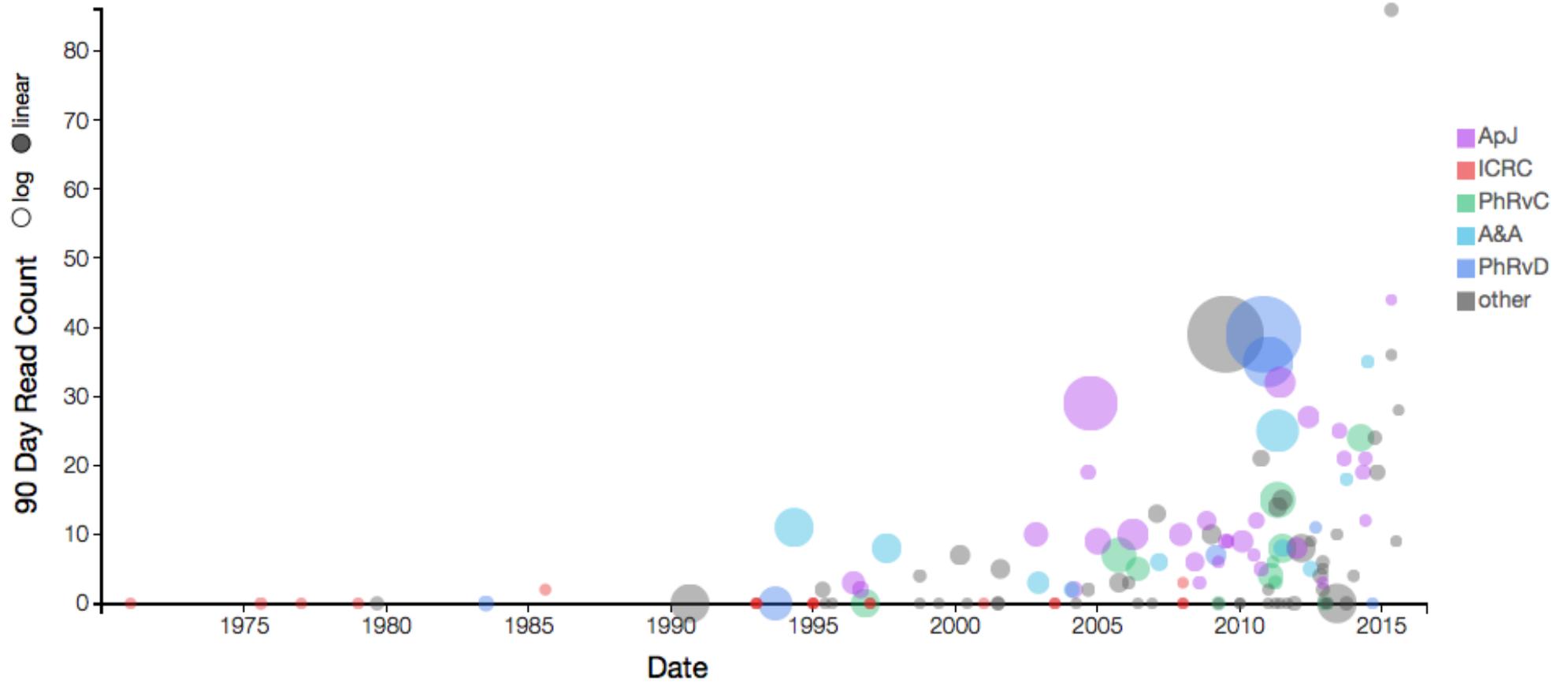


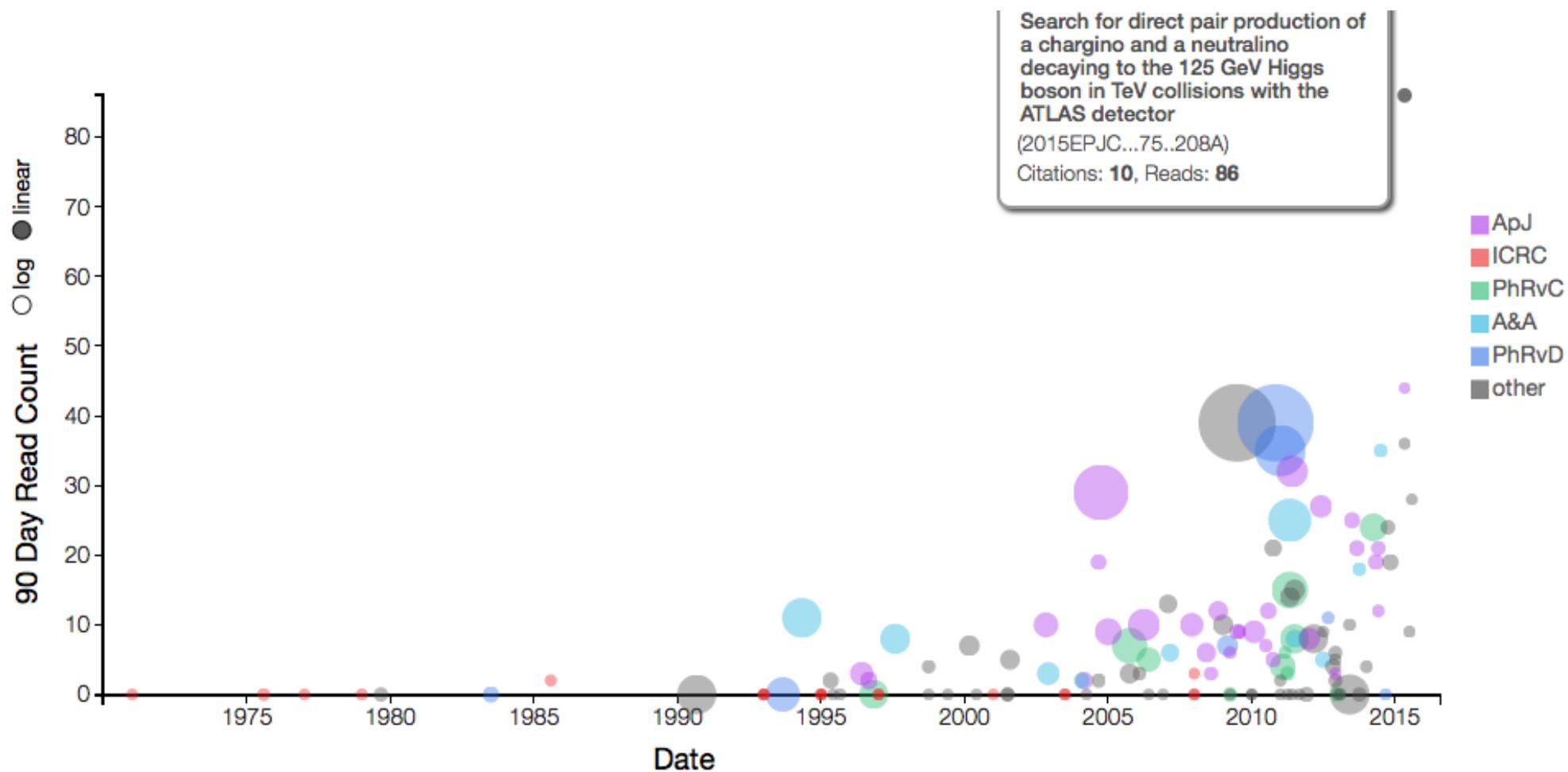
Connections between GeV and TeV gamma-ray observations

Stefan Funk, Erlangen Center for Astroparticle Physics (ECAP)

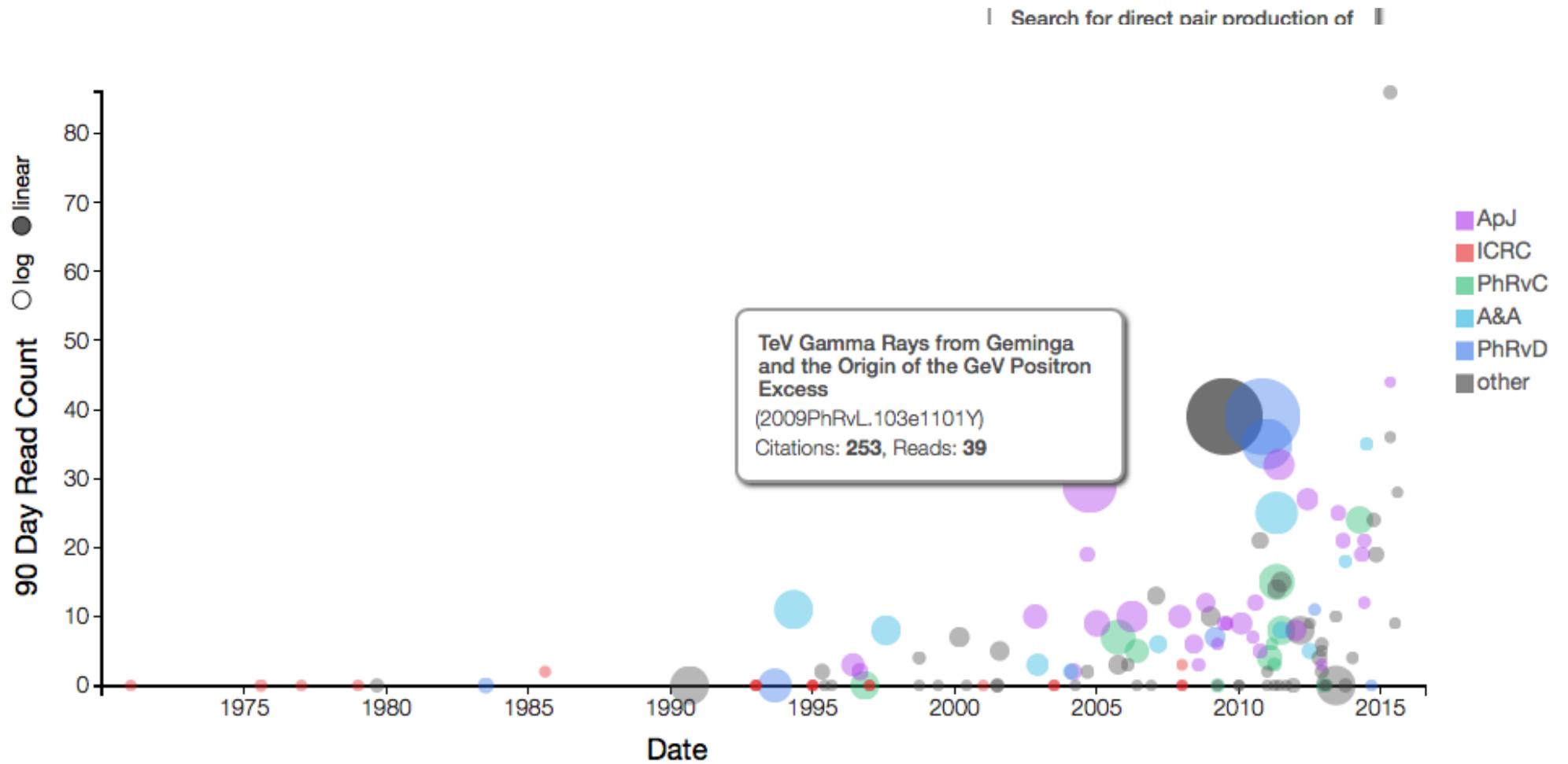
GeV-TeV connection so far



GeV-TeV connection so far

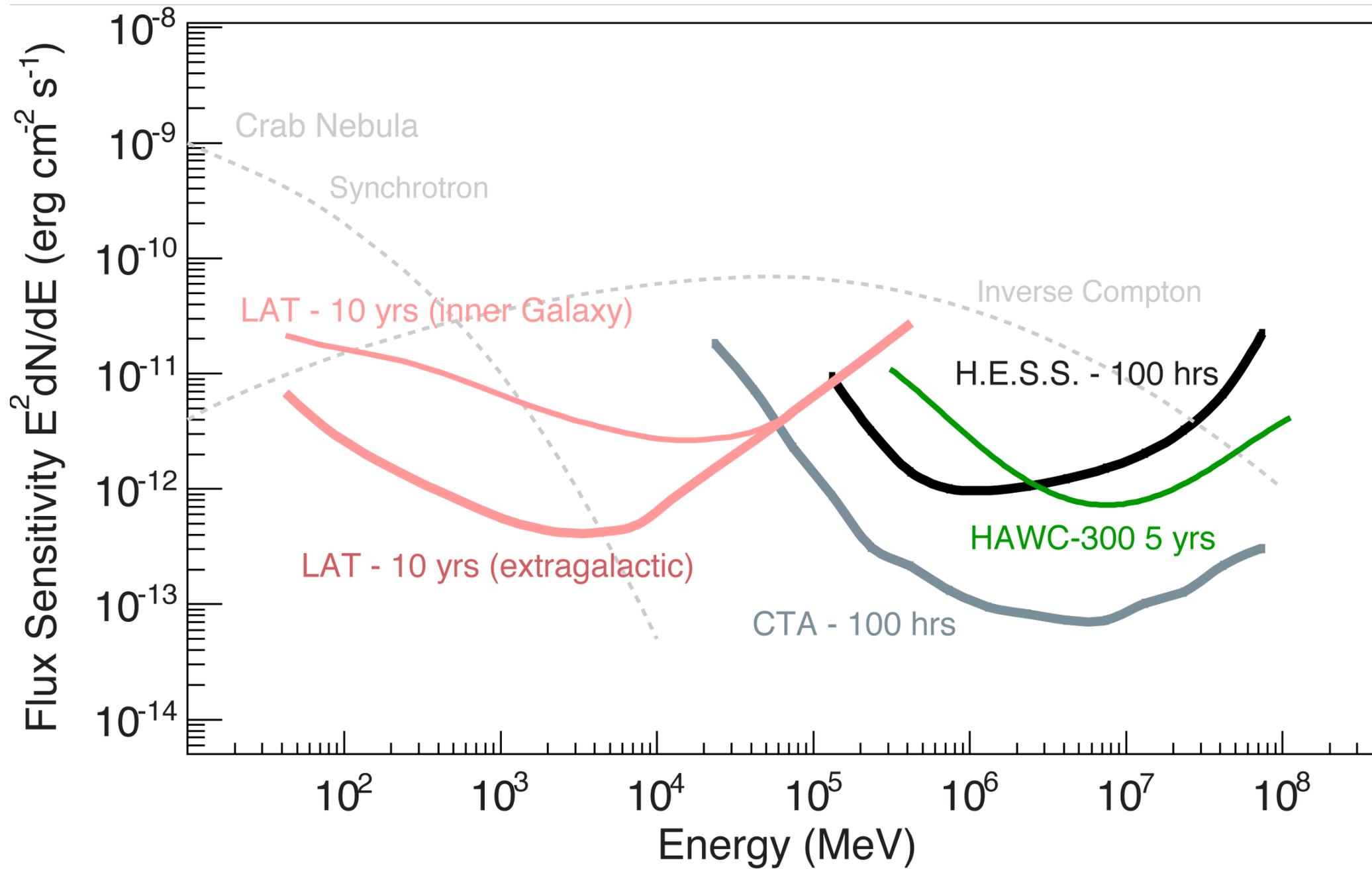


GeV-TeV connection so far



My task (from the SOC)

- We'd very much like you to give a talk on the connections between GeV and TeV astrophysics (i.e. a forward looking talk on what kinds of things we can do with good statistics that comes with more years of Fermi data and new capabilities for the ground based instruments).



New capabilities (IACTs)

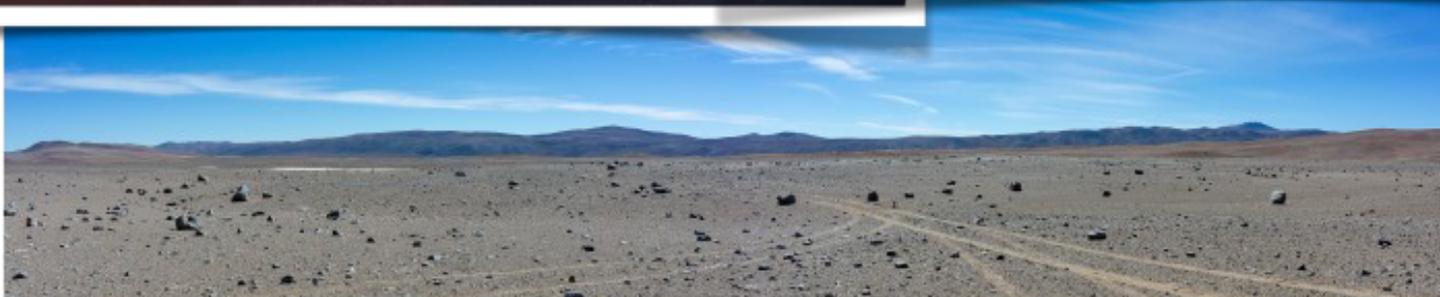
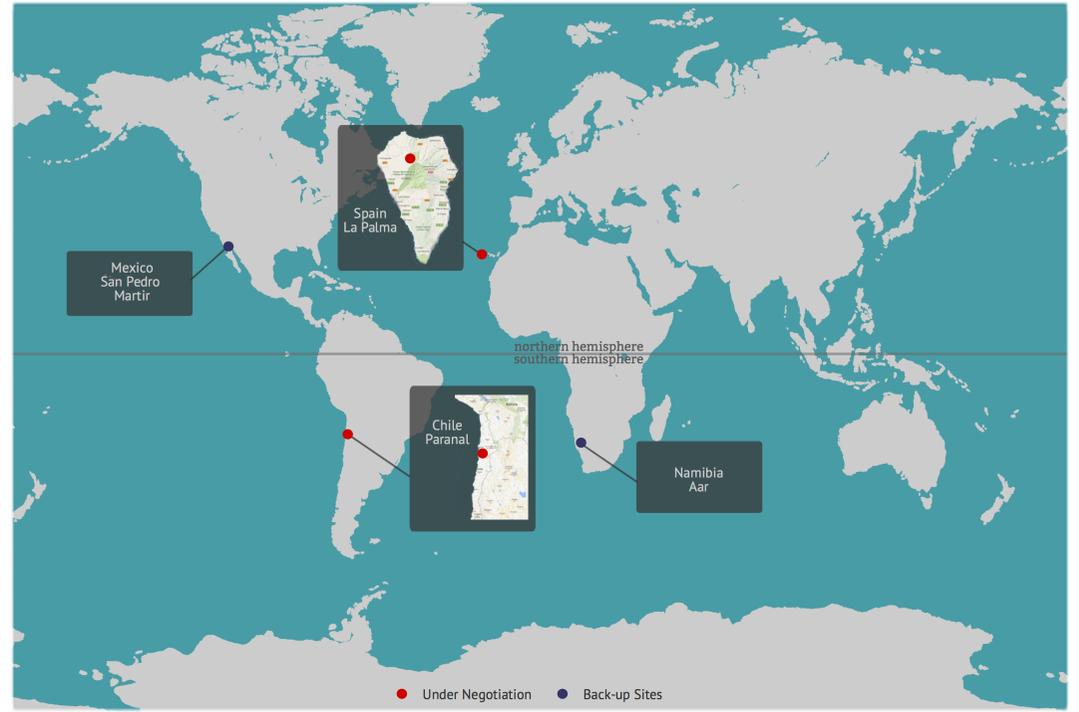
4 x 107 m² (since 2003)
1 x 614 m² (since 2012)



New capabilities (HAWC)

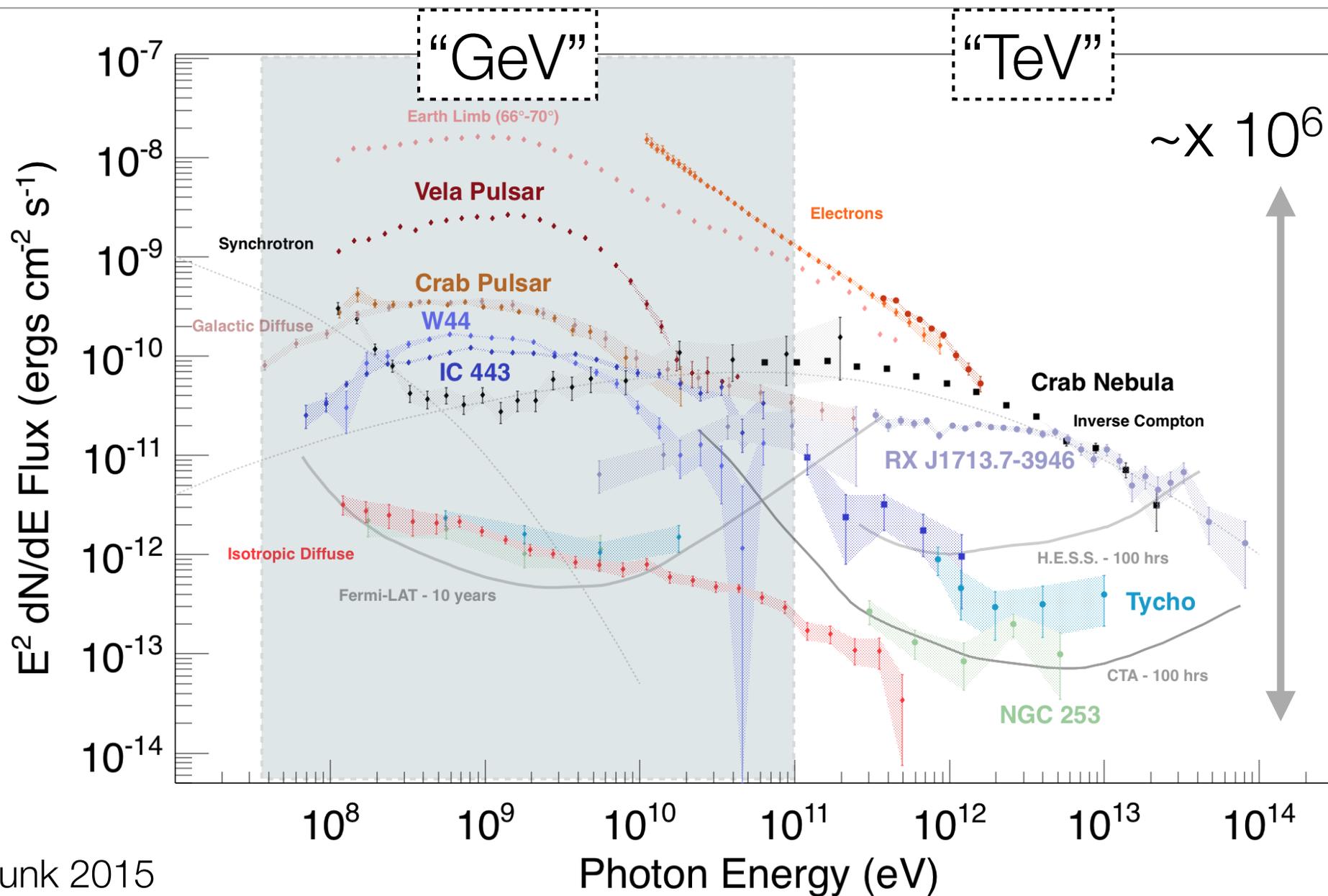


... long-term: CTA

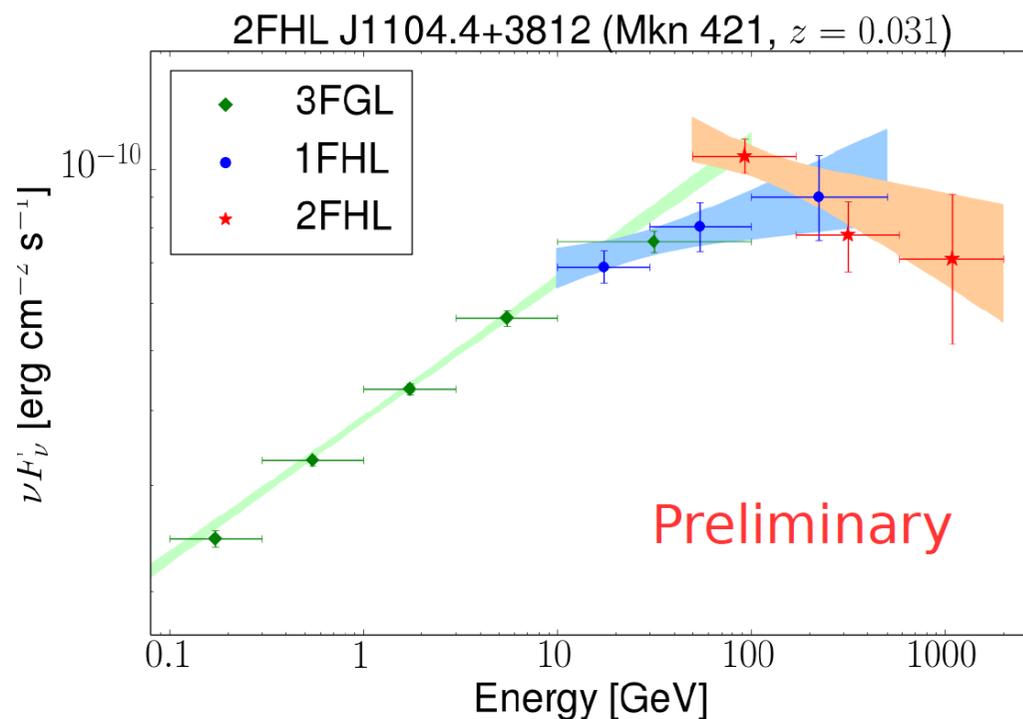
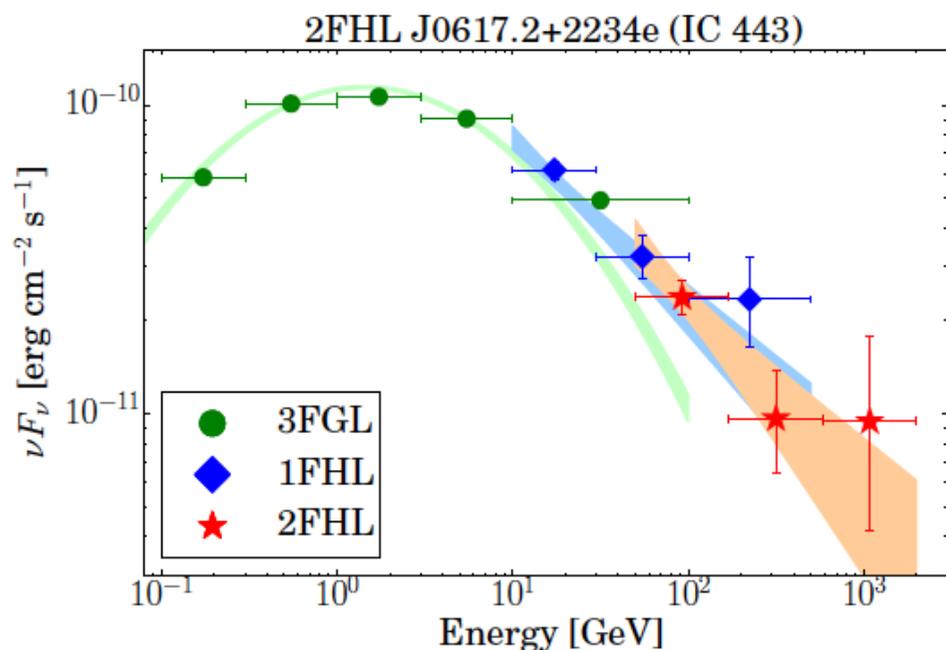


The current situation

The overall picture - Spectral studies



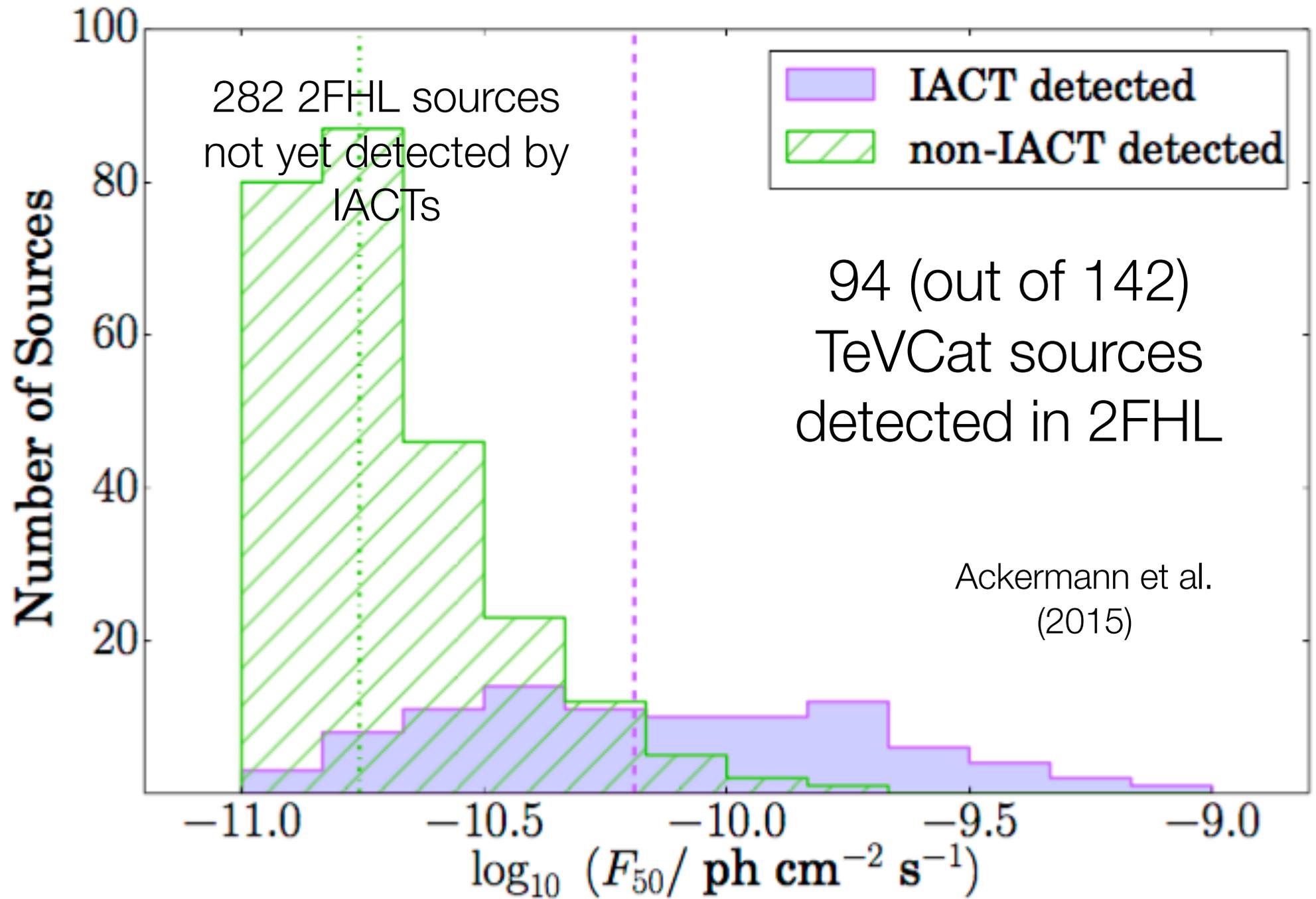
2 FHL (360 sources)



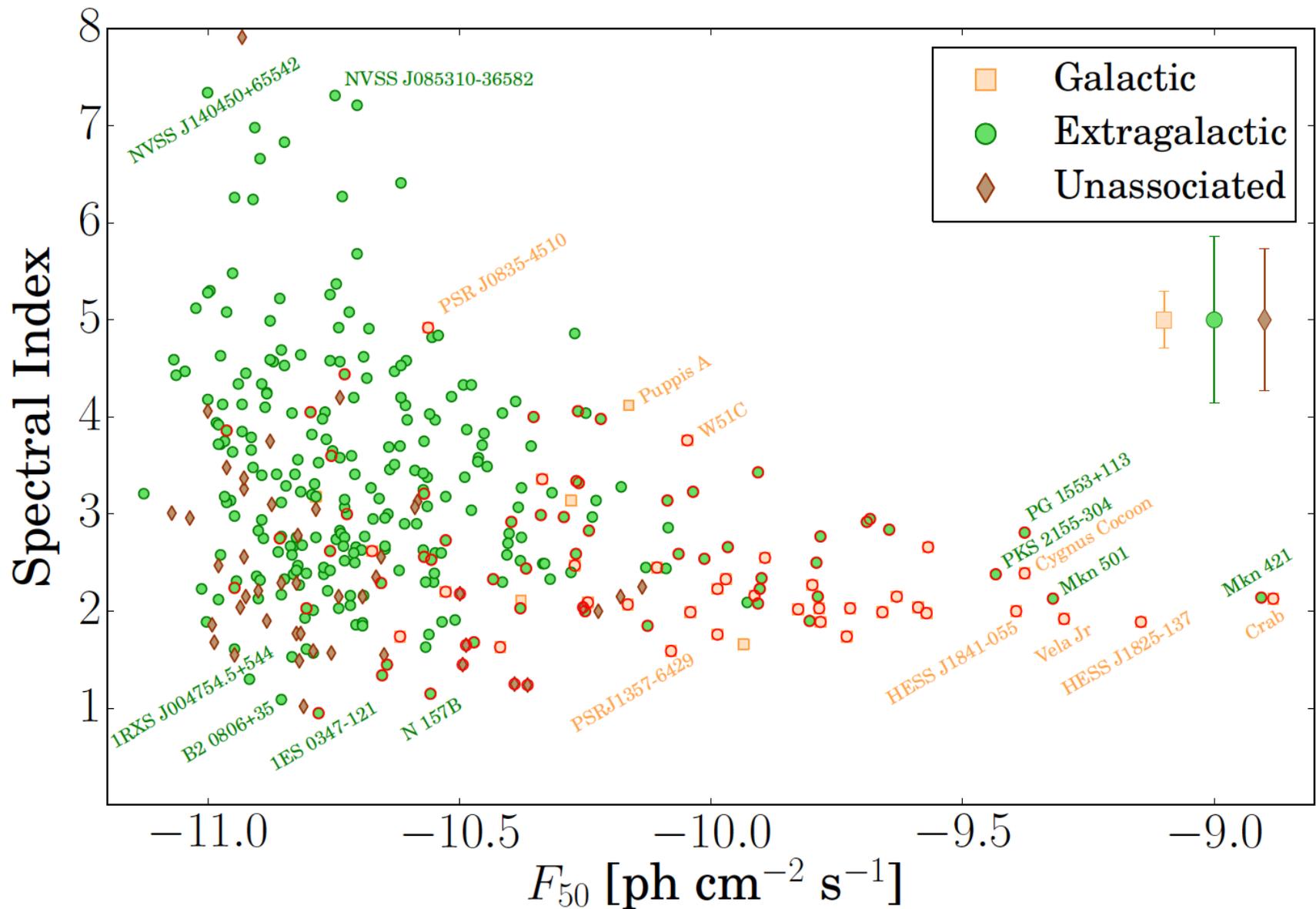
Ackermann et al. (2015)

- 51,000 photons $E > 50$ GeV
- 18,000 photons $E > 100$ GeV
- 2,000 photons $E > 500$ GeV

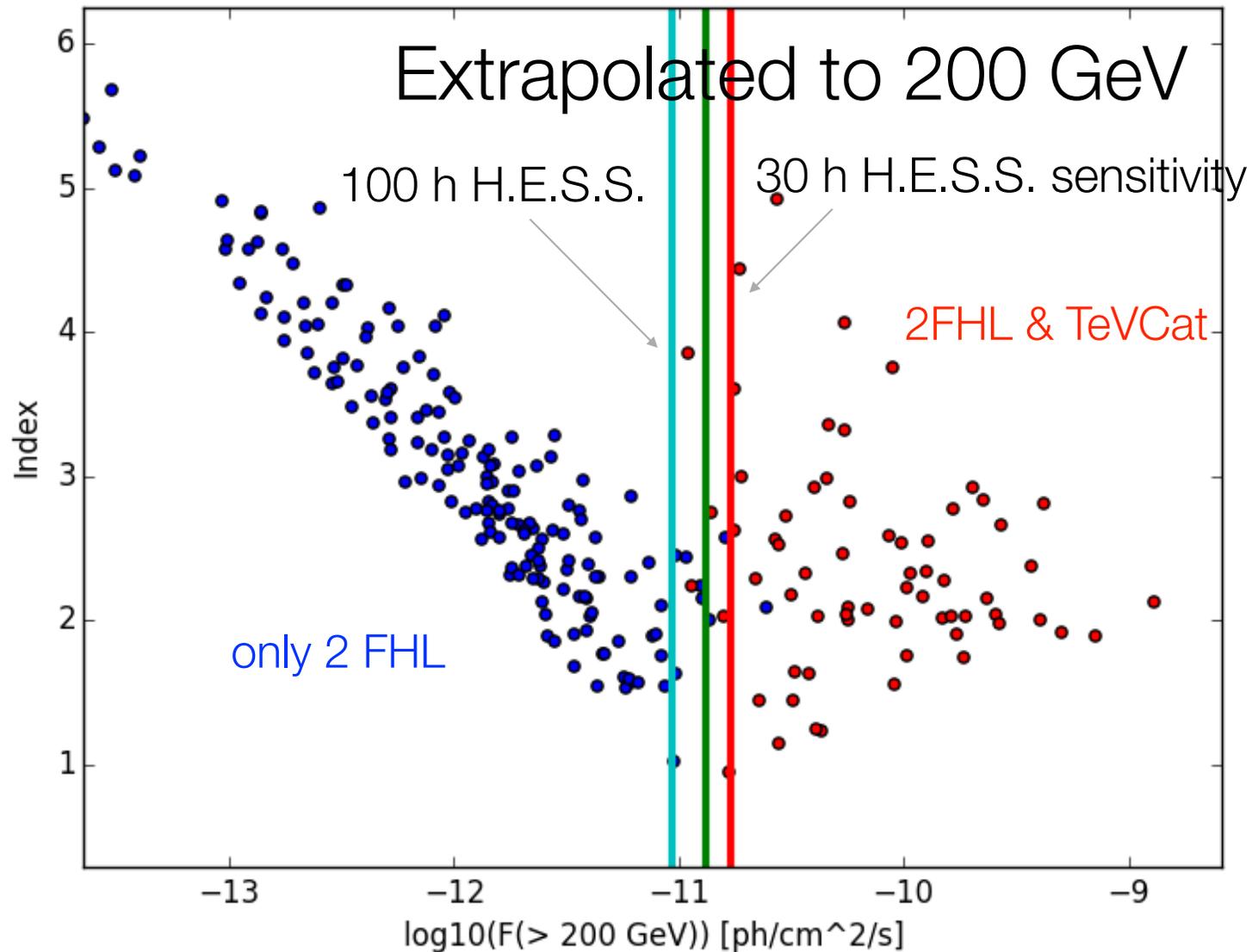
See Talk by M. Ajello



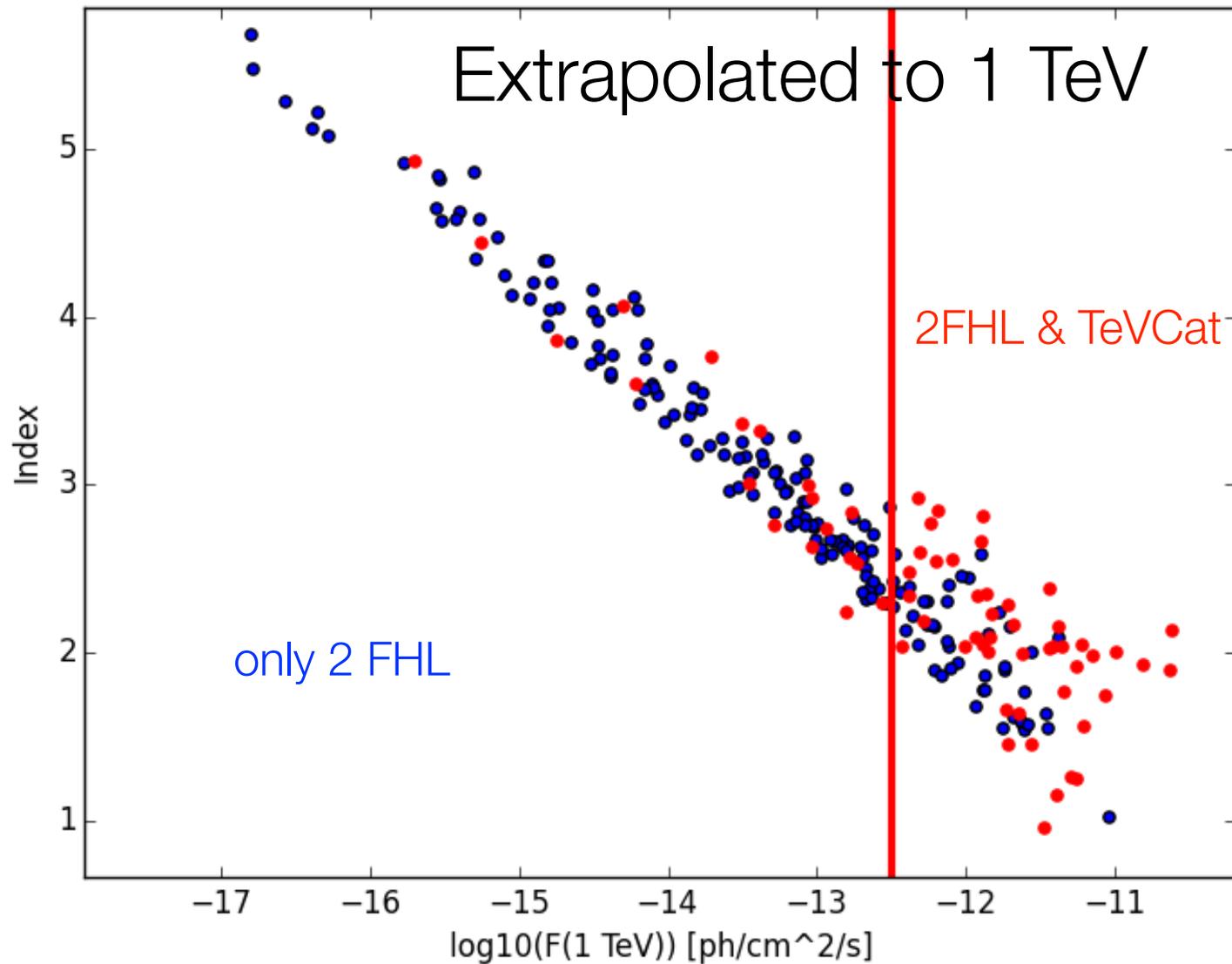
2FHL versus TeVCat



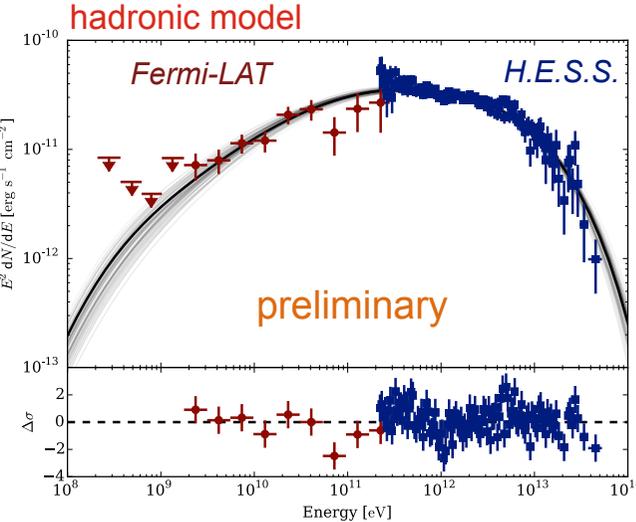
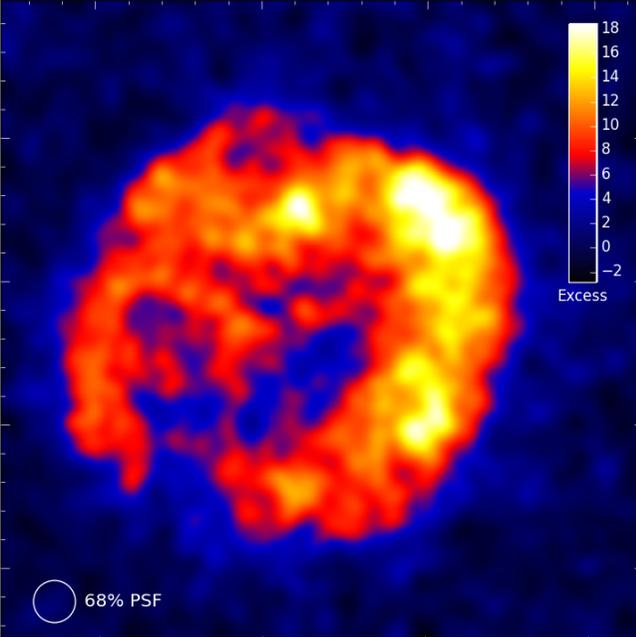
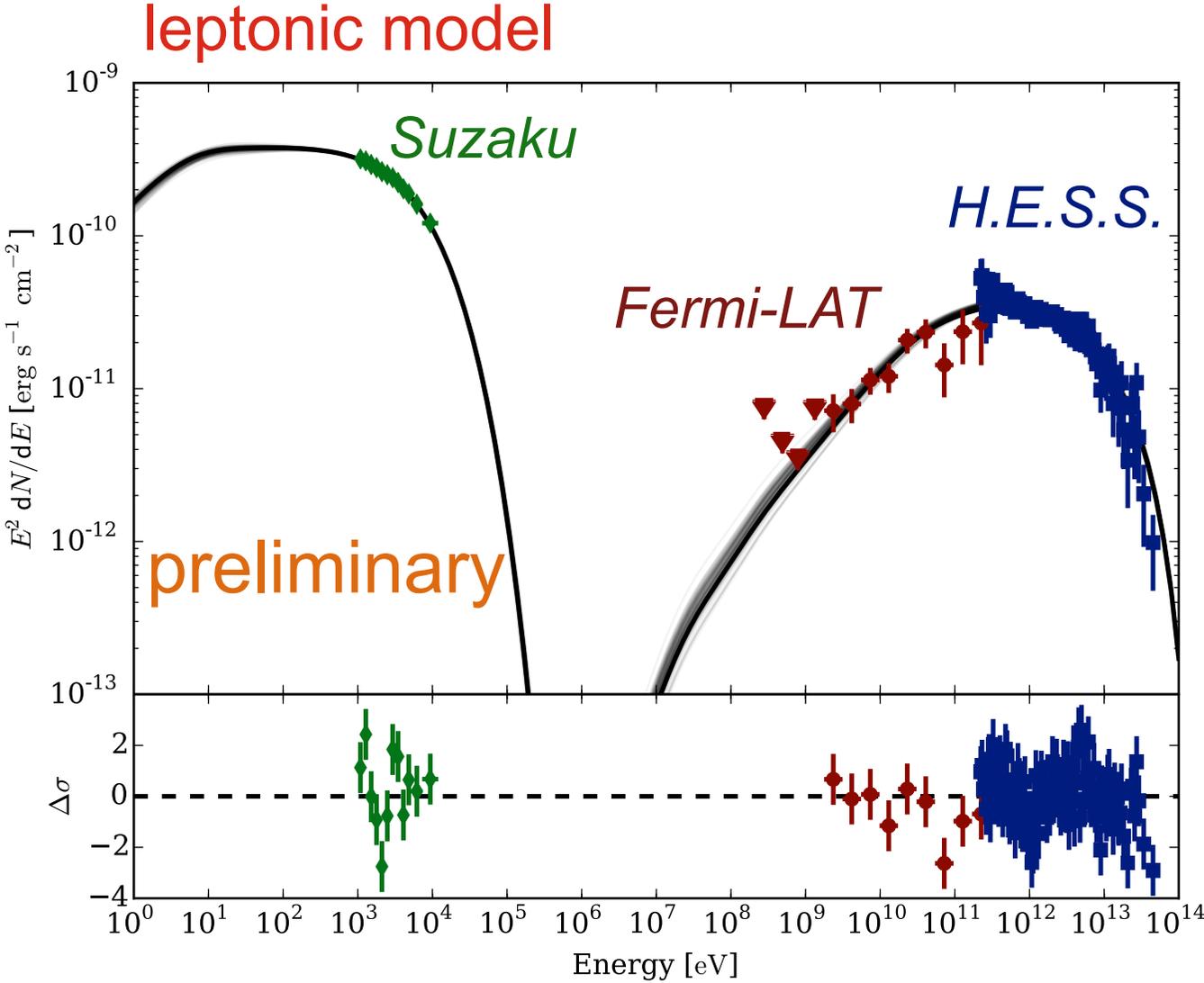
... extrapolated to higher energies



... extrapolated to higher energies

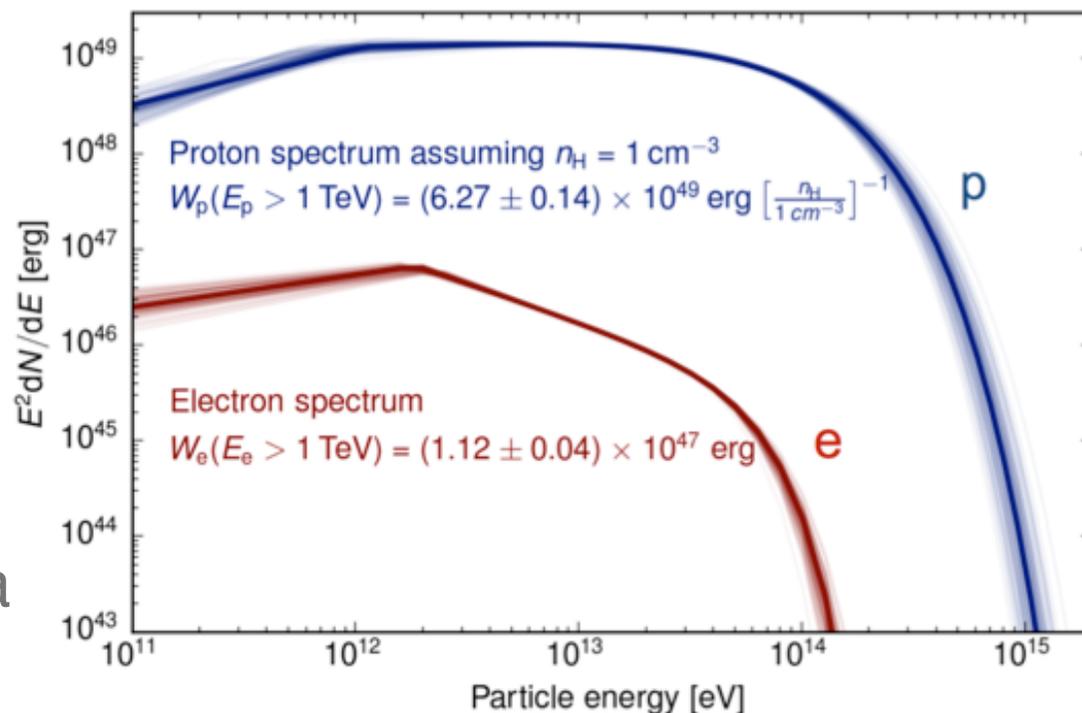


Detailed spectral and morphological studies > 100 GeV



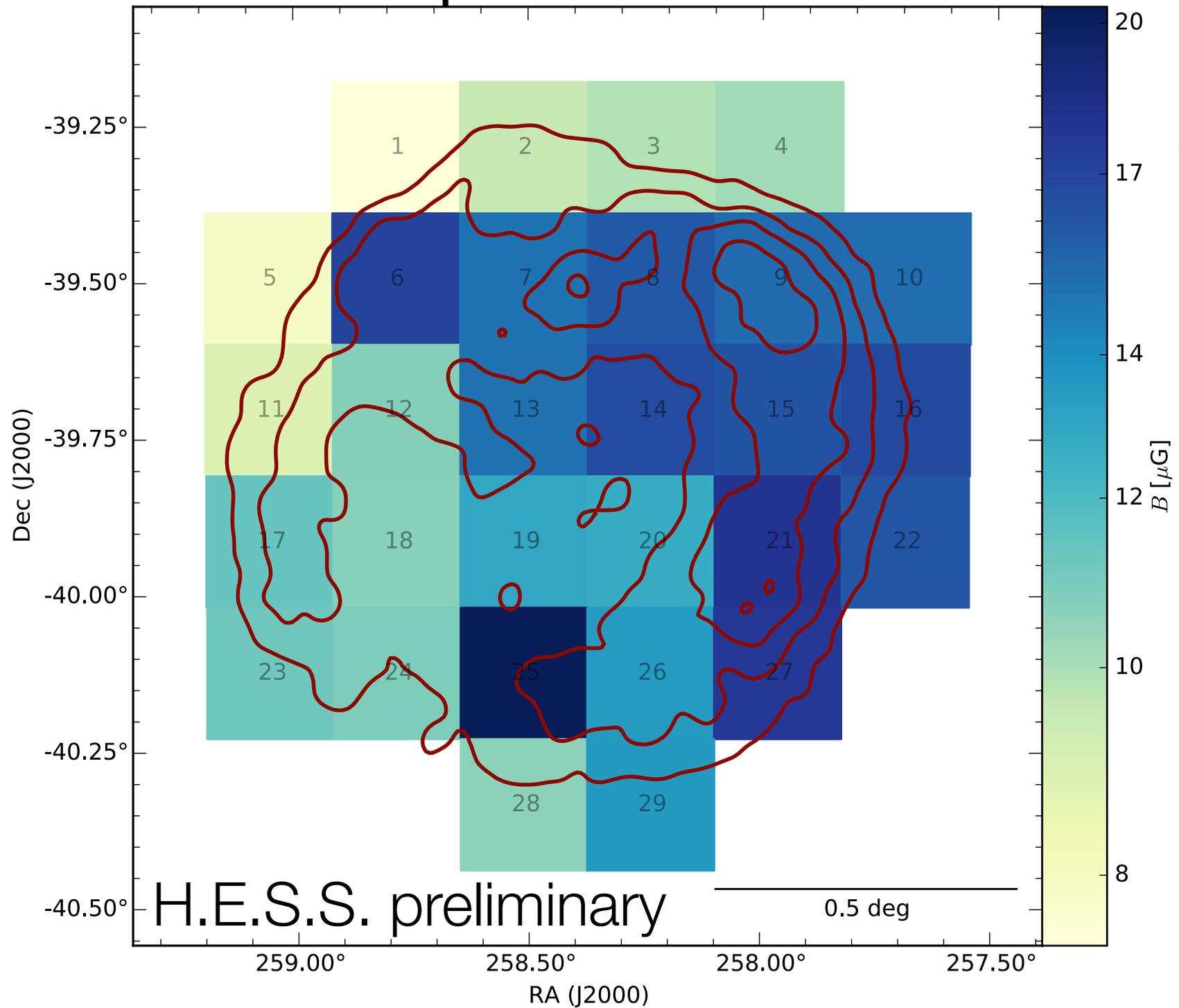
Inferred particle population

- Definitely need a break in the spectrum (thanks to GeV + TeV data)
 - Either protons in “cold clumps”
 - ... or significant cooling in a leptonic scenario ... infers high magnetic field (70 μG), at odds with the low magnetic field inferred from the synchrotron/IC ratio

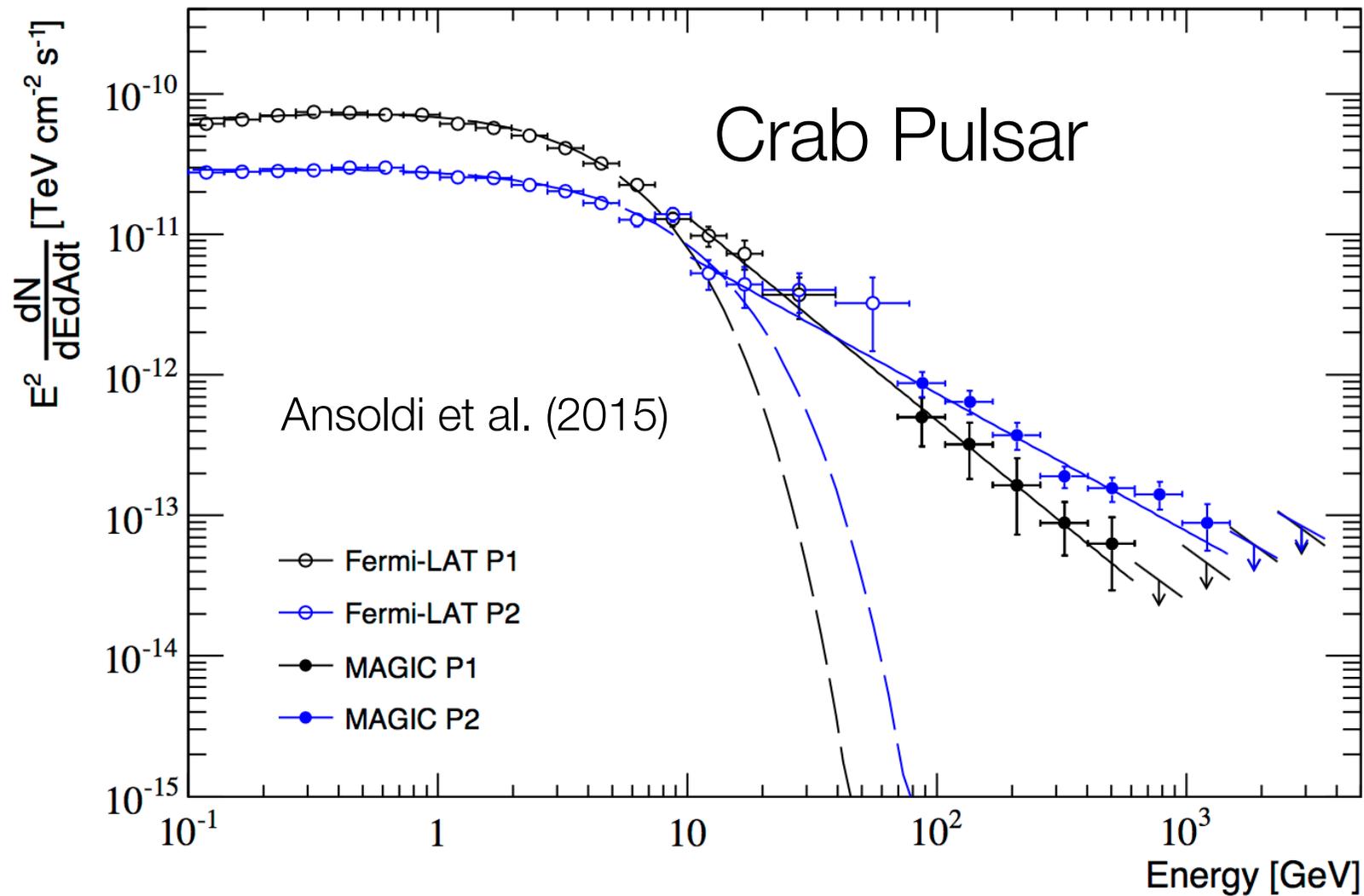


H.E.S.S. preliminary

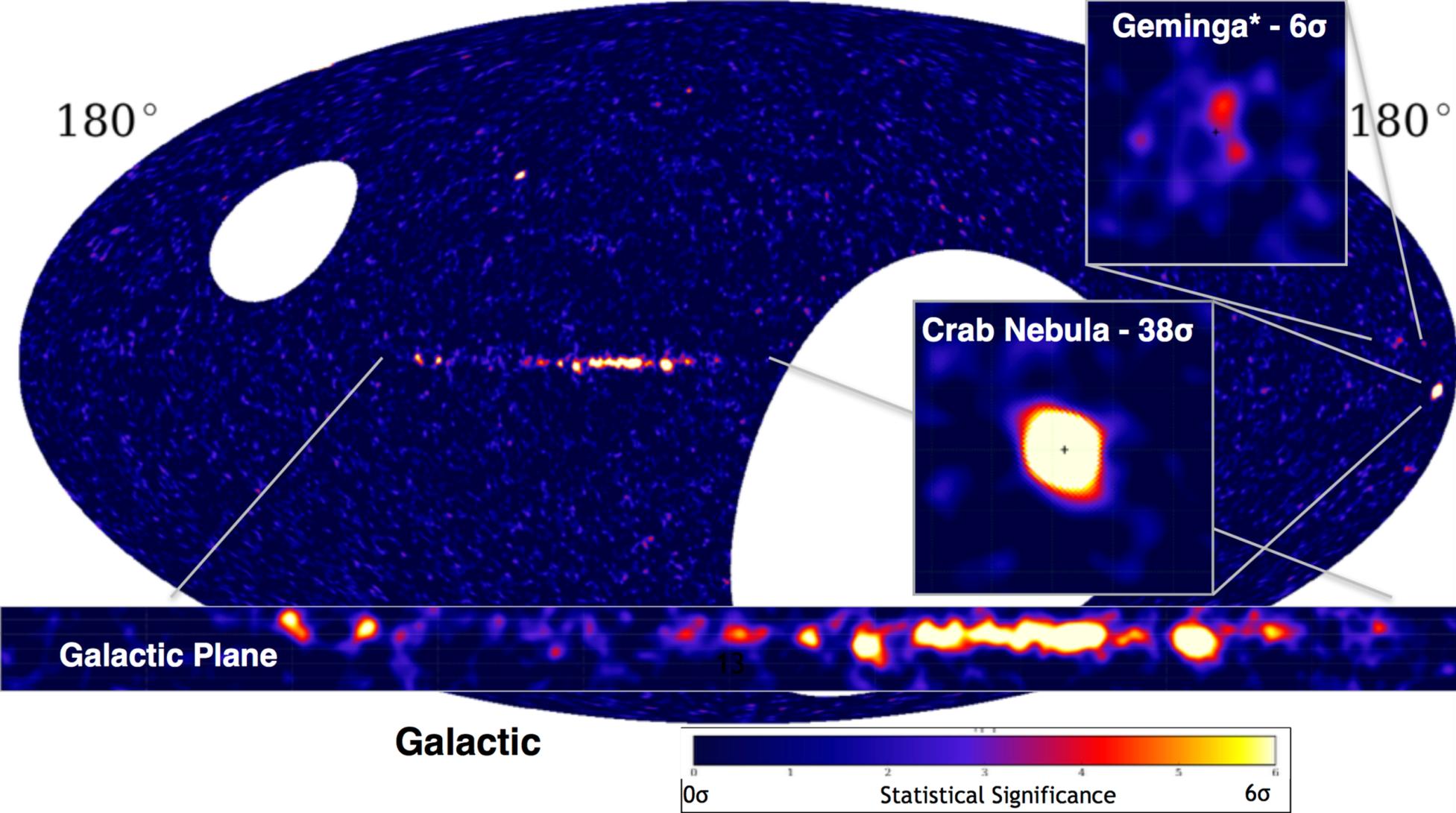
B-field map



... can start to constrain the physics of sources



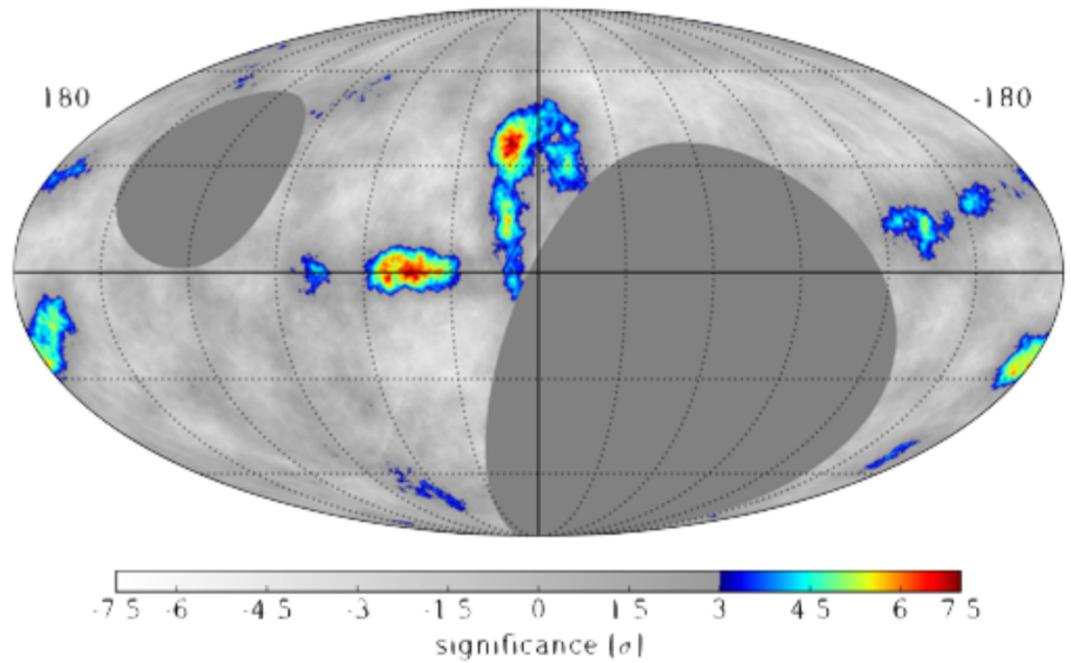
38 σ Crab



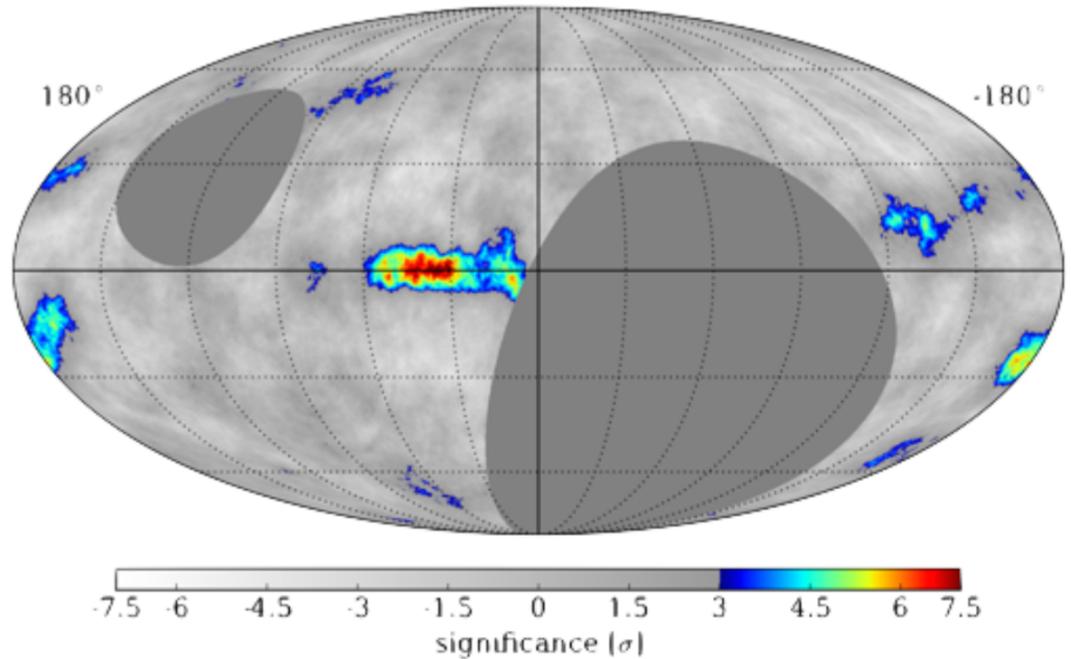
HAWC

Significance Map for 3 years of HAWC observations

- a) Fermi Bubbles follow power-law spectrum with $\Gamma=2$
- b) Fermi Bubbles follow power-law spectrum with $\Gamma=2$ and cutoff at 150 GeV



(a)

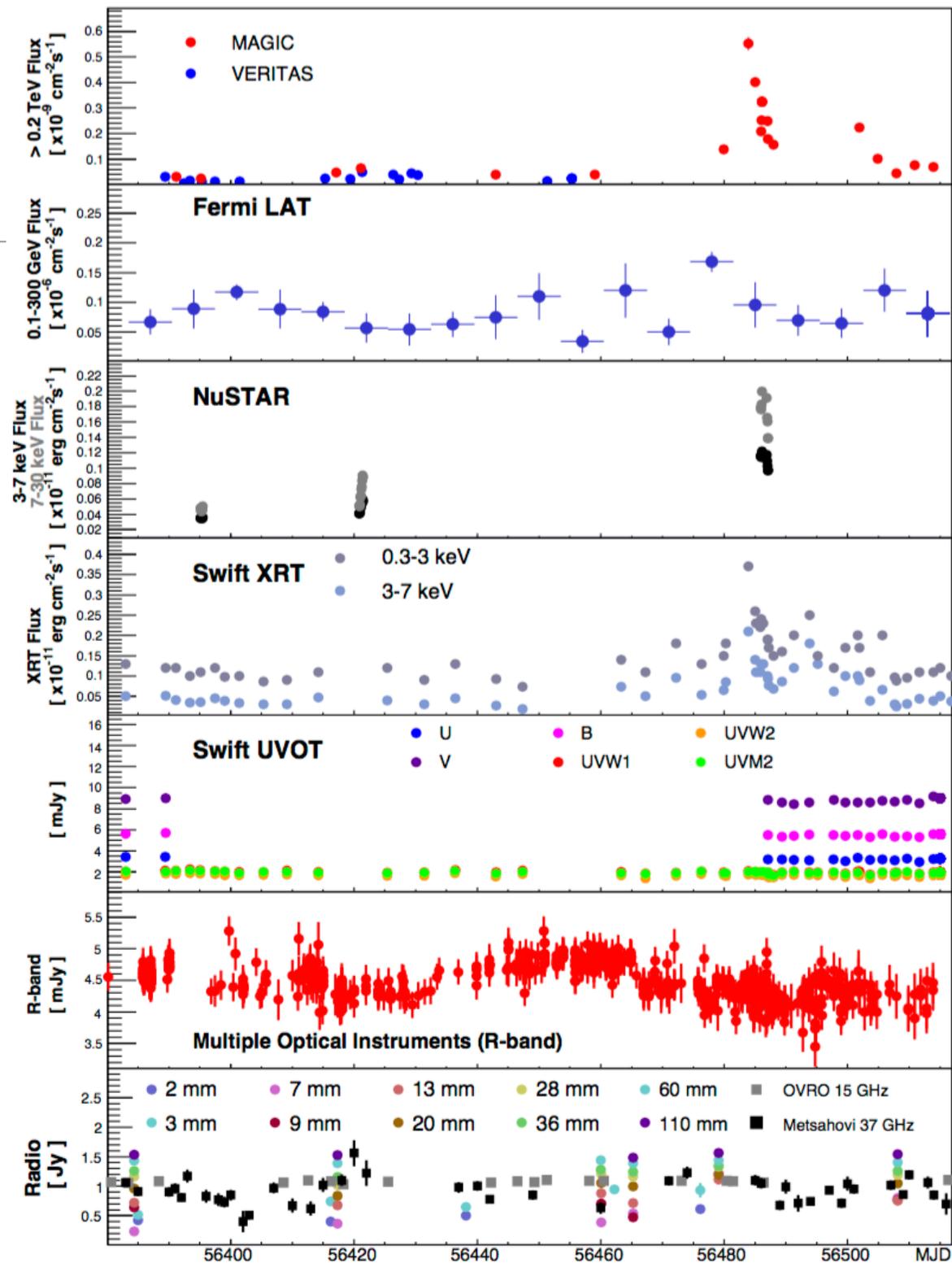


(b)

Mrk 501

- The era of multi-wavelength campaigns
- SSC model can reproduce data (decrease in B-field coinciding with increase in luminosity and hardness of electrons).

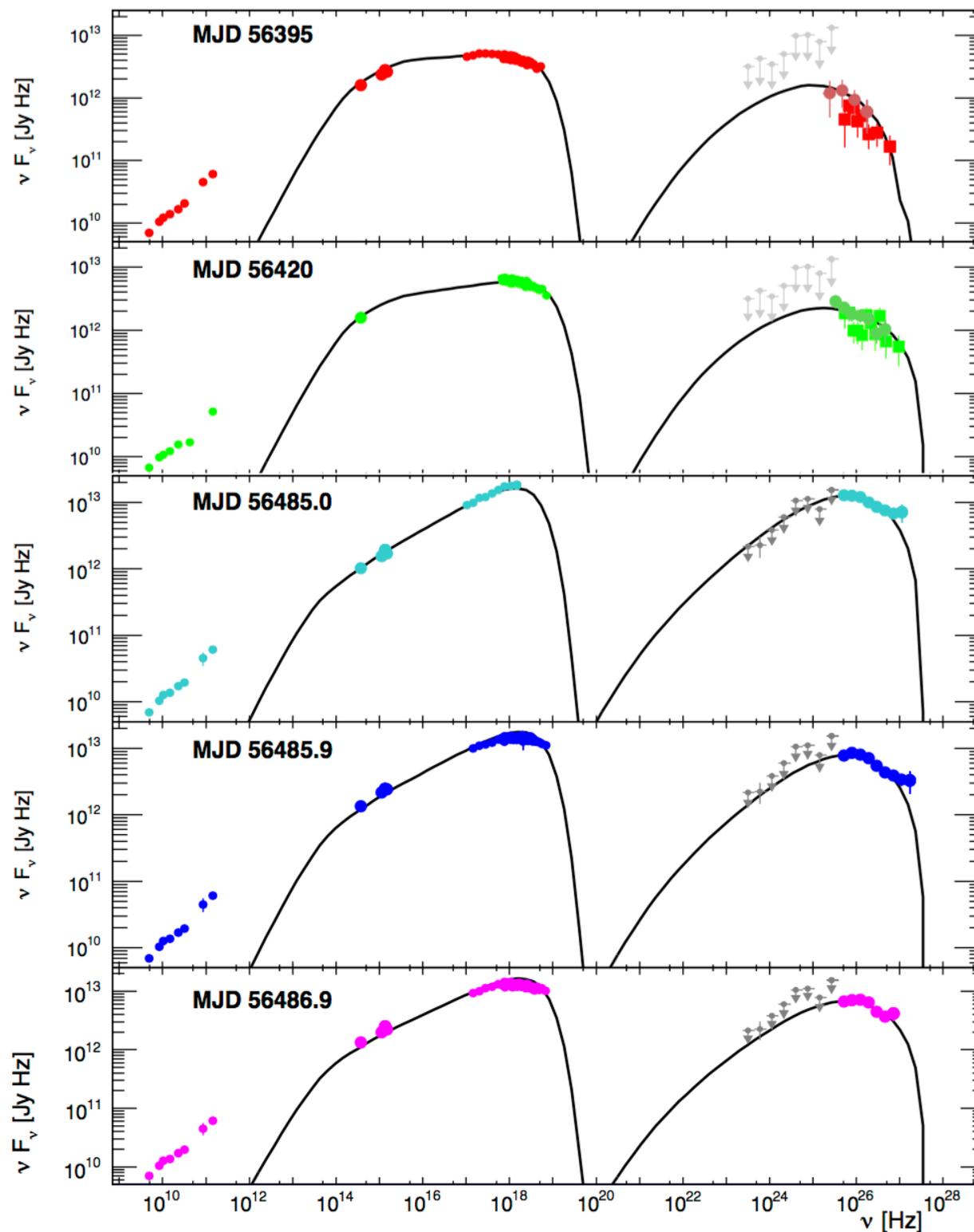
Furniss et al. (2015)



Mrk 501

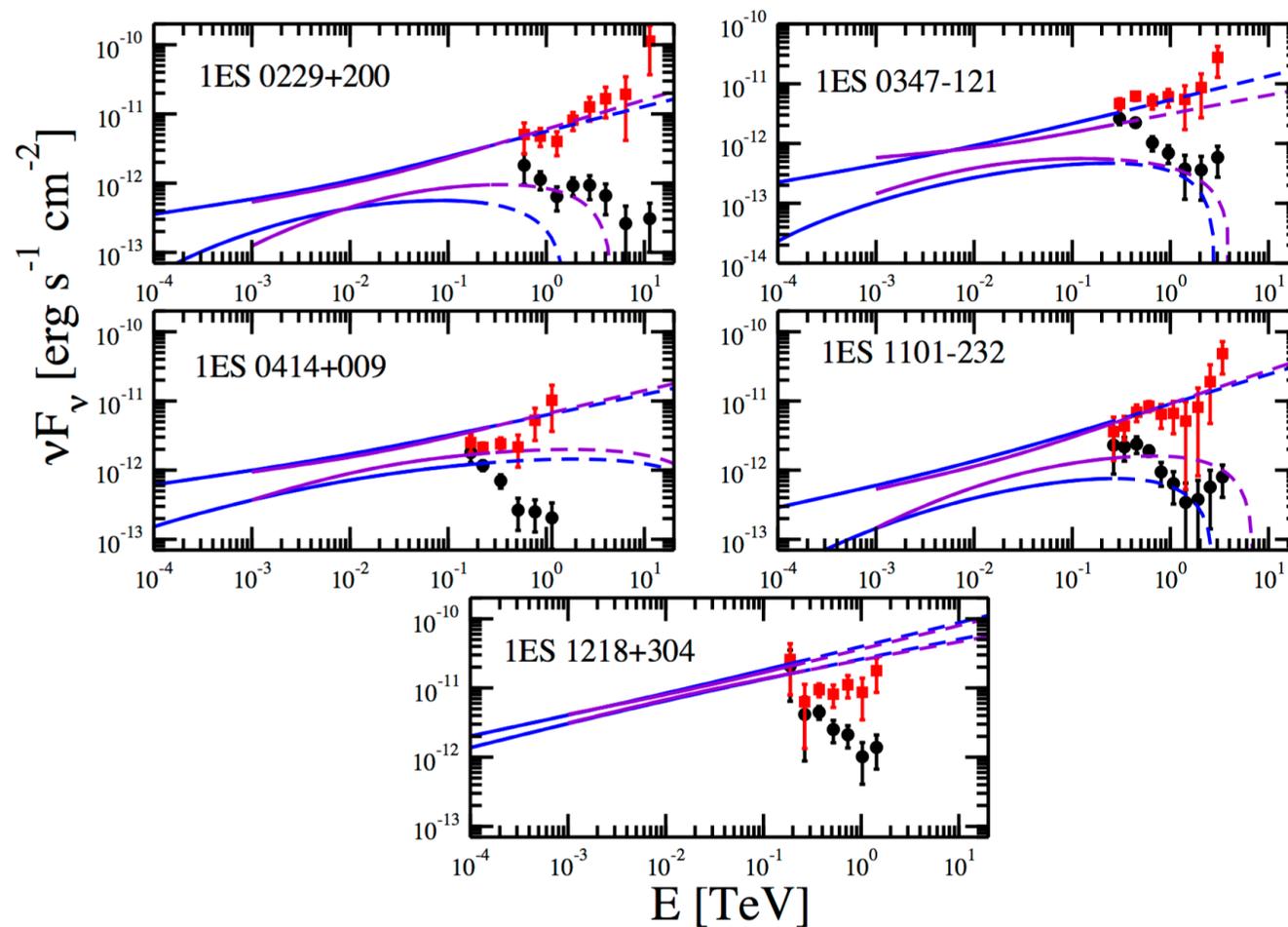
- The era of multi-wavelength campaigns
- SSC model can reproduce data (decrease in B-field coinciding with increase in luminosity and hardness of electrons).

Furniss et al. (2015)



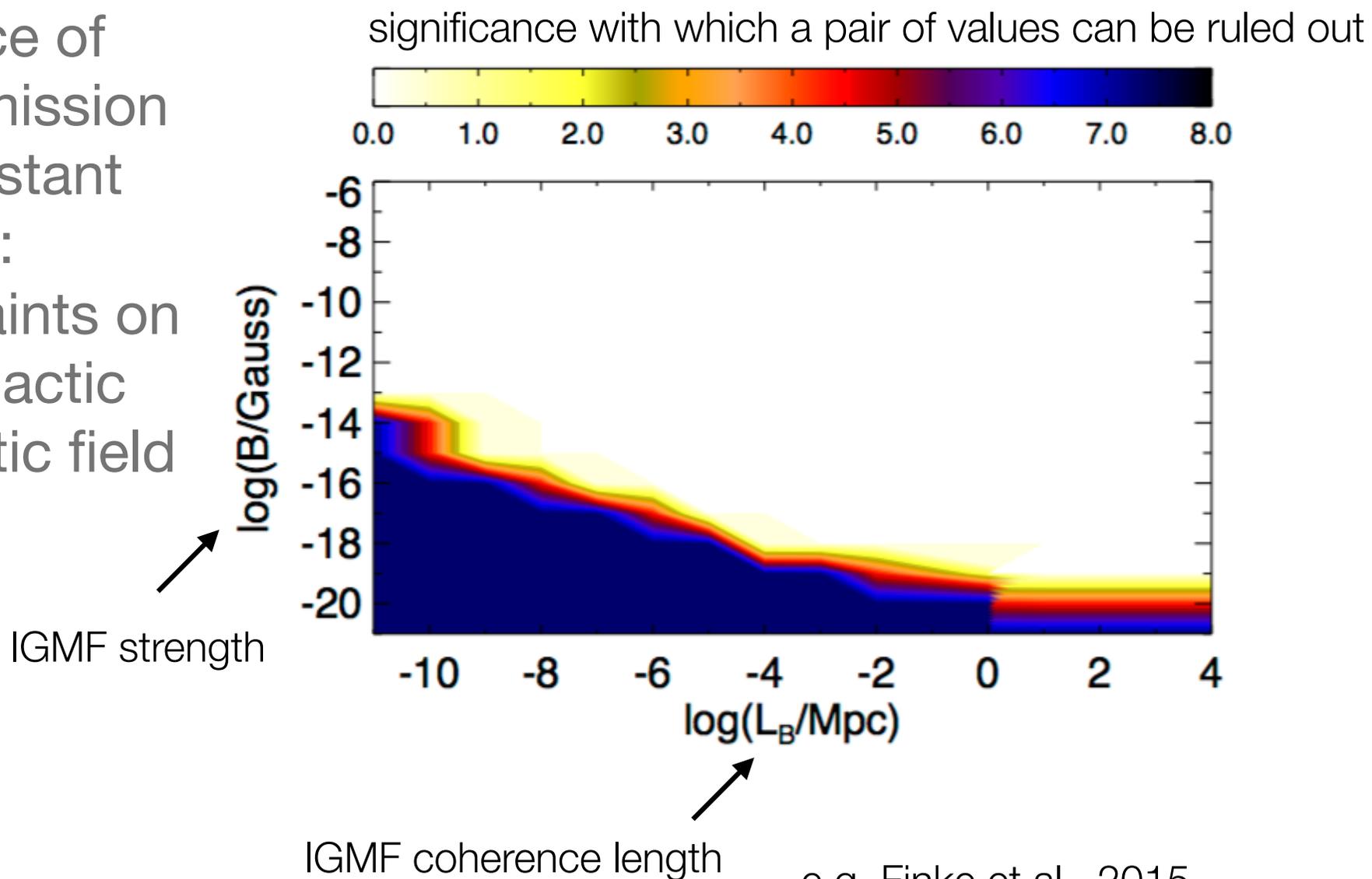
TeV sources without GeV detection

- Absence of GeV emission from distant blazars: constraints on intergalactic magnetic field



TeV sources without GeV detection

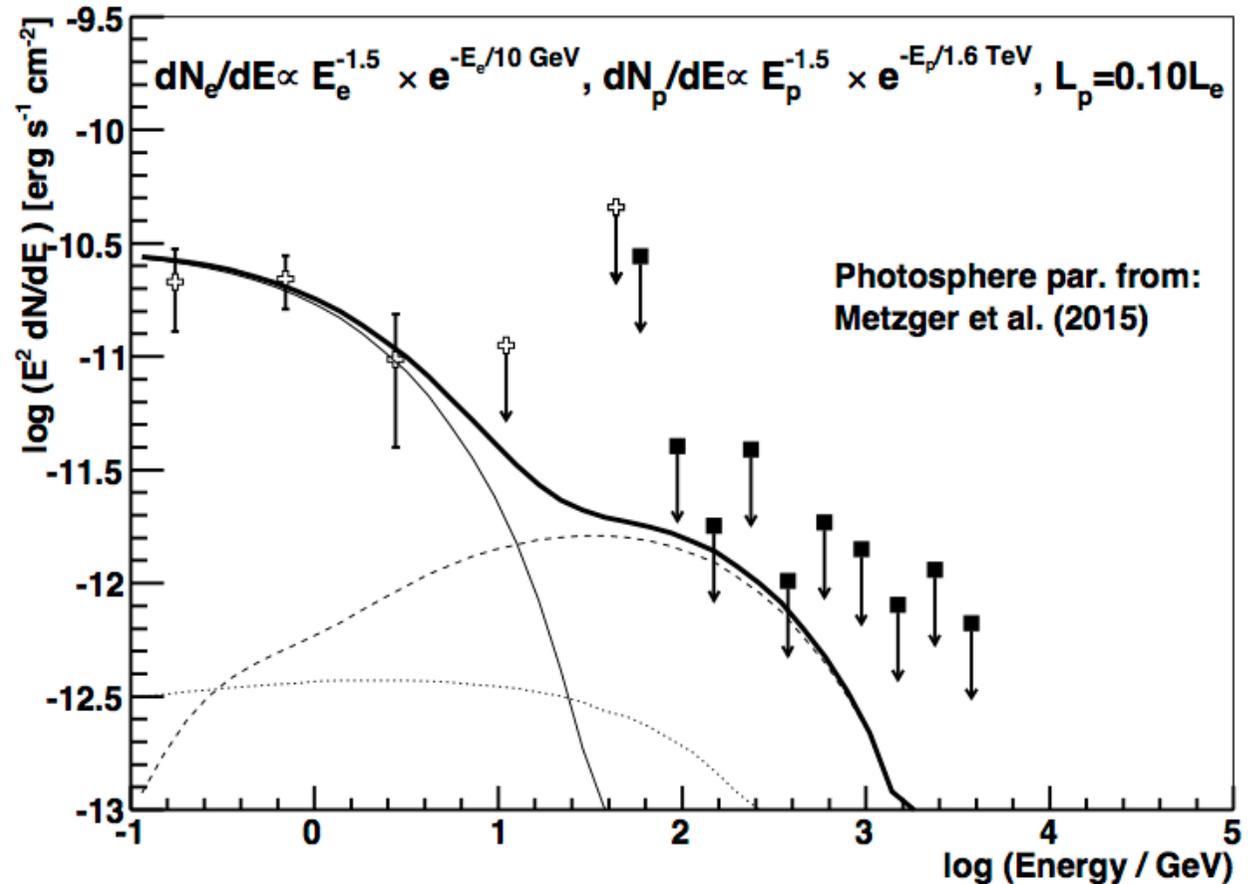
- Absence of GeV emission from distant blazars: constraints on intergalactic magnetic field



GeV sources without TeV detection

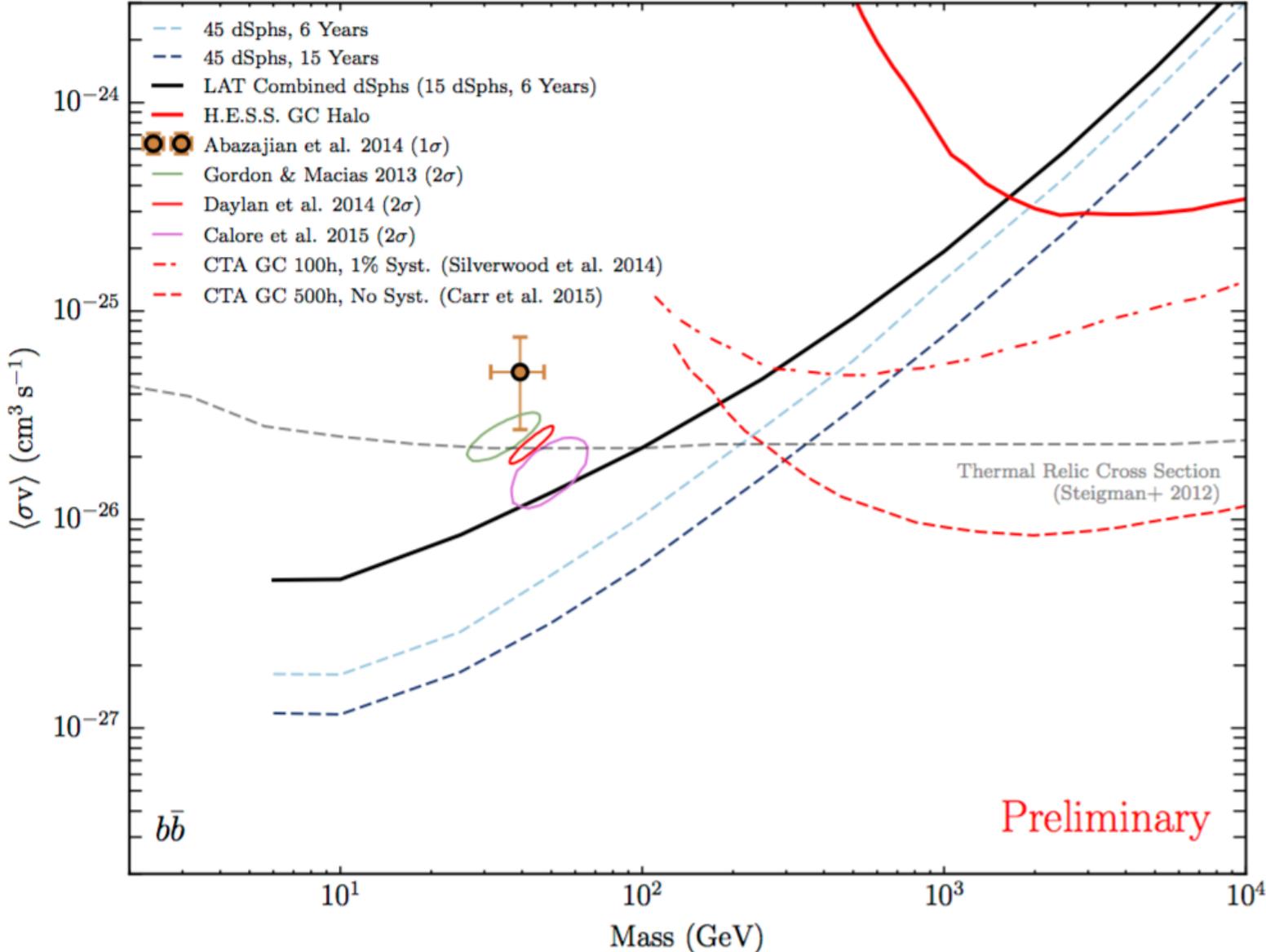
e.g. MAGIC
observations of
Novae

Ahnen et al. (2015)



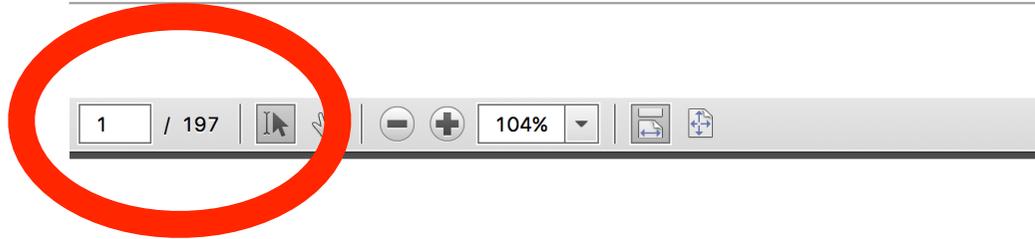
- total power of accelerated protons must be $\leq 15\%$ of the total power of accelerated electrons.

Non-detections



The future

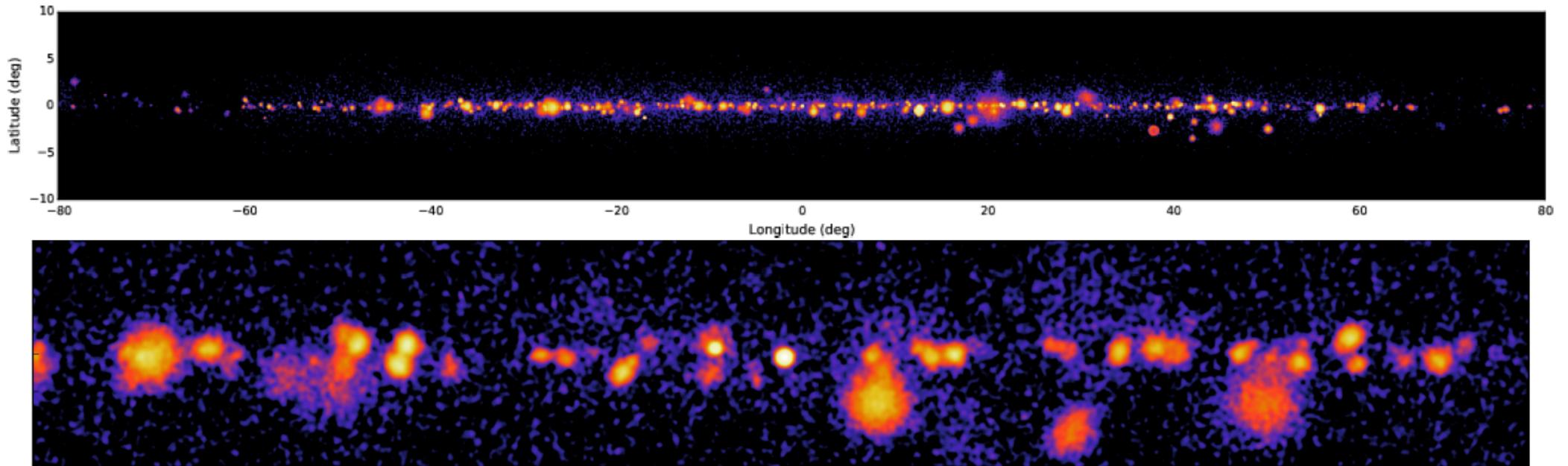
CTA - the future



Science Case

- Core science program in the first years in KSPs
- Surveys:
 - Galactic
 - Extragalactic (1/4 sky)
 - LMC
- Fundamental physics (DM)
- Individual classes
 - AGN
 - Galaxy clusters
 - Star-forming systems
 - Pevatrons

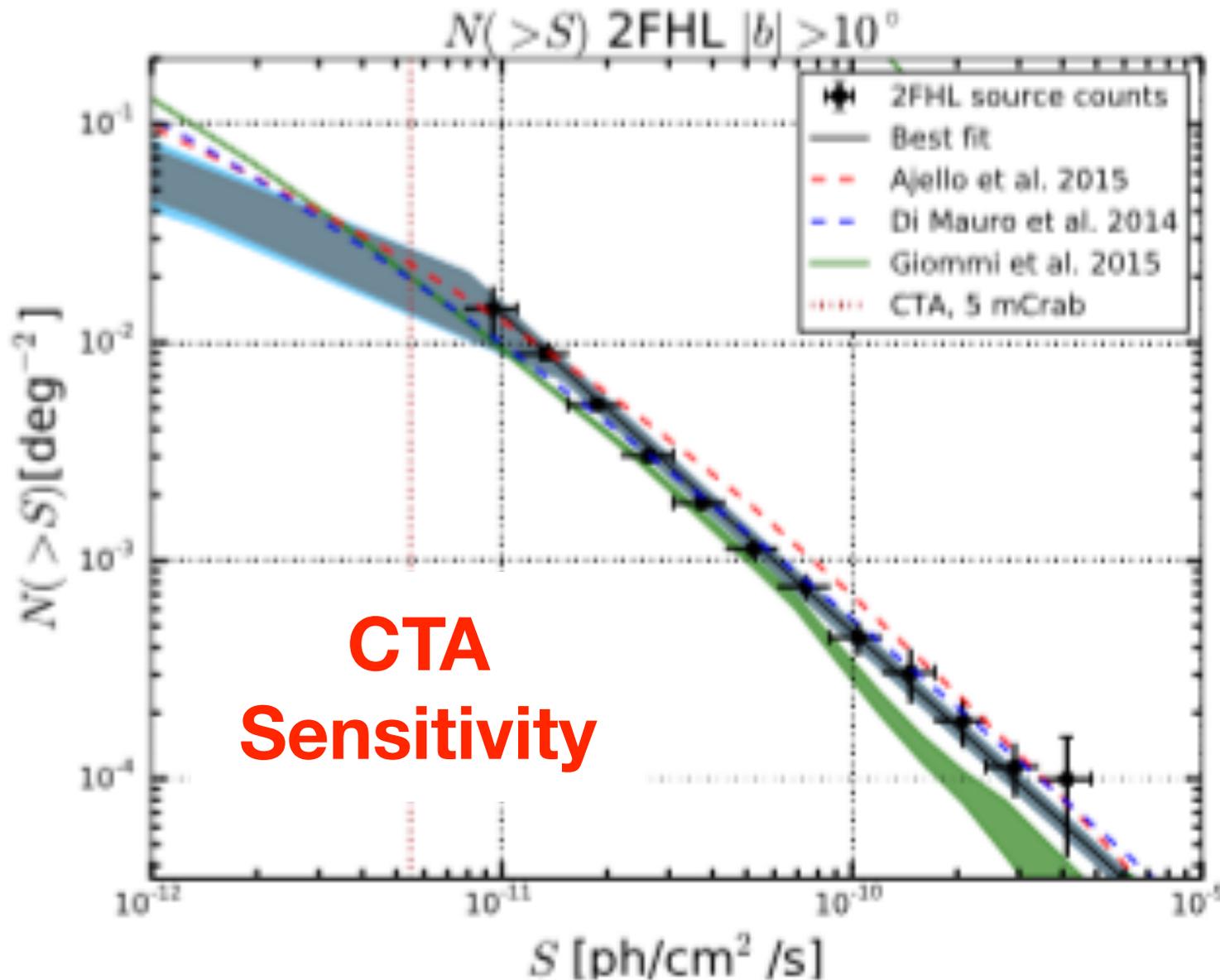
Galactic Plane Survey



- Will clearly run into some of the same difficulties Fermi-LAT is facing (source confusion, some level of diffuse emission, ...)
- Will provide a trove of data for joint GeV/TeV studies

The extragalactic survey

See Talk by M. Di Mauro

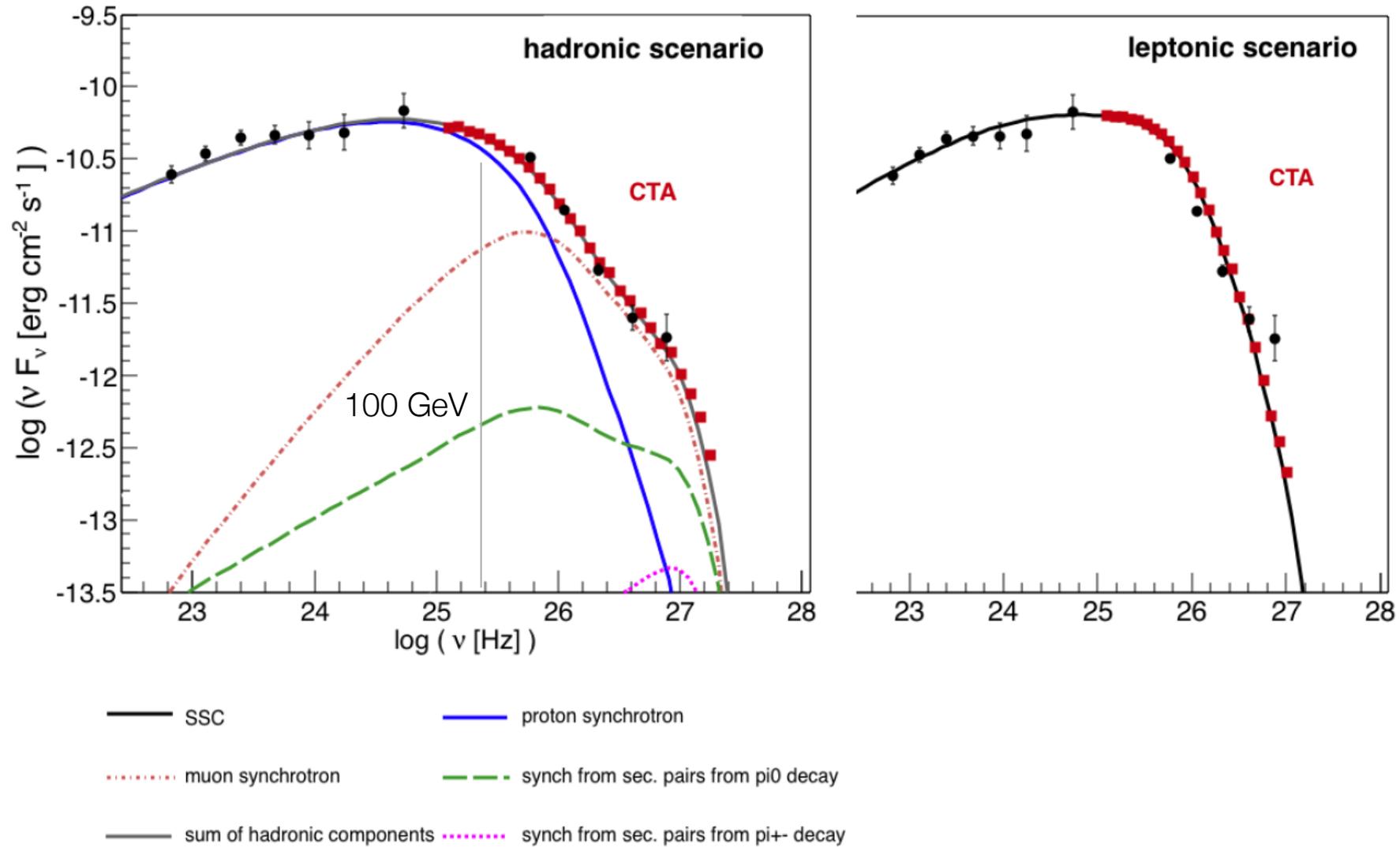


- Source density: $\sim 0.02 \text{ deg}^{-1}$
- ~ 800 sources all over the sky

Ackermann et al. 2015 (1511.00693)

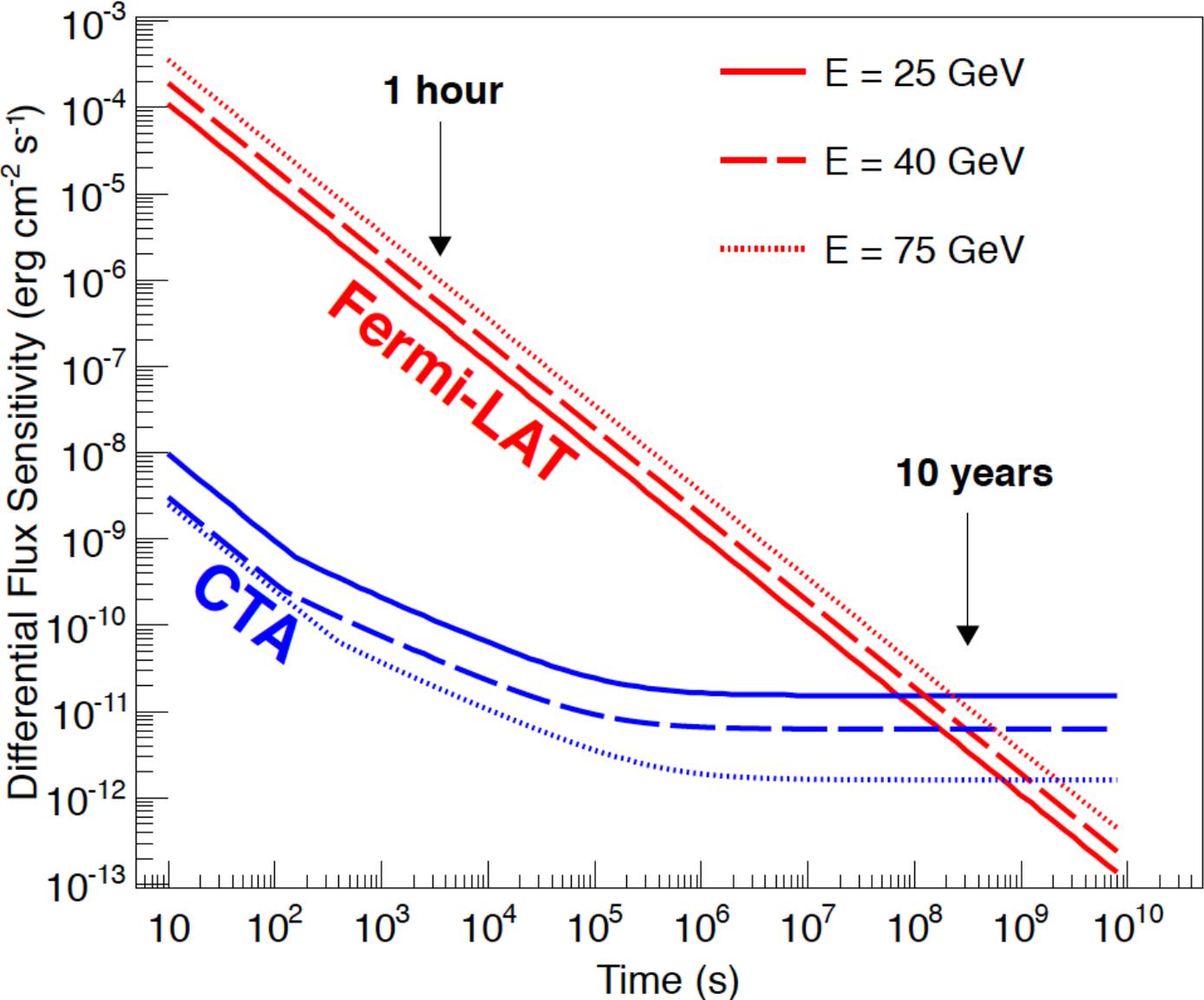
Spectral studies

e.g. PKS 2155-304

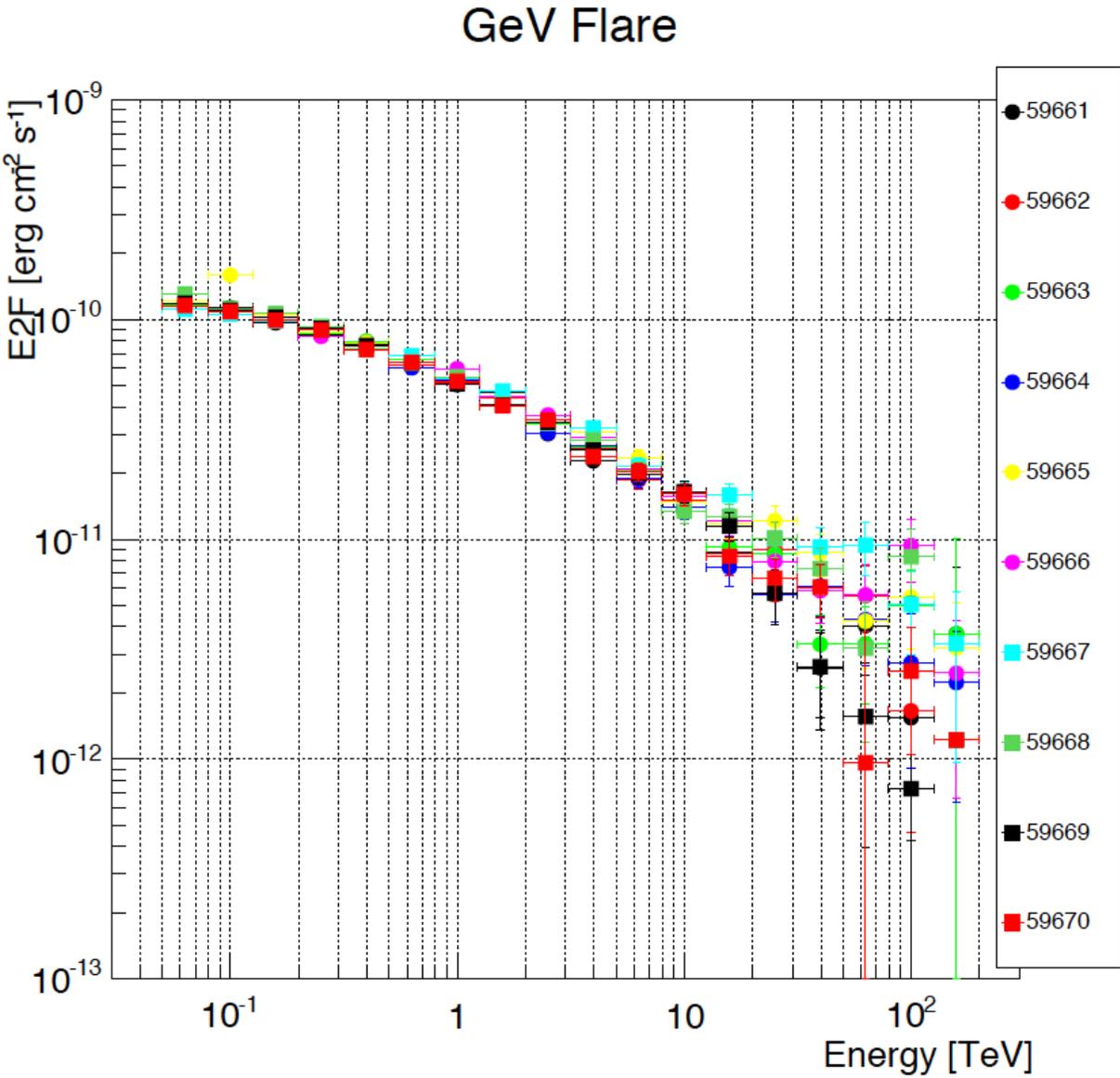


Boosting the time domain > 25 GeV

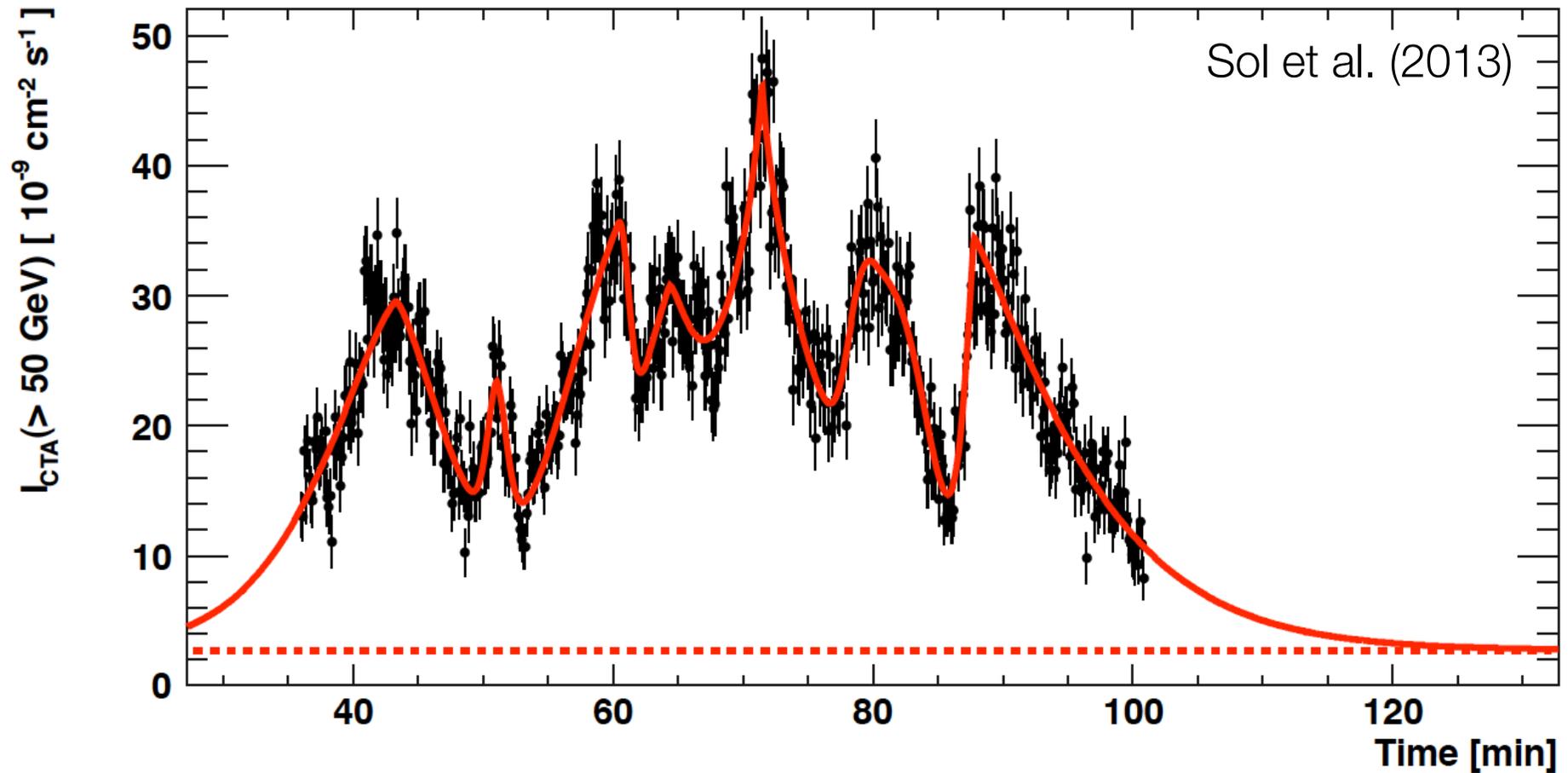
Funk & Hinton (2013)



Example: CTA observations of Crab Nebula Flares



Probing extreme environments



- Simulated CTA lightcurve for 2006 flare of PKS 2155-304

Fermi-LAT and its impact on TeV instruments

- Extremely powerful mission for every aspect of TeV science
 - Spectral response > 50 GeV (background free)
 - Variability alerts
 - Interpretation of scientific results
- Still lots to come ...

