



## Abstract

Configuration file containing relevant specifications for *AXIS*. The current Values of all calibration files and all available configuration are documented here. Changes to the configuration and calibration files must be reflected here.

## Change Record

<i>Issue</i>	<i>Date</i>	<i>Description of Change</i>	<i>Affected Pages</i>
1	09/17/2025	Initial Release	All

## Distribution List

<i>Organization</i>	<i>Name</i>	<i>Organization</i>	<i>Name</i>	<i>Organization</i>	<i>Name</i>
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# List of TBC Issues

# List of Acronyms



**AXIS:** Advanced X-Ray Imaging Satellite  
**ARF:** Ancillary Response File  
**CCD:** Charge Coupled Device  
**CXRB:** Cosmic X-Ray Background  
**FOV:** Field of View  
**FWHM:** Full Width at Half Maximum  
**NXB:** Non X-ray Background  
**PHA:** Pulse Height Amplitude  
**PSF:** Point Spread Function  
**RMF:** Redistribution Matrix File  
**SIXTE:** Simulation of X-ray TElescopes  
**SXRB:** Soft X-Ray Background  
**FPA:** Focal Plane Assembly  
**XML:** eXtensible Markup Language

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## Documentation


### Reference Articles

Bluem J., Kaaret P., Kuntz K.D., et al., 2022, Astrophysical Journal 936, 72

## Typographic Conventions

The following typographic conventions are used:

- Files belonging to the set of instrument files are written in **typewriter font**.
  - Names of files, programs, functions and software libraries are typeset in an *italic font*.
  - Items to be determined are marked **TBD**. A list of all of these items is given on p. 3.
  - Items to be confirmed are marked **TBC**. A list of all of these items is given on p. 3.
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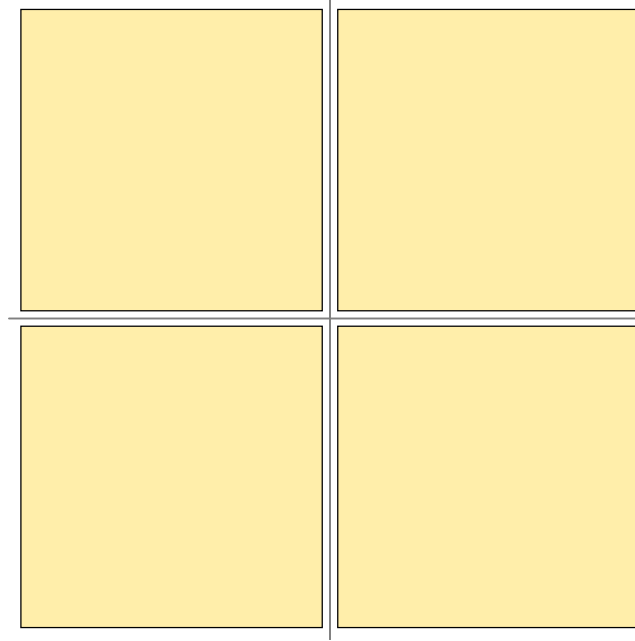


Figure 1: The chip layout of *AXIS*. The optical axis is centered at the cross.

## 1 Introduction

## 2 Chip layouts and readout modes

### 2.1 Chip geometry

The *AXIS* Focal Plane Assembly (FPA) consist of 4 detector chips each with a pixel layout of  $1440 \times 1440$  pixels. Each pixel measures  $0.024 \text{ mm} \times 0.024 \text{ mm}$ . Between the detectors is a gap is  $1.774 \text{ mm}$ . The total detector area is therefore  $4777.5744 \text{ mm}^2$  covering an area of  $5025.959236 \text{ mm}^2$ .

*AXIS* will be able to perform a Lissajous dithering pattern

$$\begin{aligned} X &= A \cos(\nu_1 t + \phi) \\ Y &= B \cos(\nu_2 t) \end{aligned} \tag{1}$$

with  $A = B = 1 \text{ arc min}$ ,  $\nu_1 = 0.1 \text{ Hz}$ ,  $\nu_2/\nu_1 = 5/4$ , and  $\phi = \pi/2$ .

### 2.2 Chip Readout

The detector readout for each frame happens with a frequency of  $5 \text{ Hz}$ . One pixel row is processed within  $10^{-6} \text{ s}$ . For *SIXTE* this means a process time of  $1440 \times 10^{-6} \text{ s} = 1.44 \times 10^{-3} \text{ s}$ . A wait time of  $0.19856 \text{ s}$  is therefore necessary to reach the target frame rate.

The readout noise of each pixel is estimated to be  $3 \text{ e}^- \times 3.7 \text{ eV/e}^-$ . Currently it is expected that readout does not require a threshold. The event threshold is currently set to  $10 \times$  the readout noise. The pattern split threshold is set to  $4 \times$  the readout noise. The upper threshold for pattern analysis is set to  $20 \text{ keV}$  (the nominal upper value).

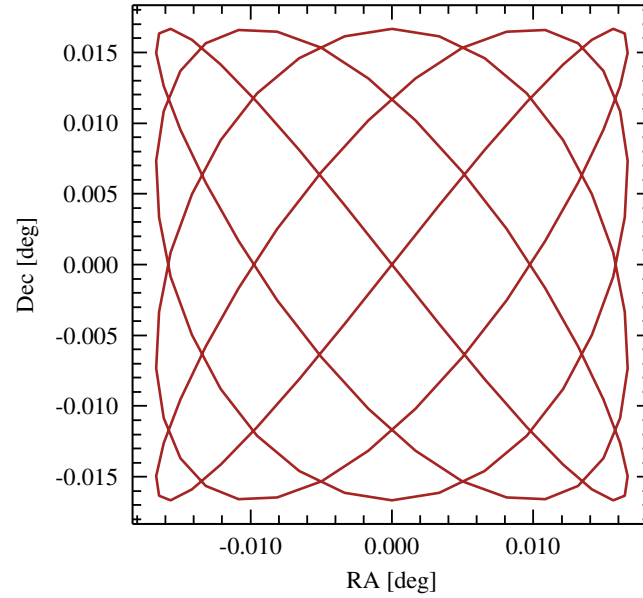


Figure 2: The nominal dither pattern for axis covers 2 arc min

Table 1: Readout values for *AXIS*.

SIXTE variable	value
threshold_readout_lo_keV	0 keV
threshold_readout_up_keV	–
threshold_event_lo_keV	0.111 keV
threshold_split_lo_keV	0.0444 keV
threshold_pattern_up_keV	20 keV

### 3 Calibration data

#### 3.1 ARF

The ARF file as provided by the mission team. Nominal values are from the baseline of step 2.  
Current ARF file: `axis_onaxis_20250611.arf`.

#### 3.2 Quantum Efficiency

TBD

Table 2: ARF values at some energies

Energy [keV]	Effective Area [cm <sup>2</sup> ] on-axis	FOV averaged (9'')	(12'')
0.5	2800	2140	1980
1.0	3900	2990	2600
6.0	600	360	260

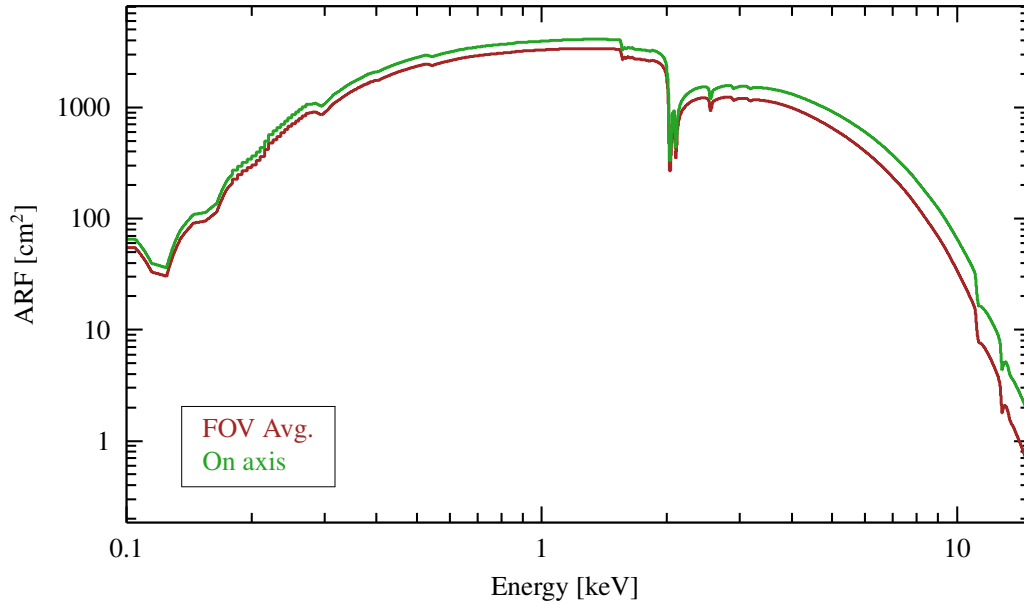


Figure 3: Current effective area file, FOV averaged and on axis (both 20250611).

Table 3: Energy resolution

Energy [keV]	Full Width at Half Maximum (FWHM) [eV]
0.5	70
1.0	100
6.0	150

### 3.3 RMF

The detector resolution is modeled with a energy dependent Gaussian following the Suzaku response. Currently the threshold values are inside the second channel. As a consequence, simulated spectra have 0 counts in the first channel and a reduced number in the second.

Current RMF file: `axis_ccd_20221101.rm`.

### 3.4 Vignetting

There are two vignetting files. One contains vignetting due to geometric setup. The other additionally includes contamination of the surfaces.

Current Vignetting file: `axis_vignetting_20250425.fits`.

### 3.5 PSF

The PSF for *AXIS* is currently estimated based on Chandra. The full PSF is defined by a Voigt profile with energy and off-axis angle dependent Lorentzian and Gaussian widths.

The current PSF is based on design values (Ptak A.) and by an estimate of wing contribution (Guenther H. M.). Compared to the description of the wings here the core is scaled to match the target value.

The FOV radius is 12 arc min. Wings of the PSF are described by a Lorentzian, such that the PSF is a Voigt function. The FWHM of the core is scaled to 1.25 arc sec.



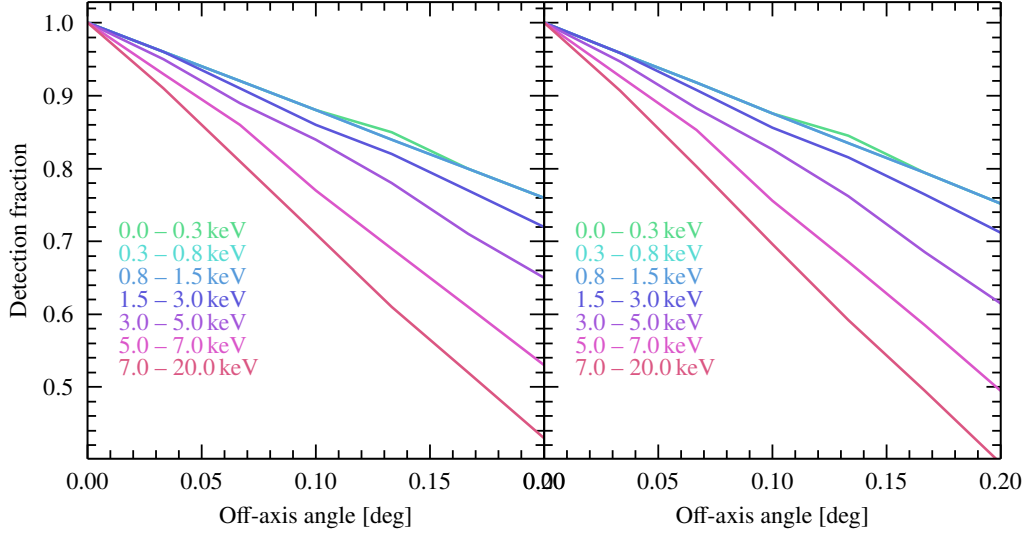


Figure 4: Vignetting function for the geometry (left) and with additional contamination (right).

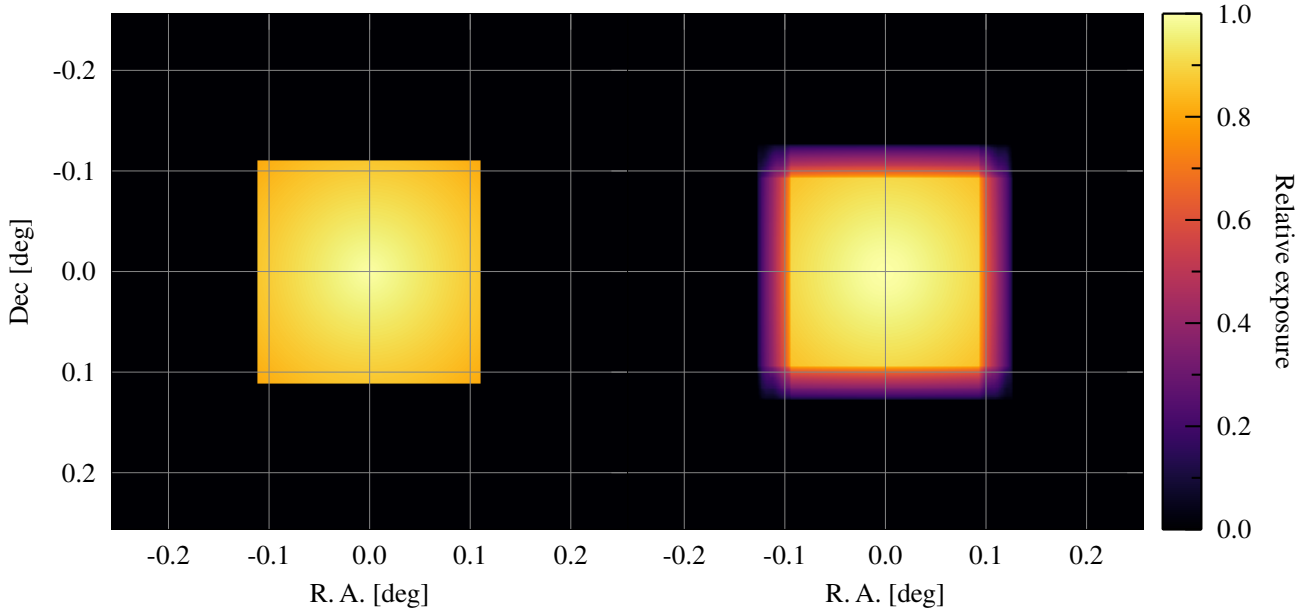


Figure 5: The exposure map including vignetting (left). And the same exposure map taking the dither pattern into account (right)

Current PSF file: axis\_psf\_baseline\_20250611.psf.

### 3.6 PHA background

The particle background for the L2 orbit is estimated to be below  $7 \times 10^{-4}$  cts s<sup>-1</sup> keV<sup>-1</sup> arc min<sup>-2</sup> for 90% of the time (at 6 keV).

The Non X-ray Background (NXB) can be defined by an `xspec` model that generates the background spectrum: `constant(1) * (powerlaw(1) + powerlaw(2) + spxpcut(1) * pegpwlw(1) + gaussian(1) + gaussian(2) + gaussian(3) + gaussian(4) + gaussian(5) + gaussian(6) + gaussian(7) + gaussian(8)) * constant(2)`

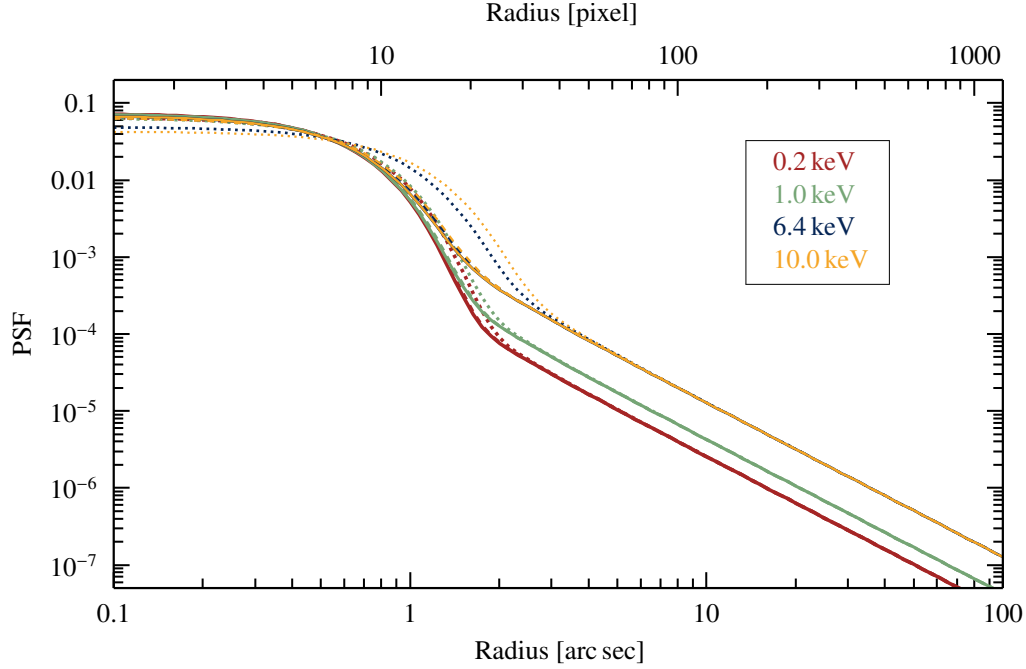


Figure 6: The PSF as modeled with a Voigt profile. The energy and angle dependence of the core is based on `axis_psf_baseline_20250611.dat` (Ptak A.). The wings have an estimated energy dependence (Guenther H. M.). The solid, dashed, and dotted lines correspond to off-axis angles of 0, 4, and 8 arc min, respectively.

Table 4: Energy dependent PSF values

Energy [keV]	PSF HPD [arc sec] on-axis	FOV averaged (9'') (12'')	
0.5	1.5	1.8	2.15
1.0	1.5	1.8	2.15
6.0	1.5	2.4	3.50

This model is fixed except the first constant which allows for scaling the FOV. If set to unity the model calculates the flux for a FOV of 1 arc min<sup>2</sup>. For SIXTE this model has to be scaled to a flux through a 1 m<sup>2</sup> area. Using thin lens approximation the conversion is  $2f \tan(0.5') = 2.62 \times 10^{-3}$  m, where  $f = 9$  m is the focal length. The FOV is approximately 452 amin<sup>2</sup>.

Foreground soft x-ray model SXRb:  $constant(1) * (apec(1) + tbabs(1) * (apec(2) + apec(3)))$ .

The soft background model does not include the Cosmic X-Ray Background (CXRB).

Current background PHA file: `axis_background_baseline_20250210.pha`.

### 3.7 Charge cloud size

The charge cloud size produced on impact is estimated by a Gaussian distribution with  $\sigma = 5 \mu\text{m}$ . The size is not scaled by energy.

## 4 Simulation configurations

The XML files provide configurations for SIXTE for a number of setups. The detailed configurations for each file are given below.

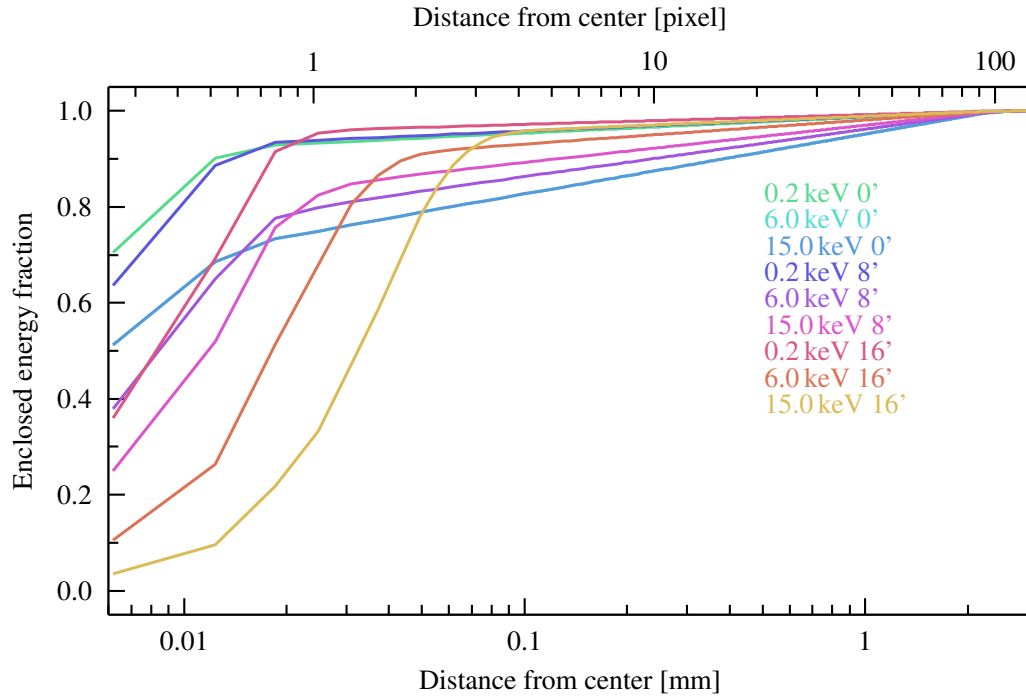


Figure 7: Enclosed energy fraction for a source in the center of the PSF for different energies and off-axis angles.

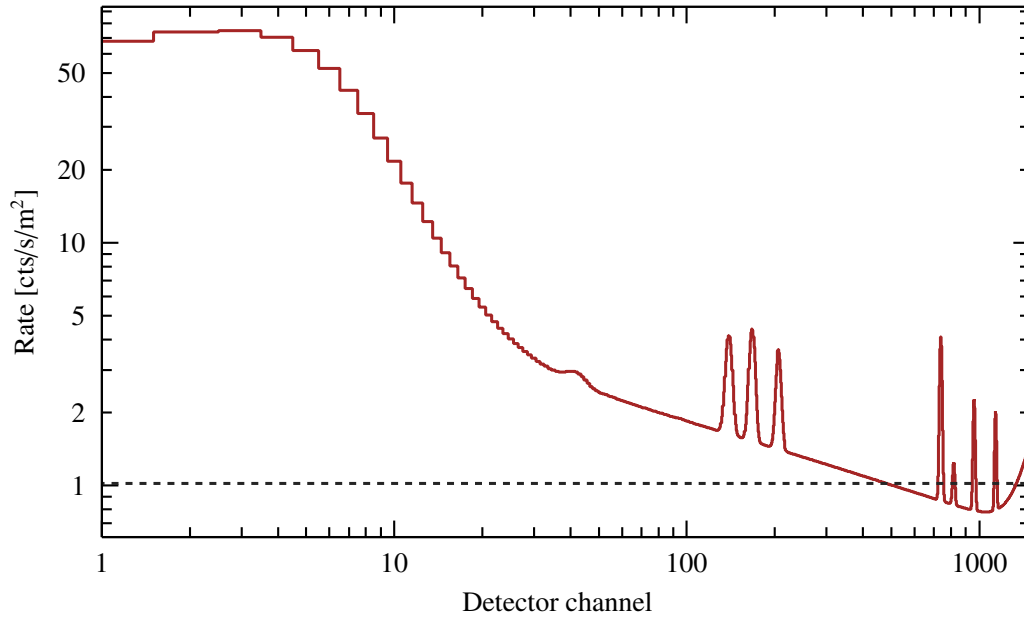


Figure 8: The particle background spectrum scaled to an area of 1 m<sup>2</sup> and as seen by the detectors (including RMF effects). The dashed gray line shows scaled value for  $7 \times 10^{-4}$  cts/s/amin<sup>2</sup> at 6 keV.

#### 4.1 All chips

Configuration reflecting the full satellite. All four chips are used with the default readout. This resembles the current satellite design.

Current eXtensible Markup Language (XML) file: `axis_baseline_all_chips.xml`.


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Table 5: NXB background model parameters (Miller, E.) for L2 orbit.

Parameter	Value	Parameter	Value
constant(1).factor	1	gaussian(3).LineE	1.76633
powerlaw(1).norm	$1.08494 \times 10^{-6}$	gaussian(3).Sigma	$1.0 \times 10^{-4}$
powerlaw(1).PhoIndex	4.4497	gaussian(4).norm	$2.66144 \times 10^{-5}$
powerlaw(2).norm	0.000227838	gaussian(4).LineE	2.15301
powerlaw(2).PhoIndex	0.391021	gaussian(4).Sigma	$1.0 \times 10^{-4}$
spexpcut(1).Ecut	0.65	gaussian(5).norm	$6.62182 \times 10^{-5}$
spexpcut(1).alpha	0.91461	gaussian(5).LineE	7.48161
pegpwlw(1).norm	1697.65	gaussian(5).Sigma	$1.0 \times 10^{-4}$
pegpwlw(1).PhoIndex	-24.2195	gaussian(6).norm	$8.88541 \times 10^{-6}$
pegpwlw(1).eMin	10	gaussian(6).LineE	8.27183
pegpwlw(1).eMax	10	gaussian(6).Sigma	$1.0 \times 10^{-4}$
gaussian(1).norm	1.48735	gaussian(7).norm	$3.34808 \times 10^{-5}$
gaussian(1).LineE	0.513074	gaussian(7).LineE	9.69517
gaussian(1).Sigma	$1.0 \times 10^{-4}$	gaussian(7).Sigma	$1.0 \times 10^{-4}$
gaussian(2).norm	$2.58487 \times 10^{-5}$	gaussian(8).norm	$2.97883 \times 10^{-5}$
gaussian(2).LineE	$2.5573 \times 10^{-6}$	gaussian(8).LineE	11.4647
gaussian(2).Sigma	$2.58487 \times 10^{-5}$	gaussian(8).Sigma	$1.0 \times 10^{-4}$
gaussian(3).norm	$3.19796 \times 10^{-5}$	constant(2).factor	4.5

Table 6: Soft X-Ray Background (SXRb) background model parameters after Bluem et al..

Parameter	Value	Parameter	Value
constant(1).factor	1.0	apec(2).kT	0.21
apec(1).norm	$4.83 \times 10^{-7}$	apec(2).Abundanc	0.5
apec(1).kT	$9.9 \times 10^{-2}$	apec(2).Redshift	0.0
apec(1).Abundanc	1.0	apec(3).norm	$4.953 \times 10^{-8}$
apec(1).Redshift	0.0	apec(3).kT	0.7
tbabs(1).nH	$1.8 \times 10^{-2}$	apec(3).Abundanc	0.5
apec(2).norm	$4.04 \times 10^{-7}$	apec(3).Redshift	0.0

## 4.2 CCD Aim

Configuration for CCDn only, placed at its location in the full setup.

Current XML file: `axis_baseline_ccd1_aim.xml`.

## 4.3 CCD1 Full Frame

Configuration for CCD1 centered in the FOV.

Current XML file: `axis_baseline_ccd1_ff.xml`.

## 5 Conclusions

The files for AXIS are available here: <https://www.sternwarte.uni-erlangen.de/sixte/instruments> and should be used with SIXTE (<http://www.sternwarte.uni-erlangen.de/sixte>).

Questions regarding the setup and the simulations should be directed to [sixte-support@lists.fau.de](mailto:sixte-support@lists.fau.de).