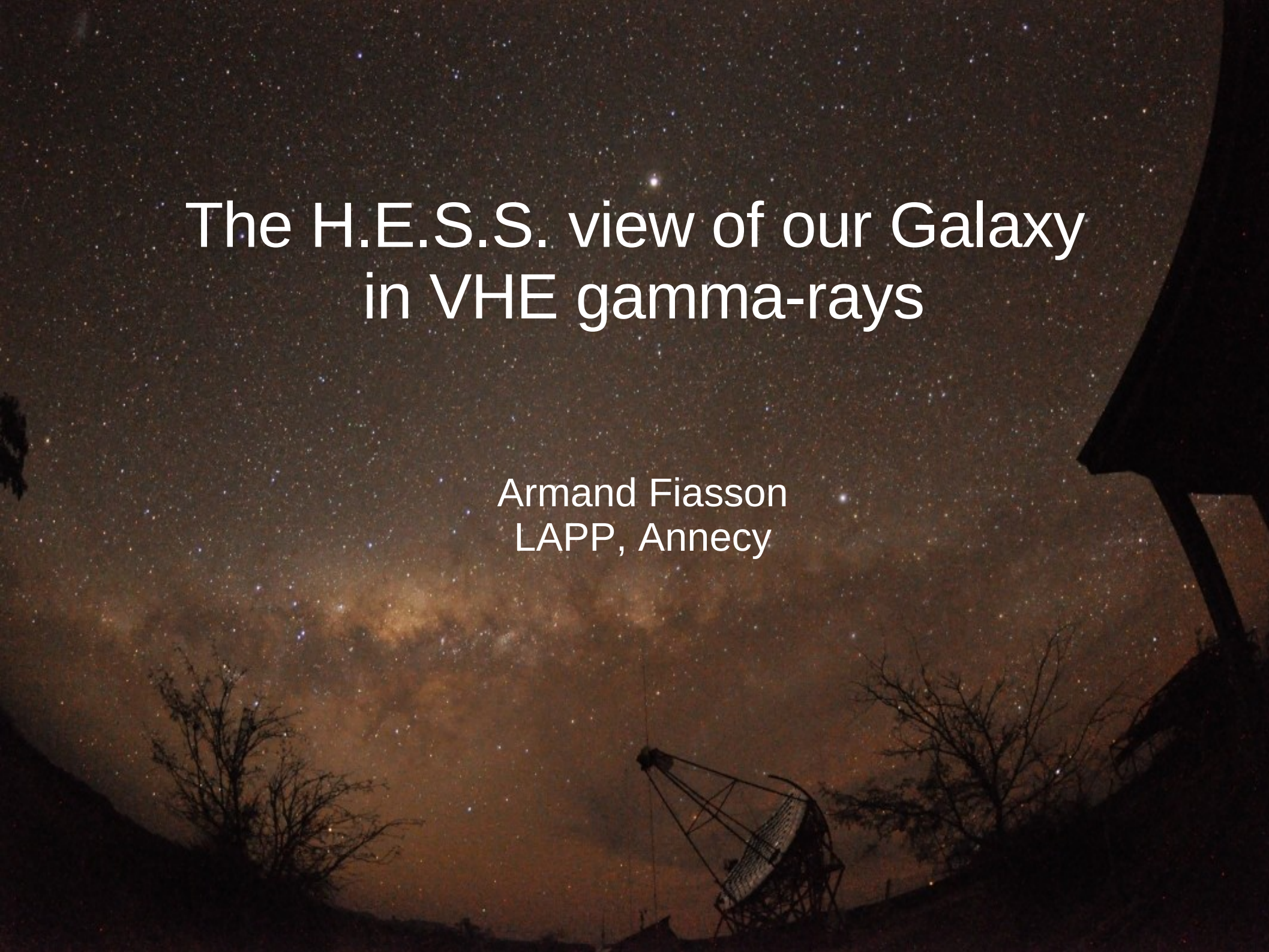
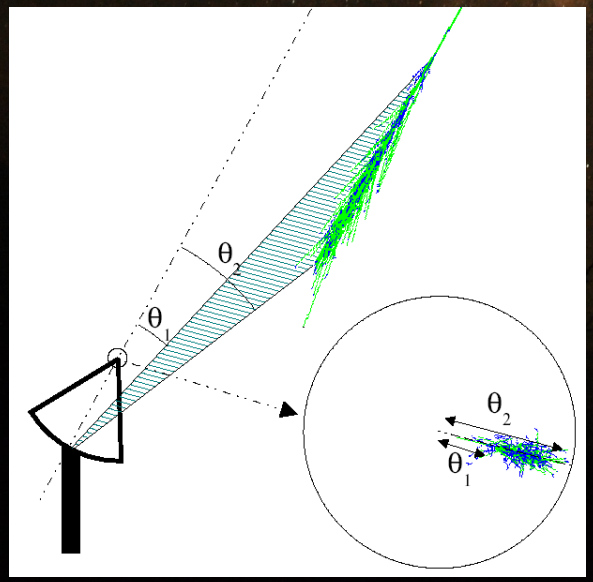


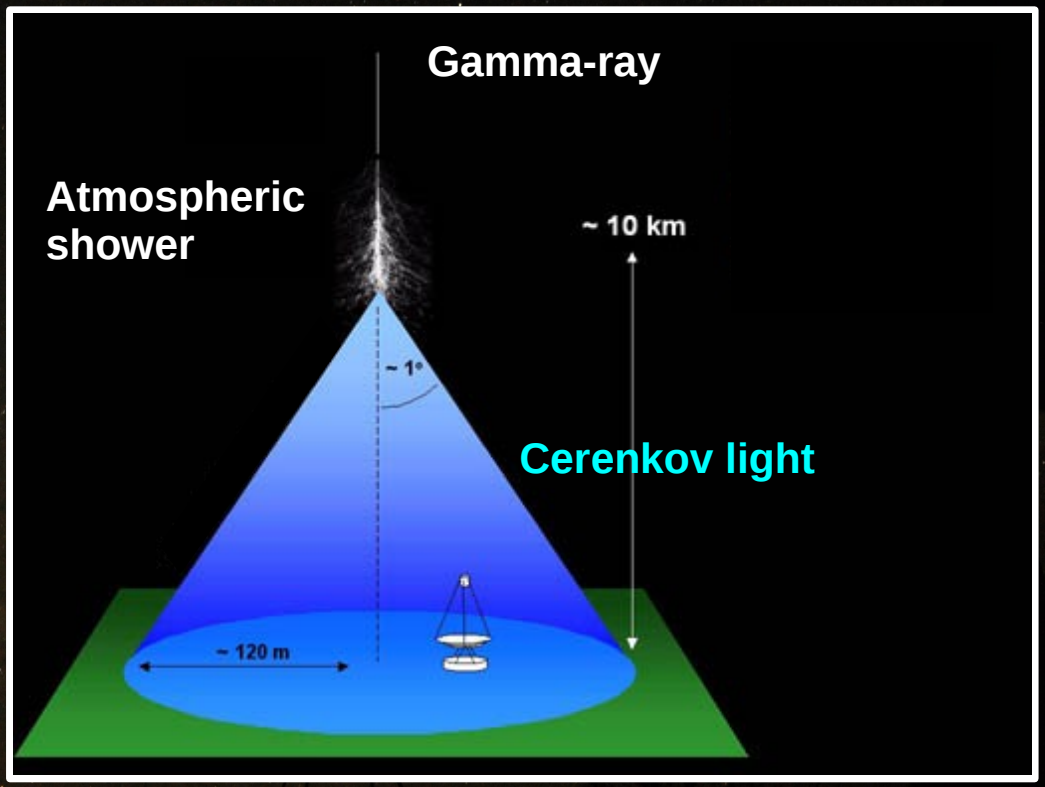
The H.E.S.S. view of our Galaxy in VHE gamma-rays

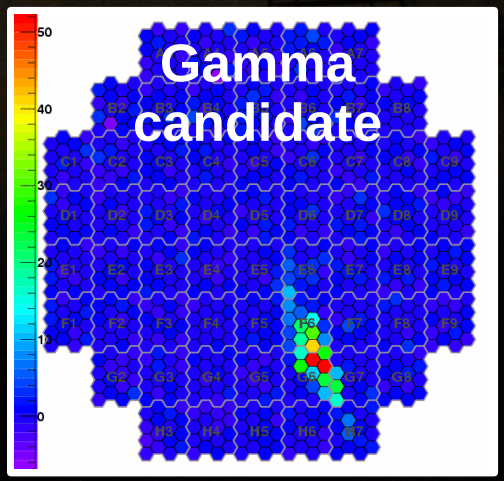
Armand Fiasson
LAPP, Annecy

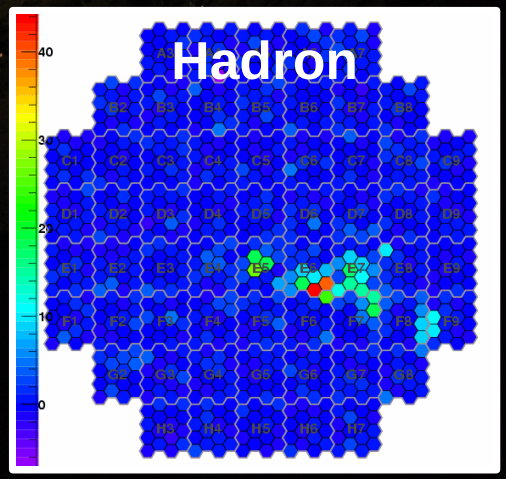
TeV γ-ray detection

- **Ground based telescopes**
  - Atmosphere as a calorimeter
  - Shower Cerenkov light visible from the ground
- **Imaging Atmospheric Cerenkov Telescope:**
  - Shower image at the focal plane







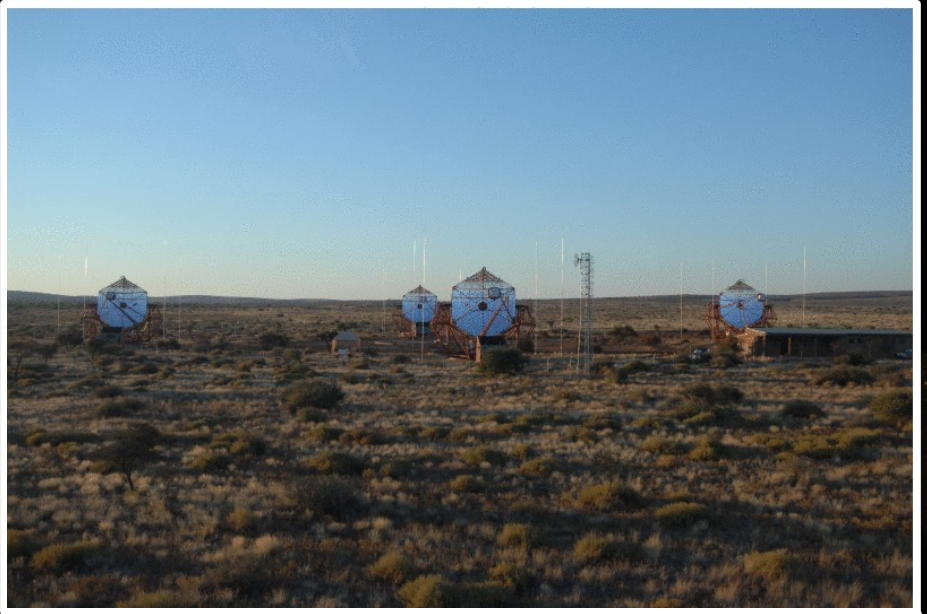


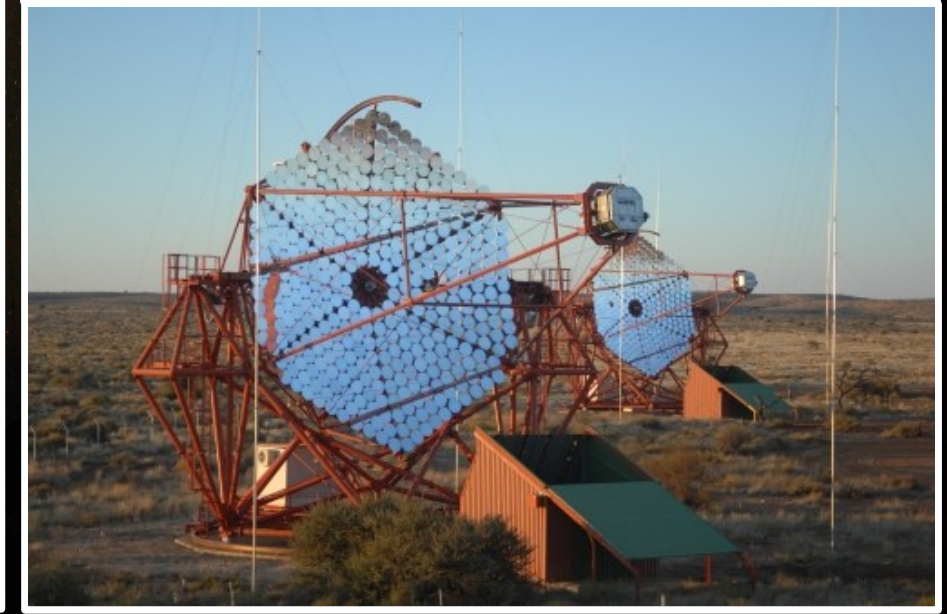
High Energy Stereoscopic System (H.E.S.S.)

- **Array of 4 Imaging Atmospheric Cherenkov Telescopes**
  - Detects the Cherenkov light from atmospheric showers
  - Stereoscopic mode
  - Large field of view: 5°
  - Energy range: 100 GeV to a few 10 TeV
  - Résolution: $\Delta\theta \sim 0.1°$ and $\Delta E/E \sim 16\%$
- **Located in the Khomas Highlands of Namibia**
  - Southern hemisphere

  => Ideal position to oberve the inner Galactic plane
- **Construction completed in December 2003**

  => more than 6 years in full operation mode

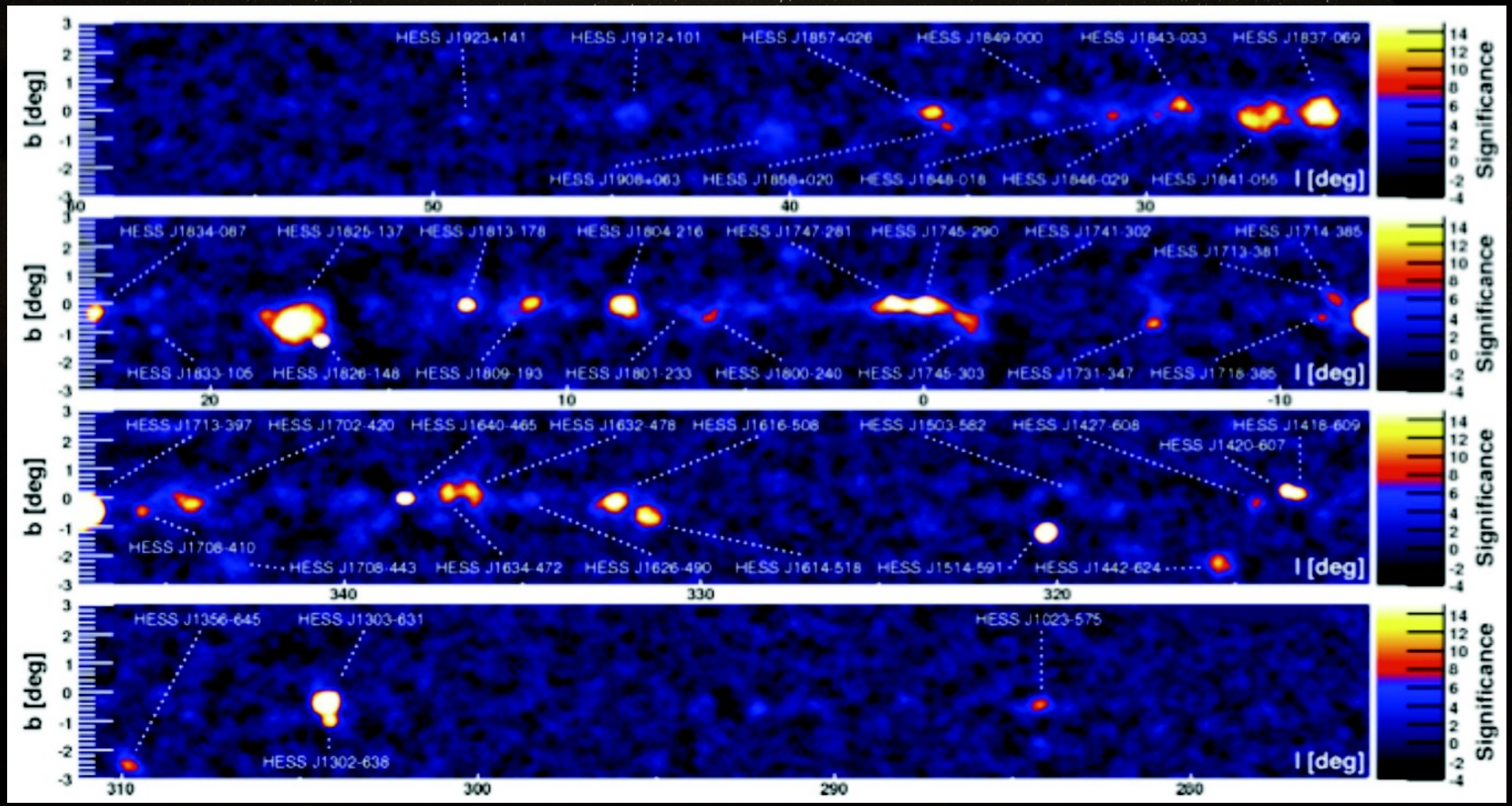




The H.E.S.S. Galactic Plane Survey

- **Systemactic survey of the inner galactic plane conducted since 2004**
  - -85 ° < l < + 60° and - 3° < b < + 3°
  - Low diffuse flux => individual sources appear

  => successful: ~ 30 new sources



Which galactic sources are detected?

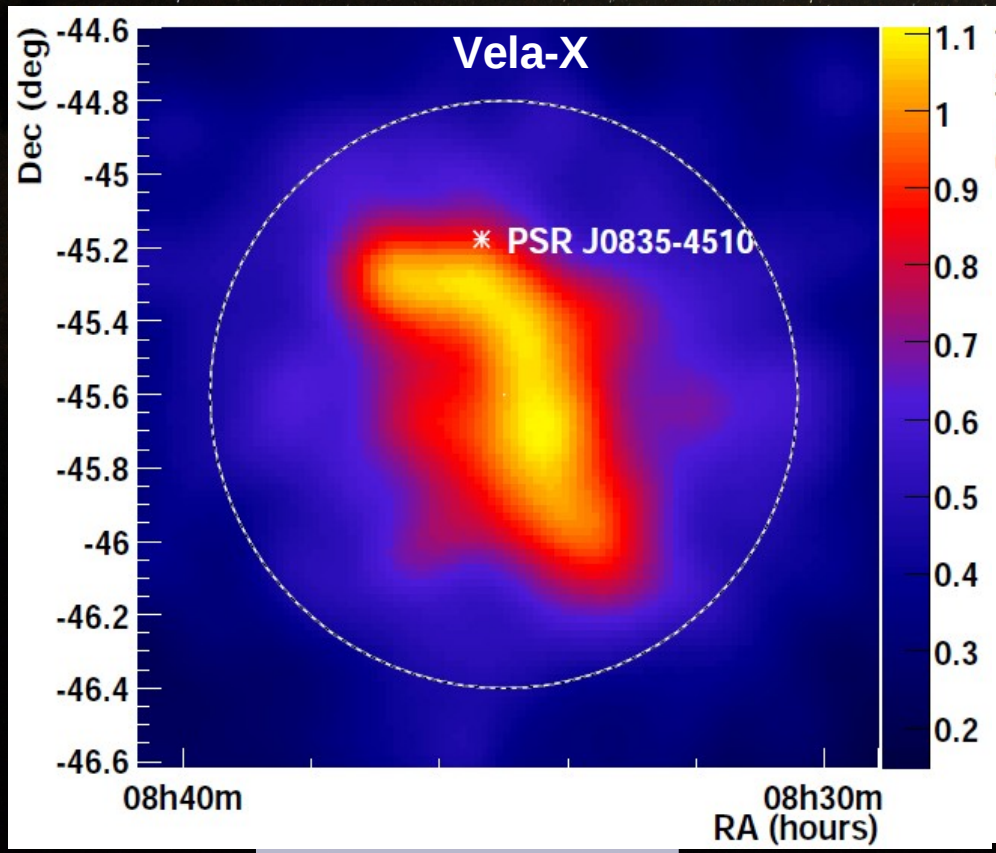
- **VHE gamma-rays are tracers of non-thermal particle acceleration within our Galaxy**
  - Hadrons: Π^0 decay after deep inelastic pp scattering
  - Electrons: Inverse Compton (CMB, dust radiation, stellar radiation fields...)
- **Most of the identified new sources are related to supernova remnants**
  - Pulsar wind nebulae
    - Acceleration at the terminal shock of the pulsar wind
  - Shell type supernova remnants
    - Particle acceleration through Fermi mechanism
- **Some of the new sources remains unidentified**
  - Mostly extended sources along the Galactic plane
  - No obvious counterparts at other wavelengths

Pulsar wind nebulae

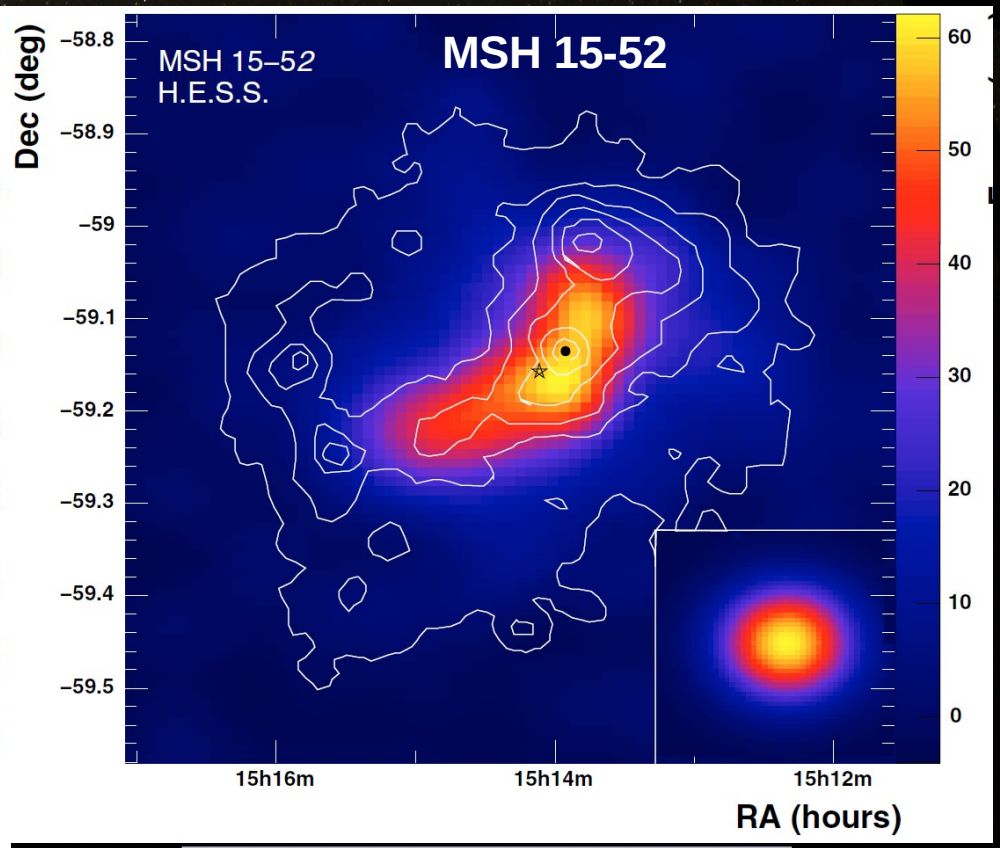
- **An important fraction of the H.E.S.S. Sources are associated with PWN**

  G0.9+0.1, Crab Nebula, MSH 1552, VelaX …
- **Association with known pulsars or PWN without pulsars detected**

  => the largest class of the HESS Galactic sources

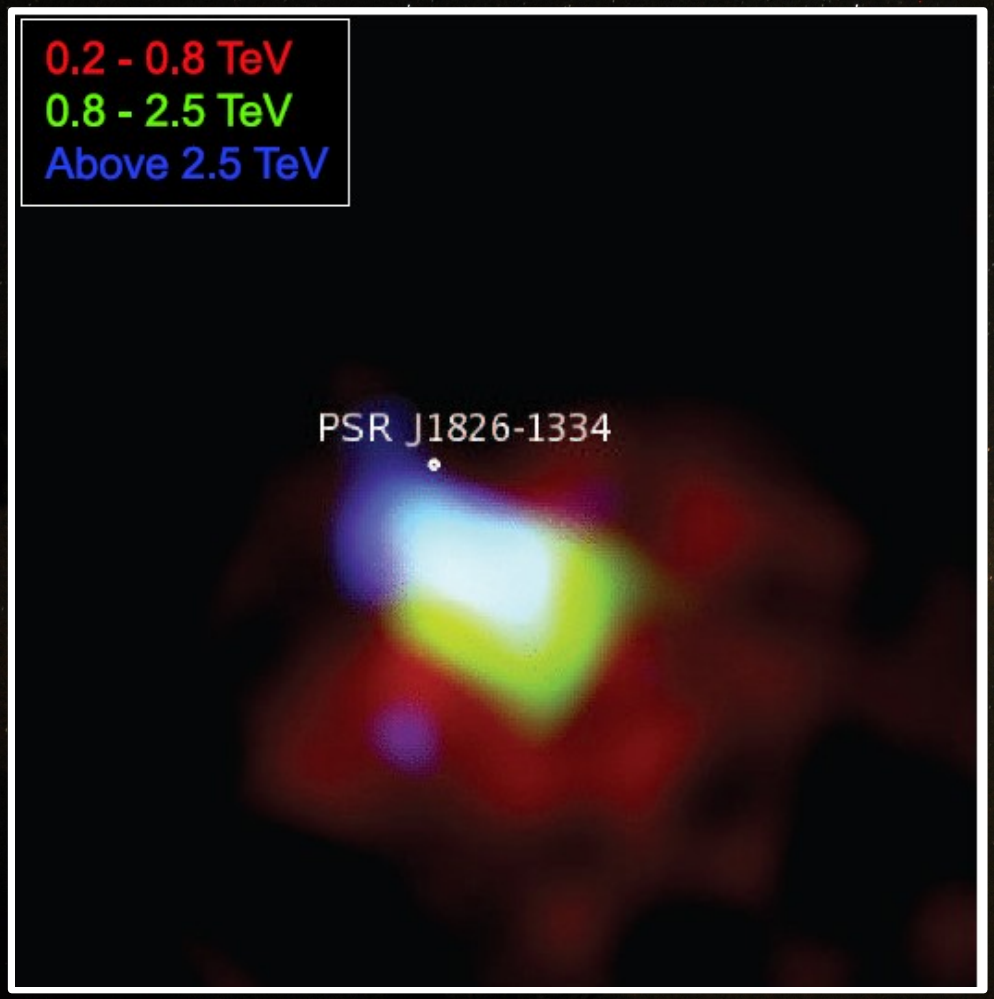


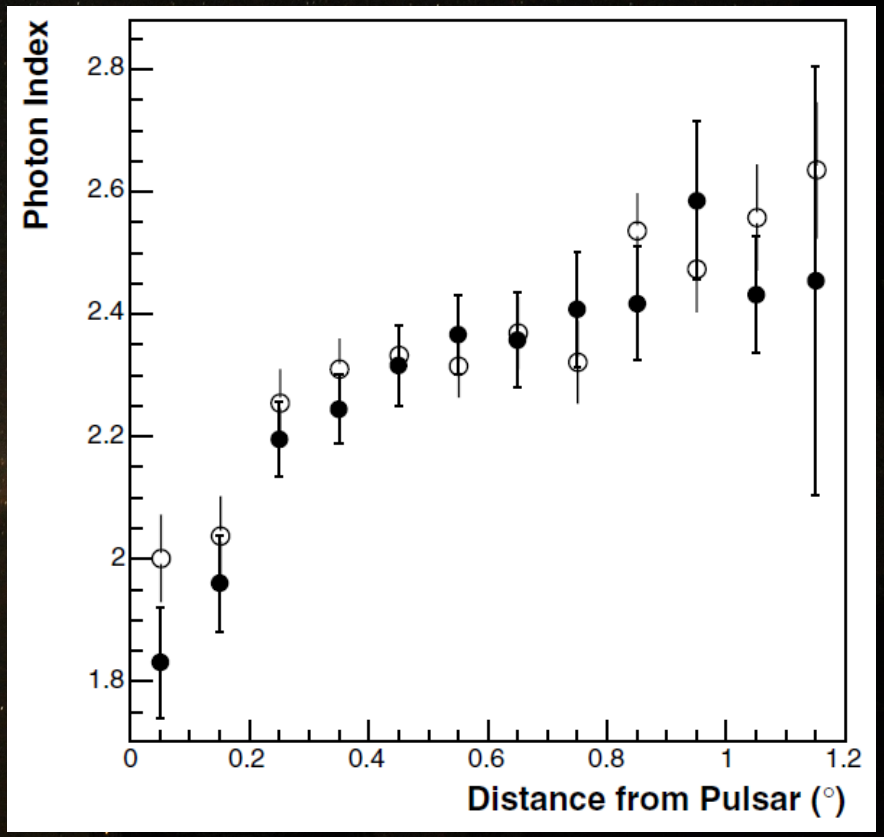
[Aharonian et al. in prep.]
[Dubois et al. ICRC 2009]



[Aharonian et al. A&A 435 17 2005]

Leptonic accelerators

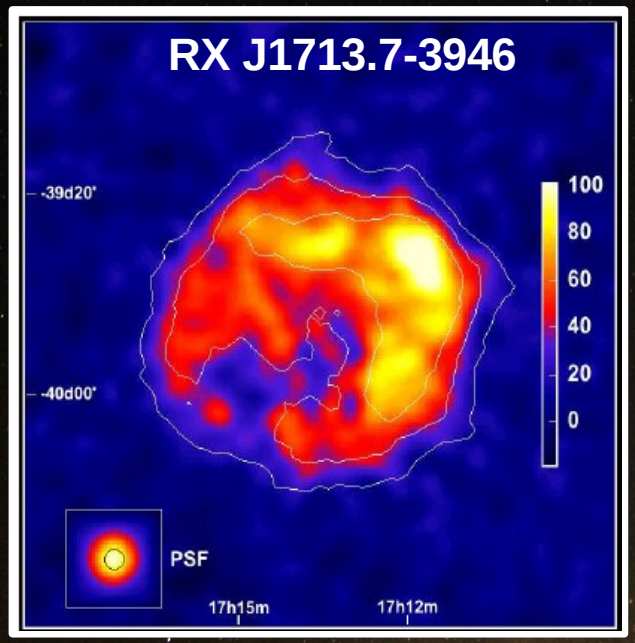




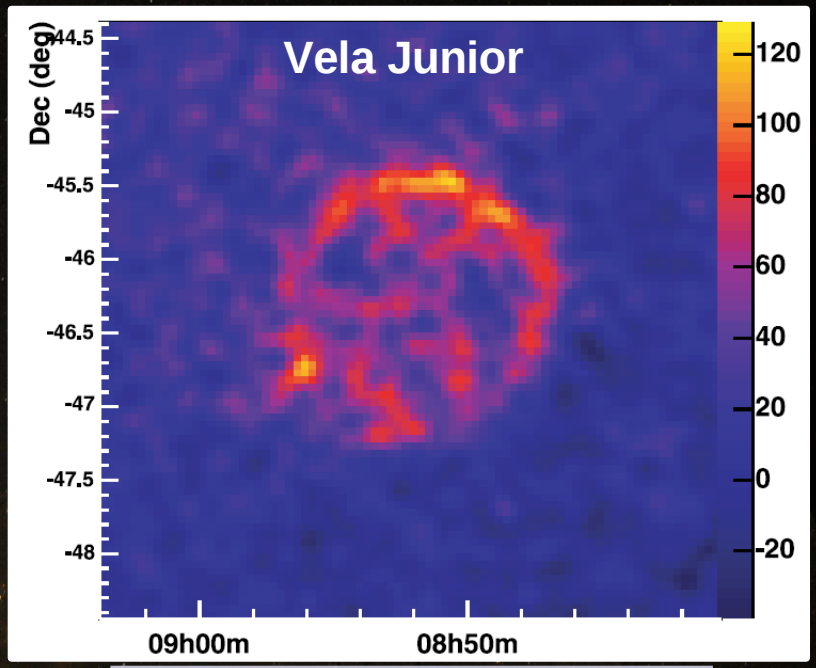
- **Radiation losses of the accelerated electrons deduced from the gamma-ray flux**

  => steepening spectrum with increasing distance to the pulsar
- **Gamma-ray flux of order of 1% of the spin-down luminosity of the pulsar**

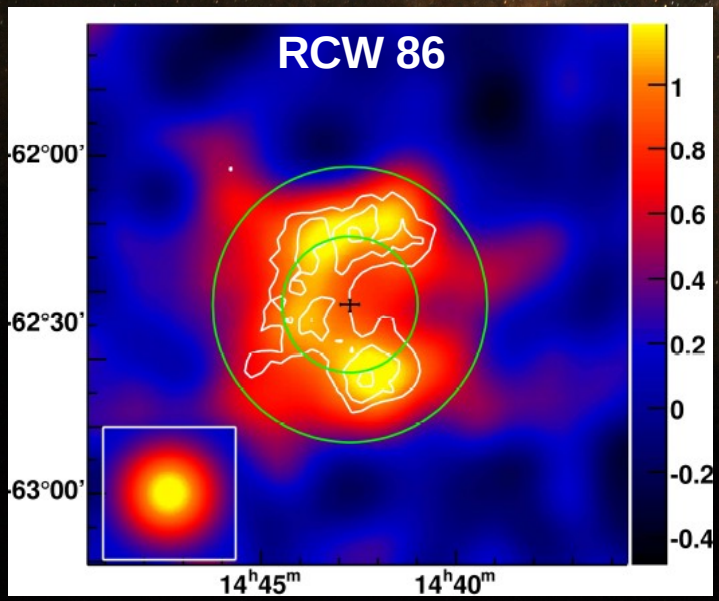
Shell-type supernova remnants



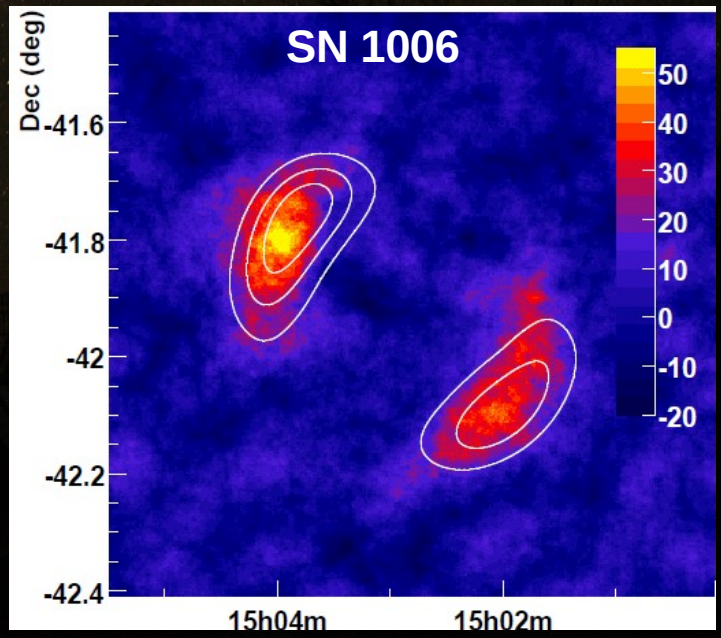
[Aharonian et al. A&A 464, 235 2007]



[Aharonian et al. ApJ 661, 236 2007]

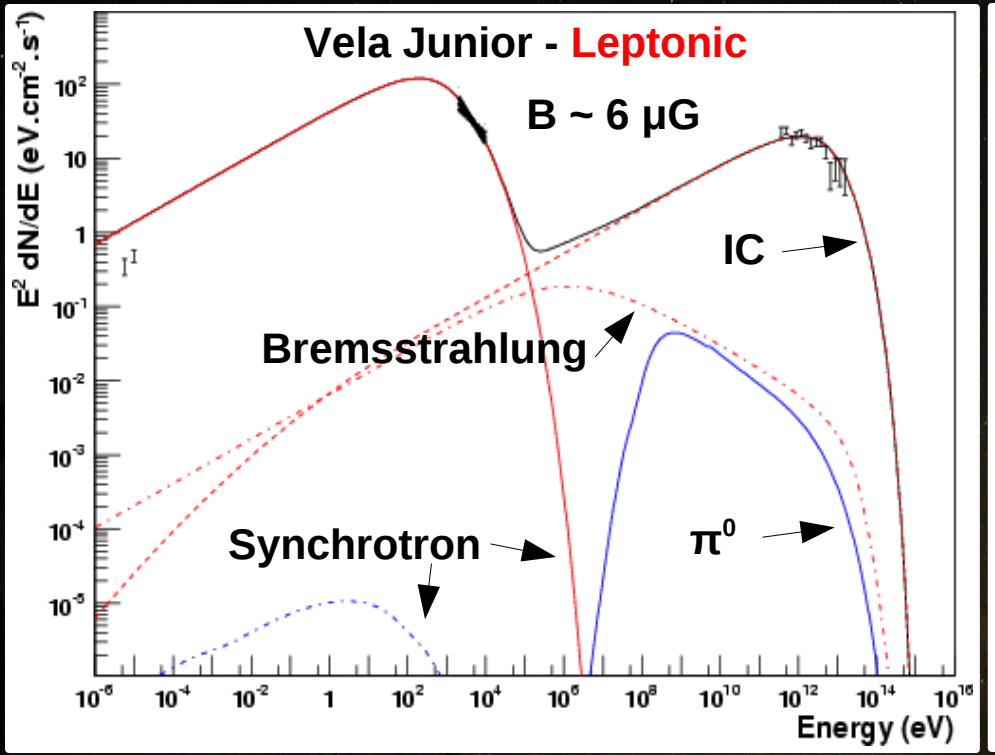


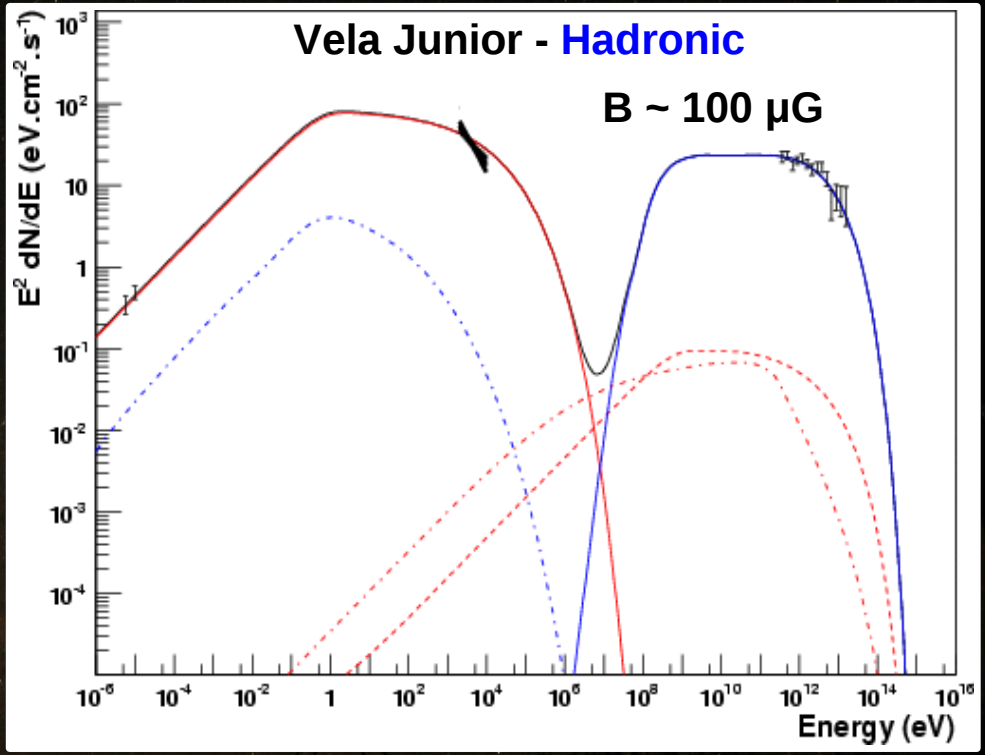
[Aharonian et al. ApJ 692, 1500A 2009]



[M. Naumann-Godo et al. 2009]

Hadronic accelerators?



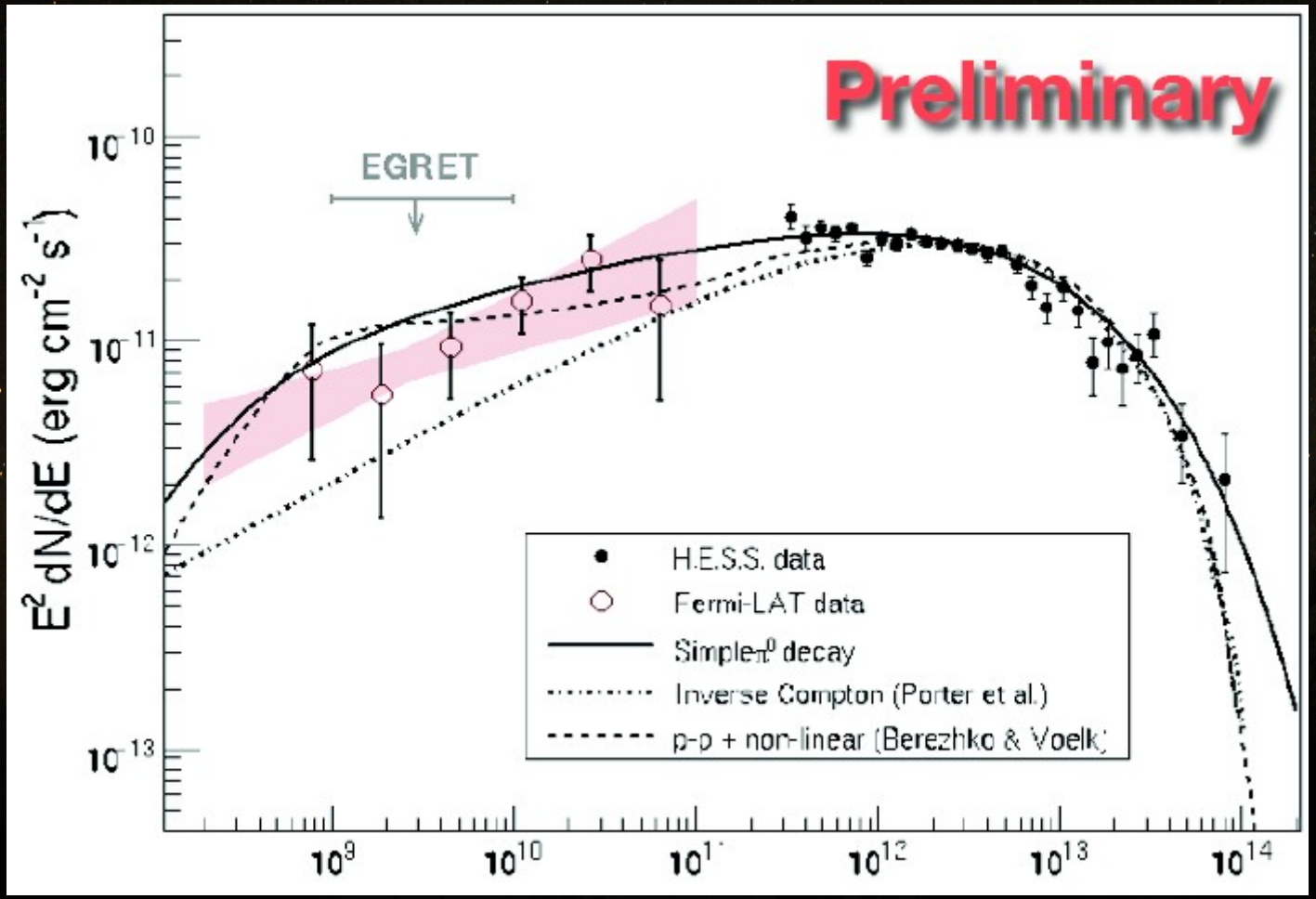


[Aharonian et al. ApJ 661, 236 2007]

- **Spectrum = Powerlaw with spectral index close to 2 up to 30 TeV**

  => confirm the acceleration of particles with E > 10^{14} eV
- **The nature of particle remains unidentified**
  - Electrons in a low intensity magnetic field (~ a few µG)
  - Hadrons in a higher magnetic field (~ 100 µG, predicted by theoreticals models)

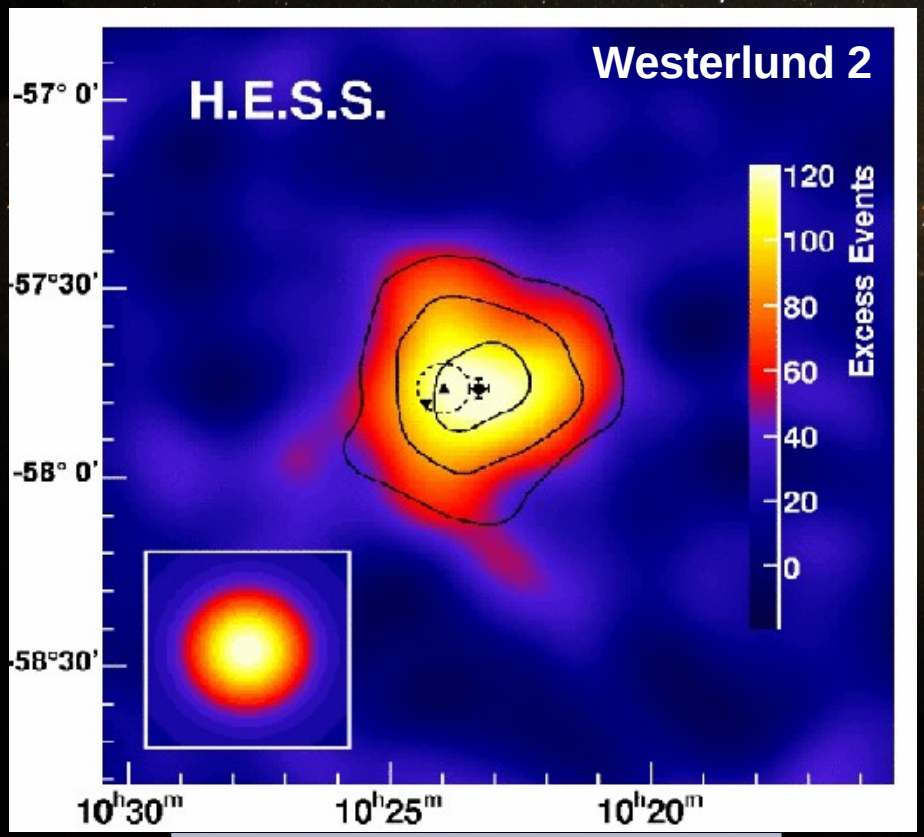
GeV-TeV : RX J1713.7-3946



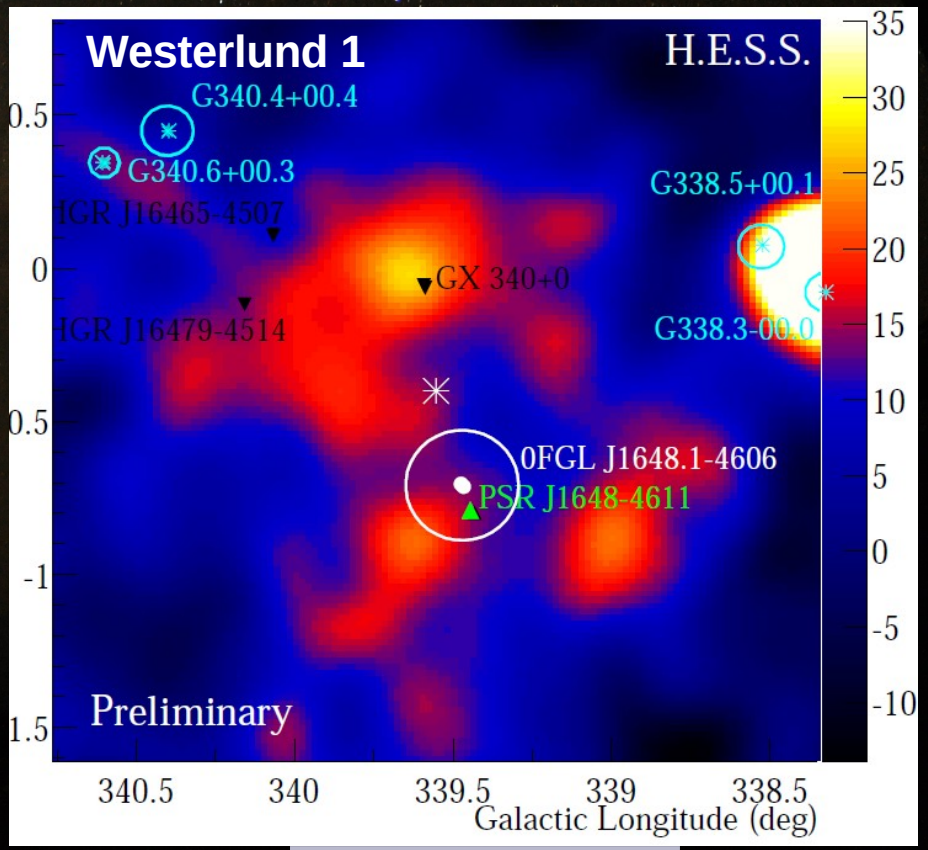
Stellar clusters

Particle acceleration within supershells?

- Massive binary systems
- Collective stellar winds
- SN explosions



[Aharonian et al. A&A 467, 1075, 2007]



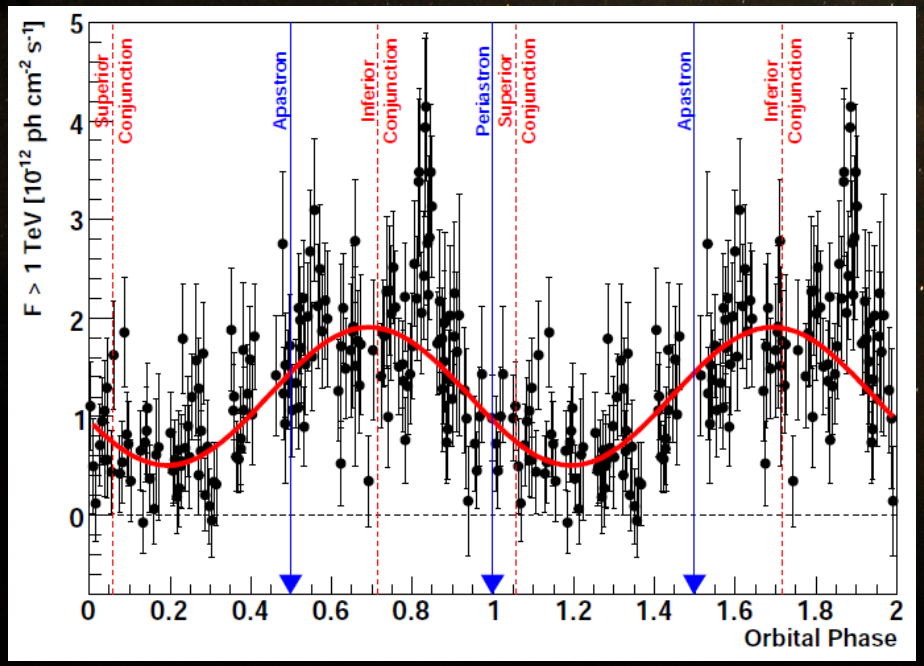
[Ohm et al. Jaen 2009]

Binary systems

Massive bright star + compact companion (pulsar / black hole)

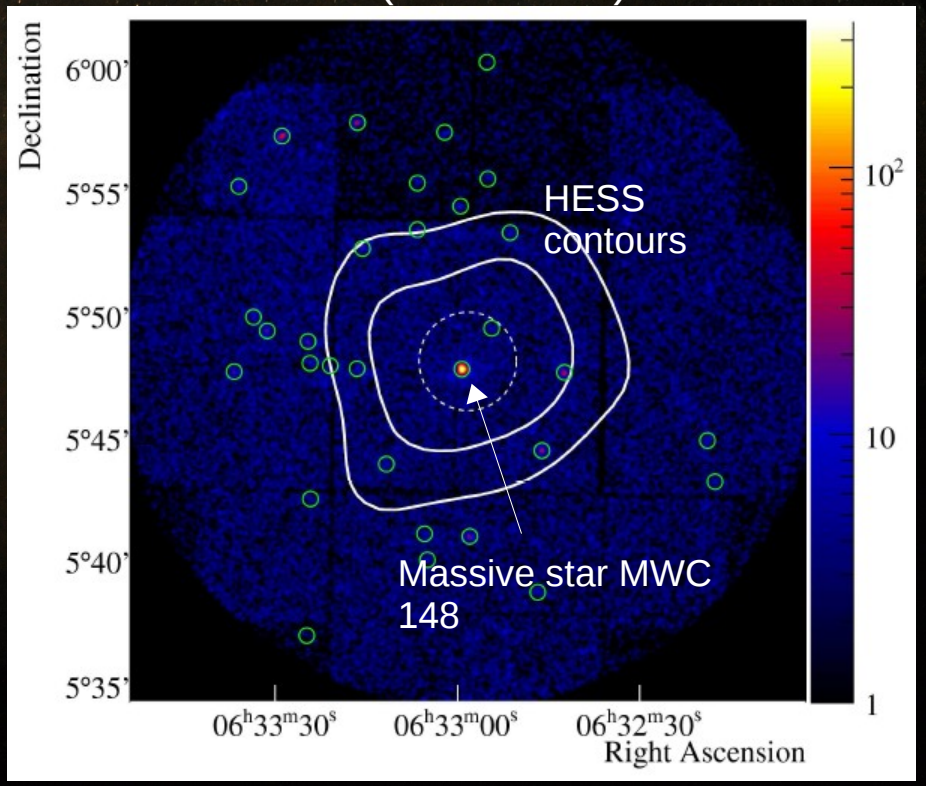
- LS 5039: orbital period observed at TeV energies
- PSR B1259-63: TeV emission at periastron passage
- HESS J0652+057: TeV discovered binary?

LS 5039



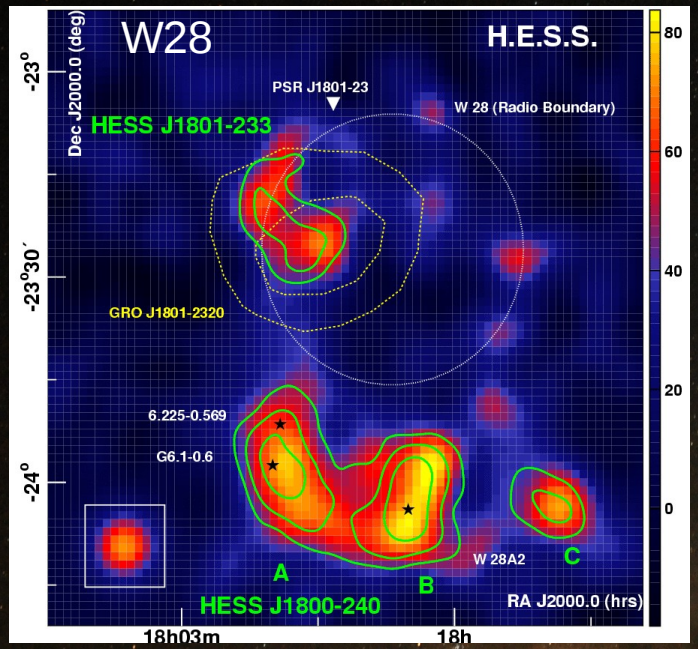
[Aharonian et al. A&A 460, 743, 2006]

HESS J0652+057 (Monoceros)

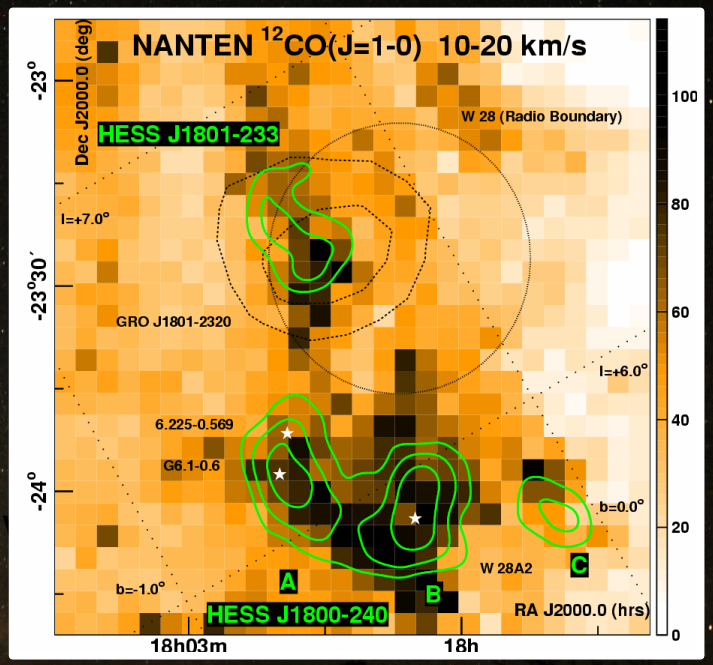


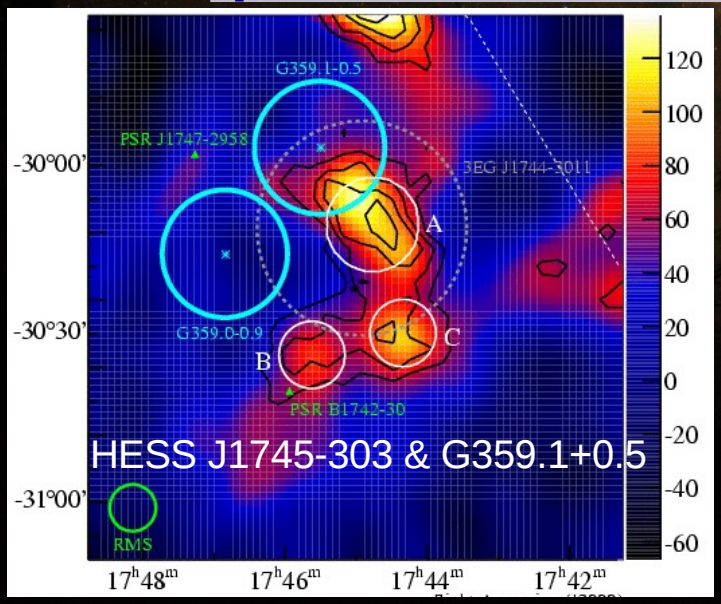
[Aharonian et al. A&A 469, L1, 2007]

SNR / molecular cloud associations



[Aharonian et al. A&A 481, 401, 2008]





[Aharonian et al. A&A 483, 509, 2008]

W28:

- SNR at 2-3 kpc

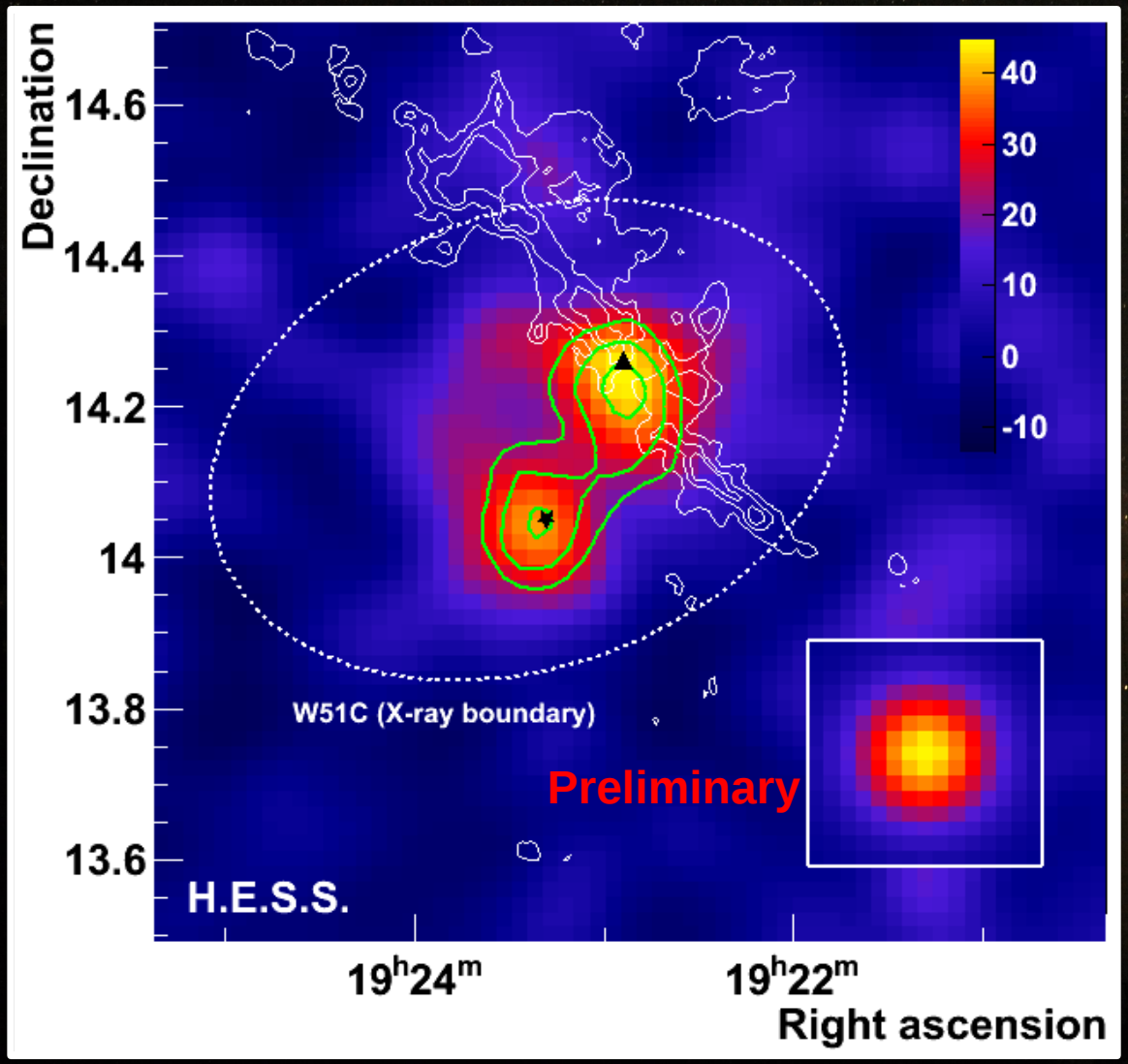
  => Several molecular clouds

G359.1+0.5:

- SNR close to the Galactic Center (~8kpc)

  => surrounded by a ring of matter

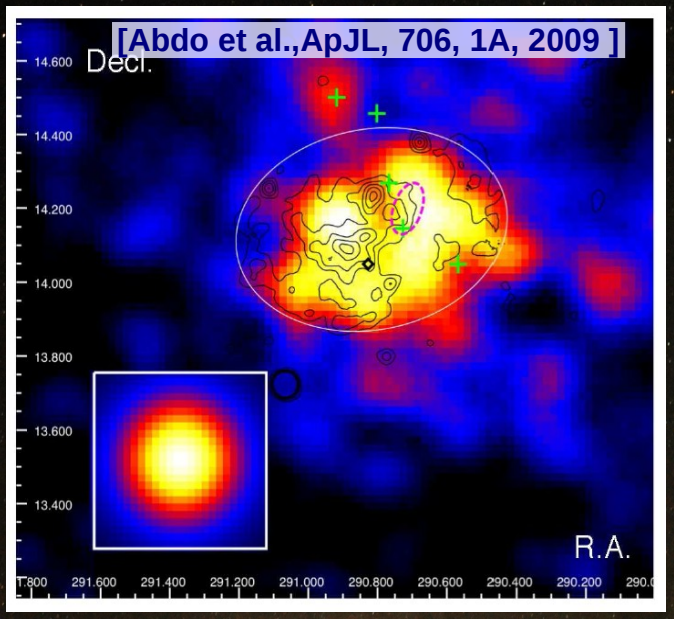
W51C & HESS J1923+141

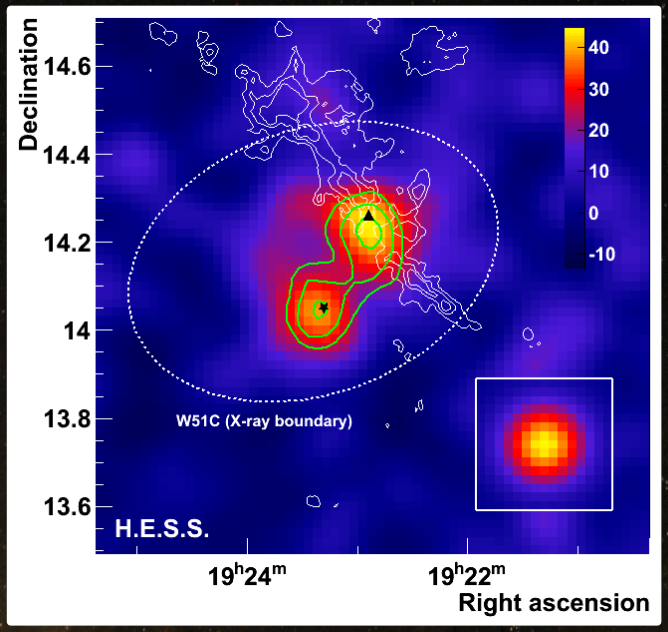


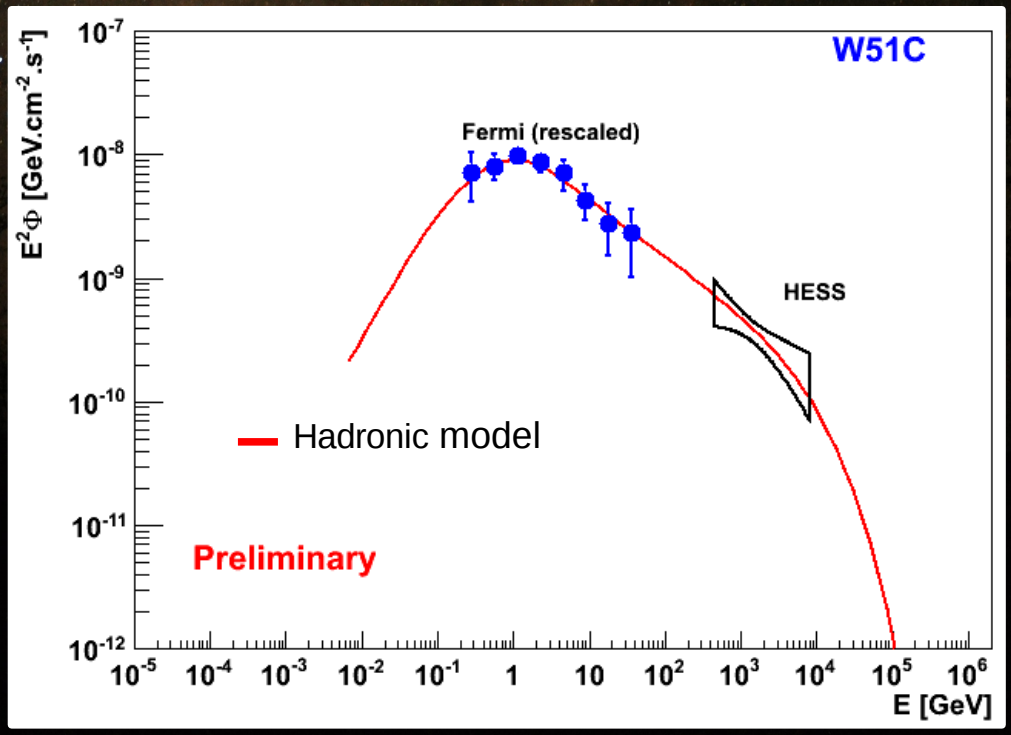
Aharonian et al., en prep.]

- **W51 region observed between 2007 and 2009**
- **Hadronic and leptonic origin in the same field of view?**
  - Pulsar wind nebula
  - Shocked molecular cloud

Gev-TeV : W51C


[Abdo et al.,ApJL, 706, 1A, 2009]
Decl.
R.A.


Declination
W51C (X-ray boundary)
H.E.S.S.
Right ascension


W51C
Fermi (rescaled)
HESS
Hadronic model
Preliminary
E²Φ [GeV.cm⁻².s⁻¹]
E [GeV]

Summary

- **The H.E.S.S. experiment, with its high sensitivity, is ideally located to observe at TeV energies the inner part of the Galactic plane**
- **Several supernova remnant have been detected**
  - Shell-type SNRs resolved for the first time at TeV energies
  - Plenty of PWNe
- **Several binaries system have been also detected with different periods**
- **New classes of objects have been more recently detected in the TeV range by H.E.S.S.**
  - Young stellar cluster (Westerlund 1&2)
  - Molecular clouds in the vicinity or particle accelerators (W28,...)
- **A significant number of gamma-ray sources are still unidentified**
- **Extra-galactic sky also covered by HESS**
  - **12 blazars / radio galaxy**
  - **Starburst galaxy**
  - **PWN in the LMC?**

The extra-galactic sky

object name	redshift	class	discovery at VHE	Flux level (in % Crab)	observed photon index	shortest variability time scale
Centaurus A	0.0018	FR I	2008 (H.E.S.S.)	0.8	2.7±0.5	
M 87	0.004	FR I	2003 (HEGRA)	~1.4	2.20±0.15	~1 day
Mrk 421	0.030	HBL	1992 (Whipple)	300 (high state)	2.1±0.1 (Ec = 3.1 TeV)	<1 hour
PKS 0548-322	0.069	HBL	2007 (H.E.S.S.)	1.4	2.8±0.3	
PKS 2005-489	0.071	HBL	2005 (H.E.S.S.)	2.8	4.0±0.4	~1 month
RGB J0152+017	0.080	HBL	2007 (H.E.S.S.)	2	2.95±0.36	~1 month
PKS 2155-304	0.116	HBL	1999 (Mark VI)	15 (up to 1500)	3.32±0.06 (low state)	~3 min
1ES 0229+200	0.139	HBL	2006 (H.E.S.S.)	1.8	2.50±0.19	
H 2356-309	0.165	HBL	2006 (H.E.S.S.)	2.3	3.09±0.24	~1 month
1ES 1101-232	0.186	HBL	2006 (H.E.S.S.)	2.3	2.94±0.20	~1 year
1ES 0347-121	0.188	HBL	2007 (H.E.S.S.)	2	3.10±0.23	~1 year
PG 1553+113	>0.250	HBL	2006 (H.E.S.S./MAGIC)	3.4	4.5±0.3	