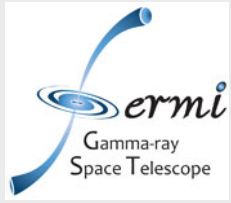
Fermi GBM and Spectral Fitting GRBs

Michael S. Briggs
(UAHuntsville)



University of Alabama in Huntsville

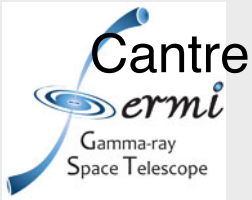
NASA Marshall Space Flight Center

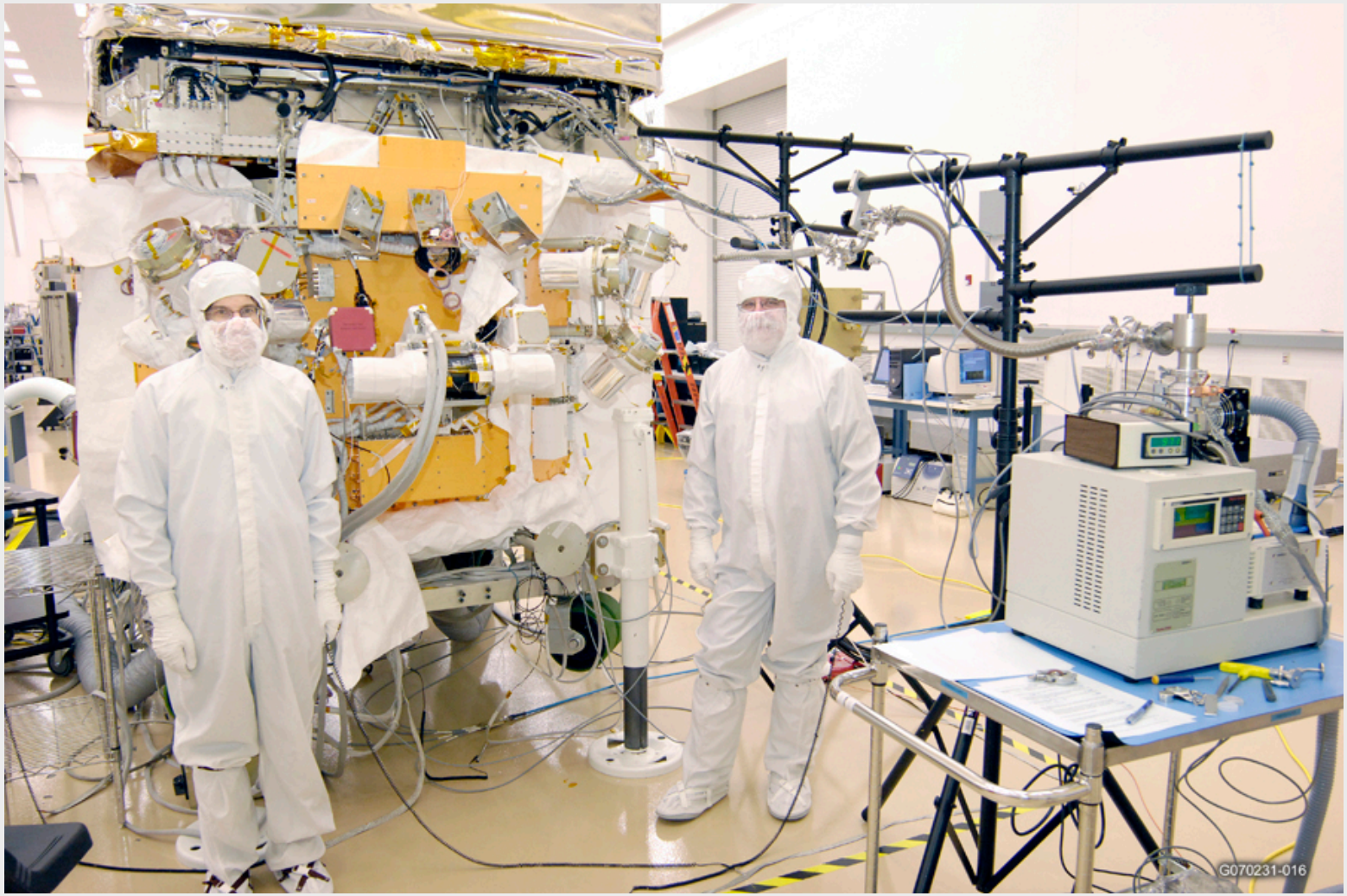
Max-Planck-Institut für extraterrestrische Physik

University College Dublin

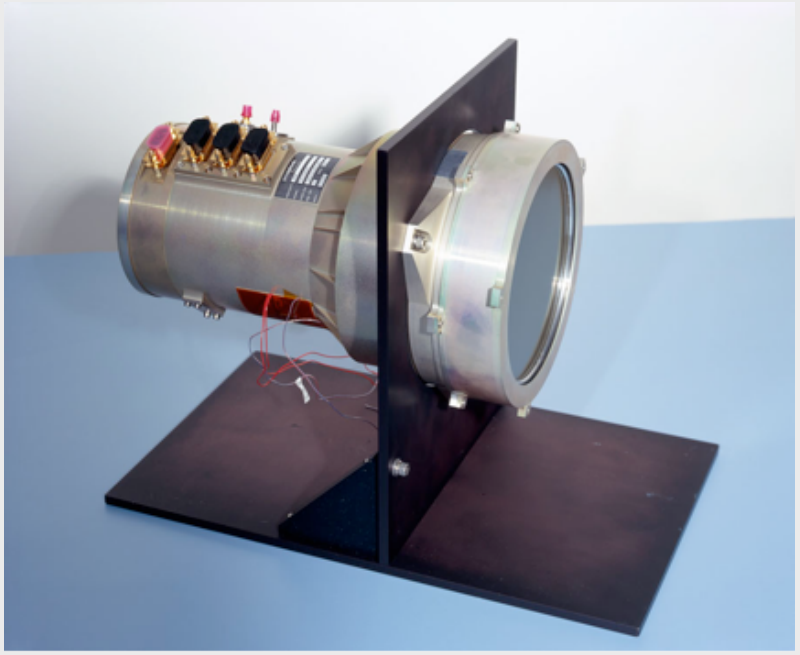
The current GBM Team: Narayana Bhat, Michael Briggs, Michael Burgess, Vandiver Chaplin, Bill Cleveland, Valerie Connaughton, Roland Diehl, Steve Elrod, Mark Finger, Jerry Fishman, Gerard Fitzgerald, Suzanne Foley, Lisa Gibby, Misty Giles, Adam Goldstein, Jochen Greiner, David Gruber, Alexander van der Horst, Andreas von Kienlin, Pete Jenke, Marc Kippen, Chryssa Kouveliotou, Emily Layden, Sheila McBreen, Sinead McGlynn, Chip Meegan, Bill Paciesas, Veronique Pelassa, Rob Preece, Arne Rau, Dave Tierney, Colleen Wilson-Hodge and Shaolin Xiong.

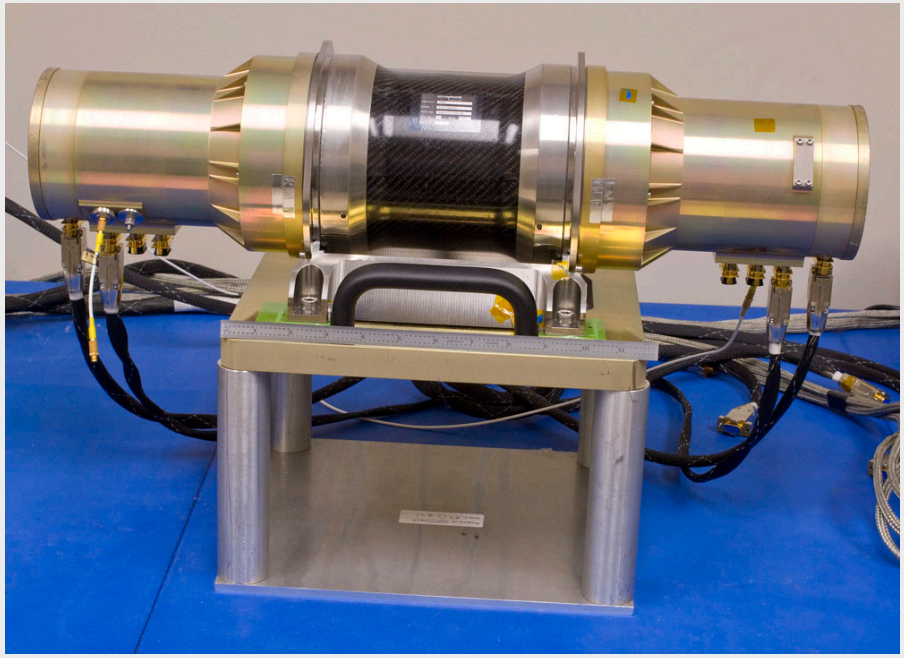
Others before launch: Giselher Lichti, Fred Berry, Ron Cantrell, Al English, Fred Kroeger, …




G070231-016

Fermi
Gamma-ray
Space Telescope





- Sodium iodide (NaI)
- 12.7 cm diameter X 1.27 cm thick
- 8 keV to 1 MeV

- Bismuth germanate (BGO)
- 12.7 cm diameter X 12.7 cm long
- 200 keV to 40 MeV

Fermi Gamma-ray Space Telescope

Very wide field-of-view / non-imaging / high background.

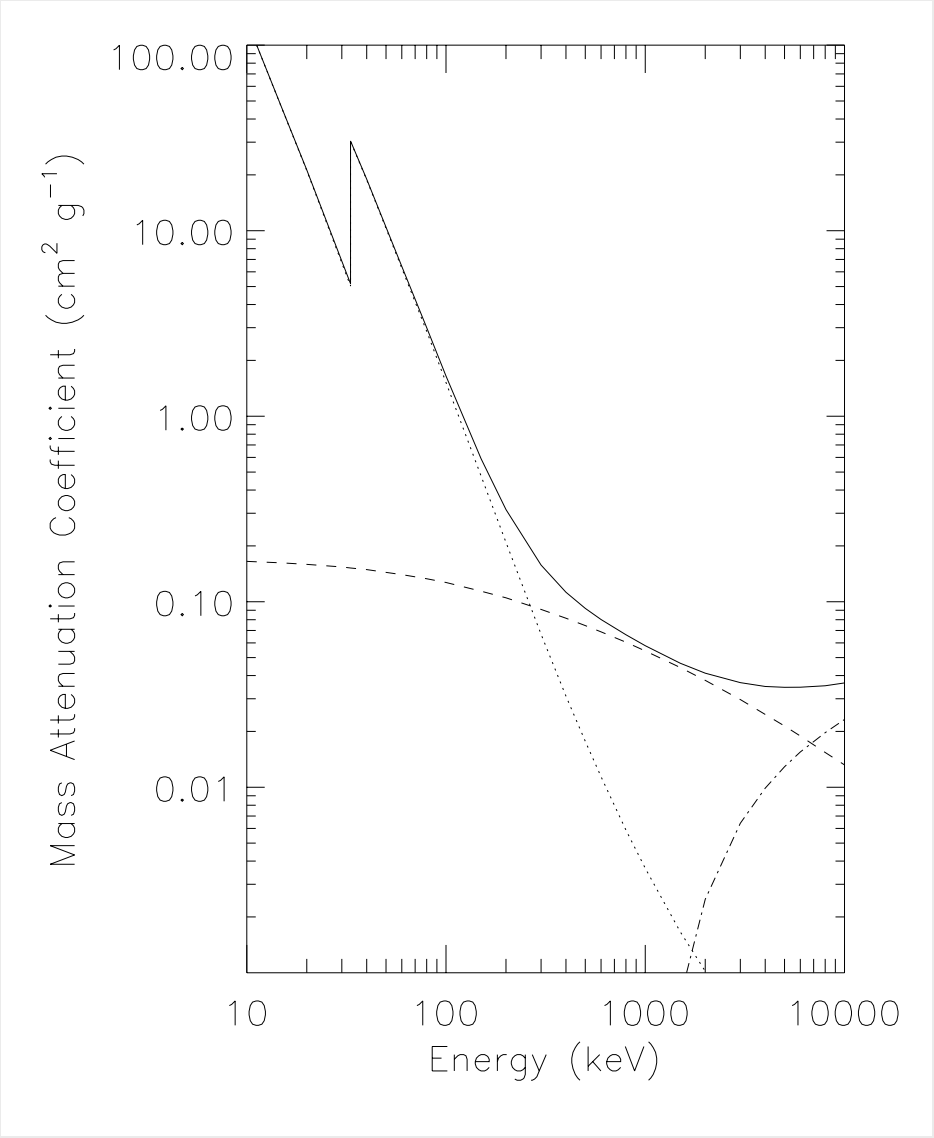
Well suited for transients such as GRBs, solar flares, SGRs, and TGFs.

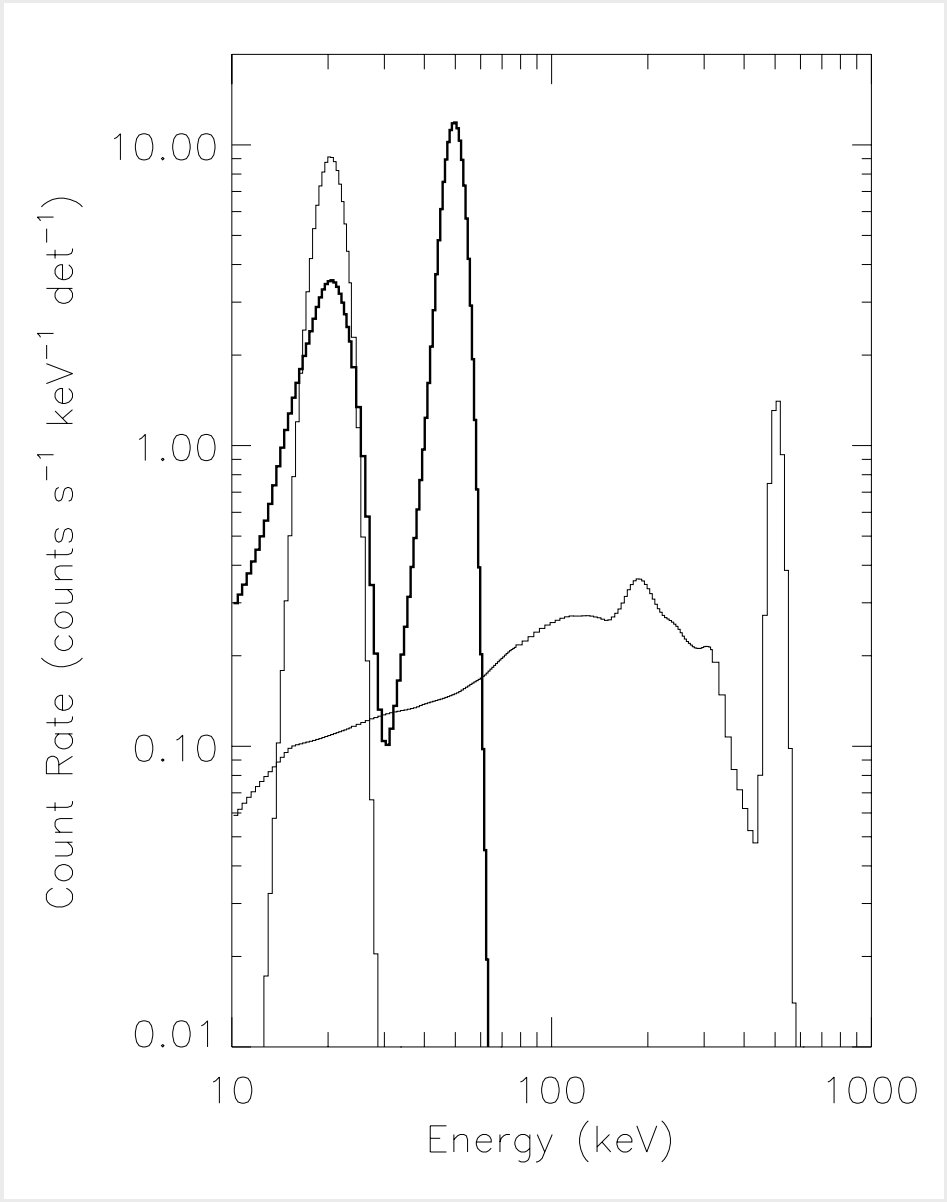
Persistent or long-timescale sources can be detected by timing analysis (pulsars) or detecting Earth occultation steps.

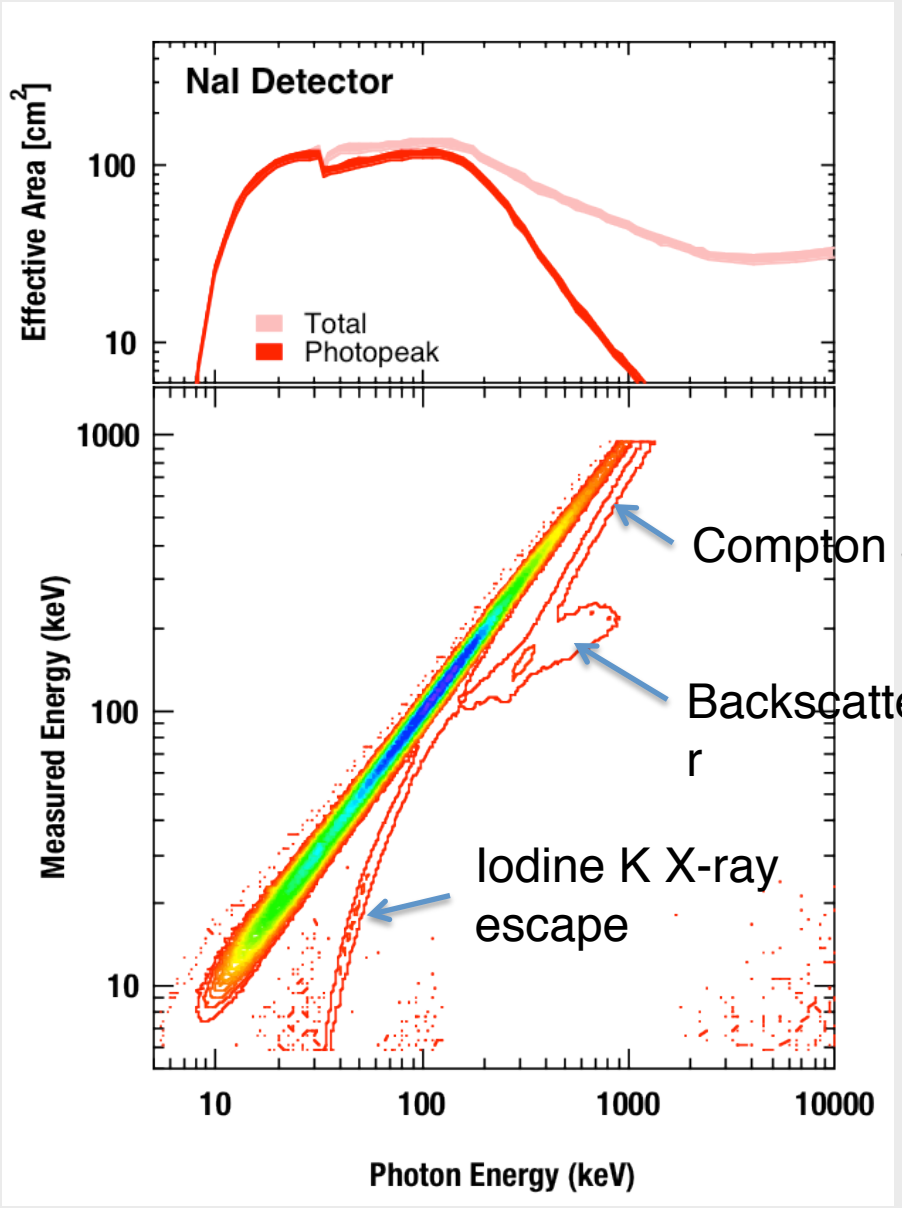
71 AGN are being monitored. There are 12 clear detections:

- Seyfert 2 galaxies:
  - NGC 1275
  - NGC 2110
  - NGC 4388
  - Cen A
  - NGC 5252
  - Circinus Galaxy
  - NGC 5506
- Seyfert 1 galaxies:
  - NGC 4151
  - IC 4329A)
- radio galaxy: IGR J21247+5058)
- quasars:
  - 3C 273
  - 3C 454.3

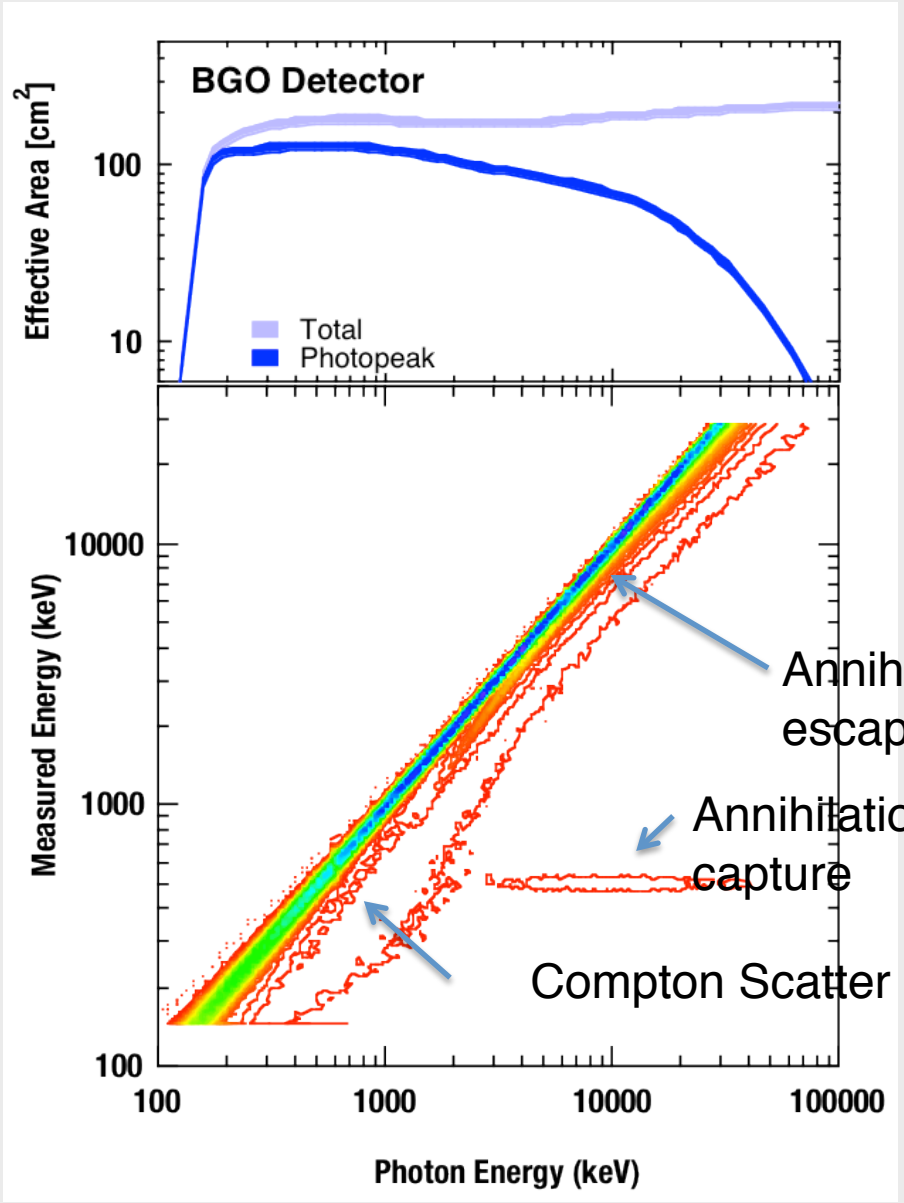
Mass attenuation coefficient μ:
T/T0 = exp (-μx),
where
x is the column density of NaI traversed in g cm^{-2}.




10.00
1.00
0.10
0.01
Count Rate (counts s^{-1} keV^{-1} det^{-1})
10
100
1000
Energy (keV)


NaI Detector
Effective Area [cm^2]
100
10
Total
Photopeak
1000
100
10
Measured Energy (keV)
Compton scatter
Backscatte
r
Iodine K X-ray
escape
10
100
1000
10000
Photon Energy (keV)

R. M. Kippen


BGO Detector
Effective Area [cm^2]
100
10
Total
Photopeak
Measured Energy (keV)
10000
1000
100
100
1000
10000
100000
Photon Energy (keV)
Annihilation escape
Annihilation capture
Compton Scatter

R. M. Kippen

Count spectrum (binned)

=

DRM X photon model

so:

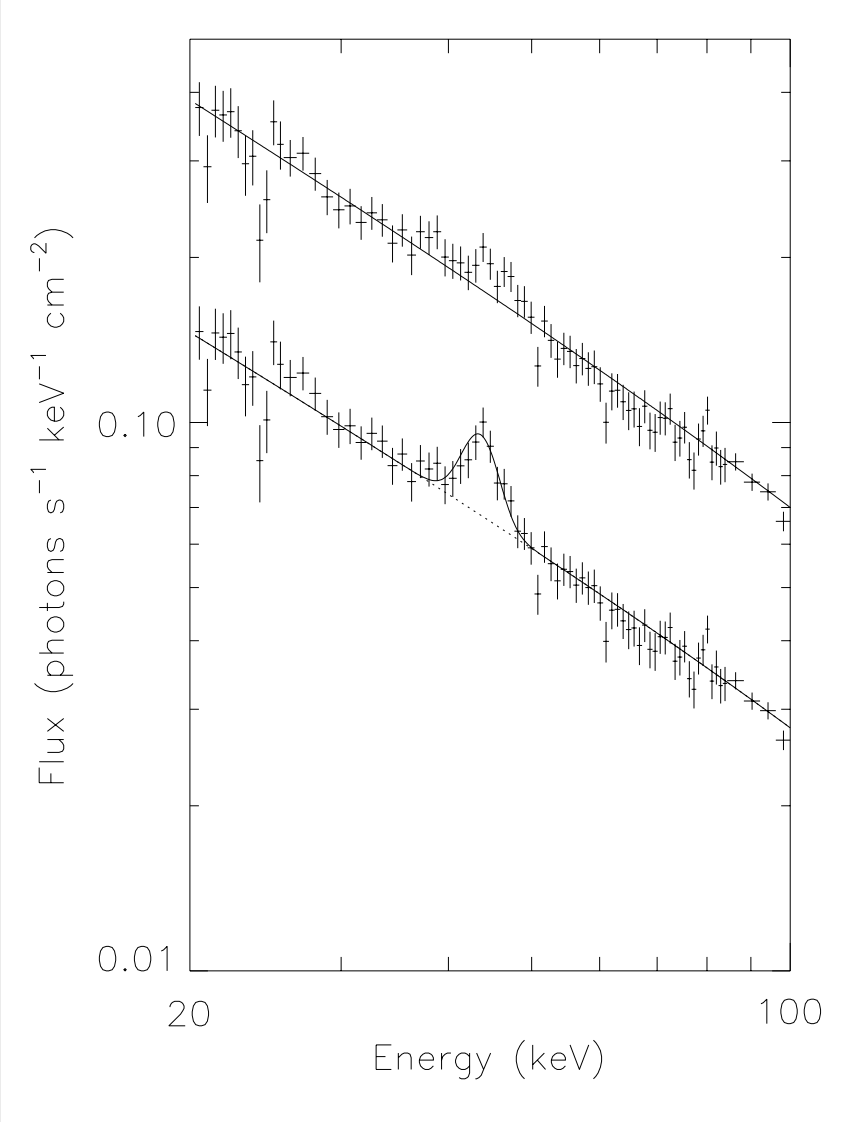
Photons = DRM^{-1} X Data ?

Forward-folding fitting

1) Assume a parameterized photon model.
2) Select a fitting statistic – likelihood or C-Stat (or χ^2)

3) Calculate the count model using the DRM / IRF,
4) Calculate the fitting statistics,
5) Change the photon model parameters to improve the fitting statistic,
6) Repeat steps 3 to 5 to optimize the model.

7) The answer is based upon the model that you assumed – the process cannot automatically find the true model.

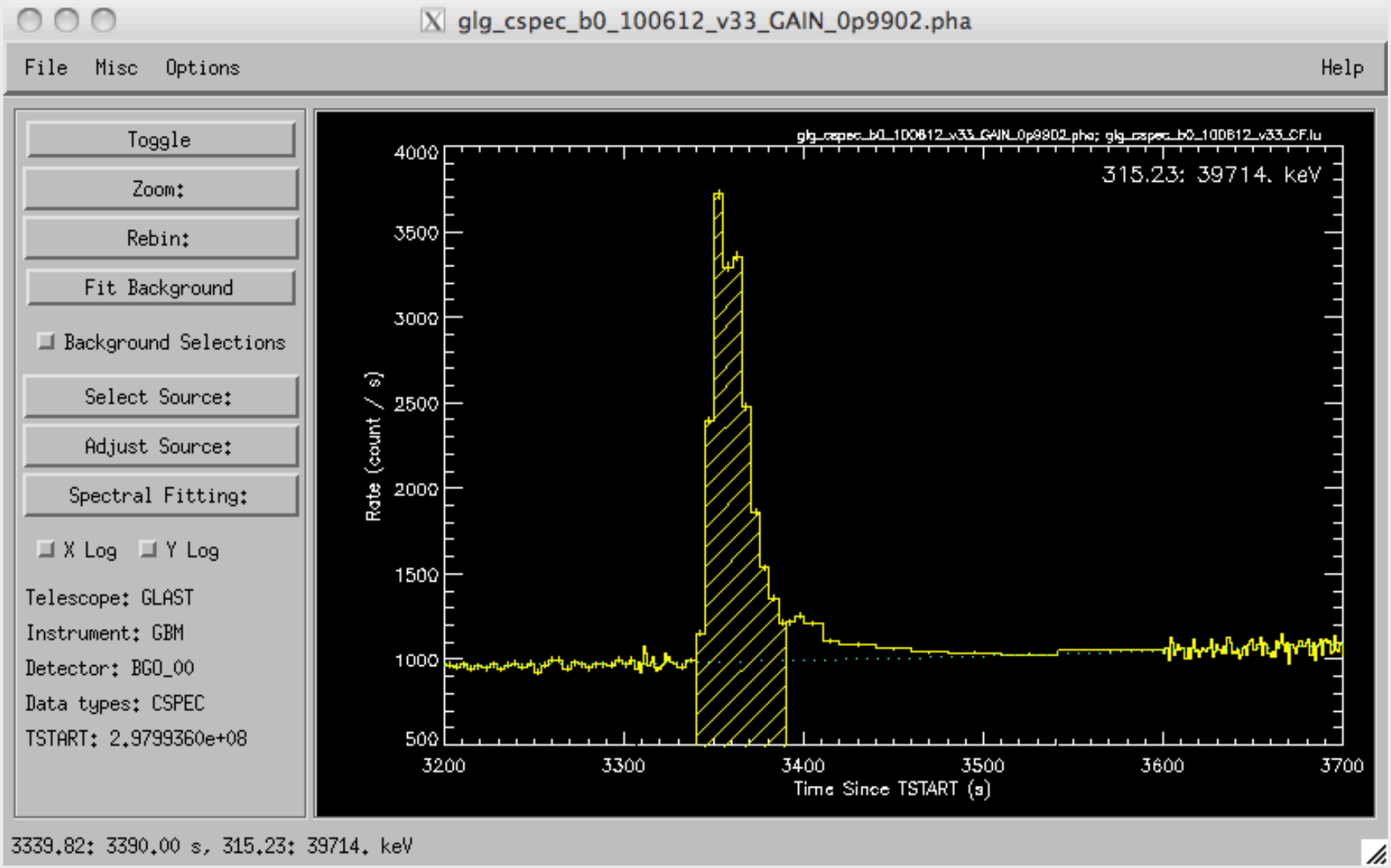


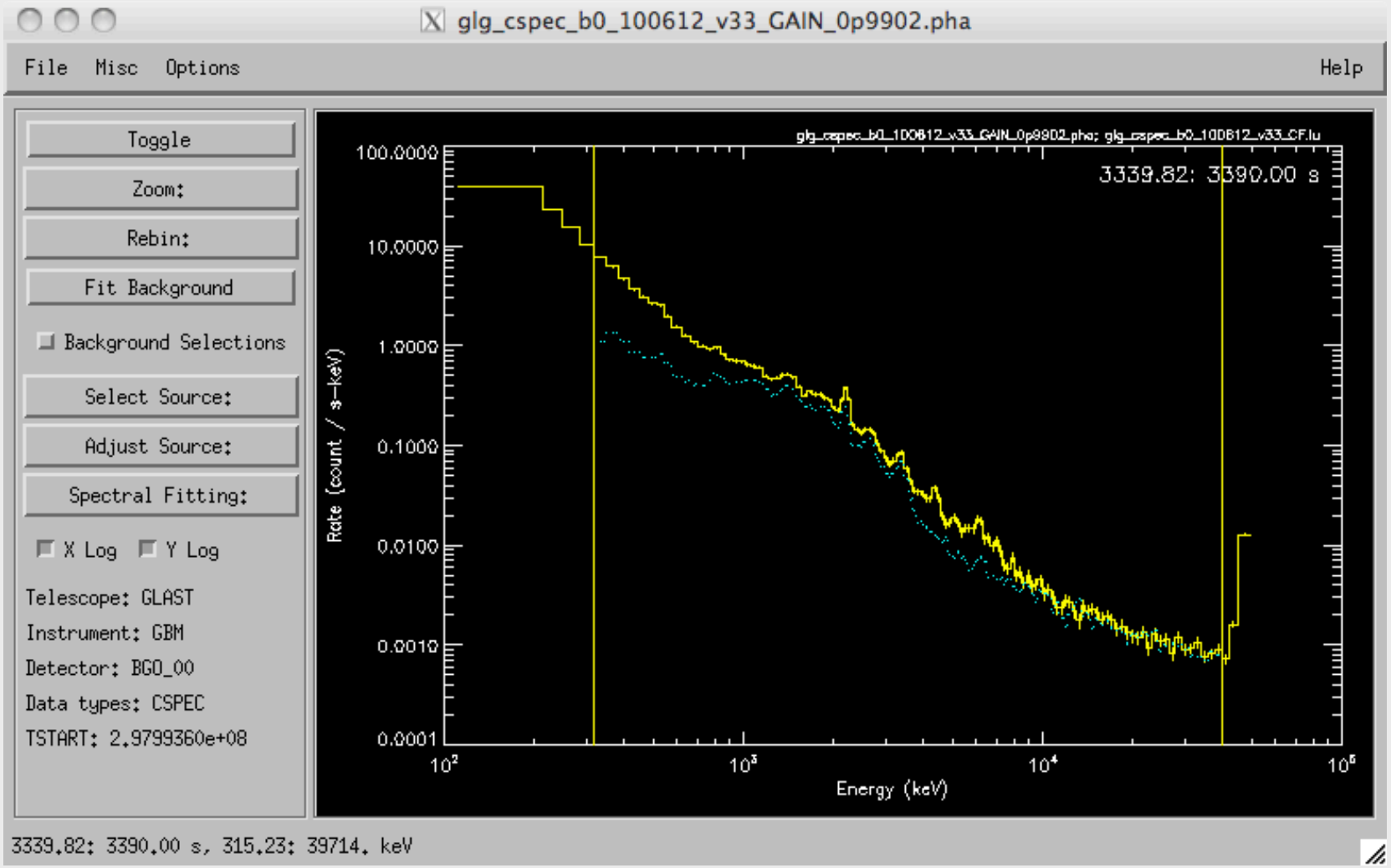
What not do do!

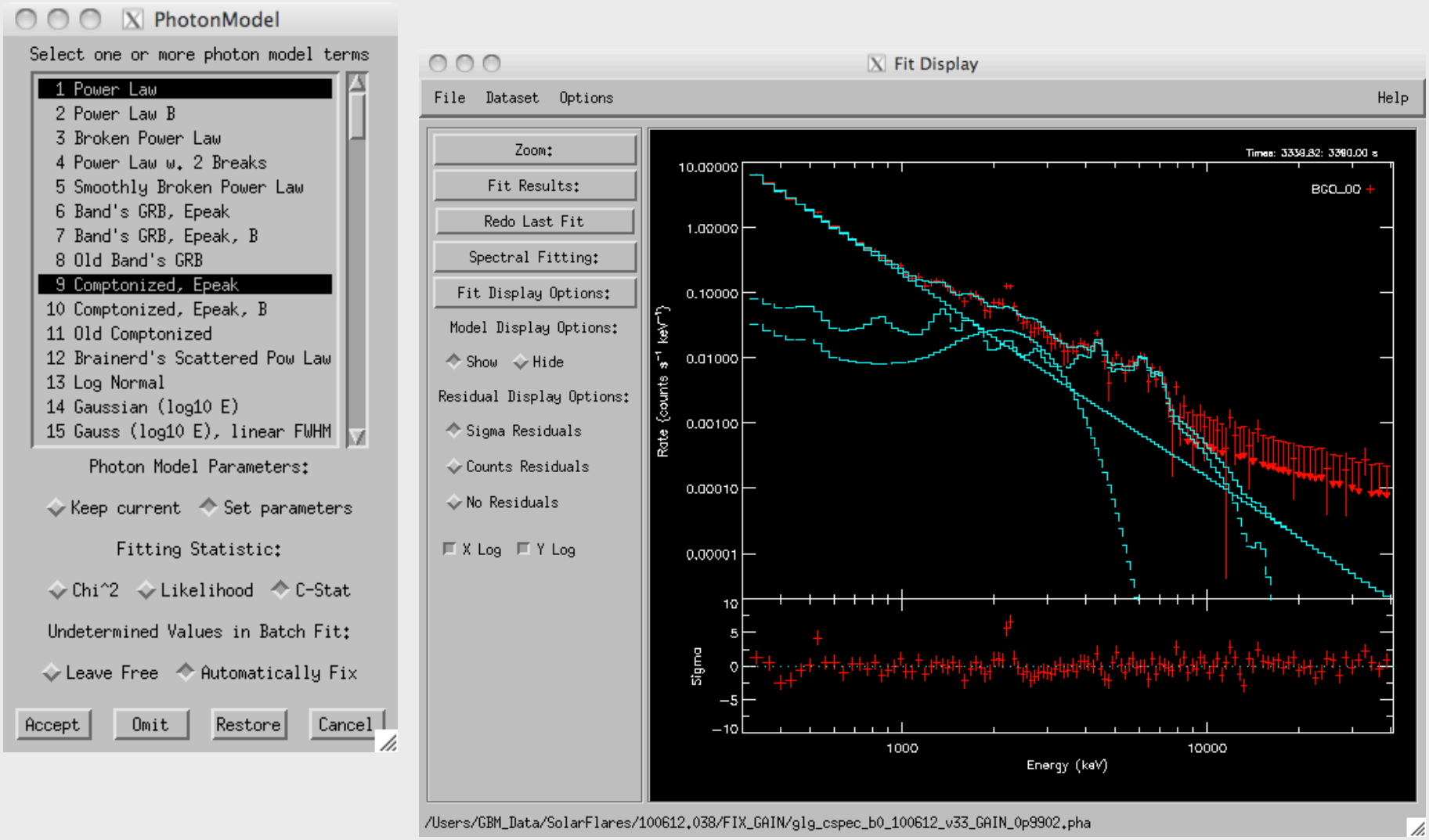
GBM Datatypes

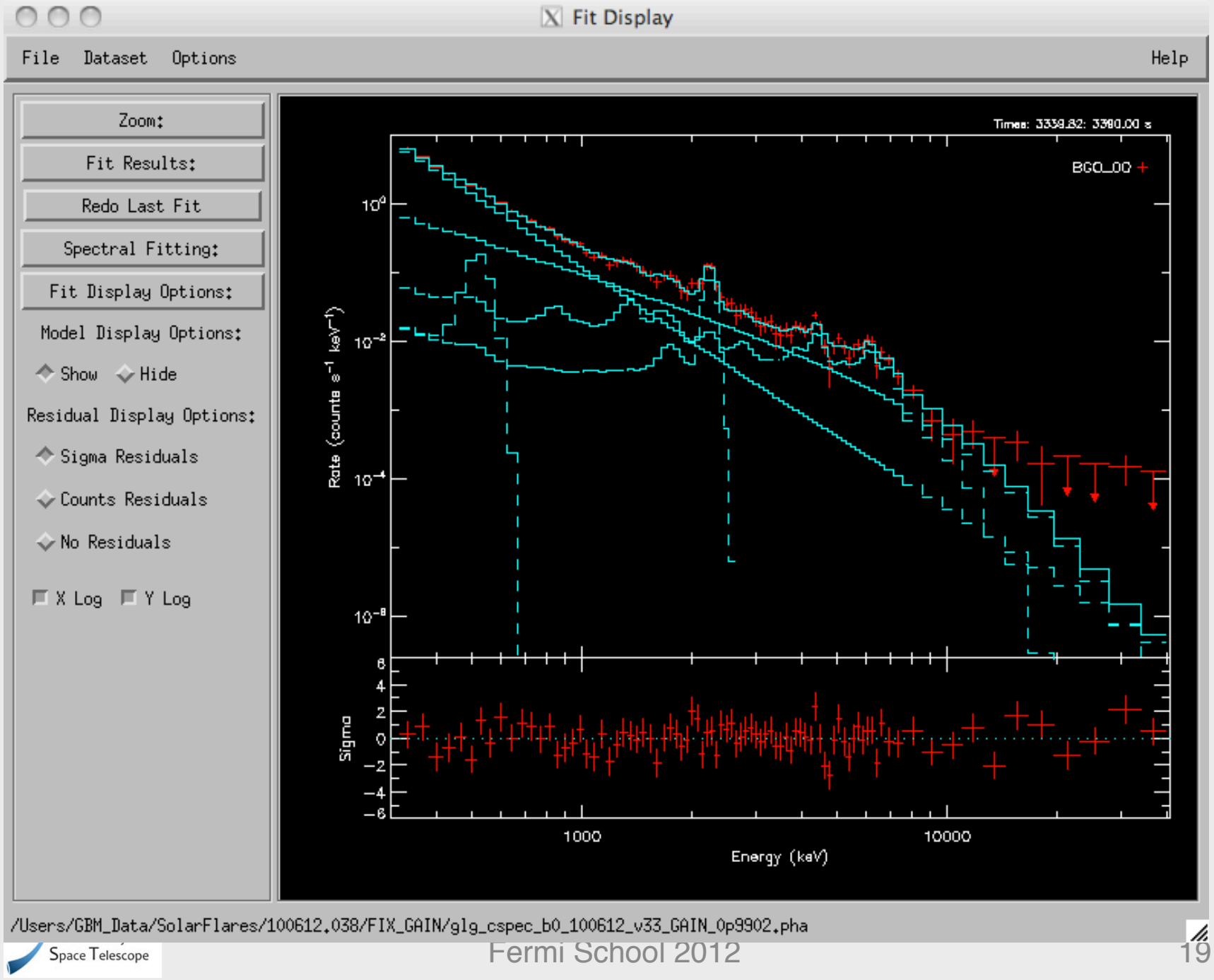
GBM datatypes: designed to meet a stringent telemetry requirement. Currently 2% of the mission volume.

- Triggered:
  - CSPEC: 128 channels, binned at 1.024 s
  - CTIME: 8 channels, binned at 0.064 s
  - TTE: 128 channels, individual counts at 2 μs
- Continuous / daily:
  - CSPEC: 128 channels, binned at 4.096 s
  - CTIME: 8 channels, binned at 0.256 s
  - *NEW*: TTE: 128 channels, individual counts at 2 μs


glg_cspec_b0_100612_v33_GAIN_0p9902.pha
File
Misc
Options
Help
Toggle
Zoom:
Rebin:
Fit Background
Background Selections
Select Source:
Adjust Source:
Spectral Fitting:
X Log
Y Log
Telescope: GLAST
Instrument: GBM
Detector: BGO_00
Data types: CSPEC
TSTART: 2.9799360e+08
glg_cspec_b0_100612_v33_GAIN_0p9902.pha; glg_cspec_b0_100612_v33_CF.lu
315.23: 39714. keV
Rate (count / s)
4000
3500
3000
2500
2000
1500
1000
500
3200
3300
3400
3500
3600
3700
Time Since TSTART (s)
3339.82: 3390.00 s, 315.23: 39714. keV


glg_cspec_b0_100612_v33_GAIN_0p9902.pha
File
Misc
Options
Help
Toggle
Zoom:
Rebin:
Fit Background
Background Selections
Select Source:
Adjust Source:
Spectral Fitting:
X Log
Y Log
Telescope: GLAST
Instrument: GBM
Detector: BGO_00
Data types: CSPEC
TSTART: 2.9799360e+08
glg_cspec_b0_100612_v33_GAIN_0p9902.pha; glg_cspec_b0_100612_v33_CF.lu
3339.82: 3390.00 s
100.0000
10.0000
1.0000
0.1000
0.0100
0.0010
0.0001
Rate (count / s-keV)
10^2
10^3
10^4
10^5
Energy (keV)
3339.82: 3390.00 s, 315.23: 39714. keV


PhotonModel
Select one or more photon model terms
1 Power Law
2 Power Law B
3 Broken Power Law
4 Power Law w. 2 Breaks
5 Smoothly Broken Power Law
6 Band's GRB, Epeak
7 Band's GRB, Epeak, B
8 Old Band's GRB
9 Comptonized, Epeak
10 Comptonized, Epeak, B
11 Old Comptonized
12 Brainerd's Scattered Pow Law
13 Log Normal
14 Gaussian (log10 E)
15 Gauss (log10 E), linear FWHM
Photon Model Parameters:
Keep current
Set parameters
Fitting Statistic:
Chi^2
Likelihood
C-Stat
Undetermined Values in Batch Fit:
Leave Free
Automatically Fix
Accept
Omit
Restore
Cancel
Fit Display
File
Dataset
Options
Help
Zoom:
Fit Results:
Redo Last Fit
Spectral Fitting:
Fit Display Options:
Model Display Options:
Show
Hide
Residual Display Options:
Sigma Residuals
Counts Residuals
No Residuals
X Log
Y Log
Times: 3339.82: 3380.00 s
BGO_00
Rate (counts s-1 keV-1)
10.00000
1.00000
0.10000
0.01000
0.00100
0.00010
0.00001
Sigma
10
5
0
−5
−10
1000
10000
Energy (keV)
/Users/GBM_Data/SolarFlares/100612.038/FIX_GAIN/glg_cspec_b0_100612_v33_GAIN_0p9902.pha


Fit Display
File
Dataset
Options
Help
Zoom:
Fit Results:
Redo Last Fit
Spectral Fitting:
Fit Display Options:
Model Display Options:
Show
Hide
Residual Display Options:
Sigma Residuals
Counts Residuals
No Residuals
X Log
Y Log
Times: 3338.82: 3380.00 s
BGO_00
Rate (counts s^{-1} keV^{-1})
Sigma
Energy (keV)
1000
10000
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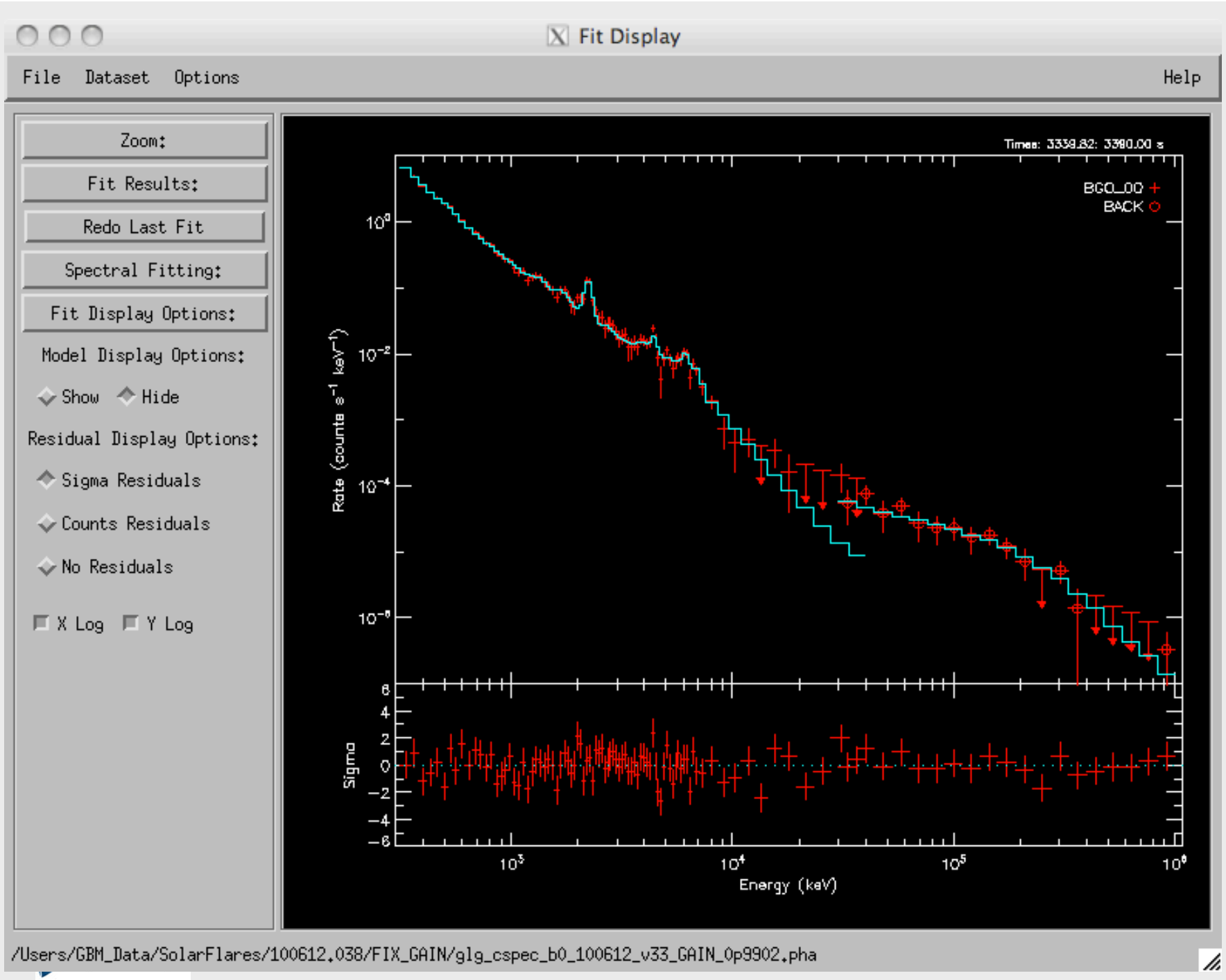
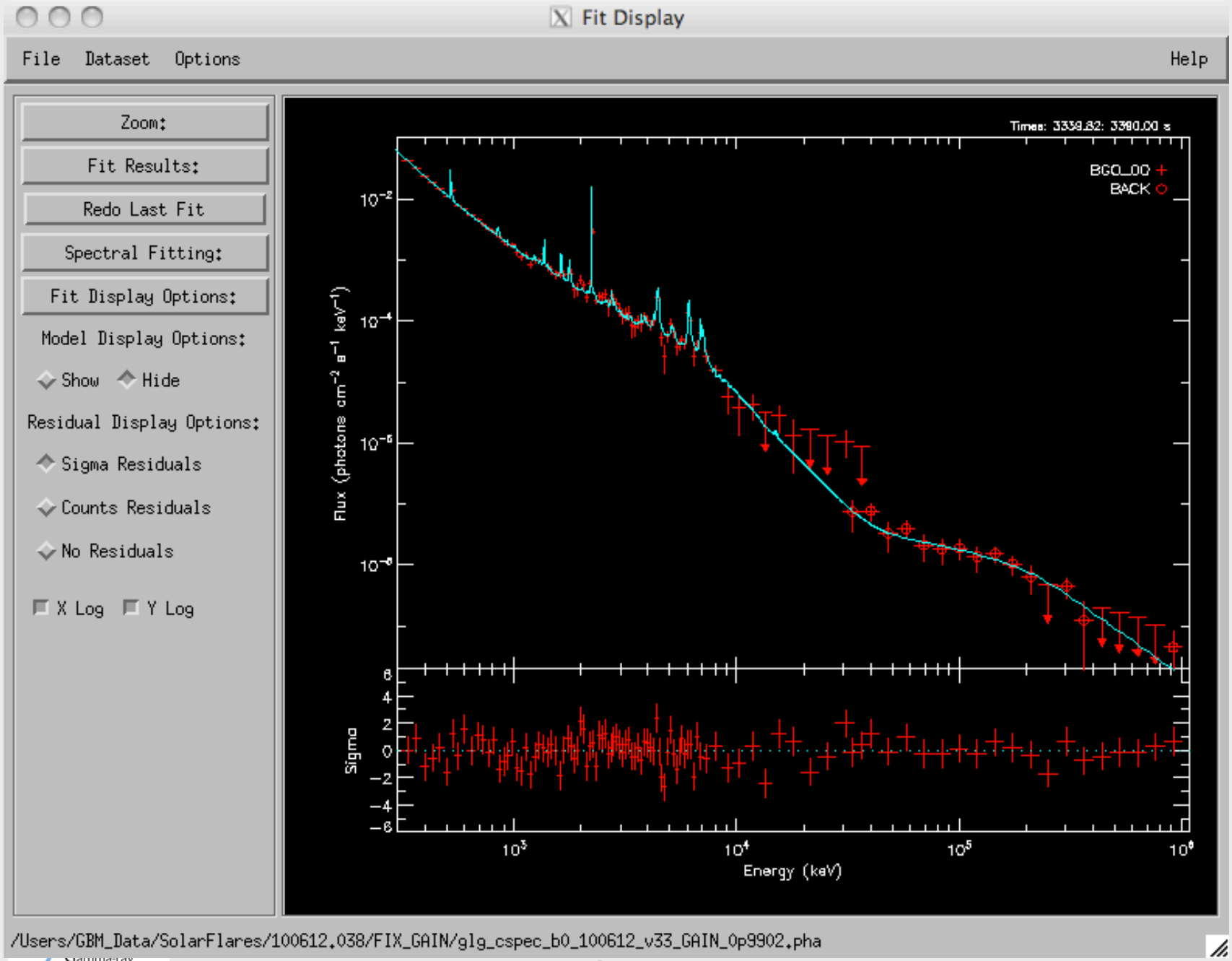

Fit Display
File
Dataset
Options
Help
Zoom:
Fit Results:
Redo Last Fit
Spectral Fitting:
Fit Display Options:
Model Display Options:
Show
Hide
Residual Display Options:
Sigma Residuals
Counts Residuals
No Residuals
X Log
Y Log
Time: 3338.82: 3380.00 s
BGO_00
BACK
Rate (counts s^{-1} keV^{-1})
Sigma
Energy (keV)
/Users/GBM_Data/SolarFlares/100612.038/FIX_GAIN/glg_cspec_b0_100612_v33_GAIN_0p9902.pha


Fit Display
File
Dataset
Options
Help
Zoom:
Fit Results:
Redo Last Fit
Spectral Fitting:
Fit Display Options:
Model Display Options:
Show
Hide
Residual Display Options:
Sigma Residuals
Counts Residuals
No Residuals
X Log
Y Log
Time: 3338.82: 3380.00 s
BGO_00
BACK
Flux (photons cm^{-2} s^{-1} keV^{-1})
Sigma
Energy (keV)
/Users/GBM_Data/SolarFlares/100612.038/FIX_GAIN/glg_cspec_b0_100612_v33_GAIN_0p9902.pha