

Fermi Archive: Search, Data Download, and Analysis

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The Fermi Science Support Center

- The FSSC is located at the NASA Goddard Space Flight Center.
- It provides help for scientists around the world to analyze data from Fermi.
 - <http://fermi.gsfc.nasa.gov/ssc/>
- The FSSC provides -
 - Access to LAT and GBM data
 - Software to analyze the data
 - Information about the instruments
 - Information on what the spacecraft is doing
 - A place to ask questions
 - And more...

FITS Format Data Files

- FITS stands for “Flexible Image Transport System”.
- It is the standard astronomical data format.
- FITS is primarily designed to store scientific data sets consisting of multi-dimensional arrays such as:
 - *1-D spectra*
 - *2-D images*
 - *3-D data cubes*)
- Or, 2-dimensional tables containing rows and columns of data.

Structure of a FITS File

- FITS files, in addition to containing data (e.g. an image or a table of data also “metadata”:
 - *Information about the dataset*
- Each data set within a file is called an HDU or an extension.

Fermi Data Files

- All Fermi data are provided in FITS format.
- For the LAT the file types provided are:
 - *photon files. Contain information on the properties of each event thought to be a photon (e.g. energy, sky location etc.)*
 - *spacecraft files. Contain information about the spacecraft (e.g. location in orbit).*
 - *extended information on properties of photon events. (Not generally used.*
- GBM data also provided in FITS format.

Working with FITS Files – FTOOLS

- FTOOLS is a collection of programs used to create, examine, or modify the contents of FITS data files.
- The FTOOLS package forms the core of the HEASARC software system for reducing and analyzing data in the FITS format.
- Each FTOOLS task is a separate program that performs a single simple operation.
- The FTOOLS are primarily a Unix based package.
- Scripts are available for combining several FTOOLS to perform complex tasks.

Examples of Basic Tools to Examine FITS Data

- `fv` - interactive way of examining a FITS file.
- `ds9` - displays FITS images.
- `fstruct` - gives the structure of a FITS file.
- `fdump` - lists the contents of a FITS file.
- `fhelp` - gives information on other FTOOLS.

Science Analysis Tools: FTOOLS for Fermi

- ▶ *Overview of capabilities*
 - *Maximum likelihood tool—spatial-spectral analysis of region (source detection, flux)*
 - *Includes background models*
 - *Pulsars—period analysis, blind searches*
 - ▶ *Includes ephemerides database*
 - *gamma-ray bursts—temporal cuts, spectral analysis: Maximum likelihood tool, XSPEC*
- *Tools and documentation are released through FSSC website (<http://fermi.gsfc.nasa.gov/ssc/>)*

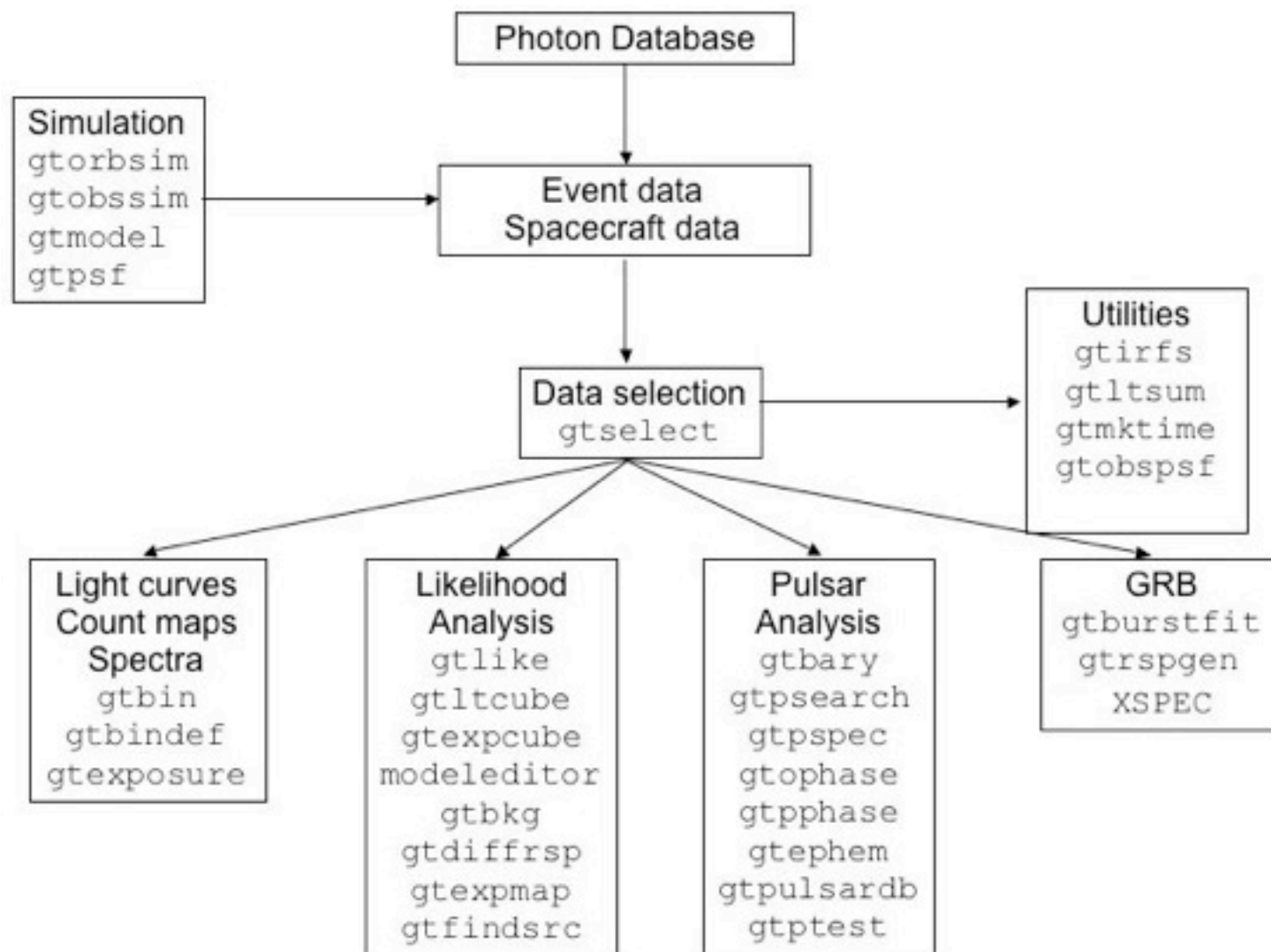
Science Tools: Documentation

- ▶ *Different types of documentation*
 - *Full set accompanies software release*
 - *Fermi Mission Technical Handbook*
 - *Multiple levels:*
 - *Detailed analysis description ('Cicerone')*
 - *Individual tool descriptions (like fhhelp)*
 - *Analysis threads (cook book examples)*

Science Tools: Structure

- ▶ *“Atomic” executables*
 - *Allows for divergent analysis without task repetition*
 - *Scriptable into more complex analysis chains*
- ▶ *Standard file types*
 - *FITS data i/o*
 - *IRAF style parameter files*
 - *XML source models*
 - *Text-based supporting files*
- ▶ *Standard toolsets*
 - *fv, ds9, XSPEC*

Science Tools: Flowchart



Parameter Files

- ▶ *Contain parameter defaults or previous values*

```

#
# $Header: /nfs/slac/g/glast/ground/cvs/dataSubselector/pfiles/gtselect.par,v 1.16
#
infile,f,a,"",,, "Input FT1 file"
outfile,f,a,"",,, "Output FT1 file"
ra,r,a,0,0,360,RA for new search center (degrees)
dec,r,a,0,-90,90,Dec for new search center (degrees)
rad,r,a,180,0,180,radius of new search region (degrees)
tmin,r,a,0,0,,start time (MET in s)
tmax,r,a,0,0,,end time (MET in s)
emin,r,a,30,0,,lower energy limit (MeV)
emax,r,a,300000,0,,upper energy limit (MeV)
zmax,r,a,180,0,180,maximum zenith angle value (degrees)
evclsmin,i,h,3,0,10,"Minimum event class ID"
evclsmax,i,h,3,0,10,"Maximum event class ID"
convtype,i,h,-1,-1,1,"Conversion type (-1=both, 0=Front, 1=Back)"
phasemin,r,h,0,0,1,minimum pulse phase
phasemax,r,h,1,0,1,maximum pulse phase

evtable,s,h,"EVENTS",,, "Event data extension"

chatter,i,h,2,0,4,Output verbosity
clobber,      b, h, yes, , , "Overwrite existing output files"
debug,        b, h, no, , , "Activate debugging mode"
gui,          b, h, no, , , "GUI mode activated"
mode,         s, h, "ql", , , "Mode of automatic parameters"

```

Science Tools: Execution

- ▶ *Parameters can be input in three ways*
 - *Command line entry - useful for scripting*
 - *Allows modification of “hidden” parameters (likely not needed for standard analyses)*
 - *Last value stored in param file for next use*
 - *Interactive prompted entry*
 - *No access to hidden parameters*

- ▶ *Parameter input can be mixed*
 - *%gtselect*
 - *%gtselect clobber=no*
 - *%gtselect clobber=no, infile=events.fits, outfile=events_cut.fits, etc...*

LAT Data Access: File types

► *Events File (2 types)*

- *Photon files contain all needed information for science analysis*
- *Extended files contain additional information about each event that is used for specialized analysis*
 - *not needed by any science analysis tool*
- *All event classes are available in both file types*
 - 1) *Transient - Loose quality definition, significant background contamination*
 - 2) *Source - Moderate quality*
 - 3) ***Diffuse - Highest quality, lowest background contamination, Use this for most analyses!***

► *Spacecraft File*

- *Spacecraft Orientation and orbit position information (where are we and where are we pointed)*
- *One entry every 30 seconds*

LAT Data Access: Downloads

► *Download data from:*

- http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/extract_latdata.html
 - *Allows retrieval of data for a specified region*
 - *Default values correspond to suggested data selections for most analysis types*
- <http://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/WeeklyFiles.cgi>
 - *Weekly files contain all classes of events from the photon files*
 - *Weekly spacecraft files are also available*
- *FTP: Can be retrieved automatically using wget*
 - *Spacecraft: <ftp://legacy.gsfc.nasa.gov/fermi/data/lat/weekly/>*
 - *Photon: <ftp://legacy.gsfc.nasa.gov/fermi/data/lat/allsky/>*

LAT Data Access: Data Server – 1



HOME RESOURCES PROPOSALS DATA HEASARC HELP SITE MAP

- + FSSC Home
- Data**
- Data Policy
- Data Access
- Data Analysis
- Newsletter
- FAQ

Accessible from
Data Access menu

LAT Photon, Extended, and Spacecraft Data Query

The Photon database currently holds 224948768 photons collected between 2008-08-04T15:43:37 and 2009-12-15T11:46:39 (239557417 and 282570399 seconds Mission Elapsed Time (MET)).

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

For all-sky data, faster to download these

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.

1. Do you want to search around a position ... ?

Object Name Or Coordinates:

(e.g. '8 34 12, -45 45 00' or '128.55, -45.75' or 'Vela')

Coordinate System:

Selection Radius: degrees

Will write DSS position keywords

... and/or search by date?

Observations Dates:

Can use "START" and "END"

If you do not enter anything, it will return results from the past 6 months.

LAT Data Access: Data Server – 2

... and/or search by energy? **Default energies: 100MeV - 300 GeV**

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.)

2. What missions and catalogs do you want to search?

FERMI Data

Photon Data Extended Data Spacecraft Data **Select type(s) of data files**

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.

For questions,
contact the
Helpdesk



+ [Privacy Policy and Important Notices](#)
+ [Get Plugins \(Acrobat, etc.\)](#)
+ [Contact NASA](#)
+ [Learn More About Fermi](#)
+ [FSSC Helpdesk](#)

Curator: J.D. Myers
Responsible NASA Official: Phil
Newman
NASA Science Official: Neil
Gehrels

LAT Data Access: Results

LAT Data Query Results

Welcome to the LAT Data Query Results page. This page provides access to the LAT data requested from the FSSC's data servers.

The submitted query parameters for query ID=L100110230031E0D2F37E95 were:

Search was for 3C 454.3

Search Center (RA,Dec)=(343.491,16.1482)
 Radius =15 degrees
 Start Time (MET) =269298220 seconds (2009-07-14T21:03:40)
 Stop Time (MET) =284850220 seconds (2010-01-10T21:03:40)
 Minimum Energy =100 MeV
 Maximum Energy =300000 MeV

Save this information for future reference

<u>Server</u>	<u>Position in Queue</u>	<u>Estimated Time Remaining</u>
Photon Server	Query Completed	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 very large data return. 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

Notice the multiple photon files

<u>Filename</u>	<u>Number of Entries</u>	<u>Size (MB)</u>	<u>Status</u>
L100110230031E0D2F37E95_PH00.fits	418607	36.77	Available
L100110230031E0D2F37E95_PH01.fits	457801	40.21	Available
L100110230031E0D2F37E95_SC00.fits		0.00	Processing

Preparing your LAT data

- *Prior to beginning an analysis you must:*
 - *Select the event class (Diffuse in almost all cases)*
 - *Exclude time intervals where the bright Earth limb comes close to the edge of your region of interest (zenith angle of 105 degrees give 8 degrees of buffer)*
- *Combine photon files if necessary*
 - *For large time ranges you will likely have multiple photon files*
 - *Combine using @filelist.txt syntax where filelist.txt is a listing of all photon files to be included, one per line*

LAT Data Selection – 1

▶ *Event-specific cuts can be made with **gtselect***

- *Time range, energy range, position, ROI radius, zenith angle*

```
[wcne-2-147-110:Meetings/Oct2009_workshop/3c454_workshop] eferrara% gtselect evclsmin=3 evclsmax=3
Input FT1 file[@OJ287_indata.txt] L090923112502E0D2F37E71_PH00.fits
Output FT1 file[L090821150043E0D2F37E96_cut.fits] 3c454_ecut.fits
RA for new search center (degrees) (0:360) [133.704] 343.490616
Dec for new search center (degrees) (-90:90) [20.1085] 16.148211
radius of new search region (degrees) (0:180) [15] 15
start time (MET in s) (0:) [252460800] 266976000
end time (MET in s) (0:) [268012800] 275369897
lower energy limit (MeV) (0:) [100] 300
upper energy limit (MeV) (0:) [300000] 300000
maximum zenith angle value (degrees) (0:180) [105]
Done.
```

Hidden parameters defined
on the command line

Or @filelist.txt

Keyword values should
correspond EXACTLY to
values in header
(unless selecting a smaller
region)

▶ *Temporal cuts using spacecraft file keywords are made with **gtmktime***

- *This MUST be applied if a zenith cut was used with **gtselect***

```
[wcne-2-147-110:Meetings/Oct2009_workshop/3c454_workshop] eferrara% gtmktime
Spacecraft data file[3c454_ecut.fits] L090923112502E0D2F37E71_SC00.fits
Filter expression[DATA_QUAL==1]
Apply ROI-based zenith angle cut[yes]
Event data file[L090821150043E0D2F37E96_cut.fits] 3c454_ecut.fits
Output event file name[L090821150043E0D2F37E96_gticut.fits] 3c454_ecut_gti.fits
```

Applies zenith angle cut from **gtselect**

LAT Data Selection – 2

- ▶ *Different cuts should be used for different types of data analysis*
 - *Point Source analysis*
 - *For hard spectrum sources, may benefit from a higher minimum energy cut due to energy-dependent PSF*
 - *Pulsar Timing analysis*
 - *Requires that spacecraft file span a greater time range than event file*
 - *GRB analysis (<200 s)*
 - *Uses “Transient” class photons (evclsmin=1, evclsmax=3)*
- ▶ *The current set of cuts can be reviewed using **gtvcut***

▶ *Recommended cuts are documented at:*

http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/Cicerone_Data_Exploration/Data_preparation.html

Binning for Visualization – 1

- ▶ *gtbin* can be used to create several useful visualization products
 - *Raw counts map*
 - *Quick-look light curve*
 - *PHA1 file*
- ▶ *Results are in format used by other science tools like **XSPEC***
 - *Includes WSC keywords for ease of viewing*
- ▶ *Useful to get a rough idea of the data, but do not include:*
 - *Exposure correction*
 - *Instrument responses*
 - *Requires Likelihood analysis for valid results*

Binning for Visualization – 2

► *Making a counts map*

```
[wcne-2-147-110:Meetings/Oct2009_workshop/3c454_workshop] eferrara% gtbin
This is gtbin version ScienceTools-v9r15p2-fssc-20090808
Type of output file (CCUBE|CMAP|LC|PHA1|PHA2) [CCUBE] CMAP
Event data file name[L090821150043E0D2F37E96_gticut.fits] 3c454_ecut_gti.fits
Output file name[L090821150043E0D2F37E96_countscube.fits] 3c454_ecut_gti_cmap.fits
Spacecraft data file name[NONE] L090923112502E0D2F37E71_SC00.fits
Size of the X axis in pixels[120] 300
Size of the Y axis in pixels[120] 300
Image scale (in degrees/pixel)[0.25] .1
Coordinate system (CEL - celestial, GAL -galactic) (CEL|GAL) [CEL] CEL
First coordinate of image center in degrees (RA or galactic l)[133.704] 343.490616
Second coordinate of image center in degrees (DEC or galactic b)[20.1085] 16.148211
Rotation angle of image axis, in degrees[0] 0
Projection method e.g. AIT|ARC|CAR|GLS|MER|NCP|SIN|STG|TAN:[AIT] AIT
```

← Here, ROI diameter × image scale
= size of each axis

↑
To view the whole region,
match these values to the
header values

Binning for Visualization – 3

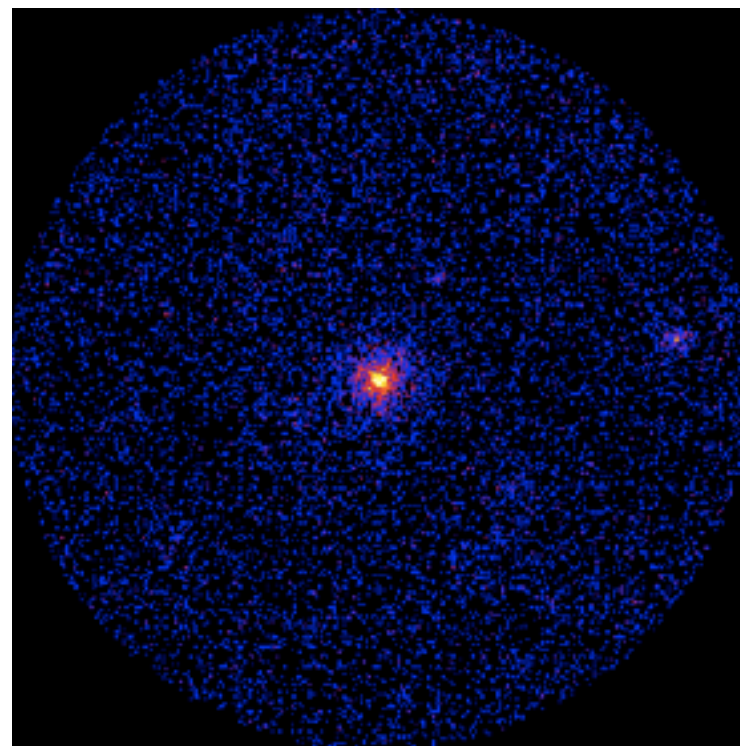
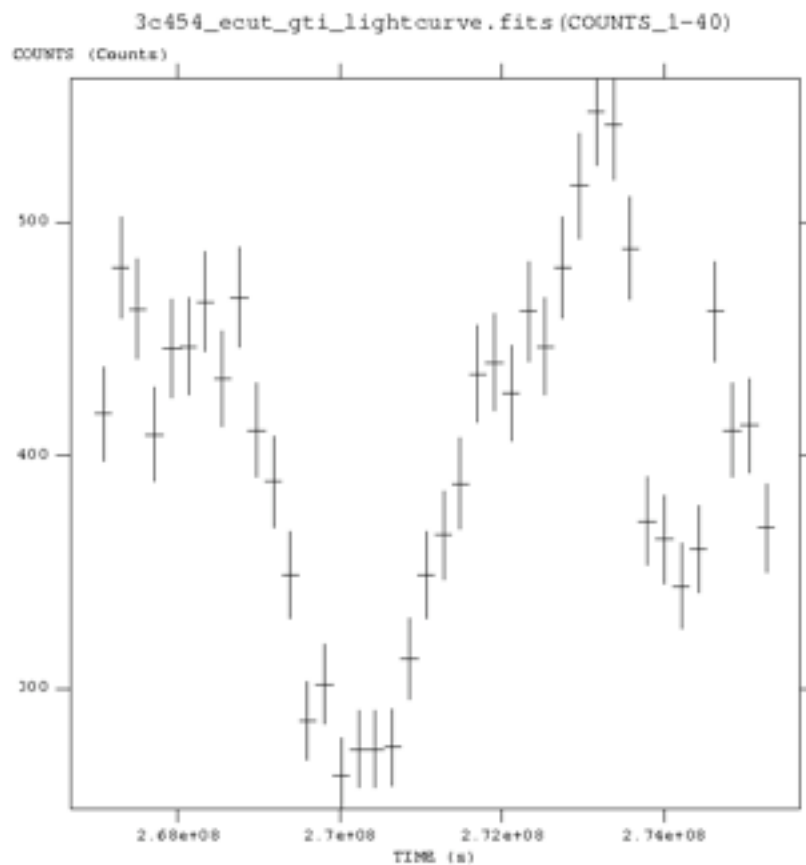
► *Making a quick-look lightcurve*

```
[wcne-2-147-110:Meetings/Oct2009_workshop/3c454_workshop] eferrara% gtbin
This is gtbin version ScienceTools-v9r15p2-fssc-20090808
Type of output file (CCUBE|CMAP|LC|PHA1|PHA2) [CMAP] LC
Event data file name[3c454_ecut_gti.fits]
Output file name[3c454_ecut_gti_cmap.fits] 3c454_ecut_gti_lightcurve.fits
Spacecraft data file name[L090923112502E002F37E71_SC00.fits]
Algorithm for defining time bins (FILE|LIN|SNR) [LIN]
Start value for first time bin in MET[0] 266976000
Stop value for last time bin in MET[0] 275369897
Width of linearly uniform time bins in seconds[0] 209850
```

← Times do not have to align to full data series

Binning for Visualization – 4

- ▶ *Gtbin products are easily viewable in fv or ds9*



GBM Data Access

- The FSSC also provides access to GBM data and data products from <http://fermi.gsfc.nasa.gov/ssc/data/access/>
 - [GBM Trigger Catalog](#)
 - [GBM Burst Catalog](#)
 - [GBM Daily Data](#)
 - [GBM Earth Occultation Light Curves](#)
 - [GBM Pulsar Spin Histories](#)
- The Trigger, Burst, and Daily data are provided using the HEASARC “Browse” system.
 - The GBM Triggers Catalog includes all triggers
 - The Burst Catalog only includes triggers classified as gamma-ray bursts.
 - GBM Daily Data contains information that is produced “continuously” such as count rates from each detector. i.e. not just from when a burst occurred.
- **Earth occultation light curves and Pulsar Spin Histories**

[Choose Tables](#) > [Parameter Search](#) > Search Results > Choose Data Products

Search was based on:

Coord. System: Equatorial, equinox 2000

Maximum Rows:

Redisplay as

Browse Tip: Do you know how to generate a script of commands to retrieve data products? [Learn more on this topic](#) or [See all tips](#)

Table Name and Row Count

[fermigbrst:Fermi GBM Burst Catalog](#) 388

Table Legend:

Display all parameters for a row

Sort by a column in order: 1,2,3 Sort by column in reverse order: 3,2,1 Current table sort

Services links: O: Digitized Sky Survey image, R: ROSAT All-Sky Survey image, N: NED objects near coordinates, S: SIMBAD objects near coordinates, D: get list of data products, H: analyze data products using [Hera](#), B: ADS bibliography holdings, F: FOV plot for observation

Scroll down below tables to select Data Products and Further Actions.

[Fermi GBM Burst Catalog \(fermigbrst\)](#) [Bulletin](#) [README](#)

Select	Services	version	trigger name	name	ra	dec	trigger time	reliability
<input type="checkbox"/>								
<input type="checkbox"/>	All							
	O R N S D H	2	bn091026550	GRB091026550	18 26 17.5	-86 06 41	2009-10-26 13:11:33.020	1.0000
	O R N S D H	0	bn100118100	GRB100118100	04 45 28.0	-81 16 00	2010-01-18 02:23:33.698	0.9804
	O R N S D H	2	bn090810659	GRB090810659	11 15 43.2	-76 24 00	2009-08-10 15:49:07.822	1.0000
	O R N S D H	1	bn100112418	GRB100112418	16 00 33.6	-75 06 00	2010-01-12 10:01:17.555	1.0000
	O R N S D H	3	bn080714425	GRB080714425	12 30 00.0	-74 00 00	2008-07-14 10:12:01.838	1.0000
	O R N S D H	2	bn091117080	GRB091117080	16 26 09.6	-73 56 24	2009-11-17 01:55:24.897	1.0000
	O R N S D H	3	bn090304216	GRB090304216	13 03 36.0	-73 24 00	2009-03-04 05:10:48.157	1.0000
	O R N S D H	3	bn090922605	GRB090922605	02 33 26.4	-73 04 48	2009-09-22 14:30:41.529	1.0000

[Choose Tables](#) > Choose Data Products > Retrieve Data Products

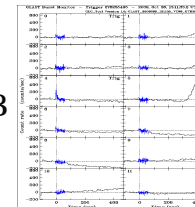
- Do you want to view a data product? Click on its hyperlinked data format.
- Do you want to retrieve data products in a tarfile? Check the boxes beside each product and click one of the buttons at the bottom of the page.

 Select all products for all rows[Fermi GBM Burst Catalog \(fermigbrst\)](#) [FTOOLS](#)

version	trigger_name	name	ra	dec	trigger_time	reliability
2	bn091026550	GRB091026550	18 26 17.5	-86 06 41	2009-10-26 13:11:33.020	1.0000

 Select all products in this row**GBM Burst Quicklook Products** GBM Trigger Quicklook Plot
(glg_lc_all_bn091026550.gif)[GIF](#)

16 kB

 GBM Trigger Quicklook Products (quicklook)[DIRECTORY](#)

1784 kB

GBM Burst Quicklook Products - Entire Directory GBM Trigger Products (current)[DIRECTORY](#)78244
kB

TAR selected products

Create Download Script

Reset

Save to Hera

[What is Hera?](#)Page maintainer: [Browse Feedback](#)



Quick Demonstration of Web pages and FTOOLS...

“Getting Started” Exercises (Benoit Lott presentation later)

- *If the data server is available, use it to extract photon files and a spacecraft file for a region (e.g. 15 degrees) around 3C 454.3.*
 - *[Instead of downloading files, use already available files here!!](#)*
- *Run “fstruct” to see the structure of the two files.*
 - *If you’ve never used the FTOOLS, type “fhhelp fstruct”.*
- *Use fv to examine the contents of the two files.*
- *Try replicating the examples in these slides to make e.g. an image. Look at the image with fv or ds9.*