NIRSpec IFU Dither and Nod Patterns

The JWST NIRSpec integral field unit (IFU) spectroscopy mode has simple nodding and dithering patterns available in with 2- or 4-point positions. Alternatively, the cycling pattern options can each use up to 60 unique offset positions at small (<0.25"), medium (0.5") or large (1") spatial scales.

Dither and nod options for NIRSpec IFU

> *Parent articles: NIRSpec Operations → NIRSpec Dithers and Nods*
> *See also: NIRSpec Dithering Recommended Strategies, NIRSpec MSA Leakage Correction for IFU Observations, NIRSpec MSA Leakage Subtraction Recommended Strategies*

The NIRSpec integral field unit (IFU) spectroscopy mode has several dither and nod options available. The IFU dither and nod pattern positions are designed to optimize the sub-spatial element sampling in both dimensions. Additionally dithers and nods can help mitigate the effects of light leakage through the MSA.

Dithers are smaller offsets of the target position that will be used to mitigate detector effects and help remove cosmic rays.

In IFU mode, nods are larger offsets that enable subtraction of the exposures for background removal. The nod options are best used for targets that are not significantly spatially extended on the scale of the offset.

The primary difference between dithers and nods is that dithered exposures will not be used for background subtraction by the calibration pipeline. The user can add another exposure specification for a separate background observation that can be subtracted from the dithered science exposures. This strategy is described as an off-scene nod option in the article NIRSpec Dithering Recommended Strategies.

IFU nod and dither options can provide between one to 60 exposures: one exposure results from the no dithering option, and 60 offset exposures will be acquired if the full IFU cycling pattern is used. The IFU dither and nod pattern positions are designed to optimize the sub-spatial element sampling in both dimensions. Table 1 defines the dither and nod options for NIRSpec IFU Spectroscopy. The NIRSpec IFU dither and nod options are also illustrated in Figure 1.

> In addition to using dither patterns to improve sampling, remove cosmic rays, and remove detector effects, IFU users can also:
>
> - Use mosaic tools to tile multiple IFU positions to map larger spatial regions.
> - Take advantage of target groups for multiple discontinuous pointings. The use of target groups to provide an off-scene background measurement is described in the article NIRspec Dithering Recommended Strategies

Table 1. NIRSpec IFU dither and nod options

Offset option	APT *Dither Type* values	Description	
No dither or nod	***NONE*** [1]	No dithering or nodding is performed. The target is positioned at the IFU aperture center.	
2-point nod	***2-POINT-NOD***	Two points separated by ~1.6" in both X and Y directions (see Figure 1). Both points lie within less than one IFU aperture of each other, so there will be some overlap in their fields. Nods will specifically be used to subtract in-field background flux in the pipeline. Nods should only be used on point-like and compact sources (with less than 0.2"–0.3" extents).	
4-point dither	***4-POINT-DITHER***	Four points constituting a box that is ~0.4" on a side (see Figure 1). The 4 points in the dither pattern have 0.025" sub-slice offsets to allow for improved sampling of the spatial point spread function (PSF). All 4 points lie within less than 1 IFU aperture of each other, so there will be some overlap in the fields.	
4-point nod	***4-POINT-NOD***	Four points constituting a box that is ~1.6" on a side (see Figure 1), but nods will specifically be used to subtract in-field background flux in the pipeline. Nods should only be used on point-like and compact sources (less than 0.2"–0.3" extents).	
Cycling patterns	The ***CYCLING*** and ***SPARSE-CYCLING Dither Type*** options allow access to dither positions in 60-point cycling patterns. If one of these is selected, the user must specify the pattern size, ***Size***, which is available in three spatial scales: ***SMALL*** (0.25" extent), ***MEDIUM*** (0.5" extent), and ***LARGE*** (1.0" extent). For the **CYCLING** option, users must also choose the ***STARTING POINT*** and ***NUMBER OF POINTS*** parameter values. For ***SPARSE-CYCLING***, values should be entered for the ***POINTS*** parameter.		
	CYCLING	***Size***	Available in three spatial scales: ***SMALL*** (0.25" extent), ***MEDIUM*** (0.5" extent), and ***LARGE*** (1.0" extent).
		Starting Point	An integer from 1 to 60. It specifies the index of the starting point. If ***Starting Point*** is defined, ***Number of Points*** must also be defined.

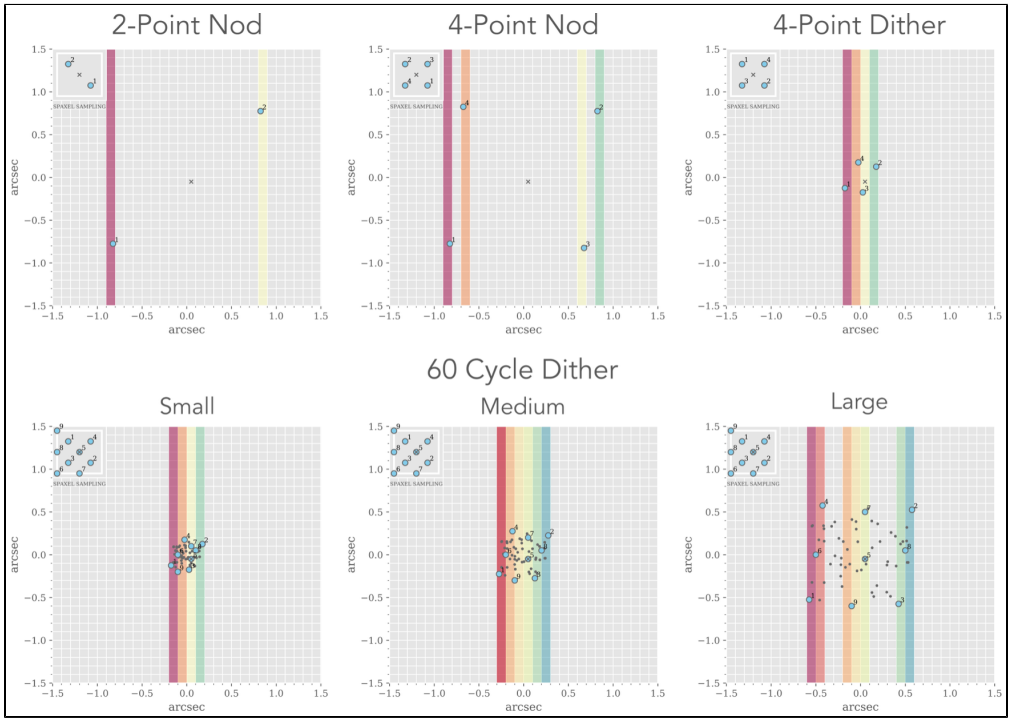
		Number of Points	An integer from 1 to 60, and less than or equal to 60 minus ***Starting Point***. This specifies the number of points of the cycling pattern to execute in sequence.
	SPARSE-CYCLING	***Size***	Available in three spatial scales: ***SMALL*** (0.25" extent), ***MEDIUM*** (0.5" extent), and ***LARGE*** (1.0" extent).
		Points	A list of the specific indices from the cycle table, that represent the desired dithers (see Table 3). This is an alternative way (compared to ***Starting Point*** plus ***Number of Points***) for the user to specify a list of selected points from the cycling table.

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

Note that the 2-point nod and 4-point nod positions span approximately twice the area covered by the largest cycling pattern. The positions in the IFU dither and nod options are presented in Table 2 and Table 3 below. Because the source is closer to the IFU corners in these cases, use of these patterns without target acquisition (i. e. ***TA Method*** "***Verify_Only***" or "***None***") is not recommended. (For more information see NIRSpec Dithering Recommendations.)

The first nine positions in each of the small, medium and large cycling patterns were designed to provide N-point dither options (N from 2 to 9). For example, selecting ***CYCLING***, ***SIZE*** = ***SMALL***, ***Starting Point*** = 1 and ***Number of Points*** = 4 will give a 4-point dither with 0.25" spatial extent with spatial PSF optimizing sub-pixel offsets.

Figure 1. IFU nod and dither patterns



Options for nod and dither pattern field positions with the NIRSpec IFU. The 2-point or 4-point nods can be used to move compact sources in the aperture for in-field background subtraction. The 4-point dither is intended for extended sources and will not execute in-field background subtraction. In the 60-point cycling patterns, as many as 60 dithers can be selected with pattern extents of 0.25", 0.5" or 1". The light blue points highlight the first nine positions in the 60-point cycling patterns. These can be selected as 2- to 9-point dither patterns using the first 2 to 9 points in the cycling pattern.

Table 2. IFU dither and nod positions

Dither Type	Position index	X (dispersion)	Y (spatial)
NONE	1	0.000	0.000
2-POINT-NOD	1	-0.825	-0.775
	2	0.825	0.775
4-POINT-DITHER	1	-0.175	-0.125
	2	0.175	0.125
	3	0.025	-0.175
	4	-0.025	0.175
4-POINT-NOD	1	-0.825	-0.775
	2	0.825	0.775
	3	0.675	-0.825
	4	-0.675	0.825

Click here to open Table 3 with Cycling dithers

Table 3. IFU dither cycling positions for the small, medium, and large patterns

Scroll across to see all columns

Dither Type	Position index	*Small*		*Medium*		*Large*	
		X (dispersion)	Y (spatial)	X (dispersion)	Y (spatial)	X (dispersion)	Y (spatial)
CYCLING or ***SPARSE-CYCLING***	1	-0.175	-0.125	-0.275	-0.225	-0.575	-0.525
	2	0.175	0.125	0.275	0.225	0.575	0.525

3	-0.025	-0.175	0.125	-0.275	0.425	-0.575
4	-0.025	0.175	-0.125	0.275	-0.425	0.575
5	0.05	-0.05	0.05	-0.05	0.05	-0.05
6	-0.1	0	-0.2	0	-0.5	0
7	0.05	0.1	0.05	0.2	0.05	0.5
8	0.1	0.05	0.2	0.05	0.5	0.05
9	-0.1	-0.20001	-0.1	-0.30001	-0.1	-0.60001
10	-0.0108	-0.0516	-0.018	-0.086	-0.0396	-0.1892
11	0.1062	0.0588	0.177	0.098	0.3894	0.2156
12	0.0348	-0.1206	0.058	-0.201	0.1276	-0.4422
13	-0.1482	0.0912	-0.247	0.152	-0.5434	0.3344
14	0.0498	-0.0984	0.083	-0.164	0.1826	-0.3608
15	0.0342	0.1074	0.057	0.179	0.1254	0.3938
16	-0.066	0.0522	-0.11	0.087	-0.242	0.1914
17	-0.1362	0.0054	-0.277	0.009	-0.4994	0.0198
18	-0.0138	0.1056	-0.023	0.176	-0.0506	0.3872
19	-0.0588	-0.0108	-0.098	0.018	-0.2156	-0.0396
20	-0.1116	0.0828	-0.186	0.138	-0.4092	0.3036
21	0.0804	-0.033	0.134	-0.055	0.2948	-0.121
22	0.1086	-0.036	0.181	-0.06	0.3982	-0.132
23	0.0168	-0.03	0.028	-0.05	0.0616	-0.11
24	-0.111	0.0432	-0.185	0.072	-0.407	0.1584
25	0.129	0.042	0.215	0.07	0.473	0.154
26	0.0024	-0.0486	0.004	-0.081	0.0088	-0.1782
27	-0.078	0.0036	-0.13	0.006	-0.286	-0.0132
28	0.093	0.0708	0.155	0.118	0.341	0.2596
29	-0.0402	0.0168	-0.067	0.028	-0.1474	0.0616
30	-0.06	-0.0318	-0.1	-0.053	-0.22	-0.1166
31	0.0228	0.1476	0.038	0.246	0.0836	0.5412

32	0.1404	0.0438	0.234	0.073	0.5148	0.1606
33	0.141	0.087	0.235	0.145	0.517	0.319
34	0.1452	-0.0246	0.242	-0.041	0.5324	-0.0902
35	-0.1464	0.093	-0.244	0.155	-0.5368	0.341
36	0.0354	0.0222	0.059	0.037	0.1298	0.0814
37	-0.1482	-0.0882	-0.247	-0.147	-0.5434	-0.3234
38	0.0828	-0.0222	0.138	-0.037	0.3036	-0.0814
39	-0.111	-0.0888	-0.185	-0.148	-0.407	-0.3256
40	-0.1272	0.0474	-0.212	0.079	-0.4664	0.1738
41	-0.0564	-0.1014	-0.094	-0.169	-0.2068	-0.3718
42	-0.0132	0.0816	-0.022	0.136	-0.0484	0.2992
43	0.0594	0.042	0.099	0.07	0.2178	0.154
44	-0.0462	-0.0402	-0.077	-0.067	-0.1694	-0.1474
45	-0.0786	0.1044	-0.131	0.174	-0.2882	0.3828
46	0.1422	-0.0246	0.237	-0.041	0.5214	-0.0902
47	-0.0882	0.0906	-0.147	0.151	-0.3234	0.3322
48	-0.0264	0.1122	-0.044	0.187	-0.0968	0.4114
49	-0.0918	-0.03	-0.153	-0.05	-0.3366	-0.11
50	-0.033	-0.03	-0.055	-0.05	-0.121	-0.11
51	-0.0084	0.0414	-0.014	0.069	-0.0308	0.1518
52	-0.0606	-0.0684	-0.101	-0.114	-0.2222	-0.2508
53	0.0912	-0.1326	0.152	-0.221	0.3344	-0.4862
54	0.0798	-0.1194	0.133	-0.199	0.2926	-0.4378
55	-0.1248	-0.1446	-0.208	-0.241	-0.4576	-0.5302
56	0.0522	0.0984	0.087	0.164	0.1914	0.3608
57	-0.1128	0.0924	-0.188	0.154	-0.4136	0.3388
58	-0.0528	0.042	-0.088	0.07	-0.1936	0.154
59	0.1218	0.0342	0.203	0.057	0.4466	0.1254
60	0.0402	-0.1332	0.067	-0.222	0.1474	-0.4884

Notes for Tables 2 and 3: X and Y positions above are expressed as offsets in arcseconds relative to the IFU aperture center. For ***Dither Type*** values other than the cycling options, all of the pointings in the table will be executed. For cycling, the user will additionally need to select a starting point and number of points or a set of index points from this table that represent the dithers to be executed. The tables present values that are representative of the dithers that the user will select. Bear in mind that values might change.