# Gamma-Ray Burst Spectral Analysis with the SAE

**Prepared by Yasushi Ikebe – GSSC**

**Presented by Dirk Petry – GSSC**

**Assistance from David Band – GSSC**

# Goal

- In this presentation we show how the existing SAE tools can be used for binned gamma-ray burst spectral analysis.
- We assume that the user knows the location and time of the burst.
- Thus, the analysis we demonstrate starts with:

  **Start and stop time**

  **RA and DEC of the burst**

- And ends with:

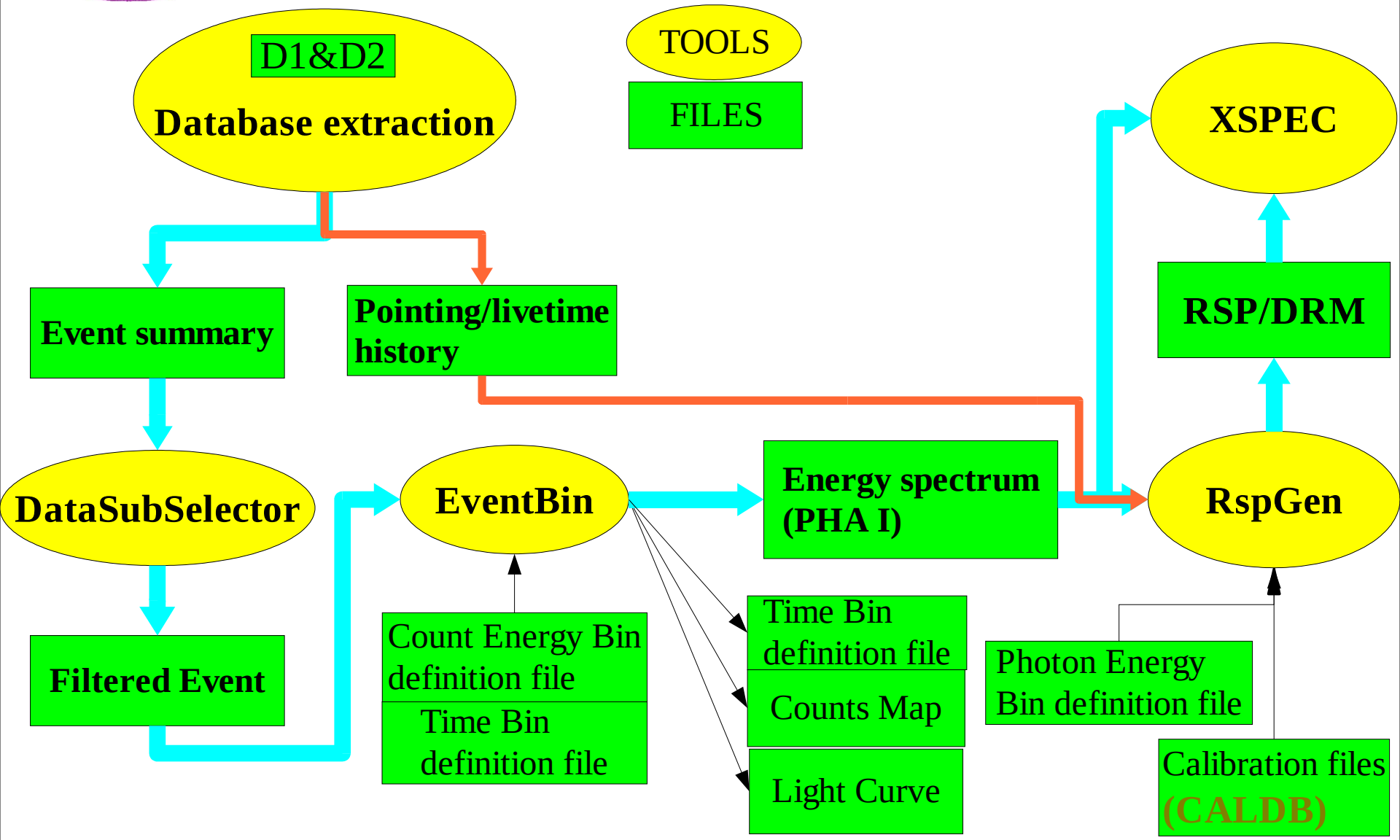
  **A spectral fit to the burst**

- An expanded tutorial can be found on the website **http//glast.gsfc.nasa.gov/ssc/dev/binned_analysis/GRB_spectra_DC1.html**

# But Where is the Burst?

- The SAE will not include any formal burst detection tools
- Your alternatives:
  - Use EventBin (event binning tool) to create a lightcurve and a sky count map, and locate the event.
    - The SAE currently does not have a dedicated tool for display. Use fv or fplot in FTOOLS, and/or DS9
  - Use DS9 to read event fits file, bin the data, and display it
  - Write your own tools
    - The on-line tutorial tells you how to pull FT1 into IDL
- After launch
  - The GBM will detect and localize bursts, and provide lightcurves and other burst information
  - The LAT will have detection software onboard and on the ground (details TBD)

# Schematic Outline of Analysis Flow



# Extract Data

- Use the U1 website to extract the necessary photon and livetime/pointing data (see talk by Tom Stephens), which have to be extracted from a circular region centered on the object.
- Necessary input:
  - Burst position (RA, DEC)
  - Extraction radius
  - Start and stop time
- FTP resulting data files to your analysis directory
- With DataSubSelector, apply the standard cuts (background, PSF, and energy resolution).
  Do not perform any additional selections, since RspGen (response matrix calculator) cannot handle complicated data screening criteria

# Bin the Photons into Spectra

- Use EventBin to bin the photons into a series of binned spectra. EventBin is part of SAE.
- Energy binning-user selected; a default is provided
- Time binning-choices:
  - User selected
  - Time bins of equal duration
  - Time bins with S/N in a given energy range greater than threshold
  - Bayesian Blocks binning (currently does not work)
- Input:
  - FT1 file with photons
  - FITS file with energy binning (default of '1024 channels in 30MeV-30GeV, equally spacing in log scale' is provided)
  - FITS file with time grid, if necessary
- Output:
  - One or a series of FITS files in PHA-I format

# Demonstration of EventBin

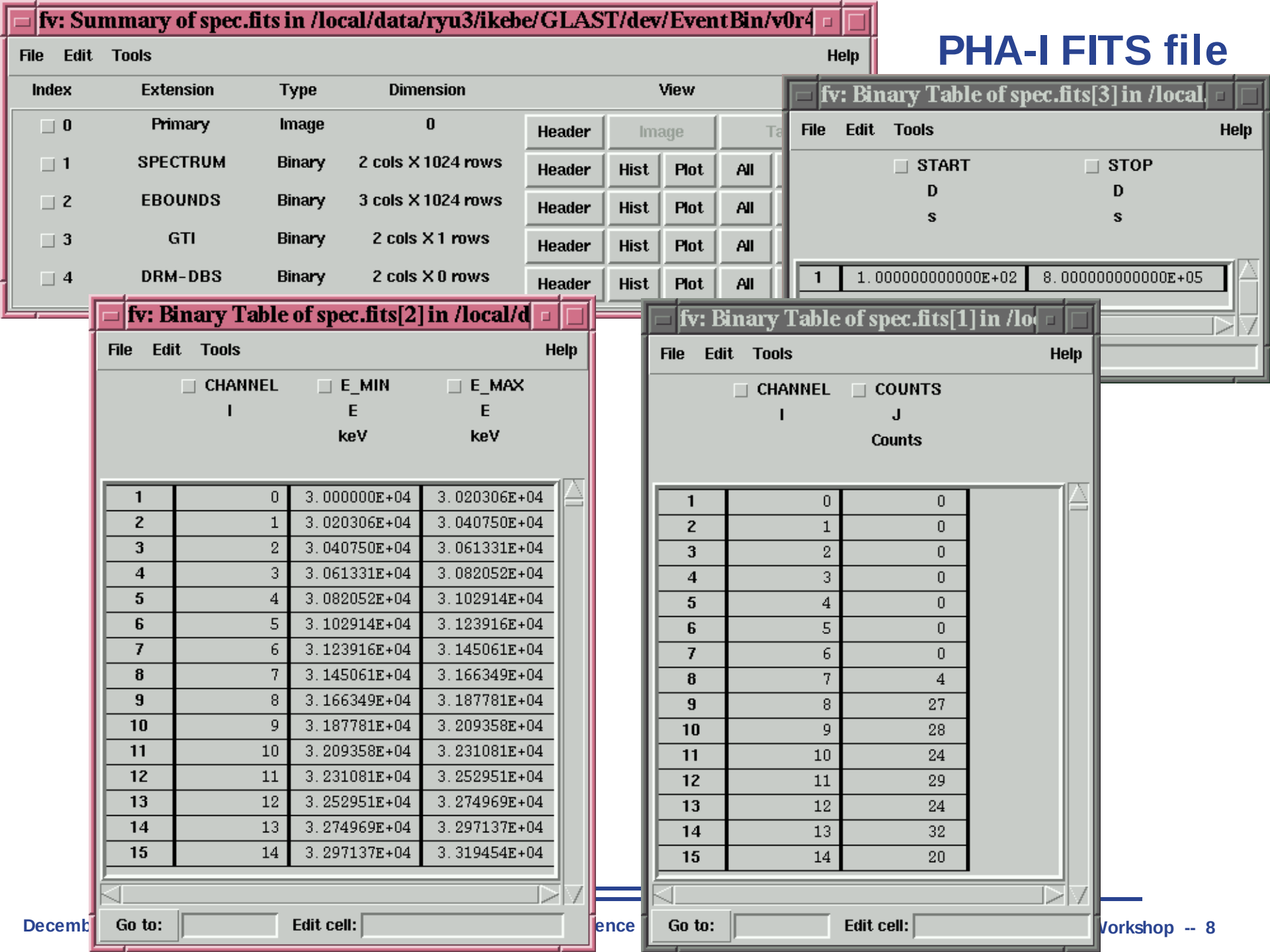
>test_EventBin.exe
Name of the Event Data File: [D1.fits] :U1WEB1121....53_D1_results.fits
Name of the output file: [spec.fits] :
Binning method (LC, PHA1, PHA2, SPEC): [PHA1] :
Name of the energy Bin File: [ChanEnergyBin.fits] : <-default provided
Algorithm for time bins calculation: (BAYESIAN, CONSTSNR, UNIFORM, USERBINS, NONE) [NONE] : <- one time bin
Start Time: [100] : 1000
Stop Time: [800000] : 2000

You'll find spec.fits

Algorithm for time bins calculation: (BAYESIAN, CONSTSNR, UNIFORM, USERBINS, NONE) [NONE] : UNIFORM
Name of the time bin file: [UniformTimeBin.fits] :
Start Time: [1] : 1000
Stop Time: [8.863475625000000E+05] : 2000
Delta Time: [100000] : 100

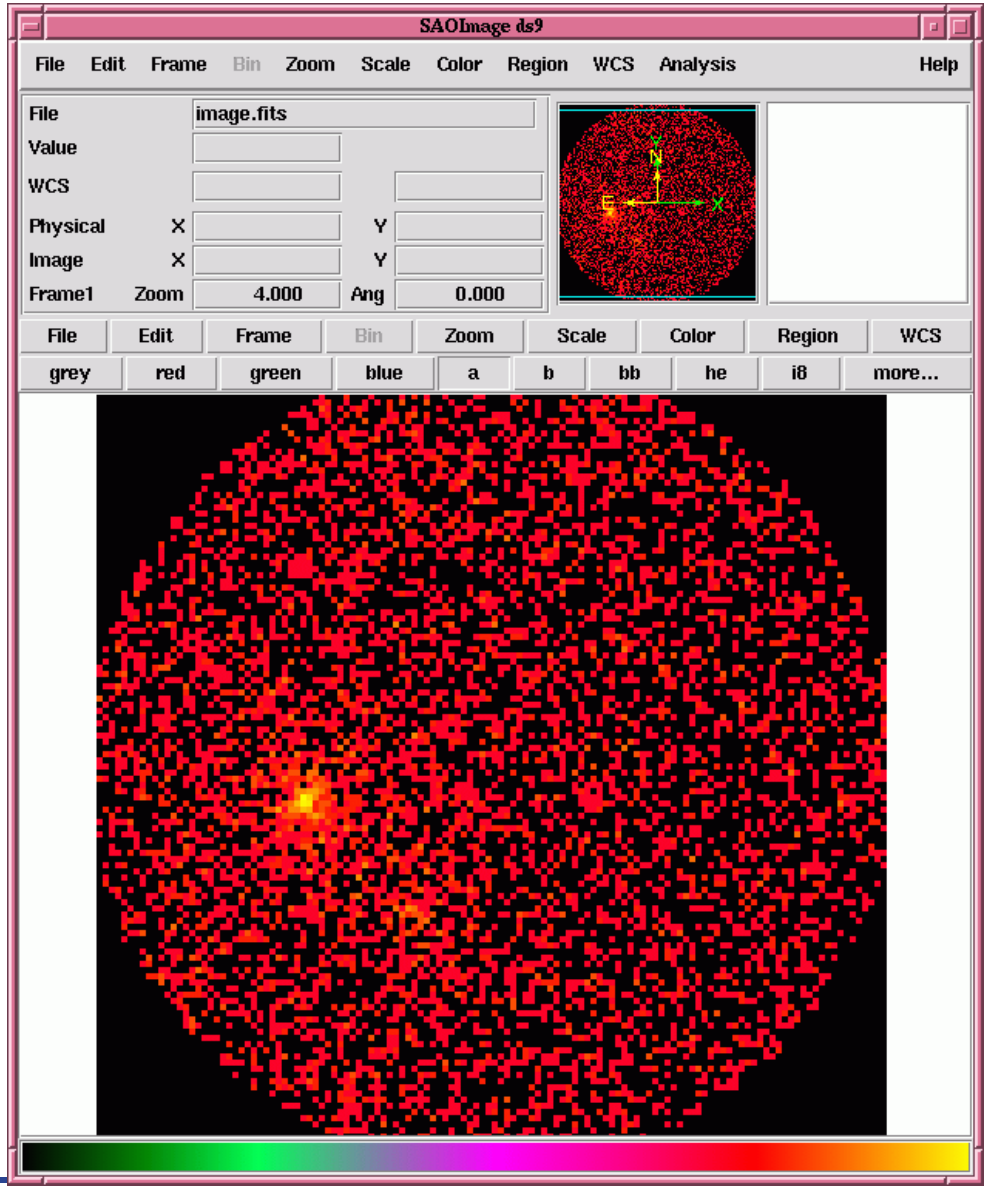
You'll find spec1.fits, spec2.fits, ,,,, spec10.fits, and UniformTimeBin.fits

# PHA-I FITS file



# Digression: Counts Map

**EventBin creates Counts Map, displayed with ds9 here**



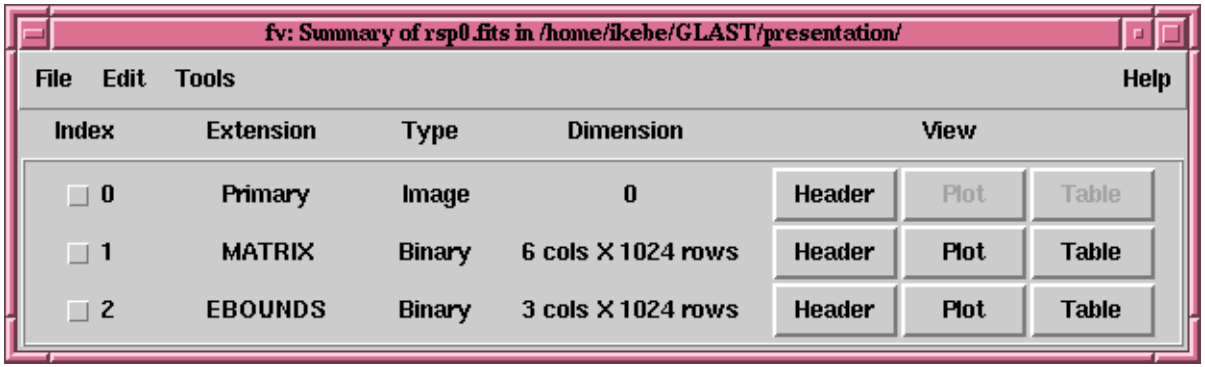
# Create Response Matrices

- The count spectra in the PHA files are functions only of measured count energy. The spectral models that will be fit are fluxes as a function of energy.
- Use RspGen to collapse the LAT response (many photon parameters ⇒ many count observables) into RSP matrix (photon energy ⇒ count energy). RspGen is part of SAE.
- RspGen calculates a response at the center of the time bin, i.e. change of the satellite attitude is not taken into account
- Input:
  - Spectrum FITS file in PHA-I format
  - FITS file with energy binning for spectral model (default of '1024 channels in 30MeV-30GeV, equally spacing in log scale' is provided)
- Output:
  - Response Matrix FITS file in the RMF format

# Demonstration of RspGen

**>test_Rspgen.exe**
**Name of the PHA Data File: [spec.fits] :**
**Name of the energy Bin File: [StdEnergyBin.fits] :**
**Name of the Spacecraft Data File: [D2.fits] :**
**U1WEB1121....53_D2_results.fits**
**Name of the output file: [rsp.fits] :**

**The file 'rsp0.fits' will appear in the output directory**



# Fit Spectra

- Use XSPEC to fit spectra
- XSPEC is part of XANADU, HEASARC suite of advanced analysis tools. XSPEC must be downloaded and installed separately from the SAE. See

  http://heasarc.gsfc.nasa.gov/docs/xanadu/xanadu.html
- XSPEC currently is supported only on UNIX platforms; it may eventually run on Windows.
- XSPEC includes a rich set of spectral models. Relevant models for GLAST are:
  - *pegpwrlw:* Pegged power law with adjustable pivot energy
  - *grbm:* 4 parameter GRB model. Typically used in GBM energy band, but may be useful for Compton component.
- Eventually scripts will be provided to automate fitting of series of spectra

# Demonstration of XSPEC (1)

```
Ikebe@debian> xspec

        Xspec 11.2.0    09:03:32 06-Nov-2003

 For documentation, notes, and fixes see  http://xspec.gsfc.nasa.gov/

 Plot device not set, use "cpd" to set it

 Type "help" or "?" for further information
XSPEC>cpd /xw              <--- create a plottong device
XSPEC>data spec.fits       <--- read a spectrum file
 Net count rate (cts/s) for file   1  8.0638E-03+/-  1.0272E-04
   1 data set is in use
XSPEC>resp rsp0.fits       <--- read a response file
XSPEC>ignore **-4e4 1e7-**   <--- choose energy range in keV
```

# Demonstration of XSPEC (2)

```
XSPEC>model pegpwrlw  <---- define model
  Model:  pegpwrlw[1]
Input parameter value, delta, min, bot, top, and max values for ...
1:pegpwrlw:PhoIndex>2.0
2:pegpwrlw:eMin>1e5
3:pegpwrlw:eMax>1e5
4:pegpwrlw:norm>1e-3

XSPEC>statistic cstat (or chi)   <---- select statistics

XSPEC>fit <---- start fitting
  Model:  pegpwrlw[1]
  Model Fit Model Component  Parameter  Unit     Value
  par   par comp
    1    1    1   pegpwrlw   PhoIndex          2.230     +/-  0.1316E-01
    2    2    1   pegpwrlw   eMin     keV      1.0000E+05 frozen
    3    3    1   pegpwrlw   eMax     keV      1.0000E+05 frozen
    4    4    1   pegpwrlw   norm             1.0251E-03 +/-  0.2562E-04
------------------------------------------------------------------------------
 C-statistic =      876.4286     using   818 PHA bins
```

# Demonstration of XSPEC (3)

**XSPEC>setplot energy**
**XSPEC>plot ld**