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Gamma Ray Direct Observation

Rapporteur Talk

ICRC 2019
Madison WI
2019/08/01

Boring outline

Mostly a list of sources as a function of z:

- Solar
- Galactic sources
- Extragalactic sources

Plus

- Instrument updates, future proposals

Contents:

- No plenary talks
- No posters (usually are referred in the contributions)

A guiding thread...

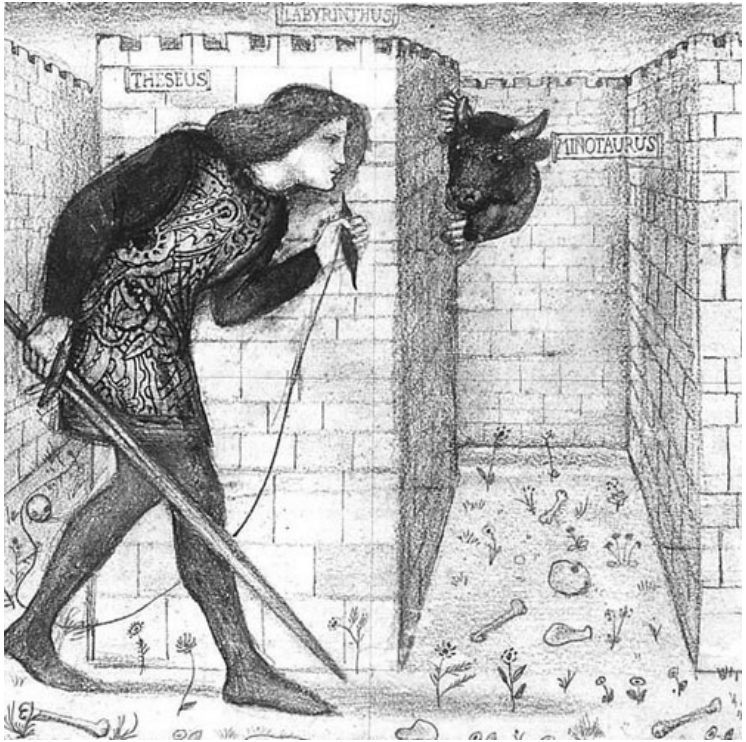
My personal view on the whole situation

A set of **excellent instruments**:

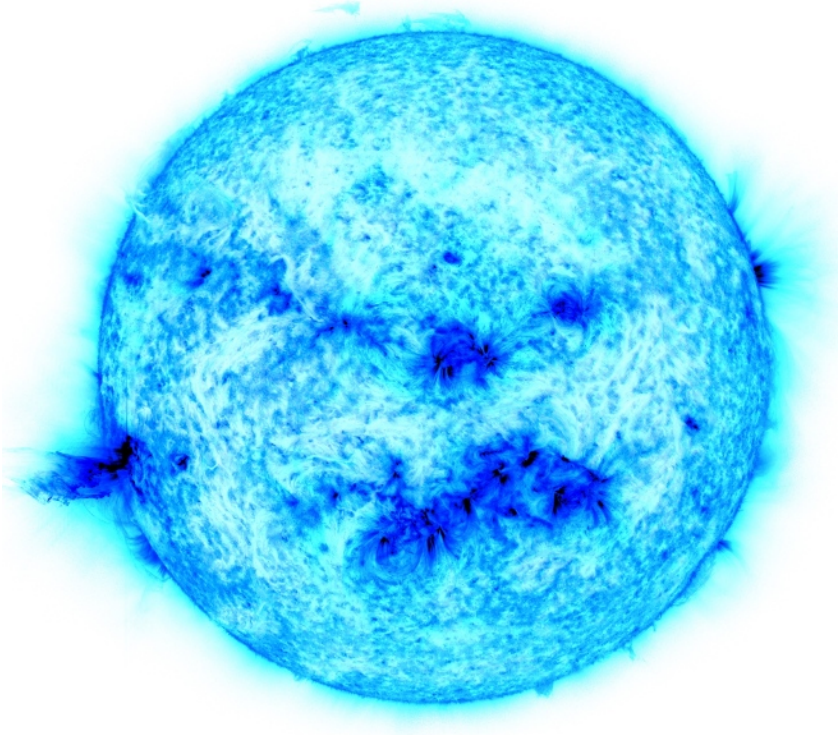
- Impressively precise measurements
- More and more extensive coverage of the sky
- Several results in **tension** with current models (DSA, SSC, …)

On the other hand:

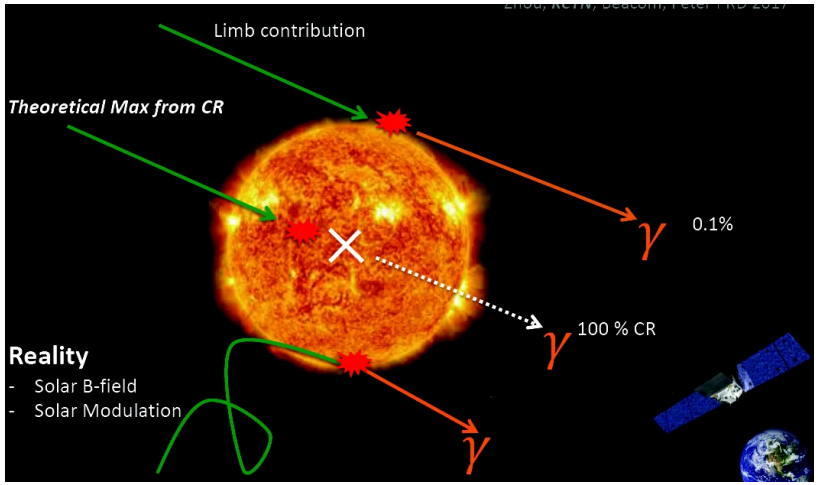
- Often very **low statistics**, esp. > 1 GeV (growing linearly with time)
- Many tantalizing **hints** of further features, discrepancies…
- The **need for MWL** is paramount, “blind” regions in the spectrum are so frustrating

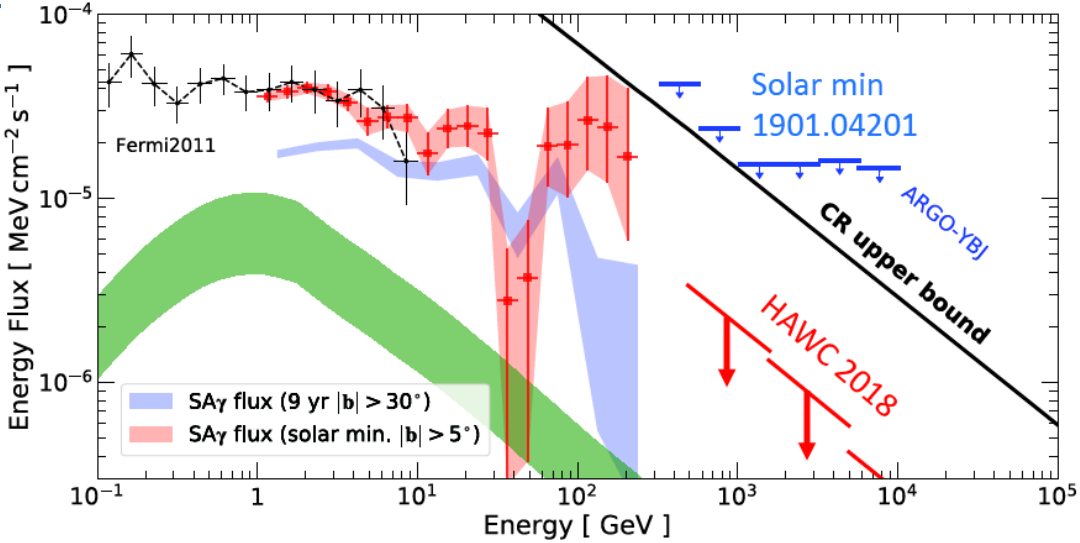


Solar



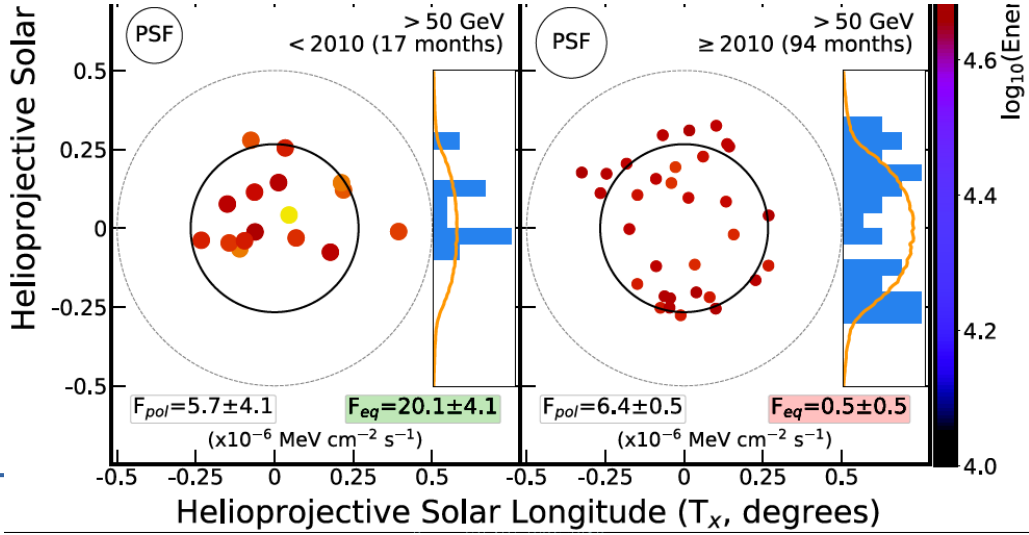
Hadronic gamma rays from the Sun



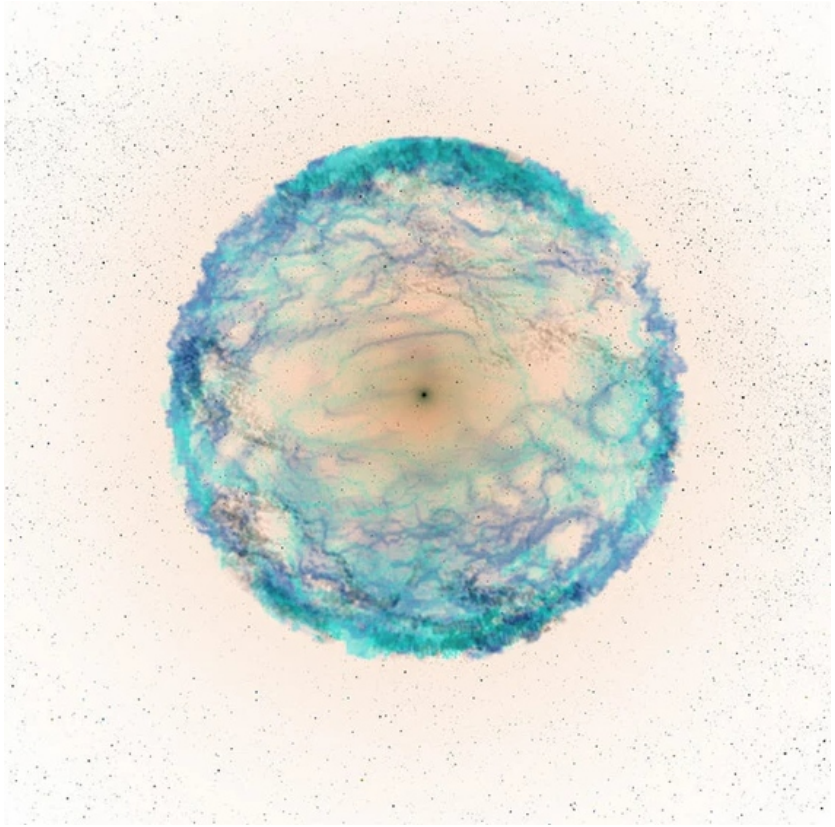


Hadronic CRs → Sun limb
Effect of solar modulation at ~GeV
What happens at 100's GeV?
Time dependent?
(6 ph >100 GeV at Smin 2009, 1 at Smin 2018)
Nothing with HAWK (but see CRI13C!)
Some morphology?

Ng GAD4C
PoS(ICRC2019)588



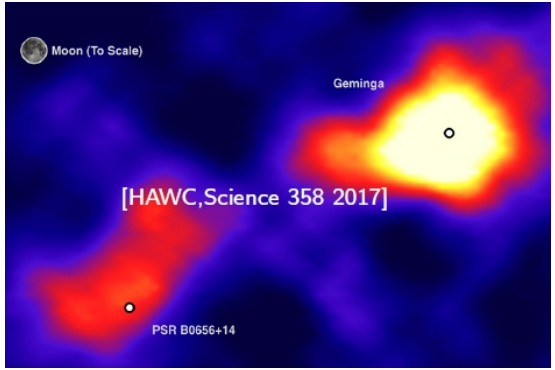
Galactic sources

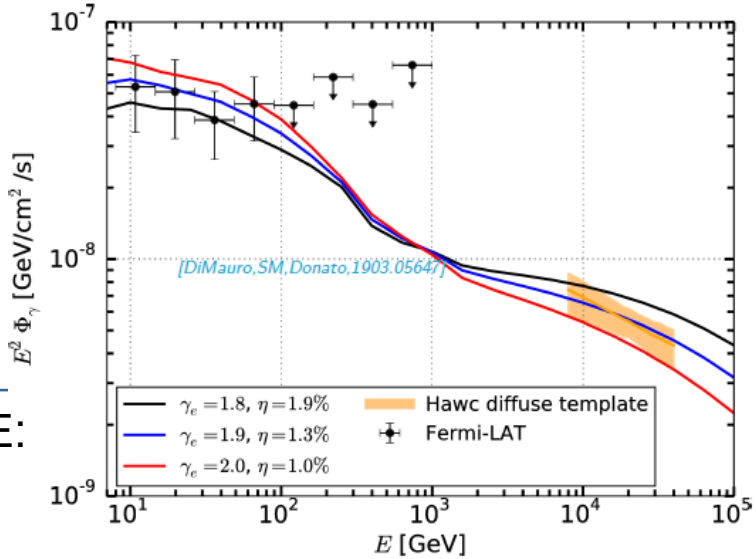


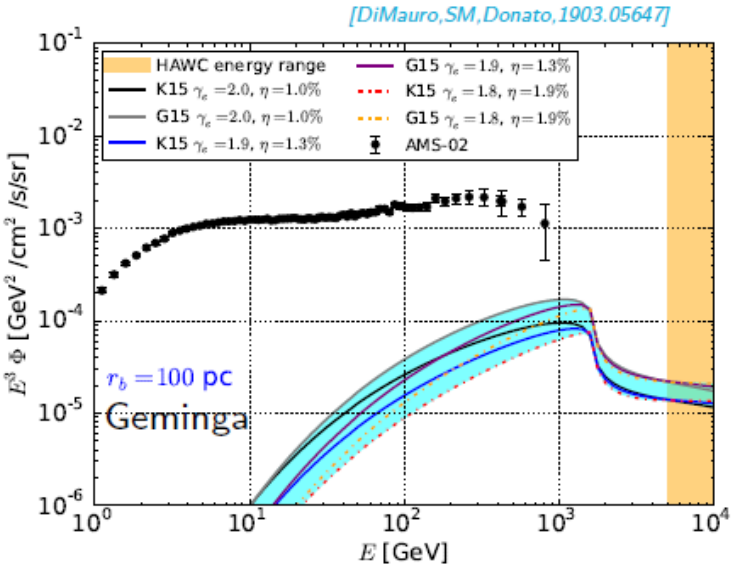
Halo around Geminga

HAWK: HE halo around Geminga, Monogem
Fermi-LAT: detected for Geminga, constrains local e+ flux
Max 10% at 800 GeV (Geminga), max 3% (Monogem)
Cumulative PWN emission: still a viable explanation of e+ excess
Note: Geminga template including proper motion favored at 4σ
First gamma ray detection of a source moving!

Manconi GAD4B
PoS(ICRC2019)580





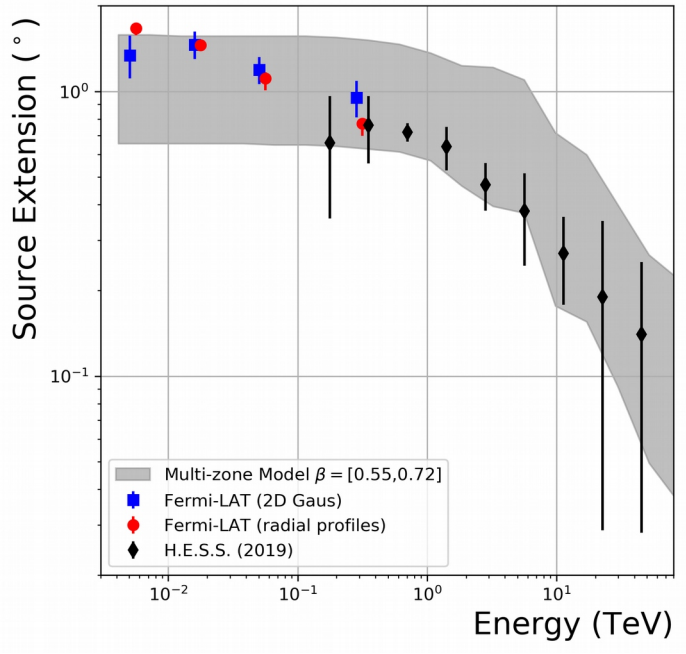


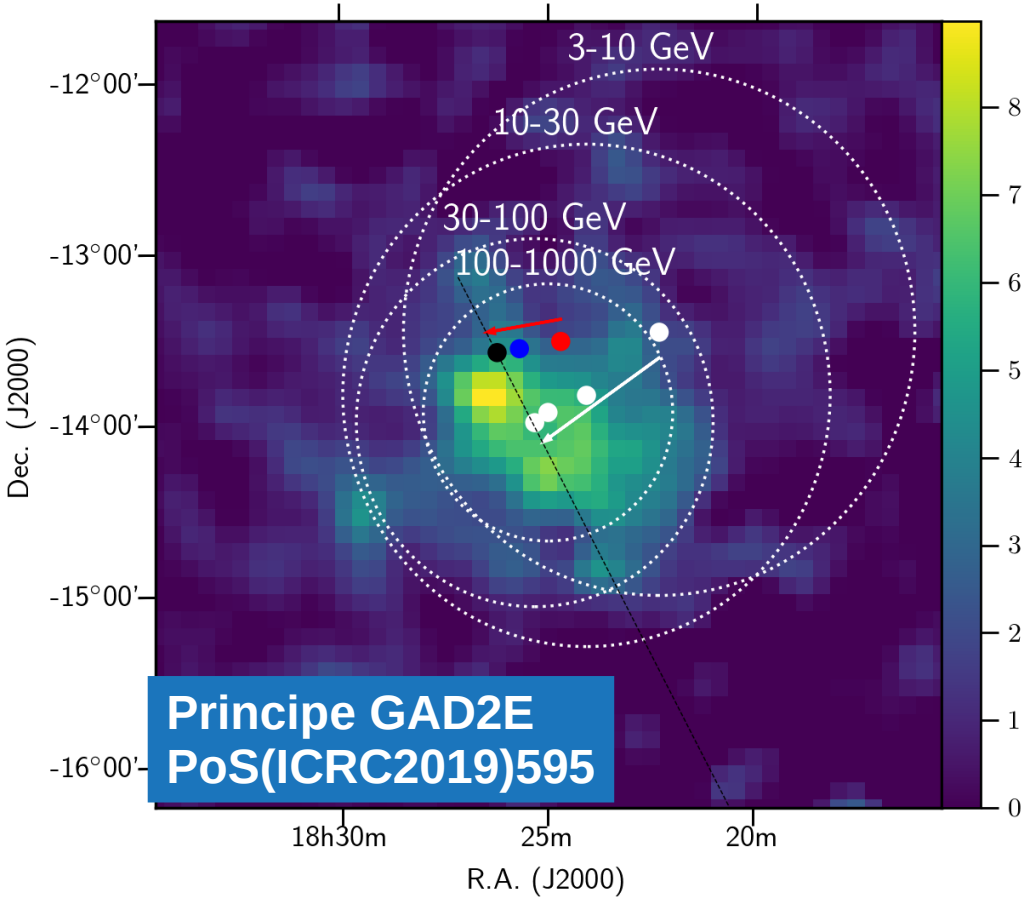
See also PSR w/ DAMPE:

Muñoz GAD2D
PoS(ICRC2019)587

Largest known PWN

HESS J1825-137
Analysis 1 GeV – 1 TeV (LAT+HESS)
Size decreases with energy, centroid moves
Apparent motion too big
Much older that 21 kyr?
Composite object?

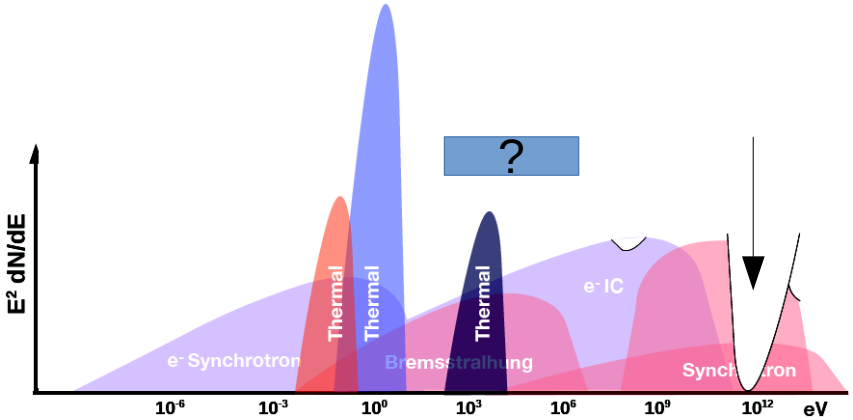


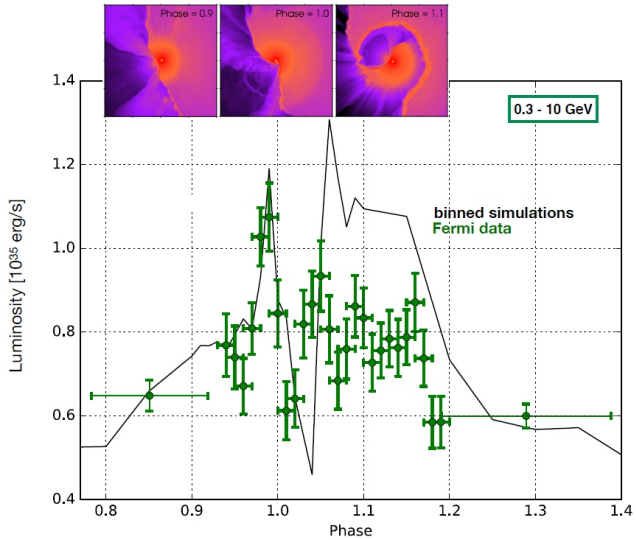


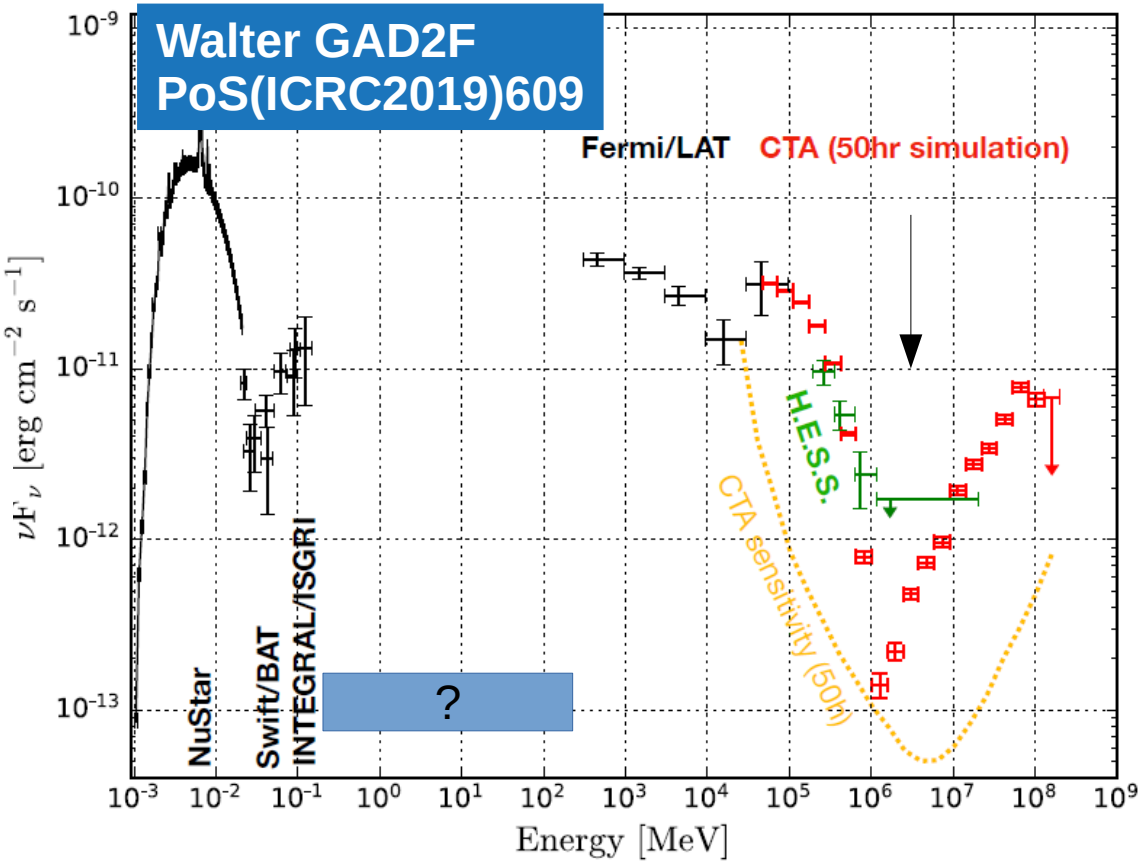
Principe GAD2E
PoS(ICRC2019)595

Eta Carinae

"Just" stars, but L~4·10^6 L$_\odot$, excellent laboratory (lots of CRs, abundant thermal photons)



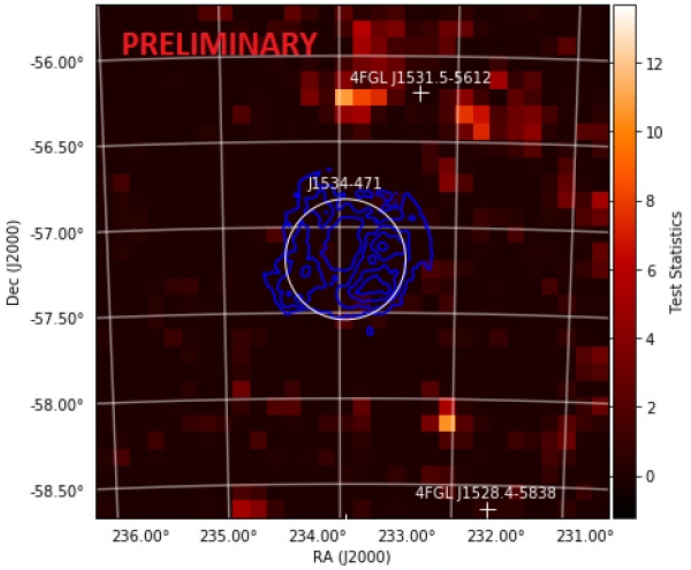




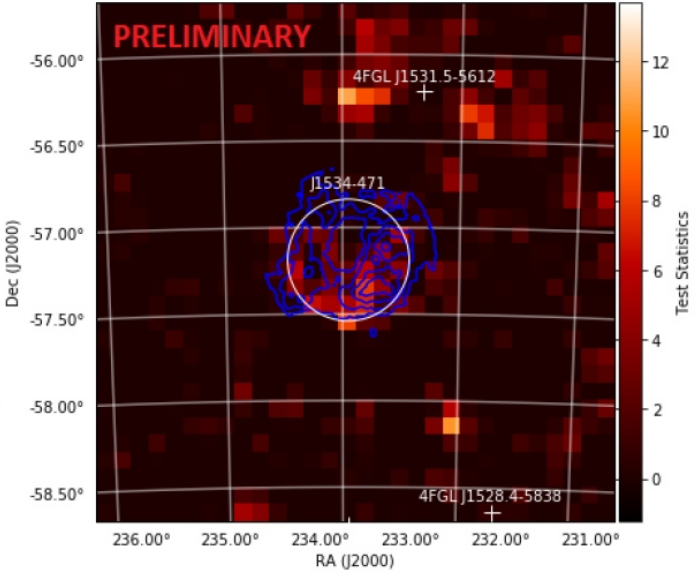
HESS SNRs with Fermi-LAT

Three candidate shell SNRs, detected as extended in 4FGL
Detailed study of morphology, SED

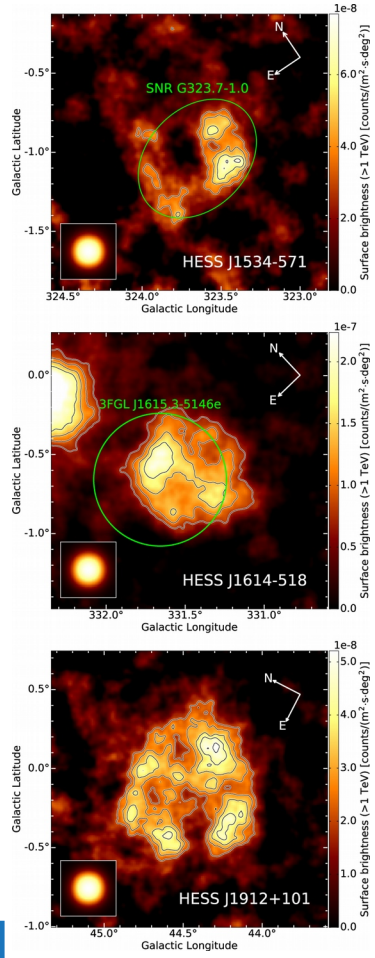
- J1534: HESS map, additional source (PSR) discovered by SED



HESS J1534−571 in the model



HESS J1534−571 removed



NB: ~100 photons

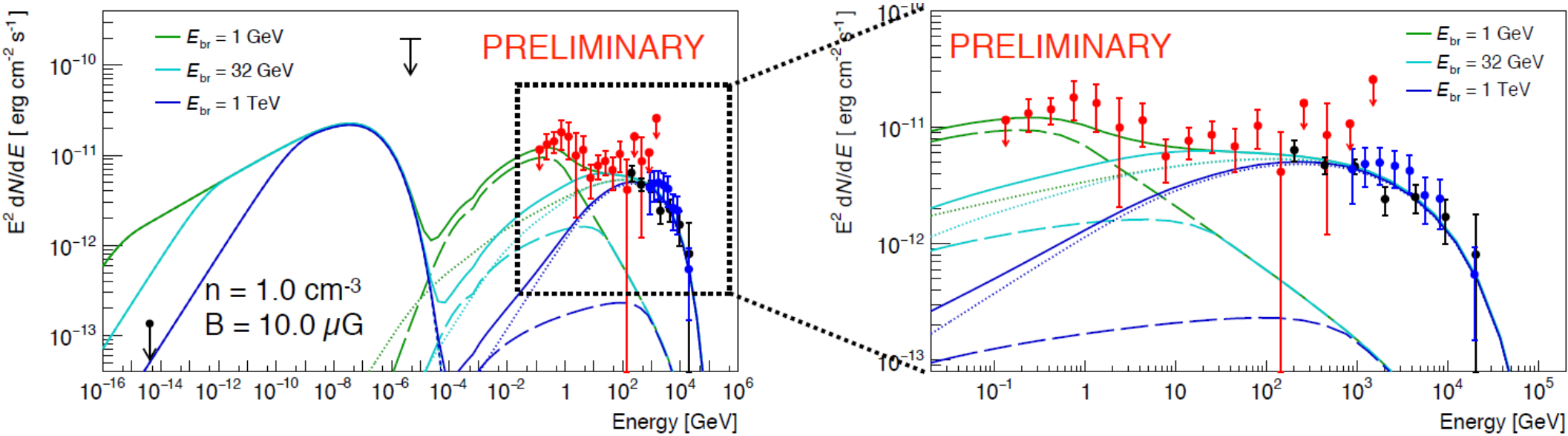
De Palma GAD2A PoS(ICRC2019)560

Green GAD2B PoS(ICRC2019)564

HESS SNRs with Fermi-LAT (2)

Detailed study of morphology, SED

- J1912: unassociated TeV source, no radio, X, PSR in the region (wrong distance)
- MAGIC morphology: ring
- LAT: Gaussian
- Joint SED: soft, slightly outside DSA, too old (130 Myr), spectral model in tension with radio, hadronic m. also not good → cries for additional MWL observations

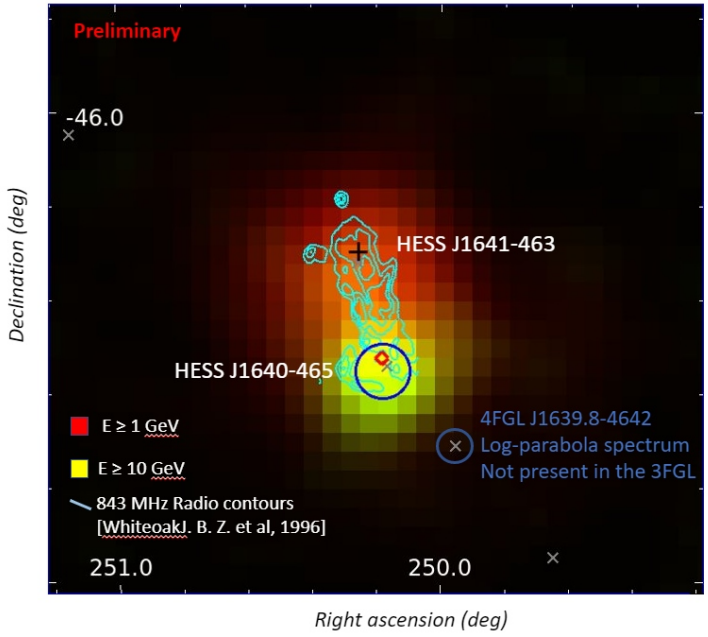


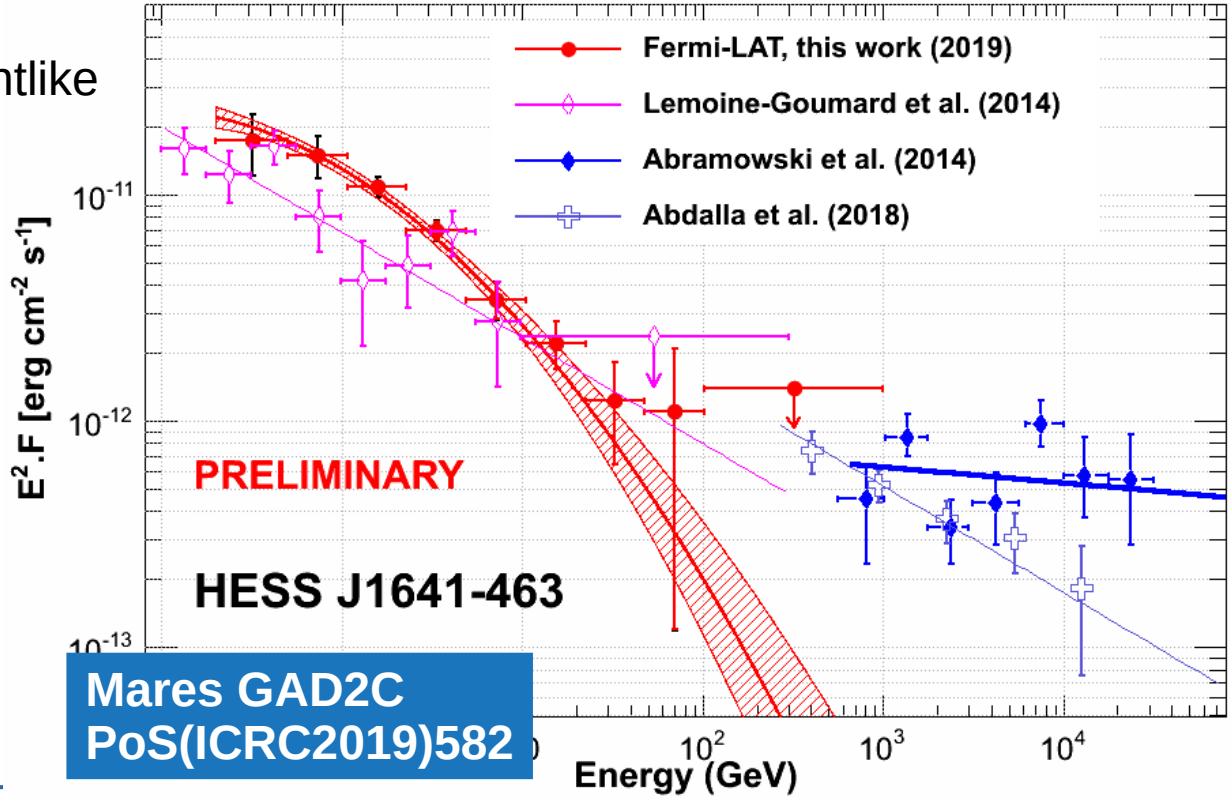
HESS Pevatron candidate

Complex structure: 2 SNRs apparently connected by a bridge, very close (~0.25°)

J1640: first detection of extension in LAT data, hard leptonic spectrum

J1641: 4 sigma SED curvature, pointlike PSR (LAT) + Pevatron (HESS)?



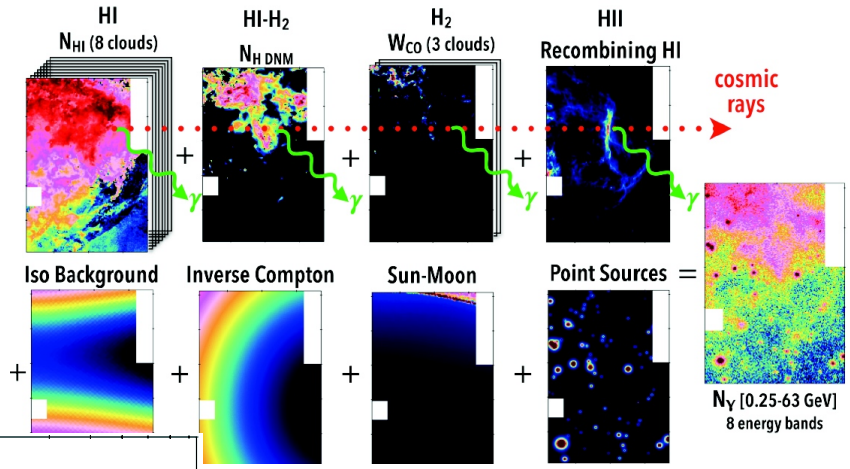


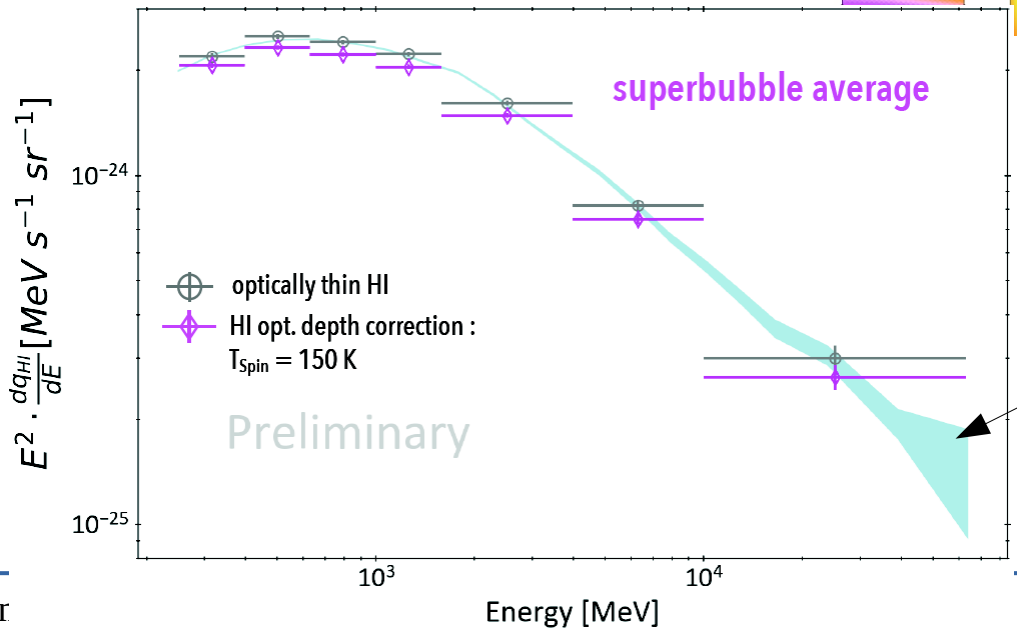
Mares GAD2C
PoS(ICRC2019)582

Orion-Eridanus superbubble w/ LAT

Compare with Cygnus:
- Closer (from 150 pc)
- 62 stars ≥ 8M$_\odot$
- 12 SN over 12 Myr

No hardening of γ-ray emissivity spectrum
Uniform emissivity



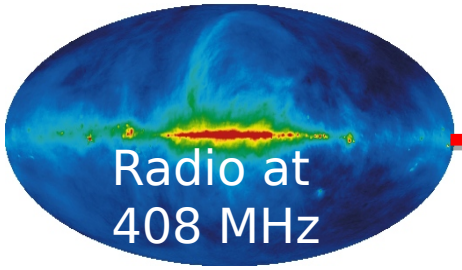


Local ISM average

Joubaud GAD4A PoS(ICRC2019)568

Modeling interstellar emission

50% of LAT photons: IS emission
Use MWL to tune it



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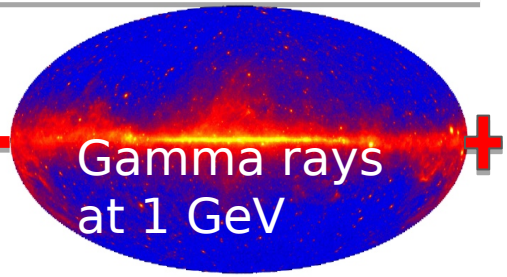

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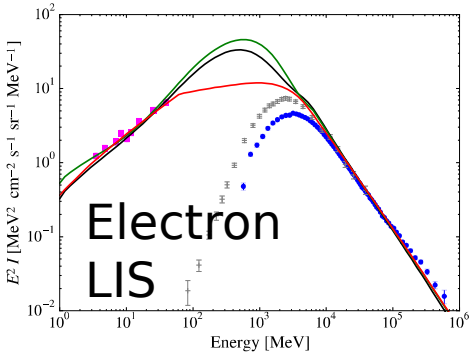
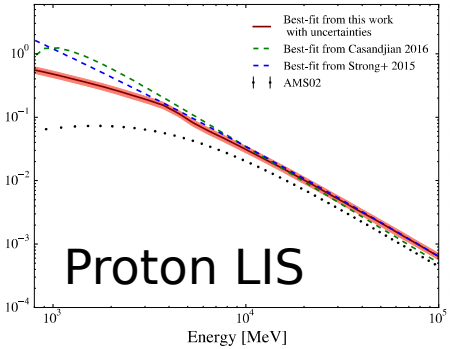
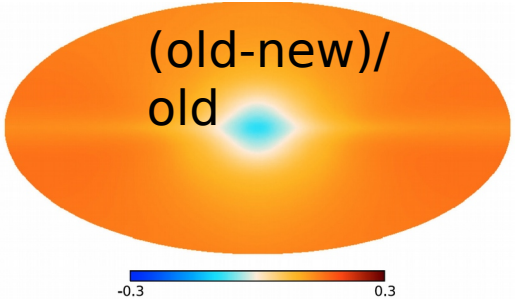






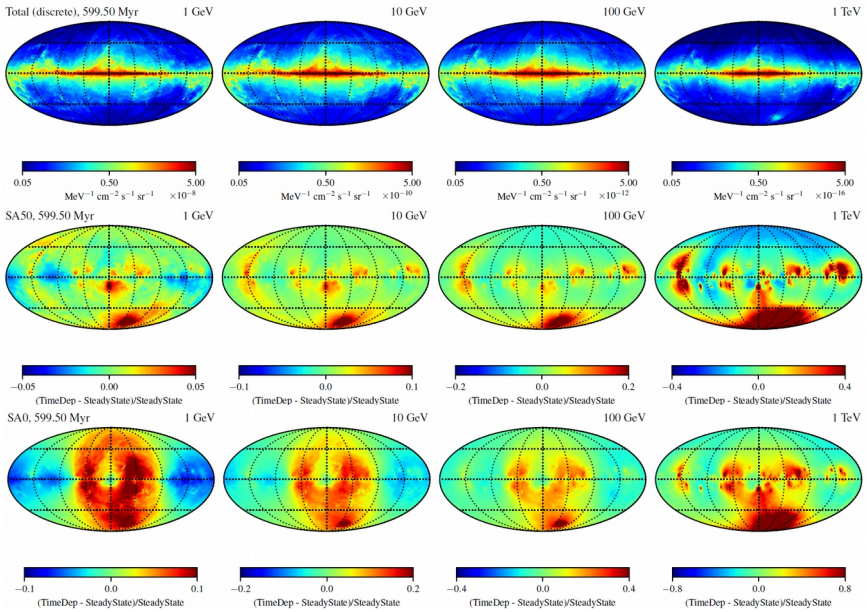
IC template @ 10 GeV

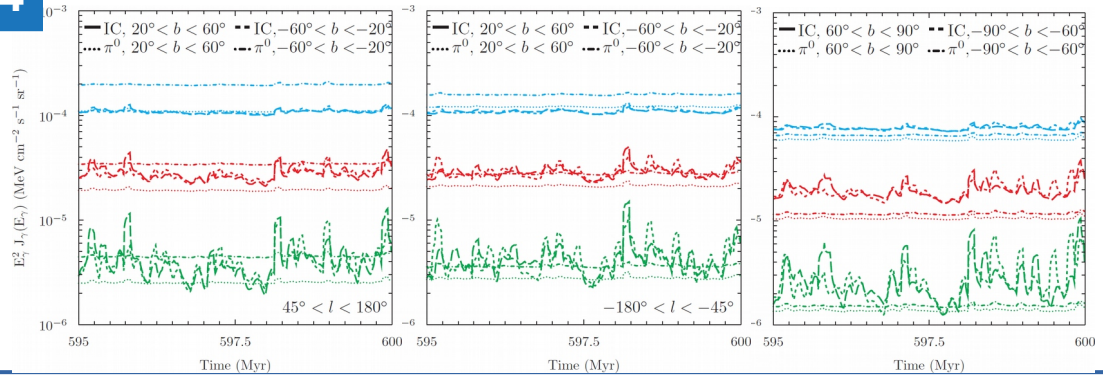
Orlando GAD4A
PoS(ICRC2019)119

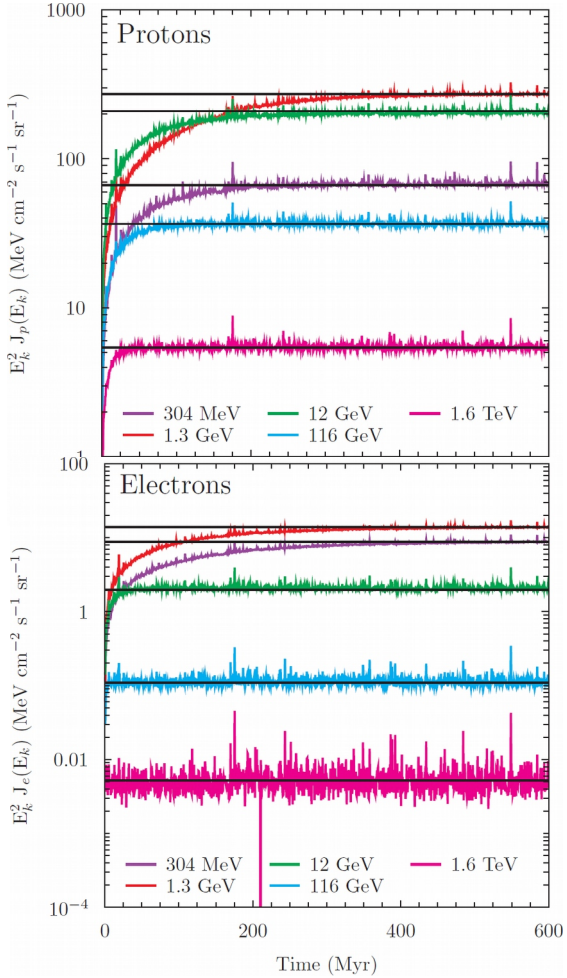
Time-dependent, discrete sources

T-dependent injection and propagation
Fluctuations on e- and p fluxes
Gamma too, especially high-E (IC)
Large-scale, significant residuals in maps (5% to 40% effects)

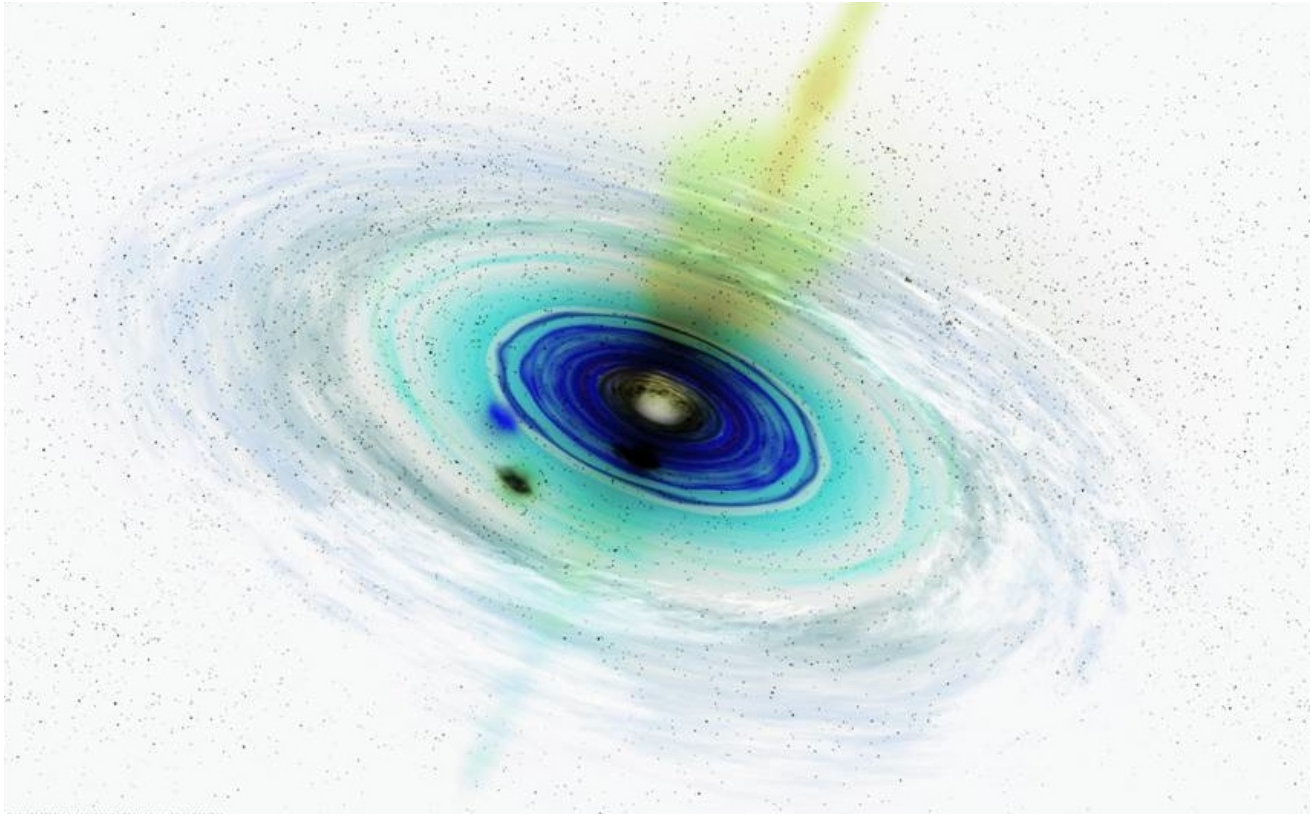
Porter GAD4E PoS(ICRC2019)594





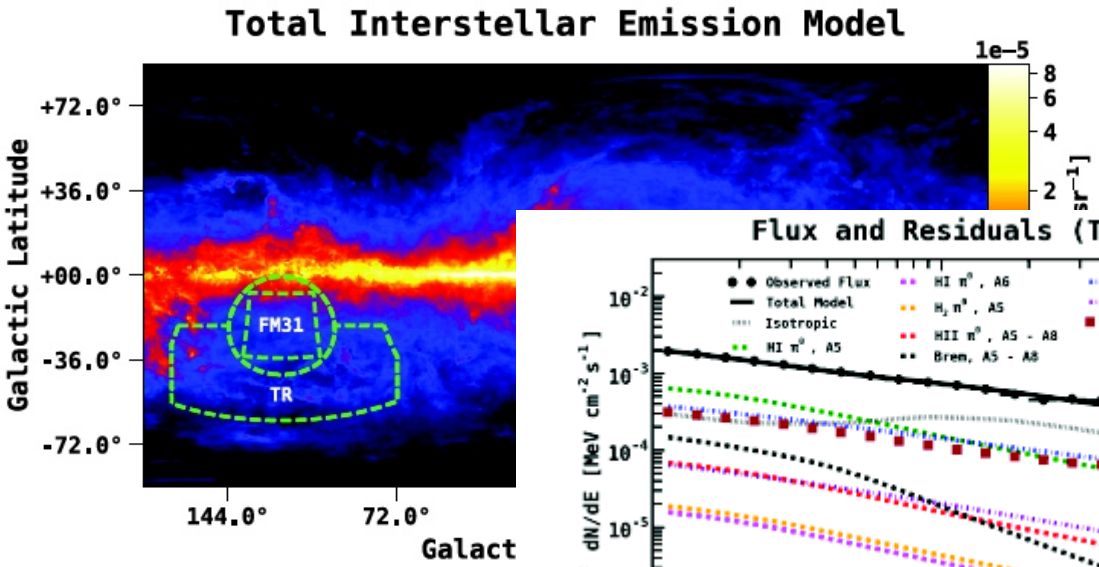


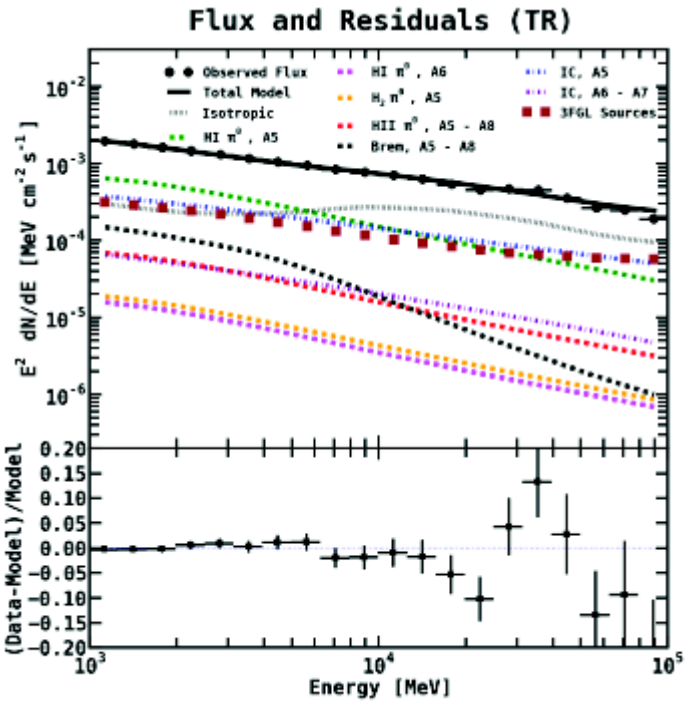
Extragalactic sources

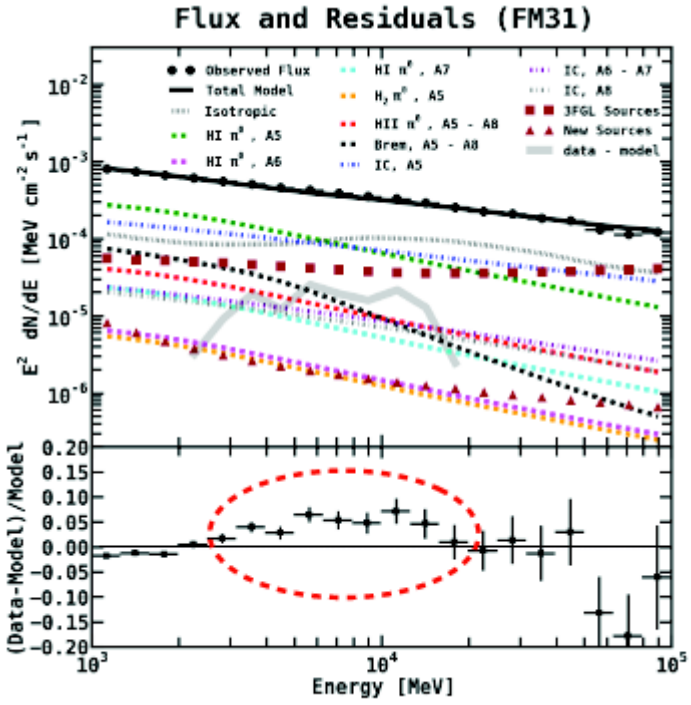


M31

M31 system, DM halo ~42°



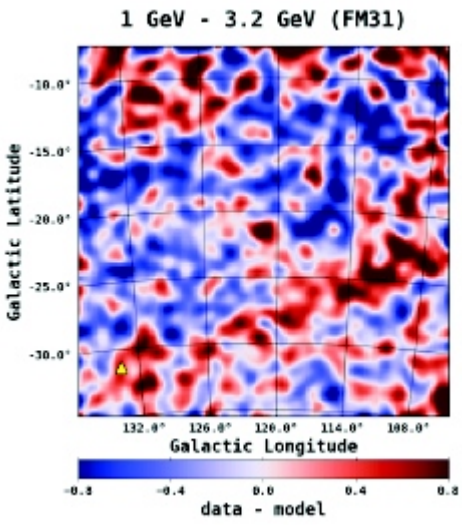




Karwin GAD1D
PoS(ICRC2019)570

Details of the modeling

Removing a spur structure, excess remains



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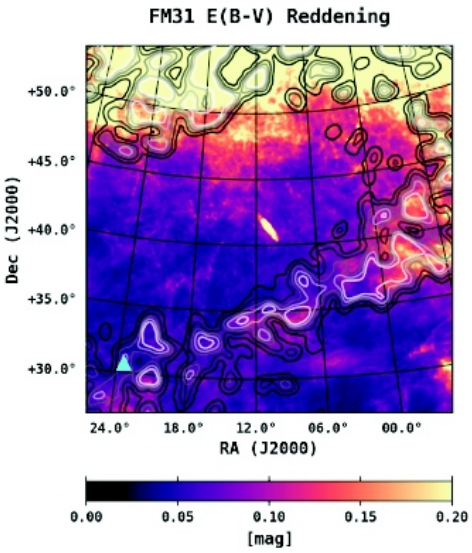

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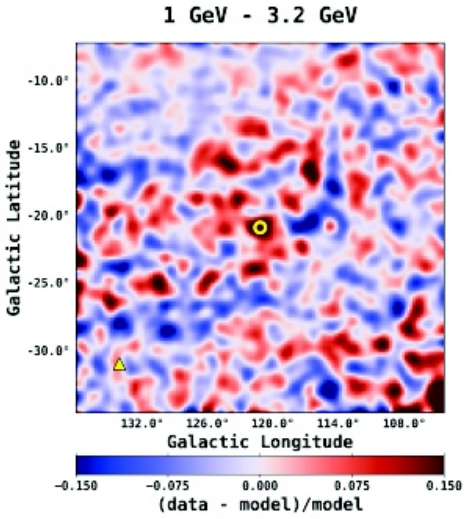
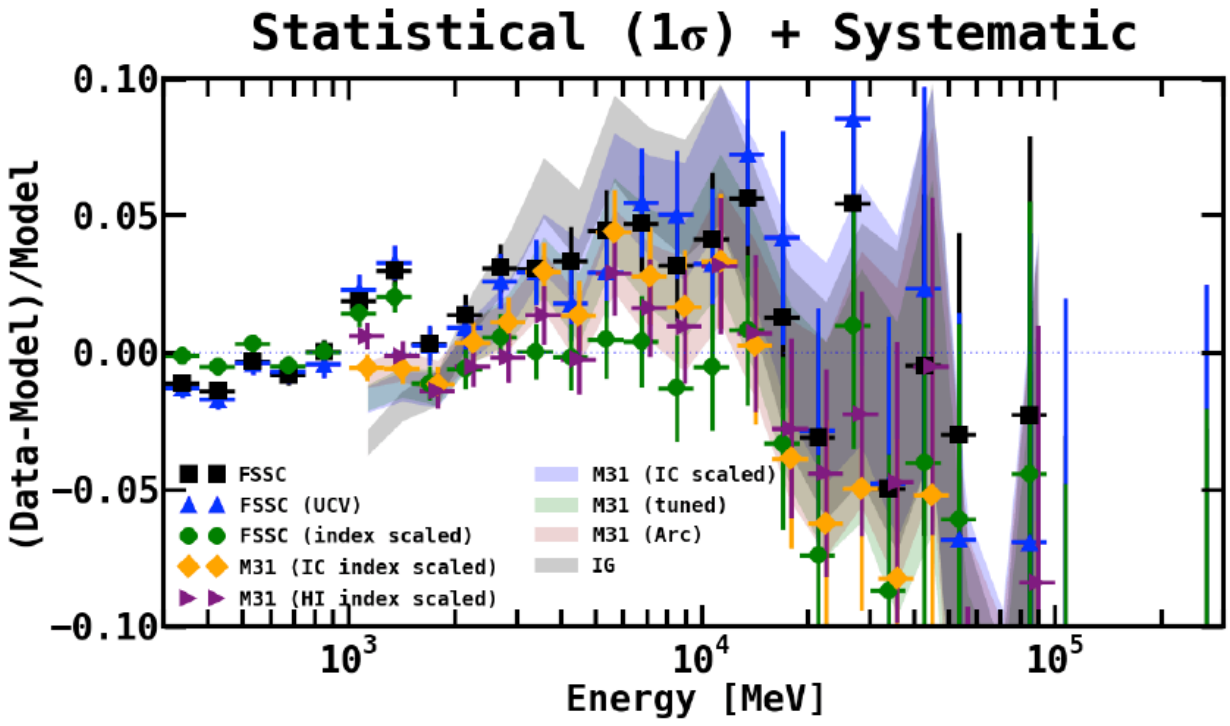
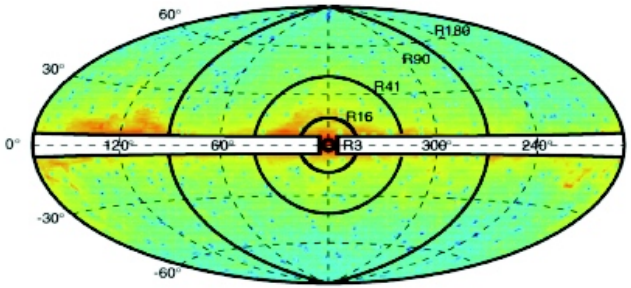


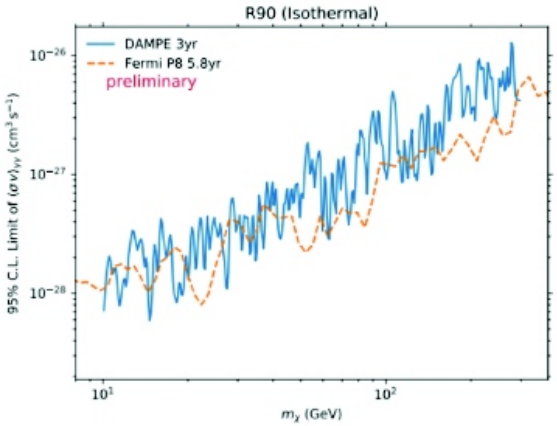
Model dependency



DM search: DAMPE

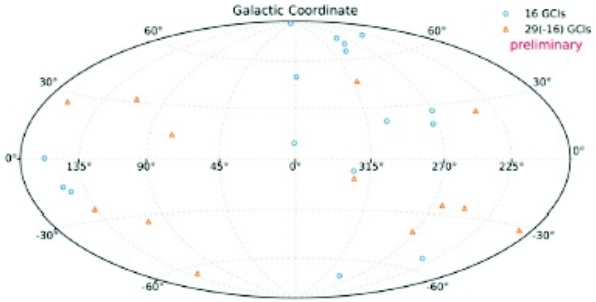
Diffuse regions

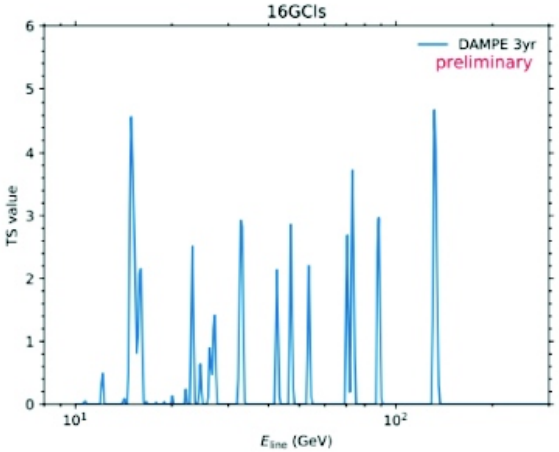




Upper limits for R90 region

Galaxy clusters





TS values for 16 GCls

Search for lines:

Li GAD3A
PoS(ICRC2019)576

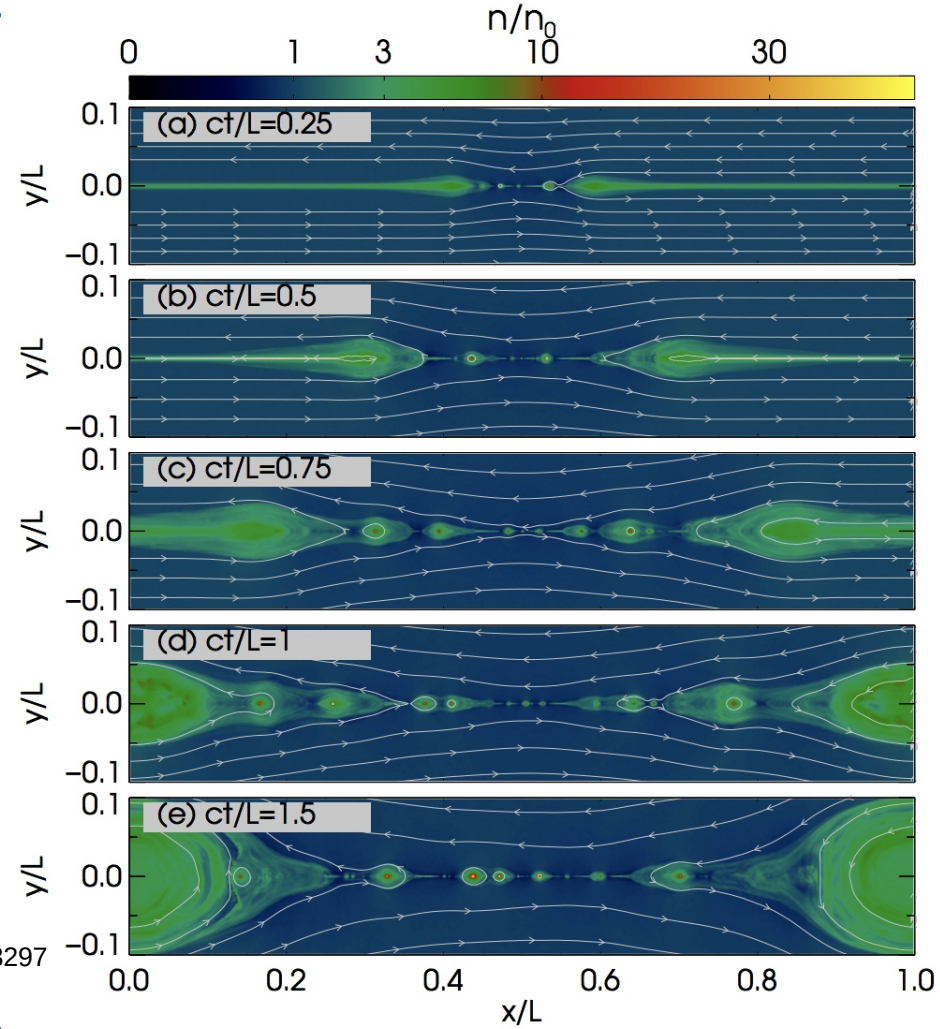
Blazars: relativistic reconnection

Blazars: more abundant sources of extragalatic gamma rays
Variability on timescales from minutes to weeks
Many additional relations to be modeled

- ratio ~1 of SC and IC peaks
- correlations between LAT and X,UV,…

PIC simulations
Plasmoids are efficiently accelerated
Collisions, illumination, can produce

- variability at all scales
- Illumination: SC/IC ratio ~1

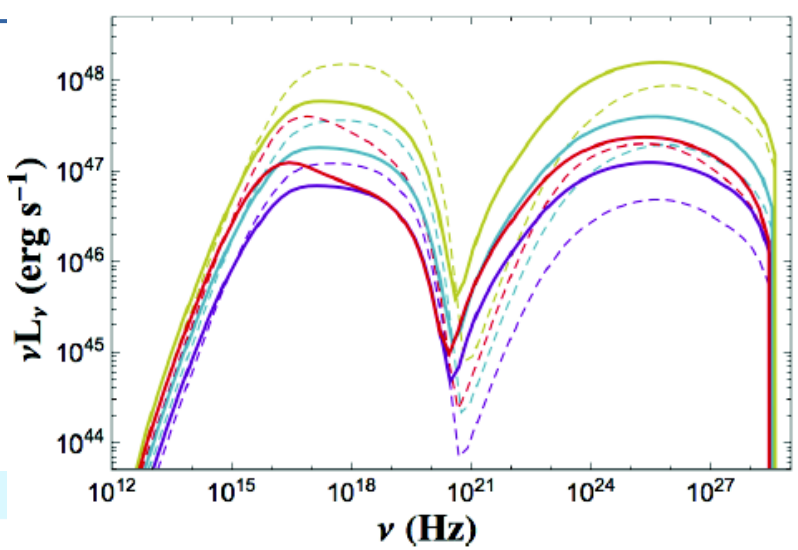


arXiv:1906.03297

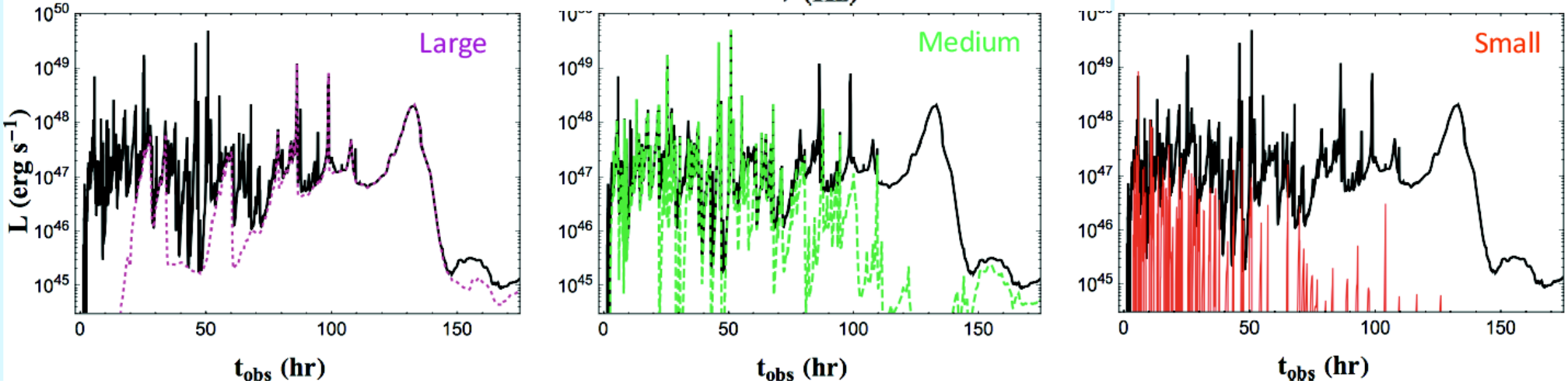
Christie GAD1C
PoS(ICRC2019)559

Relativistic reconnection

See:
DOI:10.1093/mnras/stw1832
DOI:10.1093/mnras/sty2636

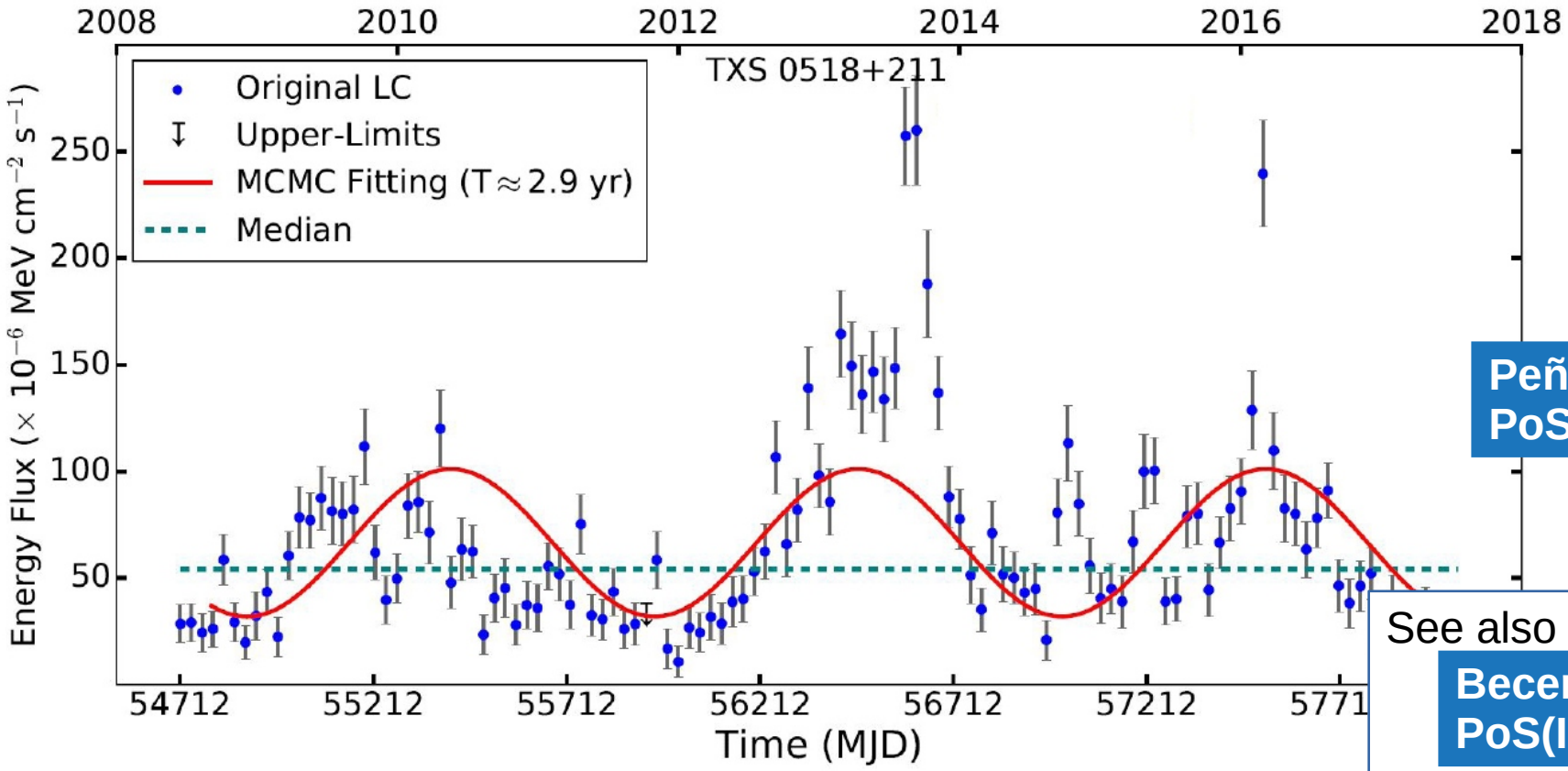


0.1 – 300 GeV Light Curve



AGN: periodicity

2276 AGNs from LAT dataset, >1 GeV, light curves with monthly binning
Automated analysis, require a 3σ positive in 3 independent tests: 23 candidates (prev. 5)



Peñil GAD1E
PoS(ICRC2019)591

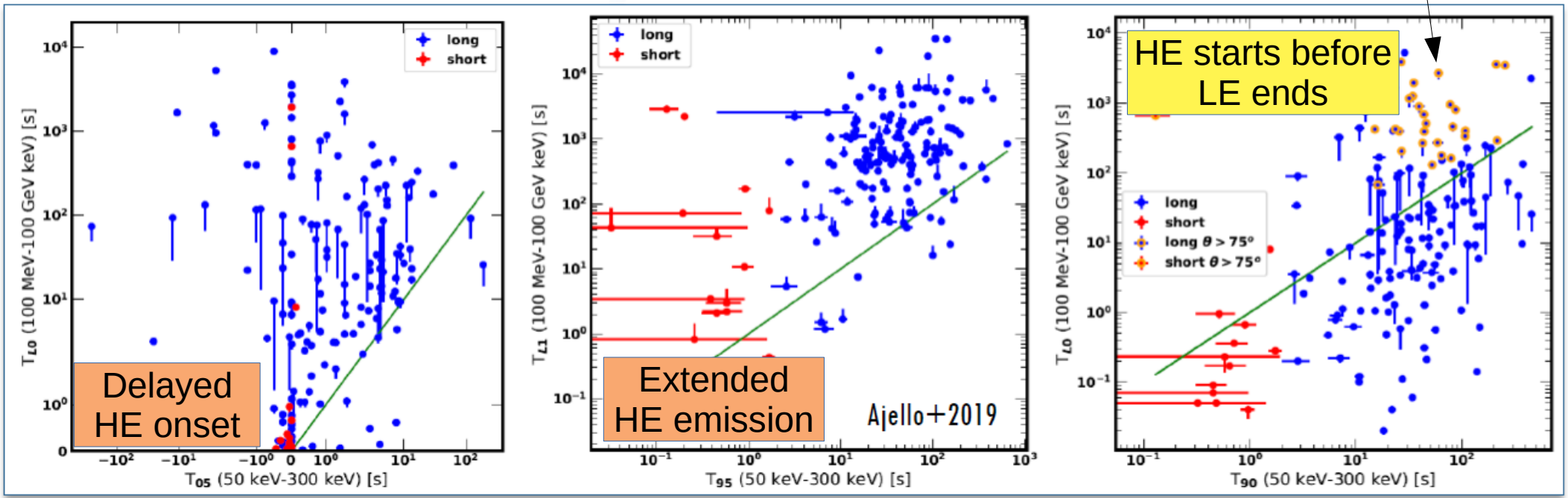
See also FSRQ PKS1510

Becerra G. GAD1A
PoS(ICRC2019)629

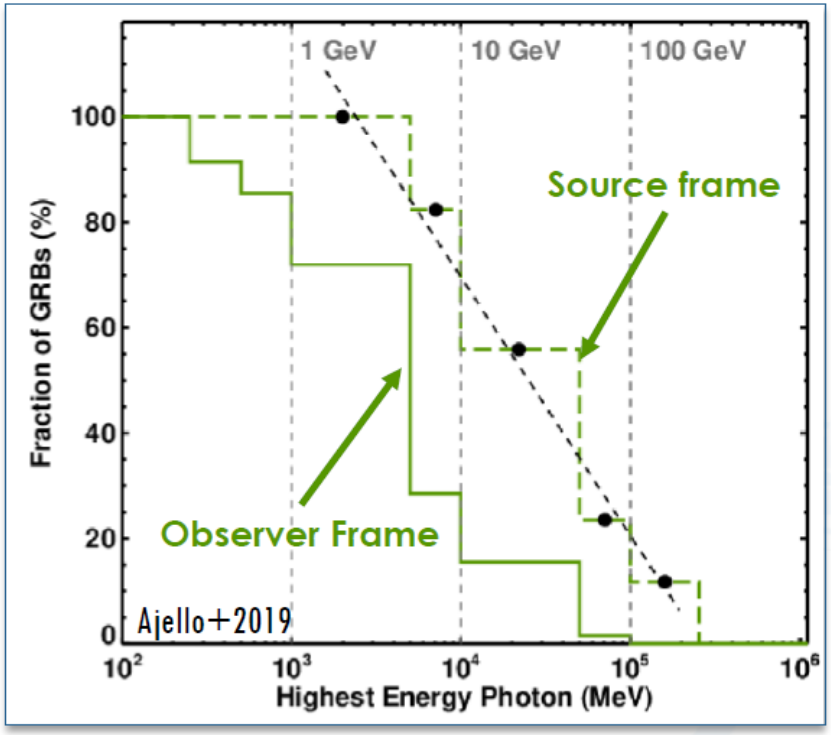
LAT GRBs: FLGC2

Second catalog, 186 GRBs (10% short, 34 with redshift)
Improved automated analysis pipeline
Paper (Ajello+, APJ 878, 52), FITS files available
Many many plots

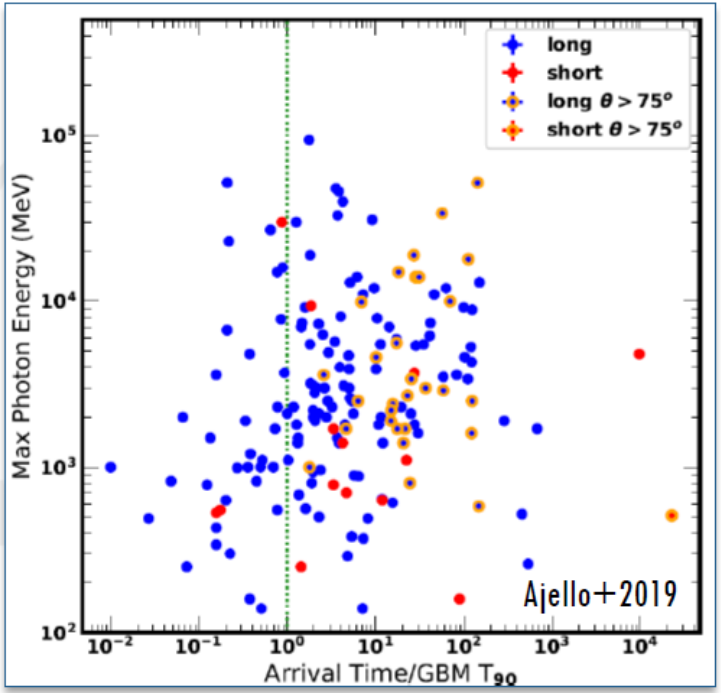
GRBs outside LAT FOV at t_{trig}



High E photons



- **<5%** of GRBs have **E > 50 GeV**
  - **Sharp drop @5 GeV (obs .frame)**
    - Record holder: **GRB 130427A**
      - **95 GeV @243 s**
      - **77 GeV @19s**
      - **34 GeV @34 ks**

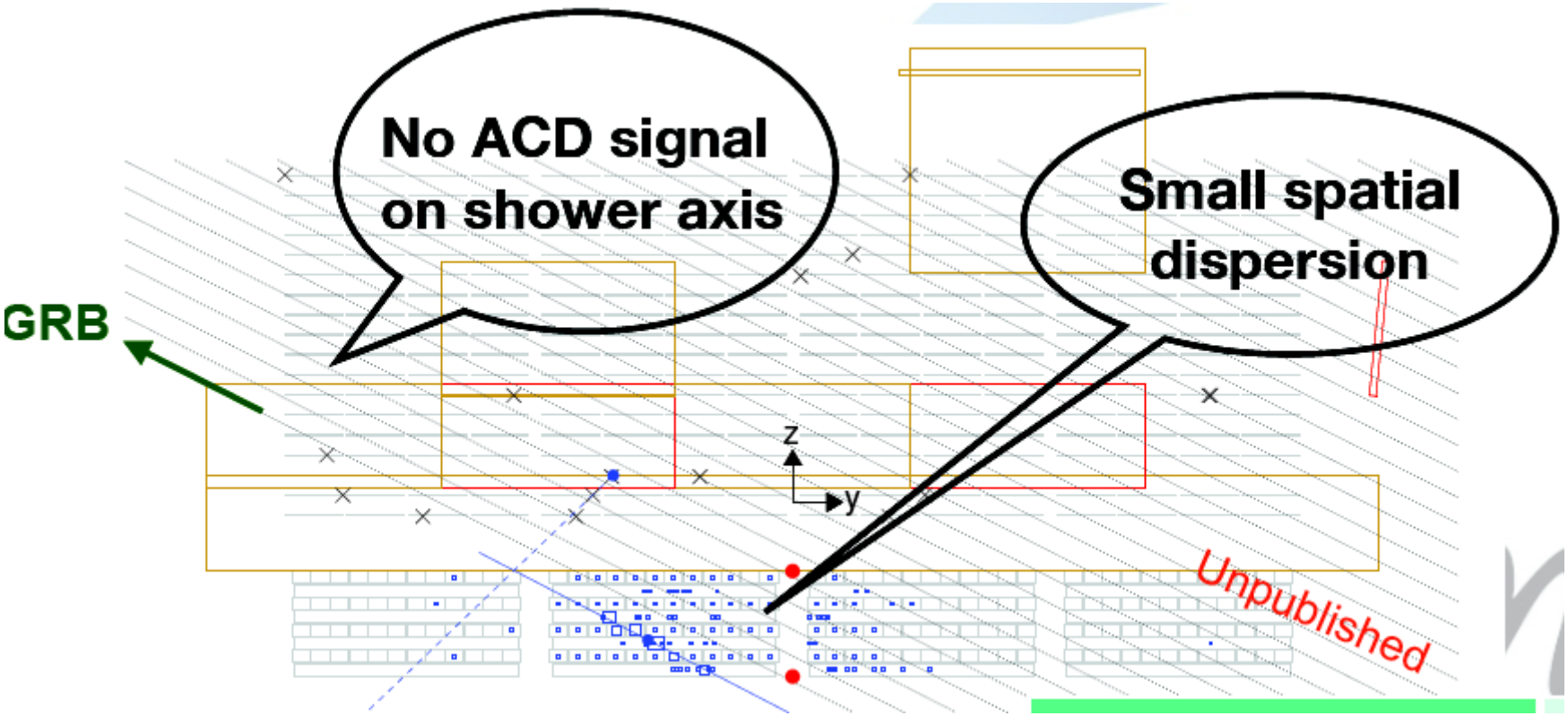


- HE photons often arrive **after** the LE emission is over
  - BUT: Highest energies can be produced either **very quickly** or **very late** ➔ challenge for the models!

Recovering additional photons

High energy photons (>10 GeV) challenging models
Recover events “missing” the tracker

Takahashi GAD1F
PoS(ICRC2019)606



CAL-Only GRB photons

Dedicated analysis to give good PSF and BKG rejection under hard circumstances
50% more statistics (50-300 GeV range), ~30x worse PSF (~2°)
Starting sample 24 GRBs → **4 new events >10 GeV**
GRB090926A

Observed energy (GRB-frame energy)	50 GeV (157 GeV)
Arrival time	T_0+424 s
Angular sep. (cf. PSF68%)	0.8° (1.7°)
BKG prob.	~0.02%

At odds with adiabatic evolution of external shocked medium:

- Photon energy is ~4 times higher than the synchrotron limit
- Inverse-Compton component?
- Energy injection from central engine at T>400s?

GRB polarization

POLAR on the CSS
Compton, 50 – 500 keV
55 SGRBs in ~6 months
5 selected for polarization analysis

POLAR2: ~2024

Smith GAD3E
PoS(ICRC2019)604

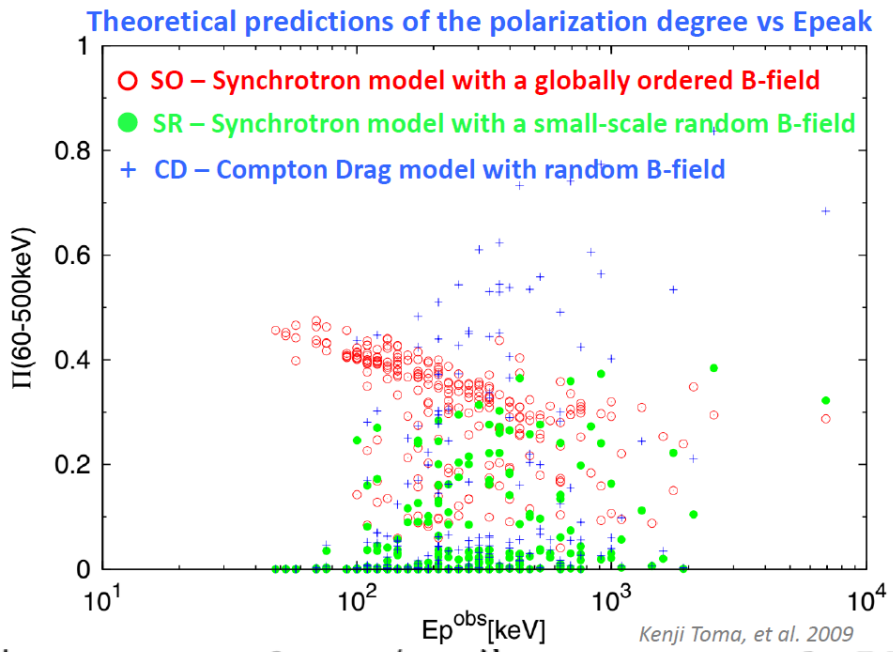
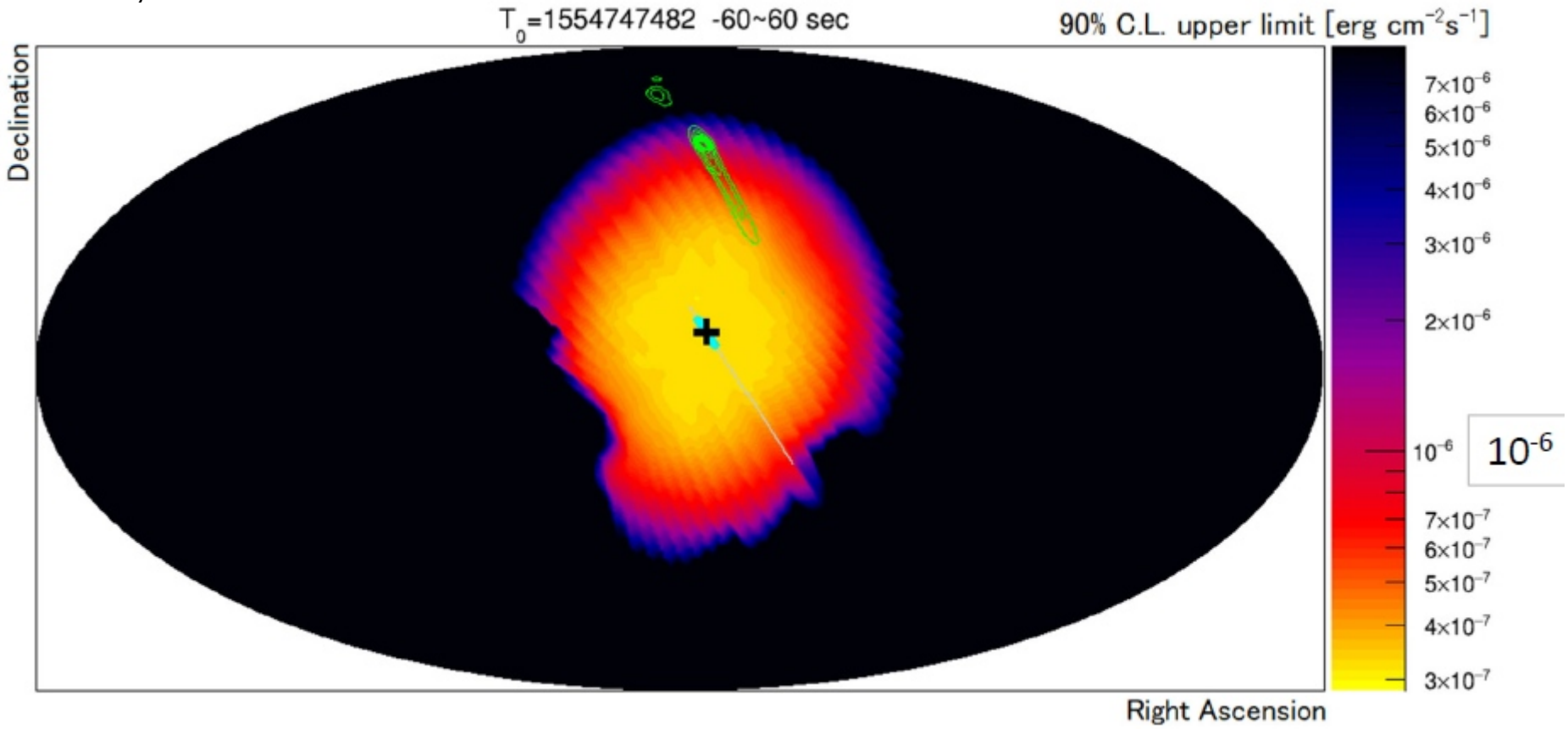


Table 1: Summary of the five GRBs selected (*in units of erg/cm^2 in 10-1000 keV)

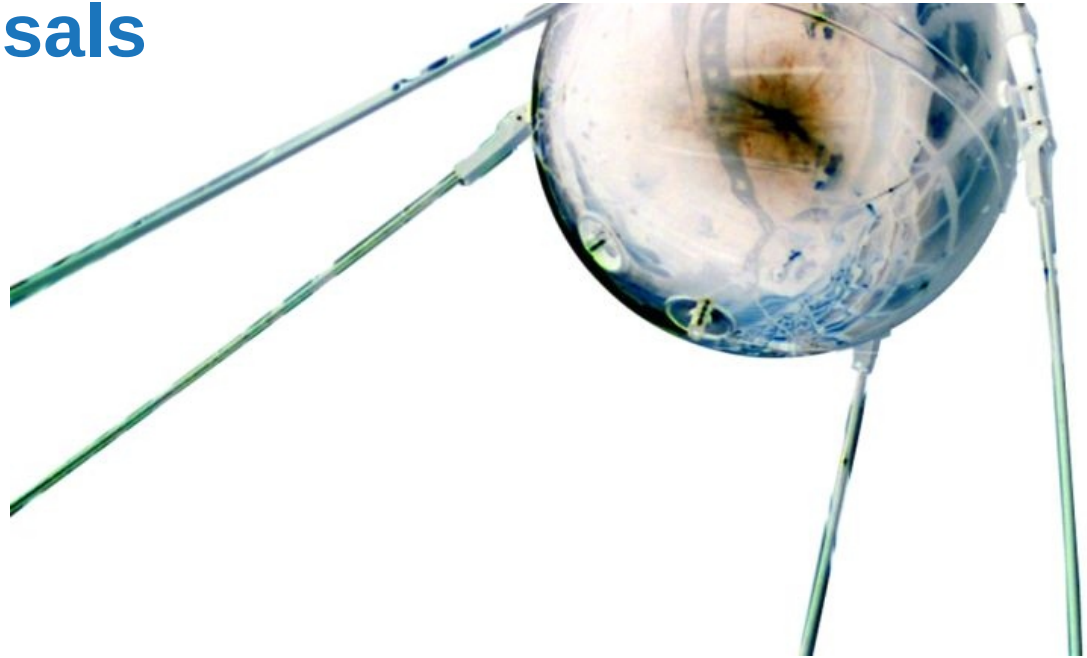
GRB	T90 (s)	Fluence*	PD	Prob(PD<2%)	PD_{up}(99%)	PA(deg.)	PA Change
161218A	6.76	1.25×10^{-5}	9%	9%	45%	40	No
170101A	2.82	1.27×10^{-5}	8%	13%	31%	164	No
170127C	0.21	7.4×10^{-6}	11%	5.8%	67%	38	Unknown
170206A	1.2	1.34×10^{-5}	10%	12%	31%	106	No
170114A	8.0	1.93×10^{-5}	4%	14%	28%	164	Yes
170114Ap1	N/A	N/A	15%	8%	43%	122	N/A
170114Ap2	N/A	N/A	41%	0.49%	74%	17	N/A

Mori GAD3C
PoS(ICRC2019)586

CALET on the ISS: GRB search for photon pairs
S190408an, 1 – 10 GeV

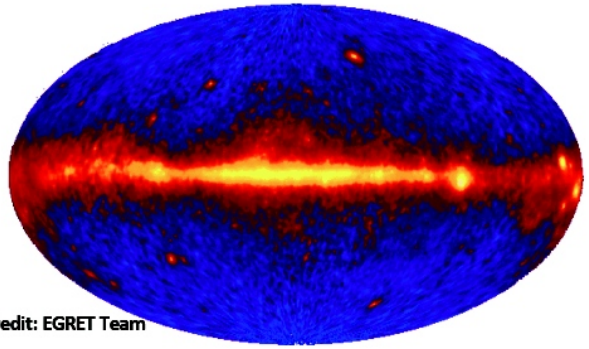


Instruments:
Updates & proposals



MeV observatories: AMEGO

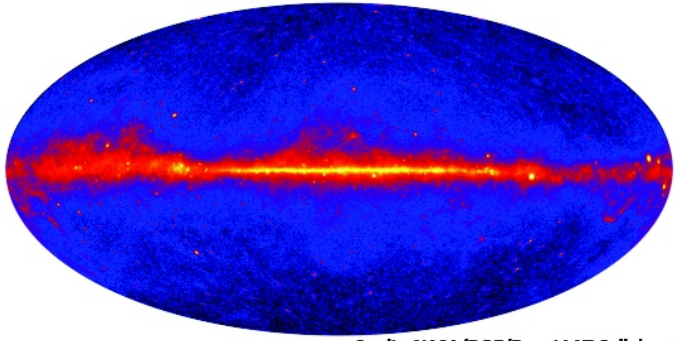
EGRET All-Sky Map Above 100 MeV



Credit: EGRET Team

~200 Sources Detected

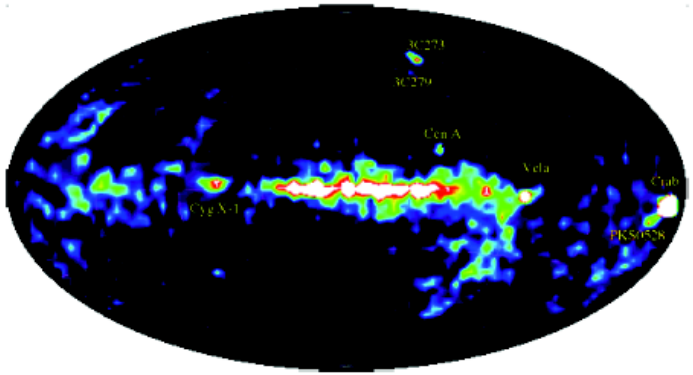
***Fermi*-LAT All-Sky Map Above 1 GeV**



Credit: NASA/DOE/Fermi LAT Collaboration

>5000 Sources Detected, 5 different catalogs

COMPTEL All-Sky Map 1 - 30 MeV



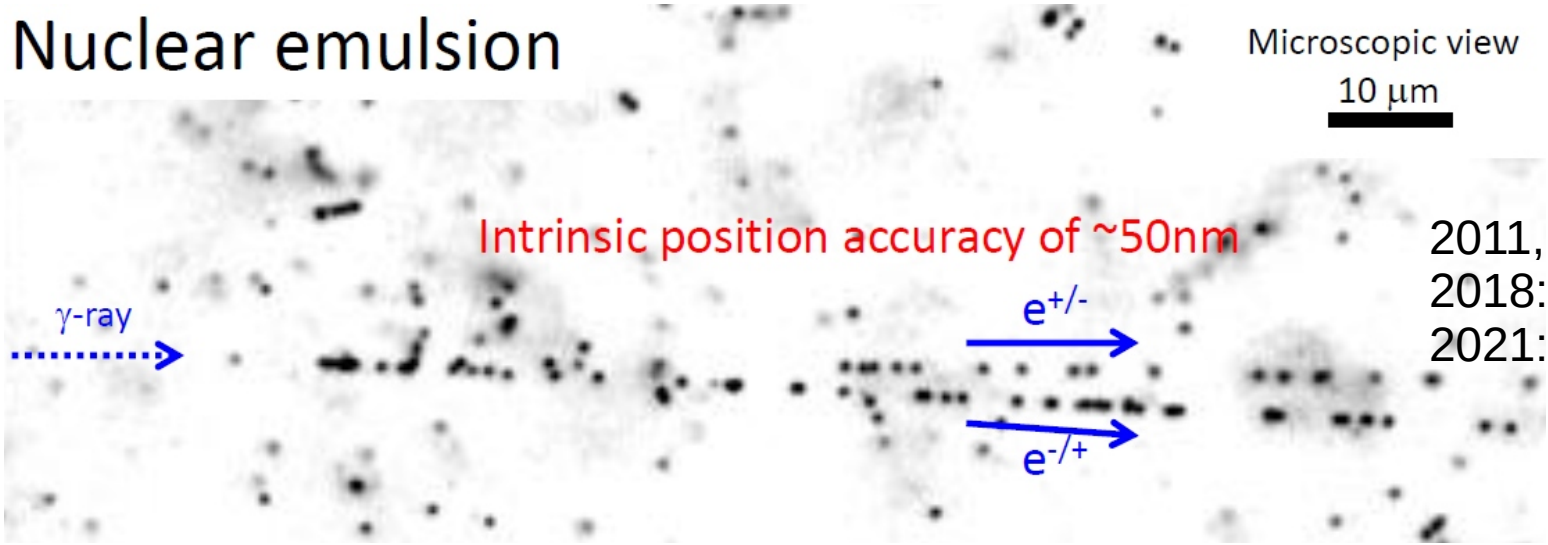
Credit: COMPTEL Collaboration

Tens of Sources Detected

We expect at least a similar progress as from EGRET to Fermi-LAT

Moiseev GAD3B
PoS(ICRC2019)583

Emulsion telescope: GRAINE



Takahashi GAD3D PoS(ICRC2019)607

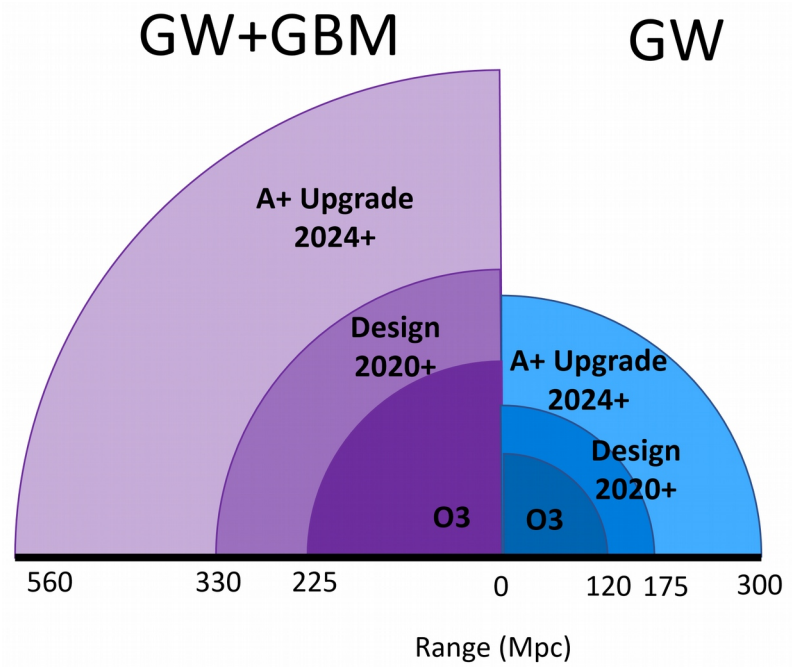
2011, 2015, 2018 balloon flights
2018: 0.39 m^2 (Vela, ongoing)
2021: 10 m^2 (+gal. center)

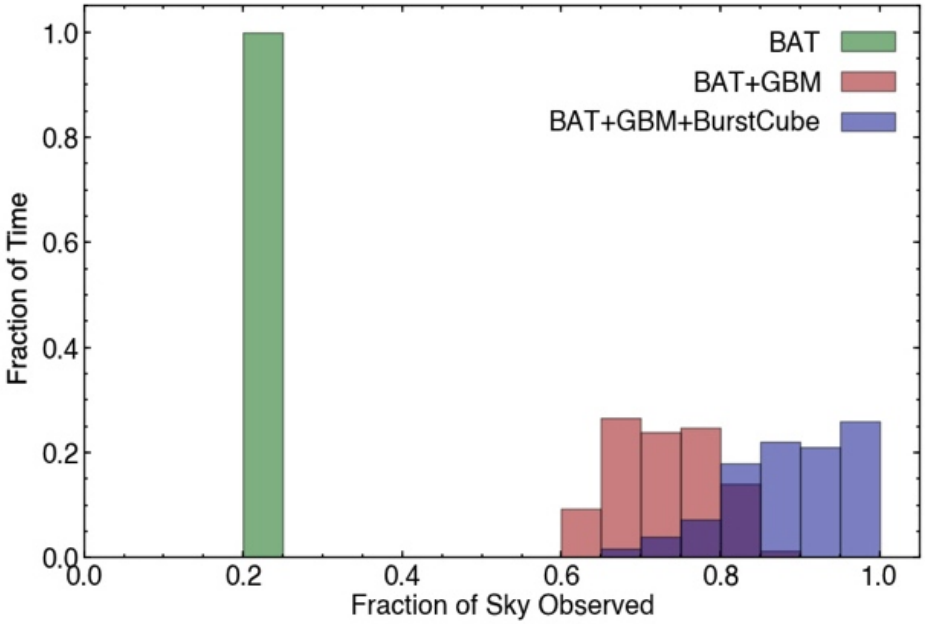
	Fermi LAT		GRAINE
Angular resolution @100MeV	6.0deg (105mrad)	x1/6 →	1.0deg (17mrad)
@1GeV	0.90deg (16mrad)	x1/9 →	0.1deg (1.7mrad)
Energy range	20MeV – 300GeV		10MeV – 100GeV
Polarization sensitivity	---		Yes

BurstCUBE

6U cubesat (6 liters)
Covers 50 keV – 1 MeV
Expected ~20 SGRB/y
Deployment ~2021

Smith GAD3E
PoS(ICRC2019)604





Conclusion

As said in the beginning...

A set of **excellent instruments**:

- Impressively precise measurements
- More and more extensive coverage of the sky
- Several results in **tension** with current models (DSA, SSC, …)

On the other hand:

- Often very **low statistics**, esp. > 1 GeV (growing linearly with time)
- Many tantalizing **hints** of further features, discrepancies…
- The **need for MWL** is paramount, “blind” regions in the spectrum are so frustrating

Thank you for your attention!