

## Fermi-LAT Catalogs

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**Thanks to Jean Ballet, Seth Digel, Toby Burnett, Jürgen Knödlseder and many others**

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# Generalities



The multifold purposes of (general) source catalogs:

- Population studies
- Ressource for single-source analysis (source model)
- Discovery potential (new source classes)

+ exercise and test the whole analysis chain.

All published catalogs available at:

<http://fermi.gsfc.nasa.gov/ssc/data/access/lat/> as « High-level products »

**Criterion:** Test Statistic > 25 over the considered period

**Consequences:**

- Transient sources (GRBs, solar flares...) are excluded (corresponding time intervals are excised in the analysis).
- Some sources listed in earlier catalogs may be missing in newer versions.

Several specialized catalogs: pulsars, AGNs, GRBs, SNRs, PWNs...

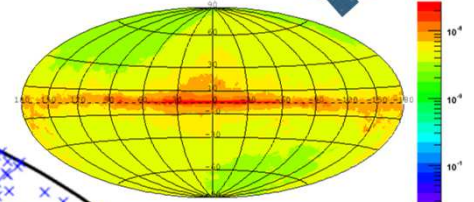
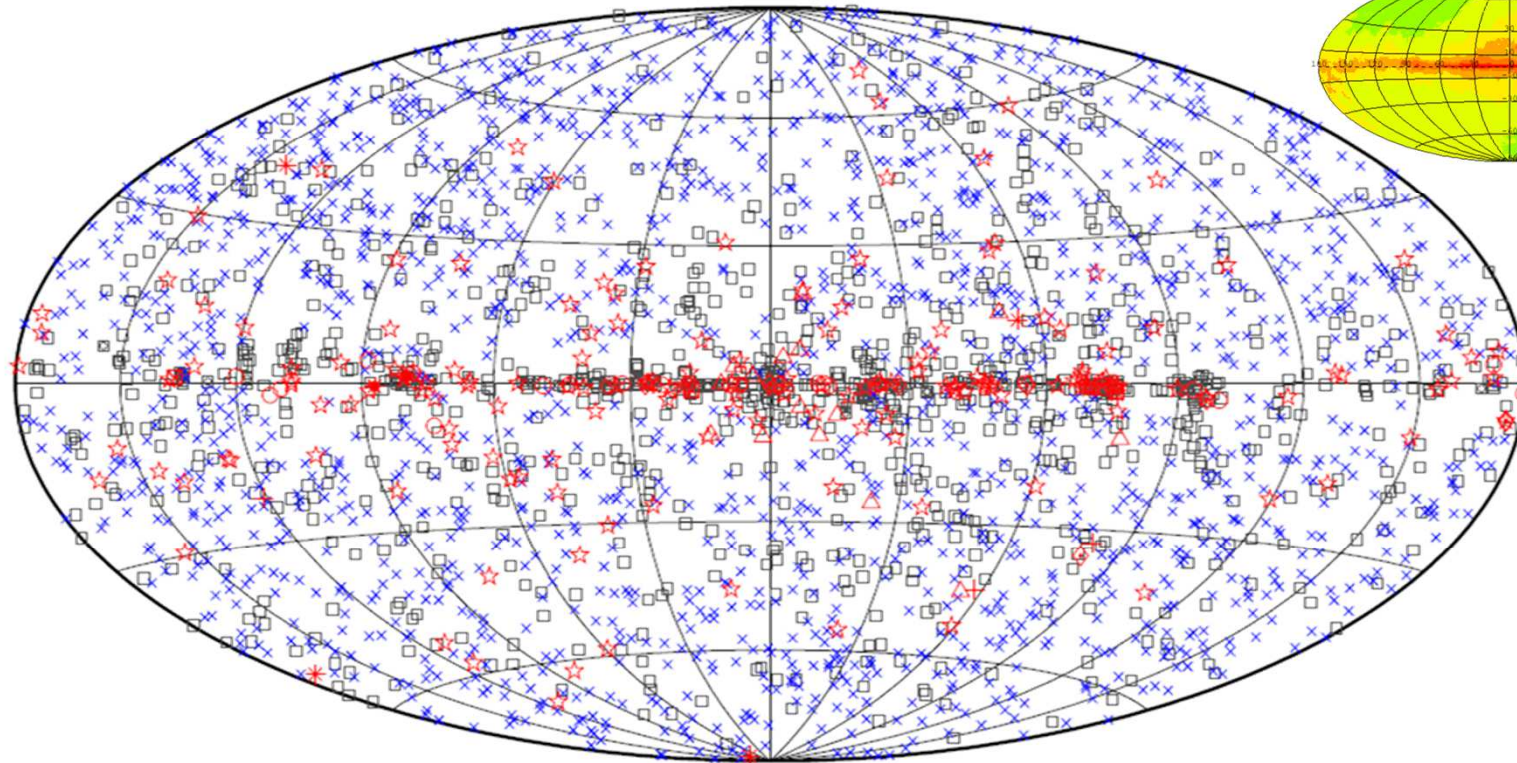
# LAT Source Catalogs (published and planned)



Catalog	Energy Range (GeV)	Data Interval (m)	Sources	Unassociated	Event Selection	Release Date
<b>0FGL</b>	0.2-100	3	205	37 (18%)	P6V1 DIFFUSE	Feb. 2009
<b>1FGL</b>	0.1-100	11	1451	630 (43%)	P6V3 DIFFUSE	Feb. 2010
<b>2FGL</b>	0.1-100	24	1873	649 (35%)	P7V6 SOURCE	Aug. 2011
<b>1FHL</b>	10-500	36	511	65 (13%)	P7V6 CLEAN	Jun. 2013
<b>3FGL</b>	0.1-300	48	3033	992 (33%)	P7V15 SOURCE	Jan. 2015
<b>2FHL</b>	50-2000	80	360	48 (14%)	P8 SOURCE	Aug. 2015
<b>3FHL</b>	10-2000	84	~1600	~30%	P8 SOURCE	Aug. 2016?
<b>4FGL</b>	0.1-1000?	84?	~5000	--	P8 SOURCE	Mar. 2017?



# 3FGL



□ No association	■ Possible association with SNR or PWN	× AGN
☆ Pulsar	△ Globular cluster	✱ Starburst Galaxy
⊠ Binary	+ Galaxy	◇ PWN
★ Star-forming region	○ SNR	✱ Nova

[http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr\\_catalog/](http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr_catalog/)

# General procedure for LAT catalog (xFGL) analysis



1. Define 'seed' source candidates
    - Pre-2FGL, merged results from multiple algorithms; now start with previous catalog, iteratively find seeds from TS maps
  2. Optimize their positions and search for additional sources
    - Via *pointlike* analysis system
  3. Evaluate spectral parameters and source significances
    - This is an all-sky analysis but in 'regions of interest' (ROIs) with the LAT likelihood analysis Science Tools
    - Iteration among the ROIs is required to allow for influences of sources on adjacent ROIs
    - The iteration also includes evaluation of spectral models
- The analysis has many other details, including explicit modeling of known spatially extended LAT sources, evaluation of analysis flags for systematic uncertainties, reanalysis on ~monthly time scales to define light curves and variability

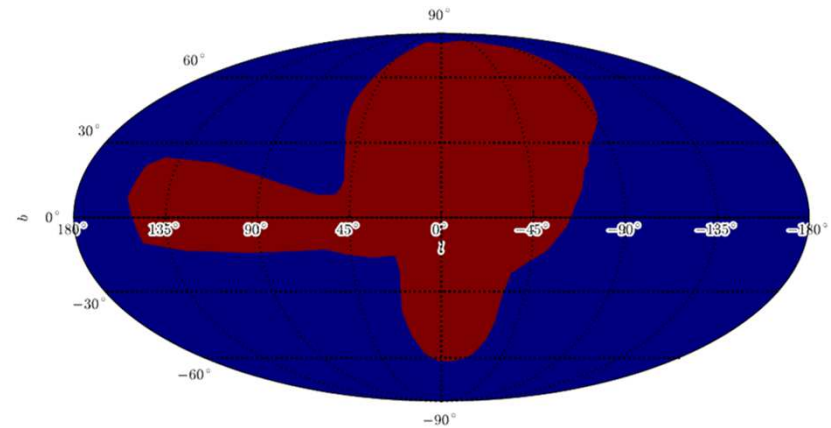
From Seth Digel

# Diffuse Gamma-Ray Background



## Modelled as:

- a linear combination of templates tracing the interstellar medium (hadronic interactions+ bremsstrahlung)
- an inverse-Compton component
- templates for large features like the radio continuum Loop
- an isotropic component (sub-threshold celestial sources plus residual charged particles misclassified as gamma-rays)
- contributions from Sun+Moon passive emissions
- an Earth-limb component



Remaining structures modeled from positive residuals  
Features with extension  $> 2^\circ$  included in the model

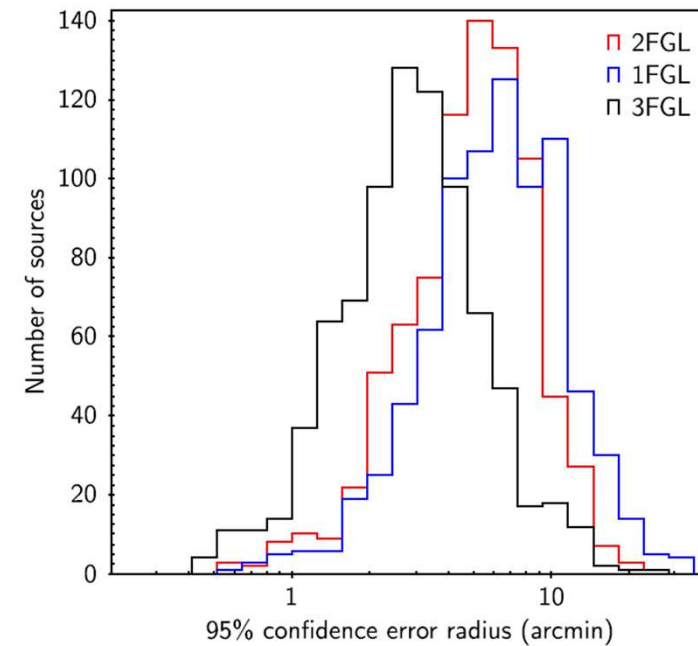
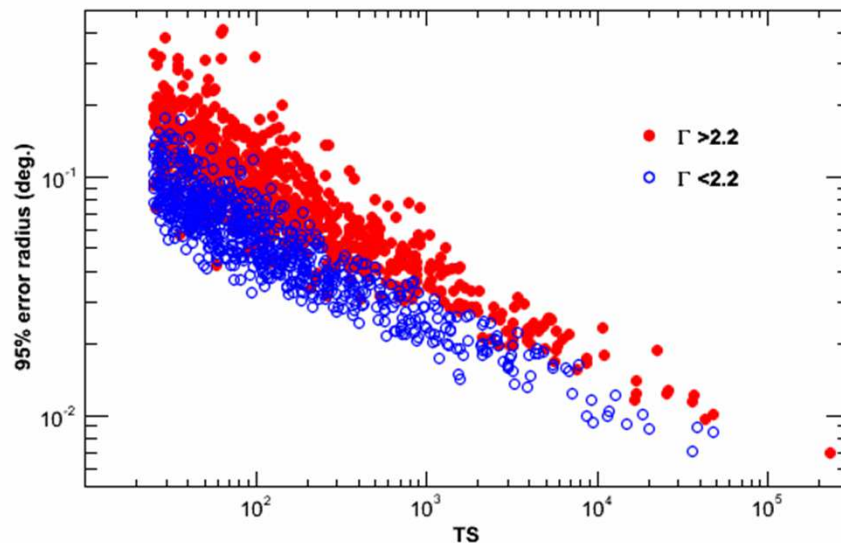
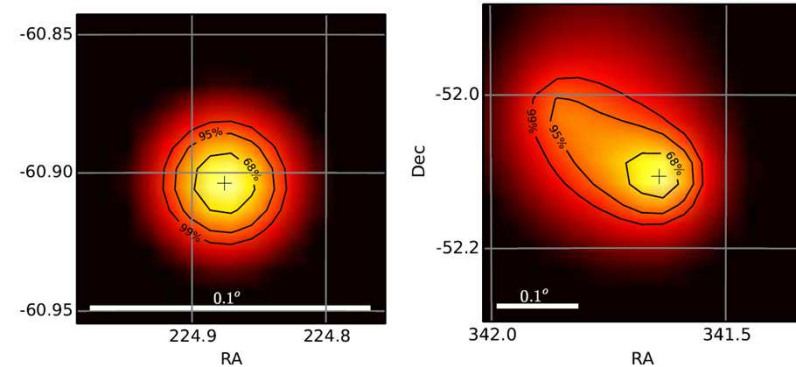
[http://fermi.gsfc.nasa.gov/ssc/data/access/lat/Model\\_details/FSSC\\_model\\_diffus\\_reprocessed\\_v12.pdf](http://fermi.gsfc.nasa.gov/ssc/data/access/lat/Model_details/FSSC_model_diffus_reprocessed_v12.pdf)

# Localization



**Good localization is crucial to performing associations.**

**Sources with high TS / hard spectra are better localized.**





# 3FGL parameters (paper)



Table 5. LAT Third Catalog Description

Column	Description
Name	3FGL JHHMM.m+DDMM[c/e/i/s], constructed according to IAU Specifications for Nomenclature; <b>m</b> is decimal minutes of R.A.; in the name, R.A. and Decl. are truncated at 0.1 decimal minutes and 1', respectively; <b>c</b> indicates that based on the region of the sky the source is considered to be potentially confused with Galactic diffuse emission; <b>e</b> indicates a source that was modeled as spatially extended (see § 3.4); the two spectral components of the Crab PWN are designated <b>i</b> and <b>s</b>
R.A.	Right Ascension, J2000, deg, 3 decimal places
Decl.	Declination, J2000, deg, 3 decimal places
<i>l</i>	Galactic Longitude, deg, 3 decimal places
<i>b</i>	Galactic Latitude, deg, 3 decimal places
$\theta_1$	Semimajor radius of 95% confidence region, deg, 3 decimal places
$\theta_2$	Seminor radius of 95% confidence region, deg, 3 decimal places
$\phi$	Position angle of 95% confidence region, deg. East of North, 0 decimal places
$\sigma$	Significance derived from likelihood Test Statistic for 100 MeV–300 GeV analysis, 1 decimal place
$F_{35}$	Photon flux for 1 GeV–100 GeV, $10^{-9}$ ph cm $^{-2}$ s $^{-1}$ , summed over 3 bands, 1 decimal place
$\Delta F_{35}$	$1\sigma$ uncertainty on $F_{35}$ , same units and precision
$S_{25}$	Energy flux for 100 MeV–100 GeV, $10^{-12}$ erg cm $^{-2}$ s $^{-1}$ , from power-law fit, 1 decimal place
$\Delta S_{25}$	$1\sigma$ uncertainty on $S_{25}$ , same units and precision
$\Gamma_{25}$	Photon number power-law index, 100 MeV–100 GeV, 2 decimal places
$\Delta \Gamma_{25}$	$1\sigma$ uncertainty of photon number power-law index, 100 MeV–100 GeV, 2 decimal places
Mod.	PL indicates power-law fit to the energy spectrum; LP indicates log-parabola fit to the energy spectrum; EC indicates power-law with exponential cutoff fit to the energy spectrum
Var.	T indicates < 1% chance of being a steady source; see note in text
Flags	See Table 3 for definitions of the flag numbers
$\gamma$ -ray Assoc.	Positional associations with 0FGL, 1FGL, 2FGL, 3EG, EGR, or 1AGL sources
TeV	Positional association with a TeVCat source, P for unresolved angular size, E for extended
Class	Like 'ID' in 3EG catalog, but with more detail (see Table 6). Capital letters indicate firm identifications; lower-case letters indicate associations
ID or Assoc.	Designator of identified or associated source



# 3FGL parameters (fits)



Table 16. LAT 3FGL FITS Format: LAT\_Point\_Source\_Catalog Extension

Error ellipse →

Pivot energy →

Signif. Curve →

Spectrum type →

Column	Format	Unit	Description
Source_Name	18A	...	Official source name 3FGL JHHMM.m+DDMM
RAJ2000	E	deg	Right Ascension
DEJ2000	E	deg	Declination
GLON	E	deg	Galactic Longitude
GLAT	E	deg	Galactic Latitude
Conf_68_SemiMajor	E	deg	Long radius of error ellipse at 68% confidence
Conf_68_SemiMinor	E	deg	Short radius of error ellipse at 68% confidence
Conf_68_PosAng	E	deg	Position angle of the 68% long axis from celestial North, positive toward increasing RA (eastward)
Conf_95_SemiMajor	E	deg	Long radius of error ellipse at 95% confidence
Conf_95_SemiMinor	E	deg	Short radius of error ellipse at 95% confidence
Conf_95_PosAng	E	deg	Position angle of the 95% long axis from celestial North, positive toward increasing RA (eastward)
ROI_num	I	...	ROI number (cross-reference to ROIs extension)
Signif_Avg	E	...	Source significance in $\sigma$ units (derived from Test Statistic) over the 100 MeV to 300 GeV band
Pivot_Energy	E	MeV	Energy at which error on differential flux is minimal
Flux_Density	E	$\text{cm}^{-2} \text{MeV}^{-1} \text{s}^{-1}$	Differential flux at Pivot_Energy
Unc_Flux_Density	E	$\text{cm}^{-2} \text{MeV}^{-1} \text{s}^{-1}$	$1\sigma$ error on differential flux at Pivot_Energy
Spectral_Index	E	...	Best fit photon number power-law index: for LogParabola spectra, index at Pivot_Energy; for PL(Super)ExpCutoff spectra, low-energy index
Unc_Spectral_Index	E	...	$1\sigma$ error on Spectral_Index
Flux1000	E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 1 to 100 GeV
Unc_Flux1000	E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ error on integral photon flux from 1 to 100 GeV
Energy_Flux100	E	$\text{erg cm}^{-2} \text{s}^{-1}$	Energy flux from 100 MeV to 100 GeV obtained by spectral fitting
Unc_Energy_Flux100	E	$\text{erg cm}^{-2} \text{s}^{-1}$	$1\sigma$ error on energy flux from 100 MeV to 100 GeV
Signif_Curve	E	...	Significance (in $\sigma$ units) of the fit improvement between power-law and either LogParabola (for ordinary sources) or PLExpCutoff (for pulsars)
SpectrumType	18A	...	A value greater than 4 indicates significant curvature
beta	E	...	Spectral type (PowerLaw, LogParabola, PLExpCutoff, PLSuperExpCutoff)
Unc_beta	E	...	Curvature parameter ( $\beta$ of Eq. (1)) for LogParabola; NULL for other spectral types
Cutoff	E	MeV	$1\sigma$ error on $\beta$ for LogParabola; NULL for other spectral types
Unc_Cutoff	E	MeV	Cutoff energy ( $E_c$ of Eq. (2)) for PL(Super)ExpCutoff; NULL for other spectral types
Exp_Index	E	...	$1\sigma$ error on cutoff energy for PL(Super)ExpCutoff; NULL for other spectral types
Unc_Exp_Index	E	...	Exponential index ( $b$ of Eq. (2)) for PLSuperExpCutoff; NULL for other spectral types
PowerLaw_Index	E	...	$1\sigma$ error on exponential index for PLSuperExpCutoff; NULL for other spectral types
Flux30_100	E	$\text{cm}^{-2} \text{s}^{-1}$	Best fit power-law index; equal to Spectral_Index if SpectrumType is PowerLaw
Unc_Flux30_100	E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 30 to 100 MeV (not filled)
nuFnu30_100	2E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ lower and upper error on integral photon flux from 30 to 100 MeV (not filled)
Sqrt_TS30_100	E	$\text{erg cm}^{-2} \text{s}^{-1}$	Spectral energy distribution between 30 and 100 MeV (not filled)
Flux100_300	E	...	Square root of the Test Statistic between 30 and 100 MeV (not filled)
Unc_Flux100_300	E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 100 to 300 MeV
nuFnu100_300	2E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ lower and upper error on integral photon flux from 100 to 300 MeV <sup>a</sup>
Sqrt_TS100_300	E	$\text{erg cm}^{-2} \text{s}^{-1}$	Spectral energy distribution between 100 and 300 MeV
Flux300_1000	E	...	Square root of the Test Statistic between 100 and 300 MeV
	E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 300 MeV to 1 GeV

# 3FGL parameters (fits, cont.)



Table 16—Continued

Column	Format	Unit	Description
Unc_Flux300_1000	2E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ lower and upper error on integral photon flux from 300 MeV to 1 GeV <sup>a</sup>
nuFnu300_1000	E	$\text{erg cm}^{-2} \text{s}^{-1}$	Spectral energy distribution between 300 MeV and 1 GeV
Sqrt_TS300_1000	E	...	Square root of the Test Statistic between 300 MeV and 1 GeV
Flux1000_3000	E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 1 to 3 GeV
Unc_Flux1000_3000	2E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ lower and upper error on integral photon flux from 1 to 3 GeV <sup>a</sup>
nuFnu1000_3000	E	$\text{erg cm}^{-2} \text{s}^{-1}$	Spectral energy distribution between 1 and 3 GeV
Sqrt_TS1000_3000	E	...	Square root of the Test Statistic between 1 and 3 GeV
Flux3000_10000	E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 3 to 10 GeV
Unc_Flux3000_10000	2E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ lower and upper error on integral photon flux from 3 to 10 GeV <sup>a</sup>
nuFnu3000_10000	E	$\text{erg cm}^{-2} \text{s}^{-1}$	Spectral energy distribution between 3 and 10 GeV
Sqrt_TS3000_10000	E	...	Square root of the Test Statistic between 3 and 10 GeV
Flux10000_100000	E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 10 to 100 GeV
Unc_Flux10000_100000	2E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ lower and upper error on integral photon flux from 10 to 100 GeV <sup>a</sup>
nuFnu10000_100000	E	$\text{erg cm}^{-2} \text{s}^{-1}$	Spectral energy distribution between 10 and 100 GeV
Sqrt_TS10000_100000	E	...	Square root of the Test Statistic between 10 and 100 GeV
Variability_Index	E	...	Sum of $2 \times \log(\text{Likelihood})$ difference between the flux fitted in each time interval and the average flux over the full catalog interval; a value greater than 72.44 over 48 intervals indicates <1% chance of being a steady source
Signif_Peak	E	...	Source significance in peak interval in $\sigma$ units
Flux_Peak	E	$\text{cm}^{-2} \text{s}^{-1}$	Peak integral photon flux from 100 MeV to 100 GeV
Unc_Flux_Peak	E	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ error on peak integral photon flux
Time_Peak	D	s (MET)	Time of center of interval in which peak flux was measured
Peak_Interval	E	s	Length of interval in which peak flux was measured
Flux_History	48E	$\text{cm}^{-2} \text{s}^{-1}$	Integral photon flux from 100 MeV to 100 GeV in each interval (best fit from likelihood analysis with spectral shape fixed to that obtained over full interval)
Unc_Flux_History	$2 \times 48E$	$\text{cm}^{-2} \text{s}^{-1}$	$1\sigma$ lower and upper error on integral photon flux in each interval added in quadrature with 2% systematic component
Extended_Source_Name	18A	...	Cross-reference to the ExtendedSources extension for extended sources, if any
0FGL_Name	18A	...	Name of corresponding 0FGL source, if any
1FGL_Name	18A	...	Name of corresponding 1FGL source, if any
2FGL_Name	18A	...	Name of corresponding 2FGL source, if any
1FHL_Name	18A	...	Name of corresponding 1FHL source, if any
ASSOC_GAM1	18A	...	Name of likely corresponding 1AGL source
ASSOC_GAM2	18A	...	Name of likely corresponding 3EG source
ASSOC_GAM3	18A	...	Name of likely corresponding EGR source
TEVCAT_FLAG	A	...	P if positional association with non-extended source in TeVCat, N if no TeV association
ASSOC_TEV	24A	...	E if associated with a more extended source in TeVCat, N if no TeV association
CLASS1	5A	...	Name of likely corresponding TeV source from TeVCat
ASSOC1	26A	...	Class designation for associated source; see Table 2
ASSOC2	26A	...	Name of identified or likely associated source
ASSOC3	26A	...	Alternate name of identified or likely associated source
Flags	I	...	Source flags (binary coding as in Table 3) <sup>b</sup>

## Variability Index (VI)

$$TS_{\text{var}} = 2[\log \mathcal{L}(\{F_i\}) - \log \mathcal{L}(F_{\text{Const}})]$$

$$= 2 \sum_i [\log \mathcal{L}_i(F_i) - \log \mathcal{L}_i(F_{\text{Const}})]$$

distributed as a  $\chi^2$  with 47 d.o.f.

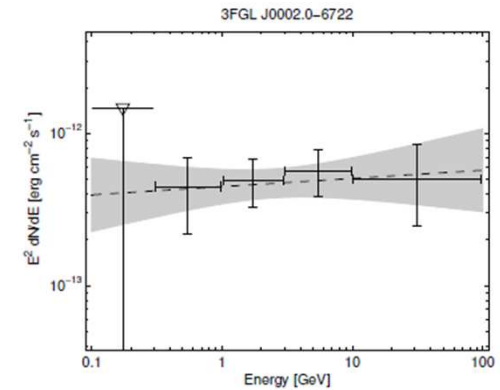
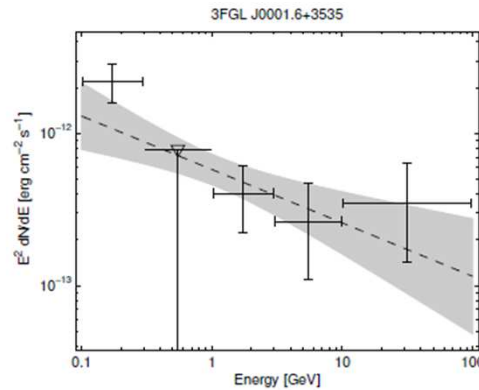
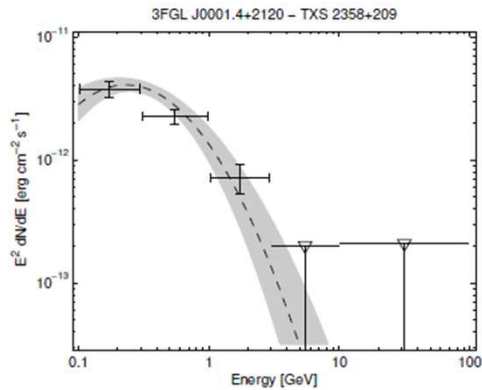
Beware: a low VI does not prove that the source is steady !

# 5-band spectra/monthly light curves



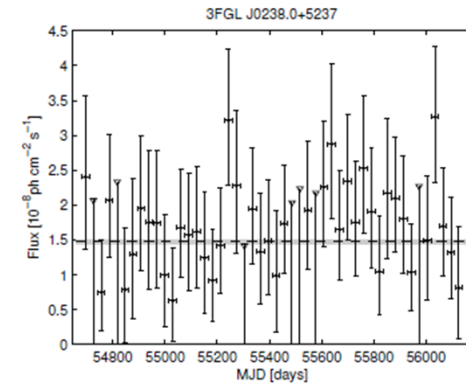
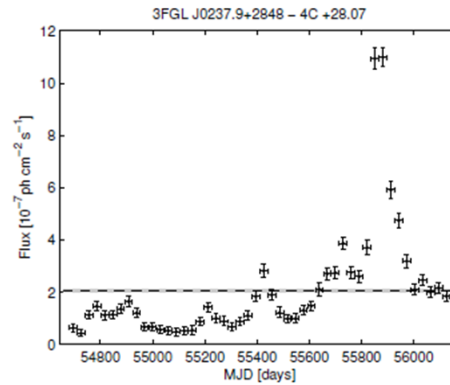
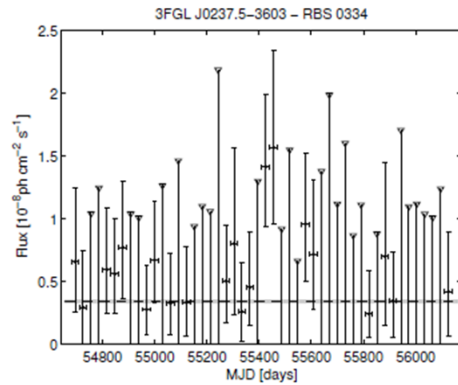
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[http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr\\_catalog/3FGL\\_spec\\_v5.tar](http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr_catalog/3FGL_spec_v5.tar)



[http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr\\_catalog/3FGL\\_lc\\_v5.pdf](http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr_catalog/3FGL_lc_v5.pdf)

[http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr\\_catalog/3FGL\\_lc\\_v5.tar](http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr_catalog/3FGL_lc_v5.tar)





# 3FGL analysis flags



**Flags reflect potential analysis issues in assessing the TS, flux, spectrum, position... of a particular source**

**Some sources are flagged as “confused” and designated with “c” in their names**

Table 3. Definitions of the Analysis Flags

Flag <sup>a</sup>	Meaning
1	Source with $TS > 35$ which went to $TS < 25$ when changing the diffuse model (§ 3.7.3) or the analysis method (§ 3.7.4). Sources with $TS \leq 35$ are not flagged with this bit because normal statistical fluctuations can push them to $TS < 25$ .
2	Not used.
3	Flux ( $> 1$ GeV) or energy flux ( $> 100$ MeV) changed by more than $3\sigma$ when changing the diffuse model or the analysis method. Requires also that the flux change by more than 35% (to not flag strong sources).
4	Source-to-background ratio less than 10% in highest band in which $TS > 25$ . Background is integrated over $\pi r_{68}^2$ or 1 square degree, whichever is smaller.
5	Closer than $\theta_{\text{ref}}$ from a brighter neighbor. $\theta_{\text{ref}}$ is defined in the highest band in which source $TS > 25$ , or the band with highest $TS$ if all are $< 25$ . $\theta_{\text{ref}}$ is set to 2:17 (FWHM) below 300 MeV, 1:38 between 300 MeV and 1 GeV, 0:87 between 1 GeV and 3 GeV, 0:67 between 3 and 10 GeV and 0:45 above 10 GeV ( $2 r_{68}$ ).
6	On top of an interstellar gas clump or small-scale defect in the model of diffuse emission; equivalent to the c designator in the source name (§ 3.8).
7	Unstable position determination; result from <i>gtfindsrc</i> outside the 95% ellipse from <i>pointlike</i> .
8	Not used.
9	Localization Quality $> 8$ in <i>pointlike</i> (§ 3.1) or long axis of 95% ellipse $> 0:25$ .
10	Spectral Fit Quality $> 16.3$ (Eq. 3 of <a href="#">Nolan et al. 2012</a> , 2FGL).
11	Possibly due to the Sun (§ 3.6).
12	Highly curved spectrum; <i>LogParabola</i> $\beta$ fixed to 1 or <i>PLExpCutoff</i> <i>Spectral_Index</i> fixed to 0.5 (see § 3.3).



# Associations: Bayesian method



gamma-ray source  $i$ , potential counterpart  $k$ , angular distance  $r_{ik}$   
true association (id) or confusing source (c)?

$$P_{ik} = p_{ik}(id|r_{ik})$$

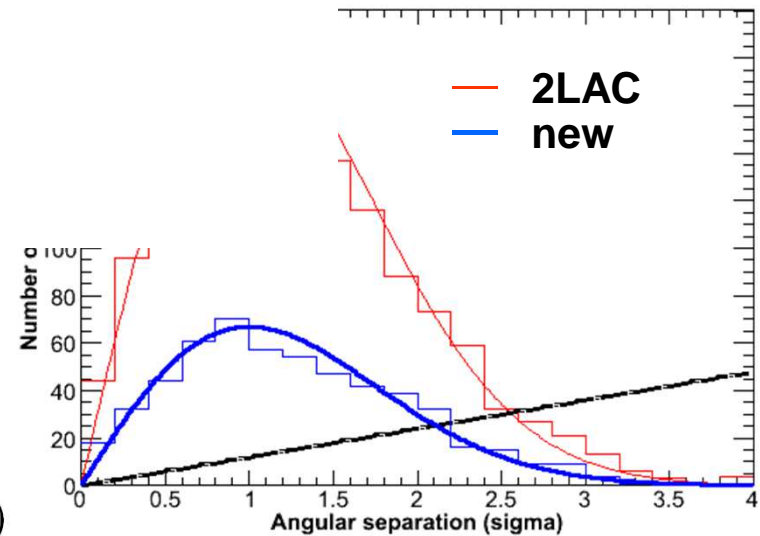
**Rule of thumb:**

$$\eta \sim N_{assoc} / N_{TOT}$$

$N_{assoc}$ : number of associations obtained from the counterpart catalog

$N_{TOT}$ : number of LAT sources.

*Note: Another, complementary method (Likelihood ratio) is also used for AGNs*



# Counterpart catalogs



known or  
plausible  
 $\gamma$ -ray-emitting  
source classes

surveys at other  
frequencies

GeV sources

identified  
gamma-ray  
sources

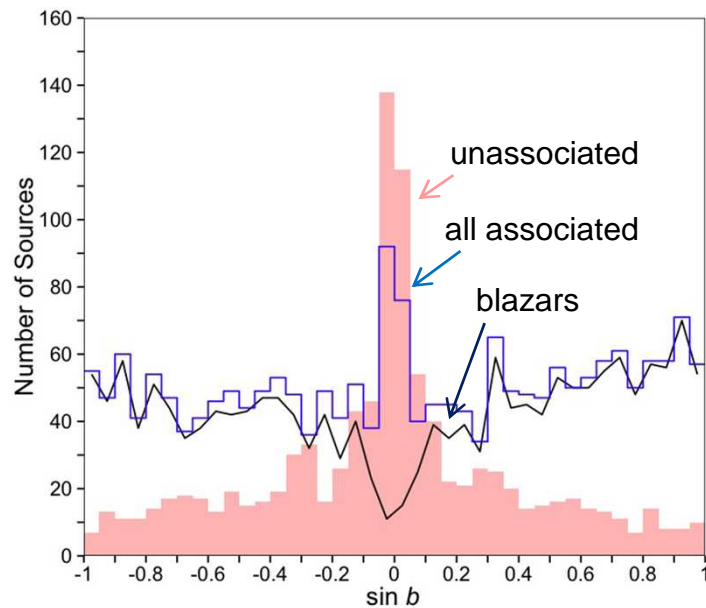
High $\dot{E}/d^2$ pulsars	213	<a href="#">Manchester et al. (2005)<sup>b</sup></a>
Other normal pulsars	1657	<a href="#">Manchester et al. (2005)<sup>b</sup></a>
Millisecond pulsars	137	<a href="#">Manchester et al. (2005)<sup>b</sup></a>
Pulsar wind nebulae	69	Collaboration internal
High-mass X-ray binaries	114	<a href="#">Liu et al. (2006)</a>
Low-mass X-ray binaries	187	<a href="#">Liu et al. (2007)</a>
Point-like SNR	157	<a href="#">Green (2009)</a>
Extended SNR <sup>†</sup>	274	<a href="#">Green (2009)</a>
O stars	378	<a href="#">Maíz-Apellániz et al. (2004)</a>
WR stars	226	<a href="#">van der Hucht (2001)</a>
LBV stars	35	<a href="#">Clark et al. (2005)</a>
Open clusters	2140	<a href="#">Dias et al. (2002)</a>
Globular clusters	160	<a href="#">Harris (1996)</a>
Dwarf galaxies <sup>†</sup>	100	<a href="#">McConnachie (2012)</a>
Nearby galaxies	276	<a href="#">Schmidt et al. (1993)</a>
IRAS bright galaxies	82	<a href="#">Sanders et al. (2003)</a>
BZCAT (Blazars)	3060	<a href="#">Massaro et al. (2009)</a>
BL Lac	1371	<a href="#">Véron-Cetty &amp; Véron (2010)</a>
AGN	10066	<a href="#">Véron-Cetty &amp; Véron (2010)</a>
QSO	129,853	<a href="#">Véron-Cetty &amp; Véron (2010)</a>
Seyfert galaxies	27651	<a href="#">Véron-Cetty &amp; Véron (2010)</a>
Radio loud Seyfert galaxies	29	Collaboration internal
1WHSP	1000	<a href="#">Arsioli et al. (2014)</a>
WISE blazar catalog	7855	<a href="#">D'Abrusco et al. (2014)</a>
NRAO VLA Sky Survey (NVSS) <sup>c</sup>	1,773,484	<a href="#">Condon et al. (1998)</a>
Sydney University Molonglo Sky Survey (SUMSS) <sup>c</sup>	211,050	<a href="#">Mauch et al. (2003)</a>
Parkes-MIT-NRAO survey <sup>c</sup>	23277	<a href="#">Griffith &amp; Wright (1993)</a>
CGRaBS	1625	<a href="#">Healey et al. (2008)</a>
CRATES	11499	<a href="#">Healey et al. (2007)</a>
VLBA Calibrator Source List	5776	<a href="http://www.vlba.nrao.edu/astro/calib/vlbaCalib.txt">http://www.vlba.nrao.edu/astro/calib/vlbaCalib.txt</a>
ATCA 20 GHz southern sky survey	5890	<a href="#">Murphy et al. (2010)</a>
ATCA follow up of 2FGL unassociated sources	424	<a href="#">Petrov et al. (2013)</a>
ROSAT All Sky Survey (RASS) Bright and Faint Source Catalogs <sup>c</sup>	124,735	<a href="#">Voges et al. (1999)<sup>d</sup></a>
58 months BAT catalog	1092	<a href="#">Baumgartner et al. (2010)</a>
4 <sup>th</sup> IBIS catalog	723	<a href="#">Bird et al. (2010)</a>
1st AGILE catalog <sup>*</sup>	47	<a href="#">Pittori et al. (2009)</a>
3rd EGRET catalog <sup>*</sup>	271	<a href="#">Hartman et al. (1999)</a>
EGR catalog <sup>*</sup>	189	<a href="#">Casandjian &amp; Grenier (2008)</a>
0FGL list <sup>*</sup>	205	<a href="#">Abdo et al. (2009d, 0FGL)</a>
1FGL catalog <sup>*</sup>	1451	<a href="#">Abdo et al. (2010d, 1FGL)</a>
2FGL catalog <sup>*</sup>	1873	<a href="#">Nolan et al. (2012, 2FGL)</a>
1FHL catalog <sup>*</sup>	514	<a href="#">Ackermann et al. (2013a, 1FHL)</a>
TeV point-like source catalog <sup>*</sup>	82	<a href="http://tevcat.uchicago.edu/">http://tevcat.uchicago.edu/</a>
TeV extended source catalog <sup>†</sup>	66	<a href="http://tevcat.uchicago.edu/">http://tevcat.uchicago.edu/</a>
LAT pulsars	147	Collaboration internal
LAT identified	137	Collaboration internal

# Identification/Association summaries



Table 6. LAT 3FGL Source Classes

- “identified” if correlated variability found, “associated” otherwise
- 30% of sources unassociated
- >60% at low galactic lat.

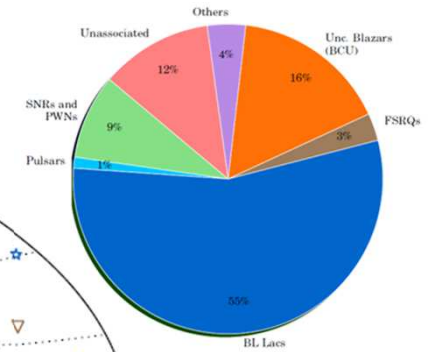
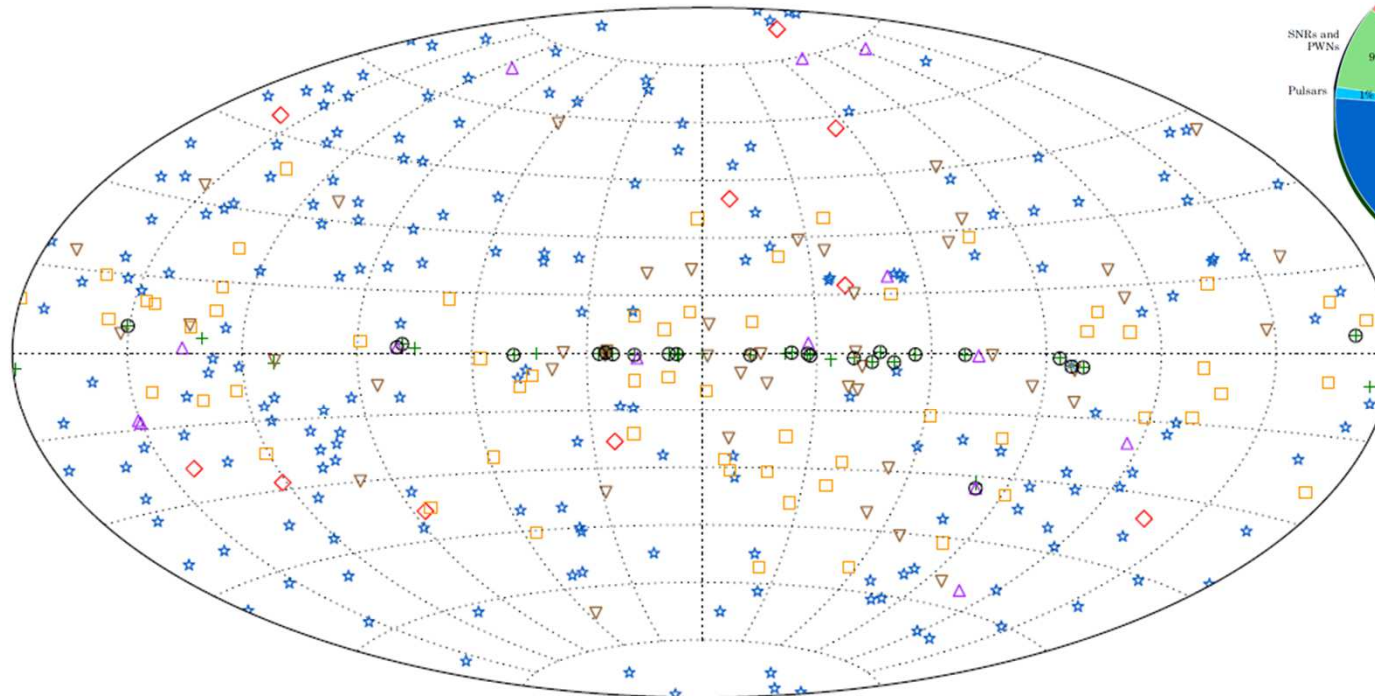


Description	Identified		Associated	
	Designator	Number	Designator	Number
Pulsar, identified by pulsations	PSR	143	...	...
Pulsar, no pulsations seen in LAT yet	...	...	psr	24
Pulsar wind nebula	PWN	9	pwn	2
Supernova remnant	SNR	12	snr	11
Supernova remnant / Pulsar wind nebula	...	...	spp	49
Globular cluster	GLC	0	glc	15
High-mass binary	HMB	3	hmb	0
Binary	BIN	1	bin	0
Nova	NOV	1	nov	0
Star-forming region	SFR	1	sfr	0
Compact Steep Spectrum Quasar	CSS	0	css	1
BL Lac type of blazar	BLL	18	bll	642
FSRQ type of blazar	FSRQ	38	fsrq	446
Non-blazar active galaxy	AGN	0	agn	3
Radio galaxy	RDG	3	rdg	12
Seyfert galaxy	SEY	0	sey	1
Blazar candidate of uncertain type	BCU	5	bcu	568
Normal galaxy (or part)	GAL	2	gal	1
Starburst galaxy	SBG	0	sbg	4
Narrow line Seyfert 1	NLSY1	2	nlsy1	3
Soft spectrum radio quasar	SSRQ	0	ssrq	3
Total	...	238	...	1785
Unassociated	...	...	...	1010

# 2FHL



**E>50 GeV, 80 months of Pass8 data, 360 sources, 25% TeV-detected**  
**Useful ressource for ground-based Cherenkov telescopes including CTA**



+	SNRs and PWNe	★	BL Lacs	□	Unc. Blazars	▽	Unassociated
×	Pulsars	◇	FSRQs	△	Others	○	Extended



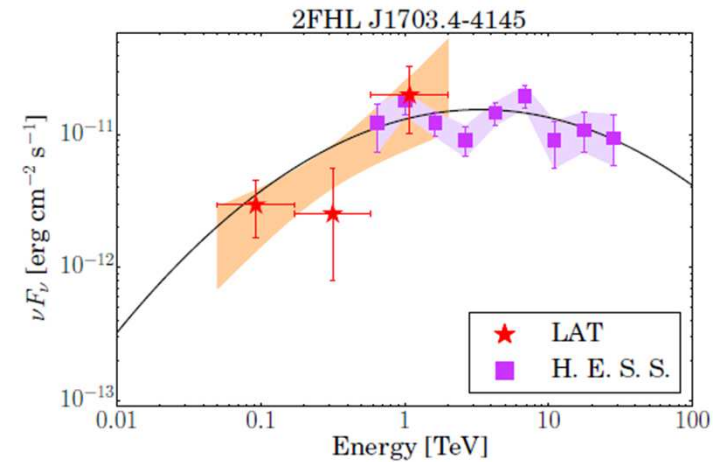
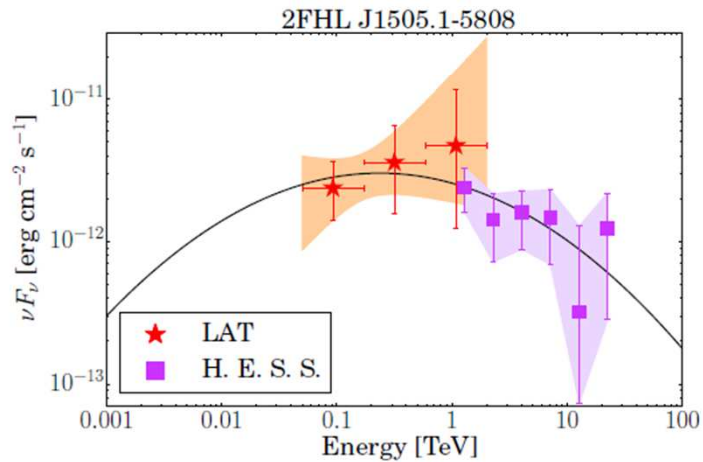
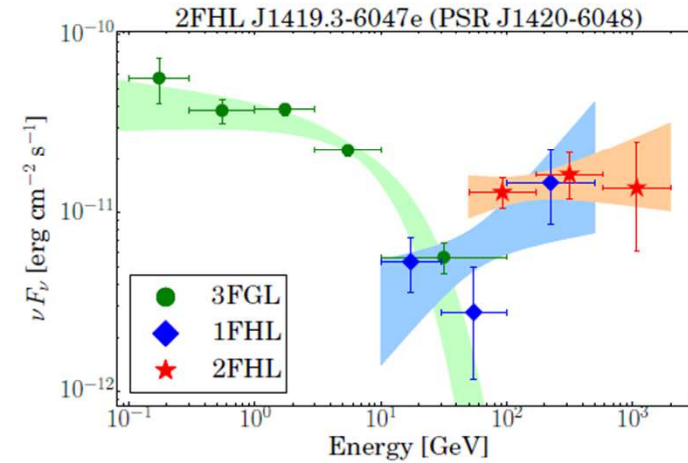
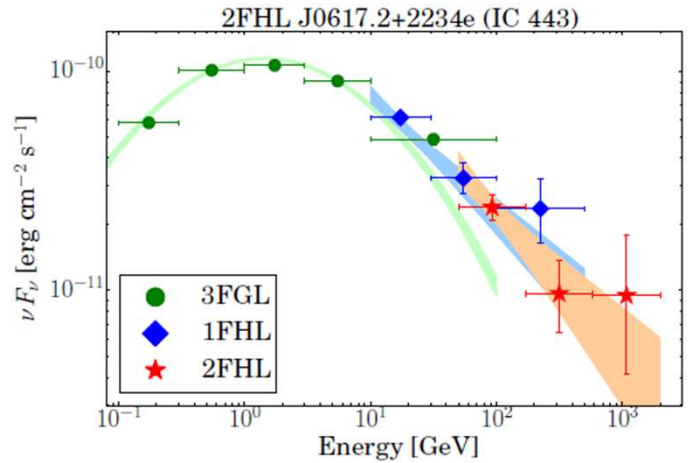
# 2FHL source classes



TABLE 1  
2FHL SOURCE CLASSES

Description	Associated	
	Designator	Number
Pulsar	psr	1
Pulsar wind nebula	pwn	14
Supernova remnant	snr	16
Supernova remnant / Pulsar wind nebula	spp	4
High-mass binary	hmb	2
Binary	bin	1
Star-forming region	sfr	1
BL Lac type of blazar	bll	180
BL Lac type of blazar with prominent galaxy emission	bll-g	13
FSRQ type of blazar	fsrq	10
Non-blazar active galaxy	agn	2
Radio galaxy	rdg	4
Radio galaxy / BL Lac	rdg/bll	2
Blazar candidate of uncertain type I	bcu I	7
Blazar candidate of uncertain type II	bcu II	34
Blazar candidate of uncertain type III	bcu III	19
Normal galaxy (or part)	gal	1
Galaxy cluster	galclu	1
Total associated	...	312
Unassociated	...	48
Total in 2FHL	...	360

# Combined E>100 MeV SED



# Summary

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- **Catalogs are important resources to Fermi-LAT users.**
- **It is good practice to cross-check ones results against those of the latest catalog.**
- **Any significant discrepancy should be carefully investigated.**
- **Beware of flags!**
- **More catalogs (3FHL, 4FGL) are in the works.**