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DOCUMENT

NIRSpec Gain and Readnoise Reference Files for Build 7

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DISTRIBUTION

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Table of Contents

1 INTRODUCTION

In this report we describe the generation of the reference files for the pixel-to-pixel gain map and the readnoise map for the NIRSpec Focal Plane Array (FPA) The report is an update of a previous document (Sirianni et al 2014) issued for a former FPA. We will refer to that document often since it describes in great detail the same methodology used to build the maps for current FPA.

The flight NIRSpec FPA, serial number 106 (hereafter referred as FPA106), consists of two Sensor Chip Assemblies (SCAs) controlled by two ASIC SIDECAR. Table 1 lists the serial number of the SCAs and ASICs in the two separate channels of FPA106. In the following sections we will use 491 and 492 to indicate the SCAs.

	Channel 1 (**491**)	Channel 2 (**492**)
SCA S/N	17163	17280
SIDECAR ASIC S/N	252	244

Table 1-1. Component of FPA106 and paired ASIC controllers.

The characterization of FPA106 at NASA Detector Characterization Laboratory (DCL) occurred between May and September 2014. The entire set of data and the overall characterization results are reported in Lindler (2015).

2 GAIN MAPS

Following Sirianni et al (2014) the gain maps are created from two components:

- a pixel to pixel map
- average gain used for normalization of the map.

2.1 Pixel-to-pixel map

Pixel-to-pixel gain maps have been derived from dedicated test data acquired during the FPA106 characterization campaign at GSFC/DCL in 2014 with the FPA at the operating temperature of 38.5K. The acquisition of the data, 12088 exposures in total, were spread out over different periods. Table 2-1 lists the common exposure name root OBSID and the period of acquisition.

Date	**Exposure OBSID root**
May 31-Jun 3 2014	A_38_PPGain
Aug 29-Sep 3 2014	P2PGAIN
Sep 9-16 2014	P2PGAIN

Table 2-1 roots of the OBSID and time of acquisition of the pixel-to-pixel exposures.

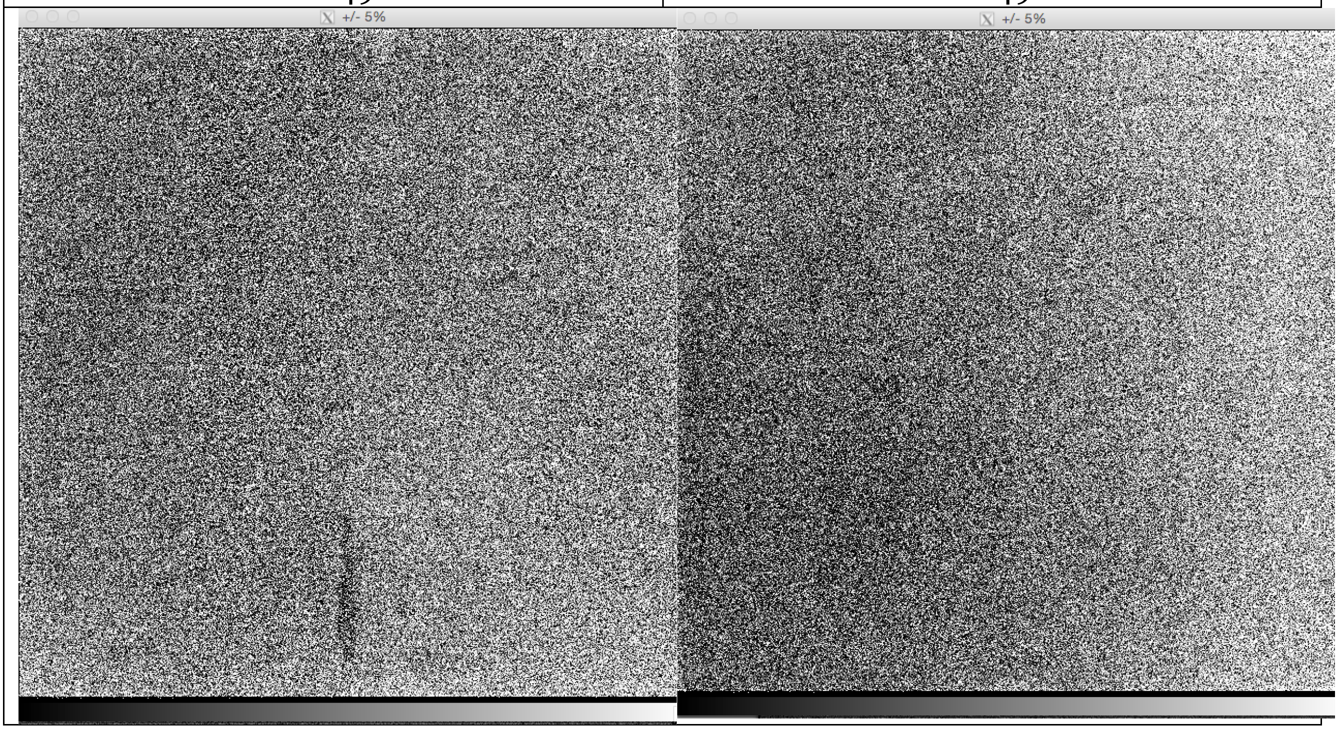
As detailed in Sirianni et al. (2014) the gain of each pixel is calculated with the photon transfer test with the average signal and variance calculated temporally over many exposures.

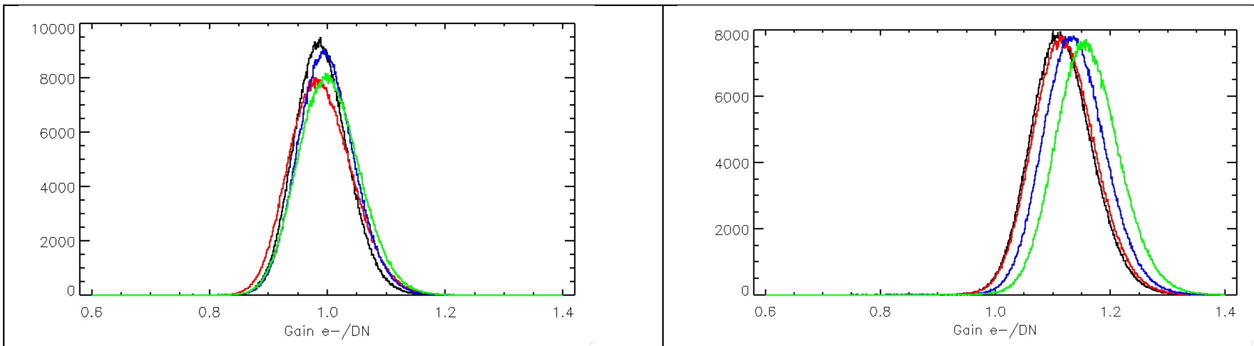
Two IDL scripts have been written to search, sort, process, and combine the more than 12000 exposures into the two pixel-to-pixel gain maps. The two scripts, named `P2PGain_Part1.pro` and `P2PGain_Part2.pro` can be found in the ESA JWST SVN repository in JWST_IDL/lib/nirspec/Reference_Files/GAIN/. Due to its size the list of exposures are not listed in this document but they are available in the SNV repository.

The output of these two procedures consists of two pixel-to-pixel gain maps already corrected for interpixel capacitance (IPC) effect using the correlation coefficient alpha from Lindler (2014).

Figure 2-1 shows the pixel-to-pixel maps, scaled to +/- 5% of the mean value, this distribution and statistics per output for both SCAs. In the case of SCA491 the distribution is very uniform with a small (2-3%) reduction in gain in the area of the epoxy void in the bottom part of the array. SCA492 shows instead a variation of ~5% across the field.

SCA491	SCA492





Output	Mean Gain	Stdev
1 (Black)	0.989	0.040
2 (Red)	0.989	0.044
3 (Blue)	0.998	0.043
4 (Green)	1.002	0.045

Output	Mean Gain	Stdev
1 (Black)	1.115	0.048
2 (Red)	1.119	0.050
3 (Blue)	1.137	0.050
4 (Green)	1.160	0.052

Figure 2-1 Map, histogram and statistics for the pixel-to-pixel maps for FPA106.

2.2 Average gain and renormalization

After the installation of the focal plane in the instrument new gain maps cannot be obtained anymore. The global gain can still be measured at instrument level by producing a fairly uniform illumination with a dedicated MSA configuration file and the internal lamps. A verification of the global gain is planned during OTIS testing and commissioning. If necessary, the gain maps can be renormalized to a new global gain value. With the final step described in Section 2.3 the gain maps have been renormalized to the average gain listed in Table 2-2.

Table 2-2 Adopted Average Gain for the two SCAs of FPA106 (Lindler 2014)

SCA	Gain (e/DN)
491	0.998
492	1.138

2.3 Reference files

The structure and format of the reference files matches the instructions provided in the confluence page “JWST Calibration Reference Files: File Format for Build 6 Pipeline”, with one important exception: the orientation of the images is in the native detector readout orientation, in order to be compatible with the ESA NIRSpec pipeline. Keywords that indicate the orientation (FASTAXIS and SLOWAXIS) are populated accordingly, so DMS can handle the reference file as needed.

The IDL script `P2PGain_Part3.pro` normalizes the gain maps created in Section 2.1 and create the reference files by calling create`_gain_stsci.pro` also present in the ESA NIRSpec SVN repository.

Figure 2-2 shows the structure of the gain map reference file for one SCA.

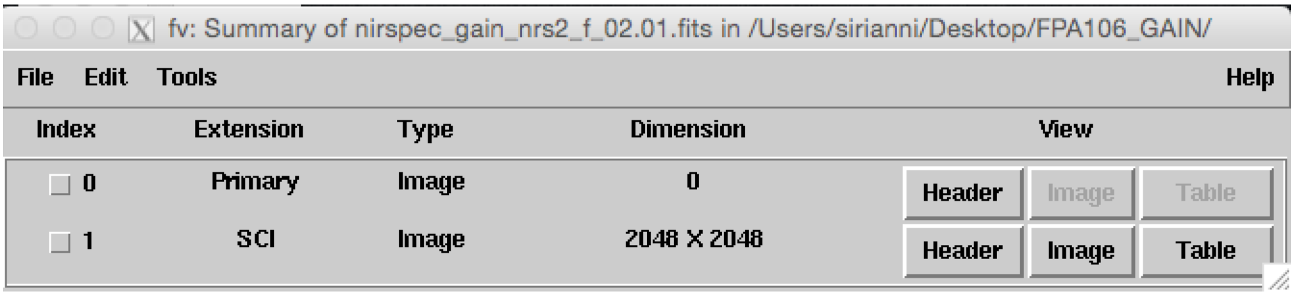


Figure 2-2. Structure of the gain map reference files

Table 2-3 lists the names of the two reference files delivered for Build 7.

Table 2-3 Delivered reference files

NAME	USE-AFTER
nirspec_gain_nrs1_f_02.01.fits	2015-01-01
nirspec_gain_nrs2_f_02.01.fits	2015-01-01

These reference files should be used for all NIRSpec data, regardless of the readout mode (traditional vs IRS2, full frame vs subarray) and temperature (38.5 or 42.8 K).

IMPORTANT NOTE: with the upcoming version of the ASIC microcode 10.1 it will be possible to select a different gain for the SIDECAR A2D conversion step for subarray exposures. For exposures of bright sources, normally done in subarray mode, a different gain conversion factor will allow us to sample the entire physical full well and therefore increase the dynamic range of the exposure. The new gain setting, already tested during the DCL testing will be approximately 2e-/DN. No changes are expected in the relative pixel-to-pixel distribution but rather a change in the global gain. After OTIS testing the ESA SOT will deliver a new set of gain reference files just for subarray exposures.

3 READNOISE MAPS

In previous deliveries the readnoise map reference files contained the correlated double sampling (CDS) noise averaged spatially for each readout output in a SCA. Using data acquired during the ISIM CV3 cryo test we have produced pixel based CDS noise maps from data acquired the with the flight detector system and flight detector electronics. Noise proprieties depend on the readout scheme, so in the case of these readnoise maps we created two different sets of reference files for the traditional and the IRS2 readout.

3.1 CDS noise maps

In order to generate the CDS maps we used dark current exposures acquired during CV3 at the FPA operating temperature of 42.8K. Data acquired at different temperature is available from previous detector level testing.

Table 3-1 List of NID[1]s for the dark exposures used for the CDS noise maps

Readout	List of NIDs
Traditional	29848,29849,29851,29852,29862,29863,30409,30410,30411,30413,30414,30415,30416,30417,30418,30419,30421,30422,30423,30424,3042,30426,30427,30429,30430, 30431,30432,30433,30434,30435,30441
IRS2	29895,29898,29900,29903,29907,29910,29913,29914,29916,29918,29922,29925,29929,29933,29935,29937,29939,29942,29946,29949,29954,29955,29958,29960,29967

In the case of traditional readout the exposures have 10 groups each, while for the IRS^2 readout the exposures have 65 groups. In both cases each group contains one single frame.

We processed all the exposures with the IDL script `CDSnoiseMAP_Part1_process.pro` available in the ESA NIRSpec SVN repository. The ESA NIRSpec pipeline was used to perform the basic reference pixel correction to all frames in each of the exposures. In the case of IRS^2 exposures the correction does correct for both reference output and interleaved reference pixels (Rauscher 2014).

For each reference pixel subtracted cube of n-slices we produced a CDS cube of n-1 slices obtained from the difference of the contiguous groups. The scrip also produces detailed graphic reports (see examples in the Appendix), which are used to detect any anomaly with the exposure.

All CDS frames in all cubes are then combined with the IDL script `CDSnoiseMAP_Part2_combine.pro` to produce the final CDS average maps and the CDS noise map. Figure 3-1 and Figure 3-2 display the map of the average CDS frame and CDS noise map for both SCA in the case of traditional and IRS2 readout respectively. Figure 3-3 shosw the distribution of the pixel-to-pixel CDS noise for the two readout modes.

[1] NID – Nirspec ID is the reference number used in the ESA NIRSpec ground data acquisition system and database

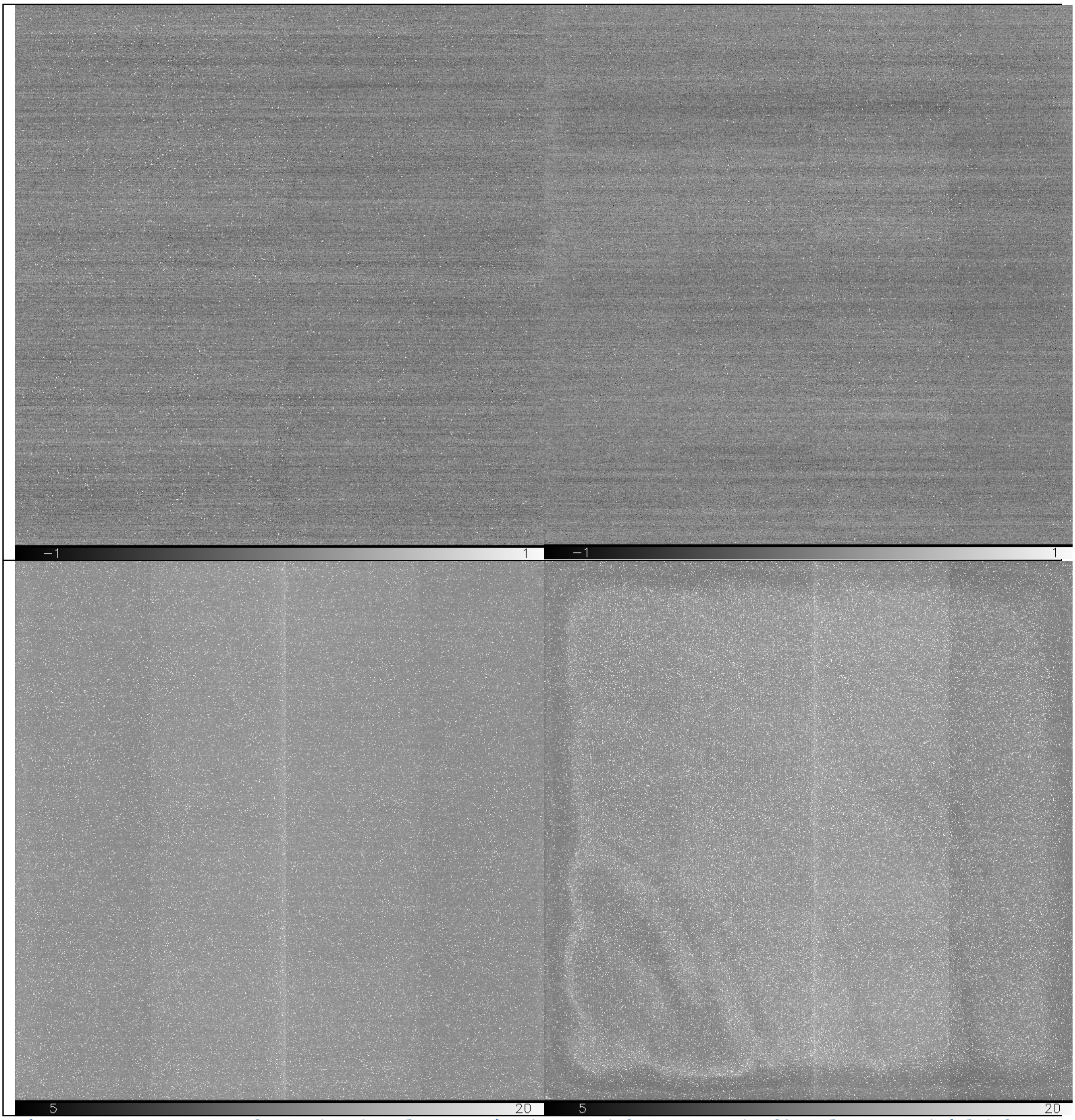


Figure 3-1 Average CDS frame (Top) and CDS Noise (Bottom) for SCA491 (Left) and SCA492 (Right) for traditional readout

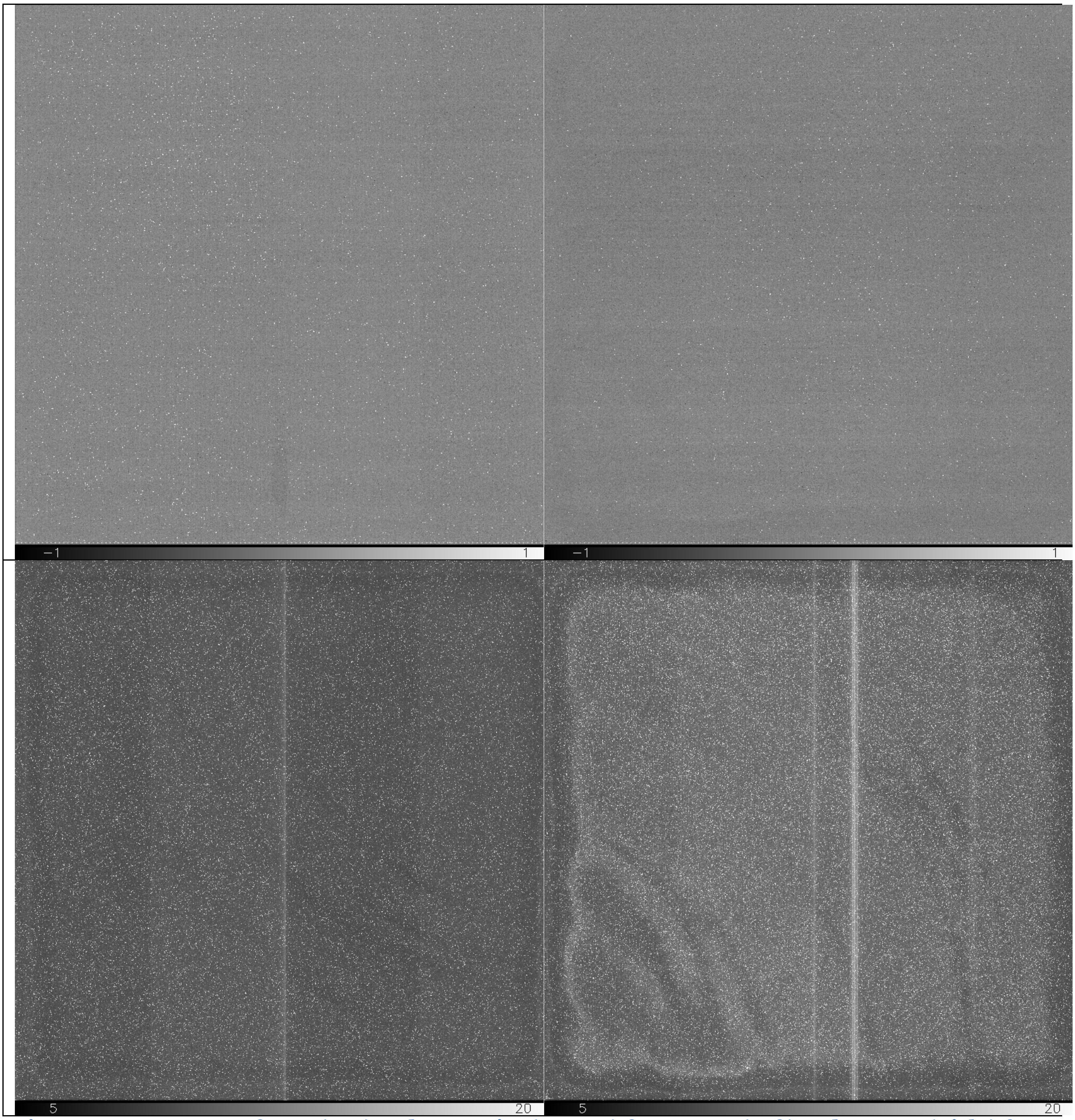


Figure 3-2 Average CDS frame (Top) and CDS Noise (Bottom) for SCA491 (Left) and SCA492 (Right) for IRS2 readout

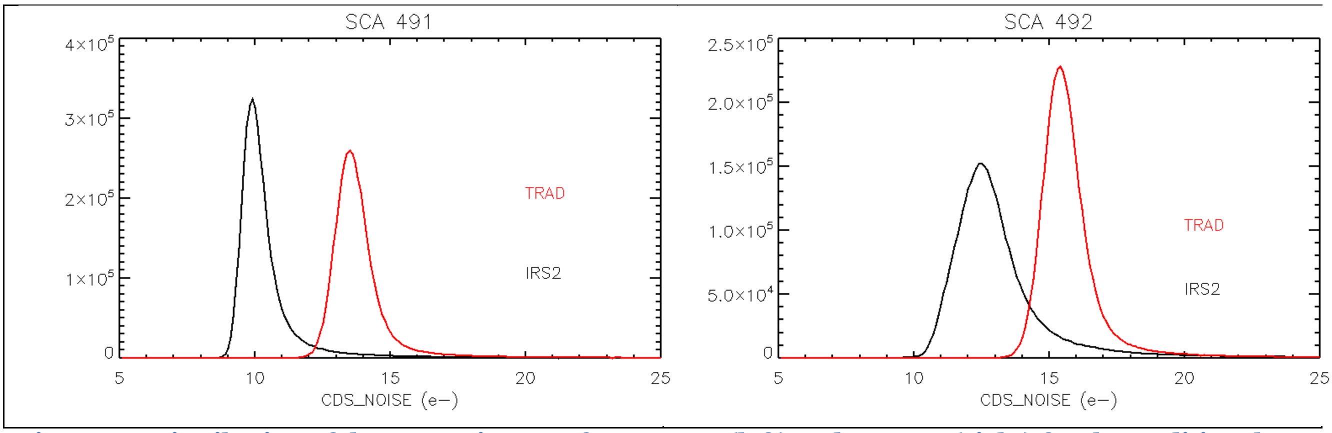


Figure 3-3 Distribution of the CDS noise map for SCA491 (left) and SCA492 (right) for the traditional readout (Red curve) and IRS2 readout (black).

3.2 Reference files

The structure and format of the files matches the instructions provided in the the confluence page “JWST Calibration Reference Files: File Format for Build 6 Pipeline”, with one important exception: the orientation of the images is in the native readout orientation, in order to be compatible with the ESA NIRSpec pipeline. Keywords that indicate the orientation (FASTAXIS and SLOWAXIS) are populated accordingly, so DMS can handle the reference file as needed.

The final IDL script `CDSnoiseMAP_Part3_create_ref_file.pro` multiplies each map by the appropriate e-/DN gain and then creates the final reference file structure shown in Figure 3-4.

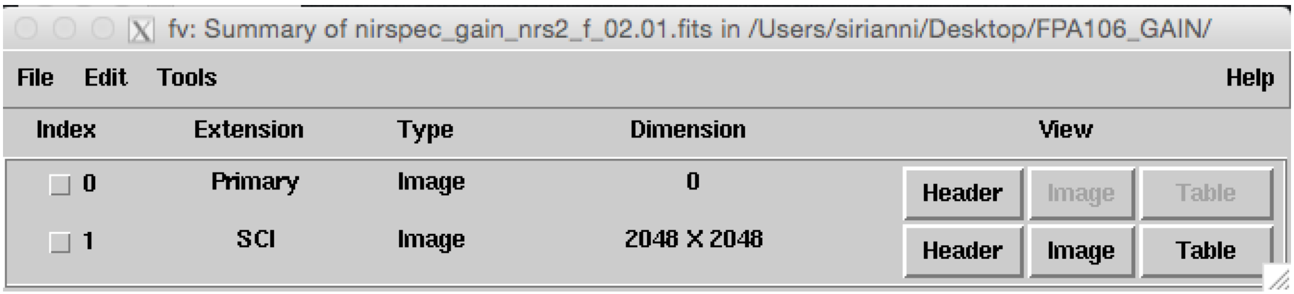


Figure 3-4. Structure of the CDS noise map a.k.a readnoise reference files.

Table 3-2 lists the names of the four reference files delivered for Build 7.

Table 3-2 Delivered reference files

Filename for IRS2 readout	Filename for traditional readout	USE-AFTER
nirspec_rnoise_nrs1_i_01.00.fits	nirspec_rnoise_nrs1_f_01.00.fits	2015-01-01
nirspec_rnoise_nrs2_i_01.00.fits	nirspec_rnoise_nrs2_f_01.00.fits	2015-01-01

4 REFERENCES

Rauscher, B. J. 2014, Algorithm for Processing IRS2 Data, Tech. Rep. JWST-ARTL-025437 Rev A, NASA

Lindler, D. 2015 NIRSpec DS Focal Plane Assembly S/N 106 Characterization with SCAs 17163 and 17280 JWST-RPT-025384

Sirianni, M., S. Birkmann, 2014,FPA104 Gain and Readnoise Maps, ESA-JWST-TN-20073/NTN-2013-005 Rev 2. 04, ESA

5 APPENDIX– EXAMPLE OF CDS REPORTS

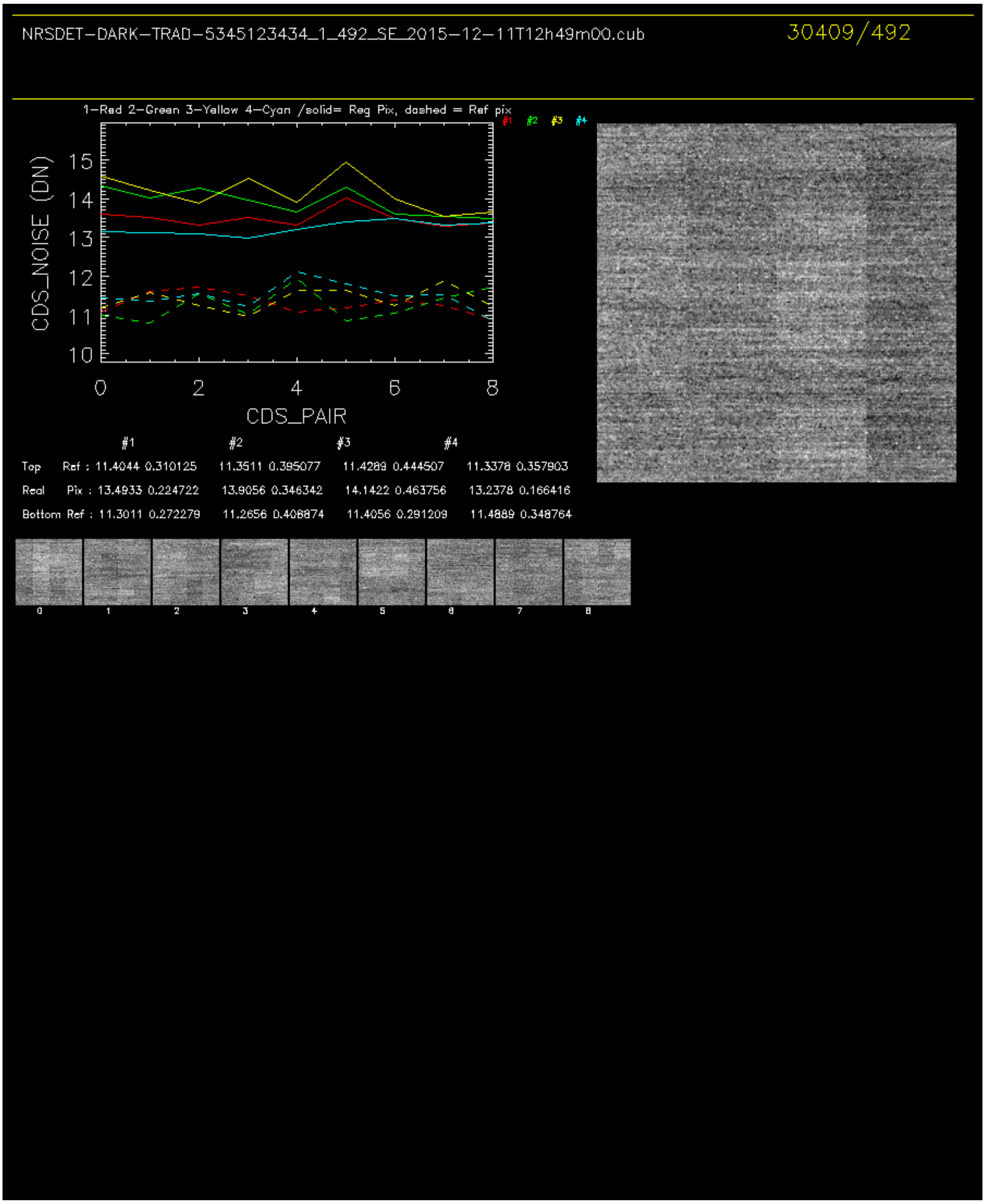


Figure 5-1 Example of CDS report for traditional readout

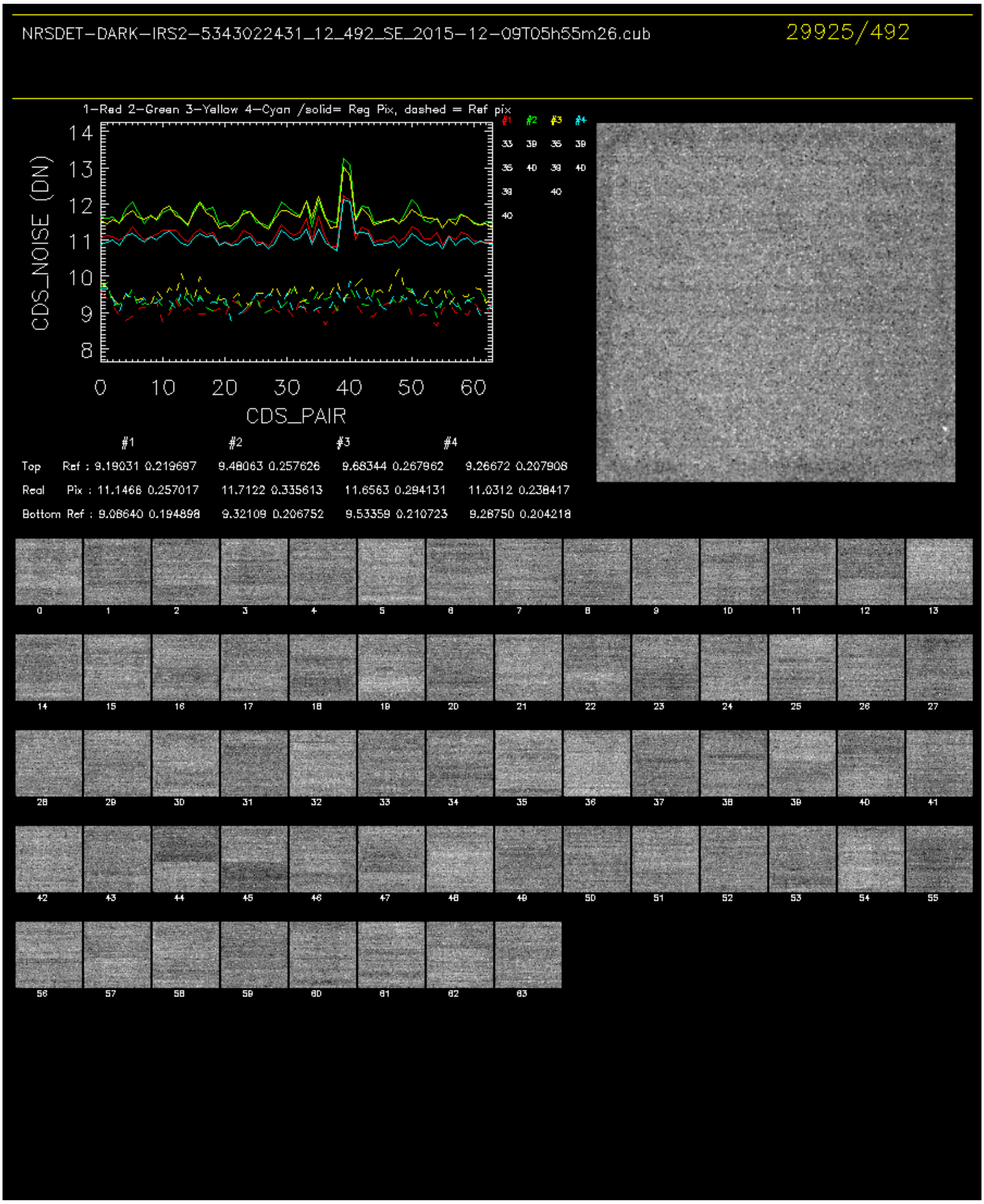


Figure 5-2 Example of CDS report for IRS2 readout