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Cite as: AIP Conference Proceedings **1792**, 030001 (2017); https://doi.org/10.1063/1.4968902
Published Online: 04 January 2017

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The Key Science Projects of the Cherenkov Telescope Array

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Abstract. The Cherenkov Telescope Array (CTA) will be the next generation gamma-ray observatory, open to the scientific community, to investigate the very high-energy emission from a large variety of celestial sources in the energy range 20 GeV – 300 TeV. The full array, distributed over two sites, one in the northern and one in the southern hemisphere, will provide whole-sky coverage and will improve by about one order of magnitude the sensitivity with respect to the current major arrays. CTA will investigate a much higher number of already known classes of sources, going to much larger distances in the Universe, performing population studies, accurate variability and spatially-resolved studies. Moreover, new light will be shed on possible new classes of high-energy sources, such as GRBs, cluster of Galaxies, Galactic binaries, and on fundamental physics. By pushing the high-energy limit to $E > 100$ TeV it will allow a thorough exploration of the cut-off regime of the cosmic accelerators. We review the main CTA Key Science Projects, which will focus on major scientific cases, a clear advance beyond the current state of the art, and we discuss the production of legacy data-sets of high value to a wider community.

Keywords: instrumentation: detectors – telescopes – radiation mechanisms: non-thermal
PACS: 95.30.-k, 95.30.Cq, 95.35.+d, 95.55.Ka

THE CHERENKOV TELESCOPE ARRAY

The very high-energy (VHE) portion of the electromagnetic spectrum (above ≈ 100 GeV) is currently being investigated by means of ground-based imaging atmospheric Cherenkov telescopes (IACTs, see [1] for a recent review). In order to dramatically boost the current IACT performance and to widen the VHE science, a new Cherenkov telescope array (CTA) has been proposed, as described in [2] and more recently in [3]. The wide energy range covered by the CTA (from a 20 GeV up to 300 TeV) requires different classes of telescopes. The large size telescopes (LSTs, D$\sim$ 23 m) will lower the energy threshold down to a few tens of GeV, the medium size telescopes (MSTs, D$\sim$ 12 m, SCTs, D$\sim$ 9.5 m) will improve by a factor of ten the sensitivity in the 0.1–10 TeV energy range, and the small size telescopes (SSTs, primary mirror D$\sim$ 4 m) will enhance Galactic plane investigations in the energy range beyond 100 TeV. To allow all-sky coverage, the full array will be installed in two sites, one for each hemisphere. About thirty telescopes (a few LSTs and several MSTs) will be installed at both sites, covering an area of $\sim 1\,\mathrm{km}^2$, with LSTs at the center. The CTA southern site, covering an area of about $4\,\mathrm{km}^2$, will be completed with 70 SSTs. A detailed review of the CTA project is given in [4].

CTA PERFORMANCE AND SCIENCE TOPICS

The CTA performance was accurately investigate by means of detailed and extensive Monte-Carlo simulations over a period of more that ten years. These simulation allowed us to obtain a set of performance curves which can be publicly downloaded from the CTA webpages[1].

In Figure 1 we show, for both the northern and the southern arrays, the CTA differential energy flux sensitivity (E^2 dN/dE) in five independent logarithmic bins per decade of energy. The required level of confidence in each bin is a five standard deviation statistical significance (calculated with equation 17 from [5]) and the presence of at least 10 excess events above background. We also required that the signal excess is at least five times the assumed background systematic uncertainty of 1% of the background remaining after cuts. These requirements are applied for each energy bin. The CTA curves are compared with the H.E.S.S., MAGIC, VERITAS, and HAWC ones.

[1] https://portal.cta-observatory.org/Pages/CTA-Performance.aspx

High Energy Gamma-Ray Astronomy
AIP Conf. Proc. 1792, 030001-1–030001-12; doi: 10.1063/1.4968902
Published by AIP Publishing. 978-0-7354-1456-3/$30.00

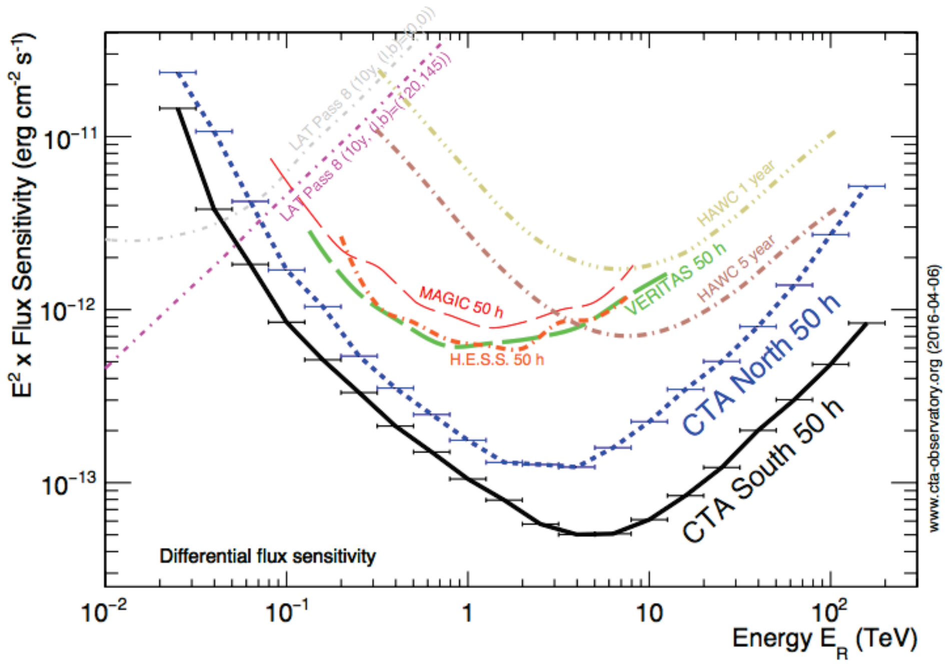

FIGURE 1. CTA differential energy flux sensitivity compared with the H.E.S.S., MAGIC, VERITAS, and HAWC ones. See text for details.

Two unique characteristics of the CTA sensitivity can be appreciated: first, a factor of ten improvement in the domain of about 100 GeV to some 10 TeV; second, the extension of the accessible energy range from well below 100 GeV to above 100 TeV.

Another typical performance figure is the angular resolution, expressed in terms of the 80% containment radius. Figure 2 shows the CTA angular resolution for the southern array as a function of the reconstructed energy. We note that this curve has been obtained by maximising the sensitivity figure, therefore higher resolution is possible at the expense of some collection area. The curve for the northern array is comparable. The most updated reference for the CTA Monte Carlo performance is [6].

CTA will address a wide range of major questions in and beyond astrophysics, which can be grouped in to three broad themes.

The origin and the role of relativistic cosmic particles. We aim to investigate the sites of high-energy particle acceleration in the universe, mechanisms for cosmic particle acceleration, and the role that accelerated particles play in feedback on star formation and galaxy evolution.

The cosmic extreme environments. CTA will investigate the physical processes which are at work close to compact objects, such as neutron stars and black holes, what are the characteristics of relativistic jets, winds, and cosmic explosions, the intensity of radiation and magnetic fields in cosmic voids, and how these evolve over cosmic time.

New frontiers in physics. The improved CTA performance will allow scientists to investigate what the nature of dark matter is and how it is distributed, if there are quantum gravitational effects on photon propagation, and if axion-like particles do exist.

When compared to the baseline CTA number of telescopes, the current imaging atmospheric Cherenkov arrays are composed of much smaller arrays (2–5 telescopes). The significant increase of the number of telescopes planned to be deployed in both hemispheres as well as the huge increase of the effective area will allow CTA to explore new science windows. CTA will have the unique capability to point in almost any direction in the sky. Figure 3 shows how with two sites virtually the entire sky can be covered at zenith angles (ZA) below 60°, with a small exception of the sources near the terrestrial south pole. White, light pink, dark pink, and black areas correspond to $0^\circ < \mathrm{ZA} < 30^\circ$,

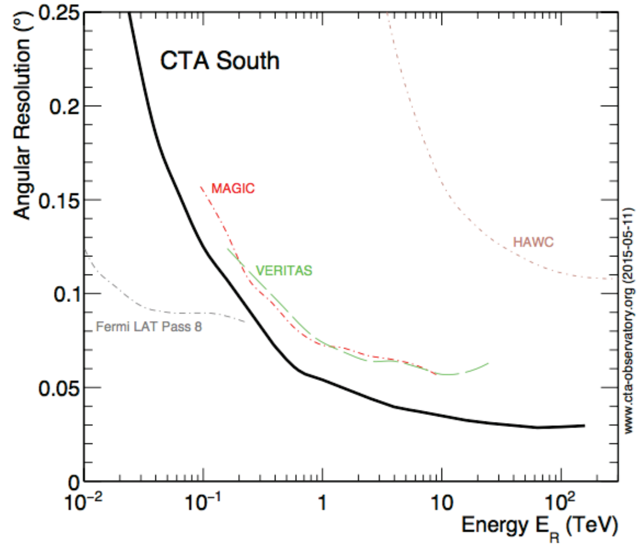

FIGURE 2. CTA differential angular resolution compared with the H.E.S.S., MAGIC, VERITAS, and HAWC ones. See text for details.

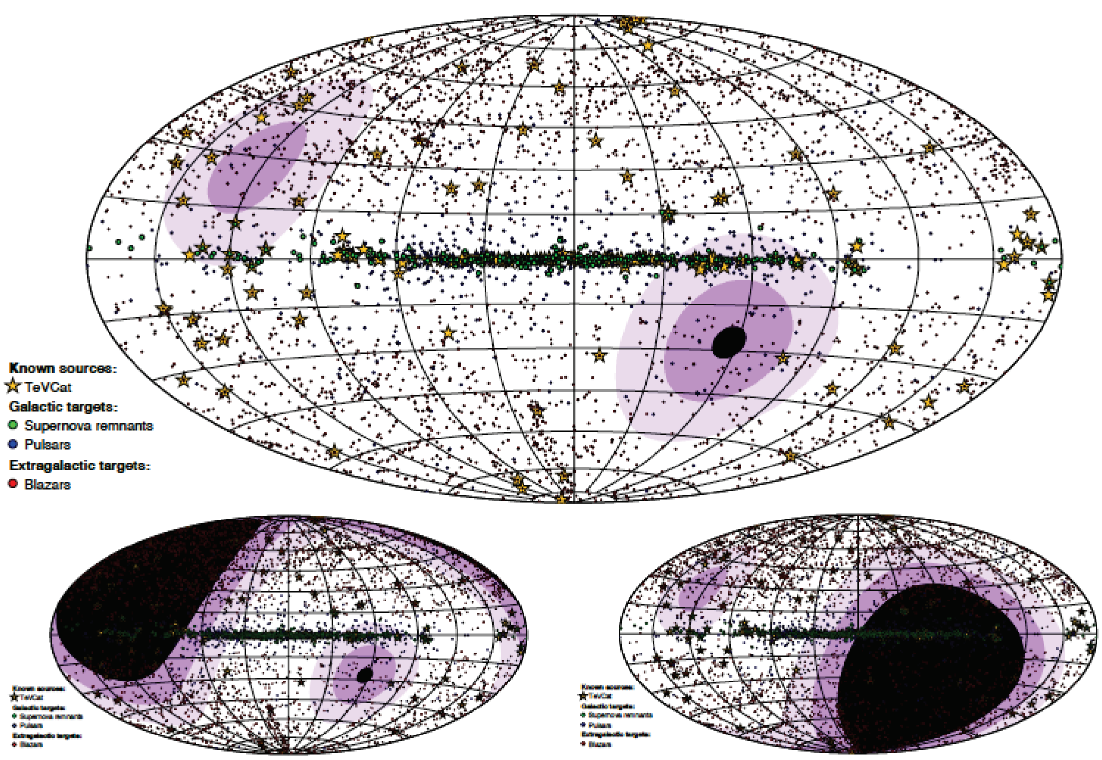

FIGURE 3. Sky coverage obtained with the two CTA array sites, compared to the Southern (bottom left) or Northern (bottom right) observatory alone. The sky is shown in Galactic coordinates, with the Galactic plane along the equator.

$30^\circ < \text{ZA} < 45^\circ$, $45^\circ < \text{ZA} < 60^\circ$, and $\text{ZA} > 60^\circ$, respectively. Golden stars are TeVCat[2] sources, while Galactic and extra-galactic sources are taken from the Fermi-LAT 2-year Point Source Catalog [7].

CTA KEY SCIENCE PROJECTS

The expected lifetime of CTA is about 30 years. During this time-span, the majority of the available observation time at both CTA sites will be open time, awarded by a Time Allocation Committee to Guest Observer proposers from CTA member countries, based on the scientific merit. During the first decade of operation, about 40% of the time will be used by the CTA Consortium to exploit a Core Programme consisting of a number of Key Science Projects (KSPs). The criteria used for selection of the baseline KSPs are the following:

1. an excellent scientific case and clear advance beyond the state of the art;
2. the production of legacy data-sets of high value to a wider community;
3. a clear added value of doing a particular investigation as a KSP rather than as part of the Guest Observer Programme:
    (a) the scale of the project in terms of observing hours, since very large projects will be difficult to accommodate in the open time early in the lifetime of the observatory;
    (b) the need for a coherent approach across multiple targets or pointings;
    (c) the technical difficulty of performing the required analysis and hence reliance on CTA Consortium expertise.

The CTA Consortium selected the following KSPs, which can be gathered in major groups according to the main technical method to exploit a specific task or to a specific physics case:
Dark matter: the dark matter program is particularly relevant for the CTA science and overlaps considerably in terms of observation fields with other science topics.
Surveys: Galactic Centre (KSP #1), Galactic Plane (KSP #2), Large Magellanic Cloud (KSP #3), and Extra-galactic (KSP #4, 25% of the sky).
Transients phenomena: (KSP #5) both Galactic and extra-galactic, including GRBs.
Pointed observations: Cosmic-ray PeVatrons (KSP #6), Star-forming Systems (KSP #7), Active Galactic Nuclei (KSP #8), and Cluster of Galaxies (KSP #9).

An exhaustive review of the CTA Key Science Projects is well beyond the scope of this paper. However, an updated review of the *CTA Science Case Volume of the CTA Technical Design Report* will be posted on arXiv shortly [8].

The Dark Matter Program

It is now well established that dark matter is the dominant gravitational mass in the Universe, but its detailed nature is at present still unknown. It has been proposed that dark matter particle are Weakly Interacting Massive Particles (WIMPs), which can self-annihilate, converting their large rest masses into other Standard Model particles, including gamma rays. Indirect detection from such annihilations provides a unique test of the particle nature of dark matter. The priority for the CTA dark matter program is to discover the nature of dark matter with a positive detection, by adopting as principal target the Galactic halo. These observations will be taken within several degrees of the Galactic Centre and the most intense diffuse emission regions removed from the analysis. 500 hours in this region provide sensitivities below the thermal cross-section and give a significant chance of discovery in some of the most popular models for WIMPs. In Fig. 4 we show a comparison of predicted sensitivities in σv for the different targets. CTA sensitivity curves use the W^+W^- annihilation modes for each target and the Navarro-Frenk-White (NFW) dark matter profile. The sensitivity calculations have a 30 GeV threshold for the Galactic halo and Sculptor and 200 GeV for the LMC. The sensitivities for the three targets are all for 500 hours taking into account only statistics errors. For the Galactic halo and the LMC, the systematics of backgrounds must be very well controlled to achieve this statistically possible sensitivity. The comparisons with the H.E.S.S. and Fermi-LAT results are drawn from [9] and [10], respectively. A review of the CTA prospects on indirect dark matter searches with CTA is given in [11].

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[2] `http://tevcat2.uchicago.edu/`

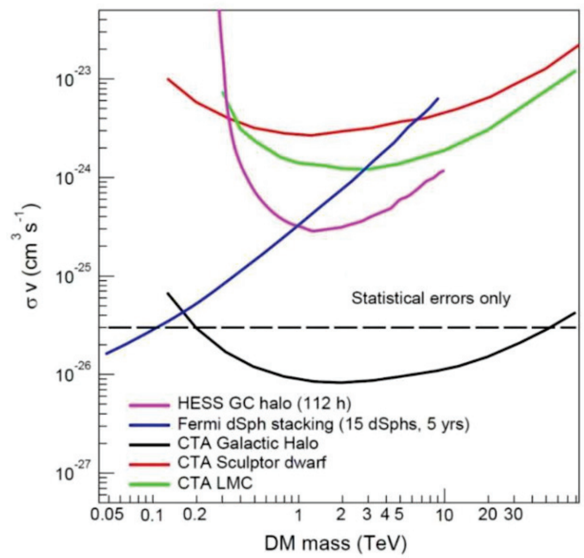

FIGURE 4. Comparison of predicted sensitivities in σv for the targets of: the Galactic Halo, the Large Magellanic Cloud (LMC), and the dwarf galaxy Sculptor.

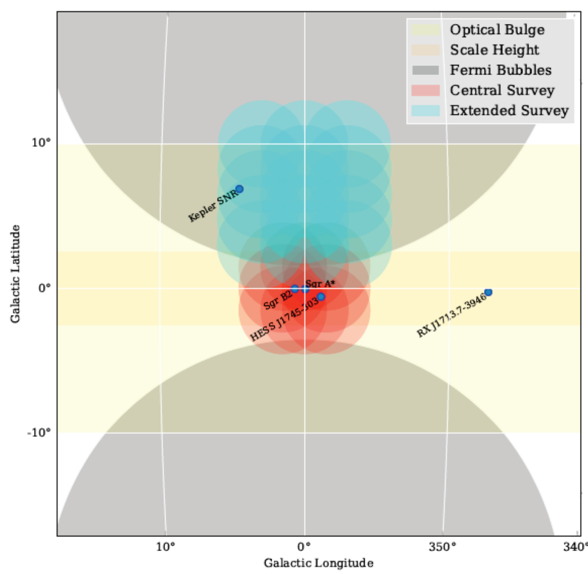

FIGURE 5. Schematic representation of the the Galactic Centre Survey pointing strategy.

The Galactic Centre Survey

The region within a few degrees of the Galactic Centre is full of a wide variety of high-energy emitters (see [12] for a review). The Galactic centre region has been studied in depth with H.E.S.S., VERITAS, and MAGIC, yielding major discoveries such as an unidentified central point-like gamma-ray source that may be associated with Sgr A*, and a complex pattern of diffuse emission that may be an indication of local PeV cosmic-ray acceleration in the recent past (see also [13]). Nevertheless, the central VHE source still remains unidentified due to source confusion and limited sensitivity to variability and small-scale morphology. Deep CTA observations of this object will provide an angular

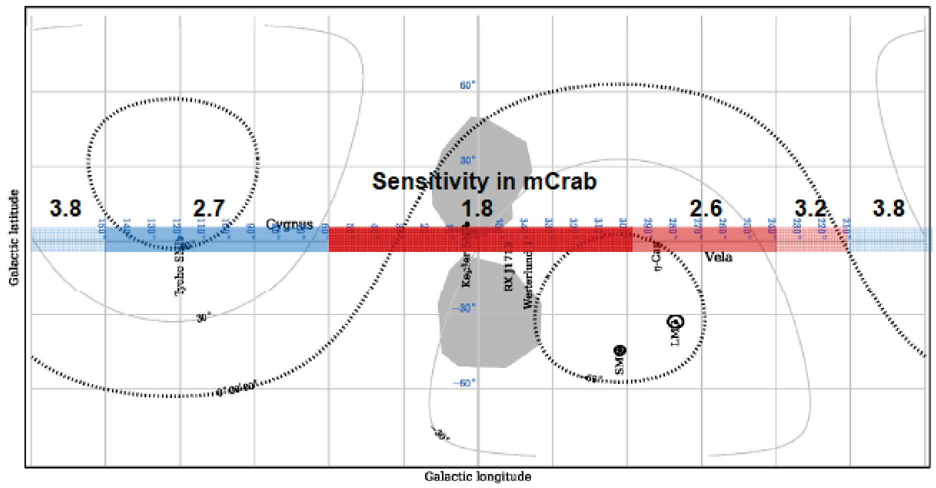

FIGURE 6. Point-source sensitivities (in mCrab) above a threshold of 125 GeV achieved in the full ten-year programme of the CTA Galactic Plane Survey for various regions along the Galactic plane. For reference, some VHE objects of note are labeled, and the Fermi GeV bubbles are schematically drawn in grey.

resolution to image the arc-minute scale VHE source, the possibility to search for variability of the central source, and a sufficient spectral sensitivity and energy coverage to determine the maximum energy reached by accelerated cosmic rays in this region. In Figure 5 the deep survey region is shown in red, with the Galactic bulge extension shown in cyan (each circle represents a 6° field of view for a typical CTA configuration). Several object positions are overlaid with blue dots for reference. The Galactic Centre Survey will consist of ~ 500 hr of exposure on a region of $\pm 1^\circ$ around Sgr A*, while the Galactic bulge extension will account for ~ 300 hr of exposure out to 10° in latitude. The expected results might include the determination of the nature of the central source, a detailed view of the VHE diffuse emission the discovery of new, previously undetectable sources, the study of possible variability in the VHE source near Sgr A*, and the investigation of the interaction of the central source with neighbouring clouds.

The Galactic Plane Survey

The Galactic Plane Survey (GPS) KSP will carry out a survey of the full Galactic plane using both the southern and northern CTA arrays. The survey will be graded so that more promising regions (especially the inner Galactic region of $-60^\circ < l < 60^\circ$) will receive significantly more observation time than other regions.

The survey will fulfil a number of important science goals, including: 1) providing a complete census of Galactic very-high-energy (VHE) gamma-ray source populations, namely supernova remnants (SNRs) and pulsar wind nebulae (PWNe), through the detection of hundreds of new sources, substantially increasing the Galactic source count and permitting more advanced population studies, 2) identifying a list of promising targets for follow-up observations, such as new gamma-ray binaries and PeVatron candidates, to be carried out by the CTA Consortium within the Key Science Projects (KSPs) or to be proposed through the Guest Observer (GO) programme, 3) determining the properties of the diffuse emission from the Galactic plane, 4) producing a multi-purpose, legacy data set, comprising the complete Galactic plane at very high energies, that will have long-lasting value to the entire astronomical and astroparticle physics communities, and 5) discovering new and unexpected phenomena in the Galaxy, such as new source classes and new types of transient and variable behaviour. Figure 6 shows that in the south, CTA will go deeper in the inner region ($|l| < 60^\circ$) by a factor of 5–20 compared to H.E.S.S. and will cover more uniformly a wider range of latitudes. In the north, CTA will go deeper by a factor of at least ~ 5 compared to HAWC (5 year data set), at a factor 10–20 lower energy, with a factor ~ 5 better angular resolution. The typical observing time is about 1000 and 600 hr in the South and in the North, respectively. The expected results might include the discovery of new and unexpected phenomena in the Galaxy as well the discovery of PeVatron candidates, the detection of many new VHE sources O(300–500) -particularly PWNe and SNRs- the measurement of the large-scale diffuse VHE gamma-ray emission, the discovery

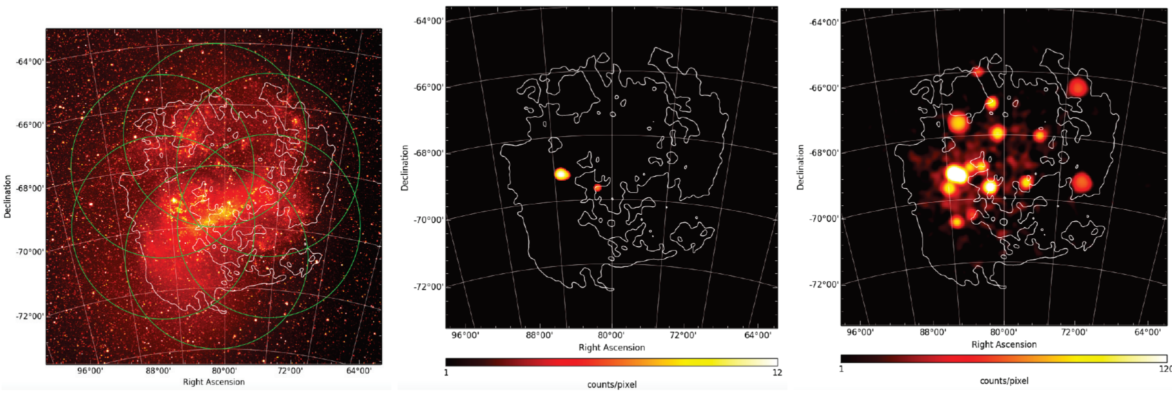

FIGURE 7. *Left panel:* possible pointing pattern for the LMC deep scan (optical image in the background). *Central panel:* current LMC view provided by existing instruments (H.E.S.S.). *Right panel:* expected results for CTA. See text for details.

of new VHE gamma-ray binary sources. Moreover, the plan the production of a multi-purpose legacy data set and periodic release of sky maps and source catalogues.

The Large Magellanic Cloud Survey

The Large Magellanic Cloud (LMC) is a unique galaxy hosting extraordinary objects, including the star-forming region 30 Doradus (the most active star-forming region in the local group of galaxies), R136 (an exceptional super star cluster with a large concentration of very massive O and Wolf-Rayet stars), supernova SN1987A (the closest supernova in modern times), and the puzzling 30 Dor C super-bubble (a rare super-bubble with non-thermal emission). As a satellite of the Milky Way, it is one of the nearest star-forming galaxies, and a very active one; it has one tenth of the star formation rate of the Milky Way, distributed in only about two percent of its volume. This activity is attested by more than 60 supernova remnants (SNRs), dozens to hundreds of HII regions, and bubbles and shells observed at various wavelengths, all of which promise fruitful gamma-ray observations. The LMC is seen nearly face-on at high Galactic latitude, and hence source confusion, line of sight crowding, and interstellar absorption do not hamper these studies, in contrast to the case for our own Galaxy. It is therefore a unique place to obtain a significantly resolved global view of a star-forming galaxy at very high energies. In addition, the distance to the LMC is known at the few percent level, thus allowing precise luminosity measurements to be made, something which is often very difficult for Galactic sources.

The LMC KSP consists of an initial deep scan over a circular region of radius 3.5°. This will be achieved over the first four years of CTA from a small number of pointings with the southern array, for a total of 340 hr of observations. Then, if SN1987A is detected in this deep scan, a second part of the project will consist of the monitoring of SN1987A over the following six years at a level of 50 hr every 2 years. Figure 7 shows (left panel) a possible pointing pattern for the LMC deep scan. The pattern consists of six pointings evenly distributed around the LMC centre at a separation distance of 2° (green circles, for a typical field-of-view radius of 3°. The central panel shows the current view provided by existing instruments (H.E.S.S.), while the right panel shows the expected results for CTA. Simulation includes currently detected sources, plus ten point-like sources with $L_{(E>1\,TeV)} \sim 10^{34}$ erg s^{-1}, and a handful of regions enriched in cosmic rays.

The Extra-galactic Survey

This Key Science Project consists of an unbiased survey of 25% of the sky. The survey is aimed primarily at extragalactic science and its area will connect to the Galactic Plane Survey. The main objective of the Extragalactic Survey KSP is to construct an unbiased very high energy (VHE) extragalactic source catalogue with an integral sensitivity limit of ~ 5 mCrab.

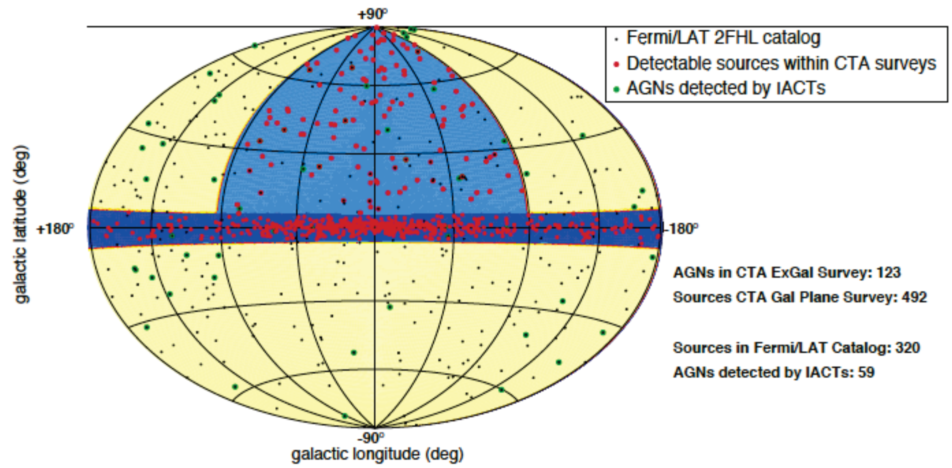

FIGURE 8. Proposed region of the extragalactic survey in Galactic coordinates: $b > 5°$ and $-90° < l < 90°$, 25% of the sky, marked in a light blue. The Galactic Plane Survey is indicated by a darker blue. Red points show a hypothetical example of the sources to be detected in the extragalactic and Galactic CTA surveys. Extragalactic and unidentified Fermi hard-spectrum sources (2FHL catalogue) are displayed as black dots whereas green points show the AGN that have been detected so far by IACTs.

A possible scheme for the extra-galactic survey is shown as the light blue area of Figure 8. The survey would connect with the Galactic Plane Survey ($|b| < 5°$ dark blue area) and cover 25% of the sky, over Galactic longitude $-90° < l < 90°$. The proposed survey would be performed using both CTA arrays for zenith angles of observations smaller than 45° to ensure uniformity in the energy threshold and resulting sensitivity. Several highly interesting regions, such as Cen A (south) and the Virgo cluster, Coma cluster, and Fermi bubbles (north), will be covered by the proposed survey. A hypothetical result of the survey is illustrated by the red dots. The black dots represent 2FHL sources (Galactic sources are not shown, [14]). The red dots result from CTA simulations extrapolating 2FHL sources for a CTA exposure of 6 hr, assuming an averaged flux state and that 5% of the sources will be found in a flaring state. The Galactic sources are simulated to follow the spatial distribution of pulsars in the ATNF pulsar catalogue. The green points show extragalactic sources already detected in the TeV gamma-ray regime. Current simulations suggest that a wide-field, shallow survey should detect more sources than a narrow-field, deep survey (given an equal survey time). In a recent work [15], Padovani & Giommi derived the expected number of blazars on the sky in the GeV-TeV domain. They found that with the expected 5 mCrab sensitivity during the proposed survey, CTA should detect around 100 sources in 10,000 deg^2.

Transients

Transients are a diverse population of astrophysical objects. Some are known to be prominent emitters of high-energy gamma-rays, while others are sources of non-photonic, multi-messenger signals. We aim to perform follow-up observations of six classes of targets triggered by external or internal alerts, together with an unbiased survey for transients by means of the divergent pointing observations: gamma-ray bursts (GRBs), Galactic transients, high-energy neutrino transients, gravitational wave transients, radio, optical, and X-ray transients, serendipitous VHE transients, and VHE transients survey (to be performed via divergent pointings (see [16] for a recent review of its technique and scientific performance) and concurrently with parts of the extragalactic survey). Gamma-ray bursts have so far being elusive sources at energies above 100 GeV [17, 18]. Several basic physical properties of GRBs remain poorly understood, such as the nature of the central engine and the mechanisms of jet formation, particle acceleration and radiation. Figure 9 (left panel) shows that CTA detections of bright GRBs would allow measurements of their VHE light curves in unprecedented detail. The assumed GRB template is the measured Fermi-LAT light curve above 0.1 GeV [19], extrapolating the intrinsic spectra to VHE with power-law indices as determined by Fermi-LAT. We expect CTA to detect ~ 1 GRB yr^{-1} $site^{-1}$.

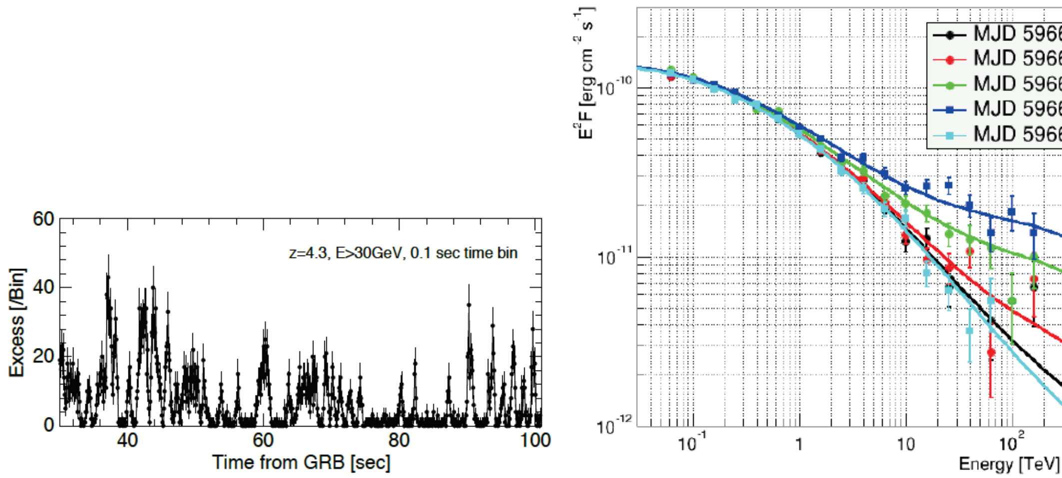

FIGURE 9. *left panel:* simulated CTA light curve of GRB 080916C at z=4.3, for observed photon energies above 30 GeV with 0.1 sec time binning. *Right panel:* Simulated energy spectra of a Crab nebula flare observed with CTA. See text for detailes.

Another elusive transient source at VHE is the Crab. Figure 9 (right panel) shows a simulation of the inverse Compton component of the 2011 April Crab flare detected by Fermi-LAT [20], following the model by [21] . A sequence of 10 observations, 4 hr each, should allow to detect and investigate the variable spectral tail from 10 to 100 TeV, and therefore allow time-dependant VHE spectroscopy during GeV gamma-ray flares.

Cosmic-ray PeVatrons

Cosmic rays are primarily energetic nuclei which fill the Galaxy. Supernova remnants (SNRs) are able to satisfy the cosmic-ray energy requirement if they can somehow convert $\sim 10\%$ of the supernova kinetic energy into accelerated particles [22]. If SNRs indeed are the sources of cosmic rays, they should also be bright VHE gamma-ray sources, due to the decay of neutral pions produced in the interactions between the accelerated cosmic rays and the gas swept up by the shock. An essential way to make progress would be to observe SNRs in the almost unexplored multi-TeV energy domain. The detection of an SNR whose spectrum extends without any appreciable attenuation up to energies of $\sim 100\,\mathrm{TeV}$ would imply that the emission is hadronic, because the leptonic emission is strongly suppressed at such high energies due to Compton losses in the Klein-Nishina regime, and that the SNR is a PeVatron, because $\sim 100\,\mathrm{TeV}$ photons are produced by $\sim$PeV protons. The proposed observational strategy is two-fold. First, we plan to perform deep observations of known sources with particularly hard spectra and with hints for a possible spectral extension into the multi-TeV energy domain. Second, we also plan to search for diffuse gamma-ray emission from the vicinity of prominent gamma-ray bright SNRs, such as RX J1713.7−3946. Figure 10 shows a simulations of the gamma-ray emission from RXJ1713.7−3946 obtained by assuming different emission mechanisms, supported by the existing multi-wavelength observations. To evaluate different levels of hadronic and leptonic distributions, we consider several cases with different values of $A_\mathrm{p}/A_\mathrm{e}$, where A_p and A_e are the leptonic and hadronic normalisation parameters, respectively. A detailed description of the method and the results are given in [8].

Star-forming Regions

Cosmic rays are believed to be an important regulator of the star-formation process. Therefore, it is important to understand where cosmic rays are being accelerated, how they propagate, and where they interact in the interstellar medium (ISM). Gamma rays are among the best tools to study cosmic-ray properties in star-forming environments. Within the Galaxy, observations of the Carina and Cygnus regions and the most massive stellar cluster Westerlund 1 will allow us to constrain the fraction of mechanical stellar wind energy transferred into gamma rays, to study particle

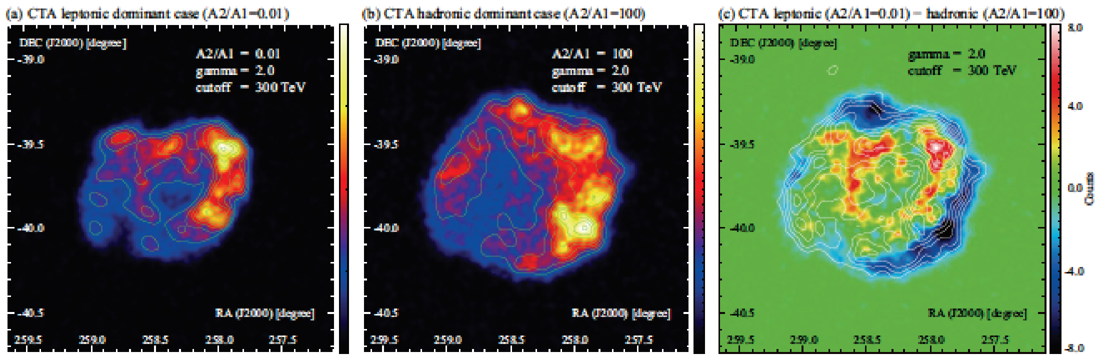

FIGURE 10. Simulated gamma-ray images of RXJ1713.7−3946 in different scenarios: (a) $A_p/A_e = 0.01$ (lepton-dominated case) and (b) $A_p/A_e = 100$ (hadron-dominated case), while (c) is the (a) - (b) subtracted image. Further details in [8].

acceleration in Galactic stellar clusters and super-bubbles, and to search for clear signs of cosmic-ray propagation and interaction with the ISM. Outside the Galaxy, the Large Magellanic Cloud is the only other galaxy for which CTA will be able to resolve the very high-energy gamma-ray source population and study in detail the similarities and differences to our own Galaxy. Observations of the Andromeda galaxy will provide important measurements and estimates of cosmic-ray properties and diffusion in the nearest spiral galaxy. Other promising targets are the two starburst galaxies NGC253 and M82 and of the only ultra-luminous infrared galaxy (ULIRG) likely within the reach of CTA, Arp 220.

Cluster of Galaxies

Galaxy clusters are expected to be reservoirs of cosmic rays accelerated by structure formation processes, galaxies and active galactic nuclei. The detection of diffuse synchrotron radio emission in several clusters confirms the presence of cosmic-ray electrons and magnetic fields permeating the intra-cluster medium. While there is no direct proof for proton acceleration yet, gamma rays can prove it unambiguously. Focusing on the gamma-ray emission induced by proton-proton interactions and based on both theoretical studies and hydrodynamical simulations, Perseus should be the brightest cluster of galaxies in gamma rays. Perseus also contains two gamma-ray-bright AGN: NGC 1275, one of the few radio galaxies known to emit gamma rays, and IC 310, potentially the closest known blazar. Our simulations for CTA show that a 300 hr observation will potentially allow a detection of the Perseus cluster in gamma rays or, alternatively, set unprecedented limits on the cosmic-ray proton content potentially triggering a substantial revision of the current paradigm of proton acceleration and confinement in galaxy clusters.

Active Galactic Nuclei

AGNs are known to emit variable radiation across the entire electromagnetic spectrum up to multi-TeV energies, with fluctuations on time-scales from several years down to a few minutes. VHE observations of active galaxies harbouring super-massive black holes and ejecting relativistic outflows represent a unique tool to probe the physics of extreme environments, to obtain precise measurement of the extragalactic background light (EBL) and to constrain the strength of the intergalactic magnetic field. AGNs will be useful to investigate fundamental physics phenomena such as the Lorentz invariance violation and signatures of the existence of axion-like particles.

CTA performance will allow us to investigate with an unprecedented level of accuracy both spectral and timing AGN properties. Figure 11 (left panel) shows a comparison of the expected CTA spectra for two specific (simple) emission models for the blazar PKS 2155−304. A hadronic scenario, where high-energy emission is caused by proton- and muon-synchrotron photons and secondary emission from proton-photon interactions, is shown on the left, and a standard leptonic synchrotron self-Compton (SSC) model on the right. The exposure time assumed for the simulations (33 hs) is the same as the live time for the H.E.S.S. observations (black data points above 3×10^{25} Hz). Sampling

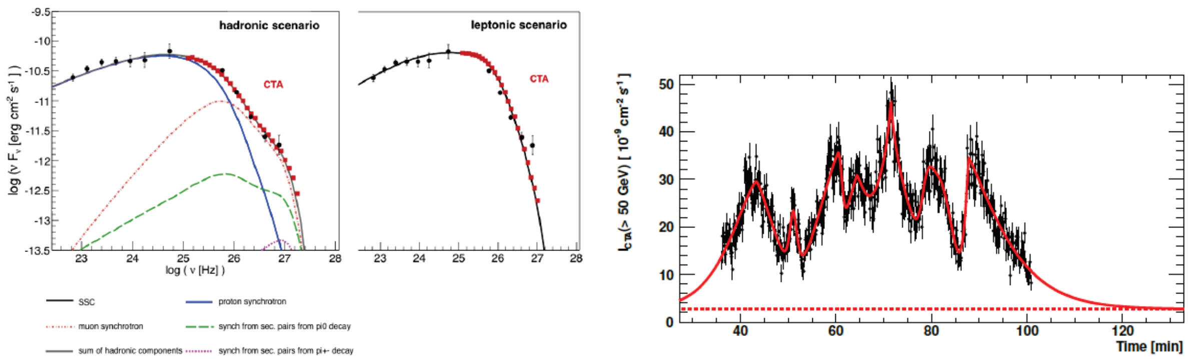

FIGURE 11. *Left panel:* comparison of the expected CTA spectra for two specific (simple) emission models for the blazar PKS 2155−304. *Right panel:* Simulated CTA light curve for the 2006 flare of PKS 2155−304 (see [23] for details). Such observations provide access to timescales much shorter than the light-crossing time of the supermassive black hole.

blazar fluxes below the light-crossing time scale and during the whole visibility window of a night is a key strategy to understand the flickering behaviour of blazars on short time scales. Such measurements put strong constraints on the bulk Doppler factor, as well as on particle acceleration and cooling processes. Very rapid variability has so far only been studied in a few extreme flares. Figure 11 (right panel) shows the simulated CTA light curve of a hypothetical AGN flare modelled on a flare detected from the blazar PKS 2155−304 in 2006. As can be seen, CTA will for the first permit to probe sub-minute time-scales.

The potential of extra-galactic background light (EBL) studies with CTA has been discussed in [24]. With CTA, we aim for a substantial improvement over current measurements of the EBL performed with Fermi-LAT and current atmospheric Cherenkov telescopes. We will take advantage of the unique capability of CTA to measure simultaneously and with high precision both the unabsorbed intrinsic (GeV) and attenuated (TeV) parts of the blazar spectra and thereby disentangle intrinsic physical processes from external absorption features, which will be essential for a precise EBL density determination.

CONCLUSIONS

The Cherenkov Telescope Array will transform our understanding of the high-energy universe and will explore questions in physics of fundamental importance. As a key member of the suite of new and upcoming major astroparticle physics experiments and observatories, CTA will exploit synergies with gravitational wave and neutrino observatories as well as with classical observatories.

ACKNOWLEDGMENTS

We gratefully acknowledge support from the agencies and organizations listed under Funding Agencies at this website: http://www.cta-observatory.org/.

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