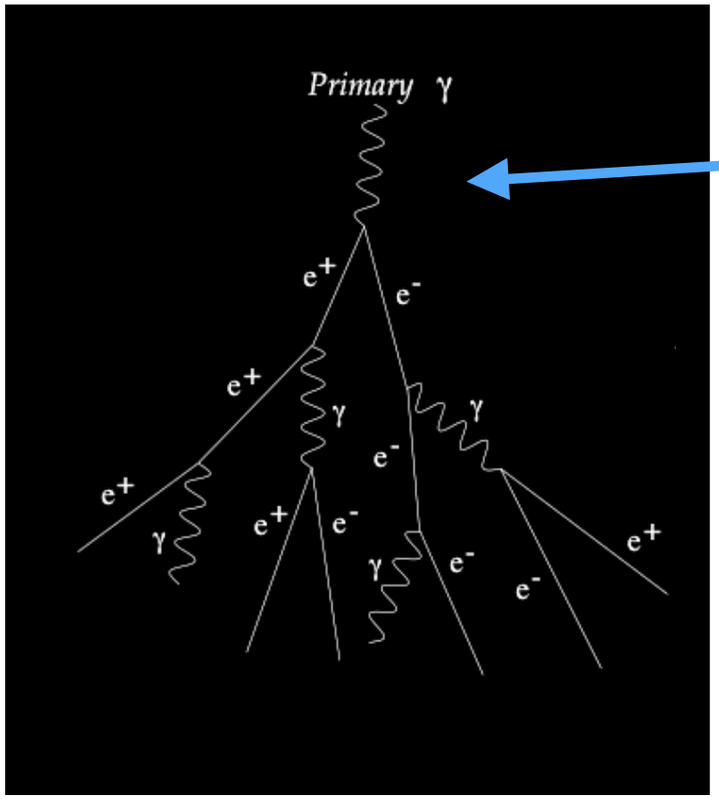
The CTA consortium and global reach

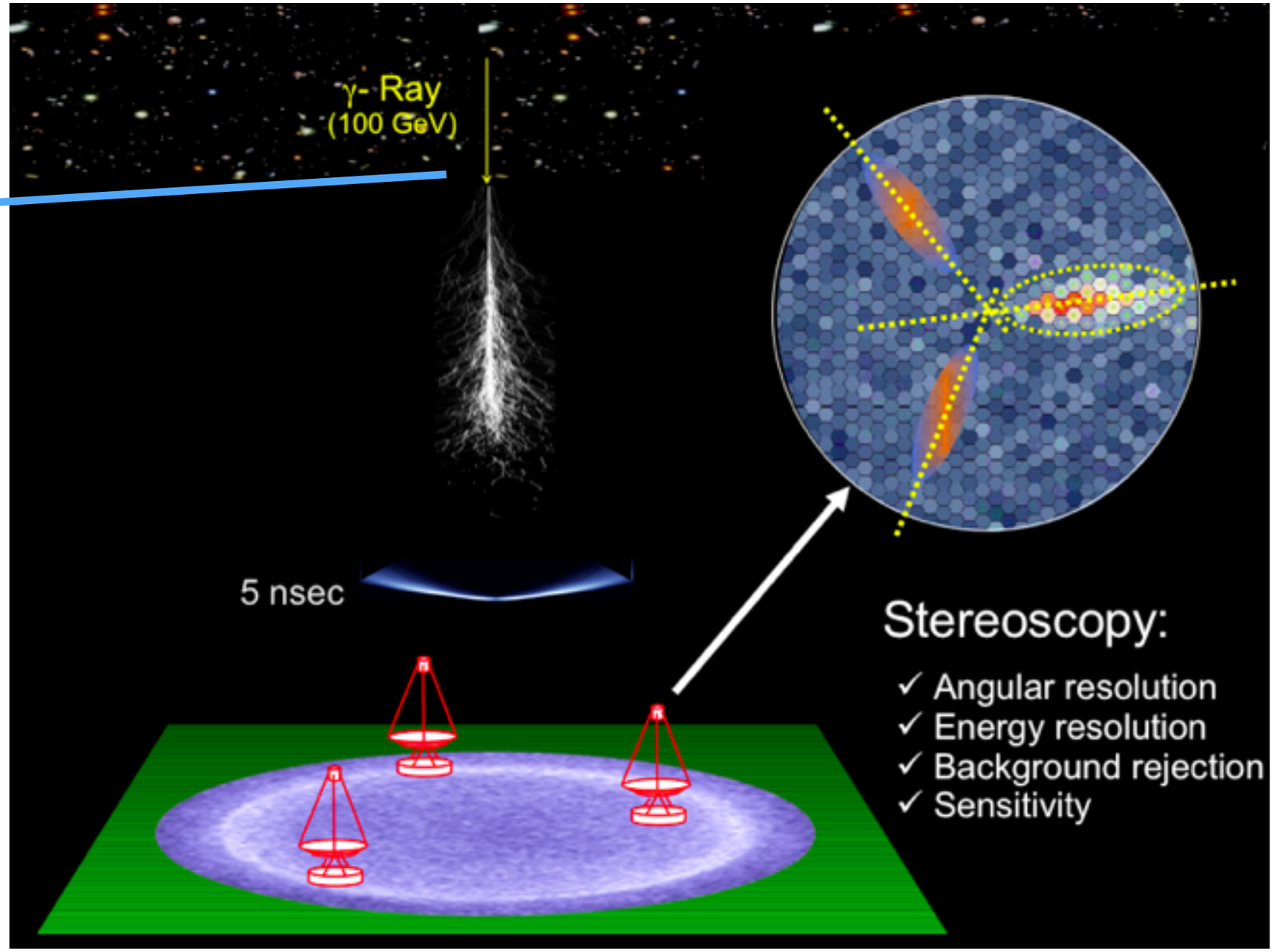


- CTA involves institutes from 28 countries: most EU countries, Argentina, Brazil, Japan, ..
- Involves more than 1000 people, and 127 institutes
- CTA is now a legal entity: for practical reasons a German GmbH
- CTA is listed in the European Science Research Infrastructures (ESFRI)
- CTA is listed top among large-sized infrastructure ASPERA roadmap (1 of the magnificent 7)

- CTA project office: Heidelberg
- Spokespersons: W. Hofmann (D), Rene Ong (US)

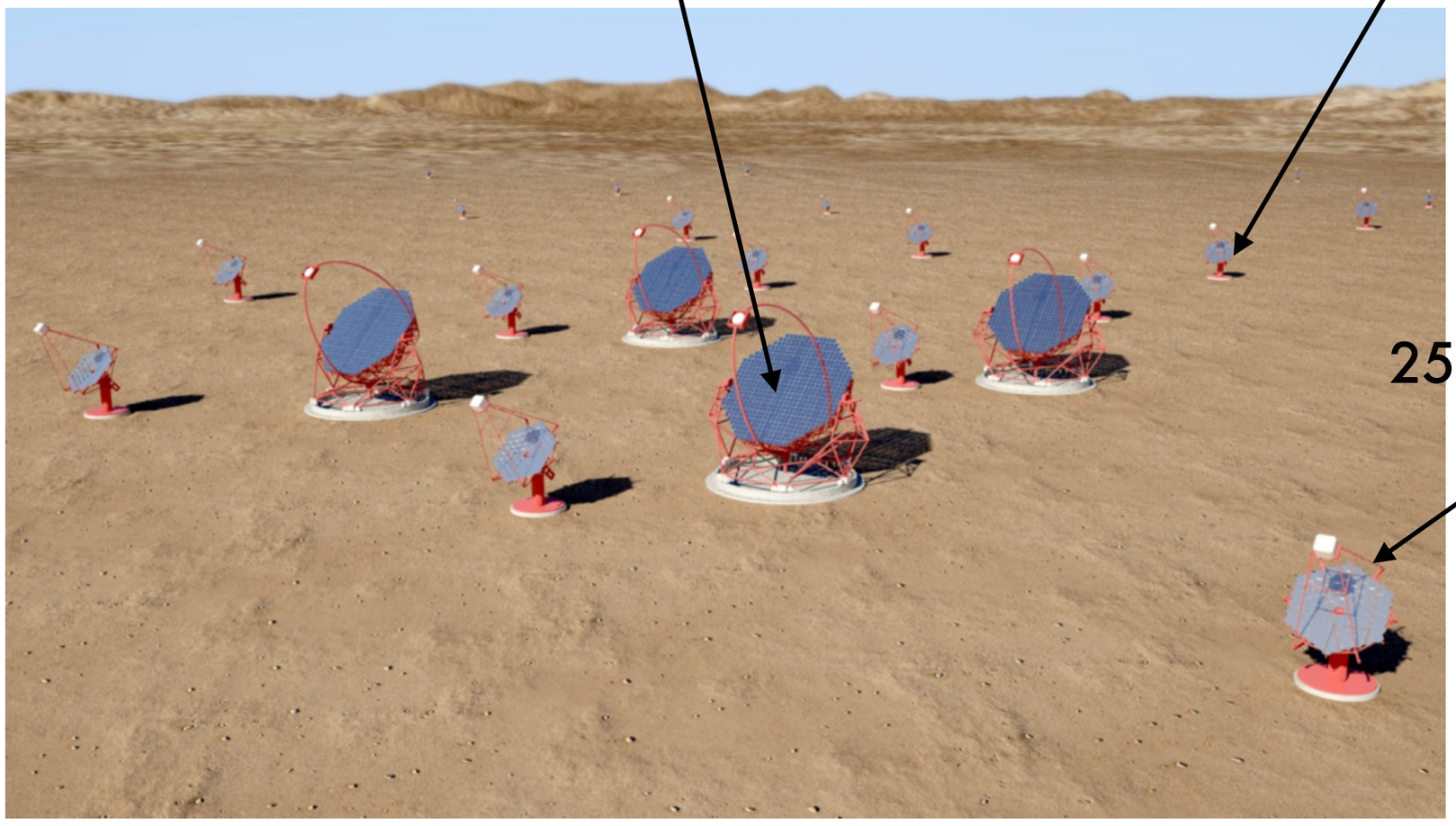
Cherenkov Telescope Array principle





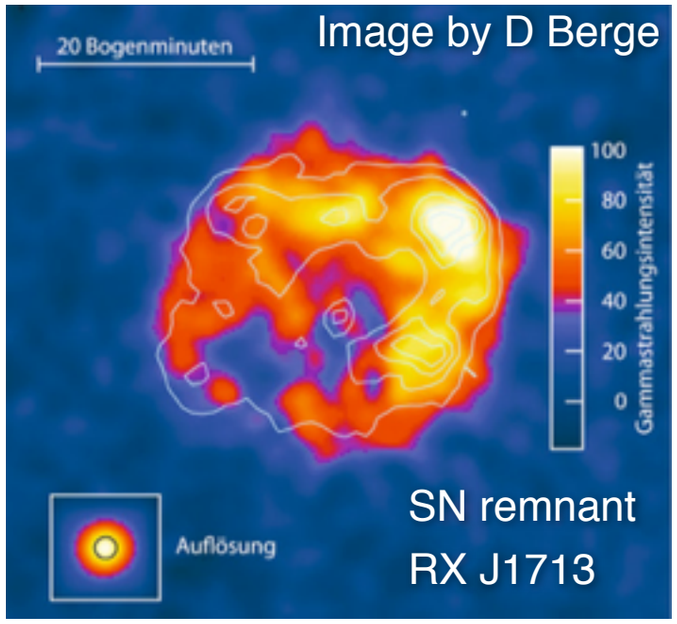
- Telescope/camera resolution: tuned to shape/size of air shower tracks (arcminutes)
- Camera triggers fast to image shower shape and development
- Gamma-ray/cosmic-ray separation: shape of the shower

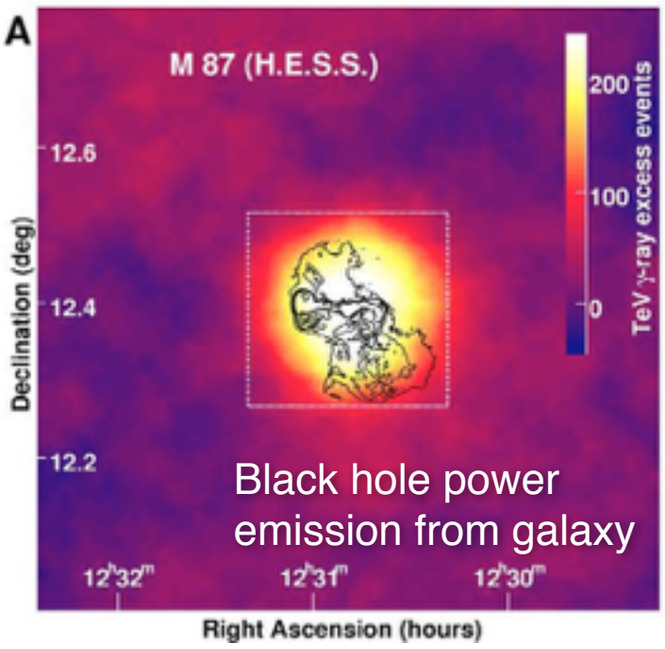
Different telescope sizes



- #photons falls off with energy: many low energy gamma-rays, few high energy gamma-rays
- low energy gamma-rays: faint showers ⇒ big telescopes
- high energy gamma-rays: bright showers ⇒smaller telescopes, but many telescopes needed

Why study very high energy gamma-rays?

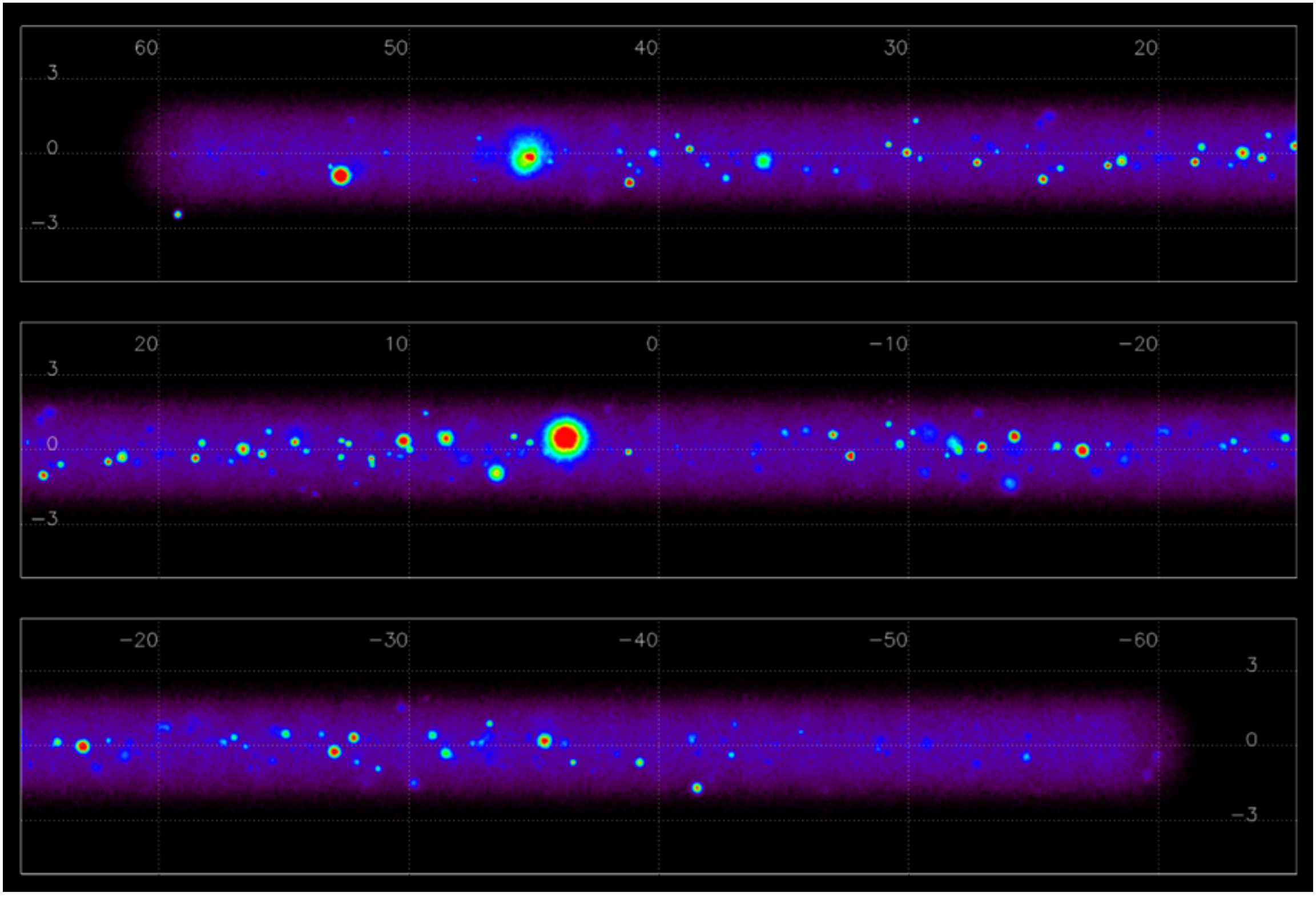




- Gamma-rays produced by the most powerful astrophysical sources:
  - Massive black holes + their jets in distant galaxies
  - Gamma-ray bursts
  - Pulsar winds
  - Supernova remnants
- In addition: Gamma-rays are potentially produced by dark matter annihilation
  - 80% of all matter in the Universe in form of enigmatic dark matter

- The gamma-ray emission caused by the presence of energetic atomic nuclei and electrons
- We observe these particles also on Earth: cosmic rays
  - What is the origin of cosmic rays?

The Milky Way as it may look like observed with CTA

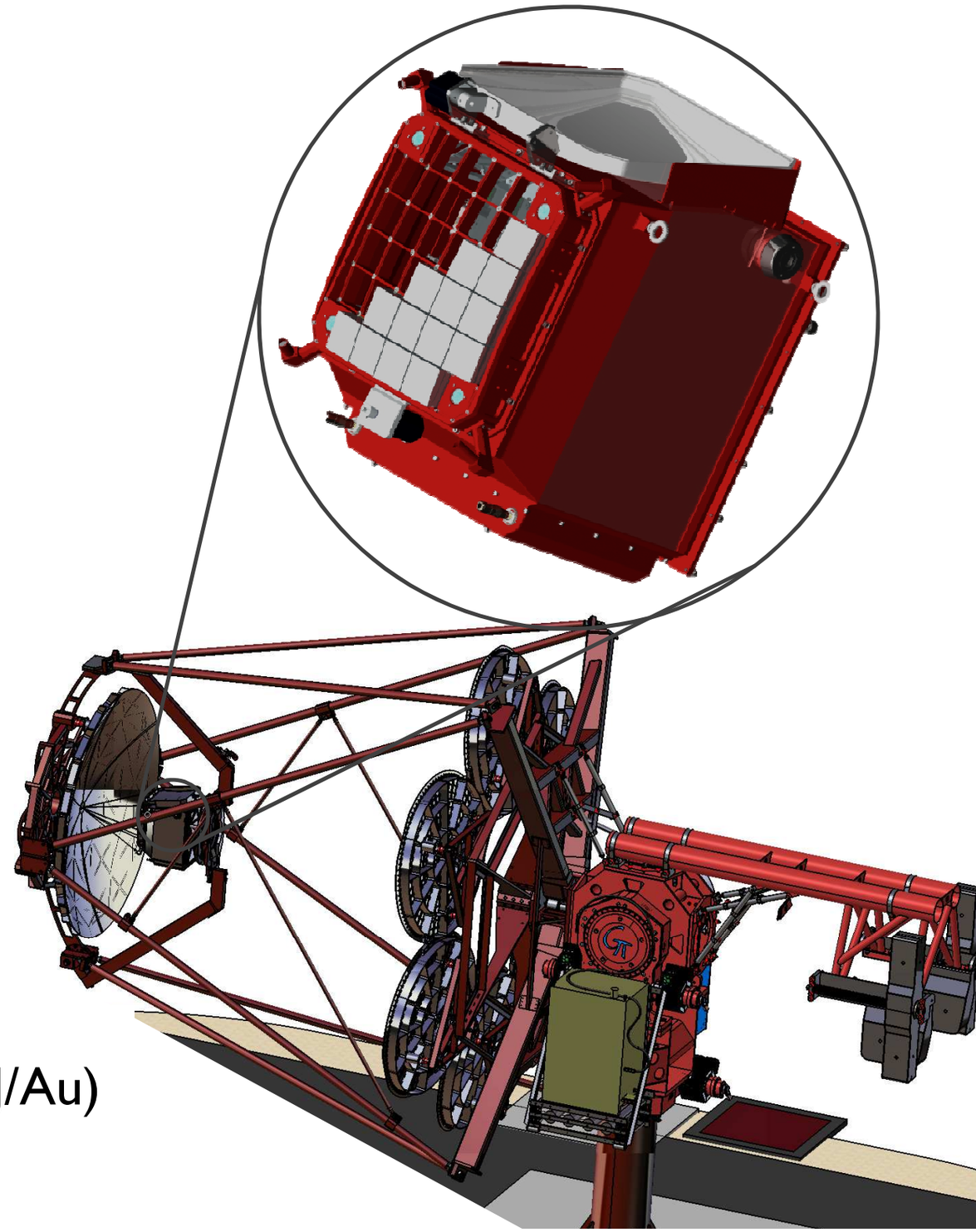


CTA in the Netherlands

- Currently two Universities are involved in the CTA prototype phase (since 2012):
  - University of Amsterdam (D. Berge, J. Vink)
  - Radboud University Nijmegen (J. Hoerandel)
- Dutch R&D involvement financially supported by NOVA (1.5 M€)
- NOVA support includes involvement of NOVA/ASTRON lab Dwingeloo
- Additional financial 0.5 M€ available for construction phase and project office support

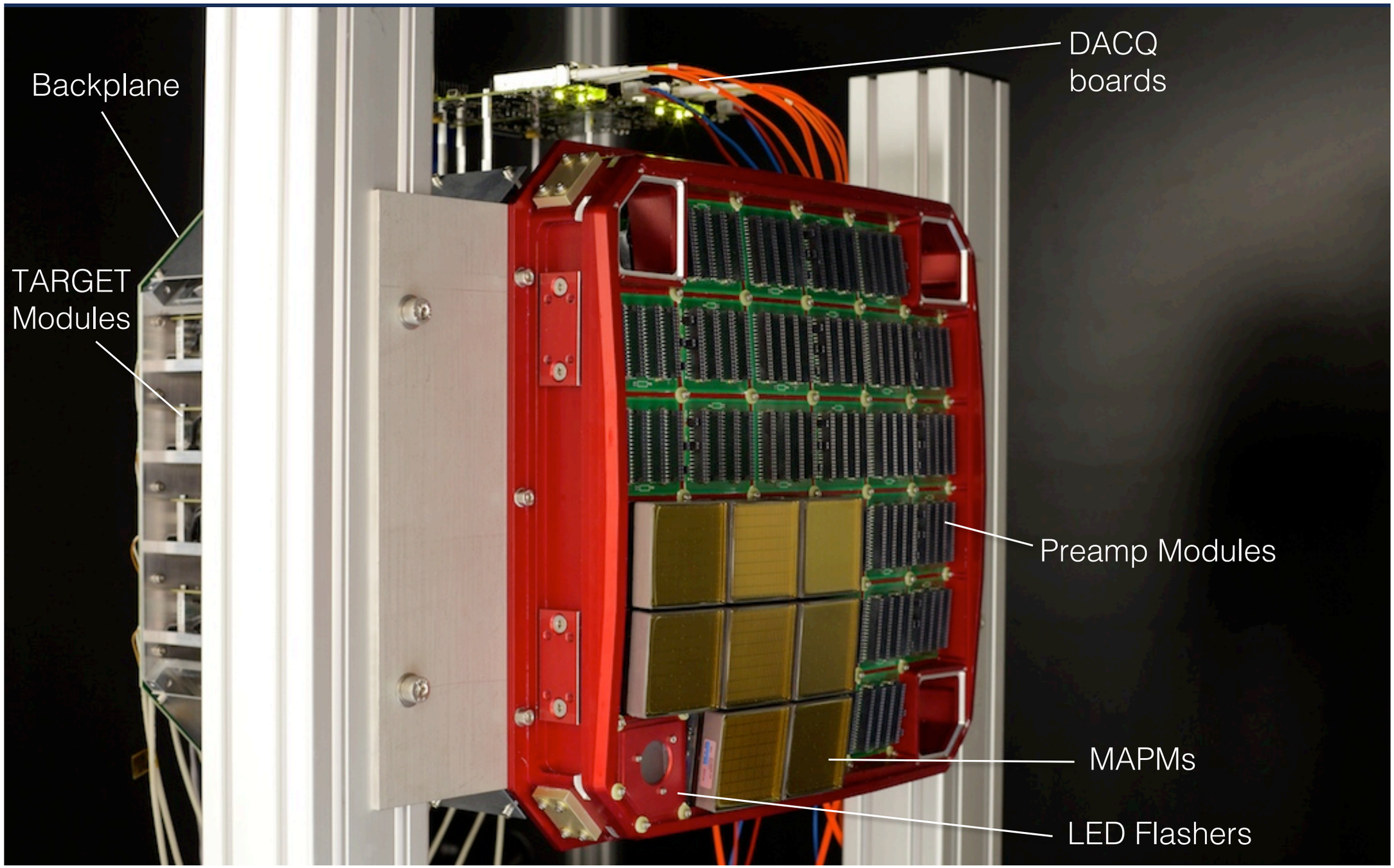
- Amsterdam: partner in development of camera (CHEC) for small-sized telescopes (SSTs)
  - since a few month: merging of GATE telescope and CHEC consortium merged: GCT
  - additional sub-project: a system for pointing reconstruction
- Nijmegen: detector developing and testing

GATE/CHEC Telescope (GCT)

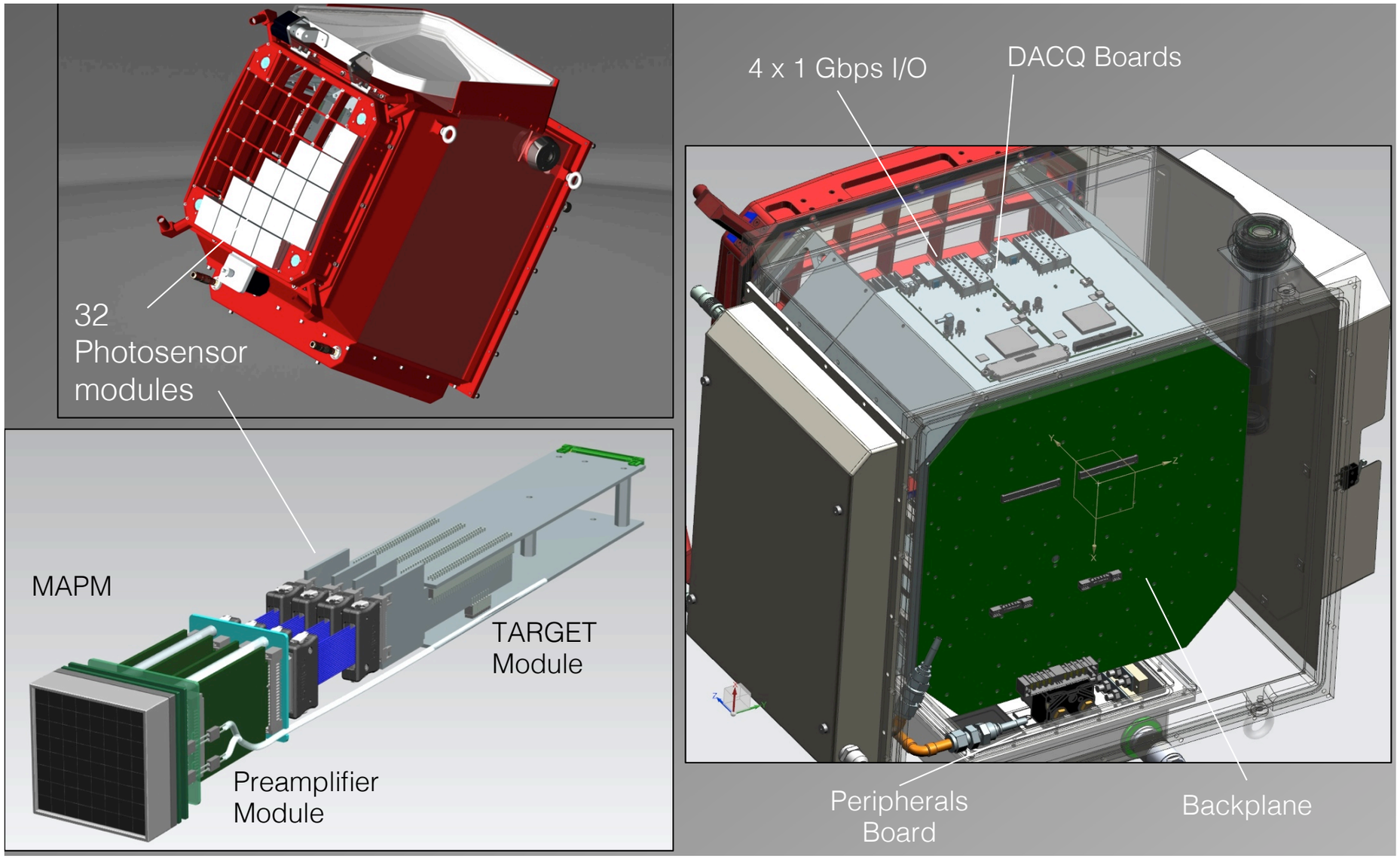


- Combination of SST camera+telescope
- CHEC=Compact High Energy Camera (UK/NL/J/Au)
- GATE= Gamma-ray Telescope Elements (F/UK)
- *35 SSTs of CTA will be GCTs*
- Telescope diameter 4 m
- Consist of primary and secondary mirrors:
  - not yet used in current arrays
  - smaller focal plane/more compact cameras with advanced detectors

GCT-camera prototype

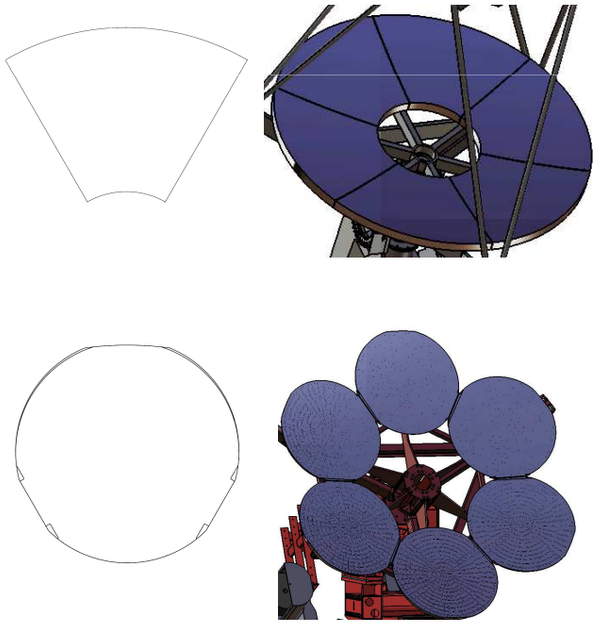


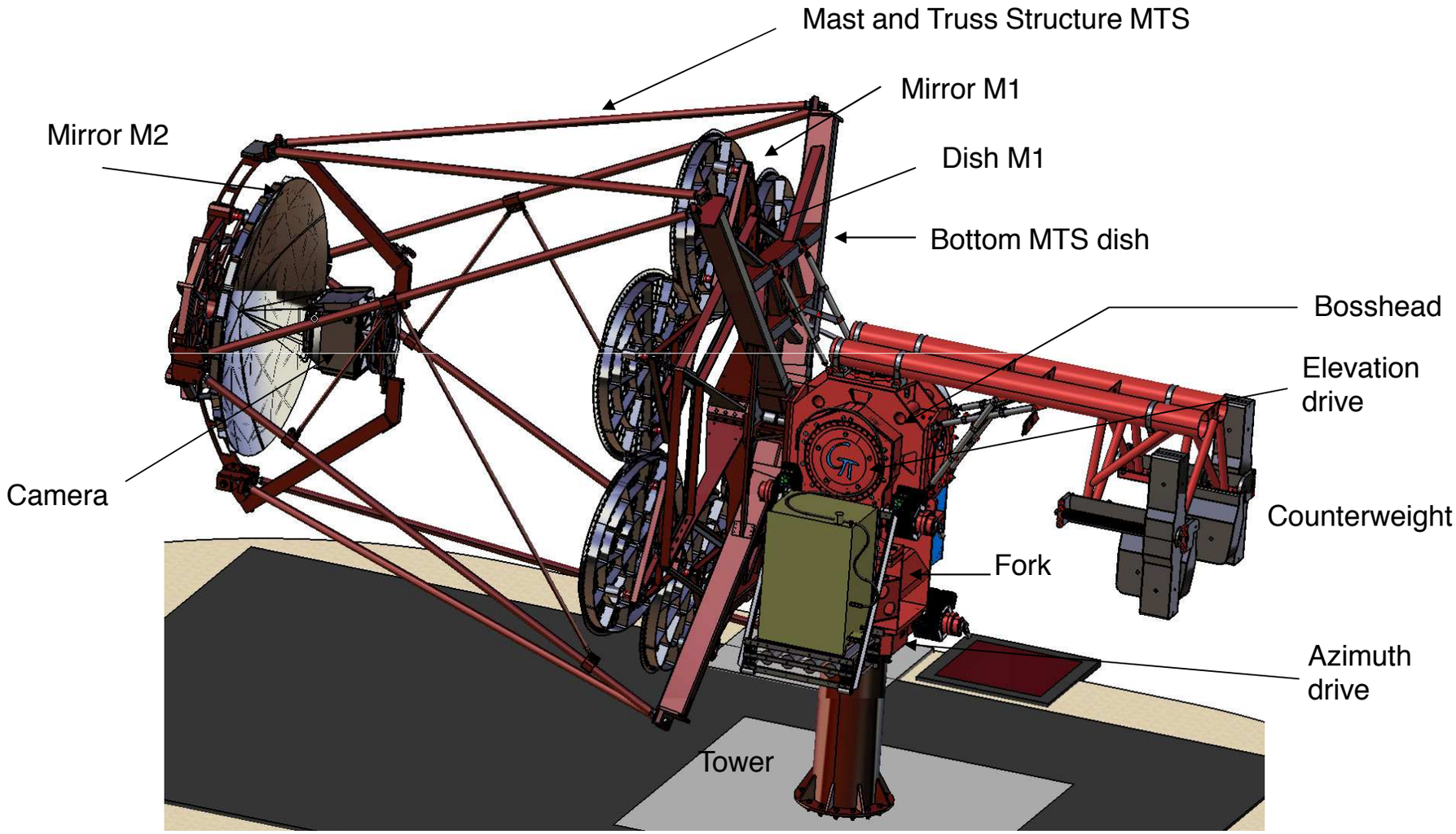
GCT-camera



- Two prototypes developed:
  - With Multi-anode Photo Multipliers (lead: Leicester)
  - With SiPMs (lead: UvA)
- Readout electronics (TARGET): developed by Stanford/SLAC
- Backplane module: UvA

GCT telescope





- Schwarzschild-Couder telescope
- Segmented primary mirror
  - prototype 6 mirrors not filling aperture (AE 6.8m^2)
  - final version: probably 6 petals (AE 10m^2)
- Monolithic secondary mirror
- Easy system mount/dismount camera

Possible partnerships with Dutch industry

- A Dutch partnership in CTA currently not funded: NL contribution will be ~4-6 M€
- First big funding opportunity: NWO-G, *April 2015*
- Our aim is to cooperate for funding proposals with industry:
  - Dutch investment in CTA will result in both Science and economic returns
  - It will help to optimise the designs for replicability (35 cameras/telescopes)

- Technical areas for which cooperation is open:
  - GCT-camera (which has already heavy Dutch involvement)
    in particular backplane electronics, the camera-to-central-control-room interface card (data routing, clock and time transfer) and optical alignment and monitoring units
  - GCT-telescope:
    -Dutch now also partner in telescope (PI country France)
    -Currently no NL involvement in telescope prototype
    -This likely has to change in order to balance budget camera/telescope
    ⇒ potential Dutch involvement in mechanics, mirrors and drives
  - Next generation detectors (high QE, easy handling): handled through RU Nijmegen

More information

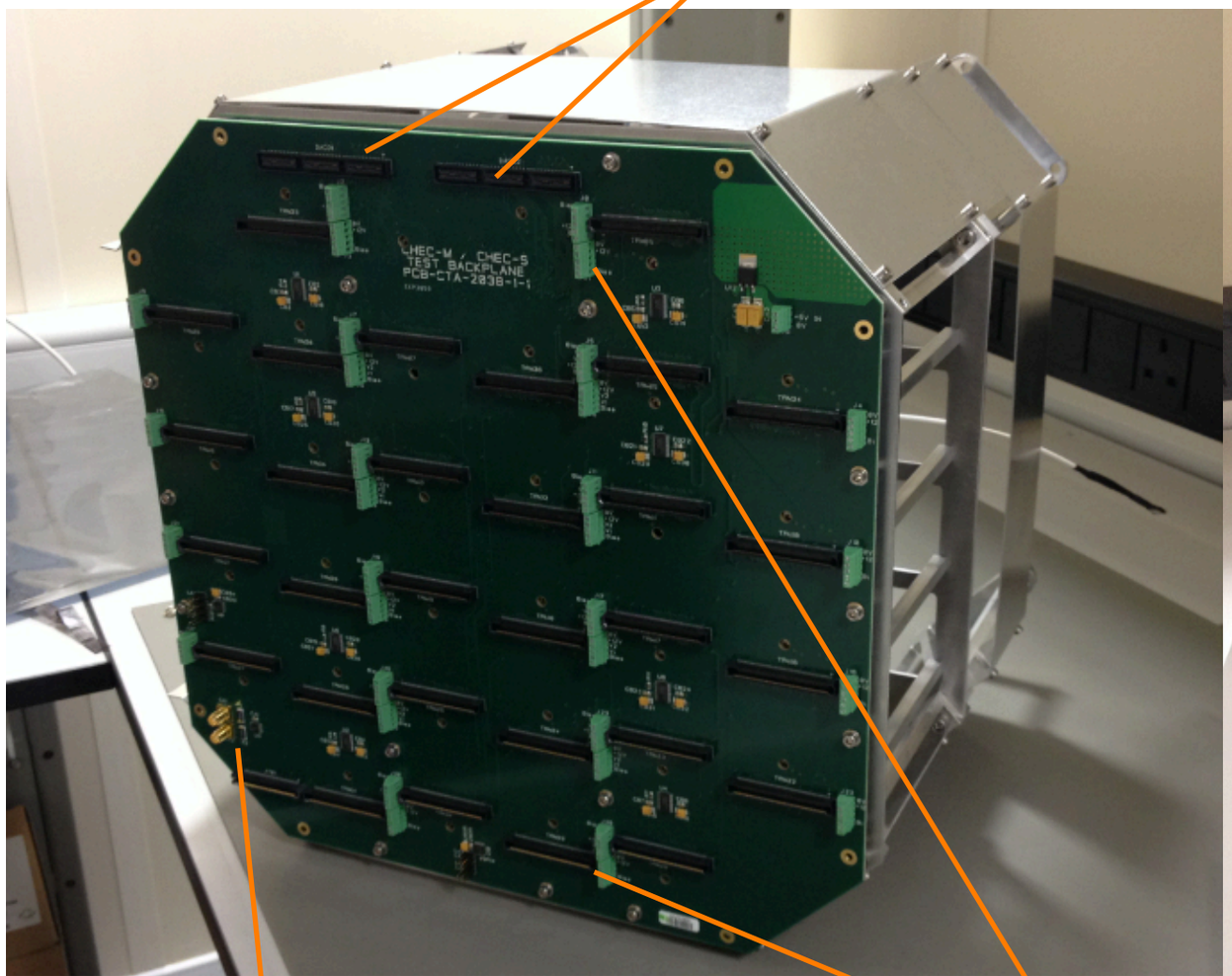
- Website CTA: www.cta-observatory.org
- For industry: http://www.cta-industries.org
- For the Netherlands: contact David Berge (d.berge@uva.nl)

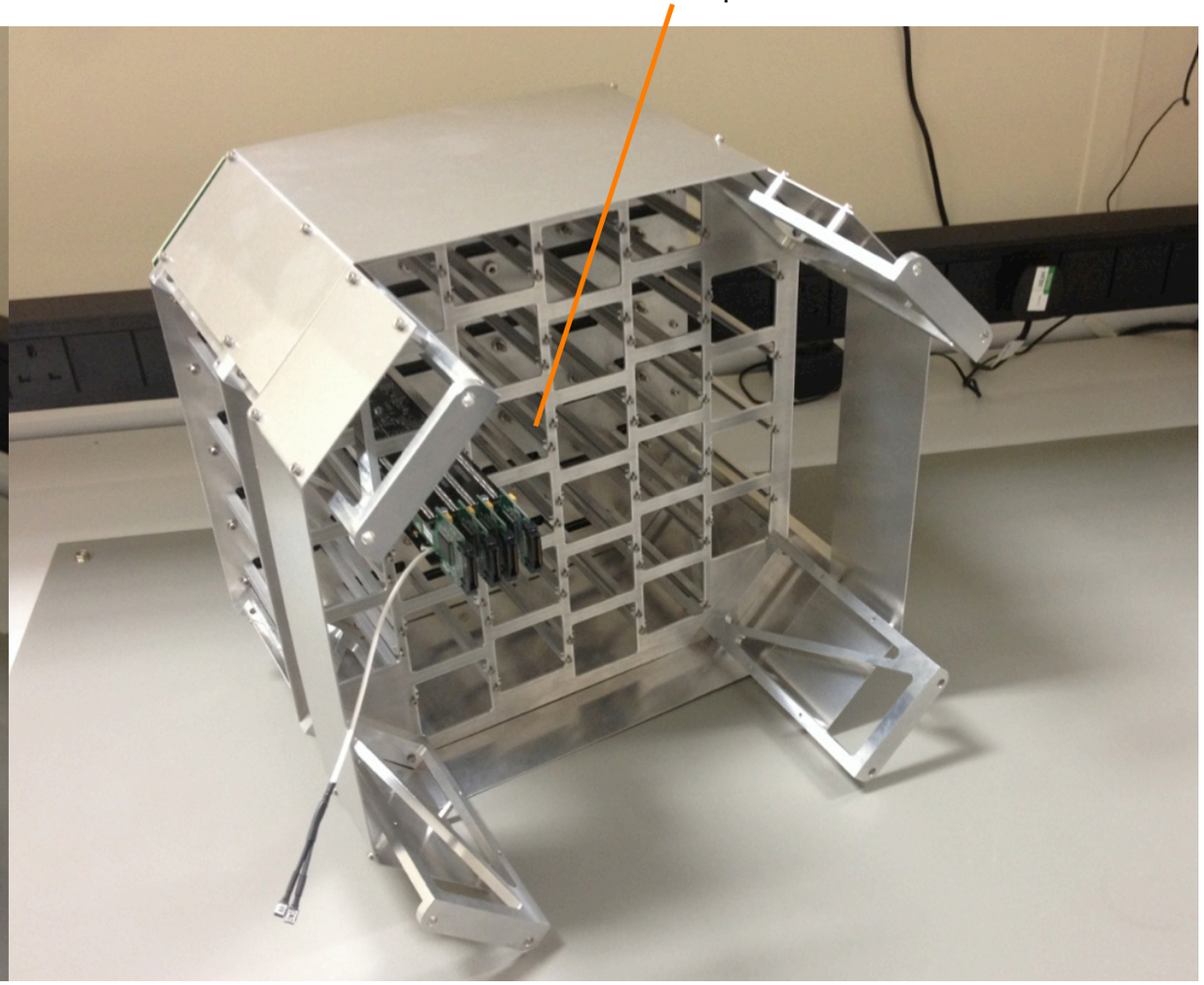
Back-up slides

CHEC-M proto-Backplane

Connection to DACQs

Accommodates TARGET modules in identical way to real Backplane

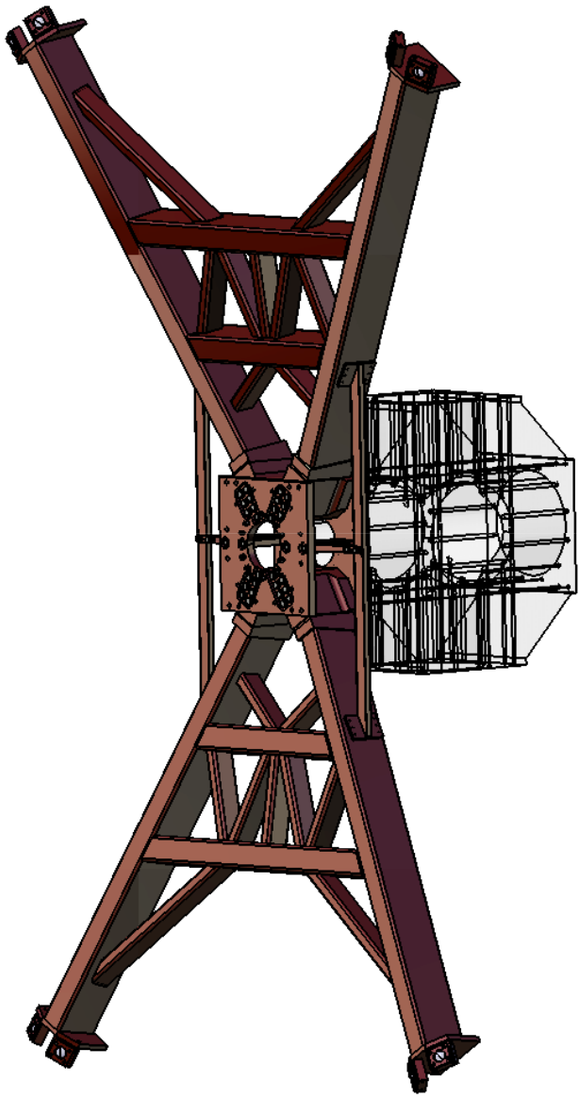




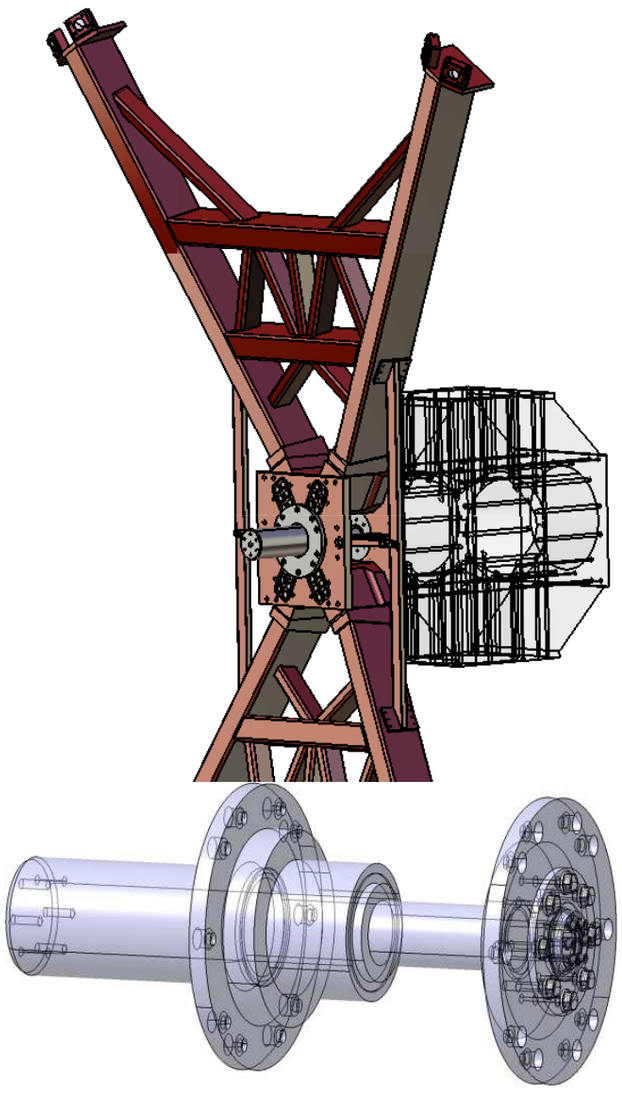
Trigger and CLK input & fan-out

Power to TARGET modules

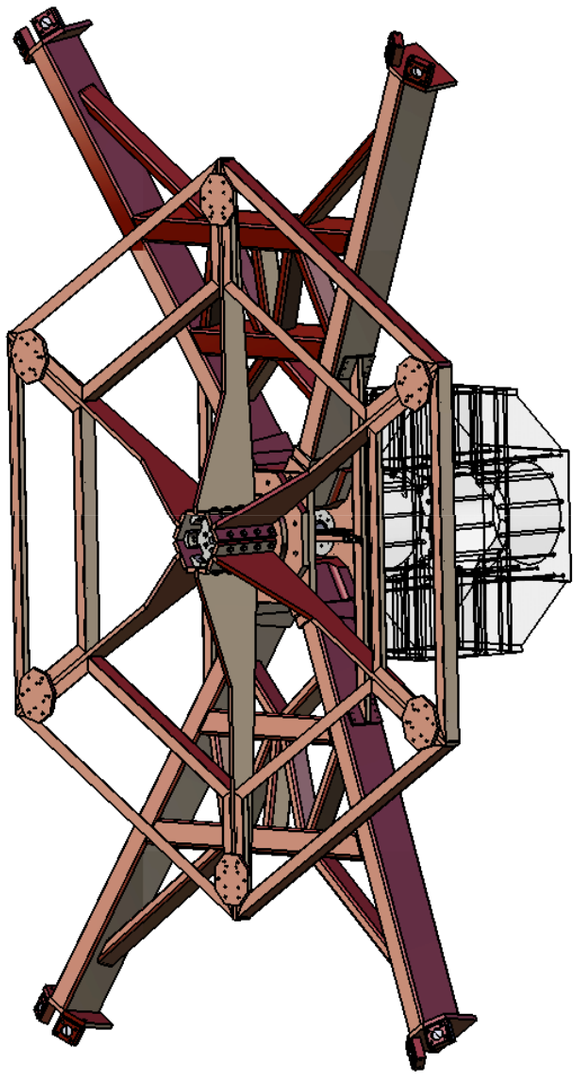
Optical structure assembly



Manufactured in 3 parts welded machined triangular parts and 2 flanges



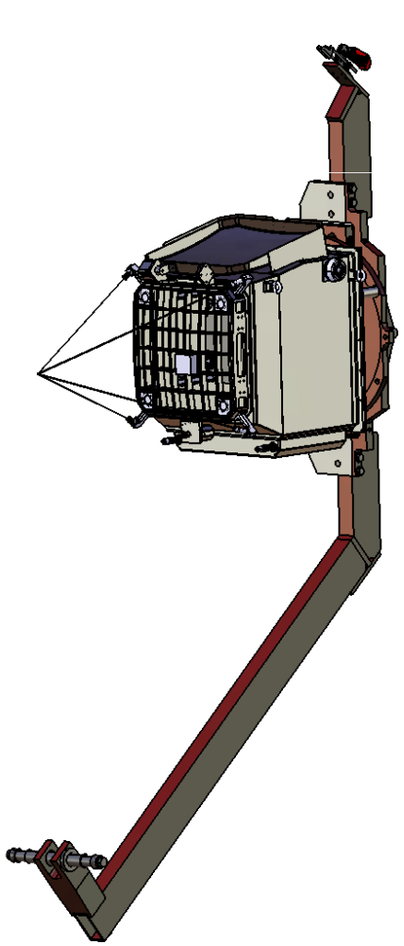
Add the rotating system for M1 dish made by cylindrical bushings

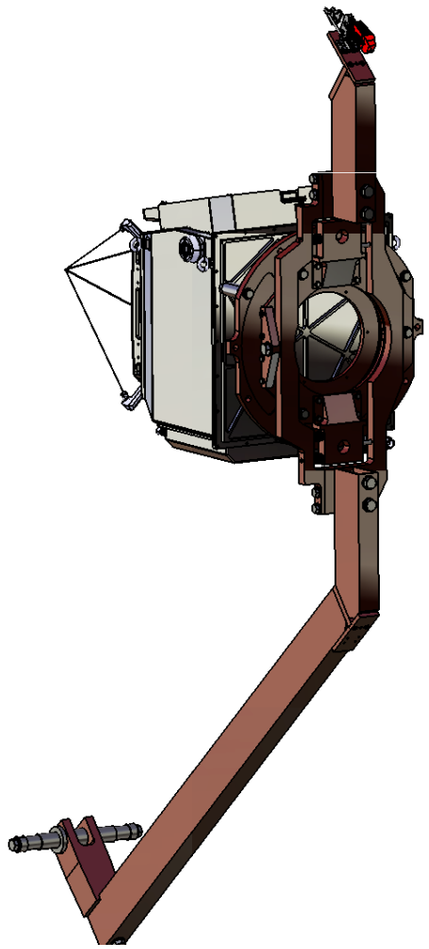


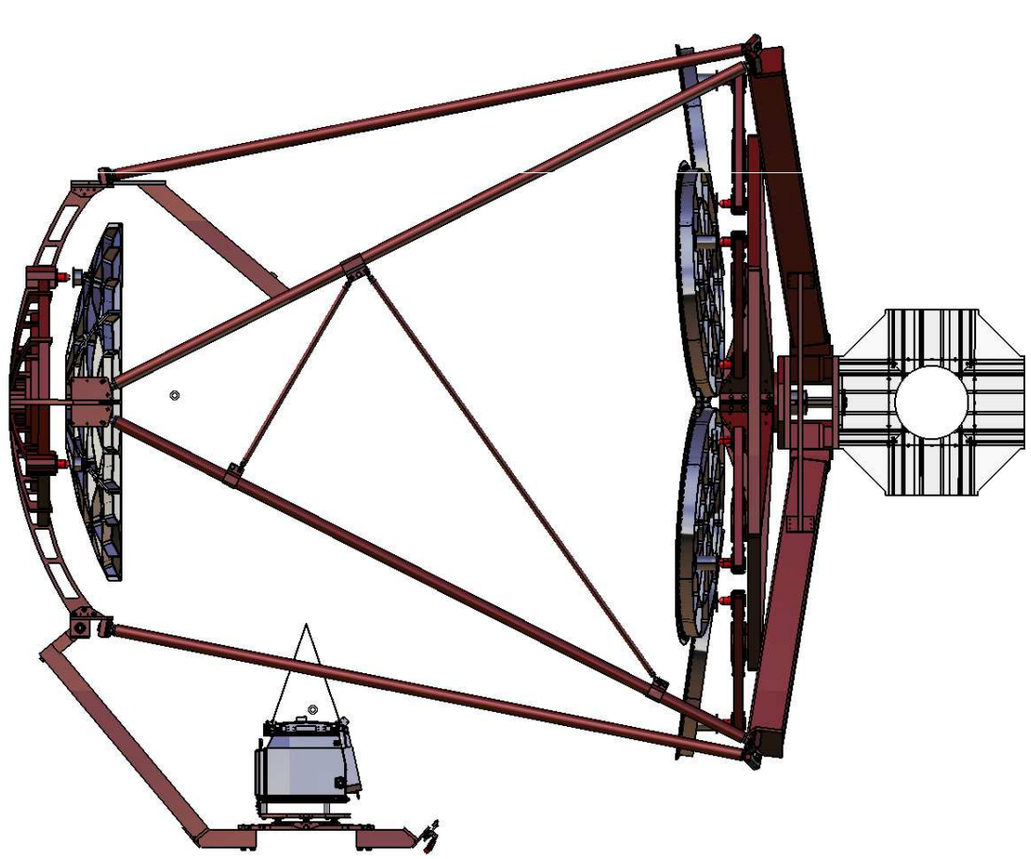
Integration of the M1 dish in hexagonal shape

Camera removal mechanism

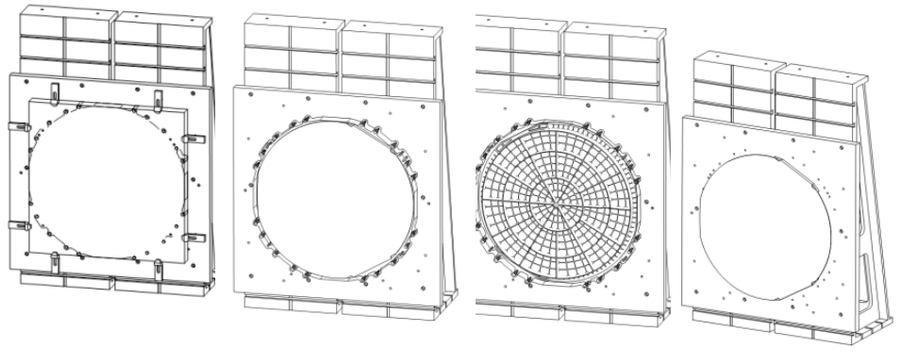
- Sytem to remove the camera is still available.
- Give access to the camera at a height of 99 cm

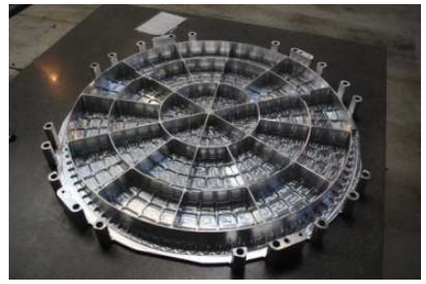






M1 progress





- Mirror M1
  - Machining finished end of June
  - Polishing finished end of July
  - Coating planned in coming weeks
  - Tests at the CEA IRFU