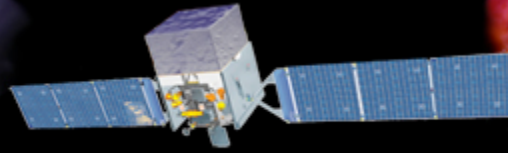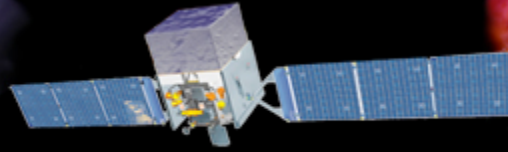# FSSC Science Tools

Data Selection and Exploration

Science Analysis Tools
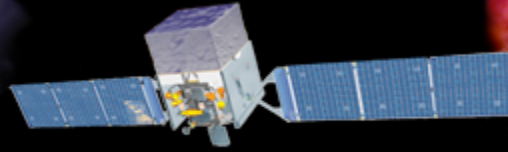
▶ *Overview of capabilities*

– *Maximum likelihood tool—spatial-spectral analysis of region (source detection, flux)*

- *Includes background models*

– *Pulsars—period analysis, blind searches*

- *Includes ephemerides DB*

– *GRBs—temporal cuts, spectral analysis: Maximum likelihood tool, XSPEC*

▶ *Tools and documentation are released through FSSC website (http://fermi.gsfc.nasa.gov/ssc/)*
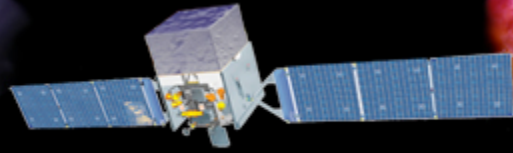
Science Tools: Documentation

▶ *Multi-tier Documentation*

   – *Full set accompanies software release*

      • *Fermi Mission Technical Handbook*

   – *Multiple levels:*

      • *Detailed analysis description ('Cicerone')*

      • *Individual tool descriptions (like fhelp)*

      • *Analysis threads (cook book examples)*

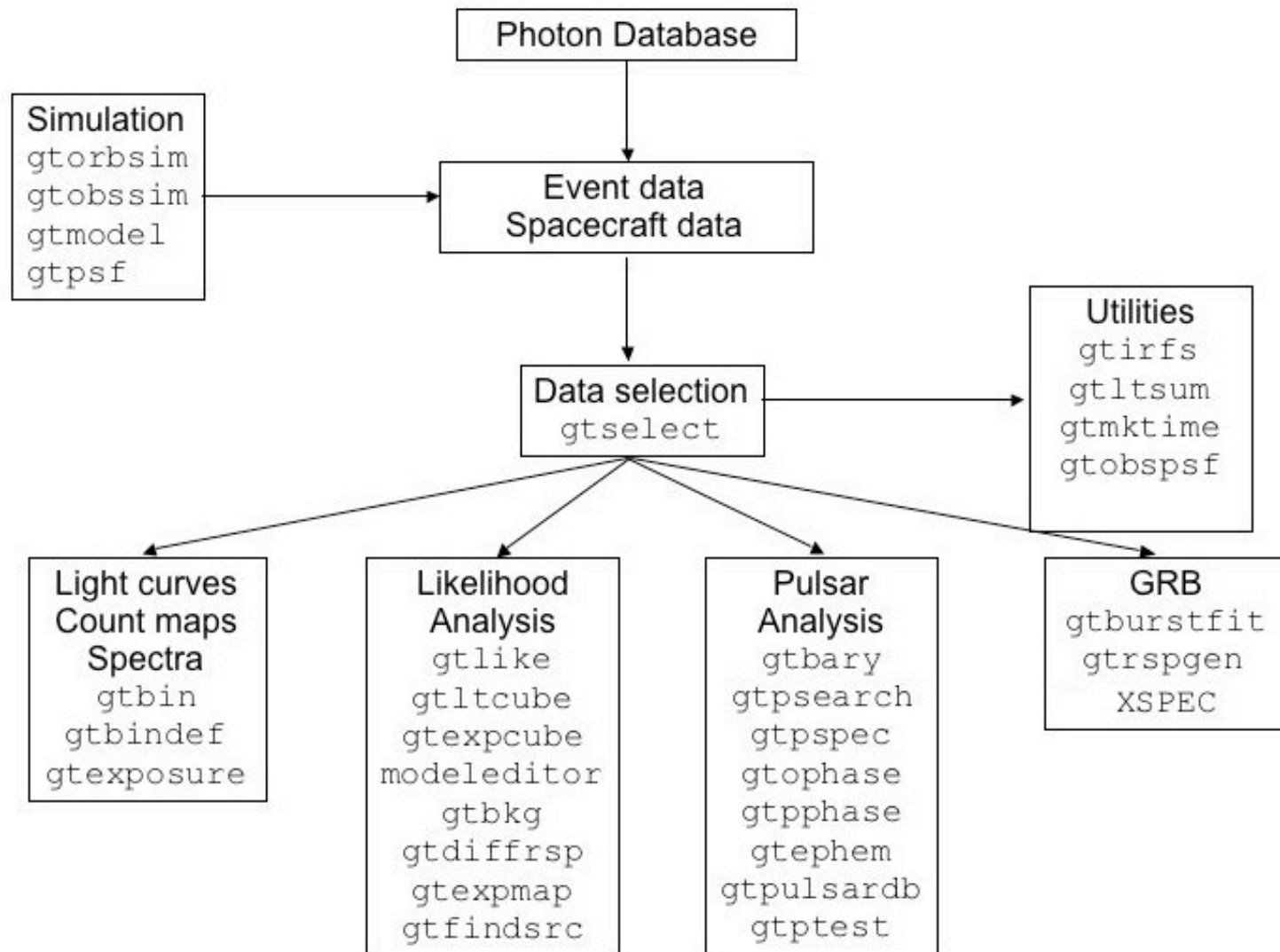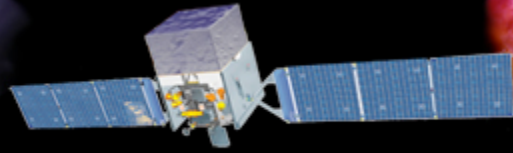# Science Tools: Structure

▶ *"Atomic" executables*

   – *Allows for divergent analysis without task repetition*

   – *Scriptable into more complex analysis chains*

▶ *Standard file types*

   – *FITS data i/o*

   – *IRAF style param 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"
```
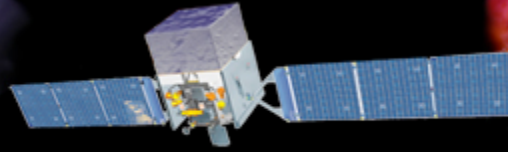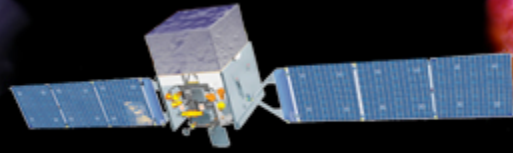
Science Tools: Execution

▶ *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...*
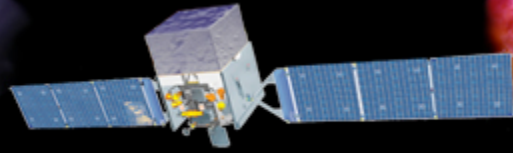
Data Access: File types

▶ *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)*
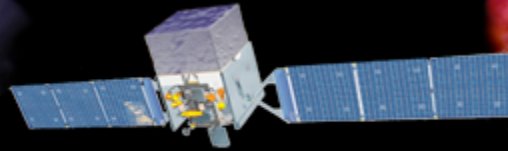
- *One entry every 30 seconds*

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 only Diffuse-class 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/*

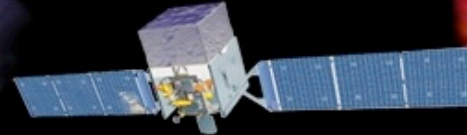 • *Photon: ftp://legacy.gsfc.nasa.gov/fermi/data/lat/allsky/*

Data Access: Data Server - 1

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 →

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

Coordinate System: [J2000 ▼]

Selection Radius: [15] degrees — Will write DSS position keywords
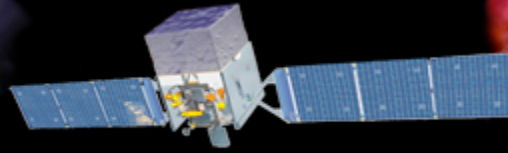
... and/or search by date?

Observations Dates: [   ] [Gregorian ▼] — Can use "START" and "END"

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

Accessible from Data Access menu

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.
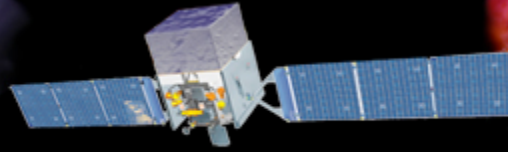
(Start Search)   (Reset)

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

Data Access: Data Server - 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
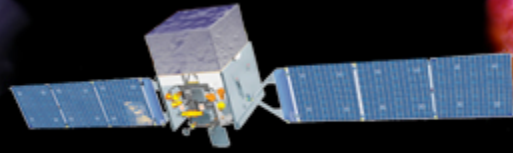
Save this information for future reference

Server	Position in Queue	Estimated Time Remaining
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

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

Preparing your 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*

Data Selection - 1

Hidden parameters defined on the command line

▶ *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.
```
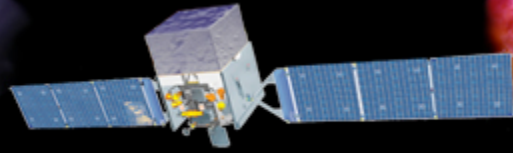
Or @filelist.txt

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
```

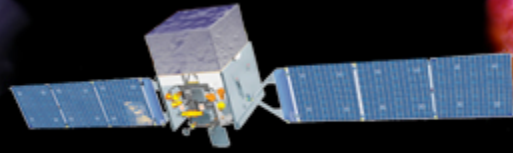Applies zenith angle cut from gtselect

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
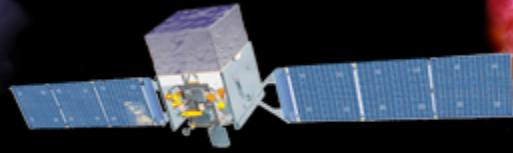
Binning for Visualization - 1

▶ ***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*

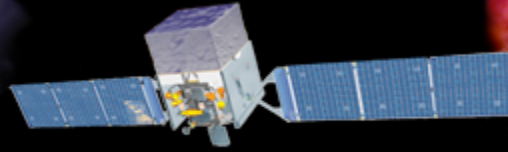- – *Requires Likelihood analysis for valid results*

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,
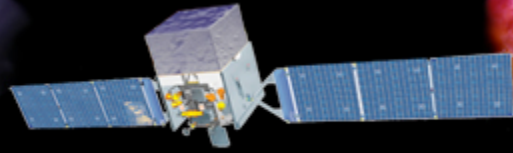match these values to the
header values

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[L090923112502E0D2F37E71_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*

3c454_ecut_gti_lightcurve.fits(COUNTS_1-40)