ASTRO-H

INSTRUMENT CALIBRATION REPORT
SXS GATE VALVE AND FILTER WHEEL FILTERS
ASTH-TEL-CALDB-FILT

Version 1.0

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ISAS/GSFC

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Introduction

1.1 Purpose

This document describes data in the CALDB files that contain calibration data for the SXS gate valve and the four filters on the filter wheel located in the optical path between the SXS and the X-ray telescope. The file format is the same for all five cases. An object in the optical path may consist of components that have a spatially dependent transmission, and those that do not. There is provision in the CALDB files for both types of transmission data: spatially dependent transmission is in the TRANSMISSION extension, and spatially uniform transmission is in the SURFACETRANSMISSION extension. This document describes only data in the CALDB files supplied by the SCT. The following table shows which data for each file are supplied by the SCT, and which by the SXS team (indicated by SXS). A "1.0" indicates a "dummy" transmission that is 1.0 for all energies.

Filename	Filter Name	TRANSMISSION	SURFACETRANSMISSION
ah_sxs_gatevalv_20140101v002.fits	Gate Valve	SCT	SXS
ah_sxs_fwnd_20140101v001.fits	Neutral Density	SCT	1.0
ah_sxs_fwbe_20140101v001.fits	Beryllium	SCT	1.0
ah_sxs_fwpoly_20140101v001.fits	Polyimide	SXS	1.0
ah_sxs_fwfe55_20140101v001.fits	Fe 55 Cal Source	SCT	1.0

1.2 Scientific Impact

The gate valve and the filter wheel are located in the optical path between the soft X-ray telescope (SXT-S) and the SXS at the focal plane. Calculation of the transmission due to components in the optical path that have a spatially dependent opacity must account for geometrical effects. For this, pre-calculated raytracing results are incorporated into the calibration files. The gate valve and filters directly impact the net effective area of the telescope and detector system. The CALDB files are used by the tool *ahsxtarfgen* for calculating the net effective area as a function of energy (i.e. the Ancillary Response Function, or ARF).

2 Release CALDB 20160623

Filename	Valid date	Release date	CALDB Vrs	Comments
ah_sxs_gatevalv_20140101v001.fits	2014-01-01	2016-06-24	20160624	
ah_sxs_fwnd_20140101v001.fits	2014-01-01	2016-06-24	20160624	
ah_sxs_fwbe_20140101v001.fits	2014-01-01	2016-06-24	20160624	
ah_sxs_fwpoly_20140101v001.fits	2014-01-01	2016-06-24	20160624	
ah_sxs_fwfe55_20140101v001.fits	2014-01-01	2016-06-24	20160624	

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2.1 Data Description

PRIMARY Extension Image

The geometry of each object in the optical path (gate valve or filter) is modeled as a highly simplified 2-D structure (i.e the object has a depth perpendicular to the focal plane of zero). The image in the primary extension of the CALDB file shows the model that was adopted.

TRASMISSION (extension 1)

The transmission fraction versus energy function in this extension describes the effect of components of an object in the optical path that have a spatially non-uniform opacity. Note that this transmission fraction refers to all photons impacting the focal plane, not just those that fall inside the SXS detector region (this filtering is done downstream by *ahsxtarfgen*). If there is no component that has a spatially non-uniform opacity, the value of the function is 1.0 for all energies. Note that this extension is used for spatially non-uniform opacity even if, in the end, a spatially uniform transmission is used if it is shown to be an adequate approximation.

SURFACETRASMISSION (extension 2)

The transmission fraction versus energy function in this extension describes the effect of components of an object in the optical path that have a spatially uniform opacity. If there is no component that has a spatially uniform opacity, the value of the function is 1.0 for all energies.

PIXELRATIOMAP (extension 3)

For each SXS pixel, this extension contains the following ratio of fractional counts in a pixel, where the fraction is relative to the full 6x6 SXS array:

(fractional counts WITH object in path)/(fractional counts WITHOUT object in path).

The fractional counts are computed using on-axis, point-source raytracing simulations, in the 0.030-30 keV range (i.e. the ratios are averages over this energy range). The fractional counts without the object in the optical path are computed with the SXS filter wheel in the OPEN position. The pixel ratios here pertain only to components of the object that have an opacity that is spatially non-uniform. If there are no such components, all values of the pixel ratios are set equal to 1.0.

Example: If pixel 17 contains 2.90% of the total SXS counts with the gate valve in place, but 2.80% without the gate valve, the value in the PIXELRATIOMAP row for pixel 17 is (2.9/2.8) = 1.03571. Note that the value can be >1.0 because pixels that are not affected by the gate valve structure can have a larger share of the SXS counts compared to the case when there is no gate valve in place.

Note that the values of PIXELRATIOS only affect the ARF calculated by *ahsxtarfgen* through any position-dependent detector QE. The effective area of the telescope and obstructing object (gate valve or filter) does not depend on the values of PIXELRATIOS.

KEYWORDS

Each extension in the CALDB filter wheel files contains the keyword FLHEIGHT, which specifies the perpendicular height (in mm) of the 2-D model of the filter above the focal plane. Each extension also contains the keyword FLRADIUS, which specifies the radius (in mm) of the filter. The tool ahsxtarfgen utilizes its own raytracing run to calculate the ARF, and the two keywords are used to reject raytracing events that miss the filter. The results in the CALDB file are then used to weight photon paths that do intercept the filter (instead of internally applying the filter model).

Although the gate valve CALDB file has corresponding keywords for the gate valve height (GVHEIGHT) and radius (GVRADIUS), they are not used by ahsxtarfgen because the pre-calculated raytracing transmission results already incorporate this information. The keywords provide a reference for the values assumed in the pre-calculated raytracing results. This also applies to the keywords XOFFSET and YOFFSET that specify the X and Y offsets respectively of the center of the gate valve structure relative to the telescope z-axis (i.e. the geometrical optical axis). Another keyword, GVROTANG, specifies the rotation angle of the gate valve structure (as depicted in the image in the primary extension of the CALDB file) relative to the SXS X-axis. The value in the currently released CALDB file (ah_sxs_gatevalv_20140101v002.fits) is +45 degrees. If different values of any of the five keywords (GVHEIGHT, GVRADIUS, XOFFSET, YOFFSET) are desired, the raytracing must be performed again with the new model, to produce a new CALDB file.

2.2 Data Analysis

For cases in which the transmission function is spatially non-uniform, the raytracing code *xrtraytrace* (version 9.02) was run for energies in the range 0.03-30 keV, using CALDB files appropriate for SXT-S. The raytraced photons were propagated through the model of only that component of the obstructing object (gate valve or filter) that has a spatially non-uniform opacity, counting those that survived to impact the focal plane for each energy. For this purpose the simplified 2-D model of the spatial structure in the primary extension of the CALDB file was utilized. The transmission fractions in the TRANSMSSION extension of the CALDB files could thus be calculated. Photons landing on the focal plane were then classified by which SXS pixel was impacted, and in this way the ratios in the PIXELRATIOSMAP were calculated. For this purpose pixel gaps were ignored and the telescope optical axis was assumed to correspond to the geometrical center of the SXS. When spatially non-uniform transmission could be approximated by a simple one-dimensional function, in some cases that function was supplied by the SXS team (such cases are identified below in the results for individual filters and files). Values of transmission versus energy, in the SURFACETRANSMISSION extension, when not equal to the dummy value of 1.0, were calculated using cross-sections from Henke tables. Details are given below in the results for individual filters and files.

2.3 Results

Gate Valve

The image in the primary extension (2-D geometrical model) of the gate valve CALDB file ah_sxs_gatevalv_20140101v002.fits is shown in Fig. 1. It is an approximation based on engineering diagrams. The transmission fraction in extension 1 of the file (TRANSMISSION) is shown in Fig. 2. Note that the raytracing results were fitted by a polynomial in order to give a smooth function. Note also that the raytracing was performed with no filter in the filterwheel. The transmission function for the Be/mesh film covering the gate valve is stored in extension 2 (SURFACETRANSMISSION) of the CALDB file and was provided by the SXS team, and is described elsewhere. The pixel ratio values in extension 3 (PIXELRATIOSMAP) correspond to the raytracing results in extension 1.

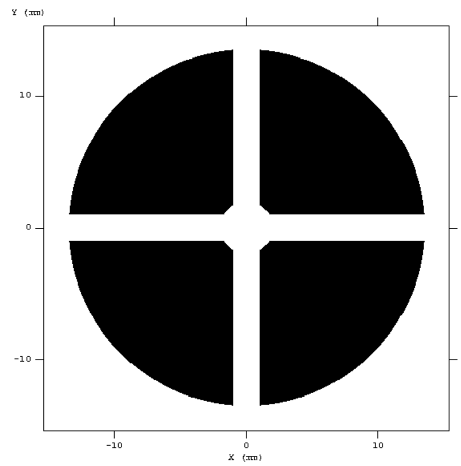

Figure 1: 2-D image in the primary extension of the gate valve CALDB file, representing the gate valve support structure. White areas are opaque to X-rays, black areas are transparent (but are covered by the Be filter/Mesh).

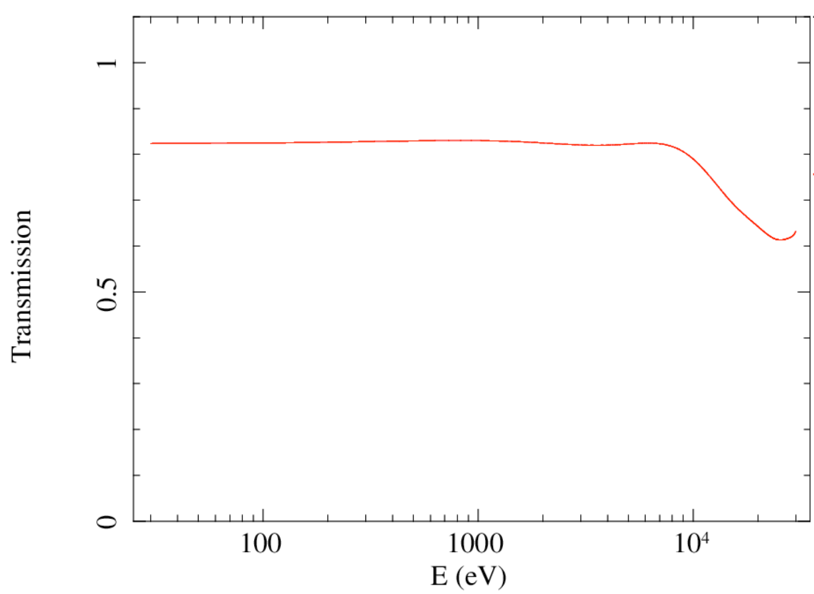

Figure 2: Transmission due to the gate valve structure as a function of energy (without the Be filter/Mesh).

Neutral Density Filter

The image in the primary extension of the CALDB file for the neutral density filter (ah_sxs_fwnd_20140101v001.fits) is shown in Fig. 3 and is a 2-D representation of the sturcture. It was provided by the SXS team and is described elsewhere. The structure transmission fraction in extension 1 (TRANSMISSION) is shown in Fig. 4. It was made by modeling raytracing results, combined with Molybdenum transmission (with cross-section data taken from Henke tables). The height of the filter above the focal plane assumed in the raytracing was 921 mm. The function in extension 2 (SURFACETRANSMISSION) has dummy values of 1.0 for all energies since there is no other component of the neutral density filter other than that represented in extension 1. The pixel ratio values in extension 3 (PIXELRATIOSMAP) correspond to the raytracing results in extension 1, which in this case are all exactly 1.0 since the raytracing results were consistent with this value.

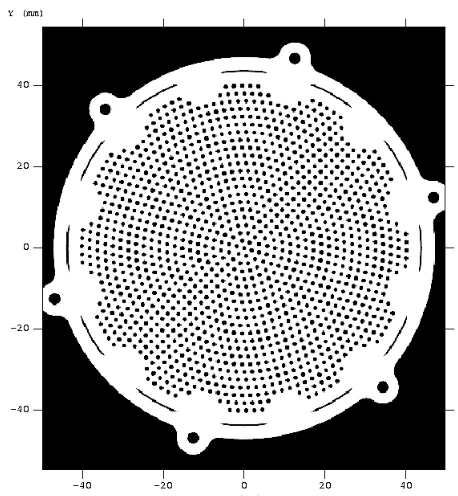

Figure 3: 2-D image in the primary extension of the neutral density filter CALDB file. White areas are pixels with full covering, black areas are partially transparent, the effective covering factor of each pixel is equal to the ratio of the value in the pixel (effective thickness in microns) to the value assigned to fully covering pixels (maximum thickness in microns).

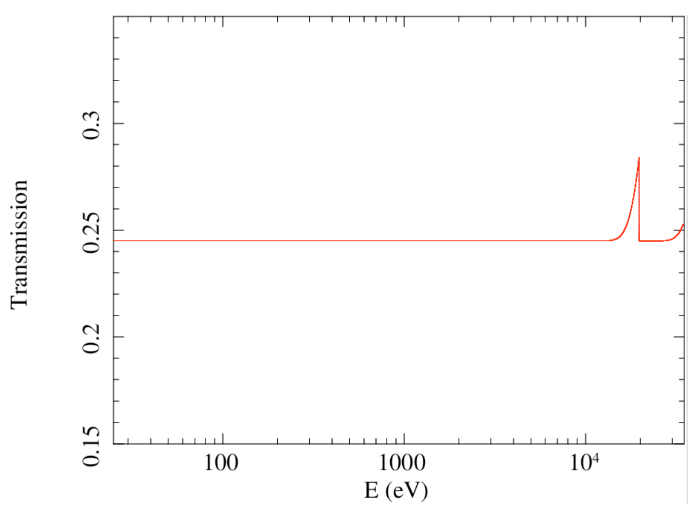

Figure 4: Transmission due to the neutral density filter as a function of energy.

Be filter

The image in the primary extension of the CALDB file for the Be filter is a simple 2-D model (ah_sxs_fwbe_20140101v001.fits) and is shown in Fig. 5. It is a circle with radius 44 mm and assumes a uniform thickness of the Be filter which can be set to a value corresponding to the mean thickness of the inflight filter (which is unknown). Raytracing simulations applied to non-uniform Be filters similar to the inflight one show that use of a single mean thickness is an adequate approximation. The actual thickness value used was 28.2604 um, which is the average of two Be filters similar to the inflight one. The structure transmission fraction in extension 1 (TRANSMISSION) is shown in Fig. 6. It was calculated as a simple 1-dimensional transmission, using cross-section data taken from Henke tables. The function in extension 2 (SURFACETRANSMISSION) has dummy values of 1.0 for all energies since there is no other component of the neutral density filter other than that represented in extension 1. The pixel ratios in extension 3 (PIXELRATIOSMAP) are all dummy values of 1.0.

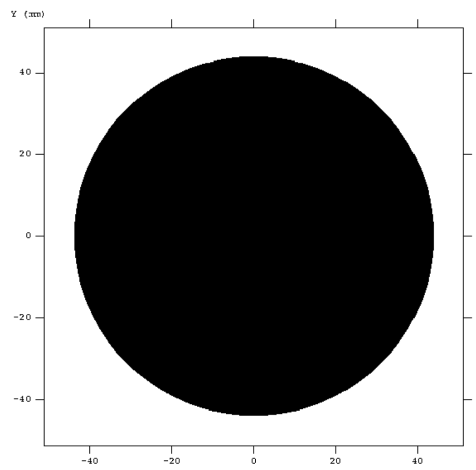

Figure 5: 2-D image in the primary extension of the Be filter CALDB file, representing a simple model of the filter. White area is opaque to X-rays, black area is the Be filter itself.

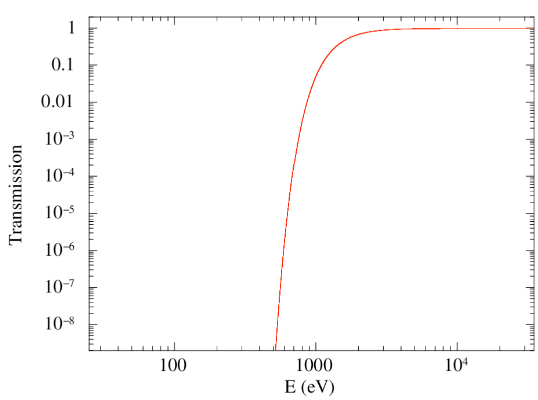

Figure 6: Transmission due to the Be filter as a function of energy.

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Polyimide Filter

The image in the primary extension of the CALDB file for the Polyimide filter (ah_sxs_fwpoly_20140101v001.fits) is shown in Fig. 7 and is a 2-D representation of the structure. It was provided by the SXS team and is described elsewhere. The structure transmission fraction in extension 1 (TRANSMISSION) is shown in Fig. 8. It was supplied by the SXS team and is described elsewhere. It includes 10% blocking and tranmission by the supporting mesh in addition to transmission by the filter. The transmission function did not utilize raytracing results, but raytracing simulations showed that the difference is negligible. The function in extension 2 (SURFACETRANSMISSION) has dummy values of 1.0 for all energies since there is no other component of the Polyimide filter other than that represented in extension 1. The pixel ratio values in extension 3 (PIXELRATIOSMAP) are all dummy values of 1.0.

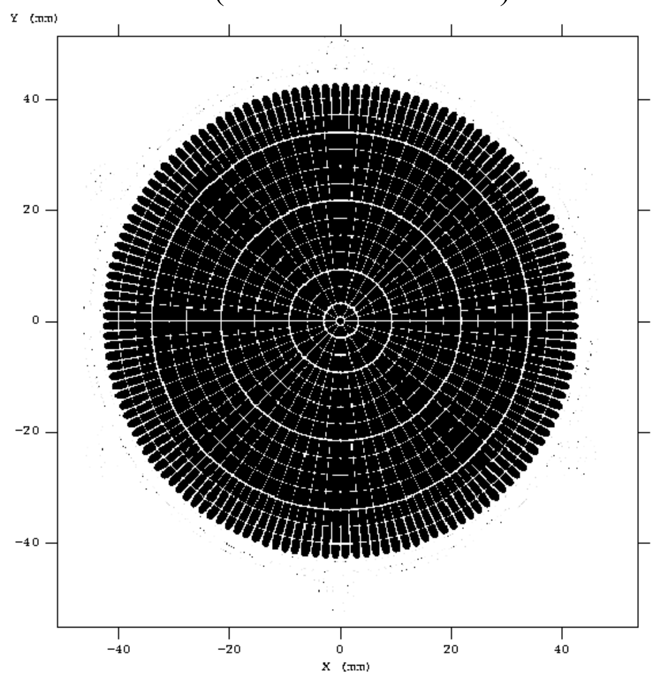

Figure 7: 2-D image in the primary extension of the neutral density filter CALDB file. White areas are pixels with full covering, black areas are partially transparent, the effective covering factor of each pixel is equal to the ratio of the value in the pixel (effective thickness in microns) to the value assigned to fully covering pixels (maximum thickness in microns).

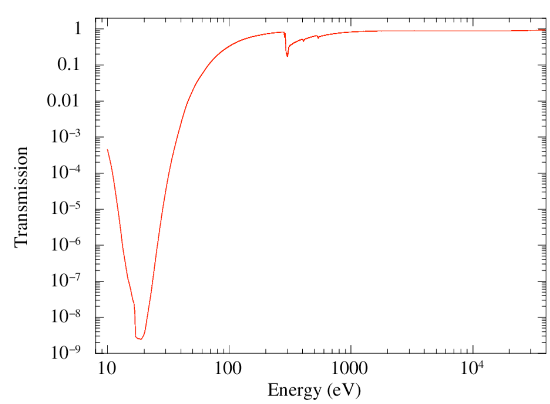

Figure 8: Transmission due to the Polyimide filter as a function of energy.

Fe 55 filter

The image in the primary extension of the CALDB file for the Fe 55 calibration source filter (ah_sxs_fwfe55_20140101v001.fits) is shown in Fig. 9 and is a 2-D representation of the sturcture. It is an approximation based on engineering diagrams. The structure transmission fraction in extension 1 (TRANSMISSION) is shown in Fig. 10. It was made using raytracing simulations, assuming that the strcuture is opaque. The height of the filter above the focal plane assumed in the raytracing was 921 mm. The function in extension 2 (SURFACETRANSMISSION) has dummy values of 1.0 for all energies since there is no other component of the Fe 55 filter other than that represented in extension 1. The pixel ratio values in extension 3 (PIXELRATIOSMAP) correspond to the raytracing results in extension 1.

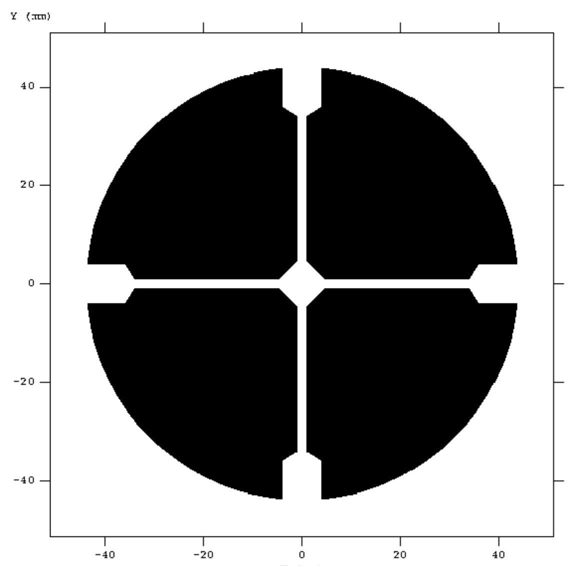

Figure 9: 2-D image in the primary extension of the Fe 55 source filter CALDB file, representing a simple model of the filter structure. White areas are opaque to X-rays, black areas are transparent.

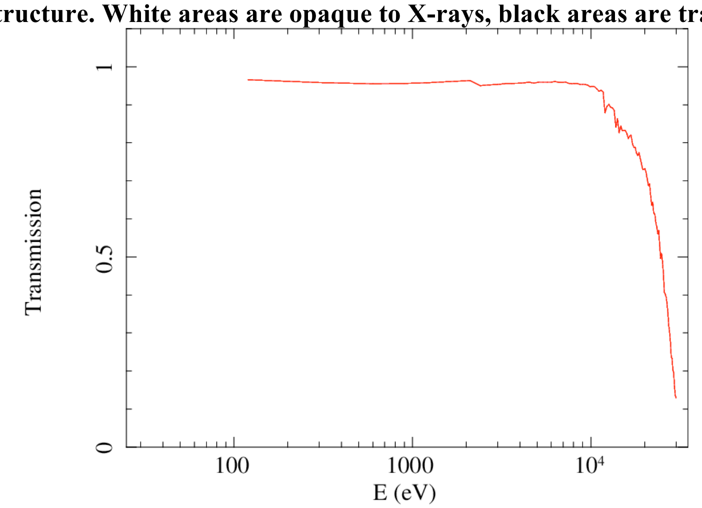

Figure 10: Transmission due to the Fe 55 filter structure as a function of energy.

2.4 Final Remarks

This is the first official release of this document.