



# The *Fermi* LAT mission at the SSDC

AGN catalogs and interactive data exploitation

**Stefano Ciprini** <sup>1,2\*</sup>

(presented by Francesco Verrecchia)

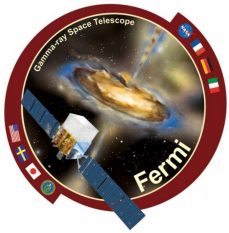
(\* also on behalf of the Fermi LAT Collaboration)

1. Space Science Data Center - ASI, Rome, Italy
2. INFN Section of Perugia, Italy



Treasures Hidden in High Energy Catalogues,  
IRAP, Toulouse, France, 22-24 May 2018





# Fermi Gamma-ray Space Telescope



**Large Area Telescope (LAT)**  
- pair conversion telescope

- 20 MeV – > 300 GeV

**Gamma-ray Burst Monitor (GBM) - counters**

- 8 keV – 40 MeV

**Huge field of view (2.4sr)**

- 20% sky any instant
- All sky for 30' every 3h

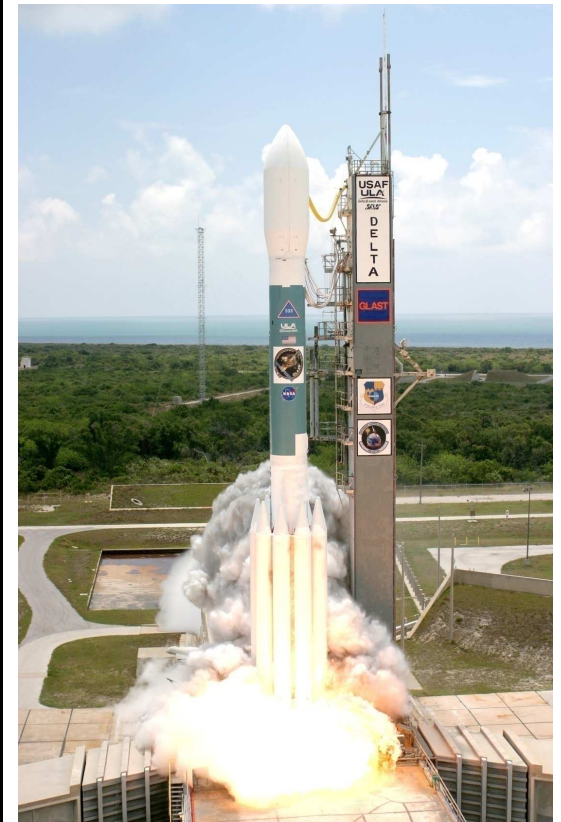
**Huge energy range**

- Including 10-100 GeV

**Public data**

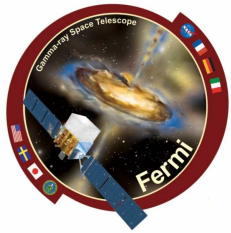
- ~500 collaboration papers
- ~2500 total nb of papers

launch from Cape Canaveral 11-6-2008

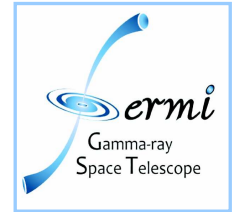


☐ Launched 11 June 2008, Delta II Rocket, circular orbit, 565km altitude, 25.6 deg inclination. **Operations.** Primary mode: all-sky survey with scan of the entire sky for 30min every 3 hours. Autonomous Repoint Request (ARR). Target of Opportunity (ToO). Huge field of view (2.4sr).





# Celebrations of 10 years of *Fermi* and the 8th International *Fermi* Symposium



☐ [fermi.gsfc.nasa.gov/fermi10/](http://fermi.gsfc.nasa.gov/fermi10/)

☐ [fermi.gsfc.nasa.gov/science/mtgs/symposia/2018/](http://fermi.gsfc.nasa.gov/science/mtgs/symposia/2018/)

NASA National Aeronautics and Space Administration Goddard Space Flight Center Fermi - HEASARC - Sciences and Exploration

## Celebrating 10 Years of Fermi June 11, 2018

Home What is Fermi Science Fermi@10 Support Center Mission Page Students/Teachers

### June 11, 2018 is Fermi's Tenth Launch Anniversary

Welcome to a Fermi's 10th year!

We'll be celebrating throughout 2018, sharing Fermi's influence on science, technology, and art. If you want to stay on top of all the Fermi fun, be sure to follow/friend NASA/Fermi on Facebook and Twitter!

Here are some of the great features you can look forward to:

- Fermi on Tumblr: Monthly posts introducing Fermi's topic for the month
- Fermi Fridays: Weekly posts discussing all things Fermi
- Fermi-related Facebook: Live events throughout 2018!
- The 8th International Fermi Symposium: October 15-19, Baltimore, MD

Fermi Launch 10<sup>th</sup> Anniversary - June 11

## 8th International Fermi Symposium

October 15-19, 2018

Baltimore Inner Harbor Baltimore Maryland USA

<https://go.nasa.gov/2H5qh1g>

### **Eighth International *Fermi* Symposium** **Oct 14-19, 2018, Baltimore, MD, USA**

The 8th Fermi Symposium (2018) follows previous symposia at Stanford, CA (February 2007), Washington, DC (November 2009), Rome, Italy (May 2011), Monterey, CA (November 2012), Nagoya, Japan (October 2014), Arlington, VA (November 2015), and Garmisch-Partenkirchen, Germany (October 2017).

**Invitation** for the Toulouse HE Gems Conference participants to analyze the, public, *Fermi* LAT data and to **submit abstracts to this 8th Fermi Symposium!** Also **X-rays based science is welcome!**



Meet Fermi's Flight Ops Team



Treasures in HE Cat., 22-24 May 2018, IRAP, Toulouse

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# Fermi Gamma-ray Space Telescope



## Fermi (formerly GLAST): two Instruments

### The Large Area Telescope (LAT)

20 MeV - 300 GeV  
>2.5 sr FoV



**Gamma Ray Burst Monitor (GBM):**  
correlative transient observations  
~ 8 keV – 30 MeV

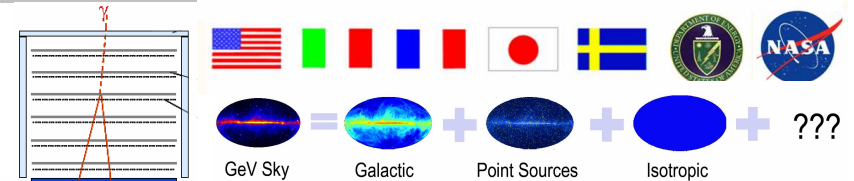
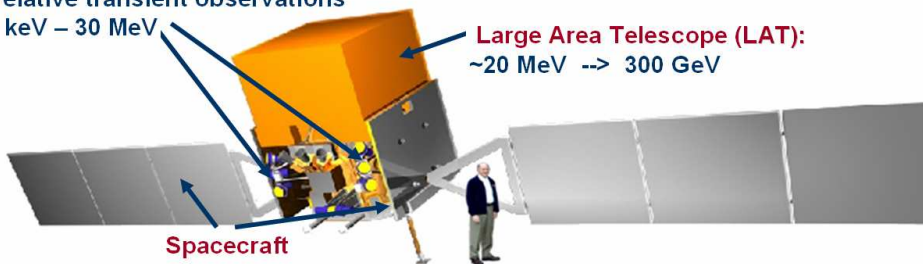
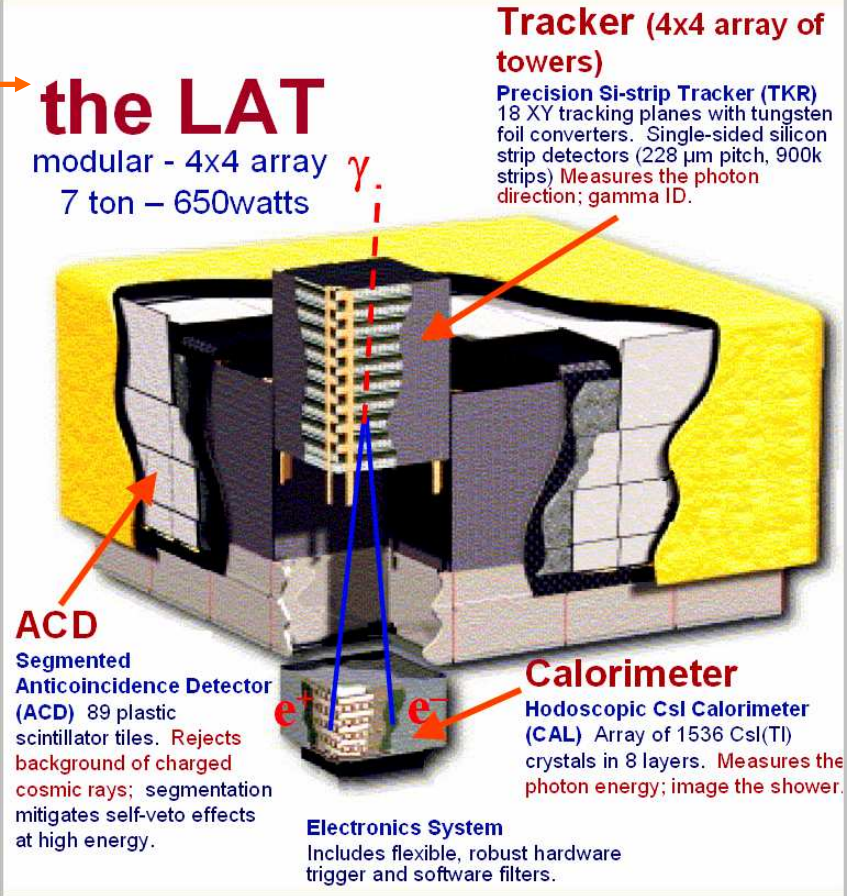
### The Burst Monitor (GBM)

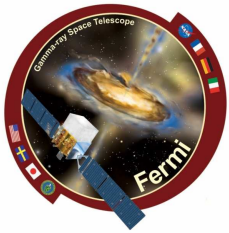
8 keV – 40 MeV  
9.5 sr FoV



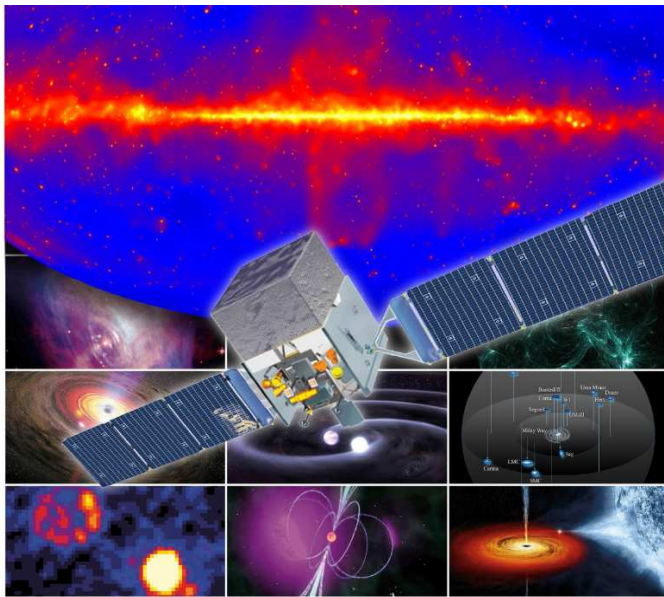
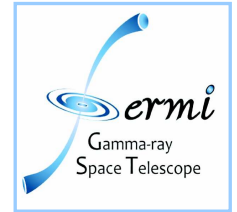
## the LAT

modular - 4x4 array  
7 ton – 650watts





# Fermi gamma-ray sources and science menu

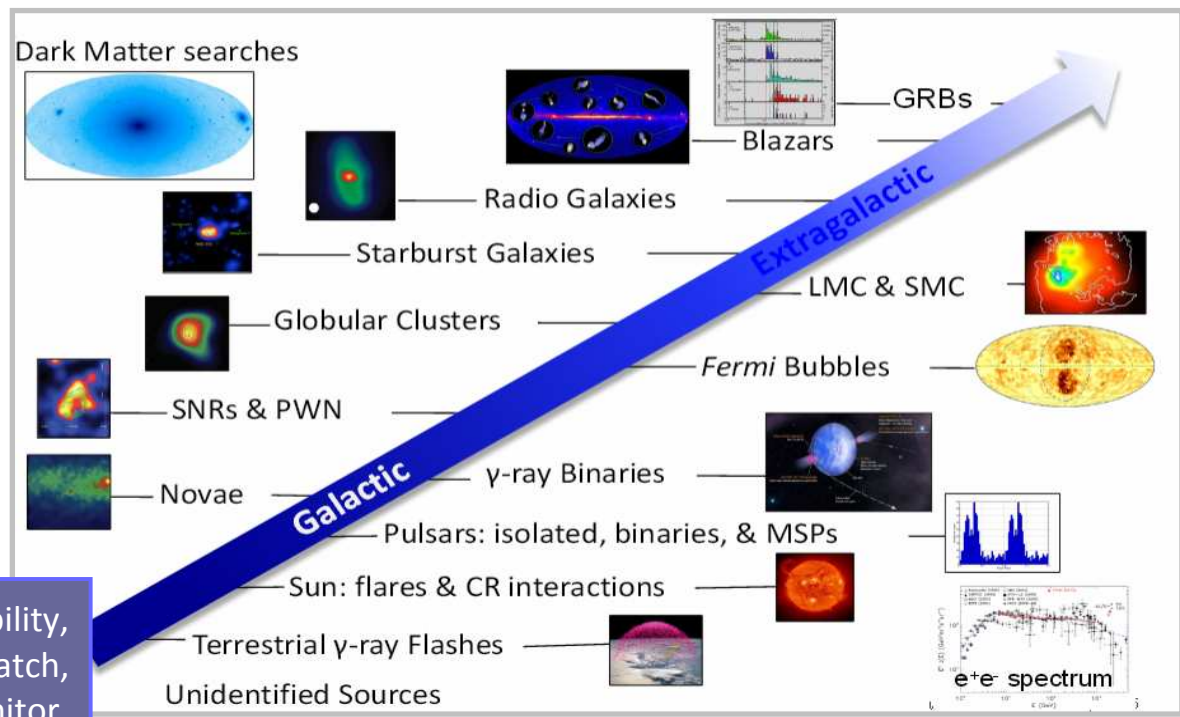


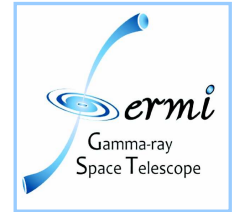
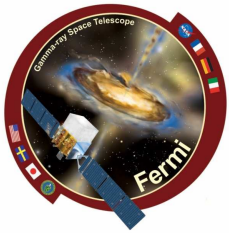
NASA Senior Review 2016 Fermi science themes:

- Messengers** (gammas, electrons, and MM/MW astroph.)
- Time** (millisecond transients to multi-year variability/modulations)
- Dark Matter** (WIMPs and axion candidates)
- Particle Astrophysics** (CR acceleration sites and mechanisms).

*Fermi*: unique **ALL-SKY + ALL-TIMES** mission for the HE cosmic laboratory and natural astrophysical accelerators.

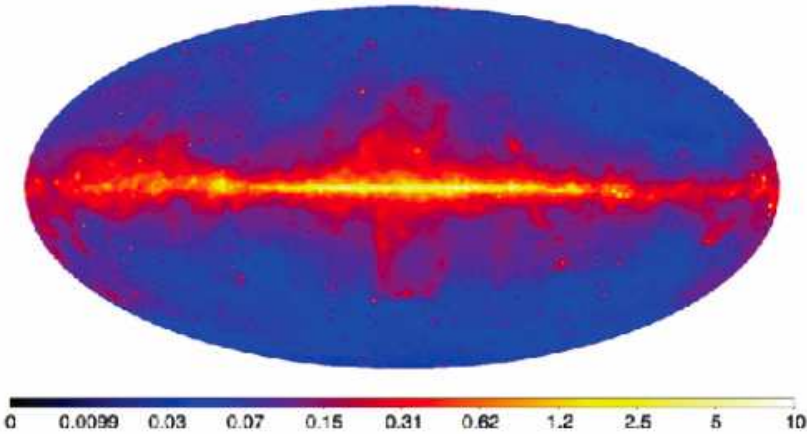
**SURVEY** → uniformity, serendipity, variability, transients, cross-corr, cross-match, time domain monitor.



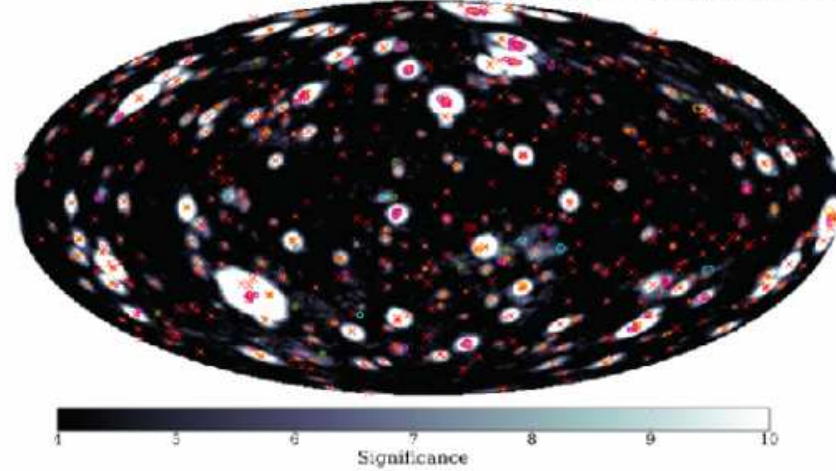


# Different gamma-ray *Fermi* skies

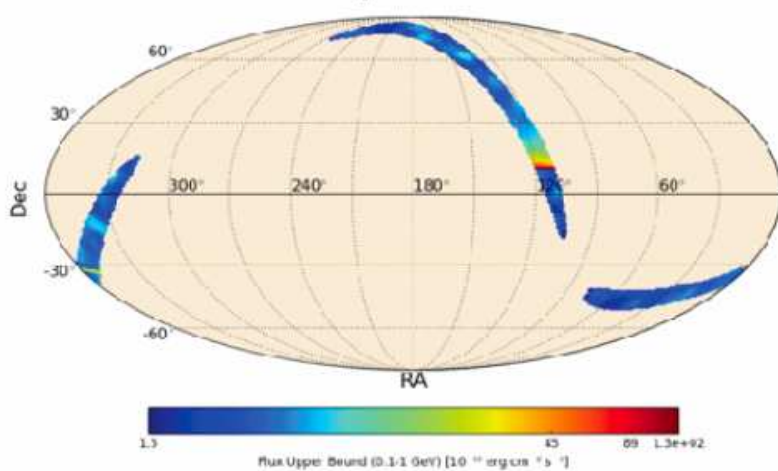
High Energy - 3FHL - arxiv.1702.00644



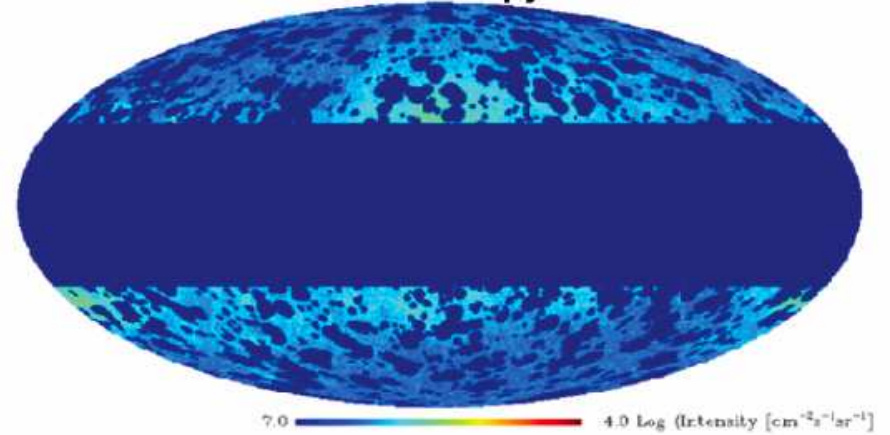
Flares - 2FAV - arxiv.1612.03165



GW170104 EM counterpart searches - arxiv.1706.00199



IGRB anisotropy - arxiv.160807289





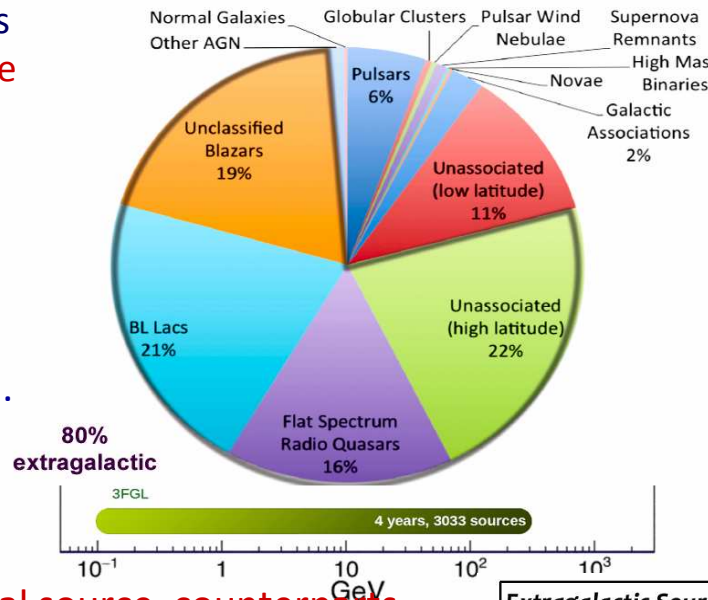
# Fermi LAT as an AGN and blazar telescope

Active Galactic Nuclei (AGN) and blazars in particular (they represent the extragalactic sky), dominated the gamma-ray source counts in Fermi LAT general catalogs.

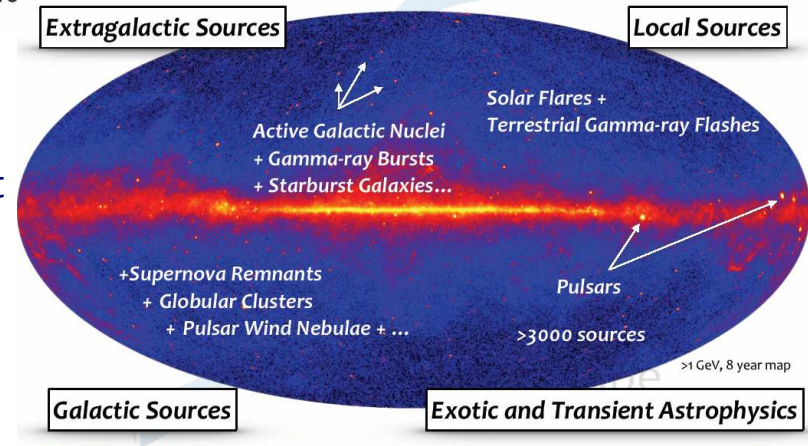
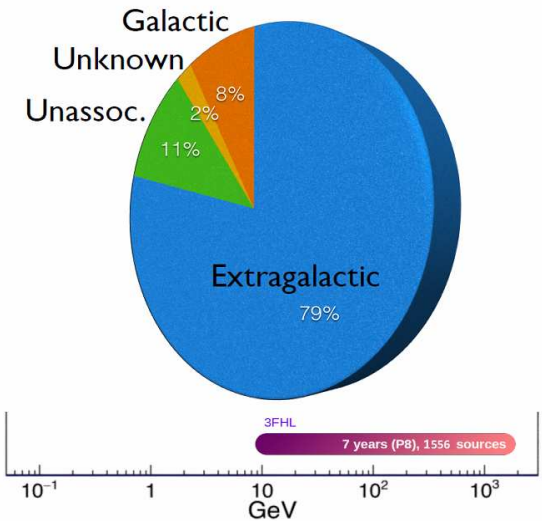
The 3rd LAT AGN catalog (3LAC) follows in the footsteps of the 3FGL catalog. It has 1773 AGN (1591 located at high ( $|b| > 10^\circ$ ) Gal. lat.). 71% increase over the 2LAC. 2% are associated with non-blazar sources.

Association of e.m. astrophysical source counterparts (radio/optical/IR/X-ray) is generally the strongest statement that we can make: two quantitative methods, Bayesian method (BM) likelihood ratio method (LRM), for assignment of associations in the 3FGL/3LAC.

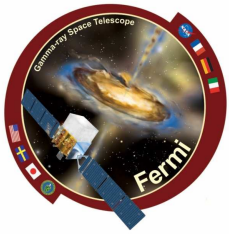
## 3FGL demographics



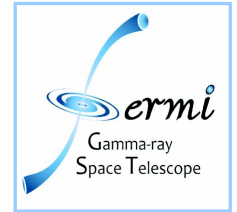
## 3FHL demographics



Catalog	Energy Range (GeV)	Data Interval (months)	Sources	Event Selection	Release Date
3FGL	0.1-300	48	3033	P7V15 SOURCE	Jan.2015



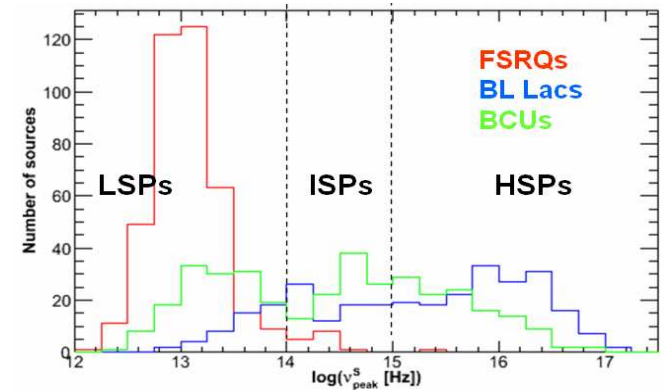
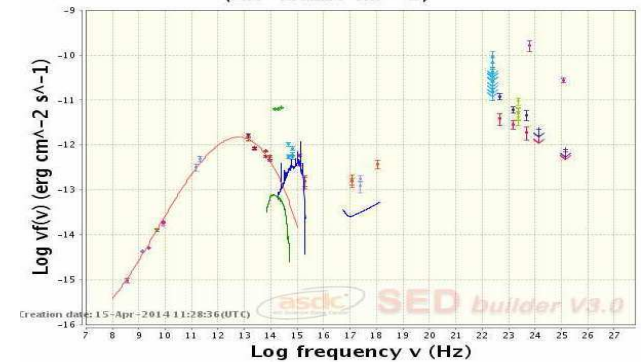
# The 3rd LAT AGN catalog (3LAC)



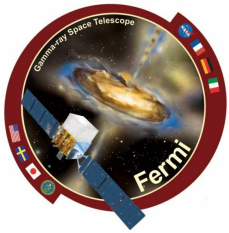
- ❑ The 3LAC follows in the footsteps of the 3FGL (blazars dominates). The 3LAC is a significant improvement over the 2LAC also in term of analysis method/data quality. Main properties in 1LAC and 2LAC confirmed.
- ❑ Association of source counterparts is generally the strongest statement that we can make: two quantitative methods, Bayesian method (BM) Likelihood ratio method (LRM), for assignment of associations in the 3FGL/3LAC.
- ❑ The source counterpart association is like calibrated cross correlation between source catalogs and surveys (covering the entire sky or complementary, ex: NVSS/SUMSS/PMN/ATCA20/RASS), providing quantitative probabilities of association and to controlled false positive association rate (1,2,3FGL/1,2,3LAC catalogs we adopted  $P > 0.8$  threshold in one of the two methods).
- ❑ 3LAC: LRM specific for this catalog. Association probability  $> 0.8$  in one of the 2 methods: 71% BM & LRM, 379 only BM, 62 only LRM, false-positive rate  $< 2\%$ .
- ❑ 3LAC: 2 classification schemes for the associated AGN: 1) optical spectrum-based (strength of broad lines, FSRQs, BL Lacs, BCUs aka Blazar Candidates of Unknown type); 2) Spectral Energy Distribution (SED) based (Low-, Intermediate-, High-Synchrotron-Peaked AGN/blazars LSPs, ISPs, HSPs). Algorithm-/manually-controlled fit.
- ❑ Identification: strong term, based on correlated variability or spatial extent (in the 3FGL: 25 extended sources, 232 identified sources, 132 of which were pulsars, the other are mostly blazar with correlated multifrequency variability).

Catalogs used for 3LAC source association: Véron-Cetty & Véron; BZCAT; VLBA Calibrator list; CRATES; CGRaBs; TeVCat; ATCA 20-GHz survey; WISE gamma-ray blazar candidates; 1WHSP; NRAO VLA Sky Survey; Sydney University Mongolo Sky Survey; ROSAT All Sky Survey Bright and Faint Source Catalogs.

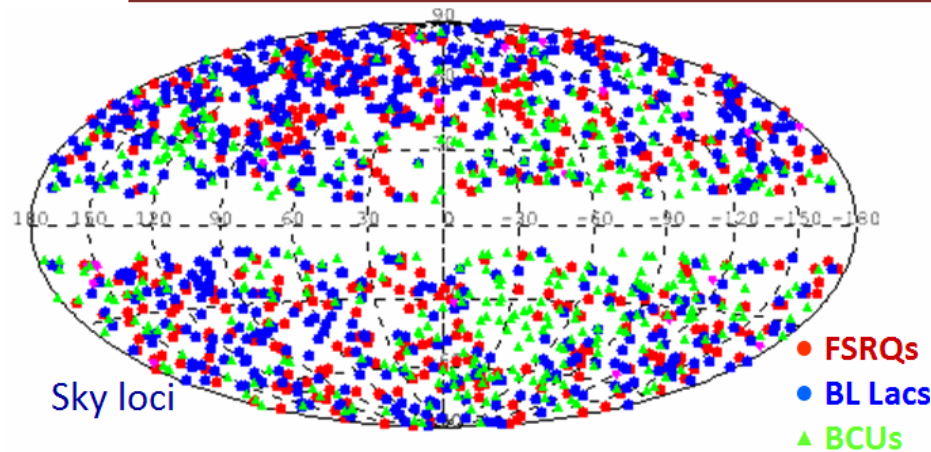
sed-2005m2310 Ra=301.48542 deg Dec=-23.17417 deg (NH=7.6E20 cm<sup>-2</sup>)



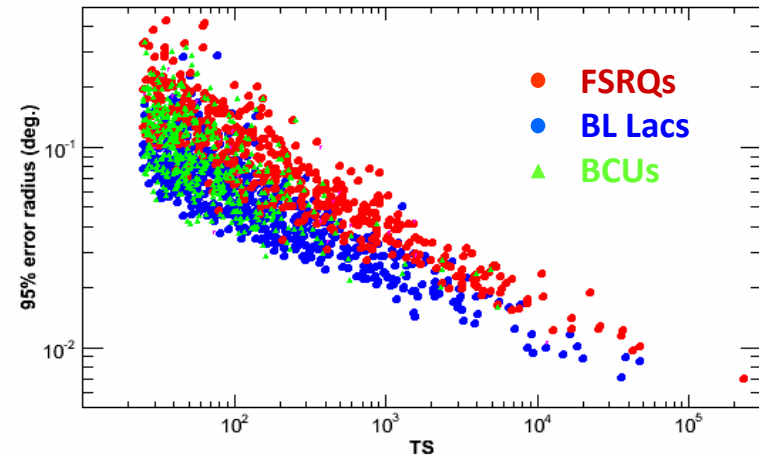




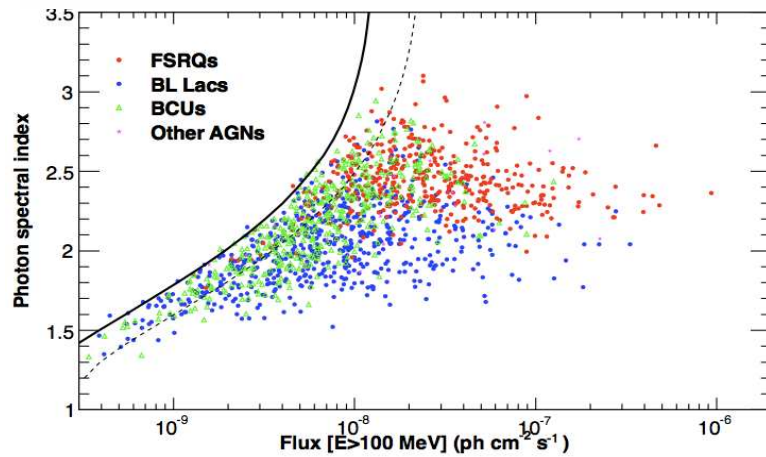
# 3LAC sample properties



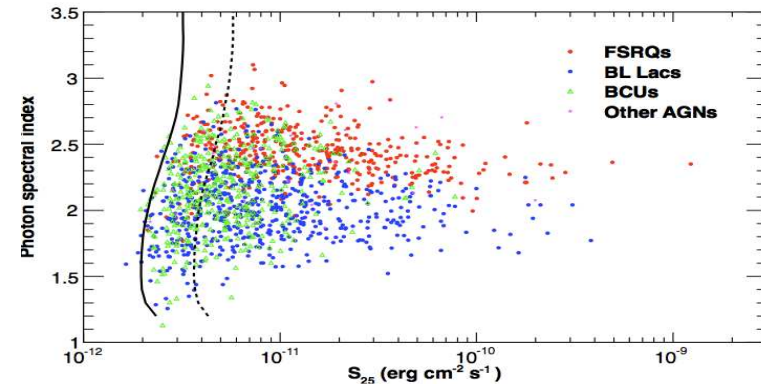
Sky loci



95% position error radii vs TS (detection significances)



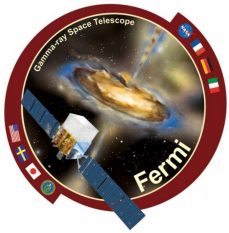
Spectral photon index vs integrated ( $E > 100$  MeV) gamma-ray flux



Spectral photon index vs gamma-ray (100 MeV - 100 GeV) energy flux (less biased by the ph.index).

Flat Spectrum Radio Quasars (FSRQs), BL Lacertae objects (BL Lacs), blazar candidates of unknown type (BCUs)

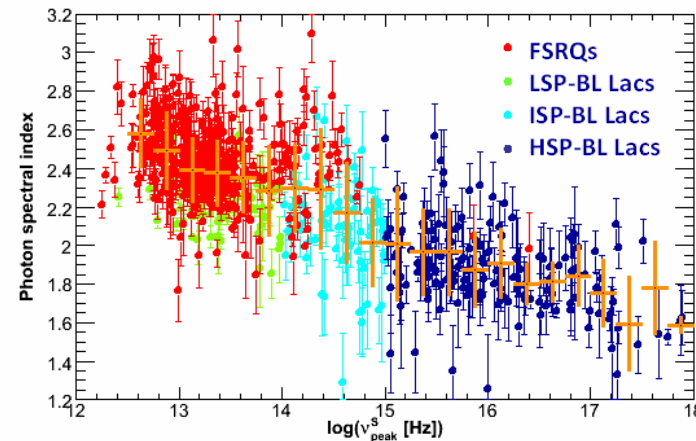




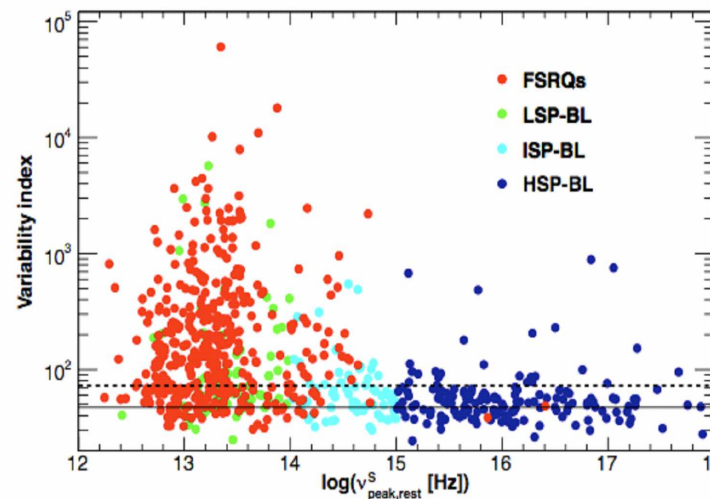
# 3LAC sample properties

☐ Radiogalaxies/misaligned AGN in 3LAC (12 FRI, 3 FRII, 8 SSRQ/CSS). Significant increase of non-blazar AGN population (3 new FRI, 2 new FRII, 4 new SSRQ).

Name	3FGL	Type	Photon index <sub>L</sub>
NGC 1218	J0308.6+0408*	FRI	2.07±0.11
IC 310	J0316.6+4119*	FRI/BLL	1.90±0.14
NGC 1275	J0319.8+4130*	FRI	2.07±0.01
1H 0323+342	J0325.2+3410*	NLSy1	2.44±0.12
4C +39.12	J0334.2+3915*	FRI/BLL?	2.11±0.17
TXS 0348+013	J0351.1+0128*	SSRQ	2.43±0.18
3C 111	J0418.5+3813	FRII	2.79±0.08
Pictor A	J0519.2-4542*	FRII	2.49±0.18
PKS 0625-35	J0627.0-3529*	FRI/BLL	1.87±0.06
4C +52.17	J0733.5+5153	AGN	1.74±0.16
NGC 2484	J0758.7+3747*	FRI	2.16±0.16
4C +39.23B	J0824.9+3916	CSS	2.44±0.10
3C 207	J0840.8+1315*	SSRQ	2.47±0.09
SBS 0846+513	J0849.9+5108*	NLSy1	2.28±0.04
3C 221	J0934.1+3933	SSRQ	2.28±0.12
PMN J0948+0022	J0948.8+0021*	NLSy1	2.32±0.05
PMN J1118-0413	J1118.2-0411*	AGN	2.56±0.08
B2 1126+37	J1129.0+3705	AGN	2.08±0.13
3C 264	J1145.1+1935*	FRI	1.98±0.20
PKS 1203+04	J1205.4+0412	SSRQ	2.64±0.16
M 87	J1230.9+1224*	FRI	2.04±0.07
3C 275.1	J1244.1+1615	SSRQ	2.43±0.17
GB 1310+487	J1312.7+4828*	AGN	2.04±0.03
Cen A Core	J1325.4-4301*	FRI	2.70±0.03
Cen A Lobes	J1324.0-4330e	FRI	2.53±0.05
3C 286	J1330.5+3023*	SSRQ/CSS	2.60±0.16
Cen B	J1346.6-6027	FRI	2.32±0.01
Circinus	J1413.2-6518	Seyfert	2.43±0.10
3C 303	J1442.6+5156*	FRII	1.92±0.18
PKS 1502+036	J1505.1+0326*	NLSy1	2.61±0.05
TXS 1613-251	J1617.3-2519	AGN	2.59±0.10
PKS 1617-235	J1621.1-2331*	AGN	2.50±0.23
NGC 6251	J1630.6+8232*	FRI	2.22±0.08
3C 380	J1829.6+4844*	SSRQ/CSS	2.37±0.04
PKS 2004-447	J2007.8-4429*	NLSy1	2.47±0.09

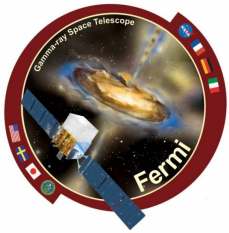


Correlation between gamma-ray spectral hardness and synchrotron peak frequency confirmed (also for BCUs).

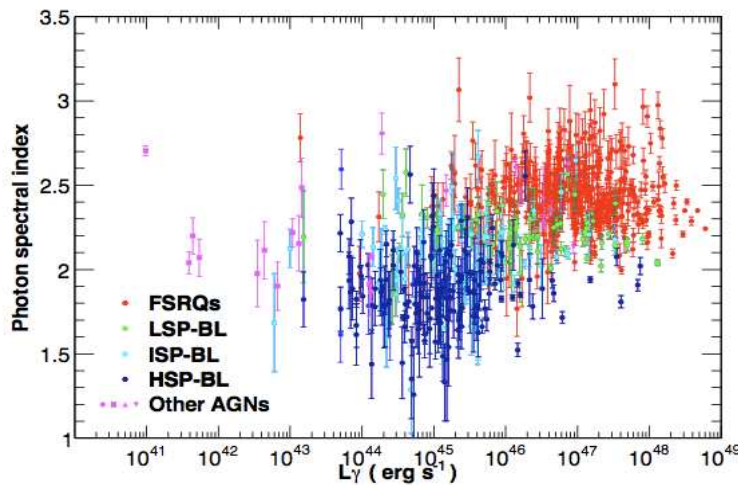


Fractions of sources showing significant gamma-ray variability  
 FSRQs: 69%  
 BL Lacs 23%  
 (39%, 23%, 15%) for (LSP, ISP, HSP).

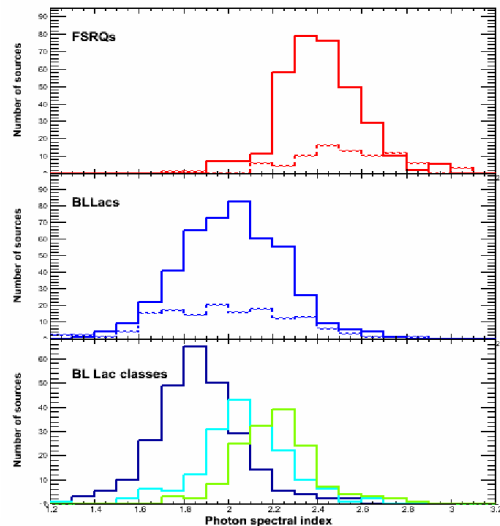




# 3LAC sample properties

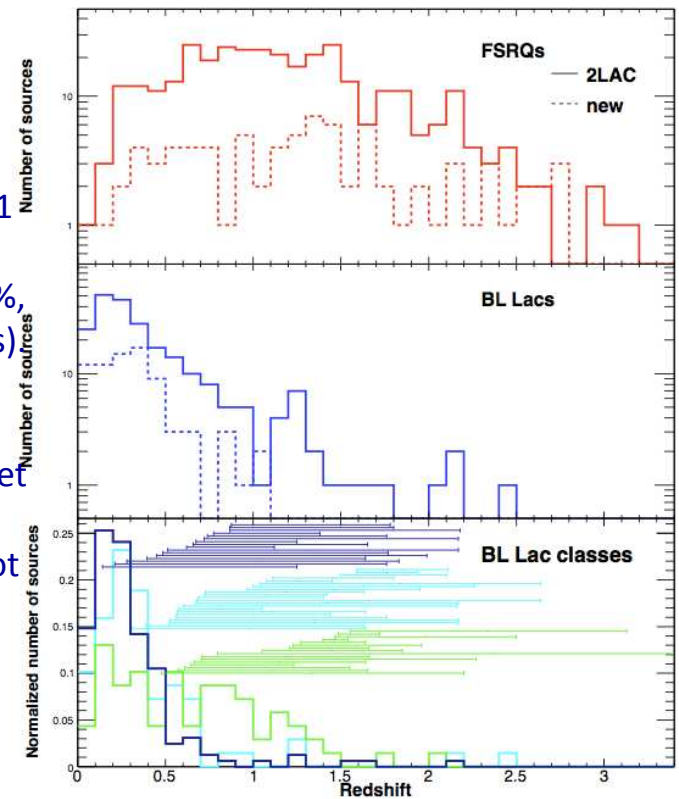


Spectral photon index vs gamma-ray power (luminosity).



## Redshifts

- Slightly higher  $z$  for new FSRQs relative to 2LAC ones  $\langle z \rangle = 1.33$  vs. 1.17.
- Maximum redshift still  $z = 3.1$
- 295/604 BL Lacs have no measured redshifts (55%, 61%, 40%) for (LSPs, ISPs and HSPs)
- Narrower  $z$  distribution for BL Lacs in 3LAC than 2LAC.
- 134 constraints from Shaw et al. (2013).
- Redshift limits for BLLacs not compatible with measured redshifts: measured redshifts are biased low.



## Photon spectral indexes

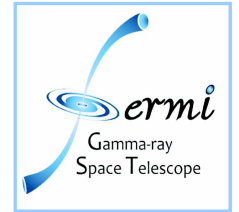
- Little overlap between FSRQs and BL Lacs
- New FSRQs slightly softer than 2LAC ones:  $\langle \Gamma \rangle = 2.53$  vs. 2.41, and not so for BL Lacs
- BCUs' index distribution straddling the two classes and extending beyond 2.5

## Gamma-ray blazar luminosity functions:

a rise in HSP density corresponds to a drop-off in that of FSRQs. Are HSPs an accretion-starved end state of an earlier merger-driven, gas-rich phase (FSRQs)?



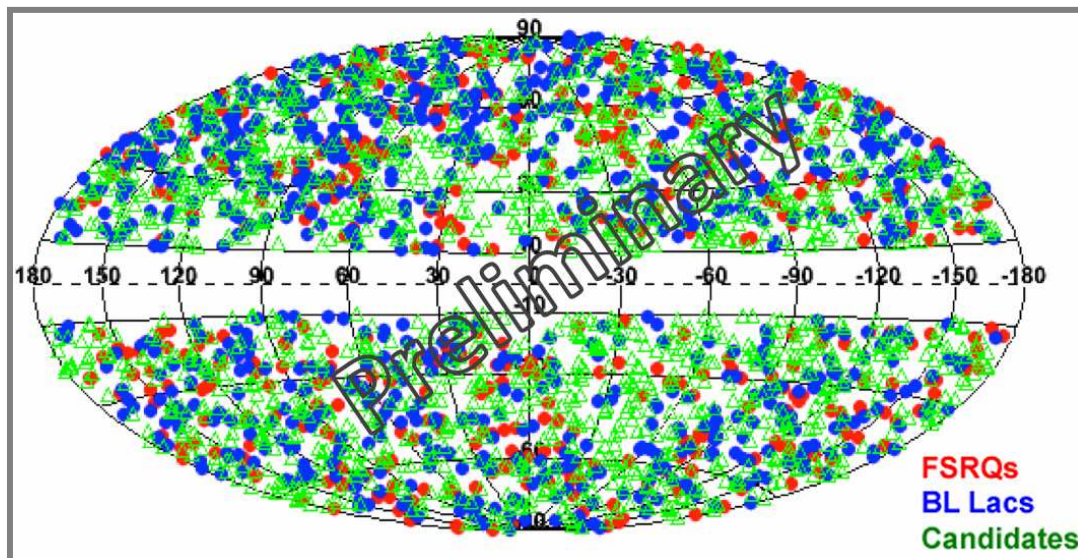
# The next 4th LAT AGN catalog (4LAC)



□ The 4th LAT AGN Catalog (4LAC) is the companion catalog containing sources associated with blazars and other AGNs counterparts being in the 4FGL general catalog. The 4LAC will follow the publication of the 4FGL catalog. The 4LAC will be a reference for works on individual sources in the next years.

□ The 4LAC catalog will be a significant improvement over the 3LAC and, preliminary, the first working internal releases represent about 75% of the all the high galactic-latitude sources in the 4FGL catalog.

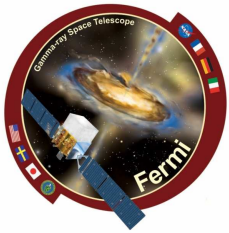
(see also D. Gasparrini at “The 7th Fermi International Fermi Symposium”).



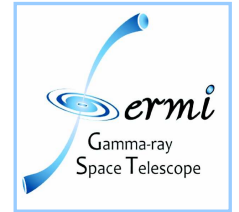
Pictorial all sky map (Galactic coordinates) of the sky loci of a very preliminary list of sources for the 4LAC catalog.

□ New candidates need to be checked one by one to confirm their "blazarness".

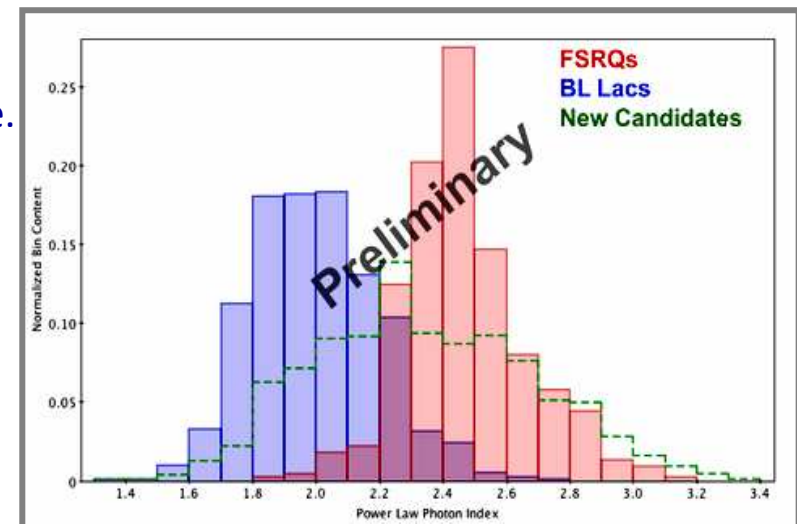


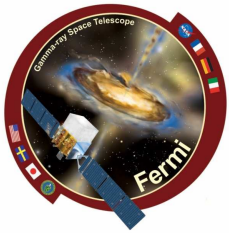


# The next 4th LAT AGN catalog (4LAC)

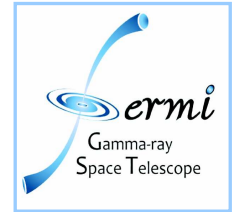


- ❑ 4LAC content: AGN/blazar source associations, redshifts, estimation of the synchrotron peak and, for the first time all the parameters of the synchrotron SED hump (3rd polynomial degree SED component fit parameters), more focused discussion on the AGN class populations (blazar sequence, BL Lac-FSRQ dichotomy, blazar cosmological evolution).
- ❑ Like in the 3LAC, two source counterpart association methods (Bayesian method based on catalogs of known source types, and likelihood ratio method using surveys in radio and X-ray bands).
- ❑ Probability threshold is fixed to 0.8.  
Possible sub-threshold releases in consideration for particular purposes (ToO, GIs,...) but false positives increase.
- ❑ Classification schemes based on optical class (optical spectrum, FSRQ, BL Lac, etc.), and SED class (synchrotron peak estimation, HSP, ISP, LSP).
- ❑ 4LAC very preliminary counts:
  - >2900 AGN/blazars and candidates
  - >2600 AGN/blazars and candidates at high Galactic latitude ( $|b| > 10^\circ$ ).

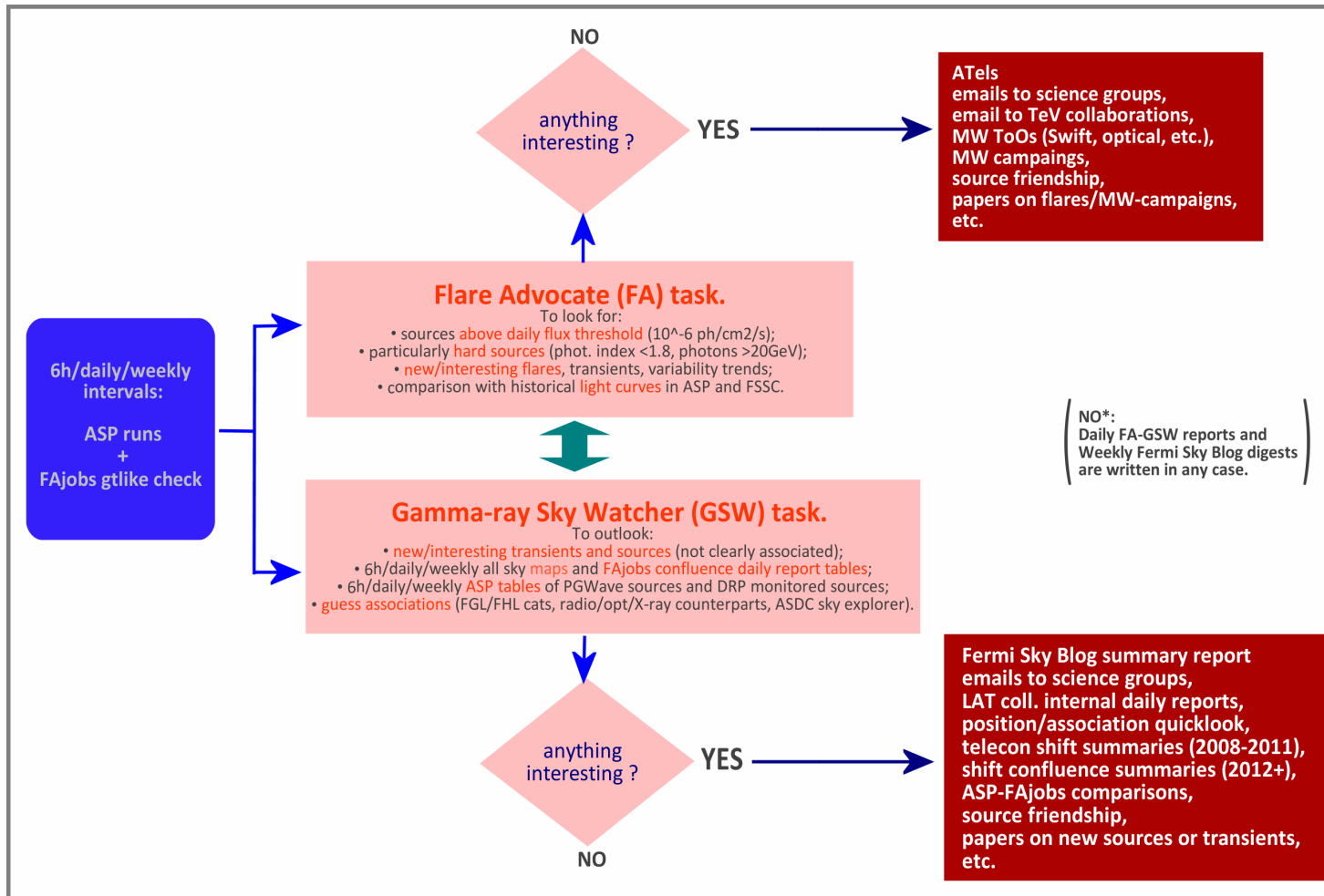




# Fermi Flare Advocate Gamma-ray Sky Watcher (FA-GSW)



Twofold role of the FA-GSW duty: 1) Flare Advocate (FA). 2) Gamma-ray Sky Watcher (GSW).  
The aim is to try to timely identify something interesting on the day-by-day LAT sky.



## The FA-GSW LOOKS FOR:

- flares of LAT sources;
- slower brightening of LAT sources;
- variability trends, and state changes of LAT sources;
- new (wrt LAT catalogs) gamma-ray sources / transients (on daily scales).

## The FA-GSW WATCHES and OUTLOOKS:

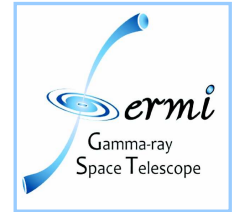
- tables of results by FA scripts analysis (to be launched day by day);
- ASP runs and ASP sources in SLAC ASPDataViewer tables

## The FA-GSW CHECKS:

- preliminary detection and localization;
- preliminary guess association with radio/IR/opt./X-ray counterparts and multiwavelength catalogs.

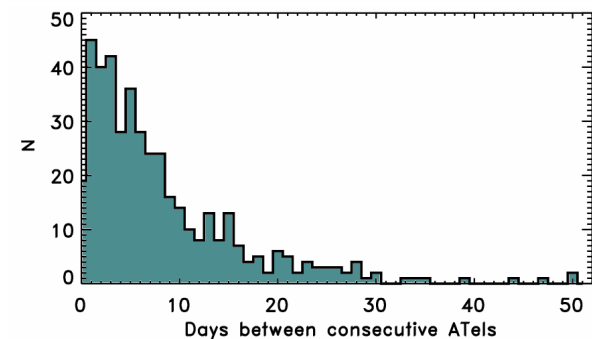
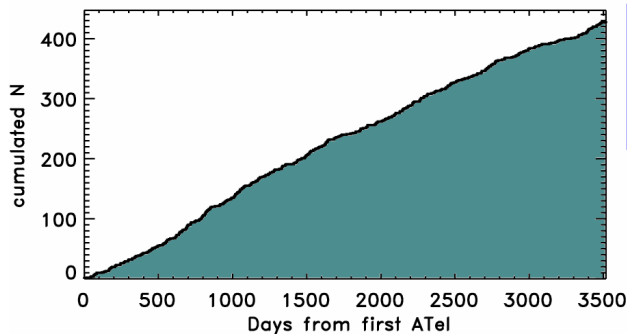
NO\*:  
Daily FA-GSW reports and Weekly Fermi Sky Blog digests are written in any case.



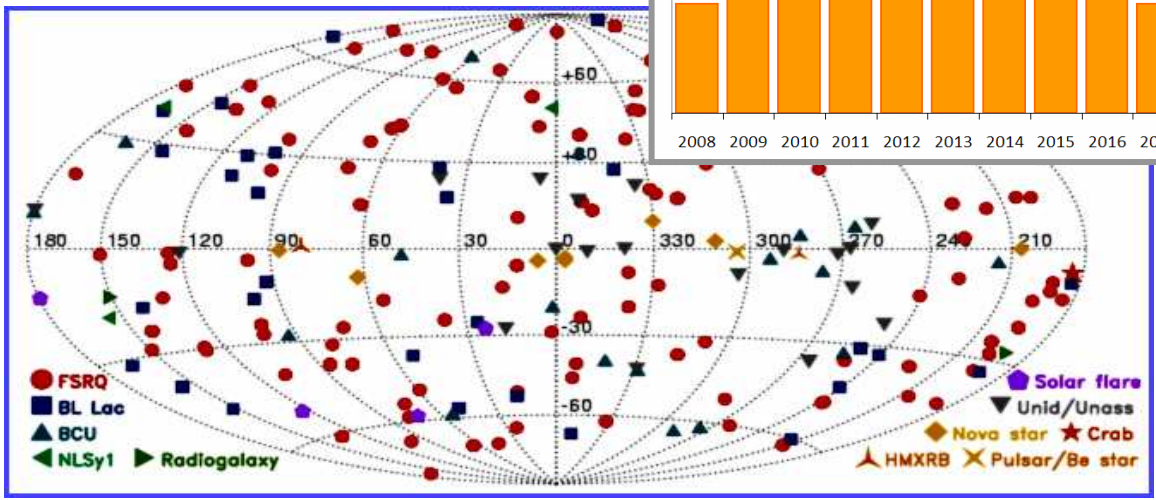
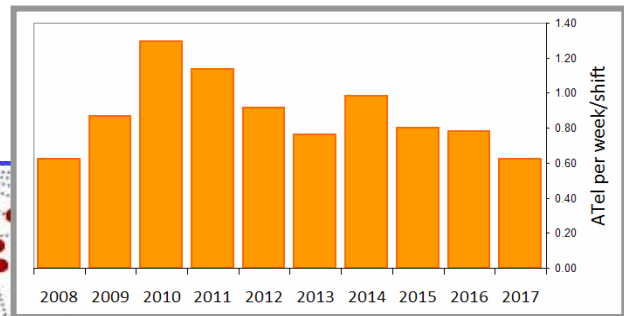


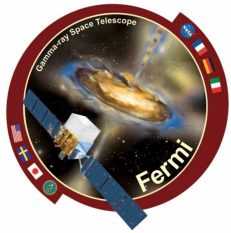
# Fermi Flare Advocate Gamma-ray Sky Watcher (FA-GSW)

- ❑ The **FA-GSW service** communicate basic and relevant **news** to the external astrophysical community (ATels, e-mail to MW group and TeV Cherenkov telescopes), in order to increase **the rate of multifrequency data** following-up LAT flares, transients and interesting pop-up of potential new gamma-ray sources.
- ❑ For example **a lot of ToO to Swift were triggered**, obtaining optimal **simultaneous data in X-ray and UV bands**.
- ❑ Since July 24, 2008, **430 ATels are published** (3 erratums) by the Fermi LAT Collaboration in a **9.6 years**.
- ❑ Since Sept. 21, 2011, **140 GCNs are issued** by the Fermi LAT Collaboration.
- ❑ News are continuing to be posted through the **Fermi multi-wavelength (MW) mailing list**, **Astronomer's Telegrams (ATels)**, **Gamma-ray Coordination Network notes (GCNs/Fermi Notices)**, other notes, emails and communications to VHE community. [www-glast.stanford.edu/cgi-bin/pub\\_rapid](http://www-glast.stanford.edu/cgi-bin/pub_rapid), [www.asdc.asi.it/feratel/](http://www.asdc.asi.it/feratel/) (on update)

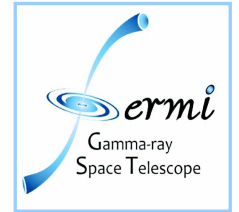


▪ FA-GSW service coordinated by people of the Fermi team at SSDC since 2008 joined to D.J.Thompson (the LAT MW coordinator)





# ASI Space Science Data Center (SSDC)



❑ Formerly ASI Science Data Center (ASDC): multi-mission, multi-disciplinary, science operation center, providing data processing and archiving support to several **scientific space missions**. Center built on the experience acquired within ASI with the management of the *Beppo-SAX* Science Data Center in the late 1990s. Located at the ESA-ESRIN in Frascati since 2000, then in Rome at the ASI Headquarter starting from 2013.

❑ ASDC and Earth observation sections merged in the **new** “**Space Science Data Center**” (SSDC) ASI facility established in 2016.

❑ SSDC is now: 1) **observation of the Universe**, 2) **Earth observation**, 3) **information and computing technologies**.

❑ SSDC composed by around 40 researchers. Management and organization led by ASI involving national research institutes and industries.

- **ASI** Italian Space Agency
- **INAF** National Institute for Astrophysics
- **INFN** National Institute for Nuclear Physics



- **Support to scientific operations**
- **Data analysis software, online quicklook analysis, data visualization, pipelines**
- **High level data production (ex.: spectra, light curves, catalogs)**
- **Mission science data archives, mirroring, source catalogs**
- **Data preservation and distribution**
- **Future scientific missions feasibility studies**
- **Data mining including big data (ex.: Gaia mission)**
- **Education and Public outreach**

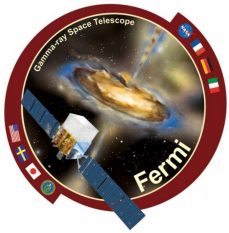
## Research topics

- **Astroparticle physics** · **X-ray/gamma-ray astrophysics**
- **Stellar astrophysics** · **Cosmology** · **Large datasets**
- **Solar system exploration** · **Time domain astronomy**
- **Exploit of large archives of multifrequency data**
- **X-ray polarimetry** · **X-ray/gamma-ray cross correlation wrt optical/radio data** · **Population studies**
- **Multimessenger neutrino astronomy**
- **Multimessenger gravitational wave astronomy**
- **Technical activities and software development,**
- **Calibrations, simulations, modeling** · **HPS, computing accelerators, artificial intelligence, data mining**









# Fermi catalogs web tables at SSDC



### The Fermi All-sky Variability Analysis Catalog

This is an interactive version of the Fermi-LAT FAVA Catalog extracted from Ackermann et al. 2013 (preprint)

The Fermi All-sky Variability Analysis (FAVA) is a tool to systematically study the variability of the gamma-ray sky measured by the Large Area Telescope (LAT) on board the Fermi Gamma-ray Space Telescope. For each direction on the sky, FAVA compares the number of gamma rays observed in a given time window to the number of gamma rays expected for the average emission detected from that direction. This method was used in weekly time intervals to derive a list of 213 flaring gamma-ray sources using the first 47 months of LAT data. The position of these sources are shown above in an Hammer-Aitoff projection and galactic coordinates. For more information see the publication or contact Rolf Buehler (rolf.buehler[at]ssdc.az.it).

Export Current view of Table in: [Latex format](#) | [FITS format](#) | [Raw text format](#) | [CSV text format](#)

Previous Page | Next Page | Page Size (# of lines) 50 | Refresh page | Reset all filters | Show all entries

Entry number	# Flares	Fava ID	RA (J2000.0) hh mm ss.d	Dec (J2000.0) dd mm ss.d	# HE Flares	# Neg. Flares	LAT Assoc.	Assoc.	Atel #
1	1	J0019-05	00 19 04.7	-05 20 59.9	0	0	2FGL_J0017.6-0510 PMN_J0017-0512	0	0
2	1	J0029-55	00 29 07.2	-55 02 59.9	0	0	2FGL_J0032.7-5521	none	0
3	1	J0031-02	00 31 23.9	-02 17 59.9	1	0	none	none	0
4	7	J0104+58	01 04 09.5	+58 20 24.0	5	0	2FGL_J0102.7+5827 TXS_0059+581	0	0
7	7	J0112+61	01 12 28.7	+61 16 11.8	3	0	2FGL_J0109.9+6132 TXS_0106+612	0	0
7	7	J0112+61	01 12 28.7	+61 16 11.8	3	0	2FGL_J0112.1+2245 S2_0109+22	0	0
7	7	J0112+61	01 12 28.7	+61 16 11.8	3	0	2FGL_J0112.8+3208 4C_31.03	0	0
7	7	J0112+61	01 12 28.7	+61 16 11.8	3	0	2FGL_J0116.0-1134 PKS_0113-118	0	0
7	7	J0112+61	01 12 28.7	+61 16 11.8	3	0	2FGL_J0136.9+4751 OC_457	0	0
7	7	J0112+61	01 12 28.7	+61 16 11.8	3	0	2FGL_J0205.3-1657 PKS_D202-17	0	0

FAVA ID: J0113-11 LAT Assoc: 2FGL 30116.0-1134 Assoc: PKS 0113-118  
Number HE Flares: 5  
Number of Pos. negative Flares: 0

Show table entries

Show [1] entries

FAVA ID	TSTART	TSTOP	SIGMA	EXP. Ev. #	OBS. Ev. #	EXP. HE Ev. #	OBS. HE Ev. #	SIGMA HE	SUN. DIST.
J0113-11	27947418.00	28007918.00	7.939997952	40	10	14	1	4.769999959	130.5500005
J0113-11	28007918.00	28068418.00	8.340000526	46	12	12	1	4.820000117	130.5500005
J0113-11	27924618.00	27985118.00	3.839999428	33	52	10	1	5.130000289	149.809999758
J0113-11	27985118.00	27942618.00	4.620000578	35	54	10	0	5.980000391	144.910000288
J0113-11	27942618.00	27900118.00	1.769999959	40	18	12	1	5.800000155	154.949999112

Showing 1 to 5 of 5 entries

### Fermi-GBM GRB list of detections

UPDATED TO 2016/12/06

This List is based on GCN Circulars issued by the GBM collaboration. The list is monthly updated

Columns description

Export Current view of Table in: [Latex format](#) | [FITS format](#) | [Raw text format](#) | [CSV text format](#) | [Show all entries](#)

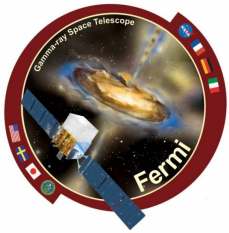
Previous Page | Next Page | Page Size (# of lines) 200 | Reset all filters | Show all entries

This view includes 1958 entries

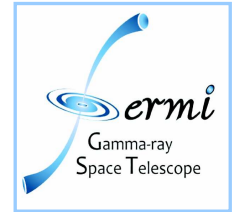
RA (J2000.0) hh mm ss.d	trigger time MJD	Error Radius	Redshift	GBM fluence (ergs/cm <sup>2</sup> )	LAT Bore (degree)
090423330	476e-7	0	0	0	0
018139	0	0	0	0	0

### Fermi Catalogs

- LAT Bright Sources List (0FGL)
- LAT Bright AGN Source List (LBAS)
- 1 Year LAT Sources Catalog (1FGL)
- 1 Year LAT AGN Catalog (1LAC)
- 1st LAT Pulsar Catalog (1PC)
- 2nd LAT Pulsar Catalog (2PC)
- 2 Year LAT Sources Catalog (2FGL)
- 2 Year LAT AGN Catalog (2LAC)
- 4 Year LAT Sources Catalog (3FGL)
- 4 Year LAT AGN Catalog (3LAC)
- 1st GBM GRB Catalog
- 1st LAT Catalog Sources >10 GeV (1FHL)
- 2nd LAT Catalog of HE Sources (2FHL)
- 3rd LAT Catalog of HE Sources (3FHL)
- 1st F.A.V.A. Catalog
- List of LAT AGN
- List of LAT ATel Sources
- List of GBM GRBs
- List of LAT GRBs
- List of GBM solar flares
- List of bright AGN light curves



# Table links to SSDC sky region data explorer



## On-line web service allowing a multi-frequency analysis of a source

Sky position Data Explorer allows the user to **navigate through catalogs** and to **explore large data sets** from radio to TeV. **Subsamples, complete database of catalogs stored at SSDC and external catalogs can be explored.** It is possible to refine search criteria and

create a new sky plot. Further services allows the user to **browse the internal catalogs (grouped by energy band) stored for sources around the current coordinates**, in a user-defined search radius. The "Search Other Services" panel **queries external databases.** "Access to Public Data Archives" button will expand the Data Explorer window.

Search ASDC Catalogs [?](#) [i](#)

Group of catalogues Selected catalogues

Radio IR Optical X-ray Gamma QORG AGN BZCAT ZCAT NAMES NGC ZWICKY

Search radius 0.2 arcmin

Search Other Services [?](#) [i](#)

VIZIER(X-R-G) NED SIMBAD HEASARC(X-R-G) GSC2 STSCI MAST 2MASS SDSS USNO-B1.0 NVO

Search radius 0.2 arcmin

Access to Public Data Archives -

Quick data viewer [?](#)

Gamma Ray Data

AGILE [?](#) Fermi EGRET

Search radius 50 degrees

X-Ray data

BeppoSAX ROSAT ASCA EINSTEIN EXOSAT CHAND Swift

Search radius 15 arcmin

Optical data

Opt-DSS from eso Image size 3 arcmin

SuperCOSMOS Sky S. J O R O I O POSS

SDSS DR7 Navigate tools

Radio data

NVSS from NRAO Image pixel size 15 arcsec Image size 10 arcmin

ASDC ASI Science Data Center

Entry PBC J1044.1+8054 --- S5 1039+81  
R.A.(J2000) = 10 44 09.7 (161.0404 deg) l=128.74  
Dec (J2000) = +80 54 48.8 (80.9136 deg) b=34.73  
Galactic nH = 2.51E+20

Error circle EXPLORER Source Details

TUTORIAL HELP

Default catalogs (always selected) [?](#) [i](#)

Selectable catalogs: [?](#) [i](#)

Default selection  [?](#) [i](#)

Radio  [?](#) [i](#)

Optical  [?](#) [i](#)

X-Ray  [?](#) [i](#)

Gamma  [?](#) [i](#)

Sources Catalogs  [?](#) [i](#)

[Selected catalogs List >>]

size (arcmin) 20 [?](#) [i](#)

Create new image

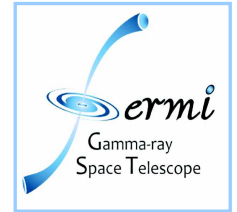
Position selected for the analysis: R.A.=10 44 09.7 (161.0404 deg) l=128.74 Dec=+80 54 48.8 (80.9136 deg) b=34.73 Galactic nH= 2.51E+20

Reset Position SED Builder



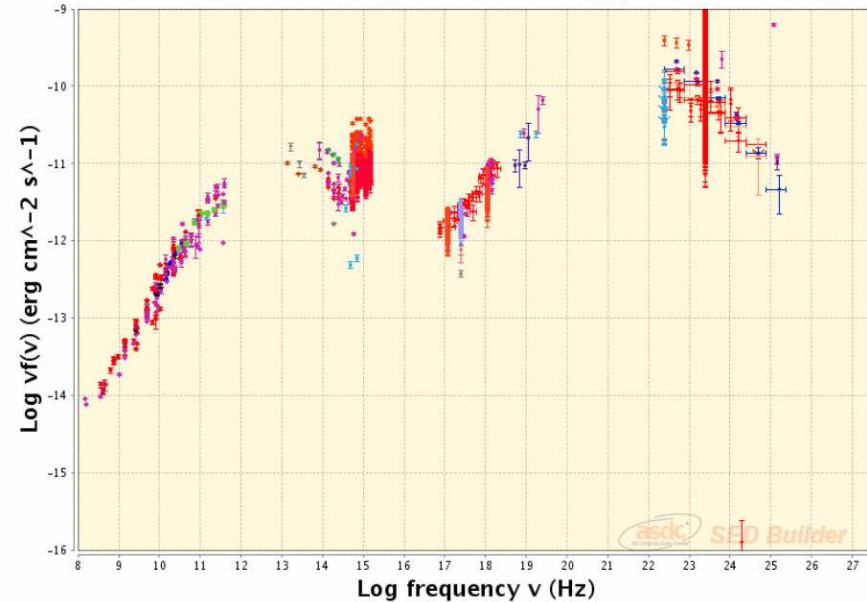


# Table links to SSDC SED builder+archive tool



Version 2.2  
 ciprini (Logout) Feedback  
 Tutorial DATA EXPLORER  
 User Data Existing SEDs  
 Current SED Search and build new SEDs

PKS1510-08 Ra=228.21042 deg Dec=-9.10000 deg (NH=6.9E20 cm<sup>-2</sup>)



Buttons: Load Data, Show Data, Save, Duplicate Sed

Redshift:  Frame:

X Axis:  Y Axis:

Update Plot

Buttons: Input Data, Models, Fit Functions, Templates, Instr Sensitivity, Plot options, Existing SEDs, Export, VO Tools

+ Time Filtering

ASDC Catalogs

Type	ASDC Catalogs	External Catalogs	Options
<input type="checkbox"/>	Radio	<input checked="" type="checkbox"/> 2MASS	V S U
<input type="checkbox"/>	Infrared	<input checked="" type="checkbox"/> USNO B1	V S U
<input type="checkbox"/>	Optical UV	<input checked="" type="checkbox"/> Catalina RTS	V S U
<input type="checkbox"/>	Soft X Ray	<input checked="" type="checkbox"/> NED	V S U
<input type="checkbox"/>	Hard X Ray	<input type="checkbox"/> SDSS7	U
<input type="checkbox"/>	Gamma Ray	<input checked="" type="checkbox"/> USNO A2.0	V S U
<input type="checkbox"/>	VHE		

User Catalogs

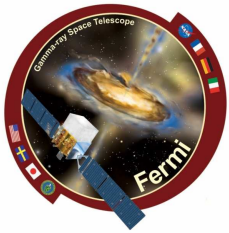
Name	Options
<input checked="" type="checkbox"/> PKS1510-089_archive	V S U
<input checked="" type="checkbox"/> PKS1510-089_simultNoG...	V S U
<input checked="" type="checkbox"/> PKS1510-089_archive	V S U
<input checked="" type="checkbox"/> PKS1510-089_UVOT_USA	V S U
<input checked="" type="checkbox"/> GTLIKE_P6v3	V S U
<input checked="" type="checkbox"/> RATAN	V S U
<input checked="" type="checkbox"/> VISIR MIR	V S U
<input checked="" type="checkbox"/> swift_obs00031173049	V S U
<input checked="" type="checkbox"/> UVOT_obs00031173049	V S U
<input checked="" type="checkbox"/> PKS1510-08_PLANCK_UNF...	V S U
<input checked="" type="checkbox"/> PKS1510-08_PLANCK_POI...	V S U
<input checked="" type="checkbox"/> Fermi_Planck_glike_2...	V S U
<input checked="" type="checkbox"/> effelberg_planck	V S U
<input checked="" type="checkbox"/> WG6_Northen_sample_ER...	V S U
<input checked="" type="checkbox"/> IRAM-Planck Revised D...	V S U
<input checked="" type="checkbox"/> SWIFT_XRT_sim_2nd_sur...	V S U
<input checked="" type="checkbox"/> Fermi_27m_2bins	V S U
<input checked="" type="checkbox"/> Fermi_sim_1stsurvey_2...	V S U

## SED builder main menu:

- Input data - Models - Fit functions - Instrument sensitivity
- Plot options - Existing archived built SEDs - Export options
- VO interface tools - Time data filtering
- SSDC or external or user SED data catalogs

- "ASDC SED Builder" web based program (SED: Spectral Energy Distribution of astrophysical sources).
- Based on a Java code and MySQL database.
- Combines data from several missions and experiments. Access to ASDC-resident catalogs and query to external archives (e.g. NED, 2MASS, WISE, SDSS, CSS, etc.).
- Latest improvements (in V.2.2): filter data in time (construction of time resolved SEDs), several units, photometric redshift calculator. Construction of time resolved SEDs suitable for multifrequency variability and cross correlation studies.
- Possibility to save SED data as VO table.





# SSDC Fermi LAT light curves tables



## Fermi ASDC Light Curve Explorer:

- 1) interactive display of catalogued Fermi LAT light curves
  - 2) on-line basic temporal analysis on the displayed light curve
- First version of Variability index and autocorrelation function implemented (**work in progress**).

**Fermi-LAT light curves list of brightest sources**  
Fermi ASDC Light Curve Explorer (FALCE V0)

Help | All | BL Lacs | FSRQs

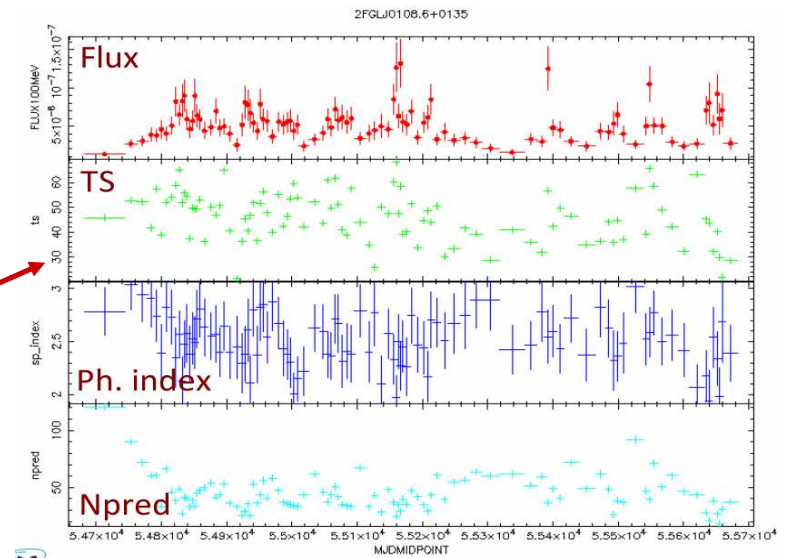
Show/hide columns | Advanced filtering | Print current view of table | Print complete table | Reset all filters

This is an interactive version of the Fermi-LAT light curves list of brightest sources  
Adaptive binning, internal use only  
(credits: Lott, B. and Escande, L.; University of Bordeaux)

Export Current view of Table in: Latex format | FITS format | Raw text format | CSV text format

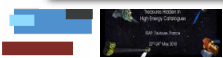
Previous Page | Next Page | Page Size (# of lines) 50 | Refresh page | Reset all filters | Show all entries

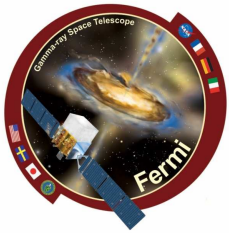
Entry number	Source name	Counterpart name	RA (J2000.0)	Dec (J2000.0)	Gamma Assoc	Flux 100-100 GeV	Spectral index	Spectral index Error	Optical classification
1	LC Explorer	2FGLJ0050.6+0929	PKS 0048-09	00 50 40.3	-09 29 45.0	(38.5+/-2.5) e-10	2.14	0.041	
2	LC Explorer	2FGLJ0108.6+0135	4C +01.02	01 08 41.5	+01 35 26.4	(63.5+/-3) e-10	2.262	0.042	
3	LC Explorer	2FGLJ0112.1+2245	S2 0109+22	01 12 07.7	+22 45 49.2	(71.3+/-3.2) e-10	2.066	0.038	
4	LC Explorer	2FGLJ0112.8+3208	4C 31.03	01 12 49.6	+32 08 19.1	(45.6+/-2.6) e-10	2.31		
5	LC Explorer	2FGLJ0118.8-2142	PKS 0116-219	01 18 53.8	-21 42 22.3	(43.3+/-2.6) e-10	2.122		
6	LC Explorer	2FGLJ0120.4-2700	PKS 0118-272	01 20 29.7	-27 00 53.6	(43.5+/-2.6) e-10	1.927		
7	LC Explorer	2FGLJ0136.5+3905	B3 0133+388	01 36 34.3	+39 05 21.0	(45.3+/-2.6) e-10	1.692		
8	LC Explorer	2FGLJ0136.9+4751	OC 457	01 36 57.4	+47 51 39.5	(72+/-3.2) e-10	2.148		
9	LC Explorer	2FGLJ0210.7-5102	PKS 0208-512	02 10 46.9	-51 02 04.3	(37.9+/-2.4) e-10	2.395		
10	LC Explorer	2FGLJ0217.9+0143	PKS 0215+015	02 17 55.9	+01 43 48.9	(56.6+/-2.9) e-10	2.152		
11	LC Explorer	2FGLJ0221.0+3555	S4 0218+35	02 21 04.0	+35 55 49.1	(53+/-2.8) e-10	2.275		
12	LC Explorer	2FGLJ0222.6+4302	3C 66A	02 22 38.8	+43 02 08.9	(256+/-6.1) e-10	1.847		
13	LC Explorer	2FGLJ0237.8+2846	4C +28.07	02 37 53.0	+28 46 39.2	(37.7+/-2.5) e-10	2.158		
14	LC Explorer	2FGLJ0238.7+1637	AO 0235+164	02 38 42.0	+16 37 26.6	(187+/-5.1) e-10	2.023		
15	LC Explorer	2FGLJ0245.9-4652	PKS 0244-470	02 45 54.5	-46 52 14.5	(45.4+/-2.5) e-10	2.434		



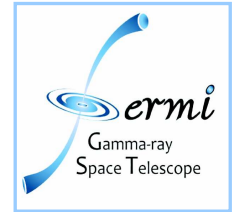
Partial datasets (obsolete) only for tests produced by this method: bright AGN light curves with adaptive time binning (ADB). Lott et al. 2012, A&A 2012A&A...544, 6

ADB light curve catalog archive name	Variables	LC list code	Time range
FERLCAD1	TSTART, TSTOP, MJDSTART, MJDSTOP, FLUX100MeV, FLUX100MEV_ERROR, SP_INDEX, SP_INDEX_ERROR, TS, NPRED.	P6_V3-ADB	August 2008 - April 2011
FERLCAD2	TSTART, TSTOP, MJDSTART, MJDSTOP, FLUX100MeV, FLUX100MEV_ERROR, SP_INDEX, SP_INDEX_ERROR, TS, NPRED.	P7_CLE AN_V6-ADB	Aug. 2008 - April 2012





# SSDC *Fermi* LAT light curves tables

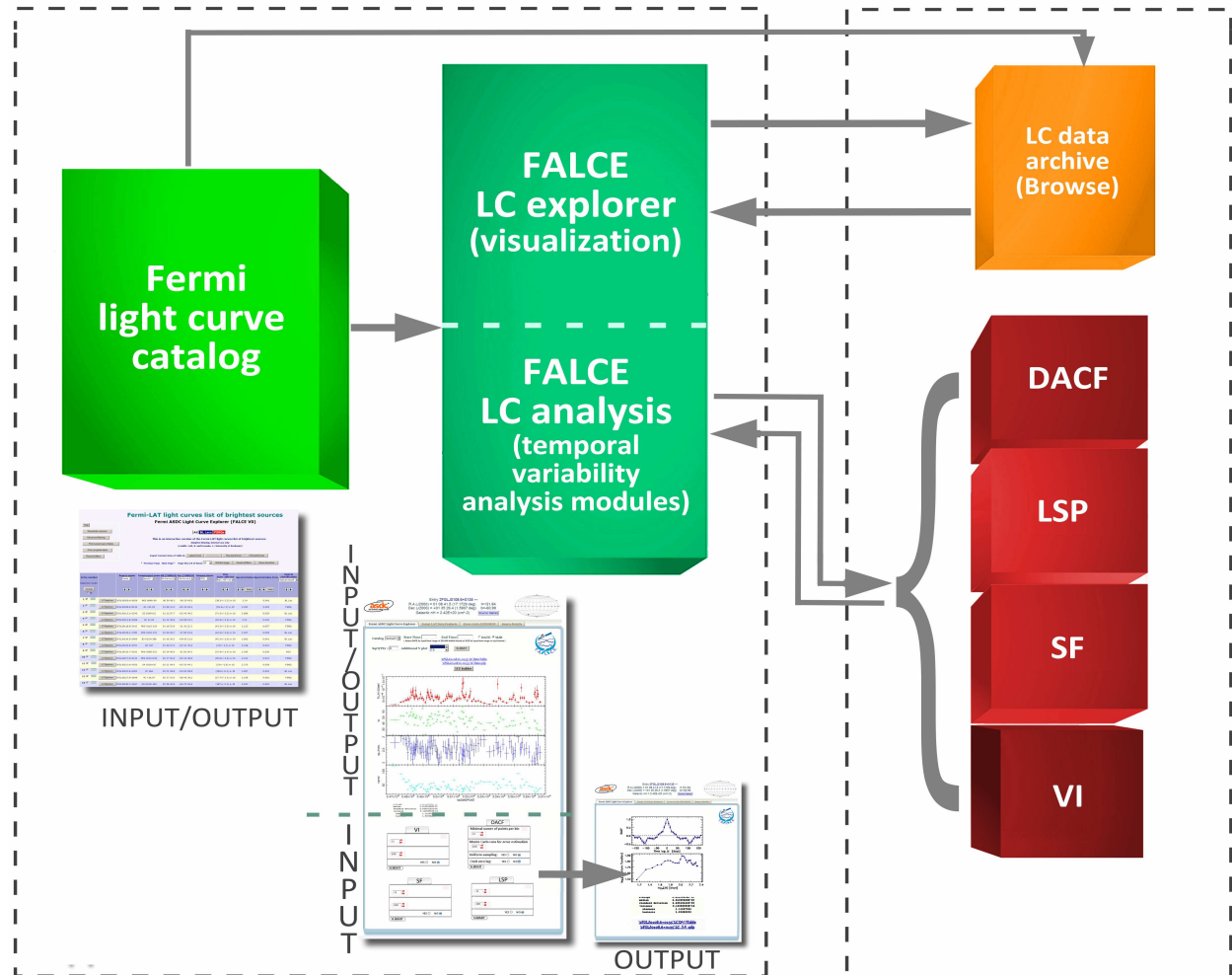


Light curve data exploration and visualization part (implemented for ADB P6 light curves). Work in progress to build the ADB P7 database of light curves ( $E < E_{pivot}$  fluxes)

Light curve data analysis through interactive online discrete (also unevenly sampled) time series analysis (TSA) modules (work in progress. Variability index, DACF, Structure Function, Periodogram are possibly foreseen in next future).

Logical block diagram for the design idea of the FALCE tool with the three main characteristics and tasks:

- The web catalog list of ADB LCs
- The ADB LC interactive exploration and visualization
- The ADB LC interactive time series analysis tools



Web I/O user interface





# Fermi LAT public data archive at SSDC



FT1 and FT2 public science FITS data. Now serving Pass-8 data.

Photon data in circular region retrieval and data preview (XImage) with MW catalogs overlay.

**Fermi LAT photon event and spacecraft data query and online data analysis**

The data server is now loaded with IRFs Pass8 photon data. It is highly recommended that users read the [Pass8 Usage Page](#) before proceeding with LAT Pass8 analysis and use the latest version of analysis software (v10005) available here.

The Photon database currently holds 1124973508 photons collected between 04/08/2008 15:43:36 UTC and 23/05/2018 23:42:32 UTC (239557417 and 548811757 seconds Mission Elapsed Time (MET)).

NOTE: For queries encompassing the whole sky (or close to it), please use the pre-generated [Weekly Allsky Files](#).

Email:

Enter your email address to receive notification when done

Search by Name:

Object Name:   SSC Name Server  SIBAC  HSC

Coordinates:

RA/Dec: RA:  Dec:

Selectic Coordinates:

L:  B:

Ecliptic Coordinates:

Lon:  Lat:

Medium:

and/or search by date?

Observations Dates:

If you do not enter anything, it will return results from the past 5 months. For Gregorian dates, please enter in the format YYYY-MM-DD HH:MM:SS, with the start and (optional) end time separated by commas. For MET (Mission Elapsed Time), enter any integer values >= 0, separated by commas. If you would like to search from the beginning of the mission, put in START instead of a start value. If you would like to search up until the most recent point, put in END instead of an end value.

and/or search by energy?

Energy Range:  MeV

Enter the minimum and (optional) maximum energy, separated by a comma. (By default, only data between 100 MeV and 300 GeV is returned.)

class type

Event Class:

FERMI Data:  Photon Data  Spacecraft Data

FERMI Online Data Analysis:  GTDICE  High-Energy Filter

Heterogeneous

Clear Submit



## LAT Data Query Results

The submitted query parameters for query ID=L1106131257475 were:

Search Center (RA,Dec) = (194.046667,-5.78944444)  
 Radius = 20.0 degrees  
 Start Time (MET) = 2.52460802E8 seconds (2009/01/01 00:00:00)  
 Stop Time (MET) = 3.28579202E8 seconds (2011/06/01 00:00:00)  
 Minimum Energy = 100 MeV  
 Maximum Energy = 300000 MeV

The filenames of the result files consist of the Query ID string with an ident the form: \_DDNN where DD indicates the database and NN is the file num data return. In that case the data is broken up into multiple files. The values of the database field are:

- PH - Photon Database
- SC - Spaccraft Pointing, Livetime, and History Database

### File Name

L1106131257475\_PH00.fits  
 L1106131257475\_PH01.fits  
 L1106131257475\_PH02.fits  
 L1106131257475\_PH03.fits  
 L1106131257475\_PH04.fits  
 L1106131257475\_PH05.fits  
 L1106131257475\_PH06.fits  
 L1106131257475\_PH07.fits  
 L1106131257475\_SC00.fits

Clicking on "data preview" an image will be generated running XIMAGE which provides a preview of the source field to help the user in any possible in cursor on image to explore it. WARNING The XIMAGE detect task runs with pre-tuned values, you can change them using the dedicated menu. We remind the user that the data analysis should be run with the proper Fermi ST.

**FERMI Imaging Tool @ ASDC**

Image parameters:

Source Name:  Search

RA:  Dec:

LI:  BI:

Image size (deg):

Emin:

Emax:

Catalog Overlay:

Image smoothing parameters:

Smoothing filter:

sigma:

back:

Image display parameters:

Color scaling:

Minimum level displayed:

Image detect parameters:

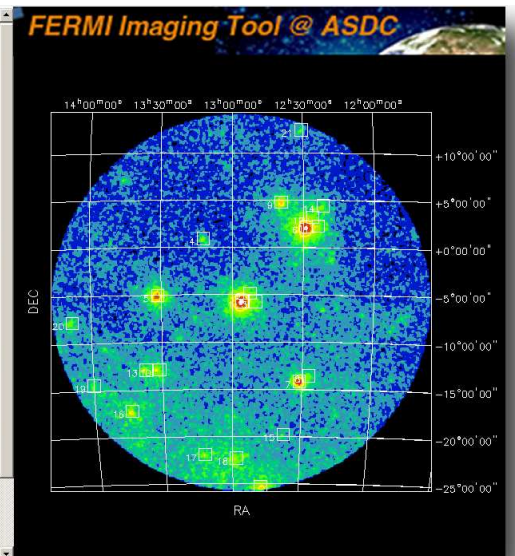
Probability threshold:

Source box size (deg):

Signal-to-noise ratio threshold:

Skygrid:

Run Reset to default



To get the results from another query, enter the query ID string below:

The Photon database currently holds 1124973508 photons collected between 04/08/2008 15:43:36 UTC and 23/05/2018 23:42:32 UTC (239557417 and 548811757 seconds Mission Elapsed Time (MET)).

Posta in Arrivo: ASDC tools: Fermi Lat Archive (2465 di 2466)

Contrassegna come:  Sposta Copia Questo messaggio a

Elimina | Rispondi | Inoltra | Reindirizza | Visualizza per Argomento | Intestazioni Messaggio | Salva con Nome | Stampa | Intestazioni

Data: Thu, 30 Aug 2012 08:07:14 +0200 [08:07:14 CEST]

Da: noreply@asdc.asi.it

A: @asdc.asi.it

Oggetto: ASDC tools: Fermi Lat Archive

Your request is completed.

Object Name:

Search Center (RA,Dec): 10.19958,-79.24083

Radius = 20.0 degrees

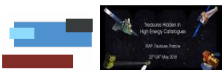
Start Time (MET)= 352191559 seconds (29/02/2012 06:59:17)

Stop Time (MET)= 362599559 seconds (28/06/2012 06:59:17)

Minimum Energy = 100 MeV

Maximum Energy = 300000 MeV

Click on the link below to download : <http://tools.asdc.asi.it/Fermi/results.jsp?id=L12083007591188>

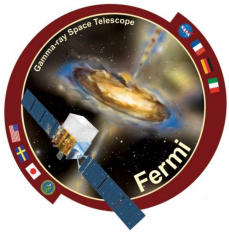


Treasures in HE Cat., 22-24 May 2018, IRAP, Toulouse

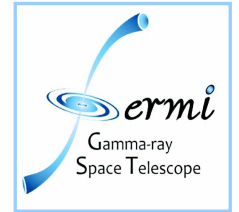


stefano.ciprini@ssdc.asi.it – INFN & ASI-SSDC Rome





# SSDC Fermi LAT quicklook likelihood analysis



From Fermi public FT1/FT2 data retrieval -> now there is the possibility to choose also a **basic online data analysis**, and/or calculation of **highest energy photon**.

## FERMI Data



Photon Data



Spacecraft Data

## FERMI Data Online Analysis



GTLIKE 



Highest Energy Photon

Clear

Submit

Fermi Online Data likelihood Analysis (FODA) is a **wrap-up of Science Tools** using python scripts and web user interfaces

FODA allows to choose a **2 weeks time interval** from the TSTART time at maximum. It also works only for sources with  $|b| > 5$  degrees.

Posta in Arrivo: ASDC tools: Fermi Lat Archive : GTLIKE (2466 di 2466) 

Contrassegna come:  Sposta Copia Questo messaggio a

Elimina Rispondi Inoltra Reindirizza Visualizza per Argomento Intestazioni Messaggio Salva con Nome Stampa Intestazioni

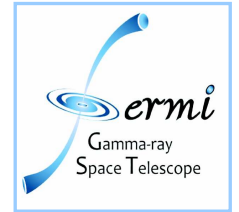
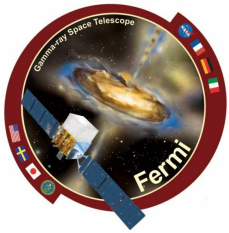
**Data:** Thu, 30 Aug 2012 08:24:18 +0200 [08:24:18 CEST]  
**Da:** noreply@asdc.asi.it   
**A:** [username@asdc.asi.it](mailto:username@asdc.asi.it)

**Oggetto:** ASDC tools: Fermi Lat Archive : GTLIKE

Your request is completed.  
Object Name:  
Search Center (RA,Dec): 10.19958,-79.24083  
Radius = 20.0 degrees  
Start Time (MET)= 352191559 seconds (29/02/2012 06:59:17)  
Stop Time (MET)= 353401159 seconds (14/03/2012 06:59:17)  
Minimum Energy = 100 MeV  
Maximum Energy = 300000 MeV  
Click on the link below to download : <http://tools.asdc.asi.it/fermi/results.jsp?id=L12083007591188>  
GTlike Result :  
src10--79 RA=10.19958 DEC= -79.24083 TS= -2.43715476245e-07  
Time Interval (MJD) 55986.2911921 56000.2911921  
Flux 2.09941963039e-08 0



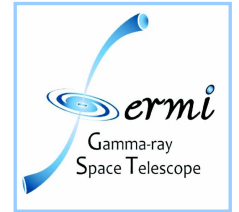
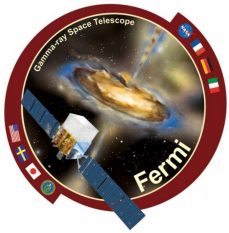




## Conclusions (I)

- ❑ The dynamic/variable high-energy , GeV, gamma-ray sky seen by *Fermi* LAT is continuing to be **very interesting**.
- ❑ The **4th LAT AGN/blazar catalog (4LAC, >2900 preliminary sources)** will represent a significant improvement over the 3LAC, also in term of **analysis, information content and data quality**. It will be also a **reference** for multi-frequency/multi-messenger works on individual AGN/blazar sources in the next years.
- ❑ The *Fermi* LAT FA-GSW service is continuing to **trigger important alerts and multi-frequency follow-up** (ToOs to Swift, NuSTAR, radio/optical telescopes, etc.). Very important **multi-frequency** (radio, X-ray, optical) **data simultaneous** to *Fermi* LAT **GeV source flares, transients, pop-ups, variability trends**, are now in archives thanks to the FA-GSW service.
- ❑ *Fermi* **public data archive** at the SSDC as partial mirror (FT1/FT2 fits main science data) of the NASA GSFC FSSC official archive. All the **data are immediately public**. Special **interactive tools** related to the SSDC archive. For example a quicklook, approximated, maximum likelihood source analysis, interactive tables for *Fermi* catalogs, or the sky circle (<3deg) data explorer.





## Conclusions (II)

- Scientific activities of the Fermi SSDC team involve **several tasks**. Among the other:
  - AGN/blazar gamma-ray source catalogs** building and population studies;
  - multifrequency** astronomy on AGN/blazar individual/sample sources.
  - time-domain variability** analysis on AGN/blazar individual/sample sources.
- Future development regarding **data visualization, interactive exploration, quicklook analysis**, will help to find HE (and multi-frequency) gems also in SSDC mission data archives and source catalogs.

