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

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on behalf of the H.E.S.S. Collaboration

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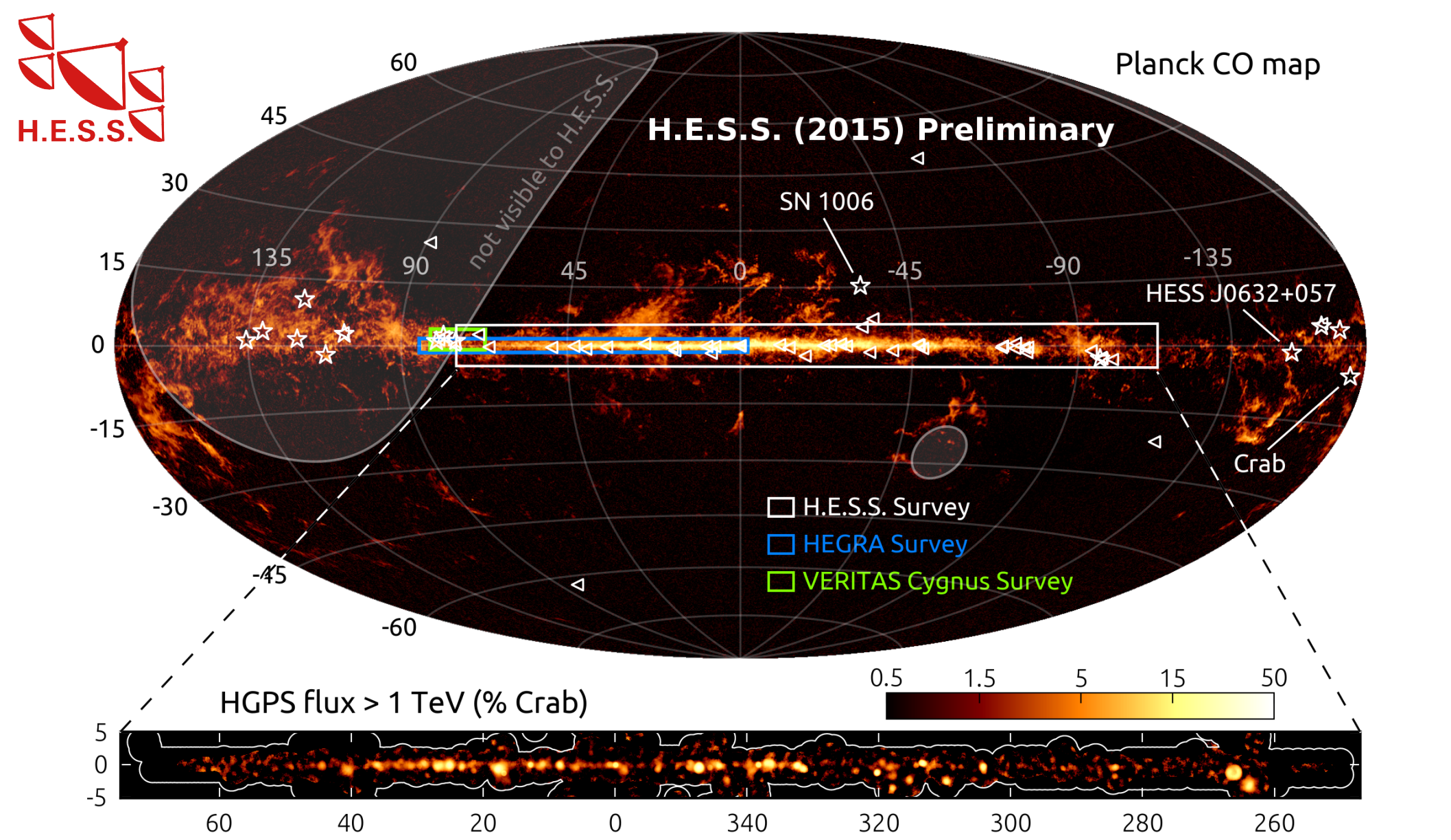
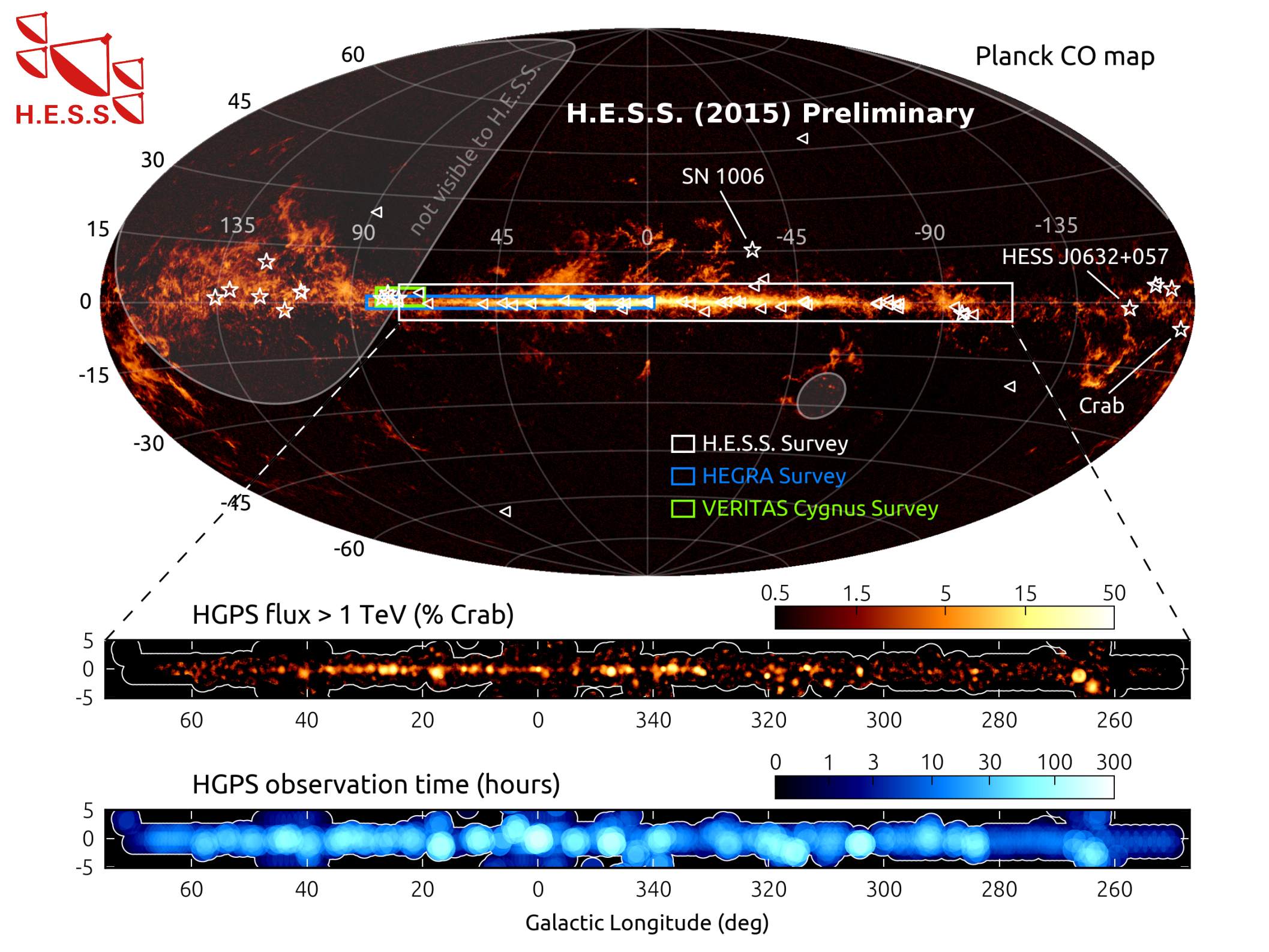
The 5-tel hybrid Cherenkov telescope array

4 12-m IACTs w/ recoated mirrors + **1 28-m IACT**

Multiple triggering & pointing schemes available

CT5: 2048 PMTs 614 m^2 **3.2° FoV** E_{min} **~ 20 GeV** f = 38 m


H.E.S.S.
Planck CO map
H.E.S.S. (2015) Preliminary
not visible to H.E.S.S.
SN 1006
HESS J0632+057
Crab
H.E.S.S. Survey
HEGRA Survey
VERITAS Cygnus Survey
HGPS flux > 1 TeV (% Crab)
0.5
1.5
5
15
50
60
45
30
15
0
-15
-30
-45
-60
135
90
45
0
-45
-90
-135
5
0
-5
60
40
20
0
340
320
300
280
260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Planck CO map
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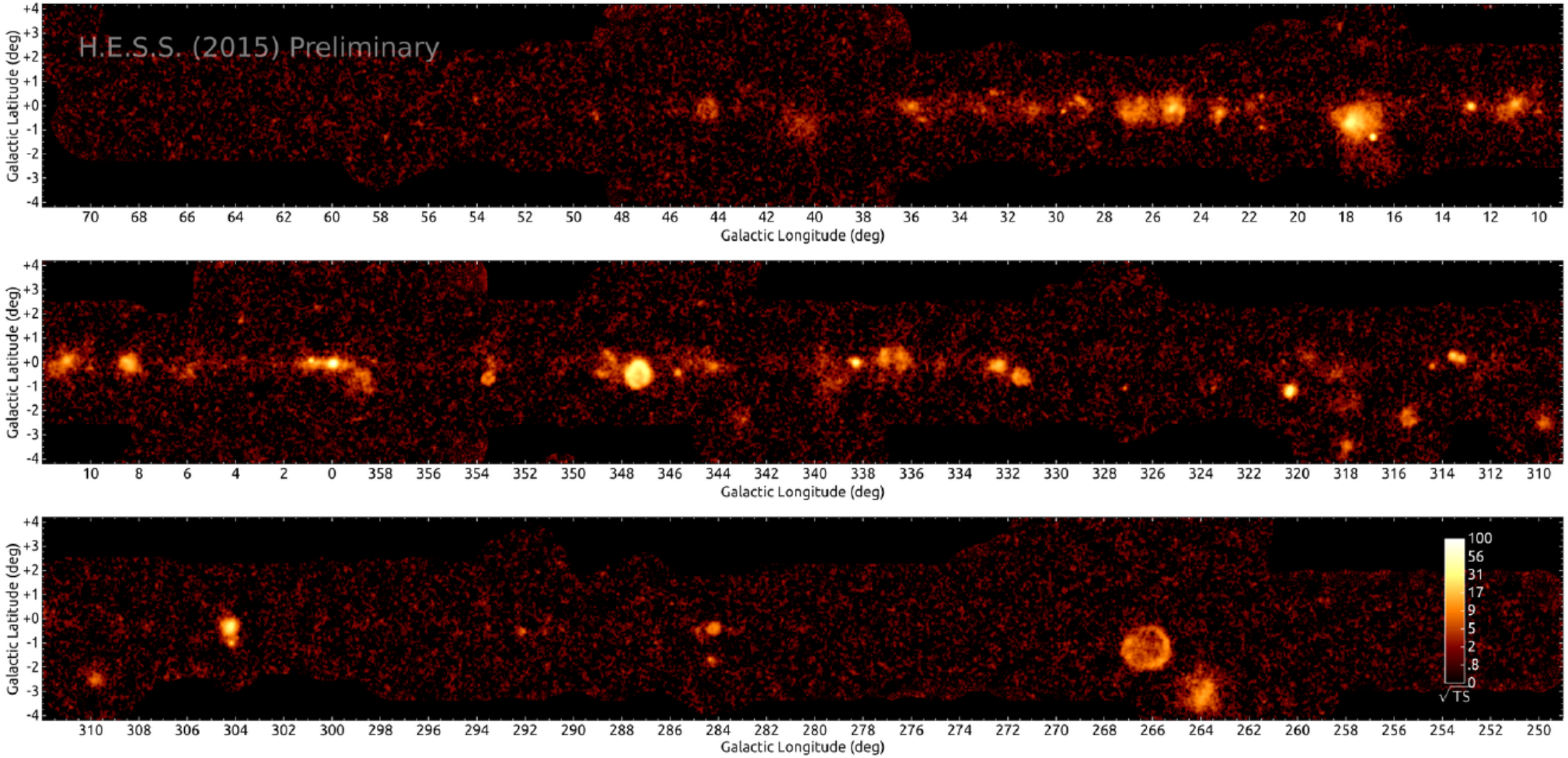
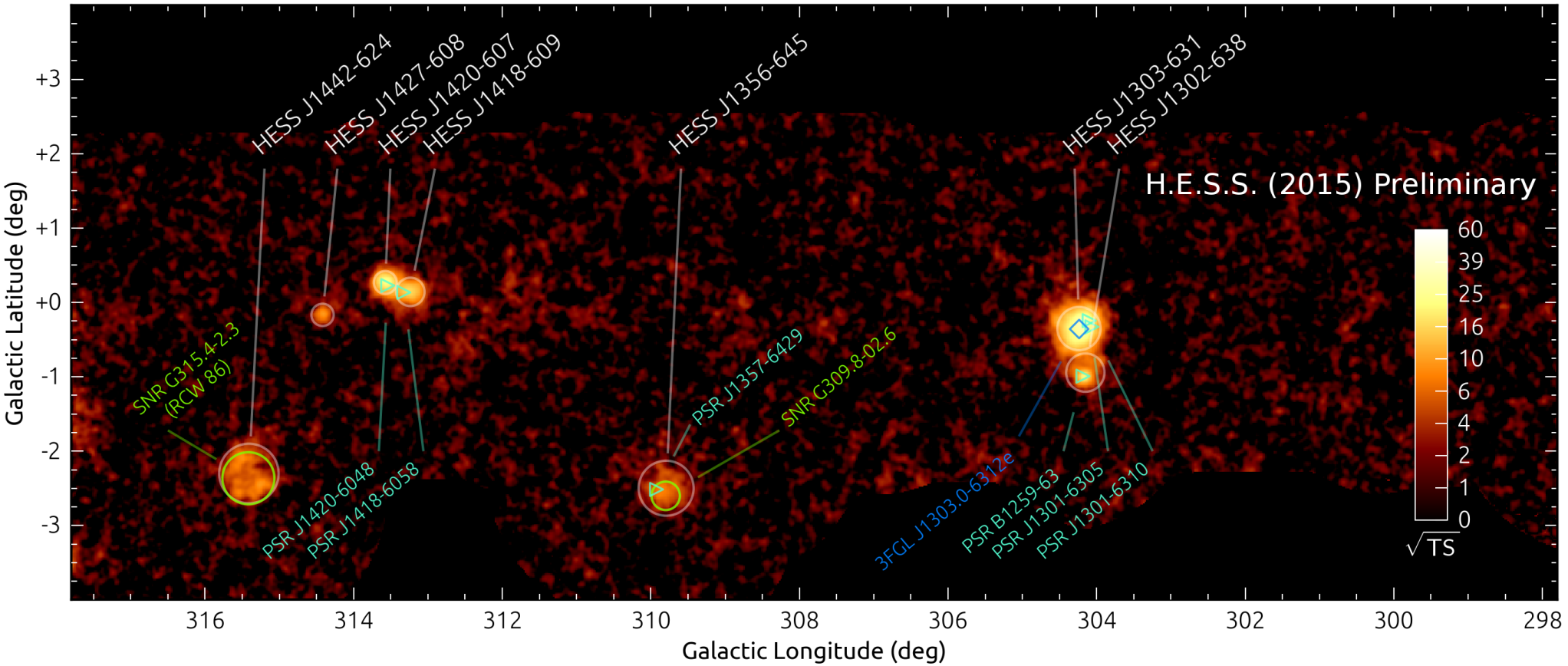
not visible to H.E.S.S.
SN 1006
HESS J0632+057
Crab
H.E.S.S. Survey
HEGRA Survey
VERITAS Cygnus Survey
HGPS flux > 1 TeV (% Crab)
0.5 1.5 5 15 50
HGPS observation time (hours)
0 1 3 10 30 100 300
Galactic Longitude (deg)

Significance, in full detail

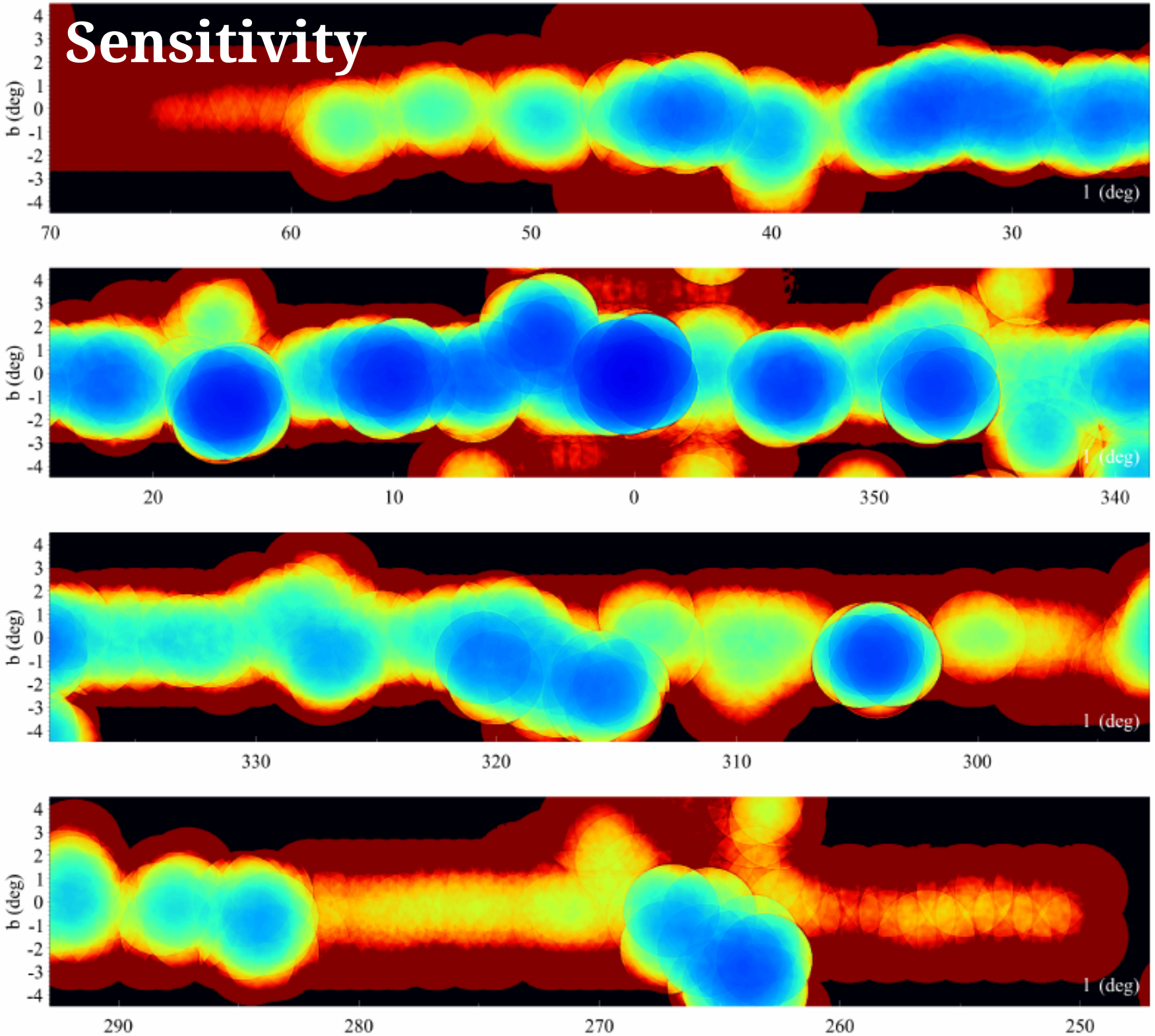


Zoom-in



Full detail TeV sky images, catalog, & MWL associations

Sensitivity



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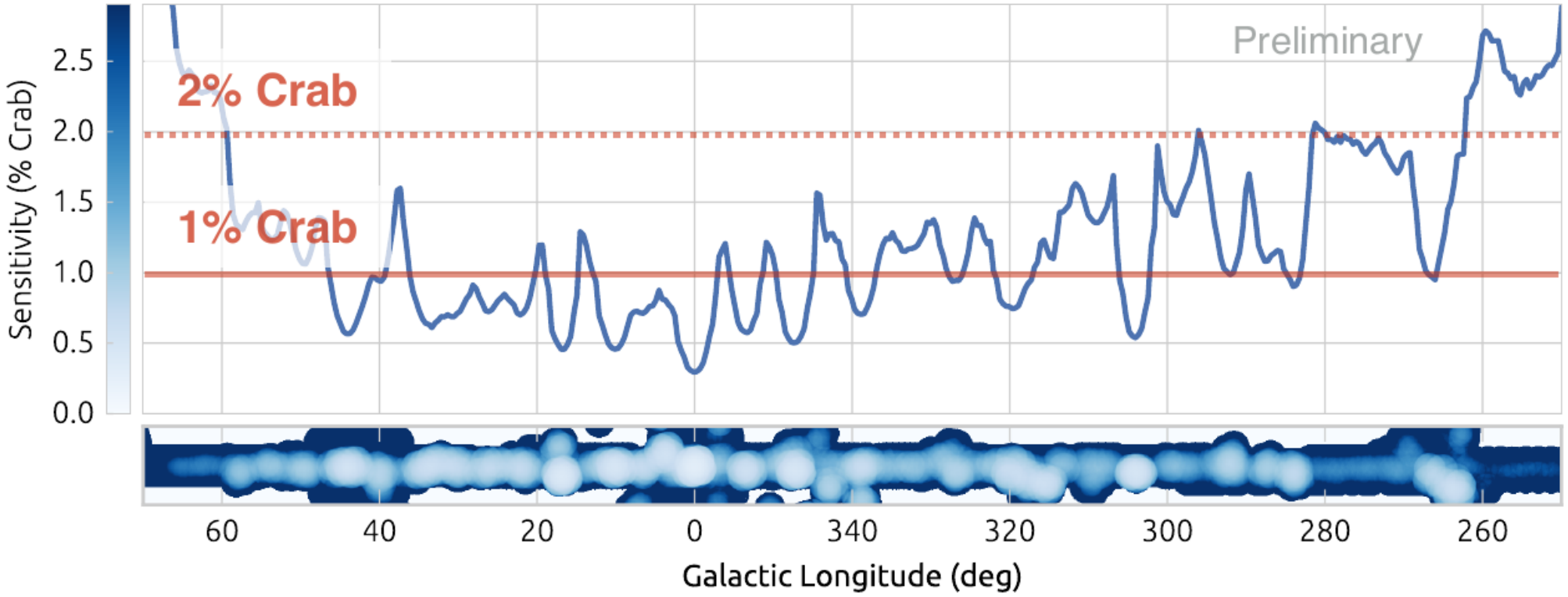
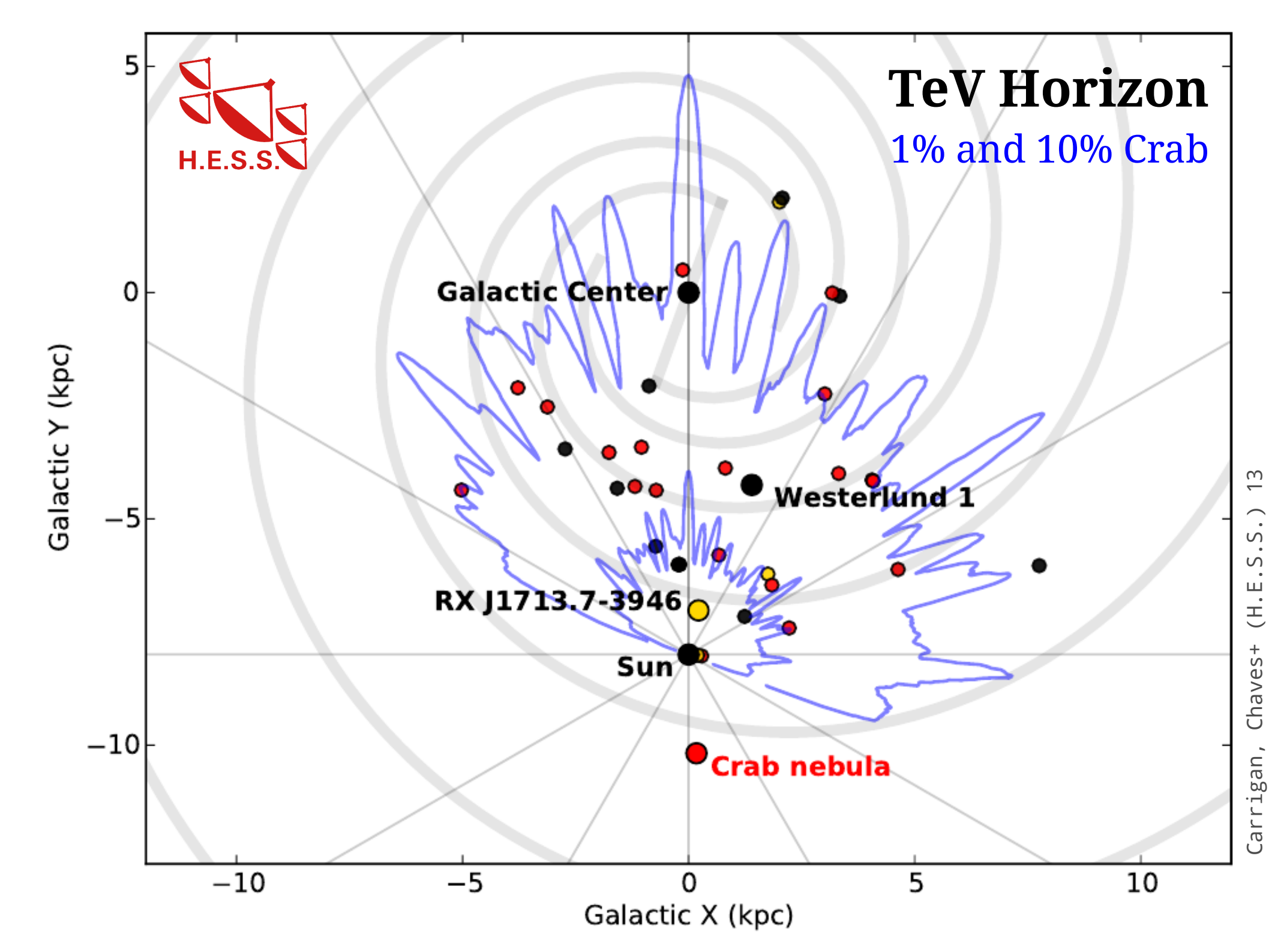
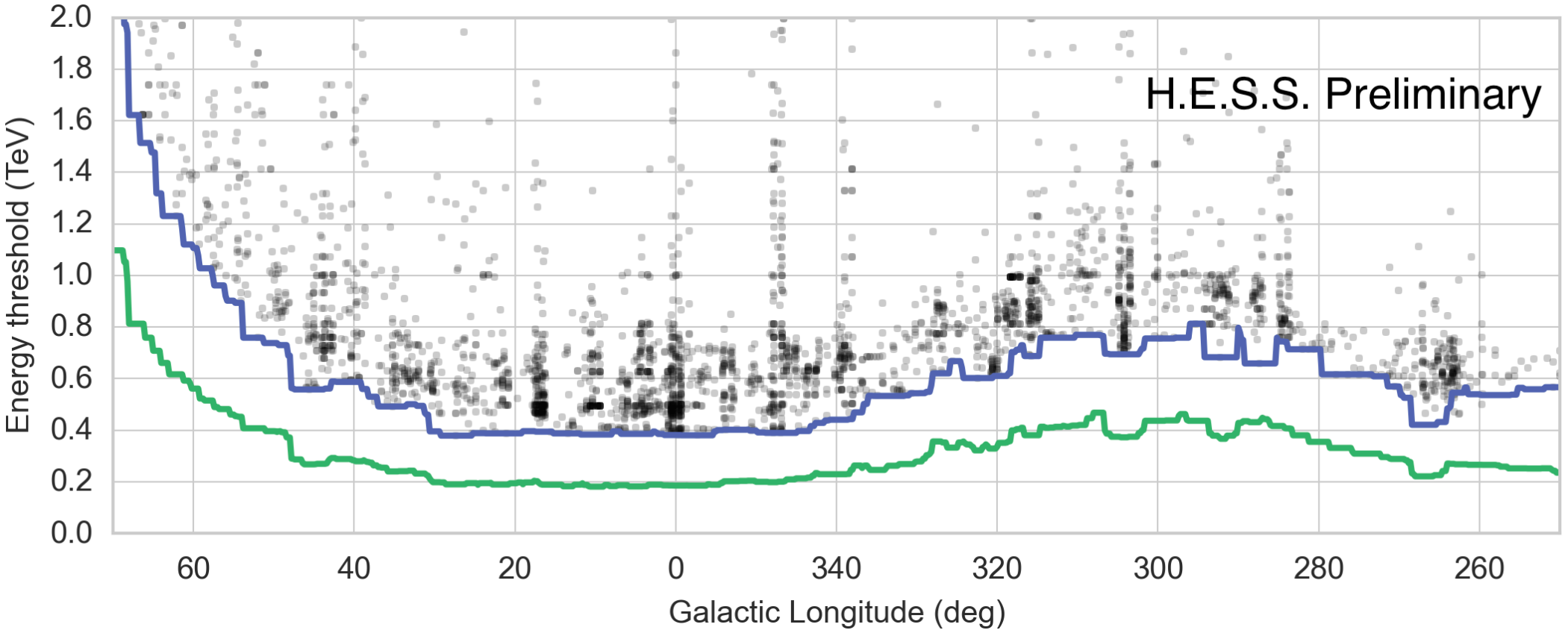
HGPS Sensitivity

along b = 0° for a 5-σ detection




TeV Horizon
1% and 10% Crab
H.E.S.S.
Galactic Center
Westerlund 1
RX J1713.7-3946
Sun
Crab nebula
Galactic Y (kpc)
Galactic X (kpc)
5
0
−5
−10
−10
−5
0
5
10
Carrigan, Chaves+ (H.E.S.S.) 13

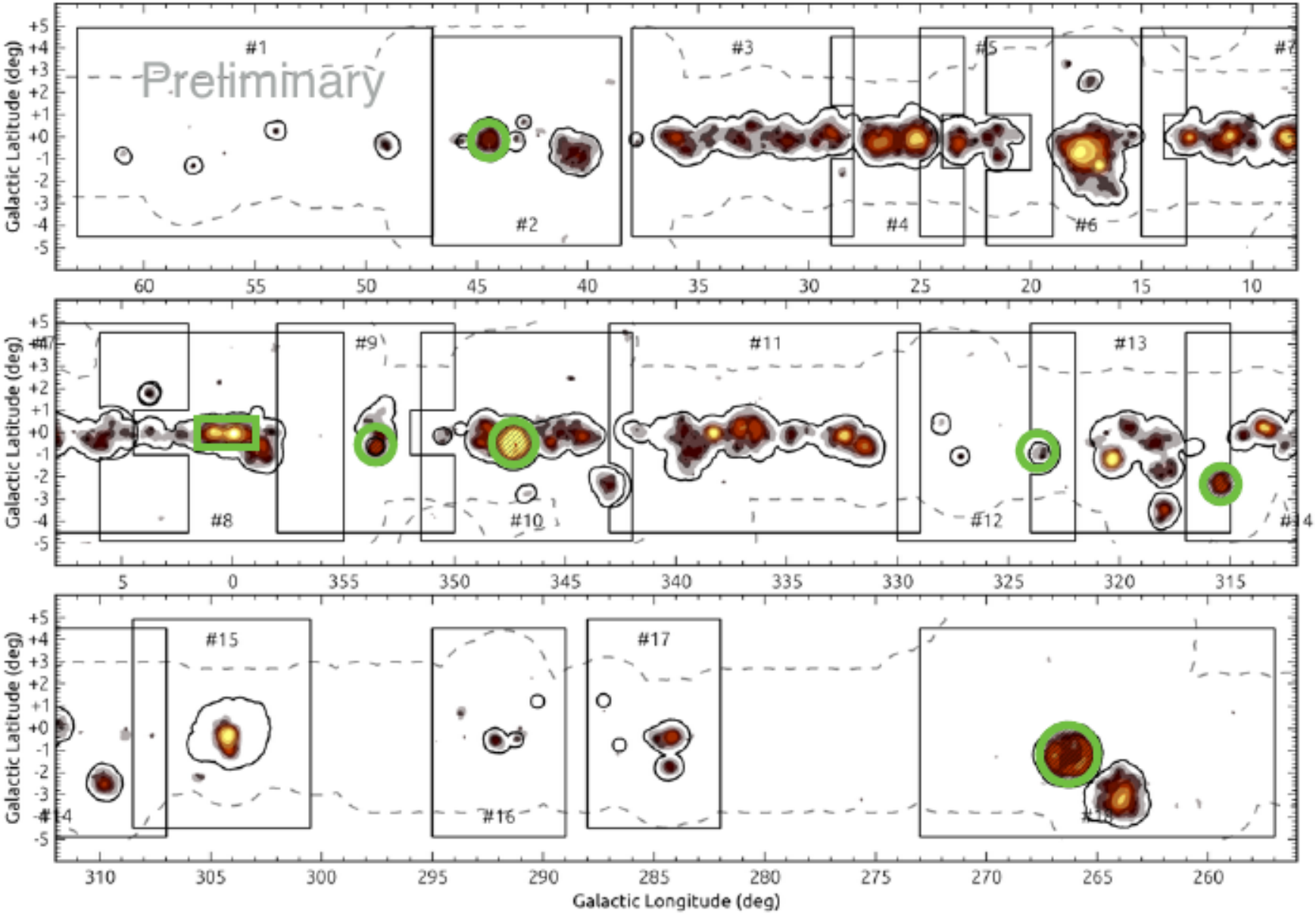
Energy threshold



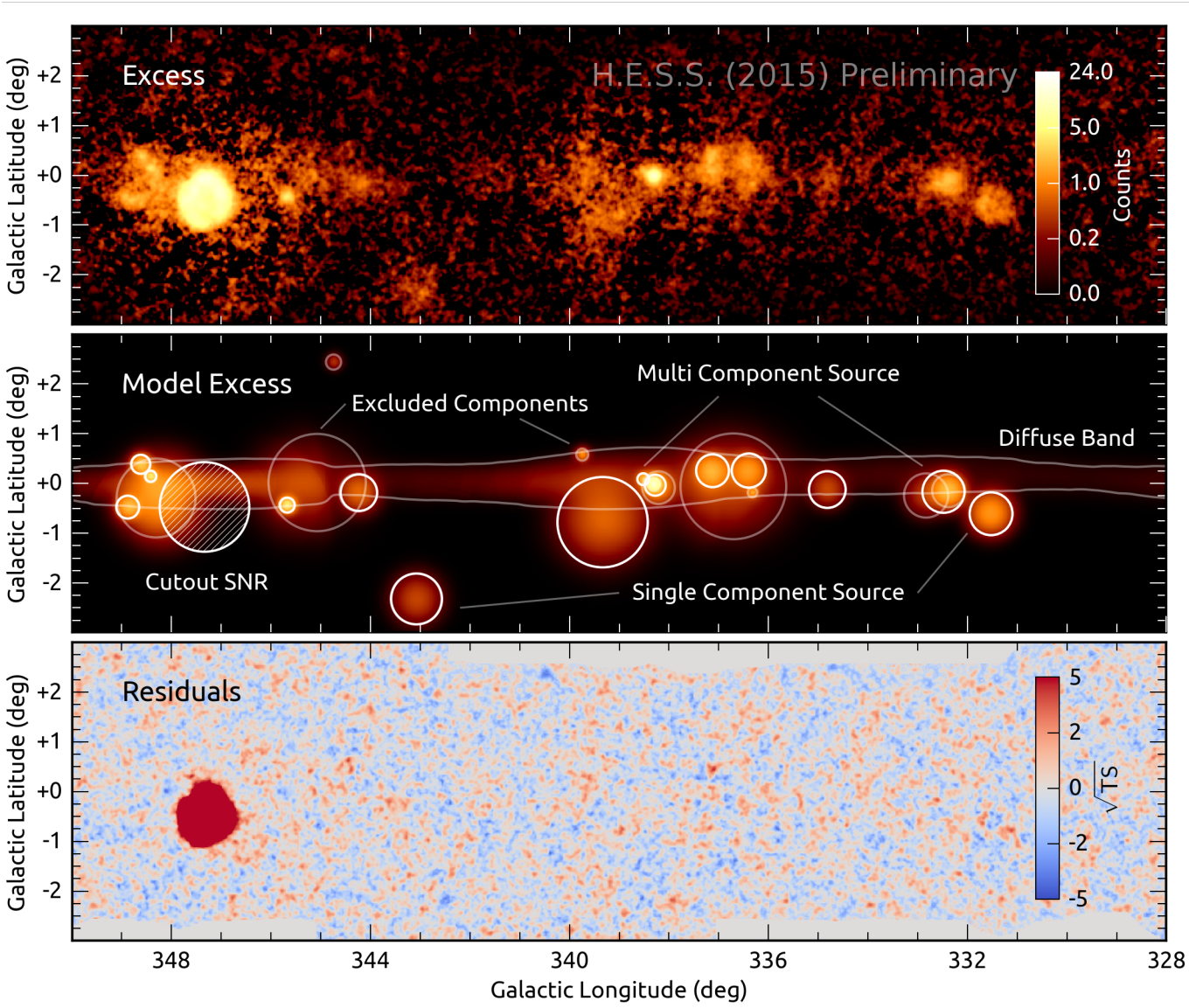
Reflects zenith angle dependency on longitude

~6000 observations → ~3000 h dataset

RoI-based analysis pipeline

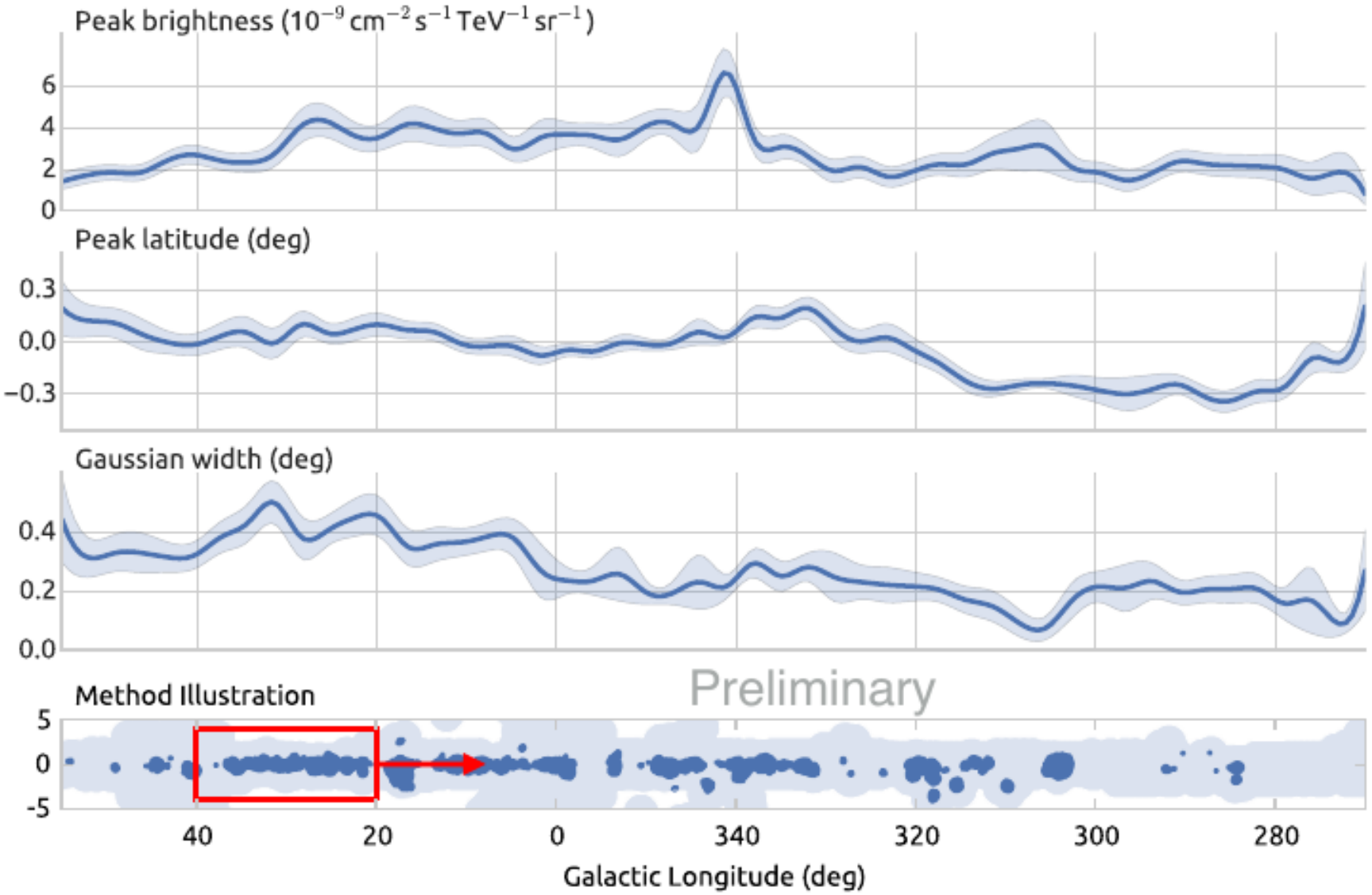


A 2D likelihood approach



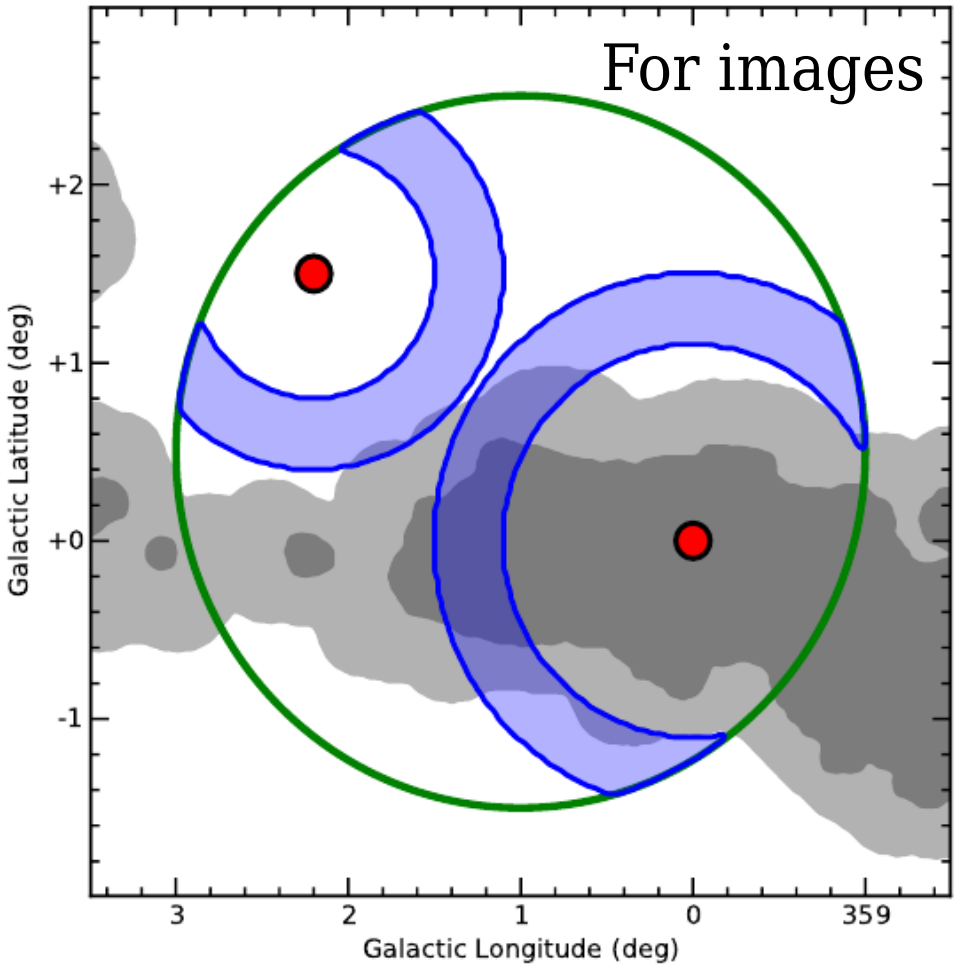
- Semi-automated, MLE-based source detection & morphology fitting
- Model sources as Gaussian plus an underlying “diffuse” component

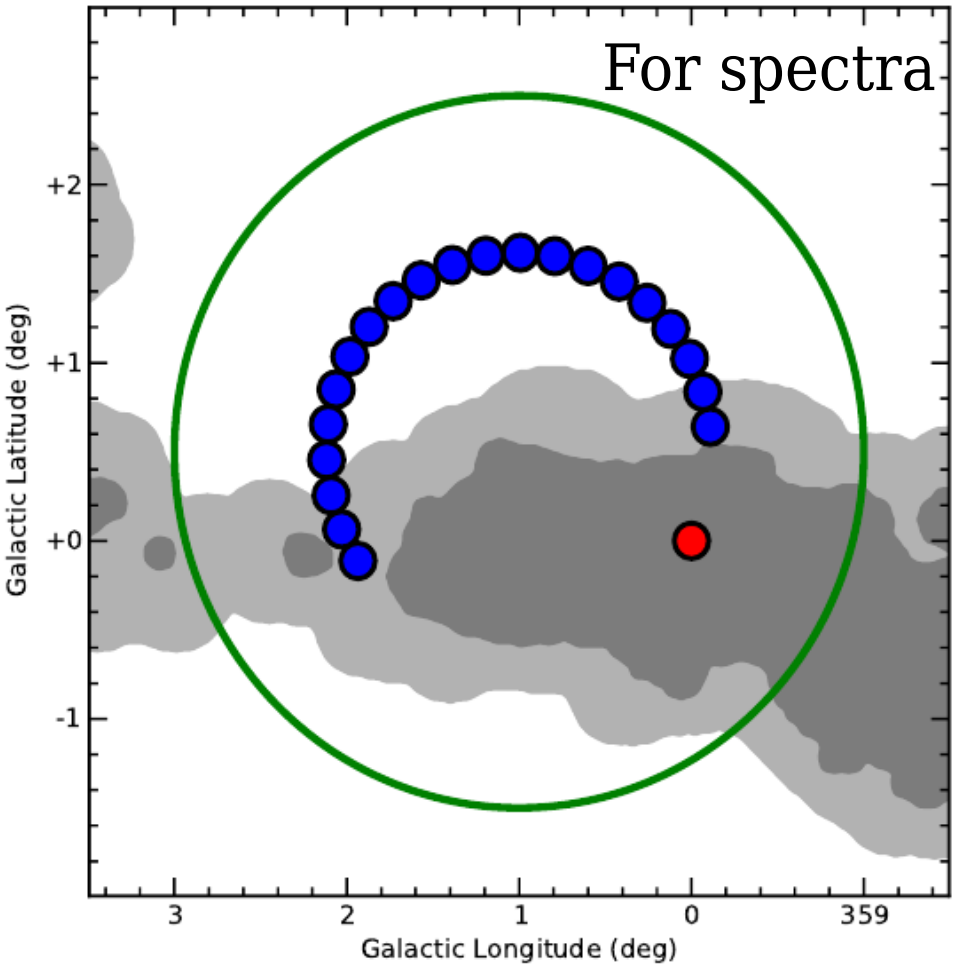
Handling diffuse emission in the HGPS



Empirical not physical model: 20 deg sliding window w/ Gaussian in *b*

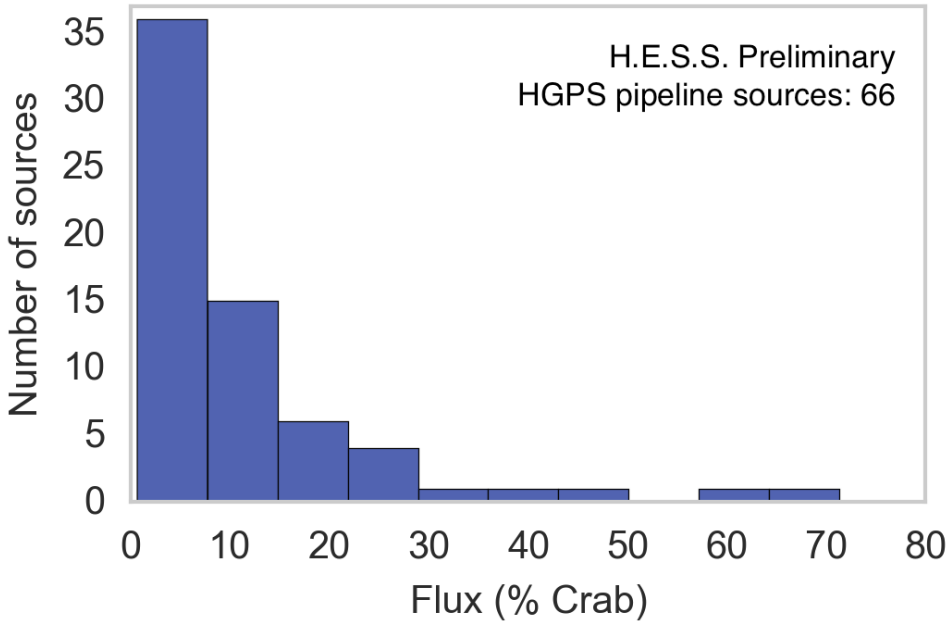
Background estimation

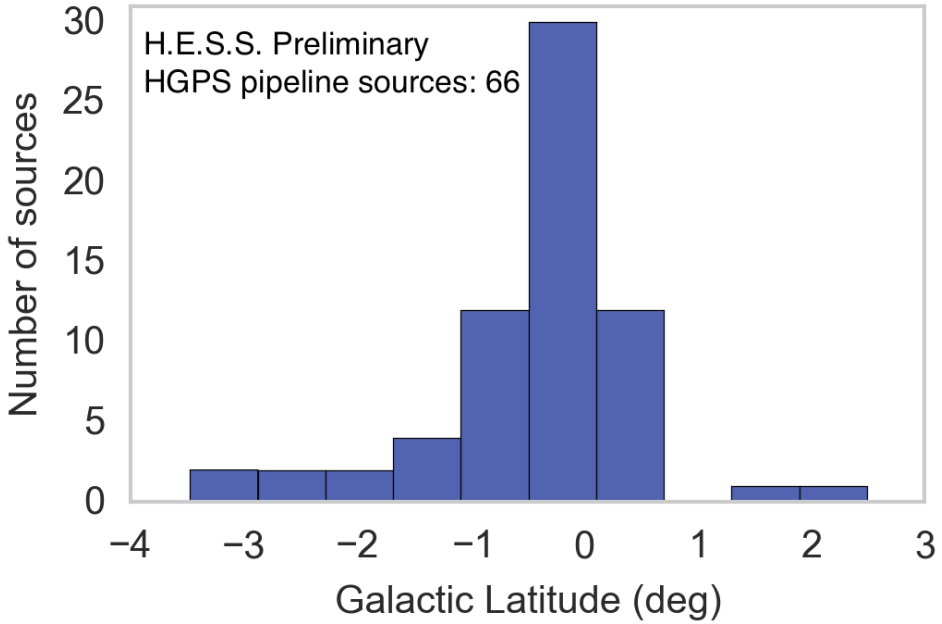




Adaptive background estimation with exclusion region masks

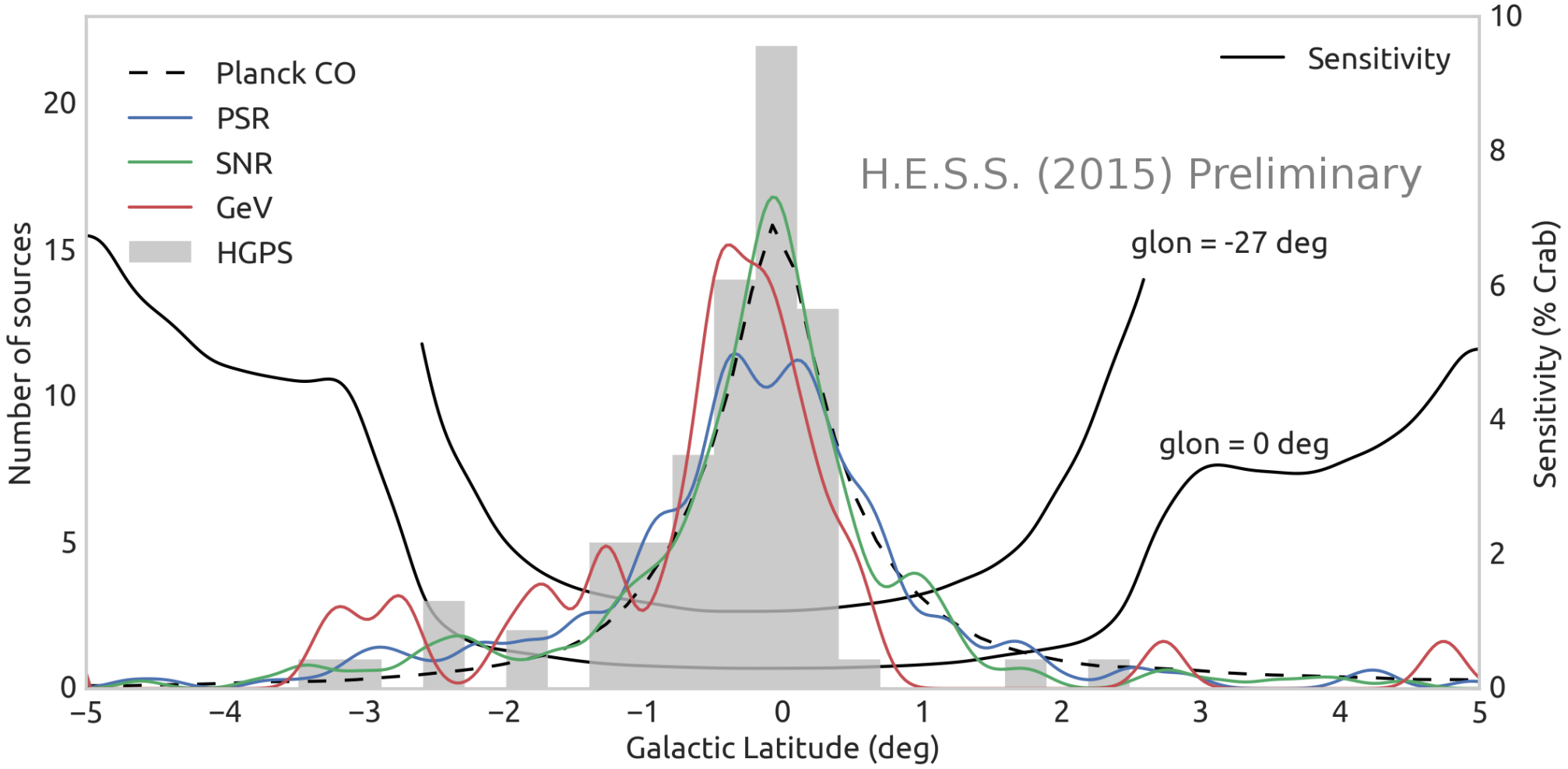
Galactic TeV sources



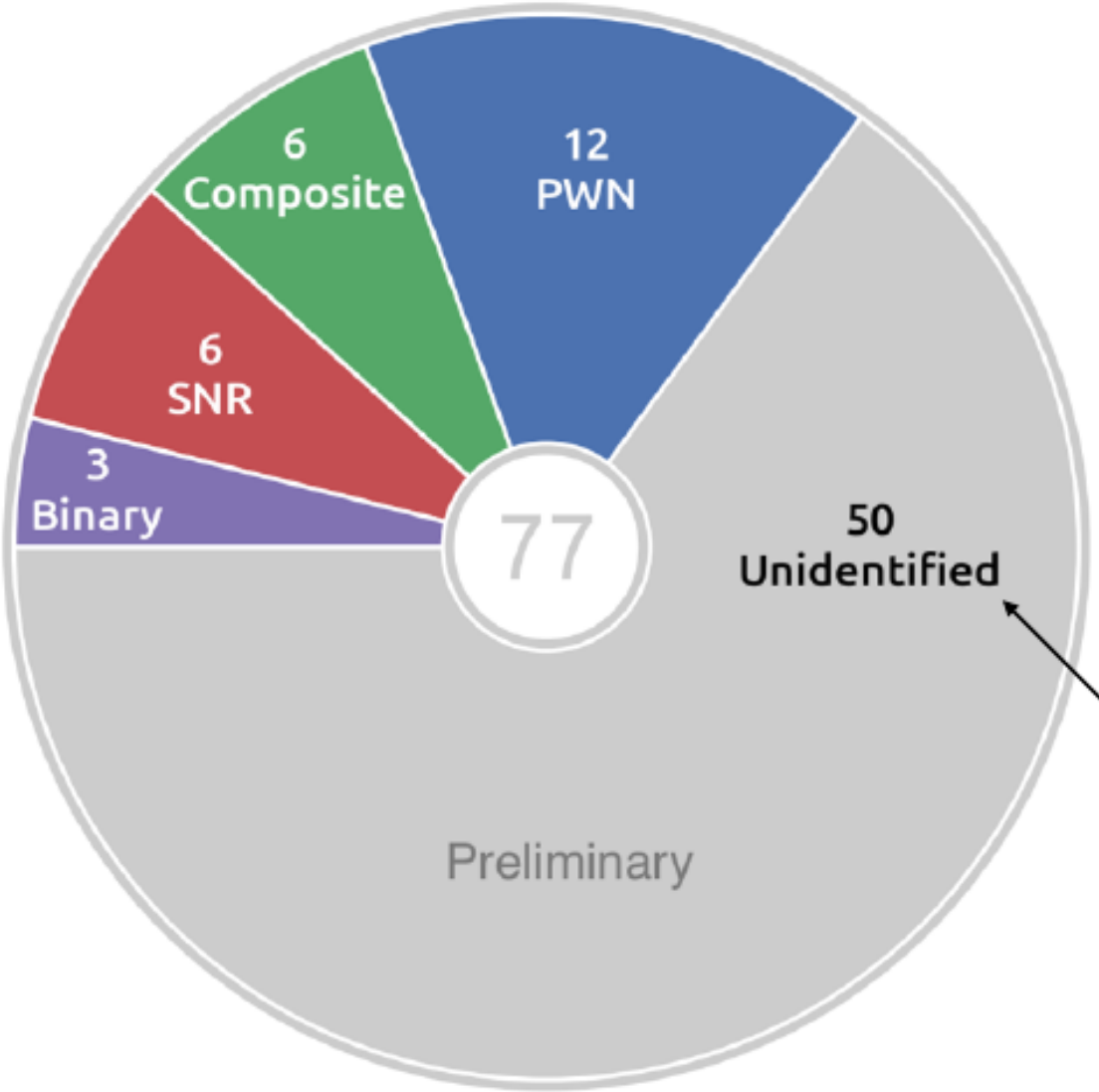


66 HGPS pipeline sources
+ 11 sources treated manually (Galactic center region, TeV shells)
+ 3 sources outside HGPS region (Crab Nebula, SN 1006, HESS J0632)
= 80 Galactic sources detected by H.E.S.S.

TeV source distribution



HGPS Firm identifications

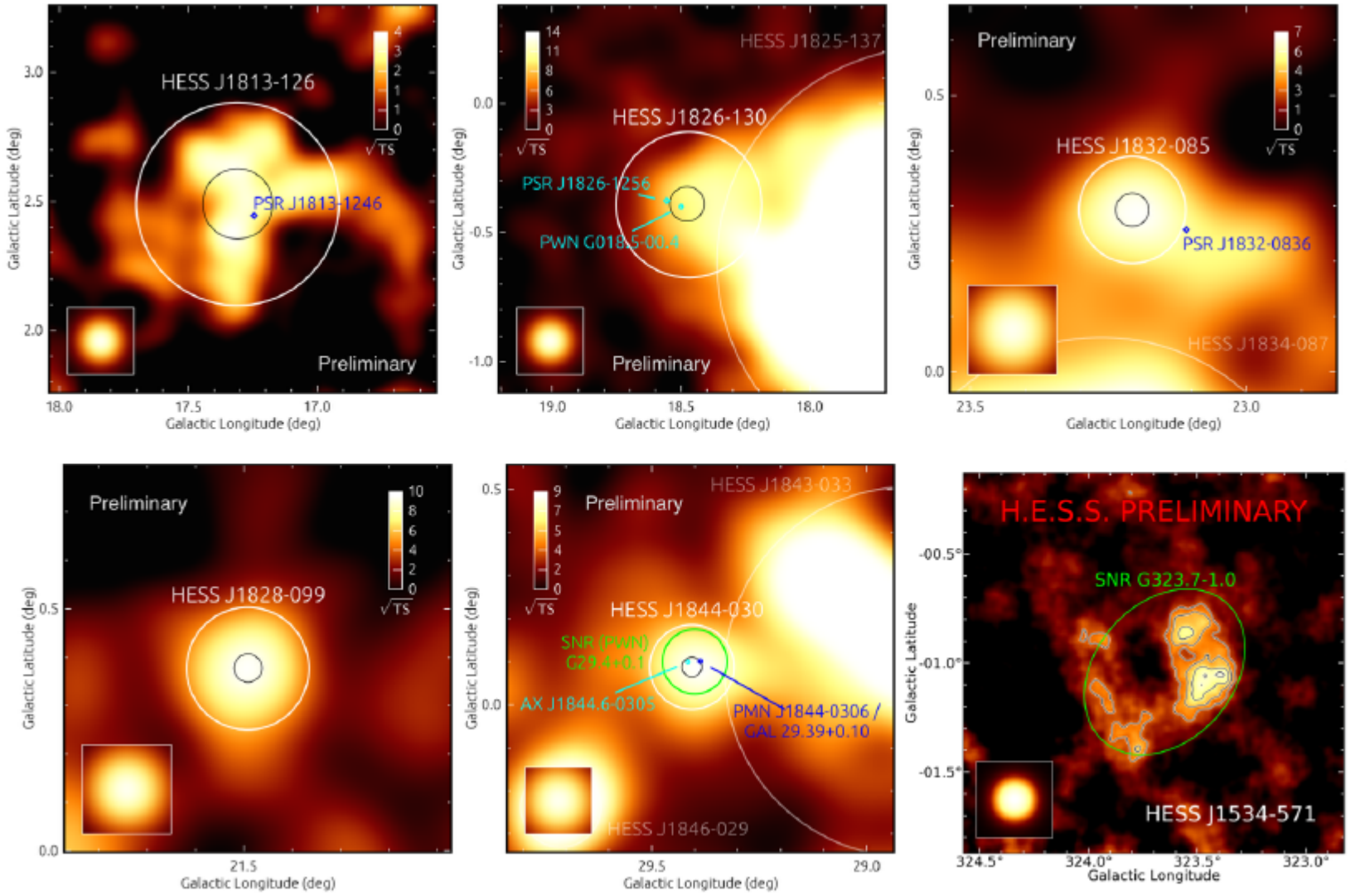


N.B.
associations
(spatial coincidences)
vs. identification

Mostly sources with
multiple associations

MWL counterparts:
Pulsars (ATNF), **PWN** (SNRcat), **SNRs** (SNRcat), **HE sources** (1FHL, 3FGL)

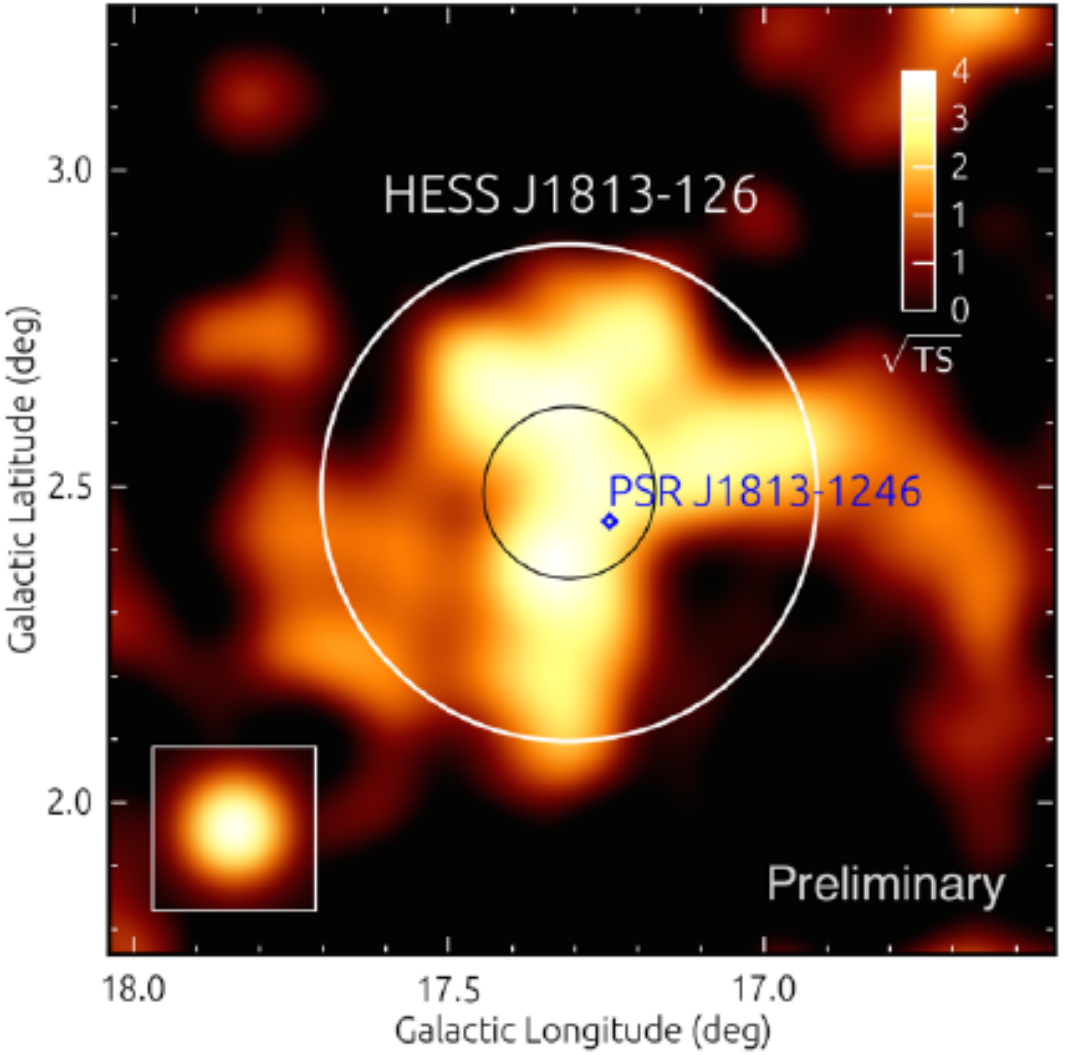
New source discoveries



HESS J1813-126

New

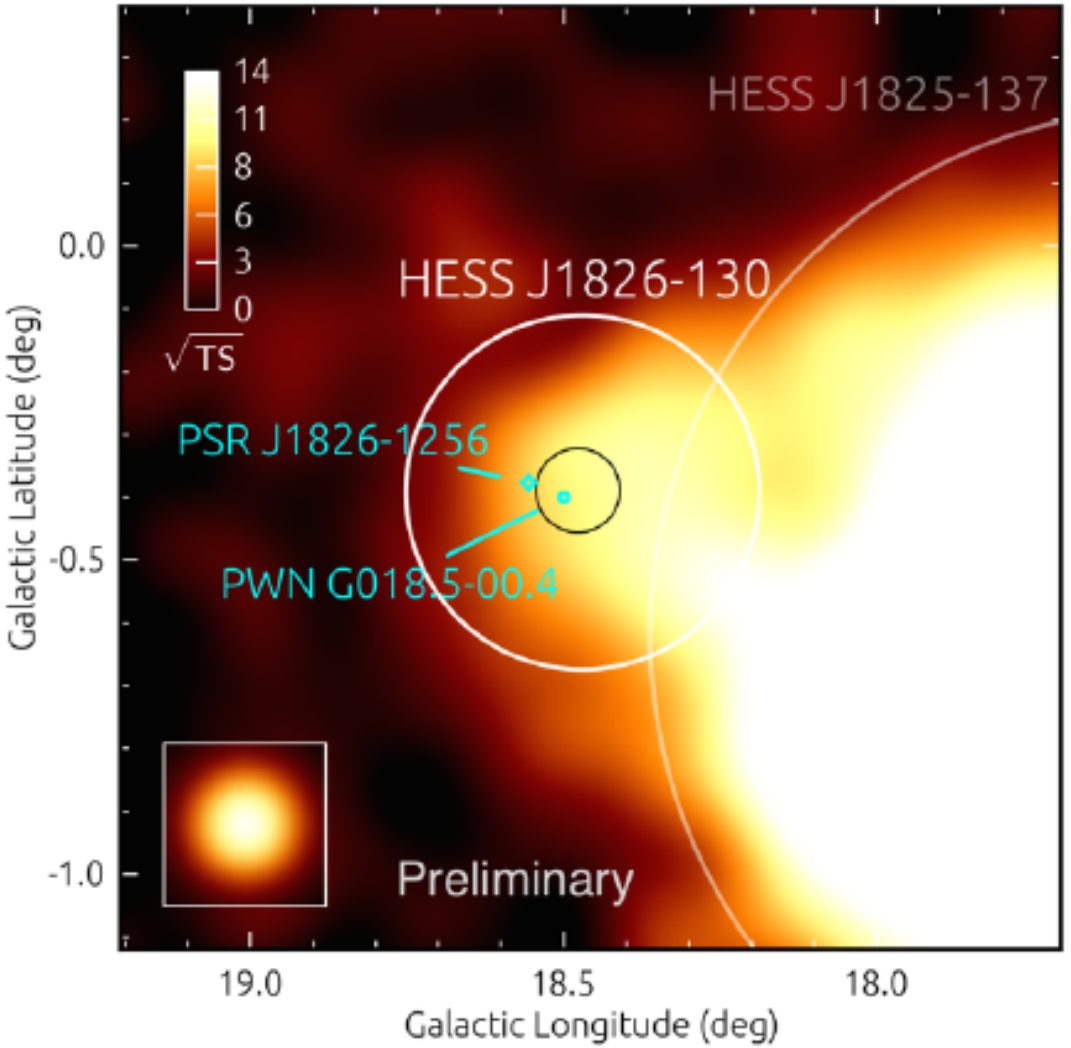
- Position:
  (l, b) = (17.31, 2.49) deg
  (α, δ) = (273.34, -12.69) deg
- Extension: 0.21 deg
- Flux: 4.2% Crab



HESS J1826-130

New

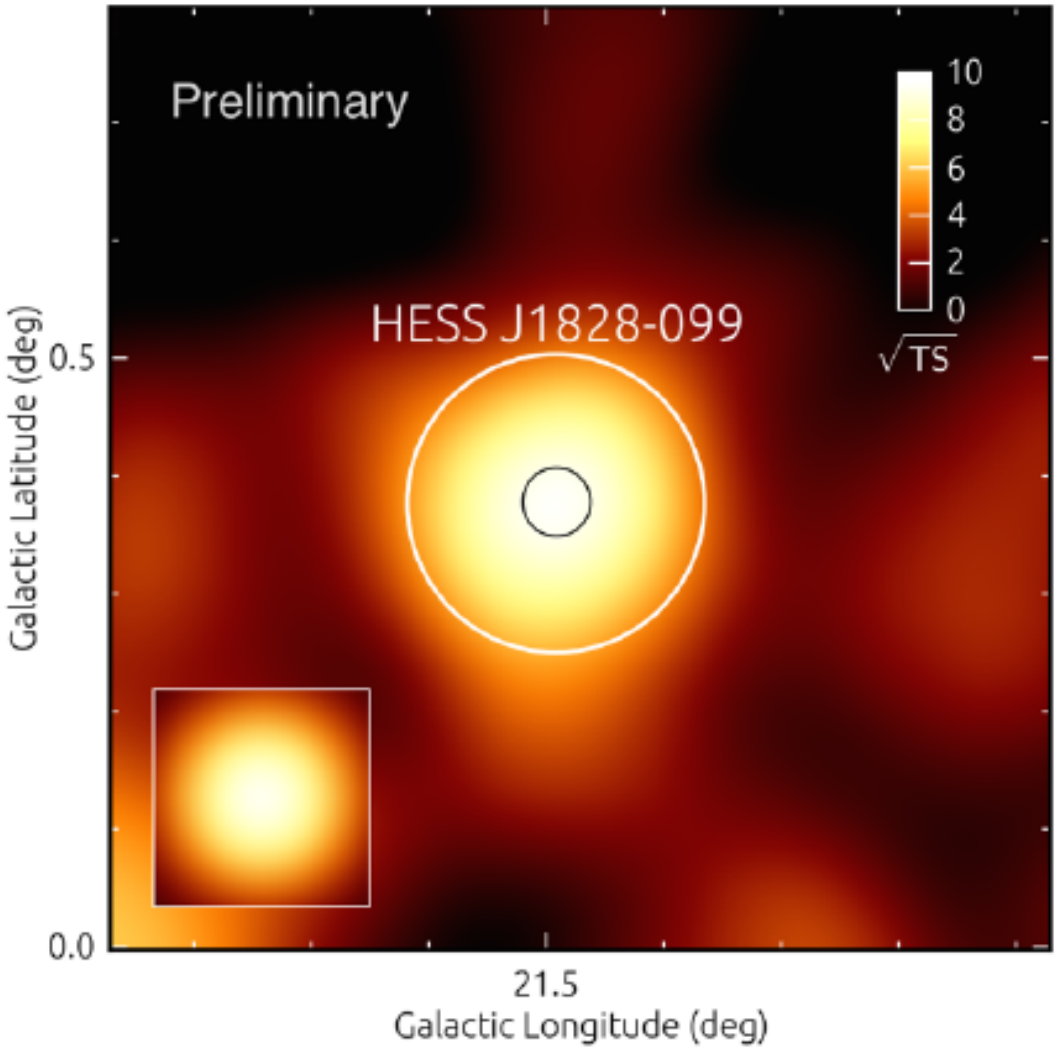
- Position:
  (l, b) = (18.48, -0.39) deg
  (α, δ) = (276.51, -13.02) deg
- Extension: 0.15 deg
- Flux: 3.3% Crab



HESS J1828-099

New

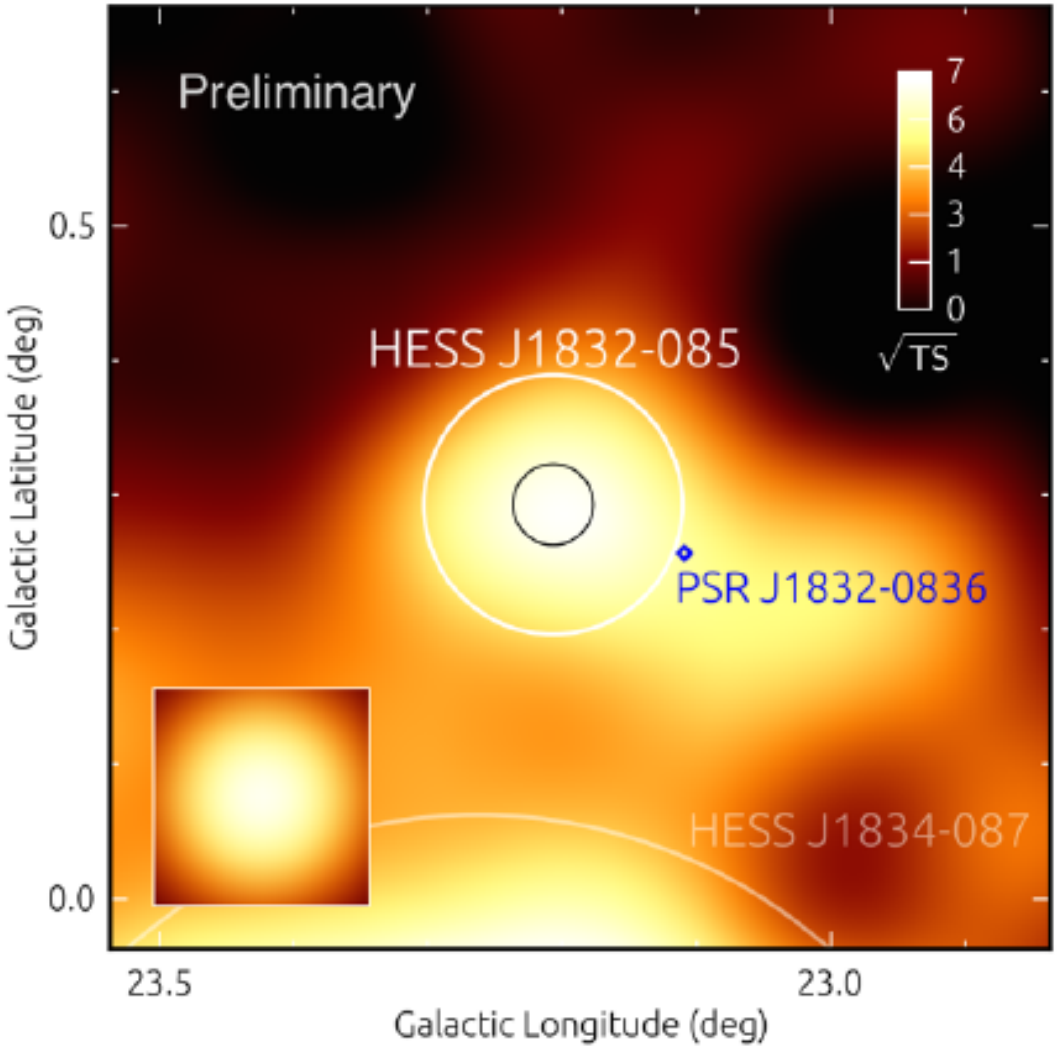
- Position:
  (l, b) = (21.49, 0.38) deg
  (α, δ) = (277.25, -9.99) deg
- Extension upper limit:
  < 0.07 deg
- Flux: 1.7% Crab



HESS J1832-085

New

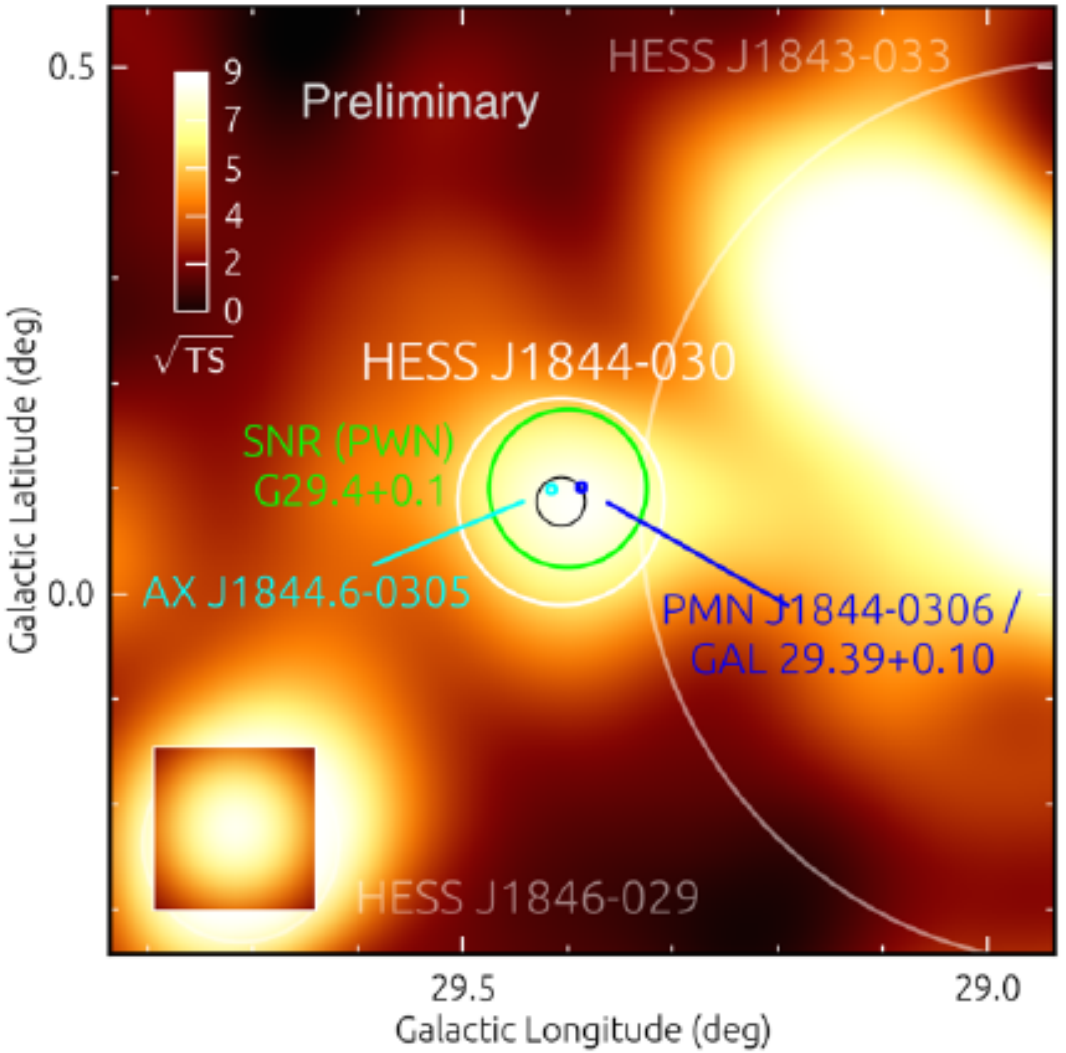
- Position:
  (l, b) = (23.21, 0.29) deg
  (α, δ) = (278.13, -8.51) deg
- Extension upper limit:
  < 0.05 deg
- Flux: 0.8% Crab



HESS J1844-030

New

- Position:
  (l, b) = (29.41, 0.09) deg
  (α, δ) = (281.17, -3.10) deg
- Extension upper limit:
  < 0.05 deg
- Flux: 1.0% Crab



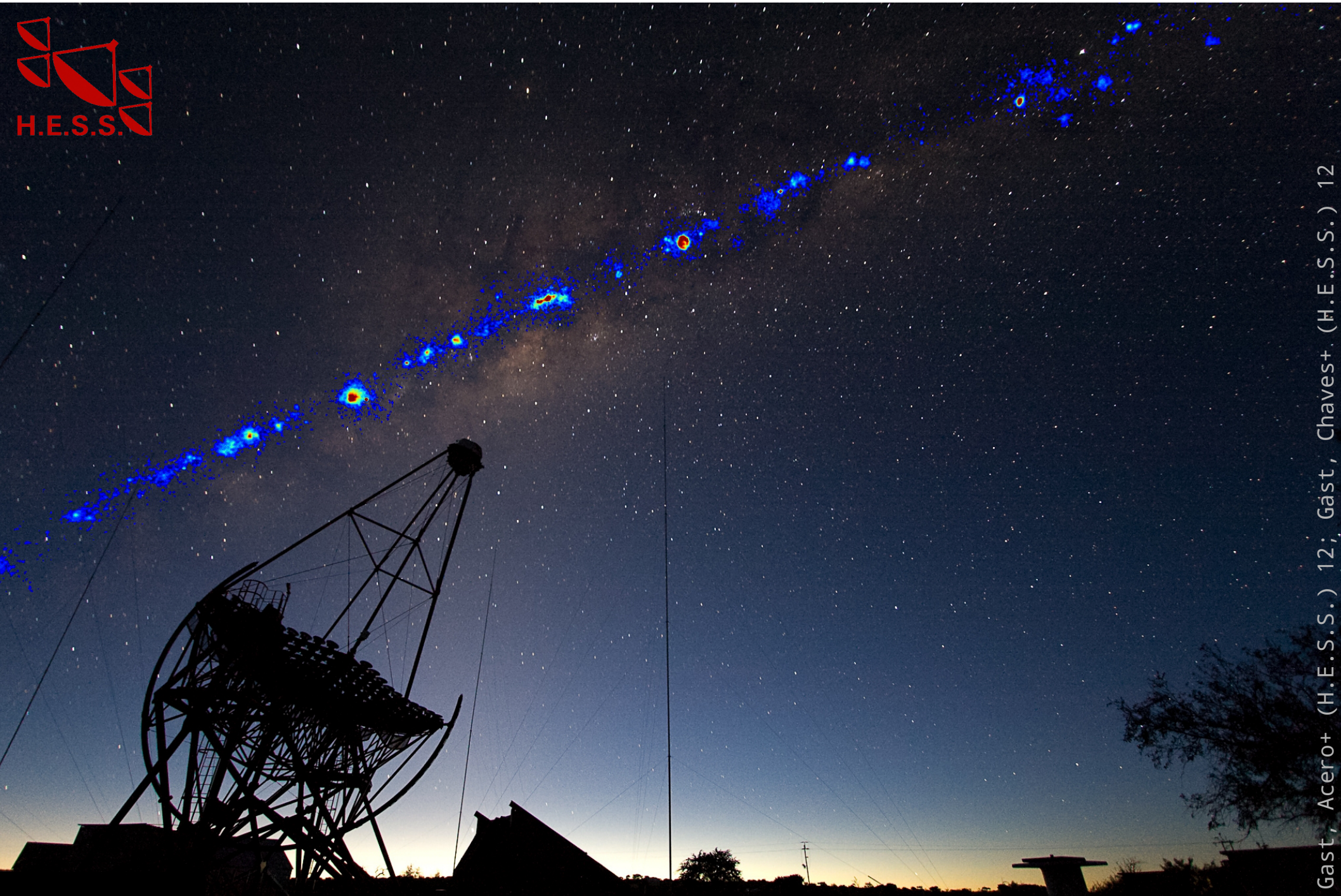
Conclusion

Demonstrated power of surveying with wide-FoV imaging atmospheric Cherenkov telescopes → **TeV gamma-ray astronomy**

Decade-long H.E.S.S. I Galactic Plane Survey completed

- Legacy paper in preparation
- Final catalog, high-level FITS data release, including spectra
- 17 new source discoveries
- Associations & firm identifications
- Coupled with population studies (SNRs, PWNe) & new TeV shells

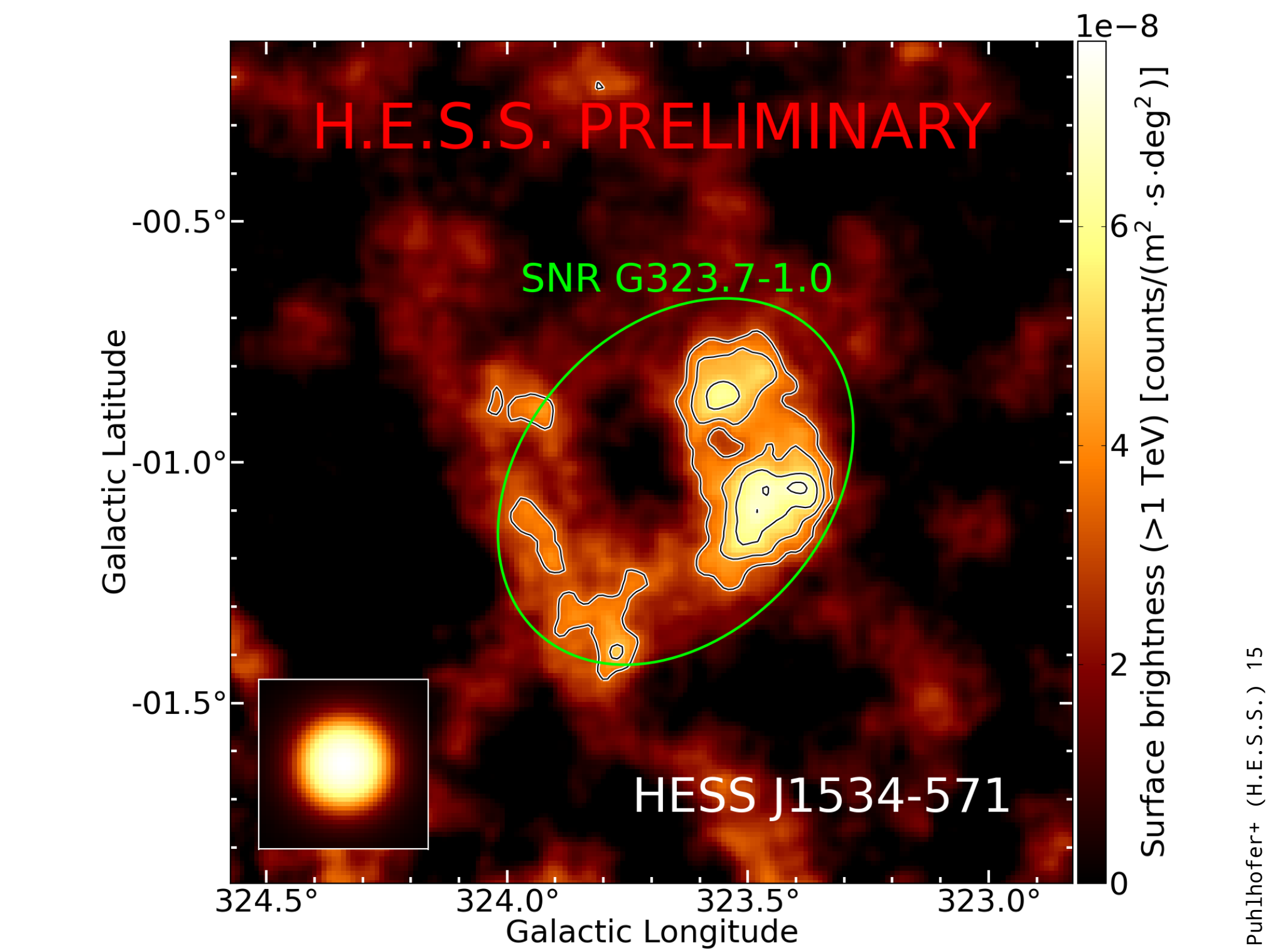
The TeV Galactic Plane



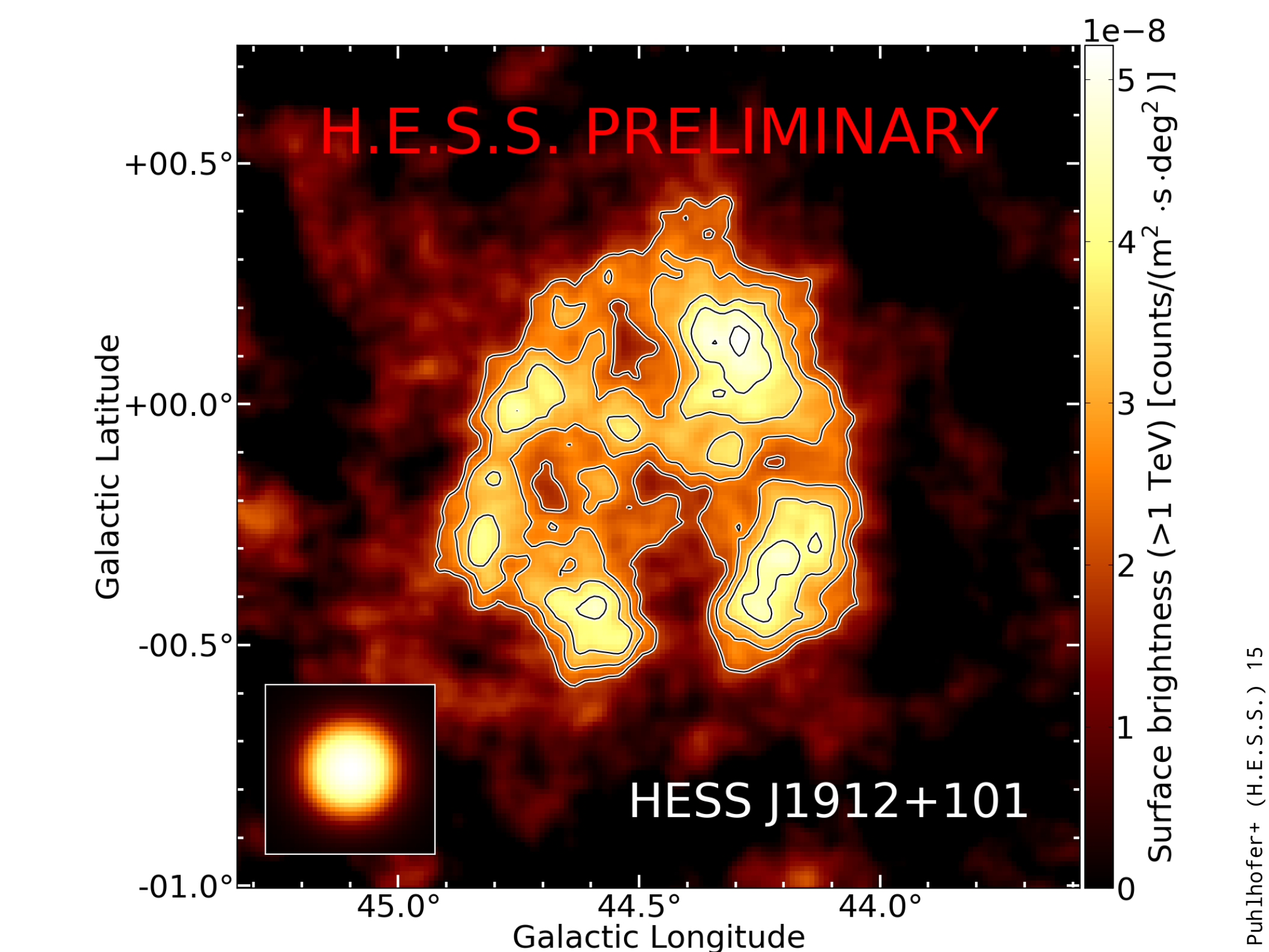
Backup slides

Firm identifications

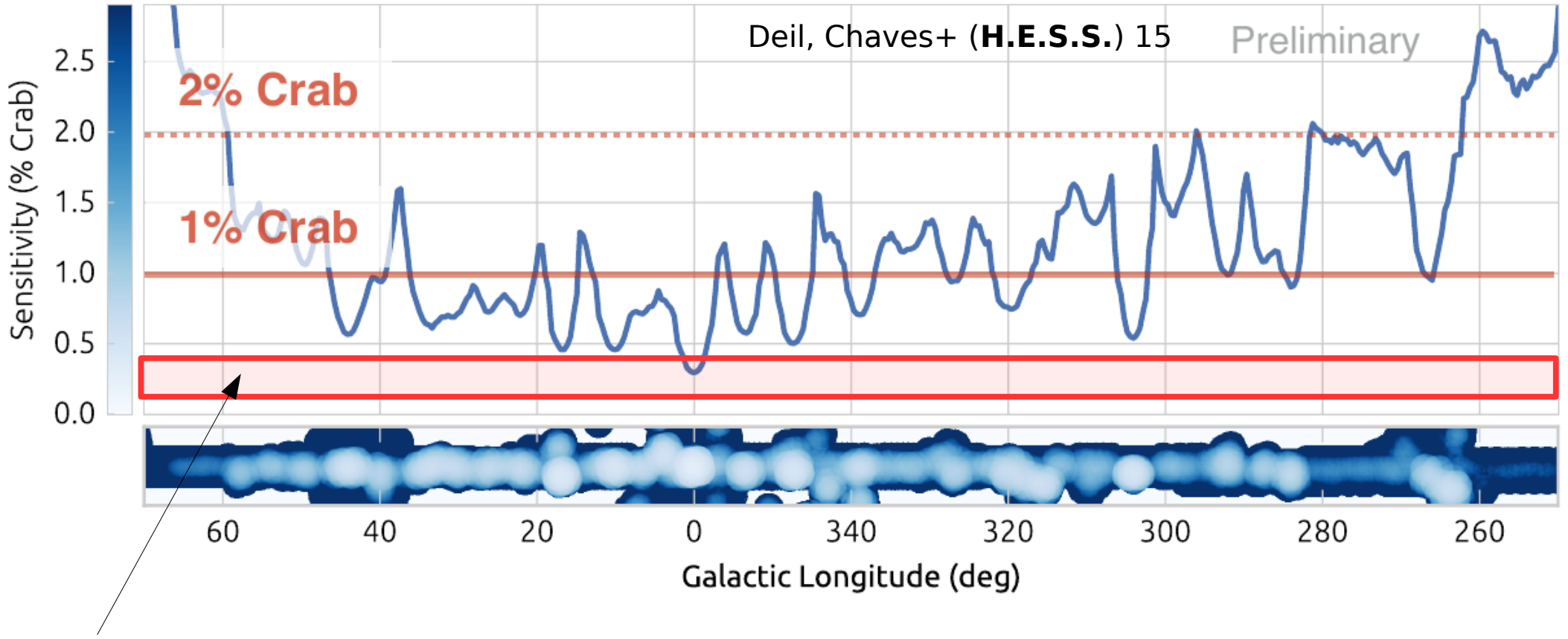
Source Name	Associated object	Class	Evidence	Reference
HESS J1018−589A	1FGL J1018.6−5856	Binary	Variability	H. E. S. S. Collaboration et al. (2015a)
HESS J1302−638	PSR B1259−63	Binary	Variability	Aharonian et al. (2005a)
HESS J1826−148	LS 5039	Binary	Variability	Aharonian et al. (2006c)
HESS J0852−463	Vela Junior	SNR	Morphology	Aharonian et al. (2005b)
HESS J1442−624	RCW 86	SNR	Morphology	Aharonian et al. (2009)
HESS J1534−571	G323.7-01.0	SNR	Morphology	HESS SNR shell paper (2015)
HESS J1713−397	RX J1713.7−3946	SNR	Morphology	Aharonian et al. (2004)
HESS J1731−347	G353.6−0.7	SNR	Morphology	H.E.S.S. Collaboration et al. (2011b)
HESS J1800−240	W 28	SNR	Position	Aharonian et al. (2008)
HESS J0835−455	Vela X	PWN	Morphology	Aharonian et al. (2006a)
HESS J1303−631	PSR J1301−6305	PWN	ED Morph.	H.E.S.S. Collaboration et al. (2012)
HESS J1514−591	MSH 15−52	PWN	Morphology	Aharonian et al. (2005a)
HESS J1825−137	PSR J1826−1334	PWN	ED Morph.	Aharonian et al. (2006d)
HESS J1356−645	PSR J1357-6429	PWN	Position	H.E.S.S. Collaboration et al. (2011a)
HESS J1418−609	PSR J1418-6058	PWN	Position	Aharonian et al. (2006b)
HESS J1420−607	PSR J1420-6048	PWN	Position	Aharonian et al. (2006b)
HESS J1554−550	G327.1-01.1	PWN	Morphology	Section 5.7.5
HESS J1747−281	G0.9+0.1	PWN	Morphology	Aharonian et al. (2005b)
HESS J1818−154	G015.4+00.1	PWN	Morphology	H. E. S. S. Collaboration et al. (2014)
HESS J1849−000	PSR J1849−0001	PWN	Position	Section 5.7.15
HESS J1837−069	PSR J1838−0655	PWN?	Morphology	Marandon et al. (2008)
HESS J1640−465	G338.3-0.0	Composite?	Position	Abramowski et al. (2014b), Gotthelf et al. (2014)
HESS J1119−614	PSR J1119-6127	Composite	Position	Section 5.7.1
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 5.7.10
HESS J1846−029	PSR J1846-0258	Composite	Position	Section 5.7.13
HESS J1930+186	G54.1+0.3	Composite	Position	Acciari et al. (2010), Section 5.5



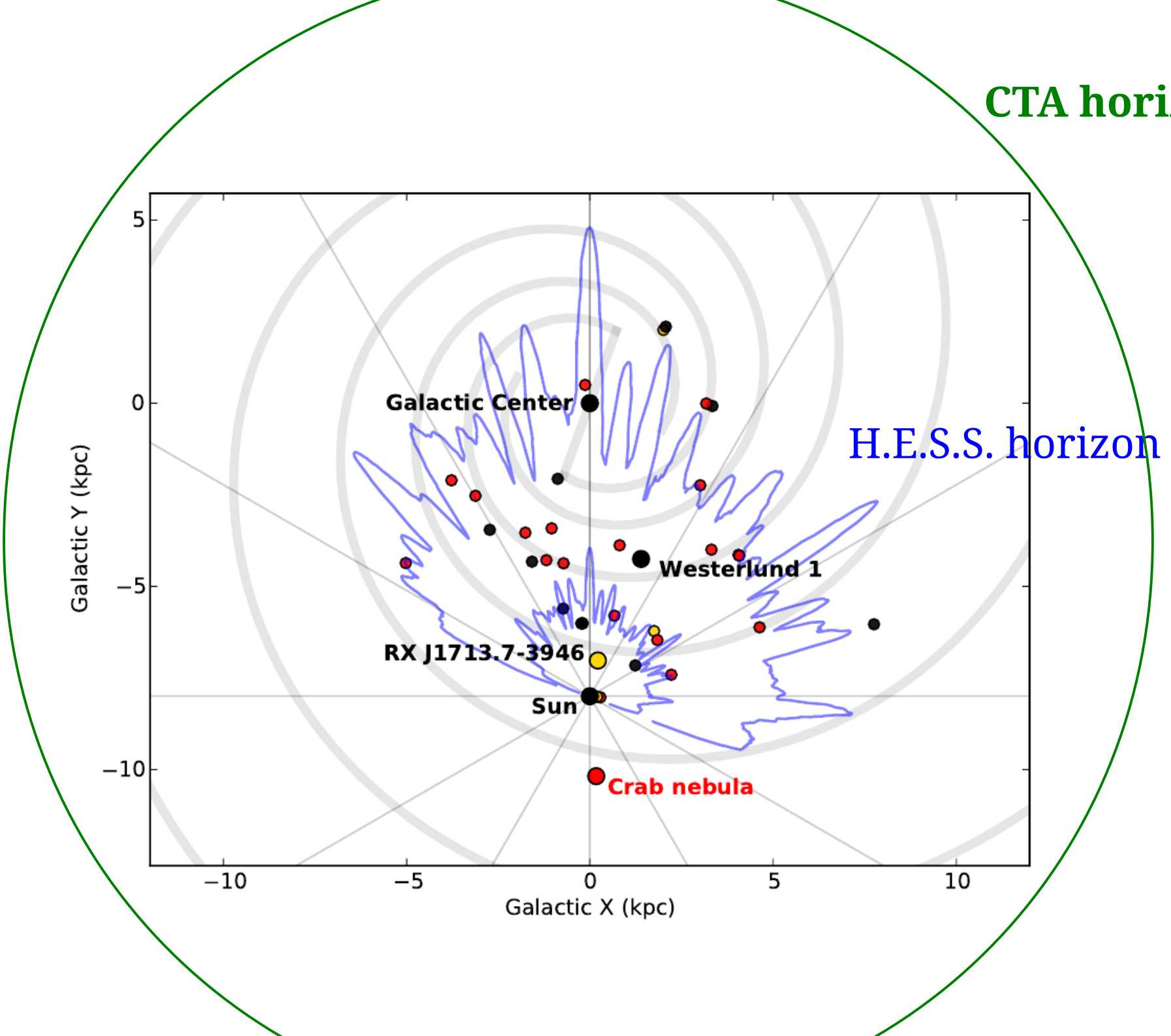
Puhlhofer+ (H.E.S.S.) 15



GPS IN CONTEXT



~mCrab and uniform sensitivity with CTA GPS in just 2 years


CTA horizon
H.E.S.S. horizon
Galactic Center
Westerlund 1
RX J1713.7-3946
Sun
Crab nebula
Galactic Y (kpc)
Galactic X (kpc)
5
0
−5
−10
−10
−5
0
5
10