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INSTRUMENT CALIBRATION REPORT

XMA ON-AXIS HIGH-FIDELITY EFFECTIVE AREA FUNCTIONS

RESOLVE-SCI-RPT-0165

REVISION (A)

XRISM-XMA-CALDB-TELAREA-403

X-ray Imaging and Spectroscopy Mission (XRISM) Project

NASA/GSFC Code 461

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

XMA On-Axis High-Fidelity Effective Area Functions

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Preface

This document is an XRISM Project signature-controlled document. Changes to this document require prior approval of the applicable Product Design Lead (PDL) or designee. Proposed changes shall be submitted in the Technical Data Management System (TDMS) via a Signature Control Request (SCoRe) along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

All of the requirements in this document assume the use of the word "shall" unless otherwise stated.

Questions or comments concerning this document should be addressed to:
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Change History Log

Revision	Effective Date	Description of Changes (Reference the SCoRe Approval Date)
-	12/11/2023	Initial Release per RESOLVE-SCoRe-0566
A	09/16/2024	Changed title page to “XRISM-XMA-CALDB-TELAREA-403,” updating “ GEN” to “XMA” to match CalDB structure. No other changes. Release per RESOLVE-SCoRe-0572

NOTE to editors: The document name will be XRISM-CAL-RPT-XXXX, where XXXX is assigned by the TDMS system. The document will be cross-referenced in TDMS to the filename in the format XRISM-XXX-CALDB-FILEDESC-NN where XXX is the instrument or component (e.g. RESOLVE), FILEDESC refers to a specific calibration report (e.g., rmfparams) and NN the corresponding number assigned to that report by the SDC. For example the calibration report addressing the Resolve LSF calibration may be assigned XRISM-RESOLVE-CALDB-RMFPARAMS-01, that addressing the Resolve gain calibration XRISM-RESOLVE-GAINPIX-CALDB-02, etc. (where the numbers are to be provided by the SDC).

These documents are updated as needed, e.g. when the relevant CALDB files, or the relevant calibration data analysis, is revised. The document version will be assigned by the TDMS system. The tracking tool should be used to record changes.

This document must include the CalDB file name, an explanation of how the data were collected and the analysis conducted and, if using standard Ftools, the software version number. All revisions are consolidated into the same document to maintain a full record of all changes.

Table of Contents

1 Introduction

1.1 Purpose

This document describes data in the CalDB files containing the on-axis effective area (derived from raytracing simulations), as a function of energy for each of the two XMA aboard XRISM. There is one CalDB file for each telescope. The files are used by the XRISM ARF generator software (*xaarfgen* and *xaxmaarfgen*).

1.2 Scientific Impact

The on-axis effective area data for XMA-Resolve and XMA-Xtend are used by the tasks *xaxmaarfgen* for the calculation of the combined telescope and detector effective area (ARF) for arbitrary off-axis angles and arbitrary energies. Note that *xaxmaarfgen* may be run in a standalone mode, or it may be driven by *xaarfgen*. There are two effective area functions in each CalDB file (i.e., two functions for each telescope). One of the functions is based on a coarse energy grid, whilst the other is based on a finer energy grid that captures all of the necessary atomic features at an energy resolution that is better than the instrument that the CalDB file is associated with (see Figure 1). Raytracing simulations show that the ratio of the off-axis effective area to the on-axis effective area is only a weak function of energy. Since the on-axis high-resolution effective area captures the strong energy dependence of the reflectivity and transmission, the run-time for calculating the off-axis effective area at sufficiently high energy resolution can be significantly reduced, by more than an order of magnitude. This is achieved in the task *xaxmaarfgen* by (1) running the raytracing code xrtraytrace on a coarse energy grid, (2) modeling the ratio of the resulting effective area to the on-axis coarse effective area in the CalDB file, (3) evaluating the fitted function on the fine energy grid, and then (4) using the fine-grid on-axis effective area in the CalDB file to arrive at the fine-grid off-axis effective area.

1.3 Data Generation and File Format

The on-axis telescope effective area files were made by running the raytracing code *xrtraytrace* with 10,000,000 photons per energy. The events file output from each raytrace run contains information about all of the photons that impact the focal plane. The events that include a double reflection (one reflection on a primary mirror, and one on a secondary mirror) were selected, and compared with the injected number of photons at each energy, yielding an effective area as a function of energy. No region selection on the focal-plane was imposed. These selection criteria do not affect the generation of an effective area by the ARF generator for data analysis because the “telarea” CalDB files are used only for bootstrapping (as discussed in section 1.2). The value of the geometric area used is calculated by xrtraytrace from the XMA CalDB files, and is 1503.03 cm^2 for both telescopes. There are three XMA CalDB files that are needed for the raytracing runs for each telescope: (1) the “mirror” file, containing the geometrical information for the reflecting foils, pre-collimators, thermal shield, and support structures; (2) the "reftrans" file, containing the reflectivity and transmissivity functions of the various telescope components; (3) the "scatter" file, containing the scattering profiles for reflections by the mirror foil Au surfaces.

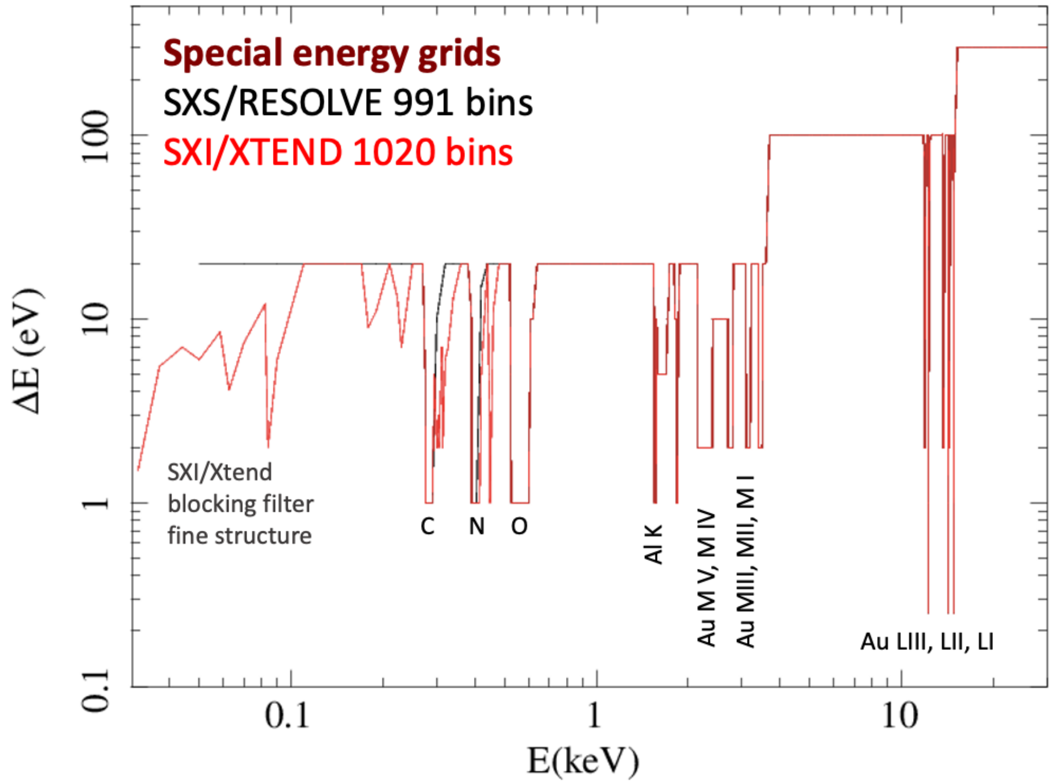

Figure 1: Energy bin width versus bin center energy for the fine-energy grids for Resolve (Black), and xtend (red).

The data format of the "telarea" CalDB files is as follows:

Extension	Content
PRIMARY	Blank
EFFAREAFNE	Effective area vs. energy, fine grid
EFFAREACRS	Effective area vs. energy, coarse grid

Table 1: Format of the "telarea" CalDB files.

(Note that the corresponding *Hitomi* files have the same format, but the HXI CalDB files had a primary extension that was not empty, containing image data to model the baffle.) The on-axis effective area data cover the energy range 0.030 to 30.000 keV for XMA-R (991 points) and XMA-X (1020 points), for the fine-grid effective area. The coarse-grid effective area is a subset of 36 of these points, covering the same energy band.

2 First Version – Release CalDB 20230615 (Build 6)

CalDB Filename	Validity date	File(s) as delivered	Delivery date	Comment
xa_rsl_telarea_20190101v001.fits xa_xtd_telarea_20190101v001.fits	20190101 00:00 UT 20190101 00:00 UT	N/A N/A	N/A N/A	High-statistics raytracing on-axis XMA-only effective area. Data for files generated by SDC.

Table 2: Files in CalDB release 20230615 (Build 6).

2.1 Data Description

The raytracing data were generated as described in 1.3, using Build 6 XMA CalDB files (CalDB version 20230615).

2.2 Data Analysis

The raytracing events were collected and effective areas calculated as described in 1.3.

2.3 Results

The effective area functions on the fine-energy grids are shown in Figure 2.

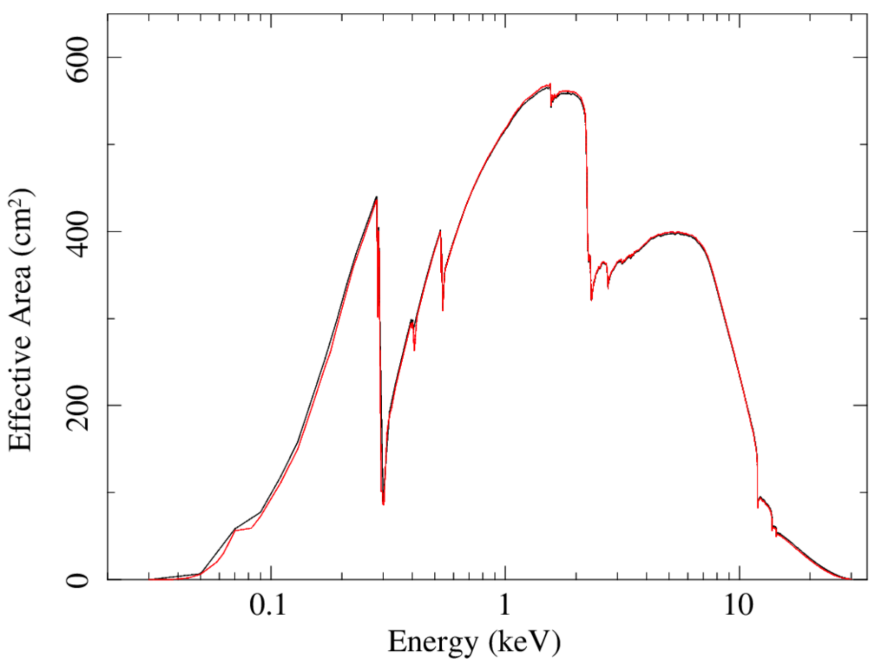

Figure 2: XMA on-axis fine-grid effective areas in the Build 6 CalDB "telarea" files for Resolve (black) and Xtend (red).

2.4 Final remarks

The CalDB files in this release contain on-axis XMA effective areas calculated with high-statistics raytracing that are based for the first time on a complete set of self-consistent XMA CalDB files (as opposed to CalDB files that contain *Hitomi* place-holders).

3 Revision for Release CalDB 20230815 (Build 7)

CalDB Filename	Validity date	File(s) as delivered	Delivery date	Comment
xa_rsl_telarea_20190101v002.fits	20190101 00:00 UT	N/A	N/A	High-statistics raytracing on-axis XMA-only effective area. Data for files generated by SDC.
xa_xtd_telarea_20190101v002.fits	20190101 00:00 UT	N/A	N/A	

Table 3:Files in CalDB release 20230815 (Build 7).

3.1 Data Description

The raytracing data were generated as described in 1.3, using Build 7 XMA CalDB files (CalDB version 20230815). The Build 7 XMA CalDB files introduce a bevel on the thermal shield mesh, and refining of the XMA support structures modeling. Both updates are identical for Resolve and Xtend.

3.2 Data Analysis

The raytracing events were collected and effective areas calculated as described in 1.3.

3.3 Results

The effective area functions on the fine-energy grids are shown in Figure 3.

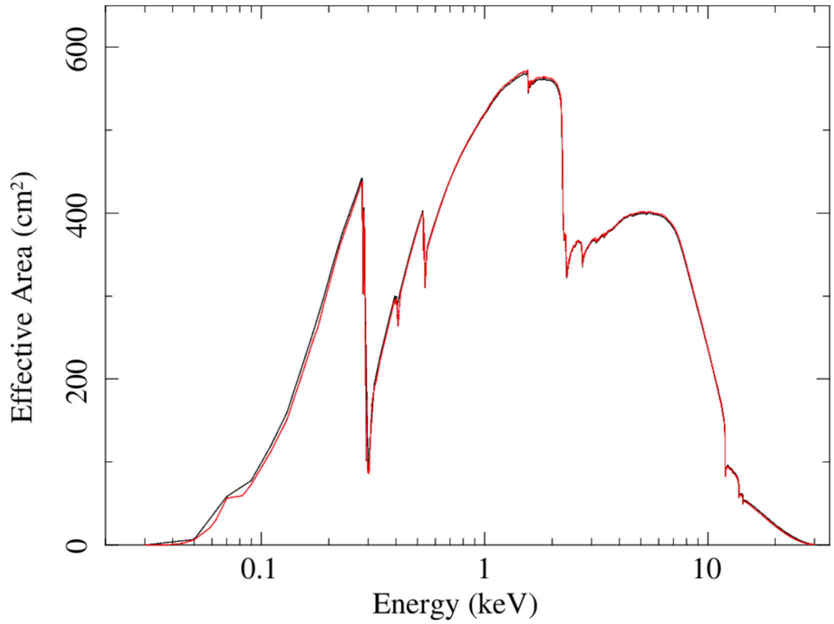

Figure 3: XMA on-axis fine-grid effective areas in the Build 7 CalDB "telarea" files for Resolve (black) and Xtend (red).

3.4 Comparison with Previous Releases

For each instrument, the ratio of the fine-grid effective area calculated for this release (Build 7 CalDB), to the corresponding effective area from the previous release (Build 6 CalDB), is shown in Figure 4.

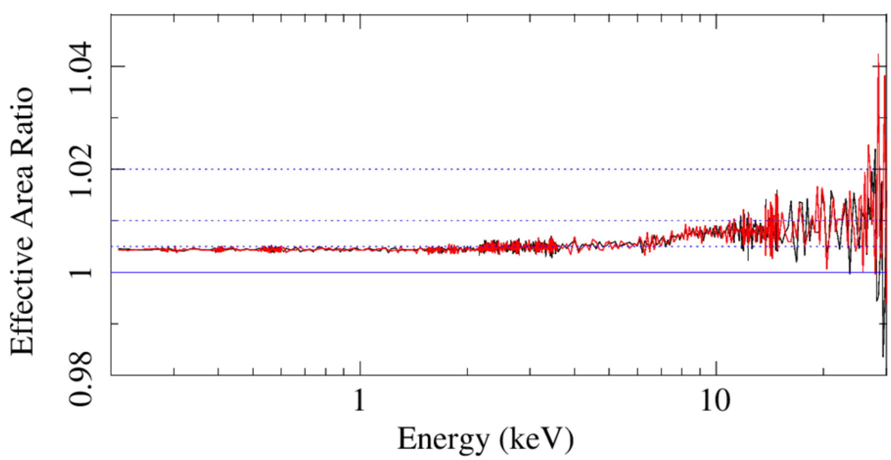

Figure 4: The ratios of the effective areas calculated for the release (Build 7 CalDB) to those from the previous release (Build 6 CalDB), for Resolve (black) and Xtend (red).