

INSTRUMENT CALIBRATION REPORT

XTEND PIXEL PATTERN

XRISM_XTEND_CALDB_PATTERN

REVISION (-)

X-ray Imaging and Spectroscopy Mission (XRISM) Project



**Goddard Space Flight Center
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Signature/Approval Page

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Change History Log

[illegible]

NOTE to editors: These documents are updated as needed, e.g. when the relevant CALDB files, or the relevant calibration data analysis, is revised.

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.

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1 Introduction

1.1 Purpose

This document describes the pixel patterns needed to assign grades to Xtend events with the tool `xtdpi`, and how these patterns are stored in the CalDB file.

1.2 Scientific Impact

The grade hit pattern CalDB file converts a 3×3 pixel pulse-height pattern, encoded in the PHAS column of an Xtend event list, to an ASCA-type grade, which is used as the first step in the grade assigned by the task `xtdpi`. Further grading uses the Suzaku XIS scheme, which changes certain ASCA grades to other values depending on the exact 3×3 pixel PHAS values and the pulse heights in the outer 5×5 (16-pixel) ring, as encoded in the P_OUTER_MOST column in the event file.

2 Release CalDB 20181205, 20230515

CalDB Filename	Validity date	File(s) as delivered	Delivery date	Comment
xa_xtd_pattern_20140101vh001.fits	20140101 00:00 UT	ah_sxi_pattern_20140101v001.fits	N/A	Copied from Hitomi SXI, released 20181205
xa_xtd_pattern_20190101v001.fits	20140101 00:00 UT	N/A	N/A	Copied from previous, released 20230515

2.1 Data Description

The ASCA grade defines which of the pixels in a 3×3 event island have pulse height above the split threshold. This definition was obtained from the ASCA ABC guide (<http://heasarc.gsfc.nasa.gov/docs/asca/abc>), including Figure 4.1 from that guide, which is reproduced as Figure 1 here. Based on this definition, a full list of all 256 possible combinations of 3×3 hit patterns was constructed and assigned by hand the appropriate ASCA grade, with the exception of grade 8, which is not strictly an ASCA grade but rather a subset of ASCA grade 6 in which the enclosed corner pixel is below the split threshold. This change was implemented for the *Suzaku* XIS grades to allow more refined grading of grade 6 events by requiring that the “surrounded” corner pixel have a lower pulse height than its neighbors. The full list of 3×3 hit patterns and their initially assigned grades are shown in Figure 2.

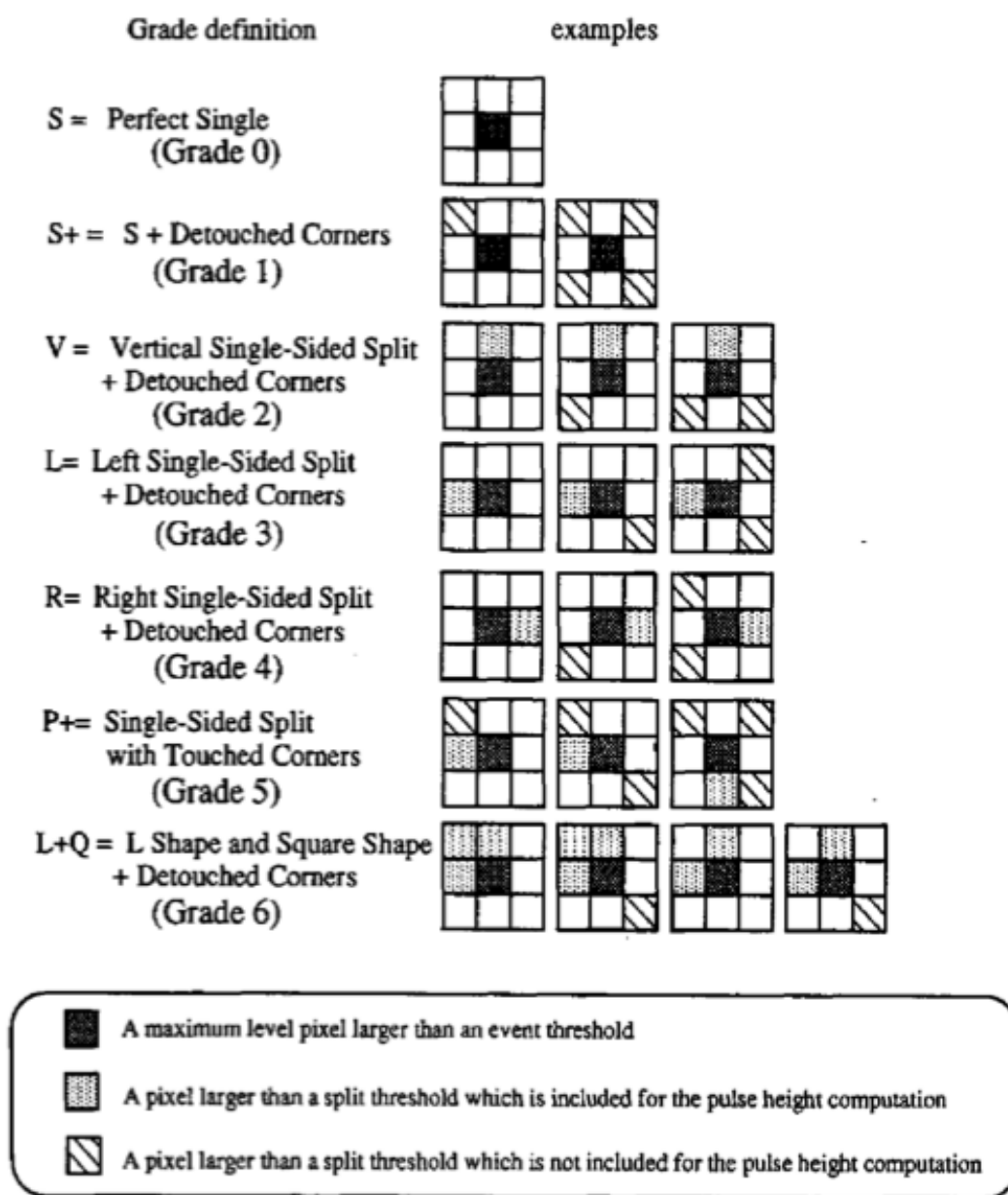


Figure 1. ASCA grades from the ASCA ABC guide. The pixel to the lower left in each pattern is closest to the CCD read-out node. For clarity, not all combinations are shown for each grade, except for grades 0, 3, and 4. Grade 2 includes vertical flips of the patterns shown, and grades 1, 5, and 6 include all rotations and flips not shown. Grade 7 is assigned to any event with a pattern not included in Grades 0–6.



Figure 2. Schematic of all 256 possible 3x3 hit patterns with corresponding initial grades. Each grid shows a 3x3 pixel event island, with the readout node toward the lower left. Green pixels indicate a pulse-height greater than or equal to the split threshold, with the central pixel (with a dot) required to be a local maximum above the event threshold. The corresponding initial grade number (0–8) is shown below the 3x3 grid.

After this initial 3×3 grade is assigned, a larger 5×5 pixel island is considered for further grade refinement. While this algorithm does not require further use of this or other CalDB files, it is detailed in this document for reference. This grading algorithm was first introduced for the Suzaku XIS, and is used for both Hitomi SXI and XRISM Xtend. Figure 3 shows the event island pixels as they are ordered in the Xtend event list PHAS and PHASALL columns.

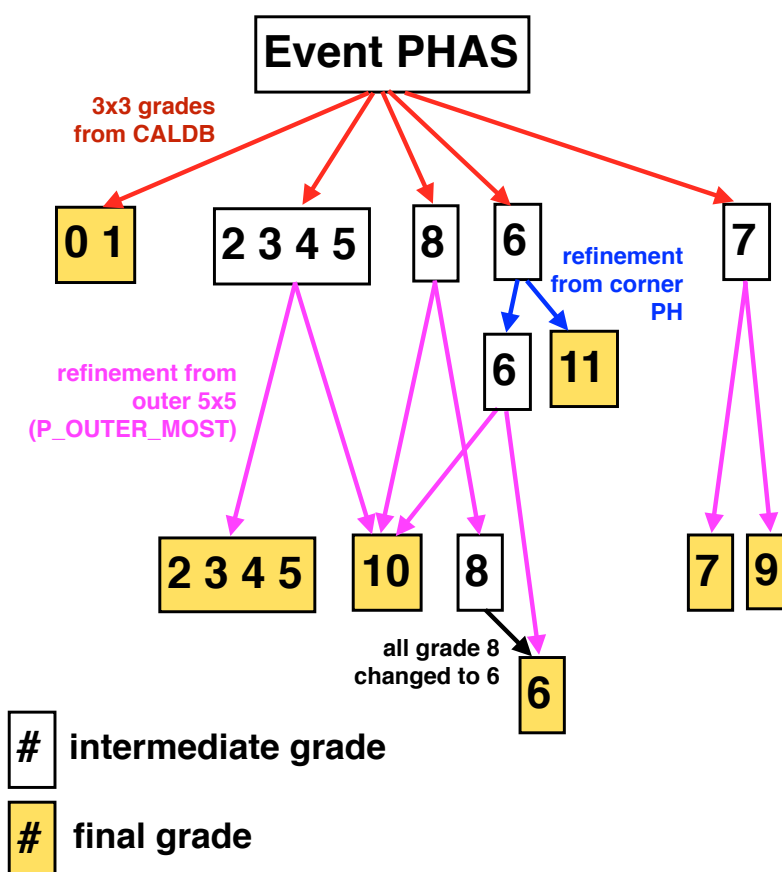
20	21	22	23	24
18	6	7	8	19
16	4	E	5	17
14	1	2	3	15
9	10	11	12	13

read out direction

Figure 3. Event island orientation and pixel ordering scheme in Xtend event data. 'E' is the event central pixel, a local maximum.

A flow chart of grade assignment is shown in Figure 4. The initial 3×3 grade is assigned according to the CALDB file contents, and the refinement is coded within `xtendpi`.

Suzaku/XIS 5x5 Grades

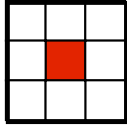


- Grade 8 is introduced to allow Grade 6 to Grade 11 refinement
 - All Grade 8 are changed to Grade 6 in final step to allow G02346 filter
- ASCA Grade 7 changed to 9

Figure 4. The flow of grade assignment for Xtend events.

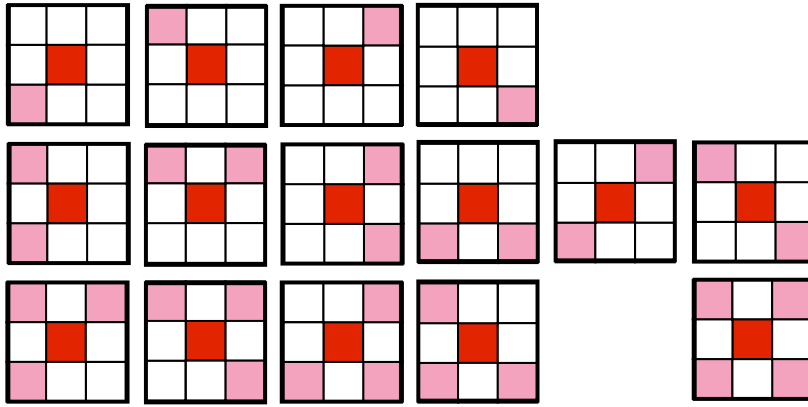
SXI Final Grades

Grade 0 No split pixels. The outer 16 pixels are not considered.



No split pixels.

Grade 1 Corner split. The outer 16 pixels are not considered.



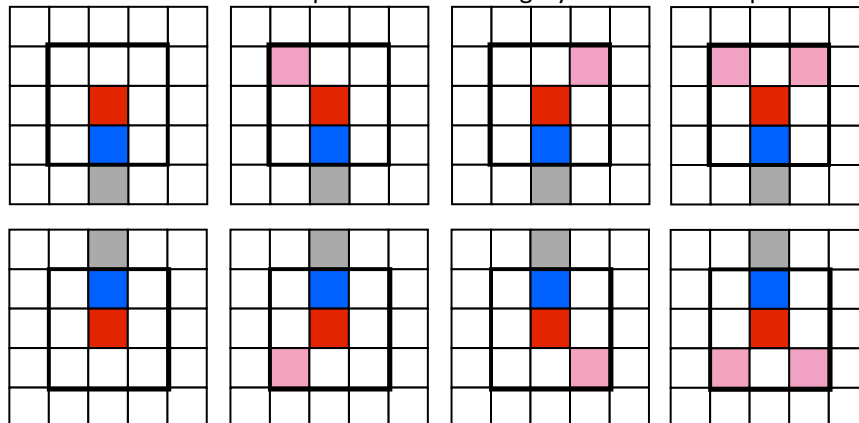
 Event center.
  PH $\geq$ sp. th. Not added to the sum of PHA.

Figure 5. Final event grades for Xtend.

A full set of all Xtend grades is shown in Figure 5, continued in the following pages. In all cases, the lower left pixel is closest to the CCD read-out node. All possible orientations are shown for each grade except for grades 7 and 9, which encompass all remaining patterns. Note that grade 7 is changed from what has been used previously for ASCA; events with grade 7 have at least one pixel in the outer 5×5 above the split threshold, as long as this pixel abuts an inner 3×3 pixel also above threshold. Grade 9 events do not, so are similar to ASCA grade 7.

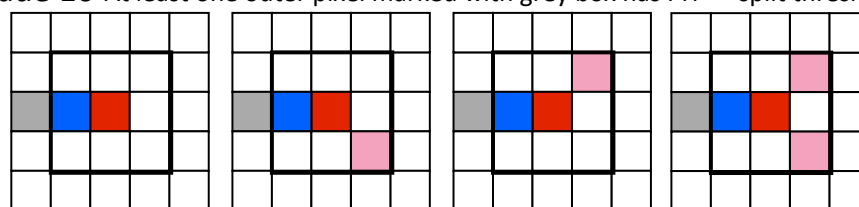
Grade 2 Vertical split, with or without opposite corners. All outer pixels marked with grey boxes have $PH < \text{split threshold}$.

Grade 10 At least one outer pixel marked with grey box has $PH \geq \text{split threshold}$.



Grade 3 Left split, with or without opposite corners. All outer pixels marked with grey boxes have $PH < \text{split threshold}$.

Grade 10 At least one outer pixel marked with grey box has $PH \geq \text{split threshold}$.



Grade 4 Right split, with or without opposite corners. All outer pixels marked with grey boxes have $PH < \text{split threshold}$.

Grade 10 At least one outer pixel marked with grey box has $PH \geq \text{split threshold}$.

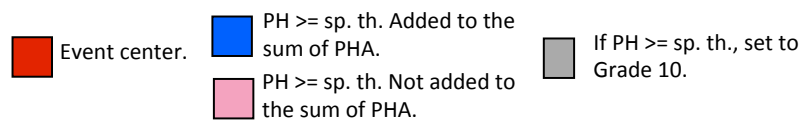
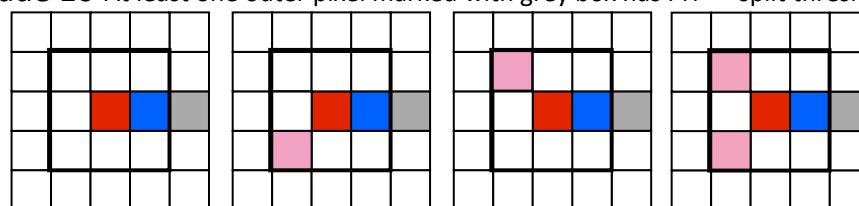
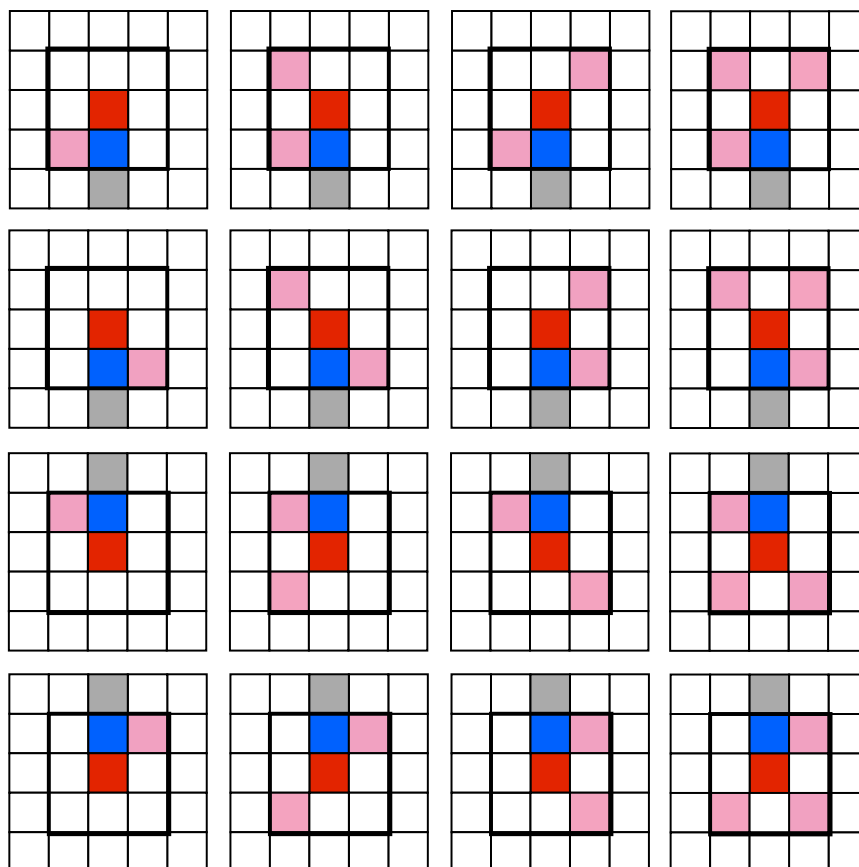


Figure 5 (cont'd). Final event grades for Xtend.

Grade 5 Vertical, left, or right split plus a corner, with or without opposite corners.

All outer pixels marked with grey boxes have $PH < \text{split threshold}$.

Grade 10 At least one outer pixel marked with grey box has $PH \geq \text{split threshold}$.



Event center.

$PH \geq \text{sp. th.}$ Added to the sum of PHA.

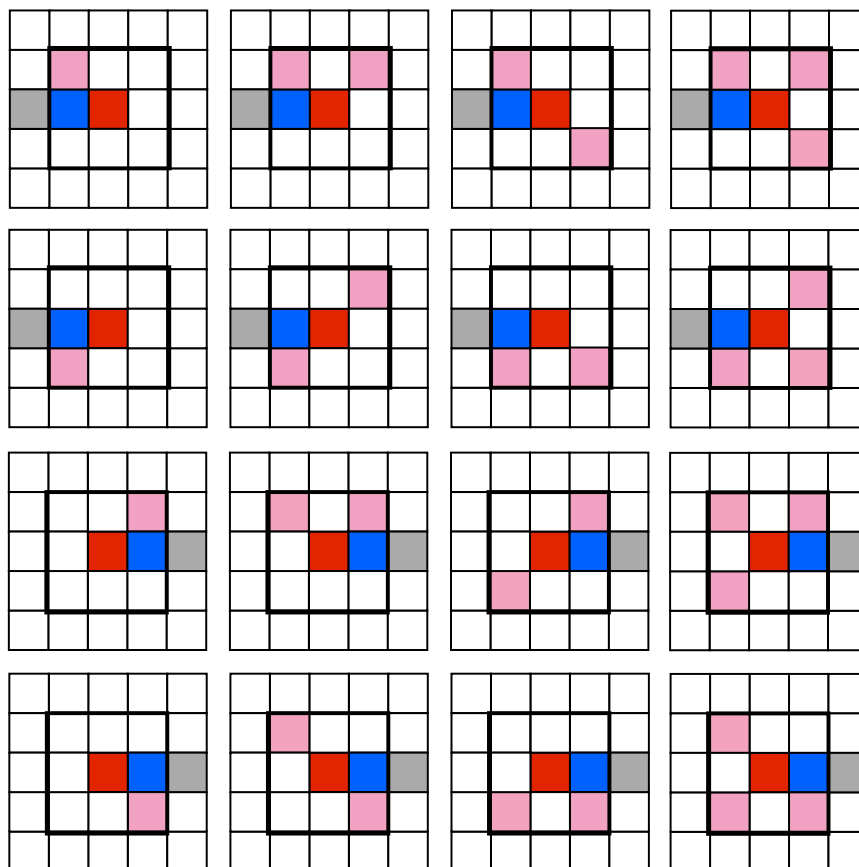
$PH \geq \text{sp. th.}$ Not added to the sum of PHA.

If $PH \geq \text{sp. th.}$, set to Grade 10.

Figure 5 (cont'd). Final event grades for Xtend.

Grade 5 (continued)

Vertical, left, or right split plus a corner, with or without opposite corners.

All outer pixels marked with grey boxes have $PH < \text{split threshold}$.**Grade 10** At least one outer pixel marked with grey box has $PH \geq \text{split threshold}$.
 Event center.

 $PH \geq \text{sp. th.}$ Added to the sum of PHA.

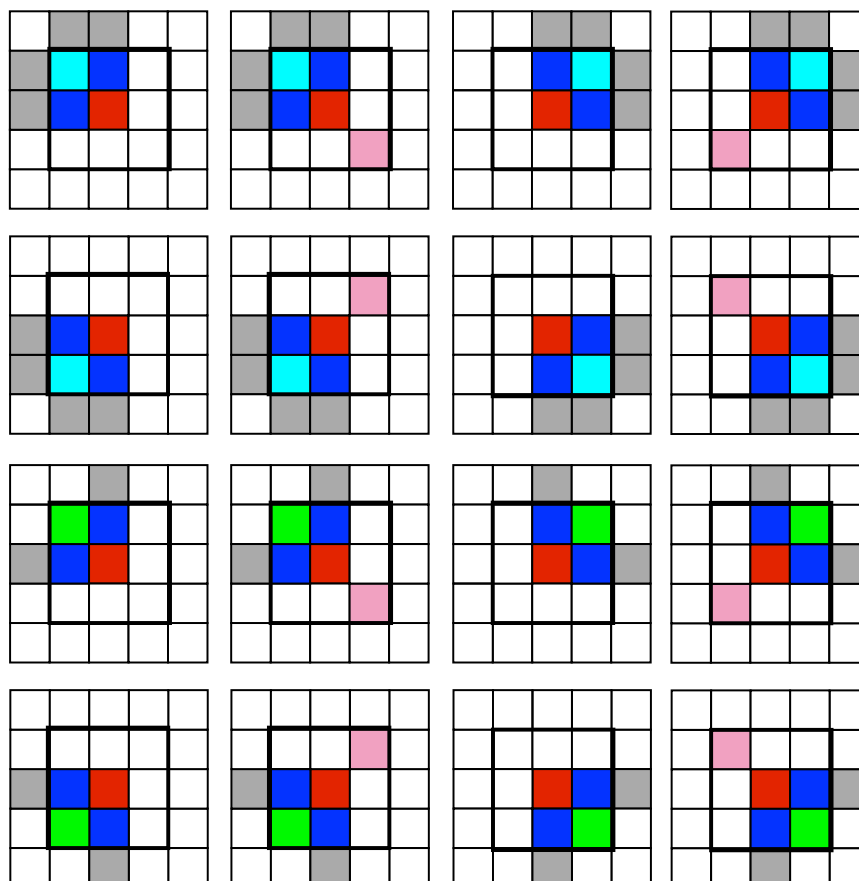
 $PH \geq \text{sp. th.}$ Not added to the sum of PHA.

 If $PH \geq \text{sp. th.}$, set to Grade 10.
Figure 5 (cont'd). Final event grades for Xtend.

Grade 6 Vertical, left, or right split plus a corner, with or without opposite corners.

All outer pixels marked with grey boxes have $PH < \text{split threshold}$.

Grade 10 At least one outer pixel marked with grey box has $PH \geq \text{split threshold}$.



■ Event center.

■ $PH \geq \text{sp. th.}$ Added to the sum of PHA.

■ $PH \geq \text{sp. th.}$ Not added to the sum of PHA.

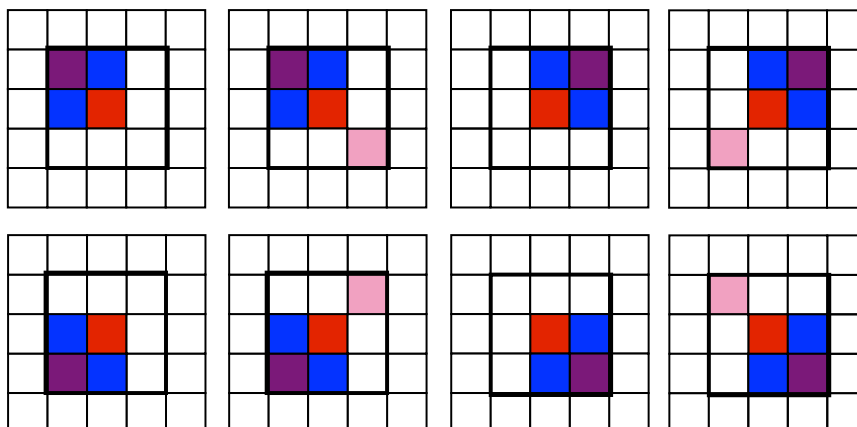
■ $PH \geq \text{sp. th.}$ and $\leq PH$ of blue pixels. Added to the sum of PHA.

■ $PH < \text{sp. th.}$ Added to the sum of PHA.

■ If $PH \geq \text{sp. th.}$, set to Grade 10.

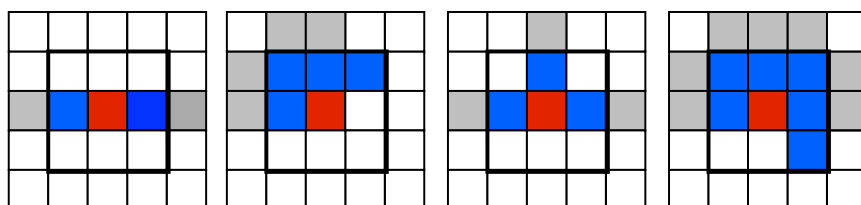
Figure 5 (cont'd). Final event grades for Xtend.

Grade 11 Vertical, left, or right split plus a corner, with or without opposite corners.
 The surrounded corner has PH greater than the two blue neighbor pixels.
 The outer 16 pixels are not considered for this Grade.



Grade 7 Any 3x3 pattern not previously shown, with three pixels in a row or column having $PH \geq \text{split threshold}$. At least one outer pixel abutting a split pixel must have $PH \geq \text{split threshold}$ (grey pixels). Some examples are shown.

Grade 9 Same as Grade 7 except out pixels abutting split pixels must have $PH < \text{split threshold}$.



 Event center.

 $PH \geq \text{sp. th.}$ Added to the sum of PHA.

 $PH \geq \text{sp. th.}$ Not added to the sum of PHA.

 PH value is larger than bordering pixels. Added to the sum of PHA.

 If at least one of these pixels has $PH \geq \text{sp. th.}$, set to Grade 7. Otherwise Grade 9. Not added to the sum of PHA.

Figure 5 (cont'd). Final event grades for Xtend.

2.2 Data Analysis

The hit pattern/grade conversion was tested with flight Suzaku data by converting the event list to Hitomi (ASTRO-H) format, running `sxipi` on the data, and comparing to the Suzaku `xispi` grade assignment, which should be the same. This test has not been repeated for XRISM, since the relevant functional parts of the XRISM Xtend tool `xtdpi` have not changed from the Hitomi SXI tool `sxipi`.

2.3 Results

Since the contents are identical, the contents of the *Hitomi* version of the SXI pattern CALDB file were simply copied to a new XRISM Xtend version, with relevant FITS header keywords updated appropriately for the new mission and instrument name.

2.4 Final Remarks

This is the first release of this XRISM CalDB file. Due to the static nature of ASCA grade definitions, this file is not expected to be updated.