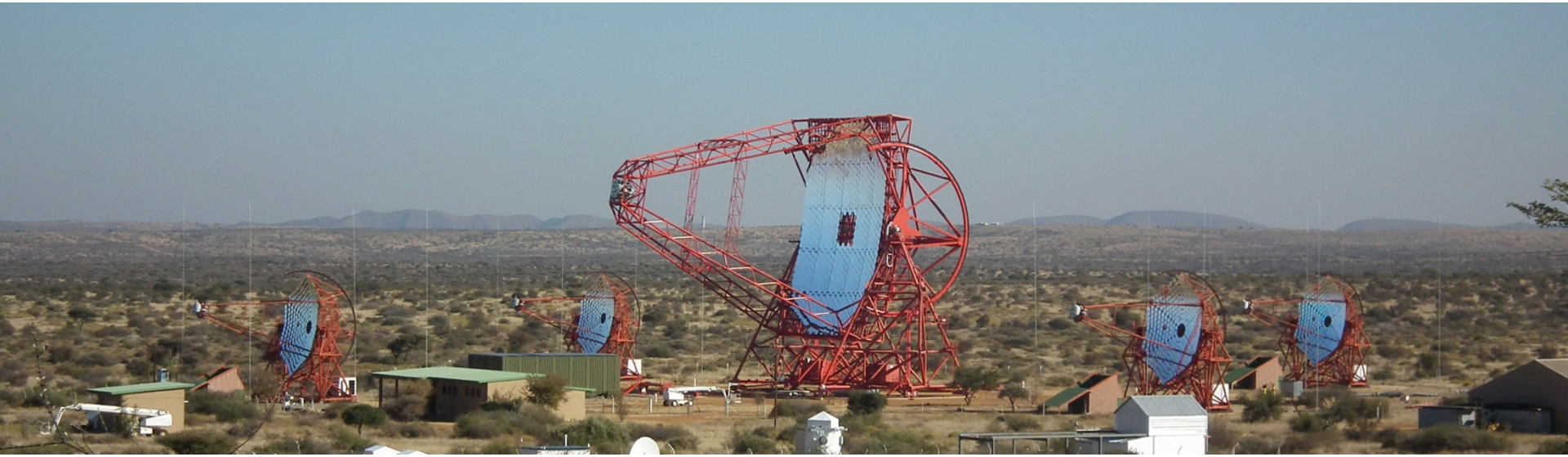
H.E.S.S. Highlights

Christian Stegmann for the H.E.S.S. collaboration
IPA 2014
August 2014, London

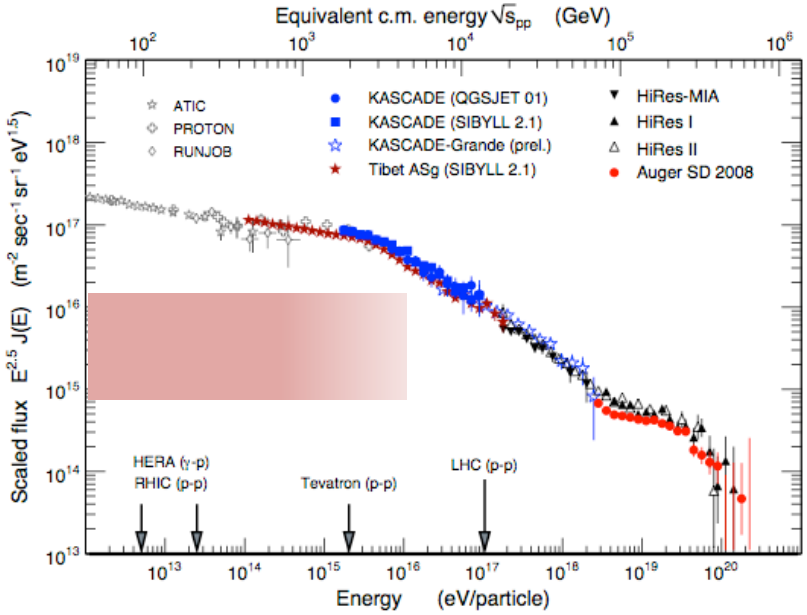
The H.E.S.S. collaboration

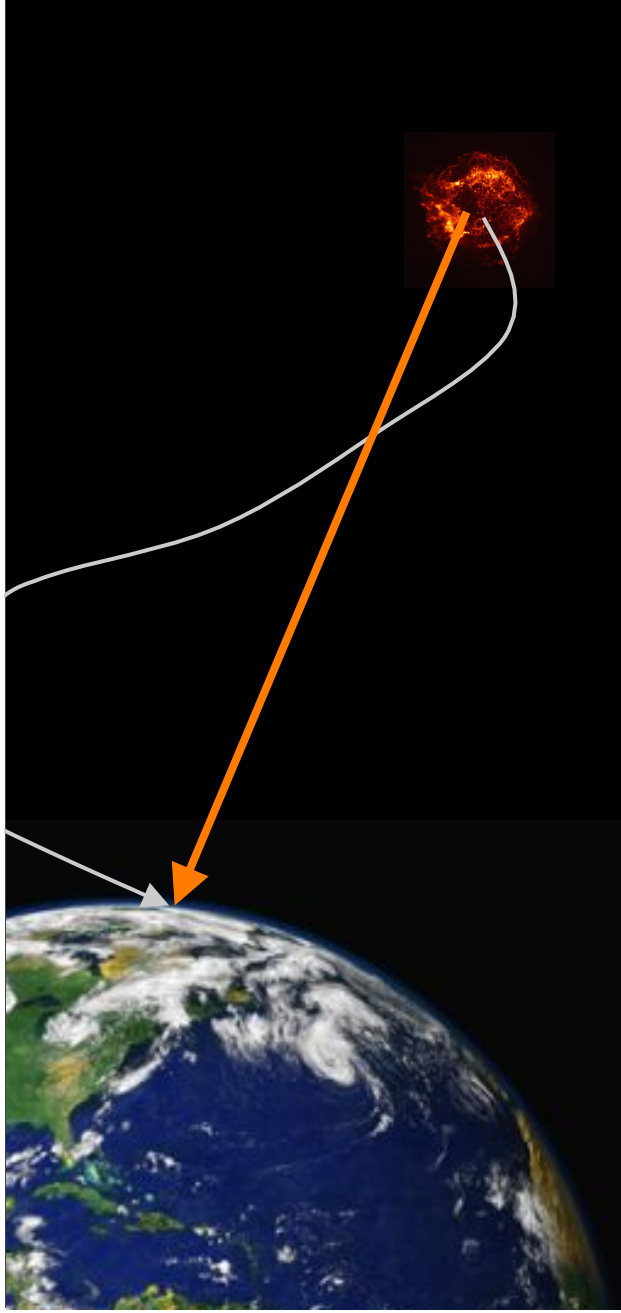


- MPI Kernphysik, Heidelberg, Humboldt Univ. zu Berlin, Ruhr-Univ. Bochum, Univ. Erlangen-Nuremberg, Univ. Hamburg, LSW Heidelberg, Univ. Potsdam, Univ. Tübingen, DESY
- Ecole Polytechnique, Palaiseau, APC Paris, Univ. Paris VI-VII, Univ. Bordeaux, Observatory Paris, Meudon, LAPP Annecy, LUPM Montpellier, CEA Saclay, IPAG Grenoble
- Stockholm University, Royal Institute, Linnaeus University, Durham Univ., Univ, Leicester, Dublin Inst. for Adv. Studies, GRAPPA U. Amsterdam
- Polish Academy of Sciences; Jagiellonian University, Cracow; Nicolaus Copernicus University, Torun; University of Warsaw, Warsaw
- Univ. Adelaide, North-West Univ., Potchefstroom, Wits Univ., Johannesburg, Univ. of Namibie, Windhoek

H.E.S.S.

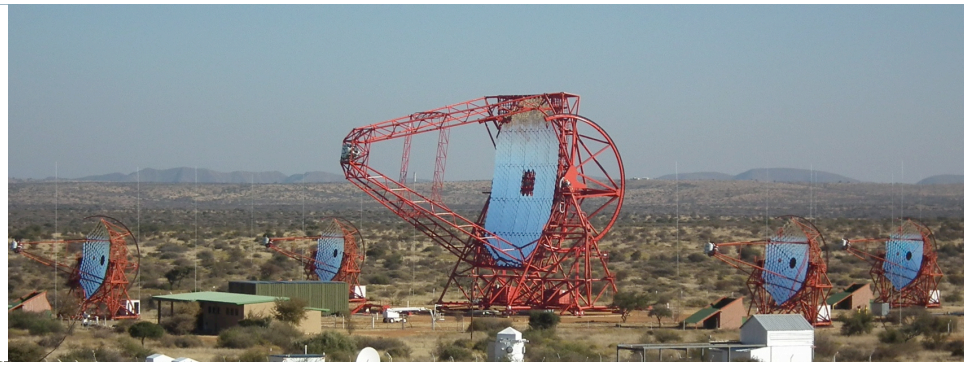
Gamma rays – Messengers from the High Energy Universe





- Gamma rays are excellent tracers of the acceleration sites of ultra-relativistic cosmic rays
- Production
  - protons: pion-decay: $\pi^0 \longrightarrow \gamma\gamma$
  - electrons: Inverse Compton Scattering: $e^{\pm}\gamma \longrightarrow e^{\pm}\gamma$

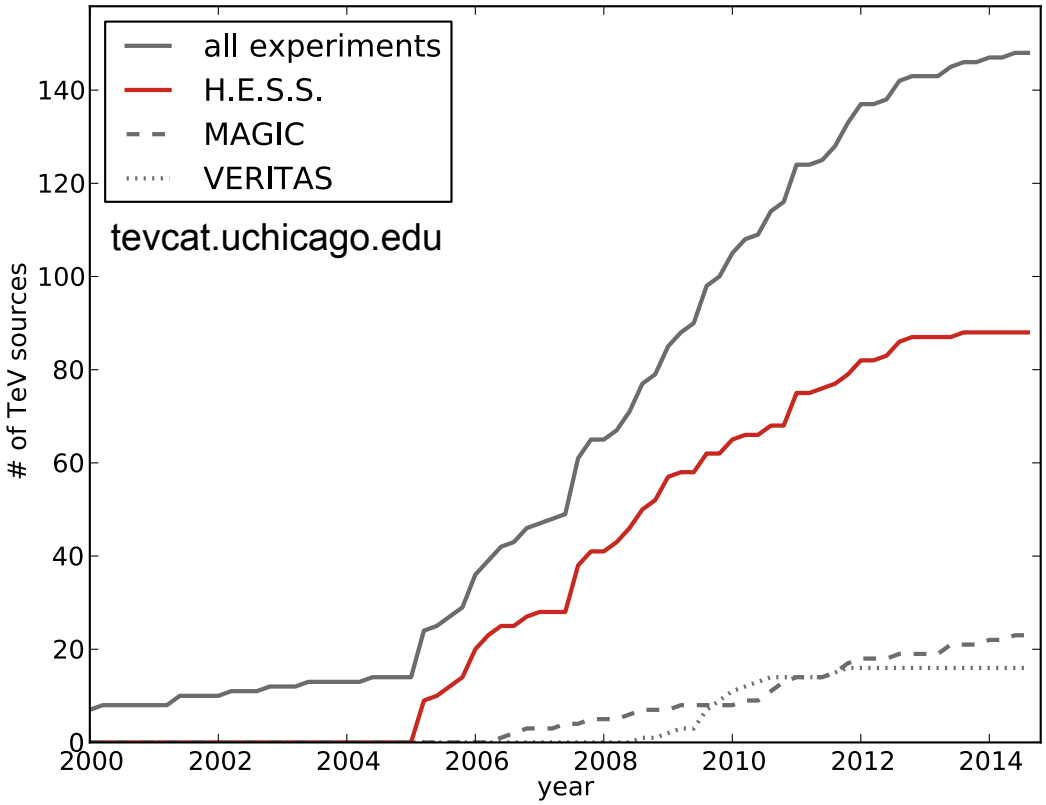
The H.E.S.S. experiment



- H.E.S.S. phase I
  - four 12m telescopes
  - FoV 5 deg
  - energy threshold 100 GeV
  - angular resolution < 0.1 deg
- H.E.S.S. phase II
  - four 12m telescopes
  - one 28m telescope (FoV 3.5 deg)
  - energy threshold O(30 GeV)
  - angular resolution from 0.4 deg to less than 0.1 deg

H.E.S.S. phase I H.E.S.S. phase II

The H.E.S.S. experiment



- H.E.S.S. phase I
  - more than 10000 hours of data
  - discovered over 80 new VHE gamma ray sources
  - published over 100 scientific papers, plus numerous conference contributions
- H.E.S.S. phase II
  - towards lower threshold and transients

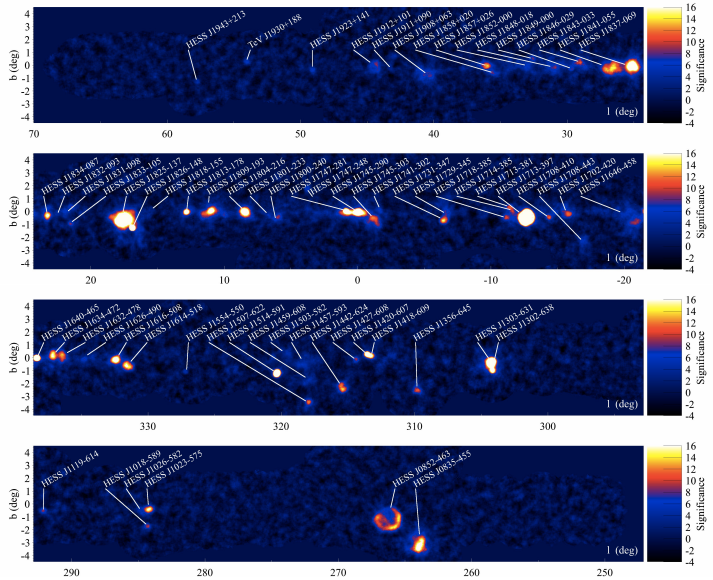
H.E.S.S. phase I

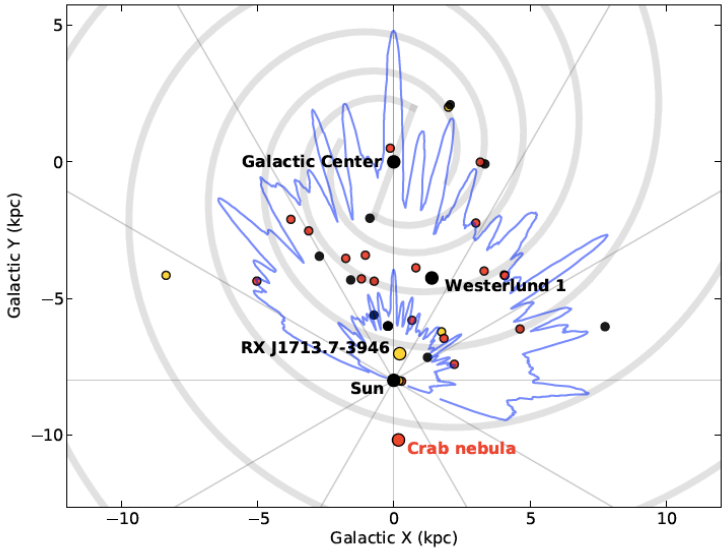
H.E.S.S. phase II

H.E.S.S. I Highlights: The Galactic Plane Scan

- Pre-trials significance map, correlation radius 0.1°
- Blue-red transition corresponds to ~5σ post trial

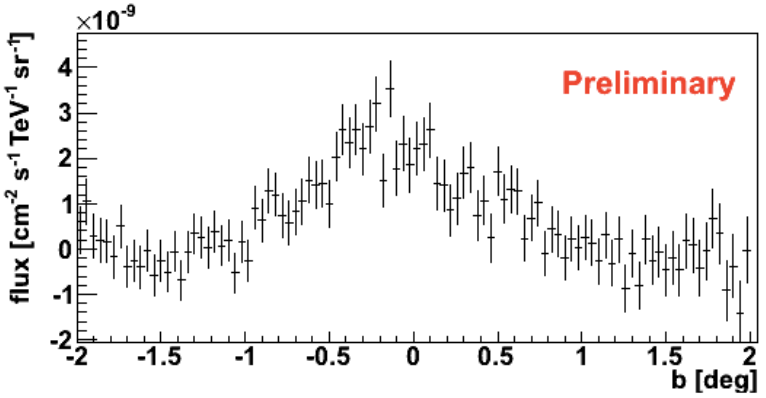
- Blue lines: H.E.S.S. horizons for 1% and 10% Crab
- Dots: H.E.S.S. Galactic sources
  - Red: PWNe
  - Yellow: SNRs
  - Black: other sources

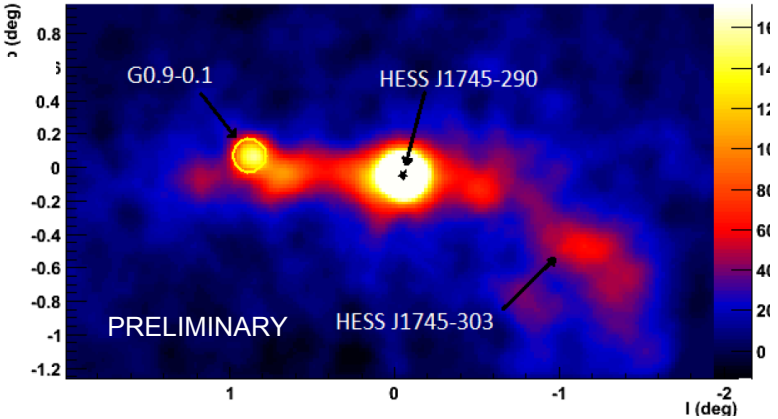


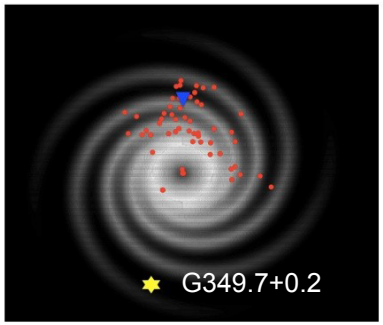


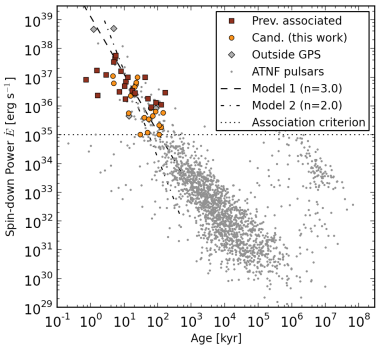
H.E.S.S. I Highlights: A selection

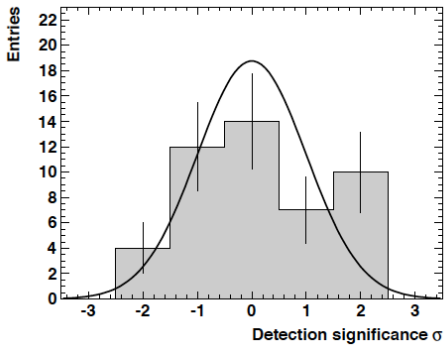
- Diffuse emission
  - after subtraction of sources
- Galactic center
- Extreme SNR
  - HESS J1640-465: The brightest
  - G349.7+0.2: The farthest
- Population studies
  - Pulsar wind nebulae population
  - AGN limits
- many more



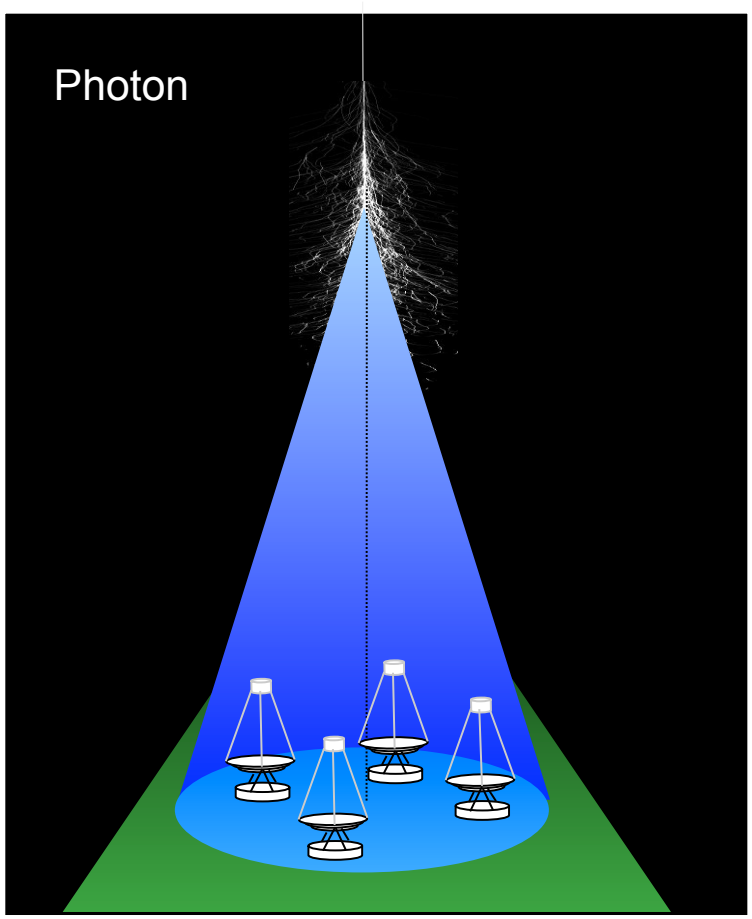


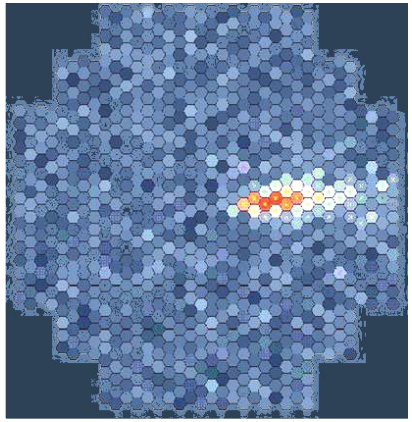




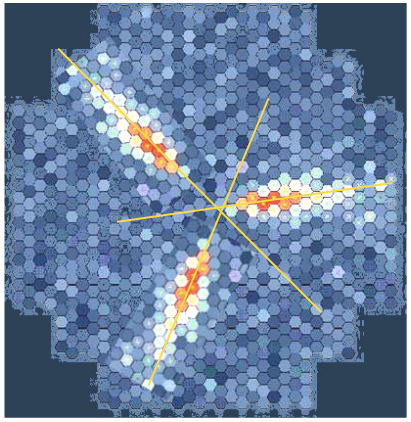


How to measure gamma rays





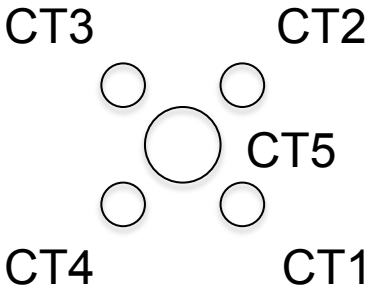
Single telescope event



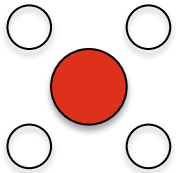
3 telescope event in common camera place

- Intensity → Energy
- Orientation → Direction
- Shape → Primary Particle

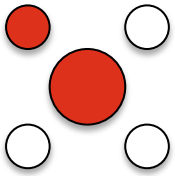
H.E.S.S. II



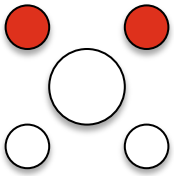
- Operation of the first mixed system of Cherenkov telescopes
- Trigger
  - all configurations simultaneously



CT5 mono
65%



CT5 + ≥ 1 CT1-4
30%

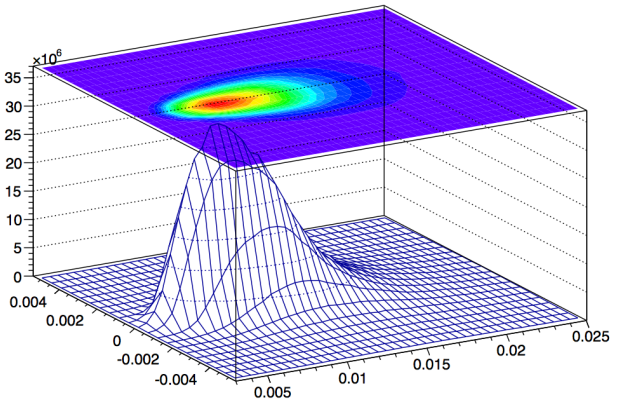


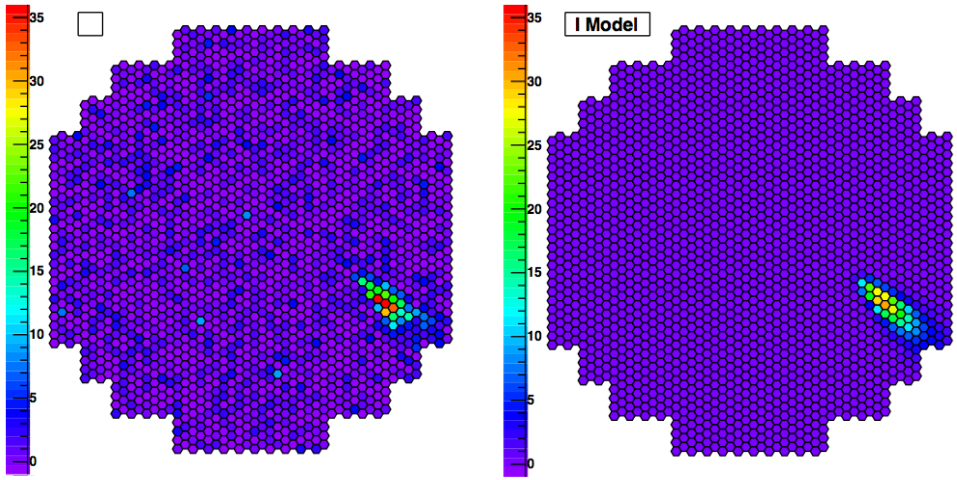
≥ 2 CT1-4
5%

- Analysis
  - **CT5 mono: presented here**
  - full H.E.S.S. array analysis under study

Single telescope reconstruction

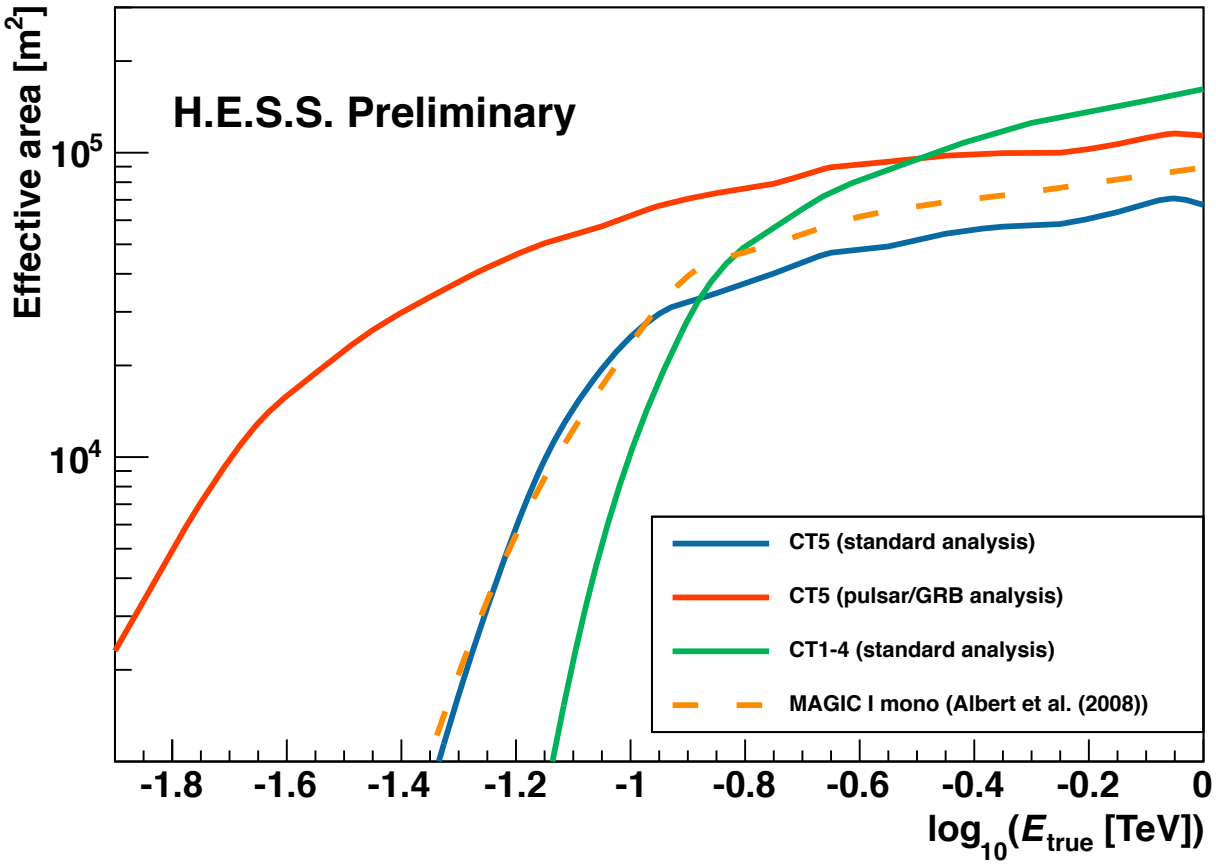
- Template (model) based photon reconstruction
  - Adapted from de Naurois et al APh 32, 231 (2009)
- Standard analysis
  - optimized for source observations
- PSR/GRB analysis
  - optimized for low E detections





camera event fit

Collection area

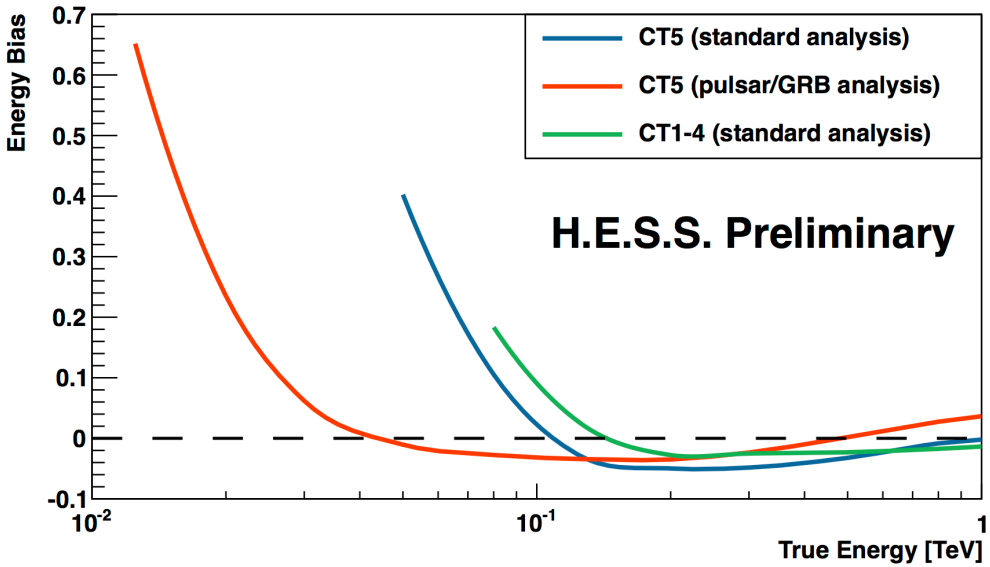


- Systematics at low energies under study

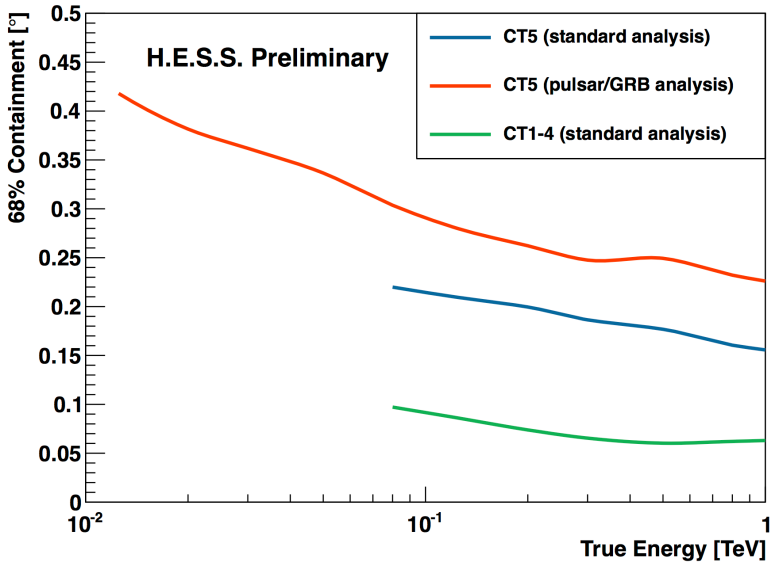
Energy and angular resolution

	Energy resolution	Angular resolution
Standard analysis	30%	0.2 deg
Pulsar/GRB analysis	30% - 40%	0.3 - 0.4 deg

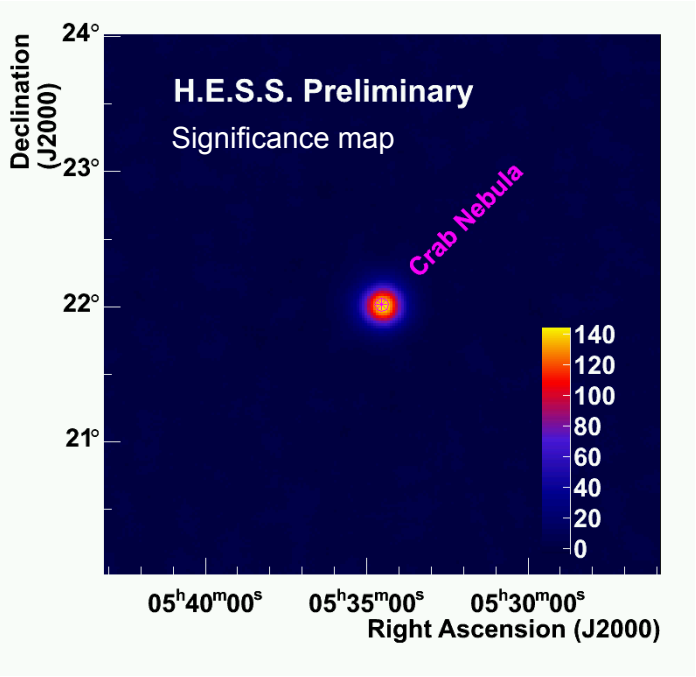
Energy bias

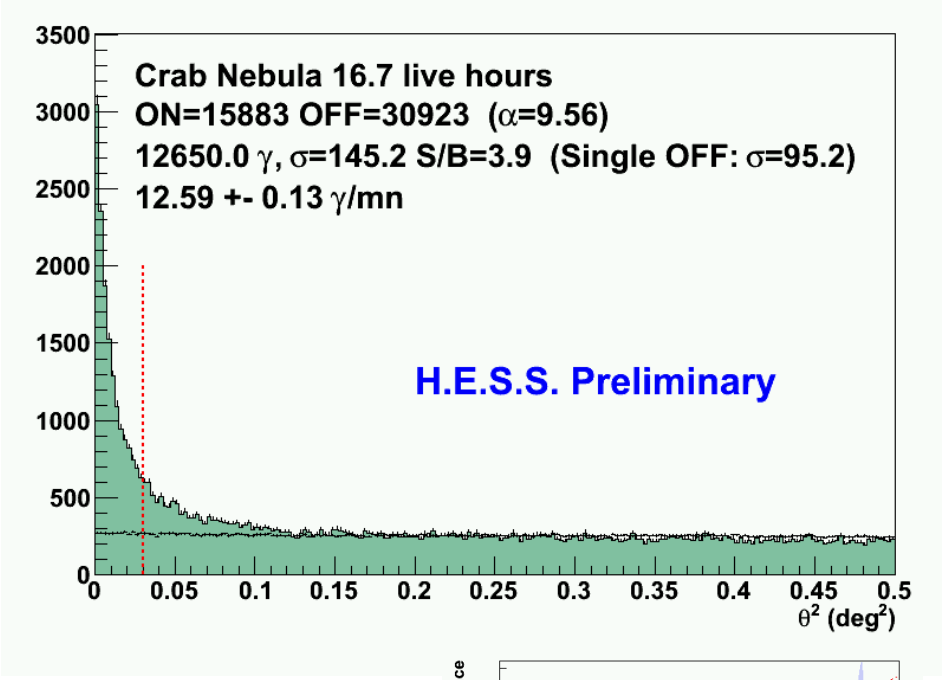


Angular resolution

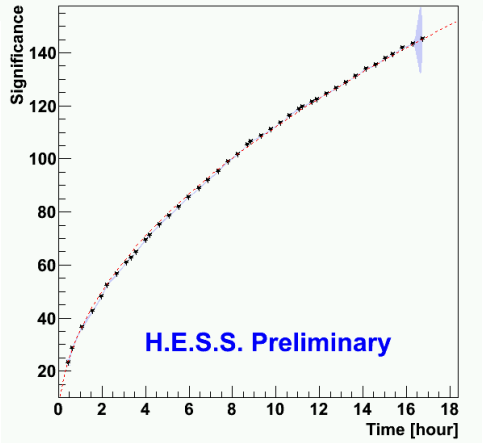


The Crab with CT5



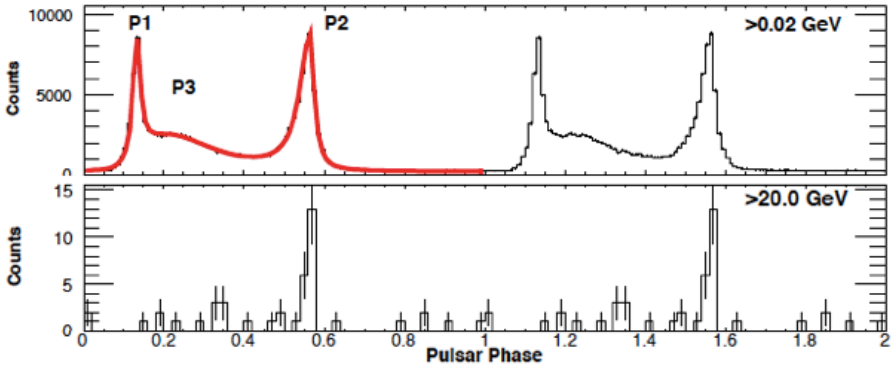


- <zenith> = 48 deg
- Standard analysis
  - photon rate = 12.6 ± 0.1 γ/mn
  - MC expectation = 13 γ/mn



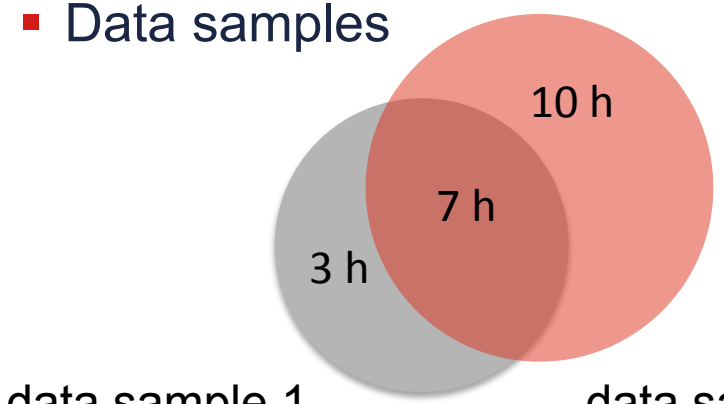
The Vela pulsar

Fermi-LAT, arXiv:1002.4050

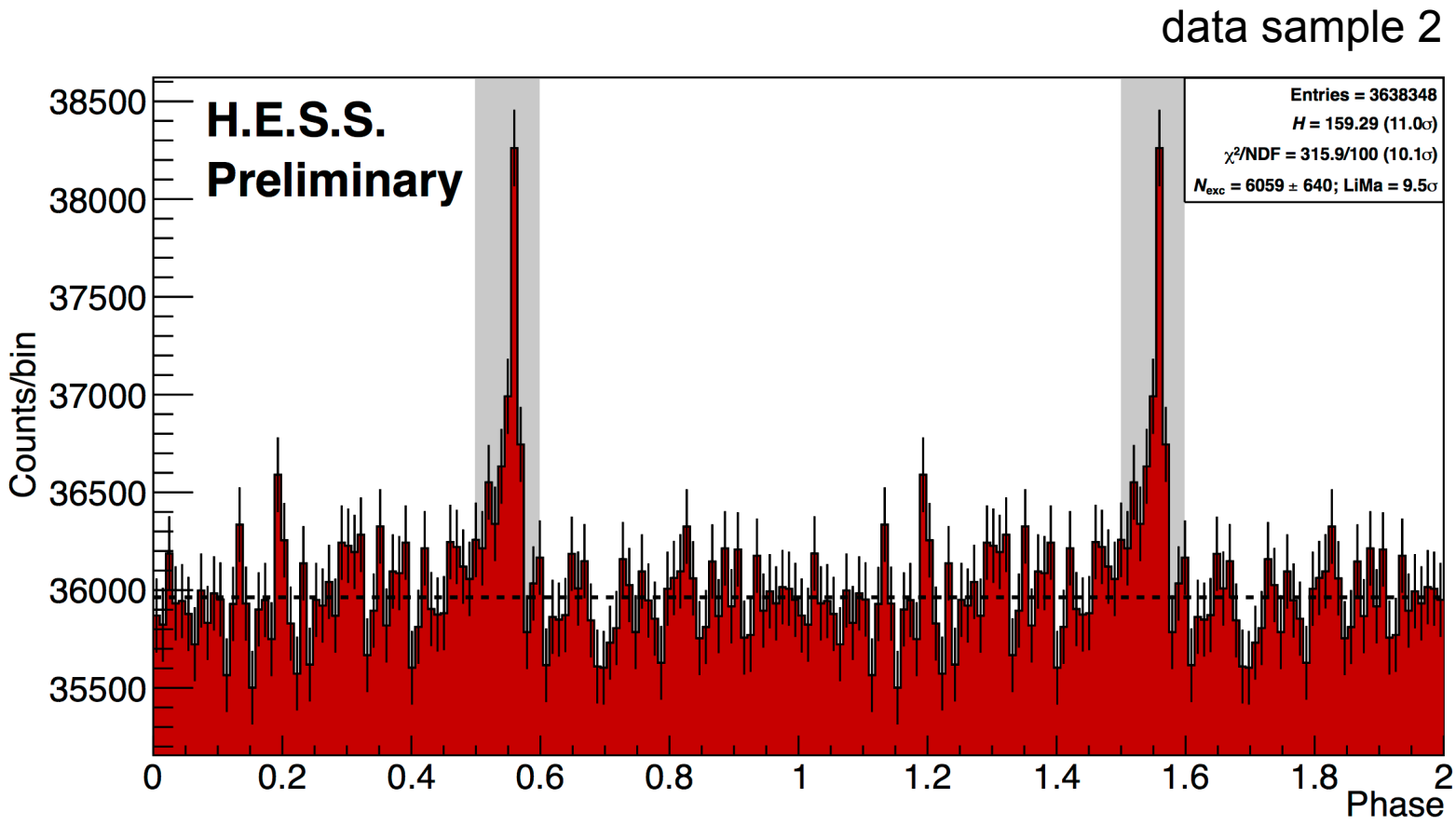


	$n_{10\ GeV}$	$P_{10\ GeV}$	$n_{25\ GeV}$	$P_{25\ GeV}$
Crab	674	5.4σ	191	2.3σ
Vela	1005	>6σ	56	>6σ

- Observation
  - lifetime 20 h
  - <zenith angle> 27 deg – 35 deg
- PSR analysis
  - optimized cuts for low energies
- Data samples

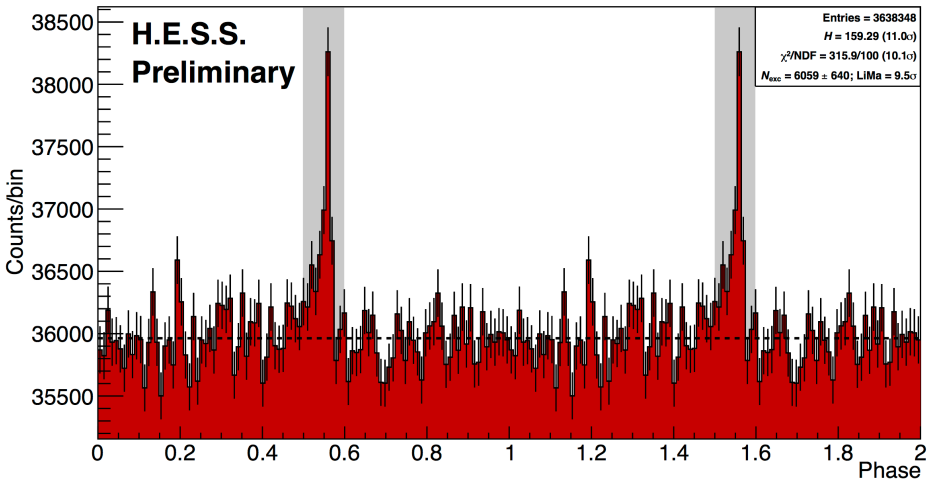


The Vela pulsar seen with CT5

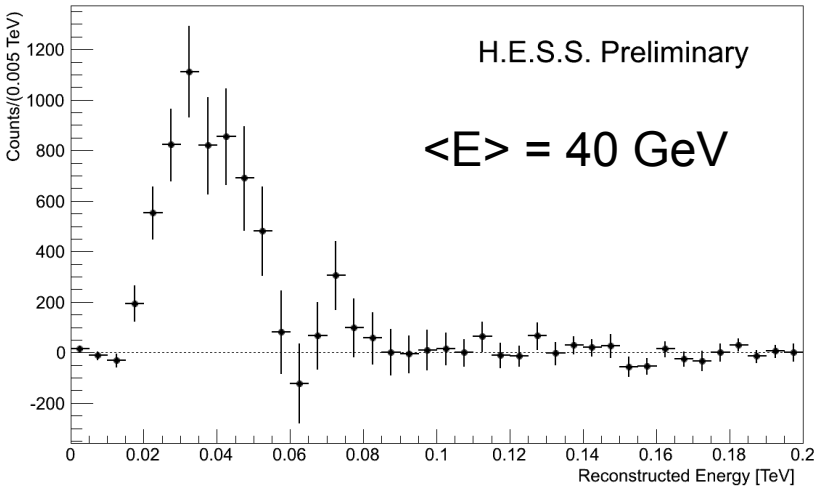


- a priori significance = 8 σ (data sample 2 – data sample 1 (10h))
- N_{excess} = 6059 ± 640

The Vela pulsar seen with CT5

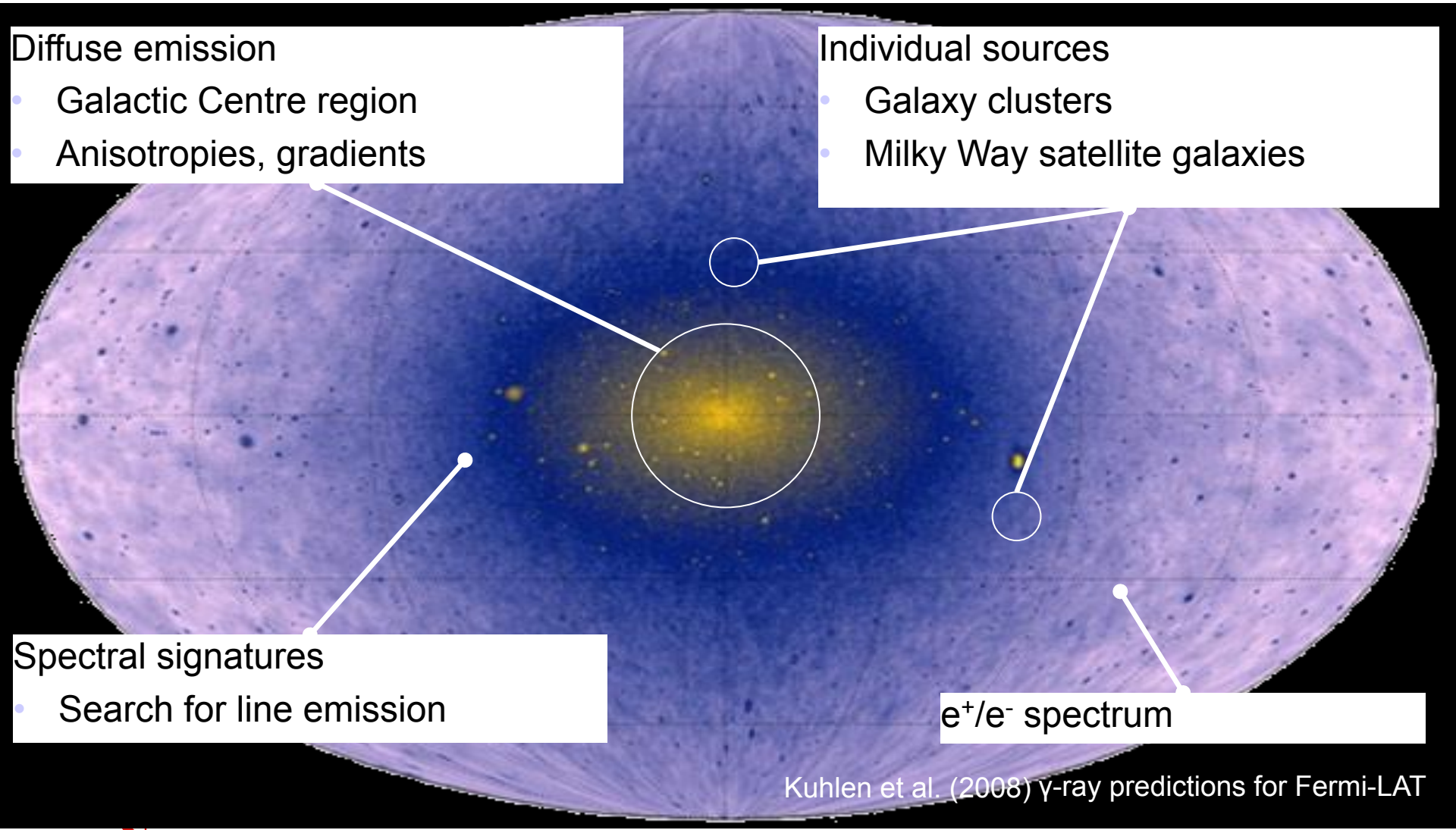


Energy distribution



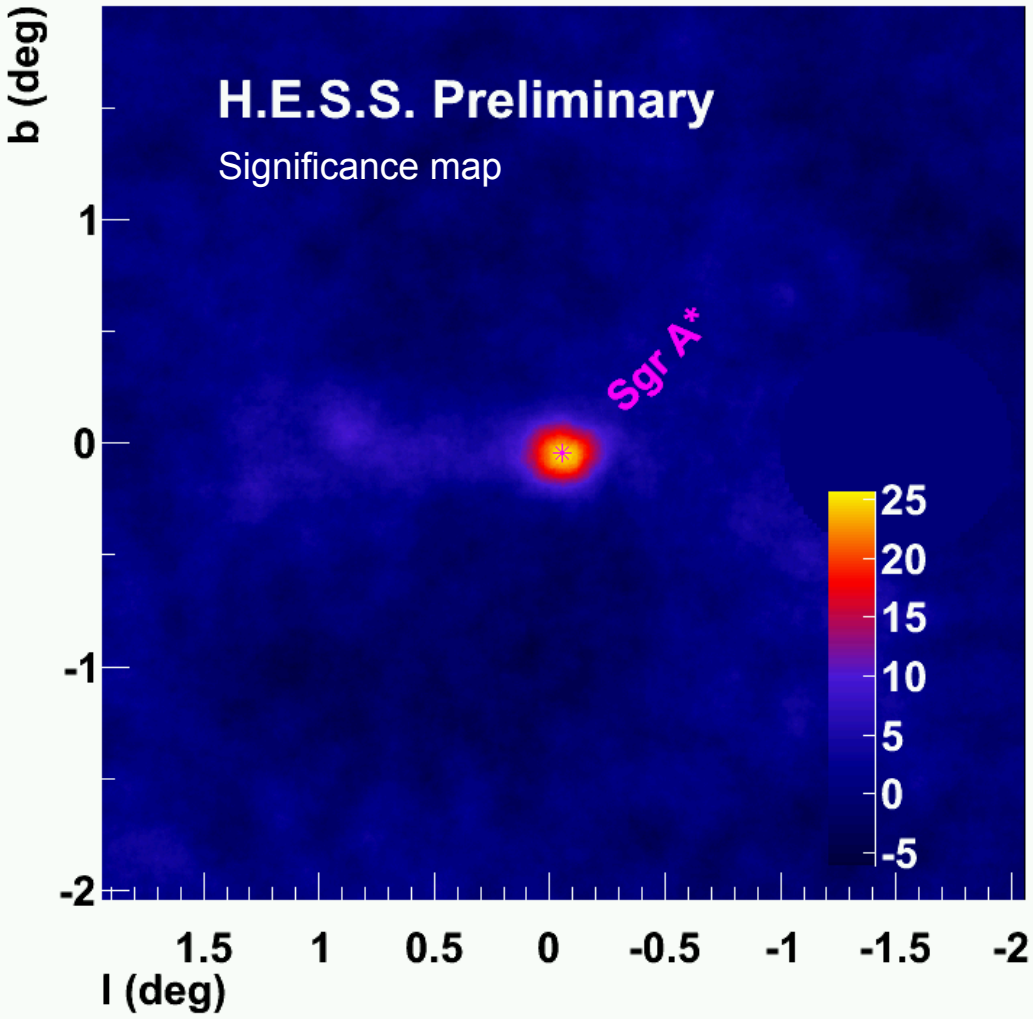
- Pulsar physics (not only Vela)
  - what is the spectrum above 20 GeV?
  - constraining the cut-off?
- For H.E.S.S. II
  - calibration source at the threshold in standard observation mode
  - well prepared for GRB search

Dark Matter Searches with Gamma rays

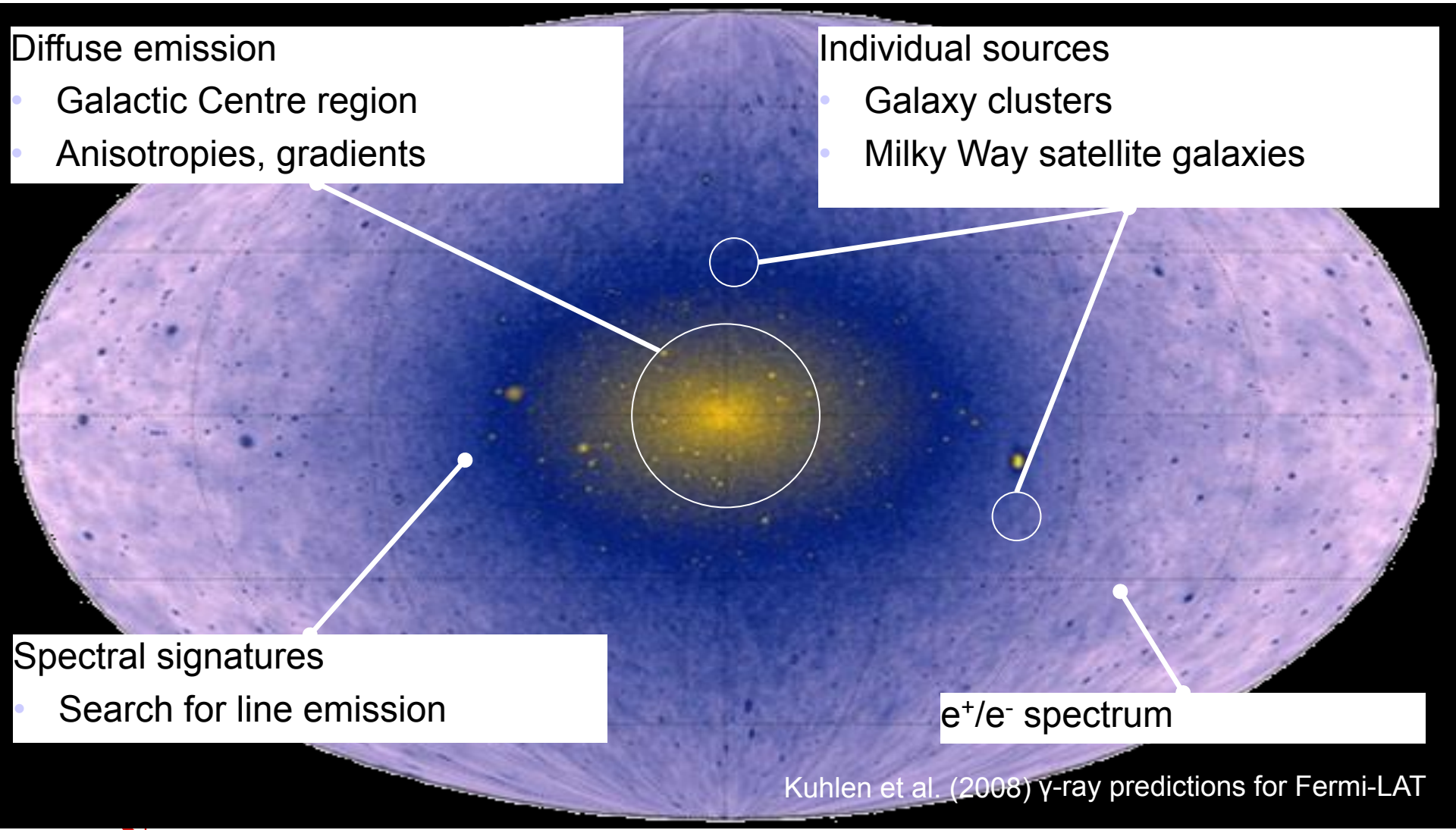


The Galactic Centre with CT5

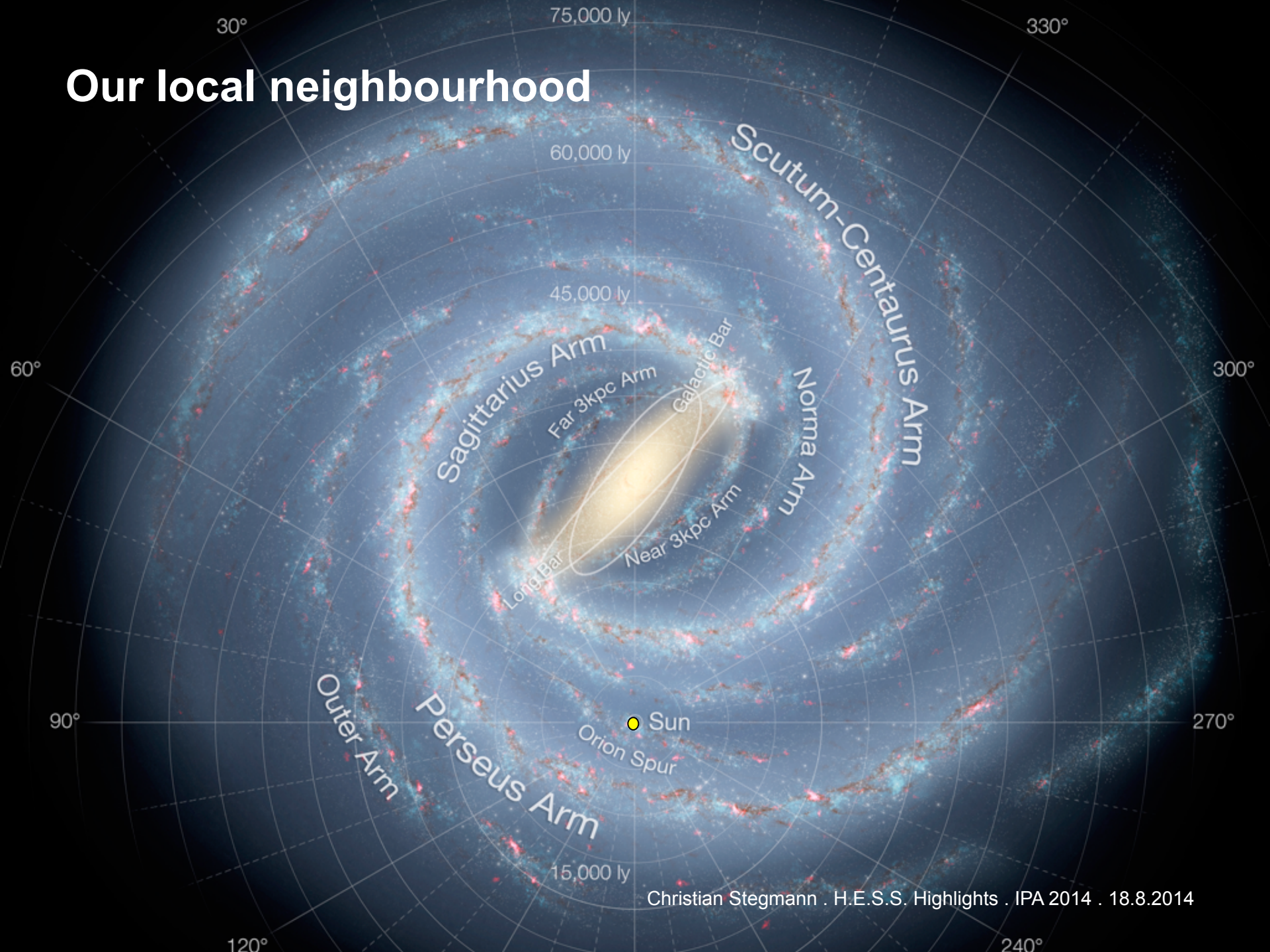
- The Galactic Centre is one of the most complicated regions
- Observation and analysis
  - Life time 68.8 h
  - Signal with 25 σ
  - extended emission
- Background needs to be further studied



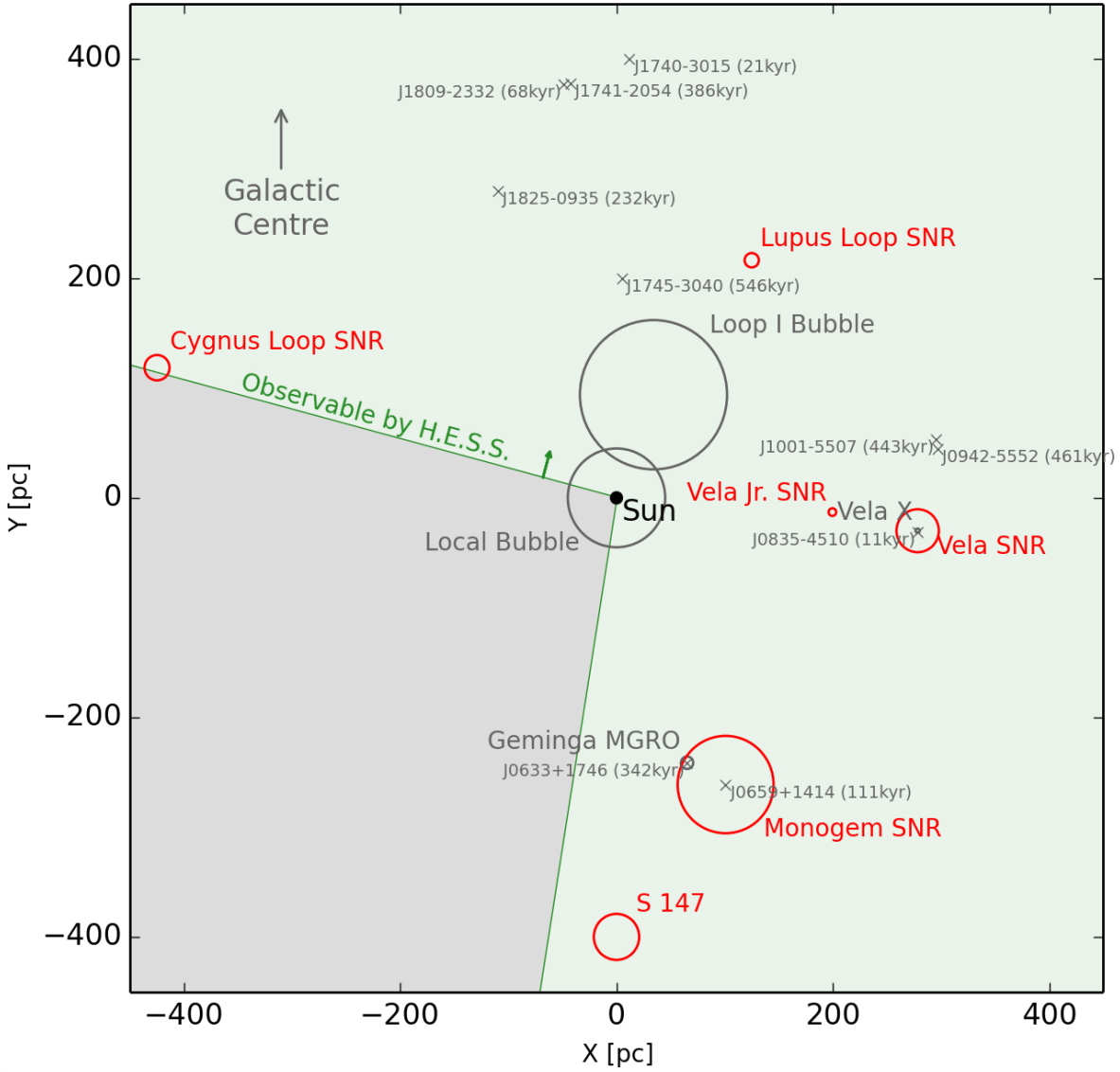
Dark Matter Searches with Gamma rays



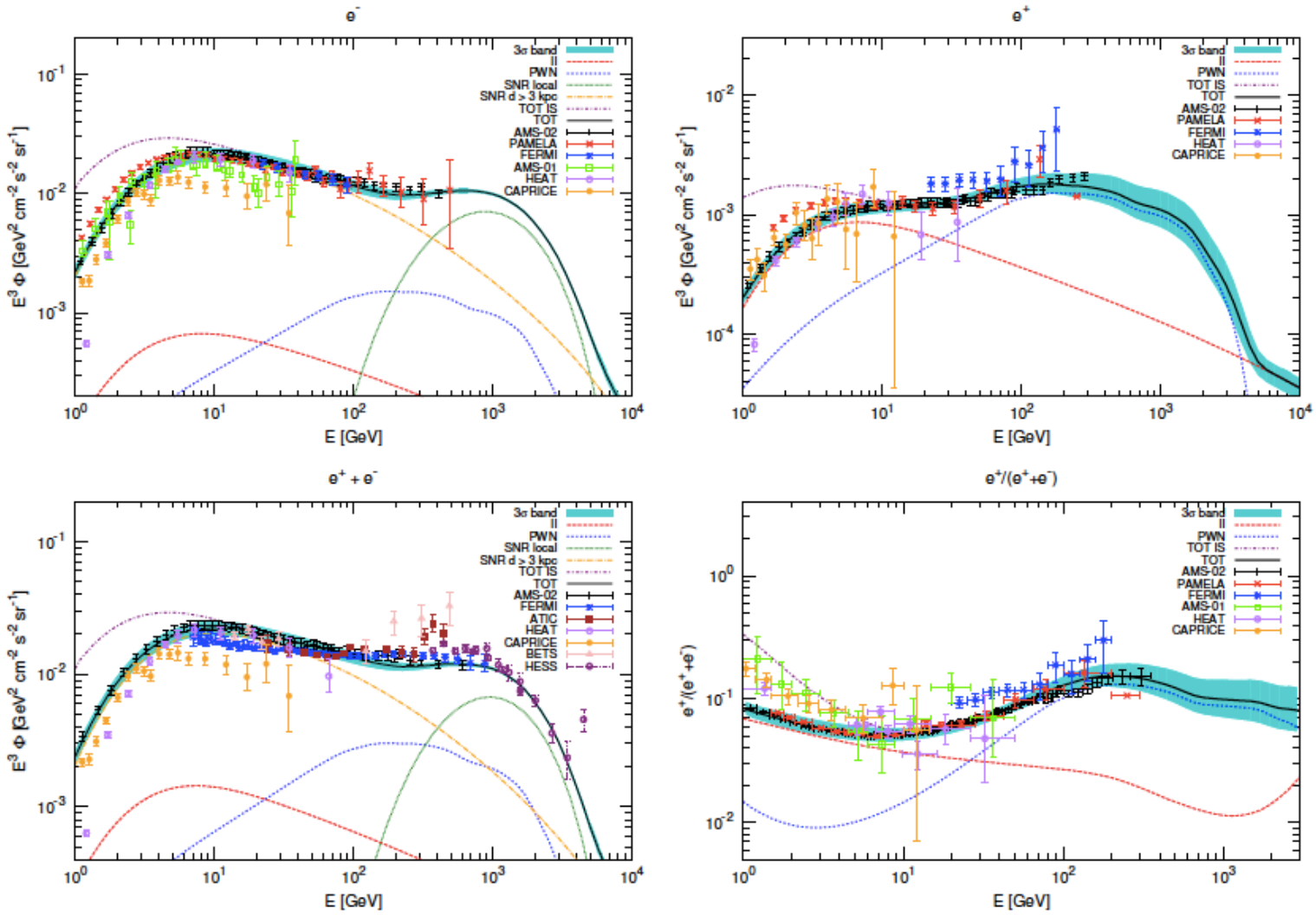
Our local neighbourhood



Nearby Sources

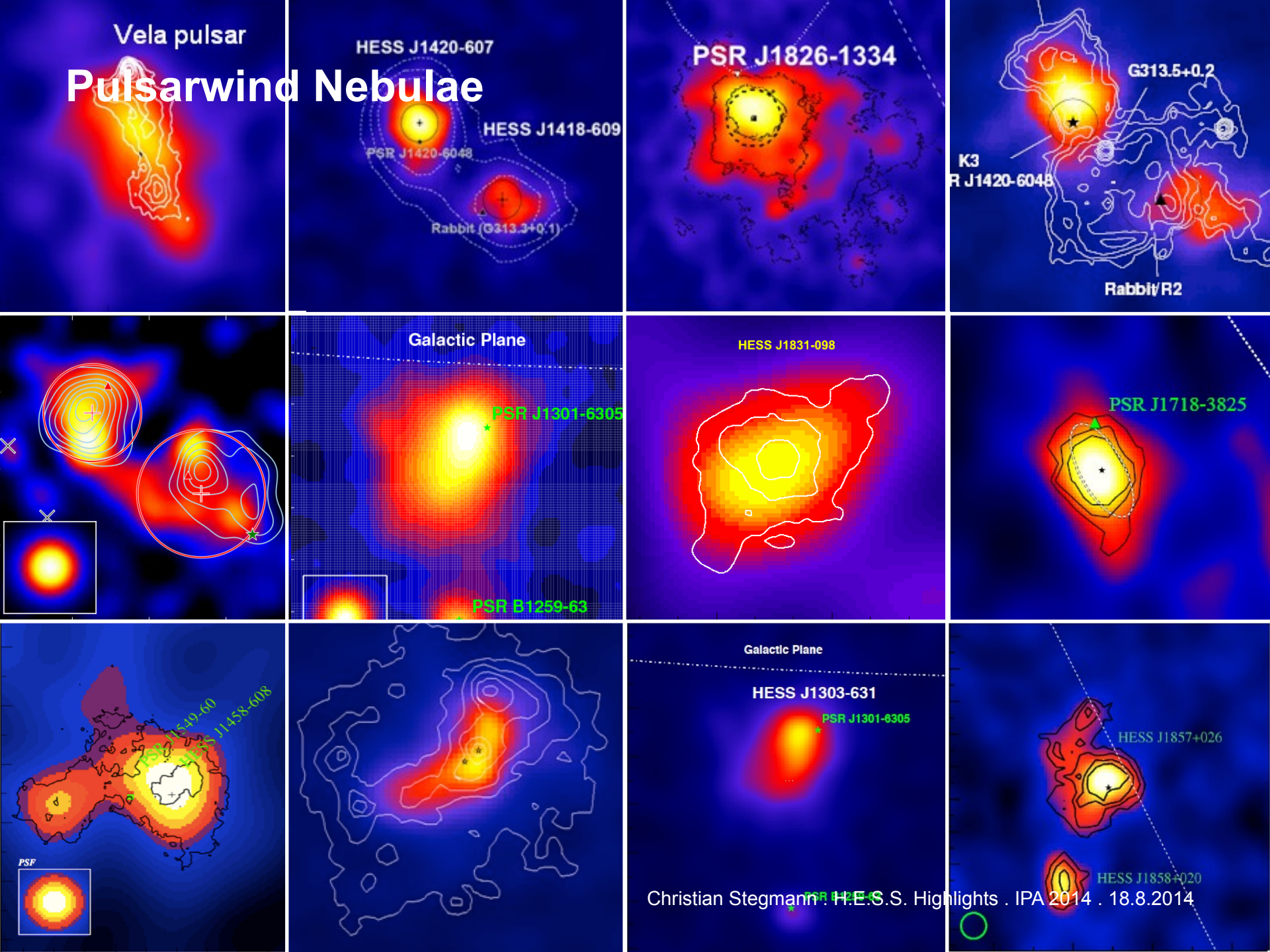


Electron/Positron Spectra



M. Di Mauro, F. Donato, N. Formengo, R. Lineros, A. Vittino, arXiv:1402.0321

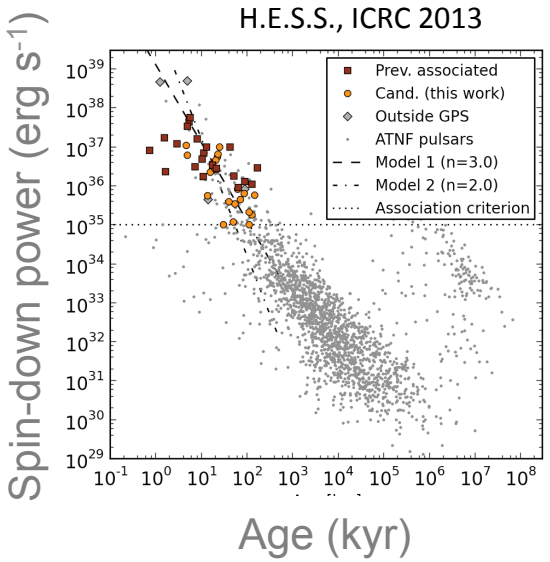
Pulsarwind Nebulae

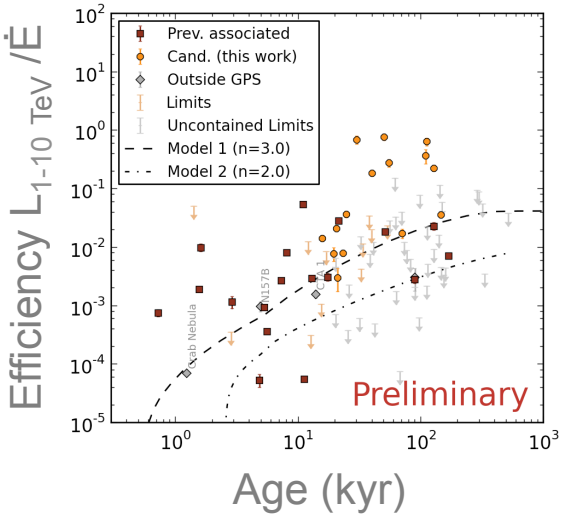


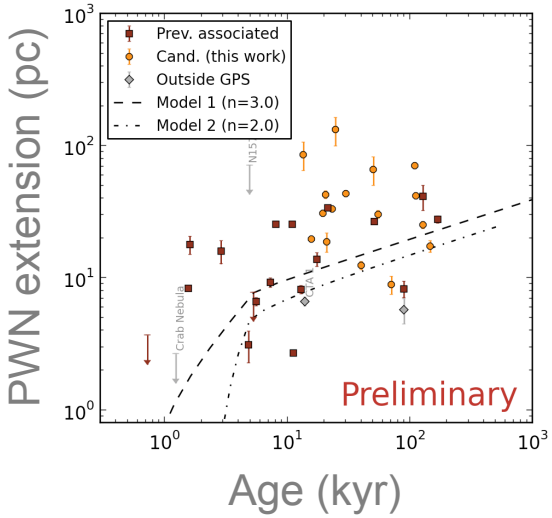
PWN Population Study

- Selection results
  - young pulsars (age < 100 kyr)

- Population plots to benchmark models



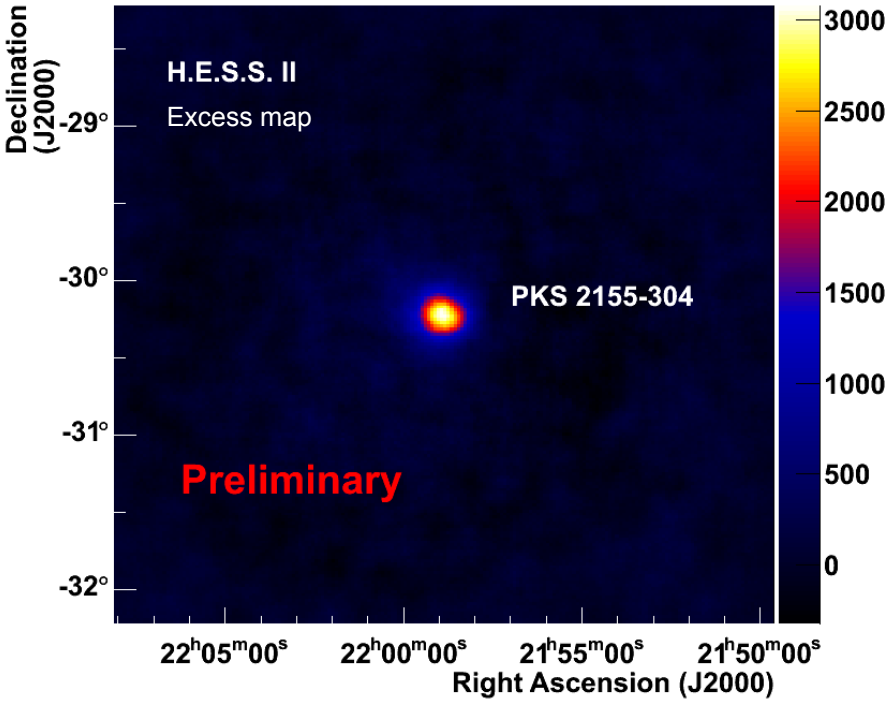


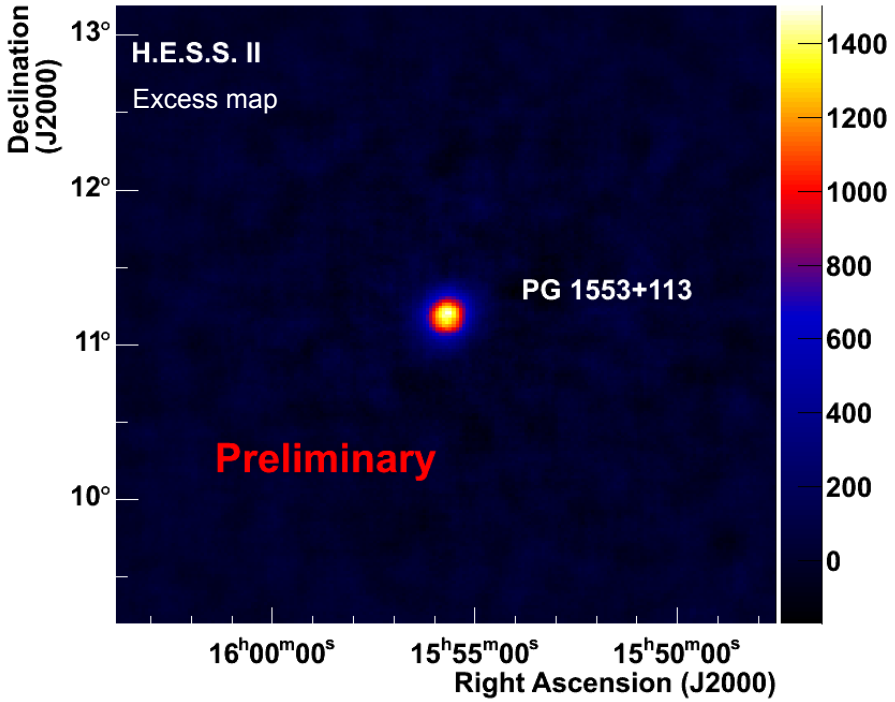


Summary

- H.E.S.S. II is
  - continuing to contribute to our understanding of the high-energy Universe
  - measuring point sources and extended sources
  - filling the gap between Fermi-LAT and IACTs
- Exciting times ahead of us

AGN seen with CT5

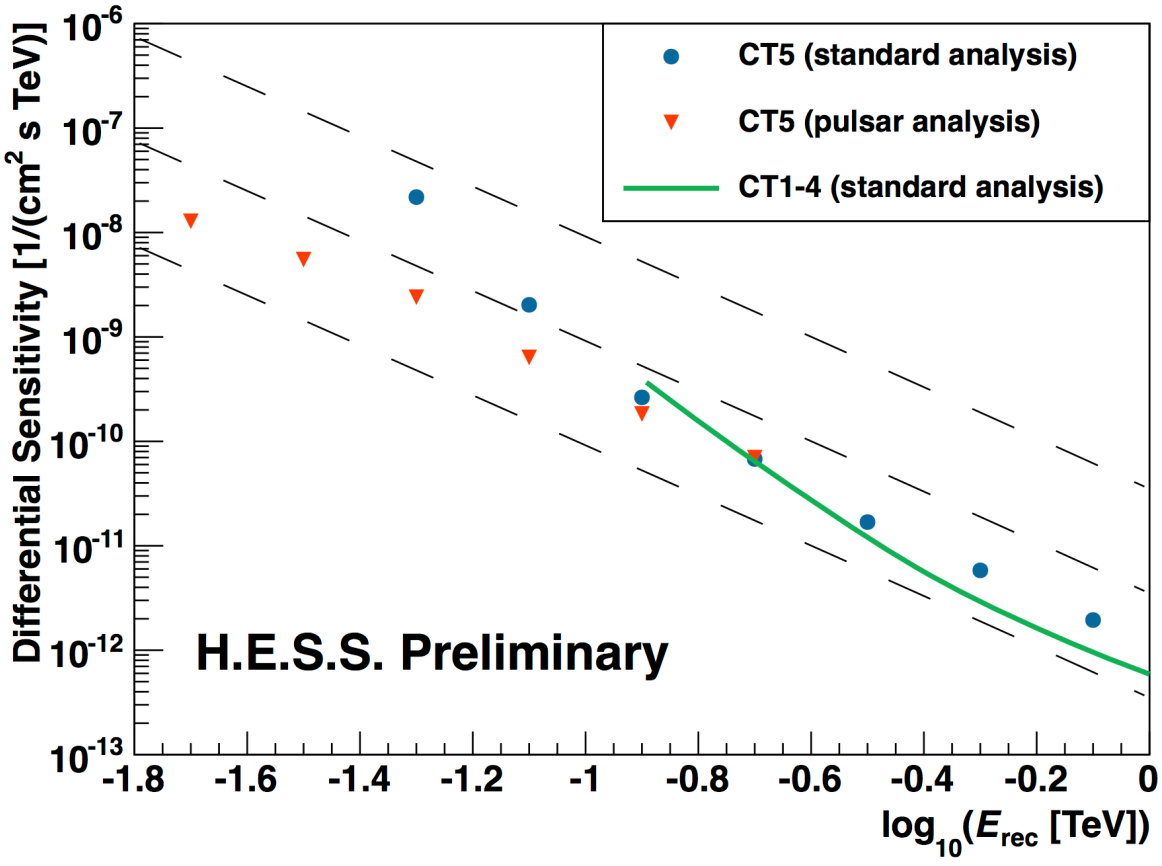




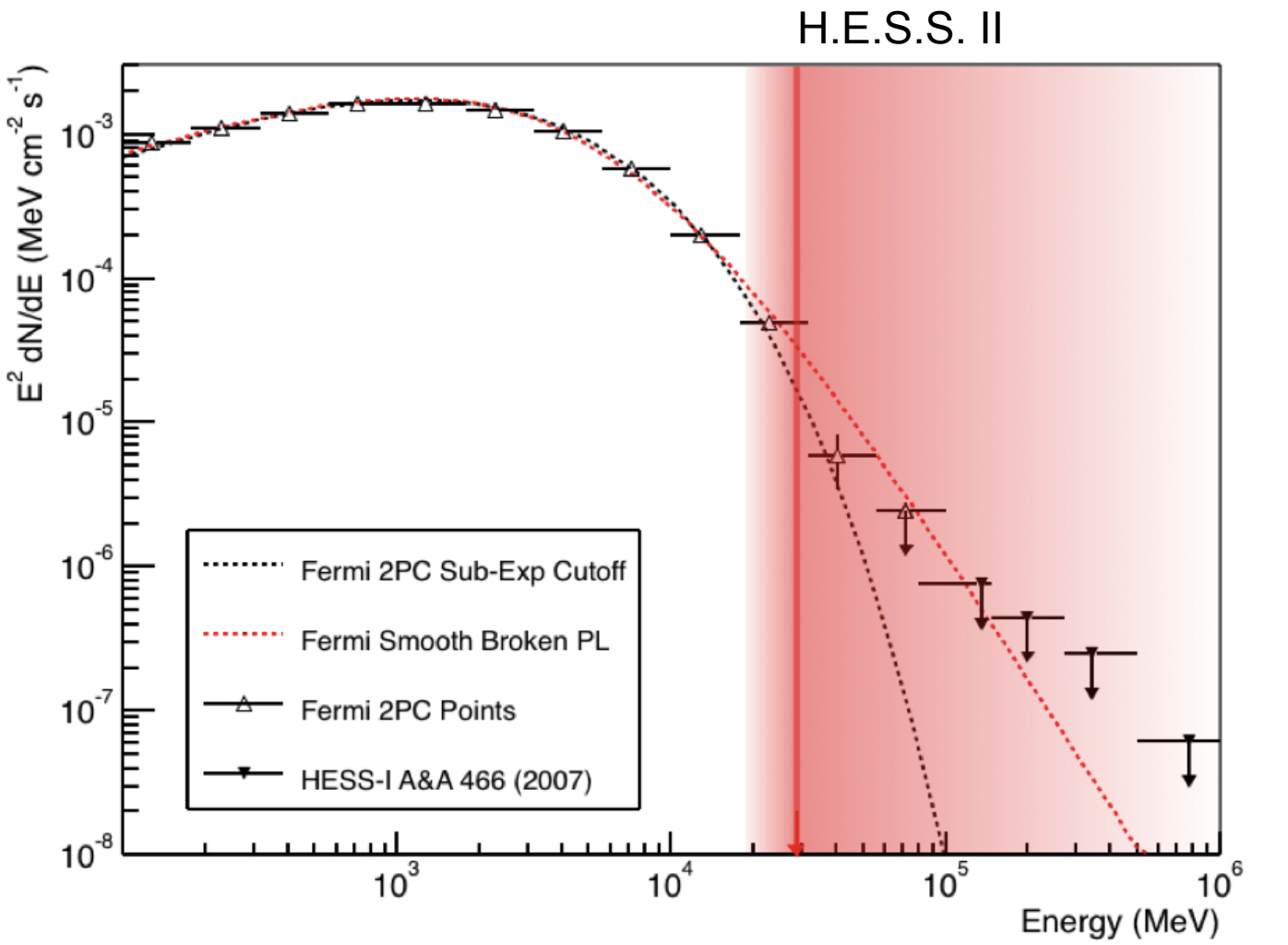
	Live time	Excess	Sign.	Rate
PKS 2155-304	35.7 h	3669 γ	29 σ	1.71 ± 0.06 γ/mn
PG 1553+113	15.4 h	2358 γ	25 σ	2.55 ± 0.11 γ/mn

Sensitivity

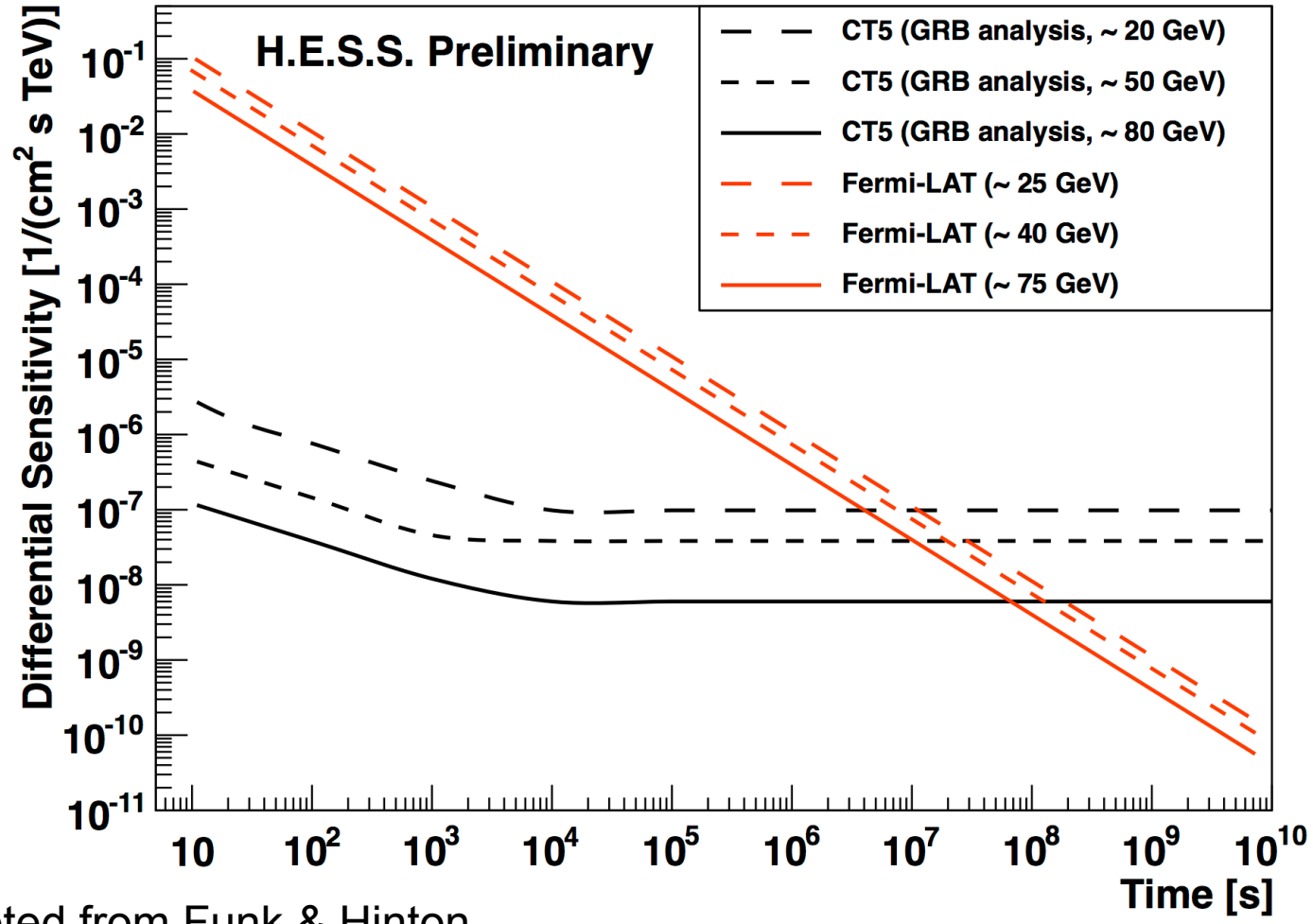
- Standard analysis
  - 5σ in 100 h
  - 5% background systematics
- Pulsar analysis
  - 5σ in 100 h
  - no background systematics



The Vela pulsar spectrum

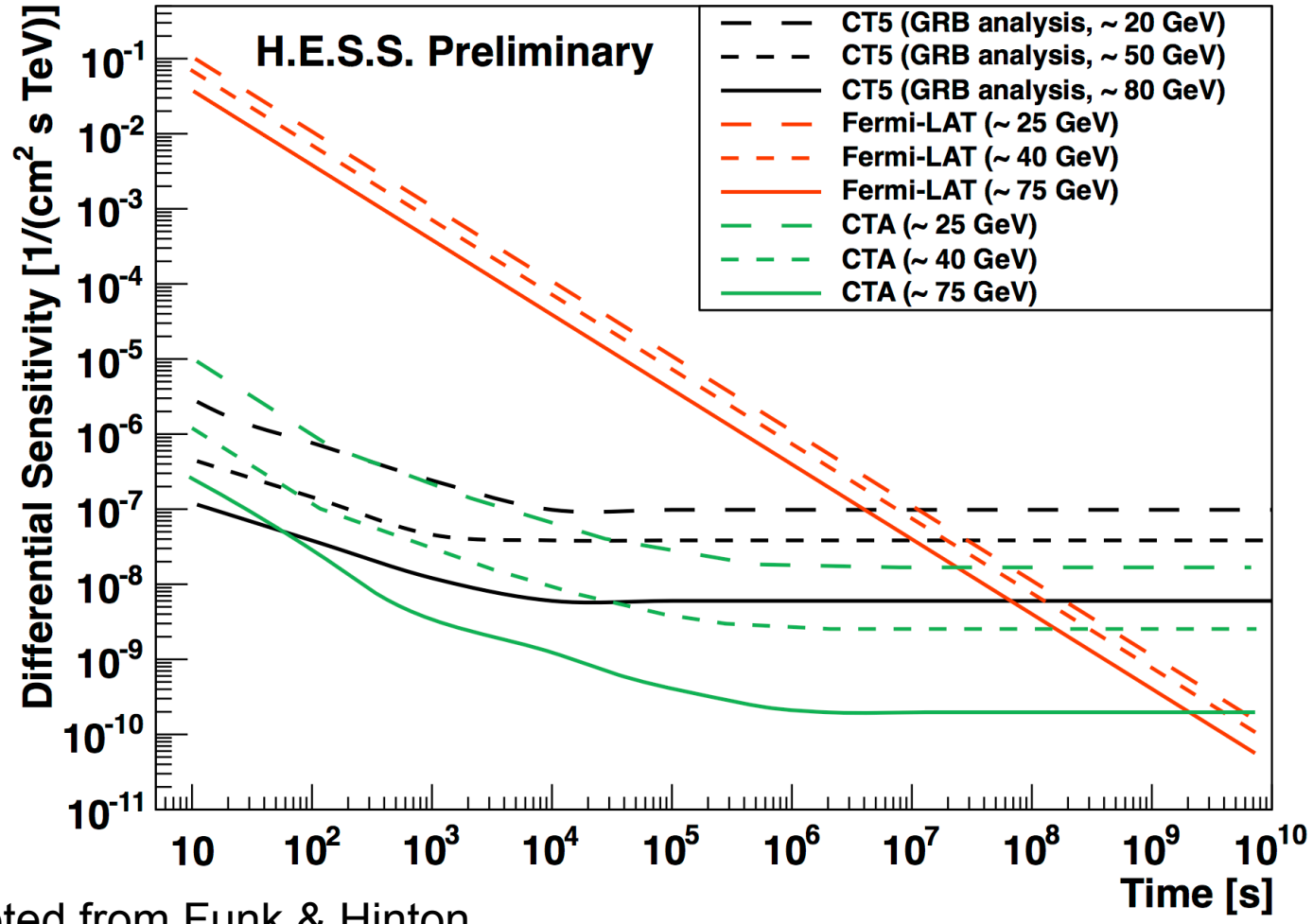


Transients with H.E.S.S. II



adapted from Funk & Hinton

Transients with H.E.S.S. II



adapted from Funk & Hinton