



Cherenkov
telescope
array

TECHNOLOGY



The World's Most Advanced Ground-Based Gamma-Ray Observatory

Credit: Gabriel Pérez Díaz, IAC (SMM)

Some quick facts about CTA technology:

CTA will use more than 100 telescopes located in both the northern and southern hemispheres to explore the entire sky.

CTA's three classes of telescope will provide broad energy coverage from billions to trillions times the energy of visible light (20 GeV to 300 TeV).

The telescope structures will stand between about 8 and 45 metres tall and weigh between 8 and 100 tonnes. Despite the largest telescopes' weight and size, they will still be able to rapidly slew towards targets within a few tens of seconds thanks to an ultra-light carbon fibre structure.

CTA will use more than 7,000 highly-reflective mirror facets (90 cm to 2 m diameter) to focus light into the telescopes' cameras.

CTA's cameras will use both photomultiplier tubes (PMTs) and silicon photo multipliers (SiPMs) to provide more than 200,000 ultra-fast light-sensitive pixels.

The observatory is expected to generate approximately 100 petabytes (PB) of data by 2030 (1 PB = 1 million GB).

Building the next generation very-high energy gamma-ray detector

CTA is the next generation ground-based observatory for gamma-ray astronomy at very-high energies. With more than 100 telescopes located in the northern and southern hemispheres, CTA will detect high-energy radiation with unprecedented accuracy and a sensitivity that is approximately 10 times better than current instruments.

CTA will be building on the technology of current generation ground-based gamma-ray detectors (H.E.S.S., VERITAS and MAGIC) with an expected tenfold increase in the number of known gamma-ray-emitting celestial objects, detecting more than 1,000 new objects.

More than 1,350 scientists and engineers from 32 countries are

engaged in the scientific and technical development of CTA. The Observatory will be constructed by the CTAO gGmbH, which is governed by shareholders and associate members from a growing number of countries.

The project to build CTA is well advanced: working prototypes exist or are under construction for all the proposed telescope designs and significant site characterization has been undertaken. The southern hemisphere site will be located close to the existing European Southern Observatory site at Paranal, Chile. The northern array will be located at the Roque de los Muchachos astronomical observatory on the island of La Palma. Construction is expected to begin in 2019.



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How CTA works

The gamma rays that CTA will detect do not make it all the way to the Earth's surface. When they reach the earth's atmosphere they interact with it, producing cascades of subatomic particles and a blue flash called Cherenkov light. These cascades are so rare (one gamma-ray photon per m² per year from a bright source or one per m² per century from a faint source), that CTA will be using more than 100 telescopes spread over a large area to improve its ability to detect gamma rays.

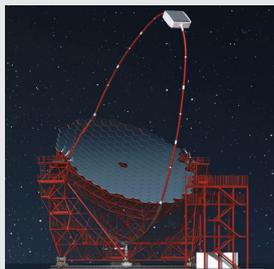
Three classes of telescope types are required to cover the full CTA energy range (20 GeV to 300 TeV). For its core energy range (100 GeV to 10 TeV), CTA is planning 40 Medium-Sized Telescopes distributed over both array sites. Eight Large-Sized Telescopes and 70 Small-Sized Telescopes are planned to extend the energy range below 100 GeV and above 10 TeV.

Once the mirrors reflect the light, the CTA cameras capture and convert it into data. Each telescope has its own variation of camera, but the designs are all driven by the brightness and short duration of the Cherenkov light flash.

A Cherenkov light flash lasts only a few billionths of a second and is extremely faint. The cameras are sensitive to these faint flashes and use extremely fast exposures to capture the light. Photomultiplier tubes (PMTs) or silicon photomultipliers (SiPMs) will convert the light into an electrical signal that is then digitised and transmitted to record the image of the cascade.

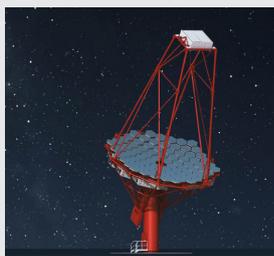
CTA telescope types

Large-Sized Telescope (LST)



Because gamma rays with low energies produce a small amount of Cherenkov light, telescopes with large mirrors are required to capture the images. The LST mirror will be 23 metres in diameter and parabolic in shape. Its camera will use PMTs and have a field of view of about 4.5 degrees. The entire structure will weigh about 100 tonnes but will be extremely nimble, with the goal to be able to re-position within 20 seconds.

Medium-Sized Telescope (MST)



This will be CTA's "workhorse." The MST mirror will be 12 metres in diameter and will have two different camera designs that use PMTs. Its large field of view of 7-8 degrees will enable the MST to take rapid surveys of the gamma-ray sky. A dual-mirrored version of the MST, the Schwarzschild-Couder Telescope (SCT) is proposed as an alternative type of medium telescope with greater imaging detail and improved detection of faint sources.

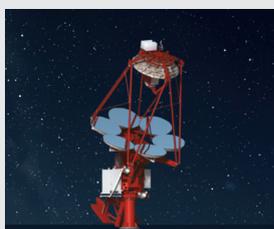
Small-Sized Telescope (SST)



The SSTs will outnumber all the other telescopes and will be spread out over several square kilometers in the southern hemisphere array. This is because very high-energy gamma-ray showers produce a large amount of Cherenkov light, and the SST is sensitive to the highest energy gamma rays. The SST mirror will be about 4 metres in diameter and will have a large field of view of about 9 degrees. Three different SST implementations are being prototyped and tested:



SST-1M (image 1): a single-mirror design with a camera that uses SiPMs and is a down-scaled version of the MST mount.



SST-2M ASTRI (image 2) and SST-2M GCT (image 3): both are dual-mirror designs that allow excellent imaging across a wide field of view with a short focal length. They use SiPMs in very compact cameras.

Image Credits: Gabriel Pérez Diaz, IAC (SMM)

The CTA Consortium includes more than 1,350 members from 210 institutes in 32 countries.

