
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
 - **Simulation tools**
- ▶ **Tools and documentation are released through FSSC website (<http://fermi.gsfc.nasa.gov/ssc/>)**

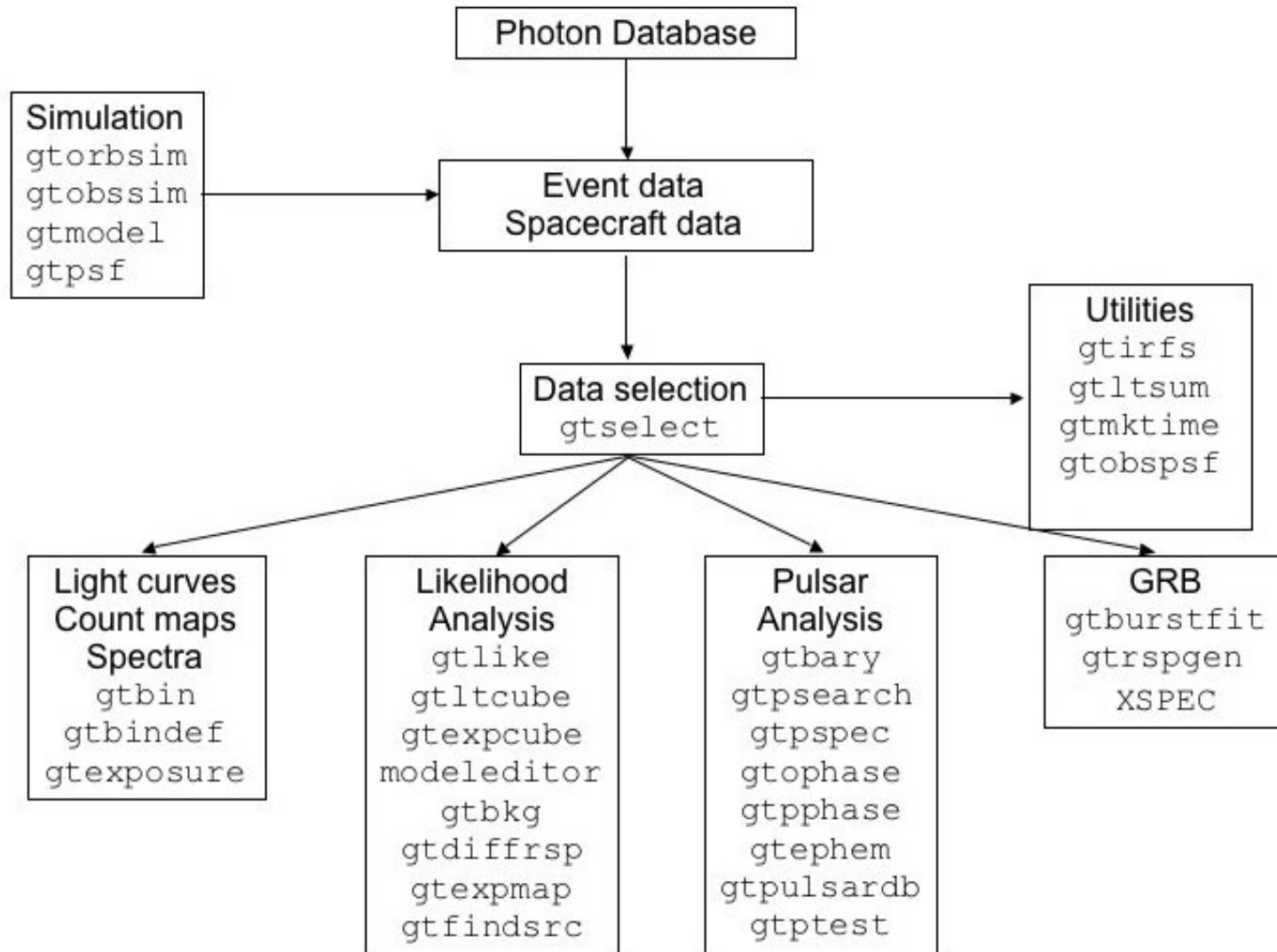
Science Tools: Documentation

- ▶ **Multi-tier Documentation**
 - **Full set accompanies software release**
 - **Fermi Mission Technical Handbook**
 - **Multiple levels:**
 - **Detailed analysis description ('Cicerone')**
 - **Individual tool descriptions (like fhelpt)**
 - **Analysis threads (cook book examples)**

Science Tools: Structure

- ▶ **“Atomic” executables**
 - Allows for divergent analysis without task repetition
 - Scriptable into more complex analysis chains
- ▶ **file types**
 - FITS data i/o
 - IRAF style param files
 - XML source models
 - Text-based supporting files
- ▶ **Compatible with 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
 - Diffuse - Highest quality, lowest background contamination, Use this for most analyses!
 - Source - Moderate quality
 - Transient - Loose quality definition, significant background contamination

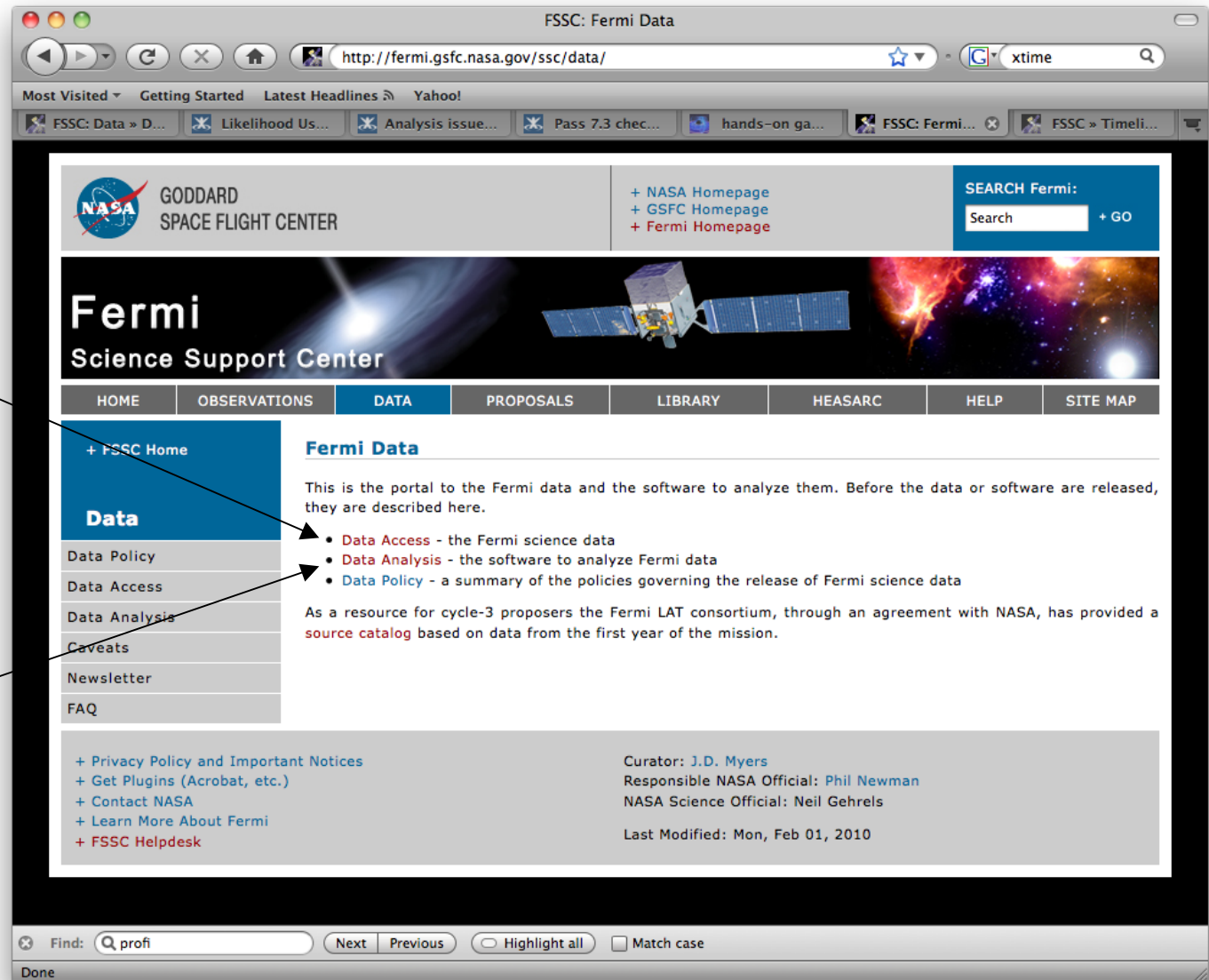
▶ Spacecraft File

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

Data Access: Downloads

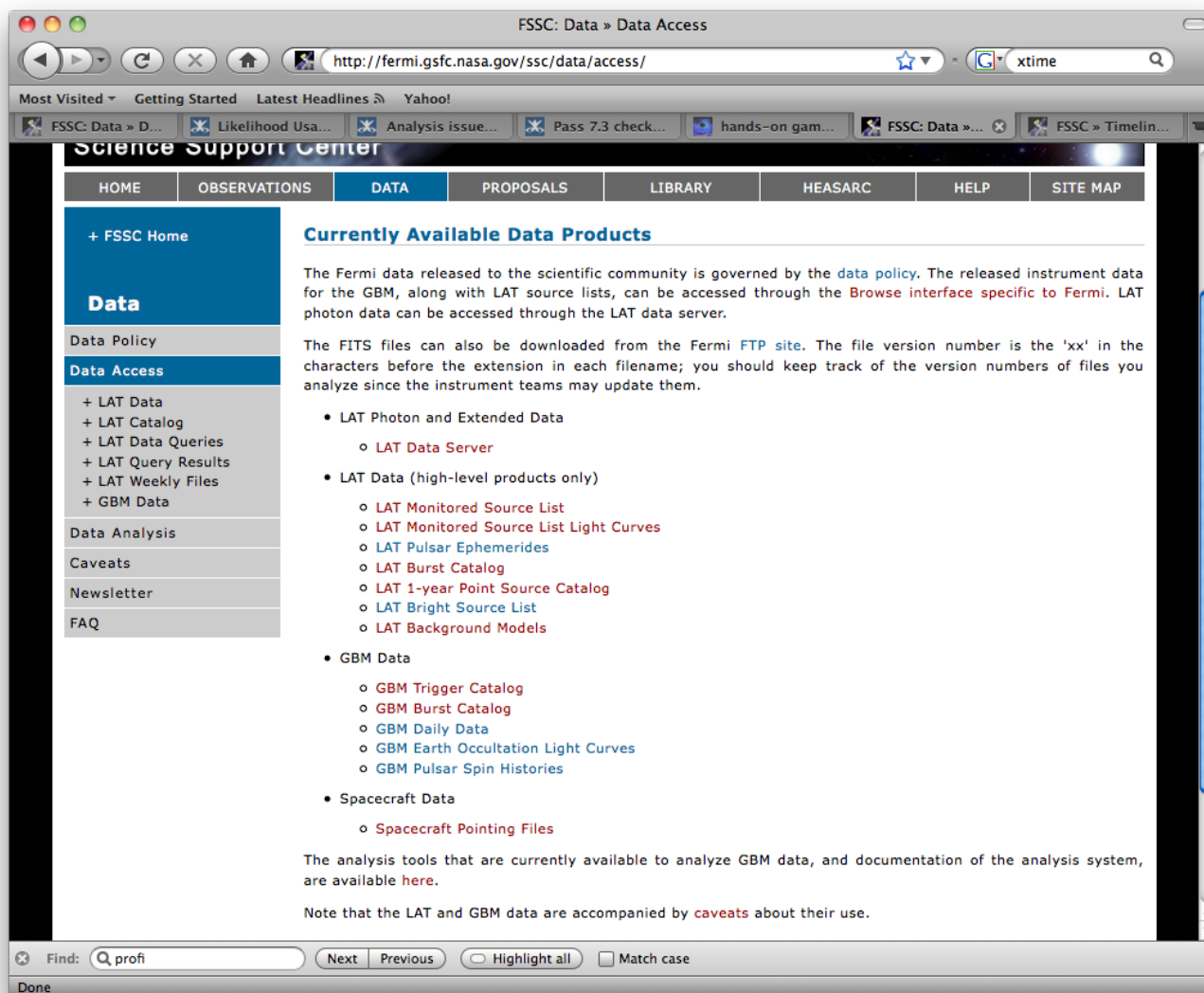
► **Download data from:**

- 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

Software/software
documentation



Additional Fermi Information

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

+ FSSC Home

Data

Data Policy

Data Access

+ LAT Data

+ LAT Catalog (**New!**)

+ GBM Data

Data Analysis

Newsletter

FAQ

Currently Available Data Products

The Fermi data released to the scientific community is governed by the [data policy](#). The released instrument data for the GBM, along with LAT source lists, can be accessed through the [Browse interface specific to Fermi](#). LAT photon data can be accessed through the LAT data server.

The FITS files can also be downloaded from the Fermi [FTP site](#). The file version number is the 'xx' in the characters before the extension in each filename; you should keep track of the version numbers of files you analyze since the instrument teams may update them.

- LAT Photon and Extended Data
 - [LAT Data Server](#)
- LAT Data (high-level products only)
 - [LAT Monitored Source List](#)
 - [LAT Monitored Source List Light Curves](#)
 - [LAT Pulsar Ephemerides](#)
 - [LAT Burst Catalog](#)
 - [LAT 1-year Point Source Catalog \(**New!**\)](#)
 - [LAT Bright Source List](#)
 - [LAT Background Models](#)
- GBM Data
 - [GBM Trigger Catalog](#)
 - [GBM Burst Catalog](#)
 - [GBM Daily Data](#)
 - [GBM Earth Occultation Light Curves](#)
 - [GBM Pulsar Spin Histories](#)
- Spacecraft Data
 - [Spacecraft Pointing Files](#)

The analysis tools that are currently available to analyze GBM data, and documentation of the analysis system, are available [here](#).

Note that the LAT and GBM data are accompanied by [caveats](#) about their use.

+ Privacy Policy and Important Notices

+ Get Plugins (Acrobat, etc.)

Curator: J.D. Myers

Responsible NASA Official: Phil Newman

Newsletters/
mailing lists

Quicklook
results from the
instrument
teams

Helpdesk

Fermi Mailing lists

- <http://fermi.gsfc.nasa.gov/ssc/resources/newsletter/>
 - fermi-news - General news about the Fermi mission
 - Gammamw - Information on multiwavelength observations relevant to fermi
 - fermi-soft - Information/updates on Fermi science data/software

LAT monitored source list

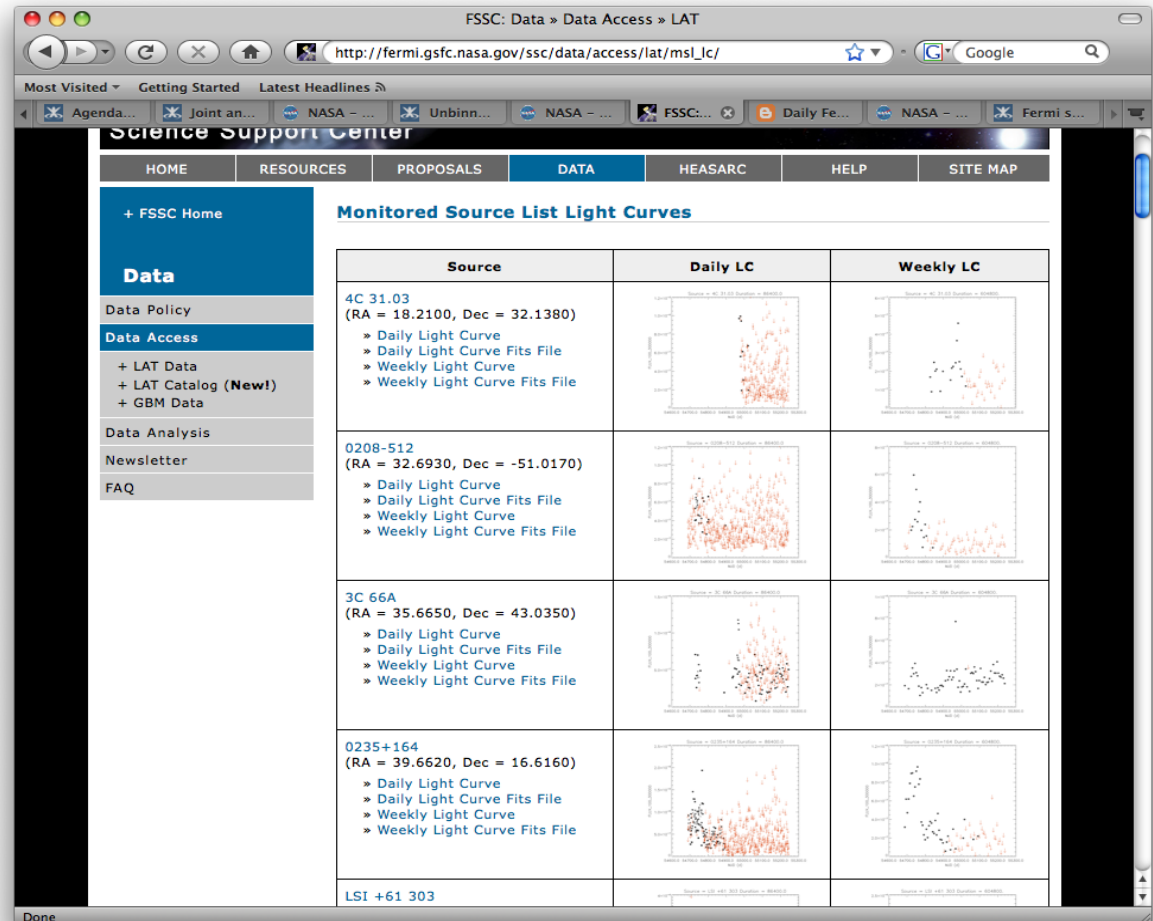
The LAT team releases flux/spectra as a function of time for all sources in a pre-defined list + flaring sources during flares.

- Modified data release after ~6months:

- Lowered flux threshold to release information on flaring sources by factor of 2.

- Provided information continuously (not just during flares).

- started with 23 sources, now have >40



FERMI GAMMA-RAY SKY

WEDNESDAY, JUNE 3, 2009

Fermi LAT Weekly Report N. 52

Covered period: 2009.May.25 - 2009.May.31

- Candidate blazar **4C31.03** (see [ATel #2054](#)) seen in day timescales with flux levels reaching $0.8e-6$ ph/cm²/s.
- **PKS 1510-089** remains in the $1e-6$ to $2e-6$ daily flux range (>100MeV)
- **PKS 1502+106** shows a steady trend with daily fluxes (>100MeV) around $1e-6$ ph/cm²/s.
- **3C 454.3** showed consistent daily flux levels (>100MeV) just below $1e-6$ ph/cm²/s.

LAT DATA

[LAT Monitored Source List Light Curves](#)

[LAT Bright Source List](#)

[Browse interface to monitored source data](#)

BLOG ARCHIVE

▼ 2009 (8)

▼ June (1)

[Fermi LAT Weekly Report N. 52](#)

► May (4)

► April (3)

CONTRIBUTORS

[Flare Advocate](#)

<http://fermisky-daily.blogspot.com/>

Daily Fermi Gamma-Ray Sky

<http://fermisky-daily.blogspot.com/>

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jmcenery@yahoo.com New Post Customize Sign Out

DAILY FERMI GAMMA-RAY SKY

THURSDAY, FEBRUARY 18, 2010

Daily report - February 17, 2010

Extragalactic Science

- * PKS 0537-441 (TS=78) at $(0.8 \pm 0.3) \times 10^{-6}$
- * Mkn 421 (TS=111 !!!) at $(0.3 \pm 0.1) \times 10^{-6}$ Note the index: 1.39 ± 0.17
- * 4C +21.35 (TS=84) at $(0.96 \pm 0.31) \times 10^{-6}$
- * 3C 454.3 (TS=242) at $(2.77 \pm 0.45) \times 10^{-6}$

Unidentified source

- * 1FGL J0623.5+3330 (TS=40), yet unassociated, at $(0.5 \pm 0.22) \times 10^{-6}$

POSTED BY JULIE AT 7:50 PM 0 COMMENTS

Daily Report - February 16, 2010

Extragalactic Science

- * Mrk421 detected with a daily flux below $0.5E-6$
- * 4C 21.35 with TS=79 and a daily flux of $(0.8 \pm 0.3)E-6$
- * J1332-0509 detected with a daily flux of $(0.9 \pm 0.3)E-6$ and TS=22
- * 3C 454.3 with a daily flux of $(3.9 \pm 0.6)E-6$

POSTED BY JULIE AT 1:43 AM 0 COMMENTS

Done

WHAT IS THIS?

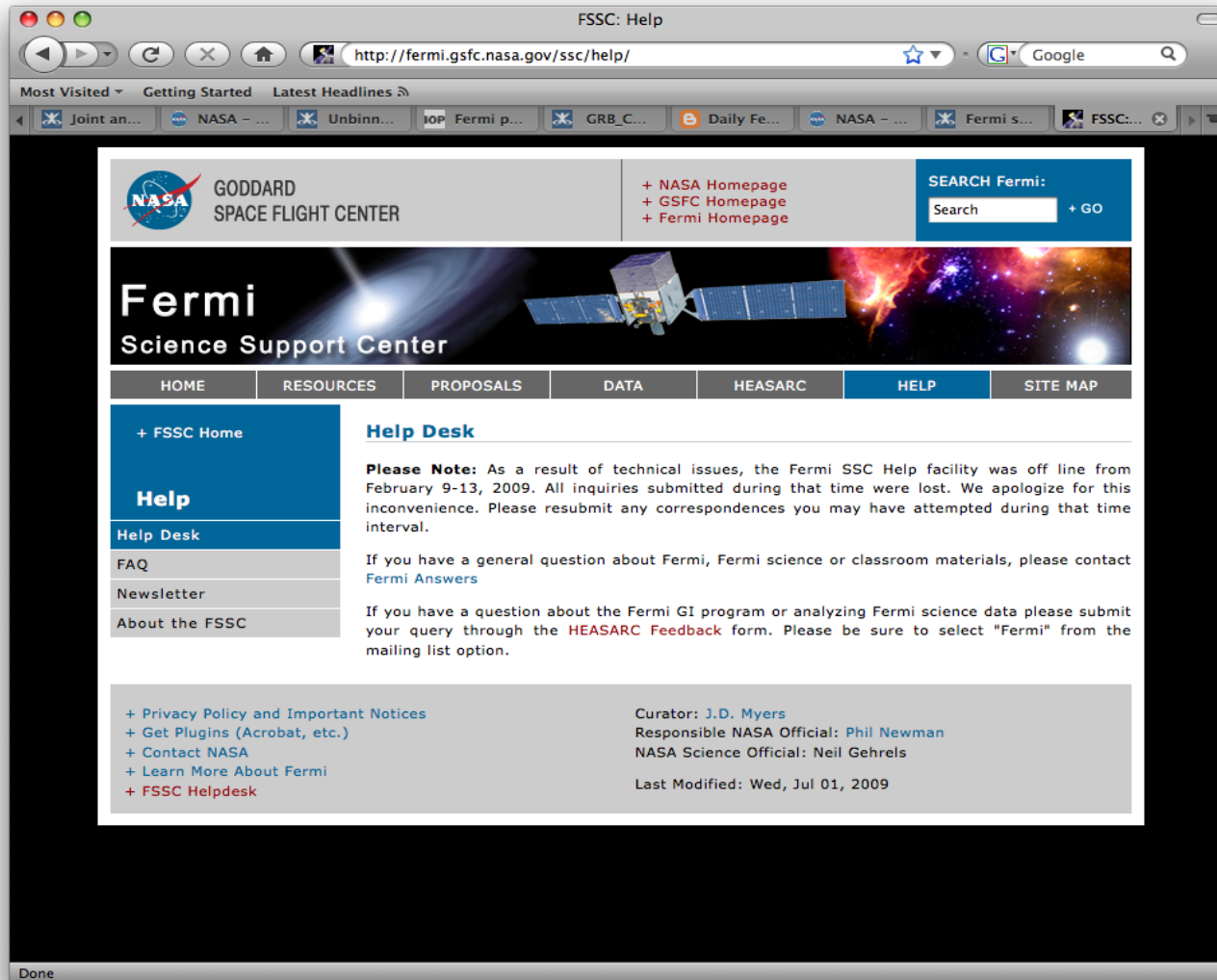
This is a copy of the daily communication from the LAT Flare Advocate (team member following up on flaring activity found in the LAT data) to the LAT team. Since this is largely a verbatim copy of an internal communication, you may notice some internal jargon - we apologize in advance for this.

The purpose of this blog is to publicly provide information about the activity in the high energy gamma-ray sky with lower latency than the main sky blog.

LAT DATA

- Main FermiSky blog
- Contact Information by Individual Sources
- Browse interface to monitored source data
- LAT First Catalog
- LAT Monitored Source List Light Curves

If you have more questions...

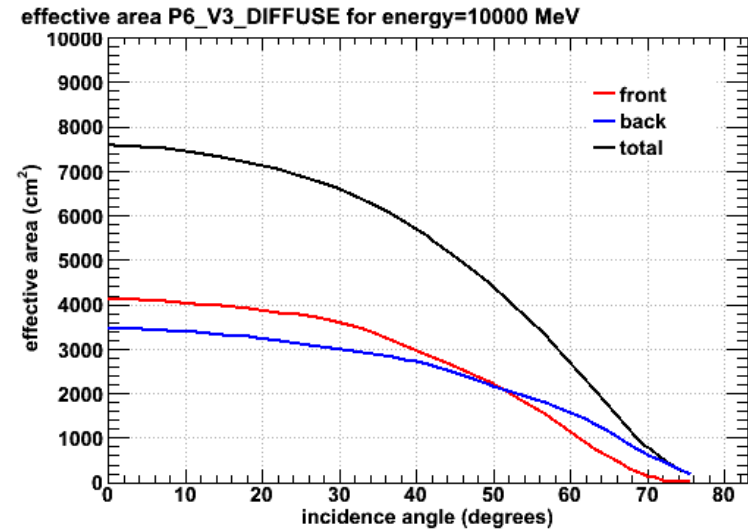
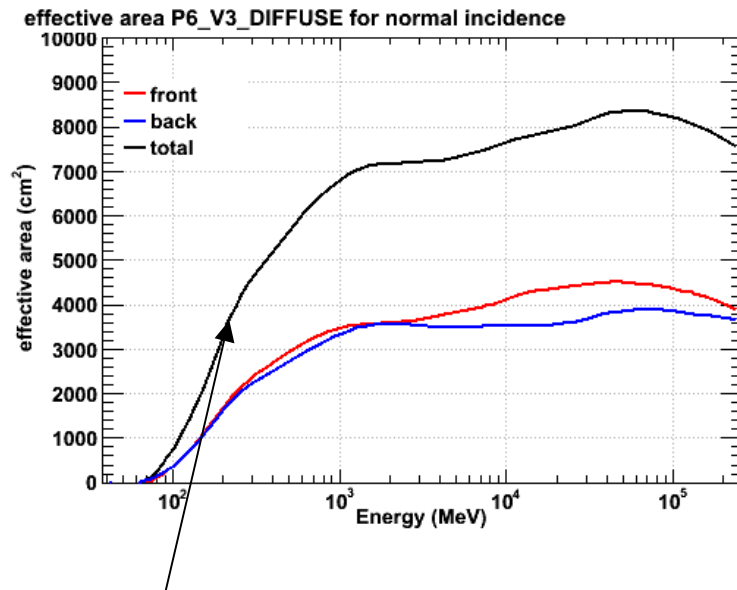


The helpdesk!

- Or send mail directly to glasthelp@milkyway.gsfc.nasa.gov

Event selection

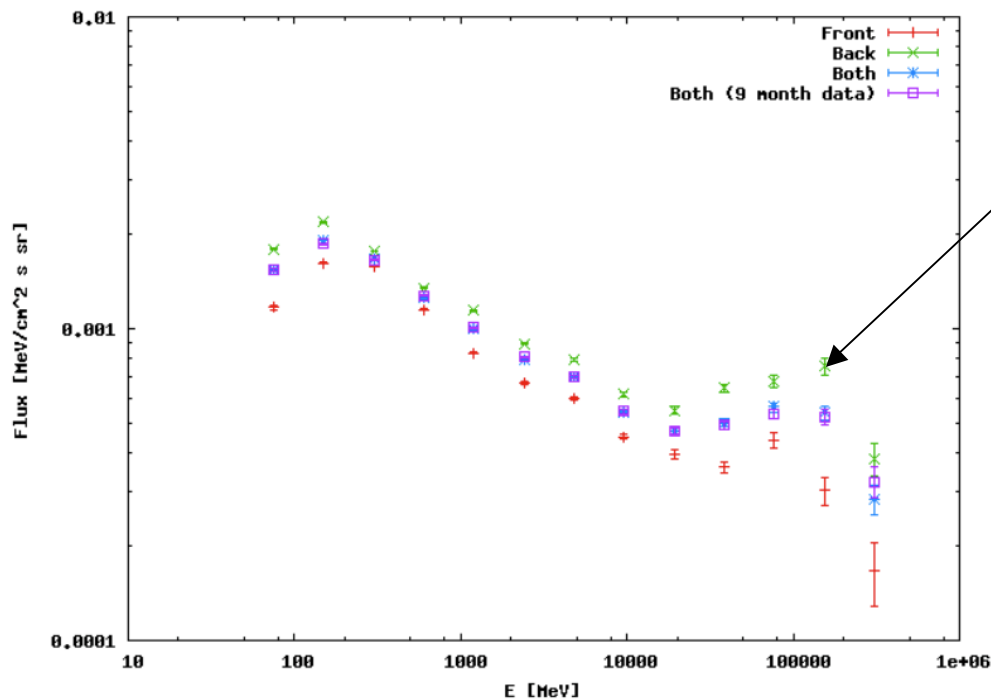
- Use Events >100 MeV for spectral analysis
 - To avoid spurious features due to rapidly changing effective area with energy and because of residual uncertainty in the instrument response.



Small uncertainty in energy scale results in relatively large systematic error in final result.

Event selection

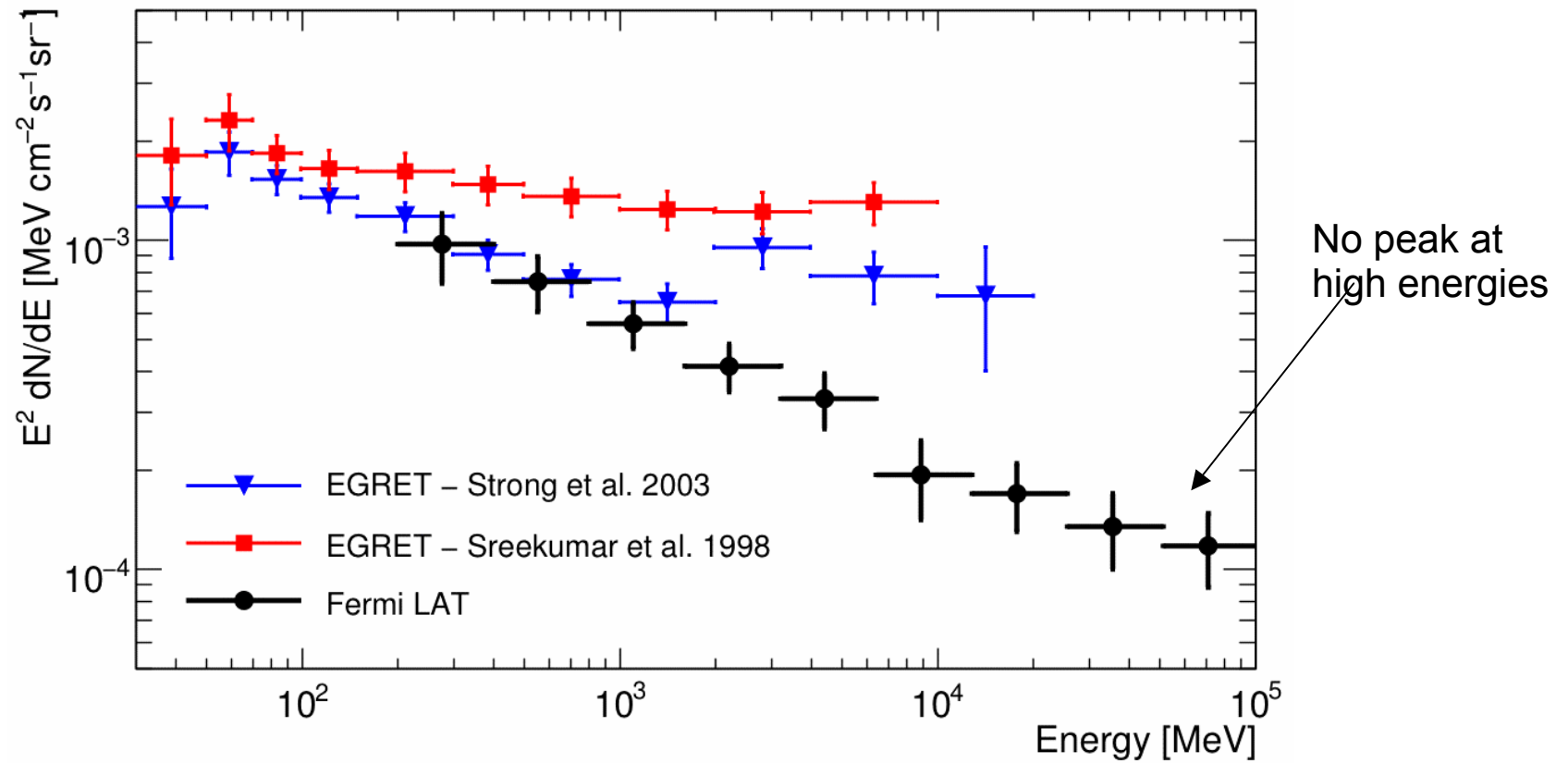
- Use "Diffuse" class for diffuse, extended, and point source analysis. (evclsmin=3, evclsmax=4). NOTE - this applies to P6 IRFs only, future recommended event selections might change.
 - Other event classes have higher charged-particle background contamination and may result in spurious spectral features.



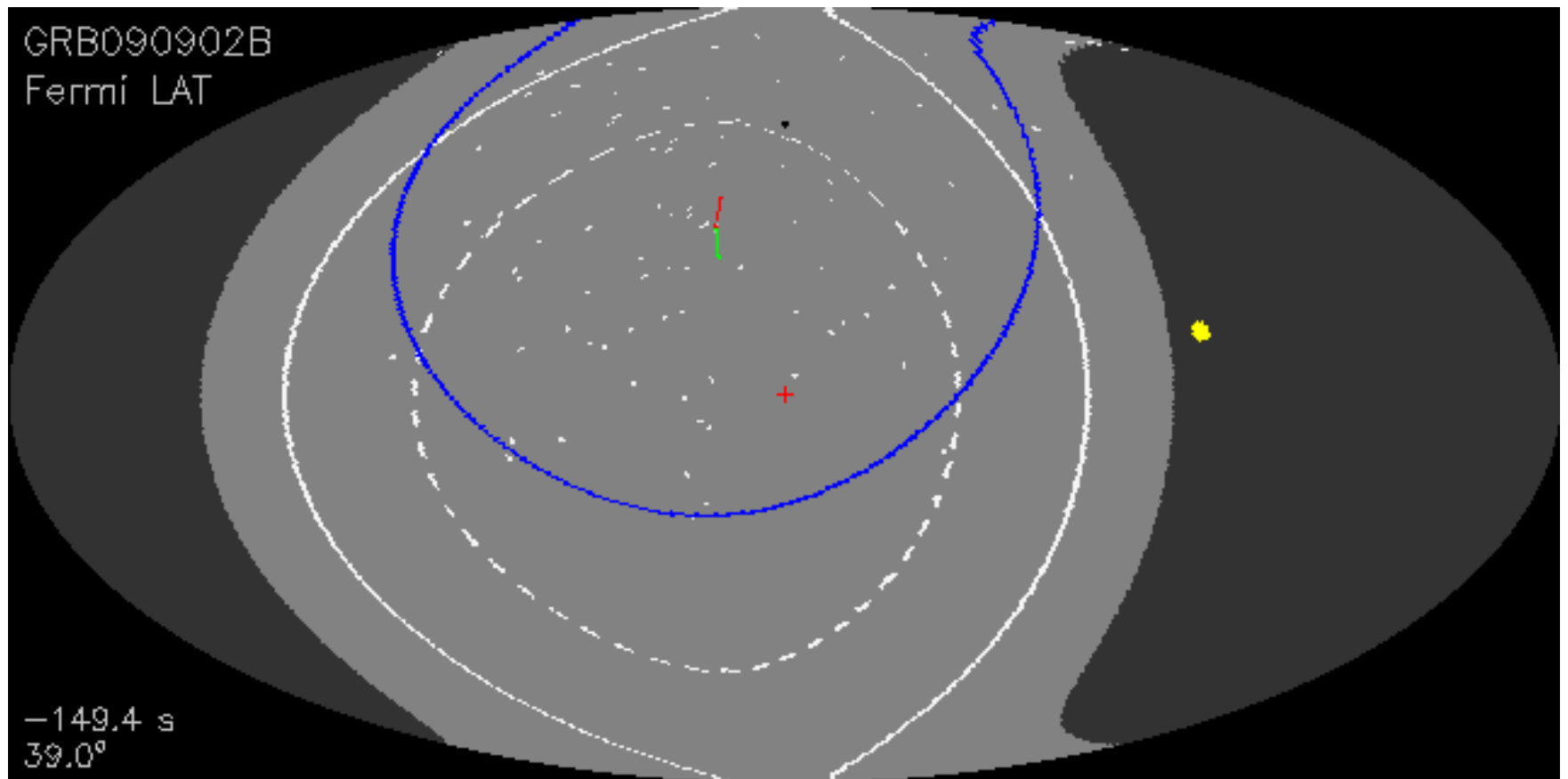
Residual cosmic-ray
(charged particle)
background.

Spectral templates are provided for the **diffuse class** event selection that allow you to account for the presence of residual cosmic-ray backgrounds in your model fits.

Isotropic gamma-ray spectrum (for comparison)



The Earth is Bright!



- Exclude all periods where the edge of your region of interest comes within 8 deg of the Earth's limb (zenith angle of 105 deg)

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 your region of interest (zenith angle of 105 degrees)**
-

Data Selection - 1

- ▶ **Event-specific cuts can be made with gtselect**
 - **Time range, energy range, position, ROI radius, zenith angle**

- ▶ **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
```

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=4)
- ▶ **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**

Making a counts lightcurve

- `gtselect evlslmin=3 evlslmax=4 infile=3c454.3_long_PH00.fits
outfile=3c454.3_long_3deg_sel.fits ra=343.490616 dec=16.148211
rad=3 tmin=278121600 tmax=286070400 emin=100 emax=300000
zmax=105`
- `gtmktime scfile=3c454.3_long_SC00.fits filter="(DATA_QUAL==1)"
roicut=yes evfile=3c454.3_long_3deg_sel.fits
outfile=3c454.3_long_3deg_mkttime.fits`

```
-----  
mcenery-2:amsterdam mcenery$ gtbin  
This is gtbin version ScienceTools-v9r15p2-fssc-20090808  
Type of output file (CCUBE|CMAP|LC|PHA1|PHA2) [LC]  
Event data file name[3c454.3_Dec2009_3deg_mkttime.fits] 3c454.3_long_3deg_mkttime.  
fits  
Output file name[lc_3c454.3_3deg.fits]  
Spacecraft data file name[NONE]  
Algorithm for defining time bins (FILE|LIN|SNR) [LIN]  
Start value for first time bin in MET[280800000] 278121600  
Stop value for last time bin in MET[282009600] 286070400  
Width of linearly uniform time bins in seconds[86400]
```

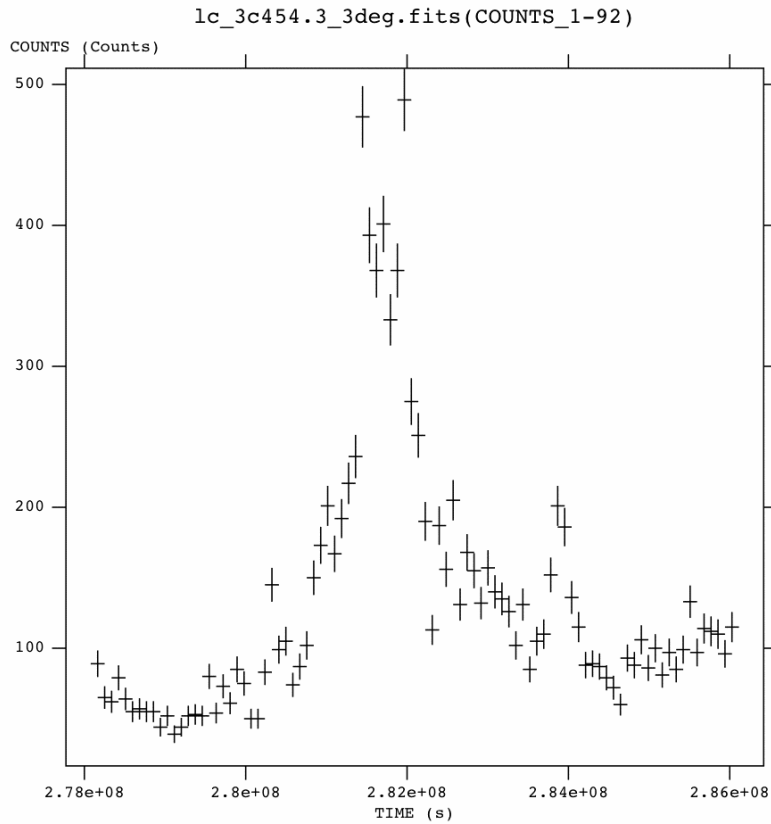
Note that the resulting lightcurve, `lc_3c454.3_long_3deg.fits`, is not background subtracted or exposure corrected!

Exposure vs time

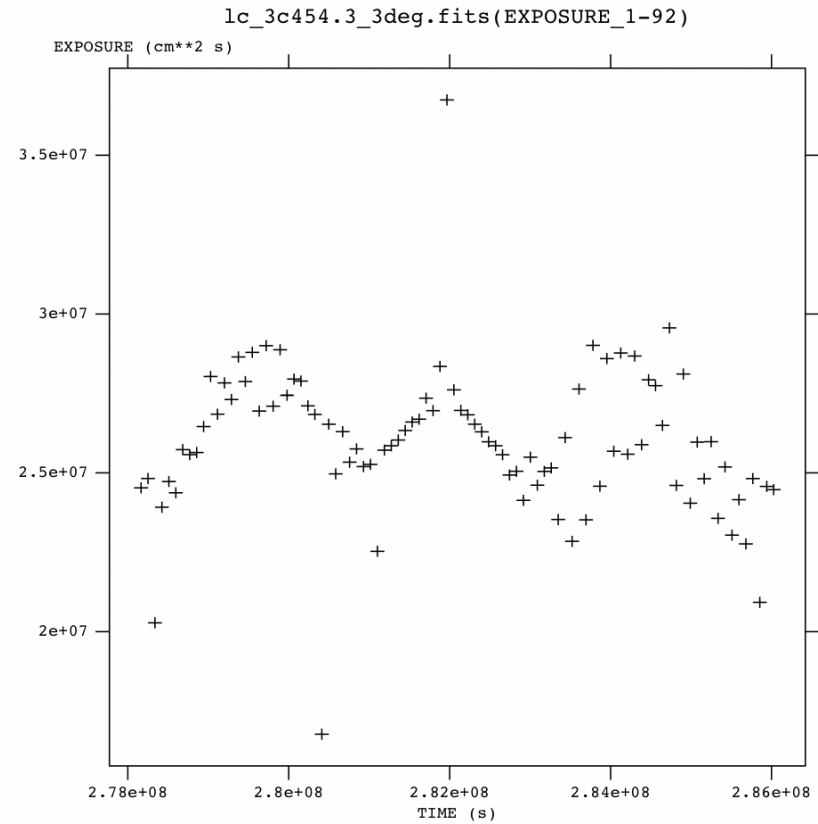
- The exposure (effective area x live time) can vary from interval to interval (because the target moves around the FoV).
- `gtexposure` adds a column to the lc file containing the exposure for each time interval.

```
mcenery-2:amsterdam mcenery$ gtexposure
Light curve file[lc_3c454.3_3deg.fits]
Spacecraft file[3c454.3_long_SC00.fits]
Response functions[P6_V3_DIFFUSE]
Source model XML file[none]
Photon index for spectral weighting[-2.1]
mcenery-2:amsterdam mcenery$ █
```

Plotting the results (using fv)



Counts vs time

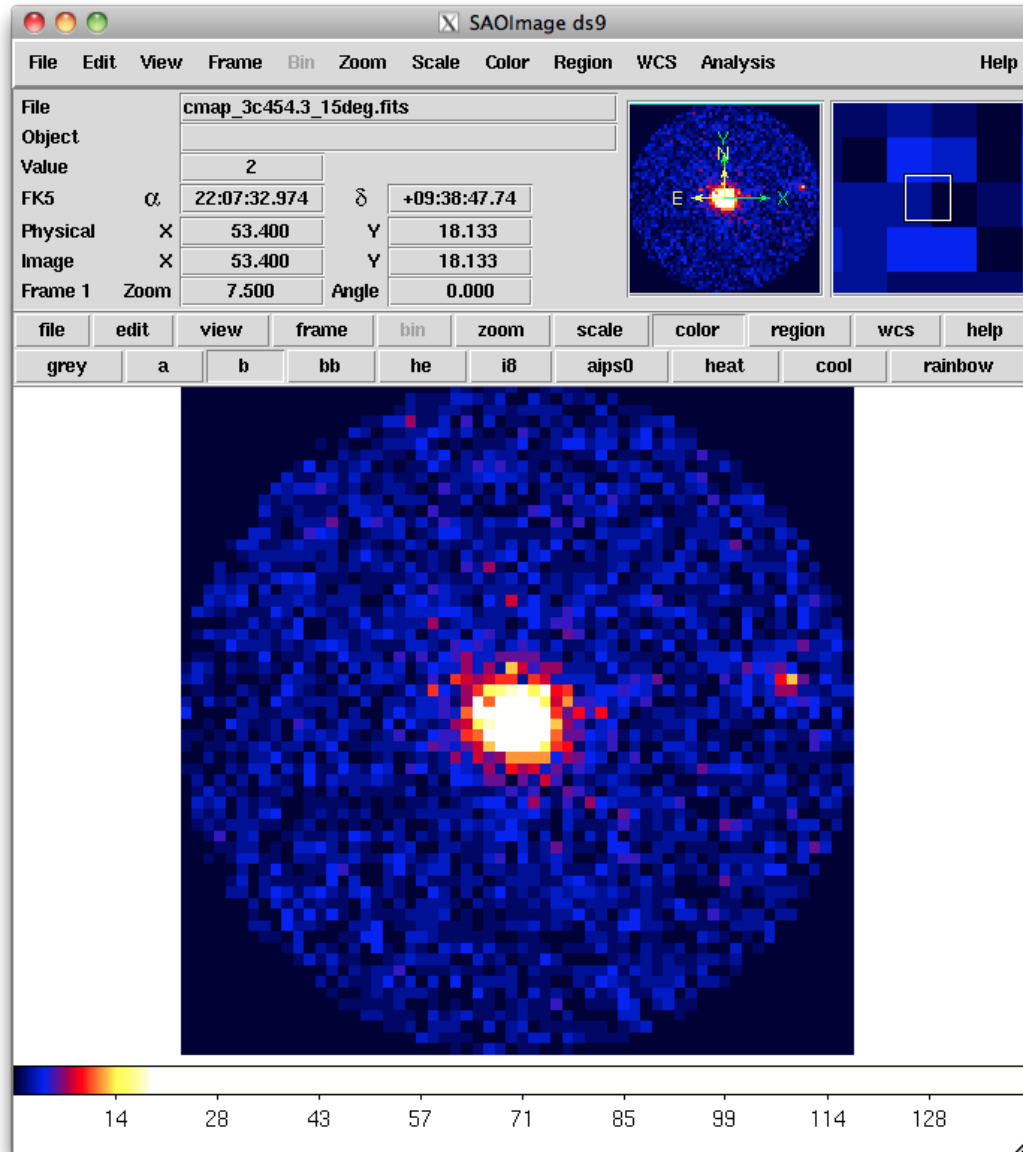


Exposure vs time, y-axis is zero suppressed the exposure is relatively constant compared with the counts variations

Counts map

- **gtselect evclsmin=3 evclsmax=4 infile=3c454.3_long_PH00.fits
outfile=3c454.3_long_15deg_sel.fits ra=343.490616 dec=16.148211
rad=15 tmin=284256002 tmax=286070400 emin=100 emax=300000
zmax=105**
- **gtmktime scfile=3c454.3_long_SC00.fits filter="(DATA_QUAL==1)"
roicut=yes evfile=3c454.3_long_15deg_sel.fits
outfile=3c454.3_long_15deg_mkttime.fits**
- **gtbin algorithm=cmap evfile=3c454.3_long_15deg_mkttime.fits
outfile=cmap_3c454.3_15deg.fits scfile=3c454.3_long_SC00.fits
nxpix=60 nypix=60 binsz=0.5 coordsys=cel xref=0 yref=0 axisrot=0
proj=ait**

View region with ds9



`>ds9 cmap_3c454.3_15deg.fits`

All-sky exposure map

- To get a sense of the nature of an observation, it can be useful to make (and look at) an all-sky exposure map.

Start by making a livetime cube (this creates a histogram of the livetime vs inclination angle for each bin on the sky)

```
mcenery-2:amsterdam mcenery$ gtltcube
Event data file[3c454.3_Dec2009_mktime.fits] 3c454.3_long_15deg_mktime.fits
Spacecraft data file[3c454.3_Dec2009_SC00.fits] 3c454.3_long_SC00.fits
Output file[3c454.3_Dec2009_expCube.fits] 3c454.3_long_expCube.fits
Step size in cos(theta) (0.:1.) [0.025]
Pixel size (degrees)[1]
Working on file 3c454.3_long_SC00.fits
.....!
mcenery-2:amsterdam mcenery$ █
```

Making the exposure map

The livetime cube is convolved with the instrument response functions to obtain an exposure map

```
mcenery-2:amsterdam mcenery$ gtexpcube
```

This is gtexpcube version N/A

Exposure cube input file name[3c454.3_long_expCube.fits]

FT1 events input file name[3c454.3_long_15deg_mktime.fits]

Count map input file name (NONE for manual input of map geometry)[NONE]

Exposure map output file name[expmap.fits]

Response function to use. Run gtirfs for a list[P6_V3_DIFFUSE]

Size of the X axis in pixels (leave at 1 for auto full sky (1:) [1]

Size of the Y axis in pixels (leave at 1 to copy nxpix or auto full sky) (1:) [1]

Image scale (in degrees/pixel)[1]

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

First coordinate of image center in degrees (RA or galactic l)[0]

Second coordinate of image center in degrees (DEC or galactic b)[0]

Rotation angle of image axis, in degrees[0]

Projection method (AIT|ARC|CAR|ZEA|GLS|MER|NCP|SIN|STG|TAN) [AIT]

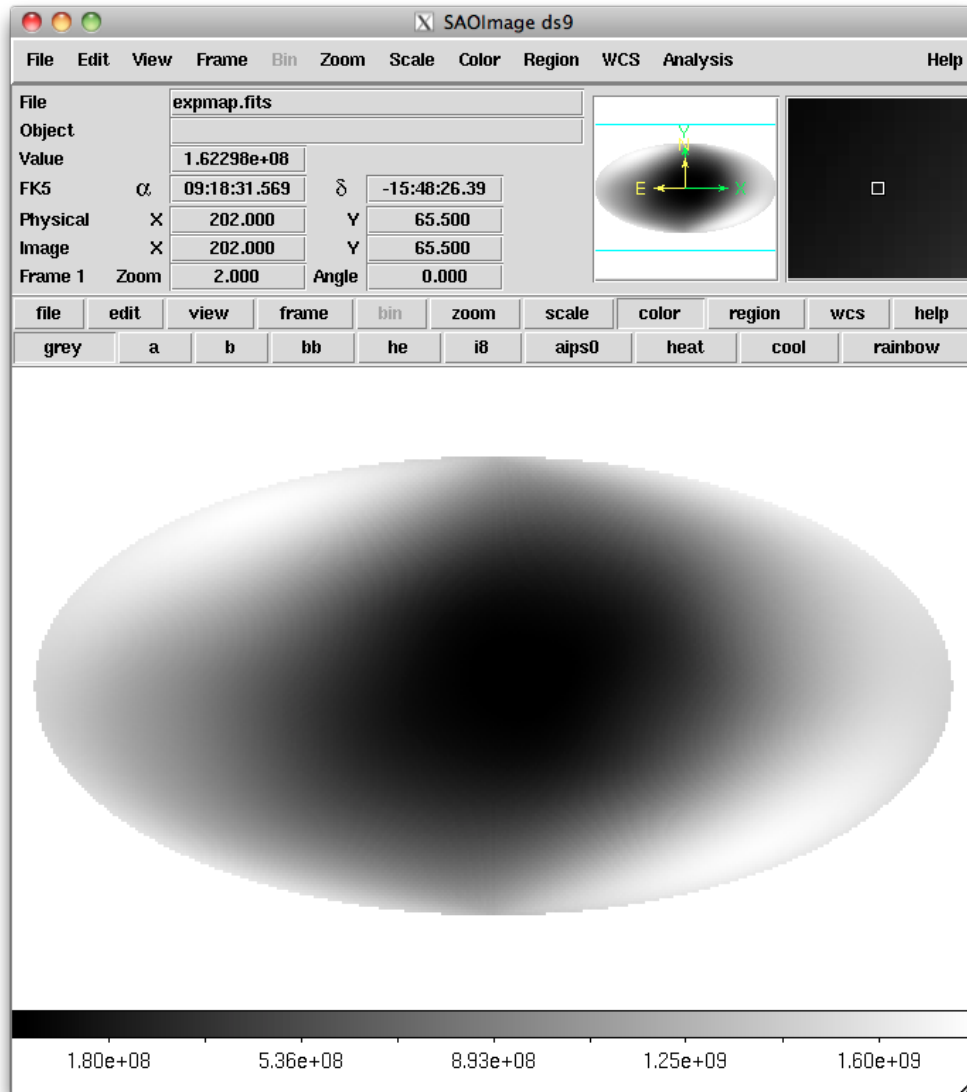
Start value for first energy bin[100] 1000

Stop value for last energy bin[10000] 1000

Number of logarithmically uniform energy bins[4] 1

How are energy layers computed from count map ebounds? (CENTER|EDGE) [CENTER]

All-sky exposure map



ds9 expmap.fits

Try making an all-sky map with the April 3c454 dataset (this contains a pointed mode observation)

Building a source model (1) - ModelEditor

Add
GALPROP
source

Add
extragalactic
source (use
filefunction
spectral type
with
isotropic_iem_
v02.txt)

The screenshot shows the ModelEditor window with the following configuration:

- Title: Source Library
- Source Name: 3c454
- Source Type: PointSource
- Spectrum Type: PowerLaw2
- File: (empty)
- Table 1 (Spectrum Parameters):

name	value	scale	min	max	free
Integral	1.0	1e-06	1e-05	1000.0	<input checked="" type="checkbox"/>
Index	-2.0	1.0	-5.0	-1.0	<input checked="" type="checkbox"/>
LowerLimit	100	1.0	20.0	200000.0	<input checked="" type="checkbox"/>
UpperLimit	200000.0	1.0	20.0	200000.0	<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>

- Spatial Model Type: SkyDirFunction
- File: (empty)
- Table 2 (Spatial Model Parameters):

name	value	scale	min	max	free
RA	343.491	1.0	0.0	360.0	<input type="checkbox"/>
DEC	16.1482	1.0	-90.0	90.0	<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>
					<input type="checkbox"/>

mcenery-2:amsterdam mcenery\$ gtxpmap
The exposure maps generated by this tool are meant
to be used for *unbinned* likelihood analysis only.
Do not use them for binned analyses.
Event data file[3c454.3_long_15deg_mktime.fits]
Spacecraft data file[3c454.3_long_SC00.fits]
Exposure hypercube file[3c454.3_long_expCube.fits]
output file name[3c454.3_long_expMap.fits]
Response functions[P6_V3_DIFFUSE]
Radius of the source region (in degrees)[30]
Number of longitude points (2:1000) [120]
Number of latitude points (2:1000) [120]
Number of energies (2:100) [20]
Computing the ExposureMap using 3c454.3_long_expCube.fits
.....!