SNR-PWN Workshop

The H.E.S.S. Galactic Plane Survey: Mission accomplished?

Ryan C. G. CHAVES
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SNR-PWN Workshop
Montpellier
November 2012

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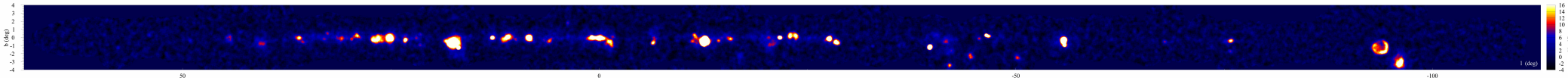
The H.E.S.S. Galactic Plane Survey: Mission accomplished?



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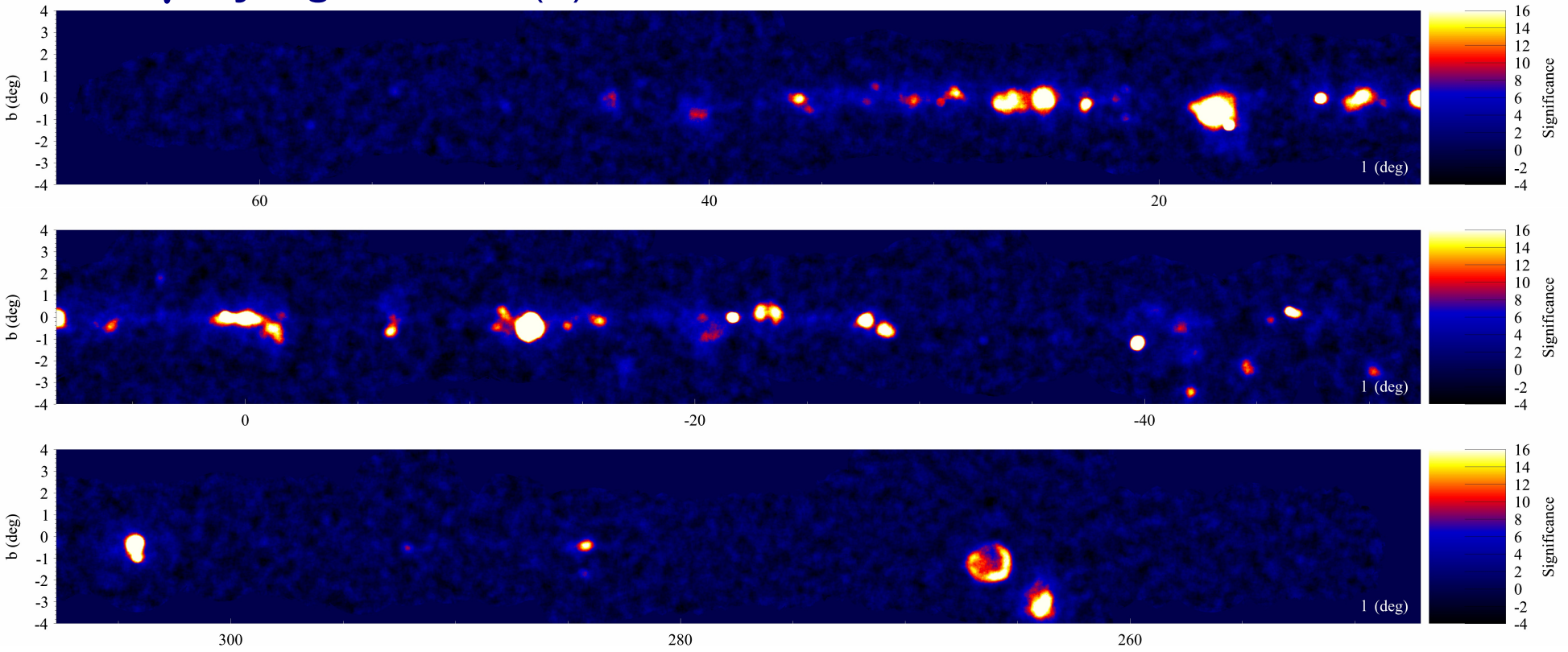
VHE Galactic Plane Survey

VHE γ-ray significance (σ)



Gast, …, Chaves, …, Djannati-Atai, Gallant+ (H.E.S.S.) 2012

VHE Galactic Plane Survey

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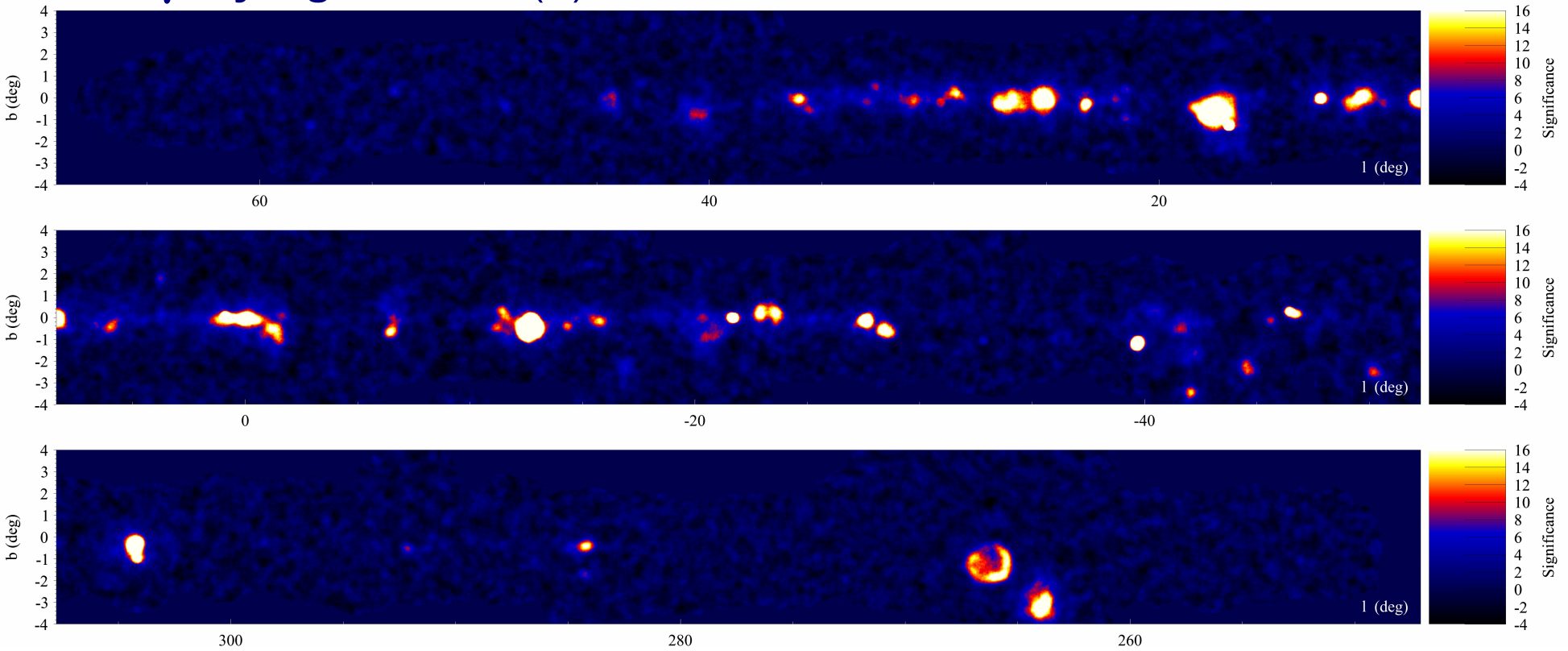


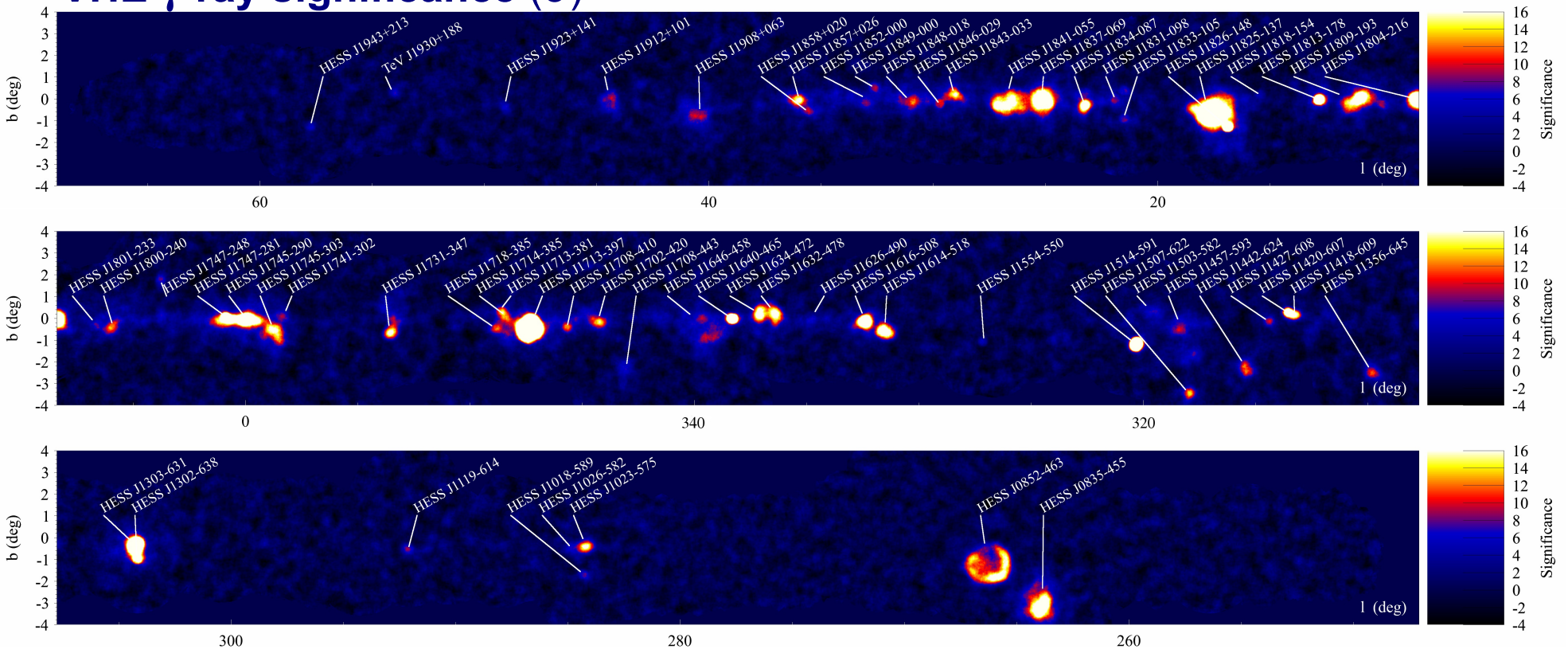
H.E.S.S.-I Galactic Plane Survey 2004-2012

> 2300 h exposure (live-time)
~1200 sq. deg. coverage

TMVA-based γ-hadron separation
Adaptive ring background subtraction

Gast, …, Chaves, …, Djannati-Atai, Gallant+ (H.E.S.S.) 2012

VHE γ-ray source discovery



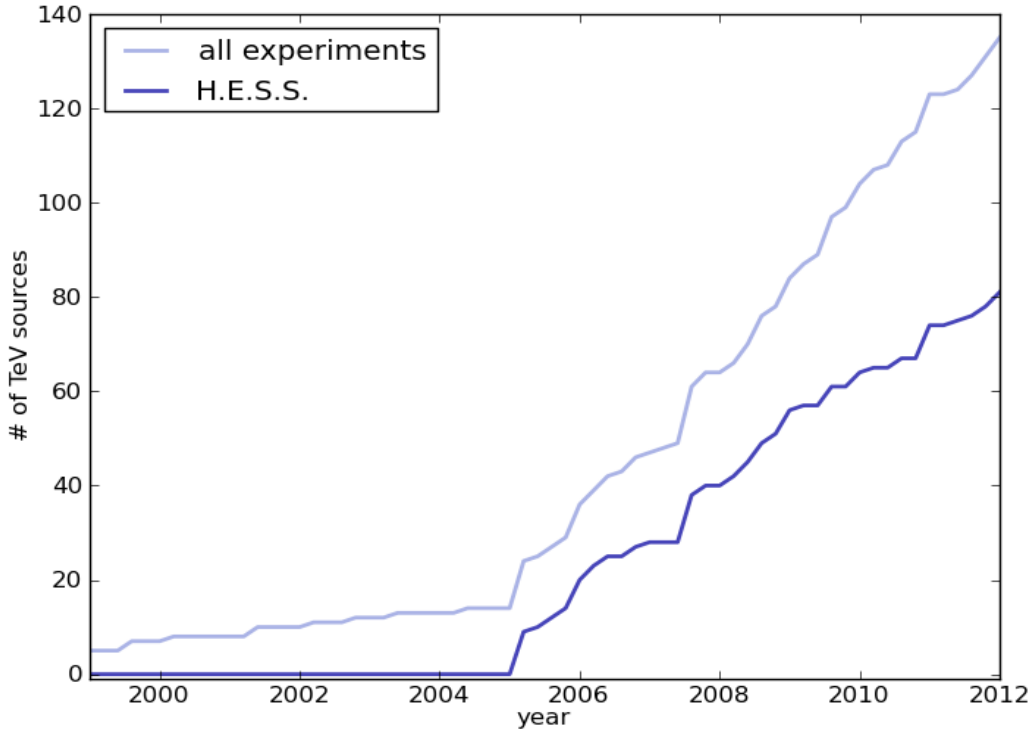
H.E.S.S.-I Galactic Plane Survey 2004-2012

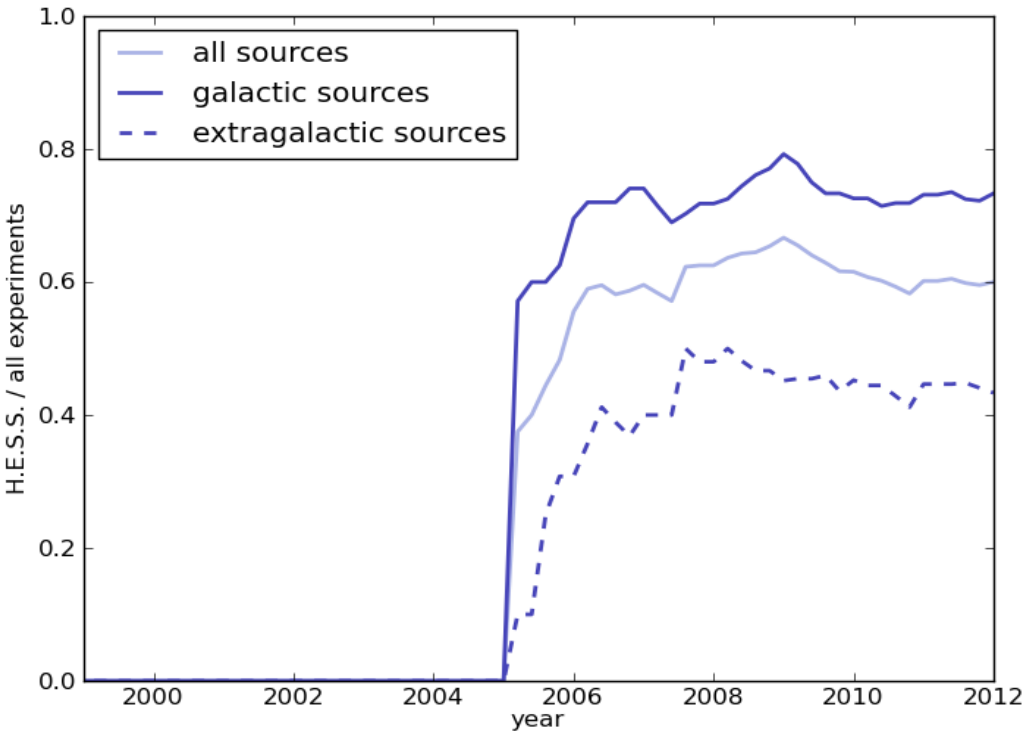
> 65 sources discovered

Mostly PWNe, some SNRs, some binaries, the Galactic center, & many unIDs

Gast, …, Chaves, …, Djannati-Atai, Gallant+ (H.E.S.S.) 2012

Just a little propaganda





H.E.S.S.-I Legacy Survey

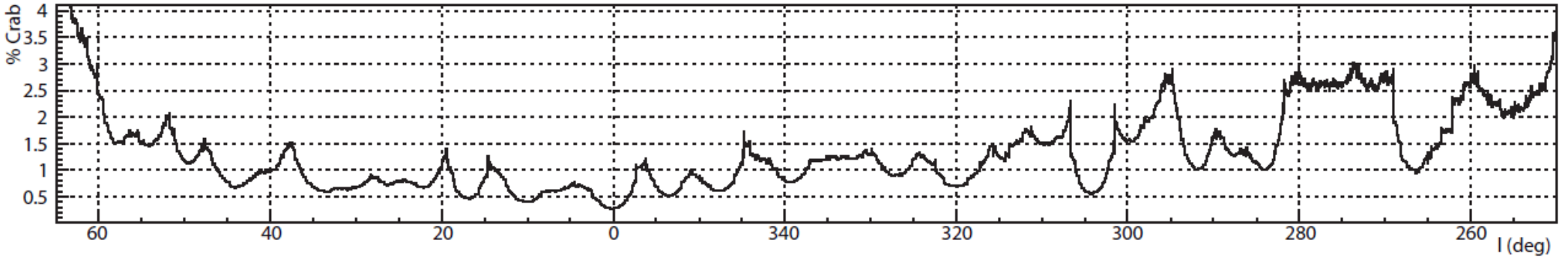
HLS 2009-2012

Motivation:
Majority of observations are targeted, not raster scan
Aid popuation studies
Source discovery

Observation campaign to achieve more uniform exposure (sensitivity)

H.E.S.S.-I Legacy Survey

Point-source sensitivity along Galactic plane $b \sim -0.3°$, $\Gamma = 2.5$, $5\,\sigma$ 2011 status



HLS 2009-2012

Motivation:
Majority of observations are targeted, not raster scan
Aid popuation studies
Source discovery

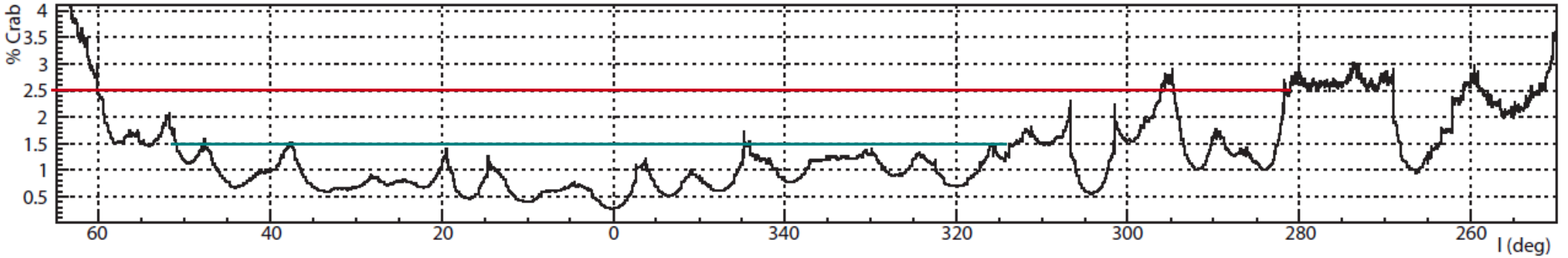
Observation campaign to achieve more uniform exposure (sensitivity)

~150 h live-time added
< 2% Crab sensitivity along inner Galactic plane, to mCrab levels

e.g. Chaves, Gallant, Renaud, Djannati-Atai+ (H.E.S.S)

H.E.S.S.-I Legacy Survey

Point-source sensitivity along Galactic plane $b \sim -0.3°$, $\Gamma = 2.5$, $5\,\sigma$ 2011 status



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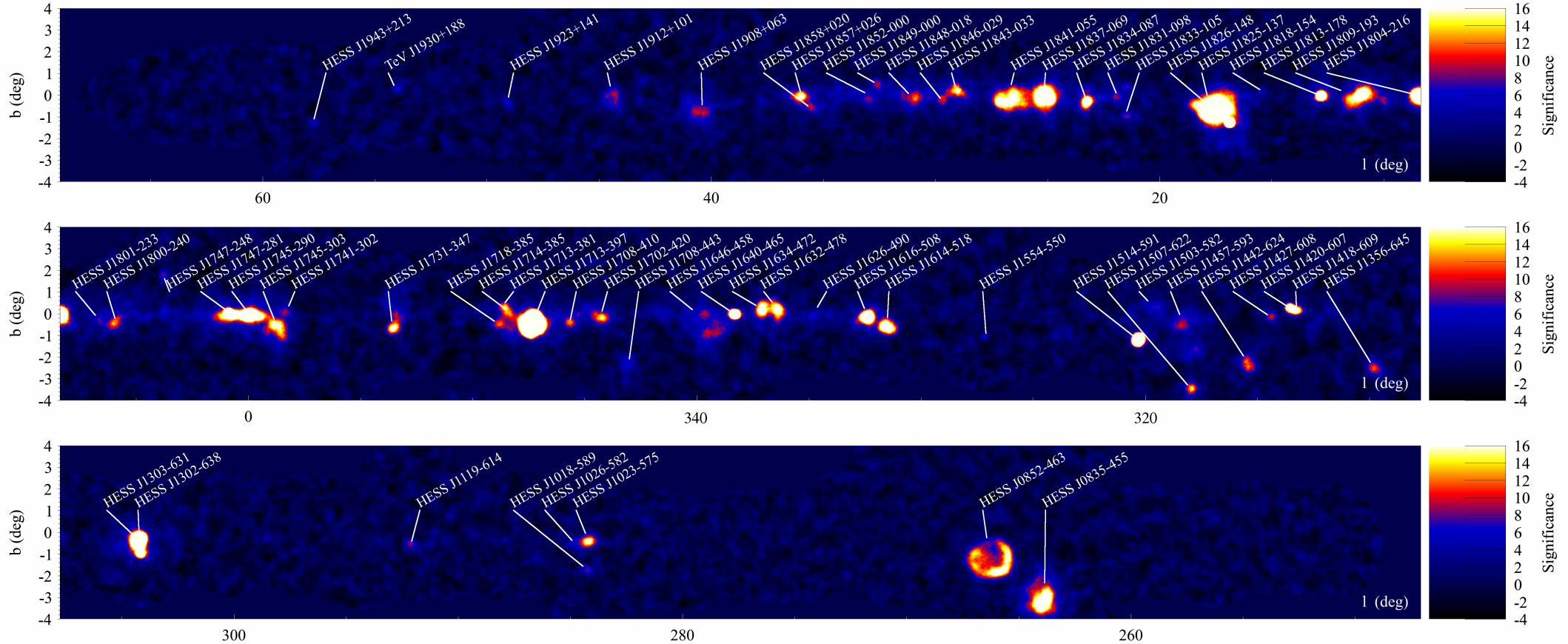
VHE γ-ray Survey Extensions

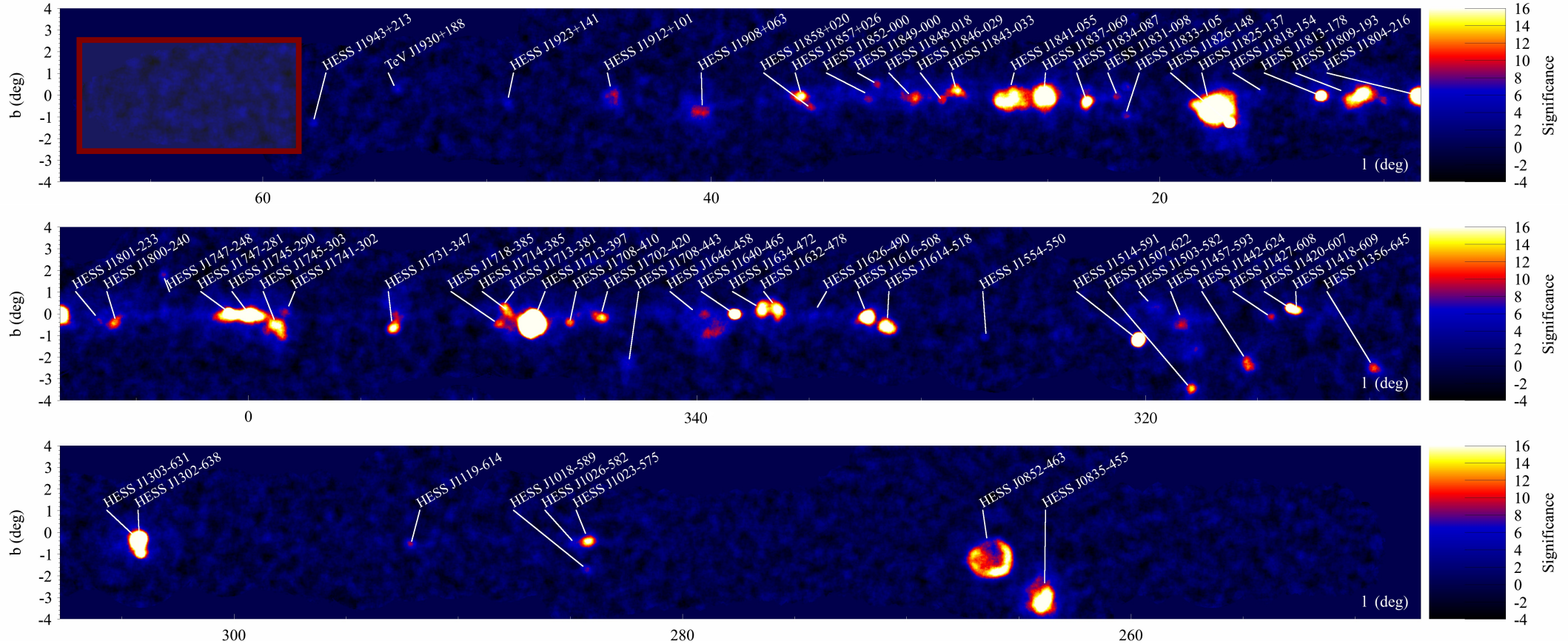
H.E.S.S.-I Survey extensions 2007 – 2012



VHE γ-ray Survey Extensions

H.E.S.S.-I Survey extensions 2007 – 2012

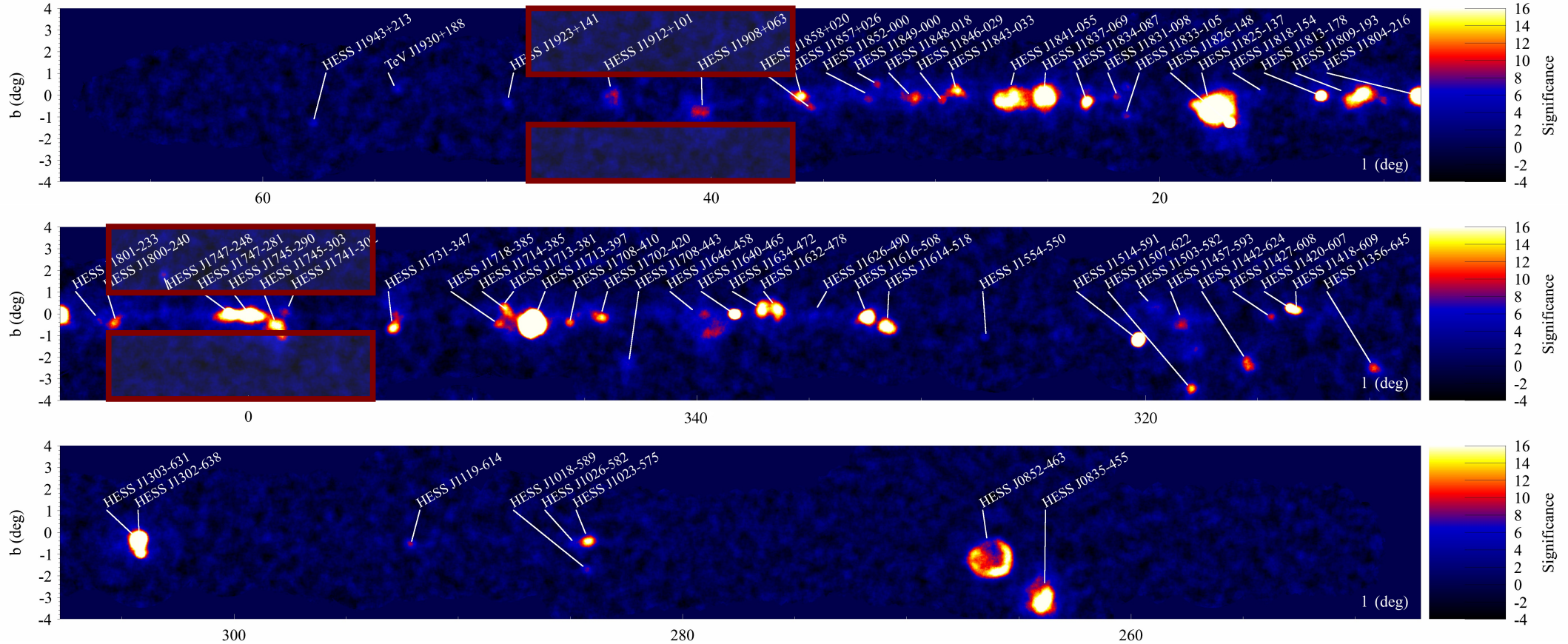
Towards North, almost reaching VERITAS Cygnus Region Survey



VHE γ-ray Survey Extensions

H.E.S.S.-I Survey extensions 2007 – 2012

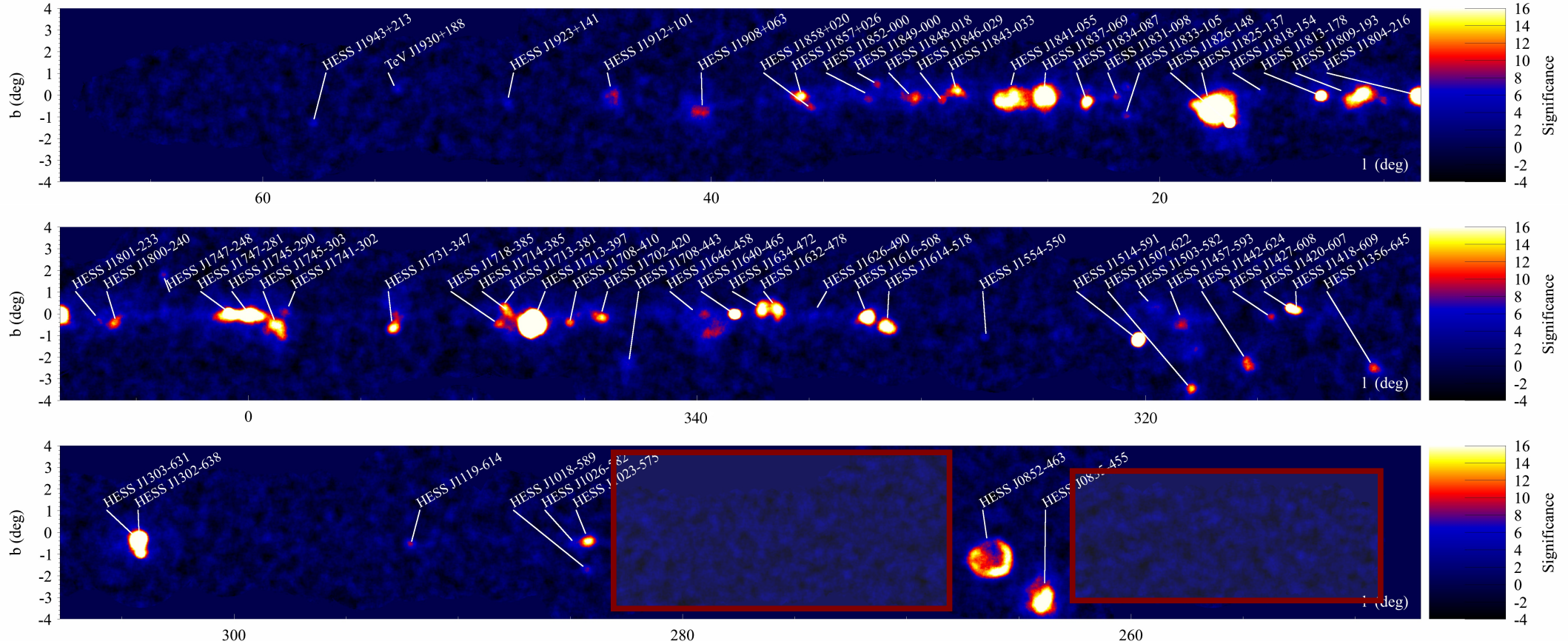
Off-plane / high-latitude (to sensitivity ~5-10% Crab)



VHE γ-ray Survey Extensions

H.E.S.S.-I Survey extensions 2007 – 2012

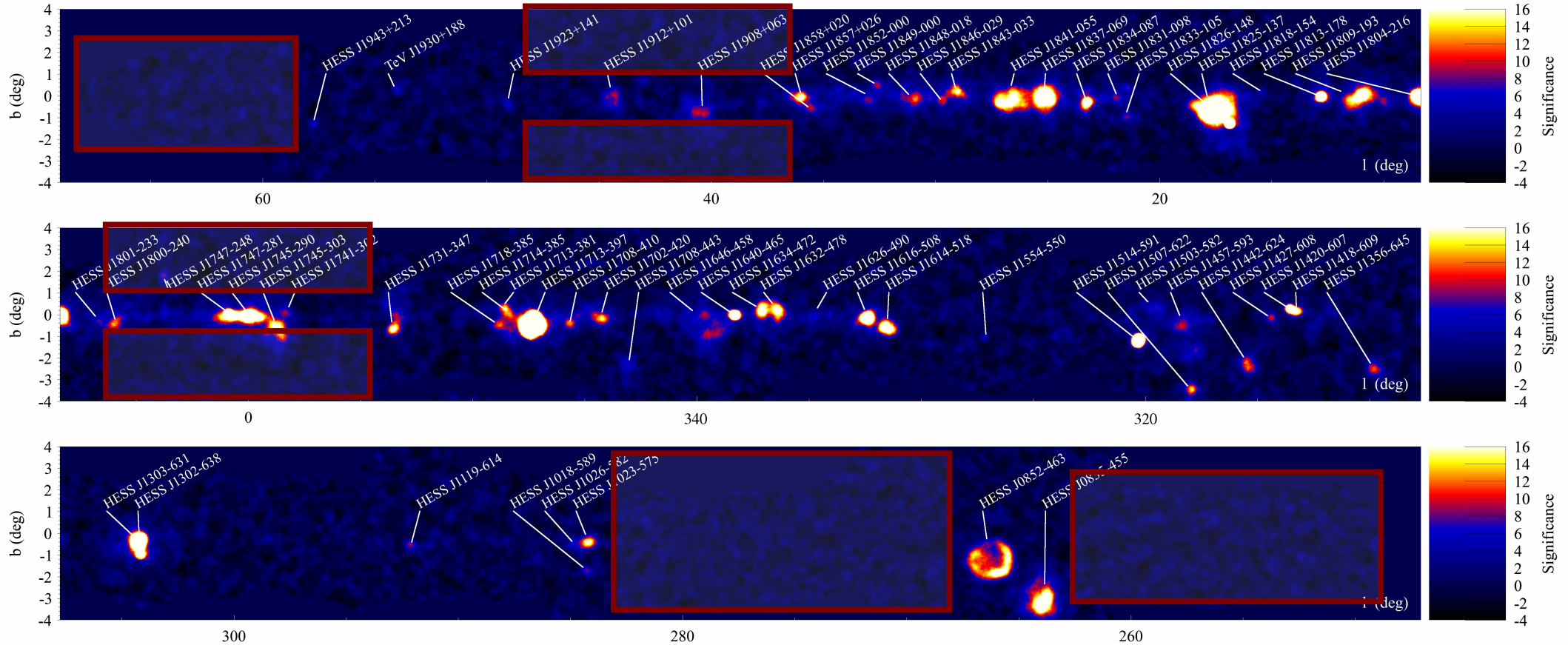
Inter-arm regions towards Vela



VHE γ-ray Survey Extensions

H.E.S.S.-I Survey extensions 2007 – 2012

Towards North, almost reaching VERITAS Cygnus Region Survey
Off-plane / high-latitude (to sensitivity ~5-10% Crab)
Inter-arm regions towards Vela
Extensions thus far revealed no bright sources off-plane or in outer Galaxy.



Summary 1

H.E.S.S.-I Galactic Plane Survey 2004 – 2012

Surveyed ~1000 sq. deg. to ~2% Crab sensitivity

Discovered over 65 sources of VHE γ-ray sources; order of magnitude increase

Identified PWNe as primary Galactic source class

Relatively simple leptonic acceleration models suffice for most sources

Uncovered large population of dark/unidentified Galactic sources (~25%)

Revealed diffuse emission around Galactic center

Resolved 4 SNR shell morphologies

(Observation) Mission accomplished!
But much works remains to fully exploit the scientific potential of the unique dataset

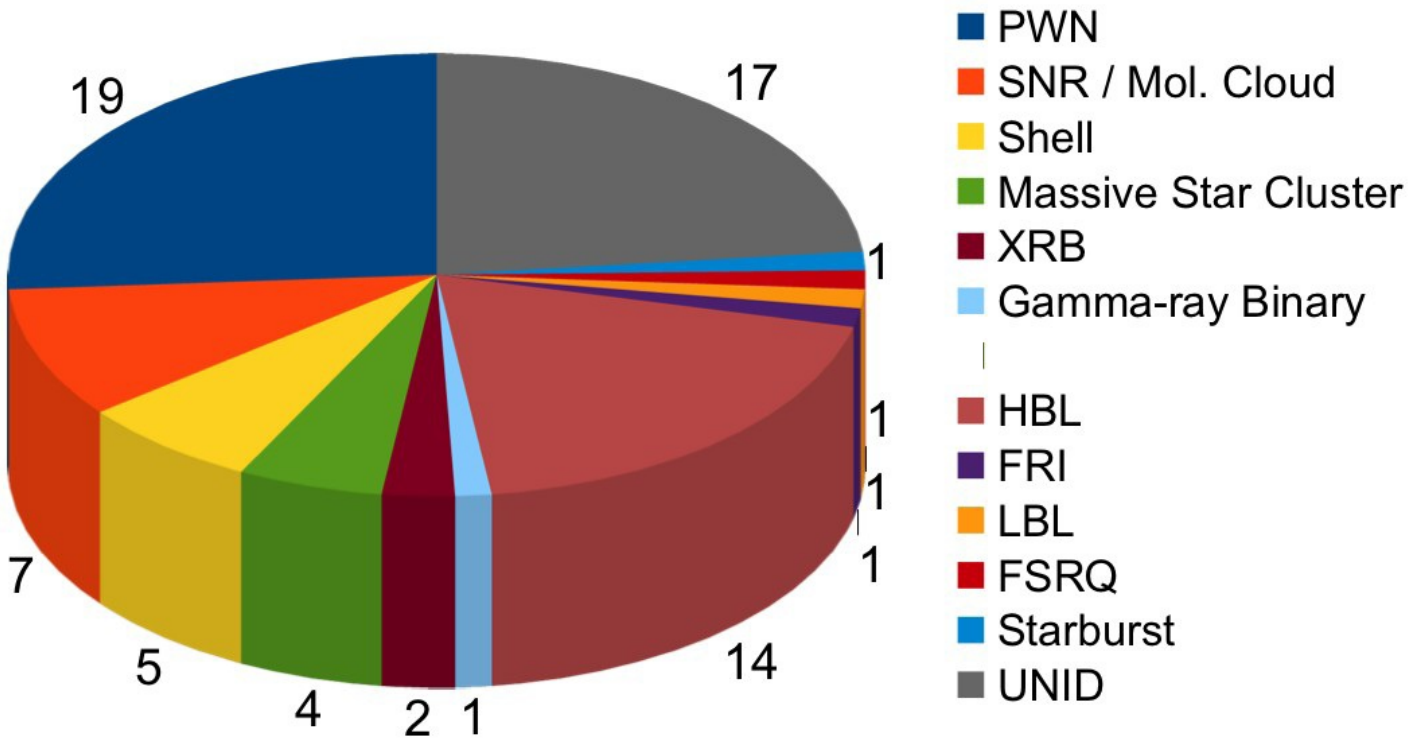
Summary 1

H.E.S.S.-I Galactic Plane Survey 2004 – 2012

(Observation) **Mission accomplished!**

But much work remains to fully exploit the scientific potential of the unique dataset

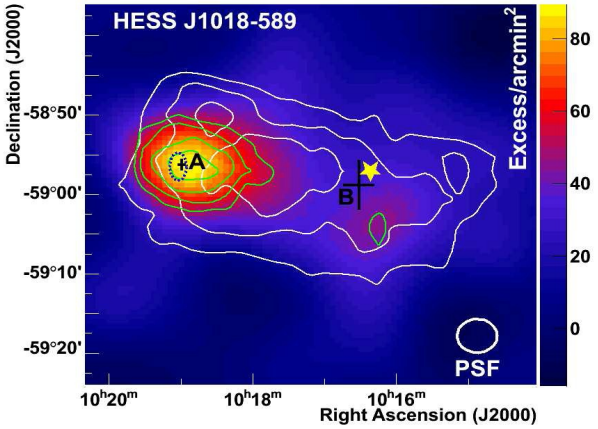
New VHE source classes?

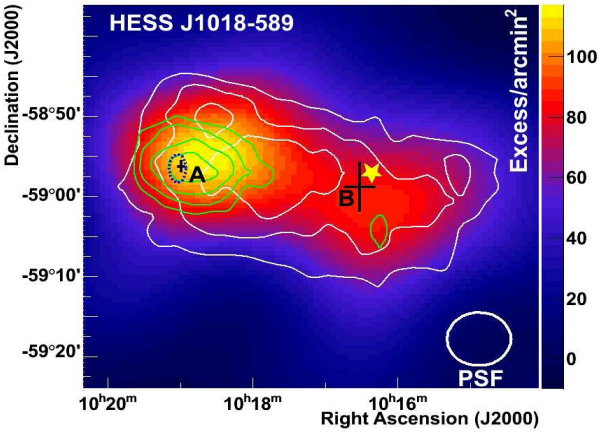


Eger+ (H.E.S.S) 2011

New VHE source classes?

HESS J1018-589: New VHE γ-ray binary *or PWN or SNR?*

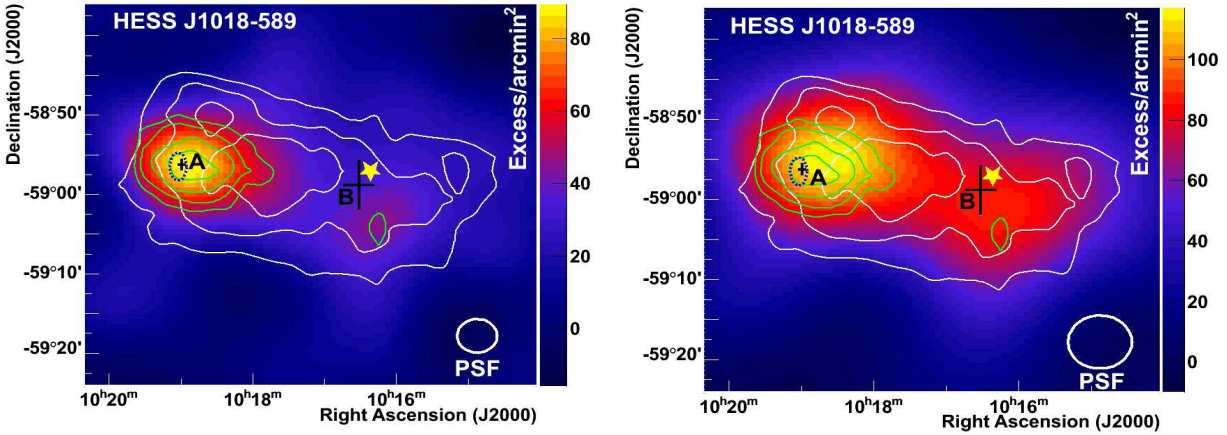




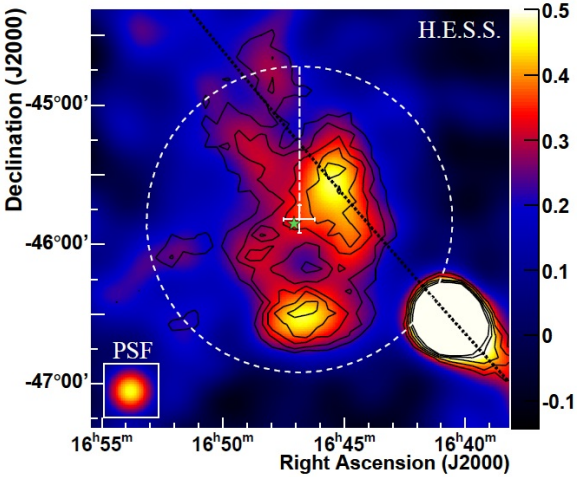
Abramowski+ (H.E.S.S) 2012

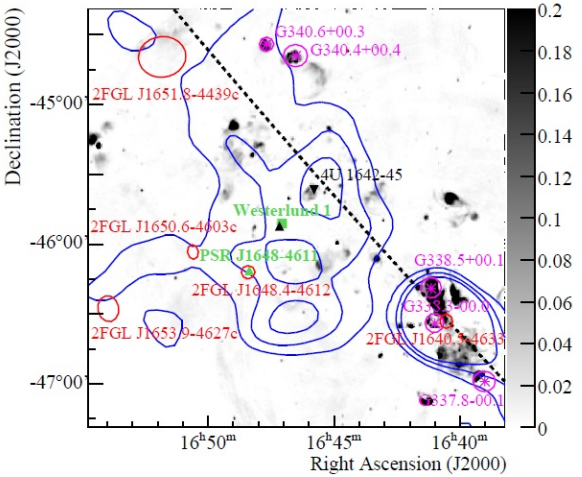
New VHE source classes?

HESS J1018-589: New VHE γ-ray binary *or PWN or SNR?*



HESS J1646-458: Massive stellar cluster *or PWN?*





Abramowski+ (H.E.S.S) 2012

Globular clusters in VHE γ-rays

H.E.S.S.-I Globular Cluster Observation Program 2004 – 2012

Previous VHE γ-ray observations of GCs (e.g. 47 Tucanae) yielded only ULs

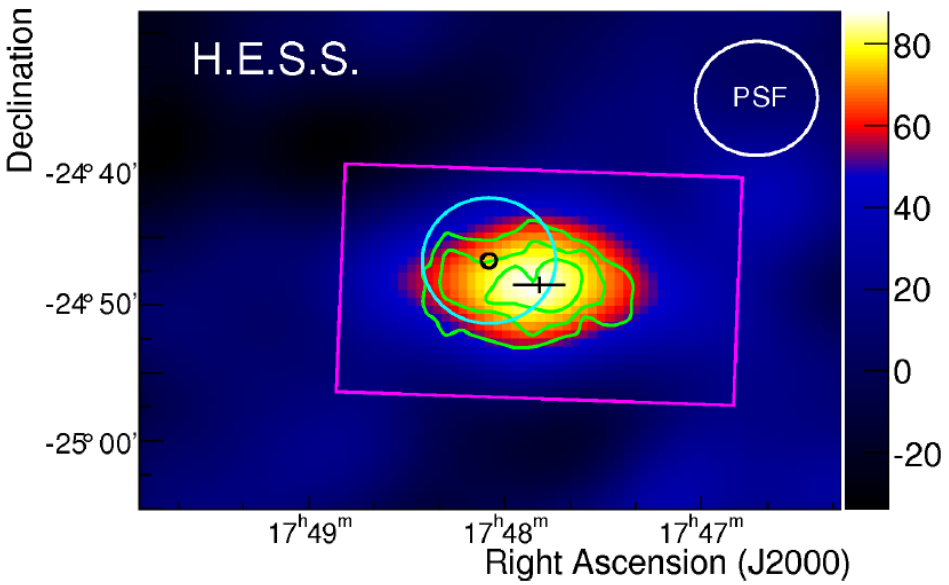
Globular clusters in VHE γ-rays

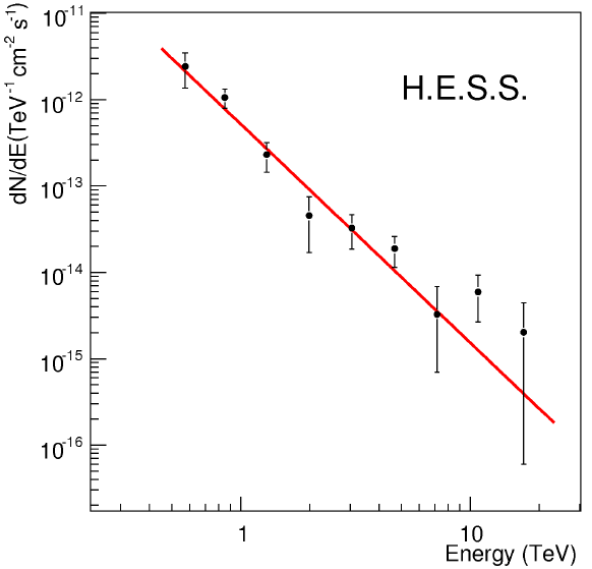
HESS J1747−248:

Terzan 5

or...

radio-quiet PWN?





H.E.S.S.-I Globular Cluster Observation Program 2004 – 2012

Previous VHE γ-ray observations of GCs (e.g. 47 Tucanae) yielded only ULs

VHE source: 1.5% Crab Γ = 2.5 power law spectrum (E > 380 GeV); 62 h live-time

Terzan 5: msPSR/msPSR PWN model energetics OK (d = 5.9 kpc); GeV γ-rays present

PWN?
- Significantly offset from GC center (2.1 σ)
- Significantly asymmetric morphology (2.2 σ)
- Significantly off-plane (b = 3.8°; ~5 σ)
- Chance spatial coincidence w/ energetic ATNF pulsar unlikely (~10^{-4})

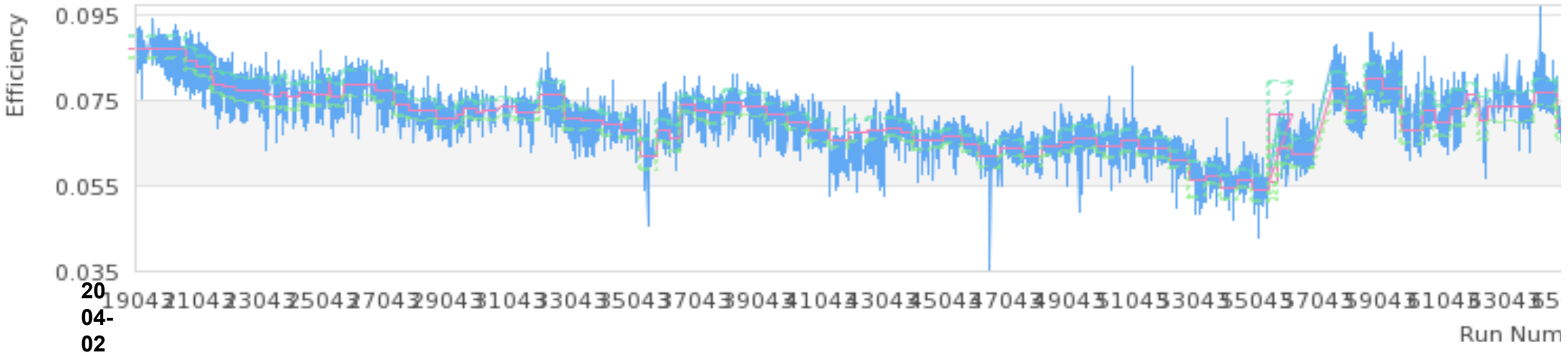
Abramowski+ (H.E.S.S.) 2012

Restored optical efficiency

H.E.S.S.-I Mirror Recoating Project 2010-04 – 2011-10

1 telescope per 6 months → increase in 3-tel observations
Original optical efficiency mostly recovered (*N.B.* aging PMTs)

Example: **History of μ efficiency of one Cherenkov telescope**



2004-02

Some recent H.E.S.S.-I work

Investigating systematics

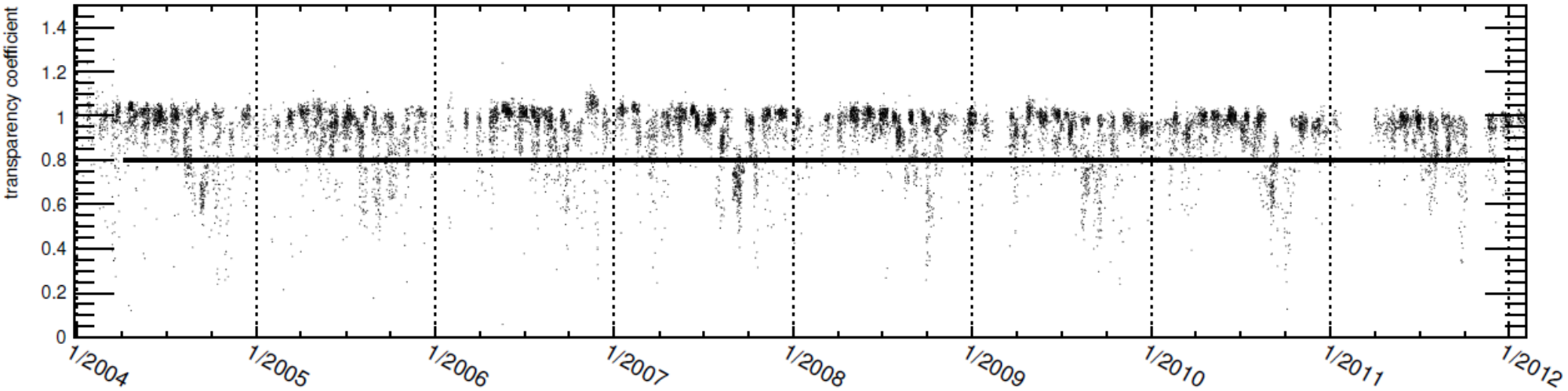
Data quality & atmospheric conditions

Transparency coefficient:
- independent of e.g. optical efficiency

Hahn+ (H.E.S.S.) 2012

Investigating systematics

Example: **History of atmospheric quality**



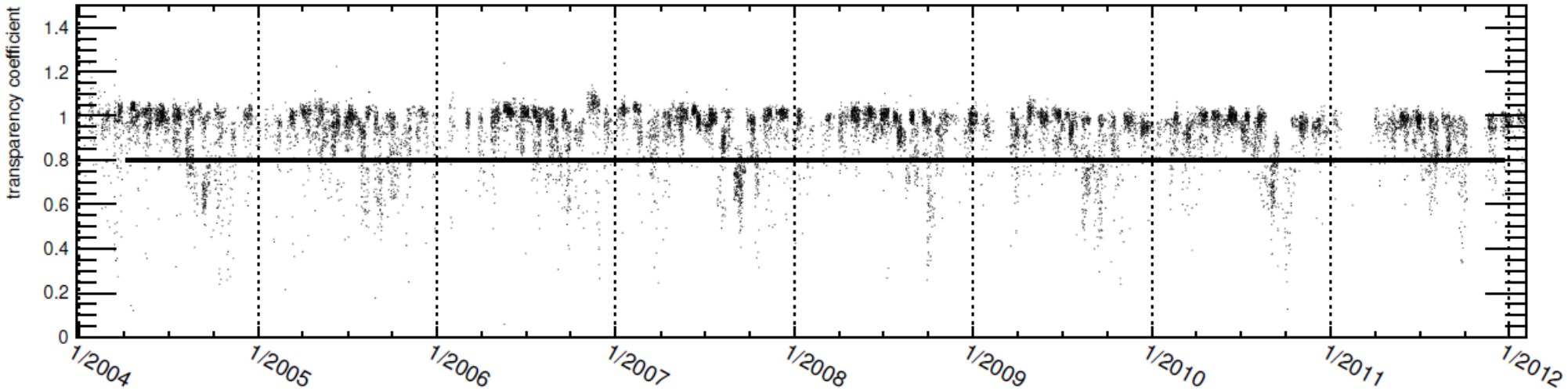
Data quality & atmospheric conditions

Transparency coefficient:
- independent of e.g. optical efficiency
- as data quality criterion

Hahn+ (H.E.S.S.) 2012

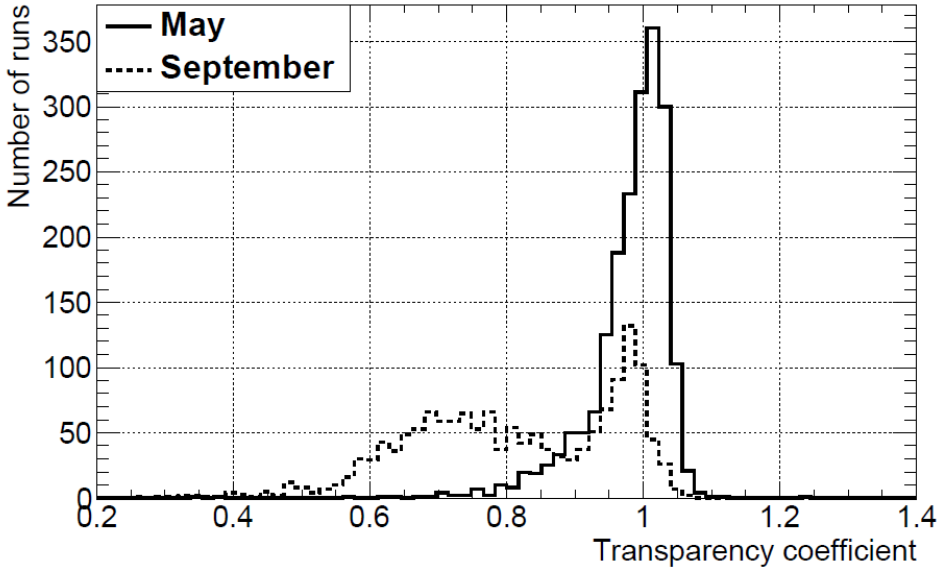
Investigating systematics

Example: **History of atmospheric quality**



Data quality & atmospheric conditions

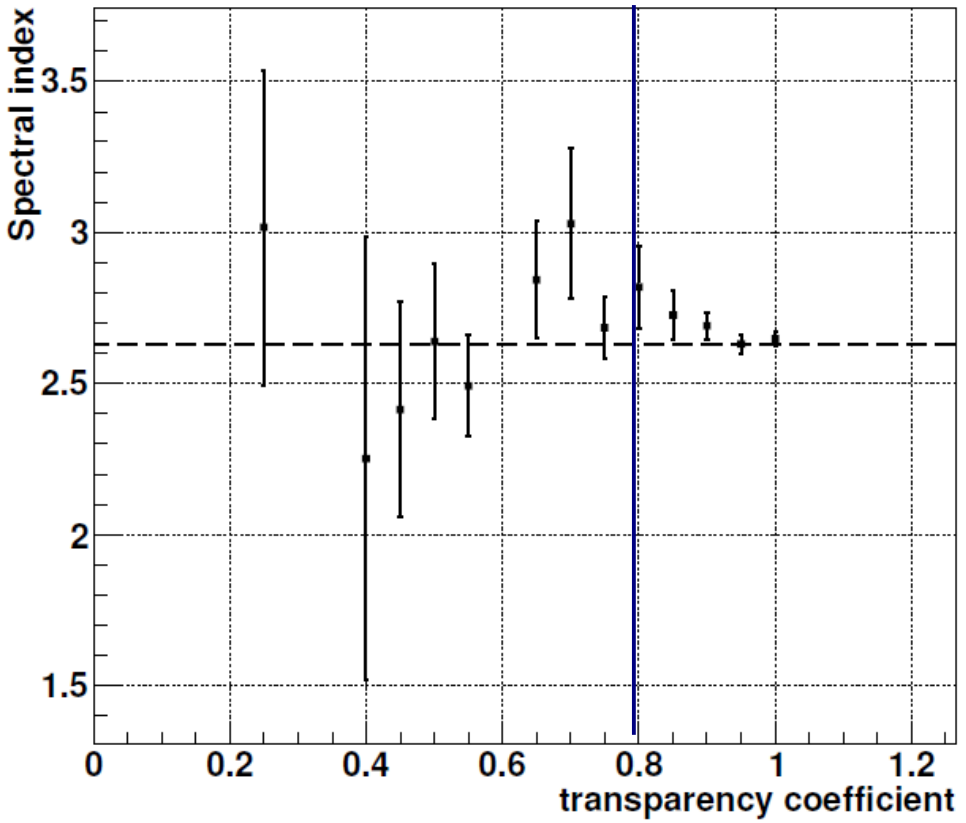
Transparency coefficient:
- independent of e.g. optical efficiency
- as data quality criterion
- as proxy for atmospheric quality



Hahn+ (H.E.S.S.) 2012

Investigating systematics

Example: **Spectral index dependency on transparency coefficient**



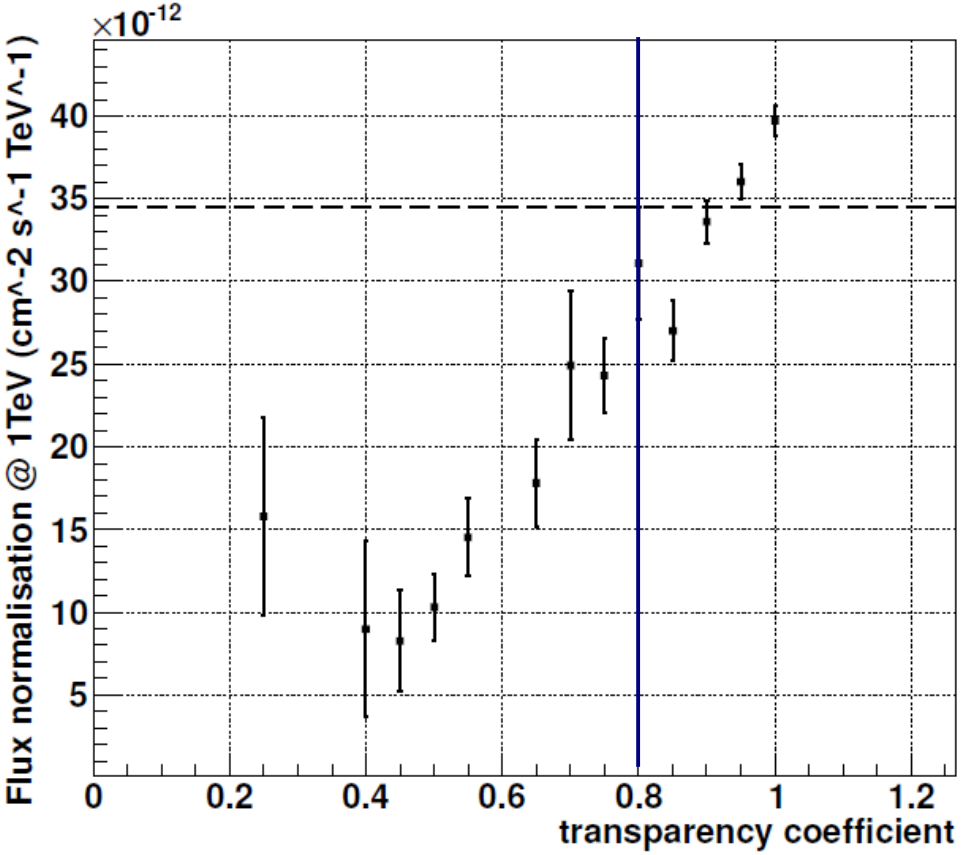
Crab Nebula case study: spectral index

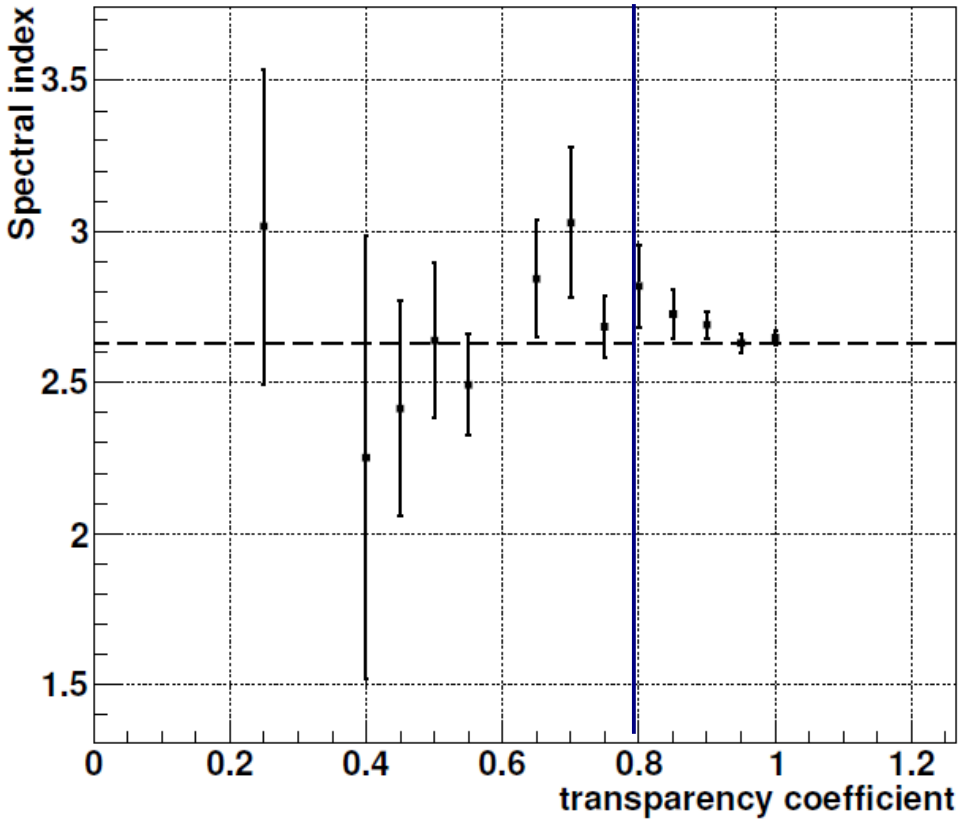
No dependency of Γ on T

Hahn+ (H.E.S.S.) 2012

Investigating systematics

Example: **Flux normalization dependency on transparency coefficient**





Crab Nebula case study: Flux normalization

Significant effect but minimized (~20%) w/ cut T > 0.8; data lost

Hahn+ (H.E.S.S.) 2012

H.E.S.S.-II First Light

H.E.S.S.-II 2012-07 – present

Towards a ~50 GeV threshold
Improvements in sensitivity (~2X) & angular resolution (~1.4X)
Faster slew speed for transients

H.E.S.S.-II Survey outlook

Scan

Delay in construction actually benefited HLS
Time req. for improvement of H.E.S.S.-I Survey unrealistic despite sensitivity increase
Smaller CT5 FoV (3.7° vs. 5.0°), factor ~2 penalty in time
Next-generation VHE Survey awaits CTA
Miniscans remain a possibility

H.E.S.S.-II Survey outlook

Scan

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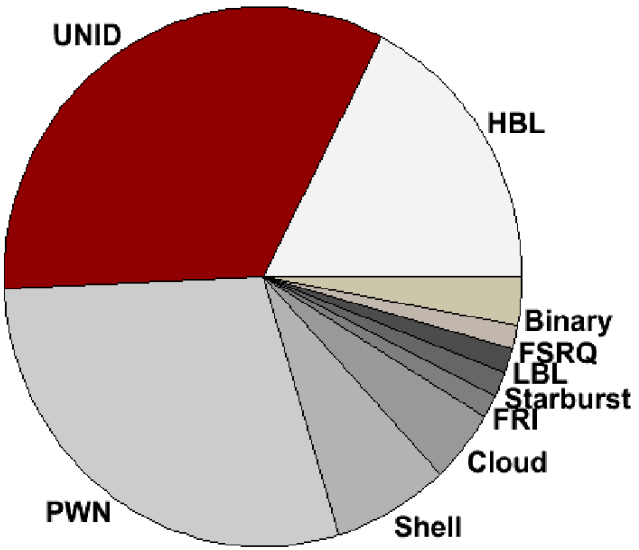
Facilitate identification & study

Lower energies (*Fermi*/LAT connection, E-dep morphology)
Improved angular resolution (spatial correlations w/ MWL counterparts)
Improved sensitivity (deeper datasets, better TeV characterization)
Not just resolve SNR/PWN confusion, but also the Galactic Center



Summary 2

H.E.S.S. Galactic scence A selection of recent/active projects

Source population studies, e.g.
- hadronic SNRs Bochow+ (H.E.S.S.) 2011
- maser-emitting SNRs Chaves+ (H.E.S.S.) 2011
- globular clusters, incl. stacking *in preparation*

Exploring new Galactic source classes, e.g.:
- globular clusters
- massive stellar clusters
- magnetars

Multi-messenger projects:
- joint H.E.S.S./*Fermi* papers
- X-ray & radio follow-up of unID VHE γ-ray sources
- (VHE follow-up of IceCube & ANTARES υ hotspots, 2009 – present)

A few more (faint) source discoveries, dealing w/ complex morphology regions, resolving source confusion, quantifying diffuse emission, systematics (incl. atmospheric), ...

→ H.E.S.S.-I Galactic Source Catalog