JWST Master Class 2020

WFSS hands-on

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Wide Field Slit-less Spectroscopy Hands-on

1. Science Case

We will use the GTO program developed by Alex Scholz (GTO 1202) to survey the star forming region NGC 1333 to search for very low-mass members of that young star cluster, objects less massive than 5 Jupiter masses. The project requires a mosaic over about 8'x8' to cover most of the region, avoiding the bright stars. Note that there is little background emission but dust extinction in that region. We will compare NIRCam and NIRISS WFSS for this case. In fact, we will start with NIRISS then make a similar APT for NIRCam.

2. ETC

Question 1 - For our brown dwarf spectrum (of an L7 dwarf with Bessel H band = 21 Vega), what is the total integration time required to achieve SNR=10 through the F150W blocking filter with GR150C if we are interested by the SNR at 1.5 microns?

Answer – Approximately 650 seconds (ngroup=60, nint=1, NISRAPID, FULL)

Method

1. In the ETC, first upload the spectrum of the brown dwarf (user_spectrum_wfss.txt).
   Upload spectra → browse → upload
2. In Scene and Source, assign that spectrum to a source and renormalize to H=21.
   Source editor → Continuum → Uploaded File → user_spectrum_wfss
   Renorm → Normalize in bandpass → 21 Vegamag → other Bessel H
3. In Calculations, create a NIRISS WFSS calculation with that source. Assign the correct grism (GR150C) and blocking filter (F150W) and wavelength of interest for the SNR calculation (1.5 microns).
   Calculations → NIRISS → WFSS
   Instrument Setup → Grism = GR150C, Filter = 150W
   Strategy → Wavelength of Interest = 1.5

4. Set the detector properly in FULL subarray and NISRAPID readout pattern. Then vary Groups per integration until the SNR is about 10.

Question 2 (optional, a bit harder) – Can you use that spectrum to run NIRCam WFSS calculations? No. Because it is not defined in the >2.5 micron domain. Instead, assume that the source was a black body with Teff=2000 K and you wanted to spend as much time with NIRCam WFSS in the GRISMC+F356W blocking filter as you spent with the above NIRISS WFSS (~650 sec). What VEGA magnitude (expressed in the F356W JWST filter) is the source that would produce a spectrum with the same SNR=10 as NIRISS at the wavelength of interest of 3.56 microns?

Answer – F356W ~= 17.3

Method

1. Create a new source and a new scene with it.
2. Use a black body with Teff=2000K. Renormalize to JWST NIRCam F356W = 17 Vegamag.
3. In the Instrument setup, choose GRISMR and F356W.
4. In Detector setup, use FULL subarray. Pick a readout pattern and Ngroup that yields about 650 sec. Hint: Medium2 and NGroup=7 yields.
5. In Strategy, pick the wavelength of interest of 3.56 microns.
6. In Calculations, create a NIRCam WFSS calculation using that new scene.

3. APT

NIRISS

1. The target, NGC 1333, is centered at position 03 29 3.0000, +31 21 0.00.

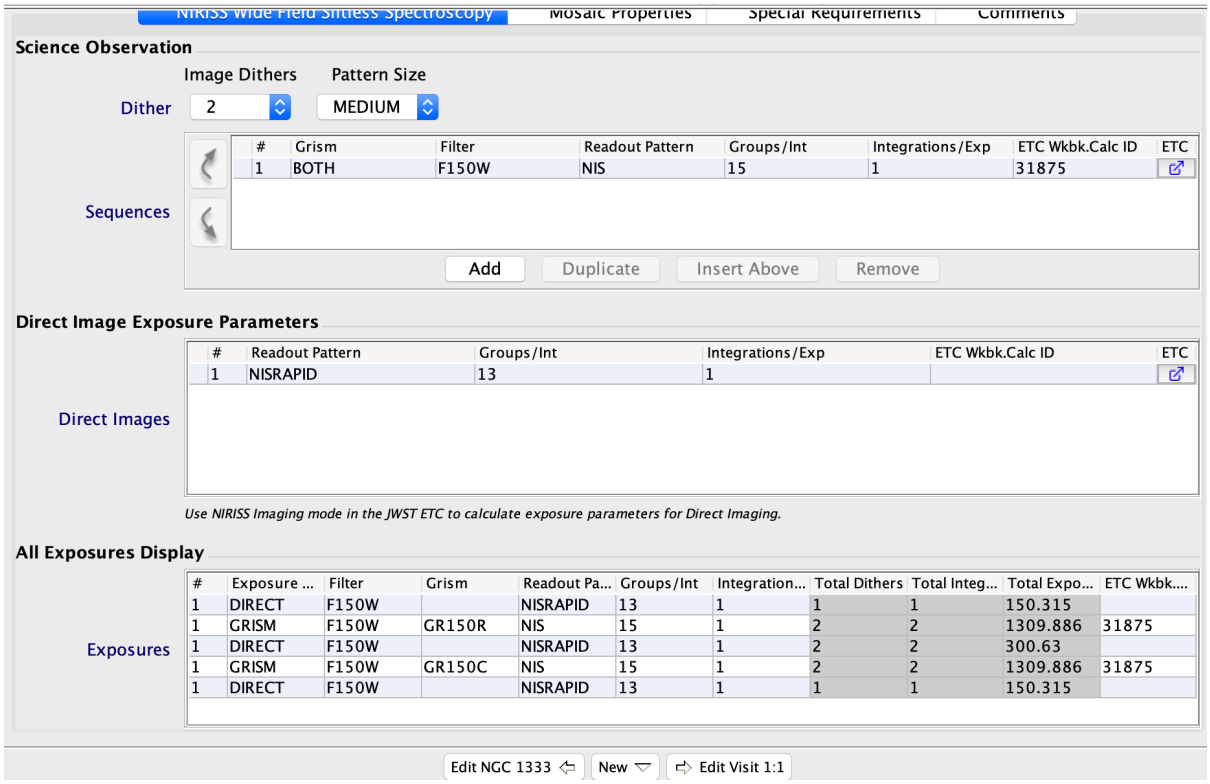
2. Setup the NIRISS WFSS observation for NGC 1333. Assume that we use BOTH grisms with the integration time determined in the ETC exercise above (650 sec). We work in the F150W blocking filter.

3. Can we use the Ngroup=60 NISRAPID? No, a maximum of Ngroup=30 is allowed in NISRAPID. Instead, choose NIS and Ngroup=15. That is equivalent in terms of integration time.

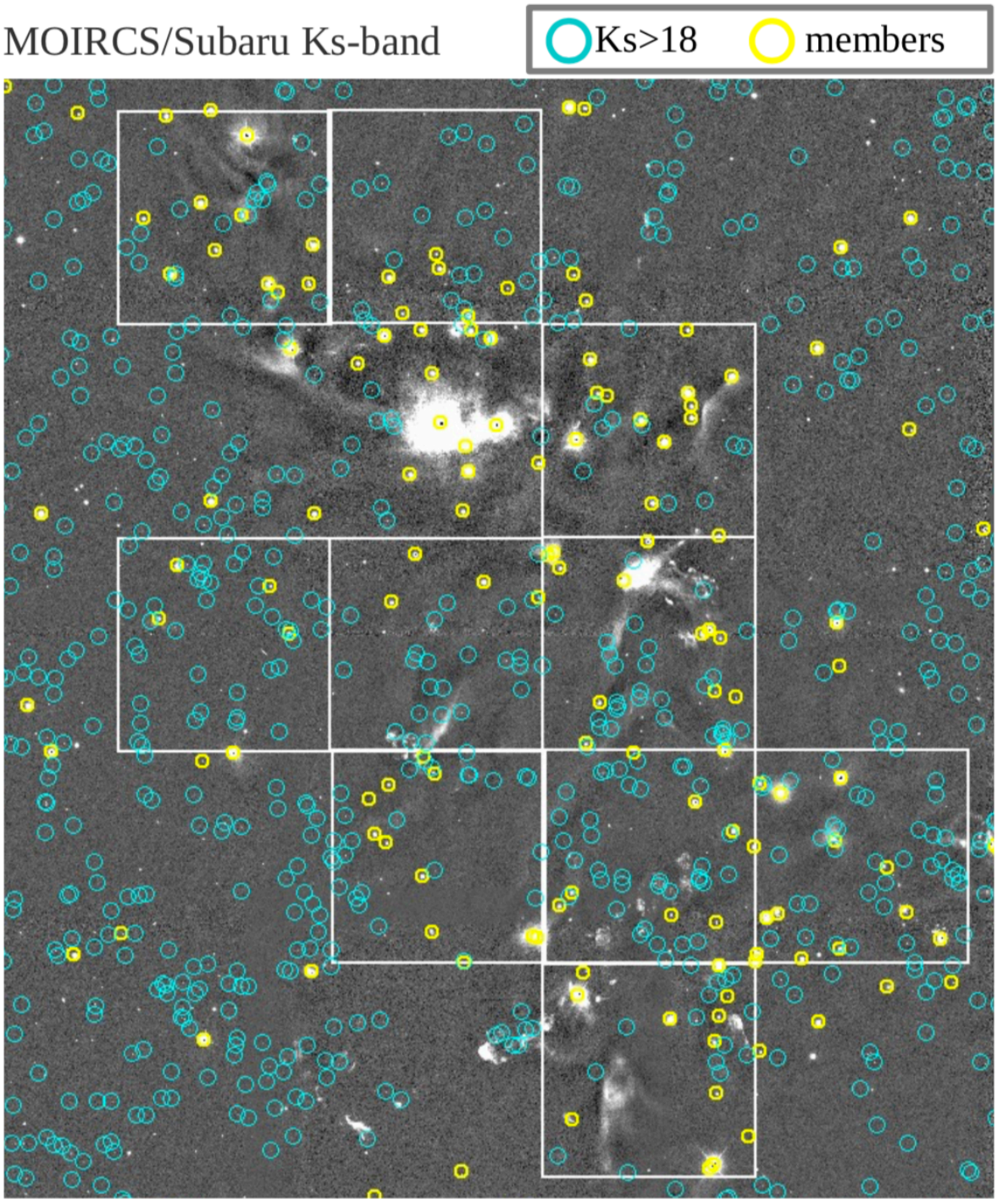
4. Choose Dither=2 with MEDIUM pattern. This means (coupled with using both grisms) that the final SNR of our spectra once the 2 dithers and 2 orientations are combined should reach roughly SNR=20 rather than SNR=10 as calculated in the ETC. Because SNR goes as sqrt(integration).

5. For the Direct images, assume Ngroup=13 and NISRAPID.

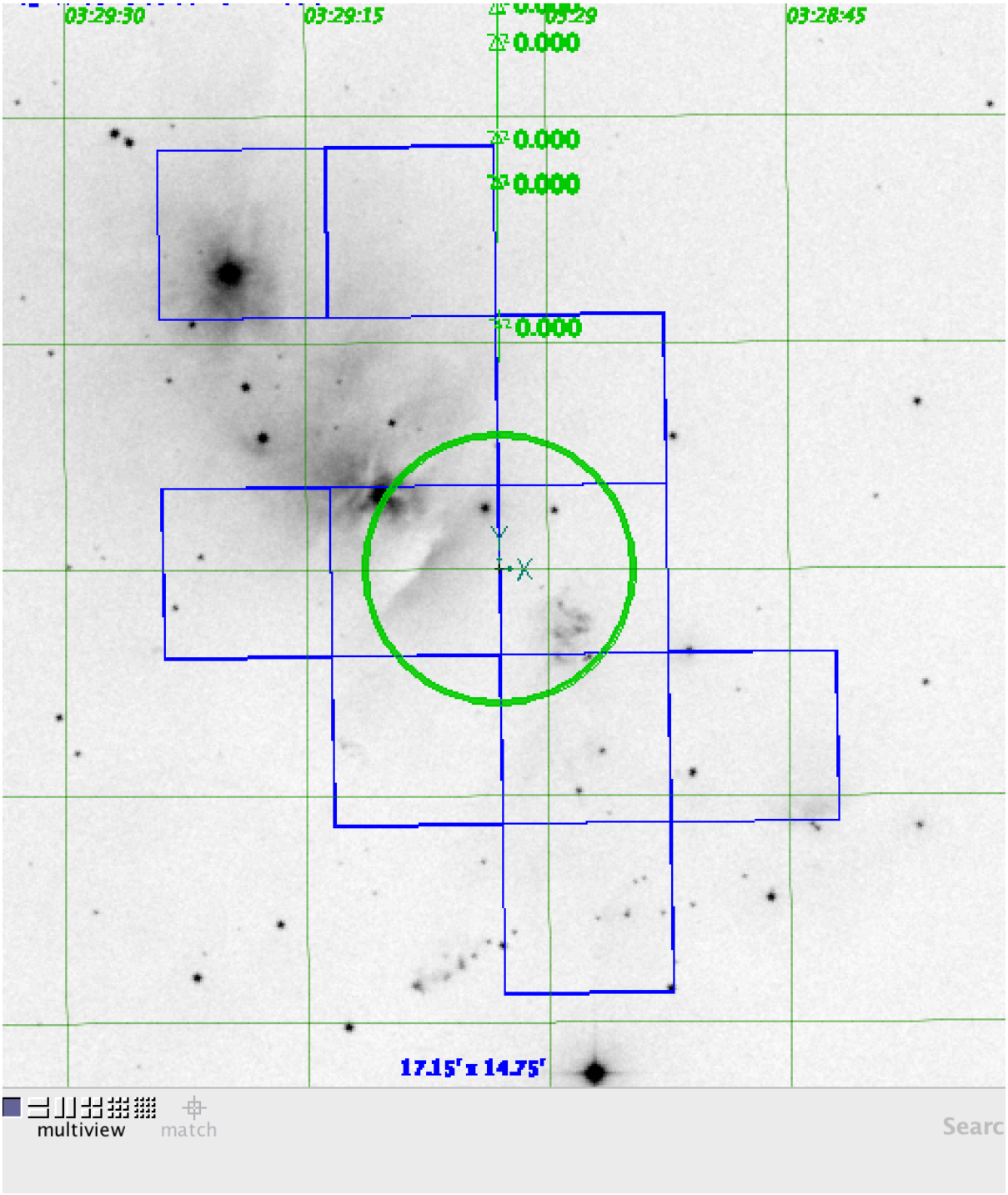
6.


NIRISS Wide Field Slitless Spectroscopy
Mosaic Properties
Special Requirements
Comments
Science Observation
Image Dithers
Pattern Size
Dither
2
MEDIUM
Sequences
Grism Filter Readout Pattern Groups/Int Integrations/Exp ETC Wkbk.Calc ID ETC
1 BOTH F150W NIS 15 1 31875
Add
Duplicate
Insert Above
Remove
Direct Image Exposure Parameters
Direct Images
Readout Pattern Groups/Int Integrations/Exp ETC Wkbk.Calc ID ETC
1 NISRAPID 13 1
Use NIRISS Imaging mode in the JWST ETC to calculate exposure parameters for Direct Imaging.
All Exposures Display
Exposures
Exposure ... Filter Grism Readout Pa... Groups/Int Integration... Total Dithers Total Integ... Total Expo... ETC Wkbk....
1 DIRECT F150W NISRAPID 13 1 1 1 150.315
1 GRISM F150W GR150R NIS 15 1 2 2 1309.886 31875
1 DIRECT F150W NISRAPID 13 1 2 2 300.63
1 GRISM F150W GR150C NIS 15 1 2 2 1309.886 31875
1 DIRECT F150W NISRAPID 13 1 1 1 150.315
Edit NGC 1333
New
Edit Visit 1:1

7. Now, let's create a mosaic over the NGC 1333 field. You want a mosaic that cover approximately the following 10 pointings.



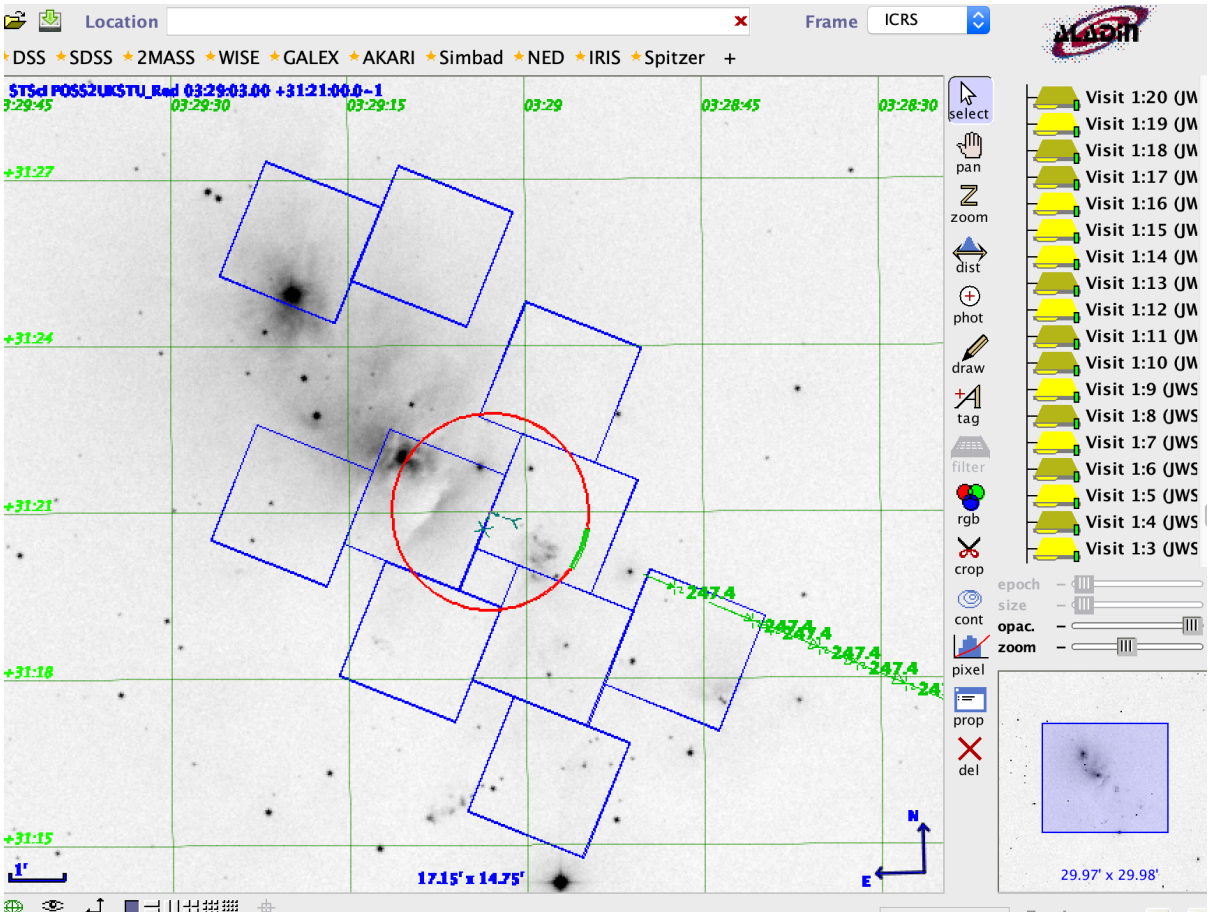
8. That is a 4x5 pattern, from which several tiles are removed. Go in the mosaic property pane and enter a 4x5 mosaic. Then remove mosaic tiles to create the above pattern in Aladin. Hint: click on the individual visits in APT to display just the tile selected, or the observation folder to show all of them. Remember, deleting tiles in Aladin will not remove them from the observation in APT (delete the visit in APT to truly remove a tile).



9. That was assuming that the field Position Angle was aligned perfectly North. But can JWST access that target with PA=0? Run the visit planner and look at the reports to find which PA are possible for this target (Report → Sun roll analysis). There are two visibility seasons. Let's look at the one with 236 < PA < 260.

10. Special requirements → Position angle → PA range = 245 to 255. This PA range accommodates almost all observing dates. Then run the visit planner again. You will see that one of the two visibility seasons has disappeared. You are constraining the observation. Now look at the mosaic orientation with Aladin… Your nicely worked-

out tiling has gone wrong. It is rotated! You'll have to redo it.



11. Modify the tiling and remove some tiles to best fit the sky coverage. First, change the pattern to 4 Rows, 5 Columns. Then you can change the Row shift to 20 and Column shift to -20 to apply offsets between tiles as illustrated above. You can use Aladin to highlight in yellow the pale green visits to remove the unwanted tiles from your mosaic. But this is only the Aladin view, you really need to actually edit the mosaic in APT to remove the correct tiles. The final pattern should be as shown above.

NIRCam (extra exercise at home)

1. NIRCam WFSS. Let's reproduce the same observation with NIRCam WFSS. You'll have to create a new observation, select GRISMC only. The Ngroups, Nintegration are the ones you derived from the ETC above. We select GRISMC because the effective FOV (where spectra a full) line up horizontally which facilitate later mosaic design.

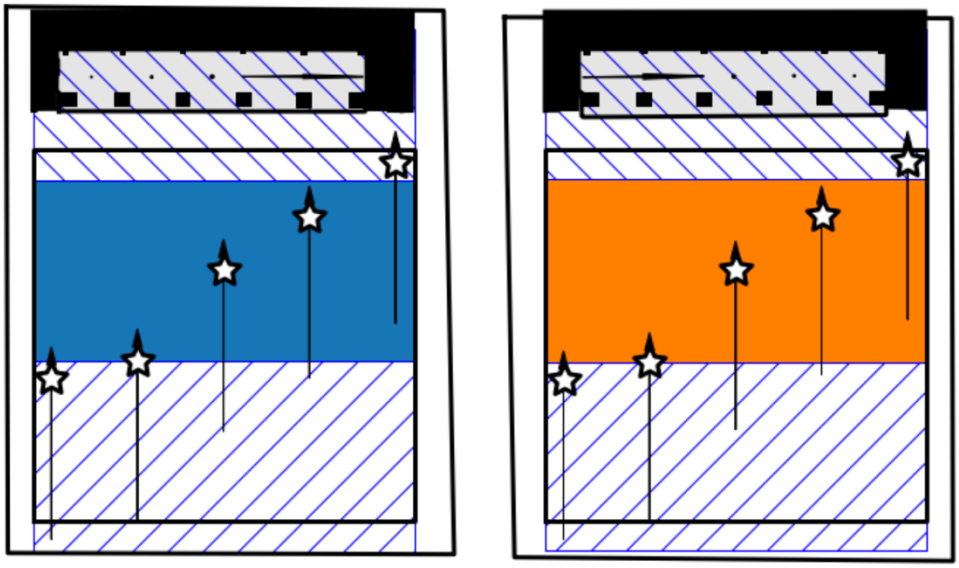
2. Check the Direct images to obtain undispersed images as well. Use Ngroup=2 and Rapid.

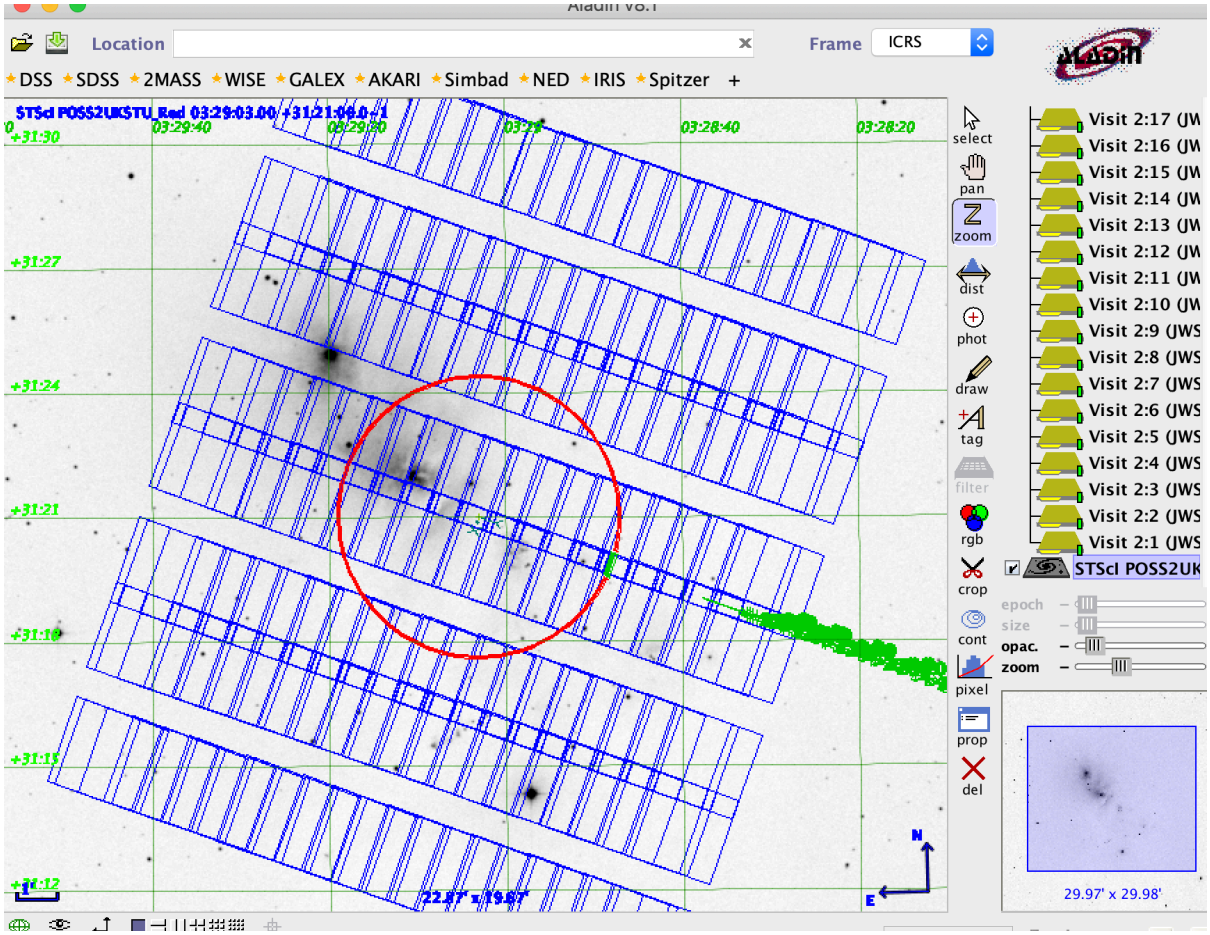
3. The shortwave (blue) channel filter, Ngroups, Integration are irrelevant for this exercise. Ngroups=2, RAPID, Nint=1, F150W will do.

4. Set the PA constraints at 245 < PA < 255 as you did before for NIRISS.

5. In the mosaic pane, then create a 4x5 mosaic. Look in Aladin. There are a large number of rectangles. Make sure you used Dither=None for simplicity of this demo. If you select a single visit, then it becomes clearer what happens. Each visit has 3 pointings corresponding to the target plus 2 additional direct image offsets.

6. We want to interleave tiles to cover ½ the FOV where NIRCam does not have full spectra (see F356W sketch below). This means that we need to have 50% overlap in the Row direction, and increase by 2 the number of Row tiles to 10. That yields the mosaic pattern in the Aladin figure below.




Location
Frame
ICRS
DSS
SDSS
2MASS
WISE
GALEX
AKARI
Simbad
NED
IRIS
Spitzer
select
pan
zoom
dist
phot
draw
tag
filter
rgb
crop
cont
pixel
prop
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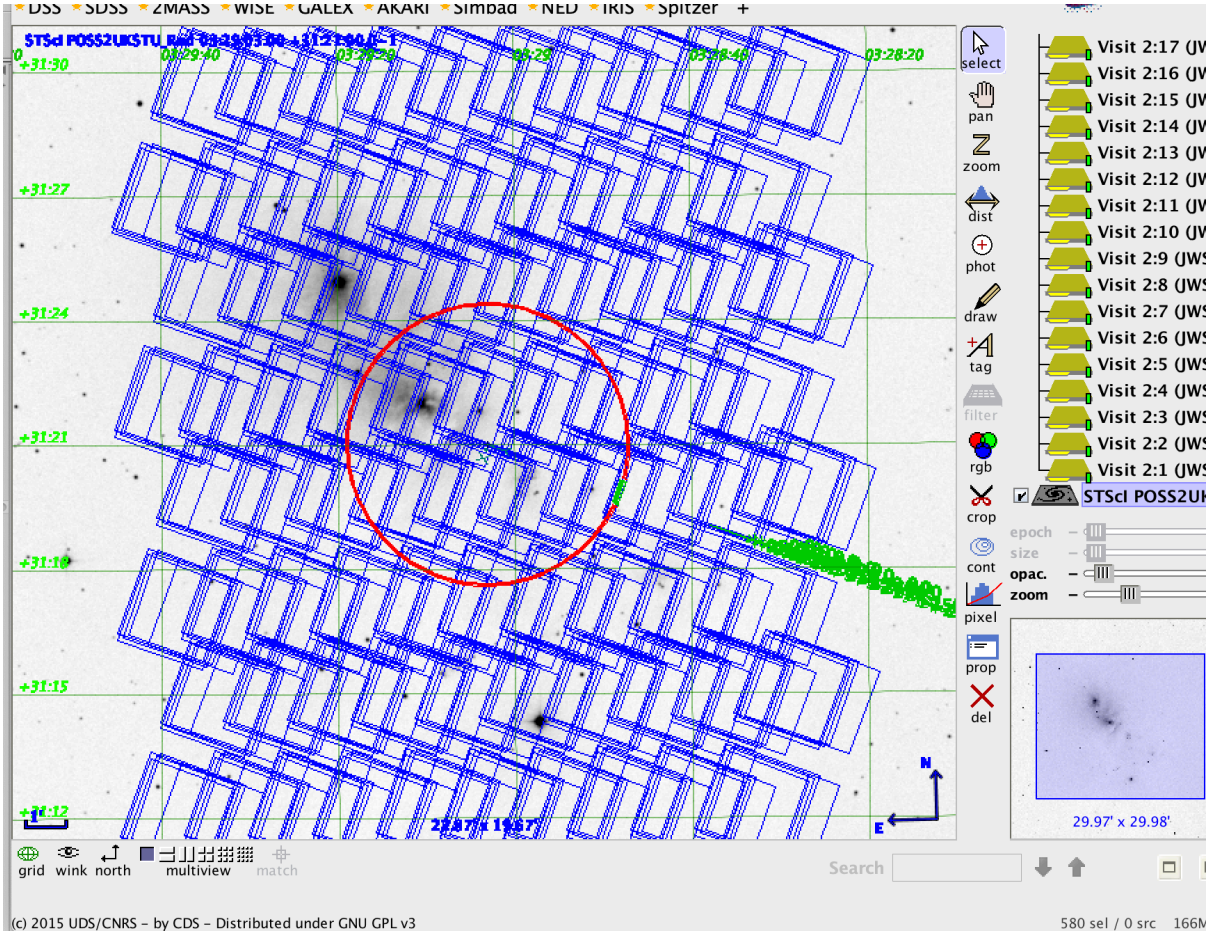
Visit 2:17 (JW
Visit 2:16 (JW
Visit 2:15 (JW
Visit 2:14 (JW
Visit 2:13 (JW
Visit 2:12 (JW
Visit 2:11 (JW
Visit 2:10 (JW
Visit 2:9 (JWS
Visit 2:8 (JWS
Visit 2:7 (JWS
Visit 2:6 (JWS
Visit 2:5 (JWS
Visit 2:4 (JWS
Visit 2:3 (JWS
Visit 2:2 (JWS
Visit 2:1 (JWS
STScI POSS2UK
epoch
size
opac.
zoom
29.97' x 29.98'
N
E

7. Change the Row shift to +20 and Column shift to -20. You will then get a more familiar shape (similar to NIRISS).



8. We will leave as an exercise for home, removing the unwanted tiles ☺. In fact, we should reduce the number of columns from 4 to 3 to cover a similar FOV as NIRISS, because NIRCam is 2 modules wide. **The take away point is the need for 50% overlap when using the F356W blocking filter on NIRCam**.