Abstract

This document describes the assumptions underlying the response files released for the ATHENA X-ray Integral Field Unit (X-IFU).

Change Record

Issue	*Date*	*Description of Change*	*Affected Pages*
1	2014 December 10	Initial Release	All
2	2015 March 18	Update to new configuration	6,7,8
3	2015 March 27	Update to new configuration	6,7,8
4	2016 March 31	RSP Version 20160331: effective area	all
		now takes into account a total	
		of 50 nm of oxidized Al	
5	2016 April 01	RSP Version 20160401: QE Table updated	all

Distribution List

Organization	*Name*	*Organization*	*Name*	*Organization*	*Name*
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Function	*Name*	*Date*	*Signature*
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List of Acronyms

ARF: Ancillary Response File
Athena: Advanced Telescope for High ENergy Astrophysics
RMF: Redistribution Matrix File
X-IFU: X-ray Integral Field Unit

Documentation

Reference Documents

RD1	*Athena*+ Response Files (Brand, T.)	ECAP-ATHENA+-20140210

Reference Articles

Henke B.L., Gullikson E.M., Davis J.C., 1993, Atomic Data and Nuclear Data Tables 54, 181

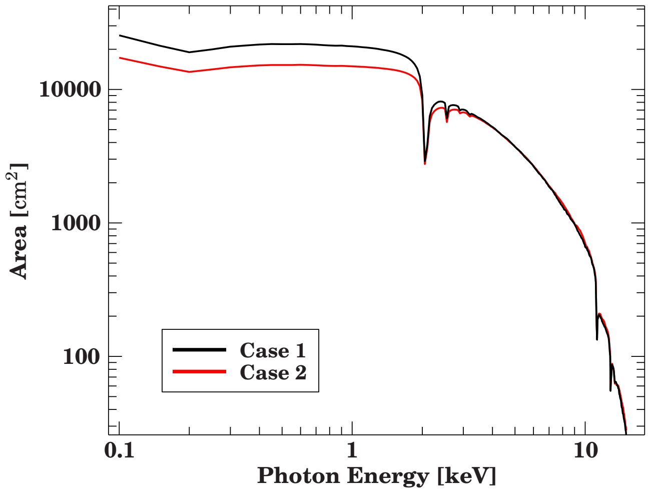

Figure 1: The mirror area data provided by R. Willingale and D. Lumb, after uniformly applying a blanket factor of 0.9 (see text).

1 Introduction

For simulations of astronomical observations with the *Athena* X-IFU, 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 X-IFU ARF is composed of two components, the mirror area and the quantum efficiency.

2.1 Mirror Area

The mirror area information has been provided by R. Willingale and D. Lumb on 2015 March 15. It describes two cases:

- Case **1**: Mirror module radius $R_{max} = 1469$ mm, 2.3 mm rib spacing, on-axis case.
  File: `1469_2.3_irb4c_area_vs_kev.dat`
- Case **2**: Mirror module radius $R_{max} = 1190$ mm, 2.3 mm rib spacing, on-axis case.
  File: `1190_2.3_irb4c_area_vs_kev.dat`

A blanket factor of 0.9 for contingency and manufacturing errors in the mirror has been multiplied to the values contained in the data files. The mirror areas with the blanket factor are shown in Fig. 1.

2.2 Filter Setup

The current baseline filter setup for the X-IFU consists of five filters with a total thickness of 280 nm Polyimide and 210 nm Al. For each filter, an outer layer of 10 nm is assumed to consist of Al_2O_3, leaving an effective absorber thickness of 160 nm Al and 50 nm of Al_2O_3.
Furthermore, the two largest filters have a support mesh of 10 μm Polyimide with an open area fraction of 93%. The transmissivity of the materials is obtained from the Henke tables (Henke et al., 1993). Note that the energy

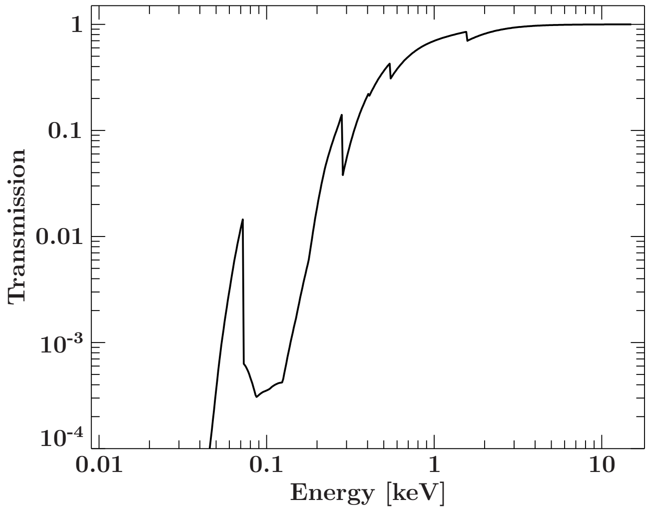

Figure 2: The filter transmission as described in the text.

Table 1: The filenames for the two different cases of the X-IFU ARF.

Mirror case	ARF file name
1	`athena_xifu_1469_onaxis_pitch249um_v20160401.arf`
2	`athena_xifu_1190_onaxis_pitch249um_v20160401.arf`

resolution of these tables is not high enough to describe the complex edge structure at the Al and O edges expected from this material.
The resulting transmission curve is shown in Fig. 2.

2.3 Quantum Efficiency

The quantum efficiency is the probability that a photon hitting the detector surface is detected. The data have been provided by S. Bandler as file `qe_Au_1p7_Bi_4p2.xlsx`. It assumes a detector with $245\,\mu$m $\times$ $245\,\mu$m absorbers and a gap distance of $4\,\mu$m, corresponding to a pixel filling factor of $A_{\text{absorber}}/A_{\text{total}} = 0.968$. The absorber composition is $1.7\,\mu$m of Au covered by $4.2\,\mu$m of Bi.
There are some possible small variations in heat capacity and temperature of operation that could lead to slight modifications to the relative thicknesses of the Au and Bi, while maintaining essentially the same total quantum efficiencies and certainly adherence to all the quantum efficiency requirements. In addition, if, for example, the pixel pitch become slightly larger, the gold would become slightly thinner and the bismuth slightly thicker.
The quantum efficiency data are shown in Fig. 3. The edges are caused by absorption thresholds of the atoms in the path of the photons.

2.4 ARF Construction

The ARF is the result of the multiplication of the mirror area and the quantum efficiency. No additional dead pixel factor is multiplied to the data. Table 1 lists the different cases and the file names.
The two ARFs are depicted in Fig. 4.

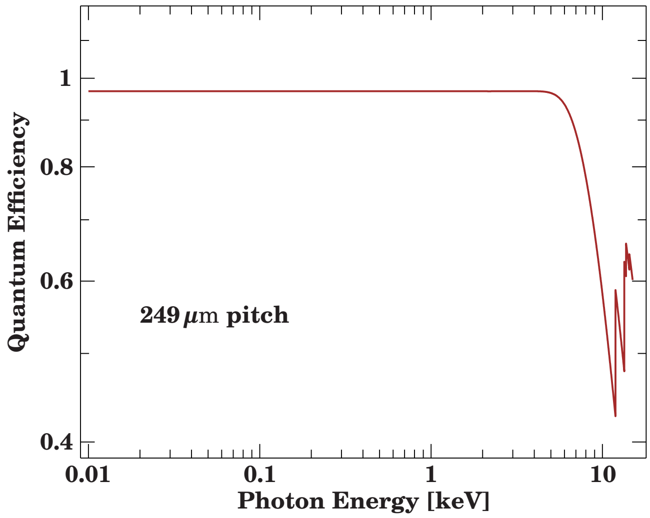

Figure 3: The quantum efficiency of the X-IFU.

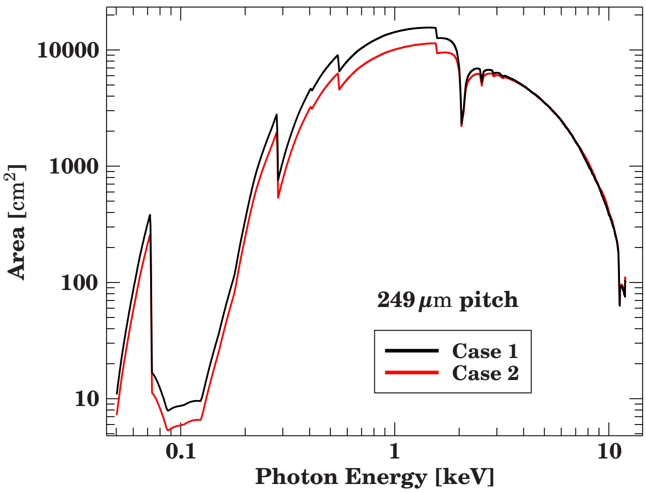

Figure 4: The final effective area for all cases.

3 RMF

The RMF assumes an energy resolution of 2.5 eV FWHM up to 7 keV. At higher energies, the resolution is assumed to grow proportionally with the photon energy, as shown in Fig. 5.
The RMF is available as the file `athena_xifu_rmf_v20160401.rmf` .

4 RSP

The overall response files are obtained by multiplying the two ARF s with the RMF (Table 2).

5 Conclusion

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

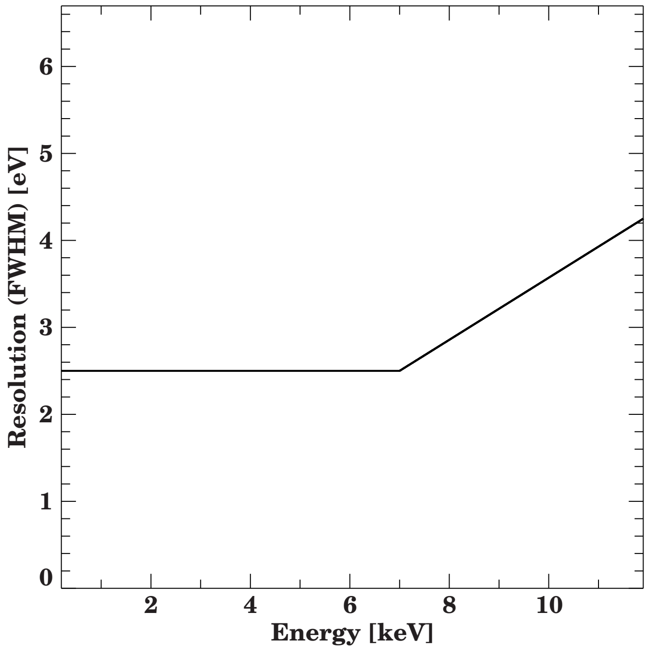

Figure 5: The FWHM-resolution of the X-IFU RMF. Below 7 keV the resolution is at a constant level of 2.5 eV. Above this energy it grows proportional to E.

Table 2: The filenames for the two different cases of the X-IFU RSP.

Mirror case	RSP file name
1	`athena_xifu_1469_onaxis_pitch249um_v20160401.rsp`
2	`athena_xifu_1190_onaxis_pitch249um_v20160401.rsp`