ChiByEye: An Interactive XSPEC Model Visualizer

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Overview

ChiByEye is an interactive graphical interface built with PyQt5 and Matplotlib that allows users to explore how XSPEC model parameters affect the resulting spectral shape. It provides dynamic visualization, easy model loading, parameter manipulation through sliders or textboxes, and integrated data fitting.

This tool is ideal for astrophysics researchers or students looking to understand model behavior or inspect XSPEC fitting results without manually entering commands in the XSPEC terminal.

Requirements

- Python 3.x

- **XSPEC** and the `pyxspec` Python bindings (part of HEASoft)

- Python packages:

  - `numpy`
  - `matplotlib`
  - `PyQt5`

Additionally, the code attempts to load the `relxill` model on startup. If your system does not have `relxill` installed, comment out `AllModels.lmod('relxill')` (line 38).

Launching the Interface

After installing the dependencies and verifying XSPEC is properly configured, run the software with:

```
python xspec_plot_interface.py
```
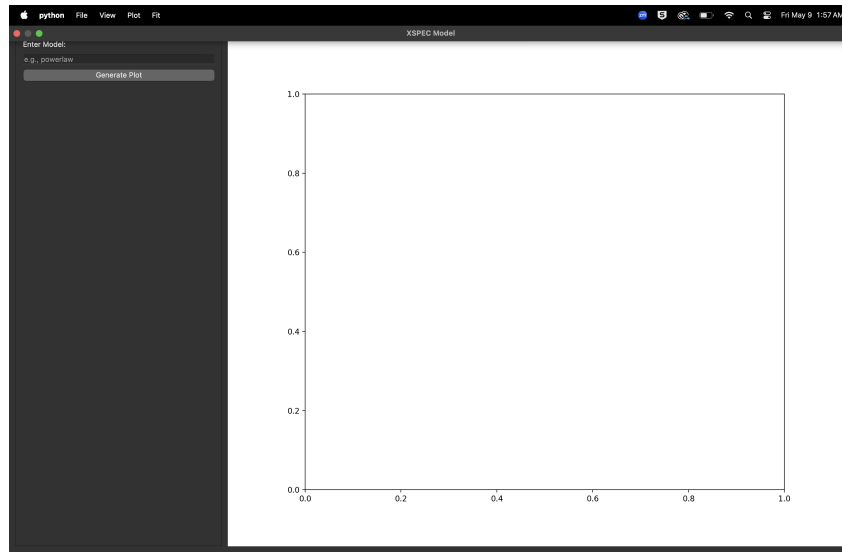
Main Interface

Figure 1: The initial ChiByEye interface upon launch.

- **Manual model entry:** Type the model expression and press `Enter`.

- **File → Load Model as XCM:** Load a model from an existing `.xcm` file.

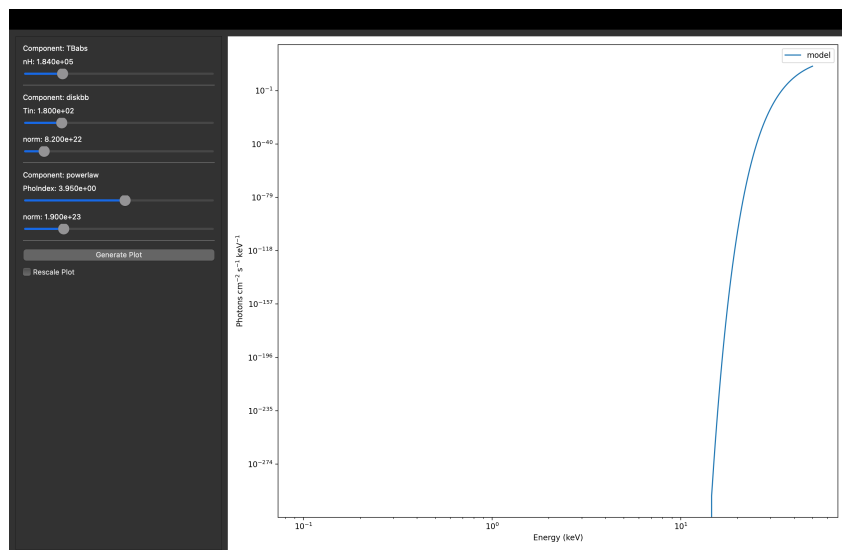- **File → Load Data as XCM:** Load both spectra and model from an XSPEC session file.

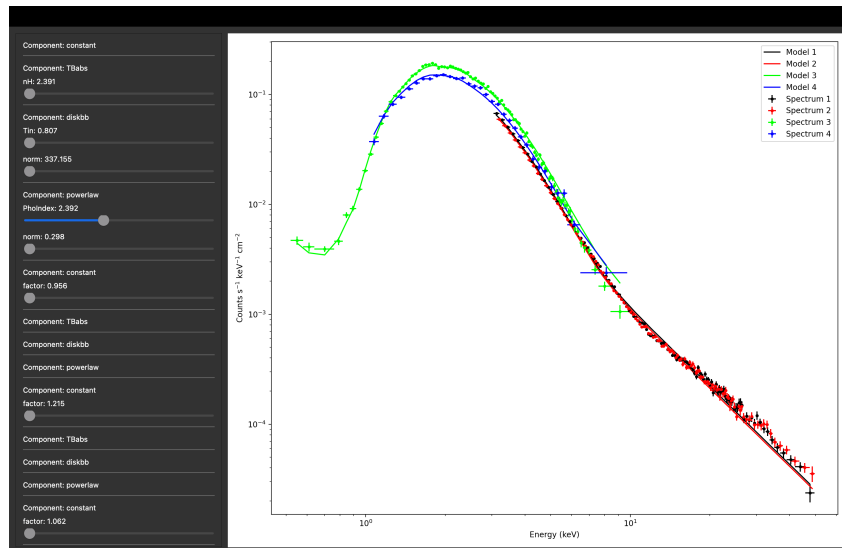Figure 2: Model plot after adjusting parameters using sliders.

Figure 3: Loading data and model from an XSPEC .xcm session file.

An example XCM file (`test_file.xcm`) is provided to demonstrate functionality.

View Menu Options

- **Use Textboxes for Parameters:** Toggles between sliders and textboxes for editing model parameters.

- **Set Axes Limits:** Manually define x and y-axis limits for the plot.

- **Freeze Axes:** Lock current axis limits for consistent comparison between plots.

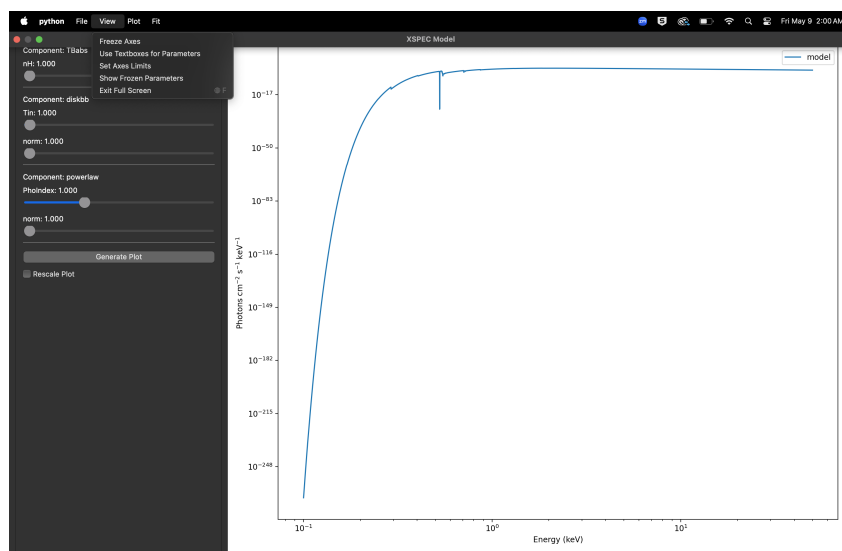- **Show Frozen Parameters:** Display parameters that are frozen in XSPEC.

Figure 4: The View menu allows toggling interface features and parameter display.
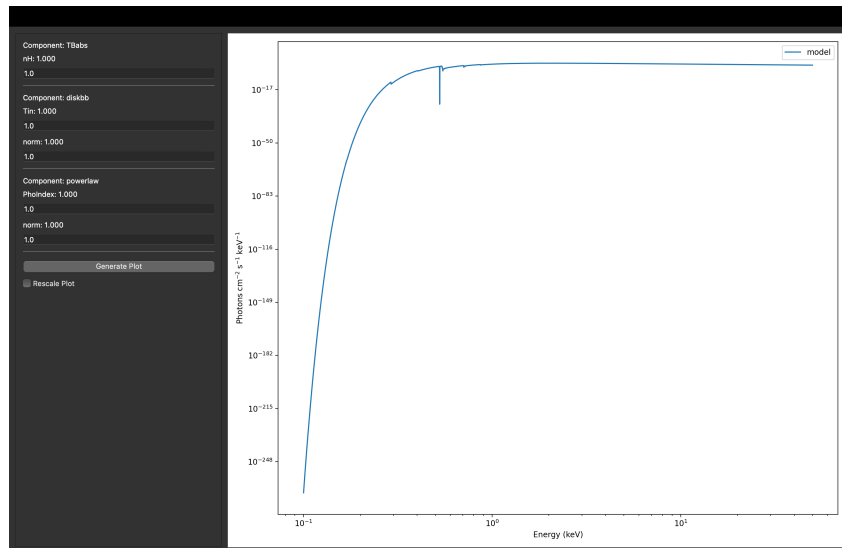
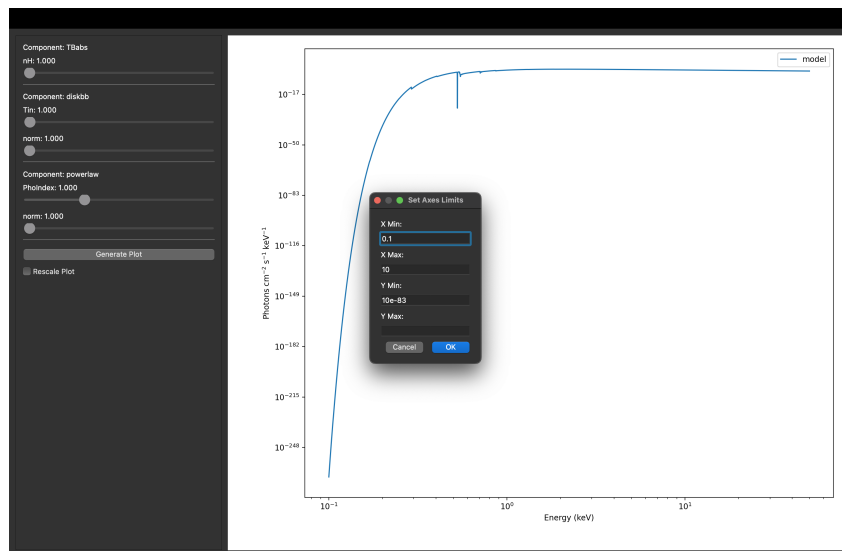Figure 5: Switching between sliders and textboxes for parameter input.

Figure 6: Dialog for setting plot axes limits.

Buttons and Controls

- **Generate Plot:** Refresh the model plot using the current parameters.

- **Rescale Plot (Checkbox):** Rescales the y-axis to focus on relevant data. Useful when plotted values become too small in log space (e.g., $10^{-\infty}$).

Plot Menu Features

- **Plot Different Components:** Visualize each additive component of a model individually (e.g., diskbb + powerlaw).

- **Plot Model:** Select XSPEC plot styles: `model`, `emodel`, `eemodel`.

- **Plot Data:** Choose from data-only, data+ratio, or unfolded spectrum + delchi representations.

- **Plot Same Curve N Times:** Sweep a parameter across multiple values and show the resulting curves using a color map.
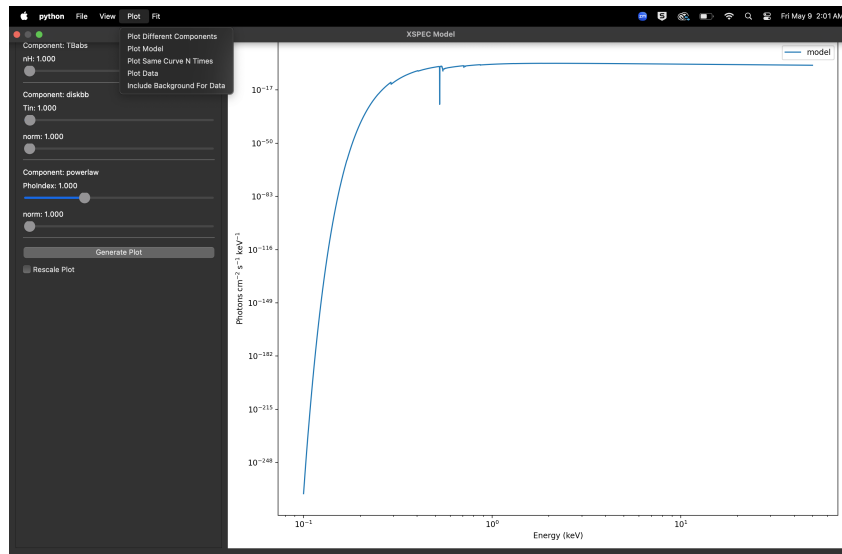

Figure 7: The Plot menu enables selection of plot types and fitting options.
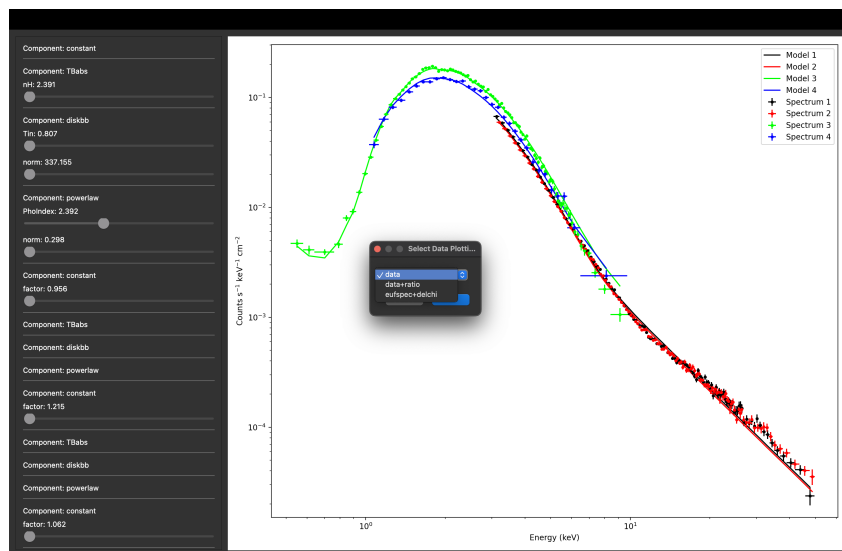

Figure 8: Different data plot options: data-only, data+ratio, unfolded spectrum + delchi.
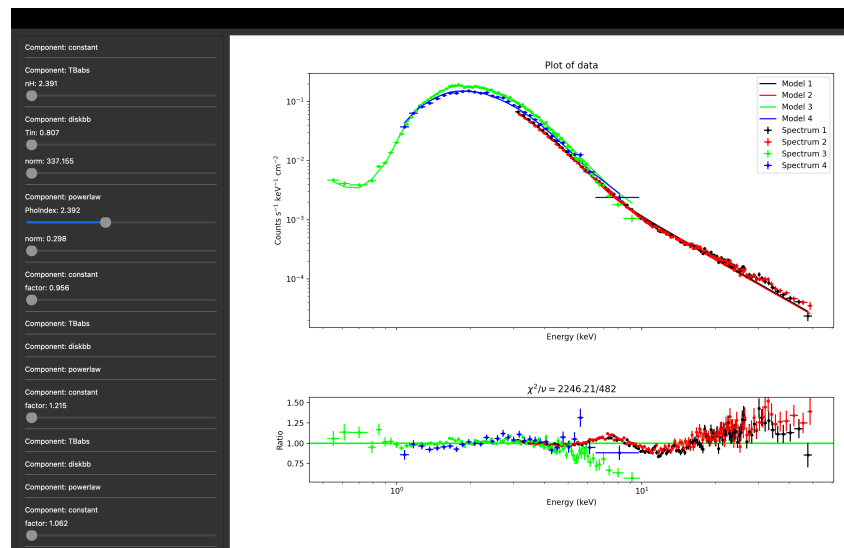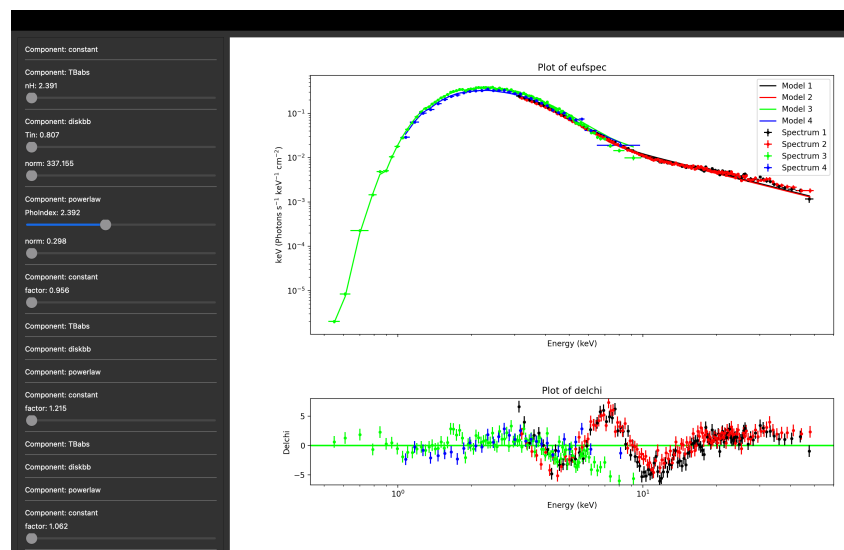
Figure 9: Data+ratio plot mode.

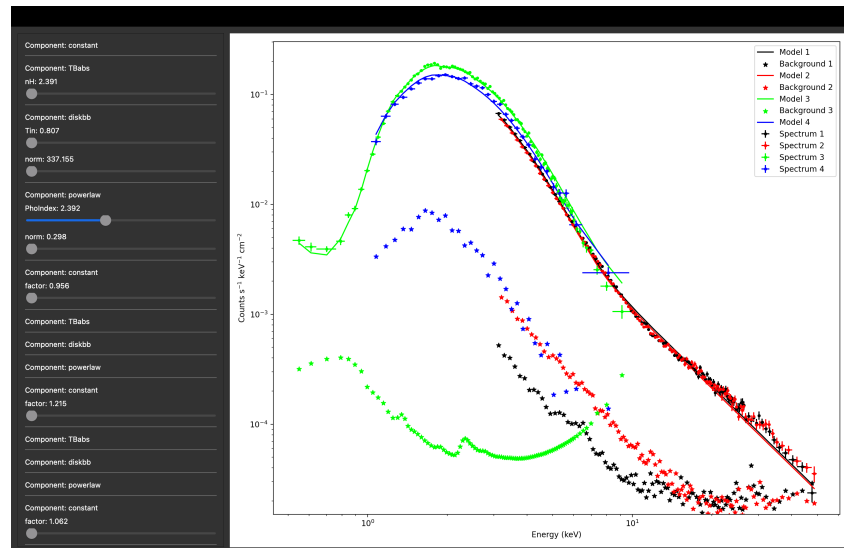Figure 10: Unfolded spectrum + delchi plot mode.

Figure 11: Option to include or exclude background in the plot.

Saving and Exporting

- **File → Save Parameters as XCM:** Export the current model setup.

- **File → Save Plot:** Save the currently displayed plot to a PNG file.

- **File → Load Plot Style File:** Import a custom `.mplstyle` configuration for plot styling.

Additional Notes

- The software currently supports fitting loaded data via the **Perform Fit** option in the Plot menu.

- Default XSPEC fit settings are used unless otherwise modified.

- All parameter updates are immediately reflected in the XSPEC backend.
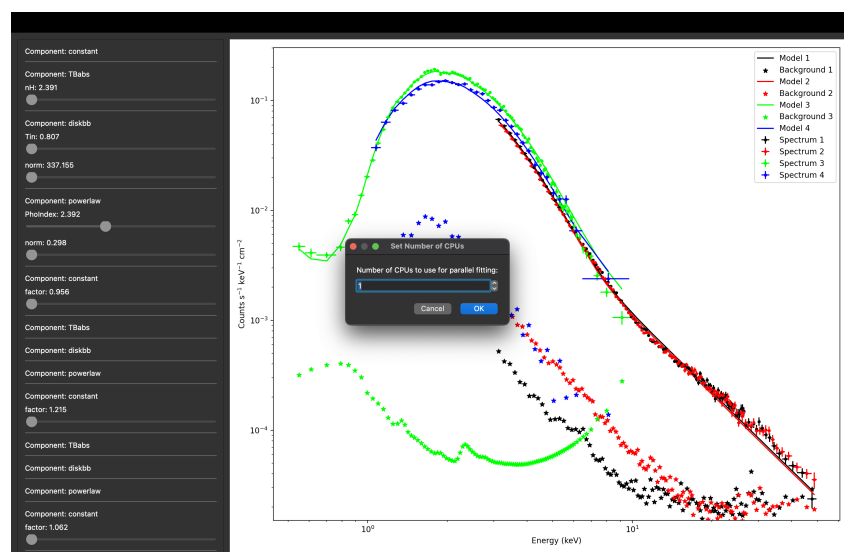

Figure 12: Setting the number of CPUs for parallel fitting.

Future Work

We are actively developing new features, including:

- A fitting assistant for user-guided χ^2 minimization (*hence the name – ChiByEye*).

- Advanced residual diagnostics.

- Support for time-resolved and multi-spectral fits.

Feedback and Contributions

If you encounter bugs, want to suggest new features, or simply have feedback about usability, we would love to hear from you! This is an early-release version of **ChiByEye**, and we appreciate any help in improving it.

Acknowledgments

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- **Paulo Silva** – Massachusetts Institute of Technology

- **Paul Draghis** – Massachusetts Institute of Technology

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