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Toward a new generation of Cherenkov telescopes with CTA

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Summary. — Gamma-rays provide a powerful insight into the non-thermal universe and a valid probe for new physics beyond the standard model. Despite its relatively recent appearance, very high energy (VHE) gamma-ray astronomy from the ground has proven to have reached a mature technology stage, with fast assembling, relatively cheap and reliable telescopes. The scientific outcome is impressive, with more than 140 sources discovered in few years, and several astrophysical scenarios of particle acceleration and gamma-ray transport already disproved by VHE data. The goal of future installation is to increase the sensitivity by a factor 10 compared to current installations, and enlarge the energy domain from few tens of GeV to several tens of TeV with unprecedented angular and energy resolution and a factor 3 larger field of view. Hereafter, we present design considerations for the Cherenkov Telescope Array (CTA), a project for a new generation of highly automated telescopes for VHE gamma-ray astronomy.

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Despite the relevant scientific achievements from the current generation of Imaging Atmospheric Cherenkov Telescopes (IACTs, see also, *e.g.*, Prandini, this conference), there is a number of limitations that CTA [1-3] will overcome: a) IACTs of the current generation are sensitive in the approximate photon energy range 0.1–50 TeV. At the lower end, IACTs are limited by the background from atmospheric hadronic showers. At the high end, the limit is posed by insufficient statistics; b) their spectral reconstruction is limited by systematic bias and statistical uncertainties on the energy reconstruction; c) they have a limited aperture, with typical field of view (FOV) of the order of 3°–5° diameter; d) they have a limited angular resolution which currently states around few arcmin.

On the other hand, from the physics point of view, there are strong arguments to improve the design of future telescopes and improve in all of the aspects above.

For this reason, a new generation of IACT is under design now with expected performance well above the current generation, as shown in fig. 1. We believe that with CTA we are heading toward an era of *precision VHE gamma-ray astronomy.*

To comply with the science requirements and to maintain an overall high technical performance, the CTA concept is based on few general ideas: 1) increase the number

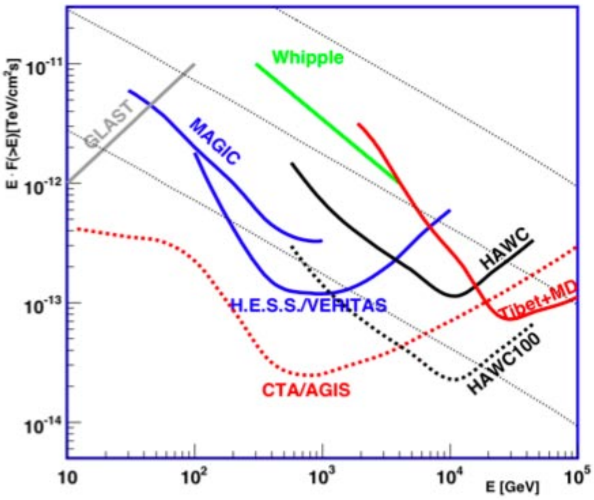

Fig. 1. – Integral sensitivity for a Crab-like spectrum for several current IACT and expected for CTA/AGIS (5σ, 50 h) and Fermi/GLAST (5σ, 1 y).

and type of telescopes, 2) distribute them over a total area of several km^2 3) fully automatize and remotely operate the telescopes 4) Create two installations for a complete sky coverage, one in the Southern hemisphere and one in the Northern hemisphere.

Basic array design. – A scheme of the array is shown in fig. 2. The CTA project is being designed both to provide an expansion of the energy range down to a few tens of GeV and up to about 100 TeV and with at least 10 times improvement in sensitivity compared to current installations. This can only be achieved by combining many telescopes distributed over a large area and using telescopes of different sizes. CTA is planned to comprise about a hundred telescopes of 2–3 different sizes: several small size telescopes (SST) of 6 m diameter, several medium size telescopes (MST) of 12 m diameter and few large size telescopes (LST) of 23 m diameter. However, the number of the telescopes,

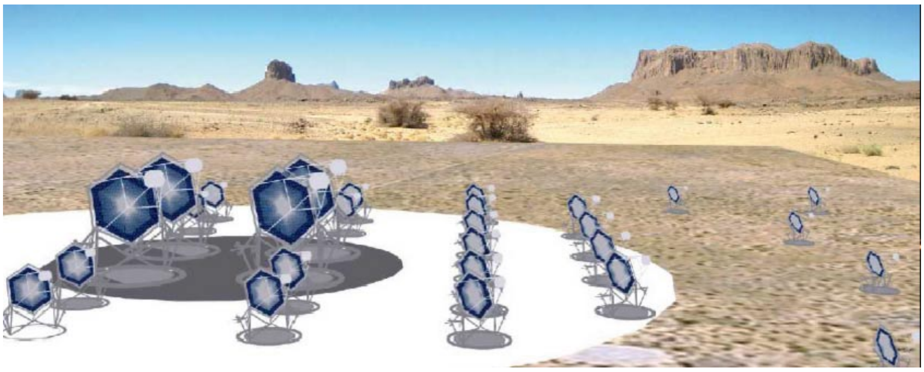

Fig. 2. – Artist's view of the compound different size telescopes CTA system. The area coverage is of 1–10 km^2.

their size, their configuration and the overall performance are still under investigation and the final layout will come after Monte Carlo optimization of the design *versus* the range of science cases has been reached.

The reason to have three telescope size is the following. At low energies, below 100–200 GeV, the photon density at ground is low, and therefore the large reflective surfaces of the LST are needed. At the other extreme, super-TeV showers provide ample photon signal, but at low statistics (consider that for a typical target, there are 10^6 event a 100 GeV for a single event at 10 TeV), and therefore several SSTs should be distributed over a large surface to increase the collection area. In the regime around the TeV, several telescopes of the MST size are needed to perform the core observations at the TeV, where good event statistics and good signal-to-noise ratio are achievable. Very roughly, the cost ratio between LST/MST and MST/SST is a factor 10. Several tens of MSTs will perform the bulk TeV search. Those telescopes will come from the well-proven experience of the HESS, MAGIC [4] and VERITAS collaborations. The main goal is to reduce the costs and maintenance activities. They will constitute the core of the array, and will perform the fundamental task of vetoing the LST triggers to reduce the hadronic background. Several different designs are currently taken into account and the construction of the first prototype is expected soon. Finally, several tens of SSTs will complete the array to perform the super-TeV search. They will be very simple in construction and distributed in between and around the core array of MSTs.

Improved angular and energy resolution. – The improvement of energy and angular resolution is also a key feature in the performance of CTA w.r.t. current IACTs. The angular resolution should be kept as low as possible in the entire FOV. This has the important effect of reducing source confusion should help with identifying sources in very crowded regions, like the Galactic Center. An increase in energy resolution (down to 5%) boosts the capability to observe spectral features. This can be achieved by improving both the calibration of the detector (light sensor, photon conversion, etc.) and the monitoring of the atmosphere through remote sensing devices, like LIDARs [5].

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