The Milky Way observed in TeV gamma-rays with H.E.S.S.

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H.E.S.S.

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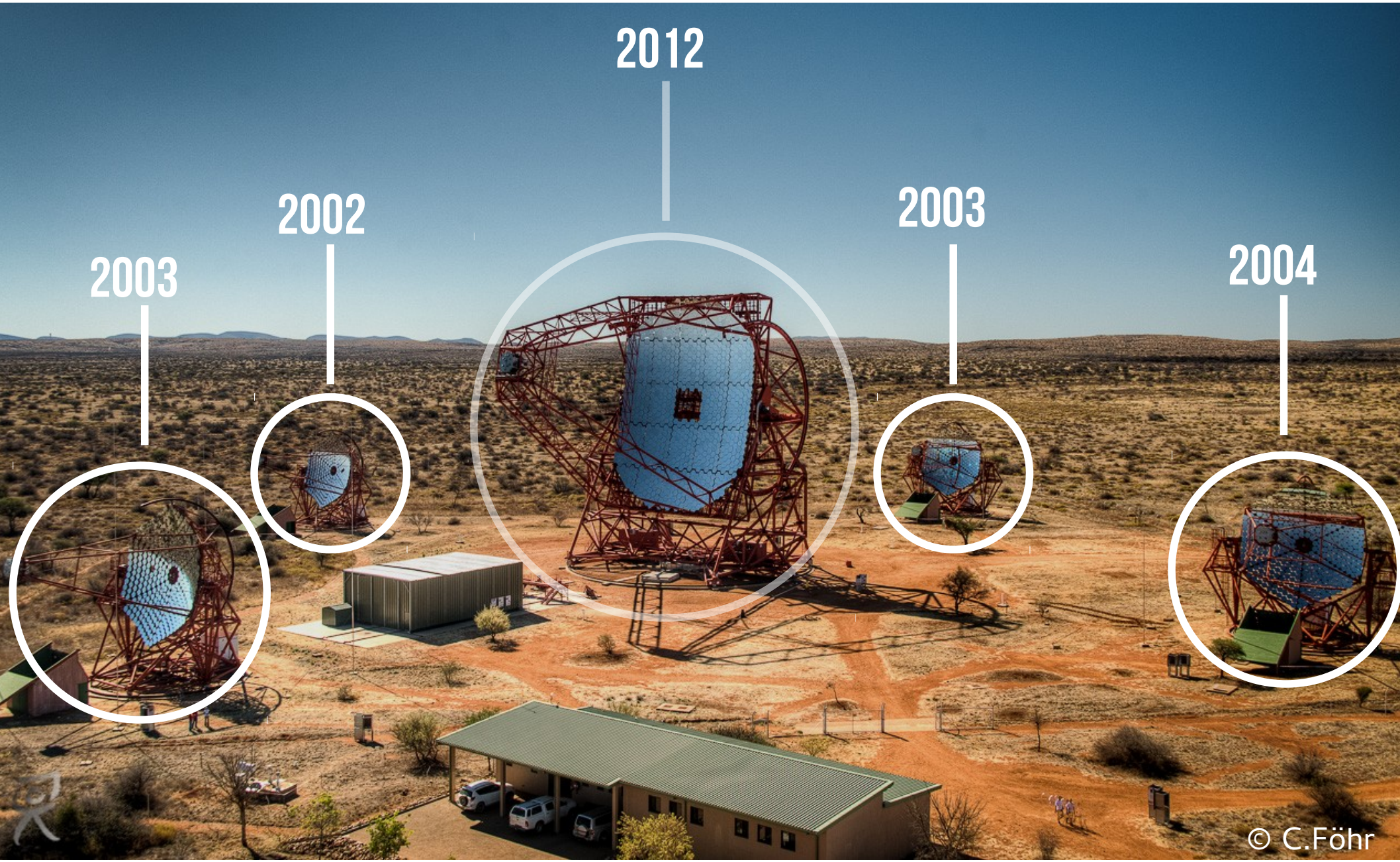
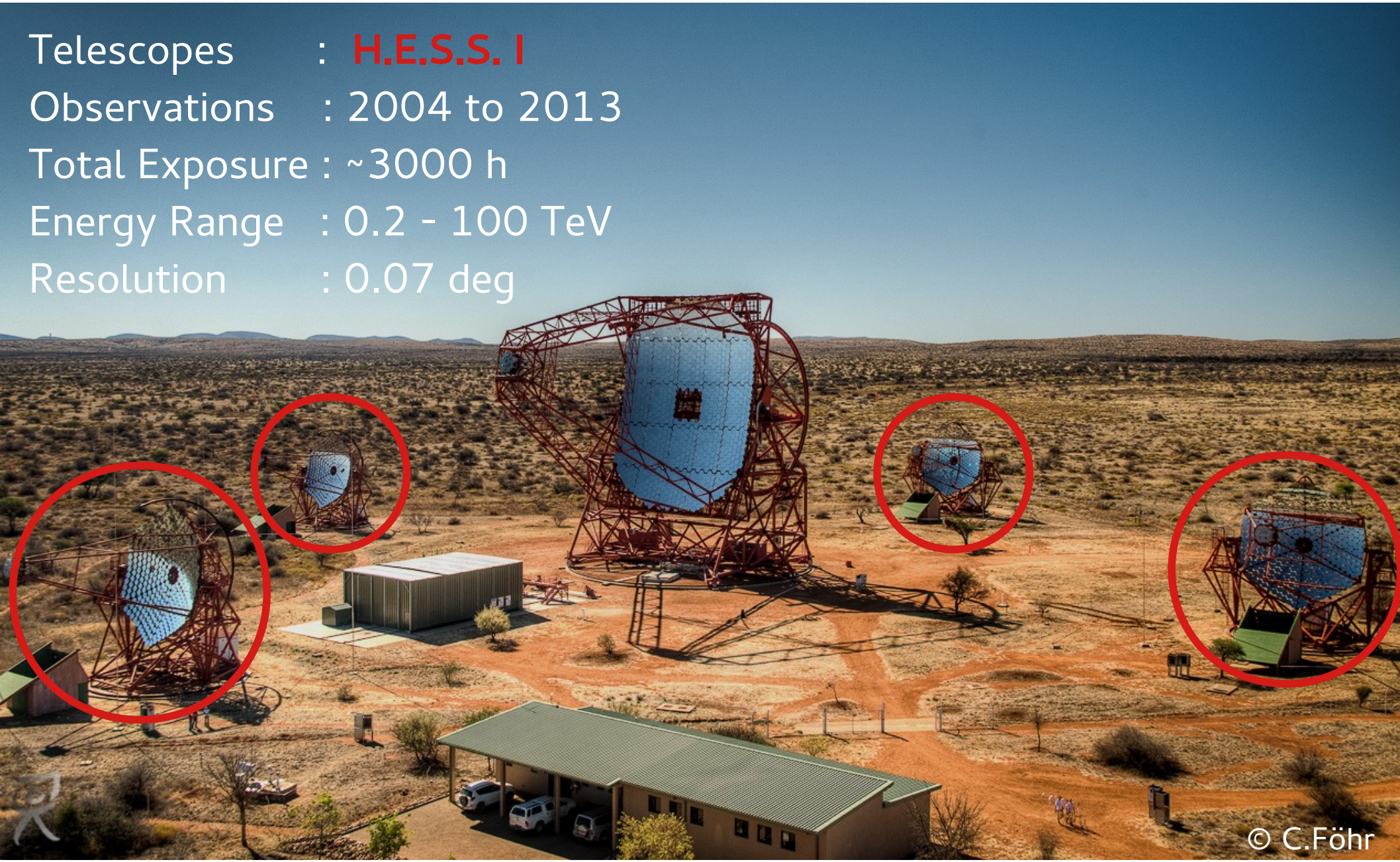
H.E.S.S. TELESCOPES



THE HGPS DATASET

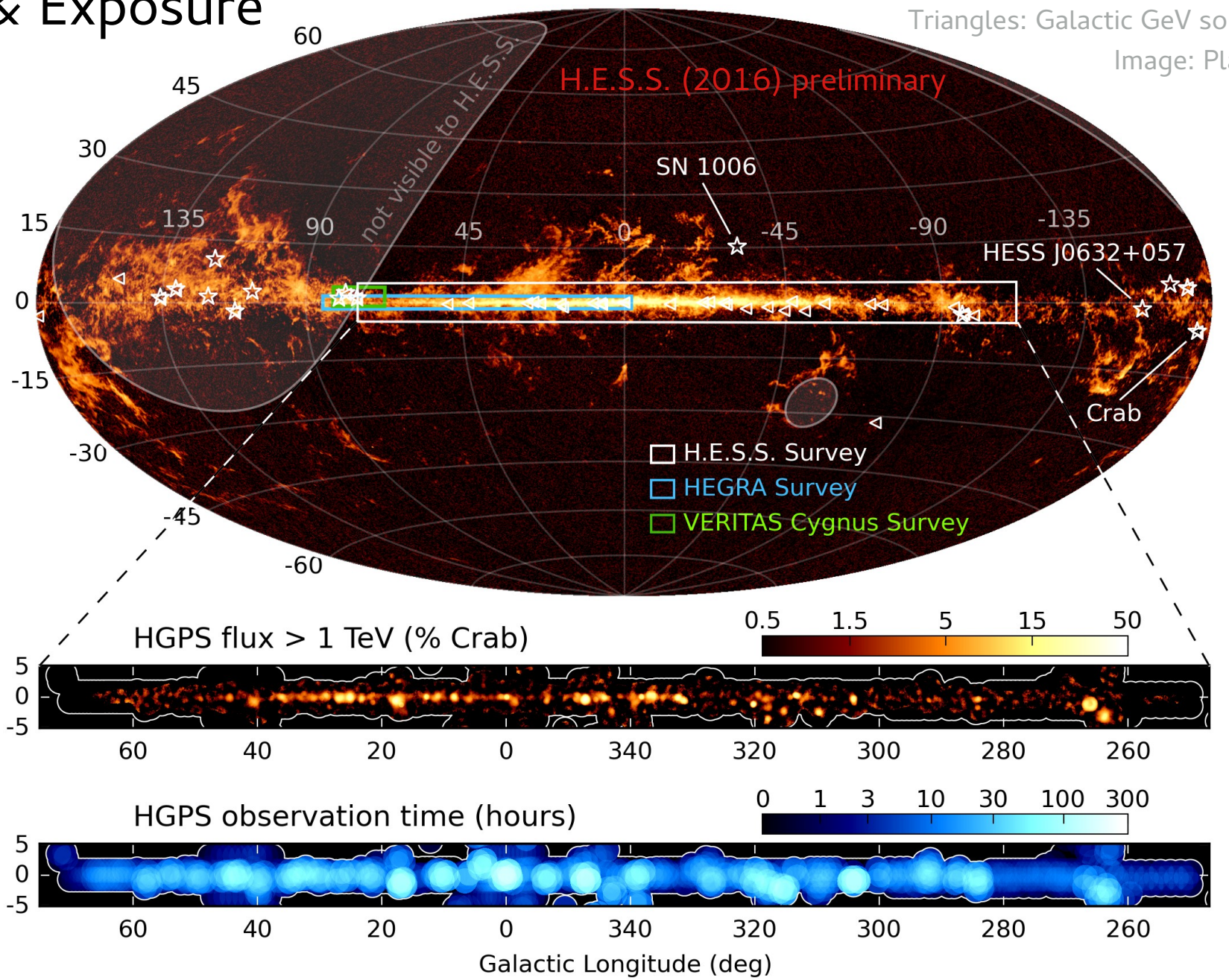


Telescopes : **H.E.S.S. I**
Observations : 2004 to 2013
Total Exposure : ~3000 h
Energy Range : 0.2 - 100 TeV
Resolution : 0.07 deg

SURVEY REGION

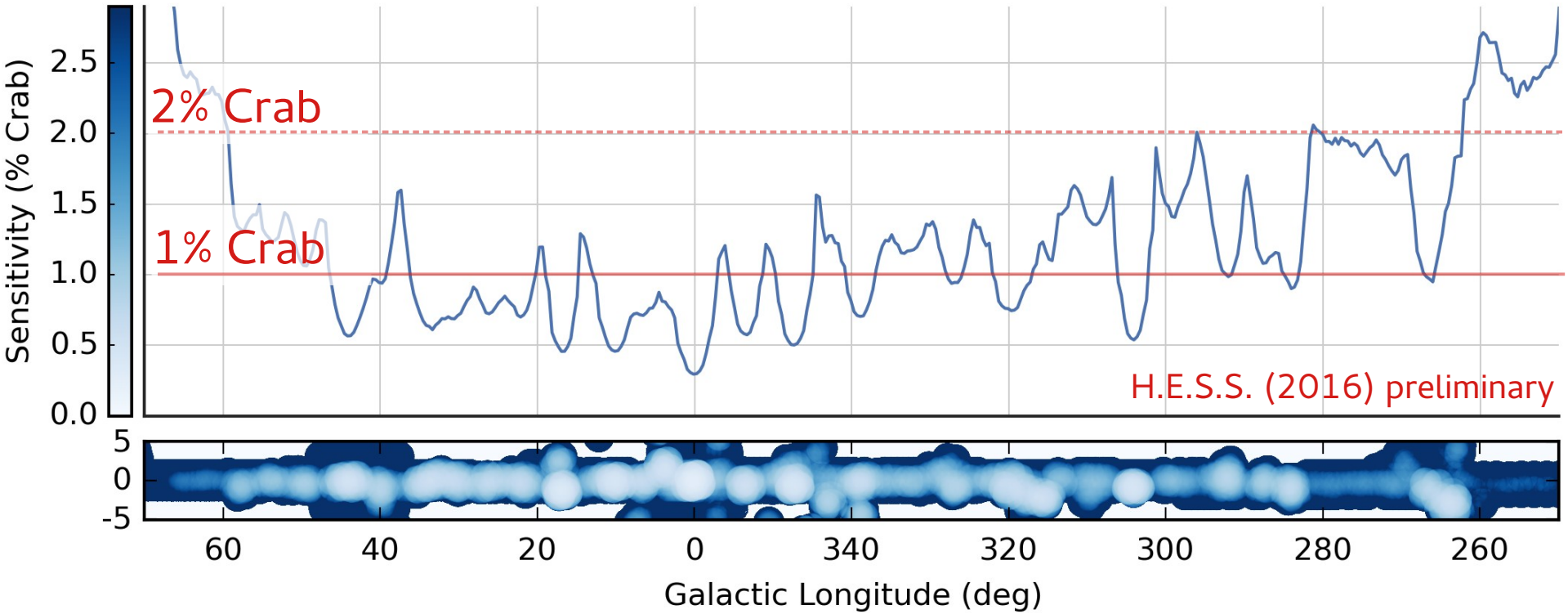
Flux & Exposure

Stars: Galactic TeV sources outside HGPS region
Triangles: Galactic GeV sources (2FHL)
Image: Planck CO map



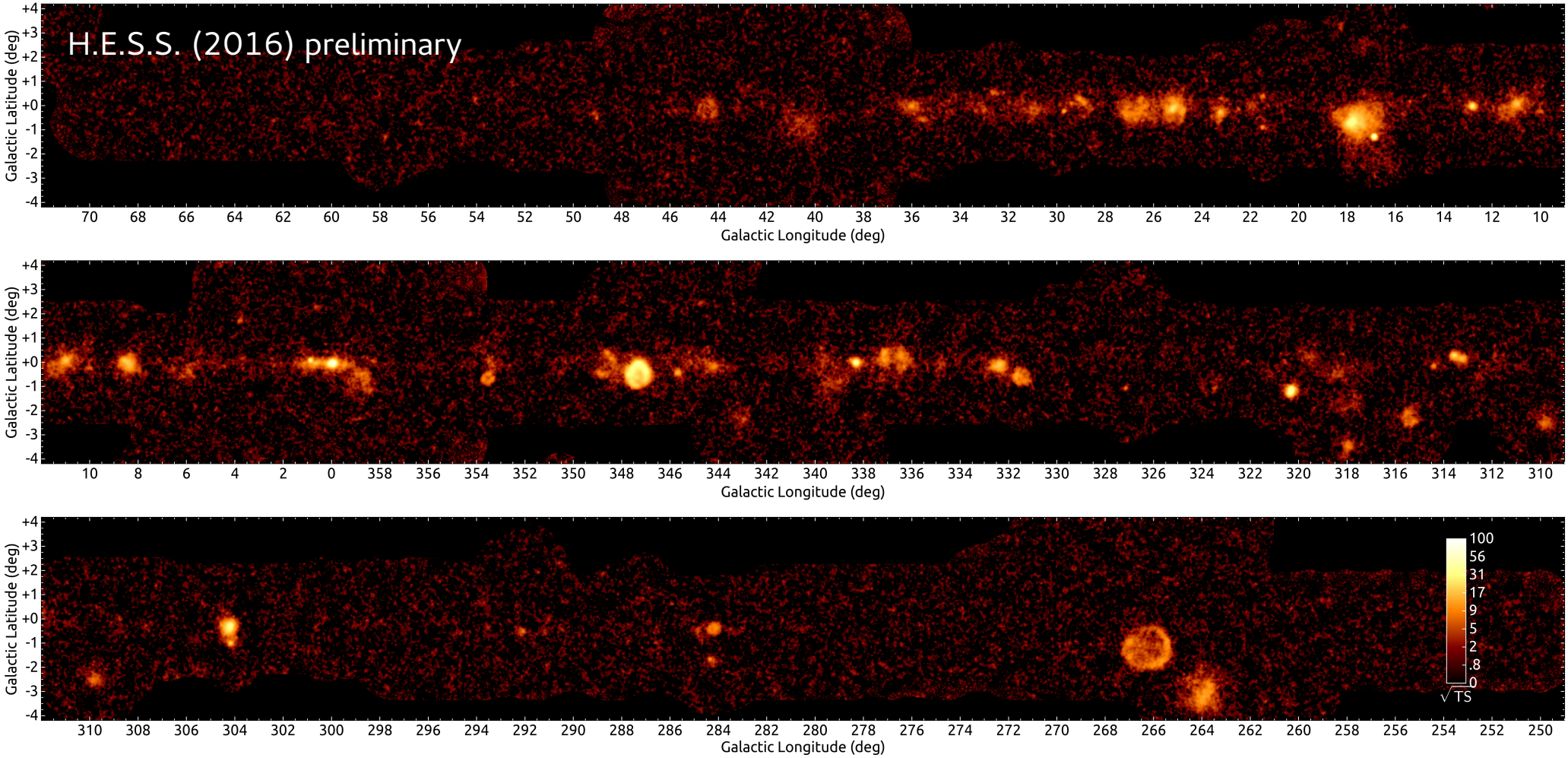
SENSITIVITY PROFILE

Point-like for 5 sigma detection



SURVEY MAP

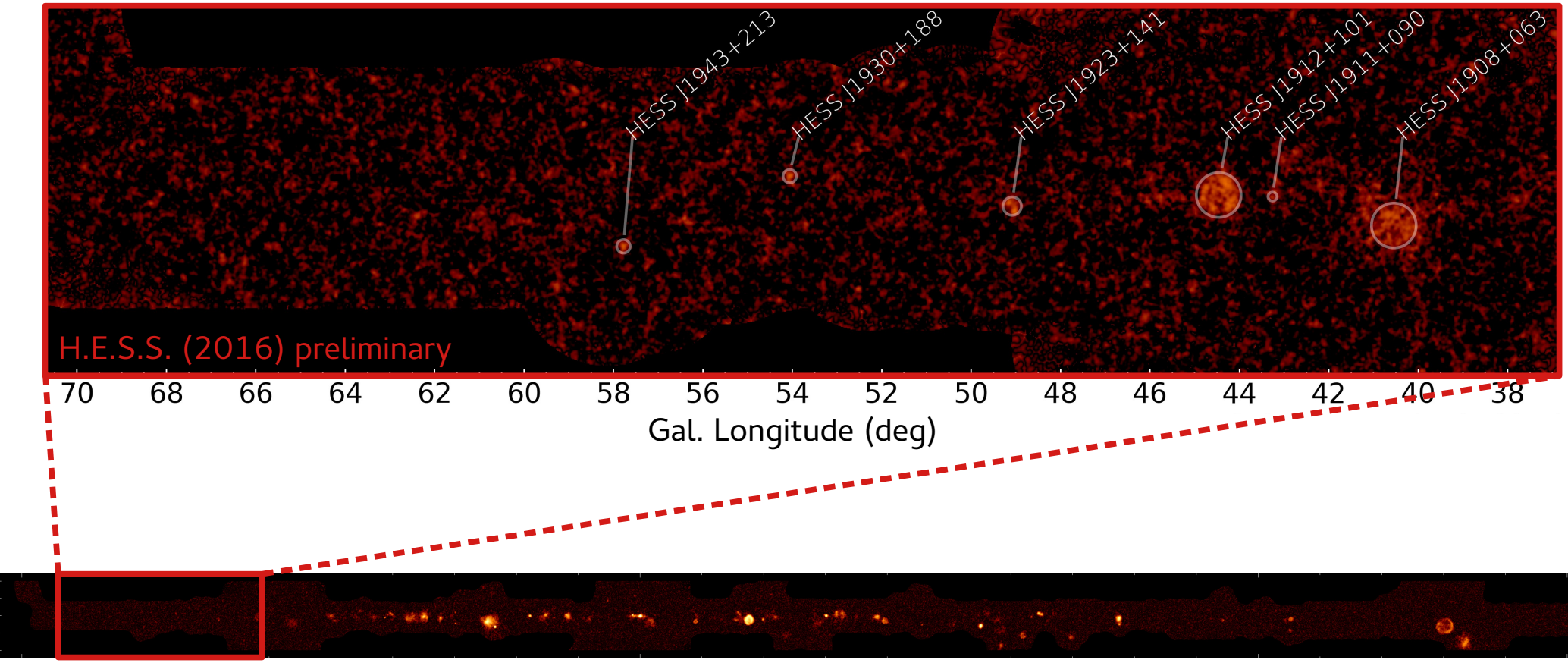
Point-like significance



Map also available from the HGPS ICRC 2015 poster contribution:
https://indico.cern.ch/event/344485/contributions/1743714/

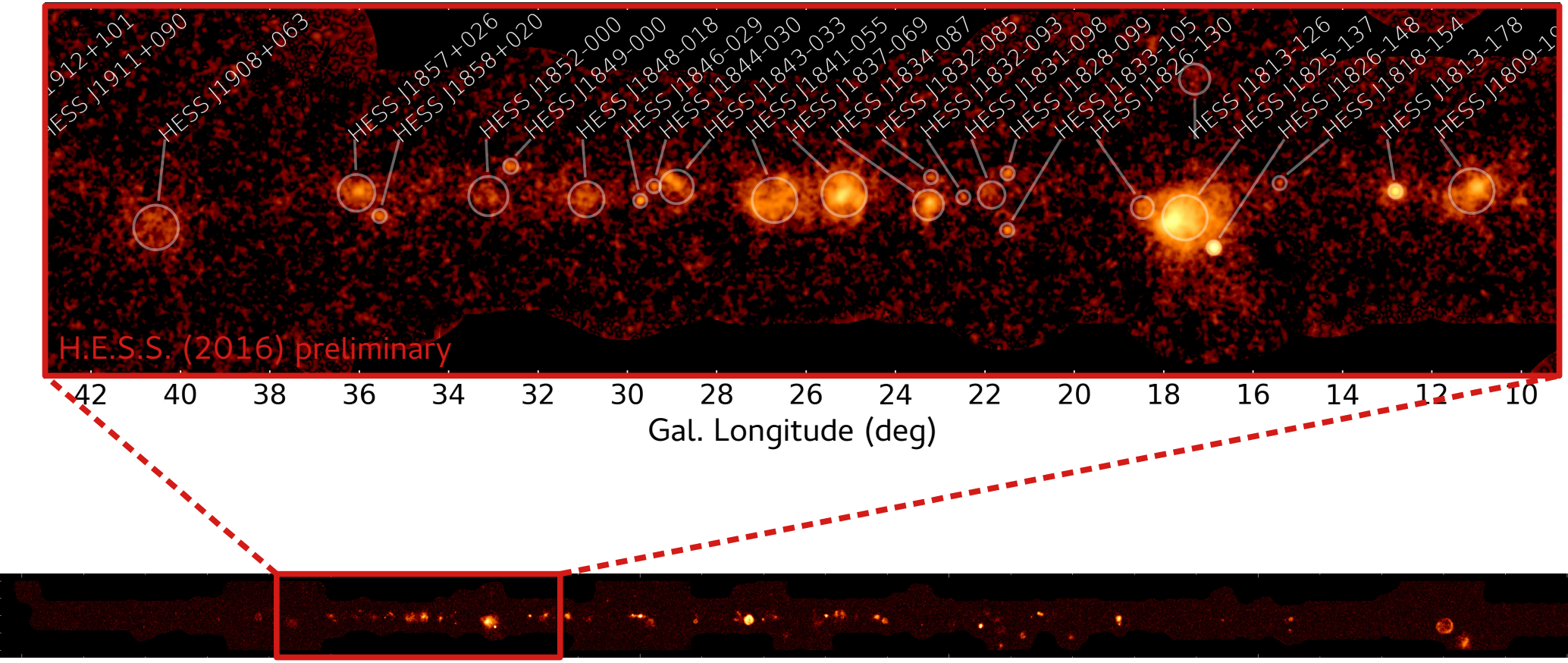
SURVEY MAP

Pan from left to right



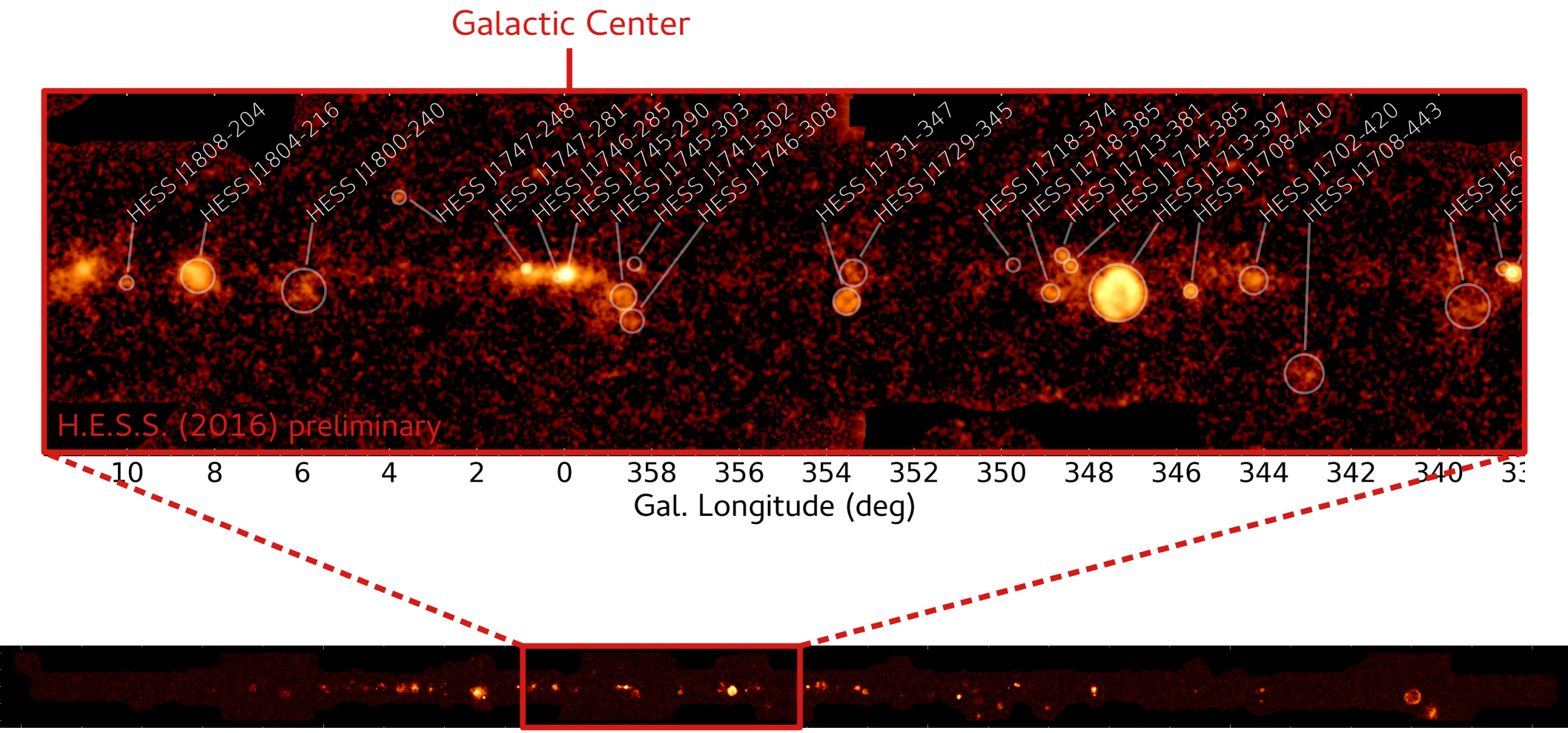
SURVEY MAP

Pan from left to right



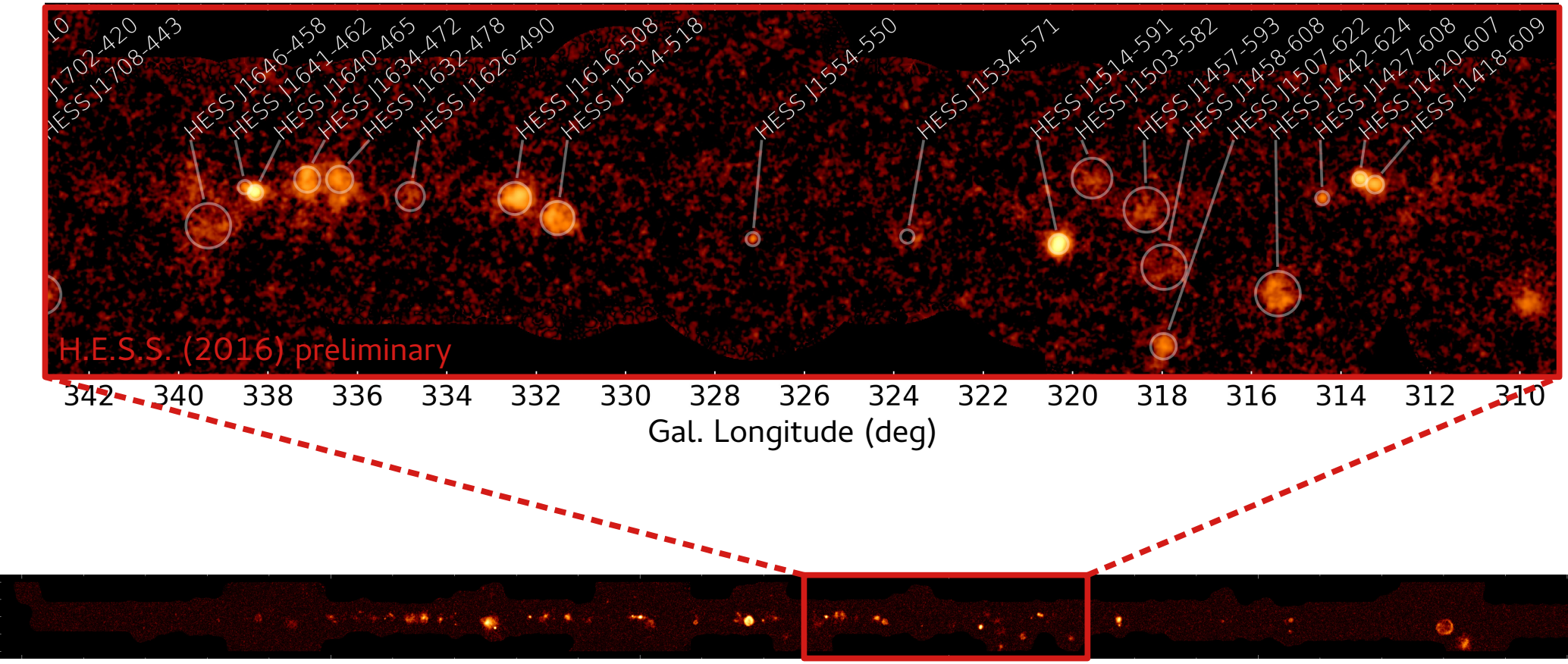
SURVEY MAP

Pan from left to right



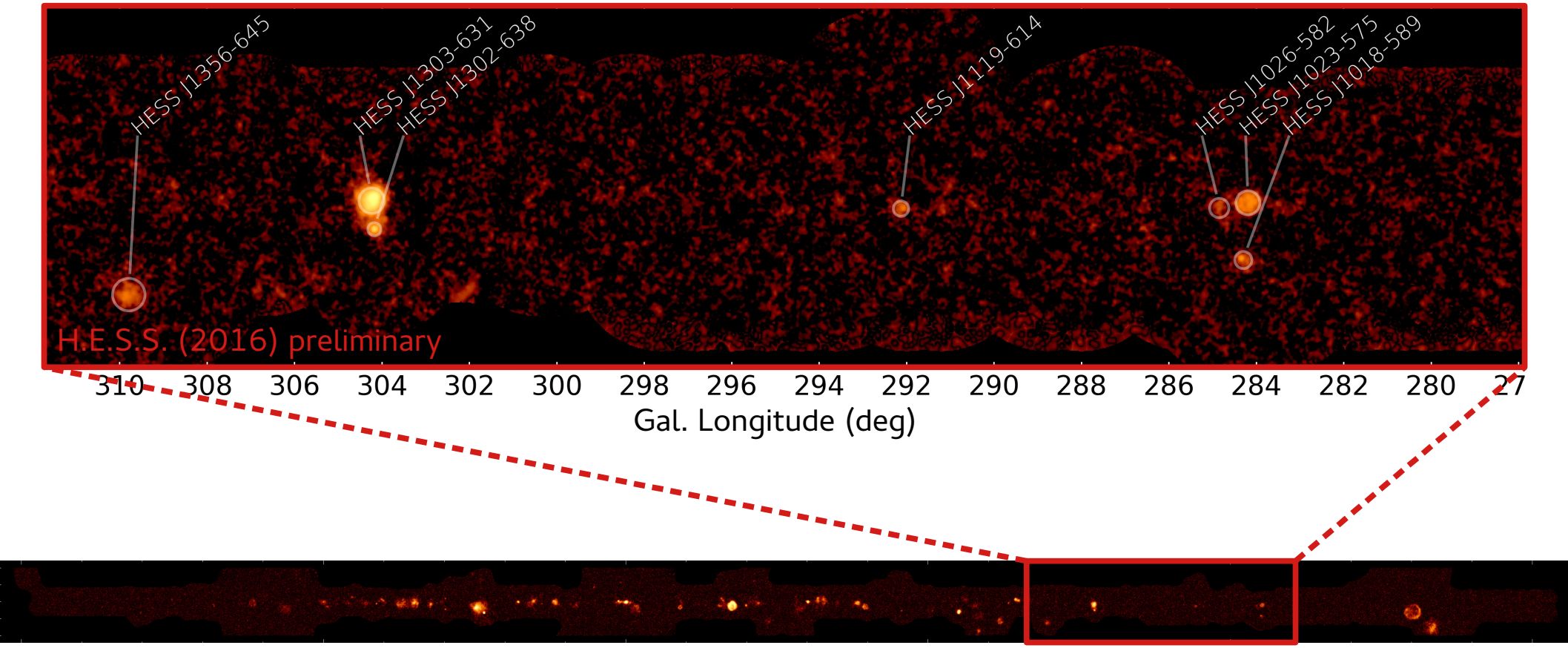
SURVEY MAP

Pan from left to right



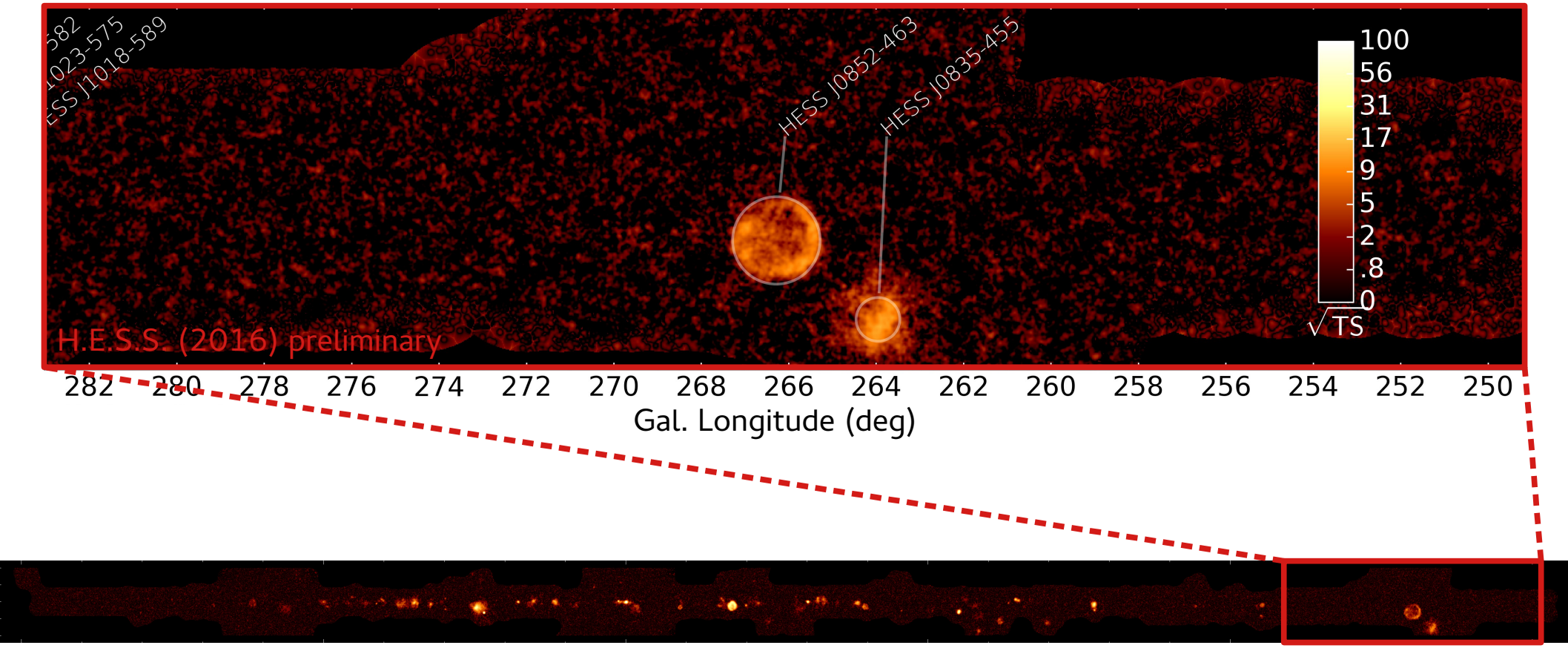
SURVEY MAP

Pan from left to right



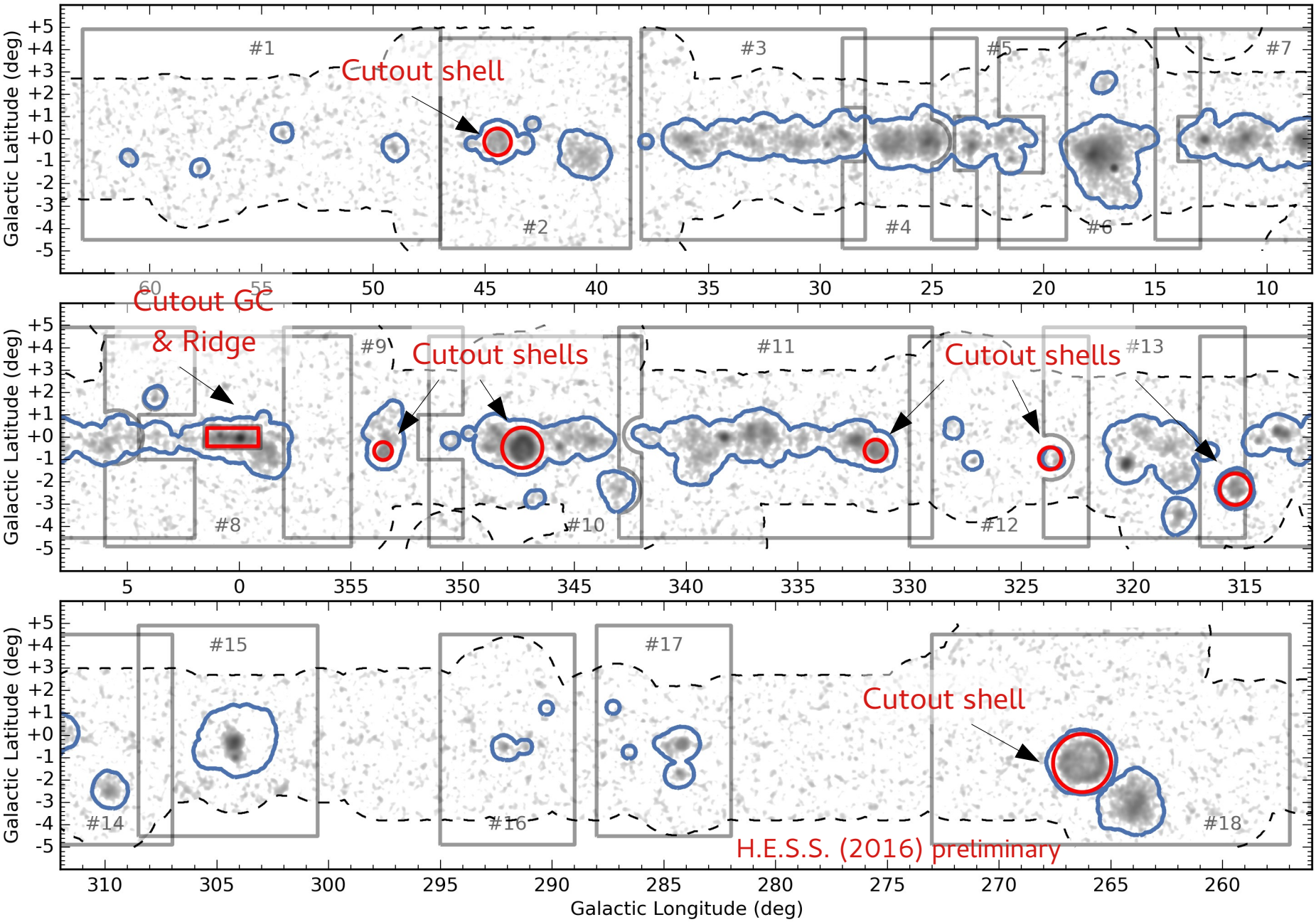
SURVEY MAP

Pan from left to right



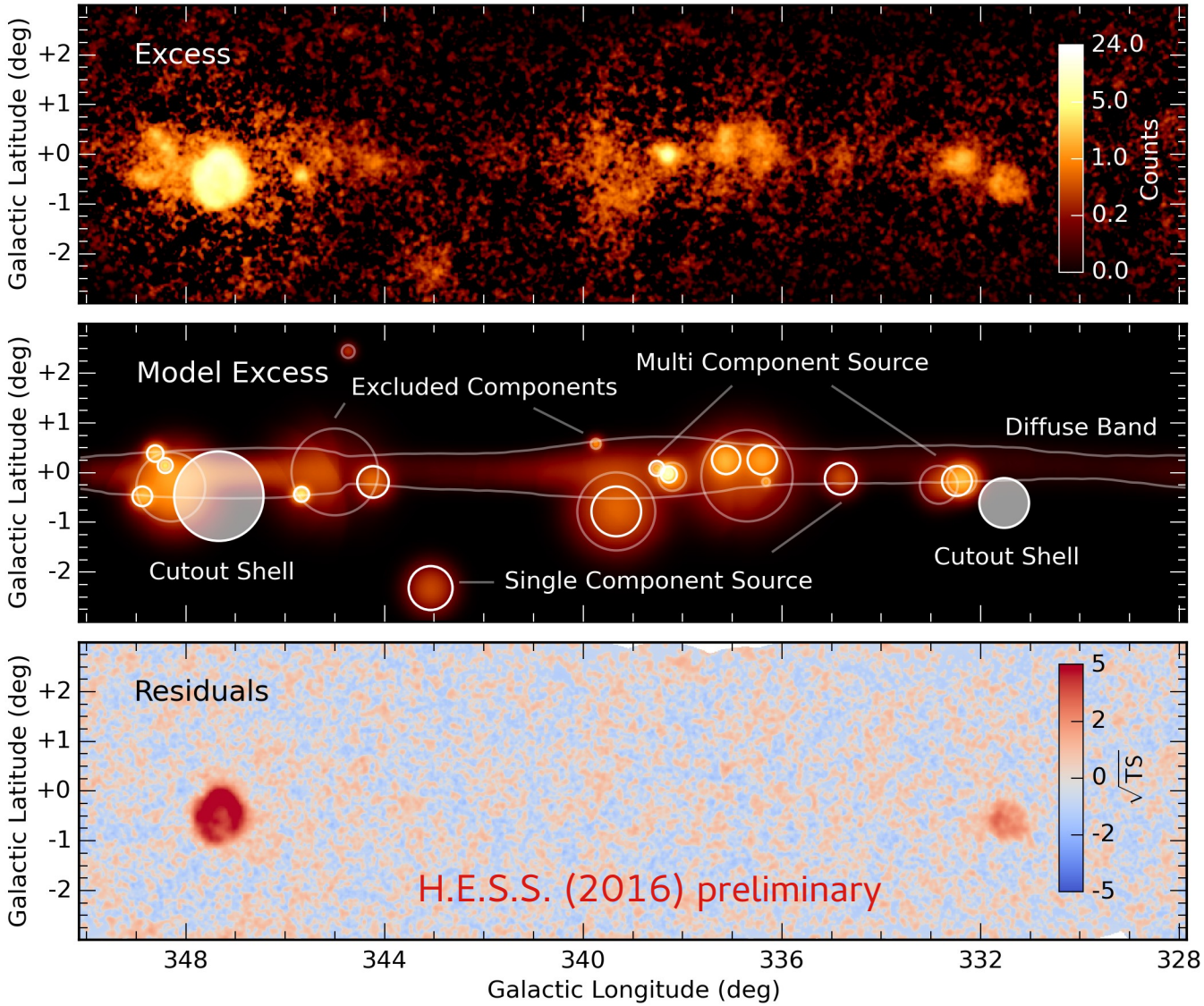
ROI BASED ANALYSIS

Excluding regions of complex emission



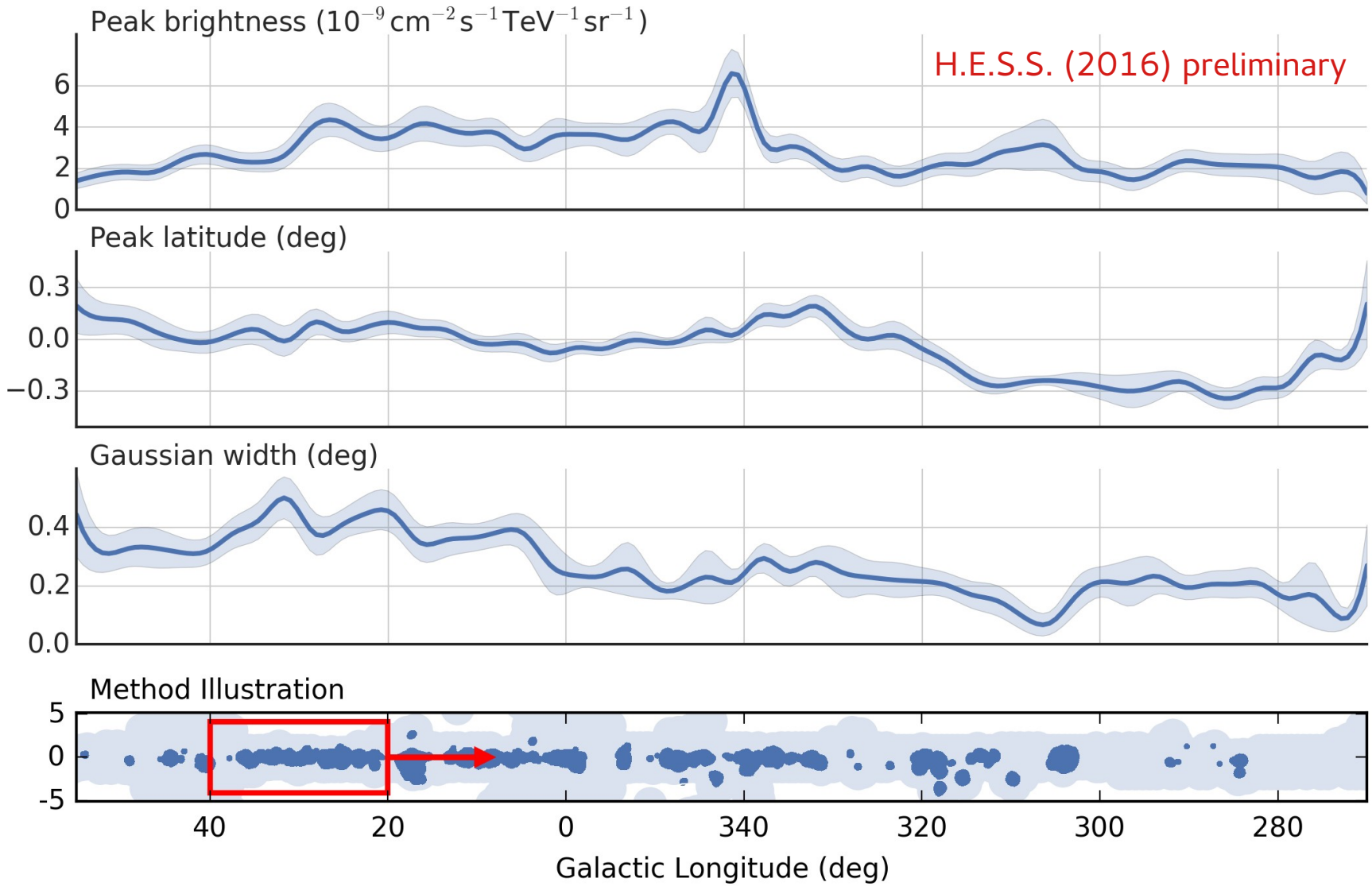
MORPHOLOGY MODEL

For 2D Poisson max. likelihood fit



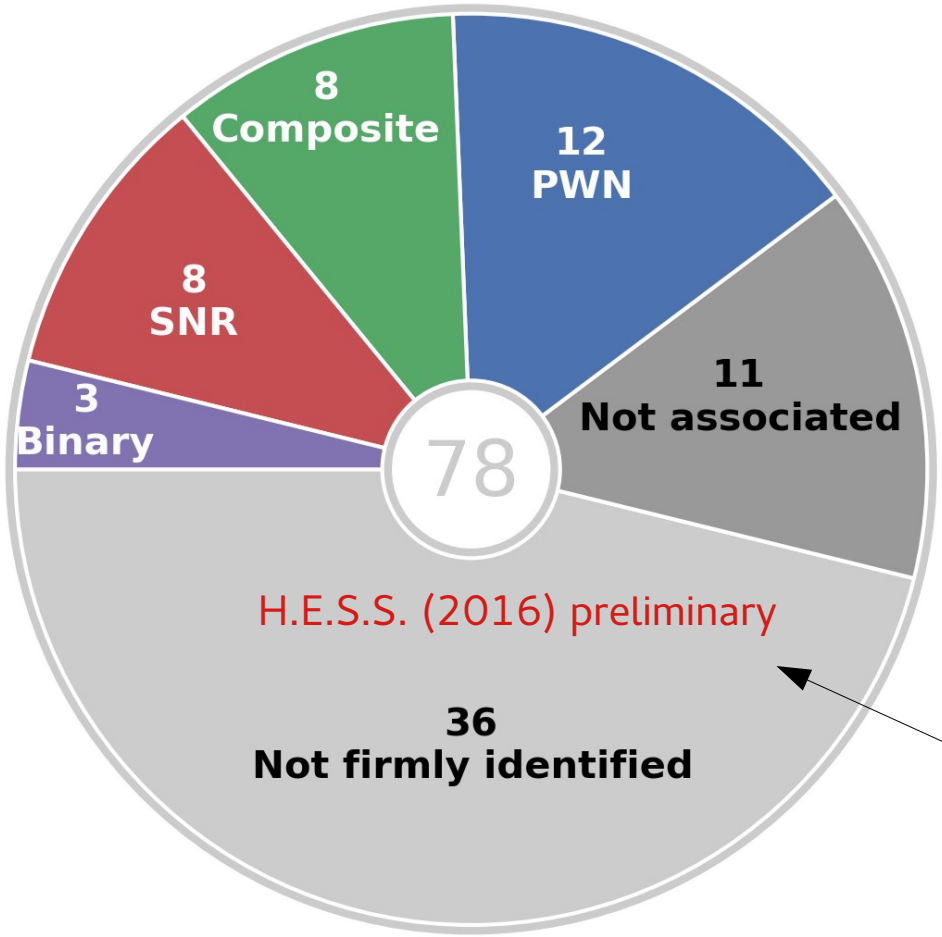
LARGE SCALE EMISSION MODEL

Empirical, not physical "Gaussian band"



FIRM IDENTIFICATIONS

& associations by spatial coincidence



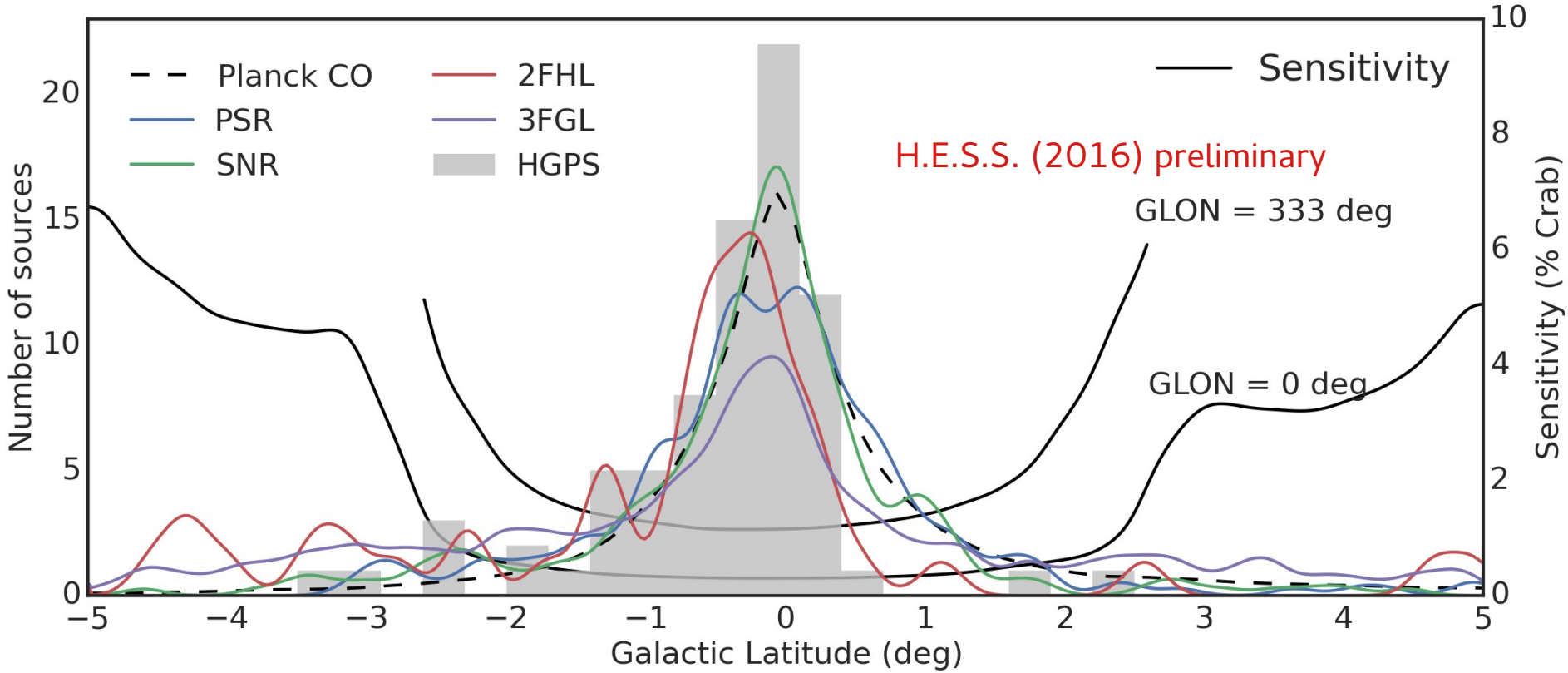
MWL counterparts:

- Pulsars (ATNF)
- PWN (SNRcat)
- SNRs (SNRcat)

Sources with **multiple associations**

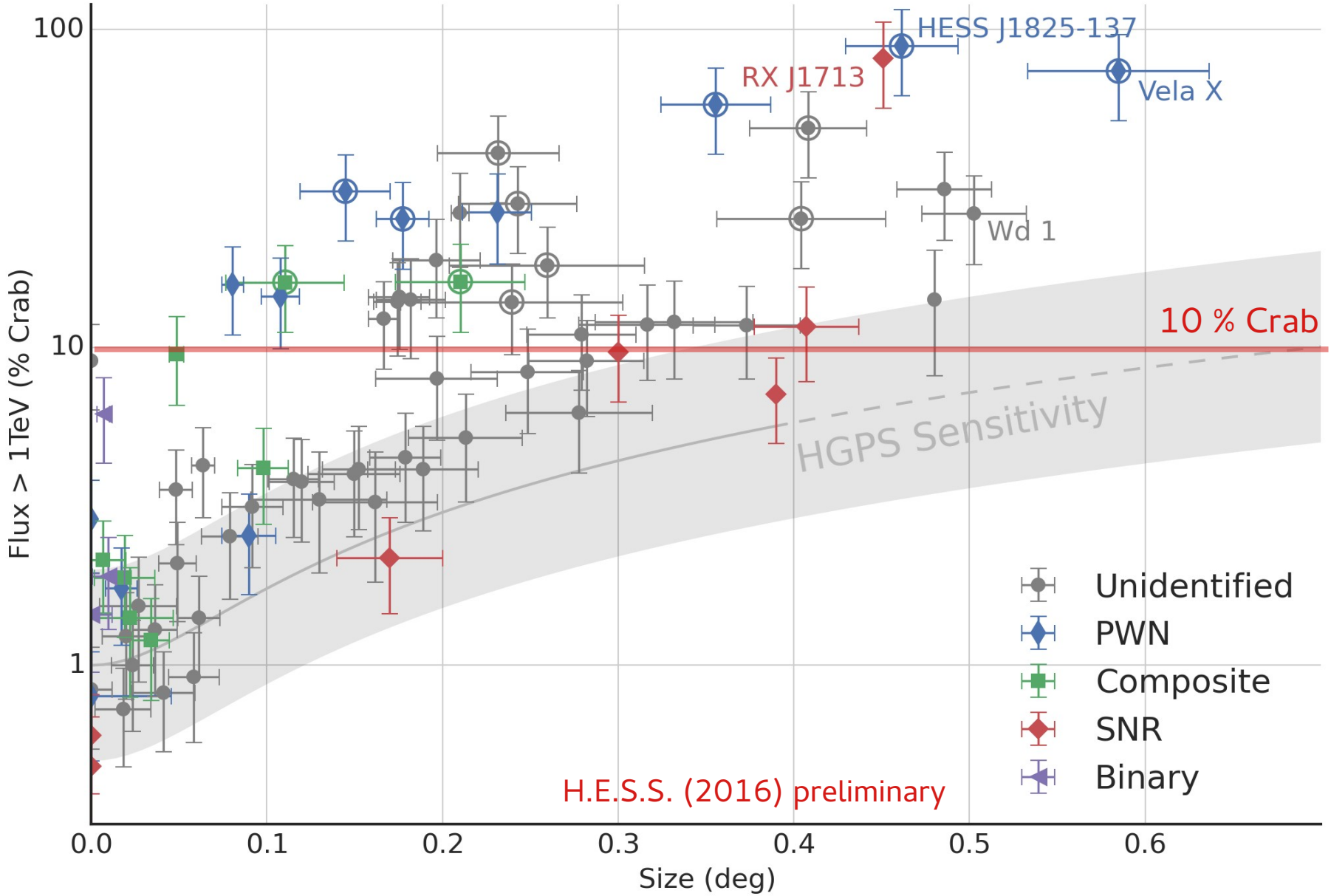
SOURCE LATITUDE DISTRIBUTION

In relation to MWL counterparts and Galactic CO



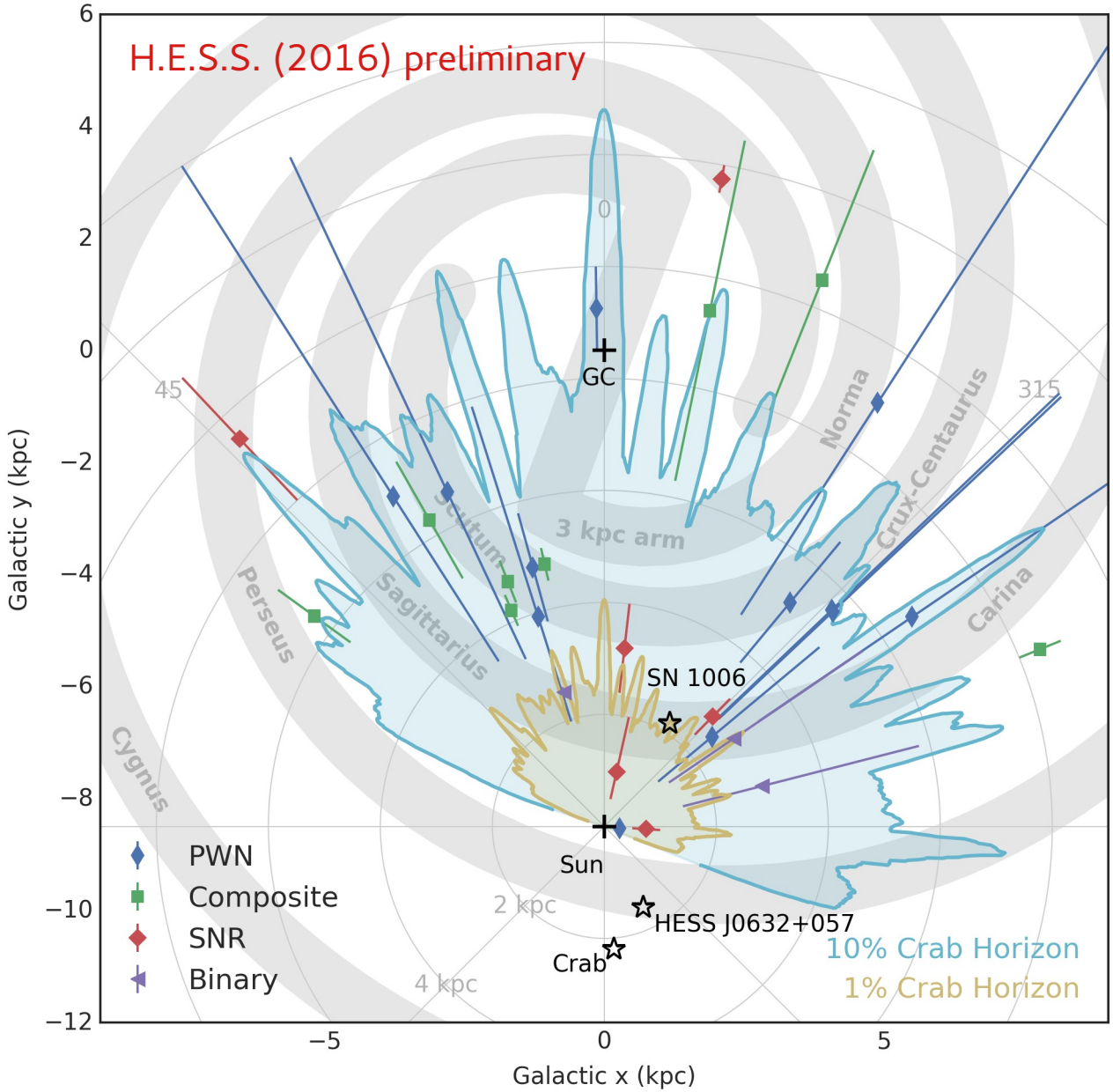
SOURCE FLUX VS SIZE

In relation to HGPS sensitivity

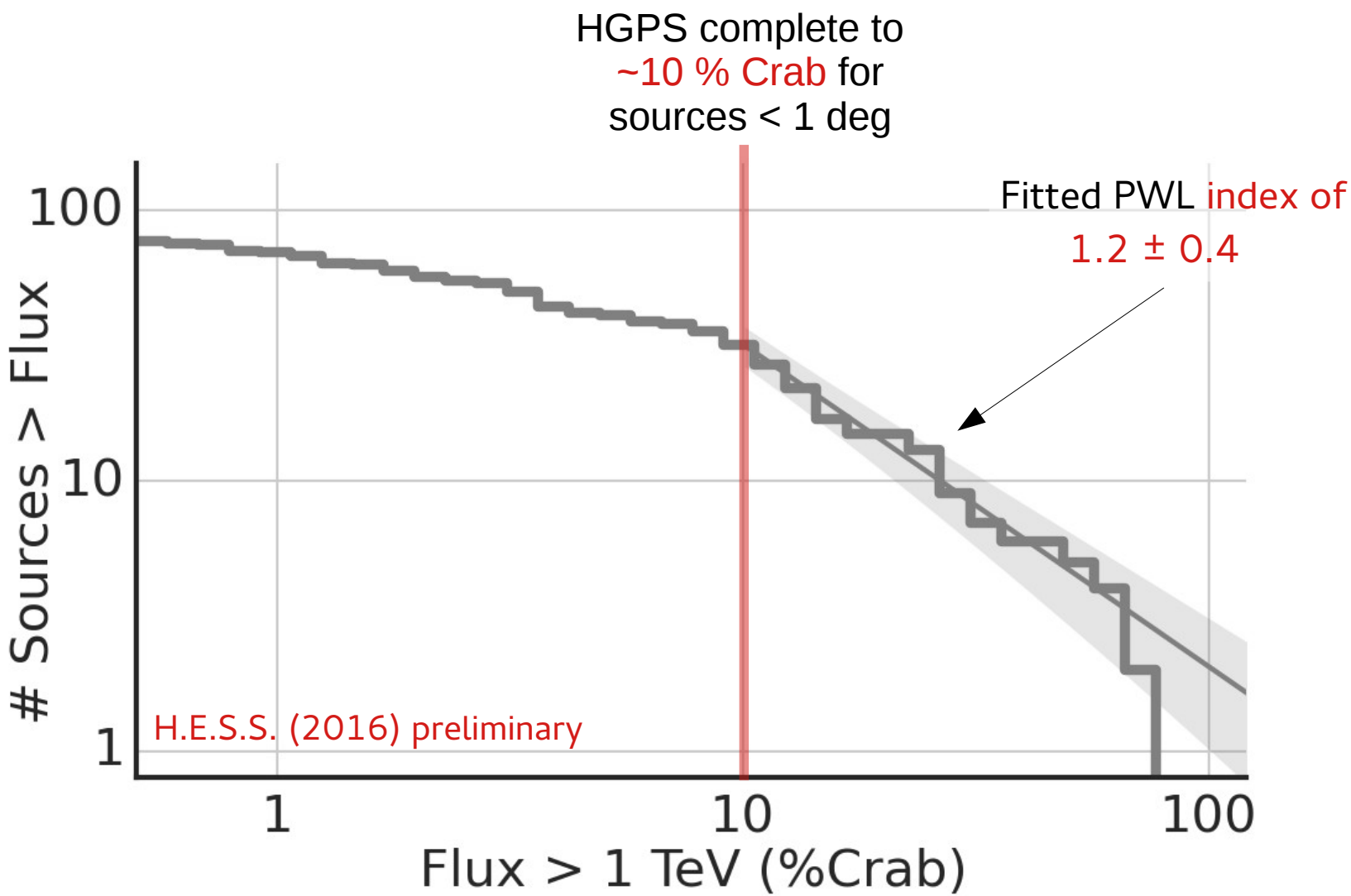


DISTRIBUTION IN THE GALAXY

& HGPS horizon



LOG N – LOG S DISTRIBUTION



SUMMARY

- Decade-long H.E.S.S. I Galactic Plane Survey (HGPS) is completed
- Release of paper, FITS maps and catalog coming soon

Related work:

- PWN population study

(Presented at Gamma 2016, https://www.mpi-hd.mpg.de/hd2016/pages/presentations/Klepser.pdf)

- Systematic search for new SNR shells

(Presented at ICRC 2015, https://indico.cern.ch/event/344485/contributions/1744848/)

- SNR population study in preparation

(Presented at ICRC 2015, https://indico.cern.ch/event/344485/contributions/1744441/)


END
(c) F. Acero & H. Gast

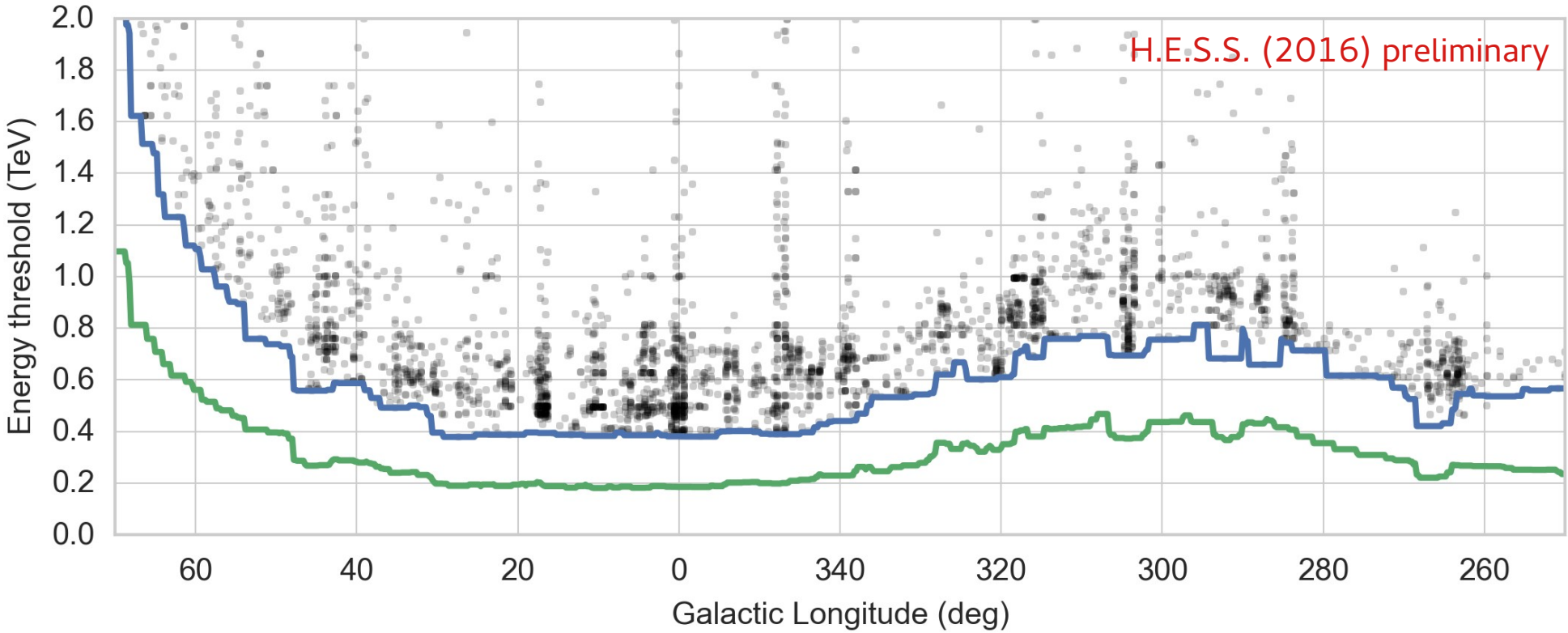
BACKUP SLIDES

FIRM IDENTIFICATIONS TABLE

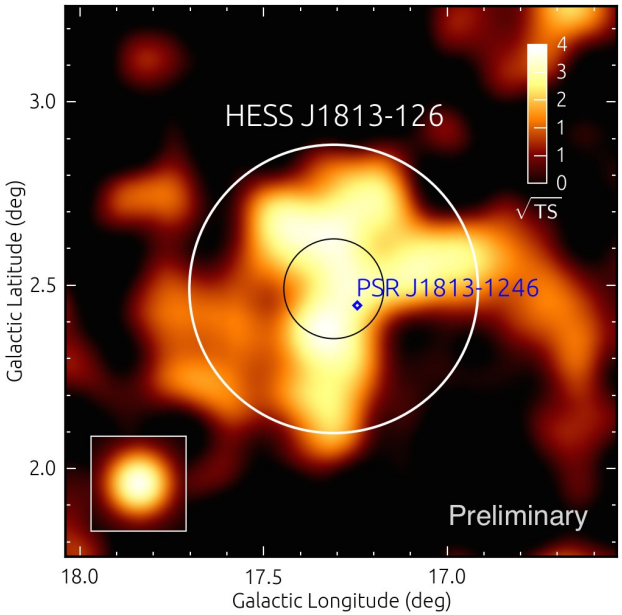
Source Name	Associated object	Class	Evidence	Reference
HESS J1018−589A	1FGL J1018.6−5856	Binary	Variability	Abramowski et al. (2015d)[5]
HESS J1302−638	PSR B1259−63	Binary	Variability	Aharonian et al. (2005a)
HESS J1826−148	LS 5039	Binary	Variability	Aharonian et al. (2006d)
HESS J0852−463	Vela Junior	SNR	Morphology	Aharonian et al. (2005e)
HESS J1442−624	RCW 86	SNR	Morphology	H. E. S. S. Collaboration et al. (2016)
HESS J1534−571	G323.7-01.0	SNR	Morphology	H.E.S.S. Collaboration (2016f)
HESS J1713−397	RX J1713.7−3946	SNR	Morphology	Aharonian et al. (2004)
HESS J1718−374	G349.7+0.2	SNR	Position	Abramowski et al. (2015a)
HESS J1731−347	G353.6−0.7	SNR	Morphology	Abramowski et al. (2011a)
HESS J1801−233	W 28	SNR	Position	Aharonian et al. (2008d)
HESS J1911+090	W 49B	SNR	Position	H.E.S.S. Collaboration (2016i)
HESS J0835−455	Vela X	PWN	Morphology	Aharonian et al. (2006b)
HESS J1303−631	PSR J1301−6305	PWN	ED Morph.	Abramowski et al. (2012b)
HESS J1514−591	MSH 15−52	PWN	Morphology	Aharonian et al. (2005d)
HESS J1825−137	PSR J1826−1334	PWN	ED Morph.	Aharonian et al. (2006e)
HESS J1356−645	PSR J1357-6429	PWN	Position	Abramowski et al. (2011b)
HESS J1418−609	PSR J1418-6058	PWN	Position	Aharonian et al. (2006c)
HESS J1420−607	PSR J1420-6048	PWN	Position	Aharonian et al. (2006c)
HESS J1554−550	G327.1-01.1	PWN	Morphology	Section 5.4.5
HESS J1747−281	G0.9+0.1	PWN	Morphology	Aharonian et al. (2005b)
HESS J1818−154	G015.4+00.1	PWN	Morphology	Abramowski et al. (2014a)
HESS J1849−000	PSR J1849−0001	PWN	Position	Section 5.4.15
HESS J1837−069	PSR J1838−0655	PWN	Morphology	Marandon et al. (2008)
HESS J1640−465	G338.3-0.0	Composite	Position	Abramowski et al. (2014d), Gotthelf et al. (2014)
HESS J1119−614	PSR J1119-6127	Composite	Position	Section 5.4.1
HESS J1714−385	CTB 37A	Composite	Position	Aharonian et al. (2008c)
HESS J1813−178	PSR J1813-1749	Composite	Position	Funk et al. (2007),Gotthelf & Halpern (2009)
HESS J1833−105	G21.5−0.9	Composite	Position	Section 5.4.10
HESS J1834−087	W41	Composite	Morphology	H. E. S. S. Collaboration et al. (2015)
HESS J1846−029	PSR J1846-0258	Composite	Position	Section 5.4.13
HESS J1930+186	G54.1+0.3	Composite	Position	Acciari et al. (2010), Section 5.3

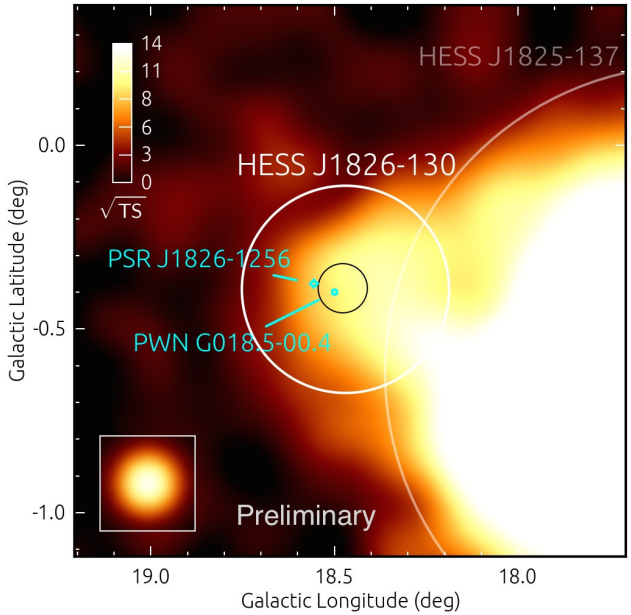
ENERGY THRESHOLD

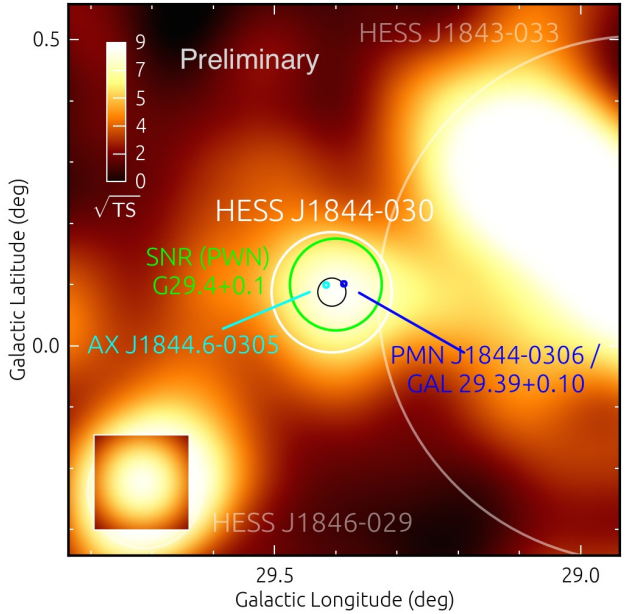
For maps and spectral analysis

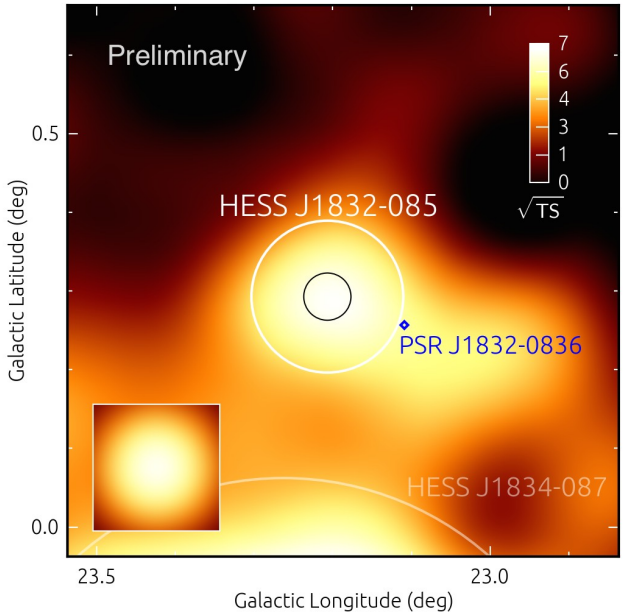


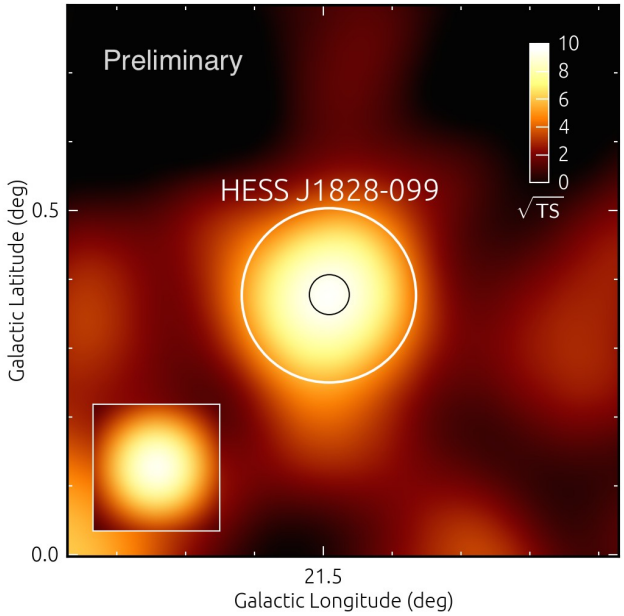
NEW SOURCES


HESS J1813-126
PSR J1813-1246
Preliminary
√TS
Galactic Latitude (deg)
Galactic Longitude (deg)

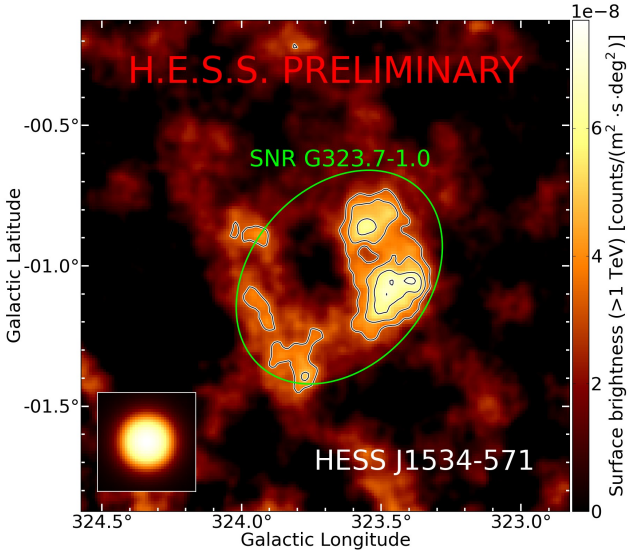

HESS J1825-137
HESS J1826-130
PSR J1826-1256
PWN G018.5-00.4
Preliminary
√TS
Galactic Latitude (deg)
Galactic Longitude (deg)

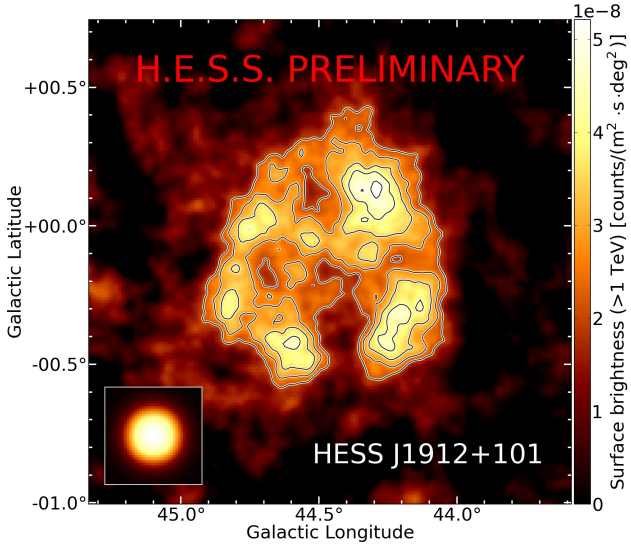

HESS J1843-033
Preliminary
HESS J1844-030
SNR (PWN)
G29.4+0.1
AX J1844.6-0305
PMN J1844-0306 /
GAL 29.39+0.10
HESS J1846-029
√TS
Galactic Latitude (deg)
Galactic Longitude (deg)

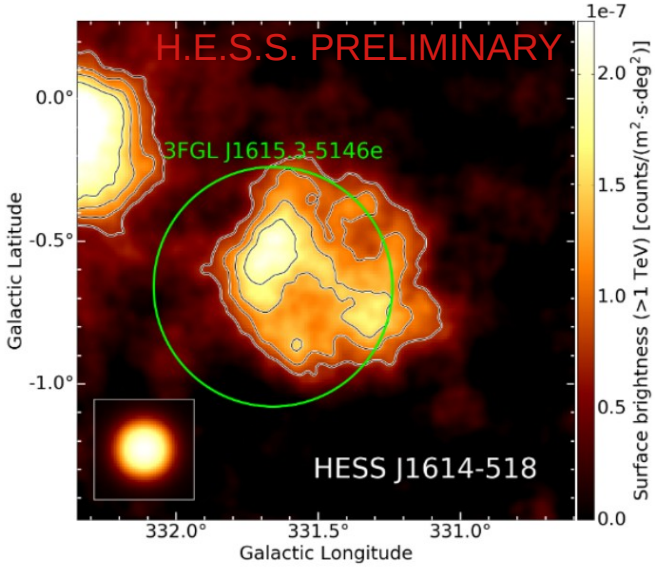

Preliminary
HESS J1832-085
PSR J1832-0836
HESS J1834-087
√TS
Galactic Latitude (deg)
Galactic Longitude (deg)


Preliminary
HESS J1828-099
√TS
Galactic Latitude (deg)
Galactic Longitude (deg)

NEW SNR SHELLS

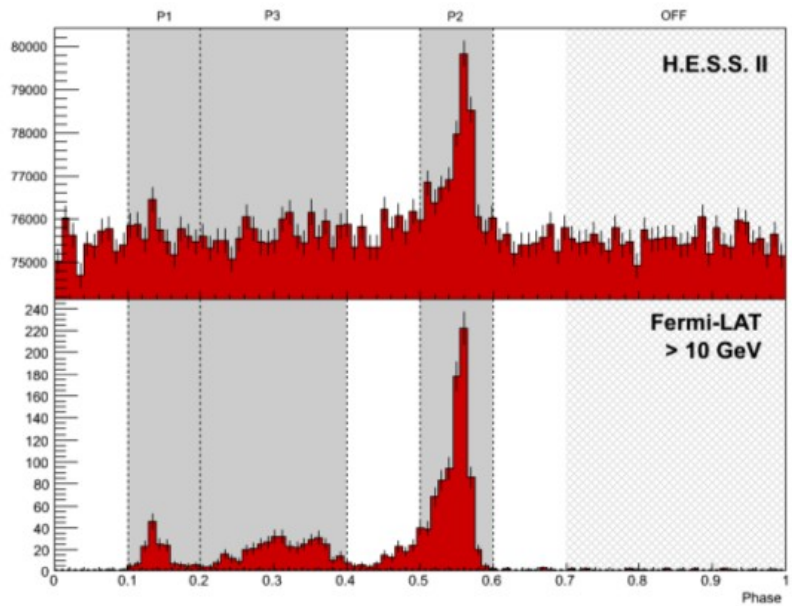






VELA PULSAR WITH H.E.S.S. II

Detection & Light Curve



→ P2 is detected with 15841 excess events at a significance of 15.6 σ.
→ P1 & P3 show some excess, but they are not significant

	Interval	On	Off	Exc	Sig
P1	[0.1-0.2]	764378	2.28833e+06	1600	1.6
P2	[0.5-0.6]	778619	2.28833e+06	15841	15.6
P3	[0.2-0.4]	1.52829e+06	2.28833e+06	2738	1.7

Event statistics in On- & Off-phase regions defined a priori for P1, P2 & P3

→ No measurable change in P2 position and width

Instrument	Range (GeV)	Position	σ_1	σ_2
Fermi-LAT	10-45	0.563 ± 0.001	0.023 ± 0.001	0.0045 ± 0.0005
H.E.S.S. II	< 45	0.567 ± 0.001	0.022 ± 0.003	0.005 ± 0.001
H.E.S.S. II	> 45	0.567 ± 0.002	0.023 ± 0.005	0.004 ± 0.002

Best-fit parameters for the position and width of P2 when using an asymmetric Lorentzian function as in [Abdo, A.et al. 2010a, ApJ, 713, 154].

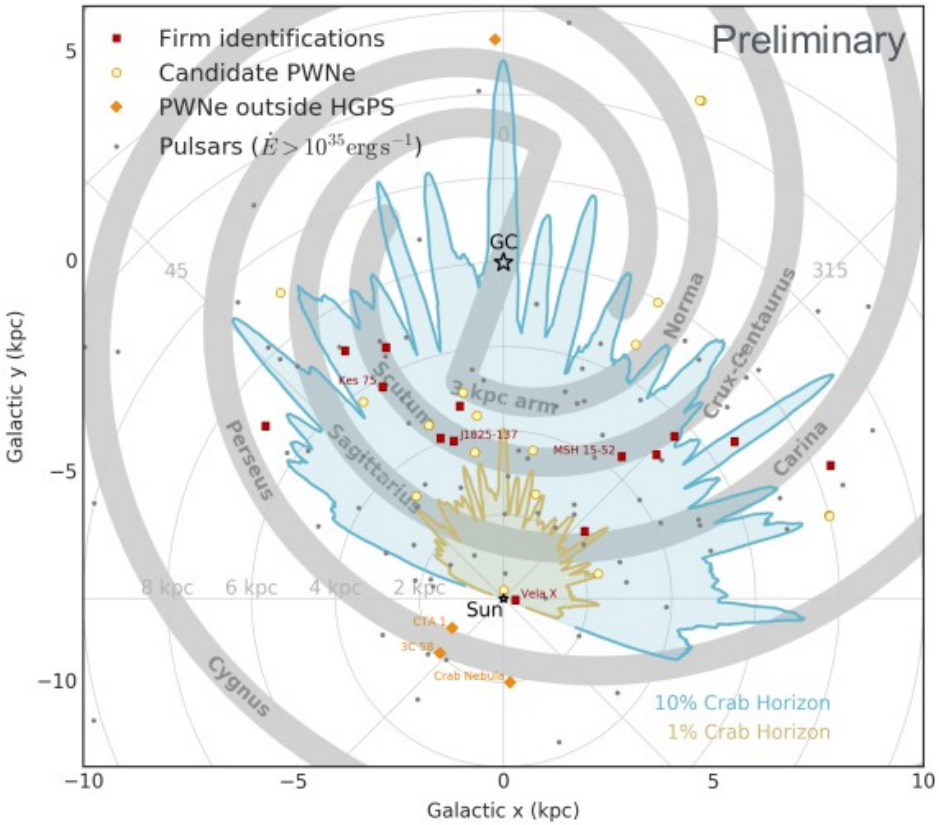
→ Results cross-checked with alternative template-based pipeline
[de Naurois, M. & Rolland, L. 2009, Astroparticle Physics, 32, 231]

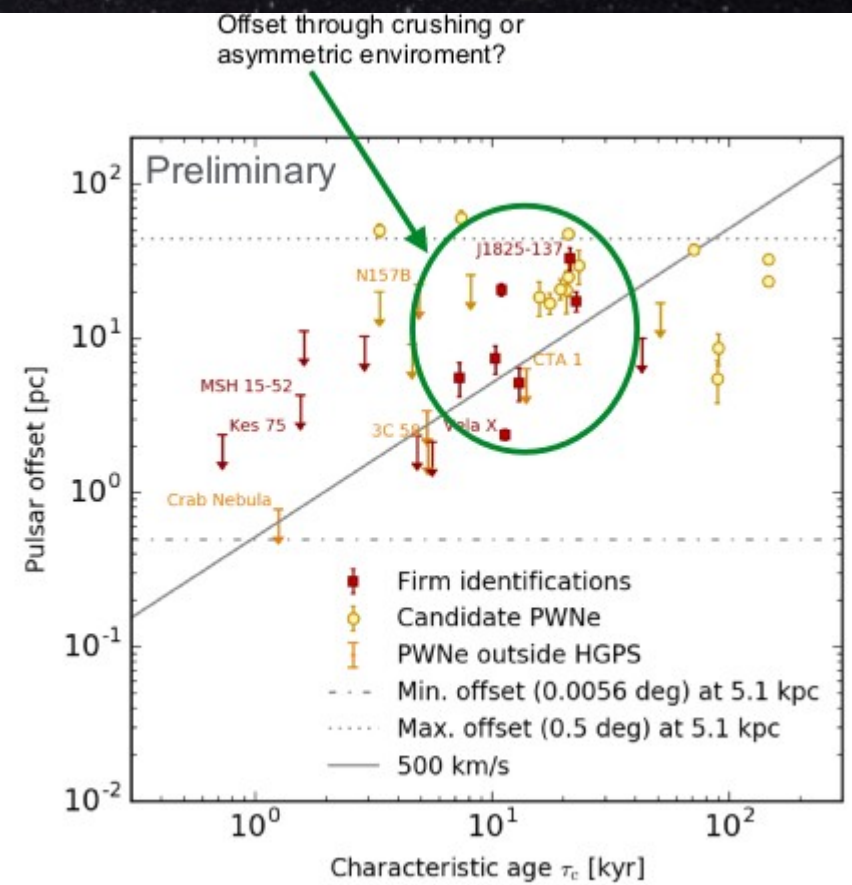
Conclusions

- Pulsed emission has been detected from the P2 peak of the Vela pulsar at > 15σ significance in the 20−110 GeV
- Results are based on 40 h of data from the H.E.S.S. II array in mono-telescopic mode using a dedicated very-low-threshold analysis method
- Comparison with results obtained using 60 months of Fermi-LAT data shows very good agreement, thereby validating the the overall analysis chain and the model of the H.E.S.S. II CT5 telescope down to an unprecedentedly low energy of 20 GeV
- We emphasize, however, that thanks to the pulsed nature of the signal, it is possible to extract the On- and Off-pulse events from the same portion of the field of view; This plays a major role in reducing the systematic effects
- The position of P2 and its width were studied using both the H.E.S.S. II and the Fermi-LAT data : they are mutually compatible
- The P2 spectrum has been fitted in the 20-110 GeV : only a marginal (<1σ) preference for curvature has been found
- Continued observations are important to probe the Vela pulsar emission above > 100 GeV and disentangle between a power-law and a (sub-) exponential cut-off

PWN POPULATION

- The TeV Milky Way hosts many extended TeV pulsar wind nebulae
- PWNe generally grow, get fainter and more offset with time
- Ejected electron plasma softens as it moves away from the PSR





PWN dynamical evolution