



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

**EXPANDING THE FRONTIERS OF SPACE ASTRONOMY**

## Coordinated Parallels Level 2

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JWST Master Class  
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Thanks to: Bill Blair, Karla Peterson, Tea Temim, Crystal Mannfolk, Shelly Meyett, & Amber Armstrong



# JWST Science Parallels: Project History



- JWST Project and budget originally not include support for science parallels
  - However, parallel observations were planned for calibrations (darks, “sky flats”)
    - Hence, ground and flight systems were designed all along to handle parallel SI Ops and visit planning
  - HST demonstrated that science parallels do deliver major gains to science impact and efficiency
    - Over HST Cycles 11-21, science parallels increased total observatory efficiency from ~50% to ~70%
    - Many large HST programs would not be feasible without science parallels (e.g., GOODS, GHOSTS, HUDF, 3D-HST, PEARS, Orion Treasury Program, Multi-Cycle Treasury Programs, Frontier Fields)
- 2013-2014: JWSTMO chartered Efficiency WG to look into gains to typical science cases, implementation options, and potential technical barriers
  - Supported by NASA, since JWST’s design goal of 70% efficiency wasn’t met without parallels
- Efficiency WG report on JWST science parallels released in 2014
  - Estimated total efficiency gain of 16-26%
    - Gain depending on fraction of prime visits that will allow “useful” parallels (exp. times / dithers)
  - Preliminary estimate on increase of Data Volume looked manageable
    - With some restrictions



# JWST Science Parallels: Project History & Modes Implemented



- June 2015: NASA releases funding for JWST science parallels (engineering only)
- May 2016: Working Group put in charge of science input into APT implementation
  - Left only 5 months to get to implementation into APT for the GTO teams (!)
  - *Coordinated Parallel* modes implemented:

SI Mode 1	SI Mode 2	Both Ways?
NIRCam Imaging	MIRI Imaging	Yes
NIRCam Imaging	NIRISS WFSS	Yes
MIRI Imaging	NIRISS WFSS	Yes
NIRSpec MOS	NIRCam Imaging	No
NIRCam Imaging	NIRISS Imaging	No

- 2018 launch delay allowed us to implement three more combinations:
  - Will be in place in APT 2020.1
  - Not further discussed here
  - Usage similar to cases mentioned above

SI Mode 1	SI Mode 2	Both Ways?
NIRCam WFSS	MIRI Imaging	No
NIRCam WFSS	NIRISS Imaging	No
NIRSpec MOS	MIRI Imaging	No



# JWST Science Parallels: Coordinated vs. Pure Parallels



Coordinated Parallels	Pure Parallels
Science case in proposal needs to <b>justify parallel as well as prime observations</b> . Science goals need to call for both.	Distinct proposal type, <b>using parallel slots derived from separate (primary) programs</b> .
Proposer can <b>craft exposure times, number of exposure specifications, dithers etc.</b> to make things work for their science with the prime <b>and</b> parallel observations.	Pure parallel observations <b>cannot change the properties of primary observations</b> to which the proposed parallel ones will be attached.
Coordinated parallel proposal specifies <b><i>all parallel exposures</i></b> in detail.	<ul style="list-style-type: none"><li>• Proposal specifies <b><i>one Observation per type of proposed exposure</i></b> (e.g., different filters or grisms).</li><li>• <b>Exposure times need to specify the minimum allowable lengths</b> for the proposed science.</li><li>• Scientific Justification needs to specify <b>minimum number of distinct primary targets per observation</b> to fulfill science goals.</li></ul>
APT templates for coordinated parallels are <b>based on the “normal” templates</b> of the prime observing modes.	APT templates for pure parallels are <b>distinct from the “normal” observing templates</b> , selected in Proposal Information section of APT.



# JWST Science Parallels: Pure Parallels

- Pure parallels *not* covered here in detail
- Dedicated articles in JDoc
  - [JWST Parallel Observations](#)
  - [JWST APT Pure Parallel Observations](#)
- After acceptance by the TAC, and when the available parallel slots are known, successful proposers will develop a “Phase II” APT proposal using dedicated tool
  - Or: STScI will provide a listing of observing slots and their properties
  - Details will depend on the severity of competition for the available slots
  - Calibration Parallels (i.e., darks) will get access to the parallel slots before science pure parallels do
  - Formally, pure parallel observations are not guaranteed until visits have been scheduled



## Filling out APT forms for pure parallel proposals

- In the *Proposal Information* section, check box **Pure Parallel Proposal**.
- In the *Observations* section, click on **New Observation Folder**.
- Create one observation for each type of observation and exposure required to execute the proposed pure parallel science. In this context, “type of observation and exposure” means a combination of instrument, observing mode, optical element selection (filter(s) or grism), and minimum exposure duration. **Note that if more than one exposure setup is proposed to be obtained at a given position on the sky** (e.g., imaging with more than one filter per filter wheel, or WFSS observations with a grism as well as direct images), **one observation needs to be created for each of those exposure setups**. This is different from regular observation template specifications where multiple filters could just be listed sequentially within a given instance of the observation template.
- For each of the observations specified, fill out the exposure specifics. This is done as follows for the observing modes available for pure parallel observations:
  - For the *NIRCam Imaging* template (Instrument = NIRCam, Template = NIRCam Imaging):
    - Select desired **Module** and **Subarray**.
    - Select desired **Short Filter**, **Long Filter**, **Readout Pattern**, **Groups/Int**, and **Integrations/Exp**.
    - Read off duration of Observation in “Total Charged” box in top area of the template. *Note down this value for this Observation*.
  - For the *MIRI Imaging* template (Instrument = MIRI, Template = MIRI Imaging):
    - Select desired **Subarray**.
    - Select desired **Filter**, **Readout Pattern**, **Groups/Int**, and **Integrations/Exp**.
    - Select **Exposures/Dith = 1**.
    - Read off duration of Observation in “Total Charged” box in top area of the template. *Note down this value for this Observation*.
  - For the *NIRISS Imaging* template (Instrument = NIRISS, Template = NIRISS Imaging):
    - Select **Subarray = FULL**
    - Select desired **Filter**, **Readout Pattern**, **Groups/Int**, and **Integrations/Exp**.
    - Read off duration of Observation in “Total Charged” box in top area of the template. *Note down this value for this Observation*.
  - For the *NIRISS WFSS* template (Instrument = NIRISS, Template = NIRISS Wide Field Slitless Spectroscopy):
    - Select **Mode** (“DIRECT”, “GR150C”, or “GR150R”). *Note that for NIRISS WFSS Pure Parallel proposals, one of the Observations needs to specify a Direct Image exposure.* (To direct the user in this respect, the **Mode** is defaulted to “DIRECT”. For Cycle 1, we recommend that one Direct Imaging Observation be created for each Filter used in the proposal.)
    - Select desired **Filter**, **Readout Pattern**, **Groups/Int**, and **Integrations/Exp**.
- For each of the Observations created as described above, evaluate how many distinct pointings (meaning distinct targets of the primary observations, i.e., *ignoring dithers*) will be required at a minimum to fulfill the science goals laid out in the proposal. Make sure these numbers are mentioned and justified in the *Description of Observations* section of the proposal PDF attachment.
- Calculate the grand total duration of the pure parallel observations proposed. Calling the durations of the  $m$  different Observations “ $D_{\text{ur}_i}$ ” and the associated minimum number of pointings for each Observation “ $N_i$ ”, this grand total duration is equal to the following:  $\sum_{i=0}^m N_i D_{\text{ur}_i}$
- In the “Proposal Information” section in APT, click on “Request custom time allocation” button.
- In the “Requested Time” box that shows up, enter the grand total duration value calculated in the previous step. Make sure you choose the correct time unit (which is currently defaulted at “Days”). You can ignore the accounting numbers produced by APT automatically, as they are not relevant for pure parallel proposals.
- In the “Time Req Explanation” box, enter the following: “Pure Parallel proposal. Allocation value entered following prescription given in the **JWST APT Pure Parallel Observations** article.”





# JWST Coordinated Parallels: Implementation within APT



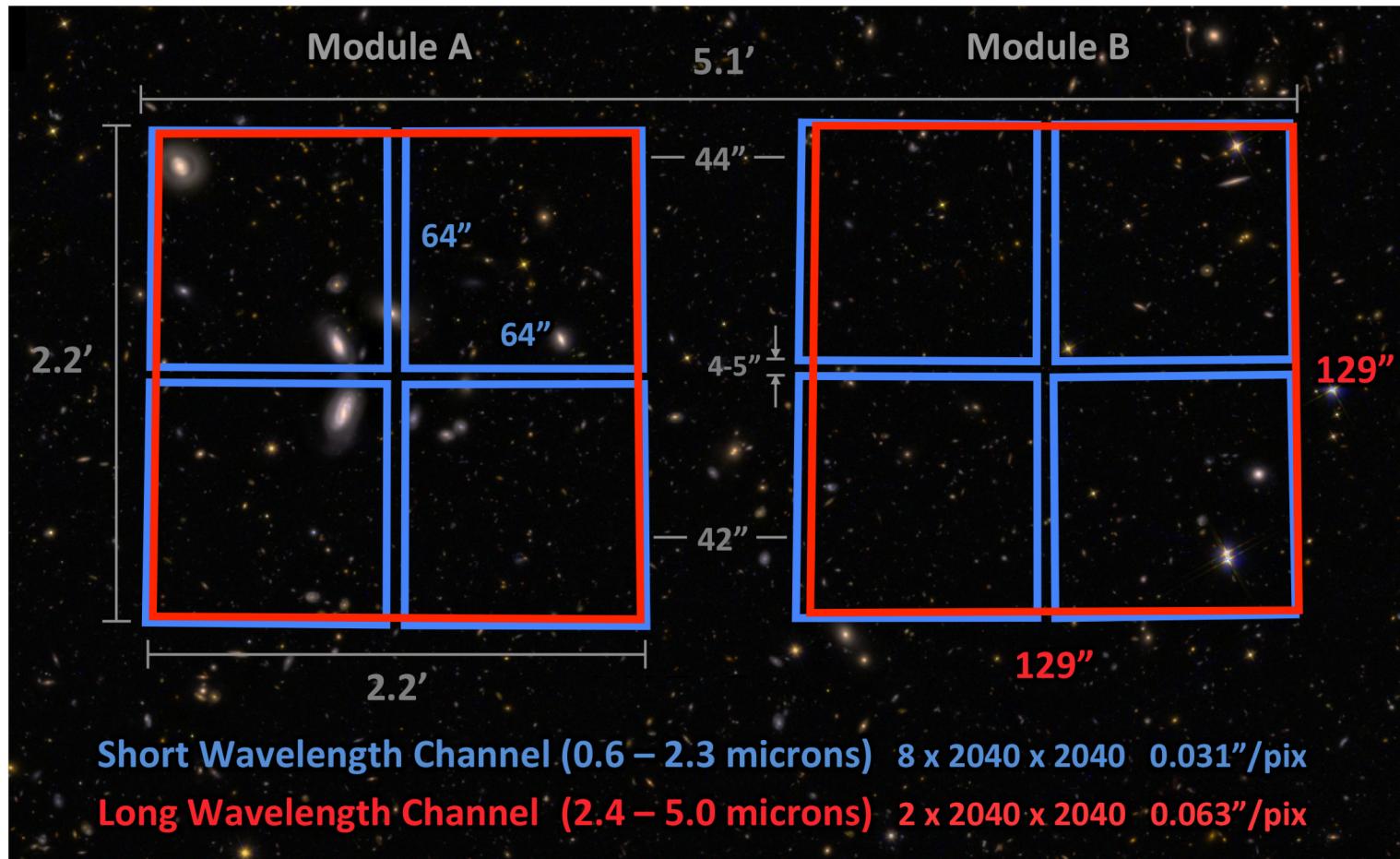
- Operational Constraints & Limitations
  - No mechanism motions while other SI is exposing
  - No simultaneous mechanism motions (i.e., occurring serially) while FGS is in Fine Guide
- Observatory Constraints & Limitations implemented in APT (only):
  - Parallel SI same number of exposure *specifications* (“activities”) as Prime SI
  - Data Volume constraints: *Calculated within APT and flagged when formal limit exceeded*
  - Data Rate constraints: *Imposed within APT through restrictions on available readout patterns*
    - ✓ *ICDH must sustain up to five 2048x2048 frames plus FGS “postage stamp” into SSR every 10.7 s*
    - ✓ Using this as **upper limit** to data rate; only an issue when NIRCam is involved.
- Goals for the determination of *dither patterns for coordinated parallels*:
  - Pixel phase sampling should be good for both SI’s (*if their PSFs are undersampled*)
  - Dither step size should be large enough for PSFs of both SI’s
  - Choice of dither step sizes for various target types (star field / distant galaxies / nearby galaxies)
  - However, science with Prime SI should not be compromised (e.g., NIRSpec MOS)



# JWST Coordinated Parallels: Customized Dither Patterns



## NIRCam



SW channel		LW channel	
Filter	$\lambda / \lambda_{\text{crit}}$	Filter	$\lambda / \lambda_{\text{crit}}$
F070W	0.35	F277W	0.69
F090W	0.45	F356W	0.89
F115W	0.58	F444W	1.11
F150W	0.75		
F200W	1.0		

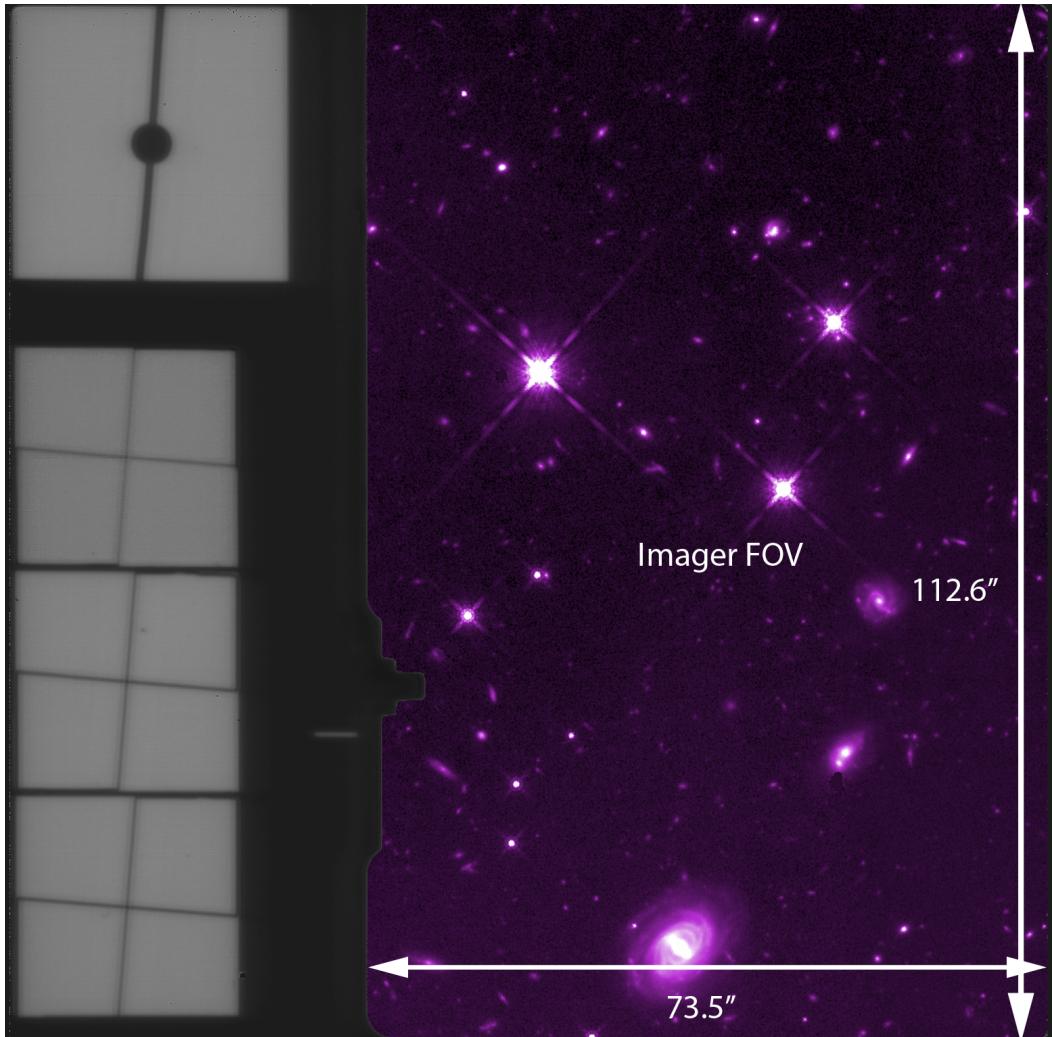
- *NIRCam dither patterns independent of filter*
- *NIRCam sampling limited by SW channel*



# JWST Coordinated Parallels: Customized Dither Patterns



MIRI



Filter	$\lambda / \lambda_{\text{crit}}$	Filter	$\lambda / \lambda_{\text{crit}}$
F560W	0.9	F1500W	2.3
F770W	1.2	F1800W	2.8
F1000W	1.5	F2100W	3.2
F1130W	1.7	F2550W	3.9
F1280W	2.0		

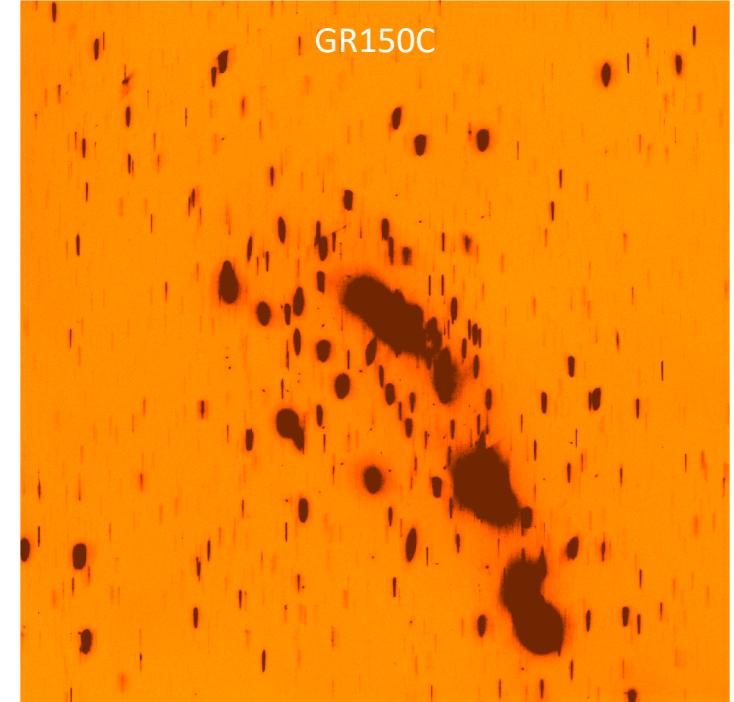
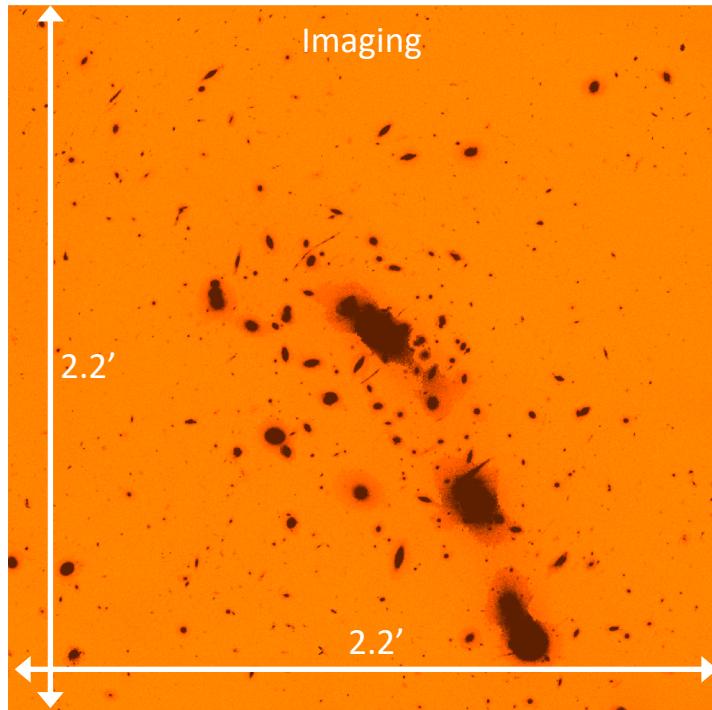
- *MIRI dither patterns based on filter (due to wide range of PSF FWHMs)*
- *MIRI sub-pixel sampling constraints only enforced for F560W and F770W*



# JWST Coordinated Parallels: Customized Dither Patterns



## NIRISS/WFSS



Filter	$\lambda / \lambda_{\text{crit}}$	Filter	$\lambda / \lambda_{\text{crit}}$
F090W	0.23	F150W	0.38
F115W	0.29	F200W	0.50

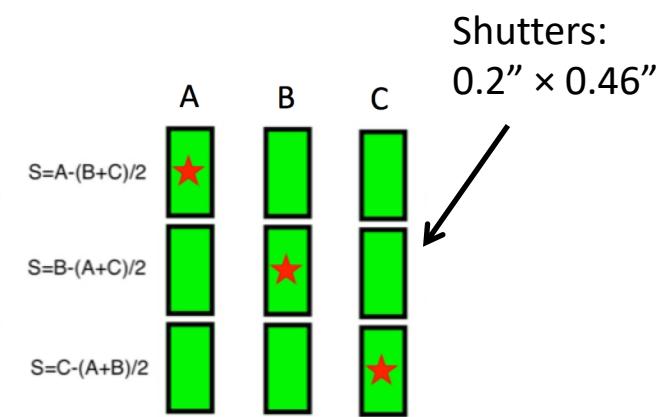
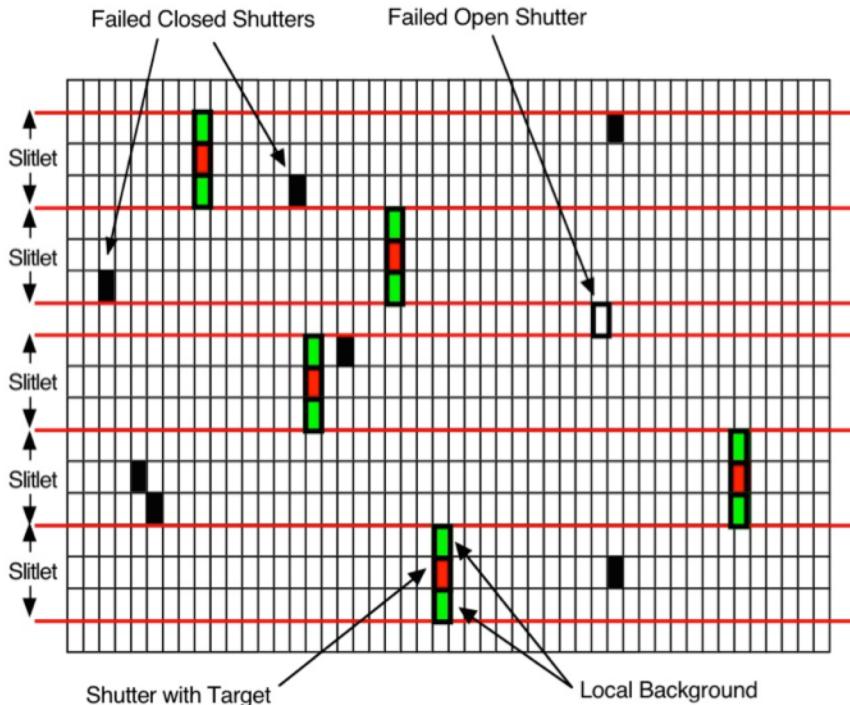
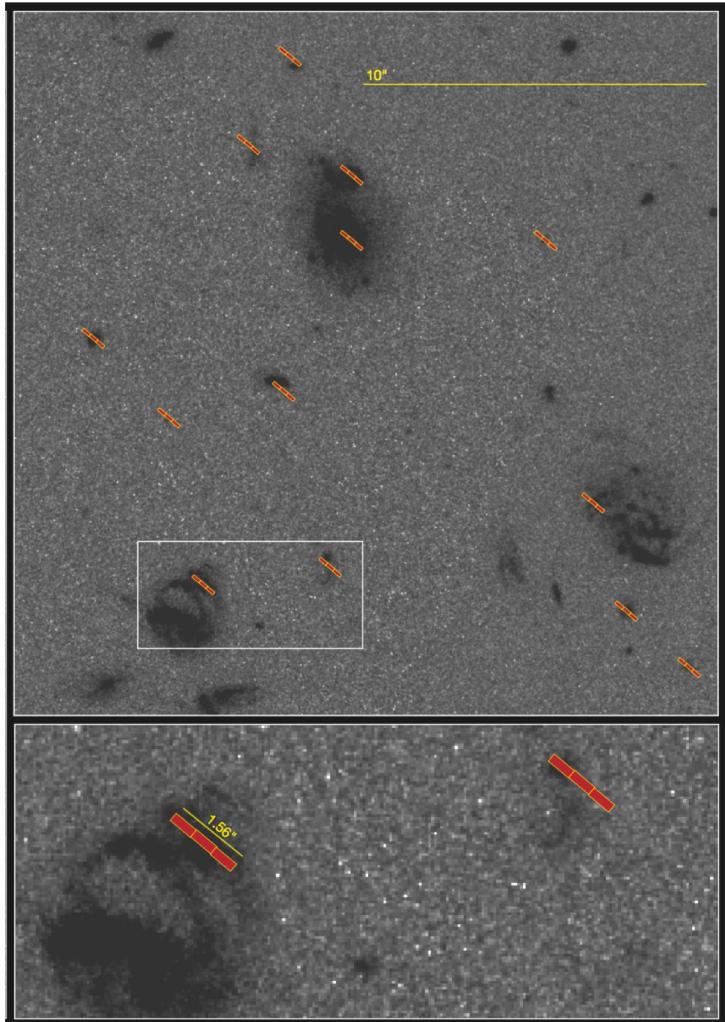
- **NIRISS/WFSS strongly undersampled, dithering crucial**



# JWST Coordinated Parallels: Customized Dither Patterns



## NIRSpec MOS w/MSA

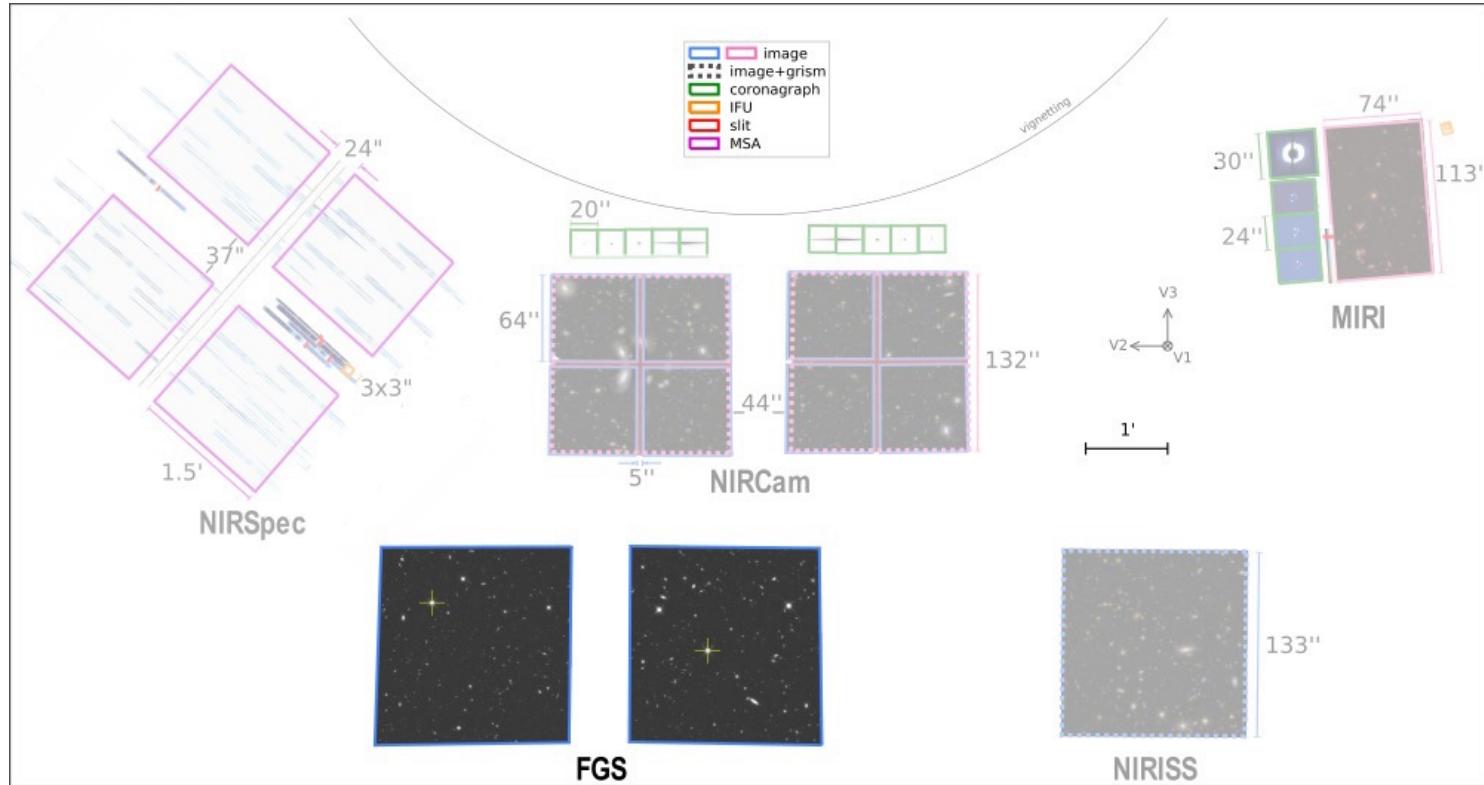


For comparison:  
NIRCam SW pixel is 0.0317''

- “*Nods*” (done mainly for background subtraction for compact sources) allow some “*wiggle room*” for compromise w/NIRCam as parallel
- Offering 2-pt and 3-pt dithers at each “*nod*” for 3 sub-pixel step sizes (plus “*None*” as in “*no change to MOS setup*”)



# JWST Coordinated Parallels: Customized Dither Patterns



- Input parameters in determination of dithers for various combinations:
  - Pixel sizes
  - Mean angles of FOV w.r.t. (V2, V3) coordinate system (*determined from ground testing*)
  - PSF FWHM (mainly for MIRI; requirement is dither throw  $\geq 3 \times$  PSF FWHM)



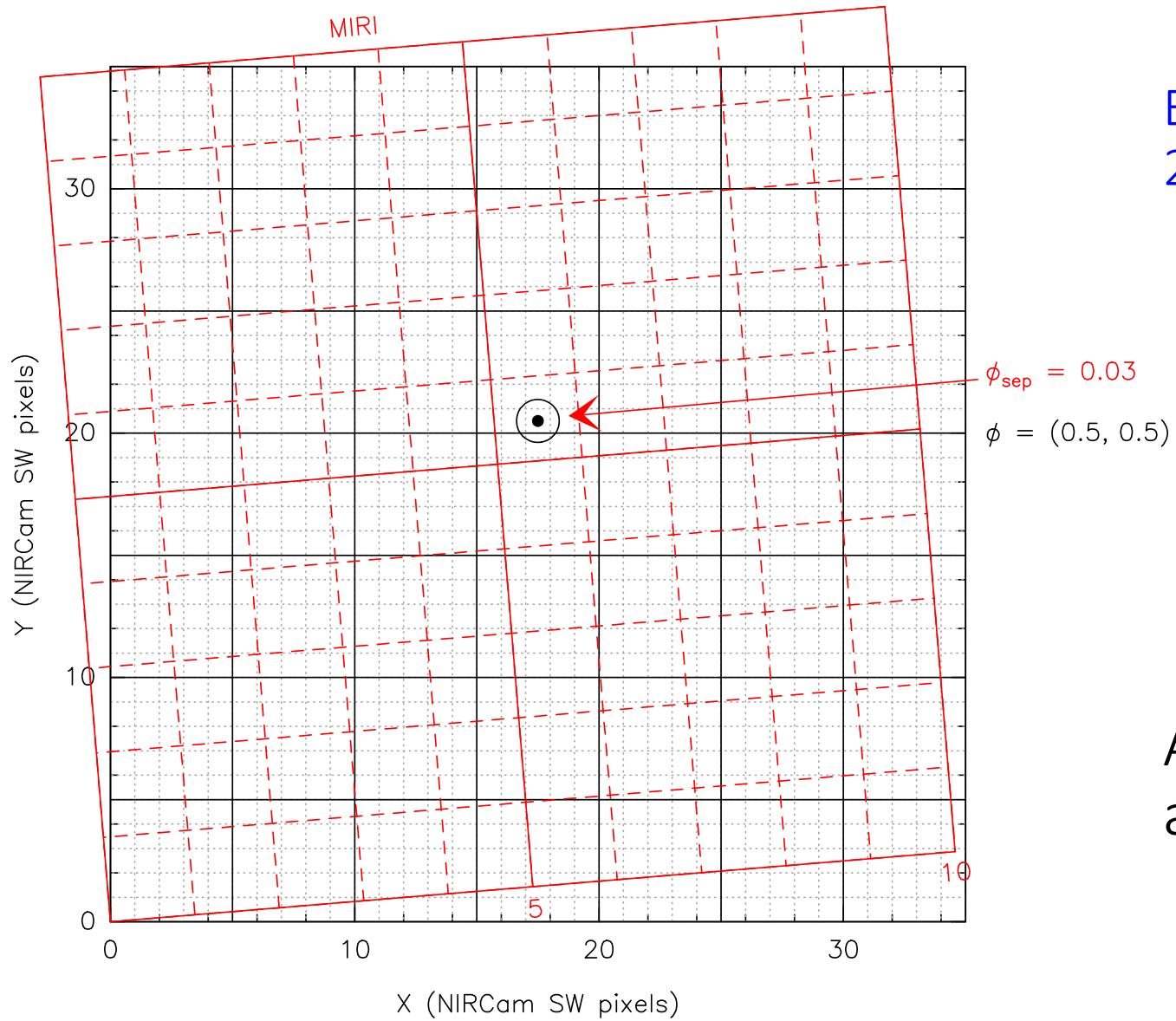
# JWST Coordinated Parallels: Customized Dither Patterns



- Approach:
  - MIRI, NIRCam, & NIRISS: Pixel phase sampling “ideal” for Prime SI, “close to ideal” for parallel SI
    - ✓ Define level of pixel phase mismatch  $\varphi_{\text{sep}}$  (= distance from ideal location in pixels)
    - ✓ For NIRCam & NIRISS combinations: *three dither step sizes (for three different typical target sizes)*
    - ✓ For combinations involving MIRI: *dither sizes provided for each (or almost each) MIRI filter*
      - ✓ This range of dither sizes will also allow one to select them based on *target size* (for extended targets)
  - NIRSpec MOS + NIRCam Imaging:
    - ✓ *Small sub-pixel dither patterns to be executed at each “nod” position*
    - ✓ *2-pt and 3-pt patterns, choice of 3 step sizes*
  - All: do not place dither within 2 pixels in X or Y from other dither in same pattern
  - In all cases, customized dither patterns are provided *in addition to* “normal” dithers/nods for prime SI



# JWST Coordinated Parallels: Customized Dither Patterns



Example solution for NIRCam + MIRI/F560W  
2-pt or 4-pt

- FOV orientations offset by  $\sim 5^\circ$
- $\varphi_{sep} < 0.05$  “when it counts”  
(i.e., NIRISS or MIRI @  $< 10 \mu\text{m}$  as parallel)
- $\varphi_{sep} < 0.11$  when NIRCam [SW] is parallel
  - Still only 40% of JWST pointing uncertainty
- Compromise dithers typically have relatively large pixel offsets for NIRCam SW

All custom dither patterns described  
and [available on JDoc](#)



# JWST Coordinated Parallels: APT implementation



- Coordinated Parallel option appears in appropriate templates; combo options come up

The screenshot shows two side-by-side configurations of the APT software's 'Parallel' dialog. Both dialogs have identical fields: 'Number' (1), 'Status' (UNKNOWN), 'Duplication' (unchecked), 'Label' (empty), 'Instrument' (NIRCAM), 'Template' (NIRCam Imaging), and 'Target' (2 M-32). The left dialog has the 'Coordinated Parallel' checkbox unchecked. The right dialog has the 'Coordinated Parallel' checkbox checked, and a dropdown menu is open, listing three options: 'NIRCam-MIRI Imaging' (selected with a checkmark), 'NIRCam-NIRISS Imaging', and 'NIRCam Imaging-NIRISS WFSS'. Red arrows point from the text 'Coordinated Parallel' to both the checkbox and the dropdown menu.

Ref no.	Template combination	Comments
1	MIRI Imaging – NIRCam Imaging	Either can be primary
2	NIRCam Imaging – NIRISS WFSS	Either can be primary
3	MIRI Imaging – NIRISS WFSS	Either can be primary
4	NIRSpec MOS – NIRCam Imaging	NIRSpec MOS must be primary
5	NIRCam Imaging – NIRISS Imaging	NIRCam must be primary



# JWST Coordinated Parallels: APT implementation



- Template then adds second tab for the parallel SI mode; custom dithers added to prime template

Number: 1 Status: UNKNOWN  Duplication

Label:

Prime Instrument: NIRCAM

Template: NIRCam Imaging

Coordinated Parallel:  NIRCam-MIRI Imaging

Target: 2 M-32

Splitting Distance Number of Visits

Visit Splitting: 60.0 Arcsec 1

Science	Total Charged
NIRCam Imaging Duration (secs) 1216	6611
MIRI Imaging Duration (secs) 1152	

Data volume: 4,154 MB

NIRCam Imaging  MIRI Imaging Mosaic Properties Special Requirements Comments

Module: ALL

Subarray: FULL

Dither Parameters: INTRAMODULE 4

Filters: # Short Filter Long Filter  
1 F070W F277W

Primary Dither Type Primary Dithers Subpixel Dither Type

4-POINT-WITH-MIRI-F560W

NIRCam Only  
3-POINT-WITH-MIRI-F560W  
 4-POINT-WITH-MIRI-F560W  
2-POINT-WITH-MIRI-F770W  
3-POINT-WITH-MIRI-F770W  
4-POINT-WITH-MIRI-F770W  
9-POINT-WITH-MIRI-F770W  
2-POINT-WITH-MIRI-F1000W

Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	16	16	1374.307	

Add Duplicate Insert Above Remove



# JWST Coordinated Parallels: APT implementation



- Parallel SI mode shows up as usual *but without dither interface*
  - Exposure duration must be  $\leq$  that of prime SI*

Number: 1 Status: UNKNOWN  Duplication

Label:

Prime Instrument: NIRCAM

Template: NIRCam Imaging

Coordinated Parallel:  NIRCam-MIRI Imaging

Target: 2 M-32

Splitting Distance Number of Visits

Visit Splitting: 60.0 Arcsec 1

Science	Total Charged
NIRCam Imaging Duration (secs) 1216	6611
MIRI Imaging Duration (secs) 592	

Data volume: 4,577 MB

NIRCam Imaging MIRI Imaging Mosaic Properties Special Requirements Comments

Subarray: FULL

#	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	F560W	FAST	13	1	2	16	32	1154.417	

Filters

Add Duplicate Insert Above Remove



# JWST Coordinated Parallels: APT implementation



- *Mosaic Properties* tab unchanged from “normal” templates (w/o coordinated parallels)
  - Mosaics can be relevant for parallels involving NIRCam Imaging, e.g., to cover gaps between detectors.

Number: 1 Status: UNKNOWN  Duplication

Label:

Prime Instrument: NIRCAM

Template: NIRCam Imaging

Coordinated Parallel:  NIRCam-MIRI Imaging

Target: 2 M-32

Splitting Distance Number of Visits

Visit Splitting: 60.0 Arcsec 1

Science	Total Charged
1216	6611

NIRCam Imaging Duration (secs) 1216

MIRI Imaging Duration (secs) 592

Data volume: 4,577 MB

NIRCam Imaging MIRI Imaging **Mosaic Properties** Special Requirements Comments

Subarray: FULL

#	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	F560W	FAST	13	1	2	16	32	1154.417	

Filters

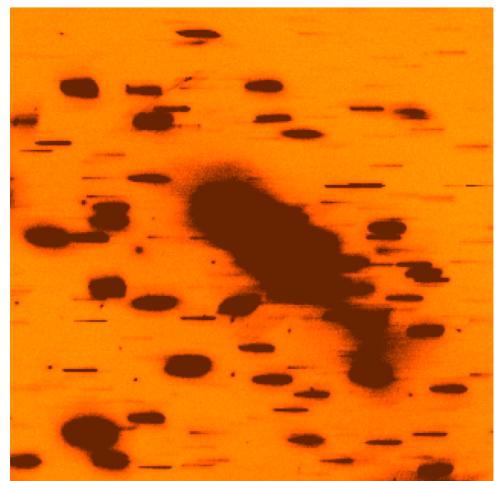
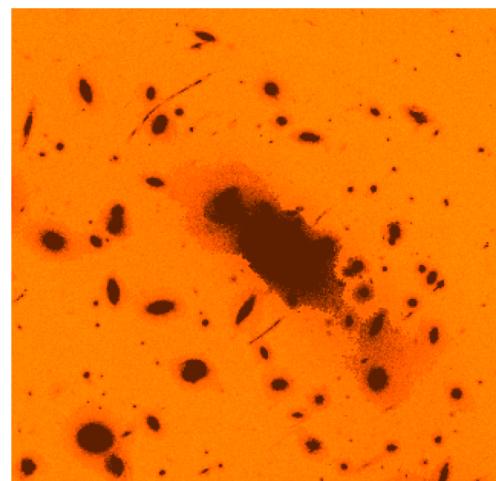
Add Duplicate Insert Above Remove



# JWST Coordinated Parallels: APT implementation



- Special Case #1: Coordinated Parallels with NIRISS/WFSS
  - NIRISS/WFSS exposure specification results in 3 “activities”:
    1. Direct image at first dither position
    2. Grism exposures (one at each dither position)
    3. Direct image at last dither position
  - Thus, each NIRISS/WFSS exp. spec needs to be accompanied by *3 exp. spec's of the other SI*
    - *Even when NIRISS/WFSS is the parallel SI mode (!)*
    - Breaks paradigm of “parallel SI shall not influence prime SI”
    - But: Only way to implement NIRISS/WFSS in current APT architecture
  - Created dedicated, illustrated [JDox article on how to set up NIRISS/WFSS as Coordinated Parallel](#)
  - We will cover the opposite-but-similar case of NIRISS/WFSS as Prime with NIRCam Imaging as Coordinated Parallel in this Class

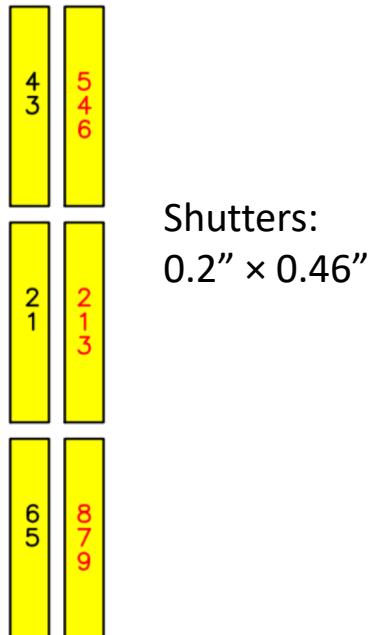




# JWST Coordinated Parallels: APT implementation



- Special Case #2: NIRSpec MOS + NIRCam Imaging
  - Small sub-pixel dither patterns to be executed at each “nod” position (i.e., MSA shutter)
  - 2-pt and 3-pt patterns, choice of 3 step sizes (10, 15, 20 mas/step – can be executed while guiding!)





# JWST Coordinated Parallels: APT implementation



- Special Case #2: NIRSpec MOS + NIRCam Imaging
  - Small sub-pixel dither patterns to be executed at each “nod” position
  - 2-pt and 3-pt patterns, choice of 3 step sizes (10, 15, 20 mas/step – can be executed while guiding!)

Observation 1 of JWST Draft Proposal (Unsaved)

Number: 1 Status: UNKNOWN  Duplication

Label:

Instrument: NIRSPEC

Template: NIRSPEC MultiObject Spectroscopy

Coordinated Parallel:

Target: 1 M-31

Visit Splitting: Splitting Distance: 60.0 Arcsec Number of Visits: 1

Duration (secs): Science: 0 Total Charged: 4500

Data Volume: 326 MB

NIRSPEC MultiObject Spectroscopy  Mosaic Properties  Special Requirements  Coordinated Parallel

Pre-Image Availability: Not required

TA Method: MSATA

**Target Acquisition Parameters**  
NirSpec Target Acquisitions using the MSA are designed for each visit.

**Science Parameters**  
Science Aperture: MSA Center   

#	Grating/Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Autocal	Total Dither:
1	Grating 1	MSA Center	Readout 1	1	1	Off	0.2" x 0.46"
2	Grating 2	MSA Center	Readout 2	1	1	Off	0.2" x 0.46"
3	Grating 3	MSA Center	Readout 3	1	1	Off	0.2" x 0.46"
4	Grating 4	MSA Center	Readout 4	1	1	Off	0.2" x 0.46"
5	Grating 5	MSA Center	Readout 5	1	1	Off	0.2" x 0.46"
6	Grating 6	MSA Center	Readout 6	1	1	Off	0.2" x 0.46"
7	Grating 7	MSA Center	Readout 7	1	1	Off	0.2" x 0.46"
8	Grating 8	MSA Center	Readout 8	1	1	Off	0.2" x 0.46"
9	Grating 9	MSA Center	Readout 9	1	1	Off	0.2" x 0.46"
10	Grating 10	MSA Center	Readout 10	1	1	Off	0.2" x 0.46"
11	Grating 11	MSA Center	Readout 11	1	1	Off	0.2" x 0.46"
12	Grating 12	MSA Center	Readout 12	1	1	Off	0.2" x 0.46"
13	Grating 13	MSA Center	Readout 13	1	1	Off	0.2" x 0.46"
14	Grating 14	MSA Center	Readout 14	1	1	Off	0.2" x 0.46"
15	Grating 15	MSA Center	Readout 15	1	1	Off	0.2" x 0.46"
16	Grating 16	MSA Center	Readout 16	1	1	Off	0.2" x 0.46"
17	Grating 17	MSA Center	Readout 17	1	1	Off	0.2" x 0.46"
18	Grating 18	MSA Center	Readout 18	1	1	Off	0.2" x 0.46"
19	Grating 19	MSA Center	Readout 19	1	1	Off	0.2" x 0.46"
20	Grating 20	MSA Center	Readout 20	1	1	Off	0.2" x 0.46"
21	Grating 21	MSA Center	Readout 21	1	1	Off	0.2" x 0.46"
22	Grating 22	MSA Center	Readout 22	1	1	Off	0.2" x 0.46"
23	Grating 23	MSA Center	Readout 23	1	1	Off	0.2" x 0.46"
24	Grating 24	MSA Center	Readout 24	1	1	Off	0.2" x 0.46"
25	Grating 25	MSA Center	Readout 25	1	1	Off	0.2" x 0.46"
26	Grating 26	MSA Center	Readout 26	1	1	Off	0.2" x 0.46"
27	Grating 27	MSA Center	Readout 27	1	1	Off	0.2" x 0.46"
28	Grating 28	MSA Center	Readout 28	1	1	Off	0.2" x 0.46"
29	Grating 29	MSA Center	Readout 29	1	1	Off	0.2" x 0.46"
30	Grating 30	MSA Center	Readout 30	1	1	Off	0.2" x 0.46"
31	Grating 31	MSA Center	Readout 31	1	1	Off	0.2" x 0.46"
32	Grating 32	MSA Center	Readout 32	1	1	Off	0.2" x 0.46"
33	Grating 33	MSA Center	Readout 33	1	1	Off	0.2" x 0.46"
34	Grating 34	MSA Center	Readout 34	1	1	Off	0.2" x 0.46"
35	Grating 35	MSA Center	Readout 35	1	1	Off	0.2" x 0.46"
36	Grating 36	MSA Center	Readout 36	1	1	Off	0.2" x 0.46"
37	Grating 37	MSA Center	Readout 37	1	1	Off	0.2" x 0.46"
38	Grating 38	MSA Center	Readout 38	1	1	Off	0.2" x 0.46"
39	Grating 39	MSA Center	Readout 39	1	1	Off	0.2" x 0.46"
40	Grating 40	MSA Center	Readout 40	1	1	Off	0.2" x 0.46"
41	Grating 41	MSA Center	Readout 41	1	1	Off	0.2" x 0.46"
42	Grating 42	MSA Center	Readout 42	1	1	Off	0.2" x 0.46"
43	Grating 43	MSA Center	Readout 43	1	1	Off	0.2" x 0.46"
44	Grating 44	MSA Center	Readout 44	1	1	Off	0.2" x 0.46"
45	Grating 45	MSA Center	Readout 45	1	1	Off	0.2" x 0.46"
46	Grating 46	MSA Center	Readout 46	1	1	Off	0.2" x 0.46"
47	Grating 47	MSA Center	Readout 47	1	1	Off	0.2" x 0.46"
48	Grating 48	MSA Center	Readout 48	1	1	Off	0.2" x 0.46"
49	Grating 49	MSA Center	Readout 49	1	1	Off	0.2" x 0.46"
50	Grating 50	MSA Center	Readout 50	1	1	Off	0.2" x 0.46"
51	Grating 51	MSA Center	Readout 51	1	1	Off	0.2" x 0.46"
52	Grating 52	MSA Center	Readout 52	1	1	Off	0.2" x 0.46"
53	Grating 53	MSA Center	Readout 53	1	1	Off	0.2" x 0.46"
54	Grating 54	MSA Center	Readout 54	1	1	Off	0.2" x 0.46"
55	Grating 55	MSA Center	Readout 55	1	1	Off	0.2" x 0.46"
56	Grating 56	MSA Center	Readout 56	1	1	Off	0.2" x 0.46"
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58	Grating 58	MSA Center	Readout 58	1	1	Off	0.2" x 0.46"
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66	Grating 66	MSA Center	Readout 66	1	1	Off	0.2" x 0.46"
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75	Grating 75	MSA Center	Readout 75	1	1	Off	0.2" x 0.46"
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124	Grating 124	MSA Center	Readout 124	1	1	Off	0.2" x 0.46"
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126	Grating 126	MSA Center	Readout 126	1	1	Off	0.2" x 0.46"
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133	Grating 133	MSA Center	Readout 133	1	1	Off	0.2" x 0.46"
134	Grating 134	MSA Center	Readout 134	1	1	Off	0.2" x 0.46"
135	Grating 135	MSA Center	Readout 135	1	1	Off	0.2" x 0.46"
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138	Grating 138	MSA Center	Readout 138	1	1	Off	0.2" x 0.46"
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141	Grating 141	MSA Center	Readout 141	1	1	Off	0.2" x 0.46"
142	Grating 142	MSA Center	Readout 142	1	1	Off	0.2" x 0.46"
143	Grating 143	MSA Center	Readout 143	1	1	Off	0.2" x 0.46"
144	Grating 144	MSA Center	Read				



# JWST Coordinated Parallels: APT implementation



- Special Case #2: NIRSpec MOS + NIRCam Imaging
  - Small sub-pixel dither patterns to be executed at each “nod” position
  - 2-pt and 3-pt patterns, choice of 3 step sizes (10, 15, 20 mas/step)

**Observation 1 of JWST Draft Proposal (Unsaved)**

Number: 1 Status: UNKNOWN  Duplication

Label:

Instrument: NIRSPEC

Template: NIRSpec MultiObject Spectroscopy

Coordinated Parallel:

Target: 1 M-31

Visit Splitting: Splitting Distance: 60.0 Arcsec Number of Visits: 1

Science Duration (secs): 0 Total Charged: 4500

Data Volume: 326 MB

NIRSpec MultiObject Spectroscopy  NIRCam Imaging  Mosaic Properties  Special Requirements  Coordinated Parallel

Pre-Image Availability: Not required

TA Method: MSATA

**Target Acquisition Parameters**  
NirSpec Target Acquisitions using the MSA are designed for each visit.

**Science Parameters**  
Science Aperture: MSA Center   
 Gratings/Filters   

#	Grating/Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Autocal	Total Dithers
1	GR1	Config 1	Pattern 1	1	1	1	1

Add Duplicate Insert Above Remove

**Observation 1 of JWST Draft Proposal (Unsaved)**

Number: 1 Status: UNKNOWN  Duplication

Label:

Prime Instrument: NIRSPEC

Template: NIRSpec MultiObject Spectroscopy

Coordinated Parallel:  NIRSpec MOS-NIRCam Imaging

Target: 1 M-31

Visit Splitting: Splitting Distance: 60.0 Arcsec Number of Visits: 1

Science Duration (secs): 0 Total Charged: 4465

NIRCam Imaging Duration (secs): 0

Data Volume: 325 MB

NIRSpec MultiObject Spectroscopy  NIRCam Imaging  Mosaic Properties  Special Requirements  Coordinated Parallel

Pre-Image Availability: Not required

TA Method: MSATA

**Target Acquisition Parameters**  
NirSpec Target Acquisitions using the MSA are designed for each visit.

**Science Parameters**  
Dither Type:  NONE  2-POINT-WITH-NIRCam-SIZE1  2-POINT-WITH-NIRCam-SIZE2  2-POINT-WITH-NIRCam-SIZE3  3-POINT-WITH-NIRCam-SIZE1  3-POINT-WITH-NIRCam-SIZE2  3-POINT-WITH-NIRCam-SIZE3  
Science Aperture: MSA Center   
 Gratings/Filters   

#	Grating/Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Autocal	Total Dithers
1	GR1	Config 1	Pattern 1	1	1	1	1

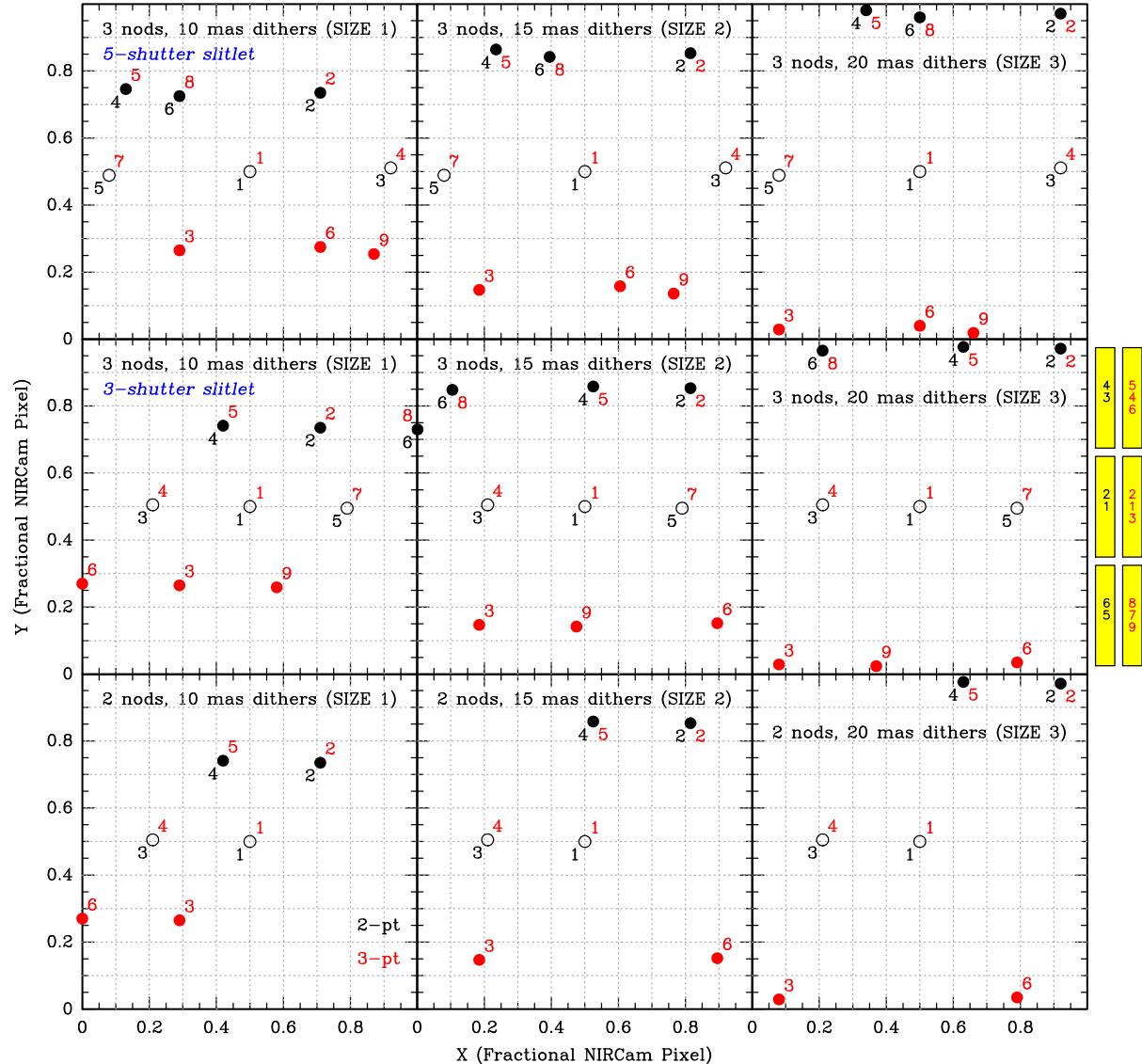
Add Duplicate Insert Above Remove



# JWST Coordinated Parallels: Custom Dither Patterns



## Dithers for NIRSpec MOS + NIRCam Imaging





# JWST Coordinated Parallels: Exercises



- Refer to Exercise handout
  - Contain steps to guide work
  - Hyperlinks to JDox articles at end of each exercise
- Exercise #1: NIRCam Imaging + MIRI Imaging
  - “Deep Field” imaging program (GOODS-South) using 2 sets of filters (SW/LW)
  - Adjusting mosaic to make MIRI parallels (with 2 filters) cover a contiguous area
- Exercise #2: NIRISS WFSS + NIRCam Imaging
  - Slitless spectroscopy of center of HST Frontier Field galaxy cluster (using 3 filters & 2 grisms)
  - Multi-filter NIRCam parallels to find candidate high-z emission-line galaxies

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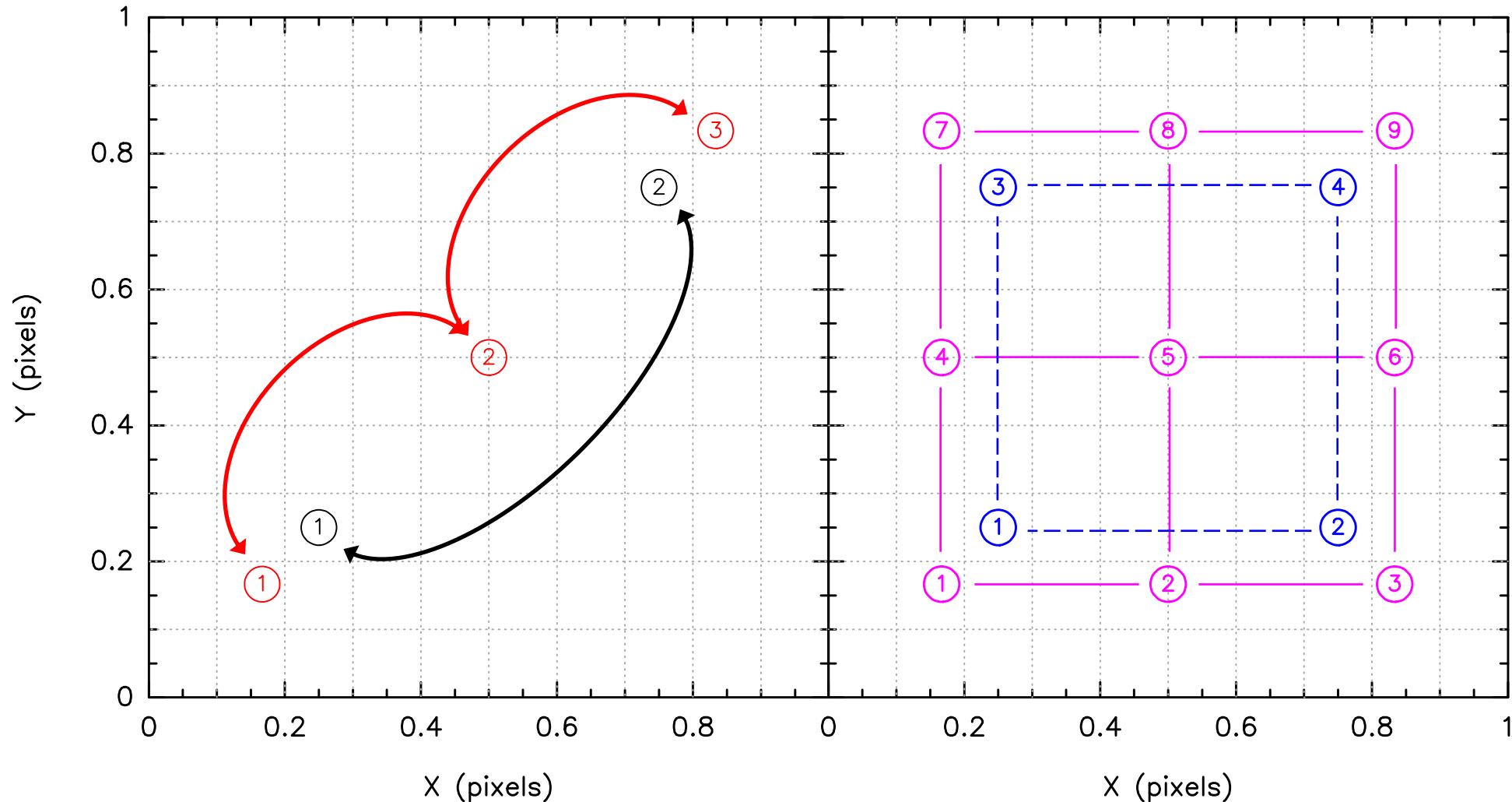
# Backup Slides



# JWST Coordinated Parallels: Custom Dither Patterns

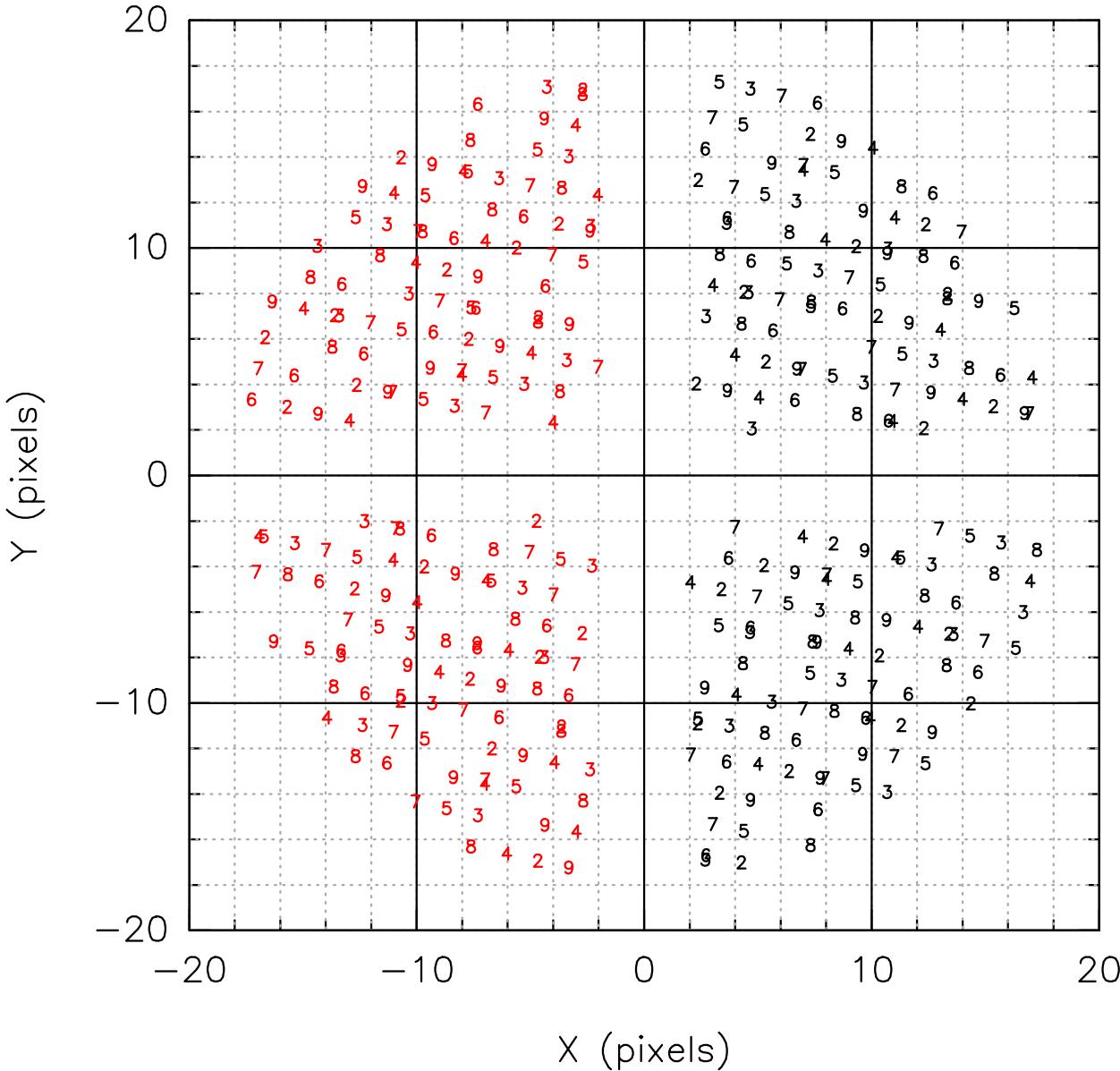


“Optimal” dither positions (pixel phases)





# JWST Coordinated Parallels: Custom Dither Patterns

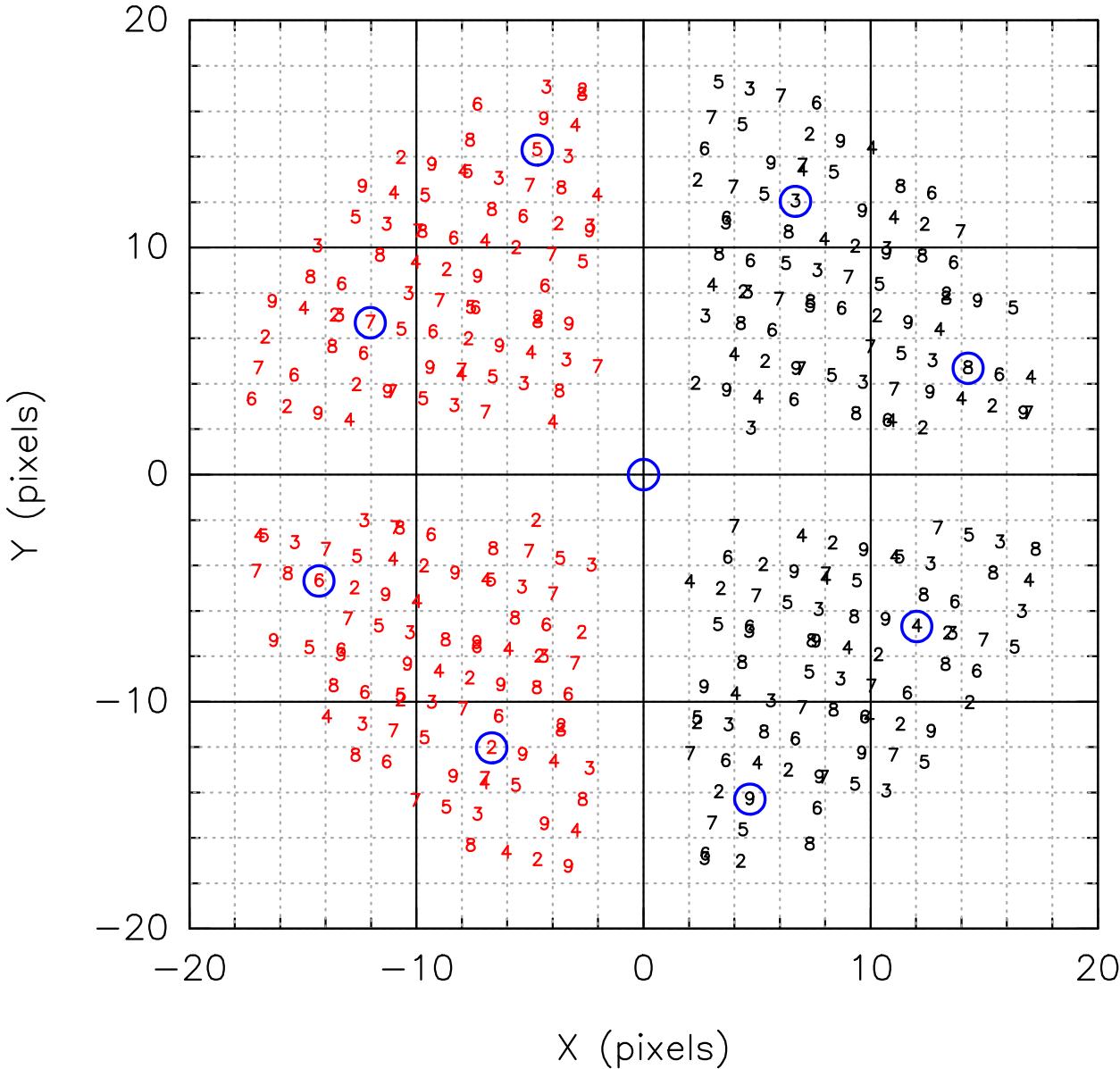


NIRISS + MIRI/F560W 9-pt

- $\varphi_{sep} < 0.05$
- $0.33 \leq \text{Radius/arcsec} \leq 2.0$



# JWST Coordinated Parallels: Custom Dither Patterns

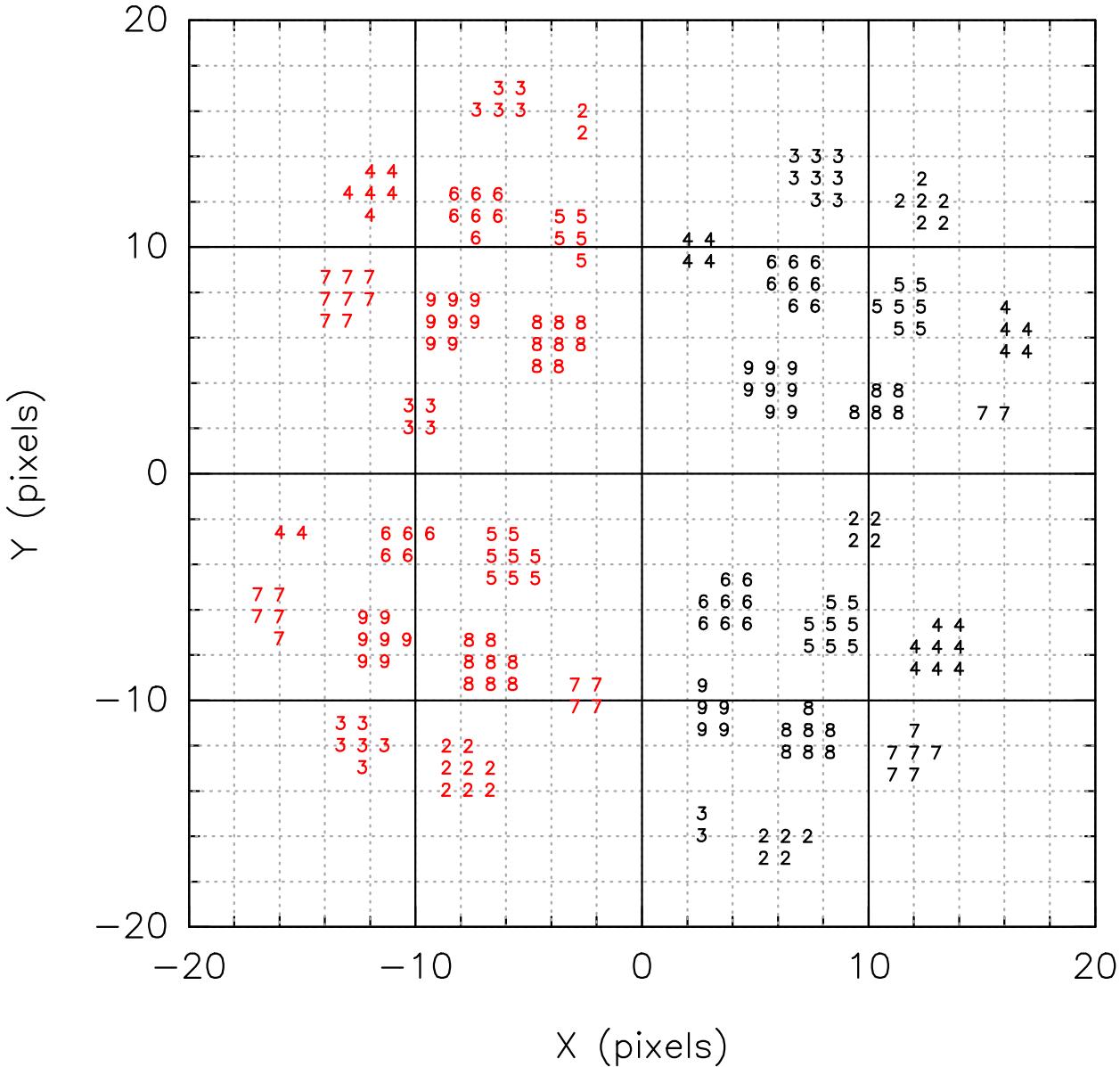


NIRISS + MIRI/F560W 9-pt

- $\varphi_{sep} < 0.05$
- $0.33 \leq \text{Radius/arcsec} \leq 2.0$
- $\Delta X, \Delta Y \geq 2$  pixels from all other dithers
- Radius  $\geq 0.33$  arcsec from all other dithers



# JWST Coordinated Parallels: Custom Dither Patterns

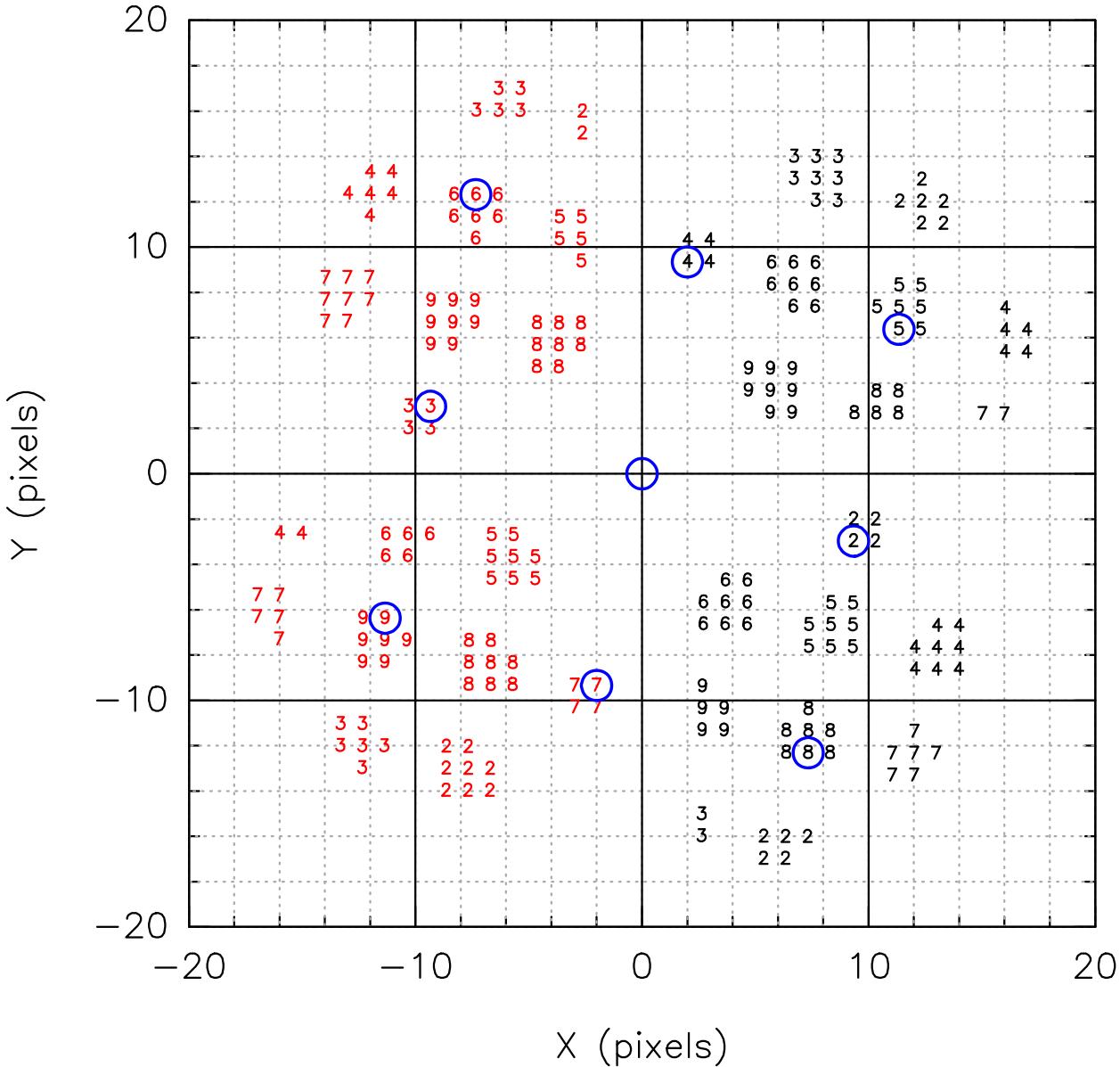


NIRCam SW + NIRISS 9-pt (medium throws)

- $\varphi_{\text{sep}} < 0.05$
- $0.2 \leq \text{Radius/arcsec} \leq 1.2$



# JWST Coordinated Parallels: Custom Dither Patterns



NIRCam SW + NIRISS 9-pt (medium throws)

- $\varphi_{\text{sep}} < 0.05$
- $0.2 \leq \text{Radius/arcsec} \leq 1.2$
- $\Delta X, \Delta Y \geq 2$  pixels from all other dithers
- Radius  $\geq 0.2$  arcsec from all other dithers



# JWST Coordinated Parallels: Custom Dither Patterns



- Wishes / aims:
  - Pixel phase sampling
  - Dither step sizes
  - Choice of dither patterns
  - However, science
- Approach:
  - MIRI, NIRCam,
    - ✓ Introduce large
    - ✓ For NIRCam
    - ✓ For combined
  - NIRSpec MOS
    - ✓ Sub-pixel dithering
    - ✓ Small 2-pt

