

# H.E.S.S.: Status and future plan

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**Abstract.** The H.E.S.S. (High Energy Stereoscopic System) experiment has been in operation in its current set-up since the beginning of 2004. The construction of the extension of H.E.S.S. (“Phase II”) has started: A telescope with a mirror surface of 600 m<sup>2</sup> in the center of the four existing H.E.S.S. Phase I telescopes. This “Large Cherenkov Telescope” (LCT) will operate stand-alone as well as in coincidence together with the Phase I telescopes. The LCT will start triggering on gamma-ray initiated air showers at an energy of 20 GeV. In this contribution, a status of the existing installation and plan for the future will be given.

## 1. Introduction

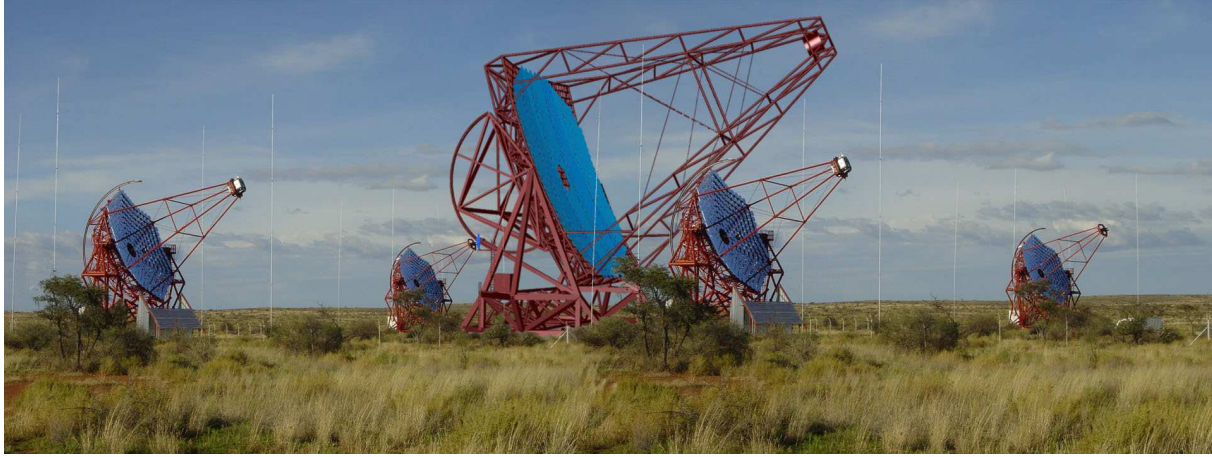
The H.E.S.S. collaboration is currently composed of roughly 100 scientists working in 24 institutes in 9 countries (for more details on the collaboration, see e.g. [1]). The original concept of a 100 GeV threshold telescope array was first sketched about 10 years ago [2, 3]. The H.E.S.S. collaboration formed in 1998 as an effort driven by the French and German groups involved in the CAT [4] and HEGRA [5] Cherenkov telescope experiments. The H.E.S.S. site in Namibia was chosen for mainly two reasons: its excellent record of clear and dark nights as well as for its geographic location in the southern hemisphere where the inner part of the Galaxy culminates at small zenith angles. The built-up phase of the H.E.S.S. telescopes started with the ground-breaking in 2000 and the first telescope structure was in place in July 2001 followed shortly after by the installation of the mirrors and the camera. This telescope saw “first light” in summer 2002. The installation of the remaining three telescopes took on average six months for each additional telescope such that the final fourth telescope was operational in December 2003. Data-taking continued without interruption throughout the installation phase with changing setups. Since January 2004, the telescope system (H.E.S.S. Phase I) has been operational in its current form without the need to introduce major upgrades and changes.

In the following, the setup and performance of the H.E.S.S. Phase I telescopes will be reviewed. In the third section, the design and status of the construction of the LCT will be given (see Fig. 1 for a view of the existing telescopes including an artist’s conception of the LCT).

## 2. Status: H.E.S.S. Phase I

### 2.1. System layout and telescope structure

The H.E.S.S. experiment is an array of four identical imaging air Cherenkov telescopes arranged at the corners of a square with 120 m side length. The array is located in the Khomas Highlands in Namibia at 1800 m a.s.l. The four telescopes consist each of a light concentrator with a



**Figure 1.** An artist view of the LCT located in the center of the existing H.E.S.S. Phase I telescopes

diameter of 13 m and a focal length of 15 m. The reflective area of  $107 \text{ m}^2$  is comprised of 380 quartz coated spherical mirror facets of 60 cm diameter [7] which are individually adjustable with a remote controlled alignment system [8].

### *2.2. Camera and electronics*

The prime focus is equipped with an integrated camera consisting of 960 fast read out photo-multiplier tubes (PMTs) including the corresponding triggering and digitization electronics [6]. The PMTs (Photonis XP2960) are arranged in drawers of 16 tubes which can be replaced as a unit. The PMTs are equipped with Winston cones which constrain the field of view of each tube to avoid stray light contamination and to increase the effective entrance window of each tube. The angular size of the PMT is  $0.16^\circ$  which is well-matched by the point-spread function of the concentrator: 80 % of the light of a point source is imaged in a region with a diameter of  $0.04^\circ$  for on-axis and  $0.16^\circ$  for  $2^\circ$  off-axis observations [8].

The point spread function is remarkably stable over the time of operation. Dedicated pointing-runs are used to monitor the point spread function. During pointing runs, the telescopes are tracking a star with the camera lid closed. The image of the star on the camera lid is used to characterize the point spread function of the telescope: As expected, the point spread function is found to slowly increase with time. However, the rate of change is sufficiently small to operate the telescopes without the need for re-adjusting the mirrors.

While the telescopes provide their own single telescope trigger, a multi-telescope coincidence is formed to initiate the read-out of triggered telescopes. The multi-telescope trigger coincidence is used to discriminate air shower events from possible background events due to muons or night sky background fluctuations which affect only individual telescopes [9].

### *2.3. Data calibration and analysis*

The data are analysed in parallel to the data-taking and first results are available in real-time to the shift crew on-site. This feed-back allows a immediate response to flaring activities of sources as e.g. were observed recently from the Blazar PKS 2155-304 [10] (see also Giebels et al. these Proceedings). While the online analysis is performed on the coarsely calibrated real-time data, the offline scientific analysis is applied to the fully calibrated data which includes identification of switched off or broken pixels, electronic pedestal subtraction, relative gain calibration, flat-fielding correction, and optical efficiency corrections [11].

#### *2.4. Operation and performance*

The H.E.S.S. array is fully operational since the beginning of 2004 and performs within the expectations at an energy threshold of 100 GeV for vertical incidence gamma-ray events. On average, individual events are reconstructed with an angular accuracy better than  $0.1^\circ$  and a relative energy resolution of 15 %. Faint gamma-ray sources with a flux of 1 % of the Crab nebula are detected within a 25 hour observation.

The wide field of view covering a region in the sky with a diameter of  $5^\circ$  in combination with the good gamma-hadron separation has been proven to be well suited for the survey of parts of the Galactic plane and to study the spatially extended emission of sources like shell type supernova remnants and pulsar wind nebulae. For a review of the recent results of H.E.S.S. observations see the accompanying articles in these proceedings.

### **3. Under Construction: H.E.S.S. Phase II**

The Large Cherenkov telescope (LCT) will start the Phase II operation of the H.E.S.S. experiment. The LCT will extend the energy range with an expected trigger threshold of  $\approx 20$  GeV while improving the performance and reducing the threshold of the existing Phase I telescopes. The first test assemblies of the steel structure in Namibia have started. The time schedule foresees the beginning of operation in 2008.

#### *3.1. Design of the Large Cherenkov telescope (LCT)*

The LCT is planned to have an increased mirror collection area of  $600 \text{ m}^2$ . The overall structure is based on a steel frame architecture. The mirror dish consists of a space frame support structure and 25 mirror panels. The arrangement of the flat panels approximates the shape of a parabolic dish with a focal length of 35 m. The concentrator is of parabolic design in order to minimize the arrival time spread of the Cherenkov light pulse in the focal plane.

Up to 1006 hexagonal mirrors with a flat-to-flat size of 90 cm can be mounted on the panels. Each mirror will be aligned with two remote controlled motors which will drive the mirrors into the correct alignment using a procedure very similar to the one successfully used for H.E.S.S. Phase I. The steel structure will be sufficiently rigid under gravity and wind load to maintain a stable point spread function for observations up to zenith angle distances of  $\approx 50^\circ$ . For larger zenith angle observations, a re-alignment of mirrors during operation will be necessary. Similarly, the camera position will be adjusted automatically during observations to maintain a focus on the air shower images at different zenith angles (and therefore distance to the telescope).

#### *3.2. Camera design*

The camera of the LCT will be based largely on the existing camera design of the Phase I telescopes [12]. The size of the PMTs will remain the same as well as the dimensions of the drawers. However, as a result of the increased focal length of 35 m, the angular diameter of the pixels will be reduced to  $0.07^\circ$ . The number of pixels will be increased to 2048 to cover a total field of view of  $3.17^\circ$  diameter.

Similar to H.E.S.S. Phase I, the pixel read-out will be based on an analogue ring sampling system integrated on a chip directly connected to the base of the PMTS. The new ring sampling chips have been largely improved with respect to the version used for H.E.S.S. Phase I with an increased memory depth and sampling speed (up to 2 GHz) and larger bandwidth (300 MHz) resulting in an increased dynamical range of 6 000 photoelectrons. Most importantly, the readout speed has improved from  $60 \mu\text{s}$  to an average of  $2 \mu\text{s}$  (see also Feinstein, these Proceedings). The reduced read-out time is crucial to keep the overall dead-time negligibly small ( $< 1 \%$ ) for the expected trigger rate of up to 3 kHz. While the expected read-out and network transfer rate is sufficiently high to deal with the anticipated 3 kHz rate, a second level trigger is foreseen to allow for tagging and/or rejecting night-sky background and muon induced events.

### 3.3. Performance of the LCT

H.E.S.S. Phase II will register mainly three different types of events: (i) A coincidence of  $\geq 2$  Phase I telescopes (ii) a coincidence of the LCT and at least one Phase I telescope, and (iii) LCT provides a trigger. The event class (i) is similar to what is observed with the current telescopes. The event class (ii) will be a new type of hybrid event which will predominantly occur at photon energies below the current 100 GeV threshold. In this transition energy range, the LCT will provide well defined images with roughly one hundred photo-electrons while the Phase I telescopes operate at their trigger threshold of a few ten photo-electrons. While the  $\geq 2$  images are sufficient to provide a stereoscopic view of the air shower with the benefits of good angular resolution and redundancy on the shower parameters, the large number of detected photoelectrons and high definition view of the shower obtained with the LCT will provide excellent gamma-hadron separation based on the shape of the image. The hybrid events will decrease the threshold for events seen by the Phase I array as well as improve the sensitivity at the 100 GeV energy range. Finally, the events of type (iii) are “mono LCT” events which will be already triggering at energies as low as  $\approx 20$  GeV. The performance (especially of gamma-hadron separation) is known to degrade for air shower events at energies below 100 GeV. However, Monte Carlo simulations show that the sensitivity of the LCT mono events is expected to be better than  $10^{-10}$  ph/(cm<sup>2</sup> s) integral fluxes above 20 GeV in 50 hrs observation time.

## 4. Summary and Outlook

Ground based gamma-ray astronomy is rapidly evolving. The H.E.S.S. Phase I telescopes have finally reached a sensitivity which is sufficient to explore Galactic and extragalactic sources of gamma-rays. The extension of the H.E.S.S. telescopes with a Large Cherenkov telescope (LCT) will start the Phase II of the H.E.S.S. experiment: The LCT will improve the performance of the existing telescopes in the 100 GeV energy range and extend the accessible energy range to 20 GeV opening a new window for exploration of sources established with H.E.S.S. Phase I as well as discover new sources as e.g. AGN at high red-shift, pulsars, and possibly gamma-rays from Dark matter particle self-annihilation.

The LCT will start operation in 2008, which will be in time to operate simultaneously with the GLAST satellite (see J. Carson, these Proceedings).

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