FSSC Science Tools

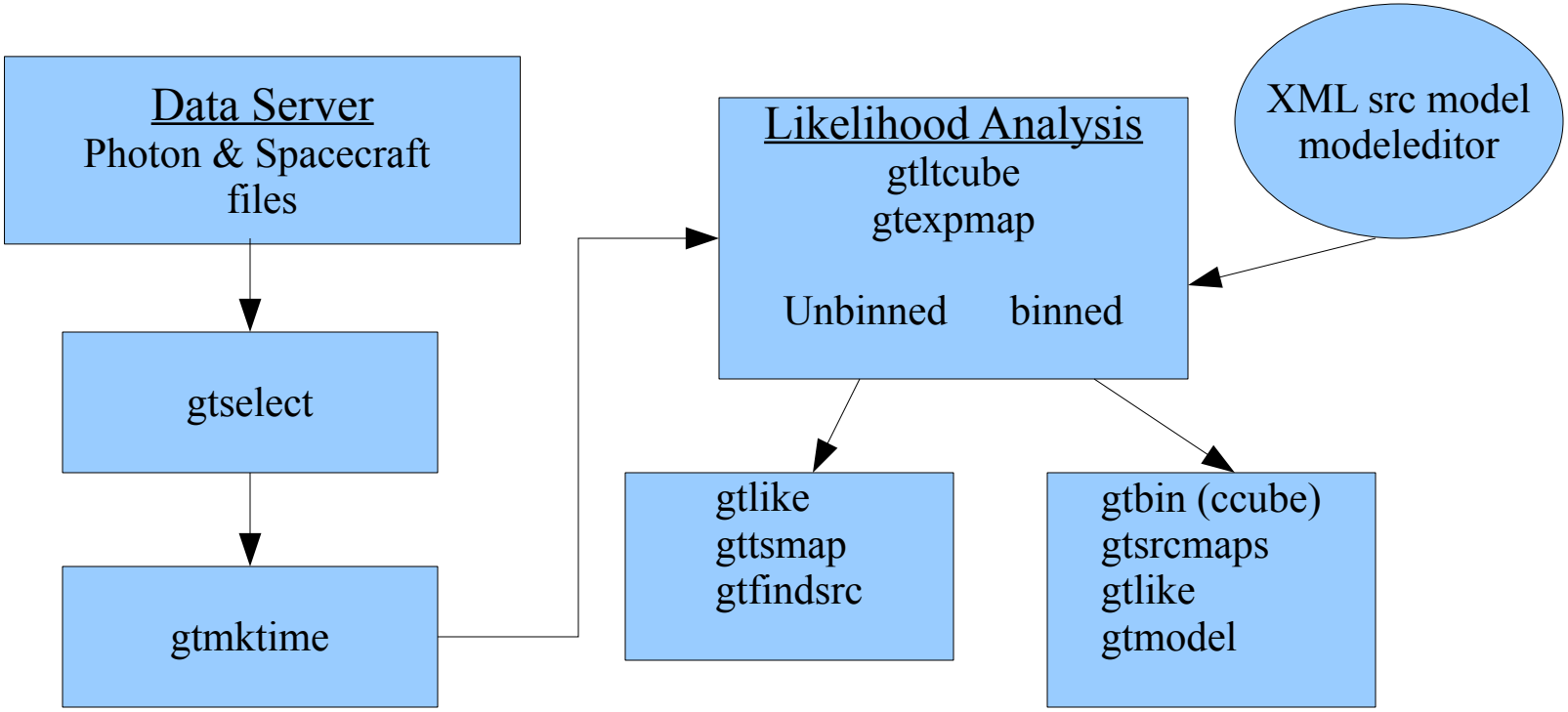
Source Analysis

Binned Likelihood

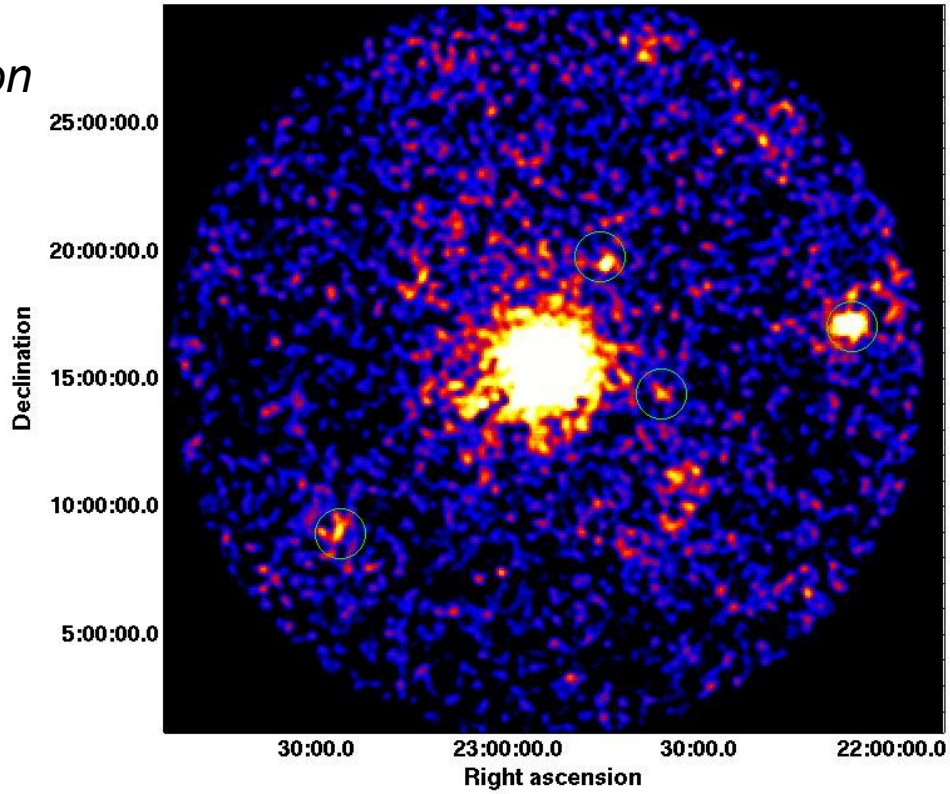
Science Tools: Documentation

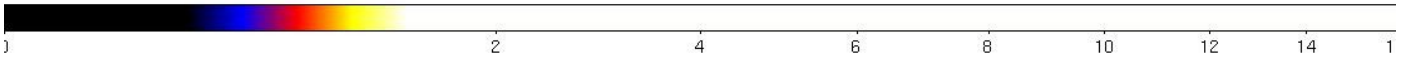
- *Multi-Tier Documentation*
  - *Full set accompanies SW release*
    - *Fermi Mission Technical Handbook*
  - *Multiple levels:*
    - *Detailed analysis description ('Cicerone')*
    - *Individual tool descriptions (like fhelp)*
    - *Analysis threads (cook book examples)*

Science Tools: Overview



- *3c454 region*





Likelihood Analysis

- *Unbinned and binned modes are available. Now I'll describe binned analysis.*
- *Several tools are needed to define the model and prepare the data*
  - *modeleditor: GUI for preparing the xml model definition file*
  - *gtselect: applies region-of-interest cuts – sky acceptance cone, energy range (0.2 – 300 GeV), time range, zenith angles (< 105^0)*
  - *gtmktime: constructs good time intervals (GTIs) based on pointing information selections, zenith angle cuts and information on the instrument*

Likelihood Analysis (binned)

- *gtltcube: integrates LAT livetime as a function of sky position and off-axis angle*
- *gtexpmap: computes RoI-specific exposure maps*
- *gtlike: fits model parameters using maximum likelihood*

- *Details of the method can be found in http://fermi.gsfc.nasa.gov/ssc/data/analysis/documentation/Cicerone*

Likelihood Analysis cont.

You will need a description of the source in your field. This is most easily achieved by using the LAT source catalog and the user contributed script make1FGLxml found at http://fermi.gsfc.nasa.gov/ssc/data/analysis/user/ and comes with a complete instruction manual. This can be run from the python command line or from a python script.

```
from make1FGLxml import *
mymodel=srcList('gll_psc_v02.fit','3c454_100_300000_evt02.fits','srcmdl_01.xml')
mymodel.makeModel('gll_iem_v02.fits','gal_v02','isotropic_iem_v02.txt','eg_v02')
```

- Reads information from your event file (RA, DEC, radius)
- Generates xml model file from the catalog parameters
- Writes this out in a gtlike compatible format sorted by radius

Likelihood Analysis cont.

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Likelihood Analysis (binned)

Data preparation remains as in the unbinned case.
After gtmktime we need to create products for the binned analysis

```
>gtbin
This is gtbin version ScienceTools-v9r18p6-fssc-20101025
Type of output file (CCUBE|CMAP|LC|PHA1|PHA2) [PHA2] ccube
Event data file name[] 3c454_100_300000_evt02.fits
Output file name[] 3c454_100_300000_ccube.fits
Spacecraft data file name[NONE] 3c454_SC00.fits
Size of the X axis in pixels[] 100
Size of the Y axis in pixels[] 100
Image scale (in degrees/pixel)[] 0.2
Coordinate system (CEL - celestial, GAL -galactic) (CEL|GAL) [CEL]
First coordinate of image center in degrees (RA or galactic l)[] 343.490616
Second coordinate of image center in degrees (DEC or galactic b)[] 16.148211
Rotation angle of image axis, in degrees[0.]
Projection method e.g. AIT|ARC|CAR|GLS|MER|NCP|SIN|STG|TAN:[AIT] STG
Algorithm for defining energy bins (FILE|LIN|LOG) [LOG]
Start value for first energy bin in MeV[30] 100
Stop value for last energy bin in MeV[200000] 300000
Number of logarithmically uniform energy bins[] 20
```

We're now creating
a 3-d counts map
with log energy spacing

Likelihood Analysis (binned)

After the counts cube is done we need to generate a binned exposure map
First generate a livetime cube as before the use gtsrcmaps to create a binned exposure map.

```
>gtsrcmaps expcube=3c454_100_300000_bExpCube.fits \
cmap=3c454_100_300000_ccube.fits srcmdl=3c454_srcmdl01.xml \
bexpmap=3c454_100_300000_bExpMap.fits outfile=3c454_100_300000_srcMap.fits
scfile=3c454_SC00.fits
Response functions[P6_V3_DIFFUSE]
Generating SourceMap for EG_v02.....!
Generating SourceMap for Field1.....!
Generating SourceMap for Field2.....!
Generating SourceMap for Field3.....!
Generating SourceMap for GAL_v02.....!
Generating SourceMap for _3c454.....!
>
```

Likelihood Analysis (binned)

- *Finally, running gtlike:*

```
>gtlike statistic=BINNED expcube=3c454_100_300000_bExpCube.fits\
? srcmdl=3c454_srcmdl01.xml evfile=3c454_100_300000_evt02.fits \
? scfile=3c454_SC00.fits expmap=3c454_100_300000_ExpMap.fits \
? cmap=3c454_100_300000_ccube.fits bexpmap=3c454_100_300000_bExpMap.fits
Response functions to use[P6_V3_DIFFUSE]
Optimizer (DRMNFB|NEWMINUIT|MINUIT|DRMNGB|LBFGS) [MINUIT]
Generating SourceMap for EG_v02.....!
```

…

Various output based on the chatter level

_3c454:
Integral: 15.3713 +/- 0.707518
Index: 2.52326 +/- 0.75221
LowerLimit: 100
UpperLimit: 300000
TS value: 9596.18
Flux: 1.54458e-06 +/- 7.07552e-08 photons/cm^2/s

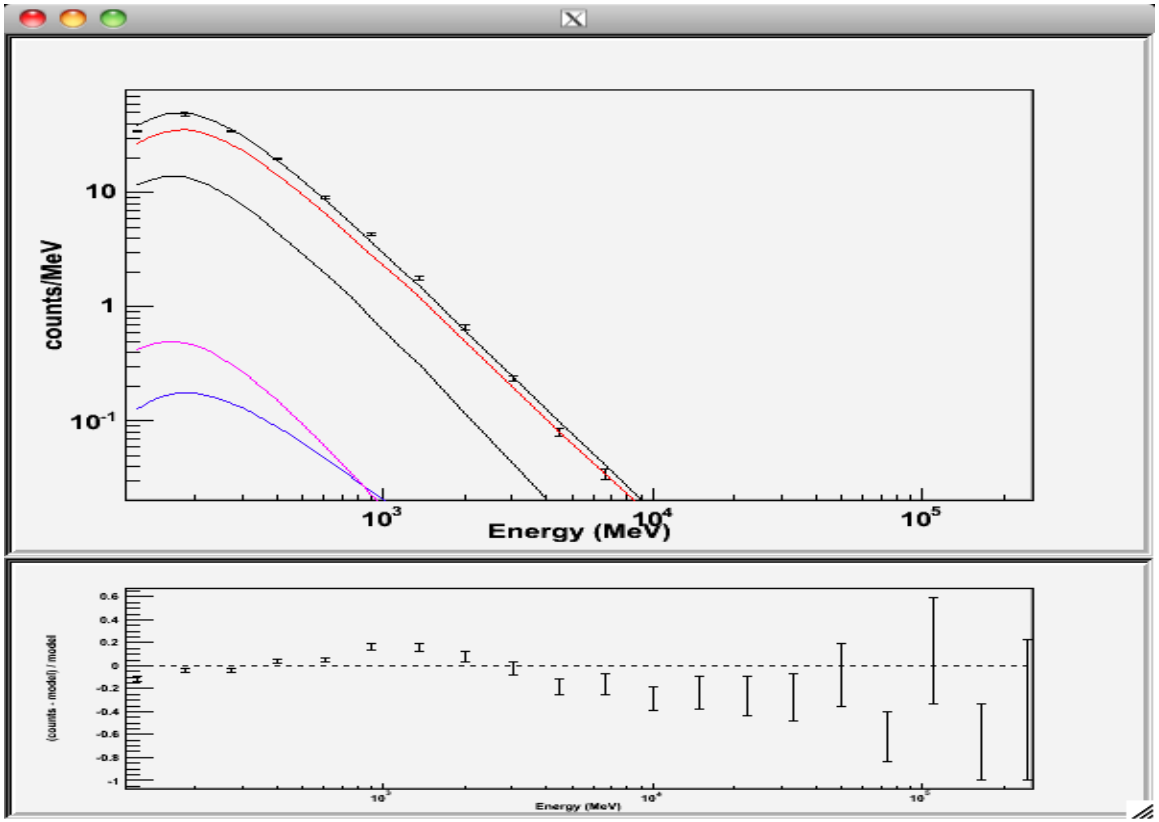
Total number of observed counts: 18178
Total number of model events: 18178.5

-log(Likelihood): 40322.83782

Elapsed CPU time: 131.092388

Likelihood Analysis cont.

- *Plot the results (gtlike plot=yes)*



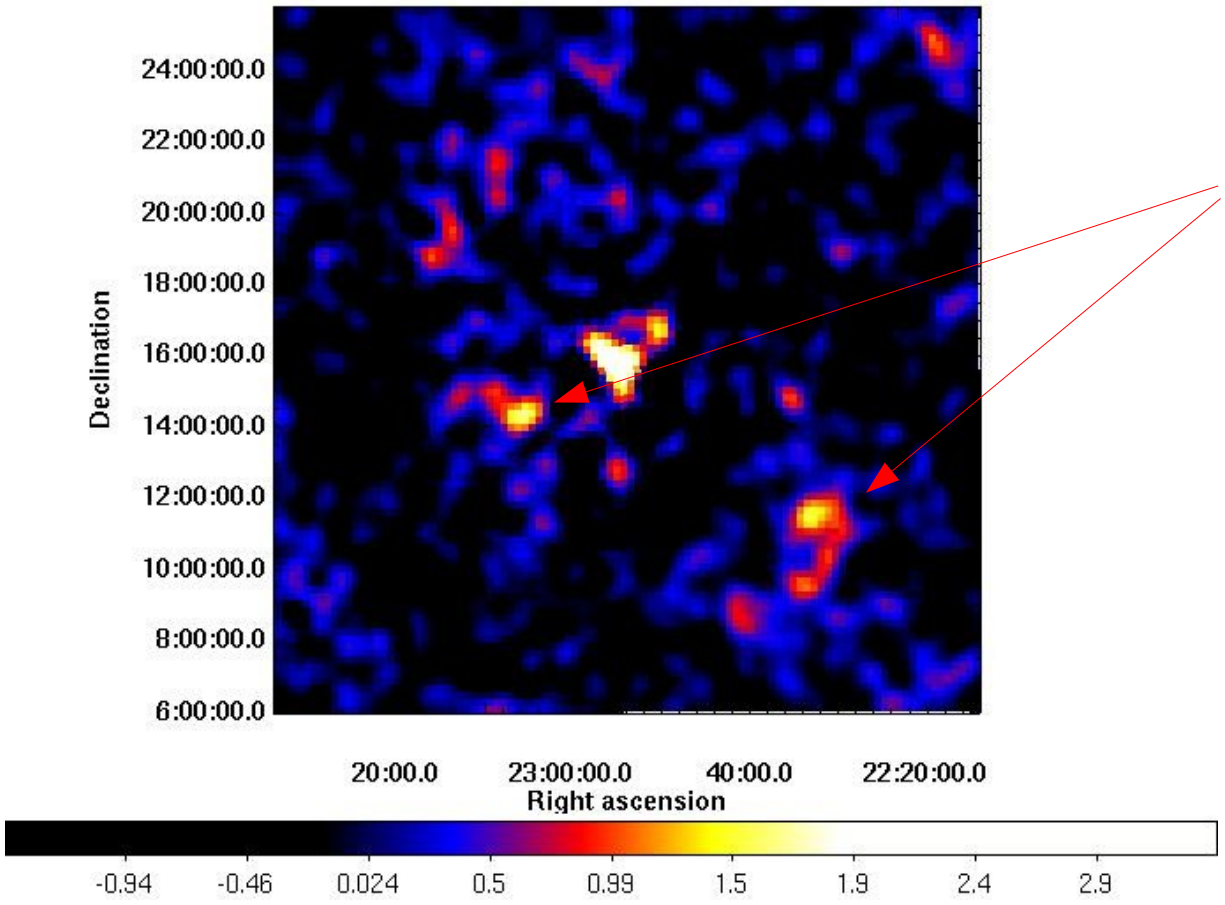
Residual Maps

Once you have an acceptable fit we need to create a model map from the xml file

>gtmodel
Source maps (or counts map) file[] 3c454_100_300000_srcMap.fits
Source model file[] 3c454_100_300000_sfile.xml
Output file[] 3c454_100_300000_model.fits
Response functions[P6_V3_DIFFUSE]
Exposure cube[] 3c454_100_300000_bExpCube.fits
Binned exposure map[none] 3c454_100_300000_bExpMap.fits

farith 3c454_100_300000_cmap.fits 3c454_100_300000_model.fits \
3c454_100_300000_diff.fits SUB

Residual Maps



Some of the same catalog sources that were missed in the initial model