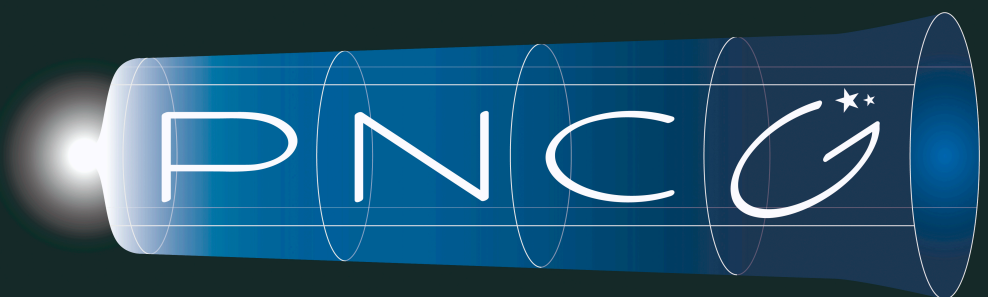


JWST Master Class Workshop

Imaging:
Strategies and Hands-On



PROGRAMME NATIONAL DE COSMOLOGIE ET GALAXIES

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Introduction



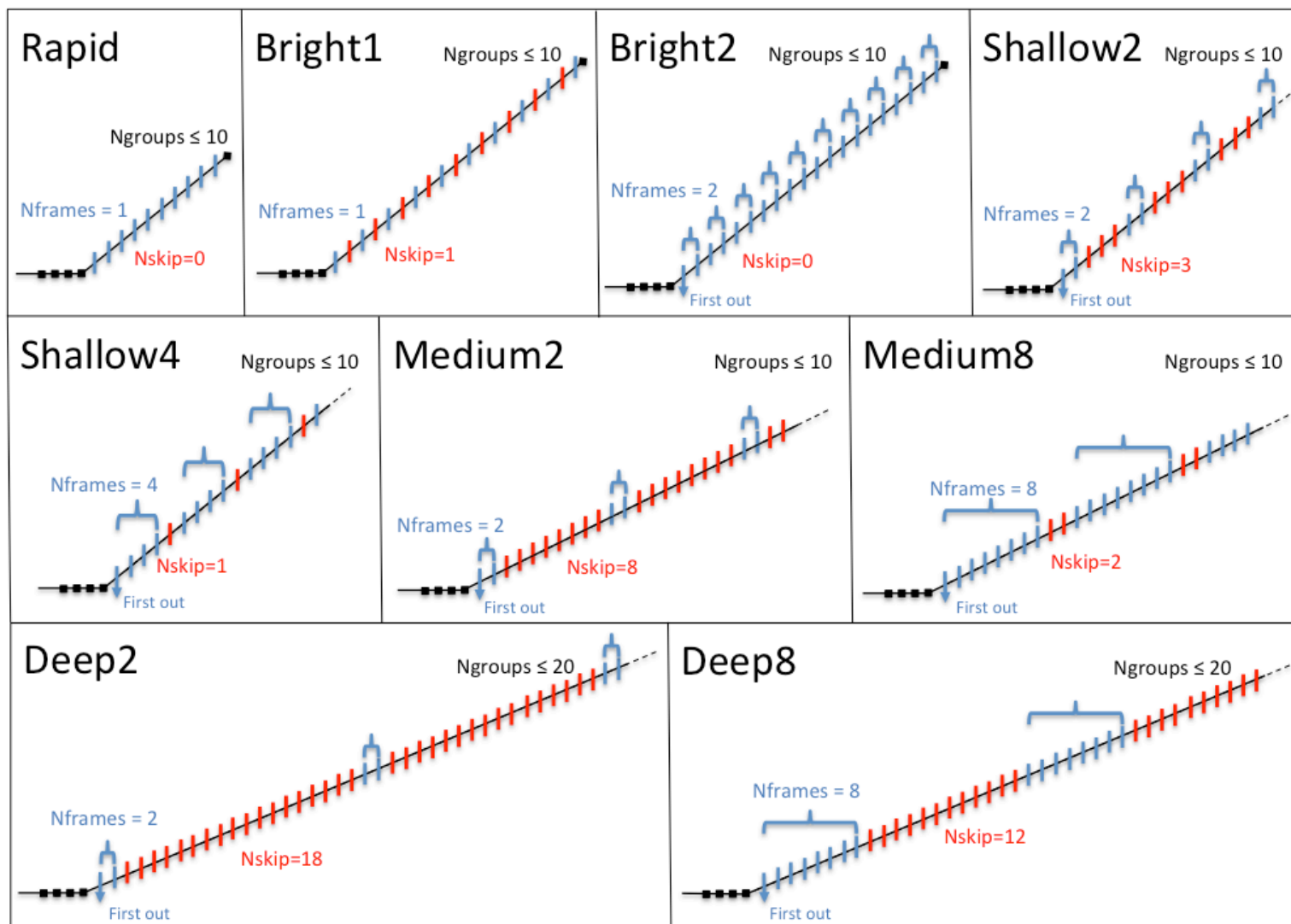
- In preparation for the Imaging hands-on exercise, in these slides we go over general imaging observing strategies, including:
 - ▶ Readout modes selection.
 - ▶ Subarrays usage.
 - ▶ Target acquisition.
 - ▶ Dithers and mosaics.
 - ▶ Background strategies.

The focus of the hands-on exercise will be MIRI and NIRCam



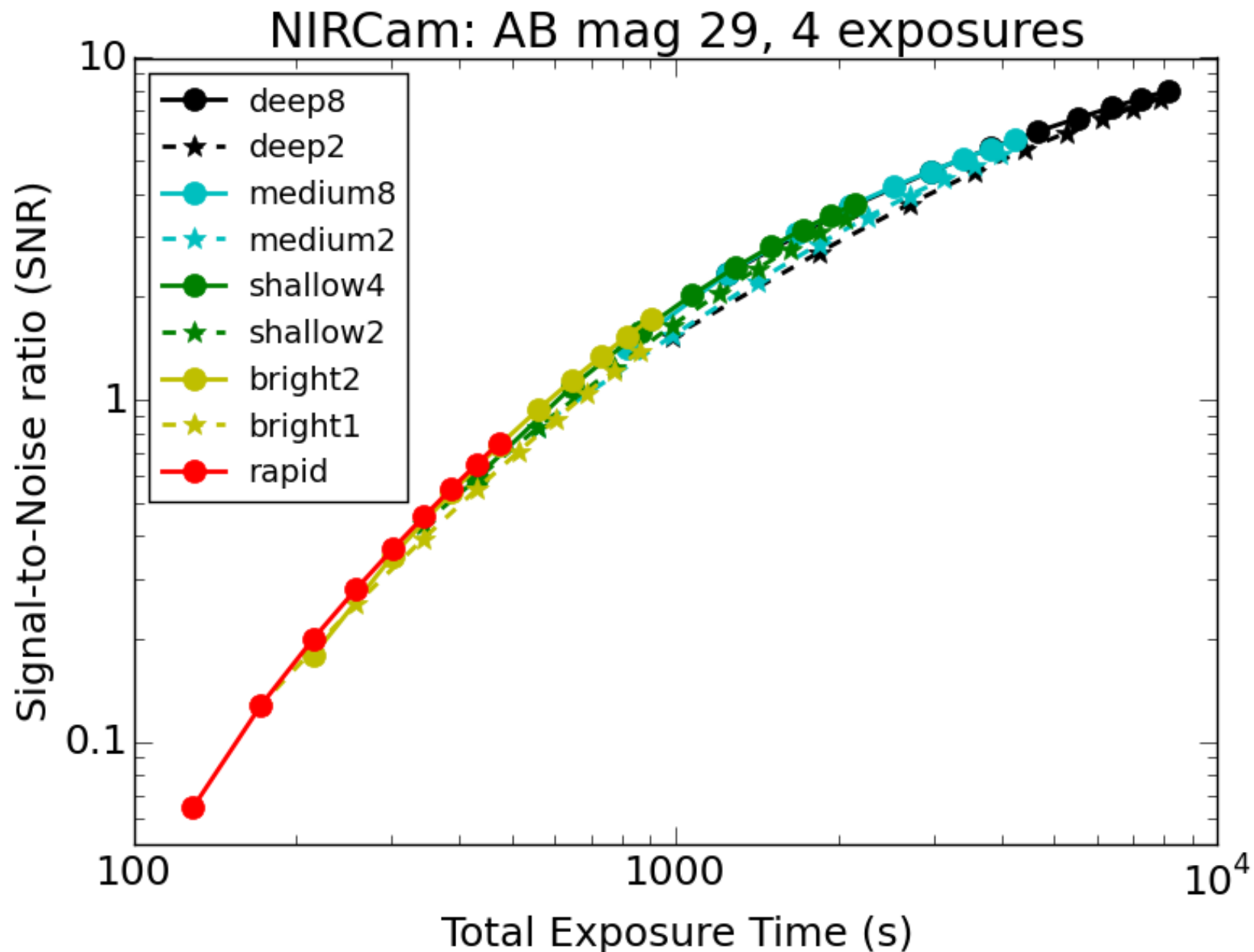
Readout modes: NIRCam

- NIRCam offers 9 different readout modes. This combination of readout modes and subarrays (see next section) provides a broad variety of group times (e.g. ~86 s to 0.1 s)



- Which readout mode? Names are indicative of the use cases, but users should be guided by the science case, ETC results and spatial coverage to choose a readout mode.
- Note the limitations in #groups (data volume)

Readout modes: NIRCam



[See more information in JDOx](#)

Comparison of signal-to-noise ratio for various readout specifications for F200W imaging of an AB mag 29 point source. Each point shows the estimate given four exposures, each comprising a single integration that consists of multiple groups (between two and 10) of a given readout pattern. This analysis shows that *RAPID*, *BRIGHT2*, *SHALLOW4*, *MEDIUM8*, and *DEEP8* yield higher signal-to-noise ratio than other patterns for a given exposure time. These are plotted as filled circles; the other patterns are plotted as stars. Note *BRIGHT2* is restricted to a maximum of four groups when reading out the full detectors in both modules.



Readout modes: NIRCam

How do I do this? Basic guideline

- RAPID, BRIGHT2, SHALLOW4, and MEDIUM8 maximize signal-to-noise for a given integration time < 1000 seconds.
- **More groups are preferred to mitigate cosmic rays** for all pixels: e.g. 8 groups of SHALLOW4 rather than 4 groups of MEDIUM8. The minimum number should be 5 groups (although shorter allowed).
- **1 integration at each dither position will be sufficient for most programs.**

Subarrays Usage

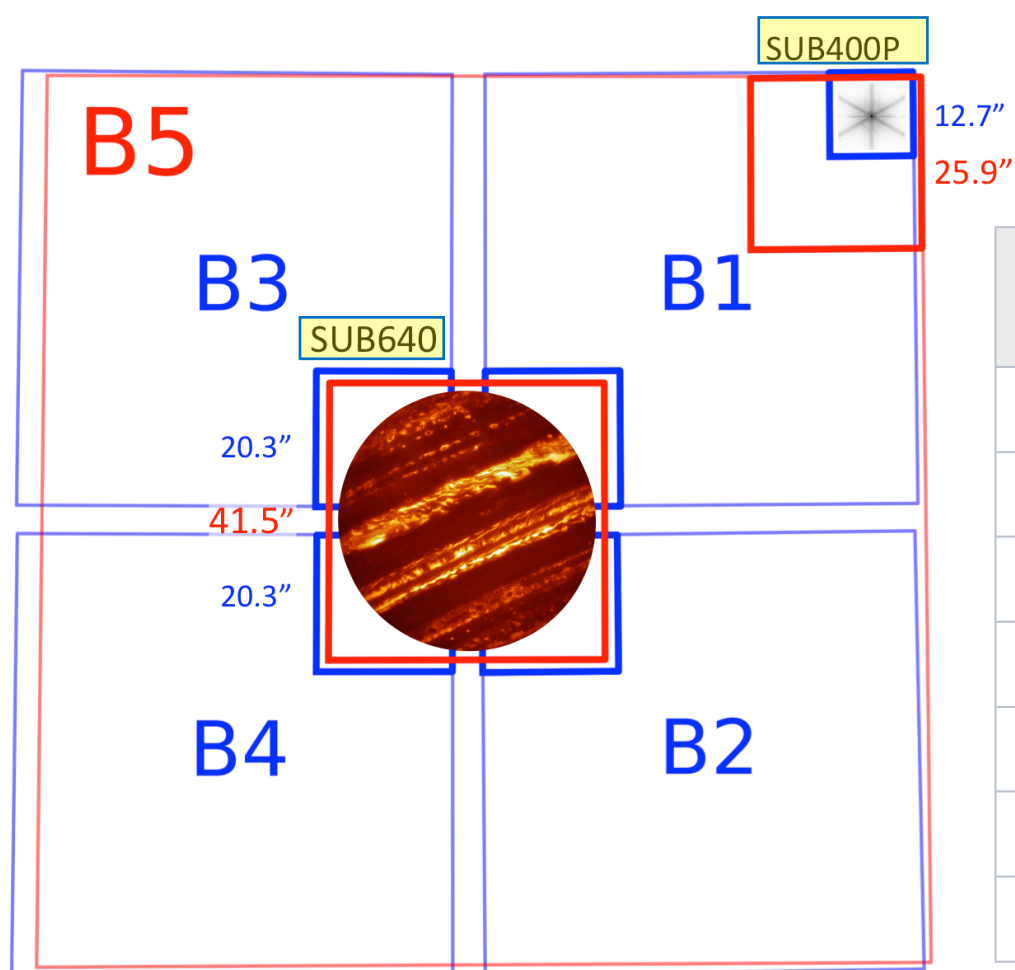


- In subarray only a portion of the detector is read out:
 - ▶ Readout time is reduced, enabling rapid observations of bright objects without saturation.
 - ▶ Data volume is reduced (most relevant for NIRCam).
 - ▶ To decide which subarray, users should consider the source brightness and size.
 - ▶ Using the ETC in conjunction with APT is key to decide which subarray is most suitable for your source.



NIRCam imaging subarrays

- All defined in module B. Subarrays ending in "P" only use a single detector in the short wavelength channel. The other subarrays are read in all 5 detectors of the module. The resulting images include 4–5" gaps along the center of both axes.



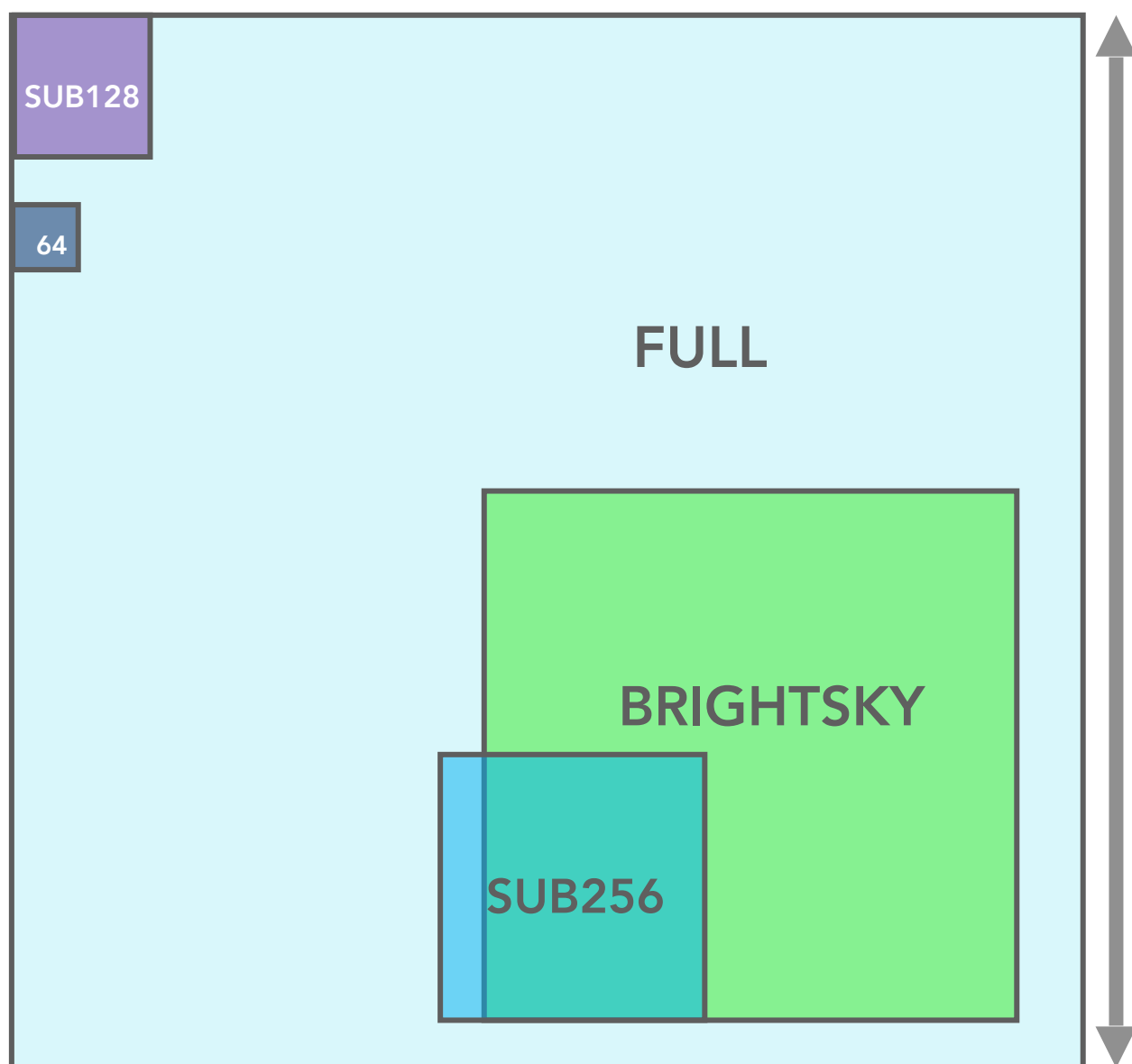
Imaging subarray	Size in pixels $N_{\text{rows}} \times N_{\text{columns}}$	Short wavelength FOV (each side) †	Long wavelength FOV (each side)	Frame time (s)	N_{outputs}
<i>FULL</i>	2048 × 2048	2 × 64" + 4–5" gap	129"	10.73677	4
<i>SUB640</i>	640 × 640	2 × 19.9" + 4–5" gap	40.4"	4.18584	1
<i>SUB320</i>	320 × 320	2 × 9.9" + 4–5" gap	20.2"	1.06904	1
<i>SUB160</i>	160 × 160	2 × 5.0" + 4–5" gap	10.1"	0.27864	1
<i>SUB400P</i>	400 × 400	12.4"	25.0"	1.65624	1
<i>SUB160P</i>	160 × 160	5.0"	10.0"	0.27864	1
<i>SUB64P</i>	64 × 64	2.0"	4.0"	0.05016	1

Remember the group time (i.e. APT and ETC parameters) will depend not only on the frame time, but on other detector parameters. It will change with the readout mode.



MIRI imaging subarrays

- Four different imager subarrays with group times ranging from 0.867 to 0.085 s.
- For MIRI use subarrays only if required for bright sources/high backgrounds, not just to image small targets.

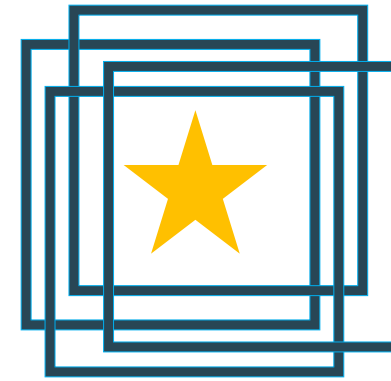


112.6"

Subarray	Size (pixels)	Usable size (arcsec)	Frame time (s)
<i>FULL</i>	1024 × 1032	74 × 113	2.775
<i>BRIGHTSKY</i>	512 × 512	56.3 × 56.3	0.865
<i>SUB256</i>	256 × 256	28.2 × 28.2	0.300
<i>SUB128</i>	128 × 136	14.1 × 14.1	0.119
<i>SUB64</i>	64 × 72	7 × 7	0.085

Remember the group time (i.e. APT and ETC parameters) and frame time is the same for MIRI.

Dithering

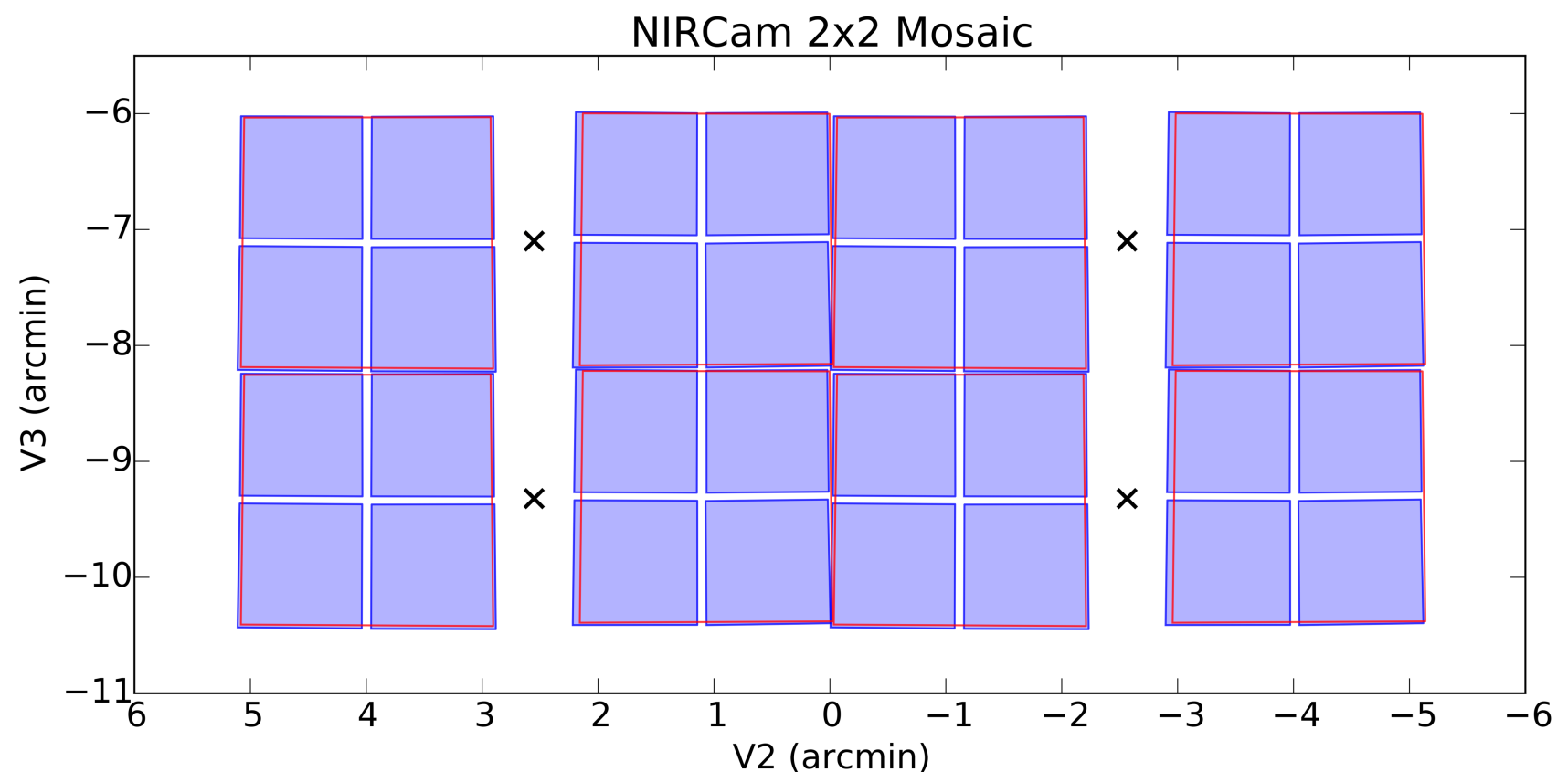


- Dithering is highly recommended in all imaging observations:
 - ▶ It allows good PSF sampling—this is mostly relevant when using the F560W filter in MIRI (Nyquist sampled at longer wavelengths), and for most NIRCам and NIRISS filters.
 - ▶ It minimizes detector cosmetics and defects
 - ▶ It makes possible accurate background measurements for point sources, and at longer (MIRI) wavelengths permits tracking of potential telescope thermal emission variations.
 - ▶ It mitigates the impact of bad pixels.
 - ▶ It allows tracking detector drifts.
- In NIRCам larger primary dithers are useful to fill gaps in sky coverage. Smaller subpixel dithers are optimized to improve sampling in stacked images.
- Dedicated dithers for NIRCам/NIRISS parallel observations.

Mosaics



- Used to cover areas larger than the nominal FOV: 5.1' × 2.2' NIRCcam and 1.8'x1.2' for MIRI.
- Depending on the NIRCcam module/subarray and overlap, mosaics may have module and detector gaps.
- To obtain a roughly even observing depth over large areas, consider using the NIRCcam FULL primary dither patterns in conjunction with mosaics with tile spacings of 5.8' × 2.25'.
- For MIRI a minimum of 10% overlap is suggested, larger overlaps will facilitate image combinations.
- Users are encouraged to use Aladin to verify source placement in different orientations, as well as APT shift rows and columns, to ensure that science requirements are always met



Background



- JWST imagers cover a large spectral region, roughly from 0.6 to 28 microns.
 - ▶ For $<15 \mu\text{m}$, in-field zodiacal background dominates the background.
 - ▶ At longer wavelengths, thermal emission from JWST itself is the dominant source of background. This component only affects MIRI.
 - ▶ The ETC can be used to assess if observations are background limited; the **Background Limited** special requirement in APT will limit scheduling to when the background is relatively low.



Background observations

Point sources



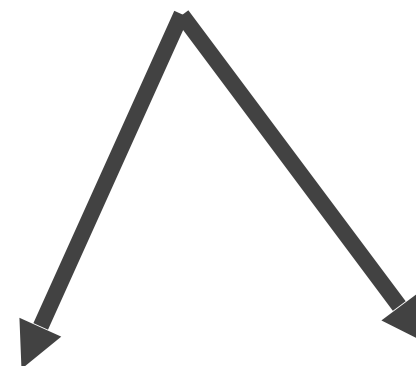
No background observations needed. In high background observations, the flat field uncertainty will affect the SNR.

As a "rule of thumb" the background will change for different observing periods.

Extended sources
(covering entire FOV)



Advised to obtain background data in every spectral configuration used by the science data.



As part of a mosaic
(Recommended)

Off-source target