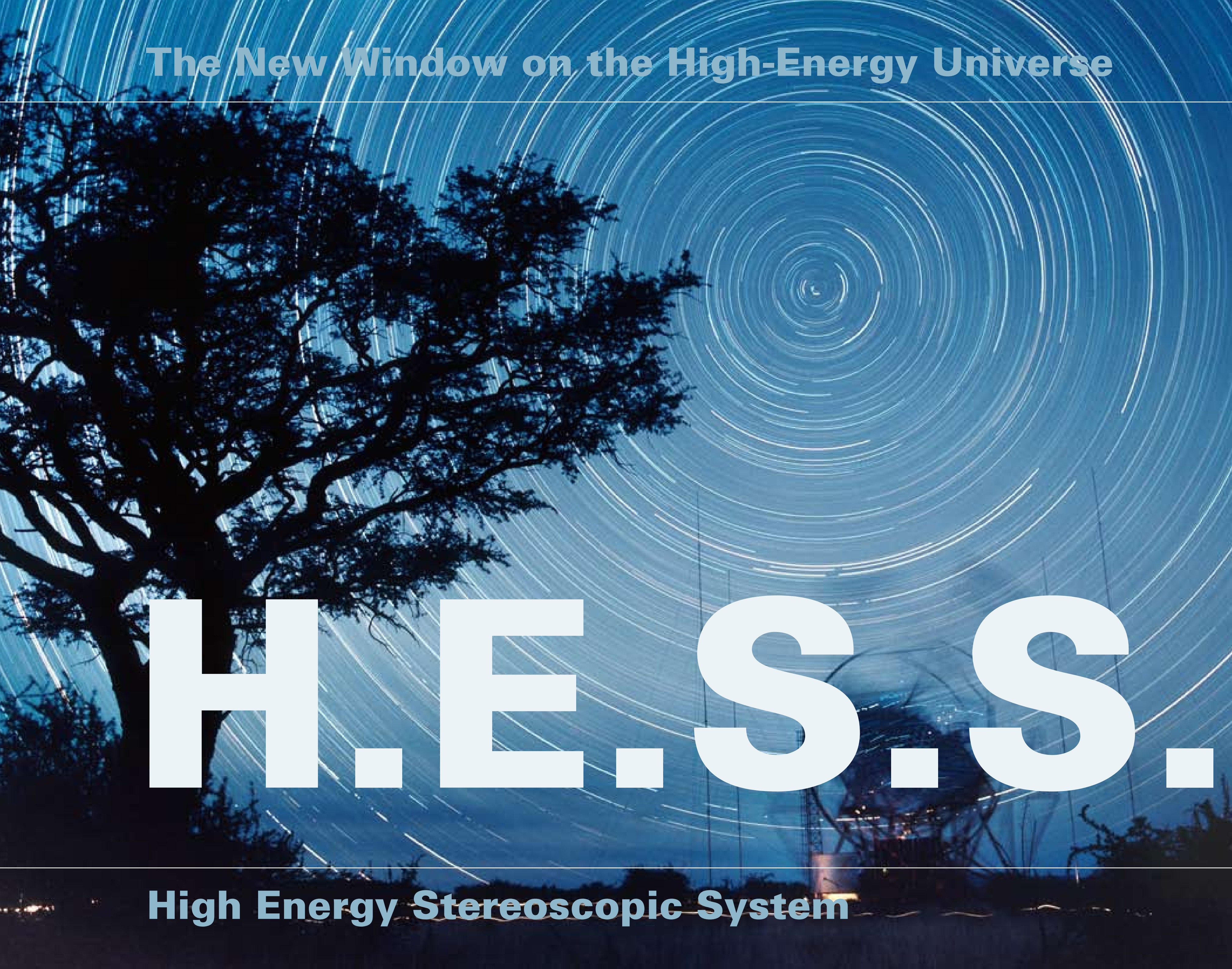


The New Window on the High-Energy Universe

H.E.S.S.

High Energy Stereoscopic System

Contents

Title page: The Sky at the H.E.S.S. Site in the Khomas Highlands of Namibia. *Copyright: S. Elleringmann/laif*

Imaging the Universe

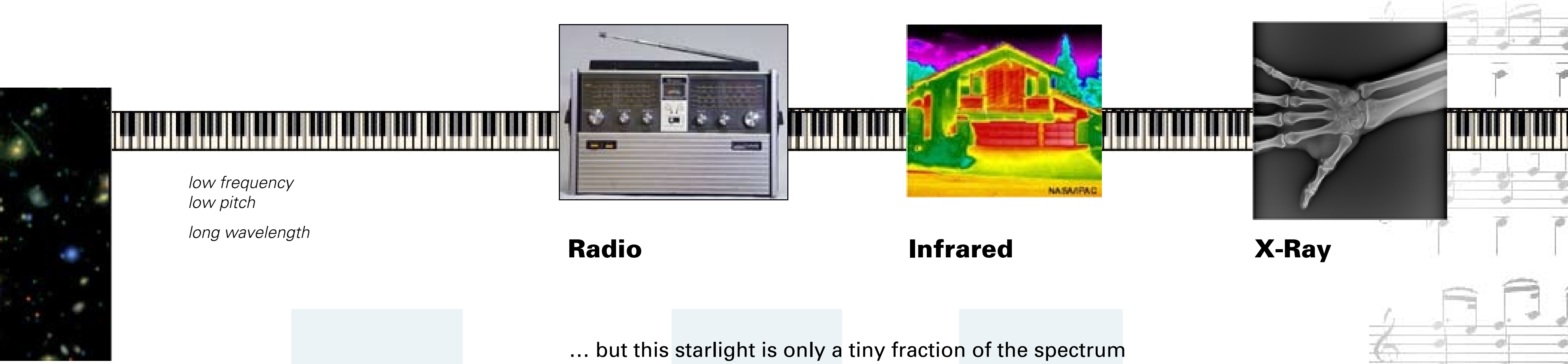
The warped spiral galaxy ESO 510-13
(C. Conselice et al., Hubble Heritage Team, NASA)

The Sagittarius Star Cloud
(Hubble Heritage Team, AURA/STScI/NASA)

Most of our knowledge about the Universe comes from the observation of electromagnetic radiation from heavenly objects – starlight is the most obvious example of this radiation. Even with the naked eye, it is hard not to be overwhelmed by the view of the starry sky on a clear dark night. Images generated by modern large optical telescopes combine fascinating beauty with an enormous wealth of information for scientists ...

Background: The Cone Nebula *(ACS Science and Engineering Team, NASA)*

Astronomy in many wavelength



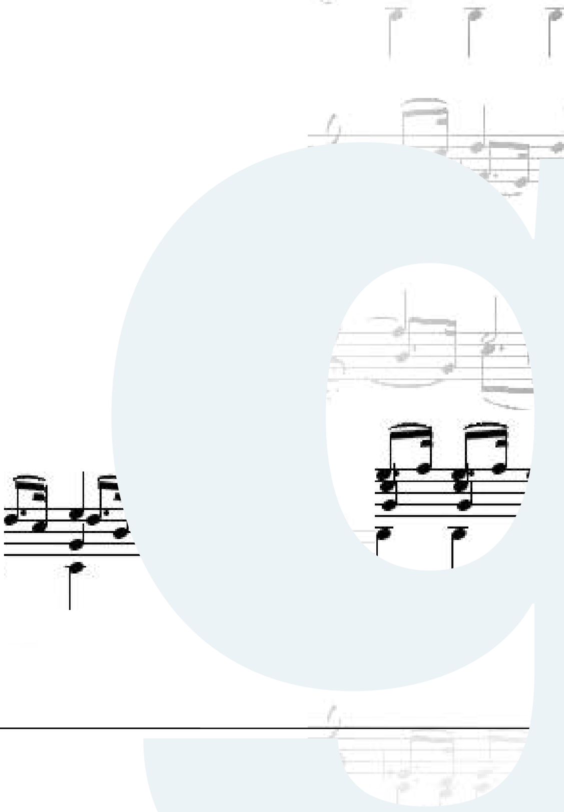
Radio

Infrared

X-Ray

… but this starlight is only a tiny fraction of the spectrum of radiation incident upon the Earth. From red to blue, the spectrum of visible light covers just one octave in frequency. The full spectrum, on the other hand, ranges over about 70 decades from radio frequencies up to the gamma rays which the H.E.S.S. telescopes aim to study. One way to visualise this is to image a 15 m long piano.

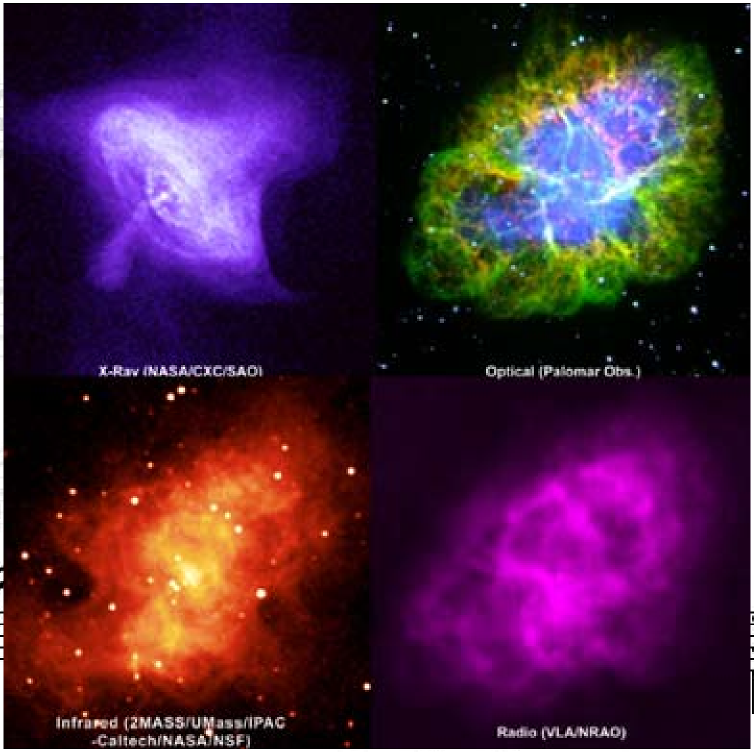
Visible light corresponds to an octave somewhat left of the middle. Further left – at lower pitch - comes infrared radiation, and then radio waves. To the right follow X-rays, gamma rays such as detected, e.g., by a PET scanner, and – at the very right end – the very high energy gamma rays studied with H.E.S.S. Of all this radiation, only visible light and radio waves reach the ground; all other radiation is absorbed in the Earth's atmosphere.

Modern astrophysics explores all of this vast spectral range, trying to learn more about our stellar neighbourhood, about our own and distant galaxies, and about the Universe and its history.

A cosmic symphony

In a symphonic performance, the sounds we experience and enjoy are a mix of fundamentals and overtones extending over 10 octaves, and it is the overtones which give each instrument its specific timbre.

Similarly, in astrophysics, it is crucial to ‘listen’ to a cosmic object in the entire regime where it emits radiation. Each waveband exposes specific features and only by combining all information can scientists fully apprehend the astrophysical processes in these objects.

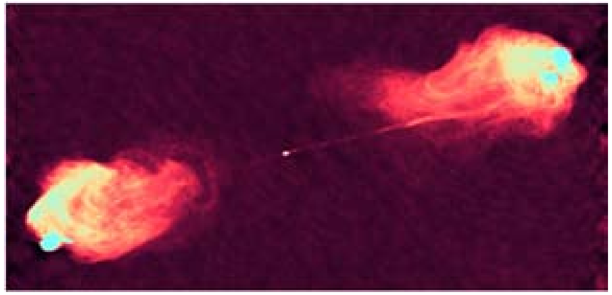
High-energy gamma rays detected with H.E.S.S. cover the topmost 10 octaves of the spectrum of radiation; a range comparable to the full range of audio frequencies. For the first time, H.E.S.S. allows to image details of celestial bodies in high-energy gamma rays.



The Crab Nebula viewed in different regions of the electromagnetic spectrum *(NASA/Chandra)*

Very high energy gamma rays...

...from the Cosmos



Left: The Crab Nebula is the relic of a stellar explosion in the year 1054 A.D. It was the first strong source of very high energy gamma rays which was discovered in 1989 by the American Whipple Cherenkov telescope. (*FORS Team, VLT, ESO*)

Middle: The Supernova Cassiopeia A exploded in 1680 A.D., sending a shock wave into space which by now has expanded to 15 light years. Particles crossing the shock wave can be accelerated to the highest energies (*R.J. Tuffs, MPIK*)

Right: The active galaxy Cygnus A – the small white spot at the centre – sends beams of matter across many hundreds of thousands of light years, generating turbulent 'plumes' when they are finally stopped, accelerating particles. (*NRAO*)

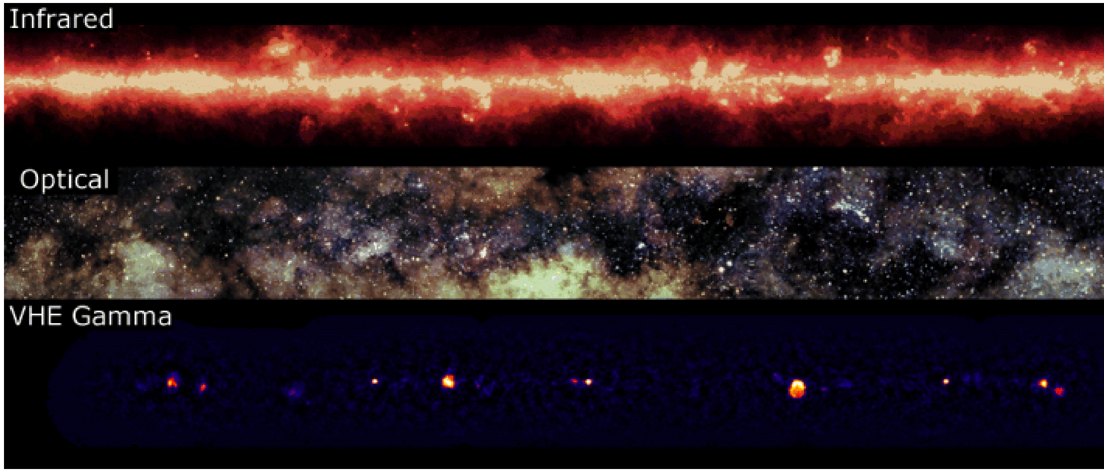
The H.E.S.S. telescopes teach us about the laws of nature under such extreme conditions.

Why are gamma rays so interesting?
High-energy gamma rays allow us to explore some of the most extreme and most interesting objects in the Universe. Most of the radiation we detect is thermal radiation, created by hot bodies such as our Sun. The hotter the source, the higher is the frequency – the 'pitch' – of the radiation.

However, very basic considerations show that no material body can be hot enough to emit very high energy gamma rays; these must be generated in unusual, 'non-thermal' conditions. These occur in the aftermath of stellar explosions – supernovae – or in the vicinity of the giant black holes suspected to be at the cores of so-called active galaxies, which are continuously fed by stellar material from the surrounding galaxy.

The Galaxy viewed with H.E.S.S.

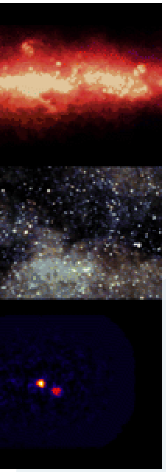
The unprecedented sensitivity of the H.E.S.S. telescopes combined with their relatively large field of view allowed for the first time to image a large section of the Milky Way in high-energy gamma rays. To the right, the gamma ray image is contrasted with the optical and infrared images. Many new gamma-ray sources were discovered in the H.E.S.S. survey of the galaxy, lining the Galactic equator like a string of pearls. Each gamma-ray source is believed to represent a cosmic particle accelerator creating a stream of high-energy particles. The accelerated particles themselves are tangled up in interstellar magnetic fields and rarely one of them will reach the Earth, but they generate the gamma rays which H.E.S.S. uses to image the accelerators.

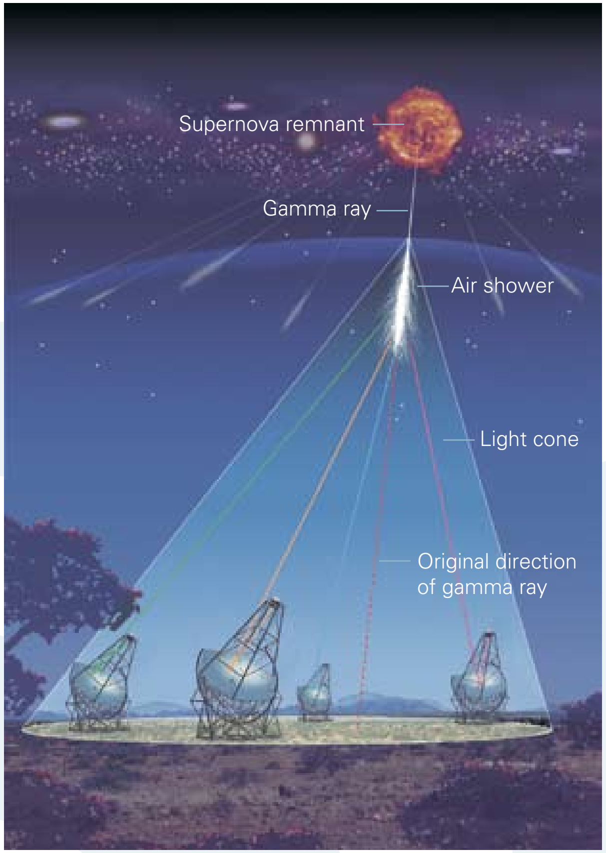


The central region of the Milky Way viewed in the infrared, in the visible light, and – for the first time – in high-energy gamma rays.
(Optical image: A. Mellinger; Infrared image: S.L. Wheelock, et al.)

How does H.E.S.S. generate such maps of the gamma ray sky?

The H.E.S.S. Telescopes





For a H.E.S.S. telescope, an air shower generated by a gamma ray looks a bit like a shooting star. Rushing through the air, these particles emit a faint beam of blue light – so-called Cherenkov light – which on the ground illuminates an area of only about 250 m in diameter. *(Figure: Sterne und Weltraum)*

Observing very high energy gamma rays: Astromomy with Cherenkov Telescopes

Unlike starlight, which penetrates the Earth's atmosphere almost unimpeded and can be viewed from the ground, cosmic gamma rays interact with atoms in the Earth's atmosphere and are absorbed long before they reach the ground. They are therefore often studied with instruments on satellites orbiting the Earth. However, the most interesting very high energy gamma rays are so rare that it would take many thousands of years to collect enough of them with current satellites.

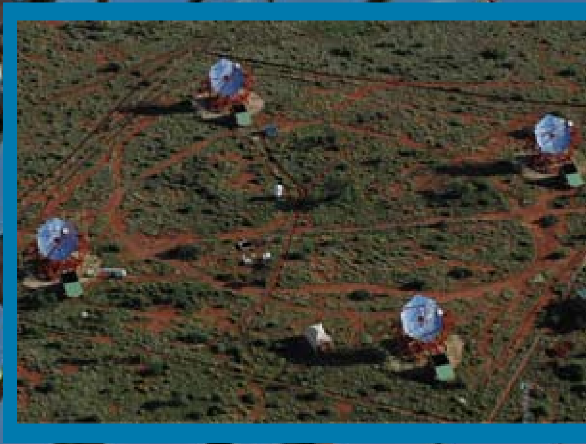
The H.E.S.S. telescopes exploit the interactions of gamma rays in the atmosphere to detect them from the ground. When a gamma ray is absorbed, its energy is converted into a cascade of secondary particles forming an 'air shower'. Rushing through the air, these particles emit a faint beam of blue light – so-called Cherenkov light – which on the ground illuminates an area of about 250 m in diameter. The light flash is very short – it lasts only a few billionths of a second – and is far too faint to be detected by the human eye. However, a telescope with a large mirror to collect light and a light detector with a fast enough response can detect the Cherenkov light and 'see' the air shower generated by the high-energy gamma ray.

For a H.E.S.S. telescope, a gamma ray stopping in the atmosphere looks a bit like a shooting star: an elongated track, resembling a big pointer in the sky. However, from a single image alone one cannot tell exactly in which direction in space the track of a meteor or a gamma ray is pointing, and therefore one cannot locate the origin of the gamma ray.

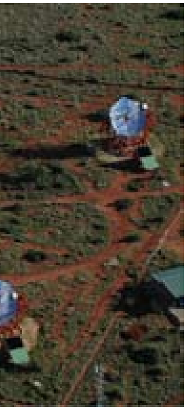
Four Cherenkov Telescopes

The solution is simple in principle, but quite complex once it comes down to the details: two or more images taken from different points provide a perception of space and depth. For humans, the 10 cm spacing of our eyes provides depth perception up to a distance of a few meters; in order to disentangle air showers at about 10 km height above the ground, one uses telescopes spaced by about 100 m.

The H.E.S.S. system uses four big telescopes, arranged in the corners of a 120 m square for best sensitivity. It is located in the Khomas Highland of Namibia, an excellent site for astronomical observations of the southern sky.



The H.E.S.S. technology



Christopher van Eldik from Germany and Eben Tjingaete from Namibia checking mirror facets

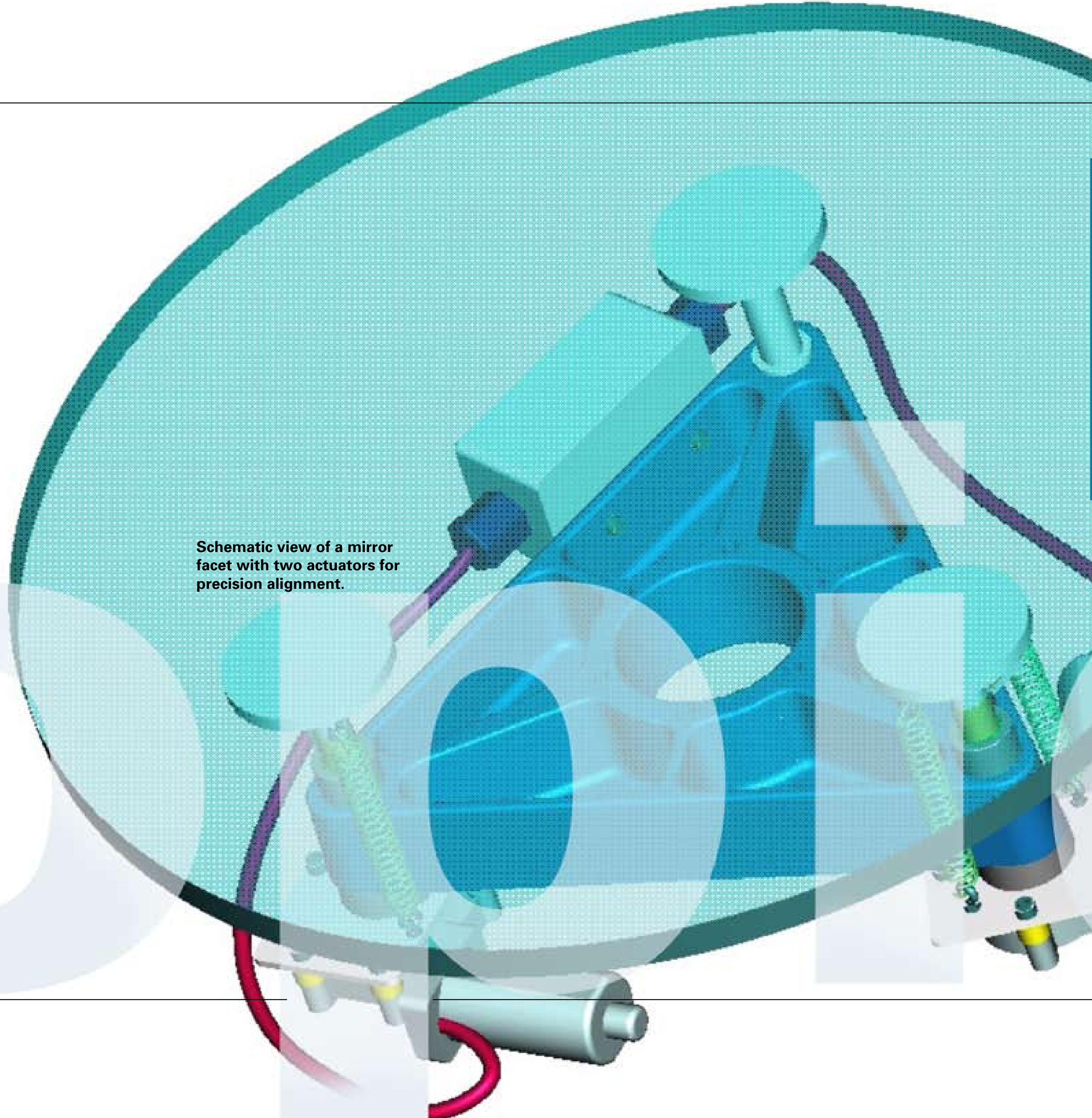
Just like big optical telescopes, the H.E.S.S. Cherenkov telescopes consist of a mirror which focuses the incident light, and a light detector (the 'camera') to record the images. A mount allows the telescope to rotate and to track celestial objects as they move across the sky.

Mount and mirror dish

Mount and dish are sturdy steel structures, designed for high rigidity. The steel structure weighs 60 tons; it was designed in Germany and fabricated in Namibia. Computer-controlled drive systems steer the telescopes with high precision.

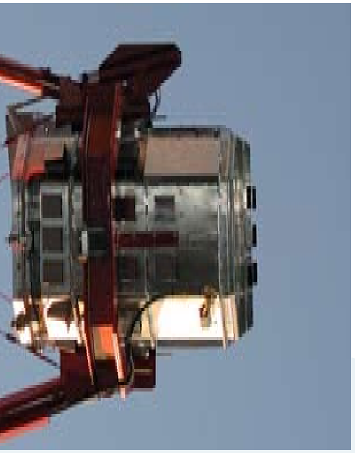
Mirrors

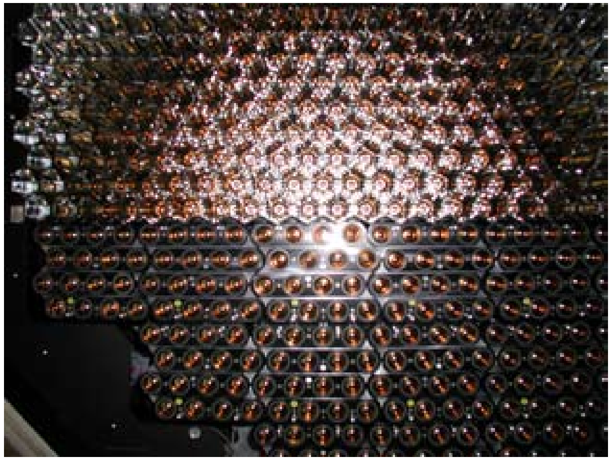
The diameter of the dish is more than 12 m, and the mirror area 107 m^2. Mainly for cost reasons, the mirror is composed of 380 individual facets, made of ground glass and aluminised for best reflectivity. Each facet can be aligned under remote control using two motor-driven actuators, with a precision of a few thousandth of a millimeter.



Schematic view of a mirror facet with two actuators for precision alignment.

The H.E.S.S. cameras





A team from France led by Pascal Vincent, installing the light sensors in the camera body and testing the camera. A big lid protects the sensors during daytime. A door on the back side of the camera allows accessing the sophisticated electronics hidden in the camera body.

The cameras are the equivalent of a photographic film: they serve to record the short and faint light flashes generated by air showers. Electronic devices called photomultipliers are used to convert the light into electrical signals. Each camera provides 960 image elements (pixels). The 960 pixels cover an area of about 1.4 m diameter, equivalent to a field of view of 5° on the sky, or about 10 times the diameter of the moon. The main difference to modern digital cameras is that the H.E.S.S. cameras allow much shorter exposure times, almost a million times faster. Such short exposures are essential to detect the faint Cherenkov flashes, which would otherwise be drowned in the background light of even the darkest Namibian skies.

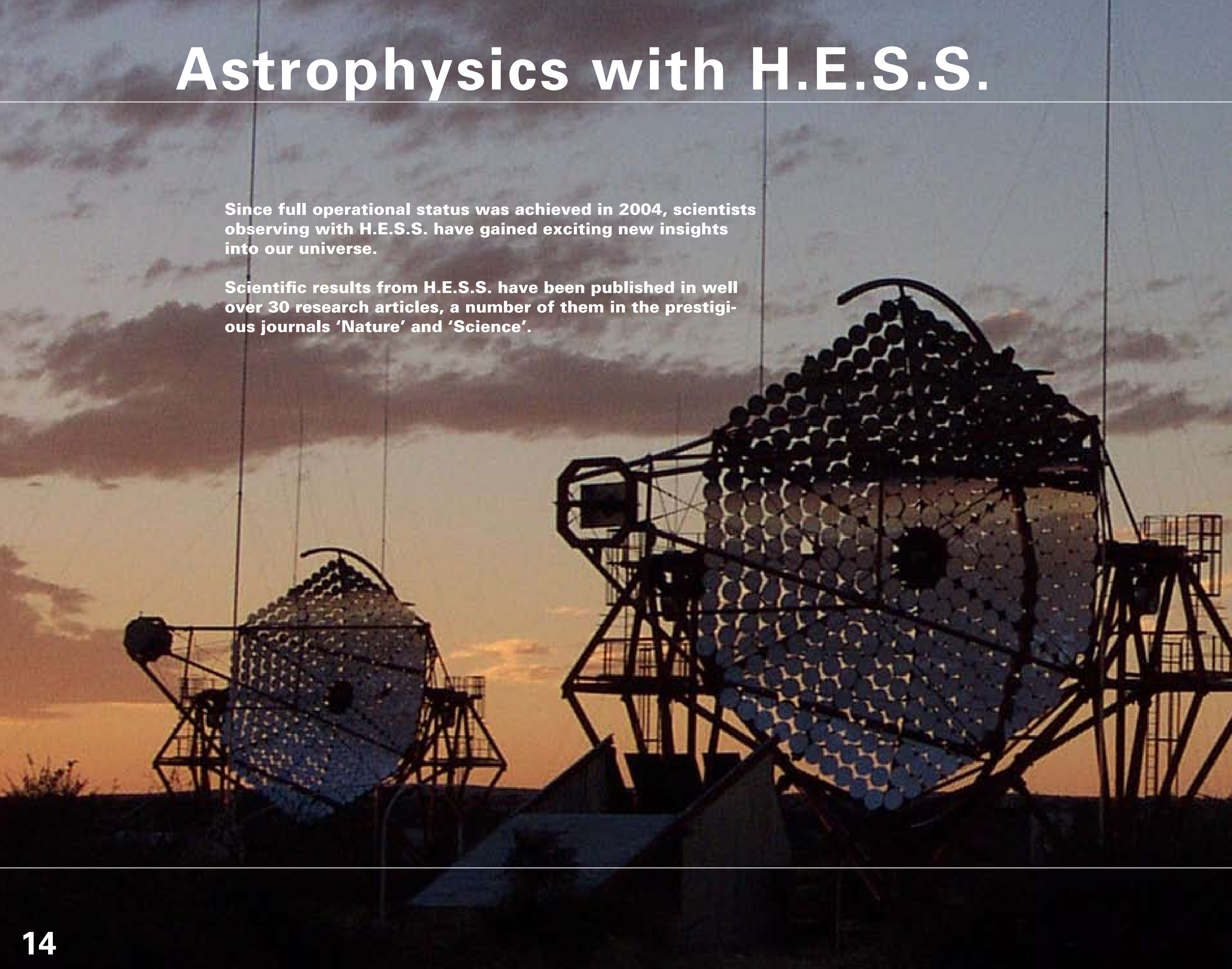
Observing with H.E.S.S.

H.E.S.S. scientists accumulate about a 1000 hours of observation each year during moonless nights, which provide the best conditions for recording the faint shower tracks. When the telescopes observe an interesting object in the sky, up to 300 air shower tracks are recorded each second. Most of these tracks, however, are caused by cosmic ray atomic nuclei hitting the atmosphere; at most some 10 per minute are genuine gamma rays. The strongest sources of gamma rays can be detected with a few minutes of observations; others may require tens of hours. A processor 'farm' immediately analyses the recorded images. Computer programs brought to perfection over many years allow to reject the unwanted cosmic rays, and to select the gamma-ray tracks. About one Terabyte of data per month is written to tape and shipped to the processing centres in Heidelberg and Lyon for final data analysis.

The control computers steer the telescopes and control data acquisition automatically throughout the night, slewing the telescopes from one object to the next according to a target list. However, a crew of two or three observers is present during observations, both to intervene in case of technical problems and to react in case of unexpected results. The observers come from the participating institutions; they come to the H.E.S.S. site for a full new-moon period of two to three weeks, and are assisted by the local experts.

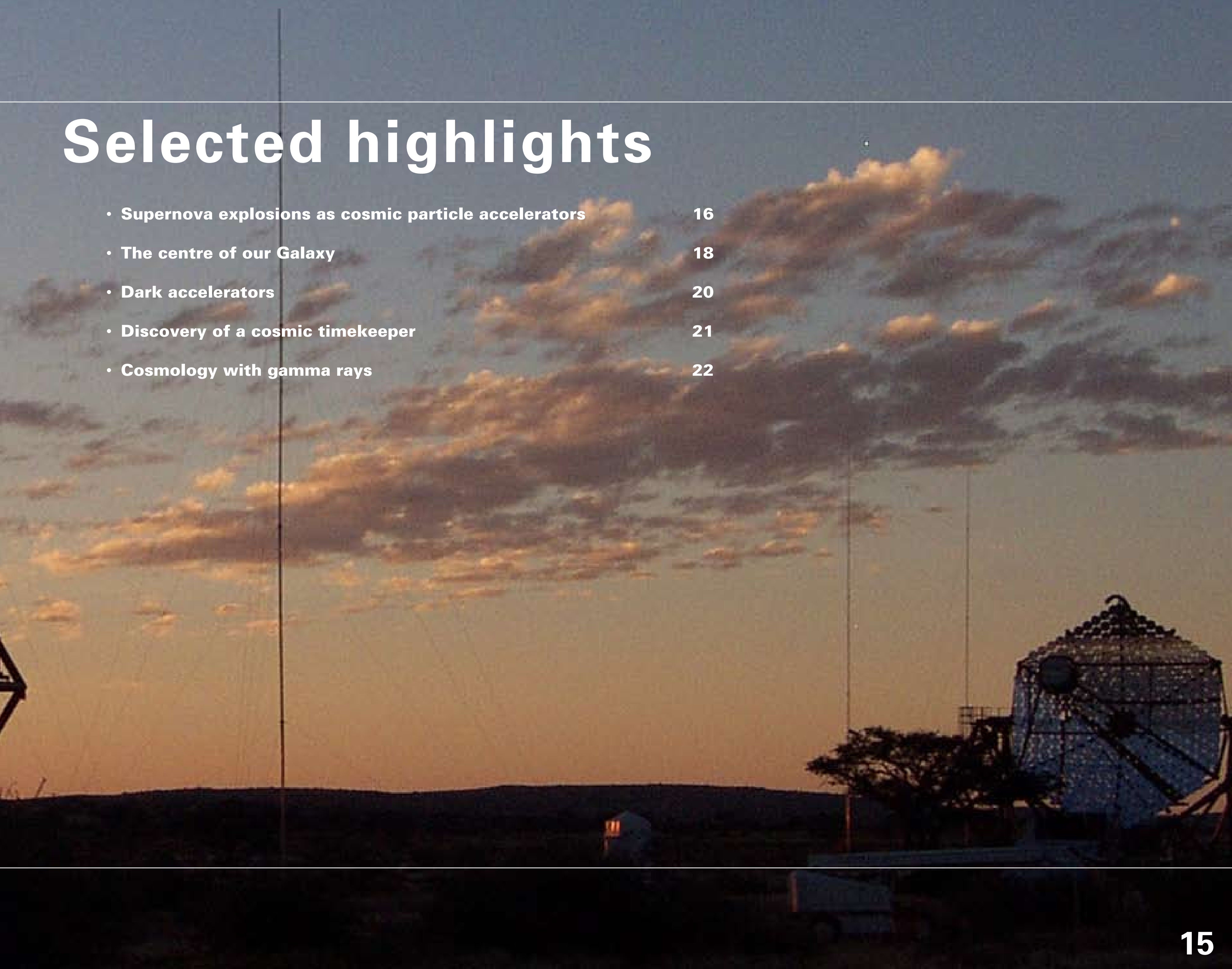
What results have already been achieved with H.E.S.S.?

Astrophysics with H.E.S.S.



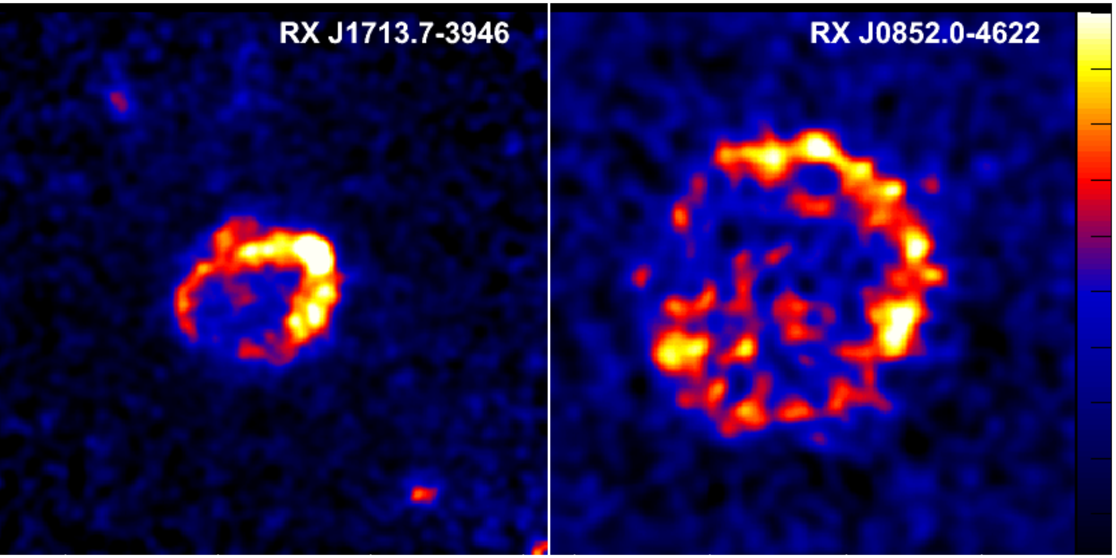
Since full operational status was achieved in 2004, scientists observing with H.E.S.S. have gained exciting new insights into our universe.

Scientific results from H.E.S.S. have been published in well over 30 research articles, a number of them in the prestigious journals ‘Nature’ and ‘Science’.



Selected highlights

Supernova explosions ...



If supernova explosion waves are cosmic accelerators - as long suspected by scientists - they should be clearly visible in gamma rays. Indeed, H.E.S.S. images resolve the ring-like shock fronts for the first time and show them glowing in high-energy gamma rays.

One of the first highlights of the H.E.S.S. observations was the discovery of high-energy gamma rays from two supernova explosion shells, whose 'names' RX J1713.7-3946 and RX J0852.0-4622 refer to their celestial coordinates and the fact that they were first seen as X-ray sources. The H.E.S.S. telescopes were able to resolve the spatial structure of the gamma-ray source; as predicted, gamma rays were found to exactly trace the supernova shell. This discovery proves conclusively that supernova explosion waves work as cosmic accelerators, at least up to energies of 100 million million electrons volts ('electron volt' is a unit characterising the energies of particles and radiation; visible light has 2 to 4 electron volts).

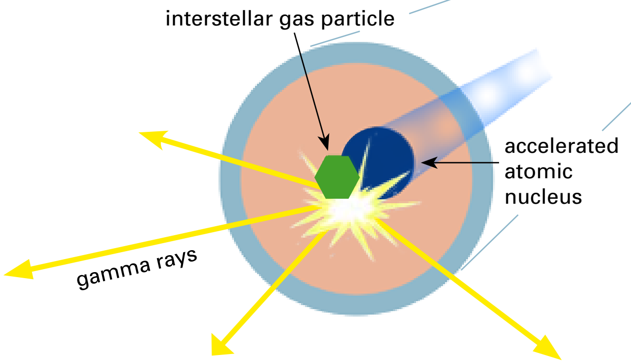
Background

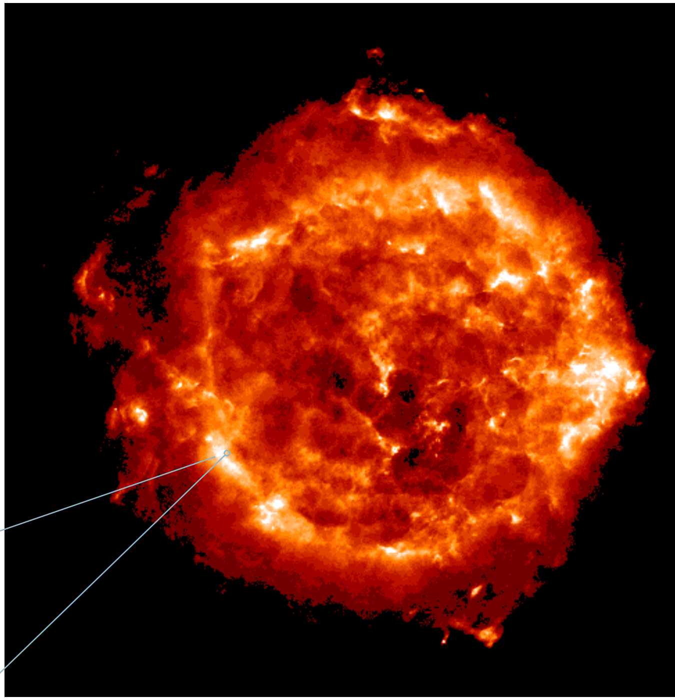
Our entire Galaxy is permeated by cosmic rays – atomic nuclei accelerated to very high energies. The existence of cosmic rays was discovered by Victor Hess in 1912, almost 100 years ago. Throughout this time, the origin of cosmic rays was heavily debated: Somewhere in our Galaxy must be cosmic particle accelerators capable of creating particle energies many orders of magnitude beyond the biggest man-made accelerators on Earth.

… as cosmic particle accelerators

Supernova explosions have long been postulated as likely sources of cosmic rays. A supernova occurs when a star collapses under its weight, sending a shock wave of ejected matter into interstellar space. Supernova explosions are among the very few processes which could conceivably provide enough energy to fill the Galaxy with cosmic rays. Atomic nuclei can be caught in the explosion wave, and – riding the wave like a surfer rides a water wave – they gain energy. Most nuclei ride the wave only for a short time before the wave outruns them and gain just a bit of energy; very few succeed to stay on top for thousands of years and reach very high energies. This effect quite naturally reproduces the measured energy spectrum of cosmic rays, where the number of particles decreases rapidly with increasing energy.

Gamma rays are generated when these energetic cosmic ray nuclei collide with interstellar gas particles. The intensity of the gamma rays therefore indicates the density of the cosmic ray nuclei at a source and the density of the surrounding medium.





An atomic nucleus can be caught in the supernova explosion wave. Riding the wave akin to a surfer riding a water wave, the nuclei substantially gain energy. When they occasionally collide with interstellar gas particles, gamma rays are created, tracing the distribution of high-energy nuclei *(Radio image of supernova Cassiopeia A, R. Tuffs, MPIK).*

The centre of our Galaxy …

Artists view of a black hole, as present at the centre of our Galaxy. Particle acceleration might take place in shock waves in the gas streams falling into the black hole, or in the magnetic fields associated with the rapidly spinning black hole. *(Drawing Credit: XMM-Newton, ESA, NASA)*

One of the most exciting regions
in the sky is the central part of our Galaxy. Within a few parsecs around the Galactic Centre there is a large number of young, massive and evolved stars, of diffuse hot gas and ionised gas streams, several powerful supernova remnants and finally even a supermassive black hole with a mass of about 3 million times that of our Sun. Quite a number of potential sources of high-energy gamma rays are located within this small volume. Last but not least, hypothetical particles of the Dark Matter apparently filling the entire Universe are predicted to accumulate at the Galactic Centre, and upon colliding with each other, they can annihilate and create gamma rays.

The two frames on the right show the H.E.S.S. view of the Galactic Centre. The top image – giving the observed flux of high-energy gamma rays – exhibits two gamma-ray sources, one coincident with a known supernova explosion shell (G0.9+0.1), the other to better than a minute of arc on top of the supermassive black hole. But this image does not tell the full story. Subtracting the two prominent sources and adjusting the contrast of the image, one obtains the lower frame, which shows a band of gamma-ray emission along the Galactic Plane indicated by the dashed line. In addition, another ‘mystery source’ — HESS J1745-303 — pops up.

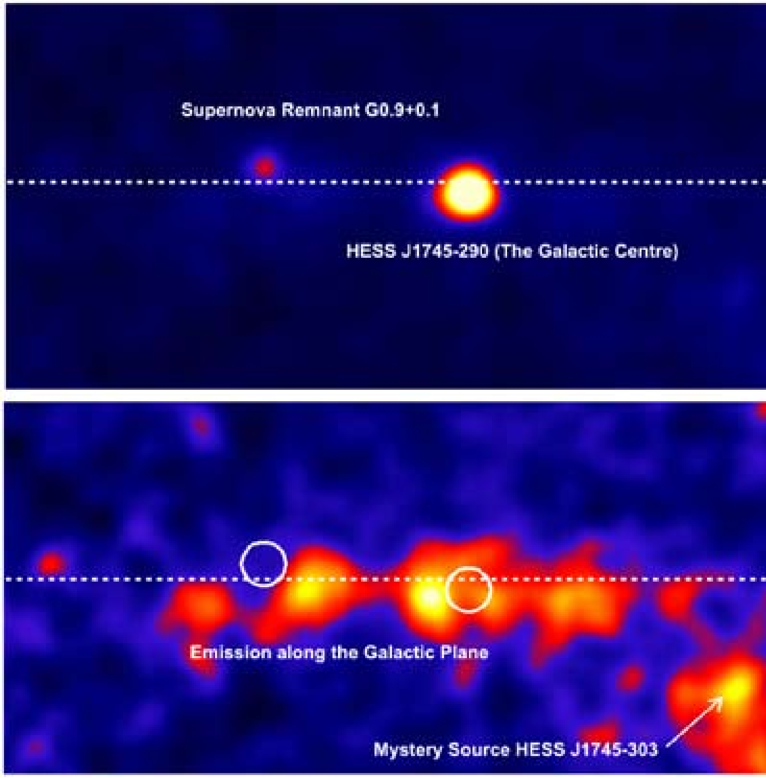
The band of gamma-ray emission traces gigantic clouds of interstellar gas known to exist in this area. A likely explanation is that a cosmic accelerator located at the centre of the Galaxy sends out a stream of high-energy particles, which, upon collision with the gas particles, create the gamma rays

... in high-energy gamma rays

observed by H.E.S.S. From the fact that very distant gas clouds do not shine in gamma rays, one concludes that this accelerator is active since some 10 000 years, and particles have not had sufficient time to reach the more distant clouds.

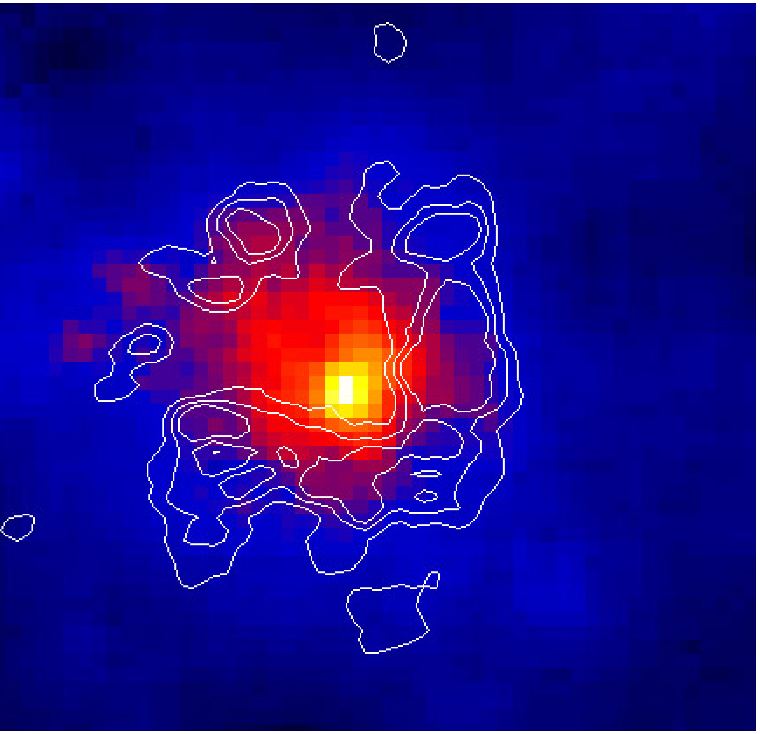
Could this source at the Galactic Centre hint the long-sought annihilation of Dark Matter particles? To explain the gamma rays, the masses of the Dark Matter particles would have to be much higher than usually assumed — at least 10 tera electron volts — and their annihilation rate would have to be quite high, but models for the hypothetical Dark Matter particles are sufficiently flexible to accommodate such features. Also, initial observations showed that the angular distribution of gamma rays had a slight 'halo', as predicted for a distribution of Dark Matter particles with a peak at the Galactic Centre, but with a smooth distribution extending out into the Galaxy.

However, the recent H.E.S.S. precision data revealed that the halo is explained by the emission from the gas clouds. Another characteristic feature of Dark Matter annihilation is the energy distribution of gamma rays. Rather than the predicted annihilation spectrum with a peak energy flow at intermediate energies, the latest H.E.S.S. results show a monotonically falling energy spectrum, now measured over almost two decades in energy, in contradiction with dark-matter predictions. This pretty much rules out Dark Matter as the dominant source of the observed radiation. The exact nature of the gamma-ray source, however, remains mysterious; particle acceleration in the turbulent gas streams falling into the black hole may be the answer, and studies combining new data from different wavebands may some day provide the answer.



Two point-like sources – about 1° apart – dominate the gamma-ray image of the Galactic Centre region (top). After mathematical subtraction of their contribution, diffuse emission from molecular clouds becomes apparent (bottom).

‘Dark accelerators’



X-ray image of the region near HESS J1813-178. The white contour lines indicate levels of radio emission.

Among the objects discovered by H.E.S.S. are quite a few mysterious gamma-ray sources dubbed ‘dark accelerators’. These objects are only seen in highest-energy gamma rays, without counterparts in other wavelength regions. In a few cases, deeper observations at radio or X-ray wavelength finally revealed some additional signatures of the objects; in other cases, nothing is detected despite significant efforts with the most sensitive instruments available.

Background

One example where counterparts of the gamma-ray source were finally discovered is the object HESS J1813-178 *(left)*. Close to the position of the gamma-ray source, radio images show a partial supernova shell. X-ray observations with the XMM-Newton satellite reveal an X-ray source at the centre of the shell, interpreted as radiation generated by the rapidly spinning neutron star left over from the explosion. Either the neutron star or the shell are plausible sources of the gamma rays.

For other objects, such as HESS J1616-508, no trace of radio or X-ray emission is detected. Since radio waves or X-rays are radiated by high-energy electrons, the only explanation is that this source does not contain any such electrons, which is very surprising, since one would expect electrons and nuclei to be accelerated simultaneously. What made all the electrons disappear? Astrophysicists in the US speculated that such objects might be remainders of gamma-ray bursts in our own Galaxy. In these extremely energetic stellar explosions, magnetic fields are so high that electrons rapidly radiate all their energy and only the accelerated nuclei are left. Whether this is the correct explanation remains to be shown; fact is that there are objects in the Universe generating most of their energy output at gamma-ray wavelengths.

Discovery of a cosmic timekeeper

In November 2006, the H.E.S.S. scientists announced the discovery of periodic emission of very high energy gamma rays from a binary system known as LS 5039. The rate of gamma rays detected by H.E.S.S. showed a pattern repeating every 3.9 days. This is the highest energy at which any periodic signal has been observed from a cosmic object, nearly 100 000 times higher than previously known.

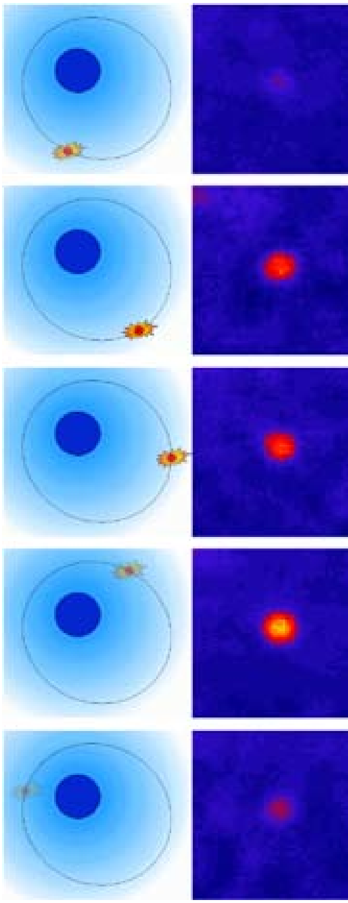
Background

LS 5039 is a binary system, comprised of a massive blue star - 20 times heavier than the Sun - around which a compact object - perhaps a black hole - is orbiting on a highly eccentric orbit, at closest approach almost touching the massive star. As it dives towards the blue-giant star, the compact companion is exposed to the intense light radiated by the star and to its strong stellar 'wind'. A 'wind' is the flux of particles accelerated in a star's atmosphere which causes, in the case of our Sun, magnetic storms and the aurora borealis or 'Northern Lights' seen near the Earth's poles.

In the violent interaction between the compact object and the stellar wind, particles may plausibly be accelerated to high energies, emitting the detected gamma rays. The compact object, in moving along its orbit, acts like a probe of the star's environment. "This is the first time in the history of very high energy gamma-ray astronomy that we can observe a repeating, evolving, particle-acceleration experiment in a well-determined environment" says Mathieu de Naurois from the Nuclear and High-Energy Physics Laboratory, LPNHE, in Paris.

Another effect adds a further modulation to the flux of gamma rays observed from the Earth. We know since Einstein derived his famous equation ($E=mc^2$) that matter and energy are equivalent, and that pairs of particles and antiparticles can mutually annihilate to give light. Symmetrically, when very energetic gamma rays meet the light from a massive star, they can be converted into matter (an electron-positron pair in this case). So, the light from the star acts like a fog for gamma rays, absorbing them especially when their source — the compact object — is behind the star, and so is partially eclipsed. "The periodic absorption of gamma rays is a nice illustration of the production of matter-antimatter pairs by light" explains Guillaume Dubus, Astrophysical Laboratory of Grenoble, LAOG.

The discovery by the H.E.S.S. collaboration of this orbital clock, thanks to the precision of the measurements, will open the way to a better understanding of the environment of black holes, neutron stars, and more generally of the sites of particle acceleration in the Universe.



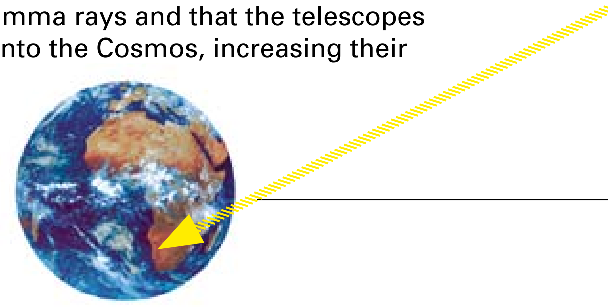
Schematics of the orbital position on a dramatically extended scale (left) and the corresponding variation of the high energy gamma-ray intensity with a 3.9 day periodicity as discovered by H.E.S.S. (right).

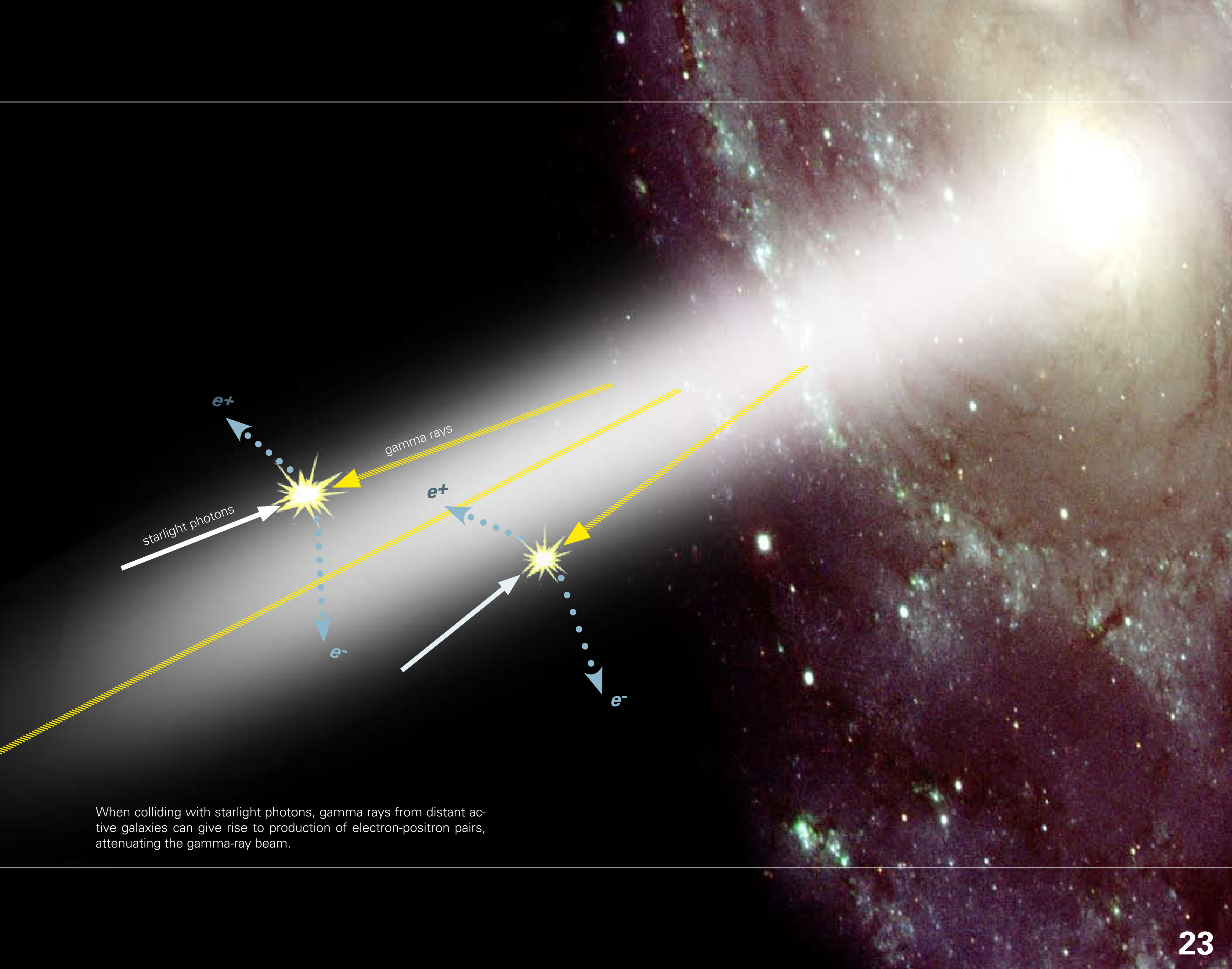
Cosmology with gamma rays

How many stars are there in the sky? Gamma-ray astronomers add a new twist to an old question
If the Universe is infinite, and there are infinitely many stars in it, why is the sky dark at night — shouldn‘t there be stars everywhere? This old question is known as Olber‘s paradox; its answer relates to the fact that the visible Universe is not infinite, that it has a finite age, and that there is only a finite amount of energy available to be converted into starlight. The question how much — or how little — starlight there exactly is, is a very interesting issue since it tells scientists about the history of star formation in the Universe. However, there is a catch: the amount of cosmic light measured on Earth or with instruments on satellites is mostly ‘foreground’ light, emitted by dust in the solar system and by ‘nearby’ objects in our own Galaxy; this intensity is not at all representative of the typical intensity of light in intergalactic space and in the vast volume of the Universe. It‘s a bit like attempting to watch stars on a sunny day — the starlight is certainly there, but it is all hidden in the scattered sunlight of the blue sky.

What one should really do is measure starlight in the space between galaxies, away from all sources of foreground light. This may sound impossible, but gamma-ray astronomers have actually found a trick to perform this measurement. The idea is to use distant ‘active galaxies’ which send a beam of high-energy gamma rays towards Earth, across billions of light years of intergalactic space. The gamma rays are produced at the cores of such galaxies, where black holes with a mass a billion times the mass of the sun gobble up nearby stars and convert part of the accreted mass into beamed high-energy radiation. The energy of these gamma rays is so high that sometimes when they ‘hit’ a quantum of starlight, the energy is sufficient to create an electron-positron pair, converting energy into matter according to Einstein‘s $E = mc^2$. By this process, the beam of gamma rays is attenuated. The attenuation is the stronger the higher the energy of the gamma rays is — because then it is easier to produce a particle pair — and the more intense the ‘target’ starlight is. By measuring the spectrum of high-energy gamma rays from such distant active galaxies — known as ‘Blazars‘ — one can identify the absorption features imprinted on their gamma-ray spectrum, and conclude from there on the intensity of starlight in intergalactic space.

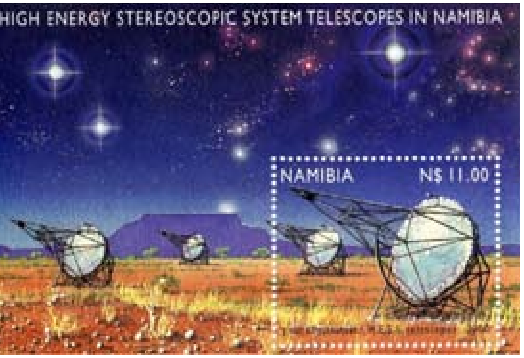
In 2004, H.E.S.S. scientists discovered the so far most distant gamma-ray emitting Blazars, a few billion light years from Earth. The gamma-ray spectra of these two Blazars were expected to show strong absorption features, effectively cutting off all gamma rays above a certain energy. Yet the measured spectra show no such effect, indicating that intergalactic absorption and hence the intensity of near-infrared starlight in intergalactic space must be significantly lower than previously assumed. H.E.S.S. results imply that there are few sources of starlight in the cosmos beyond the galaxies seen in deep observations with the Hubble Space Telescope. The discovery of low levels of intergalactic near-infrared starlight has the interesting side effect that the Universe becomes more transparent to gamma rays and that the telescopes can look deeper into the Cosmos, increasing their reach for further discoveries!





When colliding with starlight photons, gamma rays from distant active galaxies can give rise to production of electron-positron pairs, attenuating the gamma-ray beam.

H.E.S.S. in Namibia



Namibian stamp portraying the H.E.S.S. instrument

Inauguration of the H.E.S.S. instrument by the Namibian Prime Minister in September 2004.

Namibia - an excellent partner for astronomy

Building a major astrophysics experiment like H.E.S.S. is a long process from the idea to the first observations. The first concept of building such a telescope system was born in 1995. In 1998, the H.E.S.S. collaboration was established, uniting a number of European research groups working in the field, and combining their intellectual and technical resources. At the same time, Namibia was identified as an ideal site for the new instrument. An exchange of diplomatic notes between Germany and Namibia in 2000 allowed the start of construction in Namibia. Already in 2002, the first telescope was inaugurated and started observations. Full operation of the new telescope system began in January 2004, almost a decade after the first ideas were conceived.

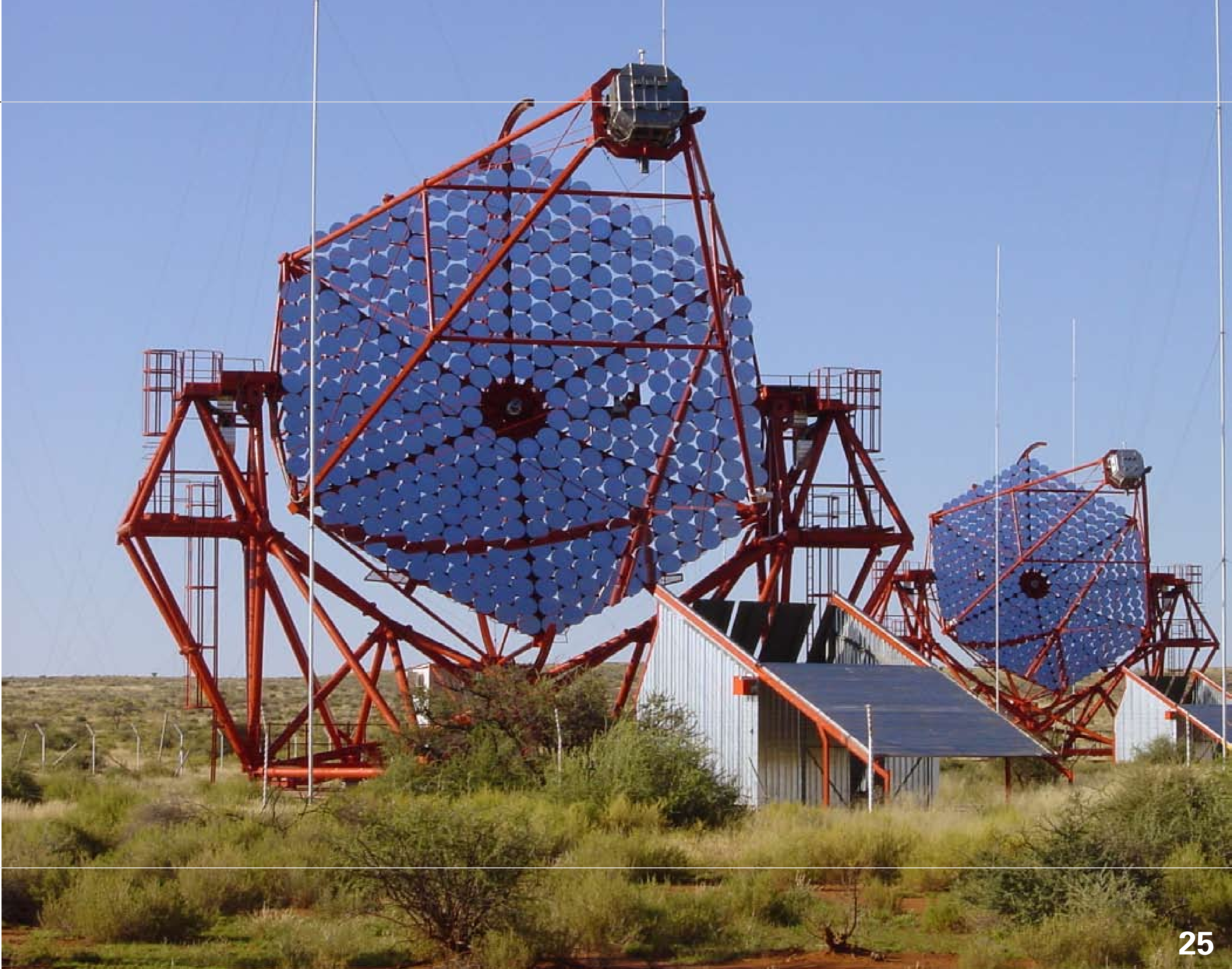
A key component in the decision for the Gamsberg site was the participation of the University of Namibia. Construction and operation of H.E.S.S. is defined and supported by an Exchange of Notes between the Namibian and German governments, and by cooperation agreements between the University of Namibia and H.E.S.S. institutes.

Namibia provides excellent conditions for astronomy

- The Gamsberg area in the Khomas Highland of Namibia has long been known for its excellent conditions for optical astronomy, with many clear nights and dark skies.

- A location in the Southern Hemisphere offers optimal viewing conditions for many objects in our Galaxy. In particular, the Galactic Centre is almost passing through the zenith.

- The mild climate allows the operation of the telescopes without protective enclosures.



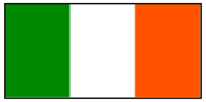
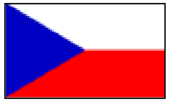
The H.E.S.S. Team

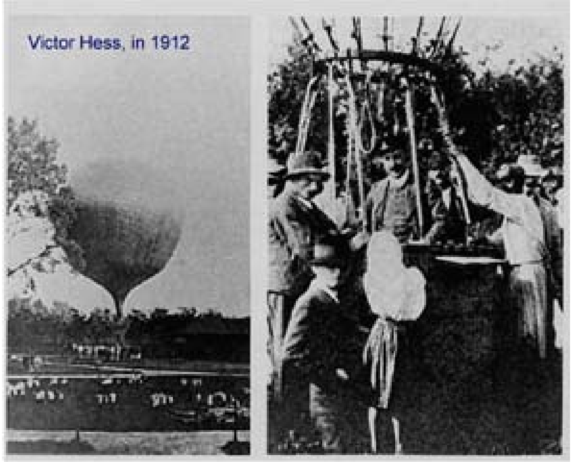
H.E.S.S. scientists at a meeting at the Dublin Institute for Advanced Studies

The H.E.S.S. telescopes are built and operated by an international collaboration of more than 100 scientists from nine countries.

The participating institutes are:

- Max-Planck-Institut für Kernphysik, Heidelberg, Germany
- Humboldt Universität Berlin, Germany
- Ruhr-Universität Bochum, Germany
- Universität Erlangen-Nürnberg, Germany
- Universität Hamburg, Germany
- Universität Heidelberg, Germany
- Universität Tübingen, Germany
- Laboratoire Leprince-Ringuet (LLR), Palaiseau, France
- LPNHE, Universités Paris VI - VII, France
- APC, Paris, France
- LAPP Annecy, France
- LPTA, Université Montpellier II, France
- Observatoire de Paris-Meudon, France
- Université de Grenoble, France
- CESR, Toulouse, France
- DAPNIA/CEA Saclay, France
- Durham University, UK
- University of Leeds, UK
- Dublin Institute for Advanced Studies, Ireland
- Nicolaus Copernicus Astronomical Center, Warsaw, Poland
- Jagiellonian University, Cracow, Poland
- Charles University, Prague, Czech Republic
- Yerevan Physics Institute, Armenia
- North-West University, Potchefstroom, South Africa
- University of Namibia, Windhoek, Namibia
- LEA, supported by MPG and CNRS

What does H.E.S.S. stand for ?
H.E.S.S. is an acronym that stands for ‘High Energy Stereoscopic System’ and characterises the key features of the instrument.

At the same time, the name honors VICTOR F. HESS, the Austrian physicist, born in 1883, who emigrated to the United States in 1938. Hess, whose discovery of cosmic rays made him the co-recipient of the 1936 Nobel Prize in Physics, has in the course of more than fifty years made basic contributions to the understanding of radiation and its effects on the human body. In ten balloon ascents between 1911 and 1913, he detected ionising radiation; from the observation that the intensity increased with height, he deduced that this radiation was incident from outer space. Cosmic rays and their sources have been the subjects of intense research since then.

More information about the H.E.S.S. project can be found on the H.E.S.S. web pages:

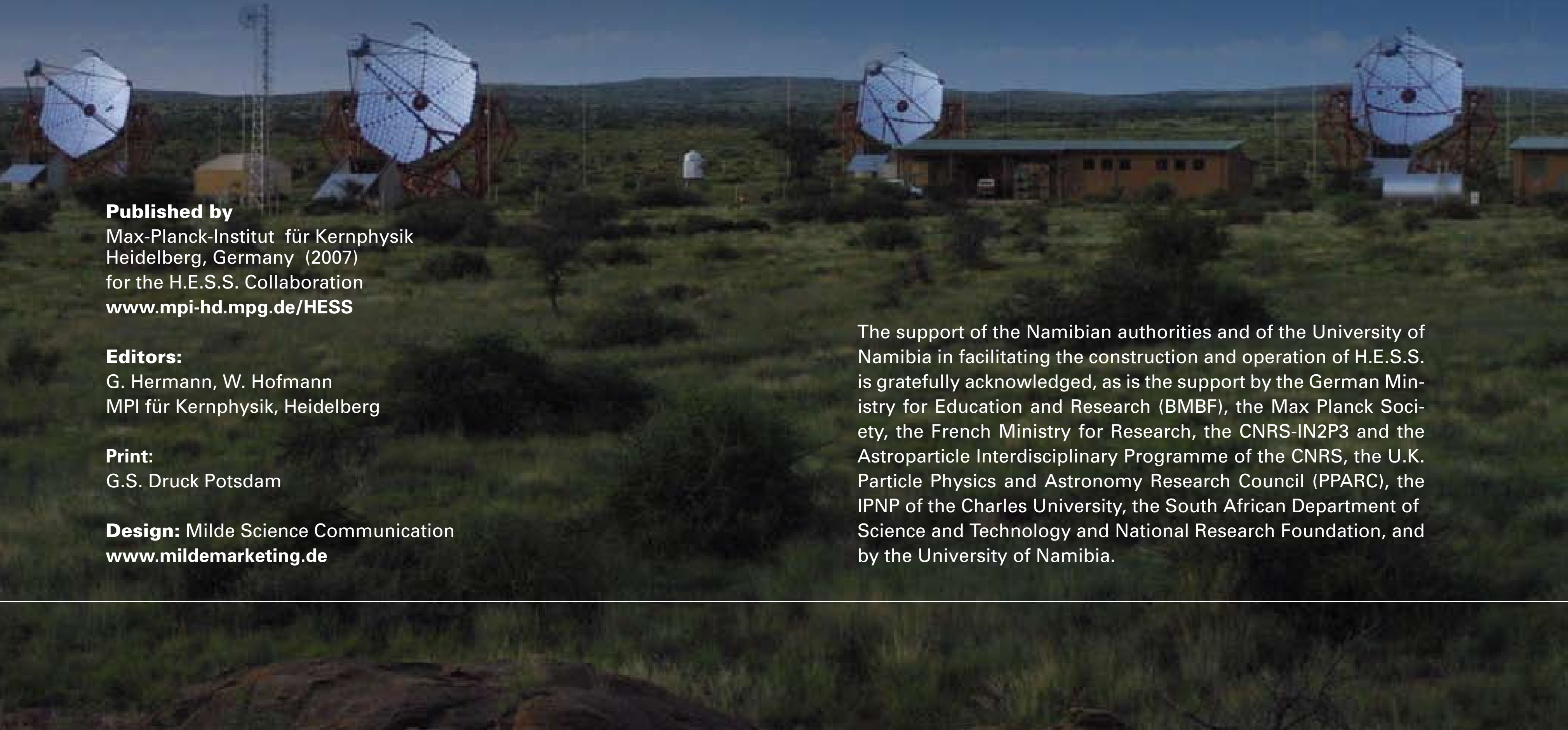
http://www.mpi-hd.mpg.de/HESS/info
H.E.S.S. home page

http://www.mpi-hd.mpg.de/HESS/som
H.E.S.S. Source of the Month where each month a gamma-ray source studied with H.E.S.S. is explained

http://www.mpi-hd.mpg.de/HESS/highlights
H.E.S.S. science highlights

http://www.mpi-hd.mpg.de/HESS/images
H.E.S.S. image collections

MAX-PLANCK-GESELLSCHAFT



Published by
Max-Planck-Institut für Kernphysik
Heidelberg, Germany (2007)
for the H.E.S.S. Collaboration
www.mpi-hd.mpg.de/HESS

Editors:
G. Hermann, W. Hofmann
MPI für Kernphysik, Heidelberg

Print:
G.S. Druck Potsdam

Design: Milde Science Communication
www.mildemarketing.de

The support of the Namibian authorities and of the University of Namibia in facilitating the construction and operation of H.E.S.S. is gratefully acknowledged, as is the support by the German Ministry for Education and Research (BMBF), the Max Planck Society, the French Ministry for Research, the CNRS-IN2P3 and the Astroparticle Interdisciplinary Programme of the CNRS, the U.K. Particle Physics and Astronomy Research Council (PPARC), the IPNP of the Charles University, the South African Department of Science and Technology and National Research Foundation, and by the University of Namibia.