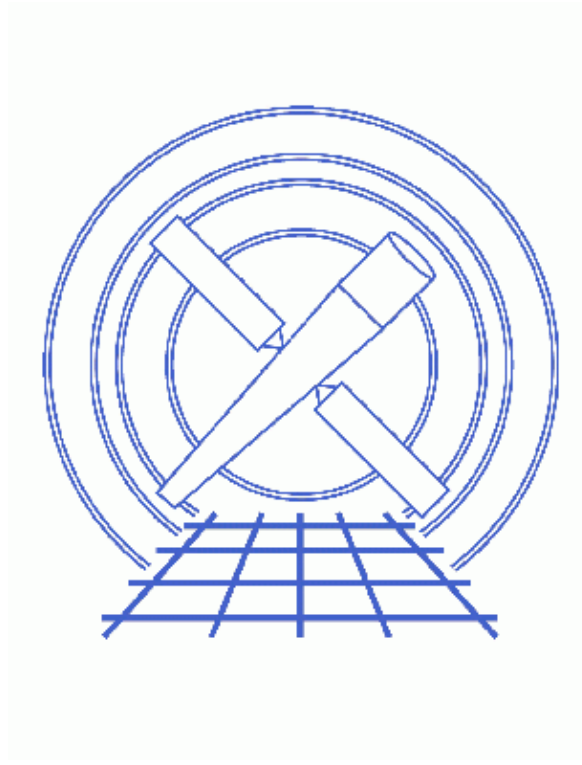


Simulation for Suzaku: Evaluate HXD systematic errors



Sherpa Threads (CIAO 3.4)

Table of Contents

- *Getting Started*
- *Simulate the Model Spectra*
- *Examine the HXD Background Level*
- *Effect of Background Systematic Error*
- *Save the Results*
- *Commands Used in this thread*
- *History*
- *Images*
 - ◆ Background-subtracted data and backgrounds
 - ◆ Source and background backscals = 1.0
 - ◆ Overestimate background: backscals = 0.9
 - ◆ Underestimate background: backscals = 1.1

Simulation for Suzaku: Evaluate HXD systematic errors

Sherpa Threads

Overview

Last Update: 1 Dec 2006 – updated for CIAO 3.4: removed "AO1" from thread title

Synopsis:

This thread describes how to simulate Suzaku/HXD (Hard X-ray Detector) observations and evaluate the HXD background using *Sherpa*. It is based on the [Cookbook for HXD Simulations](#) described by the HXD Team, but uses a somewhat different approach that leads to similar but not identical results. It is presented here to show how HXD simulations can be done with *Sherpa*, and to show how systematic errors can be treated within *Sherpa*.

Related Links:

- Related thread: [Simulating 1-D Data: the Sherpa FAKEIT Command](#)

Proceed to the [HTML](#) or *hardcopy* (PDF: [A4](#) / [letter](#)) version of the thread.

Getting Started

The sensitivity of the HXD is dominated by the systematic error of the instrumental background estimates. Only objects brighter than the systematic error of the background estimate at the energy band in question are detectable. *The HXD team strongly suggests that users check the effect of background systematic error (BGD-sys-err) in the simulation.*

The PHA and response files used in this thread may be obtained from the [Cookbook for HXD Simulations](#). The following files are needed:

```
ae_hxd_gso_20051019.rsp
ae_hxd_gsobkg_20051105.pha
ae_hxd_pinbkg_20051105.pha
ae_hxd_pinhxnom_20051104.rsp
```

Note that we use the HXD nominal position from the file `ae_hxd_pinhxnom_20051104.rsp` in these simulations. If you choose to use the default XIS nominal position instead, you will need to replace that file with `ae_hxd_pinxinom_20051104.rsp` in your analysis.

Simulate the Model Spectra

In order to create a simulated dataset, it is necessary to define a source model and a grid over which to evaluate the model stack. We will use the datasets `ae_hxd_pinbkg_20051105.pha` and `ae_hxd_gsobkg_20051105.pha` to create the grid; the input datasets will be overwritten by the simulated data created by `FAKEIT`. Note that we read each file twice, first as a data set (with the "`data`" command) and then as a background ("`back`" command). After reading the data and the background files, we input the response files and set the instrument models for the two data sets.

```
sherpa> paramprompt off
Model parameter prompting is off
sherpa> sherpa.dataplot.x_log = 1
sherpa> sherpa.dataplot.y_log = 1

sherpa> data 1 ae_hxd_pinbkg_20051105.pha
The inferred file type is PHA.  If this is not what you want, please
specify the type explicitly in the data command.

sherpa> back 1 ae_hxd_pinbkg_20051105.pha
The inferred file type is PHA.  If this is not what you want, please
specify the type explicitly in the data command.

sherpa> data 2 ae_hxd_gsobkg_20051105.pha
The inferred file type is PHA.  If this is not what you want, please
specify the type explicitly in the data command.

sherpa> back 2 ae_hxd_gsobkg_20051105.pha
The inferred file type is PHA.  If this is not what you want, please
specify the type explicitly in the data command.

sherpa> rsp[pin]
sherpa> rsp[gso]
sherpa> pin.rmf = ae_hxd_pinhxnom_20051104.rsp
sherpa> gso.rmf = ae_hxd_gso_20051019.rsp
sherpa> instrument 1 = pin
sherpa> instrument 2 = gso
```

Next, define the source model and set the initial value of various model parameters. Here we use a power law model multiplied by a constant:

```
sherpa> source 1,2 = const1d[c1]*powlaw1d[p1]
sherpa> c1 integrate off
sherpa> c1.c0 = 0.1
sherpa> p1.gamma = 2.1
sherpa> p1.ref = 1.0
sherpa> p1.ampl.min = 0.0
sherpa> p1.ampl.max = 100.0
sherpa> p1.ampl = 9.7
sherpa> freeze p1.ampl
```

The simulation time is set to $1e5$ seconds for each of the datasets before running `fakeit` to create the spectra:

```
sherpa> fakeit 1 time = 1e5
sherpa> fakeit 1
FAKEIT: The current background data have been added to the faked spectrum.

sherpa> fakeit 2 time = 1e5
sherpa> fakeit 2
FAKEIT: The current background data have been added to the faked spectrum.
```


Finally, restrict the energy range of each file to the default energy band of the Hard X-ray Detector (HXD):

```
sherpa> ignore 1 energy 60.0:
sherpa> ignore 2 energy :30.0,600.0:
```

Examine the HXD Background Level

Now we can examine the HXD background levels and plot the data and the background. First we subtract the background from the simulated PHA files, then overplot the data and background for both instruments. The color of the curves is changed to distinguish between them easily.

```
sherpa> subtract 1,2
sherpa> oplot data 1 data 2 back 1 back 2
Warning: negative and zero values ignored in log scale
sherpa> limits x 10 600
sherpa> limits y 0.001 1
sherpa> c 2 blue
sherpa> c 3 green
sherpa> c 4 red
sherpa> redraw
```

Figure 1  shows the resulting plot. Another filter is used to ignore the undetectable band:

```
sherpa> ignore 2 energy 250.0:
```

Effect of Background Systematic Error

We can evaluate the background systematic error using the backscale in *Sherpa*. First we unsubtract the data and set the backscale parameter to 1 for both simulated data sets and the background files. Then we fit the data to get the best fit parameters for the photon index and the constant, and obtain the confidence range for these parameters (projection). Note that the power law amplitude remains frozen at the simulated value.

```
sherpa> unsubtract 1,2
sherpa> setdata 1 backscale = 1.0
sherpa> setdata 2 backscale = 1.0
sherpa> setback 1 backscale = 1.0
sherpa> setback 2 backscale = 1.0
sherpa> subtract 1,2
sherpa> fit
LVMQT: V2.0
LVMQT: initial statistic value = 76.9445
LVMQT: final statistic value = 76.5725 at iteration 9
      c1.c0  0.0997023
      pl.gamma  2.09921


sherpa> projection
Projection complete for parameter: c1.c0
Projection complete for parameter: pl.gamma

Computed for sherpa.proj.sigma = 1
-----
Parameter Name      Best-Fit Lower Bound      Upper Bound
-----
      c1.c0          0.0997023  -0.000915563  +0.000925169
      pl.gamma       2.09921    -0.00321998   +0.00322589

sherpa> oplot data 1 data 2 back 1 back 2
Warning: negative and zero values ignored in log scale
sherpa> limits x 10 600
sherpa> limits y 0.001 1
```

Simulation for Suzaku – Sherpa

```
sherpa> c 2 blue
sherpa> c 3 green
sherpa> c 4 red
sherpa> redraw
```

Figure 2  shows the results with all backscalls set to 1.0. The simulated values of photon index and constant parameters are recovered with a 1 sigma lower and upper bound as indicated by projection. This range needs to be compared to the systematic background error, which is 10%.


Next the background is overestimated by setting the background backscalls to 0.9:

```
sherpa> unsubtract 1,2
sherpa> setback 1 backscale = 0.9
sherpa> setback 2 backscale = 0.9
sherpa> subtract 1,2
sherpa> fit
LVMQT: V2.0
LVMQT: initial statistic value = 6215.34
LVMQT: final statistic value = 4071.34 at iteration 9
      c1.c0  0.144673
      p1.gamma  2.24062

sherpa> projection
Projection complete for parameter: c1.c0
Projection complete for parameter: p1.gamma

Computed for sherpa.proj.sigma = 1
-----
Parameter Name      Best-Fit Lower Bound      Upper Bound
-----
      c1.c0          0.144673 -0.00140331      +0.00142631
      p1.gamma        2.24062  -0.00346758      +0.00350342

sherpa> oplot data 1 data 2 back 1 back 2
Warning: negative and zero values ignored in log scale
sherpa> limits x 10 600
sherpa> limits y 0.001 1
sherpa> c 2 blue
sherpa> c 3 green
sherpa> c 4 red
sherpa> redraw
```

Figure 3  shows the results with background backscalls set to 0.9.

Finally we underestimate the background by setting the background backscalls to 1.1:

```
sherpa> unsubtract 1,2
sherpa> setback 1 backscale = 1.1
sherpa> setback 2 backscale = 1.1
sherpa> subtract 1,2
sherpa> fit
LVMQT: V2.0
LVMQT: initial statistic value = 11579.9
LVMQT: final statistic value = 2763.36 at iteration 12
      c1.c0  0.0679399
      p1.gamma  1.95657


sherpa> projection
Projection complete for parameter: c1.c0
Projection complete for parameter: p1.gamma

Computed for sherpa.proj.sigma = 1
-----
Parameter Name      Best-Fit Lower Bound      Upper Bound
-----
```

Simulation for Suzaku – Sherpa

```
      c1.c0          0.0679399  -0.000576908   +0.000579968
      p1.gamma       1.95657   -0.00290537   +0.00289905

sherpa> oplot data 1 data 2 back 1 back 2
Warning: negative and zero values ignored in log scale
sherpa> limits x 10 600
sherpa> limits y 0.001 1
sherpa> c 2 blue
sherpa> c 3 green
sherpa> c 4 red
sherpa> redraw
```

Figure 4  shows the results with background backscalses set to 1.1.

The three `p1.gamma` values obtained in this thread for different background backscale indicate a range of the systematic error in the simulation. The systematic error is larger than the statistical error (found by projection in each case). We assumed `p1.gamma=2.1` and `c1.c0=0.1` in the simulation. The systematic error in this simulation indicates `p1.gamma` values between 1.95–2.24 and `c1.c0` values between 0.06–0.14.

Save the Results

First we write out the simulated datasets. The `save` and `write_mdl` commands are then used to record the rest of the session information.

```
sherpa> write data fake1.pha PHA
sherpa> write data 2 fake2.pha PHA
sherpa> save all suzaku.shp
sherpa> write mdl "suzaku_mdl.fits"
```

`suzaku.shp` is text file with all the information needed to restore this session. `suzaku_mdl.fits` (the MDL file) stores the data, model, and other information in FITS format.

Commands Used in this thread

The text file `suzaku_commands.txt` contains all the commands issued in this thread:

```
paramprompt off
sherpa.dataplot.x_log = 1
sherpa.dataplot.y_log = 1

data 1 ae_hxd_pinbkg_20051105.pha
back 1 ae_hxd_pinbkg_20051105.pha
data 2 ae_hxd_gsobkg_20051105.pha
back 2 ae_hxd_gsobkg_20051105.pha

rsp[pin]
rsp[gso]
pin.rmf = ae_hxd_pinhxnom_20051104.rsp
gso.rmf = ae_hxd_gso_20051019.rsp
instrument 1 = pin
instrument 2 = gso

source 1,2 = const1d[c1]*powlaw1d[p1]
c1 integrate off
c1.c0 = 0.1
```

Simulation for Suzaku – Sherpa

```
p1.gamma = 2.1
p1.ref = 1.0
p1.ampl.min = 0.0
p1.ampl.max = 100.0
p1.ampl = 9.7
freeze p1.ampl

fakeit 1 time = 1e5
fakeit 1
fakeit 2 time = 1e5
fakeit 2

ignore 1 energy 60.0:
ignore 2 energy :30.0,600.0:

subtract 1,2
oplot data 1 data 2 back 1 back 2
limits x 10 600
limits y 0.001 1
c 2 blue
c 3 green
c 4 red
redraw

ignore 2 energy 250.0:

unsubtract 1,2
setdata 1 backscale = 1.0
setdata 2 backscale = 1.0
setback 1 backscale = 1.0
setback 2 backscale = 1.0
subtract 1,2
fit
projection
oplot data 1 data 2 back 1 back 2
limits x 10 600
limits y 0.001 1
c 2 blue
c 3 green
c 4 red
redraw

unsubtract 1,2
setback 1 backscale = 0.9
setback 2 backscale = 0.9
subtract 1,2
fit
projection
oplot data 1 data 2 back 1 back 2
limits x 10 600
limits y 0.001 1
c 2 blue
c 3 green
c 4 red
redraw

unsubtract 1,2
setback 1 backscale = 1.1
setback 2 backscale = 1.1
subtract 1,2
fit
projection
oplot data 1 data 2 back 1 back 2
limits x 10 600
limits y 0.001 1
c 2 blue
```


Simulation for Suzaku – Sherpa

```
c 3 green
c 4 red
redraw

write data fake1.pha PHA
write data 2 fake2.pha PHA
save all suzaku.shp
write mdl "suzaku_mdl.fits"
```

History

- 14 Jan 2005 reviewed for CIAO 3.2: no changes
- 14 Dec 2005 updated for CIAO 3.3: Astro–E2 is now named Suzaku; new HXD data files, fits and plots updated accordingly
- 01 Dec 2006 updated for CIAO 3.4: removed "AO1" from thread title

URL: http://cxc.harvard.edu/sherpa/threads/astro_e2/

Last modified: 1 Dec 2006

Image 1: Background-subtracted data and backgrounds

This plot shows the two simulated datasets (with the background subtracted) and the background from the original PHA files.

- white: dataset 1
- blue: dataset 2
- green: background 1 (ae_hxd_pinbkg_20051105.pha)
- red: background 2 (ae_hxd_gsobkg_20051105.pha)

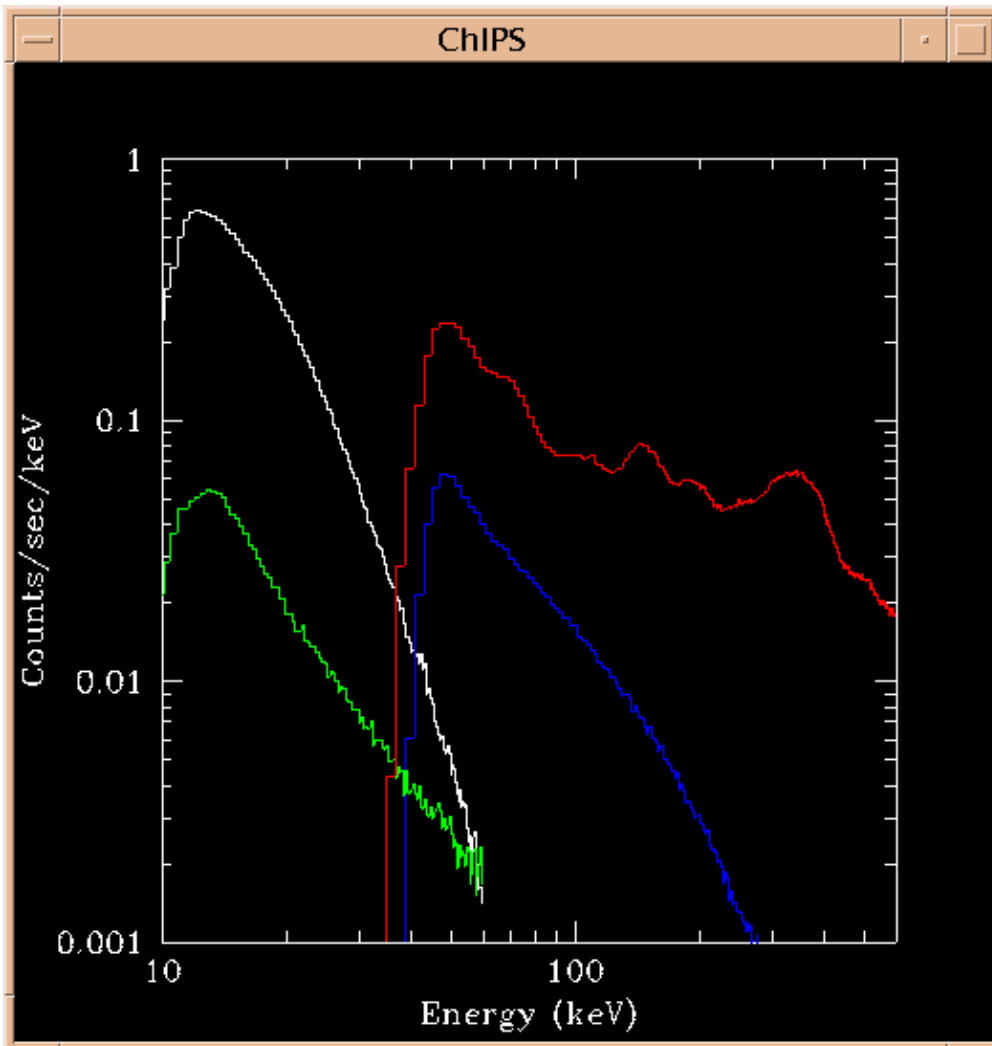


Image 2: Source and background backscales = 1.0

- white: dataset 1
- blue: dataset 2
- green: background 1 (ae_hxd_pinbkg_20051105.pha)
- red: background 2 (ae_hxd_gsobkg_20051105.pha)

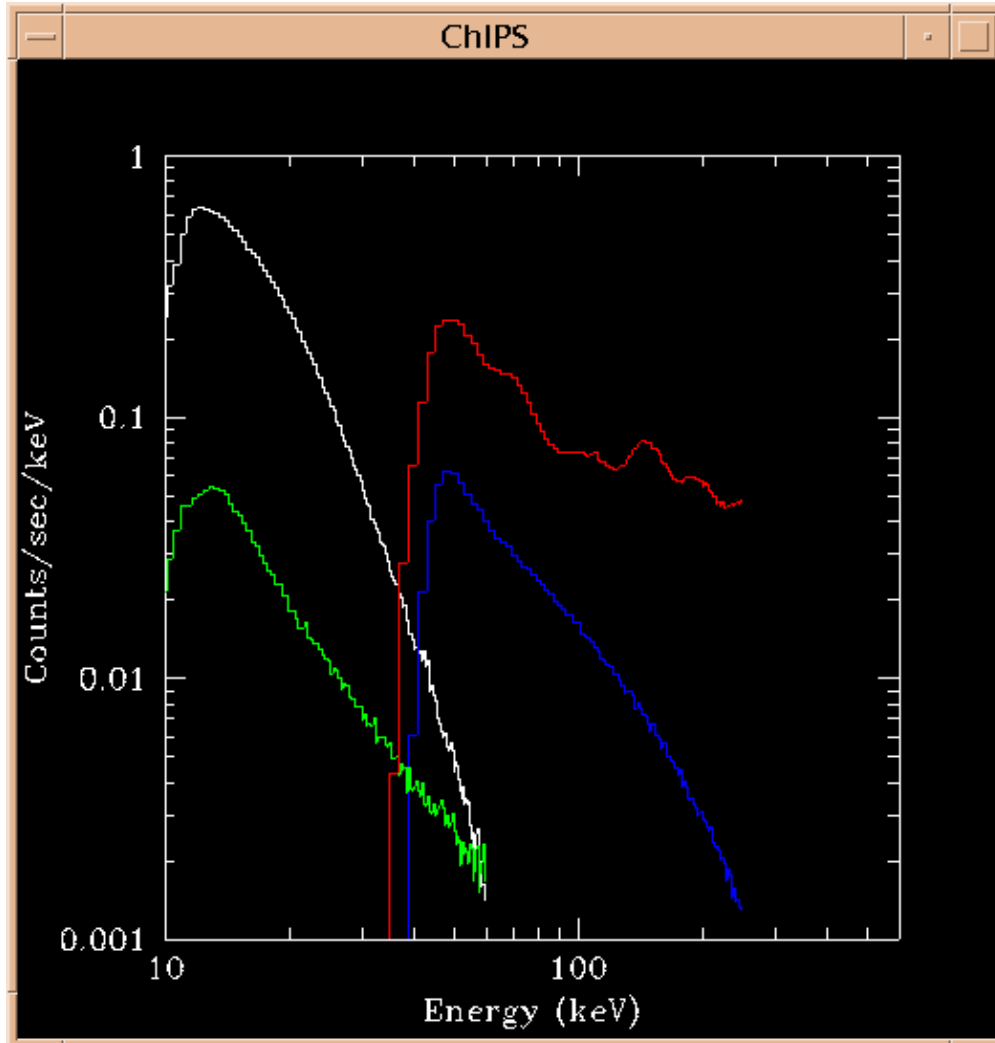


Image 3: Overestimate background: backscales = 0.9

- white: dataset 1
- blue: dataset 2
- green: background 1 (ae_hxd_pinbkg_20051105.pha)
- red: background 2 (ae_hxd_gsobkg_20051105.pha)

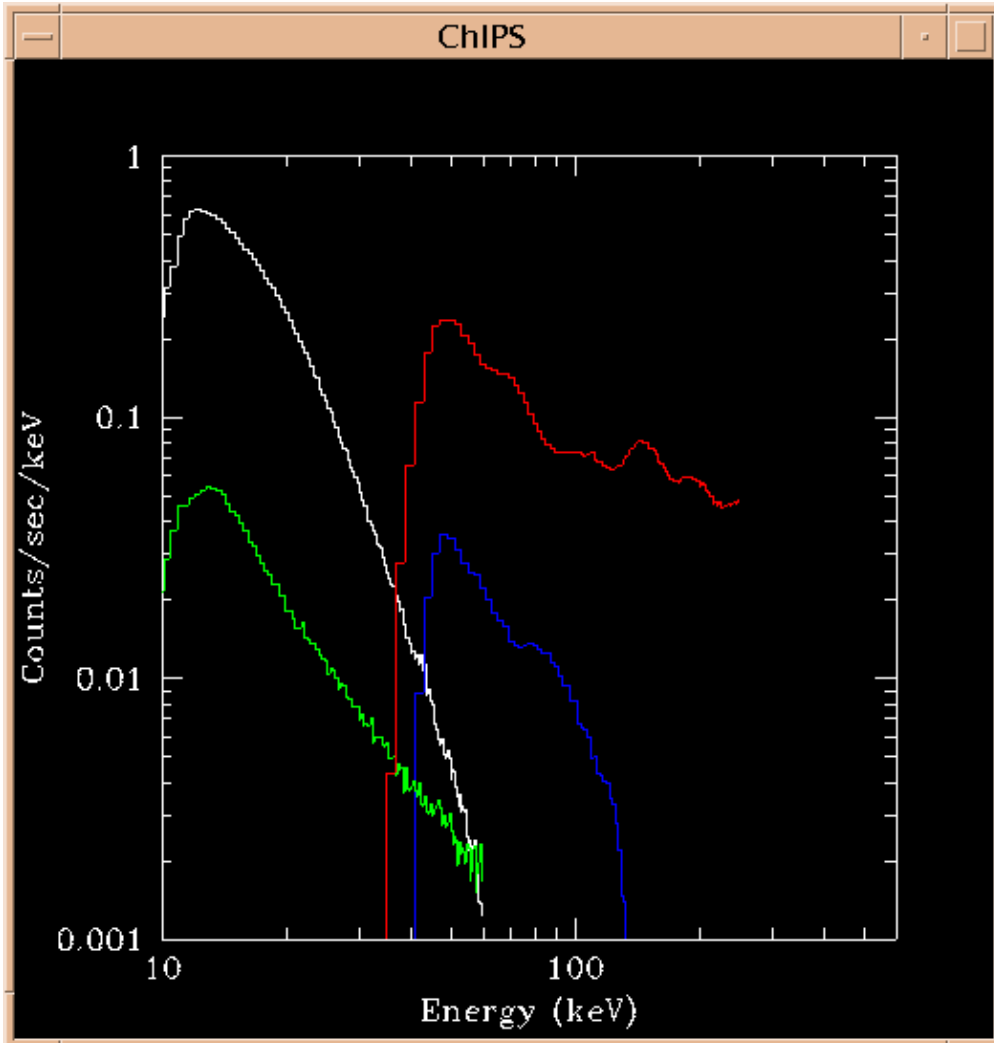
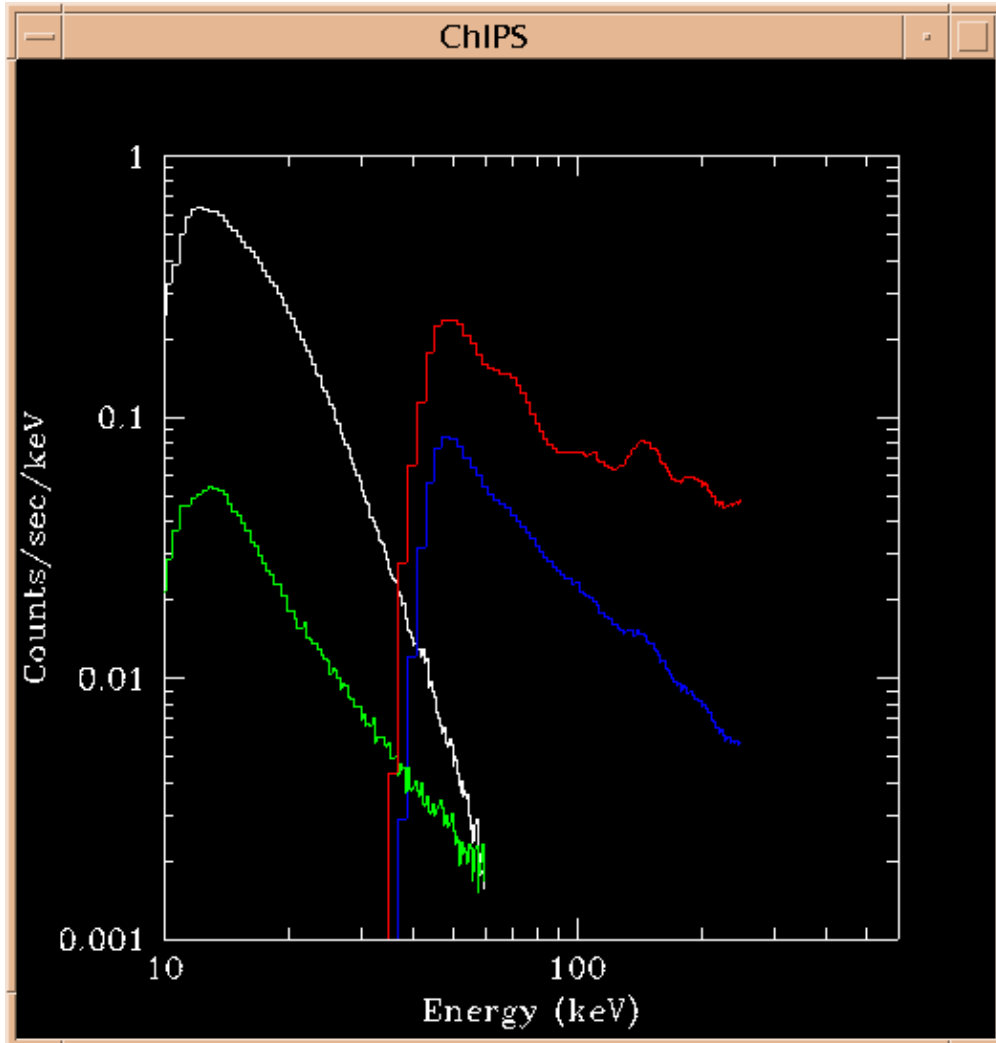


Image 4: Underestimate background: backscyles = 1.1

- white: dataset 1
- blue: dataset 2
- green: background 1 (ae_hxd_pinbkg_20051105.pha)
- red: background 2 (ae_hxd_gsobkg_20051105.pha)



Simulation for Suzaku – Sherpa