NICER CALIBRATION: Window Transmission Functions

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Version 1.0 2021-07-07
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Summary and Release History

This document briefly describes NICER window transmission function files provided in CALDB.

- `nixtixrctranYYYYMMDDvVVV.fits` - NICER XRC thermal shield transmission function
- `nixtixrccorrYYYYMMDDvVVV.fits` - NICER XRC throughput correction function
- `nixtidettranYYYYMMDDvVVV.fits` - NICER FPM window transmission function
- `nixtidetqeYYYYMMDDvVVV.fits` - NICER FPM detector quantum efficiency function

XRC Transmission Functions

Public Release	NICER CALDB Ver	File Name	Comments
2021-07-07	xti20210707	`nixtixrctran20170601v001.fits`	XRC thermal shield transmission function
2024-02-06	xti20240206	`nixtixrctran20170601v002.fits`	XRC thermal shield transmission function corrected naming
2021-07-07	xti20210707	`nixtixrccorr20170601v001.fits`	XRC throughput correction spline function corresponding to xti20200722
2021-07-07	xti20210707	`nixtixrccorr20170601v002.fits`	XRC throughput correction spline function for off-axis ARF models

Detector Transmission Functions

Public Release	NICER CALDB Ver	File Name	Comments
2021-07-07	xti20210707	`nixtidettran20170601v001.fits`	FPM window transmission function
2024-02-06	xti20240206	`nixtidettran20170601v001.fits`	FPM window transmission function corrected naming
2021-07-07	xti20210707	`nixtidetqe0170601v001.fits`	FPM detector quantum efficiency function

Introduction

In order to calculate the NICER Ancillary Response File (ARF) response function, several tabulated transmission functions are required. This document provides information about these tables. By nature, each of these transmission functions is energy dependent, and thus has an energy-dependent effect on the total NICER throughput function.

Each of the files uses the Calibration Database codename "WTRANS" which indicates that the file contains tabulated window transmission values. In reality, not all of the tabulated values are window transmissions, but this codename is the closest practical identification.

The files are tabulated according to energy (and have an ENERG_LO and ENERG_HI column). This value indicates the true photon energy. The tables are intended to be interpolated in lin-log space (linear energy, log response).

XRC Thermal Shield Transmission Function

Each XRC module has a thermal shield attached to its aperture. This shield provides a form of thermal control to prevent extreme temperature excursions that could push the modules out of alignment.

The thermal shield is composed of a strongback mesh, which supports a polyimide film coated with aluminum. The transmission profile for these shields were measured by the NICER team at the BESSY synchrotron facility.

The resulting curve is shown in Figure 1.

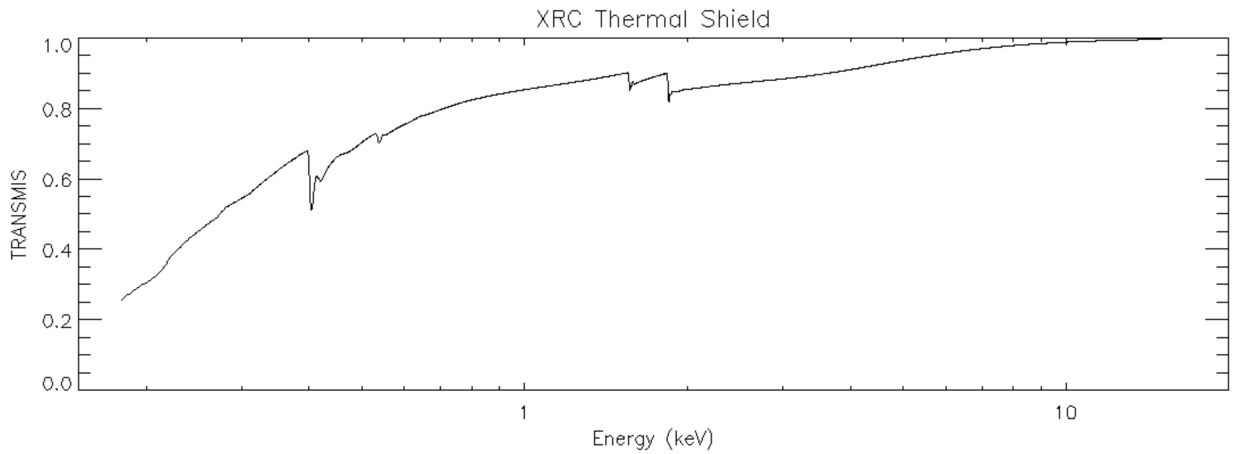

Figure 1. Transmission curve for the XRC thermal shield.

XRC Throughput Correction Spline Function

The NICER response modeling process involves a detailed adjustment of each module's response to match the template spectrum (Crab spectrum). After fitting, small residuals remain, and these are corrected for by applying a spline correction function, which is solved for at an array level. Thus, the spline corresponds to "common mode" adjustments that are required for the entire array. By construction, the spline correction is only applied in the 1-20 keV range. Below 1 keV, no correction is applied, so the spline correction value is 1 in this range.

There are two versions stored in CALDB

- v001 - corresponds to the values released in July 2020 (xti20200722), which are now deprecated
- v002 - results after including off-axis vignetting information

The following Figures 3 and 4 show the throughput correction splines for both models. One can see in the full 0.2-20 keV range, there is a large correction which dominates at high energies. However, in the limited range of 0.2-10 keV range, the correction factors are small (<3%). The largest adjustments occur in the 1.8-3.5 keV range, which is dominated by the Si K-alpha edge and the Gold M edge profiles. Although these features are largely the same in both versions, there are slightly variations between them which correspond to differences in analysis due to the addition of the off-axis vignetting profile.

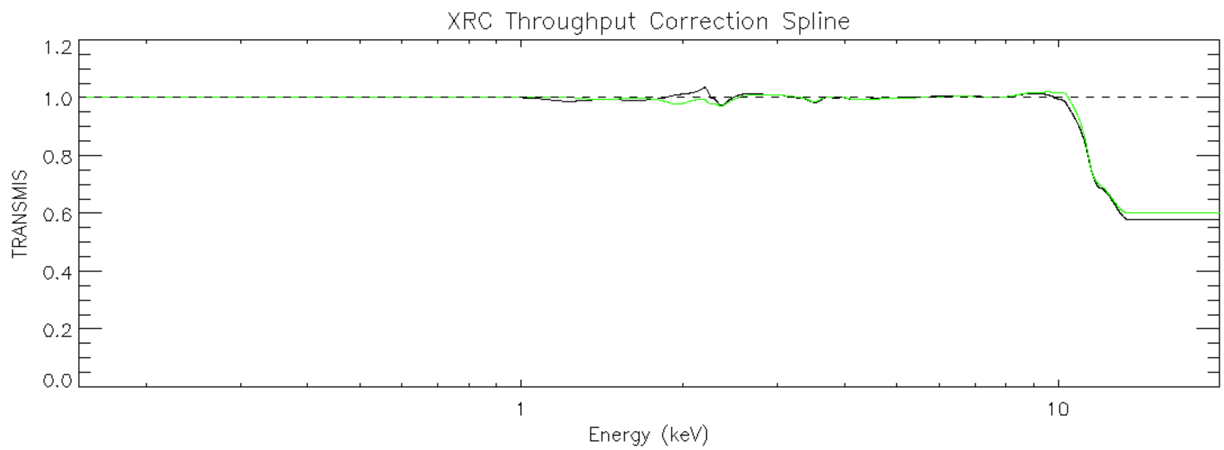

Figure 2. XRC throughput correction spline function for xti20200722 (black) and xti20210707 (green) in the full 0.2-20 keV range.

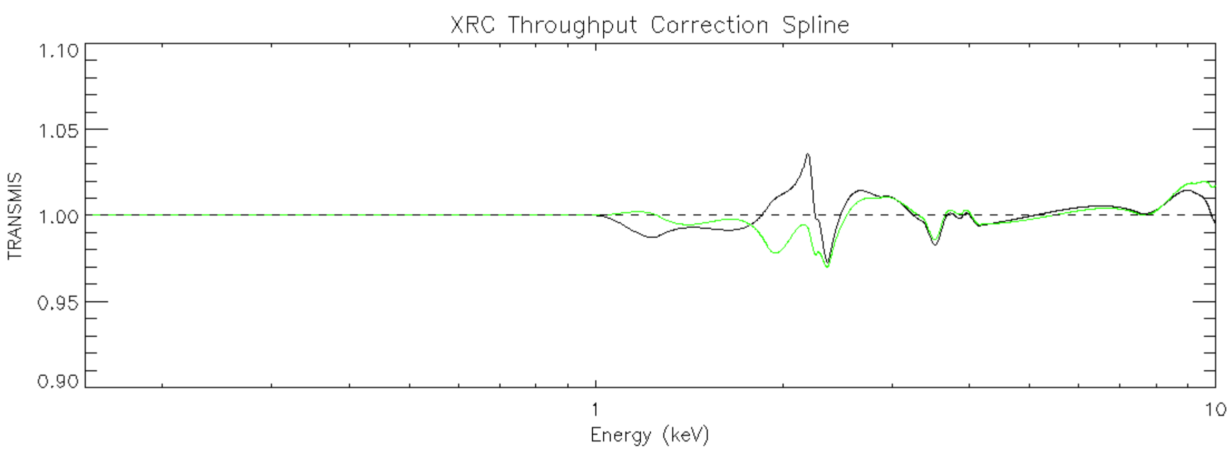

Figure 3. XRC throughput correction spline function for xti20200722 (black) and xti20210707 (green) in the limited 0.2-10 keV range.

FPM Detector Window Transmission Function

Each Focal Plane Module (FPM) has an entrance window. This window protects the detectors, and during ground testing prevents room air from reaching the silicon detector and degrading it.

The window is composed of silicon nitride,The transmission profile for these shields were measured by the NICER team at the BESSY synchrotron facility.

The resulting curve is shown in Figure 4. Transmission is primarily affected by the presence of silicon and nitrogen, and to a lesser extent oxygen.

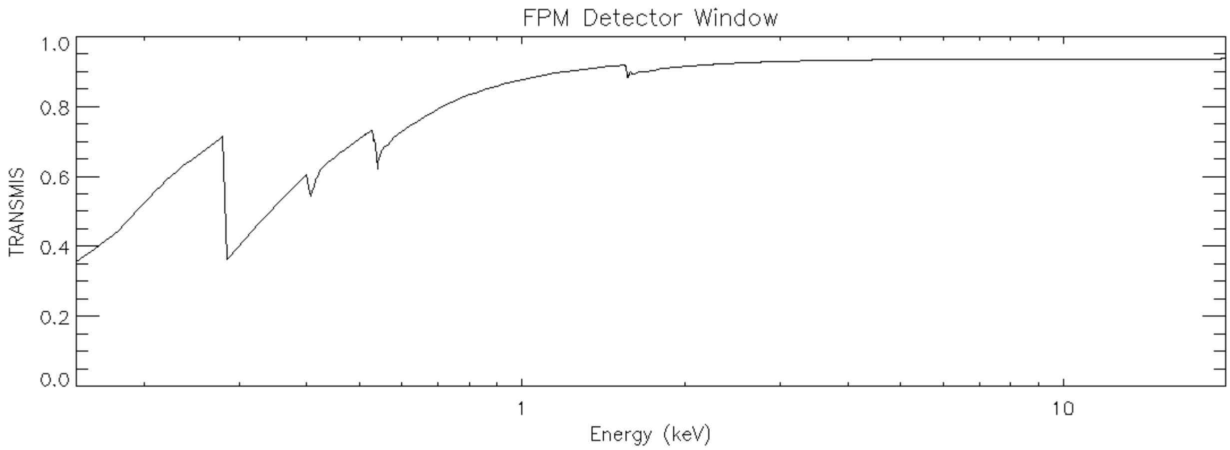

Figure 4. Transmission curve for the FPM window.

FPM Detector Quantum Efficiency Function

The total detector quantum efficiency determines how efficient the SDD is at converting arriving photons into detected counts. At low energies, this is driven by the probability of the photon being absorbed outside the active volume (i.e. in a dead layer), and at high energies, it is driven by the probability of a photon passing through the entire detector thickness (500 um) without being photo-converted.

Unlike other items in this document, the quantum efficiency is a derived quantity. It is based upon measurements in ceratin energy bands, as well as theoretical considerations, which are applied when extending the measurements to the full energy range.

The resulting curve is shown in Figure 5. Below 2 keV, the curve has features for oxygen and silicon corresponding to the dead layer of oxidized silicon. Above ~10 keV, the QE drops because of the finite optical thickness of the detector.

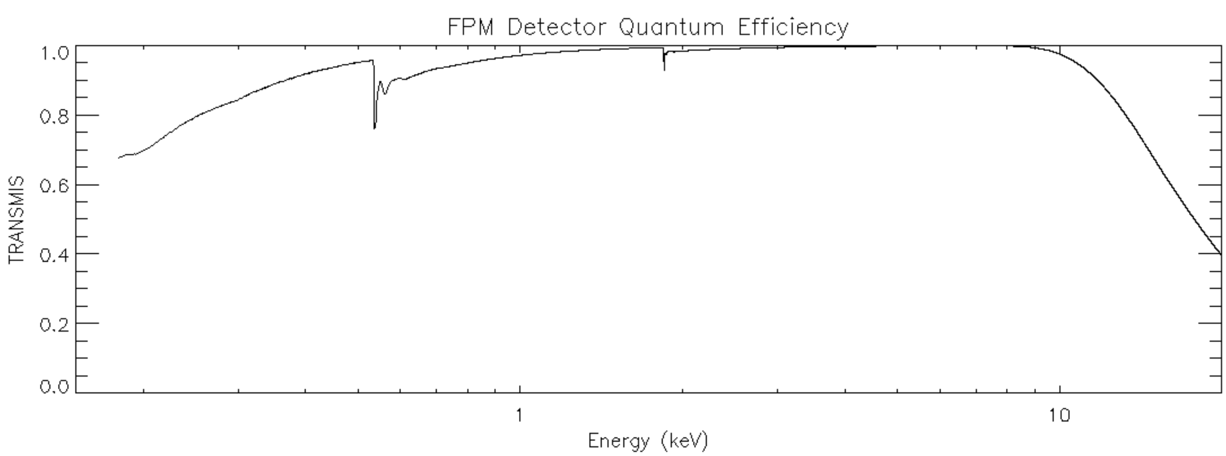

Figure 5. FPM detector quantum efficiency curve.

Changes

xti20210707

This is the initial release of products.

xti20240206

As of CALDB release xti20240206, the XRC thermal film transmission curve was updated to version 2, and the FPM detector window transmission curve was updated to version 2.

The reason for this update is that it was discovered that these two files were swapped. I.e. they were labeled with the incorrect contents. Because the two curves are multiplied, the actual numerical results do not change after this update. This update is essentially a book-keeping update.