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JWST TECHNICAL REPORT

Title: An analysis of the sky areas mapped by NIRCam LW grisms.		Doc #: JWST-STScI-005995, SM-12 Date: 26 September 2017 Rev: -
Authors: M. Robberto	Phone: 410 338-4382	Release Date: 9 November 2017

1. Abstract

With 4 grisms that can be paired with 12 medium/wide passband filters, NIRCam has unique versatility for slitless spectroscopy between 2.4 and 5.0 micron. Crafting a well designed Wide-Field-Slitless Spectroscopy (WFSS) observation, however, requires taking into account the complex geometry of the fields observed by the grisms. Depending on the position of the sources , the spectra can be full or partial over any selected bandpass; the spectra can be produced by sources both within and outside the direct-imaging field-of-view; optimal dithering/mosaic patterns can be completely different depending on the selected filter. In this report I illustrate how different detector areas map different sky areas depending on each Grism+Filter combination, distinguishing between regions that produce partial or full spectra, both within and outside the direct imaging field-of-view. I explore the key parameters that need to be considered to optimally perform pre-imaging, dithering and mosaicking, with a few illustrative examples, and finally list some possible upgrade to the APT that could facilitate crafting an optimally designed NIRCam-WFSS observation,

2. Introduction

NIRCam is equipped with 4 grisms that allow slitless spectroscopy over the full field of view of the instrument. The grisms are installed on the Long Wavelength channels of the two NIRCam modules, a pair of grisms for each module. The grisms can disperse either along the detector columns (GRISM-C) or along the rows (GRISM-R) with nearly identical dispersion, ~10A/pixel, corresponding to a resolving power R~1500 across the LW channel wavelength range, ~2.4-5.0micron. The grisms are installed on the pupil wheels and can be paired with any filter hosted on the filter wheel, in particular with 8 Medium-Band filters (F250M, F300M, F335M, F360M, F410M, F430M and F460M), 3 Wide-Band filters (F277W, F356W and F444W) and an Extra-Wide-Band filter (F322W2). The grisms installed on module B have only one side A/R coated, and for this reason their throughput is lower by about 20%.

Astronomers planning slitless spectroscopy observations with NIRCam need to consider a number of factors:

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1. Wide-Band filters capture a wider spectral range; Medium-Band filters capture shorter spectra. The advantage of having a wide spectral range comes at the price of higher background and source crowding/confusion.
2. The position on the detector of the spectra of a given source "walks" with the selected bandpass. The characteristics of the field project by the grisms onto the detectors are strongly filter dependent.
3. The GRISM-R spectral images and field coverage are, on the V2-V3 ("sky") plane, the mirror images of each other.
4. The instrument has no field stop, and therefore the spectra of sources in the fields adjacent the detector can "leak-in" adding spurious contaminating signal.

In principle, a NIRCam program using both GRISM-C and GRISM-R with a suitable choice of dither and mosaic moves can map a relatively extended region. In practice, the issues 2, 3 and 4 listed above require optimizing the moves for each filter, which may degrade efficiency. To facilitate planning, in this report I illustrate the main characteristics of the field coverage for each grism+filter combination.

3. Focal plane geometry

I use pixel coordinates in the V2-V3 plane with "V2-to-V3" clockwise orientation, i.e. as projected on the plane of the sky. The scale is the one of the NIRCam LW channels, 63 mas/pixel, and the field of view for each module is assumed to be square with 2040x2040 pixel; field distortion (expected to be at the level of 2%) is ignored. The separation of the two modules is assumed to be 43 arcsec; the tilt between the two modules, about 1deg, is also ignored.

NIRCam is not equipped with a field-stop to limit the celestial field reimaged on the focal plane to the exact footprint of the detector. Adjacent sky areas reach the instrument focal plane, and if a wedge is inserted into the beam they can fall on the detector. This property is actually exploited to perform coronagraphy, through a pupil wedge reimaging a coronagraphic mask out of the direct-imaging field of view. The grisms are also wedge-shaped and therefore can refract adjacent sky areas on the detector. The limiting factor in this case is a combination of a) the size of the pick-off mirrors and b) the mount of the coronagraphic masks. It turns out that the total area that can be reimaged on the detector is about 1.5 times the area of the field directly projected on the detector, i.e. 6.88 vs. 4.59arcmin^2 (Figure 1).

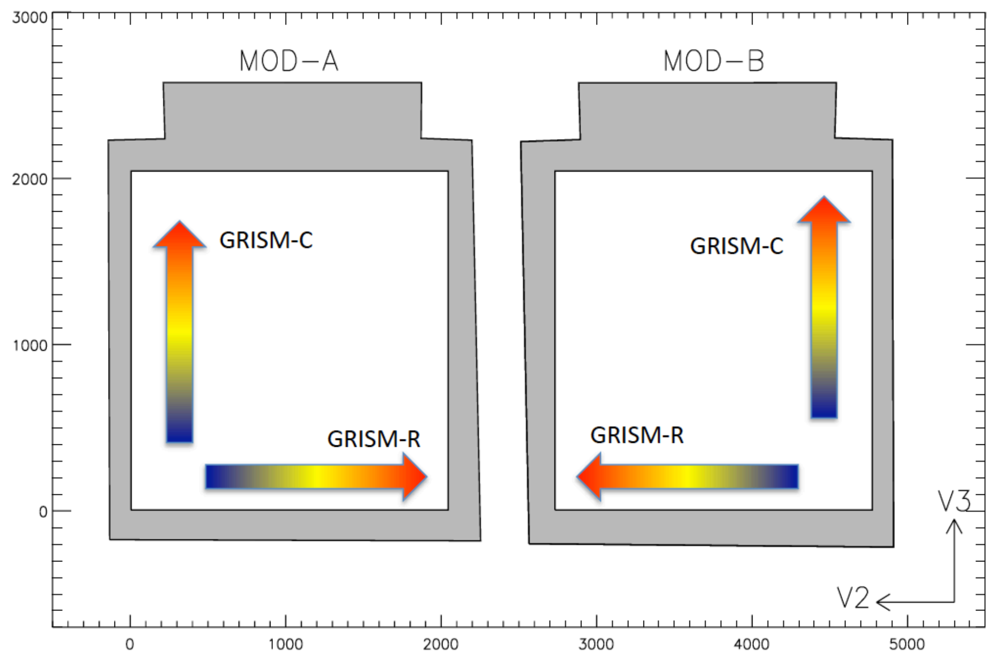

Figure 1: geometry of the NIRCam focal plane. The white areas represent the nominal field in direct imaging mode, the gray area the adjacent field limited by the pick-off mirror (on the left, bottom and right sides) and by the support of the coronagraphic mask (top side). In this figure, and in all those that follow, the coordinates are in pixels, with the Module A detector placed at (0,0); the first active pixel is (4,4).

The parameters used for the calculations are derived from the analysis of CV2 and CV3 test data, reported in the Excel file NIRCam_gris_field_of_view_FOV_DK_revised_2016Jun28.xlxs.

4. Results

4.1 Fields and color codes

Let's start reminding a few key points, using Figure 1 as a reference:

1. The dispersion direction for the GRISM-C is "blue at the bottom, red at the top"; long wavelength are pushed up. This means that they are preferably observed if the source falls on the lower part of the field of view.
2. The dispersion direction for the GRISM-R is "blue to left" on Module-A and "blue to the right" on Module-B: short wavelengths are pushed outside, red wavelengths inside. This means that long wavelengths are preferably observed if the sources fall at the outer edges of the field (left or right); vice-versa, the central part of the combined field is optimal for shorter wavelengths.

To illustrate the results of the calculations I will refer to the F250M filter. The combination of the four grisms with this filter allow us to distinguish 5 different field regions, each coded with a different color in the figures below.

1. Gray: celestial sources lying in the gray areas are **invisible with the grisms**, as their spectra fall entirely outside the detector field of view (Figure 2).
2. White: celestial sources lying in the white areas produce spectra, or sections of spectra, falling within the detector field of view. The white areas can cross

the detector borders, i.e. they can be partially **inside** and partially **outside** the direct-imaging field of view (Figure 2).

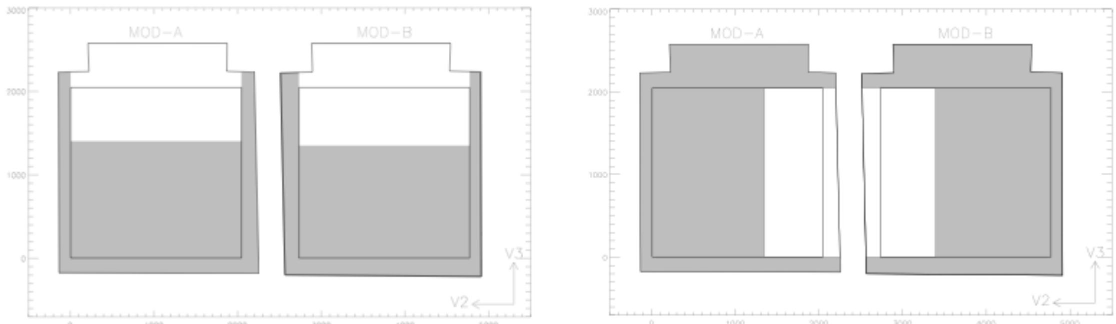

Figure 2: Extent of the focal plane regions invisible in grism mode (gray) and visible (white) for the F250M filter, for the GRISM-C (left) and GRISM-R (right).

3. Orange: celestial sources lying in the orange areas have their **full** GRISM-C spectrum (limited by the bandpass of the selected filter) falling in the detector field of view. Also in this case we can distinguish between **full-inside** and **full-outside** regions, as shown in Figure 3.

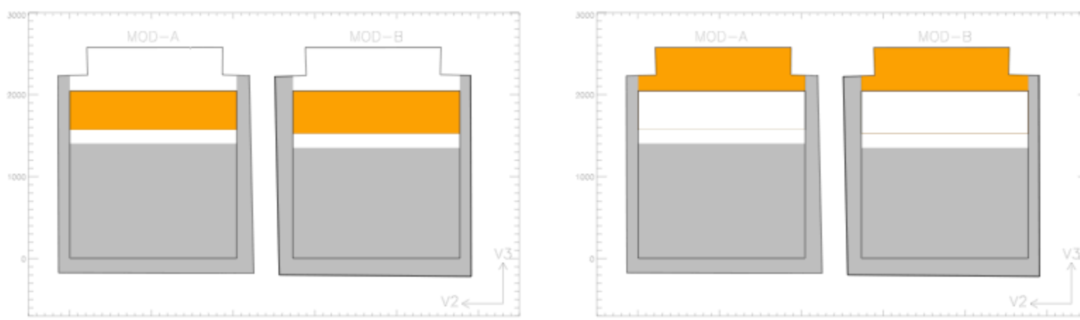

Figure 3: Extent of the areas delivering the entire GRISM-C + F250M spectra on the detector focal plane. Part of the area is inside the direct imaging field (left), part is outside (right, under the Coronographic mask in this case). The spectra are dispersed in the vertical V3) directions.

4. Yellow: same as the orange fields, for GRISM-R: celestial sources lying in the yellow areas have their **full** spectrum (limited by the bandpass of the selected filter) falling in the detector field of view.

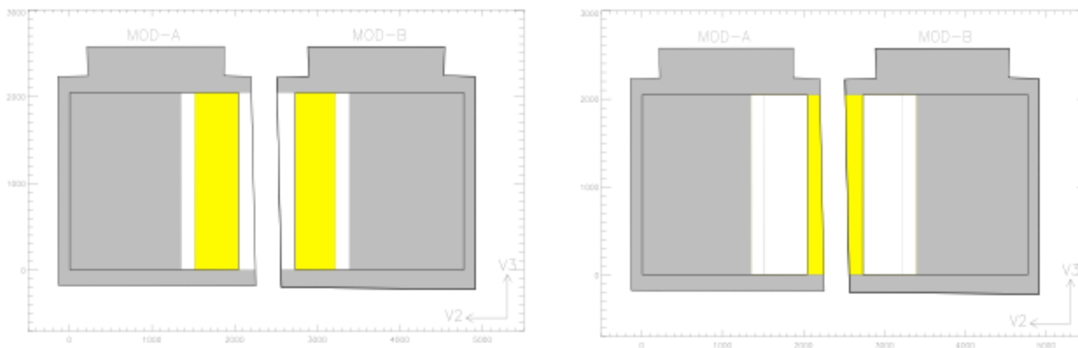

Figure 4: same as figure 3, for the GRISM-R + F250M combination.

5. Blue: finally, there is a fraction of the field inside the direct-imaging field of view and produces full spectra with both grisms. This is the ideal region where one should expect to achieve the best data quality, since the two orthogonal spectra can be combined to remove source contamination. Figure 5 shows the location of this optimal area, combined with the others to illustrate the final combination of our color codes. We will discuss the results in the next Sections.

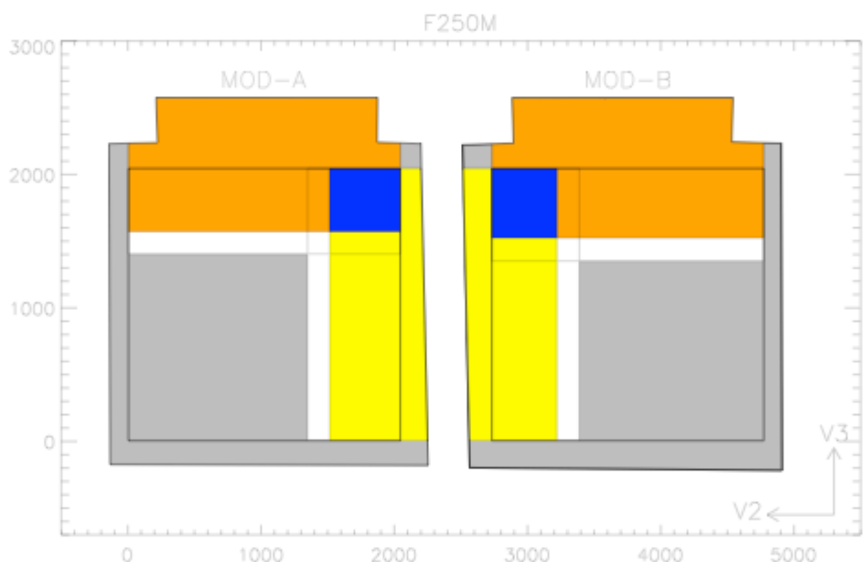

Figure 5: location of the optimal area for the GRISM-R + F250M combination.

4.2 Summary of results

In Figure 6 we show the final results obtained for the 12 filters.

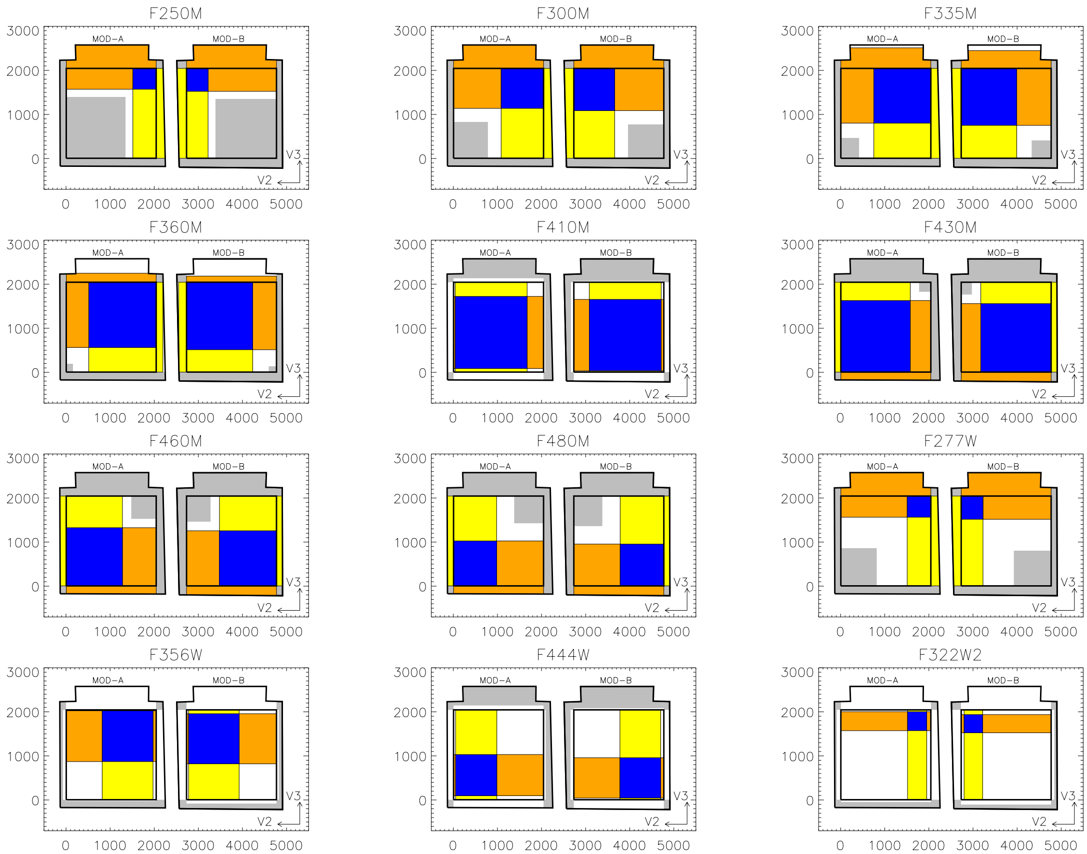

Figure 6: overview of the NIRCam field coverage with the various combinations of grisms and filters (see text for color codes).

A glimpse to Figure 6 immediately reveals a few key facts:

- There is a large amount of variation between filters; "good fields" in blue color have very different size..
- The fields drift as expected: as the wavelength increases, the optimal blue area moves from the top-inner corners (best for short wavelengths) to the bottom-outer corners (best for long wavelengths). The gray area of "invisible sources", not always present, is pushed away at the opposite corners.
- In all cases there are areas falling out of the field that project spectra inside the field. Especially at shorter wavelengths (i.e. F250M, F300M, F335M and F227W) the contamination is especially strong by sources falling in the top area covered by the coronagraphic mask. In these cases, the GRISM-R data can be significantly cleaner than the
GRISM-C data.

In the next section I present each field separately, with a table showing the amount of area covered by the various cases.

5. Detailed Results for each GRISM + Filter combination

5.1 NIRCam Grisms + F250M Filter

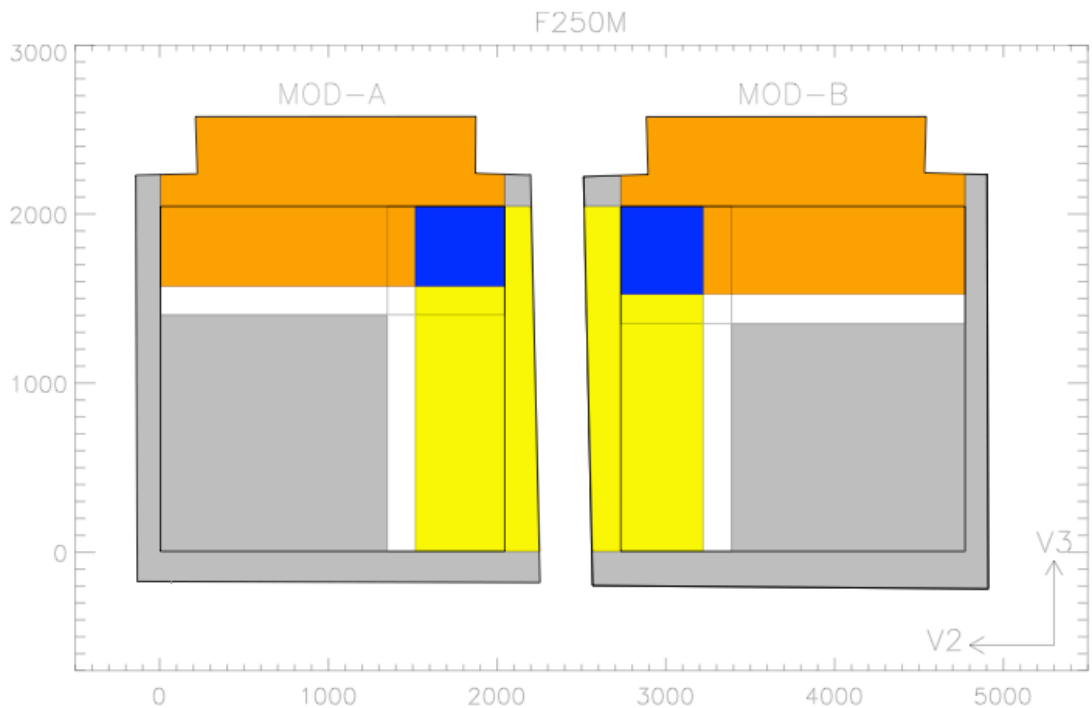

Figure 7: map of the field coverage for the four NIRCam grisms with the F250M filter

Table 1: Fractional Field Area covered by the NIRCam grisms with the F250M filter

F250M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.314	0.229	0.232	0.229	0.341	0.088	0.260	0.088	0.060
Width (pix)	640	467	473	467	695	180	529	180	473x529
MOD-B	0.340	0.228	0.255	0.228	0.322	0.095	0.239	0.095	0.061
Width (pix)	693	465	520	465	656	193	488	193	520x488

Values are normalized to the nominal area covered by the LW detectors in imaging mode, i.e. 4.59arcmin^2. The fields refer to the areas illustrated in Section 4.1:

- *Inside*: white area described at point 2, i.e. the fraction of the detector FoV containing sources that produce full or partial spectra;
- *Outside*: white area described at point 3, i.e. the external area containing sources that produce full or partial spectra.
- *Inside full*: orange/yellow areas described at point 4, i.e. fraction of the field detector **inside** the square detector footprint FoV containing sources that produce **full spectra**. These are the area shown in the left plots of Figures 3 and 4.
- *Outside full*: orange/yellow areas also described at point 4, but relative to the **outside** field. These are the area shown in the right plots of Figures 3 and 4.
- *Both:* fraction of the detector FoV containing sources that produce **only full spectra with both grism**; with reference to the figure, it corresponds to the blue area.

The Width values represent the size of the area along its shorter site, the longer side being generally equal to 2040 pixels, with the exception of the blue areas. They are relevant for planning purposes, e.g. to estimate the throw of the mosaic patterns (See Section 5).

5.2 NIRCam Grisms + F300M Filter

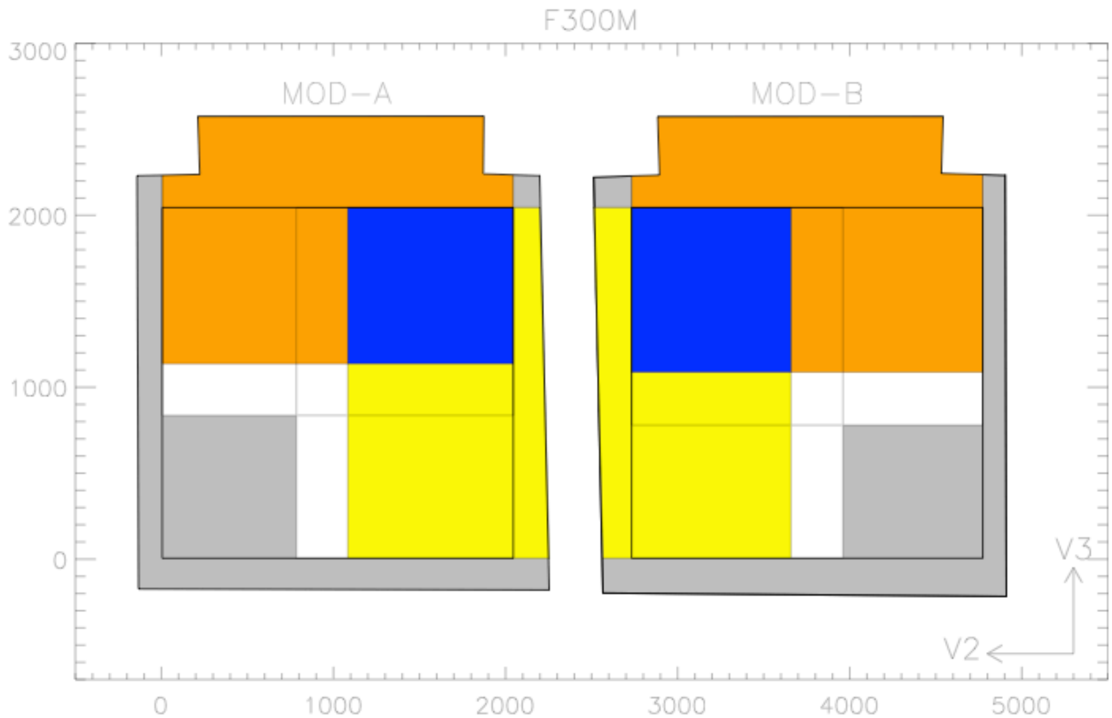

Figure 8: map of the field coverage for the four NIRCam grisms with the F300M filter

Table 2: Fractional Field Area covered by the NIRCam grisms with the F300M filter

F300M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.593	0.229	0.445	0.229	0.618	0.088	0.471	0.088	0.210
Width (pix)	1209	467	908	467	1260	180	961	180	908x961
MOD-B	0.620	0.228	0.469	0.228	0.602	0.095	0.454	0.095	0.213
Width (pix)	1265	465	957	465	1228	193	925	193	957x925

Note: see Section 5.1 for an explanation of the field contents.

5.3 NIRCam Grisms + F335M Filter

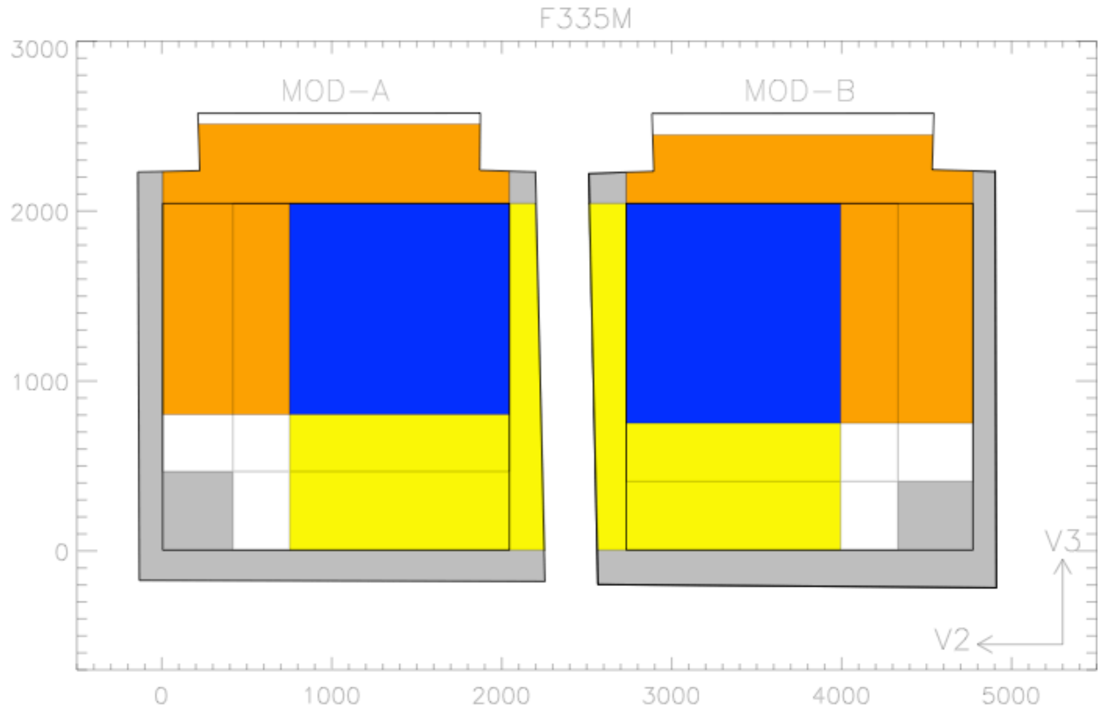

Figure 9: map of the field coverage for the four NIRCam grisms with the F335M filter

Table 3: Fractional Field Area covered by the NIRCam grisms with the F335M filter

F335M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.775	0.229	0.609	0.204	0.797	0.088	0.634	0.088	0.385
Width (pix)	1577	467	1241	415	1626	180	1292	180	1241x1292
MOD-B	0.802	0.228	0.634	0.178	0.784	0.095	0.618	0.095	0.392
Width (pix)	1636	465	1293	363	1598	193	1260	193	1293x1260

Note: see Section 5.1 for an explanation of the field contents.

5.4 NIRCam Grisms + F360M Filter

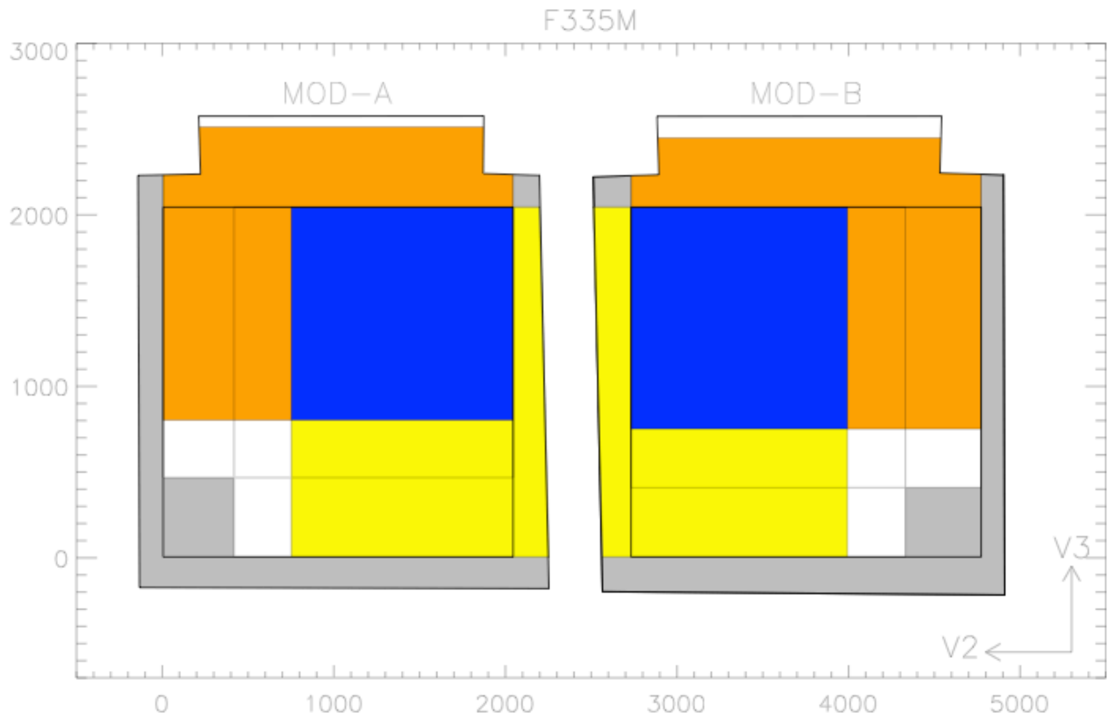

Figure 10: map of the field coverage for the four NIRCam grisms with the F360M filter

Table 4: Fractional Field Area covered by the NIRCam grisms with the F360M filter

F360M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.902	0.229	0.725	0.099	0.926	0.088	0.750	0.074	0.544
Width (pix)	1840	467	1479	201	1888	180	1529	151	1479x1529
MOD-B	0.932	0.219	0.751	0.068	0.914	0.095	0.736	0.085	0.553
Width (pix)	1900	446	1532	139	1863	193	1500	174	1532x1500

Note: see Section 5.1 for an explanation of the field contents.

5.5 NIRCam Grisms + F410M Filter

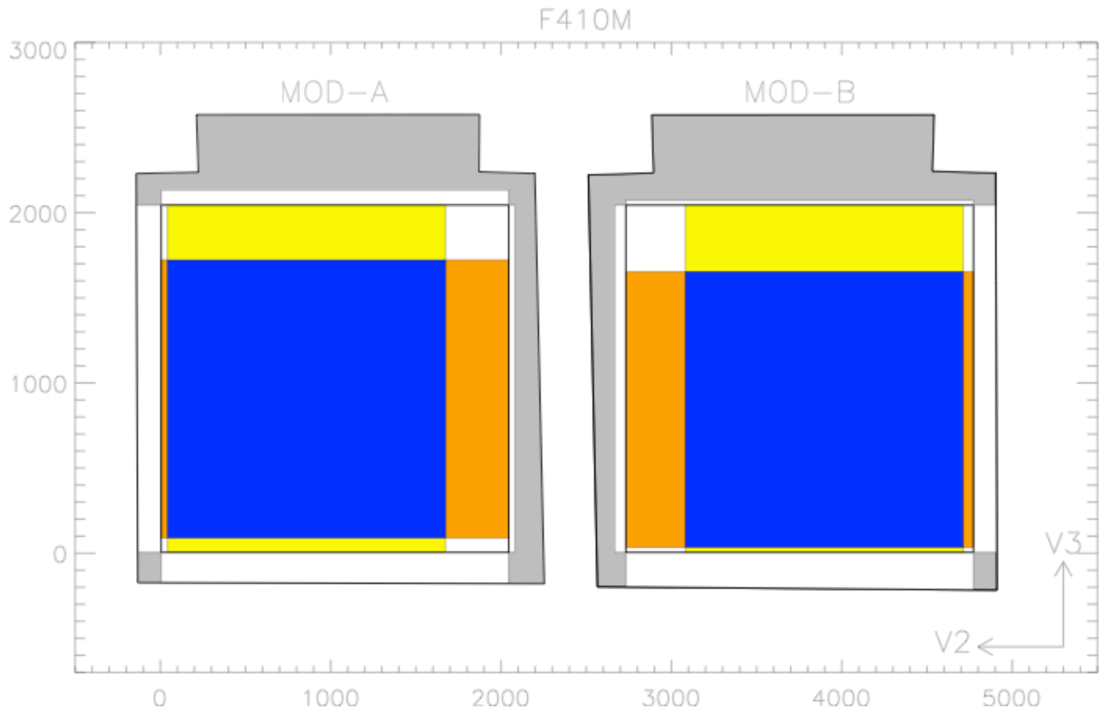

Figure 11: map of the field coverage for the four NIRCam grisms with the F410M filter

Table 5: Fractional Field Area covered by the NIRCam grisms with the F410M filter

F410M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	1.000	0.132	0.801	0.000	1.000	0.088	0.800	0.000	0.640
Width (pix)	2040	270	1633	0	2040	178	1631	0	1633x178
MOD-B	1.000	0.118	0.795	0.000	1.000	0.095	0.800	0.000	0.636
Width (pix)	2040	240	1621	0	2040	198	1631	0	1621x1631

Note: see Section 5.1 for an explanation of the field contents.

5.6 NIRCam Grisms + F430M Filter

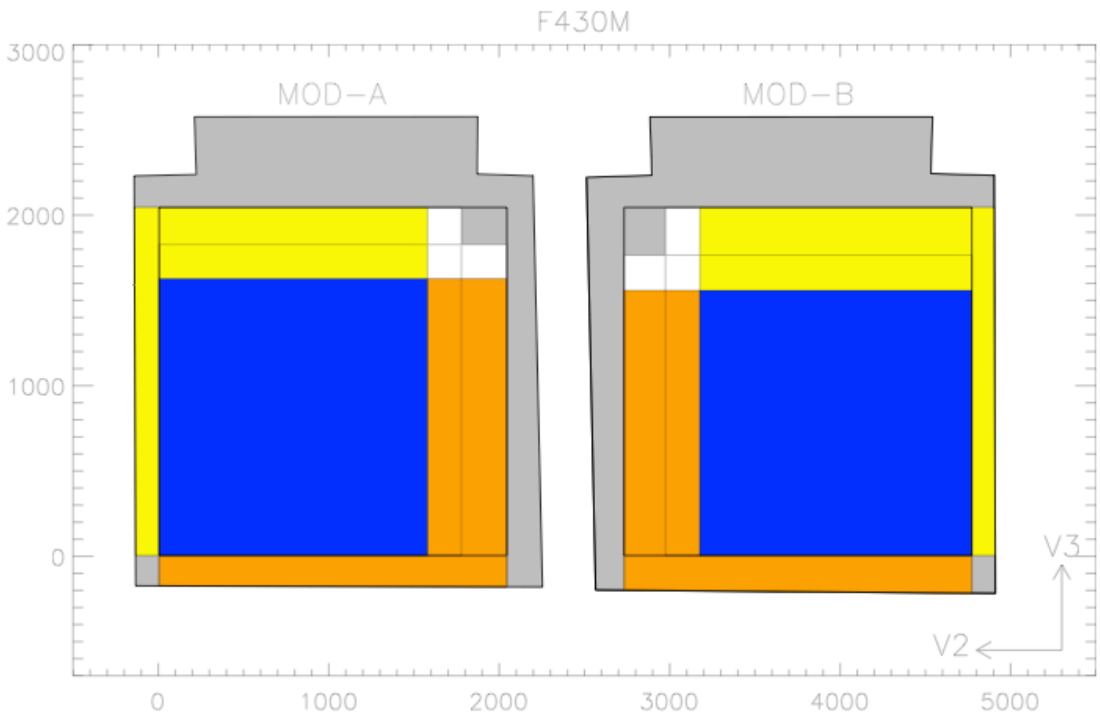

Figure 12: map of the field coverage for the four NIRCam grisms with the F430M filter

Table 6: Fractional Field Area covered by the NIRCam grisms with the F430M filter

F430M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.893	0.089	0.795	0.089	0.869	0.070	0.772	0.070	0.613
Width (pix)	1822	181	1622	181	1773	141	1573	141	1622x1573
MOD-B	0.863	0.104	0.762	0.104	0.881	0.065	0.782	0.065	0.596
Width (pix)	1760	212	1553	212	1797	133	1595	133	1553x1595

Note: see Section 5.1 for an explanation of the field contents.

5.7 NIRCam Grisms + F460M Filter

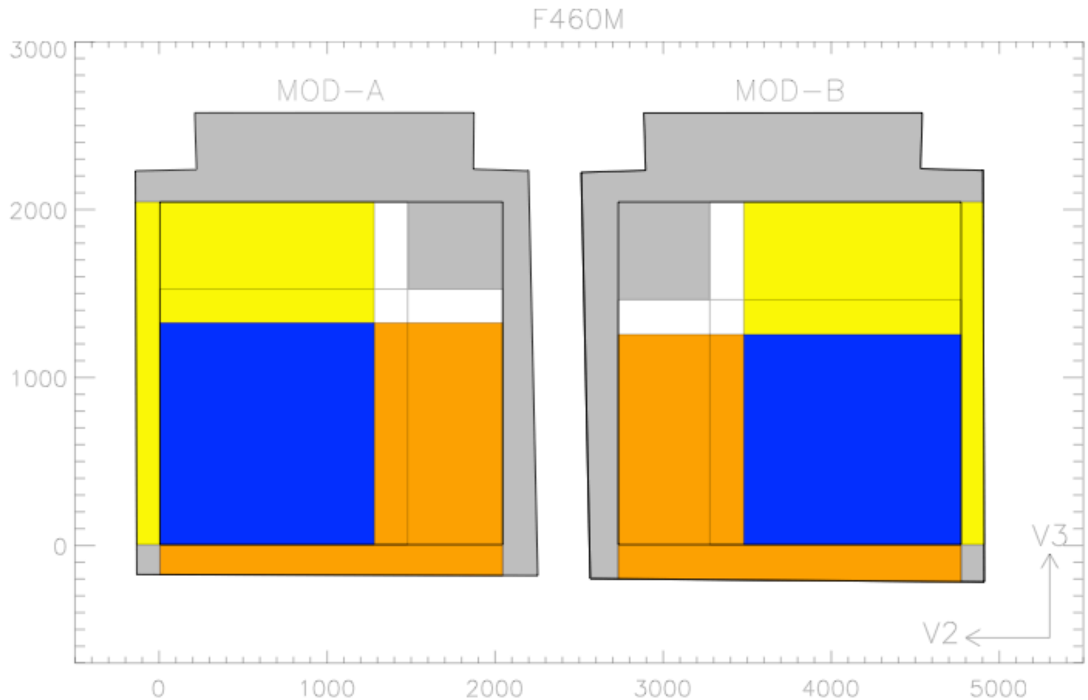

Figure 13: map of the field coverage for the four NIRCam grisms with the F460M filter

Table 7: Fractional Field Area covered by the NIRCam grisms with the F460M filter

F460M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.746	0.089	0.648	0.089	0.723	0.070	0.625	0.070	0.405
Width (pix)	1621	181	1321	181	1474	141	1274	141	1321x1274
MOD-B	0.715	0.104	0.613	0.104	0.733	0.065	0.634	0.065	0.389

Note: see Section 5.1 for an explanation of the field contents.

5.8 NIRCam Grisms + F480M Filter

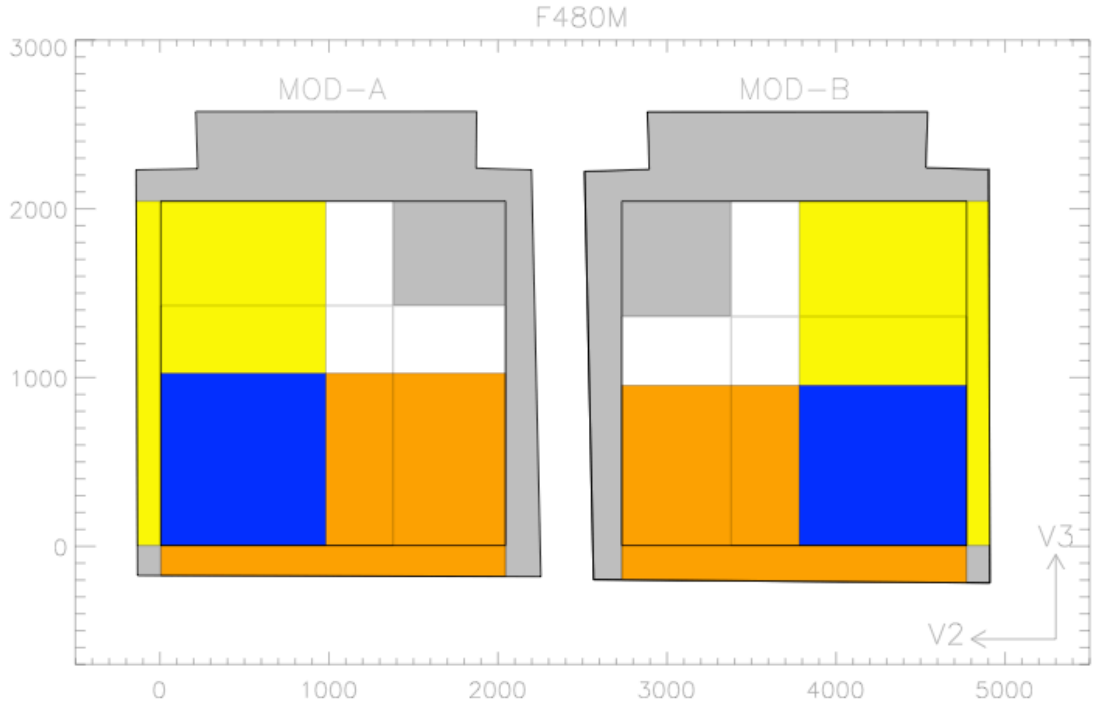

Figure 14: map of the field coverage for the four NIRCam grisms with the F480M filter

Table 8: Fractional Field Area covered by the NIRCam grisms with the F480M filter

F480M	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.697	0.089	0.500	0.089	0.674	0.070	0.478	0.070	0.239
Width (pix)	1421	181	1020	181	1374	141	976	141	1020x976
MOD-B	0.665	0.104	0.465	0.104	0.683	0.065	0.485	0.065	0.226
Width (pix)	1357	212	948	212	1393	133	990	133	948x990

Note: see Section 5.1 for an explanation of the field contents.

5.9 NIRCam Grisms + F277W Filter

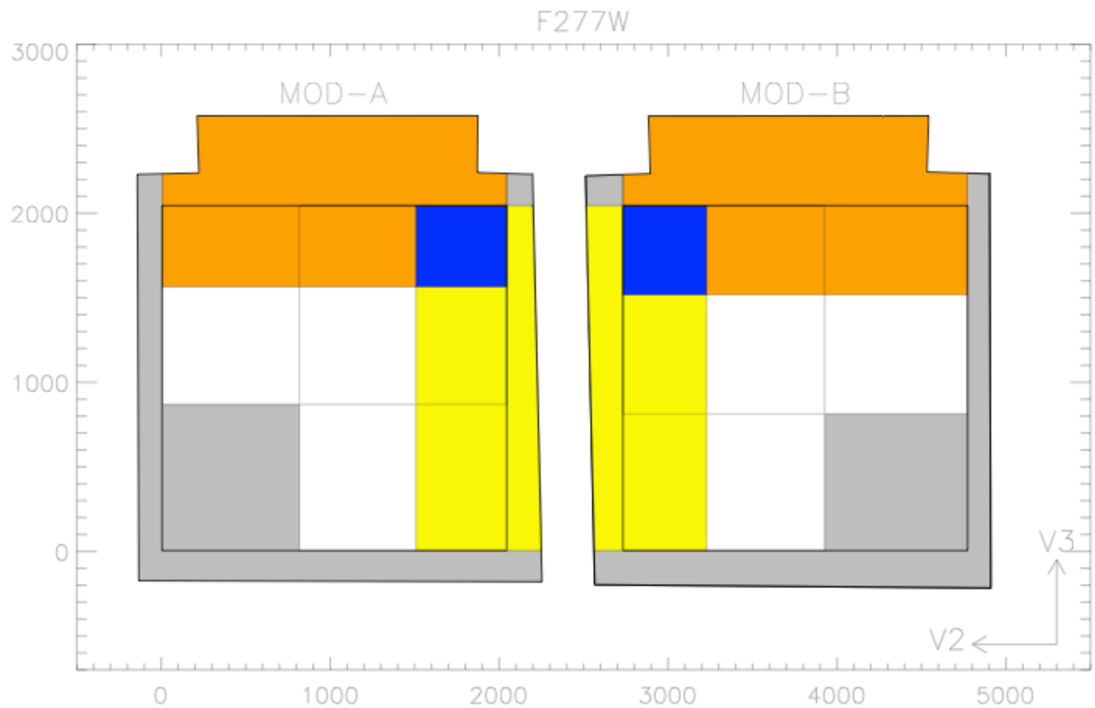

Figure 15: map of the field coverage for the four NIRCam grisms with the F277W filter

Table 9: Fractional Field Area covered by the NIRCam grisms with the F277W filter

F277W	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	0.576	0.229	0.236	0.229	0.601	0.088	0.263	0.088	0.062
Width (pix)	1175	467	480	467	1226	180	536	180	480x536
MOD-B	0.604	0.228	0.259	0.228	0.585	0.095	0.243	0.095	0.063
Width (pix)	1231	465	527	465	1194	193	495	193	527x495

Note: see Section 5.1 for an explanation of the field contents.

5.10 NIRCam Grisms + F356W Filter

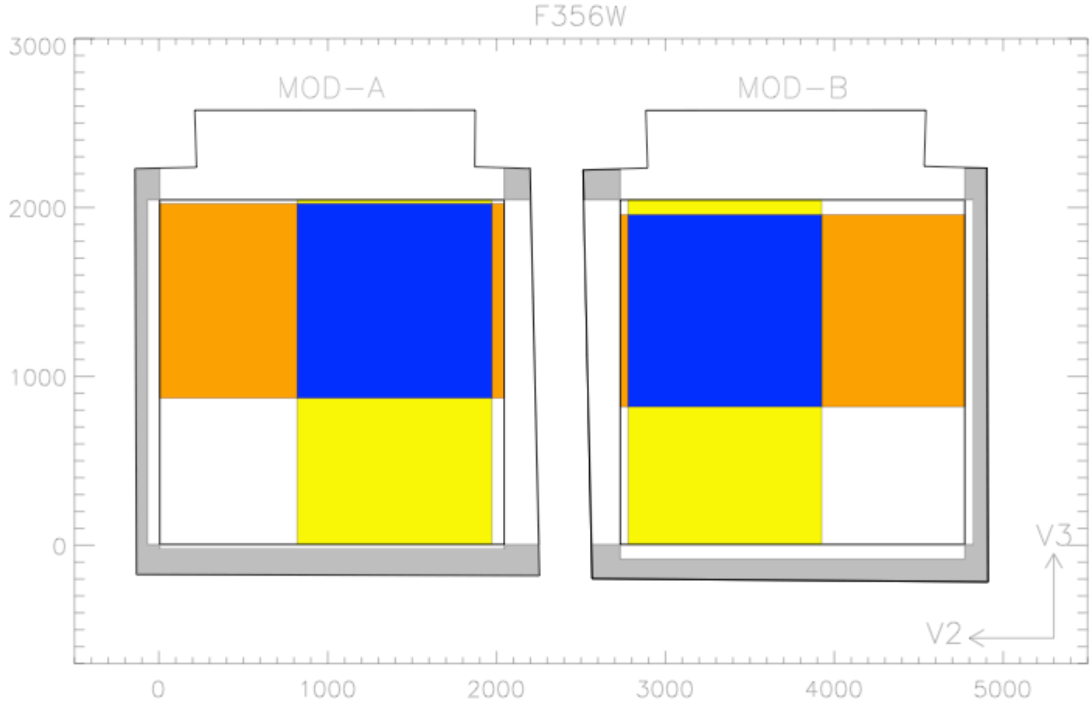

Figure 16: map of the field coverage for the four NIRCam grisms with the F356W filter

Table 10: Fractional Field Area covered by the NIRCam grisms with the F356W filter

F356W	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	1.000	0.242	0.565	0.000	1.000	0.124	0.565	0.000	0.319
Width (pix)	2040	494	1152	0	2040	252	1153	0	1152x1153
MOD-B	1.000	0.271	0.558	0.000	1.000	0.120	0.562	0.000	0.313
Width (pix)	2040	553	1137	0	2040	244	1146	0	1137x1146

Note: see Section 5.1 for an explanation of the field contents.

5.11 NIRCam Grisms + F444W Filter

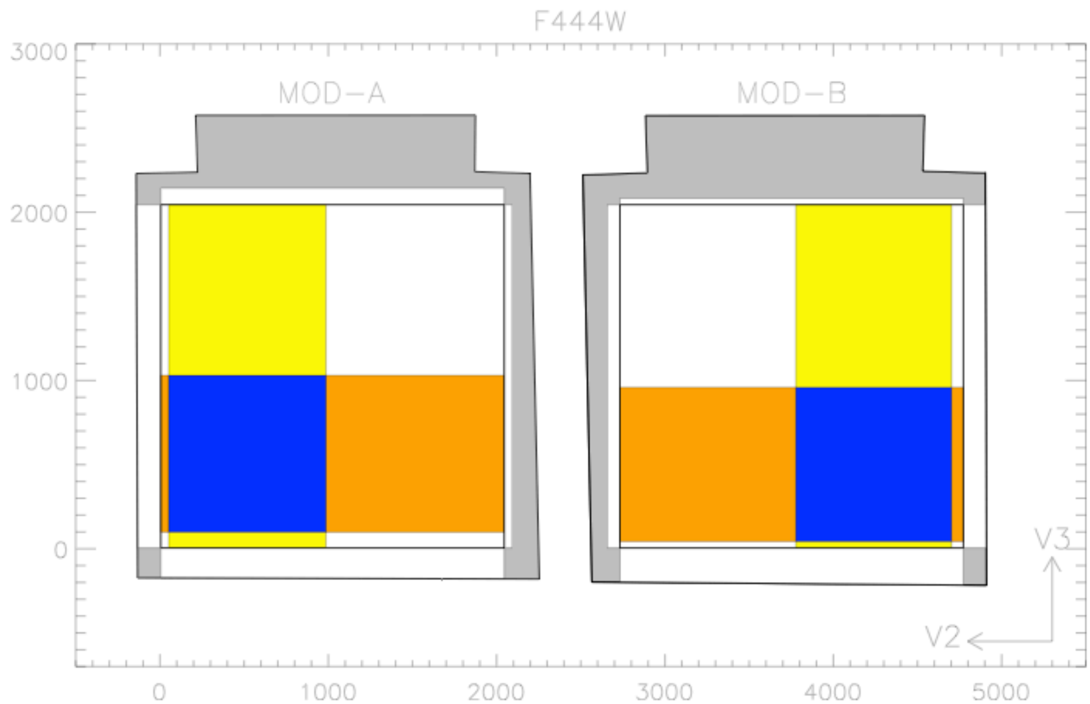

Figure 17: map of the field coverage for the four NIRCam grisms with the F444W filter

Table 11: Fractional Field Area covered by the NIRCam grisms with the F444W filter

F444W	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	1.000	0.137	0.457	0.000	1.000	0.093	0.458	0.000	0.209
Width (pix)	2040	280	931	0	2040	188	933	0	931x933
MOD-B	1.000	0.123	0.449	0.000	1.000	0.102	0.453	0.000	0.203
Width (pix)	2040	250	915	0	2040	208	924	0	915x924

Note: see Section 5.1 for an explanation of the field contents.

5.12 NIRCam Grisms + F322W2 Filter

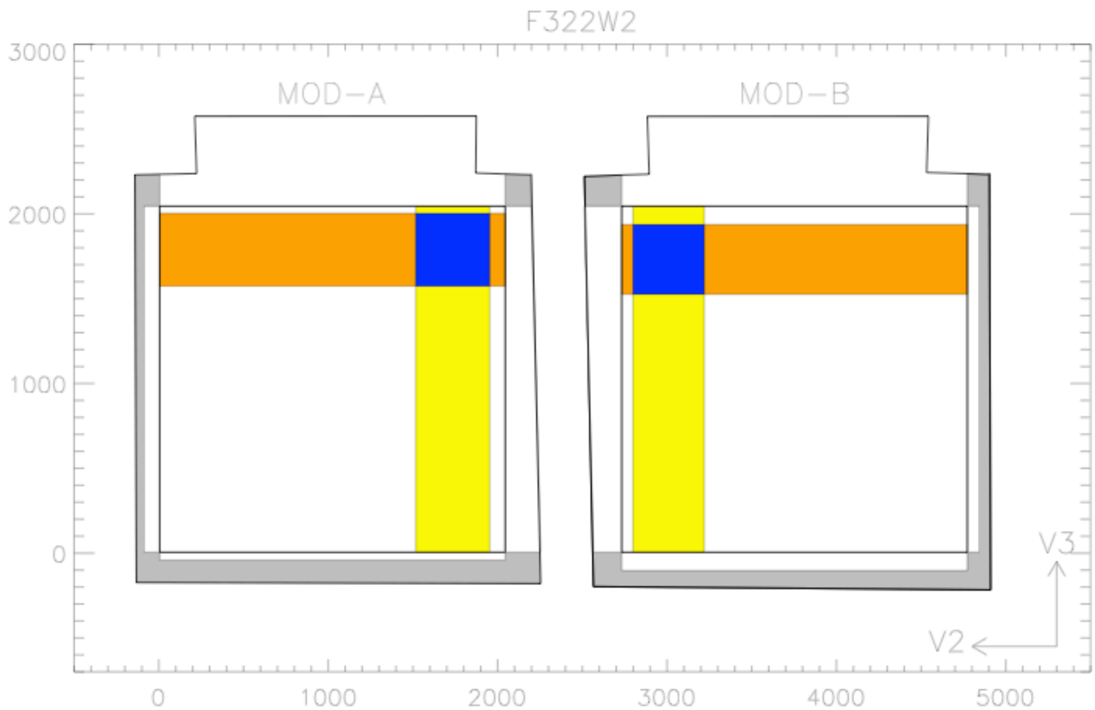

Figure 18: map of the field coverage for the four NIRCam grisms with the F322W2 filter

Table 12: Fractional Field Area covered by the NIRCam grisms with the F322W2 filter

F322W2	GRISM-C				GRISM-R				BOTH
	inside	*Outside*	*Inside full*	*Outside full*	*inside*	*Outside*	*Inside full*	*Outside full*	*Inside full*
MOD-A	1.000	0.252	0.211	0.000	1.000	0.134	0.214	0.000	0.045
Width (pix)	2040	514	430	0	2040	272	435	0	430x435
MOD-B	1.000	0.281	0.202	0.000	1.000	0.130	0.206	0.000	0.042
Width (pix)	2040	573	411	0	2040	264	420	0	411x420

Note: see Section 5.1 for an explanation of the field contents.

6. Dithering and Mosaics

The charts presented in the previous sections allow us do derive some guideline that may facilitate designing Wide Field Slitless Imaging observations with NIRCam.

6.1. Pre-imaging

Pre-imaging (or more precisely, "post-imaging" since for NIRCam these exposures are executed at the end of a WFSS visit) is needed to firmly identify the sources in the dispersed images. The size of the adjacent areas, given by the maximum widths of the *Outside* cells listed in Tables 1-12, are presented in Figure 19, in both pixel coordinates and seconds of arc. Notice that since the edges of outer fields are not parallel to the detectors, the width values are approximated (the areas, however, were accurately estimated for each polygonal shape, on the basis of the currently available data).

The WFSS template includes dedicated dithers to identify the sources outside the direct imaging FOV. For GrismR there are 2 dither points offset, +12.0" and -12.0" in the V2 direction, whereas for Grism C there are 2 points offset, +35.0" and -14.0" in the V3 direction. These dither offsets are consistent with the out of field FOV boundaries shown in Figure 19. Users are required to include these Source Identification (SID) images for at least one SW+LW filter pair, but can request them through multiple filter pairs if they wish.

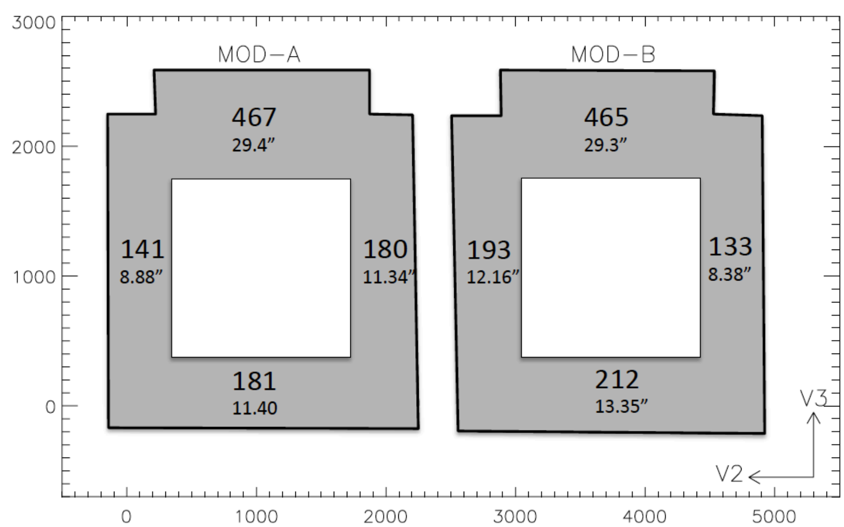

Figure 19: width of the adjacent fields that can be reimaged by the grisms into the focal plane, both in pixel coordinates and seconds of arc. The white areas are not to scale.

In the vertical direction (GRISM-C) a single offset move would be enough in most cases to cover the upper field; only with the F410M, F356W and F322W2 filters a second V3 move in the opposite direction is needed. In the horizontal (V2) direction, two moves are always needed since the fields are antiparallel.
The +35" dither in the V3 direction is large enough to require the acquisition of a new guide star, which may impact the observing efficiency. In the case of mosaics, of course, one will need to cover only the outer envelope of the field, i.e. the number of pre-imaging moves may be lower.

6.2. Dithering

Dithering is generally needed for a variety of reasons: removal of bad-pixels, cosmic-ray rejection, sampling, mitigation of spatial noise. In the case of spectroscopy, dithering along the dispersion direction allow to oversample the spectra increasing the spectral resolution; this may have substantial benefits at shorter wavelengths, where the PSF tends to be undersampled.

The WFSS template currently allows for two patterns of subpixel dithers, different from those implemented for the Imaging template. The offsets are listed in Table 13.

Table 2: Subpixel Dither Patterns for NIRCam WFSS Observations

Position	Offsets, SW Pixels		Offsets, arcsec	
#	X pix	Y pix	V2	V3
4-point Dither Pattern				
1	0.000	0.000	0.000	0.000
2	19.500	-4.000	0.618	-0.127
3	-4.000	19.500	-0.127	0.618
4	-19.500	-19.500	-0.618	-0.618
9-point Dither Pattern				
1	0.000	0.000	0.000	0.000
2	-15.667	-4.000	-0.497	-0.127
3	15.667	-8.000	0.497	-0.254
4	-4.000	-15.667	-0.127	-0.497
5	-17.667	-17.667	-0.560	-0.560
6	17.667	-11.667	0.560	-0.370
7	-8.000	15.667	-0.254	0.497
8	-11.667	17.667	-0.370	0.560
9	11.667	11.667	0.370	0.370

Offsets, LW pixels	
X pix	Ypix
4-point Dither Pattern	
0.000	0.000
9.825	-2.016
-2.016	9.825
-9.825	9.825
9-point Dither Pattern	
0.000	0.000
-7.889	-2.016
7.889	-4.032
-2.016	-7.889
-8.888	-8.888
8.888	-5.873
-4.032	7.889
-5.873	8.888
5.873	5.873

Table 13: left: copy of the current dither tables for WFSS, with offsets in units of SW pixels and arcseconds. Right: values translated for the LW pixels, assuming 0.063"/pixel.

The round values listed for the offsets in units of SW pixels indicate that the SW channel was used as a baseline. It may be possible that these values are not optimal for the LW channel, which is the prime WFSS channel, as one would probably like to resample with ~½ pixel sampling (i.e. 2.5 pixels instead of 2.0), especially at the shorter wavelengths where the PSF is mostly undersampled.

6.3. Mosaics

Mosaics will be needed not only to extend field coverage, e.g. filling the ~43" gap between the two modules, but also to make sure that all the sources falling in the direct-imaging field of view have been observed. Since the fields covered in grism-mode are generally smaller than the field covered in imaging mode, the mosaic throws will be shorter, which means that more moves and exposures will be needed to cover a certain area of interest.

Assuming one wants to observe the entire spectra across the selected bandpass, the key parameter driving the mosaic pattern is the width of the *Inside-full* areas, listed in Tables 1-12. Hereafter we provide three representative examples aimed at covering without gaps an area comparable to the field of view in direct-imaging mode

- F250M mosaic

In this case the field pattern, shown again in Figure 20, is characterized by areas of full spectral coverage lying at the top and at the center of the field. The total width of orange fields (both inside and outside) is 940 and 985 pixel for Module A and B, respectively. This means that for GRISM-C we need to move in the vertical direction by ~1000 pixels, or about 1arcmin. In the V2direction, the nominal gap between focal planes (43"=682pixels) is matched by a move of (2040+682)/2=1361 pixels, or 85.74". Figure 21 (left) shows the field covered with a 2 x 3 mosaic.
In the case of GRISM-R, the 43" central gap is actually reduced by the fact that the outside areas (180 and 193 pixels, for module A and B respectively) are now visible; the gap is therefore only 682-180-193=307 pixels, easily covered by the width of the yellow areas (sum of inside and outside), 719 and 682 pixels. Still, a single move is not enough to cover a large fraction of the imaging field; in Figure 20 (right) we achieve a good result with 4 moves.

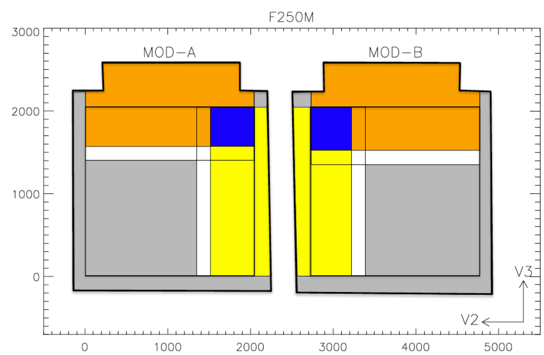

Figure 20: map of the field coverage for the four NIRCam grisms with the F250M filter (identical to Figure 7, copied here for convenience)

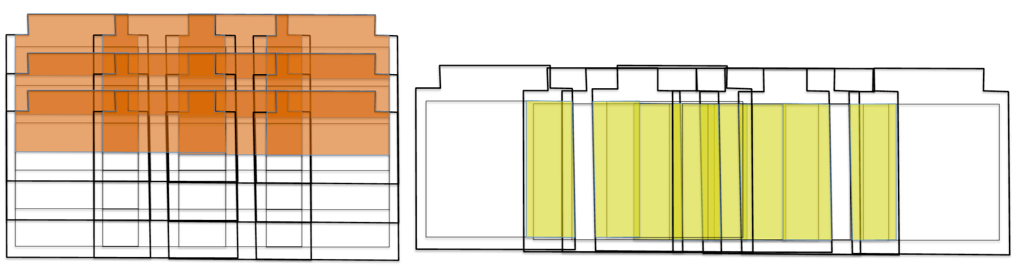

Figure 21. Left: areal coverage of a 2x3 mosaic with GRISM-C+F250M filter; Rigth: areal coverage of a 1x4 mosaic with the GRISMR+F250M filter

- F410M mosaic

The F410M filter is probably the one best matched to the characteristic of the NIRCam grisms, as shown by the extend of the blue area in Figure 22.

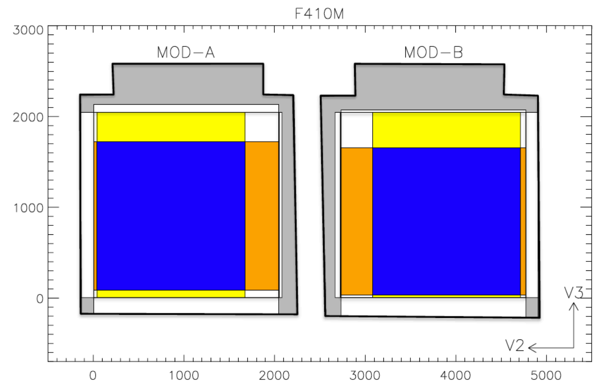

Figure 22: map of the field coverage for the four NIRCam grisms with the F410M filter (identical to Figure 11, copied here for convenience)

Considerations similar to the one made for the F250M filter lead to nice field coverage with both grisms using only a 2x1 mosaic (Figure 23).

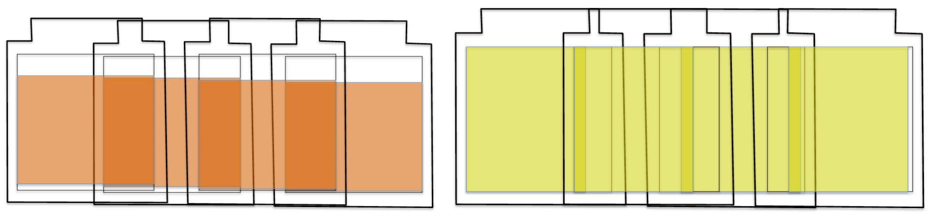

Figure 23. Left: areal coverage of a 1x2 mosaic with GRISM-C+F410M filter; Right: areal coverage of a 1x2 mosaic with the GRISMR+F410M filter.

- F444M mosaic

Finally, we consider the case of the F444M filter. In this case the field of view is at the opposite sides of the F250M filter, i.e. bottom and external. The contamination from the coronographic mask in this case is almost absent. The GRISMC mosaic is quite straightforward, as the throw is driven by the width of the orange area (931 and 915 pixels for the two modules). A 2x2 mosaic can efficiently cover a good fraction of the field. In the V2 direction, however, we have a wide gap that can be barely covered with 4 dither moves. The antiparallel orientation of the two GRISM-Rs produces in this case a wide-area mosaic with very uniform depth and no gaps. The difference between the fields cover with 4 exposures with the two grisms is quite striking.

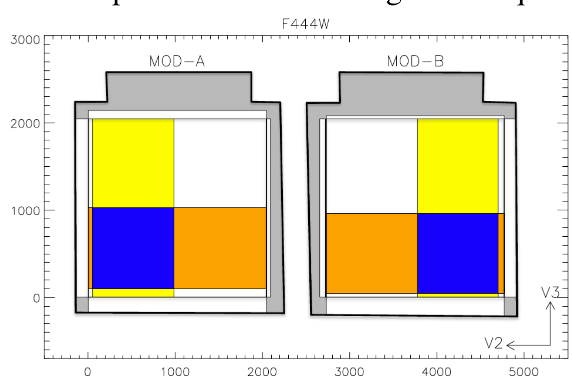

Figure 24: map of the field coverage for the four NIRCam grisms with the F444M filter (identical to Figure 17, copied here for convenience)

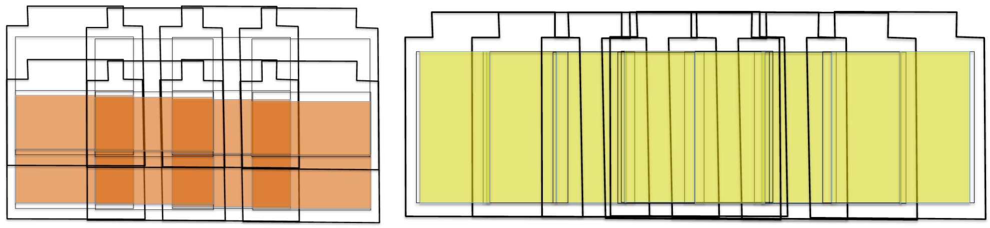

Figure 25. Left: areal coverage of a 1x2 mosaic with GRISM-C+F444M filter; Right: areal coverage of a 1x2 mosaic with the GRISMR+F410M filter

7. Possible APT upgrades

The analysis presented in this report leads to some final consideration about possible upgrades to APT that would facilitate crafting optimal science programs with NIRCam grisms. In particular:

1. When the NIRCam grisms are used in parallel mode, only pre and post exposure images are acquired without dedicated/optimal dithering moves; in this case it may be appropriate to restrict the choice of grisms to those that optimally cover the direct-imaging field, e.g F430M, F410M, and F430M;
2. The Aladdin image viewer could show, for each grism+filter combination, the actual footprint of the sky area seen by the grism;
3. A set of mosaicking patterns optimally designed for each grism+filter combination could be introduced.

8. Conclusion

I have analyzed how the different combinations of NIRCam grisms and filters can project different sky areas onto the focal plane. I have distinguished between areas that produce full or partial spectra, across each selected bandpass, and between areas falling within the direct-imaging field of view or in the adjacent regions. The 12 filters generate very different patterns that require mosaicking/dithering patterns optimized for each combination of grism+filter. I have explored a few combinations to illustrate the key parameters that need to be taken into account to optimally craft an observing program, and made some suggestion for future upgrades of the APT.