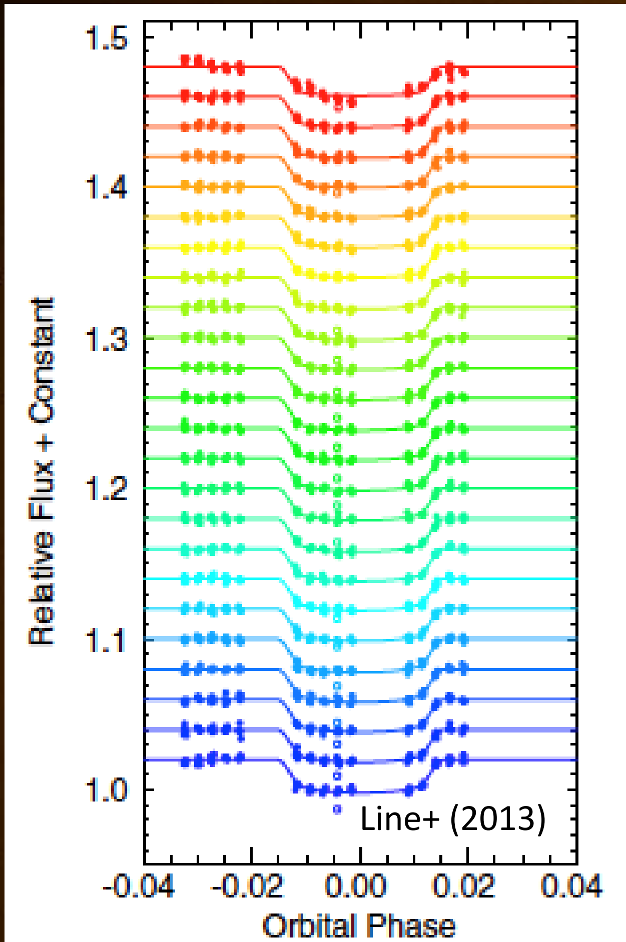
Single Object & Time Series Spectroscopy with JWST NIRCam



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AAS 230 JWST MIM

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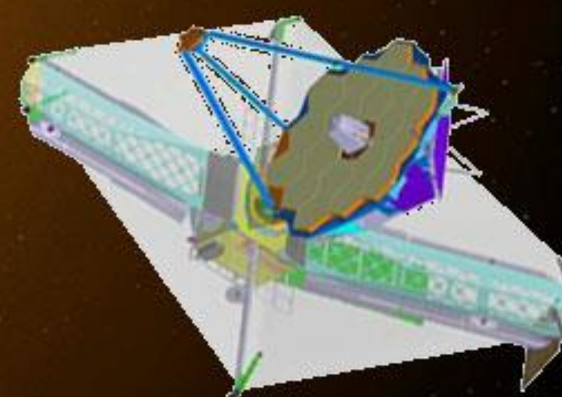
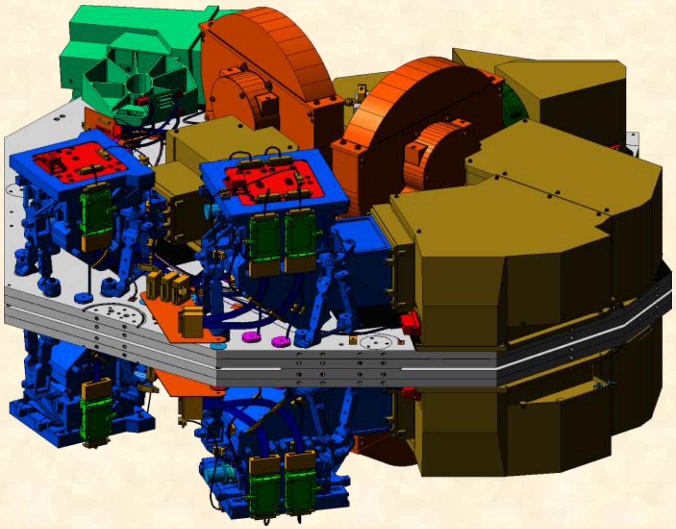
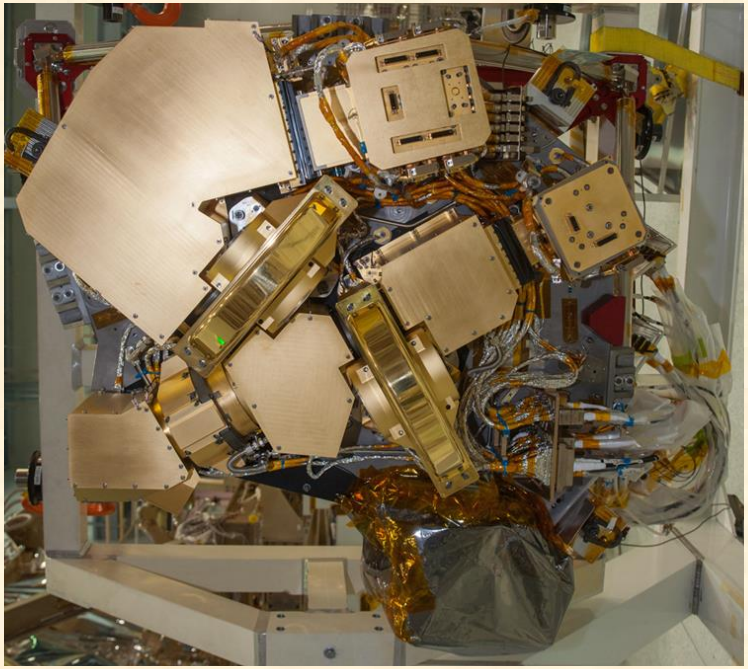


Contents

- NIRCam overview
- NIRCam modes and spectra
- Spectral resolution and wavelength coverage
- Bright star limits and sensitivity
- APT template and subarrays
- Operations concept
- Calibration & pipeline processing
- Further information

NIRCam: 0.6-5 μm imaging + 2,4-5 μm spectroscopy



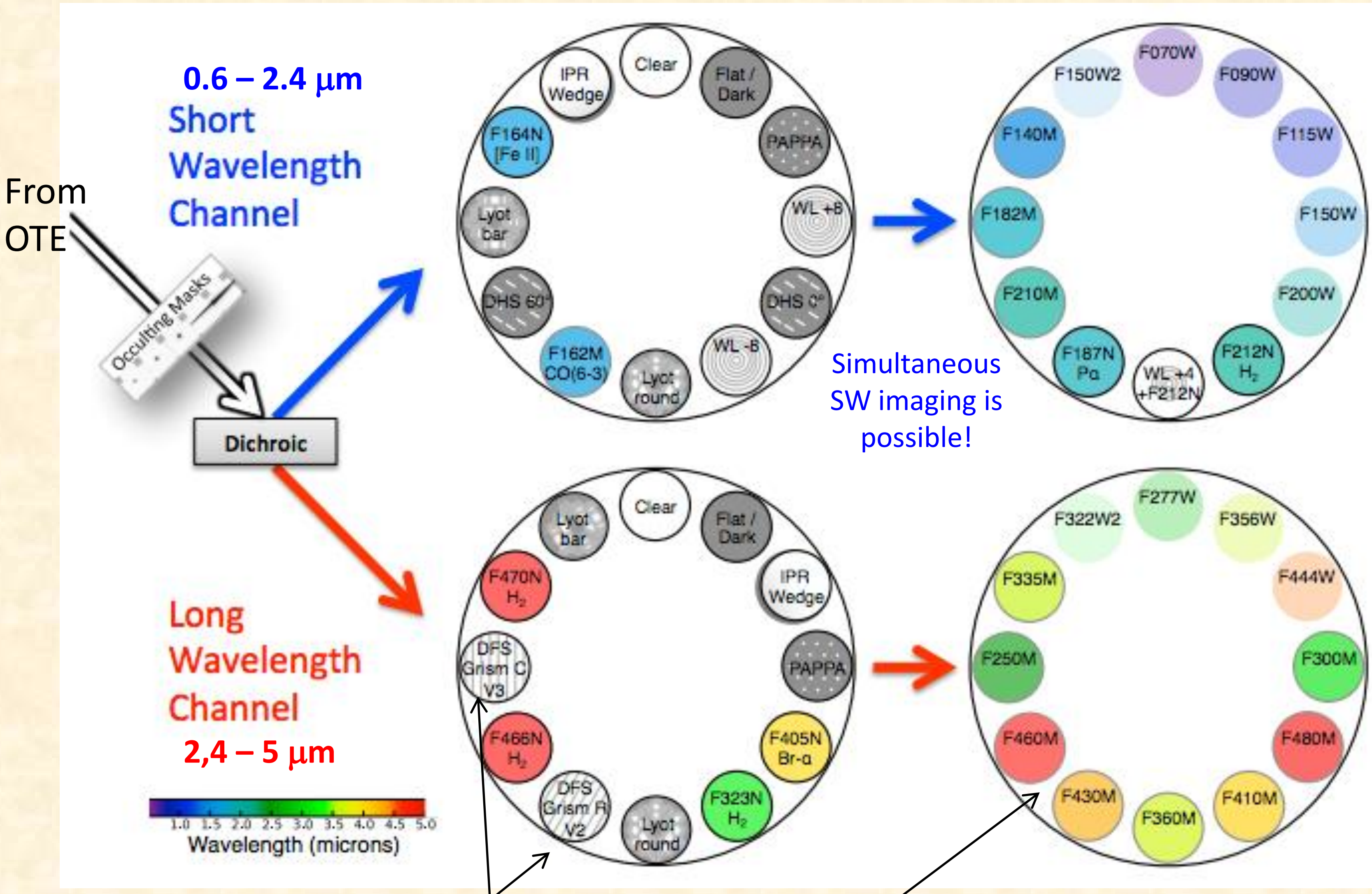


- **NIRCam is the JWST near-infrared camera for JWST**
  - **Two nearly identical modules (A & B) with refractive designs to minimize mass and volume**
  - **Dichroic used to split range into short (0.6–2.3μm) and long (2.4–5μm) channels**
  - **Nyquist sampling at 2 and 4μm**
  - **2.2 arc min x 4.4 arc min total field of view seen in two colors (40 MPixels)**
  - **Coronagraphic capability for both short and long wavelengths (Chas Beichman talk)**
  - **Dispersive components in short and long channels allow *slitless spectroscopy***

- **NIRCam is also the telescope wavefront sensor**

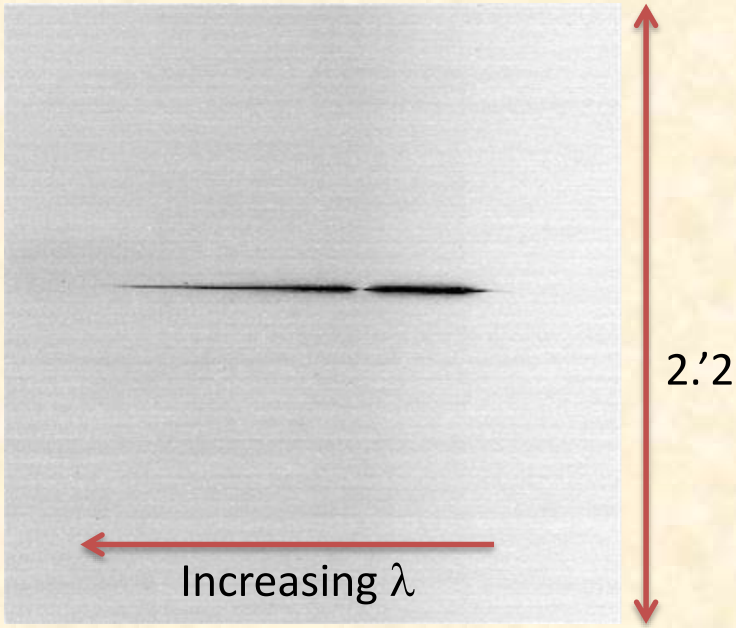
NIRCam modes: selectable with wheels

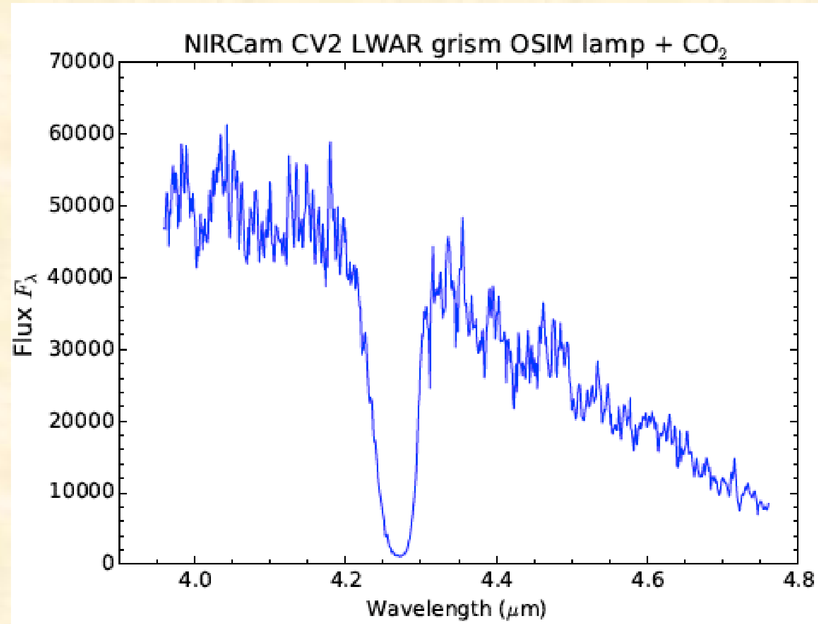
No Short Wavelength Spectroscopic Capabilities in Cycle 1



2 LW grisms in each module provide R~1500 slitless spectroscopy:
Chose dispersion orientation and filters to suit your science

NIRCam LW Grism Spectra





Left: NIRCam spectral image of the OSIM super-continuum lamp point source taken with the LWA R grism and F444W filter during JWST instrument testing.

Right: Extracted spectrum. The continuum decreases toward longer wavelengths due to low fiber transmittance, and the broad feature near 4.27 μm is due to CO_2 absorption. These are artifacts of the test equipment and not NIRCam itself.

*** NIRCam FOV is 2.′2 x 2.′2 with dispersion of 10 Å per 0.″065 x 0.″065 pixel ***

NIRCam Spectral Coverage & Resolution

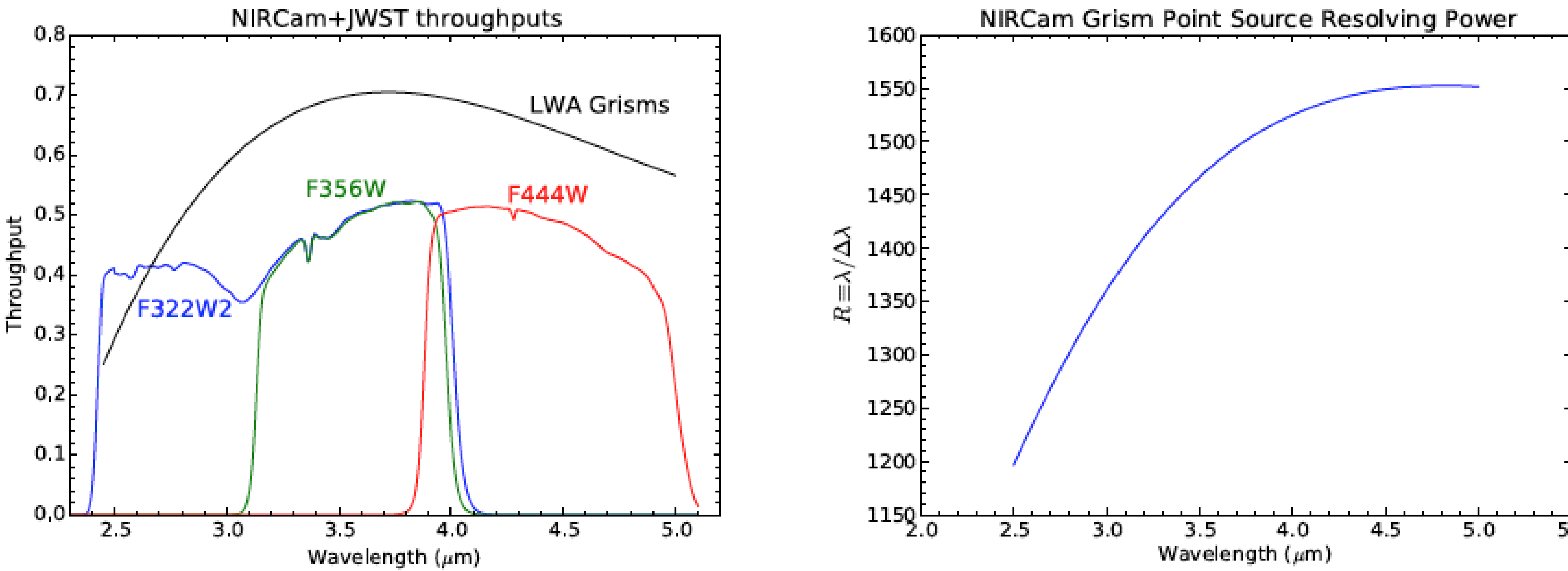


Figure 3. Left: Total system throughput including all OTE and NIRCam optics and the detector quantum efficiency for several NIRCam filters. The theoretical LW grism efficiency curve (shown for the A module) must be multiplied by the filter curves to produce the system throughput at each wavelength. The Module B LW grisms are anti-reflection coated on only 1 side and therefore have throughputs approximately 25% lower than the LWA grisms. Right: Grism FWHM spectral resolving power vs. wavelength for point sources, limited by pixel sampling of the PSF at shorter wavelengths ($\lambda \lesssim 4\ \mu$m) and limited by the circular beam factor[7] and diffraction at longer wavelengths ($\lambda \gtrsim 4\ \mu$m).

Time Series Wavelength (filter) Options

- The 2.4 – 5 μm region can be covered in as few as 2 separate filters:
  - F322W2: 2.4 – 4.0 μm
  - F444W: 3.9 – 5.0 μm

Table 2. Filters available for use with LW grisms in Cycle 1

Filter Name[a]	λ_1 (μm)[b]	λ_2 (μm)[c]	# dispersed pixels	# pixels/2048[d]	Mode[e]
F277W	2.416	3.127	711	0.35	TS + WF
F322W2	2.430	4.013	1583	0.77	TS + WF
F356W	3.140	3.980	840	0.41	TS + WF
F444W	3.880	4.986	1106	0.54	TS + WF

[a] All LW M filters will also likely be available in wide-field mode; F430M and F460M are expected to be popular and are included for illustrative purposes
[b] Half-power wavelength (blue side)
[c] Half-power wavelength (red side)
[d] Fraction of the detector that a continuum spectrum occupies in the dispersion direction
[e] TS = single-object time series and WF = wide field modes

Module A Grism Saturation & Sensitivity

λ (μm)	F_{cont} (μ Jy)[b]	F_{line} (W m^{-2})[c]	K_{sat} (A0V)[d]	K_{sat} (M2V)[d]	Filter[e]
2.5	11.1	1.09E-20	4.3	4.3	F322W2
2.7	8.7	7.35E-21	4.5	4.6	F322W2
2.9	8.0	5.98E-21	4.3	4.5	F322W2
3.1	7.9	5.22E-21	4.2	4.4	F322W2
3.3	6.7	3.97E-21	4.2	4.5	F322W2
3.5	6.5	3.45E-21	4.0	4.3	F322W2
3.7	6.3	3.05E-21	3.9	4.2	F322W2
3.9	7.0	3.11E-21	3.6	3.9	F322W2
4.1	12.1	4.99E-21	3.5	3.8	F444W
4.3	13.5	5.18E-21	3.2	3.5	F444W
4.5	15.1	5.38E-21	2.9	3.0	F444W
4.7	19.1	6.38E-21	2.5	2.7	F444W
4.9	25.1	7.88E-21	2.2	2.3	F444W

a. Module B grisms will have sensitivities approximately 1.16 times higher (worse) and saturation limits 0.33 mag brighter.

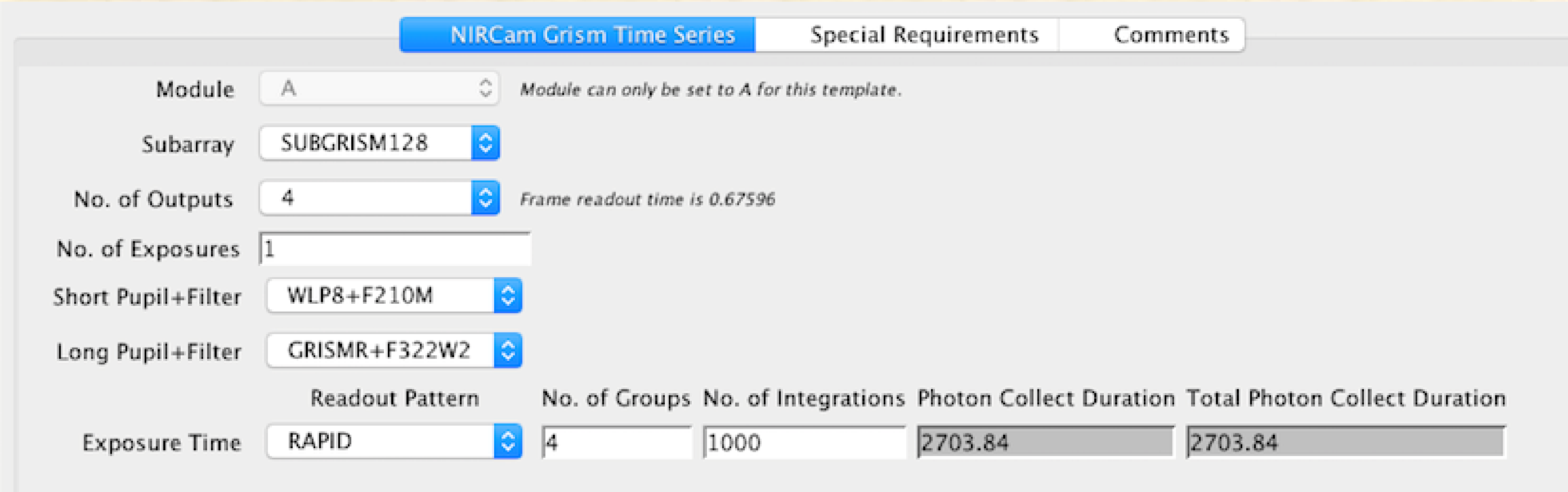
b, c 10 σ point-source and unresolved emission line sensitivities for 10,000 s integrations

d K-band Vega magnitudes for saturation (80% full well or 65,000 electrons) for 0.68 s integrations (2 reads) of 2048 x 64 pixel regions in stripe mode (4 outputs).

e Narrower filters will have similar saturation values and somewhat better sensitivities

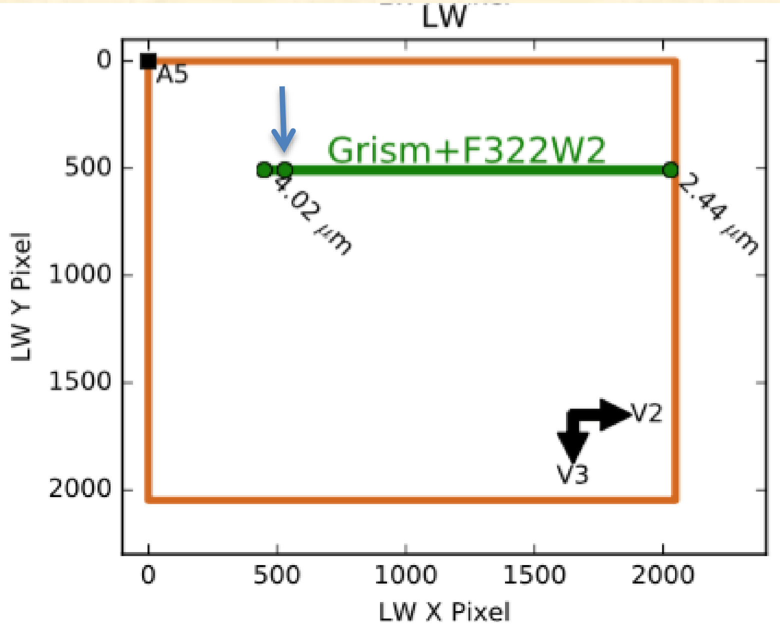
Sensitivities are ~2-5x worse than NIRSpec depending on filter bandpass and zodiacal background

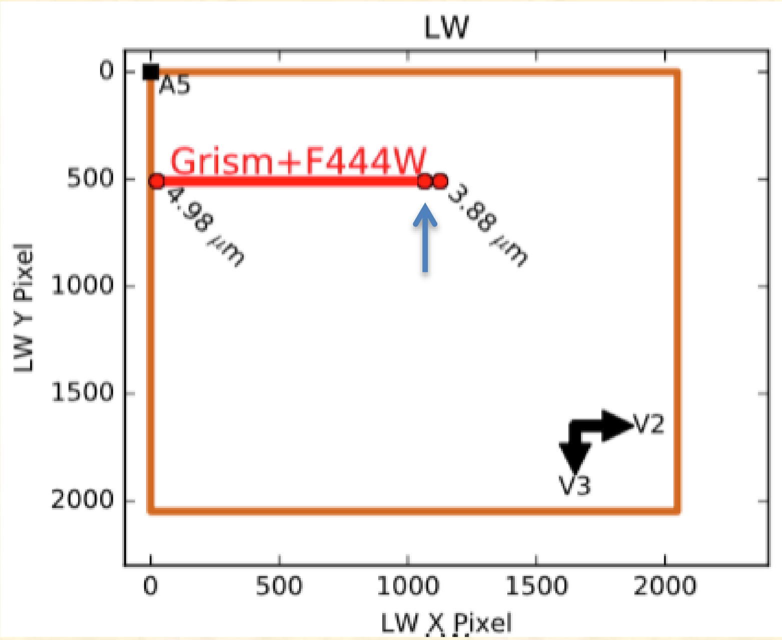
Time Series Spectroscopy APT Template



- Can choose from 64, 128, 256, & 2048 x 2048 subarrays
- 1 or 4 outputs (4 for very bright stars)
- Simultaneous short wavelength imaging with weak lens to spread the light over many pixels is possible
- No dithering
- Flexible detector exposure and readout parameters

Target Acquisition & Spectral Pixels

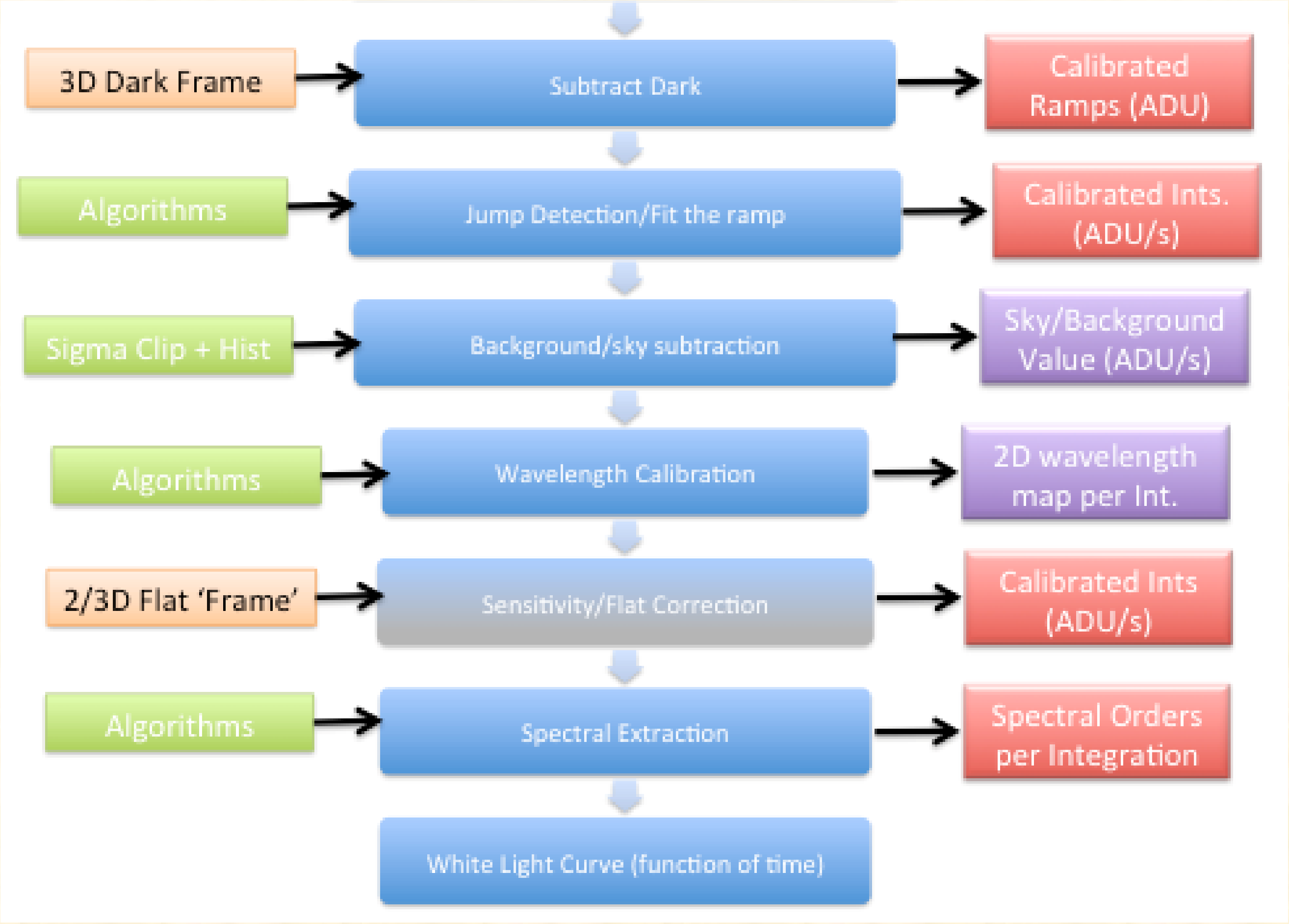




*** Note: Field point positions may / will be revised before launch ***

- Target acquisition field points allow significant overlap of same pixels in F322W2 and F444W spectra
- Targets are positioned at the undeviated wavelength locations (blue arrow; $\lambda \sim 3.95\ \mu m$)

NIRCam uses the JWST time-series data pipeline



- Users can download & re-run the pipeline with different options, additions, or removals

Further Information

- General NIRCam information: http://www.stsci.edu/jwst/instruments/nircam
- Greene et al. (2016) SPIE paper "Slitless Spectroscopy with JWST NIRCam" http://adsabs.harvard.edu/abs/2016arXiv160604161G
- STScI User Training in JWST Data Analysis II Workshop, November 9 – 11 (can attend remotely): https://jwst.stsci.edu/events/events-area/stsci-events-listing-container/user-training-in-jwst-data-analysis-ii?mwc=4
- Astronomer's Proposal Tool for planning observations: http://www.stsci.edu/hst/proposing/apt
- JWST exposure time calculator is coming in January 2017 with PandExo exoplanet transit simulator afterward.