NewATHENA WFI

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

Reference WFI-MPE-ANA-10-013

Issue 9.2

Date 23.02.2024

Abstract

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

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Engineering:

Project Management:

Product Assurance:

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 number changed from WFI-MPE-ANA-0010 to WFI-MPE-ANA-10-013			

8.3	11.03.2022	All	Now includes two non-X-ray background intensity predictions w/ and w/o systematic uncertainties. Uses response files v20220308 with updated instrument efficiencies. This is delivered to SRR.
9.0	01.06.2023	All	Update with NewAthena effective area curves and revised RMF. Using response files v20230524. This is delivered to the SRDT.
9.1	17.07.2023		New release v20230717 after fixing normalization for all 7asec nxb=5 files.
9.2	23.02.2024		v20240223 with updated mirror files (effective area, vignetting) and restricted to NewAthena constraints (9" HEW, nxb=8E-3 cgs)

List of Contributors

Organisation	Name	Organisation	Name

Document Distribution List

Organisation	Name	Organisation	Name

Applicable Documents

Ref.	Document Title / Number	Issue	Date
[AD1]			
[AD2]			
[AD3]			
[AD4]			
[AD5]			
[AD6]			
[AD7]			
[AD8]			

Reference Documents

Ref.	Document Title / Number	Issue	Date
[RD1]	List of Documents WFI-MPE-LIS-10-002	1	03/03/2022
[RD2]	List of Acronyms WFI-MPE-LIS-10-001	1	03/03/2022
[RD3]	Athena WFI Response Files WFI-ECAP-TNO-10_011	1.15	09/02/2024
[RD4]	Instrumental Background WFI-MPE-ANA-10-009	1	21/02/2022
[RD5]	Recommendations about the model for the extragalactic Cosmic X-ray Background to be used for the simulations of the stray light and for X-IFU and WFI background simulations SWG123-TN-0003	5.1	07/03/2022
[RD6]	„A High Spectral Resolution Observation of the Soft X-Ray Diffuse Background with Thermal Detectors", McCammon et al. 2002, ApJ 576, 188		
[RD7]	Instrument Efficiency WFI-MPE-ANA-10-011	3	22/02/2023
[RD8]	NewAthena mirror performance	1.2	24/05/2023

Acronyms

AD	Applicable Document
ATHENA	Advanced Telescope for High-Energy Astrophysics
B4C	Boron Carbide (B_4C)
BB	Bread Board
FD	Fast Detector
LDA	Large Detector Array
PHA	Standard FITS File Format in X-ray Astronomy
PSF	Point Spread Function
RD	Reference Document
RMF	Redistribution Matrix File
SiC	Silicon Carbide
SPO	Silicon Pore Optics
TBC	To Be Confirmed
TBD	To Be Defined
TCS	Thermal Control System

A complete list of documents is available in [RD2].

Contents

1 Introduction

This document summarises the photon and particle background file preparation for scientific simulations for NewAthena/WFI.

1.1 Response Files

The response files used in the following are described in [RD3]. They use the RMF

athena_wfi_rmf_v20230523.rmf

and the naming convention of

NewAthena_WFI_<#ROWS>_<DETECTOR>_<FILTER>_<AREA>_<DATE>.rsp

with

Table 1: Naming convention for response files

Item	Values
<#ROWS> = number of rows	13rows
<DETECTOR>	LDA FD
<FILTER>	w_filter wo_filter w_thick_filter
<AREA> = area over which the response is averaged	OnAxis FovAvg 5aminAvg
<DATE>	20240209

The response files use the NewAthena effective as described in [RD8], which include all optics-related loss effects as well as loss factors to account for expected losses such as misalignments, coating imperfections, contamination, etc. Furthermore, the instrument efficiencies as described in [RD7] are used.

The thick filter will be implemented only for the Fast Detector (FD). Therefore, only an OnAxis version of the response files is available.

1.2 Non-X-ray Background

The non-X-ray background spectrum is flat over the full 0.2-15keV energy band. Files are generated for the intensity of 8.0 cnt/keV/s/cm^2 and for two integration areas (1amin^2; and 9" radius). The file names are constructed as

NewAthena_WFI_bkgd_particle_<EXT_REG>pha

and summarised in Table 2.

Table 2: Non-X-ray background files.

File	Value	Meaning
<AEXT_REG> = extraction region	1amin 9asec	1amin^2 9" radius

1.3 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+bknpower)

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. Normalisations refer to 1amin^2—parameters for the apec components from [RD6] and the CXB from [RD5].

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	
bknpower	photon index 1	1.728	
bknpower	break energy	1.468	keV
bknpower	photon index 2	1.452	
bknpower	norm	1.96E-7	pho/keV/cm^2/s/amin^2 @ 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

NewAthena_WFI_13rows_<DETECTOR>_<DATE>_bkgd_photon_<EXT_REG>_<FILTER>_<AREA>.pha

with

Table 4: Naming convention for celestial background files

Item	Values
<DETECTOR>	LDA FD
<DATE>	20240223
<EXT_REG> = extraction region	1amin 9asec
<FILTER>	w_filter wo_filter w_thick_filter
<AREA> = area over which the response is averaged	OnAxis FovAvg 5aminAvg

1.4 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:

NewAthena_WFI_13rows_<DETECTOR>_<DATE>_bkgd_sum_<EXT_REG>_<FILTER>_<AREA>.pha

with the values listed in Table 3 and Table 4.

The files are provided as tarball New*Athena_WFI_bkgd_v20240223.tar.gz* attached to this document.

The individual components, as well as the sum, are shown in Figure 1 for the example of NewAthena_WFI_13rows_LDA_20240223_bkgd_sum_1amin_w_filter_OnAxis.

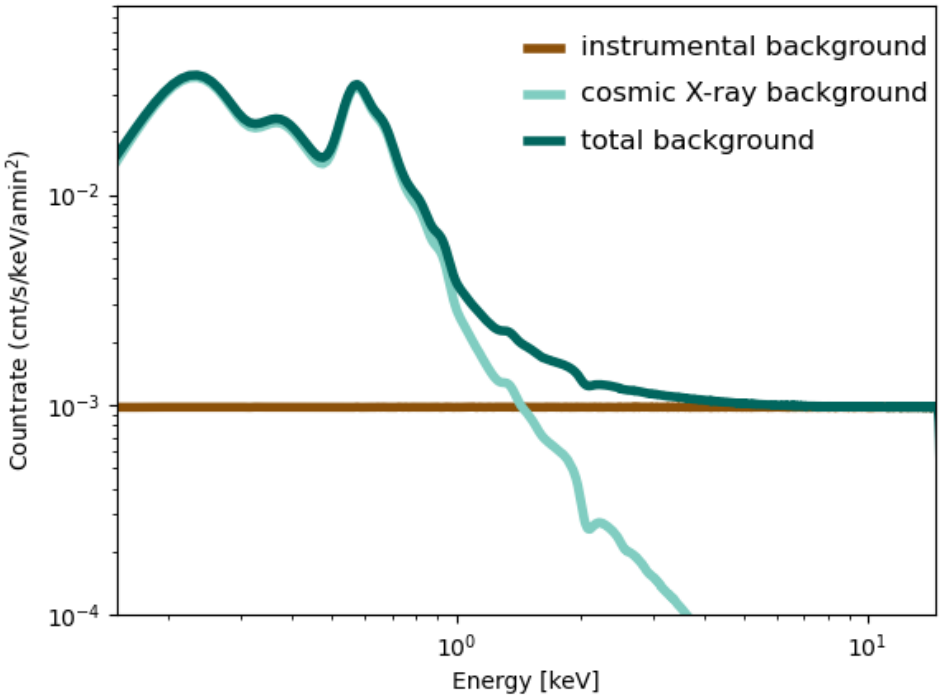

Figure 1: Background components for extended sources, on-axis, and with external optical blocking filter. The photon background (light green), the particle background with systematic uncertainties (brown), and the sum of both (dark green) are shown.