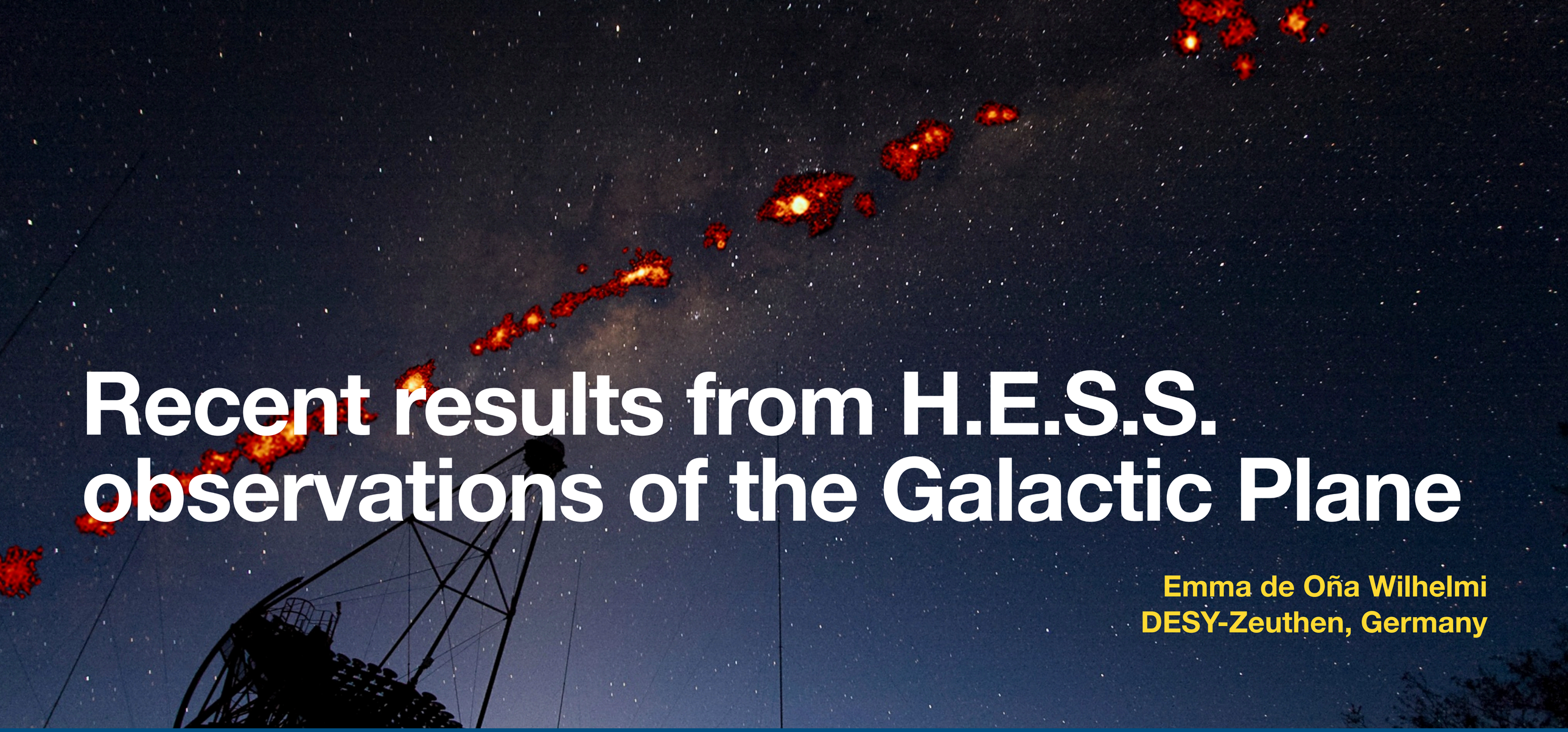


Recent results from H.E.S.S. observations of the Galactic Plane

Emma de Oña Wilhelmi
DESY-Zeuthen, Germany

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

H.E.S.S.

DESY.

Outlook

the H.E.S.S. Galactic Plane Survey

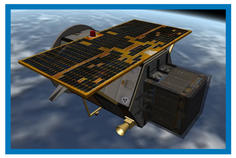
- H.E.S.S. and the Imaging Atmospheric Cherenkov Telescope (IACT) array technique
  => Strengths and weakness when looking at the Galactic Plane

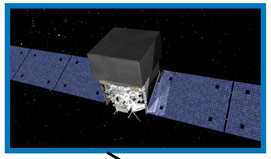
- New results related to Galactic science
  => Discovering of new TeV emitters and revisiting previous results

- The TeV Galactic Population
  => Pulsar wind nebulae and Supernova Remnants
  => New TeV source classes

Gamma-rays above a few ~GeV

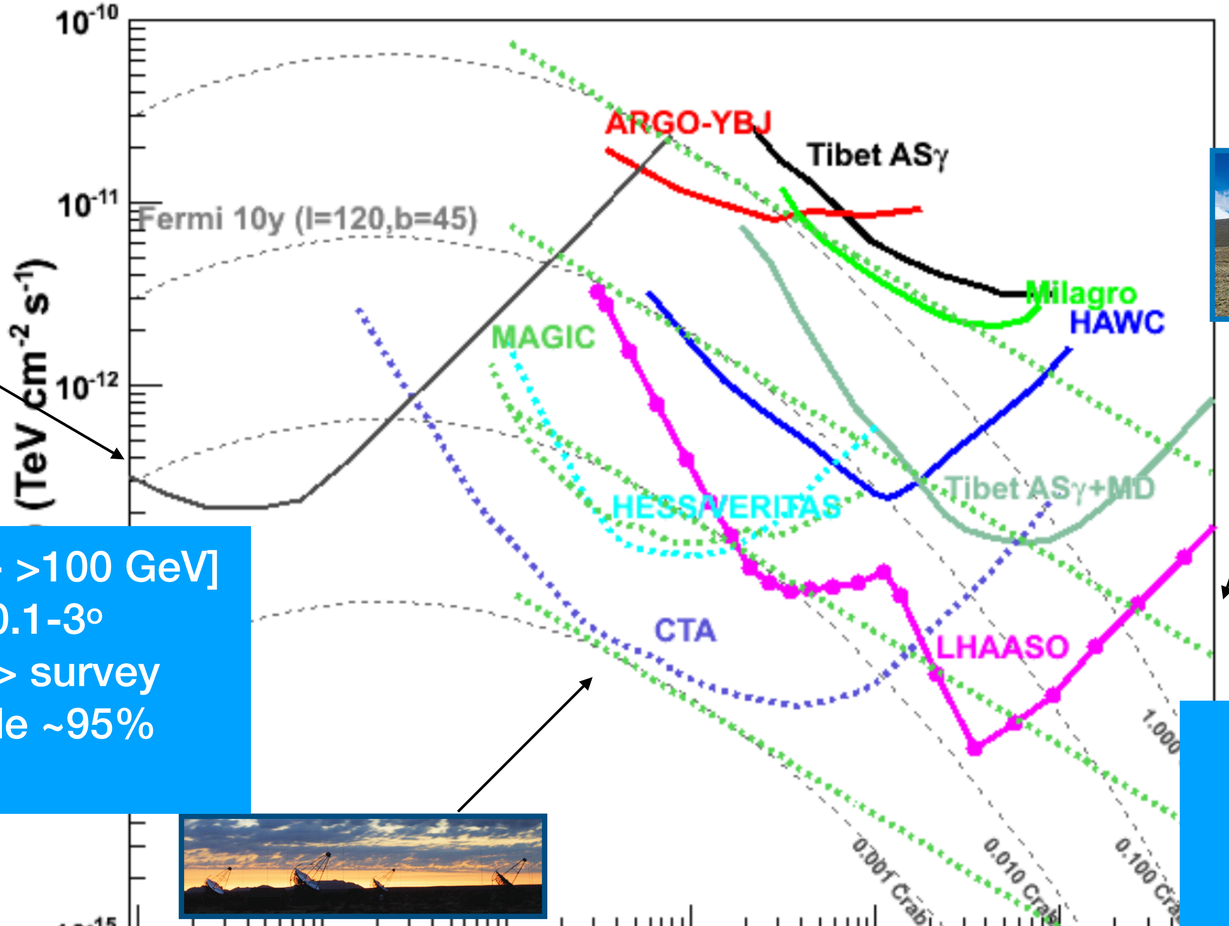
Detection techniques





Satellites

E=[100MeV - >100 GeV]
PSF ~0.1-3°
Aperture > survey
Duty Cycle ~95%



E=[10 - >1000] TeV
PSF ~0.2-0.7°
Aperture > 2 sr
Duty Cycle ~90%

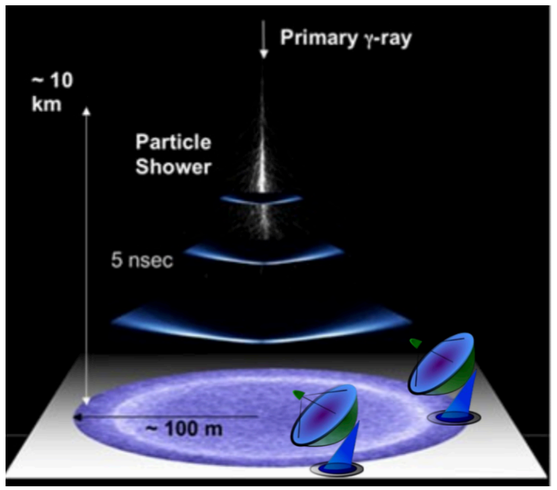
Particle Detectors

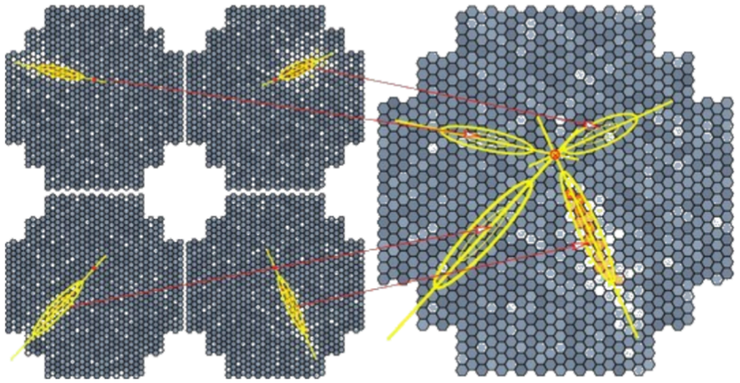
IACTs

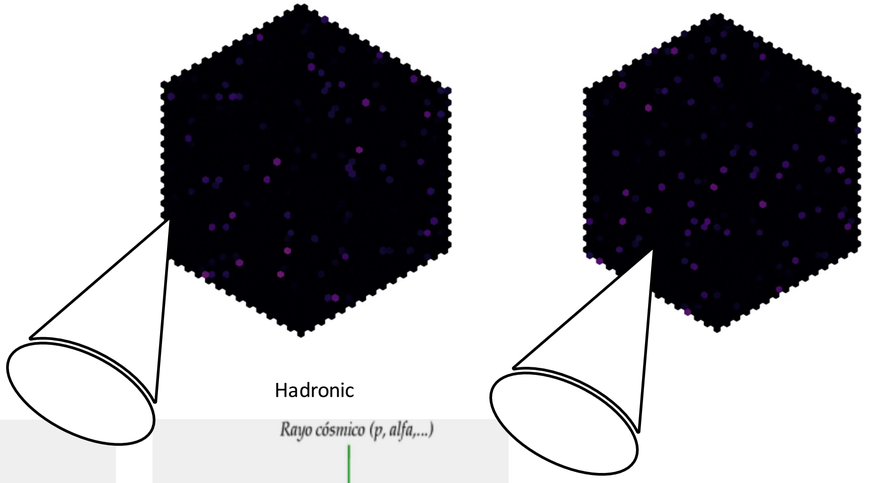
E=[0.02 - 100] TeV
PSF ~0.05°
Aperture ~0.003 sr
Duty Cycle ~10%

The IACT Technique

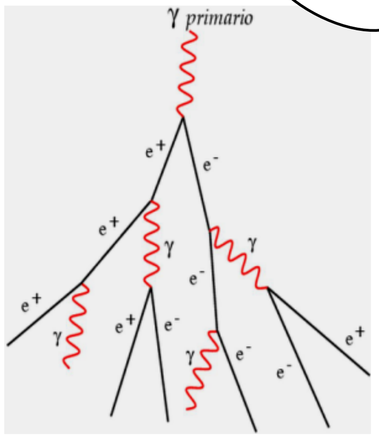
Detecting high energy photons



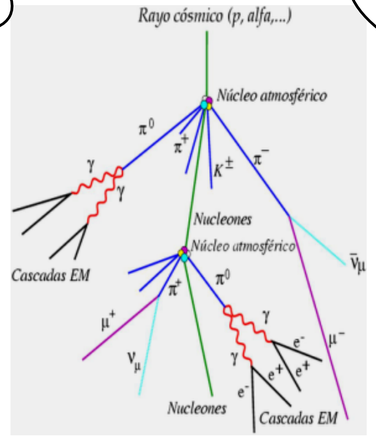




Electromagnetic

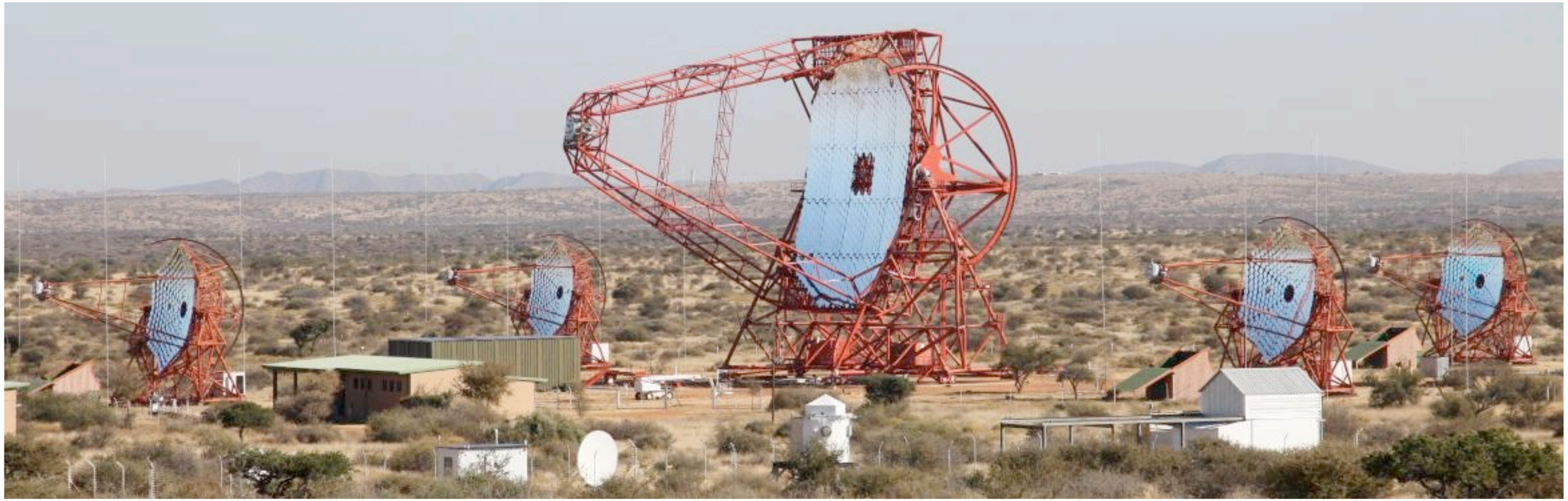


Hadronic



- From the shape => gamma/hadron separation
- From the axis => arrival direction / angular resolution
- From the ‘size' => light / energy resolution

The H.E.S.S. telescope array

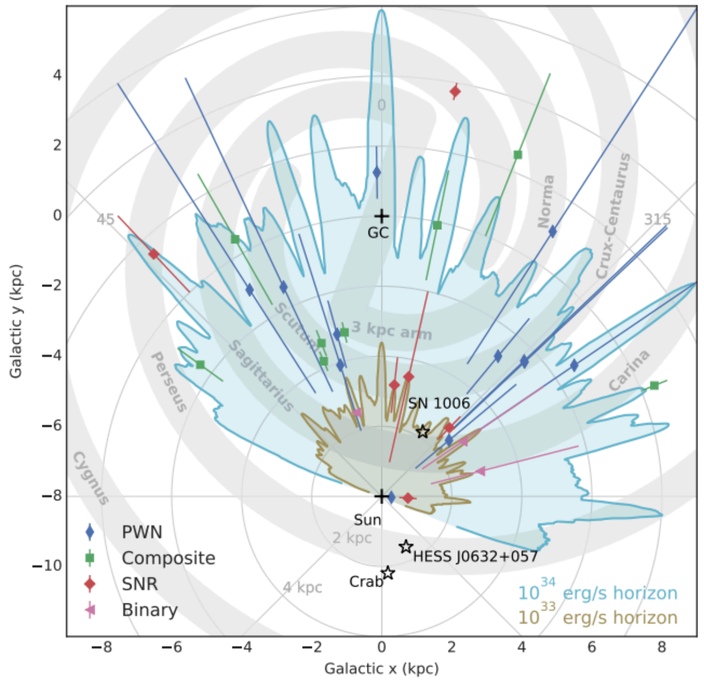


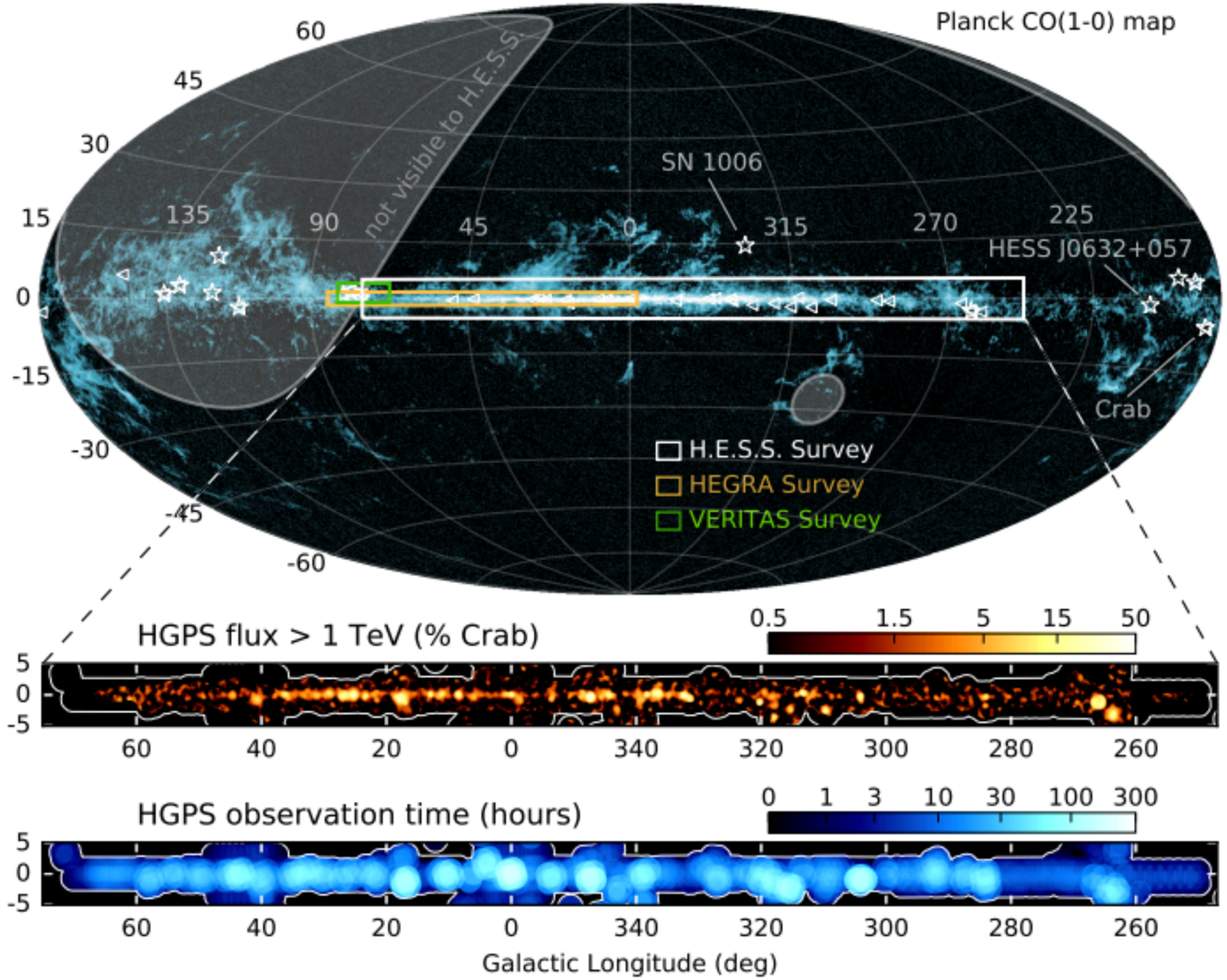
- 5 operating telescopes (4 x 12 m with upgraded cameras, 1 x 28 m)
- Energy threshold mono : ~30 GeV , stereo : ~ 80 GeV
- Only IACT array in the Southern Hemisphere

The H.E.S.S. telescope array

H.E.S.S. Characteristics

- Good location - Visibility





DESY.

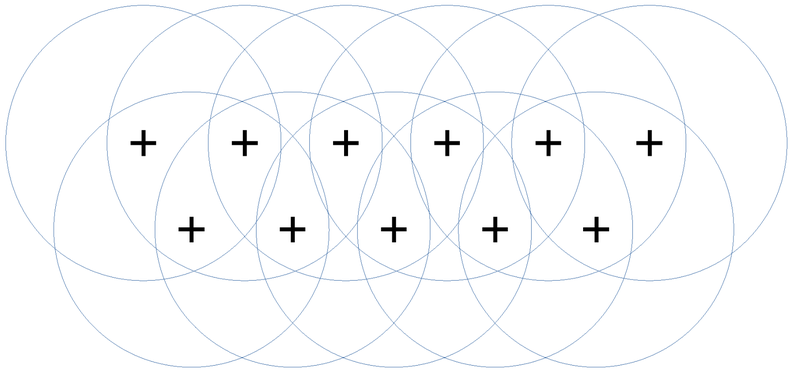
The H.E.S.S. telescope array

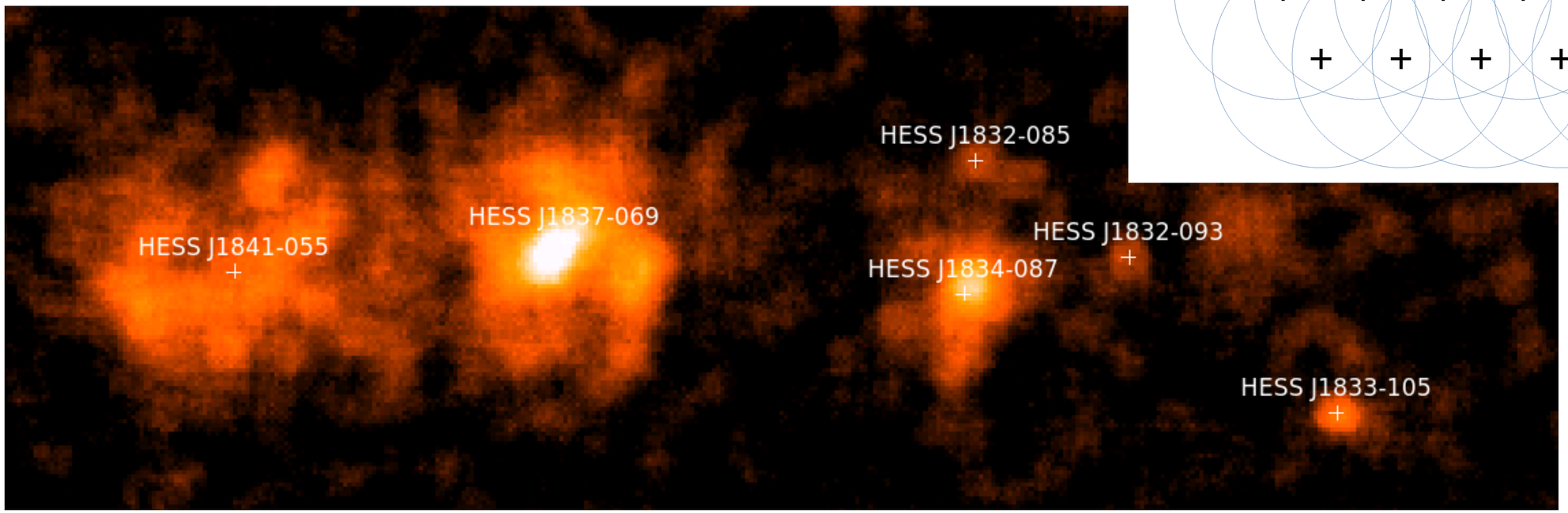
H.E.S.S. Characteristics

- Large FoV cameras (5 degree)
  => Large number of (extended) sources in the inner part of the Galaxy
  => Diffuse emission steaming from active regions (Galactic centre)

de Naurois, 2021

maximise the sky coverage & minimising the acceptance variations





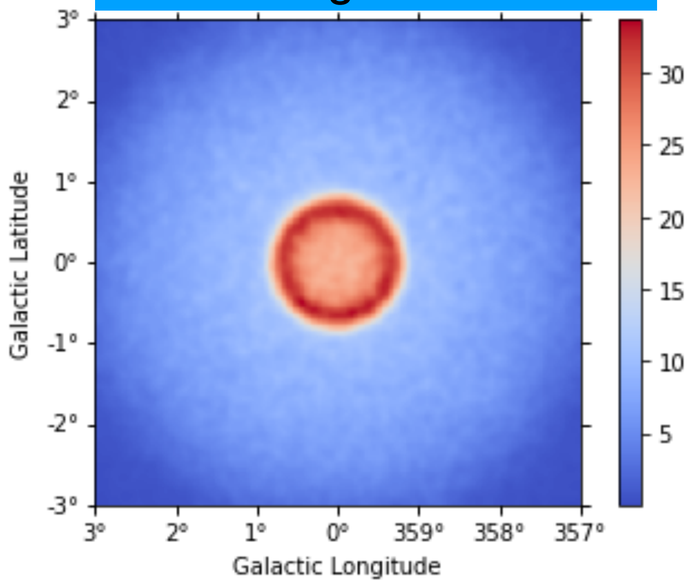
The H.E.S.S. telescope array

H.E.S.S. Characteristics

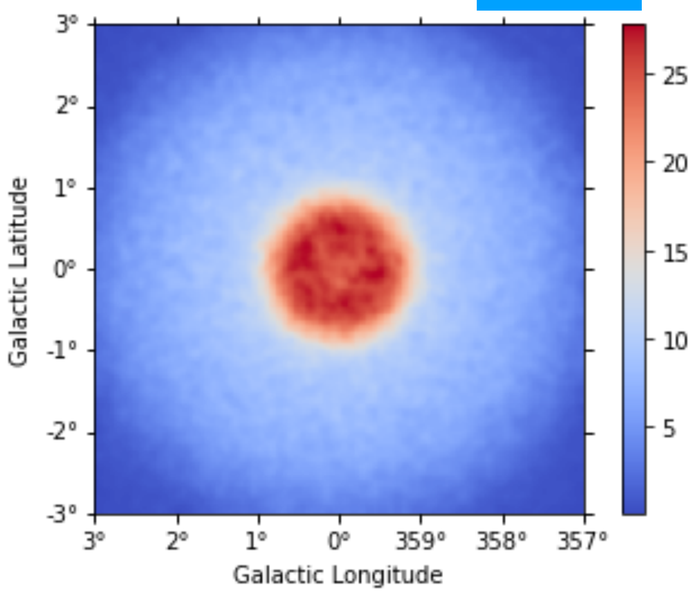
- Good Angular Resolution (<0.05 degree)
  => Resolving morphology

Simulation: shell-like source with radius=0.7° and width=0.1°

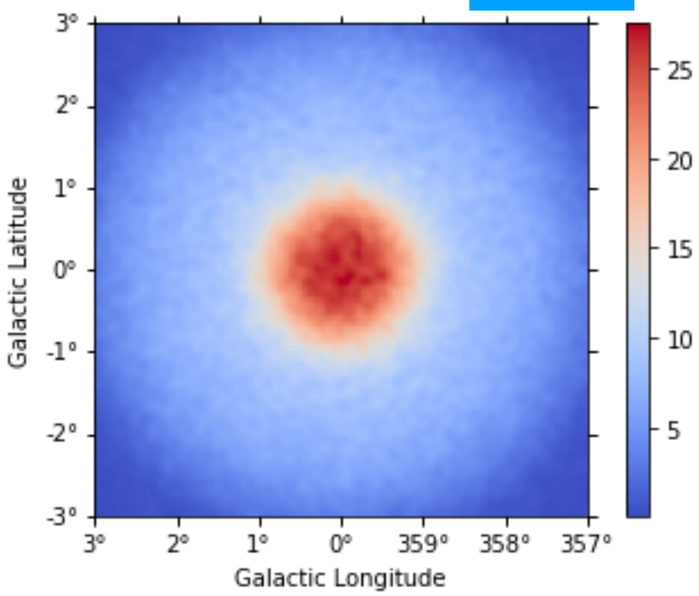
H.E.S.S. Angular Resolution



σ = 0.2°



σ = 0.3°



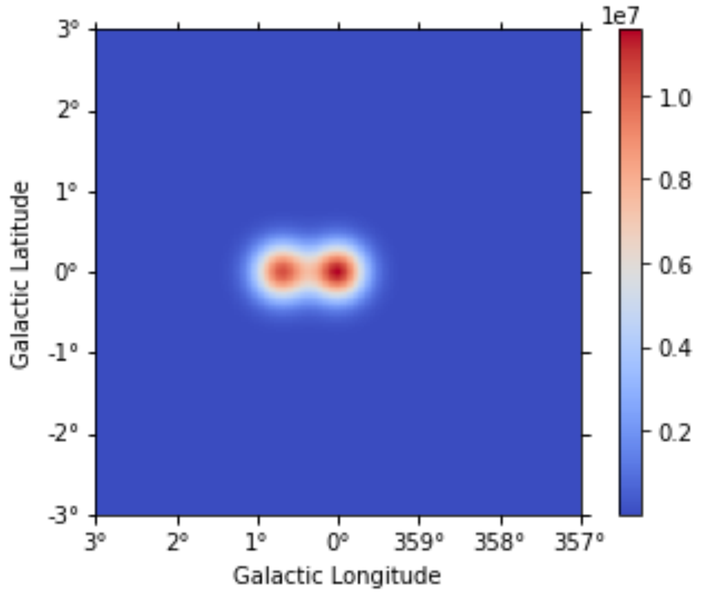
The H.E.S.S. telescope array

H.E.S.S. Characteristics

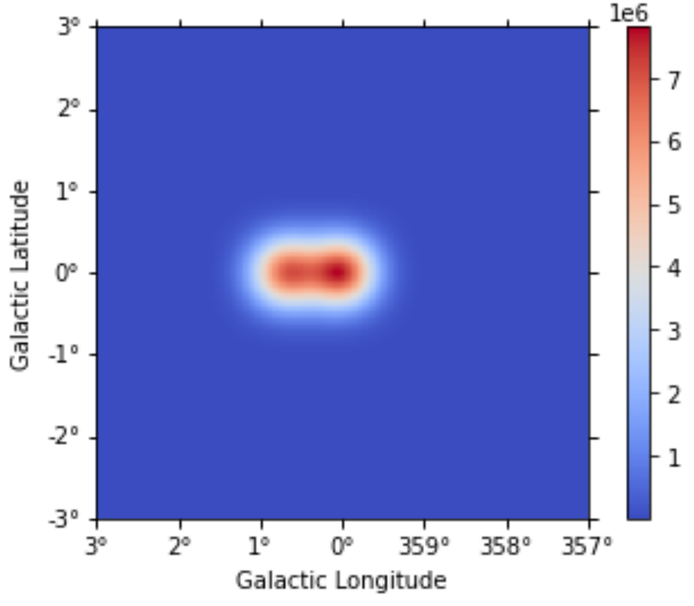
- Good Angular Resolution (<0.05 degree)
  => Resolving morphology
  => Resolving sources

Simulation: two nearby (0.7°) sources (size=0.2°)

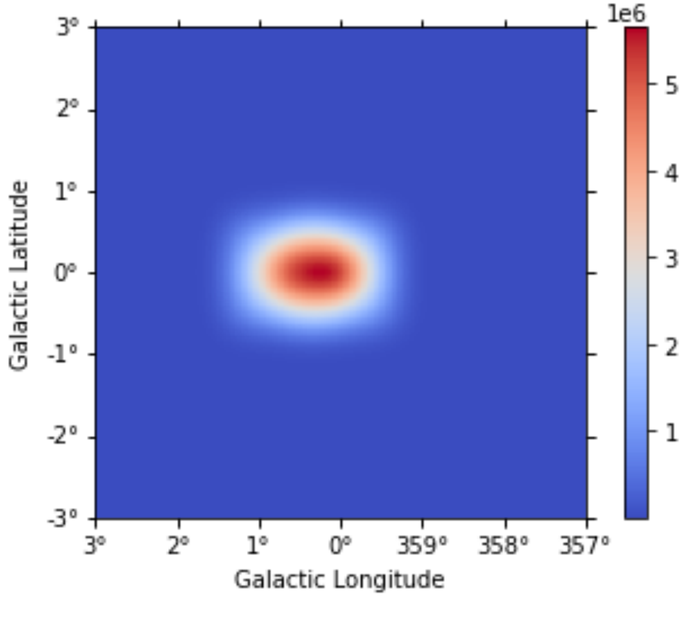
H.E.S.S. Angular Resolution



σ = 0.2°



σ = 0.3°

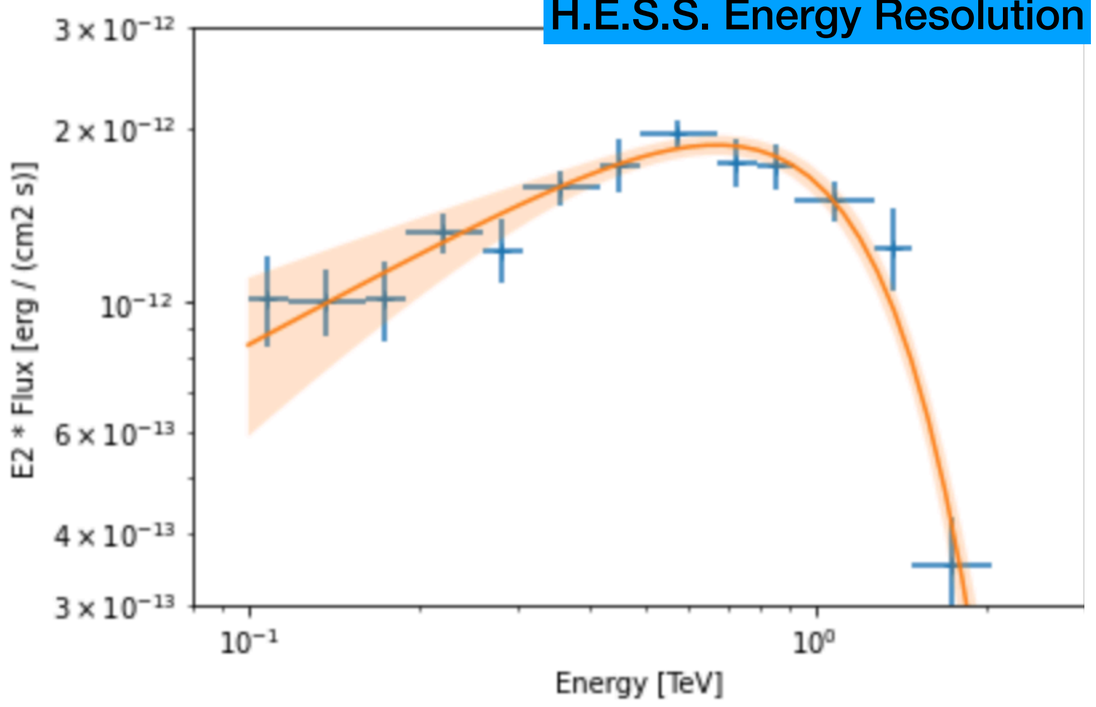


The H.E.S.S. telescope array

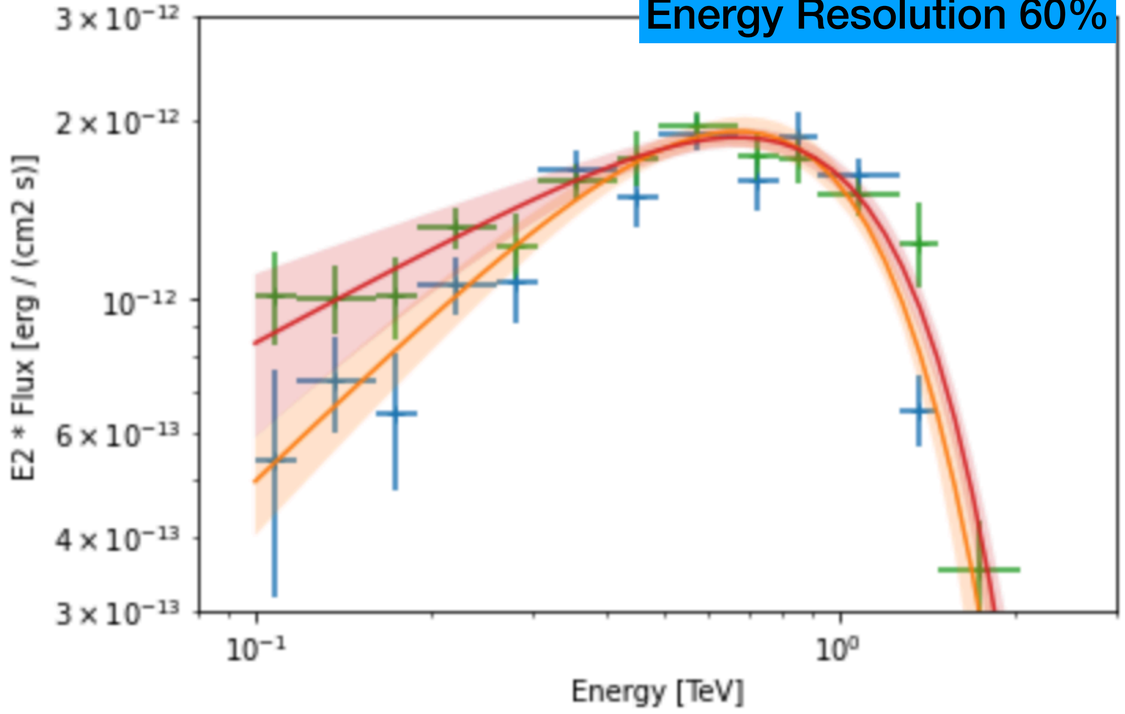
H.E.S.S. Characteristics

- Good Energy Resolution (<20%)
  => Resolving spectral features
  => Resolving sources

H.E.S.S. Energy Resolution



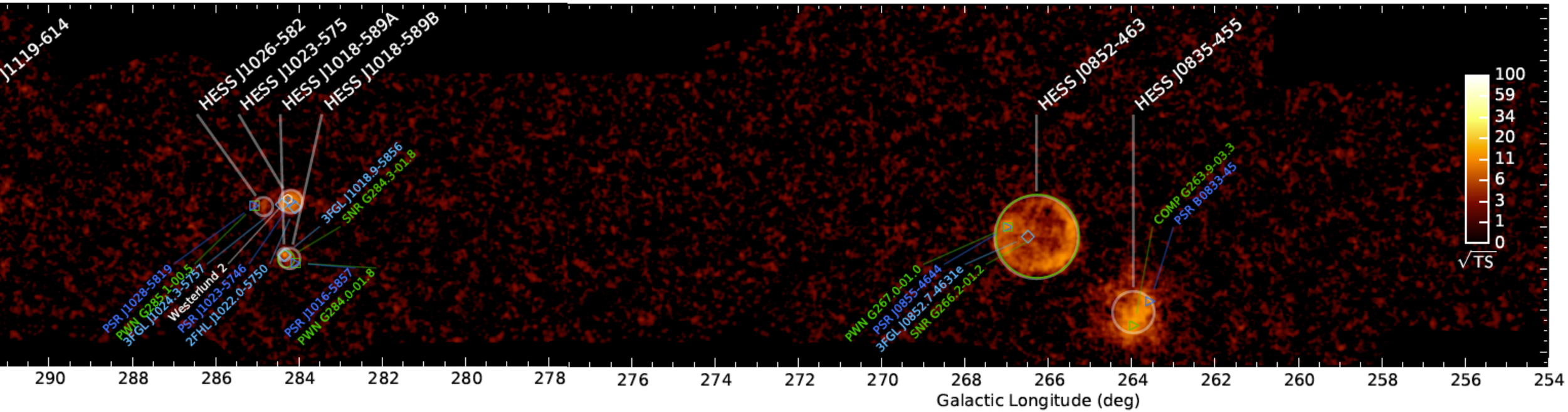
Energy Resolution 60%



The H.E.S.S. telescope array

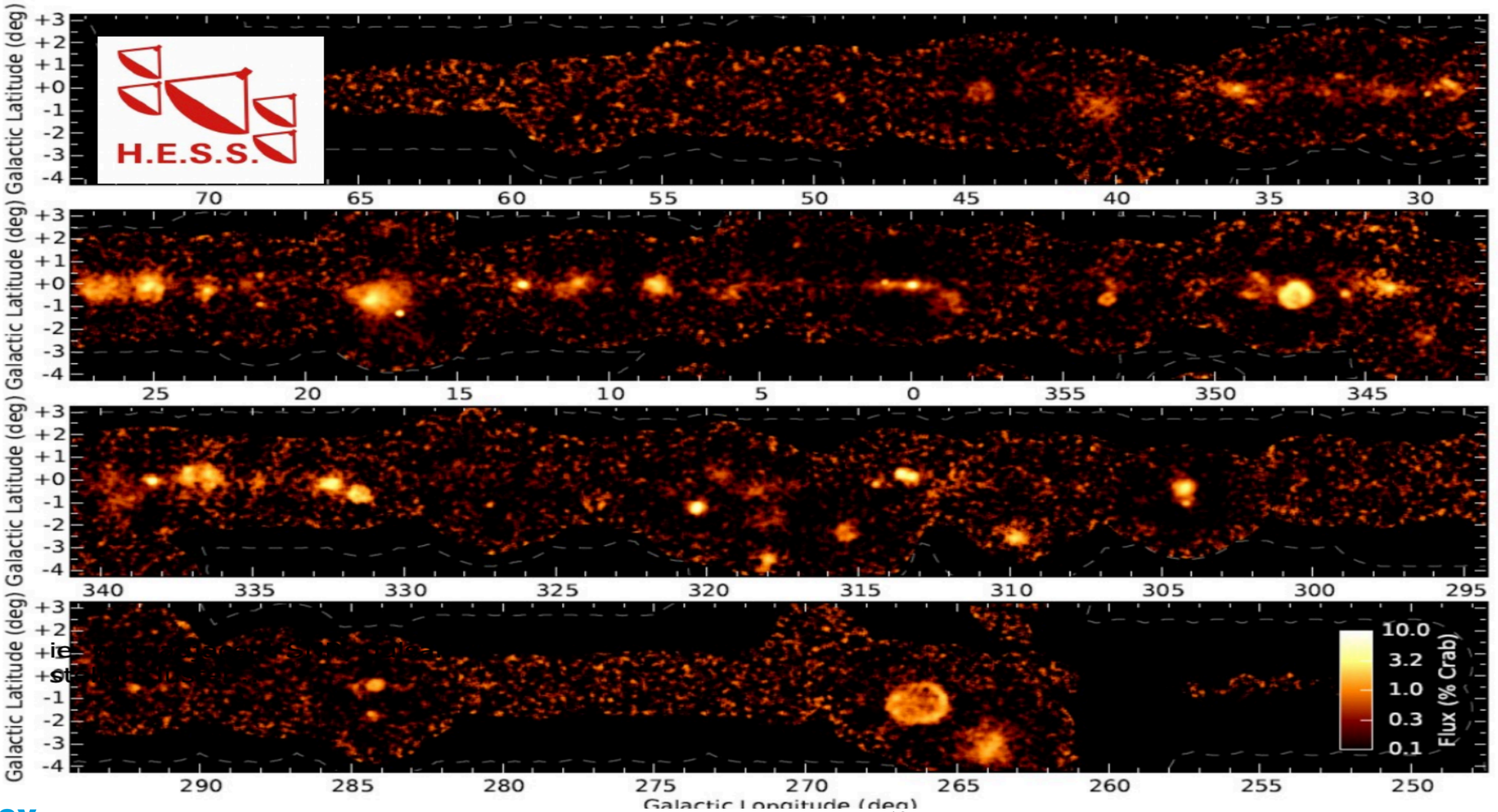
H.E.S.S. Galactic Plane Survey (HGPS)

- Published data (~2700h)
  https://www.mpi-hd.mpg.de/hfm/HESS/hgps/
- For some regions - new data with improved array up to x3 observation time



The H.E.S.S. telescope array

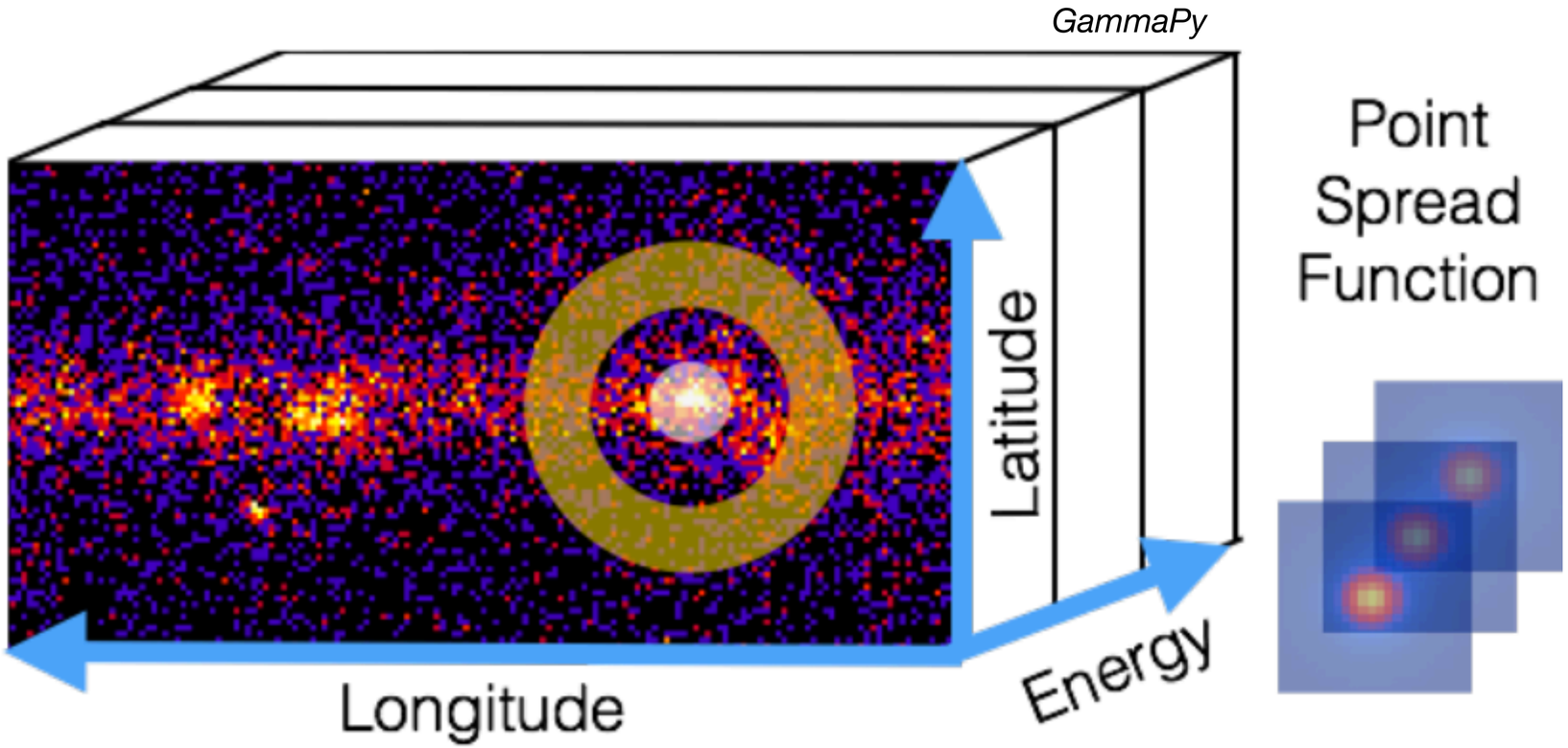
H.E.S.S. Galactic Plane Survey (HGPS)



The H.E.S.S. GPS

Improvements in the analysis & results

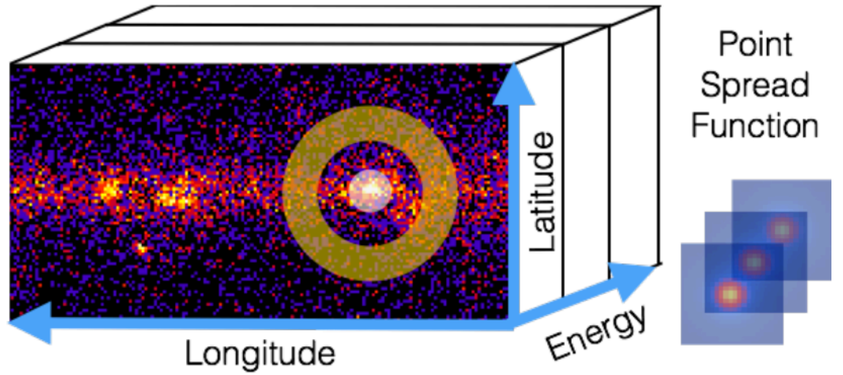
- Improve reconstruction techniques (3D technique)



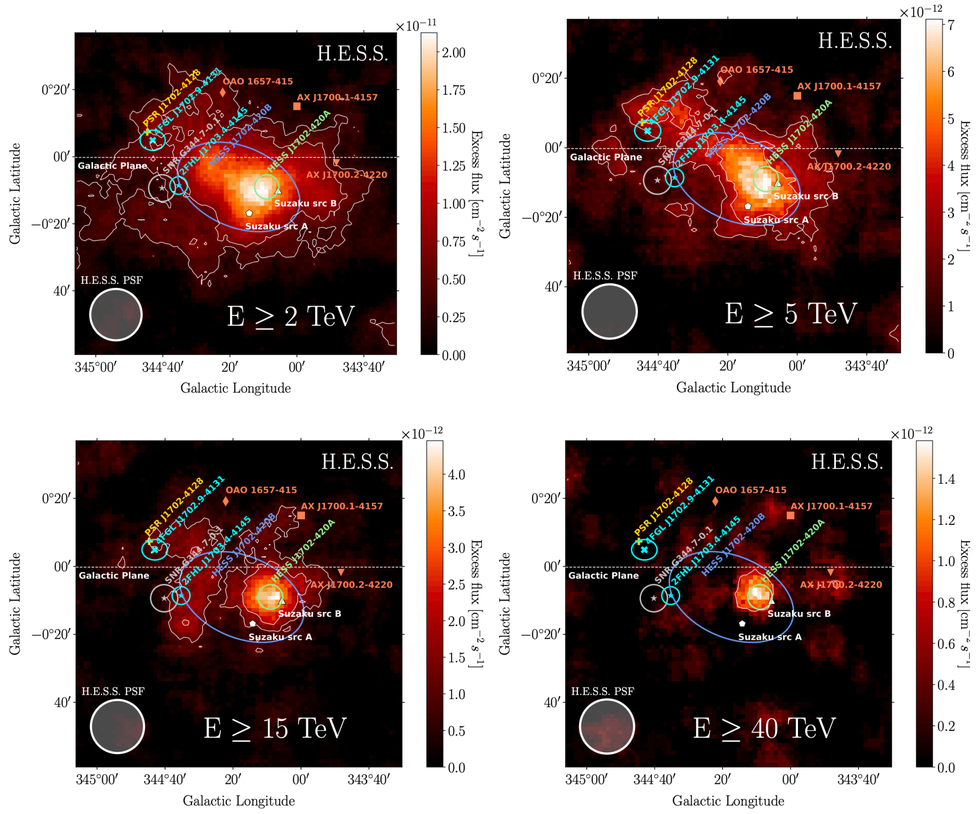
The H.E.S.S. GPS

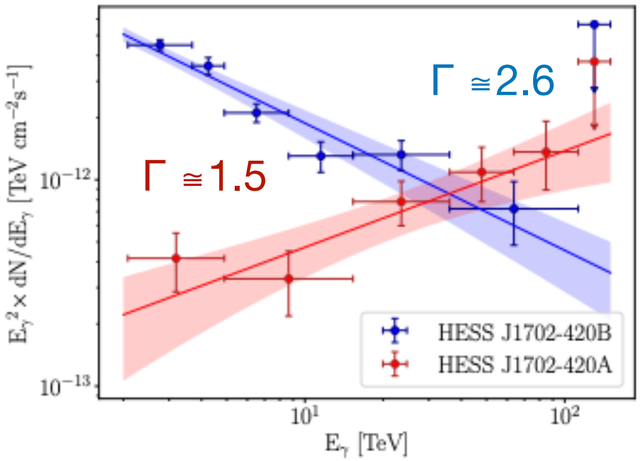
Improvements in the analysis & results

- Improve gamma/hadron separation (3D technique)



HESS J1702-420





If hadronic => E_c (Γ_p=2) > 0.83 PeV ((1.7)0.55 PeV, (2.3)1.16 PeV)
=> W_p (E_p>1 TeV) > 1.8x10^{47} erg

If leptonic => E_c (Γ_e=2) > 0.12 PeV ((1.5)0.06 PeV, (2.5)0.52 PeV)
=> W_e (E_p>1 TeV) > 8.1x10^{45} erg

HESS Col. 2021

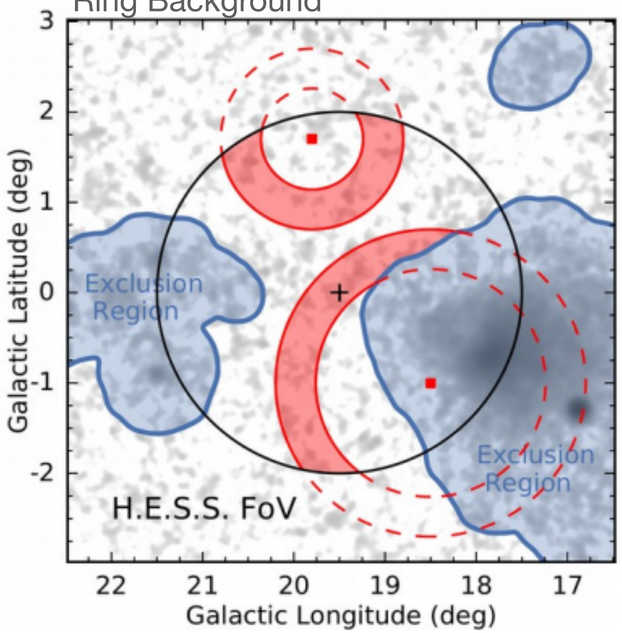
The H.E.S.S. GPS

Improvements in the analysis & results

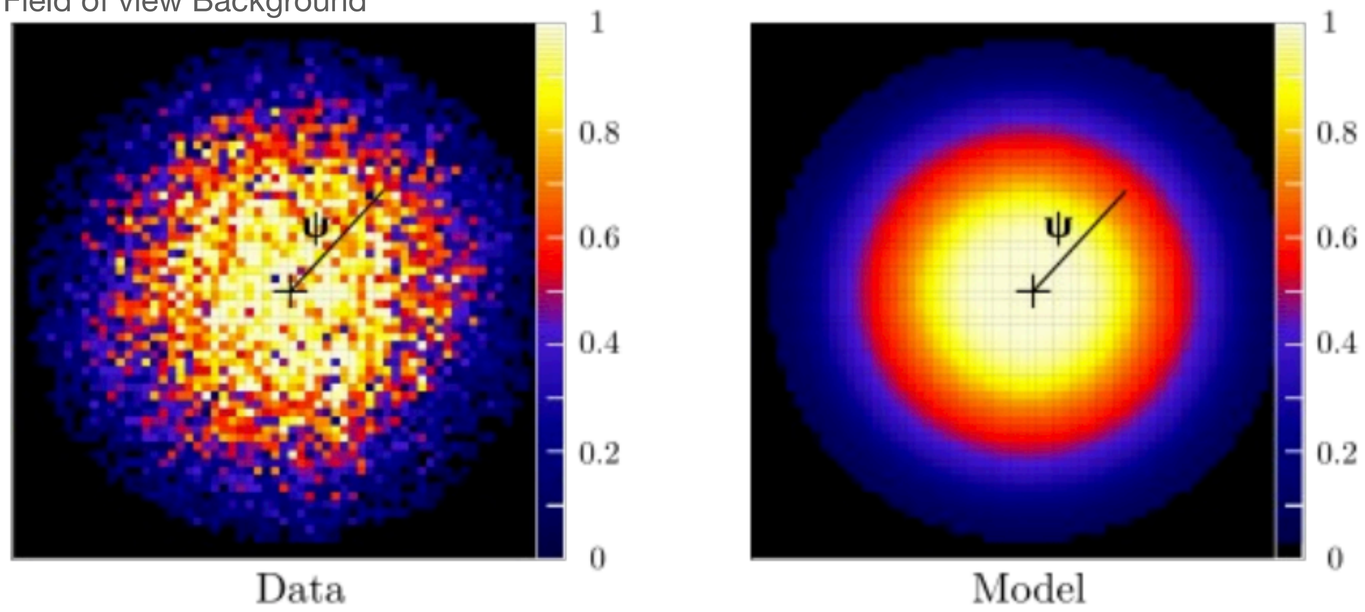
- Improve analysis for large FoV

→ uses the whole FoV
→ tabulated using extragalactic FoVs, for different zenith angles
→ applied for each run separately
→ assume radial symmetry

Ring Background



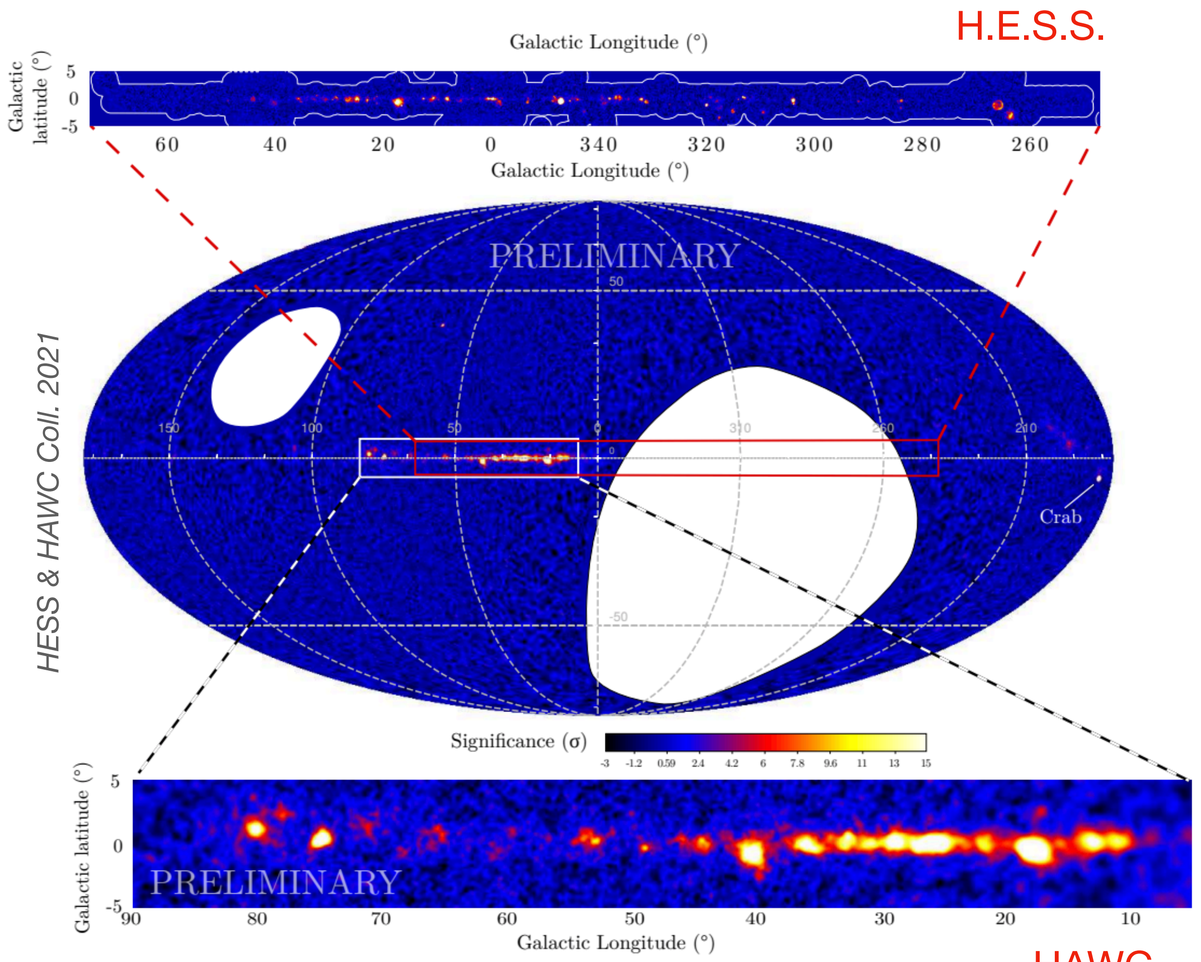
Field of view Background



The H.E.S.S. GPS

Improvements in the analysis & results

- Improve analysis for large FoV
  => Comparison with other VHE surveys

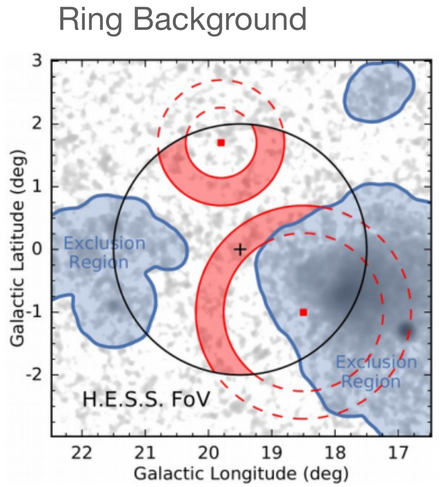


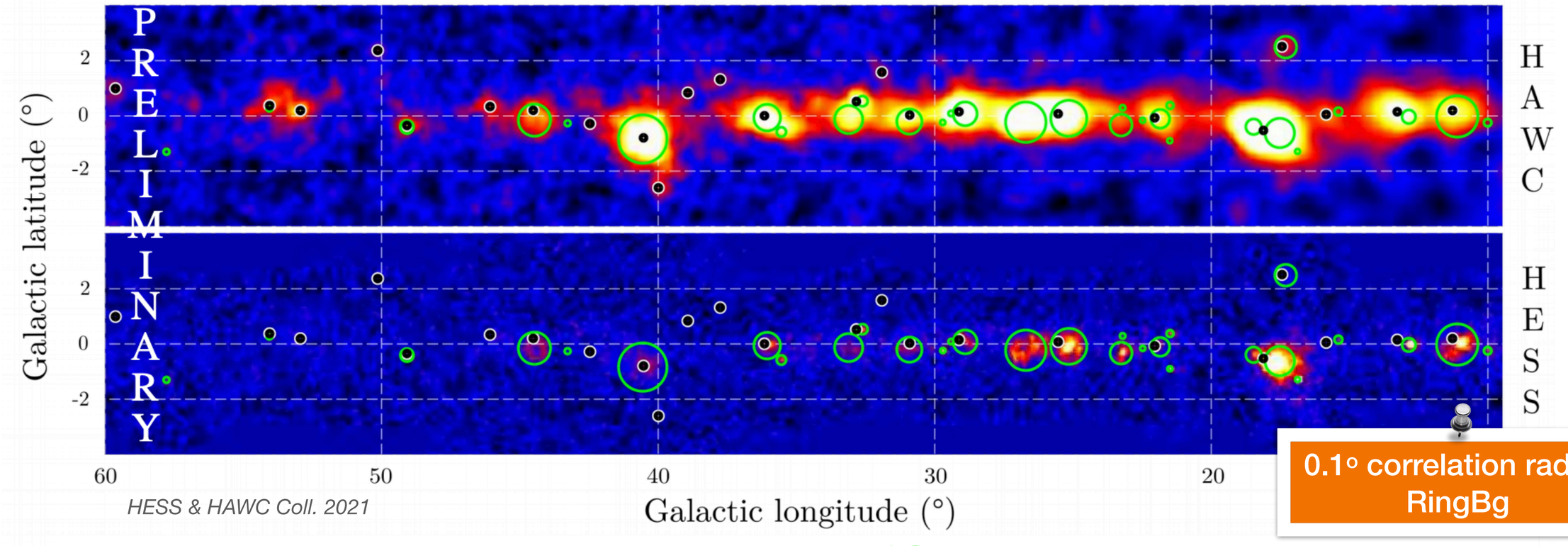
DESY.

The H.E.S.S. GPS

H.E.S.S. Galactic Plane Survey (HGPS)

- Improve analysis for large FoV
  => Comparison with other VHE surveys



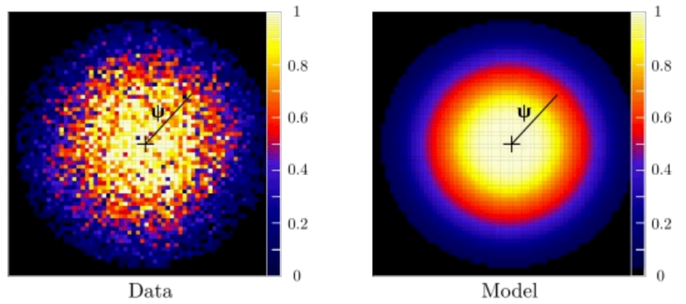


0.1° correlation radius RingBg

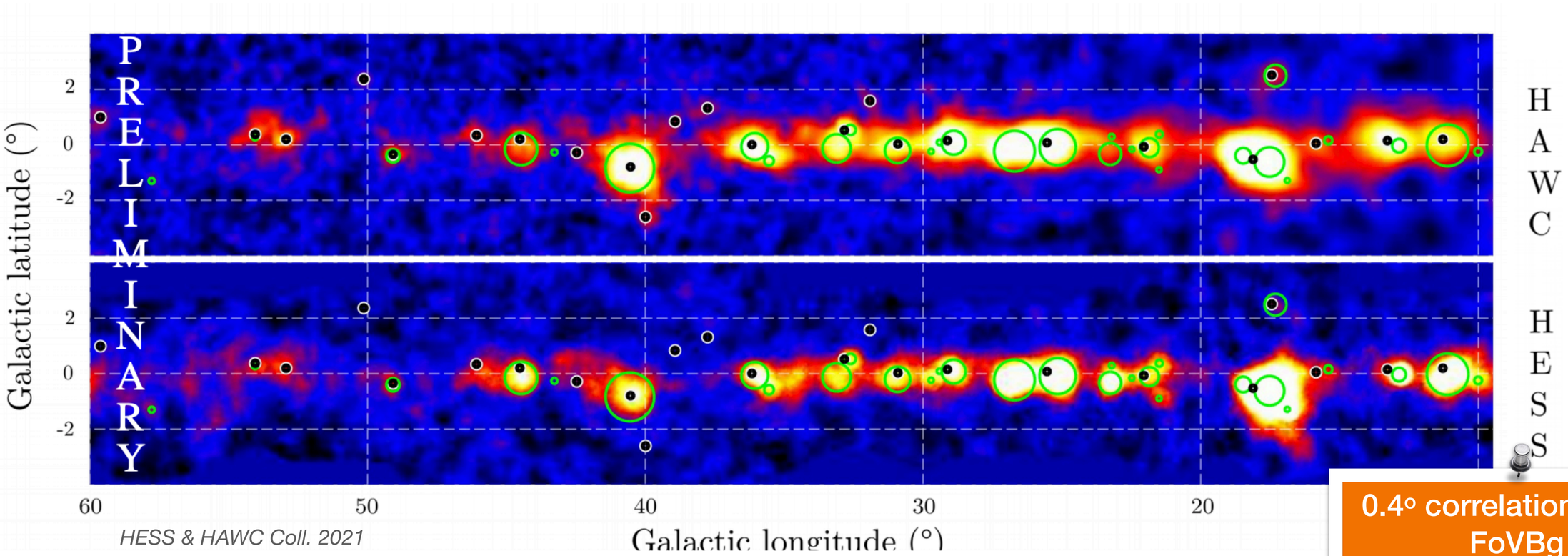
The H.E.S.S. GPS

H.E.S.S. Galactic Plane Survey (HGPS)

Field of view Background



- Improve analysis for large FoV
  => Comparison with other VHE surveys



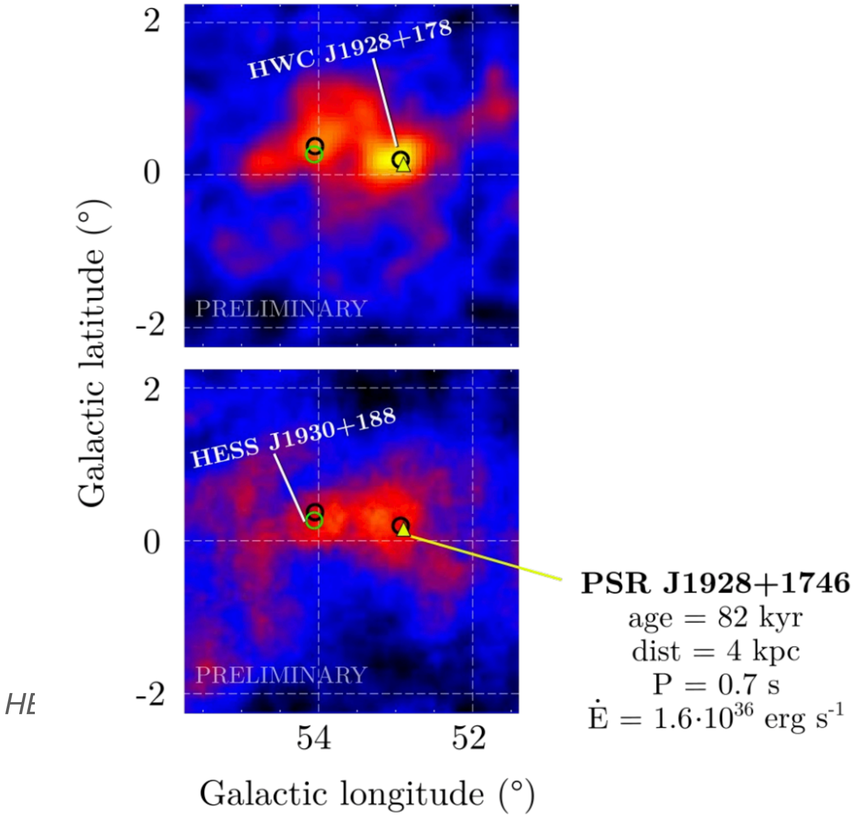
HESS & HAWC Coll. 2021

0.4° correlation radius
FoVBg

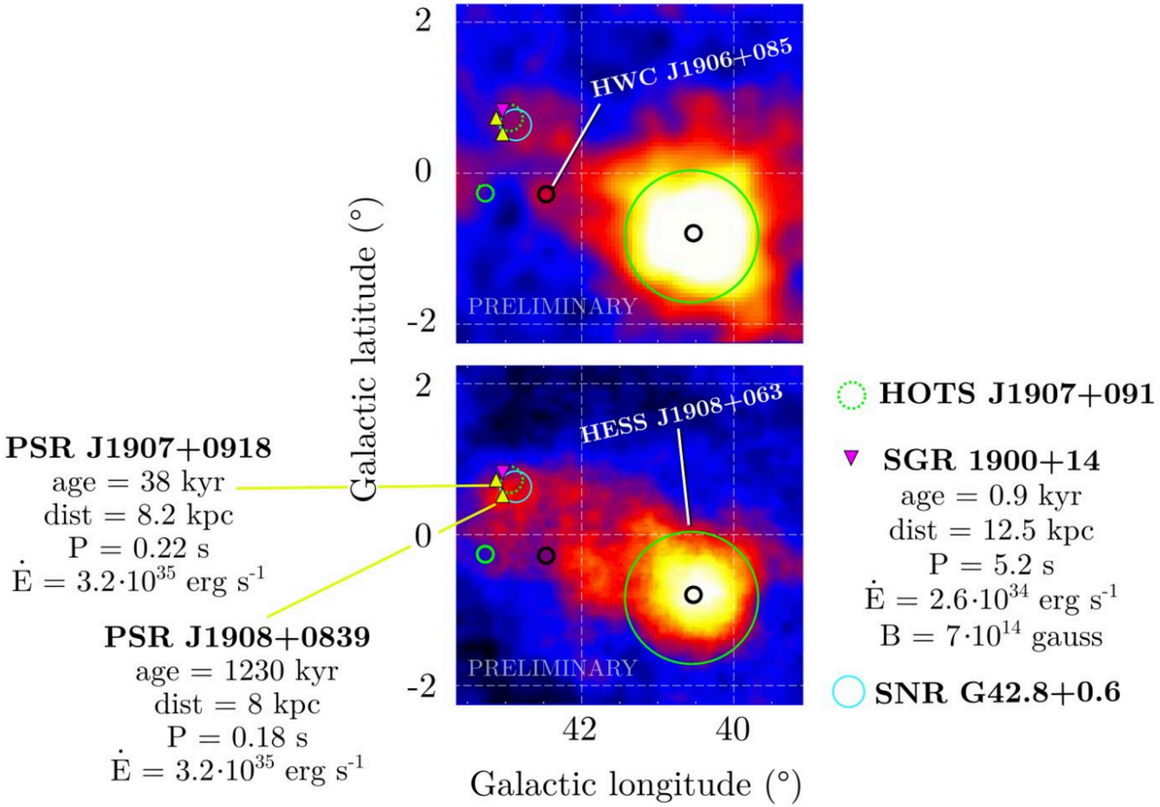
The H.E.S.S. GPS

H.E.S.S. Galactic Plane Survey (HGPS)

- Improve analysis for large FoV
  => Comparison with other VHE surveys



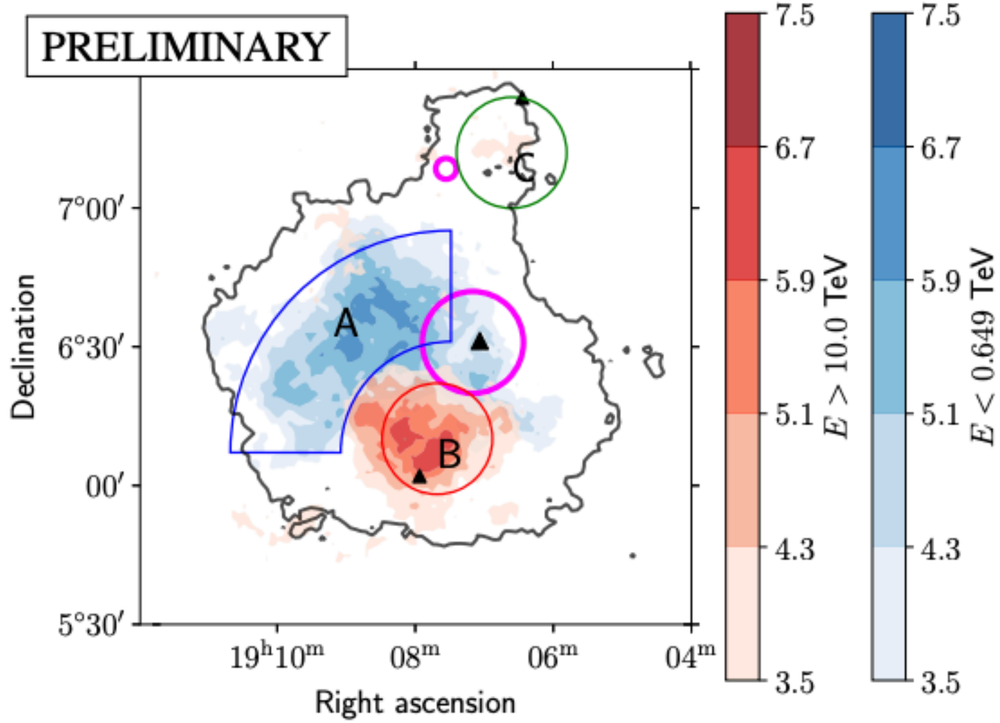
HESS & HAWC Coll. 2021



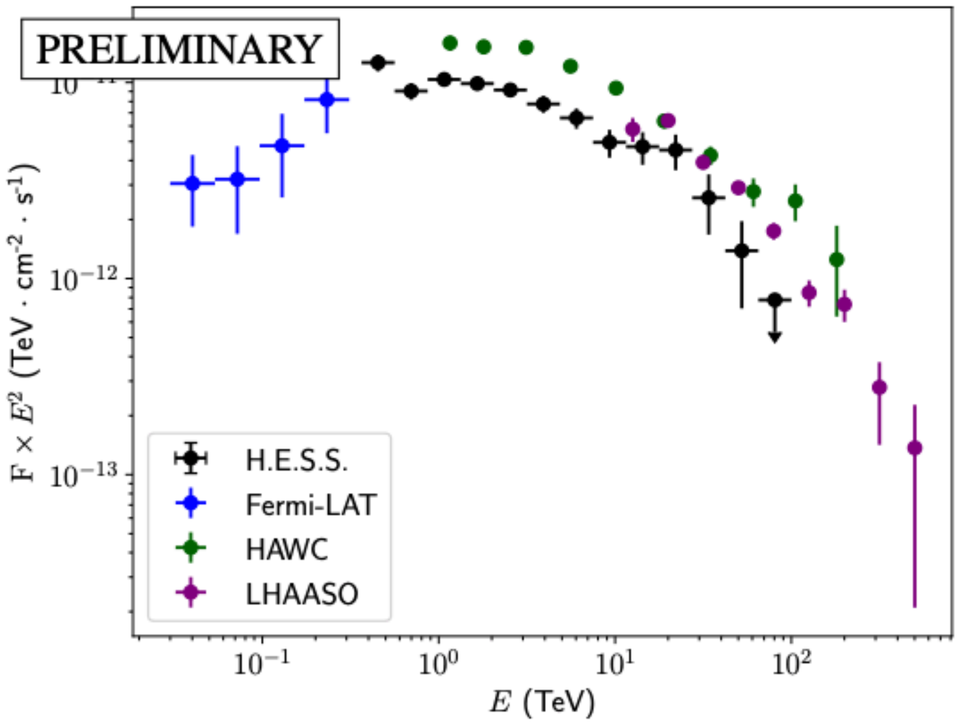
The H.E.S.S. GPS

H.E.S.S. Galactic Plane Survey (HGPS)

- Improve analysis for large FoV



HESS J1908+036



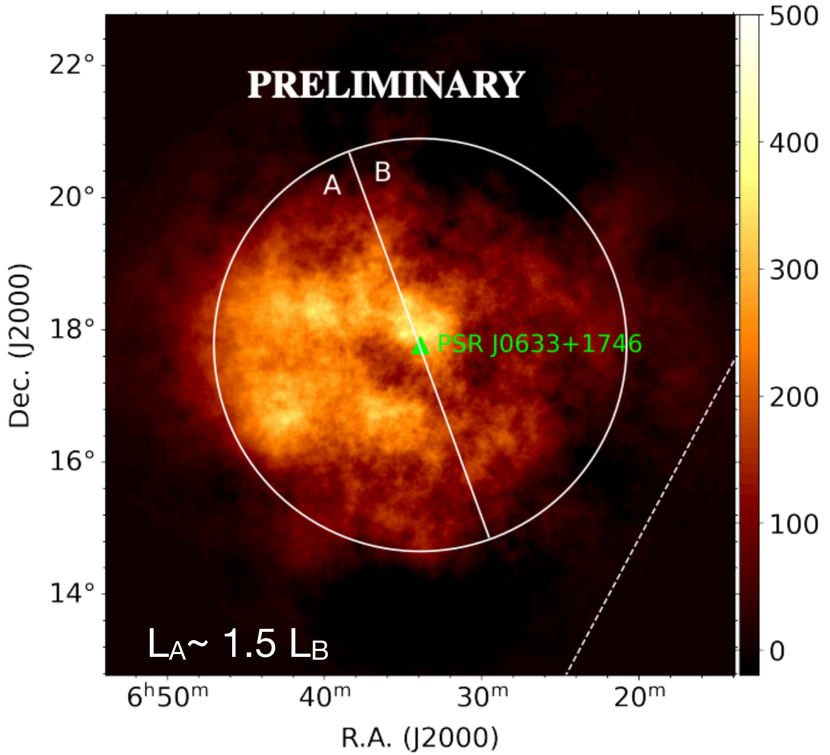
Kostunin et al, HESS ICRC 2021

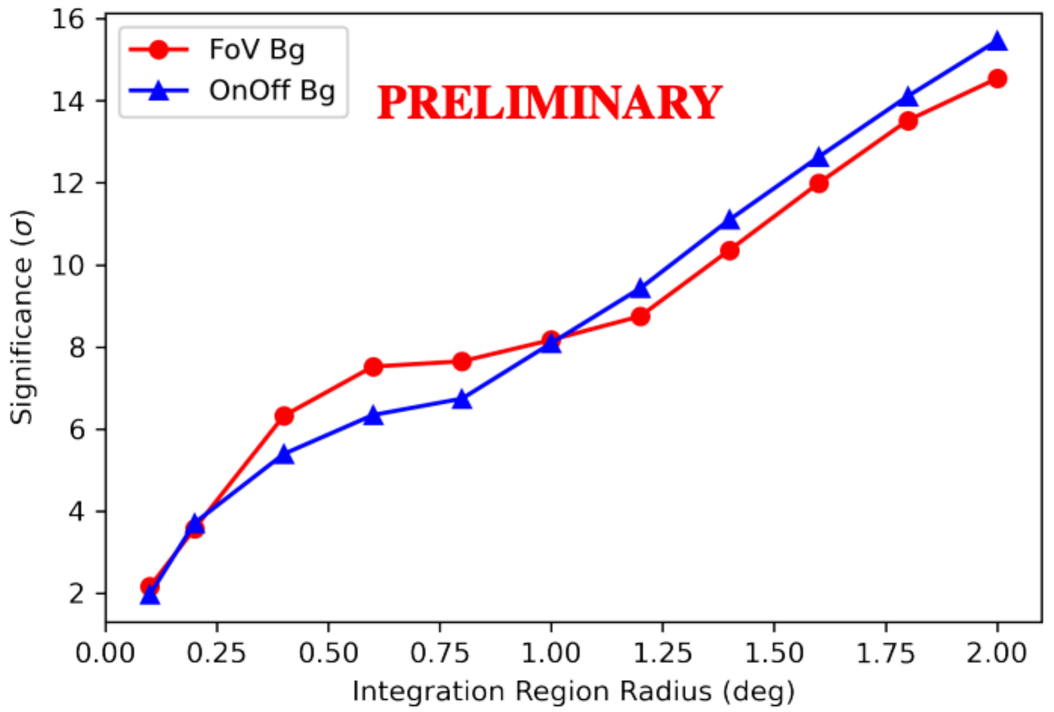
The H.E.S.S. GPS

H.E.S.S. Galactic Plane Survey (HGPS)

- Improve analysis for large FoV

  => Large sources: Electrons factories => Geminga Halo (250pc, 342 kyrs, HAWC: 5.5º)





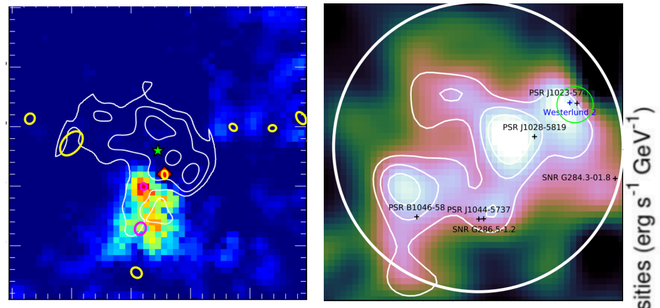
Mitchell et al, ICRC 2021

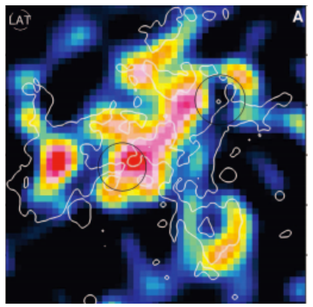
The H.E.S.S. GPS

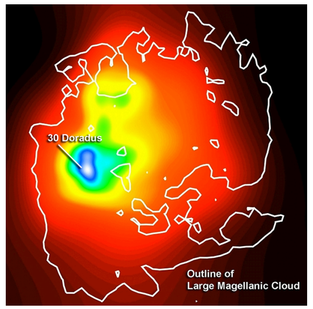
H.E.S.S. Galactic Plane Survey (HGPS)

- Improve analysis for large FoV
  => Large sources: CR factories => Westerlund 1

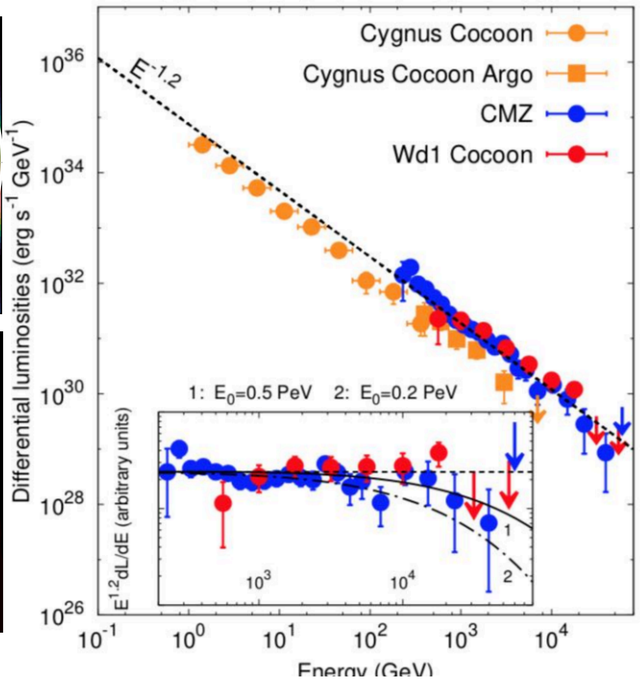
~few degree







Aharonian et al, 2019



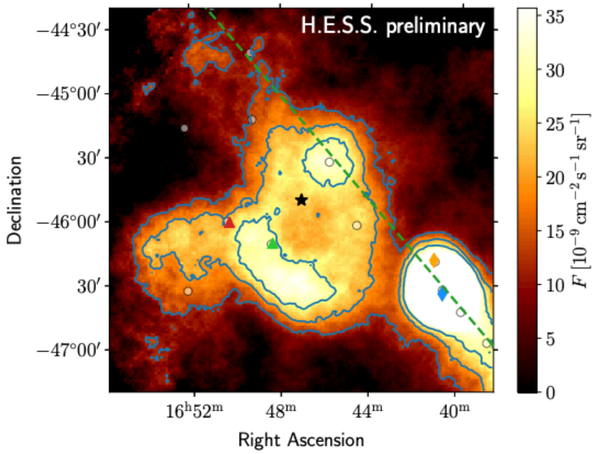
LAT (GeV) observations revealed large diffuse structures around regions of high stellar formation rate

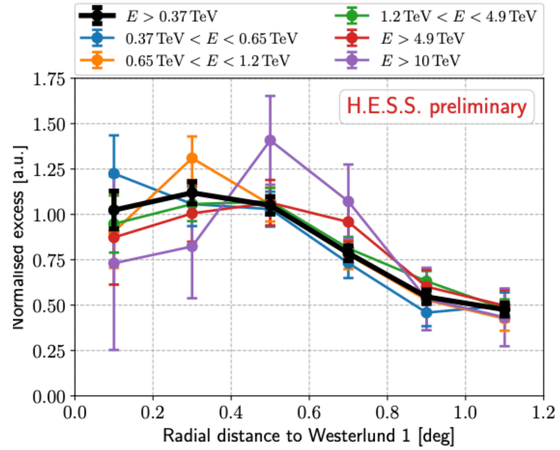
The H.E.S.S. GPS

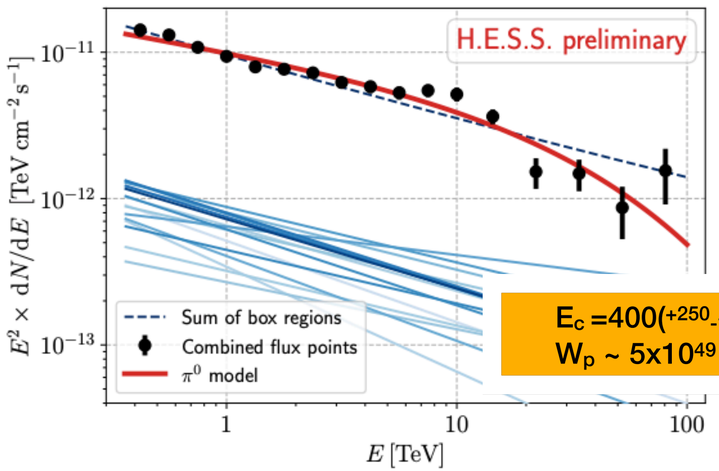
H.E.S.S. Galactic Plane Survey (HGPS)

- Improve analysis for large FoV
  => Large sources: CR factories => Westerlund 1

Mohrmann et al, ICRC 2021







$E_c = 400(^{+250}_{-130})$ TeV
$W_p \sim 5\times10^{49}\ (n/10\mathrm{cm}^{-3})(d/3.9\ \mathrm{kpc})^2$ erg

- Complex morphology
- Similar spectra along the 1° (70 pc at 3.9 kpc) source & similar radial profile at different energies
- Dip in the surrounding of Westerlund 1
- Spectrum extends to 100 TeV

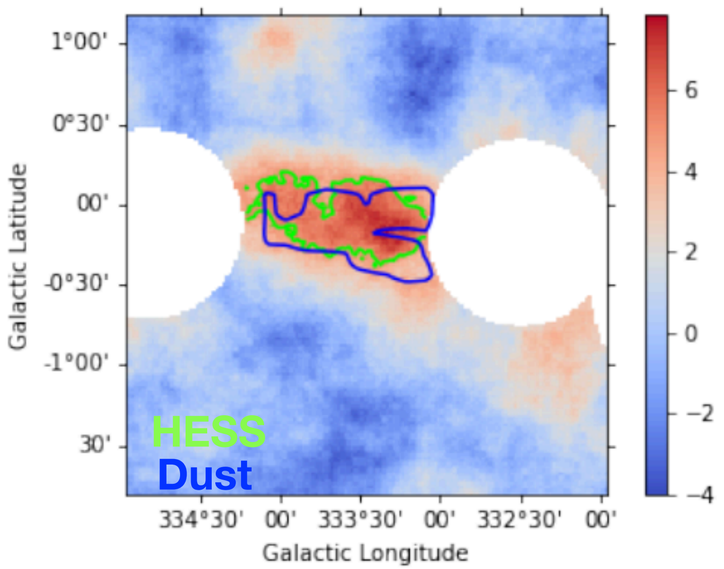
The H.E.S.S. GPS

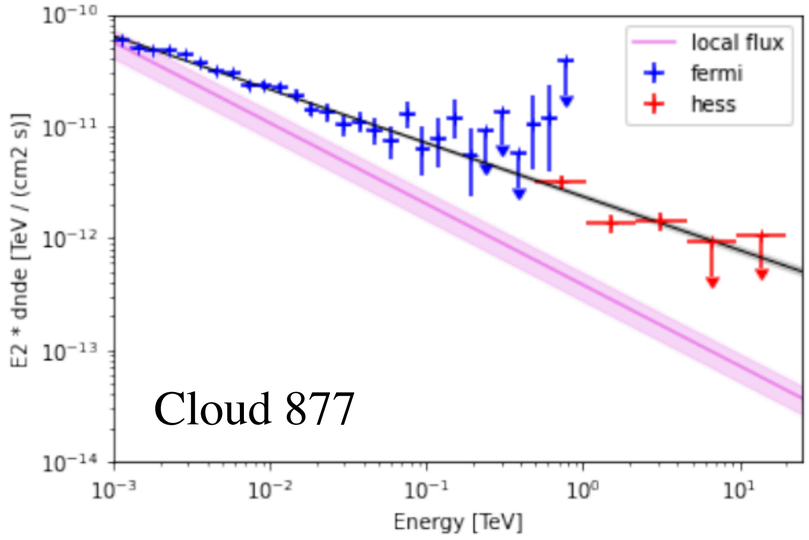
H.E.S.S. Galactic Plane Survey (HGPS)

- Improve analysis for large FoV

  => Large sources: CR factories => Molecular clouds *catching* cosmic-rays

Sinha et al, ICRC 2021

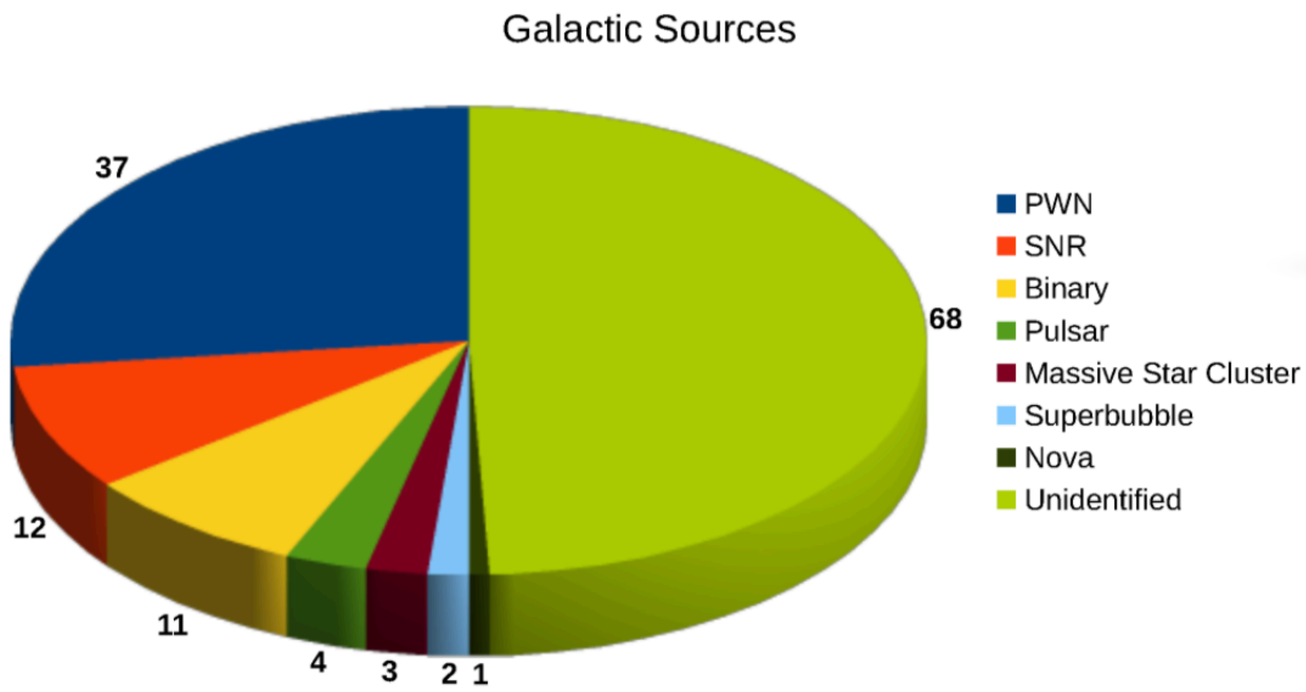




- 3D Analysis - Combined LAT + H.E.S.S on high density clouds
- Cloud 877 (0.22°x0.48°): Density of CRs 5-6 times the local density
- Harder spectrum of ~2.58

The H.E.S.S. GPS

Galactic Population

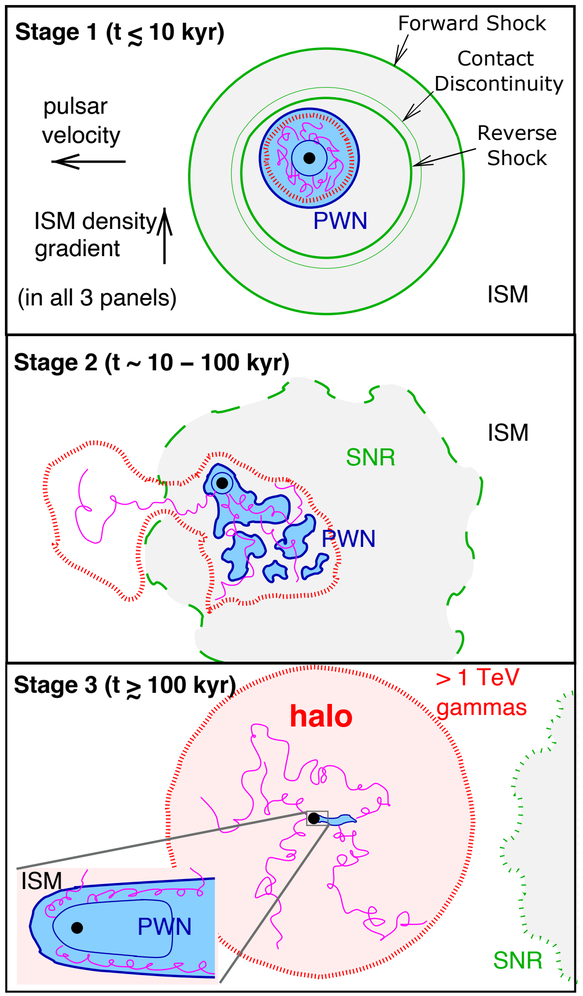


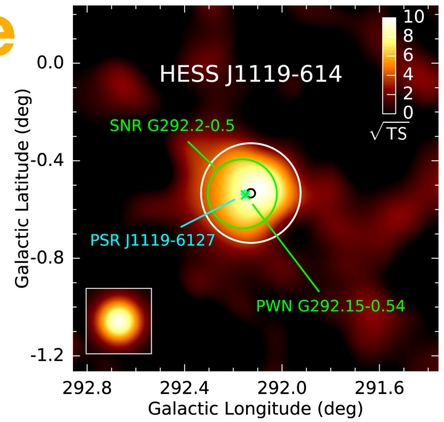
New kids on the block:

- Pulsars
- Novae

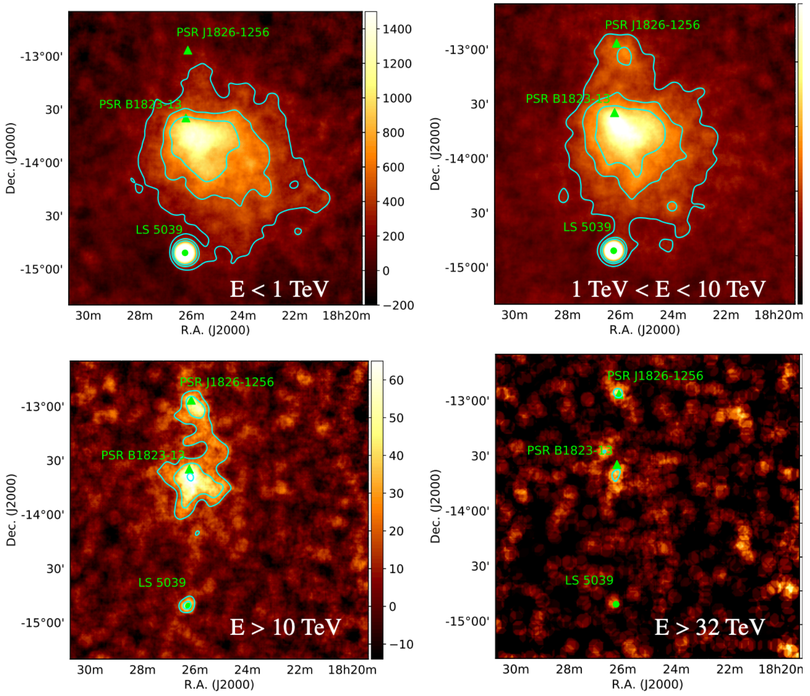
The H.E.S.S. GPS

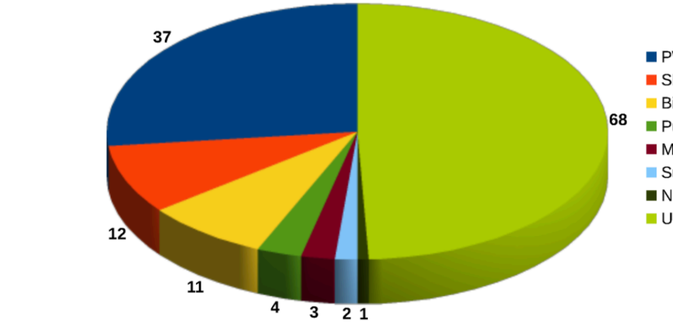
Galactic Population: PWNe

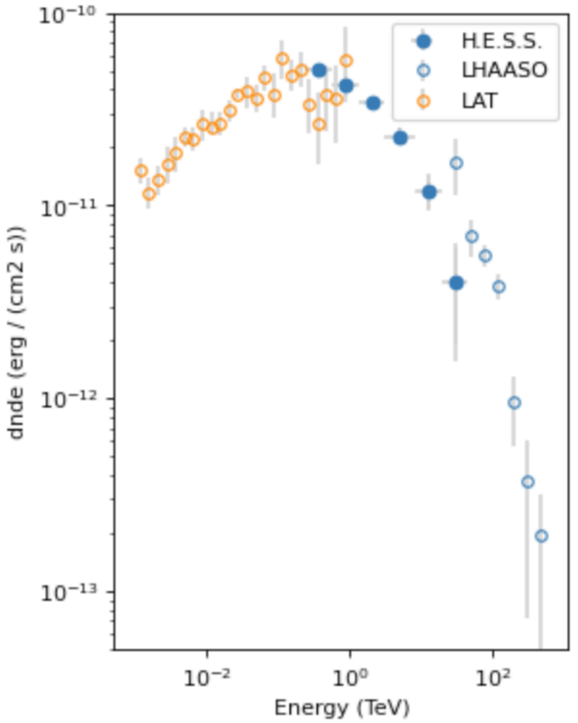




PWNe & SNR associated to a highly magnetised PSR (4×10^{13}G)



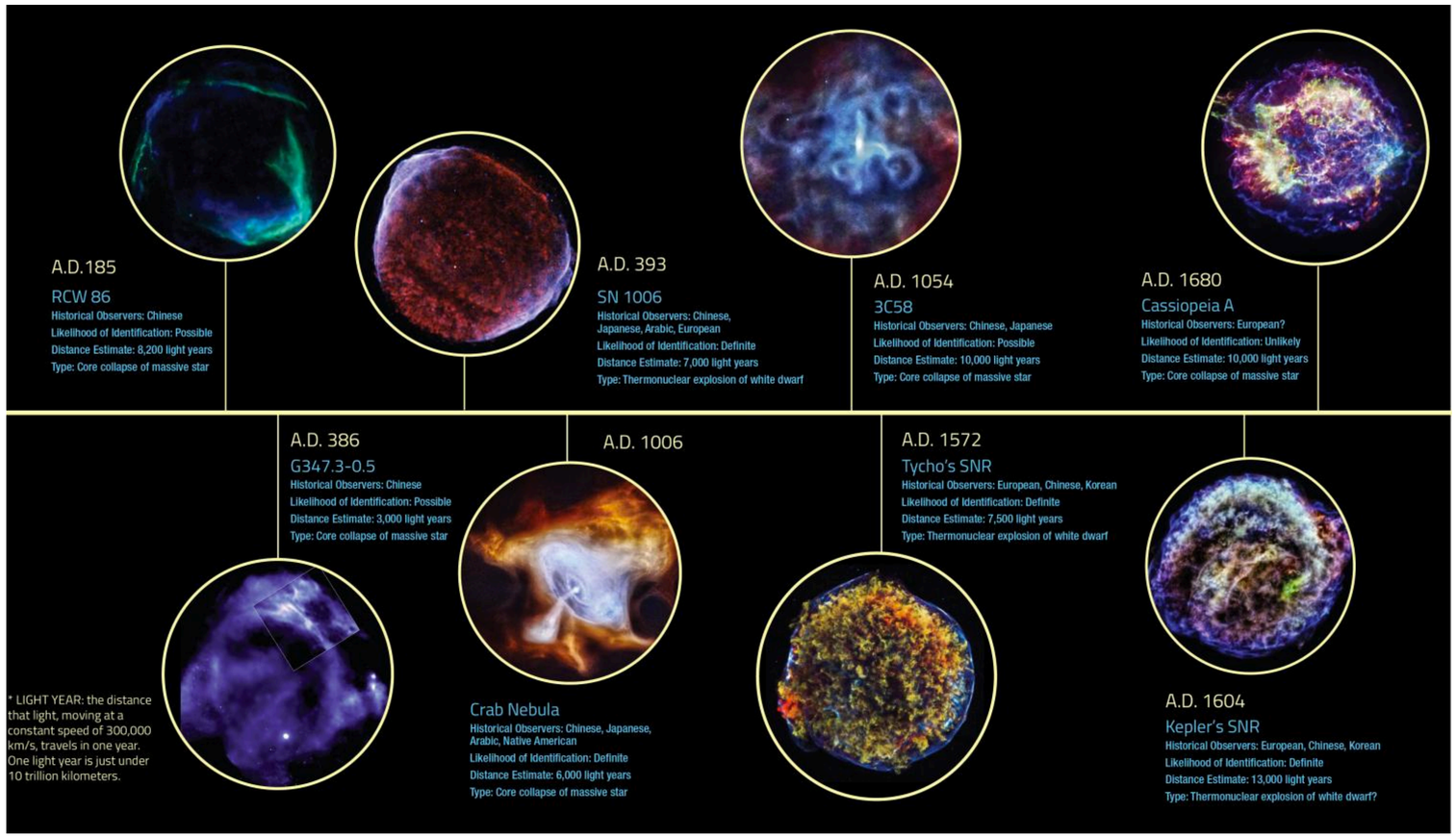




DESY.

The H.E.S.S. GPS

Galactic Population: SNRs

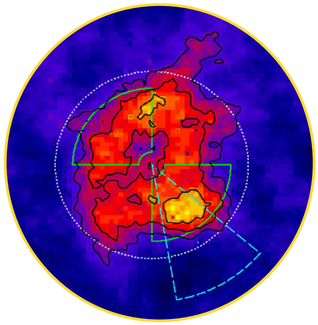


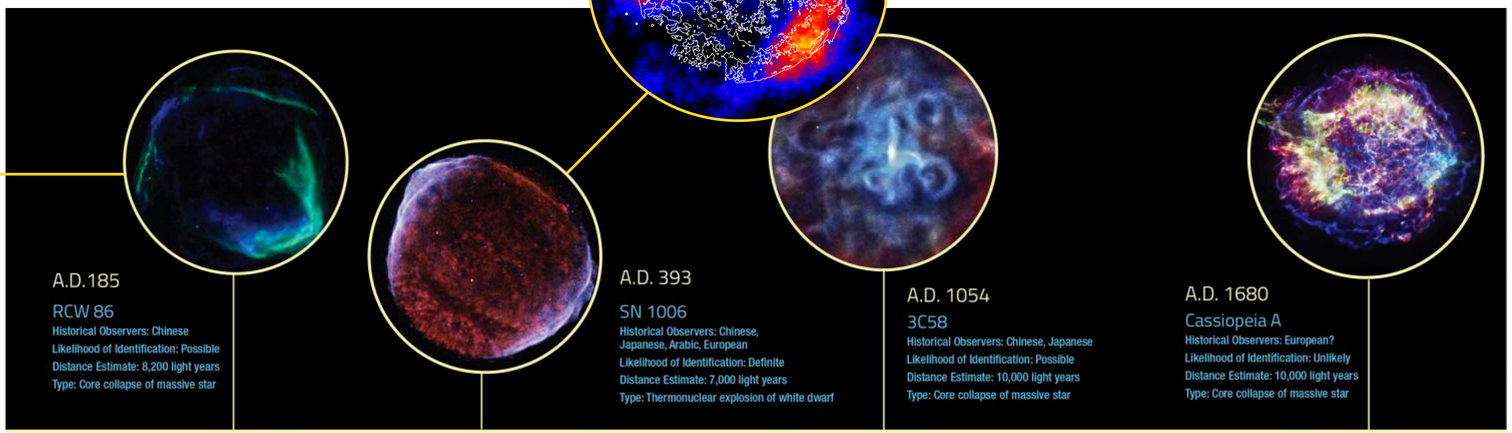
The H.E.S.S. GPS

Galactic Population: SNRs

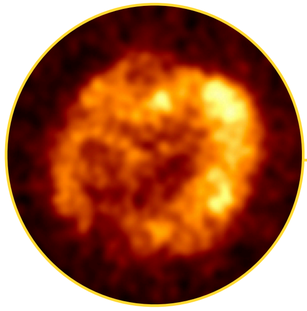
HESS Coll, 2010

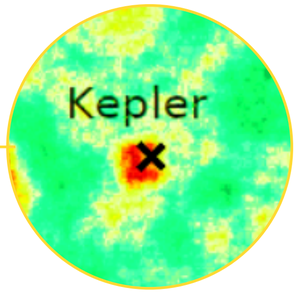
HESS Coll, 2016





HESS Coll, 2018





Prokhorov et al, ICRC 2021

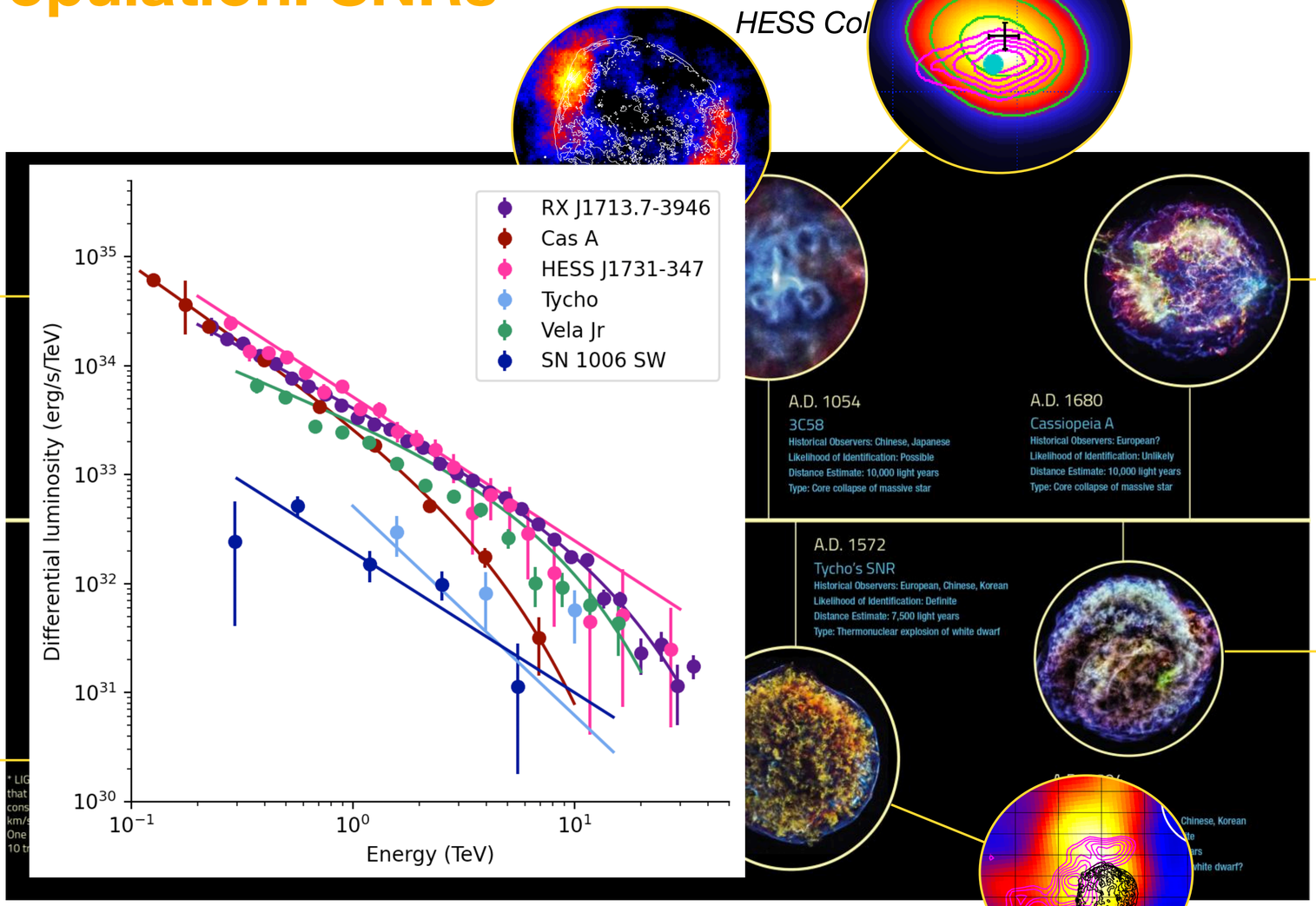
The H.E.S.S. GPS

Galactic Population: SNRs

MAGIC Coll, 2014

HESS Coll, 2016

MAGIC Coll, 2017
VERITAS Coll, 2019



HESS Coll, 2018

Kepler

Prokhorov et al, ICRC 2021

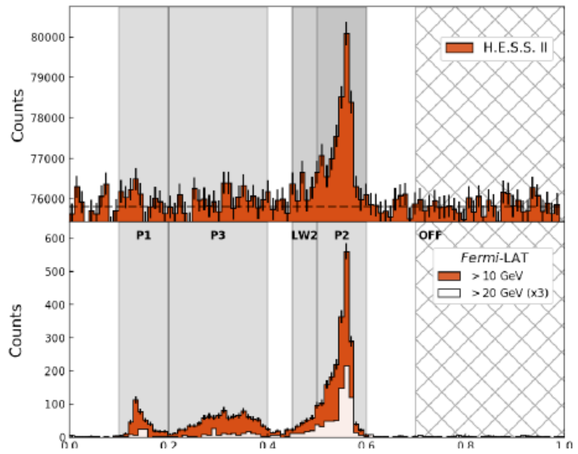
VERITAS Coll, 2017

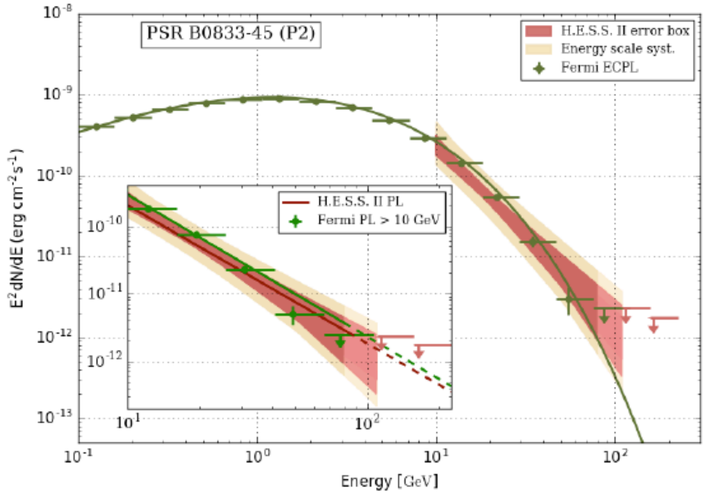
The H.E.S.S. GPS

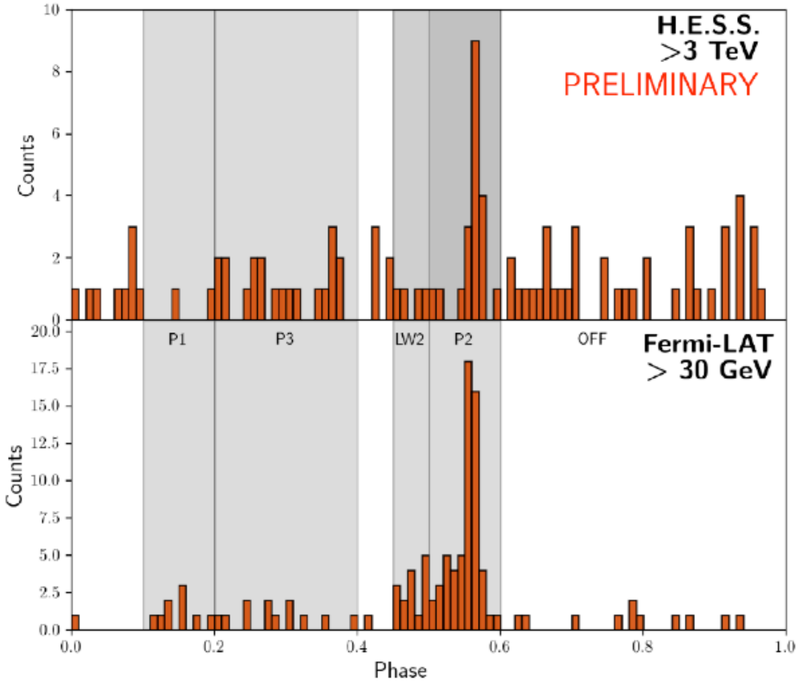
Old, bright GeV pulsar (~10^4 yrs)
Low(er) magnetic field (~$5x10^5$ G @LC)
Large low-energy photon field (FIR)

Galactic Population: Transients / Phase-dependent

- Pulsars: Vela Pulsar
  => H.E.S.S. 2018, after 40 hours observation with CT5 (very low energy threshold!)
  => Sub-exponential cut-off



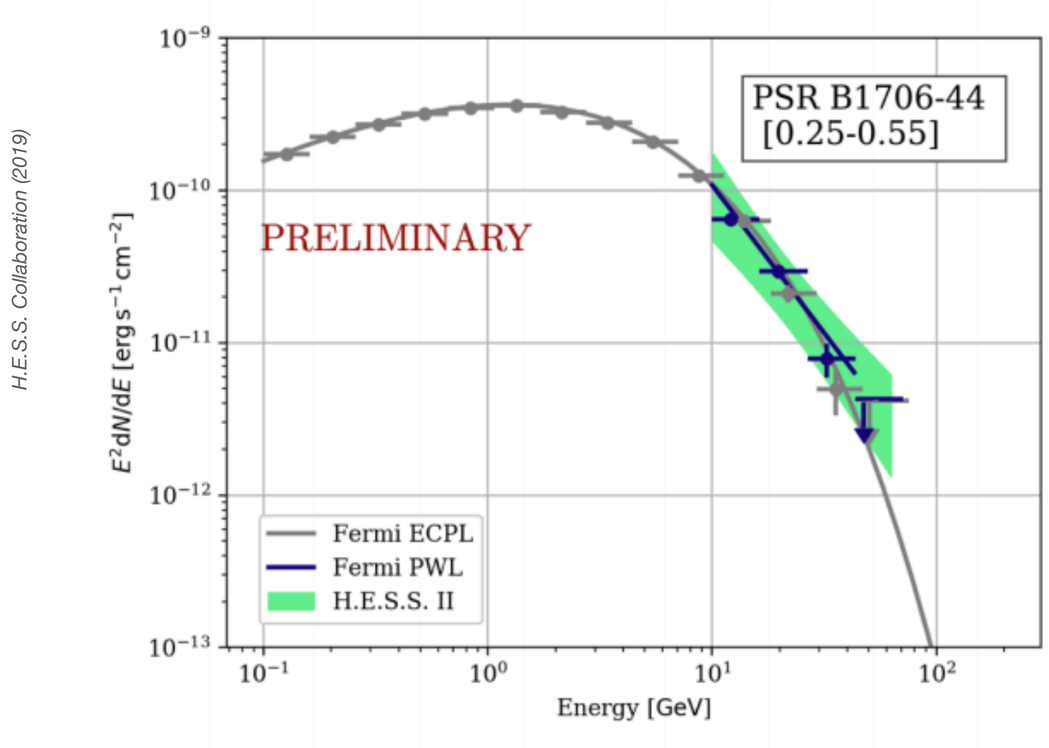


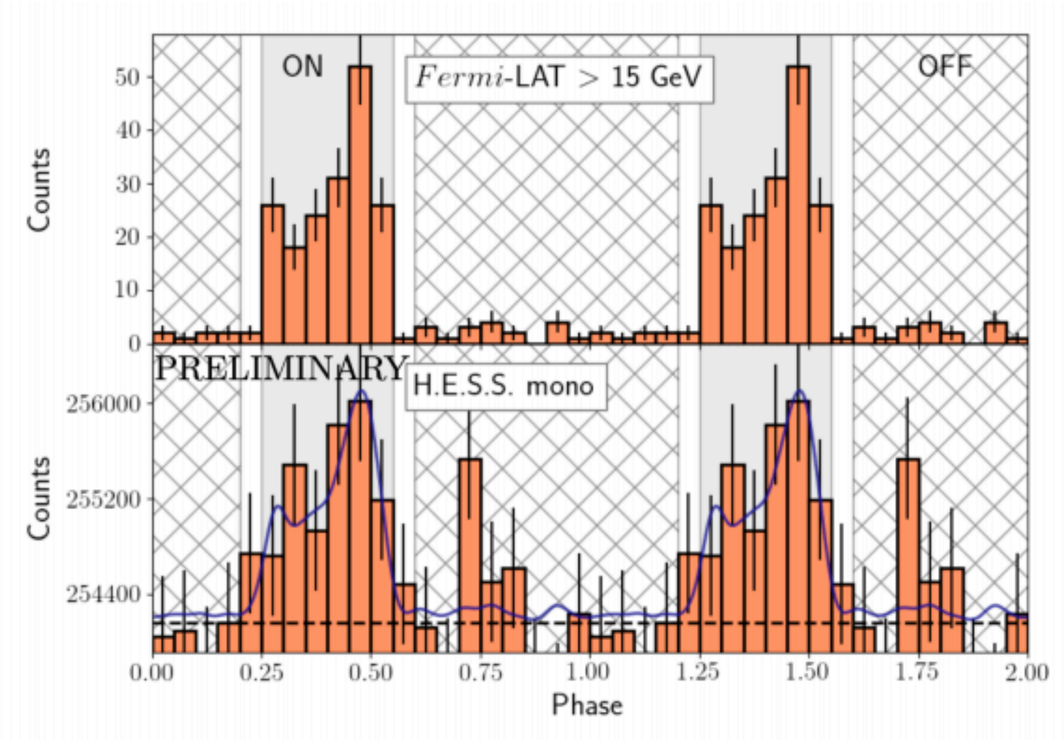


High energy radiation from pulsars

Pulsars at Very High Energies

- Pulsars: PSR B1706-44

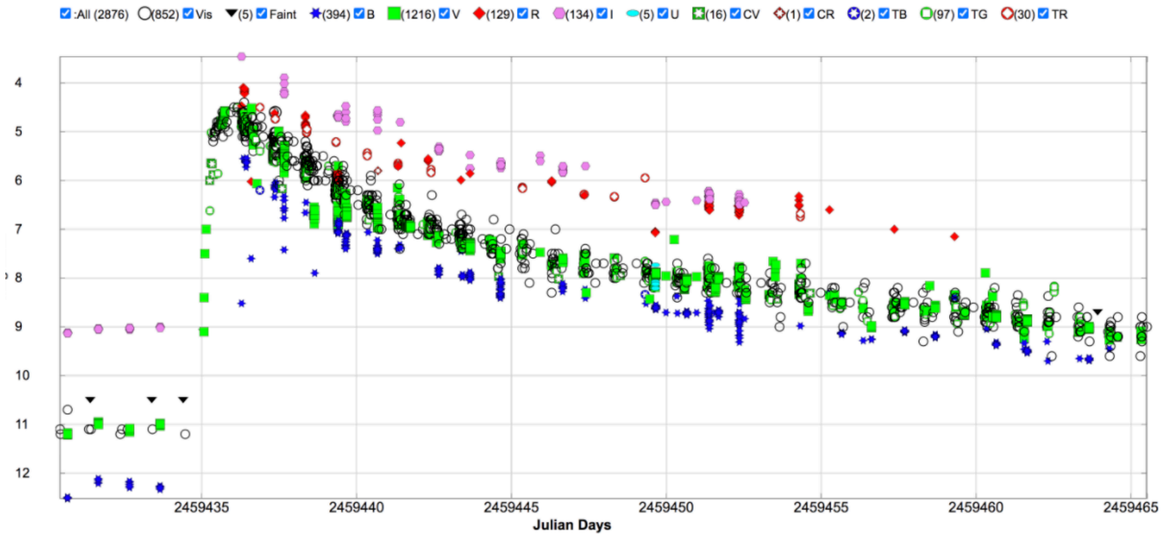




High energy radiation from pulsars

Novae! at Very High Energies

- RS Ophiuchi
  => Recurrent nova triggered H.E.S.S. observations on August 8
  => >30 ATels (<2 months)



Detection of VHE gamma-ray emission from the recurrent nova RS Ophiuchi with H.E.S.S.

ATel #14844; *Stefan J. Wagner, for the H. E.S. S. collaboration*
*on **10 Aug 2021; 18:34 UT***
Credential Certification: Stefan J. Wagner (swagner@lsw.uni-heidelberg.de)

[Previous | Next | ADS]

H.E.S.S. observations of soft spectrum VHE gamma-ray emission from the recurrent nova RS Ophiuchi

ATel #14857; *Stefan J. Wagner, for the H. E.S. S. collaboration*
*on **12 Aug 2021; 23:03 UT***
Credential Certification: Stefan J. Wagner (swagner@lsw.uni-heidelberg.de)

Conclusions

- H.E.S.S. continues observing our Galaxy and obtaining high-quality TeV results
- New analysis techniques + Large dataset + New instrument improves: exciting new results
- The experiment has been extended for two years more: into a Legacy observation program

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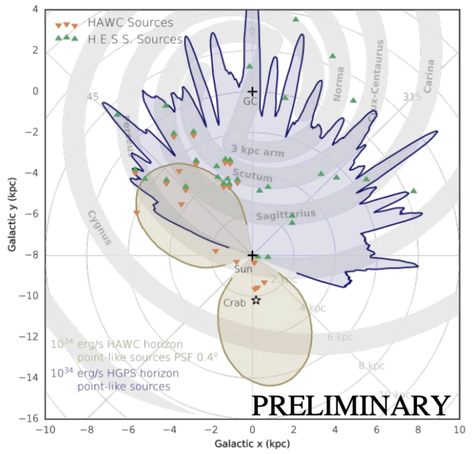
HAWC Sources
H.E.S.S. Sources
GC
Norma
Carina
3 kpc arm
Scutum
Sagittarius
Cygnus
Sun
Crab
4 kpc
6 kpc
8 kpc
10^{34} erg/s HAWC horizon
point-like sources PSF 0.4°
10^{34} erg/s HGPS horizon
point-like sources
PRELIMINARY
Galactic x (kpc)
Galactic y (kpc)

High energy radiation from pulsars

Pulsars at Very High Energies

- Vela Pulsar
  - H.E.S.S. 2017, after ~80 hours observation
  - Signal on P2 detected beyond TeV up to 20 TeV