

Status and perspectives of Cherenkov Telescope Array

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Summary. — The very-high-energy gamma-ray astrophysics in the few tens of GeV to 100 TeV domain experienced a real boost in the last decade thanks to the arrays of imaging atmospheric Cherenkov telescopes. The Cherenkov Telescope Array (CTA) project aims to extend the accessible energy range and to improve the flux sensitivity by an order of magnitude compared with the existing installations. Here I present the status and perspectives of the CTA project.

1. – Introduction

Ground-based gamma-ray astronomy —imaging the universe at very high energies (VHE) above tens of GeV and covering several decades of the electromagnetic spectrum— is a young branch of astronomy that has developed very rapidly since the detection of the first cosmic VHE source in 1989 [1]. The Cherenkov Telescope Array (CTA) Consortium formed in 2008 to develop a concept for the first major open observatory for this waveband, motivated by the success of existing imaging atmospheric Cherenkov telescopes (IACTs) such as H.E.S.S., MAGIC and VERITAS. These instruments have demonstrated that observations at these extreme energies are not only technically viable and competitive in terms of precision and depth, but also scientifically rewarding and with broad scientific impact. This success has resulted in a rapid growth of the interested scientific community. An overview of the Cherenkov technique with IACTs can be found in, *e.g.*, [2] and status of the field is discussed in, *e.g.*, [3].

2. – CTA telescopes and layouts

The CTA (see fig. 1, top) will take the VHE gamma astronomy to a next level, by constructing about 100 telescopes (compared to a dozen of currently existing ones) and operating them as open observatory. Rather than deploying one type of Cherenkov telescope on a regular grid, the CTA arrays (fig. 1, bottom) use a graded approach:

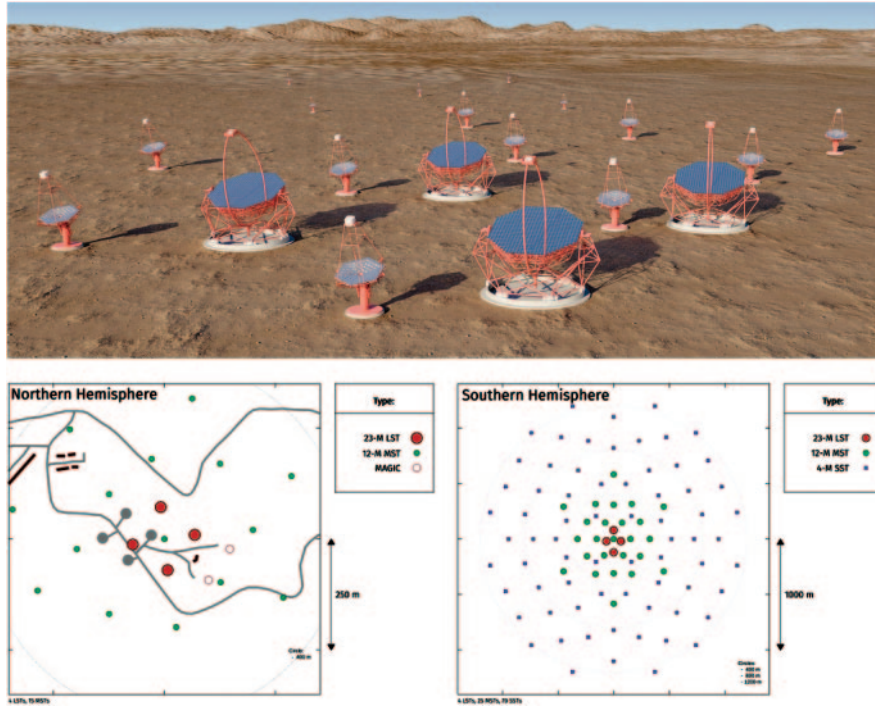


Fig. 1. – Artistic view on a CTA array (top) and array layout in the Northern (left) and Southern (right) Hemispheres (bottom).

- The lowest energies are covered by an arrangement of 4 large-size telescopes (LSTs), capable of detecting gamma rays down to 20 GeV,
- The 0.1 to 10 TeV range is covered by a larger array of 25 (south) or 15 (north) medium-size telescopes (MSTs), and
- The highest energy gamma rays are detected by a multi-km² array of 70 small-size telescopes (SSTs) in the south.

The CTA will be built on two sites, one in the Northern and one in the Southern Hemisphere to provide a full sky coverage. The small telescopes are only foreseen for the Southern array, since the highest energies are most relevant for the study of Galactic sources. The use of three different sizes of telescopes proved to be the most cost-effective solution, and it allows each telescope type to be optimised for a specific energy range. A preliminary flux sensitivity obtained with Monte Carlo simulations of the two arrays is shown in fig. 2. Note the improved energy coverage and sensitivity reached in 50 h of observations compared to the existing IACTs. Moreover, CTA will provide a full sky survey capability due to its increased field of view and a superior angular resolution.

3. – CTA organization

The CTA facility (see fig. 3 for the CTA organization) will be open to a wide community of scientific users from astronomy and astrophysics, astroparticle physics, particle physics, cosmology and plasma physics. Several modes of user access to observation time and to data products will be provided by the CTA Observatory:

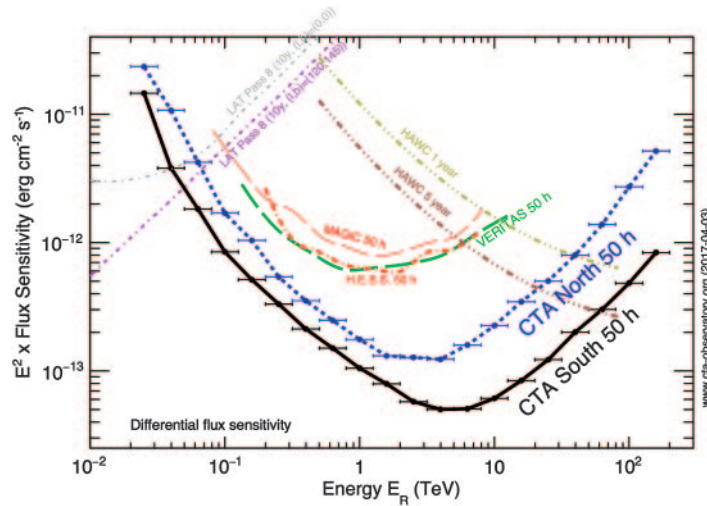


Fig. 2. – CTA differential flux sensitivity. Please find more performance characteristics at <https://www.cta-observatory.org/science/cta-performance/>.

- The Guest Observer (GO) Programme by which users can obtain access to proprietary observation time. Typical requirement is 2–100 h of observation time.
- The Key Science Projects (KSPs) are large programmes that ensure that the key science issues for CTA are addressed in a coherent fashion, and generate legacy data products. KSPs typically require 100–1000 h of observation time.
- Directors Discretionary Time (DDT) represents a small fraction of observation time reserved for, for example, unanticipated targets of opportunity.
- Archive Access under which all CTA gamma-ray data will be openly available, after a proprietary period.

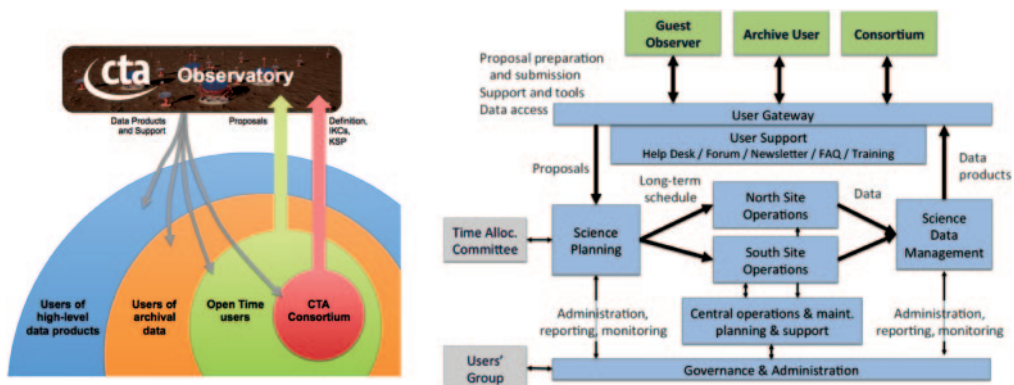


Fig. 3. – Structure of the CTA observatory.

4. – Key science projects

CTA will address major questions in and beyond astrophysics which can be classified under three broad themes:

- *Origin and role of relativistic cosmic particles.* What are the sites of high-energy particle acceleration in the universe? What are the mechanisms for cosmic particle acceleration? What role do accelerated particles play in feedback for star formation and galaxy evolution?
- *Probing extreme environments.* What physical processes are at work close to neutron stars and black holes? What are the characteristics of relativistic jets, winds and explosions?
- *Exploring frontiers in fundamental physics.* What is the nature of Dark Matter? How is it distributed? Are there quantum gravitational effects on photon propagation? Do axion-like particles exist?

The science issues to be addressed with CTA are presented in detail in an Astroparticle Physics CTA special issue [4]. Proposed CTA key science topics are sketched in fig. 4 sorted in distance to objects from Earth. Deep survey fields will be obtained for some key regions hosting prominent targets, while wider field surveys will be conducted to build up unbiased population samples and to search for the unexpected. The combination of the wide CTA FoV with unprecedented sensitivity ensures that CTA can deliver surveys 1-2 orders of magnitude deeper than existing surveys very early in the life of the CTA Observatory. The CTA surveys will open up discovery space in an unbiased way and generate legacy datasets of long-lasting value.

5. – CTA status

The site selection process was successfully finished and host agreements were finalized with the European Southern Observatory (ESO) Paranal site in Chile and the Instituto

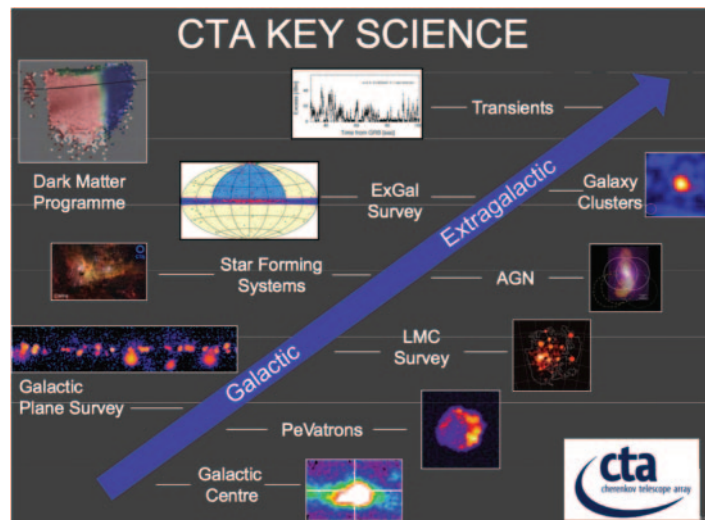


Fig. 4. – Key science of CTA.

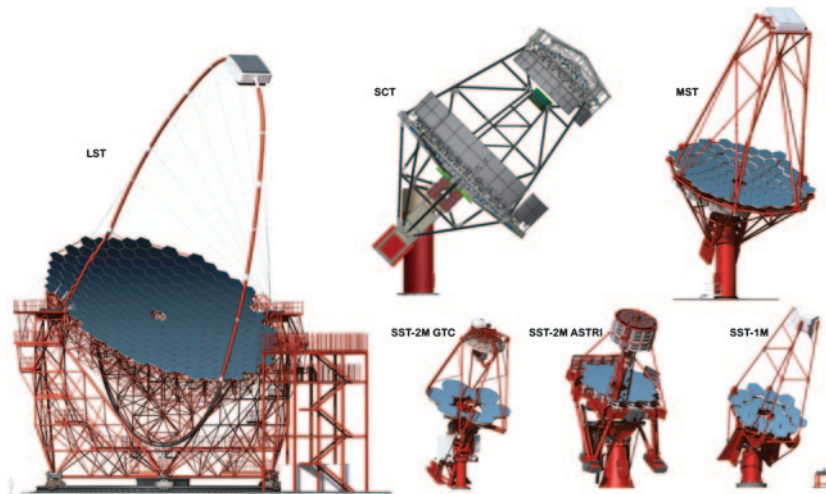


Fig. 5. – Prototypes for the three sizes of the CTA telescopes: Large Size Telescope (LST), Medium Size Telescope (MST), Schwarzschild-Couder Telescope (SCT, which is an alternative design for the MST), and three SSTs: single mirror SS-1M as well as two dual-mirror designs of SST-2M GTC and SST-2M ASTRI.

de Astrofísica de Canarias (IAC), Roque de los Muchachos Observatory in La Palma, Spain. A site development started in 2017 and first preproduction telescopes (see fig. 5 for telescope designs) are expected to be deployed in 2018-19. After a technical commissioning of the first telescopes the early science can be expected with partial arrays as early as in 2019-20 while the entire arrays should be completed by 2022-23. The lifetime of CTA is foreseen to last for 30 years. CTA perspectives in relativistic astrophysics include the in-depth understanding of known VHE gamma-ray emitters and their mechanisms, detection of new object classes, and discovery of new phenomena. As for many facilities breaking new ground, the most important discoveries may not be the ones discussed in today's science case documents.

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This presentation and write-up are largely based on the CTA Construction Proposal and the CTA Science Case document [5]. CTA gratefully acknowledges support from the agencies and organizations listed under Funding Agencies at this website: <http://www.cta-observatory.org/>.

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