Preparing for JWST: a detailed simulation of a MOS deep field with NIRSpec

Giovanna Giardino, Pierre Ferruit, Jacopo Chevallard, Emma Curtis-Lake, Aurelien Jarno, Peter Jakobsen, Arlette Pecontal, Laure Piqeras and the JADES collaboration

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NIRSpec

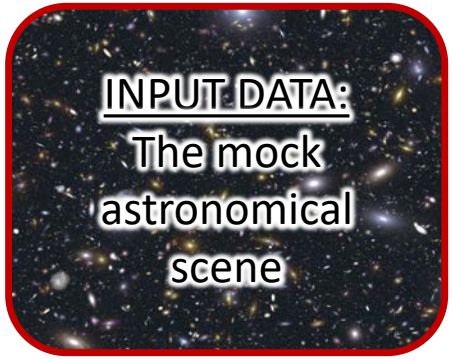
The first multi-object spectrograph (MOS) to fly in space: it will enable the simultaneous measurement of up to 200 spectra over the wavelength range 0.6 - 5.3 μ.

Galaxy assembly

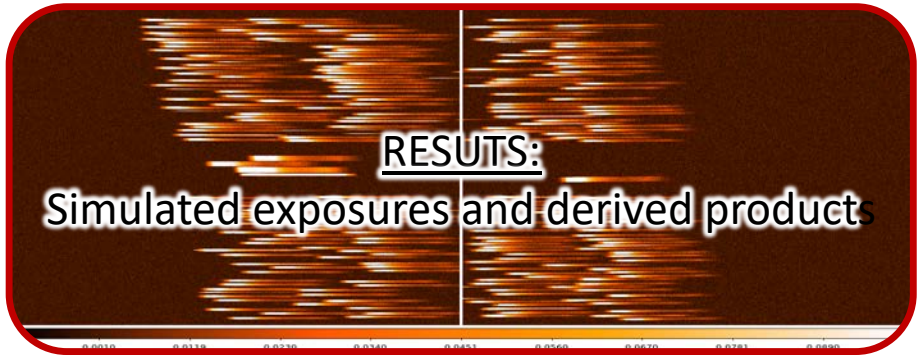
Rest-frame optical properties of large samples of galaxies out to z ~ 9, and the rest-frame UV out to z > 10

Planning

This powerful instrument mode requires careful planning and good understanding of the processing steps to go from the detectors' data to background subtracted, calibrated spectra.



METHOD:
The Instrument Performance Simulator: IPS



We present here a set of simulations closely mimicking the deep spectroscopic observations of high redshift galaxies part of the JADES survey, a joint effort of the NIRCam and NIRSpec GTO teams.

DATA Download WEB Site:

www.cosmos.esa.int/jwst-nirspec-simulations

Navigation Click in 3 rectangles above -right for more information

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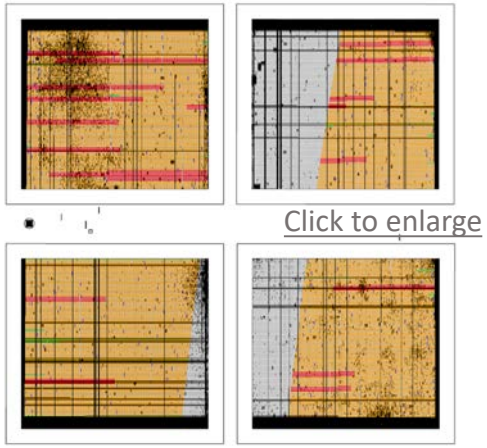
[Input DATA]: The mock astronomical scene

The target sources for the simulation were selected from the fiducial mock catalog of the JAdes extraGalactic Ultradeep Artificial Realizations (JAGUAR) package, developed by Williams et al. 2018 (ArXiv 1802.05272). The catalog was generated using a novel phenomenological model for the evolution of galaxies and their properties, based on empirical constraints from current surveys between $0.2 < z < 10$. The model follows observed stellar mass functions, UV luminosity functions, integrated distributions including $M_{\rm UV}$-$M_\star$, β-$M_{\rm UV}$, and size-mass and size-$M_{\rm UV}$ distributions, and include galaxy SEDs thanks to self-consistent modeling of the stellar and nebular emission with the BEAGLE tool (Chevallard & Charlot, 2016, MNRAS)

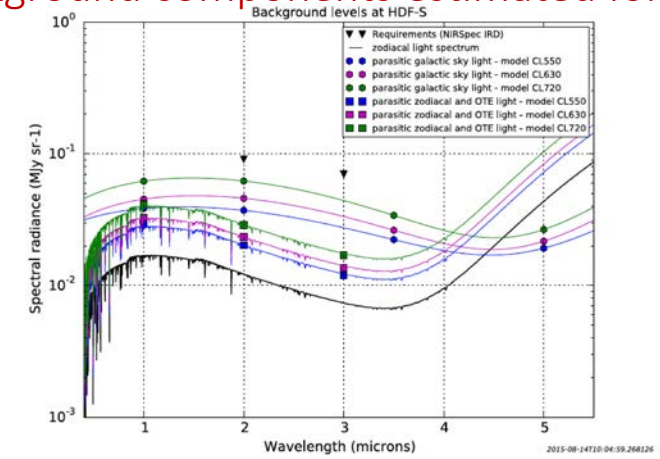
Slit mask of Micro Shutter Array



Click to enlarge

370 targets over 3 dither points (3x1 slitlet)
- 214 targets per dither pointing

Background components estimated for HDF-S



We have modeled the zodiacal light spectrum as a superposition of a reddened spectrum of a solar analogue and a black-body spectrum ($T = 256.15$ K). The level of stray light is a function of the mirror cleanliness levels; in the simulations we adopted CL630.

Click in rectangles for more information:

INPUT DATA: The mock astronomical scene

METHOD: The Instrument Performance Simulator: IPS

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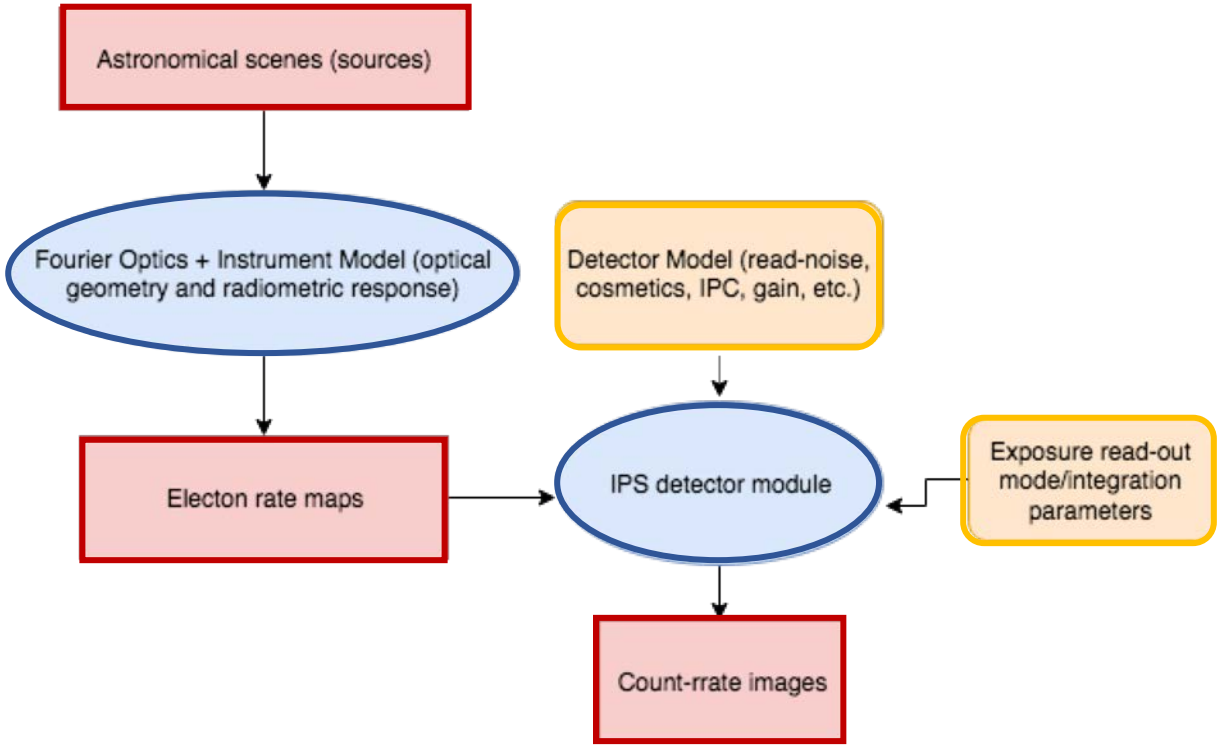
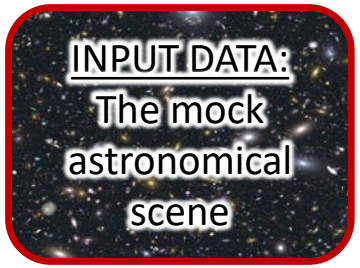


NIRSpec IPS has been developed alongside the instrument itself (Piqueras et al. 2010 SPIE).
It is implemented in C++ and consists of two main components:

- a Fourier Optics wave-propagation module coupled with a detailed model of the instruments optical geometry (Bernhard et al. 2016 A&A) and radiometric response
- a detector module reproducing the noise properties and response of NIRSpec's two H2RG sensors

Click in rectangles for more information:



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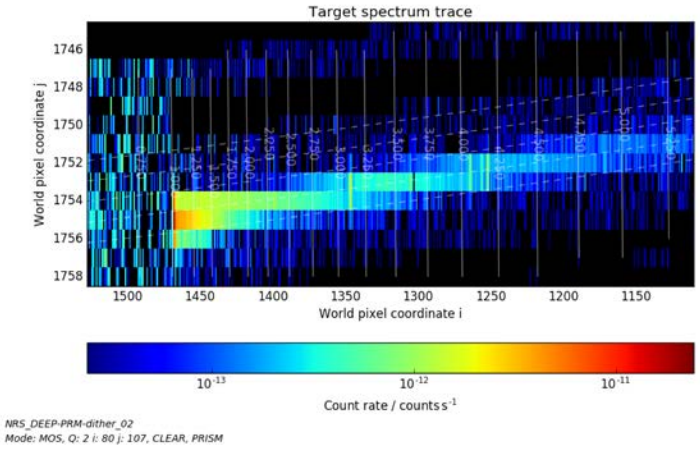
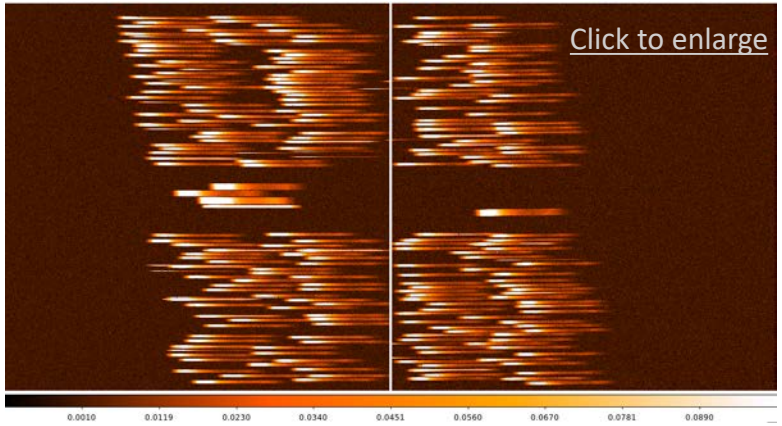
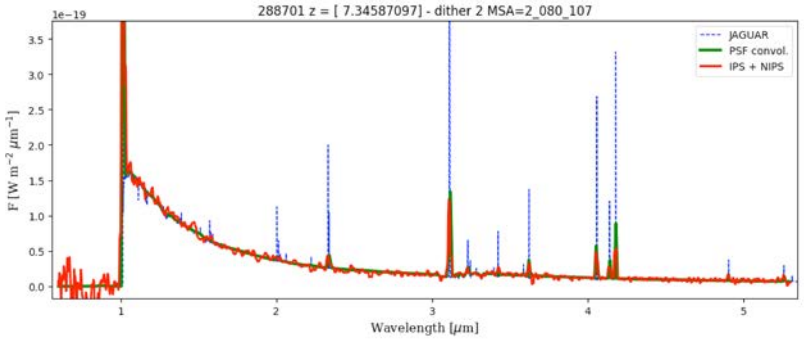
[RESULTS]: Simulated data and derived products

Config.	n. dither	n. nodding	n. exposures	total n. exposures	total int. time
CLEAR/PRISM	3	3	4	36	100,838
G140M/F070LP	3	3	1	9	25,210
G235M/F170LP	3	3	1	9	25,210
G395M/F290LP	3	3	1	9	25,210





Simulated count-rate images for each exposure



Spectrum extracted from simulated image for the prism mode of a (mock) galaxy at z=7.3, with M = 6.5 10^8 M_{sun} and L_{UV} ~ 4.6 10^{28} erg s^{-1}. Noise corresponds to an exposure time of ~33 ks.

Background subtracted products extracted from images:

- Trace (in wavelength-assigned detector pixel)
- 2D Rectified Spectrum
- Collapsed 1D spectrum 1

Click in rectangles for more information:

INPUT DATA: The mock astronomical scene

METHOD: The Instrument Performance Simulator: IPS

RESUTS: Simulated exposures and derived products

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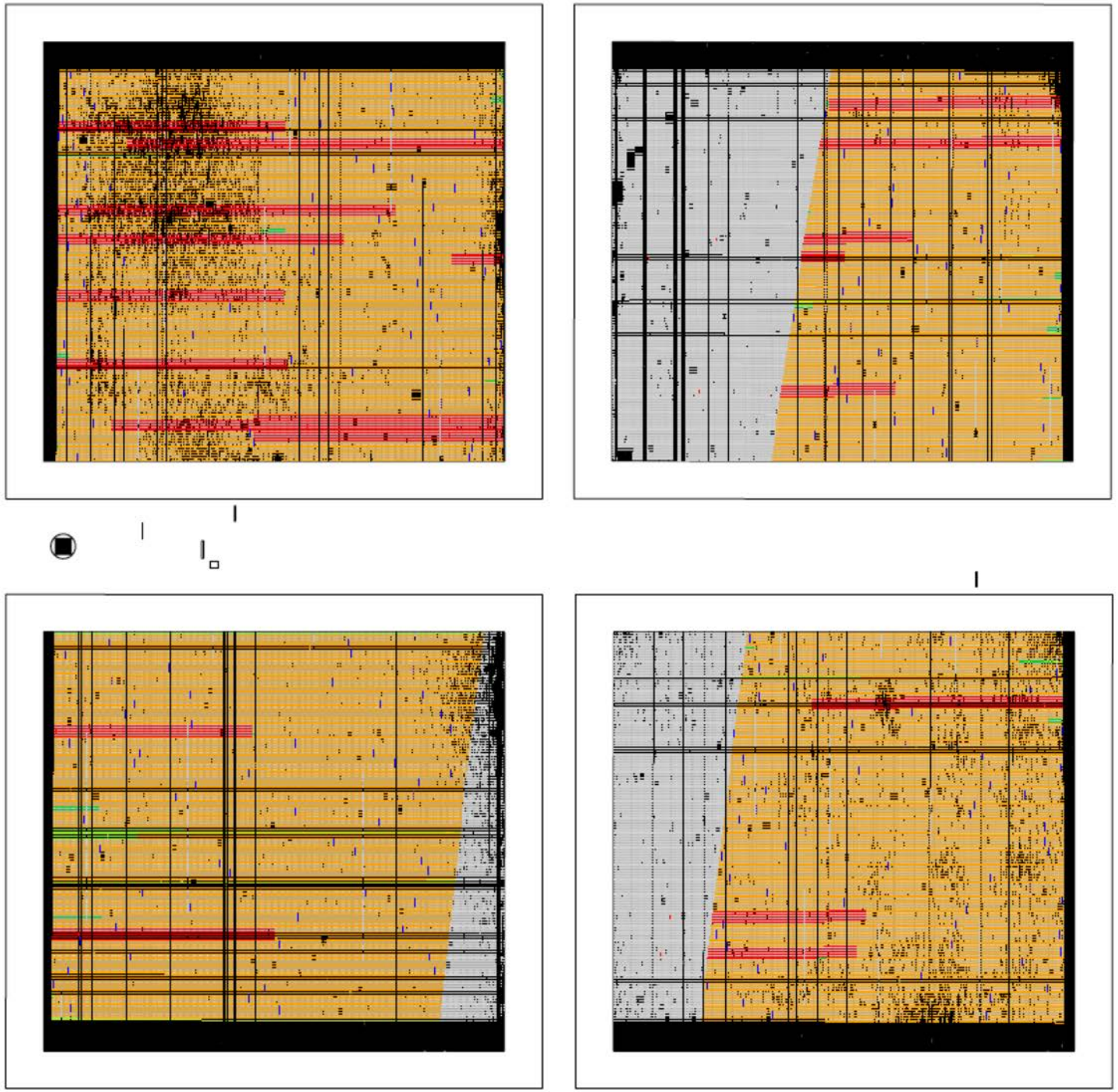
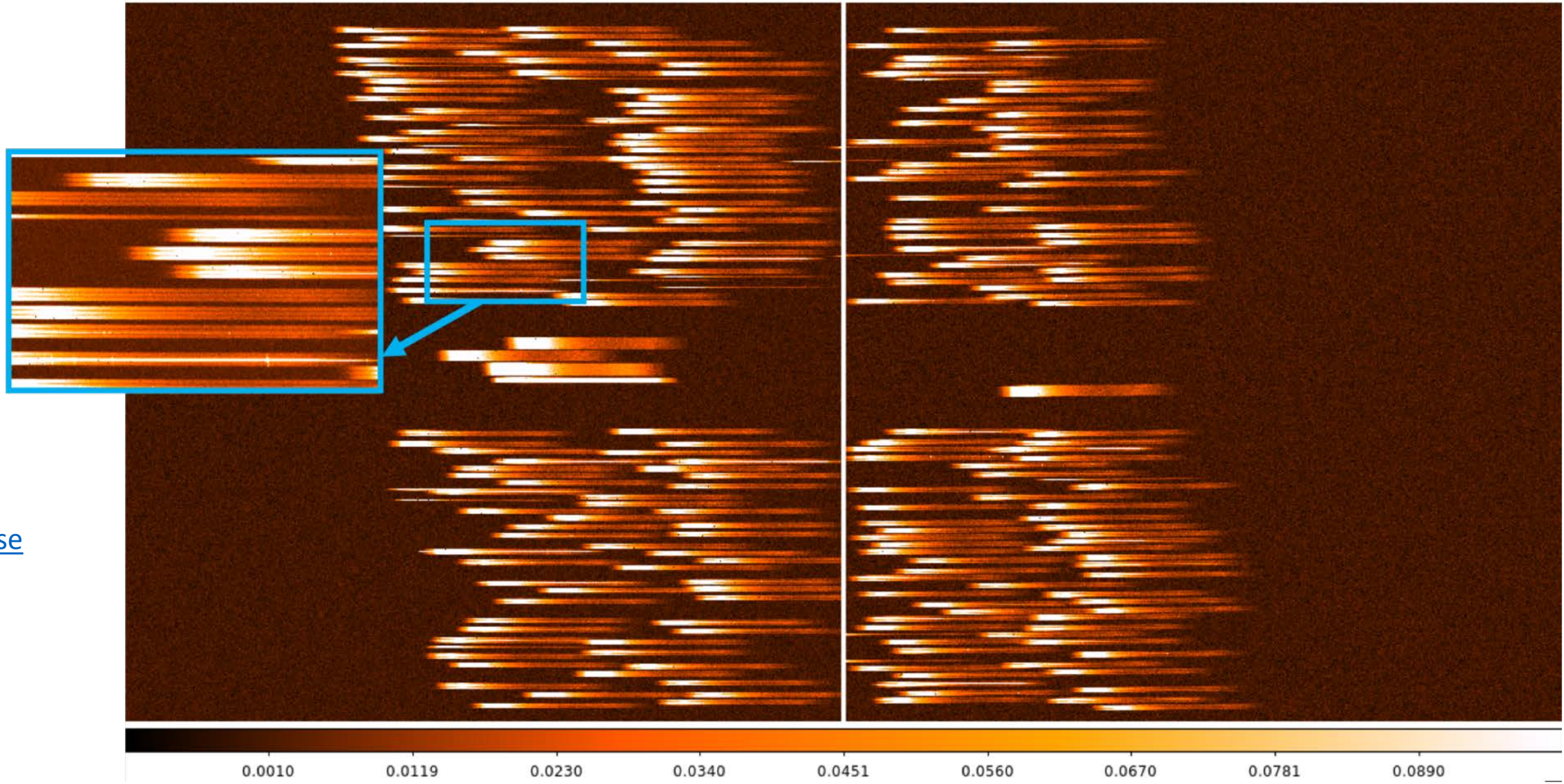


Source assignment to the MSA micro-shutters.

Orange indicate the MSA area used for the search. No source was placed in the gray area to avoid its spectrum to be affected by the detector gap. Green area are unused areas. Red areas could not be used due to the presence of defective shutters that cannot be closed and therefore would lead to the spectra of the targets to be contaminated. Black areas are shutters that are either defective and cannot be opened or deliberately kept closed to prevent electrical shorts in the MSA arrays. The individual slitlets that are being open for the (mock) observation are visible (in color blue).

Close

Close



Count-rate image for one of the simulated prism exposure (for dither 0 and nodding 0).

There are 214 targets packed in this MOS configuration, each one observed within a 3×1 slitlet. The noise level corresponds to that of an individual exposures of 2801 s. The inset provide a zoom-in on some of traces: the spectra of a couple of stronger sources are visible above the background, as well as the spurious signal from one of the defective stuck-open shutters.