JWST NIRCam:

Synthetic imaging with `mirage`

2021-10-12

What is NIRCam?

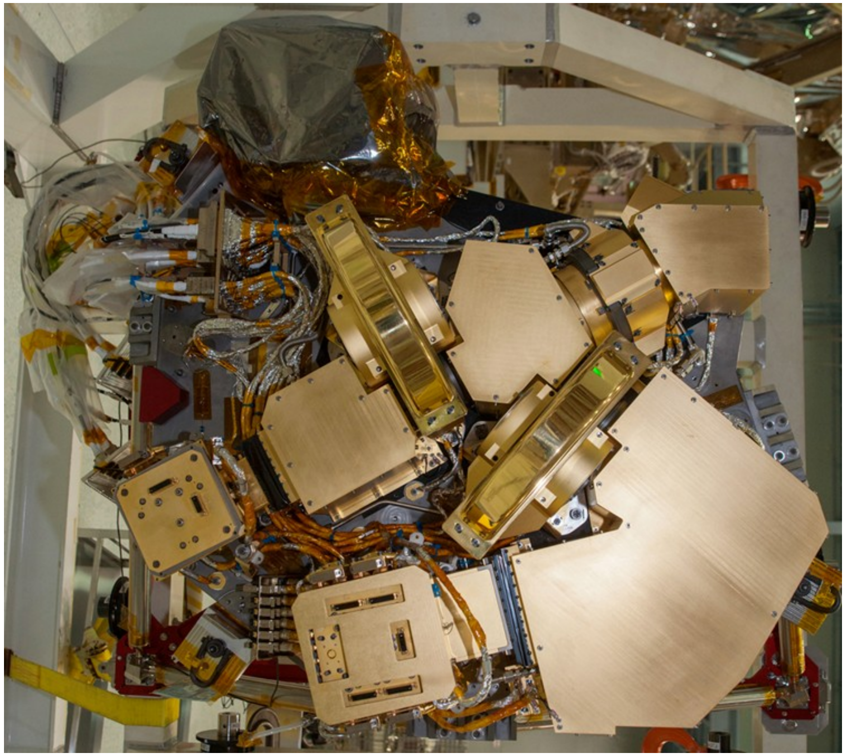
NIRCam: *Near-InfraRed Camera*

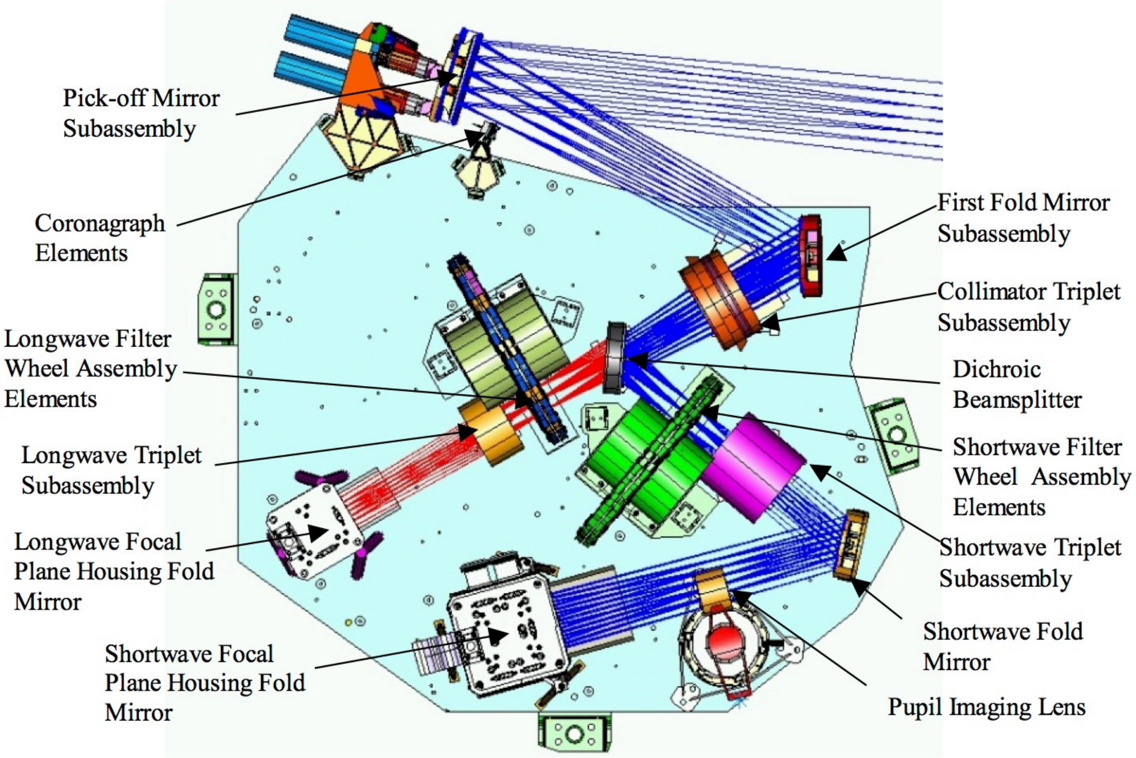
https://jwst-docs.stsci.edu/jwst-near-infrared-camera

NIRCam modules

https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-modules

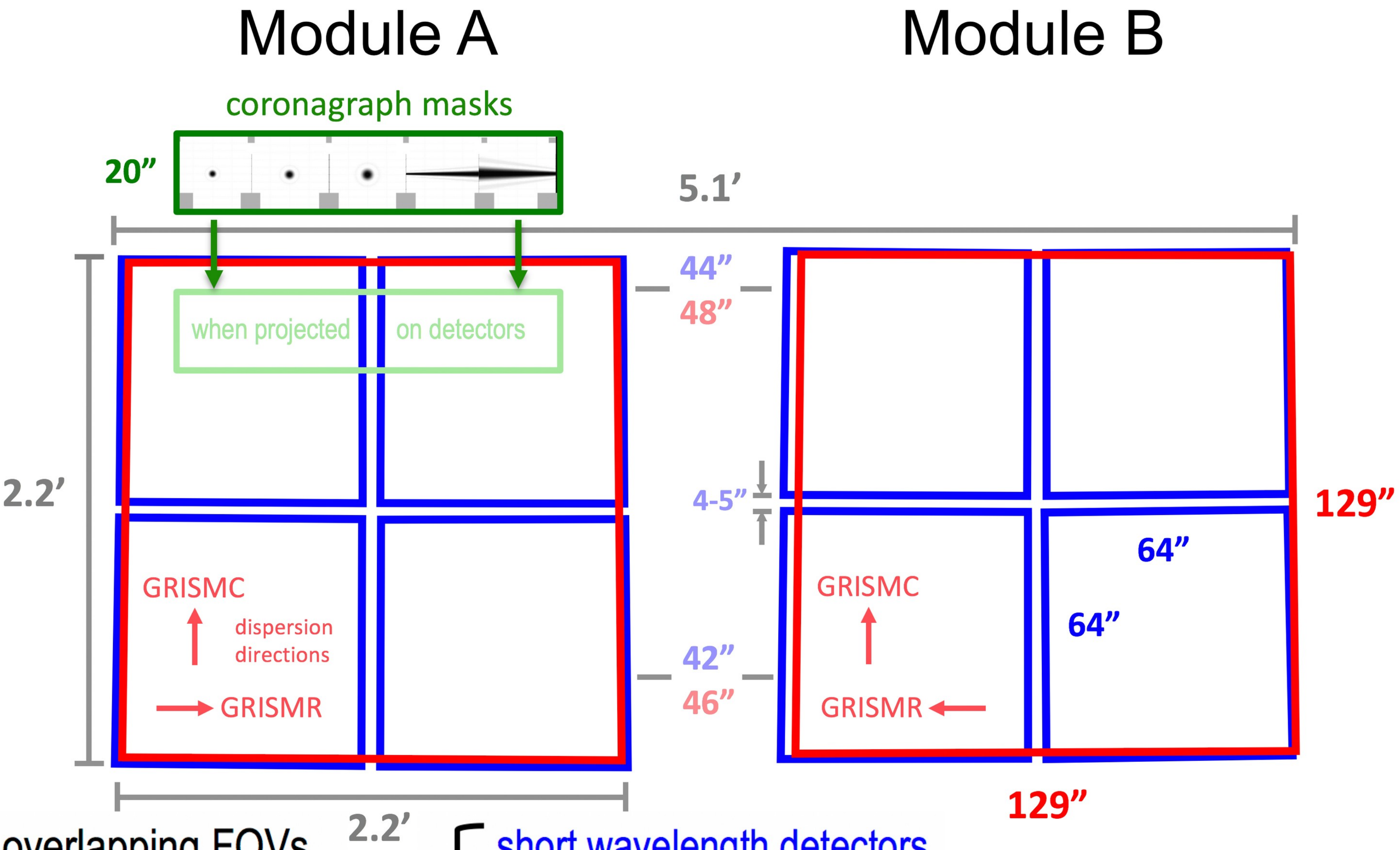
Two similar modules: A & B




Pick-off Mirror Subassembly
Coronagraph Elements
Longwave Filter Wheel Assembly Elements
Longwave Triplet Subassembly
Longwave Focal Plane Housing Fold Mirror
Shortwave Focal Plane Housing Fold Mirror
First Fold Mirror Subassembly
Collimator Triplet Subassembly
Dichroic Beamsplitter
Shortwave Filter Wheel Assembly Elements
Shortwave Triplet Subassembly
Shortwave Fold Mirror
Pupil Imaging Lens

NIRCam modules

https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-field-of-view

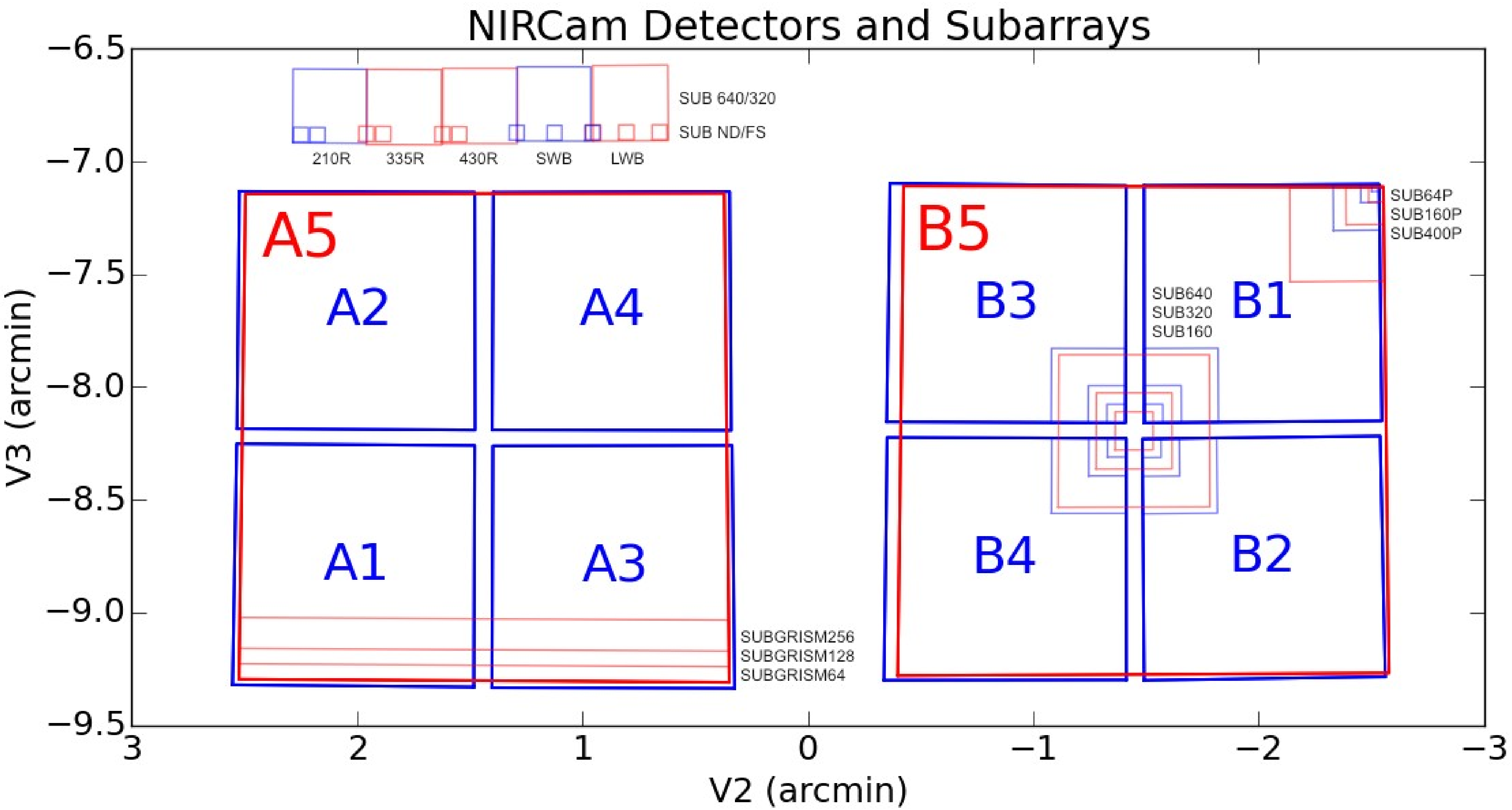


overlapping FOVs obtained simultaneously { short wavelength detectors
long wavelength detectors

NIRCam subarrays

https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-detector-overview/nircam-detector-subarrays

Each detector has 2048 x 2048 pixels.

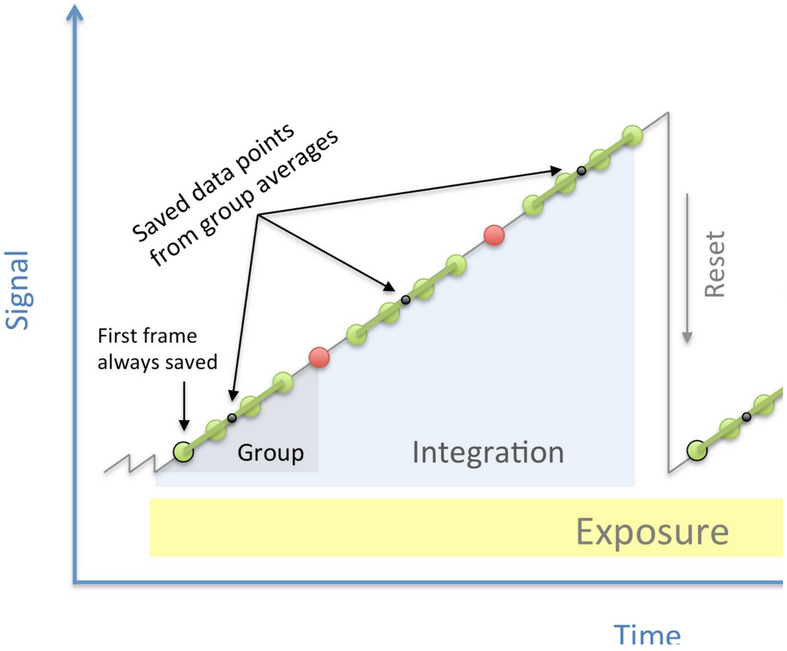


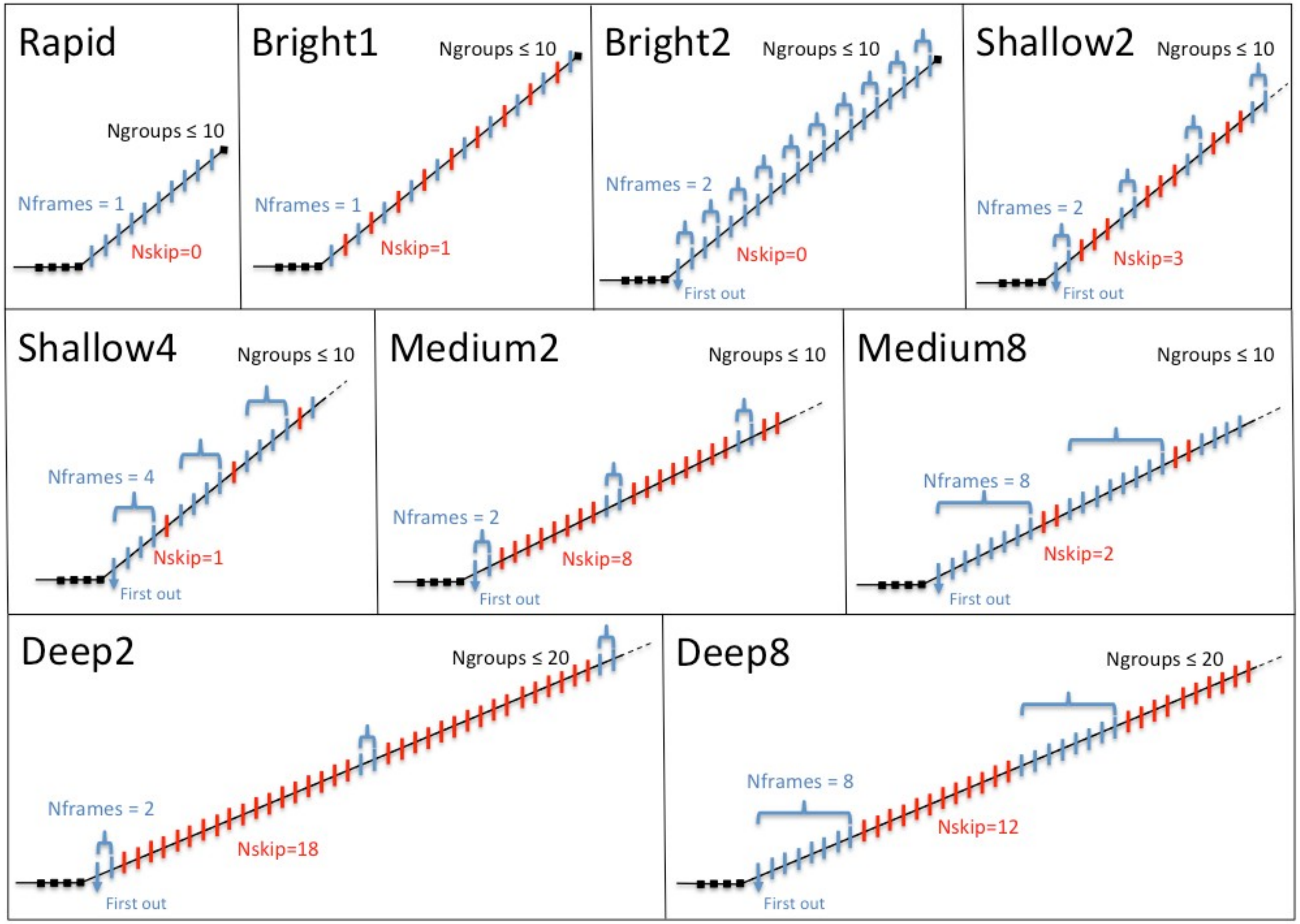
NIRCam readout patterns

https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-detector-overview/nircam-detector-readout-patterns

Readout patterns due to bandwidth limitations:
- frames are averaged for each group
- more frames mean higher likelihood of cosmic rays impacting the sensor

Example:

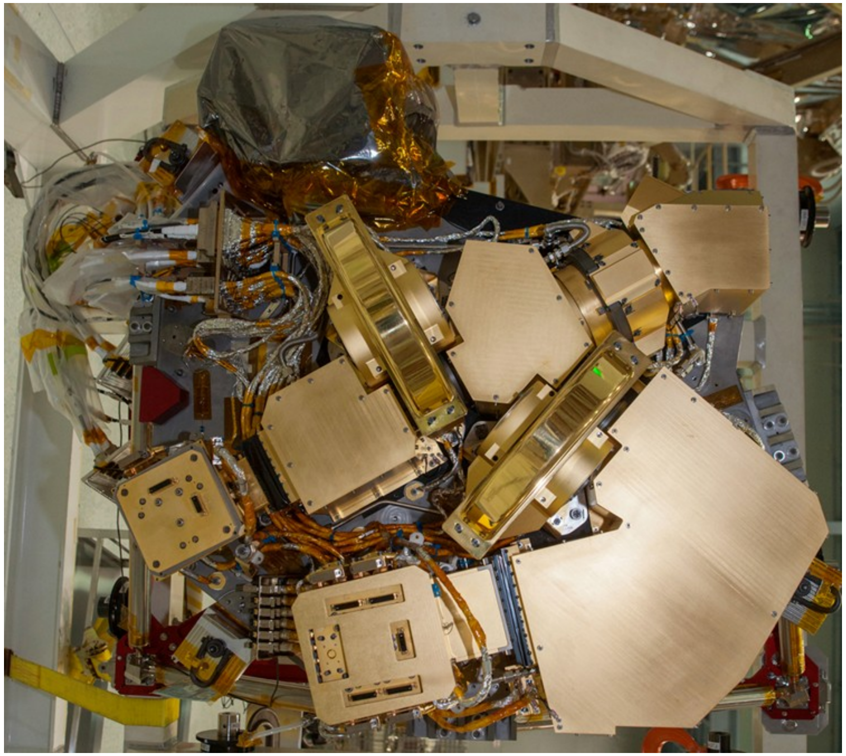


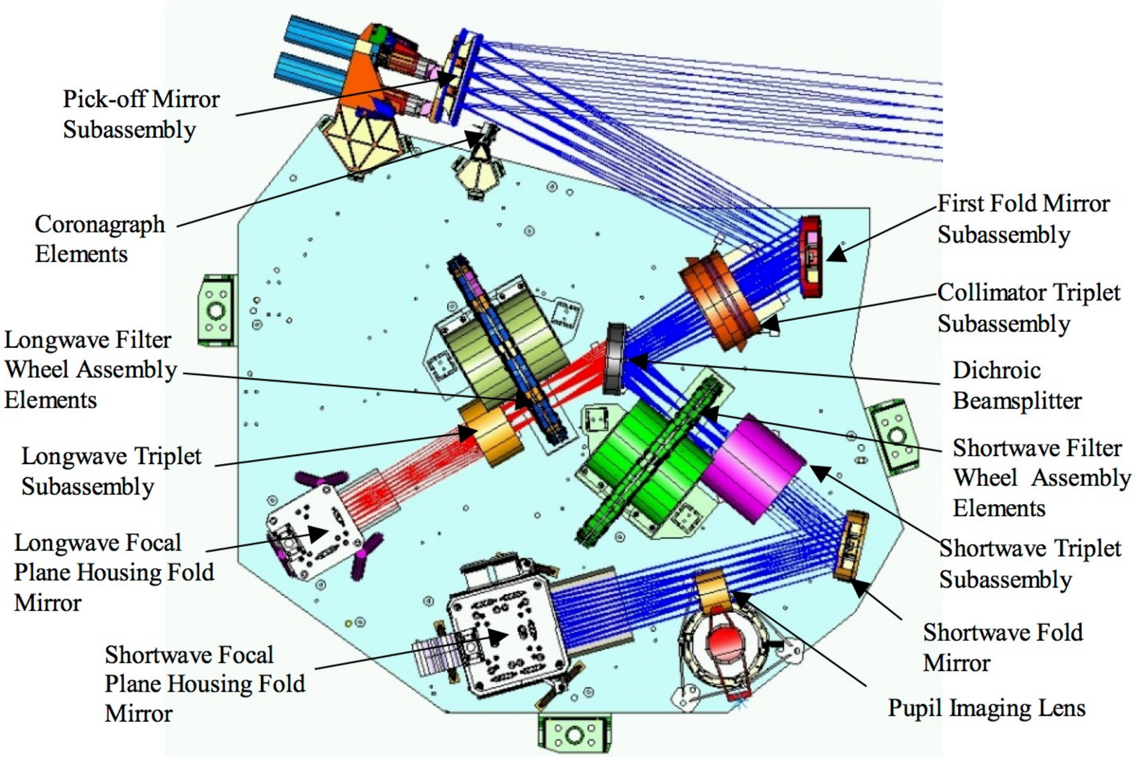


NIRCam modules

https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-modules

Two similar modules: A & B

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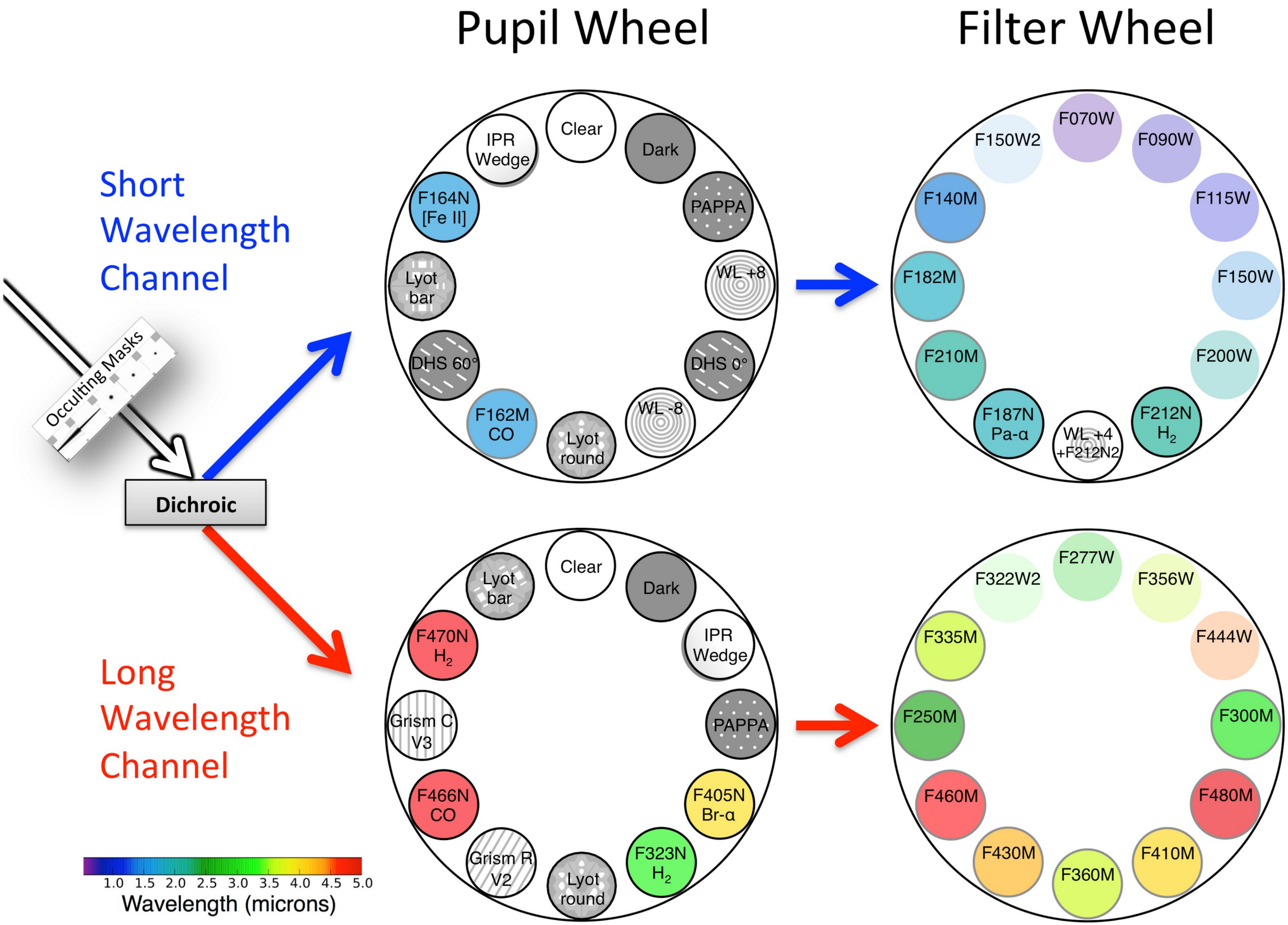
Pupil Imaging Lens

NIRCam pupils

https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-pupil-and-filter-wheels



Pupil Wheel

Filter Wheel

Short Wavelength Channel

Occulting Masks

Dichroic

Long Wavelength Channel

Clear
Dark
PAPPA
WL +8
DHS 0°
WL -8
Lyot round
F162M CO
DHS 60°
Lyot bar
F164N [Fe II]
IPR Wedge

F070W
F090W
F115W
F150W
F200W
F212N H_2
WL +4 +F212N2
F187N Pa-α
F210M
F182M
F140M
F150W2

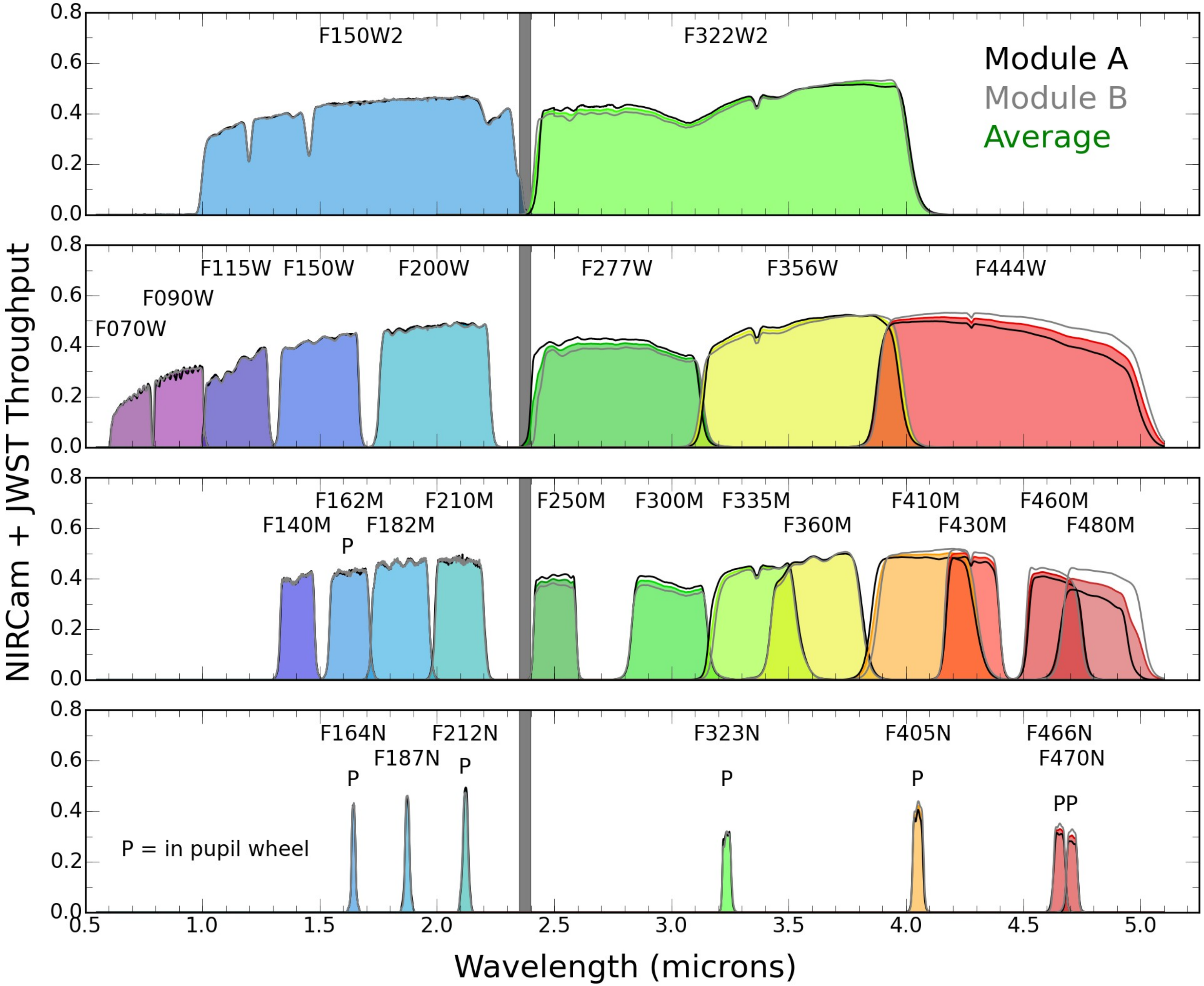
Clear
Dark
IPR Wedge
PAPPA
F405N Br-α
F323N H_2
Lyot round
Grism R V2
F466N CO
Grism C V3
F470N H_2
Lyot bar

F277W
F356W
F444W
F300M
F480M
F410M
F360M
F430M
F460M
F250M
F335M
F322W2

1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Wavelength (microns)

NIRCam filters

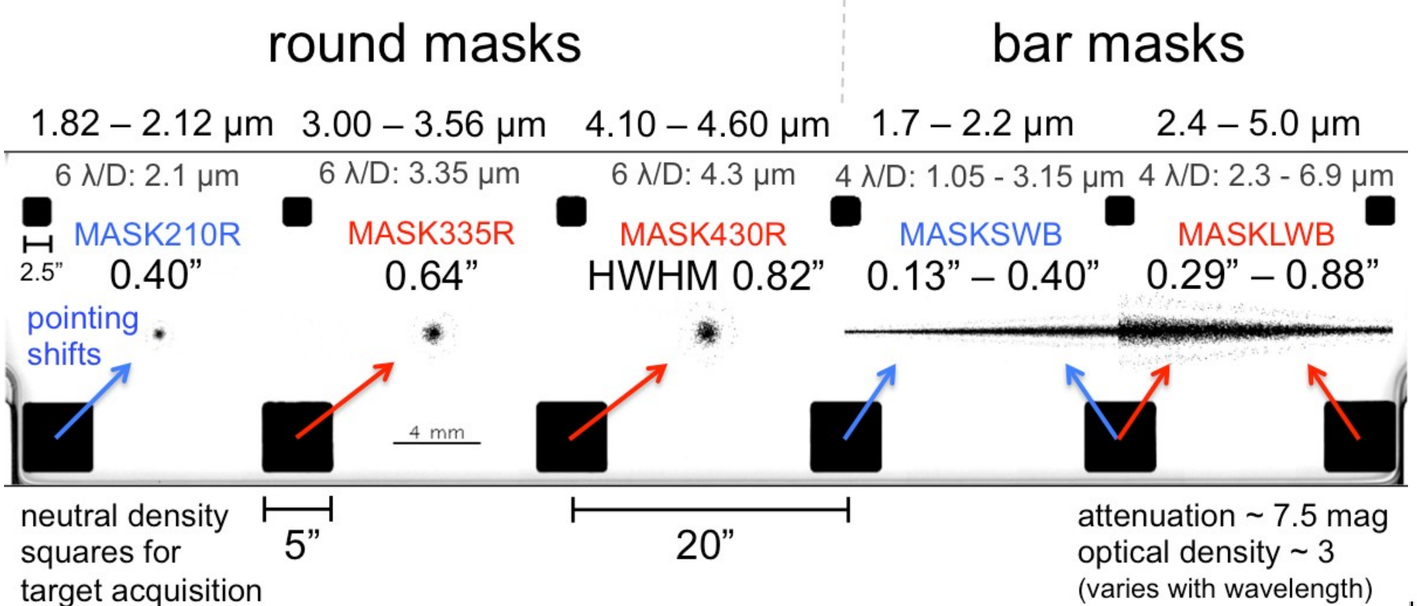
https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-filters

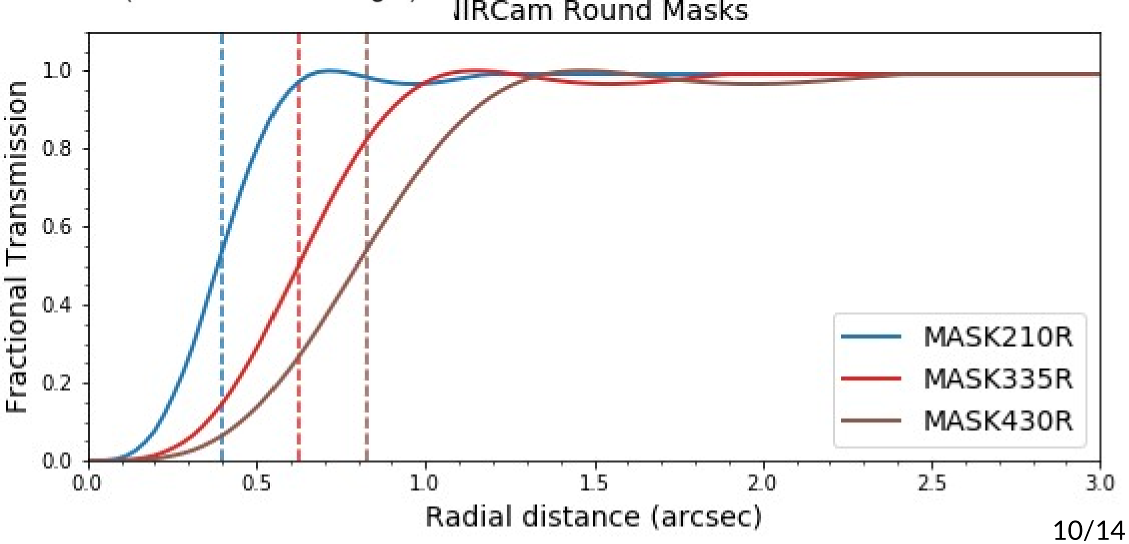


NIRCam coronagraphs

https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-filters-for-coronagraphy

Transmission curve data:
https://jwst-docs.stsci.edu/jwst-near-infrared-camera/nircam-instrumentation/nircam-coronagraphic-occulting-masks-and-lyot-stops





Setting up a synthetic observation: APT

APT: *Astronomer's Proposal Tool*

https://www.stsci.edu/scientific-community/software/astronomers-proposal-tool-apt/

Installation instructions etc on the website.

Load a template:

- File → JWST Demonstration Proposals → NIRCam Template Example

The xml (and pointing*) files exported from APT will be used by Mirage

- (* the pointing was partially hardcoded last time I checked)
- File → Export...

`mirage` does not yet support coronagraphic imaging, so use the normal imaging setup in APT.

Installing `Mirage`

MIRAGE: *Multi-Instrument RAmp Generator*

https://mirage-data-simulator.readthedocs.io/

Follow the installation instructions on the site

- set up [mini]conda
- use Python 3.7 for *conda installations (?):
  ```
  conda create -n mirage python=3.7
  ```
- install `mirage`:
  ```
  conda activate mirage
  pip install mirage
  ```
  This takes care of all dependencies. Note that `jwst` may be outdated (create a separate environment for an up-to-date version if needed); updating or not updating may cause issues.

The standard example

Get the example notebook:

https://github.com/spacetelescope/mirage/tree/master/examples

For converting radiative transfer images (e.g. `RadMC-3D` output) to mock observations, use the notebook
`Simulated_data_from_mosaic_image.ipynb`
and the folder
`imaging_example_data`

It's probably easiest to just

```
git clone https://github.com/spacetelescope/mirage/
```

and extract from there. Alternatively, use third-party tools to get just the subfolder.

Then start a `jupyter` server and go through the `ipynb` file. Some hotfixing may be still needed.

Another example

To conclude, let’s take a look at a single-purpose / streamlined notebook including the (necessary) post-processing of the synthesized images with `jwst`.