estec

European Space Research
and Technology Centre
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands
Tel. (31) 71 5656565
Fax (31) 71 5656040
www.esa.int

NIRSpec Technical Note
NTN-2013-010/
ESA-JWST-TN-20075

Authors: G. Giardino & M. Sirianni
Date of Issue: November 18, 2014
Version: 2.0

NIRSpec Mask reference file for FPA104

Abstract:

This document provides an overview of the structure and content of the NIRSpec reference files of type 'mask' for FPA104 that are used by the data processing pipeline to flag static bad pixels.

Change Log:

Version	Date	Description
1.0	Oct. 31, 2013	Initial version for Build 2 of STScI pipeline
2.0	Nov. 18, 2014	Updated to reflect changes in reference files for Build 3 pipeline

1 INTRODUCTION

When processing NIRSpec raw up-the-ramp data to derive count rate images, a process often referred to as 'ramps to slopes', the STScI processing pipeline requires pixels that are defective or inoperable to be identified. A number of such unusable or only partially usable pixels are produced during the manufacturing process and are known to be stable.
This document describes the reference 'static bad pixel mask' that identifies these static detector cosmetic defects. Following NIRSpec reference file naming convention [1], these files are of type 'mask'. Specifically, here we provide detail on the file format and data contents of files:

- `nirspec_mask_nrs1_f_01.01.fits`
- `nirspec_mask_nrs2_f_01.01.fits`

These files are being delivered by the ESA SOT team to STScI.

European Space Agency
Agence spatiale européenne

2 REFERENCE FILE FORMAT

Reference files are in FITS format. Each reference file has an empty primary data array, with the primary header containing all the necessary keywords specified in [1] and [2]. For these mask files, the REFTYPE keyword has the value MASK. The mask reference files have only one image extension named BAD PIXEL REFERENCE MASK and the image has dimensions 2048×2048.
In this mask file we identify so called open pixels, pixels adjacent to open pixels, dead pixels and pixels with low quantum efficiency (QE) — see [1] and [3] for a definition of these defective pixels. The flag value of each pixel is encoded using a 16-bit number as specified in Table 1. The bit-encoding definition are also specified in the reference file itself using the Binary Table extension DQ_DEF.

Table 1: Bit-encoded flag values in the mask reference file

Bit-encoding	Value	Name	Description
0000 0000 0000 0000	0	-	OK
0000 0000 0000 0001	1	DO_NOT_USE	Do not use
0000 0000 0000 0010	2	OPEN	Open
0000 0000 0000 0100	4	ADJ_OPEN	Adjacent to open
0000 0000 0000 1000	8	DEAD	Dead
0000 0000 0001 0000	16	LOW_QE	Low QE

The reference mask files for SCA491 and SCA492 are generated by the Python script `generateIMask.py`. This requires, as input, a mask binary file for each type of defective pixels (where a value of one identifies defective pixels); the script then combines these binary masks into the reference bad pixel mask, by computing the total flag value of each pixel according to his quality in the individual input masks — which is equivalent to combing the binary flag values of Table 1 with a bit-wise 'or' operation.
The data processing approach used to generate the individual input masks are described in the following section.

3 DATA AND ALGORITHM FOR THE IDENTIFICATION OF BAD PIXELS

3.1 Data and processing

Detector cosmetic defects are easily identifiable under flat field illumination. In April 2010 during the characterization of the FPA104 at GSFC/DCL each set of monochromatic flat field exposures acquired for the Relative Quantum Efficiency test was interleaved with a set of three background exposures. Each background exposure consists of a single up-the-ramp integration with five groups of one frame each. In total 57 background exposures were acquired. The full list the exposures is available in Appendix-1. The operating temperature of the detector was 38.5 K.

Each background exposure was processed with the raw data pipeline version 0.27 [4] to derive a count rate map. The mean background count rate and standard deviation over the full set of 57 background exposures is listed in Table 2 for each output of each SCA. No significant variations of background level were seen in the data acquired over a period of approximately eight hours.

For each SCA a high signal-to-noise background map was created as the median of all background count rate maps (Fig. 1).

Table 2. Mean background level (e-/sec) and standard deviation over the 57 exposures

	SCA 491		SCA 492	
	Mean	Stdev	Mean	Stdev
OUTPUT -1	89.02	0.52	91.29	0.52
OUTPUT -2	86.25	0.49	92.67	0.53
OUTPUT -3	82.08	0.47	91.37	0.52
OUTPUT -4	75.67	0.43	86.76	0.49

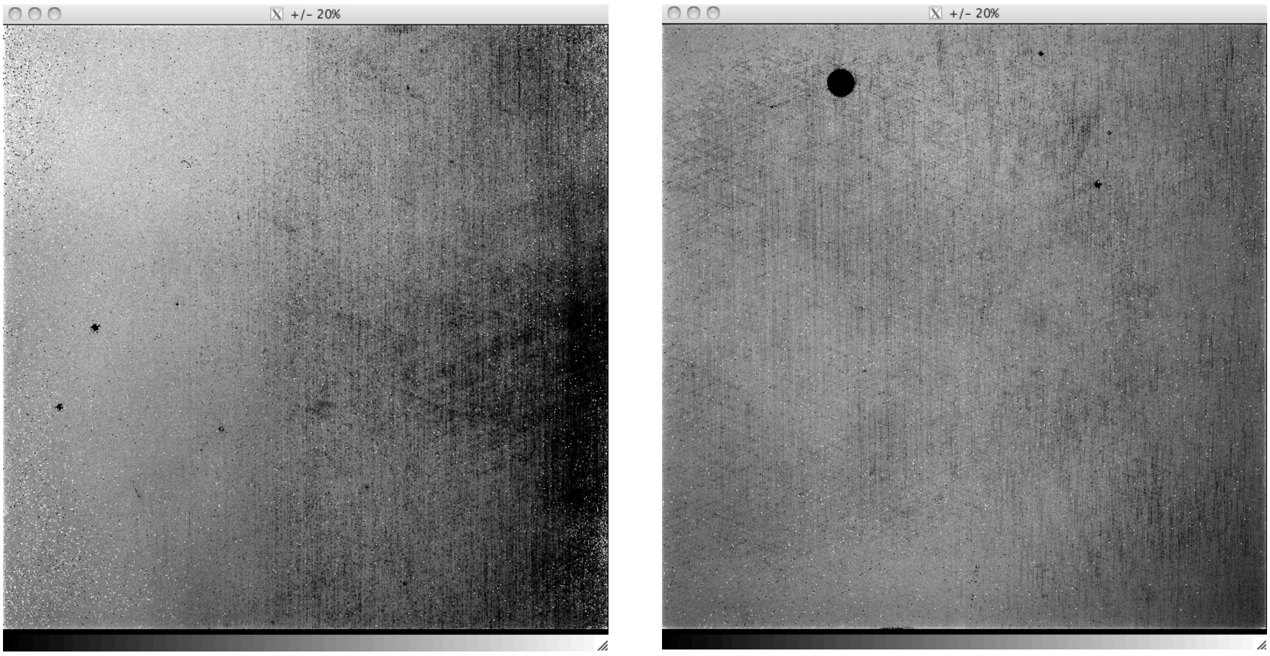

Fig. 1 Median background count rate map for SCA491 (on the left) and SCA492(on the right). These maps were used for the identification of the bad pixels.

3.2 Identification of bad pixels

The two count rate maps shown in Fig. 1 were used to derive four static bad pixel masks (one for each type of inoperable pixel) with the IDL procedure `create_BPIX_mask.pro`. These four masks are the input for the creation of the delivered reference file.

The IDL procedure script first removes the large-scale structures by dividing the input image by a smoothed version of itself. This normalised image provides a map of pixel-to-pixel variations of the local QE and is then used to identify bad pixels according to the criteria specified in the following tables:

Table 3 - Criteria used for bad pixels identification

Bad pixel Type	**Criteria**
Shorted – Dead Pixels	Normalized count rate ≤ Min LowQE
Open Pixels	Min LowQE < normalized count rate < Max LowQE **and** Median countrate of the closest 4 pixels > SigExcess
Low QE Pixels	Min LowQE < normalized count rate < Max LowQE that are

	not open pixels
Pixels around open pixels	The 8 pixels surrounding an open pixel

The three thresholds used in the criteria listed above have been selected after analysing the properties of five NIRSpec SCA and are listed in Table 4. The thresholds are also shown in Fig. 2 superimposed to the distribution of normalized count rates for SCA491.

Table 4 - Threshold used in the identification of the bad pixels

Threshold name	Value	Description
Min LowQE	0.05	Lower boundary for normalized count rate
Max LowQE	0.5	Upper boundary for normalized count rate
SigExcess	1.05	Excess of signal in pixels surrounding open pixels

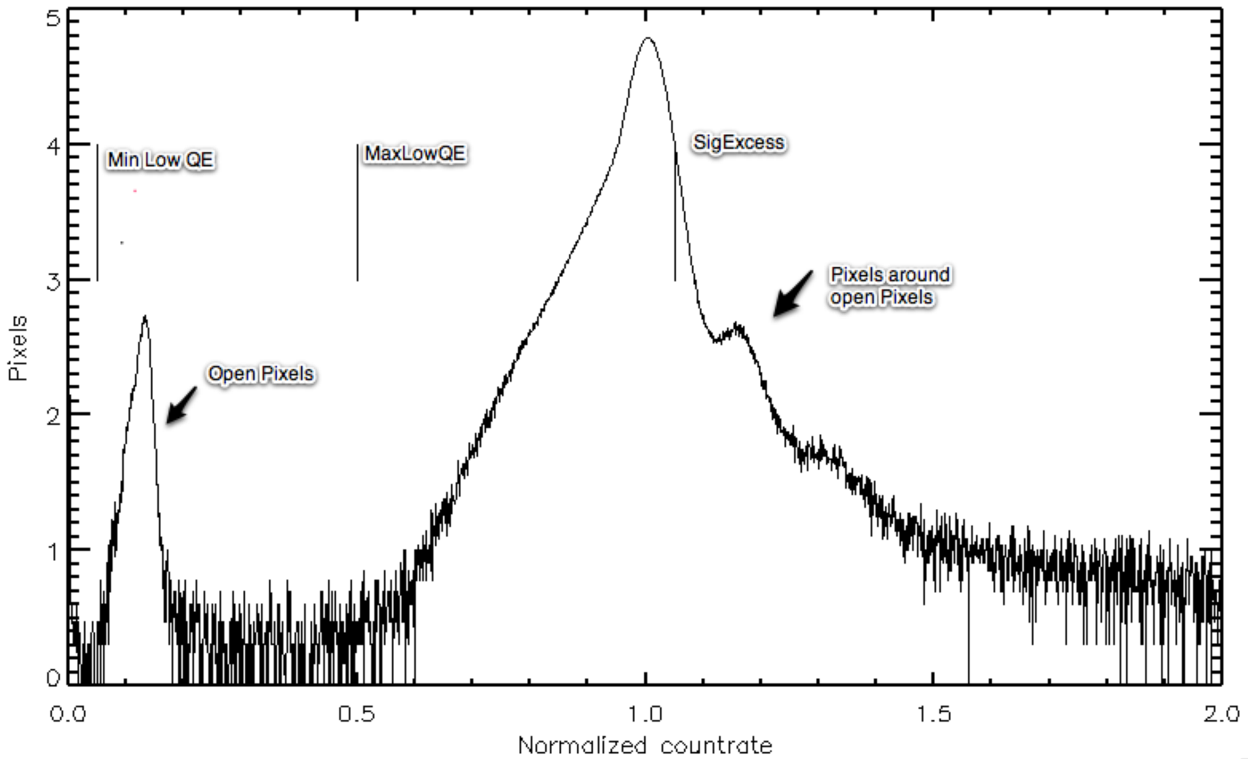

Fig. 2 Histogram of the distribution of the normalized count rate map for SCA491 with over imposed the three threshold used for discriminate the bad pixels and the population of open pixels and pixels around open pixels (y-axis scale is logarithmic).

4 REFERENCES

[1]. Giardino, G. 2013, NIRSpec reference data product specification, NIRSpec Technical Note NTN-2012-007, ESA/ESTEC, http://www.cosmos.esa.int/web/jwst/technical-notes

[2]. STSci, 2014, JWST Calibration Reference Files: File Formats for the Build 3 Pipeline, Sep 04, 2014 https://confluence.stsci.edu/display/JWSTPWG/JWST+Calibration+Reference+Files%3A+File+Formats+for+the+Build+3+Pipeline /, Space Telescope Sci- ence Institute

[3]. Sirianni, M. 2013, NPR-2013-005 Average Responsive Quantum Efficiency and average distribution of bad pixels in NIRSpec SCAs. http://www.cosmos.esa.int/web/jwst/performance-reports

[4]. Stephan, B. 2011, Description of the NIRSpec pre-processing pipeline, NIRSpec Technical Note NTN-2011-005 , http://www.cosmos.esa.int/web/jwst/technical-notes

5 APPENDIX -1

List of background exposures used to create the median countrate map used to identify the bad pixels:

NRS_A_38_5_QE_BG_600nm_01_1_6617_JW1_jlab81_20100402T114504_20100402T114625
NRS_A_38_5_QE_BG_600nm_01_2_6618_JW1_jlab81_20100402T114634_20100402T114751
NRS_A_38_5_QE_BG_600nm_01_3_6619_JW1_jlab81_20100402T114759_20100402T114915
NRS_A_38_5_QE_BG_600_02_1_6620_JW1_jlab81_20100402T115402_20100402T115521
NRS_A_38_5_QE_BG_600_02_2_6621_JW1_jlab81_20100402T115530_20100402T115647
NRS_A_38_5_QE_BG_600_02_3_6622_JW1_jlab81_20100402T115655_20100402T115813
NRS_A_38_5_QE_BG_600_03_1_6626_JW1_jlab81_20100402T121100_20100402T121221
NRS_A_38_5_QE_BG_600_03_2_6627_JW1_jlab81_20100402T121229_20100402T121345
NRS_A_38_5_QE_BG_600_03_3_6628_JW1_jlab81_20100402T121354_20100402T121511
NRS_A_38_5_QE_BG_700_01_1_6629_JW1_jlab81_20100402T122546_20100402T122707
NRS_A_38_5_QE_BG_700_01_2_6630_JW1_jlab81_20100402T122716_20100402T122833
NRS_A_38_5_QE_BG_700_01_3_6631_JW1_jlab81_20100402T122842_20100402T122959
NRS_A_38_5_QE_BG_800_01_1_6635_JW1_jlab81_20100402T124808_20100402T124927
NRS_A_38_5_QE_BG_800_01_2_6636_JW1_jlab81_20100402T124936_20100402T125053
NRS_A_38_5_QE_BG_800_01_3_6637_JW1_jlab81_20100402T125103_20100402T125219
NRS_A_38_5_QE_BG_800_02_1_6641_JW1_jlab81_20100402T133320_20100402T133441
NRS_A_38_5_QE_BG_800_02_2_6642_JW1_jlab81_20100402T133449_20100402T133607
NRS_A_38_5_QE_BG_800_02_3_6643_JW1_jlab81_20100402T133616_20100402T133733
NRS_A_38_5_QE_BG_900_01_1_6647_JW1_jlab81_20100402T140719_20100402T140839
NRS_A_38_5_QE_BG_900_01_2_6648_JW1_jlab81_20100402T140848_20100402T141005
NRS_A_38_5_QE_BG_900_01_3_6649_JW1_jlab81_20100402T141014_20100402T141131
NRS_A_38_5_QE_BG_1000_01_1_6653_JW1_jlab81_20100402T142826_20100402T142947
NRS_A_38_5_QE_BG_1000_01_2_6654_JW1_jlab81_20100402T142955_20100402T143114
NRS_A_38_5_QE_BG_1000_01_3_6655_JW1_jlab81_20100402T143121_20100402T143239
NRS_A_38_5_QE_BG_1200_01_1_6659_JW1_jlab81_20100402T145247_20100402T145409
NRS_A_38_5_QE_BG_1200_01_2_6660_JW1_jlab81_20100402T145418_20100402T145535
NRS_A_38_5_QE_BG_1200_01_3_6661_JW1_jlab81_20100402T145544_20100402T145659
NRS_A_38_5_QE_BG_1400_01_1_6665_JW1_jlab81_20100402T151218_20100402T151337
NRS_A_38_5_QE_BG_1400_01_2_6666_JW1_jlab81_20100402T151346_20100402T151503
NRS_A_38_5_QE_BG_1400_01_3_6667_JW1_jlab81_20100402T151512_20100402T151629
NRS_A_38_5_QE_BG_1600_01_1_6671_JW1_jlab81_20100402T153256_20100402T153415
NRS_A_38_5_QE_BG_1600_01_2_6672_JW1_jlab81_20100402T153424_20100402T153541
NRS_A_38_5_QE_BG_1600_01_3_6673_JW1_jlab81_20100402T153552_20100402T153707
NRS_A_38_5_QE_BG_1800_01_1_6677_JW1_jlab81_20100402T154954_20100402T155113
NRS_A_38_5_QE_BG_1800_01_2_6678_JW1_jlab81_20100402T155122_20100402T155239
NRS_A_38_5_QE_BG_1800_01_3_6679_JW1_jlab81_20100402T155248_20100402T155405
NRS_A_38_5_QE_BG_2000_01_1_6683_JW1_jlab81_20100402T161258_20100402T161417
NRS_A_38_5_QE_BG_2000_01_2_6684_JW1_jlab81_20100402T161426_20100402T161543
NRS_A_38_5_QE_BG_2000_01_3_6685_JW1_jlab81_20100402T161554_20100402T161709
NRS_A_38_5_QE_BG_2300_01_1_6689_JW1_jlab81_20100402T163129_20100402T163243
NRS_A_38_5_QE_BG_2300_01_2_6690_JW1_jlab81_20100402T163251_20100402T163410
NRS_A_38_5_QE_BG_2300_01_3_6691_JW1_jlab81_20100402T163417_20100402T163535

NRS_A_38_5_QE_BG_2600_01_1_6695_JW1_jlab81_20100402T164952_20100402T165113
NRS_A_38_5_QE_BG_2600_01_2_6696_JW1_jlab81_20100402T165121_20100402T165239
NRS_A_38_5_QE_BG_2600_01_3_6697_JW1_jlab81_20100402T165248_20100402T165405
NRS_A_38_5_QE_BG_2900_01_1_6701_JW1_jlab81_20100402T170758_20100402T170919
NRS_A_38_5_QE_BG_2900_01_2_6702_JW1_jlab81_20100402T170928_20100402T171045
NRS_A_38_5_QE_BG_2900_01_3_6703_JW1_jlab81_20100402T171054_20100402T171212
NRS_A_38_5_QE_BG_3200_01_1_6707_JW1_jlab81_20100402T172459_20100402T172621
NRS_A_38_5_QE_BG_3200_01_2_6708_JW1_jlab81_20100402T172630_20100402T172747
NRS_A_38_5_QE_BG_3200_01_3_6709_JW1_jlab81_20100402T172756_20100402T172913
NRS_A_38_5_QE_BG_3500_01_1_6713_JW1_jlab81_20100402T174134_20100402T174255
NRS_A_38_5_QE_BG_3500_01_2_6714_JW1_jlab81_20100402T174304_20100402T174421
NRS_A_38_5_QE_BG_3500_01_3_6715_JW1_jlab81_20100402T174430_20100402T174546
NRS_A_38_5_QE_BG_3800_01_1_6719_JW1_jlab81_20100402T180012_20100402T180133
NRS_A_38_5_QE_BG_3800_01_2_6720_JW1_jlab81_20100402T180142_20100402T180257
NRS_A_38_5_QE_BG_3800_01_3_6721_JW1_jlab81_20100402T180306_20100402T180423
NRS_A_38_5_QE_BG_4100_01_1_6725_JW1_jlab81_20100402T181724_20100402T181845
NRS_A_38_5_QE_BG_4100_01_2_6726_JW1_jlab81_20100402T181854_20100402T182009
NRS_A_38_5_QE_BG_4100_01_3_6727_JW1_jlab81_20100402T182018_20100402T182135
NRS_A_38_5_QE_BG_4400_01_1_6731_JW1_jlab81_20100402T184137_20100402T184251
NRS_A_38_5_QE_BG_4400_01_2_6732_JW1_jlab81_20100402T184300_20100402T184418
NRS_A_38_5_QE_BG_4400_01_3_6733_JW1_jlab81_20100402T184428_20100402T184544
NRS_A_38_5_QE_BG_4700_01_1_6737_JW1_jlab81_20100402T190038_20100402T190157
NRS_A_38_5_QE_BG_4700_01_2_6738_JW1_jlab81_20100402T190206_20100402T190323
NRS_A_38_5_QE_BG_4700_01_3_6739_JW1_jlab81_20100402T190332_20100402T190449
NRS_A_38_5_QE_BG_5000_01_1_6743_JW1_jlab81_20100402T192417_20100402T192537
NRS_A_38_5_QE_BG_5000_01_2_6744_JW1_jlab81_20100402T192545_20100402T192703
NRS_A_38_5_QE_BG_5000_01_3_6745_JW1_jlab81_20100402T192712_20100402T192829