

# RECENT HIGHLIGHTS FROM H.E.S.S.

---

Wilfried Domainko for the H.E.S.S.  
collaboration



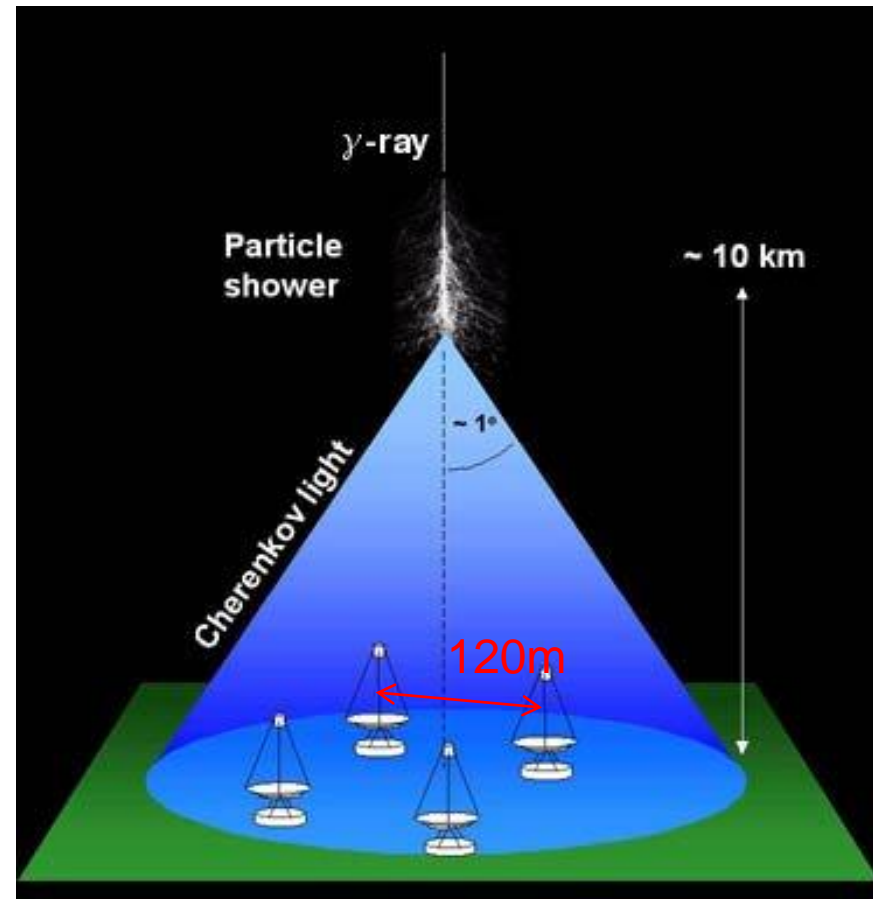
# H.E.S.S. array

- Array of imaging atmospheric Cherenkov telescopes
- Four medium size telescopes (mirror area  $100\text{m}^2$ )
- One large telescope ( $600\text{m}^2$ )
- Located at the Khomas highlands in Namibia
- Observes the sky in very-high energy (VHE) gamma-rays ( $E > 100 \text{ GeV}$ )

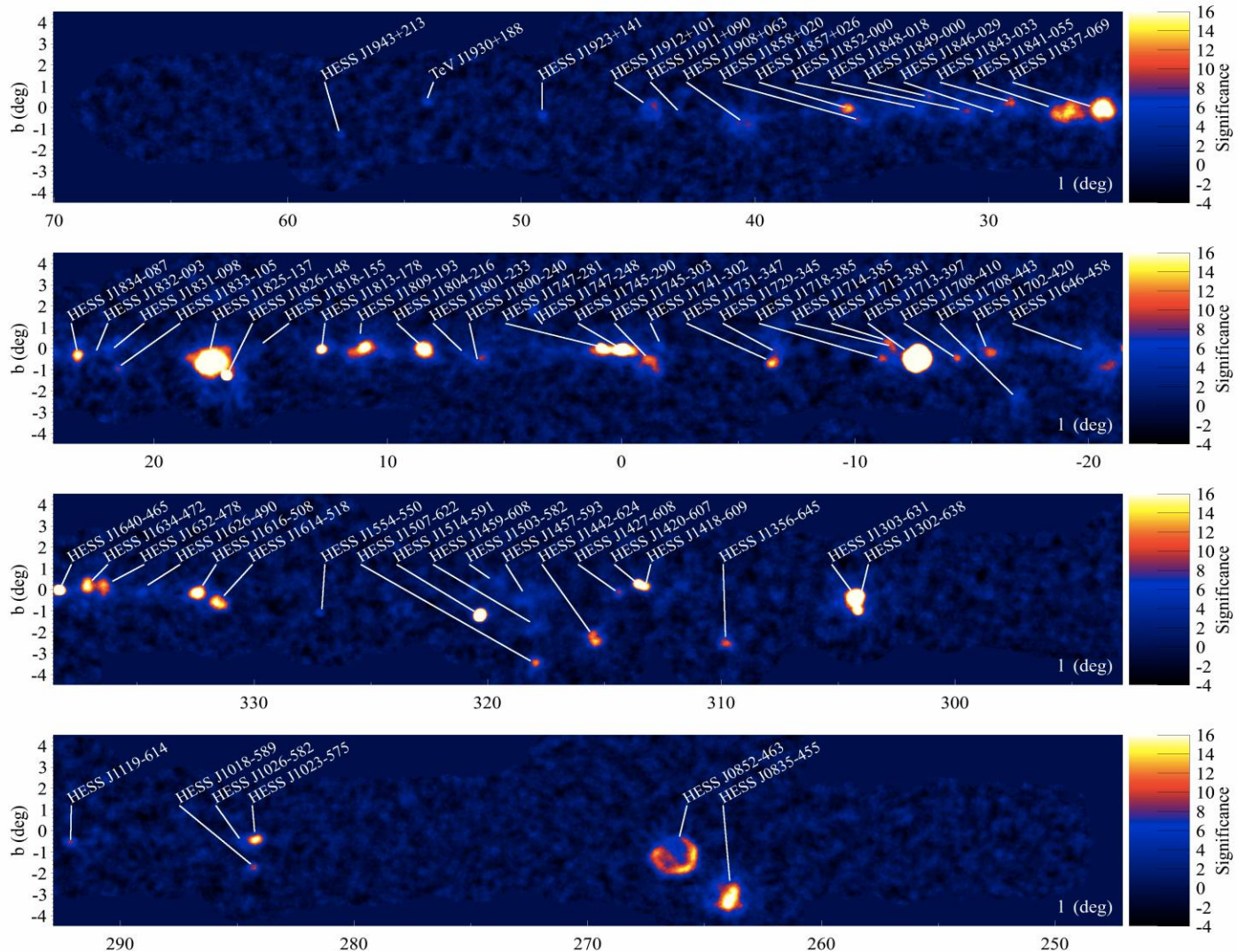


# Detection Principle

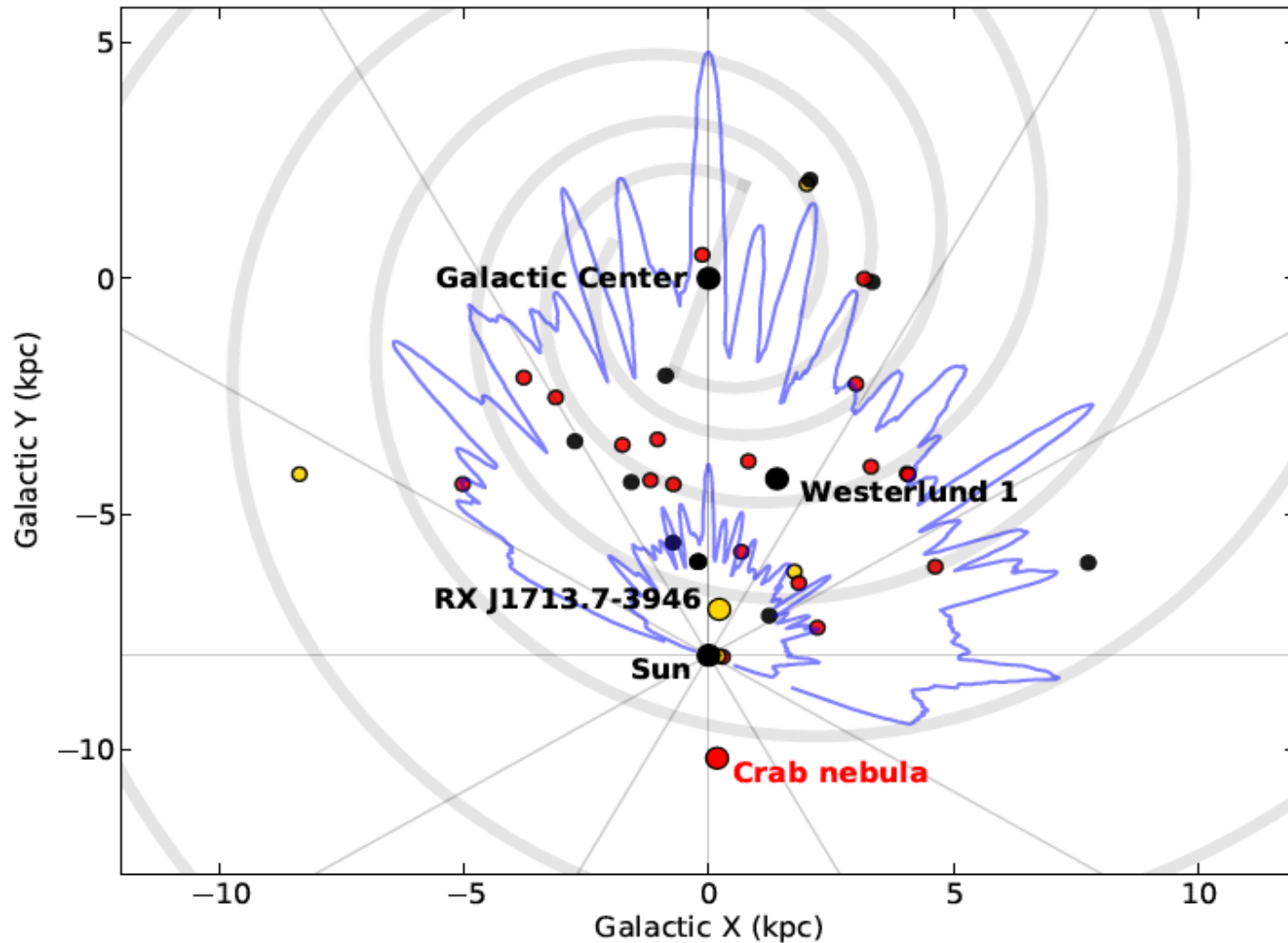
- Using the earth atmosphere as a detector
- Large effective area
- Energy threshold 30 GeV (large telescope)
- Energy resolution 15%
- Angular resolution: 0.1 degrees
- Field of view 5 degrees
- Typical exposure times 10 – 100 hours



# The galactic plane in very high energy gamma rays

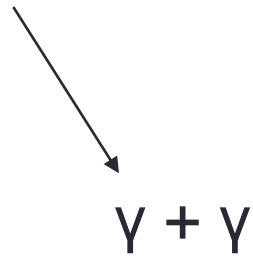


# Location in the Milky Way



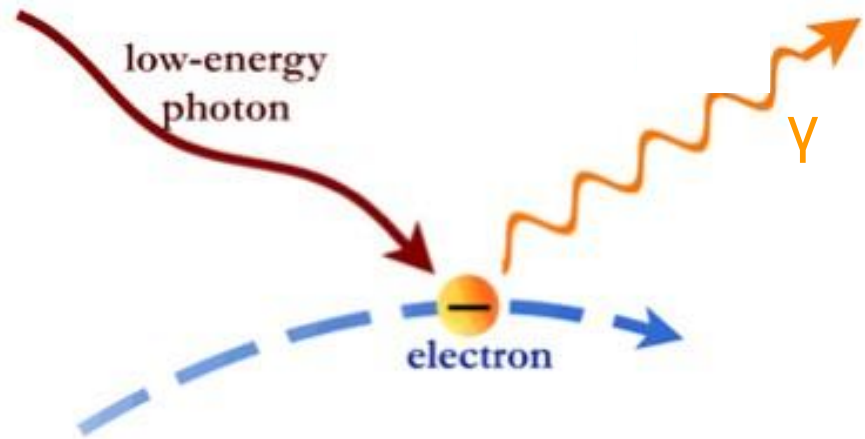
Blue lines: H.E.S.S.  
Horizon for 10% and  
1% of the Crab  
Yellow: SNR  
Red: PWN  
Black: others

# Gamma-ray production mechanisms



## hadronic channel

cosmic ray proton hits a proton of target material (ISM, IGM,...)



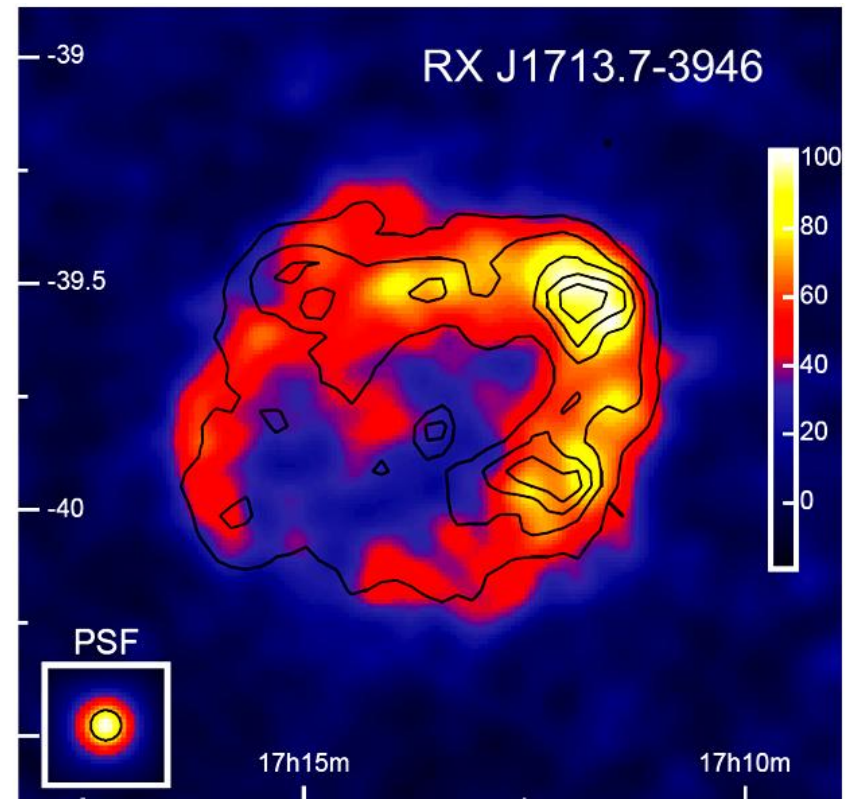
## leptonic channel

Inverse Compton upscattering of a low energy photon (e.g. cosmic microwave background photon)

# Supernova remnants



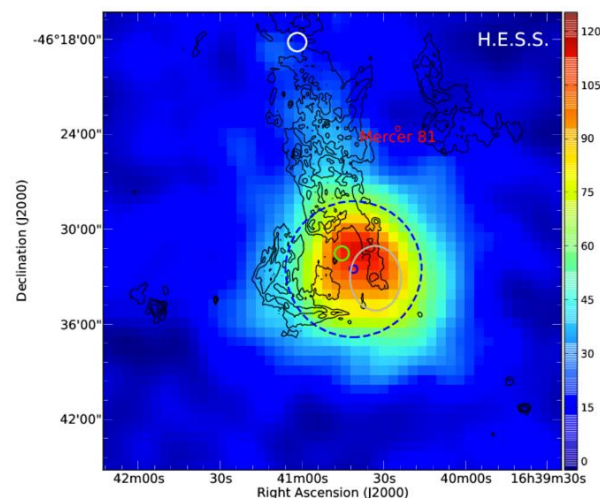
SN 1006 Chandra



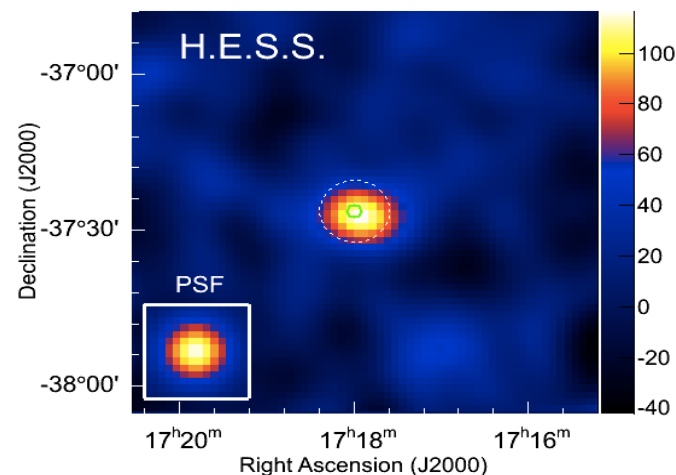
RX J1713.7-3946 H.E.S.S.

# Supernova remnants

- Particle acceleration in the fast expanding blast wave
- Particles gain energy by repeated shock crossings
- Power-law spectra
- About 10% of the kinetic energy expected to be channeled into particle acceleration
- Most luminous: HESS J1640-465:  $L_{\text{gamma}} 5 \times 10^{35}$  erg/s
- Most distant: G349.7+0.2, distance 22 kpc (other side of the Galaxy), but distance has very recently been revised to 11.5 kpc (Tian & Leahy 2014)



HESS J1640-465, radio contours on VHE

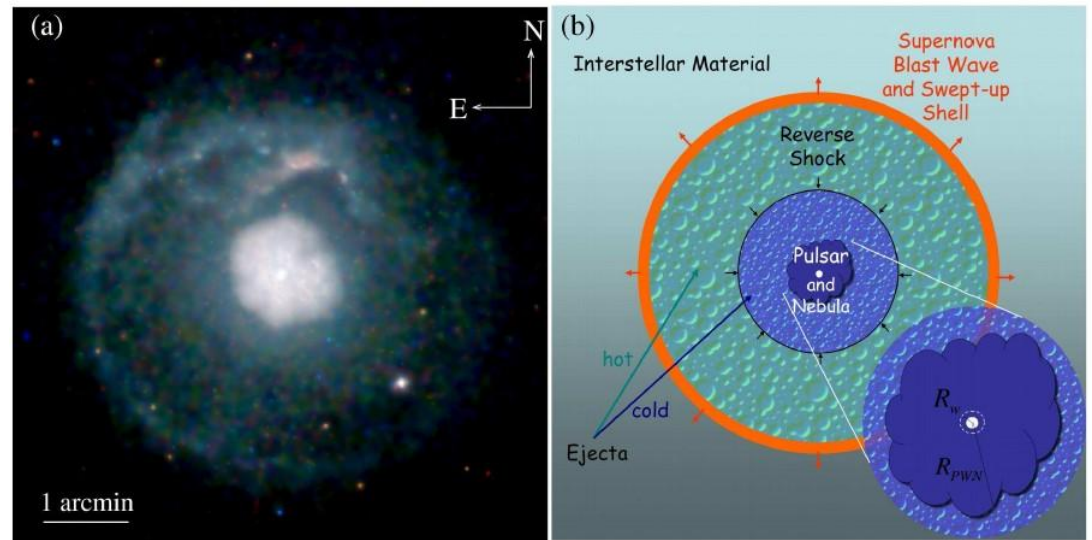


G349.7+0.2, radio contours on VHE

# Pulsar wind nebulae



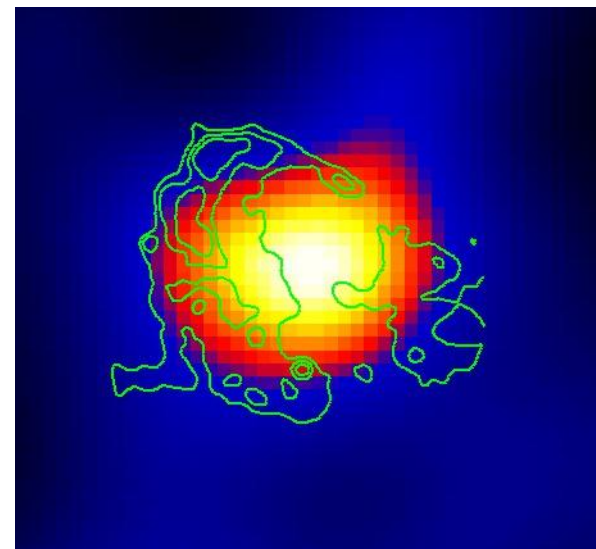
Crab VLT



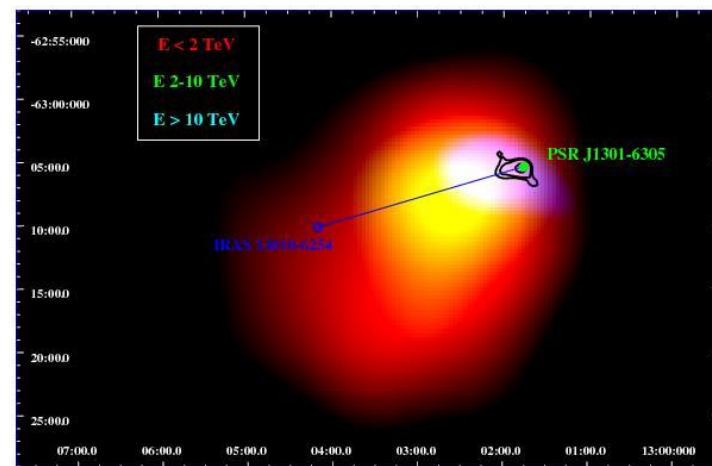
G21.5-0.9 Chandra

# Pulsar wind nebulae

- Most numerous source class in the Galactic plane survey
- Powered by the fast spinning compact remains of an exploding star (pulsar)
- Different stages of evolution
- Leptonic sources
- Aging of highly energetic electrons due to radiation losses as they diffuse away from the pulsar
- Old PWN as 'dark' sources

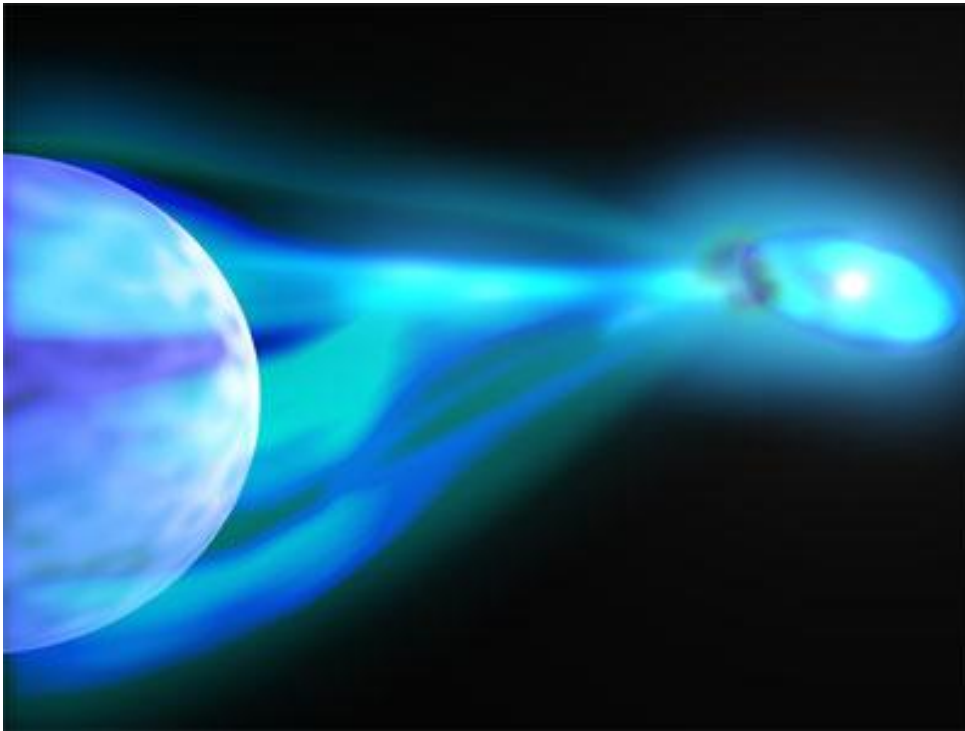


HESS J1818-154, radio  
Contours on VHE



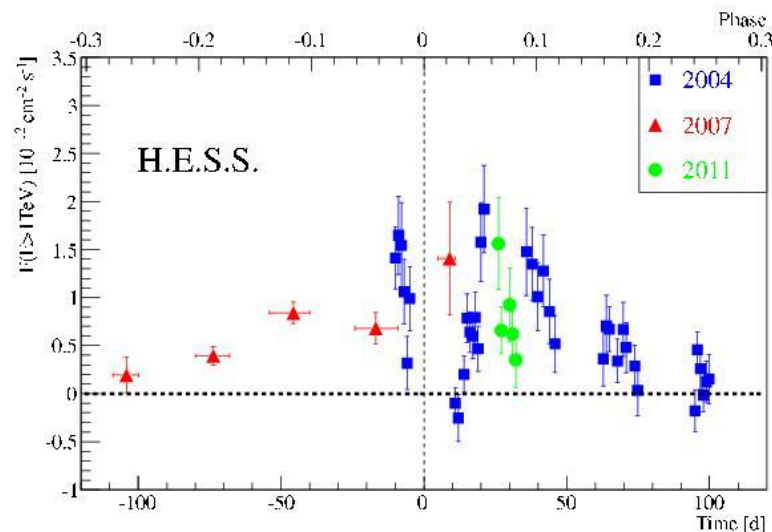
HESS J1303-631

# Stellar binaries

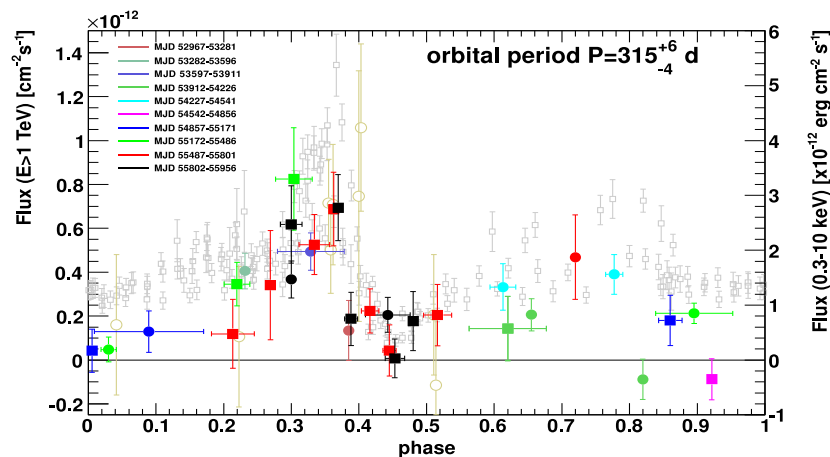


# Stellar binary systems

- Binary of a normal star and a compact object
- Binary pulsar  
PSR B1259-63 (orbital period: 3.4 years)
- HESS J0632+057 identified as a TeV binary (together with VERITAS)



PSR B1259-63

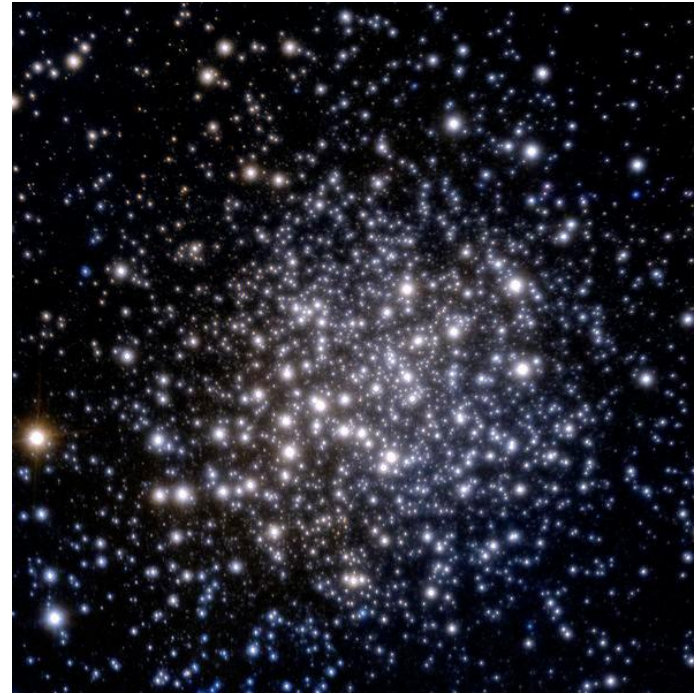


HESS J0632+057

# Stellar clusters



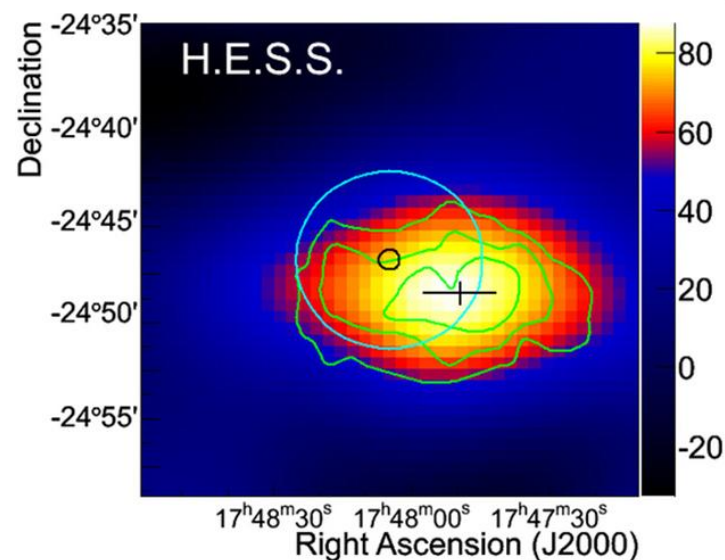
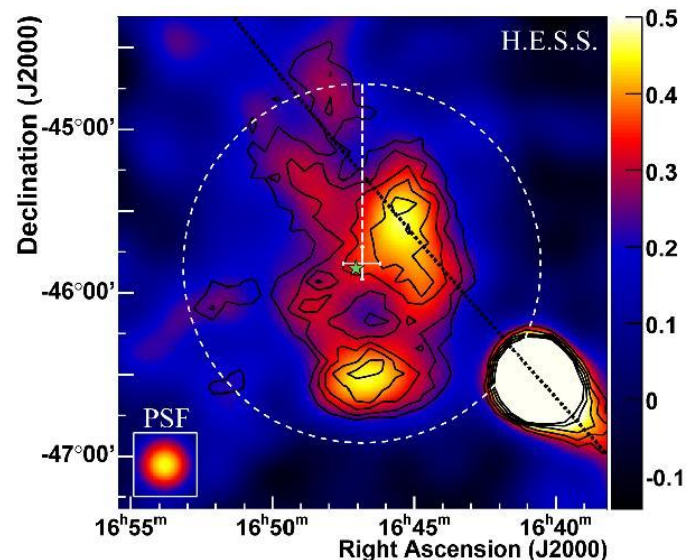
Westerlund 1, 2MASS



Terzan 5, VLT

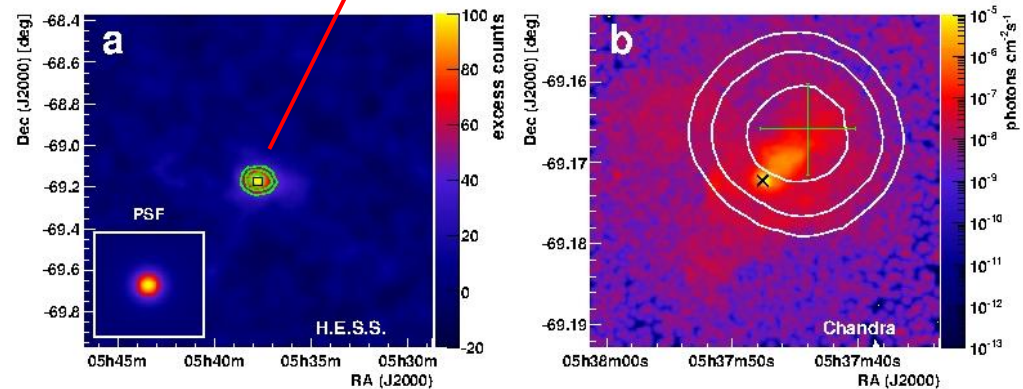
# Stellar clusters: young and old

- Westerlund 1: most massive stellar cluster ( $10^6$  solar masses)
- Combined action of massive stars, SNRs and PWN?
- Globular clusters: very old (age  $> 10$ Gyr)
- Terzan 5: extreme stellar densities in its core
- Combined action of millisecond pulsars (gained momentum from accreting from companions) in its core?
- No other globular cluster detected in VHE gamma rays



# Extragalactic Pulsar wind nebula

- Large Magellanic Cloud: Dwarf satellite galaxy to the Milky Way
- Distance: 50 kpc
- Most powerful pulsar know: PSR 0537-6910
- Seeing a galactic-type object in an external galaxy



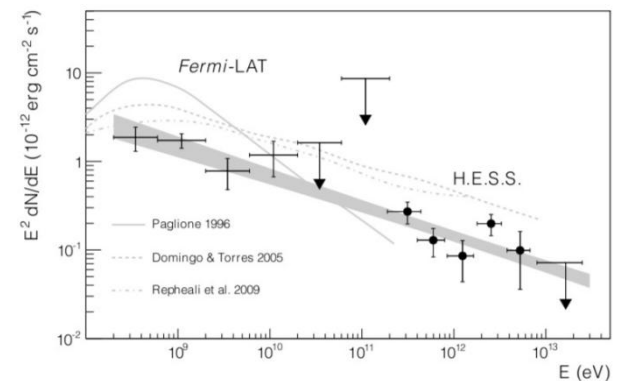
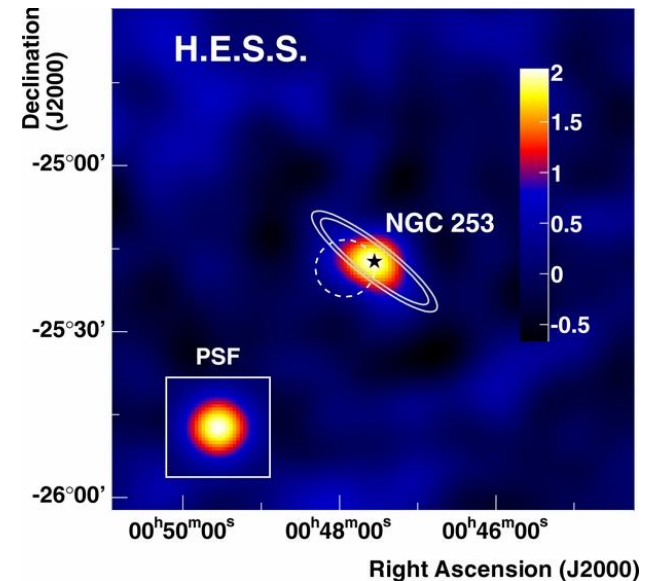
# Starburst galaxies



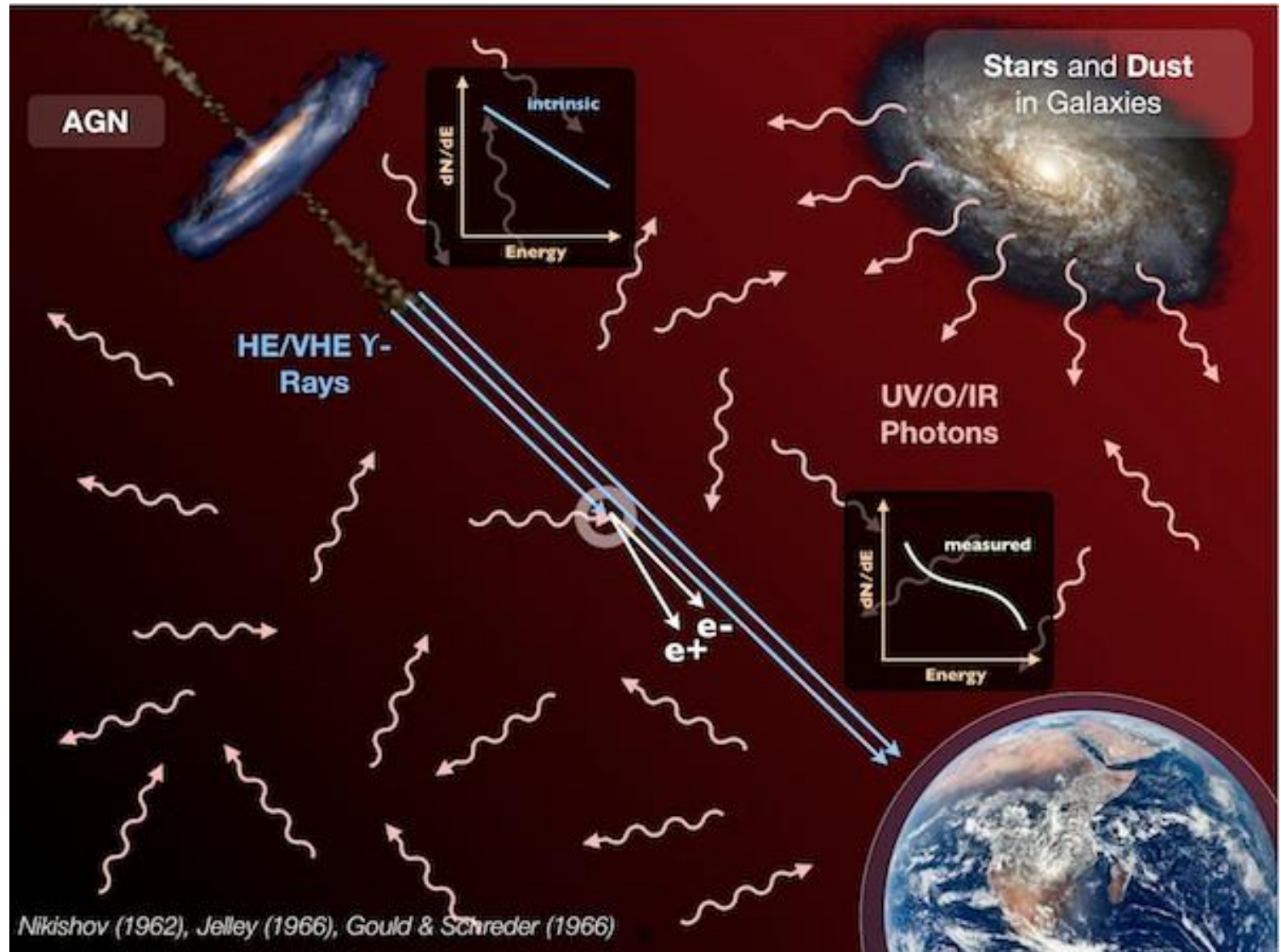
NGC 253, ESO

# Starburst galaxy: NGC 253

- Nearby (distance 3.5 Mpc) spiral galaxy with strongly enhanced star formation at its center
- Combined action of all supernovae
- High cosmic ray density, favorable conditions for gamma-ray production
- Long H.E.S.S. exposure of 170 hours
- Power-law spectrum over quite large energy range: one single process responsible for gamma-ray production

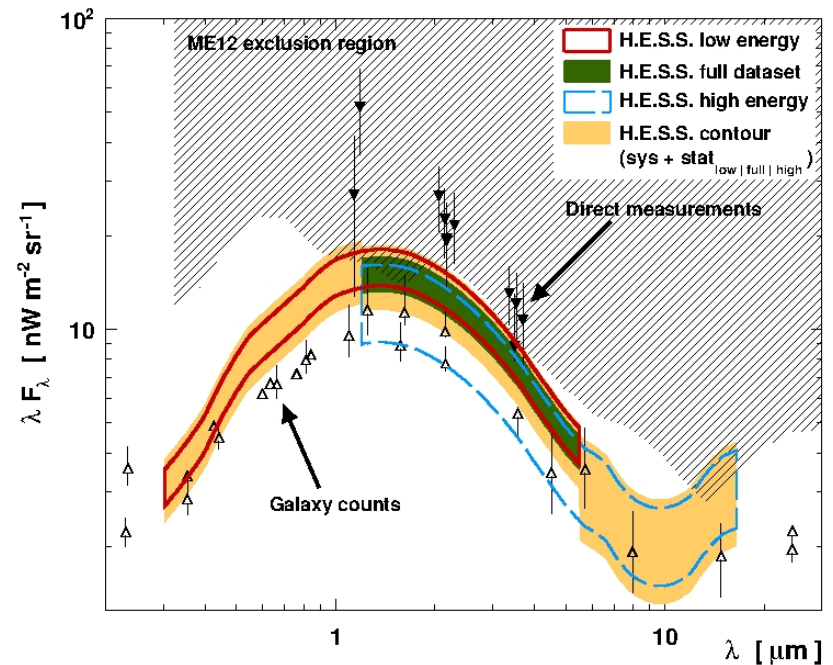


# Extragalactic background light (EBL)



# Measurement of the EBL imprint

- Using the seven brightest blazars
- 75000 gamma-ray photons
- Allowing for intrinsic spectra with curvature
- Redshift range: 0.03 – 0.19
- Parametrization of the EBL optical depth via a scaling factor

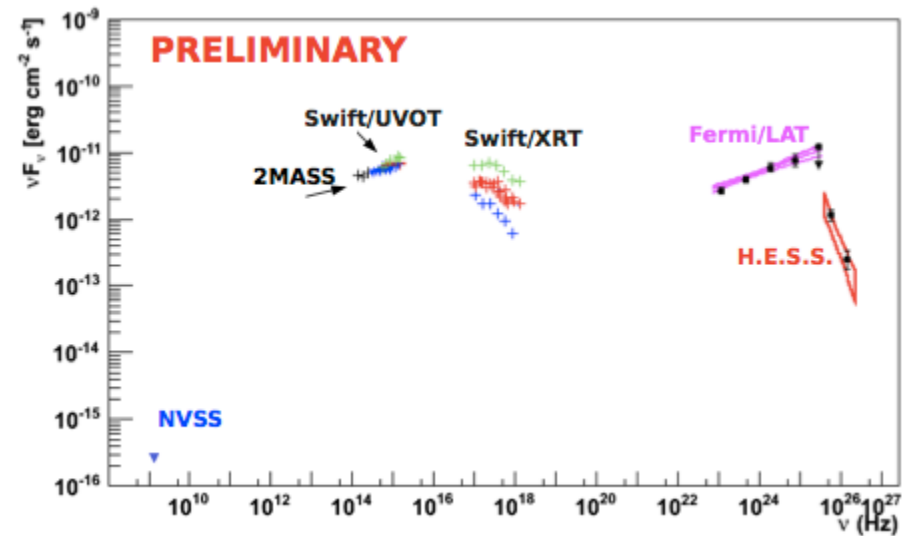


# AGNs



# Very distant source: KUV 00311-1938

- Most distant object H.E.S.S. has seen so far ( $z > 0.51$ )
- Very sharp break between high-energy and very-high energy regime

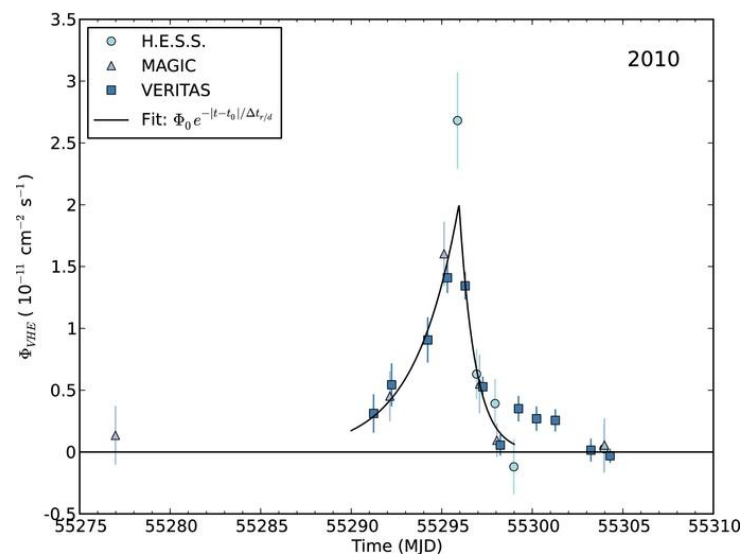


# M87 flare

- Central galaxy of the Virgo cluster
- Jet miss-aligned with the line of sight
- Dramatic flare, day-scale variability
- Light crossing time of the central black hole comparable to the variability time scale
- Gamma-ray emission likely produced close to the central black hole

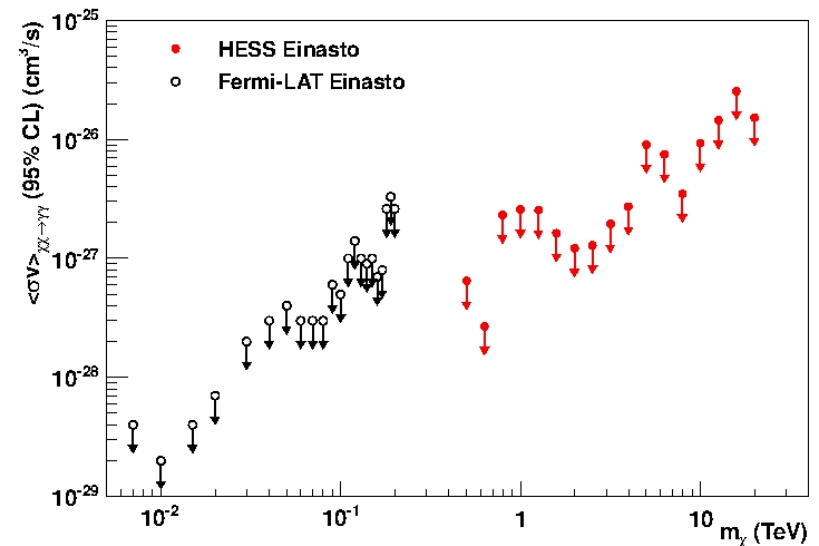


M87, HST, optical



# Dark Matter (DM) line search

- Annihilation or decay of dark matter particles can be expected to produce line-like gamma-ray signatures
- Distinguishable from ordinary astro-physical power law signals
- No such signal found



Limits on the velocity weighted DM annihilation cross section from the central galactic halo region

# H.E.S.S. II



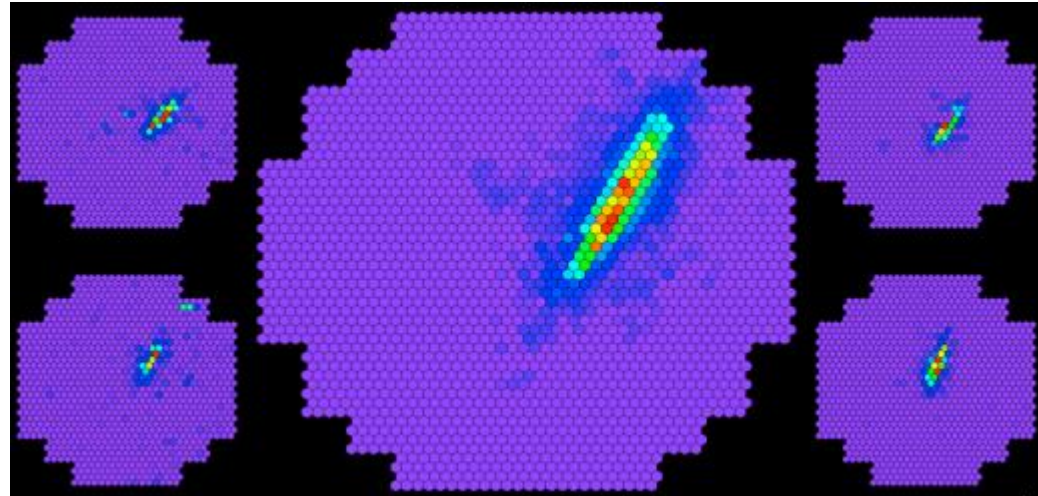
Air shower as seen with H.E.S.S.

## Large-scale telescope

Seeing air showers with  
unprecedented details

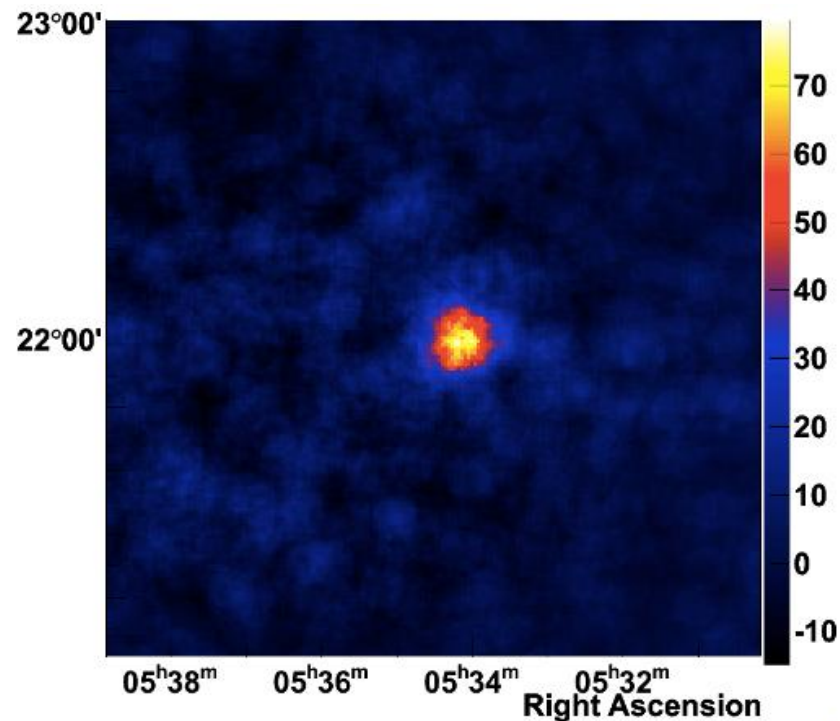
Low threshold (about 30 GeV)

Fast moving (GRBs) – reaches  
every position of the sky in < 2 min



# H.E.S.S. II cont.

- Crab nebula clearly detected as expected
- About 1 year of data taking
- About 90 hours on the galactic center
- Need some time to understand the new instrument
- More coming soon



Crab nebula as seen with H.E.S.S. II mono

# Conclusion

- VHE gamma-ray sky shows a surprising variety of objects and phenomena
- Galactic and extra-galactic sources
- New large scale telescope
- More results coming soon

**Many thanks for your attention!**