



**STScI** | SPACE TELESCOPE  
SCIENCE INSTITUTE

**JWST Master Class 2019**  
**High Contrast Imaging (HCI) Module**  
Space Telescope Science Institute  
San Martin Drive, Baltimore MD 21218

## HCI Level 2 Exercises (requires to constantly navigate JDOx)

### Common across all HCI modes

**Reference star selection and APT:** HR 8799 Example Program (NIRCam/MIRI Coronagraphy & NIRISS/AMI)

- 1) Open APT 27.3, fetch GTO Prog 1194 and save it locally with a new name
- 2) Which stars are reference stars?
  - a. For NIRCam Coronagraphy
  - b. For MIRI Coronagraphy
- 3) Consider NIRCam only, how far is the reference star from the science target?
- 4) Find a suitable brighter reference star ( $3 < K < 5$ ) within  $2^\circ$  of HR8799 with a similar spectral type (choose 2 methods)
  - a. Using Simbad
  - b. Using JMMC/SearchCal
  - c. Using Python astroquery
  - d. Using the USNO single star catalog  
<http://www.astro.gsu.edu/wds/single/singleframe.html>

### Coronagraphy

#### Coronagraphy Visibility Tool

<https://jwst-docs.stsci.edu/jwst-other-tools/target-visibility-tools/jwst-coronagraphic-visibility-tool-help>

- 5) Open the Coronagraph Visibility Tool
  - a. On your laptop if you have it installed (command line or OSX binary)
  - b. Run it on the Virtual Desktop on <https://jwst-masterclass.science.stsci.edu> otherwise
- 6) Enter HR8799 “Search” to resolve it with Simbad, then press “update plots”
- 7) Enter the b companion: PA=45° and separation=1.7” and press “update plots”

- 8) How many days per year the star is observable with JWST?
- 9) When (convert to MM-DD) is it ideal to observe HR8799b with the LW bar?
- 10) How much is the maximum roll angle around that date?

## ETC

### NIRCam

#### If time allows:

- 11) Open the ETC: <https://jwst.etc.stsci.edu/> and under “Sample Workbooks”, load “Coronagraphy Calculations with Target Acquisitions”
- 12) Adjust the scene to mimic the HR8799 system, add planet e (4<sup>th</sup> faint point source at 0.4”) following this table. Note that one must select both the Scene and the Source to be able to change these parameters.

Planet	Normalize in bandpass (vegamag, Johnson K)	Black Body Spectrum Temperature (K)	X offset	Y Offset
b	14.05	870	-1.6	0.65
c	13.13	1090	1.15	1.3
d	13.1	1090	0.75	-0.8
e	12.93	1000	0.4	0.13

**If not, skip the previous two questions and copy the ETC Workbook for HR8799 b c d e: #27313 (which should be shared with you)**

#### Load your copy

Note: in the future, we hope to make it available from the pull down menu, when this Use Case make it back to JDOx

- 13) New Calculation Set the MASK335R and filter to F335M, the detector readout to SUB320 and SHALLOW4
- 14) What is the SNR obtained on planet e with 10 groups/int, 4 int and 1 exposure?
- 15) Check report and plots for the default “PSF Subtraction” strategy: “Optimal (autoscaling)”. How many partially and fully saturated pixels are there?
- 16) Add a new, +2 mag brighter reference star (of your choice, with different offsets in the scene) and run the same calculation
- 17) Check report and plots for the default “PSF Subtraction” strategy with the new reference star: “Optimal (autoscaling)”. How many partially and fully saturated pixels are there?
- 18) Change (only) the readout pattern to RAPID to go back to < 30 partially saturated pixels, write down the Total exposure time
- 19) Check reports and plots for the 3 other “PSF Subtraction” strategies
- 20) Download all 4 data products and inspect them with ds9 (or the SW of your choice)

- 21) How many partially and fully saturated pixels does the science scene alone have?
- 22) How many partially and fully saturated pixels does the reference star have?
- 23) Run the same calculation but adjusting the readout time of the reference star to have no saturation what so ever. How much time is saved? (e.g. to do more small grid dithers)

## **MIRI**

- 24) Run the same calculation as above with MIRI 4QPM @10.6 $\mu$ m
- 25) Change the background from Low (default) to High and report the change in SNR
- 26) Check where it is possible to upload a template spectrum for a companion

## **APT (cont.)**

### **Special requirements**

- 27) Go back to APT (your copy of Prog. 1194) and check the **special requirements** of a NIRCam MASKLWB observation.
  - a. Non-interruptible sequence
  - b. Fiducial Pointing Override

### **NIRCam Target Acquisition and astrometric confirmation image**

- 28) Run smart accounting with/without astrometric confirmation image (NIRCam TA)

### **PSF Reference Stars**

- 29) NIRCam: Check how PSF Reference Observations are toggled as such
- 30) NIRCam: Run the smart accounting with the original reference star (HD220657) and compare with replacing it with a closer reference star (HD220657 CLOSER) at roughly 30" distance from HR8799.

### **Other questions (if time allows, probably not)**

- 31) What if your Observation 2's reference star is 1.5 mag brighter, can you change the SGD pattern from 5-point to 9-point one at a ~constant SNR and time budget?

## NIRISS AMI

### 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

$$\text{Total photons} = \text{flux} \times \text{NGROUPS} \times \text{NINT} \times \text{TFRAME}$$

$\text{NGROUPS} \times \text{NINT} \times \text{TFRAME}$  is the photon collect time

$$\text{NINT} = \frac{\text{Total photons}}{\text{flux} \times \text{NGROUPS} \times \text{TFRAME}}$$

- VI. What contrast can you reach with  $10^9$  total photons?
- 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  
This is similar to calculations 2, 3 and 4 in NIRISS AMI Examples sample workbook available in JWST ETC. The only difference is in the total number of photons which will change the number of integrations.
  - 4) Calculate NGROUPS=1 and NGROUPS=2 bright limits for A0V star observed with F380M  
This is similar to Example 3 in NIRISS AMI Examples. Only the filter is different.

### APT

- 5) Create 'NIRISS AMI Observations of Extrasolar Planets around a Host Star' proposal and compare with the existing program.
  - a. Select target HR8799 (or HD218396) and calibrator (HD218172).

- b. Enter/update coordinates, proper motion using information from Gaia DR2 archive, use 2015.5 epoch.
- c. Create observations for each source using NIRISS AMI template.
- d. 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.
- e. Create Group non-interruptible Special Requirement for the target and the calibrator.
- f. Update PSF Reference Observations field for the target and the calibrator.
- g. Run visit planner
- h. Run Smart accounting
- i. Create *the times report* (via APT File – Export) to look at an ASCII listing of charged times
- j. Create Target Confirmation Charts and view the observations in Aladin.