Overview of Time-Series Observation (TSO) Modes

Time-series observations can be taken with all 4 of JWST's instruments using specific imaging and spectroscopic modes.

Introduction

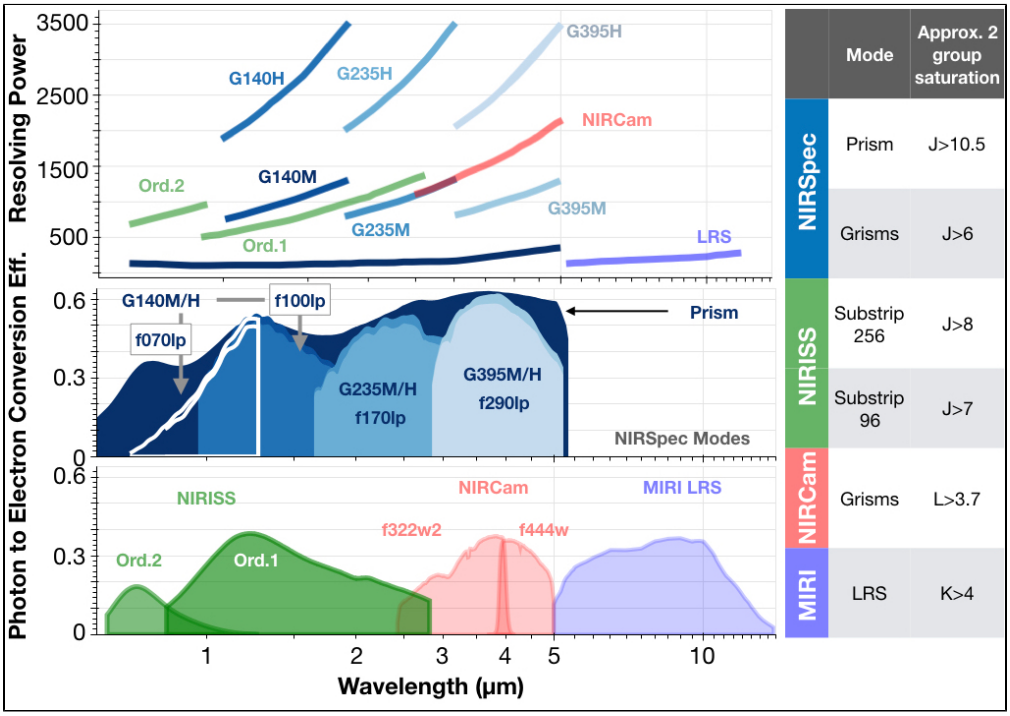
JWST has four instruments on board, three covering the near-infrared part of the spectrum, and one for the mid-infrared regime. Each instrument has at least one TSO-specific mode of observation, offering the user a range of capabilities for such observations. This article describes the basic parameters for these dedicated TSO modes.

As a reminder, the following conditions are enabled for a "TSO":

- dithering is disabled
- target acquisition is enabled (mandatory for some modes)
- exposures can take longer than 10,000 seconds
- high-gain antenna moves are allowed during the exposure
- data are processed via a dedicated, more minimal, pipeline branch (CALTSO3)

A schematic overview of the available modes is shown in Figure 1.

Figure 1. Overview of JWST capabilities for time-series observations (TSOs)



Overview of TSO modes in JWST. This figure does not yet include TSO imaging with MIRI. (Image: N. Batalha)

Modes overview: TSO imaging

> *Main articles: NIRCam Time-Series Imaging, MIRI Imaging*
> *See also: MIRI Imaging TSOs*

For time-series imaging, the only dedicated, fully-supported mode is in NIRCam, which offers simultaneous imaging in the short and long wavelength channels with a range of broad-, medium- and narrowband filters in each channel. In the short wavelength channel, the user can, in addition, select the weak lens WLP8 to increase the dynamic range. Four different array readout configurations are allowed with all of NIRCam's detector read modes. Time-series imaging is also possible with MIRI, though not with full support for all capabilities. Full details on MIRI TSO imaging capabilities and limitations can be found in the MIRI-Specific TSO Strategies article, in this section, and the MIRI TSO Imaging article in the MIRI documentation.

Links are provided below to further documentation articles on these modes and capabilities.

Table 1. TSO imaging is available in NIRCam; limited support for MIRI TSO imaging

Instrument	Mode	Wavelength range (µm)	Filter options	Subarray options	Read mode options
NIRCam	time-series imaging	short: 0.6–2.3 long: 2.4–5.0 (simultaneous)	short: any filter, with/without weak lens WLP8 long: any filter	FULL SUB400P SUB160P SUB64P	RAPID BRIGHT1 BRIGHT2 SHALLOW2 SHALLOW4 MEDIUM2 MEDIUM8 DEEP2 DEEP8
MIRI (limited)	time-series imaging	5.6–25.5	all standard imaging filters available (9)	SUB64 FULL BRIGHTSKY SUB128 SUB256	FAST

Modes overview: TSO spectroscopy

> *Main articles: NIRCam Grism Time Series, NIRISS Single Object Slitless Spectroscopy, NIRSpec Bright Object Time Series Observations, MIRI Low-Resolution Spectroscopy*
> *See also: MIRI LRS TSOs*

For time-series spectroscopy, the near-IR instruments offer three different types of spectroscopic observations. These modes are optimized for stability over long observations, throughput, and dynamic range. In the mid-IR, MIRI provides low-resolution slitless spectroscopy to 12 µm. The table below gives an overview of the available modes.

Table 2. TSO spectroscopy modes

Instrument	Mode	Wavelength range (μm)	Disperser/Filter options	Spectral resolving power	Subarray options	Read mode options
NIRCam	Grism time-series spectroscopy	2.4–5.0	short: • WLP8 + F182M • WLP8 + F187N • WLP8 + F210M • WLP8 + F212N • WLP4+CLEAR* long: GrismR plus a wide filter: • F277W • F322W2 • F356W • F444W	1500	FULL 2048 columns by 64, 128, or 256 pixel rows	Read out through 4 outputs simulatenous or via a single output
NIRISS	Single object slitless spectroscopy (SOSS)	0.6–2.8	CLEAR, GR700XD	700	SUBSTRIP256 (256 × 2048) SUBSTRIP96 (96 × 2048)	NISRAPID

NIRSpec	Bright object time-series spectroscopy (BOTS)	1. 0.7–1.27 2. 0.97–1.89 3. 1.66–3.17 4. 2.87–5.27 5. 0.7–1.27 6. 0.97–1.89 7. 1.66–3.17 8. 2.87–5.27 9. 0.6–5.3	1. G140M /F070LP 2. G140M /F100LP 3. G235M /F170LP 4. G395M /F290LP 5. G140H /F070LP 6. G140H /F100LP 7. G235H /F170LP 8. G395H /F290LP 9. PRISM/CLEAR	combinations 1–4: 1000 combinations 5–8: 2700 combination 9: 100	SUB2048 SUB1024A SUB1024B SUB512 SUB512S	NRSRAPID NRS
MIRI	Slitless low-resolution spectroscopy (LRS)	5–12	double prism (P750L)	100	SLITLESSPRISM	FAST