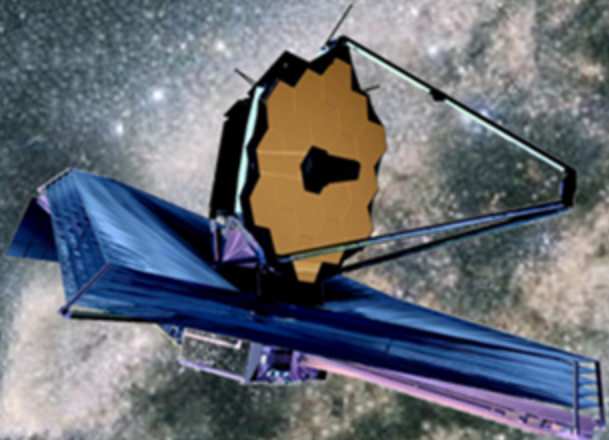
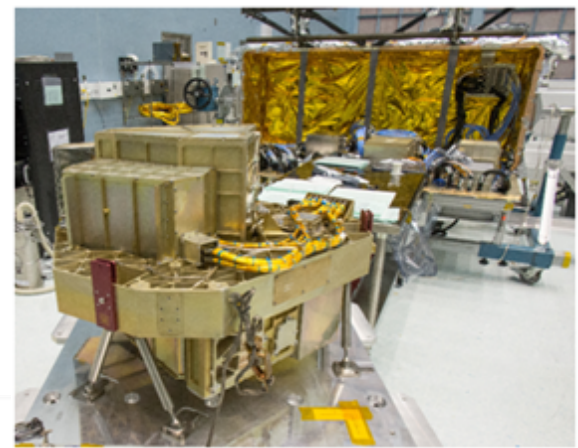
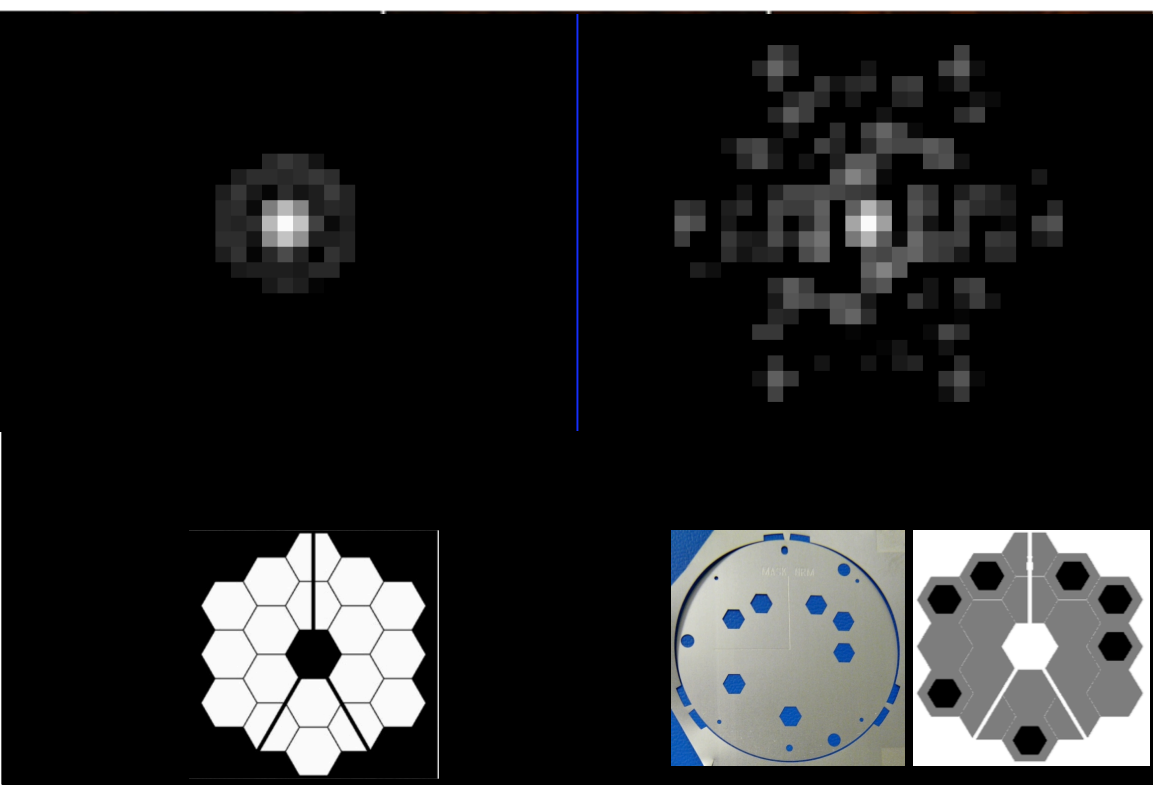


Université de Montréal
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JWST
 NASA • ESA • CSA
 SPACE TELESCOPE SCIENCE INSTITUTE
NRC - CNRC
Honeywell



JWST Master Class
November 2019



NIRISS AMI OVERVIEW AND PROPOSAL PLANNING

Deepashri Thatte, Anand Sivaramakrishnan and NIRISS team



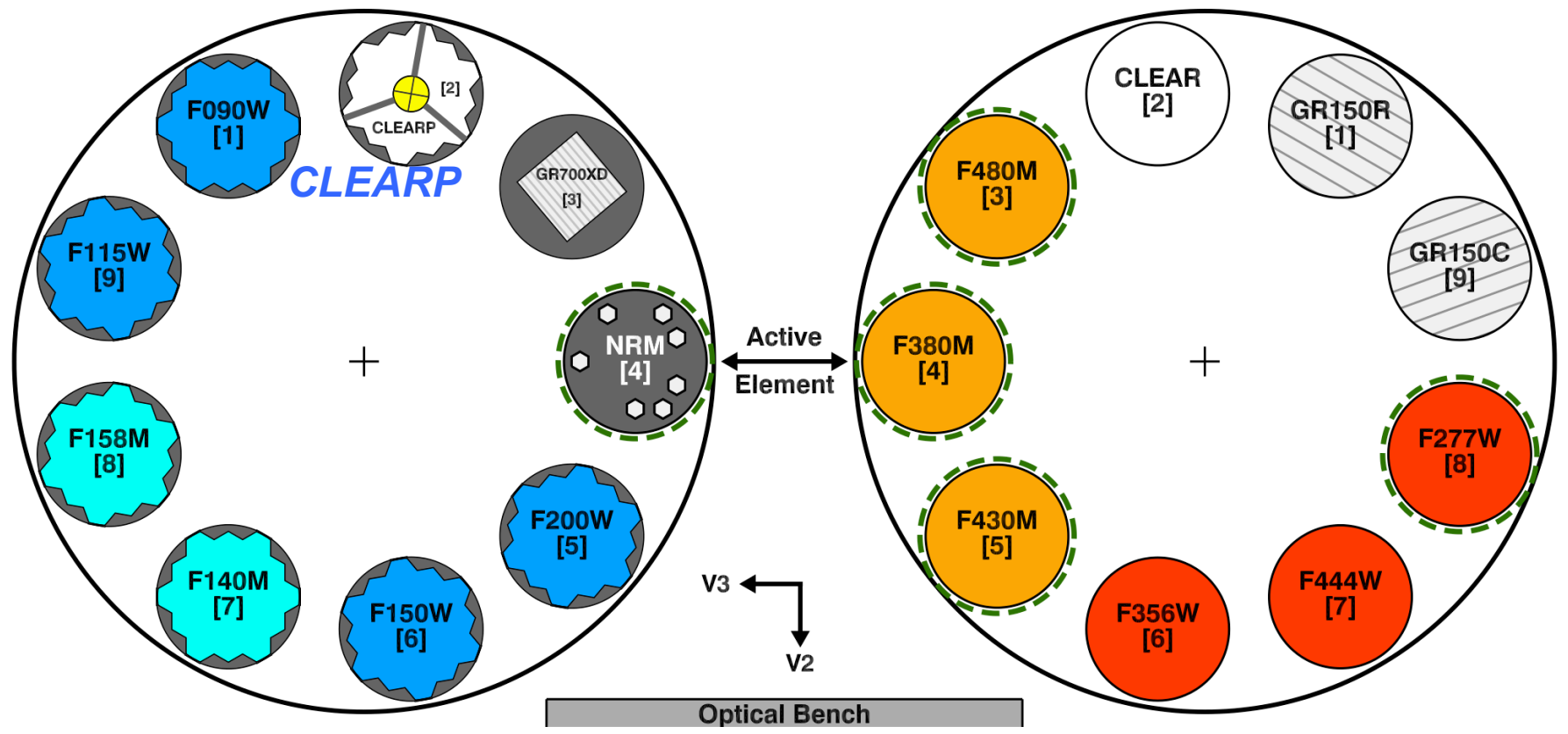
HCI capability of NIRISS AMI

- Moderate-contrast, high angular resolution imaging for exoplanets, transition disks, AGN, Io volcanoes, exozodi disks
- Uses non-redundant mask (NRM) in the pupil wheel of NIRISS in conjunction with one of the 3x medium-band filters centered at 3.8, 4.3 and 4.8 μm (F380M, F430M, F480M) or a wide-band filter centered at 2.77 μm (F277W)
- Bright limit ~ 3 to 4 magnitudes in medium filters. Goal is to reach binary point source contrast up-to 10^{-4} at separations of $\sim 70 - 400$ mas (“behind the spot” of NIRCams coronagraphs).
- Photon-noise limited, combination of flat-field error and placement can affect performance.
- Requires TA, observing calibrator star close in time to the target, dithers available but not recommended.

Dual wheel optical elements

Pupil Wheel

Filter Wheel



~65 mas pixels are Nyquist sampled at ~4um
 F277W: reduced performance but has water band
 CLEARP for 'kernel phase' on fainter targets

NIRISS NRM design

7 holes

$7 \times (7-1) / 2 = 21$ 'baseline'
interferometer, no vector baseline
repeated

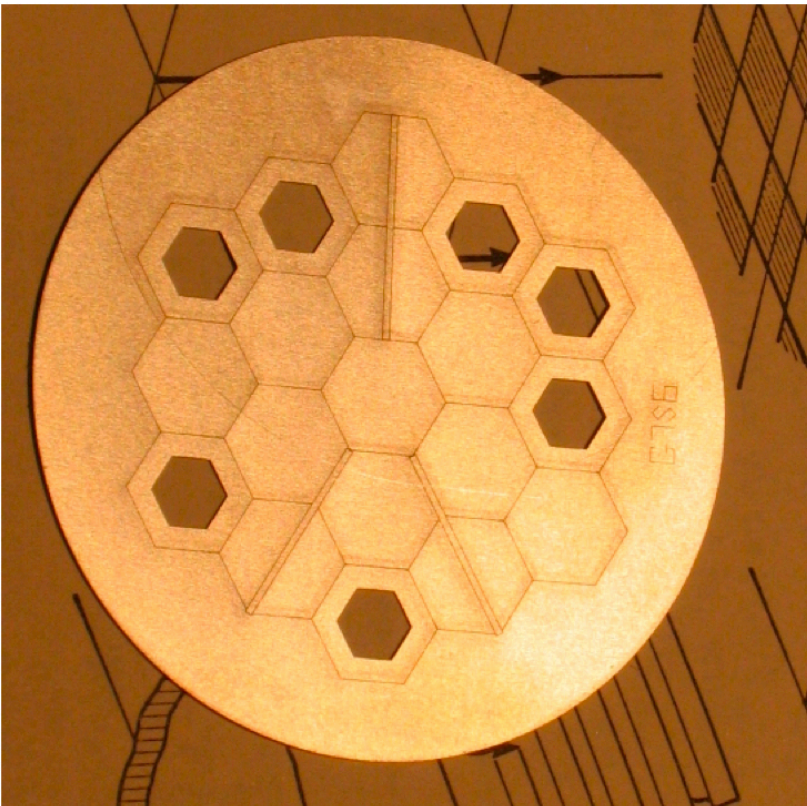
Highly calibratable images

Undersized holes accommodate inexact
pupil placement

15% throughput cf. full pupil
Peak pixel $\sim 1/40$ full pupil peak pixel

Used for target acquisition for bright
NIRISS SOSS (exoplanet transit
spectroscopy) targets

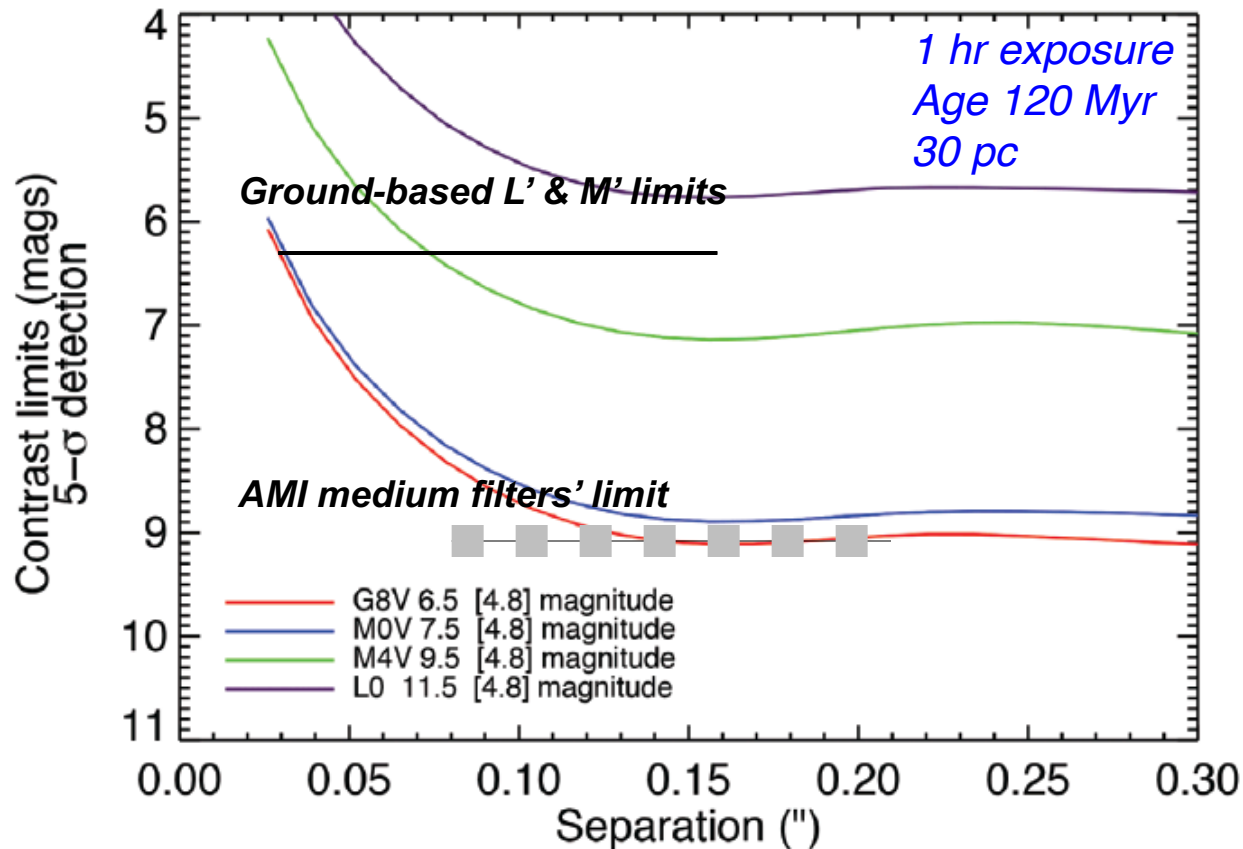
Enables coarse & fine wavefront sensing
as back-up to NIRCam





Science motivation

- Probe separations of ~ 40 to 400 mas
- At contrast of up to 9 mag
- Filters: F380M, F430M, F480M, (and F277W)

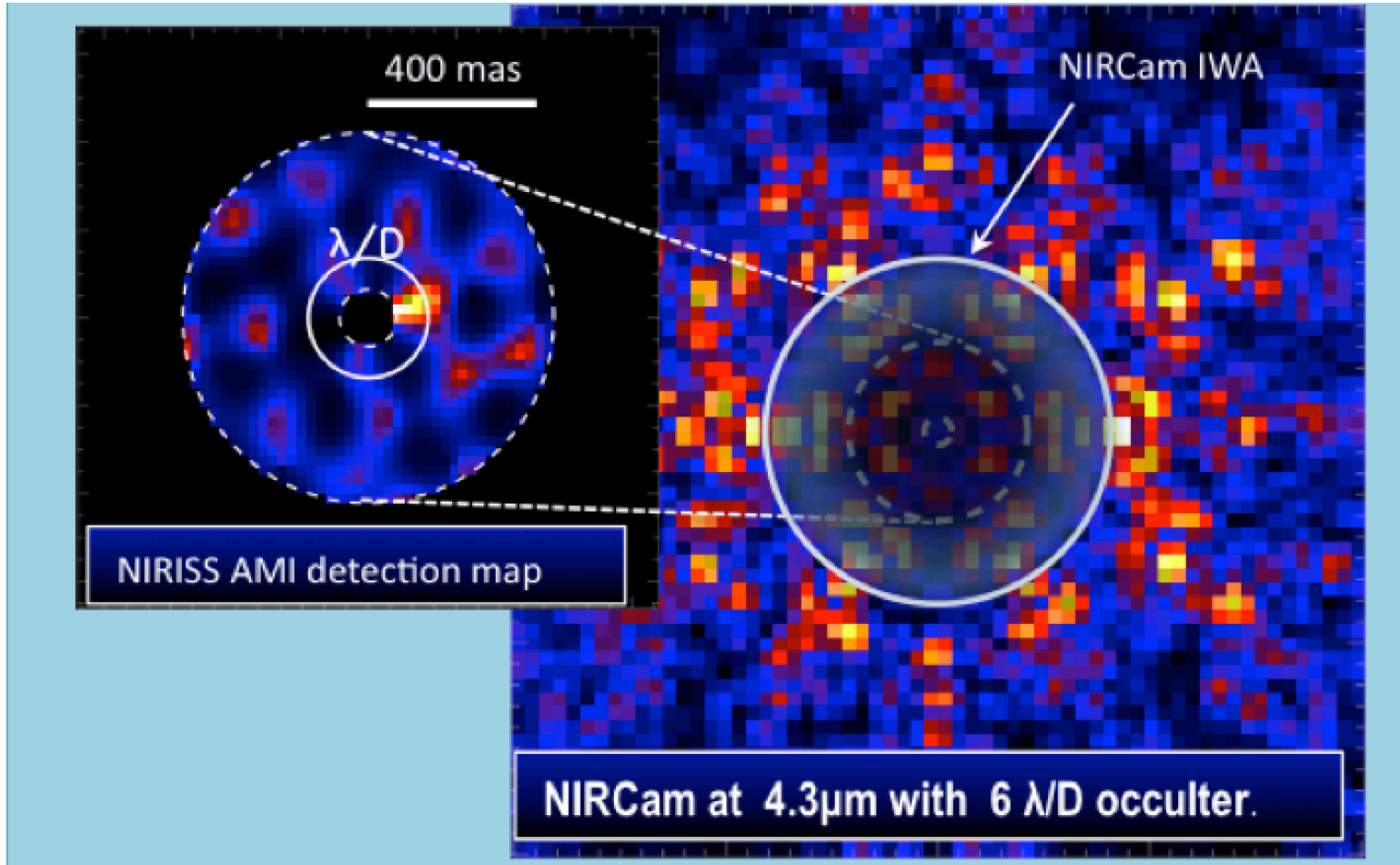


Science goals

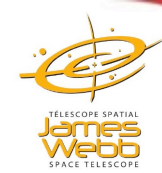
- Detection of planets very close (70-500 mas) to their parent star.
- Study of feedback and fueling structures in AGNs.
- Transition Disks
Planets/structure
- Ultracool star binarity
- Exozodi detection
- Io volcano photometry



Complements NIRCams coronagraphy

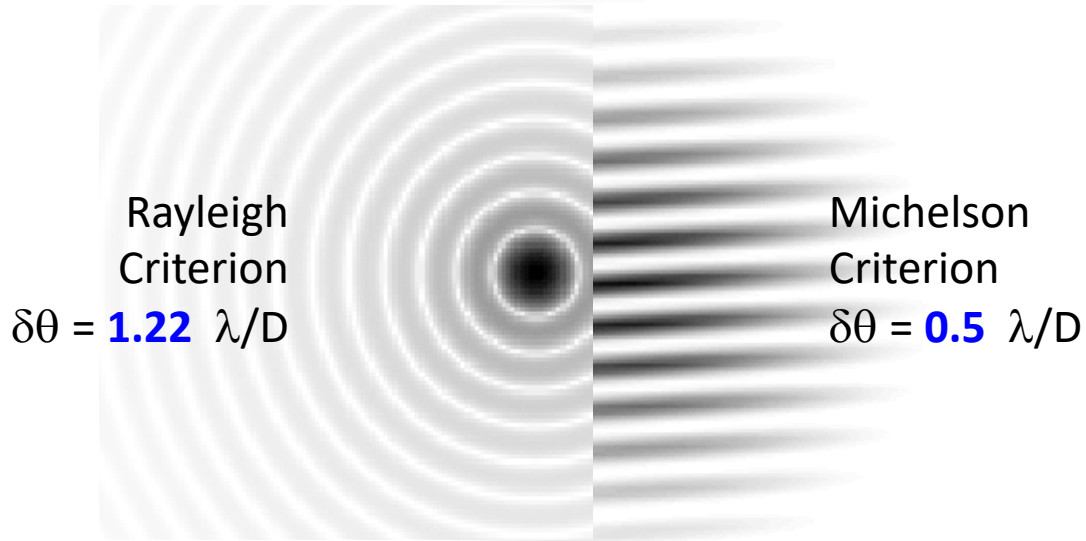


Simulation of 1-2 Jupiter mass planet at 1 AU around M0V host star at 10 pc (by NIRISS IDT). Observing time: 3 hr



Interferometric resolution, small IWA

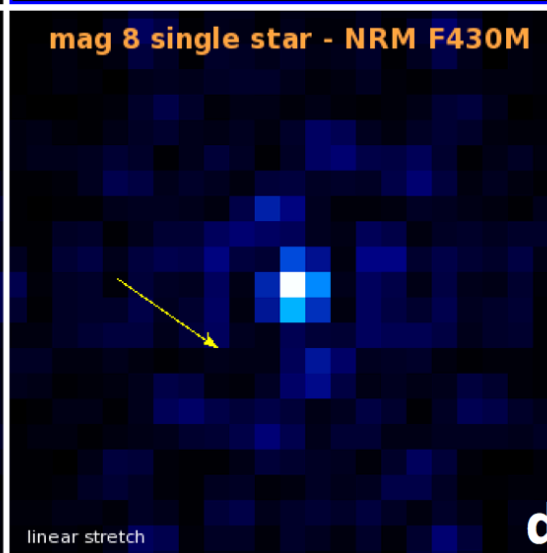
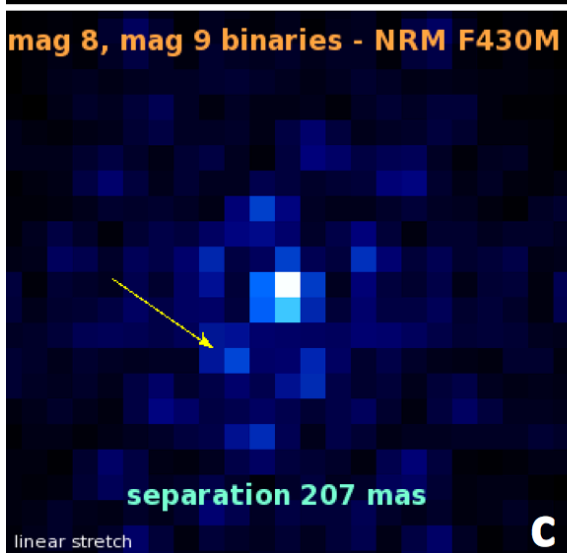
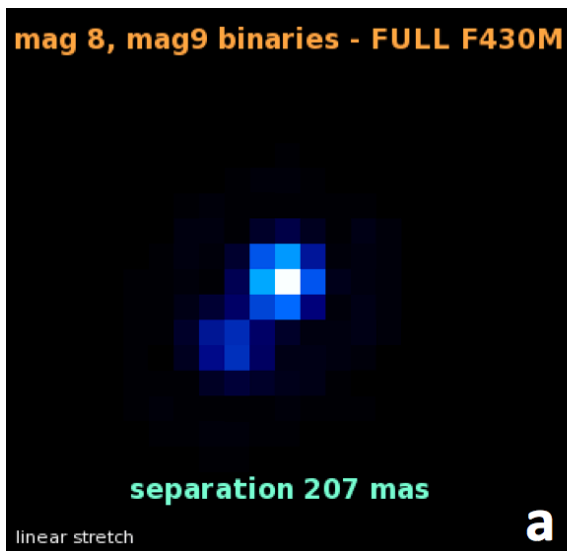
- $\delta\theta = 0.5 \lambda/D$ Michelson Criterion (NRM)
- $\delta\theta = 1.22 \lambda/D$ Rayleigh Criterion (Full aperture)
- $\delta\theta = 4\lambda/D$ NIRCcam coronagraph (Inner Working Angle)



Easier to calibrate out instrumental effects

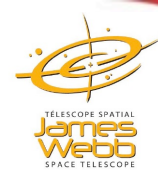


NIRISS AMI PSF

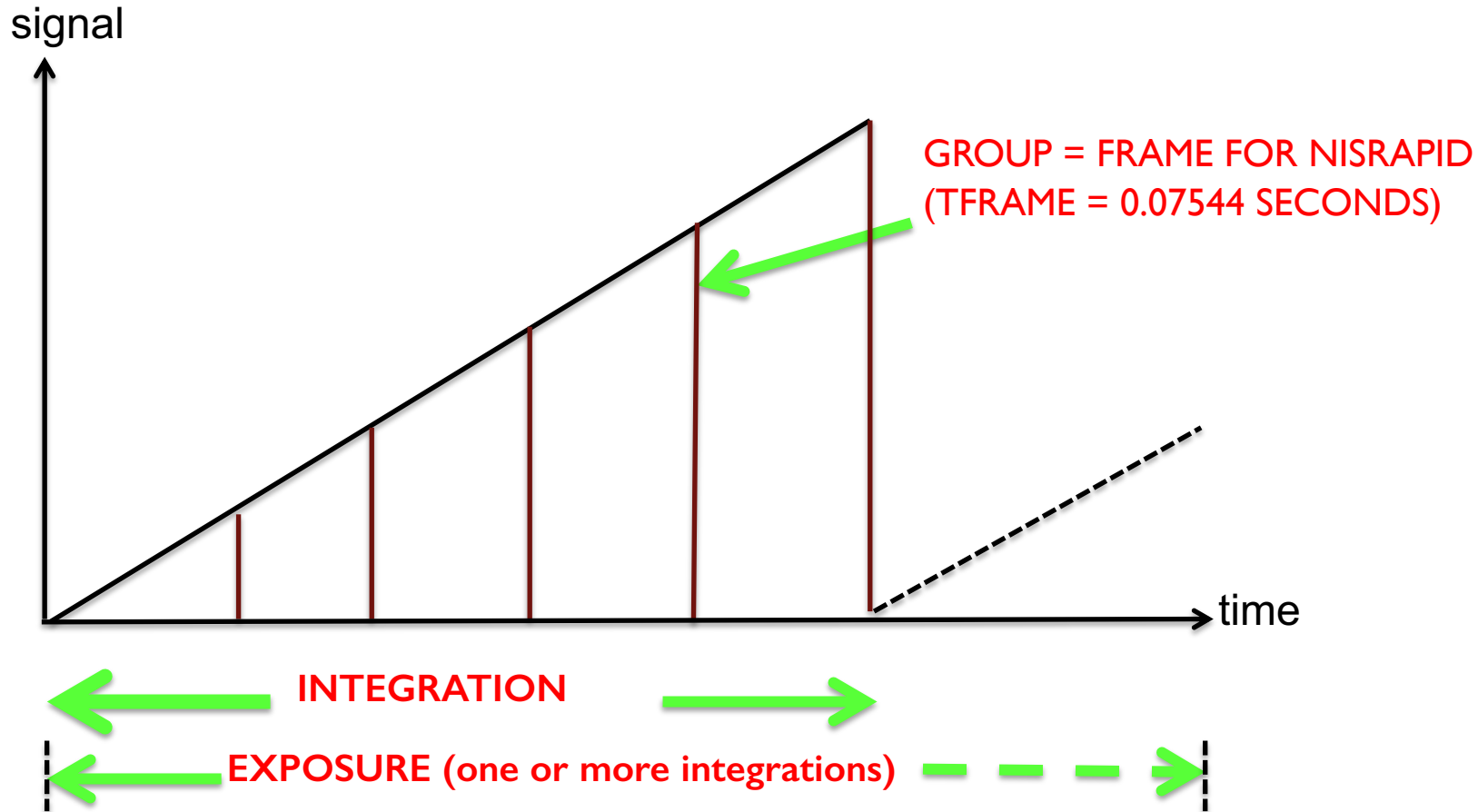




Exposure Nomenclature



The NIRISS AMI subarray is SUB80 (FULL also available)
One frame per group (NISRAPID readout pattern)

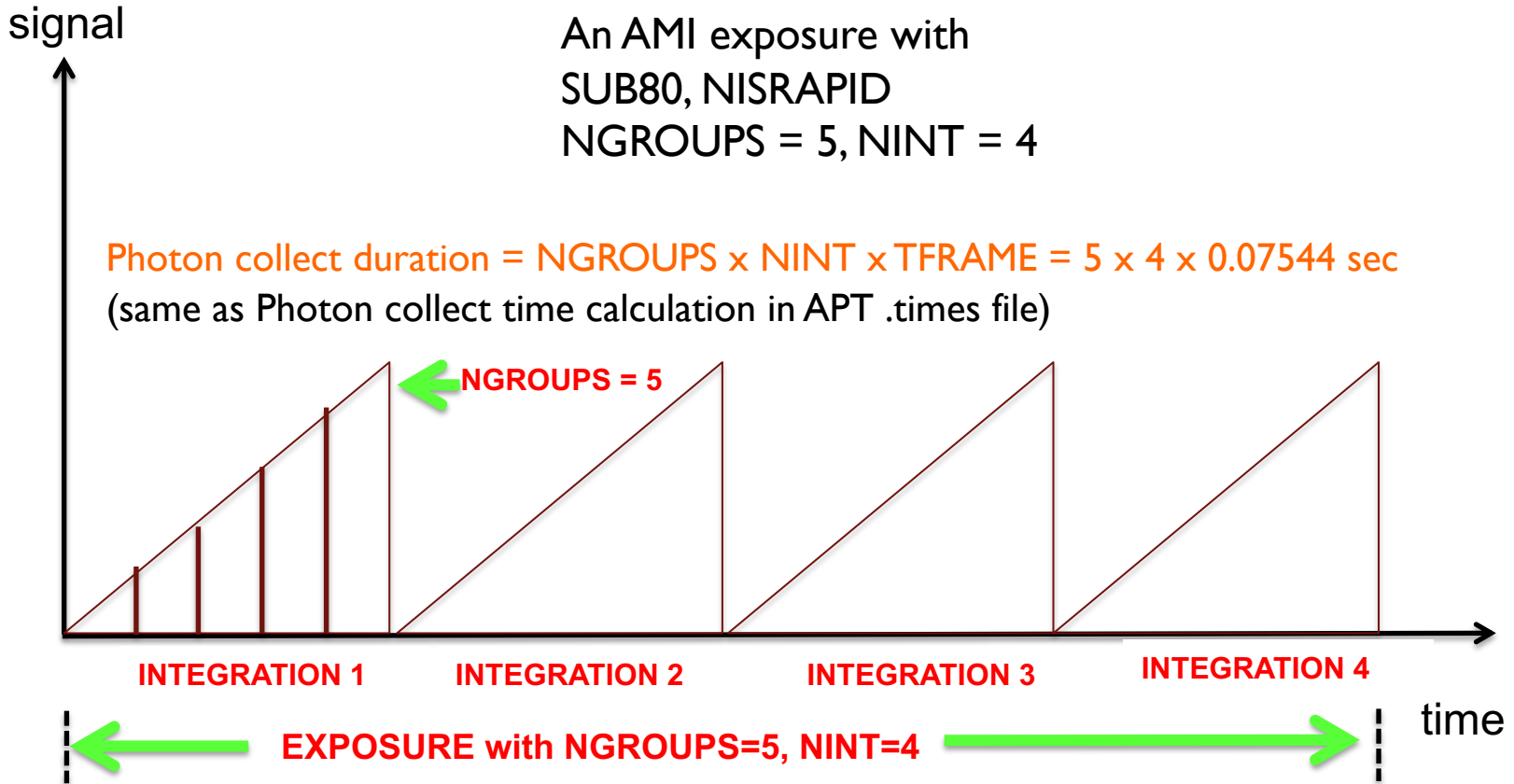




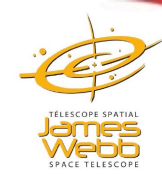
NIRISS AMI Exposure



The NIRISS AMI subarray is SUB80 (FULL also available)
One frame per group (NISRAPID readout pattern)



Note: The Total Exposure Time shown by JWST ETC includes resets, do not use it to calculate signal. Use photon collect time instead.



AMI Brightness limits (Vegamag) SUB80

Filter	NGROUPS 1	NGROUPS 2
F277W	7.0	7.6
F380M	4.1	4.7
F430M	3.4	4.0
F480M	3.1	3.7

30,000 e⁻ pixel signal limit, pixel-centered PSF

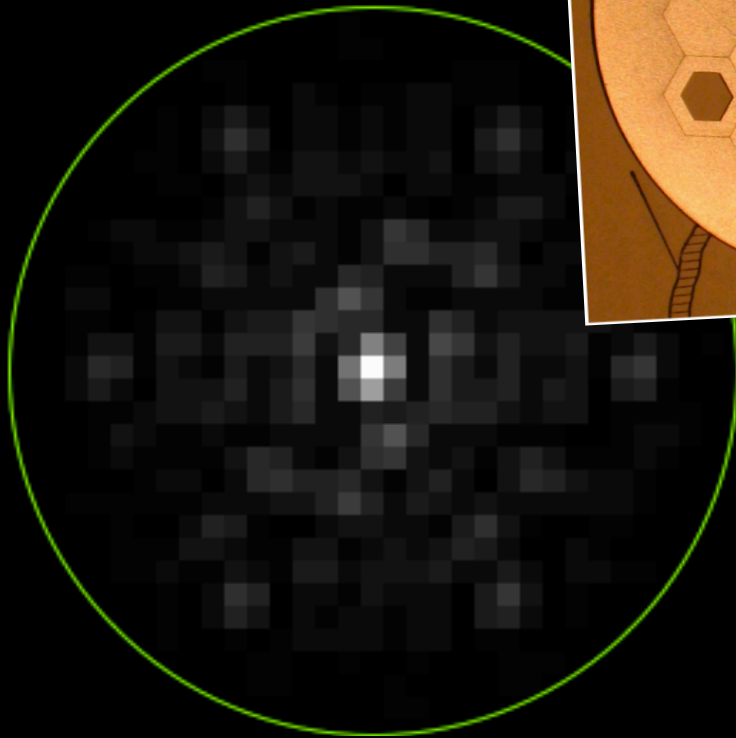
Add ~4 mag to these to get CLEARP SUB80 brightness limit (cf NRM)

Add ~5.5 mag to get FULL detector NRM brightness limit (cf SUB80)

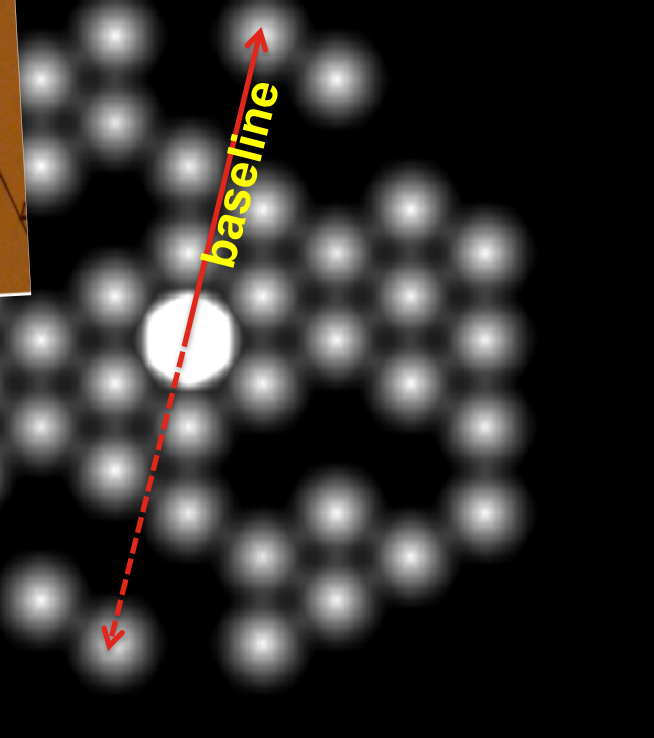
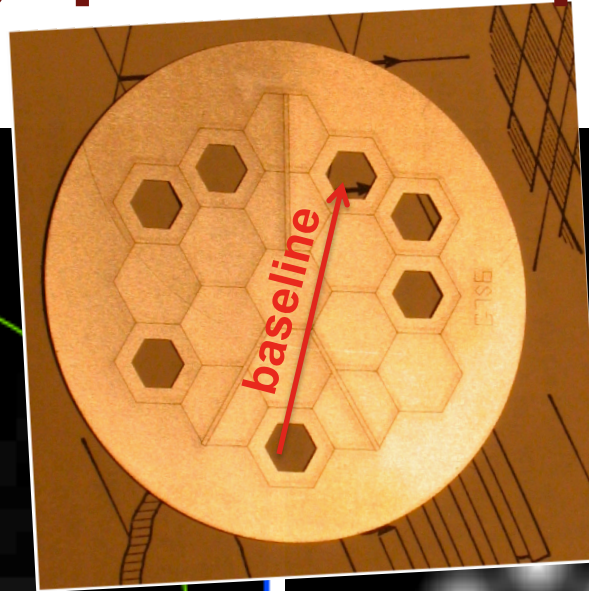
Add ~9.5 mag to get FULL CLEARP brightness limit

Fringe phases & amplitudes

Interferometric view



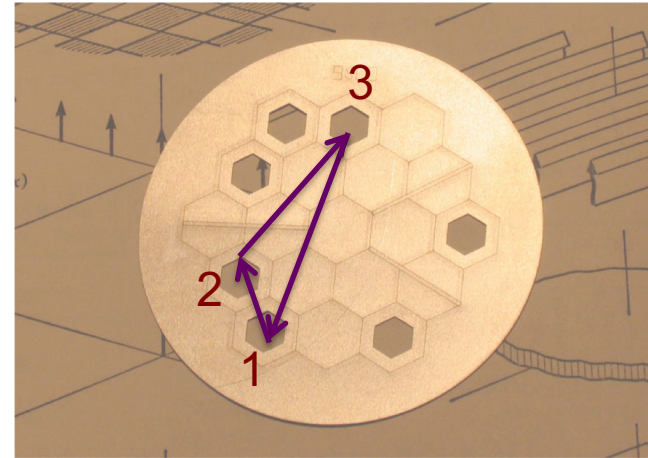
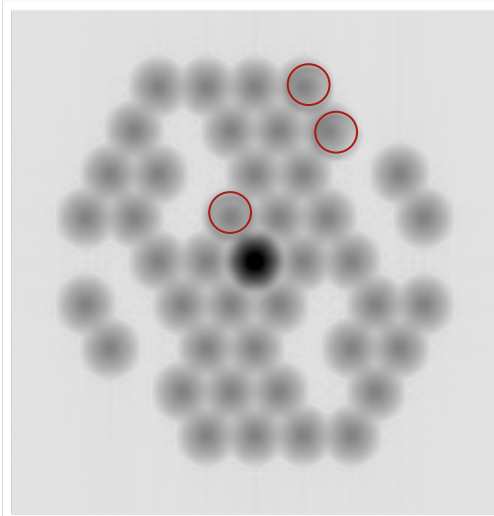
PSF or image of target



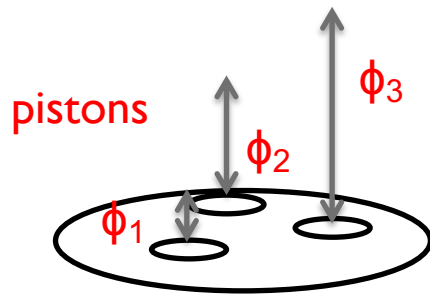
$\text{abs}(\text{FT}(\text{image}))$

7 hole mask: 21 independent baselines. FT has central splodge + 42 splodges
 Get fringe visibilities & (Fourier) phases of each of the 21 fringes (42 numbers)

Closure phase measures structure



For three holes, sum of 3
fringe phases = closure phase



$$\phi_{i,j} = \phi_j - \phi_i$$

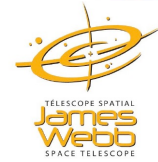
$$\phi_{1,2} + \phi_{2,3} + \phi_{3,1} = 0$$

Non-zero closure phases are a result of structure or measurement errors

$$\text{Contrast} \sim 1/\sigma_{CP}$$



Calibrating Closure phases & SqV



For a point source;

Closure phase (CP) should be 0

square visibility (SqV) should be 1

Remove residual error/instrumental contribution to closure phases by calibrating with the point source calibrator star

Subtract CAL CPs from Target CPs

$$CP_{\text{target}} = (CP_{\text{target}} + CP_{\text{instrument}}) - (CP_{\text{calibrator}} + CP_{\text{instrument}})$$

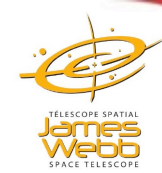
Any non-zero closure phase is due to asymmetry in the source.

CPs do not measure centro-symmetric structure, but SqV's do

Divide target visibilities by calibrator visibilities

Square calibrated visibilities to get SqV

Fit science data to fringe quantities



AMI Operations

- **AMI Target Acquisition in 64 x 64 subarray (SUBTAAMI)**
 - NGROUPS – odd numbers between 1 & 19 (avoid saturation)
 - NISRAPID readout
 - Acquire in F480M, MASK_NRM for bright, CLEARP faint
 - Small Angle Maneuver to SUB80 science subarray POS 1
- **AMI data acquisition in SUB80: 80 x 80 subarray**
 - 80 x 76 light sensitive, 4 rows of reference pixels
 - NISRAPID readout only for SUB80 (select NGROUPS, NINT)
 - Recommend POS 1 only (default is pixel center)
 - Expected POS 1 placement to ~5 mas per axis
 - User-selected offset possible
 - Dithers possible but not recommended
- **SUB80 frame time 0.07544 s (approx 1 / 15 s)**
- **Full detector possible (optional TA), NISRAPID, 10.7 s frame time**
 - NIS available for FULL



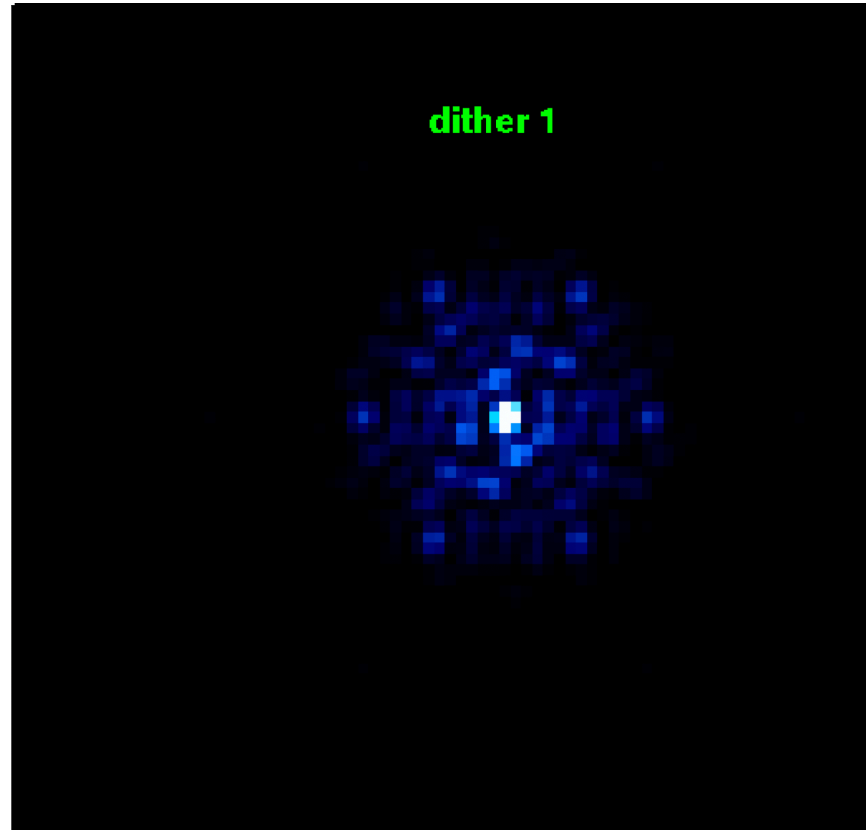
SUB80 AMI subarray 5.2" × 4.9"

76 x 80 light sensitive pixels

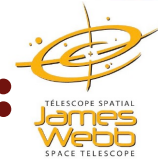


Target placement
at POS 1

Sub-dithers
available, use with
caution



Dithers possible but not recommended.



NIRISS AMI Observation planning:

Step I Select science targets(s) and calibrator(s)

- Select Science Target & (optional) PSF CAL[ibrator] star
 - Check if target and calibrator are visible using JWST General Target Visibility Tool (GTVT) or APT.
 - Similar spectral type & brightness
- Vet potential calibrators for IR excess, strong spectral lines, binarity
 - Catalog searches, 8m-class ground NRM, VLT & LBT interferometry (e.g. SearchCal)
- Shared CALs save time
 - For low required contrast (eg BD binaries) – use existing/simulated CAL
 - Cooperate across programs to select & share CALs



NIRISS AMI Observation planning:

Step 2 Exposure depth estimation

- Binary point source

$$\begin{aligned} N_{\text{photons}} &= 1.5 \times N_{\text{hole}}^2 / (\text{contrast ratio})^2 \quad \text{----- Ireland (2013)} \\ &= 73.5 / (\text{contrast ratio})^2 \end{aligned}$$

Considering the fact that NRM has not been used in space before, we use a slightly more conservative value of:

$$N_{\text{photons}} = 100 / (\text{contrast ratio})^2$$

For example, to detect a contrast ratio of 10^{-3}

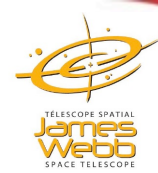
$$N_{\text{photons}} = 100 / (0.001)^2 = 10^8$$

- Therefore we need 10^8 photons from the target (and also the calibrator) with NRM and the F480M in the ETC



NIRISS AMI Observation planning

Step 3 – JWST ETC



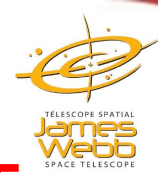
- Estimate exposure parameters using JWST ETC
 - Stay below a signal limit of 30000 electrons in the peak pixel of an integration
 - When two neighboring pixels accumulate charge at very different rates, photoelectrons from the brighter pixel migrate to its neighboring pixels (charge migration)
 - ETC issues a warning when this signal limit is exceeded
 - This signal limit is lower than the true non-linearity based saturation limit for the NIRISS detector
 - Calculate exposure parameters to reach required exposure depth (total photons) needed to detect contrast
- The extended wings of the AMI PSF can be used for data analysis
 - Strategy tab: Choose noiseless sky background when defining the extraction parameters for the source flux and for the background to be used for background subtraction. The extended PSF makes background subtraction difficult and AMI analysis handles background in the data.
 - Use the following aperture extraction radius for point sources
 - F480M: 2.5", F430M: 2.3", F380M: 2.0", F277W: 1.6"
- A note about Total Exposure Time in ETC
 - The exposure time reported by ETC includes reset time, equivalent to one tframe, between each integration and the time for full-frame reset of pixels outside the subarray, which occurs before every integration when the detector is in subarray mode. No photons are recorded during this reset time, so these reset times should not be included when calculating the total number of photons.
 - Use Photon collect time = $NGROUPS \times NINT \times TFRAME$ to estimate signal



NIRISS AMI Observation planning

Step 4 AMI specific steps in JWST APT

- Use [JWST ETC](#) to calculate [NGROUPS](#) and [NINT](#) needed to reach the required exposure depth. Input to APT.
- A [target acquisition \(TA\)](#) is required when using a subarray and strongly recommended for full frame readout to ensure that the target is always placed on the same detector pixel.
- We recommend using [GAIA DR2 archive](#) to get coordinates and proper motion of the sources and [2015.5](#) for epoch in APT
- TA is performed with the F480M filter prior to the start of science observations. Therefore [starting an exposure sequence with the F480M filter is most efficient](#). If using all the filters the sequence [F480M, F380M, F430M, and F277W](#) produces the least motion of the Filter Wheel.



NIRISS AMI Observation planning

Step 4 – AMI specific steps in JWST APT continued...

- Use same positioning (eg POS 1, because of flat-field error)
- For higher contrast needs science target and calibrator should be observed close in time and without PM/SM adjustments between observations.

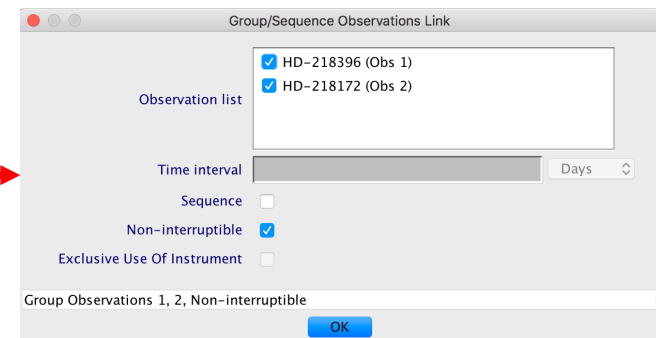
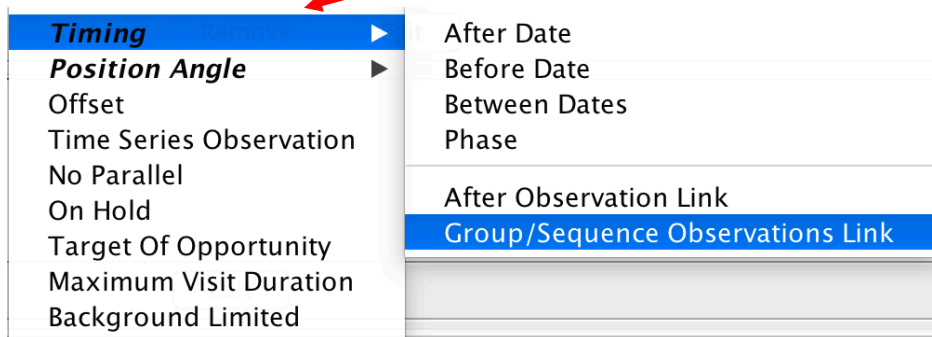
Special Requirement tab,

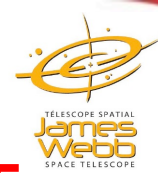
- Timing requirement of Group/Sequence Observations Link, selecting target(s) and calibrator(s) from the Observation list box
- Non-interruptible option

NIRISS Aperture Masking Interferometry

Special Requirements

Comments





NIRISS AMI Observation planning

Step 4 – AMI specific steps in JWST APT continued...

- Small slews between target and calibrator improves efficiency and stability
- Under PSF Reference Observation in Form Editor select PSF reference star to associate target with the calibrator for target observation. Choose 'This is a PSF Reference Observation' for calibrator observation. This tells the JWST pipeline to calibrate target with a specific calibrator(s).

PSF Reference Observations

This is a PSF Reference Observation

PSF Reference Observations

HD-218172 (Obs 2) (PSF Reference; Filters [F480M])

Additional justification Additional justification of self reference survey will be provided in the science justification.

← For target observation

PSF Reference Observations

This is a PSF Reference Observation (exclusive access period will be 0 months)

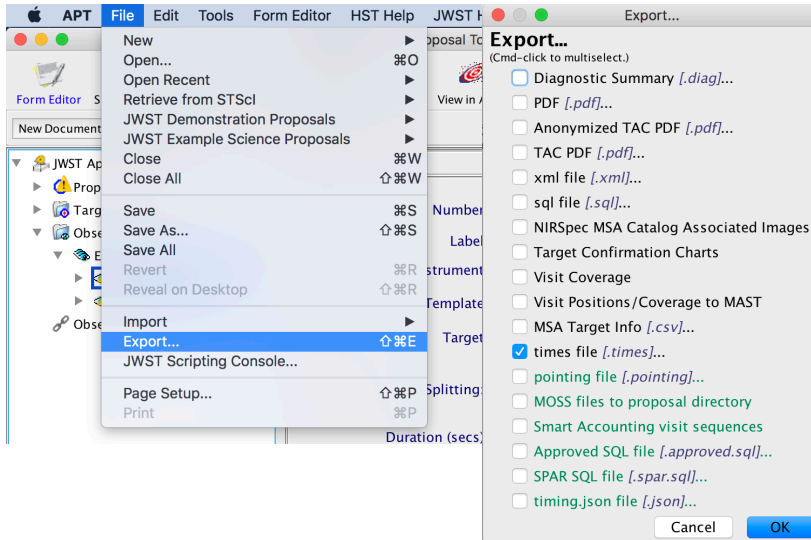
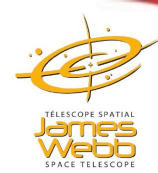
← For calibrator observation

- Verify that you entered correct coordinate information by creating target confirmation charts, view observation in Aladin
- Run visit planner
- Run Smart Accounting



NIRISS AMI Observation planning

APT timing report



```

ami_times.txt — Edited
# APT Output Product
#
# APT Version: Version 27.3.1 JWST PRD: PRDOPSSOC-M-025
# Date: Mon Nov 18 16:09:14 GMT 2019

JWST Times Report for JWST Approved Proposal 23 (Unsaved)
Note: Glossary of terms and column headers at bottom of this report

=====
* HD-218396 (Obs 1)
  Science   Total Time
  Duration  Charged
  4416      9169

Exposure Specifications:
  Exp  SUBARRAY  READOUT  FrameRead  Groups  NFrame  GrpGap  Ints  PhotonCollect  Diths  PrimDiths  SecDiths  NumExp  TotalPhoton  ExposureDuration  ExposingDuration
  Acq  SUBTAAAMI  NISRAPID  0.050      3       1       0      1      0.150           1      1           1       1      4415.956       16              5054              2
  SUBB00  NISRAPID  0.075      9       1       0      6504  4415.956       1      1           1       1      4415.956       5054              5040

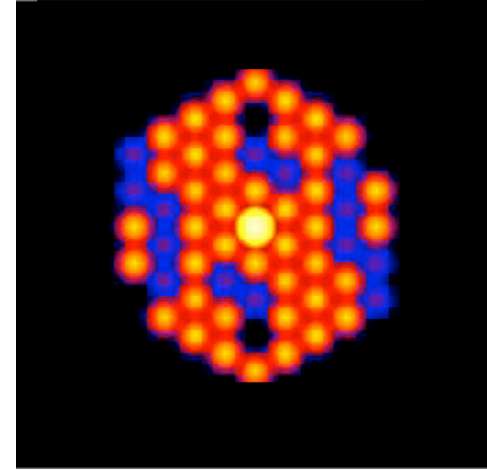
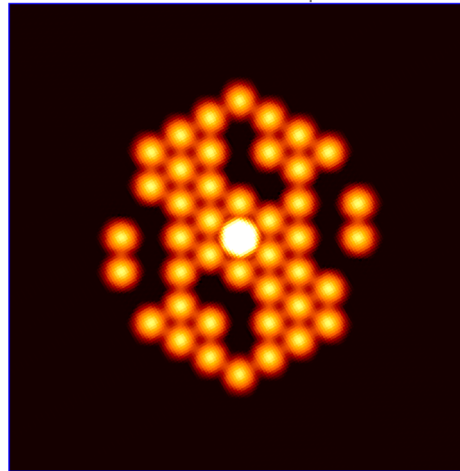
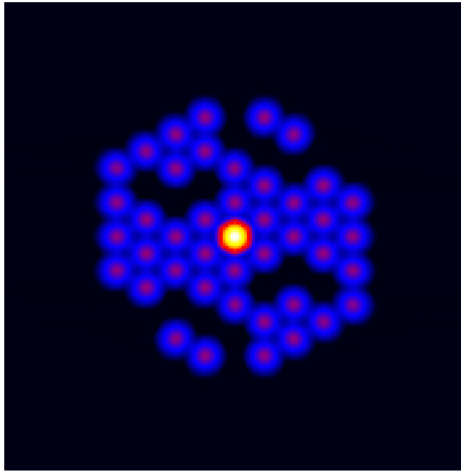
Visit Durations:
  Visit  Pointing  Science  Instrument  (GS  (Targ  (Exp  (Visit  Slew  Observatory  Direct  Sched  Total Time
  Dist  Duration  Overhead  (SAMS)  (Acq)  (Acq)  (Ovhd)  (Mech)  (OSS)  (MSA)  (IRS2)  (Ovhd)  Time  Overheads  Overhead  Charged
  1      0.00      4416     1688      ( 48)  ( 284)  ( 602)  ( 638)  ( 24)  ( 30)  ( 0)  ( 0)  ( 62)  1800     1265     0          9169

=====
* HD-218172 (Obs 2)
  Science   Total Time
  Duration  Charged

```

Rotate for good uv-coverage

Rotation helps fill uv plane coverage



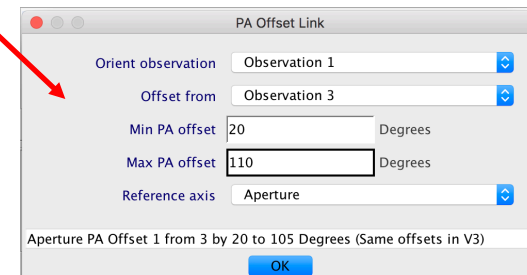
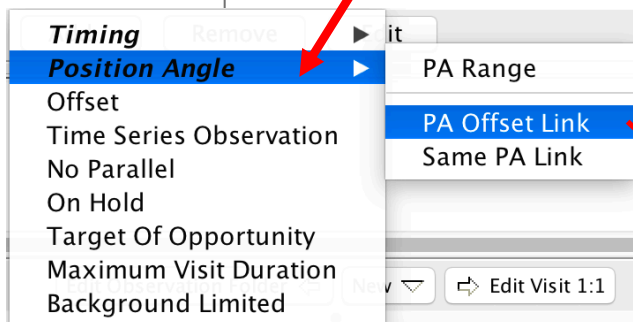
60 deg
rotation

NIRISS Aperture Masking Interferometry

Special Requirements

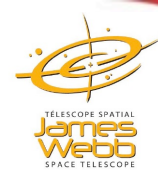
Comments

Use Special Requirement tab, to select Position Angle and then PA Offset Link to rotate an observation with respect to another observation. Sun angle constraints limit possible rotations.

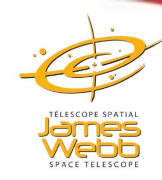




Summary



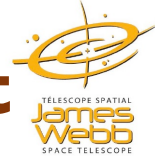
- Moderate-contrast, high angular resolution imaging using NRM+Filter (F480M, F430M, F380M, F277W)
- Exoplanets, AGNs, Transition Disks Planets/structure, Exozodi disks, Io volcano photometry
- Bright limit ~3 to 4 magnitudes in medium filters.
- Binary point source contrast goal: up-to 10^{-4} at separations of ~70–400 mas
- Complementary to NIRCam coronagraph
- AMI TA 64x64, SUB80 array with NISRAPID readout for data acquisition, FULL array available
- Calculate exposure parameters (NGROUPS, NINT) using JWST ETC, use those as an input to JWST APT.
- Send your questions to JWST help desk <https://stsci.service-now.com/jwst>



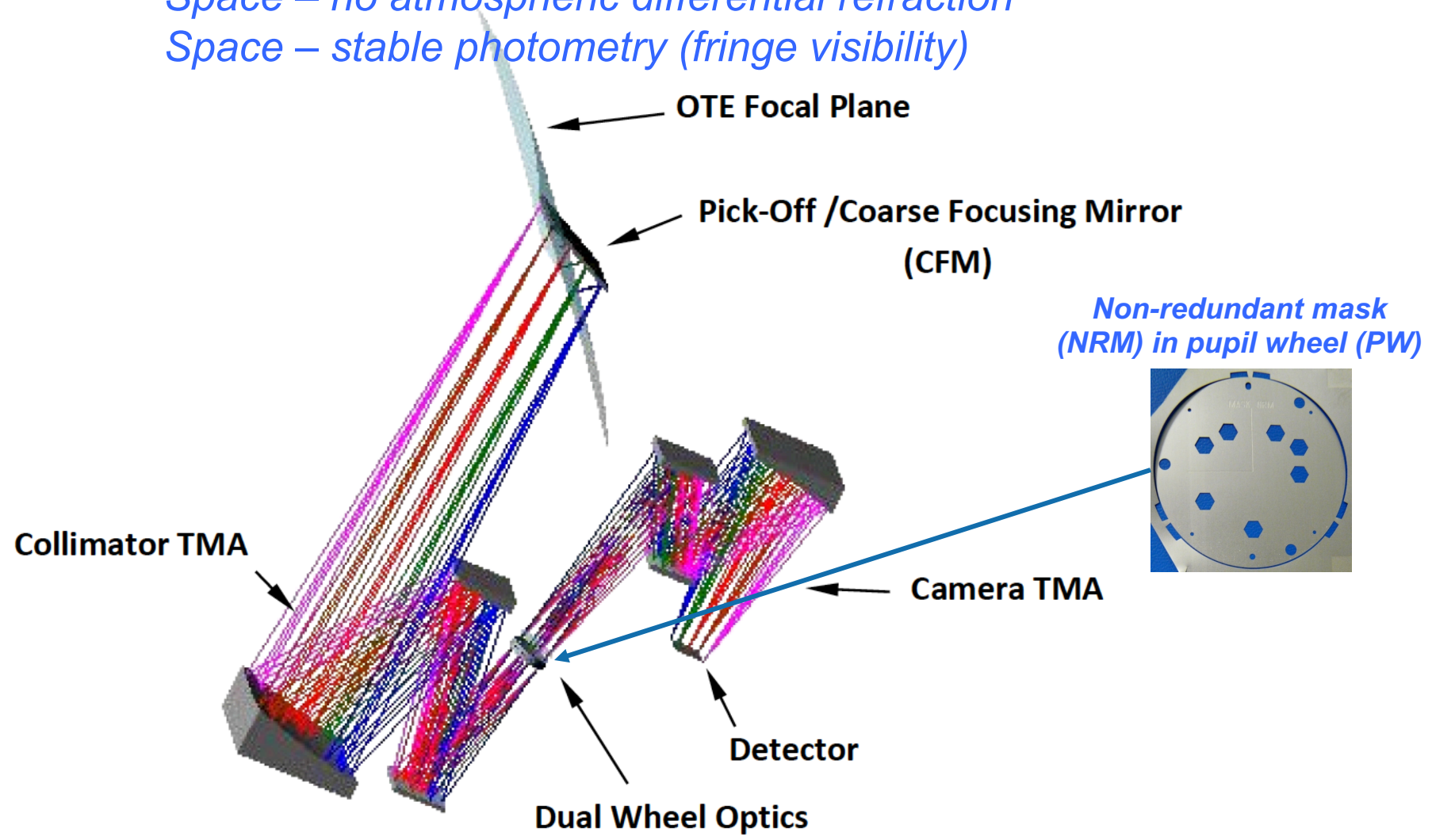
NIRISS AMI backup slides



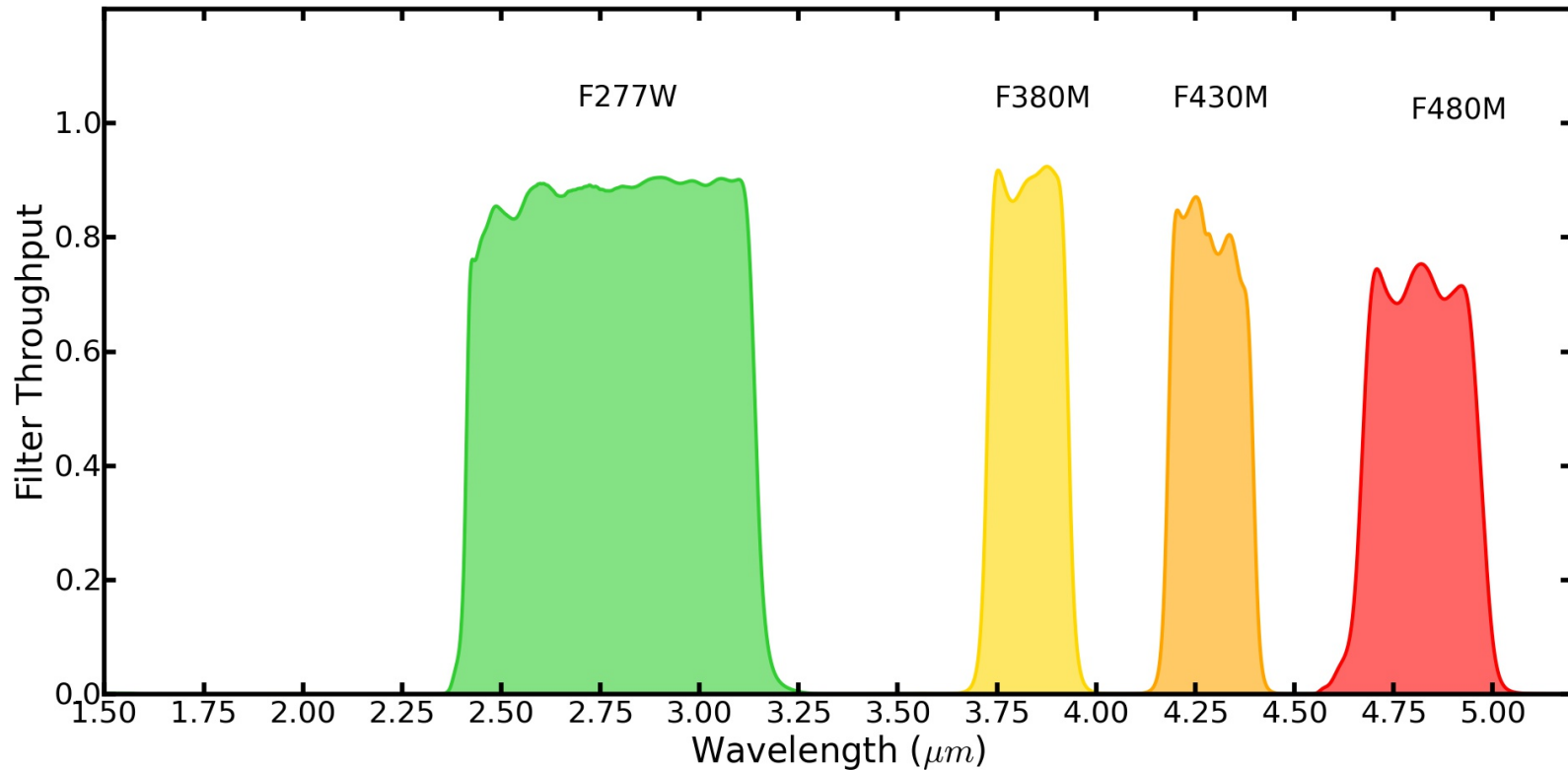
NIRISS optical design layout



All-reflective design - no chromatic aberration
Space – no atmospheric differential refraction
Space – stable photometry (fringe visibility)



AMI filter bandpasses



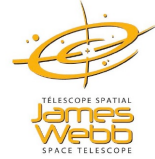
Binary point source contrast $\sim 9+$ magnitudes for F380M, F430M, F480M

Reduced performance with F277W (not Nyquist sampled) – but good for breaking Brown Dwarf/Jovian Log g/T_{eff} degeneracy to constrain bulk physical properties (Artigau et al. SPIE 2012)



Data Structure

Readout pattern, NGROUPS, NINT



For NIRISS AMI subarray is SUB80,
readout pattern is NISRAPID (one frame per group)

NGROUPS:
number of groups
in an integration

NINT: number of
integrations in an
exposure

EXPOSURE: The
end result of one or
more
INTEGRATIONS over
a finite period of time.

EXPOSURE defines
the contents of a
single FITS file

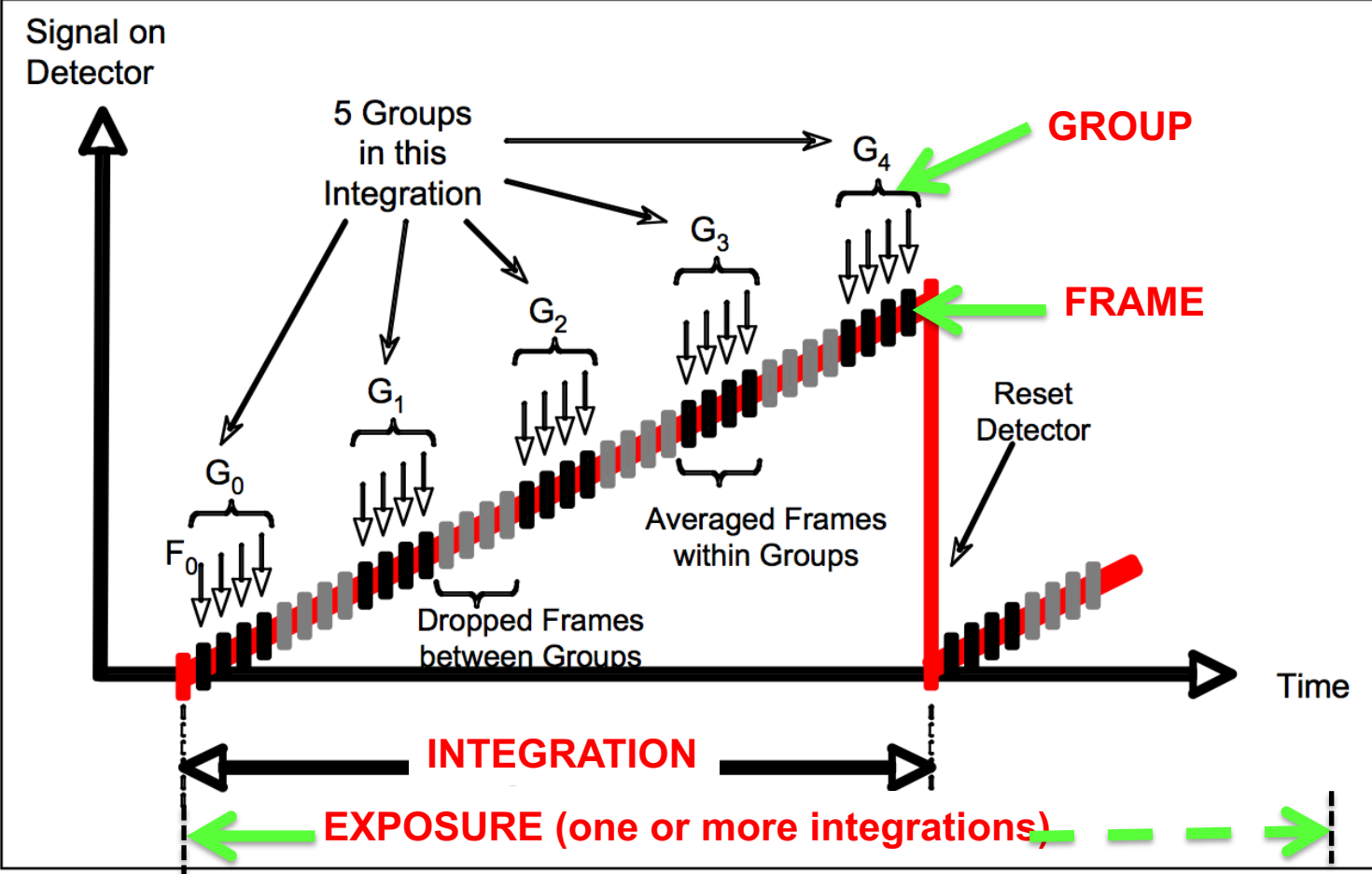
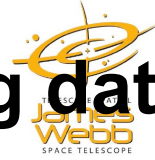


Figure adapted from JWST Mission Operations Concept Document JWST-OPS-002018 Revision E 2014



Post-observations: Calibrate imaging data



- **JWST imaging data analysis on Target or CAL**

- Common to other JWST imaging, eg NIRCam imaging
- Correct for non-linearity, flat field, cosmic rays, etc

To be determined from on-sky performance:

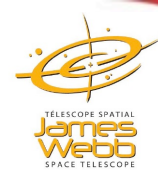
- ***EITHER*** Average all exposures
 - One final image
- ***OR*** Average all groups (recommended)
 - NINT images (per exposure – might need multiple exposures)
 - Better for statistics, image quality/stability monitoring

- **Extract observables:**

- ***EITHER Case A:*** Fringe amplitudes (visibilities) & phases, flux
 - Binary or multiple star model fitting
- ***OR Case B:*** Use image data for image reconstruction
 - CAL PSF and Target image



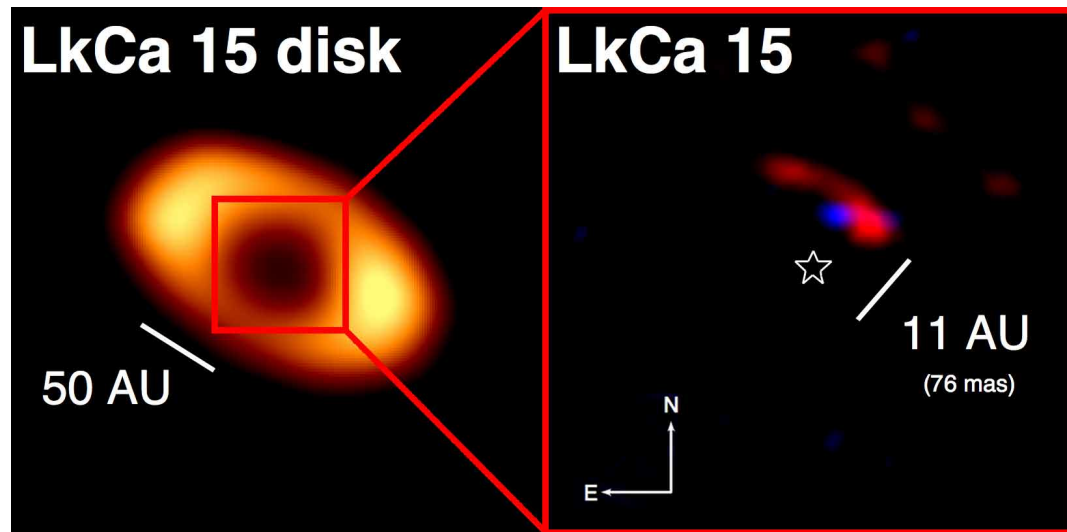
Fringe phases & amplitudes



- **Numerical Fourier transform to a complex number array**
 - Conceptually easier to understand but not what we do
 - Measure splodge heights (fringe visibilities), splodge phases in FT(data)
 - Bad pixels corrupt an FT
 - Fix bad pixels then FT? Tricky.
- **Fit analytical model to image (recommended)**
 - Fit analytical fringe model to image, ignore bad pixels
 - Determine *pupil rotation* from image
 - Least squares extraction of 21 fringe phases & visibilities, flux, pedestal
 - Calculate:
 - Closure Phases (CPs)
 - Squared visibilities (SqV)
 - See Greenbaum et al. ApJ 2015 for algorithm
 - Implemented in JWST pipeline
- **Fit model of science data to fringe quantities**

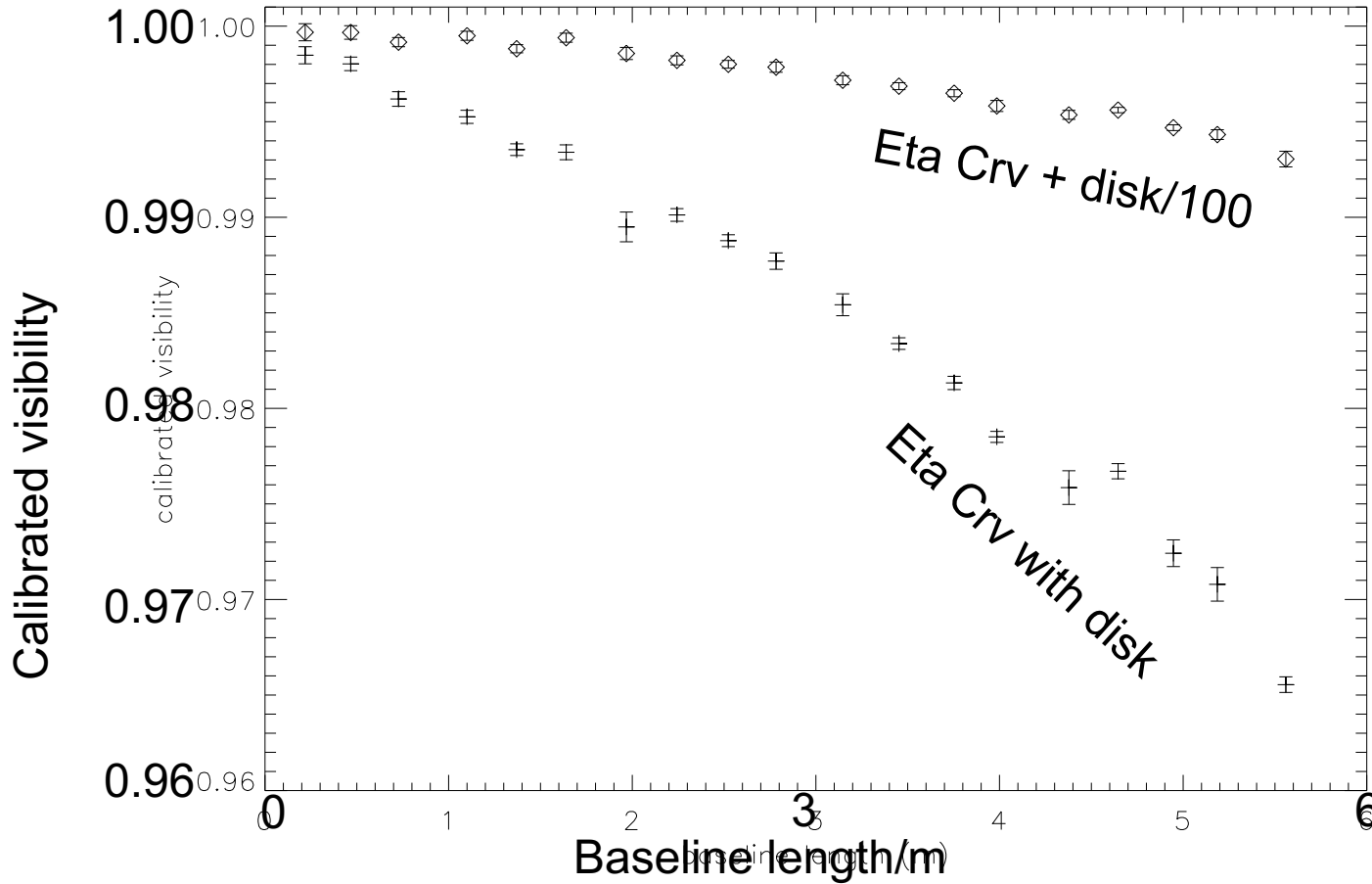
Exoplanet Imaging with AMI

- Three medium-band filters: 3.8, 4.3 & 4.8 μm
 - Provide good constraints on $\log g$ and T_{eff}
- Follow-up of GPI/SPHERE planets with separation less than ~ 0.5 arcsec and contrast $> 10^{-4}$ @ 4 μm .
 - Photometry and astrometry (e.g. Beta Pic b) (on flip side of FGS)
- Detection/confirmation/disambiguation/follow-up of suspected protoplanets in transitional disks (e.g. LkCA 15 disk)



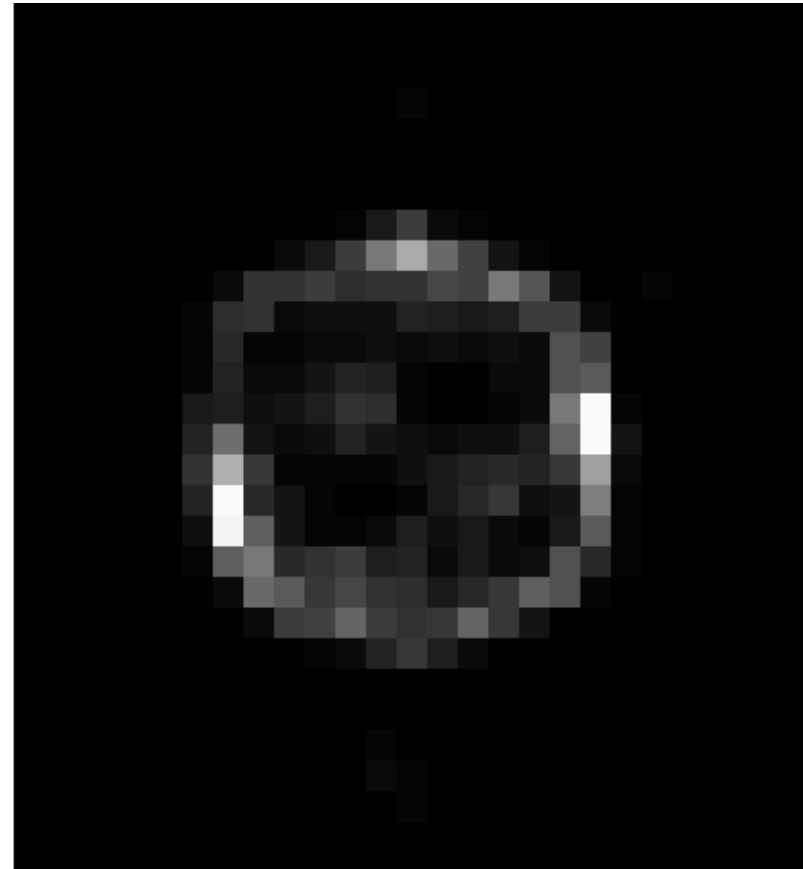
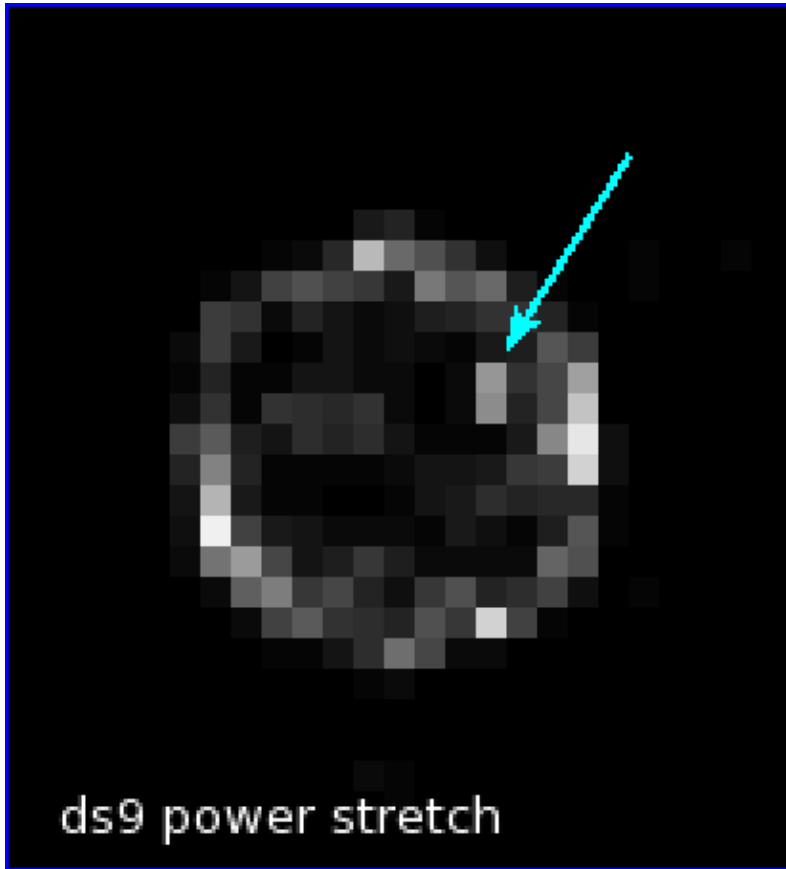
Kraus et al. 2012

Exozodi measurement



Simulated F480M and F380M visibility of Eta Crv + MCFOST disk model and Eta Crv with 1/100 the dust mass in the disk (Tuthill & Sivaramakrishnan). NIRISS photometric and JWST pointing stability should enable this measurement. Cf. ground > ~5% visibility errors

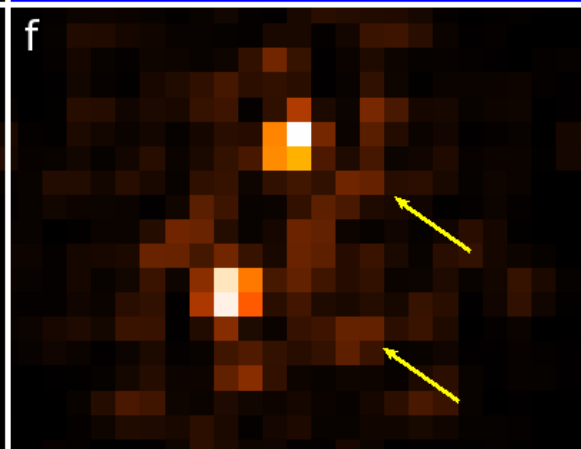
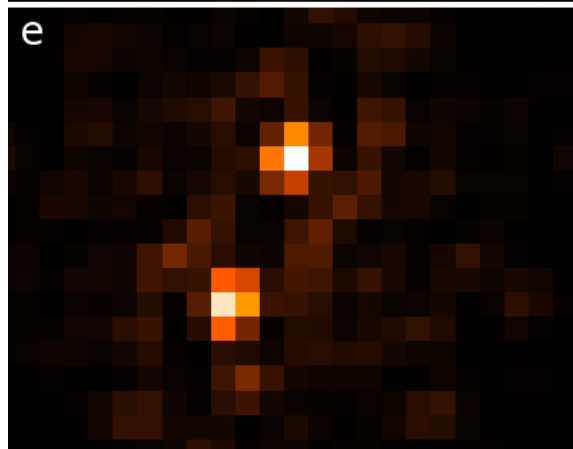
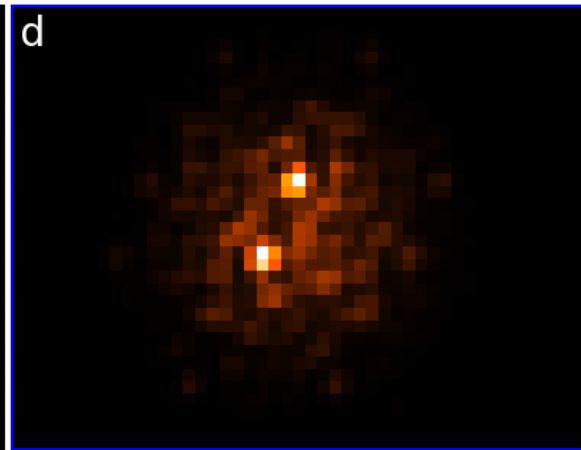
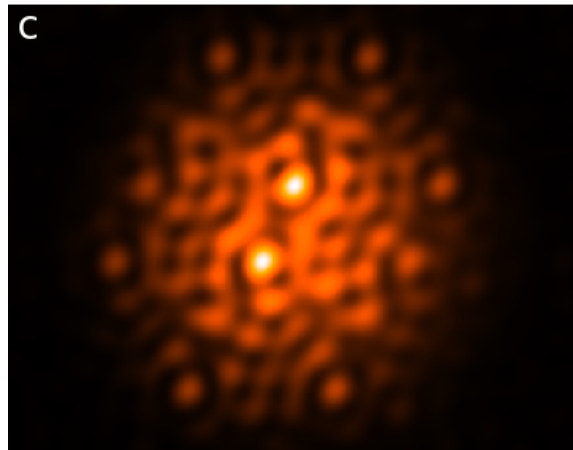
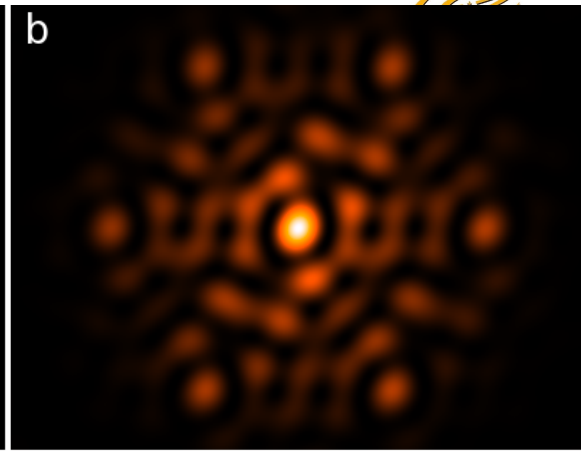
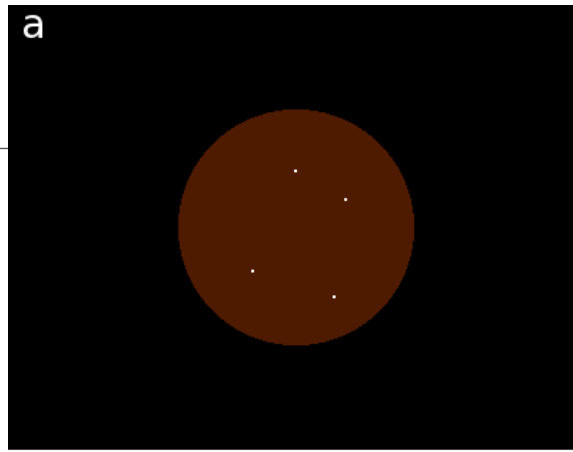
Io volcanism

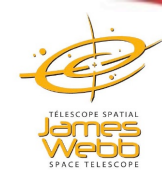


Simulated F430M images of Jupiter's closest Galilean moon, Io, with and without a typical volcanic event, after a Laplacian-like filter is applied to the simulated data. Space-based **photometry** of such a volcanic event should improve upon ground-based adaptive optics photometry (Thatte et al. LPSC 2015)



Simulated volcanoes on Jupiter's moon Io



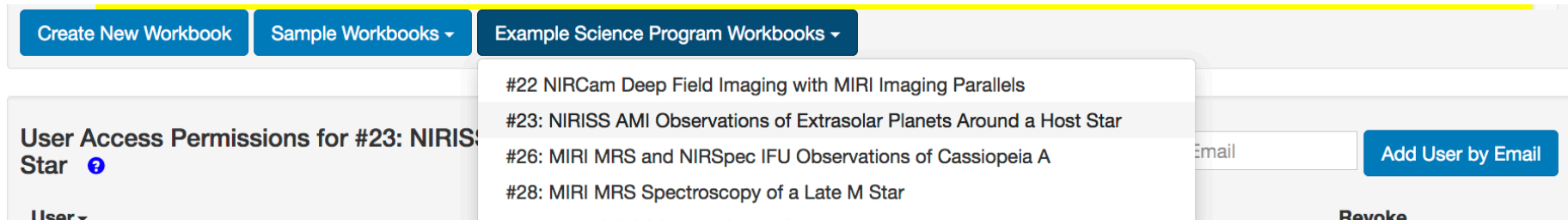


NIRISS AMI hands-on exercises



Example science program in JWST ETC

1. Log in to JWST ETC and Open program #23

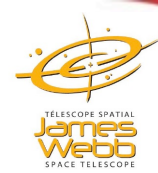


Create a scene with another target with spectral type F0V, vegamag=6.5, normalized in NIRISS F430M. Name the source 'Target 2' and name the scene 'Target 2 Scene'

- i. Create a Target Acquisition calculation for this source
- ii. Create a new calculation to use this scene
- iii. Calculate NGROUPS for an observation with NRM + F430M
- iv. Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- v. Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- vi. What contrast can you reach with 10^9 total photons?



AMI calculations in JWST ETC

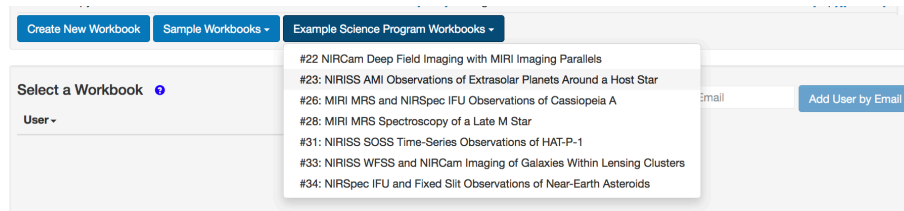


2. What is the magnitude (Vegamag) of the brightest F0V star that you can observe with NGROUPS=7 in F480M, F380M?
3. Create calculations to calculate NGROUPS and NINT required to get 10^7 photons from HD37093. Use Vegamag = 5.47 normalized in F380M and vegamag=5.46 normalized in F430M and F480M
4. Calculate NGROUPS=1 and NGROUPS=2 bright limits (Vegamag) for a A0V star observed with F380M.

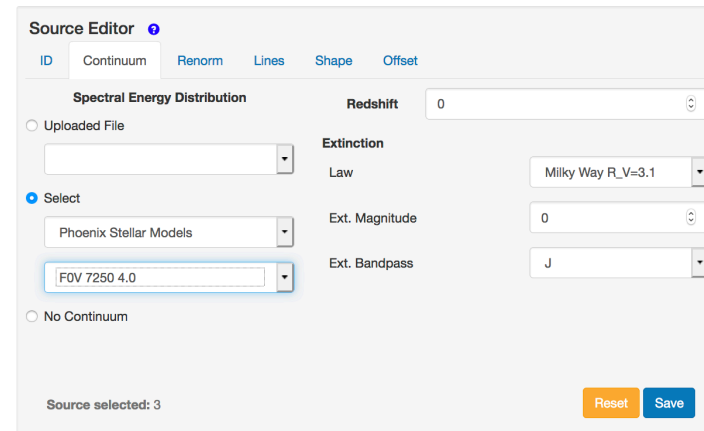
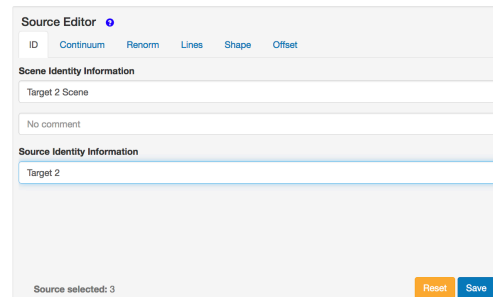
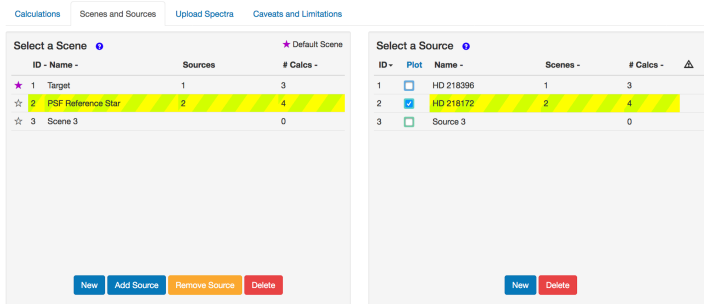
AMI calculations in JWST ETC

Answers to questions

1. Log in to JWST ETC and Open program #23



2. Create a scene with another target with spectral type F0V, vegamag=6.5, normalized in NIRISS F430M. Name the source 'Target 2' and name the scene 'Target 2 Scene'



AMI calculations in JWST ETC

Answers to questions

2. Create a scene with another target with spectral type F0V, vegamag=6.5, normalized in NIRISS F430M. Name the source 'Target 2' and name the scene 'Target 2 Scene' continued...

Source Editor

ID Continuum Renorm Lines Shape Offset

Normalize Source Flux Density

Renormalization applied after redshift

Normalize at wavelength

0.001 mly lambda 2 μm

Normalize in bandpass

6.5 vegamag

JWST NIRISS/IMAGING F430M

HST WFC3/IR F098M

Source selected: 3

Reset Save

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

Select a Scene

ID Name	Sources	# Calcs
★ 1 Target	1	3
☆ 2 PSF Reference Star	2	4
☆ 3 Target 2 Scene	3	0

Select a Source

ID Plot Name	Scenes	# Calcs
1 HD 218396	1	3
2 HD 218172	2	4
3 Target 2	3	0

Select new scene, new source and then add source

New Add Source Remove Source Delete

New Delete

Source Editor

ID Continuum Renorm Lines Shape Offset

Position of Source in Scene

X offset 0 arcsec

Y offset 0 arcsec

Orientation 0 degrees

Source selected: 3

Reset Save

Source Editor

ID Continuum Renorm Lines Shape Offset

Shape of source: Point Extended

Source selected: 3

Reset Save

AMI calculations in JWST ETC

Answers to questions



- Create a Target Acquisition calculation for this source
- Create a new calculation to use this scene
- Calculate NGROUPS for an observation with NRM + F430M
- Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- What contrast can you reach with 10^9 total photons?

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

ID	Mode	λ -	Scn - (s)	SNR -
1	niriss ami		0.85	1007.77
2	niriss ami		0.85	717.74
3	niriss ami		5039.82	7831.05
4	niriss ami	4.81	2	8050.99
5	niriss target_acq	4.81	1	104.87
6	niriss target_acq	4.81	2	72.26
7	niriss target_acq	4.81	2	117.41

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

ID	Mode	λ -	Scn - (s)	SNR -
1	niriss ami	4.81	1	0.85
2	niriss ami	4.81	2	0.62
3	niriss ami	4.81	1	5039.82
4	niriss ami	4.81	2	8050.99
5	niriss target_acq	4.81	1	0.22
6	niriss target_acq	4.81	2	0.22
7	niriss target_acq	4.81	2	0.32
8	niriss target_acq	4.81	1	0.22

Scene ★ Backgrounds Instrument Setup Detector Setup Strategy

1: Target
2: PSF Reference Star
3: Target 2 Scene

Normalize Source Flux Density
Renormalization applied after redshift

Sources in that Scene
3: Target 2

Normalize at wavelength
0.001 flam

lambda 2 μm

Normalize in bandpass
6.5 vegmag

JWST NIRISS/IMAGING F430M

HST WFC3/IR F098M

Calculation selected: 8, Mode: niriss target_acq

Reset Calculate

Scene ★ Backgrounds Instrument Setup Detector Setup Strategy

Position
Ra Dec 0:00:00.00 0:00:00.00

Background configuration
None Low Medium High

Date Jul 1 2020

NIRISS Target Acquisition

Acq Mode
SOSS or AMI Bright

Filter
F480M

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

ID	Mode	λ -	Scn - (s)	SNR -
1	niriss ami	4.81	1	0.85
2	niriss ami	4.81	2	0.62
3	niriss ami	4.81	1	5039.82
4	niriss ami	4.81	2	8050.99
5	niriss target_acq	4.81	1	0.22
6	niriss target_acq	4.81	2	0.22
7	niriss target_acq	4.81	2	0.32
8	niriss target_acq	4.81	3	0.72

Scene ★ Backgrounds Instrument Setup Detector Setup Strategy

Subarray
SOSS or AMI TA

Readout pattern
NISRAPID

Groups
13

Integrations
1

Exposures
1

Total exposure time: 00:00:01 (0.72 s)

Total integrations: 1

Calculation selected: 8, Mode: niriss target_acq

Reset Calculate



AMI calculations in JWST ETC

Answers to questions



- i. Create a Target Acquisition calculation for this source
- ii. **Create a new calculation to use this scene**
- iii. Calculate NGROUPS for an observation with NRM + F430M
- iv. Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- v. Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- vi. What contrast can you reach with 10^9 total photons?

ii

Calculations Scenes and Sources Upload Spectra Caveats and Lin

MIRI	NIRCam	NIRISS	NIRSpec	ID	Mode	(s)	SNR
		Imaging		1	niriss ami	0.85	1007.77
		SOSS		2	niriss ami	0.62	507.22
		WFSS		3	niriss ami	5039.82	7831.05
		AMI		4	niriss ami	4.81	2
		Target Acquisition		5	niriss target_acq	4.81	1
				6	niriss target_acq	4.81	2
				7	niriss target_acq	4.81	2
				8	niriss target_acq	4.81	3

Calculations Scenes and Sources Upload Spectra Caveats and Limitations

MIRI	NIRCam	NIRISS	NIRSpec	ID	Mode	λ	Scn	(s)	SNR
				1	niriss ami	4.81	1	0.85	1007.77
				2	niriss ami	4.81	2	0.62	507.22
				3	niriss ami	4.81	1	5039.82	7831.05
				4	niriss ami	4.81	2	8050.99	7836.49
				5	niriss target_acq	4.81	1	0.22	104.87
				6	niriss target_acq	4.81	2	0.22	72.26
				7	niriss target_acq	4.81	2	0.32	117.41
				8	niriss target_acq	4.81	3	0.72	157.37
				9	niriss ami	4.28	3	0.85	520.97

Scene ★ Backgrounds Instrument Setup Detector Setup Strategy

Scene for Calculation: 3: Target 2 Scene

Sources in that Scene: 3: Target 2

Scene Identity Information: Target 2 Scene

Source Identity Information: Target 2

Calculation selected: 9, Mode: niriss ami

Reset Calculate

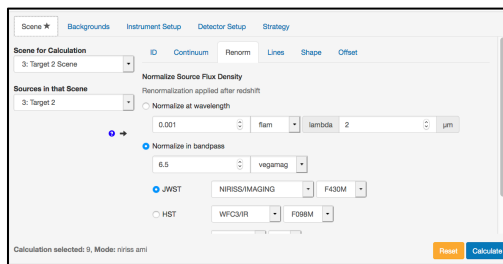
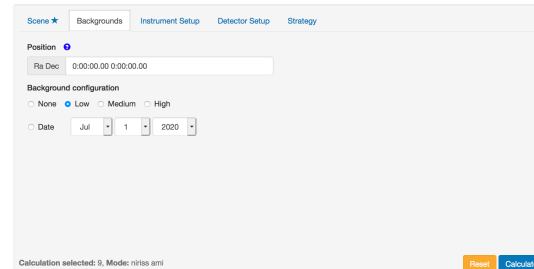
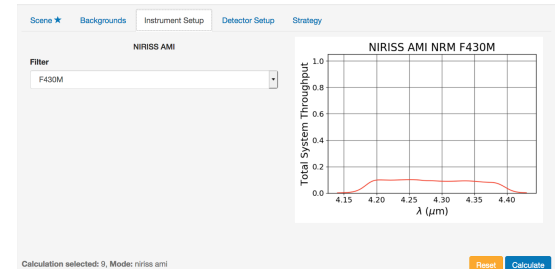
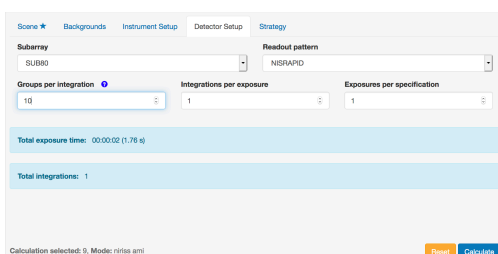
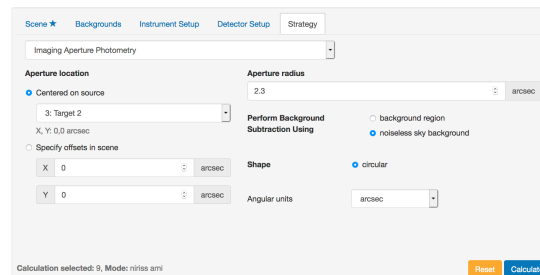
AMI calculations in JWST ETC

Answers to questions

- i. Create a Target Acquisition calculation for this source
- ii. Create a new calculation to use this scene
- iii. Calculate NGROUPS for an observation with NRM + F430M
- iv. Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- v. Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- vi. What contrast can you reach with 10^9 total photons?

iii

Update Scene, background, Instrument Setup and Strategy and run the calculation with default Detector Setup

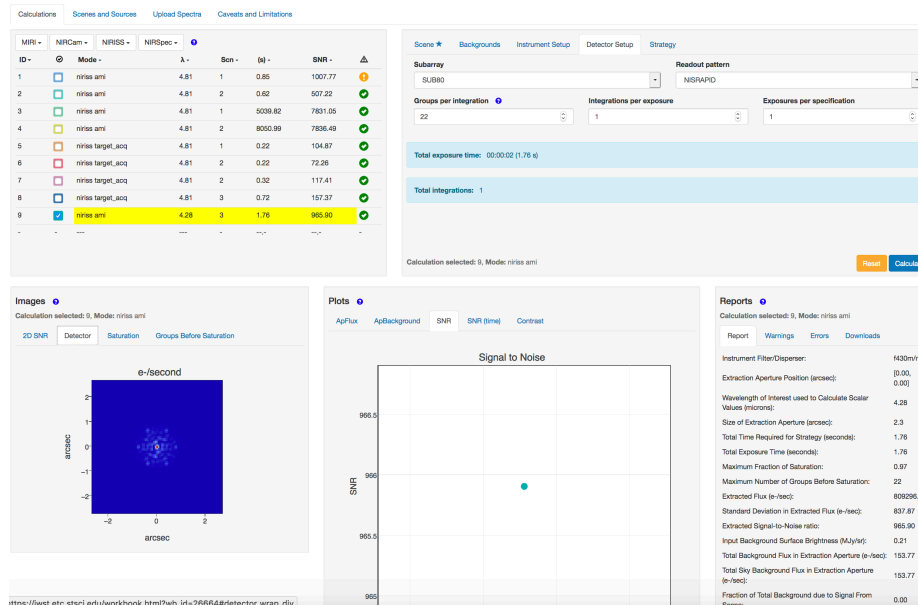






AMI calculations in JWST ETC

Answers to questions

- i. Create a Target Acquisition calculation for this source
- ii. Create a new calculation to use this scene
- iii. Calculate NGROUPS for an observation with NRM + F430M
- iv. Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- v. Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- vi. What contrast can you reach with 10^9 total photons?

iii
continued



Maximum Number of Groups Before saturation value is 22 from the Reports panel. Therefore set Groups per integration to **22**. (NGROUPS)



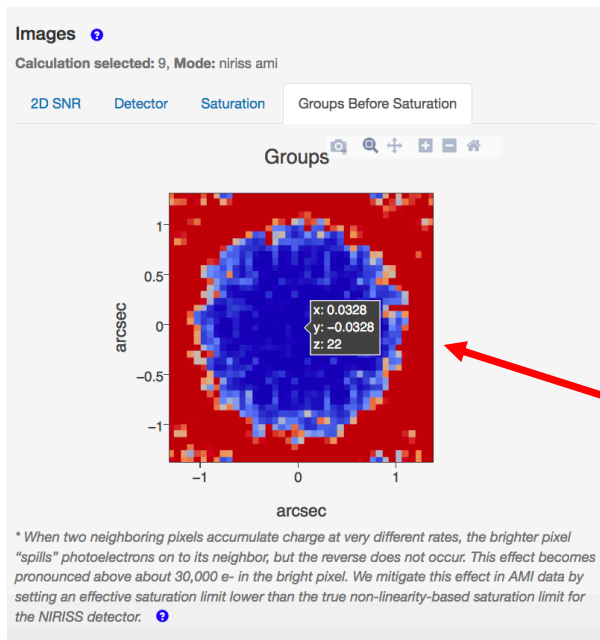
AMI calculations in JWST ETC

Answers to questions



- i. Create a Target Acquisition calculation for this source
- ii. Create a new calculation to use this scene
- iii. Calculate NGROUPS for an observation with NRM + F430M
- iv. Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- v. Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- vi. What contrast can you reach with 10^9 total photons?

iv



Reports

Calculation selected: 9, Mode: niriss ami

Report **Warnings** Errors Downloads

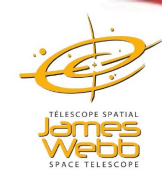
Instrument Filter/Dispenser:	f430m/null
Extraction Aperture Position (arcsec):	[0.00, 0.00]
Wavelength of Interest used to Calculate Scalar Values (microns):	4.28
Size of Extraction Aperture (arcsec):	2.3
Total Time Required for Strategy (seconds):	1.76
Total Exposure Time (seconds):	1.76
Maximum Fraction of Saturation:	0.97
Maximum Number of Groups Before Saturation:	22
Extracted Flux (e-/sec):	809296.80
Standard Deviation in Extracted Flux (e-/sec):	837.87
Extracted Signal-to-Noise ratio:	965.90
Input Background Surface Brightness (MJy/sr):	0.21
Total Background Flux in Extraction Aperture (e-/sec):	153.77
Total Sky Background Flux in Extraction Aperture (e-/sec):	153.77
Fraction of Total Background due to Signal From Scene:	0.00
Average Number of Cosmic Rays per Ramp:	1.3e-4

Maximum number of Groups Before saturation in the brightest pixel of AMI PSF.



AMI calculations in JWST ETC

Answers to questions



- i. Create a Target Acquisition calculation for this source
- ii. Create a new calculation to use this scene
- iii. Calculate NGROUPS for an observation with NRM + F430M
- iv. Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- v. Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- vi. What contrast can you reach with 10^9 total photons?

v

Total Time Required for Strategy (seconds):	1.76
Total Exposure Time (seconds):	1.76
Maximum Fraction of Saturation:	0.97
Maximum Number of Groups Before Saturation:	22
Extracted Flux (e-/sec):	809296.80
Standard Deviation in Extracted Flux (e-/sec):	837.87
Extracted Signal-to-Noise ratio:	965.90
Input Background Surface Brightness (M _v /sr):	0.21

$$\begin{aligned}\text{Total photons} &= \text{flux} \times \text{NGROUPS} \times \text{NINT} \times \text{TFRAME} \\ \text{NINT} &= \text{Total photons} / (\text{flux} \times \text{NGROUPS} \times \text{TFRAME}) \\ &= 10^9 / (809296.80 \text{ e-/sec} \times 22 \times 0.07544 \text{ sec}) \\ &= 744.5 \rightarrow \text{Round up to } 745\end{aligned}$$



AMI calculations in JWST ETC

Answers to questions



- i. Create a Target Acquisition calculation for this source
- ii. Create a new calculation to use this scene
- iii. Calculate NGROUPS for an observation with NRM + F430M
- iv. Compare the 'Maximum number of Groups Before Saturation' value with the central pixel value in Groups Before Saturation image
- v. Calculate NINT to get 10^9 total photons in the exposure.
 - Use photon collect time formula and Extracted Flux in the Reports panel
- vi. What contrast can you reach with 10^9 total photons?

vi

$$\text{sqrt}(100/(10^{**9})) = 0.0003$$

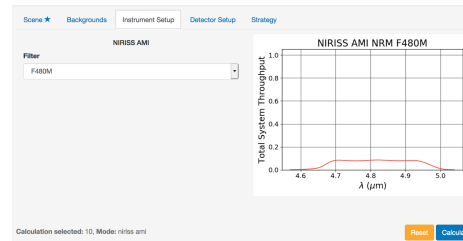
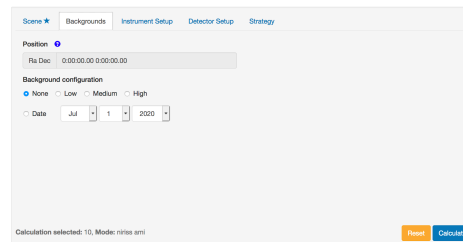
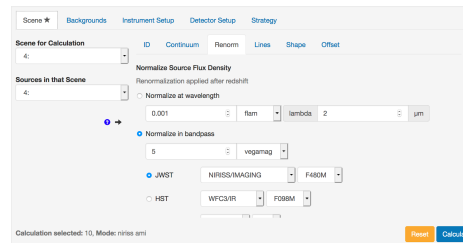
AMI calculations in JWST ETC

Answers to questions

2. What is the vegamag magnitude of the brightest F0V star that you can observe with NGROUPS=7 in F480M, F380M?

- F480M
Vegamag = 5 gives maximum number of Groups Before Saturation as 7.
Vegamag = 5.1 gives maximum number of Groups Before Saturation as 8.
Therefore **vegamag=5** is the NGROUP=7 bright limit for F480M

- F380M
vegamag = 6
for NGROUPS=7

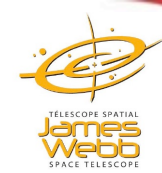


Reports

Calculation selected: 10, Mode: niriss ami

Report Warnings Errors Downloads

Instrument Filter/Disperser:	f480m/null
Extraction Aperture Position (arcsec):	[0.00, 0.00]
Wavelength of Interest used to Calculate Scalar Values (microns):	4.81
Size of Extraction Aperture (arcsec):	2.5
Total Time Required for Strategy (seconds):	0.62
Total Exposure Time (seconds):	0.62
Maximum Fraction of Saturation:	0.91
Maximum Number of Groups Before Saturation:	7
Extracted Flux (e-/sec):	2877649.50
Standard Deviation in Extracted Flux (e-/sec):	3275.57
Extracted Signal-to-Noise ratio:	878.52
Input Background Surface Brightness (MJy/sr):	0.00
Total Background Flux in Extraction Aperture (e-/sec):	0.00
Total Sky Background Flux in Extraction Aperture (e-/sec):	0.00
Fraction of Total Background due to Signal From Scene:	0.00



AMI calculations in JWST ETC

Answers to questions

3. Create calculations to calculate NGROUPS and NINT required to get 10^7 photons from HD37093. Use Vegamag = 5.47 normalized in F380M and vegamag=5.46 normalized in F430M and F480M

Answer:

This is similar to calculations 2, 3 and 4 in NIRISS AMI Examples sample workbook. The only difference is in the total number of photons which will change the number of integrations.

F480M NGROUPS=11, NINT = 7

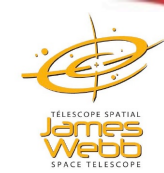
F430M NGROUPS=8, NINT = 8

F380M NGROUPS=4, NINT = 11



AMI calculations in JWST ETC

Answers to questions



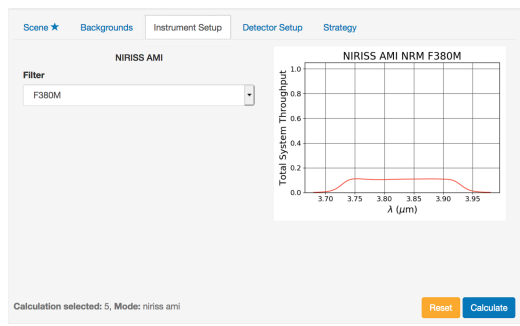
4. Calculate NGROUPS=1 and **NGROUPS=2 bright limits (Vegamag)** for A0V star observed with F380M.

This is similar to Example 3 in NIRISS AMI Examples. Only the filter is different.

NGROUPS=2 bright limit
For F380M

4.66

Change the magnitude to
4.65 and look at the warning message



Reports

Calculation selected: 5, Mode: niriss ami

Report	Warnings	Errors	Downloads
Instrument Filter/Disperser:			f380m/null
Extraction Aperture Position (arcsec):			[0.00, 0.00]
Wavelength of Interest used to Calculate Scalar Values (microns):			3.83
Size of Extraction Aperture (arcsec):			2
Total Time Required for Strategy (seconds):			0.25
Total Exposure Time (seconds):			0.25
Maximum Fraction of Saturation:			0.99
Maximum Number of Groups Before Saturation:			2
Extracted Flux (e-/sec):			6705701.97
Standard Deviation in Extracted Flux (e-/sec):			15015.28
Extracted Signal-to-Noise ratio:			446.59
Input Background Surface Brightness (MJy/sr):			0.00
Total Background Flux in Extraction Aperture (e-/sec):			0.00
Total Sky Background Flux in Extraction Aperture (e-/sec):			0.00
Fraction of Total Background due to			0.00

AMI calculations in JWST ETC

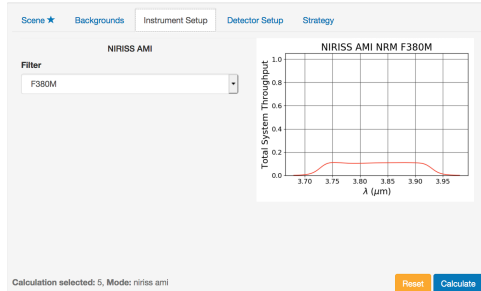
Answers to questions



4. Calculate **NGROUPS=1** and NGROUPS=2 bright limits (Vegamag) for A0V star observed with F380M.

This is similar to Example 3 in NIRISS AMI Examples. Only the filter is different.

NGROUPS=1 bright limit for F380M is 4.03. Change the magnitude to 4.02 and look at the central pixel in Groups Before Saturation image.



Reports

Calculation selected: 5, Mode: niriss ami

Report Warnings Errors Downloads

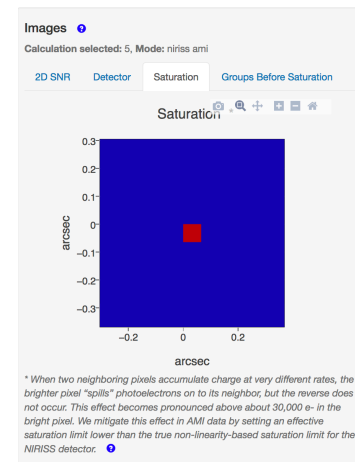
Instrument Filter/Dispenser:	f380m/null
Extraction Aperture Position (arcsec):	[0.00, 0.00]
Wavelength of Interest used to Calculate Scalar Values (microns):	3.83
Size of Extraction Aperture (arcsec):	2
Total Time Required for Strategy (seconds):	0.25
Total Exposure Time (seconds):	0.25
Maximum Fraction of Saturation:	1.77
Maximum Number of Groups Before Saturation:	1
Extracted Flux (e-/sec):	11979653.37
Standard Deviation in Extracted Flux (e-/sec):	NaN
Extracted Signal-to-Noise ratio:	0.00
Input Background Surface Brightness (MJy/sr):	0.00
Total Background Flux in Extraction Aperture (e-/sec):	0.00
Total Sky Background Flux in Extraction Aperture (e-/sec):	0.00
Fraction of Total Background due to	0.00

Reports

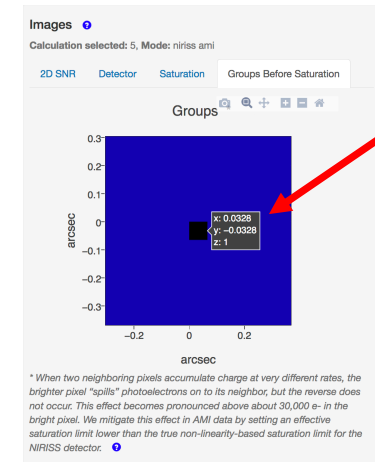
Calculation selected: 5, Mode: niriss ami

Report Warnings Errors Downloads

- Full saturation: There are 1 pixels saturated* at the end of the first group. These pixels cannot be recovered. *(See footnote in the Saturation image tab.)



Saturation image

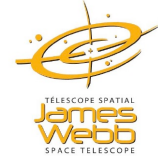


Groups Before Saturation image

Signal limit exceeded in group 2 but not in group 1

Example science program in JWST APT

AMI Specific strategies



JWST Draft Proposal (Unsaved)

- Proposal Information
- Targets**
- Observations
- Observation Links

Targets

Resolve a target name or position

Create a new Fixed Target

Create a new Target Group

Create a new Solar System Target

Create a new Generic Target

Import Fixed Targets from whitespace, CSV, TSV, or VOTable

Get coordinates from GAIA DR2 archive, enter epoch as 2015.5

- Use Fixed Target Resolver to search for target and then manually update coordinates OR
- Select New Fixed target and update information.

Astronomer's Proposal Tools Version 27.3.1 JWST PRD: PRDOPSSOC-M-025 - JWST Approved Proposal 23 (Unsaved)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | Timeline | View in Aladin | BOT | Target Confirmation | PDF Preview | Submission | Errors and Warnings

New Document | New

What's New | Roadmap | Feedback

JWST Approved Proposal 23 (Unsaved)

- Proposal Information
- Proposal Description
- Team Expertise
- PI: William Blair
- Targets
 - Fixed Targets**
 - 1 HD-218396**
 - 2 HD-218172
- Observations
- Observation Links

1 HD-218396 of JWST Approved Proposal 23 (Unsaved)

Number: 1

Name in the Proposal: HD-218396 (unique within proposal)

Name for the Archive: HD 218396 (standard resolvable name)

Category: Star

Description: +/- Exoplanet Systems F stars

Choose 1 to 5 items after selecting a category.

J2000 Coordinates (ICRS) RA: 23 07 28.8327 Dec: +21 08 2.53

Uncertainty RA: [] Arcsec Dec: [] Arcsec

Proper Motion RA: 108.30 mas/yr Dec: -49.48 mas/yr

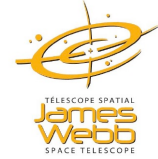
Epoch: 2015.5

Annual Parallax (arcsec): []

Extended: Unknown Recommended for spectroscopy (for advice to data reduction pipeline)



Example science program in JWST APT



Astronomer's Proposal Tools Version 27.3.1 JWST PRD: PRDOPSSOC-M-025 - JWST Approved Proposal 23 (Unsaved)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | Timeline | View in Aladin | BOT | Target Confirmation | PDF Preview | Submission | Errors and Warnings | All Tools | Stop

New Document | New

JWST Approved Proposal 23 (Unsa...)

- Proposal Information
- Targets
- Observations
 - Exoplanets in HD 218396 with
 - HD-218396 (Obs 1)
 - HD-218172 (Obs 2)
 - Observation Links

HD-218396 (Obs 1) of JWST Approved Proposal 23 (Unsaved)

Direct Imaging Parameters

Direct Image True False

PSF Reference Observations

This is a PSF Reference Observation

HD-218172 (Obs 2) (PSF Reference; Filters [F480M])

PSF Reference Observations

Additional justification Additional justification of self-reference observations will be provided in the science justification

Edit Exoplanets in HD 218396 with NIRISS AMI | New | Edit Visit 1:1

Astronomer's Proposal Tools Version 27.3.1 JWST PRD: PRDOPSSOC-M-025 - JWST Approved Proposal 23 (Unsaved)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | Timeline | View in Aladin | BOT | Target Confirmation | PDF Preview | Submission | Errors and Warn | Run All Tools | Stop

New Document | New

JWST Approved Proposal 23 (Unsa...)

- Proposal Information
- Targets
- Observations
 - Exoplanets in HD 218396 with
 - HD-218396 (Obs 1)
 - HD-218172 (Obs 2)
 - Observation Links

HD-218172 (Obs 2) of JWST Approved Proposal 23 (Unsaved)

Filters

Add Duplicate Insert Above Remove

Direct Imaging Parameters

Direct Image True False

PSF Reference Observations

This is a PSF Reference Observation (exclusive access period will be 0 months)

Edit Visit 1:1 | New | Edit Visit 2:1

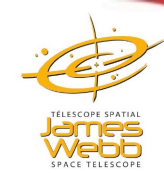
Observa... △	Number	Status	Duplication	Label	Science	Total Char...	Data Volume	Parallel Slo...	Instrument	Ter
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Show: Observation

2 errors & warnings (Click for Details)



Example science program in JWST APT AMI Specific strategies



Adding Special Requirements

Astronomer's Proposal Tools Version 27.3.1 JWST PRD: PRDOPSSOC-M-025 - JWST Approved Proposal 23 (Unsaved)

Form Editor | Spreadsheet Editor | Orbit Planner | Visit Planner | Timeline | View in Aladin | BOT | Target Confirmation | PDF Preview | Submission | Errors and Warnings | Run All Tools | Stop

New Document | New

JWST Approved Proposal 23 (Unsa) | HD-218396 | Group/Sequence Observations Link

Number: 1 | Status: IMPLEMENTED

Label: HD-218396

Instrument: NIRISS

Template: NIRISS Aperture Masking Interferometry

Target: 1 HD-218396

Splitting Distance: 50.0 Arcsec | Number: 1

Duration (secs): 4416 | Total Duration (secs): 9169

Volume: 899 MB

Observation list:
 HD-218396 (Obs 1)
 HD-218172 (Obs 2)

Time interval: [] Days

Sequence:

Non-interruptible:

Exclusive Use Of Instrument:

Group Observations 1, 2, Non-interruptible

OK

Special Requirements

Click on Add

- Timing
- Position Angle
- Offset
- No Parallel
- On Hold
- Target Of Opportunity
- Maximum Visit Duration
- Background Noise
- Group/Sequence Observations Link

Show: Observation

2 errors & warnings (Click for Details)



Example science program in JWST APT AMI Specific strategies



Create 'NIRISS AMI Observations of Extrasolar Planets around a Host Star' proposal and compare with the existing program.

- Select target HR8799(or HD218396) and calibrator (HD218172).
- Enter/update coordinates, proper motion using information from Gaia DR2 archive, use 2015.5 epoch.
- Create observations for each source using NIRISS AMI template.
- Update exposure parameters using calculations 5 and 7 for Target Acquisition and calculations 3 and 4 for science observations in JWST ETC example science program workbook #23: NIRISS AMI Observations of Extrasolar Planets Around a Host Star.
- Create Group non-interruptible Special Requirement for the target and the calibrator.
- Update PSF Reference Observations field for the target and the calibrator.
- Run visit planner
- Run Smart accounting
- Create the times report (via APT File – Export) to look at an ASCII listing of charged times
- Create Target Confirmation Charts and view the observations in Aladin.