Retrieving, Filtering and Previewing Data

Tom Stephens

GSSC Database Programmer

Outline

- ***Getting Data from the GSSC Data Server***
  - *Photon Data*
  - *Other files*
- ***Looking at the Photon Data***
  - *ds9*
  - *fv*
  - *gtbin*
- ***Making Cuts on the Data with* gtselect**
- ***Good Time Intervals***
- ***Looking at the Exposure History***

Getting Data from the GSSC

A quick review from my talk yesterday:

- ***The main web portal can be found at***

  http://glast.gsfc.nasa.gov/ssc/dev/databases/DC2

- ***GSSC is providing***
  - *Photon Data*
  - *Pointing and Livetime history Data*
  - *GBM data for the bursts*
  - *Livetime cubes*
  - *Pulsar Ephemeris*
  - *The Source Catalog*
  - *The Galactic Diffuse Emission Model*

Getting Photon Data

http://glast.gsfc.nasa.gov/cgi-bin/ssc/LAT/DC2DataQuery.cgi

- ***Selections can be made on Position, Time and Energy.***
- ***You will get back all event classes***
- ***The valid time ranges are***

	Start Time	End Time
Gregorian Dates	01-01-2008 00:00:01	25-02-2008 00:00:01
Mission Elapsed Time	220838401	225590401

- ***If you want to do object name lookup be sure to select "Object (SIMBAD Resolver)" in the coordinate system box.***
- ***Time only searches will return more data than you ask for at the beginning and end of the query times selected.***

Getting Photons (Some Examples)

- ***Example 1 – Galactic anti-center region 20° radius centered on the crab pulsar – full data set (all time and energy)***
  - *Object Name or Coordinate => crab pulsar*
  - *Coordinate System => Object (SIMBAD Resolver)*
  - *Area to Search => 20 Circle*
  - *Click "Start Search"*
- ***Example 2 – LAT Data for GRB080105885 – 2 hours on either side of burst time.***
  - *Object Name or Coordinate => 322.077, 9.55261 (from Burst page)*
  - *Coordinate System => J2000*
  - *Area to Search => 15 Circle*
  - *Observation Dates => 5-1-08 19:15:39, 5-1-08 23:15:39 Gregorian*
  - *Click "Start Search"*

Questions So Far?

- ***It's been up for a few days.***
- ***Queries have been made***
- ***Any specific questions?***

Other Data at the GSSC

- ***Pulsar Ephemeris, Source Catalog, FT2 file and Galactic Diffuse Emission Model are each single FITS files that can be downloaded from the main data access page***
- ***Livetime cubes – Link on main page takes you to a download page for these files***
  - *Download the entire set or individual files*
  - *Each file covers one day (midnight to midnight) of the simulation*
  - *More on how to use these later in the talk*
- ***Burst Data – Link on main page takes you to a page with information about the bursts***
  - *Name, date and time, duration*
  - *Position and position error*
  - *Intensity*
  - *Link to download GBM Burst data*

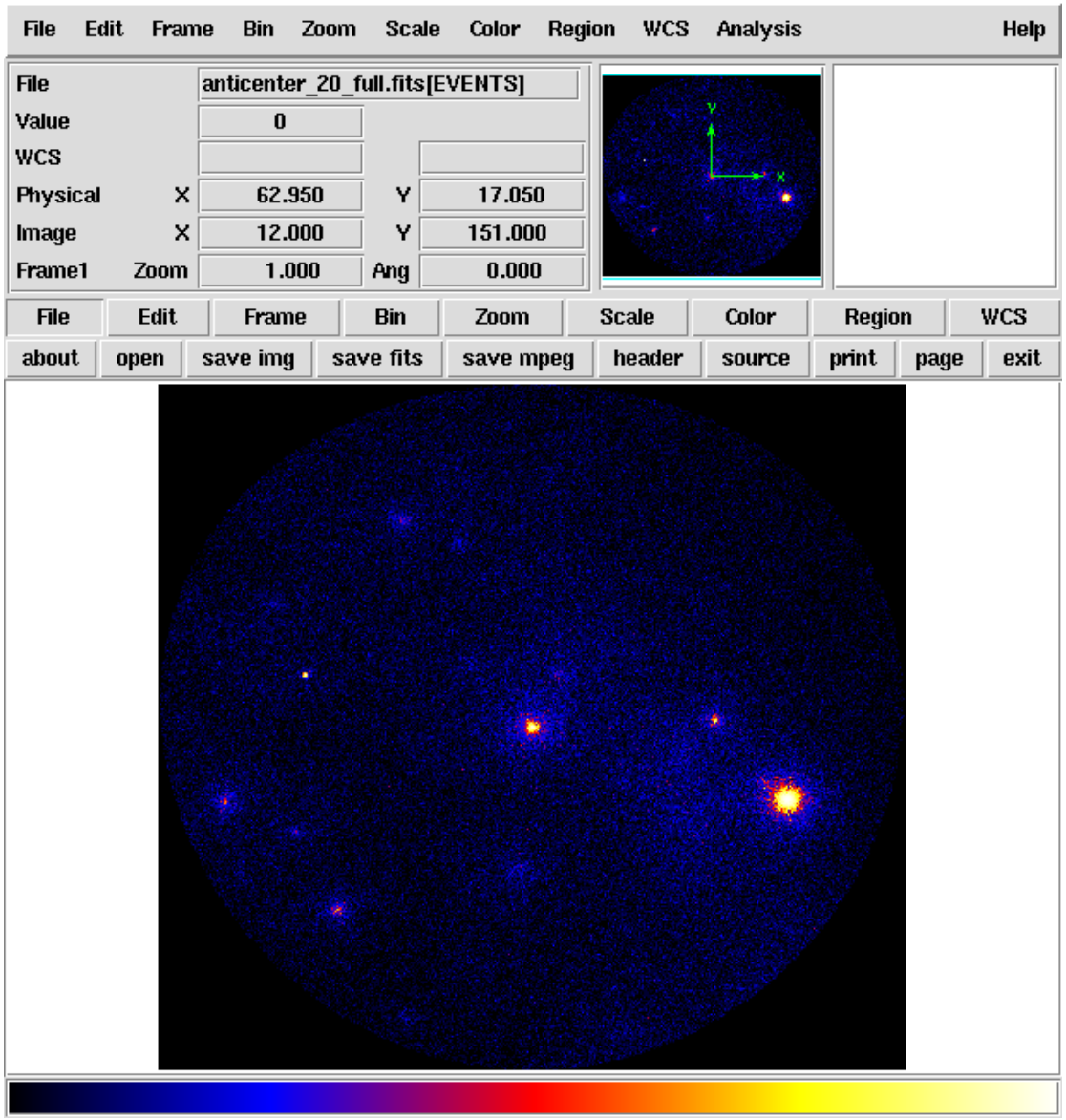
FITS File Viewers

- ***ds9***
  - *Third generation SAO Image FITS image viewer*
  - *Download and install from http://hea-www.harvard.edu/RD/ds9*
  - *Used for viewing images*
- ***fv***
  - *FITS file viewer that is part of the NASA HEASARC ftools package*
  - *Download and install from http://heasarc.gsfc.nasa.gov/docs/software/ftools/fv*
  - *Generic FITS file viewer*
    - *images, tables*
    - *Can make plots and histograms*
- ***Other FITS file viewers and converters can be found at http://fits.gsfc.nasa.gov/fits_viewer.html***

Quick-view with ds9

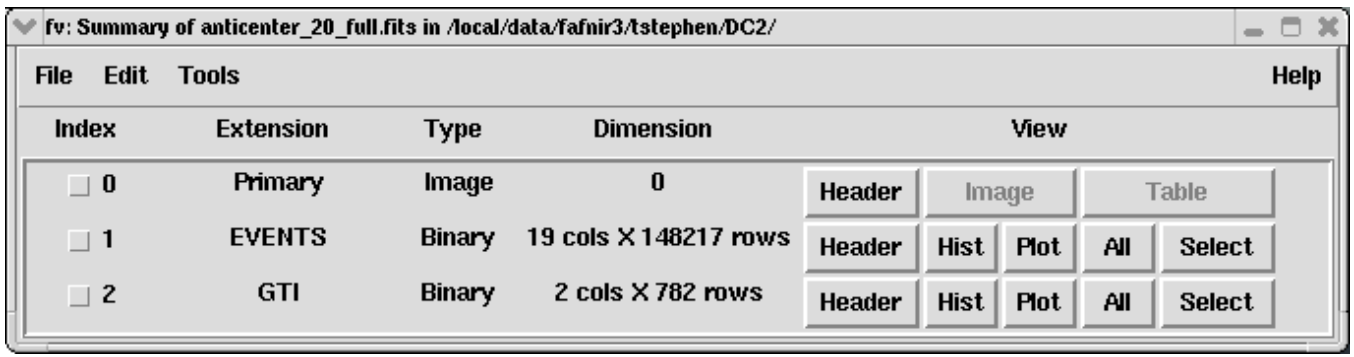
- ***So you've got some data and want to look at it.***
- ***Try this:***
  - *ds9 –bin factor 0.5 0.5 –cmap b –scale histequ "<filename>[bin=RA,DEC]"*
    - *-bin factor 0.5 0.5 sets 0.5 degree bins on RA and Dec*
    - *-cmap b selects the color map named b (my preference)*
    - *-scale histequ select the histogram equalized scale for the color map (-scale sqrt is also a good one)*
  - *Can eliminate need for [bin=RA,DEC] if you set the environment variable DS9_BINKEY equal to [bin=RA,DEC]*
- ***Doing this with the data selection on the anti-center region gives***

Anti-center Quick-view Image



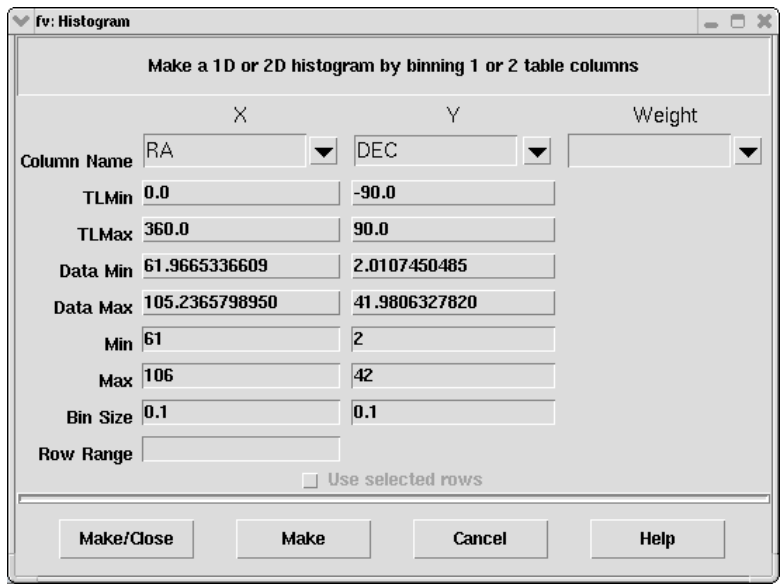
Exploring with fv

- ***fv gives a little more interactive control and allows you to look at the data in different ways.***
- ***Start it up by typing: fv <filename> and you get two windows:***
  - *At right: main fv menu window*
  - *Below: Main file option window*
    - *One line per extension in the file*
    - *Buttons to look at the extension header, the table data or make plots and histograms*

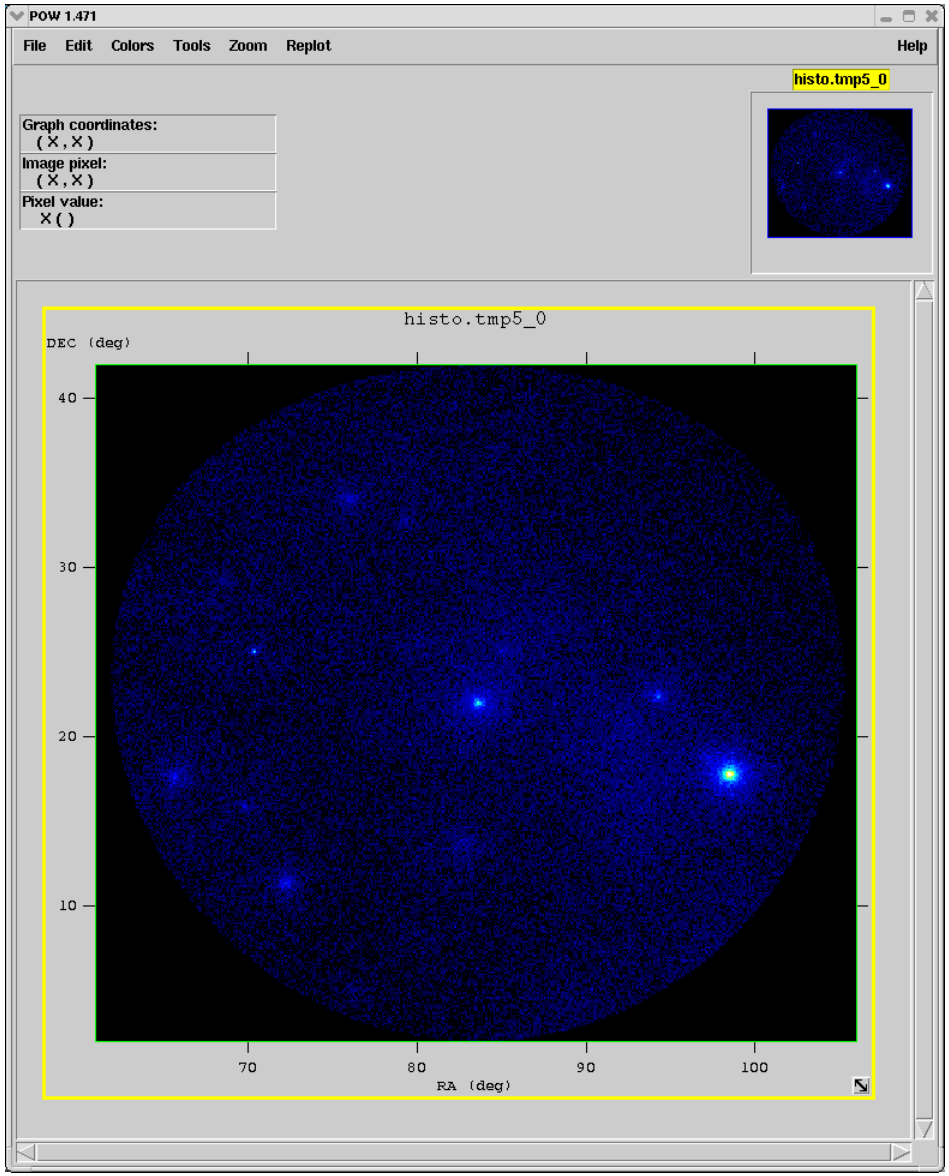


Making a Map with fv

- ***Click on the "hist" button***
- ***You get the window at top right***
- ***Select RA in the X column***
- ***Select Dec in the Y column***
- ***Set the Min, Max and bin size for each column (image at bottom right)***
- ***You can use a column (such as Energy) as a weight if you desire***
- ***Click on the "Make" button to generate the map.***

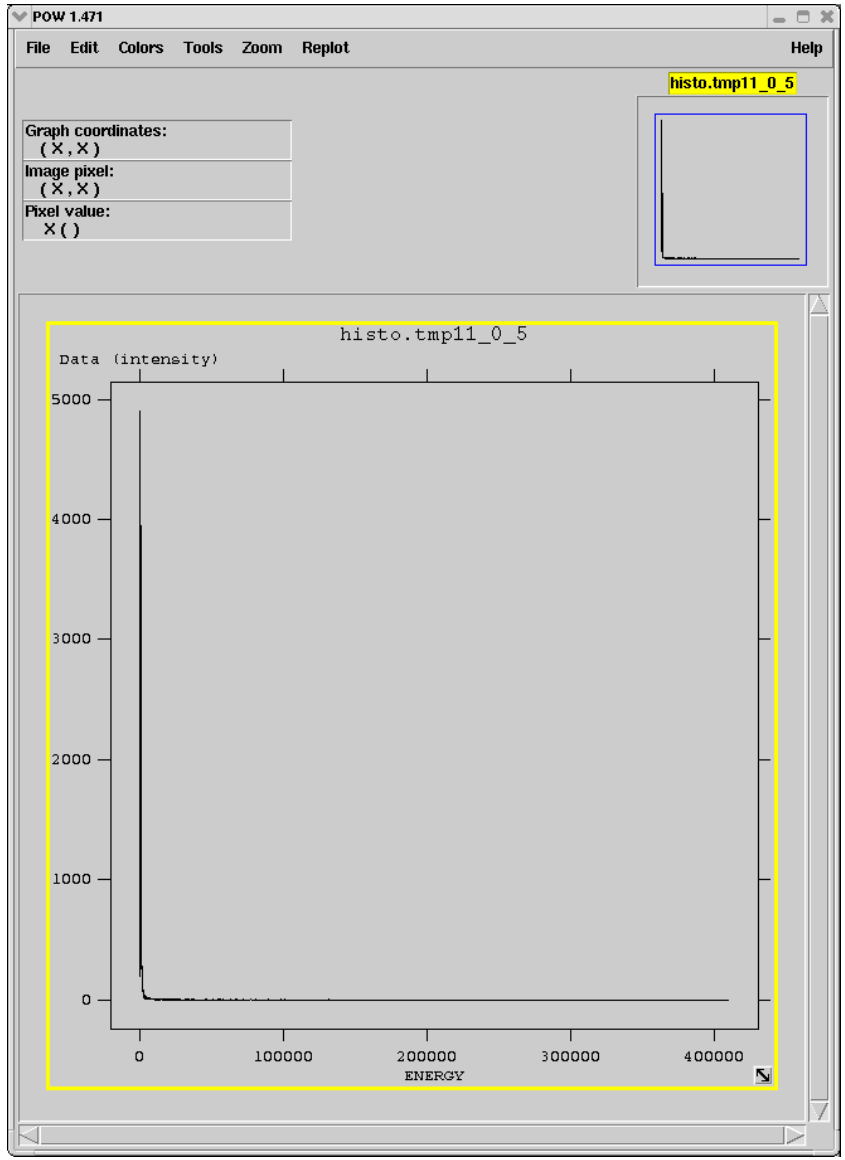


fv Generated Map



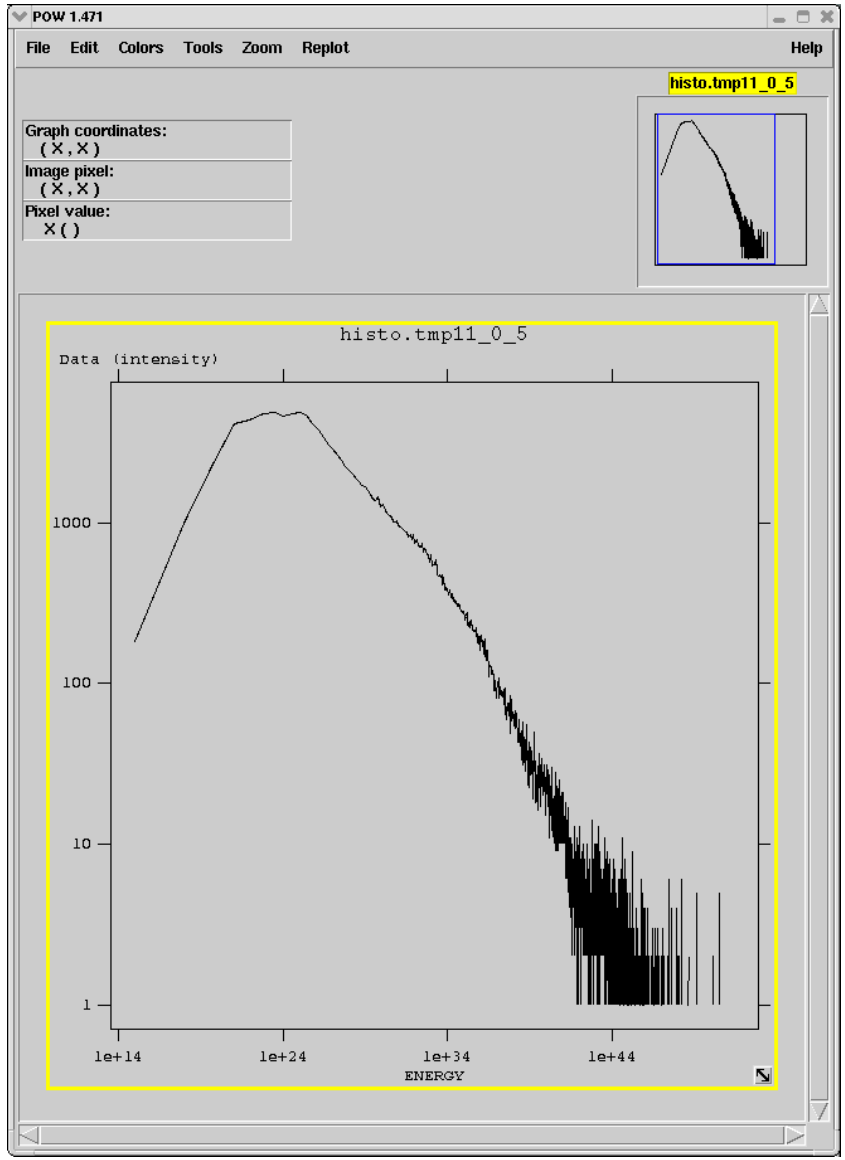
Making a Histogram with FV

- ***You already know how as we used the interface to make a map.***
- ***This time just fill in the X column and leave the Y column blank.***
- ***If we use the Energy column for the anti-center region we get the image at right***
- ***Not very interesting on a linear scale so select Edit->Axes Transform->Log-Log to get***



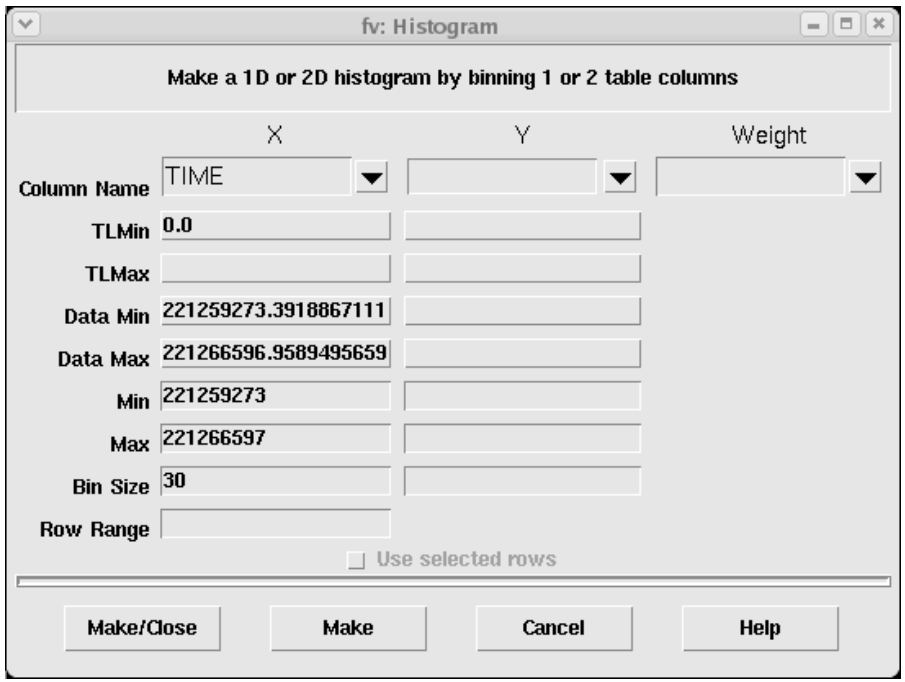
Making a Histogram with FV

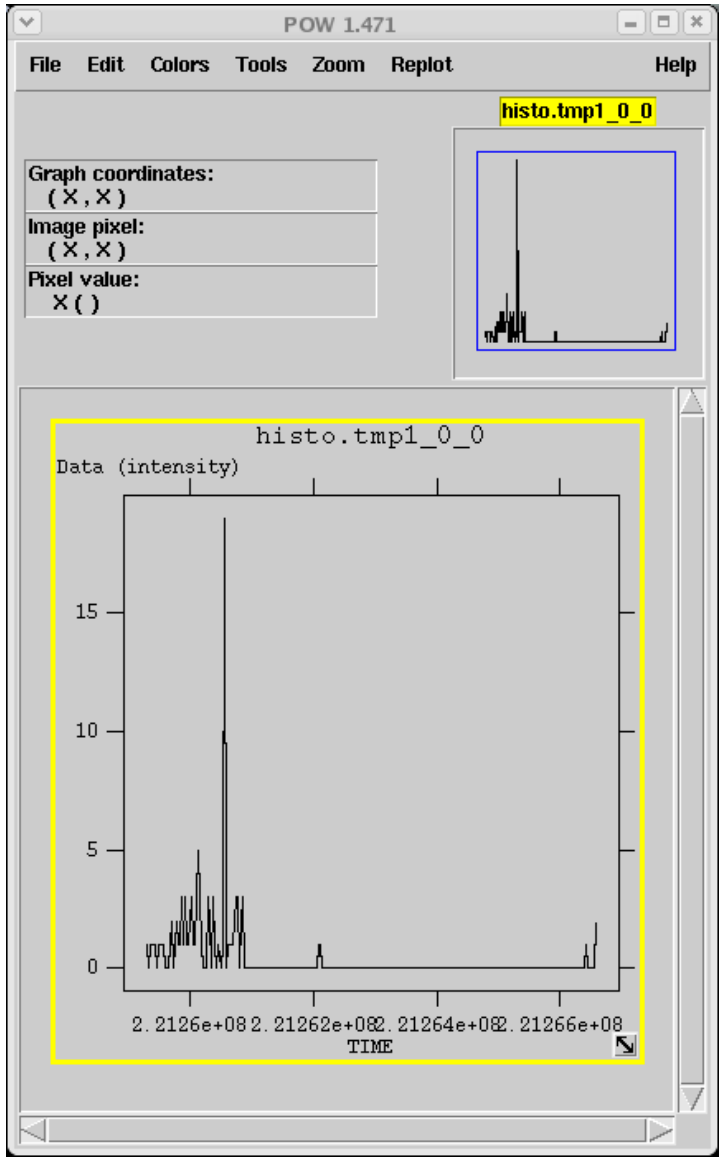
- ***You already know how as we used the interface to make a map.***
- ***This time just fill in the X column and leave the Y column blank.***
- ***If we use the Energy column for the anti-center region we get the image at right***
- ***Not very interesting on a linear scale so select Edit->Axes Transform->Log-Log to get this image***
- ***Note: scale on bottom is wrong. I don't know why.***



Binning on Time

- ***Let's look at a different file***
- ***Binning the data we extracted on the burst by time (parameters below) gives the image on the right***





Looking at the Raw Data

- ***If you just want to look at the data, click on the "All" button for the extension you want to look at. This will give you a table like the one below***

fv: Binary Table of burst.fits[1] in /home/tstephen/DC2/

File Edit Tools Help

Select All Invert

	ENERGY E MeV	RA E deg	DEC E deg	L E deg	B E deg	THETA E deg	PHI E deg
1	8.488889E+01	3.196125E+02	3.661224E-01	5.210165E+01	-3.197961E+01	3.298398E+01	7.285530E+01
2	6.169908E+01	3.227498E+02	1.073976E+01	6.394409E+01	-2.841150E+01	3.206598E+01	9.433624E+01
3	1.968599E+02	3.255253E+02	3.484162E-01	5.608533E+01	-3.689734E+01	3.312002E+01	8.426746E+01
4	1.214815E+02	3.237915E+02	1.148063E+01	6.533534E+01	-2.872891E+01	2.864745E+01	1.049374E+02
5	9.264123E+01	3.217905E+02	8.900364E+00	6.163348E+01	-2.881450E+01	2.497474E+01	1.029084E+02
6	8.429630E+01	3.222105E+02	3.864159E+00	5.723811E+01	-3.216133E+01	6.111385E+00	1.023245E+02
7	1.329176E+02	3.210327E+02	6.610307E+00	5.902215E+01	-2.959751E+01	4.006523E+00	1.270756E+02
8	3.750802E+02	3.209325E+02	8.264104E+00	6.046975E+01	-2.852794E+01	3.996705E+00	1.510800E+02
9	1.621546E+02	3.196081E+02	5.888457E+00	5.739981E+01	-2.887485E+01	2.804486E+00	1.081583E+02
10	1.033333E+02	3.205126E+02	1.372985E+00	5.367768E+01	-3.218105E+01	5.541411E+00	3.385061E+01
11	2.455396E+02	3.201808E+02	1.104513E-01	5.221192E+01	-3.259584E+01	6.494734E+01	3.148200E+02
12	6.681481E+01	3.327098E+02	4.945316E+00	6.635645E+01	-3.967527E+01	3.704285E+01	9.803329E+01

Go to: Edit cell:

Looking at the Headers

- ***Clicking on the "Header" button displays the FITS header keywords and values for the selected extension***
- ***There is a variety of useful information here***
  - *Start and stop times of the files in both MET and UTC*
  - *Selection keywords*
  - *Descriptions of the table data*
  - *Total exposure time*

gtbin

- ***The Science Tools provide a tool to bin up the photon data into different representations***
  - *Images (maps)*
  - *Light curves*
  - *Energy spectra (PHA files)*
- ***Let's take a quick look at each of these***
- ***Full details can be found in the User Workbook at***

http://glast-ground.slac.stanford.edu/workbook/science-tools/sciTools_Home.htm

  - *Click on Data Selection in the blue navigation bar*
  - *Click on Extracting Data in the gray navigation bar*

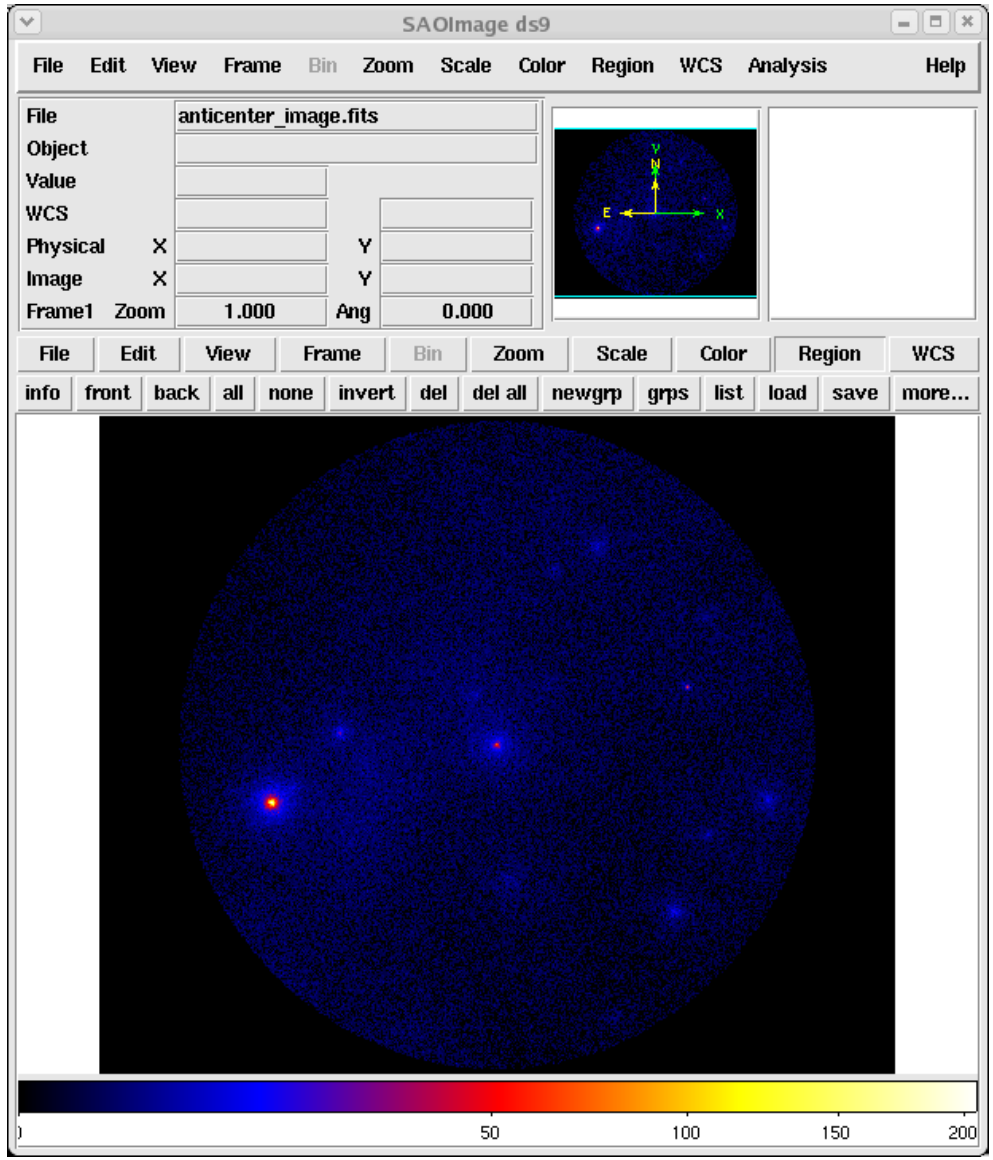
Making a Map with gtbin

- ***The previous two methods don't really incorporate the coordinate systems properly.***
- ***gtbin can make standard FITS images from the event file according to parameters specified by the user.***
- ***We want to use the CMAP option (counts map) for this***
- ***A sample run on the anti-center data we extracted looks like:***

```
[tstephen@80 DC2]$ gtbin
This is gtbin version v0r16p3
Type of output file <CMAP|LC|PHA1|PHA2> [CMAP] : CMAP
Event data file name [anticenter_20_full.fits] :
Output file name [anticenter_image.fits] :
Spacecraft data file name [NONE] :
Size of the X axis in pixels [1024] : 500
Size of the Y axis in pixels [1024] : 410
Image scale (in degrees/pixel) [0.1] :
Coordinate system (CEL - celestial, GAL -galactic) <CEL|GAL> [CEL] :
First coordinate of image center in degrees (RA or galactic l) [86.3] : 83.6
Second coordinate of image center in degrees (DEC or galactic b) [22] : 22
Rotation angle of image axis, in degrees [0] :
[tstephen@80 DC2]$
```

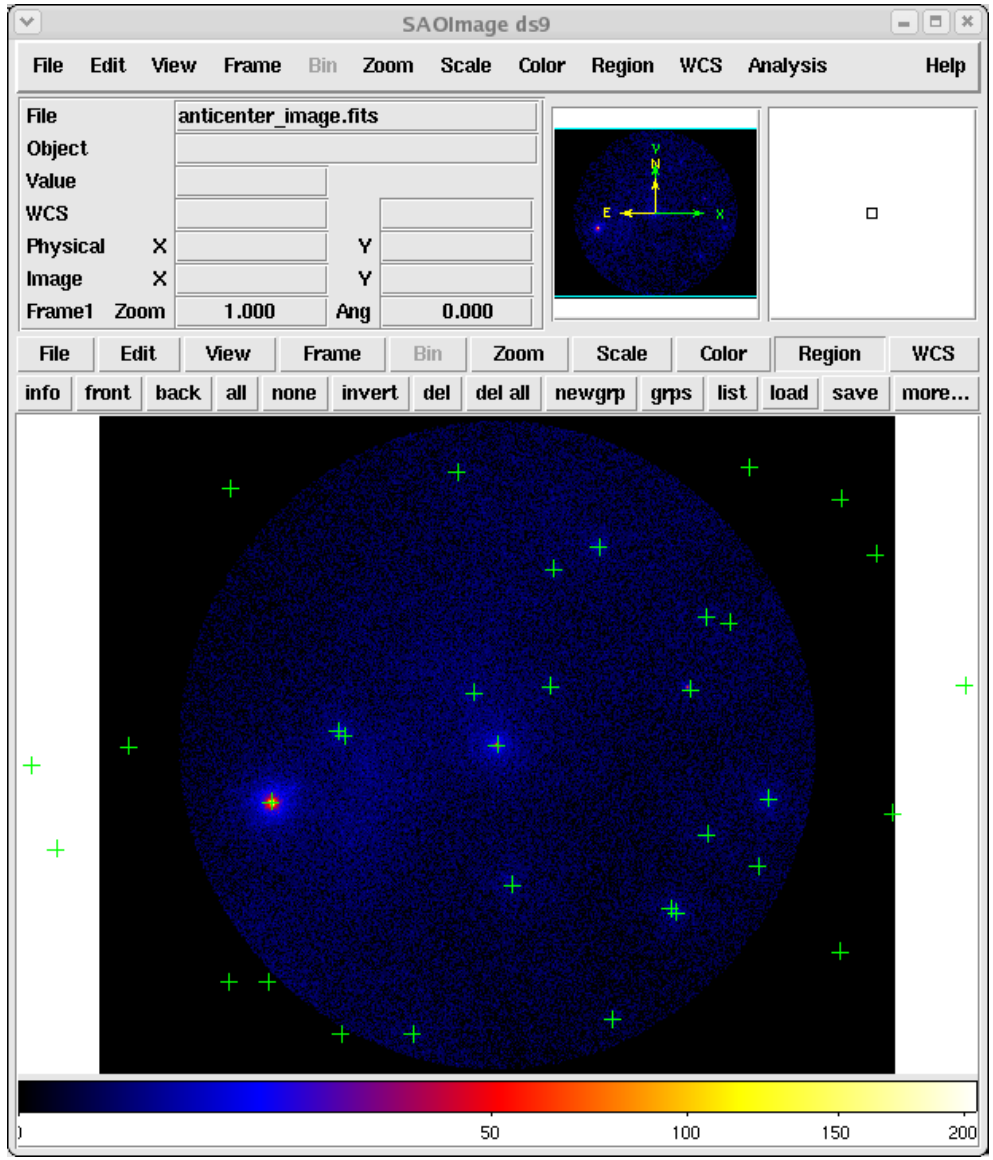
gtbin Generated Map

- ***This time the image is in the proper orientation as the WCS keywords have been added by gtbin.***



gtbin Generated Map

- ***This time the image is in the proper orientation as the WCS keywords have been added by gtbin.***
- ***The green crosses are location of sources listed in the DC2 source catalog***



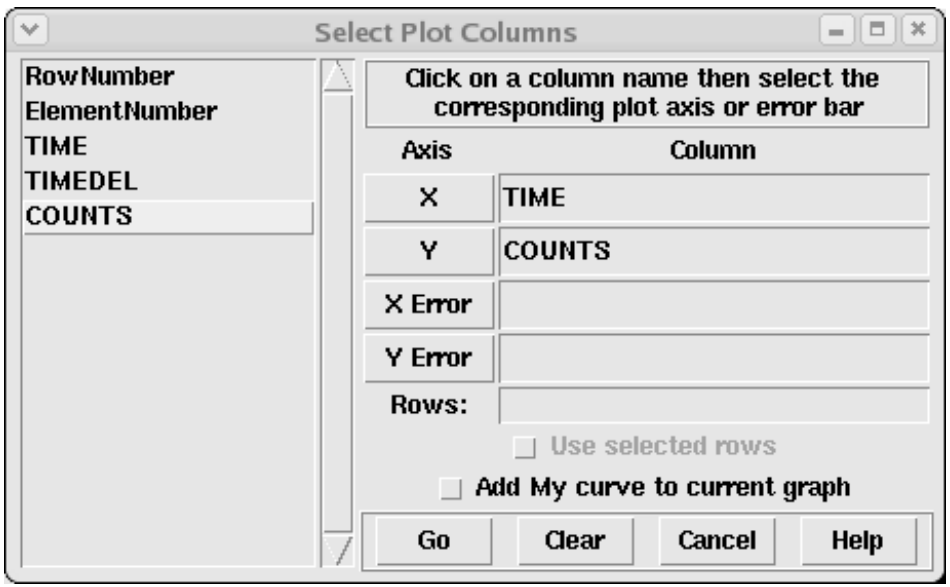
Using gtbin to make a lightcurve

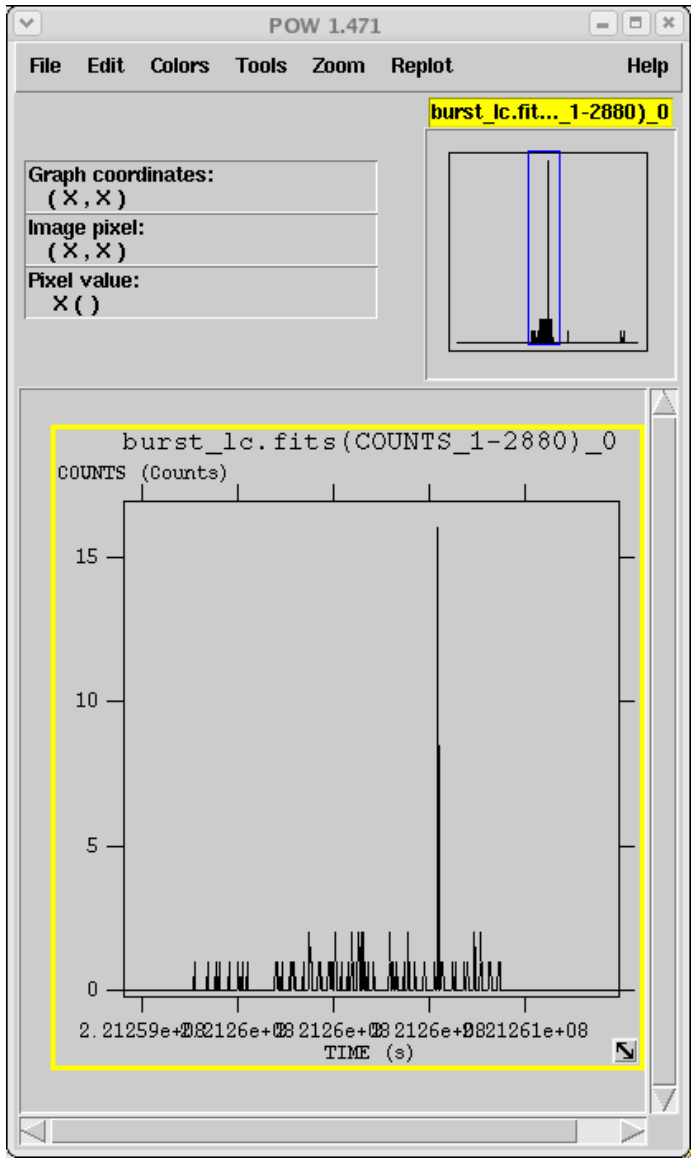
- ***Let's remake that light curve from the burst***
- ***This time we use the LC option to create the light curve***
  - *For start and start time use the TSTART and TSTOP values from the FITS header*
  - *Let's make linearly spaced bins with 5 second intervals*
- ***Here's the input:***

```
[tstephen@80 DC2]$ gtbin
This is gtbin version v0r16p3
Type of output file <CMAP|LC|PHA1|PHA2> [LC] : LC
Event data file name [burst.fits] : burst.fits
Output file name [burst_lc.fits] : burst_lc.fits
Spacecraft data file name [NONE] :
Algorithm for defining time bins <FILE|LIN|SNR> [LIN] :
Start value for first time bin [221253339] : 221253339
Stop value for last time bin [221267739] : 221267739
Width of linearly uniform time bins [10] : 5
[tstephen@80 DC2]$
```

gtbin Lightcurve

- ***We'll look at it with fv***
- ***Use the "Plot" button on the second extension***
- ***Chose the Time and Counts columns***
- ***Get the light curve at right***





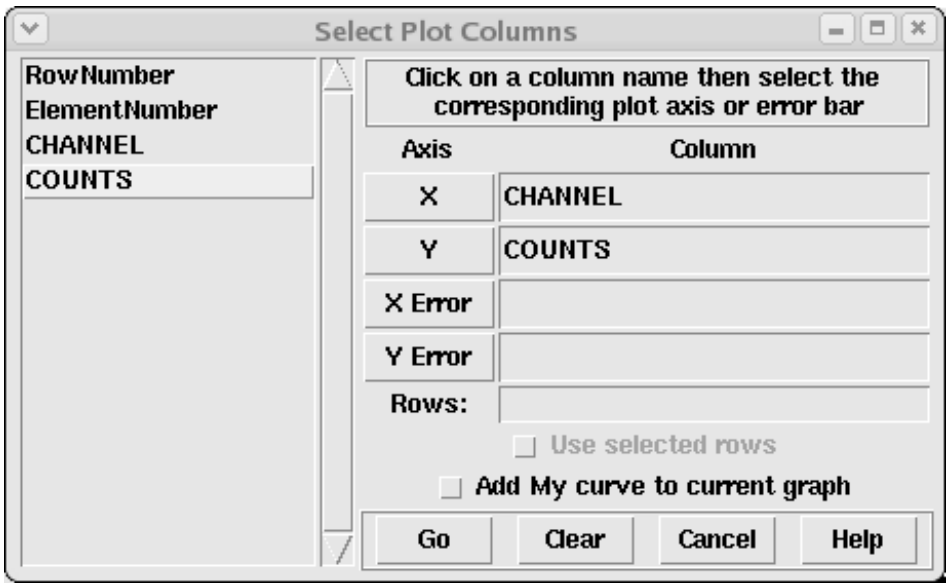
Creating an Energy Spectrum with gtbin

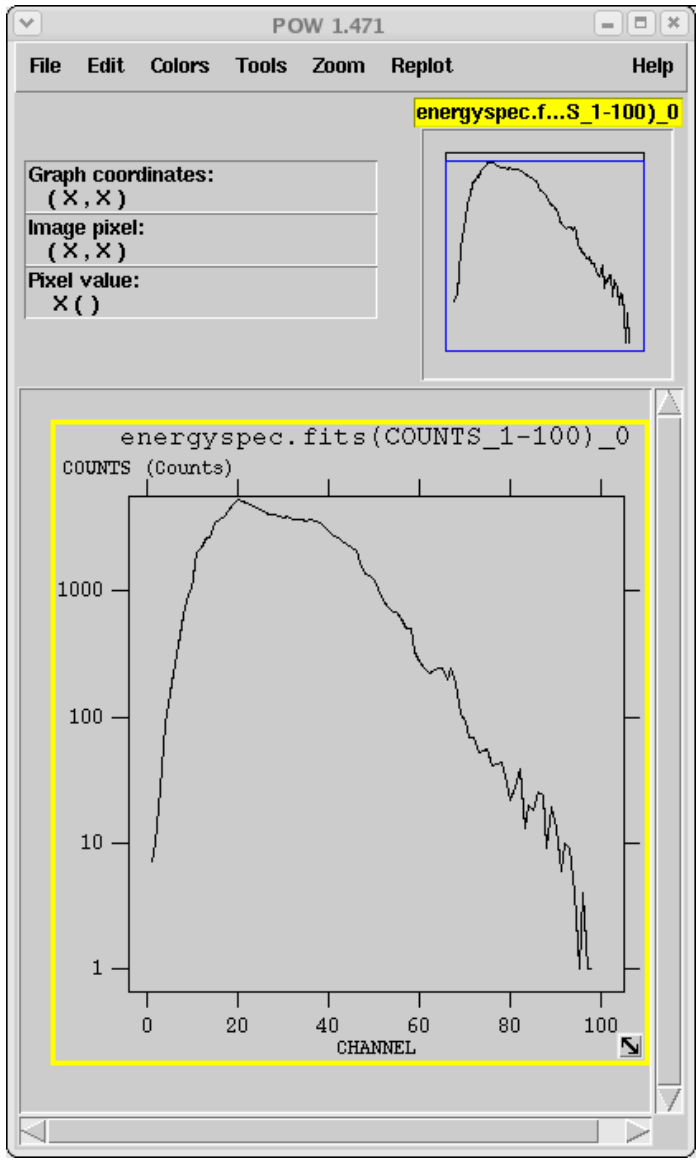
- ***Now let's remake the energy spectrum we make earlier using gtbin instead of fv***
- ***This time we use the PHA1 option to create the light curve***
  - *For the energy range lets use 20 MeV to 200 GeV*
  - *We have a lot of events (148217) so let's make 100 equally spaced logarithmic bins*
- ***Here's the input:***

```
[tstephen@80 DC2]$ gtbin
This is gtbin version v0r16p3
Type of output file <CMAP|LC|PHA1|PHA2> [PHA1] : PHA1
Event data file name [anticenter_20_full.fits] : anticenter_20_full.fits
Output file name [energyspec.fits] : energyspec.fits
Spacecraft data file name [NONE] :
Algorithm for defining energy bins <FILE|LIN|LOG> [LOG] :
Start value for first energy bin [20] : 20
Stop value for last energy bin [200000] : 200000
Number of logarithmically uniform energy bins [100] : 100
```

gtbin energy spectrum

- ***Again, use the "Plot" button in fv to look at it***
- ***This time we want the CHANNEL and COUNTS columns in the SPECTRUM extension***





Making Further Data Cuts

- ***Eventually you'll want to make additional cuts on the data***
- ***If they are only cuts on position, time and/or energy you could use the data server***
- ***If you want to cut on these and/or other parameters use the Science Tool gtselect***
- ***gtselect allows cuts on***
  - *Basic parameters*
    - *Position, Time and Energy*
    - *Event Class*
  - *Advanced Parameters*
    - *Instrument coordinates (Theta and Phi)*
    - *Zenith Angle*
    - *Latitude and Longitude*

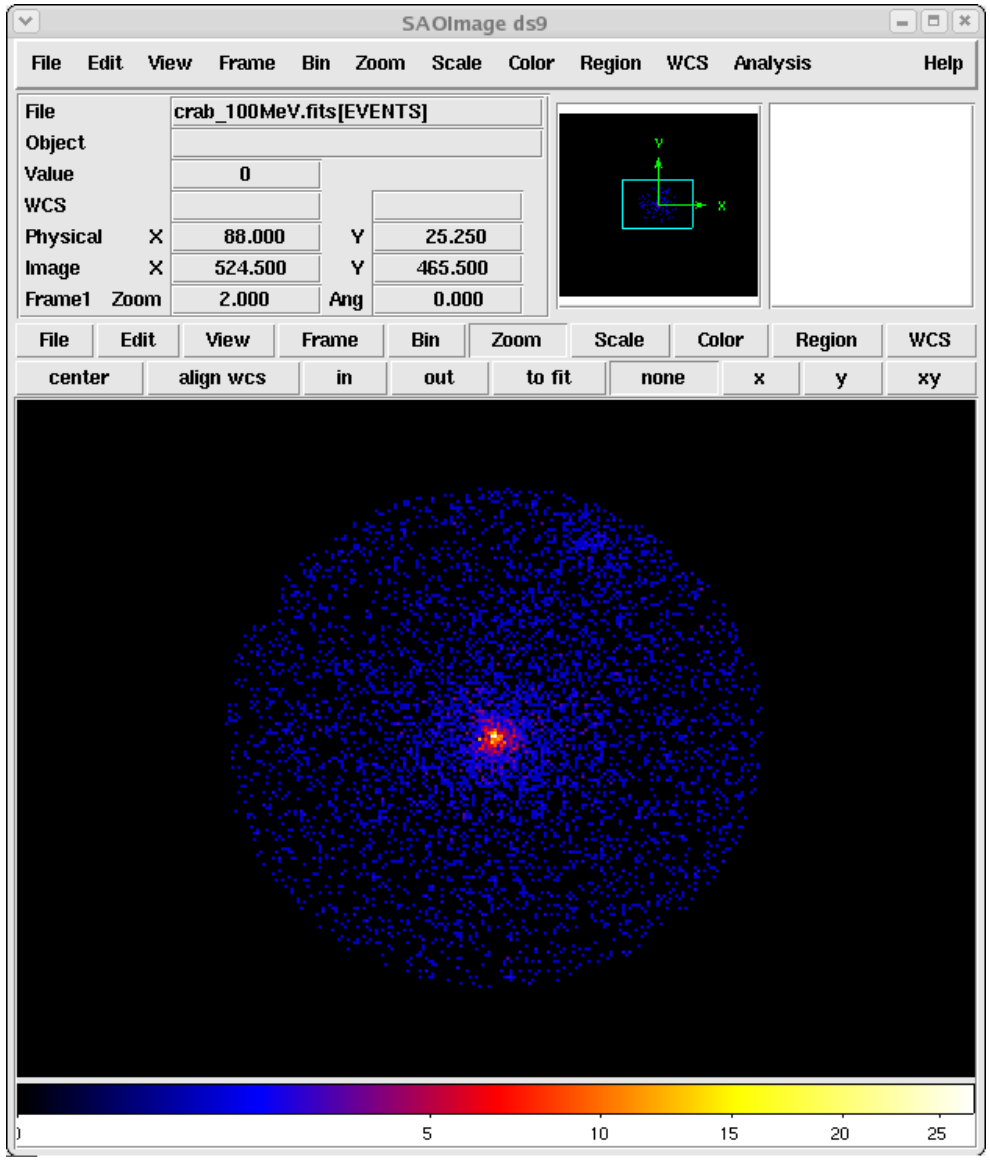
Cutting Out the Crab

- ***Let's zero in on the Crab pulsar***
- ***We now want a data set with the following characteristics***
  - *4 degree radius circle centered on the crab pulsar*
  - *Only class A events*
  - *Events above 100 MeV*
- ***Here's the input:***

```
[tstephen@sigurd DC2]$ gtselect
Input FT1 file [test_events_0000.fits] : anticenter_20_full.fits
Output FT1 file [filtered_events_0000.fits] : crab_100MeV.fits
RA for new search center (degrees) <0 - 360> [86.4] : 83.6
Dec for new search center (degrees) <-90 - 90> [28.9] : 22
radius of new search region (degrees) <0 - 180> [20] : 4
start time (MET in s) [0] : 220838401.126248
end time (MET in s) [0] : 225590400.922648
lower energy limit (MeV) [30] : 100
upper energy limit (MeV) [200000] :
Event classes (-1=all, 0=FrontA, 1=BackA, 2=FrontB, 3=BackB, 4=class A) <-1 - 4>
 [-1] : 4
Done.
[tstephen@sigurd DC2]$ []
```

The Crab Cutout

- ***Displayed with ds9 and 0.05 degree bins.***
- ***There are now 6077 events from the original 148217.***



What is a GTI anyway?

- ***If you've been paying attention, you've probably noticed that all of these files have a GTI extension in them.***
- ***So what is a GTI?***
  - *The Good Time Interval is a time range when the data can be considered valid.*
  - *The GTI extension contains a list of these GTI's for the file*
- ***How do we interpret these for GLAST***
  - *From the Data Server*
    - *The GTI's are the list of times that the LAT was collecting data over the time range you selected*
    - *Your object will most likely not be in the field of view during the entire time.*
  - *Additional data cuts made with gtmaketime will update the GTI's based on the specified cuts*
  - *The Science Tools use the GTI when calculating exposure*

Using gtmaketime

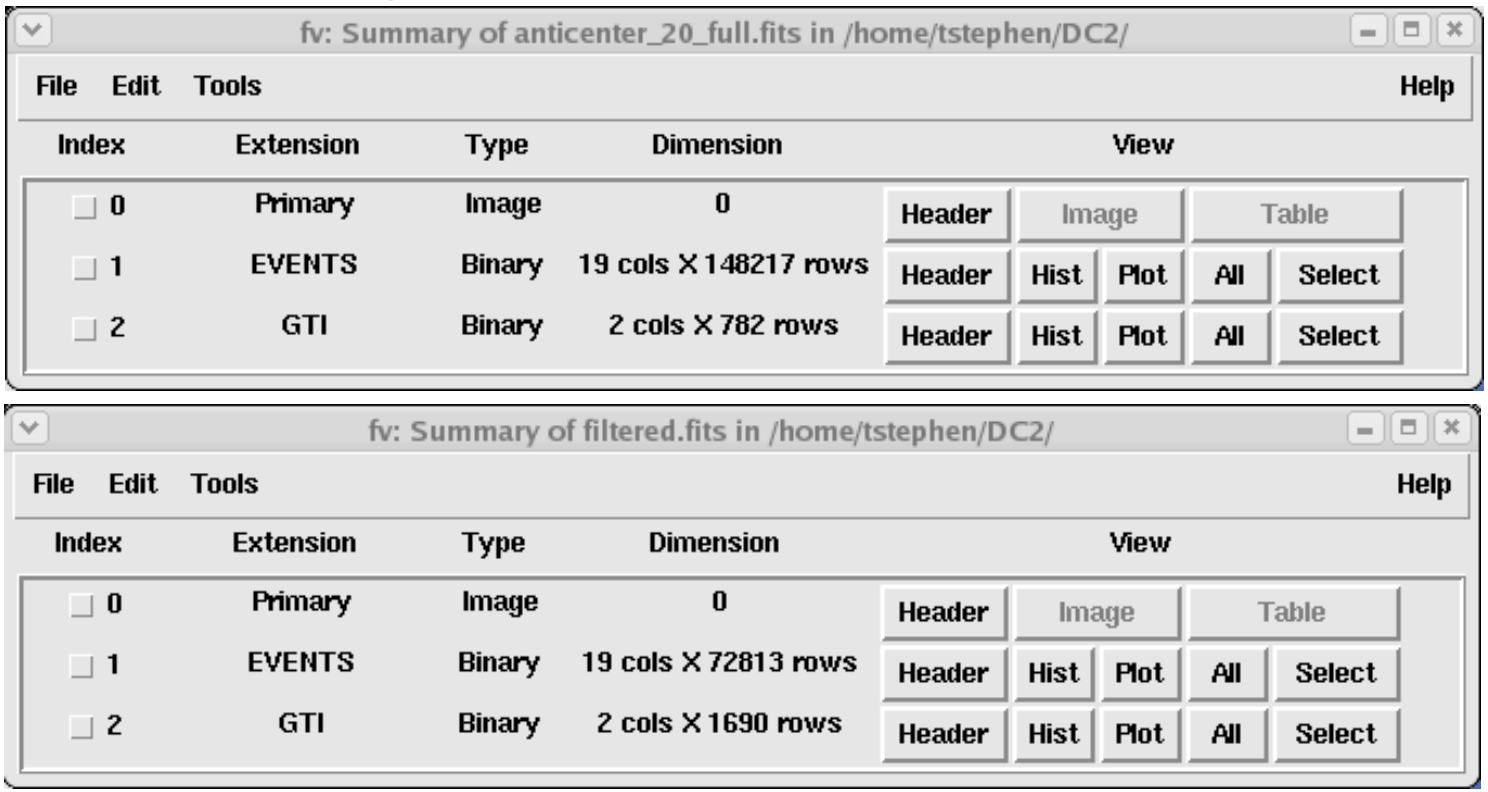
- **gtmaketime *uses the FT2 file to create a new set of GTI intervals based on the selected parameters***
  - *Takes an FT1 and FT2 file as input*
  - *Creates the new GTIs*
  - *cuts out all the events that don't fall into those GTI's*
  - *creates a new FT1 file*
- ***You can make cuts on any field in the FT2 file***
  - *The default is to select time not in the SAA (IN_SAA!=T)*
  - *Cuts are made using C-style?? relational syntax*
    - *! -> not, &&-> and, || -> or, ==, !=, >, <, >=, <=*
    - *Things like ABS(), COS(), SIN() seem to work as well*
- ***Let's make a cut on the anti-center region file to exclude the SAA and any events collected when the Geomagnetic Latitude was greater than 10°.***

Input to gtmaketime

- ***Here's the input to make the cut:***

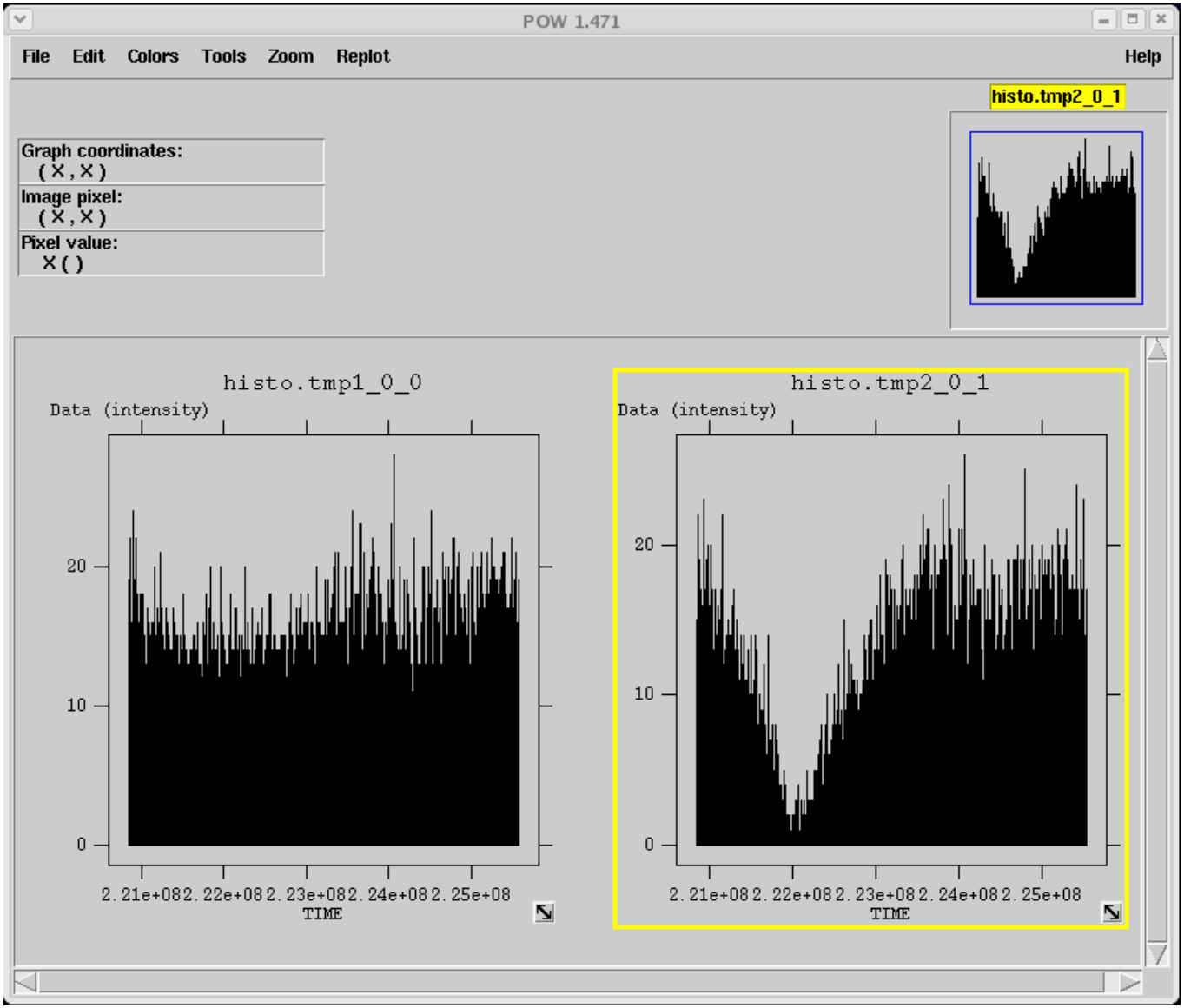
```
[tstephen@dhcpvisitor218227 DC2]$ gtmaketime
Spacecraft data file [test_scData_0000.fits] : DC2_FT2.fits
Filter expression [IN_SAA!=T] : IN_SAA!=T&&LAT_GEO<10
Event data file [test_events_0000.fits] : anticenter_20_full.fits
Output event file name [filtered.fits] :
```

- ***It did something, here are the file summaries from fv:***



The New Data Lightcurve

Before



After

Looking at the Exposure

- ***Two steps to generating an exposure map***
  - *Making an exposure cube from the FT2 file*
  - *Making an exposure map from the exposure cube*
- ***To help speed up the process pre-generated exposure cubes are available for each day of the simulation***
- ***Let's look at how to use these to generate an exposure map***
  - *With a single exposure cube*
  - *With multiple exposure cubes*

Using a Single Exposure Cube

- ***In this case we just run the* exposure_map *tool***
- ***This allows us to control the map generation parameters***
  - *Map center, size and scale*
  - *Projection type*
    - *Many choices (Aitoff, Cartesian, Mercator, Tangential, etc)*
    - *But it's a hidden parameter and doesn't prompt for an entry*
    - *Default is Aitoff*
  - *Energy range and number of energy bins*
- ***Note*: The default parameter file wants to use the Ext1 name for the exposure extension.**
  - *The exposure cubes use EXPOSURE as the extension name*
  - *You need to give the command line argument table=EXPOSURE or in the GUI select the advanced options box and enter this in the table field*

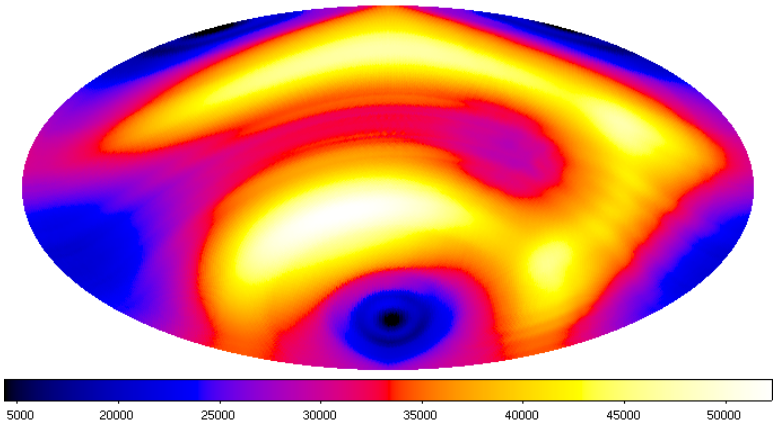
Running exposure_map

- ***Let's make an all sky Aitoff map of the first day's exposure - 8 bins from 20 MeV to 200 GeV and 0.5 degree spatial bins***
- ***Here is the input and output for this run:***

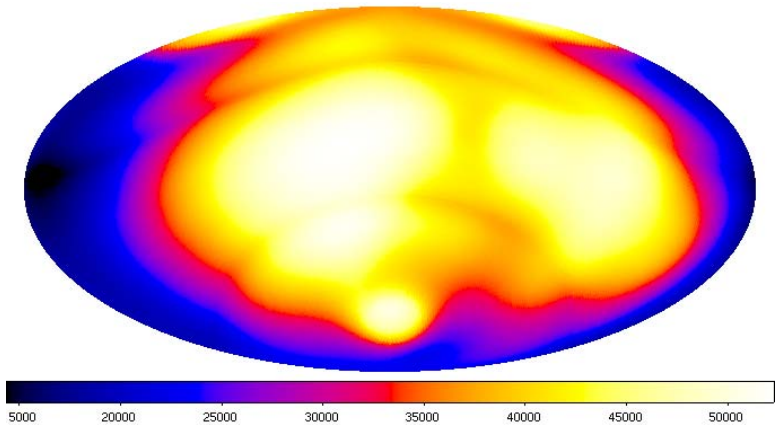
```
[tstephen@dhcpvisitor218227 DC2]$ time exposure_map table=EXPOSURE
This is exposure_map version N/A
Exposure cube input file name [expCube0.fits] :
Count map input file name (NONE for manual input of map geometry) [NONE] :
Exposure map output file name [day1exp.fits] :
Response function to use, e.g. DC1F/DC1B, G25F/G25B, TestF/TestB [DC2] :
Size of the X axis in pixels [720] :
Size of the Y axis in pixels [360] :
Image scale (in degrees/pixel) [0.5] :
Coordinate system (CEL - celestial, GAL -galactic) <CEL|GAL> [CEL] :
First coordinate of image center in degrees (RA or galactic l) [180] :
Second coordinate of image center in degrees (DEC or galactic b) [0] :
Rotation angle of image axis, in degrees [0] :
Start value for first energy bin [20] :
Stop value for last energy bin [200000] :
Number of logarithmically uniform energy bins [6] : 8
Creating an Exposure object from file expCube0.fits
        total elapsed time: 0
Using Aeff(s) DC2::FrontA, DC2::BackA, DC2::FrontB, DC2::BackB,
Creating an Image, will write to file day1exp.fits
Generating layer 0 at energy 20 MeV  Aeff(0): 6.86067 cm^2
Generating layer 1 at energy 63.2456 MeV  Aeff(0): 1140.65 cm^2
Generating layer 2 at energy 200 MeV  Aeff(0): 4407.49 cm^2
Generating layer 3 at energy 632.456 MeV  Aeff(0): 8239.31 cm^2
Generating layer 4 at energy 2000 MeV  Aeff(0): 8996.34 cm^2
Generating layer 5 at energy 6324.56 MeV  Aeff(0): 8955.51 cm^2
Generating layer 6 at energy 20000 MeV  Aeff(0): 9041.17 cm^2
Generating layer 7 at energy 200000 MeV  Aeff(0): 7683.49 cm^2
```

Exposure Map – Day 1

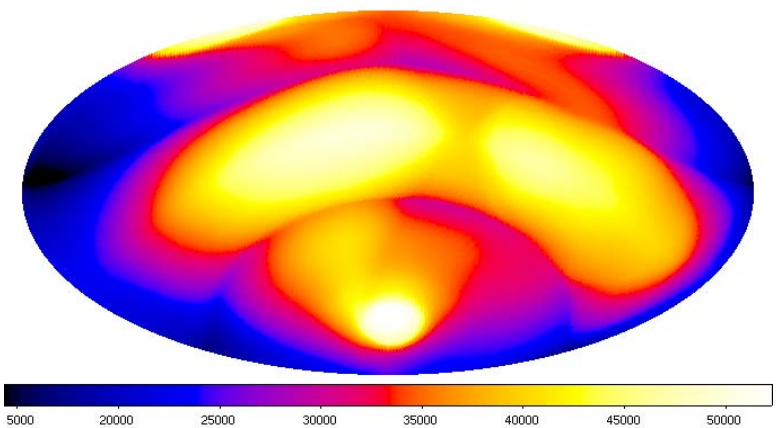
20-63.2 MeV



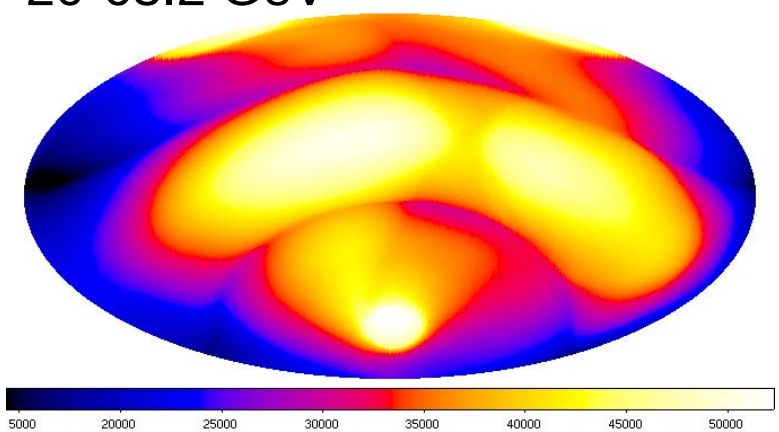
200-632 MeV



2-6.32 GeV



20-63.2 GeV



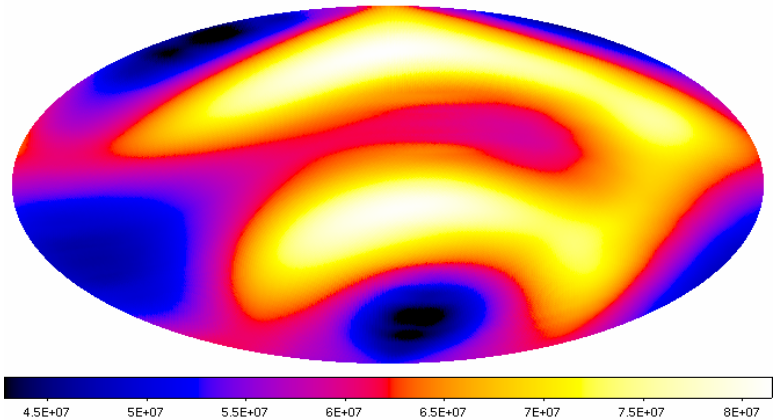
Using Multiple Exposure Cubes

- ***In order to use multiple exposure cubes we must first combine them into a single cube using* gtaddlivetime**
  - It only adds two cubes
  - You can't append to an existing cube and keep the same name
  - But it's very quick
- **Here's a sample input:**

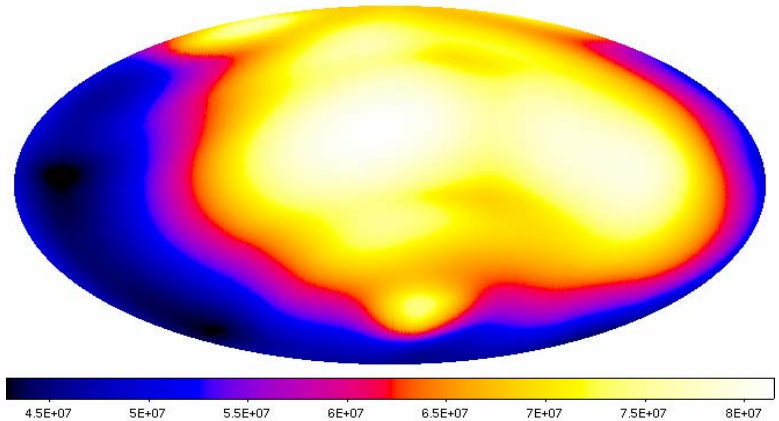
```
[tstephen@dhcpvisitor218227 DC2]$ ds9 day1exp.fits
[tstephen@dhcpvisitor218227 DC2]$ gtaddlivetime
Livetime cube 1 [expCube_00.fits] : expCube0.fits
Livetime cube 2 [expCube_01.fits] : expCube1.fits
Output file [expCube.fits] : expCube.fits
```

Exposure Map – Week 1

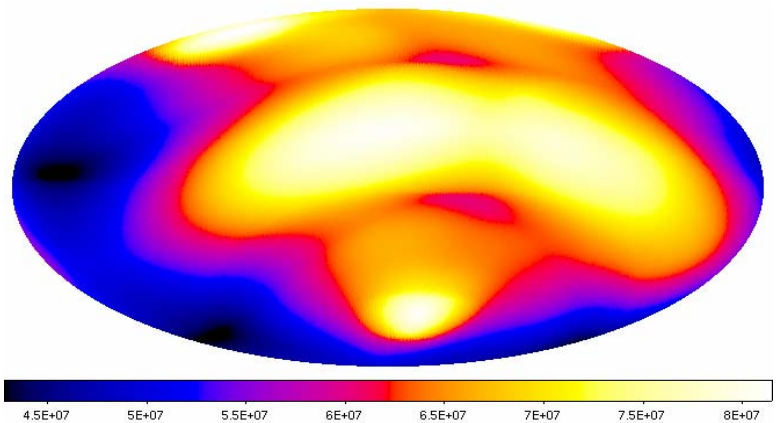
20-63.2 MeV



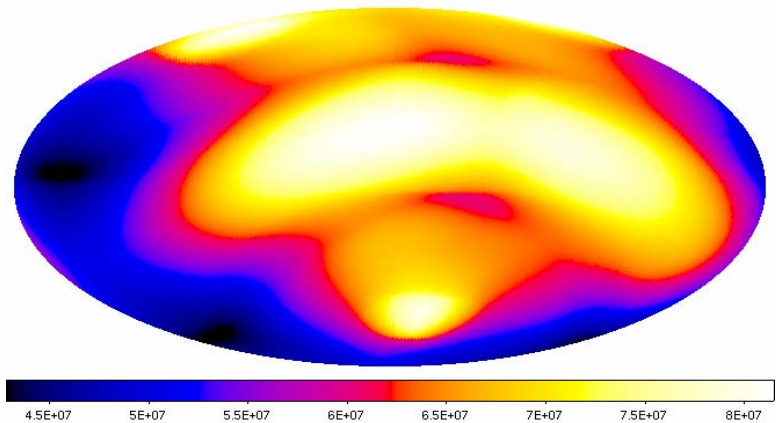
200-632 MeV



2-6.32 GeV

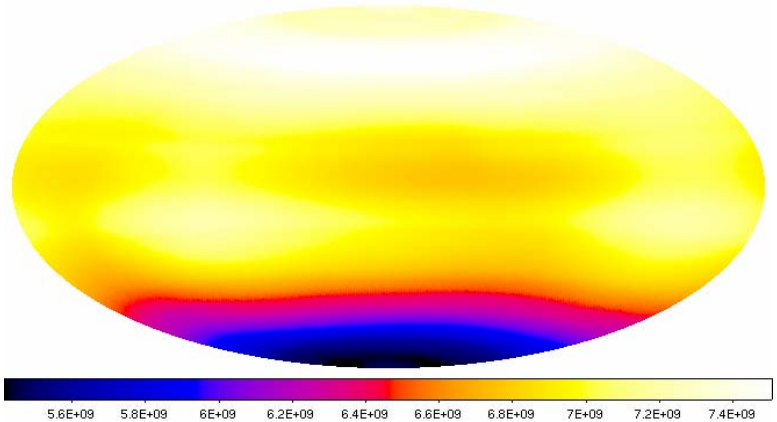


20-63.2 GeV

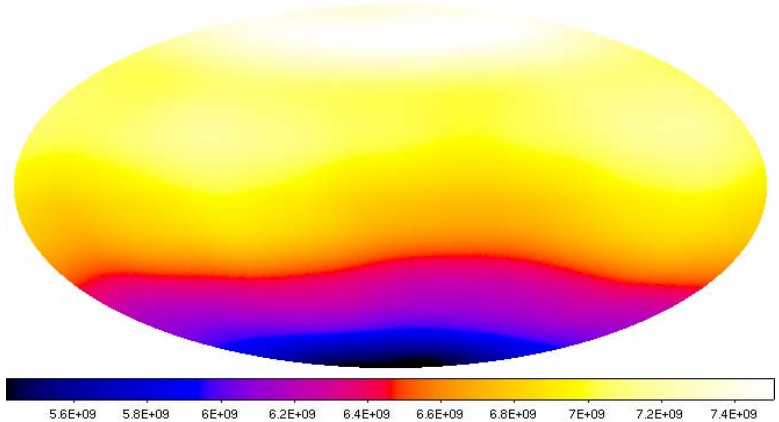


Exposure Map – Full Simulation

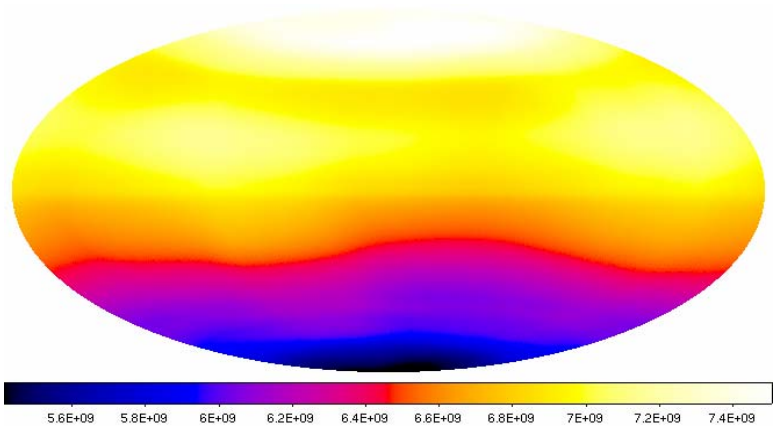
20-63.2 MeV



200-632 MeV



2-6.32 GeV



20-63.2 GeV