Steps toward the 5FGL Fermi-LAT source catalog

Jean Ballet

DAp/AIM, CEA Saclay, France

Philippe Bruel, Toby Burnett, Benoit Lott

and the LAT collaboration

ATPEM 2025, Paris
October 1, 2025

Source positions in 4FGL

uw1216 (DR3 seeds) vs uw8606 (DR1 seeds)

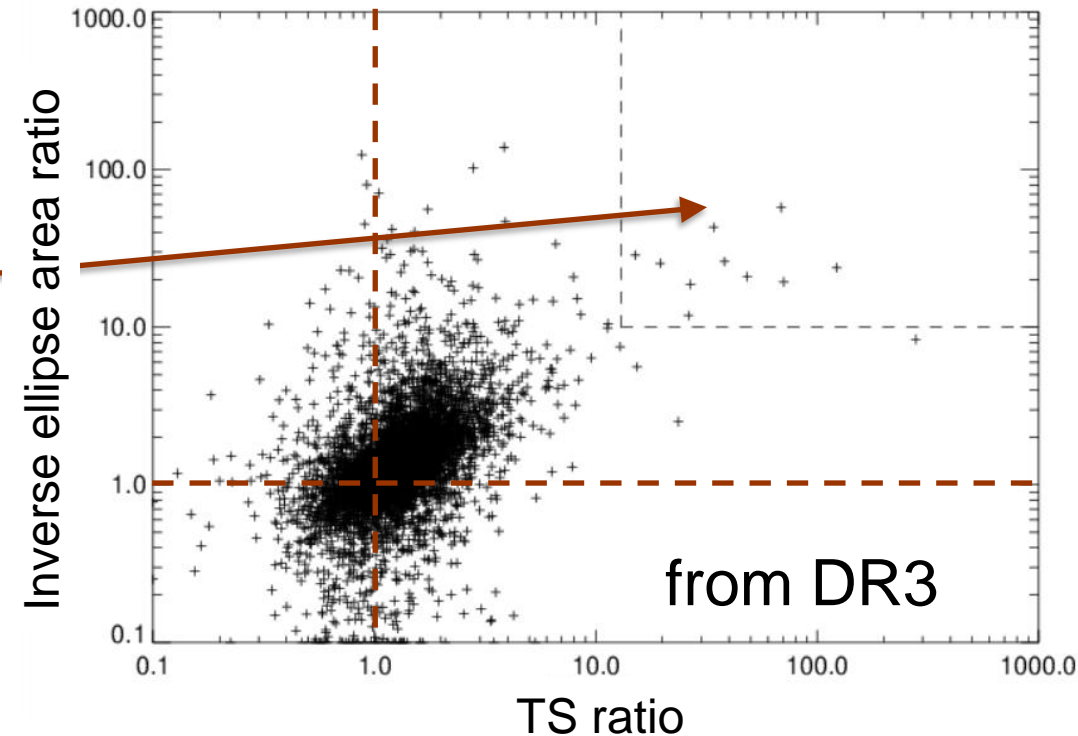4FGL DR4 (14 years) was built incrementally

Among 7112 point sources, 4938 (69%) inherited positions and error ellipses from DR1 (8 years)

Only a handful were updated, when very significant improvement

About **300** point sources inherited from former versions but **below threshold**

Nearly **600 moved beyond 95% error ellipse** when comparing with best current localization

from DR3

No new diffuse model yet, but we can still make **progress outside the Galactic plane**

Fast **fresh source list**, not updating extended sources either ➔ **FL16Y**

Source positions in FL16Y

- Source search and localization using *pointlike*, as in previous catalogs ➔ **7128 point sources at TS > 25** (vs 6793 in 4FGL DR4)

- Compare localization of faint sources with DR4; a little better because **best sensitivity moves to higher energies**

- Forced 4 recent transients below threshold over 16 years, accepted 4 associated point sources inside LMC

- All-sky verification: add manually 9 sources inside extended ones to fix strong residuals, and 3 faint isolated peaks

- Associate 6424 point sources with DR4 using 95% ellipses (at least 0.1°); **average ellipse reduction 2/3**

- Add hard power-law component to bright binaries (LS I +61 303 and LS 5039) and to Cen A for better fit

- Switch 4 EBL-absorbed BL Lacs and one black-widow pulsar candidate from LP to PLEC4

95% error radius

Preliminary
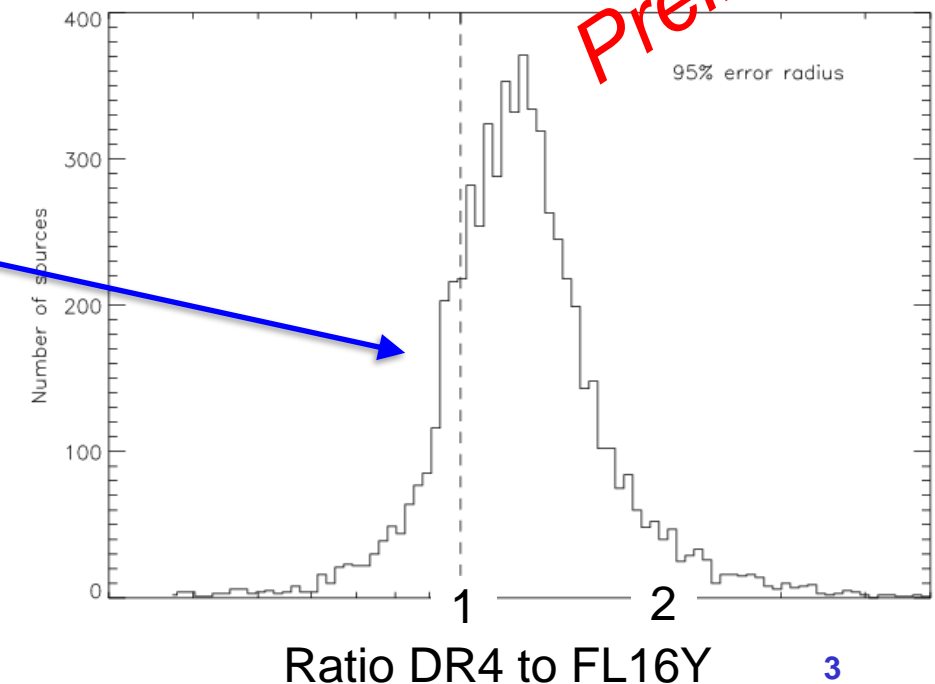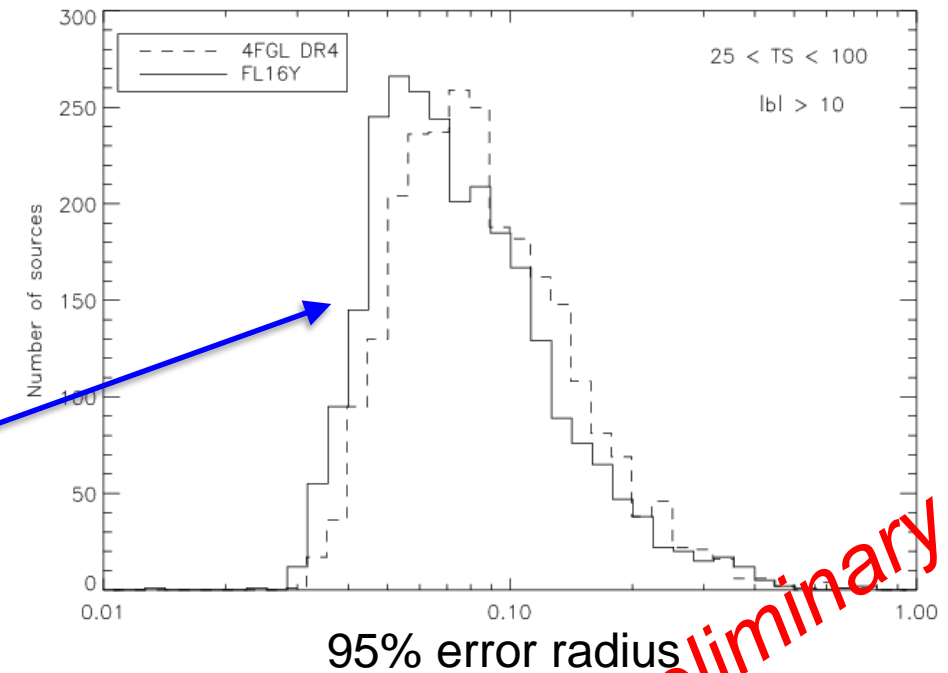
Ratio DR4 to FL16Y

Associations from 4FGL-DR4 to FL16Y

Global tallies:

- BL Lacs: about **330 more** (about 110 previously associated but unclassified)

- extraGal ($|b| > 10°$) unassociated: about **180 fewer**

- Galactic ($|b| < 10°$) unassociated: about **110 fewer**
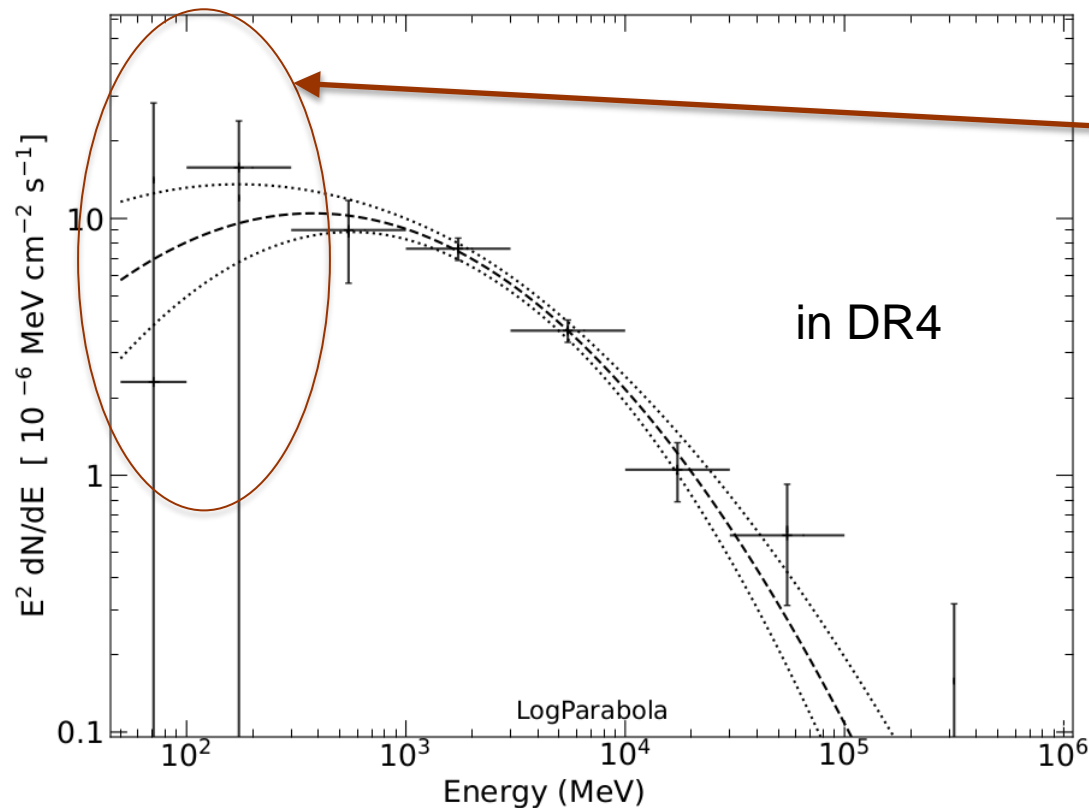
Sources already in 4FGL-DR4:

- Newly associated: **about 350** (about 1/3 from eRASS1)

- Lost association: **about 110**

- Changed association: **about 70**

DR4 sources not in FL16Y: **about 630** (TS < 25 or moved outside 95% ellipse)
incl. 200 that had TS < 25 in DR4 already

Preliminary

SEDs in LAT catalogs

4FGL J1641.0-4619 (HESS J1641-463) in Galactic Ridge

Unconstrained SED points below 300 MeV, largely uninformative

Due to **strong confusion** and leaving full freedom to all fluxes in a given band (only imposing spectral index)

R_{68} = 2.2° at 300 MeV, 8.7° at 50 MeV

Mean distance between sources < 1.5° at high latitudes, much worse in Galactic plane

SED priors for FL16Y

Introduce priors to **penalize a faint hard source becoming very bright at low energy**

Define mean from global fit, sigma as follows

$$\sigma_P^2 = \alpha^2(\sigma_C^2 + \sigma_S^2) + (\sigma_M^2 + 1)F_M^2$$
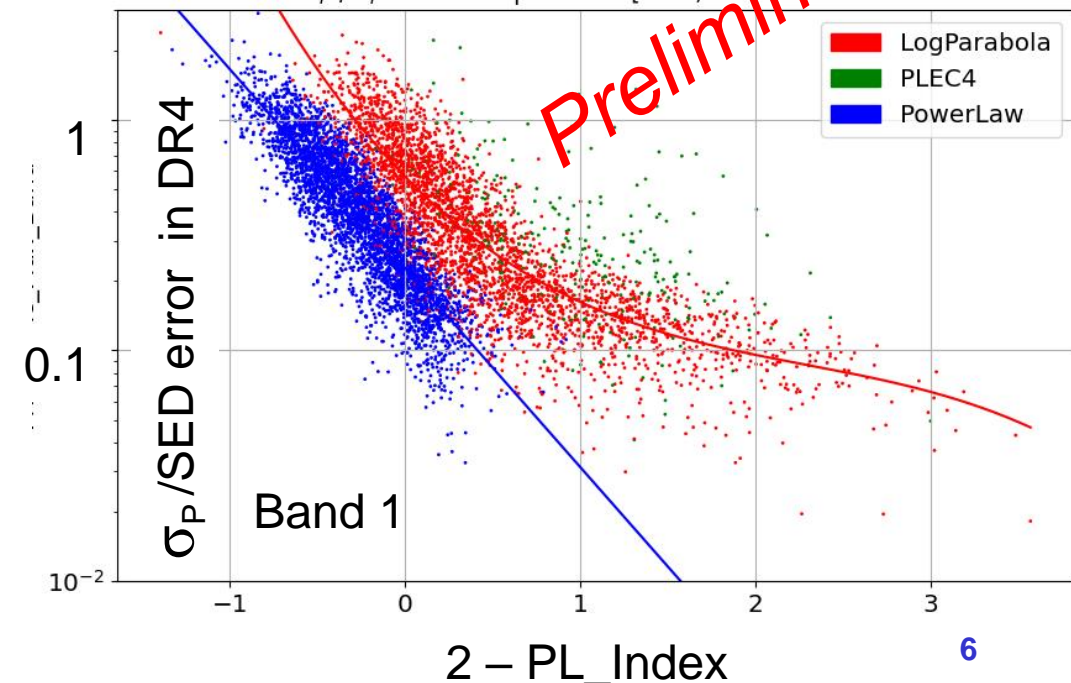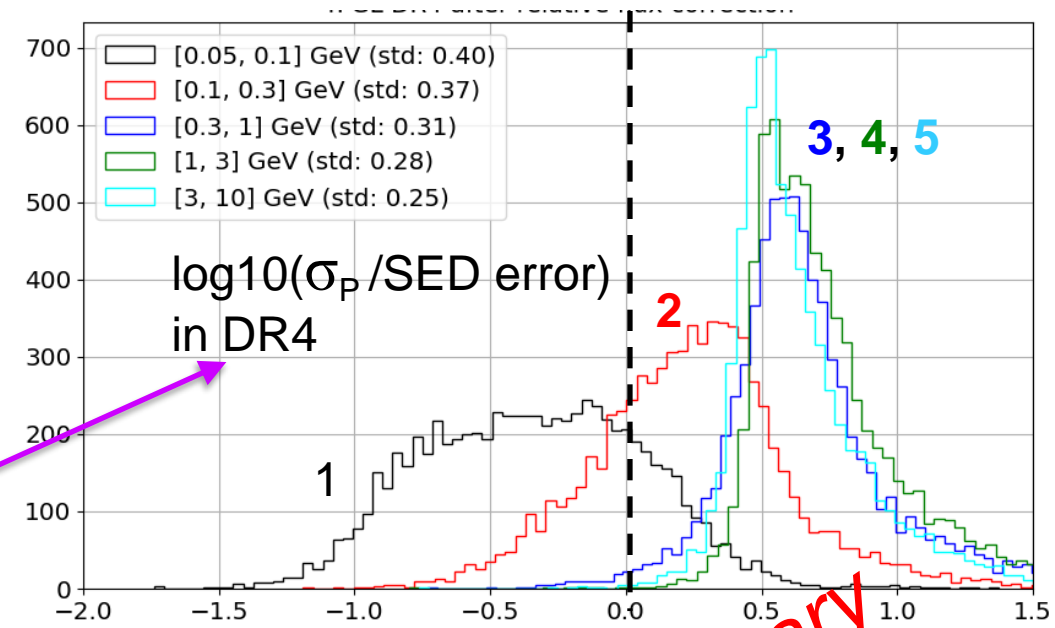
σ_C is the covariance error coming from global fit

σ_S is the statistical error (single source on flat background)

α is a security factor (set to 3) such that priors do not dominate
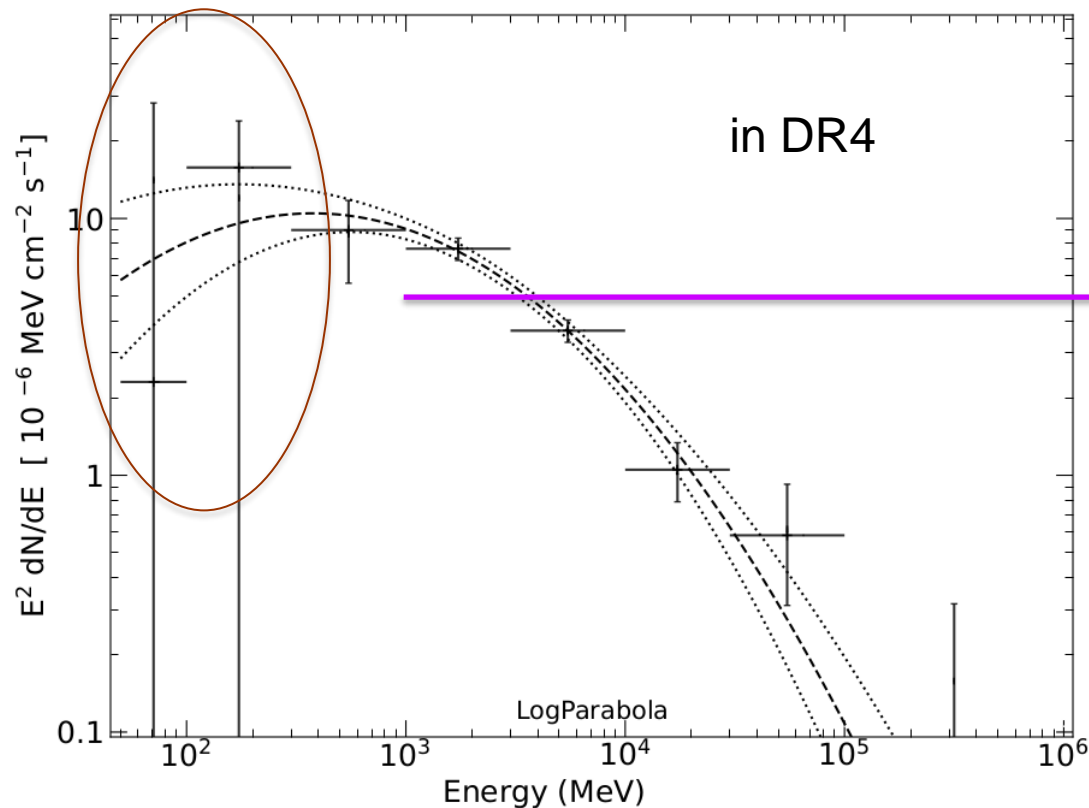
σ_M is the model error ln(PL fit/LP fit) for PL spectra

F_M is the model prediction in that band

σ_P is **smallest for hard sources**

log10(σ_P/SED error) in DR4

Legend:
- [0.05, 0.1] GeV (std: 0.40)
- [0.1, 0.3] GeV (std: 0.37)
- [0.3, 1] GeV (std: 0.31)
- [1, 3] GeV (std: 0.28)
- [3, 10] GeV (std: 0.25)

Preliminary

σ_P/SED error in DR4

Legend:
- LogParabola
- PLEC4
- PowerLaw

Band 1

2 – PL_Index

Effect of SED priors

4FGL J1641.0-4619 (HESS J1641-463) in Galactic Ridge

in DR4

with Priors

Preliminary

LogParabola

**Unconstrained** low-energy points
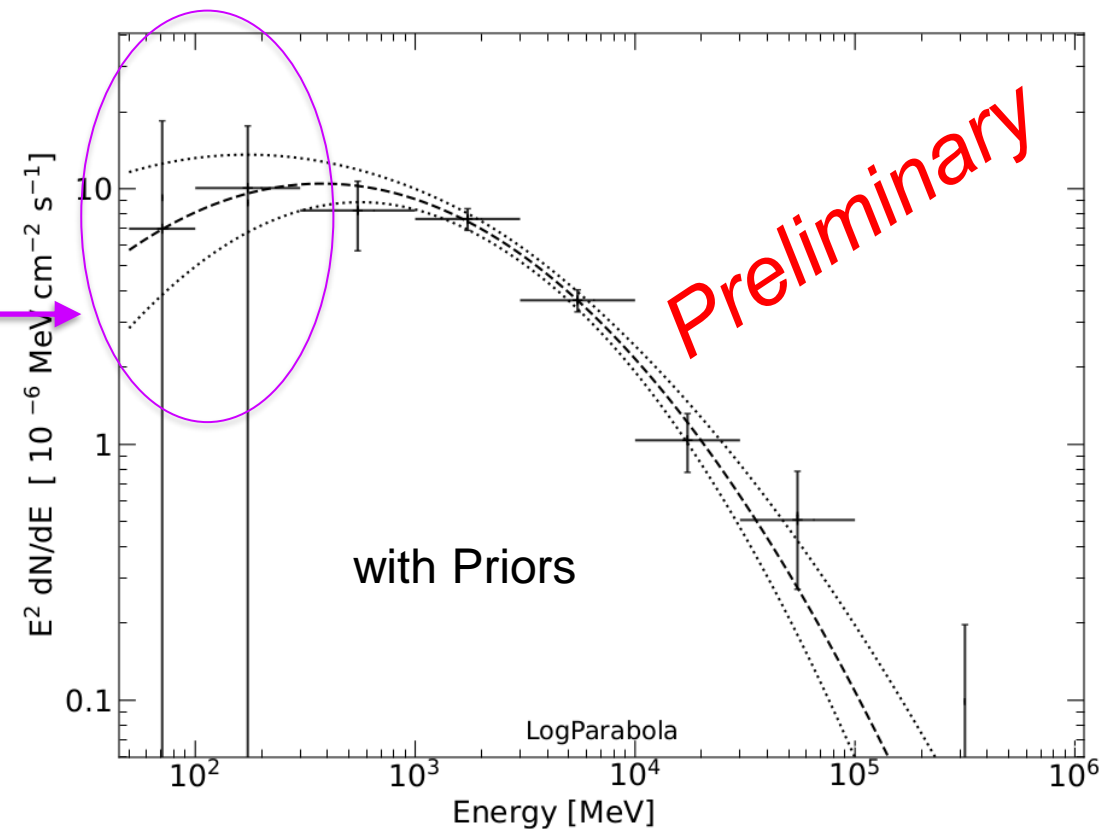
Low-energy points very close to the model and smaller upper limits

Effect of SED priors in band 1

Unc_Flux in band 1 in ph/cm2/s

- Nearly all **errors are reduced with priors** compared to DR4

- The maximum reduction is a **factor 10**, and the reduction is strongly **correlated with the spectral index** (slide 5)

Absolute error

in DR4 / with Priors

- The relative errors behave differently, because the best fit is affected as well

- Largest effect (scatter) for faint sources

- Rare **very strong sources tend to have reduced errors** because fainter sources are constrained by the priors

Preliminary

dF/F in band 1

Relative error

in DR4 / with Priors
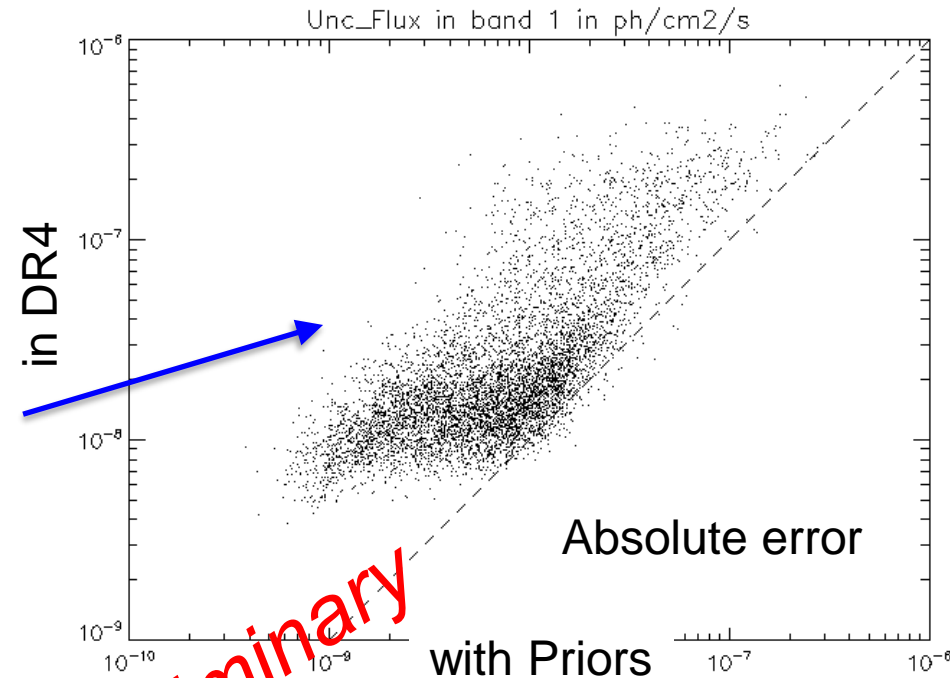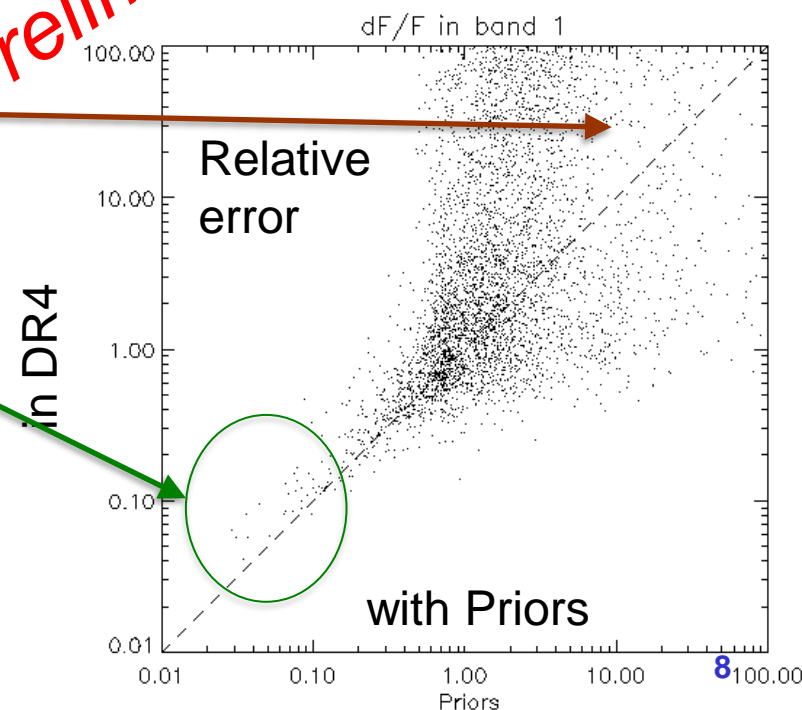
Summary

Next Fermi-LAT source catalog **will not be incremental**

5FGL catalog (expected early 2027) will be built on a **new interstellar emission model** (IEM) in preparation

Interim **FL16Y** source list is being prepared **with current IEM**

Error ellipse areas reduced (- 1/3) for 4FGL sources

Similar approach as 4FGL-DR4, except **priors in SEDs**

More than 7200 sources above threshold

Preparing **release before the end of the year**

Backup

FL16Y vs 5FGL

	4FGL DR4	FL16Y	5FGL
Data	14 years	**16 years**	same
Selection	graded PSF types, zmax		same
Main fit	FT 2.2, incremental	FT 2.4, **new**	same
Method	Weights, EDisp	same	**Larger weights**
Interstellar model	Modulated iem_v07	same	**iem_v08**
Extended sources	82	83	**Many more**
Spectral shapes	PL, LP and PLEC4	same	same
Curved spectra	TSCurv > 4 (2 σ)	same	same
SED bins	8, no priors	8, with **priors**	same
Light curves	1-year, flux only	same	1-year, flux and **index**