Abstract

Description of the response files in the current release (20240209) for the *NewAthena* Wide Field Imager (WFI). This document describes the assumptions made and lists the included files.

Change Record

Issue	*Date*	*Description of Change*	*Affected Pages*
1	10 December 2014	Initial Release	All
2	04 February 2015	Added section on Readout Threshold	7-11
3	17 March 2015	Updated new configuration	5,6,7,11,12
4	26 March 2015	Updated RMF	6,7,12
5	26 April 2017	Updated QE	6,7,13
6	2 November 2017	Added small mirror configuration	5,7,8,13
7	23 July 2018	Fixed error in small mirror configuration	7,8,13
9	22 Jan 2019	Updates RMF info mirror config	all
10	17 Nov 2020	Update for prelim. release of resources for Red Book	all
		preparation (incl. telescope reference v3.1, updates to	
		instrument description)	
11	09 Dec 2020	Update mirror effective area (4 nm SiC overcoating)	all
12	22 Dec 2020	Update filenames of ARFs and responses	7,10
12	08 Mar 2022	Update QEs, ARFs, and RSPs	all
13	24 May 2023	Update all except QEs	all
14	09 Feb 2024	Update mirror effective area and vignetting	all

Distribution List

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List of Acronyms

ARF: Ancillary Response File
NewAthena: Advanced Telescope for High ENergy Astrophysics
OBF: Optical Blocking Filter
QE: Quantum Efficiency
RMF: Redistribution Matrix File
WFI: Wide Field Imager
RSP: Response

Documentation

Reference Documents

Ref.	*Title*	*Ref. Doc.-No.*
RD1	WFI Detector Spectral Resolution - input for RMF generation (Rau, A.)	WFI-MPE-ANA-0180
RD2	Instrument Efficiency (Rau, A.)	WFI-MPE-ANA-10-011
RD3	NewAthena mirror performance (E. Kuulkers, I. Ferreira, M. Guainazzi), Issue Nr. 1, Revision Nr. 2, 24/05/2023	i3 - 22.02.2023

Reference Articles

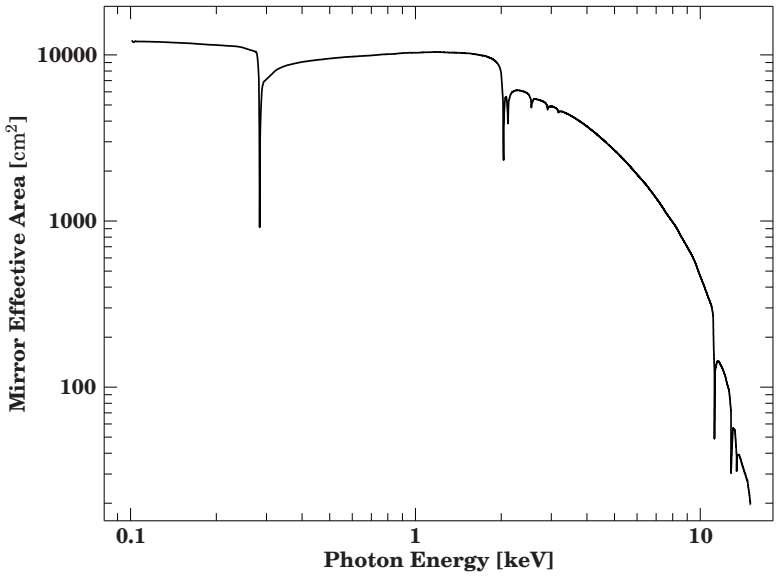

Figure 1: The on-axis mirror effective area.

1 Introduction

For simulations of astronomical observations with the *NewAthena* WFI, calibration files such as the Ancillary Response File (ARF), Redistribution Matrix File (RMF), or their product, the Response (RSP), are needed. In this document, we describe the current set of ARFs, RMFs and RSPs which are released to the public.

2 ARF

The WFI ARF is composed of two inputs: The mirror effective area and the instrument efficiency (incl. sensor and optical light blocking filter).

2.1 Mirror Effective Area

The mirror effective area is based on the mirror geometry as described in [RD3] where the requirements are implemented through the following mirror configuration:

- Mirror assembly with 13 rows, 492 mirror modules
- Mirror plate rib spacing (pitch) of 2.44 mm
- Coating: 10 nm Ir, plus 8 nm C (top) and 12 nm Cr overcoating
- 0/+2 wedging geometry

The data file containing the mirror effective area is called NewAthena_mirror_effectiveArea_IrCCr_13rows_v1.1.dat, from 24 May 2023. The on-axis mirror effective area is shown in Fig. 1.

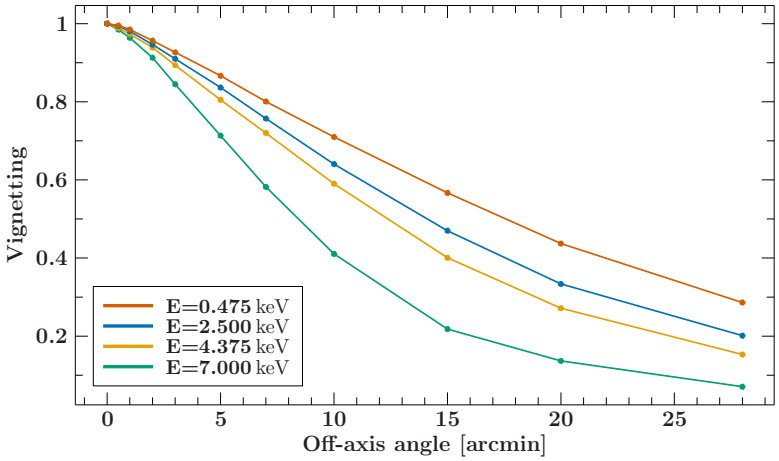

Figure 2: The vignetting as a function of the off-axis angle for different photon energies.

2.2 Vignetting

The vignetting is based on the mirror geometry as described in [RD3]. The data file containing the vignetting information is called vig_13rows_20231211.dat, from 11 Dec 2023, and can be seen in Fig. 2. The ARFs and RSPs are given for the following cases:

- **Case 1:** On-axis
- **Case 2:** FoV average (see comment below)
- **Case 3:** 5 arcmin radius average

The files in Case 2 are averaged over the quadratic $39.59 \times 39.59\,\mathrm{arcmin}^2$ FoV, correcting for an assumed 5 mm gap between the four quadrants of the WFI. Since loss effects are already accounted for in the mirror data files, the responses do not contain any additional loss factors.

2.3 Quantum Efficiency

The sensor Quantum Efficiency (QE) and filter transmission values were provided by M. Barbera and compiled in [RD2]. The final instrument efficiency depends on the configuration used. The single contributions are:

Sensor QE: 450 μm Si detector absorbing layer

On-Chip Optical Blocking Filter (OBF): 20 nm SiO_2 + 30 nm Si_3N_4 + (86.5+8.65) nm Al + 3.5 nm Al_2O_3 (incl. 10% margin on Al)

Filter wheel OBF: 150nm Polyimide + (23+5) nm Al + 7 nm Al_2O_3 (incl. 5 nm margin on Al)

Honeycomb mesh:

LDA: 4.8 mm pitch, 150 μm SS + 10 μm Au wire thickness, 75 μm SS + 10 μm Au wire width

FD: 4.8 mm pitch, 80 μm SS + 10 μm Au wire thickness, 40 μm SS + 10 μm Au wire width

Thick Filter: Polyimide 25 μm + Al 43+5 nm + Al 43+5 nm + Al2O3 14 nm, incl. 5 nm margin on both Al (available for Fast Detector only)

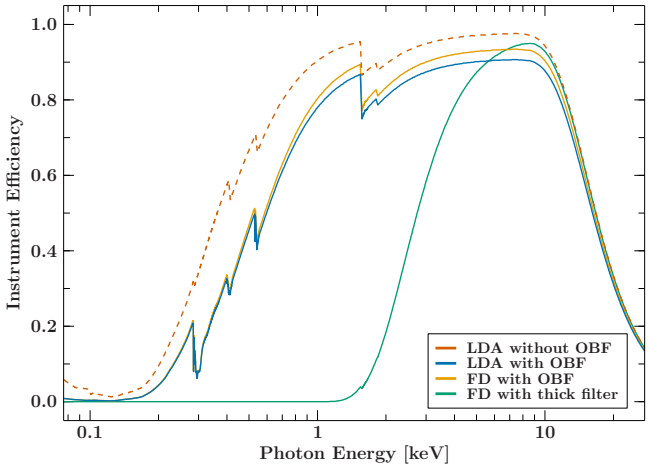

Figure 3: The instrument efficiencies for the current WFI configurations.

The data also includes estimates of the in-orbit molecular contamination (**Cont_DBP**), particle contamination (**Cont_PAC**), an average blocking factor of the **LDA OBF stiffening cross** of 2.3%, **deadtime** and event processing losses (0.02% for the LDA and 0.4% for the FD), and an overall system level **margin** of 2%. From this information we can define the five cases of interest for the WFI.

- **Case 1** (LDA w/o OBF): Sensor QE, on-chip OBF, Cont_DBP, Cont_PAC, deadtime, and margin (`WFI-eff_LDA_wo_filter_20220308.dat`)
- **Case 2** (LDA w/ OBF): Sensor QE, on-chip OBF, filter wheel OBF, LDA honeycomb mesh, LDA OBF stiffening cross, Cont_DBP, Cont_PAC, deadtime, and margin (`WFI-eff_LDA_w_filter_20220308.dat`)
- **Case 3** (FD w/ OBF): Sensor QE, on-chip OBF, filter wheel OBF, FD honeycomb mesh, Cont_DBP, Cont_PAC, deadtime, and margin (`WFI-eff_FD_w_filter_20220308.dat`)
- **Case 4** (FD w/ thick filter): Sensor QE, on-chip OBF, thick filter, Cont_DBP, Cont_PAC, deadtime, and margin (`WFI-eff_FD_thick_filter_20220308.dat`).

The instrument efficiency data is shown in Fig. 3.

2.4 ARF Construction

The ARF is the result of the multiplication of the mirror effective area and the quantum efficiency. Table 1 lists the filenames of all available configurations. The final ARFs for all cases of interest are shown in Figs. 4 and 5 respectively.

3 RMF

3.1 Currently used RMF

The RMF has been constructed in an energy range from 0.02 keV to 15 keV with a step size of 0.01 keV in both Energy and EBOUNDS. The RMF is composed of a Gaussian curve integrated in the respective EBOUNDS-bins. The width is described by the formula

$$\sigma(E) = (A * E + B)/2.355, \quad (1)$$

Table 1: The filenames for the eight different cases of the WFI ARFs.

Vignetting case	Quantum Eff. case	ARF filename
1	**1**	`NewAthena_WFI_13rows_LDA_wo_filter_OnAxis_20240209.arf`
1	**2**	`NewAthena_WFI_wfi_13rows_LDA_w_filter_OnAxis_20240209.arf`
1	**3**	`NewAthena_WFI_13rows_FD_w_filter_OnAxis_20240209.arf`
1	**4**	`NewAthena_WFI_13rows_FD_w_thick_filter_OnAxis_20240209.arf`
2	**1**	`NewAthena_WFI_13rows_LDA_wo_filter_FoVAvg_20240209.arf`
2	**2**	`NewAthena_WFI_13rows_LDA_w_filter_FoVAvg_20240209.arf`
3	**1**	`NewAthena_WFI_13rows_LDA_wo_filter_5aminAvg_20240209.arf`
3	**2**	`NewAthena_WFI_13rows_LDA_w_filter_5aminAvg_20240209.arf`

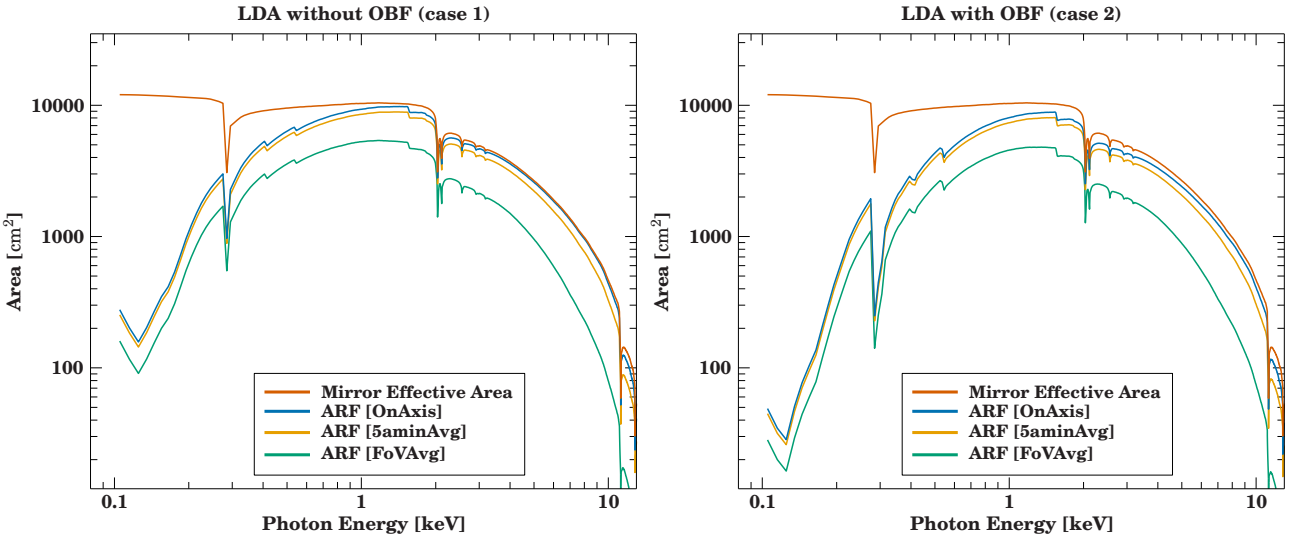

Figure 4: The final LDA ARFs for cases without (left, case 1) and with (right, case 2) OBF. The red line indicates the nominal on-axis mirror effective area. The assumptions entering the effective area are described in the text.

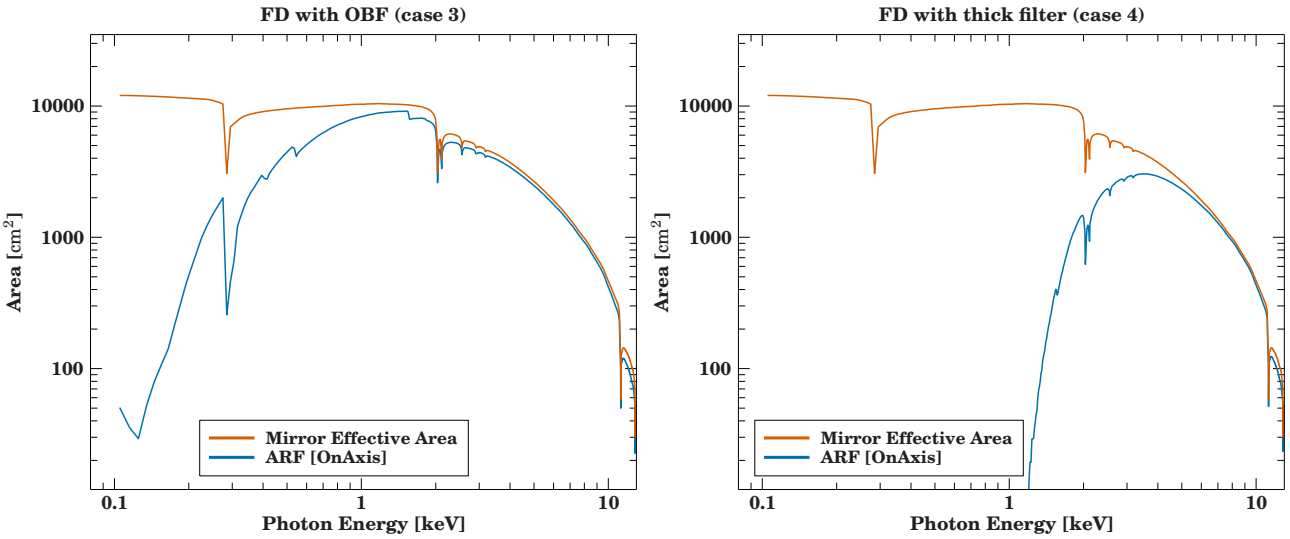

Figure 5: Same as Fig. 4, but for the FD with OBF (left, case 3) and with the thick filter (right, case 4).

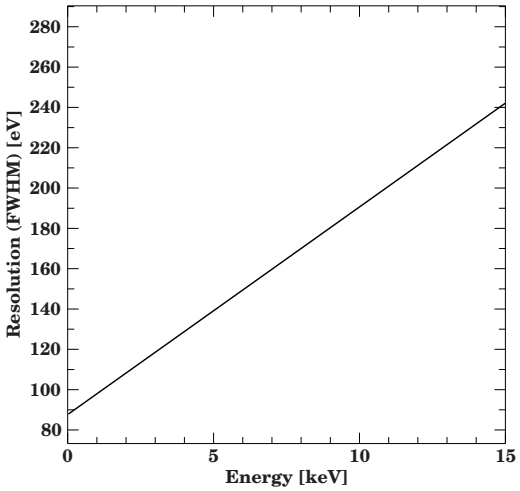

Figure 6: The width of the RMF in the relevant energy range.

Table 2: The filenames for the eight different cases of the WFI RSPs.

Vignetting case	Quantum Eff. case	RSP filename
1	**1**	`NewAthena_WFI_13rows_LDA_wo_filter_OnAxis_20240209.rsp`
1	**2**	`NewAthena_WFI_13rows_LDA_w_filter_OnAxis_20240209.rsp`
1	**3**	`NewAthena_WFI_13rows_FD_w_filter_OnAxis_20240209.rsp`
1	**4**	`NewAthena_WFI_13rows_FD_w_thick_filter_OnAxis_20240209.rsp`
2	**1**	`NewAthena_WFI_13rows_LDA_wo_filter_FoVAvg_20240209.rsp`
2	**2**	`NewAthena_WFI_13rows_LDA_w_filter_FoVAvg_20240209.rsp`
3	**1**	`NewAthena_WFI_13rows_LDA_wo_filter_5aminAvg_20240209.rsp`
3	**2**	`NewAthena_WFI_13rows_LDA_w_filter_5aminAvg_20240209.rsp`

where E is the energy in electronvolts, $A = 0.0103$ and $B = 87.67$ (parameters provided by A. Rau, representing the expected EOL performance).
The resolution is shown in Fig. 6. The RMF is available as `athena_wfi_rmf_v20230523.rmf` .

4 RSP

The overall RSP is the result of the multiplication of the ARF and the RMF. As there are eight different ARFs and one RMF, there are eight RSP files. These files are listed in Table 2.

5 Conclusion

The response files listed in this document can be used to run up-to-date simulations for the *NewAthena* WFI.