NIRSpec Traditional Detector Readout Mode

The JWST NIRSpec traditional readout mode is the same one used for the near-infrared detectors in NIRCam and NIRISS. Two readout patterns are available for NIRSpec traditional readout mode science observations. Two additional patterns were added for target acquisition.

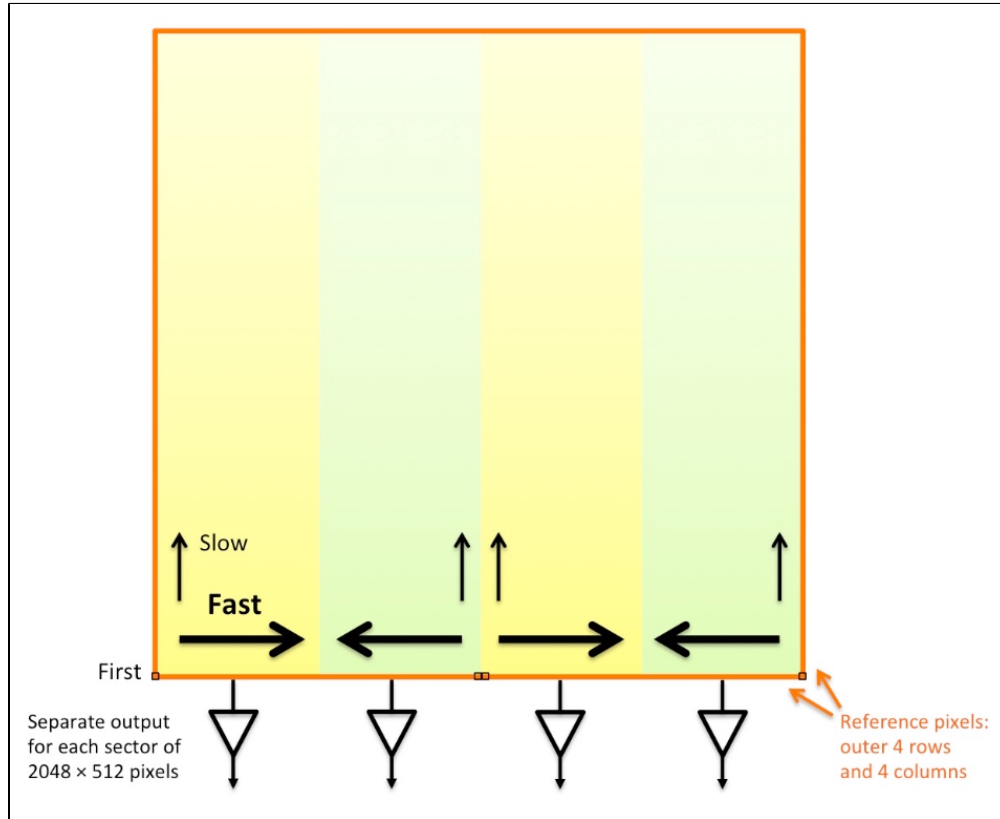## NIRSpec "traditional" readout patterns for science

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The NIRSpec "traditional" detector readout mode is the same as that used by the JWST NIRCam and NIRISS instruments.

Readout of a full NIRSpec detector (2048 × 2048 pixels) in the traditional mode is performed with four outputs simultaneously ($N_{outputs}$ = 4, see Figure 1). Each of the four outputs delivers a stripe of data (2048 pixel rows × 512 pixel columns), and the full readout takes 10.73677s. The orange border shown in Figure 1 represents the reference pixels, which are 4 pixels across (not to scale) and insensitive to light. During these readouts, each row is read one pixel at a time, beginning with the pixels along the bottom marked with small open black squares in Figure 1. Arrows show the default scan directions; pixels are read in fast scan and then slow scan directions. Readout of a subarray is done using just a single output. The readout time of a subarray is dependent on its size.

The other NIRSpec readout mode, IRS[2], will deliver enhanced noise performance and is recommended above the traditional readout patterns for all science cases that are not in danger of saturating.

Figure 1. NIRSpec 2048 × 2048 traditional detector readout

Slow

Fast

First

Separate output
for each sector of
2048 × 512 pixels

Reference pixels:
outer 4 rows
and 4 columns

A summary of the traditional readout of JWST near-infrared detectors. The yellow and green regions each designate one of the four detector channel outputs. The detectors are rimmed by 4 light-insensitive reference pixels. The 10 µsec pixel readouts progress from fast through slow scan directions for each output. The readout of a full NIRSpec detector takes 10.73677 s.

The NIRSpec traditional readout patterns are **NRS**[1] and **NRSRAPID**, which are summarized in Table 1 and presented in Figure 2. The **NRSRAPID** readout pattern saves each frame as a group, so the integration ramps are sampled every 10.737 s. The NRS readout pattern averages four frames into a group onboard the spacecraft, saving one group every 42.947 s in a ramp. In practice, using the **NRSRAPID** readout pattern with frequent recording of data groups is preferable and encouraged for all science use cases with no data volume limitations (the JWST Astronomer's Proposal Tool (APT) will warn users if data volume is an issue for an observing program). Two additional patterns are offered for MSA standard target acquisition (MSATA) called **NRSRAPIDD1** and **NRSRAPIDD2.** These patterns are used to extend the duration of the TA exposures to reach fainter magnitude reference stars.
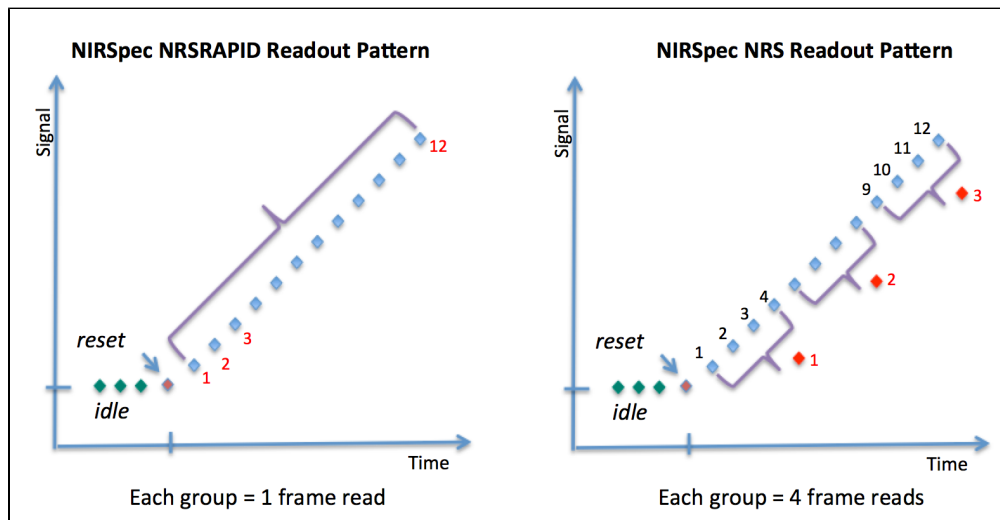
Table 1. NIRSpec traditional readout patterns

Detector readout type	NIRSpec readout pattern names	N_{frames} per group	Group time (s)	Measured total noise in 1,000 s (e⁻)	
				Detector NRS1	Detector NRS2
Traditional	*NRSRAPID*	1	10.737	5.55 [†]	6.46 [†]
	NRS	4	42.947		
	NRSRAPIDD1[††]	1	21.474		
	NRSRAPIDD2[††]	1	32.210		

[†] Detector noise was measured during ground tests by investigating ~945 s (88 group) *NRSRAPID* dark exposures. Values reported are documented in ESA-JWST-SCI-NRS-RP-2017-003.

[††] *NRSRAPIDD1* and *NRSRAPIDD2* are used exclusively for MSATA target acquisition.

Figure 2. Up-the-ramp presentation of the *NRSRAPID* and *NRS* readout patterns

The NRSRAPID (left) and NRS (right) traditional readout patterns. As in all JWST detector readouts, each blue diamond presented in these graphs represents one 2048 × 2048 pixel MULTIACCUM frame in the 3-D data cube. For the NRSRAPID readout pattern, the blue diamond is also the group that is saved, where frames = groups = 1. In the NRS readout pattern, four frames are averaged into a single saved group, shown as the red diamond.

[1] **Bold italics** font style is used to indicate parameters, parameter values, and/or special requirements that are set in the APT GUI.