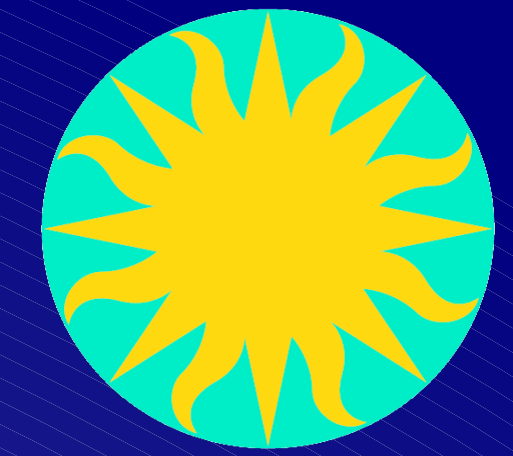
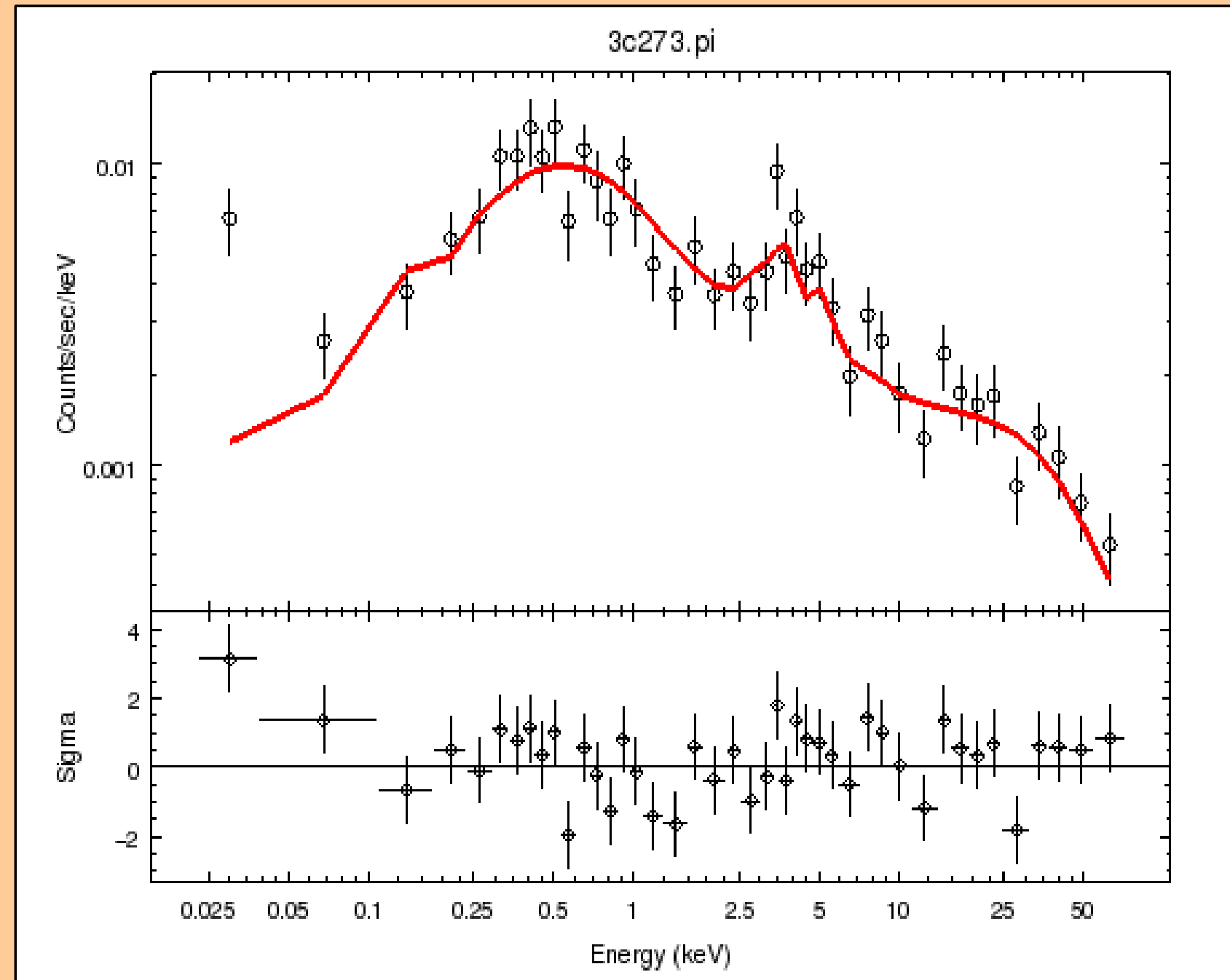


Advanced Python Scripting Using Sherpa

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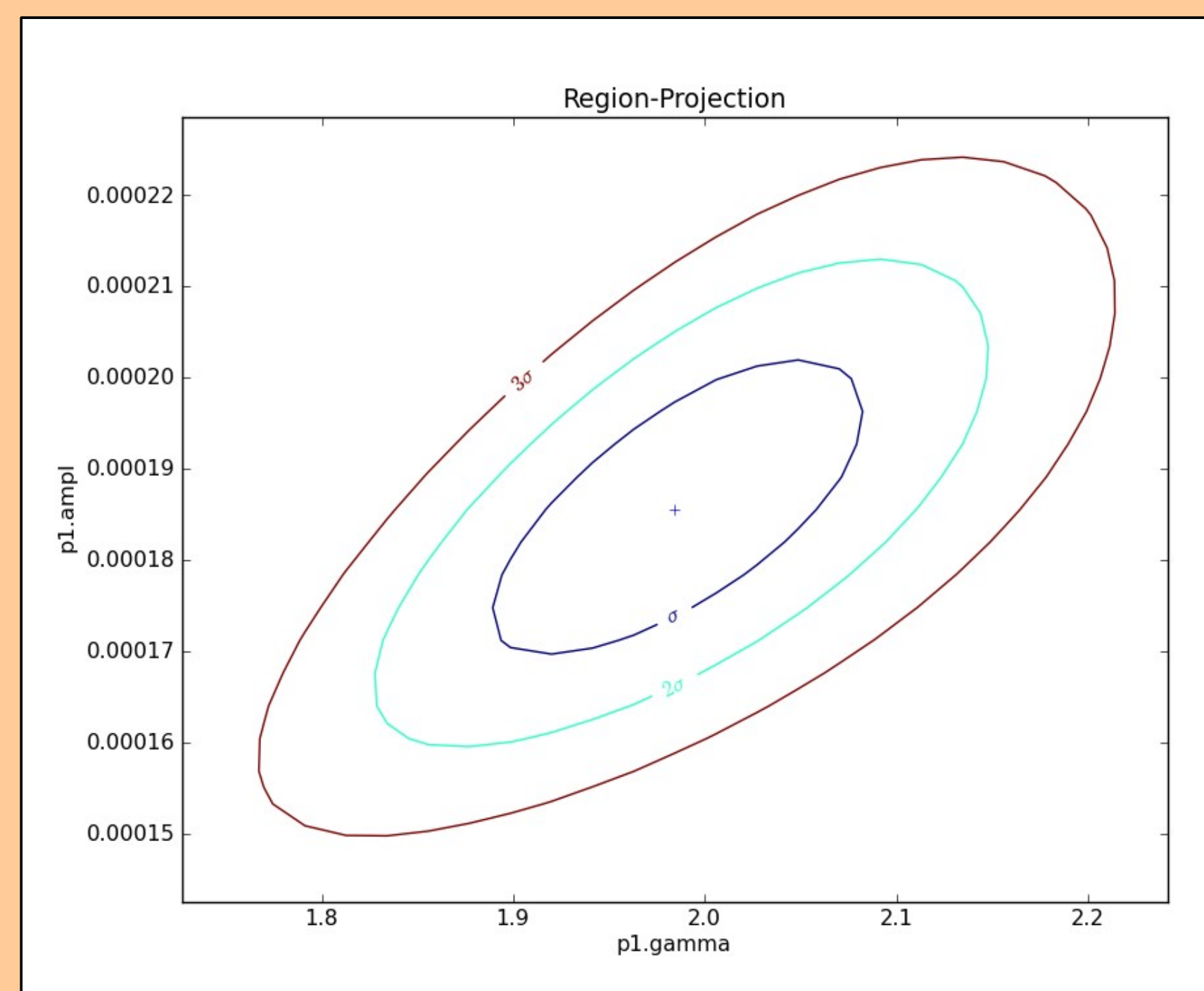
Fit to spectral x-ray source data (3C 273)



Spectral source data with an associated background file, ancillary response file, and response matrix file can be fit to a composite power law and *XSPEC* photoelectric absorption model in *Sherpa*. In the upper plot, the count rate is corrected for the background, scale, and sensitivity. The lower plot displays the fit delta chi square residuals.

Fig. 1

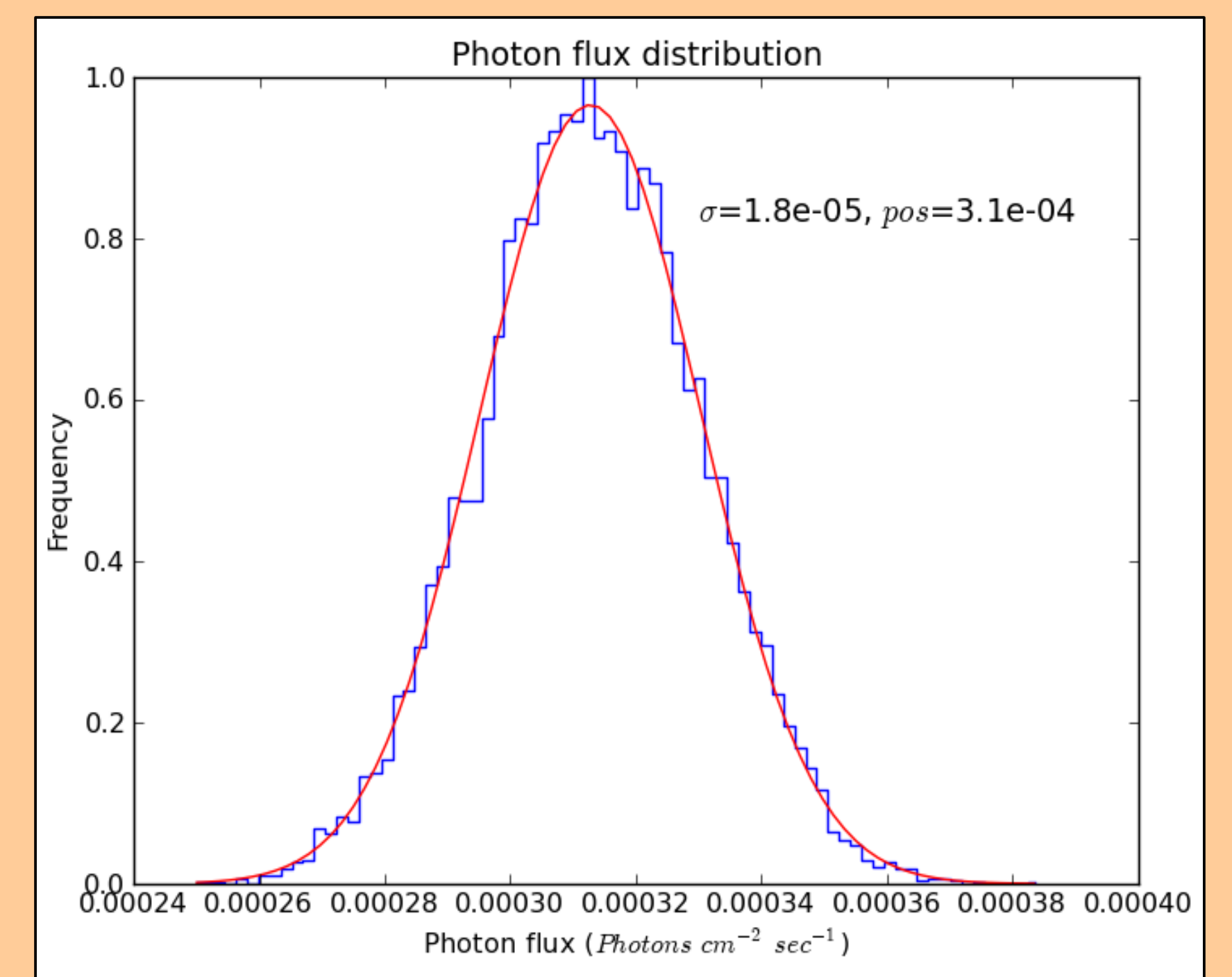
Confidence region projection of 3C 273 fit



The correlation of two fit parameters can be shown by a *matplotlib* region projection contour. The current best fit parameter values are shown by the cross while the concentric ellipses show the 2σ , 3σ slices.

Fig. 2

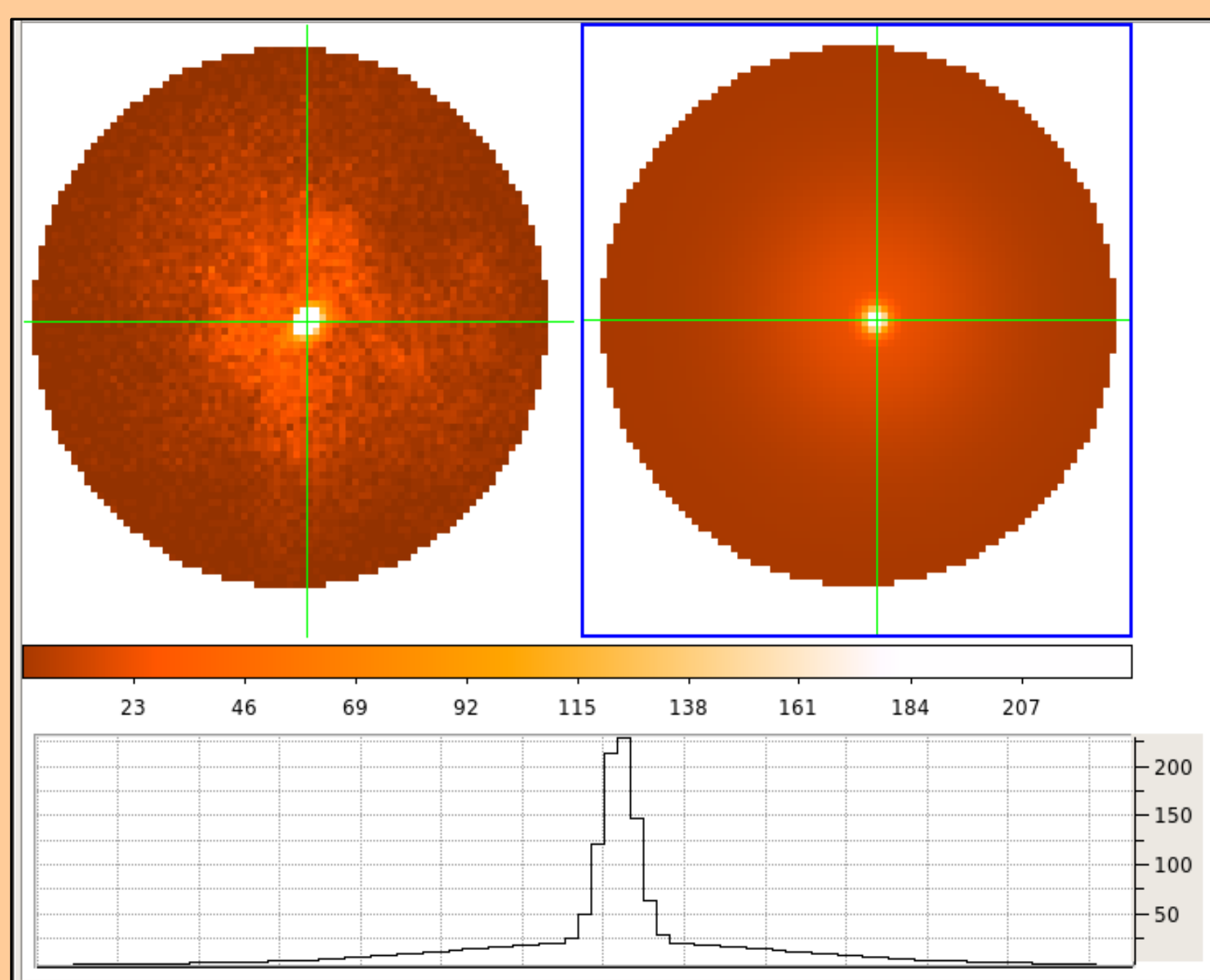
3C 273 Photon Flux Distribution with Gaussian Fit



Estimate the photon flux errors using simulations in *Sherpa*. The draws from these simulations, accessible as NumPy ndarrays, can be sampled from uni-variate and multi-variate normal distributions and can be binned and visualized using *ChIPS* or *matplotlib*. This plot shows the distribution fit with a Gaussian model.

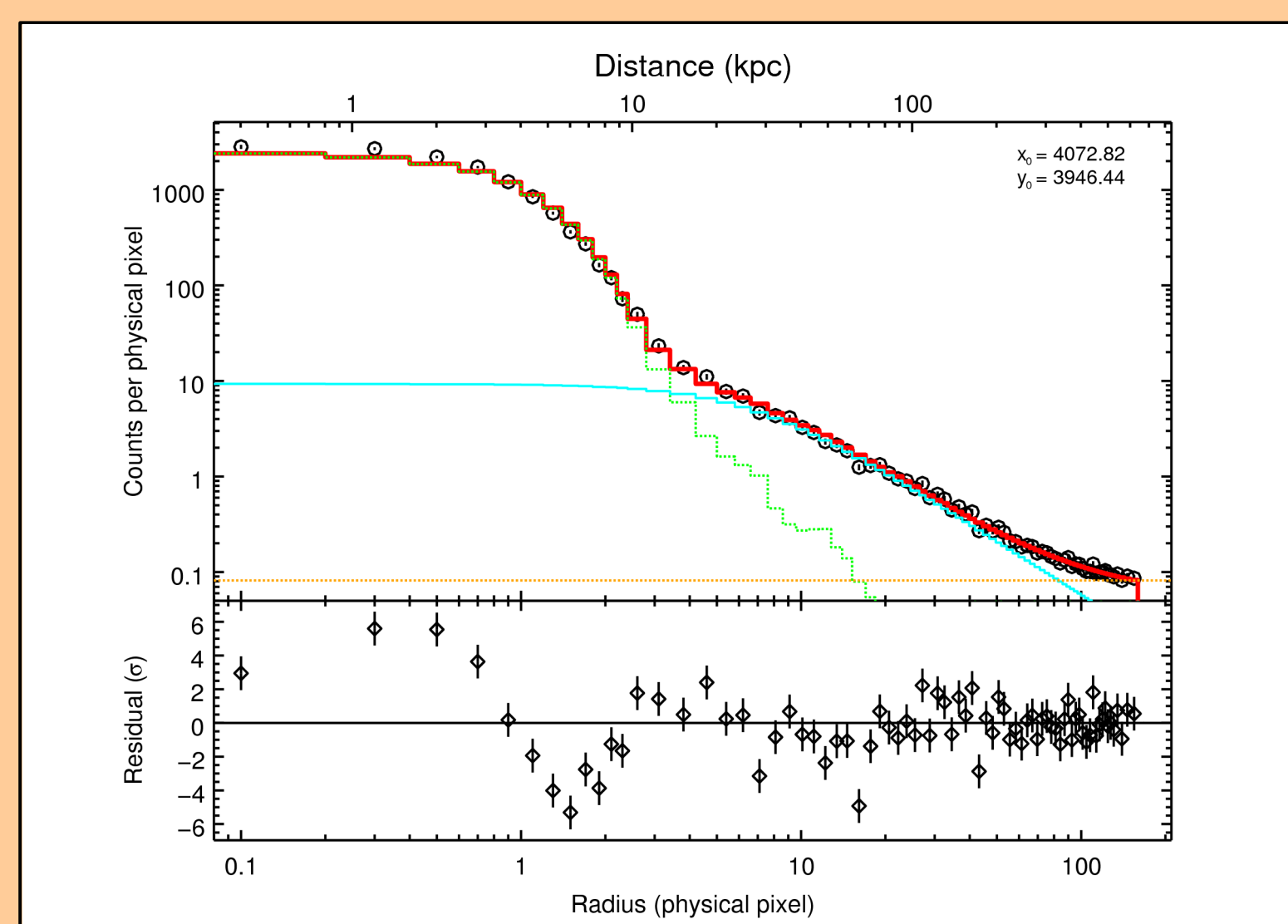
Fig. 3

Fit of source image data (G21.5-0.9)



Sherpa can also fit 2D FITS image data. The image data is viewed using *DS9* (SAO Astronomical Data Visualization Application) via *XPA* (X Public Access). The image data is shown in the upper left with the fit in the upper right using *DS9*.

Fig. 4



Sherpa can visualize surface brightness profiles extracted from 2D image data with fit and core components layered over top. In the upper plot, the profile shown in black points with errorbars is from the ACIS-S. The composite model convolved with a PSF is in red while individual components are shown in green, blue, and brown. The bottom panel shows the residuals between the composite model and the data in units of σ .

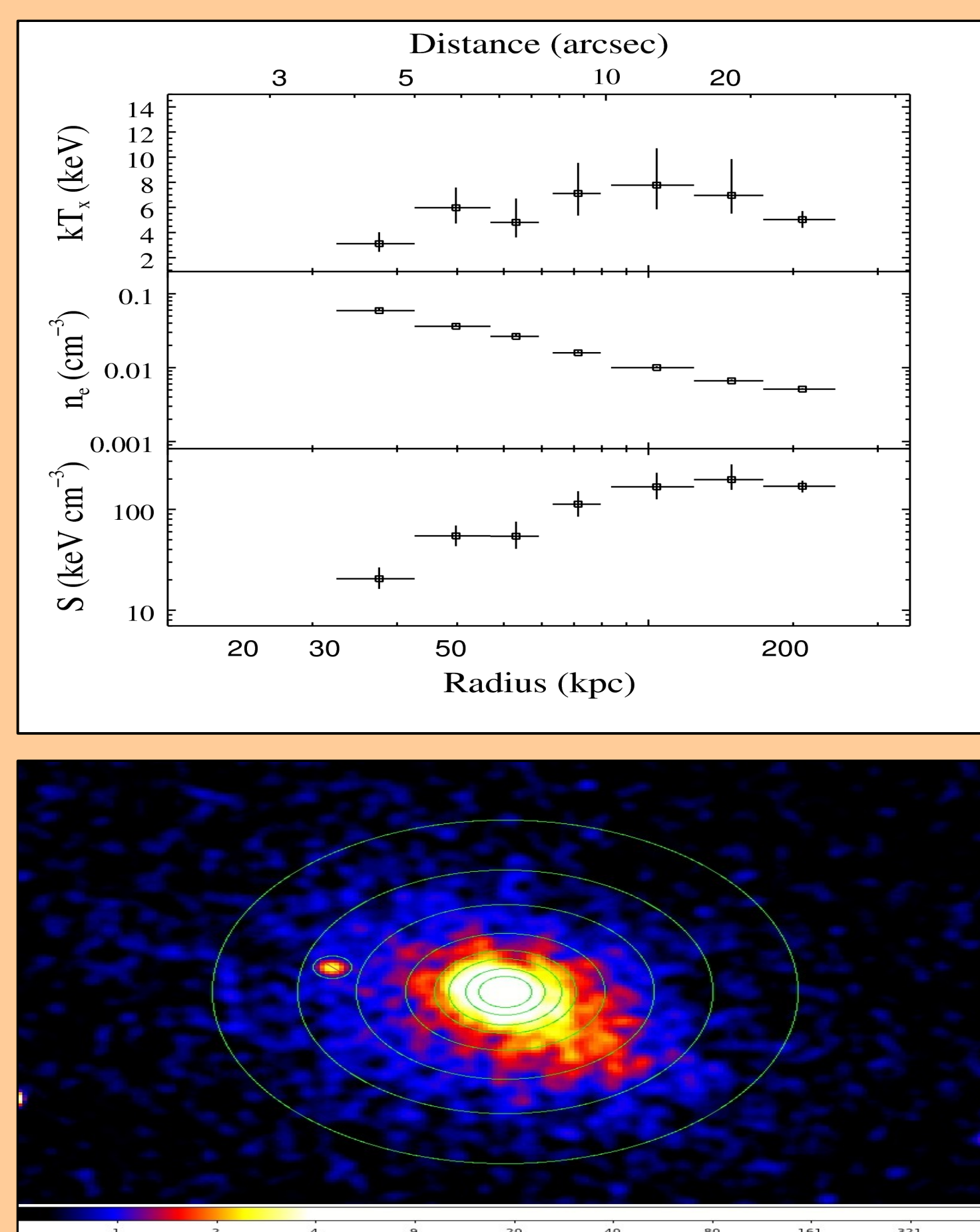
Fig. 7



General purpose modeling and fitting in Python

<http://cxc.harvard.edu/sherpa>
<http://pysherpa.blogspot.com>

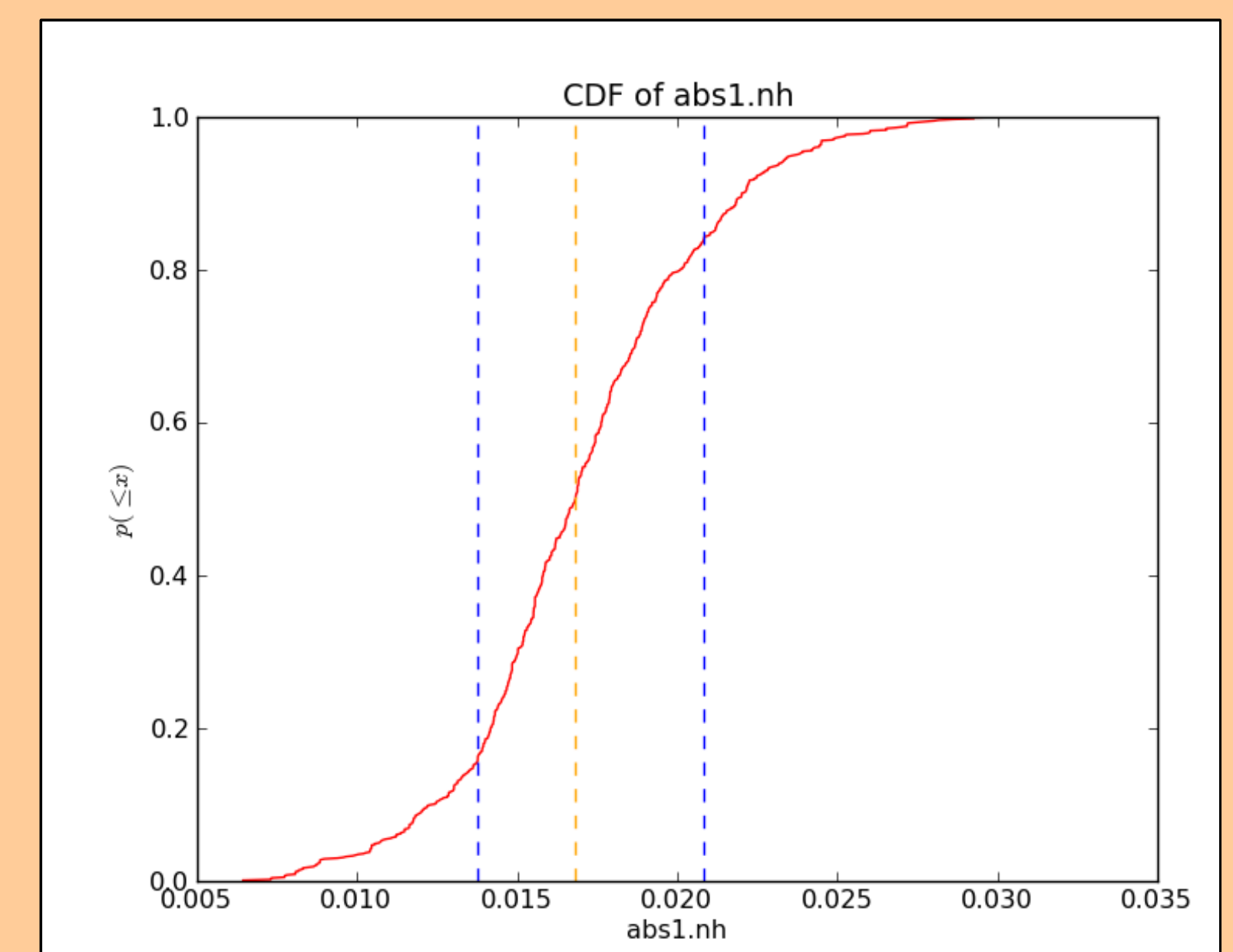
Fit of the *Deproject* Cluster Model



The image shows smoothed ACIS-S data with marked annular regions. The spectra were extracted from these annuli and fit in *Sherpa* with *apec* thermal models using the *deproject* method. The three panel plot shows the resulting temperature, density and entropy for each annulus.

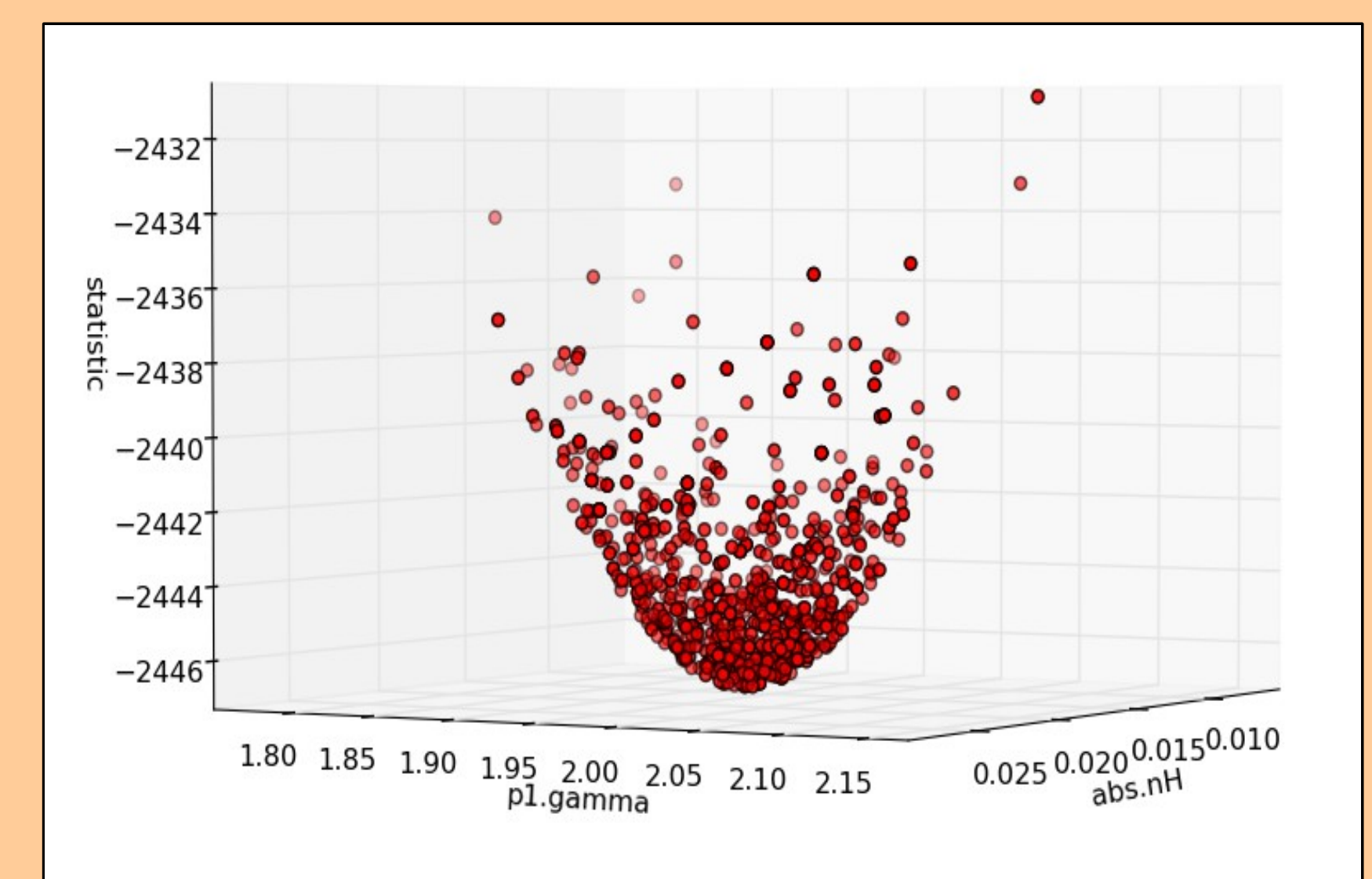
Fig. 5

Examining Parameter Space using MCMC



Sherpa can explore parameter space of a given fit using a contributed package *pyBLoCXS*. *pyBLoCXS* is MCMC-based algorithm that returns parameter draws as NumPy ndarrays according to a specified jumping rule. The draws from the *XSPEC* model parameter *abs1.nh* can be visualized in this quantile plot using *matplotlib*.

Fig. 6



pyBLoCXS provides the parameter draws as a table of statistics and parameter values which can be visualized in multiple dimensions. This 3D scatter plot shows the fit statistic as a function of the power-law gamma and the photoelectric absorption nH.

Fig. 9

Acknowledgments

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