Summer conferences 2016

- **6th International Symposium on High-Energy Gamma-Ray Astronomy (Gamma2016)**

Fabian Schüssler

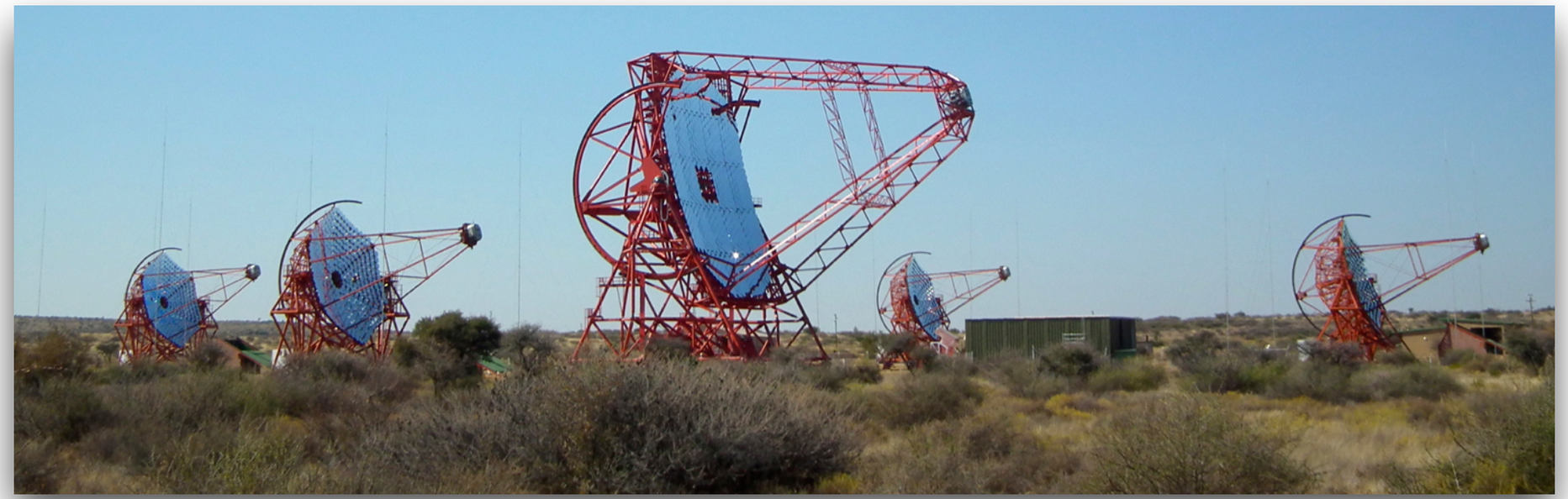
GAMMA 2016

- ”emphasis on the high (GeV) and very high (TeV) energy intervals of the electromagnetic spectrum”
- every 4 years in Heidelberg/Germany

Observatories: Imaging Air Cherenkov Telescopes

VERITAS

MAGIC



H.E.S.S.

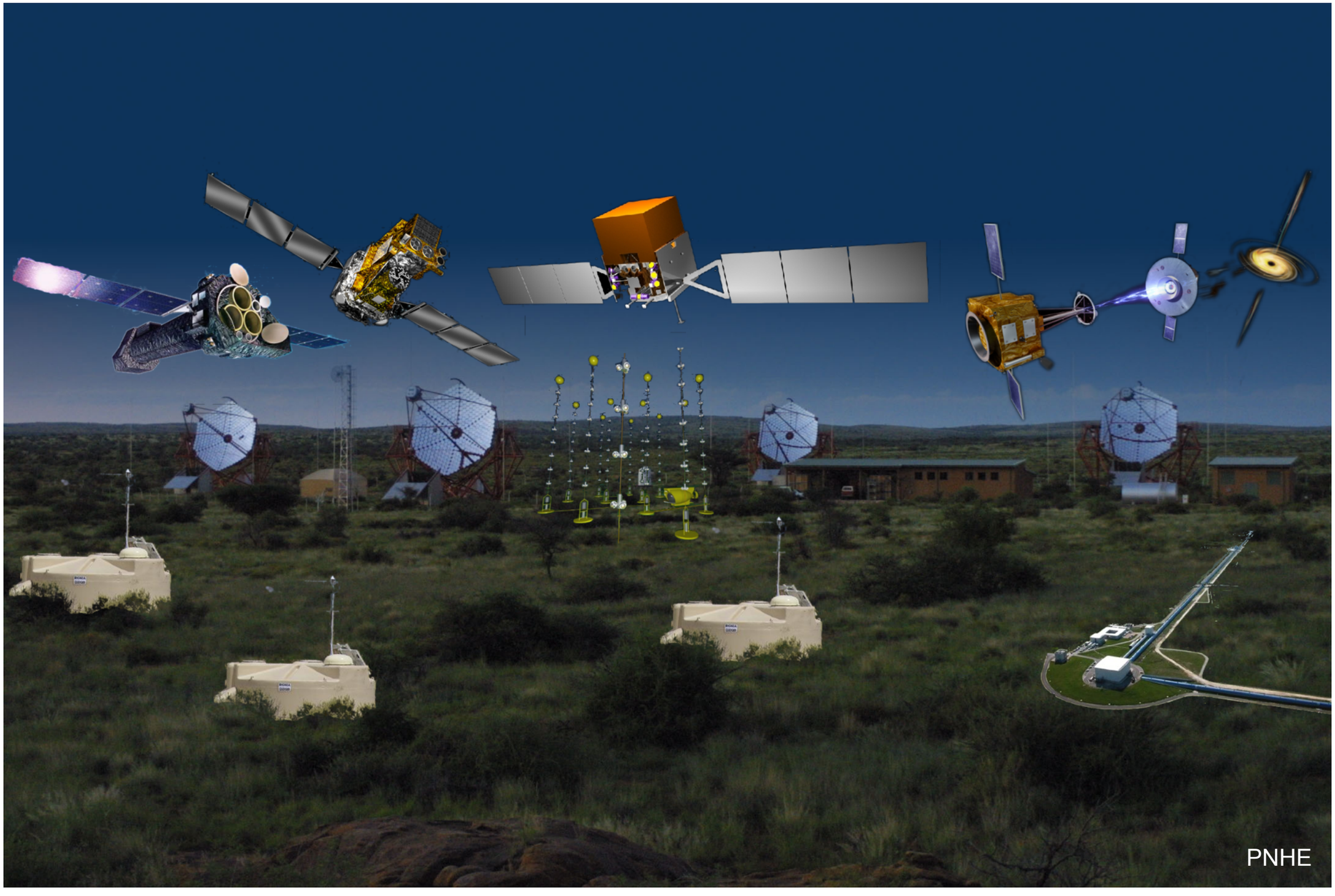
Observatories: Monitoring instruments

Fermi-LAT

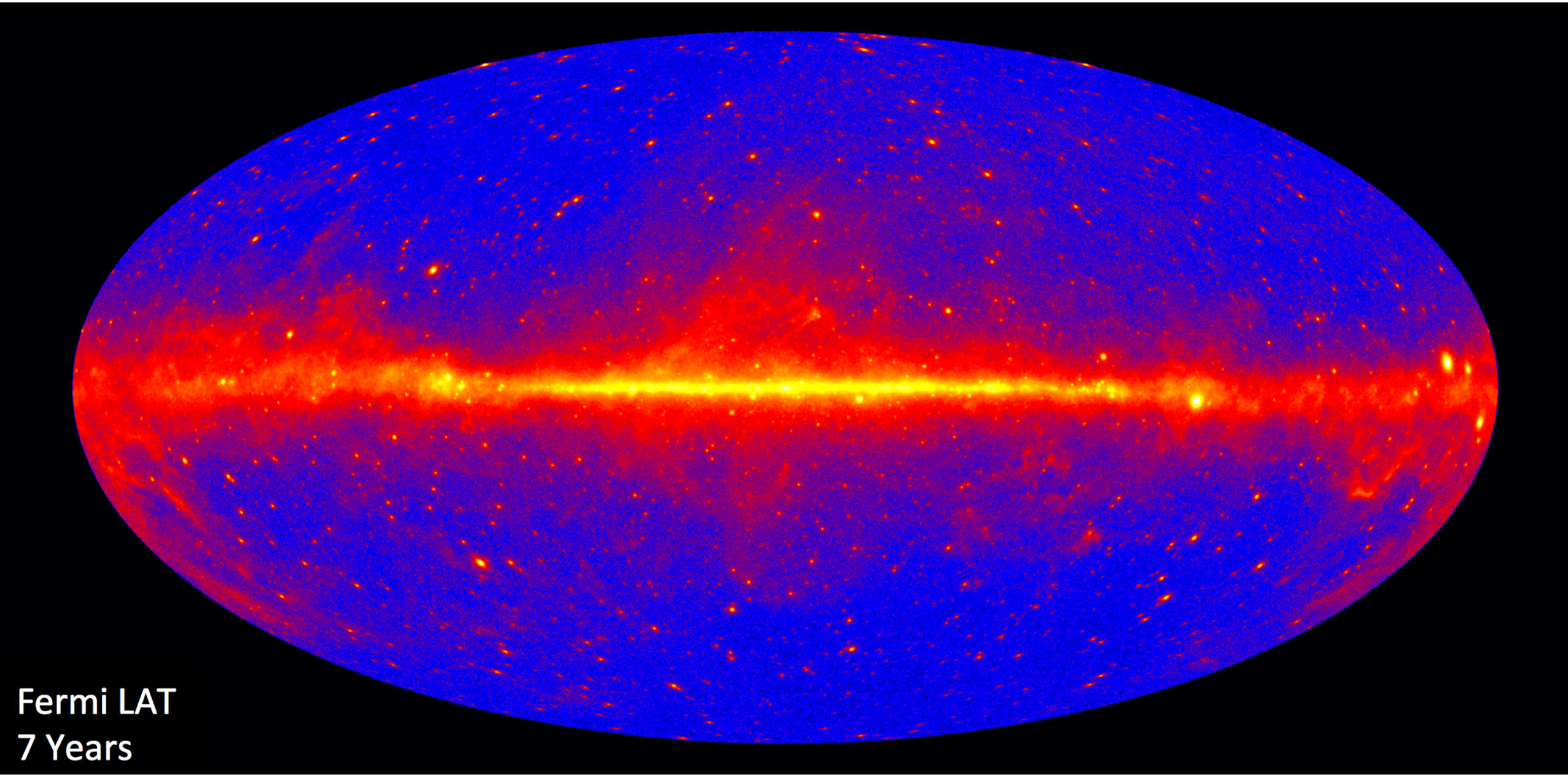
FACT

HAWC

Multi-wavelength and multi-messenger connections



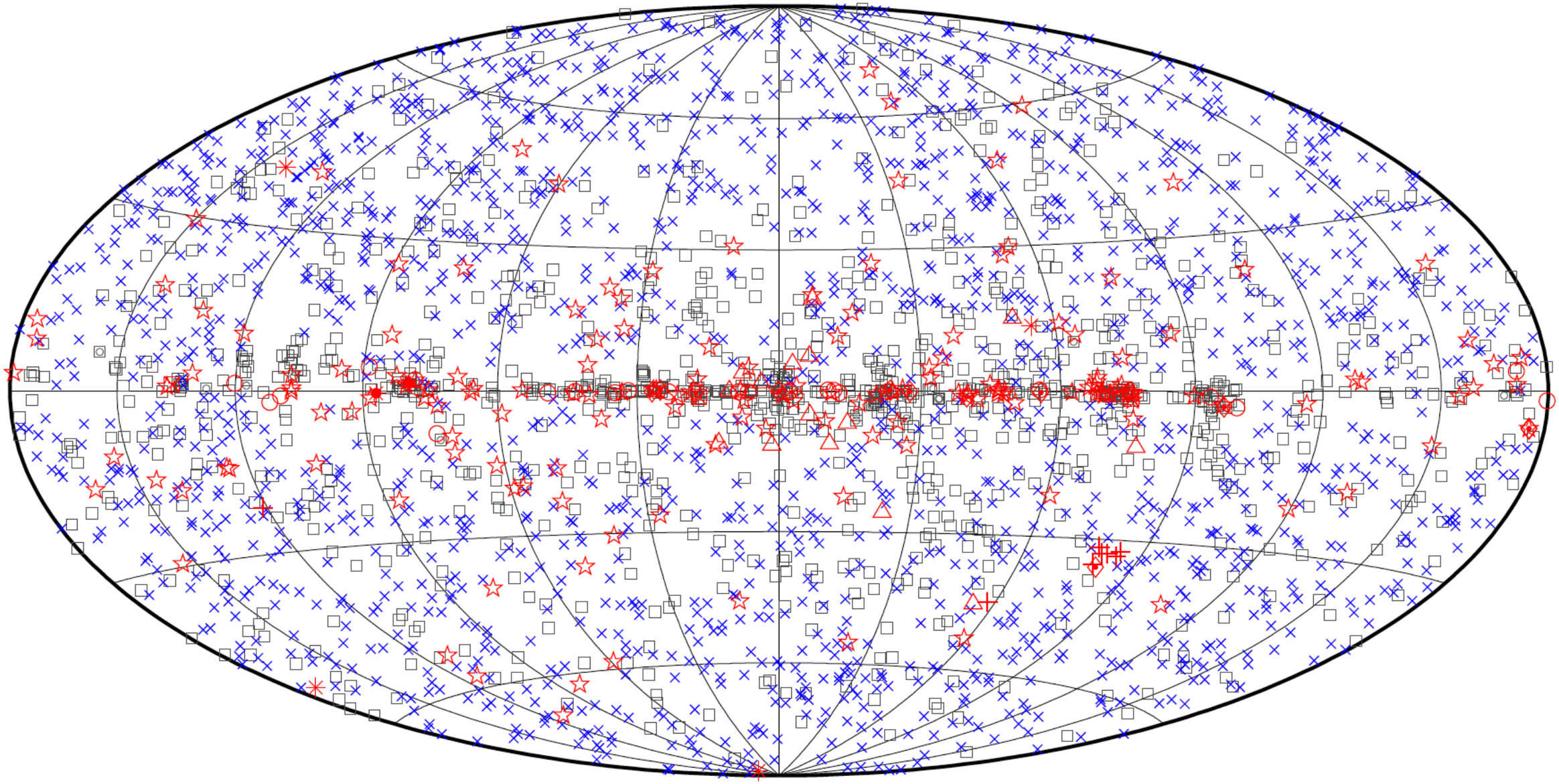
High-Energy Gamma-Ray sources



E. Hays

High-Energy Gamma-Ray sources

4yrs of data
3033 sources

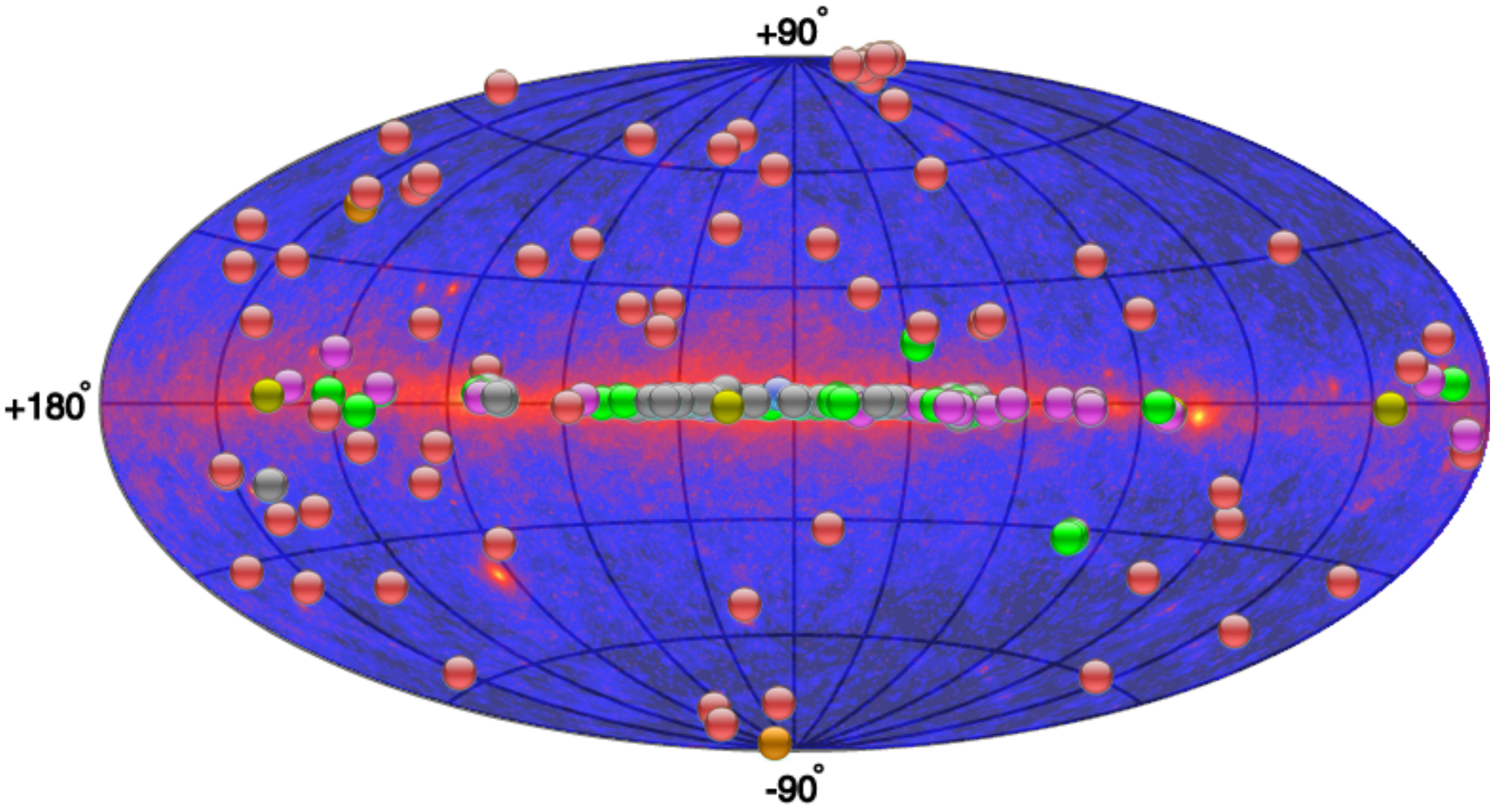


No association	Possible association with SNR or PWN		AGN
Pulsar	Globular cluster	Starburst Galaxy	PWN
Binary	Galaxy	SNR	Nova
Star–forming region			

Fermi-LAT, APJ 2015

Very High-Energy Gamma-Ray sources

177 sources

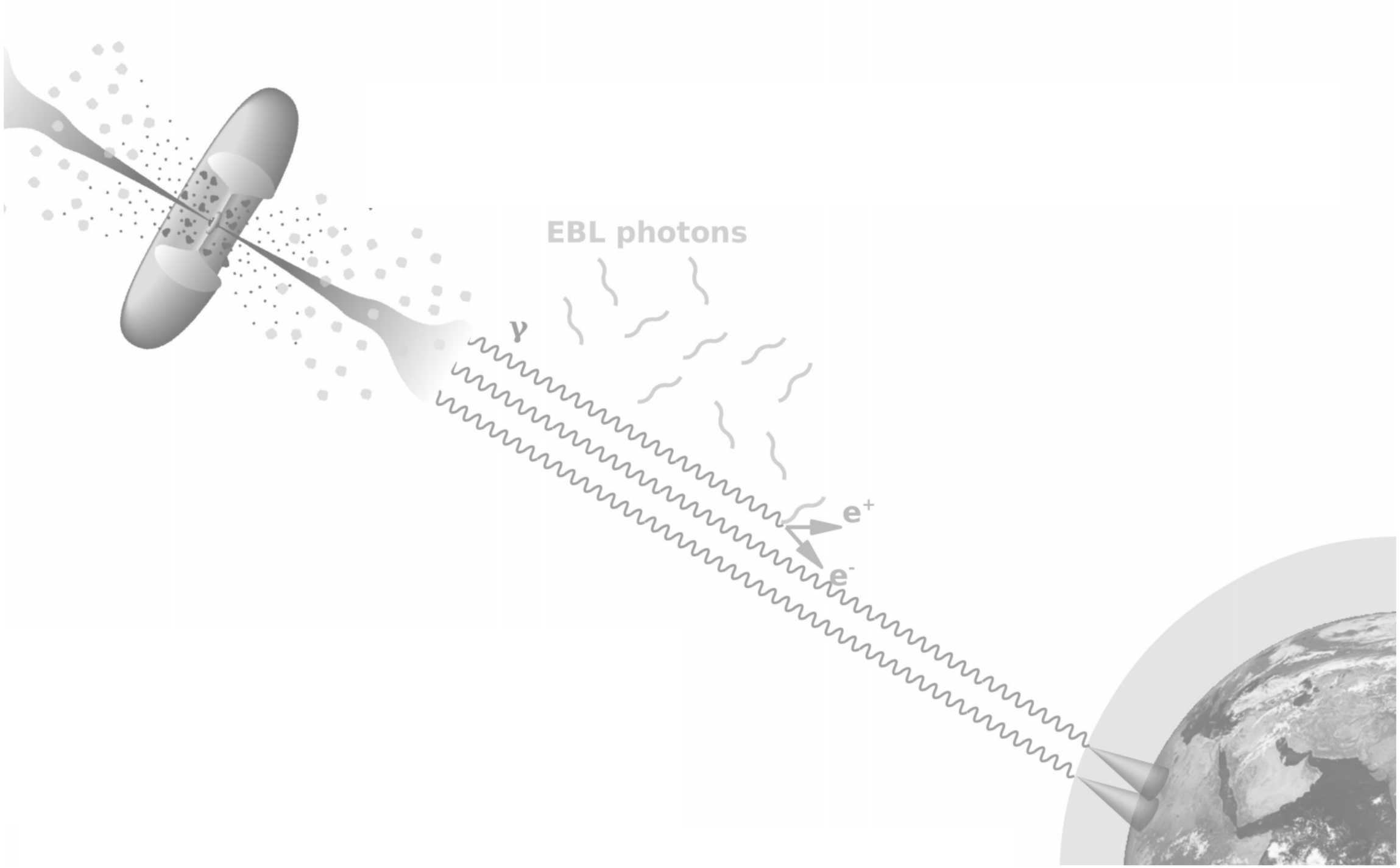


Source Types

- PWN
- Binary XRB PSR Gamma BIN
- HBL IBL FRI FSRQ Blazar LBL AGN (unknown type)
- Shell SNR/Molec. Cloud Composite SNR Superbubble
- Starburst
- DARK UNID Other
- uQuasar Star Forming Region Globular Cluster Cat. Var. Massive Star Cluster BIN BL Lac (class unclear) WR

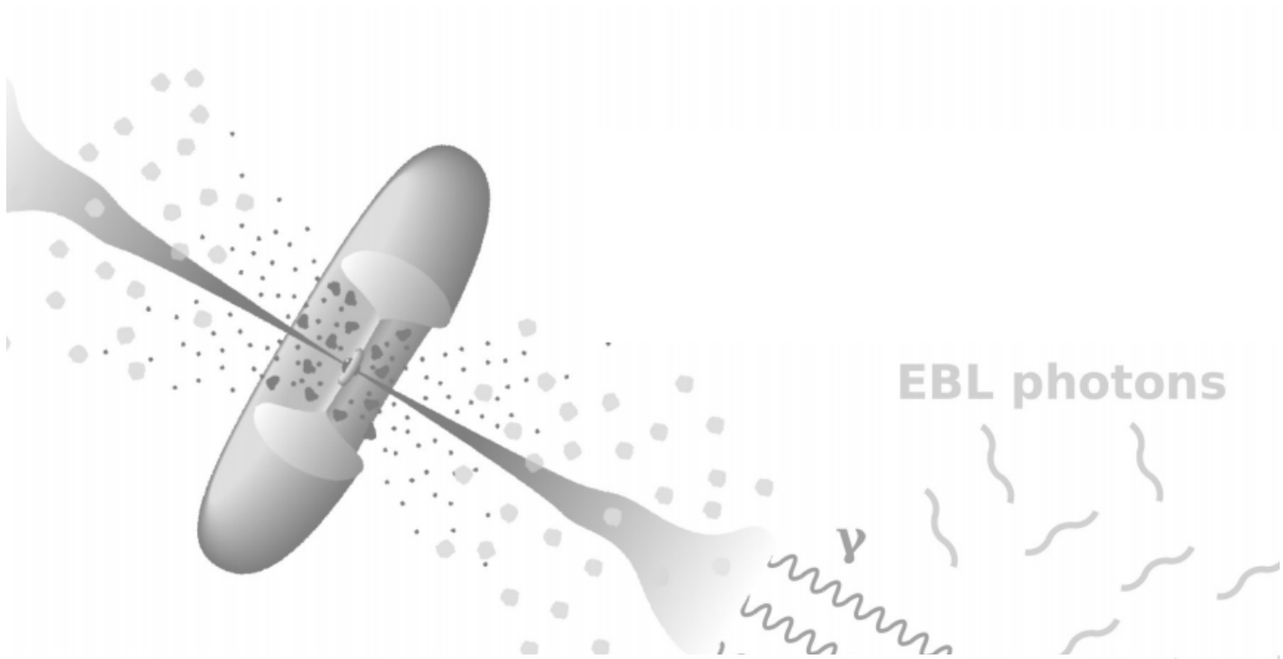
TeVCat: http://tevcat.uchicago.edu

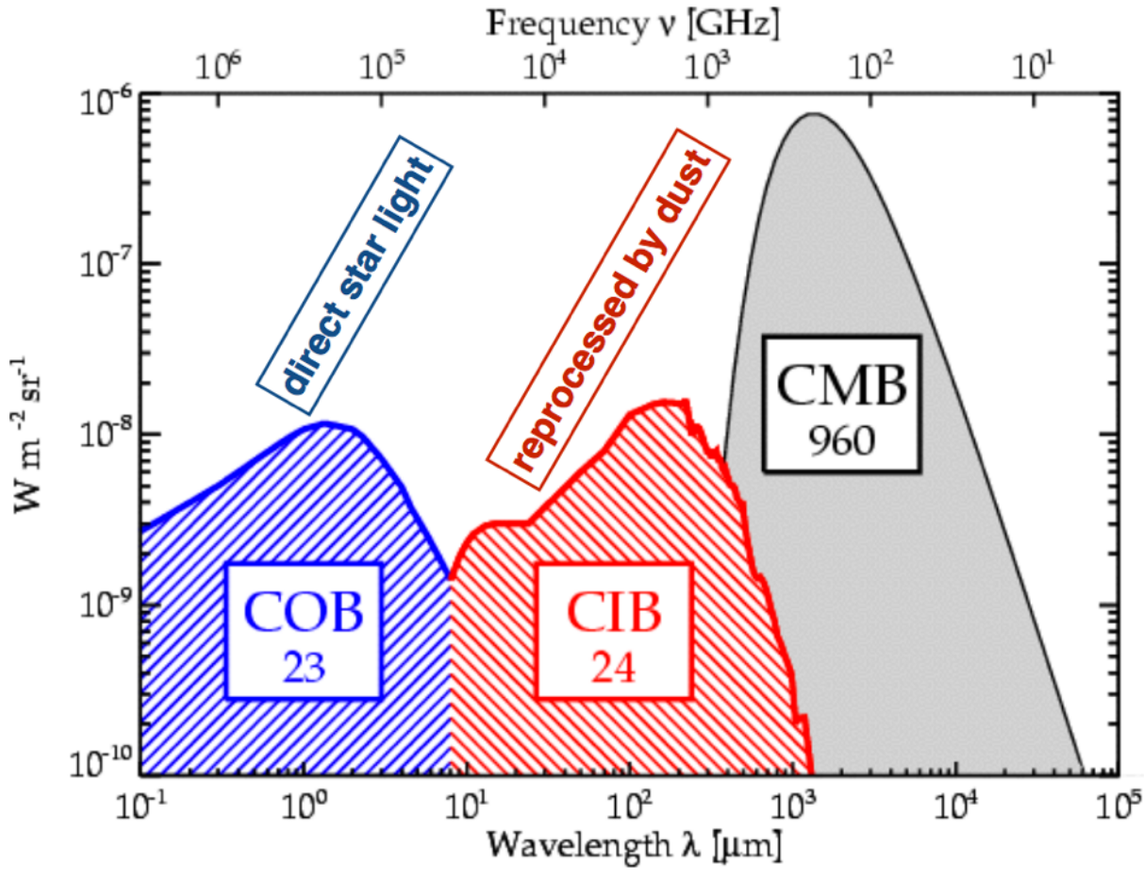
GeV - TeV connection: Extragalactic Background Light

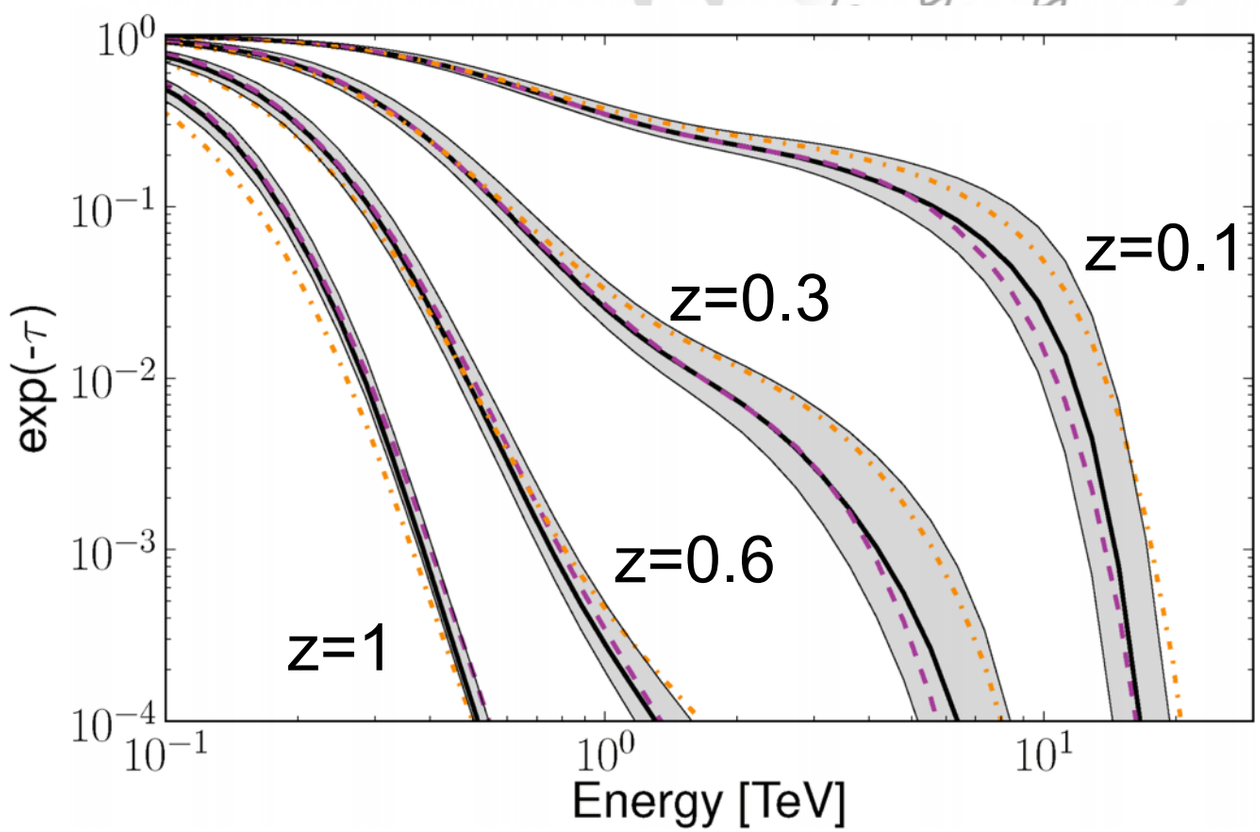


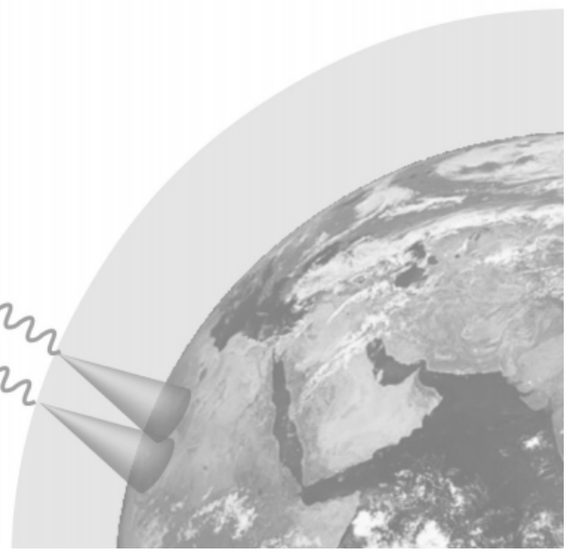
J. Biteau

GeV - TeV connection: Extragalactic Background Light



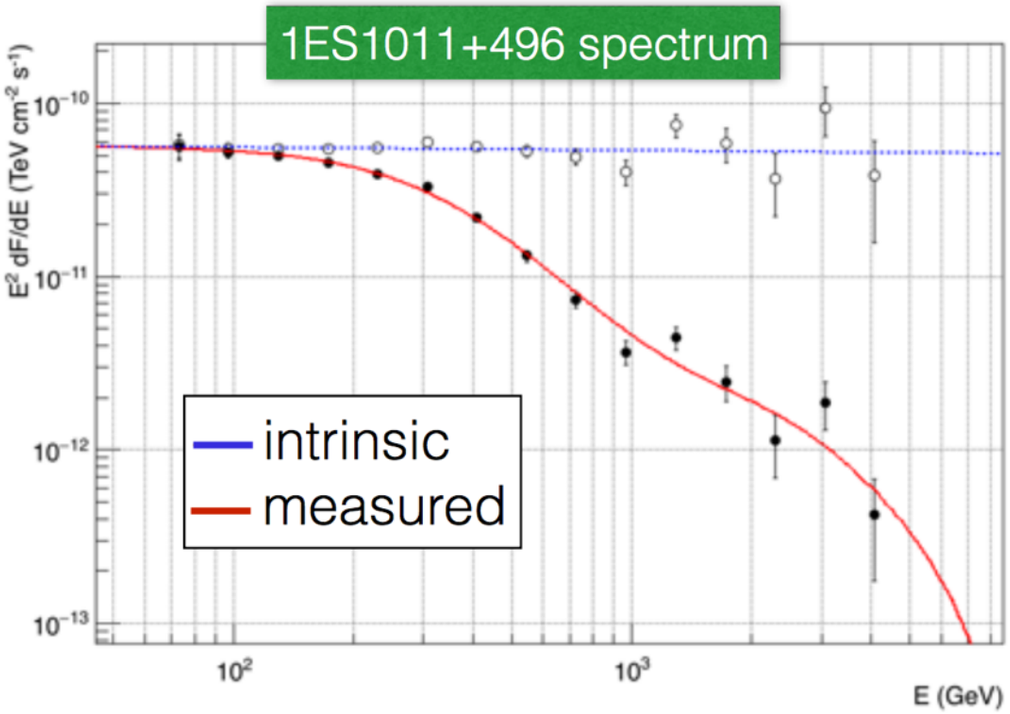






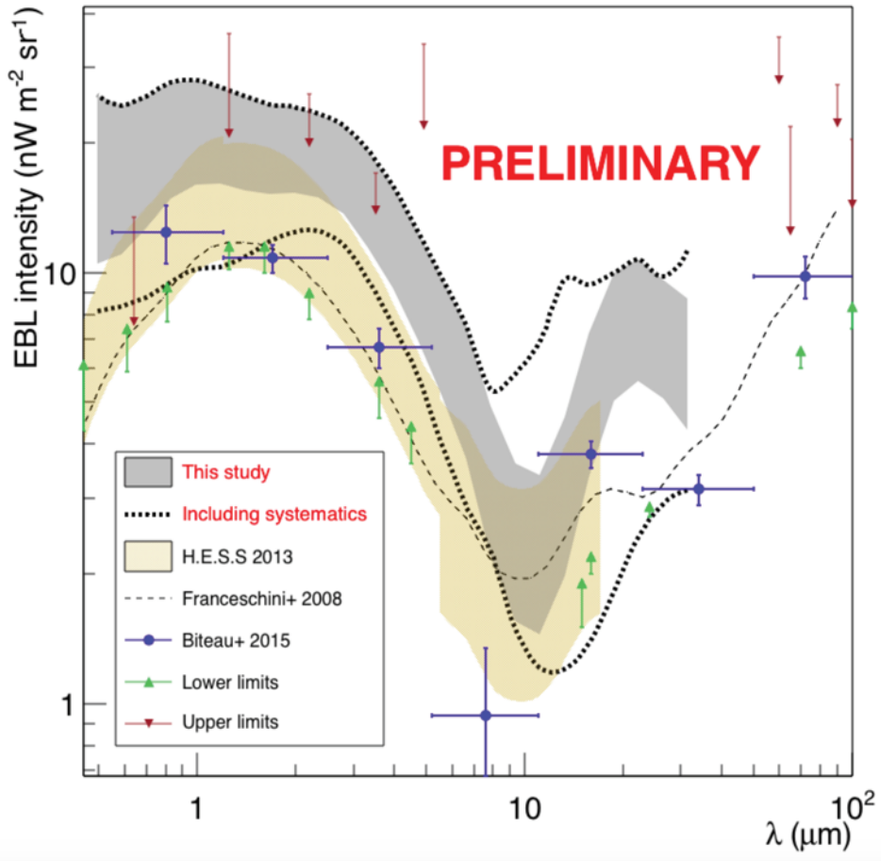
J. Biteau

Extragalactic Background Light



- determine scaling factor of EBL models

Ahnen et al. (MAGIC), A&A, 590, 24 (2016)

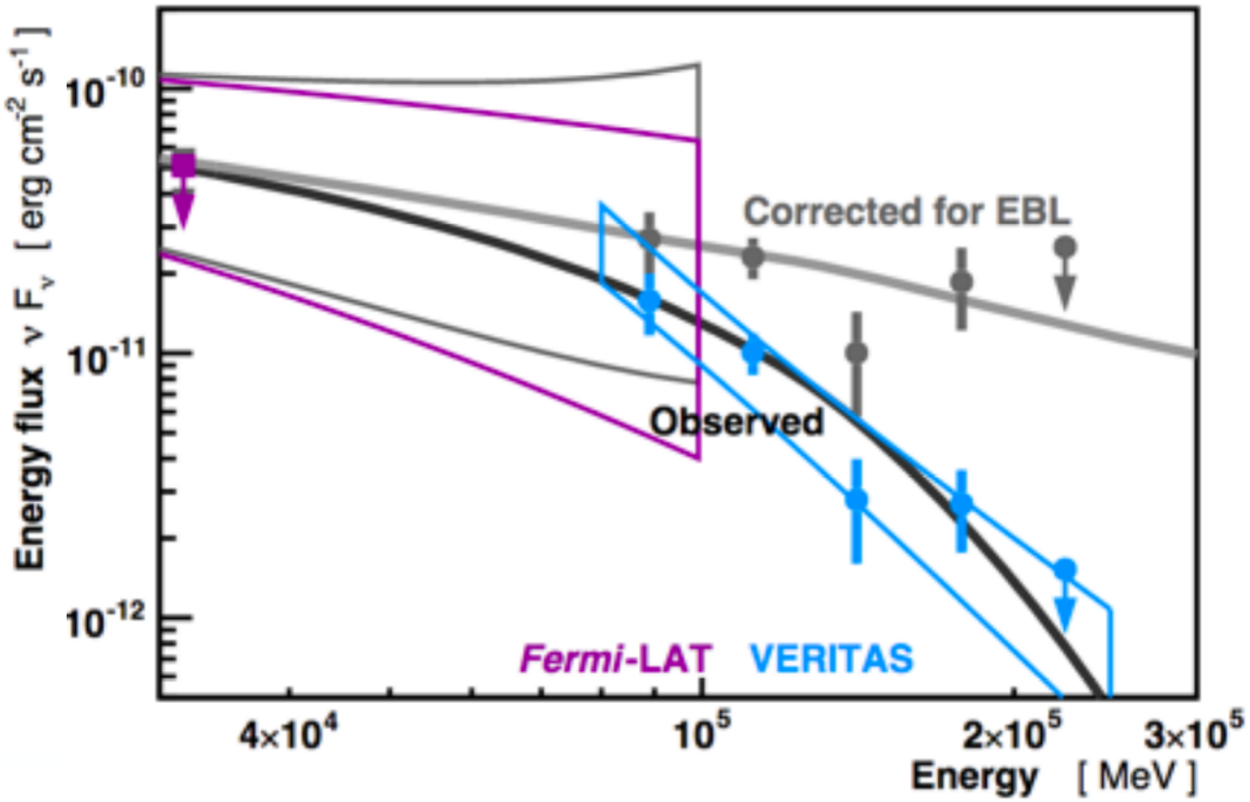


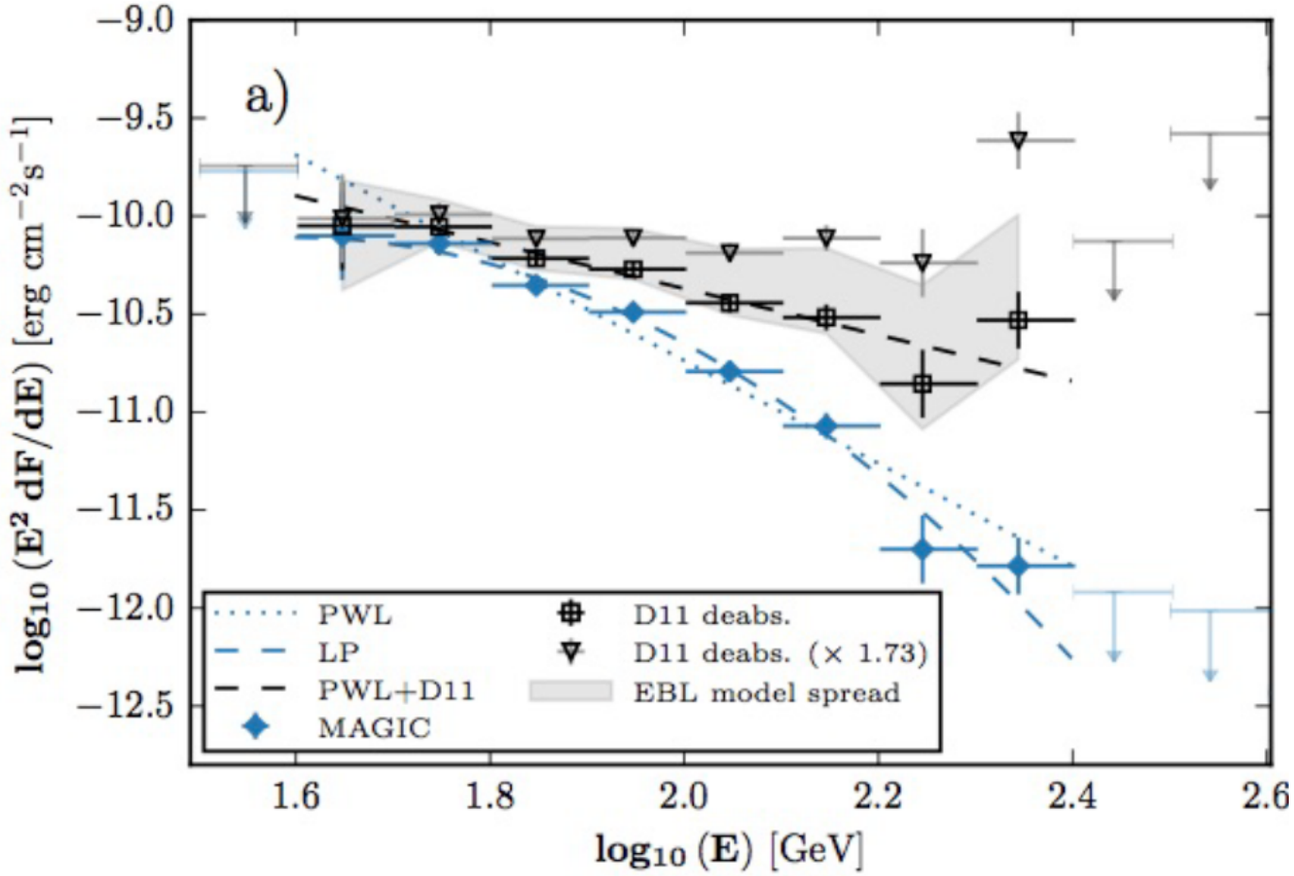
- EBL measurement with TeV gamma-rays
  - combined fit of spectrum + EBL
  - model independent measurement of the EBL

M. Lorentz et al. (H.E.S.S.), ICRC 2015

The hunt for far-away TeV sources: flaring sources

PKS1441+25 (z=0.94)





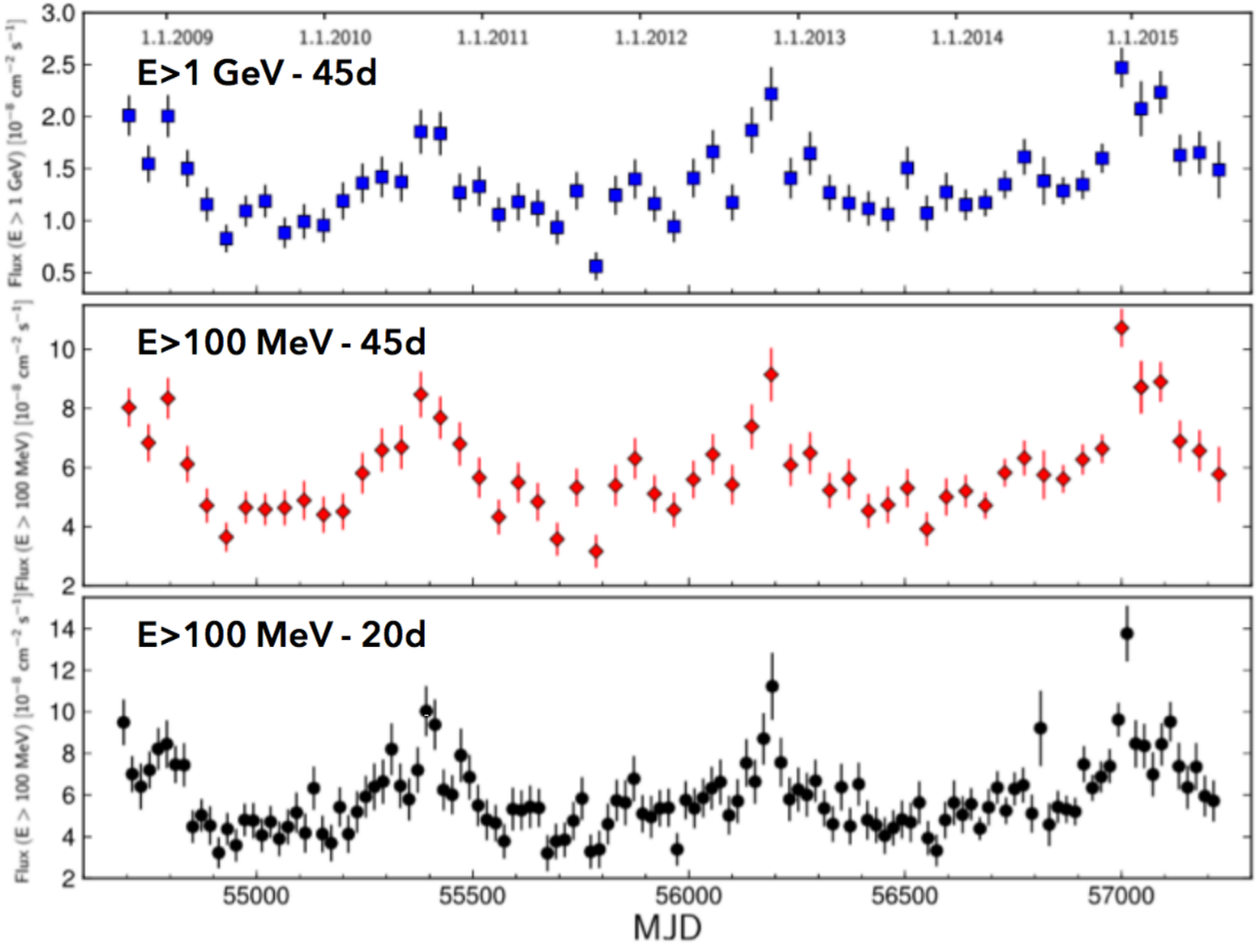
April 2015: Flare detected by Fermi-LAT => MAGIC => VERITAS

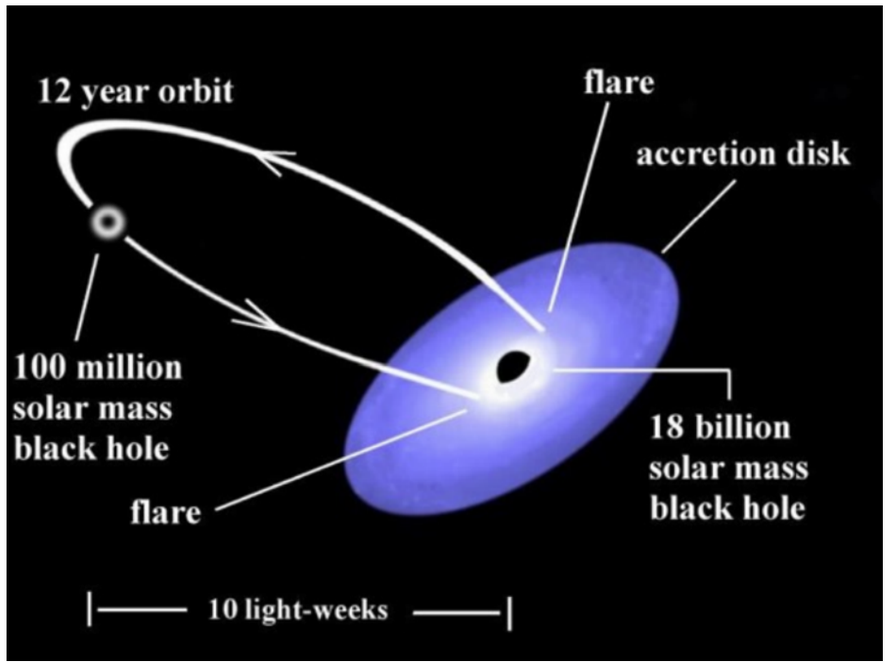
Abeysekara et al. (VERITAS), ApJL, 815, 22, 2015

Ahnen et al. (MAGIC), ApJL 815, L23, 2015

Quasi-periodic modulations in PG1553+113

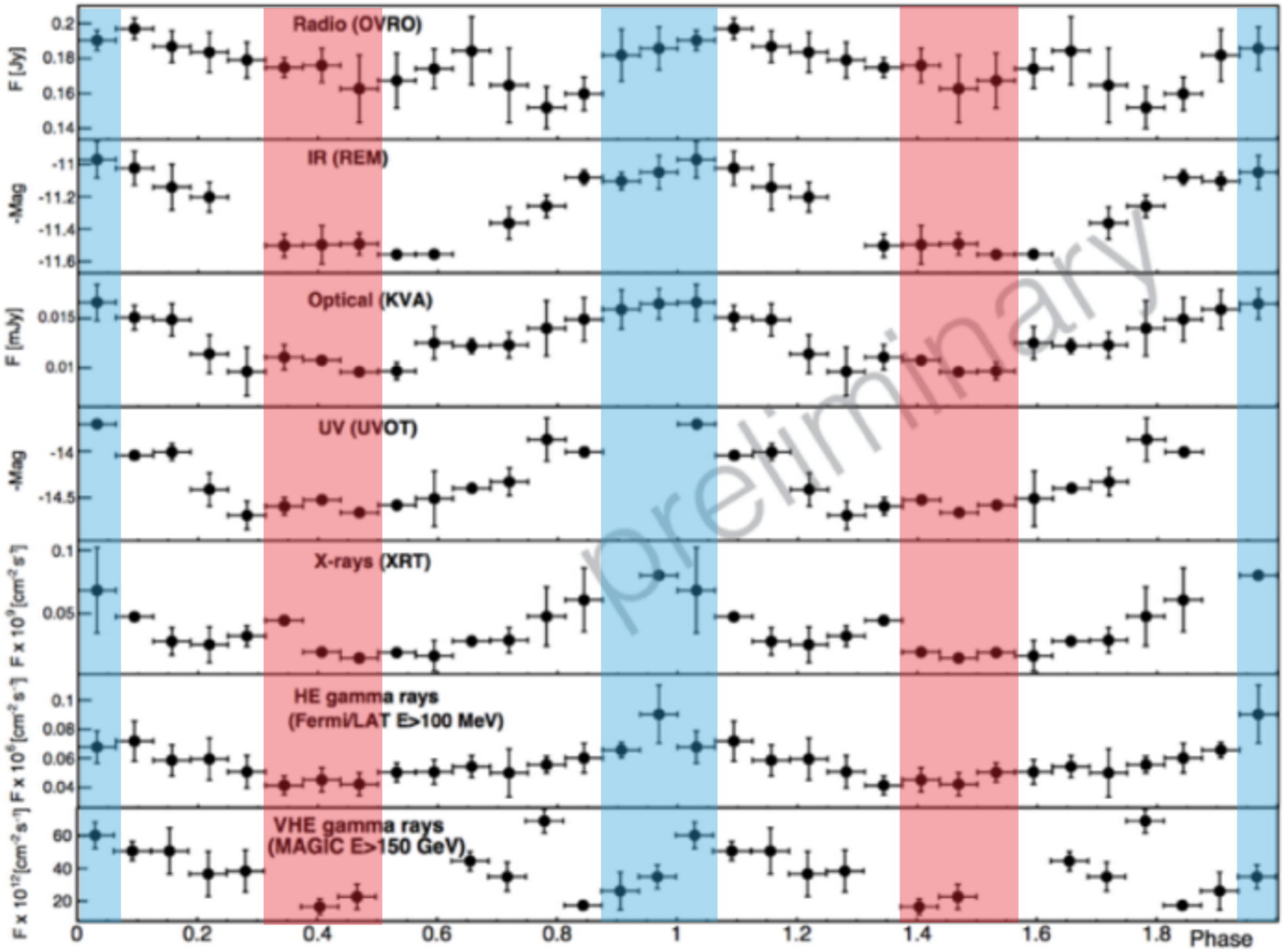
- z~0.5
- Fermi-LAT
- period ~2 years
- super-massive binary black hole?





Ackermann et al. (Fermi-LAT), 2015

Quasi-periodic modulations in PG1553+113

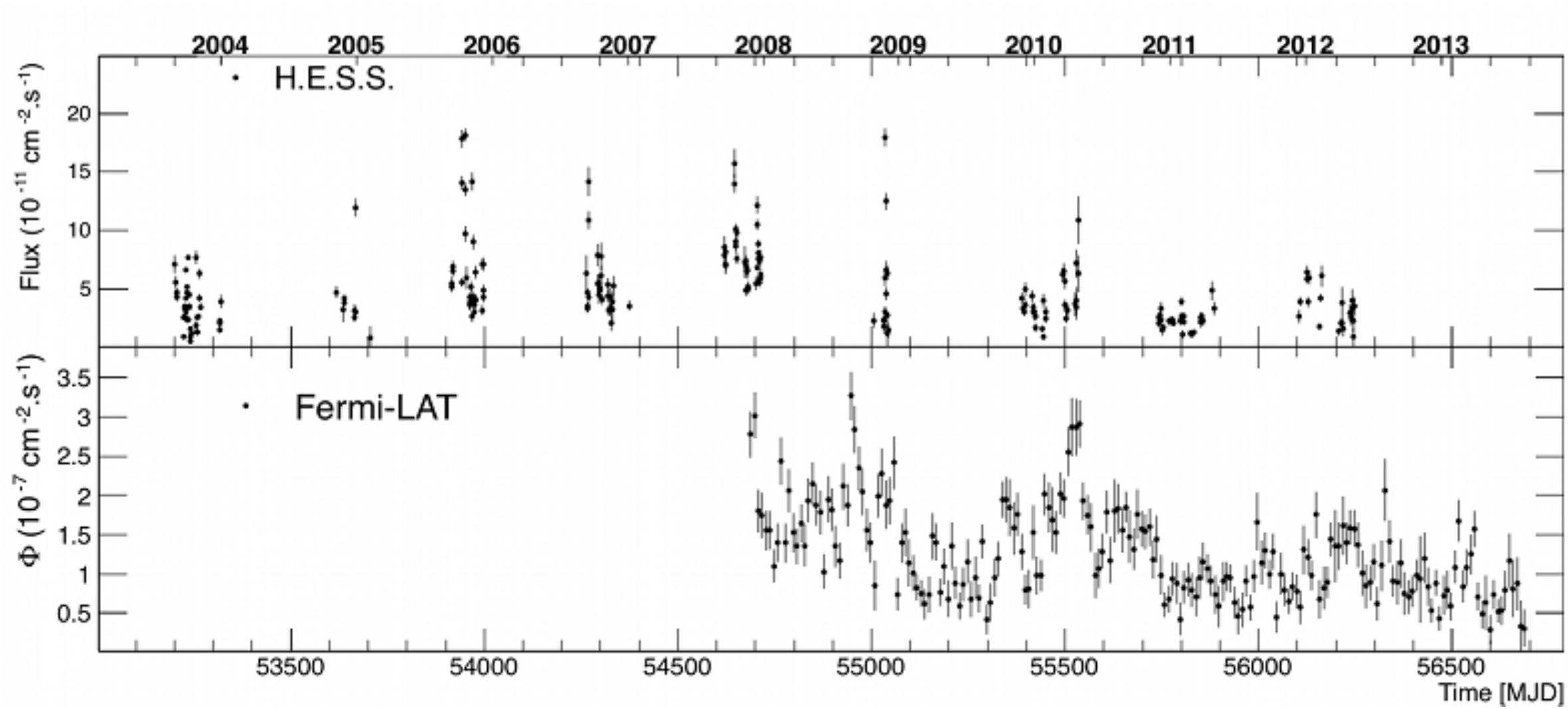


P. Da Vela (MAGIC)

Longterm monitoring + flare detection

- The high-energy sky is extremely variable
  - long-term and MWL monitoring to understand detailed behavior of sources

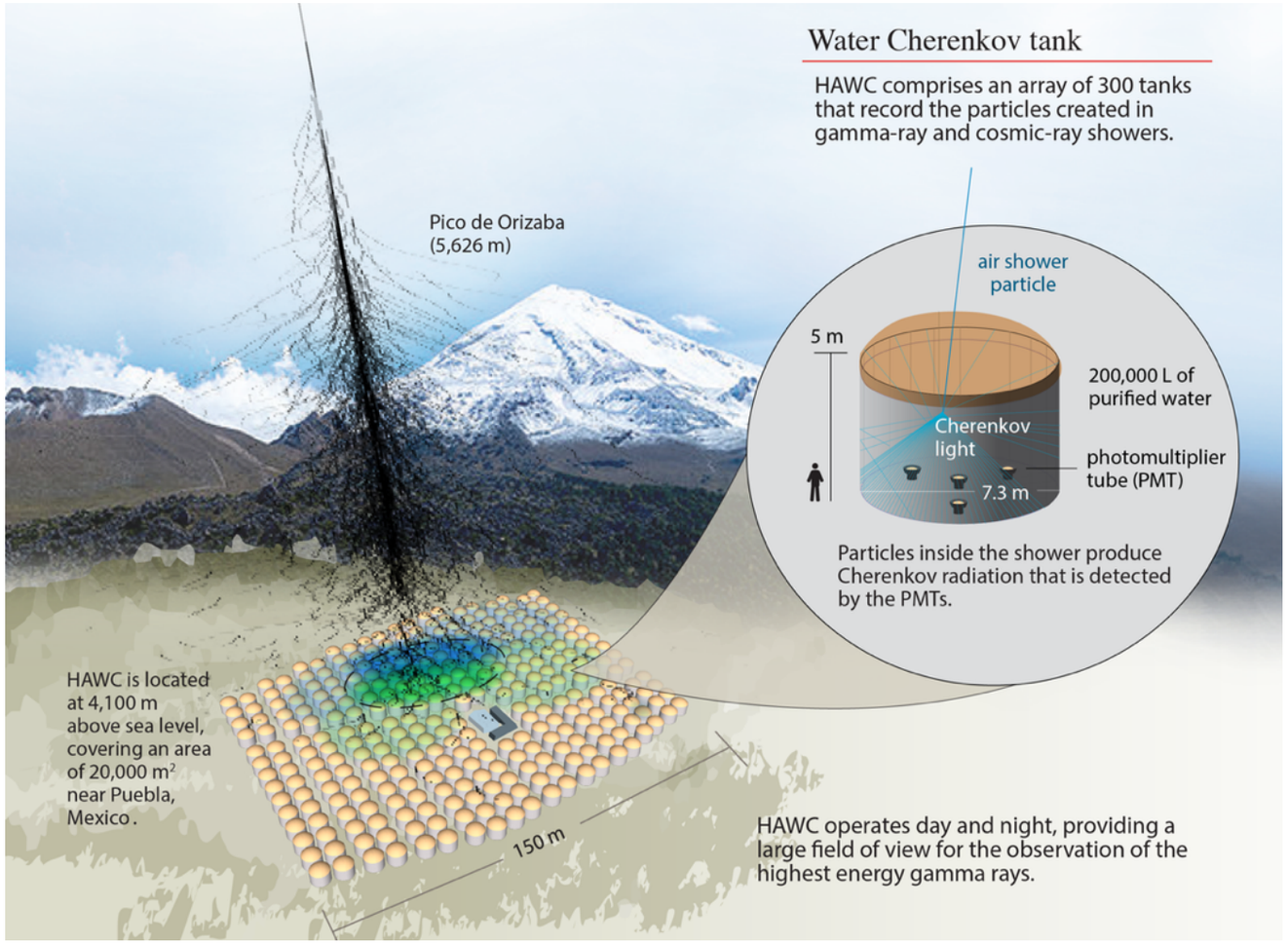
PKS 2155-304



H.E.S.S. (A&A accepted)

Longterm monitoring + flare detection: HAWC

- The high-energy sky is extremely variable
  - long-term and MWL monitoring to understand detailed behavior of sources
  - => need for large FoV + high duty-cycle monitoring observatories
- follow-up with high-sensitivity instruments (IACTs) via alerts
- new: High Altitude Water Cherenkov Observatory (HAWC)



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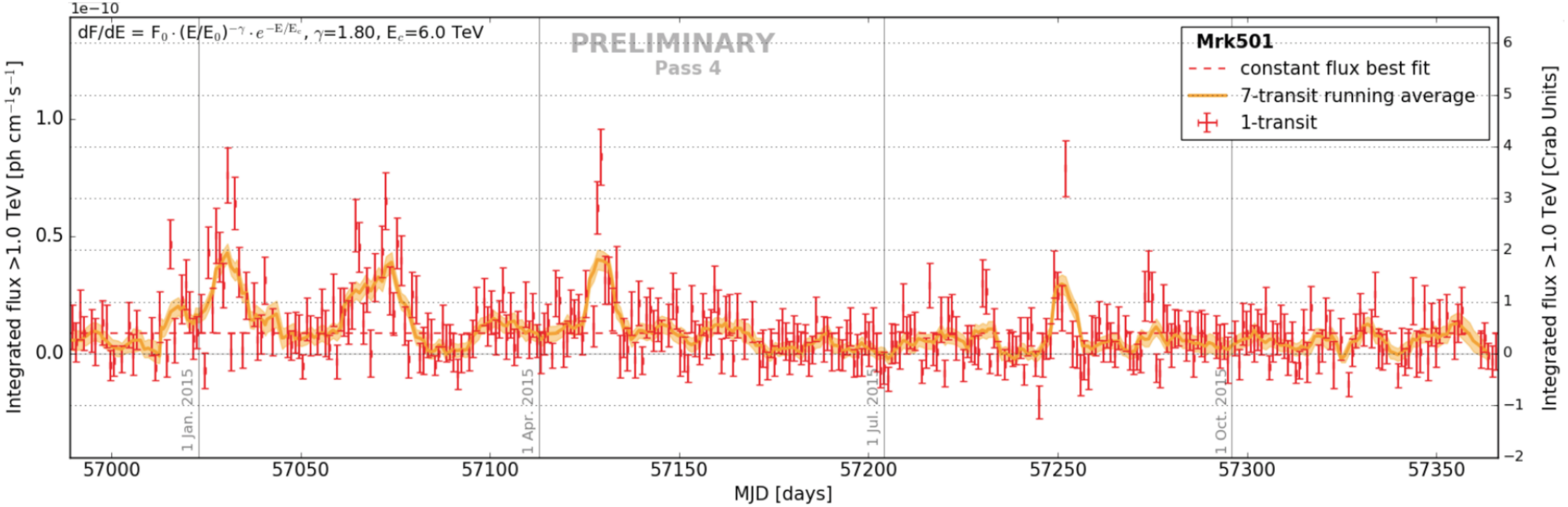
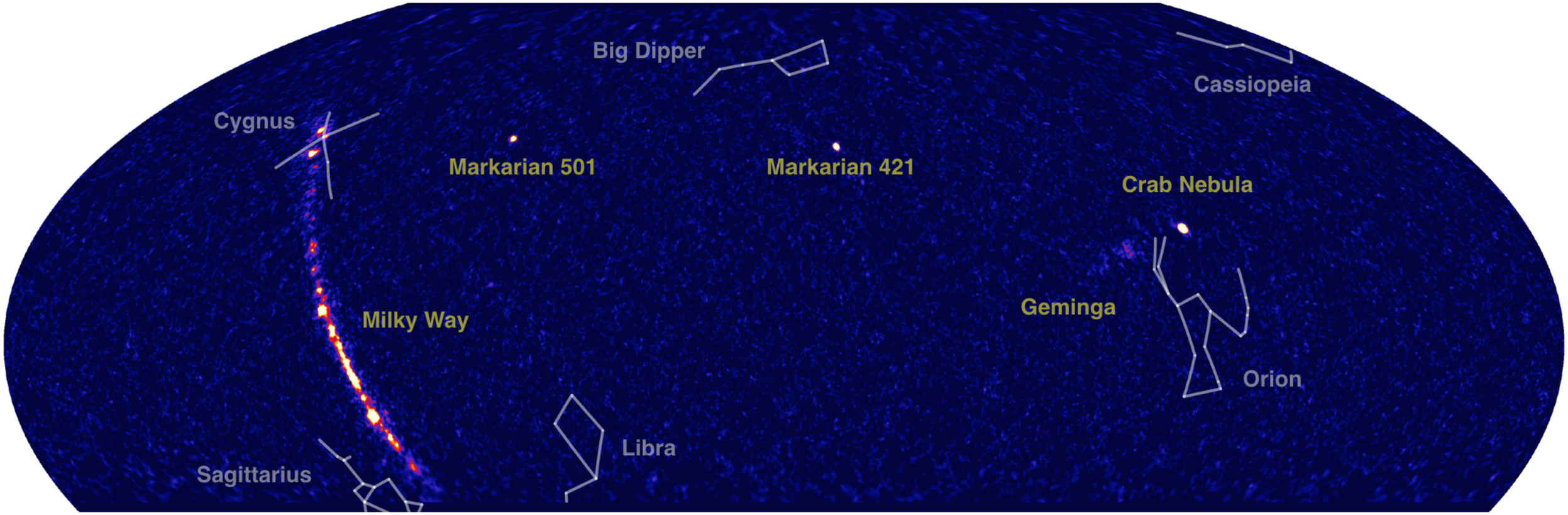
Mrk 501

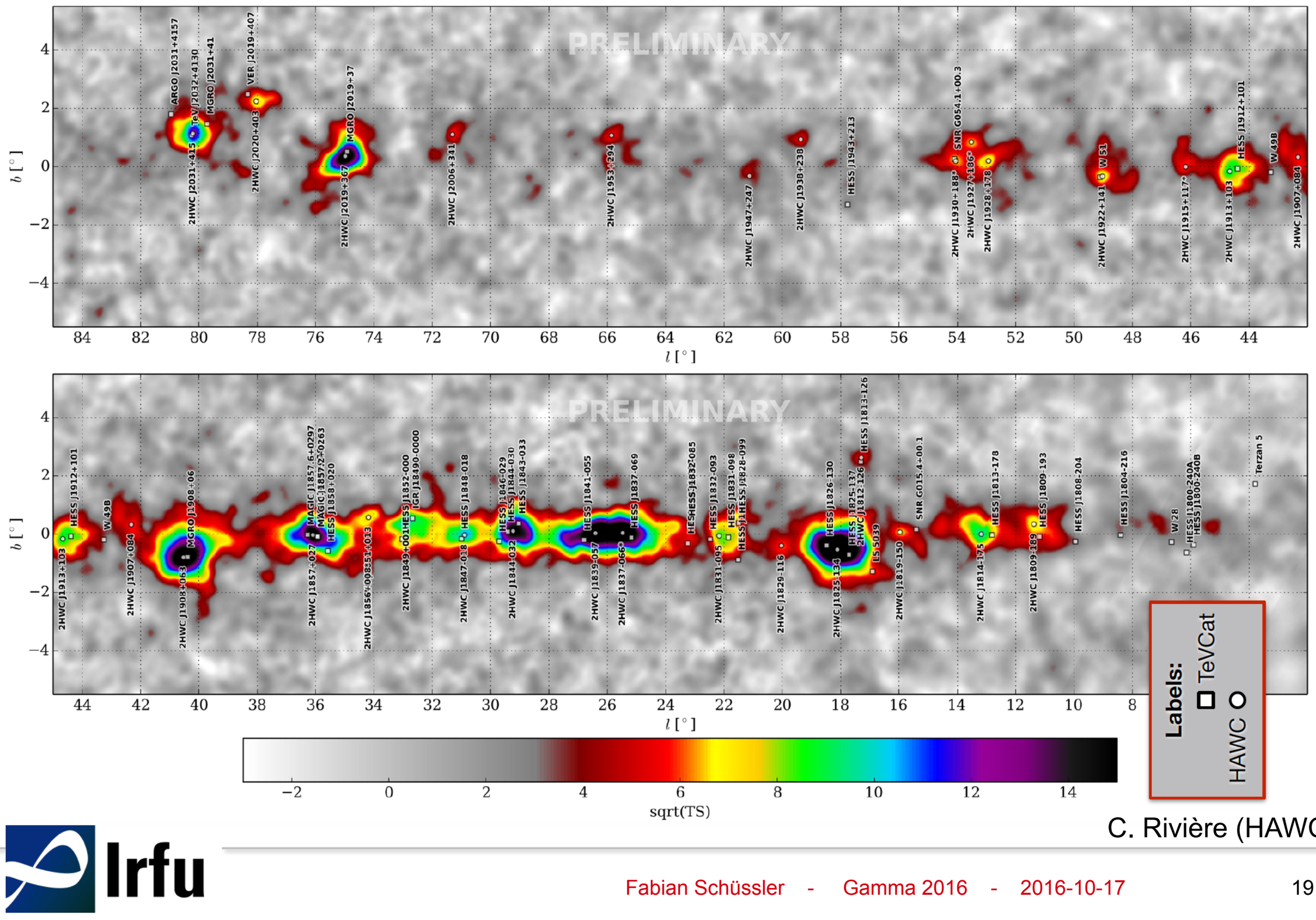


HAWC: new eyes on the TeV sky

- first year of observations, 95% duty cycle
- Energy range: 0.5-100 TeV, ang. resolution: 1-0.2 deg
- first source catalog, shared with MoU partners for follow-up observations
  - first confirmations (and non-confirmations) reported by VERITAS
  - comparison with HESS Galactic Plane Scan in progress



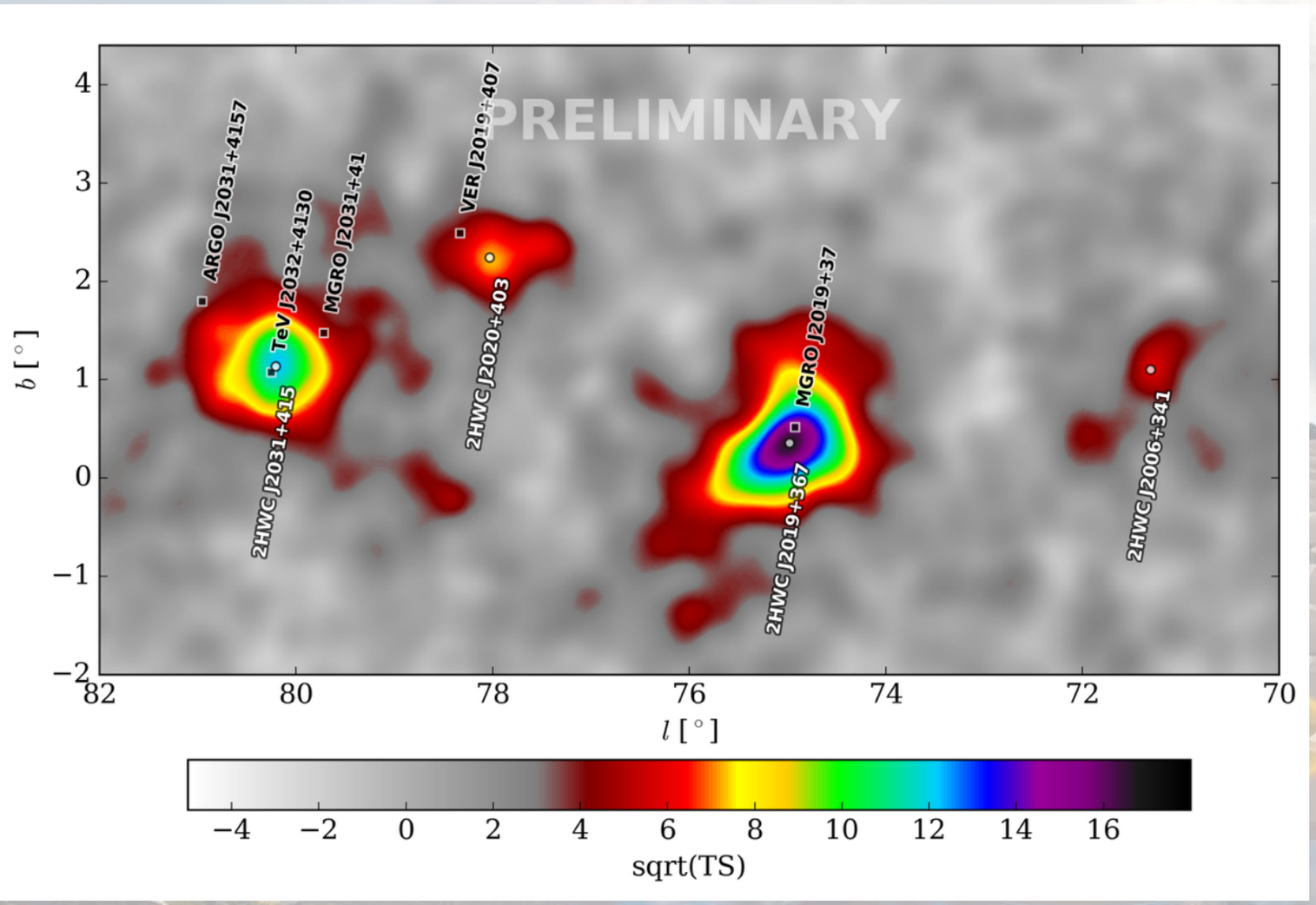
HAWC: Galactic plane



C. Rivière (HAWC)

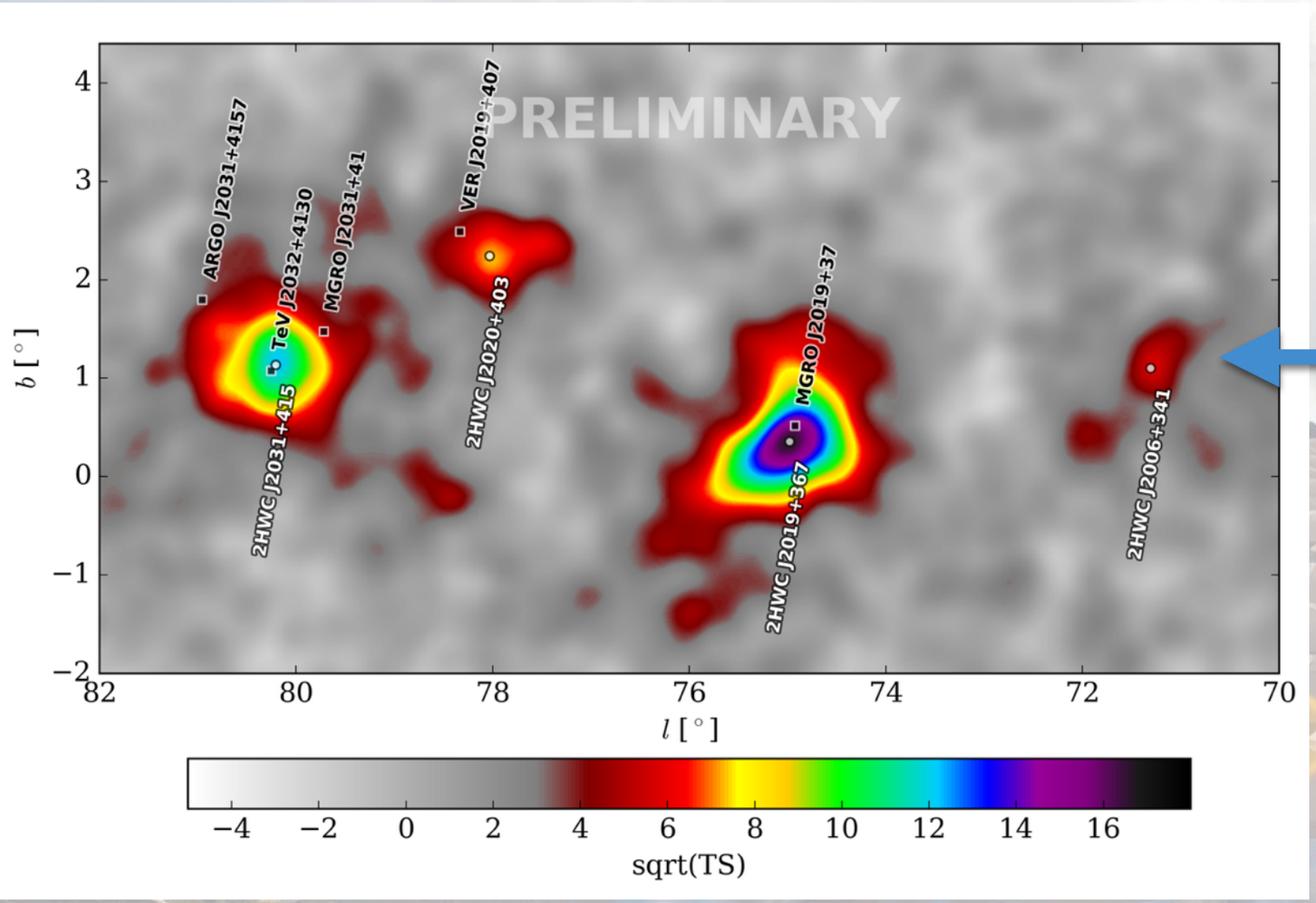
Cygnus region

C. Rivière (HAWC)



Cygnus region

C. Rivière (HAWC)

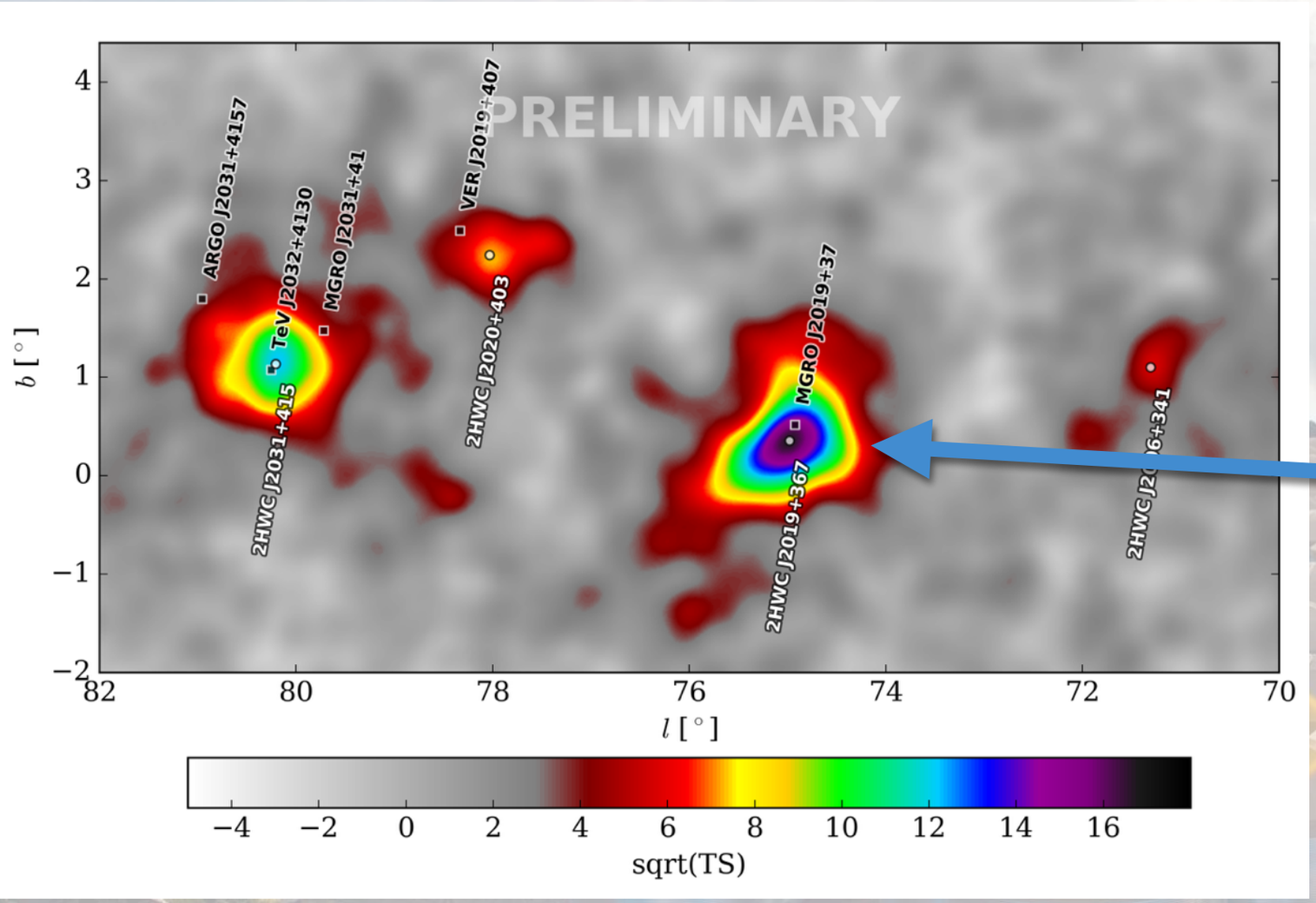


New TeV source 2HWCJ2006+341:

- **>6σ pre-trials**
- **0.6° from unidentified source 3FGL J2004.4+3338**

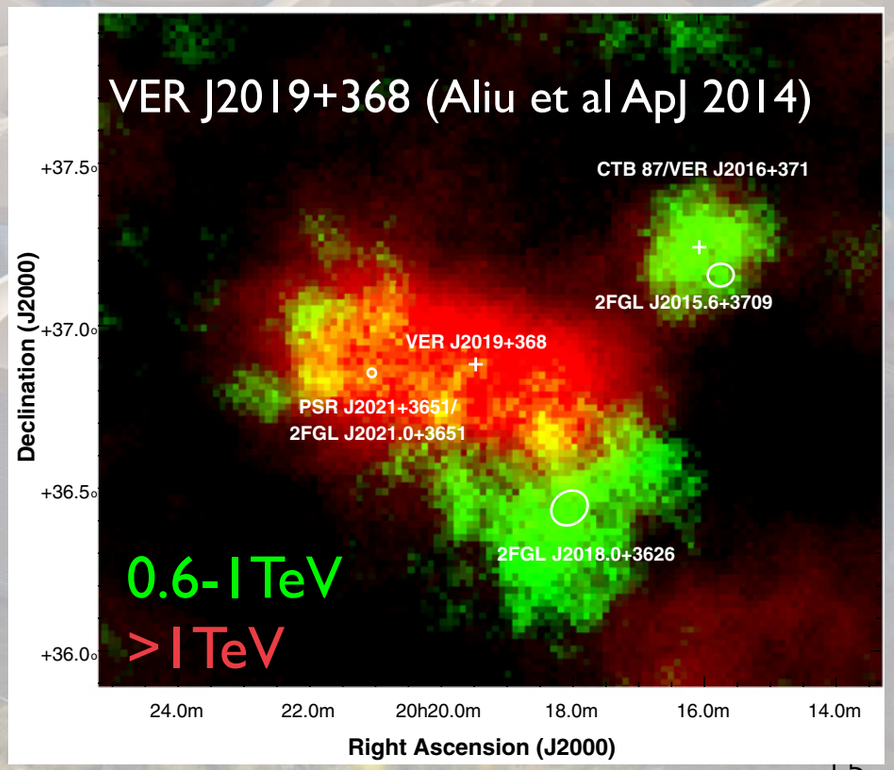
Cygnus region

C. Rivière (HAWC)

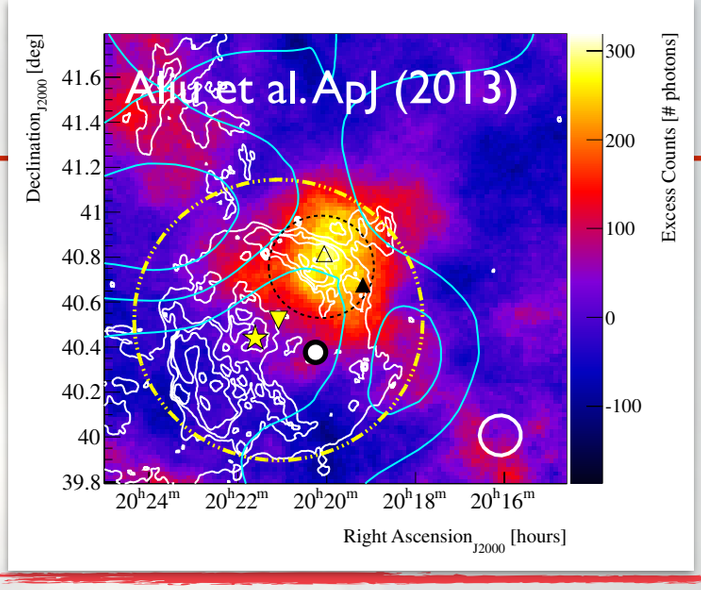


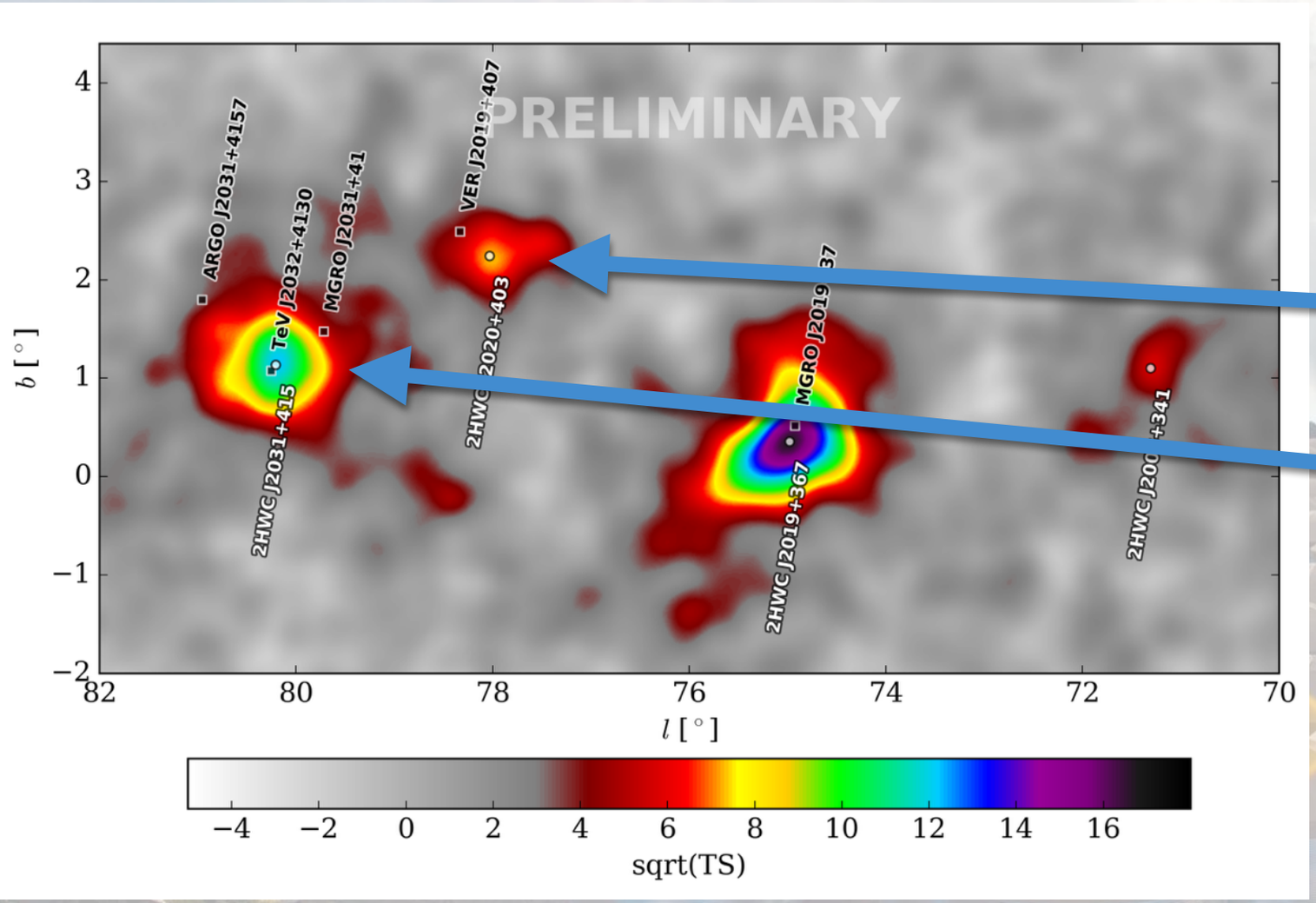
2HWC J2019+367 is coincident with MGRO J2019+37 and VER J2019+368

- **extended emission including PSR J2021+3651 and HII region Sh 2-104**



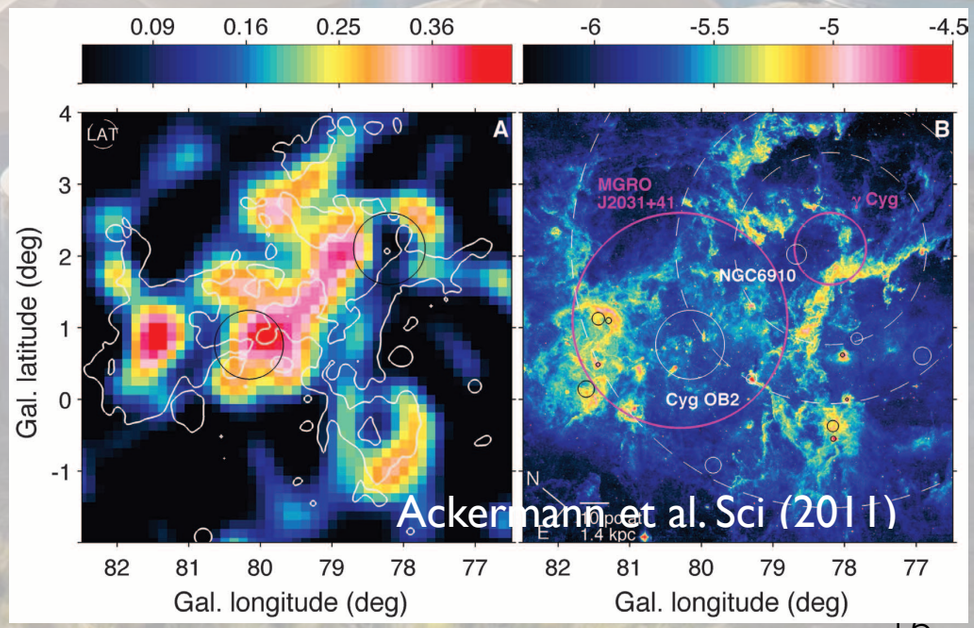
Cygnus region





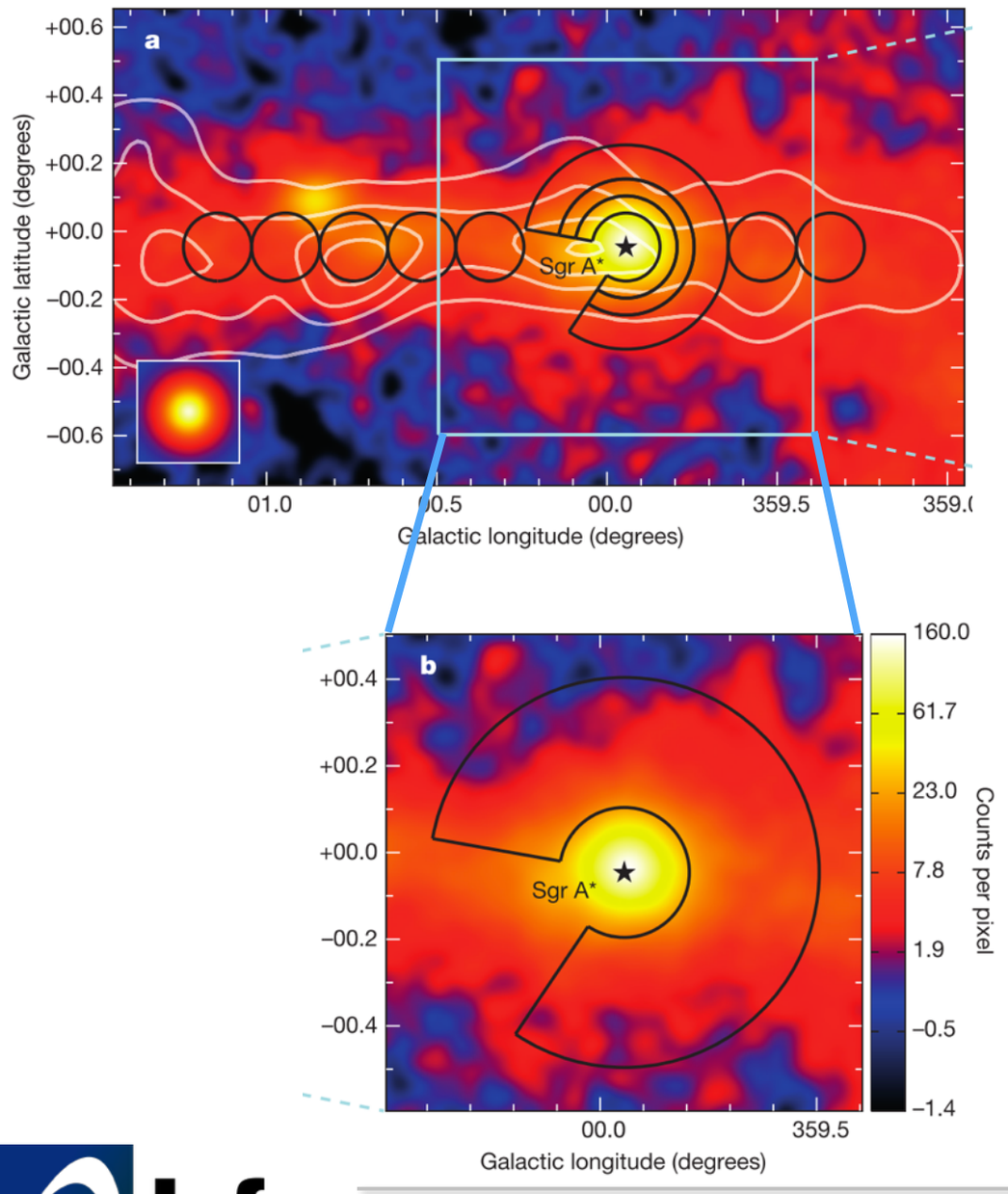
MGRO J2031+41 is resolved into two distinct TeV sources:

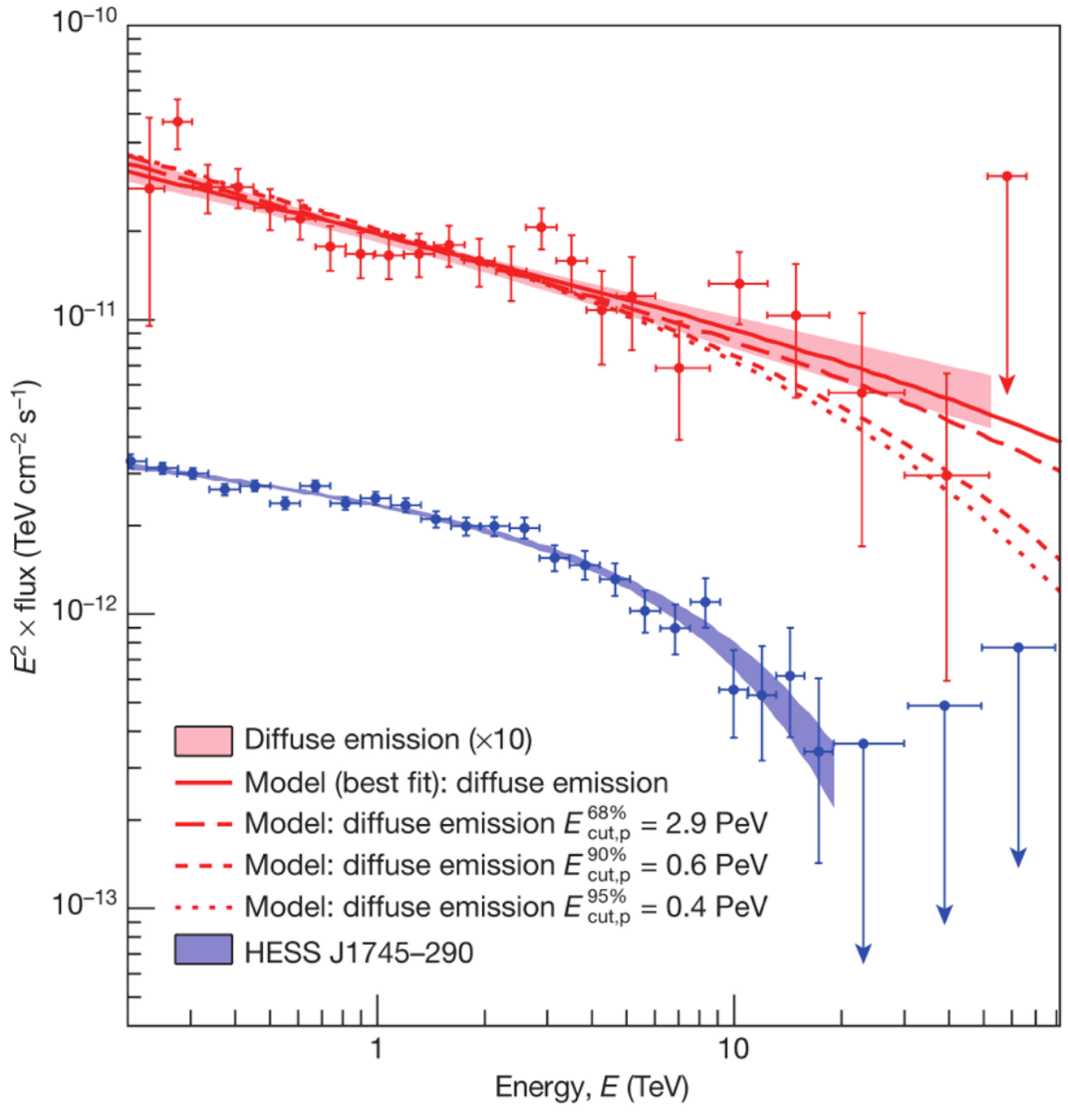
- **2HWC J2020+403 — VER J2019+407, UID encompassing SNR G78.2+2.1 and PSR J2021+4026**
- **2HWC J2031+415 — TeV J2032+4130, a PWN**
- **Hints of extended emission at Fermi cocoon?**



The Pevatron at the Galactic Center

- 10 years of H.E.S.S. observations
- central source + extended diffuse emission without energy cutoff

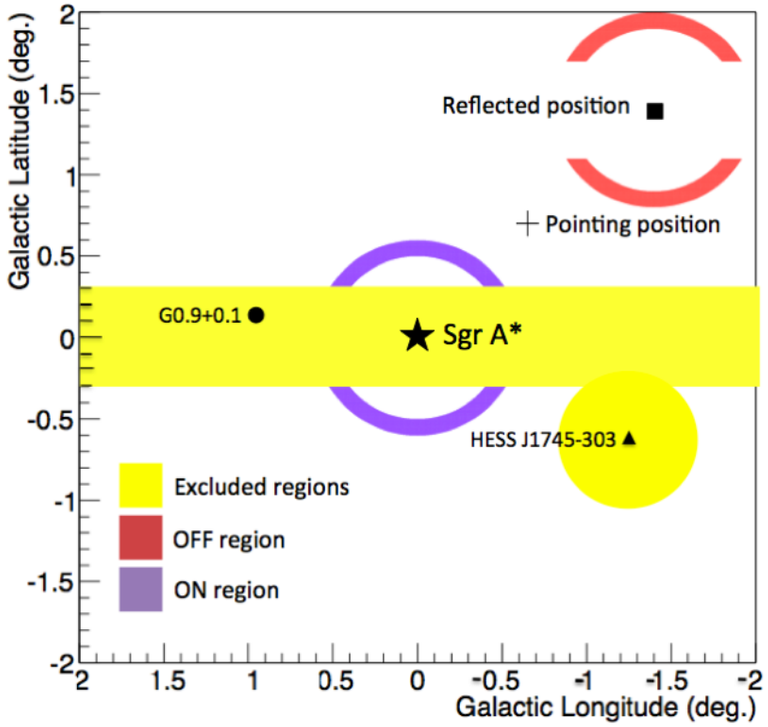


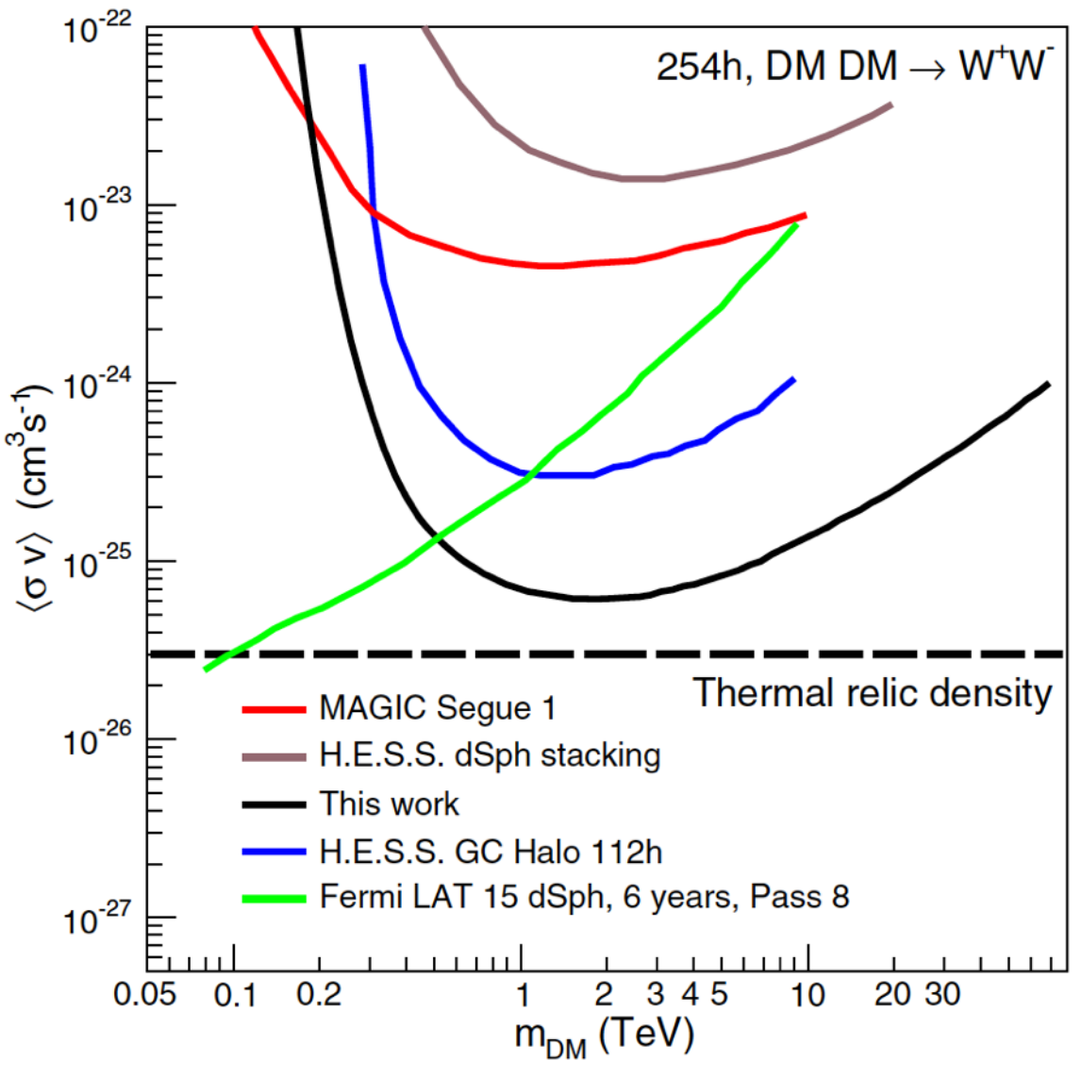


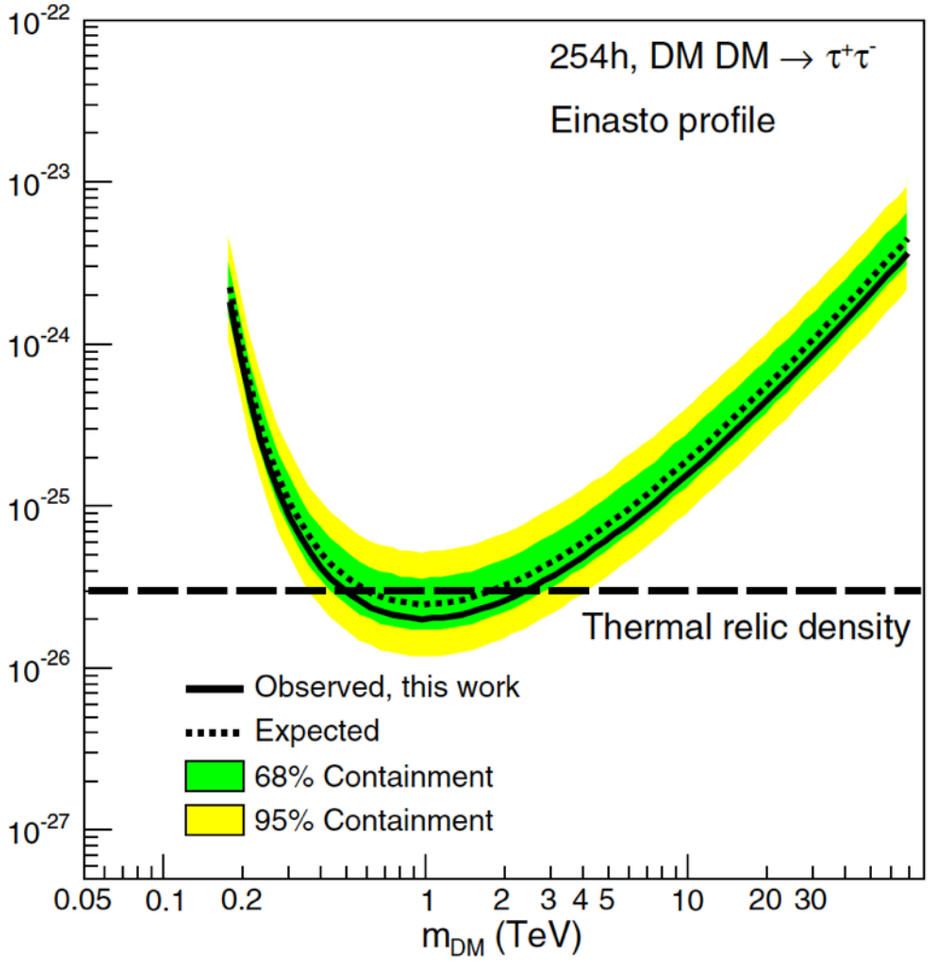
H.E.S.S., Nature (2016)

Dark matter at the Galactic Center

- 10 years of H.E.S.S. observations
- exclude central source(s)
- 2D-likelihood (spatial + energy)

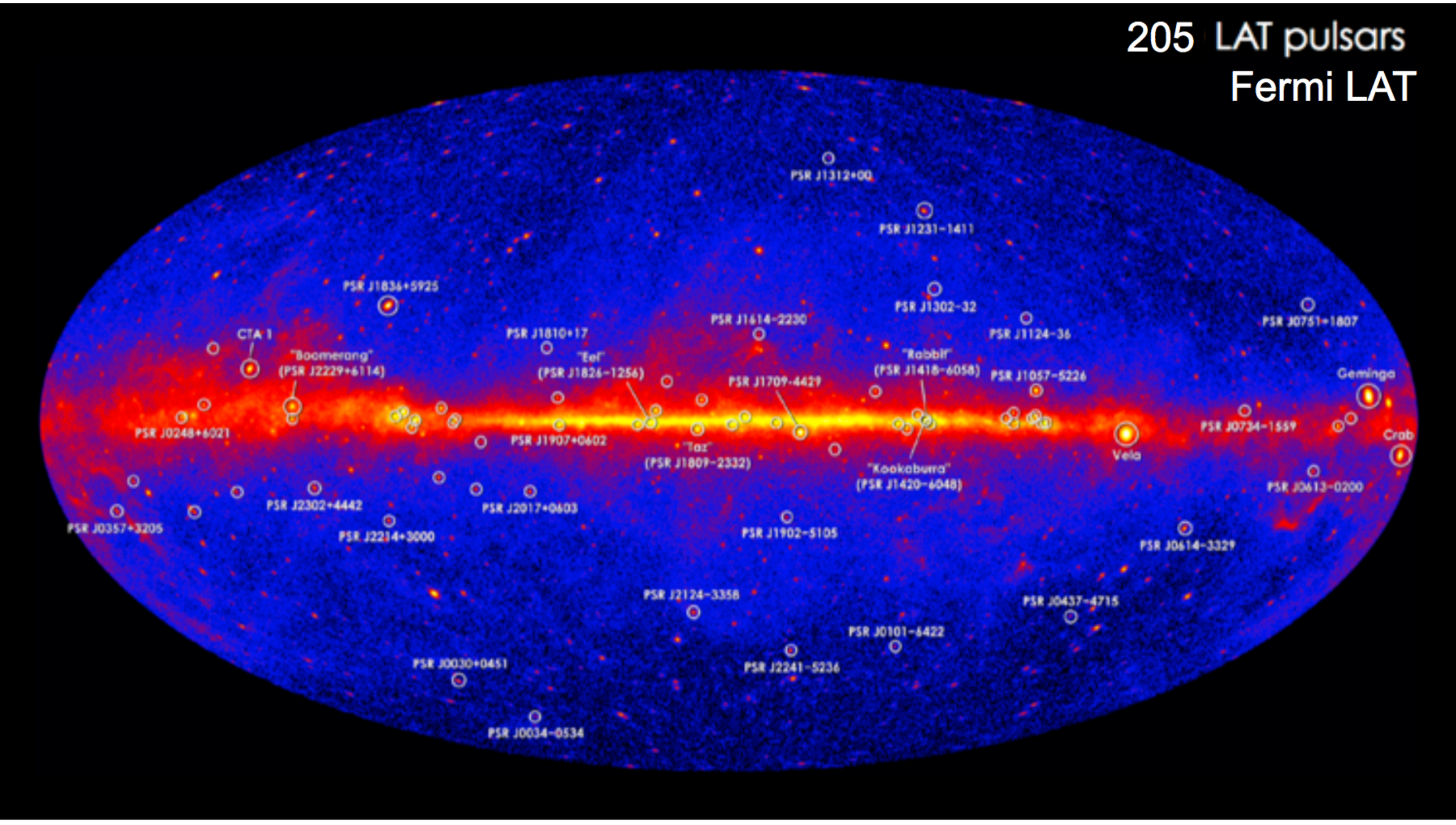






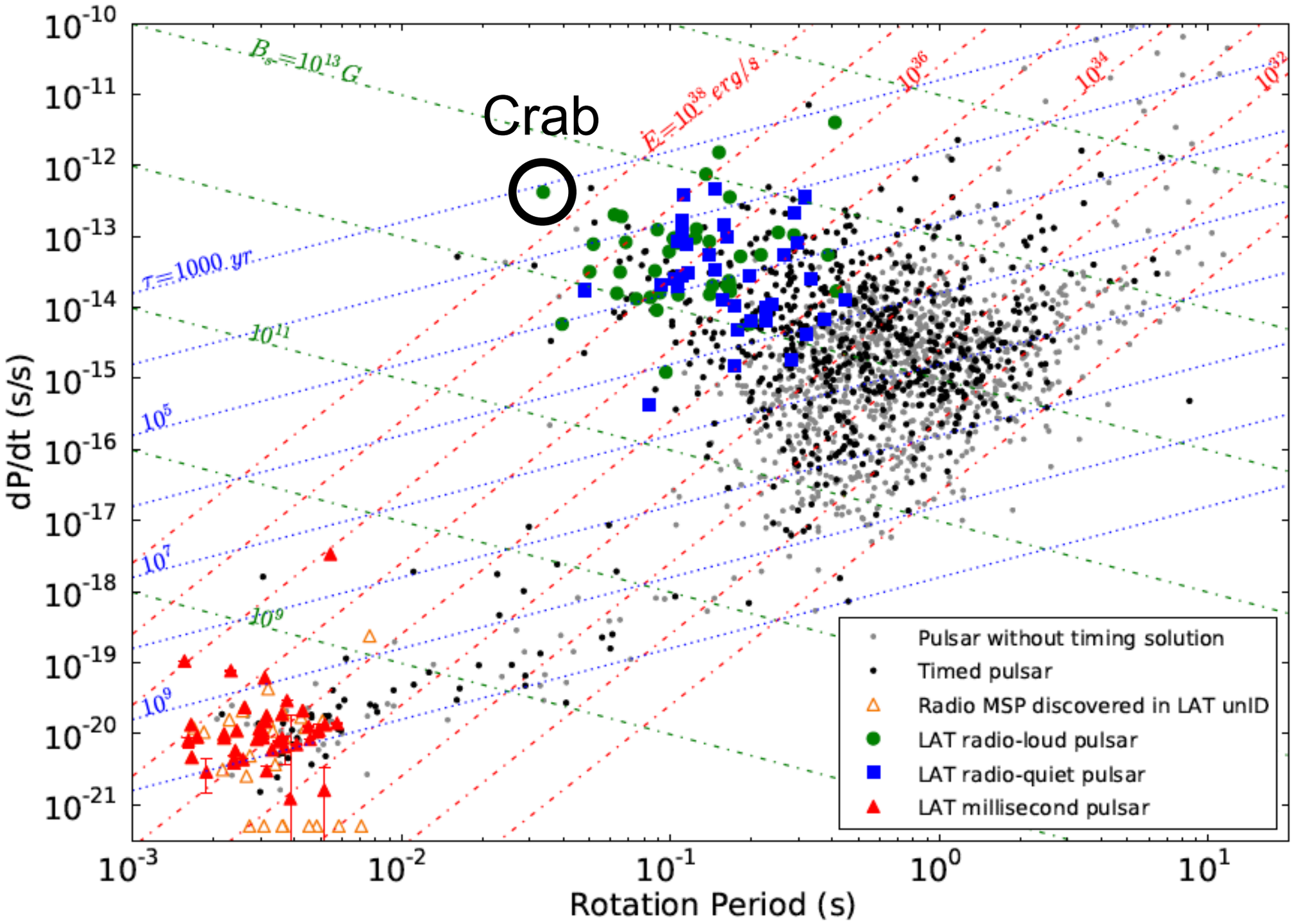
H.E.S.S., PRL (2016)

Gamma-ray pulsars



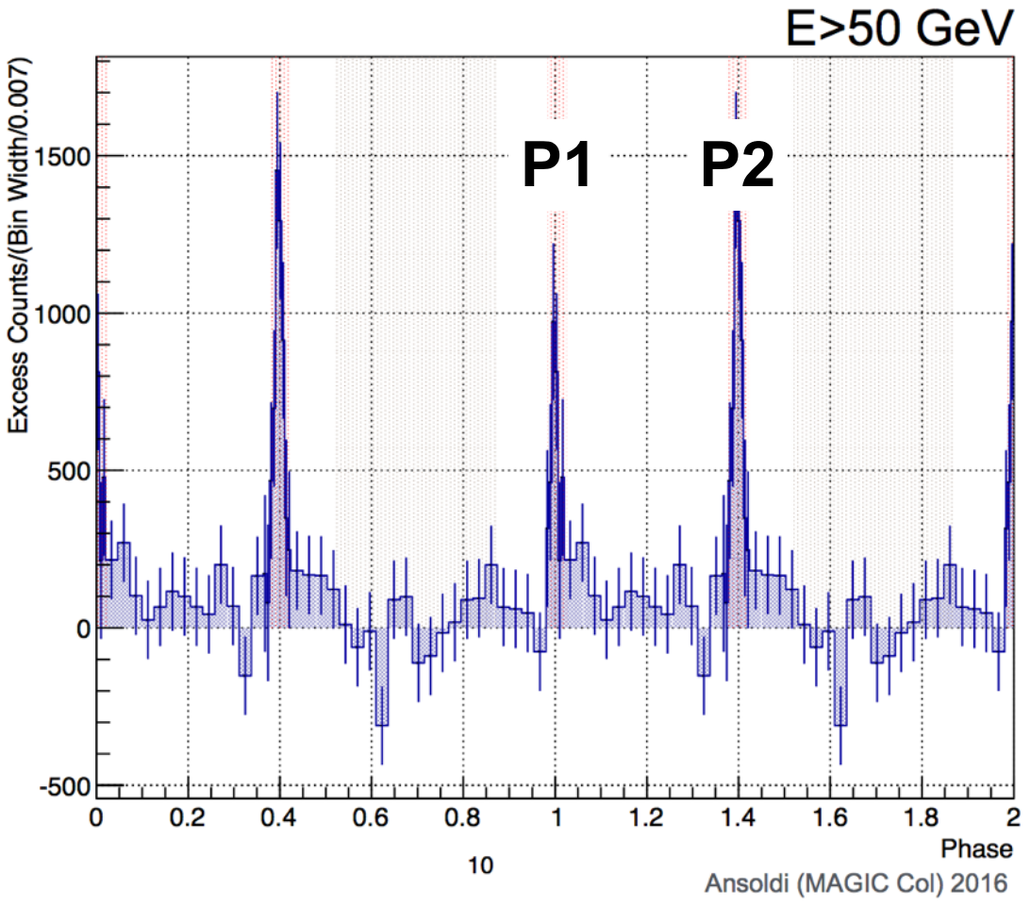
A. Harding

Gamma-ray pulsars

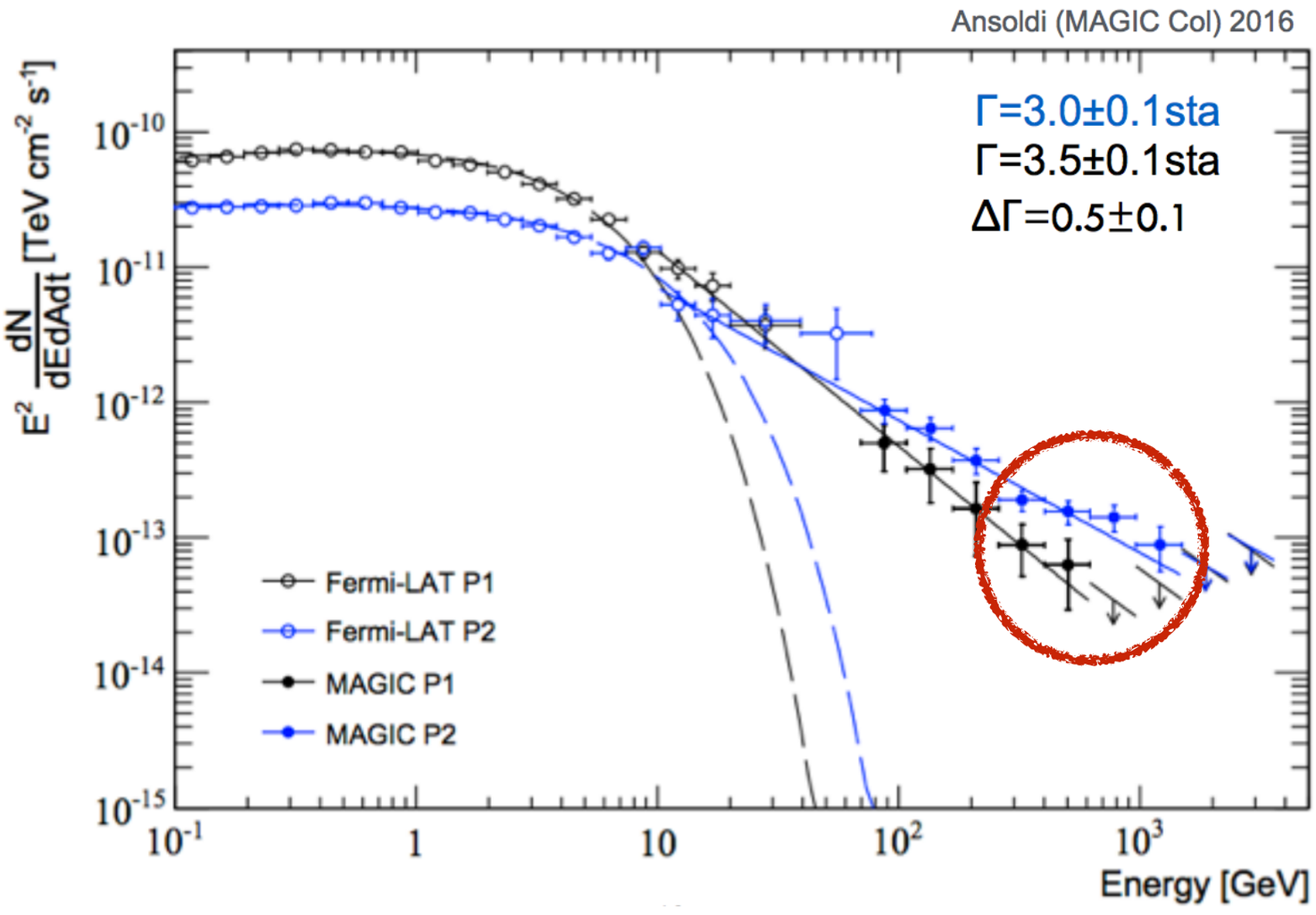


A. Harding

Gamma-ray pulsars: Crab pulsar



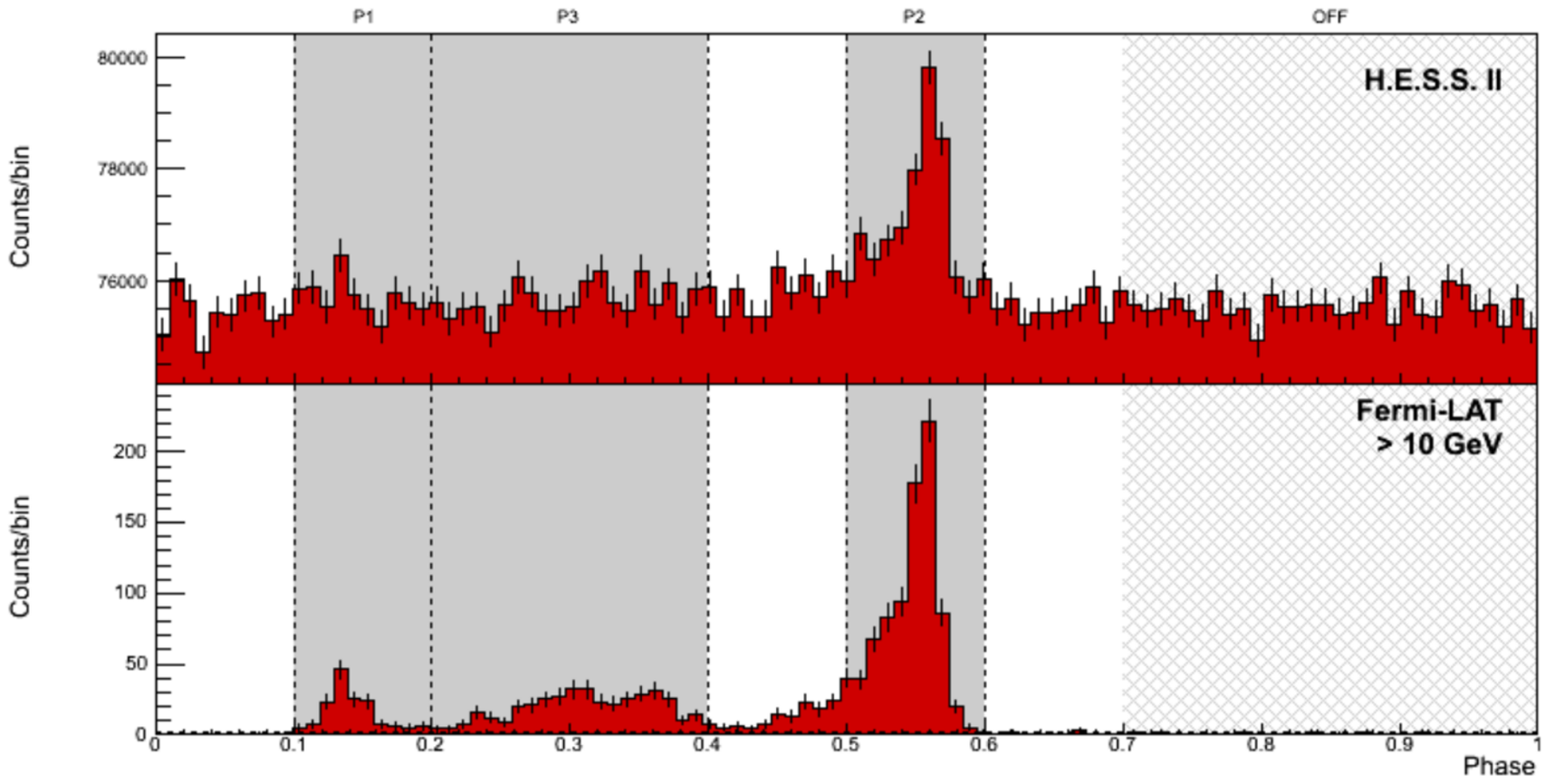
- pulsed emission exceeding TeV
- requires new modeling attempts

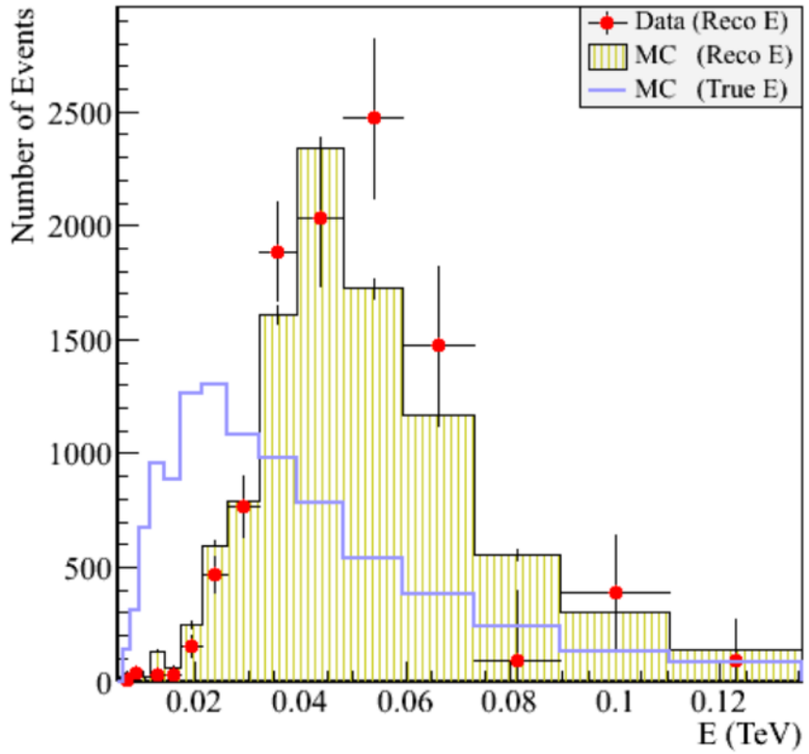


E. de Ona Wilhemi (MAGIC)

Gamma-ray pulsars: Vela pulsar

- H.E.S.S.-II 28m telescope: lower energy threshold

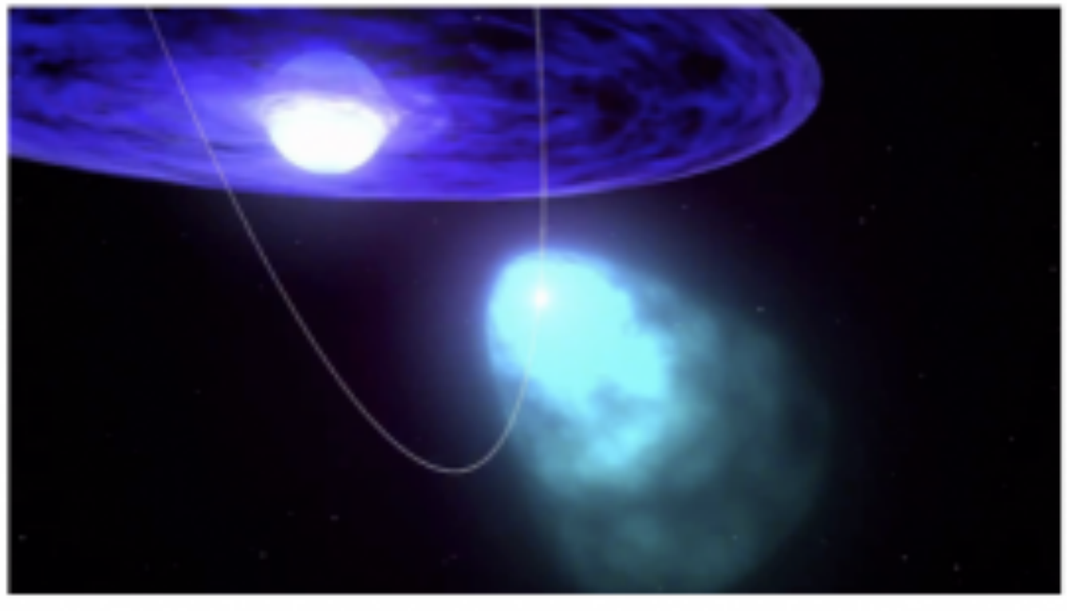


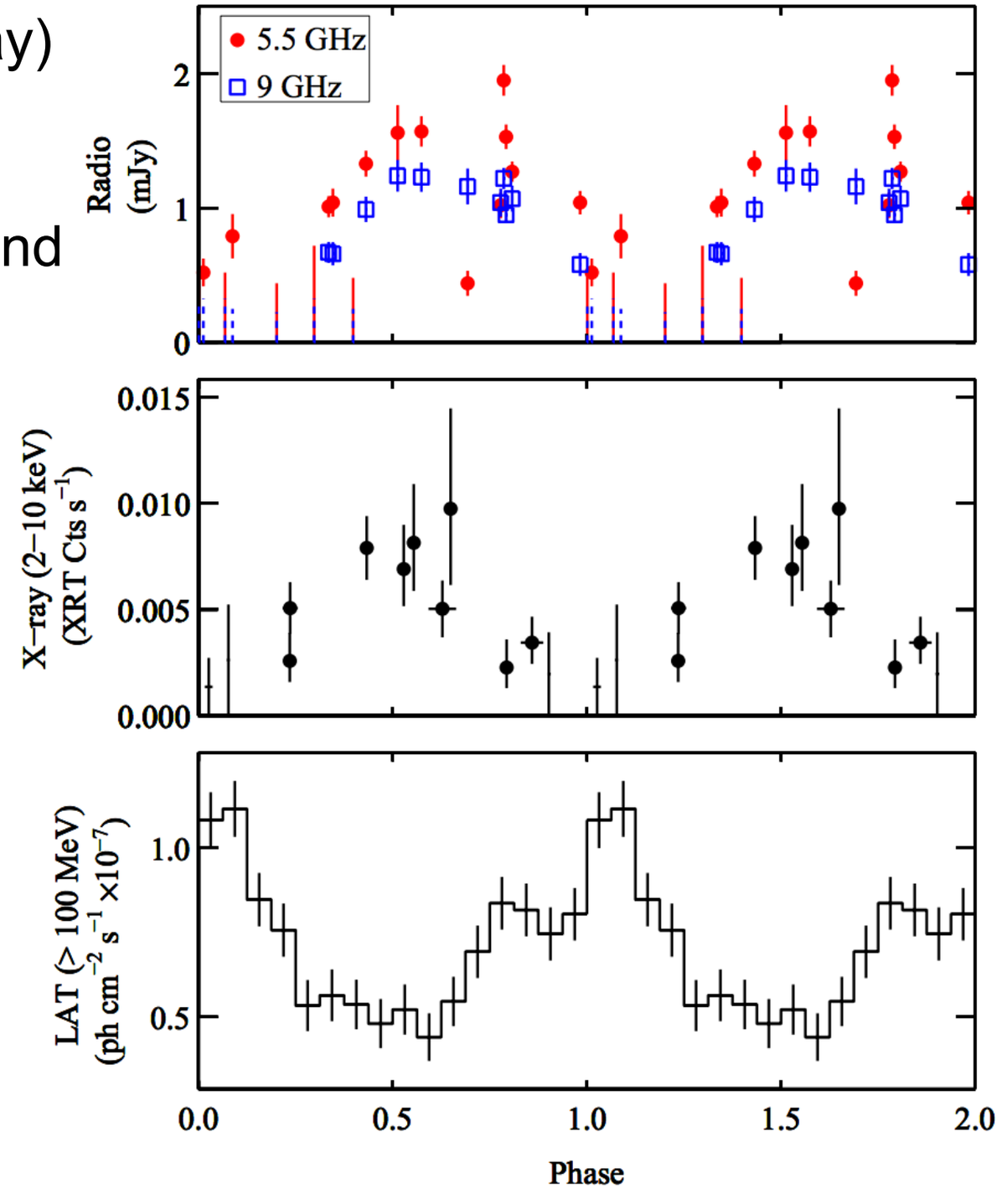


A. Djannati-Atai (H.E.S.S.)

An extragalactic gamma-ray binary

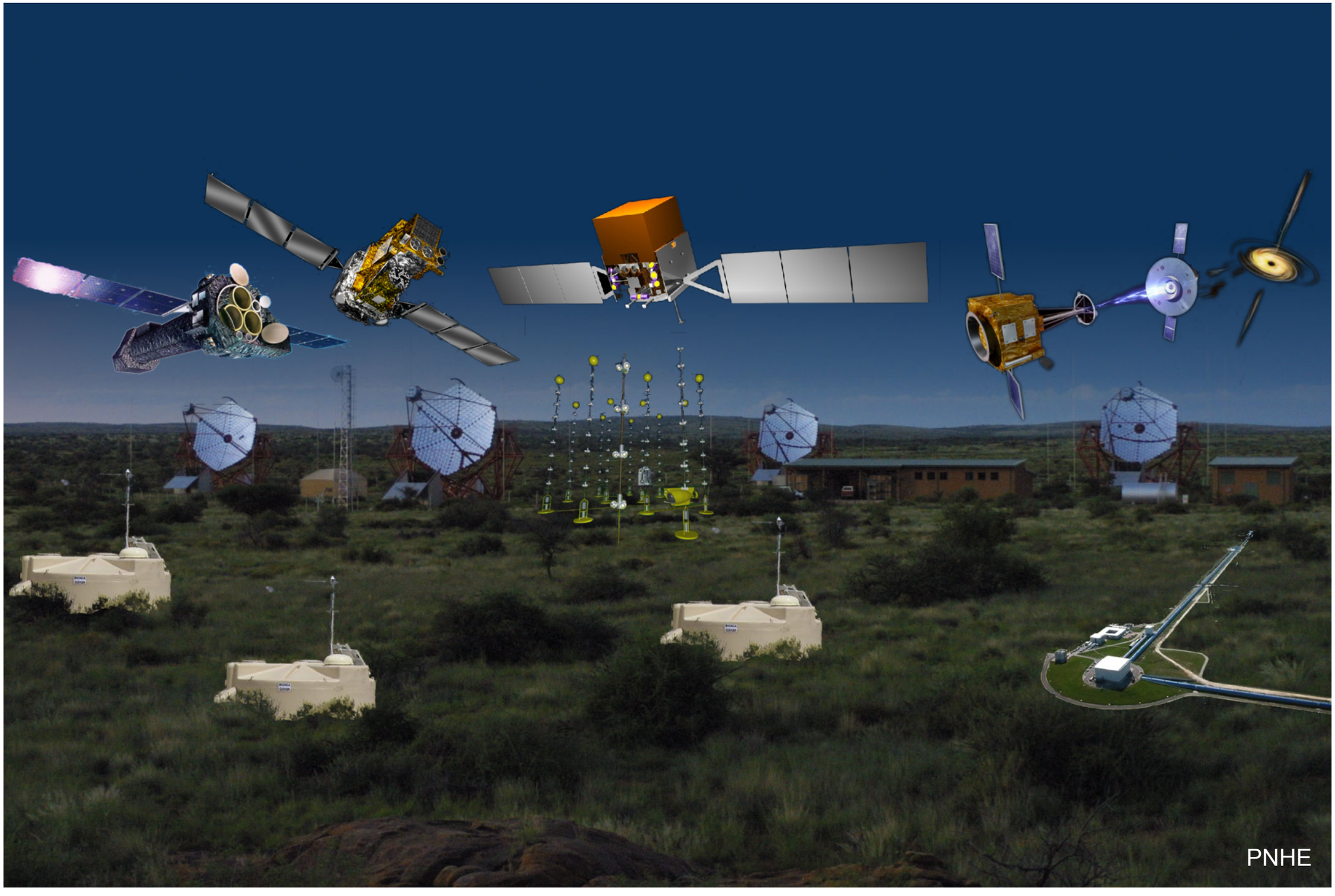
- Large Magellanic Cloud (~50 kpc away)
- Period: 10.3 days
- anti-correlation between radio/X-ray and gamma rays
- similar to PSR B1259-63 (?)





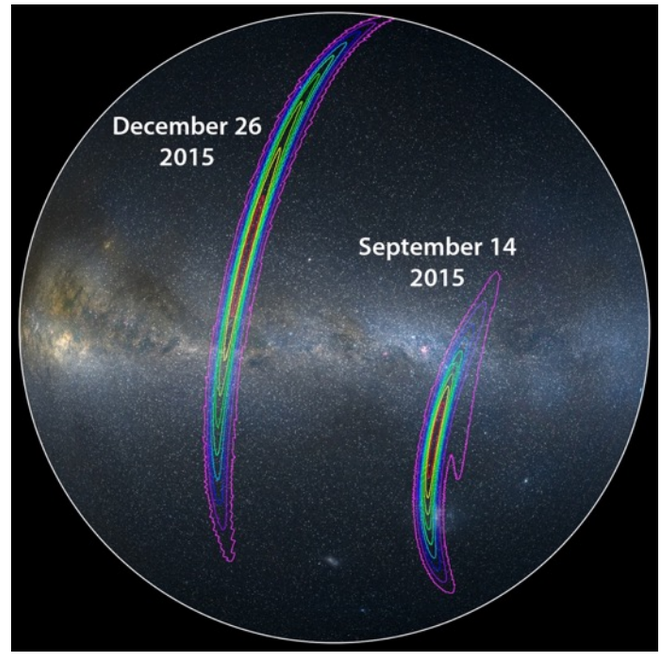
R. Corbet et al., 1608.06647

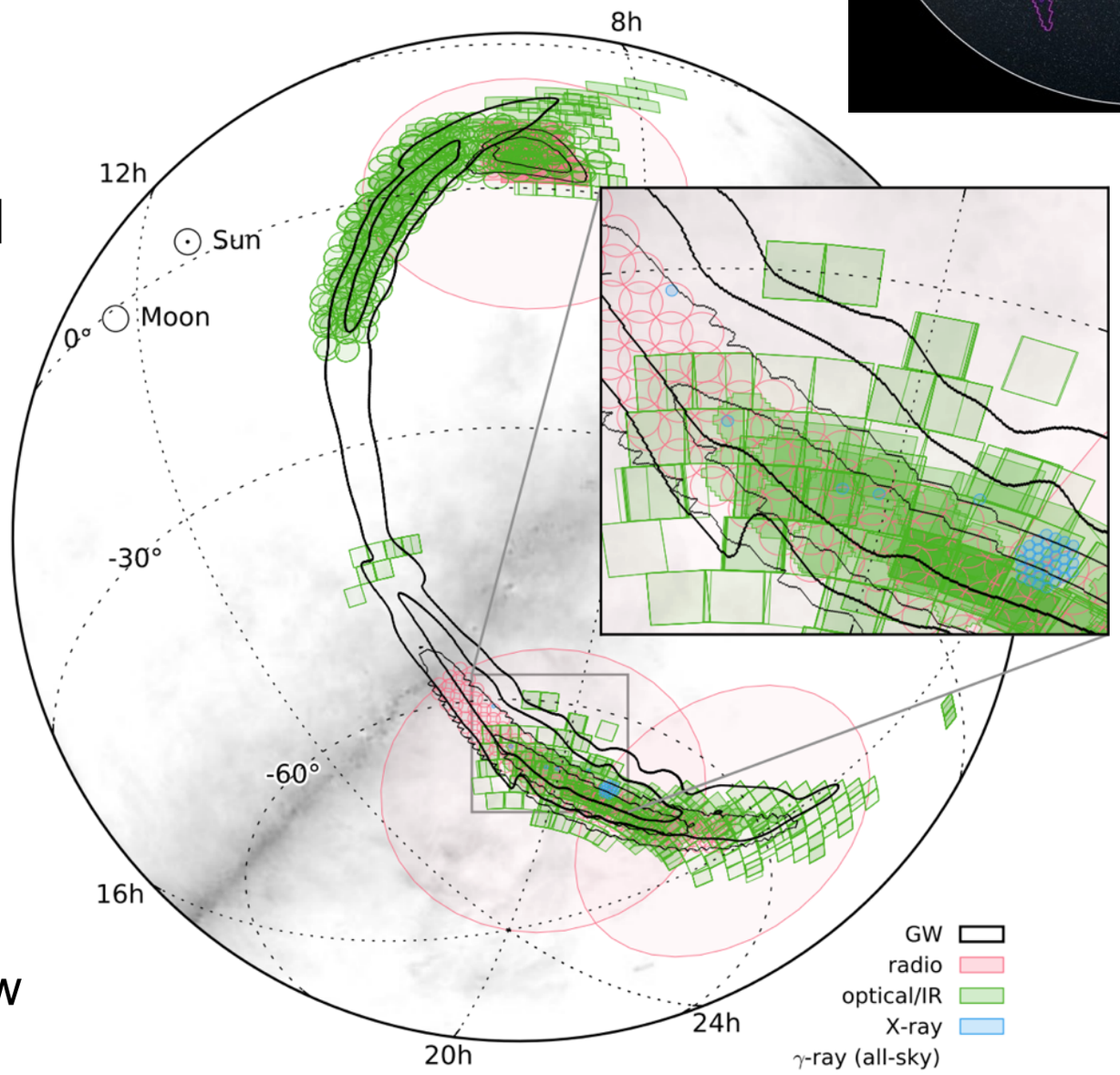
Multi-wavelength and multi-messenger connections



Gravitational waves

- gamma-ray instruments well suited for follow-ups
  - rapid response (e.g. MAGIC, H.E.S.S.-II)
  - large FoV
  - high sensitivity
  - low background
- no strong participation in O1



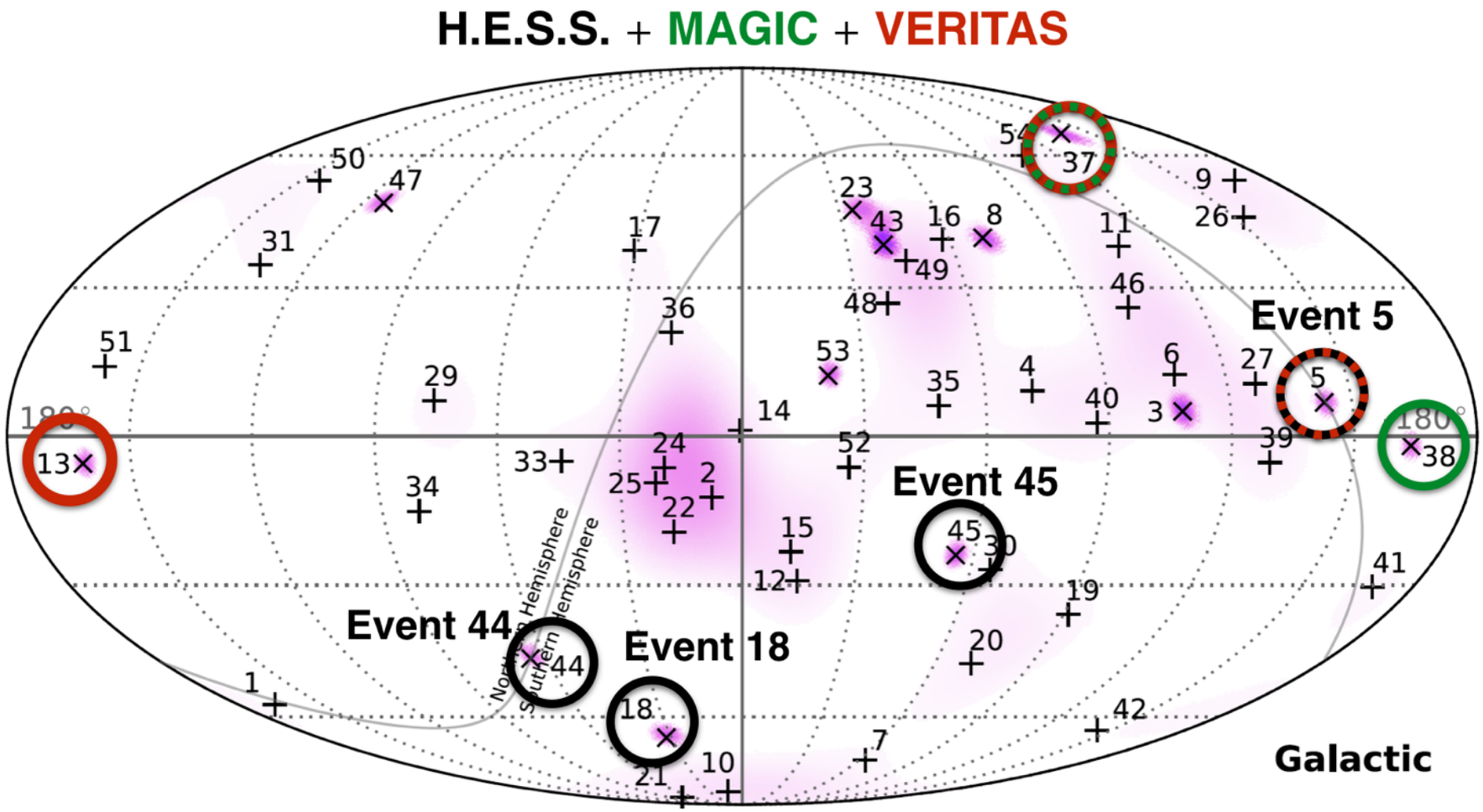


Caveats

- BH-BH mergers not expected to emit EM radiation
- Rate of NS-NS mergers (e.g. short GRBs) uncertain and potentially low

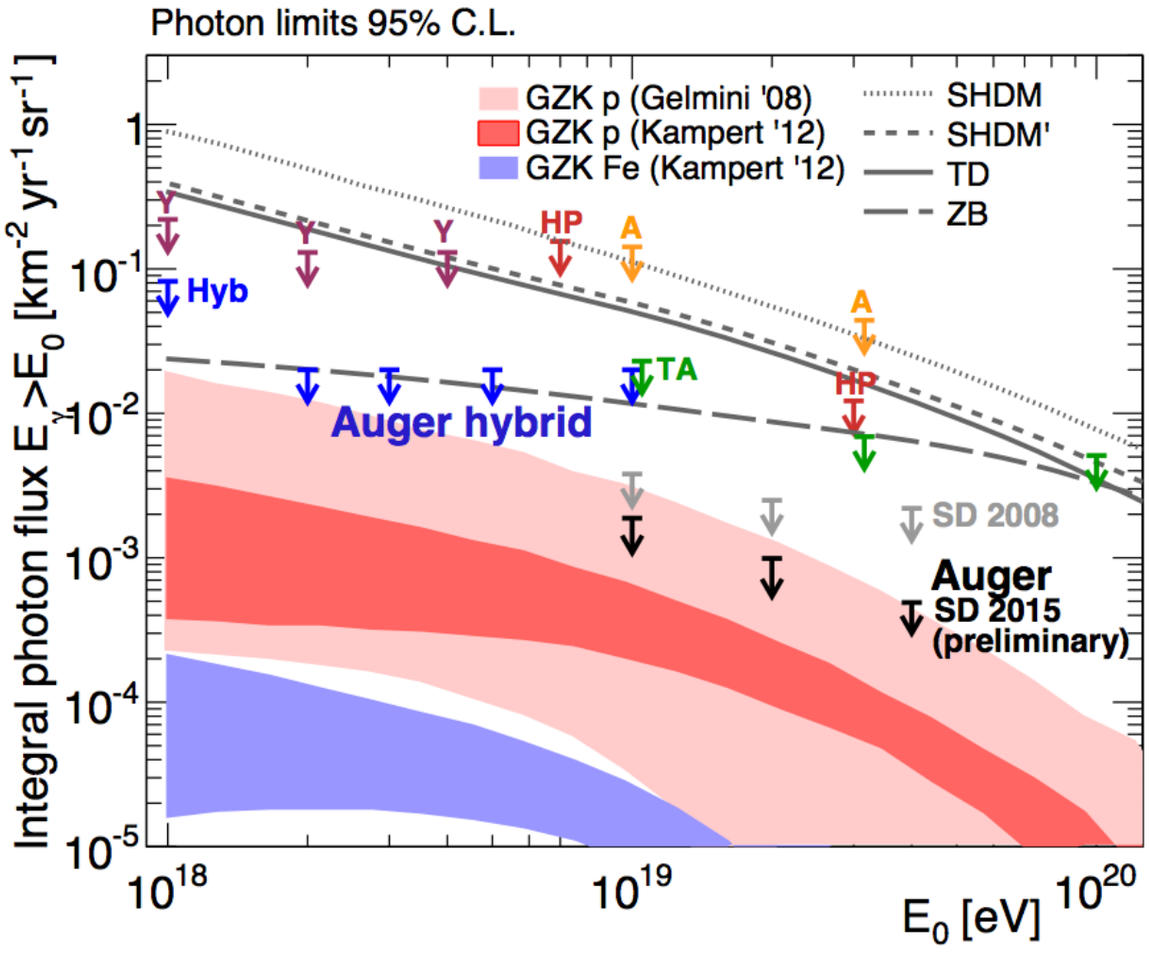
High-energy neutrinos

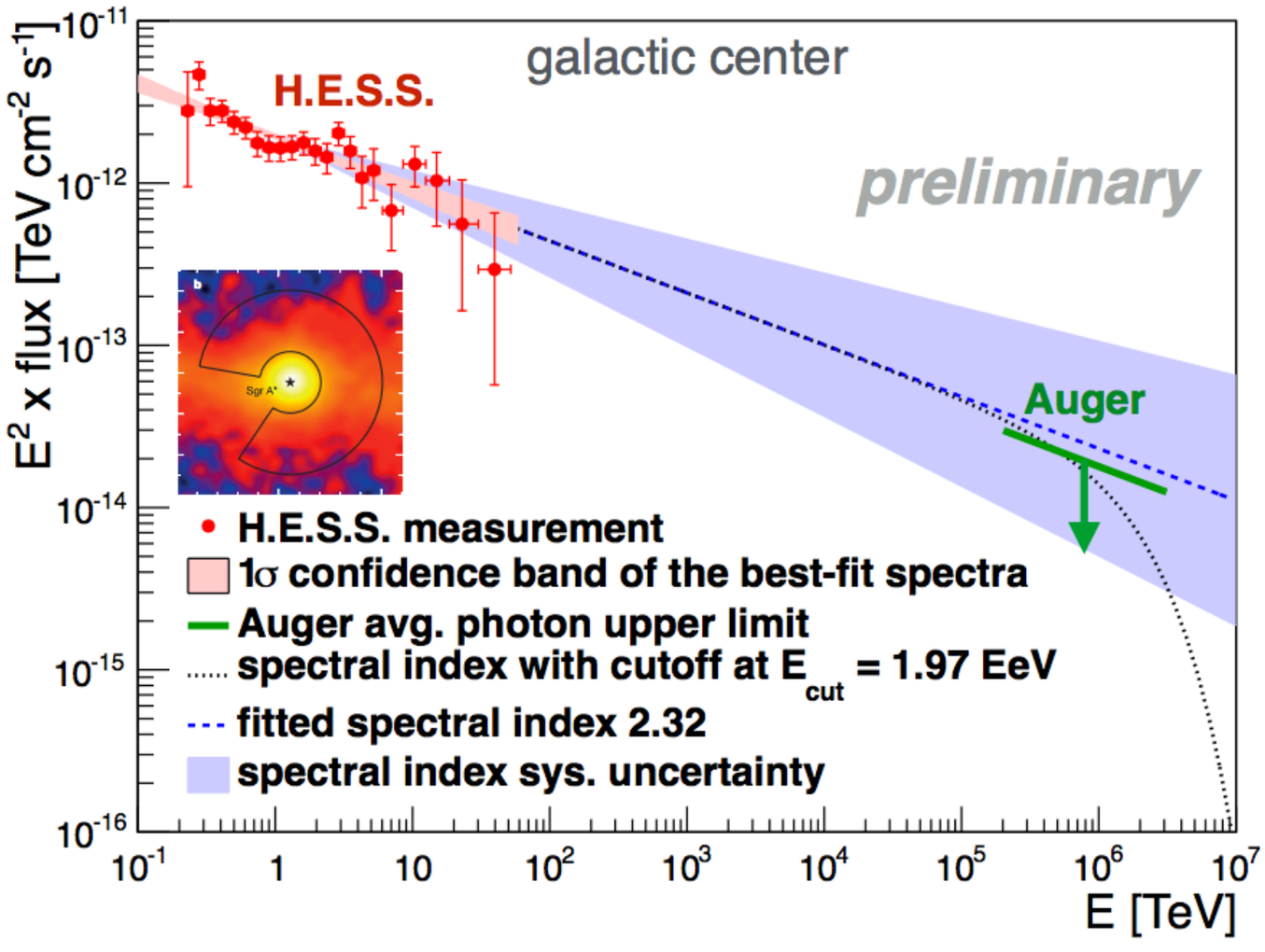
- IceCube is announcing their prime events publicly since early 2016
- alerts emitted after a few minutes
- extensive follow-up programs with all IACTs, HAWC, Fermi-LAT, etc.



K. Satalecka (MAGIC) / D. Dorner (FACT) / M. Santander (VERITAS) / F. Schüssler (H.E.S.S.)

Ultra-high energy photons: Pierre Auger Observatory

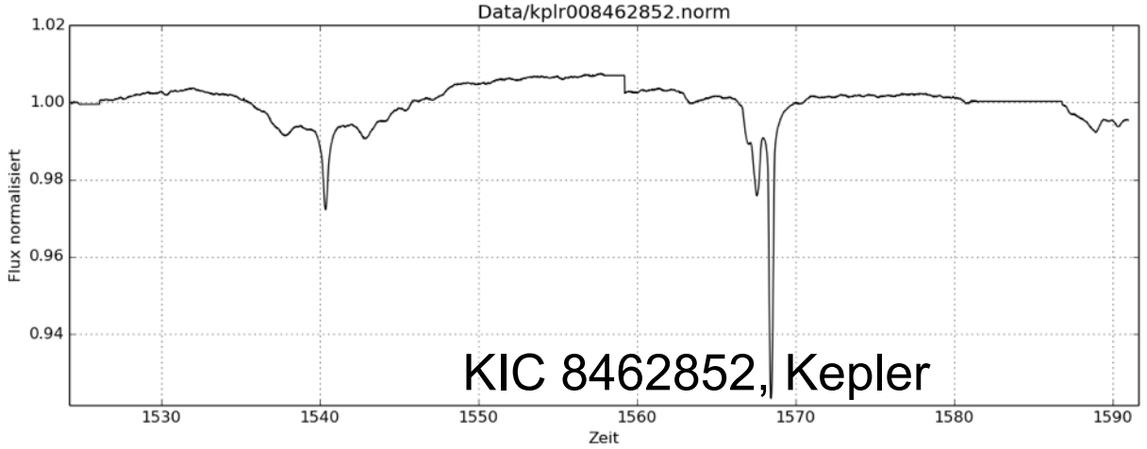


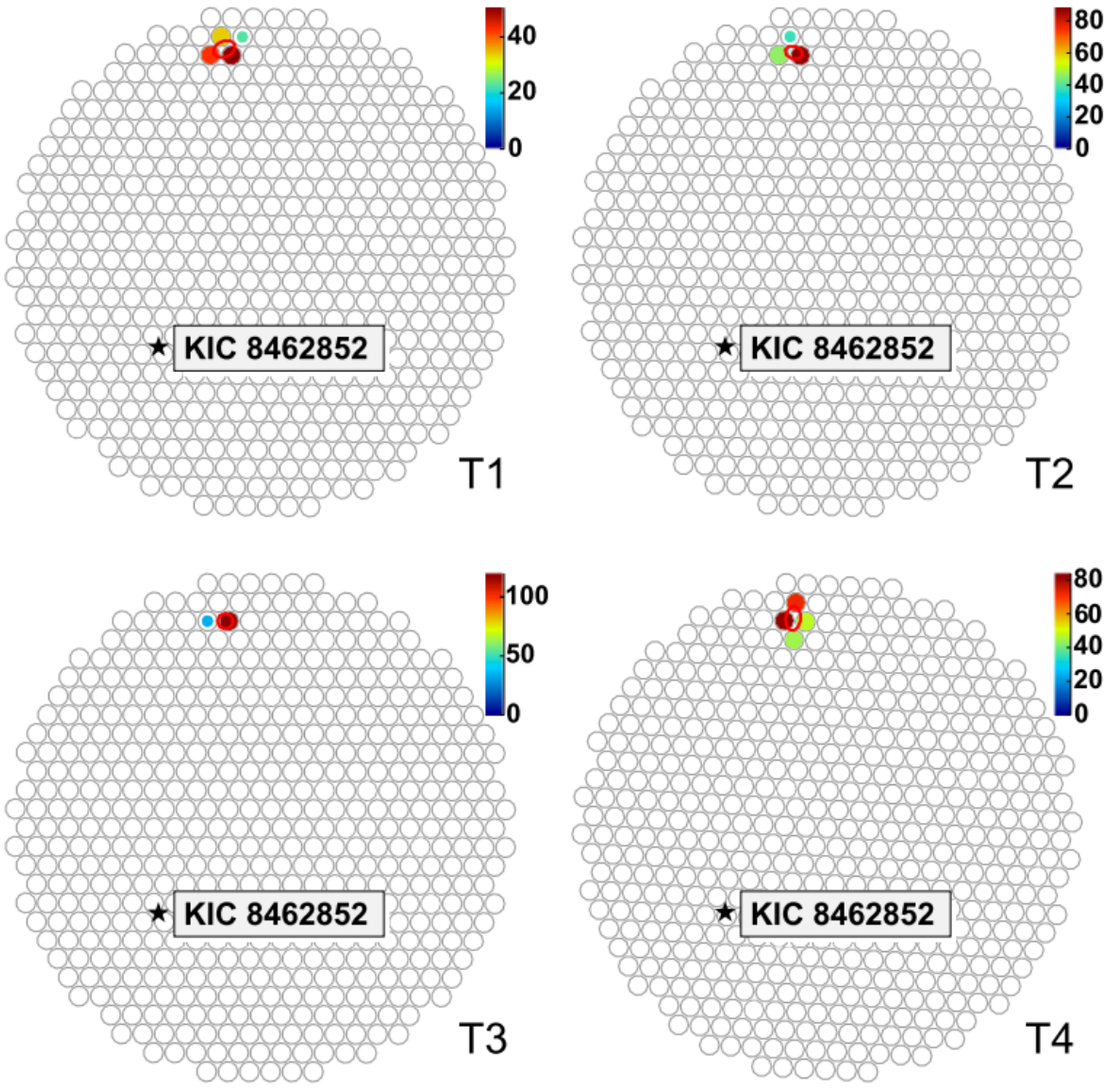


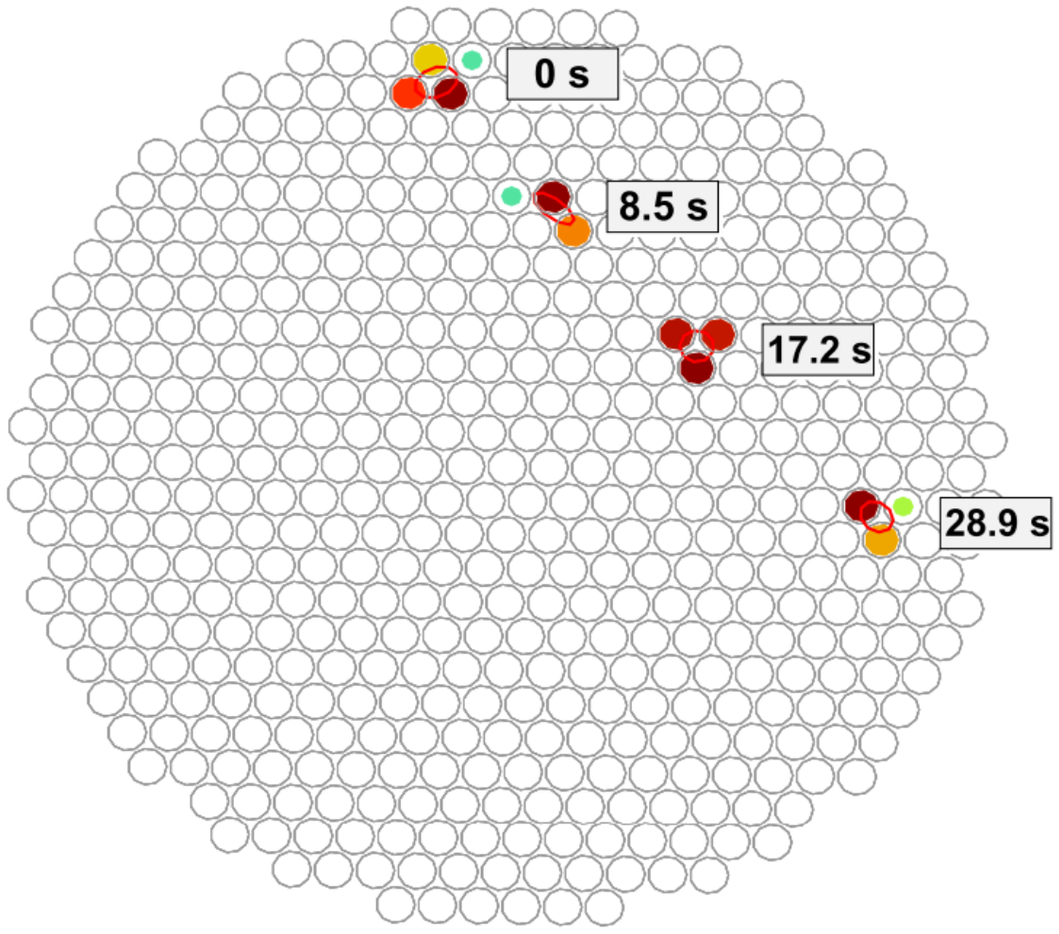
D. Kümpel (Pierre Auger Observatory)

SETI @ VERITAS

- searches for optical flashes as sign of extraterrestrial life







A. U. Abeysekara (VERITAS), ApJL 2016

CTA

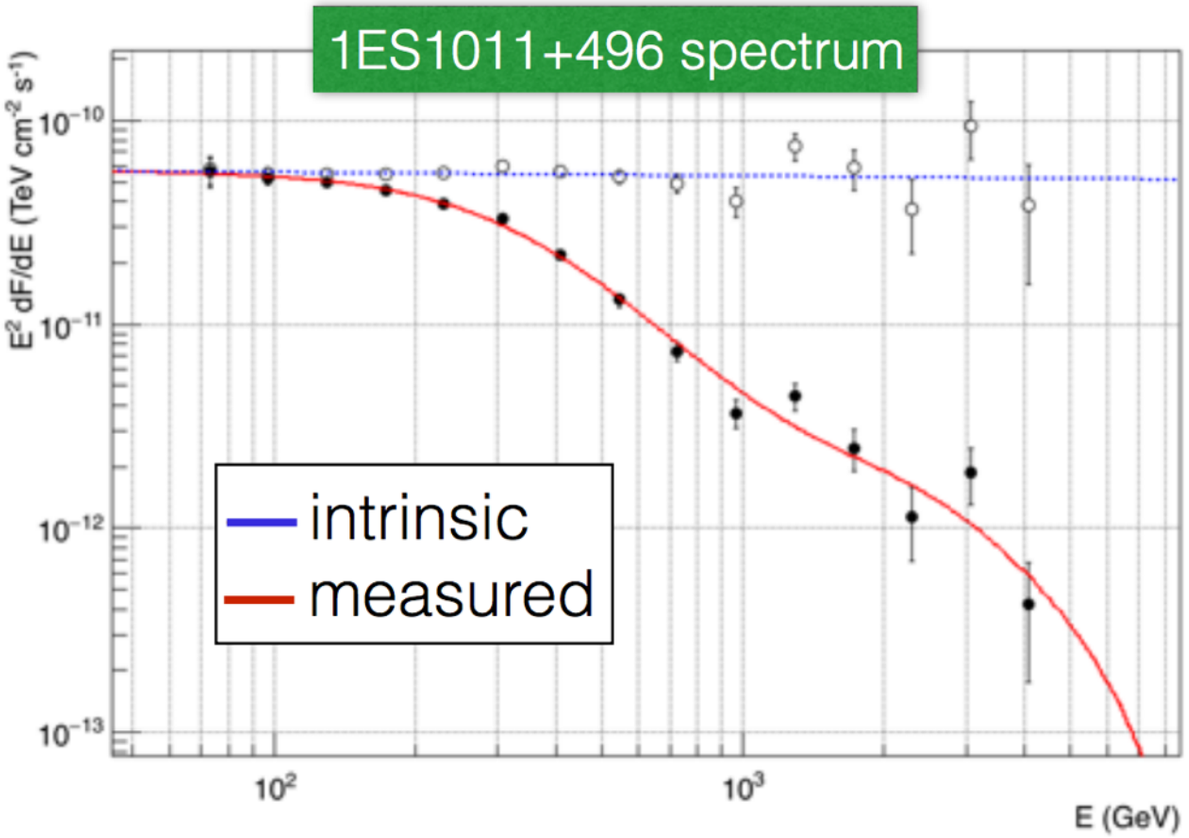
- Northern Site
  - hosting agreement signed
  - construction started

- Southern Site
  - negotiations with ESO until end 2016
  - several prototypes

Summary

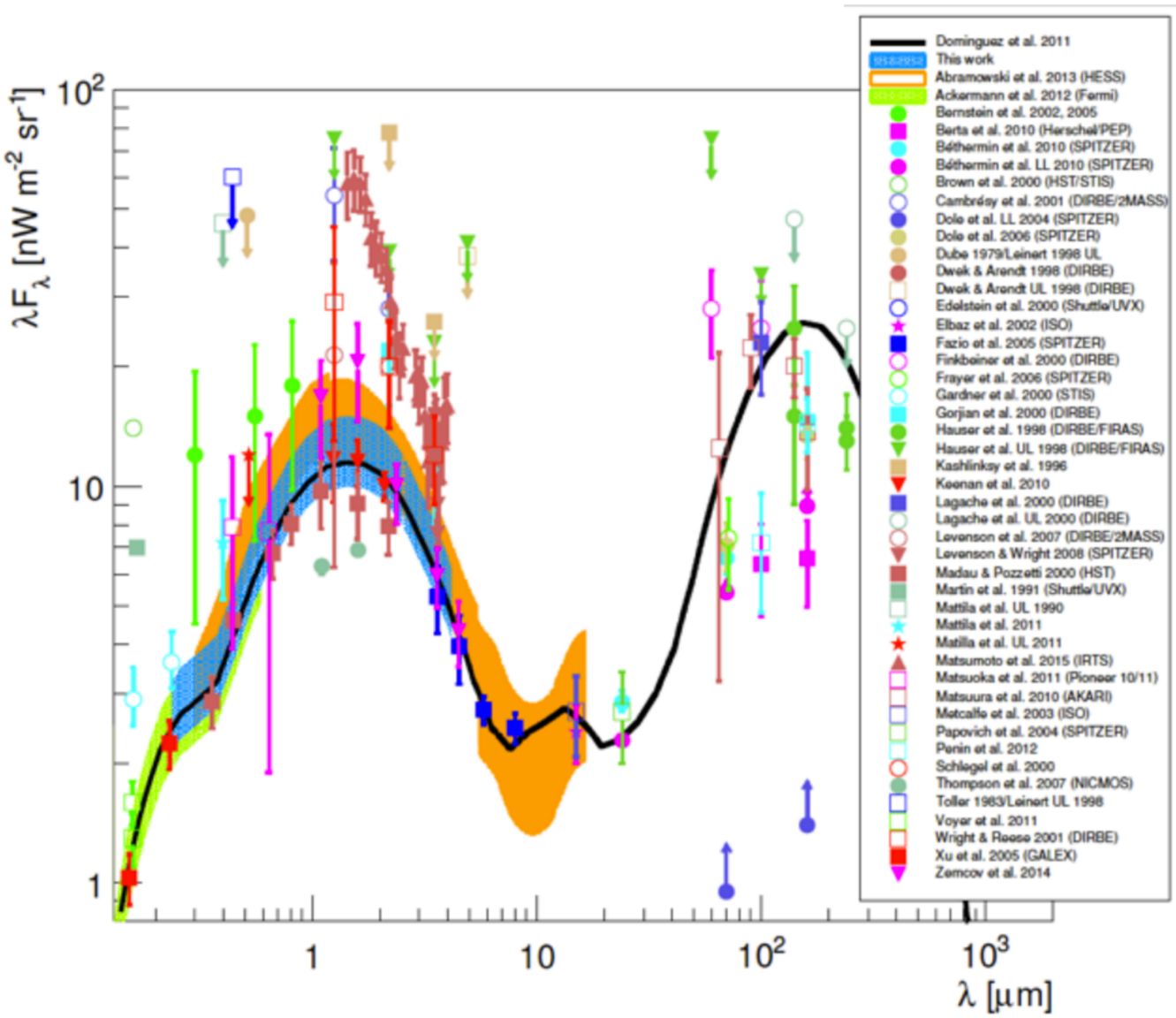
- Gamma-ray astronomy a mature discipline
  - analyses with unprecedented accuracy (e.g. time and spatial resolution, energy ranges increased, etc.)
  - legacy studies, datasets exceeding 10 years
- New instruments
  - H.E.S.S.-II: rich physic results (pulsars, AGNs, transients, etc.)
  - HAWC (started in 2015): new sources, monitoring, etc.
  - CTA: construction started, first light 2018

Extragalactic Background Light: model scaling



- determine scaling factor of EBL models

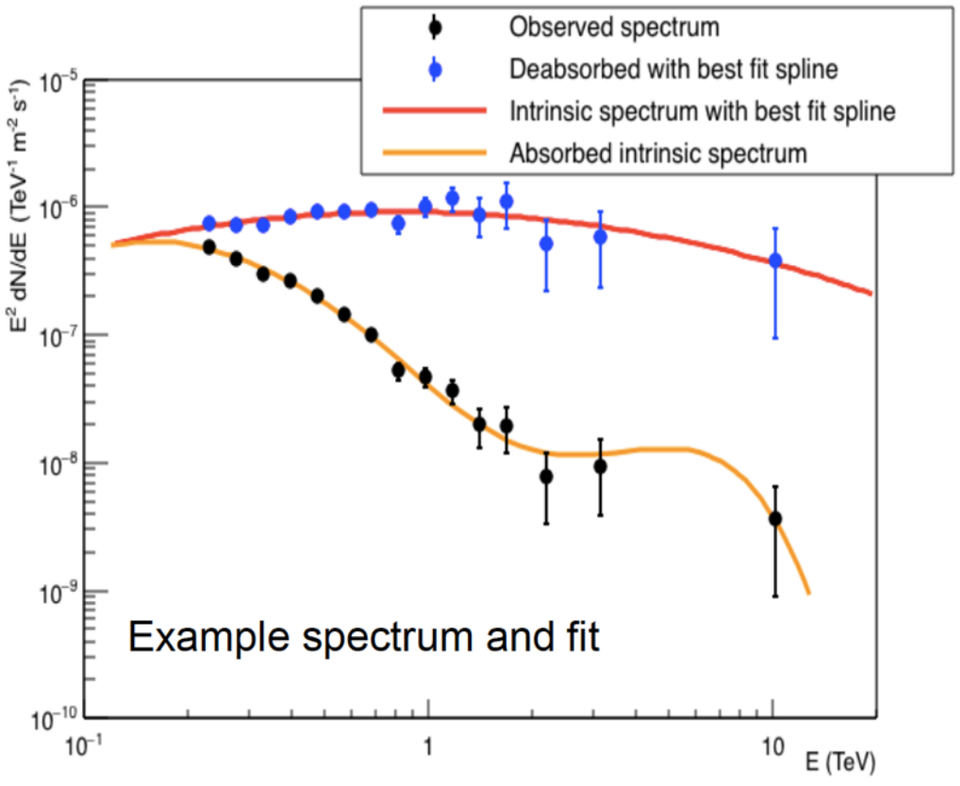
1ES1011+496 (z=0.212)

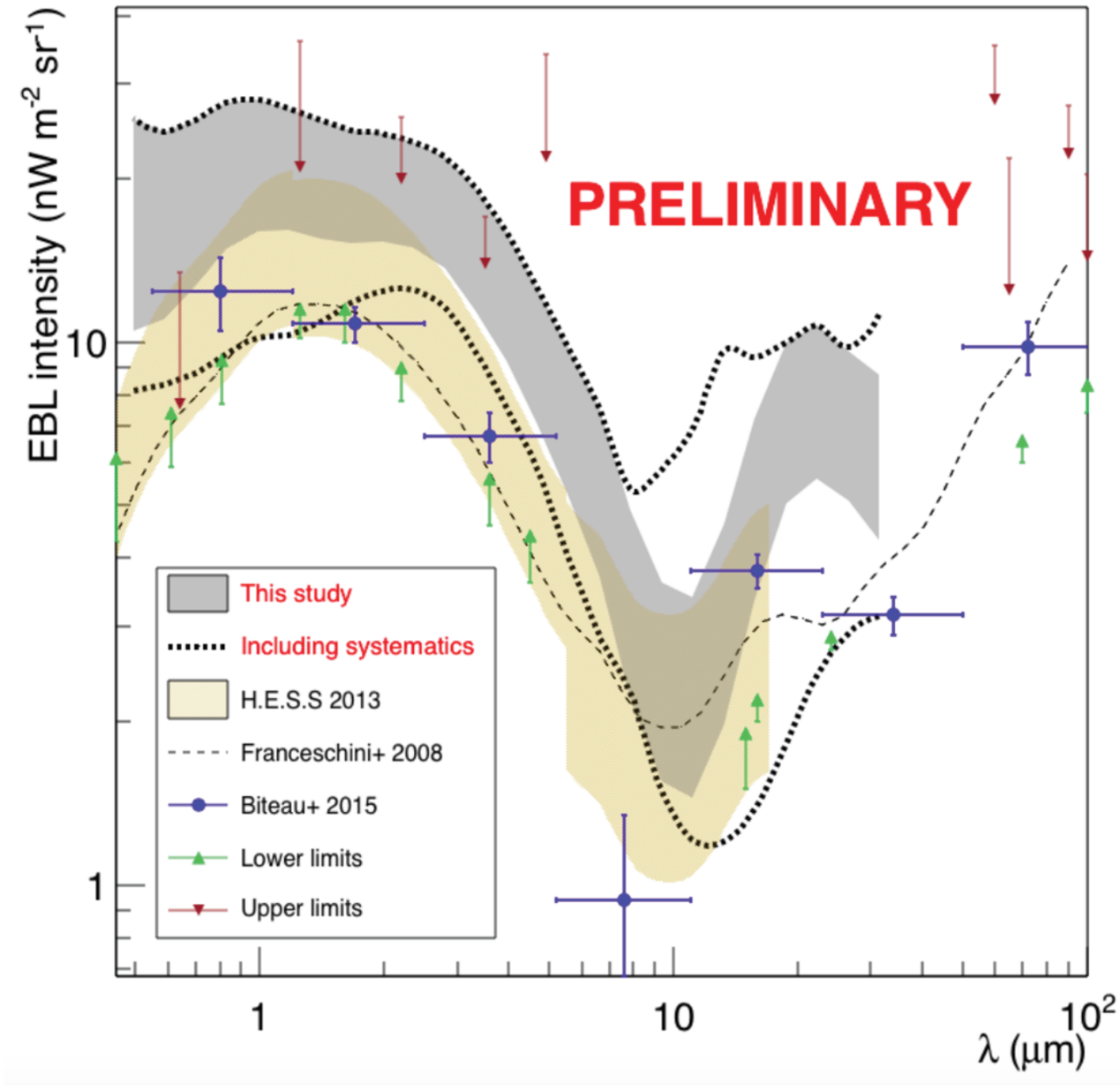


Ahnen et al. (MAGIC), A&A, 590, 24 (2016)

Extragalactic Background Light: measurements

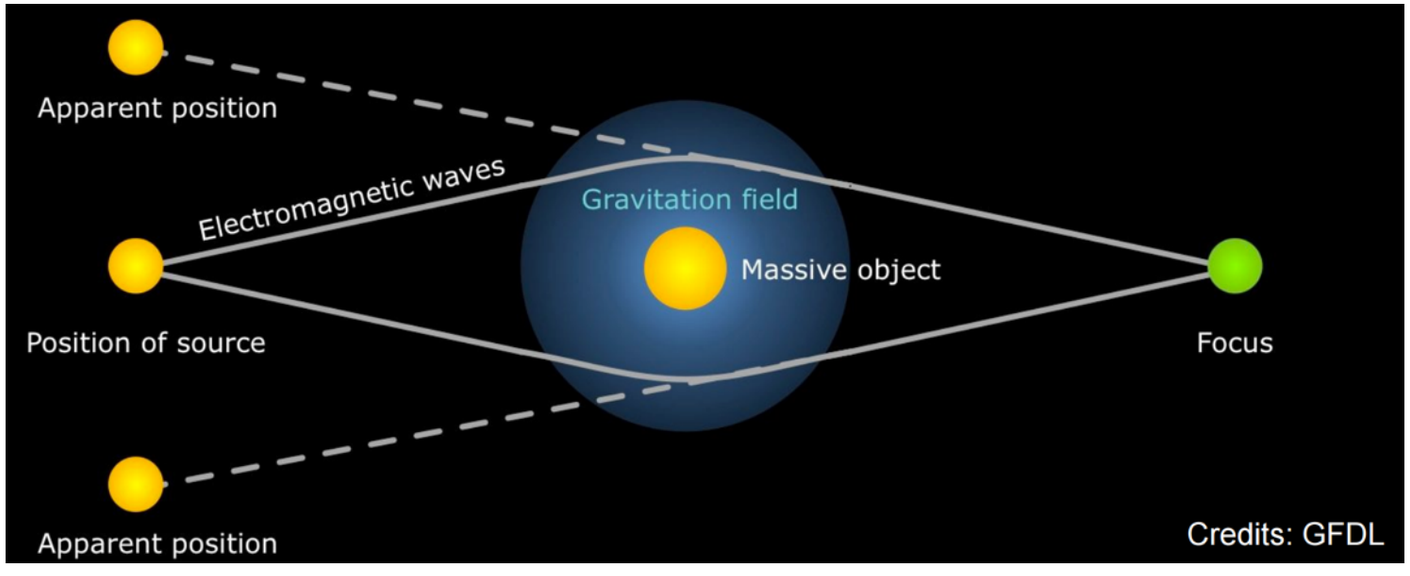
- EBL measurement with TeV gamma-rays
  - combined fit of spectrum + EBL
  - EBL represented by splines
  - model independent measurement of the EBL



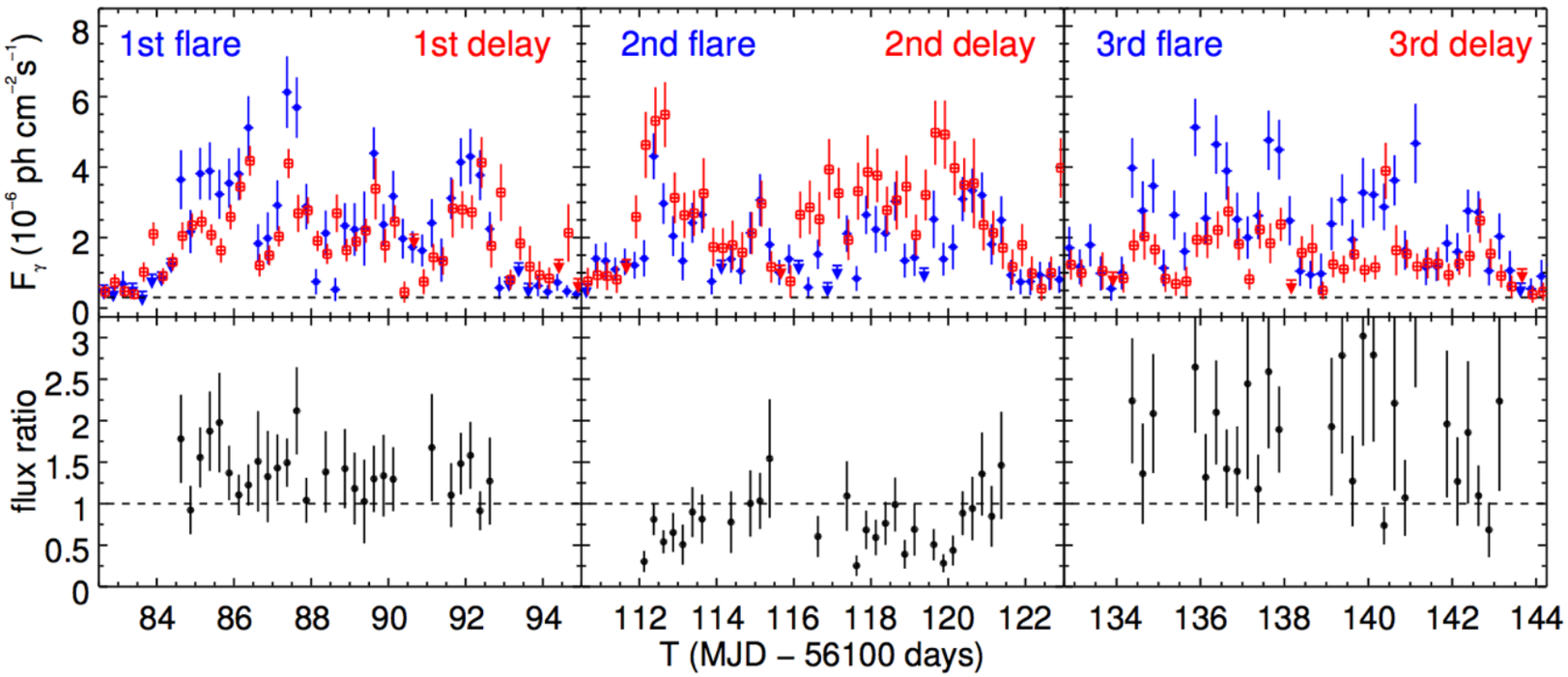


M. Lorentz et al. (H.E.S.S.), ICRC 2015

The hunt for far-away TeV sources: GW lensing



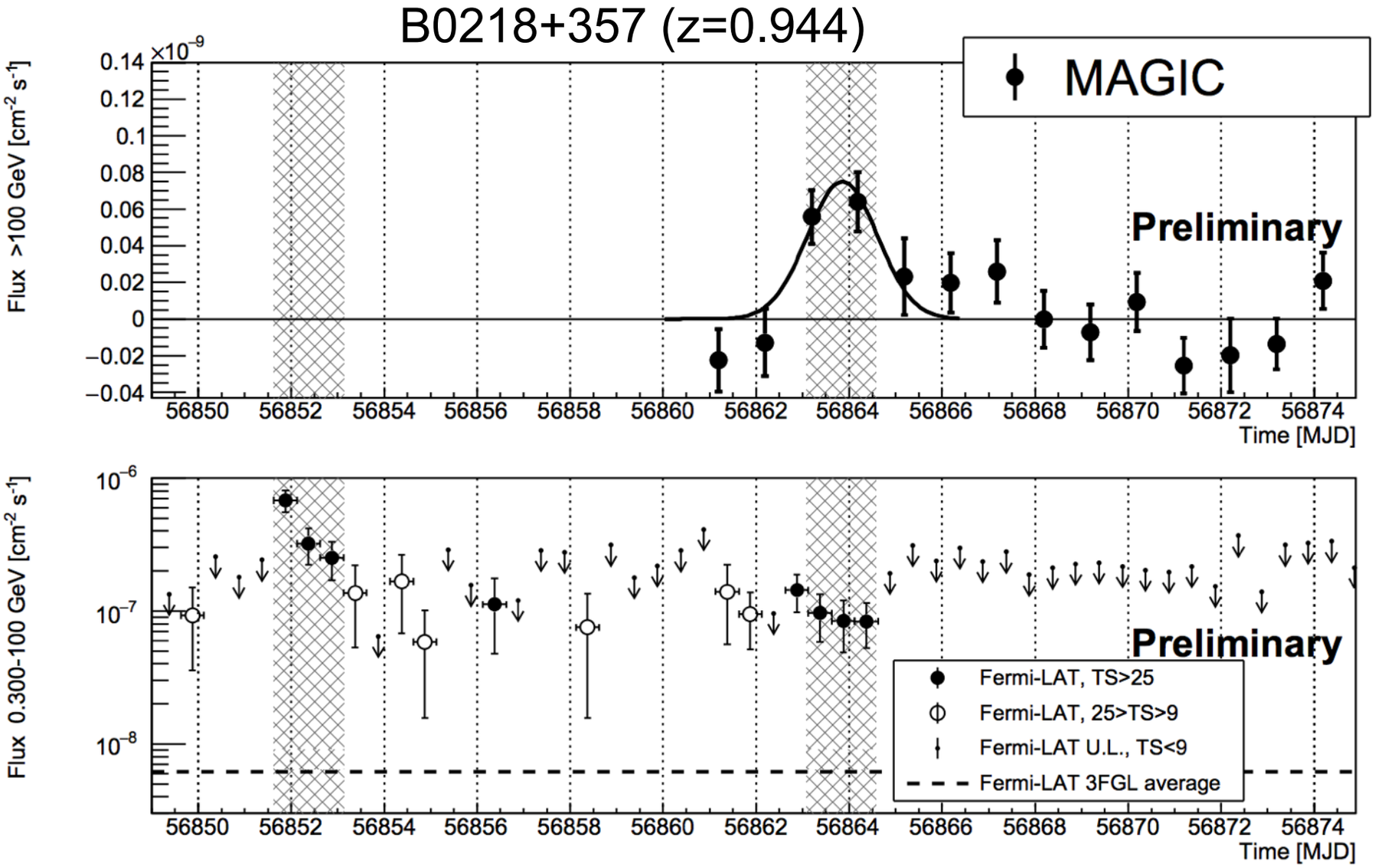
- B0218+357
  - redshift z=0.944
  - lensing galaxy at z~0.64
  - delays observed in radio
  - Fermi-LAT flares in 2012
    - delay: ~11.6 days



Cheung et al., APJL 2014

The hunt for far-away TeV sources

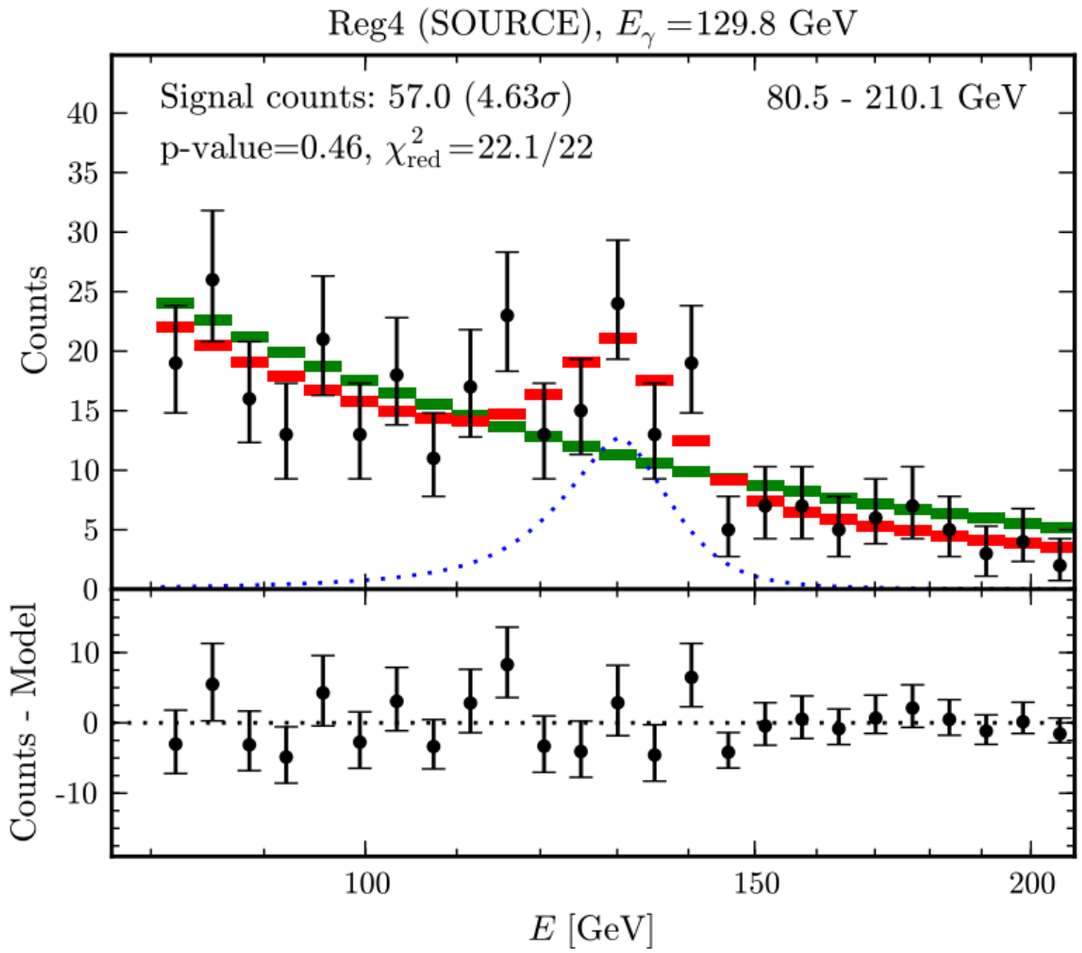
- July/August 2014: new Fermi-LAT flares detected
- MAGIC observations scheduled starting 10 days later



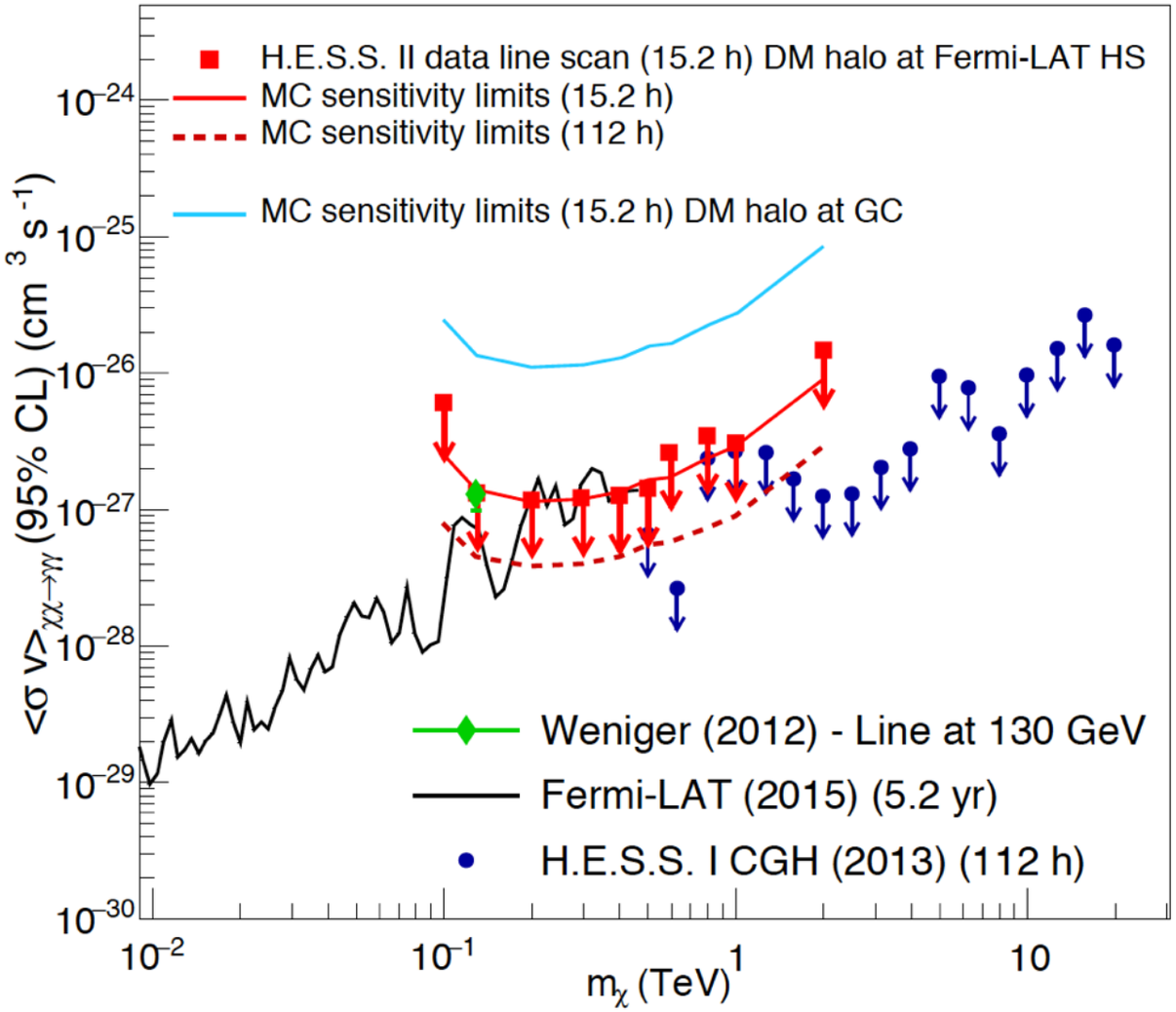
Sitarek et al. (MAGIC), ICRC 2015

Dark matter near the Galactic Center

- H.E.S.S.-II data: searching for line-like features near the GC
- triggered by hint seen in Fermi data (Bringman, Weniger, Finkbeiner, … 2012)

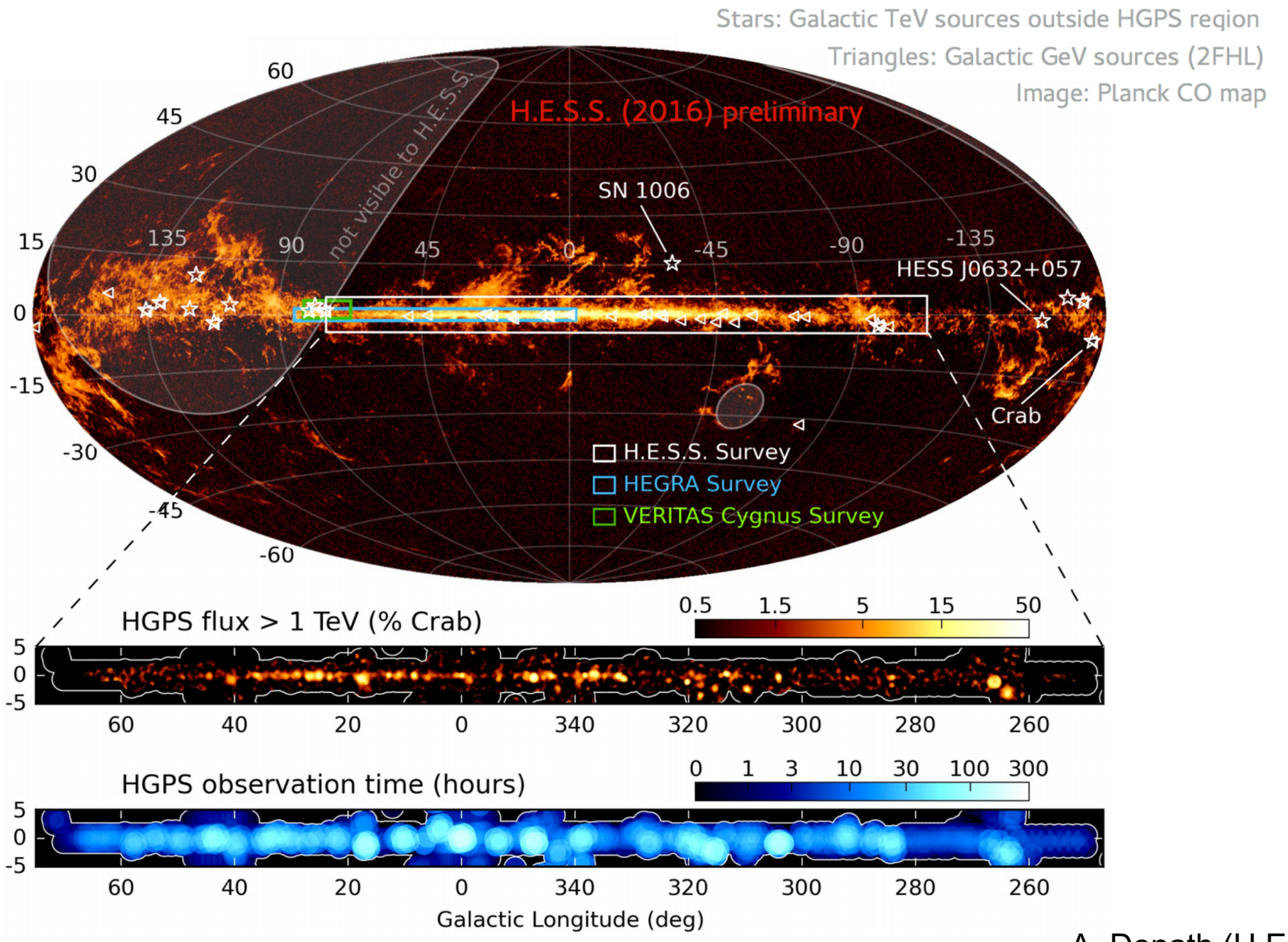


Weniger, JCAP (2012)



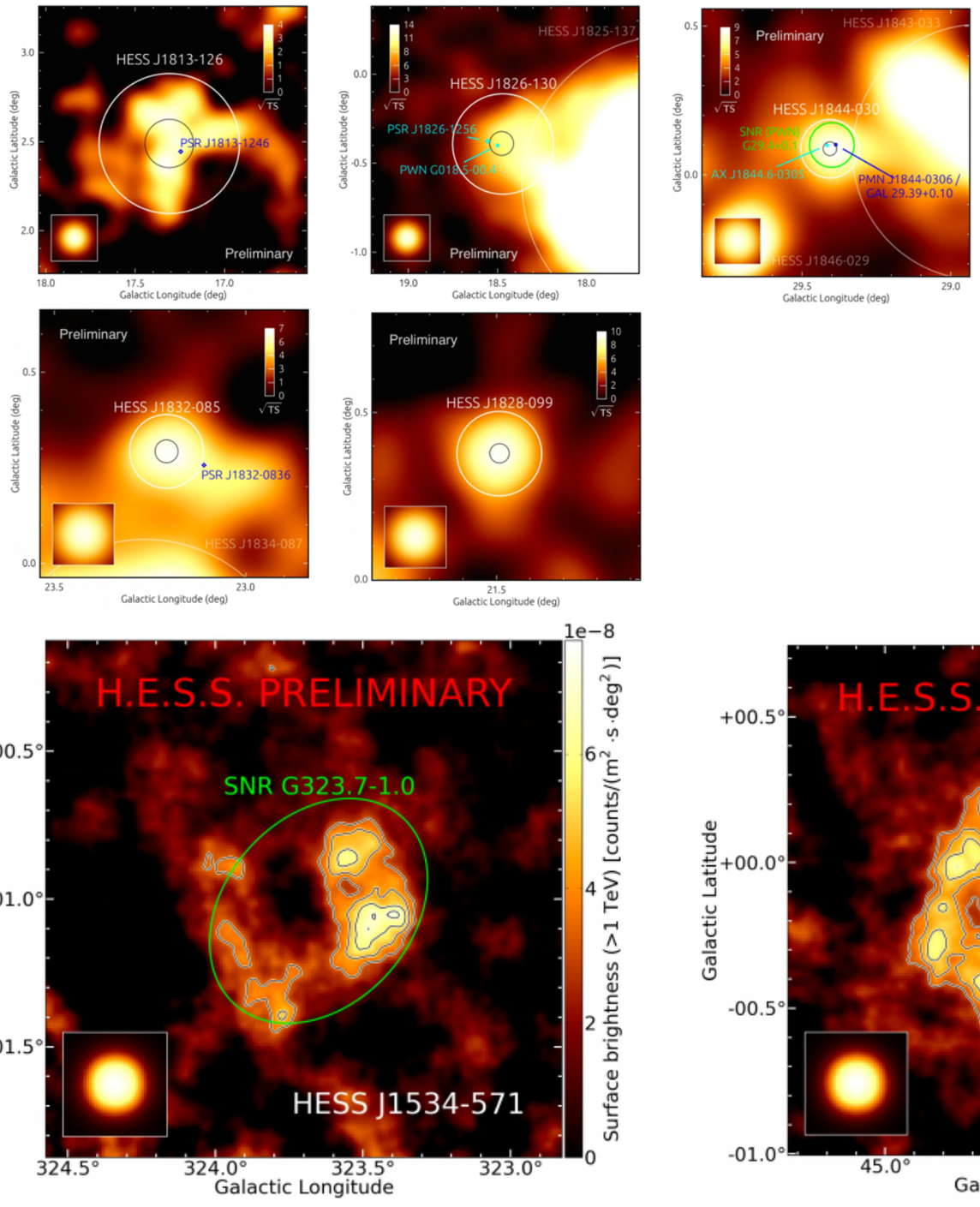
H.E.S.S., PRL (2016)

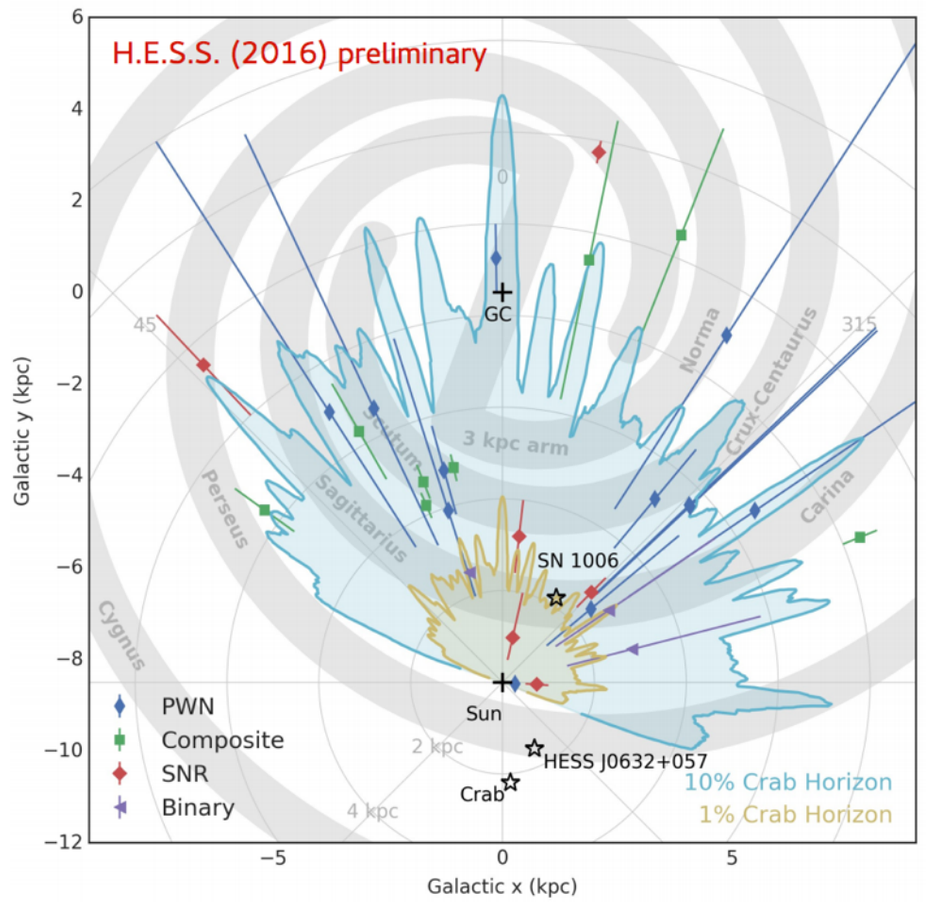
The H.E.S.S. Galactic Plane Survey

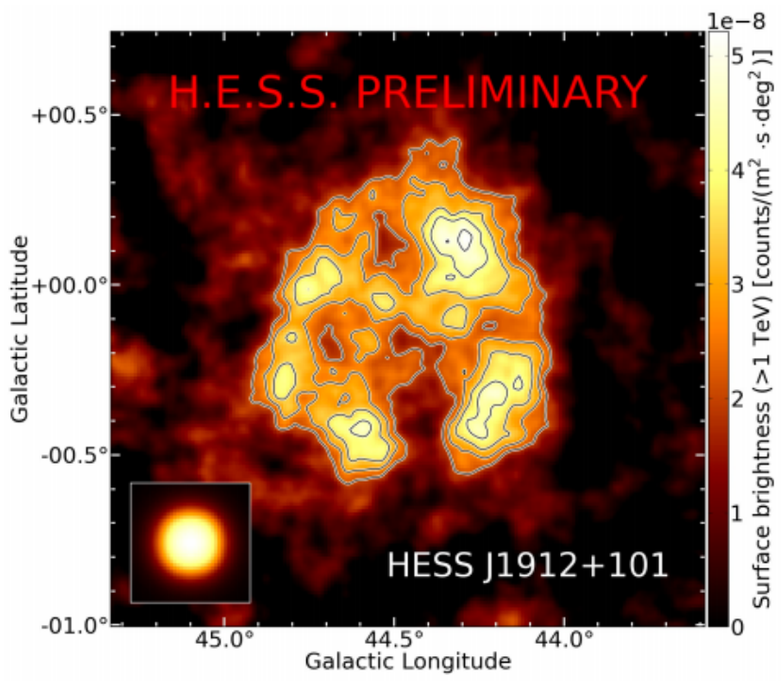


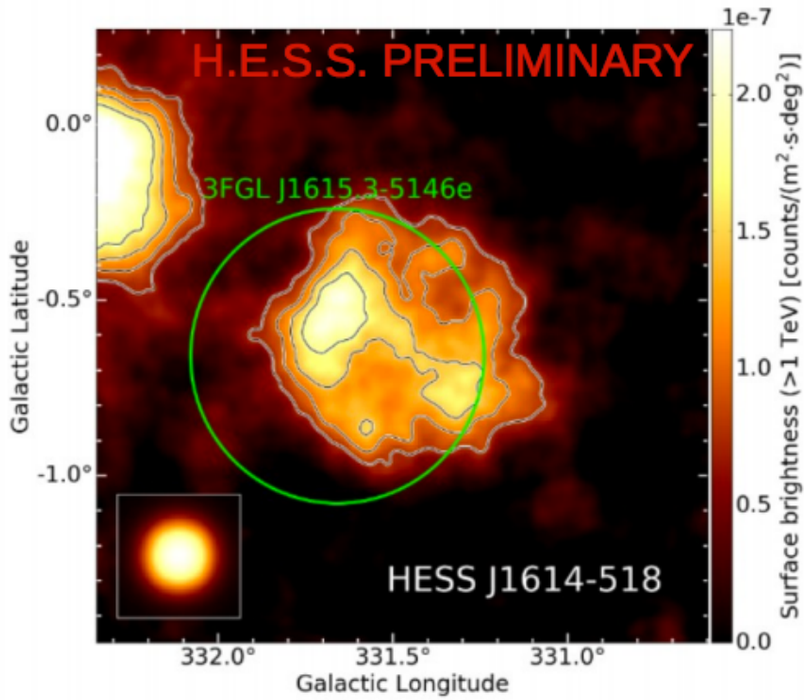
A. Donath (H.E.S.S.)

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





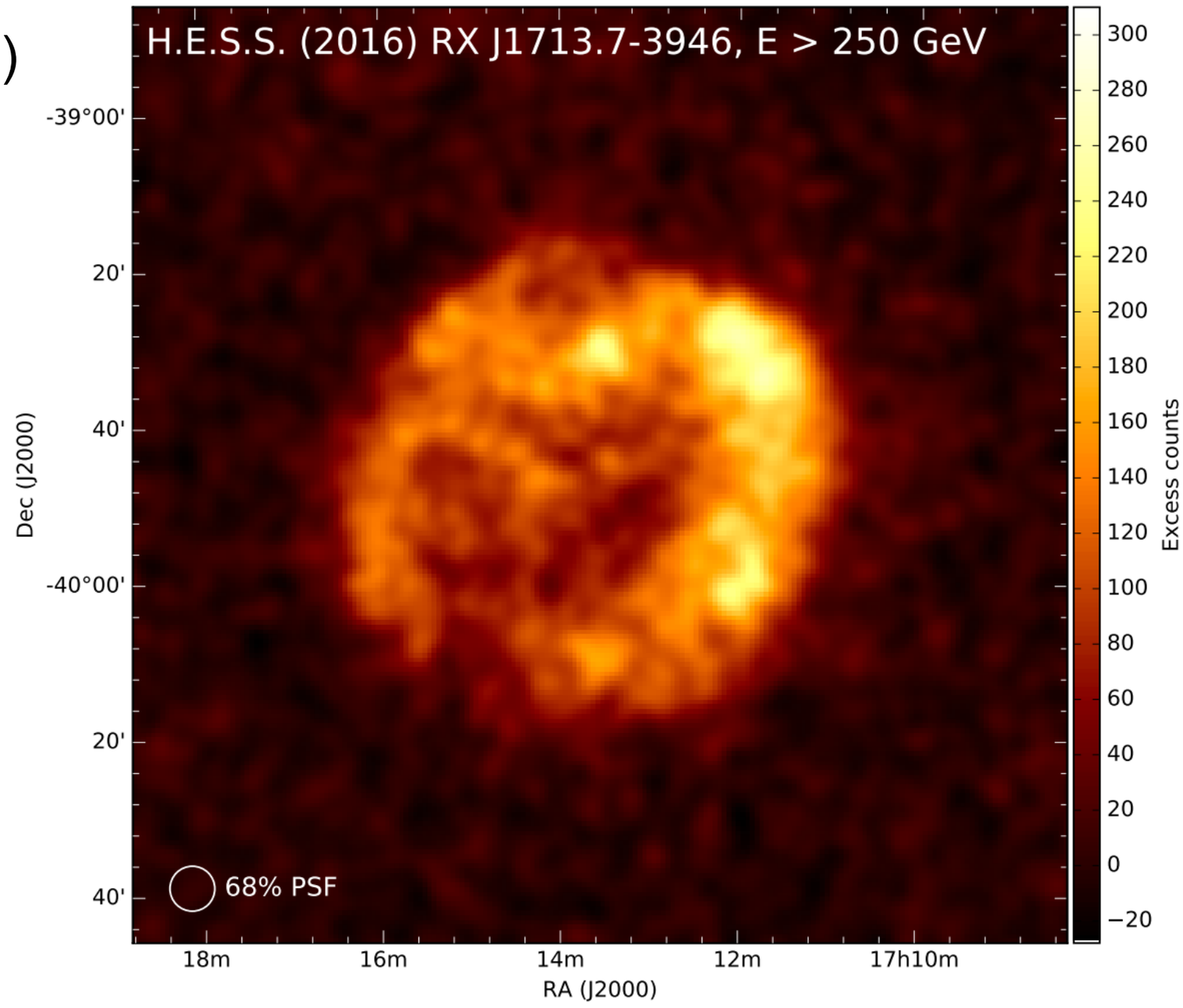




A. Donath (H.E.S.S.)

H.E.S.S.: RXJ1713.7

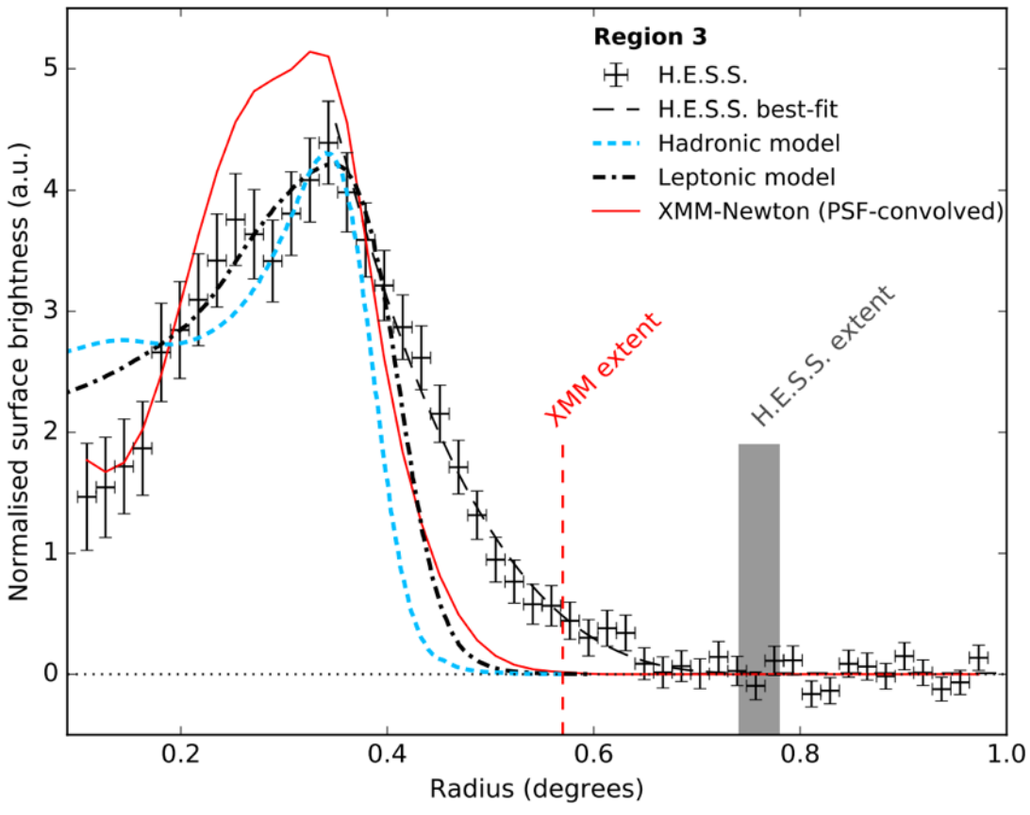
- 2004-2012
- livetime: 164h (spectrum:116h)

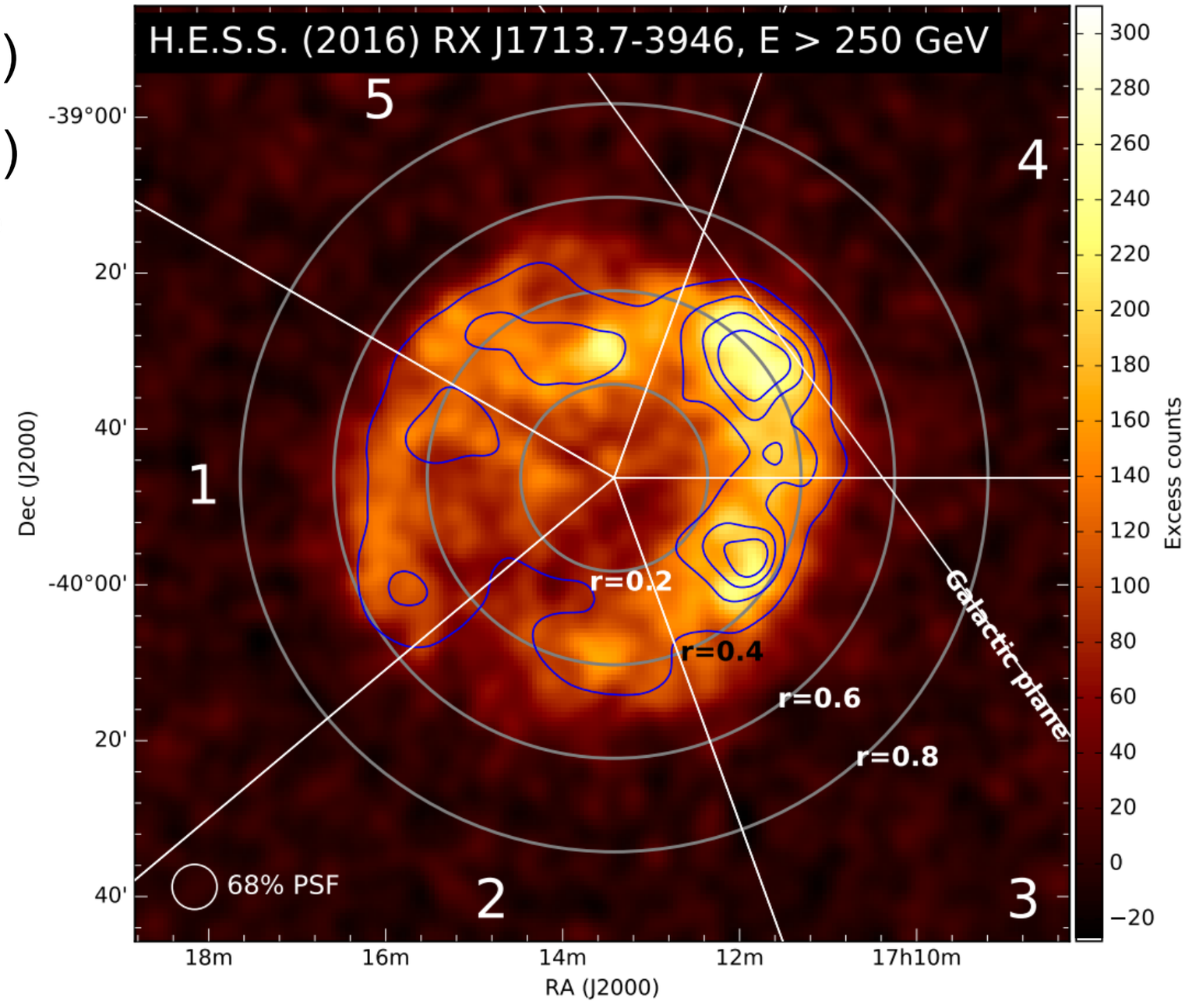


H. Abdalla et al. (H.E.S.S.), arXiv:1609.08671

H.E.S.S.: RXJ1713.7

- 2004-2012
- livetime: 164h (spectrum:116h)
- comparison with X-rays (XMM)
  - high-energy particles leaving the acceleration region

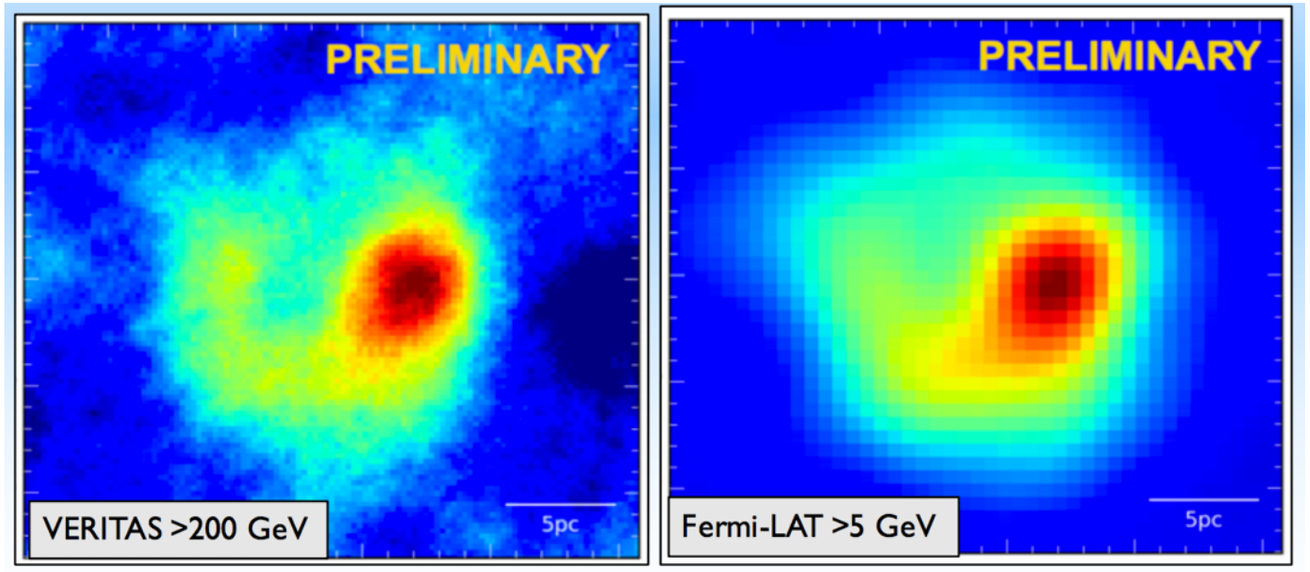




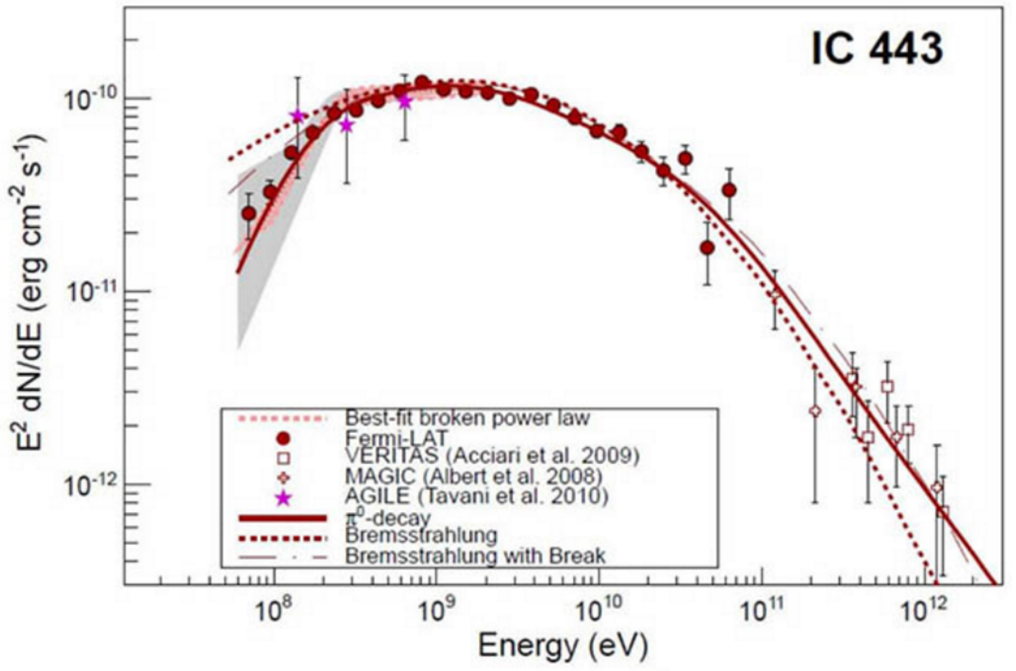
H. Abdalla et al. (H.E.S.S.), arXiv:1609.08671

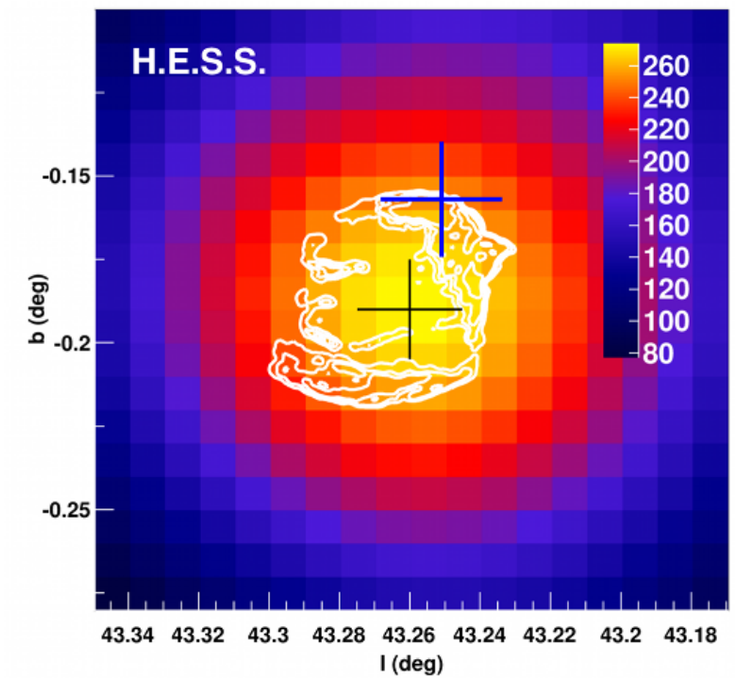
IC443 + W49B: shell type SNR with hadronic acceleration

- pion bump in Fermi-LAT => hadronic acceleration

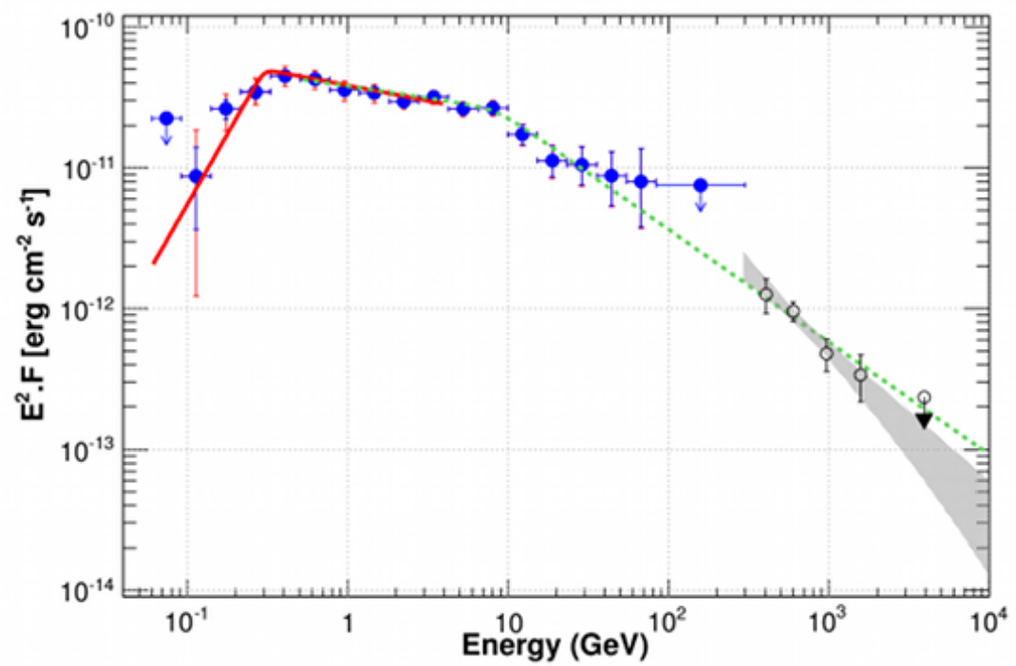


VERITAS





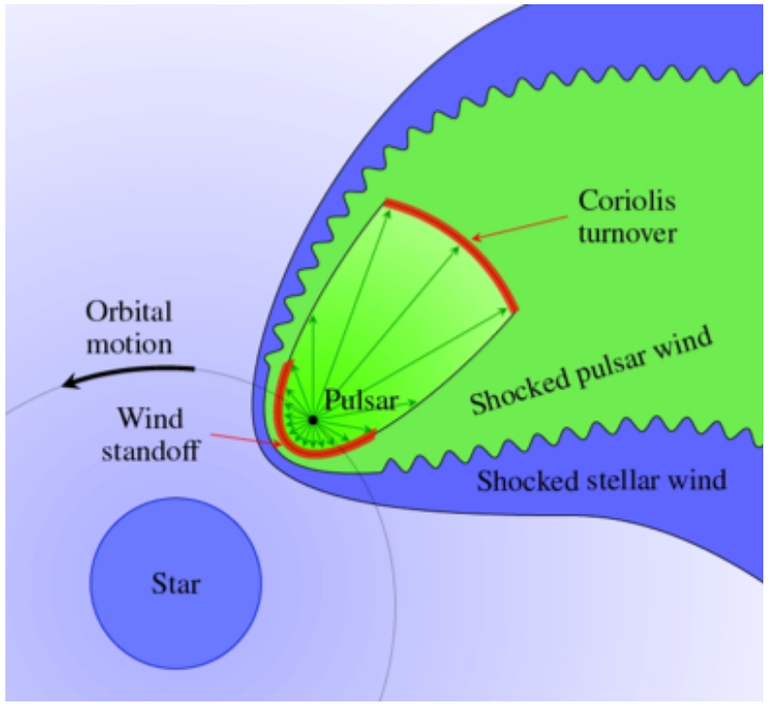
W49B

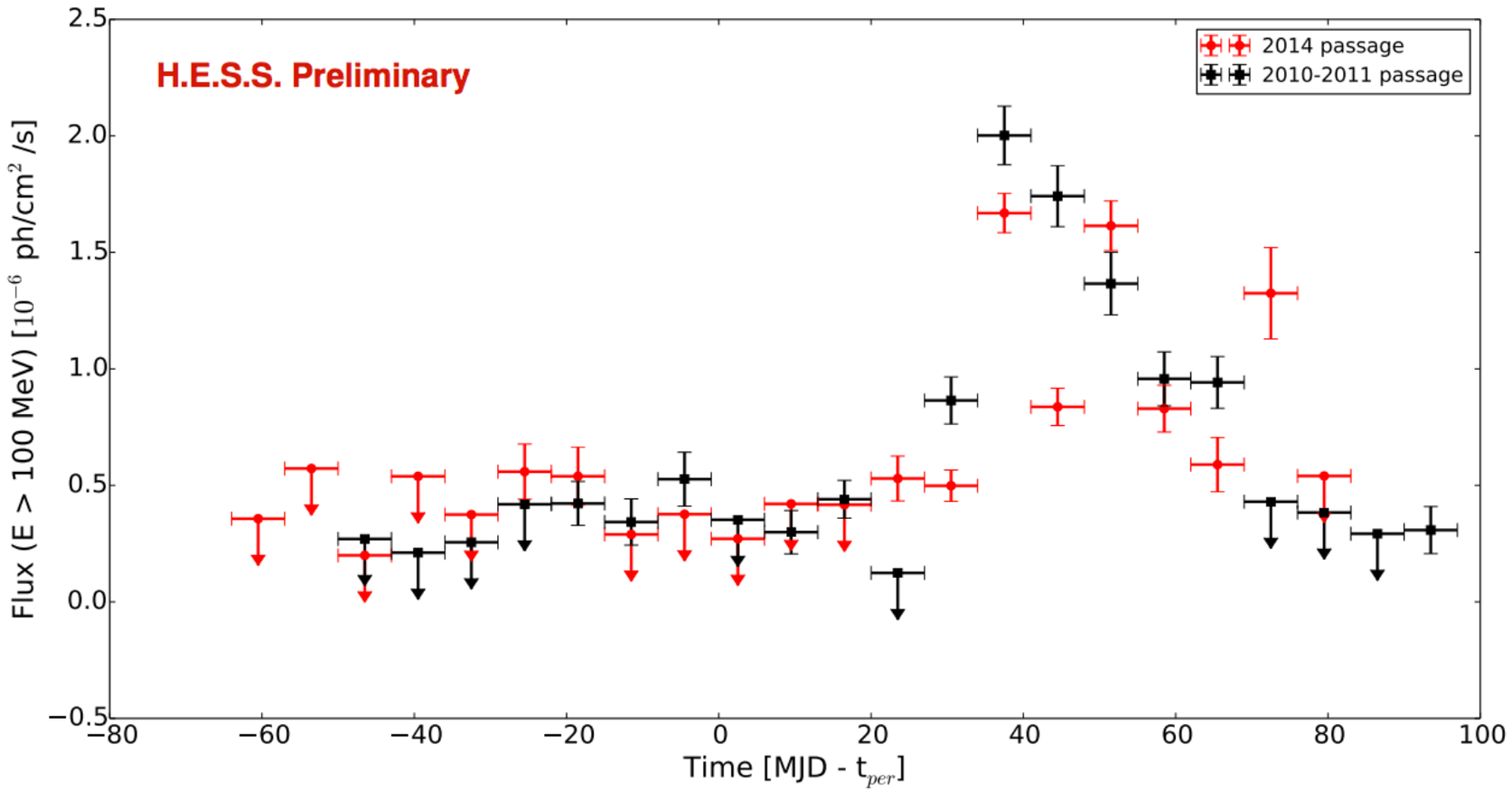


H.E.S.S. + Fermi-LAT, A&A (2016)

Galactic Binaries

- PSR B1259-63
  - only confirmed gamma-ray binary with a PSR
  - period 3.4 years (last periastron in 2014)
  - double peaked emission at GeV
    - first hints for double-peak at VHE

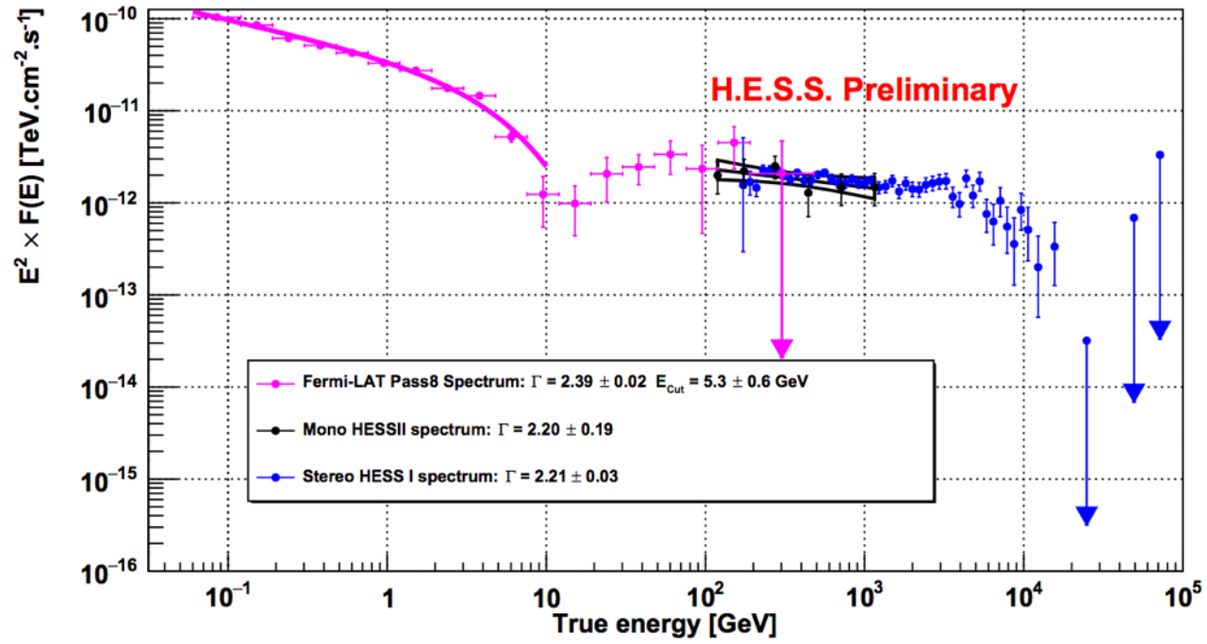


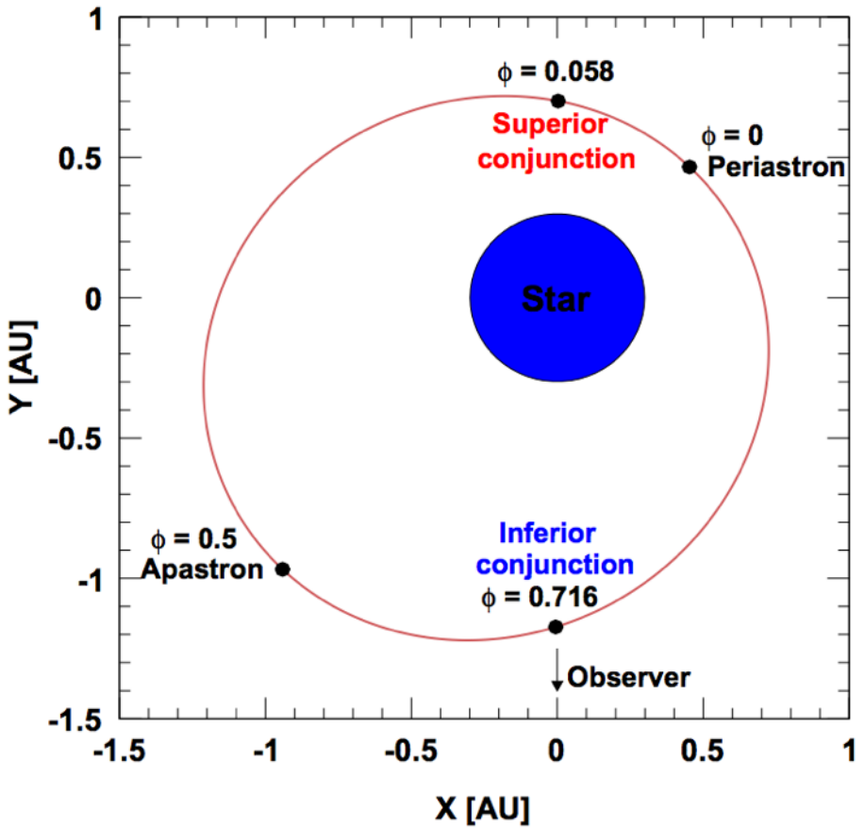


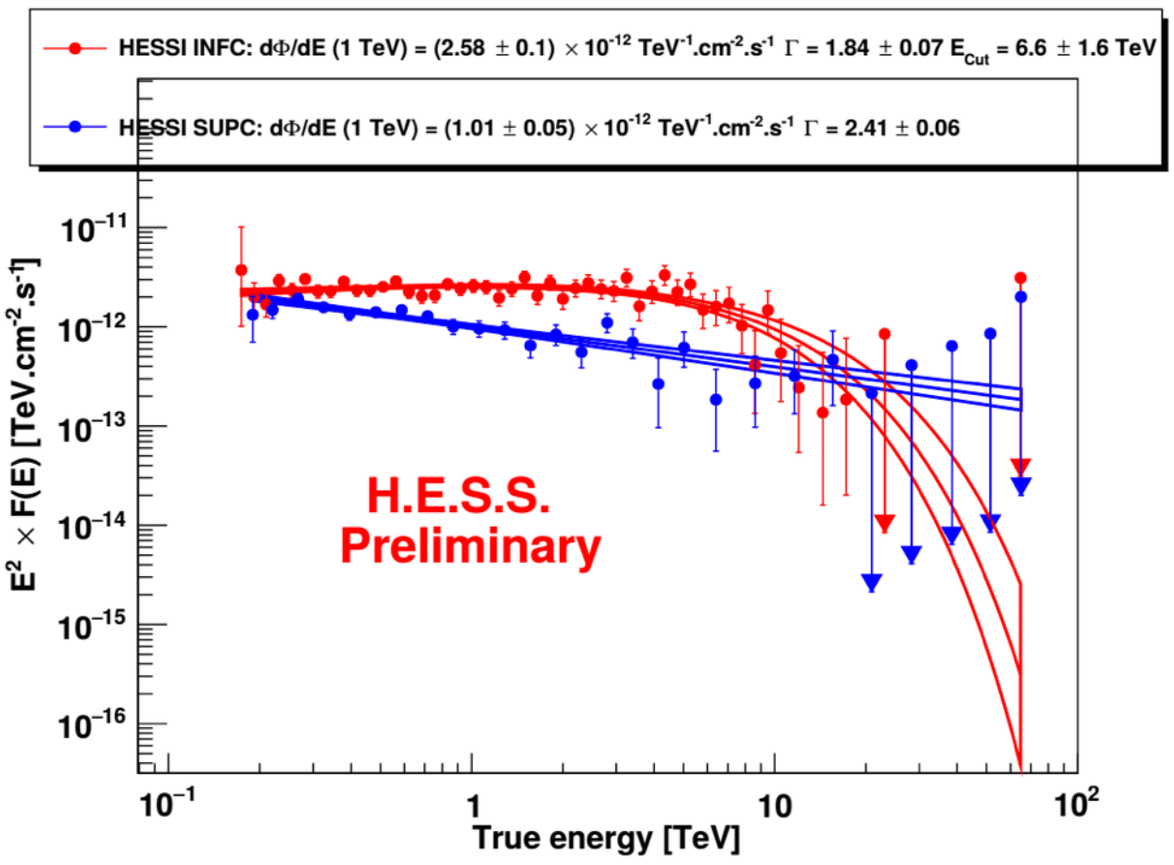
T. Murach (H.E.S.S.)

Galactic Binaries

- LS 5039
  - period 3.9 days
  - 10 years of H.E.S.S. data (incl. HESS-II)
  - spectral variations during orbit







T. Murach + C. Mariaud (H.E.S.S.)

FS et al., ICRC 2015, arXiv:1509.03035
FS et al., Gamma 2016

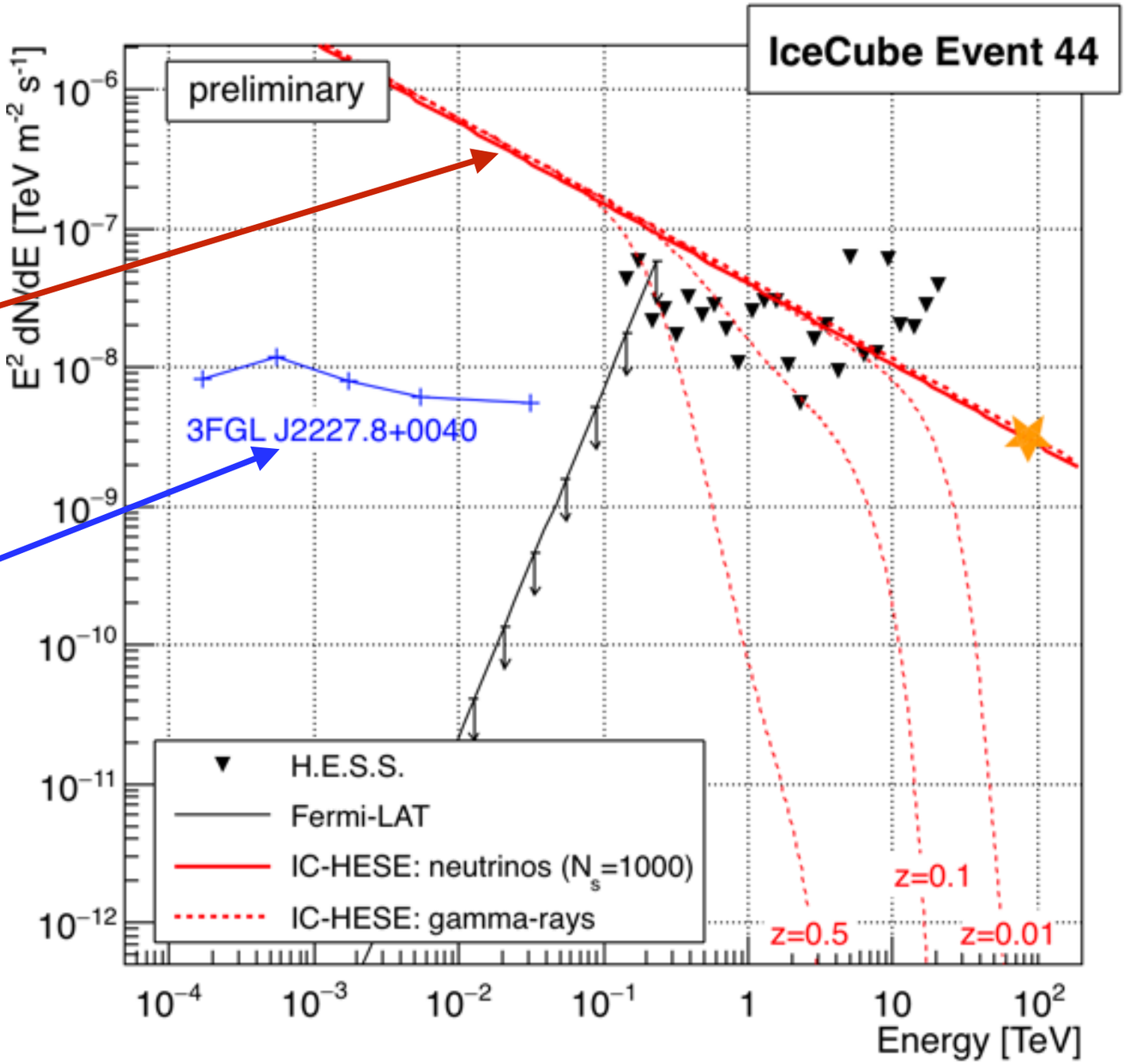
High-energy neutrinos

- Example: IceCube IC-44

H.E.S.S. + Fermi-LAT limits
for point-source in the ROI center
(acceptance smooth => representative for ROI)

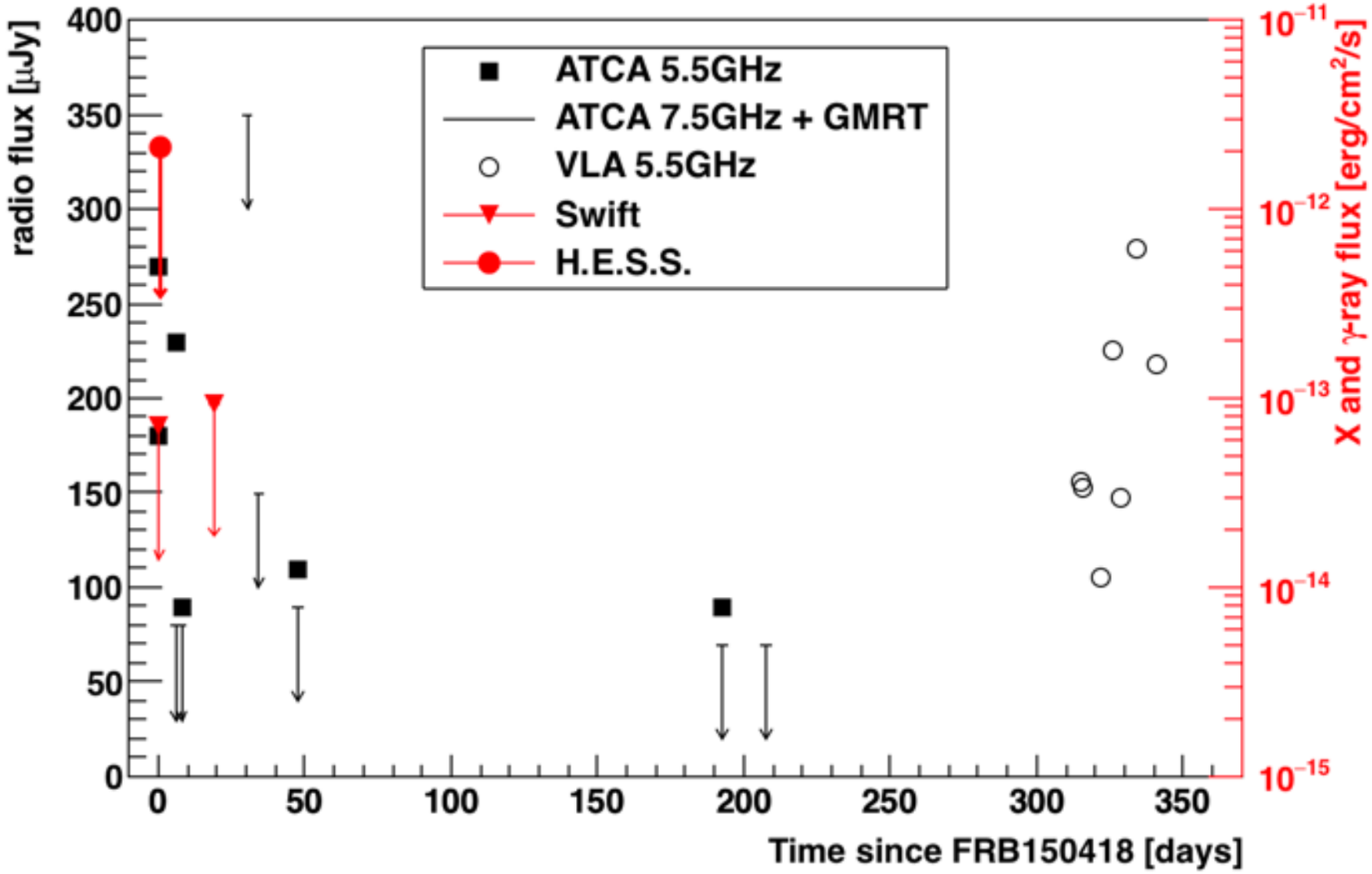
diffuse IceCube flux:
$\varphi(E) = 2.2 \times 10^{-8}\ E^{-2.58}$ GeV cm^{-2} s^{-1} sr^{-1}
assuming 1000 sources

3FGL "candidate" source
within IceCube ROI

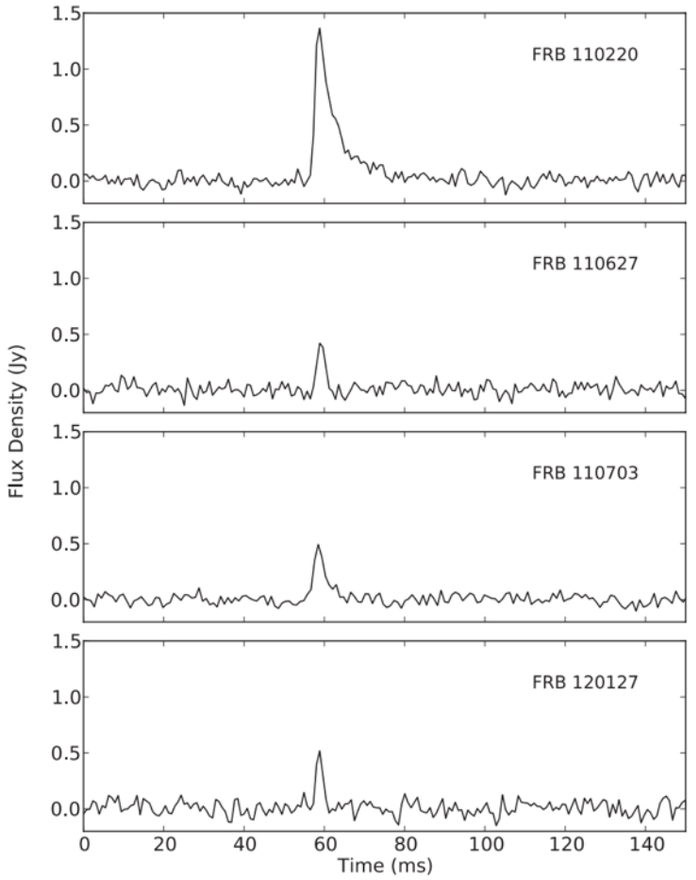


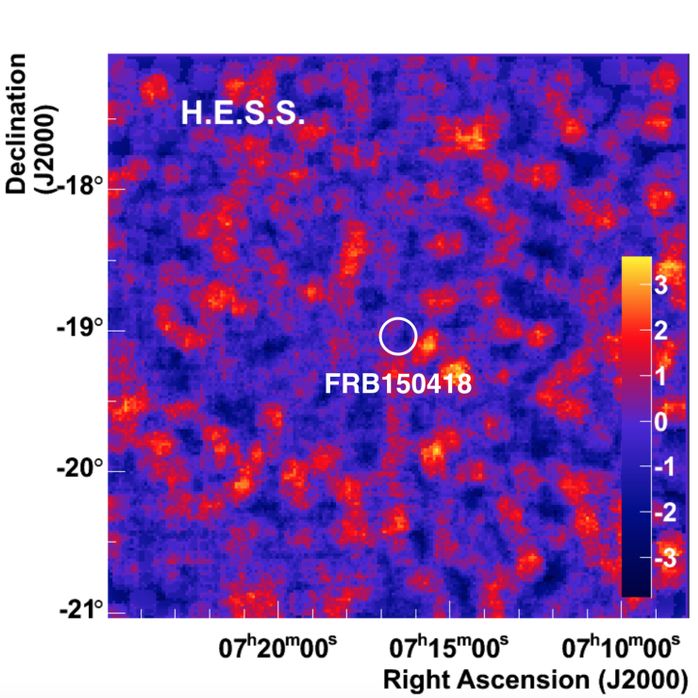
Fast Radio Bursts: TeV afterglow limits

- Burst: 2015-04-18 04:29 UTC
- H.E.S.S.: starting 2015-04-18 at 17:55 UTC for 1.5h



Thornton D. et al.2013 Science 341, 53





FS (H.E.S.S. + SUPERB)