# All About NIRCAM


Image from JWST user documentation: (stsci)

# Overview

- Two modules pointing to adjacent FOV
- Each uses a dichroic to simultaneously observe long wavelength (LW) and short wavelength (SW)
- 8 SW detectors cover roughly same sky area as the 2 LW detectors

# Overview

- Dichroic mirror - different transmission properties at different wavelengths - reflects and transmits
- Splits the beam at around 2.35μm into SW and LW
- SW is reflected, LW is transmitted

# FOV in JWST focal plane

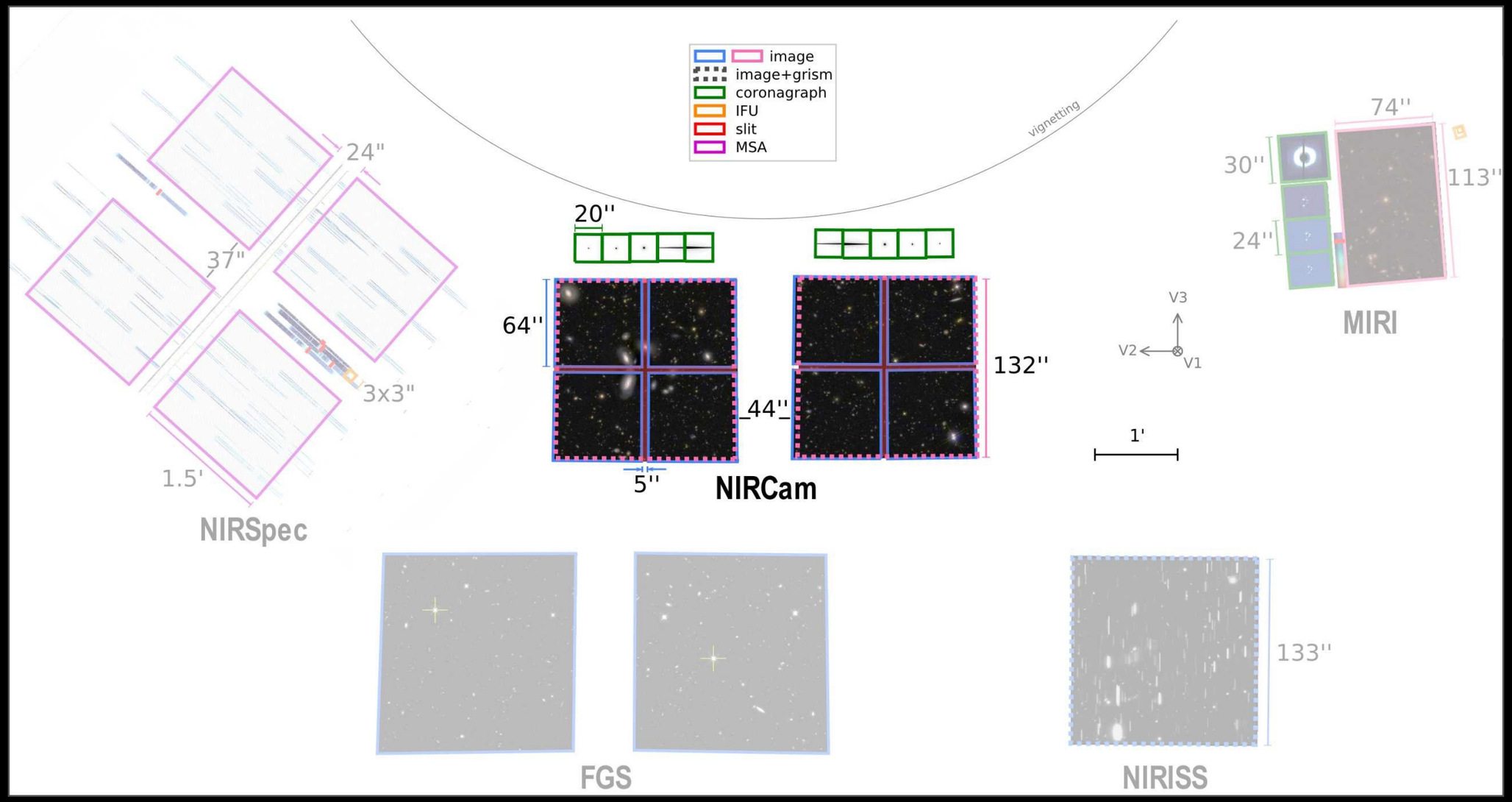



Image from JWST user documentation: (stsci)

# Imaging Modes

- Five observing modes:

1. Imaging of two 2.2’ x 2.2’ fields
2. Coronagraphic imaging
3. Wide field slitless spectroscopy
4. Time-series imaging
5. Grism time series

# Imaging

- Total field-of-view 9.7’$^2$ in both a short wavelength channel and a long wavelength channel simultaneously
- Separation of each 2.2’ by 2.2’ field is 44”
- Gaps of 5” separate the four detectors in each short wavelength module

# Imaging Field-of-View

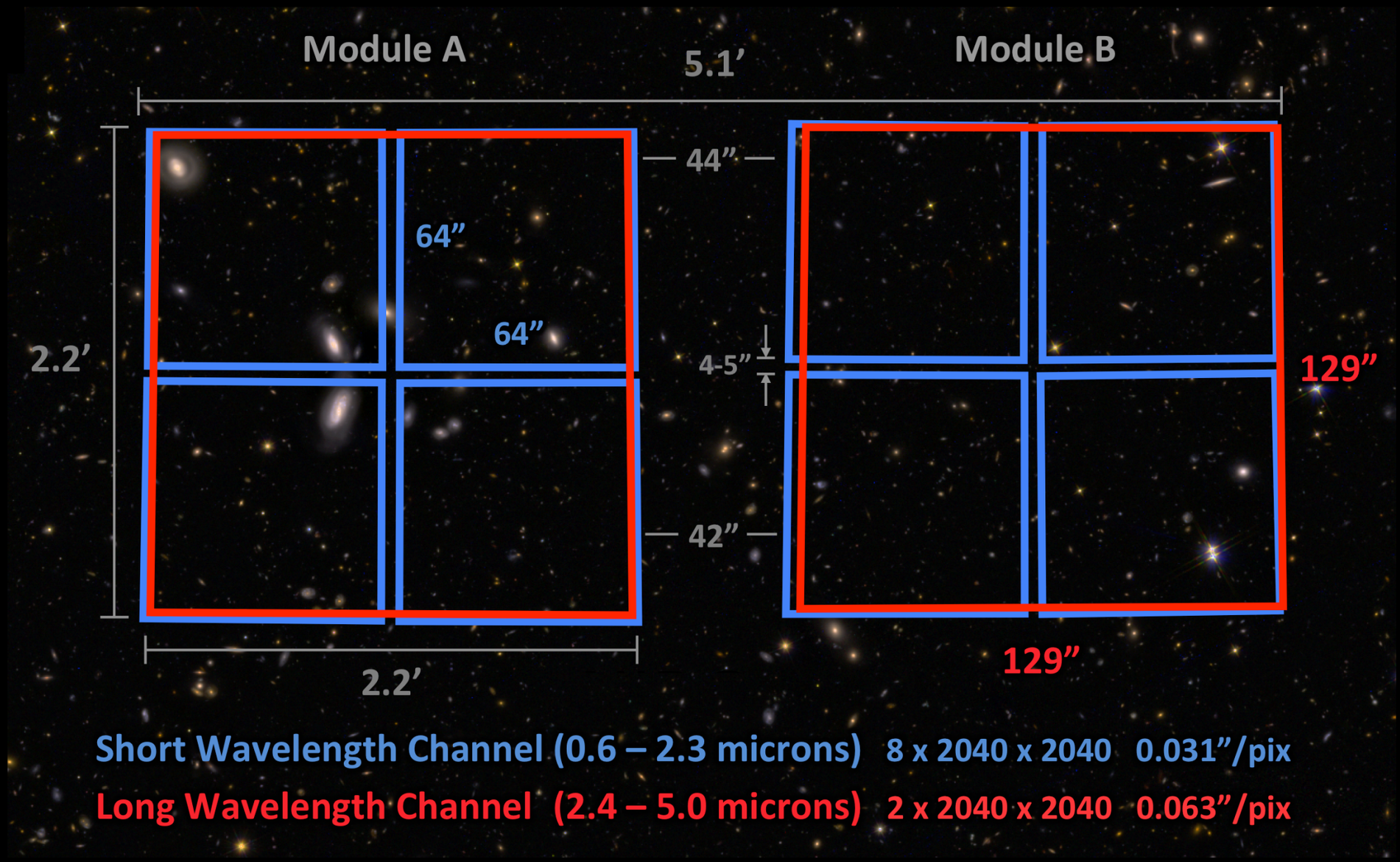



Image from JWST user documentation: (stsci)

# Imaging - Short Wavelength

- Range 0.6 - 2.3 μm
- 0.031” pixel scale
- Nyquist wavelength 2 μm
- PSF FWHM 2 pixels
- Imaging in pixels = 8 x 2040 x 2040 pixels

# Imaging - Long Wavelength

- Range 2.4 - 5.0 μm
- 0.063” pixel scale
- Nyquist wavelength 4 μm
- PSF FWHM 2 pixels
- Imaging in pixels = 2 x 2040 x 2040 pixels

# Filter set

One filter selected for each wavelength channel and both wavelengths are observed together

29 different NIRCAM filters available

- Extra wide R~1
- Wide R~4
- Medium R~10
- Narrow R~100

# Filter set

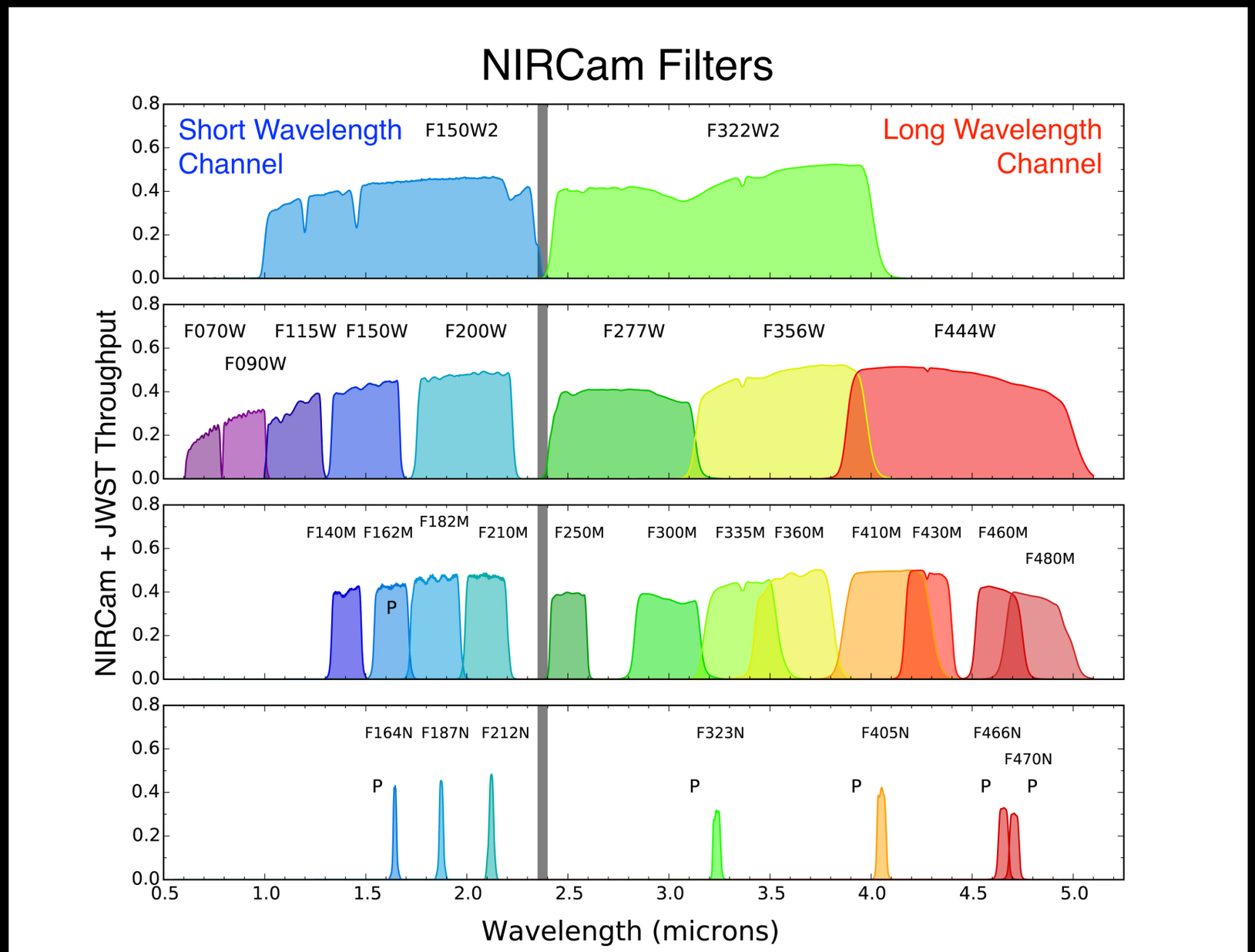



Image from JWST user documentation: (stsci)

# Filter set

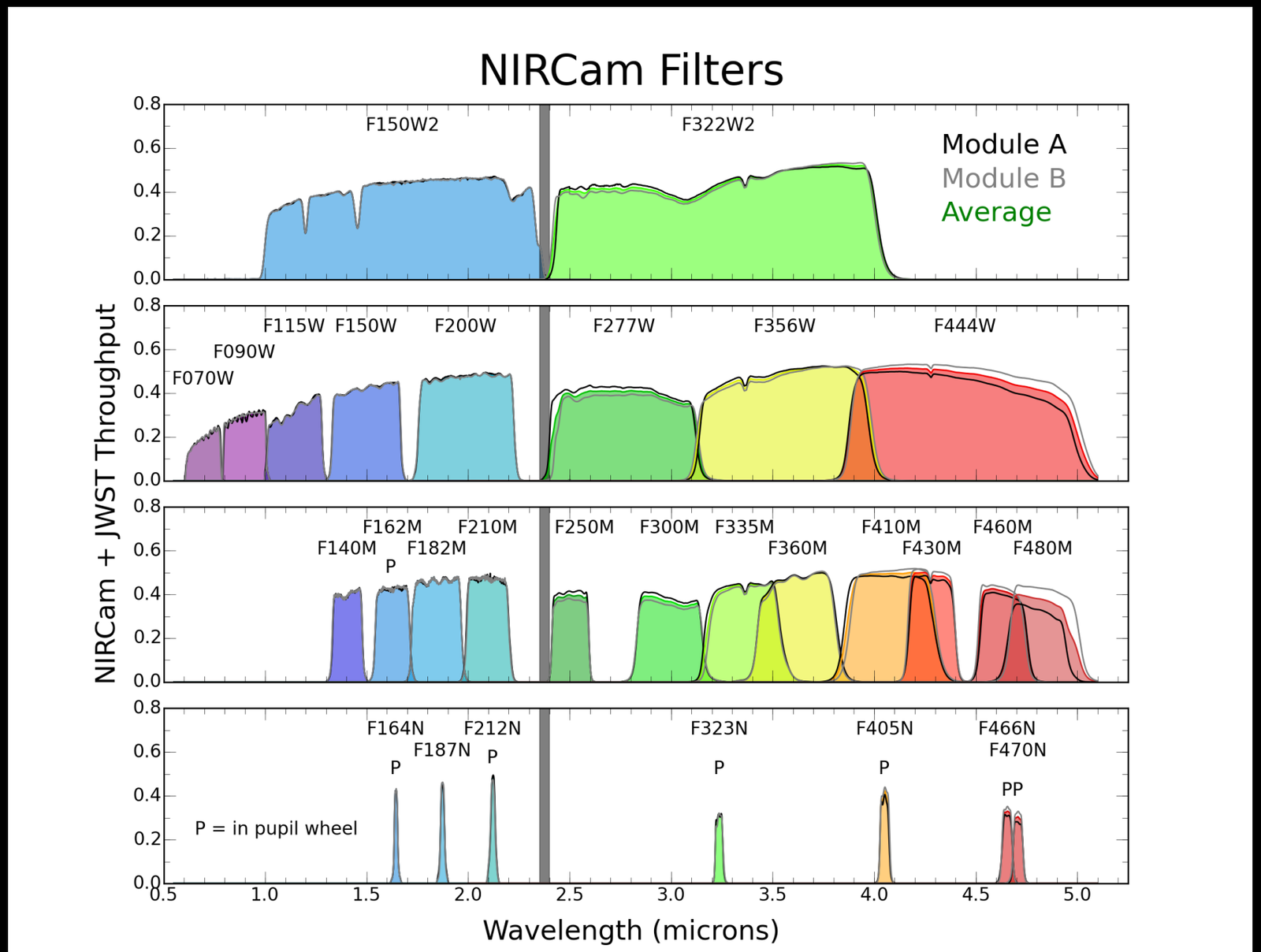



Image from JWST user documentation: (stsci)

# Dithering & Mosaicking

- Required for NIRCAM imaging except time-series

- Pointing manoeuvres which help to fill image gaps, deal with bad pixels, and mitigate uncertainties due to flat field

- Can also provide sub-pixel sampling and improve the resolution

# Dithering & Mosaicking

- primary — 4”-100” manoeuvres to fill gaps
- subarray primary — <0.4” improve spatial coverage of small subarrays
- subpixel dithers — 0.2”-2” to improve spatial resolution of stacked images - mitigate under sampled PSF
- small grid dithers — <0.06” (coronagraphy)
- mosaics — large shifts (~’ level) to tile over areas larger than the field-of-view

# Dithering & Mosaicking

Order at which dithering/mosaicking sequence is run:

- Exposure
- subpixel dither
- primary dither
- filter change
- mosaic

# Subarrays

- Can be used instead of full FOV
- Faster read-out time - as short as 49ms compared to 10.74s for other detectors
- Lower data volumes

# Exposure Time

- Governed by the detector read-out pattern
- Detector read-outs are every 10.74s (non-destructive)
  - sub-arrays can be read out quicker (smallest is 49ms)
  - Dithered images will have variable exposure time across the image - so differing depths
  - Exposure Time Calculator available on the stsci site

# Sensitivity (rough guide)

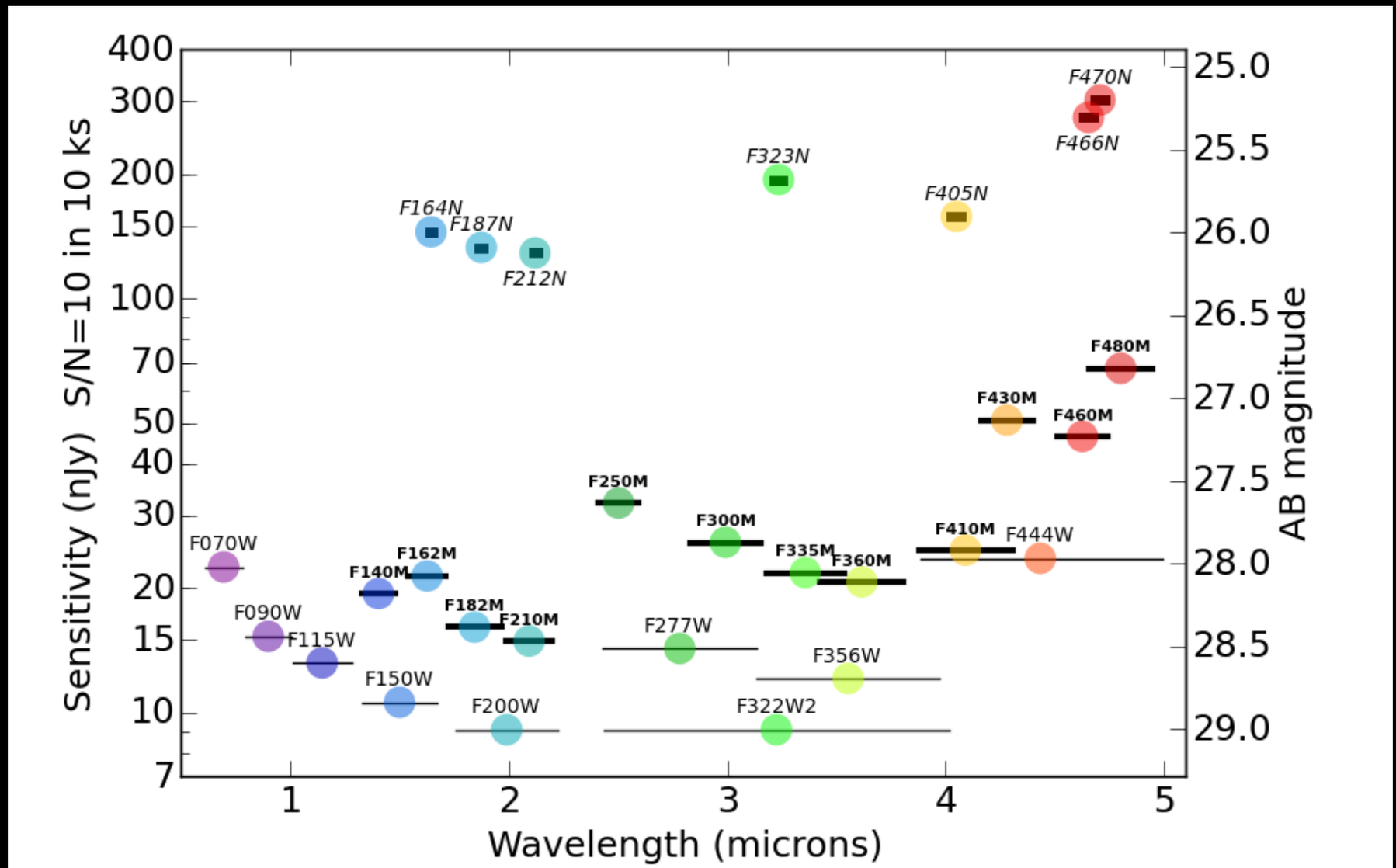



Image from JWST user documentation: (stsci)

# Saturation

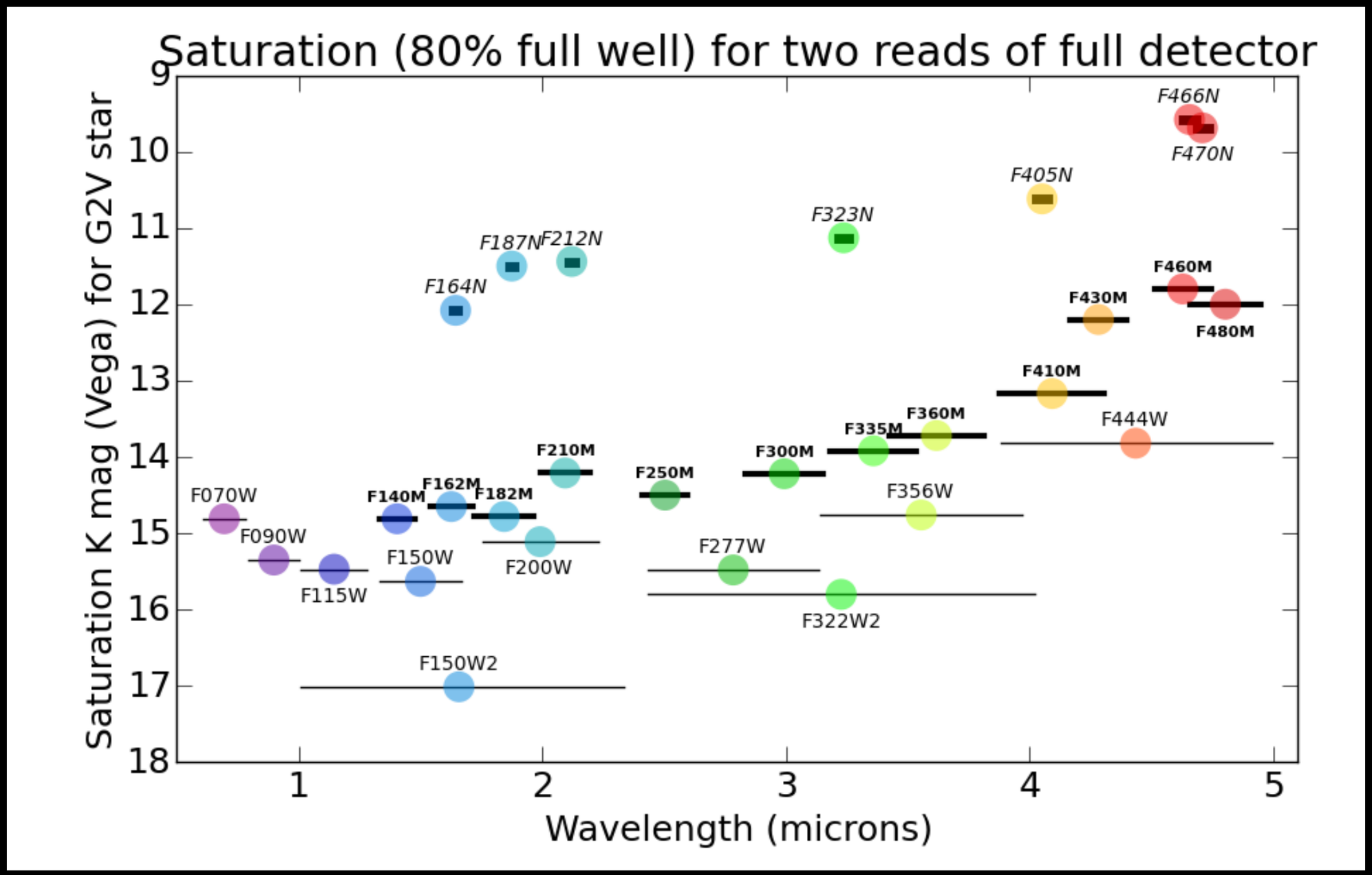



Image from JWST user documentation: (stsci)

# Saturation

- Moderately bright sources (Vega 14-17mag in K) will saturate in full-field broadband imaging
- Using narrower filters gives brighter saturation limit
- Smallest subarray (64x64 pix) brightens the limit by 6 mag
- Brightest objects = use time-series observing mode. Weak lenses for short wavelength and grism for long wavelength

# Time-series Imaging

- for precise measurements of photometric variations in relatively bright sources
- very long uninterrupted observations - many integrations, high cadence and efficiency
- No dithering is used

# Time-series Imaging

- Simultaneous imaging at long wavelengths (LW) and short wavelengths (SW):
- SW FOV is 129” x 129” (0.031” pixel scale)
- LW FOV is 132” x 132” (0.063” pixel scale)
- Should pick similar filter sensitivities and saturation limits for SW and LW, as they get the same exptime and readout patterns

# Time-series Imaging

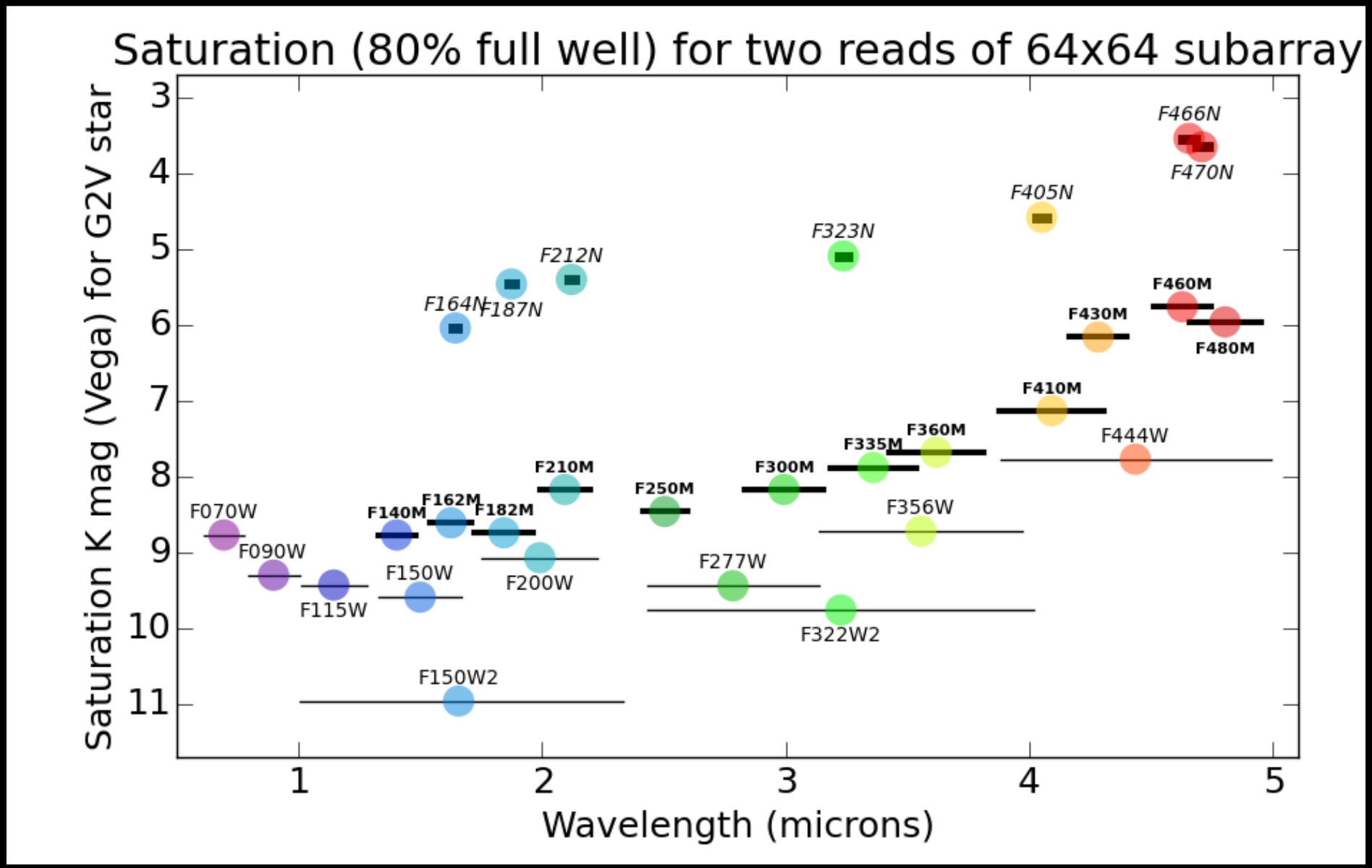



Image from JWST user documentation: (stsci)

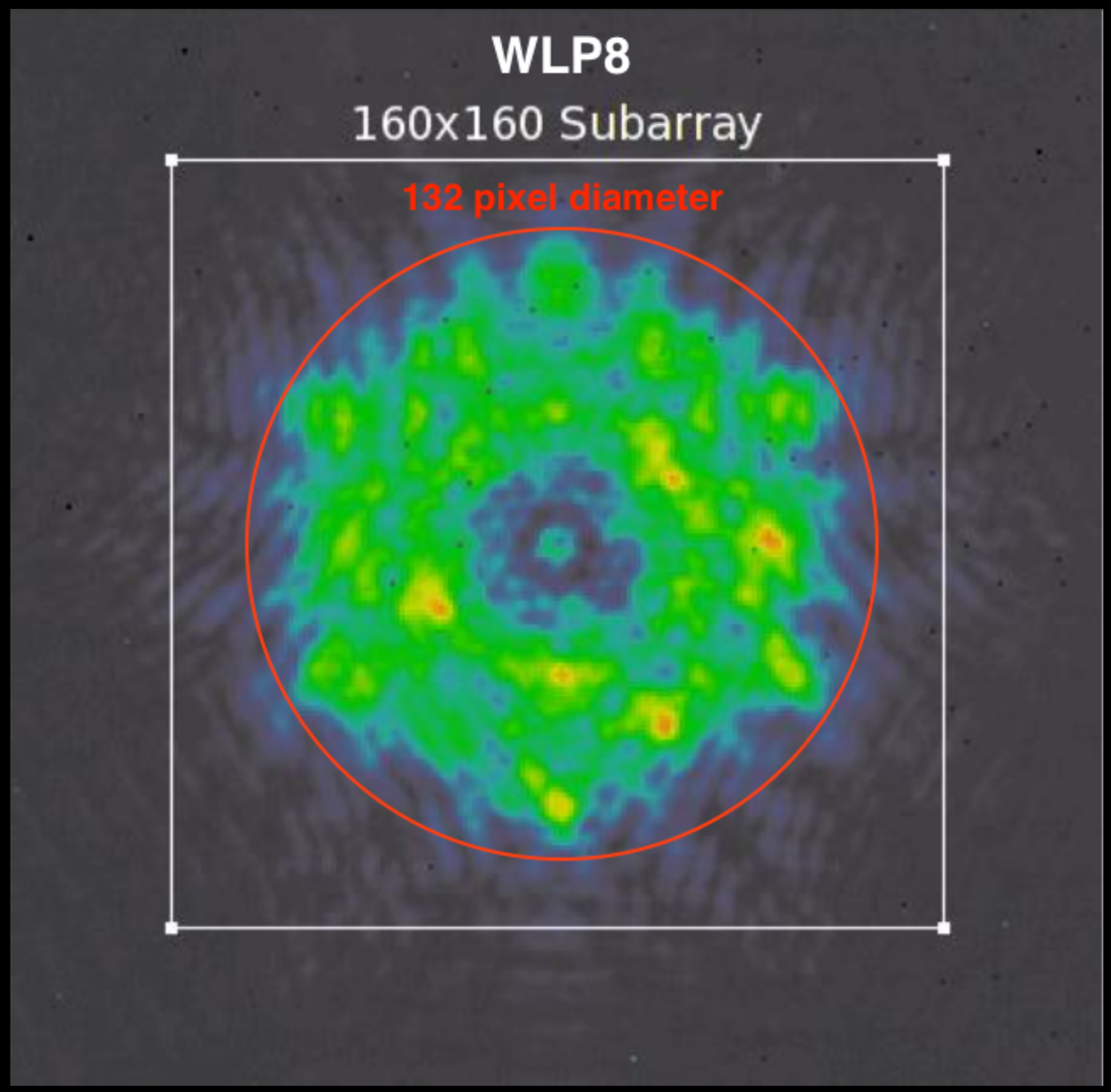
# Weak Lenses

- Used in the SW channel
- May be paired with filters between 1.3-2.2μm
- Greatly increases saturation limit (~11 mag) when used with subarrays
- Defocus image of bright source - use with a big enough subarray to encompass defocused image, for background subtraction

# Weak Lenses

- LW channel that is being used at the same time must be narrowband to prevent saturation (because the exptime and read-out pattern is the same - see earlier slide)

# Weak Lenses




Weak lensed point source fits well on 160x160 subarray

Image from JWST user documentation: (stsci)

# Time-series Imaging

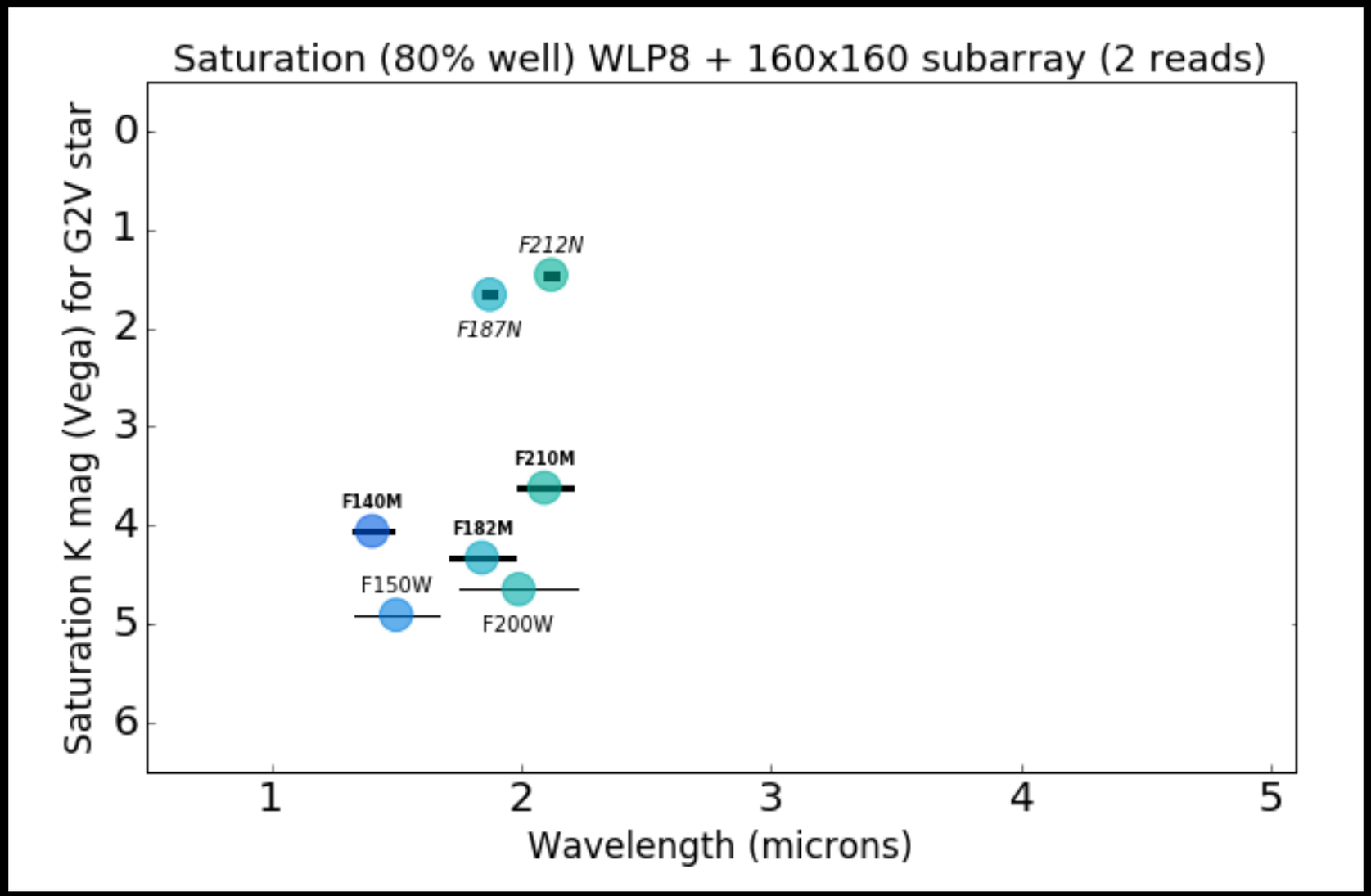
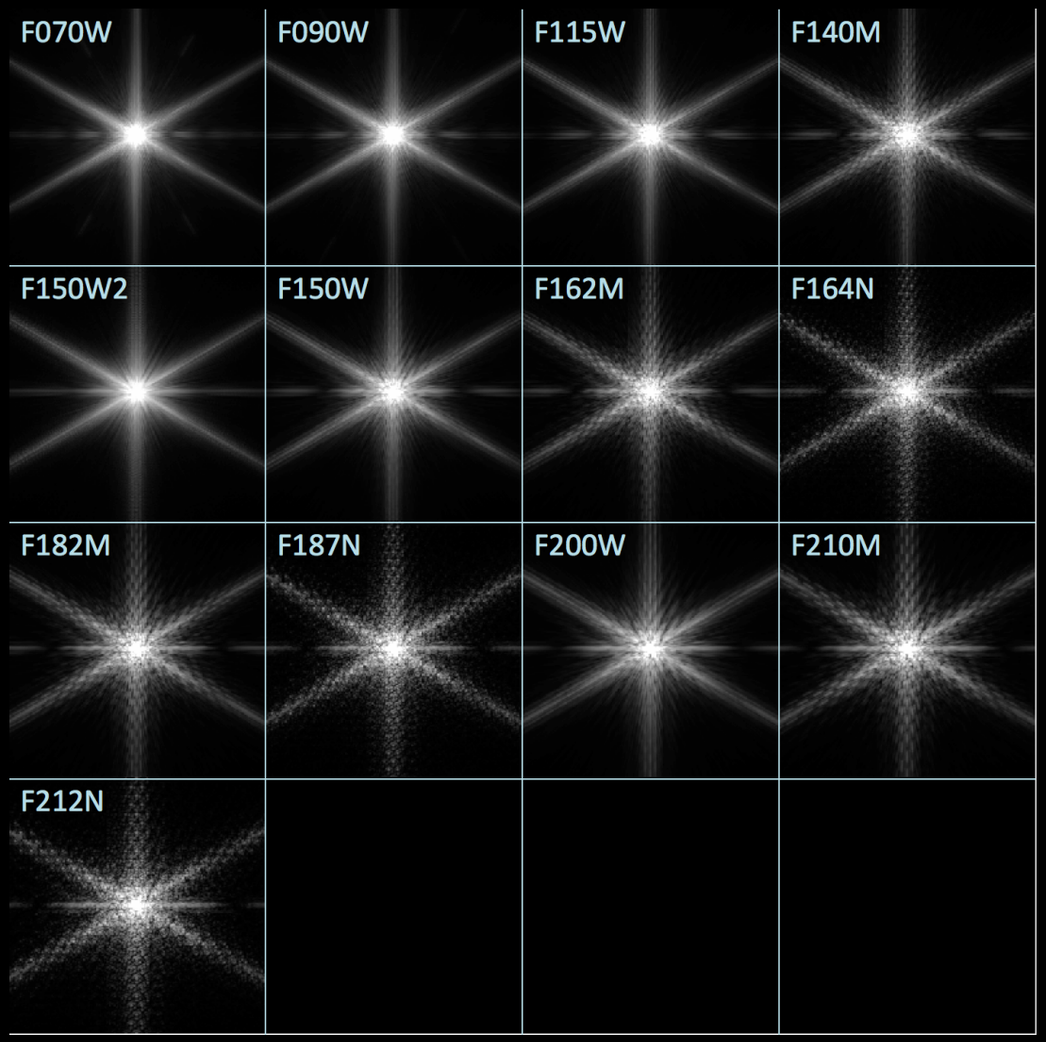
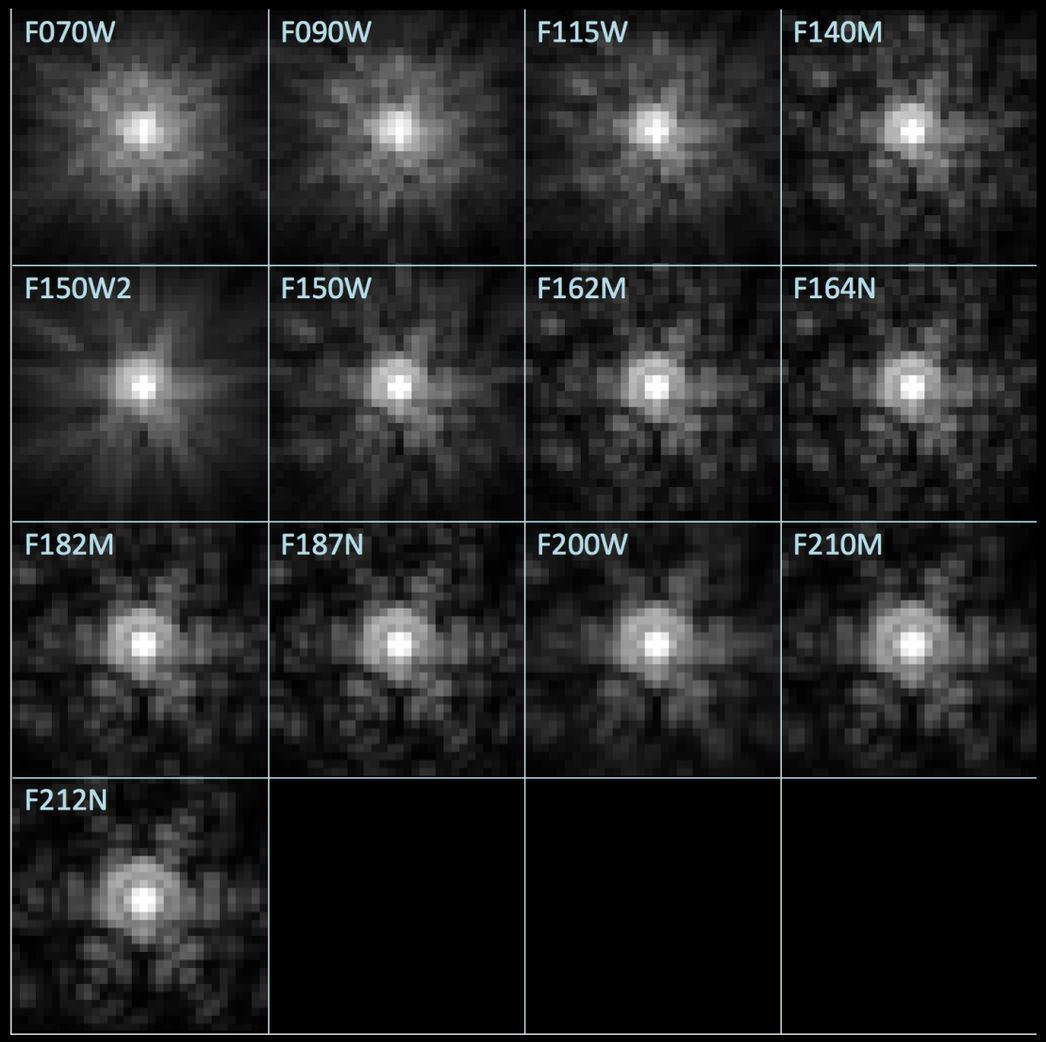



Image from JWST user documentation: (stsci)

# Simulated PSFs - SW

## Simulated with WebbPSF - 299x299 pix (core 32x32)

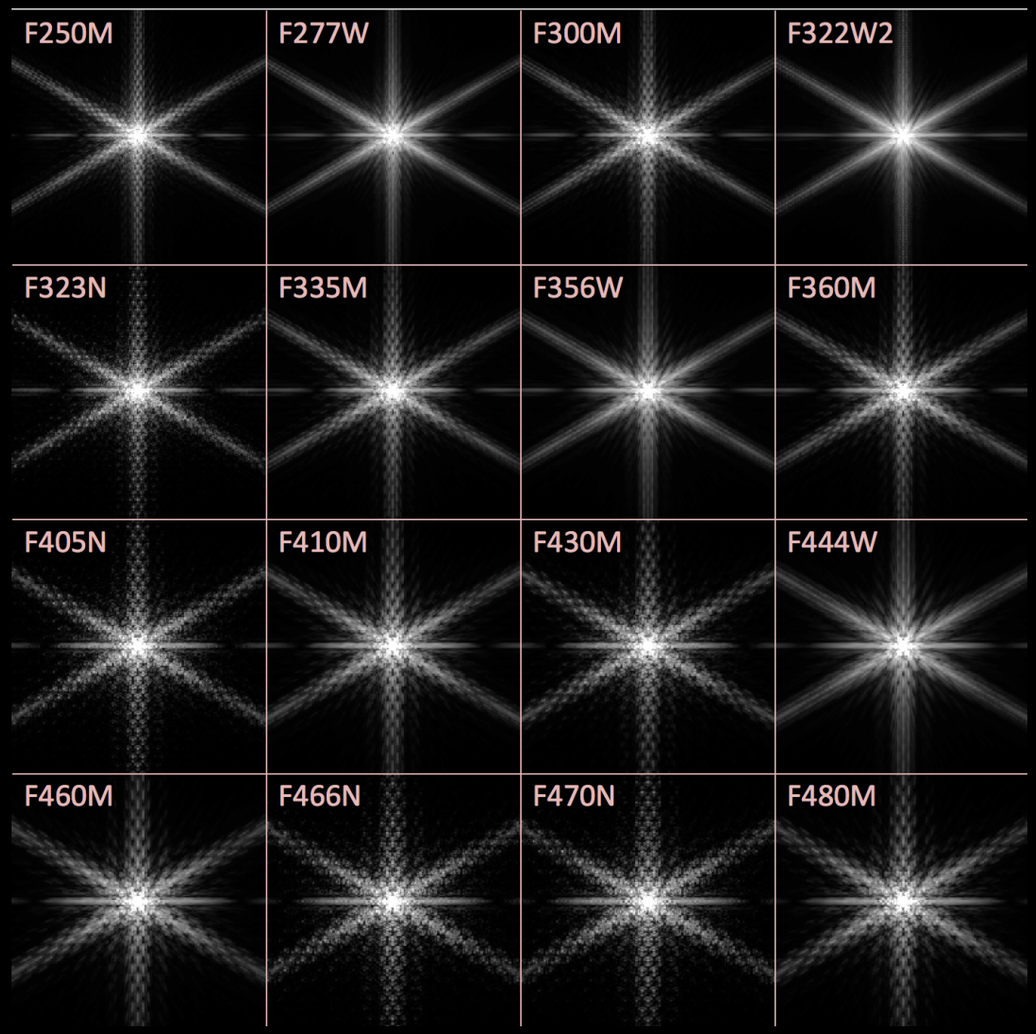


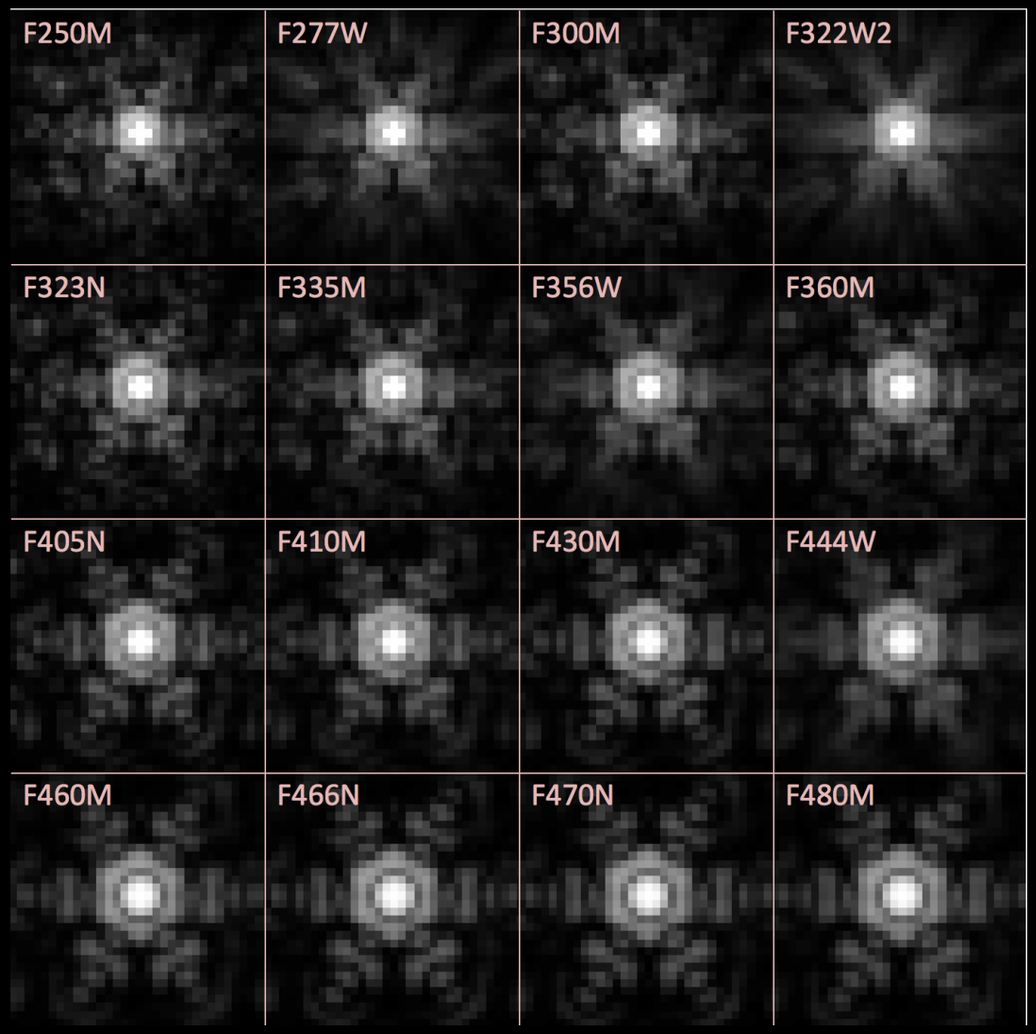




Images from JWST user documentation: (stsci)

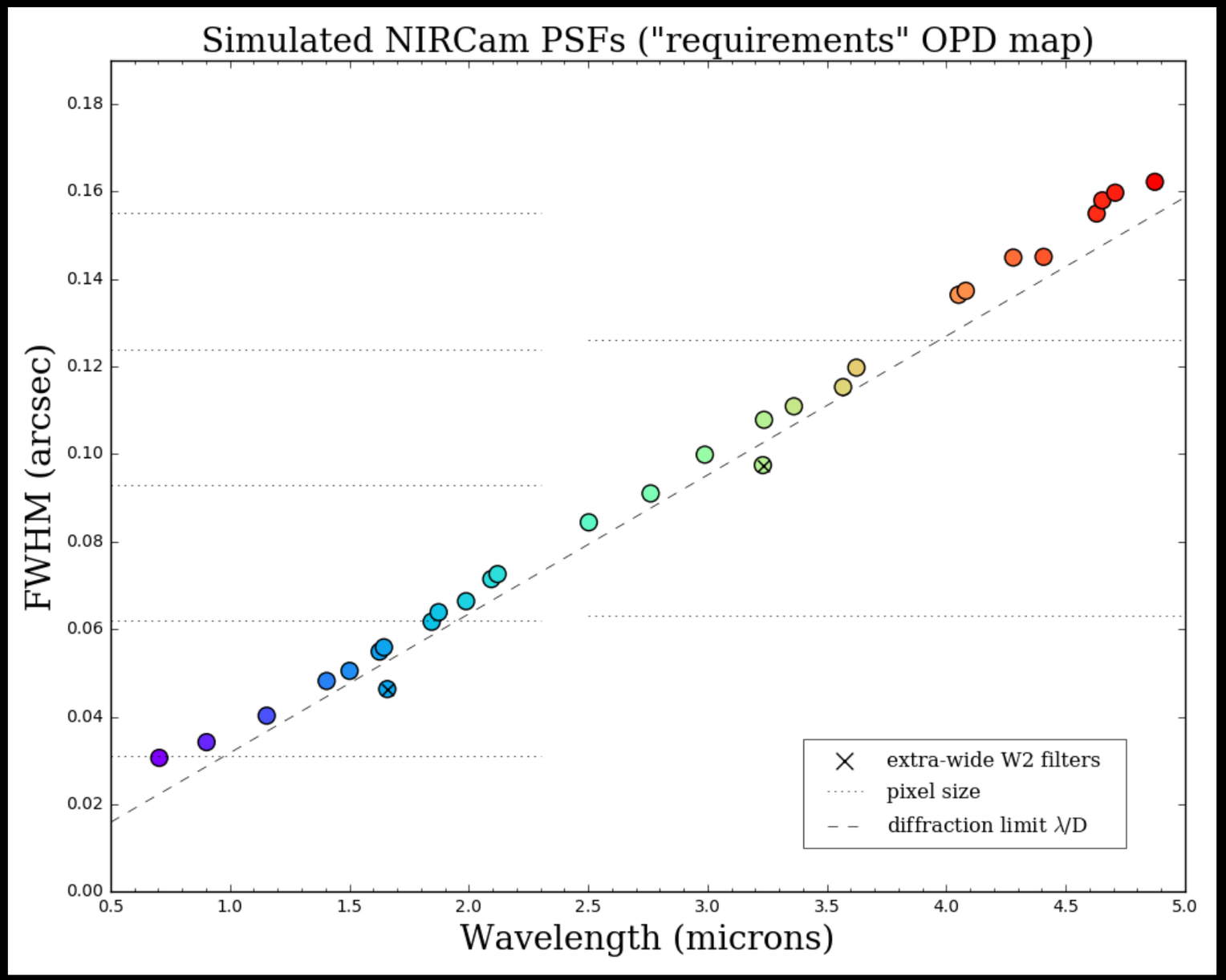
# Simulated PSFs - LW

## Simulated with WebbPSF - 299x299 pix (core 32x32)




Images from JWST user documentation: (stsci)




Undersampled below 2μm in SW, 4μm in LW
Need subpixel dithering to improve this

Image from JWST user documentation: (stsci)

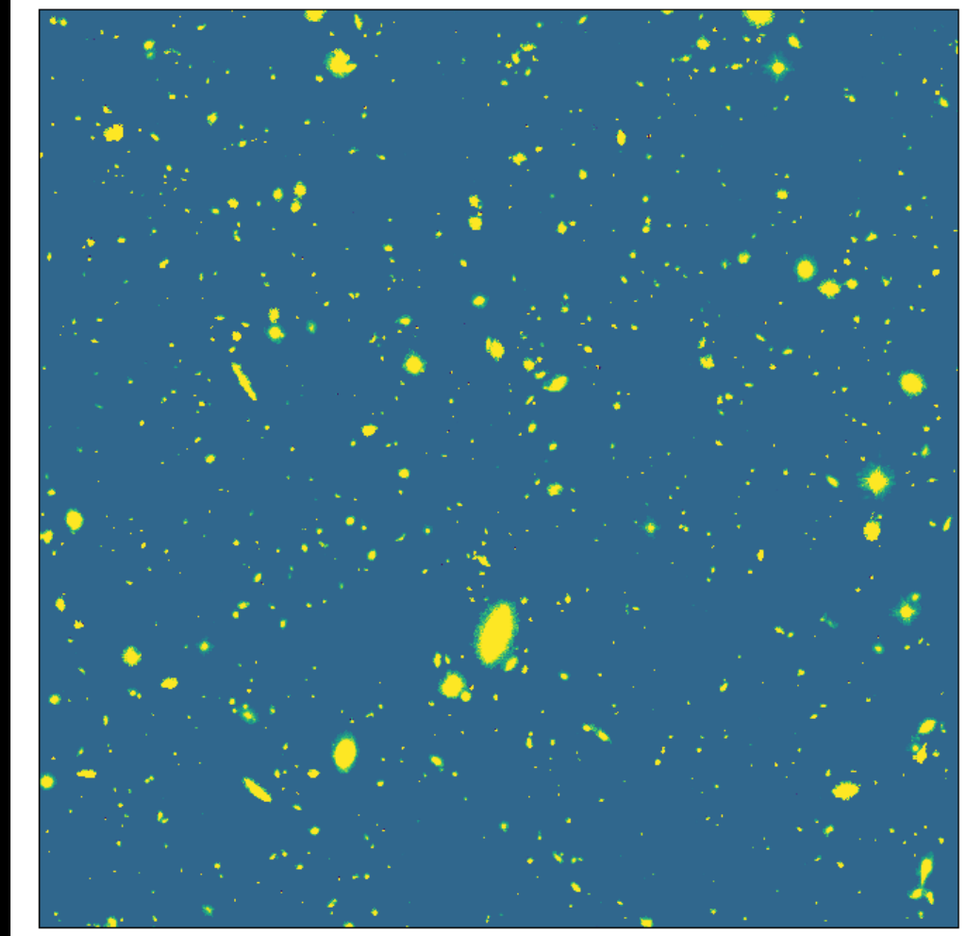
# Wide-Field Slitless Spectroscopy

- Grisms and filters - wavelength range 2.4 - 5 μm
- Spectra with R~1600 of all objects within FOV or just outside FOV
- Field of view ~9 sq. arcmin (2 x 129” x 129”)
- Two grisms available - perpendicular dispersion directions

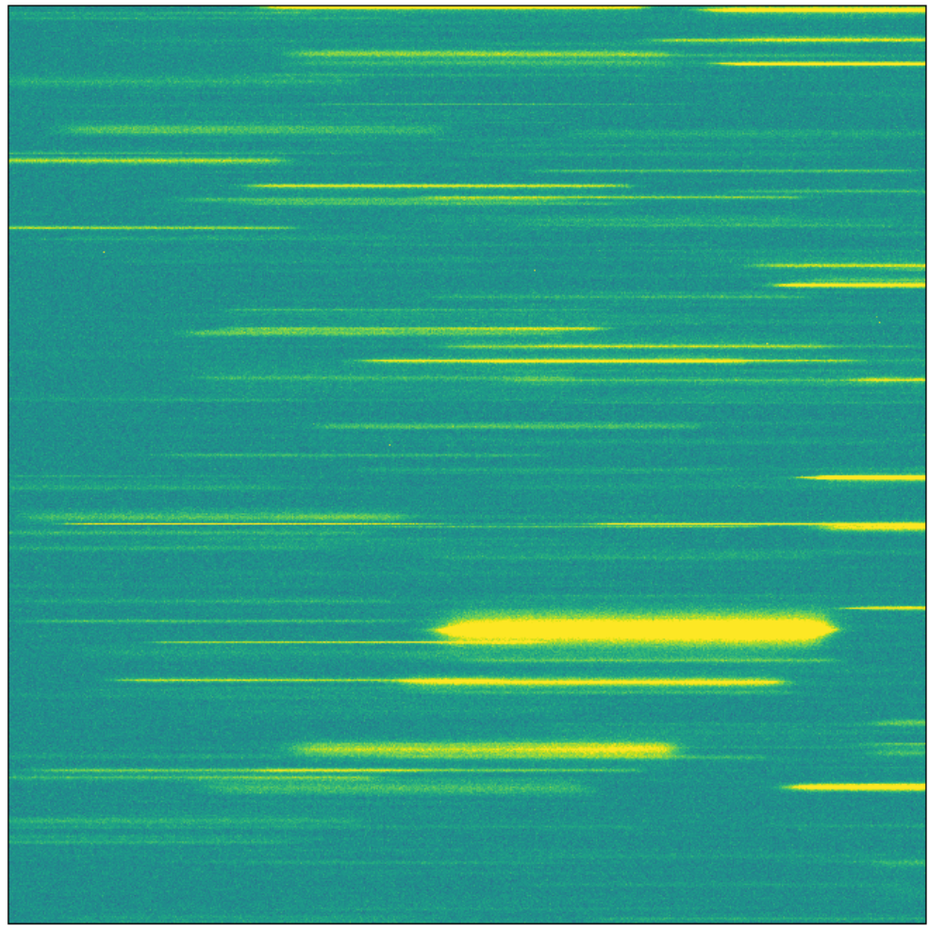
# Wide-Field Slitless Spectroscopy

- Each grism used with wide or medium filter
- SW imaging done together with LW grism
- LW direct imaging can be done after grism - needed for identifying sources
- These extra images dithered parallel to dispersion direction and are offset so as to identify outside-FOV sources

# Dispersion



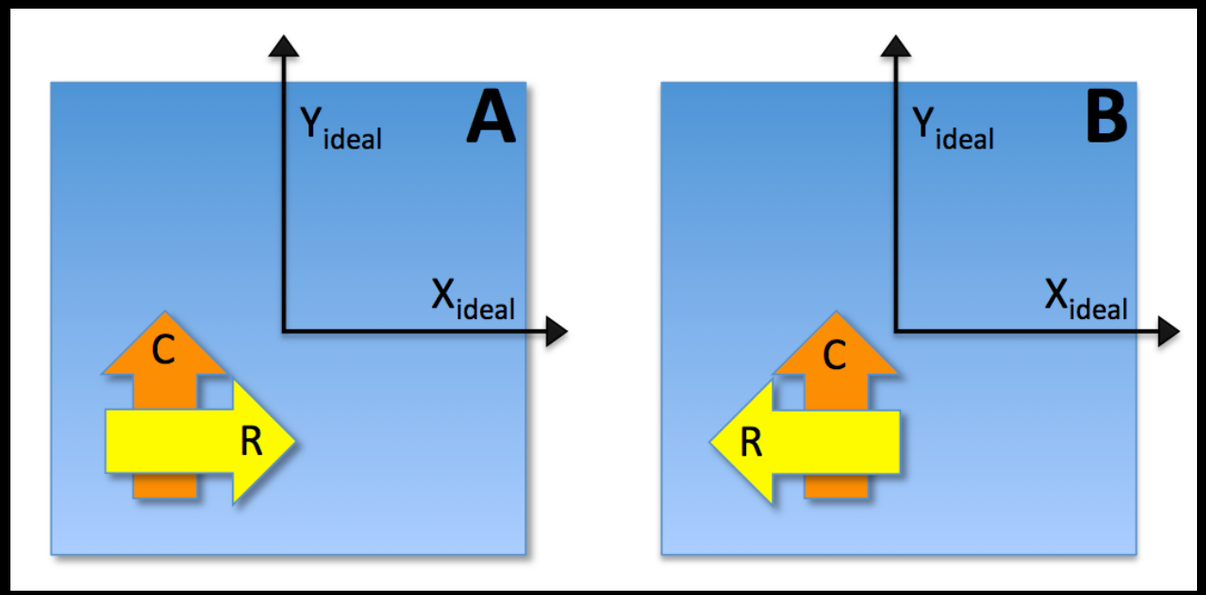
Sim F356W image

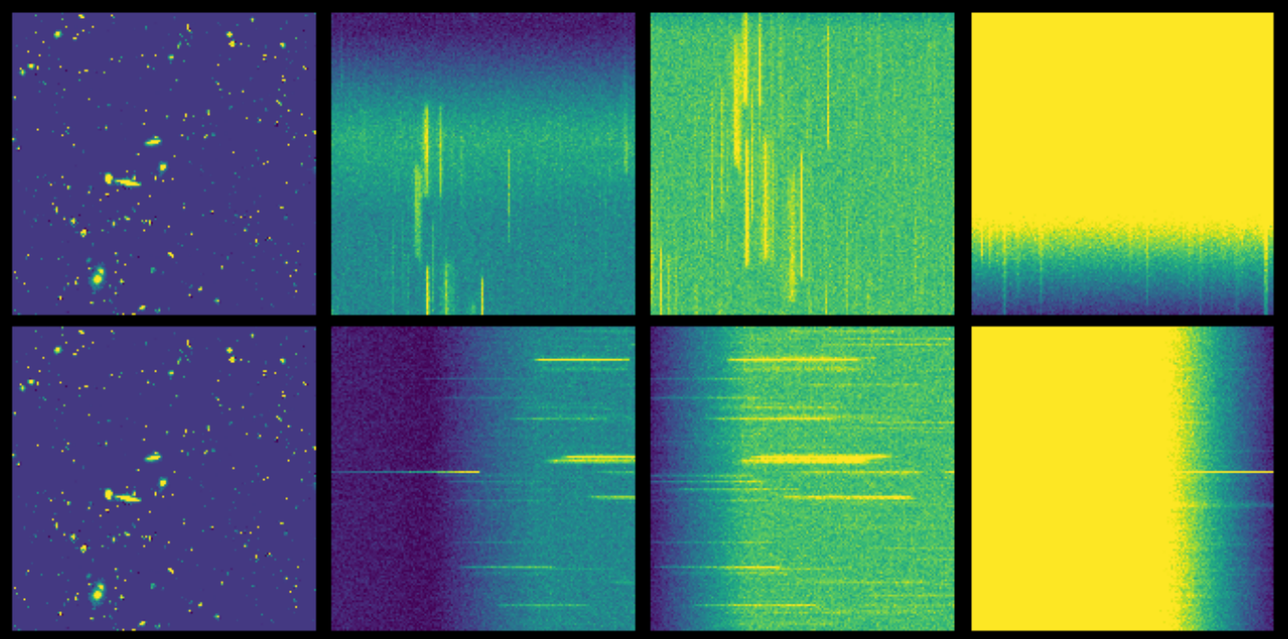


Grism R+F356W
Wavelength increases left to right

Image from JWST user documentation: (stsci)

# Dispersion



Images from JWST user documentation: (stsci, Greene+17)

# Outside FOV sources

- Deflection of light parallel to the dispersion direction for all wavelengths except 3.95μm
- Deflection ~1nm per pixel so objects outside FOV can produce streaks on detector
- Dithers parallel to dispersion direction help to directly image these outside-FOV sources

# Outside FOV sources

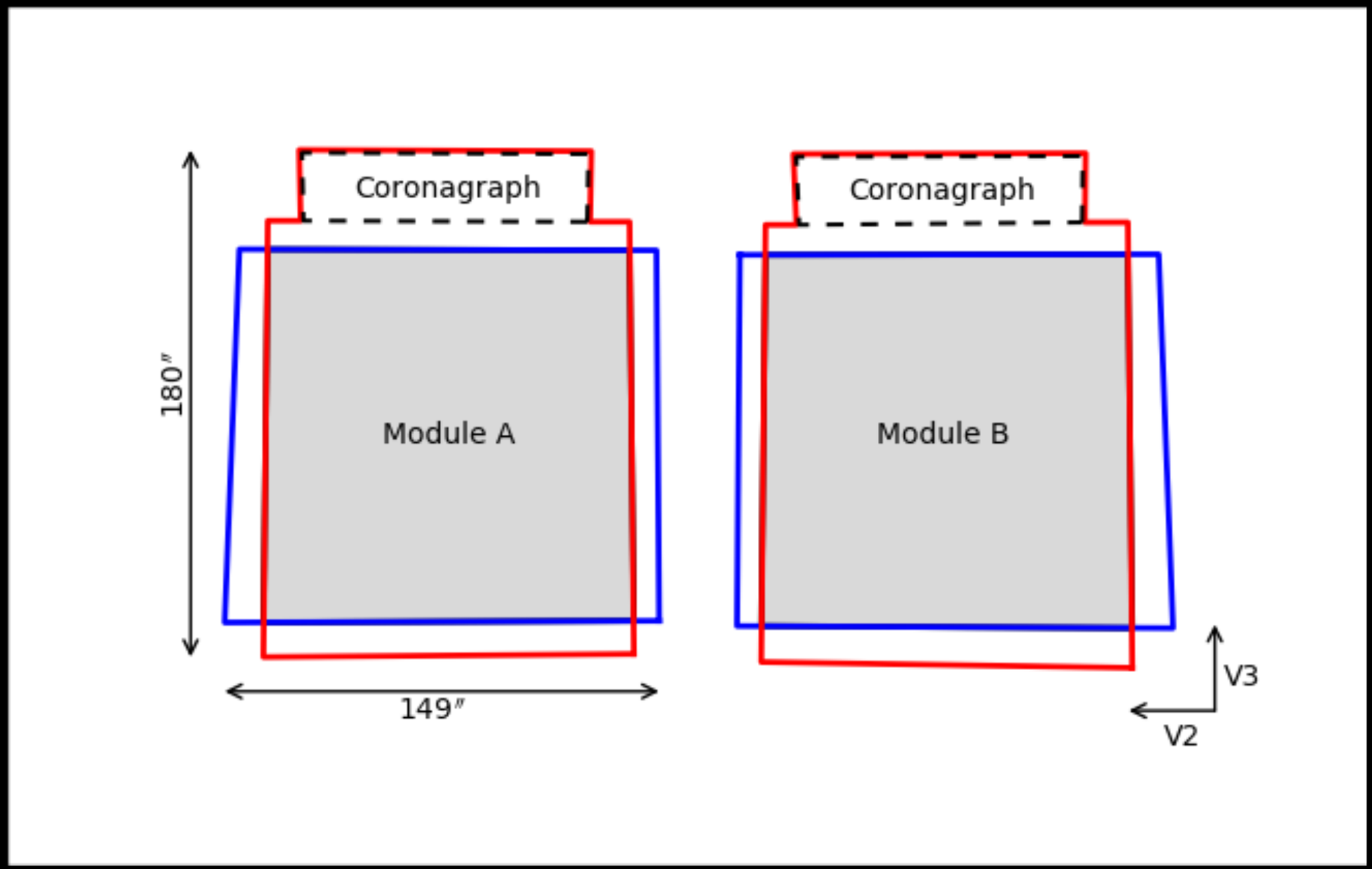



Image from JWST user documentation: (stsci)

# Sensitivity

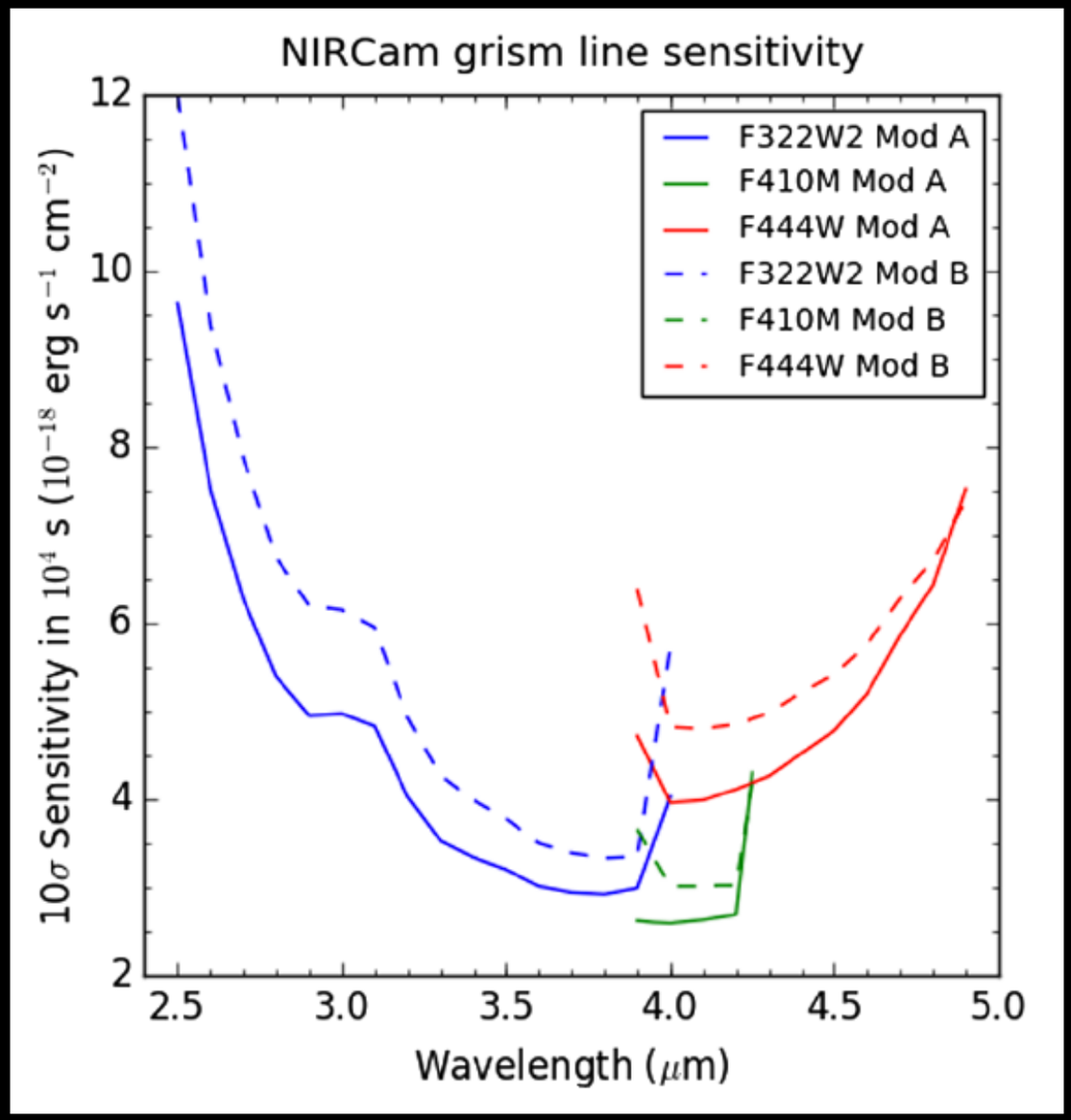



Image from JWST user documentation: (stsci)

# Sensitivity

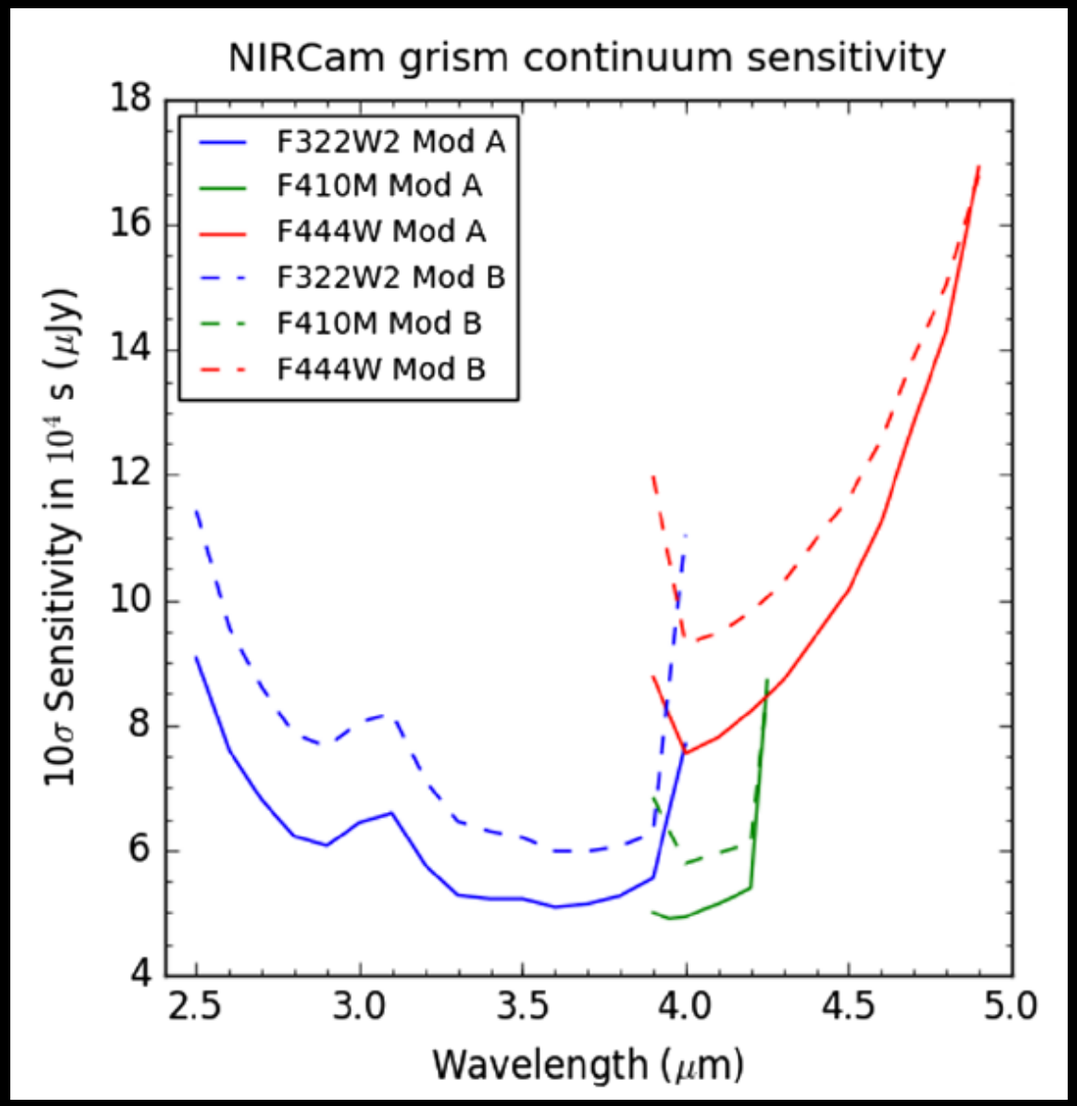



Image from JWST user documentation: (stsci)

# Grism time-series imaging

- For monitoring bright, isolated variable sources at 2.4-5μm with resolving power R~1600
- Very long exposures, but no dithering/mosaic
- Grism R disperses target spectrum parallel to detector rows
- Used in conjunction with one of 4 wide filters in LW (2.4 - 5μm). Used together with SW weak lens.

# Grism time-series imaging

- Can shorten integration time to avoid saturation due to bright objects
- Shorten readout time by only using subset of detector rows
  - subarray will contain entire spectrum for isolated compact source
  - Available subarrays have 64, 128 or 256 rows
  - Only observing mode to offer readout through 4 outputs simultaneously

# Throughput (1st order)

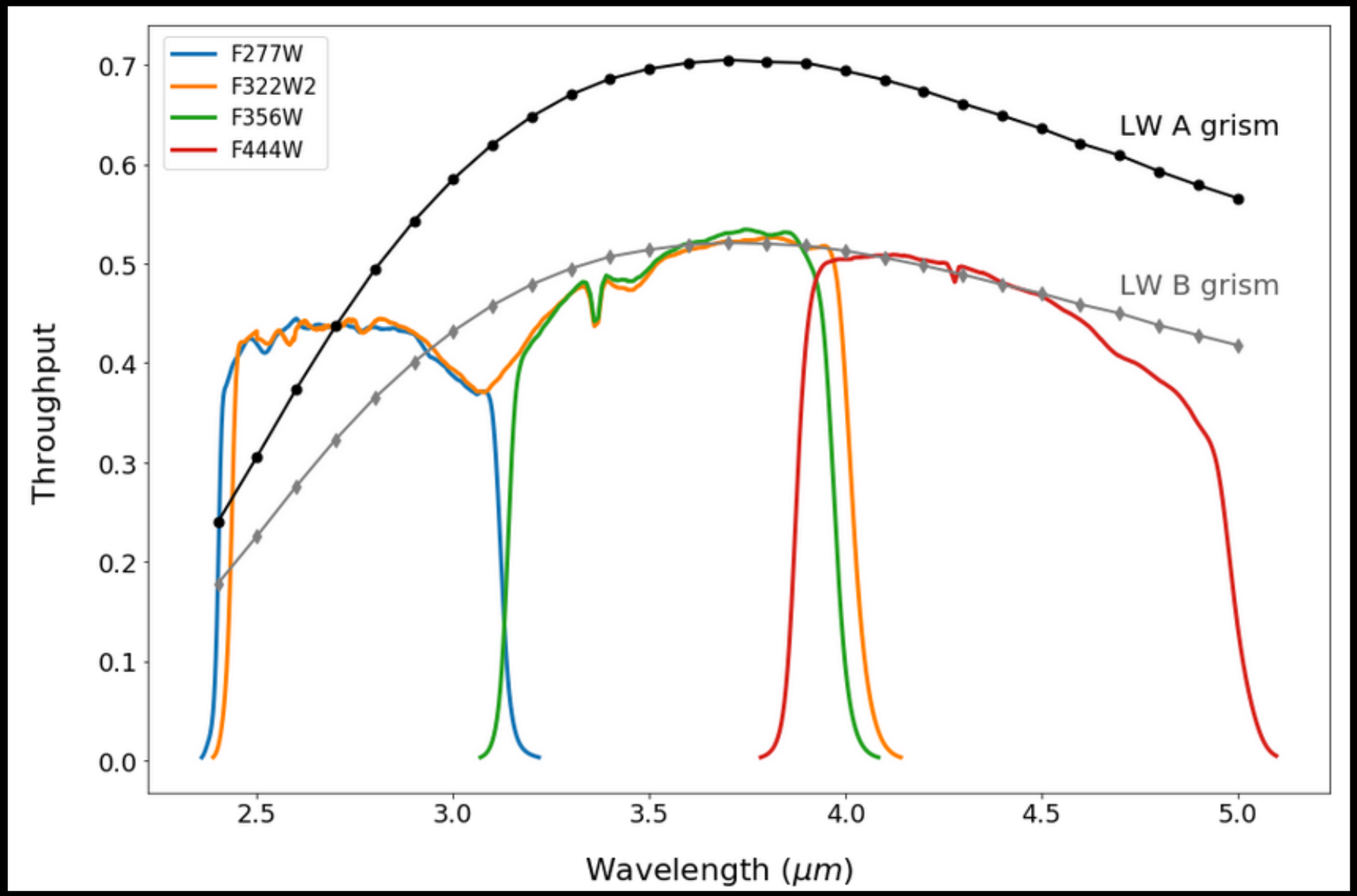



Image from JWST user documentation: (stsci)

# Throughput (2nd order)

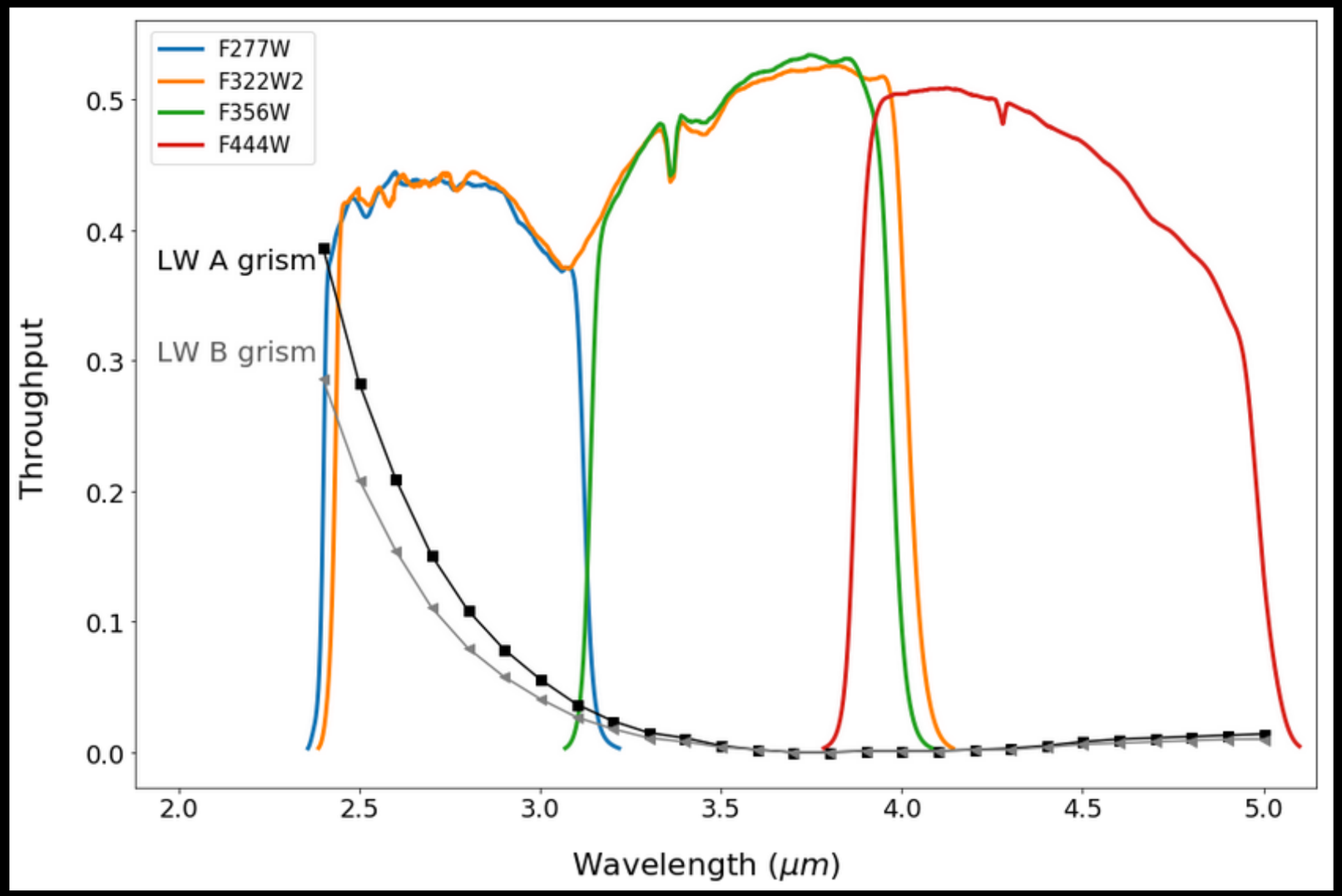



Image from JWST user documentation: (stsci)

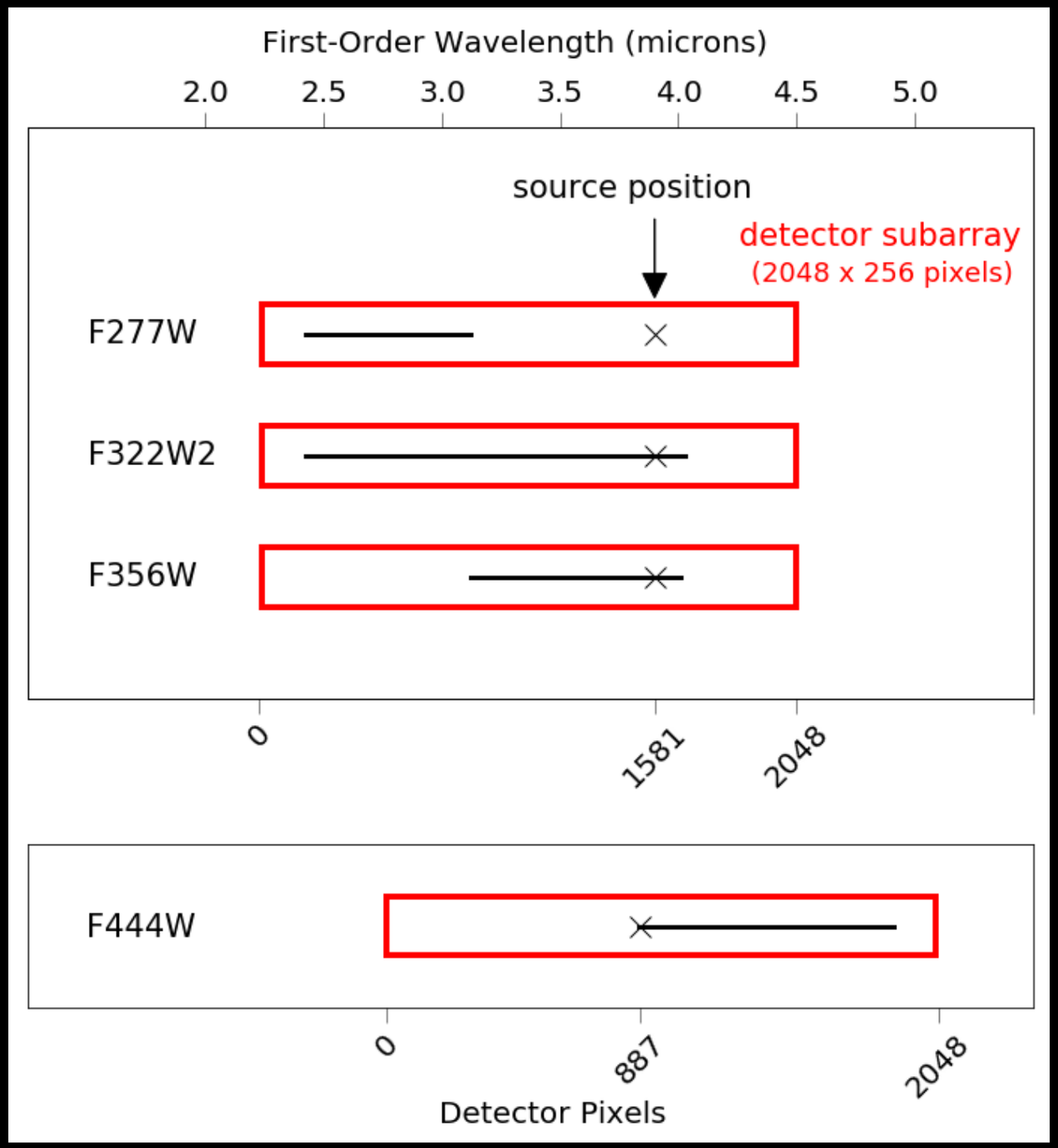



Image from JWST user documentation: (stsci)