TECHNICAL REPORT

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Title: The Coordinate Systems of NIRISS	Doc #: JWST-STScI-003338, SM-12 Date: April 4, 2014 Rev: A
Authors: André R. Martel Phone: 410 - 338 - 4888	Release Date: 16 April 2014

1 Abstract

The coordinate system of NIRISS as seen on the sky and on the detector is summarized with practical diagrams. These can serve to define the subarrays and the pointing of the OSIM sources in the ISIM-level ground test campaigns as well as to guide the user in the visualization of the images with DS9 and the instrument DHAS.

2 Sky Orientation

The fundamental axes of the coordinate system of the JWST OTE are labeled V1, V2, and V3. The OTE origin (0, 0, 0) is at the vertex of the primary mirror surface. The +V1 axis points outward, toward the secondary mirror while the +V3 axis (vertical) points toward the single SMSS strut (the upper strut). The +V2 axis completes a right-handed system with the V1 and V3 axes. Hence, when representing a view of the sky from the OTE focal plane on a printed page, the +V1 axis goes into the page, the +V3 axis points towards the top of the page, and the +V2 axis points to the left. When looking into the observatory along the –V1 axis, the +V2 axis points to the right (and the +V3 axis remains vertical).

In Figure 1, the on-the-sky projection (at the OTE focal plane) of the NIRISS detector is depicted. The four coronagraphic spots are included since they represent absolute reference points on the detector. In Figure 2, the same diagram is shown but with the superposition of the GR700XD and GR150C/R spectral traces as viewed when NIRISS will be in its final flight hardware configuration. This information was culled from the most recent and useful memoranda and documents, listed in Section 5, as well as from data collected in the CV1RR ground campaign at GSFC in the autumn of 2013. For completeness, the NIRISS field of Figs 1 and 2 is shown with those of the other JWST instruments in Figure 3.

In the FGS-NIRISS FSW, rows are along the slow axis while the columns are along the fast axis. For FGS, these correspond to FSW X and FSW Y, respectively, and are expressed as ideal coordinates in units of arcseconds. However, the FSW does not use the (X, Y) terminology for NIRISS. A pixel location on the detector is addressed as (slow, fast) or (row, column). This is opposite to the usual convention and is often the source of confusion. For the OSS, rows and columns are indexed from 1 to 2048 because Java Script is 1-based. But for internal detector configuration, rows and columns are indexed from 0 to 2047. The slow axis runs from (0, 0) towards (2047, 0) and the fast axis from (0, 0) towards (0, 2047).

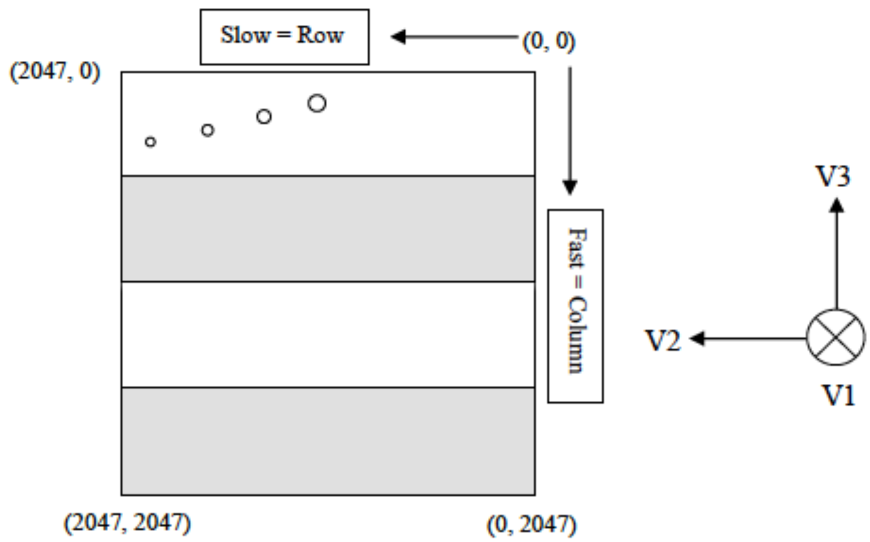

Figure 1: Projection of the NIRISS detector on the sky. The approximate locations of the four coronagraphic spots are shown.

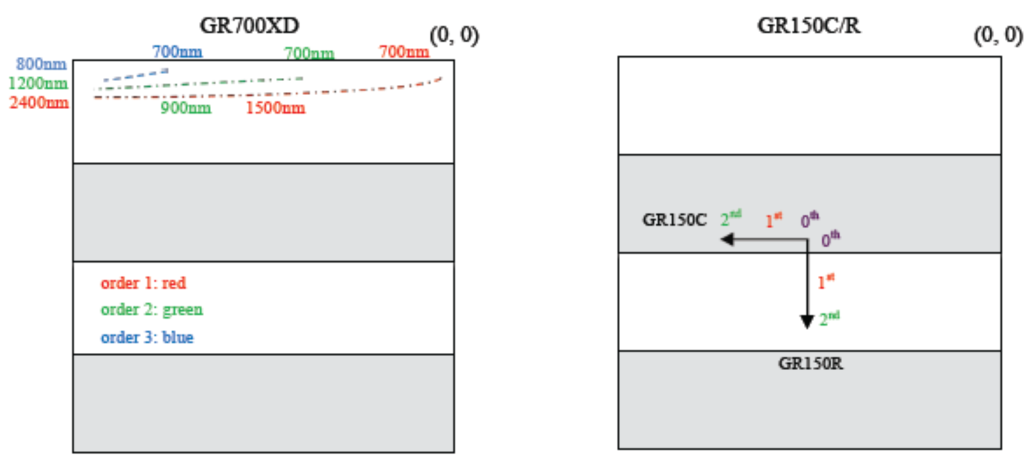

Figure 2: Left: Same as Figure 1 but with the GR700XD grism in the light path. The 0th-order is located outside the FOV of the detector. Right: The GR150C or GR150R grism is in the light path. The exact location, separation, and extent of the GR150C/R traces depend on the choice of blocking filter.

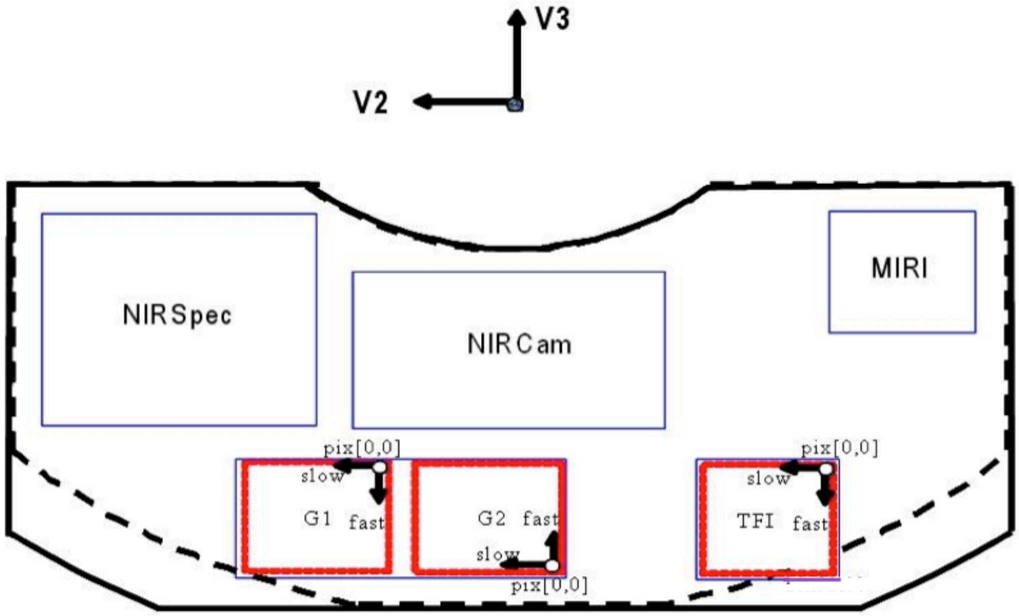

Figure 3: The NIRISS FOV of Figs 1 and 2 is depicted as part of the JWST focal plane, including all the science instruments (note that TFI = NIRISS). See also Figure 1 of Swade (2013).

3 MATLAB/DHAS and DS9 Orientations

In the FGS-NIRISS DHAS, which is based on MATLAB, the origin is in the top-left corner and leads to the orientation shown in Figure 4, obtained by rotating Figure 2 by 90^{o} counter clockwise. The *center* of the top-left pixel (the origin) is (1, 1). The GR700XD traces are located along the left edge of the detector. A location in the FOV is specified as (row, column) = (slow, fast). For example, the large coronagraphic spot is approximately located at (row, column) = (990, 165) and the small spot at (row, column) = (1920, 235).

In Figure 5, the orientation and coordinate system as viewed with the common visualization tool DS9 are shown. The *center* of the bottom-left pixel (the origin) is (1, 1). This view is obtained with a top-bottom flip of the MATLAB orientation of Figure 4 and is equivalent to looking down on the detector along the –V1 axis (flip of the +V2 axis) to preserve the right-hand coordinate system. It places the origin in the bottom-left corner and the fast axis along the horizontal axis. In the DS9 window, the pixel coordinates are labeled X_{image} and Y_{image}, which we label X_{DS9} (fast axis) and Y_{DS9} (slow axis) in the diagram. Traditionally, the columns are defined along the X_{DS9} axis and the rows along the Y_{DS9} axis, e.g., (column, row) = (fast, slow), opposite to the MATLAB convention of (row, column) = (slow, fast).

In DS9, the GR700XD traces are located along the left edge of the detector, with the short wavelength end closest to the (X_{DS9}, Y_{DS9}) = (1, 1) corner and the long wavelength end near the (X_{DS9}, Y_{DS9}) = (1, 2048) corner. The GR150R traces fall along the horizontal fast axis (along the rows) while the GR150C traces are along the vertical slow axis (along the columns). As a reference, the large coronagraphic spot is approximately located at (X_{DS9}, Y_{DS9}) = (165, 990) and the small spot at (X_{DS9}, Y_{DS9}) = (235, 1920).

In general, the DHAS representation and coordinate system are the most "natural" since they avoid the confusion of the additional flip of the DS9 view. It also offers a more direct comparison with the OSIM coordinate system (Section 4).

We note that the Data Management Subsystem (DMS) Science Data Processing (SDP) transforms the detector frame to the science frame as one of the initial steps in the JWST science data processing pipeline (Level-1a FITS files and data products; before the calibration pipeline). For imaging, the science frame X-axis is along the -V2-axis while the Y-axis is aligned with the +V3-axis, e.g., bottom-left corner in Figs 1 and 2. For spectral data, the science X-axis is aligned with the detector dispersion direction and the science frame Y-axis is at a right angle to the X-axis in a right-handed coordinate system (Swade 2013).

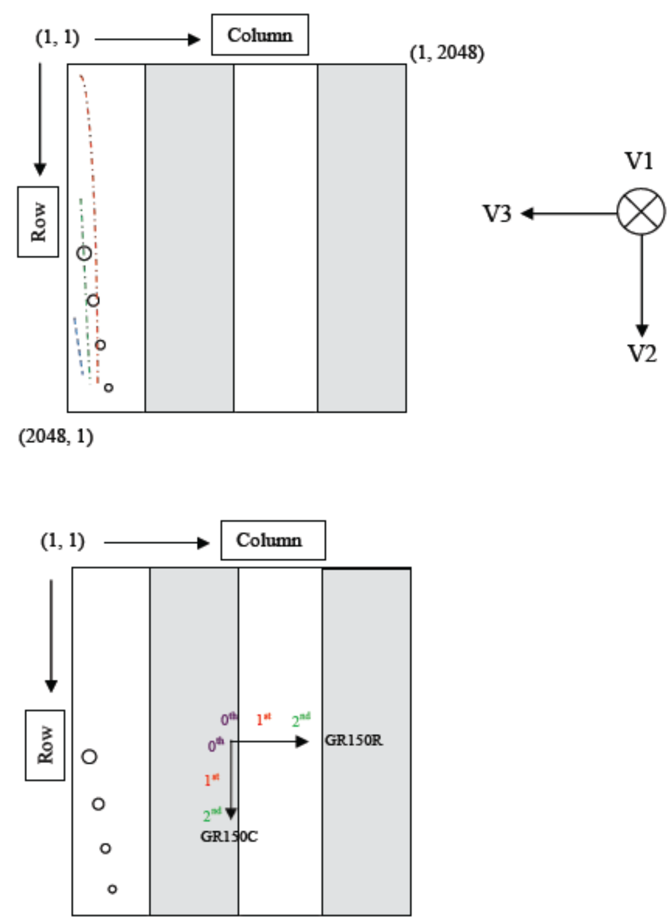

Figure 4: Orientation of the GR700XD traces (top) and GR150C/R traces (bottom) as viewed with the DHAS/MATLAB.

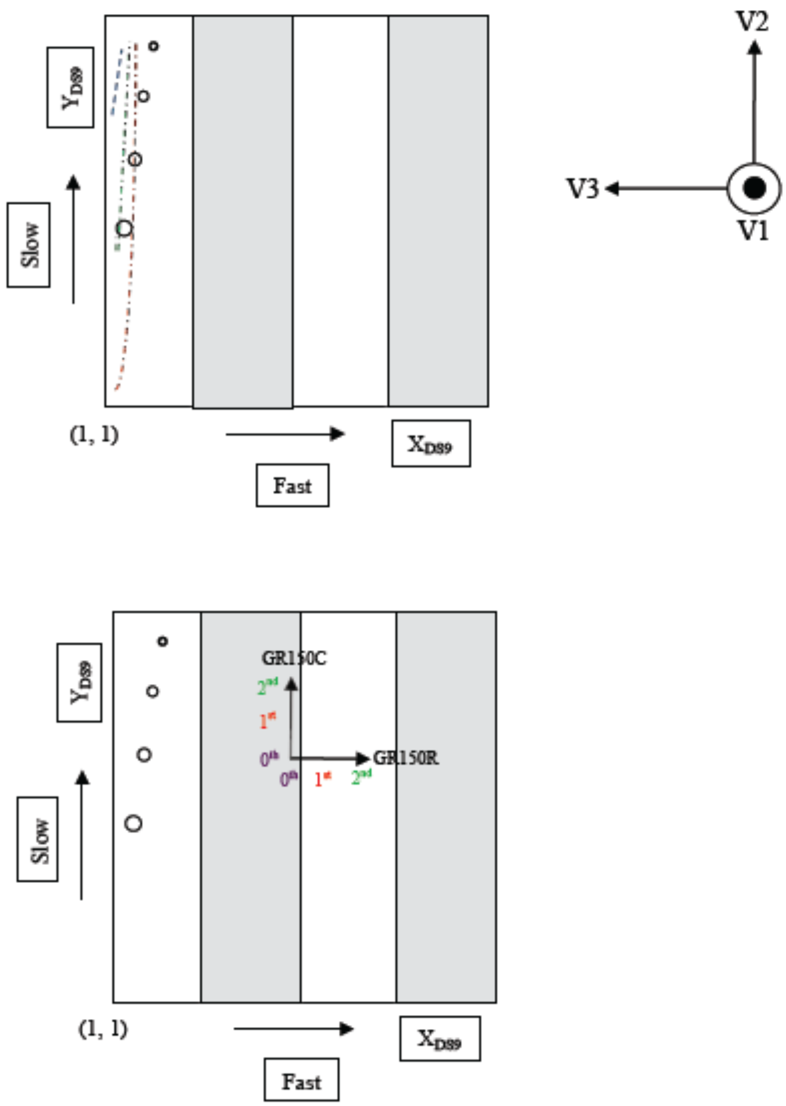

Figure 5: Orientation of the GR700XD traces (top) and GR150C/R traces (bottom) as viewed with DS9. The center of the bottom-left pixel is (1, 1).

4 OSIM Coordinate System

It is easier to visualize the OSIM view by rotating Figure 1 in a counter clockwise direction. This orientation puts X_{AN} and Y_{AN} in a "standard" (and convenient) orientation. This is shown in Figure 6, where we also include the GR700XD and GR150C/R traces.

In the FSW, a subarray is specified with ROWCORNER, COLCORNER, NROWS, and NCOLS. The OSIM state tables make use of the same parameters, also with indices of 1 to 2048.

1. NROWS and NCOLS: dimensions of the subarray along the slow and fast axes, respectively
2. ROWCORNER and COLCORNER: "lower-left" corner of the subarray along the slow and fast axes

The location of an OSIM source on the detector is specified with two other parameters:

1. FieldCoordX and FieldCoordY: location of the OSIM source on the detector in pixels in the TFI_1 or in arcminutes in the OTESKY_AM coordinate systems. The correspondence with the DS9 coordinates is (X_{DS9}, Y_{DS9}) = (FieldCoordY, FieldCoordX). These also correspond to the "raw" coordinates in Swade (2013), e.g., (X_{raw}, Y_{raw}) = (FieldCoordX, FieldCoordY).

To help clarify these coordinates, we list the corner locations as tabulated in Appendix D of Davila et al. (2013). The positions are expressed in pixels in the TFI_1 coordinate system and in arcminutes in the OTESKY_AM system, which is based on the X_{AN} and Y_{AN} coordinates.

X (pixels)	**Y (pixels)**	**X (′)**	**Y (′)**
0	0	-5.9387	2.6956
2047	0	-3.7087	2.7069
0	2047	-5.9608	4.9399
2047	2047	-3.7319	4.9526

For example, to specify the GR700XD large subarray, the state table should show NCOLS = 256, NROWS = 2048 and ROWCORNER = 1, COLCORNER = 1 in the TFI_1 system.

As a reference, the location of the coronagraphic spots in X_{AN} and Y_{AN} coordinates are given in Table 6-12 of Rowlands et al. (2010) and in the memo of Maszkiewicz (3 Apr 2013). We list them in the following table:

Spot	**X_{AN} (′)**	**Y_{AN} (′)**
1 (largest)	-4.8799	2.8919
2	-4.5421	2.9182
3	-4.2044	2.9444
4 (smallest)	-3.8668	2.9706

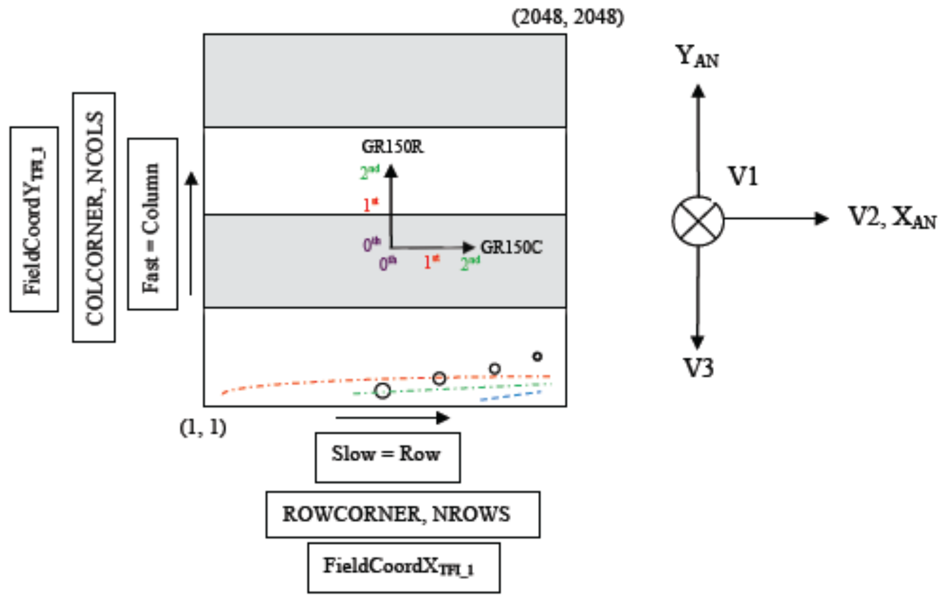

Figure 6: In the FSW and the OSIM state tables, (ROWCORNER, COLCORNER) and (NROWS, NCOLS) define a subarray and ($FieldCoordX_{TFI\_1}$, $FieldCoordY_{TFI\_1}$) point the OSIM source.

5 References

Davila, P. et al. 2013, ISIM-OSIM CryoVac#1 Optical Test Plan, JWST-PLAN-019610 Revision -, 30 Sep 2013

Martel, A.R. 2011, First Detection of the TFI Coronagraphic Occulters in Cryogenic Ground Tests, JWST-STScI-002413 (Baltimore: STScI)

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Rowlands, N., et al. 2010, JWST FGS Coordinate System Technical Note, TNO/CSA/51221/029 Rev P1

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