GSpec Version 0.9.1

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Contents

1 System Requirements

- Tested on Mac OS X 10.11+ and Linux

- Python 3.x and Tkinter

- XSPEC (for spectral fitting) preferable v12.10+

2 Included in the Install Package

- GSpec

- GBM Trigger Downloader

- *GBM Data Tools API (Future Release)*

3 Installation

Note: It is recommended that a virtual Python environment is created, but it not required. Information on how to make a virtual environment can be found at:
Regular Python 3: `https://docs.python.org/3/tutorial/venv.html`
Anaconda Python 3: `https://conda.io/docs/user-guide/tasks/manage-environments.html`

Be sure to activate the virtual environment prior to installing GBM data tools. If you installed GBM data tools within a virtual environment, then you must activate it prior to using the software. If you are not using a virtual environment or Anaconda Python, then you may need to install the software as administrator using 'sudo' on Unix like environments or by using a Windows command window running as administrator. Also, make sure that the pip you are using is associated with Python 3.

For regular or Anaconda Python:
In your terminal, type: **pip3 install gbm-data-tools-0.9.tar.gz**

4 Launching GSpec

To launch GSpec do the following:

- Ensure that the python 3 scripts directory is in your path.

- In your terminal, type **gspec**

- To launch the GBM Trigger Downloader, type **getgbmdata**

5   Uninstallation

In your terminal, type: **pip3 uninstall gbm-data-tools**

6   GSpec Help

6.1   GSpec Window

This is the main entry into GSpec. Here, data files can be loaded and removed from GSpec.

6.1.1   GUI Functions

- **Load**: Load one or more data files

- **Display**: Display selected data file

- **Hide**: Hides the selected data file viewer

- **Delete**: Removes the selected data file from GSpec

6.1.2   Main Menu Items

- **GSpec**:

    - **About...**: Show splash screen
    - **Quit**: Quit GSpec

- **File**:

    - **Load Data...**: Load one or more data files
    - **Load From Lookup...**: Load a data set from a GSpec lookup file

- **Options**:

    - **Display**: Display selected data file
    - **Hide**: Hides the selected data file viewer
    - **Delete**: Removes the selected data file from GSpec

- **Windows**:

    - **Cascade Windows**: Cascade all of the open GSpec windows
    - **Tile Windows**: Tile all of the open GSpec windows
    - **<window name>**: Brings the selected window to the front and resizes to default

6.2 Data Viewer Window

This is the display for data loaded into GSpec and where most of the action takes place. The user can view the lightcurve and spectrum, rebin the data, fit the background, and identify source regions for spectral analysis.

6.2.1 GUI Functions

- **Show Spectrum/Show Lightcurve**: Toggles between the lightcurve and spectrum views

- **Rebin Data**: Allows the user to rebin the lightcurve or spectrum. For some options, a dialog box will appear requesting the required parameter for the rebinning and additionally may allow the user to apply the binning to the full data range or to make a custom interactive selection over which to apply the rebinning.

    - **Full Resolution**: Restore the data to the original full resolution
    - **Temporal Resolution**: Bin/Rebin the data to desire temporal resolution. If rebinning natively binned data, the data will be binned to the nearest resolution not exceeding the user-defined resolution. Only available for lightcurve binning.
    - **Signal to Noise**: Bin/Rebin the data such that each bin in the user-selected range meets or exceeds the user-defined S/N threshold. This requires that a background fit has already been performed. Only available for lightcurve binning.
    - **Combine Source Intervals**: If one or more source selections have been made, this rebins each contiguous selection into a single bin. Only available for lightcurve binning.
    - **Combine Into Single Bin**: Combines the user-selected range of data into a single bin
    - **Combine by Factor**: Rebins the data by an integer factor of bin

- **Fit Background**: Fit a polynomial to user-selected background regions. Typical use is to select a region of background before the signal of interest and a region after the signal of interest. Then a 0th-4th order polynomial can be chosen to fit the selected data. The polynomial fit will be interpolated in between the selected background regions and extrapolated beyond the background regions. The fit is performed independently in each energy channel using a 2-step process minimizing the effect that low-count statistics has on non-linear least squares minimization. A plot showing the goodness-of-fit for each energy channel is shown after the fit.

- **Source Selection**: Allows the user to select a region of data as source signal or clear previous selections

    - **Source Interactive**: Allow the user to interactively select source regions.

– **Source by S/N**: Select all of the bins above a user-defined S/N threshold. The user may choose to select a custom range over which only the bins exceeding the threshold will be selected. This requires that a background fit exists.

– **Clear Selections**: Clear all source selections

- **Adjust Source**: Do fine adjustments on the source selection

  – < **Shift Selection**: Shift the source selections one bin to the left

  – > **Shift Selection**: Shift the source selections one bin to the right

  – < **Left Selection**: Shift the left boundary of the selection one bin to the left

  – > **Left Selection**: Shift the left boundary of the selection one bin to the right

  – < **Right Selection**: Shift the right boundary of the selection one bin to the left

  – < **Right Selection**: Shift the right boundary of the selection one bin to the right

- **Push Selections**: Push certain selection/settings from the current display to the other loaded displays

  – **Temporal Binning**: Push the temporal binning to the other displays

  – **Background**: Push the background selection regions to the other displays. This results in automatic fitting of the background for the other displays

  – **Source Selection**: Push the source selections to the other displays

  – **View Range**: Push the view range to the other displays

  – **All of the Above**: Push the temporal binning, background selections, source selections and view range to the other displays

- **Spectral Fitting**: Perform spectral fitting. This requires that a background fit and a source selection exists.

  – **Fit Selection...**: Do a single spectral fit, integrating over all of the source selections

  – **Batch Fit Selections...**: Do a spectral fit of each time bin in the source selections

6.2.2 Main Menu Items

- **File**:

  – **Header...**: Select one of the data file extensions to display the corresponding header information

  – **Lookup...**: Dropdown of actions for lookup files

    ∗ **Save Lookup**: Saves a lookup file for the loaded data set

* **Read Lookup**: Read a lookup file for the current display. Can read in GSpec or RMfit lookup files
* **File Content**: Display the current lookup of the display
* **Erase Current**: Revert back to the original data display with no user adjustments
  – **Response...**: Dropdown of actions for response files
    * **Load Response**: Load a response file associated with the data file
    * **Remove Response**: Remove a loaded response file
  – **Screenshot**: Take a screenshot of the current display
  – **Dismiss**: Dismiss (hide) the display without removing the data file from GSpec

* **Export**:

  – **Selected Data to XSPEC Format...**: Export the data files to .bak, .pha, and .rsp files to be used with XSPEC. This requires that a background fit and source selection exists.

6.3 Photon Models Dialog

The dialog contains a list of models and various setting for fitting. More than one photon model can be selected and all photon models selected will be fitted as an additive model. **Set Parameters** allows the setting of the initial starting values of the parameters as well as the freezing/thawing of parameters in the fit. While various fit statistics are available, the most appropriate statistic for the majority of GBM data is PG-stat. Fit weighting options are also available, as well as option for undetermined values in the batch fit.

6.4 Fit Log

The fit log displays the fit results and acts as a direct interface to XSPEC

* **Enter XSPEC Command**: XSPEC commands can be directly input into the text box. Up and down arrows allow the user to cycle through the list of previously issued commands.

* **Save Script**: Save the XSPEC commands issued (both those by GSpec and those by the user) in an XSPEC batch script.

* **Run Script**: Run an XSPEC batch script

* **Clear Text**: Clears the fit log

* **Save Text**: Save the fit log text

* **Exit**: Close the fit log and exit the XSPEC interface

6.5 Spectral Fit Display

This displays the fitted spectrum or batch fit results.

- **Counts Spectrum**: By default, GSpec displays the fitted counts spectrum for each data file

    - **Cumulative**: Display the cumulative counts of each data file
    - **Raw Counts**: Display the raw counts for each data file
    - **Photon Spectrum**: Display the photon spectrum and deconvolved data
    - **Energy Spectrum**: Display the energy spectrum and deconvolved data
    - **Nu Fnu Spectrum**: Display the νF_ν spectrum and deconvolved data

- **Spectral Fitting**: Additional options for performing spectral fits

    - **Redo Last Fit**: Perform a single time-integrated fit on the data
    - **Batch Fit Selection**: Do a spectral fit of each time bin in the source selections

- **Export Fit Results**:

    - **Write Results to File**: Writes fit results to a FITS file following the GBM SCAT standard. This file contains the information of the detectors/data files used in the fit, the fitted model parameters, fit statistic, covariance matrix, and other information.

7 GBM Trigger Downloader Help

The Trigger Downloader queries the HEASARC archive of GBM triggers, producing a full list of triggers. Users can search for, filter, and sort triggers, and then download the desired data for those triggers. Users can select one or many triggers for download.

7.1 Trigger List Window

This window displays the full trigger list, displaying the trigger number, type of trigger, time of the trigger, the localization of the event, and the localizing instrument.

- **Time Toggle**: Toggle between the trigger time in UTC or MET (Mission Elapsed Time)

- **Coordinate Format Toggle**: Toggle between decimal and sexagesimal format for the location

- **BNUM Filter**: Filter by burst number

- **All Types**: Filter by trigger type

- **Time Filter**: Filter by trigger time

- **All Instruments**: Filter by localizing instrument

- **Get Data**: Download the data for the selected triggers

7.2   Data Type Selection Dialog

This dialog displays the available data for a trigger, allowing the user to select which data to download. A new dialog is shown for each trigger selected from the list.

- **Data Types**: Select the data types to download. Numbers in parantheses show the total number of files of each datatype that is available.

- **Detectors**: Select the detectors for which the data will be downloaded. Numbers in parentheses display the angle of the detector normal to the centroid of the localization for the trigger. By default, NaI detectors with angles $< 60°$ and BGO detectors with angles $< 120°$ are selected, as is the GBM standard for burst analysis.

- **Download**: Select the directory where the data will be downloaded. A sub-directory will be written containing the downloaded files for each trigger

8   Known Issues

- Older Tcl/Tk may exhibit some issues on Mac with Python Tkinter. In particular, scroll wheel movement in Tkinter may cause a "UnicodeDecodeError." To fix this, update your Tcl/Tk version to the latest Tcl/Tk

- Fitting the background of a TTE file that is binned to fine temporal resolution may result in a Reduced Chi-squared plot that shows significant trends and/or very large reduced chi-square values. This is an indication that the number of counts in each bin is too low to rely on the background fit. Try binning the background to a coarser resolution and refitting the background.

- XSPEC does not currently have the GRB Band function, parametrized with Epeak or the cut-off power-law (Comptonized function) parametrized with Epeak. For XSPEC v12.10+, we have utilized new XSPEC functionality to re-parametrize existing XSPEC functions, however XSPEC does not allow for the renaming of the parameter names. If you fit with the Band (Epeak) function, the 'Epeak' parameter is called 'tem', and if fitting with the Comptonized function, the 'Epeak' parameter is called 'foldE'. We will work to get the native functions added to XSPEC in a future release.

9   Acknowledgments

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