Innovations in ACIS Imaging Data Analysis

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Fields with thousands of X-ray point sources pose significant data analysis challenges to the Chandra/ACIS observer, ranging from source detection to spectral modeling. We describe three innovations we are exploring as part of the ACIS Team's on-going development of the ACIS Extract (AE) analysis package (IDL Code, User's Guide, and recipes are publicly available at http://www.astro.psu.edu/xray/docs/TARA/ae_users_guide.html).

CROWDED POINT SOURCE DETECTION

We are exploring a new strategy for the difficult task of point source detection in crowded fields:

* Reconstruct (maximum likelihood) image tiles that cover the field of view (Fig. 1).

* Propose a liberal source catalog by identifying peaks in the reconstructed tiles.

* Prune the catalog using a source confidence statistic.

* The reconstruction produces a significant number of new sources, often resolving close pairs.

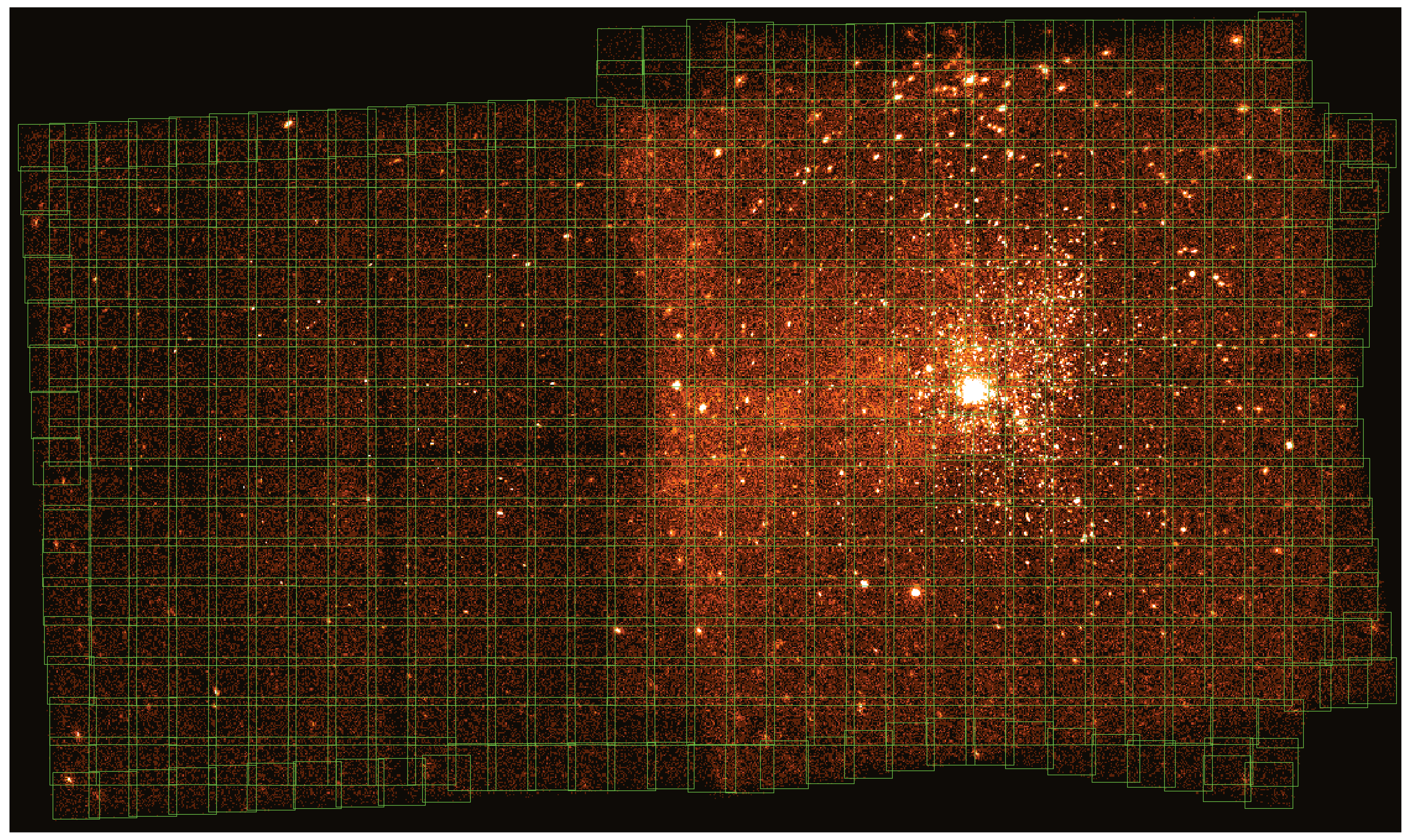

Figure 1 -- A set of overlapping image tiles covering an ACIS-I imaging study of the M17 star forming complex (17'x30'). Each tile is reconstructed using a local PSF.

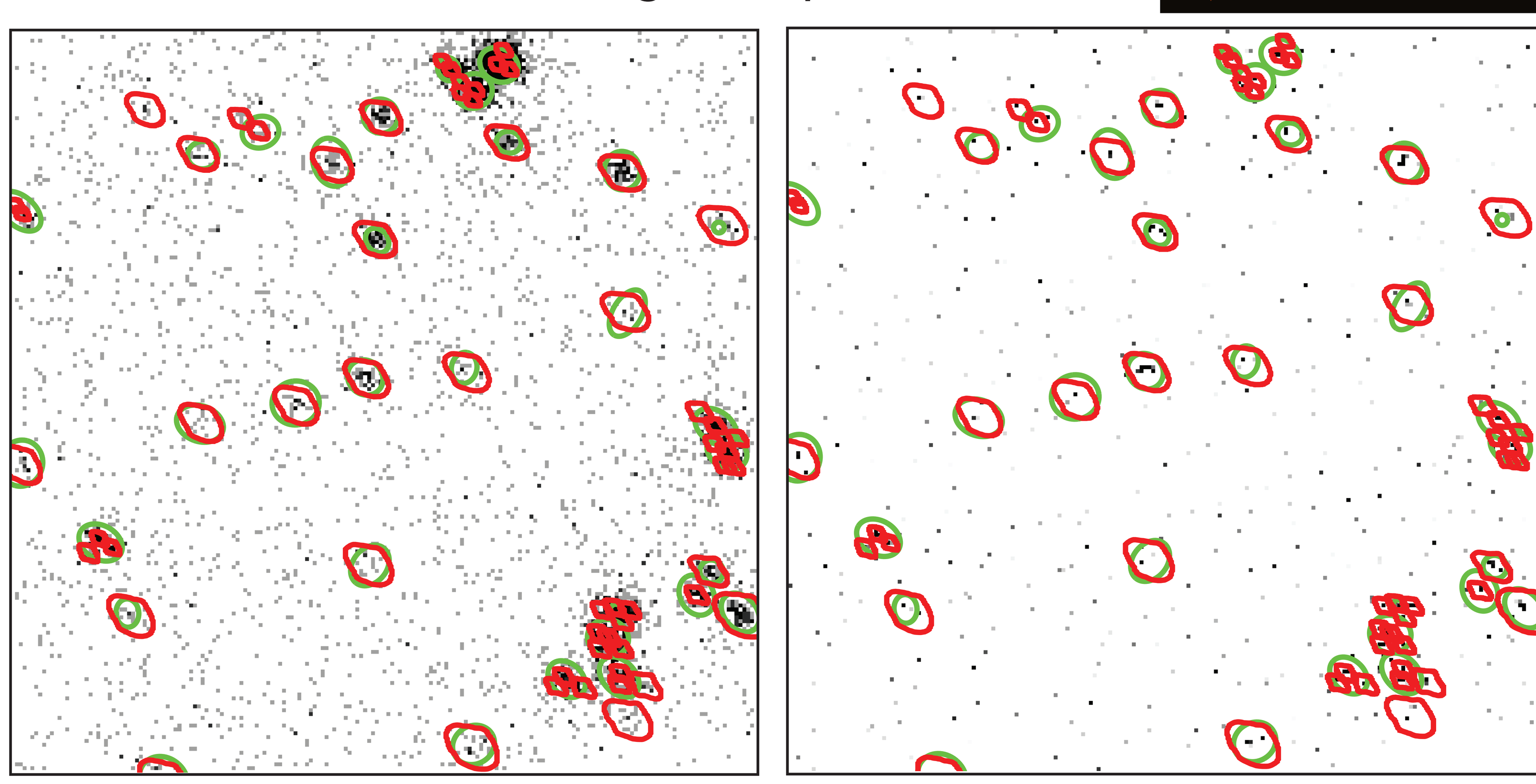

Figure 2 -- A single tile of event data (left) from Fig. 1, and a simple maximum likelihood reconstruction of the tile (right).
Sources proposed by the reconstruction (polygons representing AE extraction regions) and proposed by wavdetect (ellipses) run with sigthresh=1E-5 are marked.

COMPLEX BACKGROUNDS

We are exploring a new strategy for the difficult task of estimating backgrounds for crowded sources:

* Construct spatial models for all background components (e.g. other point sources, readout streaks, diffuse sources). Point source models use the local PSF and rough photometry from a preliminary extraction.

* Integrate those models over the extraction apertures to estimate the contamination each source suffers from each background component, e.g. neighboring point sources.

* For each source, search for a complex background region (Fig. 3) that is expected to contain just the right amount of light from each contaminating component.

* Extract observed spectrum from the background region and scale appropriately.

* We find that this technique more accurately estimates the elevated background suffered by crowded sources.

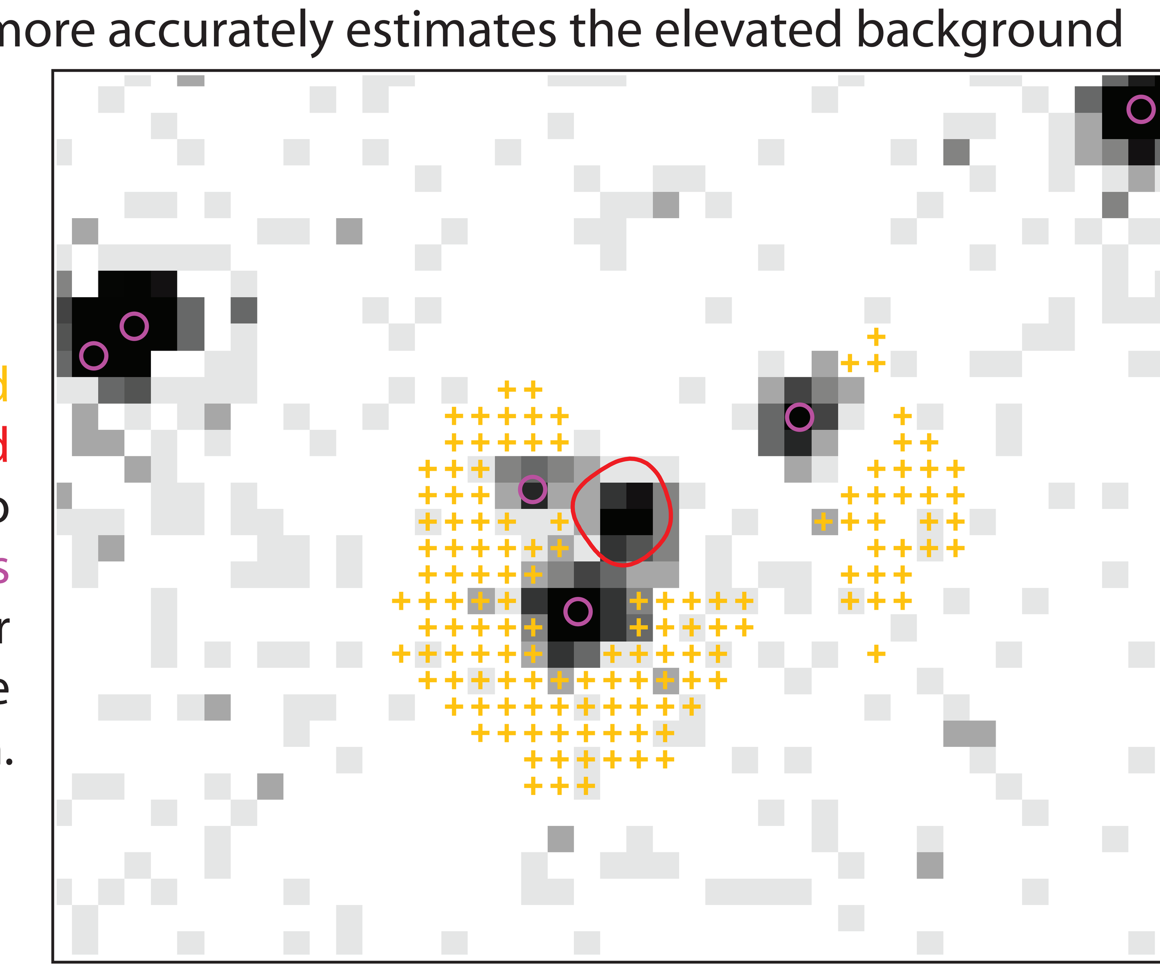

Figure 3 -- A background region (crosses) for a crowded source (polygon) that seeks to sample neighboring sources (circles) in proportion to their expected contamination of the extracted spectrum.

WEAK SPECTRA

Weak spectra are commonly analyzed with the C-statistic applied to ungrouped data. XSPEC models the background (if supplied) with a **free parameter for each spectral channel** (Wachter et al.,1979) and fits the ungrouped source and background spectra *simultaneously*.

For reasons not fully understood, the resulting model is often significantly biased.

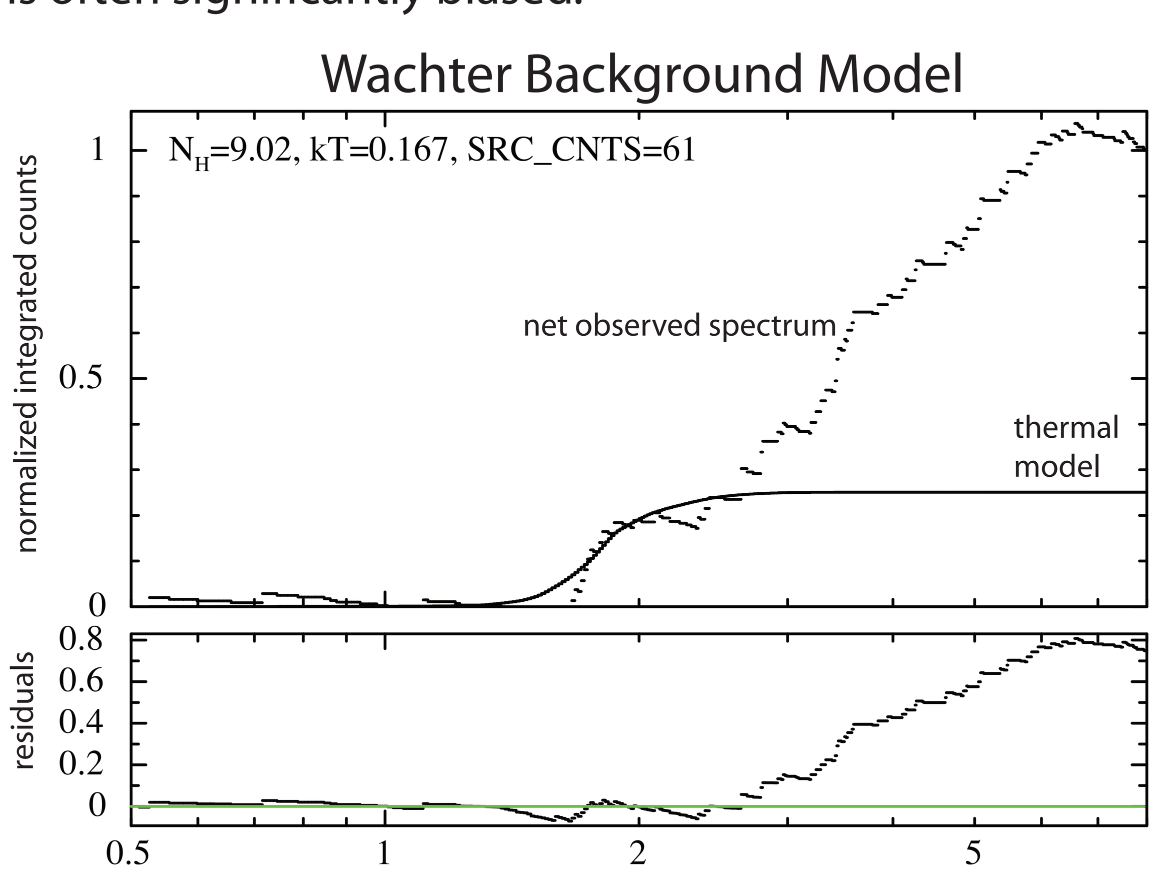

Figure 4 -- An example simultaneous XSPEC fit to the extracted and background spectra for a weak source using the C-statistic on ungrouped data. The standard internal Wachter background model used here cannot be plotted; instead the cumulative net spectrum

Our new approach models the observed background as a simple continuous piecewise-linear curve (*cplinear*) with only 10 free parameters. Energies of the vertices are chosen to segment the background data evenly .

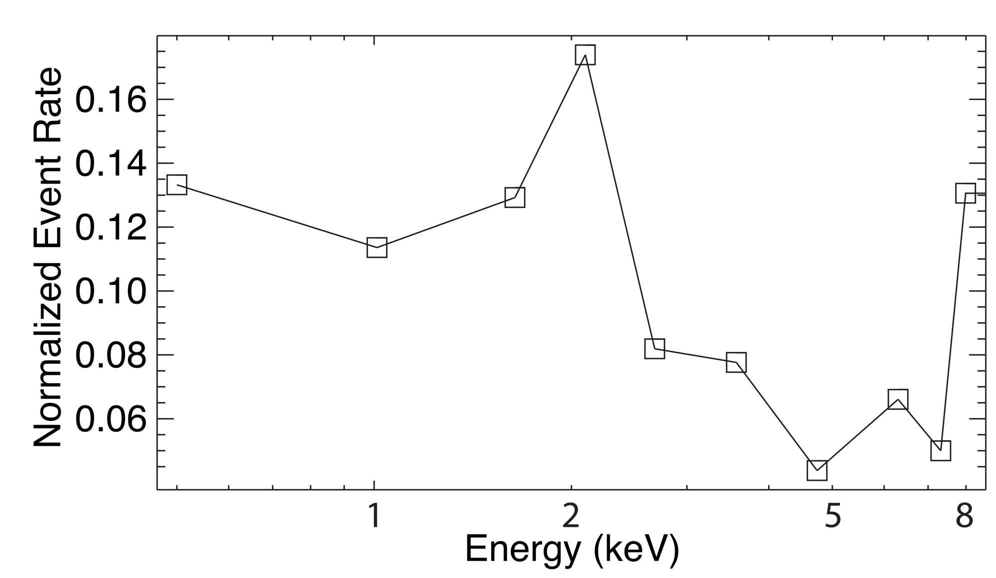

Figure 5 -- An example of a cplinear model of the observed background spectrum.

Unbinned source and background spectra are then fit simultaneously, as is done with the Wachter model.

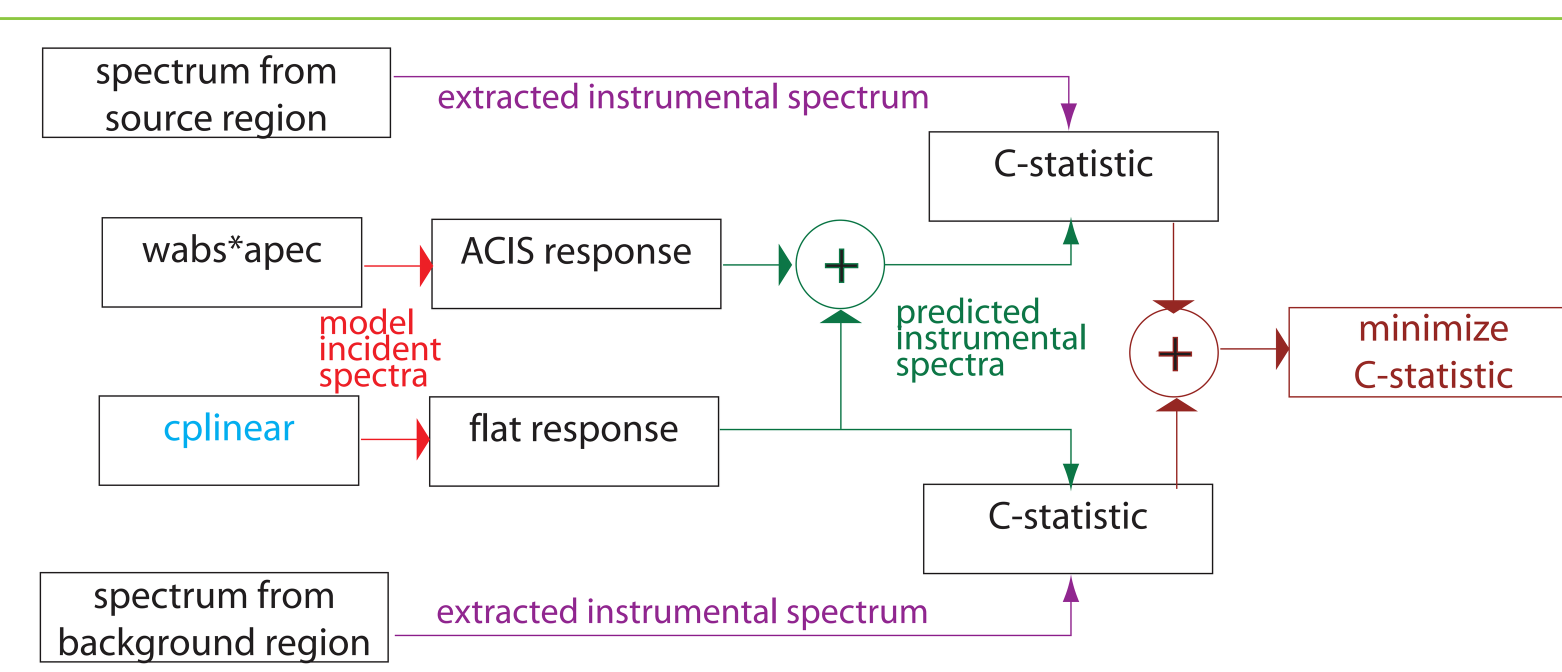

Figure 6 -- A block diagram describing simultaneous fitting of the source and background spectra.

This more constrained background model usually produces better fits.

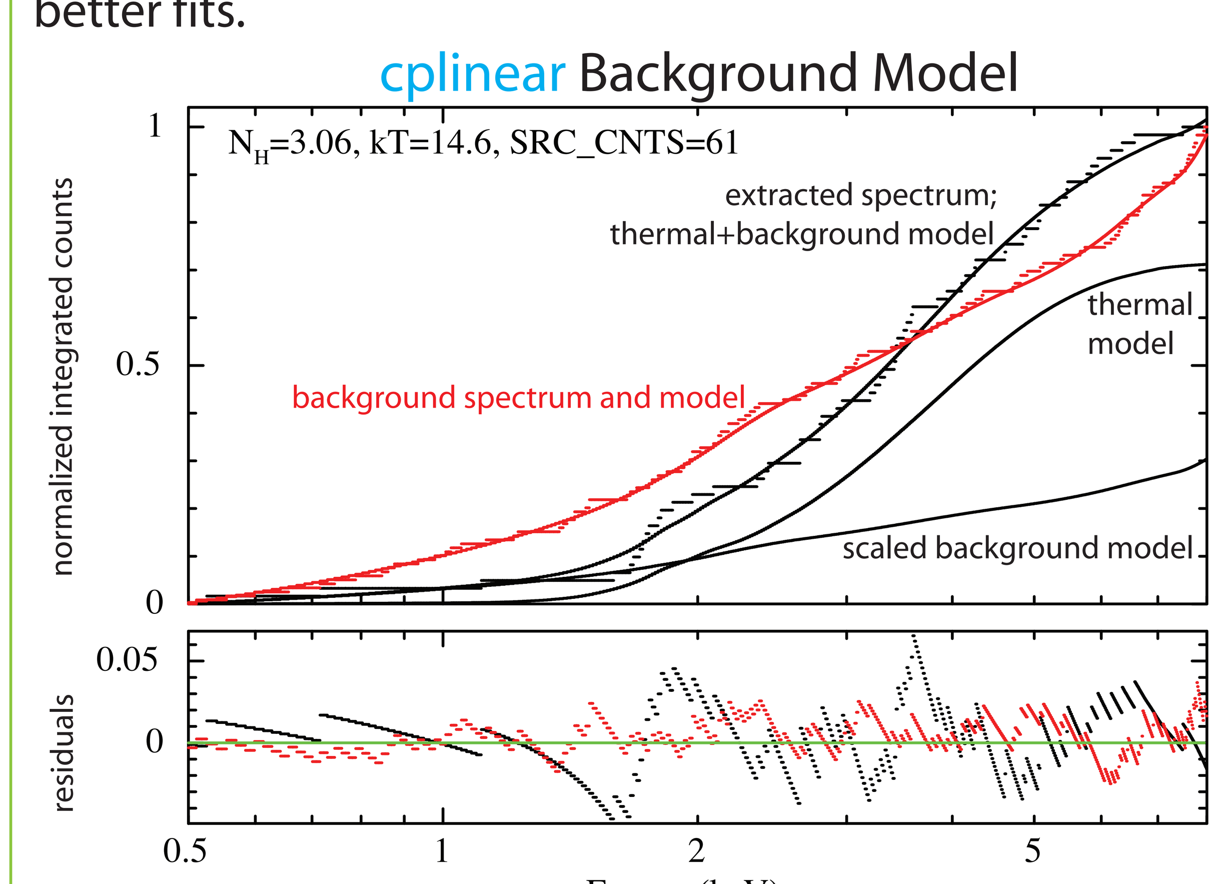

Figure 7 -- A simultaneous XSPEC fit for the same source shown in Fig. 4, but using our new explicit background model. In this configuration (see Fig. 6) XSPEC will plot the normalized cumulative spectra for both the source (black stair-step) and background (red stair-step). The background model is shown as the solid red curve near the data. A copy of this model, scaled to the extraction area, and a thermal model for the source itself are shown and labeled. The composite background+thermal model for the extracted spectrum is shown as a solid black curve near the data.