

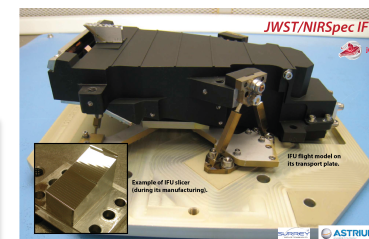
Single Object Spectroscopy and Time Series Observations with NIRSpec

Stephan Birkmann
European Space Agency
"On your mark" JWST Workshop
ESAC, September 26-28, 2016

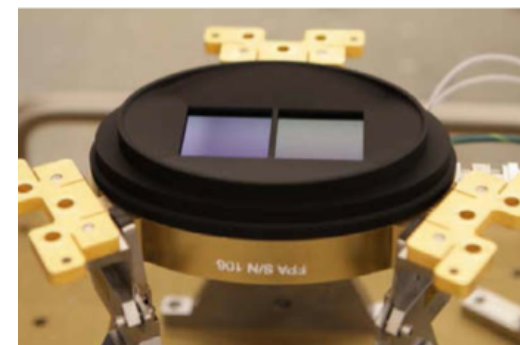
The Near-Infrared Spectrograph (NIRSpec)

❖ Four instrument modes:

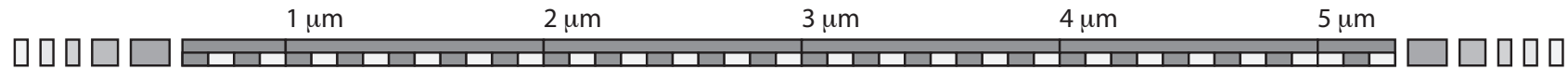
Mode	Target Type	Aperture Mask
Multi-object spectroscopy	Rich fields or extended objects	Selectable from ~250,000 0.2" x 0.46" micro-shutters
Integral-field spectroscopy	Moderately extended objects	3.0" x 3.0" IFU with 0.1" spaxels
Fixed slit spectroscopy	Single (compact) object (high contrast)	0.2" x 3.2" slits (3) 0.4" x 3.65" slit 1.6" x 1.6" aperture
Bright object time series	e.g. Transit/eclipse spectroscopy	1.6" x 1.6" aperture



- ❖ Six gratings and one prism are available as dispersers
- ❖ One mirror for target acquisition in imaging mode
- ❖ NIRSpec's Focal Plane Assembly (FPA) consists of two closely spaced HAWAII-2RG sensor chip arrays with 5.3 μm cut-off wavelength and 100 mas pixels on the sky



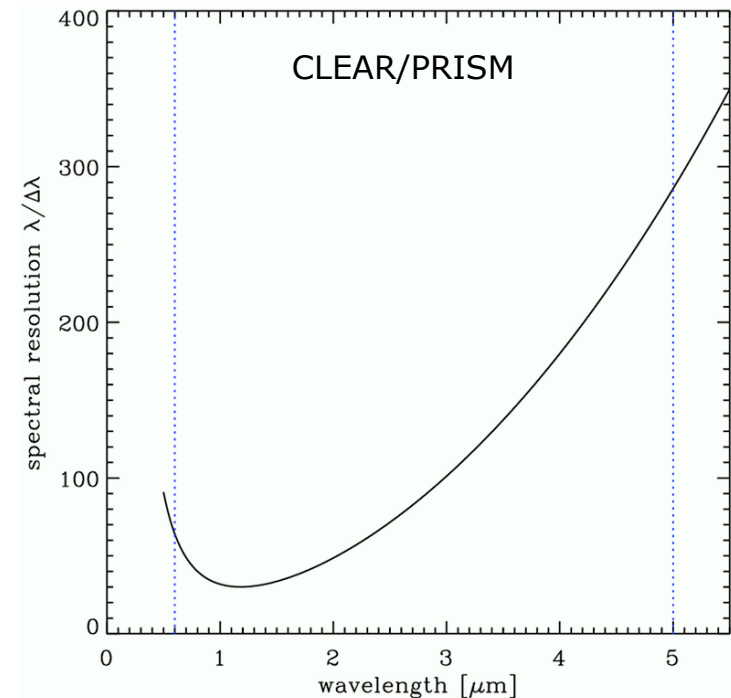
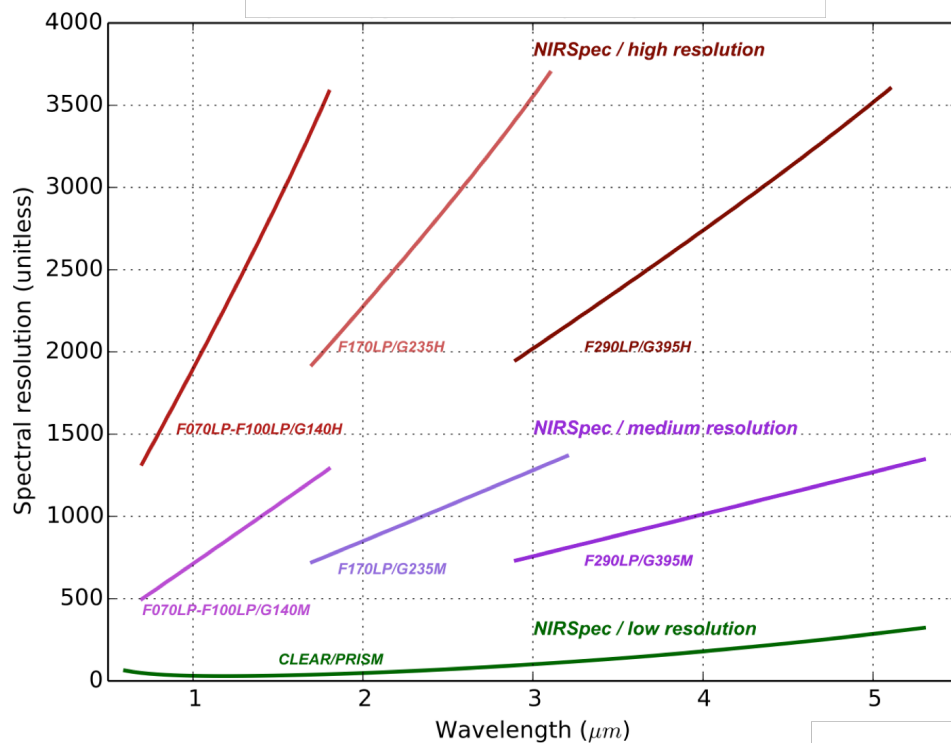
NIRSpec spectral configurations and resolution



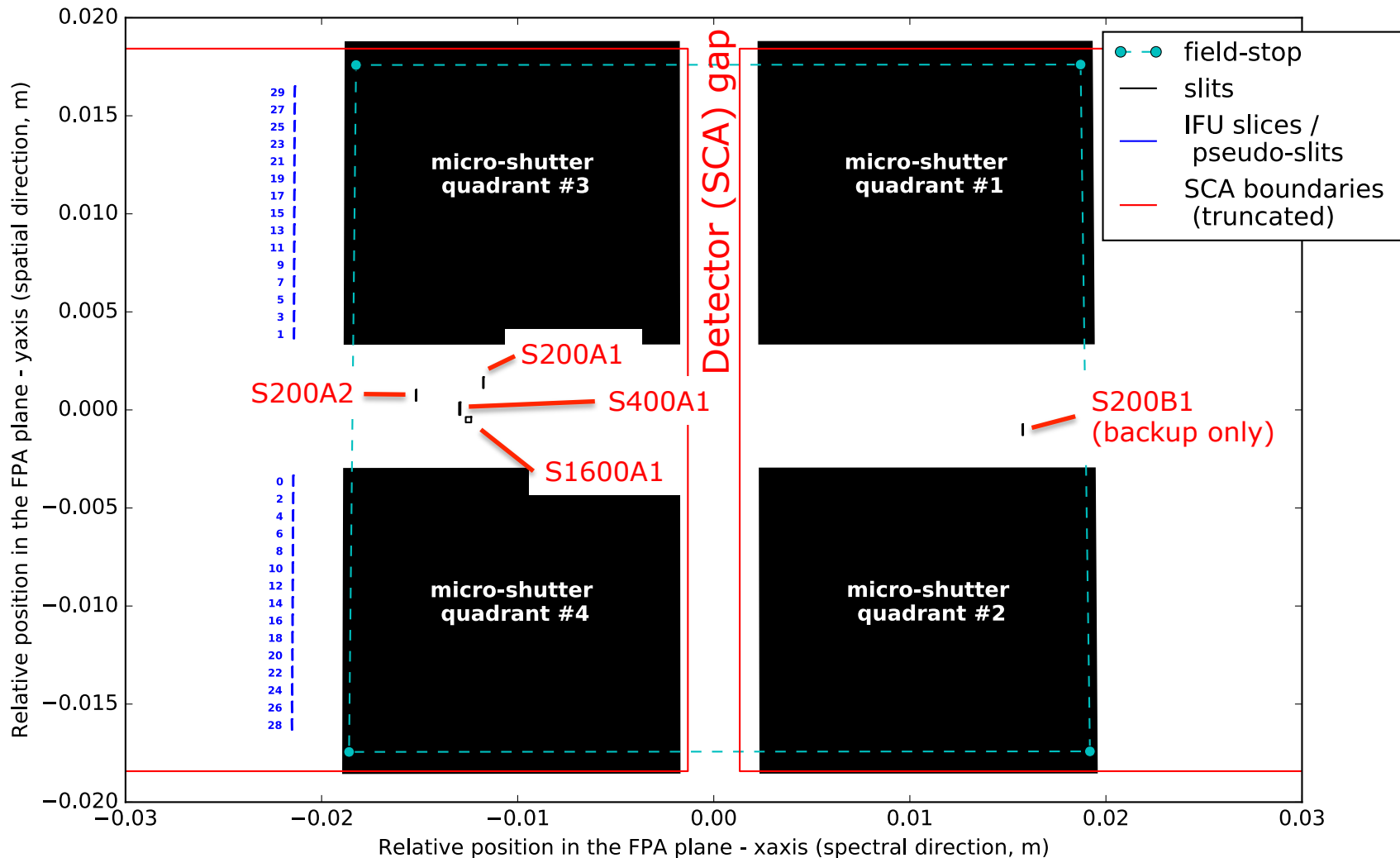
Low spectral resolution configuration



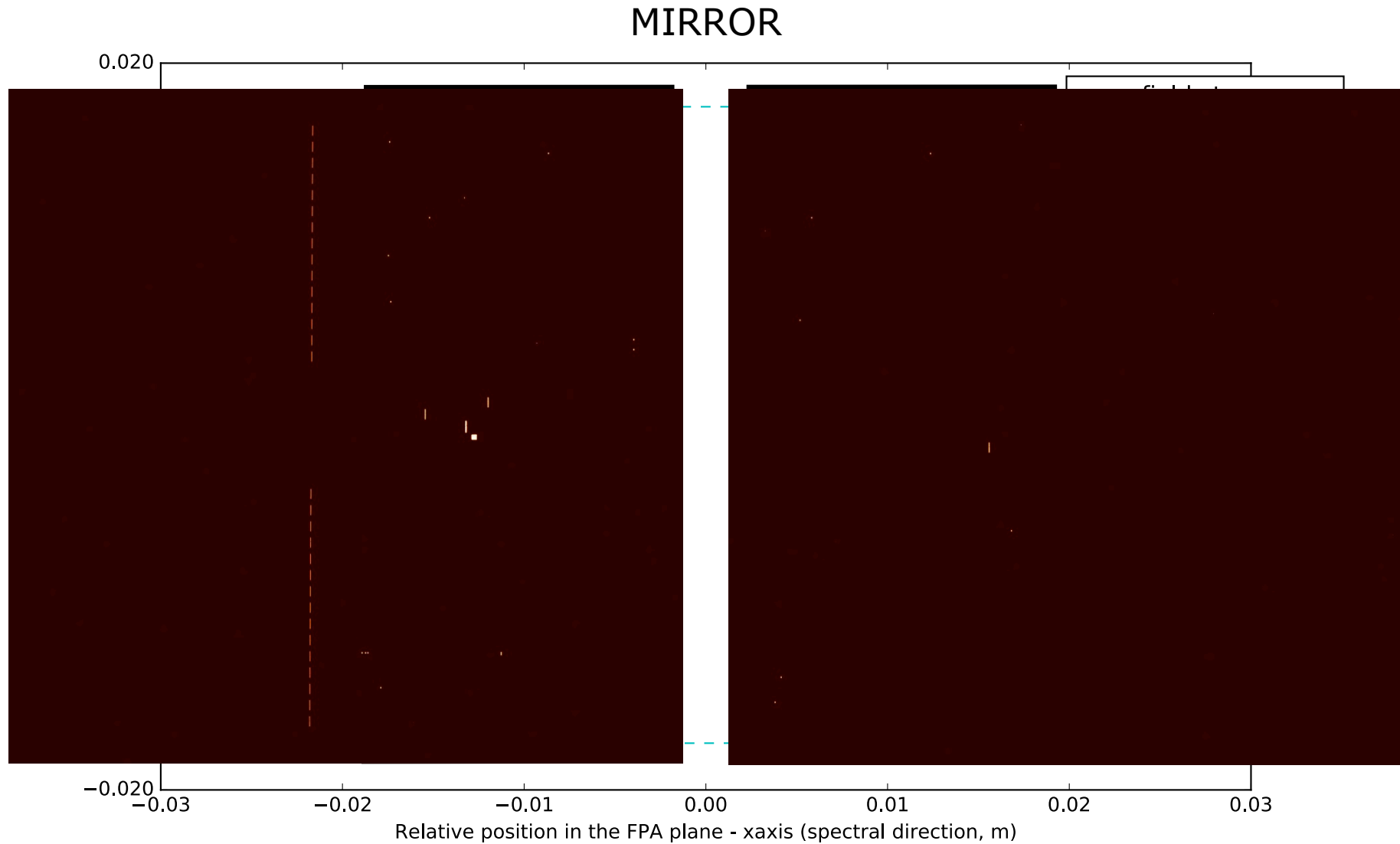
Medium and high spectral resolution configurations



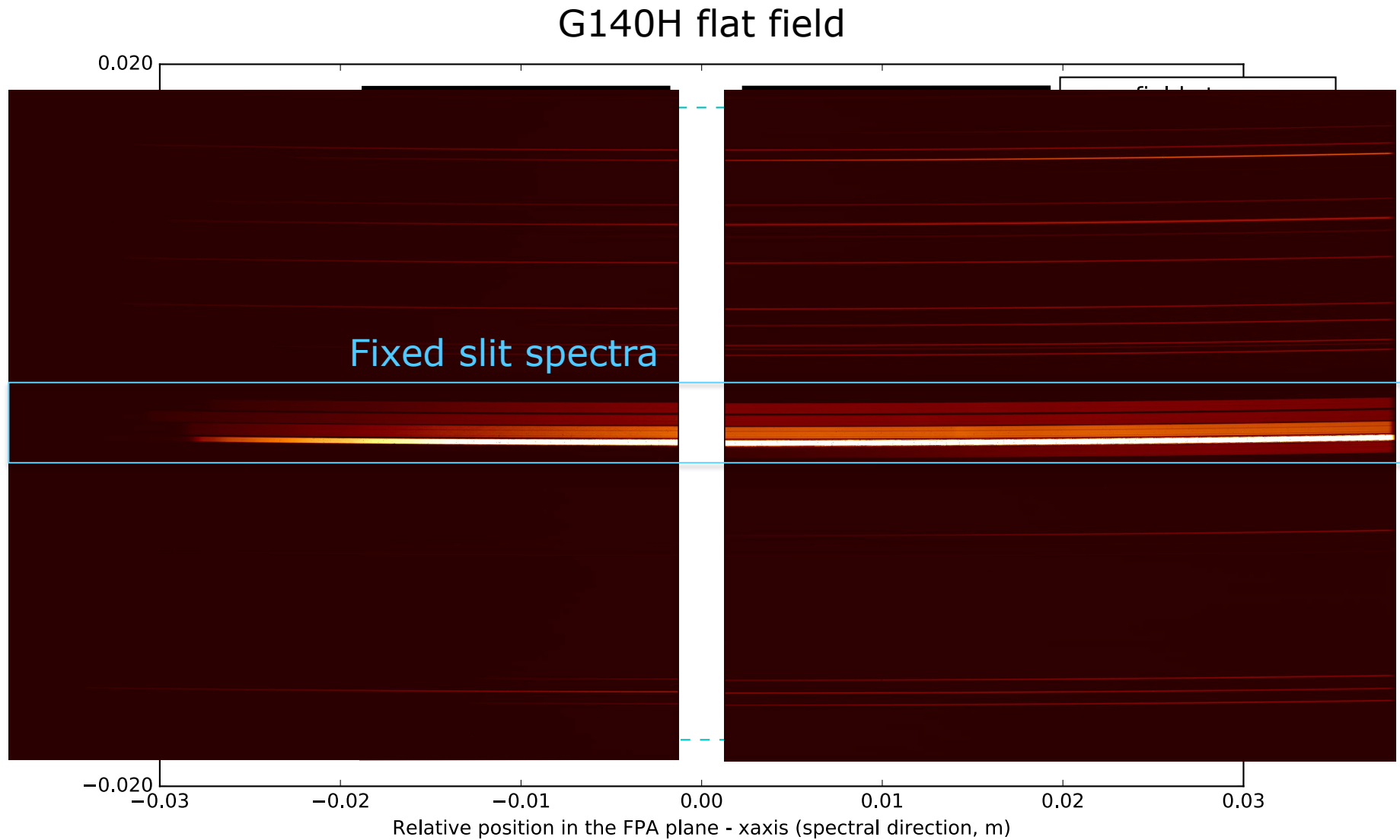
Layout of the NIRSpec field-of-view in the plane of the detectors



NIRSpec's Aperture Layout, Real Data

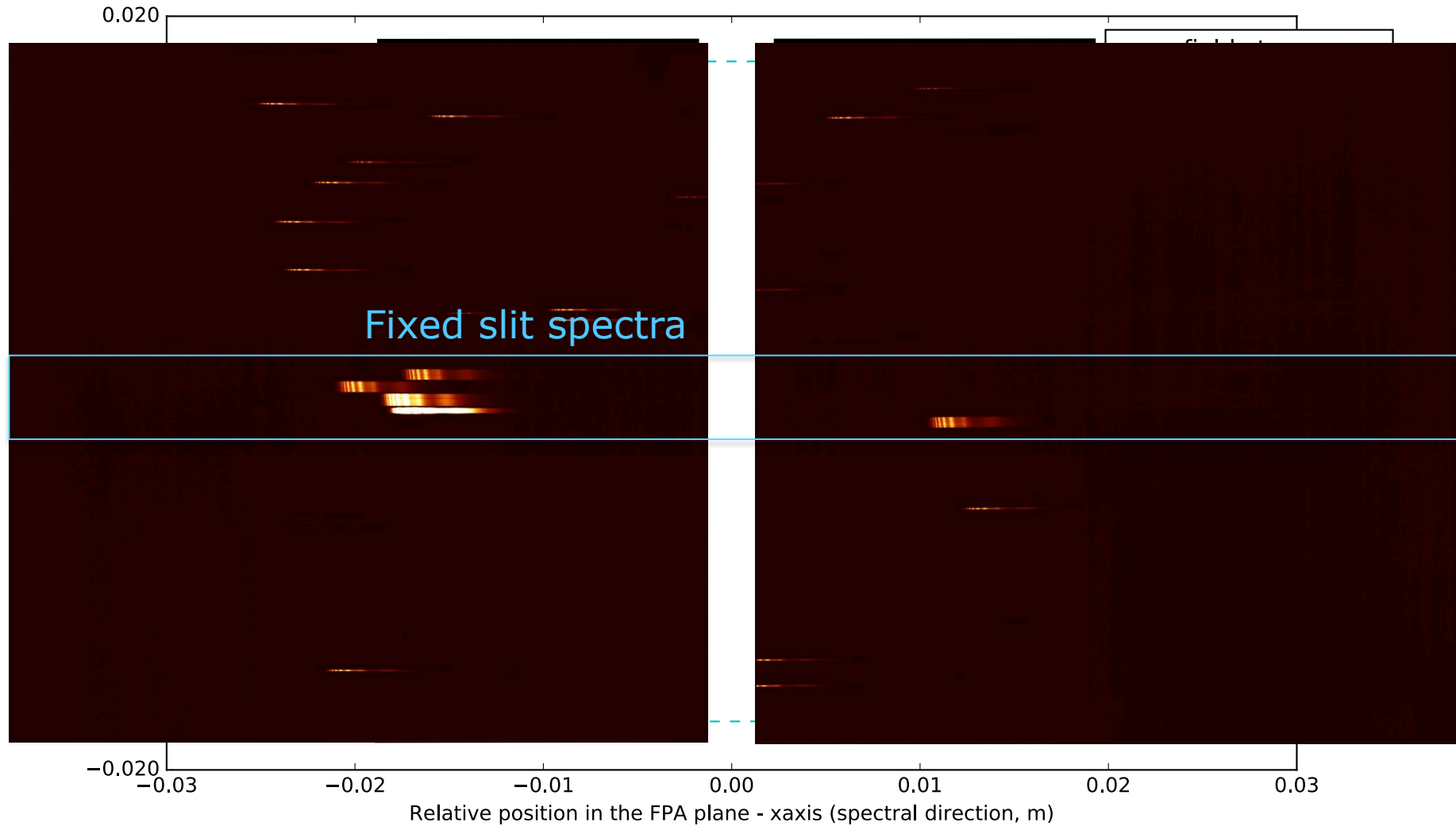


NIRSpec Fixed Slit Data Example (1)



NIRSpec Fiex Slit Data Example (2)

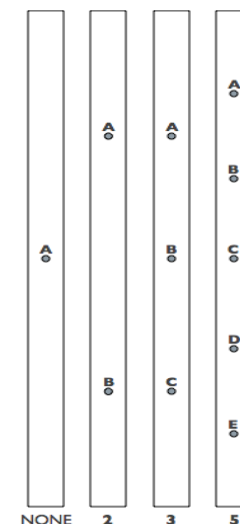
PRSM wavelength calibration lamp



- ❖ Five Slits available:
 - S200A1, S200A2, S400A1, S1600A1, S200B1 (backup)
- ❖ Three subarrays available for the S200/400 slits:

Subarray	Size	Frame Time	Comment
FULL	2048 x 2048	14.58888 s (IRS ²) 10.73676 s (non-IRS ²)	All slits and MOS region captured
ALLSLITS	256 x 2048	5.49132 s	All slits captured
SX00X1/2	64 x 2048	1.55724 s	Selected slit fully captured

- ❖ Primary (nods) and secondary dithers available:
 - 0, 2, 3, or 5 point nod
 - Additional dithers for sub-pixel sampling
 - S200A1 + S200A2 to cover SCA wavelength gap
- ❖ All dispersers available, can select multiple per observation
 - Selected nods/dithers will be repeated for each
- ❖ Need target acquisition (TA) to place object in slits



Fixed Slit Observing template

Observation 1 of JWST Draft Proposal (Unsaved)

Number1Status: UNKNOWN

Label

InstrumentNIRSPEC

TemplateNIRSpec Fixed Slit Spectroscopy

Target1 CAS-A

Splitting Distance

Number of Visits

Visit Splitting:80.0 Arcsec1

Science

Total Charged

Duration (secs)6235019

Data volume: 254 MB

NIRSpec Fixed Slit Spectroscopy

Mosaic Properties

Special Requirements

Comments

Target Acquisition Parameters

NirSpec Target Acquisitions using the MSA are designed for each visit.

Science Parameters

SlitS200A1

SubarraySUBS200A1

Primary Dither Positions

Sub-Pixel Pattern

Dither ParametersNONE

NONE

Gratings/Filters

#	Grating/Filter	Readout Pattern	No. of Groups	No. of Integrations	Autocal	Photon Collect Dur...	Total Photon Colle...
1	G140M/F100LP	NRS	10	10	NONE	622.896	622.896

Add


Duplicate

Insert Above

Remove

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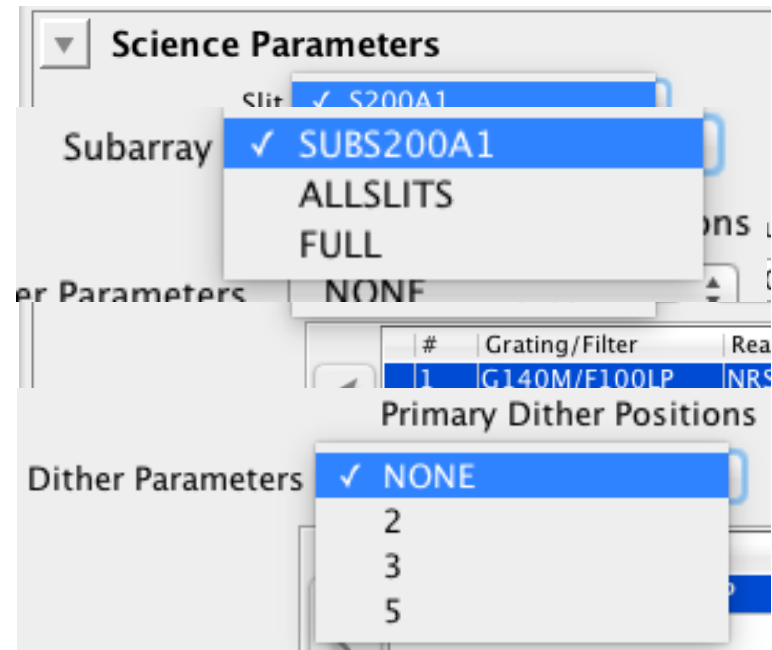
Slide 9



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Fixed Slit Observing Template

- ❖ Select slit/aperture to be used
- ❖ Select subarray: slit specific (32x2048), ALLSLIT (256x2048), or FULL frame
 - IRS² readout mode supported for full frame only
- ❖ Select nod/dither patterns
 - Secondary (sub-)dithers available
 - Nods will avoid slit irregularities
- ❖ Add activity and select grating/filter combination and exposure parameters (readout pattern, ngroups, nints)
 - Can have more than one activity per observation
 - Nods/dithers with each activity
- ❖ Define TA see next



#	Grating/Filter	Readout Pattern	No. of Groups	No. of Integrations	Autocal	Photon Collect Dur...	Total Photon Colle...
1	G140M/F100LP	NRS	10	10	NONE	622.896	622.896
2	G235M/F170LP	NRS	20	5	NONE	622.896	622.896

Gratings/Filters

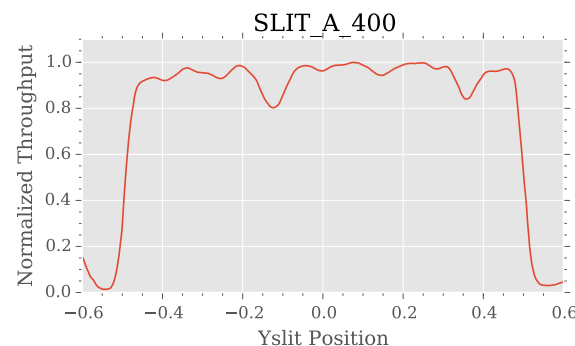
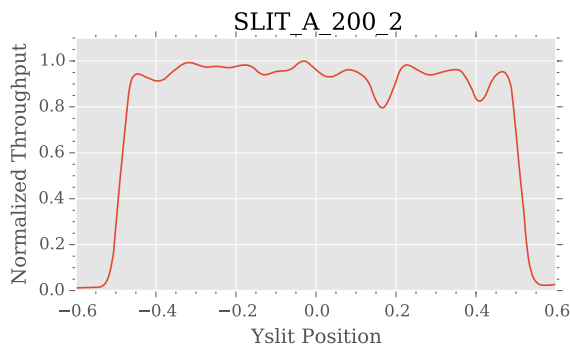
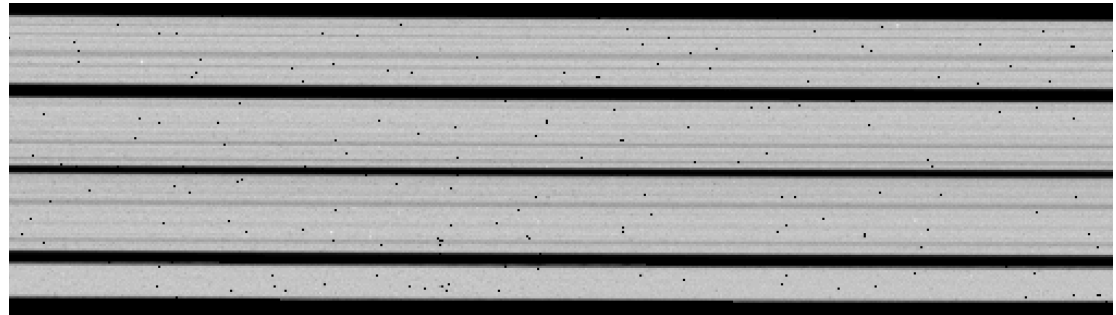
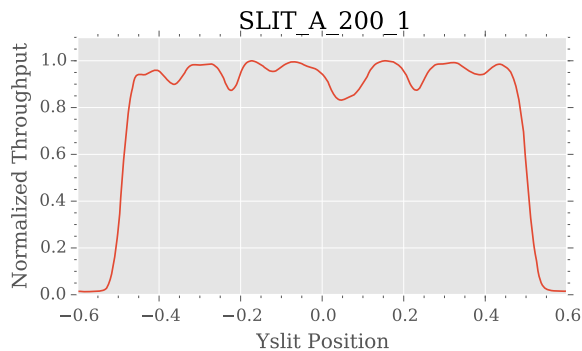
Add Duplicate Insert Above Remove

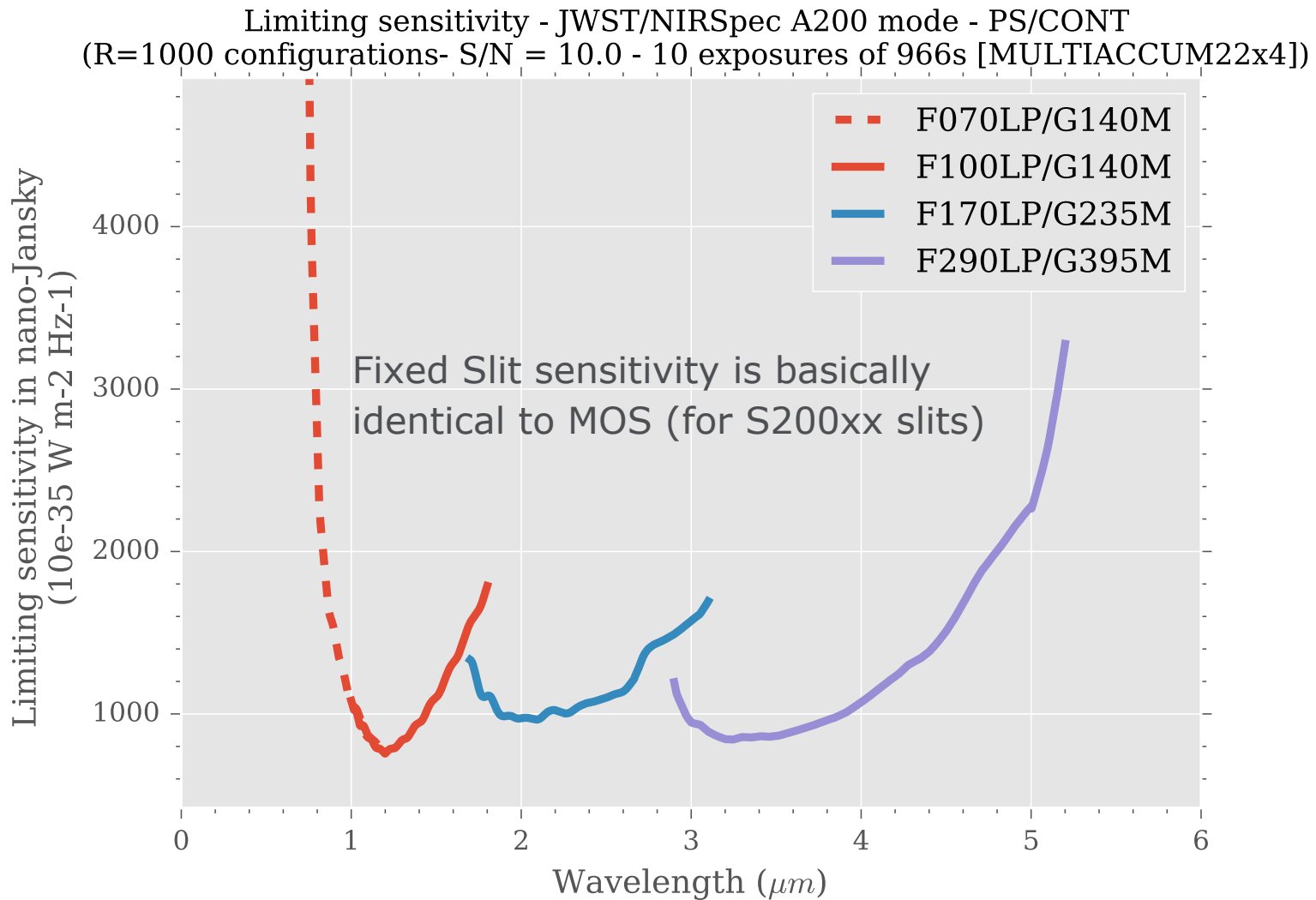
Two ways supported: “full fledged” standard TA and wide aperture (or single object) TA:

- ❖ Standard TA: same as for multi-object spectroscopy with the MSA (see MOS presentation from Torsten Böker)
- ❖ Wide aperture TA:
 - Acquire single object in S1600A1 aperture (single object can be target itself or a reference object)
 - Move target into desired aperture
 - Set of options (filter used for TA, detector readout, subarray) that should allow acquisition of virtually all targets, from very bright (think exoplanet host stars) to very faint

Fixed Slit “Stripyness”

- ❖ The S200 and the S400A1 slits have width variations of up to 20% (P-V)
- ❖ Expected to mostly flat field out
- ❖ Nodding positions will be defined to avoid narrower slit regions where possible
- ❖ Slit losses (for point sources) will be calibrated at the defined nod/dither positions



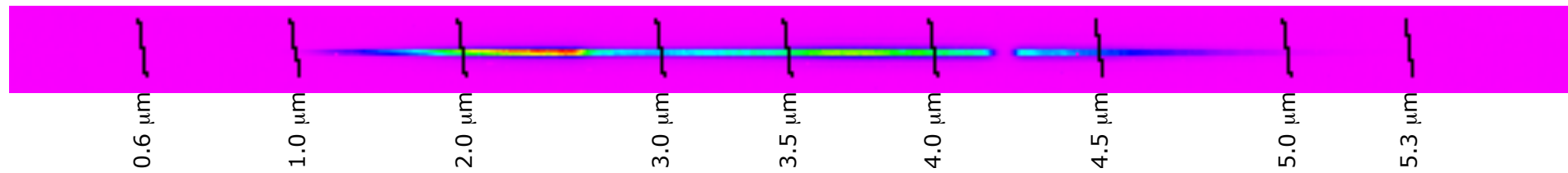


- ❖ Only S1600A1 available (minimal slit losses and best radiometric stability)
- ❖ Only one activity (instrument setup, wavelength coverage) and no nods/dithers
 - Maximum exposure time (with multiple integrations) can be longer than 10,000 seconds
 - No exposure break, best stability from detector standpoint
 - Expose through high gain antenna movement (pointing disturbance)
- ❖ Five available subarrays:

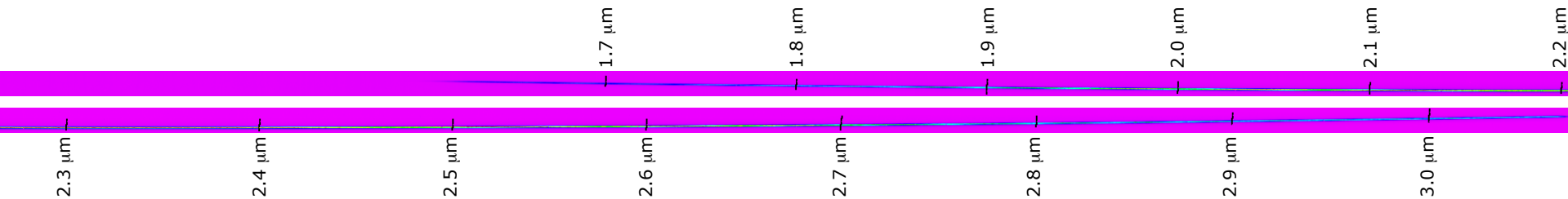
Subarray	Size	Frame Time	Comment
SUB2048	32 x 2048	0.90156 s	Full wavelength coverage for gratings
SUB1024A	32 x 1024	0.45100 s	Partial coverage for gratings (low/hi)
SUB1024B	32 x 1024	0.45100 s	Partial coverage for gratings (center)
SUB512	32 x 512	0.22572 s	Full wavelength coverage for prism
SUB512S	16 x 512	0.14364 s	No pixels outside aperture

- ❖ 2 TA methods: wide aperture (see fixed slits) and “point-and-shoot”

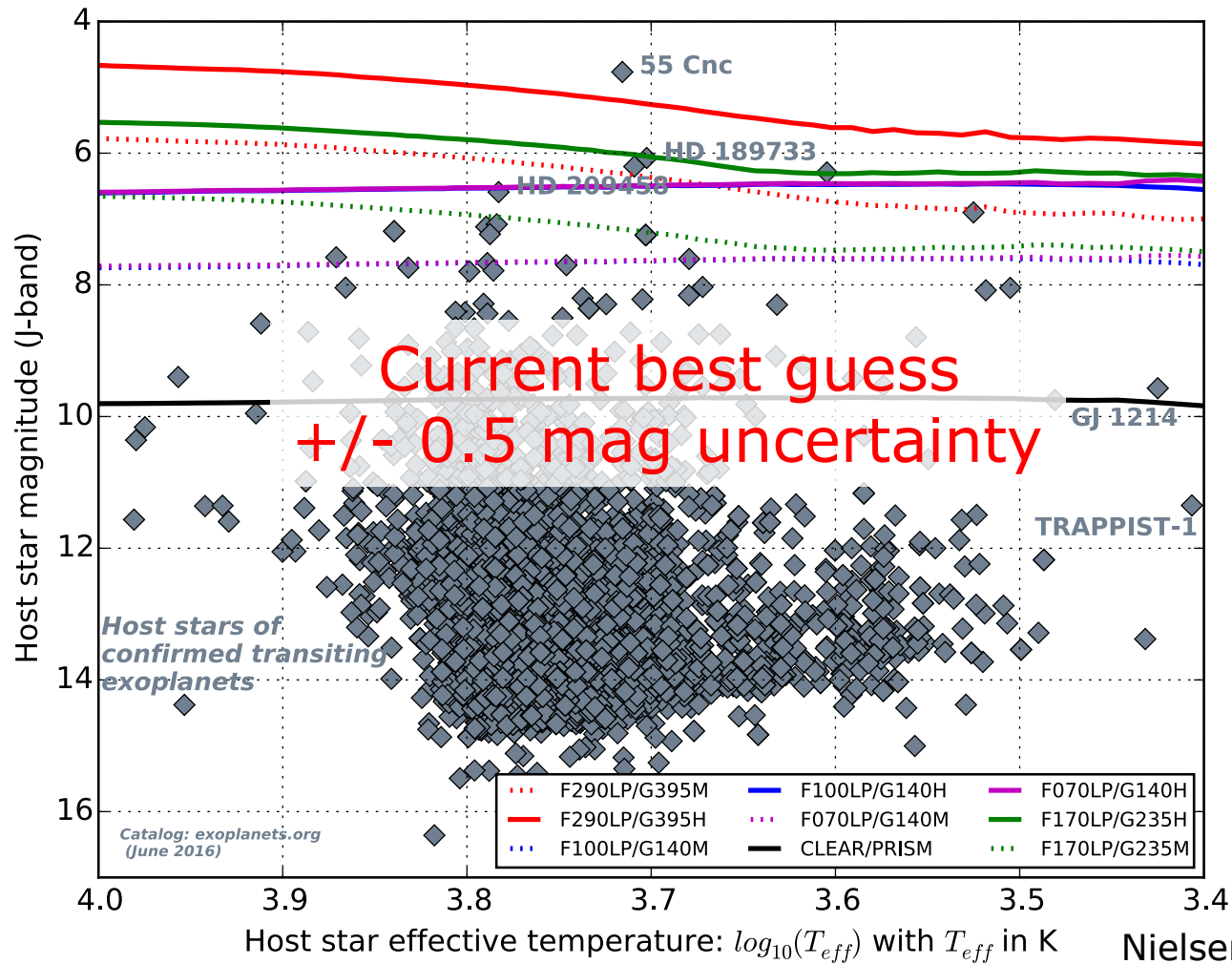
SUB512 (32 x 512) with PRISM



SUB2048 (32 x 2048) with G235H/F170LP



- ❖ below line means observable in without saturation anywhere in band



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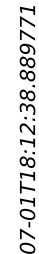


Figure 10 is a line plot showing the Differential SNR per spectral pixel (x 1000) versus Wavelength (μm) for two groups. The x-axis ranges from 0 to 6 μm , and the y-axis ranges from 0 to 25. The gray line represents '1 group (~ 0.45 s cadence)' and the red line represents '2 groups (~ 0.68 s cadence)'. Both curves show a peak around 1.5 μm , with the red curve generally having a higher SNR than the gray curve across the entire range.

- ❖ NIRSpec offers 200 mas, 400 mas, and 1600 mas wide slits/apertures
 - ❖ All NIRSpec dispersers available (0.6 – 5.3 μm wavelength coverage)
 - ❖ Slits provide very high contrast and low background
 - ❖ Excellent sensitivity
 - ❖ Pre-defined (and calibrated) nod/dither options
- ❖ NIRSpec offers a dedicated observing mode for time series observations of bright sources through the S1600A1 aperture
 - ❖ Providing high radiometric stability
 - ❖ Enabling studies of transiting/eclipsing exoplanets with host stars as bright as ~ 6.5 mag (J-band, with high resolution gratings)