Testing for a "Crab-like" Emission Tail above 10 GeV from the Vela Pulsar and PSR B1706-44 using combined H.E.S.S. & Fermi-LAT data

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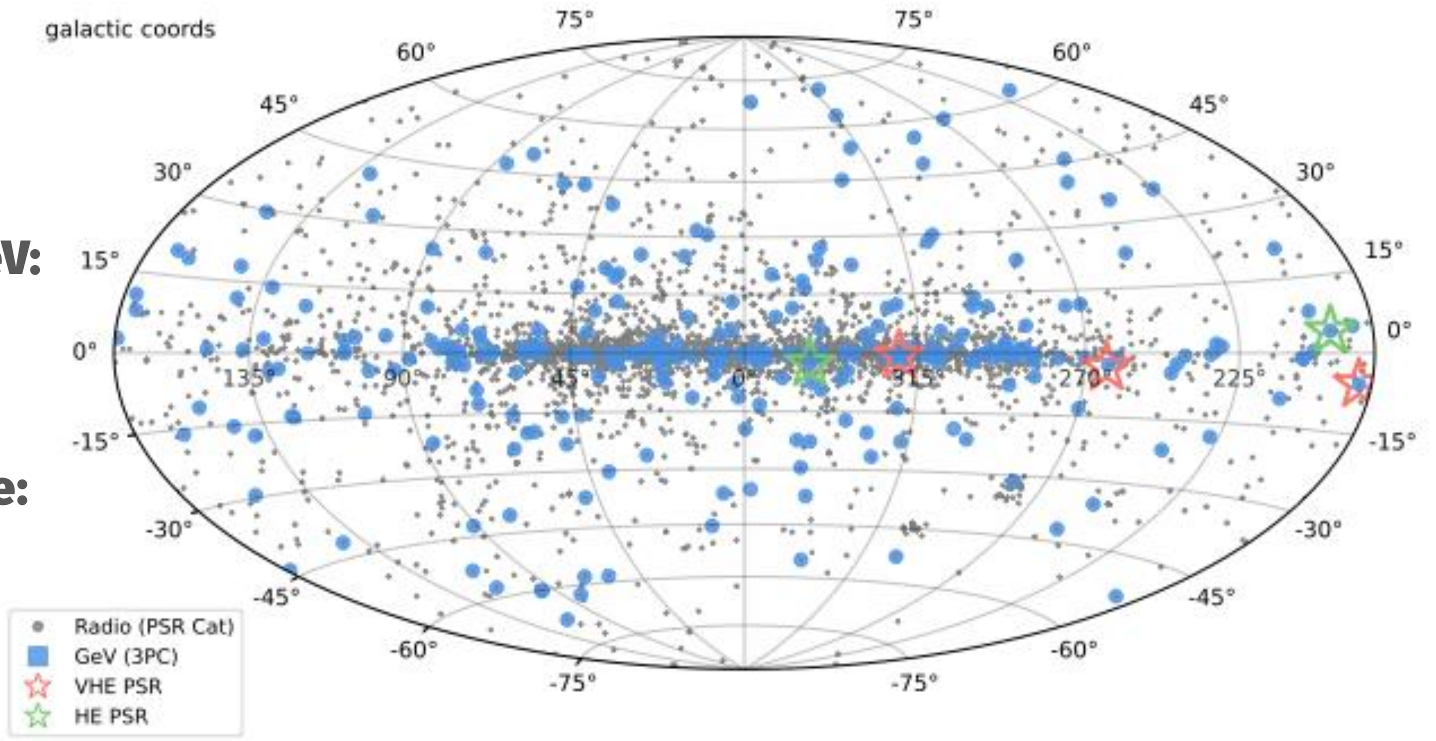
On behalf of the H.E.S.S. collaboration

Context: Pulsars in Gamma-ray



5 pulsars detected by IACTs

2 in the high energy range only < 100 GeV:
- **PSR B1706-44**
- **Geminga**

2 in the high and very-high energy range:
- **Crab (up to 1.5 TeV)**
- **Vela (beyond 20 TeV)**
- **PSR J1509-5850**

HE pulsars:
- **We detect the tail of the GeV emission as seen in Fermi-LAT data.**

VHE pulsars:
- **It's another story ...**

Crab pulsar: Veritas 2011

Detection of a signal in the up to 400 GeV

SED → First case of discrepancy with power-law exponentially cutoff as seen by Fermi-LAT

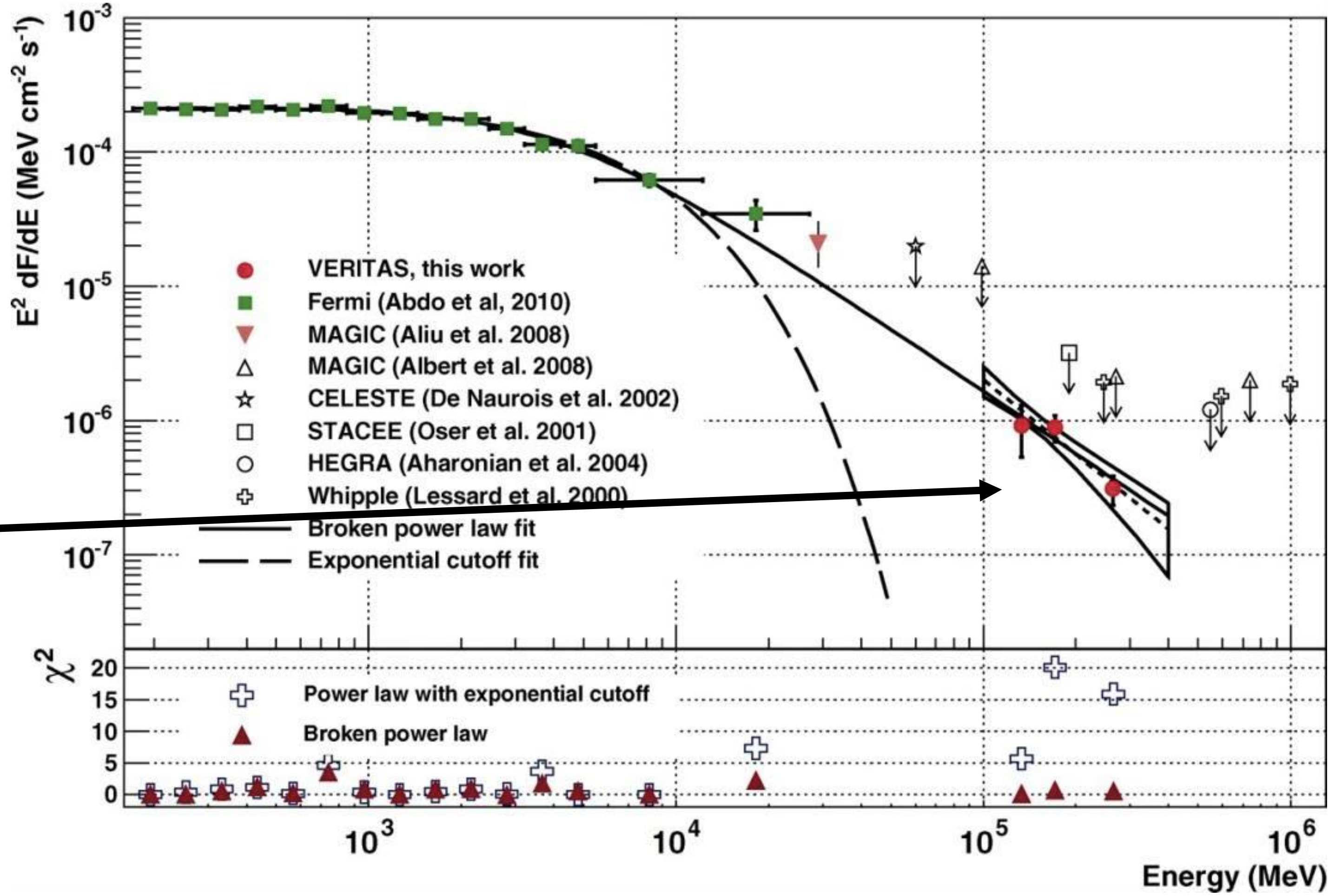


Figure 2 from [Aliu et al., 2011]

Crab pulsar: MAGIC 2016

Confirmed by MAGIC: detection of signal up to ~ 1 TeV

« Traditional » Curvature Radiation scenarii seriously challenged !

Is it the same emission component ?

What about other pulsars :
Is the high energy end of the gamma-ray pulsars' emission a power-law tail?

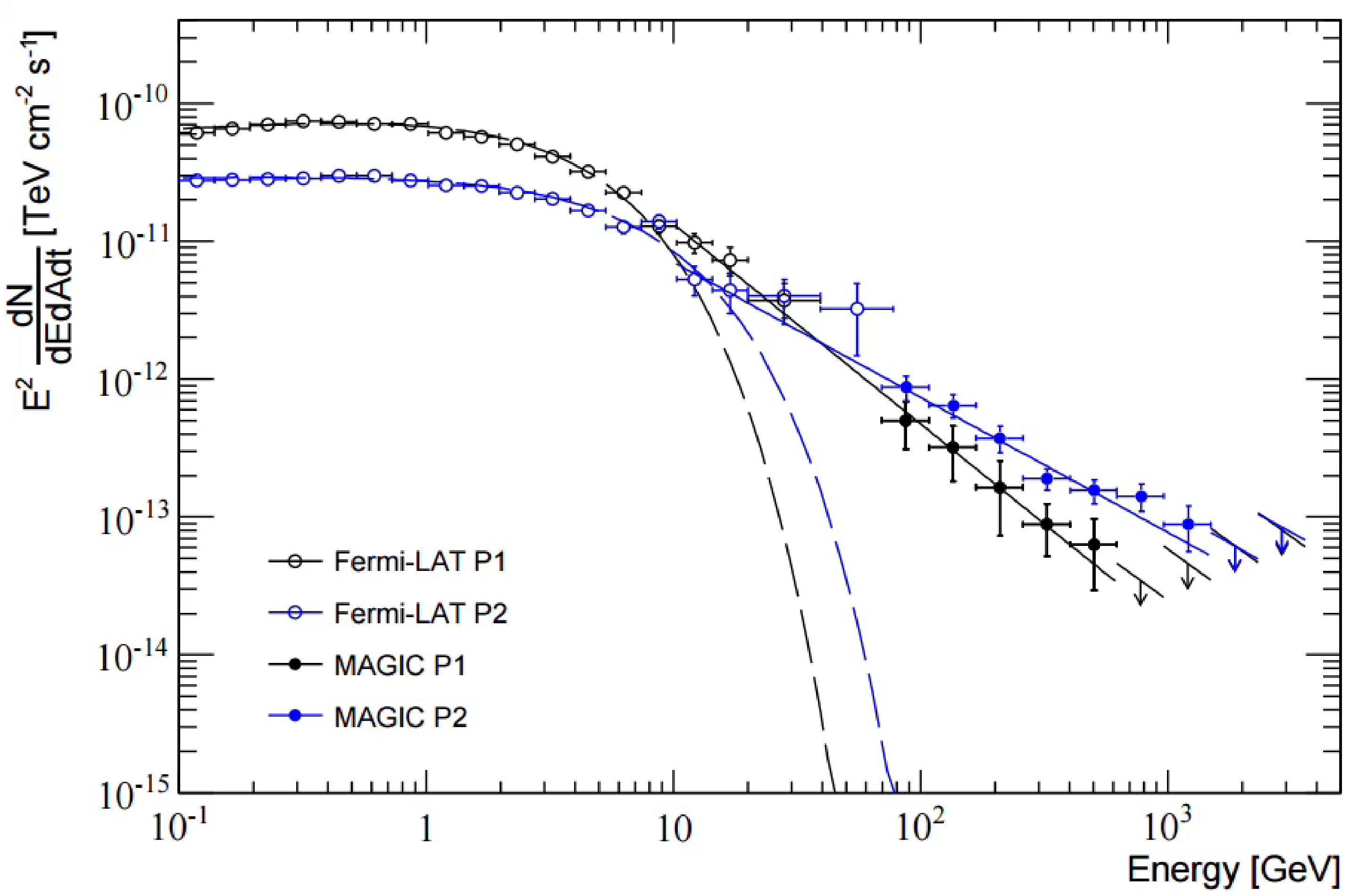


Figure 4 from [Ansoldi et al. 2016]

Vela pulsar: H.E.S.S. 2018

Detection of pulsation from the Vela pulsar by H.E.S.S. up to ~100 GeV

Propose to use a likelihood ration between a power-law and a log-parabola to probe curvature

3.3 σ in favour of a LPB in Fermi-LAT data

Not enough statistics to fit a log-parabola but …

… 3 σ in index deviation between two set of cuts in H.E.S.S. Mono data

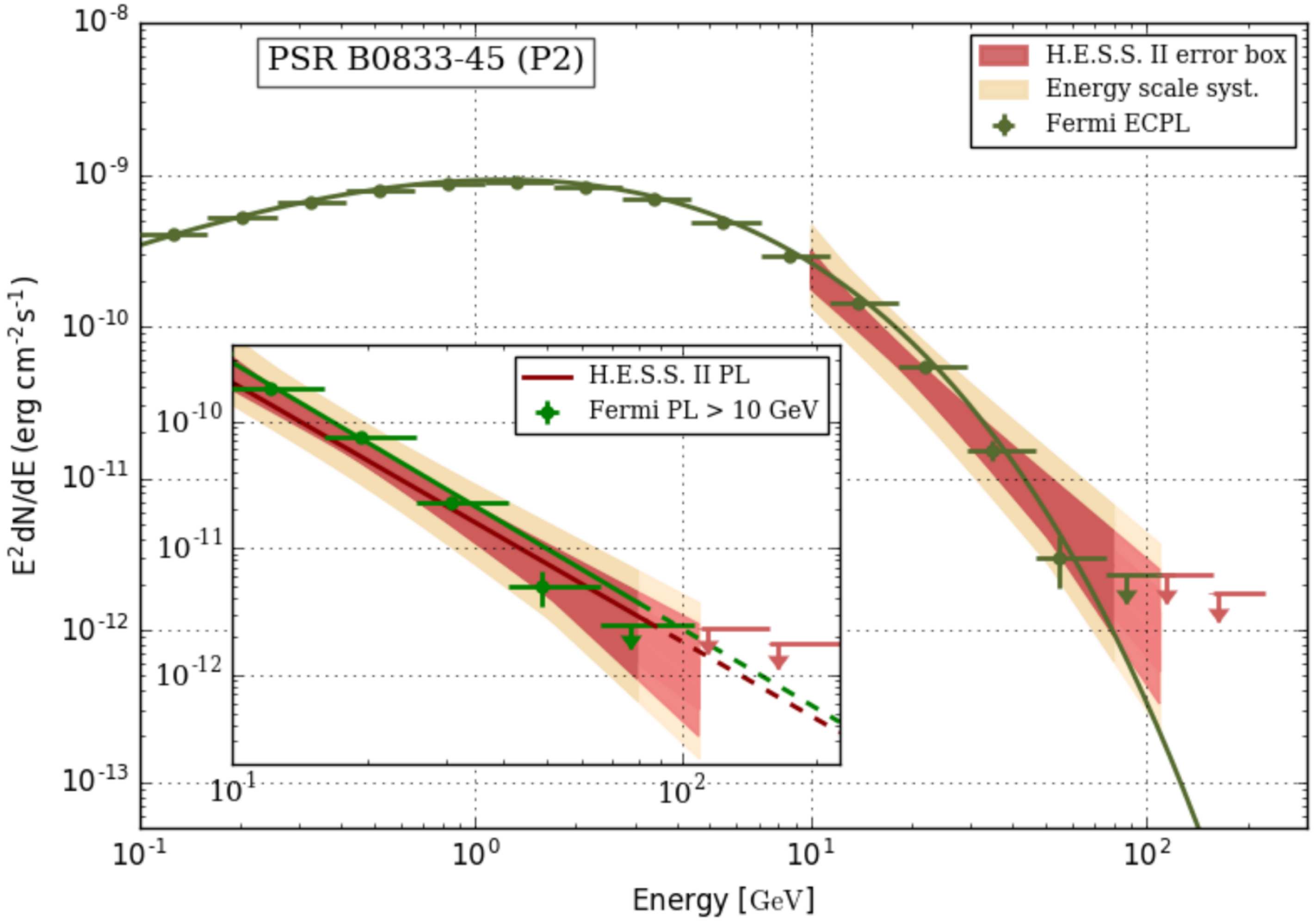


Figure 5 from [Abdalla, H. et al., 2018]

PSR B1706-44: H.E.S.S. 2019

Detection of PSR B1706-44 in the HE range by H.E.S.S.

Not enough stats to fit a log-parabola.

Power-law index harder than for Vela.

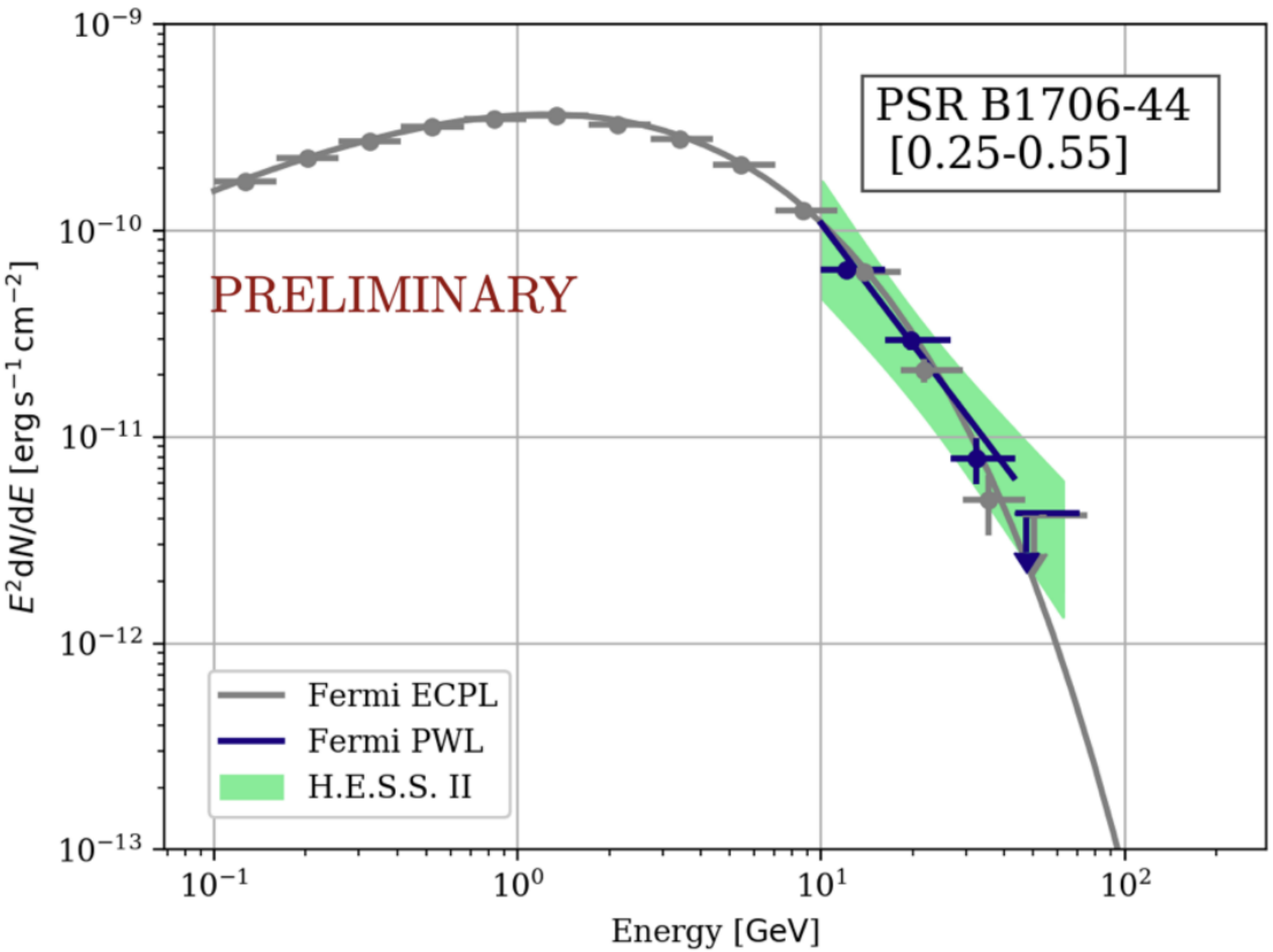


Figure 2 from [Spir-Jacob, M., et al. 2019]

Vela pulsar: H.E.S.S. 2023

Detection of pulsation from the Vela pulsar by H.E.S.S. beyond 20 TeV

TeV emission is interpreted as Inverse Compton scattering.

Reinforce classical Curvature/Synchrotron radiation models

But the question of the GeV tail shape is still open !

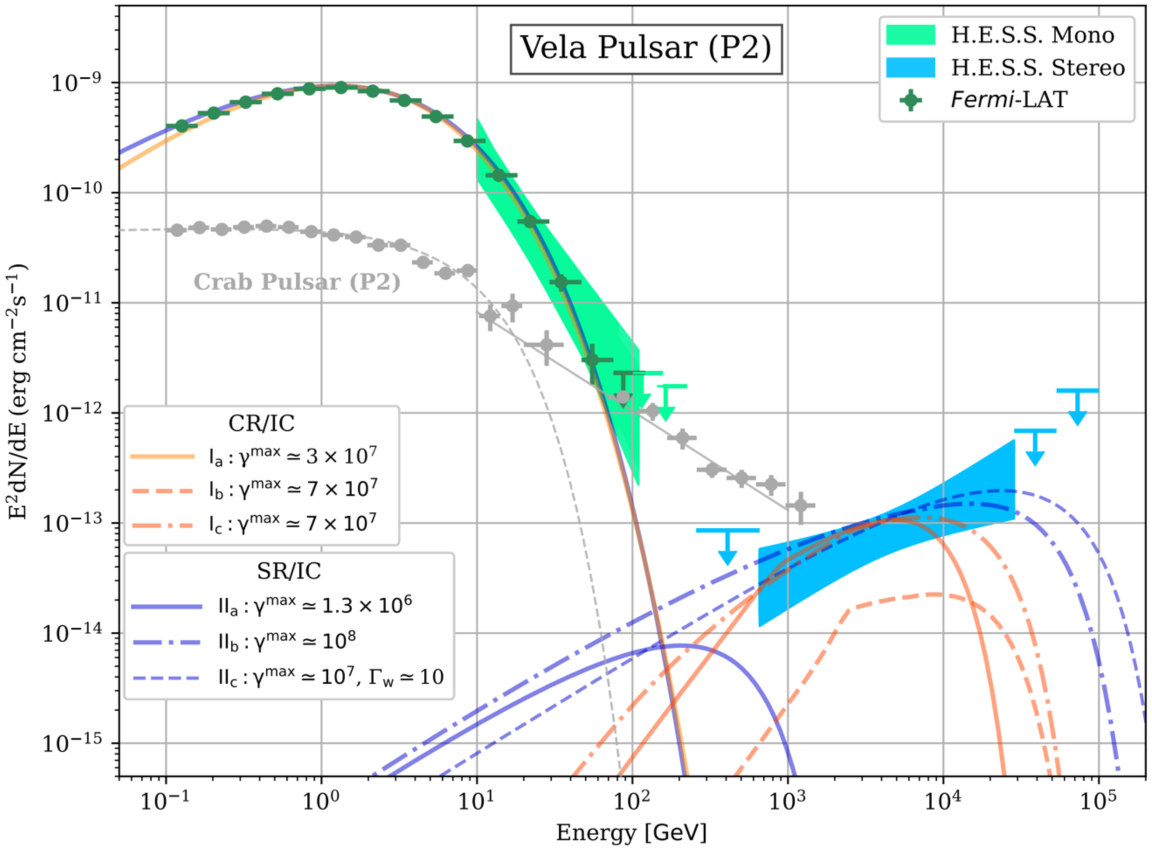


Figure 3 from [Aharonian, F., et al. 2023]

Two different pulsars at TeV

Crab pulsar

A power-law tail that extend from GeV to ~ 1 TeV

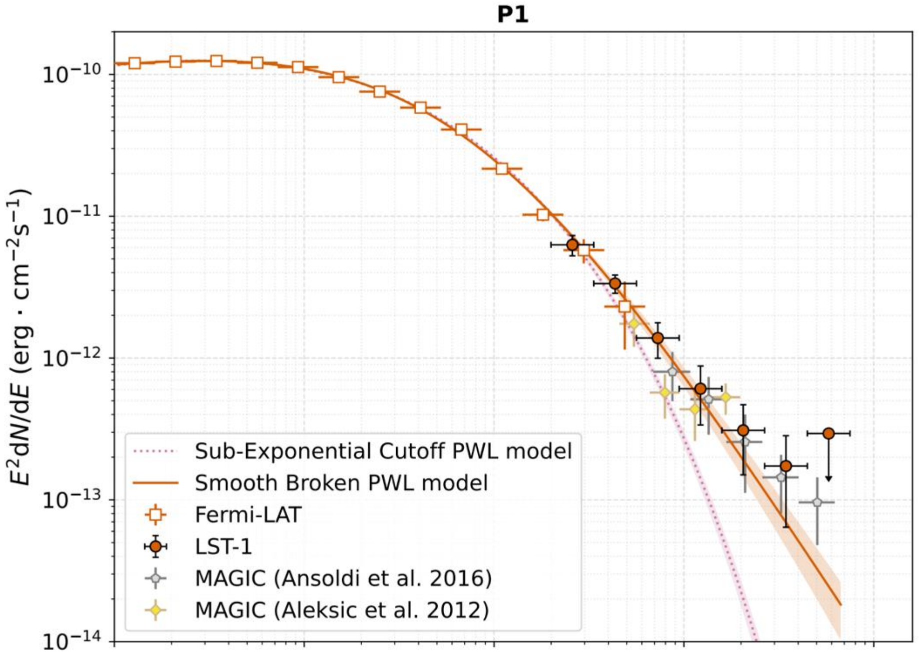


Figure 8 from [Abe, K., et al. 2024]

Vela pulsar

A second component, distinct from the GeV one

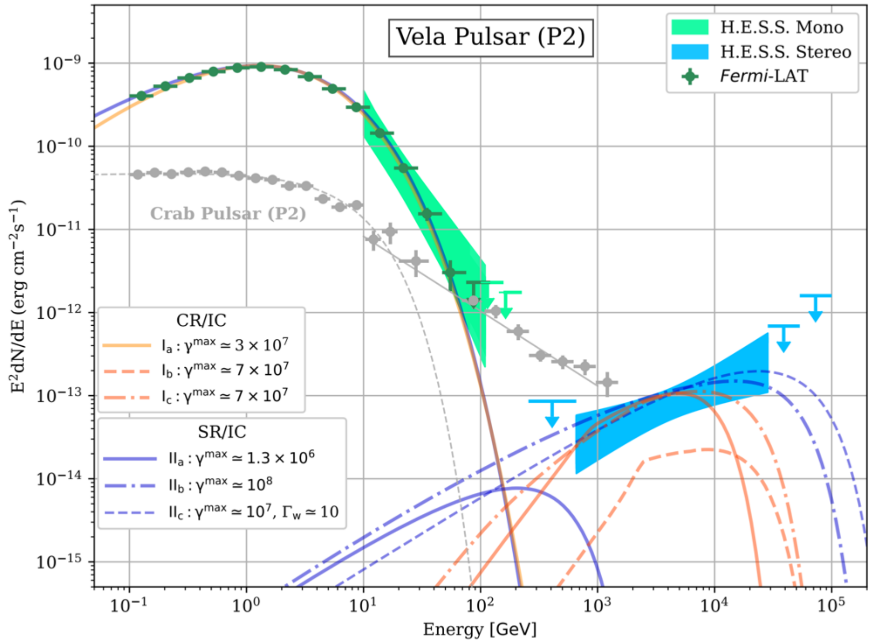


Figure 3 from [Aharonian, F., et al. 2023]

Curvature or Power-law ?

Question:

- Is the GeV tail of pulsars a power-law or not ?
- Is there curvature in the GeV tail of pulsars ?

Important to understand pulsars' emission mecanisms.

Two main radiation scenarii:
- Synchrotron Radiation (SR)
- (Synchro-) Curvature Radiation (CR)

Usually these two radiation mecanisms fit properly Fermi-LAT data

If there is curvature → Reinforce such models

Crab is an exception:
- More complex models are needed
- What are the consequences on potential Inverse Compton emission

Curvature study: An unfinished business

Vela Mono paper [1] **:**
- **3.3 σ in favour of a log-parabola in Fermi-LAT data**
- **Not enough statistics to fit a log-parabola but …**
- **… 3 σ in index deviation between two set of cuts in H.E.S.S. Mono data**

PSR B1706-44 [2] **:**
- **Not enough stats to fit a log-parabola.**
- **Power-law index harder than for Vela.**

Why we think that we can unveil curvature now ?
- **Fermi-LAT data grow with time → More statistics now !**
- **Gammapy** [3] **→ Joint analysis between Fermi-LAT and H.E.S.S.**

1 : [H.E.S.S. Collaboration, Abdalla, H., Aharonian, F., et al. 2018, AA, 620, A66]
2 : [Spir-Jacob, M., Djannati-Ataï, A., Mohrmann, L., et al. 2019]
3 : [Donath, A., Terrier, R., Remy, Q., et al. 2023, Astronomy & Astrophysics, 678, A157]

Analysis method

What we want to do ?

- **Determine wether there is curvature or not in the tail of the GeV bump of pulsars**

How to do it ?

- **Perform a likelihood ratio between a power-law and a log-parabola above different energy thresholds through a joint analysis of Fermi-LAT and H.E.S.S. Mono data**
- **First energy threshold is defined as 10 GeV → begining of the Crab power-law tail**
- **Increase this energy threshold as far as the statistics allow it → 15 GeV, 20 GeV, etc.**

However

- **We are not trying to prove that a log-parabola better described the data in this energy range.**
- **We are using this model because it is the simplest model to describe curvature.**
- **Power-law and Log-parabola are nested models → assessment of statistics is straight forward.**

Vela: Datasets

H.E.S.S.

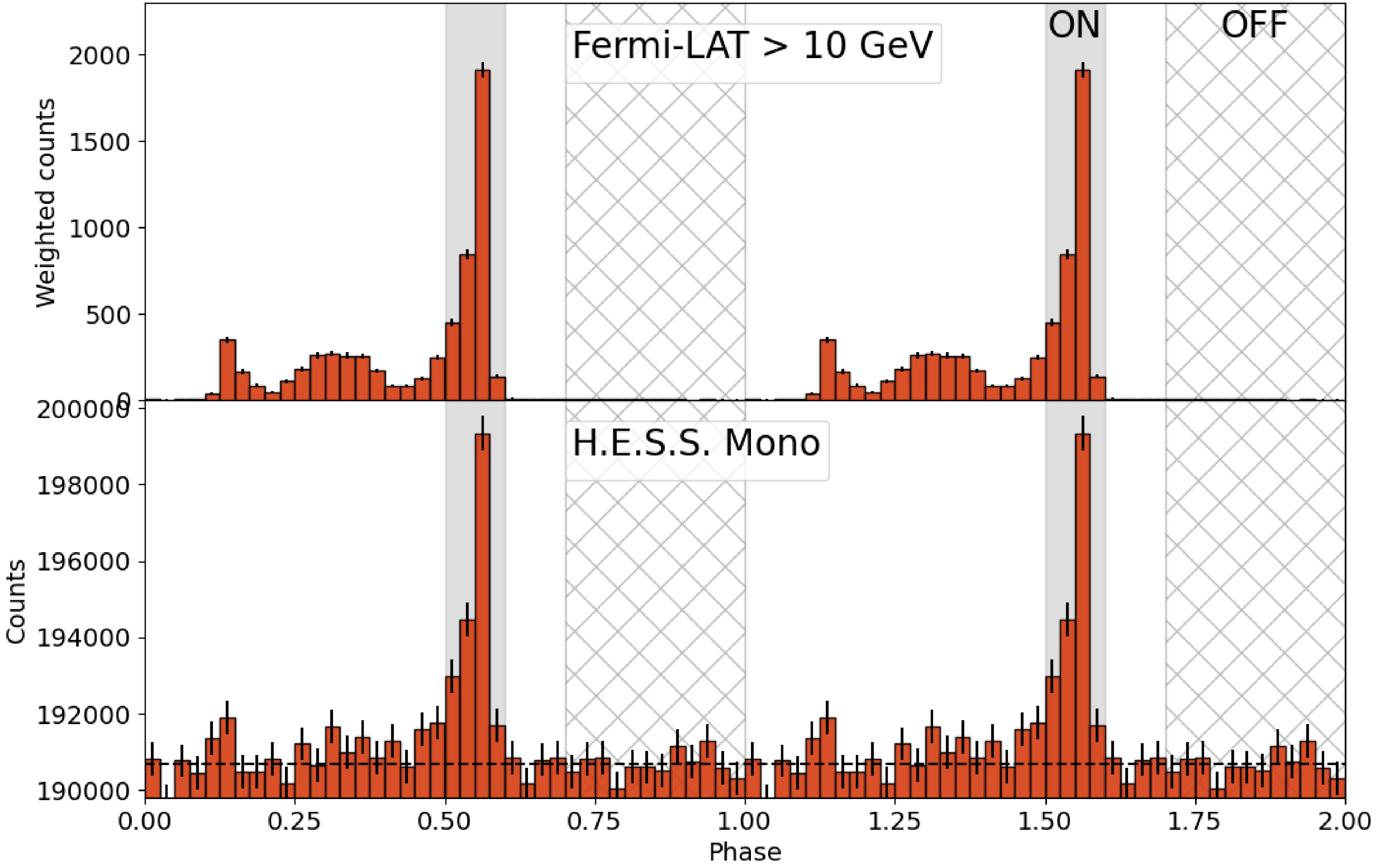
- **Vela Mono paper [1] dataset**
- **40.6 h of livetime**

Fermi-LAT

- **3PC [4] FITS file**
- **12 years of data**

1 : [H.E.S.S. Collaboration, Abdalla, H., Aharonian, F., et al. 2018, AA, 620, A66]
4 : [Smith, D. A., Abdollahi, S., Ajello, M., et al. 2023, The Astrophysical Journal, 958, 191]

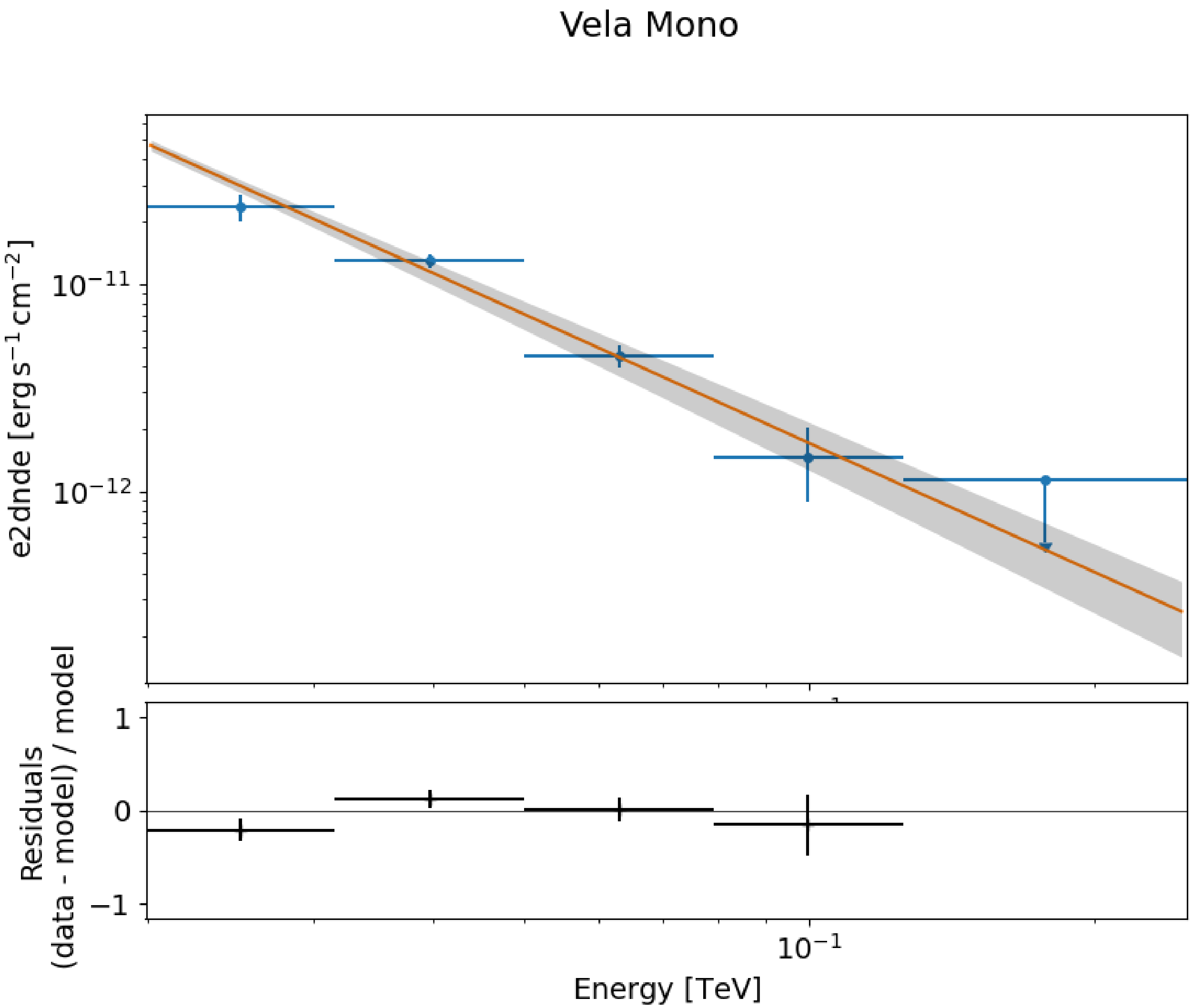
Vela: Phasograms



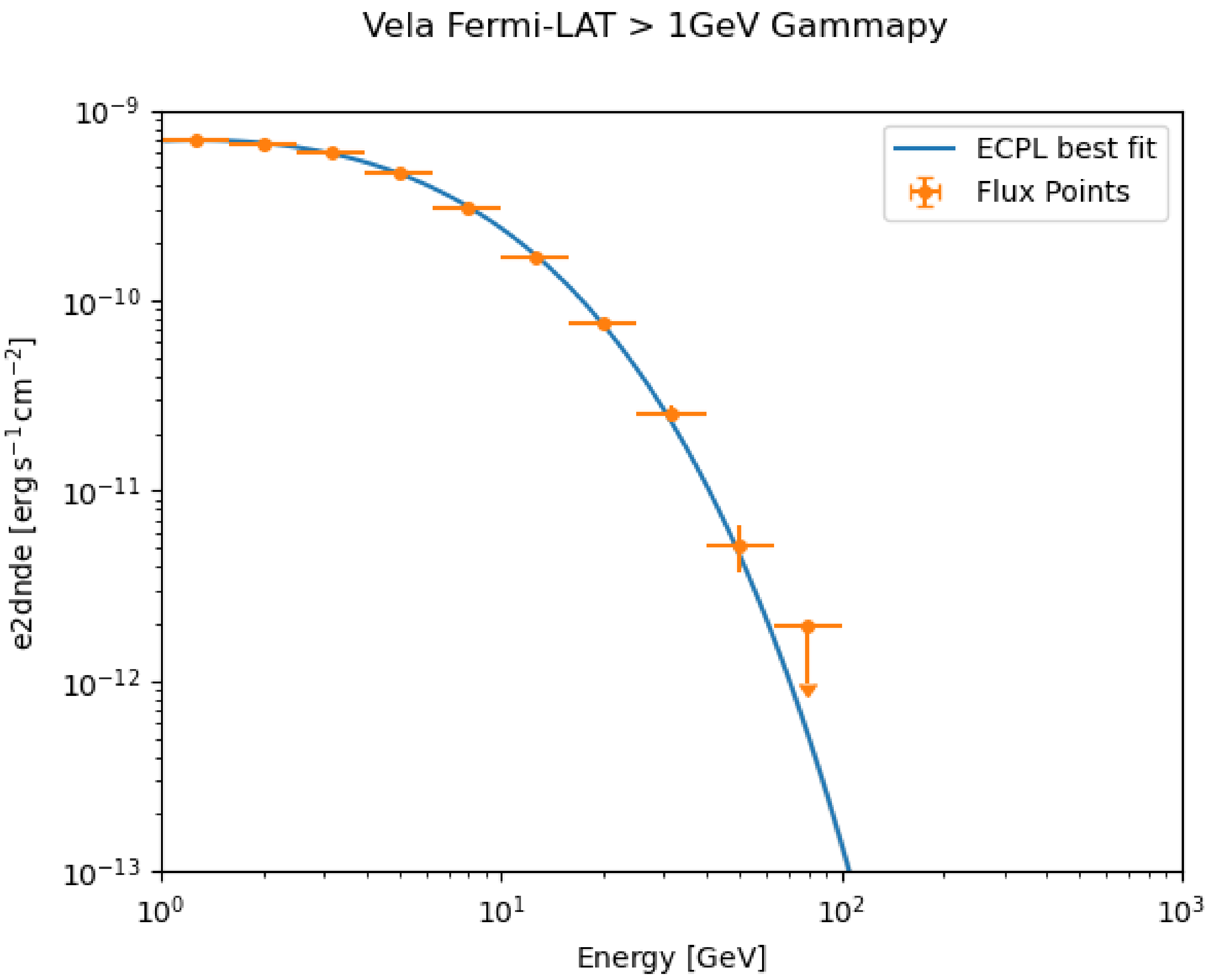
Vela: H.E.S.S. Spectrum

Power-law fit:

$\phi(25\ GeV) = 3.0 \times 10^{-8} \pm 0.2\ TeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 4.1\ \pm 0.2$



Vela: Fermi-LAT

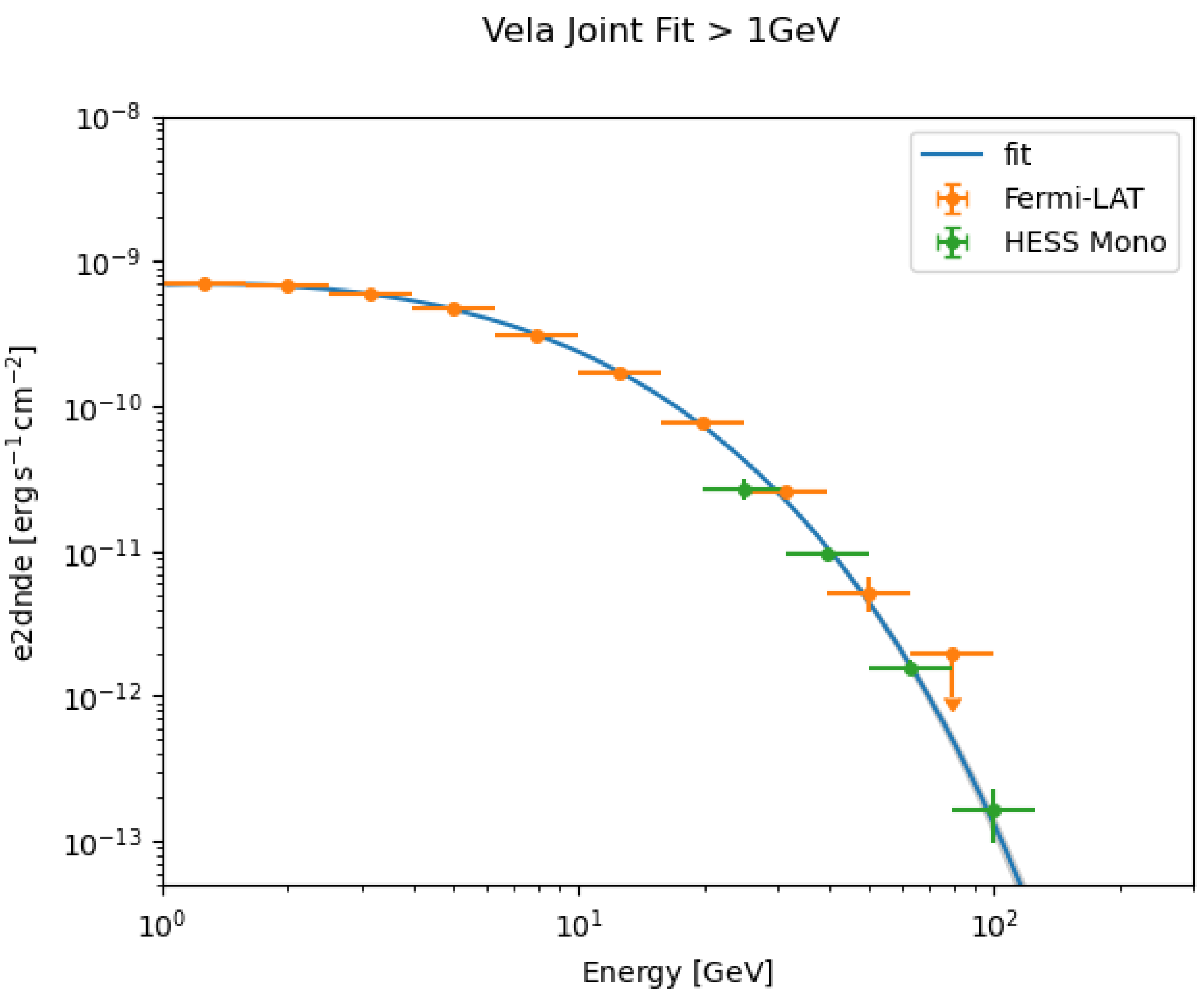


Power-law with exponential cutoff:

$$\phi(E) = \phi_0 \cdot \left(\frac{E}{E_0}\right)^{-\Gamma} \exp(-(\lambda E)^{\alpha})$$

$\phi(1.8\ GeV)$
$= 6.2 \times 10^{-10} \pm 0.8\ MeV^{-1} s^{-1} cm^{-2}$
$\Gamma = 1.3 \ \pm 0.04$
$\lambda = 1.2 \times 10^{-3} \pm 0.2\ MeV^{-1}$
$\alpha = 5.2 \times 10^{-1} \ \pm 0.2$

Vela: Fermi-LAT – H.E.S.S. Joint-fit

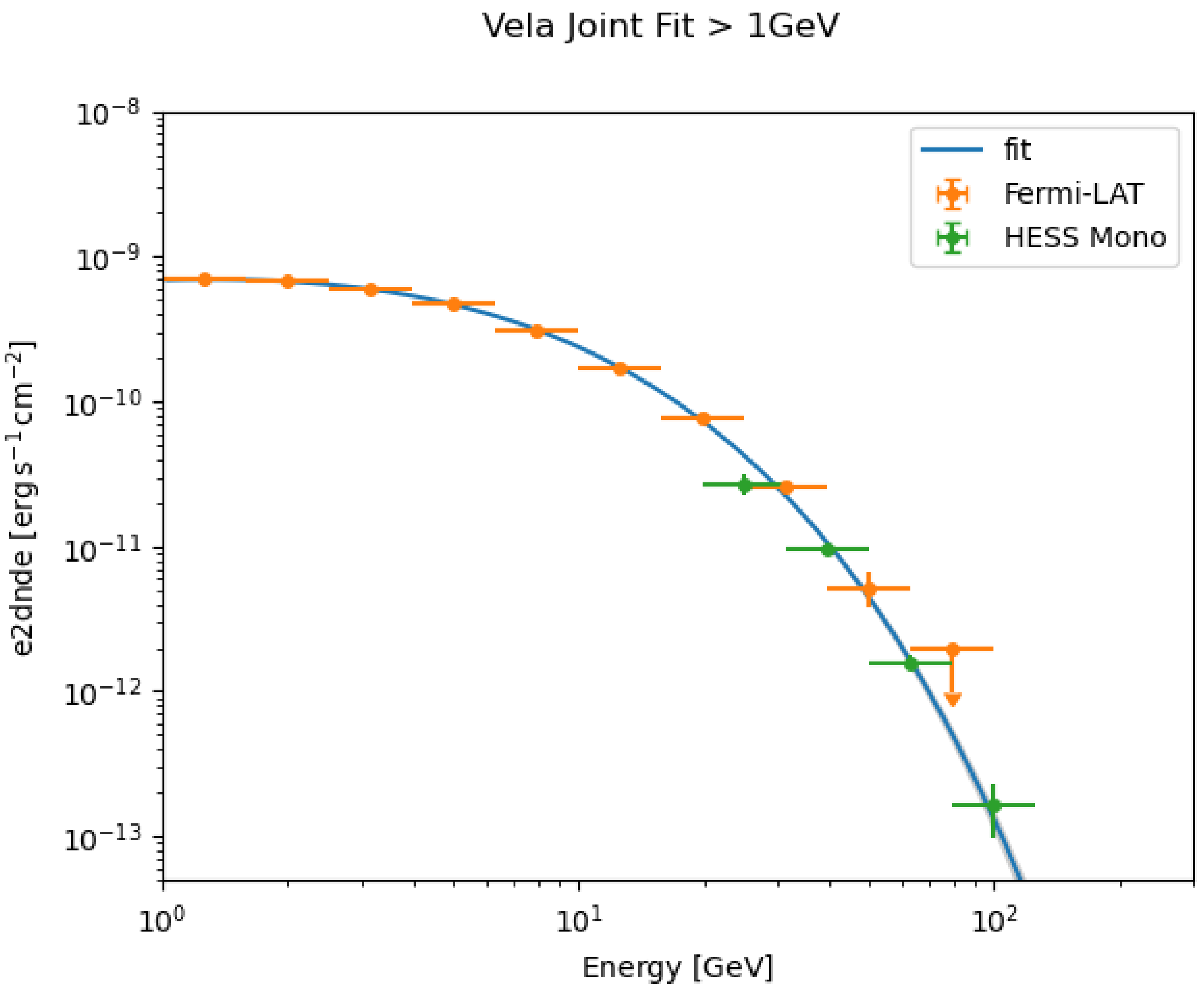


Power-law with exponential cutoff:

$$\phi(E) = \phi_0 \cdot \left(\frac{E}{E_0}\right)^{-\Gamma} \exp(-(\lambda E)^{\alpha})$$

$\phi(1.8\ GeV)$
$= 5.2 \times 10^{-10} \pm 0.6\ MeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 1.4\ \pm 0.04$
$\lambda = 9.2 \times 10^{-4} \pm 1.5\ MeV^{-1}$
$\alpha = 5.6 \times 10^{-1}\ \pm 0.2$

Vela: Fermi-LAT – H.E.S.S. Joint-fit



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$\lambda = 9.2 \times 10^{-4} \pm 1.5\ MeV^{-1}$
$\alpha = 5.2 \times 10^{-1}\ \pm 0.2$

Fermi-LAT only:

$\phi(1.8\ GeV)$
$= 6.2 \times 10^{-10} \pm 0.8\ MeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 1.3\ \pm 0.04$
$\lambda = 1.2 \times 10^{-3} \pm 0.2\ MeV^{-1}$
$\alpha = 5.2 \times 10^{-1}\ \pm 0.2$

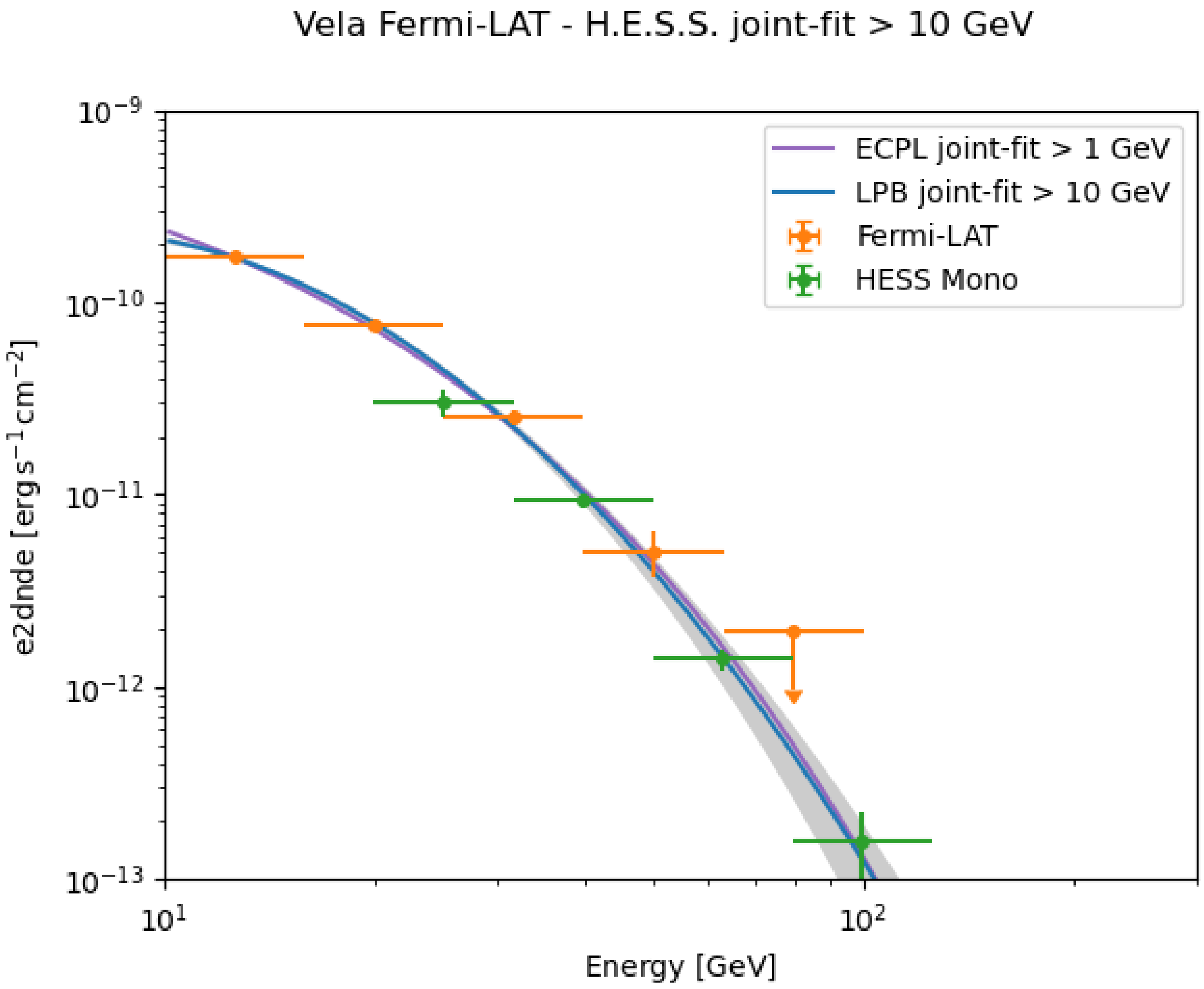
Vela: Curvature study

Log-parabola:

$$\phi(E) = \phi_0 \left(\frac{E}{E_0}\right)^{-\alpha-\beta\cdot log\left(\frac{E}{E_0}\right)}$$

$\phi(20\ GeV) = 1.2 \times 10^{-7} \pm 0.06\ TeV^{-1}s^{-1}cm^{-2}$
$\alpha = 4.2\ \pm 0.08$
$\beta = 1.1\ \pm 0.2$

Likelihood ratio:
7.3 σ in favour of the Log-parabola



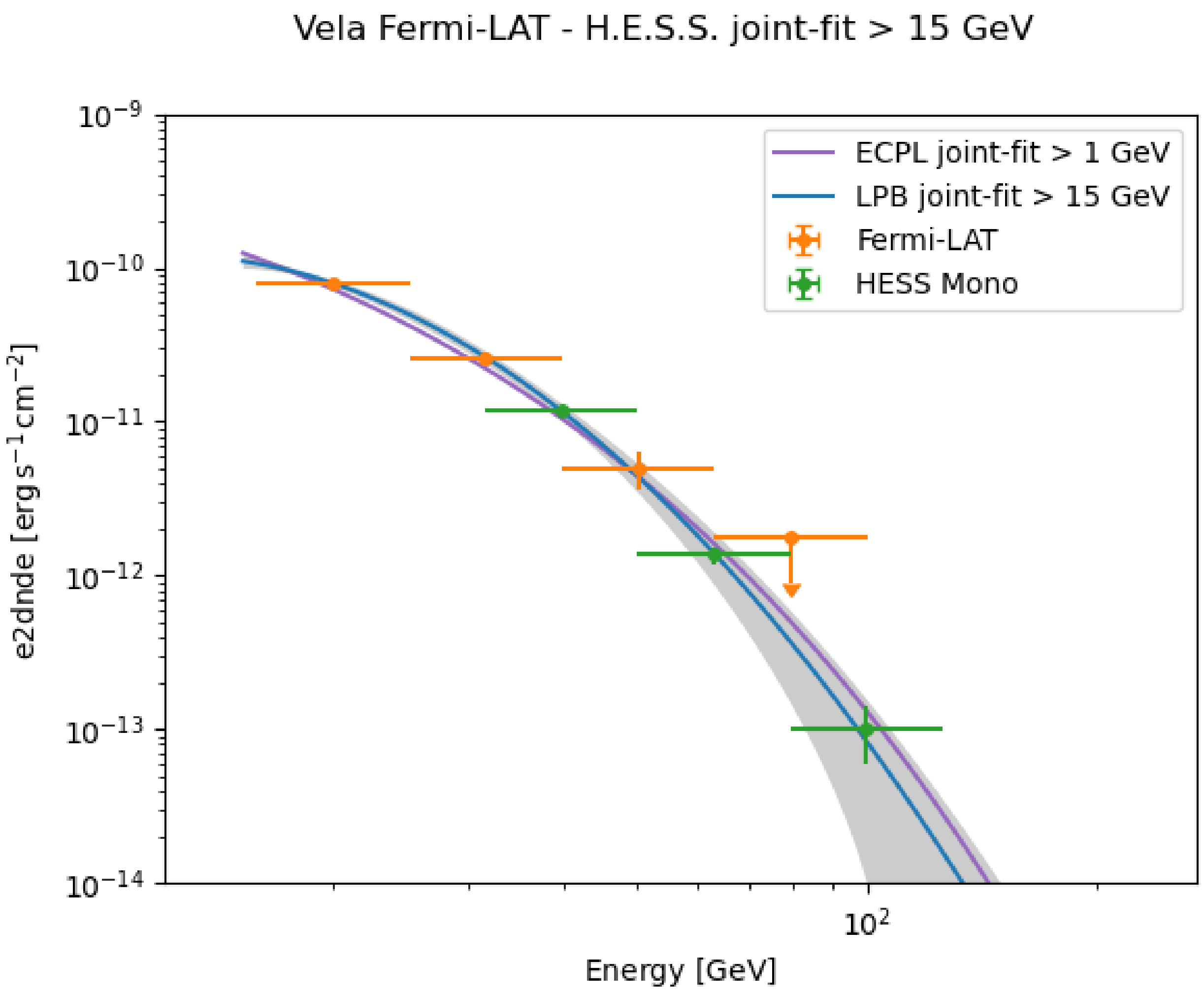
Vela: Curvature study

Log-parabola:

$$\phi(E) = \phi_0 \left(\frac{E}{E_0}\right)^{-\alpha-\beta\cdot log\left(\frac{E}{E_0}\right)}$$

$\phi(20\ GeV) = 1.2 \times 10^{-7} \pm 0.06\ TeV^{-1}s^{-1}cm^{-2}$
$\alpha = 3.7\ \pm 0.3$
$\beta = 1.6\ \pm 0.5$

Likelihood ratio:
5.7 σ in favour of the Log-parabola



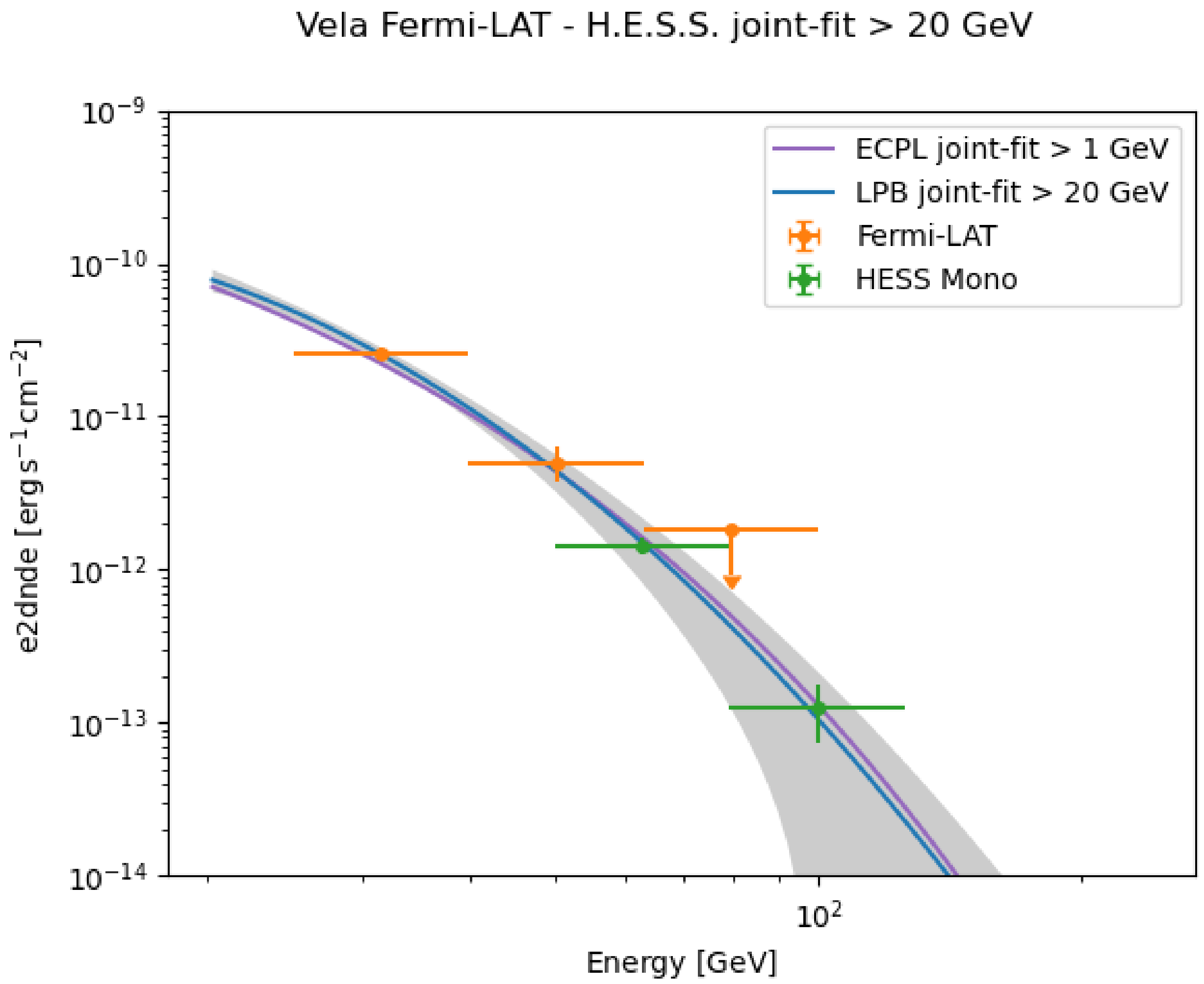
Vela: Curvature study

Log-parabola:

$$\phi(E) = \phi_0 \left(\frac{E}{E_0}\right)^{-\alpha-\beta\cdot log\left(\frac{E}{E_0}\right)}$$

$\phi(20\ GeV) = 2.0 \times 10^{-7} \pm 0.02\ TeV^{-1}s^{-1}cm^{-2}$
$\alpha = 5\ \pm 0.4$
$\beta = 1.4\ \pm 0.6$

Likelihood ratio:
3.1 σ in favour of the Log-parabola



Vela: Curvature study

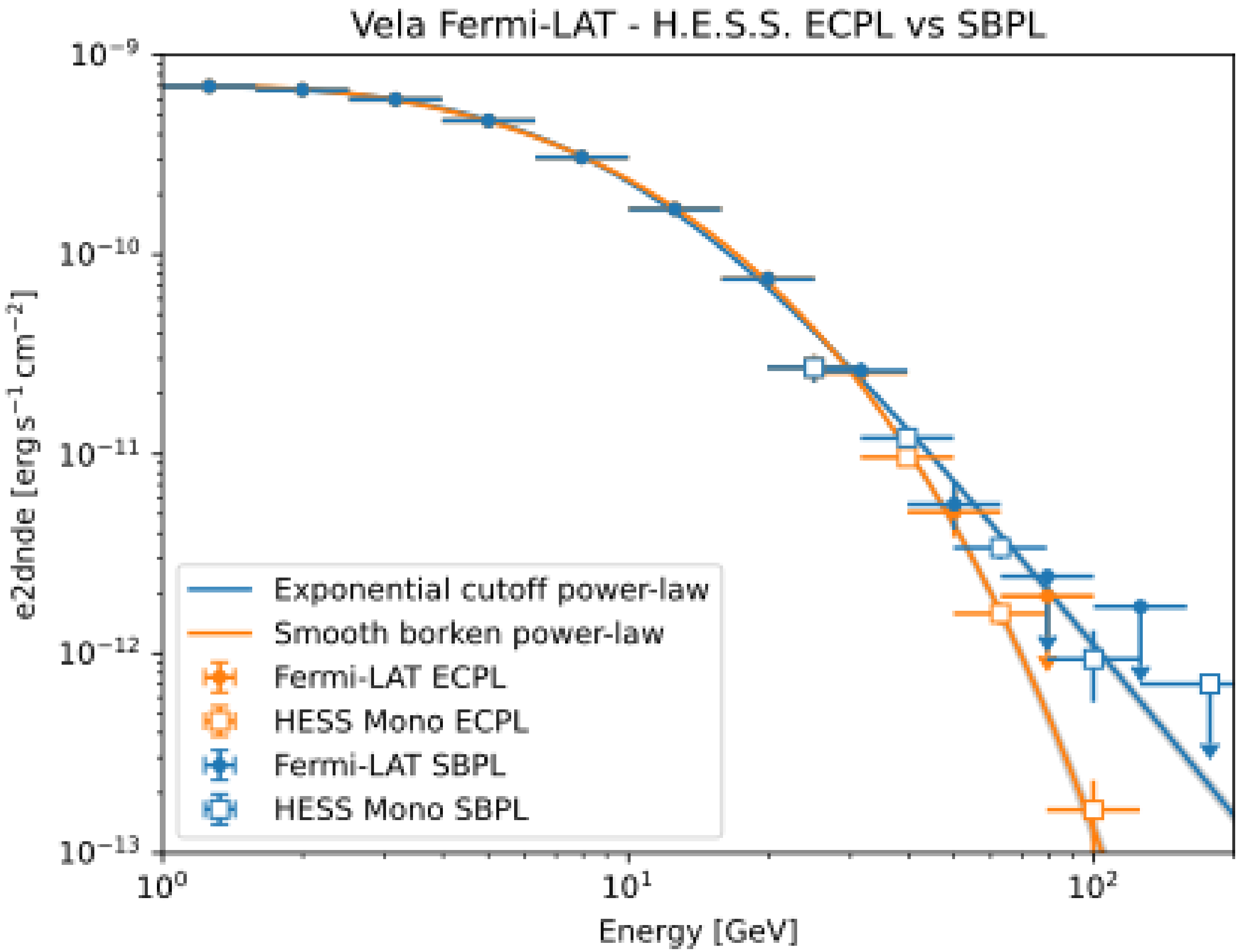
Dataset	Significance	PowerLaw	LogParabola
H.E.S.S.	X	$\alpha = 4.1 \pm 0.2$	X
Fermi-LAT (>10 GeV)	5.6σ	$\alpha = 4.0 \pm 0.07$	$\alpha = 4.1 \pm 0.1$ $\beta = 1.0 \pm 0.2$
Fermi-LAT (>15 GeV)	3σ	$\alpha = 4.6 \pm 0.2$	$\alpha = 3.6 \pm 0.4$ $\beta = 1.6 \pm 0.7$
Joint (>10 GeV)	7.3σ	$\alpha = 4.1 \pm 0.05$	$\alpha = 4.2 \pm 0.08$ $\beta = 1.1 \pm 0.2$
Joint (>15 GeV)	5.7σ	$\alpha = 4.4 \pm 0.1$	$\alpha = 3.7 \pm 0.3$ $\beta = 1.6 \pm 0.5$
Joint (>20 GeV)	3.1σ	$\alpha = 4.8 \pm 0.2$	$\alpha = 5.0 \pm 0.4$ $\beta = 1.4 \pm 0.6$

ECPL vs SBPL: Vela

ECPL vs SBPL :

- **SBPL fit gives an E_{break} of 38 GeV but not statistically favoured**

- **Further tests favour ECPL, e.g.: Fixing E_{break} to 10 GeV**
  $\Delta TS(AIC) = 8.2,$
  $\Delta TS(BIC) = 8.2$



Vela: Conclusion

We measure the presence of curvature at the 5 σ level above 15 GeV and at the 3 σ level above 20 GeV.

This excludes the onset of a power-law at these energies.

Vela emission mechanism is clearly different from the Crab pulsar:

- **This is in line with the scenario depicted in the TeV Vela paper (**[Aharonian, F., et al. 2023]**)**
- **Confirms the preliminary HE-VHE pulsar classification proposed here: Crab-like vs Vela-like**

PSR B1706-44: Datasets

H.E.S.S.

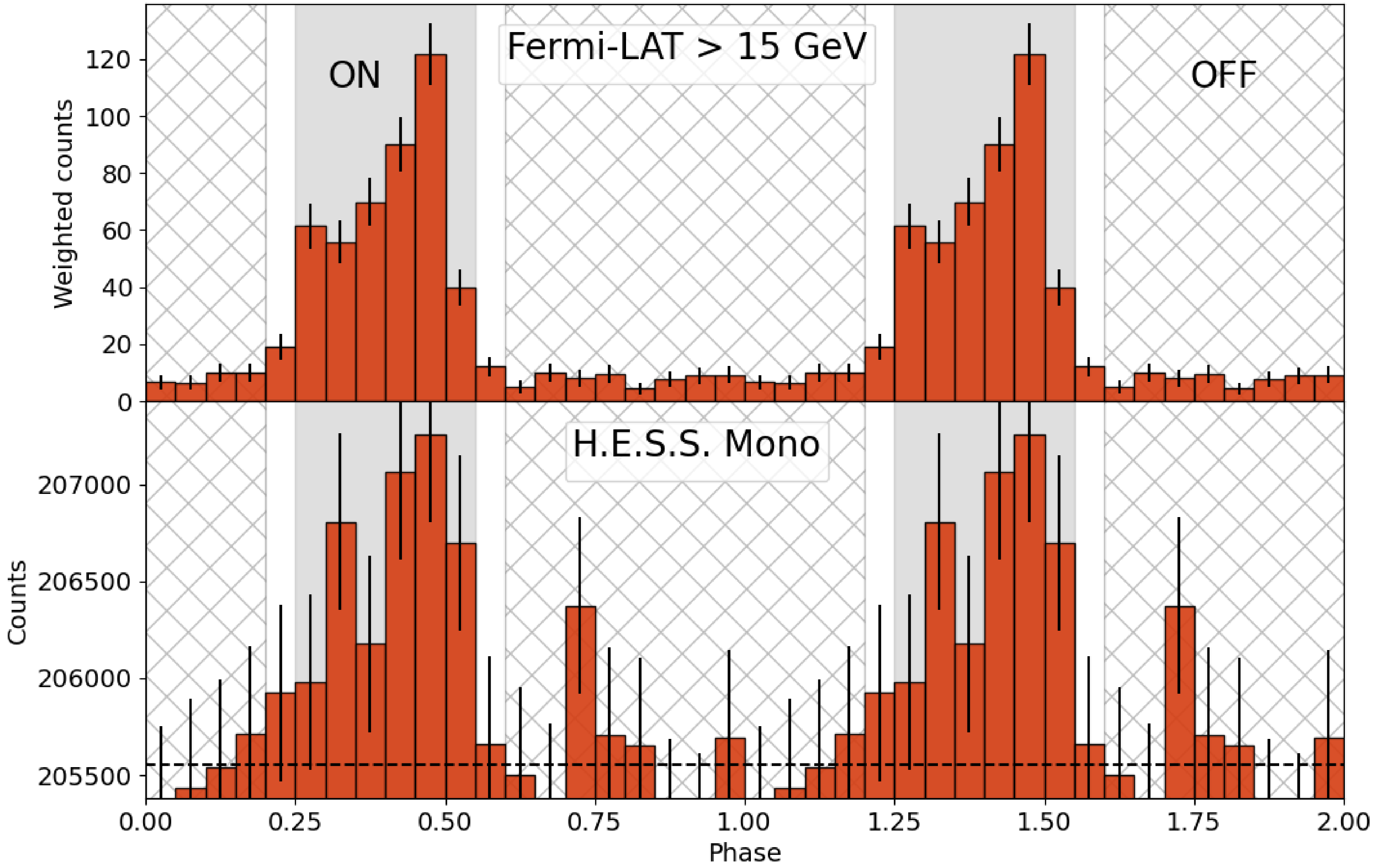
- **PSR B1706-44 ICRC proceeding** [2]
- **21.7 h of livetime**

Fermi-LAT

- **3PC** [4] **FITS file**
- **10.9 years of data**

2 : [Spir-Jacob, M., Djannati-Ataï, A., Mohrmann, L., et al. 2019]
4 : [Smith, D. A., Abdollahi, S., Ajello, M., et al. 2023, The Astrophysical Journal, 958, 191]

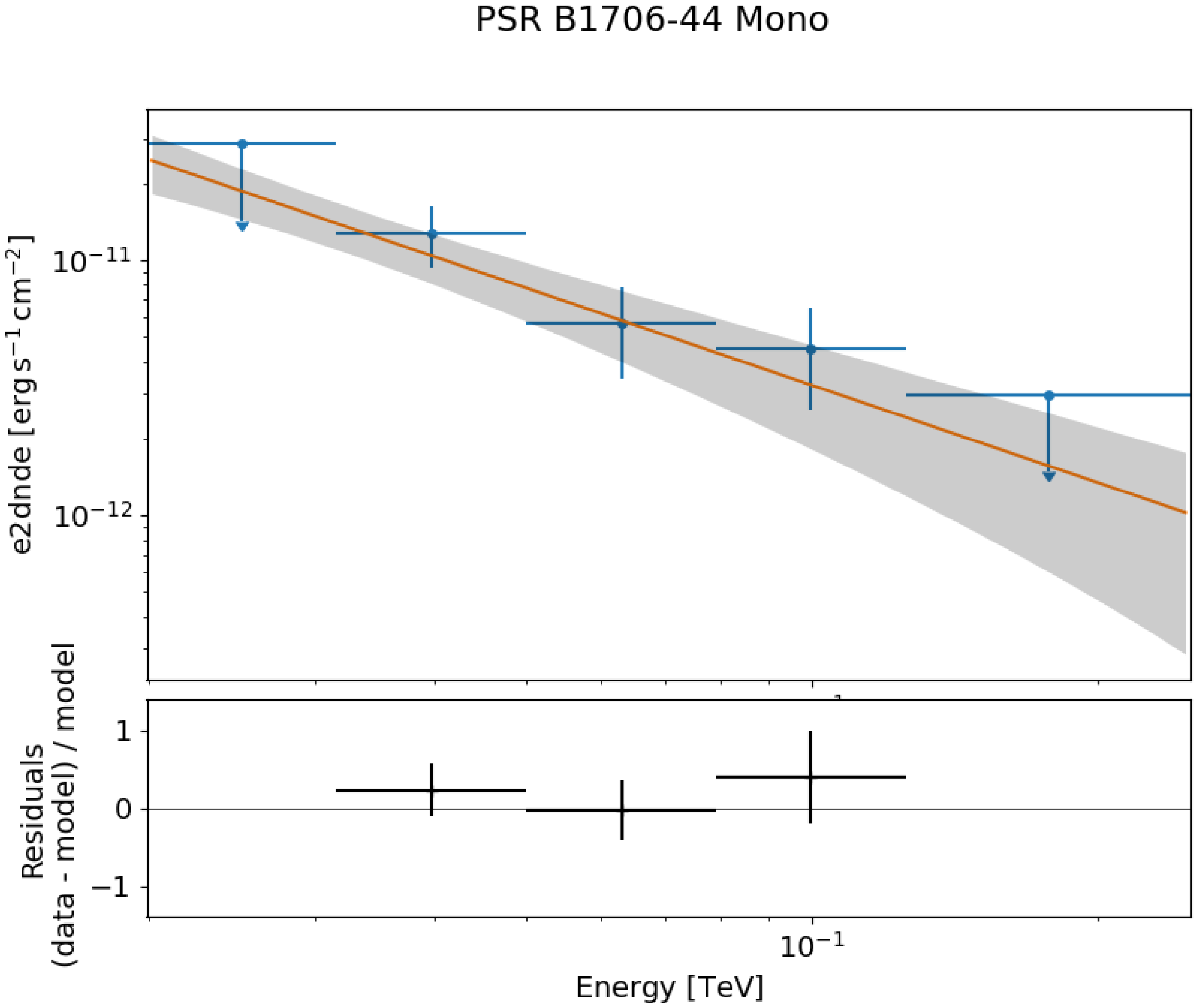
PSR B1706-44: Phasograms



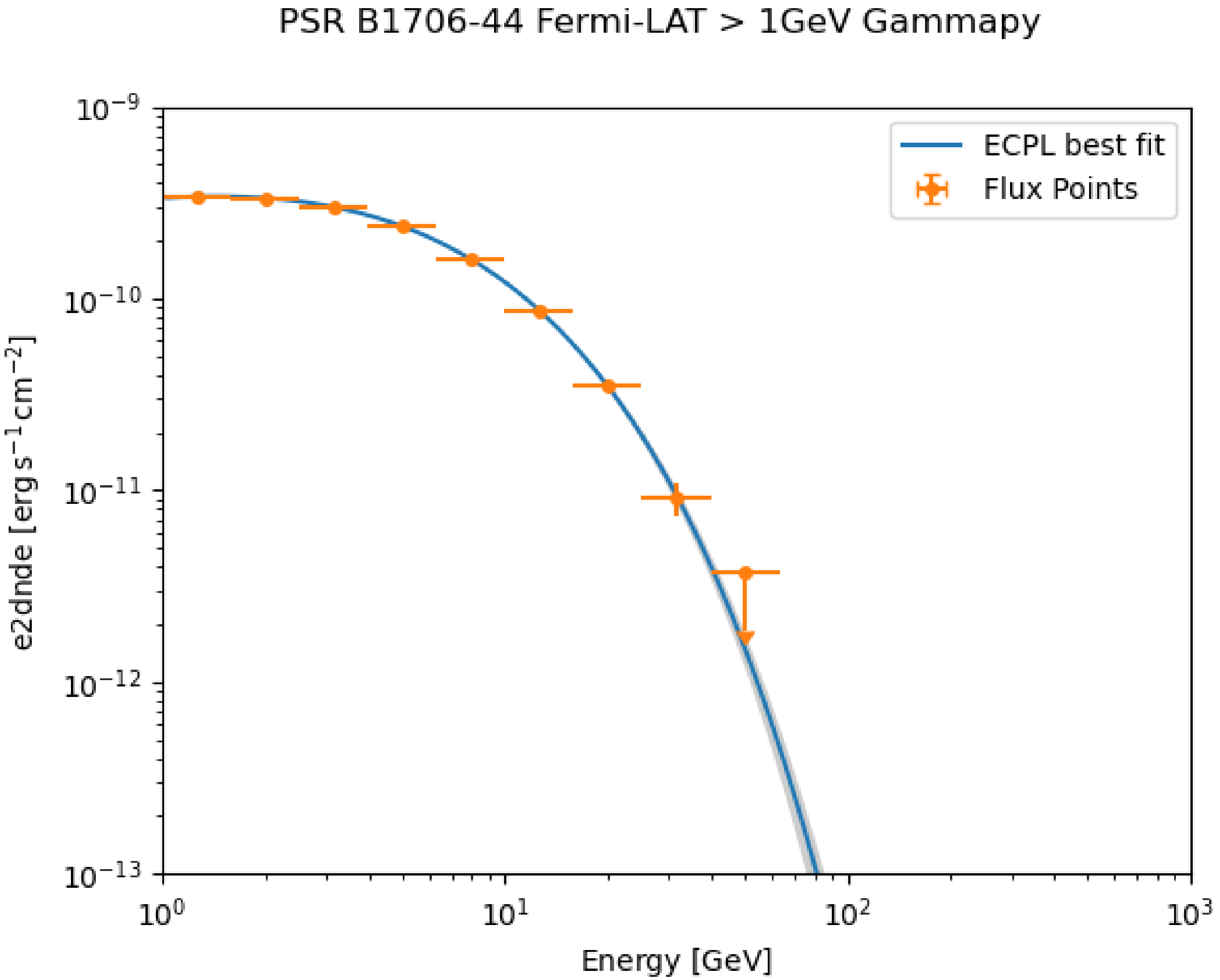
PSR B1706-44: H.E.S.S. Spectrum

Power-law fit:

$\phi(20\ GeV) = 3.96 \times 10^{-8} \pm 0.98\ TeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 3.4\ \pm 0.3$



PSR B1706-44: Fermi-LAT

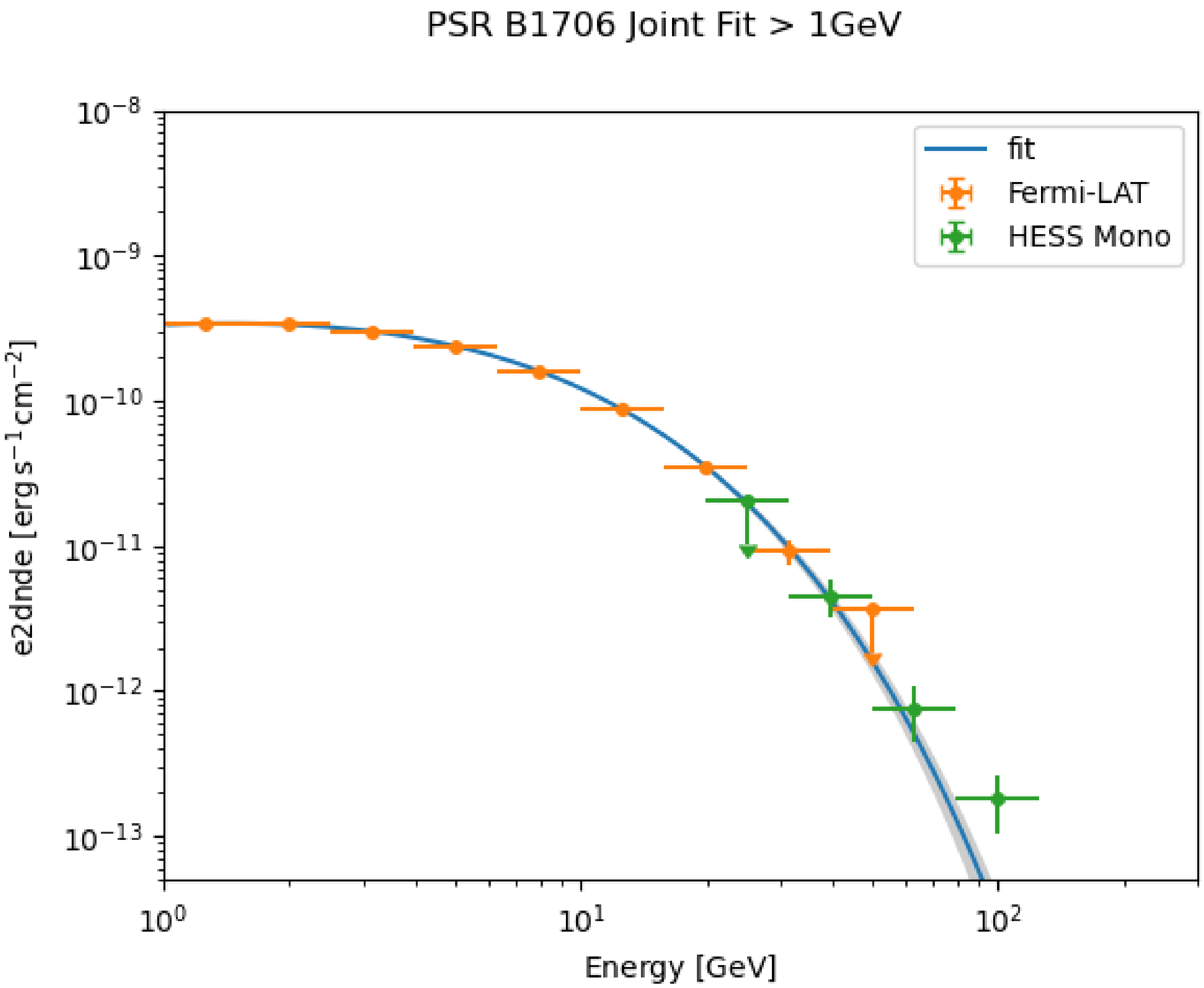


Power-law with exponential cutoff:

$$\phi(E) = \phi_0 \cdot \left(\frac{E}{E_0}\right)^{-\Gamma} \exp(-(\lambda E)^{\alpha})$$

$\phi(1.8\ GeV)$
$= 1.8 \times 10^{-10} \pm 0.3\ MeV^{-1} s^{-1} cm^{-2}$
$\Gamma = 1.5 \pm 0.06$
$\lambda = 5.3 \times 10^{-4} \pm 1.4\ MeV^{-1}$
$\alpha = 6.4 \times 10^{-1} \pm 0.4$

PSR B1706-44: Fermi-LAT – H.E.S.S. Joint-fit

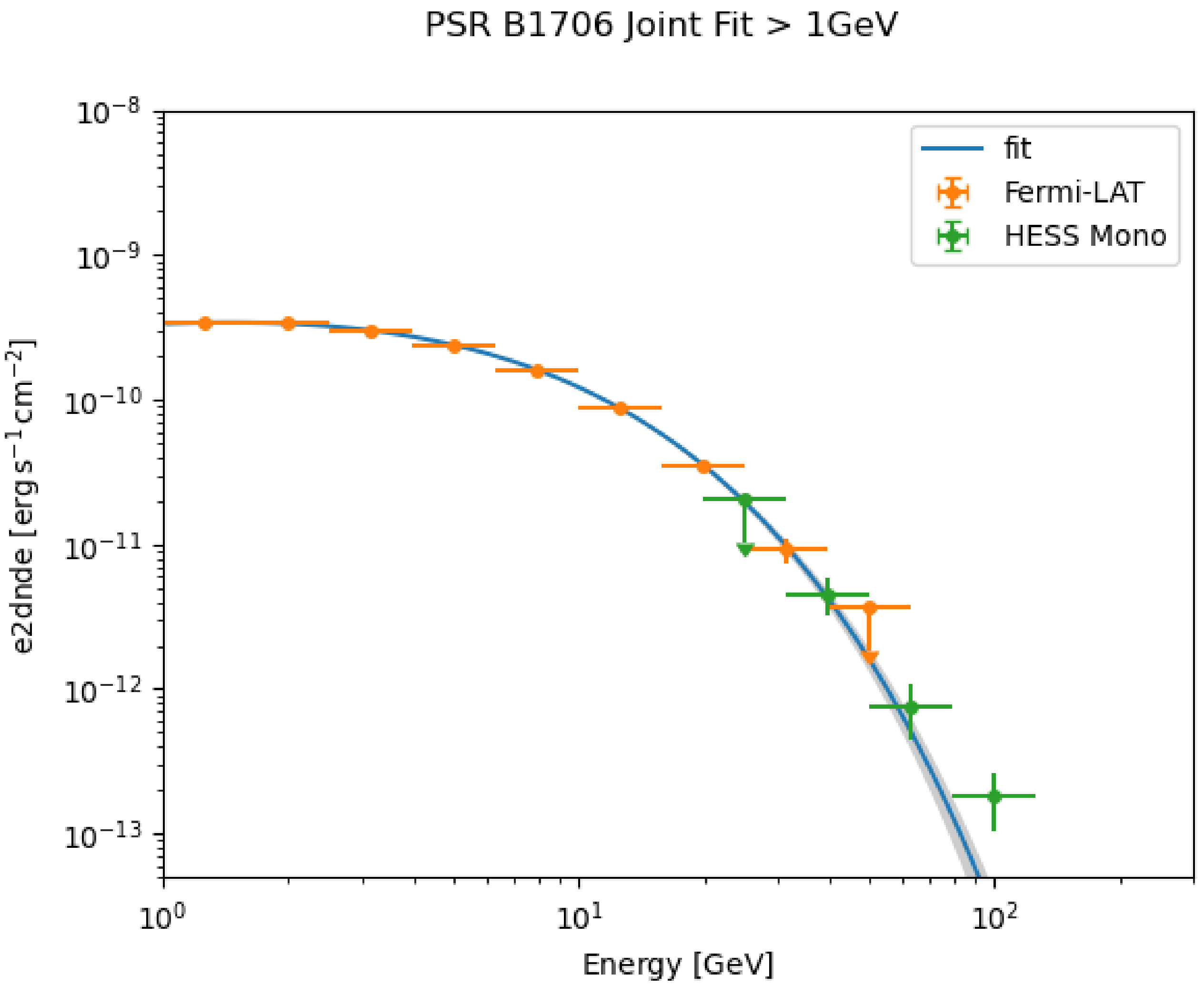


Power-law with exponential cutoff:

$$\phi(E) = \phi_0 \cdot \left(\frac{E}{E_0}\right)^{-\Gamma} \exp(-(\lambda E)^{\alpha})$$

$\phi(1.8\ GeV) = 1.9 \times 10^{-10} \pm 0.3\ MeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 1.4\ \pm 0.07$
$\lambda = 6.0 \times 10^{-4} \pm 1.6\ MeV^{-1}$
$\alpha = 6.2 \times 10^{-1} \pm 0.4$

PSR B1706-44: Fermi-LAT – H.E.S.S. Joint-fit



Power-law with exponential cutoff:

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$\phi(1.8\ GeV) = 1.9 \times 10^{-10} \pm 0.3\ MeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 1.4\ \pm 0.07$
$\lambda = 6.0 \times 10^{-4} \pm 1.6\ MeV^{-1}$
$\alpha = 6.2 \times 10^{-1} \pm 0.4$

Fermi-LAT only:
$\phi(1.8\ GeV) = 1.8 \times 10^{-10} \pm 0.3\ MeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 1.5\ \pm 0.06$
$\lambda = 5.3 \times 10^{-4} \pm 1.4\ MeV^{-1}$
$\alpha = 6.4 \times 10^{-1}\ \pm 0.4$

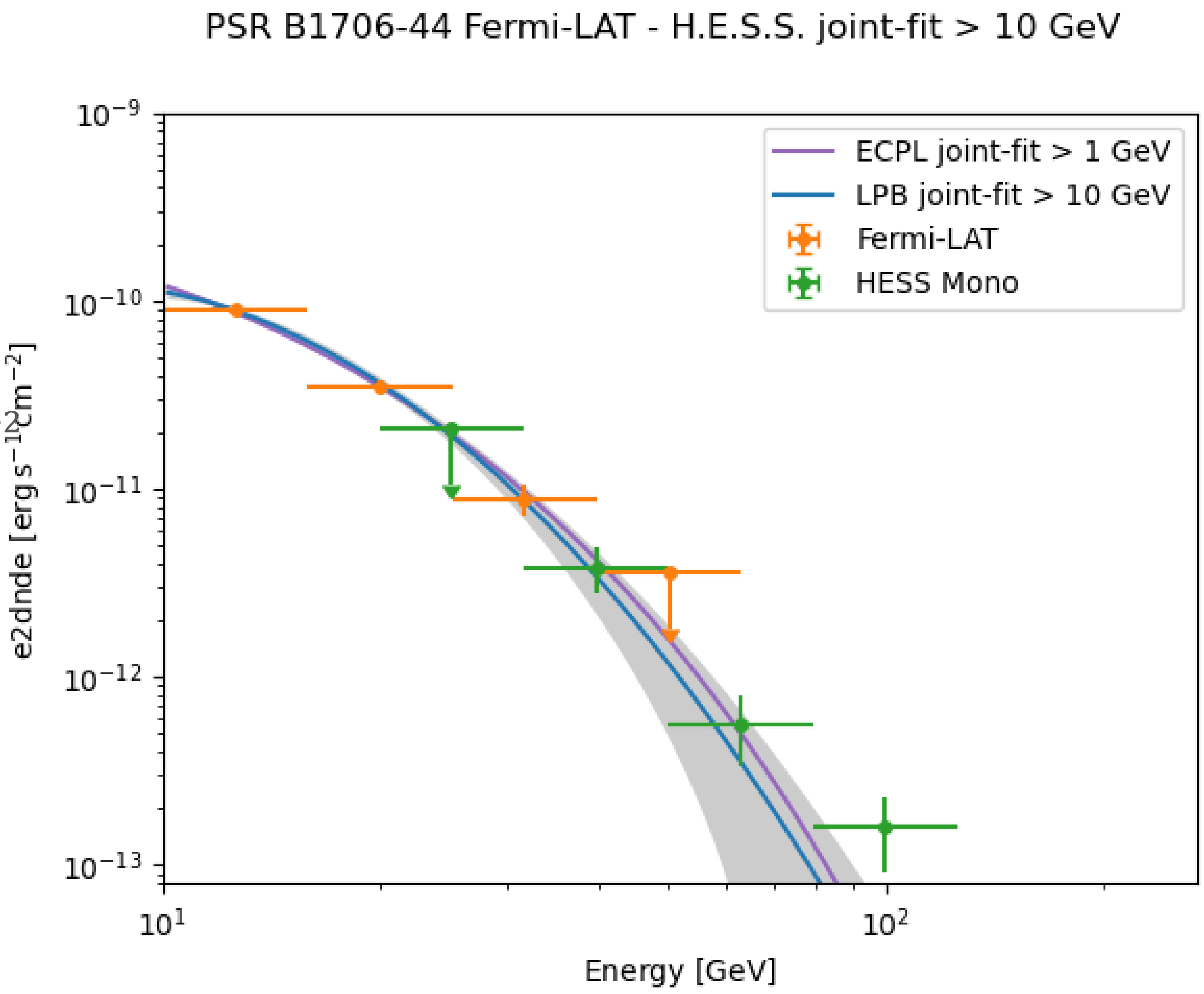
PSR B1706-44: Curvature study

Log-parabola:

$$\phi(E) = \phi_0 \left(\frac{E}{E_0}\right)^{-\alpha-\beta\cdot log\left(\frac{E}{E_0}\right)}$$

$\phi(20\ GeV) = 5.6 \times 10^{-8} \pm 0.4\ TeV^{-1}s^{-1}cm^{-2}$
$\alpha = 4.5\ \pm 0.2$
$\beta = 1.3\ \pm 0.5$

Likelihood ratio:
3.8 σ in favour of the Log-parabola



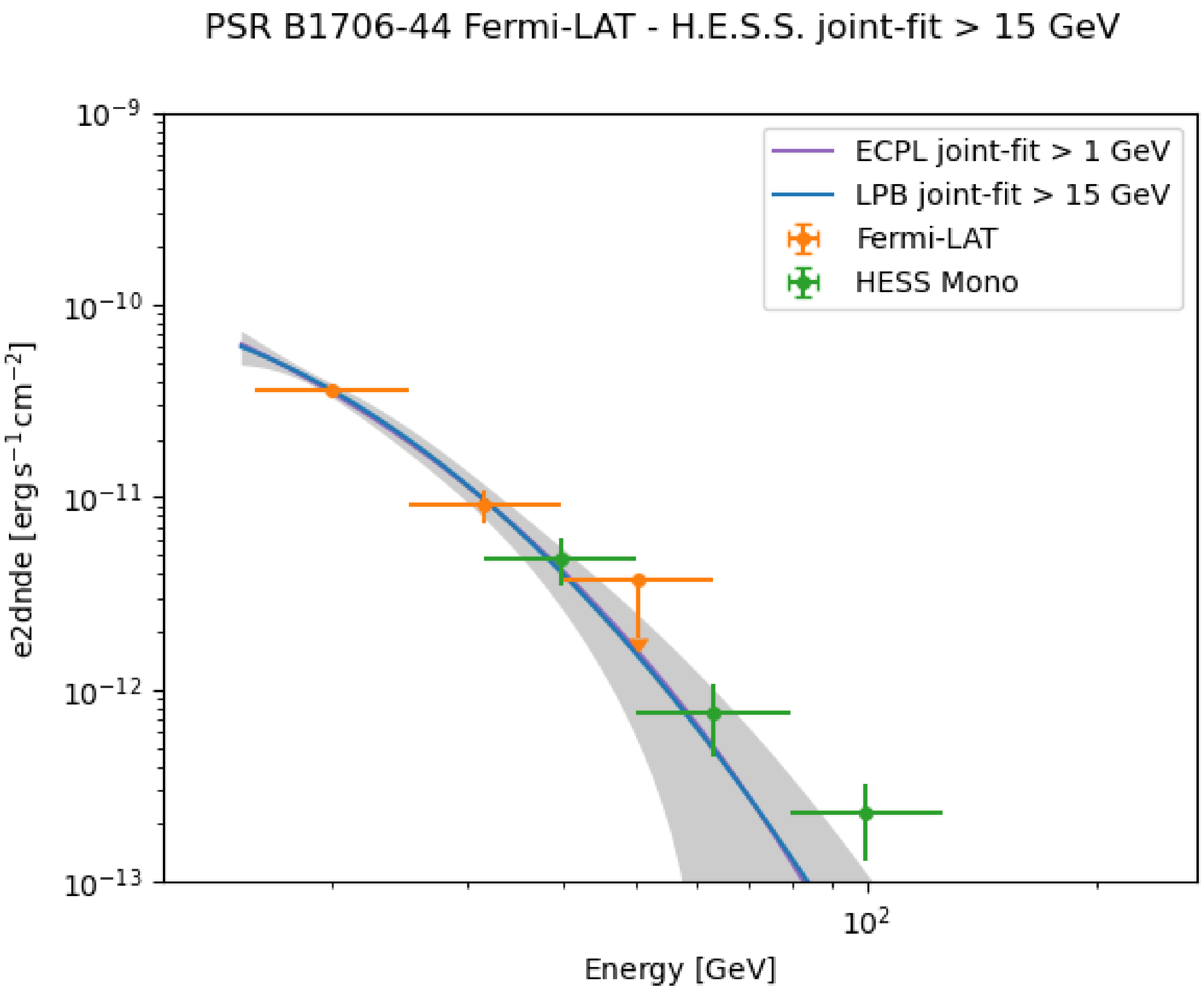
PSR B1706-44: Curvature study

Log-parabola:

$$\phi(E) = \phi_0 \left(\frac{E}{E_0}\right)^{-\alpha-\beta\cdot log\left(\frac{E}{E_0}\right)}$$

$\phi(20\ GeV) = 5.6 \times 10^{-8} \pm 0.5\ TeV^{-1}s^{-1}cm^{-2}$
$\alpha = 4.3\ \pm 0.6$
$\beta = 1.3\ \pm 1.1$

Likelihood ratio:
1.8 σ in favour of the Log-parabola



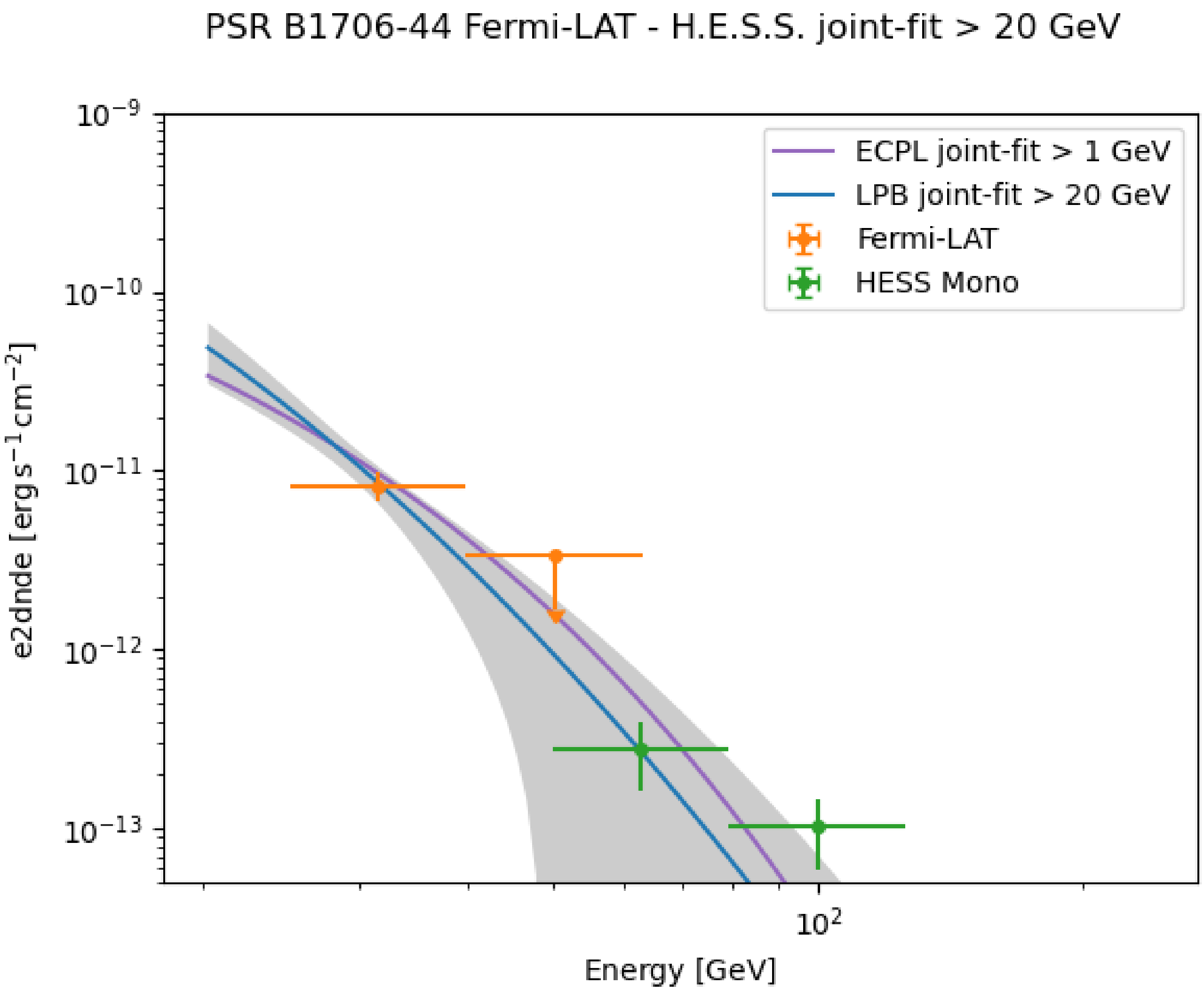
PSR B1706-44: Curvature study

Log-parabola:

$$\phi(E) = \phi_0 \left(\frac{E}{E_0}\right)^{-\alpha-\beta\cdot log\left(\frac{E}{E_0}\right)}$$

$\phi(20\ GeV) = 7.9 \times 10^{-8} \pm 3.0\ TeV^{-1}s^{-1}cm^{-2}$
$\alpha = 5.4\ \pm 0.9$
$\beta = 0.9\ \pm 1.5$

Likelihood ratio:
0.8 σ in favour of the Log-parabola



PSR B1706-44: Curvature study

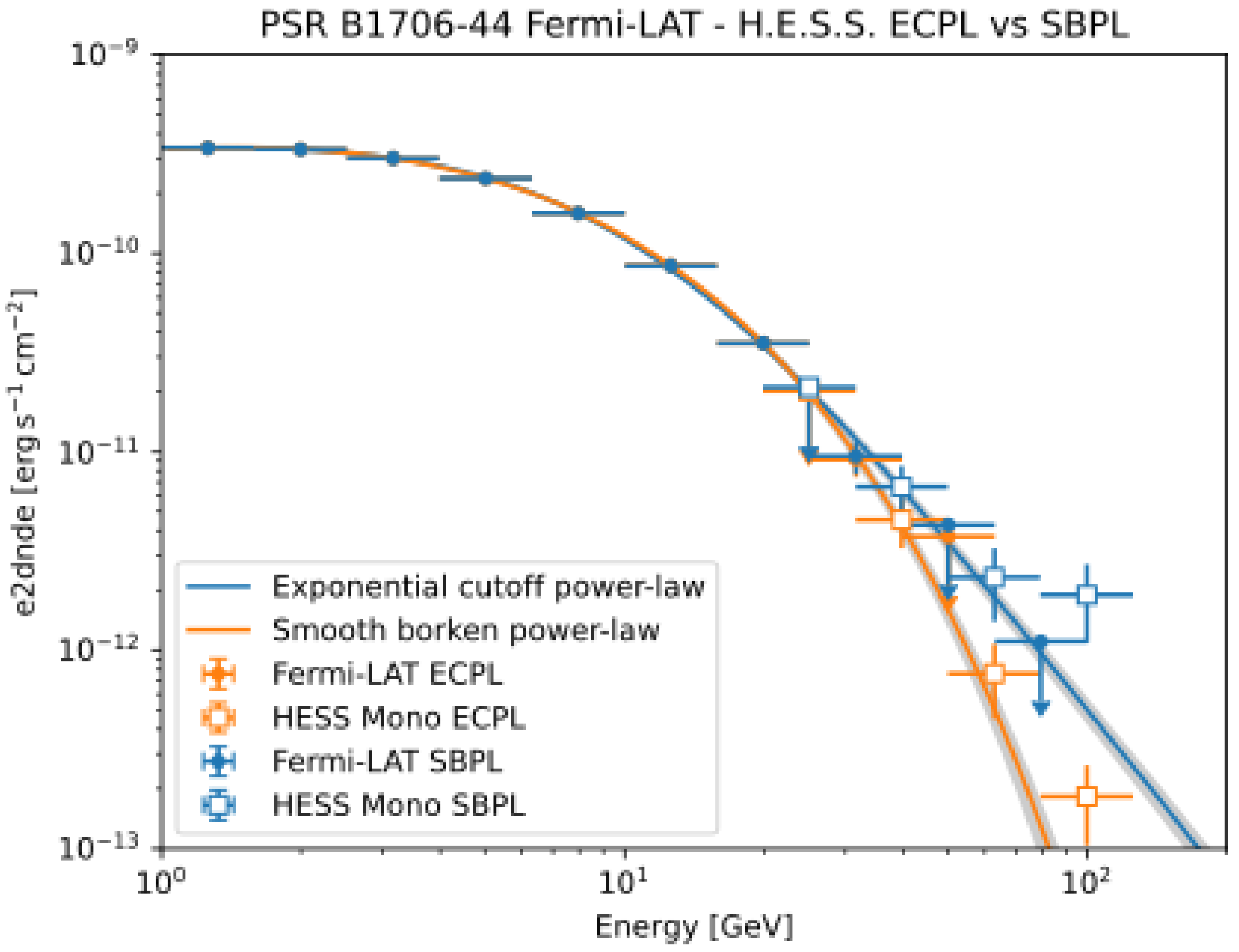
Dataset	Significativity	PowerLaw	LogParabola
H.E.S.S.	X	$\alpha = 3.3 \pm 0.3$	X
Fermi-LAT (>10 GeV)	3.9σ	$\alpha = 4.3 \pm 0.1$	$\alpha = 4.6 \pm 0.04$ $\beta = 1.4 \pm 0.3$
Fermi-LAT (>15 GeV)	X	$\alpha = 5.1 \pm 0.4$	X
Joint (>10 GeV)	3.8σ	$\alpha = 4.2 \pm 0.1$	$\alpha = 4.5 \pm 0.6$ $\beta = 1.3 \pm 0.1$
Joint (>15 GeV)	1.8σ	$\alpha = 4.8 \pm 0.3$	$\alpha = 4.3 \pm 0.6$ $\beta = 1.3 \pm 1.1$
Joint (>20 GeV)	0.8σ	$\alpha = 5.6 \pm 0.6$	$\alpha = 5.4 \pm 0.9$ $\beta = 1 \pm 1.5$

ECPL vs SBPL: PSR B1706-44

ECPL vs SBPL:

- **SBPL fit gives an E_{break} of 22.6 GeV but not statistically favoured**

- **Further tests favour ECPL, e.g.: Fixing E_{break} to 10 GeV**
  $\Delta TS(AIC) = 7.7,$
  $\Delta TS(BIC) = 7.7$



PSR B1706-44: Conclusion

We measure the presence of curvature at the 3 σ level above 10 GeV.

This exclude the onset of a power-law at this energy.

Such detection favours a Vela-like emission scenario.

We cannot exclude the onset of a power-law at energies of 15-20 GeV.

Crab: Validation

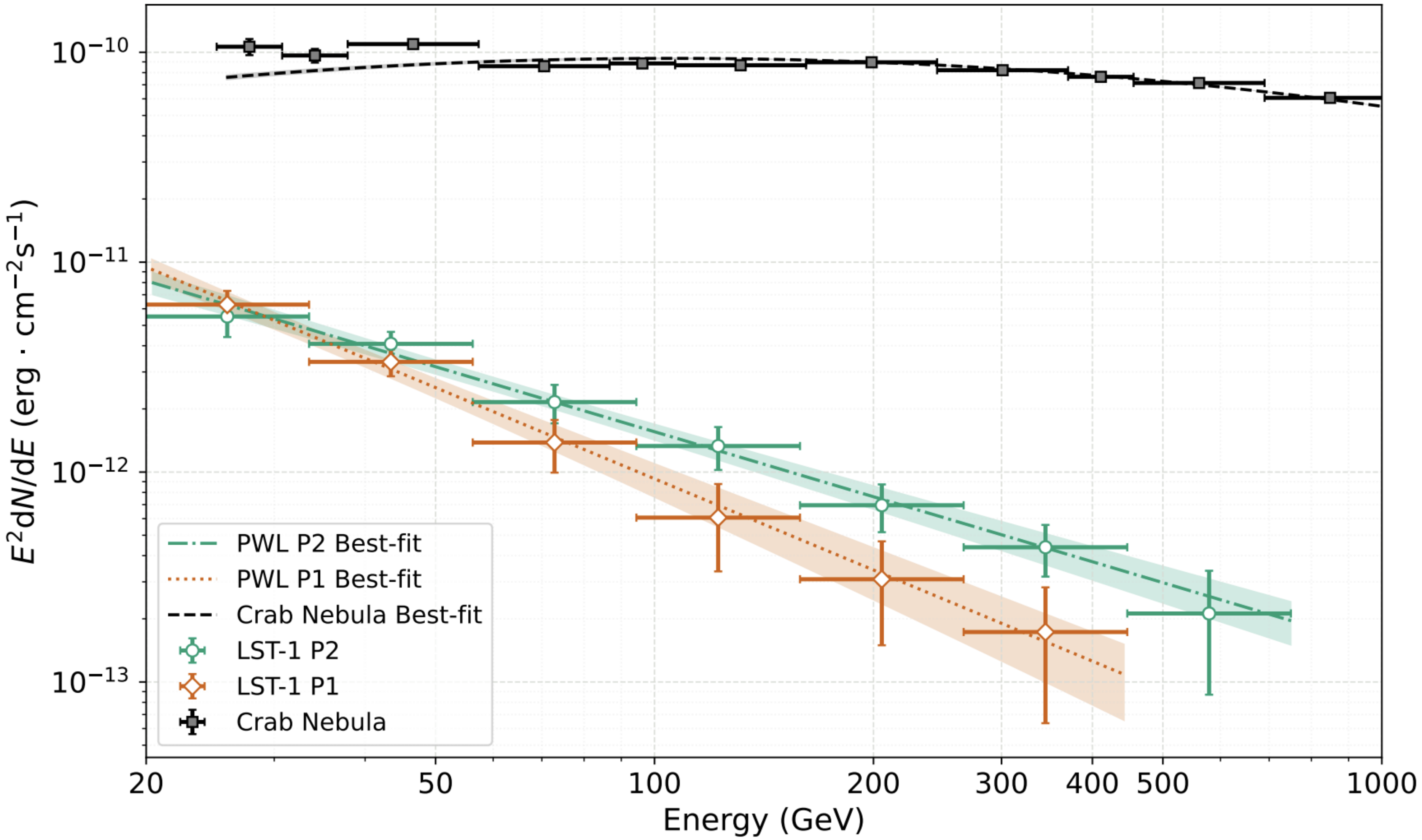
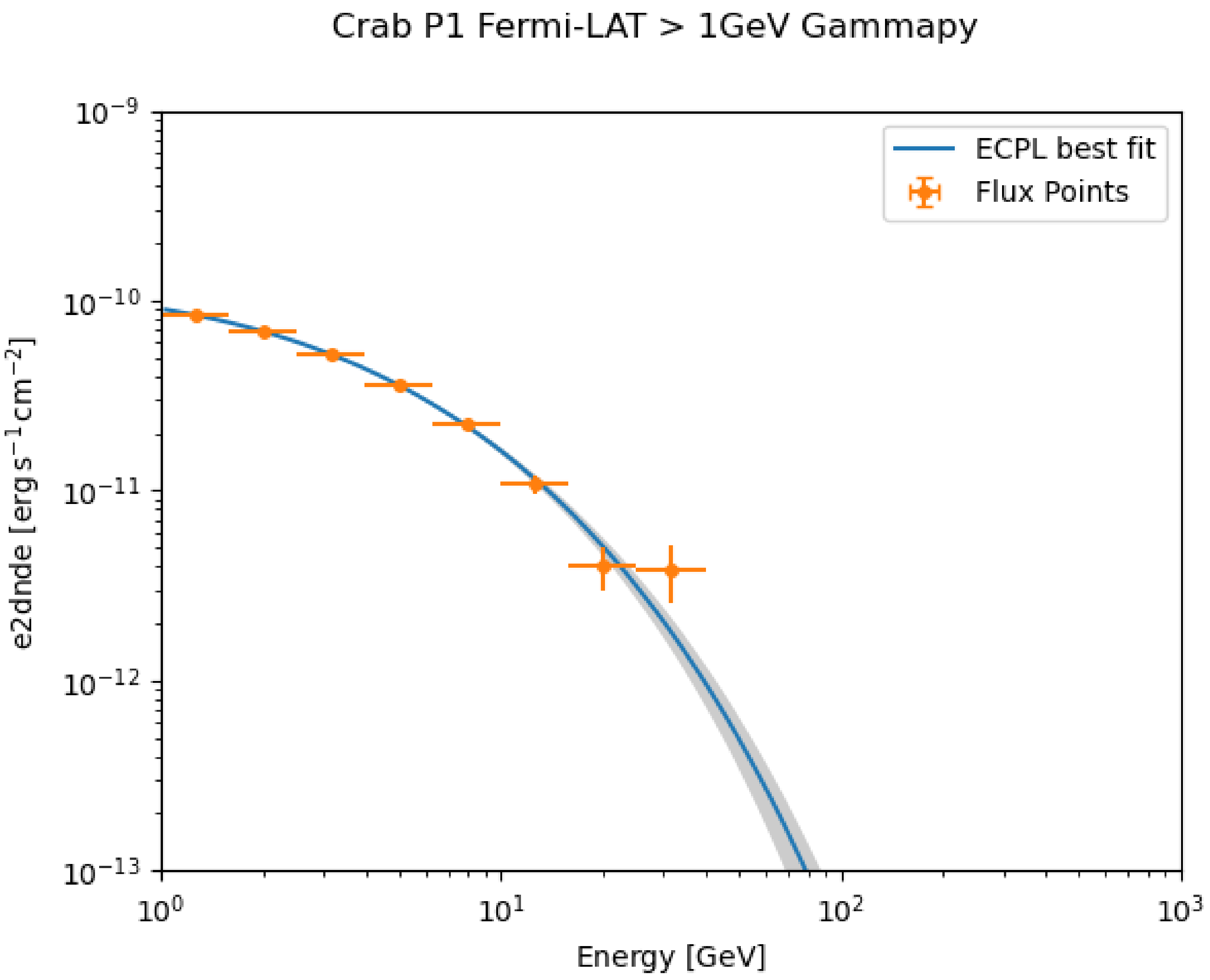


Figure 7 from
[Abe, K., et al. 2024]

Crab: Fermi-LAT



Power-law with exponential cutoff:

$$\phi(E) = \phi_0 \cdot \left(\frac{E}{E_0}\right)^{-\Gamma} \exp(-(\lambda E)^{\alpha})$$

$\phi(1.8\ GeV)$
$= 9.7 \times 10^{-11} \pm 1.8\ MeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 1.7\ \pm 0.07$
$\lambda = 2.4 \times 10^{-3} \pm 0.7\ MeV^{-1}$
$\alpha = 4.4 \times 10^{-1}\ \pm 0.3$

Crab: Curvature study

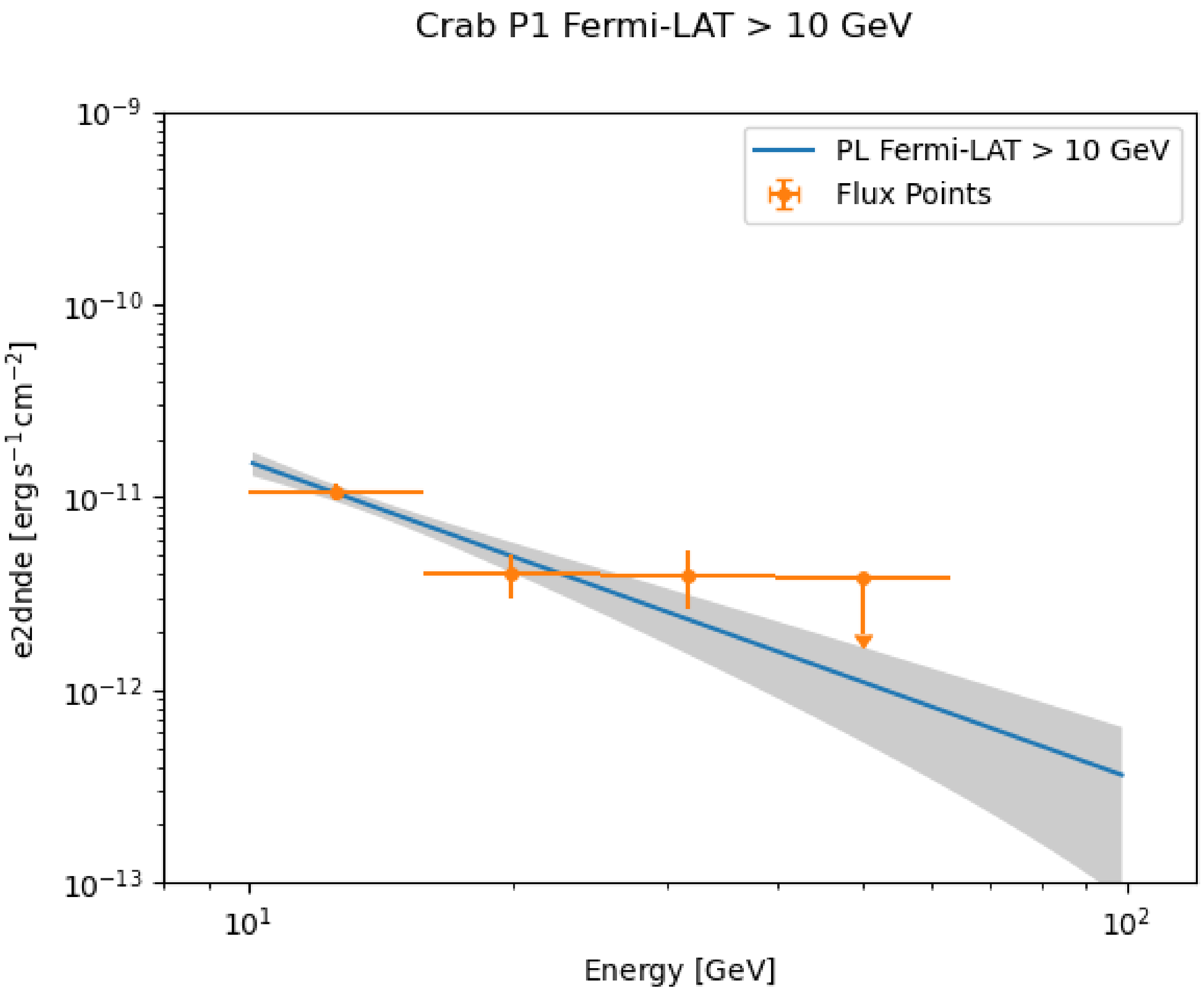
Power-law:

$$\phi(E) = \phi_0 \left(\frac{E}{E_0}\right)^{-\Gamma}$$

$\phi(20\ GeV) = 7.7 \times 10^{-9} \pm 1.4\ TeV^{-1} s^{-1} cm^{-2}$
$\alpha = 3.6\ \pm 0.4$

Likelihood ratio:
0.1 σ in favour of the Log-parabola

We don't detect curvature !
This validate our curvature measurement method



Summary and conclusions:

- Qualifying the behaviour of the high energy end of pulsar spectra in the tens of GeV range is of prime importance for constraining emission models
  - As seen in the case of the Crab pulsar the extension of its emission challenged dramatically the standard CR picture

- Methods : we elaborated on a quantitative method ([Abdalla, H. et al., 2018]) to test for curvature for two pulsars detected with HESS : Vela and B1706-44

- The method was tested and validated on the Crab with Fermi-LAT data

- We are able to detect a curvature and exclude the onset of a power-law, up to 20 GeV for Vela and up to 10 GeV for B1706-44

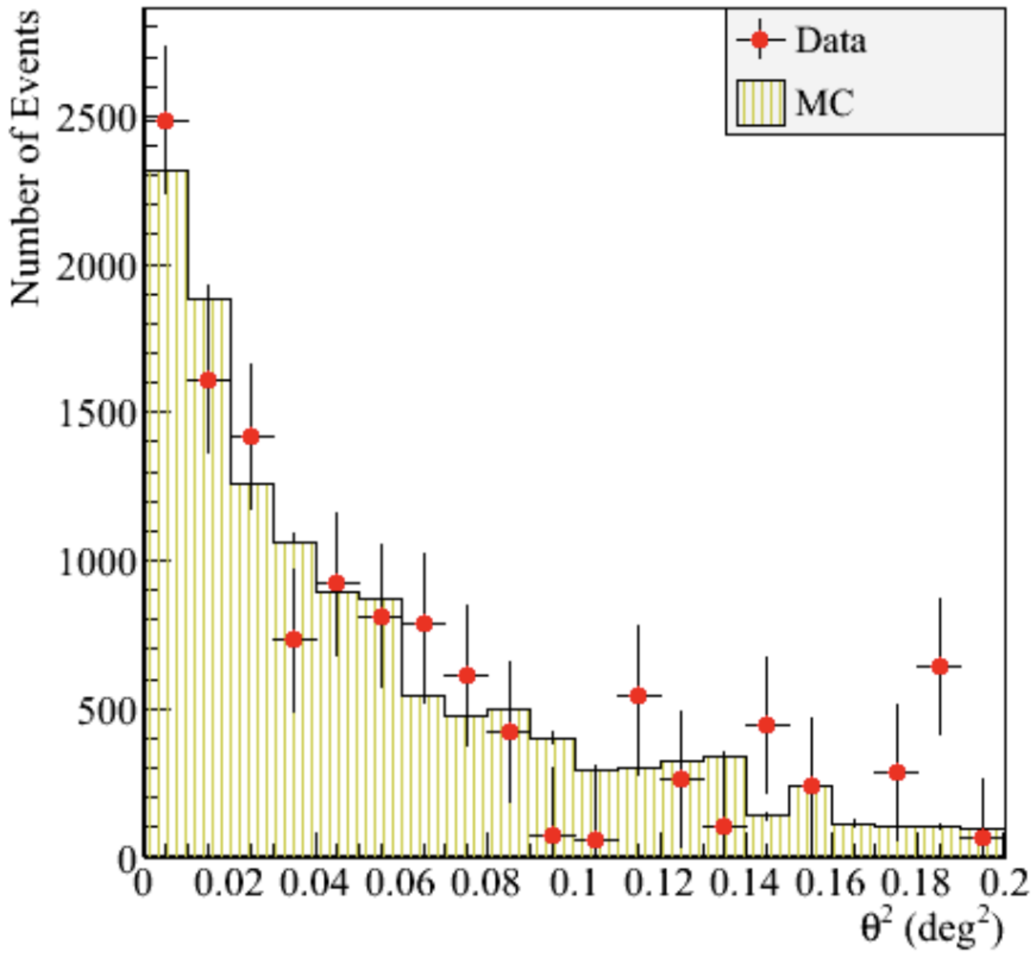
- Testing for a SBPL against an ECPL model confirms the above

- The case for the other HE pulsar, Geminga, was discussed in the talk by Giulia Brunelli

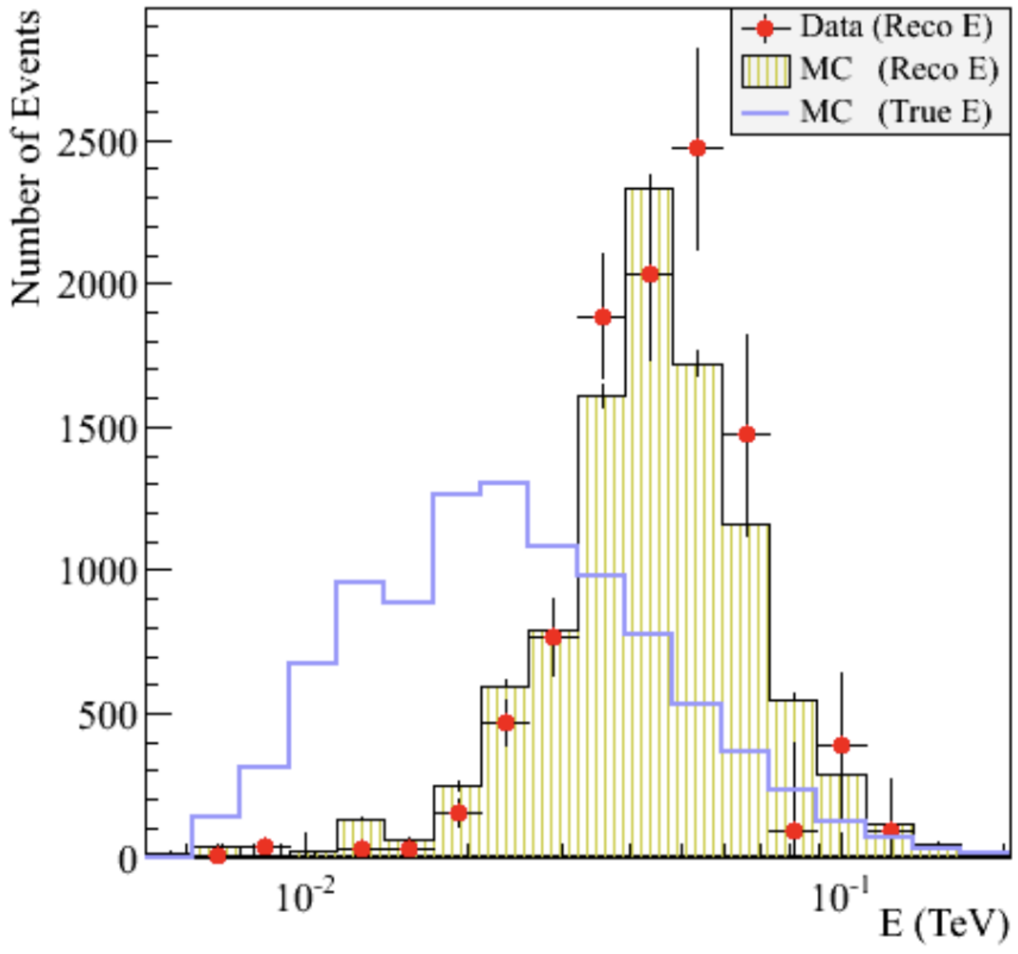
- CTAO with its low threshold and high sensitivity should provide valuable data in this matter

Backup

Backup

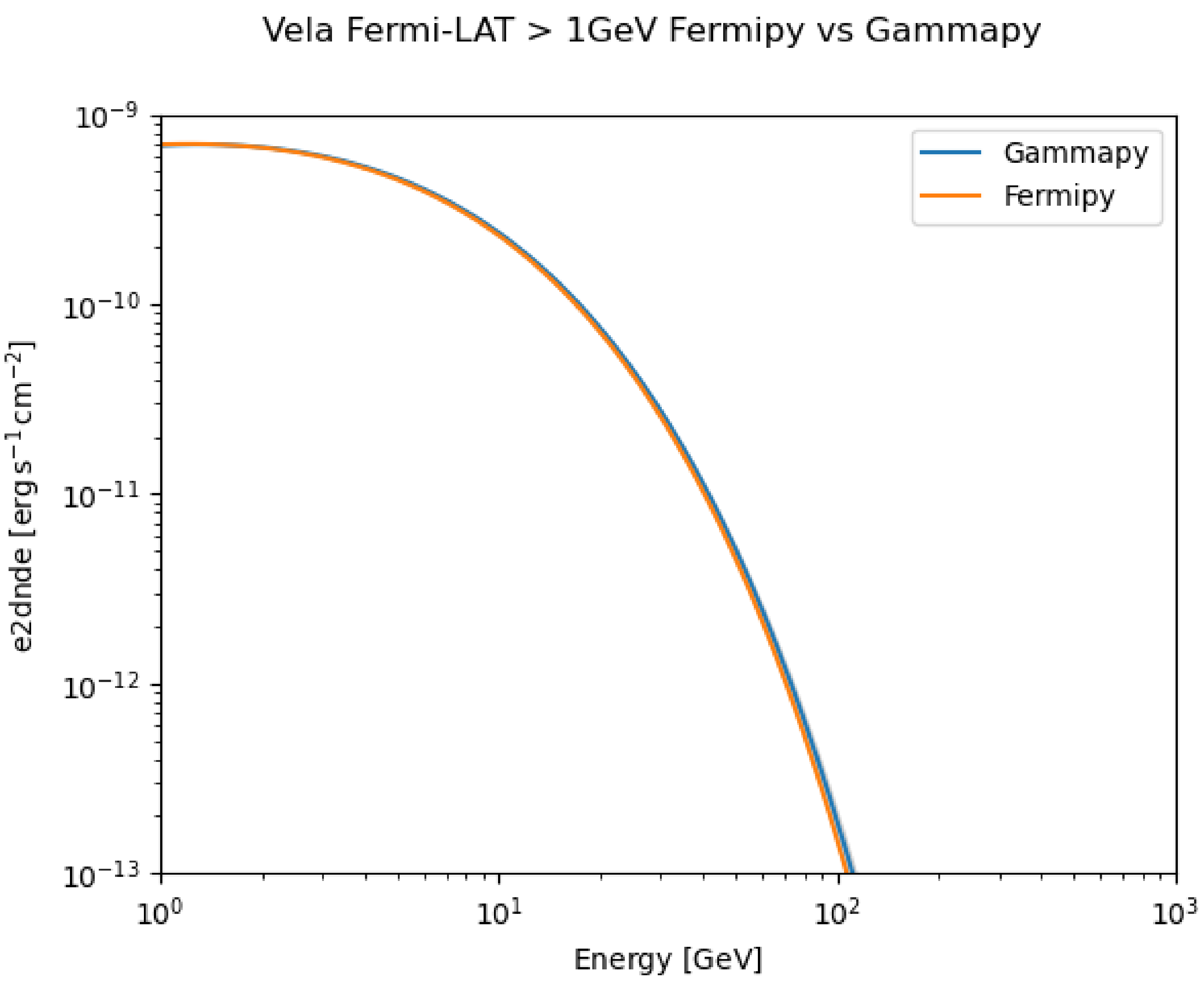


Number of Events
Data
MC
0
500
1000
1500
2000
2500
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2
θ^2 (deg^2)

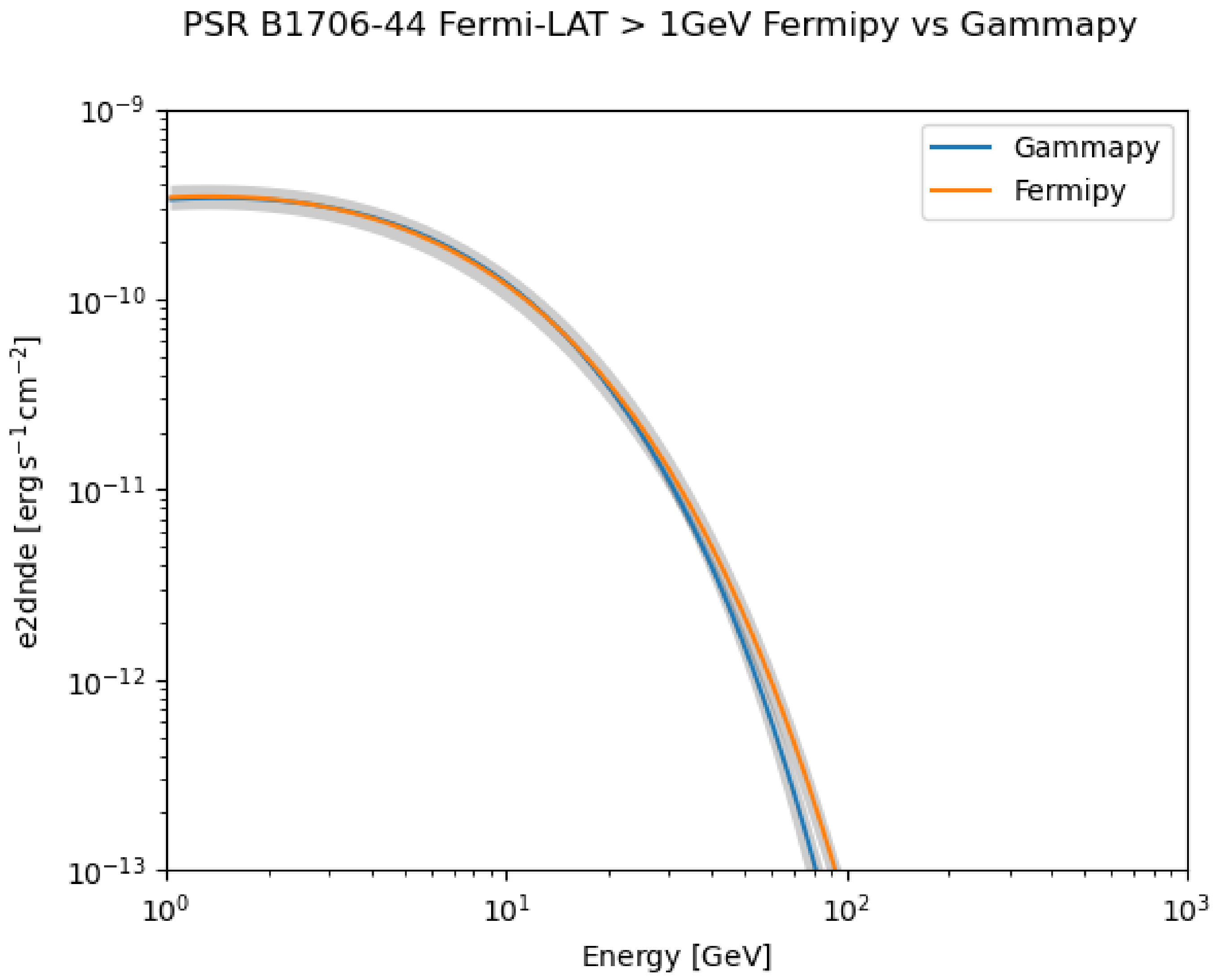


Number of Events
Data (Reco E)
MC (Reco E)
MC (True E)
0
500
1000
1500
2000
2500
10^{-2}
10^{-1}
E (TeV)

Vela: Fermi-LAT



PSR B1706-44: Fermi-LAT

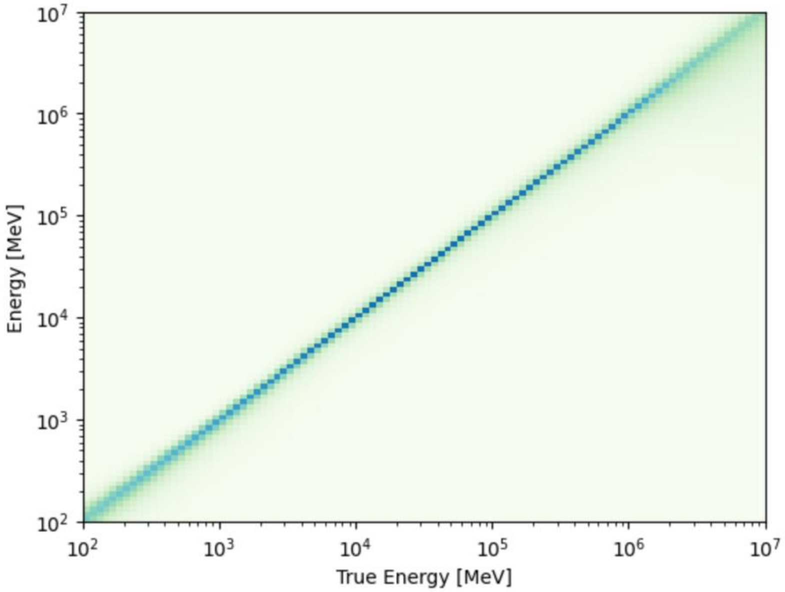


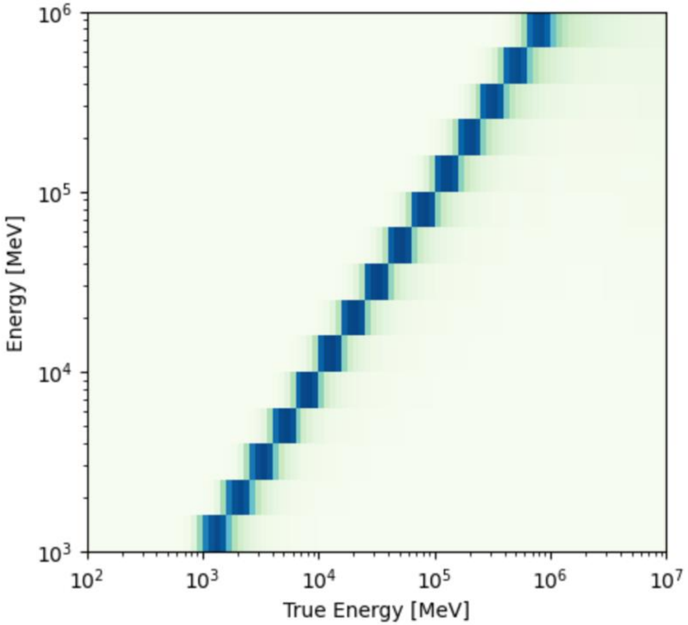
Reading Fermi-LAT energy dispersion in Gammapy

To properly fit Fermi-LAT data we need to take into account the energy dispersion matrix

In Gammapy , the best practice is to have a true energy axis with more bins and over a wider energy range than the reco energy axis.
→ Not straight forward with Fermitools/fermipy

Solution:
- Oversample IRFs: between 100 MeV and 10 TeV (to do an analysis between 1 GeV and 1 TeV)
- Resample the reco energy axis into the analysis one.





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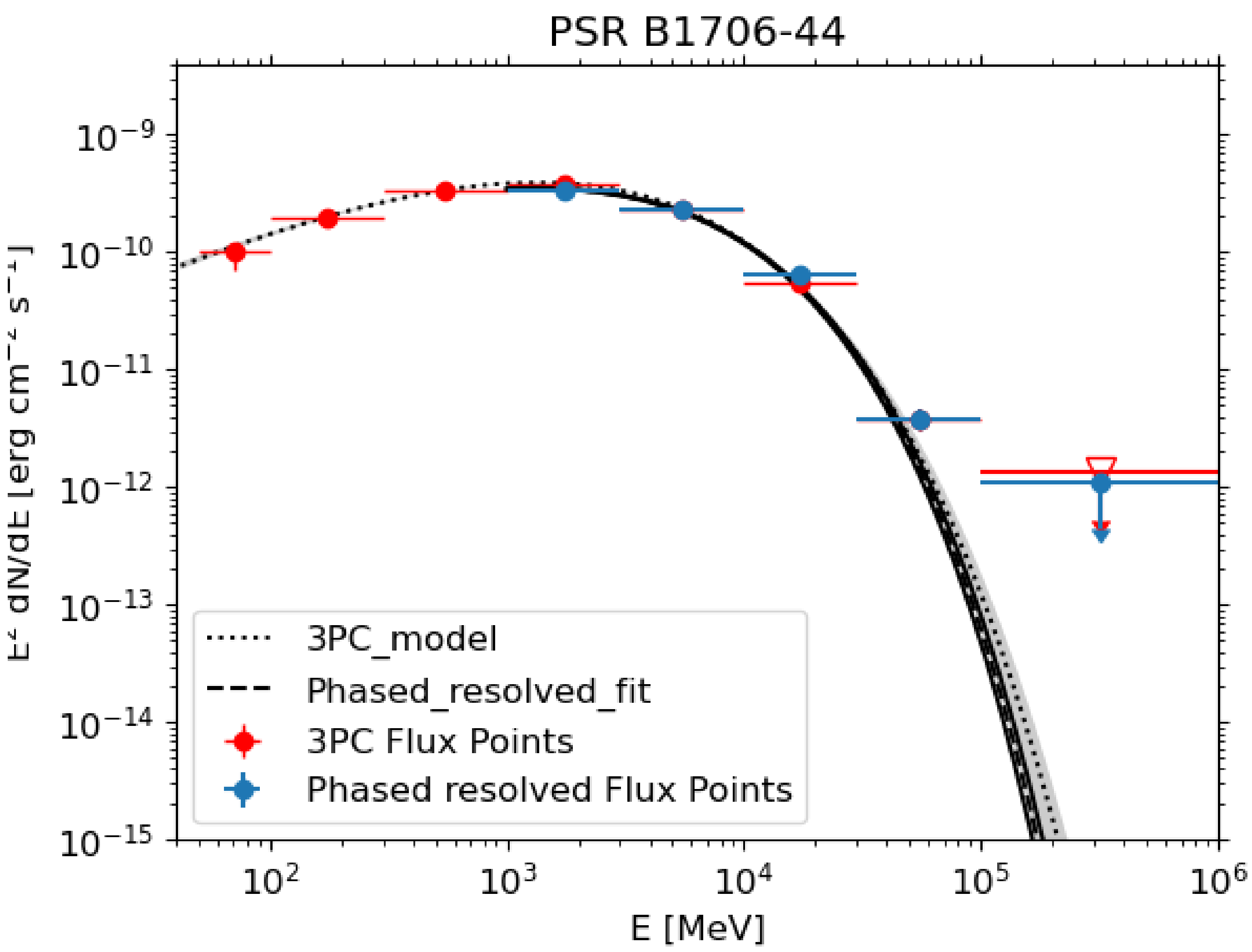
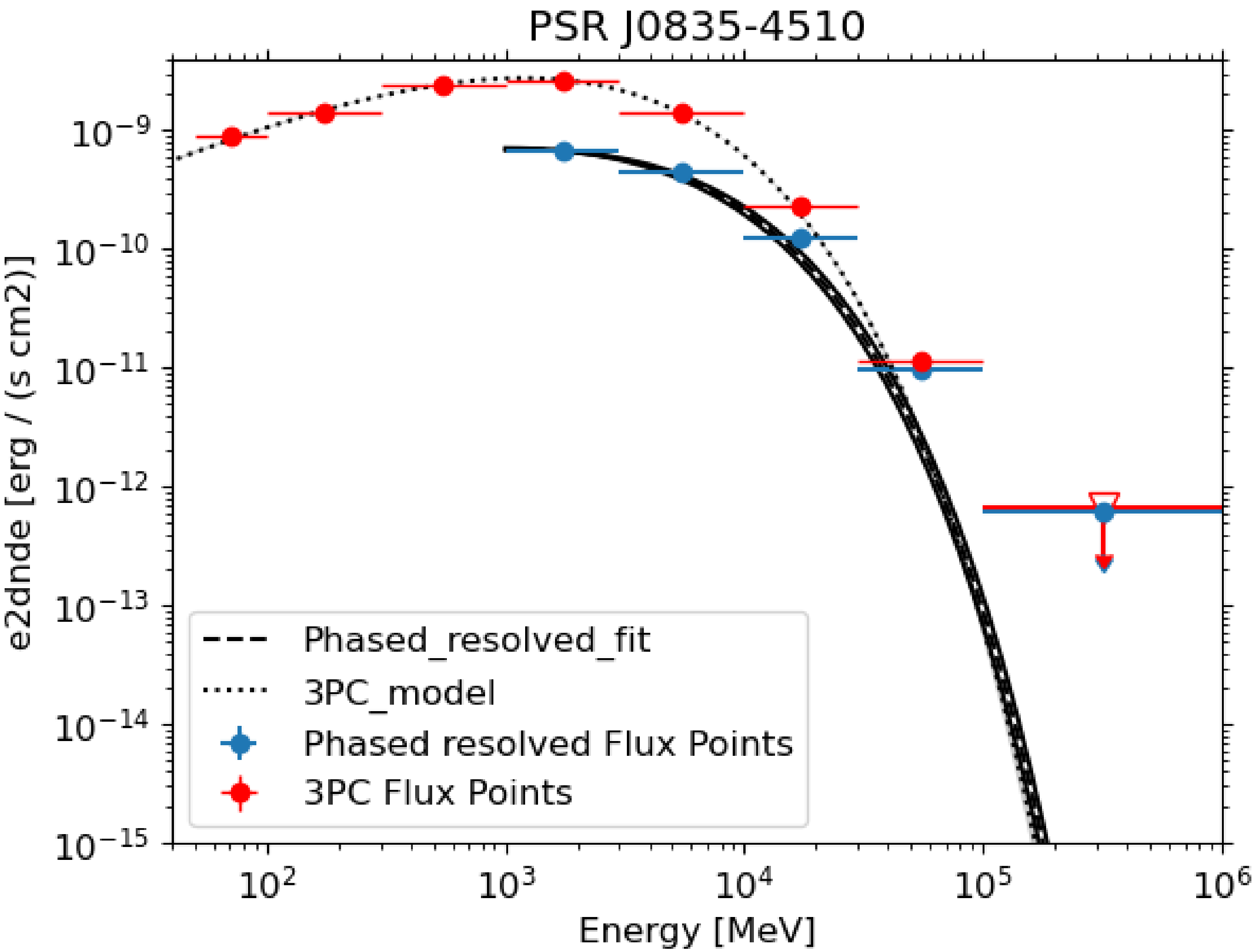


PSR B1706-44
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
E^2 dN/dE [erg cm^{-2} s^{-1}]
10^2
10^3
10^4
10^5
10^6
E [MeV]
3PC_model
Phased_resolved_fit
3PC Flux Points
Phased resolved Flux Points

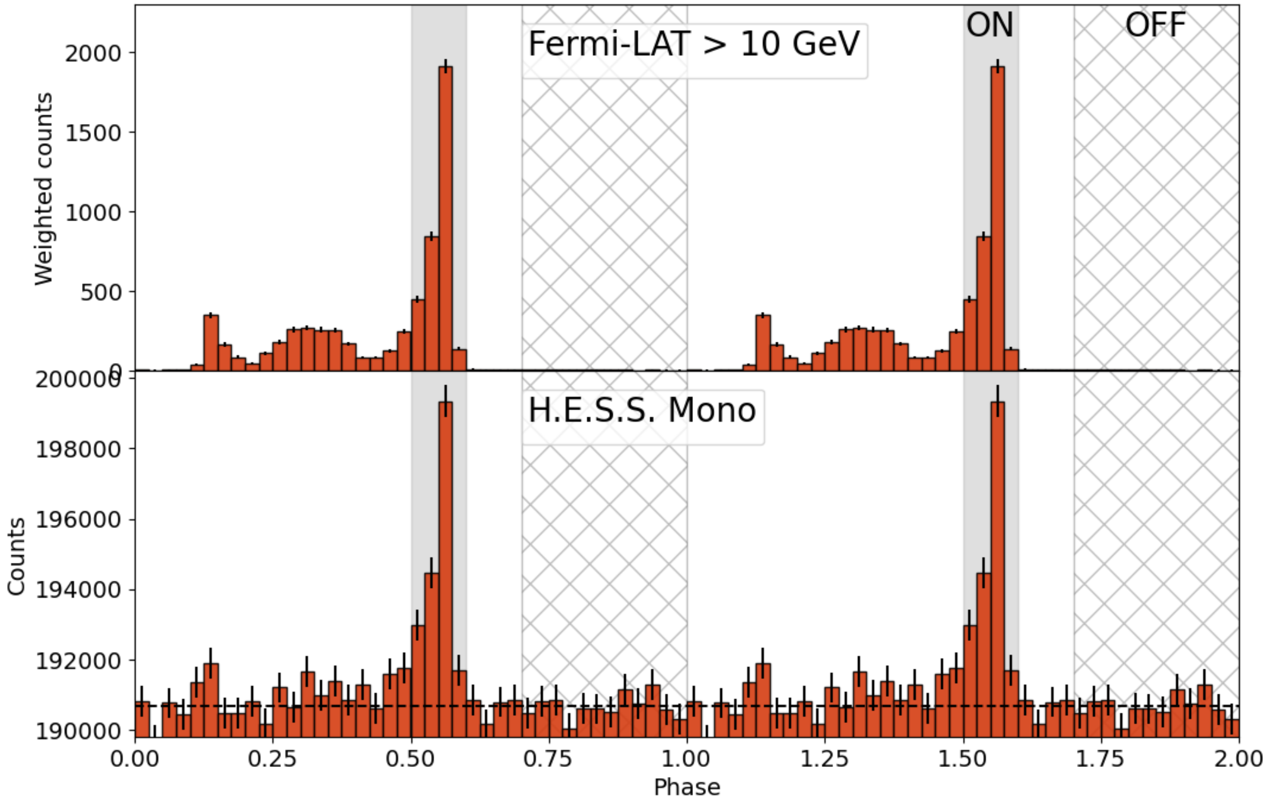
Backup



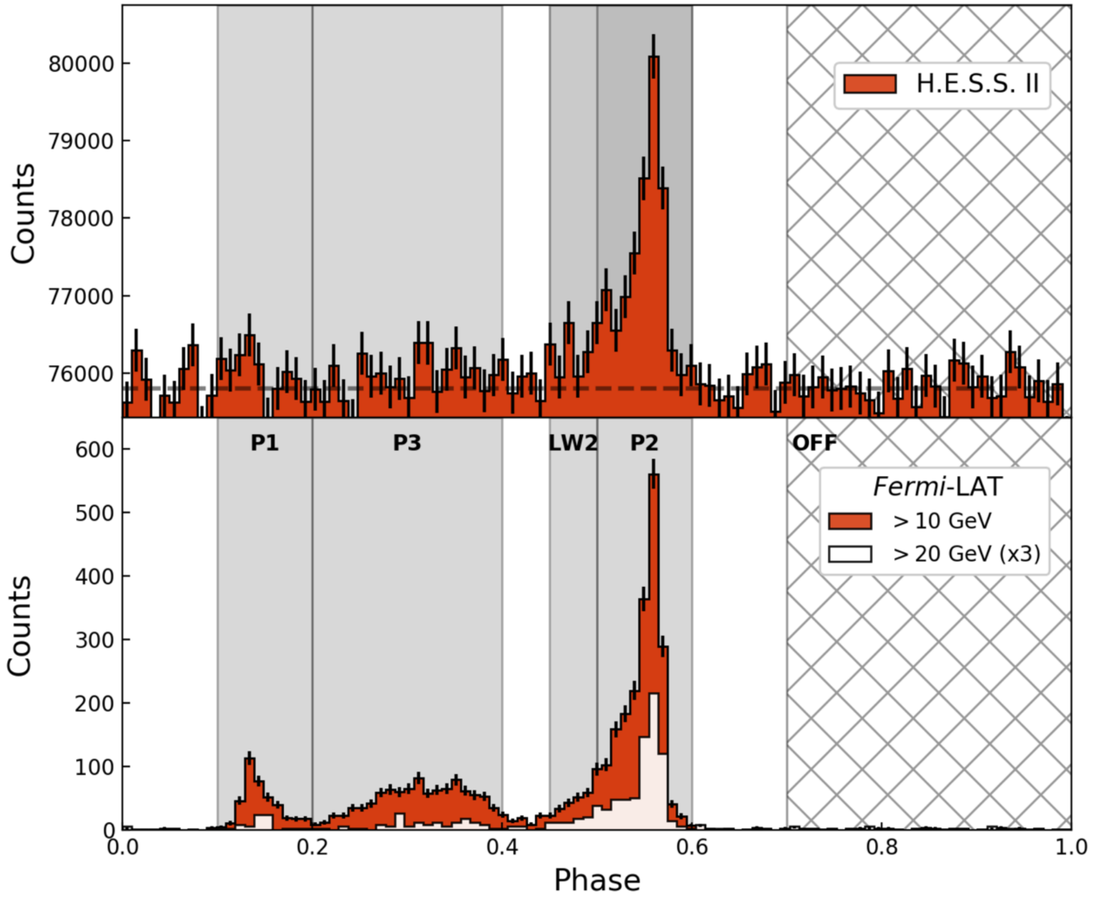
PSR J0835-4510
e2dnde [erg / (s cm2)]
Energy [MeV]
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
Phased_resolved_fit
3PC_model
Phased resolved Flux Points
3PC Flux Points

Vela: Phasograms

This work

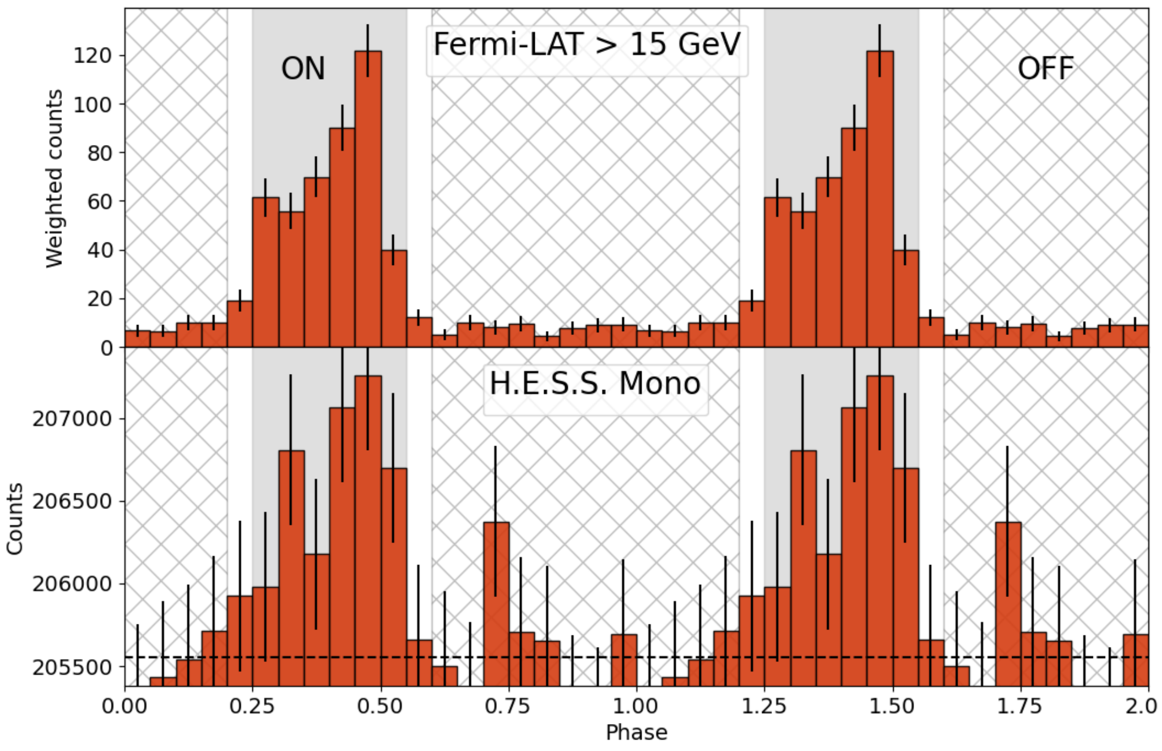


Vela Mono Paper

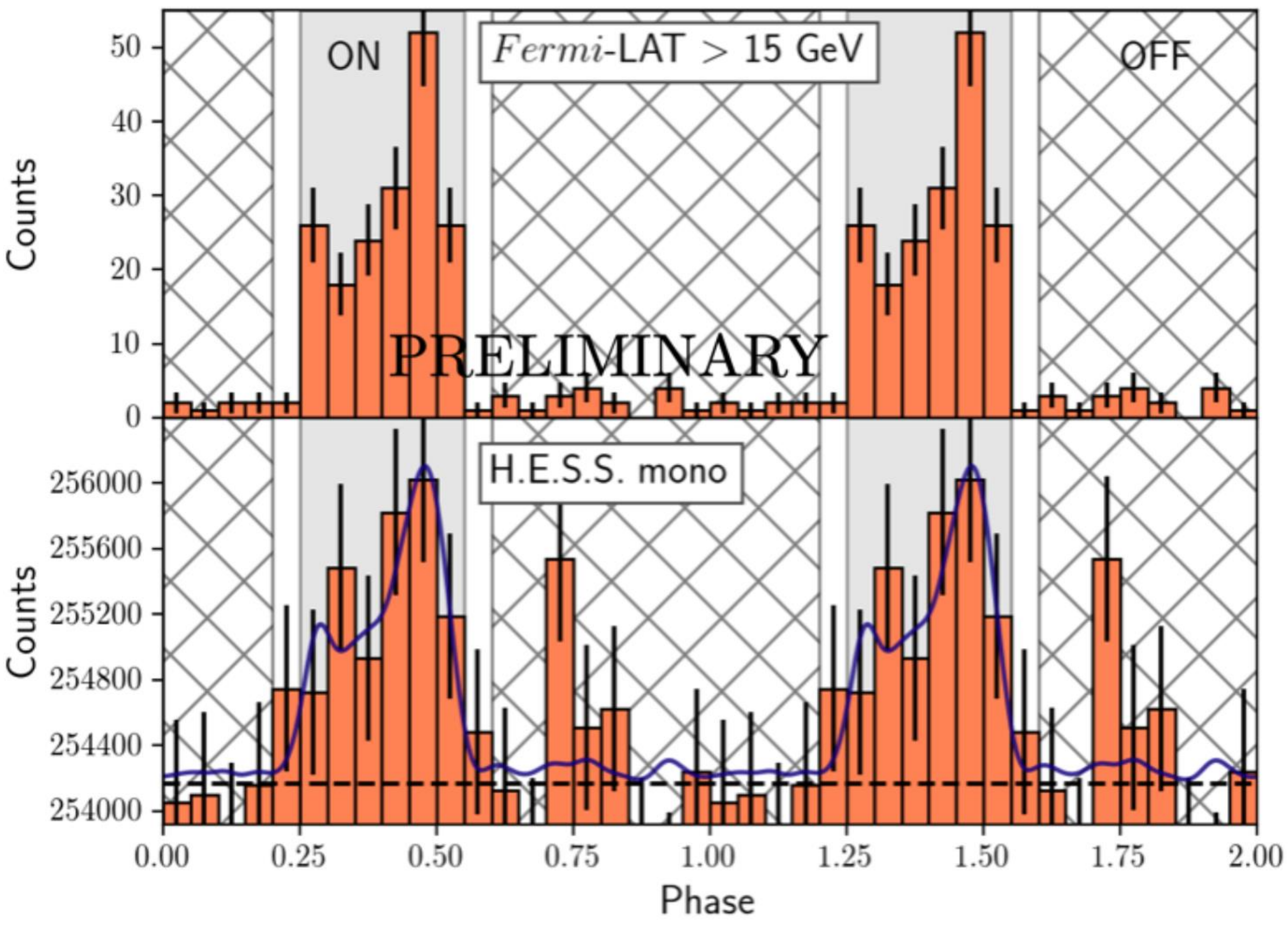


PSR B1706-44: Phasograms

This work



ICRC Proceeding 2019



Vela: H.E.S.S. Spectrum

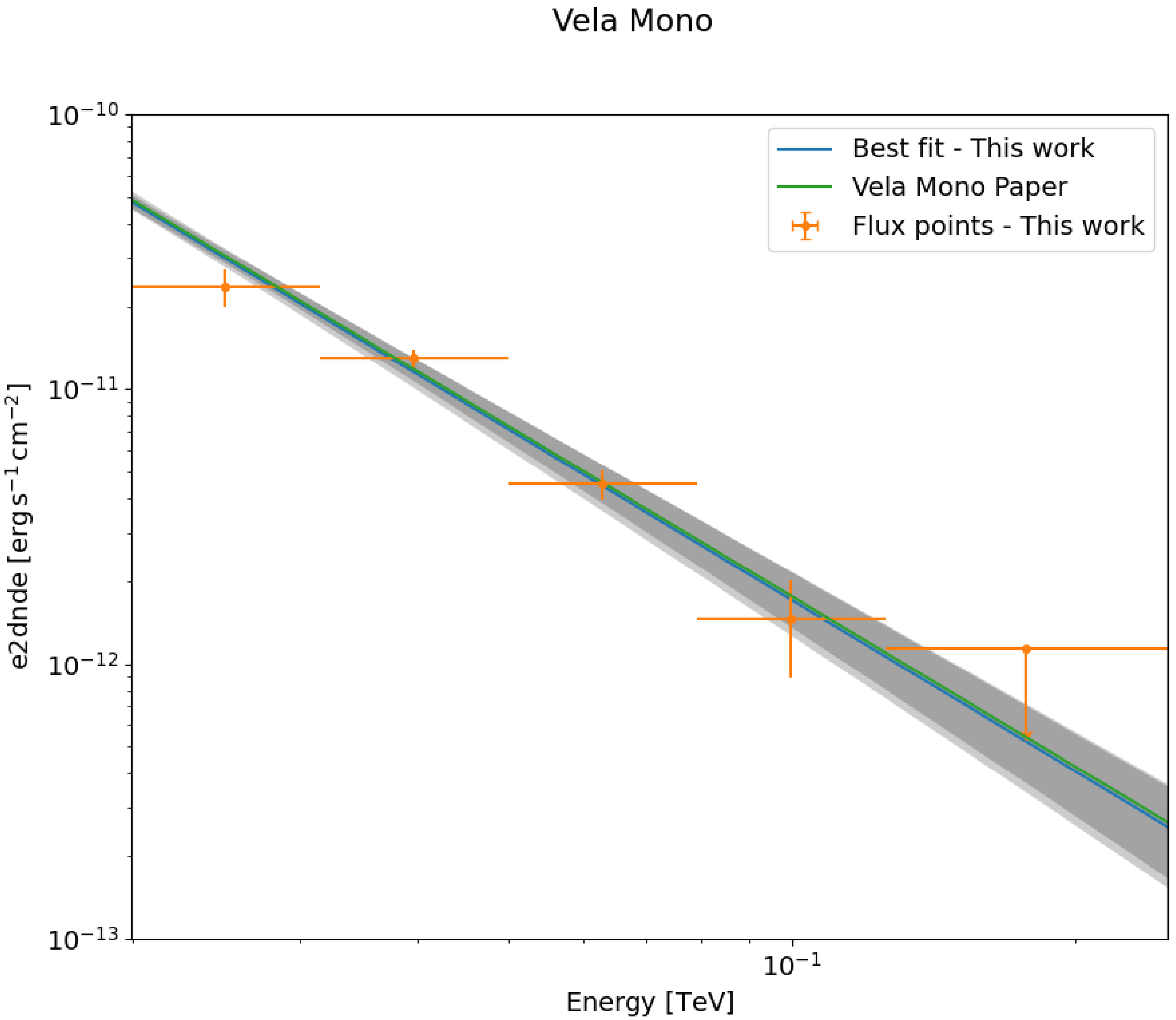
Power-law fit:

$\phi(25\ GeV) = 3.0 \times 10^{-8} \pm 0.2\ TeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 4.1\ \pm 0.2$

Power-law Paper:

$\phi(25\ GeV) = 3.0 \times 10^{-8} \pm 0.2\ TeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 4.1\ \pm 0.2$

Perfect agreement between the two models !



PSR B1706-44: H.E.S.S. Spectrum

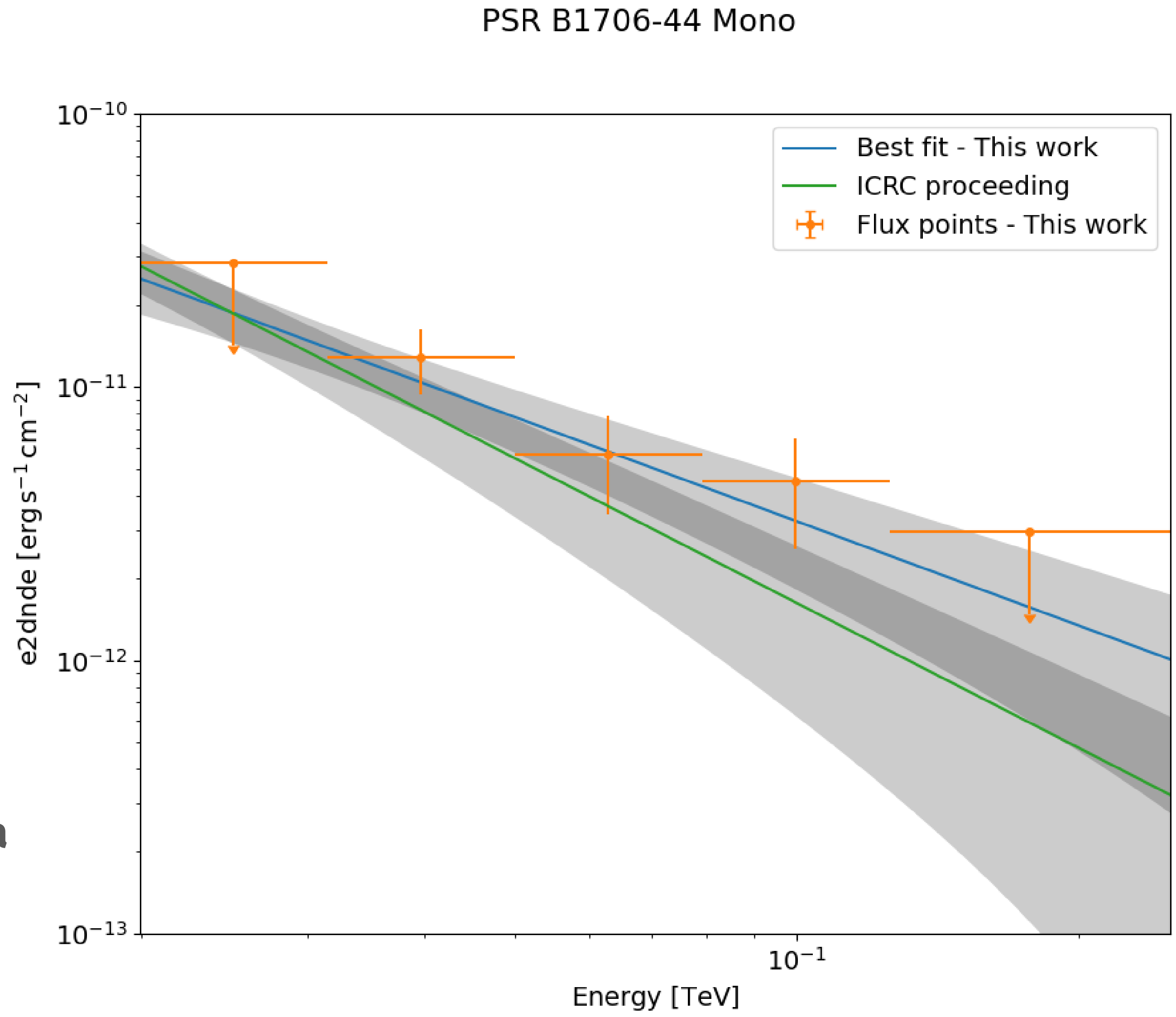
Power-law fit:

$\phi(20\ GeV) = 3.9 \times 10^{-8} \pm 0.9\ TeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 3.4\ \pm 0.3$

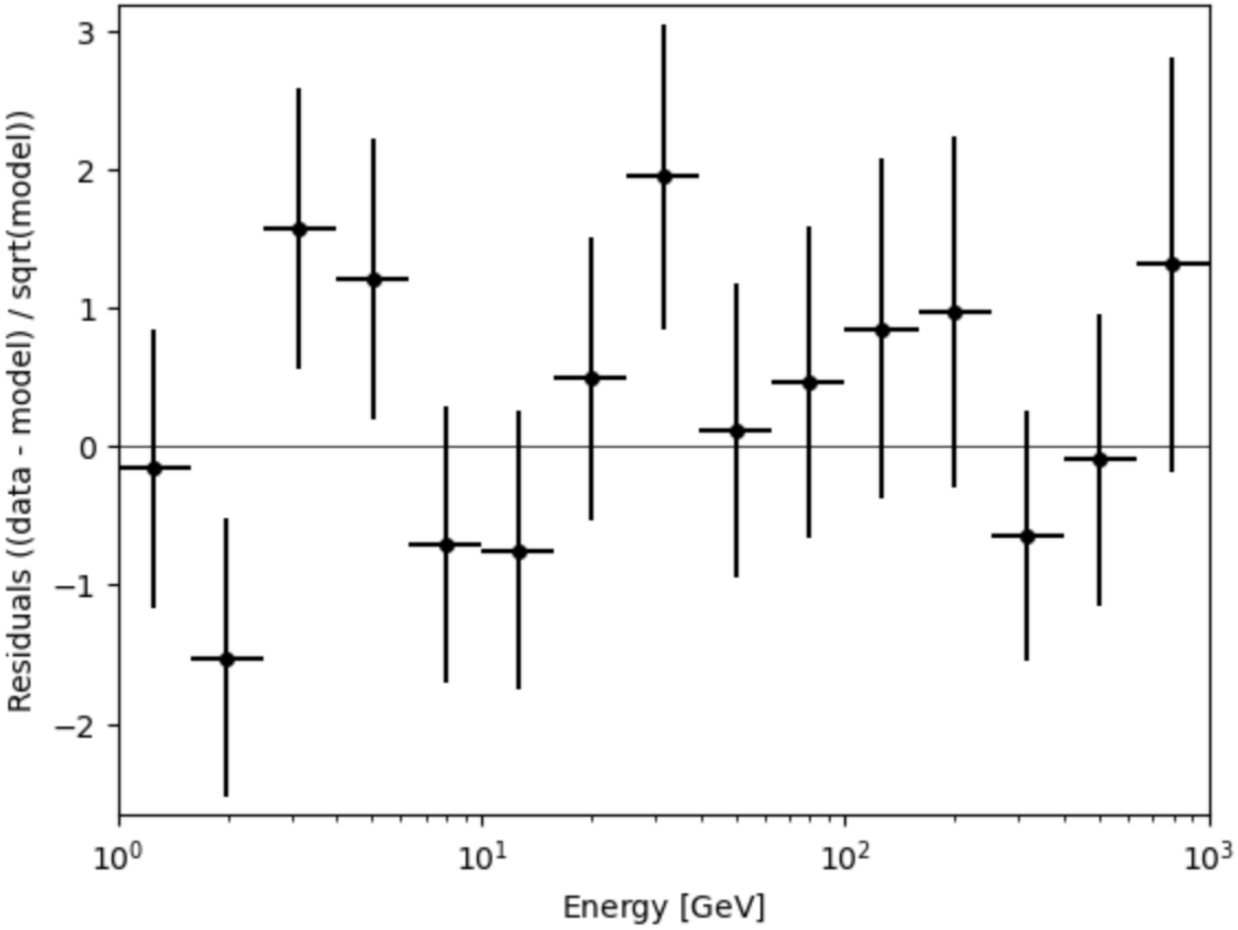
Power-law ICRC 2019:

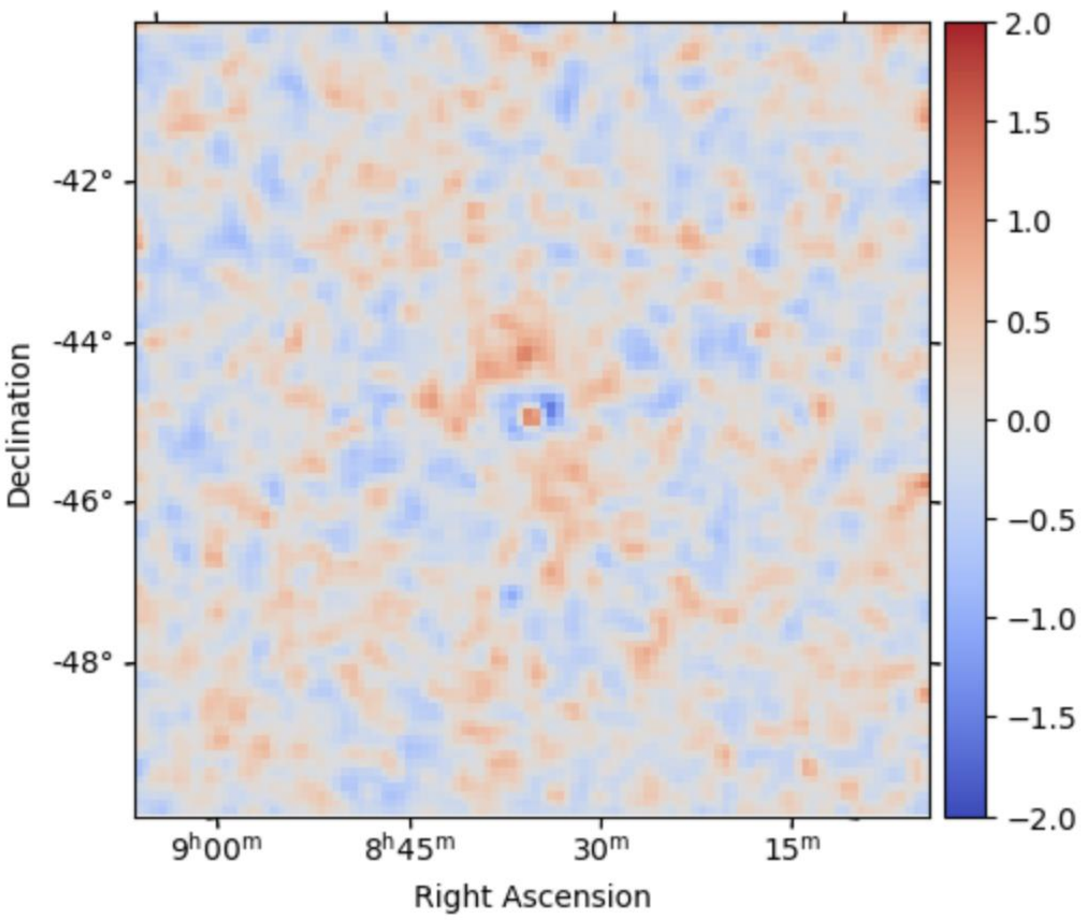
$\phi(20\ GeV) = 4.3 \times 10^{-8} \pm 0.9\ TeV^{-1}s^{-1}cm^{-2}$
$\Gamma = 3.7\ \pm 0.4$

The fitted index is harder than the ICRC proceeding but compatible.
This is due to the difference between the two data sets.

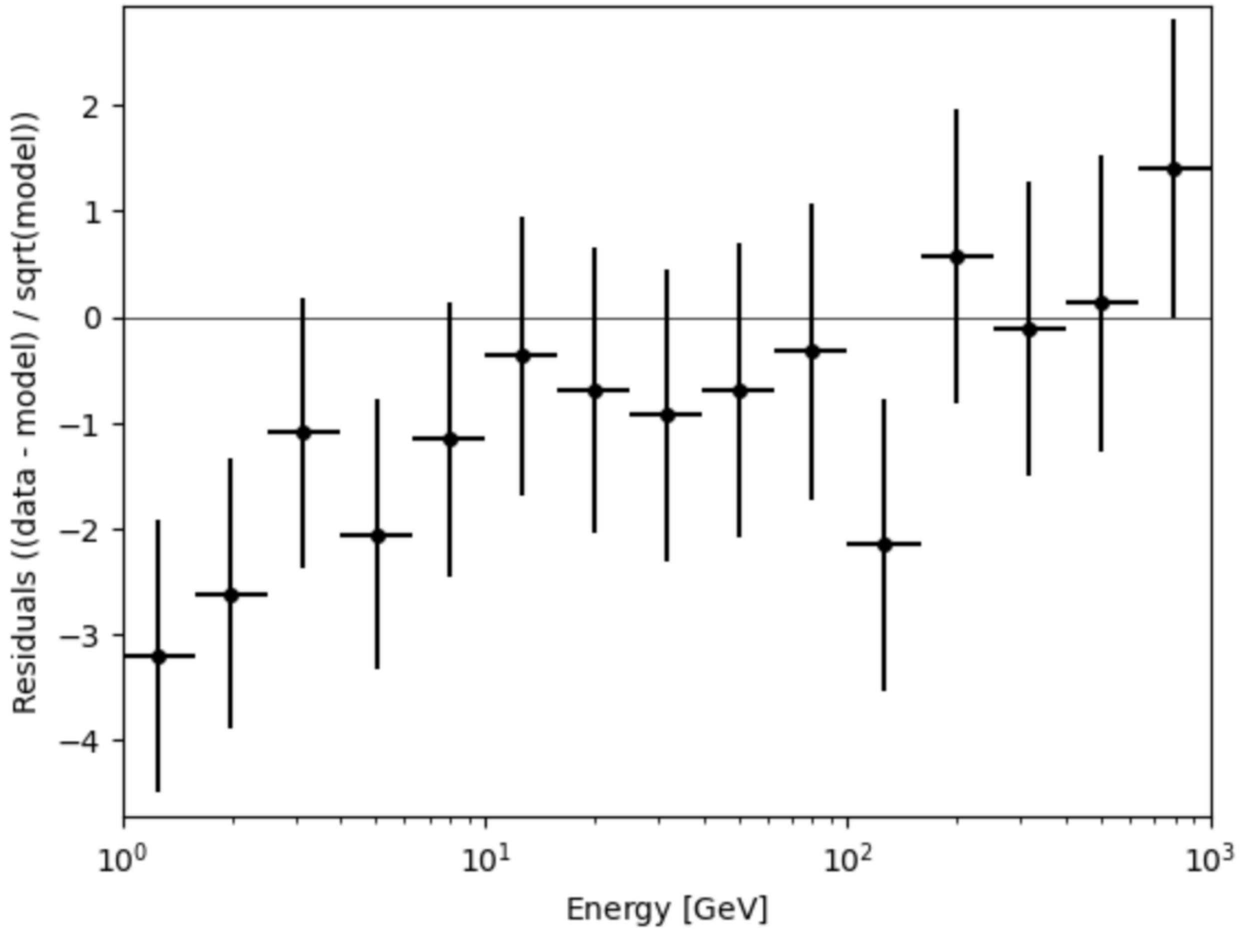


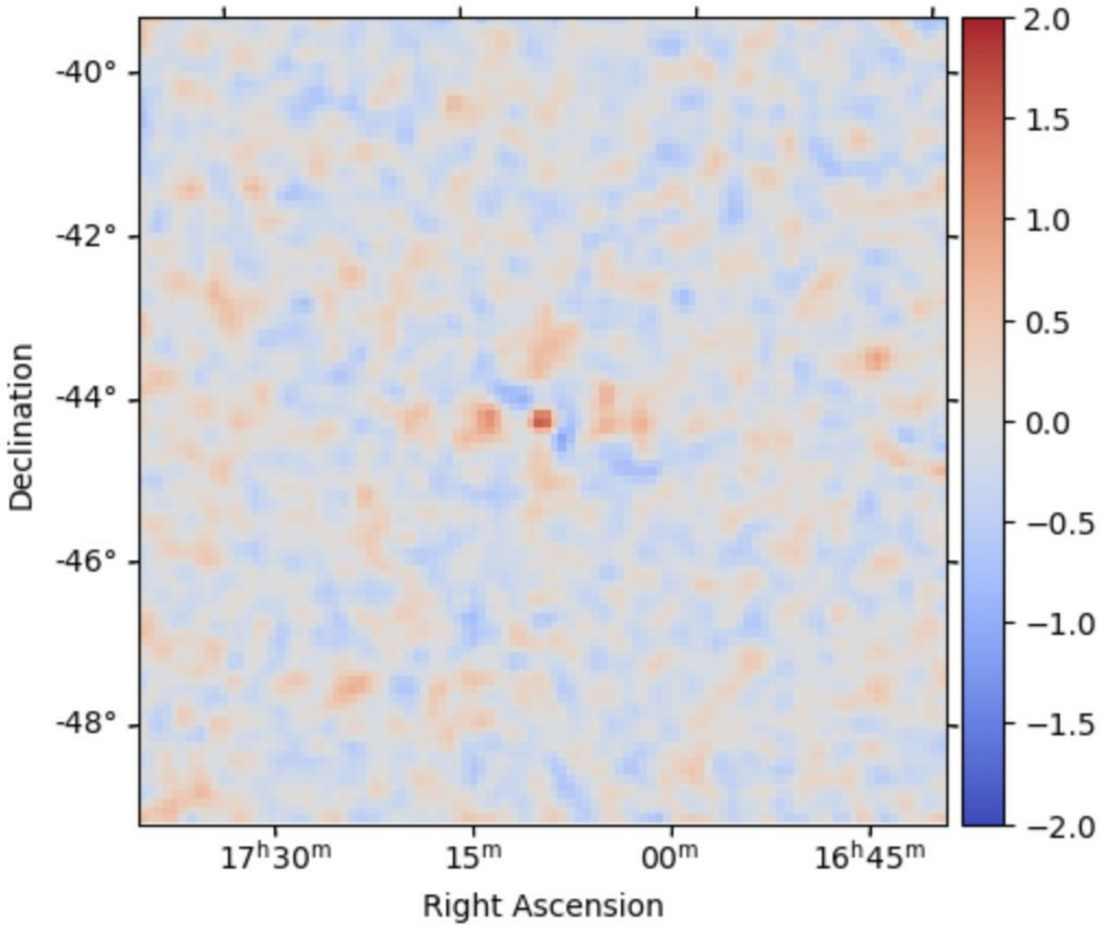
Vela: Fermi-LAT



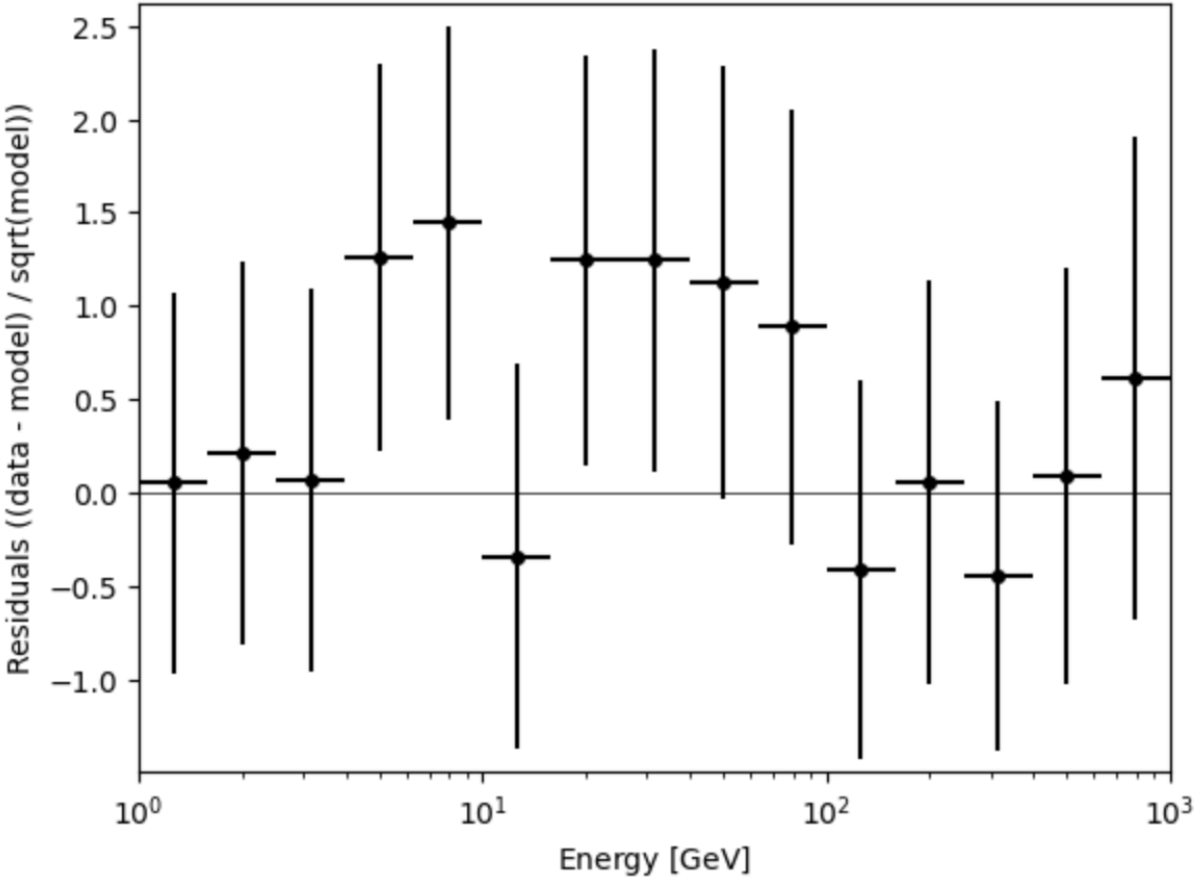


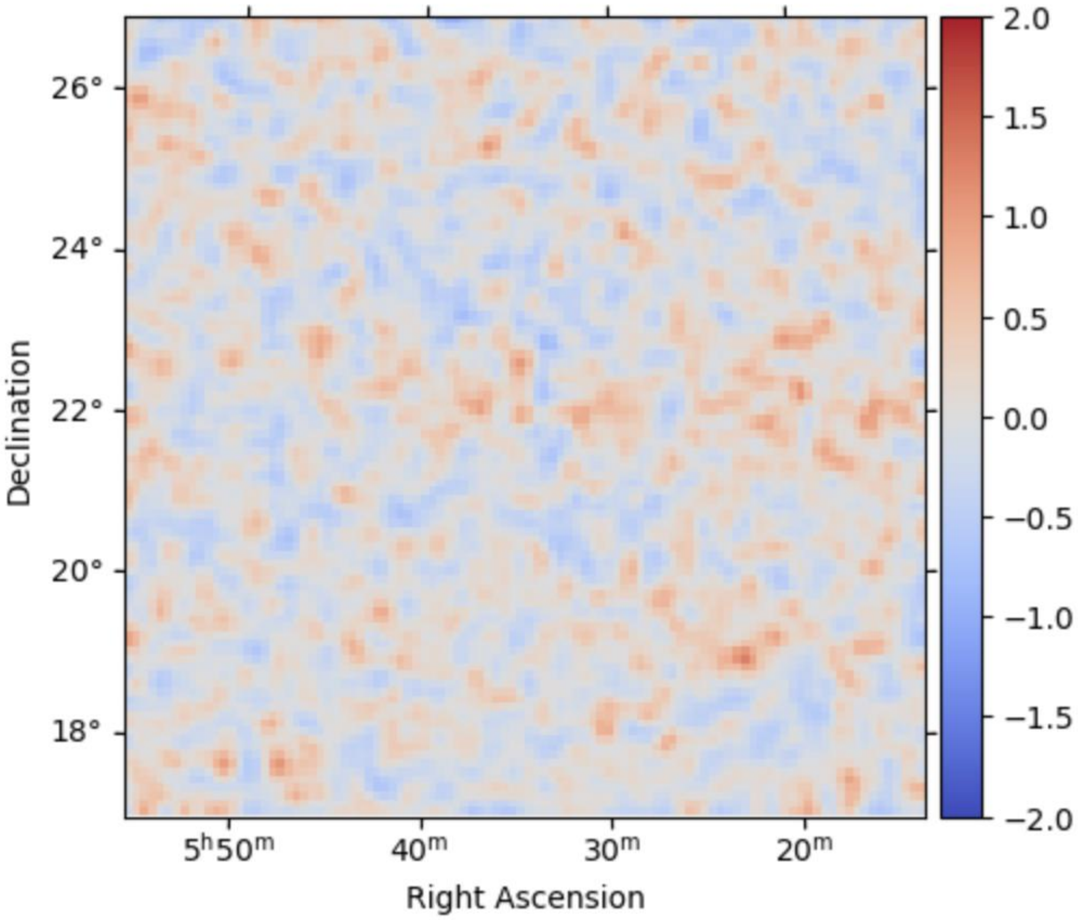
PSR B1706-44: Fermi-LAT



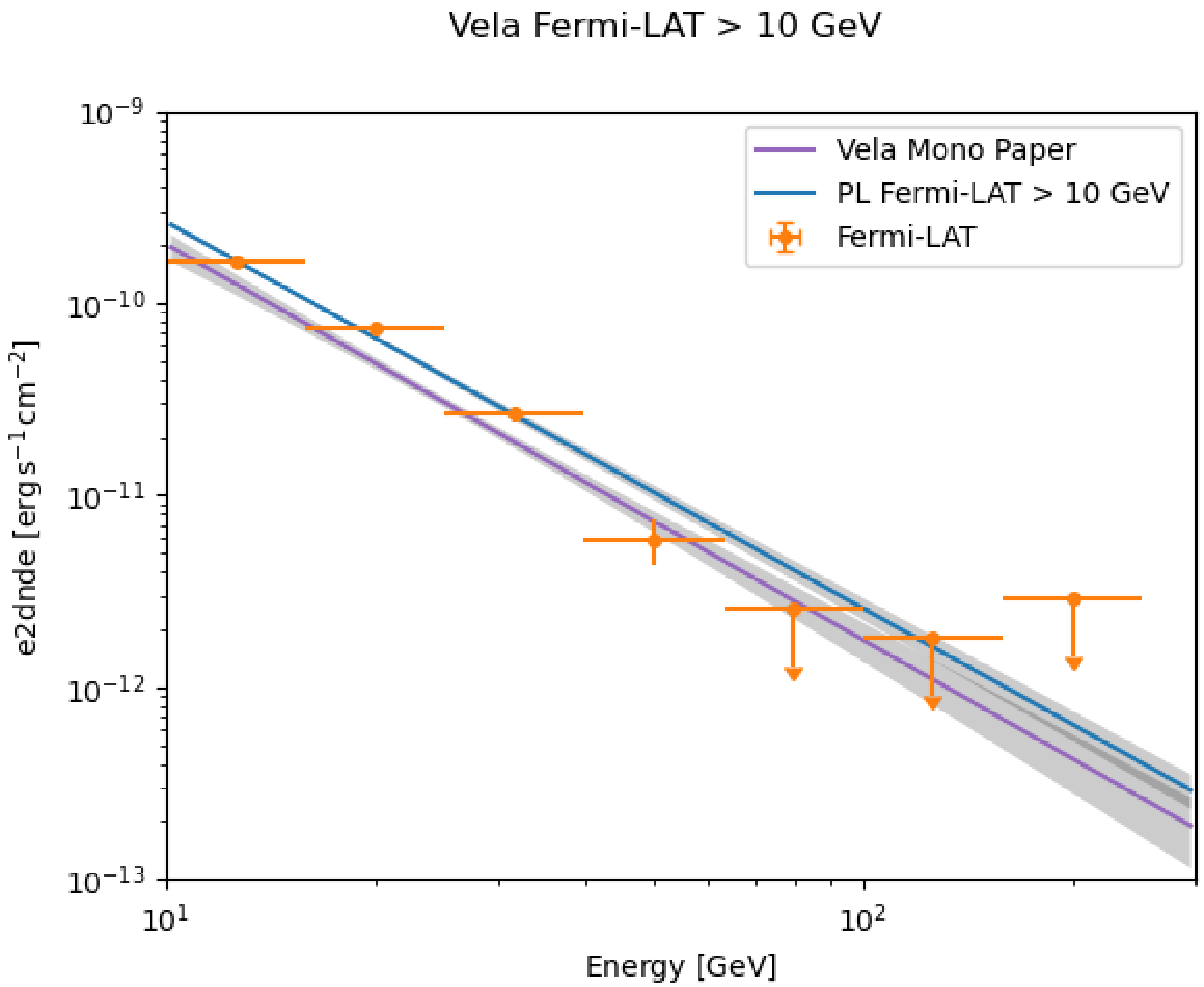


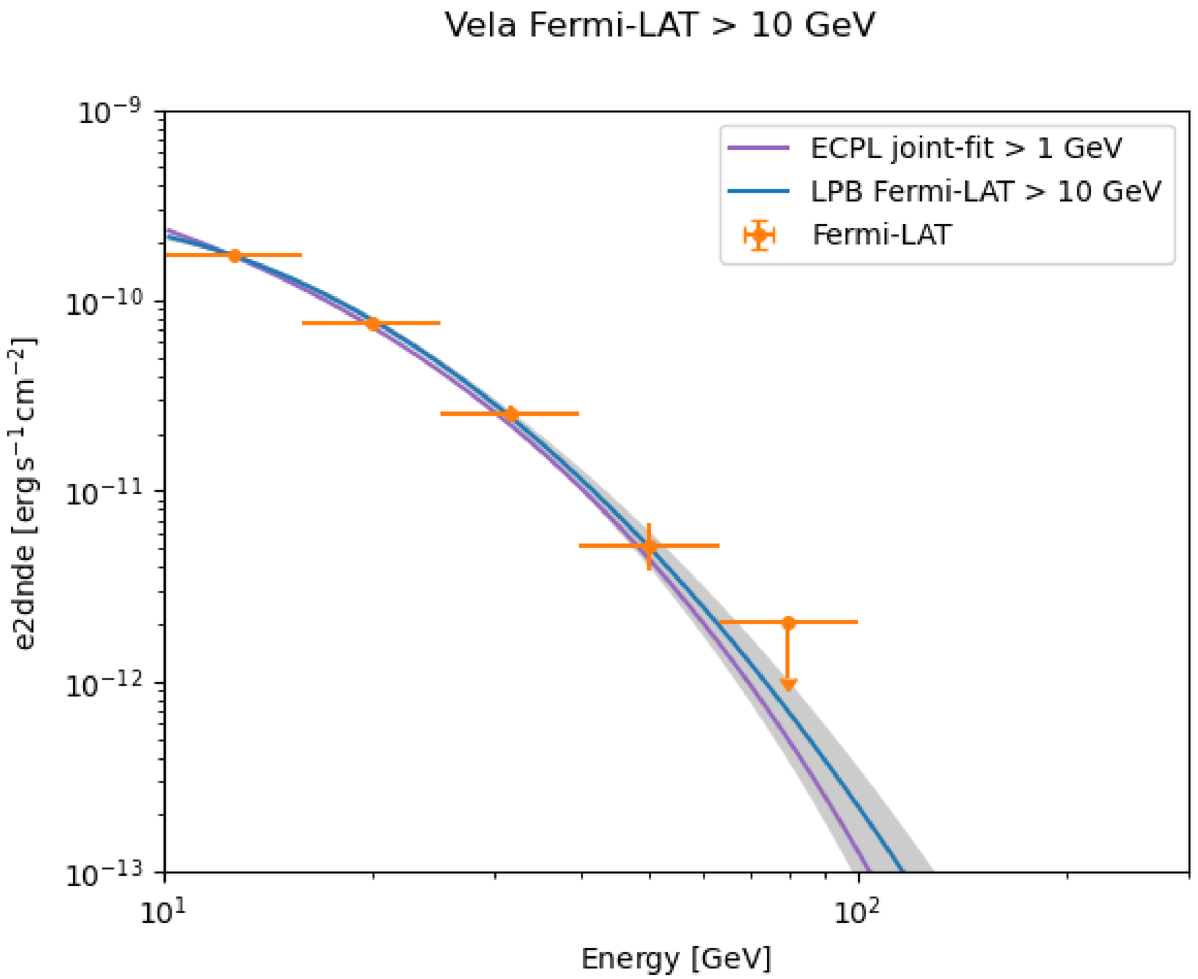
Crab: Fermi-LAT



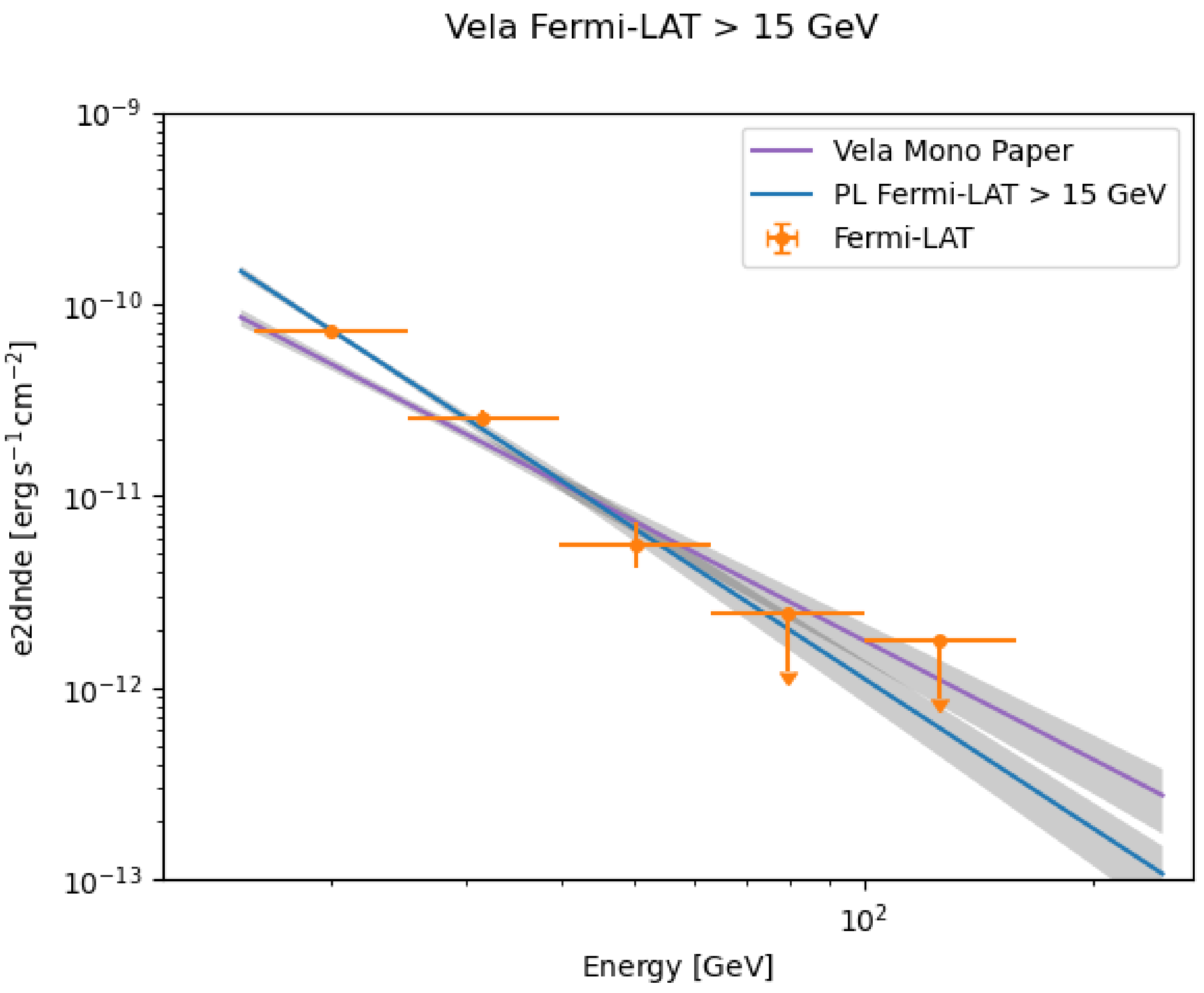


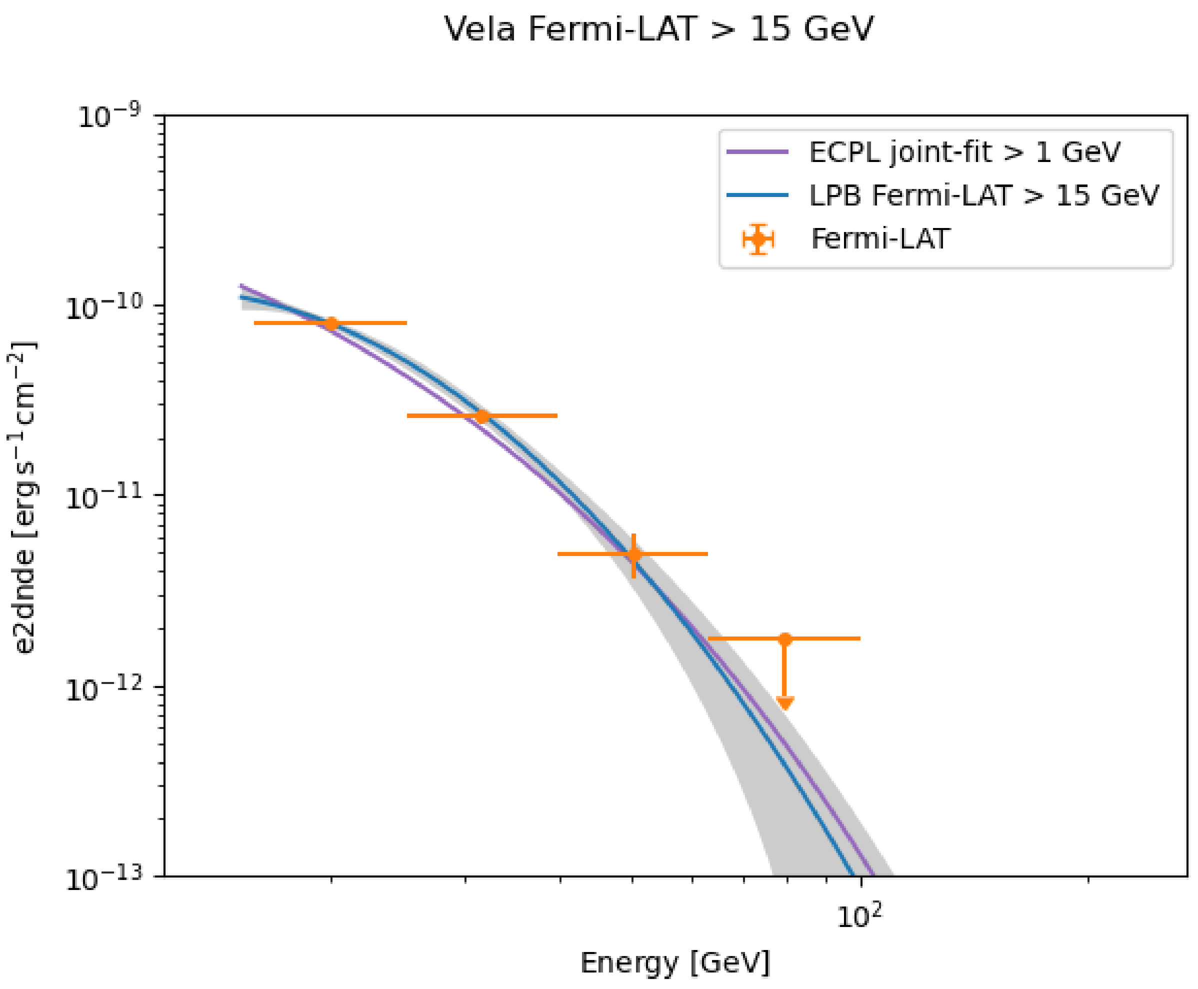
Backup


Vela Fermi-LAT > 10 GeV
Vela Mono Paper
PL Fermi-LAT > 10 GeV
Fermi-LAT
e2dnde [erg s^{-1} cm^{-2}]
Energy [GeV]
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{1}
10^{2}

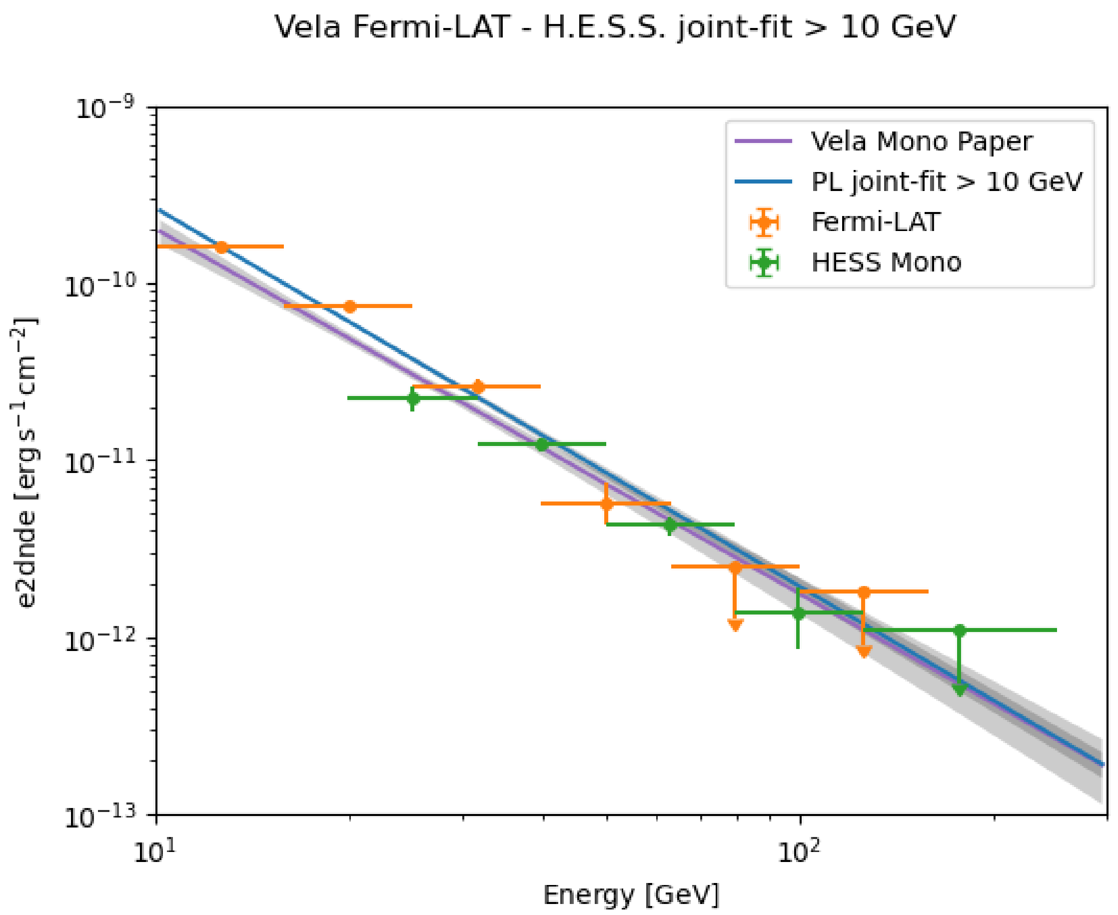

Vela Fermi-LAT > 10 GeV
ECPL joint-fit > 1 GeV
LPB Fermi-LAT > 10 GeV
Fermi-LAT
e2dnde [erg s^{-1} cm^{-2}]
Energy [GeV]
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{1}
10^{2}

Backup

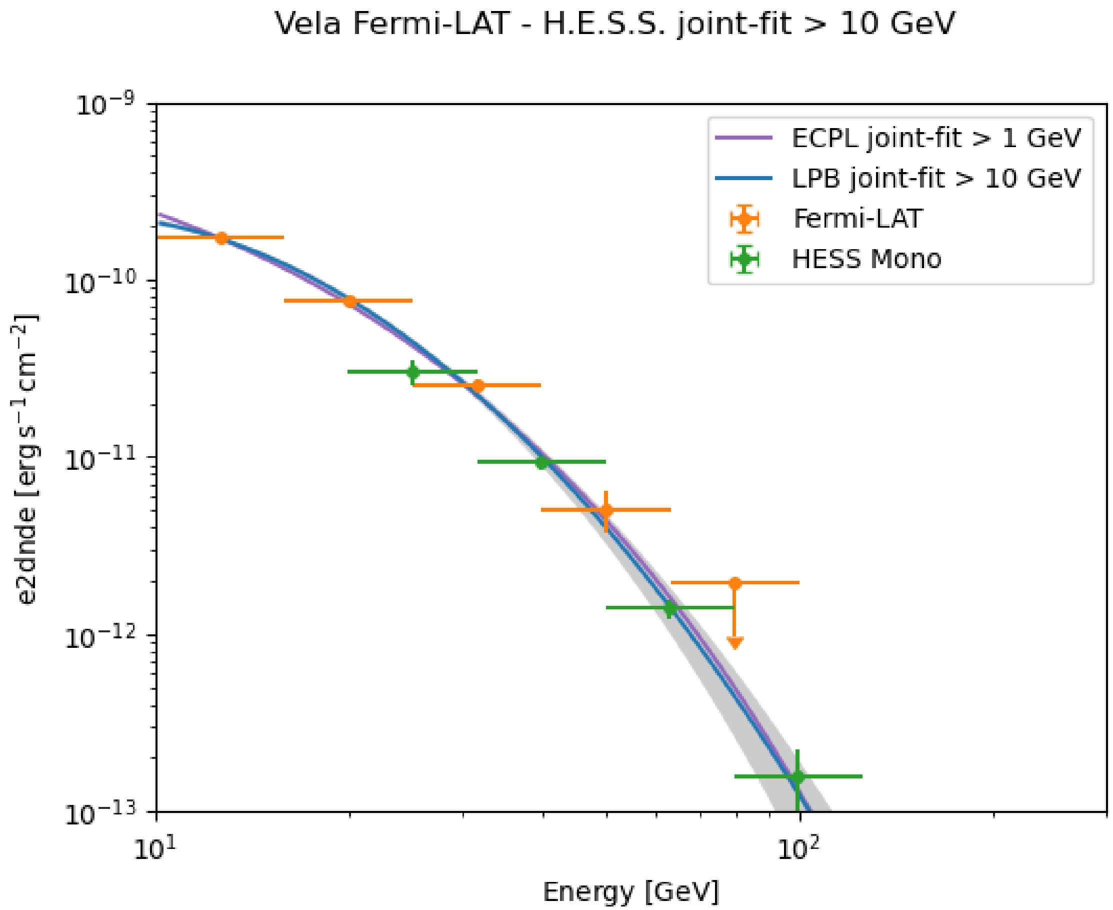

Vela Fermi-LAT > 15 GeV
Vela Mono Paper
PL Fermi-LAT > 15 GeV
Fermi-LAT
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
e2dnde [$\mathrm{erg\,s^{-1}cm^{-2}}$]
10^2
Energy [GeV]


Vela Fermi-LAT > 15 GeV
ECPL joint-fit > 1 GeV
LPB Fermi-LAT > 15 GeV
Fermi-LAT
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
e2dnde [$\mathrm{erg\,s^{-1}cm^{-2}}$]
10^2
Energy [GeV]

Backup

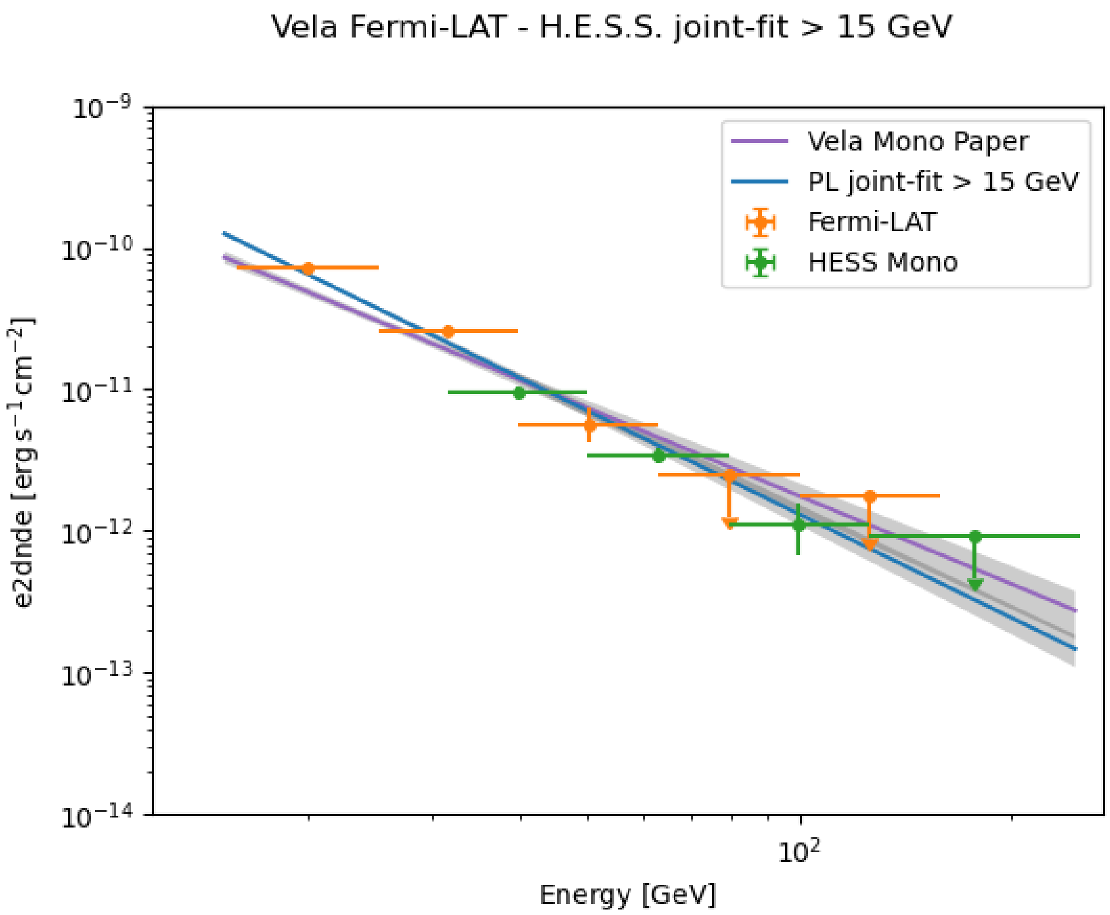


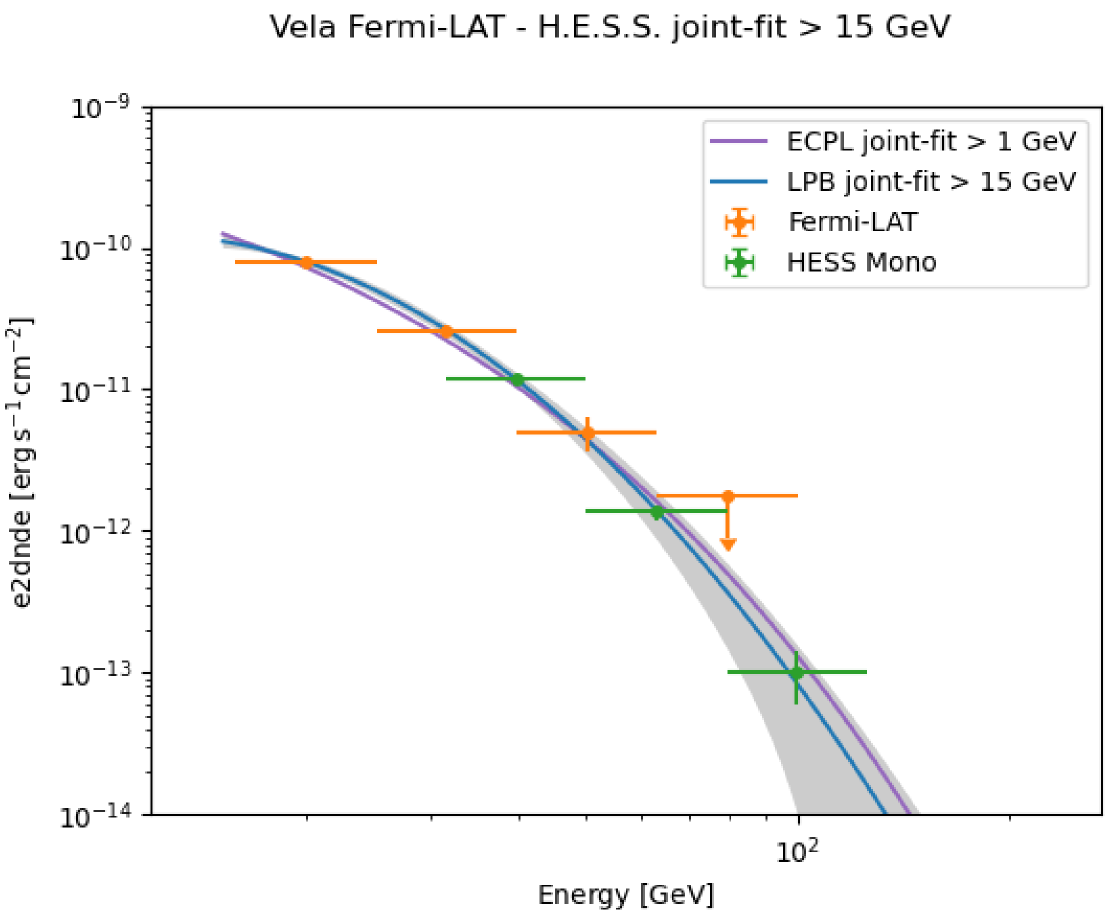
Vela Fermi-LAT - H.E.S.S. joint-fit > 10 GeV
Vela Mono Paper
PL joint-fit > 10 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s−1 cm−2]
Energy [GeV]



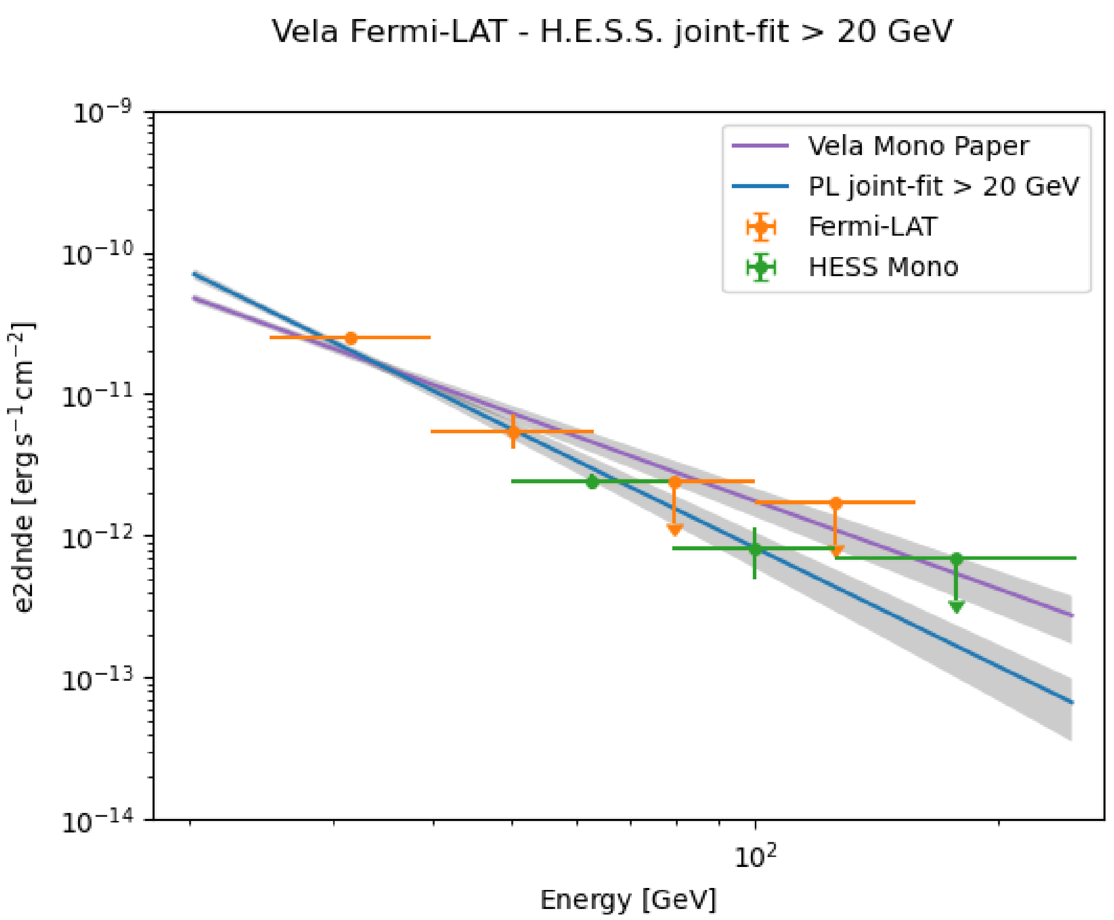
Vela Fermi-LAT - H.E.S.S. joint-fit > 10 GeV
ECPL joint-fit > 1 GeV
LPB joint-fit > 10 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s−1 cm−2]
Energy [GeV]

Backup

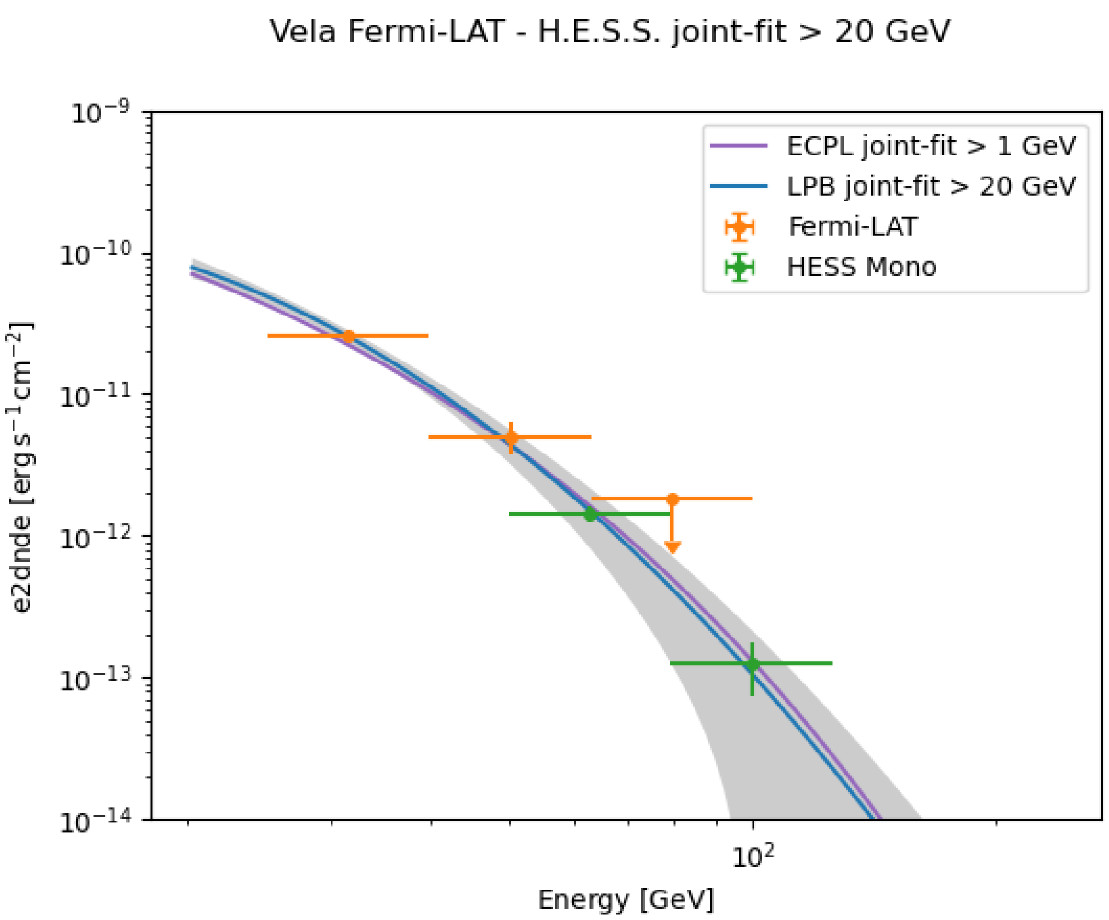

Vela Fermi-LAT - H.E.S.S. joint-fit > 15 GeV
Vela Mono Paper
PL joint-fit > 15 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s−1 cm−2]
Energy [GeV]


Vela Fermi-LAT - H.E.S.S. joint-fit > 15 GeV
ECPL joint-fit > 1 GeV
LPB joint-fit > 15 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s−1 cm−2]
Energy [GeV]

Backup

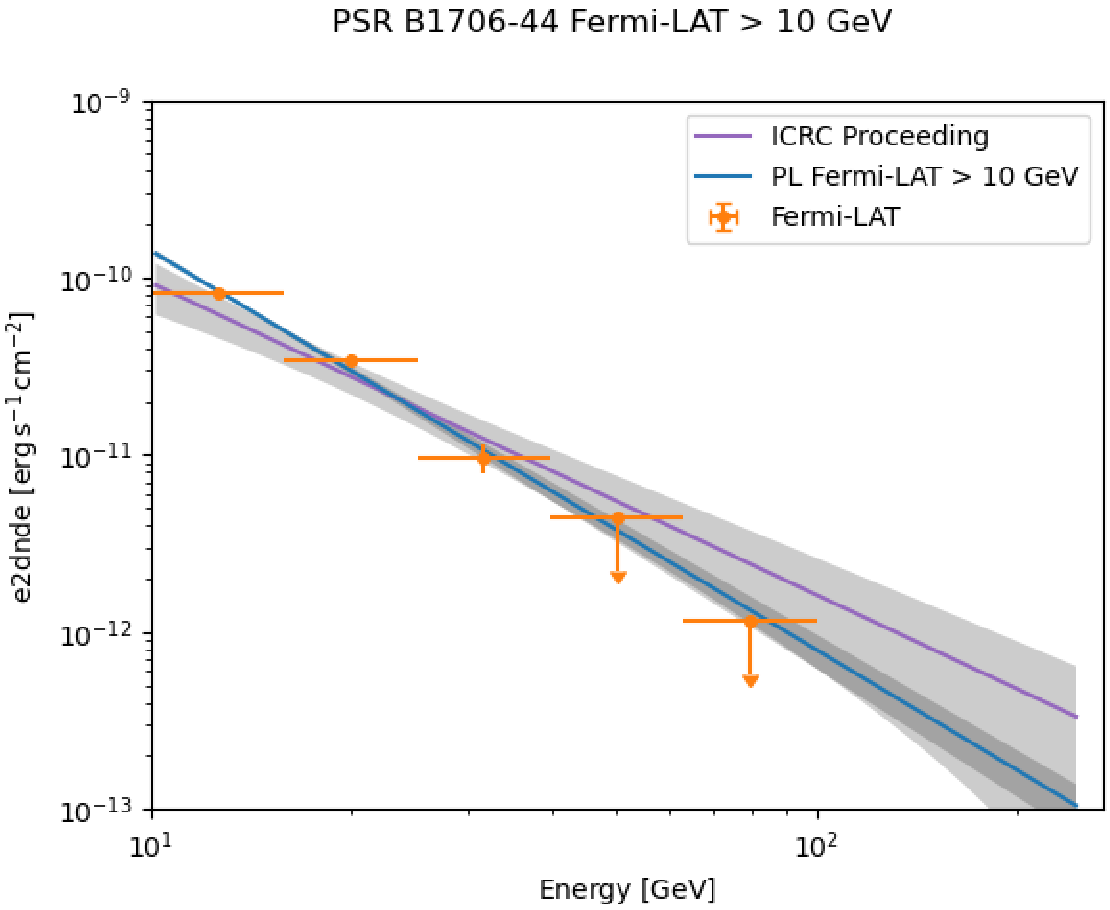


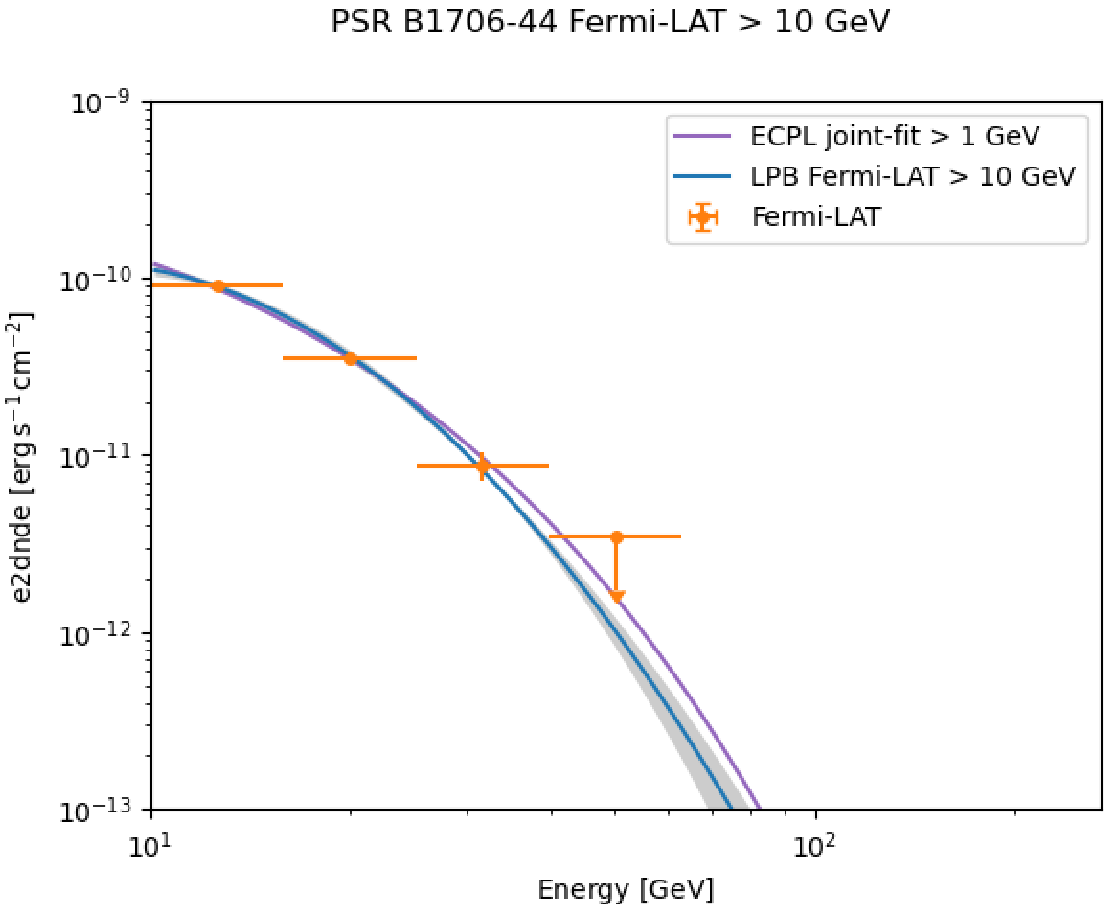
Vela Fermi-LAT - H.E.S.S. joint-fit > 20 GeV
Vela Mono Paper
PL joint-fit > 20 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s^{-1}cm^{-2}]
Energy [GeV]



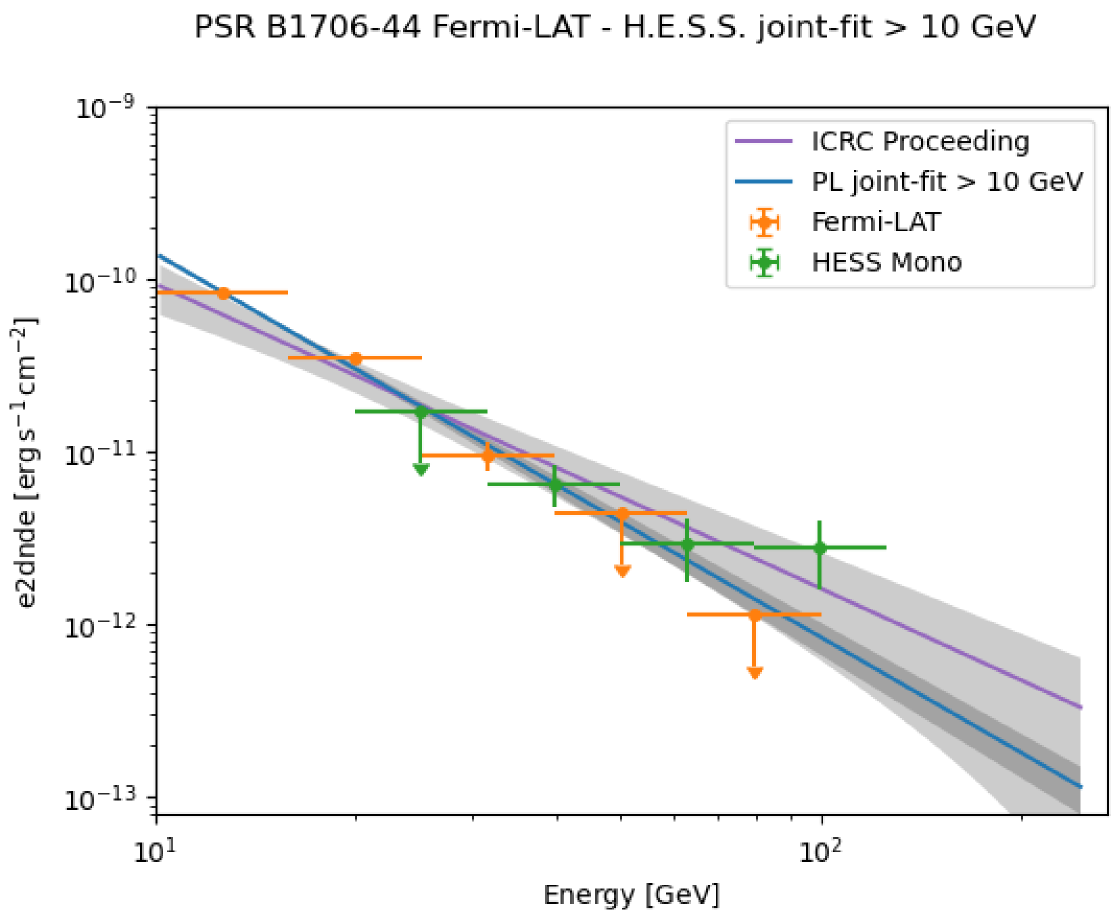
Vela Fermi-LAT - H.E.S.S. joint-fit > 20 GeV
ECPL joint-fit > 1 GeV
LPB joint-fit > 20 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s^{-1}cm^{-2}]
Energy [GeV]

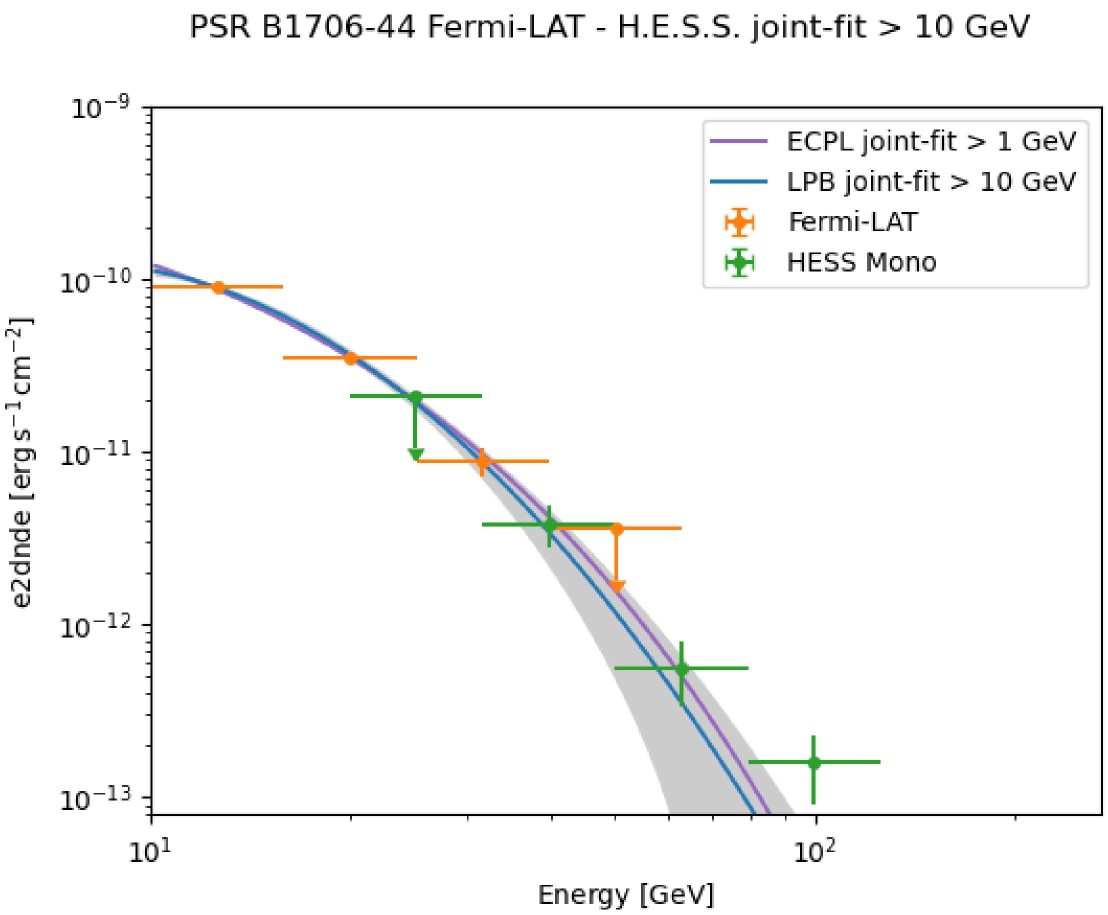
Backup


PSR B1706-44 Fermi-LAT > 10 GeV
ICRC Proceeding
PL Fermi-LAT > 10 GeV
Fermi-LAT
e2dnde [erg s^{-1} cm^{-2}]
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{1}
10^{2}
Energy [GeV]

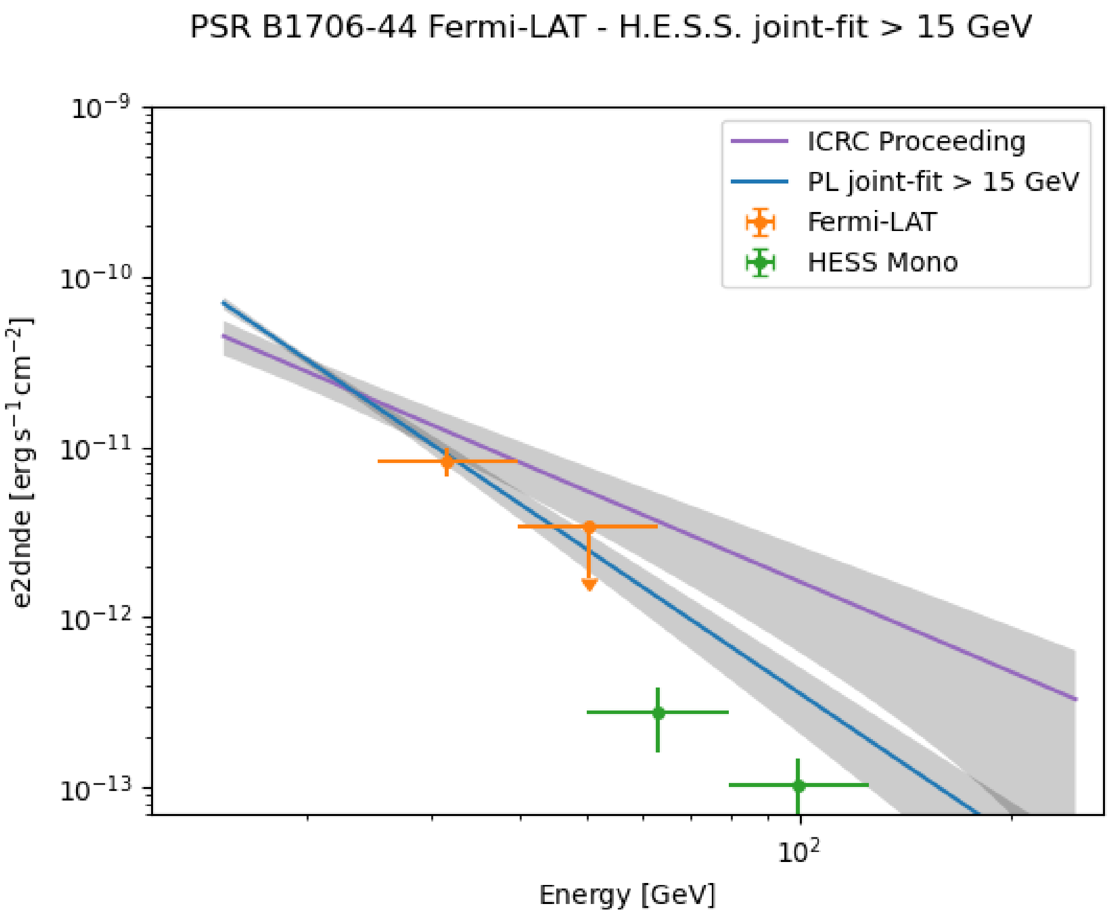

PSR B1706-44 Fermi-LAT > 10 GeV
ECPL joint-fit > 1 GeV
LPB Fermi-LAT > 10 GeV
Fermi-LAT
e2dnde [erg s^{-1} cm^{-2}]
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{1}
10^{2}
Energy [GeV]

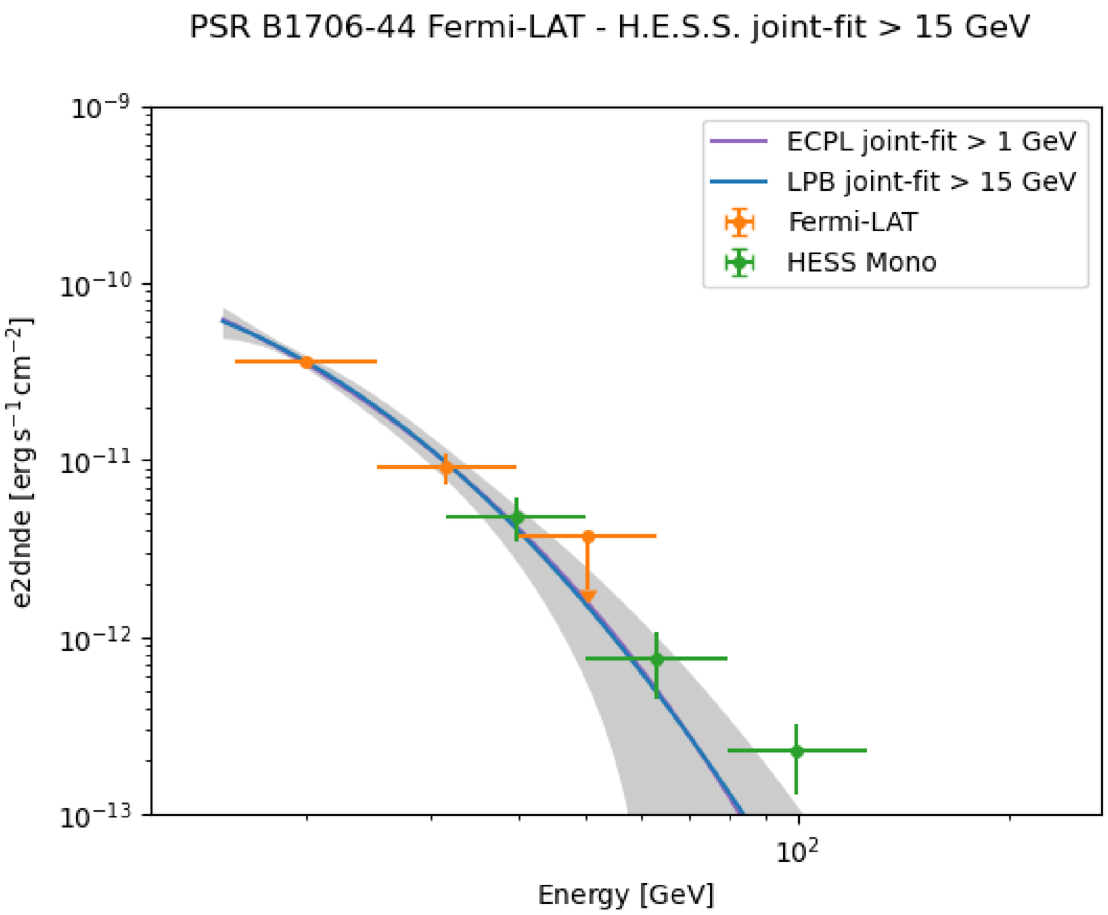
Backup


PSR B1706-44 Fermi-LAT - H.E.S.S. joint-fit > 10 GeV
ICRC Proceeding
PL joint-fit > 10 GeV
Fermi-LAT
HESS Mono
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
e2dnde [$\mathrm{erg\,s^{-1}cm^{-2}}$]
10^{1}
10^{2}
Energy [GeV]

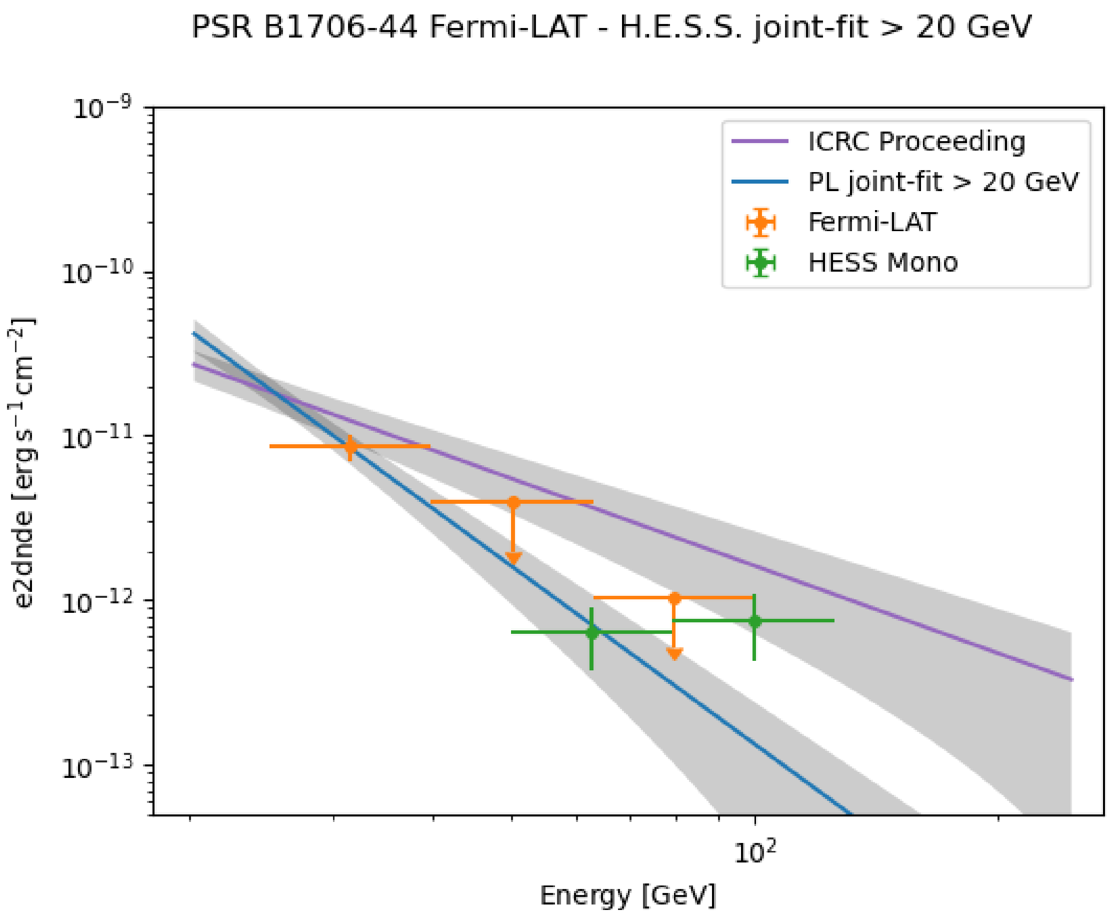

PSR B1706-44 Fermi-LAT - H.E.S.S. joint-fit > 10 GeV
ECPL joint-fit > 1 GeV
LPB joint-fit > 10 GeV
Fermi-LAT
HESS Mono
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
e2dnde [$\mathrm{erg\,s^{-1}cm^{-2}}$]
10^{1}
10^{2}
Energy [GeV]

Backup

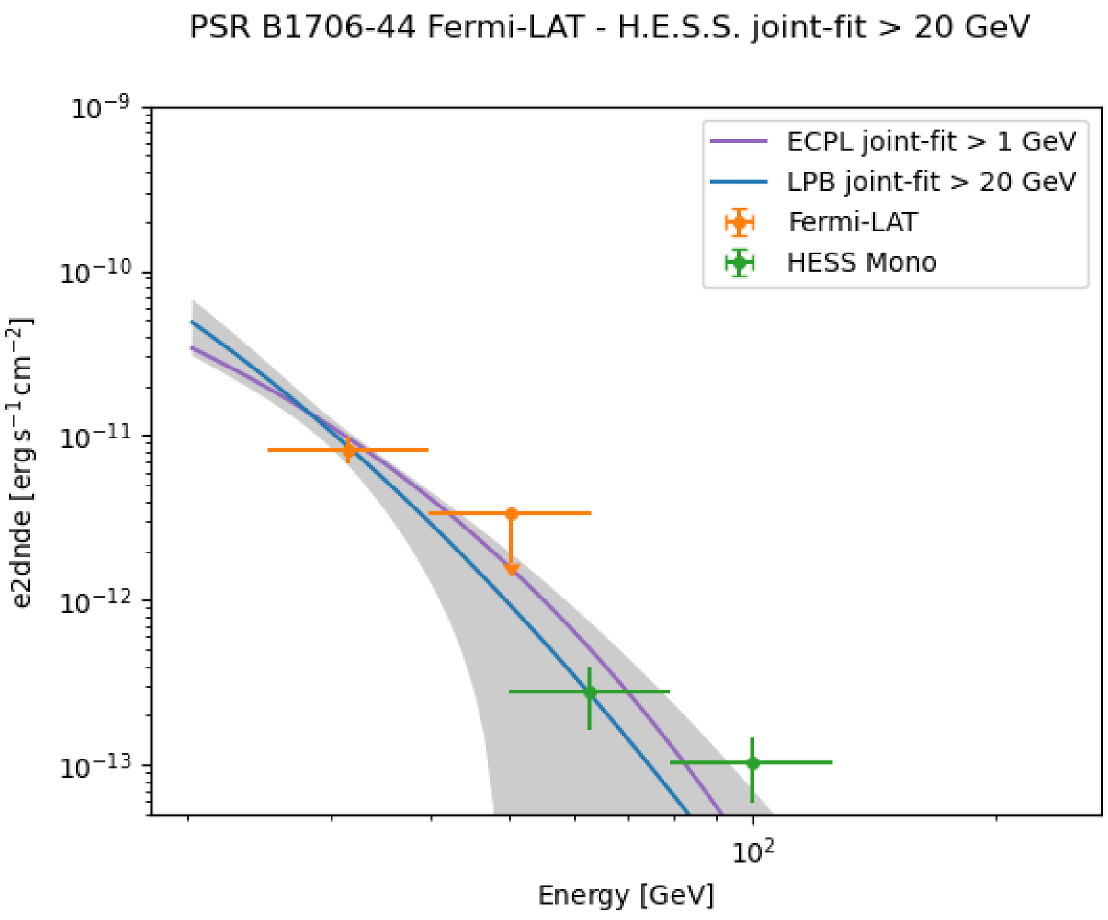

PSR B1706-44 Fermi-LAT - H.E.S.S. joint-fit > 15 GeV
ICRC Proceeding
PL joint-fit > 15 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s^{-1}cm^{-2}]
Energy [GeV]


PSR B1706-44 Fermi-LAT - H.E.S.S. joint-fit > 15 GeV
ECPL joint-fit > 1 GeV
LPB joint-fit > 15 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s^{-1}cm^{-2}]
Energy [GeV]

Backup



PSR B1706-44 Fermi-LAT - H.E.S.S. joint-fit > 20 GeV
ICRC Proceeding
PL joint-fit > 20 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s^{-1} cm^{-2}]
Energy [GeV]



PSR B1706-44 Fermi-LAT - H.E.S.S. joint-fit > 20 GeV
ECPL joint-fit > 1 GeV
LPB joint-fit > 20 GeV
Fermi-LAT
HESS Mono
e2dnde [erg s^{-1} cm^{-2}]
Energy [GeV]