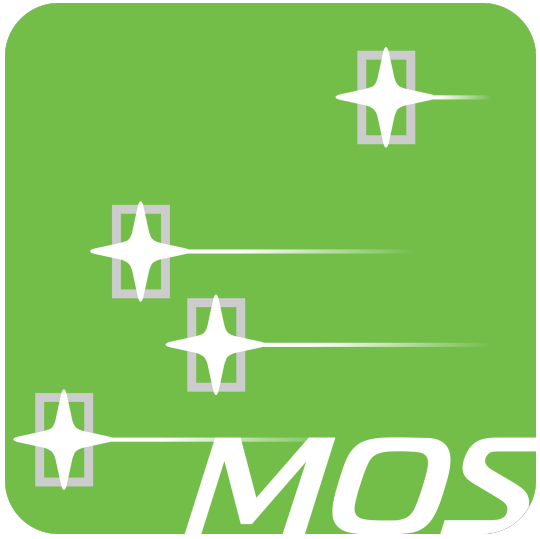
JWST IAC Workshop-GO1 Proposal Planning



NIRSpec Multi-Object Spectroscopy of High-z Galaxies

Tim Rawle (ESA/STScI)

Pierre Ferruit, Giovanna Giardino (ESA/ESTEC)

CENTRO DE ASTROBIOLOGÍA
ASOCIADO AL NASA ASTROBIOLOGY INSTITUTE

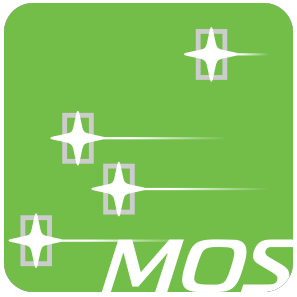
Acknowledgements

This guide makes heavy use of the material prepared for the ESAC "Get Set" workshop in autumn 2017, as well as ETC workbooks and APT files generated by members of the NIRSpec STScI team for the JWST proposal planning workshops in Baltimore and Pasadena in 2017.

https://www.cosmos.esa.int/web/jwst-2017-esac/hands-on-material

https://jwst.stsci.edu/news-events/events/events-area/stsci-events-listing-container/jwst-proposal-and-planning-workshop

https://jwst.stsci.edu/news-events/events/events-area/stsci-events-listing-container/jwst-proposal-and-planning-workshop-1

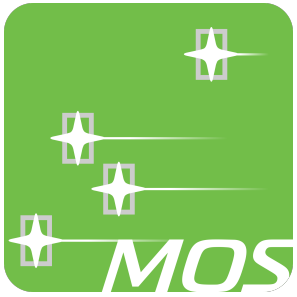


Tools used in this guided preparation

In this proposal preparation example, we will use the following tools:

- The JWST General Target Visibility Tool (GTVT)
- The JWST Exposure Time Calculator (ETC)
- The Astronomer's Proposal Tool (APT)

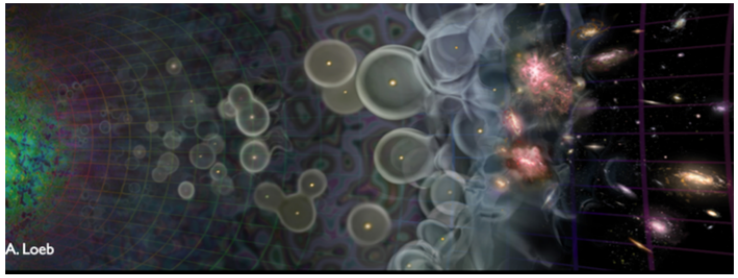
MOS observations also rely heavily on the NIRSpec MOS Planning Tool (MPT), which is part of the APT. An in-depth guide to the usage of MPT was covered yesterday by Giovanna Giardino.

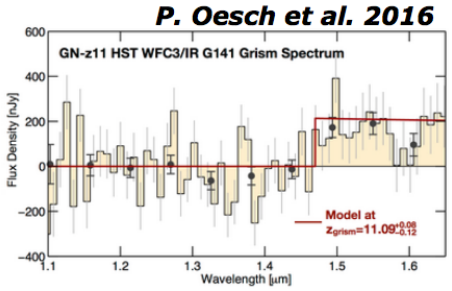


Overview

Goal: This program aims to study the evolution of galaxies from their initial birth (z>10), through the end of the dark ages (z=7-9) and down to the main epoch of galaxy assembly (z=2-6).

- Understanding the very early stages of galaxy formation
- Probing the role of galaxies in the epoch of reionization
- Tracking the build-up of stellar mass, metallicity and the quiescent populations (feedback, quenching)
- Understanding the role of AGNs
- And looking for surprises…





Overview

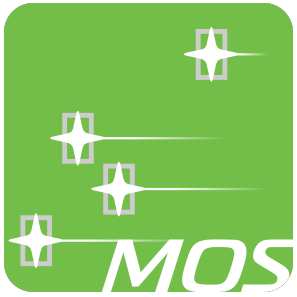
Methodology: An in-depth program of this type would likely combine deep imaging (NIRCam) and follow-up spectroscopy (NIRSpec MOS). A large mosaicked FoV could even allow for parallel NIRCam/NIRSpec.

However, in the following example, we concentrate on the NIRSpec MOS component, by imagining a deep single "pointing" of the MSA, using an input source catalogue derived from existing HST imaging.

Planned observations: single-pointing NIRSpec MOS at low and medium spectral resolution

Type of sources: galaxies over a wide range of redshifts, all assumed to be compact objects

Observations strategy: combination of 3-shutter "slitlet" nodding and dithering



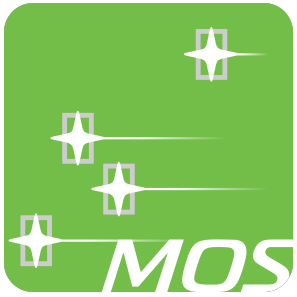
Instrument configurations

Low spectral resolution (CLEAR/PRISM): Sensitivity to continuum; wavelength coverage (0.6 to 5-3 microns in one shot); highest multiplexing

Main drawback: lack of spectral resolution

Medium spectral resolution (F100LP/G140M, F170LP/G235M, F290LP/G395M): Clean separation of emission lines; accurate information on the position of the centroid of the lines

Main drawback: 3 configurations required to cover the 1.0-5.2 micron range; lower multiplexing, unless some overlap of spectra allowed

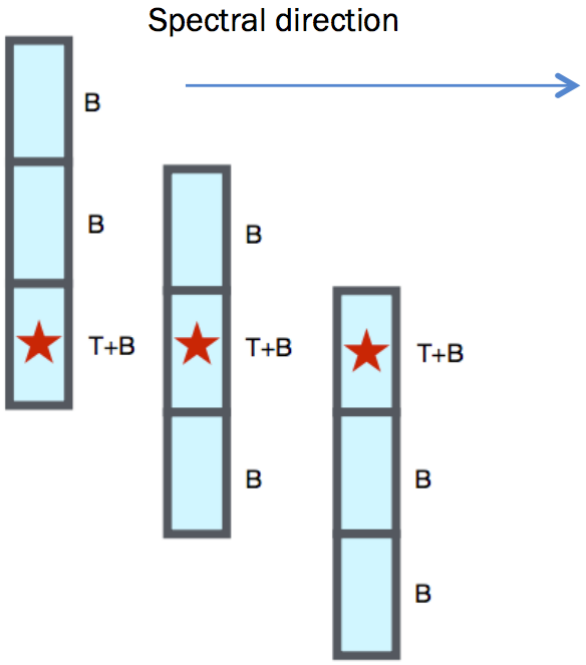


$\Longrightarrow$ Complementary information, so will obtain all 4 optical configurations

Observation strategy – 3-shutter slitlets

3-shutter nodding pattern: In MOS mode, this is the recommended basic pattern for faint and compact sources. It will constitute the basic building block for our observing program.

Each object is assigned a slitlet made from 3 shutters



The baseline strategy is to "nod", i.e. to move the object into each shutter in three consecutive exposures.

For compact objects, this allows powerful exposure-level background subtraction:

[T+B] – 0.5 * ([B]+[B])

In this scheme, the number of exposures is a multiple of 3

Target Visibility Tool: when is HUDF visible?

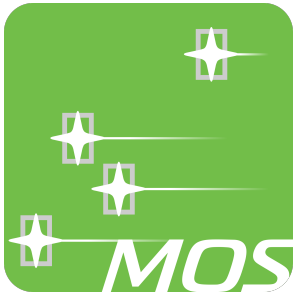
Task: Use the "quick look" General Target Visibility Tool (GTVT) to assess the schedulability of the of field, and to find an approximate PA to use in APT during program preparation.

Field of interest: Hubble Ultra-deep Field (HUDF): 03:32:28.0 -27:48:30

Date (~Cycle 1): 2019-12-01 to 2020-12-01

Instrument: NIRSpec

Additional task: Find whether NIRCam pre-imaging would be possible in the same cycle (a minimum of 4-6 weeks turnaround is required before the NIRSpec component can be executed)



ETC: S/N for an AB=27.5 mag z~6 galaxy observed during 100ks in CLEAR/PRISM?

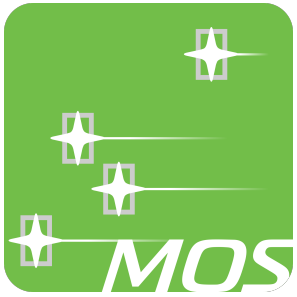
Task: Prepare an ETC simulation for a ~100ks MOS CLEAR/PRISM observation of a z~6 galaxy of AB=27.5 (or ~50nJy) around 2 microns.

Scene and source: single point source; use the Blue Compact Dwarf template spectrum from Brown et al., z=6 and normalize it to AB=27.5 (NIRCam/F150W) or 50 nJy at 2 microns

Background & strategy: medium background at 03:32:28.0 -27:48:30; MSA full shutter extraction

Instrument setup: NIRSpec MOS; CLEAR/PRISM; 3-shutter slitlet; target centered in the micro-shutter

Detector setup: NRSIRS2 (recommended for long exposure and faint-object); ~1.5ks per exposure = 18 groups; total of 72 integrations (multiple of 3)



ETC: S/N for emission lines observed at medium spectral resolution?

Task: Prepare an ETC simulation made of 3 calculations for MOS F100LP/G140M+F170LP/G235M+F290LP/G395M observations of emission lines for a total exposure time of ~100ks

Scene and source: single point source, containing 3 (manually) redshifted emission lines (see below)

Background & strategy: medium background at 03:32:28.0 -27:48:30; MSA full shutter extraction

Instrument setup: NIRSpec MOS; F100LP/G140M, F170LP/G235M, F290LP/G395M; 3-shutter slitlet; target centered in the micro-shutter

Detector setup: NRSIRS2 (recommended for long exposure and faint-object); ~1.5ks per exposure = 18 groups; total of 24+24+24 integrations

Name	Center -	Width -	Strength -
[OII] at z=6	2.61	40	7e-19
CIII[	1.34	40	2.1e-18
Ha at z=6	4.59	40	5.15e-19

Plan your observation strategy before playing with APT/MPT

Task: Prepare an observation layout that you will implement in APT/MPT

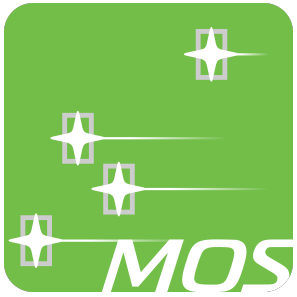
Your inputs: basic building block of 3 exposures corresponding to a 3-shutter nodding scheme; 72 exposures in CLEAR/PRISM; 24 exposures in each medium grating

Your wishes (not necessarily compatible…):

- Obtain each group of 3 nodded exposures at a different detector location (i.e. different slitlets) to minimize systematics and effect from bad pixels
- Maximize the number of objects in all exposures (i.e. most objects should see the complete exposure time) and maximize the total number of objects

$\Longrightarrow$ when dithering, you reduce the effective FoV, which is the intersection of the footprint of each individual dither position

$\Longrightarrow$ reducing the effective FoV reduces the number of objects that can be observed in all exposures



Plan your observation strategy before playing with APT/MPT

What you choose will depend on your science case: for this example program, depth is very important, so we choose to put emphasis on getting as many common objects as possible between exposures. Therefore, we limit the number of dithers and use the fixed-dither option.

Get the layout of the observations: assume that we limit ourselves to 3 dither positions and that each will have a 3-shutter nod. Allocate exposures of each spectral configuration.