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

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)	

Distribution List

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List of Acronyms

ARF: Ancillary Response File
Athena: Advanced Telescope for High ENergy Astrophysics
OBF: Optical Blocking Filter
RMF: Redistribution Matrix File
WFI: Wide Field Imager

Documentation

Reference Documents

Ref.	*Title*	*Ref. Doc.-No.*
RD1	WFI Detector Spectral Resolution - input for RMF generation (Rau, A.)	WFI-MPE-ANA-0180

Reference Articles

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 are released to the public.

2 ARF

The WFI ARF is composed of two inputs: The mirror effective area and the instrument quantum 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 the Athena Telescope Reference Document version 3.1 by Tim Oosterbroek (ESA/ESTEC) where the requirements are implemented through the following mirror configuration:

- Mirror assembly with 15 rows, 6 sectors, 600 mirror modules
- Active mirror apertures radius 244-1256 mm
- Mirror plate rib spacing (pitch) of 2.3 mm
- 10 nm of Ir coating on each individual module, plus 10 nm SiC overcoating in rows 9-15 (the outermost)
- -1/+1 wedging geometry

In addition to this nominal baseline configuration with an Ir+SiC overcoating, a second set of ARFs and responses is released which is based on the effective area data corresponding to an Ir+B4C overcoating[1].
The following cases are given for both coating solutions:

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

The files in Case 2 are averaged over the quadratic 39.59×39.59 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.
The on-axis mirror effective areas with Ir+SiC and Ir+B4C coating 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 μmSi) and on-chip Optical Blocking Filter (OBF) (20 nm SiO_2 + 30 nm Si_3N_4 + 86.5 nm Al + 3.5 nm Al_2O_3)

[1]The data files containing the mirror effective areas for both coatings are called `15_row_rib_2.3_SiC_1_15_vs_kev.dat` and `15_row_rib_2.3_B4C_1_15_vs_kev.dat`, downloaded from `https://www.cosmos.esa.int/web/athena/resources-by-esa`

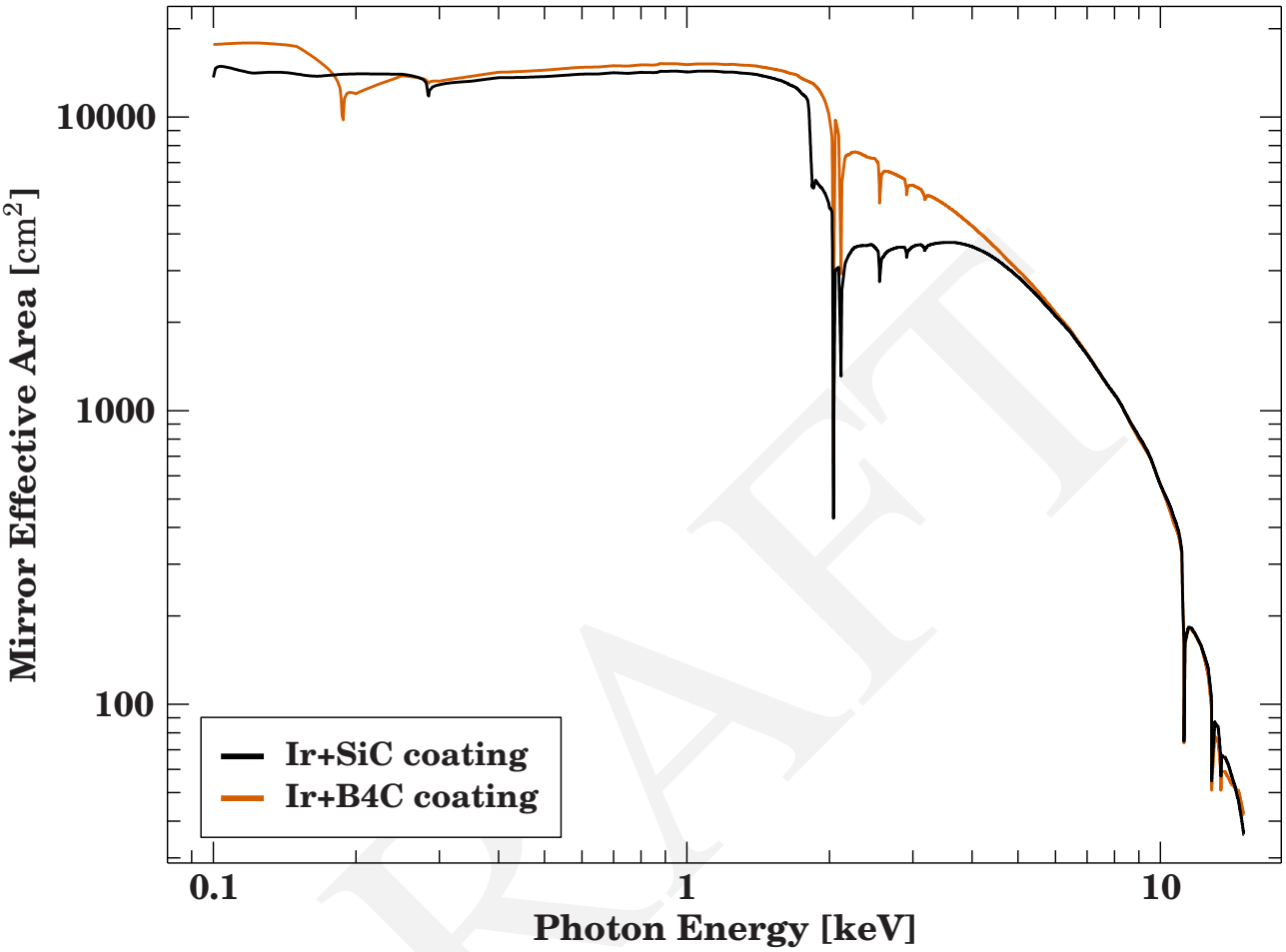

Figure 1: The on-axis mirror effective areas with Ir+SiC and Ir+B4C coating as provided by R. Willingale.

Filter transmission Filter wheel OBF (150nm Polyimide + 23nm Al + 7nm Al_2O_3) and mesh made of Au plated SS with an average geometrical blocking factor of 3.99% (available for Large Detector Array and Fast Detector)

Be Filter 100 μm Be filter (available for Fast Detector only)

The Sensor QE and filter transmission were provided 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_20200922.dat`)
- Case **2**: Sensor QE and OBF transmission (`WFI-eff_w_filter_450sensor_20200922.dat`)
- Case **3**: Sensor QE and thick 100 μm Be filter (`WFI-eff_Be100mum_filter_450sensor_20190122.dat`)

The quantum efficiency data is shown in Fig. 2.

2.3 ARF Construction

The ARF is the result of the multiplication of the mirror effective area and the quantum efficiency. Table 1 lists the seven different cases and the file names. The different ARFs with and without OBF for both mirror coatings

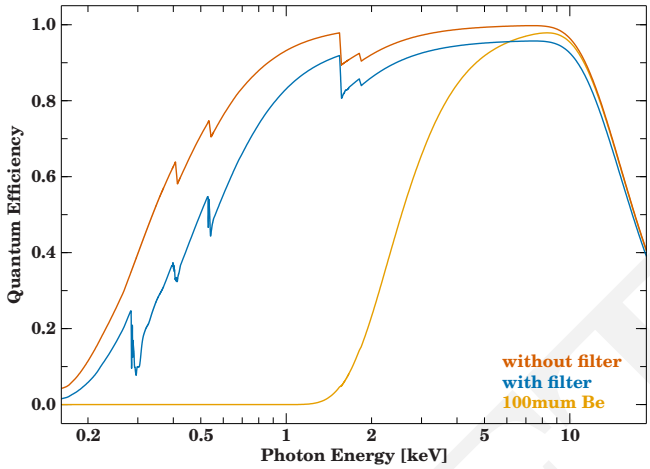

Figure 2: The quantum efficiencies for the current WFI configurations: Without (red) and with (blue) OBF, and for a thick 100 μm Be filter.

Table 1: The filenames for the seven different cases of the WFI ARF existing for each mirror configuration. The names are identical for the two different mirror coatings, except that either "SiC" or "B4C" is contained in the filename for the SiC or B4C coating, respectively.

Mirror case	Quantum Eff. case	ARF file name
1	**1**	athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_OnAxis.arf
1	**2**	athena_wfi_rib2.3_SiC/B4C_20200925_w_filter_OnAxis.arf
1	**3**	athena_wfi_rib2.3_SiC/B4C_20200925_Be_filter_OnAxis.arf
2	**1**	athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_FoVAvg.arf
2	**2**	athena_wfi_rib2.3_SiC/B4C_20200925_w_filter_FoVAvg.arf
3	**1**	athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_5aminAvg.arf
3	**2**	athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_5aminAvg.arf

are shown in Figs. 3 and 4 respectively. The ARFs for the thick 100 μm Be filter are shown in Fig. 5.

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, with a width that was fit to FD lab measurements as described in [RD1].
The width is described by the formula

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

where E is the energy in electronvolts, $A = 0.01221$ and $B = 64.62$.
The resolution is shown in Fig. 6. The RMF is available as athena_wfi_rmf_v20200925.rmf .

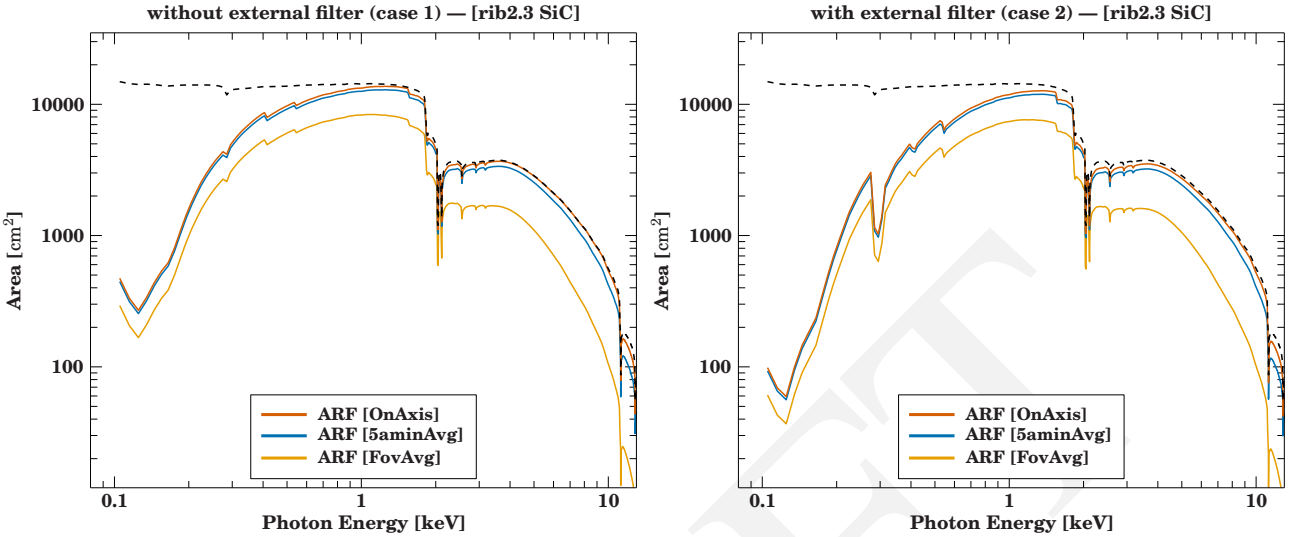

Figure 3: The final ARFs for cases without (left, case 1) and with (right, case 2) OBF for the mirror configuration with an Ir+SiC overcoating. The dashed line indicates the nominal on-axis mirror effective area.

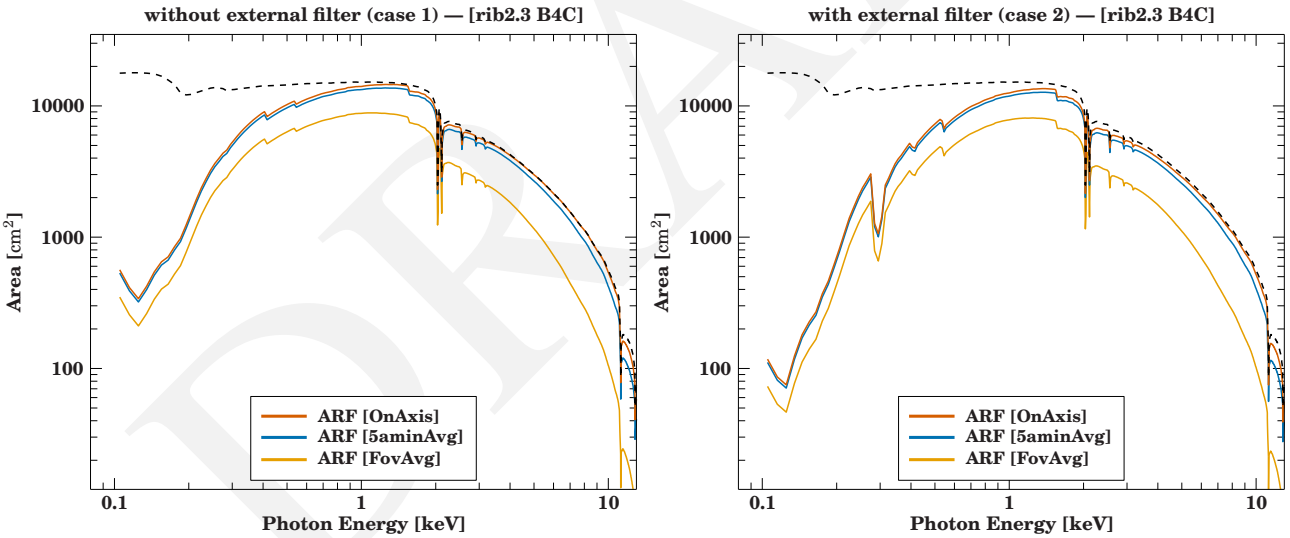

Figure 4: The final ARFs for cases without (left, case 1) and with (right, case 2) OBF for the mirror configuration with an Ir+B4C overcoating. The dashed line indicates the nominal on-axis mirror effective area.

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 for each coating solution. These are listed in Table 2.

5 Conclusion

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

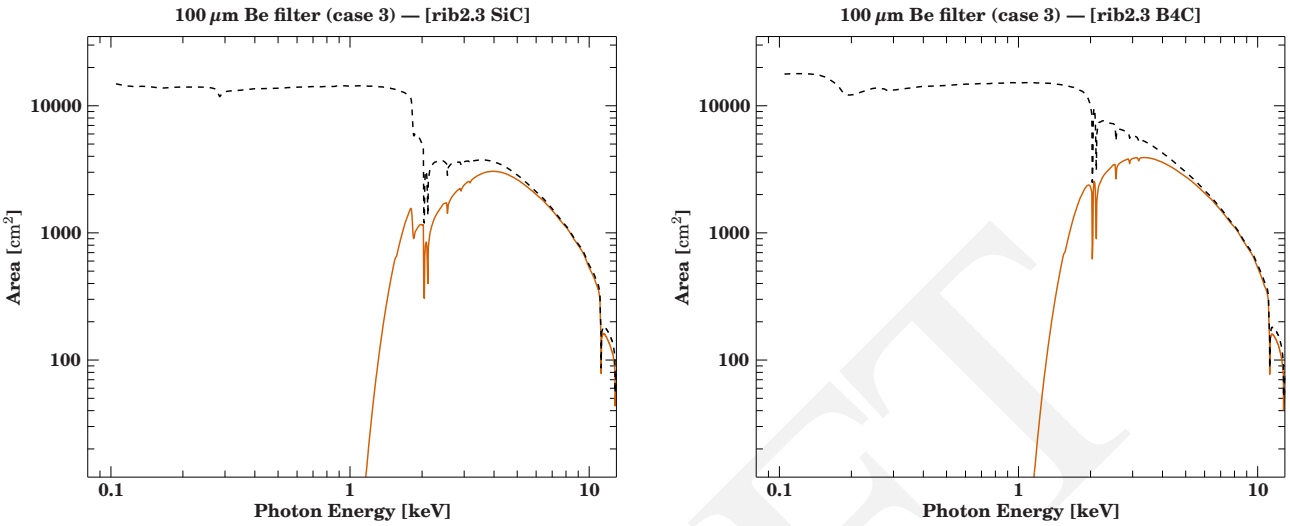

Figure 5: The final ARFs with the thick 100 μm Be filter (case 3) for the two mirror configurations with Ir+SiC (left) and Ir+B4C coating (right). The dashed line indicates the nominal on-axis mirror effective area.

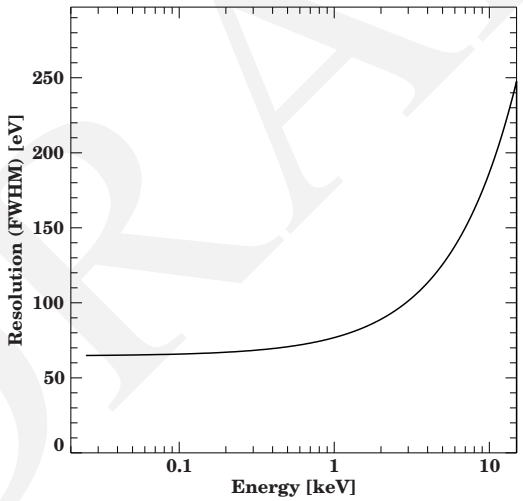

Figure 6: The width of the RMF in the relevant energy range.

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 coatings, except that either `"SiC"` or `"B4C"` is contained in the filename for the SiC or B4C coating, respectively.

Mirror case	Quantum Eff. case	RSP file name
1	**1**	`athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_OnAxis.rsp`
1	**2**	`athena_wfi_rib2.3_SiC/B4C_20200925_w_filter_OnAxis.rsp`
1	**3**	`athena_wfi_rib2.3_SiC/B4C_20200925_Be_filter_OnAxis.rsp`
2	**1**	`athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_FoVAvg.rsp`
2	**2**	`athena_wfi_rib2.3_SiC/B4C_20200925_w_filter_FoVAvg.rsp`
3	**1**	`athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_5aminAvg.rsp`
3	**2**	`athena_wfi_rib2.3_SiC/B4C_20200925_wo_filter_5aminAvg.rsp`