Project **ATHENA WFI**

Title **Preparation of Background Files for Scientific Simulations**

Reference WFI-MPE-ANA-0010

Issue 8.2

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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)

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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 deliverables to 20180705. Corrected typo ('wabs' should have been 'phabs').
7.0	02.05.2019	All	Update to 20190122 response files. XSPEC and APEC version specified.
8.0	20.11.2020	All	Update with telescope v3.1 files and RMF 20200925. File now provide for SiC and B4C overcoating options.
8.1	14.12.2020	All	Update to SiC layer thickness from 10nm to 4nm.
8.2	19.01.2021	Table 1 & 4	Responses fixed to work with Heasoft 6.28

Document Distribution List

Issue:		**1**	**2**	**3**	**4**	**5**	**6**
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1 Scope

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

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2 Applicable and Reference Documents

RD Doc.-No. and Title	Issue	Date
[RD1] ECAP-ATHENA-WFI-RSP_20201117.pdf	10	17.11.2020
[RD2] „A High Spectral Resolution Observation of the Soft X-Ray Diffuse Background with Thermal Detectors", McCammon et al. 2002, ApJ 576, 188		
[RD3] "Athena Science Requirements Document", SRE-S/ATH/2015/01	2.6	22.02.2020
[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_v20200925.rmf

and the naming convention of

athena_wfi_rib2.3_<COATING>_<DATE>_<F>_filter_<AREA>.rsp

with

Table 1: Naming convention for response files

Item	Values
<COATING> = over coating assumed for SPO	SiC B4C
<DATE>	20201222 (SiC) 20201222 (B4C)
<F> = with or without external light blocking filter, or (thick) Be filter	w wo Be
<AREA> = area over which the response is averaged	OnAxis FovAvg 5aminAvg

These response files correspond to the Athena telescope reference model v3.1 with 15 rows with 6 sectors and 600 modules, and active aperture radius 244-1256 mm, a mirror plate rib spacing of 2.3mm, and a -1/+1 wedging. SiC[1] is the baseline coating, while B4C is include for historical reference and for compliance with the original nominal science requirements.

The files include all optics related loss effects as well as loss factors to account for expected losses such as misalignments, coating imperfections, contamination, etc

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

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 5.5×10^{-3} cnt/keV/s/cm^2 (i.e, 6.7×10^{-4} cnt/keV/s/amin^2). This corresponds to the Athena

[1] To be more precise, the assumption is 10µm Ir coating with 4µm SiC overcoating on rows 9-15.

science requirement for the combined focused and non-focused non-X-ray background component in WFI LDA observations over the energy band from 2 to 7 keV (SCIRD-901; [RD3]).

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

Table 2: 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_<COATING>
_<DATE>_bkgd_<P/E>_<F>_filter_<AREA>.pha

with

Table 4: Naming convention for celestial background files

Item	Values
<COATING> = over coating assumed for SPO	SiC B4C
<DATE>	20201222 (SiC) 20201222 (B4C)
<P/F> = point source (normalized to a 5" radius extraction region) or extended (normalized to 1 arcmin[2)]	extended psf
<F> = with or without external light blocking filter	w wo Be
<AREA> = area over which the response is averaged	OnAxis FovAvg 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_<COATING>_<DATE>_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_SiC_20201222_bkgd_sum_extended_wo_filter_OnAxis.pha.

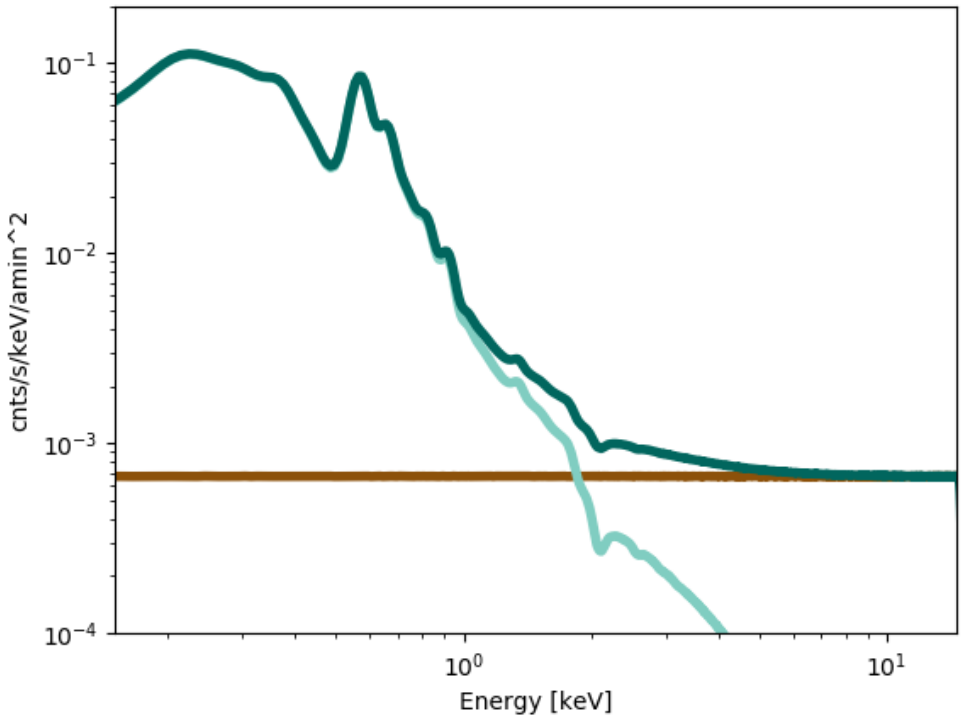

Figure 1: Background components for extended sources, on-axis, without external optical blocking filter, and with the baseline SiC overcoating. The photon background (light green), the particle background (brown), and the sum of both (dark green) are shown.

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_4C)
FD	Fast Detector
LDA	Large Detector Array
PHA	Standard FITS File Format in X-ray Astronomy
PSF	Point Spread Function
RMF	Redistribution Matrix File
SiC	Silicon Carbide
SPO	Silion Pore Optics
WFI	Wide Field Imager