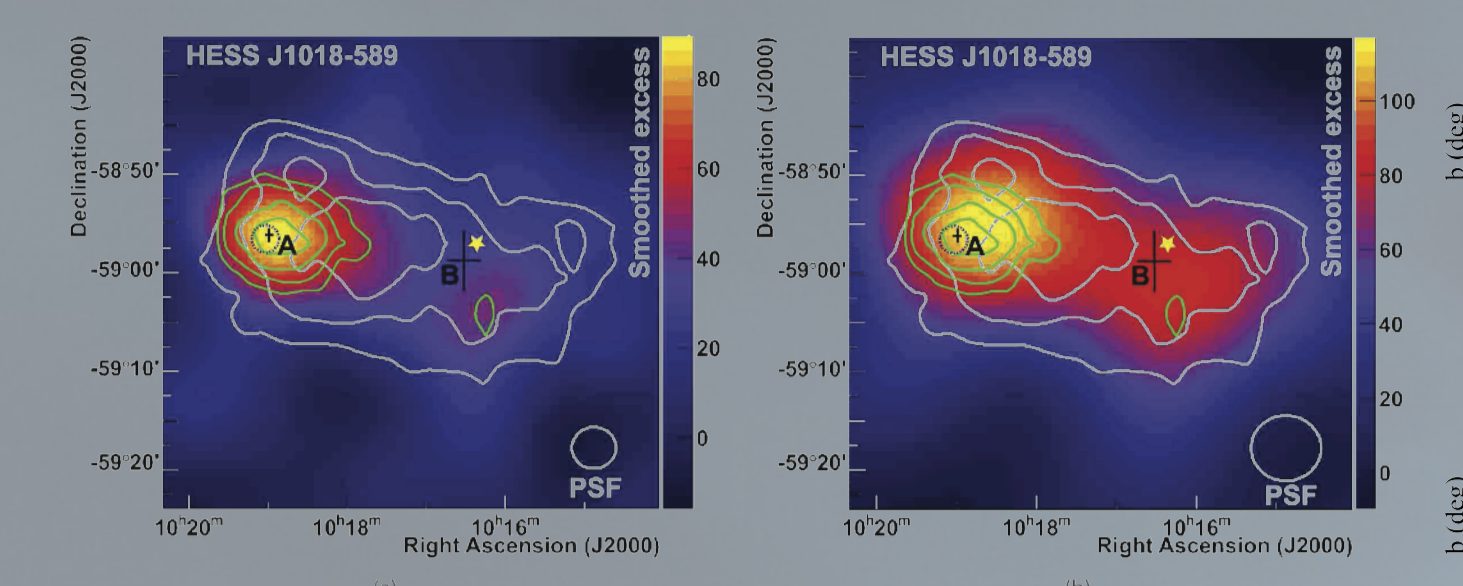


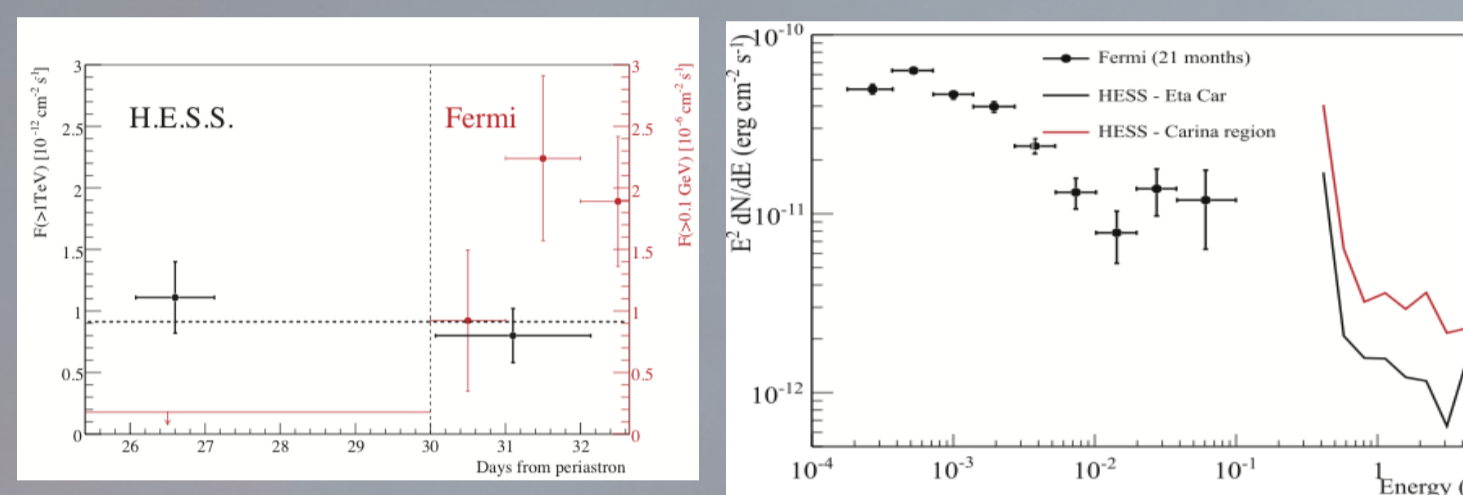
Status and Recent Results from H.E.S.S.

The H.E.S.S. instrument consists of four 13 m (HESS I) and one 28 m diameter (HESS II) Atmospheric Cherenkov Telescopes (ACTs) located in the Khomas Highland in Namibia, 1800 m above sea level. The HESS I array began operations in 2003, and has achieved recent scientific results allowed by the synergy with the Fermi-LAT, some of which are outlined here. The HESS II telescope started operations in July 2012, and is expected to provide its first scientific results by the end of the year. Since the inauguration of the first telescope in September 2002, HESS has taken 9415 hours of data, with 4234h in the band of the Galaxy and 5181 h in extragalactic space, discovered over 80 new very high energy γ -ray sources (according to TeVCat listings), among them more than 60 galactic objects and 19 extragalactic sources.

Binary Systems



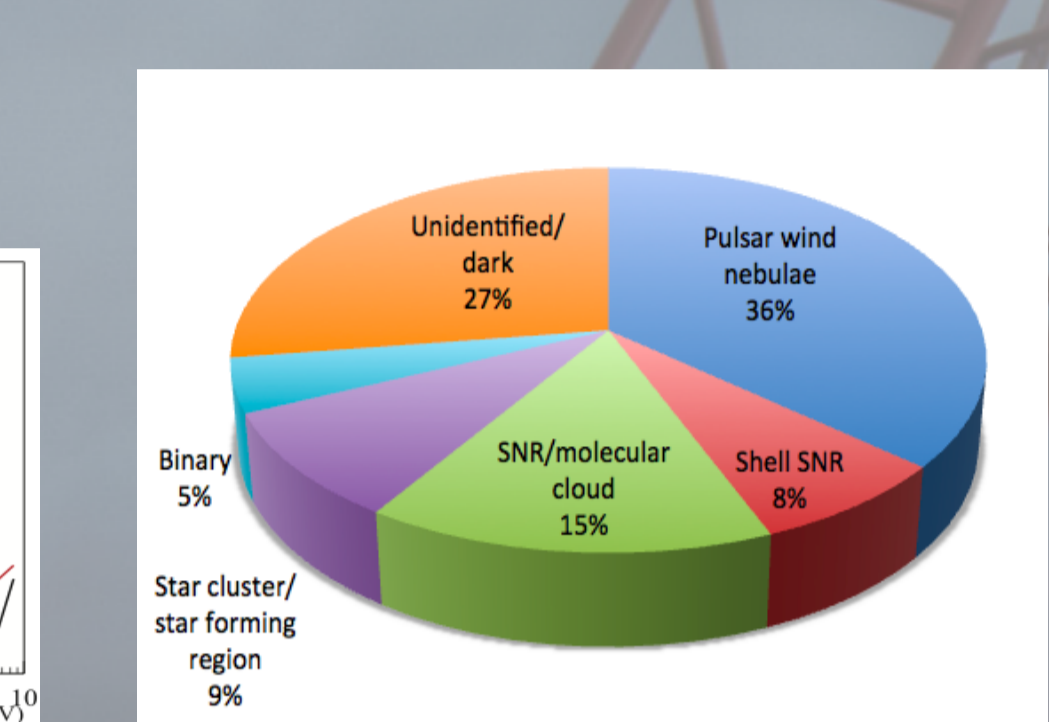
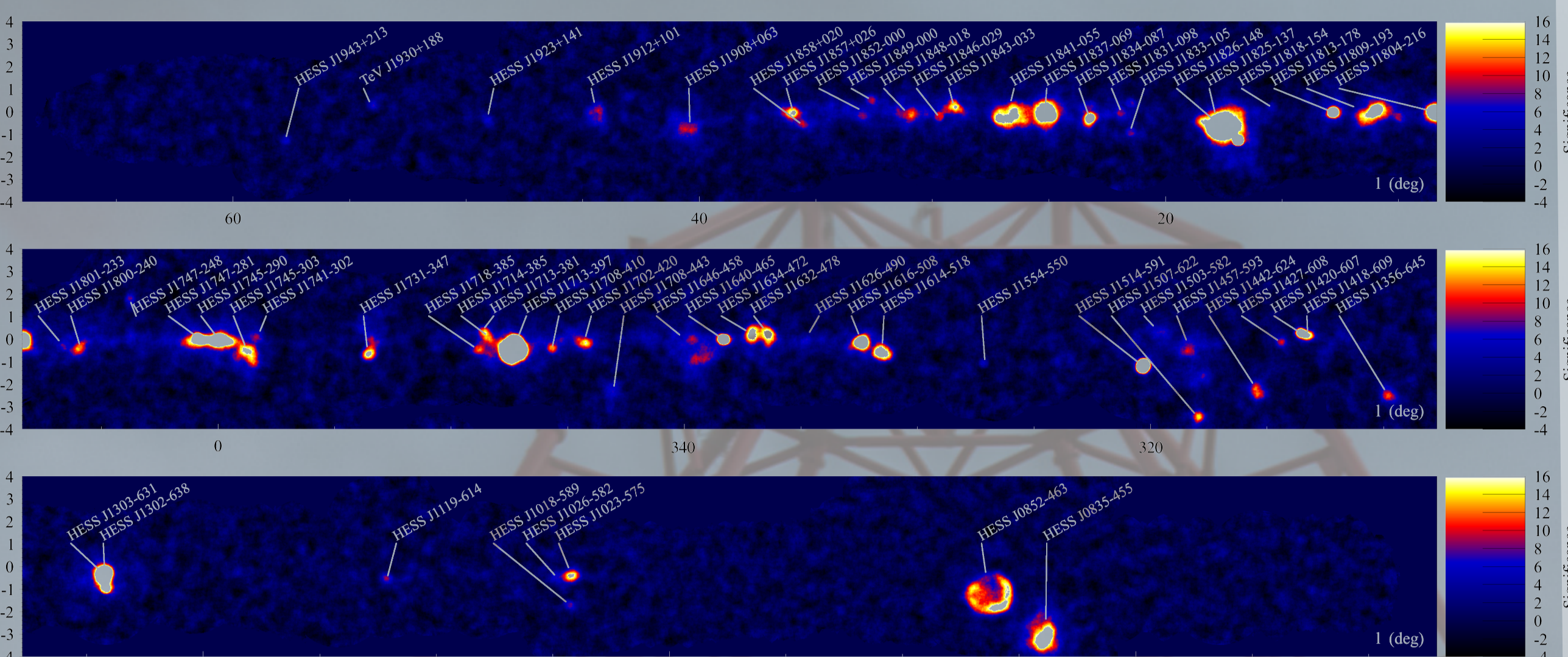
HESS observations of the FoV around the position of the new γ -ray binary discovered by Fermi, 1FGLJ1018-5856, shows the presence of HESSJ1018-586, a combination of a point-like source which could be the VHE counterpart of the binary system (A), and an extended emission region probably related to the nearby pulsar PSR J1016-5857 (B). The spectral analysis shows a photon index $\Gamma=2.7 \pm 0.5$ for the point-like source, with a normalization at 1 TeV of $(4.2 \pm 1.1) \times 10^{-12} \text{ TeV}^{-2} \text{ cm}^{-2} \text{ s}^{-1}$. Inspection of the source lightcurve does not reveal any clear indication of periodicity, although further H.E.S.S. Observations homogeneously sampling the phase-space range are required to properly assess the source variability at TeV energies (A&A, 2012, 541, A5).



PSR B1259-63 was observed in the 2010/2011 periastron passage, in which contemporaneous Fermi-LAT data were also taken, showing an unexpected flare occurring about 30 days after periastron. Whilst the GeV flare shows a factor ≥ 9.2 between the pre-flare and flare flux levels, at VHE the flux does not increase by a factor greater than 3.3 at the 99.7% confidence level. This implies that the GeV flare and the TeV emission have a different physical origin.

The FoV around η Carinae and the Carina nebula was observed during 2004-2010. The massive binary system η Car is of particular interest due to its spatial coincidence with the Fermi-LAT source 2FGLJ1045.05941. The HESS observations account for about 33.1h live-time and corresponds to six periods covering different orbital phases. No detection is found at energies >470 GeV yielding upper limits to the emission from the central system and the extended Nebula at 0.72 and $4.4 \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1}$, respectively (MNRAS, 2012, 424, 128). If the HE spectrum of Eta Car is extended to the VHE regime, it would have been detectable in the current HESS data. Therefore the non-detection of a significant VHE γ -ray signal from η Car in the complete H.E.S.S. data set implies the presence of a spectral cut-off in the range 0.1-1 TeV.

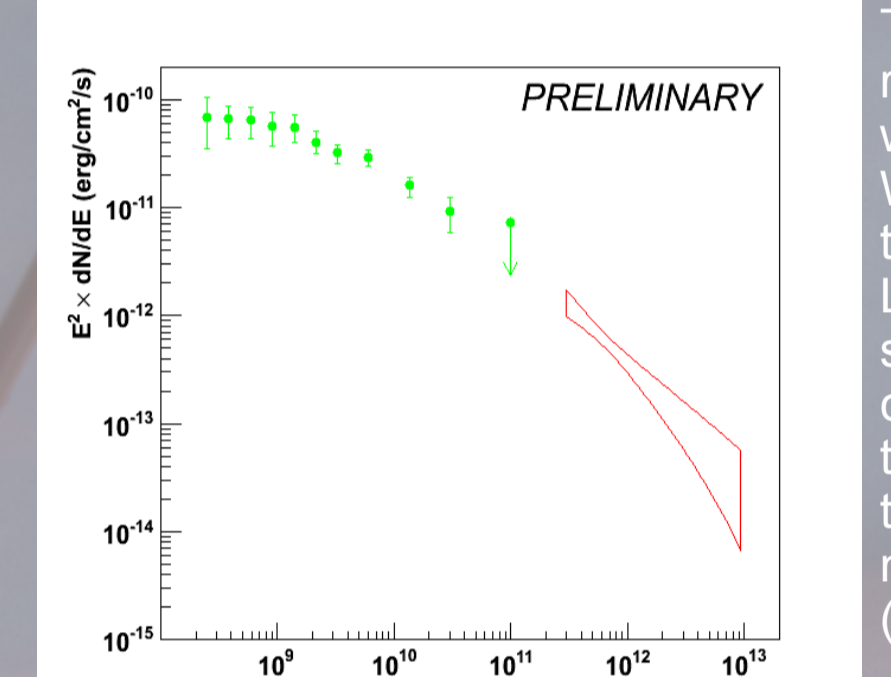
The Galactic Plane Survey



Most rewarding in terms of source discoveries proved to be the H.E.S.S. Galactic Plane Survey (top Figure), which revealed a large variety of sources of VHE γ -rays lining the Milky Way. Pulsar wind nebulae (PWNE) - giant bubbles filled with electrons and positrons created by spinning neutron stars - emerge as the most abundant source type. The Figure at left shows the breakdown of nature of the Galactic sources, as classified in TeVCat, illustrating the diversity of celestial gamma ray emitters. Most likely, a significant fraction of the unidentified sources are pulsar wind nebulae, where the pulsar is not (yet) detected. Work is ongoing to provide flux maps based on the HESS Galactic Plane Survey as well as a unified source catalog based on a semiautomatic pipeline, as a basis for ensemble studies of source classes (arXiv:1204.5860).

Supernova Remnants

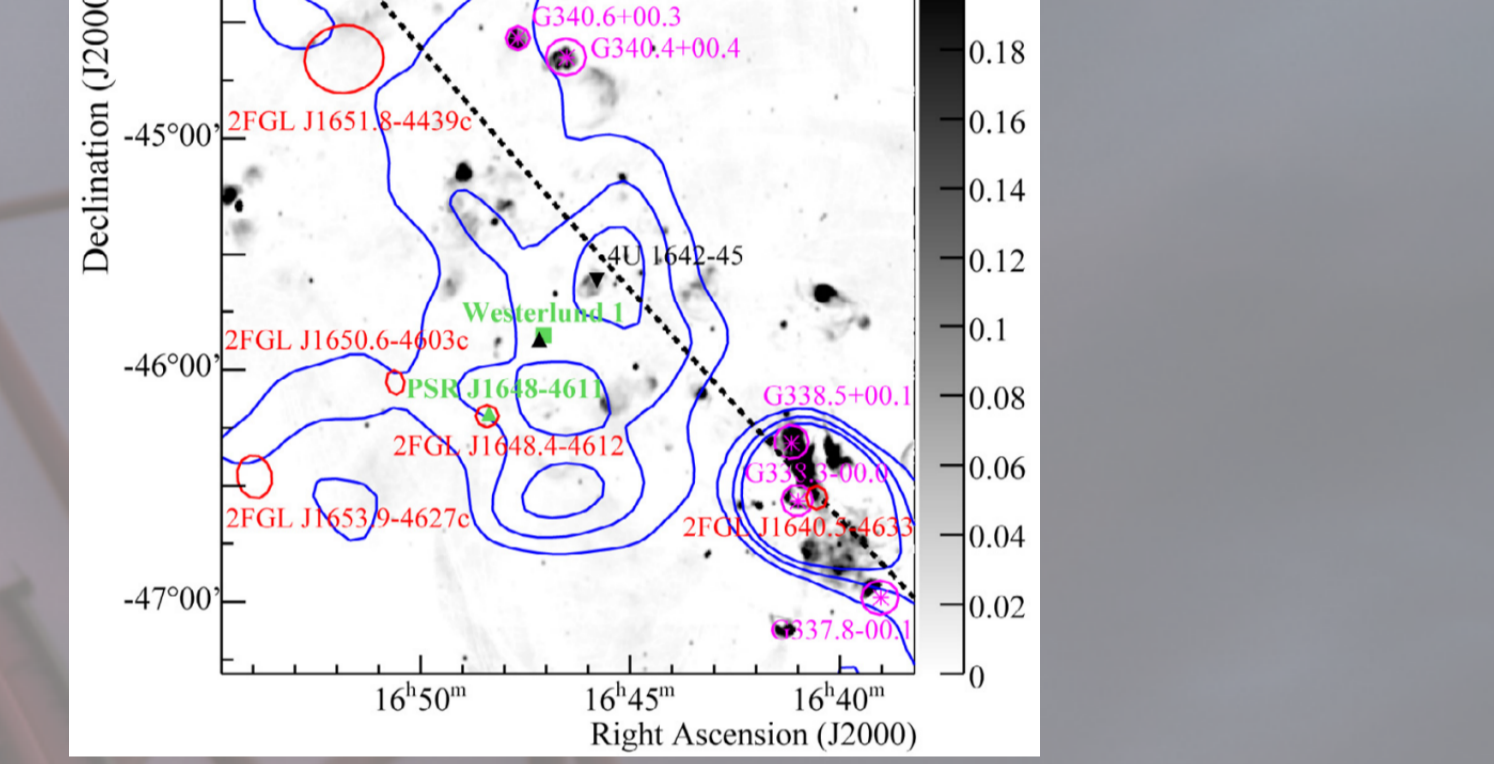
Resolved supernova remnant shells - the 'classical' cosmic particle accelerators - as well as supernovae interacting with molecular clouds, binary systems, and star clusters, constitute the next most abundant type of γ -ray sources in the Galactic Plane. The point in case here is the W49 region, a prime candidate for ACT observations since it hosts a star forming region (W49A) and a mixed morphology supernova remnant interacting with molecular clouds (W49B).



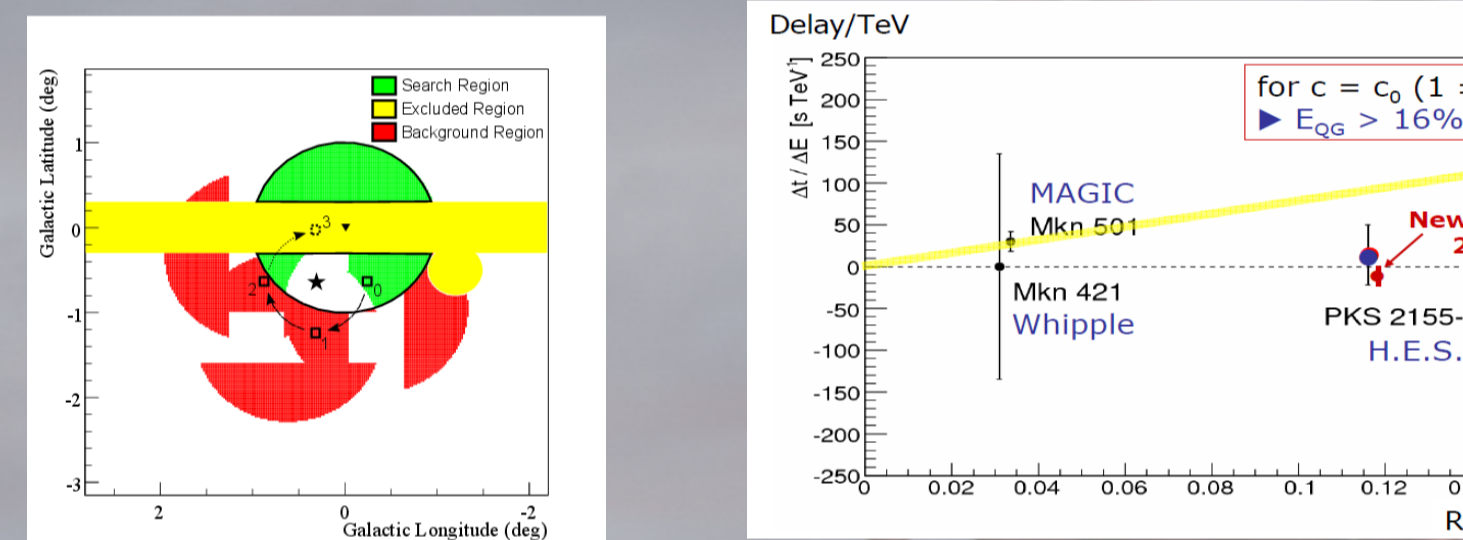
The Figure on the right shows the HESS γ -ray excess towards W49B, well coincident with the brightest radio emission of the W49B remnant (white contours), and with the GeV emission detected by the Fermi-LAT (green circle). The combined GeV-TeV spectrum (left Figure) shows a smooth connection between both regimes. Given the very high GeV luminosity and the fact that the SNR is interacting with dense material, a hadronic scenario is favored (arXiv:1104.5003).

Stellar Clusters

HESS J1646-458 is a new VHE γ -ray source found towards the unique massive stellar cluster Westerlund 1 (A&A, 2012, 537, A114) with observations performed in 2004, 2007-2008 for a total 33.8 h live-time. The spectrum in the range 0.45-75 TeV of the entire region is well fit by a power law with $\Gamma=2.19 \pm 0.08$ and a normalization at 1 TeV of $(9.0 \pm 1.4) \times 10^{-12} \text{ TeV}^{-2} \text{ cm}^{-2} \text{ s}^{-1}$. The integrated flux above 0.2 TeV amounts to $(3.49 \pm 0.52) \times 10^{-11} \text{ cm}^{-2} \text{ s}^{-1}$. The VHE γ -ray luminosity between 0.1-100 TeV is $1.9 \times 10^{35} \text{ (d/4.3 kpc)}^2 \text{ erg s}^{-1}$. The large size of HESS J1646-458, over 2° in diameter, makes it one of the largest VHE sources so far detected by HESS and presents a challenge in identifying clear counterpart(s) to explain the VHE γ -ray emission. Among the potential counterparts are three unidentified Fermi-LAT sources (bottom Figure) 2FGLJ1650.6-4603c, 2FGLJ1651.8-4439c, and 2FGLJ1653.9-4627c, as well as the γ -ray pulsar 2FGLJ1648.4-4612. The latter has been associated with the high spin-down power pulsar PSR J1648-4611, although the unprecedented high conversion efficiency needed and the size of the VHE emission region disfavor HESS J1646-458 as a single, very extended PWN.



Exotic Physics



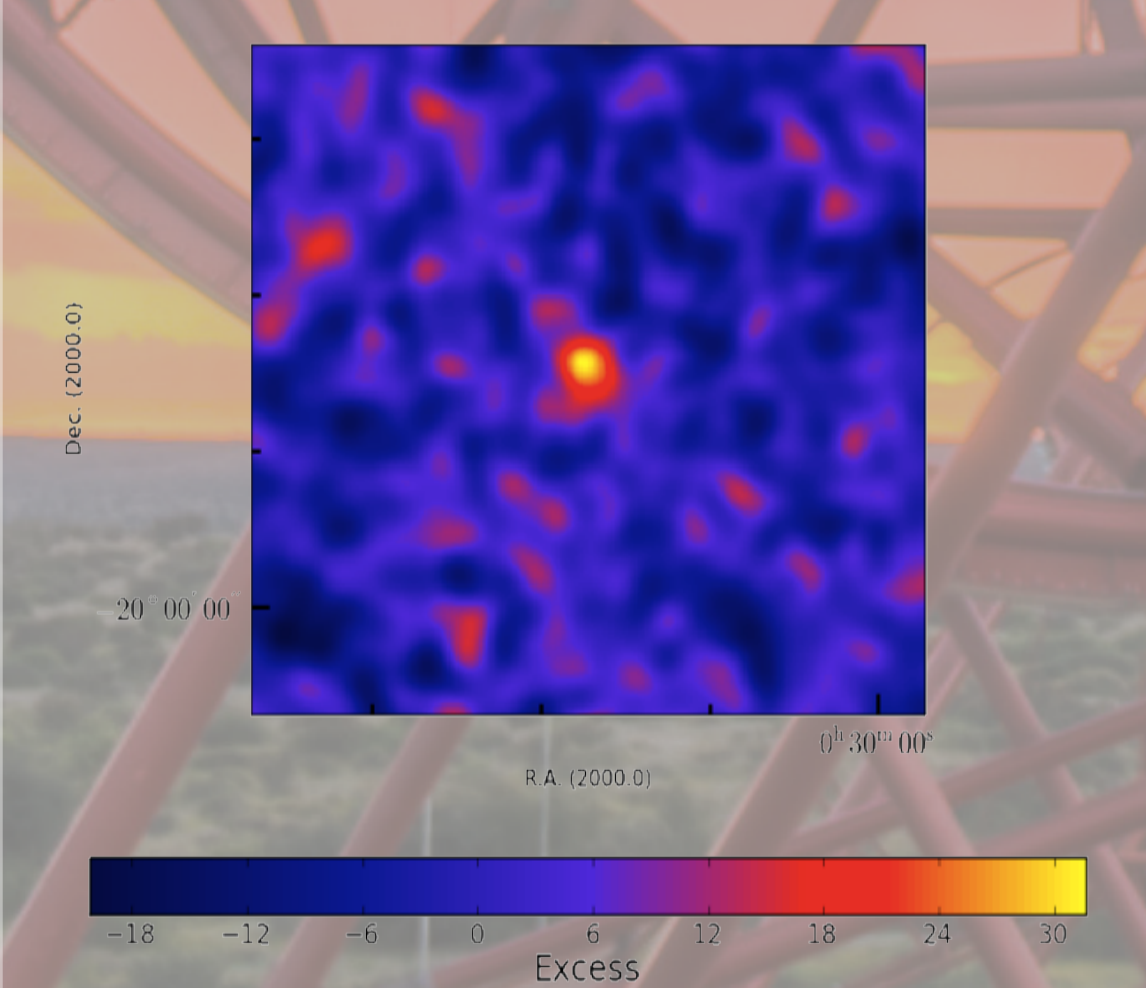
Search for Dark Matter (DM)
From 2004 to 2008, HESS acquired 112h of observations of the Galactic Centre (GC) region. A particular observation strategy was used in order to detect VHE radiation from WIMP annihilations, and is displayed on the top Figure: the green area, closer to the Galactic Centre, is expected to hold a larger DM density than the red areas from which the cosmic-ray background was determined. The yellow area is excluded since contaminated by known sources unrelated to DM. No significant excess of VHE radiation were found, allowing to establish upper limits in the DM mass vs velocity weighted annihilation cross-section plan for two particular models of DM distribution profile, NFW and Einasto, both describing the structures observed in N-body simulations. The central part of the Galaxy, suffering large uncertainties on the profile adopted by the DM, was excluded from the analysis. The constraints established by HESS from these observations are reported by the two black lines on the bottom Figure. They correspond to the best limits obtained so far for DM particle masses between few 100 of GeV to few 10 of TeV, and are complementing the results obtained by the Fermi-LAT at lower mass range, like the one obtained in direction of the dwarf spheroidal galaxy Draco (green line). (PRL, 2011, 106, 301)

Search for Lorentz Invariance Violation
According to different Quantum Gravity theories, Lorentz symmetry might be broken at energy scales close to the Planck scale ($\sim 10^{19}$ GeV). In those theories, the light velocity would vary as a function of the energy of the photons. As a consequence, time delays for photons from cosmological sources showing fast flux variability (GRBs, flares of AGNs), might be measurable by space or ground based γ -ray experiments. Contrary to space telescope experiment such as Fermi-LAT, which can observe GeV events from very distant sources (up to $z \sim 8$) but with limited statistics, ACTs such as HESS are able to detect large number of events with energies up to few tens of TeV, but for nearby sources. On July 28, 2006, the HESS experiment observed an extreme flare from the AGN PKS2155-304, located at a redshift of $z=0.116$. More than 8000 on-source events were recorded during ~ 85 minutes of observation of this transient phenomena, for energies >120 GeV. After application of tight constraints on the energy and direction of the incoming events, and performing an event-by-event likelihood fit on the observed lightcurve of PKS2155-304, constraints were derived on the first and second orders of the photon dispersion relation development. The 95%CL lower limit on the Quantum Gravity energy scale obtained from the linear, resp. quadratic, term is 2.1×10^{18} GeV (0.5×10^{11} GeV), thus the best limits obtained so far from AGN studies. A compilation of time-delay constraint from ground-based Cherenkov experiments obtained from the observations of AGNs is provided on the top Figure (Aph, 2011, 34, 738).

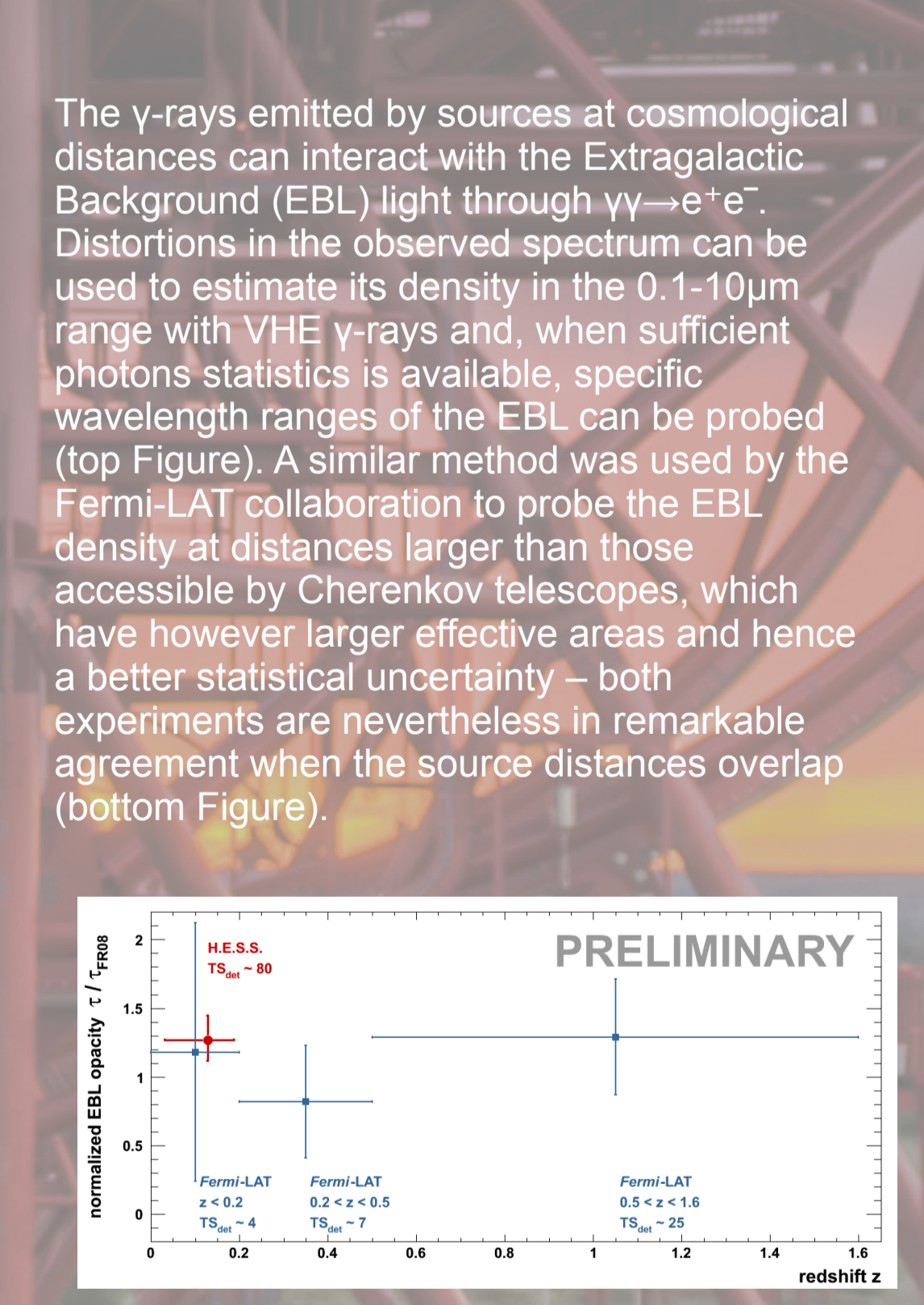
Extragalactic VHE Sources

The hunt for (distant) Blazars Probing the Extragalactic Background light Extended/Starburst Galaxies

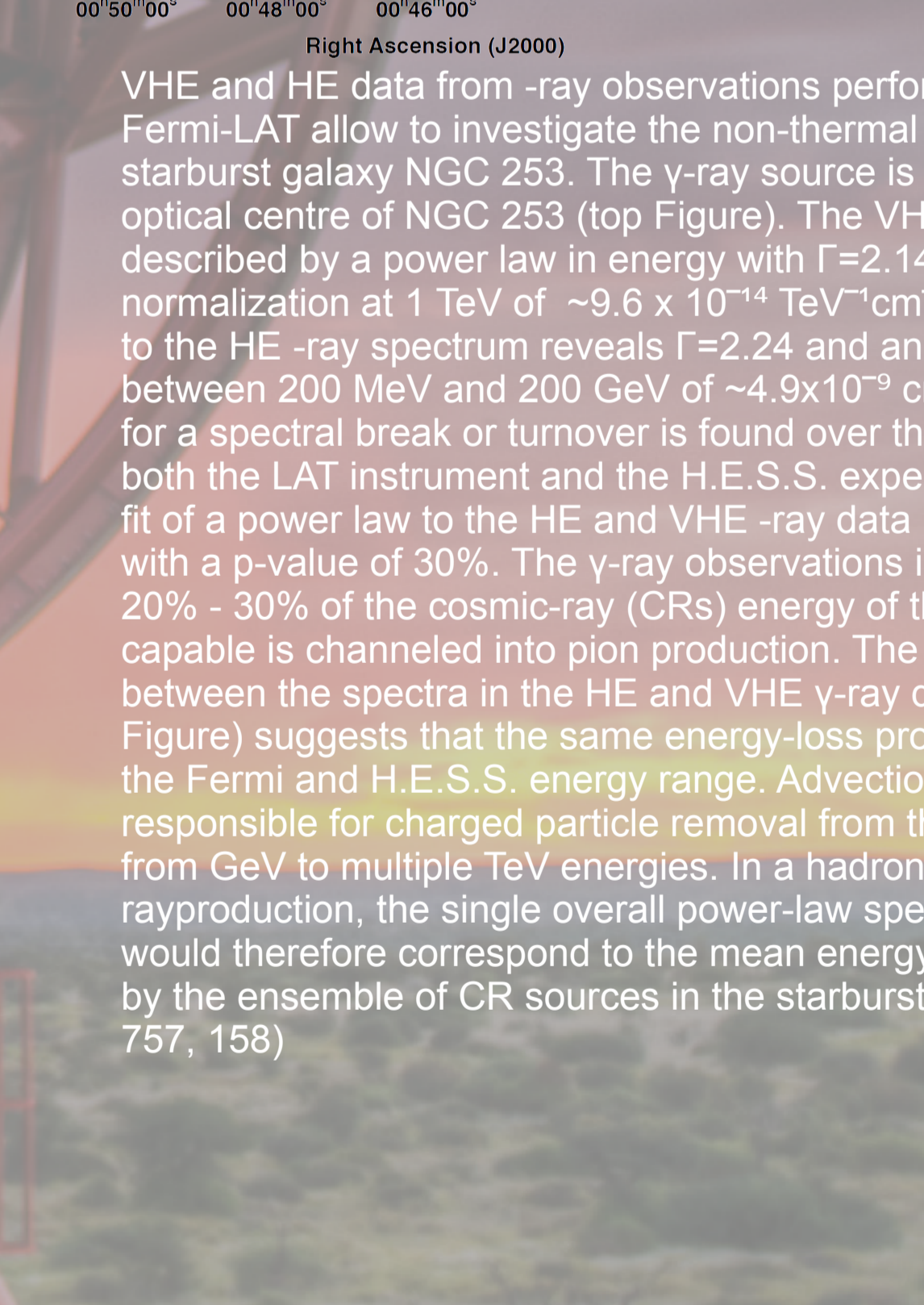
The small field of view (a few degrees) and the limited number of observation hours (~ 1000 h/yr) from Atmospheric Cherenkov Telescopes (ACTs) require elaborate strategies to optimize the detection of new extragalactic VHE emitters. With the Fermi-LAT effective area improvement over EGRET's at energies $E > 10$ GeV, the successive HE γ -ray catalogs have been an invaluable tool to direct observations from all currently operating ACTs. Even in the case of BL Lac objects, of which only 50% have a firmly established redshift, a Fermi-LAT spectrum with a photon index in the range $1.5 < \Gamma < 2$ and a few photons at energies ~ 100 GeV are strong indicators of potentially successful VHE measurements. This is the case for the recently detected BL Lac objects PKS 0447-439 (ATEL2350, 'H.E.S.S. discovers VHE emission from the Fermi LAT source PKS 0447-439') and, more recently, of the object KUV 0311-1938 (bottom Figure) which, at $z=0.6$, is currently the most distant source of VHE γ -rays.



The γ -rays emitted by sources at cosmological distances can interact with the Extragalactic Background (EBL) light through $\gamma\gamma \rightarrow e^+e^-$. Distortions in the observed spectrum can be used to estimate its density in the 0.1-10 μm range with VHE γ -rays and, when sufficient photons statistics is available, specific wavelength ranges of the EBL can be probed (top Figure). A similar method was used by the Fermi-LAT collaboration to probe the EBL density at distances larger than those accessible by Cherenkov telescopes, which have however larger effective areas and hence a better statistical uncertainty - both experiments are nevertheless in remarkable agreement when the source distances overlap (bottom Figure).



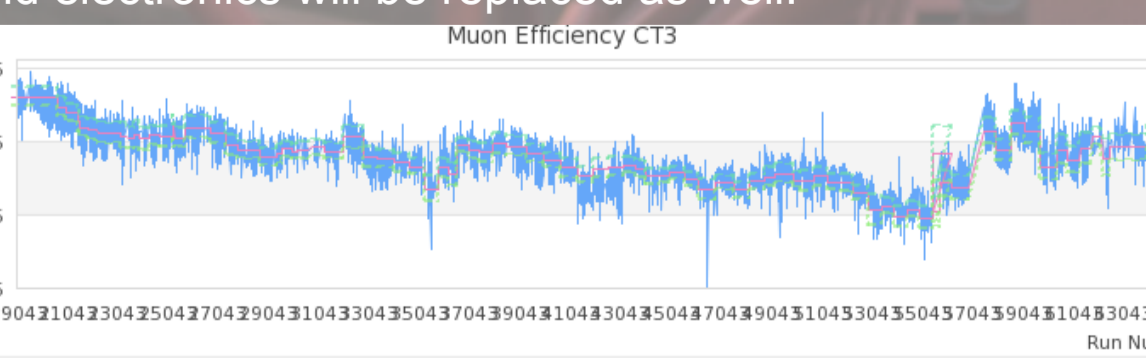
VHE and HE data from γ -ray observations performed with HESS and Fermi-LAT allow to investigate the non-thermal processes in the starburst galaxy NGC 253. The γ -ray source is compatible with the optical centre of NGC 253 (top Figure). The VHE γ -ray data can be described by a power law in energy with $\Gamma=2.14$ and differential flux normalization at 1 TeV of $\sim 9.6 \times 10^{-14} \text{ TeV}^{-2} \text{ cm}^{-2} \text{ s}^{-1}$. A power-law fit to the HE γ -ray spectrum reveals $\Gamma=2.24$ and an integral flux between 200 MeV and 200 GeV of $\sim 4.9 \times 10^{-9} \text{ cm}^{-2} \text{ s}^{-1}$. No evidence for a spectral break or turnover is found over the dynamic range of both the LAT instrument and the H.E.S.S. experiment: a combined fit of a power law to the HE and VHE γ -ray data results in a $\Gamma=2.34$ with a p-value of 30%. The γ -ray observations indicate that about 20% - 30% of the cosmic-ray (CRs) energy of the capable is channelled into pion production. The smooth alignment between the spectra in the HE and VHE γ -ray domain (bottom Figure) suggests that the same energy-loss processes dominate in the Fermi and H.E.S.S. energy range. Advection is most likely responsible for charged particle removal from the starburst nucleus from GeV to multiple TeV energies. In a hadronic scenario for the γ -ray production, the single overall power-law spectrum observed would therefore correspond to the mean energy spectrum produced by the ensemble of CR sources in the starburst region. (ApJ, 2012, 757, 158)



The Future of the HESS Array

HESS I Array upgrades

The HESS I telescopes are undergoing a long process of different upgrades. Recently, all 380 mirrors of each 13-m tessellated telescope mirrors were recoated over the span of 2 years, making for a spectacular recovery of optical efficiency (bottom Figure) which dropped progressively over the past ~ 8 years of operations. More improvement is expected when the aging Winston cones, phototubes and electronics will be replaced as well.



The HESS II telescope

With its 28-meter-sized segmented mirror, HESS II is the largest ACT ever built. The peak positioning speed of 100 degrees/minute allows to point the instrument extremely fast towards transient phenomena such as γ -ray bursts, and its large mirror allows the detection of sources down to a few tens of GeV. The combination of all 5 ACTs in hybrid mode allows an improved sensitivity thanks to better defined shower images. HESS II saw its first light at 0:43 a.m. on 26 July 2012.



Science with HESS II

The expected sensitivity of the HESS array including the HESS II telescope (green) shows the improvement in the 100 GeV range as well as the decrease in energy threshold. This should allow a more performant search for pulsed emission in some Galactic sources, improve the chances to catch the elusive VHE γ -ray glow GRBs, as well as detect new classes and more distant extragalactic objects.

