



Fermi LAT Data Extraction and Preparation

Aous Abdo

< Aous.Abdo@nrl.navy.mil >

National Academy of Sciences &

Naval Research Laboratory

Washington DC



Overview

- ❖ We will learn how to extract Fermi LAT data and prepare for analysis with the Science Tools
- ❖ Data Access:
 - File types
 - Event classes
 - Obtaining the data
 - Preparing the data for analysis
- ❖ Science Tools:
 - What are Science Tools?
 - Documentation
 - Execution modes



Data Access

File Types:

❖ Event file

- Photon files: contain all information needed to perform science analysis
- Extended files: contain additional information about each photon. Not necessary for most science analysis

❖ Spacecraft pointing and livetime history file:

- Contains info about the spacecraft (the LAT to be more specific) position and orientation in 30 seconds intervals
- Used to make time cuts on events based on Good Time Intervals (GTIs)



Event Classes

- ❖ There are three classes available in both types of event files:
 - **Transient:** Loose quality definition. Likely some background contamination
 - **Source:** Tighter quality cuts. Typically included in transient analyses
 - **Diffuse:** Tightest background rejection cuts. Highest probability of being a photon. Used for most analyses.



Data Selection

- ❖ We will extract data in a 10 degree radius around the CTA1 pulsar (RA = 1.7656, DEC = 73.02552).
- ❖ Leaving the date and energy range fields empty will retrieve all data available in the 100 MeV - 300 GeV range
- ❖ We are interested in the photon data and spacecraft data files.

Fermi SSC - LAT Event and Spacecraft Data

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

HOME RESOURCES PROPOSALS DATA HEASARC HELP SITE MAP

+ FSSC Home

Data

Data Policy

Data Access

- + LAT Data
- + LAT Catalog
- + LAT Data Queries
- + LAT Query Results
- + LAT Weekly Files
- + GBM Data

Data Analysis

Newsletter

FAQ

LAT Photon, Extended, and Spacecraft Data Query

The Photon database currently holds 305431469 photons collected between 2008-08-04T15:43:37 and 2010-04-21T11:44:08 (239557417 and 293543048 seconds Mission Elapsed Time (MET)).

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

Start Search Reset

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: 1.7565, 73.02552
(e.g. 'R 34 12, -45 45 00' or '128.55, -45.75' or 'Vela')

Coordinate System: J2000

Selection Radius: 10 degrees

... and/or search by date?

Observations Dates: [] Gregorian

If you do not enter anything, it will return results from the past 6 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.
Enter the start and (optional) end MJD in the form
MMMM.mmmmm,MMMM.mmmmm
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.)

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

Photon Data Extended Data Spacecraft Data



Data Selection

- ❖ You will get a page like this which summarizes your query and gives an estimated time for your data to be ready to download
- ❖ You can retrieve this same data in the future using the unique query number assigned to this one query. **L100422162532E0D2F37E35** in this case
- ❖ To access this query in the future just go to:
<http://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/QueryResults.cgi>
≥
and use the query #

Groups Time Workbook GLAST

xTime - A D... CTA1 paper... Possible Gal... PSUE with o... Agendae for... PrWid

NASA GODDARD SPACE FLIGHT CENTER

+ NASA Homepage
+ GSFC Homepage
+ Fermi Homepage

SEARCH Fermi:
Search + GO

Fermi Science Support Center

HOME RESOURCES PROPOSALS DATA HEASARC HELP SITE MAP

+ FSSC Home

Data

Data Policy

Data Access

- + LAT Data
- + LAT Catalog
- + LAT Data Queries
- + LAT Query Results
- + LAT Weekly Files
- + GBM Data

Data Analysis

Newsletter

FAQ

Query Successfully Submitted

Your query has been successfully submitted to the search system.

The submitted query parameters for query ID=L100422162532E0D2F37E35 were:

Search Center (RA,Dec)=(1.7565,73.0255)
Radius =10 degrees
Start Time (MET) =239557417 seconds (2008-08-04T15:43:37)
Stop Time (MET) =293543047.1 seconds (2010-04-21T11:44:07)
Minimum Energy =100 MeV
Maximum Energy =300000 MeV

The estimated time until completion of the query is 87 seconds. The results of the query can be accessed at:

<http://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/QueryResults.cgi?id=L100422162532E0D2F37E35>

If you would like to receive an e-mail notification when your query is complete, please submit your e-mail address in the form below

Submit e-mail address Reset

+ 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
Last Modified:



Data Selection

❖ If you click on the link in the query summary page you will get the requested files.

- Files tagged with the PH## string are the photon events files
- Space craft file is tagged with the SC string

❖ Download the files

```
[abdo@heselin tutorial]$ ls -l L100422151847E0D2F37E30_*
L100422151847E0D2F37E30_PH00.fits
L100422151847E0D2F37E30_PH01.fits
L100422151847E0D2F37E30_PH02.fits
L100422151847E0D2F37E30_PH03.fits
L100422151847E0D2F37E30_PH04.fits
L100422151847E0D2F37E30_SC00.fits
[abdo@heselin tutorial]$
```

Fermi Science Support Center

HOME RESOURCES PROPOSALS **DATA** HEASARC HELP SITE MAP

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=L100422151847E0D2F37E30 were:

Search Center (RA,Dec)=(1.7565,73.0255)
 Radius =10 degrees
 Start Time (MET) =239557417 seconds (2008-08-04T15:43:37)
 Stop Time (MET) =293543047.1 seconds (2010-04-21T11:44:07)
 Minimum Energy =100 MeV
 Maximum Energy =300000 MeV

Server	Position in Queue	Estimated Time Remaining
Photon Server	Query Completed	N/A
Spacecraft 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

Filename	Number of Entries	Size (MB)	Status
L100422151847E0D2F37E30_PH04.fits	495630	43.53	Available
L100422151847E0D2F37E30_PH01.fits	342503	30.10	Available
L100422151847E0D2F37E30_PH00.fits	485517	42.67	Available
L100422151847E0D2F37E30_PH02.fits	576548	50.64	Available
L100422151847E0D2F37E30_PH03.fits	769541	67.57	Available
L100422151847E0D2F37E30_SC00.fits	1503704	199.37	Available

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

Submit Reset

You may submit a new search at:

Fermi LAT Data Query Page



Weekly Files

- ❖ Often one is interested in multiple regions of the sky and would like to keep an all sky data files handy on the cluster.
- ❖ The easy way to do this is to download the weekly files already merged from the FSSC.
 - <http://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/WeeklyFiles.cgi>
- ❖ The weekly files contain only the “Diffuse” class photon events
- ❖ Weekly spacecraft files are also available
- ❖ An easy way to get these files is using wget:

```
$wget -m -P . -nH --cut-dirs=4 -np http://fermi.gsfc.nasa.gov/FTP/fermi/data/lat/weekly/
```

- ❖ This will download all weekly files (spacecraft, photon, and skymap images)



Science Tools

- ❖ Developed by the Fermi LAT team and is available on the FSSC website:
 - < <http://fermi.gsfc.nasa.gov/ssc/data/analysis/> >
 - ❖ Documentation at < <http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/> >:
 - **Cicerone** <<http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/>>:
Describes the full Fermi Science Tools. It is a detailed description of the analysis environment and its methodology.
 - **Reference manual** < <http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/references.html> > :
Detailed description of each tool
 - **Analysis threads** < <http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/> > :
Cookbook examples of some common analyses
 - ❖ User contributed S/W:
 - < <http://fermi.gsfc.nasa.gov/ssc/data/analysis/user/> >
 - Any body can contribute! FSSC is in no way responsible for this S/W
-



Science Tools

- ❖ A list of all available Science Tools:
< <http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/overview.html> >

Utilities:

gtbin	Computes the counts maps for use in a binned likelihood analysis; bins are 'cubes' in latitude, longitude, and log(energy).
gtexposure	Given a counts light curve prepared using gtbin for a specific location on the sky, this tool computes the exposure (cm ² -s) associated with each time bin.
gtirfs	List all available response functions.
gtitsum	Adds together livetime cubes produced by gtltcube.
gtmktime	Create Good Time Intervals (GTIs) based on selections made on the spacecraft data file variables.
gtpsf	Calculates the effective point spread function as a function of energy at a given source location, averaged over an observation.
gtselect	Creates a new filtered FITS file based on cuts applied to the values in each row of an input event file. Enables more detailed selections to be made on data obtained from the data server.
gtsrcid	Creates a counterpart candidate catalog by correlating the objects from a list of detected sources with the objects of an existing source catalog, such as the 3EG catalog.
gtvcut	Prints a summary of the Data Sub-Space keywords.

Likelihood:

gtbin	Computes the counts maps for use in a binned likelihood analysis; bins are 'cubes' in latitude, longitude, and log(energy).
gtexpmap	Computes the exposure maps for use in an unbinned likelihood analysis.
gtdiffrsp	Computes the event-specific response for each diffuse source in the input source model. A column containing these data is added to the event file for each source.
gtfindsrc	Optimizes a point source location using the likelihood test-statistic.
gtlike	Enables LAT data to be analyzed using an unbinned or binned formulation of the log-likelihood.
gtltcube	Integrates the livetime as a function of sky position and off-axis angle, using the spacecraft data file and the time range and GTI selections in the event file. The sky is represented using a nested HEALPix array.
gtmodel	Creates a model counts map by summing up convolved source maps that have been scaled by the spectral parameters given in the source model XML file.
gtsrcmaps	Convolve components of the specified source model with the instrument response for a given observation. The geometry in sky and energy coordinates of the output maps match that of the input counts map.
gttsmap	Computes a test statistic map for source localization and detection in an unbinned likelihood analysis.

Gamma-ray Burst Analysis:

gtbkg	Creates a background spectrum file for use in XSPEC analysis.
gtbin	Bins an event list in time, energy, or space, and results in spectra, lightcurves or a count map.
gtbindef	Utility used to read in an ASCII file with the time or energy bin definitions, and produce the FITS file, which can be used by gtbin.



Science Tools

❖ Execution:

- Interactive:

- ❖ User will be asked for parameter entries on the command line
- ❖ Allows for access of some parameters of the tool. No access for hidden parameters

```
$ gtselect
Input FT1 file[@events.txt]
Output FT1 file[FT1.fits]
RA for new search center (degrees) (0:360) [0] 1.7565
Dec for new search center (degrees) (-90:90) [0] 73.02552
radius of new search region (degrees) (0:180) [180] 10
start time (MET in s) (0:) [0] 239557417
end time (MET in s) (0:) [0] 293543047
lower energy limit (MeV) (0:) [100]
upper energy limit (MeV) (0:) [300000]
maximum zenith angle value (degrees) (0:180) [180] 105
```

- Command line style:

- ❖ Allows access for all parameters of a given tool.
- ❖ Useful for scripting

```
$gtselect infile=@events.txt outfile=FT1.fits ra=1.7565 dec=73.02552 rad=10.0 tmin=239557417 tmax=293543047 emin=100
emax=300000 evclsmin=3 evclsmax=3 zmax=105
```



FITS Format Data Files

- ❖ Standard file format for astronomical data
- ❖ FITS stands for Flexible Image Transport System
- ❖ Designed to store scientific data sets consisting of multi-dimensional arrays such as:
 - 1-D spectra
 - 2-D images
 - 3-D data cubes
 - Tables containing rows and columns of data
- ❖ In addition to data stored FITS files contain “metadata” which is a list of information about the data set



FITS Data Files

24 Event parameters 485517 Events

❖ One can look at what is inside a FITS file with fv:

```
$fv L100422151847E0D2F37E30_PH00.fits
```

Contains helpful information about the data such as the energy cuts, start and stop times, and info about the ROI

Extensions

```
INDEXES = 1:0D*30 / Maximum value
EXTVER = 1 / auto assigned by template parser
HISTORY Input merit file: /scratch/glastmp/P105-FT1/0/r0239557414-000000_merit.r
HISTORY oot
HISTORY Filter string: (FswGamState==0||FswGamState==3) && (CTBCORE>0) && (CTBBe
HISTORY stEnergyProb>0) && (CTBBestEnergy>10) && (CTBBestEnergyRatio<5) && (CTBC
HISTORY lassLevel>0) && (EvtElapsedTime >= 239557417) && (EvtElapsedTime <= 239
HISTORY 558070)
DSTYP1 = 'TIME'
DSUNI1 = 's'
DSVAL1 = 'TABLE'
DSREF1 = ':GTI'
NDSKEYS = 4 / Number of data subspace keywords in header
HISTORY CFITSIO used the following filtering expression to create this table:
HISTORY /scratch/glastmp/P105-FT1/0/foo.fit[EVENTS][gtifilter("/scratch/glastmp/
HISTORY P105-FT1/0/gll_ph_r0239557414_v105.fit_tempgti")]
DSTYP2 = 'POS (RA,DEC)'
DSUNI2 = 'deg'
DSVAL2 = 'circle(1.756500,73.025520,10.000000)'
DSTYP3 = 'TIME'
DSUNI3 = 's'
DSVAL3 = '239557417.000000:293543047.085000'
DSTYP4 = 'ENERGY'
DSUNI4 = 'MeV'
DSVAL4 = '100.000000:300000.000000'
END
```

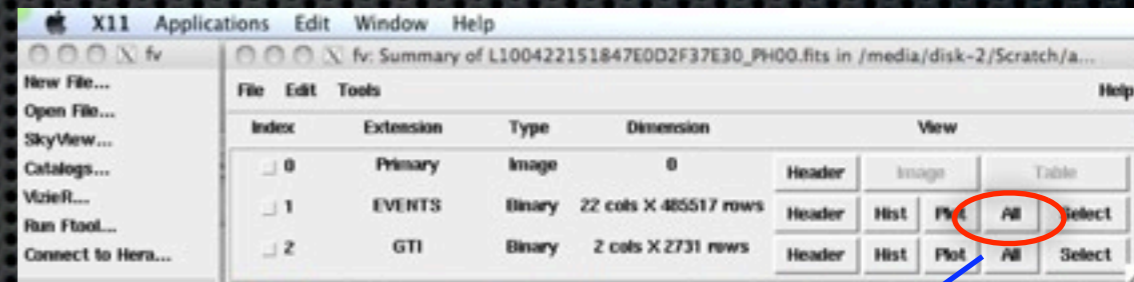
The screenshot shows the fv software interface. At the top, a table lists the file's extensions:

Index	Extension	Type	Dimension	View
0	Primary	Image	0	Image Table
1	EVENTS	Binary	22 cols, 485517 rows	Header Hist Plot All Select
2	GTI	Binary	2 cols X 2731 rows	Header Hist Plot All Select

Below this, the 'extension header' is displayed, listing 24 parameters (TTYPE1-TTYPE24) and their corresponding data formats (TFORM1-TFORM24). Parameters include ENERGY, RA, DEC, GALACTIC LONGITUDE, GALACTIC LATITUDE, INCLINATION ANGLE, PHASE ANGLE, PHASE ANGLE, TIME, EVENT ID, RUN ID, RECON_VERSION, CALIB_VERSION, EVENT CLASS, CONVERSION_TYPE, LIVETIME, and DIFFUSE RESPONSE COMPONENTS.



FITS Files



Data table

fv: Binary Table of L100422151847E0D2F37E30_PH00.fits[1] in /media/disk-2/Scratch/abdo/tutorial/

Select	ENERGY E MeV Modify	RA E deg Modify	DEC E deg Modify	L E deg Modify	B E deg Modify	THETA E deg Modify	PHI E deg Modify	ZENITH_ANGLE E deg Modify	EARTH_AZIMUTH_ANGLE E deg Modify	TIME D s Modify	EVENT_ID J Modify	RUN_ID J Modify	RECON_VERSION I Modify	CALIB_VERSION 3I Modify
1	1.422766E+02	3.594714E+02	7.979739E+01	1.204719E+02	1.718243E+01	6.910254E+01	3.022012E+02	9.885333E+01	9.534511E+00	2.395605354906E+08	3266873	239559565	0	Plot
2	6.630074E+02	3.552198E+02	8.041496E+01	1.198917E+02	1.796245E+01	5.995349E+01	3.209974E+02	8.909497E+01	6.957580E+00	2.395608211238E+08	3807054	239559565	0	Plot
3	9.023116E+02	3.574374E+02	8.135407E+01	1.205124E+02	1.877364E+01	4.585815E+01	3.542967E+02	7.540024E+01	3.445021E+00	2.395612811929E+08	4555559	239559565	0	Plot
4	1.771124E+02	3.543519E+02	8.143912E+01	1.200680E+02	1.898205E+01	3.139957E+01	2.777657E+01	6.379387E+01	3.587201E+02	2.395674775070E+08	3939947	239565645	0	Plot
5	2.098734E+02	3.475662E+02	8.066676E+01	1.187390E+02	1.862966E+01	2.459715E+01	8.939301E+01	5.936841E+01	3.514109E+02	2.395680481979E+08	4955984	239565645	0	Plot
6	3.502753E+02	3.499189E+02	8.138141E+01	1.193874E+02	1.914824E+01	2.860217E+01	1.145971E+02	6.194921E+01	3.508727E+02	2.395683214002E+08	5526752	239565645	0	Plot
7	1.781785E+02	3.578154E+02	8.157468E+01	1.206275E+02	1.897354E+01	3.936227E+01	1.460957E+02	6.969838E+01	3.510123E+02	2.395687529421E+08	6488198	239565645	0	Plot
8	2.574498E+02	3.589905E+02	7.956792E+01	1.203313E+02	1.697745E+01	5.110657E+01	1.724866E+02	7.959357E+01	3.499977E+02	2.395690757812E+08	7189960	239565645	0	Plot
9	1.656817E+02	3.504794E+02	8.159678E+01	1.195520E+02	1.931879E+01	5.690671E+01	1.920872E+02	8.629076E+01	3.535395E+02	2.395692771012E+08	7609752	239565645	0	Plot
10	1.609002E+02	3.436289E+02	8.210265E+01	1.188331E+02	2.017861E+01	2.954037E+01	3.892424E+01	6.304522E+01	3.563375E+02	2.395790453821E+08	2732559	239577663	0	Plot
11	2.314772E+02	3.510547E+02	8.081142E+01	1.193452E+02	1.855312E+01	2.657988E+01	1.074564E+02	6.039319E+01	3.507241E+02	2.395796981481E+08	3861692	239577663	0	Plot
12	6.706958E+02	3.404523E+02	8.179659E+01	1.182607E+02	2.012719E+01	2.884743E+01	3.961025E+01	6.256845E+01	3.557742E+02	2.396019843679E+08	1443949	239601276	0	Plot
13	1.048911E+03	3.473953E+02	8.144180E+01	1.190439E+02	1.934956E+01	2.734716E+01	4.231366E+01	6.118829E+01	3.561180E+02	2.396020339678E+08	1538493	239601276	0	Plot
14	1.807900E+02	3.565899E+02	7.966393E+01	1.199163E+02	1.717535E+01	2.340885E+01	8.667103E+01	5.720770E+01	3.519543E+02	2.396024279398E+08	2324489	239601276	0	Plot
15	1.419089E+02	3.432040E+02	8.167627E+01	1.185654E+02	1.982917E+01	3.856222E+01	1.364598E+02	6.954747E+01	3.511872E+02	2.396030548513E+08	3547407	239601276	0	Plot
16	1.377816E+02	3.593776E+02	8.295177E+01	1.211848E+02	2.026375E+01	6.878880E+01	2.521326E+02	9.926472E+01	3.559296E+02	2.396041253564E+08	5300410	239601276	0	Plot
17	7.190220E+02	3.557790E+02	8.199392E+01	1.204457E+02	1.945409E+01	2.384986E+01	7.394768E+01	5.882036E+01	3.544506E+02	2.396138221867E+08	3166617	239612600	0	Plot
18	3.713688E+02	3.460890E+02	8.087586E+01	1.186022E+02	1.891786E+01	3.805448E+01	1.361325E+02	6.877351E+01	3.502170E+02	2.396144999728E+08	4595556	239612600	0	Plot
19	4.937043E+02	3.576205E+02	8.193576E+01	1.206928E+02	1.933039E+01	5.253804E+01	1.722994E+02	8.161399E+01	3.525101E+02	2.396150111359E+08	5521101	239612600	0	Plot
20	1.544778E+02	3.561945E+02	7.945380E+01	1.197861E+02	1.699154E+01	7.462011E+01	6.216640E+01	5.929400E+01	3.579223E+02	2.396306385893E+08	1706290	239629788	0	Plot
21	5.892498E+03	3.595913E+02	8.284727E+01	1.211878E+02	2.015600E+01	6.792636E+01	4.949624E+01	5.907465E+01	3.554954E+02	2.396310314699E+08	2966742	239629788	0	Plot



Preparing The Data

- ❖ After you have downloaded the data from the FSSC server there are some necessary steps to prepare your data for the analysis:
 1. Select the event class suitable for your type of analysis. In most cases you want to select the “Diffuse” class event. This is done with `gtselect`
 2. Exclude “bad” time intervals with `gtmktime`.
 3. If you got more than one event file, like in our case, you could either merge all these files on one event file to use in your analysis or you could use a list of these files.
 4. Files from the FSSC are not time ordered. It is a good practice to time order these files especially before performing pulsar analysis. This will make some of the Science Tools run much faster. This is done with `ftsrt` or `fsort`



1. Selecting Event Class

- ❖ So now we have four event files that we just downloaded from the FSSC. We will select only “Diffuse”
- ❖ We will first make a list of these files and store it in a text file:

```
$ls
L100422151847E0D2F37E30_PH00.fits
L100422151847E0D2F37E30_PH01.fits
L100422151847E0D2F37E30_PH02.fits
L100422151847E0D2F37E30_PH03.fits
L100422151847E0D2F37E30_PH04.fits
L100422151847E0D2F37E30_SC00.fits

$ls -l L100422151847E0D2F37E30_PH0* > events.txt
```



1. Selecting Event Class Cont'd

- ❖ By default, gtselect prompts for cuts on:
 - Time
 - Energy
 - Position (RA,Dec,radius)
 - Maximum Zenith Angle
- ❖ However, by using hidden parameters (or the 'Show Advanced Parameters' check box in GUI mode), you can also make cuts on:
 - Minimum event class ID
 - Maximum event class ID
 - Minimum pulse phase
 - Maximum pulse phase

```
Search Center (RA,Dec)=(1.7565,73.0255)
Radius =10 degrees
Start Time (MET) =239557417 seconds (2008-08-04T15:43:37)
Stop Time (MET) =293543047.1 seconds (2010-04-21T11:44:07)
Minimum Energy =100 MeV
Maximum Energy =300000 MeV
```

```
$gtselect infile=@events.txt outfile=FT1.fits ra=1.7565
dec=73.02552 rad=10.0 tmin=239557417 tmax=293543047
emin=100 emax=300000 evclsmin=3 evclsmax=3 zmax=105
```

- ❖ Selection on event class is done through the evclsmin and evclsmax hidden parameters



2. Good Time Intervals

- ❖ A GTI is a time range in which the data collected is considered to be valid.
- ❖ Why would that happen:
 - Dead time
 - Additional cuts, especially on the zenith angle, might mean that the source will not be in FOV
 - Space craft problems(SIUs).
- ❖ gtmktime will update the GTI extension in the events file
- ❖ GTIs are used by Science Tools to calculate the exposure for a given observation



2. Good Time Intervals Cont'd

❖ Parameters to use with gtmktime:

- DATA_QUAL: Data quality flag in spacecraft files
(use `DATA_QUAL == 1`)
- IN_SAA: Was FERMI in the Southern Atlantic Anomaly region, if yes then discard events from this time period
(use `IN_SAA != T`)
- LAT_CONFIG: Configuration of the spacecraft.
(use `LAT_CONFIG == 1` for science intended data)
- ROCK_ANGLE: Angle range at which the spacecraft “rocks” in its survey mode.
(use `ABS (ROCK_ANGLE) < 52`)

❖ Overall expression will be:

- `DATA_QUAL == 1 && LAT_CONFIG == 1 && ABS (ROCK_ANGLE) < 52 && IN_SAA != T`



2. Good Time Intervals Cont'd

```
$ gtmktime  
Spacecraft data file[]L100422151847E0D2F37E30_SC00.fits  
Filter expression[] DATA_QUAL==1 && LAT_CONFIG==1 &&  
ABS(ROCK_ANGLE)<52 && IN_SAA!=T  
Apply ROI-based zenith angle cut[yes]  
Event data file[]FT1.fits  
Output event file name[]FT1_gtmktime.fits
```

Applies zenith angle based on the value from gtselect (105 deg. in this case)



2. Good Time Intervals Cont'd

Original file

Index	Extension	Type	Dimension	View
<input type="checkbox"/> 0	Primary	Image	0	Header Image Table
<input type="checkbox"/> 1	EVENTS	Binary	22 cols X 352285 rows	Header Hist Plot All Select
<input type="checkbox"/> 2	GTI	Binary	2 cols X 9390 rows	Header Hist Plot All Select

gtmktime file

Index	Extension	Type	Dimension	View
<input type="checkbox"/> 0	Primary	Image	0	Header Image Table
<input type="checkbox"/> 1	EVENTS	Binary	22 cols X 315033 rows	Header Hist Plot All Select
<input type="checkbox"/> 2	GTI	Binary	2 cols X 11822 rows	Header Hist Plot All Select

Number of GTIs increased

Number of events decreased

- ❖ The increase in the numbers of GTIs is due to the fact that after applying the cuts the original GTIs were split into smaller intervals.



3. Time Ordering

- ❖ To time order events in a given event file we will use the `ftsort` tool:

```
$ ftsort FT1_gtmktime.fits FT1_gtmktime_sorted.fits TIME  
clobber=yes
```

- ❖ The time ordering is done over the `TIME` parameter in the events file
- ❖ The file (`FT1_gtmktime_sorted.fits`) is the new file we will be using