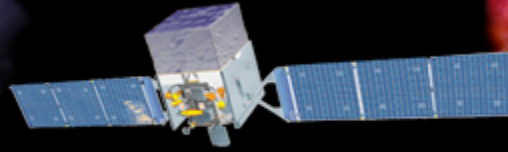# FSSC Science Tools

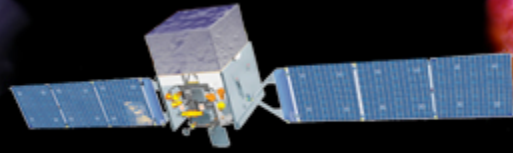## Data Selection and Exploration

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/)*
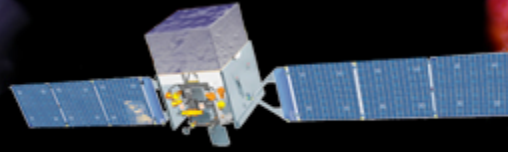
Science Tools: Documentation

► *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)*

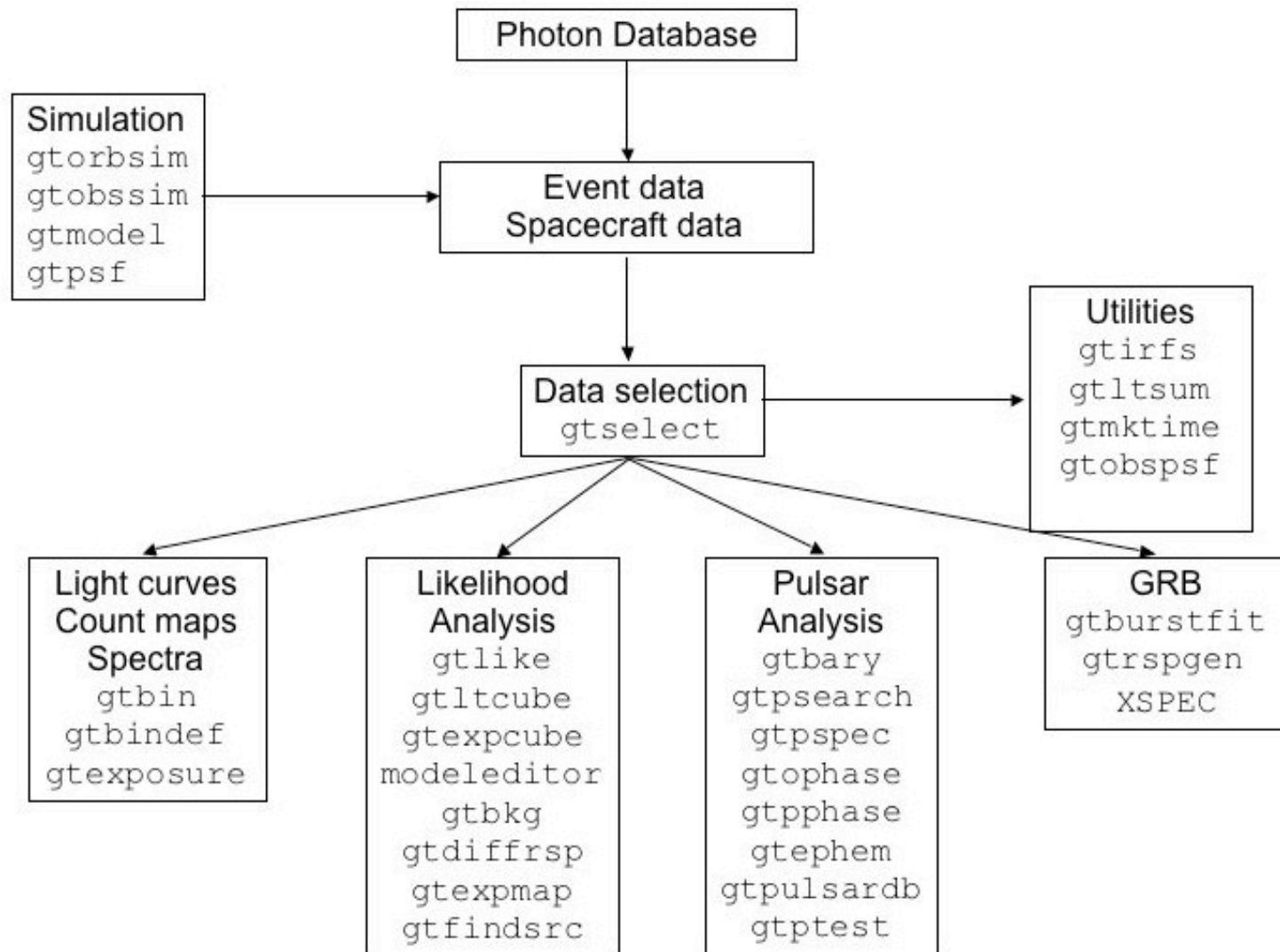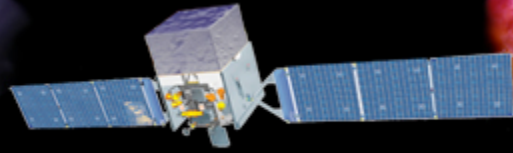# Science Tools: Structure

- *"Atomic" executables*
  - *Allows for divergent analysis without task repetition*
  - *Scriptable into more complex analysis chains*

- *Familiar file types*
  - *FITS data i/o*
  - *IRAF style param files*
  - *XML source models*
  - *Text-based supporting files*

- *Familiar toolsets*
  - *FV, DS9, XSPEC*
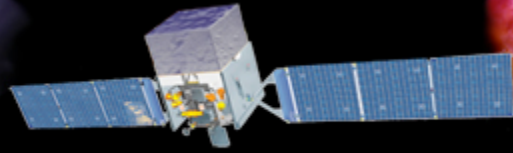
Science Tools: Flowchart

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"
```
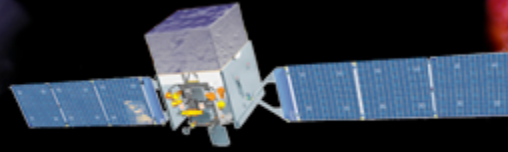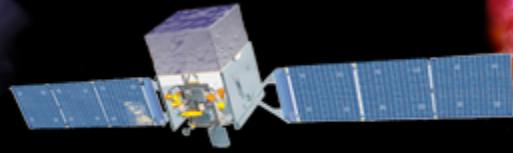
Science Tools: Execution

▶ *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...*
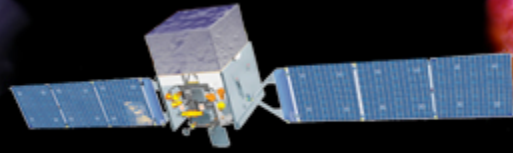
Data Access: File types

► *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/*
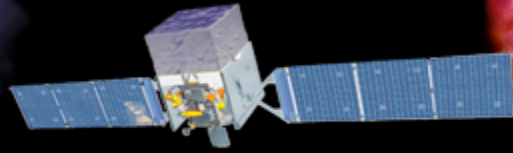
Preparing your data

- *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)*
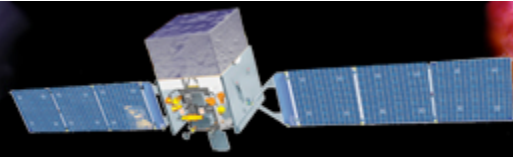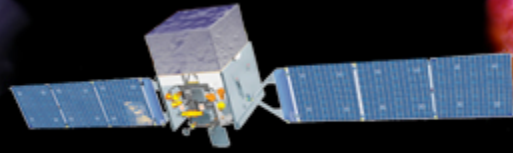
Event selection

- *Use "Diffuse" class for diffuse, extended, and point source analysis. (evclsmin=3, evclsmax=3)*
  - *Other event classes have higher charged-particle background contamination and may result in spurious spectral features.*

- *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.*
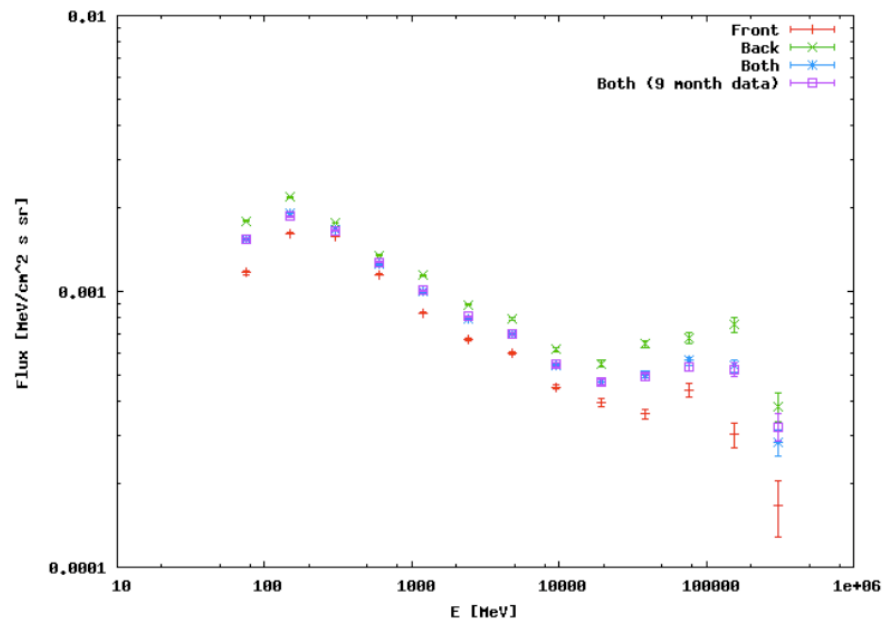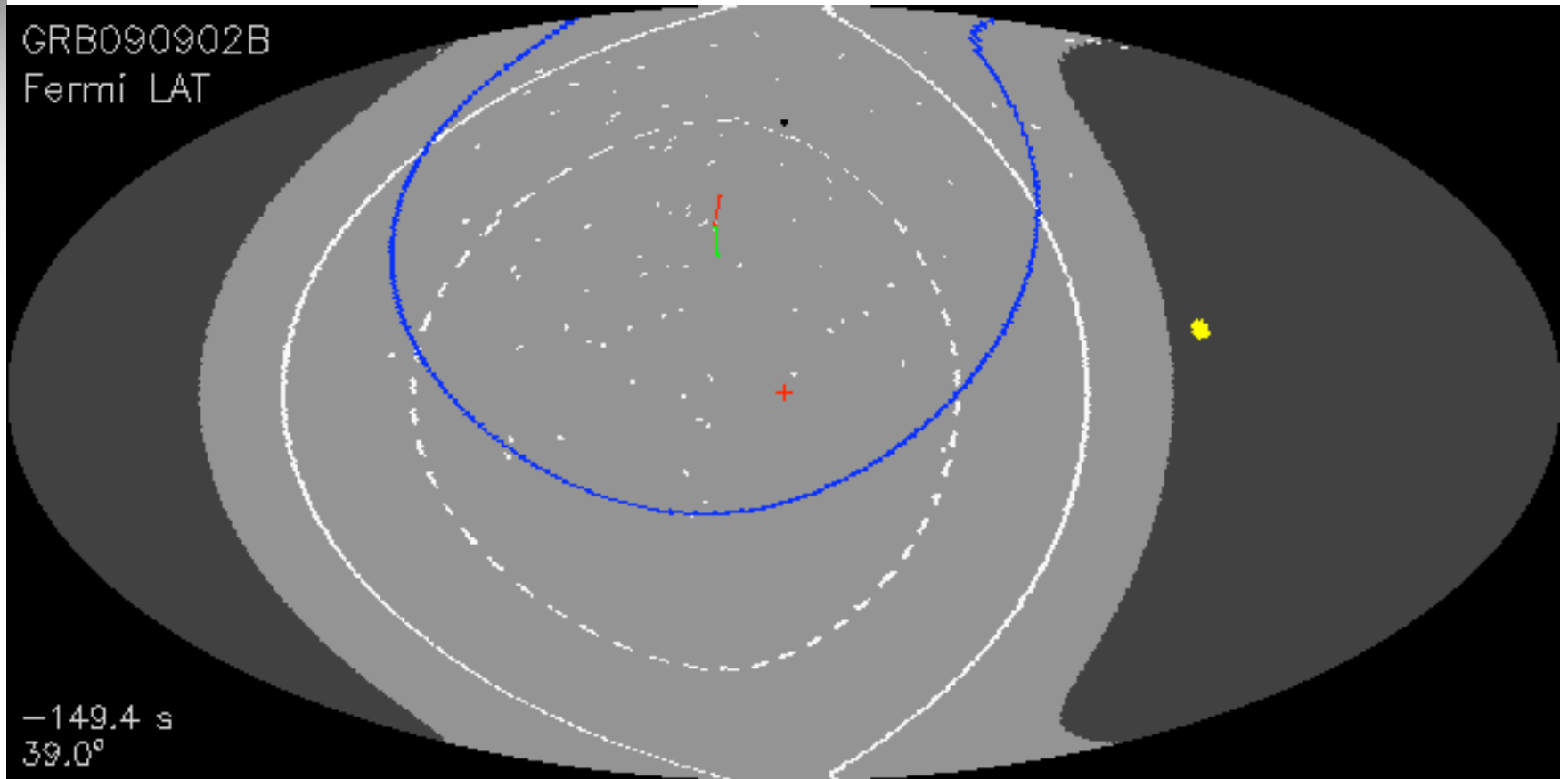

Spectral templates are provided for the **diffuse class** event selection that allow you to account for the presence of residual cosmic-ray backgrounds in your model fits.
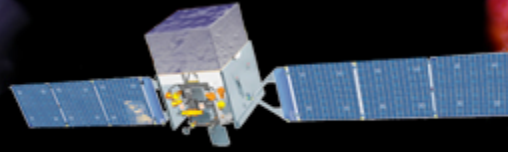
The Earth is Bright!

GRB090902B
Fermi LAT

−149.4 s
39.0°

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

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.
```
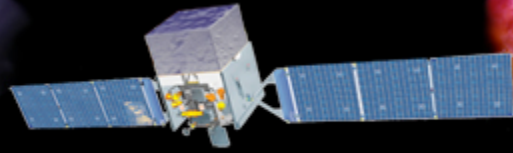
Keyword values should correspond EXACTLY to values in header (if they exist)
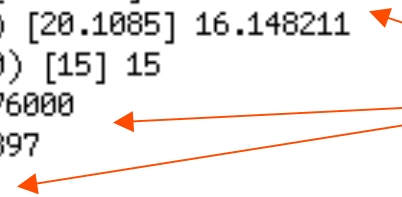
▶ *Temporal cuts using spacecraft file keywords are made with **gtmktime***

– *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=3)*

► *The current set of cuts can be reviewed using **gtvcut***
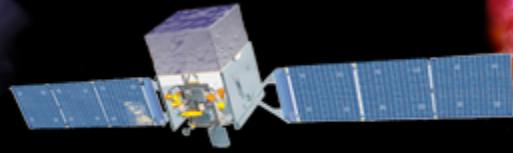
► *Recommended cuts are documented at:*

http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone/Cicerone_Data_Exploration/Data_preparation.html
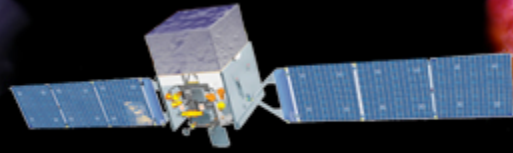
Binning for Visualization - 1

▶ *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*

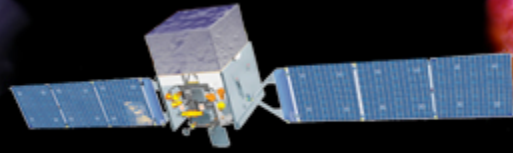 – *Requires Likelihood analysis for valid results*

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 radius × image scale
= size of each axis

Keyword values should
correspond EXACTLY to
values in header

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
```

Keyword values should correspond EXACTLY to values in header

Caution! Final bin may not be valid if full duration is not included
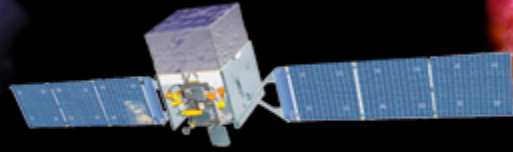
Binning for Visualization - 4

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

3c454_ecut_gti_lightcurve.fits(COUNTS_1-40)