JWST-STScI-005798
SM-12

JWST TECHNICAL REPORT

Title: More Efficient NIRCam Dither Patterns		Doc #: JWST-STScI-005798, SM-12 Date: 3 November 2017 Rev: -
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1 Abstract

The NIRCam dither patterns were originally designed in 2009, well before the slew times and overheads were known. We now know that for JWST Cycle 1 observations, APT 25.4 will charge slew (and Small Angle Maneuver, or SAM) times that increase significantly at three distance thresholds: 0.06", 25", and the Visit Splitting Distance, which ranges from 30" to 80", depending on the target. Here we design new, more efficient NIRCam dither patterns that perform slews (SAMs) that are smaller than these thresholds as often as possible. The three new primary dither patterns are:

1) FULLBOX, covering all gaps between detectors and modules, including an extra large pattern for NIRSpec pre-imaging;

2) INTRAMODULEX, covering gaps between short wavelength detectors only; and

3) INTRAMODULEBOX, similar but with more compact initial steps.

We also design a new Subpixel dither pattern:

4) SMALL-GRID-DITHER, which uses the Fine Steering Mirror (without slewing the telescope) while still mitigating bad pixels in the short wavelength channel.

These dither patterns are available in APT 25.4 for JWST Cycle 1 observations in the NIRCam Imaging and Wide Field Slitless Spectroscopy (WFSS) observing modes.

2 Introduction

Dithers are small telescope pointing adjustments between exposures. They serve to fill gaps in sky coverage, mitigate bad pixels and flat field uncertainties, and/or improve the spatial sampling of the scene. These are especially important for NIRCam, given the gaps in the spatial coverage (Figure 1) and the undersampled images obtained at wavelengths below 2 μm and 4 μm in the short and wavelength channels, respectively.

NIRCam dither strategies were first studied in detail by Koekemoer and Linday (2005). The dither patterns first implemented for NIRCam were developed by Anderson (2009).

The data quality and optimal observing strategies for these patterns were studied by Anderson (2014).

Dithers are performed in the "ideal" coordinate system of the NIRCam aperture in use. For NIRCam, the ideal coordinate axes are nearly parallel to the JWST (V2, V3) coordinate system (within 1 degree of rotation). When imaging with both NIRCam modules and all detectors, the ALL aperture is in use, and its ideal coordinate system is rotated only 0.0265 degrees relative to the JWST (V2, V3) coordinate system. In this work, when plotting coverage maps, we assume the dither ideal coordinate system is parallel to (V2, V3) and centered on the ALL reference position: X = –V2+0.32"; Y = +V3+492.59". The NIRCam detectors' coverage of the field of view is detailed in Figure 2 and Table 1.

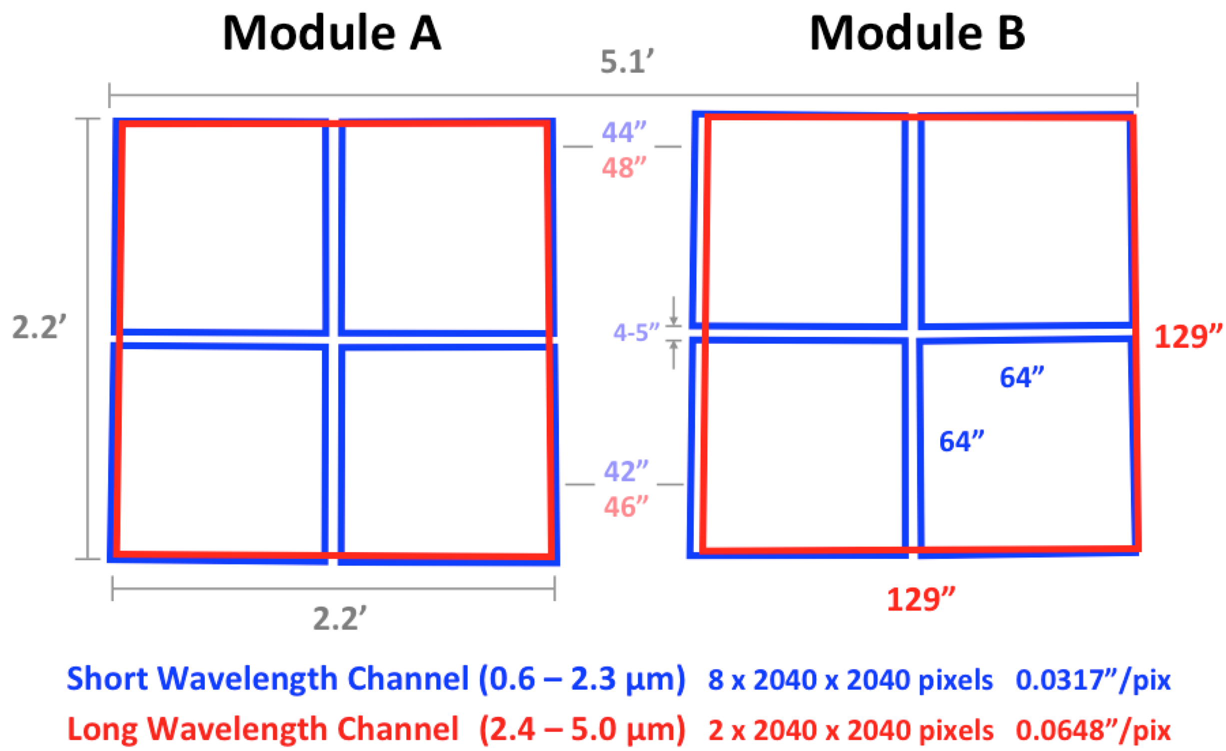


Figure 1: The NIRCam Field of View. Ten detectors observe the sky in two wavelength channels simultaneously via dichroics.

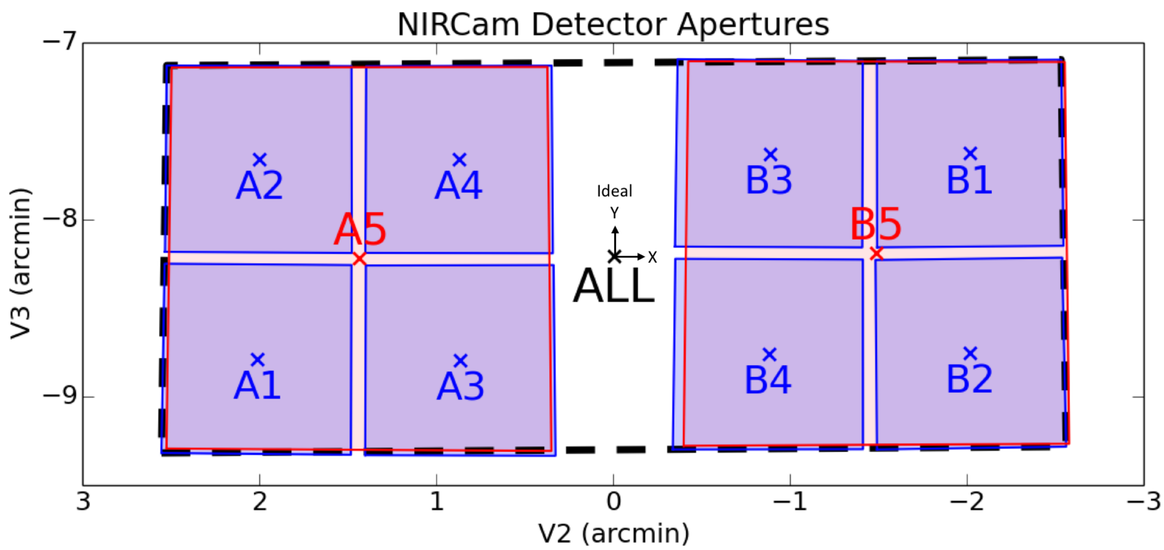


Figure 2: NIRCam apertures (defining pointings) in the JWST (V2, V3) coordinate system, with reference positions and vertices provided in Table 1. We assume the NIRCam Ideal Coordinate system (X, Y) is parallel to JWST (–V2, V3) with the origin at the ALL aperture reference position V2 = -0.32, V3 = -492.59.

Table 1: Reference positions and vertices of NIRCam apertures in arcseconds in the JWST (V2, V3) coordinate system, as plotted in Figure 2 in arcminute

SCA	V2_Ref	V3_Ref	V2_1	V2_2	V2_3	V2_4	V3_1	V3_2	V3_3	V3_4
A1	120.67	-527.39	88.90	153.16	152.08	88.69	-559.88	-559.27	-495.15	-495.59
A2	120.11	-459.68	151.38	88.68	88.56	151.95	-427.95	-428.17	-491.49	-491.11
A3	51.93	-527.80	19.49	84.05	83.83	20.15	-560.22	-560.03	-495.73	-495.59
A4	52.28	-459.81	83.71	20.80	20.39	84.00	-428.20	-428.00	-491.59	-491.46
A5	86.10	-493.23	20.88	151.45	149.73	22.23	-558.60	-557.79	-428.63	-428.46
B1	-120.97	-457.75	-89.52	-152.07	-152.82	-89.59	-426.35	-426.00	-489.07	-489.58
B2	-121.14	-525.46	-153.74	-89.55	-89.05	-152.37	-557.14	-558.09	-493.86	-493.08
B3	-53.12	-457.78	-21.93	-84.75	-84.57	-21.05	-425.81	-426.40	-489.59	-489.32
B4	-52.82	-525.73	-84.82	-20.32	-21.16	-84.77	-557.99	-558.08	-493.47	-493.71
B5	-89.39	-491.44	-25.54	-153.25	-154.75	-23.98	-426.52	-426.75	-556.16	-556.87
ALL	-0.32	-492.59	153.16	-153.74	-152.07	153.16	-559.27	-557.14	-426.00	-427.95

3 Original Dither Patterns

Four sets of dither patterns for NIRCam imaging were designed by Anderson (2009) and then implemented to serve the following purposes:

Primary dither patterns

- FULL – fill all gaps between detectors and modules; provide relatively smooth coverage when used in conjunction with mosaics
- INTRAMODULE – fill gaps between detectors, but not between modules
- INTRASCA – move a relatively small science target to all corners of a detector (Sensor Chip Assembly, or SCA) to mitigate flat field uncertainties

Subpixel dither patterns

- STANDARD – optimally improve spatial sampling while also mitigating bad pixels

We do not plan to modify these patterns. The community has been using these for some time to plan their observations. However there are two small tweaks that should be implemented:

- The FULL primary patterns including many pointings should be reordered to minimize the slew distances and numbers of visits required.
- The STANDARD subpixel pattern #9 has a typo: the X-offset of position #2 / 9 should be 1.0 pixel = 0.032" instead of 1.1 pixel = 0.0352".

4 Slew Times and Overheads

When these dither patterns were designed, the overheads were not known. In fact the overheads are still evolving today as engineers revise estimates and work to improve efficiency. We now know the overheads that Cycle 1 observers will be charged in APT 25.4 for all telescope slews and other pointing shifts. These times jump significantly at 0.06”, 25”, and the Visit Splitting Distance, which ranges from 30” to 80”, depending on the target.[1] Based on this knowledge, we can now design significantly more efficient dither patterns.

[1] We refer to distances in arcseconds between one telescope pointing and the next. These are in the NIRCam Ideal Coordinate System (X, Y), which is very nearly aligned to the telescope's (V2, V3) axes. Visit splitting actually considers the maximum distance between all pairs of pointings in a visit. The Fine Steering Mirror can move ±0.06" in each direction (X, Y), but APT 25.4 simply checks the distance from the previous pointing as being less or greater than 0.06" to calculate the time charged.

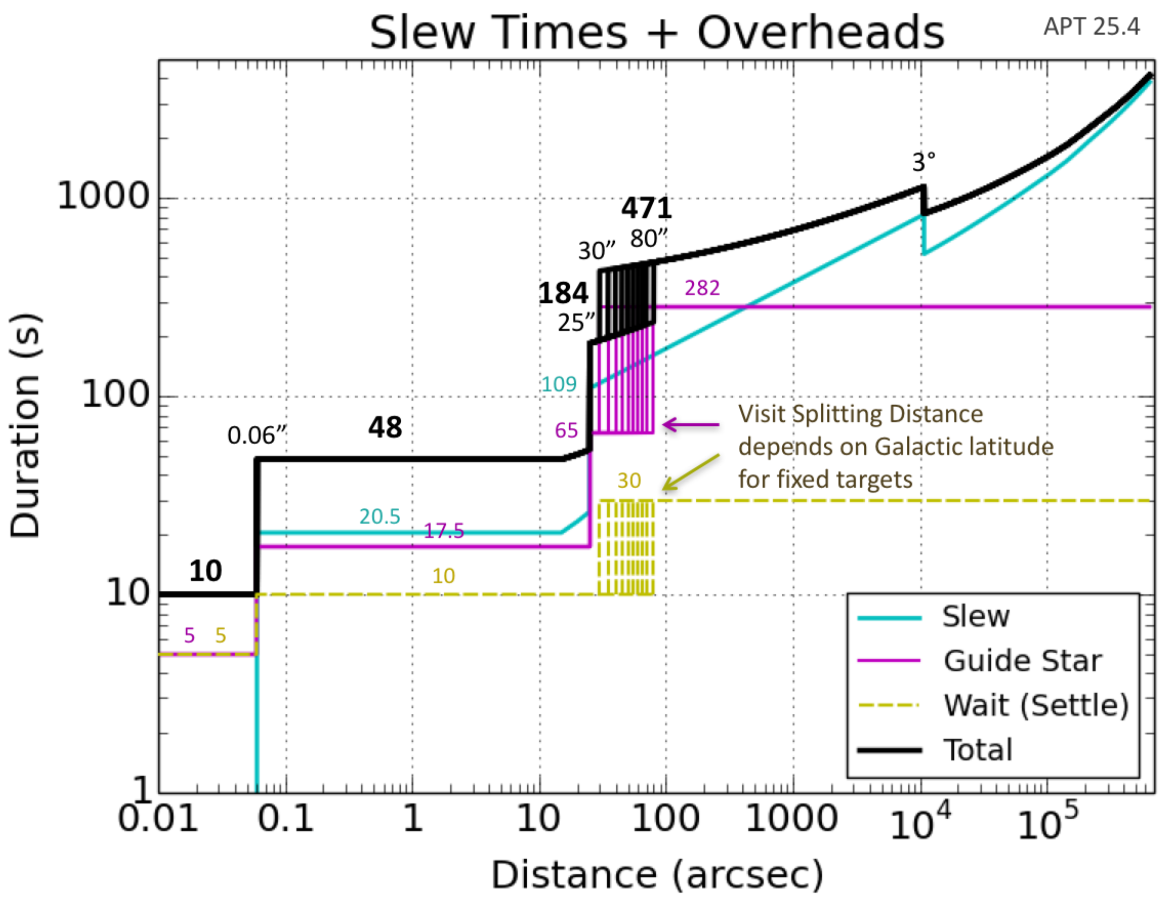


Figure 3: Slew times plus overheads versus distance, as charged by APT 25.4. Note the significant jumps at 0.06", 25", and the Visit Splitting Distance, which can vary between 30" and 80" (see Figure 4).

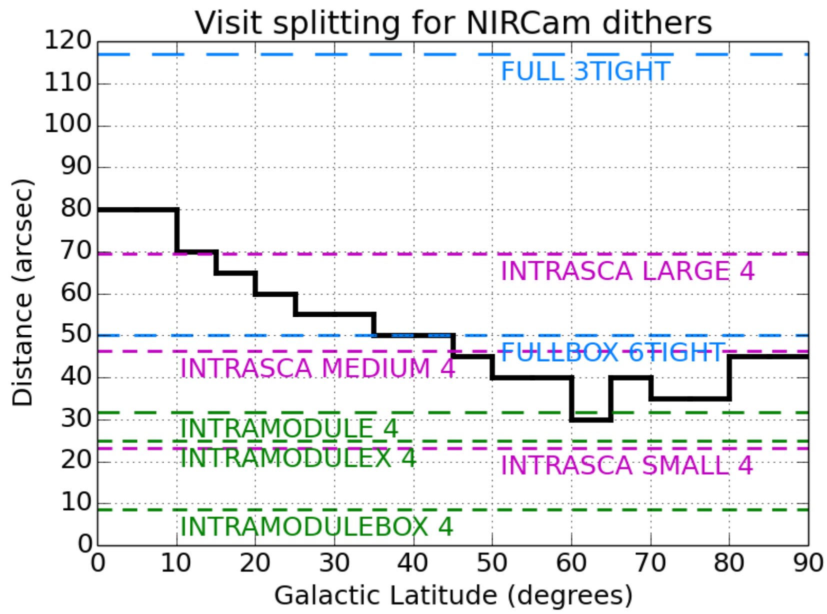


Figure 4: The Visit Splitting Distance (VSD) as a function of Galactic latitude (thick black line, reported by APT) for fixed (stationary) targets compared with the diagonal extent of each NIRCam primary dither pattern (dashed lines). Any pair of pointings separated by more than the VSD will require a new visit and new guide star, adding substantial overheads. For example, FULLBOX 6TIGHT has a diagonal extent of 49.98", meaning it can be performed in a single visit if VSD >= 50", or the target is at a Galactic latitude of > 45 deg. All moving targets are assigned VSD = 30".

5 New Dither Patterns

Here we design four new sets of NIRCam dither patterns, which are more efficient than the original patterns, based on our understanding of the Cycle 1 slew times and overheads. These include three new primary dither patterns:

- FULLBOX – covering most or all 5" gaps between detectors and the 49" gap between modules; including an extra large 5' x 5' pattern for NIRSpec pre-imaging
- INTRAMODULEX – fill gaps between detectors, but not between modules
- INTRAMODULEBOX – similar but with more compact initial steps

and one new subpixel dither pattern:

- SMALL-GRID-DITHER – optimally improve spatial sampling while also mitigating bad pixels; uses the Fine Steering Mirror (without slewing the telescope)

The existing INTRASCA pattern includes a SMALL option, which is already efficient. It extends ±8.19" along each axis (x,y), and all dithers are < 16.4". We make no attempt here to improve that pattern.

The new dither pattern designs include the following considerations for efficiency, coverage (for primary dithers), and subpixel phase sampling (for subpixel dithers):

Primary dithers, when possible and/or desired:

- < 25" to next dither position (or back to the starting position, if that is an option)

- diagonal extent reduced below possible Visit Splitting Distances (multiples of 5")
- >= 5.88" horizontally and vertically to cover the SWC gaps
- >= 48.8" horizontally to cover the gaps between modules, if desired
- 5' x 5' coverage for NIRSpec pre-imaging
- 0.2" horizontal and vertical offsets to mitigate any row / column uncertainties

Subpixel dithers:

- Same subpixel phasing as in Anderson 2009
- To use the Fine Steering Mirror, the following are **required**:
    - <= 0.06" to next position (or from final position back to the start)
    - stay within ±0.06" on both axes (x,y)
    - starting position is (0", 0")

The patterns are summarized in Tables 2 and 3 and then shown in more detail in Figures 5 – 8. Guidance for their usage is provided in the next Section 6.

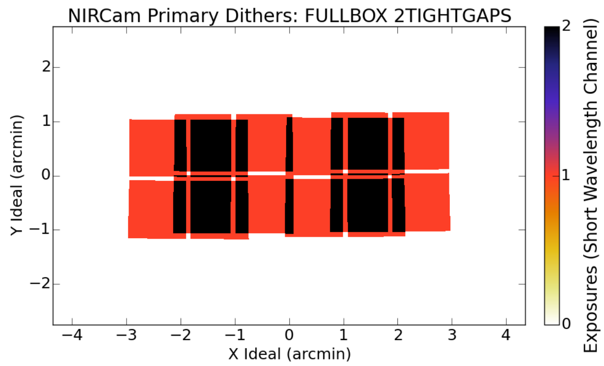
Table 2: New primary dither pattern summary. All distances are in arcseconds. Extent refers to the dither pattern; the full extent of the stacked images is larger by 5.1' × 2.2'.

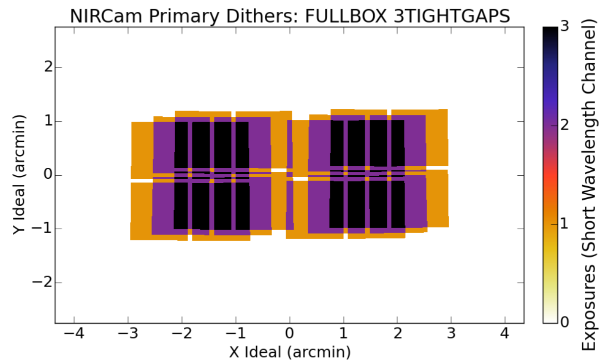
	Horizontal slews			Vertical slews				Max slew (incl. return to start)	Diagonal (visit splitting)
Primary Pattern	#	size	extent	#	size	extent	Max slew		
FULLBOX 2TIGHTGAPS	1	49.6	49.6	1	6	6	49.96	49.96	49.96
FULLBOX 3TIGHTGAPS	2	24.2	48.4	1	6	6	24.93	24.93	49.87
FULLBOX 4TIGHT	1	49.4	49.4	1	7.5	7.5	49.4	49.4	49.97
FULLBOX 4	1	49	49	1	24.9	24.9	48.9	48.9	54.96
FULLBOX 5TIGHT	2	24.4	48.8	1	10.8	10.8	24.8	49.98	49.98
FULLBOX 6TIGHT	2	24.4	48.8	1	10.8	10.8	24.4	24.4	49.98
FULLBOX 6	2	24.5	49	1	24.9	24.9	25	25	54.96
FULLBOX 8NIRSPEC	1	49	49	3	2 24.9" 1 128"	177.8	128	128	184.43
INTRAMODULEX	3	5.88	17.64	3	5.88	17.64	24.9	24.9	24.95
INTRAMODULEBOX	3	6	18	3	6	18	6	13.4	25.46

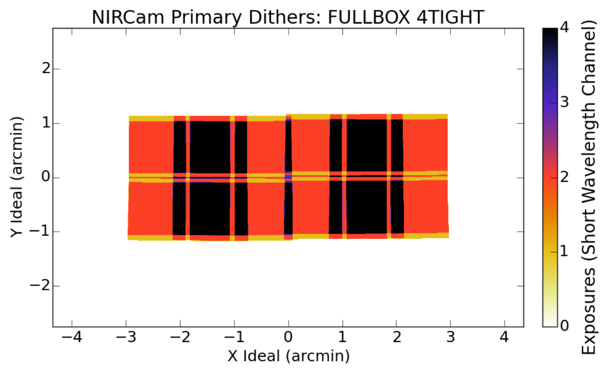
Table 3: New dither pattern options. The final column indicates whether each option consists of a sequence of pointings or separate individual patterns.

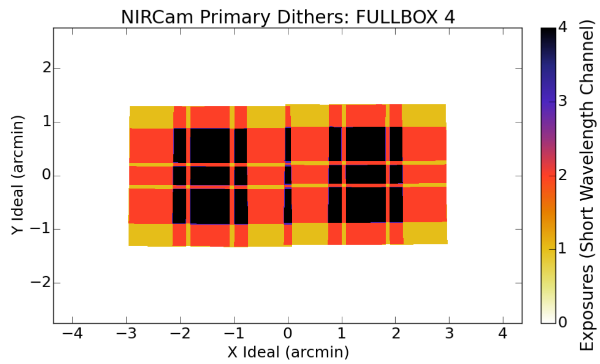
Type	Name	Options	Seq?
Primary	FULLBOX	2TIGHT, 3TIGHT, 4TIGHT, 4, 5TIGHT,	Indiv.

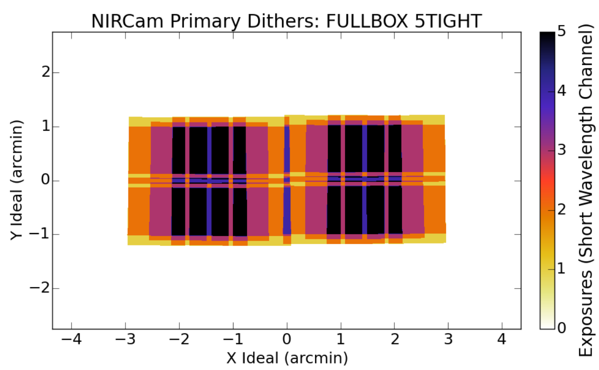
Type	**Name**	**Options**	**Seq?**
		6TIGHT, 6, 8NIRSPEC	
Primary	INTRAMODULEX	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	Seq.
Primary	INTRAMODULEBOX	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	Seq.
Subpixel	SMALL (FSM)	1, 2, 3, 4, 5, 6, 7, 8, 9	Indiv.

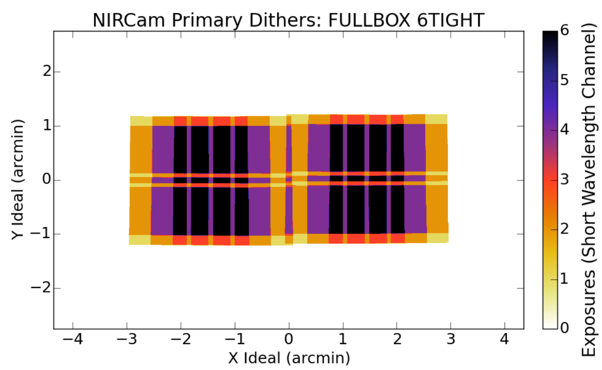












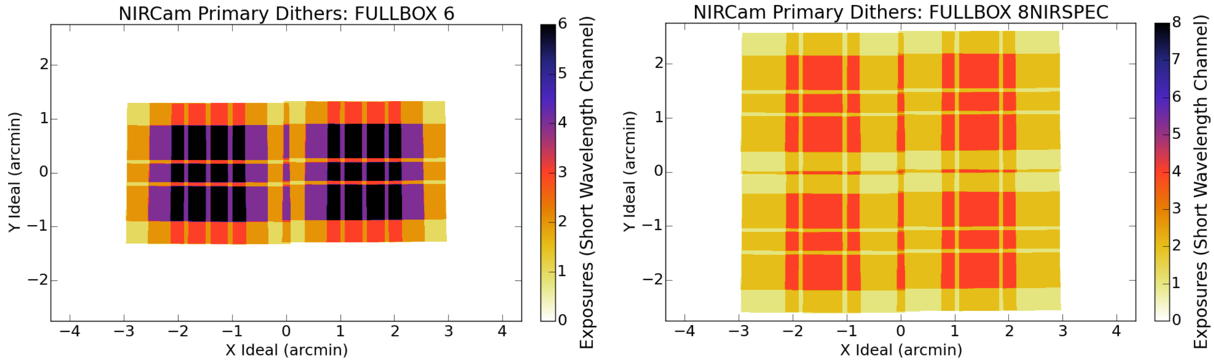


Figure 5: FULLBOX primary dither patterns 2TIGHT, 3TIGHT, 4TIGHT, 4, 5TIGHT, 6TIGHT, 6, and 8NIRSPEC. Depth in the short wavelength channel is color-coded.

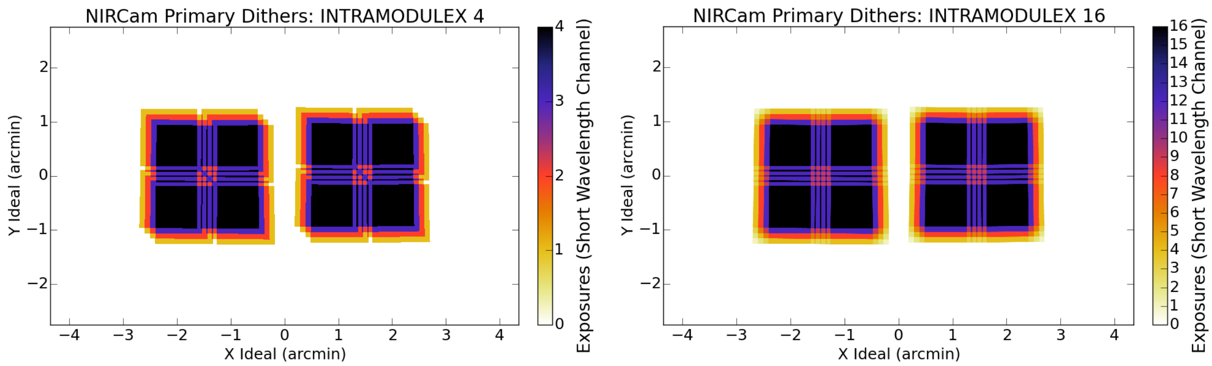


Figure 6: INTRAMODULEX pattern after 4 (left) and all 16 (right) dither positions. Depth in the short wavelength channel is color-coded.

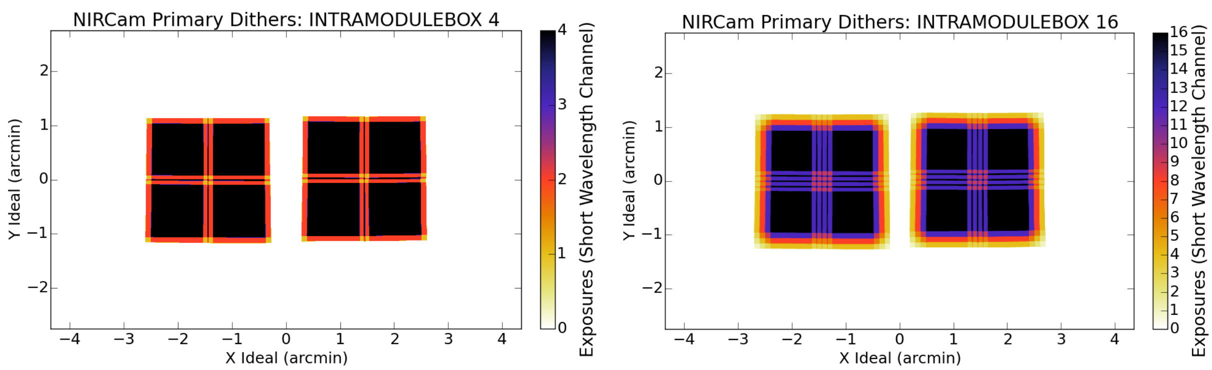


Figure 7: INTRAMODULEBOX pattern after 4 (left) and all 16 (right) dither positions. Depth in the short wavelength channel is color-coded.

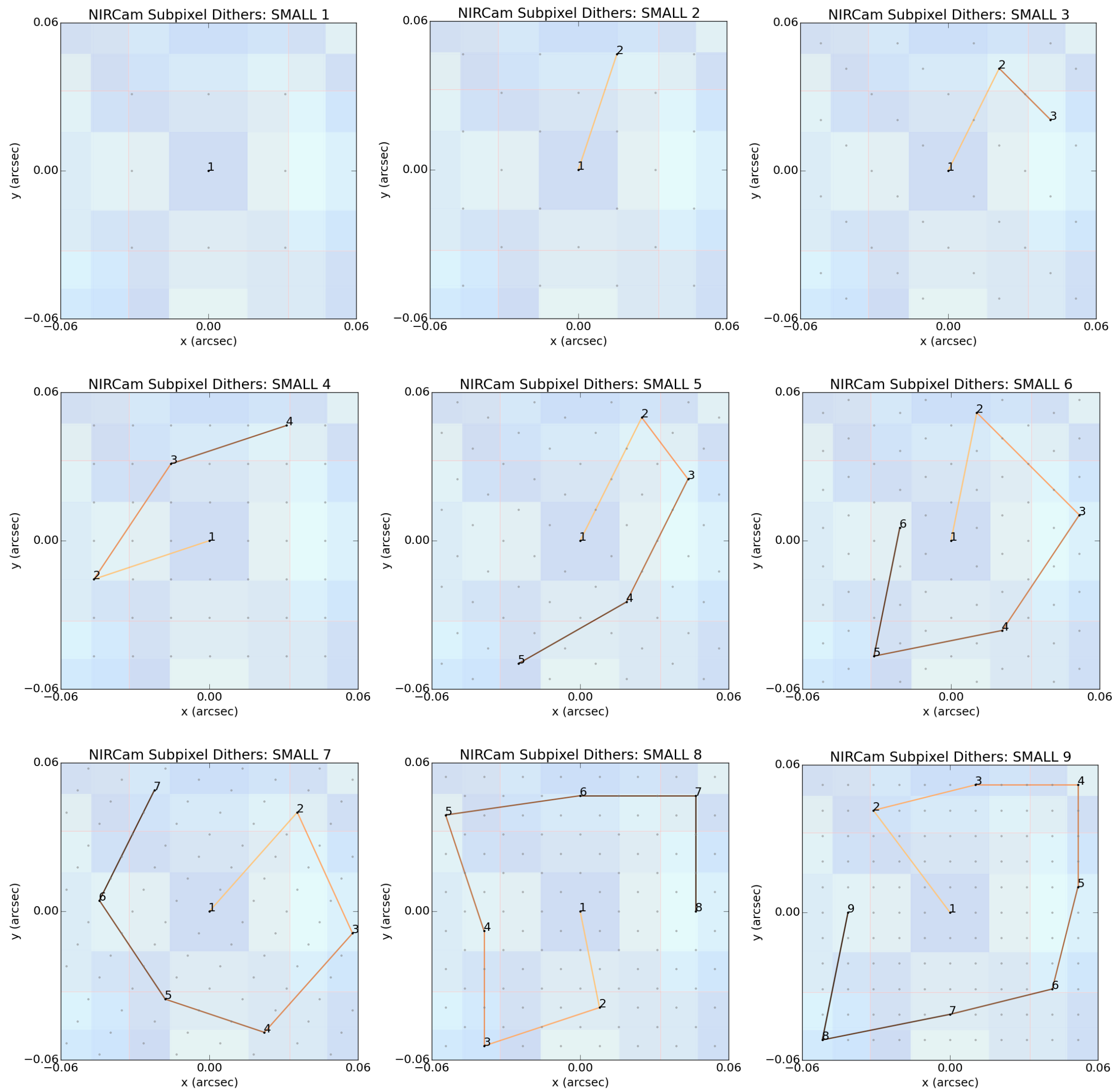


Figure 8: SMALL-GRID-DITHER subpixel dither patterns for 1, 2, 3, 4, 5, 6, 7, 8, and 9 positions. NIRCam short and long wavelength pixels are shown in blue and red, respectively. Dither points are black and numbered. The dither path is colored yellow – brown – black. Light gray points mark the subpixel phasing covered by each pattern.

6 Guidance for Usage

All of the new dither patterns presented here are available for NIRCam imaging. The INTRAMODULE variants are also available in the Wide Field Slitless Spectroscopy (WFSS) mode, where they serve to fill the gaps in short wavelength images obtained simultaneously with long wavelength grism observations.

Deep imaging programs (tens of hours per target) should generally perform combinations of primary and subpixel dithers to cover gaps and optimally improve image resolution. Shallower imaging programs (a few hours per target) may have to choose between primary and subpixel dithers. Primary dithering offers some (sub-optimal) pixel sampling (Anderson 2014).

Depending on the science goals, we provide the following guidance in selecting among the NIRCam dither patterns:

6.1 Covering all gaps, including the gap between modules; extending to wide mosaics

The original FULL and new FULLBOX patterns will cover all gaps between NIRCam detectors and modules. The FULL patterns were designed to be combined with mosaics, yielding roughly even depth across large areas (Anderson 2009). These patterns are elegant mathematical constructs, but unfortunately they are impractical given the current slew overheads. FULL dithers always split an observation into multiple visits, at least 2 but often 3 or more.

The new FULLBOX patterns are significantly more efficient, while sacrificing on even depth. All FULLBOX TIGHT patterns can be executed within a single visit if the target's Visit Splitting Distance (VSD) >= 50"; otherwise 2 visits (never more) are required for each pattern. The wider FULLBOX patterns 4 and 6 require VSD >= 55" for a single visit.

FULLBOX 6TIGHT is one of the most efficient patterns to cover all gaps, despite consisting of 6 dithers. Each dither is < 25", including the return from the final dither position to the start after changing filters. Each of these is charged ~50 seconds in APT 25.4 if VSD >= 50".

FULLBOX 5TIGHT is most efficient when few filter changes are performed. All dithers are < 25" except for the return to start, which is 49.4" and charged ~212 seconds for VSD >= 50". 6TIGHT is more efficient when observing with 4 or more filter pairs.

FULLBOX 4TIGHT consists of two 49.4" dithers, which increase the total overheads more than the extra dithers of 5TIGHT or 6TIGHT. The extra ~160 seconds for the longer dither is more than the time charged for an extra dither: ~50 seconds for the SAM and 69 seconds for the exposure.

FULLBOX 4 and 6 are wider patterns covering more area with less depth, if desired, within a single visit if VSD >= 55". These patterns may be advisable unless VSD = 50", in which case they would split visits while the TIGHT patterns would not.

FULLBOX 8NIRSPEC covers the largest area: 6' × 5' to serve as pre-imaging for NIRSpec MSA spectroscopy. The pattern is similar to a 2 × 1 mosaic of FULLBOX 4. The 5th dither and the return to the start are very large and will result in visit splitting for any target.

FULLBOX 2TIGHTGAPS and 3TIGHTGAPS offer quick coverage of the NIRCam footprint, leaving some coverage gaps.

Any of the FULLBOX patterns may be used in combination with mosaics to cover even wider areas. If they would split visits (VSD < 50"), then INTRAMODULEBOX 2 and 4 should also be considered.

6.2 Covering the short wavelength gaps only, leaving the gap between modules

INTRAMODULEBOX 4 is a compact pattern of 4 dithers yielding coverage of two square regions. It delivers maximal area at full depth and minimal area with a single pointing, including a small (~10" × 10") area of short wavelength pixels at the center of the pattern. Areas with a single pointing are susceptible to bad pixels, leaving holes in the stacked image.

INTRAMODULEX 3 should also be considered by small programs. Total overheads are reduced by performing only 3 dithers. All short wavelength gaps are filled, but more area has only a single exposure.

INTRAMODULEX 4 fills all central regions (including the short wavelength detector gaps) with a minimum of 2 pointings, but leaves more outer area with a single pointing compared to INTRAMODULEBOX.

INTRAMODULEX is very similar to the original INTRAMODULE pattern, but the new pattern is generally preferred. INTRAMODULEX is slightly more compact, and the ordering has been optimized for efficiency gains that begin with the 4th dither. The more compact pattern also yields less area with fewer exposures.

All INTRAMODULEX and INTRAMODULEBOX dithers are < 25" and charged ~50 seconds. The original INTRAMODULE pattern moves 31.8" between positions #3 and #4 and again between positions #5 and #6. Each of these moves is charged ~193 seconds.

Larger programs may consider using up to 16 dither points of INTRAMODULEBOX or INTRAMODULEX, but a combination of primary and subpixel dithers may be preferred.

6.3 Moving a small source within a detector to mitigate flat field uncertainties

The original INTRASCA SMALL 8" pattern is recommended for moving a source around within a detector. The larger INTRASCA patterns include SAMs > 25", resulting in larger overheads. The INTRAMODULE variants may also be considered for this purpose.

6.4 Improving subpixel sampling

Primary dithers deliver some random subpixel sampling, which can improve resolution of the stacked image. This may suffice for many programs. But optimal subpixel sampling requires use of a subpixel dither pattern (Anderson 2014). Using a subpixel pattern alone (without a primary pattern) may be preferred if the science target(s) are small, resolution is the highest priority, and detector gaps in the image are acceptable. In that case, the original STANDARD subpixel pattern may be recommended for better mitigation of bad pixels.

The SMALL-GRID-DITHER (SGD) subpixel patterns are more efficient and compact, while still providing some mitigation of bad pixels (better in the short wavelength channel than in the long wavelength channel). A different SGD pattern is designed for each number of dithers between 2 and 9. The patterns with more dithers extend to greater distances, providing better mitigation of bad pixels.

Each SMALL-GRID subpixel dither, performed with the Fine Steering Mirror, will be charged 10 seconds, significantly less than the 48 seconds charged for each STANDARD subpixel dither. This reduces the cost of adding subpixel dithers somewhat, however each additional exposure will still be charged 69 seconds for detector overheads.

SGD subpixel dithers may be best accompanied by a primary pattern. For example, INTRAMODULEBOX 4 combined with SMALL-GRID-DITHER 2 would deliver two square images with all area covered by multiple exposures to mitigate bad pixels and improve resolution. The 8 total dithers would require somewhat more observing time.

7 Conclusions

Based on the slew times and overheads versus distance, we have developed 4 efficient new dither patterns available in APT 25.4 for Cycle 1 observations:

FULLBOX primary – NIRCam imaging with both modules
INTRAMODULEBOX primary – NIRCam imaging and WFSS
INTRAMODULEX primary – NIRCam imaging and WFSS
SMALL subpixel – NIRCam imaging

They will be available alongside the existing patterns, which will not be changed:

FULL primary – NIRCam imaging with both modules
INTRAMODULE primary – NIRCam imaging and WFSS
INTRASCA primary – NIRCam imaging with one module
STANDARD subpixel – NIRCam imaging

We recommend the following patterns for general use:

- FULLBOX 6TIGHT – to cover all gaps
- INTRAMODULEBOX 4 – to cover two square areas with maximal depth
    - ideally combined with SMALL-GRID-DITHER 2 (or more) to improve the stacked image resolution and help mitigate bad pixels

If time is scarce, INTRAMODULEX 3 may be considered, though more area will be covered by only a single pointing and subject to bad pixels

The greatest efficiency gains should come with our new FULLBOX patterns at Galactic latitudes < 45 degrees with Visit Splitting Distances >= 50". In this case, all gaps may be covered between NIRCam detectors and modules without splitting visits at all. The previous FULL patterns always split visits.

8 References

Anderson, J. 2009, JWST-STScI-001738
Dither Patterns for NIRCam Imaging

Anderson, J. 2014, JWST-STScI-002473
NIRCam Dithering Strategies II: Primaries, Secondaries, and Sampling

Koekemoer, A.M. & Linday, K. 2005, JWST-STScI-000647
An Investigation of Optimal Dither Strategies for JWST

9 Appendix – Dither tables

				Distance color coding (arcsec):
			<=	0.06
			<=	20
			<=	25
			<=	30
			<=	80
			>	80

Table 4 – INTRAMODULEX primary dither pattern

Index	X-offset (arcsec)	Y-offset (arcsec)	Distance from previous (arcsec)	Distance from start (arcsec)
INTRAMODULEX	**5.88**	**5.88**		
1	-8.82	8.82		
2	-2.94	2.94	8.3	8.3
3	2.94	-2.94	8.3	16.6
4	8.82	-8.82	8.3	24.9
5	-8.82	-8.82	17.6	17.6
6	8.82	8.82	24.9	17.6
7	2.94	2.94	8.3	13.1
8	-2.94	-2.94	8.3	13.1
9	-2.94	-8.82	5.9	18.6
10	-8.82	-2.94	8.3	11.8
11	2.94	8.82	16.6	11.8
12	8.82	2.94	8.3	18.6

13	8.82	-2.94	5.9	21.2
14	2.94	-8.82	8.3	21.2
15	-8.82	2.94	16.6	5.9
16	-2.94	8.82	8.3	5.9

Table 5 – INTRAMODULEBOX primary dither pattern

Index	X-offset (arcsec)	Y-offset (arcsec)	Distance from previous (arcsec)	Distance from start (arcsec)
INTRAMODULEBOX	**6**	**6**		
1	-2.9	-3.1		
2	-3.1	2.9	6.0	6.0
3	2.9	3.1	6.0	8.5
4	3.1	-2.9	6.0	6.0
5	3.3	-8.9	6.0	8.5
6	-2.7	-9.1	6.0	6.0
7	-8.7	-9.3	6.0	8.5
8	-8.9	-3.3	6.0	6.0
9	-9.1	2.7	6.0	8.5
10	-9.3	8.7	6.0	13.4
11	-3.3	8.9	6.0	12.0
12	2.7	9.1	6.0	13.4
13	8.7	9.3	6.0	17.0
14	8.9	3.3	6.0	13.4
15	9.1	-2.7	6.0	12.0
16	9.3	-8.7	6.0	13.4

Table 6 – FULLBOX primary dither pattern

Index	X-offset (arcsec)	Y-offset (arcsec)	Distance from previous (arcsec)	Distance from start (arcsec)
FULLBOX 2TIGHTGAPS				
1	-24.8	-3		
2	24.8	3	49.96	49.96
FULLBOX 3TIGHTGAPS				
1	-24.2	-6		
2	0	0	24.9	
3	24.2	6	24.9	49.9
FULLBOX 4TIGHT				
1	-24.6	-3.1		
2	-24.8	2.9	6.0	6.0
3	24.6	3.1	49.4	49.6
4	24.8	-2.9	6.0	49.4
FULLBOX 4				
1	-24.35	-12.58		
2	-24.55	12.38	24.96	24.96
3	24.35	12.58	48.90	54.82
4	24.55	-12.38	24.96	48.90
FULLBOX 5TIGHT				
1	-24.4	5.3		
2	-24.2	-5.5	10.80	10.80
3	0	0	24.82	24.97
4	24.2	5.5	24.82	48.60

5	24.4	-5.3	10.80	48.60
FULLBOX 6TIGHT				
1	-24.2	-5.5		
2	-24.4	5.3	10.8	10.8
3	-0.1	5.4	24.3	26.5
4	24.2	5.5	24.3	49.6
5	24.4	-5.3	10.8	48.6
6	0.1	-5.4	24.3	24.3
FULLBOX 6				
1	-24.4	-12.55		
2	-24.6	12.35	24.9	24.9
3	-0.1	12.45	24.5	34.9
4	24.4	12.55	24.5	54.9
5	24.6	-12.35	24.9	49.0
6	0.1	-12.45	24.5	24.5
FULLBOX 8NIRSPEC				
1	-24.6	-64.1		
2	-24.4	-89.0	24.9	24.9
3	24.6	-88.8	49.0	55.1
4	24.4	-63.9	24.9	49.0
5	24.6	64.1	128.0	137.3
6	24.4	89.0	24.9	160.8
7	-24.6	88.8	49.0	152.9
8	-24.4	63.9	24.9	128.0

Table 7 – SMALL-GRID-DITHER subpixel dither pattern

X-offset (SWC pixels)	Y-offset (SWC pixels)	Index	X-offset (arcsec)	Y-offset (arcsec)	Distance (arcsec)	Distance back to start (arcsec)
		SMALL 1				
0	0	1	0.0000	0.0000		
		SMALL 2				
0	0	1	0.0000	0.0000		
0.5	1.5	2	0.0156	0.0467	0.0492	0.0492
		SMALL 3				
0	0	1	0.0000	0.0000		
0.6667	1.3333	2	0.0207	0.0415	0.0464	
1.3333	0.6667	3	0.0415	0.0207	0.0293	0.0464
		SMALL 4				
1.5	0.5	1	0.0000	0.0000		
0	0	2	-0.0466	-0.0156	0.0492	
1	1.5	3	-0.0155	0.0311	0.0561	
2.5	2	4	0.0312	0.0466	0.0492	0.0561
		SMALL 5				
0.8	1.6	1	0.0000	0.0000		
1.6	3.2	2	0.0249	0.0498	0.0567	
2.2	2.4	3	0.0436	0.0249	0.0317	
1.4	0.8	4	0.0187	-0.0248	0.0567	
0	0	5	-0.0249	-0.0497	0.0511	0.0567
		SMALL 6				
2.000	2.000	1	0.0000	0.0000		
2.333	3.667	2	0.0104	0.0518	0.0529	
3.667	2.333	3	0.0518	0.0104	0.0586	
2.667	0.833	4	0.0207	-0.0363	0.0561	
1.000	0.500	5	-0.0311	-0.0467	0.0529	
1.333	2.167	6	-0.0207	0.0052	0.0529	0.0214

		SMALL 7				
2.000	2.000	1	0.0000	0.0000		
3.143	3.286	2	0.0355	0.0400	0.0535	
3.857	1.714	3	0.0578	-0.0089	0.0537	
2.714	0.429	4	0.0222	-0.0489	0.0535	
1.429	0.857	5	-0.0178	-0.0355	0.0421	
0.571	2.143	6	-0.0444	0.0044	0.0481	
1.286	3.571	7	-0.0222	0.0489	0.0497	0.0537
		SMALL 8				
2.000	2.000	1	0.0000	0.0000		
2.250	0.750	2	0.0078	-0.0389	0.0396	
0.750	0.250	3	-0.0389	-0.0544	0.0492	
0.750	1.750	4	-0.0389	-0.0078	0.0467	
0.250	3.250	5	-0.0544	0.0389	0.0492	
2.000	3.500	6	0.0000	0.0467	0.0550	
3.500	3.500	7	0.0467	0.0467	0.0467	
3.500	2.000	8	0.0467	0.0000	0.0467	0.0467
		SMALL 9				
1.667	1.667	1	0.0000	0.0000		
0.667	3.000	2	-0.0311	0.0415	0.0518	
2.000	3.333	3	0.0104	0.0519	0.0427	
3.333	3.333	4	0.0519	0.0519	0.0415	
3.333	2.000	5	0.0519	0.0104	0.0415	
3.000	0.667	6	0.0415	-0.0311	0.0427	
1.667	0.333	7	0.0000	-0.0414	0.0427	
0.000	0.000	8	-0.0518	-0.0518	0.0529	
0.333	1.667	9	-0.0414	0.0000	0.0529	0.0415