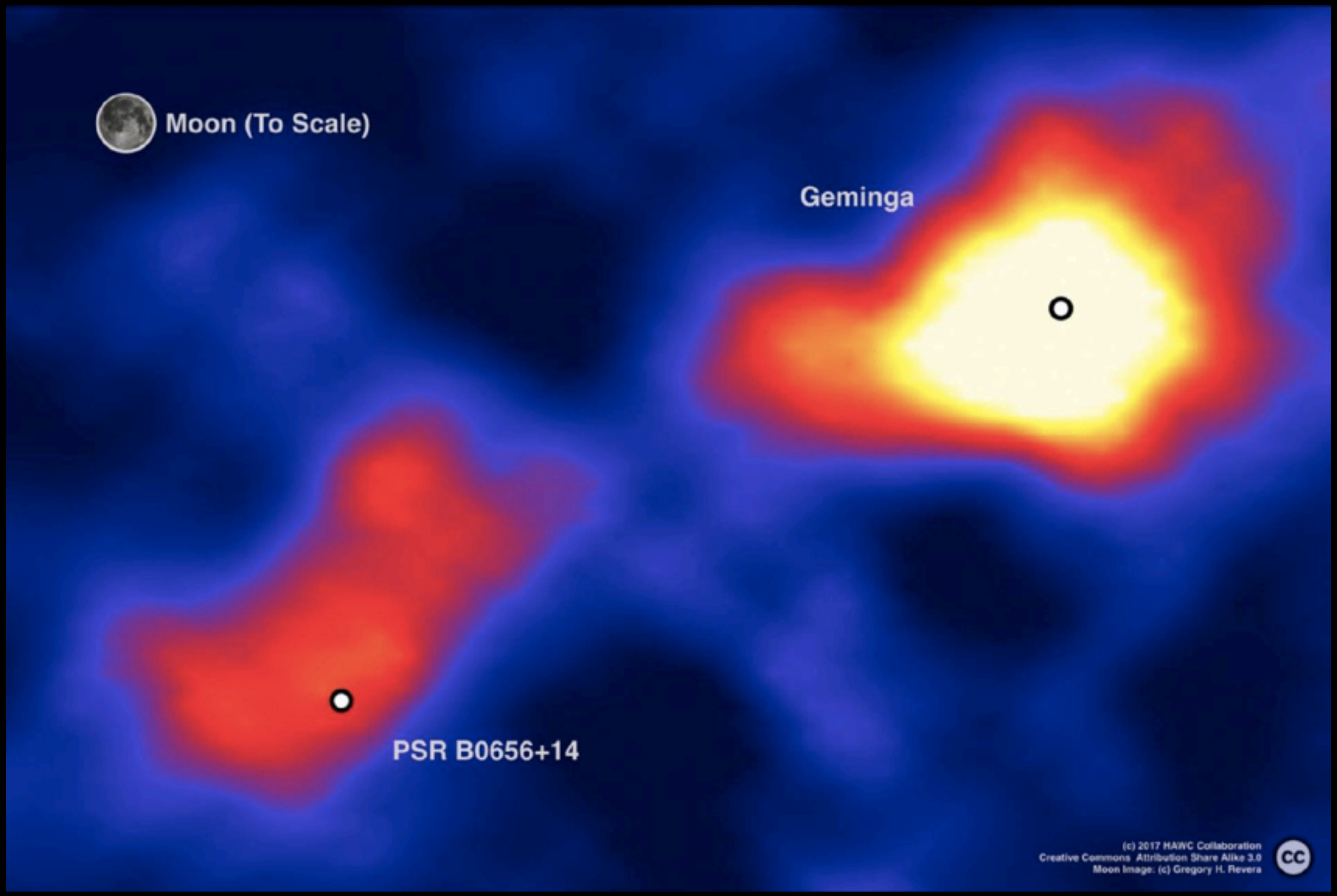


Science Case for Condor

Fabian Schüssler

Marcos Santander, Harm Schoorlemmer, et al.

Buenos Aires - December 2017

Status

- **Pre-Rochester**
  - Paper skeleton prepared by Miguel, Harm and Segev
- **Rochester**
  - focus on main science drivers vs. source classes
- **Saclay (Nov. 20-22)**
  - overview of science drivers
  - status of performance estimation
  - paper skeleton updated (e.g. science drivers, placeholder plots, etc.)

Science Case

Galactic

- PeVatrons
- Nearby pulsars (e+ flux)
- Extended sources and diffuse emission
- Monitoring of galactic sources (binaries, microquasars)

Extragalactic

- AGN (continuous monitoring => alerts)
- GRBs
- Isotropic background

Dark Matter & BSM

- dSph and halos
- Axions, ALPs
- LIV
- PBH

Multimessenger

- GW
- Neutrinos
- FRBs, optical transients
- correlations (e.g. AMON)

Cosmic ray

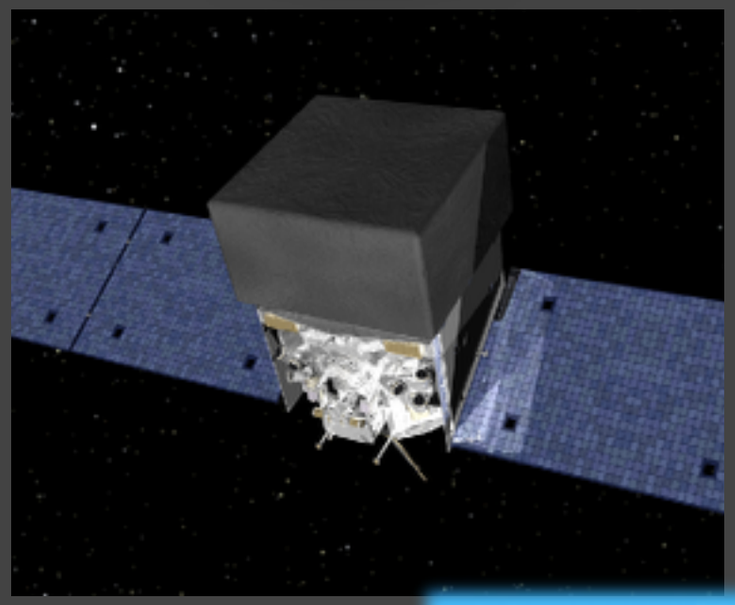
- Anisotropy
- Flux and composition
- Particle/antiparticle

Scientific drivers

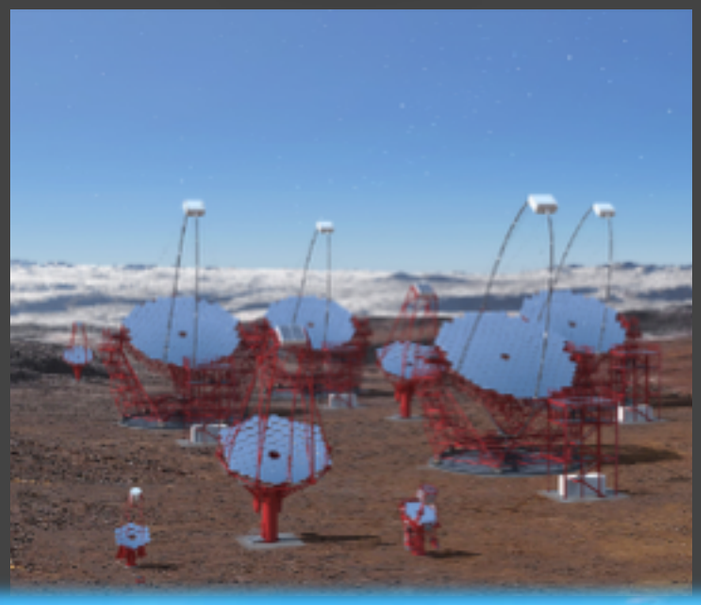
- **Studying Galactic Particle Accelerators**
  - PWN, SNRs, extended sources, Galactic Center region, cosmic ray measurements. Diffuse Galactic emission.
- **Monitoring the Transient Sky**
  - AGN, GRBs, FRBs, multi-messenger (nus and GWs), binaries
- **Probing physics beyond the SM**
  - Dark matter, LIV, Axions, PBH

Synergies with current and future instruments

Fermi

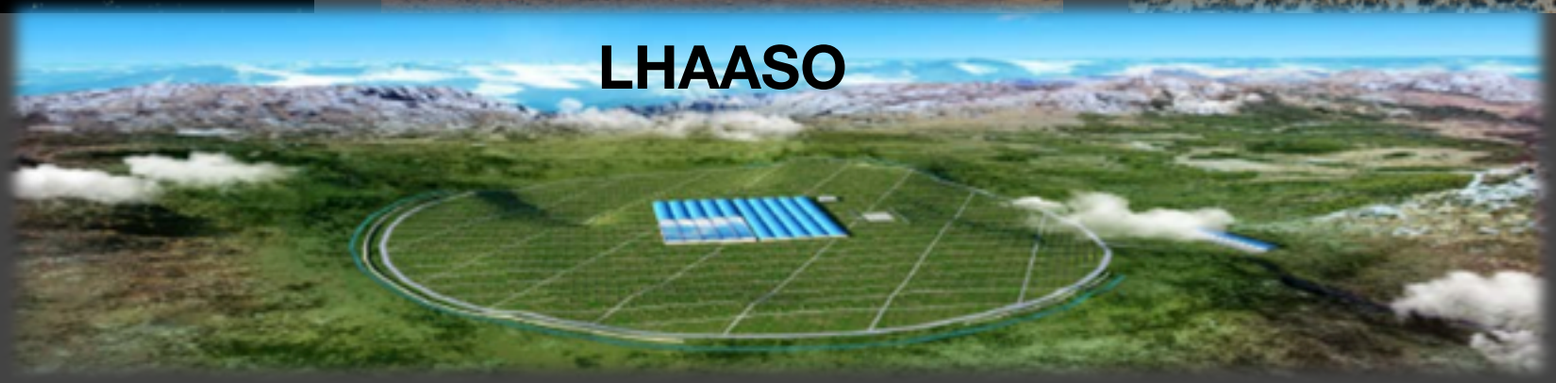


CTA



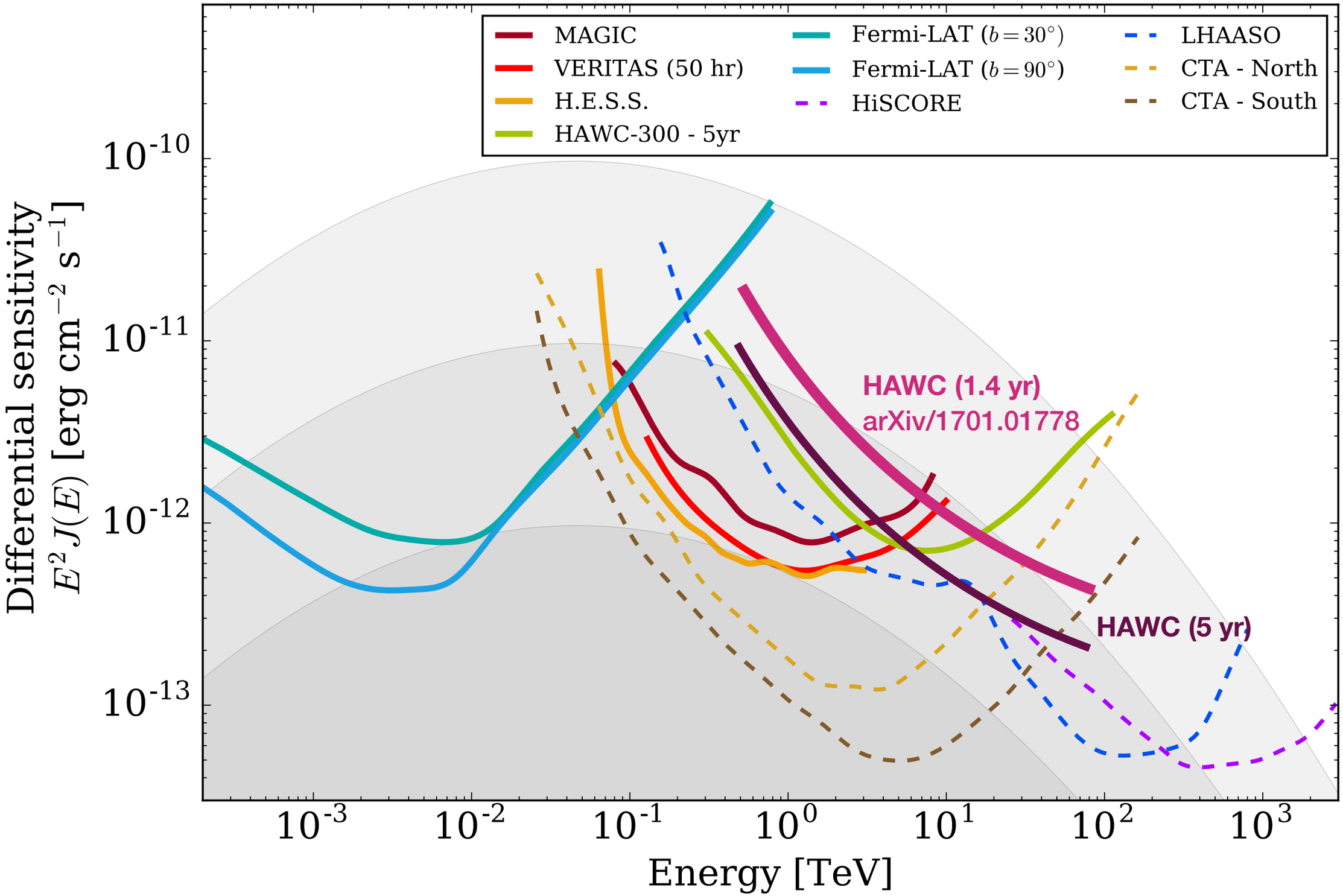
HAWC

LHAASO



- Define overlap with current and future instruments.
- Exploit advantages of SGSO (Southern sky, wide field, high duty cycle, lower Ethres <X00 GeV)
- Enables archival searches.
- What science can only (or better) be done with SGSO?

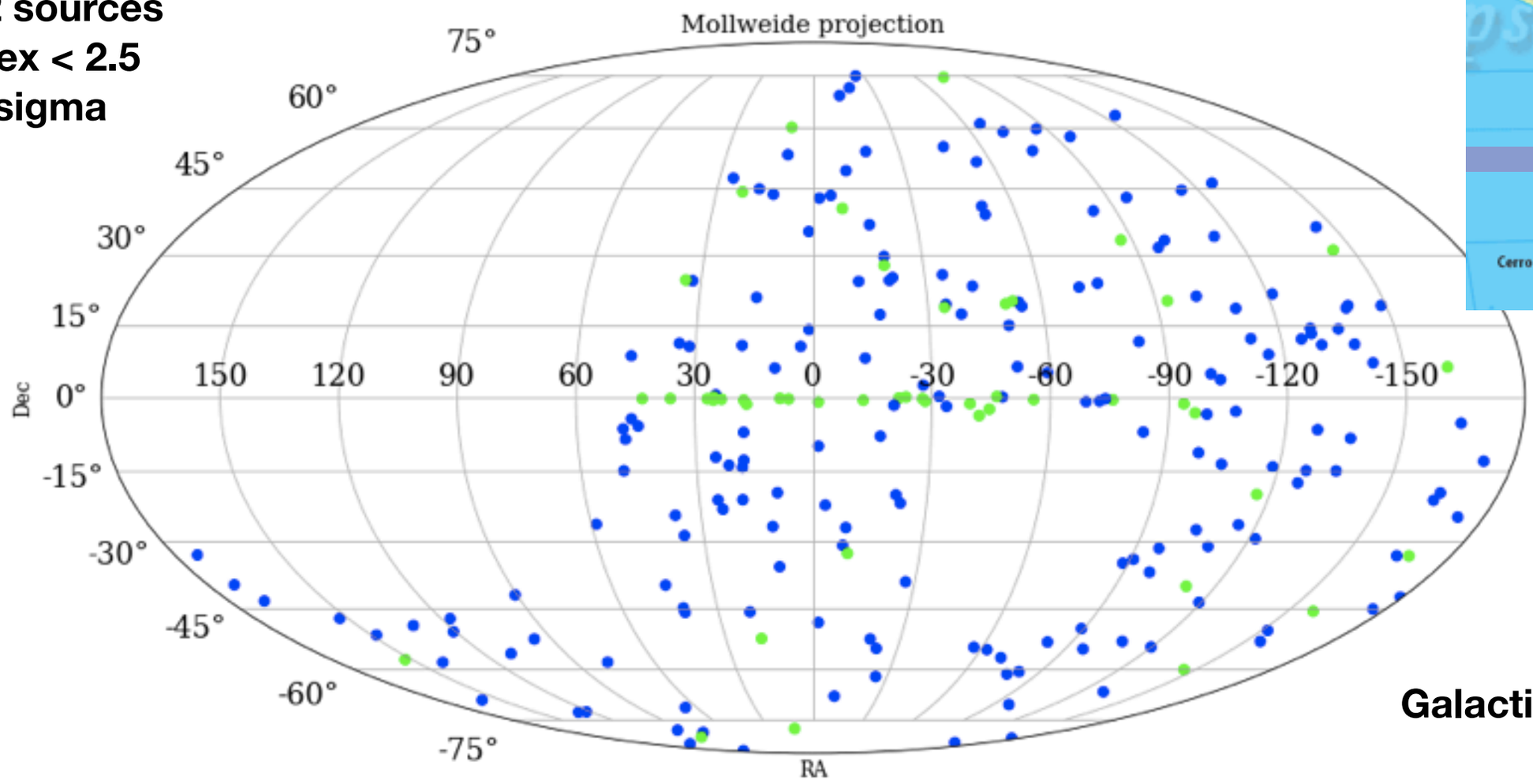
Gamma-ray sensitivities



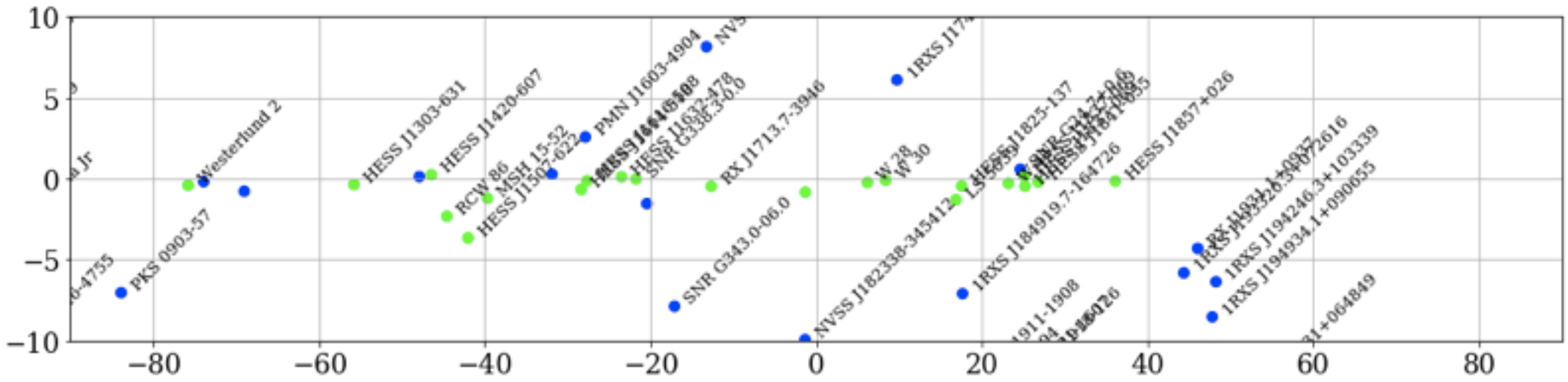
Southern >10 GeV sky (3FHL)

232 sources
Index < 2.5
>8 sigma

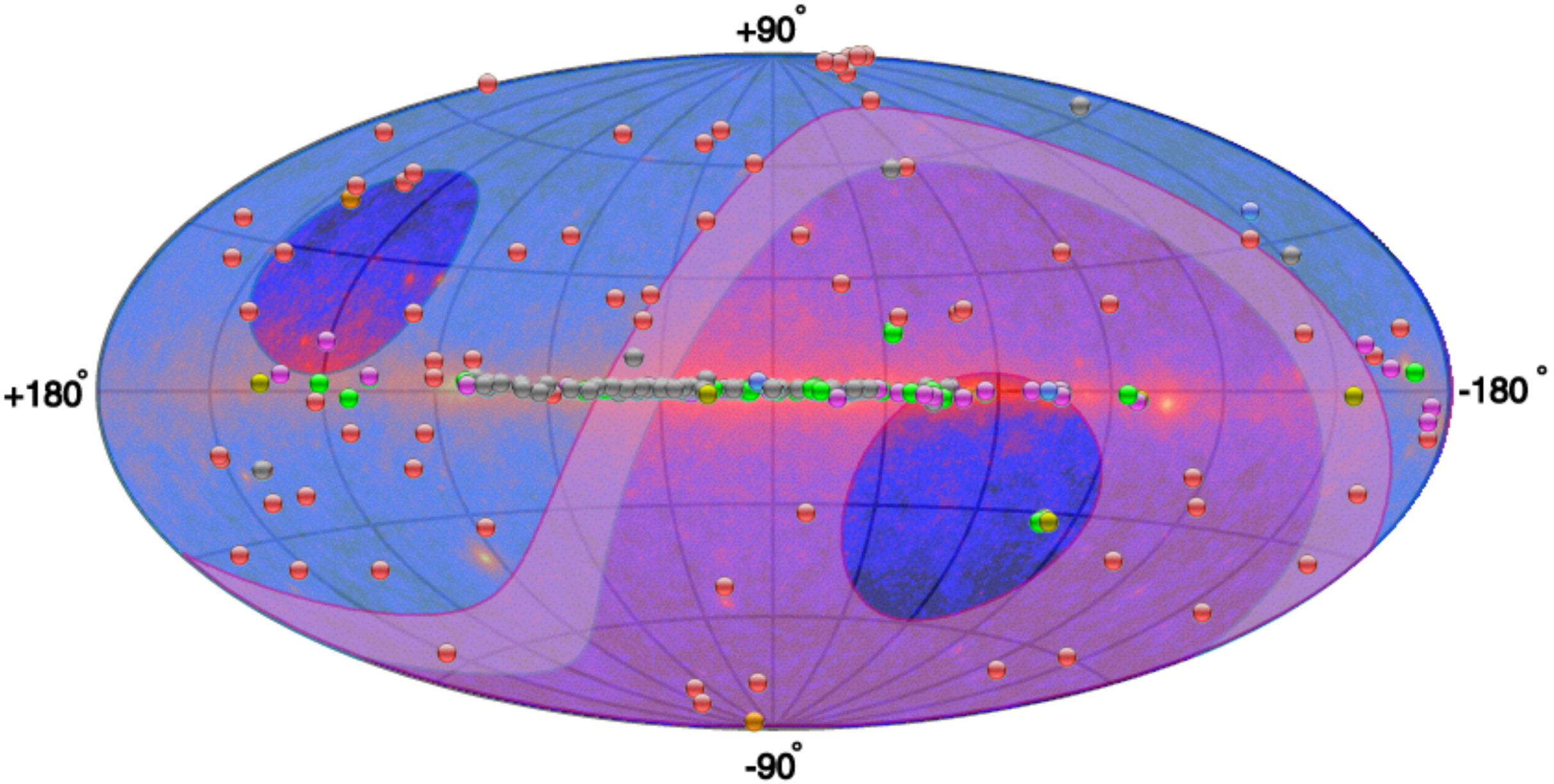
Detector at lat 25°S
40° zenith cut



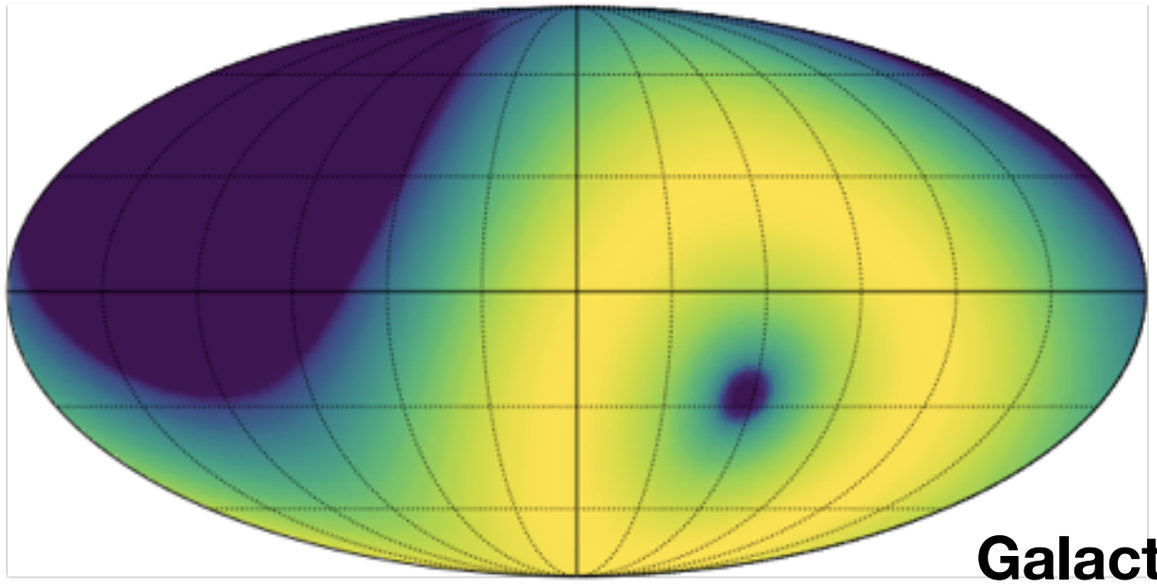
Galactic



Comparison with HAWC



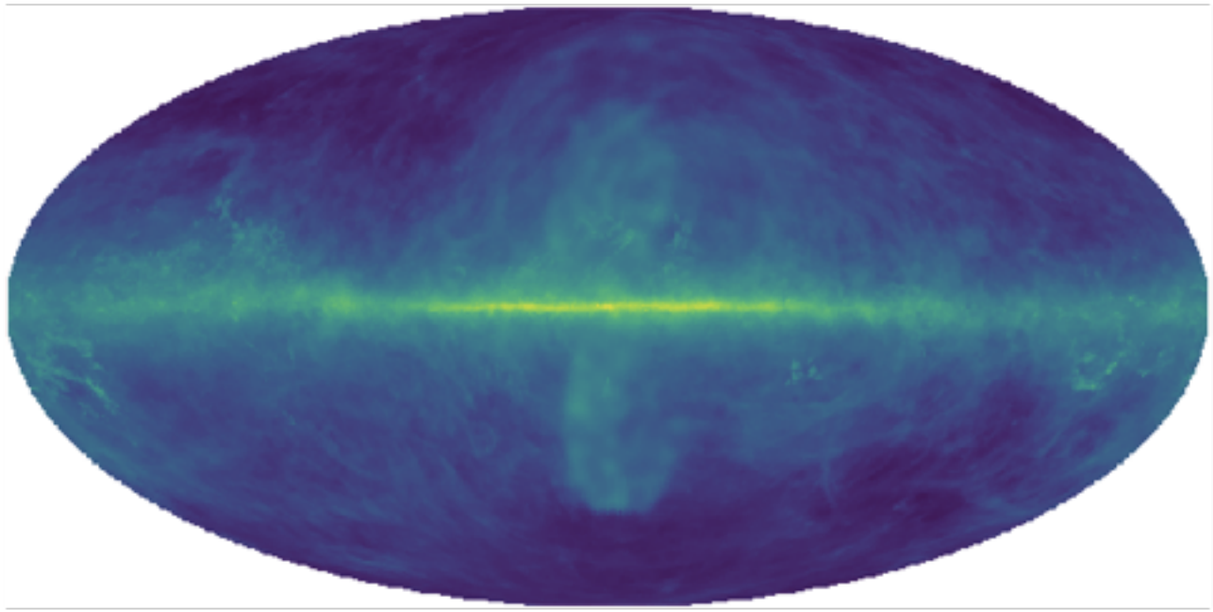
Galactic diffuse emission



0 27747.5

Exposure / day [s]

Galactic



-16.4538 -12.701

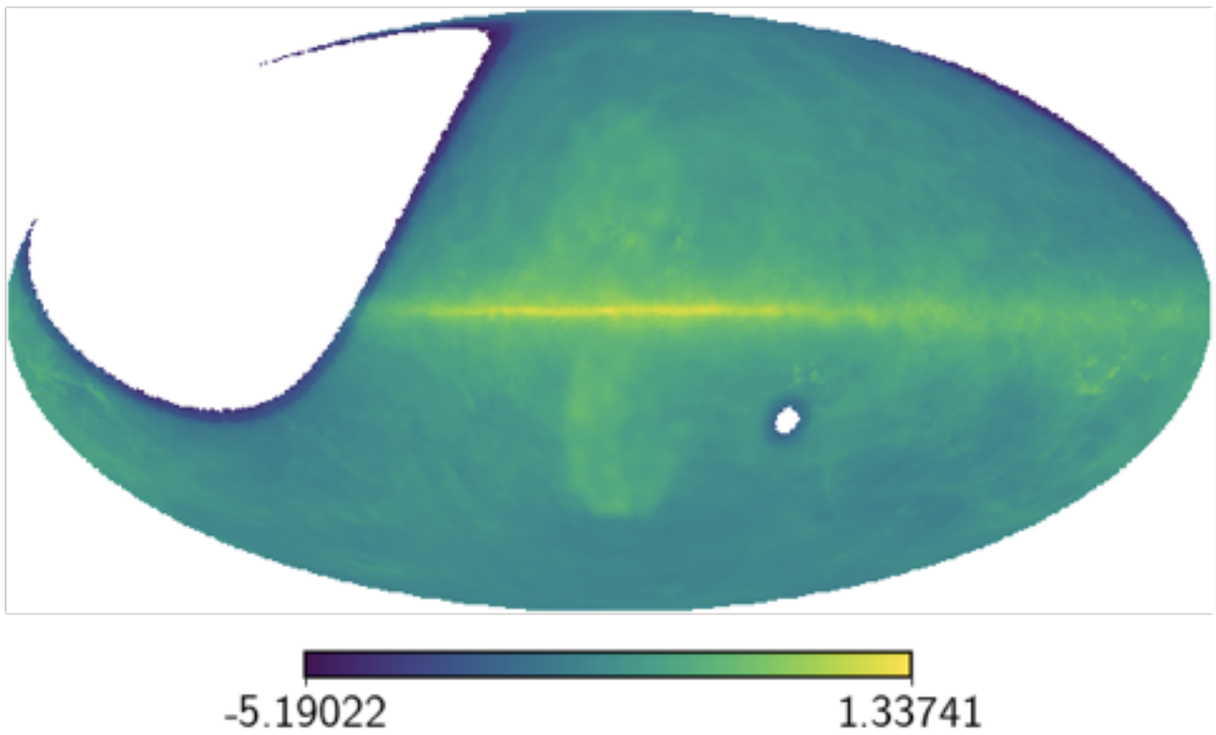
log F(E) [cm^{-2} s^{-1} sr^{-1} MeV^{-1}]

- Each sky position weighted by cos(zenith). Detector at -24.2 latitude.
- Only zenith < 60° allowed.

- Galactic diffuse emission at 523 GeV
- From Fermi IGM model

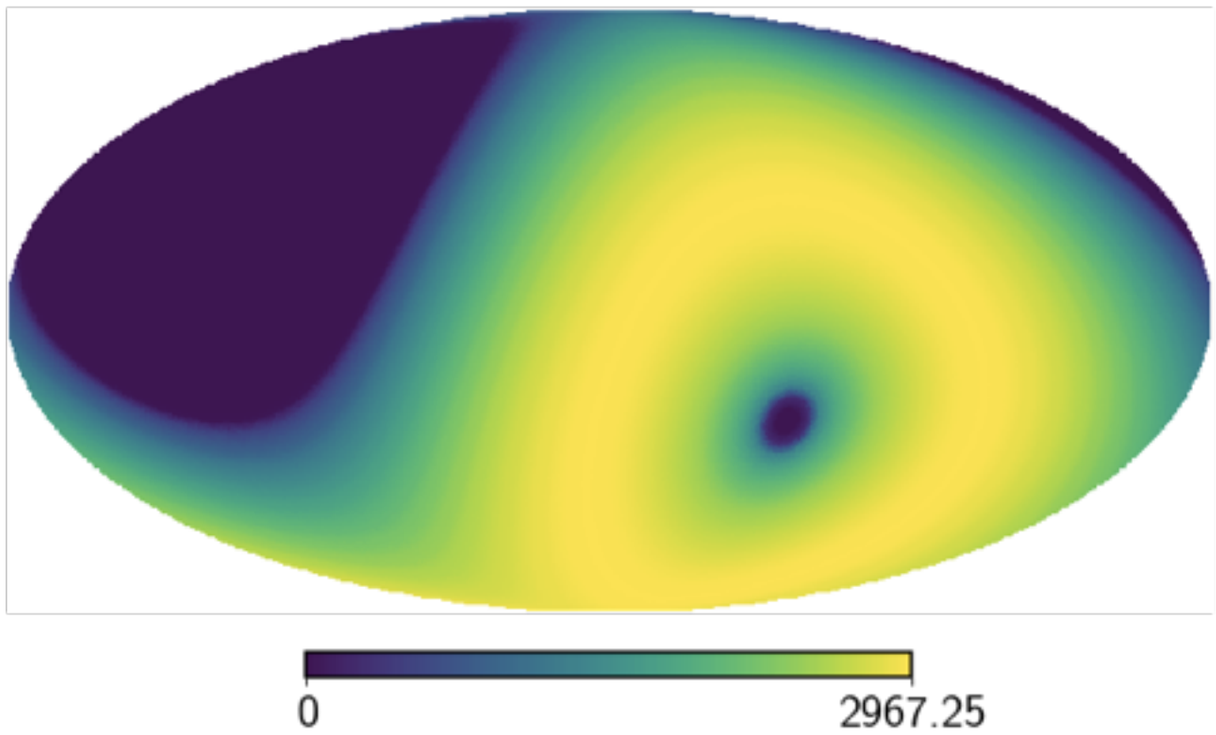
Galactic diffuse emission

Gammas



Log Counts/day

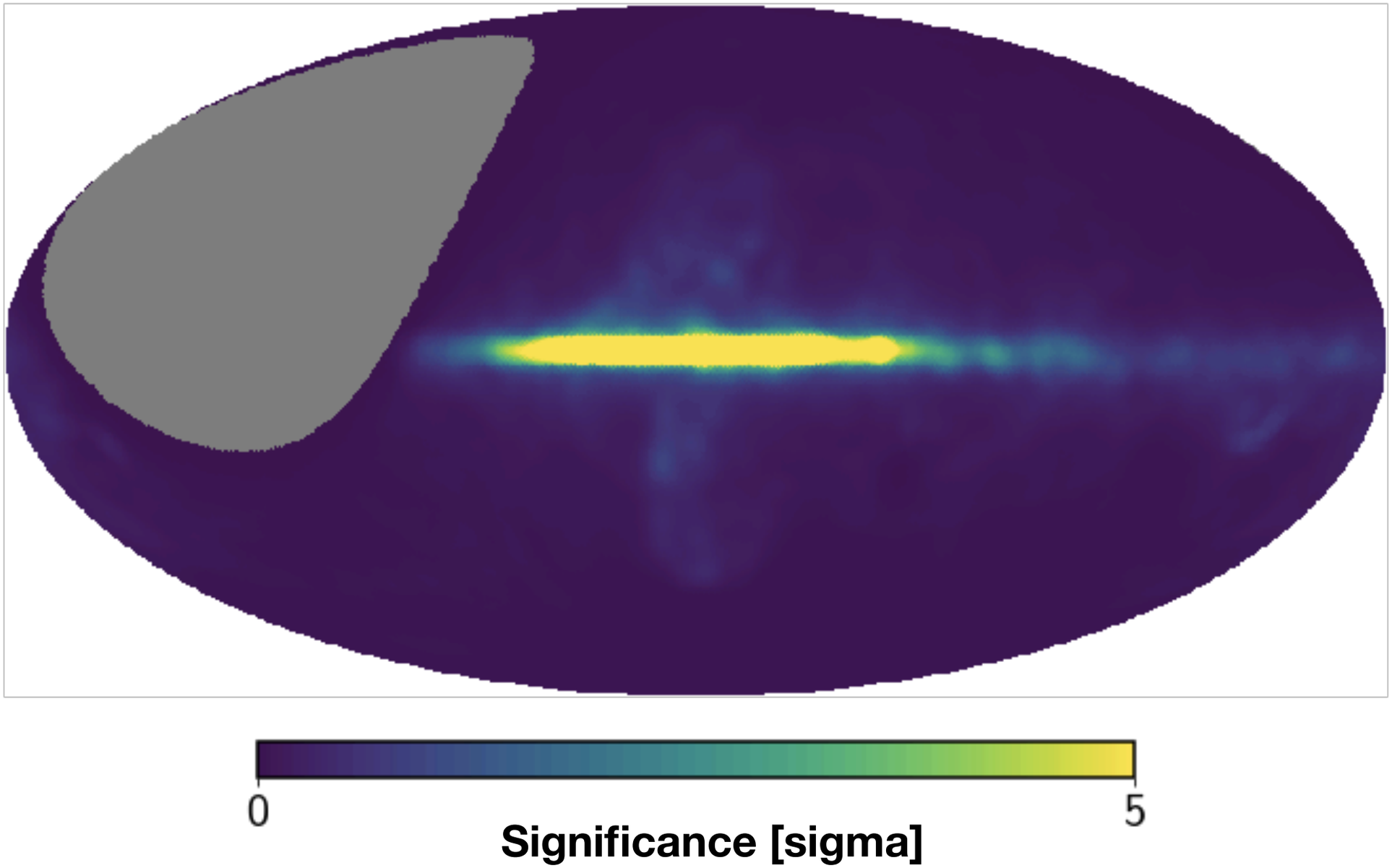
CRs



Counts/day

- Very simplistic (aka optimistic) assumptions, e.g. no zenith dependence of bkg rejection.
- No energy dependence of background and signal yet (all fluxes calculated at energy threshold).

Galactic diffuse emission (1 yr)

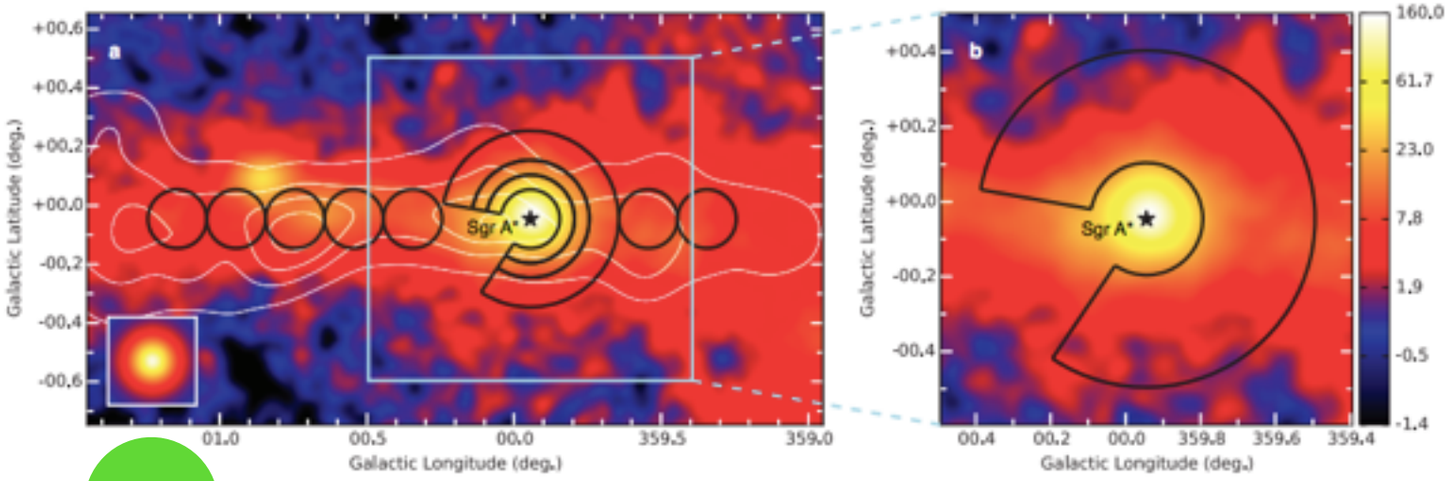


- 1 yr exposure with 3° smoothing. Perfect knowledge of the background level (S/sqrt(B))
- High significance observation of the inner-Galactic emission. Fermi bubbles evident and could be revealed in a dedicated analysis.

Properties of energetic particles in the Galaxy

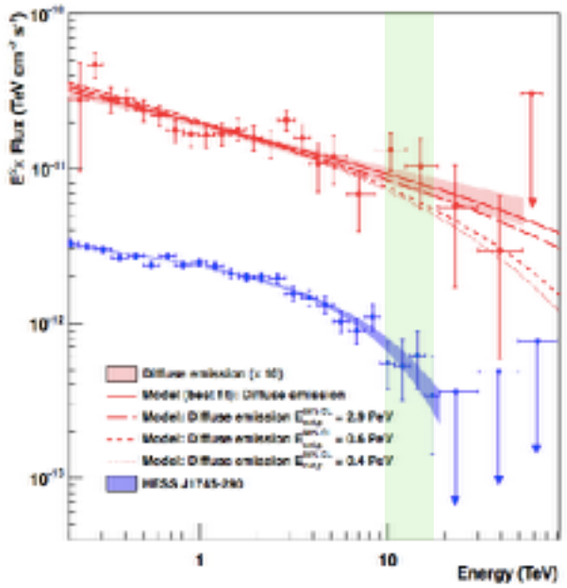
PeVatrons

Galactic Center region. Challenging resolution requirements (~ 0.1 deg) and competition from CTA.

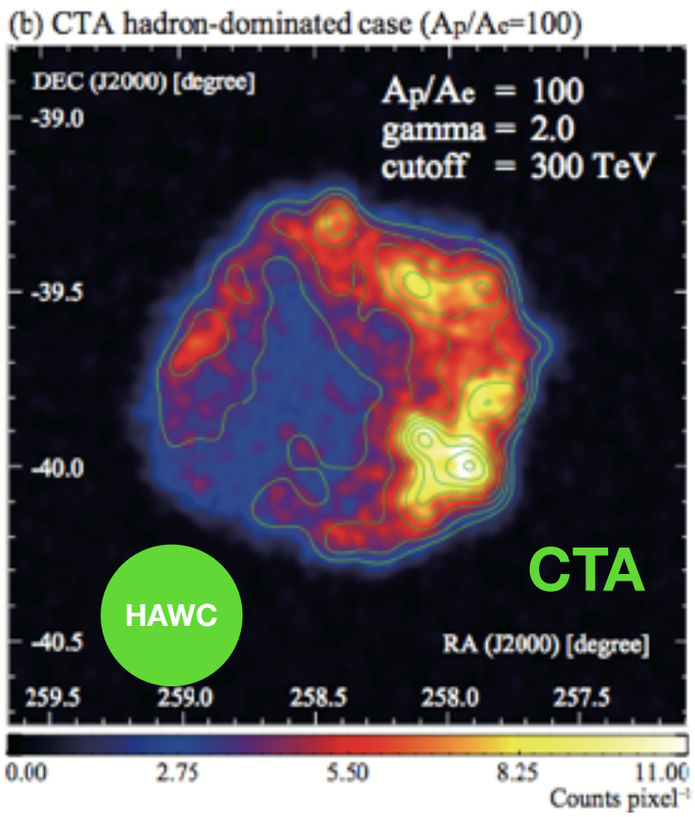


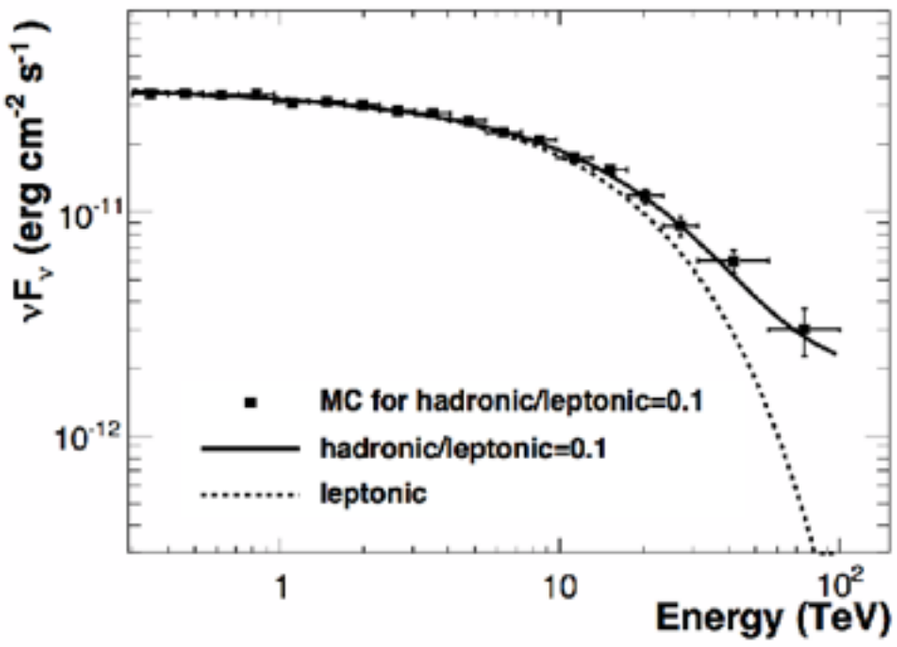
HAWC

@40 TeV



Source morphology - RX J1713.7-3946

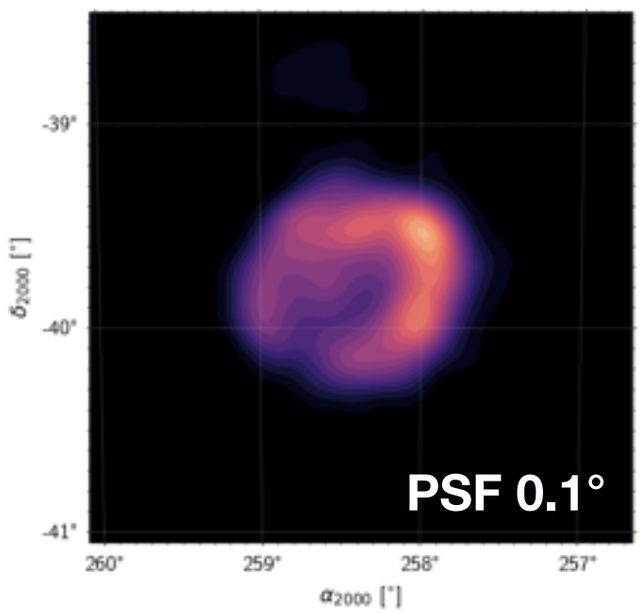


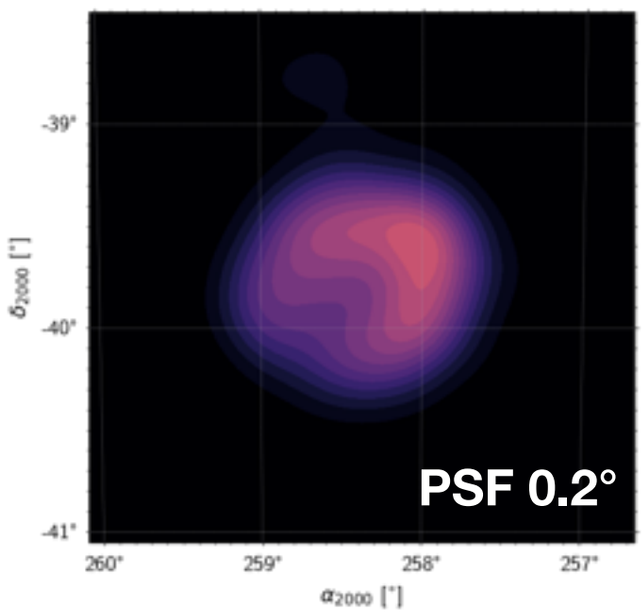


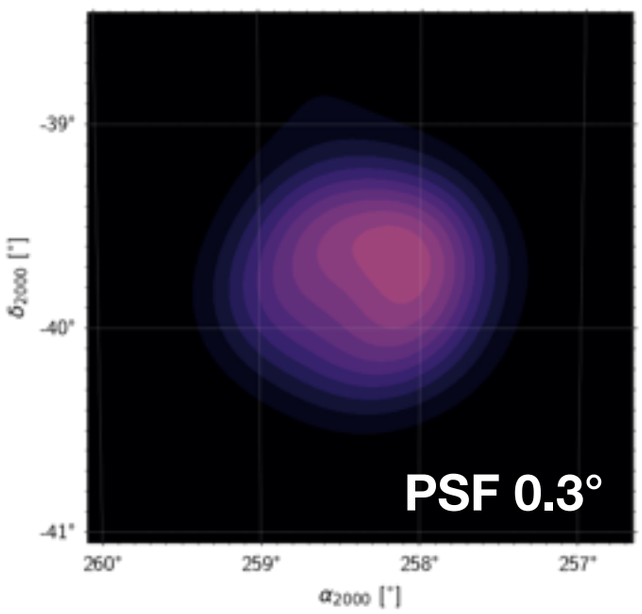
Effective area crucial at high E. Can be compensated with exposure.

Source confusion a critical issue. Advantage for very extended sources.

Spectral mapping possible starting at ang res < 0.2°



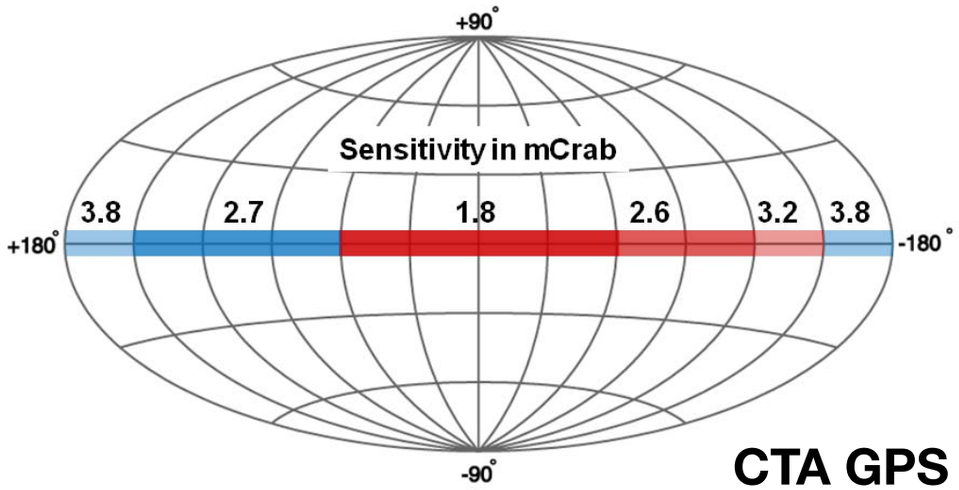




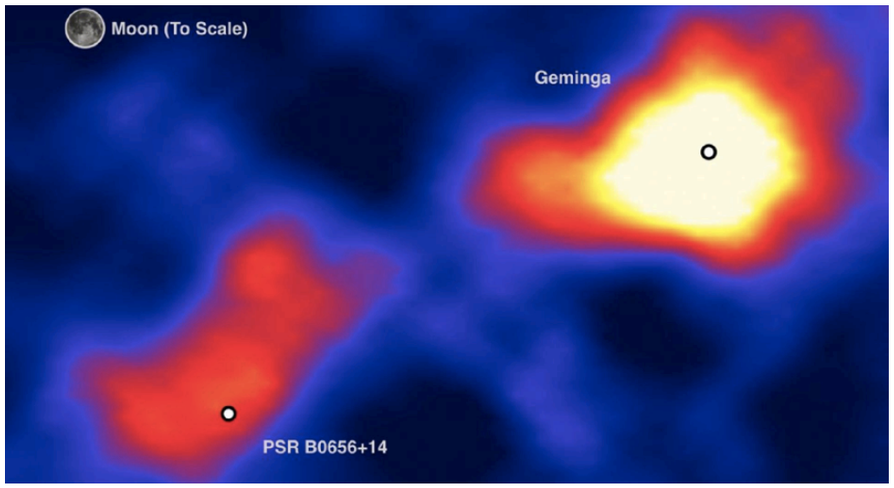
Properties of energetic particles in the Galaxy

- **Nearby pulsars ("Gemingas")**

  Very extended. Good target for SGSO. Constrain CR origin in the vicinity of the Sun. Implications for indirect DM searches. Vela complex? High galactic latitude? Connection with CTA GPS



CTA GPS



HAWC
arXiv/1711.06223

- **Microquasars and binaries:** Wide field survey but no detections from HAWC.
- **Cosmic rays**: Spectrum, anisotropy and composition. Secondary science driver. Correlation with IceCube/IceTop anisotropy.
- **Star-forming regions ("Cygnus")**: VHE emission, spatially extended. Neutrino sources? Already studies by HAWC, source confusion likely an issues.
- **Molecular clouds**: Extended, CR interactions. Flux prospects? MWL information needed
- **LMC/SMC**: Interesting, but perhaps weak to be observed by SGSO (sensitivity)
- **Fermi bubbles**: Very extended emission

Properties of energetic particles in the Galaxy

- **Nearby pulsars ("Gemingas")**

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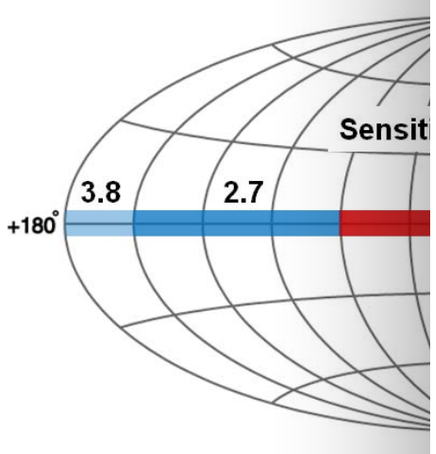
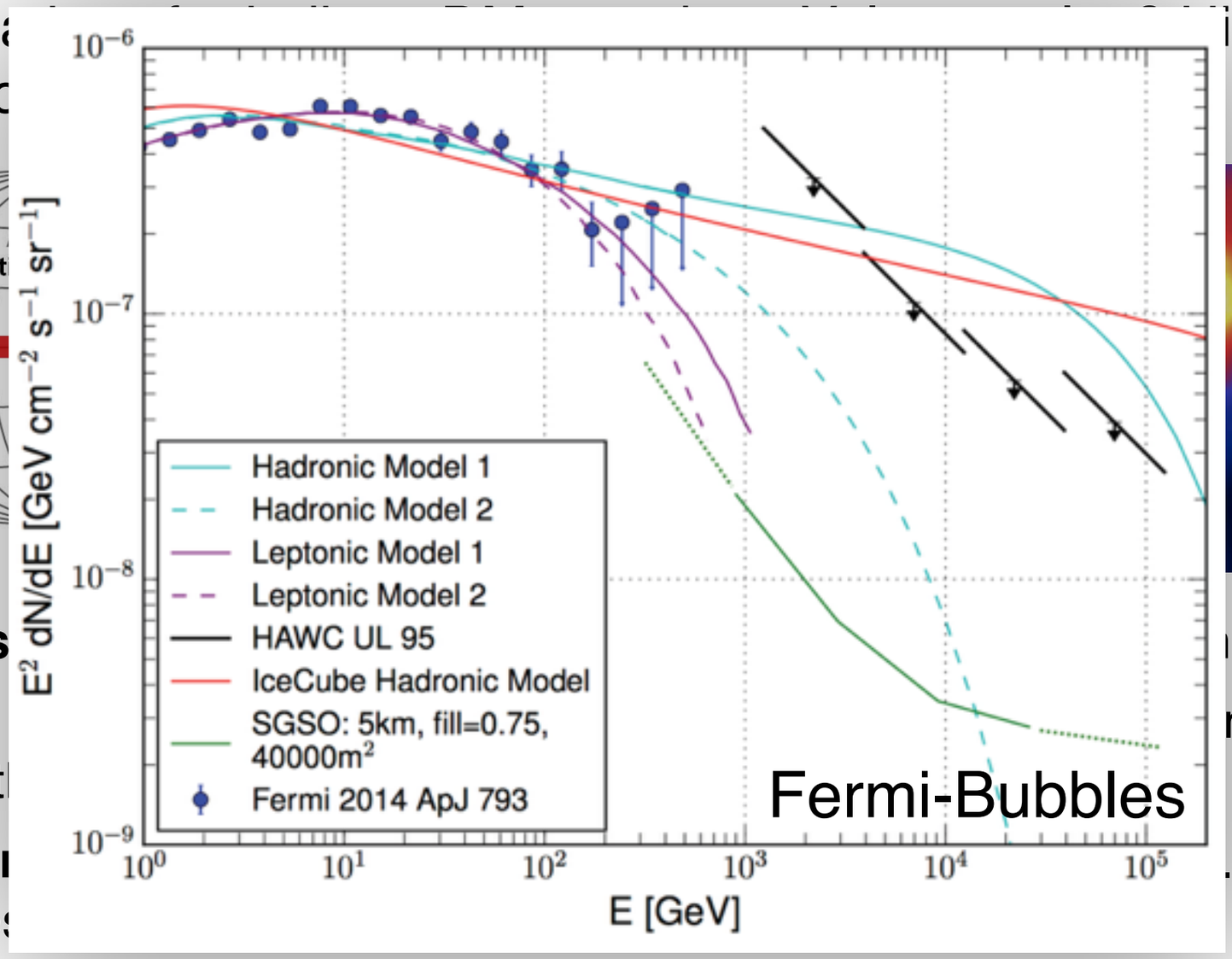


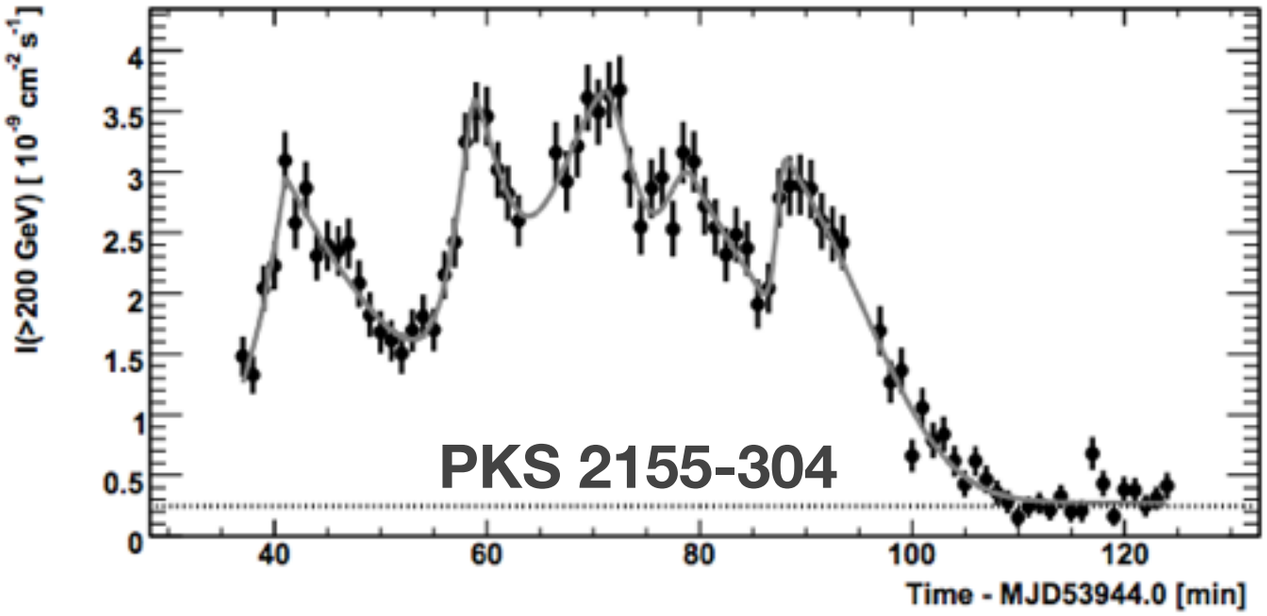


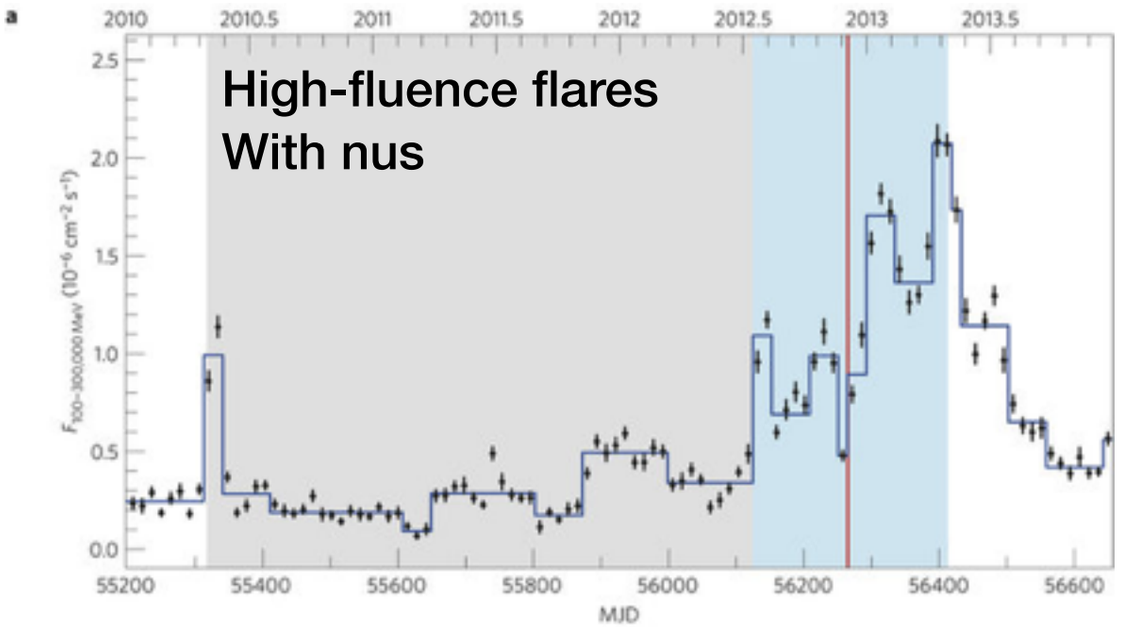
HAWC
arXiv/1711.06223

- **Microquasars** … HAWC.
- **Cosmic rays**: … nce driver. Correlation wit…
- **Star-forming r…** … Neutrino sources? Already studie…
- **Molecular clouds**: Extended, CR interactions. Flux prospects? MWL information needed
- **LMC/SMC**: Interesting, but perhaps weak to be observed by SGSO (sensitivity)
- **Fermi bubbles**: Very extended emission

Monitoring the transient sky

- **AGN:** Capabilities depend on low energy threshold. Continuous monitoring of sources, flare monitor for CTA, correlation with neutrinos. Source populations at VHE. X-gal bkg?

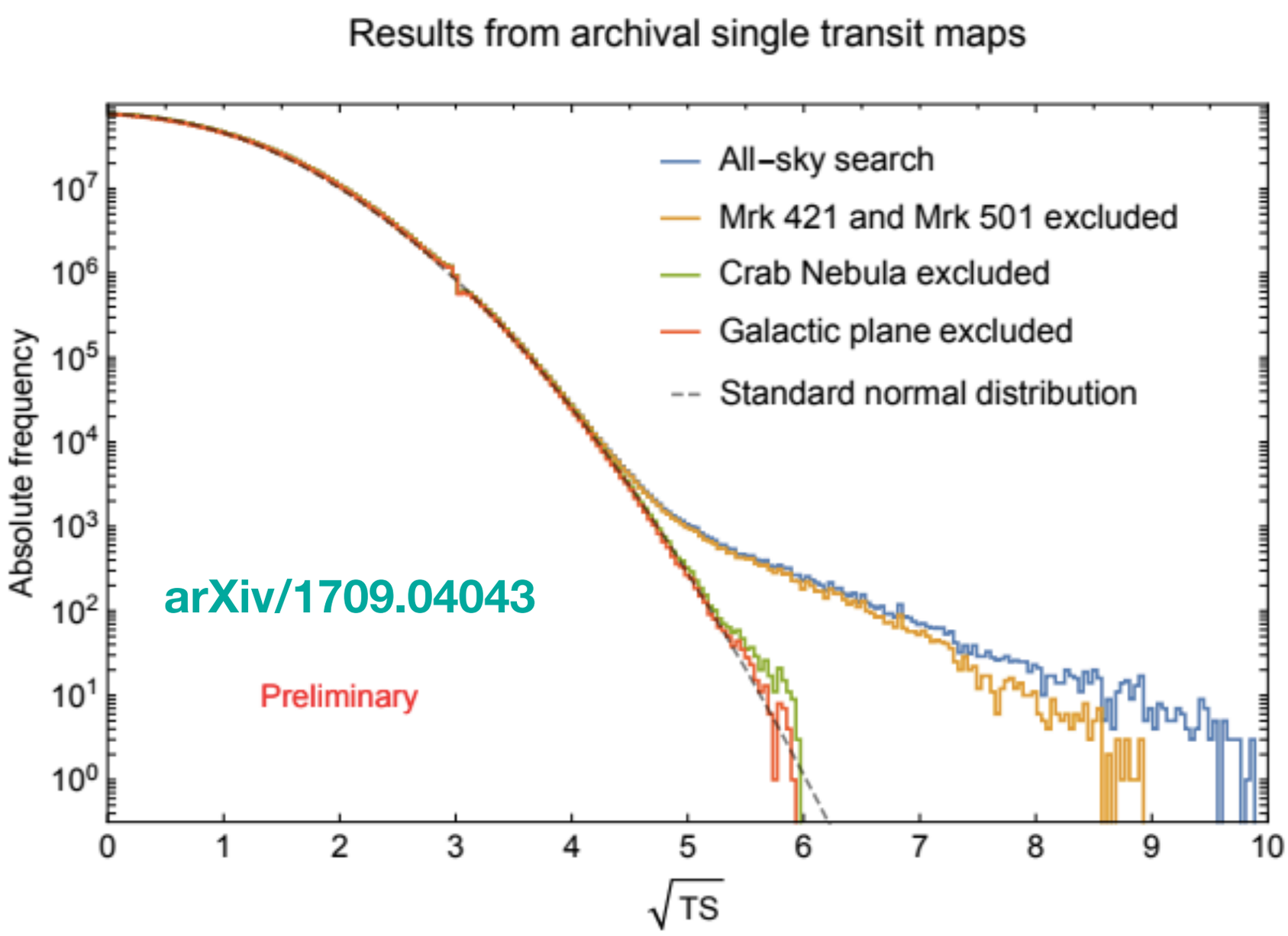




- **GRB:** Wide field and high duty cycle are advantages. What can we learn that is not provided by HAWC or CTA? Sensitivity requirements? GW connection.
- **FRB**: Good example of things that can be studied in archival data.

Monitoring the transient sky

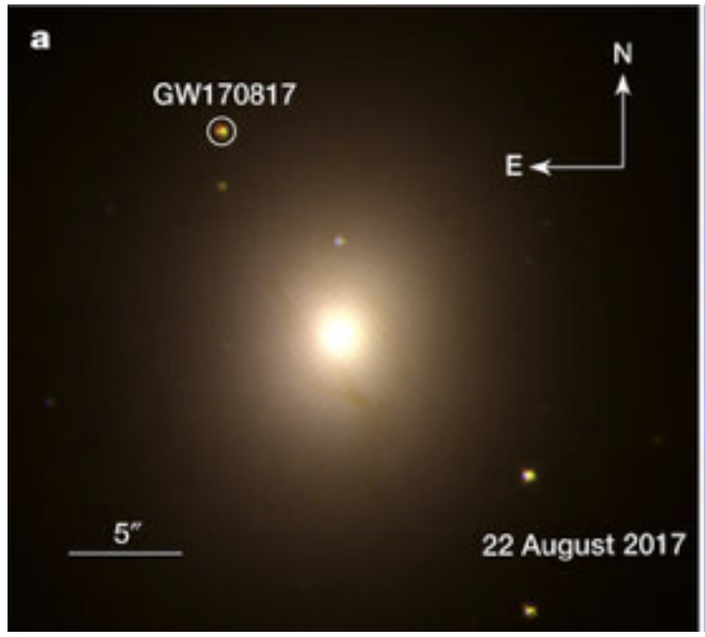
What have we learned from HAWC?

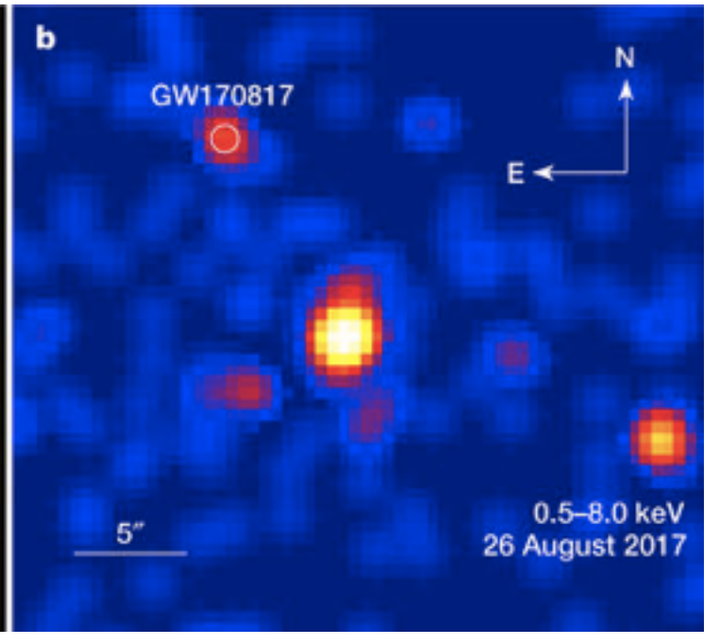


- **HAWC has only detected 2 extragalactic sources.**
- Need to improve fluence sensitivity of the instrument to be competitive.

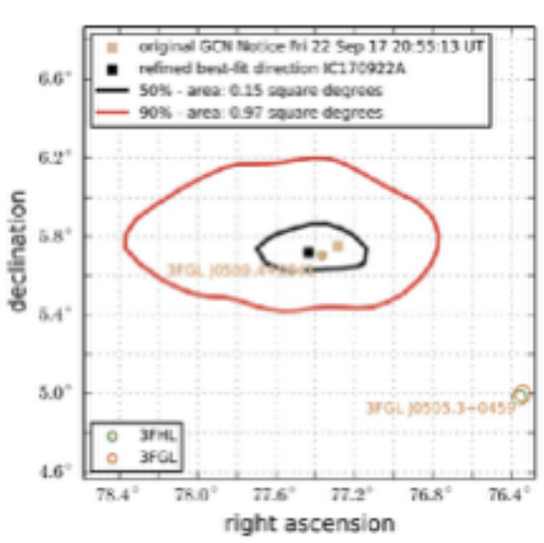
Monitoring the transient sky

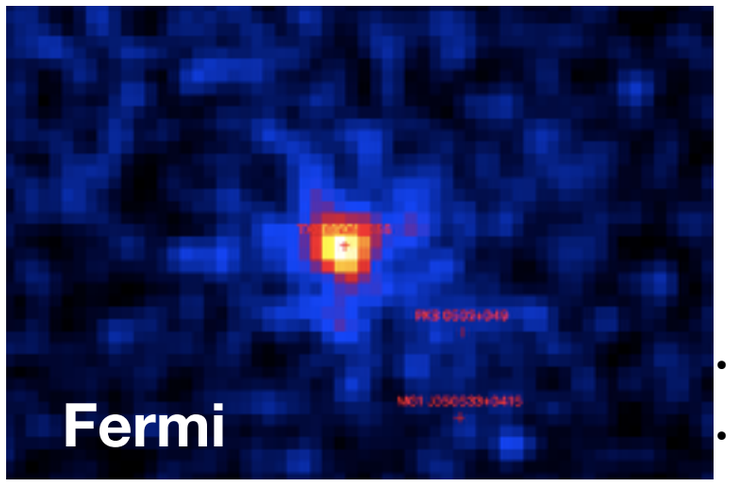
- **GW:** Wide field and large uncertainty regions. Detection of EM counterpart makes this very relevant. Fluence sensitivity crucial ingredient.

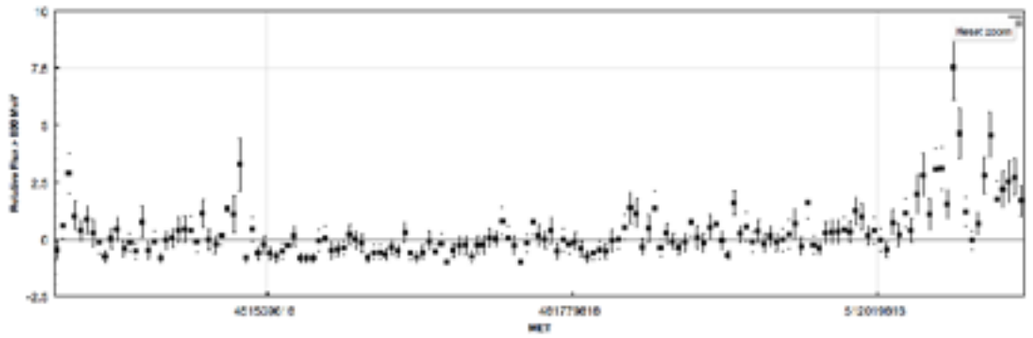




- **Neutrinos:** Recent detection of a HE IceCube neutrino in coincidence with a blazar is a strong motivation for neutrino follow-up in the south.







- Low energy threshold vital.
- Fluence sensitivity.

Probing physics beyond the SM

- **Dark matter halos and dSphs**: peaked profiles favor CTA but new discoveries favor archival searches. GC limit probably not competitive with CTA.
- **Lorentz Invariance Violation**: limits on photon decay from HE photons. Already done by HAWC? Perhaps higher flux from GC not visible from HAWC.
- **Axions and ALPs:** alternative to WIMPs. Secondary science topic given the competition. Strong constraints from HESS.
- **Primordial Black Holes:** Hawking radiation from BH evaporation. Can we learn something that has not been done in HAWC?

Key ingredients to assess the science reach

All parameters as function of energy

- Effective area
- Angular resolution
- Background rejection
- Energy resolution
- Zenith dependence of sensitivity and energy threshold
- *-> Fluence sensitivity*

Next steps

- Based on instrument response functions and background rates start working on science prospects:
  - Spectral measurements of certain sources (3FHL and 2HWC catalogs)
  - Sensitivity to AGN variability
  - Sensitivity in very short time windows to GRBs, Multimessenger, etc.
- Provide feedback to specifications to improve science performance.