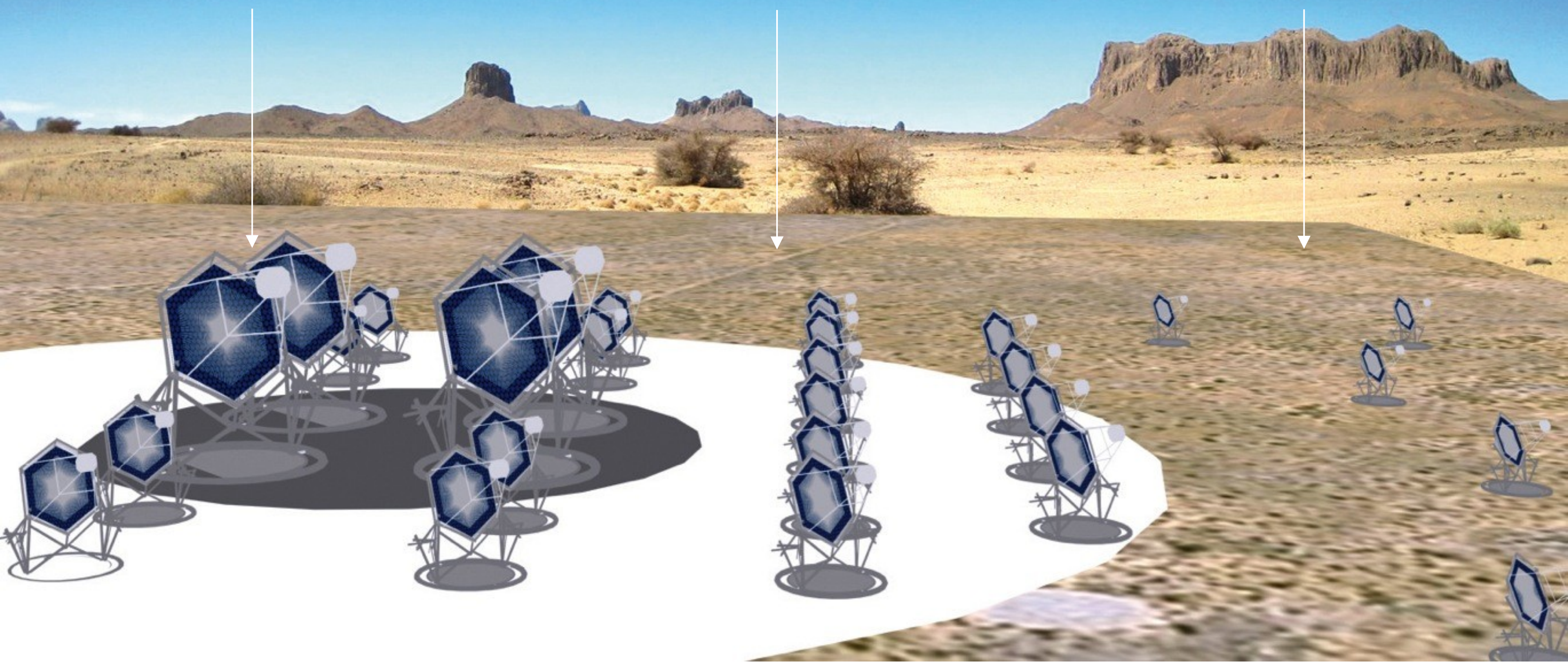
The VHE future

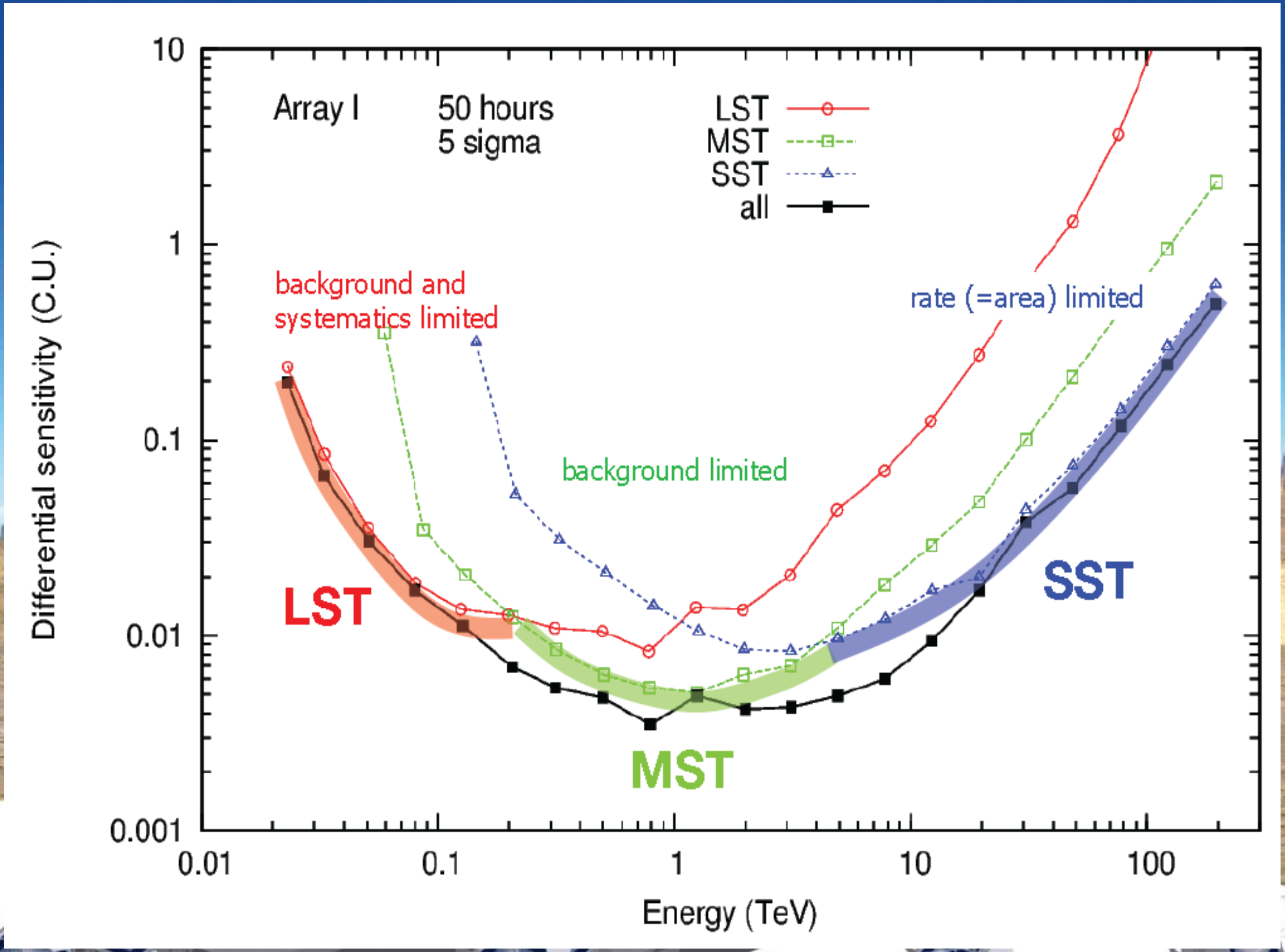
A. Giuliani

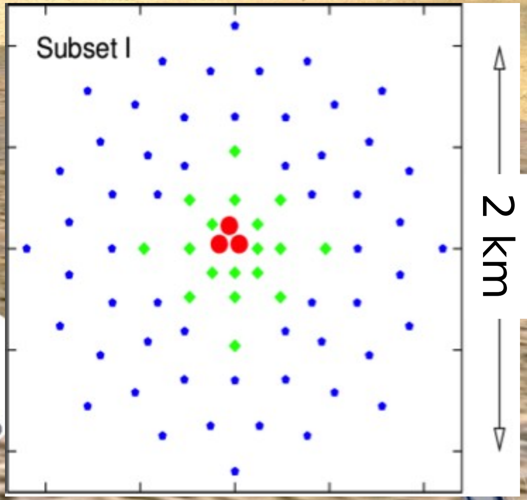
The Cherenkov Telescope Array

Low energy	Medium energy	High energy
4.5° FoV	7° FoV	10° FoV
2000 pixels	2000 pixels	2000 pixels
~ 0.1	~ 0.18	~ 0.2 - 0.3



The Cherenkov Telescope Array






ASTRI Astrofisica con Specchi
a Tecnologia Replicante Italiana
cta
cherenkov telescope array
INAF
ISTITUTO NAZIONALE DI ASTROFISICA
NATIONAL INSTITUTE FOR ASTROPHYSICS
Universidade de São Paulo
Instituto de Astronomia, Geofisica
e Ciencias Atmosferica
MIUR
MINISTERO DELL'ISTRUZIONE DELL'UNIVERSITA' E DELLA RICERCA
NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

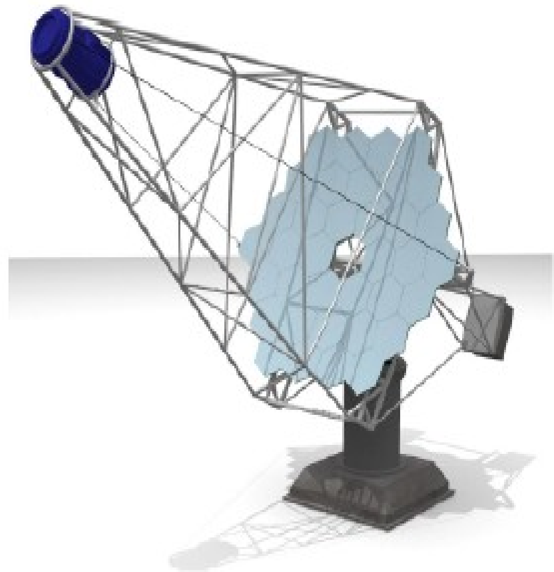


Fig. 5 The Davies-Cotton design.

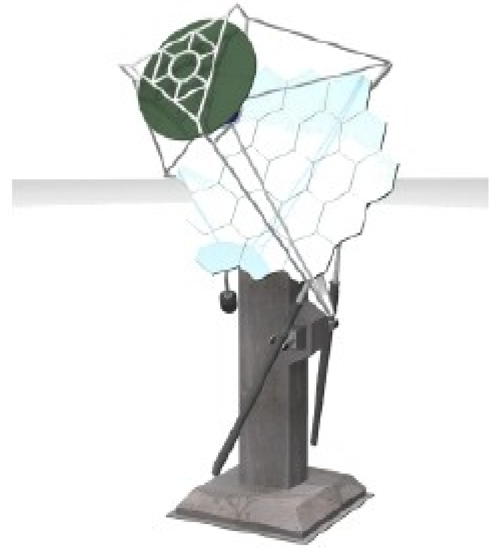


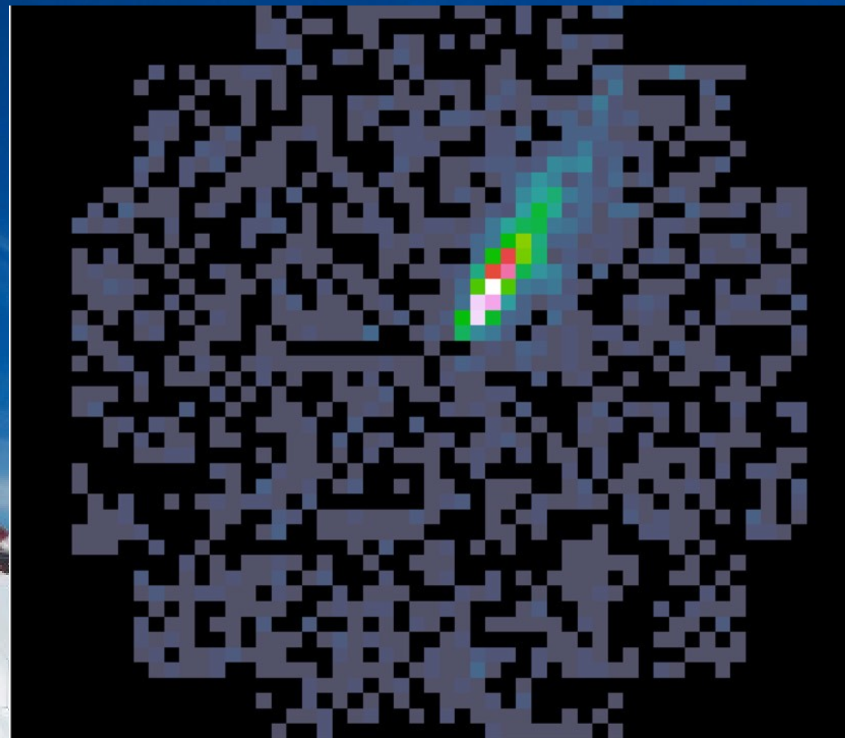
Fig. 6 The Schwarzschild-Couder design.

- Reduce the dimension, the weight, and the cost of the camera at the focal plane of the telescope

- Compact and stiffer mechanical structure

- Silicon-based photo-multipliers as light detectors, thanks to the reduced plate-scale. SiPMs allow us to perform observations during Moon-light, increasing the observatory duty-cycle

- Optimal imaging resolution across a wide field of view



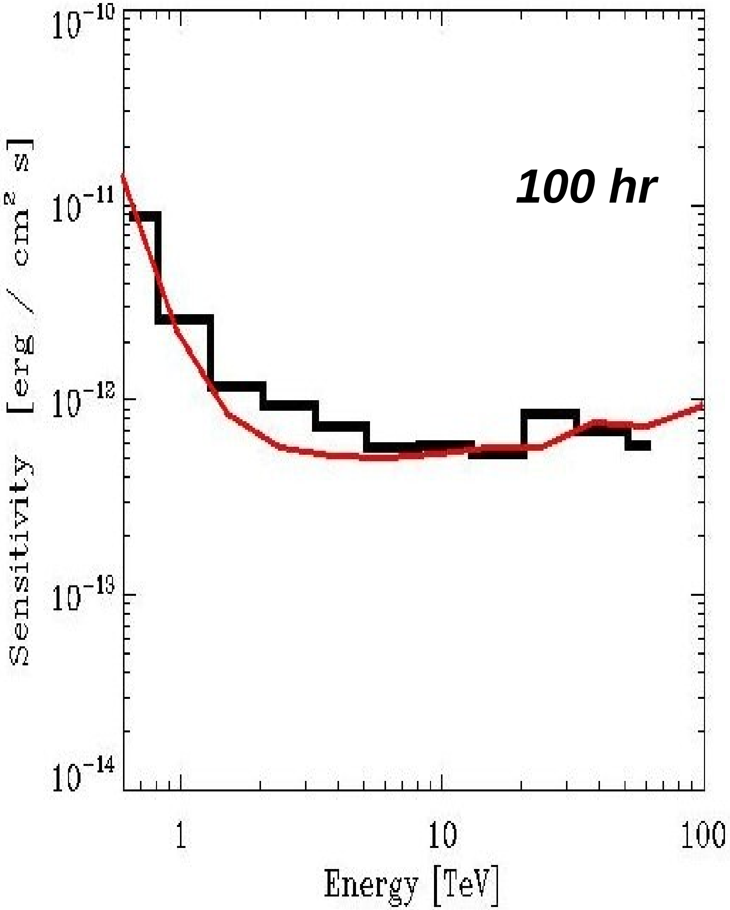
The primary gamma-ray signal had an energy of 10 TeV and a core distance of 142.77m.

The night sky background is at a level of 1.9×10^{12} phm^{-2} s^{-1} sr^{-1} (about three photoelectrons per pixel).

Color-bar shows number of photoelectrons per pixel.

Good sensitivity for energies greater than 10 TeV

High-Energy end of the source spectra

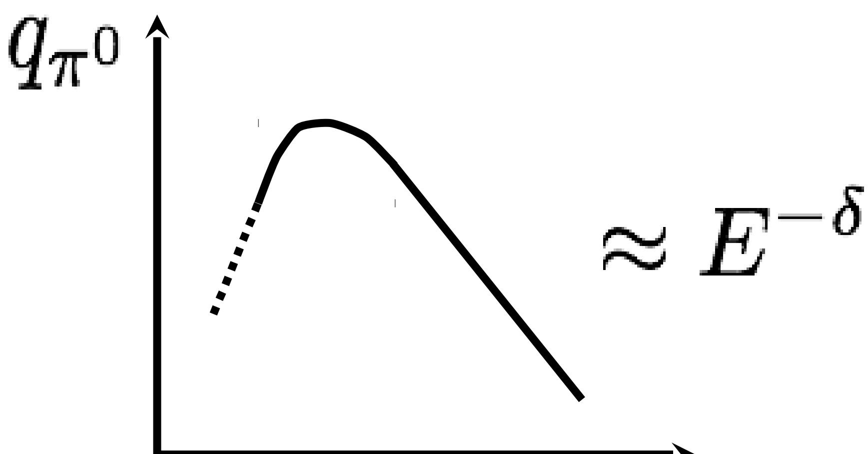


Stamerra et al

p-p interactions

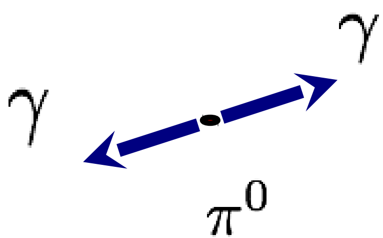
We assume a power law spectrum for CRs: $N_p(E_p) \propto E_p^{-\delta}$

Fraction of proton kinetic energy transferred to pion (from data): $f_{\pi^0} \approx$



p-p interactions

Pion rest frame:



$$E^*_\gamma = \frac{m_{\pi^0}}{2}$$

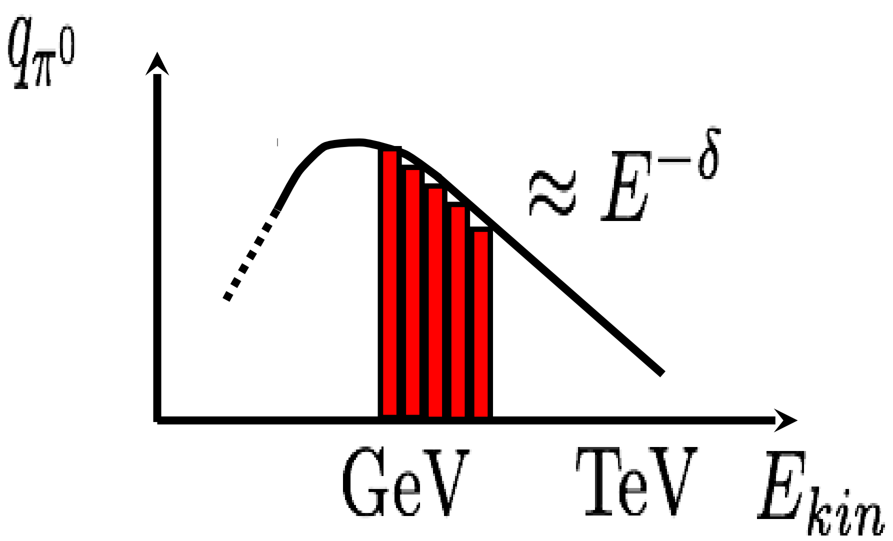
Lab frame:

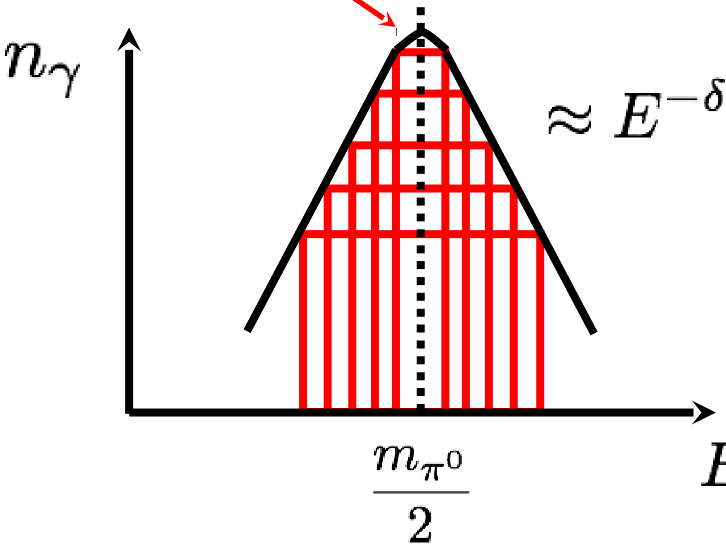
$$E_\gamma = \gamma\left(E^*_\gamma + v p^*_\gamma \cos\theta^*\right)$$

max and min energies -> $\cos\theta^*$

$$\frac{m_{\pi^0}}{2}\sqrt{\frac{1-\beta}{1+\beta}} \leq E_\gamma \leq \frac{m_{\pi^0}}{2}\sqrt{\frac{1}{1}}$$

p-p interactions



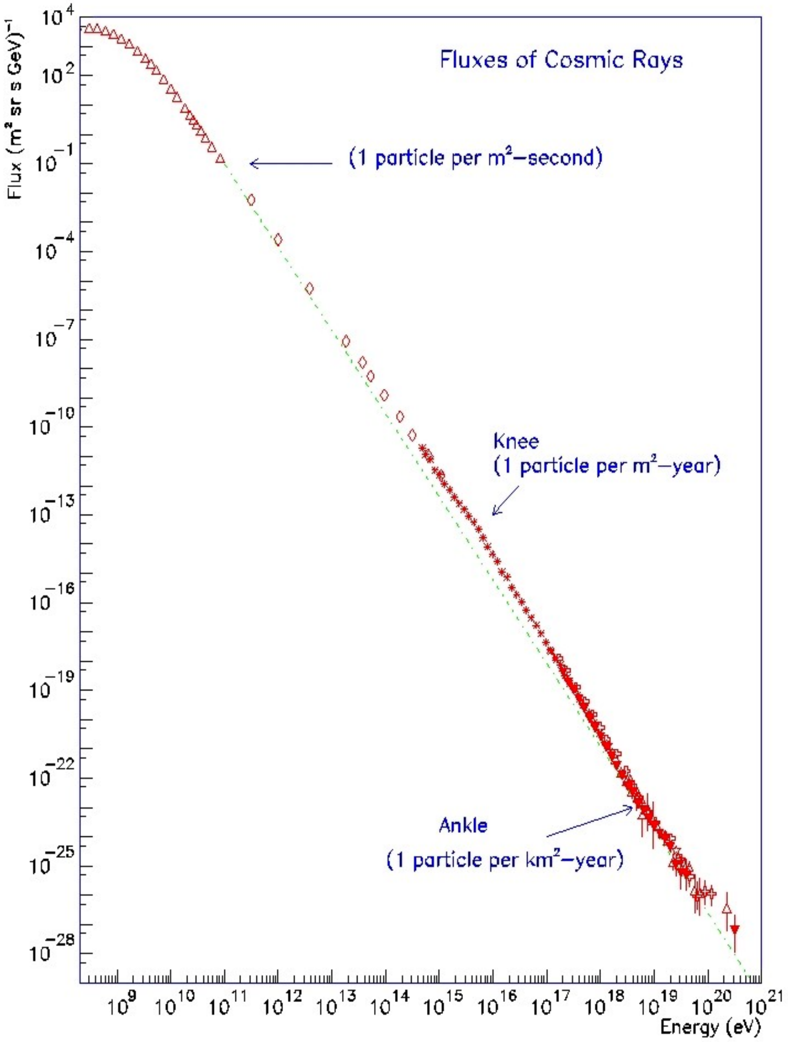


the gamma ray spectrum is symmetric (in log-log) with respect to: $\frac{m_{\pi^0}}{2} \sim 70$

Good sensitivity for energies greater than 10 TeV

High-Energy end of the source spectra

Particles spectra very near the “knee” energy

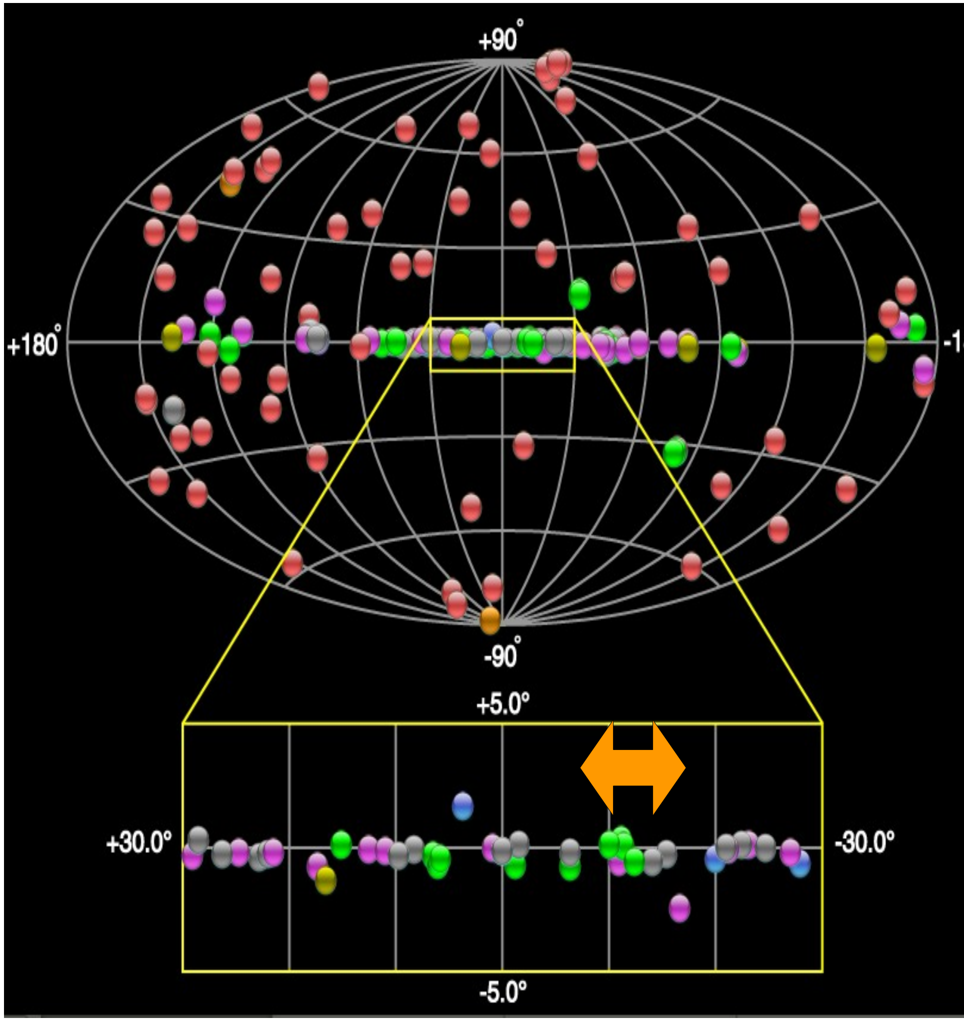


Large Field of View

Large exposure of the Galactic plane

Multiple source observations

Transient and serendipitous sources

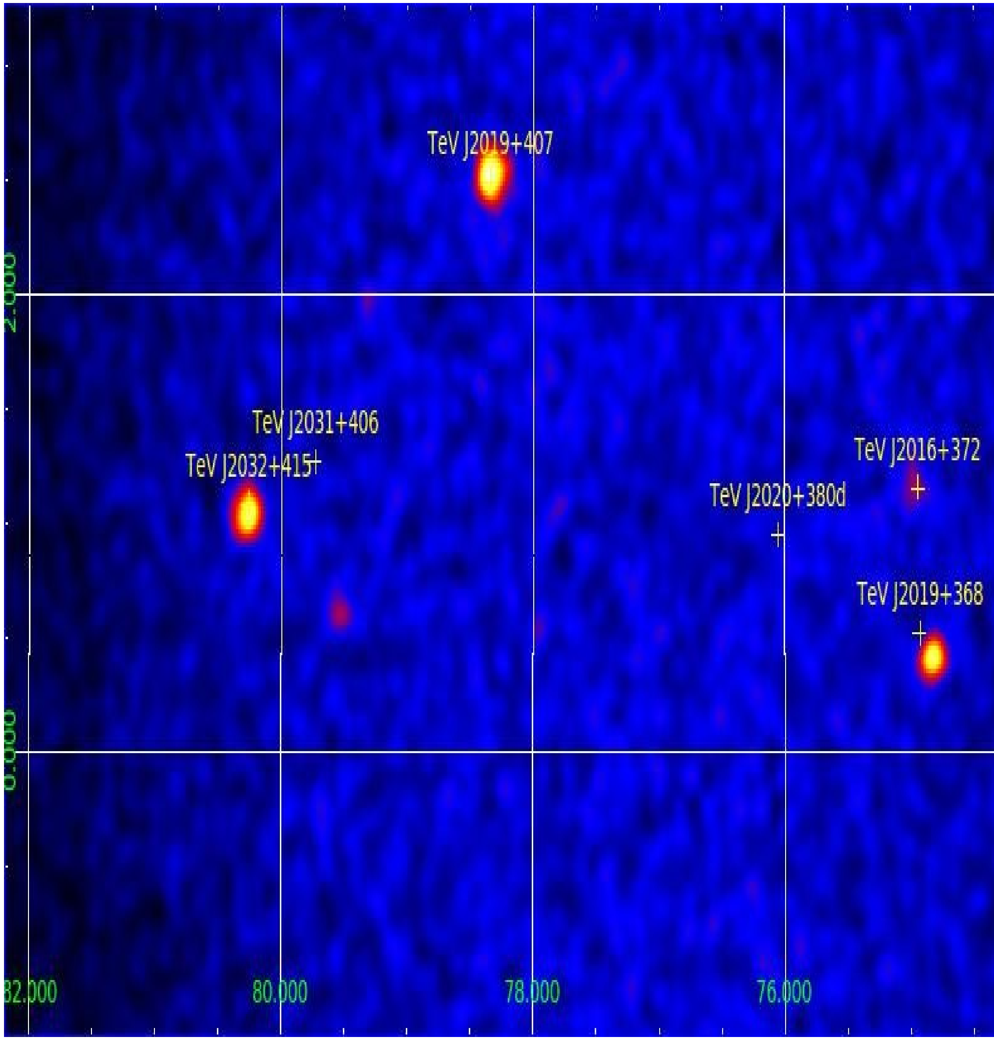


Large Field of View

Large exposure of the Galactic plane

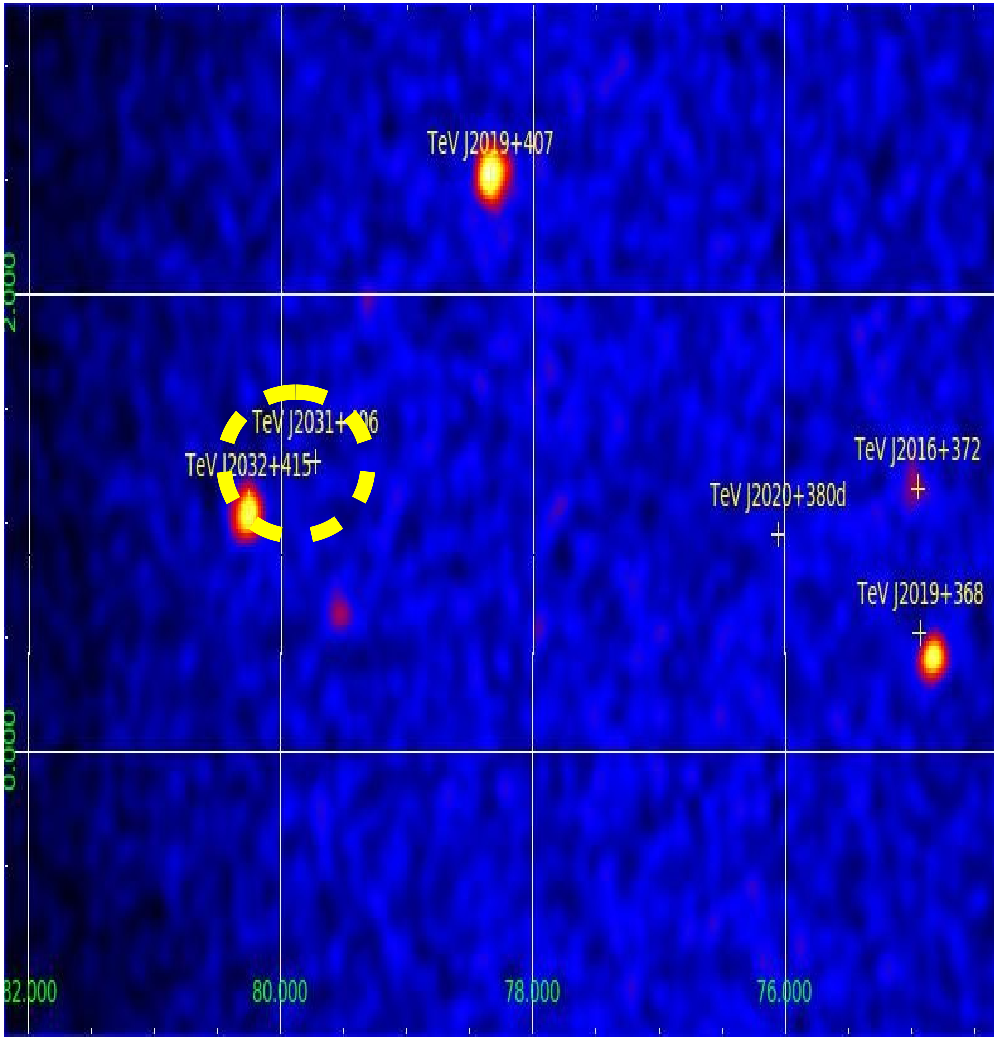
Multiple source observations

Transient and serendipitous sources



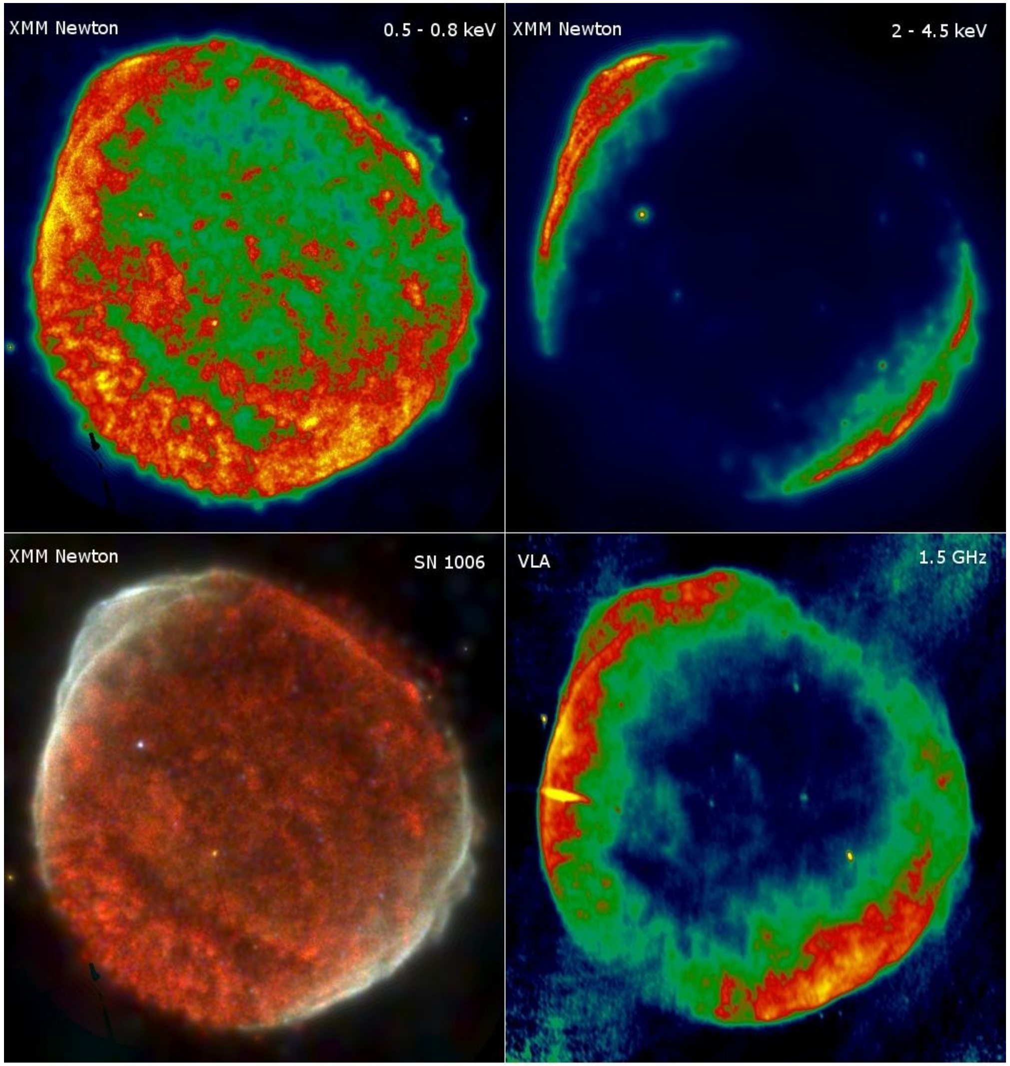
Good angular resolution @ HE

Unidentified Sources



Remnant of the historical SN 1006

Strong Radio and X emission due to synchrotron demonstrates the presence of TeV electrons,



Particle acceleration in SN 1006

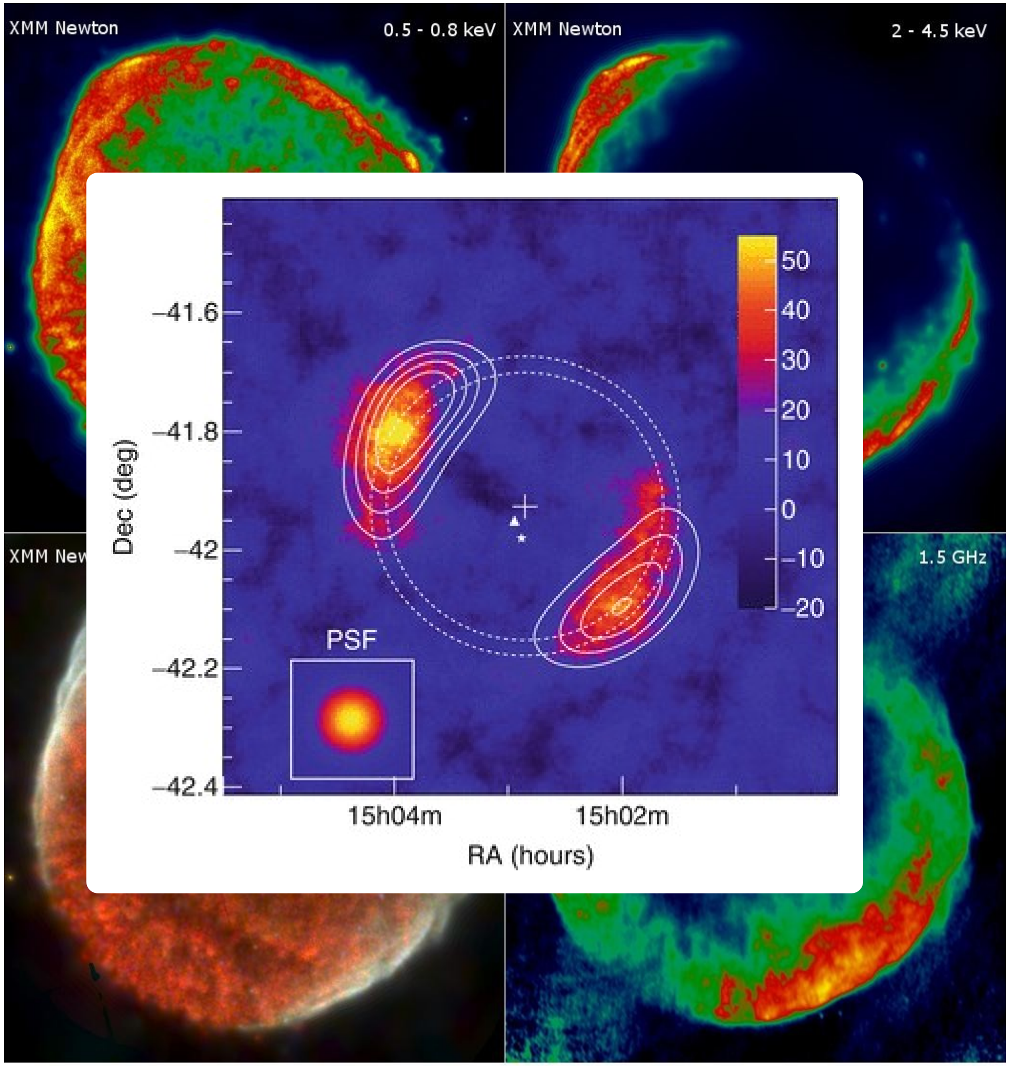
Image courtesy of CEA/DSM/DAPNIA/SAp

European Space Agency

Remnant of the historical SN 1006

Strong Radio and X emission due to synchrotron demonstrates the presence of TeV electrons,

TeV emission detected by HESS, morphologically well correlated with the emission in the Hard X band (after convolution with HESS Psf)



Particle acceleration in SN 1006

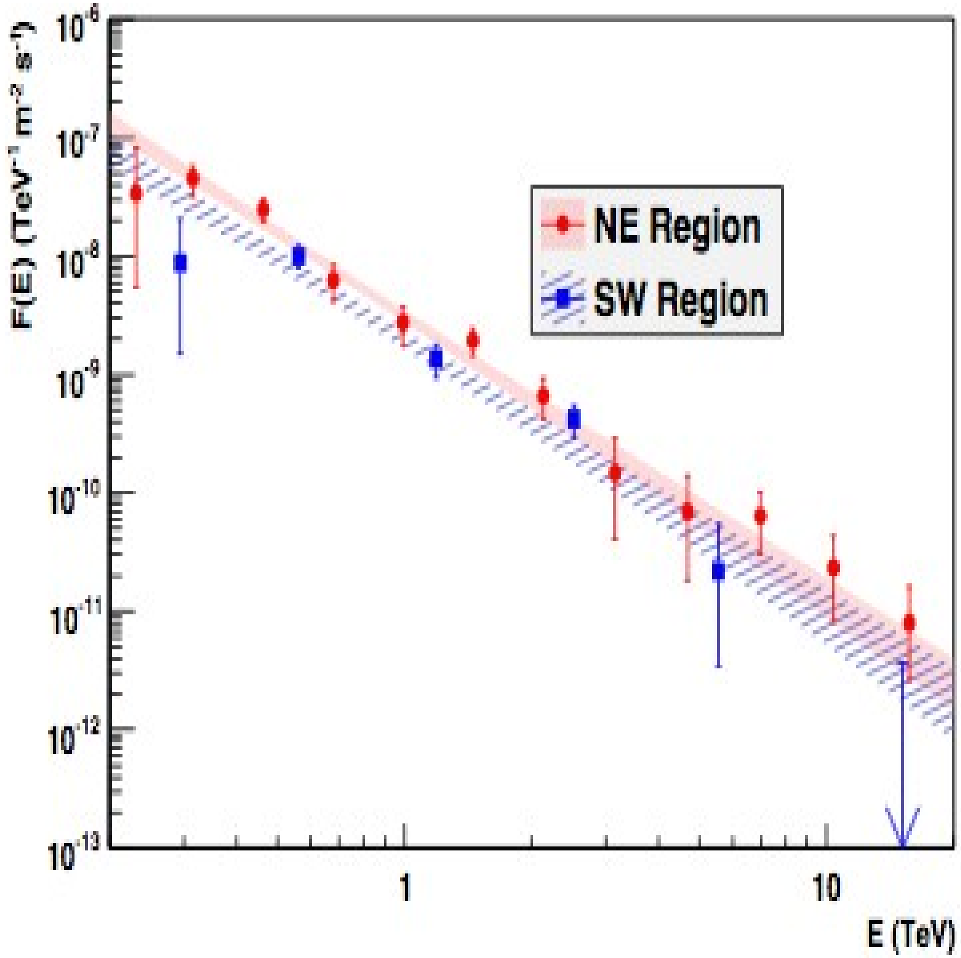
SN 1006

Remnant of the historical SN 1006

Strong Radio and X emission due to synchrotron demonstrates the presence of Tev electrons,

TeV emission detected by HESS, morphologically well correlated with the emission in the Hard X band (after convolution with HESS Psf)

N/S regions with similar spectrum ~ 2.3 btw .1 and 10 TeV



Acero et al. 2010, A&A, A62

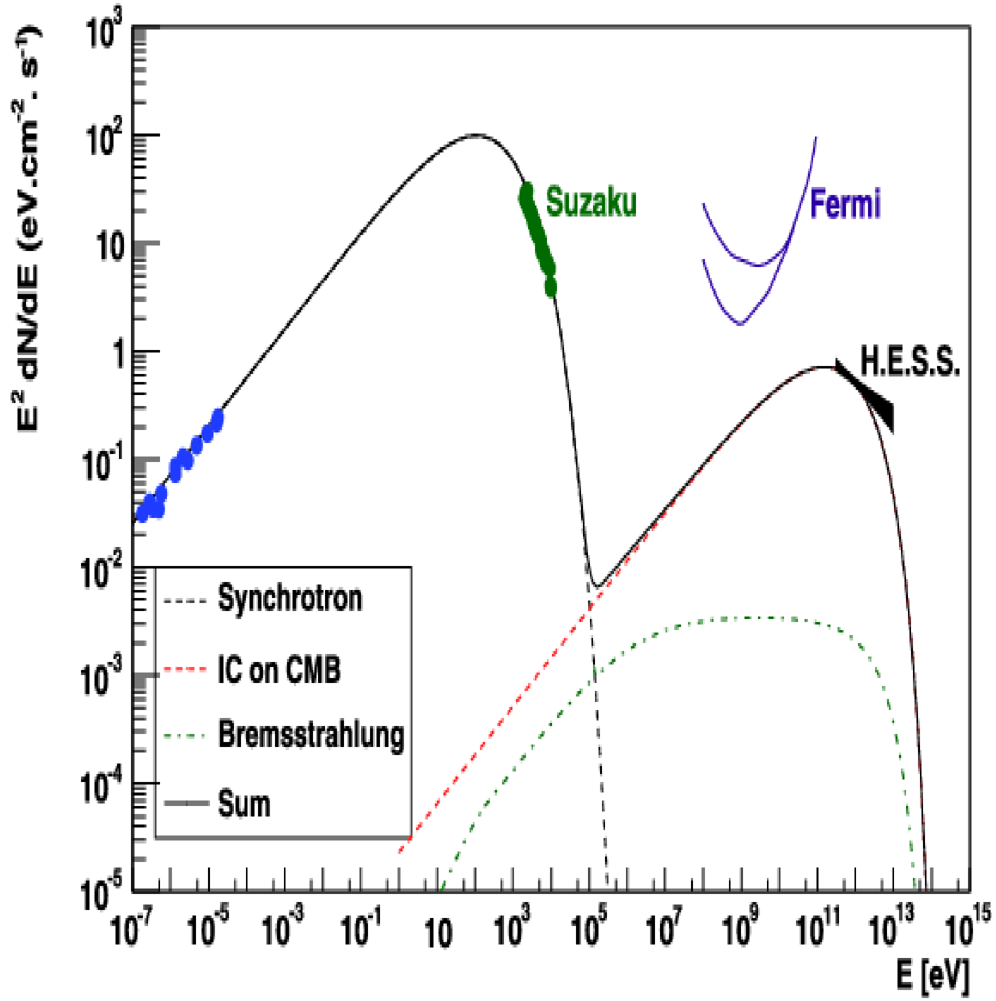
Remnant of the historical SN 1006

Strong radio and x emission due to synchrotron demonstrates the presence of TeV electrons,

TeV emission detected by HESS, morphologically well correlated with the emission in the Hard X band (after convolution with HESS Psf)

N/S regions with similar spectrum ~ 2.3 btw .1 and 10 TeV

The leptonic scenario fail to fit the data > 10 TeV



Acero et al. 2010, A&A, A62

Remnant of the historical SN 1006

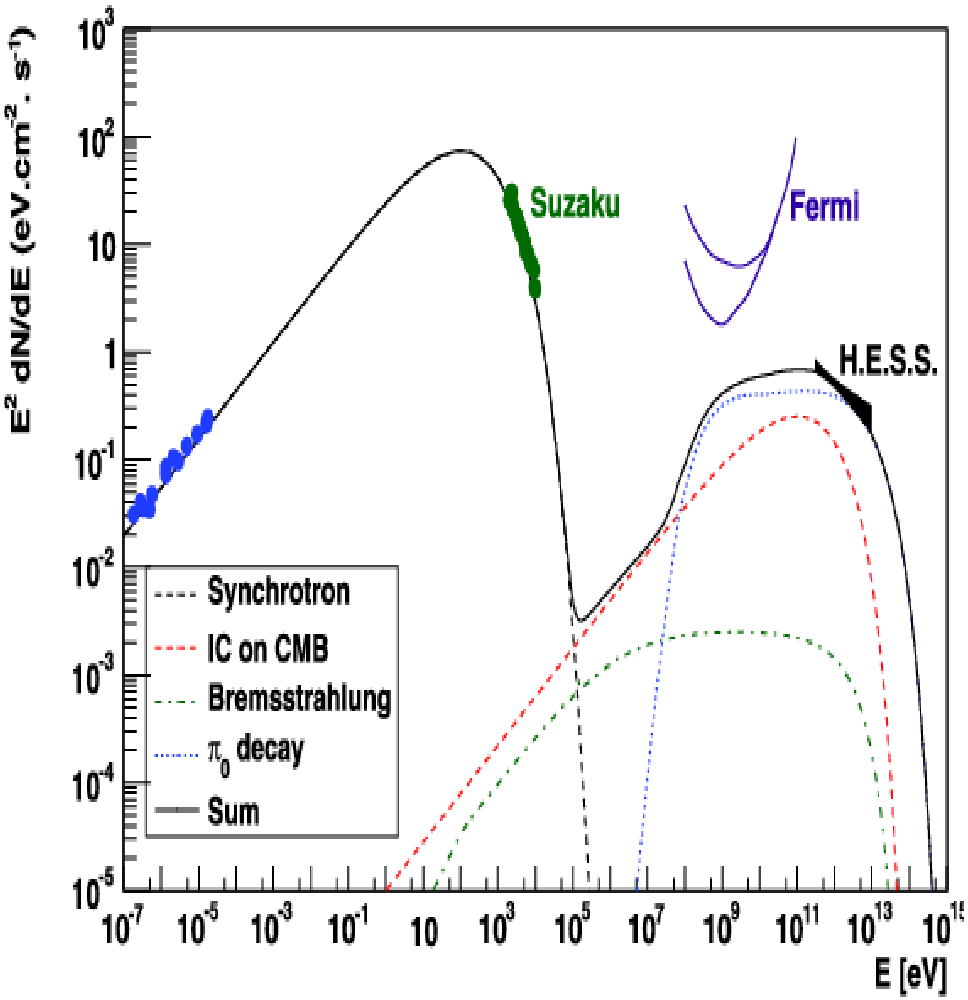
Strong radio and x emission due to synchrotron demonstrate the presence of
tev electrons,

TeV emission detected by HESS, morphologically well correlated with the emission in the Hard X band (after convolution with HESS Psf)

N/S regions with similar spectrum ~ 2.3 btw .1 and 10 TeV

The leptonic scenario fail to fit the data > 10 TeV

Hadronic component @ HE



Acero et al. 2010, A&A, A62

Remnant of the historical SN 1006

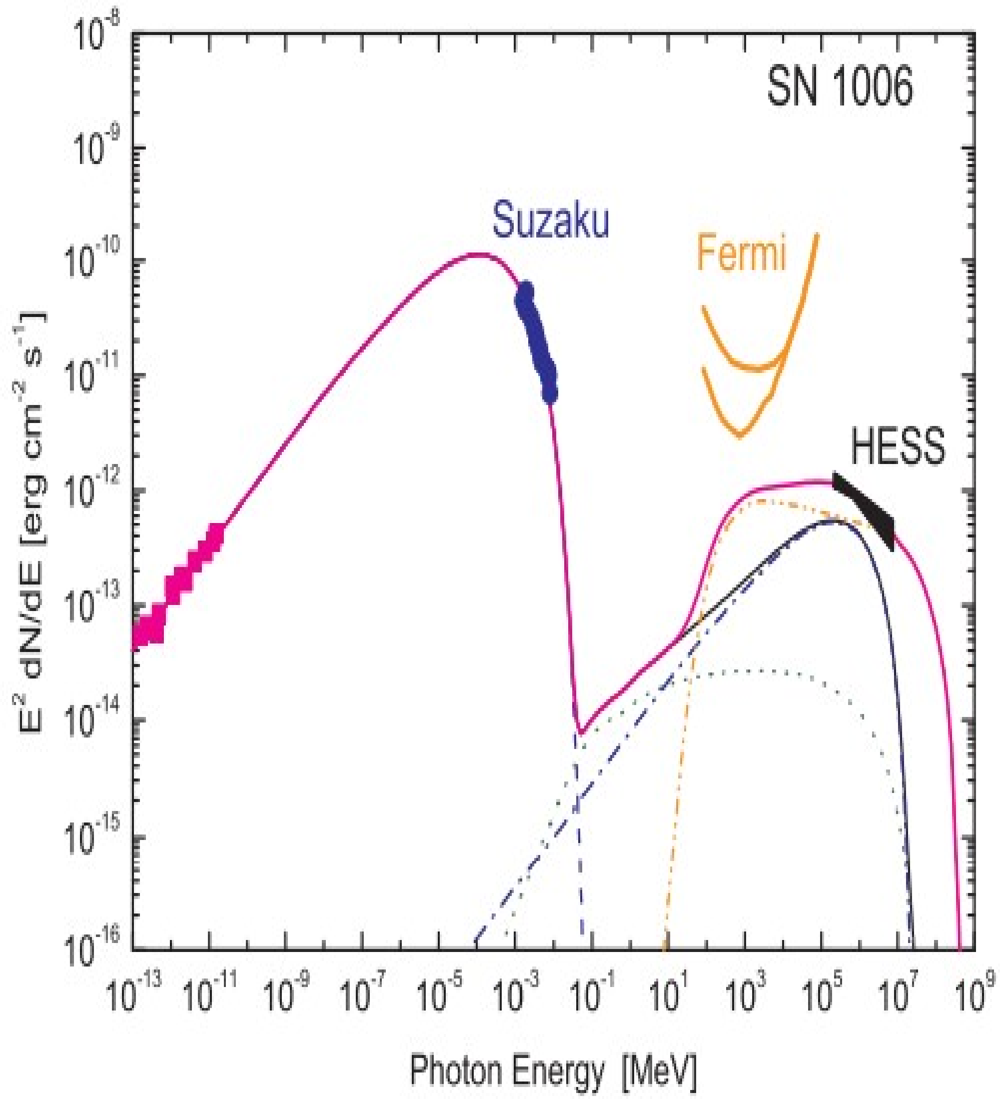
Strong Radio and X emission due to synchrotron demonstrate the presence of
tev electrons,

TeV emission detected by HESS, morphologically well correlated with the emission in the Hard X band (after convolution with HESS Psf)

N/S regions with similar spectrum ~ 2.3 btw .1 and 10 TeV

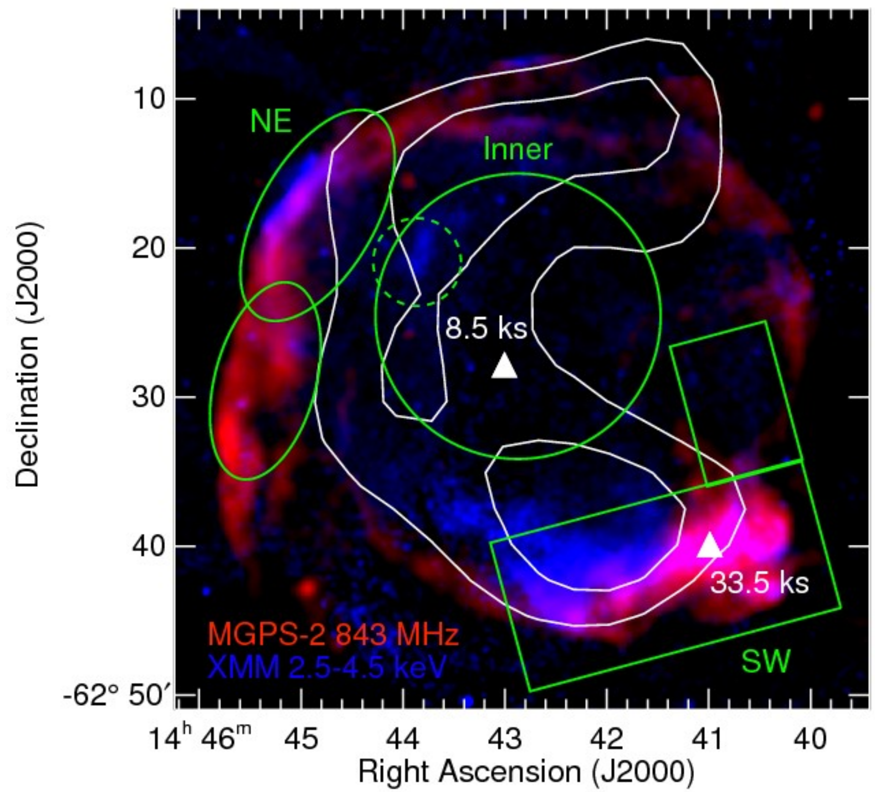
The leptonic scenario fail to fit the data > 10 TeV

Hadronic component @ HE

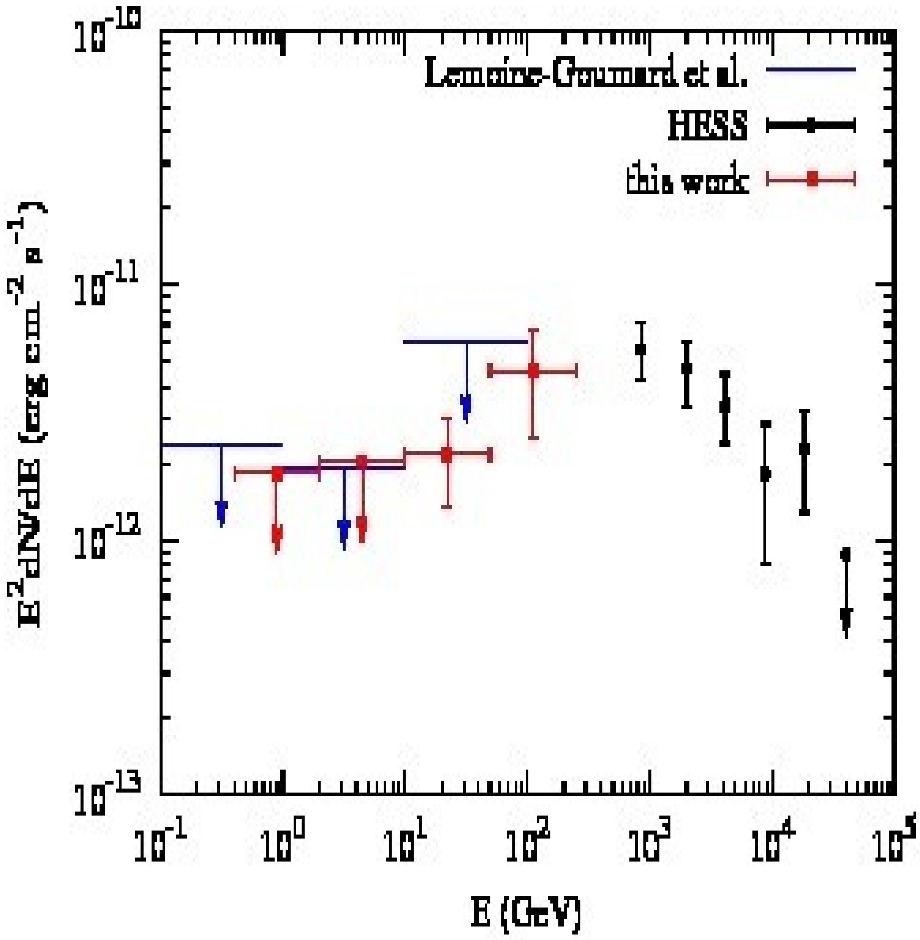


Tang et al 2013, RAA, 13

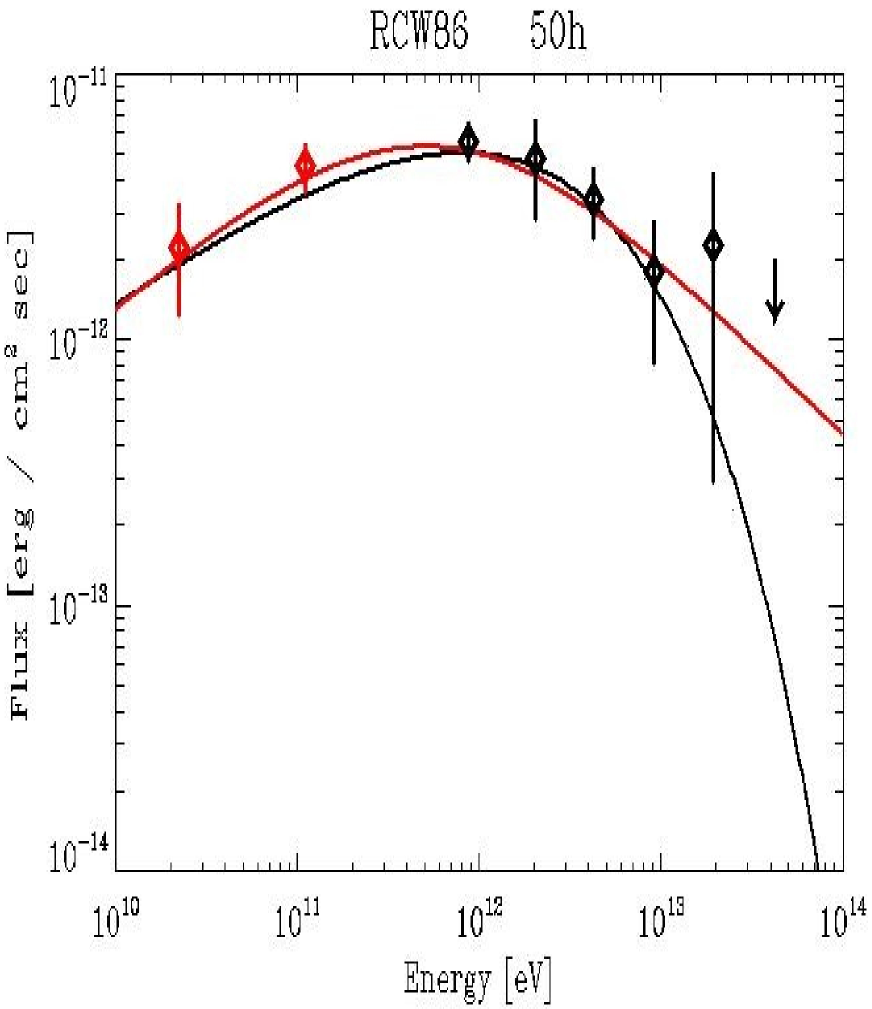
- Young remnant (~2000 yrs)
- Sees in Radio band, X-rays, Gev (Fermi) and TeV (HESS)
- Interacting with molecular clouds or 1713-like ?



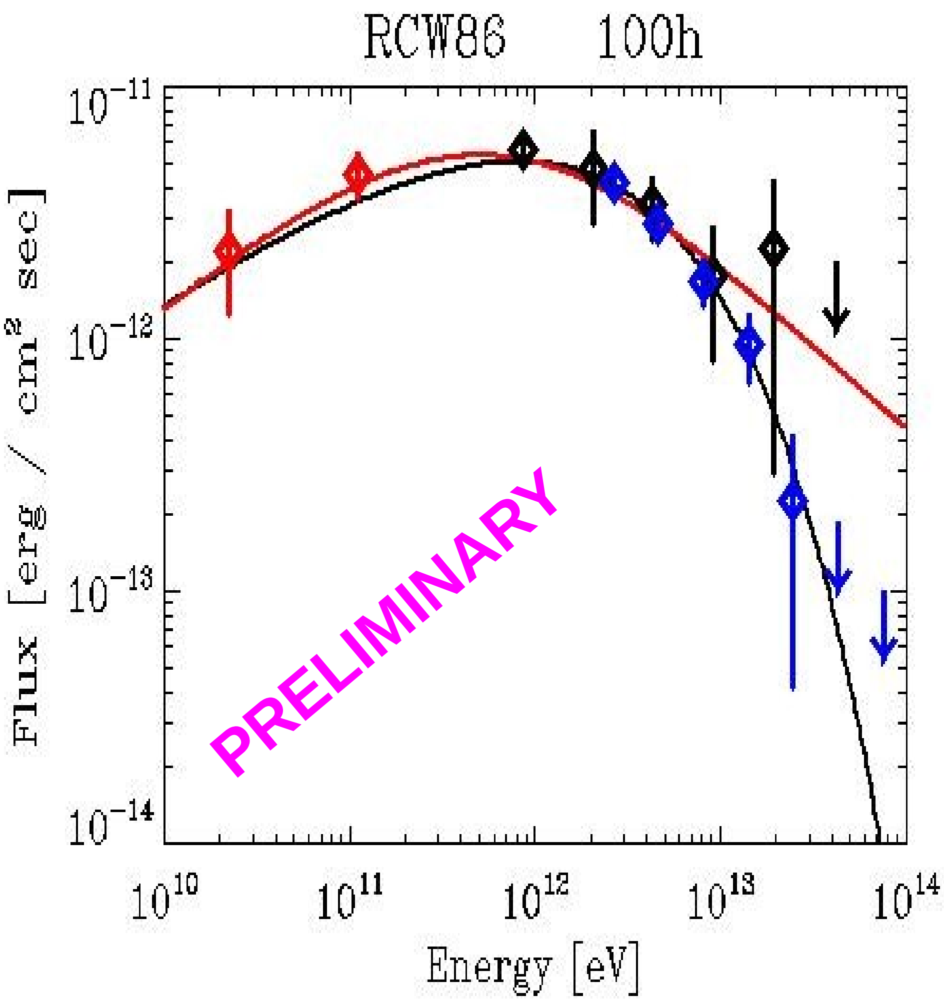
- Young remnant (~2000 yrs)
- Sees in Radio band, X-rays, Gev (Fermi) and TeV (HESS)
- Interacting with molecular clouds or 1713-like ?



- Young remnant (~2000 yrs)
- Sees in Radio band, X-rays, Gev (Fermi) and TeV (HESS)
- Interacting with molecular clouds or 1713-like ?



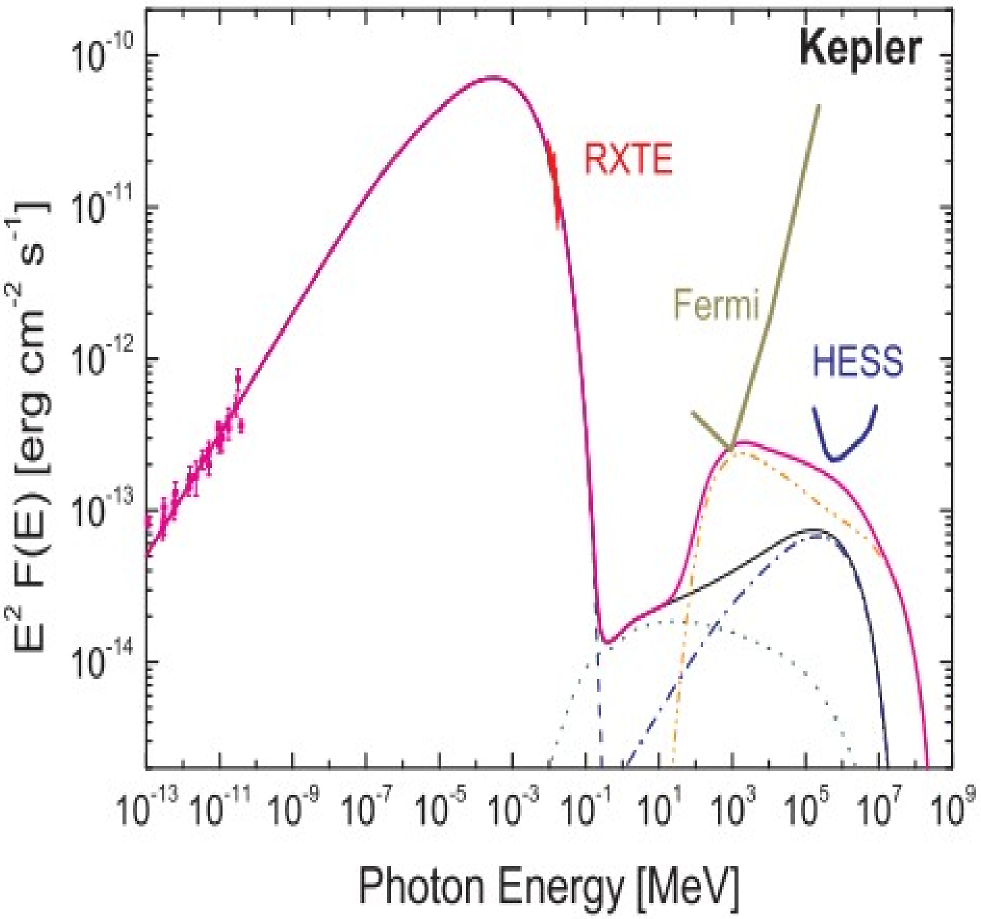
- Young remnant (~2000 yrs)
- Sees in Radio band, X-rays, Gev (Fermi) and TeV (HESS)
- Interacting with molecular clouds or 1713-like ?



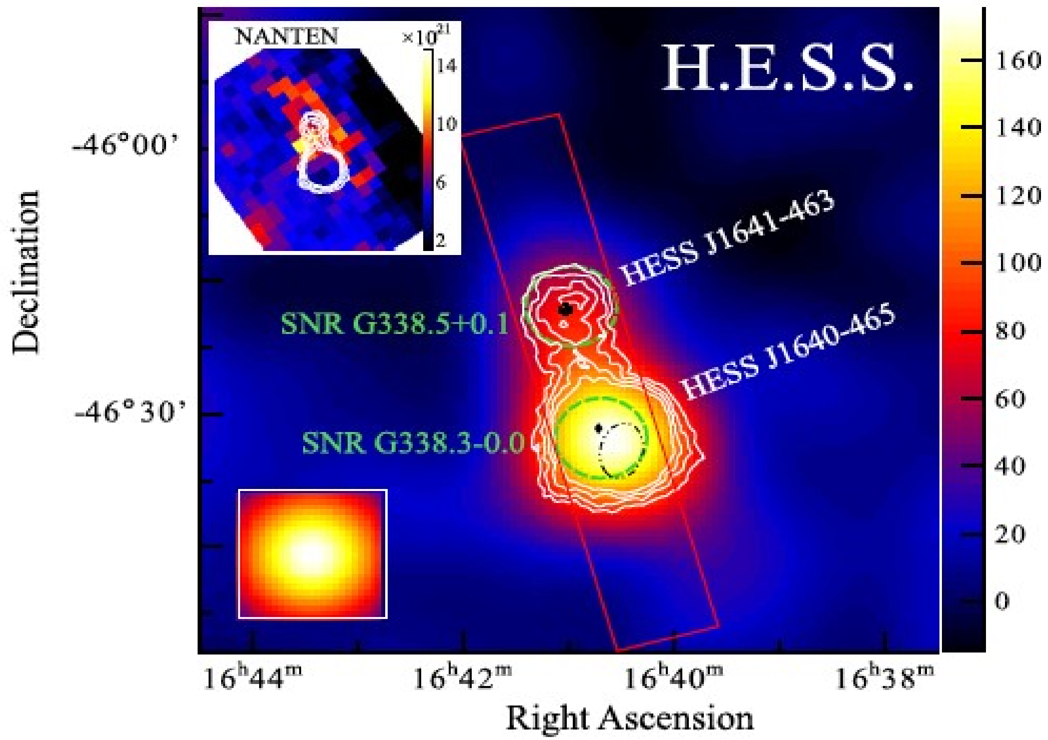
Giuliani et al., ICRC 34, in prep.

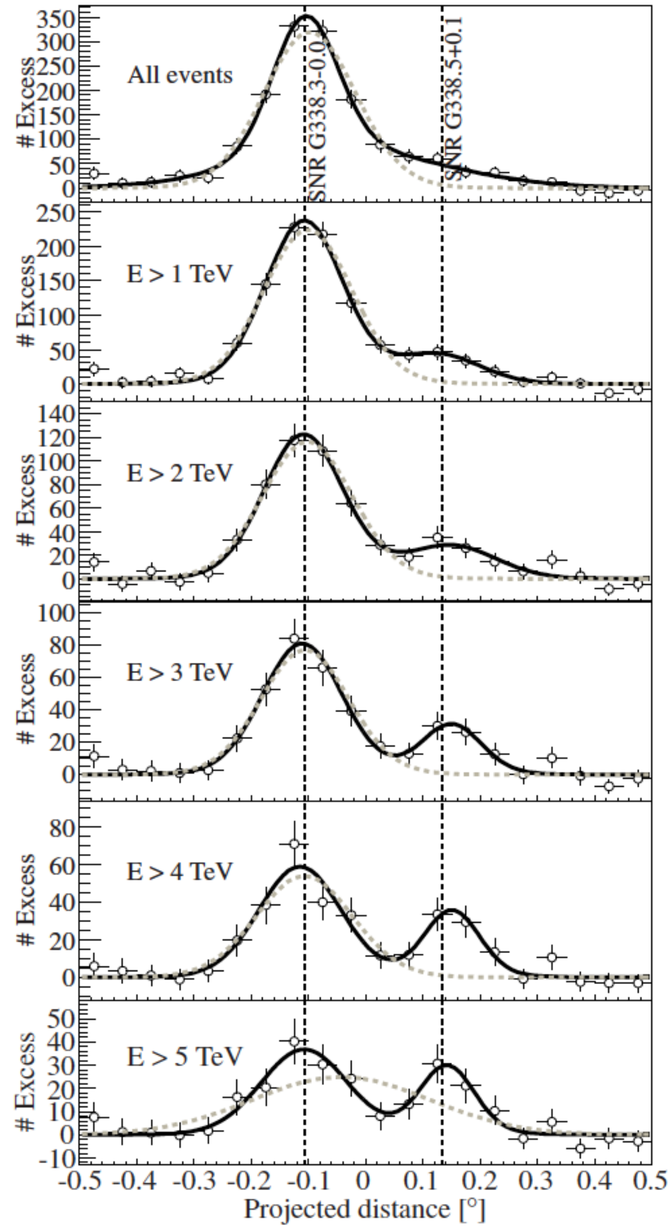
- ***Kepler SNR***
- ***SN 1987A***

- ***Not yet observed in gamma-rays***
- ***Hard TeV emission expected***



Tang et al 2013, RAA, 13

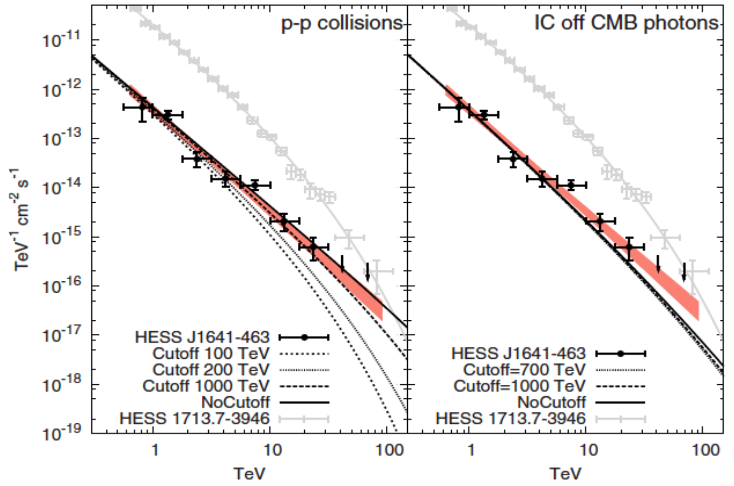




H.E.S.S. spectrum accumulated in 72 hr

Very hard source, sp.ind. ~ 2.1

Abramowski et al, 2014

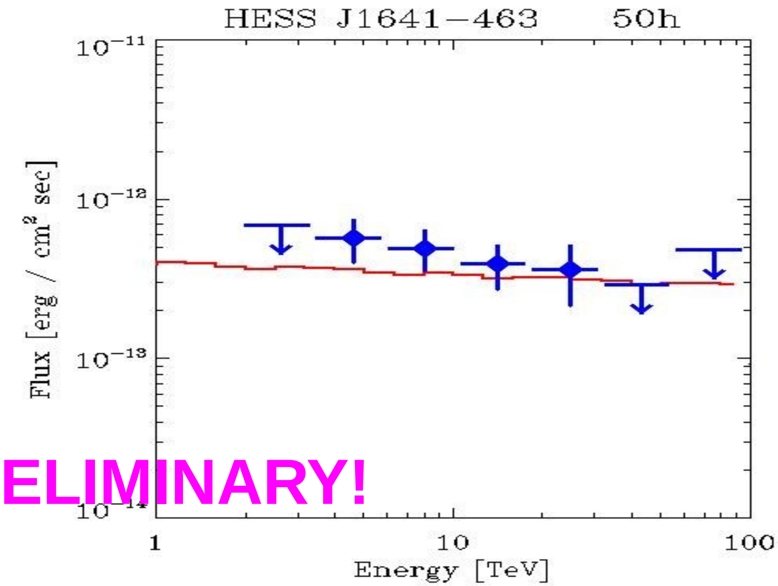


H.E.S.S. spectrum accumulated in 72 hr
Very hard source, sp.ind. ~ 2.1

It can be monitored for 492 hr
[Feb. - Sept., ZA < 35deg]

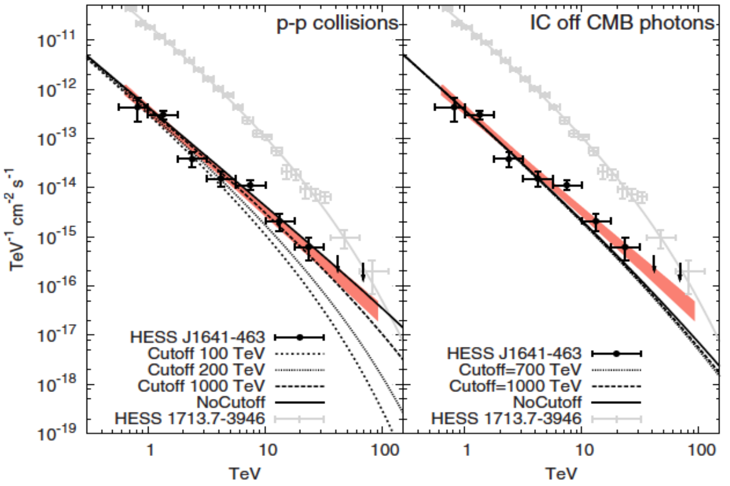
(Work in progress) We can investigate:

- performance of the mini-array (SVP);
- is there a spectral cut-off? at which energy?
- nature of this source, SNR? PWN? Binary?



HESS J1641-463

Abramowski et al, 2014

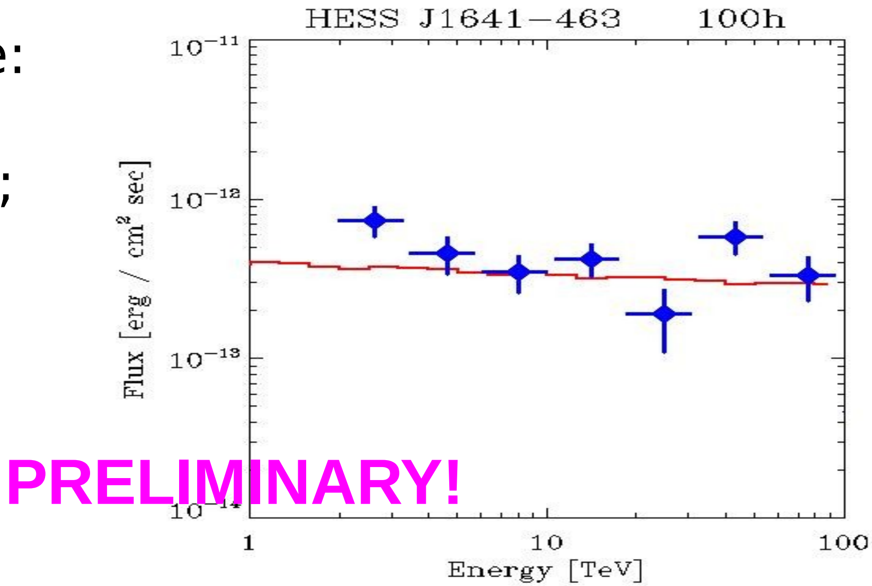


H.E.S.S. spectrum accumulated in 72 hr
Very hard source, sp.ind. ~ 2.1

It can be monitored for 492 hr
[Feb. - Sept., ZA < 35deg]

(Work in progress) We can investigate:

- performance of the mini-array (SVP);
- is there a spectral cut-off? at which energy?
- nature of this source, SNR? PWN? Binary?



Romano, Vercellone, Giuliani et al., ICRC 34, in prep.

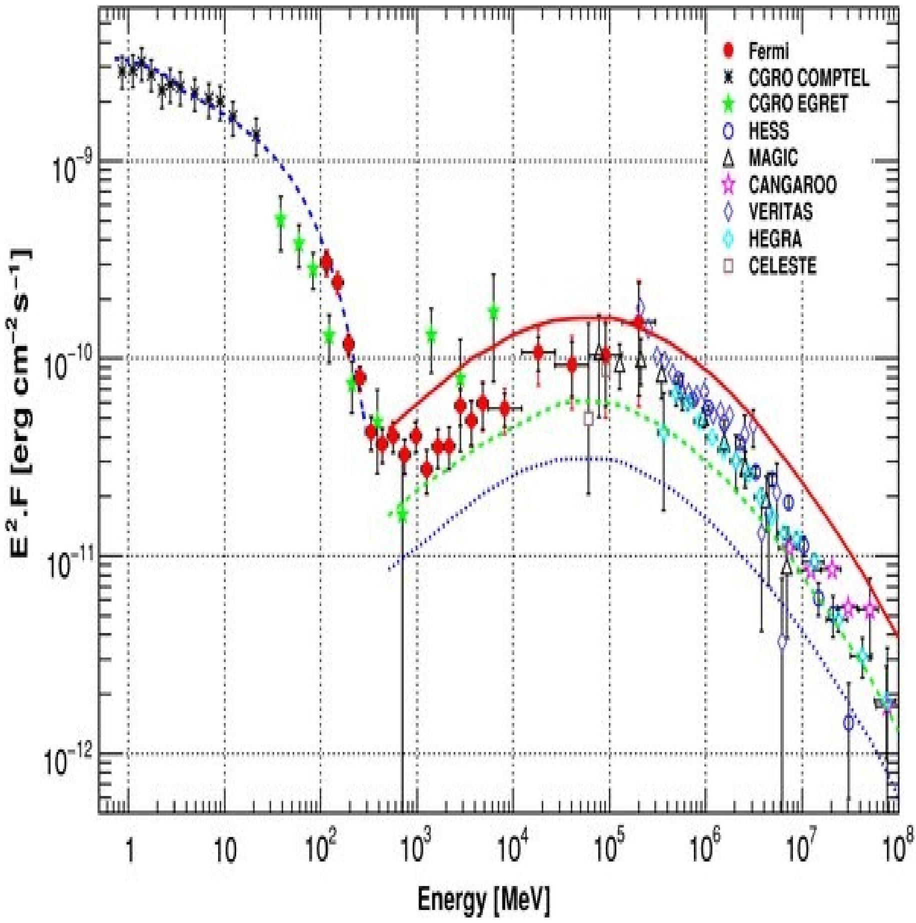
Features @ HE end of the spectrum

- other not-IC components ?

- B → the TeV cut-off location depends on Sync vs IC coolings processes

Variability above 10 TeV

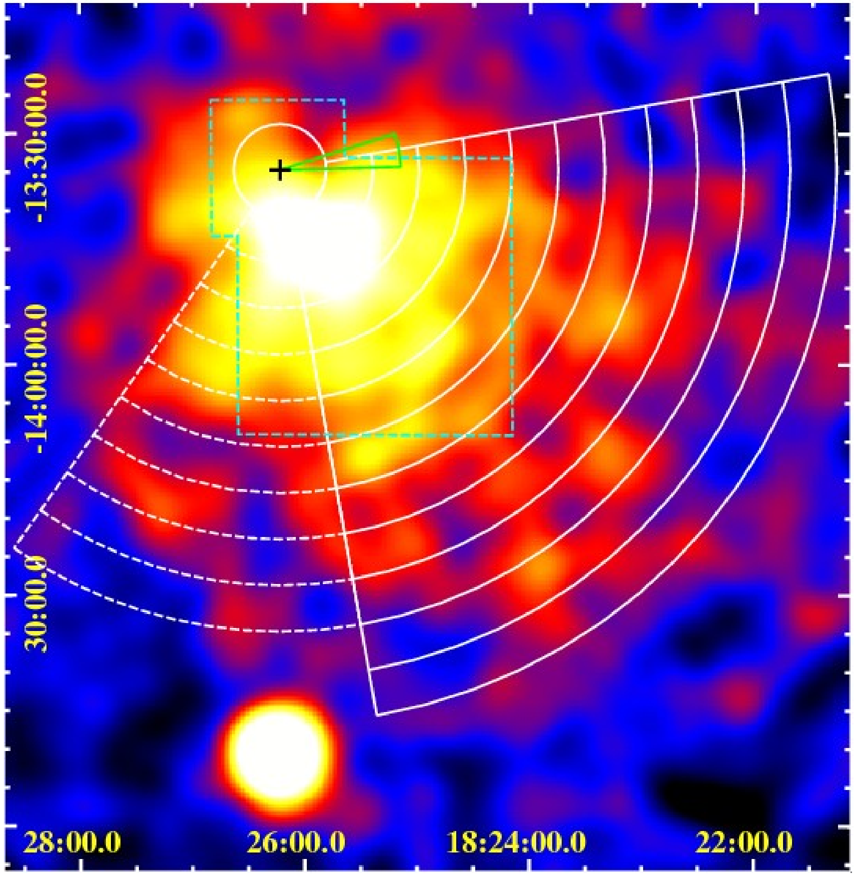
(Electrons ~100 TeV producing syc. flares @ 100 MeV produce IC @ 10 TeV)

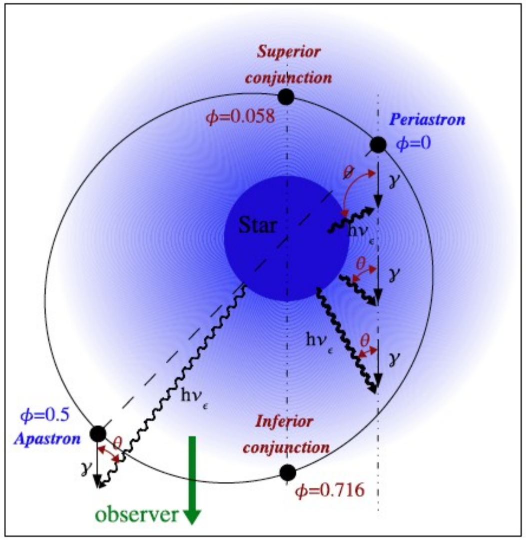


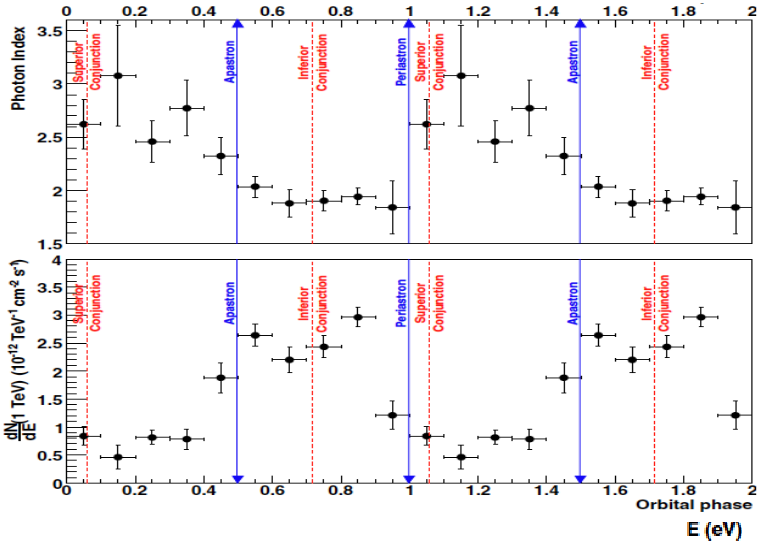
Morphological Studies
- morphology / size vs energy (HESS 1825-137, Vela X)
- Evolution of the PWNe

HE spectrum:
- maximum electron energies
- derive B

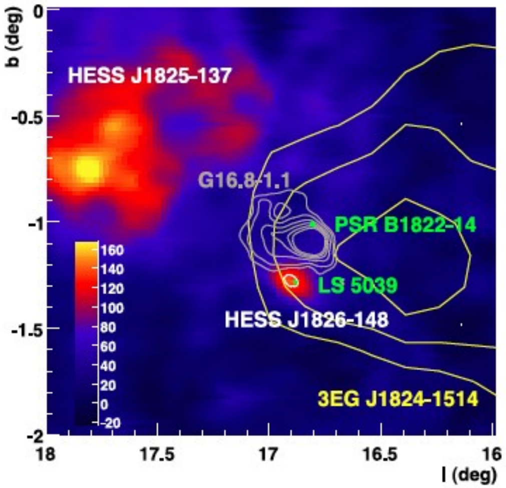
PWN in Milagro sources (Geminga)







Aharonian et al, 2006



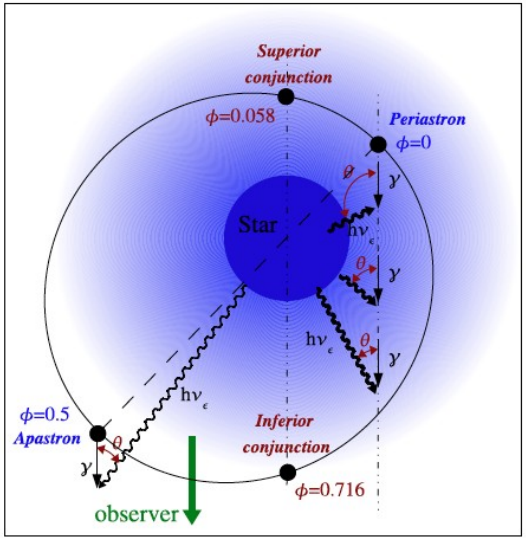
Dubus, 2013

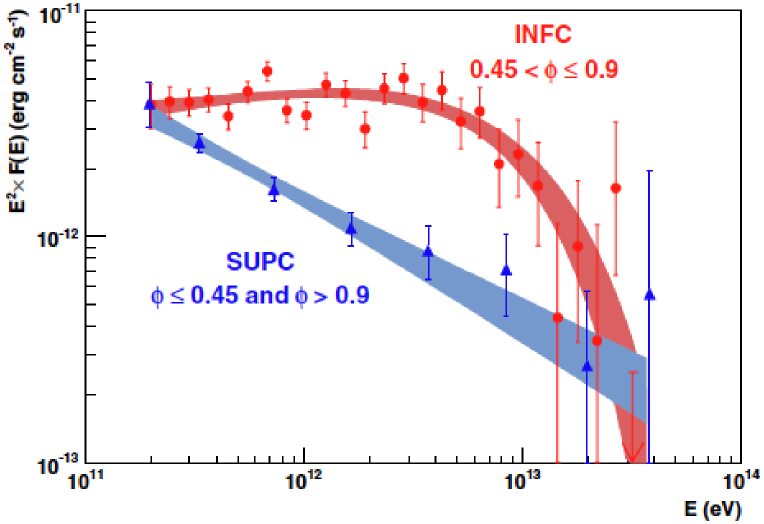
H.E.S.S. spectrum accumulated in 70 hr
Data are not well constrained above 10 TeV

It can be monitored [Mar. - Sept., ZA<35 deg] for more than 400 hr
It can be studied simultaneously with PWN HESS J1825-137
We can investigate:

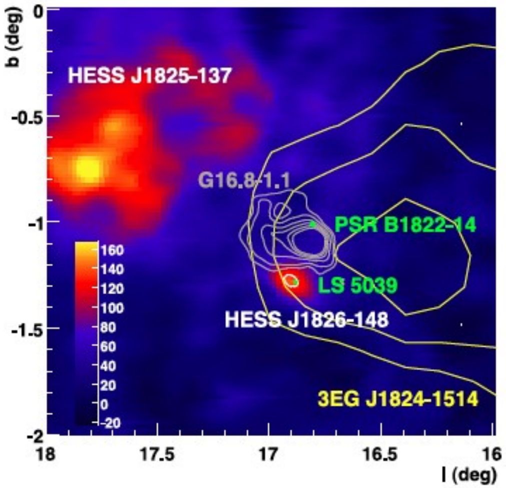
- phase-dependent gamma-ray absorption/emission;
- phase-dependent spectral modulation.

LS 5039





Aharonian et al, 2006



Dubus, 2013

H.E.S.S. spectrum accumulated in 70 hr
Data are not well constrained above 10 TeV

It can be monitored [Mar. - Sept., ZA<35 deg] for more than 400 hr
It can be studied simultaneously with PWN HESS J1825-137
We can investigate:

- phase-dependent gamma-ray absorption/emission;
- phase-dependent spectral modulation.

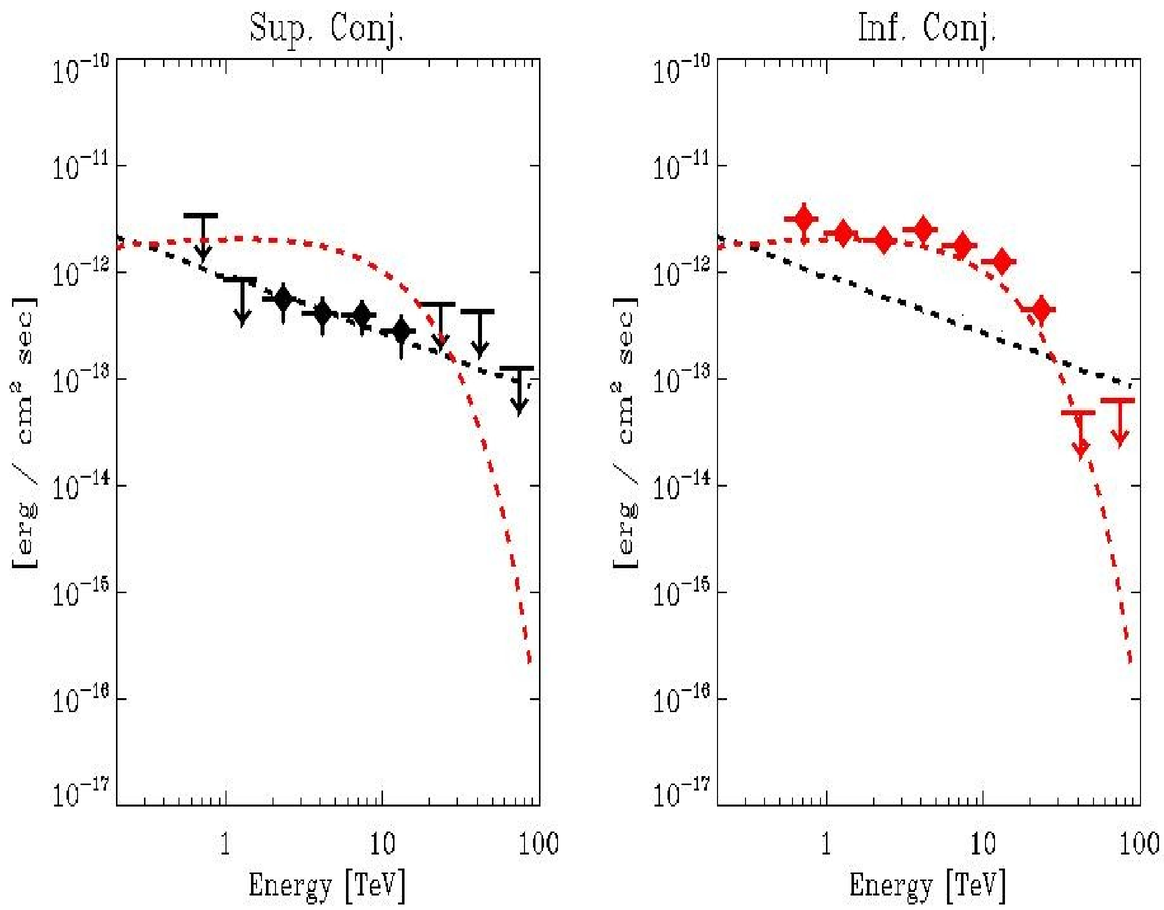
ASTRI/CTA Mini-array, 7 units.

ASTRIsim 100 hr simulation

- 50 hr INFC
- 50 hr SUPC

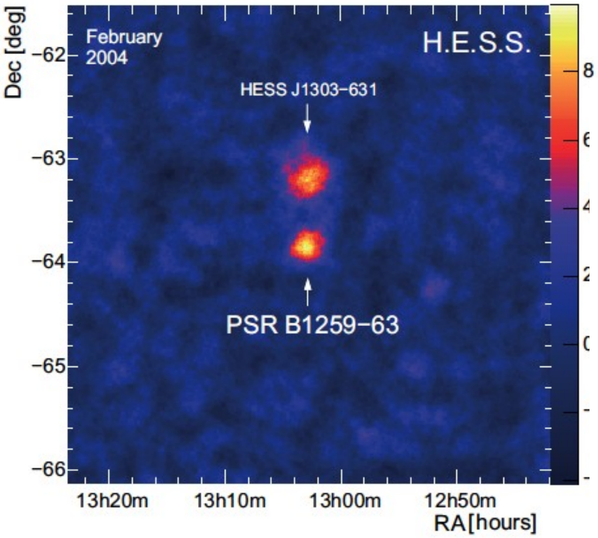
Next step:

Simulation of the detecti
performance at different
orbital phases.

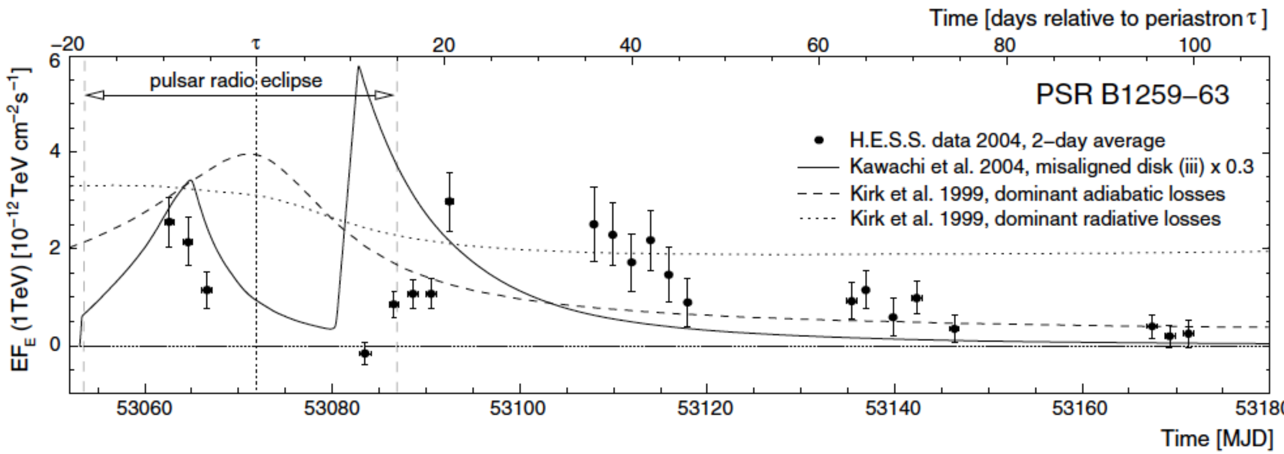


PRELIMINARY!

Romano, Vercellone, Giuliani et al., ICRC 34, in prep.



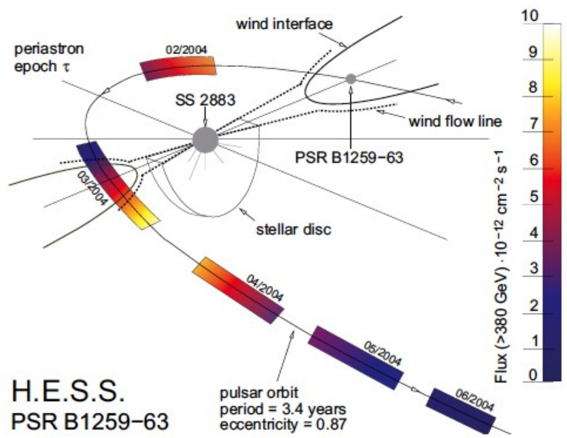
Aharonian et al, 2005



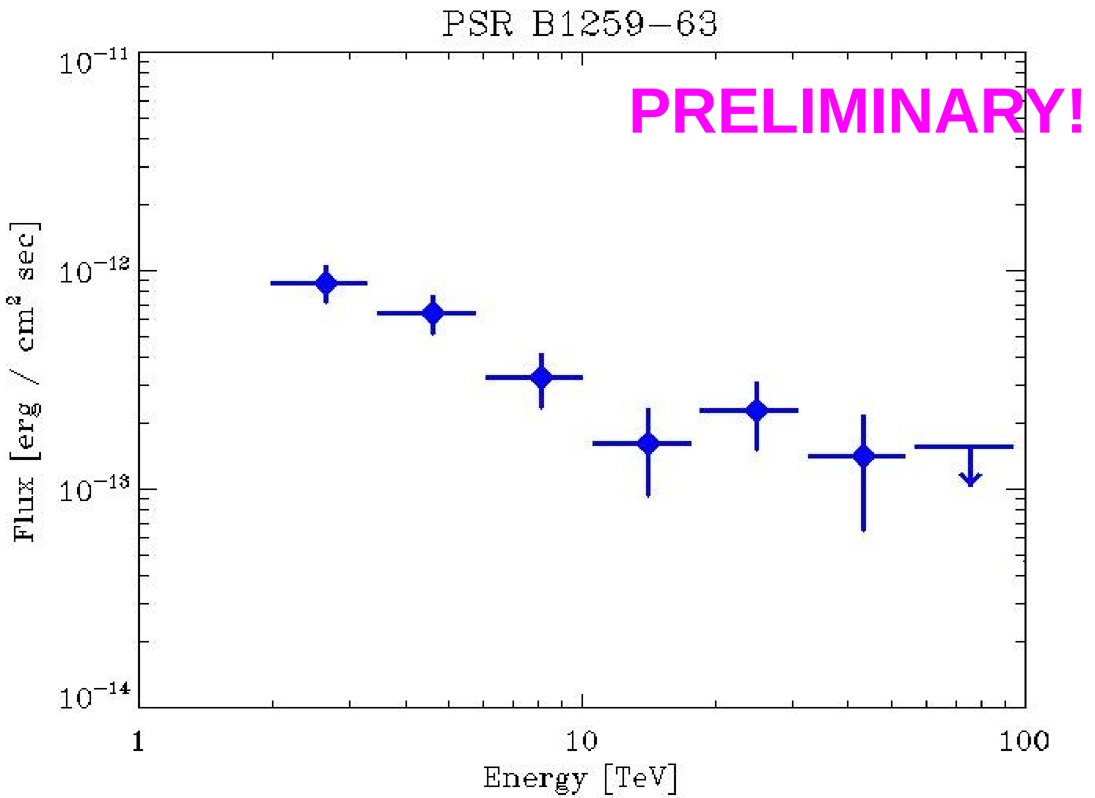
H.E.S.S. spectrum accumulated in 50 hr   Porb ~ 1236.72 d (~ 3.4 yr). A few points above a few TeV

It can be monitored [Jan. - Jun, ZA < 35deg] for more than 150 hr.   It can be studied simultaneously with PWN HESS J1303-631.

We can investigate [next periastron passage: ~ 2017-09-21]:   phase-dependent gamma-ray flux, probing different theoretical emission models (peak and dim around periastron, is it periodic?)



Aharonian et al, 2005



ASTRI/CTA mini-array, 7-units.
ASTRIsim 100 hr simulation of the average spectrum.

Next step:
simulation of the possible flux evolution as a function of the time relative to the periastron passage in order to possibly discriminate different emission scenarios.

Conclusion :

We will have a lot of fun with the ASTRI-CTA mini-array !

Thanks !