Chapter 31

NIRSpec Integral Field Unit (IFU) Spectroscopy

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31.1 Introduction

The NIRSpec Integral Field Unit (IFU) template is to be used for all observations using the IFU mode of NIRSpec. NIRSpec IFU observations can be used to study moderately extended targets. The IFU offers either the option of the standard MSA target acquisition, or to simply take an image to verify pointing during post-analysis. The parameters described in this section are used to specify the Observations for the NIRSpec IFU. More complete descriptions of the detector readout parameters, filters/dispersers, detector characteristics, etc. are available in the NIRSpec Instrument Handbook; see also Chapter 8 of the document for more details on the NIRSpec Observation Planning tool.

The following fields are defined in Chapter 5: Observation Number (5.1), Observation Label (5.2), Observation Comments (5.3), Target Name (5.4), Observation-Level Special Requirements (5.5), and On Hold Comments (5.6), and will not be discussed in this Chapter.

The NIRSpec Fixed Slit Spectroscopy **[NRS0069]** template consists of the following parameters:

Field	Details	Values	Notes
Dither Pattern			
Slitlet Offset **[NRS0365]**	select number of slitlets for dither	choose from list **[NRS0366]**	see Table 31-1
Sub-Pixel Offset **[NRS0367]**	select dither offset	choose from list **[NRS0368]**	
TA_Method **[NRS0374]**	select mode	TACQ or VERIFY_ONLY **[NRS0375]**	
Target Acquisition			
TACQ Filter **[NRS0072]**	select filter name	choose from list **[NRS0073]**	see Table 31-2
TACQ Readout Pattern **[NRS0074]**	select readout pattern	choose from list **[NRS0075]**	see Table 31-3
MSA TACQ	specify filename(s)		if needed

Configuration Filename(s) **[NRS0076]**	**[NRS0077]**		
Reference Stars **[NRS0078]**	select targets	choose from list **[NRS0079]**	
Pointing Verification Image			
Pointing Verification Image Filter **[NRS0114]**	select filter name	choose from list **[NRS0312]**	see Table 31-2
Pointing Verification Image Readout Pattern **[NRS0313]**	select readout pattern	choose from list **[NRS0314]**	see Table 31-3
Pointing Verification Image Number of Groups **[NRS0315]**	specify number of groups	number **[NRS0316]**	
Pointing Verification Image MSA Configuration Filename(s) **[NRS0317]**	specify filename(s) **[NRS0378]**		If needed
Science Observation			
Science Grating/Filter **[NRS0080]**	select grating/filter name	choose from list **[NRS0081]**	see Table 31-4
Science Readout Pattern **[NRS0082]**	select readout pattern	choose from list **[NRS0083]**	
Science Number of Groups **[NRS0084]**	specify number of groups	number **[NRS0085]**	
Science Number of Integrations **[NRS0086]**	specify number of integrations	number **[NRS0087]**	
Automatic Calibration Option **[NRS0446]**	Select Auto Calibration option	DEFAULT, NONE, WAVECAL **[NRS0447]**	

*Note that **ALL** parameters listed below are required as part of your Phase I submission.*

31.2 NIRSpec Integral Field Unit (IFU) Spectroscopy

The following parameters are used to define NIRSpec Integral Field Unit observations.

31.2.1 Dither Pattern

Most observations with JWST will require dithering. The following parameters define the dither pattern for NIRSpec Integral Field Unit (IFU) Spectroscopy. Note that the dither pattern does **NOT** apply to the target acquisition image **[NRS0369]**.

Two exposures result from all combinations of NIRSpec IFU dither parameters, except for a slitlet offset of **NONE** combined with a sub-pixel offset of **NONE [NRS0370]**. This case only produces a single exposure **[NRS0371]**.

Note for developers: SLITLET OFFSET **[NRS0xxx]** and SUB-PIXEL OFFSET **[NRS0xxx]** should be required fields, and there should be no default value (i.e. do not make NONE the default).

31.2.1.1 Slitlet Offset

SLITLET OFFSET [SLITLET_OFFSET] = NONE [NRS0372], 1 [NRS0373], 3 [NRS0374], 5 [NRS0375]

This parameter specifies the number of IFU slitlets by which to space the dither**.**

31.2.1.2 Sub-Pixel Offset

SUB-PIXEL OFFSET [SUBPIXEL_OFFSET] = NONE [NRS0376], SPECTRAL [NRS0377], SPATIAL [NRS0378], BOTH [NRS0379]

This parameter specifies whether to add an offset in the spectral and/or spatial direction to the magnitude of the move specified by **SLITLET OFFSET** (see Table 31-1).

Table 31-1 Sub-Pixel Dither Offset

Sub-Pixel Dither Offset	Description
NONE	No secondary sub-pixel offset
SPECTRAL	Additional 0.5” offset in the spectral direction
SPATIAL	Additional 1.5” offset in the spatial direction
BOTH	Combined 0.5” spectral and 1.5” spatial offset

Note for developers: see Appendix F3 for dithering details.

31.2.2 Target Acquisition (TA) Method

TA METHOD [TA METHOD] = TACQ [NRS0450] (default) [NRS0451], VERIFY_ONLY [NRS0452]

Select the target acquisition method to be used. The standard MSA TACQ is used for observations that require precision of 20 mas RMS, such as when observing many point sources with the MSA or moderately extended sources such as high-redshift galaxies. Pointing Verification can be used for observations that do not require greater precision than 100 mas. Pointing Verification meets the requirements for extended objects such as extended solar system objects (comets, Jovian planets).

Note for developers: TA METHOD is a required parameter **[NRS0453]**. If TACQ is selected, APT should accept Target Acquisition parameters below **[NRS0454]**. If VERIFY_ONLY is selected, APT should accept Pointing Verification Image parameters below **[NRS0455]**.

31.2.2.1 Target Acquisition

If **TA METHOD = TACQ** then the following parameters are used to define NIRSpec Target Acquisition observations. Note that, after the acquisition is complete, a reference image will be obtained to allow observers to check the status of the acquisition.

31.2.2.1.1 Target Acquisition Filter

Select the name of the **TACQ FILTER** [TACQ FILTER] (see Table 31-2) you wish to use for target acquisition.

Table 31-2 Filters Available for NIRSpec Target Acquisition

Acq. Filter	Center Wavelength λ_0 (μm)	Filter Bandpass $\Delta\lambda$ (μm)	Comment	TACQ	VERIFY_ONLY
F140X	1.4	1.2	broad band	**[NRS0091]**	**[NRS0095]**
F110W	1.1	0.2	narrow band	**[NRS0092]**	**[NRS0456]**

31.2.2.1.2 Acquisition Readout Pattern

READOUT PATTERN [TACQ PATTERN] = NRS [NRS0093], NRSRAPID [NRS0094]

This field specifies the readout pattern to be used to obtain the acquisition data; see Table 31-3. **NRS** is used for faint targets, while **NRSRAPID** is used for bright targets.

Table 31-3 NIRSpec Acquisition Readout Patterns

Readout Pattern	NGROUP used	Integration Time	Usage
NRS	3	127.2 **[NRS0380]**	default pattern for science
NRSRAPID	3	31.8 **[NRS0381]**	for bright sources

Note for developers: APT will use these values for calculating the overhead for acquisition exposure times: NINTS=1 **[NRS0321]** and NGROUPS=3 **[NRS0322]**. Also, while the SUBARRAY is not explicitly given, its value is FULL for the purposes of calculating exposure time **[NRS0338]**.

31.2.2.1.3 MSA Target Acquisition Configuration Filename

When obtaining acquisition data, the default is to have all MSA shutters open **[NRS0096]**. However, if there are bright stars in the field that you wish to mask out during the target acquisition exposure, you can provide an optional **MSA TACQ CONFIGURATION FILENAME [NRS0097]** [TACQ MSAFILE] which describes the MSA mask to be used to block the light from these stars. This file should be generated by using the MSA Planning tool. If no file is specified, then all shutters will be open.

31.2.2.1.4 Reference stars

Select the reference stars [REFSTARS] (minimum of 8 **[NRS0098]**, maximum of 20 **[NRS0099]**) to be used for analysis of the target acquisition image from those previously entered (see Section 3.3).

Note for developers: the user will choose from a multi-selection window from 8-20 of the reference stars available in the proposal. Ideally this list will be trimmed to only include those in the same region of the sky as the science target, but that is a later requirement. The maximum (20) is a hard limit **[NRS0100]**, but for now make the minimum (8) a warning only **[NRS0101]** (the limit is hard for real usage, but Vicki needs to support fewer stars for testing).

31.2.2.2 Pointing Verification Image

If **TA METHOD = VERIFY_ONLY** then the following parameters are used to define the NIRSpec Pointing Verification Image exposure. This is an image of the MSA field that will be taken after all science exposures and auto calibrations in each visit have completed. This exposure can be used during post-analysis to determine the exact pointing of every exposure within the observation.

31.2.2.2.1 Pointing Verification Image Filter

Select the name of the **POINTING VERIFICATION IMAGE FILTER [POINTING FILTER]** (see Table 31-2) you wish to use for direct image **[see Table 31-2]**.

31.2.2.2.2 Pointing Verification Image Readout Pattern

> **POINTING VERIFICATION IMAGE READOUT PATTERN [POINTING PATTERN] = NRS [NRS0457], NRSRAPID [NRS0458]**

This field specifies the readout pattern to be used to obtain the direct image data; see Table 31-3.

31.2.2.2.3 Pointing Verification Image Number of Groups

POINTING VERIFICATION IMAGE NUMBER OF GROUPS [POINTING NGROUPS] specifies the number of groups in an integration **[NRS0459]**.

31.2.2.2.4 Pointing Verification Image MSA Configuration Filename

When obtaining pointing image data for pointing knowledge, the default is to have all MSA shutters open **[NRS0460]**. However, if there are bright stars in the field that you wish to mask out during the pointing image exposure, you can provide an optional **POINTING VERIFICATION IMAGE MSA CONFIGURATION FILENAME [NRS0461] [POINTING MSAFILE]** which describes the MSA mask to be used to block the light from these stars. This file should be generated by using the MSA Planning tool. If no file is specified, then all shutters will be open.

Note for developers: APT will use these values for calculating the overhead for pointing image exposure times: NINTS=1 **[NRS0462]**. Also, while the SUBARRAY is not explicitly given, its value is FULL **[NRS0463]** for the purposes of calculating exposure time.

31.2.3 Science Observation

The following parameters are used to define NIRSpec IFU science observations.

31.2.3.1 Grating/Filter

For each grating/filter that you use, specify the name of the grating/filter and the exposure duration parameters (Readout Pattern, Number of Groups, and Number of Integrations

Note for developers: users can specify one or more combinations of the parameters below **[NRS0464]**.

31.2.3.1.1 Grating/Filter Name

Select the name of the **GRATING/FILTER [GRATING, FILTER]** (see Table 31-4) you wish to use for the science observations.

Table 31-4 Grating/Filters Available for NIRSpec IFU Observations

Grating/Filter	Center Wavelength λ_0 (μm)	Filter Bandpass $\Delta\lambda$ (μm)	Resolution	Comment	
G140M/F070LP	0.95	0.8	~1000		**[NRS0102]**
G140M/F100LP	1.40	0.8	~1000		**[NRS0103]**
G235M/F170LP	2.35	1.3	~1000		**[NRS0104]**
G395M/F290LP	3.95	2.1	~1000		**[NRS0105]**
G140H/ F070LP	0.95	0.8	~2700		**[NRS0106]**
G140H/F100LP	1.40	0.8	~2700		**[NRS0107]**
G235H/F170LP	2.35	1.3	~2700		**[NRS0108]**
G395H/F290LP	3.95	2.1	~2700		**[NRS0109]**
PRISM/CLEAR	2.8	4.4	~100		**[NRS0110]**

31.2.3.1.2 Science Readout Pattern

READOUT PATTERN [READOUT PATTERN] = NRS [NRS0111] (default) [NRS0112], NRSRAPID [NRS0113]

This field specifies the readout pattern to be used to obtain the science data. **NRS** is used for faint targets, while **NRSRAPID** is used for bright targets.

31.2.3.1.3 Science Number of Groups

NUMBER OF GROUPS [NGROUPS] specifies the number of groups in an integration **[NRS0379]**.

31.2.3.1.4 Science Number of Integrations

NUMBER OF INTEGRATIONS [NINTS] field specifies the number of times the integration is repeated **[NRS0380]**.

Note to developers: while the SUBARRAY is not explicitly given, its value is FULL for the purposes of calculating exposure time **[NRS0339]**.

31.2.4 Autocal Exposure(s)

The following parameters are used to define *optional* autocal exposure(s) in order to compensate for the inaccuracy of the grating wheel sensors during data analysis. Autocal exposure(s) should be selected when the science program will need them to increase wavelength accuracy beyond what is obtainable with the wheel sensors (or in the event of that these sensors perform poorly in flight).

> **AUTO CALIBRATION OPTION [AUTOCAL] = DEFAULT [NRS0318] (default) [NRS0319], NONE [NRS0320], WAVECAL [NRS0465]**

This parameter specifies whether automatic wavelength calibration exposure(s) will be acquired after all science exposure readouts have been obtained for each grating/filter combination.

If **DEFAULT** is chosen, then the current operational recommendation (see Section X.X of the NIRSpec Instrument Handbook for the current recommendation) will be used.

If **NONE** is chosen, then no automatic wavelength calibration exposures will be obtained.

If **WAVECAL** is chosen, the lamp used (see Section X.X of the NIRSpec Instrument Handbook for the choice of lamp) and the exposure time for calibration will be compatible with the selected science grating.