Unveiling the origin of gamma-ray emission towards the SNR W41 region with H.E.S.S. and *Fermi*-LAT

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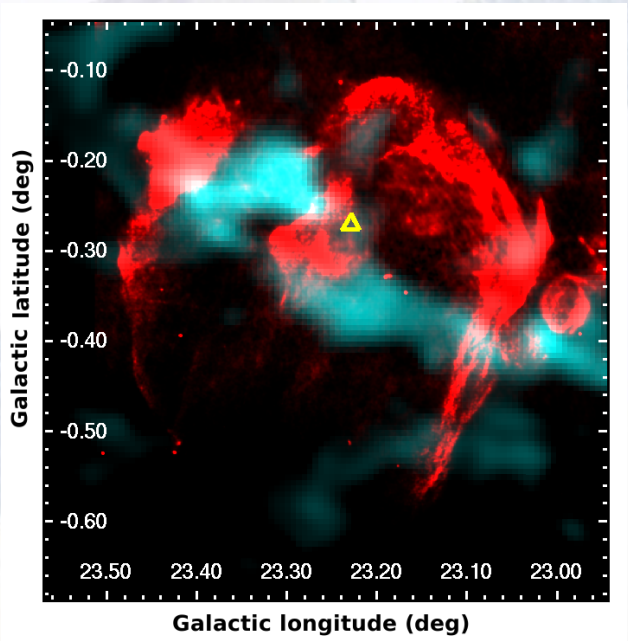
Background on supernova remnant W41

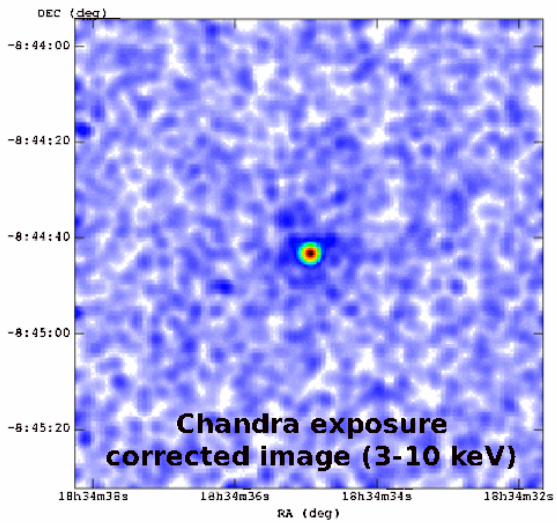


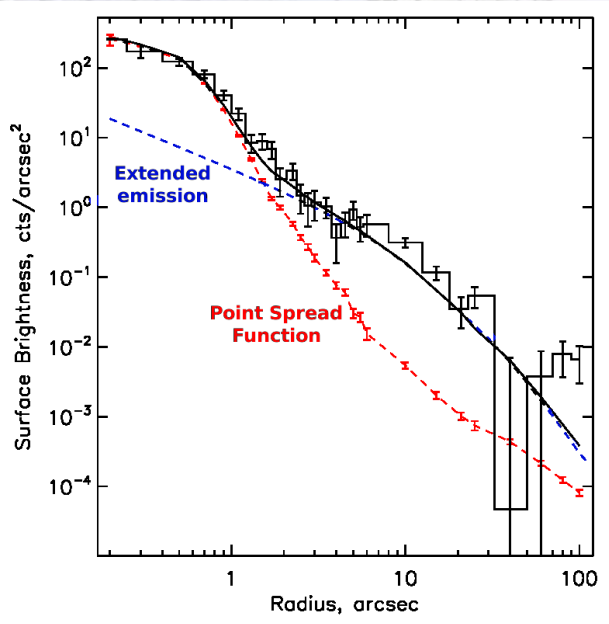
Composite image.
VLA 20 cm radio data[4],
GRS ^{13}CO data (75-82 km/s)[5].
Triangle: pulsar candidate position[2][3]

- Distance(HI - CO): 4.2 kpc [1]
- Age: $6.10^4 - 2.10^5$ yrs
- Associated with 10^5 $M_\odot$ GMC
- New PSR candidate.

$\rightarrow$ $\dot{E}_{estimated} \simeq 4.10^{36}$ erg/s [2][3]

- Compact X-ray nebula [3]

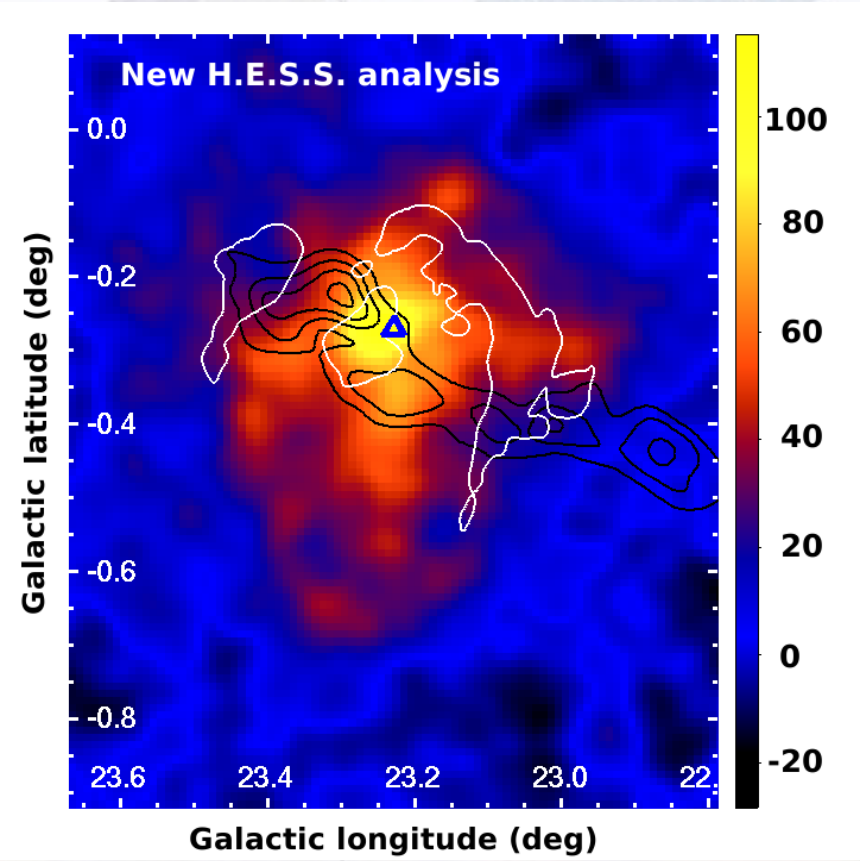




Chandra image and radial profile on X-ray data [3].

[1]Leahy et al. 2008, AJ, 135, 167 - [2]Tian et al. 2007 ApJ 657 L25 - [3]Misanovic Z. et al. 2011, astro-ph:1101.1342v1 - [4]Helfand et al. 2006, AJ, 131, 2525 - [5]Jackson et al. 2006, ApJS, 163, 145

Detected TeV emission with H.E.S.S.



- Discovered by H.E.S.S. (2005)[1]
- 2011: new Xeff analysis [2](PSF=0.06°)
  - ▷ now 52 live hours
    (vs. 7.5 hours in 2005 [3])
- Black: GRS ^{13}CO data integrated around W41 velocity
- White: VLA radio data
- Triangle: pulsar candidate

TeV morphology not compatible with CO

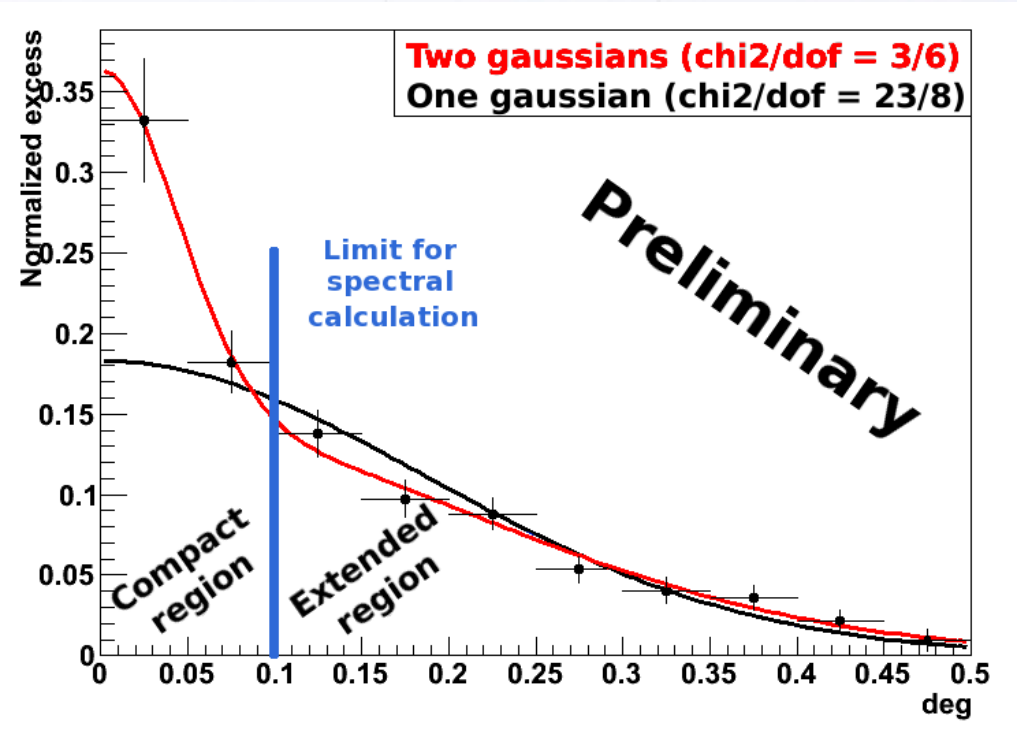
[1]Aharonian et al. 2005, Science 307, 1938
[2]Dubois et al. 2006, APh, 32, 73
[3]Aharonian et al. 2006, A&A, 636, 777

Radial profile centred on pulsar candidate

No E-dependent morphology ▷ Radial profile on all energy band

- TeV peak position:
  - ▷ $l = 23.24° \pm 0.01°_{stat}$
    $b = -0.26° \pm 0.01°_{stat}$

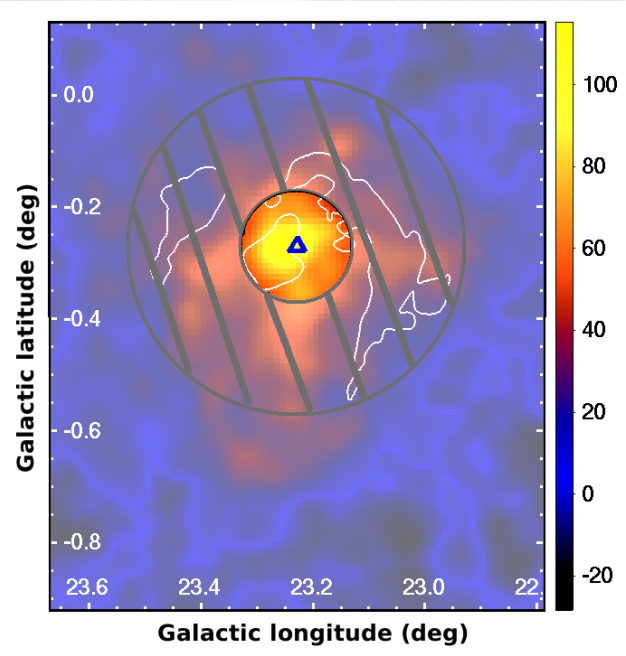
TeV PEAK COMPATIBLE WITH PULSAR CANDIDATE



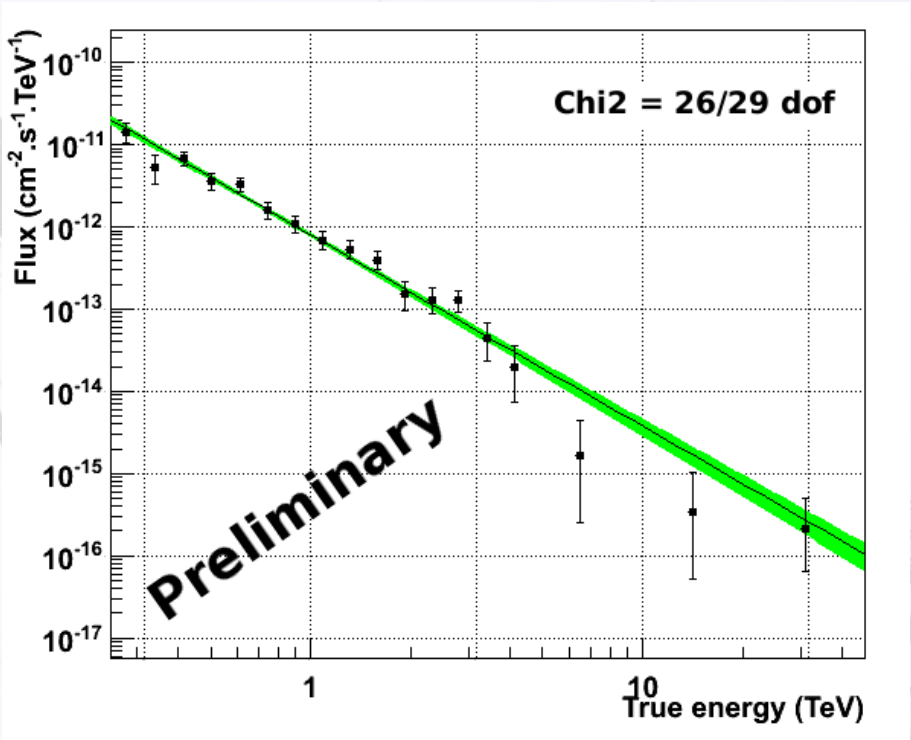
- 2 components needed:
  - Compact: $\sigma_{intrinsic} = 0.04° \pm 0.01°_{stat}$
  - Extended: $\sigma_{intrinsic} = 0.20° \pm 0.03°_{stat}$

EXTENDED EMISSION DETECTED

Spectral analyses - Compact source



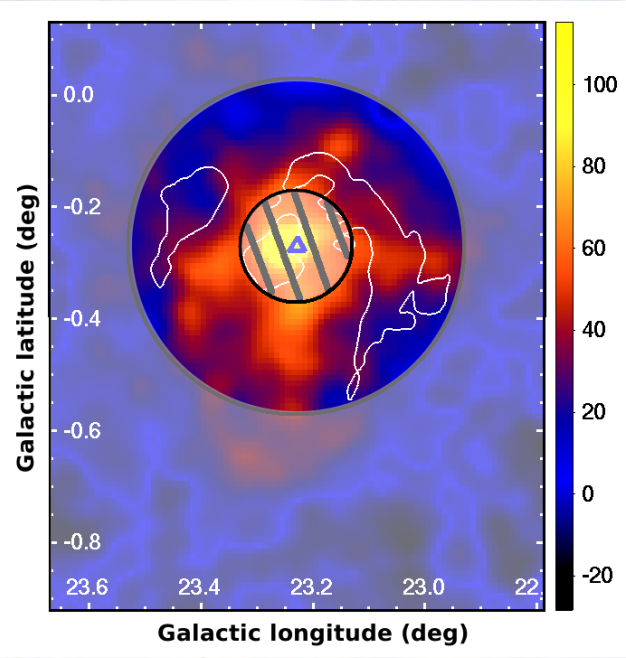
Spectra for $r < 0.1°$



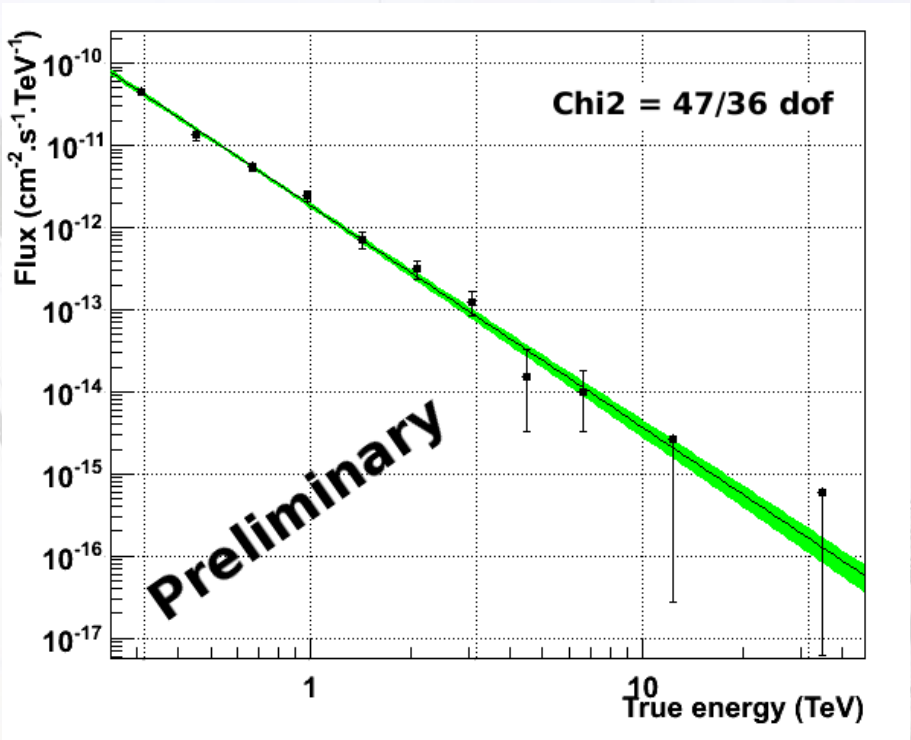
- Index: $2.33 \pm 0.09_{stat}$
- Flux: $\phi(1\ \text{TeV}) = (0.80 \pm 0.06_{stat}) \times 10^{-12}\ \text{cm}^{-2}.\text{s}^{-1}.\text{TeV}^{-1}$

NO INDICATION FOR CUTOFF

Spectral analyses - Annular region



Spectra for $r \in [0.1°; 0.3°]$



- Index: $2.70 \pm 0.08_{stat}$
- Flux: $\phi(1\ \text{TeV}) = (1.8 \pm 0.1_{stat}) \times 10^{-12}\ \text{cm}^{-2}.\text{s}^{-1}.\text{TeV}^{-1}$

NO INDICATION FOR CUTOFF

Energetic aspects on TeV emission

Using Mattana et al. (2009) results

- If pulsar candidate associated with W41: $d \simeq 4$ kpc
- X-ray nebula luminosity:
  - $L_X = (\sim 1.5) \times 10^{33}$ erg/s

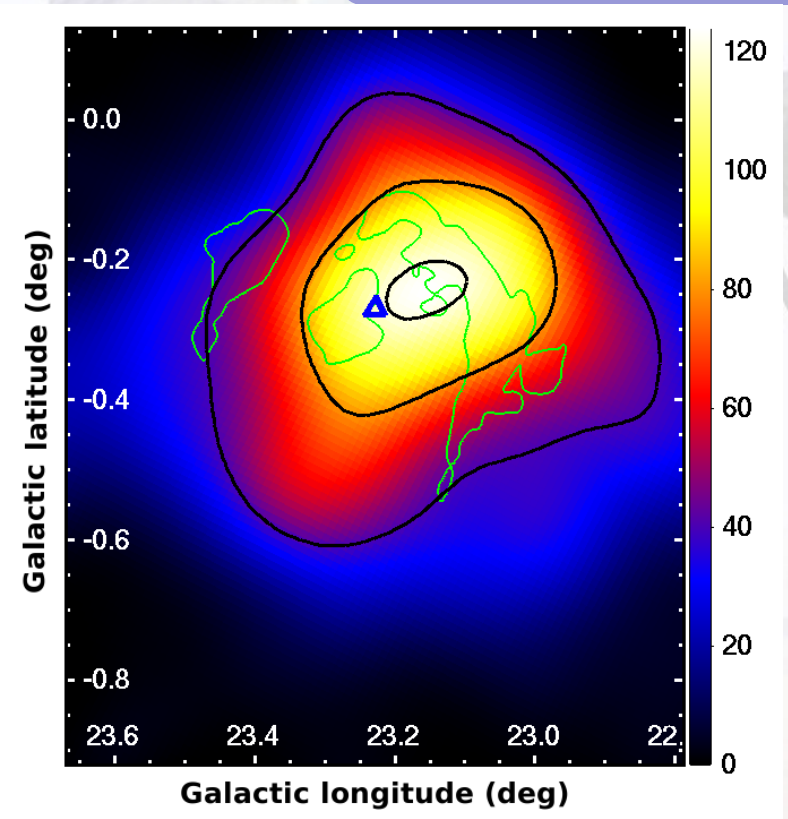
IF PULSAR CANDIDATE PRODUCES THE γ-RAY EMISSION OF...

	Compact Source	**Extended Source**
L_γ (erg/s)	$(2.97 \pm 0.78) \times 10^{33}$	$1.23 \pm 0.26 \times 10^{34}$
estimated τ_c (yr)	$\sim 5.2 \times 10^3$	$\sim 10.2 \times 10^3$
	$\bigtriangledown$	$\bigtriangledown$
W41's age: $\sim 10^5$ *yr*	younger than SNR	younger than SNR

IN ANY CASE PSR CHARACTERISTIC AGE YOUNGER THAN SNR?

Fermi-LAT data analysis for $E_\gamma > 1$ GeV

SOURCE DETECTED AT TS = 158

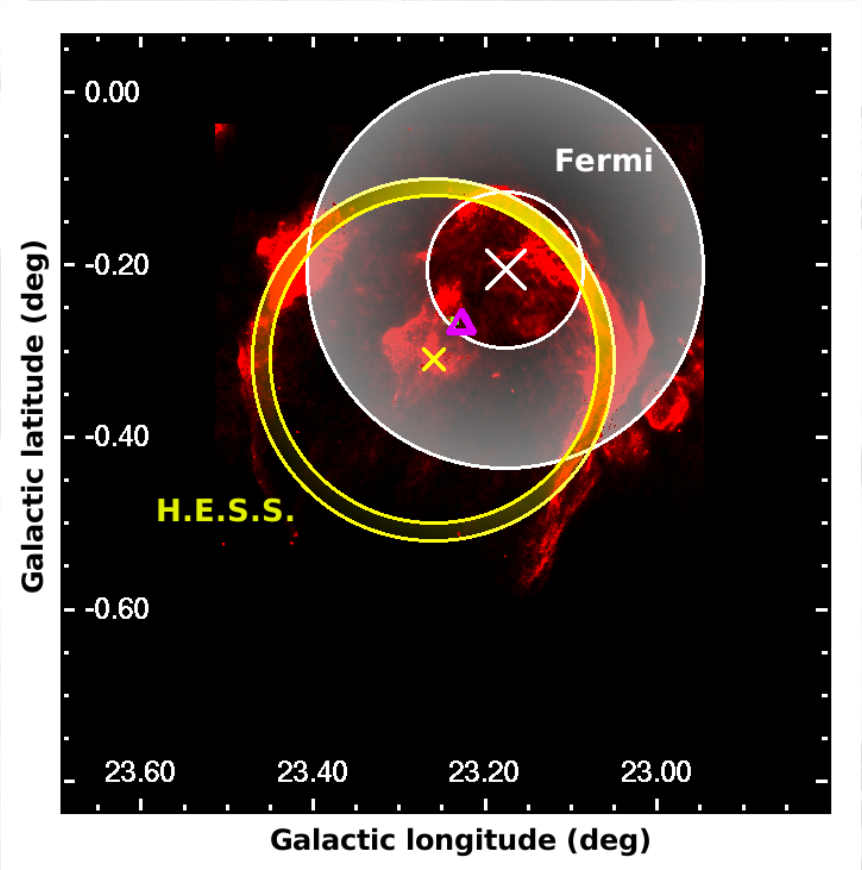


Fermi TS map. TS contours: 40, 80, 120.

- ROI size: 15°
- Preliminary 2FGL sources within 15°
- 24 months data:
  - ▷ rocking angle $< 52°$
  - ▷ zenith max $< 100°$
- IRFs: P6-V11-DIFFUSE
- PointLike analysis

- Gaussian model of W41
  - ▷ Extension: $\sigma_{intrinsic} = 0.16° \pm 0.07°$
  - ▷ TS of extension: $TS_{ext} \simeq 30$

HESS-Fermi morphological comparison



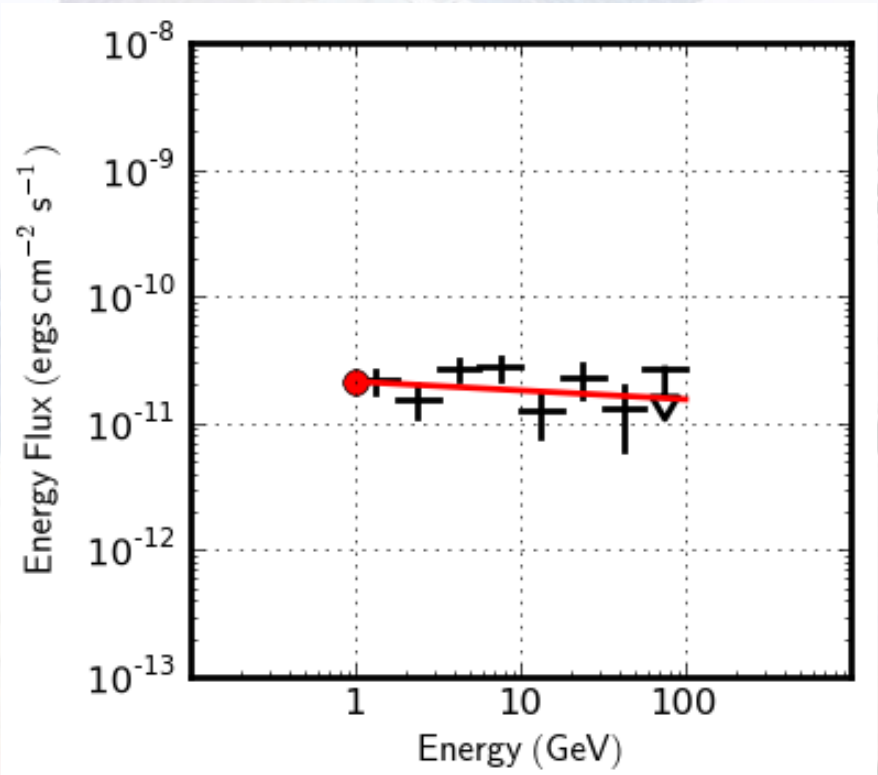
VLA 20cm radio map.
Gray ring: GeV extension.
Yellow ring: TeV extended component.
Positions with errors marked with crosses.

- TeV extended emission:
  $l = 23.26 \pm 0.01°$,
  $b = -0.31 \pm 0.01°$,
  $\sigma_{int} = 0.20 \pm 0.01°$
- GeV emission:
  $l = 23.18 \pm 0.07°$,
  $b = -0.21 \pm 0.07°$,
  $\sigma_{int} = 0.16 \pm 0.07°$

$\Rightarrow$ Intrinsic extensions: compatible

GOOD MATCHING BETWEEN GEV AND TEV EMISSIONS

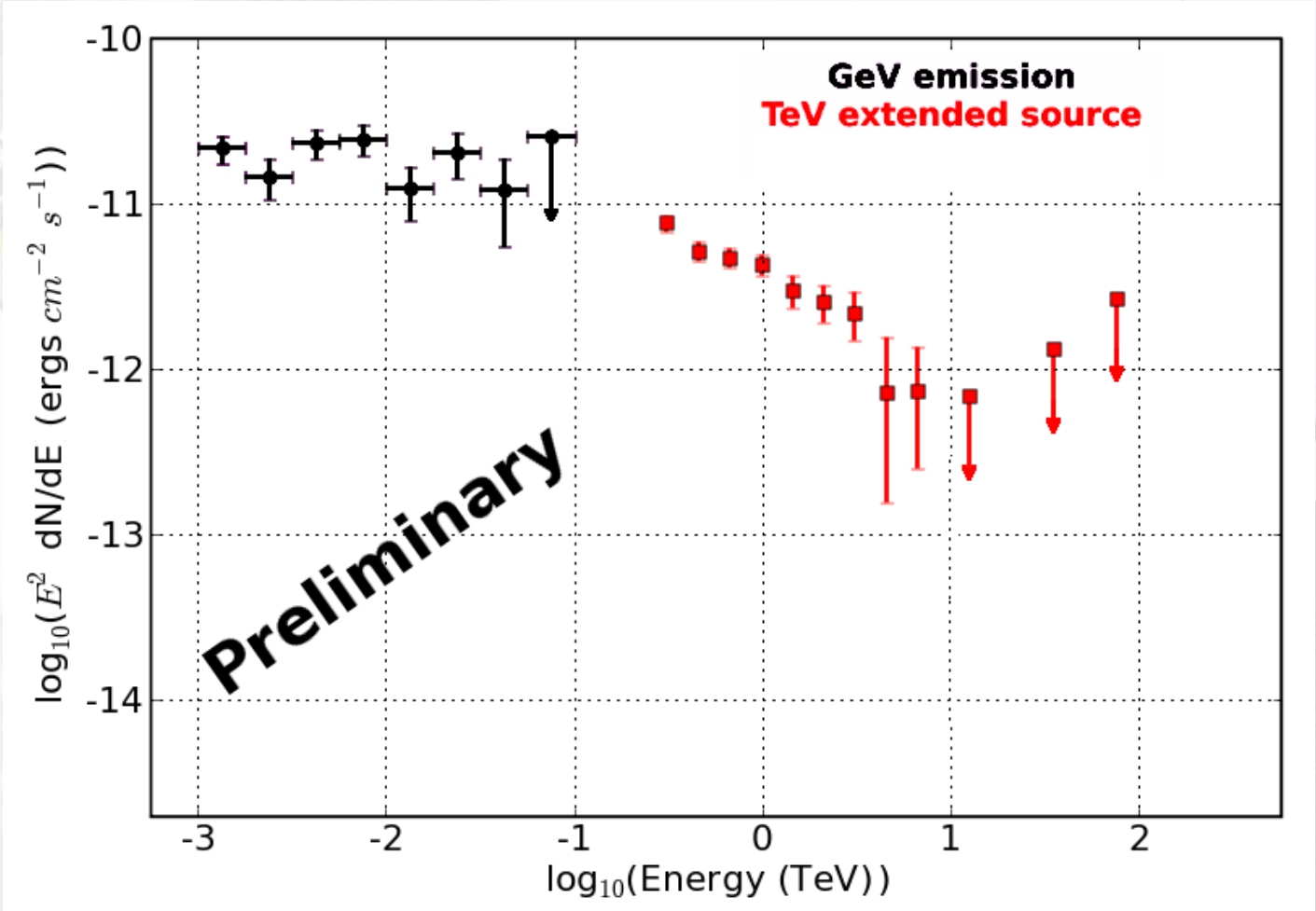
Fermi spectral analysis for $E\gamma > 1$ GeV



- Fitted with a Power Law:
- $\frac{dN}{dE} = I_0 \frac{(\alpha+1)E^{\alpha}}{E_{max}^{\alpha+1} - E_{min}^{\alpha-1}}$
- $E_{min} = 1$ GeV - $E_{max} = 100$ GeV
- $\alpha = 2.1 \pm 0.1$
- $I_0 = (1.2 \pm 0.1) \times 10^{-8}$ cm^{-2}s^{-1}

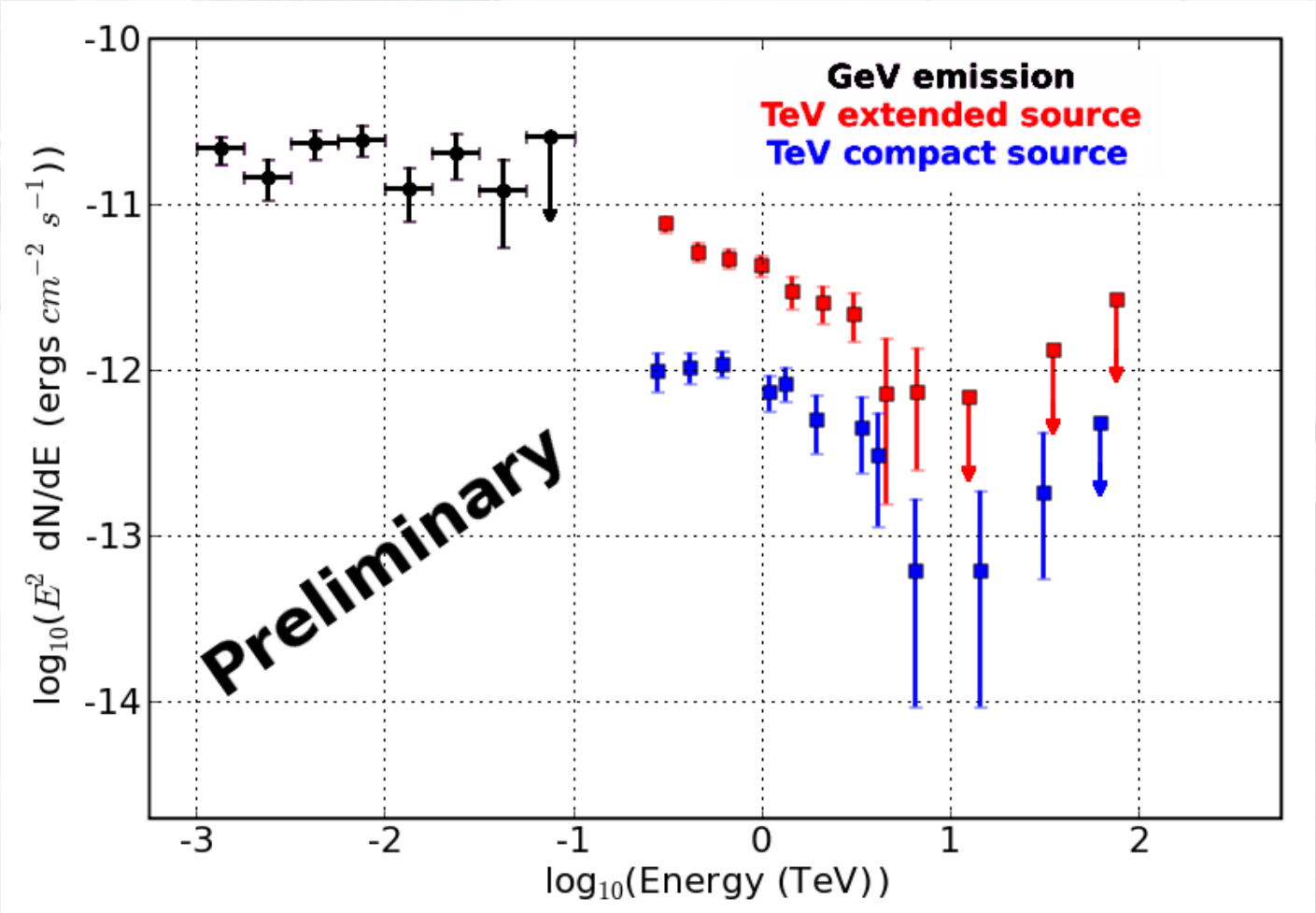
NOT TYPICAL FOR PWN SPECTRA

HESS-Fermi spectral comparison



EXTENDED TEV EMISSION JOINS SMOOTHLY GEV EMISSION

HESS-Fermi spectral comparison



COMPACT TEV EMISSION NOT SEEN BY *Fermi*-LAT

Conclusion

- **TeV Extended emission:**
  - Good matching with GeV emission
  - Compatible intrinsic sizes
  - γ-ray spectra like interacting SNRs
  - W41 possibly in interaction with a cloud
  - ▷ **Interacting SNR scenario ?**
    But TeV morphology does not match ^{13}CO density
  - ▷ **PWN scenario ?**
    But GeV spectrum not typical and PSR younger than SNR?
- **TeV Compact source:**
  - Not seen by *Fermi*-LAT
  - Coincident with *Chandra* compact nebula and pulsar candidate
  - No pulsations found in GeV, X-ray and radio data
  - ▷ **Young PWN scenario ?**
    But PSR younger than SNR?

Thanks for your attention