

Latest news from the H.E.S.S. GPS

Vincent Marandon
2nd DIAS-OKC Meeting

Svenja Carrigan, François Brun, Ryan C.G. Chaves,
Christoph Deil, Axel Donath, Henning Gast,
Vincent Marandon, Matthieu Renaud



Introduction

H.E.S.S. Instrument

- 4 imaging atmospheric Cherenkov telescopes in Namibia
- Large **5° field of view**, good **angular resolution <0.1°**
- Energy range **~200 GeV – 100 TeV**, energy resolution <15%
- High sensitivity (5 σ): **1% Crab in 25 h**



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- ⇒ **ideal for Survey of inner Galaxy**

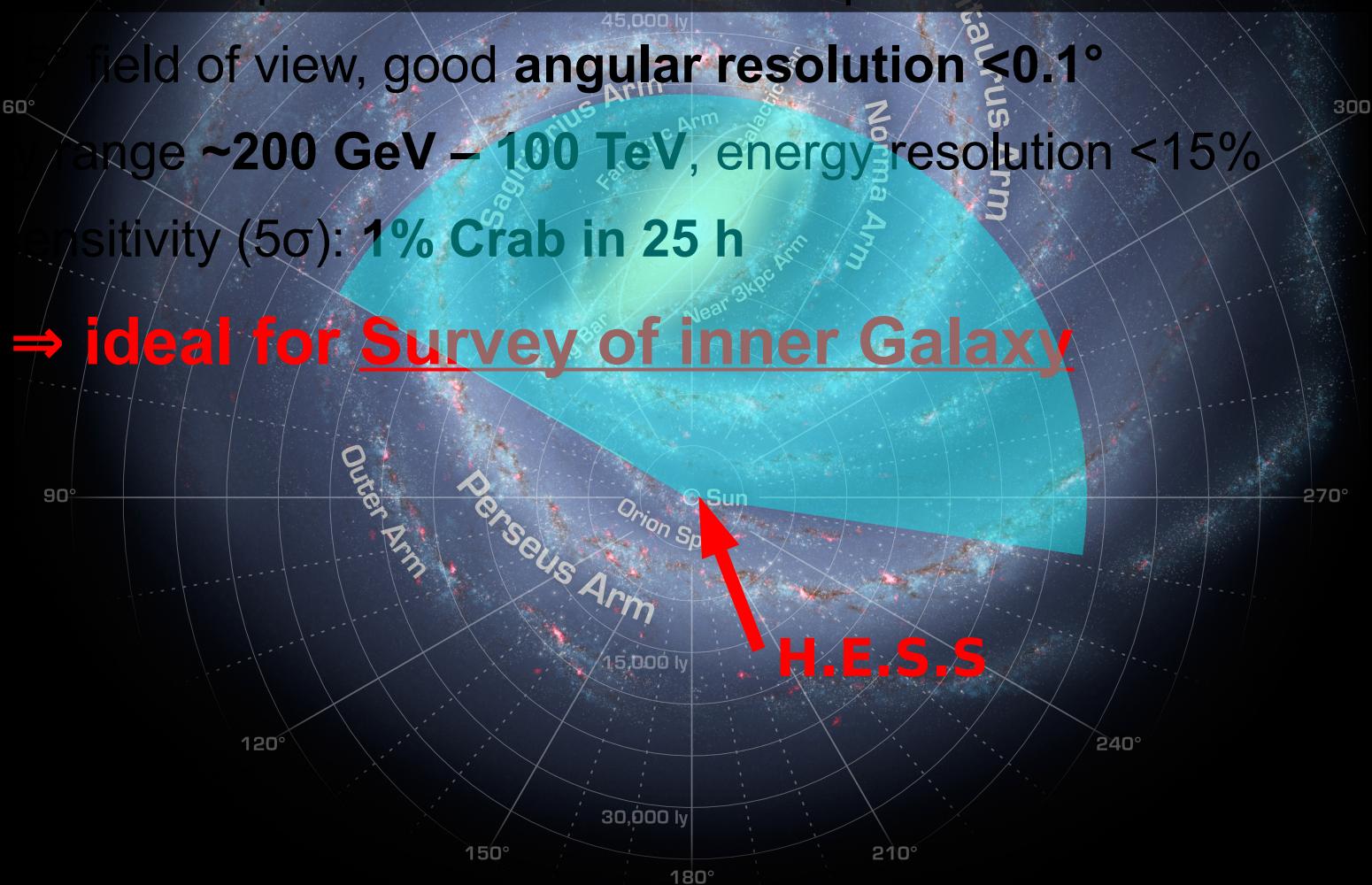


Introduction

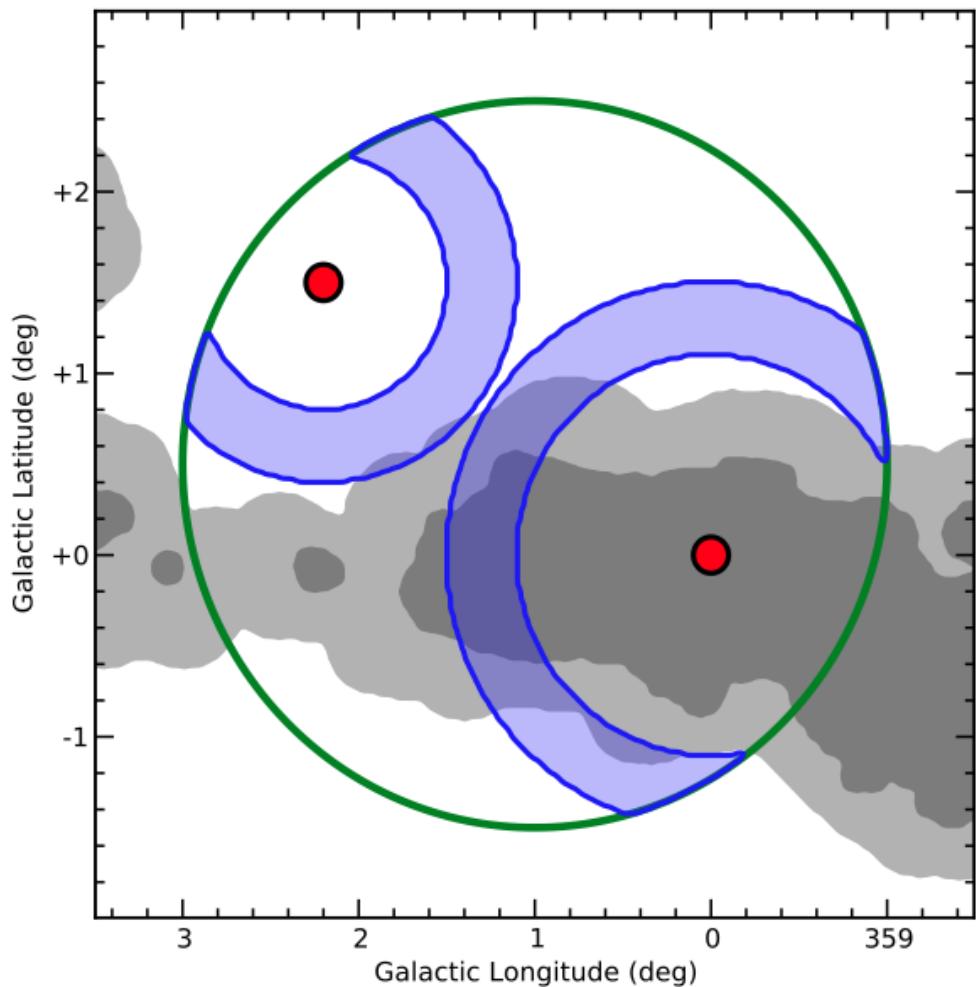
Now with >9 years of data with H.E.S.S.-I:

- ~2800 hrs high-quality data (vs ~2500 hrs @ ICRC 2011)
- Now : $-110^\circ < l < 60^\circ$
- • >60 sources \rightarrow H.E.S.S. Galactic plane survey (HGPS) catalog
- field of view, good **angular resolution** $<0.1^\circ$
- range $\sim 200 \text{ GeV} - 100 \text{ TeV}$, energy resolution $<15\%$
- sensitivity (5 σ): **1% Crab in 25 h**

\Rightarrow ideal for Survey of inner Galaxy



H.E.S.S. Galactic plane survey maps



Exclude all significant emission from background estimation

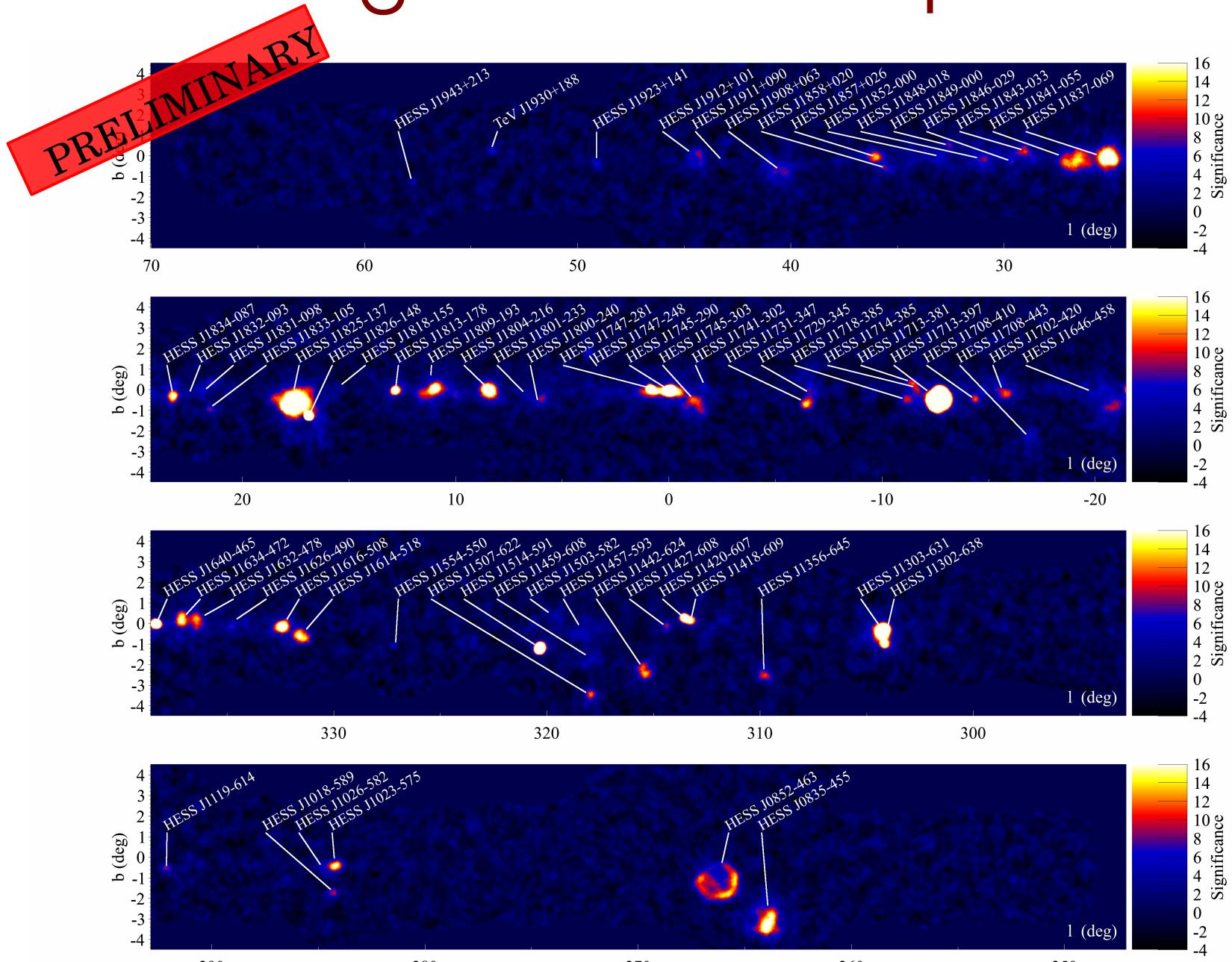
and

allowing for background estimation even in the centre of very large sources

→ new tools :

- adaptive ring background technique
- automatically generated exclusion regions

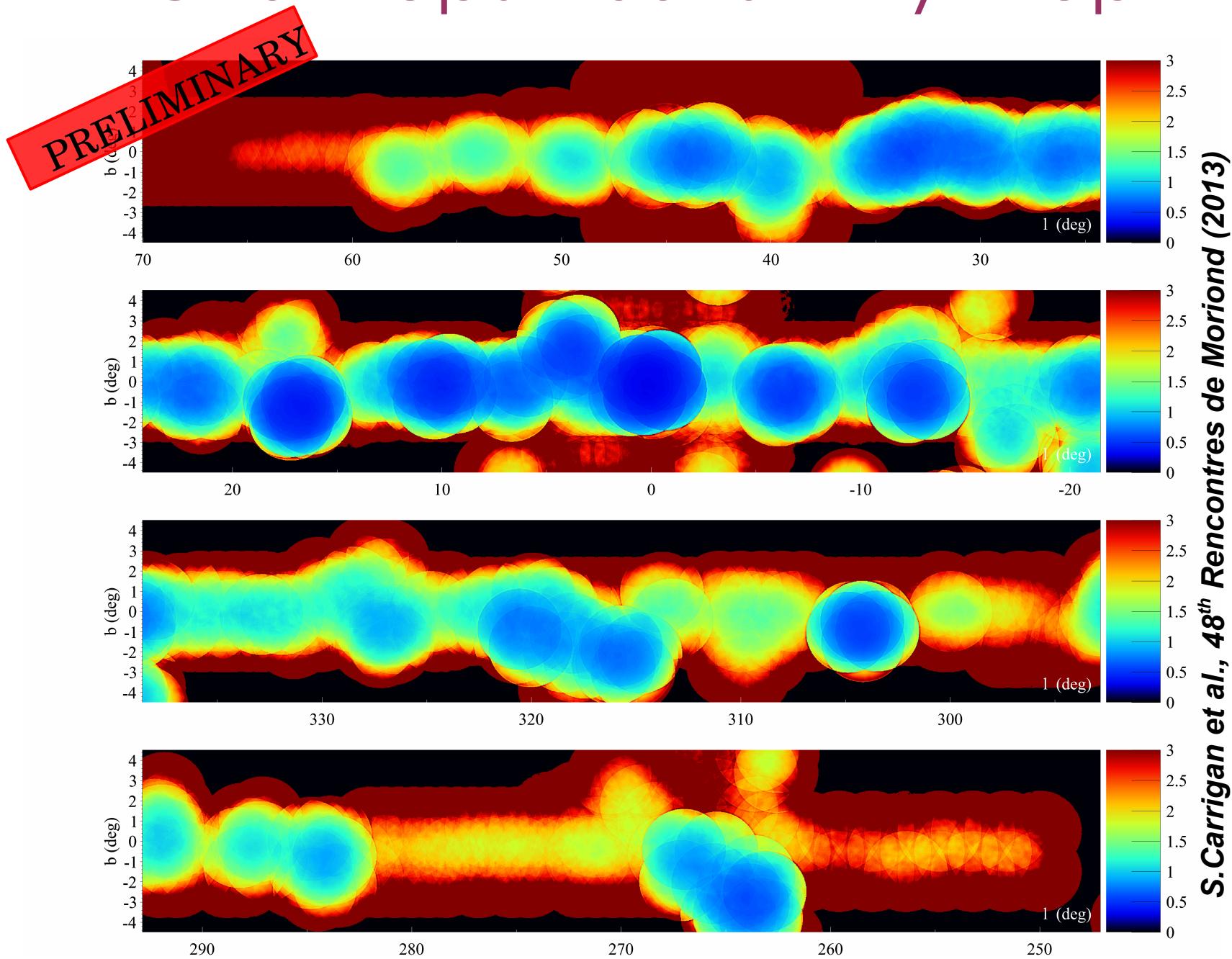
Significance Map



S.Carrigan et al., ICRC (2013)

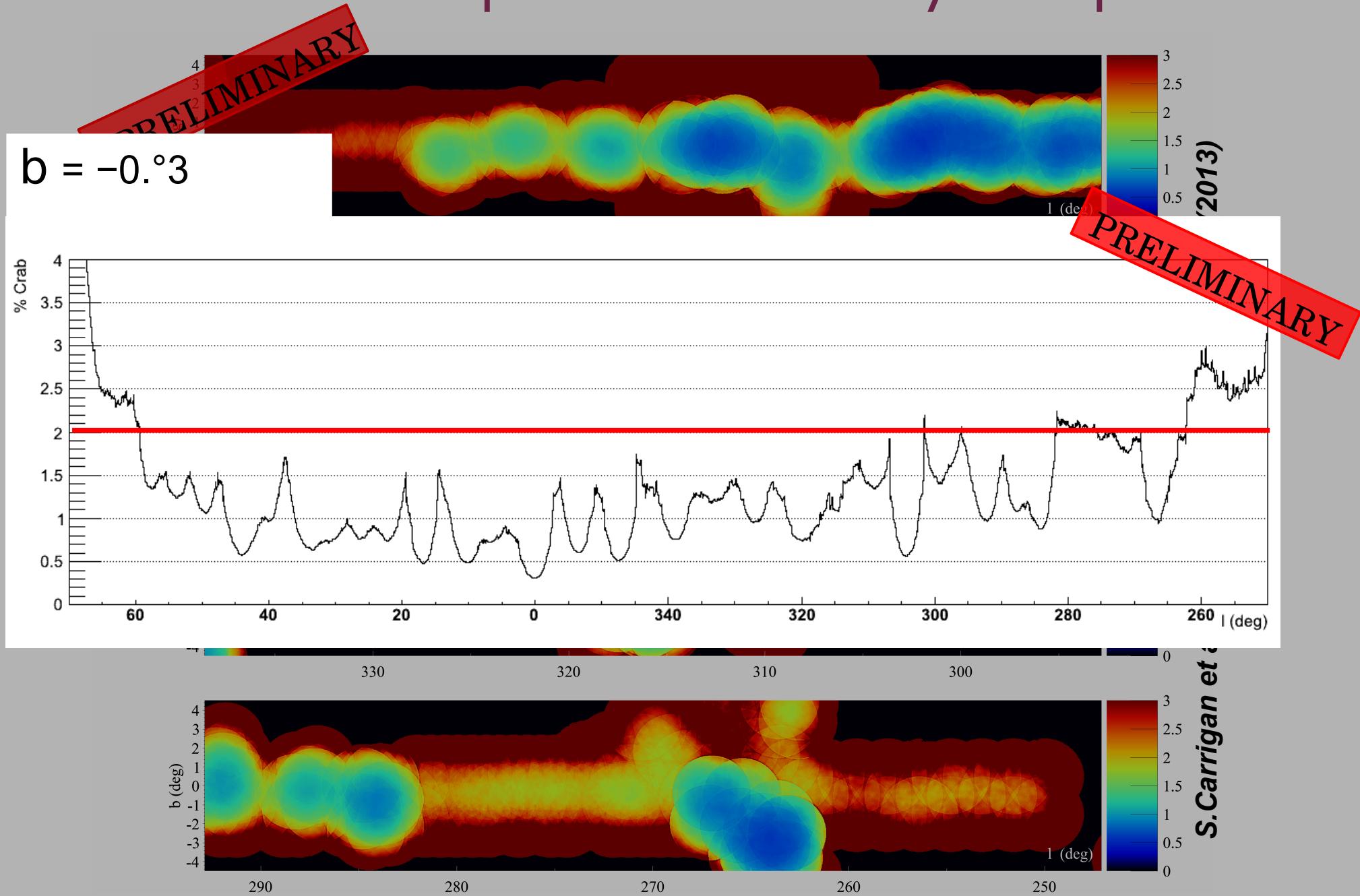
Pre-trials significance map, correlation radius 0.1 deg (filled where point-source sensitivity for 5σ is $>10\%$ Crab).
Blue-red transition corresponds to $\sim 5\sigma$ post trial.

HGPS maps – Sensitivity map



Sens. to point-like γ -ray sources with assumed $\Gamma=2.3$, 5σ pre-trial. Int. flux >1 TeV in units % Crab

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Toward a new HGPS Catalog

HGPS region:

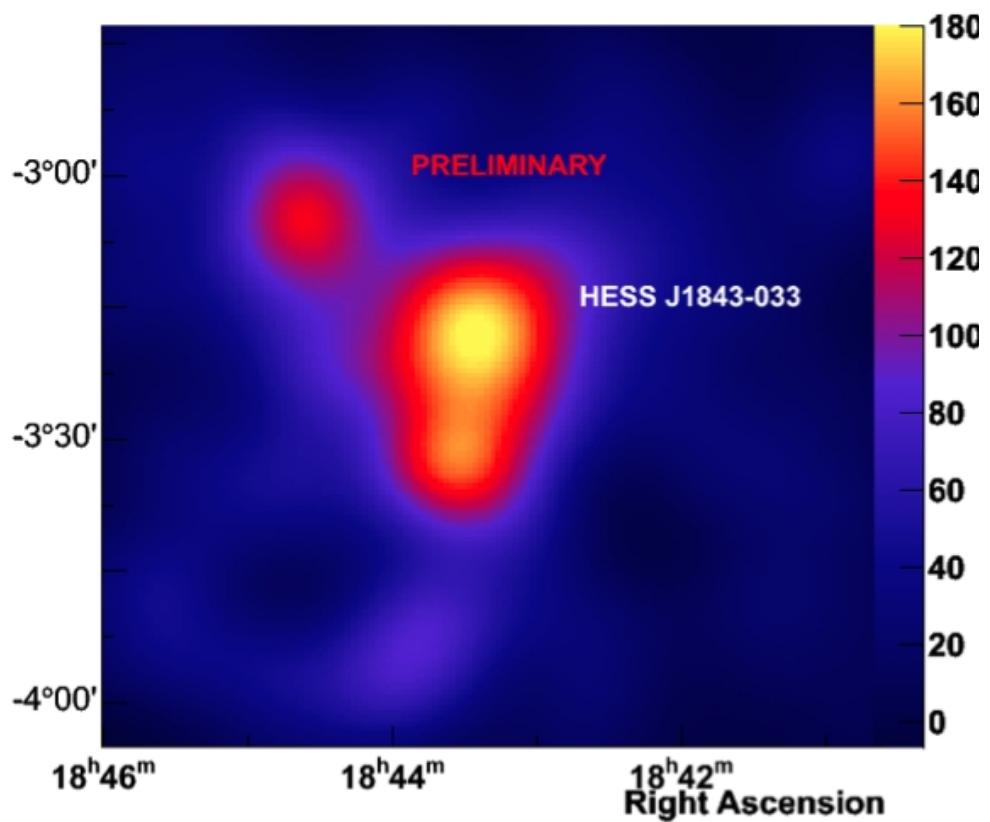
- deep exposure, several complex regions with multiple peaks & extended emission.
- **Aim for well-defined detection and source-separation criteria for HGPS catalog.**

Procedure :

- Simultaneous likelihood fitting in 'regions of interest' (ROI) on count maps for detection and morphology (taking exposure, PSF & background model into account).
- Each ROI is modelled in many different ways, decision by fit TS value.
- Spectral analysis on resulting 'source regions'.

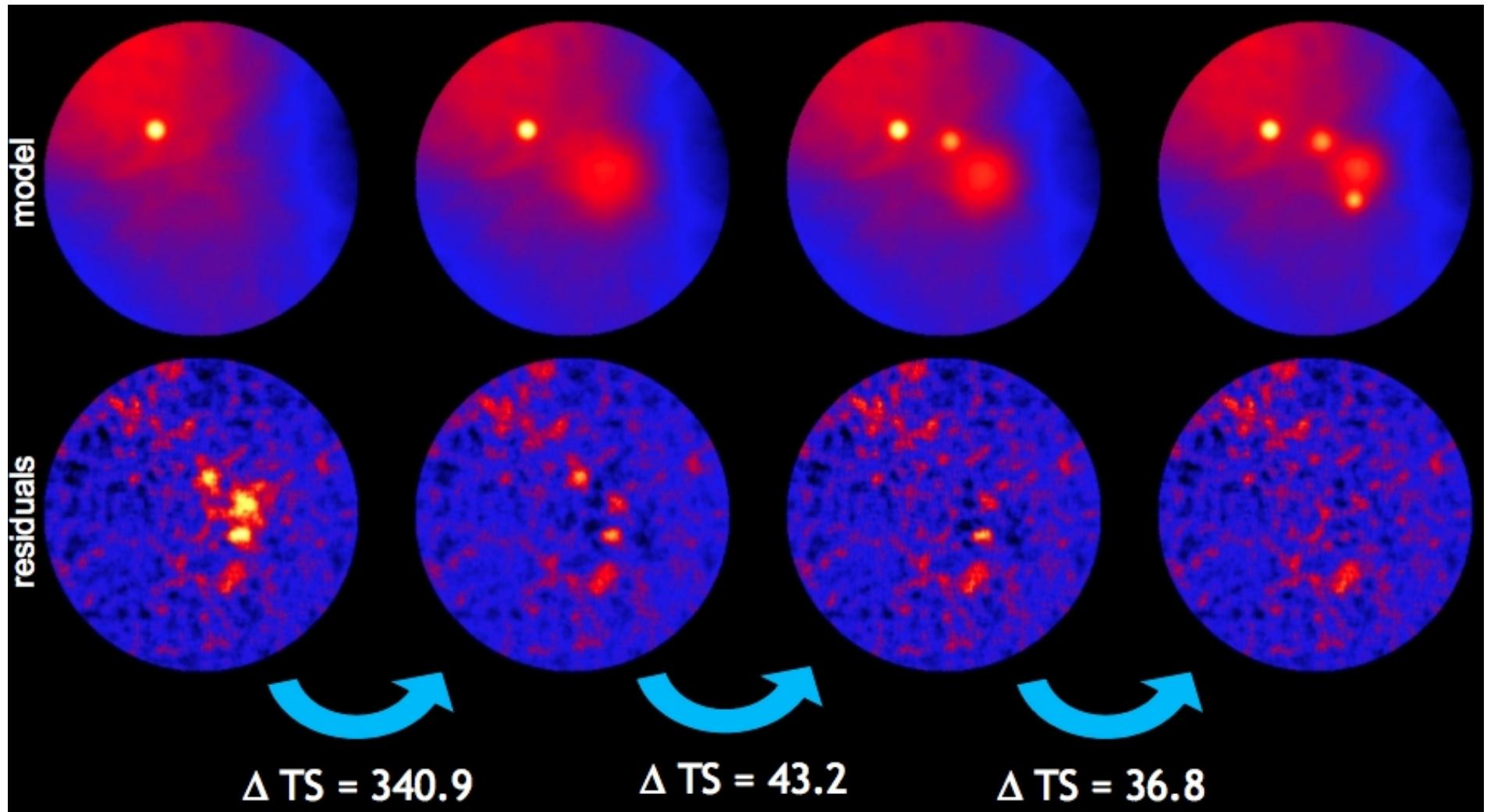
HGPS catalog - Example

e.g. case of HESS J1843-033 → how many sources?



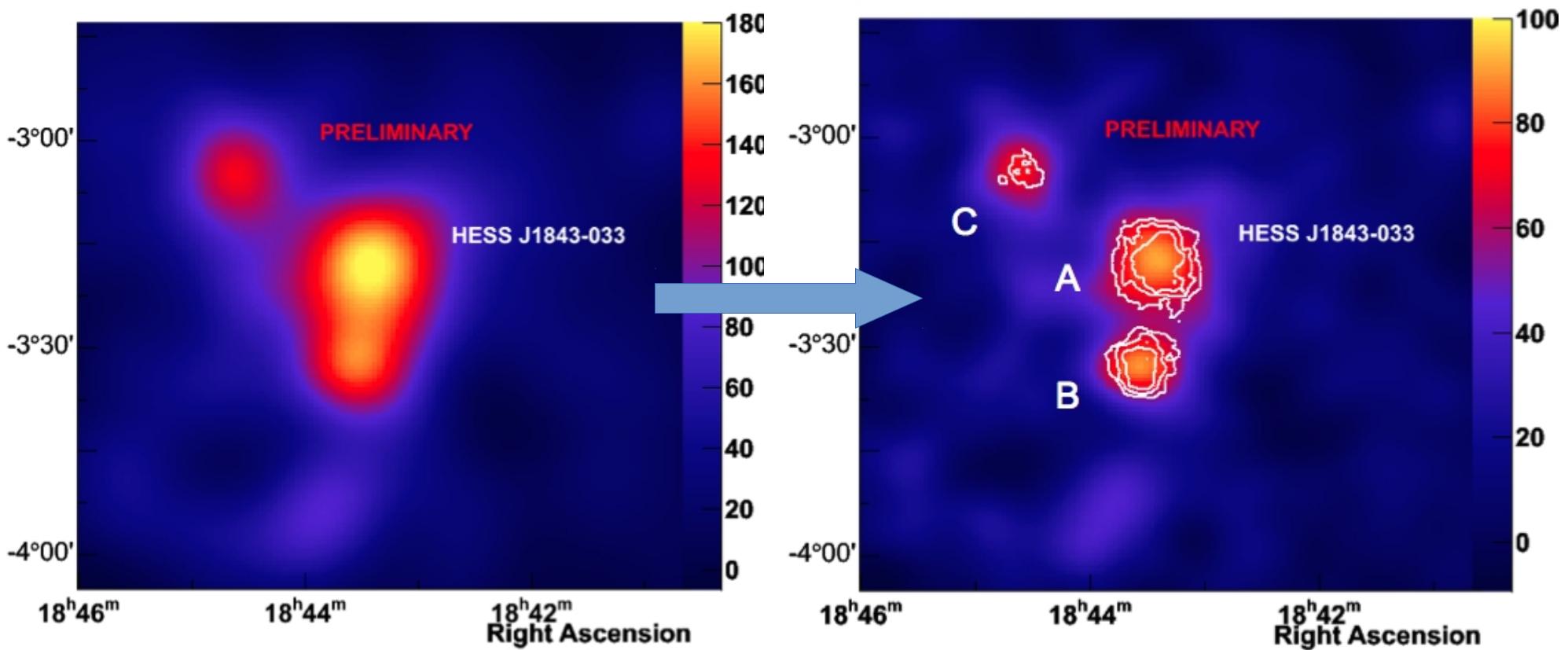
HGPS catalog - Example

e.g. case of HESS J1843-033 → example for fitting procedure



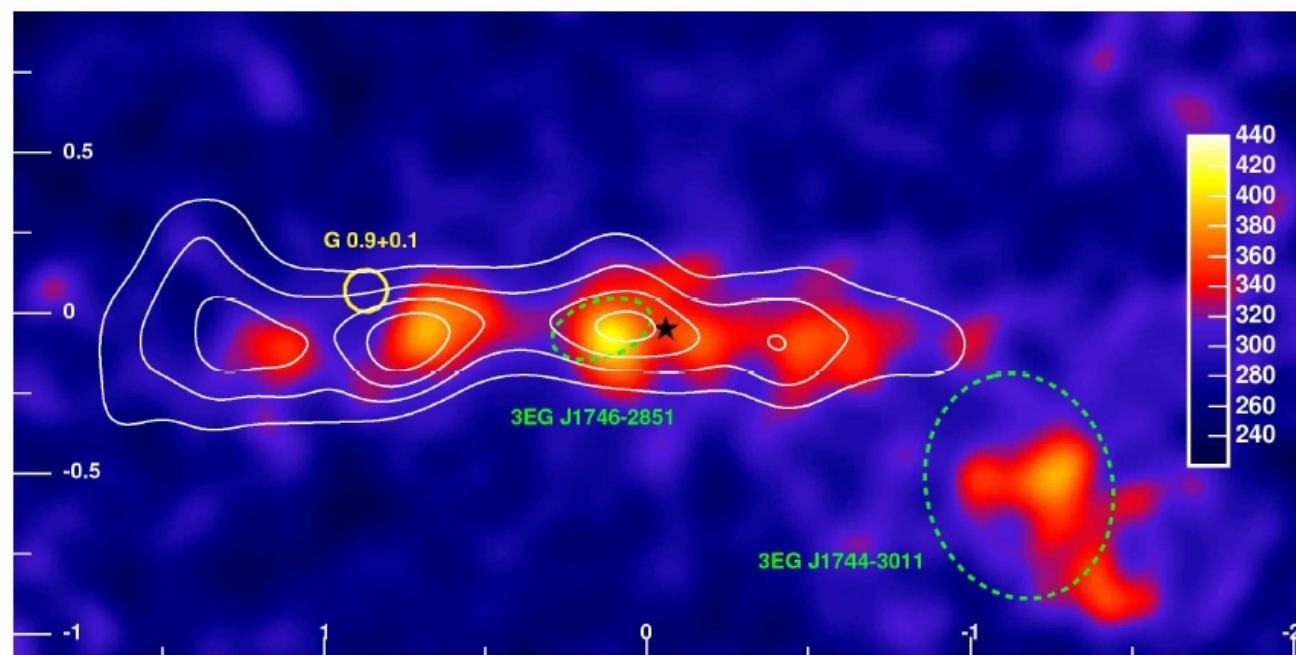
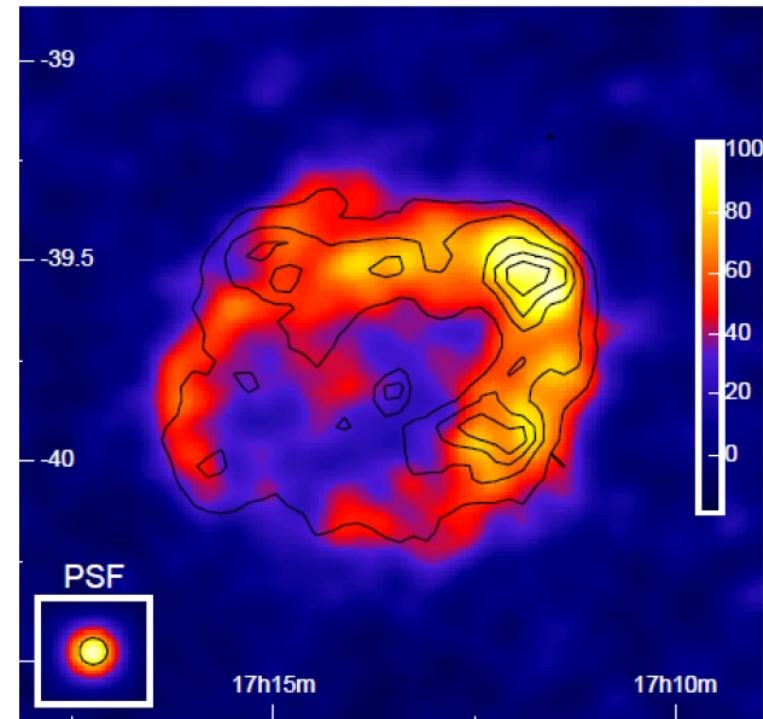
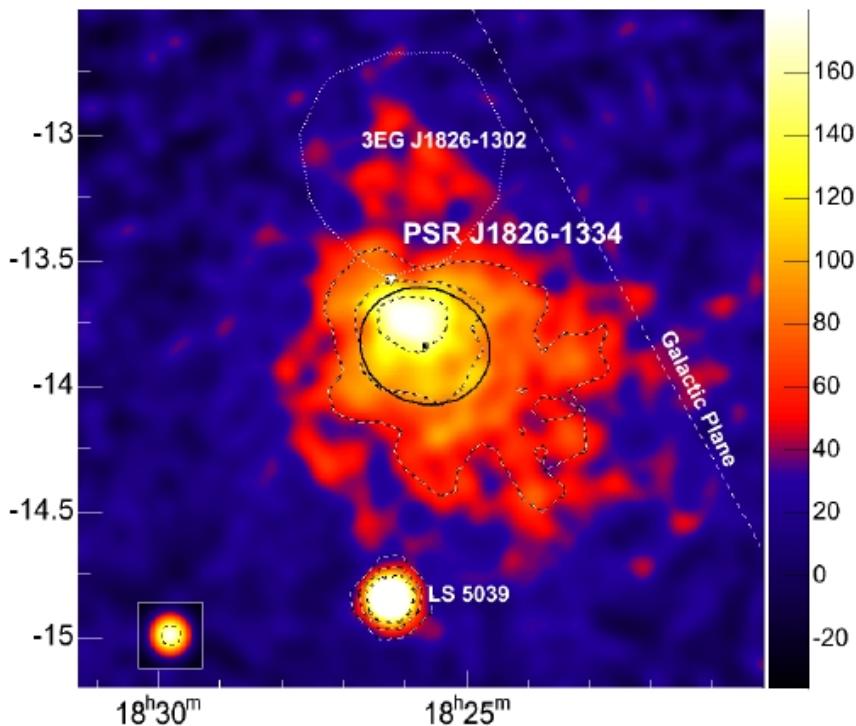
HGPS catalog - Example

e.g. case of HESS J1843-033 → 3 independent sources

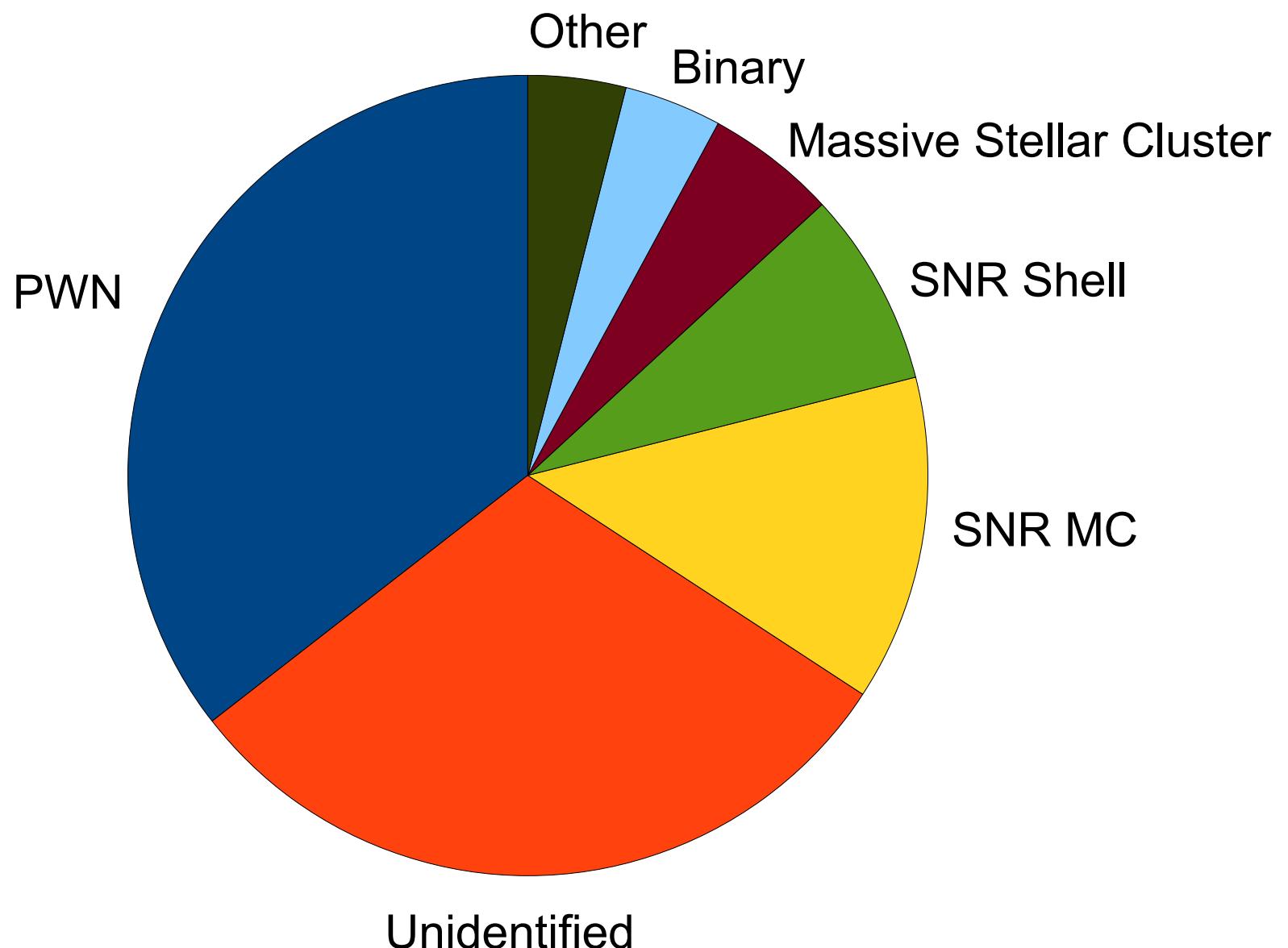


HGPS catalog - Challenges

Dec (deg.)

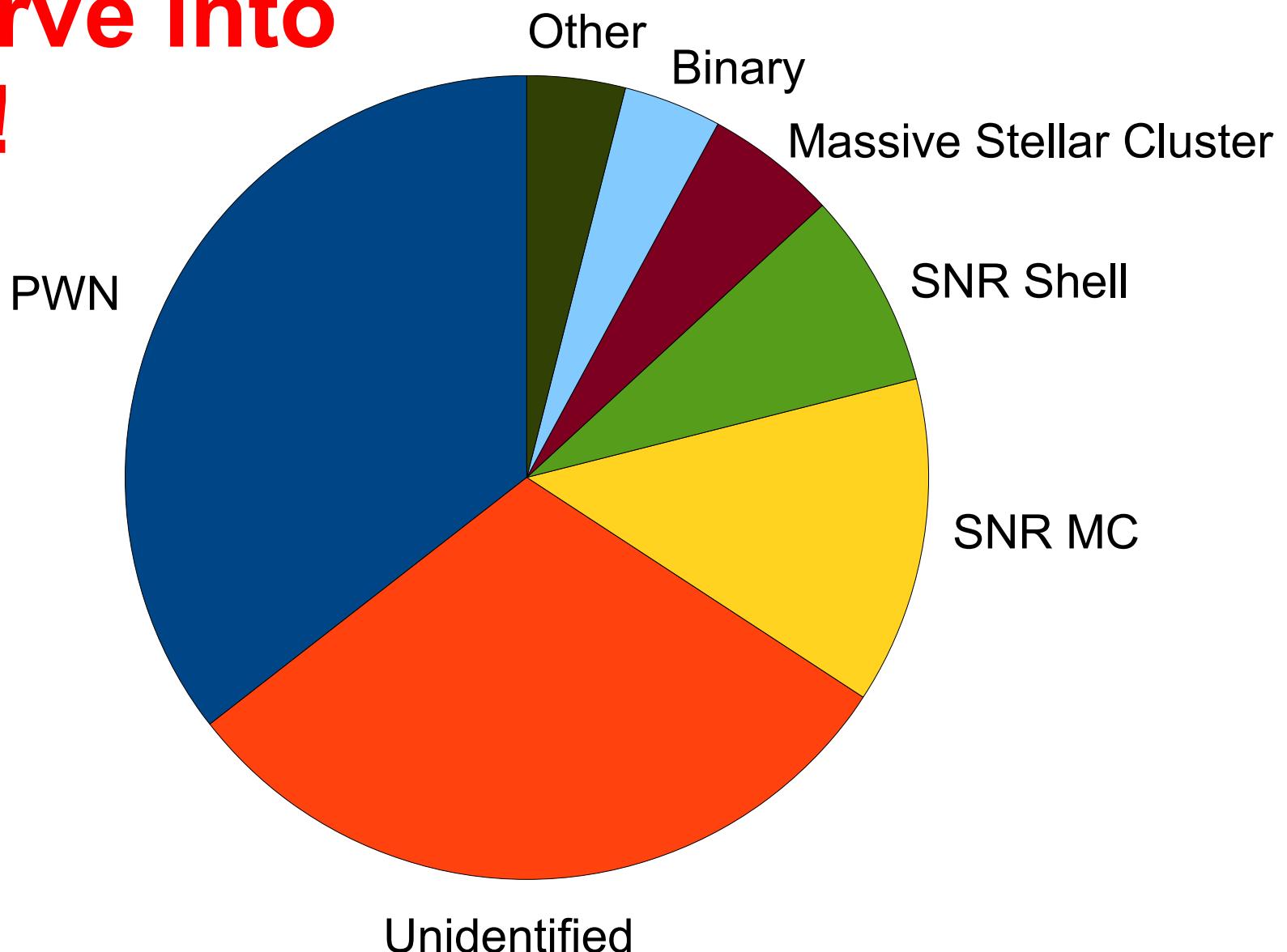


Current Source Population



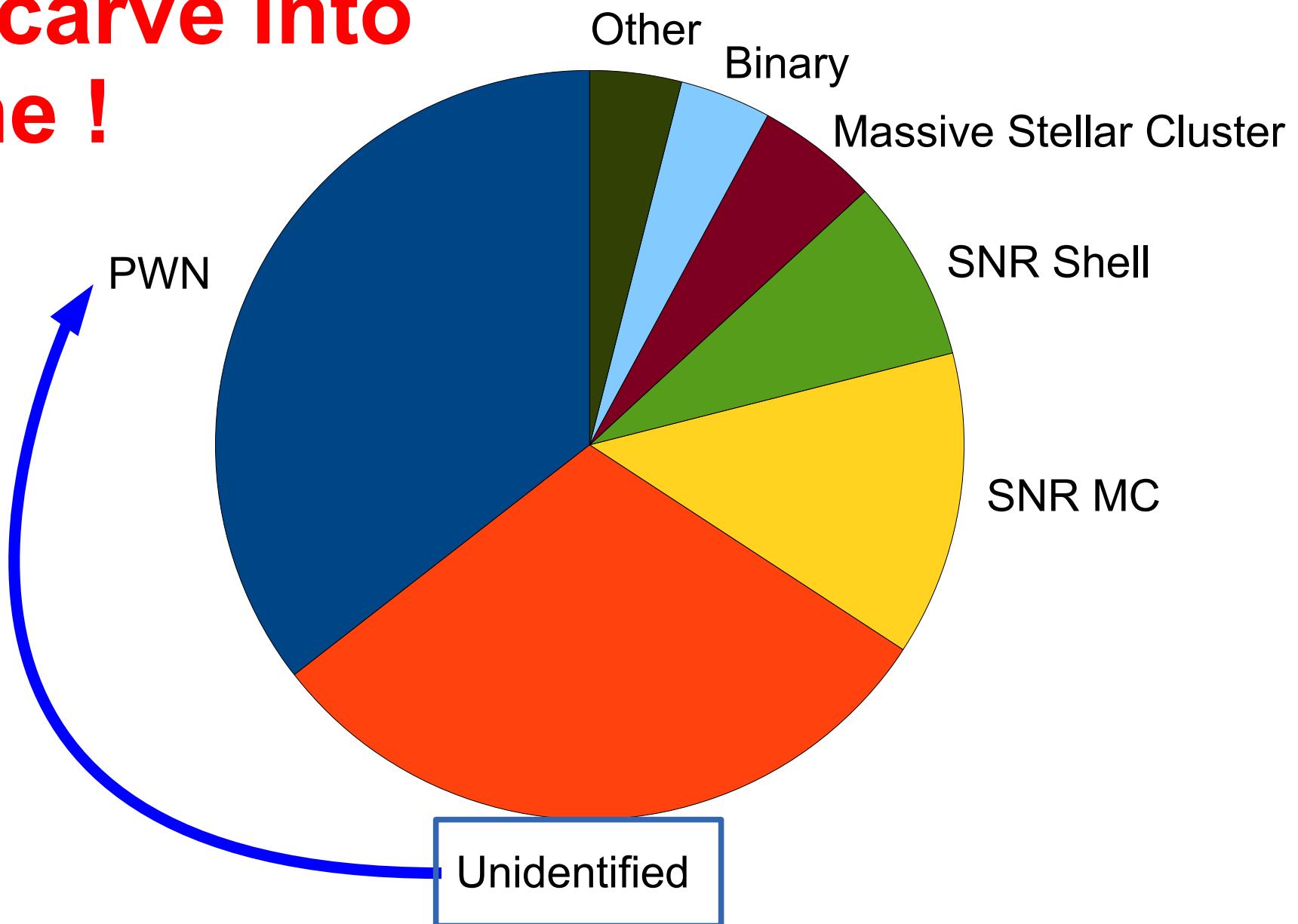
Current Source Population

**Not carve into
stone !**

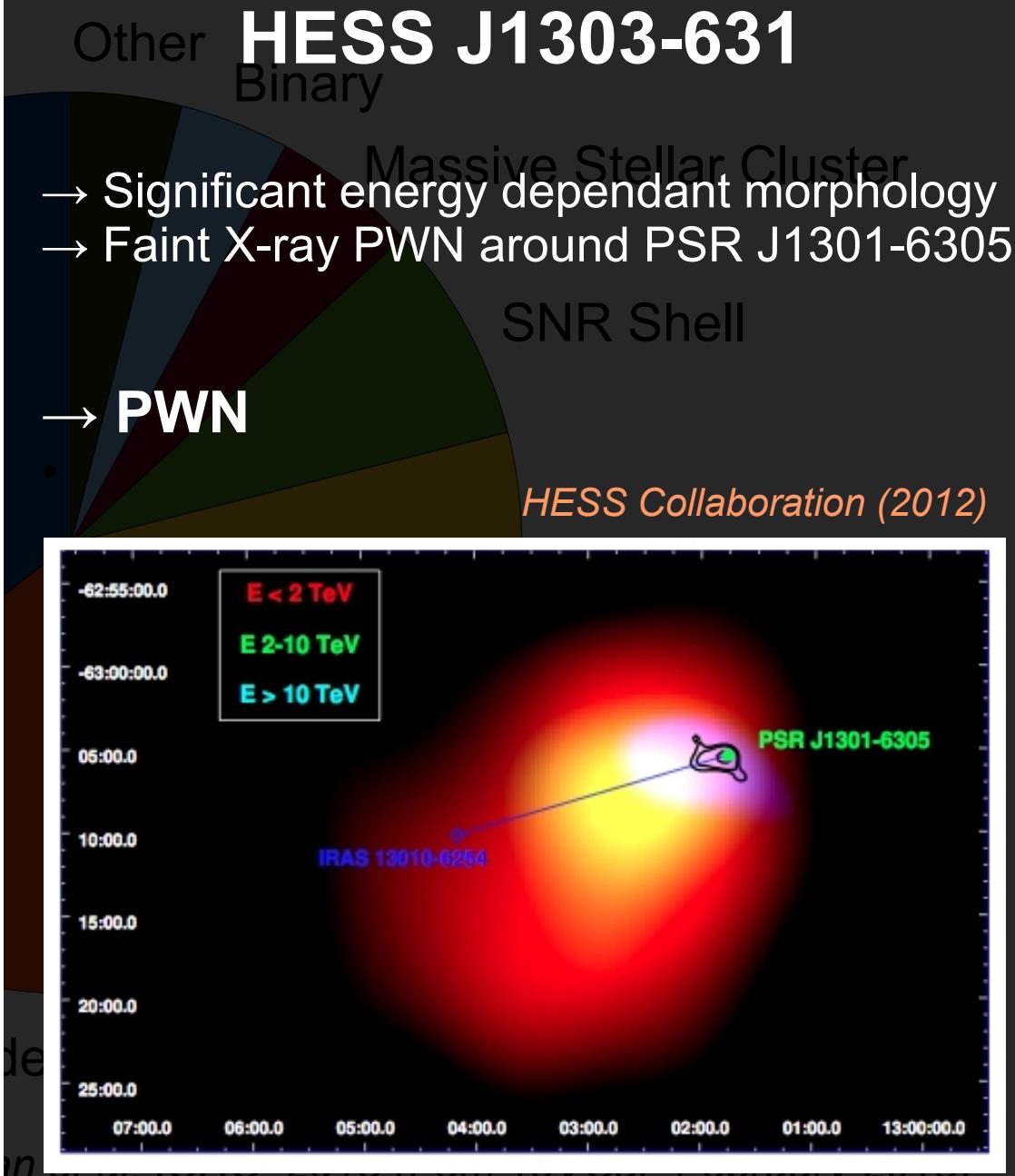
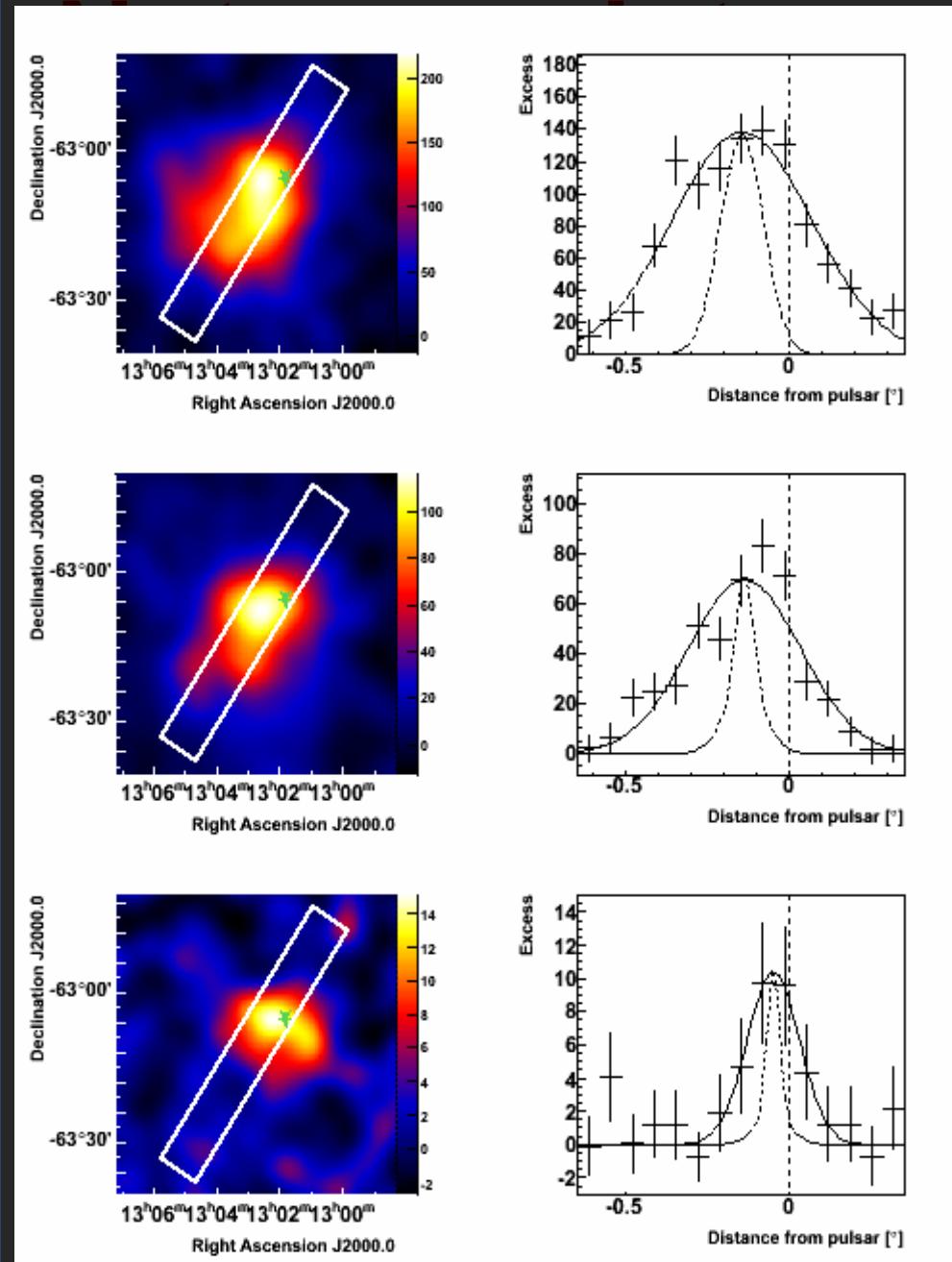


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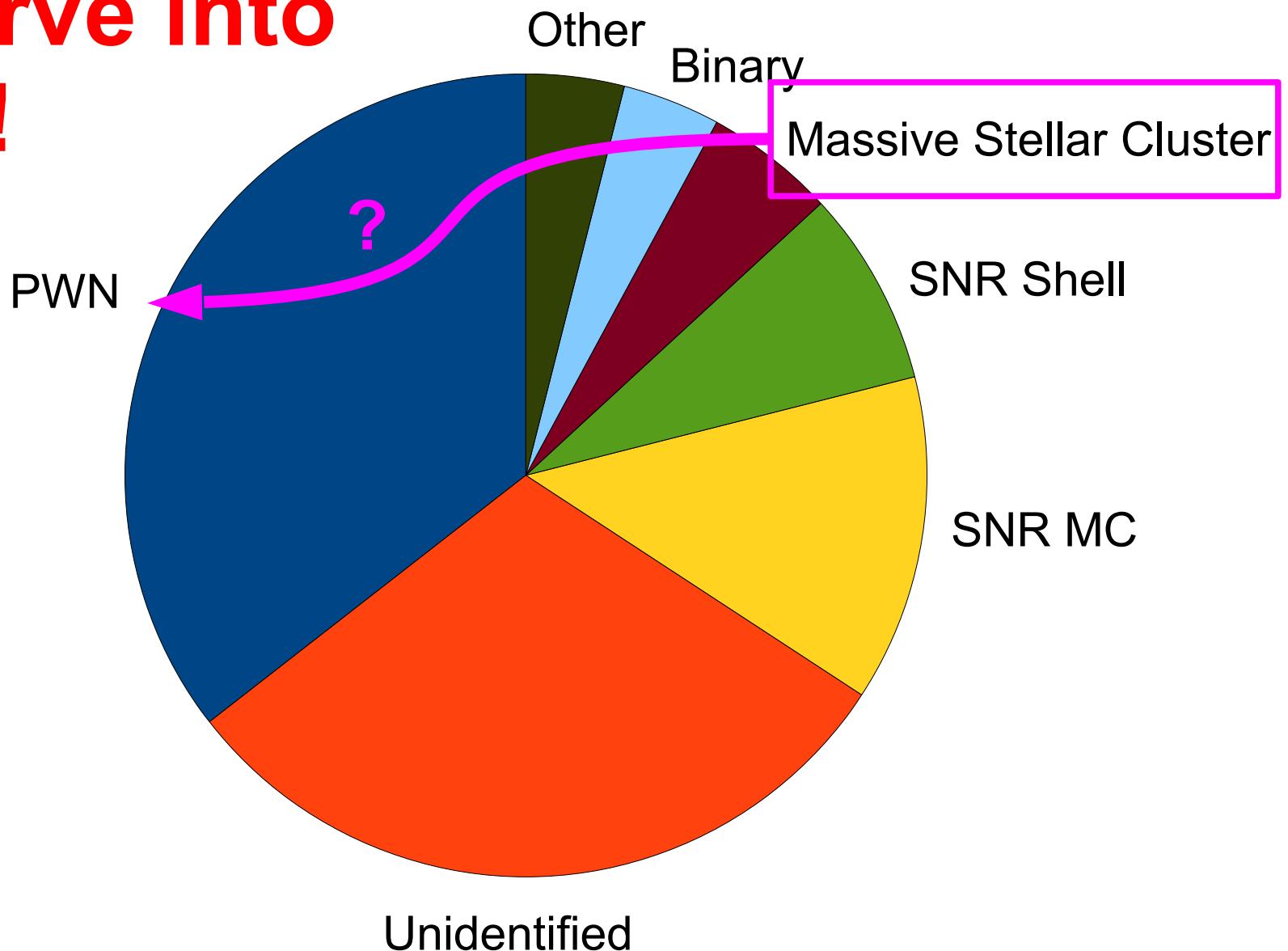


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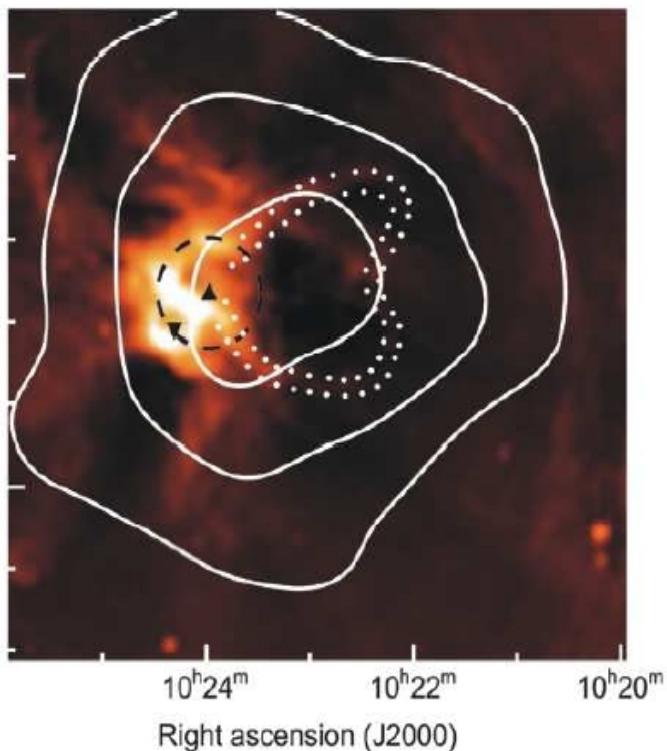


Current Source Population

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Current Source Population



Westerlund 2 region

HESS Collaboration 2007:

→ Possibly associated with the stellar cluster
Westerlund 2 (Collective wind effect at the edge ?)

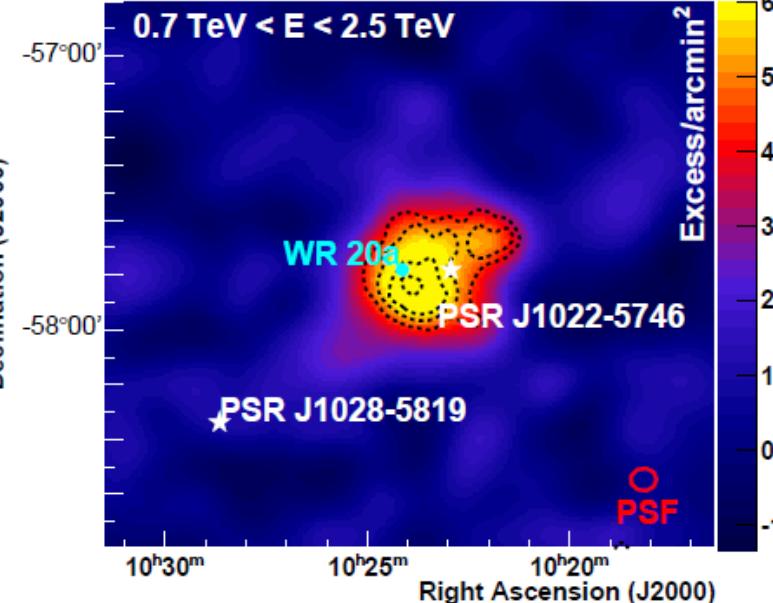
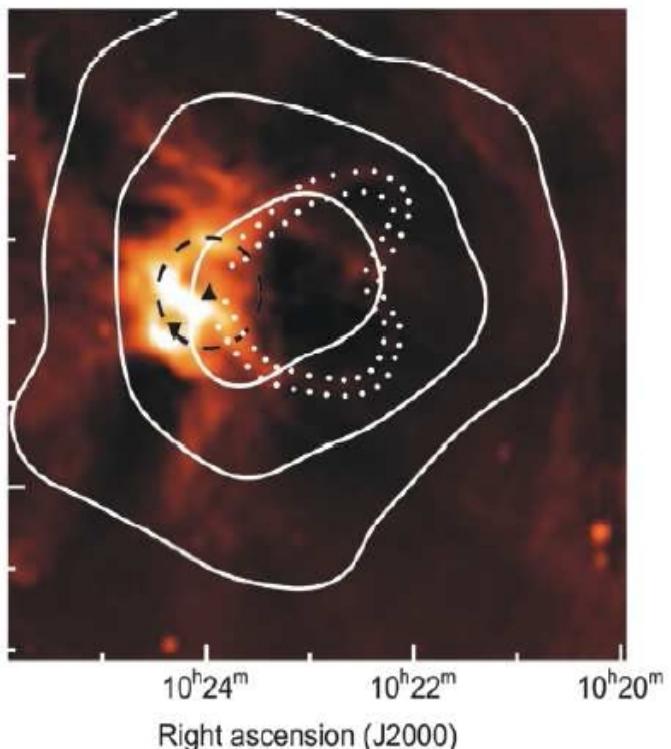
Massive Stellar Cluster

SNR Shell

SNR MC

Unidentified

Current Source Population



Westerlund 2 region

Other
Binary

HESS Collaboration 2007:

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Westerlund 2 (Collective wind effect at the edge ?)

SNR Shell

BUT: Fermi Blind Search pulsar discovery :

PSR J1023-5746 (Saz Parkinson et al. 2009)
Period : 111 ms, Edot : $1.1 \cdot 10^{37}$ erg.s⁻¹, Age : 4.6 kyr

SNR MC

$L_\gamma/Edot = 0.4\%$ (Comparable to other TeV PWN)

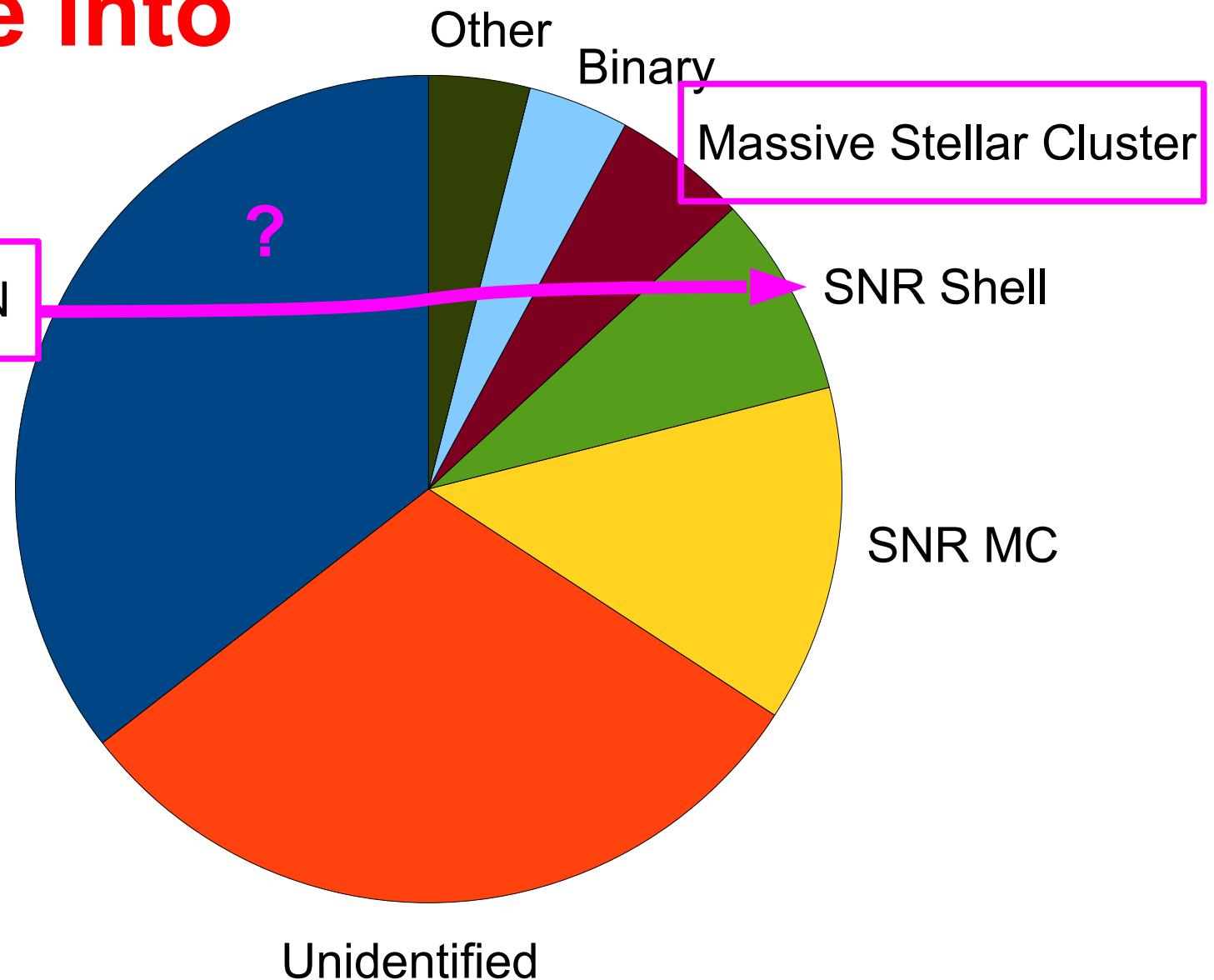
→ Powerfull enough to power TeV emission : PWN ?

Unidentified

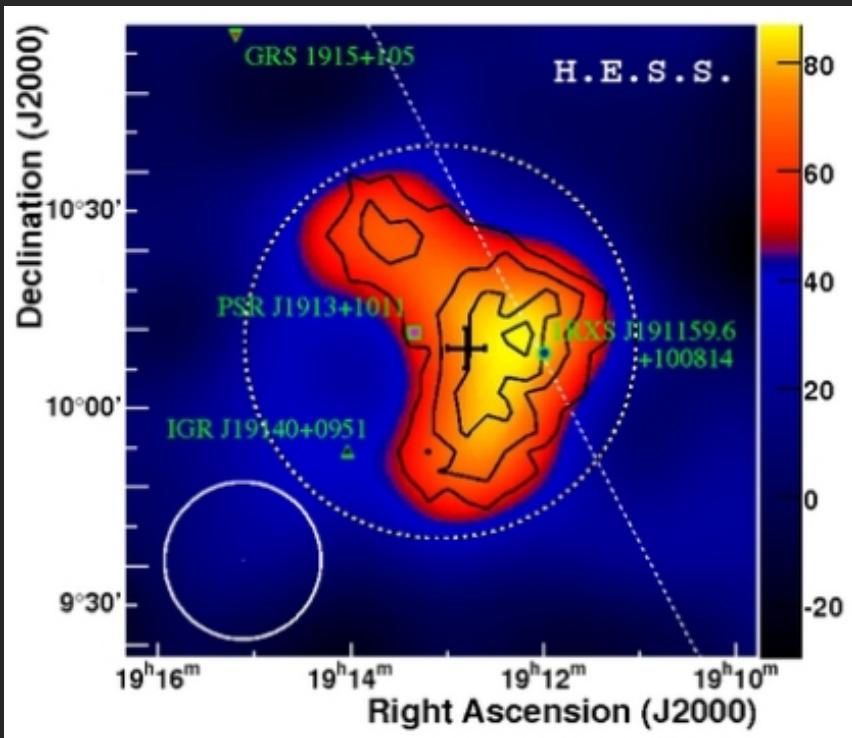
Carrigan et al. ICRC, 2013 (From TeVCat February 2013)
HESS Collaboration (2011)

Current Source Population

**Not carve into
stone !**



Current Source Population



HESS Collaboration 2008

HESS J1912+101

Other

Binary

Bright source at ~10% Crab
Rather soft spectrum $\Gamma=2.7\pm 0.2$

Close to the 36 ms PSR J1913+101
 $\dot{E}=2.9 \cdot 10^{36} \text{ erg.s}^{-1}$; $T_c = 1.7 \cdot 10^5 \text{ y}$

Offset PWN-PSR $\sim 0.15^\circ$

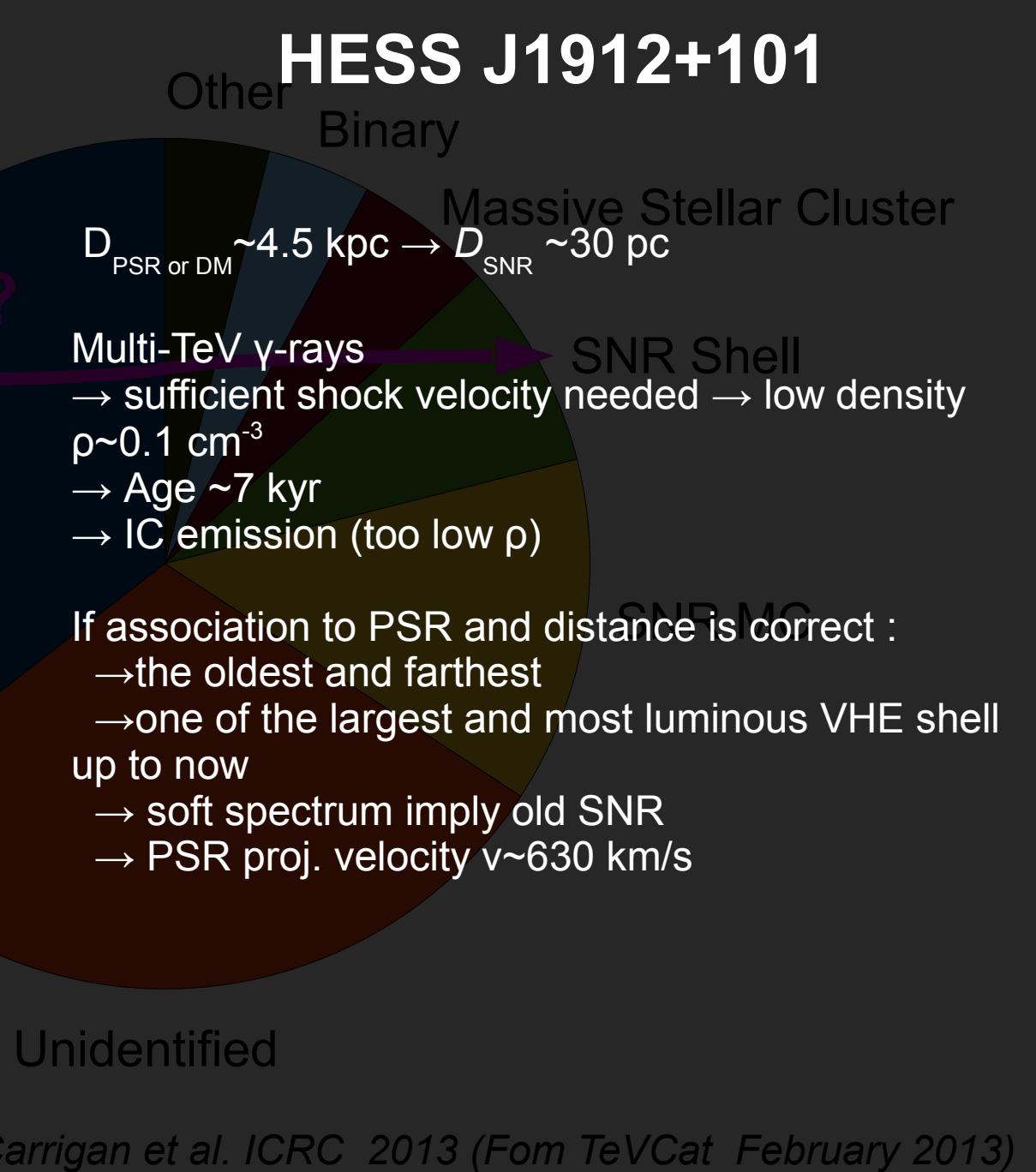
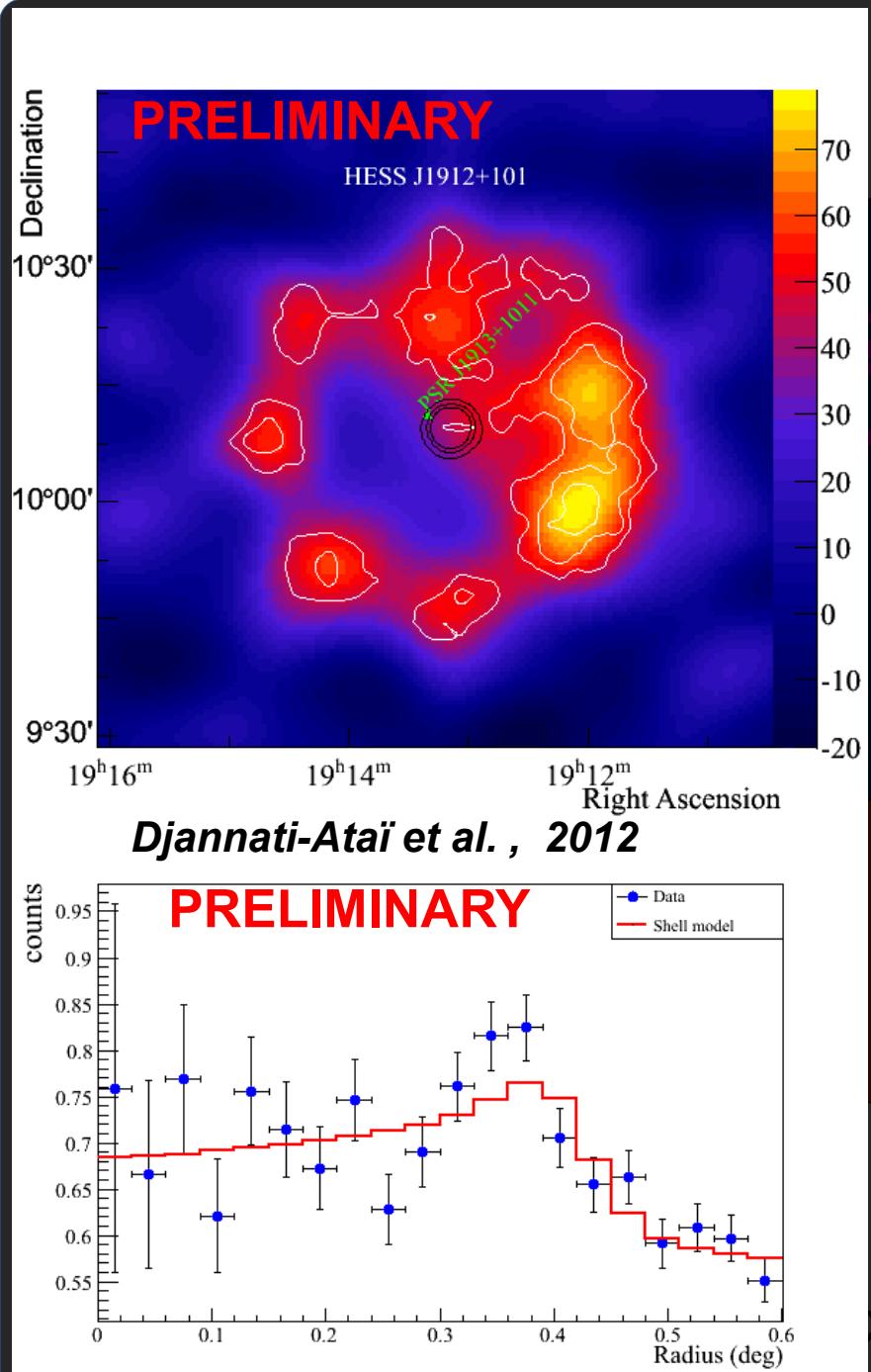
Absence of any counterparts in radio to X-rays
SNR MC

VHE emission interpreted as wind nebula of
PSR J1913+101 (Efficiency $\sim 0.5\%$)

Characteristic age : a bit high, making it the
oldest PWN (but not really reliable)

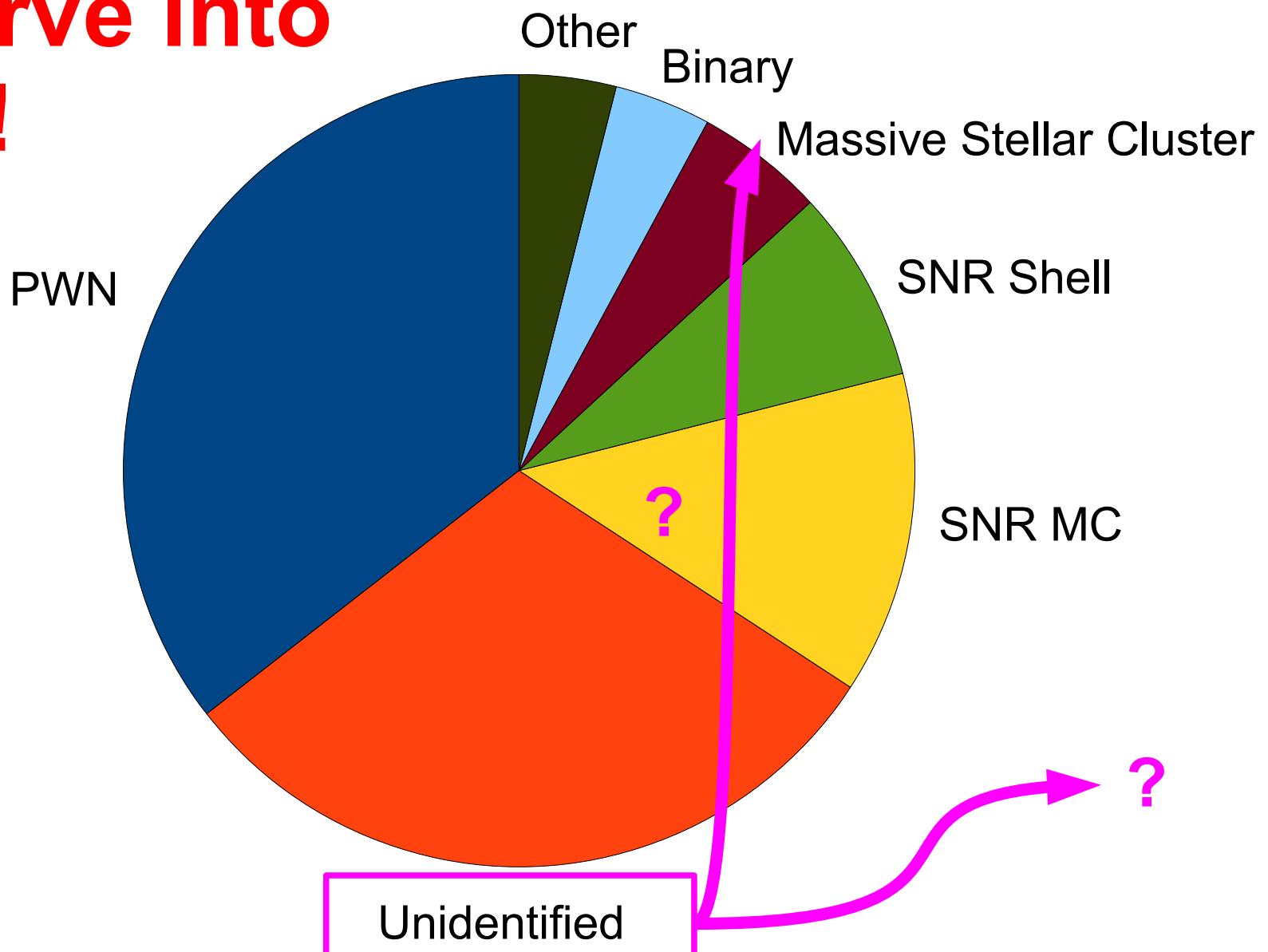
Unidentified

Current Source Population

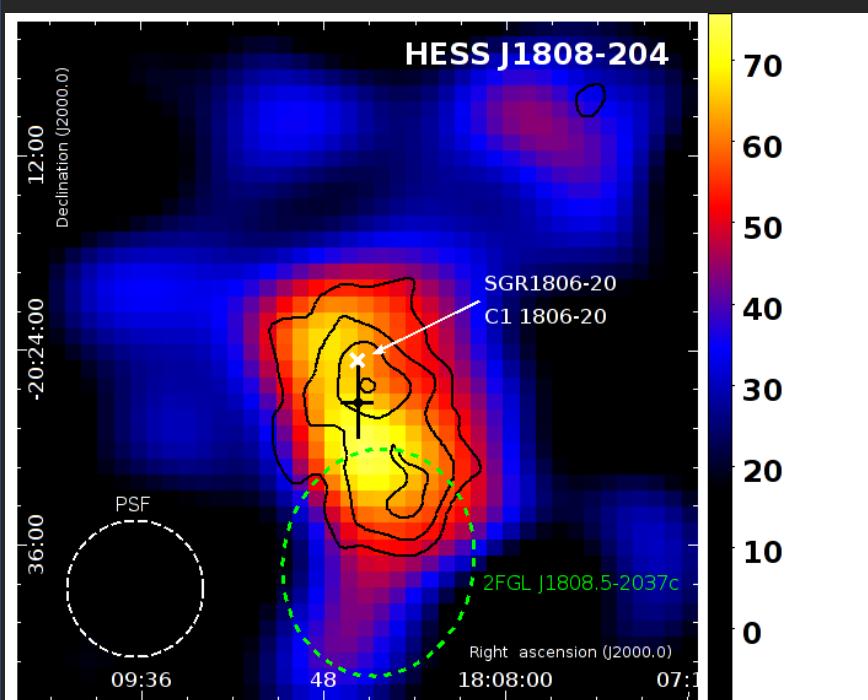


Current Source Population

**Not carve into
stone !**



Current Source Population



Other
HESS J1808-204
Binary

Massive Stellar Cluster

TeV Emission :
Extended source : $7.5' \times 4' (\leq \text{PSF})$
(~38 pc major axis at 8.7 kpc)
→ Similar in scale to radio nebula

Energetics 0.5-5 TeV ($r < 0.2^\circ$) :
 $L_{\text{TeV}} \sim 1.2 \times 10^{34} (d/8.7\text{kpc})^2 \text{ erg/s}$

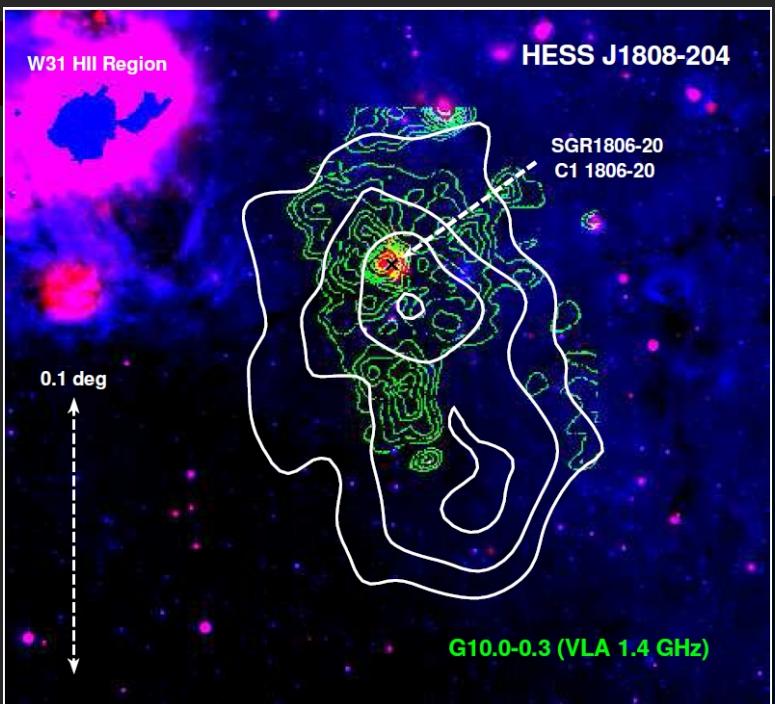
$\Gamma = 2.5 (\pm 0.2 \pm 0.2)$

Flux is steady at nightly & 30 min scales

Unidentified

?

Current Source Population



HESS J1808-204

SGR1806-20 :

Magnetar with $B_{\text{surface}} \sim 10^{14-15} \text{ G}$
 $d \sim 6-19 \text{ kpc}$

→ spin-down power $L_{\text{sd}} \sim \text{few} \times 10^{34} \text{ erg/s}$

Magnetic dissip. energy $\sim 10^{35-36} \text{ erg/s}$

Many short/interm. flares 10^{40-43} erg/s

Giant flare $\sim 10^{47} \text{ erg/s}$ 27 Dec 2004

SNR MC

C1 1806-20 :

Massive stellar cluster (parent cluster of SGR1806-20?)

4 x WR stars + luminous blue variable LBV 1806-20

→ combined stellar wind KE $> 10^{38} \text{ erg/s}$

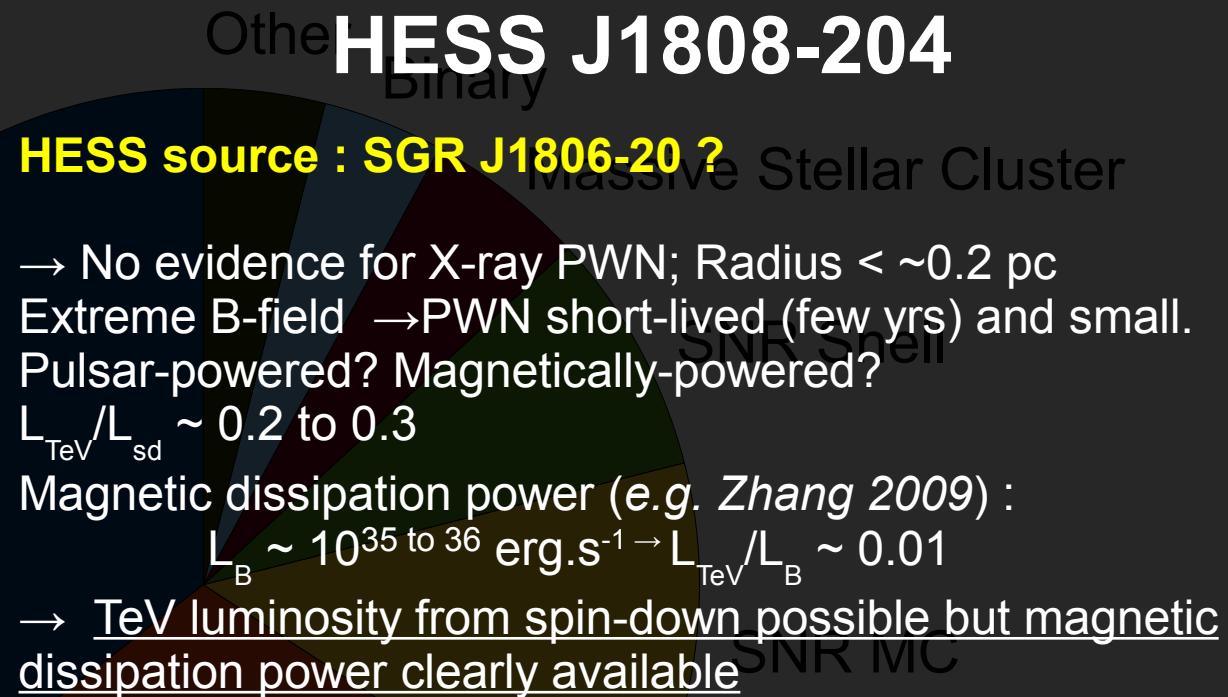
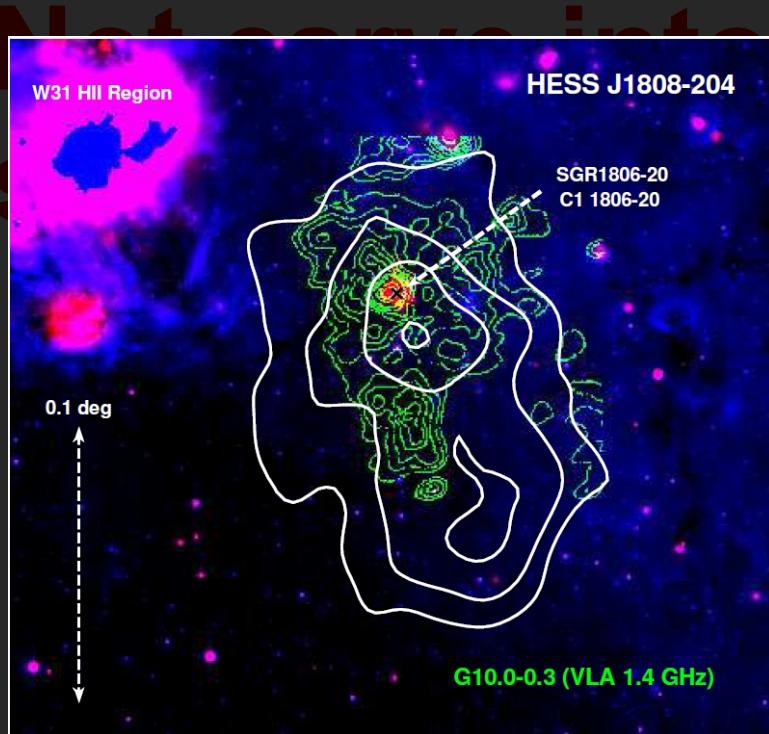
G10.0-0.3 Radio nebula :

$L_{\text{radio}} \sim \text{few} \times 10^{32} \text{ erg/s}$ ($d=8.7 \text{ kpc}$)

→ Likely powered by LBV rather than SGR
Unidentified

?

Current Source Population



HESS source : Massive Cluster ?

4 x WR stars; 4 x O stars

Lum. Blue Variable (LBV) : LBV 1806-20 (similar to Pistol star)

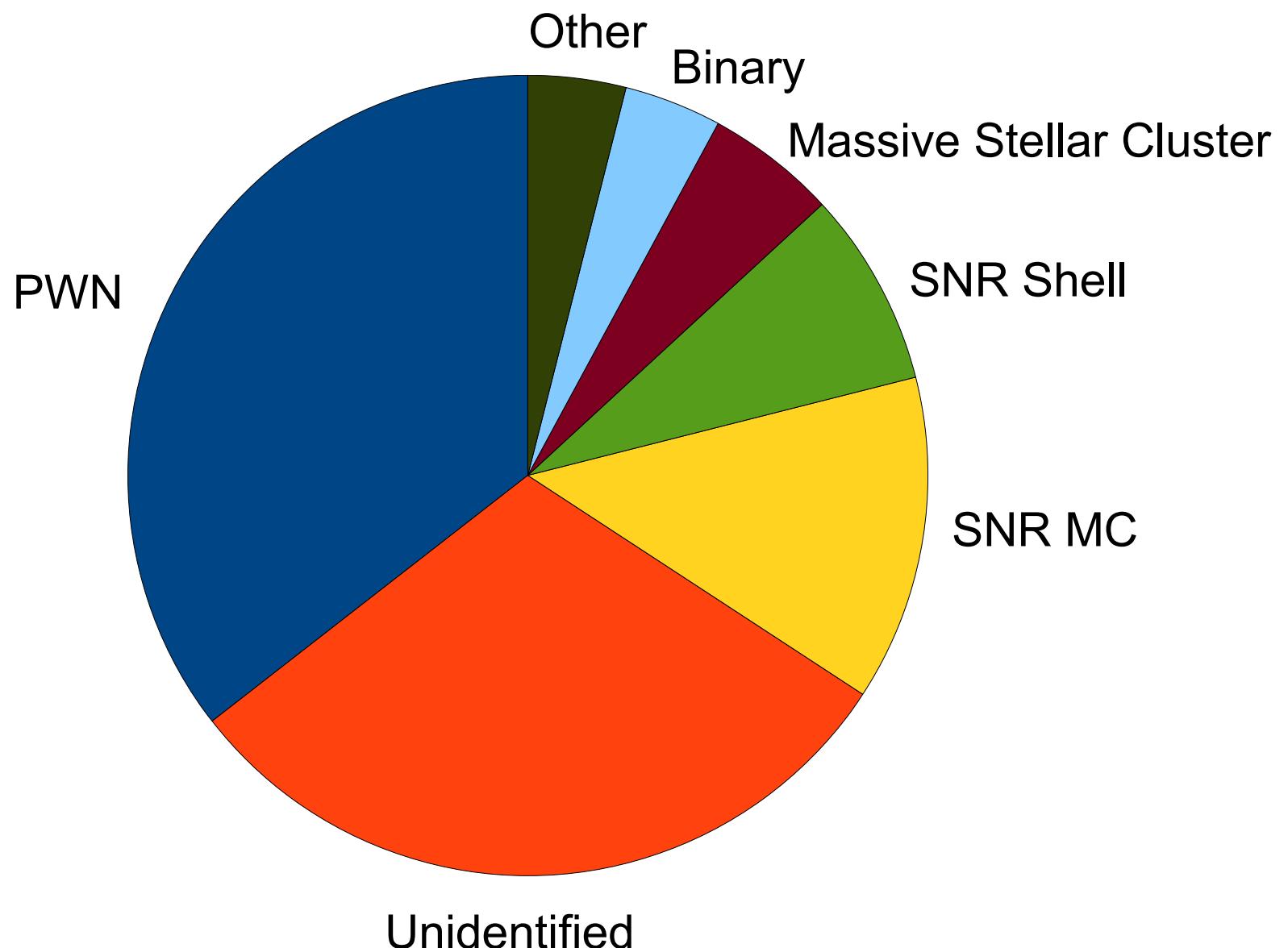
Cluster wind KE $L_{\text{KE}} > 10^{38} \text{ erg/s}$

→ $L_{\text{TeV}}/L_{\text{KE}} < 10^{-4}$

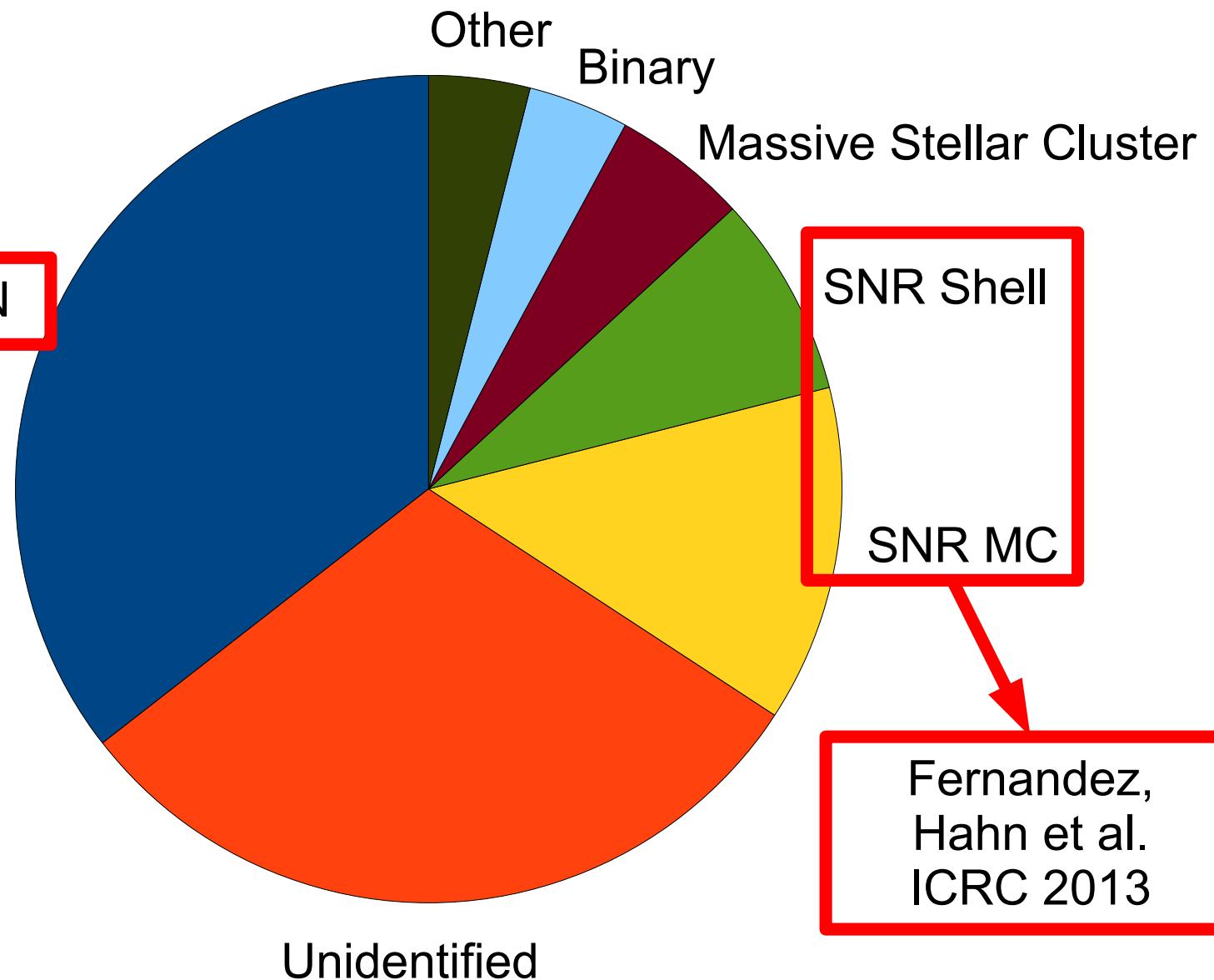
→ Stellar cluster origin possible through wind-wind/ISM interactions

→ dominated by LBV and/or WRs?

Toward Population Studies



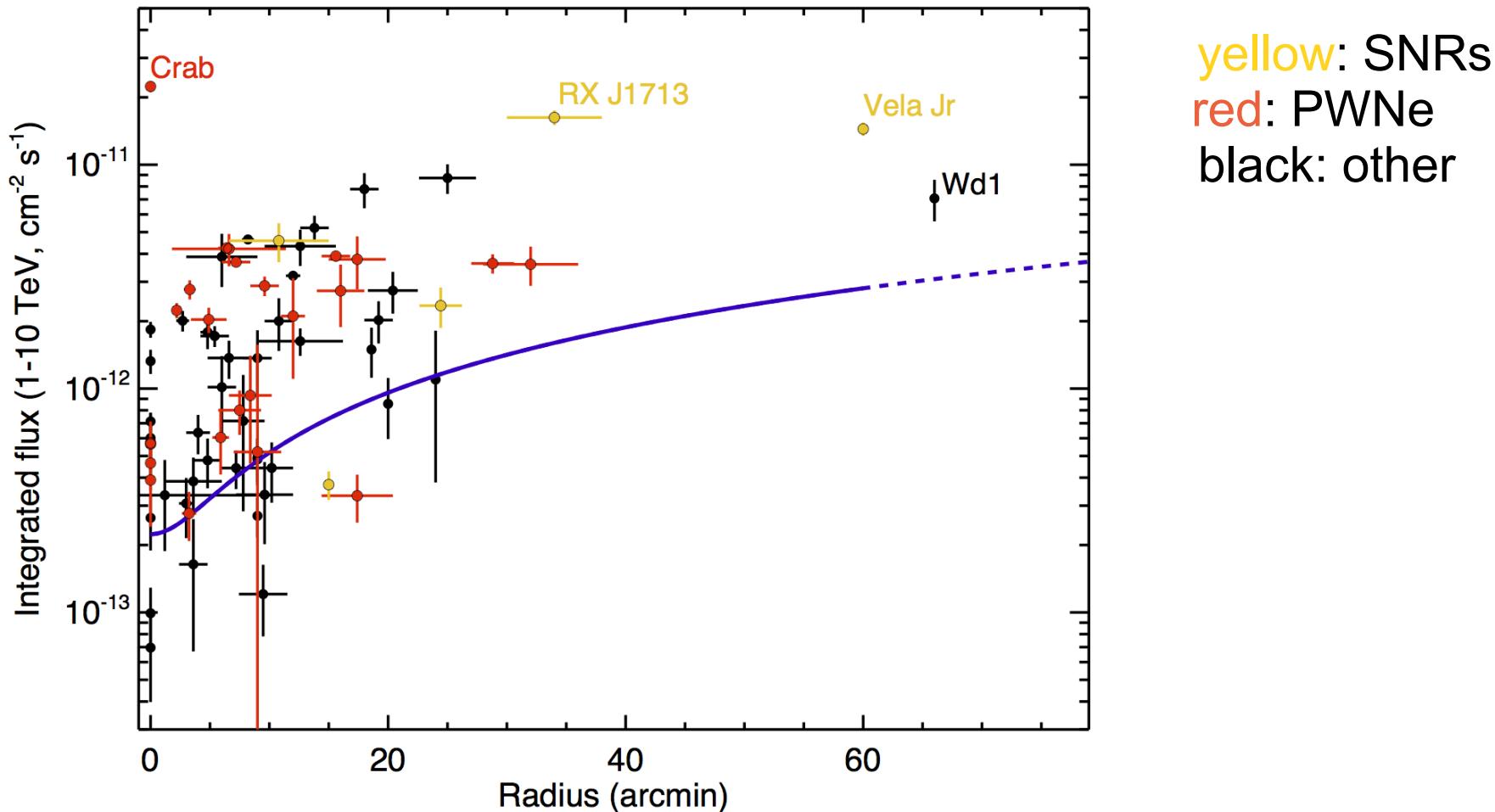
Toward Population Studies



Galactic source population

- TeVCat H.E.S.S. Galactic sources

Integrated flux vs radius

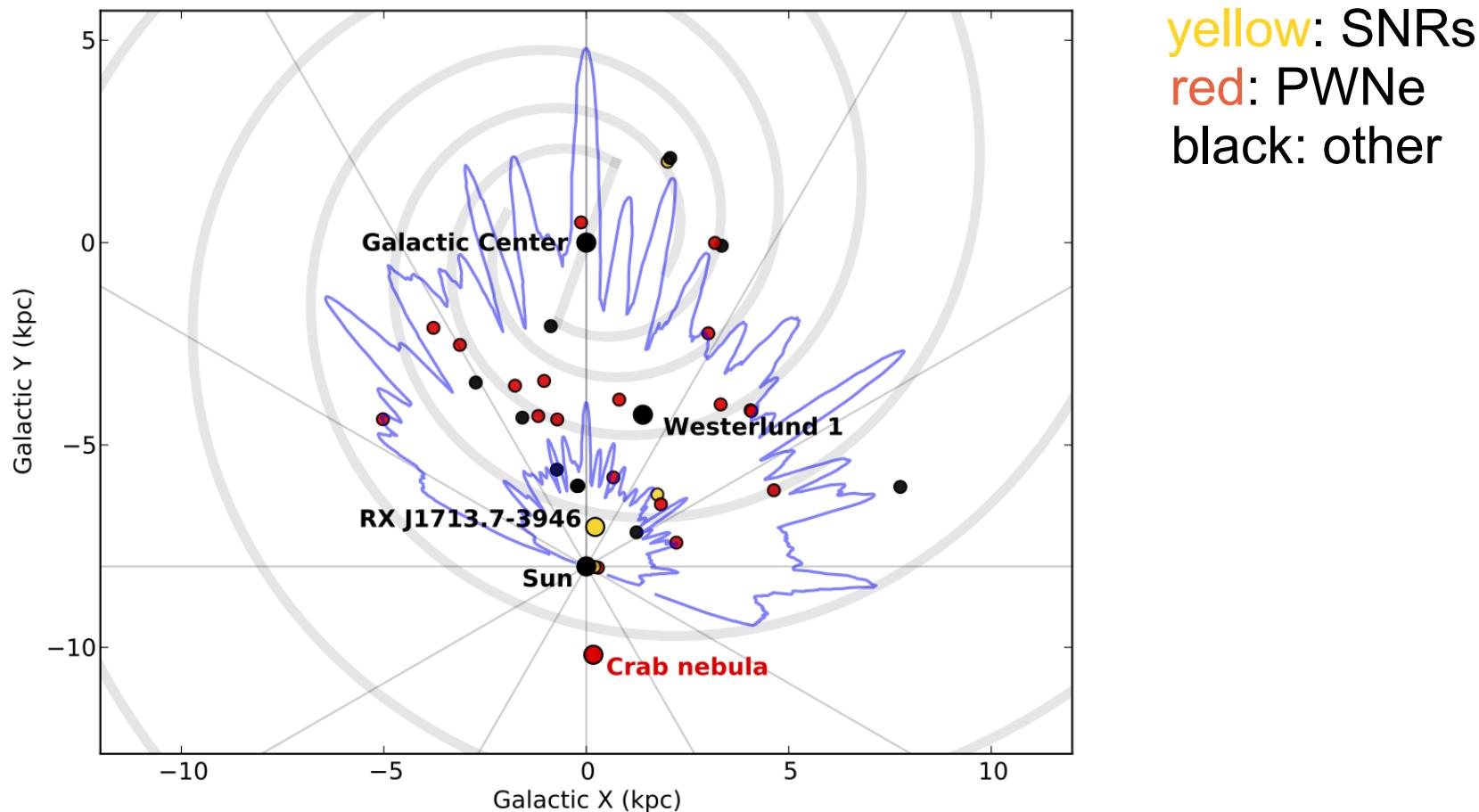


Blue line: estimate of the radius-dependant sensitivity of H.E.S.S.

Galactic source population

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Top View Galaxy

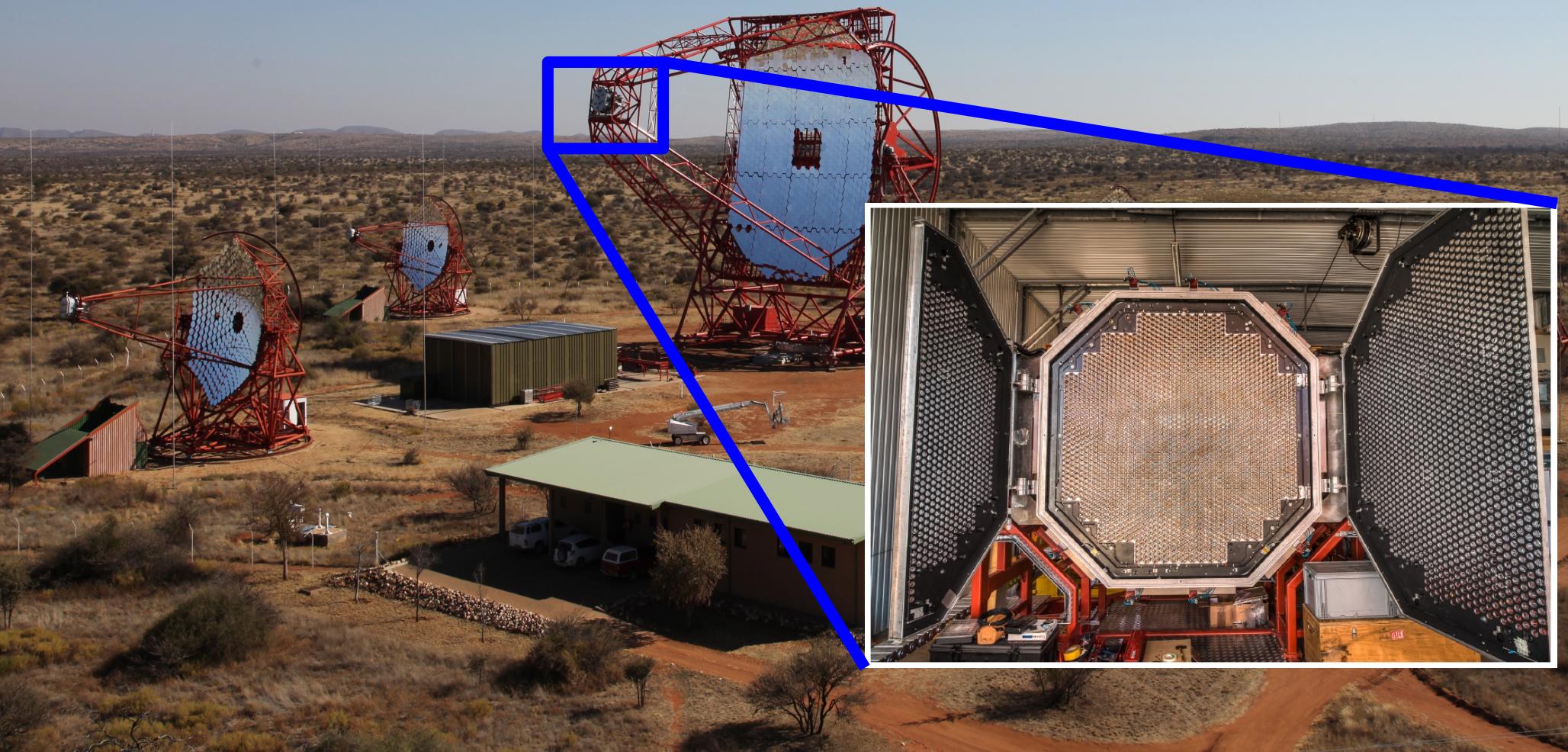


Blue line: H.E.S.S. horizons for 1% and 10% Crab above 1 TeV,
for a 5 σ point-like source

The Present : HESS-2



Characteristics



Characteristics

Mirror :

32.6 m by 24.3 m : equivalent to 28 m

Focal length : 36 m

875 hexagonal facets of 90 cm

Operation modes :

Mono > 30 GeV < ~100GeV

Stereo

(acquisition Mono + Stereo Event)

Camera Comparison :

Telescope	CT1-4	CT5
Mechanics		
Total Weight	~1 ton	~3 tons
Dimensions (W×H×D)	160×160×150 cm ³	227×240×184 cm ³
Camera FOV	5.0 deg.	3.2 deg.
Pixel FOV	0.16 deg.	0.067 deg.
Number of drawers	60	128
Number of pixels	960	2048
Dead-Time	460µs	15µs

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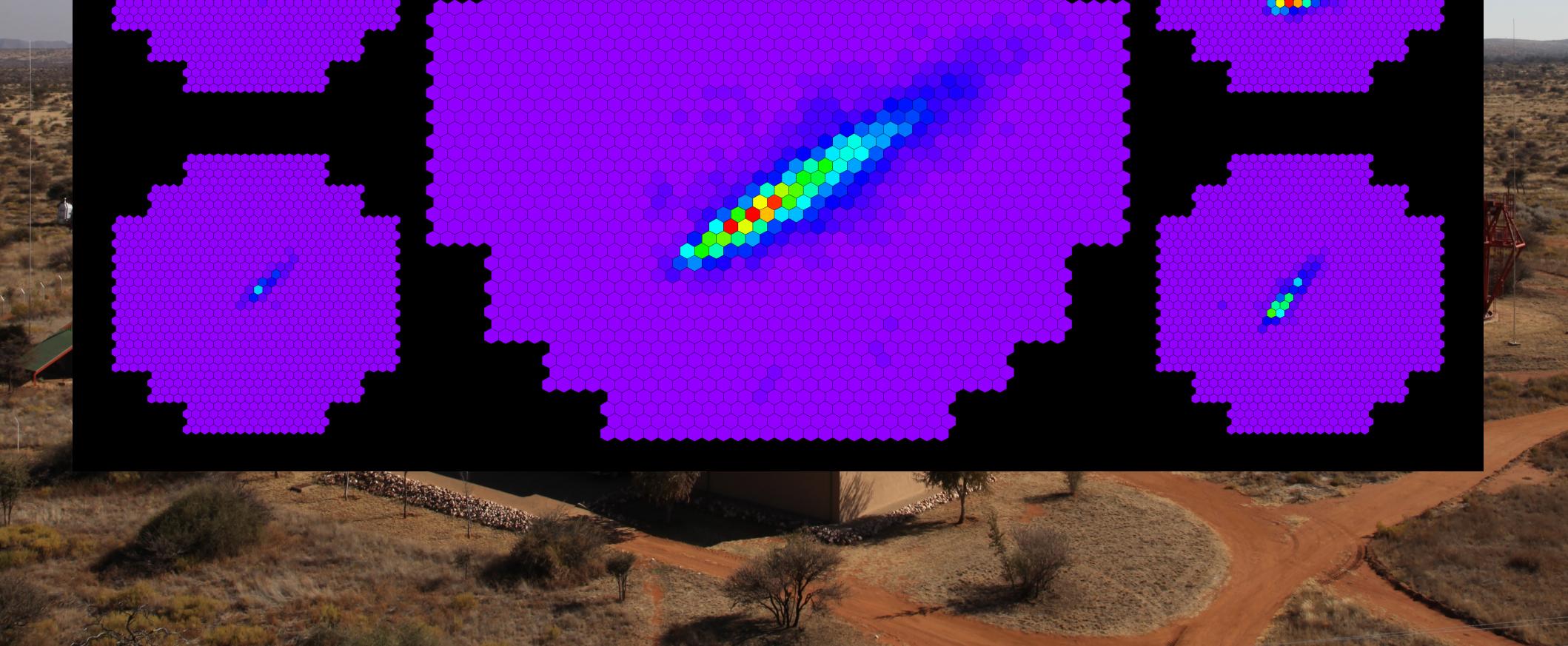
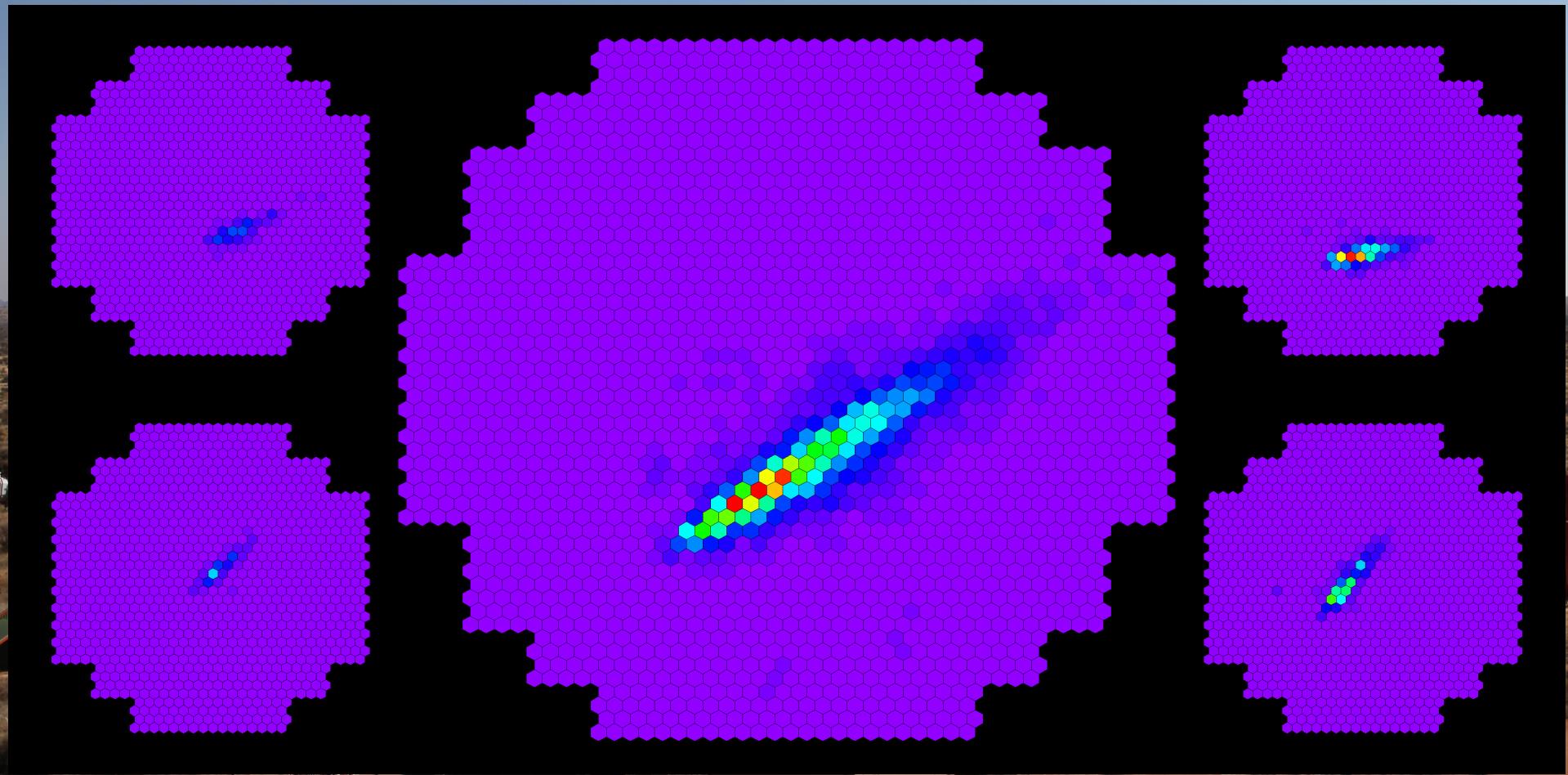
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CT5 : Not ideal for large survey

Stereoscopic Event



CT5 : Finer Details

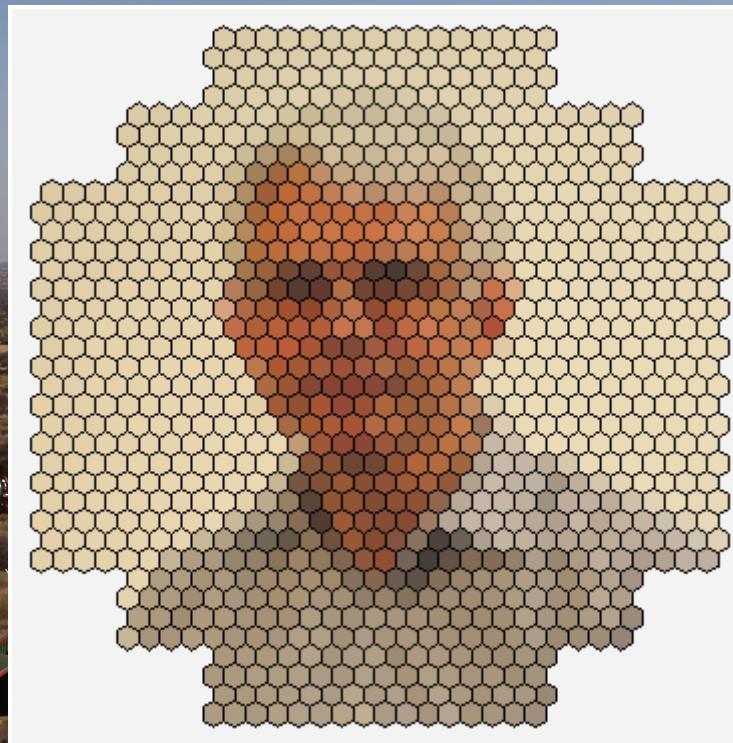
Pr Hofmann « as seen » by :



CT5 : Finer Details

Pr Hofmann « as seen » by :

CT1-4

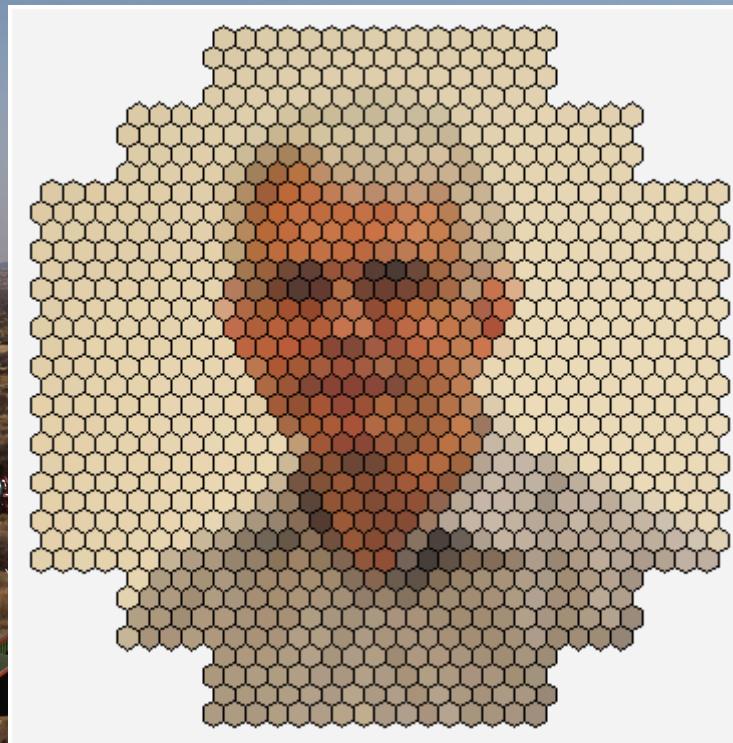


Many thanks to Ramin Marx

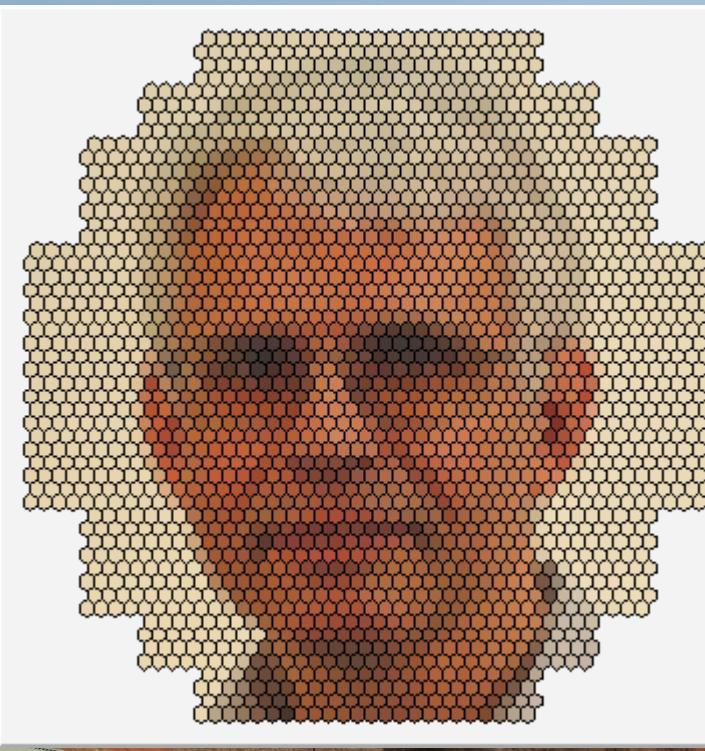
CT5 : Finer Details

Pr Hofmann « as seen » by :

CT1-4



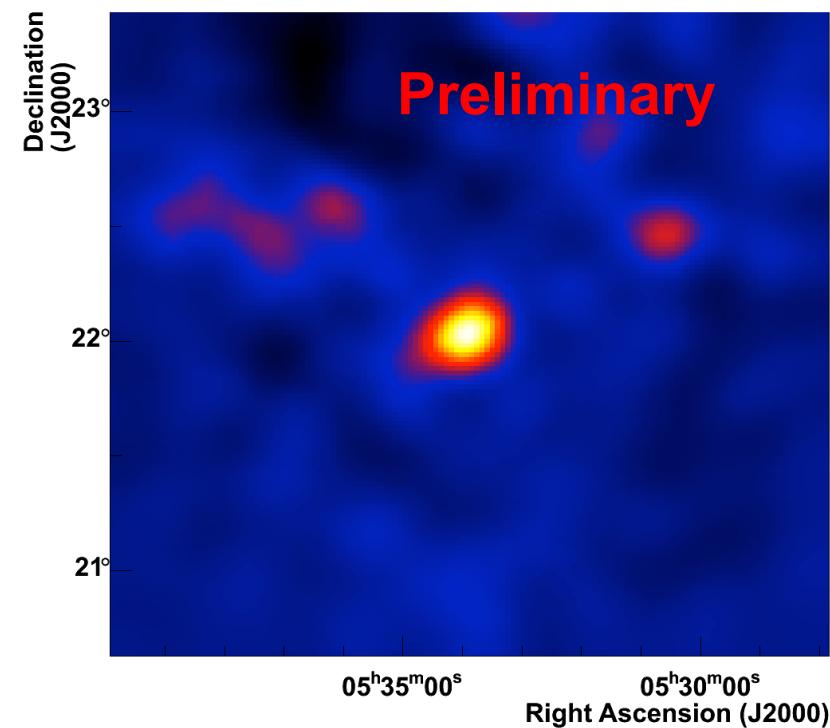
CT5



Fine Pixelisation helps gamma/hadron separation
→ Usefull in mono mode !

Many thanks to Ramin Marx

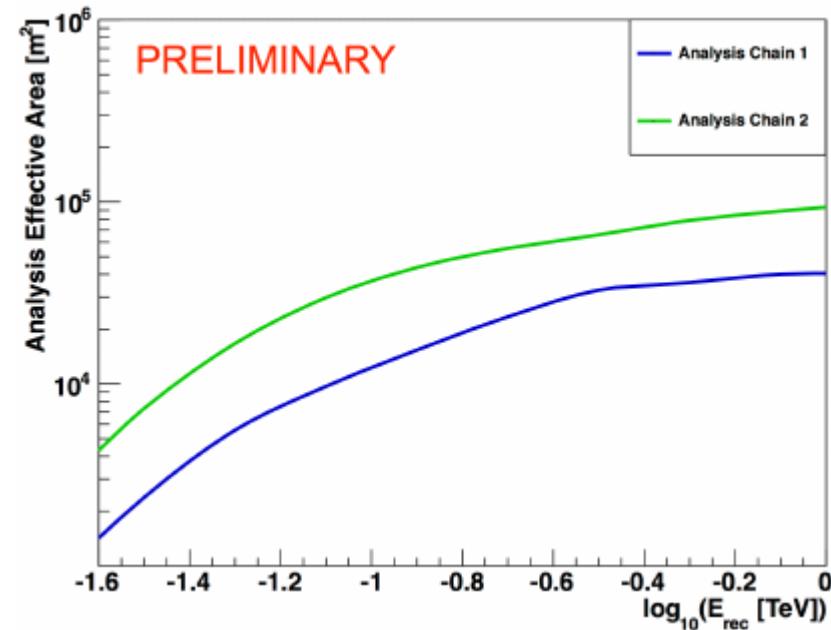
First Results



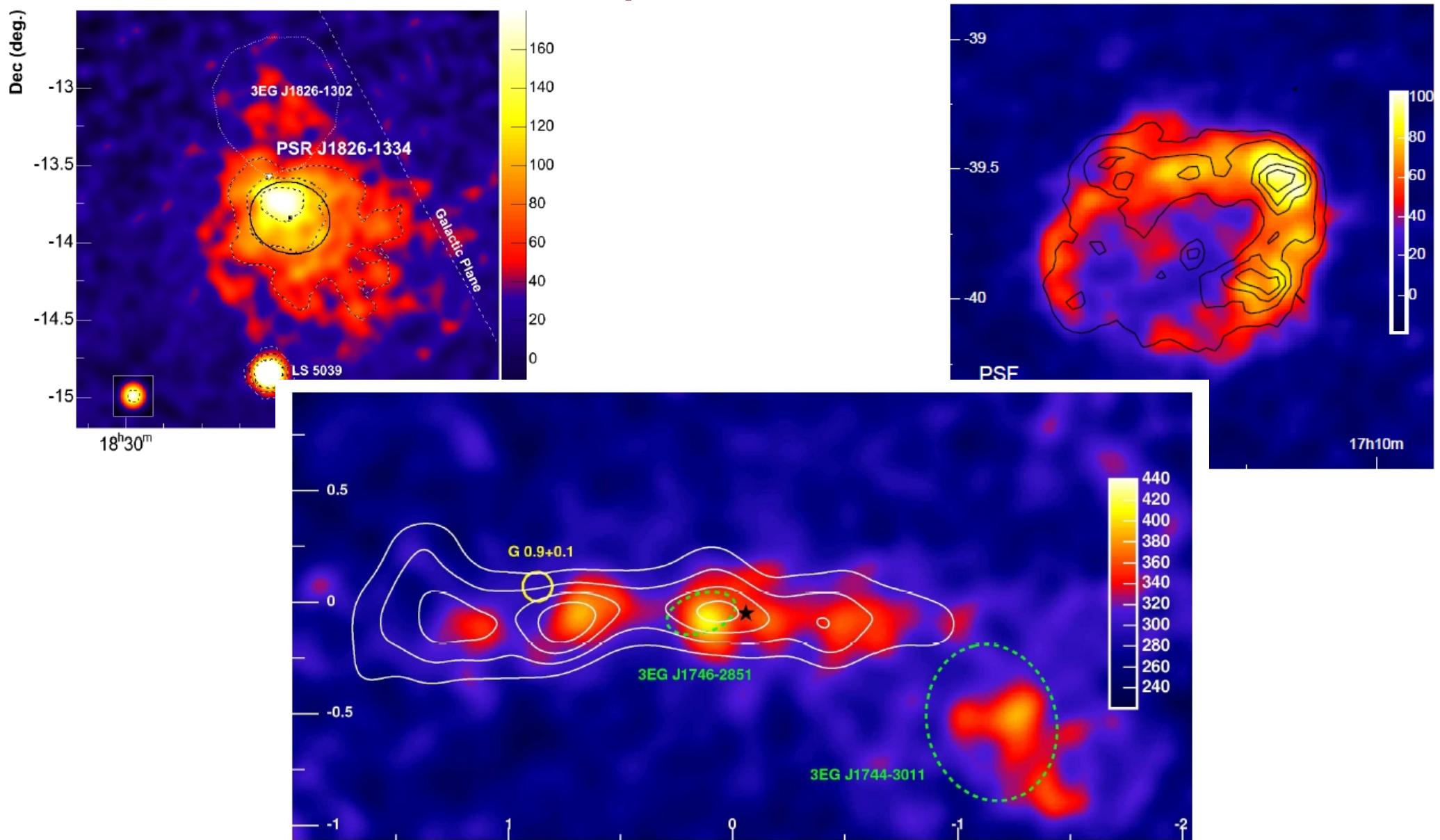
Holler et al. 2013 (ICRC)

Analysis of first data from the Crab :
Map > 50 GeV (Mono Events)

(For information : HESS-I >300-400 GeV)



CT5 Analysis - Challenges



Interesting galactic object : Extended \geq CT5 FoV

Conclusions

→ HESS-I Legacy survey program status :

- 2 % Sensitivity reach everywhere in the Galaxy
- HGPS Catalog + Maps will be released soon
- Allow population study (warning : completeness)

→ HESS-II enters in action :

- Not adapt to perform large survey
- Will allow to go much lower in energy
- Data Analysis will be challenging

HESS-I allowed us to see what was the source population at TeV,
HESS-II will allow us to understand them !

