



# Tutorial on Fermi-LAT data analysis

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Material from P.Bruehl, M.Razzano,  
S.Buson and R.Desiante

PhD course 2021 – Padova

- **Overview of the Fermi Large Area Telescope**
  - How it works
  - **LAT data**
  - LAT performance
- **Fermi Science Tools**
  - General Introduction
- Maximum Likelihood Overview
  - Source modeling
- One study case:
  - 3c454.3: Fermipy analysis tutorial
- **gtburst Analysis of GRBs**

- **Yesterday**

- Introduction to the LAT data analysis
- LAT data introduction
- LAT data exploration & preparation
- Likelihood analysis of LAT data
- Description of Sky models
- Introduction to Fermipy
- Trouble shooting on SW installation

- **Today**

- gtburst fast analysis of GRB
- fermipy Hands-on on an Extragalactic source
  - SED & Light Curves

# The observatory



Spacecraft Partner:  
General Dynamics

Large Area Telescope (LAT)  
20 MeV - >300 GeV

Gamma-ray Burst Monitor (GBM)  
NaI and BGO Detectors  
8 keV - 30 MeV

## KEY FEATURES

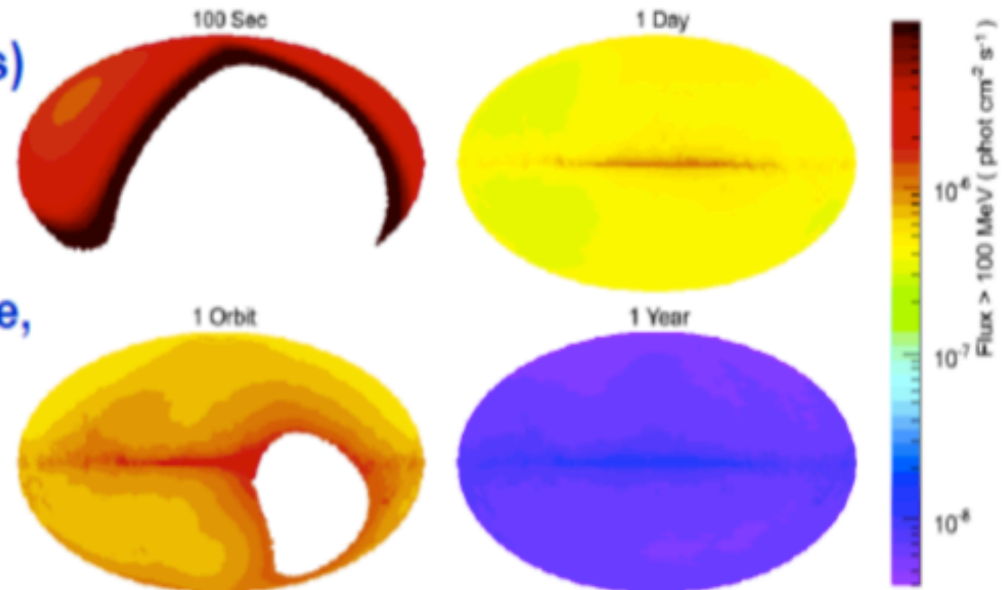
- **Huge field of view**
  - LAT: 20% of the sky at any instant; in sky survey mode, expose all parts of sky for ~30 minutes every 3 hours.
  - GBM: whole unocculted sky at any time.
- Huge energy range, including largely unexplored band 10 GeV - 100 GeV. **Total of >7 energy decades!**
- Large leap in all key capabilities. Great discovery potential.



## Operating Mode

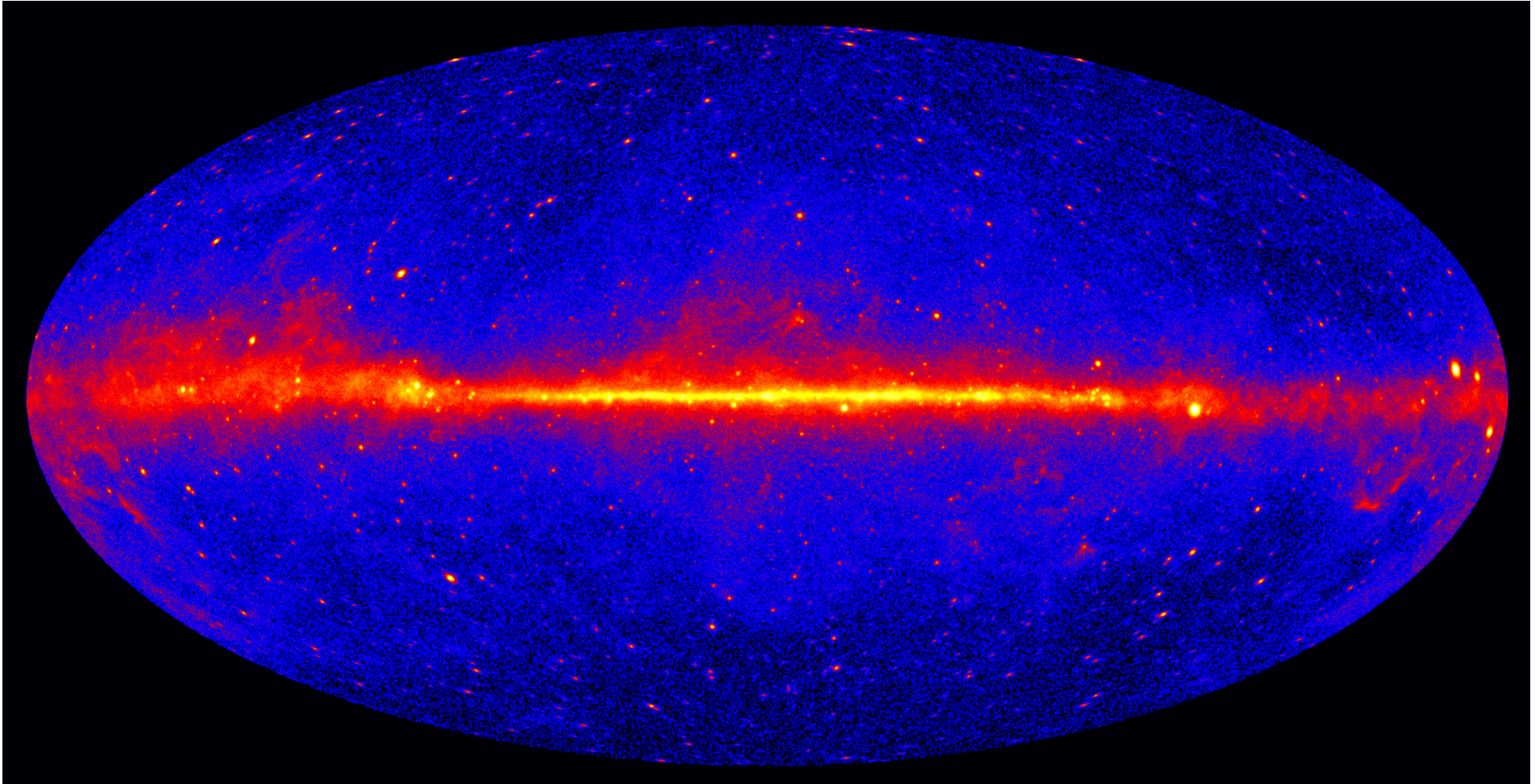
### □ Primary observing mode is Sky Survey

- Full sky every 2 orbits (3 hours)
- Uniform exposure, with each region viewed for ~30 minutes every 2 orbits
- Best serves majority of science, facilitates multiwavelength observation planning
- Exposure intervals commensurate with typical instrument integration times for sources
- EGRET sensitivity reached in days



# The Fermi Sky

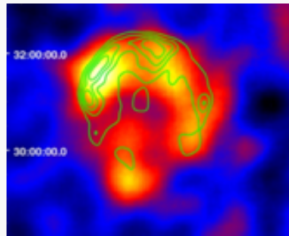
---





# 10 years of Fermi !

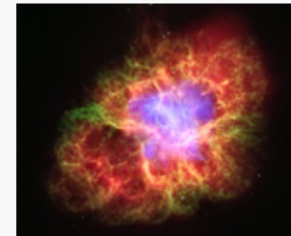
## Exploring the Extreme Universe



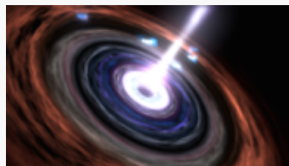
**Supernova Remnants**



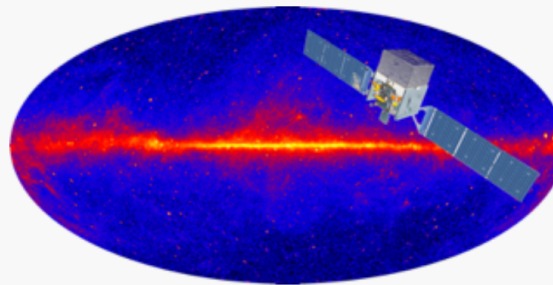
**Gamma-ray Bursts**



**Pulsar Wind Nebulae**

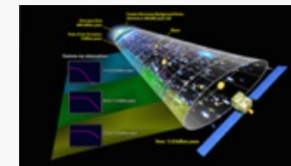


**Active Galactic Nuclei**

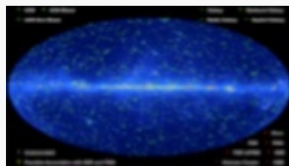


**About Fermi**

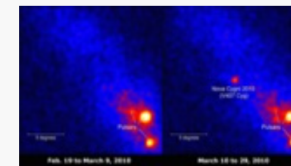
Click on the images or topic name for information about these science topics.



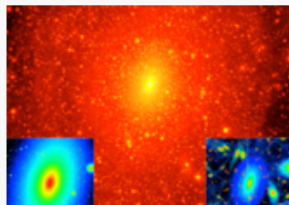
**Extragalactic Background**



**Catalogs**



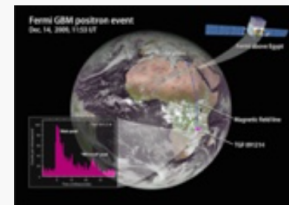
**Binary Sources**



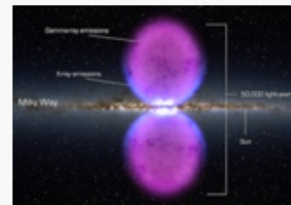
**Dark Matter**



**Pulsars**



**Terrestrial Gamma-ray Flashes**




**Diffuse Gamma Radiation**




# How to access LAT Data

<http://fermi.gsfc.nasa.gov/ssc/data/analysis/>



National Aeronautics and Space Administration  
Goddard Space Flight Center

Fermi • FSSC • HEASARC  
Sciences and Exploration



# Fermi

## Science Support Center

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### Data

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## Data Analysis

The Fermi mission is providing a suite of tools called the Fermi Science Tools for the analysis of both LAT and GBM data. This suite was developed by the FSSC and the instrument teams, and was reviewed by the [Fermi Users' Group](#).

The full suite of Fermi Science Tools, which have been public since February 2009, are listed [here](#).

From this website the released SAE tools can be [downloaded](#), and the [documentation](#) can be accessed. In addition, we will maintain a library of [user-contributed software](#).

- [List of tools in the Fermi Science Tools](#)
- [Download currently released Fermi Science Tools](#)
- [Download currently released GBM software](#)
- [Fermi Science Tools documentation](#)
- [User-contributed software](#)



- **LAT data products can be downloaded by the FSSC website**
  - **LAT Data server** <http://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/LATDataQuery.cgi>
  - **Archive of weekly files**
    - <https://heasarc.gsfc.nasa.gov/FTP/fermi/data/lat/weekly/photon/>
- **Two main data products (stored in FITS format)**
  - **Events file (FT1)**
    - i. e. “what the LAT sees”
      - (photons, their energy, coordinates, time, event classes etc..)
  - **Spacecraft files (FT2)**
    - i. e. “where the LAT is”
      - (position, angles..)

# LAT catalogs

- LAT catalogs and associated products (high-level products only)
  - LAT Source Catalog
    - LAT 10-year Source Catalog (4FGL-DR2)
    - LAT 8-year Source Catalog (4FGL)
    - Preliminary LAT 8-year Source List (FL8Y)
    - LAT 4-year Source Catalog (3FGL)
    - LAT 2-year Source Catalog (2FGL)
    - LAT 1-year Source Catalog (1FGL)
    - LAT 3-month Bright Source List (0FGL)
  - Aperture Photometry Light Curves
    - Aperture Photometry Light Curves for LAT 10-year Catalog Sources (Updated Weekly)
    - Flaring Sources in the LAT 10-year Aperture Photometry Light Curves (Updated Weekly)
    - Aperture Photometry Light Curves for LAT 4-year Catalog Sources
    - Flaring Sources in the LAT 4-year Aperture Photometry Light Curves
    - Aperture Photometry Light Curves for the LAT 2-year Source Catalog
    - Flaring Sources in the LAT 2-year Aperture Photometry Lightcurves
  - LAT High Energy Source Catalog
    - LAT Third High Energy Source Catalog (3FHL)
    - LAT Second High-Energy Source Catalog (2FHL)
    - LAT First High-Energy Source Catalog (1FHL)
  - The Fourth Catalog of Active Galactic Nuclei -- Data Release 2 (4LAC-DR2)
  - The Fourth Catalog of Active Galactic Nuclei (4LAC)
  - LAT Monitored Source List Light Curves
  - LAT GRB Catalog
  - Extended Sources in the Galactic Plane (FGES)
  - Second Fermi All-sky Variability Analysis Catalog (2FAV)
  - 1st Fermi-LAT SNR Catalog
  - LAT 3-year Catalog of Gamma-ray Pulsars

<https://fermi.gsfc.nasa.gov/ssc/data/access/>

## Event classes

Standard Hierarchy for LAT Event Classes				
Event Class	evclass	Photon File	Extended File	Description
P8R3_TRANSIENT020	16		X	Transient event class with background rate equal to two times the A10 IGRB reference spectrum.
P8R3_TRANSIENT010	64		X	Transient event class with background rate equal to one times the A10 IGRB reference spectrum.
P8R3_SOURCE	128	X	X	This event class has a residual background rate that is comparable to P7REP_SOURCE. This is the recommended class for most analyses and provides good sensitivity for analysis of point sources and moderately extended sources.
P8R3_CLEAN	256	X	X	This class is identical to SOURCE below 3 GeV. Above 3 GeV it has a 1.3-2 times lower background rate than SOURCE and is slightly more sensitive to hard spectrum sources at high galactic latitudes.
P8R3_ULTRACLEAN	512	X	X	This class has a background rate very similar to ULTRACLEANVETO.
P8R3_ULTRACLEANVETO	1024	X	X	This is the cleanest Pass 8 event class. Its background rate is 15-20% lower than the background rate of SOURCE class below 10 GeV, and 50% lower at 200 GeV. This class is recommended to check for CR-induced systematics as well as for studies of diffuse emission that require low levels of CR contamination.
P8R3_SOURCEVETO	2048	X	X	This class has the same background rate than the SOURCE class background rate up to 10 GeV but, above 50 GeV, its background rate is the same as the ULTRACLEANVETO one while having 15% more acceptance.

## Event classes

Extended Hierarchy				
Event Class	evclass	Photon File	Extended File	Description
P8R3_TRANSIENT020E	8		X	Extended version of the P8R3_TRANSIENT020 event class with a less restrictive fiducial cut on projected track length through the Calorimeter.
P8R3_TRANSIENT010E	32		X	Extended version of the P8R3_TRANSIENT010 event class with a less restrictive fiducial cut on projected track length through the Calorimeter.
NON-ACD Hierarchy				
Event Class	evclass	Photon File	Extended File	Description
P8R3_TRANSIENT015S	65536		X	Transient event class designed for analysis of prompt solar flares in which pileup activity may be present. This class has a background rate equal to 1.5 times the A10 reference spectrum.



# Recommendations

## Event Selection Recommendations (P8R3)

Analysis Type	Minimum Energy (emin)	Maximum Energy (emax)	Max Zenith Angle (zmax)	Event Class (evclass)	IRF Name
Galactic Point Source Analysis	100 (MeV)	500000 (MeV)	90 (degrees)	128	P8R3_SOURCE_V2
Off-plane Point Source Analysis	100 (MeV)	500000 (MeV)	90 (degrees)	128	P8R3_SOURCE_V2
Burst and Transient Analysis (<200s)	100 (MeV)	500000 (MeV)	100 (degrees)	16	P8R3_TRANSIENT020_V2
Galactic Diffuse Analysis	100 (MeV)	500000 (MeV)	90 (degrees)	128	P8R3_SOURCE_V2
Extra-Galactic Diffuse Analysis	100 (MeV)	500000 (MeV)	90 (degrees)	1024	P8R3_ULTRACLEANVETO_V2 or P8R3_SOURCEVETO_V2 (when interested in E>1 GeV energy range)
Impulsive Solar Flare Analysis	100 (MeV)	500000 (MeV)	100 (degrees)	65536	P8R3_TRANSIENT015S_V2

# Recommendations

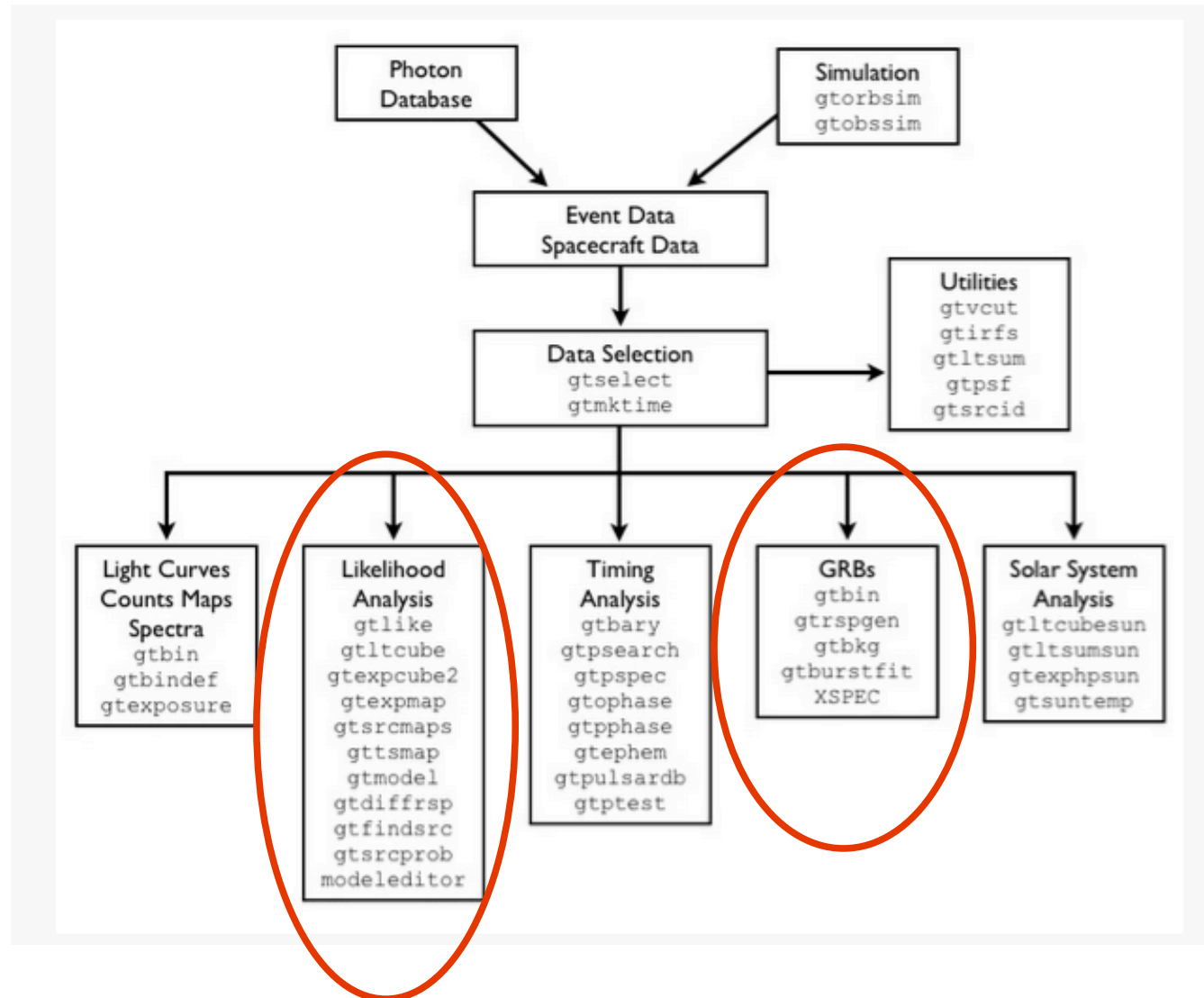
## Time Selection Recommendations

Analysis Type	ROI-Based Zenith Angle Cut (roicut)	Relational Filter Expression (filter)
Galactic Point Source Analysis	no	(DATA_QUAL>0)&&(LAT_CONFIG==1)
Off-plane Point Source Analysis	no	(DATA_QUAL>0)&&(LAT_CONFIG==1)
Burst and Transient Analysis	yes	(DATA_QUAL>0)&&(LAT_CONFIG==1)
Galactic Diffuse Analysis	no	(DATA_QUAL>0)&&(LAT_CONFIG==1)
Extra-Galactic Diffuse Analysis	no	(DATA_QUAL>0)&&(LAT_CONFIG==1)
Burst and Transient Analysis	yes	(DATA_QUAL>0  DATA_QUAL==-1)&&(LAT_CONFIG==1)

**IMPORTANT:** For analyses where an ROI-based zenith cut is NOT performed, an exposure correction must be made using the "zmax" option in the [gtltcube](#) tool.

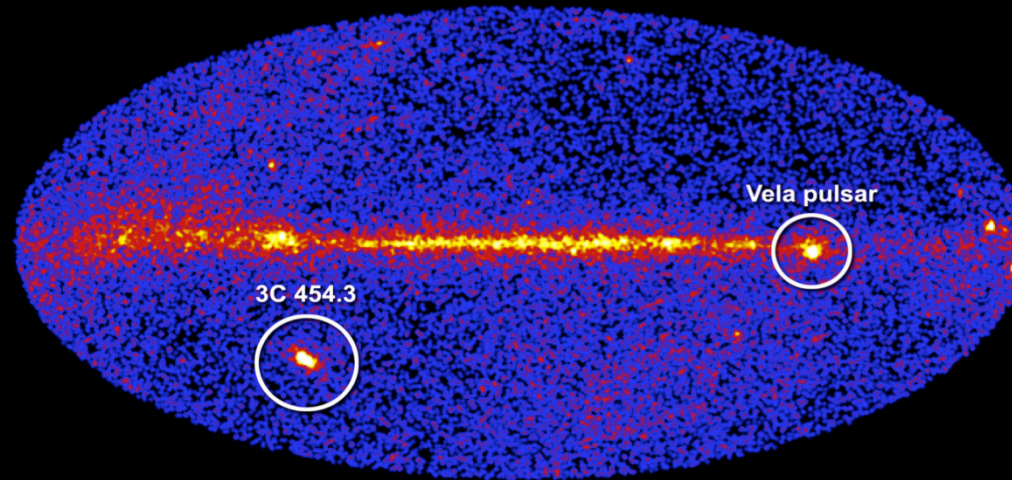
# Explore LAT data

# Overview of Fermi Science Tools

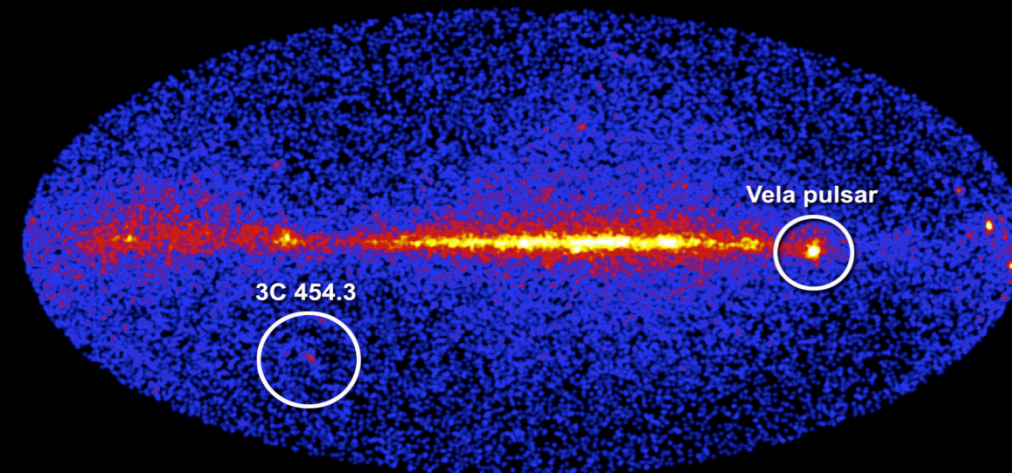




## Blazar one of ... 3c454.3's record flares!



December 2, 2009



November 3, 2009

# How to download data

<http://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/LATDataQuery.cgi>

[Home](#) [Observations](#) [Data](#) [Proposals](#) [Library](#) [HEASARC](#) [Help](#) [Site Map](#)

### Data

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#### LAT Photon, Event, and Spacecraft Data Query

**June 3, 2014:** The data server is now loaded with reprocessed Pass7 photon data. This update is to the diffuse columns of the photon data only See the [caveats page](#) for more information.

**NOTE:** For queries encompassing the whole sky (or close to it), please use the pre-generated [Weekly All-Sky Files](#) available through [HEASARC Browse](#).

**NOTE:** Additional selections must be applied to data downloaded from the data server prior to use in a data analysis. See [recommended data selections](#) and [LAT caveats](#) for more details.

The photon database currently holds 385684180 photons, collected between 2008-08-04T15:43:37 UTC and 2014-09-04T12:16:03 UTC (Mission Elapsed Time (MET) 239557417 to 431525763 seconds).

The event database currently holds 2382326033 events, collected between 2008-08-04T15:43:37 UTC and 2014-09-04T13:36:18 UTC (Mission Elapsed Time (MET) 239557417 to 431530578 seconds).

Use [xTime](#) to convert between MET and other time systems.

Object name or coordinates:

Coordinate system:

Search radius (degrees):

Observation dates:

Time system:

Energy range (MeV):

LAT data type:

Spacecraft data: ☒

The week of the giant outburst!!

→ Download both spacecraft and photon data ←  
Take note of the start and stop MET  
follow the link

► [Data Policy](#)

► [Data Access](#)

- + [LAT Data](#)
- + [LAT Catalog](#)
- + [LAT Data Queries](#)
- + [LAT Query Results](#)
- + [LAT Weekly Files](#)
- + [GBM Data](#)

► [Data Analysis](#)

► [Caveats](#)

► [Newsletters](#)

► [FAQ](#)

Your search criteria were:

Equatorial coordinates (degrees)	(343.491,16.1482)
Time range (MET)	(281318400,281923200)
Time range (Gregorian)	(2009-12-01 00:00:00,2009-12-08 00:00:00)
Energy range (MeV)	(100,300)
Search radius (degrees)	15

The state of your query is 2 (Query complete)

<u>Server</u>	<u>Position in Queue</u>	<u>Estimated Time Remaining (sec)</u>
Photon Server	Query complete	N/A
Spacecraft Server	Query complete	N/A

The filenames of the result files consist of the query ID string with an identifier appended to indicate which database the file came from. The identifiers are of the form: \_DDNN where DD indicates the database and NN is the file number. The file number will generally be '00' unless the query resulted in a large data volume. In that case the data is broken up into multiple files. The values of the database field are:

- PH - Photon Database
- SC - Spacecraft Pointing, Livetime, and History Database
- EV - Extended Database

In the event that you do not see any files with the data type you requested listed below, you should try resubmitting your query as there may have been a problem.

<u>Filename</u>	<u>Number of Entries</u>	<u>Size (MB)</u>	<u>Status</u>
L14090420274034A4AC2B81_PH00.fits	3372	0.33	<a href="#">Available</a>
L14090420274034A4AC2B81_SC00.fits	17120	2.52	<a href="#">Available</a>

If you would like to download the files via wget, simply copy the following commands and paste them into a terminal window. The files will be downloaded to the current directory in the terminal window.

```
wget http://fermi.gsfc.nasa.gov/FTP/fermi/data/lat/queries/L14090420274034A4AC2B81_PH00.fits
wget http://fermi.gsfc.nasa.gov/FTP/fermi/data/lat/queries/L14090420274034A4AC2B81_SC00.fits
```

## gtselect (select data)

```
[/home/]$ gtselect evclass=128 evtype=3
```

Input FT1 file[photon.fits]

Output FT1 file[filtered.fits]

RA for new search center (degrees) (0:360) [343.494812]

Dec for new search center (degrees) (-90:90) [16.1495]

radius of new search region (degrees) (0:180) [10]

start time (MET in s) (0:) [281318400]

end time (MET in s) (0:) [281923200]

lower energy limit (MeV) (0:) [100]

upper energy limit (MeV) (0:) [5000000]

maximum zenith angle value (degrees) (0:180) [90]

Events with a  
high prob. to be  
gammas

Setting the max ZA,  
filter gammas from  
albedo events  
(gamma from the  
Earth that can be a  
significant source of  
background)

```
> gtselect evclass=128 evtype=3 infile=ph.fits outfile=filtered.fits \  
ra=343.49 dec=16.15 rad=15 tmin=281318400 tmax=281923200 \  
emin=100 emax=5000000 zmax=90
```

Note: all analysis steps are scriptable via explicit assign parameters on command-line. Look at the manual for details.



## gtmktime (cut the bad time intervals)

---

[/home/]\$ **gtmktime**

Spacecraft data file[spacecraft.fits]

Filter expression[(DATA\_QUAL>0)&&(LAT\_CONFIG==1)]

Apply ROI-based zenith angle cut[no]

Event data file[filtered.fits]

Output event file name[filtered\_gti.fits]

Filter out events collected  
while passing in SAA and other  
low-quality events

Use ZA to filter  
only proper  
GTIs

## gtbin (Counts Map)

---

[/home]\$ gtbin

Type of output file (CCUBE|CMAP|LC|PHA1|PHA2|HEALPIX) [CMAP]

Event data file name[filtered\_gti.fits]

Output file name[cmap.fits]

Spacecraft data file name[spacecraft.fits]

Size of the X axis in pixels[120]

Size of the Y axis in pixels[120]

Image scale (in degrees/pixel)[0.25]

Coordinate system (CEL - celestial, GAL -galactic) (CEL|GAL) [CEL]

First coordinate of image center in degrees (RA or galactic l)

[343.494812]

Second coordinate of image center in degrees (DEC or galactic b)

[16.1495]

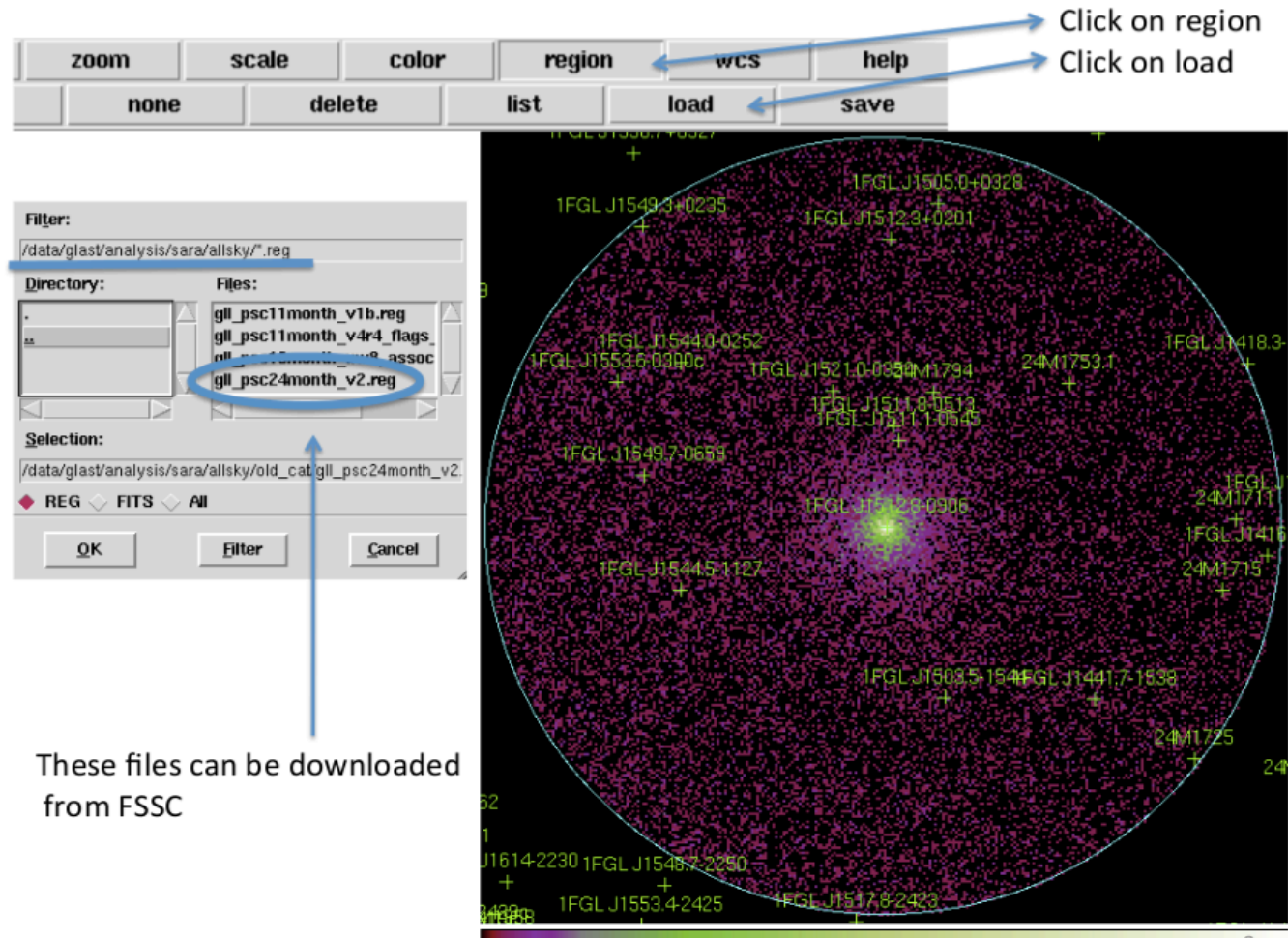
Rotation angle of image axis, in degrees[0]

Projection method e.g. AIT|ARC|CAR|GLS|MERC|NCP|SIN|STG|TAN:

[AIT]

## Look at the counts map

Use DS9 to look at the counts map of your ROI and check for close-by sources  
> ds9 CMAP.fits &



The screenshot shows the DS9 software interface. At the top, there is a menu bar with buttons: zoom, scale, color, region, wcs, help. Below this is a sub-menu with buttons: none, delete, list, load, save. To the left of the main map is a 'Filter' dialog box. It has a 'Filter:' field with the path '/data/glast/analysis/sara/allsky/\*.reg'. Below this is a 'Directory:' field with a list of files: gll\_psc11month\_v1b.reg, gll\_psc11month\_v4r4\_flags, gll\_psc11month\_v8\_assoc, and gll\_psc24month\_v2.reg. The 'gll\_psc24month\_v2.reg' file is circled in blue. Below the file list is a 'Selection:' field with the path '/data/glast/analysis/sara/allsky/old\_cat/gll\_psc24month\_v2'. At the bottom of the dialog are buttons: OK, Filter, and Cancel. To the right of the dialog is a large circular counts map. The map is filled with a dense field of green and yellow points. Several points are labeled with coordinates and names, such as 1FGL J1549.3+0235, 1FGL J1505.0+0328, 1FGL J1512.3+0201, 1FGL J1544.0-0252, 1FGL J1553.6-0300c, 1FGL J1521.0-0330M1794, 24M1753.1, 1FGL J1418.3, 1FGL J1511.8-0513, 1FGL J1511.1-0543, 1FGL J1549.7-0653, 1FGL J1512.9-0906, 1FGL J1544.5-1127, 1FGL J1603.5-1544, 1FGL J1441.7-1838, 24M1725, 24M1715, 1FGL J1416, 24M1711, 1FGL J1614-2230, 1FGL J1548.7-2250, 1FGL J1553.4-2425, and 1FGL J1517.8-2423. A blue arrow points from the 'gll\_psc24month\_v2.reg' file in the 'Filter' dialog to the counts map. Another blue arrow points from the 'load' button in the 'region' menu to the counts map. A third blue arrow points from the 'wcs' button in the 'region' menu to the counts map. A fourth blue arrow points from the 'help' button in the 'region' menu to the counts map.

Click on region  
Click on load

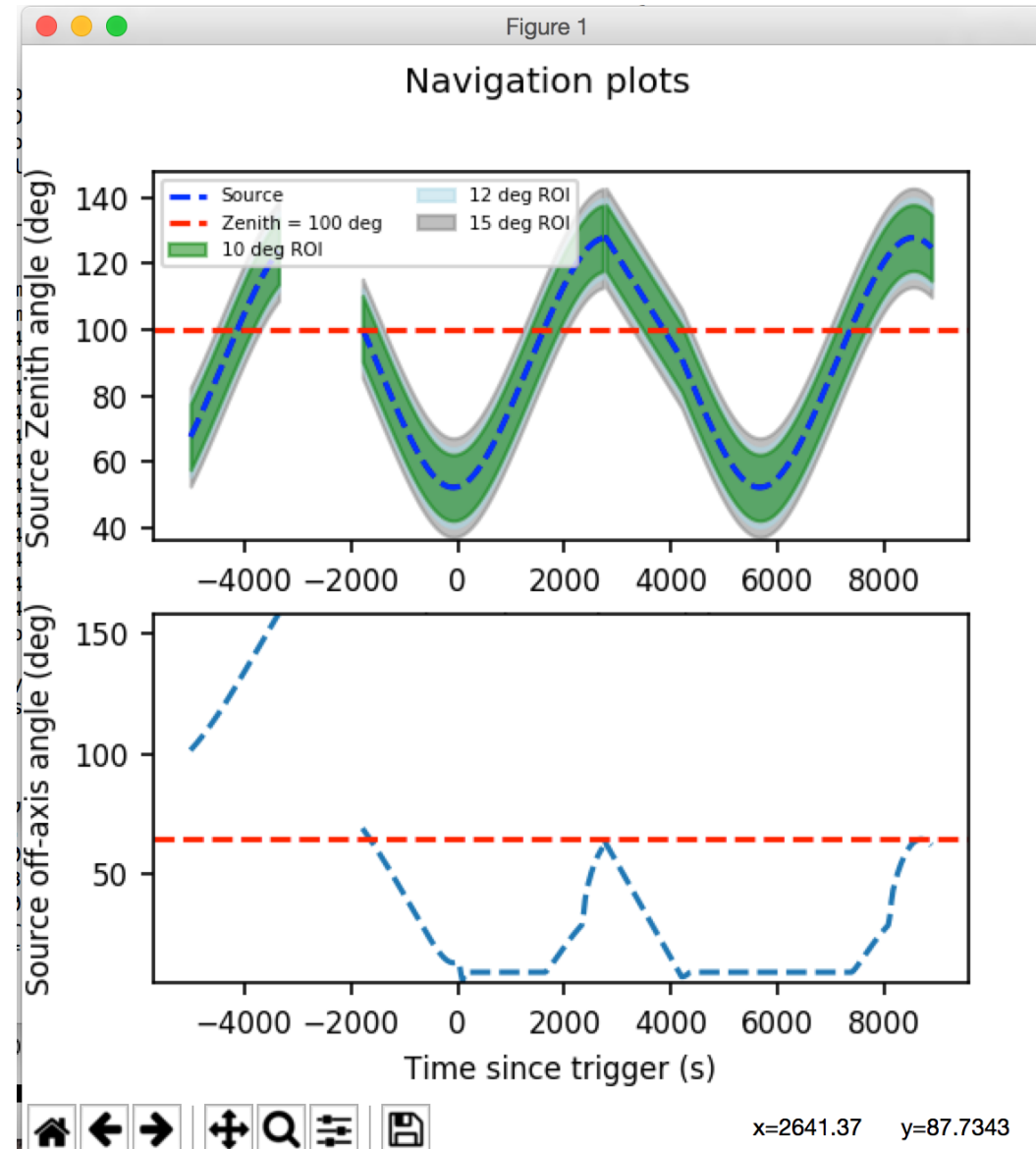
Filter:  
/data/glast/analysis/sara/allsky/\*.reg  
Directory: Files:  
gll\_psc11month\_v1b.reg  
gll\_psc11month\_v4r4\_flags  
gll\_psc11month\_v8\_assoc  
gll\_psc24month\_v2.reg  
Selection:  
/data/glast/analysis/sara/allsky/old\_cat/gll\_psc24month\_v2.  
REG FITS All  
OK Filter Cancel

These files can be downloaded from FSSC

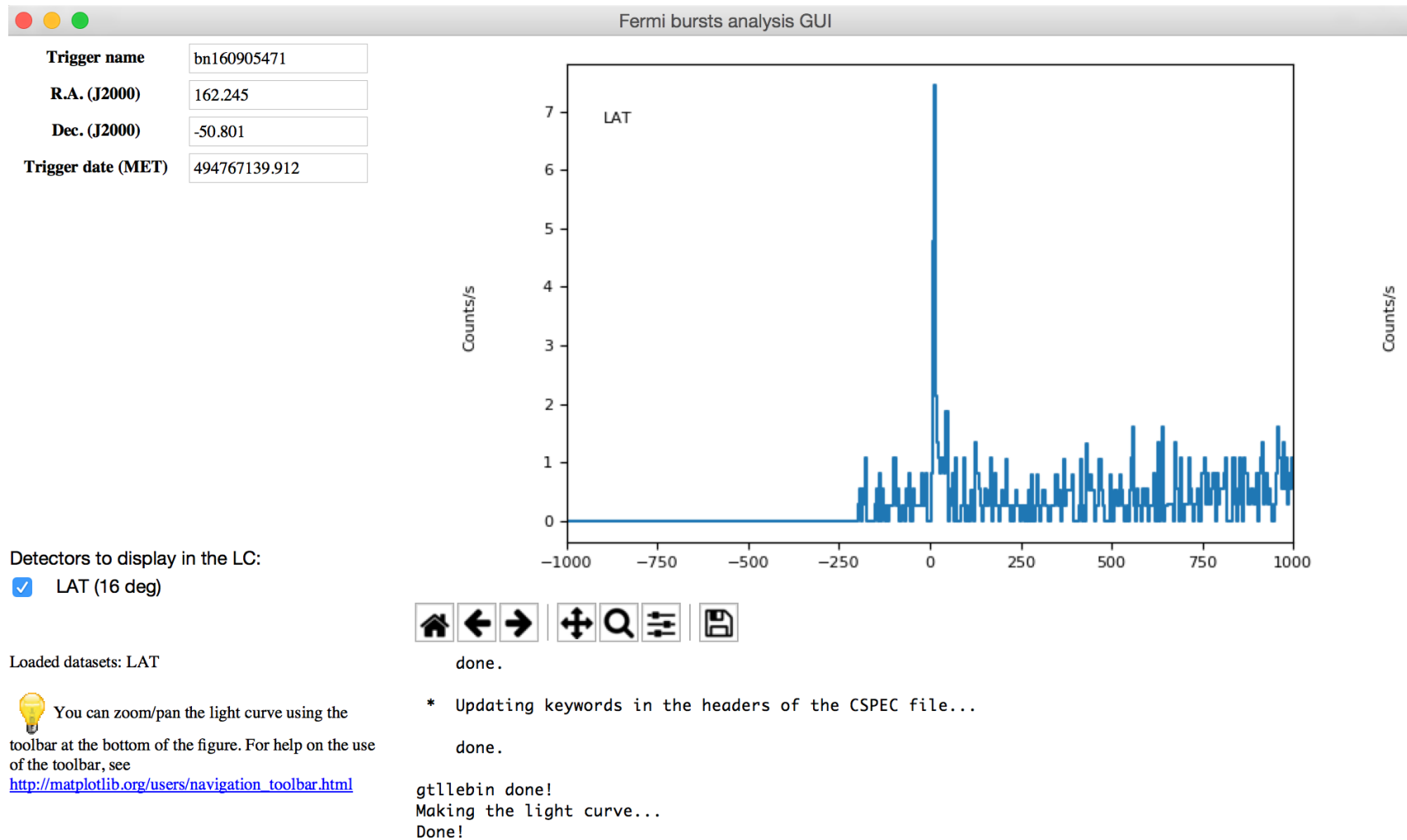
# **Analysis Tutorial**

## **likelihood analysis with gtburst**

## Check the “Navigation” plot





# Likelihood with gtburst







# Select event class


Fermi bursts analysis GUI

<b>rad</b>	<input type="text" value="12"/>	<input <="" td="" type="button" value="?"/>
<b>irf</b>	<div style="border: 1px solid gray; padding: 2px;">p8_transient020e ▾</div>	<input <="" td="" type="button" value="?"/>
<b>zmax</b>	<div style="border: 1px solid gray; padding: 2px;">p8_transient020e</div>	<input <="" td="" type="button" value="?"/>
<b>tstart</b>	<div style="border: 1px solid gray; padding: 2px;">p8_transient020</div>	<input <="" td="" type="button" value="?"/>
<b>tstop</b>	<div style="border: 1px solid gray; padding: 2px;">p8_transient010e</div>	<input <="" td="" type="button" value="?"/>
<b>emin</b>	<div style="border: 1px solid gray; padding: 2px;">p8_transient010</div>	<input <="" td="" type="button" value="?"/>
<b>emax</b>	<div style="border: 1px solid gray; padding: 2px;">p8_source</div>	<input <="" td="" type="button" value="?"/>
<b>skybinsize</b>	<div style="border: 1px solid gray; padding: 2px;">p8_clean</div>	<input <="" td="" type="button" value="?"/>
<b>thetamax</b>	<div style="border: 1px solid gray; padding: 2px;">p8_ultraclean</div>	<input <="" td="" type="button" value="?"/>
<b>strategy</b>	<div style="border: 1px solid gray; padding: 2px;">p8_ultracleanveto</div>	<input <="" td="" type="button" value="?"/>
	<div style="border: 1px solid gray; padding: 2px;">p8_transient015s</div>	<input <="" td="" type="button" value="?"/>
	<input type="text" value="180.0"/>	<input <="" td="" type="button" value="?"/>
	<div style="border: 1px solid gray; padding: 2px;">time ▾</div>	<input <="" td="" type="button" value="?"/>

Here you apply cuts on the data.

 For intervals shorter than 100 s it is usually best to use TRANSIENT class, while for longer intervals it is best to use the cleaner SOURCE class. You can use the function 'Make navigation plots' in the Tools menu to decide which Zenith cut it is best to apply.

done.

gtllebin done!

Making the light curve...

Done!

eventfile -> /Users/flongo/FermiData/bn160905471/gll\_ft1\_tr\_bn160905471\_v00.fit

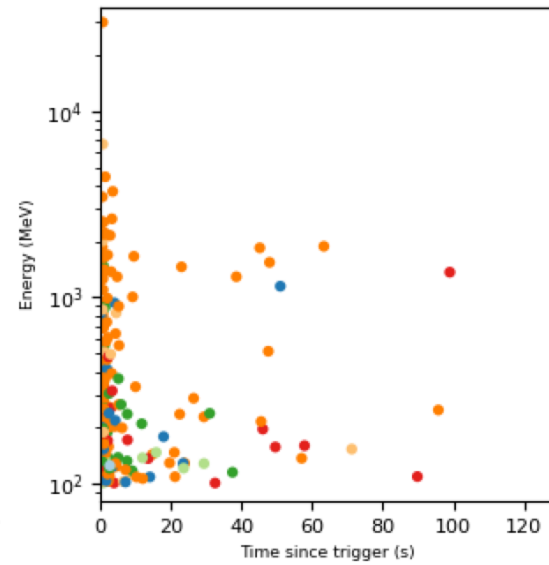
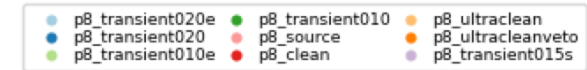
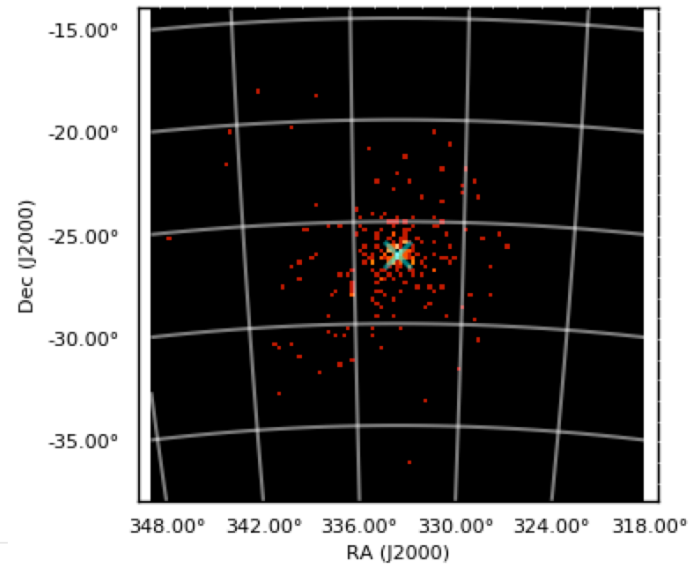
rspfile -> /Users/flongo/FermiData/bn160905471/gll\_cspectr\_bn160905471\_v00.rsp

ft2file -> /Users/flongo/FermiData/bn160905471/gll\_ft2\_tr\_bn160905471\_v00.fit



# See count map and list of photons

rad  ?  
 irf  ?  
 zmax  ?  
 tstart  ?  
 tstop  ?  
 emin  ?  
 emax  ?  
 skybinsize  ?  
 thetamax  ?  
 strategy  ?



<- Prev. 1/4 Run Next -> Cancel



Here you apply cuts on the data.



For intervals shorter than 100 s it is usually best to use TRANSIENT class, while for longer intervals it is best to use the cleaner SOURCE class. You can use the function 'Make navigation plots' in the Tools menu to decide which Zenith cut it is best to apply.

Class p8\_transient010 only: 47  
 Class p8\_source only: 0  
 Class p8\_clean only: 32  
 Class p8\_ultraclean only: 19  
 Class p8\_ultracleanveto only: 123  
 Class p8\_transient015s only: 0

=====



# Create XML model

Fermi bursts analysis GUI

particle\_model

isotr template

?

galactic\_model

template

?

source\_model

powerlaw2

?

fgl\_mode

fast

?

<- Prev.

2/4

Run

Next ->

Cancel

You have to choose which model include in the likelihood analysis. See [http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/source\\_models.html](http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/source_models.html) for the list of available spectral model for the source\_model parameter.

Use 'PowerLaw2' for normal GRB analysis.

Cutting the template around the ROI:

Keeping diffuse source 3FGL J0852.7-4631e (19.39 deg away) using template /Users/flongo/FermiTools/miniconda2/envs/fermi/share/fermitools/data/pyBurstAnalysisGUI/templates/VelaJr.fits...

Kept 1 point sources from the FGL catalog

=====

## Select the parameters of the model

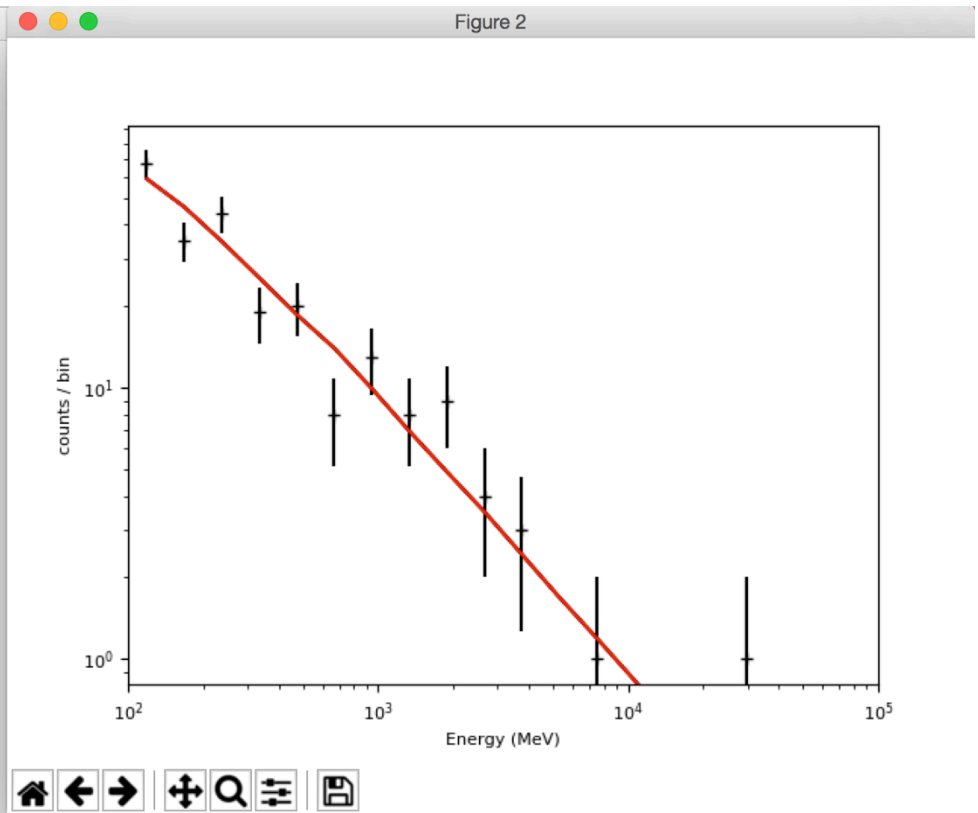
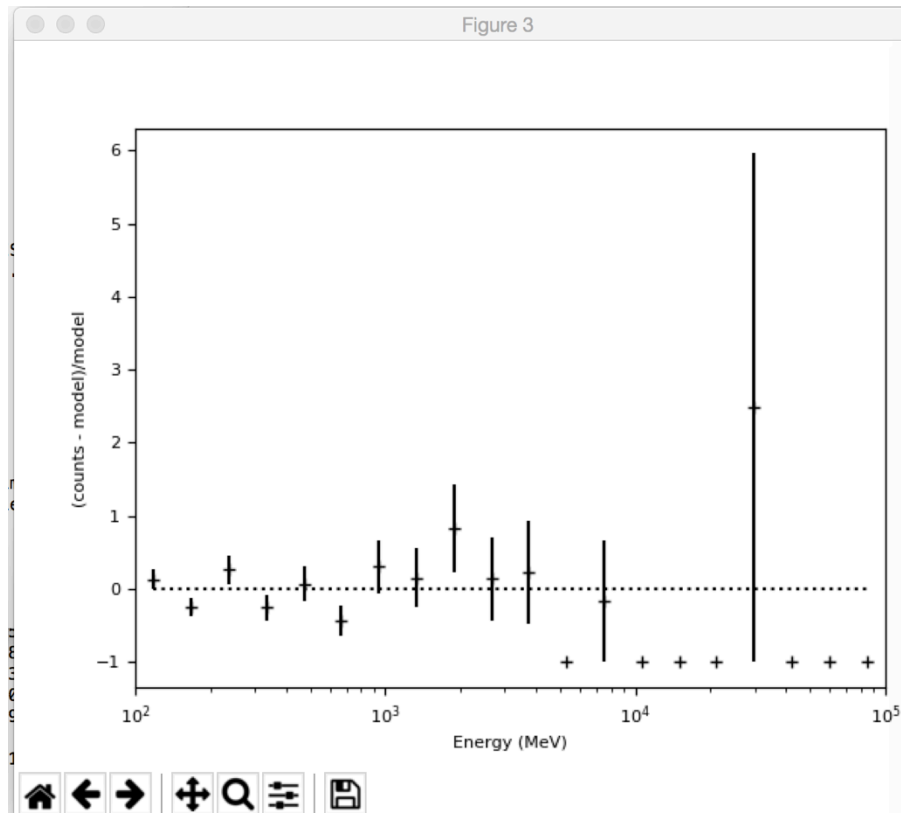
Fermi bursts analysis GUI

Double click on a parameter to change it.

Source Name	Name	Value	Error	Min	Max	Scale	Free	Source Type	Feature	Feature Type	Fe
bn090510016	Integral	0.01		1e-05	1000.0	0.00	1	PointSource	spectrum	PowerLaw2	
bn090510016	Index	-2		-6.0	0.01	1.0	1	PointSource	spectrum	PowerLaw2	
bn090510016	LowerLimit	100		20.0	200000.	1.0	0	PointSource	spectrum	PowerLaw2	
bn090510016	UpperLimit	1e+6		20.0	500000	1.0	0	PointSource	spectrum	PowerLaw2	
bn090510016	RA	333.		-360.	360.0	1.0	0	PointSource	spatialMode	SkyDirFunction	
bn090510016	DEC	-26.0		-90.0	90.0	1.0	0	PointSource	spatialMode	SkyDirFunction	
IsotropicTemplat	Normalizatio	1		0.1	10.0	1	1	DiffuseSourc	spectrum	FileFunction	[../iso_P8R2_TRA
IsotropicTemplat	Value	1		0.0	10.0	1.0	0	DiffuseSourc	spatialMode	ConstantValue	
GalacticTemplat	Value	1		0.7	1.3	1.0	1	DiffuseSourc	spectrum	ConstantValue	
GalacticTemplat	Normalizatio	1		0.001	1000.0	1.0	0	DiffuseSourc	spatialMode	MapCubeFunction	[../gll_iem_v06_ct

Done Save

# Fit plots



## Fit results

Likelihood results					
Source name	Par. Name	Value	Error	Units	TS
GalacticTemplate					0
	Value	1	0.15	-	
	Energy flux	2.1e-07	3.14e-08	erg/cm2/s	
	Photon flux	0.000443	6.63e-05	ph./cm2/s	
IsotropicTemplate					1
	Normalization	0.426	1.32	-	
	Energy flux	4.75e-08	1.47e-07	erg/cm2/s	
	Photon flux	0.000134	0.000413	ph./cm2/s	
bn090510016					2056
	Integral	0.000363	2.31e-05	ph./cm2/s	
	Index	-2.03	0.0628	-	
	LowerLimit	100	n.a. (fixed)	MeV	
	UpperLimit	1e+05	n.a. (fixed)	MeV	
	Energy flux	1.33e-07	8.44e-09	erg/cm2/s	
	Photon flux	0.00033	2.2e-05	ph./cm2/s	

\*\*\* All fluxes and upper limits have been computed in the 100.0 - 1000.0 energy range.

\*\*\* Upper limits (if any) are computed assuming a photon index of -2.0, with the 95.0 % c.l.

Log(likelihood) = 769.199818608

New localization from gtfindsrc:

(R.A., Dec) = (333.567, -26.625)

68 % containment radius = 0.028

90 % containment radius = 0.040

Distance from initial position = 0.039

Results of the last likelihood analysis. Select 'close' from the file menu to close this window.

# Fit results

Fermi bursts analysis GUI

<b>tmin</b>	<input type="text" value="20"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>
<b>optimizeposition</b>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="yes"/> <input style="width: 15px; height: 15px; background-color: #add8e6; border: 1px solid #add8e6; border-radius: 3px; vertical-align: middle;"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>
<b>showmodelimage</b>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="yes"/> <input style="width: 15px; height: 15px; background-color: #add8e6; border: 1px solid #add8e6; border-radius: 3px; vertical-align: middle;"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>
<b>spectralfiles</b>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="yes"/> <input style="width: 15px; height: 15px; background-color: #add8e6; border: 1px solid #add8e6; border-radius: 3px; vertical-align: middle;"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>
<b>liketype</b>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="unbinned"/> <input style="width: 15px; height: 15px; background-color: #add8e6; border: 1px solid #add8e6; border-radius: 3px; vertical-align: middle;"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>
<b>clul</b>	<input type="text" value="0.95"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>
<b>flemin</b>	<input type="text" value="100"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>
<b>flemax</b>	<input type="text" value="1000"/>	<input style="border: none; border: 1px solid gray; padding: 0 5px;" type="button" value="?"/>

<- Prev.
4/4
Run
Finish!
Cancel

🏠
⬅️
➡️
⛶
🔍
⚙️
💾

Here you will perform a likelihood analysis on the data you selected in the first step, using the model you selected in the 2nd step.

The likelihood analysis should take between 5 and 10 minutes to complete.

90 % containment radius = 0.040  
Distance from initial position = 0.039

NOTE: this new localization WILL NOT be used by default. If you judge it is a better localization than the one you started with, update the coordinates yourself and re-run the likelihood

=====

## Where to find info?



# Analysis Threads

## Analysis Threads


NOTE: These threads are based on the use of Pass 8 data. If you need information on Pass 7 data analysis, [look here](#). Pass 6 analysis is no longer available with the FermiTools. A description of modifications made for the Pass 8 data set is available [here](#).

- [Overview](#)
- [LAT Analysis Start Page](#)
- Data Selection
  - [Extract LAT Data](#)
  - [Data Preparation](#)
  - [Explore LAT Data](#)
  - [Explore LAT Data \(for Burst\)](#)
  - [Using LAT All-sky Weekly Files](#)
- Source Analysis
  - [Binned Likelihood Tutorial](#)
  - [Unbinned Likelihood Tutorial](#)
  - [Likelihood Analysis with Python](#)
  - [Summed Likelihood Analysis with Python](#)
  - [Binned Likelihood with Energy Dispersion \(Python\)](#)
  - [Upper Limits with Python](#)
  - [Extended Source Analysis \(Binned Analysis from Python\)](#)
  - [LAT Aperture Photometry Analysis](#)
  - [Pulsar Gating Tutorial](#)
  - [Evaluating Effective Area Systematics](#)
- GRB Analysis
  - [LAT GRB Analysis](#)
  - [GBM GRB Analysis Using RMFIT \(includes XSPEC\)](#)
  - [GRB Analysis Using GTBurst](#)
- Pulsar Analysis
  - [Pulsar Analysis Tutorial \(Video Part 1\)](#)
  - [Pulsar Analysis Tutorial \(Video Part 2\)](#)
  - [Pulsar Analysis Overview](#)
  - [Ephemeris Data File](#)
  - [Pulse Phase Calculation](#)
  - [Periodicity Test](#)
  - [Ephemeris Computation Utility](#)
  - [Period Search](#)
  - [Pulsation Search](#)
  - [Binary Orbital Phase Calculation](#)

<https://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/>


# New Tools

# 3ML fitting tool

 The Multi-Mission Maximum Likelihood framework

latest


- Installation
- Intro
- Minimization
- Bayesian Posterior Sampling
- Time-energy fit
- Plugins
- Modeling
- Features
- Tutorials
- Frequently Asked Questions
- API
- threeML



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# 3ML

The Multi-Mission Maximum Likelihood framework

Astrophysical sources are observed by different instruments at different wavelengths with an unprecedented quality. Putting all these data together to form a coherent view, however, is a very difficult task. Indeed, each instrument and data type has its own ad-hoc software and handling procedure, which present steep learning curves and do not talk to each other.

The Multi-Mission Maximum Likelihood framework (3ML) provides a common high-level interface and model definition which allows for an easy, coherent and intuitive modeling of sources using all the available data, no matter their origin. At the same time, thanks to its architecture based on plug-ins, 3ML uses under the hood the official software of each instrument, the only one certified and maintained by the collaboration which built the instrument itself. This guarantees that 3ML is always using the best possible methodology to deal with the data of each instrument.

Traditionally the Astrophysics community have been using frequentist techniques, but in recent years Bayesian methods and approaches have been gaining consensus and momentum. In 3ML both analysis are possible. Moreover, the 3ML Python interface allows for combinations with all available packages for data analysis and mining.

[Next](#) 

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<https://threeml.readthedocs.io/en/latest/>

