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# INSTRUMENT CALIBRATION REPORT

# RESOLVE DETECTOR ARRAY ABSORBER CORNER POSITIONS

RESOLVE-SCI-RPT-0066

REVISION (-)

XRISM-RESOLVE-CALDB-ABSCORNERS-200

X-ray Imaging and Spectroscopy Mission (XRISM) Project

NASA/GSFC Code 490.2

**Goddard Space Flight Center**
**Greenbelt, Maryland**

National Aeronautics and
Space Administration

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to verify that this is the correct version prior to use

400-FORM-0002 (4/16/2014)

# Resolve Detector Array
# Absorber Corner Positions

# Signature/Approval Page

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***** Electronic signatures are available on-line at: https://ipdtdms.gsfc.nasa.gov*****

# 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:
XRISM Configuration Management Office
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# Change History Log

| Revision | Effective Date | Description of Changes<br>(Reference the SCoRe Approval Date) |
|---|---|---|
| (-) | 09/20/2019 | Released per RESOLVE-SCoRe-0320.<br>This version includes measurements of the flight Resolve detector array absorber corner positions. |
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*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 the measurements and analysis performed to provide the location of the four corners of each Resolve HgTe absorber tile relative to a fiducial position on the detector array.

## 1.2 Scientific Impact

This position information is incorporated into the PIXEL_MAP extension of the Resolve teldef CALDB file, and used by the XRISM software task that calculates coordinate transformations. The position information is used indirectly by many XRISM software tasks, e.g., in calculating the instrument effective area.

## 1.3 Orientation of coordinate system for absorber corner positions in teldef CALDB file

The Resolve CALDB and associated software tasks expect absorber corner positions in a coordinate system parallel to ACT coordinates. ACT coordinates are fixed to the detector, look-down, and are linearized to the physical positions of the detector pixels. The coordinate system is described in the header of the primary extension of the teldef file. This implies, for example, a coordinate system in which Resolve pixel 11 and pixel 12 (the calibration pixel) are toward the bottom right (Figure 5). This coordinate system is rotated by 180 degrees with respect to spacecraft coordinates.

The nominal pixel pitch is 832 µm, but in practice is slightly larger. There are gaps of several microns between the absorbers. The CALDB table gives the positions relative to the geometric center of the array, between the innermost corners of pixels 0, 17, 18, and 35. The corners of each individual absorber are labeled 1–4, starting with the bottom left corner and moving counterclockwise as viewed from above, looking down at the pixels from the telescope, so that corner 1 is the lower left, 2 is the lower right, 3 is the upper right, and 4 is the upper left. The software calculates the coordinates of the center of each pixel by taking an average of the four corners. Figure 5 in Section 2.3 provides a simple graphical representation.

# 2 First Delivery – 20181219

| CalDB Filename | Validity date | Files as delivered | Delivery date | Comment |
|---|---|---|---|---|
| xa_rsl_teldef_ 20140101v002 | 20190101 00:00 UT | TELDEF_absorber_corner_DATAFILE_20181219.txt<br>TELDEF_absorber_corner_HEADER_20181219.txt<br>TELDEF_primary_HEADER_20181219.txt | 20181219 | |

The datafile delivery is described in this report. Header updates delivered on 20181219 provide minor corrections and updates from Astro-H to the text of the primary and PIXEL_MAP headers.

Primary header keyword values for the optical axis were changed to a nominal value (instead of keeping Astro-H-specific alignment values); these and other keyword values in the primary header will be updated in future releases of the teldef file.

## 2.1 Data Description

The data consist of a set of high-resolution microscope images of the completed Resolve detector array acquired on August 2, 2018, prior to integration into the detector assembly. The images were taken in the GSFC Building 34, Room 276 clean tent using a Zeiss Axioskop with 10x objective and CCD camera. The camera pixel scale was calibrated with this objective prior to the measurements of the detector array and found to be 0.45 µm per pixel, consistent with the manufacturer calibration for this configuration.

The microscope is equipped with an automated sample translation stage and image reconstruction software that tiles individual images together, allowing acquisition of a high-resolution image of the entire silicon chip that houses the detector array. The x- and y-axes of the microscope coordinate system were aligned with the axes of motion of the translation stage. Tiled images covering the chip were acquired in bright field mode at 3% fractional overlap of the tiles, and repeated at a second fractional overlap (10%) to avoid placing a seam at the measurement location.

These microscope measurements, including the camera pixel calibration, were documented on Work Order Authorization WOA-RESOLVE-DET-0562. The final tiled image was stored in the Zeiss proprietary format (.czi) with a file size of 7GB. **Figure 1** provides a jpeg of the image, for reference.

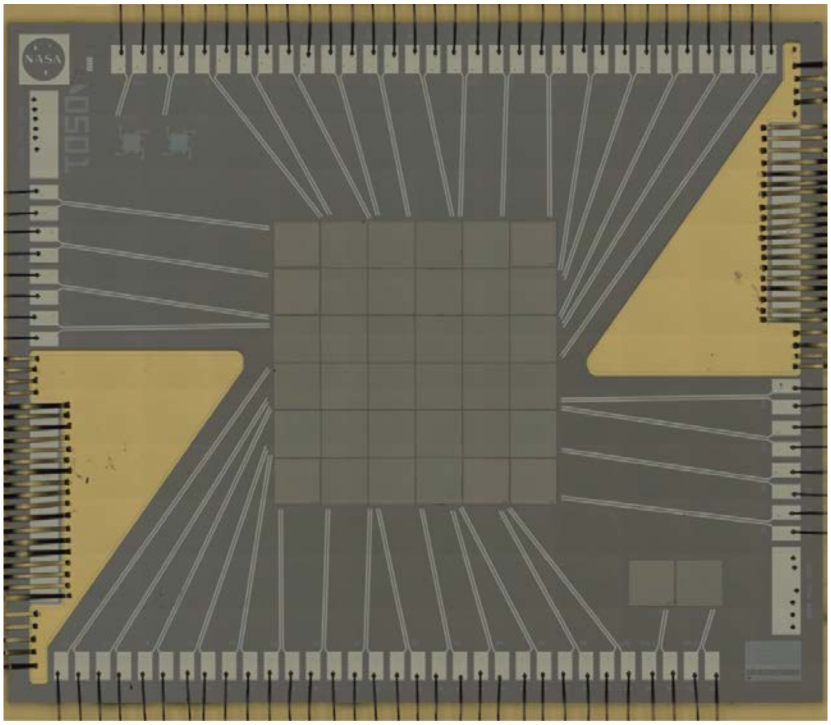

**Figure 1** Final tiled image of the detector chip. The full-resolution image is 7 GB.

## 2.2 Data Analysis

Using the tiled images (3% overlap) and the Zeiss proprietary Zen software, an instrument team member marked the location of each absorber corner by eye. Spot checks of the coordinate placement were performed by the lead detector scientist, and all checks agreed within ±2 µm, the uncertainty of which is dominated by rounding of the absorber corners and associated judgement calls (Figure 2). The positions of four separate, symmetric bond pad locations on the top/bottom and left/right of the detector chip were added to the list of absorber corner positions, and all values were exported to commercial analysis software (Excel/Igor Pro) where the coordinates were zeroed presuming zero rotation. The y-coordinates were flipped because the origin on the Zeiss software is upper left, increasing going right and down. The resulting list of pairs of x,y coordinates were then sorted and converted to comply with the format required by the SDC, described in Section 2.3. Plots were generated using this final list to verify that there were no errors introduced in these last steps (Figure 3, Figure 4).

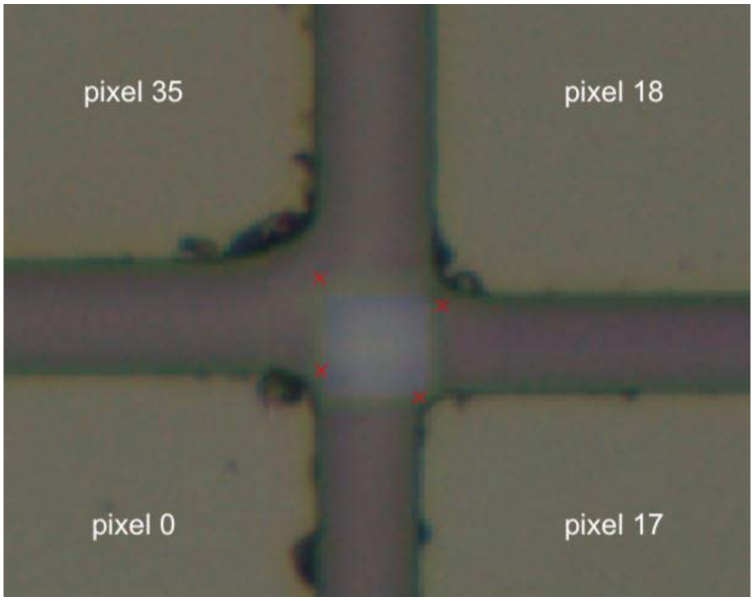


**Figure 2** Image of the center of the detector array. The absorber corner positions are marked in red, highlighting the uncertainty in coordinate placement due to rounding at the corners of the HgTe tiles.

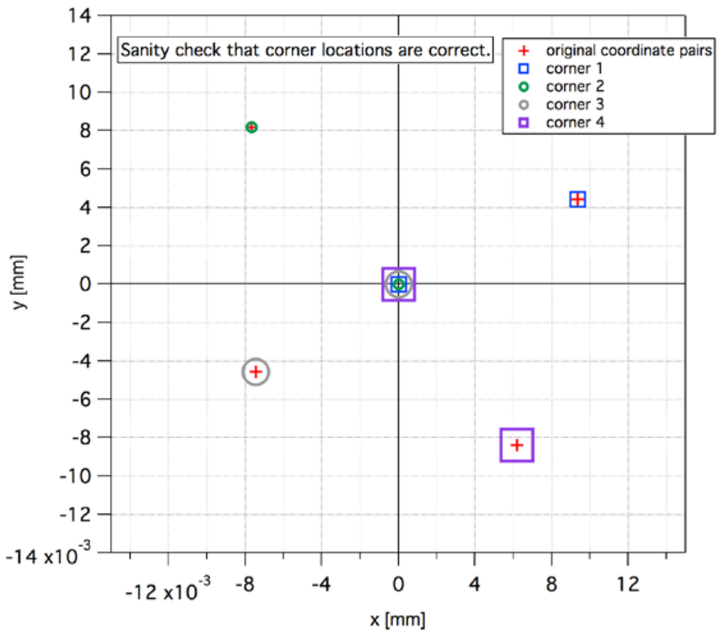


**Figure 3** Example of plots generated to check the final list of coordinates (corner 1, corner 2, corner 3, corner 4) compared to the original list of unsorted coordinates. This plot shows the area at the center of the detector array, similar to the image presented in Figure 2. The set of absorber corner positions at x=0, y=0 represent the (non-physical) calibration pixel coordinates, as requested by the SDC. The other data points show a single absorber corner for each of pixels 0, 17, 18, and 35.

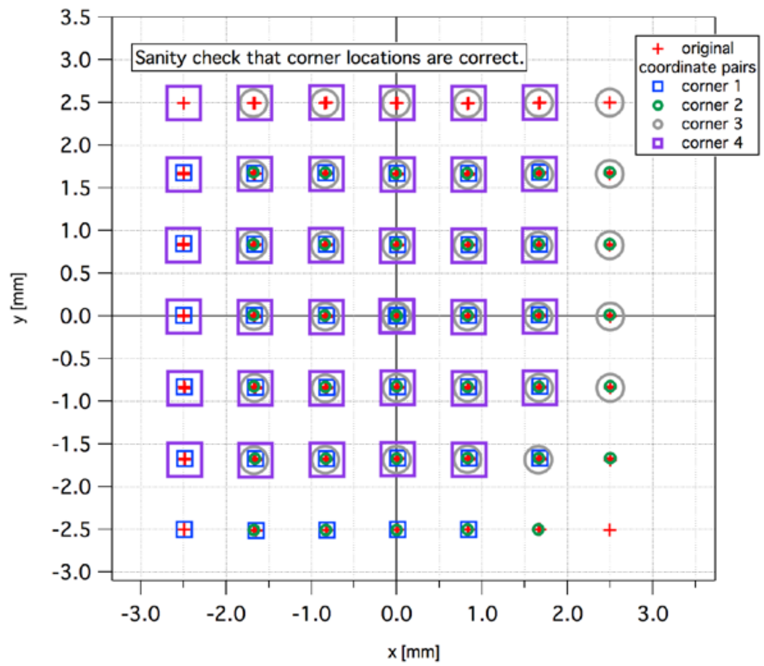


**Figure 4** Same as Figure 3, but showing the entire detector array.

### 2.3 Results

File delivered to the Science Data Center (SDC):

We delivered a text file with 36 rows, one per pixel, with the format: pixel_number, x1, x2, x3, x4, y1, y2, y3, y4.

- Here x1 is the x-coordinate of corner #1, x2 is the x-coordinate of corner #2, …, y1 is the y-coordinate of corner #1, etc.
- The orientation of the axes matches that described in Section 1.3.
- The units are mm, with positions rounded to a precision of 0.1 µm.
- The calibration pixel (pixel 12) absorber corner positions are all set to 0.0 mm. The SDC prefers that row not be blank, and we agreed to submit 0.0 in lieu of something physically accurate. Since the calibration pixel will not see photons from the sky it is excluded from all sky coordinate and effective area calculations.

CALDB FITS file created by the SDC:

The PIXEL_MAP extension of the teldef CALDB file contains three columns (pixel, pixelx, and pixely) and 36 rows (one row per pixel). The pixel column is type 1I and contains the pixel number. Pixelx and pixely are type 4E and store x1, x2, x3, x4 and y1, y2, y3, y4 for the given pixel.

```
COMMENT
COMMENT
COMMENT                          4+---+3
COMMENT                           |   |
COMMENT                          1+---+2
COMMENT
COMMENT
COMMENT               Physical dimension ~5.0 mm square
COMMENT         Corner     +---+---+---+---+---+---+
COMMENT     (-2.500,2.495) | 30| 32| 34| 26| 24| 23|
COMMENT                    +---+---+---+---+---+---+
COMMENT                    | 29| 31| 33| 25| 22| 21|
COMMENT                    +---+---+---+---+---+---+
COMMENT                    | 27| 28| 35| 18| 20| 19|
COMMENT                    +---+---+---@---+---+---+
COMMENT                    |  1|  2|  0| 17| 10|  9|
COMMENT                    +---+---+---+---+---+---+
COMMENT                    |  3|  4|  7| 15| 13| 11|
COMMENT                    +---+---+---+---+---+---+
COMMENT                    |  5|  6|  8| 16| 14|   |      Corner
COMMENT                    +---+---+---+---+---+---+ (2.494,-2.503)
COMMENT
COMMENT
COMMENT     PIXELY (mm)                               S/C X <--------
COMMENT     ^                                                       |
COMMENT     | Parallel to ACT coordinates           Rotated 180 deg |
COMMENT     |                                       from Spacecraft |
COMMENT     |                                       coordinates     |
COMMENT     +--------> PIXELX (mm)                                 \/
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**Figure 5** Screenshot of a portion of the header for the PIXEL_MAP extension of the teldef CALDB file, highlighting the orientation of the absorber corner IDs (top); a cartoon layout of the detector array, where the zero position is marked with an @ symbol (center); and the orientation of the axes (bottom)

## 2.4 Final remarks

This is the first release of the teldef CALDB file based on microscope measurements of the Resolve detector array. These measurements meet the ground calibration requirement CAL-2.2.3, knowledge of each absorber corner to ±10 μm with respect to a fiducial position on the detector array. There are no expected updates to the absorber corner positions (the PIXEL_MAP extension), barring any decision in the future to incorporate a more complicated absorber shape to reflect the slightly trapezoidal shapes and rounding at the absorber edges. We will also perform a full cross-check of the existing absorber corner coordinate placement by having one person remeasure the 3%-overlap tiled image and two people measure the 10%-overlap tiled image. If we identify any substantive difference we will provide a revised file to the SDC and update this document accordingly. Keyword values in the primary header of the teldef file will require updates before launch, for example, when telescope-to-detector alignment information is available.