J/ApJS/222/5 The second Fermi-LAT >50GeV catalog (2FHL) (Ackermann+, 2016)

2FHL: the second catalog of hard Fermi-LAT sources.

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Abstract:

We present a catalog of sources detected above 50GeV by the Fermi-Large Area Telescope (LAT) in 80 months of data. The newly delivered Pass 8 event-level analysis allows the detection and characterization of sources in the 50GeV-2TeV energy range. In this energy band, Fermi-LAT has detected 360 sources, which constitute the second catalog of hard Fermi-LAT sources (2FHL). The improved angular resolution enables the precise localization of point sources (~1.7' radius at 68% C. L.) and the detection and characterization of spatially extended sources. We find that 86% of the sources can be associated with counterparts at other wavelengths, of which the majority (75%) are active galactic nuclei and the rest (11%) are Galactic sources. Only 25% of the 2FHL sources have been previously detected by Cherenkov telescopes, implying that the 2FHL provides a reservoir of candidates to be followed up at very high energies. This work closes the energy gap between the observations performed at GeV energies by Fermi-LAT on orbit and the observations performed at higher energies by Cherenkov telescopes from the ground.

Description:

The Large Area Telescope (LAT) on board the Fermi gamma-ray space telescope has been surveying the whole sky since 2008 August. In this paper we use 80 months of Pass 8 data to produce a catalog of sources detected by the LAT at energies between 50GeV and 2TeV. This constitutes the second catalog of hard Fermi-LAT sources, named 2FHL, which allows a thorough study of the properties of the whole sky in the sub-TeV domain.

File Summary:

FileName	Lrecl	Records	Explanations
ReadMe	80	.	This file
2fhl.dat	373	360	The 2FHL source catalog (see tables 2 and 3)
rois.dat	43	154	Region of interests (ROIs) list
table4.dat	85	20	2FHL extended sources previously detected by the Fermi-LAT
table5.dat	89	5	New 2FHL extended sources

Description of file: The original $gll_{psch}v08.fit$ file in FITS format is also available on the FTP and it includes 3 bintables:
the "2FHL Source Catalog", the "Extended Sources" and the "ROIs"

See also:

See also:
VII/274 : The Roma BZCAT - 5th edition (Massaro+, 2015)
VII/189 : Catalog of Pulsars (Taylor+ 1995)
J/A+A/588/A141 : The MWA view of Fermi blazars (Giroletti+, 2016)
J/ApJ/810/14 : Third catalog of LAT-detected AGNs (3LAC) (Ackermann+, 2015)
J/ApJS/218/23 : Fermi LAT third source catalog (3FGL) (Acero+, 2015)
J/A+A/562/A64 : Fermi detection of BL Lac objects (Wu+, 2014)
J/ApJS/209/34 : The first Fermi-LAT >10GeV catalog (1FHL) (Ackermann+, 2013)
J/ApJS/208/17 : 2nd Fermi LAT cat. of gamma-ray pulsars (2PC) (Abdo+, 2013)
J/ApJS/207/16 : BL Lac candidates for TeV observations (Massaro+, 2013)
J/ApJ/764/135 : Spectroscopic redshifts of BL Lac objects (Shaw+, 2013)
J/ApJS/199/31 : Fermi LAT second source catalog (2FGL) (Nolan+, 2012)
J/ApJ/748/49 : Optical spectroscopy of 1LAC broad-line blazars (Shaw+, 2012)
J/ApJ/700/597 : FERMI LAT detected blazars (Abdo+, 2009)
http://fermi.gsfc.nasa.gov/ssc/ : Fermi Science Support Center home page
http://tevcat.uchicago.edu/ : TeVCat home page

Byte-by-byte Description of file: 2fhl.dat

Bytes	Format	Units	Label	Explanations
1- 4	A4	---	---	[2FHL]
6- 18	A13	---	2FHL	2FHL name (JHHMM.m+DDMMe) (Source_Name)
20- 27	F8.4	deg	RAdeg	Right ascension; J2000 (RAJ2000)
29- 36	F8.4	deg	DEdeg	Declination; J2000 (DEJ2000)
38- 44	F7.3	deg	GLON	Galactic longitude (GLON)
46- 52	F7.3	deg	GLAT	Galactic latitude (GLAT)
54- 57	F4.2	deg	e_pos	[0/0.2] Position uncertainty at 68% confidence level (Pos_{err}68)
59- 64	F6.1	---	TS	[25/5601] Test statistic (TS)
66- 70	F5.2	---	Gam	[0.9/15] Observed spectral index (Spectral_Index) (1)
72- 75	F4.2	---	e_Gam	? 1σ uncertainty on the observed spectral index ($Unc_{Spectral}$Index)
77- 81	F5.2	---	SpD11	? Intrinsic spectral index computed using the Dominguez et al. (2011MNRAS.410.2556D) EBL model ($Intr_{Spectr}$Index_D11) (1)
83- 86	F4.2	---	e_SpD11	? 1σ uncertainty on SpD11 ($Unc_{Intr}Spectral_{Index}$D11)
88- 92	F5.2	---	SpG12	? Intrinsic spectral index computed using the Gilmore et al. (2012MNRAS.422.3189G) (1) EBL model ($Intr_{Spectra}$Index_G12)
94- 97	F4.2	---	e_SpG12	? 1σ uncertainty on SpG12 ($Unc_{Intr}Spectral_{Index}$G12)
99-106	E8.3	ph/cm2/s	F50	Integral photon flux from 50GeV to 2TeV (Flux50)
108-115	E8.3	ph/cm2/s	e_F50	1σ uncertainty on F50 (Unc_Flux50)
117-124	E8.3	mW/m2	S50	Energy flux from 50GeV to 2TeV in erg/cm^2/s (Energy_Flux50)
126-133	E8.3	mW/m2	e_S50	1σ uncertainty on S50 (Unc_{Energy}Flux50)
135-142	E8.3	ph/cm2/s	F171	Integral photon flux from 50 to 171GeV (Flux50_171GeV)
144-152	E9.3	ph/cm2/s	e_F171	[-0.1/]? 1σ negative uncertainty on F171 (Unc_{Flux50}171GeV)
155-162	E8.3	ph/cm2/s	E_F171	? 1σ positive uncertainty on F171 ($Positive_{Unc}$Flux50_171GeV) (2)
164-168	F5.2	---	TS171	Square root of the Test Statistic between 50 and 171GeV ($Sqrt_{TS50}$171GeV)
170-177	E8.3	ph/cm2/s	F585	Integral photon flux from 171 to 585GeV (Flux171_585GeV)
179-187	E9.3	ph/cm2/s	e_F585	[-0.1/]? 1σ negative uncertainty on F585 ($Unc_{Flux171}$585GeV)
190-197	E8.3	ph/cm2/s	E_F585	? 1σ positive uncertainty on F585 ($Positive_{Unc}$Flux171_585GeV) (2)
199-203	F5.2	---	TS585	Square root of the Test Statistic between 171 and 585GeV ($Sqrt_{TS171}$585GeV)
205-212	E8.3	ph/cm2/s	F2000	Integral photon flux from 585GeV to 2TeV (Flux585_2000GeV)
214-222	E9.3	ph/cm2/s	e_F2000	[-0.1/]? 1σ negative uncertainty on F2000 ($Unc_{Flux585}$2000GeV)
225-232	E8.3	ph/cm2/s	E_F2000	? 1σ positive uncertainty on F2000 ($Positive_{Unc}$Flux585_2000GeV) (2)
234-238	F5.2	---	TS2000	Square root of the Test Statistic between 585GeV and 2TeV ($Sqrt_{TS585}$2000GeV)
240-244	F5.1	---	Npred	[3/378] Predicted number of photons from the source (Npred)
246-251	F6.1	GeV	EHEP	[52/1997]? Highest photon energy (HEP_Energy) (3)
253-256	F4.2	---	PHEP	[0.85/1]? Probability that the HEP is coming from the source, ≥0.85 (HEP_Prob) (3)
258-260	I3	---	ROI	[1/143] Region of interest number (ROI)
262-286	A25	---	Assoc	Name of the most likely associated source (ASSOC)
288-291	F4.2	---	PBAY	[0.8/1]? Probability of association from the Bayesian method ($ASSOC_{PROB}$BAY)

293-296	F4.2	---	PLR	[0.7/1]? Probability of association from the likelihood ratio method ($ASSOC_{PROB}LR$)
298-305	A8	---	Class	Class designation for the most likely association (CLASS) (4)
307-311	F5.3	---	z	[0/2.1]? Redshift (when available) of the most likely associated source (Redshift) (5)
313-320	E8.3	Hz	NuPk	? Observed Synchrotron peak frequency (NuPeak_obs)
322-325	A4	---	---	[3FGL]
327-339	A13	---	3FGL	Name of the most likely associated source in the 3FGL ($_{3FGL}$Name)
341-344	A4	---	---	[1FHL]
346-358	A13	---	1FHL	Name of the most likely associated source in the 1FHL ($_{1FHL}$Name)
360-362	A3	---	---	[TeV]
364-373	A10	---	TeVCat	Name of the most likely associated source in the TeVCat (TeVCat_Name)

Note (1): 2FHL J0811.6+0146 is detected with only few photons with energies around the 50GeV threshold. As such a measurement of its spectral index is not possible and in the catalog its value has been fixed to 15.
Note (2): In cases of blank values in e_F171, e_F585 or e_F2000, those values are the upper errors and the corresponding fluxes are upper limits.
Note (3): Two extended sources, 2FHL J1801.3-2326e and 2FHL J2028.6+4110e, despite being detected with ~39 and ~131 photons, respectively, do not have single photons that have a probability of belonging to the source >85%. As such their "HEP_Energy" (EHEP) and "HEP_Prob" (PHEP) columns are left blank.
Note (4): Class of the most likely associated source (from table 1) as follows:

Class	Description	Number
psr	= Pulsar	1
pwn	= Pulsar wind nebula	13
snr	= Supernova remnant	15
spp	= Supernova remnant/Pulsar wind nebula	6
hmb	= High-mass binary	2
bin	= Binary	1
sfr	= Star-forming region	1
bll	= BL Lac type of blazar	180
bll-g	= BL Lac type of blazar with prominent galaxy emission	13
fsrq	= FSRQ type of blazar	10
agn	= Non-blazar active galaxy	2
rdg	= Radio galaxy	4
rdg/bll	= Radio galaxy/BL Lac	2
bcu I	= Blazar candidate of uncertain type I	7
bcu II	= Blazar candidate of uncertain type II	34
bcu III	= Blazar candidate of uncertain type III	19
gal	= Normal galaxy (or part)	1
galclu	= Galaxy cluster	1
	Total associated	312
unk	= Unassociated	48
	Total in 2FHL	360

The designation "spp" indicates potential association with SNR or PWN.
The "bcu I," "bcu II," and "bcu III" classes are derived from 3LAC and describe the increasing lack of multiwavelength information to classify the source as a blazar (see Ackermann et al. 2015, J/ApJ/810/14 for more details). The designation "bll-g" is adapted from the BZCAT (Massaro et al. 2015, VII/274) and indicates a blazar whose SED has a significant contribution from the host galaxy.
Note (5): Redshifts were taken from from Shaw et al. (2012, J/ApJ/748/49; 2013, J/ApJ/764/135), Masetti et al. (2013A&A...559A..58M) and the NED and SIMBAD databases.

Byte-by-byte Description of file: rois.dat

Bytes	Format	Units	Label	Explanations
1- 3	I3	---	ROI	[1/154] Running sequence number of the Region of Interest (ROI)
5- 12	F8.4	deg	RAdeg	Right ascension in decimal degrees (J2000)
14- 21	F8.4	deg	DEdeg	Declination in decimal degrees (J2000)
23- 29	F7.3	deg	GLON	Galactic longitude
31- 37	F7.3	deg	GLAT	Galactic latitude
39- 43	F5.2	deg	Rad	[5/25] Radius

Byte-by-byte Description of file: table4.dat

Bytes	Format	Units	Label	Explanations
1- 13	A13	---	2FHL	2FHL name (JHHMM.m+DDMMe) (1)

15- 21	F7.3	deg	GLON	[6.5/347.4] Galactic longitude
23- 29	F7.3	deg	GLAT	[-32.9/3.1] Galactic latitude
31- 36	F6.2	---	TS	[28/438] Test Statistic
38- 52	A15	---	Assoc	Name of the most likely associated source
54- 56	A3	---	Class	Class designation for the most likely association
58- 68	A11	---	Mod	Spatial model
70- 85	A16	deg	Ext	Extension(s) (2)

Note (1): List of the 20 extended sources in the 2FHL that were previously detected as extended by the Fermi-LAT. All these sources are in 3FGL except W41, which is studied by Abramowski et al. (2015A&A...574A..27H).
Note (2): The extension of the disk templates is given by the radius, the extension of the two-dimensional (2D) Gaussian templates is given by the 1σ radius, and the elliptical templates are given by the semimajor axis, semiminor axis, and position angle (east of north).

Byte-by-byte Description of file: table5.dat

Bytes	Format	Units	Label	Explanations
1- 13	A13	---	2FHL	2FHL name (JHHMM.m+DDMMe) (1)
15- 21	F7.3	deg	GLON	Galactic longitude
23- 28	F6.3	deg	GLAT	Galactic latitude
30- 34	F5.1	---	TS	[75.6/109.3] Test Statistic
36- 39	F4.1	---	TSex	[29.9/83.4] Extended Test Statistic TS_{ext}
41- 44	F4.1	---	TS2p	[12.9/26.2] Second point source TS (TS_{2pts})
46- 50	F5.2	---	F50	[7.2/17.6] Integral photon flux from 50GeV to 2TeV
52- 55	F4.2	---	e_F50	[1.7/2.8] 1σ uncertainty on F50
57- 60	F4.2	---	Gamma	[1.5/2.2] Observed spectral index
62- 65	F4.2	---	e_Gamma	[0.1/0.3] 1σ uncertainty on Gamma
67- 80	A14	---	Assoc	Name of the most likely associated source
82- 84	A3	---	Class	Class designation for the most likely association
86- 89	F4.2	deg	Rad	[0.2/1.3] Radius

Note (1): List of the 5 new extended sources in the 2FHL. All these sources are characterized by an uniform disk template whose radius is given in the last column.

History:
From electronic version of the journal

(End) Prepared by [AAS], Emmanuelle Perret [CDS] 08-Feb-2016

*The document above follows the rules of the Standard Description for Astronomical Catalogues; from this documentation it is possible to generate **f77** program to load files into arrays or line by line*