NIRSpec Integral Field Spectroscopy of galaxies : Considerations for proposal preparations

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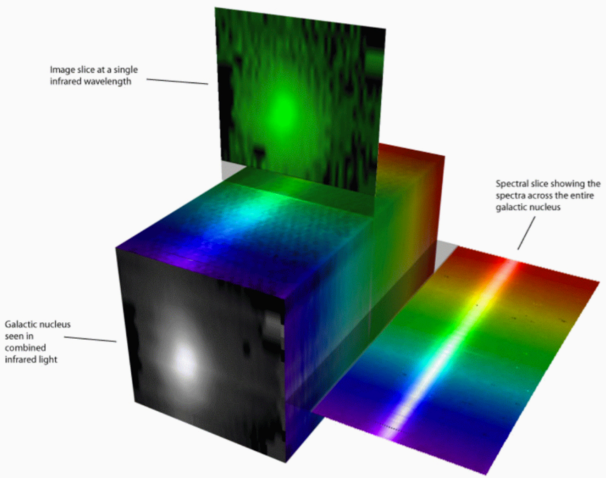
JWST IFS: Science Capability

- NIRSpec + MIRI IFUs => First time IFS in space at near- and mid-IR



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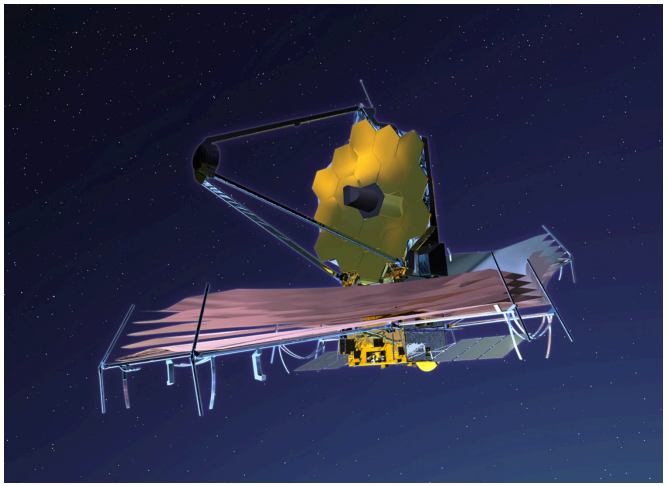


Inherent potential of IFS

JWST capabilities

- IFS at high sensitivity (orders of magnitude improvement)
- IFS over a continuous spectral coverage (0.6 – 28.8 microns)
- IFS at high angular resolutions (~ 0.1”-0.6”)
- IFS with a very stable PSF

JWST NIRSpec IFS Science Capability: Physical coverage and resolution

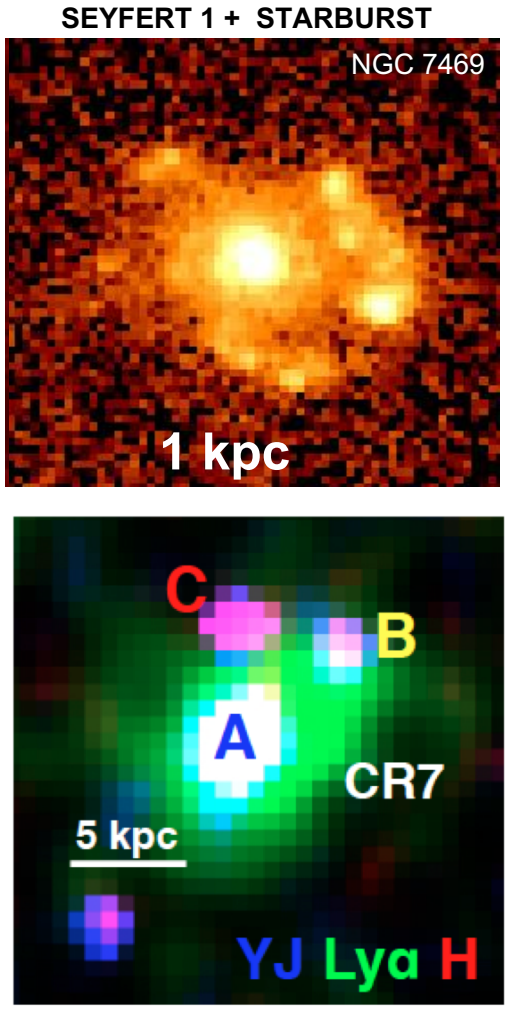
FoV	Sampling
3” x 3”	0.1”

Local galaxies (e.g. NGC7469 @ z= 0.016)

- The FoV covers the circumnuclear region (1-2 kpc), sampled at < 100pc

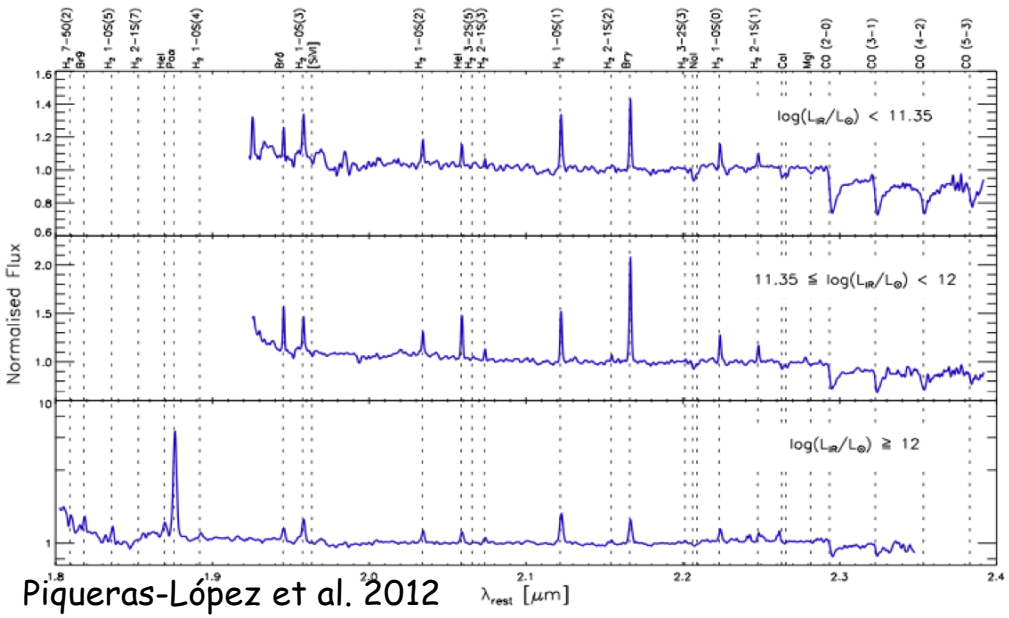
High-z galaxies (e.g. CR7 @ 6.6) 3” ~ 20 kpc (@ z 4-6)

- The FoV covers the entire galaxy, sampled on ~ (sub) kpc scales



NIRSpec FoV

JWST NIRSpec IFS Science Capability: Spectral characteristics

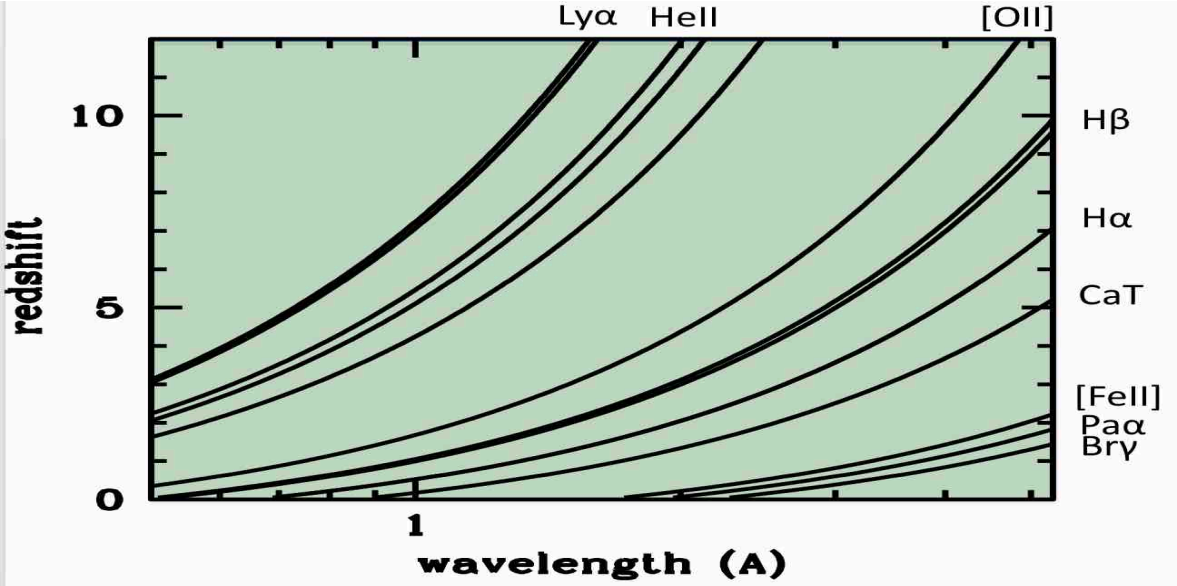


Piqueras-López et al. 2012

Spectral range	Spectral R
~ 0.6-5.3 mu	100 , 1000, 2700

Local galaxies

- Coronal ISM: [SiVI], [CaVIII]
- Ionized ISM: Pa & Br H
- Hot molecular ISM: H_2 lines
- Shocked ISM: [FeII] lines
- Star formation: PAH 3.3μm
- Stellar pop.: CaT, CO bands

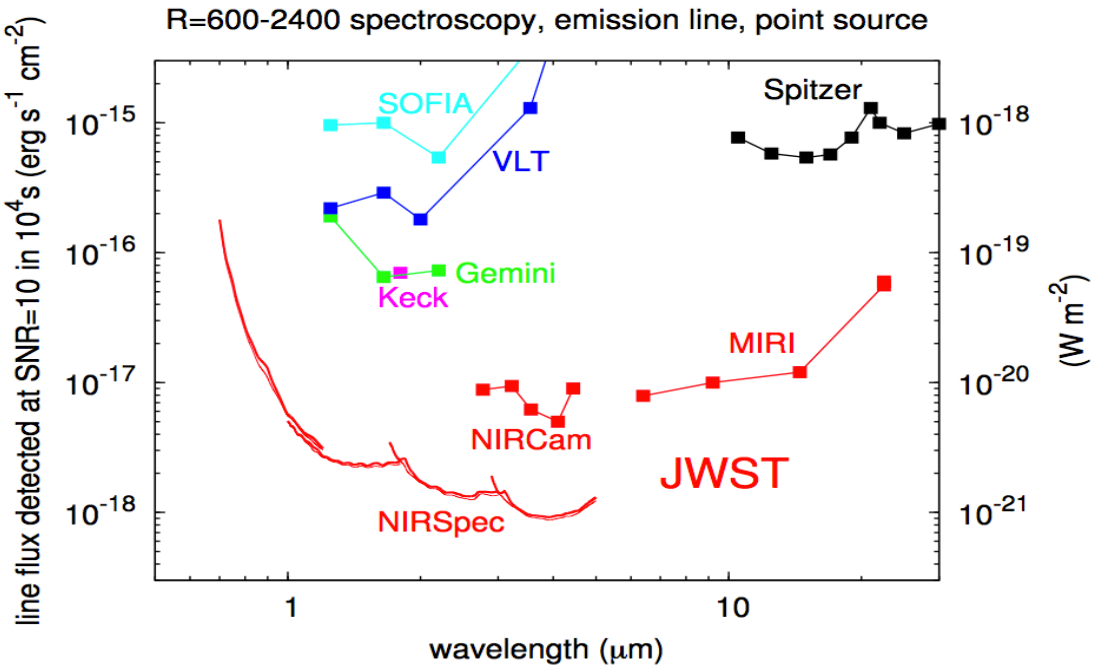


High-z galaxies

- Halpha out to z ~ 7
- Hbeta out to z ~ 10
- UV lines @ z > ~4

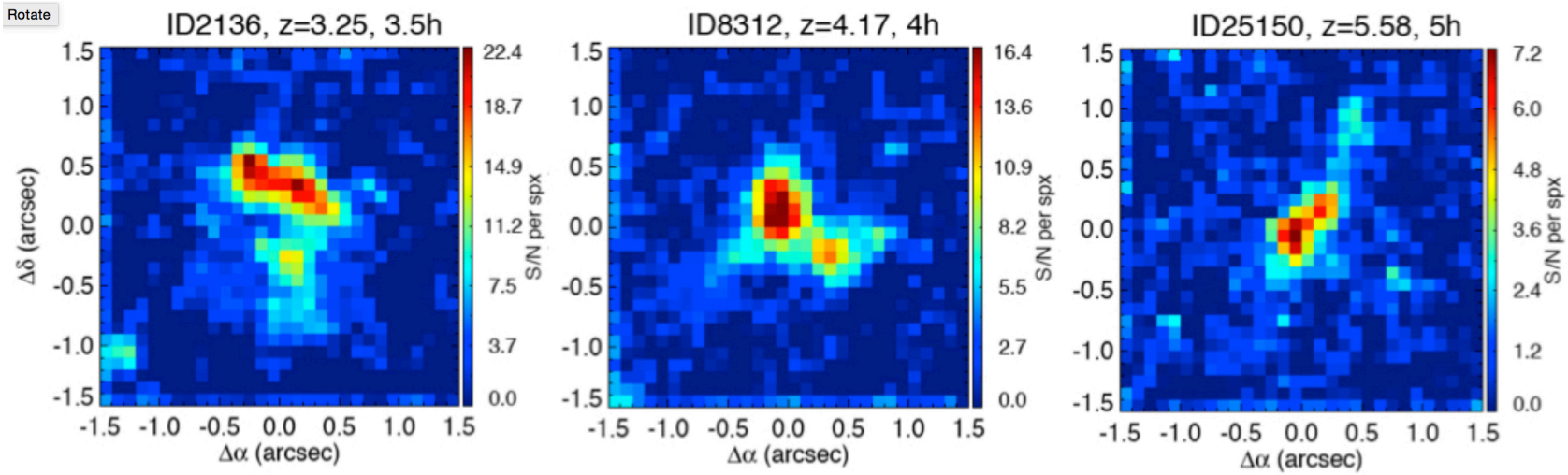
Velocity resolution up to ~100 km/s

JWST NIRSpec IFU Science Capability at high-z: Sensitivity



High-z galaxies:

Thanks to these sensitivities (and angular resolution) It will be possible to study the internal structure of the most massive and extended high-z galaxies by means of IFS



JWST NIRSpec IFU science capability

- **Very powerful but …**

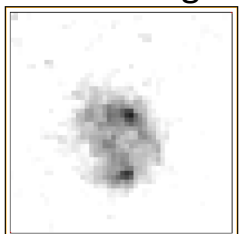
  … overheads can be significant, and the optimization of the observational strategy requires an understanding of the instrument/observatory.

- **It follows some comments on practical matters when preparing a proposal**
  - Target Acquisition (TA)
  - Spectral settings, and gap
  - Background
  - Dithering / Nodding
  - NIRSpec and MIRI IFU combined observations

Note: NIRSpec recommended strategies at
https://jwst-docs.stsci.edu/display/JPP/NIRSpec+Recommended+Strategies

NIRSpec IFU Target Acquisition (TA)

- **For standard IFU observations the recommendation is to do TA**
  - Options for TA:
    - **MSATA**: Thought for the MOS, very accurate but implies large overheads (24-30')
    - **WATA**.
      - First it locates the target or a nearby source on a wide slit → takes an image → finds the peak emission → does a final slew to locate the target on the IFU (All done automatically)
      - It requires some thinking from you : Exp. Time for the image ?, Is the acq. target compact ?
      - Still significant overheads (11-18')
      - Accuracy < 0.1"



Check the structure of the source at the filter used for WATA

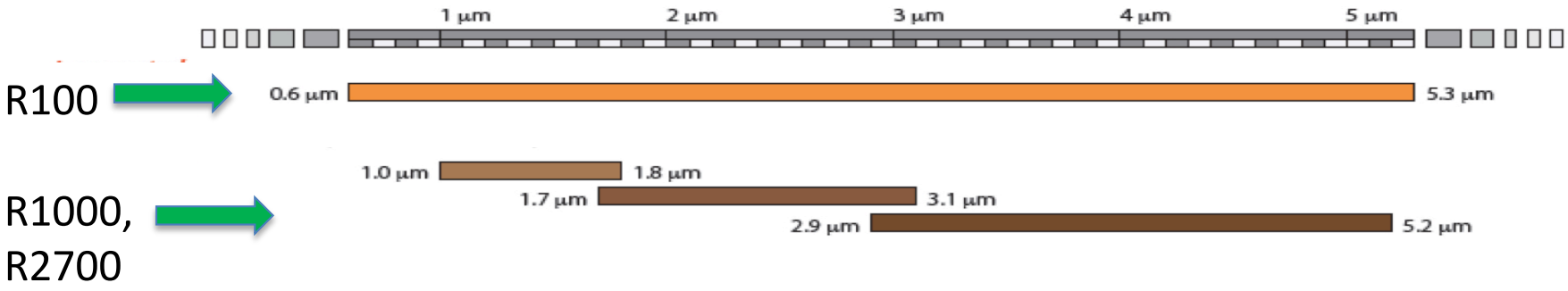
  - Options for no-TA
    - **Verify_Only**: no-TA but it takes an image to verify pointing. Overheads: 8-14'
    - **NONE** : Point & Stare.

    Accuracy ~ 0.34" 1-sigma (expected ~ 0.1", if guide stars have GAIA astrometry)

Further details in:
https://jwst-docs.stsci.edu/display/JPP/NIRSpec+Target+Acquisition+Recommended+Strategies

NIRSpec IFU spectral settings

- At low R (100) the whole range 0.6-5.3µm is covered with one → 1 setting
- At R=1000, 2700 to cover ~ 1 - 5.2µm → 3 settings



Check the exact locations of the features required for your science, and try to minimise the number of settings.

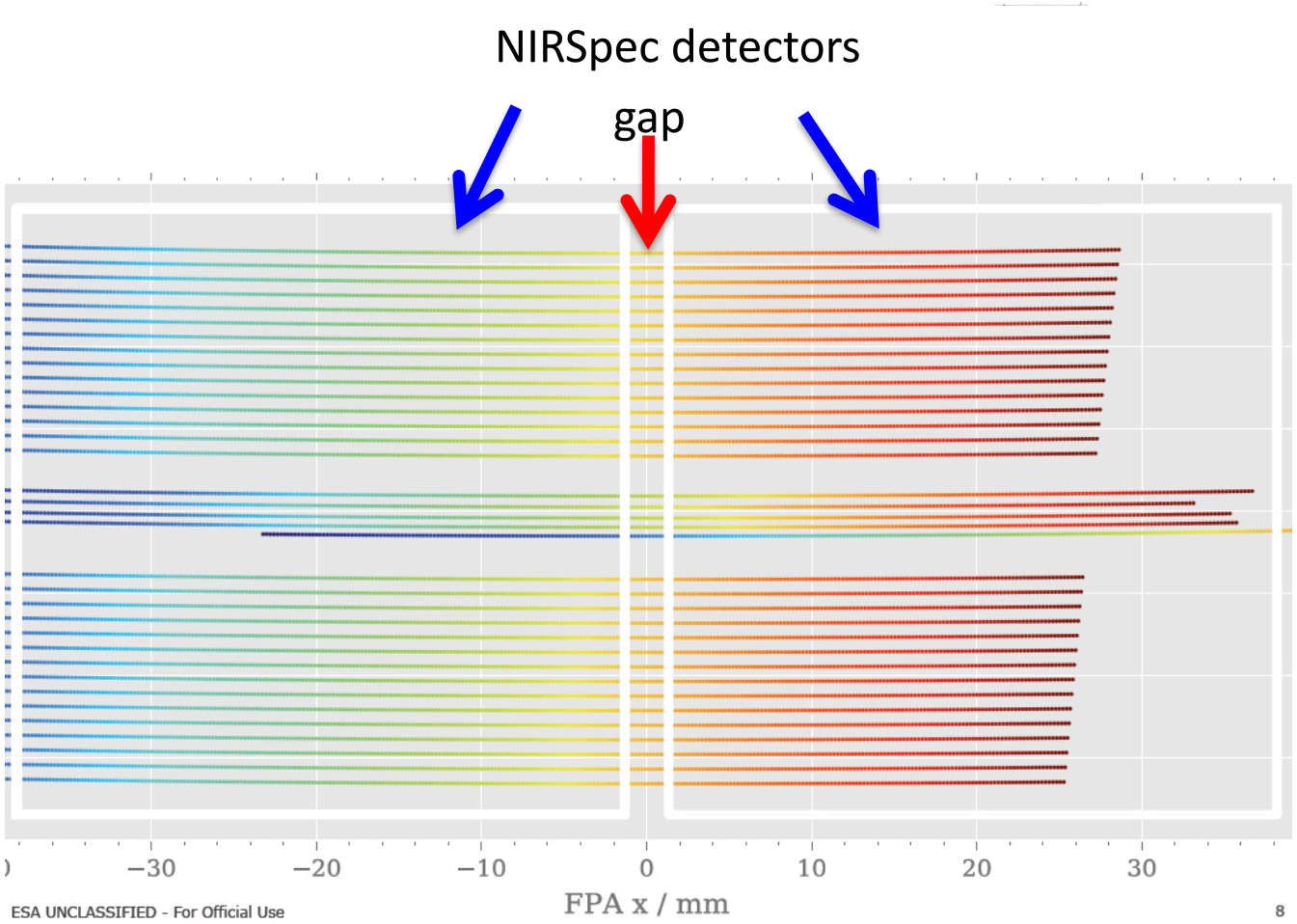
E.g., For high-z: interested in Hbeta – Halpha range [at R=1000 or R=2700]:

- for a z= 2.2 target , 2 grating settings are needed
- for a z= 2.6 target , 1 grating setting is enough

For this case, some redshift ranges make the observations more efficient

Mind the gap

- There is a gap between the two NIRSpec detectors
  - check that the there is not an important feature there
- **For the IFU this affects the R=2700 mode only**



Grating	gap range (microns)
G140H	1.408 - 1.425
G235H	2.36 - 2.49
G395H	3.985- 4.205

Will appear in ETC

https://jwst-docs.stsci.edu/display/JTI/NIRSpec+IFU+Wavelength+Ranges+and+Gaps

Background

- Zodiacal light: mainly relevant for R=100 and short wavelengths (i.e. λ< 2μm)
  - If target small wrt the FoV, for background use blank spaxels + dither /nodding in FoV
  - If target large, you may need an extra exposure

  Check with the ETC. Also a dedicated tool for the background at
  https://jwst-docs.stsci.edu/display/JPP/JWST+Backgrounds+Tool

- MSA-imprint: Specific of NIRSpec IFU,
  - The MSA and the IFU share the detectors.
  - When IFU is operating the MSA closed (and vice versa)
  - But the MSA is not totally opaque and may leak light that potentially can contaminate the IFU spectra.
  - Strategy:
    - Minimize effects selecting a PA that avoids bright sources on the MSA
    - Dither /Nodding
    - If still worried, add calibration exposure with IFU closed (+MSA closed)

Details in:
https://jwst-docs.stsci.edu/display/JPP/NIRSpec+MSA+Leakage+Subtraction+Recommended+Strategies

Dithering / Nodding

Main reasons for dithering/nodding:

- Accurate background measurements
- Good PSF sampling: (The IFU undersamples the PSF)
- Detector cosmetic/defects
- Others: Enlarge FoV

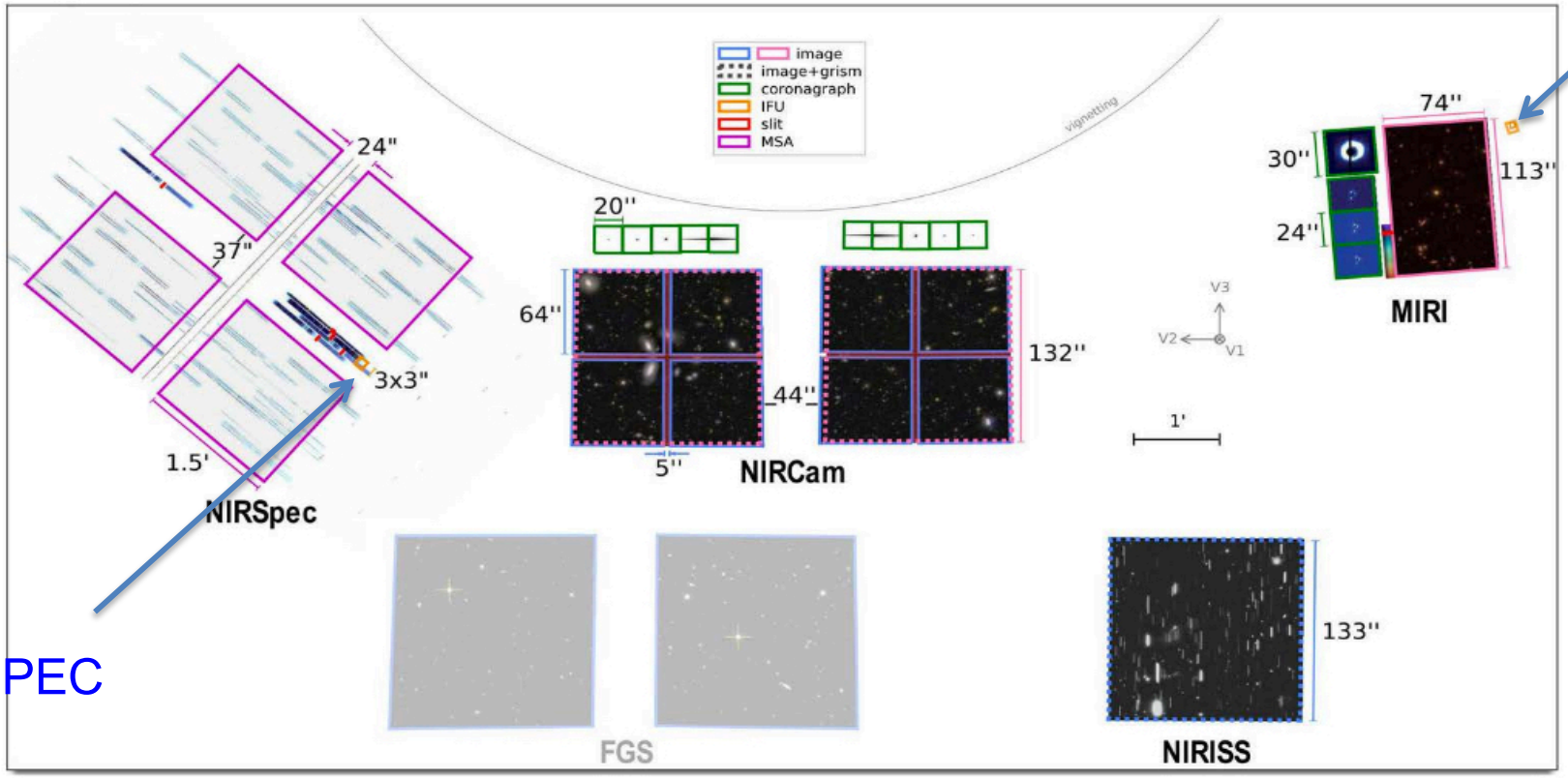
Strategy

At least 4-point dither-pattern (subpixel sampling+amplitude of, e.g., 0.5-1")

https://jwst-docs.stsci.edu/display/JTI/NIRSpec+IFU+Dither+and+Nod+Patterns

NIRSpec + MIRI IFU observations ?

- NIRSpec & MIRI IFUs are separated by about 13.5 arcmin in the JWST focal plane, so
  - Extra slew
  - Guide star will be different for NIRSpec and MIRI. If required, also two independent Target Acquisitions
- PA constrains may conflict:
  - MIRI typically uses the Imager simultaneously ➔ PA constrains to avoid bright sources
  - NIRSpec : Also may also require a specific PA to avoid bright sources in the MSA
  - If you find a common PA range you will save overheads

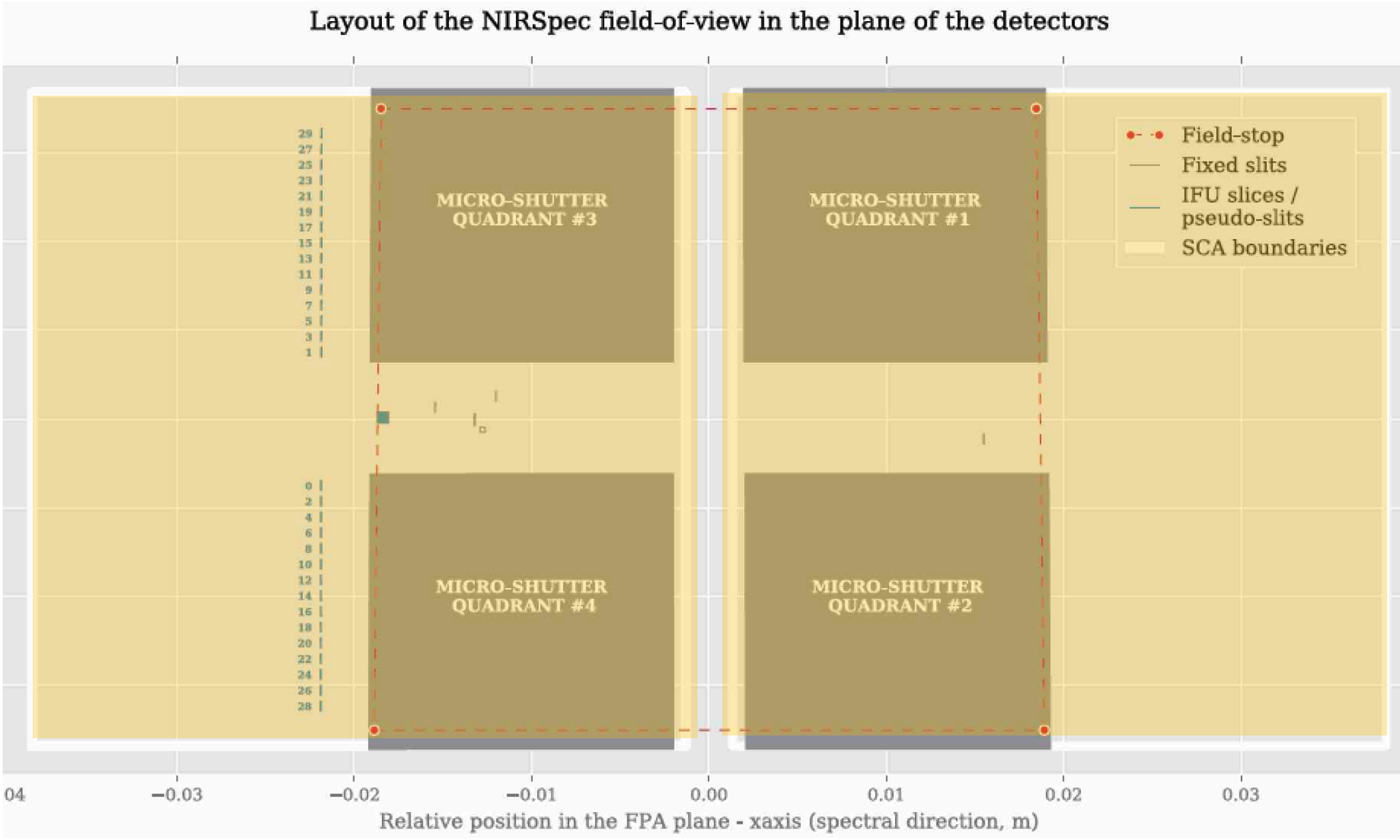


MIRI IFU

NIRSPEC IFU

Credit: STScI

- Extra


Layout of the NIRSpec field-of-view in the plane of the detectors
MICRO-SHUTTER QUADRANT #3
MICRO-SHUTTER QUADRANT #1
MICRO-SHUTTER QUADRANT #4
MICRO-SHUTTER QUADRANT #2
Field-stop
Fixed slits
IFU slices / pseudo-slits
SCA boundaries
29 27 25 23 21 19 17 15 13 11 9 7 5 3 1
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
04
−0.03
−0.02
−0.01
0.00
0.01
0.02
0.03
Relative position in the FPA plane - xaxis (spectral direction, m)