# ATHENA

# WFI ATHENA

| | |
|---|---|
| Project | **ATHENA WFI** |
| Title | **Preparation of Background Files for Scientific Simulations** |
| Reference | WFI-MPE-ANA-0010 |
| Issue | 7.1 |
| Date | 29.03.2021 |

**Abstract**

This document outlines the assumption and delivered files for the WFI background for scientific simulations.

**Contribution list**

| Institution | Name(s) | Contribution(s) | Section(s) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Responsible Author:     Arne Rau (MPE)

## CHANGE RECORD

| Issue | Date | Section/Pages | Reason for Change |
|-------|------|---------------|-------------------|
| 1D0 | 05.04.2013 | All | First Release |
| 2D0 | 09.04.2013 | 4,6,7 | simulations redone with new WFI responses; fraction of 80% of resolved sources assumed for extra-galactic background emission; removed specification of background units in section 3.2; corrected erroneous units in Tab. 1 |
| 3D0 | 27.08.2013 | 6,7,8 | Changed CXB photon model from Lumb to McCammon et al. 2002; specified integration area |
| 3D1 | 13.01.2014 | 1 | Changed document name following document identification rules described in WFI-MPE-TNO-0010-0d1-Configuration-and-Document-Management |
| 4D0 | 07.02.2014 | 7,8,9 | Added separate background files for extended sources (amin$^{-2}$) and point sources (5" radius aperture). Included reference to description for different extraction areas, response matrices, focal length by adopting text from X-IFU document IAPS-XIFU-TN-2013-002. |
| 4D1 | 13.02.2014 | 8,9,deliverables | Changed ATOMDB version from 1.3.1 to 2.0.2, which has an impact on the low energy (0.1-0.3keV) diffuse background component. Removed unused parameter (const=0.2) from Table 1. |
| 5D1 | 27.03.2015 | All | Updated to new detector geometry. New responses for mirror model trade-off study exercise. |
| 6D1 | 03.04.2018 | 7,8,9 | New responses for 15 and 19 row mirror models. |
| 6D2 | 20.06.2018 | 7 | Update version number of deliveries to 20180620 |
| 6D3 | 05.07.2018 | 7 | Bug-fix to 5" normalized background files. Update of version number of deliveres to 20180705. Corrected typo ('wabs' should have been 'phabs') in Section **Error! Reference source not found.**. |
| 7.0 | 02.05.2019 | All | Update to 20190122 response files. XSPEC and APEC version specified. |
| 7.1 | 29.03.2021 | | Update to 20210218 response files, which provided fix to HEASOFT 6.28 related bug. |

## Document Distribution List

| Issue: | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| **Name** | **Company** | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# 1   Scope

This document summarises the preparation of the photon and particle background files to be used for scientific simulations for Athena/WFI.

**TABLE OF CONTENTS**

# 2 Applicable and Reference Documents

| RD Doc.-No. and Title | Issue | Date |
|---|---|---|
| [RD1]    ECAP-ATHENA-WFI-RSP_20190122.pdf | | |
| [RD2]    „A High Spectral Resolution Observation of the Soft X-Ray Diffuse Background with Thermal Detectors", McCammon et al. 2002, ApJ 576, 188 | | |
| [RD3] | | |
| [RD4] | | |
| [RD5] | | |
| [RD6] | | |
| [RD7] | | |
| [RD8] | | |
| [RD9] | | |
| [RD10] | | |
| [RD11] | | |
| [RD12] | | |

# 3   Introduction

## 3.1   Response Files

The response files used in the following are described in [RD1]. They use the RMF

$$athena\_wfi\_rmf\_v20150326.rmf$$

and the naming convention of

$$athena\_wfi\_rib2.3\_B4C\_20210218\_<F>\_filter\_<AREA>.rsp$$

with

**Table 1: Naming convention for response files**

| Item | Values |
|---|---|
| <F> = with or without external light blocking filter, or (thick) Be filter | w<br>wo<br>Be |
| <AREA> = area over which the response is averaged | OnAxis<br>FovAvg<br>5aminAvg |

The Be filter is planned to be implemented only for the Fast Detector (FD). Therefore, only an On_Axis version of the response files is used.

These response files correspond to the baseline (v2.4) Athena SPO mirror model with 15 rows with 6 sectors and 678 modules, and active aperture radius 259-1183 mm, and a 10% collecting area loss margin at all energies.

## 3.2   Non-X-ray Background

The non-X-ray background was assumed to be flat over the entire 0.2-15keV energy band with a value of $5\times10^{-3}$ cnt/keV/s/cm$^2$ (i.e, $6\times10^{-4}$ cnt/keV/s/amin$^2$). This corresponds to the Athena science requirement for the non-focused non-X-ray background component in WFI LDA observations over the energy band from 2 to 7 keV.

Note, that the focused non-X-ray component is not included in the simulations. The requirement is that this component is less than 10% of the non-focused non-X-ray background over the same energy band.

The following two non-focused non-X-ray PHA background files with different integration regions are provided:

**Table 2: Non-focused non-X-ray background files.**

| File | Integration area |
|---|---|
| athena_wfi_bkgd_particle.pha | 1amin$^2$ |
| athena_wfi_bkgd_particle_psf.pha | 5" radius |

## 3.3   Celestial X-ray Background

The cosmic photon background consists of the integrated emission from unresolved extragalactic point sources and the diffuse Galactic foreground. The calculations have been performed using the following model:

*model  apec+phabs(apec+powerlaw)*

The parameter values are given in Table 3. The fraction of resolved sources was assumed to be 80%.

**Table 3: XSPEC model parameters for celestial photon background. Normalizations refer to 1amin$^2$. Parameters from [RD2].**

| Model | Parameter | Value | Unit |
|---|---|---|---|
| apec | kT | 9.9E-2 | keV |
| apec | abundance | 1 | |
| apec | redshift | 0 | |
| apec | norm | 1.7E-6 | $(10^{-14}/(4\pi(D_A(1+z))^2))\int n_e n_H dV$ [1] |
| phabs | $N_H$ | 0.018 | $10^{22}$ cm$^{-2}$ |
| apec | kT | 0.225 | keV |
| apec | abundance | 1 | |
| apec | redshift | 0 | |
| apec | norm | 7.3E-7 | |
| powerlaw | photon index | 1.45 | |
| powerlaw | norm | 2.0E-7 | pho/keV/cm$^2$/s @ 1 keV |

[1]:

where $D_A$ is the angular size distance to the source (cm), and $n_e$ and $n_H$ are the electron and H densities (cm$^{-3}$)

*XSPEC* version 12.11.0k with *APEC* v3.0.9 was used for simulating the background spectra.

Celestial background-only files are provided following the naming convention of

*athena_wfi_rib2.3_B4C _20210329_bkgd_<P/E>_<F>_filter_<AREA>.pha*

with

**Table 4: Naming convention for celestial background files**

| Item | Values |
|---|---|
| <P/F> = point source (normalized to a 5" radius extraction region) or extended (normalized to 1 arcmin[2)] | extended<br>psf |
| <F> = with or without external light blocking filter | w<br>wo<br>Be |
| <AREA> = area over which the response is averaged | OnAxis<br>FovAvg<br>5aminAvg |

## 3.4 Total Background

The background files listed in Table 2 and Table 4 are combined to provide to total (celestial + instrumental combined) background files with the following naming convention:

$$athena\_wfi\_rib2.3\_B4C\_20210329\_bkgd\_sum\_<P/E>\_<F>\_filter\_<AREA>.pha$$

with the values as listed in Table 4.

The individual components as well as the sum are shown in Figure 1 for the example of athena_wfi_rib2.3_B4C_20210329_bkgd_sum_extended_wo_filter_OnAxis.pha.
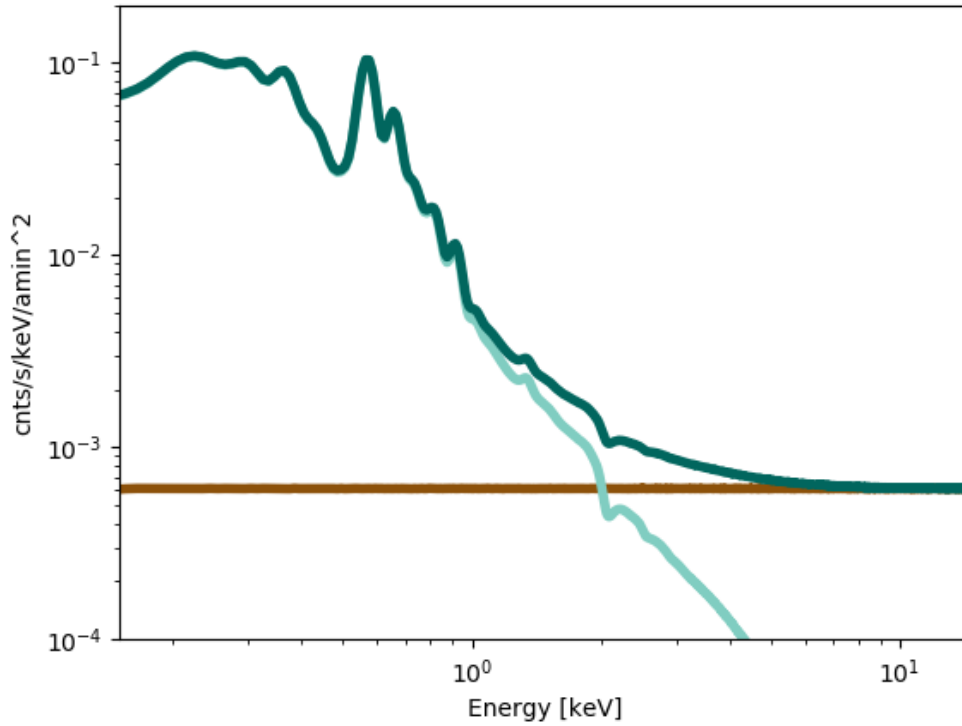
**Figure 1: Background components for extended sources, on-axis, without external optical blocking filter, in units of cnt s$^{-1}$ keV$^{-1}$ amin$^{-2}$. The photon background (light green), the particle background (brown), and the sum of both (dark green) are shown.**

# APPENDIX 1: Abbreviations and Acronyms

This document employs several abbreviations and acronyms to refer concisely to an item, after it has been introduced. The following list is aimed to help the reader in recalling the extended meaning of each short expression:

| | |
|---|---|
| B4C | Boron Carbide (B$_4$C) |
| FD | Fast Detector |
| LDA | Large Detector Array |
| PHA | Standard FITS File Format in X-ray Astronomy |
| PSF | Point Spread Function |
| RMF | Redistribution Matrix File |
| WFI | Wide Field Imager |