



ATHENA Response

Athena WFI response files

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Abstract

Description of the response files for the Athena Wide Field Imager (WFI). This document describes the assumptions made and lists the different versions.

Change Record

<i>Issue</i>	<i>Date</i>	<i>Description of Change</i>	<i>Affected Pages</i>
1	2014 December 10	Initial Release	All
2	2015 February 04	Added section on Readout Threshold	7-11
3	2015 March 17	Updated new configuration	5,6,7,11,12
4	2015 March 26	Updated RMF	6,7,12
5	2017 April 26	Updated QE	6,7,13
6	2017 November 2	Added small mirror configuration	5,7,8,13
7	2018 July 23	Fixed error in small mirror configuration	7,8,13
9	2019 Jan 22	Updates RMF info mirror config	all
10	2021 Feb 18	Update response files version	7,9
		Add changelog for response files	9

Distribution List

<i>Organization</i>	<i>Name</i>	<i>Organization</i>	<i>Name</i>	<i>Organization</i>	<i>Name</i>
MPE	K. Nandra	MPE	N. Meidinger	MPE	A. Rau
ECAP	J. Wilms				

Approvals

<i>Function</i>	<i>Name</i>	<i>Date</i>	<i>Signature</i>
Author	T. Dauser	18 Feb 2021	N/A
Author	S. Falkner	18 Feb 2021	N/A
Author	M. Lorenz	18 Feb 2021	N/A
Author	C. Kirsch	18 Feb 2021	N/A
Author	J. Wilms	18 Feb 2021	N/A



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List of TBD Issues

List of TBC Issues

List of Acronyms

ARF:	Ancillary Response File
Athena:	Advanced Telescope for High ENergy Astrophysics
PSF:	Point Spread Function
RMF:	Redistribution Matrix File
WFI:	Wide Field Imager



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Documentation

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1 Introduction

For simulations of astronomical observations with the *Athena* WFI, calibration files such as the ARF, RMF, or their product, the RSP, are needed. In this document, we describe the current set of ARFs, RMFs and RSPs which can be used in such simulations.

2 ARF

The WFI ARF is composed of two inputs: The mirror area and the instrument quantum efficiency.

2.1 Mirror Area

The current baseline mirror configuration consists of 15 rows. The Silicon Pore Optics are built with a 2.3 mm rib spacing and Ir+B4C overcoating.¹

The following cases for were given for each configuration:

- Case 1: on-axis case.
- Case 2: FoV average (see comment below).
- Case 3: 5 arcmin radius average (see comment below).

The files in Case 2 are averaged over the quadratic 40×40 arcmin² FoV, correcting for an assumed 7 mm gap between the four quadrants of the WFI and a constant 5 arcsecond PSF over the entire FoV.

A blanket factor of 0.9 for contingency and manufacturing errors in the mirror is already included in the data files. The mirror area with the blanket factor for the on-axis and FoV average case are shown in Fig. 1.

2.2 Quantum Efficiency

The final quantum efficiency depends on the configuration used. The single contributions are:

Sensor QE Absorbing layer ($450 \mu\text{mSi}$) and on-chip OBF (20 nm SiO_2 + 30 nm Si_3N_4 + 86.5 nm Al + 3.5 nm Al_2O_3)

Filter transmission Filter wheel OBF ($150 \mu\text{m}$ Polyimide + $23 \mu\text{m}$ Al + $7 \mu\text{m}$ Al_2O_3) and mesh made of Au plated SS with 96% open area

Be Filter $100 \mu\text{m}$ Be filter (foreseen for the Fast Detector)

The Sensor QE and filter transmission were provide by M. Barbera. From this information we can define the three cases of interest for the WFI. The sensor quantum efficiency is used for each of the cases.

- Case 1: only Sensor QE (WFI-eff_wo_filter_450sensor_20190122.dat)
- Case 2: Sensor QE and filter transmission (WFI-eff_w_filter_450sensor_20190122.dat)
- Case 3: Sensor QE and thick $100 \mu\text{m}$ Be filter (WFI-eff_Be100mum_filter_450sensor_20190122.dat)

The quantum efficiency data is shown in Fig. 2.

¹The data file for this configuration is called 15_row_rib_2.3_B4C_1_15_vs_kev.dat, downloaded from <https://www.cosmos.esa.int/web/athena/resources-by-esa>

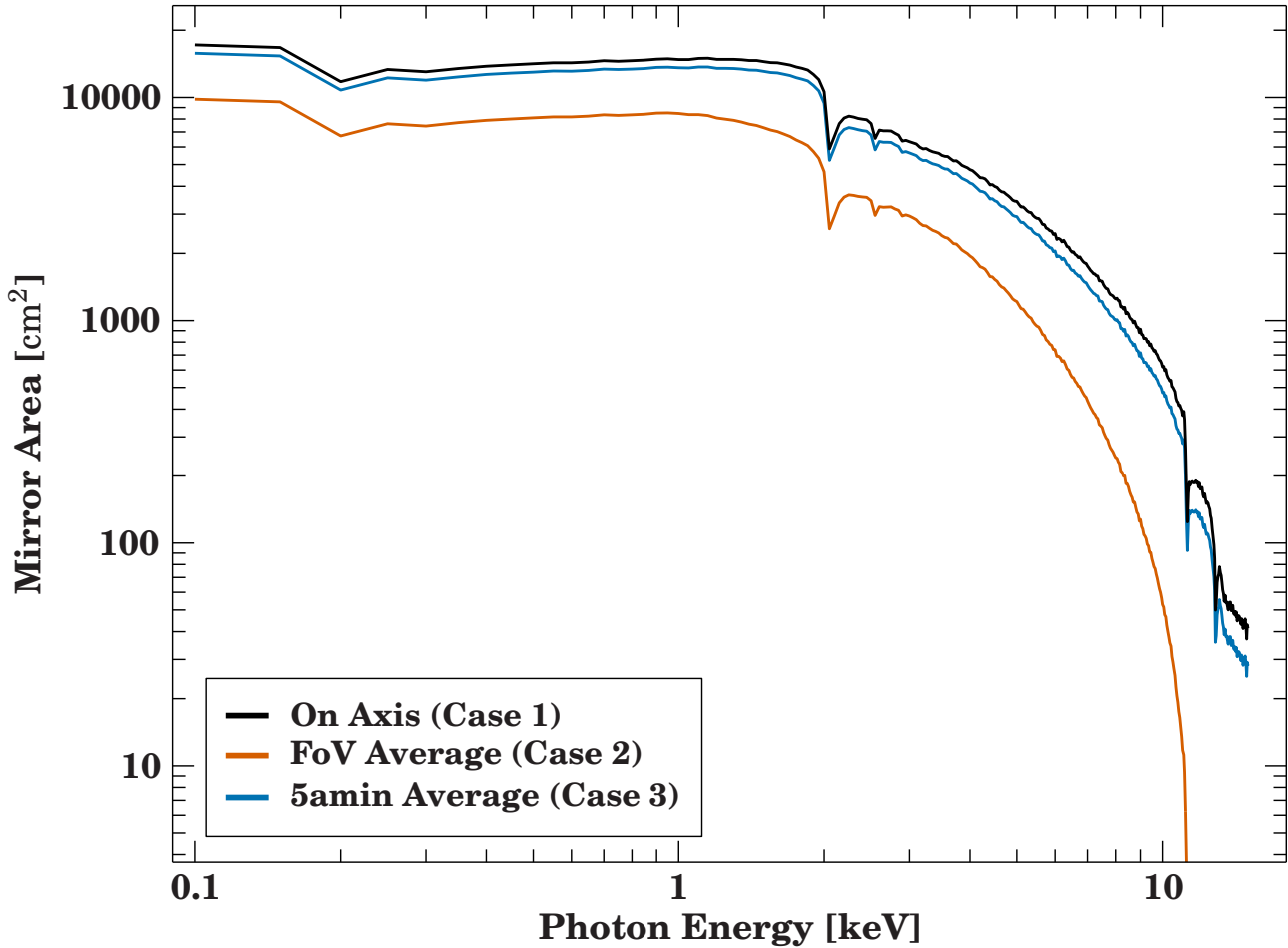


Figure 1: The mirror area for onaxis, FoV average and radial 5 amin average. as provided by R. Willingale with the blanket factor of 0.9. More information can be found in the text.

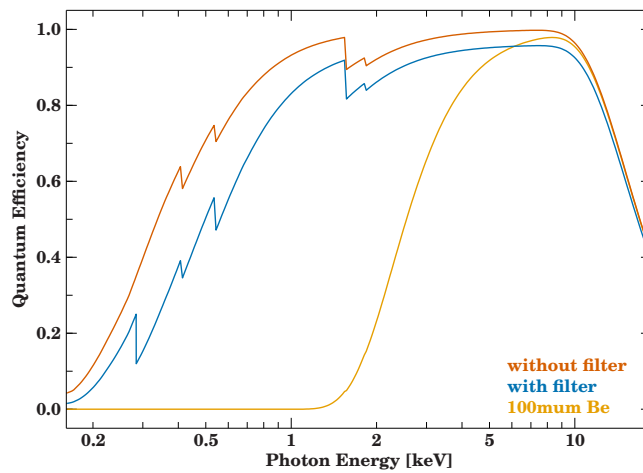


Figure 2: The quantum efficiency for the current WFI configurations: Without filter, including an external filter, and for a thick 100µm Be filter.



Table 1: The file names for the seven different cases of the WFI ARF existing for each mirror configuration.

Mirror case	Quantum Eff. case	ARF file name
1	1	athena_wfi_15row_20210218_OnAxis_wo_filter.arf
1	2	athena_wfi_15row_20210218_OnAxis_w_filter.arf
1	3	athena_wfi_15row_20210218_OnAxis_Be_filter.arf
2	1	athena_wfi_15row_20210218_FovAvg_wo_filter.arf
2	2	athena_wfi_15row_20210218_FovAvg_w_filter.arf
3	1	athena_wfi_15row_20210218_5aminAvg_wo_filter.arf
3	2	athena_wfi_15row_20210218_5aminAvg_w_filter.arf

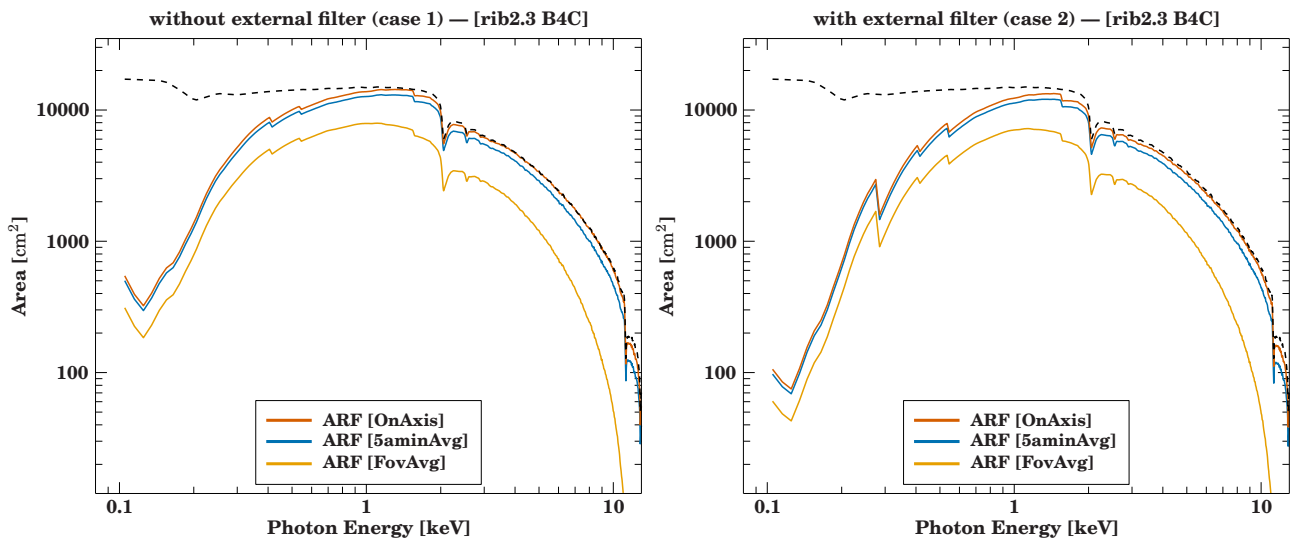


Figure 3: The final ARFs for cases without (left, case 1) and with (right, case 2) external filter. The dashed line indicates the nominal on-axis mirror area including the blanketing factor of 0.9.

2.3 ARF Construction

The ARF is the result of the multiplication of the mirror area and the quantum efficiency. Table 1 lists the seven different cases and the file names. The different ARFs are plotted in Fig. 3 and Fig. 4.

3 RMF

3.1 Currently used RMF

The RMF has been constructed in an energy range from 0.1 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, with a width given by the Fano-Limit with additional degradation and a noise term.

The width is described by the formula

$$\sigma = 3.65 \text{ eV} \cdot \sqrt{0.115 \times 1.15 \times E/3.65 \text{ eV} + 5^2} . \quad (1)$$

The resolution is shown in Fig. 5. The RMF is available as `athena_wfi_rmf_v20150326.rm f`.

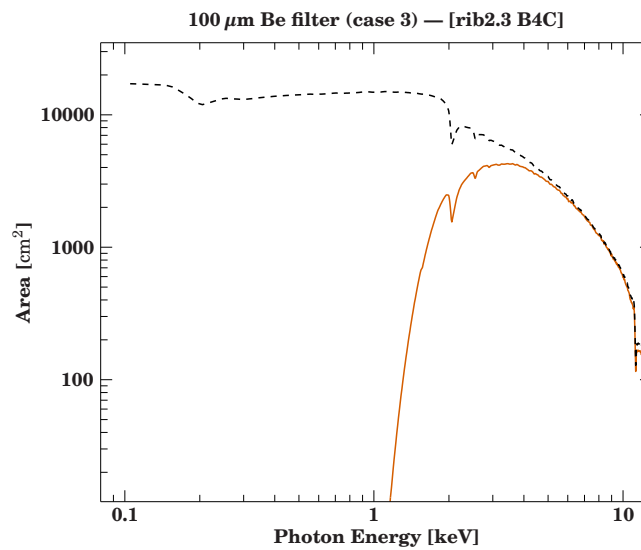


Figure 4: The final ARF for the thick 100 μm Be filter. The dashed line indicates the nominal on-axis mirror area including the blanketing factor of 0.9.

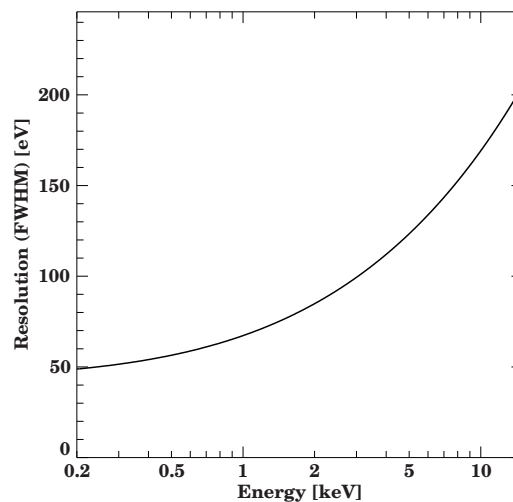


Figure 5: The width of the RMF in the relevant energy range.

4 RSP

The overall response files, the RSPs, are a multiplication of the ARF and the RMF. As there are seven different ARFs and one RMF, there are seven RSP files. These are listed in Table 2.

5 Conclusion

The calibration files listed in this document can be used for simulations of the *Athena* WFI.



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Table 2: The file names for the seven different cases of the WFI RSP existing for each mirror configuration. The file names are identical for the two different mirror assemblies, except that either 19row or 15row is given for the NMA or SMA, respectively.

Mirror case	Quantum Eff. case	RSP file name
1	1	athena_wfi_15row_20210218_OnAxis_wo_filter.rsp
1	2	athena_wfi_15row_20210218_OnAxis_w_filter.rsp
1	3	athena_wfi_15row_20210218_OnAxis_Be_filter.rsp
2	1	athena_wfi_15row_20210218_FovAvg_wo_filter.rsp
2	2	athena_wfi_15row_20210218_FovAvg_w_filter.rsp
3	1	athena_wfi_15row_20210218_5aminAvg_wo_filter.rsp
3	2	athena_wfi_15row_20210218_5aminAvg_w_filter.rsp

A Response Files Changelog

20210218

- Correct LO_THRES keyword in response files (LO_THRES was wrongly set to 0.105, but should be 0. This produced wrong results when using the response files in Xspec since version 12.11.1.. The keyword was ignored previously, but now Xspec is actually applying it).