SALT/MeerKAT/HESS synergy: A perspective on Galactic sources

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Gamma-ray production mechanisms

- Hadronic:

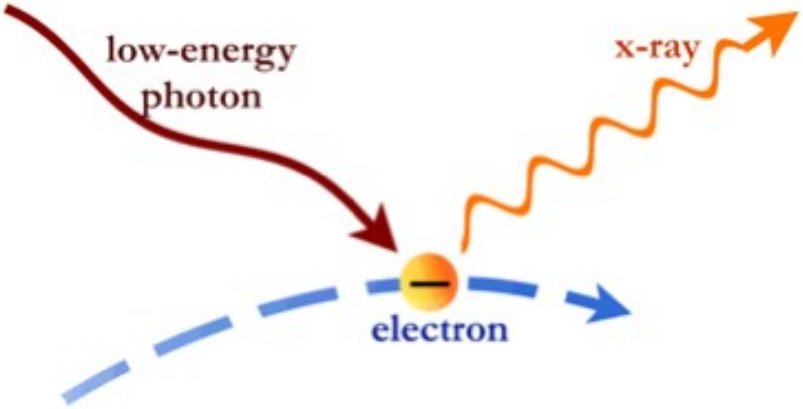
$$p + p \rightarrow \pi^0 + \cdots$$

followed by

$$\pi^0 \rightarrow \gamma\gamma$$

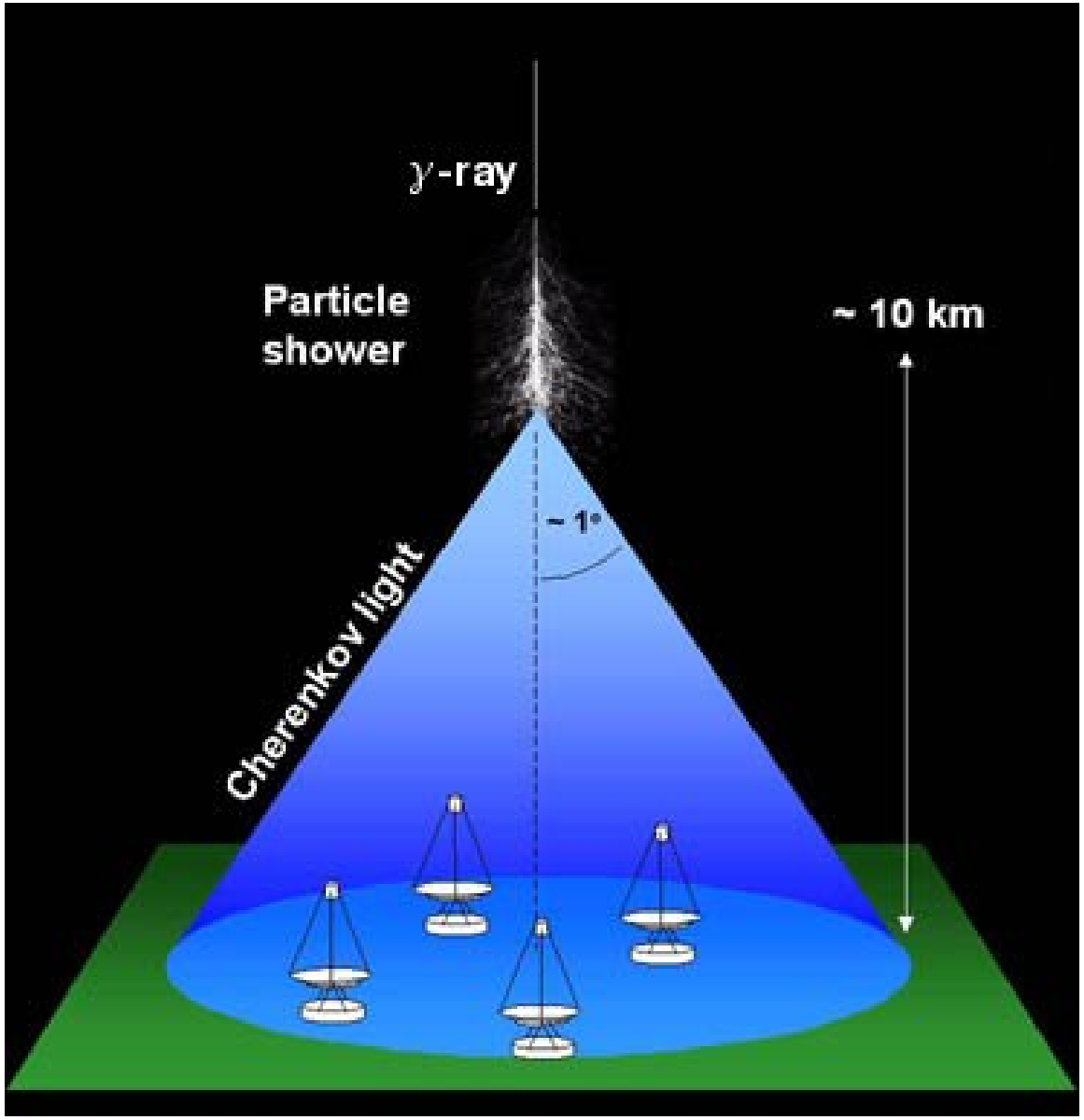
Requires (a) acceleration of hadrons, and (b) sufficient target material

- Leptonic: Inverse Compton (IC) Scattering



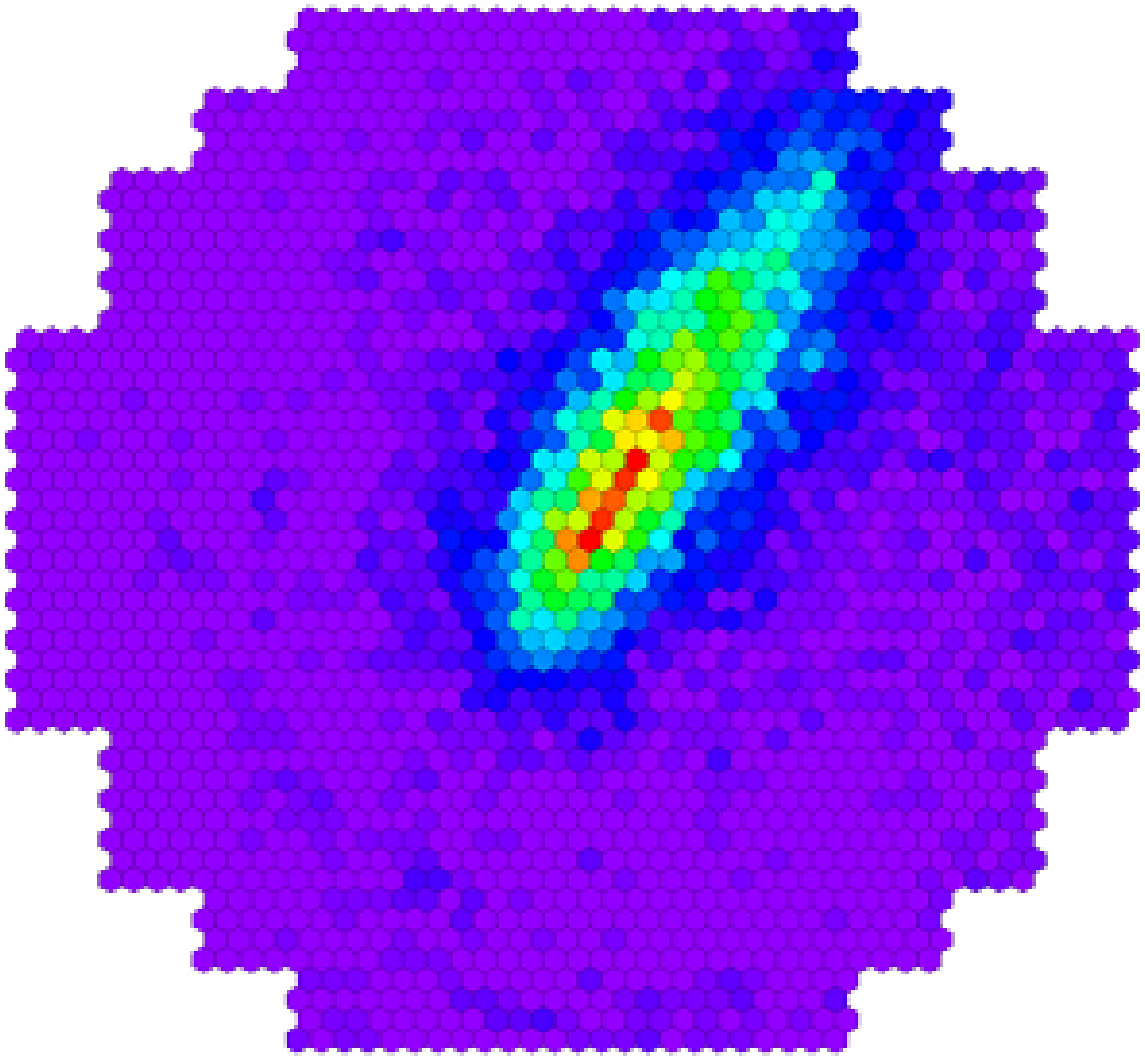
Requires (a) Acceleration of electrons, and (b) photon field

Detection of TeV gamma rays: ACT



The H.E.S.S. array

Shower images



General remarks on HESS/SALT/MeerKAT synergy

- Gamma-ray production is non-thermal (HESS)
- Optical is by far thermal in origin (SALT)
- Radio can be both thermal and non-thermal (MeerKAT)
- HESS/SALT $\Rightarrow$ non-thermal/thermal combination. Can be difficult and synergy not always as obvious.
- HESS/MeerKAT an easier match; Eg. IC $\Rightarrow$ relativistic electrons $\Rightarrow$ synchrotron emission.
- Simultaneous HESS/SALT may be difficult: two different weather systems.
- Should not expect an obvious synergy for each and every HESS detection.

HESS sources

1. Extended:
   - Supernova Remnants (SNR)
   - Pulsar Wind Nebulae (PWN),
   - Star Forming Regions/ Clusters of massive stars
   - Cosmic Ray illuminated molecular clouds.
2. Compact objects: Pulsars, X-ray binary systems.
3. Diffuse emission from the Galactic plane
4. Unknown sources

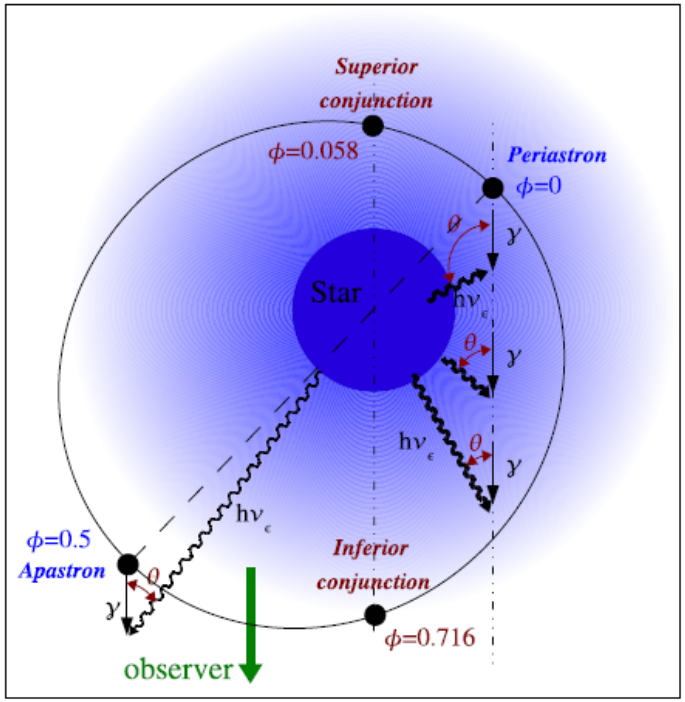
Two examples

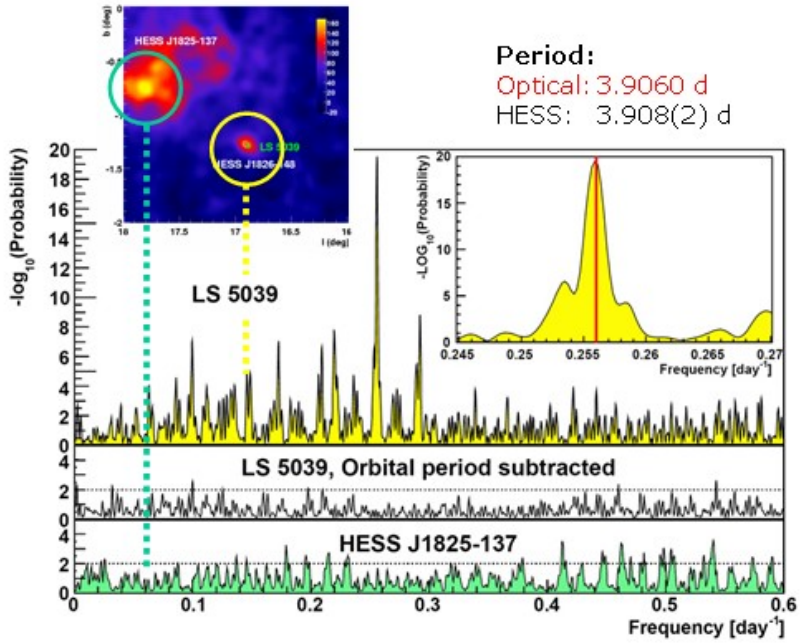
1. HMXB/Microquasar: LS5039
2. Globular Cluster: Terzan 5

Pulsars with massive companions: HMXB/Microquasars

- Young pulsars ($< 10^6$ years)
- Companions $M > 4M_\odot$
- Birth rate $\sim 10^{-3}$/year
- LS5039 (HESS) shows non-orbital variability

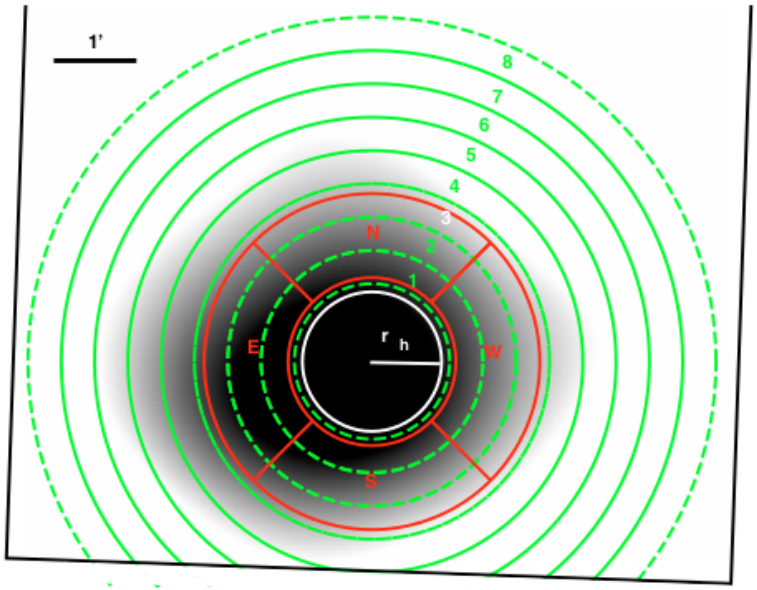
- Need info about stellar wind - optical spectral line profiles
- Simultaneous HESS & MeerKAT monitoring? See also LS I+61°303

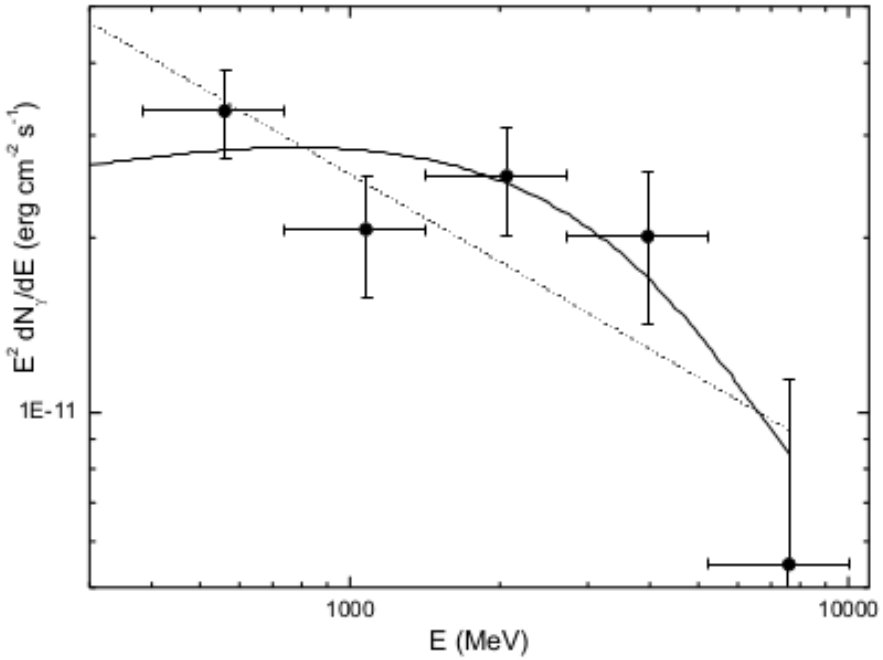




Terzan 5: X-rays & Fermi

Harbours 32 millisecond pulsars!

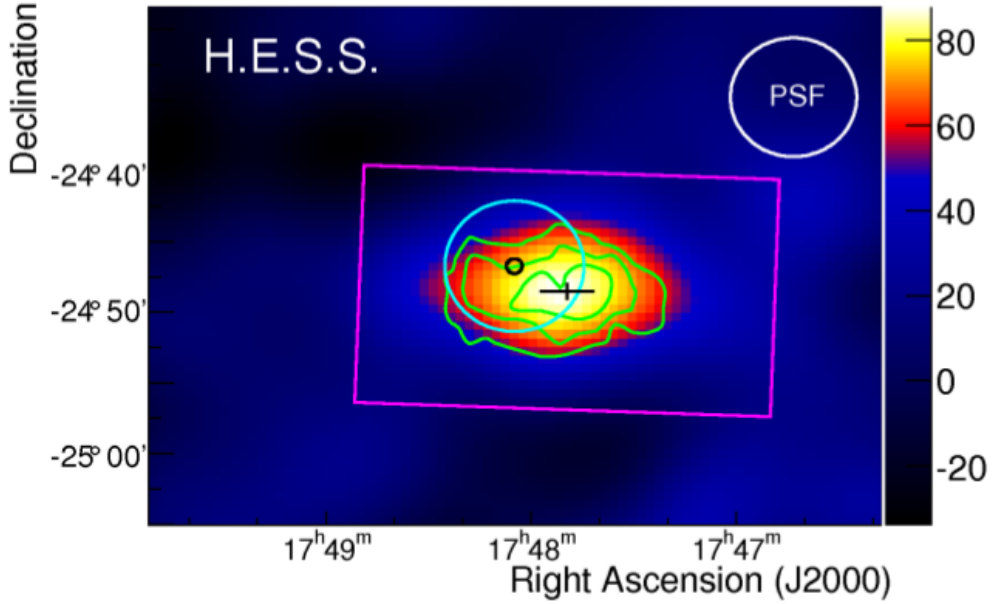


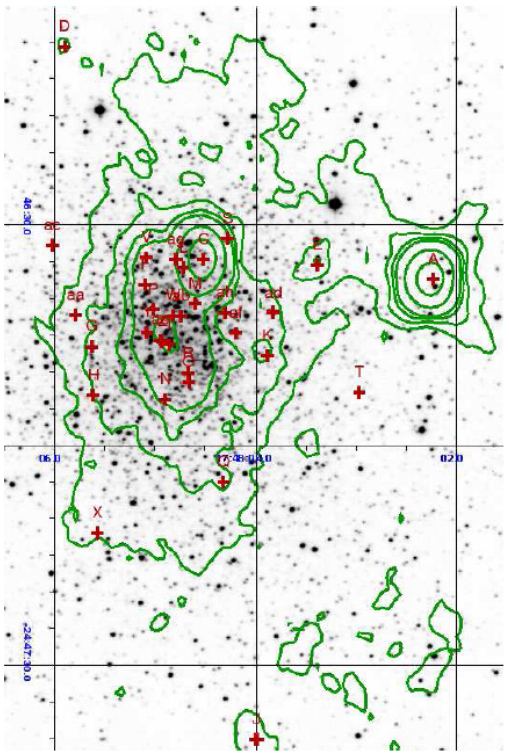


X-rays: 1 – 7 keV

Fermi: Gamma-rays

Terzan 5: HESS and radio morphology

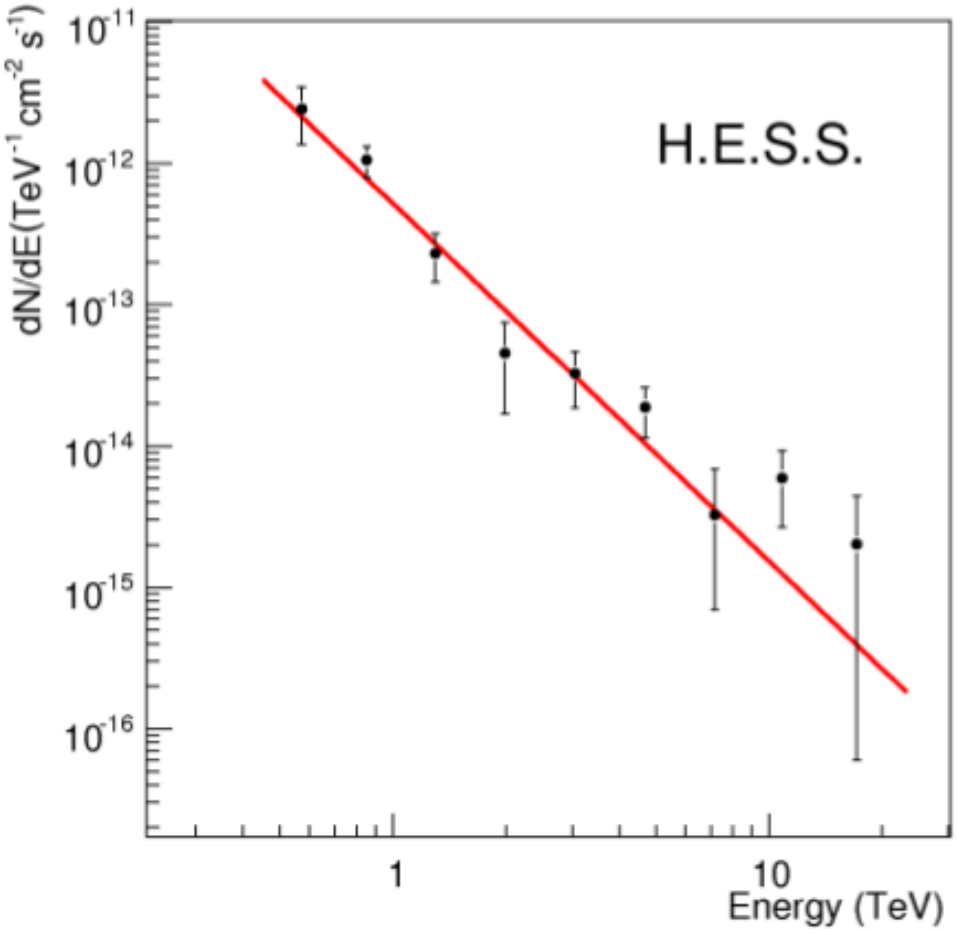




Eclipsing pulsar J1748-2446A almost coincident with HESS J1747-24A. $\dot{P} < 0$. Need to determine the acceleration of the pulsar! (SALT - not direct measurement on pulsar)

Green contours: 1.4 GHz $\Rightarrow$ 7 GeV electrons for B $= 5\ \mu$G; 14 GHz $\Rightarrow\sim$ 22 GeV.

Terzan 5: HESS spectrum



Is not an extension of the Fermi result.

Terzan 5

Laboratory for:

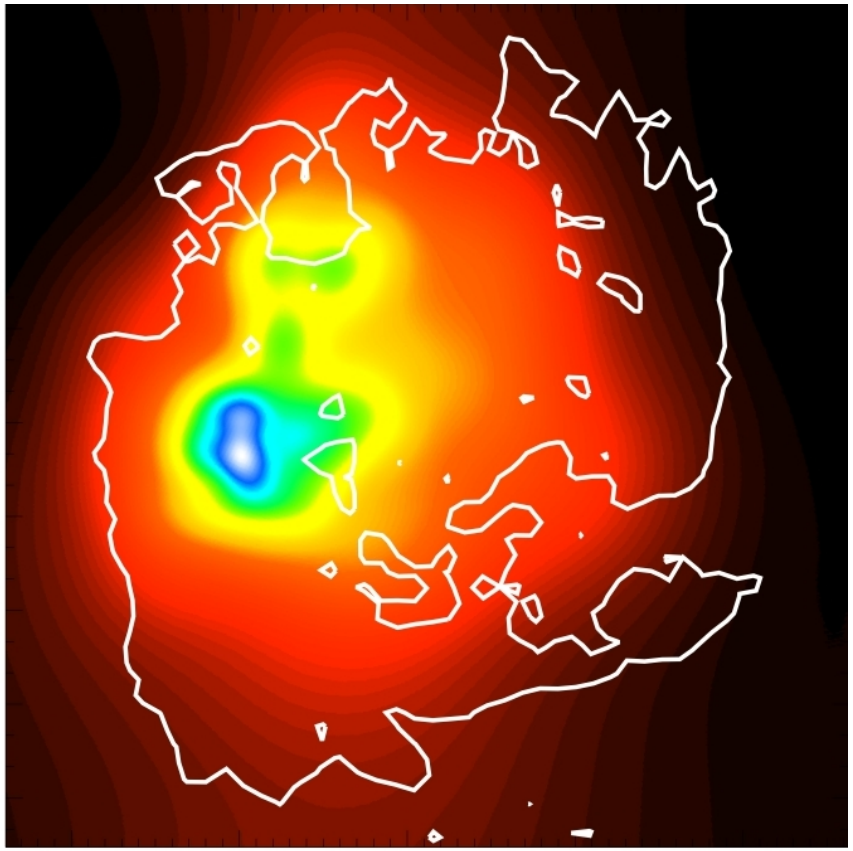
- Pulsars as sources of high energy electrons
- Re-acceleration to TeV energies
- Almost pure IC scattering of relativistic electrons
- Propagation of relativistic electrons
- Magnetic fields in globular clusters

Pulsar Wind Nebulae (PWN) & Unidentified Sources

- Identification of PWNe require also radio observations
- Targeted observations! Survey data often provides only upper limits; not good enough!
- Unidentified HESS sources: targeted radio and optical observations needed

Fermi detection of LMC

- 30 Doradus SFR is a bright source of γ-rays.
- Powerful cosmic ray accelerator
- Spectrum consistent with π^0 decay
- γ-ray emission correlates well with massive star forming regions. Little with the gas
- Compactness suggests little CR diffusion
- HI and possibly OH maser with MeerKAT?



Conclusions

- VHE Gamma-ray measurements in many cases not enough to fully understand the physics of the sources and their environments.
- Numerous opportunities for synergistic HESS-SALT-MeerKAT multiwavelength observations on galactic gamma-ray sources.
- Targeted (dedicated) observations needed to answer specific questions.
- Suggest a high level HESS-SALT-MeerKAT meeting to discuss collaboration and priorities.