NIRCam Grism Time-Series Target Acquisition

JWST NIRCam target acquisition (TA) positions the source with subpixel accuracy on a specific part of the detector. A TA is required for NIRCam grism time-series observations.

Introduction

> *Parent pages: NIRCam Operations → NIRCam Target Acquisition Overview*
> *Main article: NIRCam Target Acquisition Overview*
> *See also: NIRCam Grism Time-Series*

Observations in NIRCam’s grism time-series mode require a target acquisition (TA) to precisely place the target at specific points on the detector. Precise positioning is required in order to achieve the highest possible calibration stability and enable enhanced flat field determination. The grisms are in the NIRCam pupil wheels and are always paired with filters in the filter wheel, either F277W, F322W2, F356W, or F444W for grism time-series observations. Depending on the selected filter, some portion of the spectrum from 2.4–5 µm is dispersed onto the detector, with an undeviating wavelength at 3.95 µm. To ensure that the spectrum falls completely on the detector, the target is placed at either of two field points, one for F444W or another for the other 3 filters.

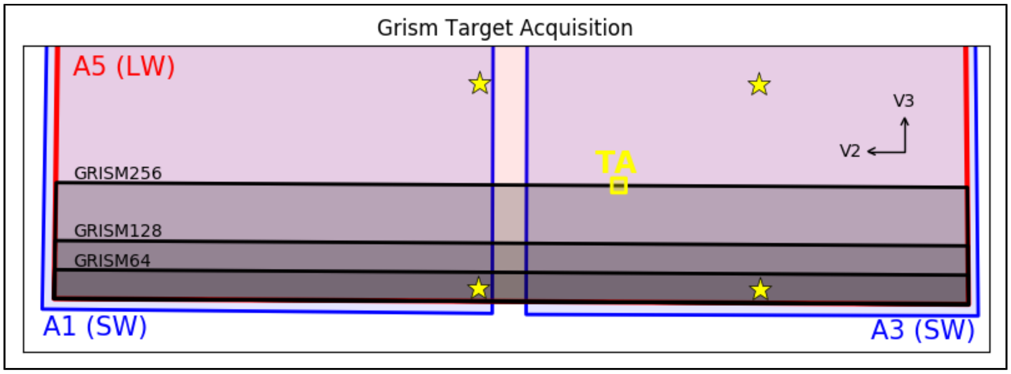
GRISMR is required for time-series observations, so spectra will disperse in the row direction. When F277W, F322W2, or F356W are used, TA places the target towards the right of the long wavelength detector (yellow stars on the right in Figure 1), and the spectrum disperses towards the left. When F444W is used, TA places the target at one of at the yellow stars on the left of Figure 1, and the spectrum disperses towards the right. The positions of these field points are discussed in more detail on the main grism time-series article.

The TA subarray is 32 × 32 pixels in size on the long wavelength detector and is offset from all field positions to avoid saturating the pixels at the field points prior to science observations. All TAs are performed with the F335M filter for operational simplicity, and because it offers a good combination of sensitivity and saturation limit (see below). The TA procedure is as follows:

- The telescope slews to place the target in the TA subarray.
- One TA exposure is taken with the F335M filter.
- The on-board TA software processes the image as needed (to realign the image, flag bad pixels, remove cosmic rays, and subtract the background level), and applies a centroiding algorithm to determine the target coordinates.
- A small slew then moves the target to the nominal center of the TA subarray.
- A larger slew is then executed to precisely position the target at the science position on the detector.

Data from the TA exposure will be delivered to observers along with that from subsequent science exposures.

Figure 1. Target acquisition for grism time-series observations



Target acquisition is performed with a 32 × 32 pixel subarray (yellow square) near the bottom of the long wavelength detector A5. The grism subarrays are shown in black for long-wavelength channel. The corresponding short wavelength subarrays are not shown; they span the short wavelength detectors horizontally and are centered vertically within the long-wavelength subarrays. The target acquisition pointing is centered on the TA subarray. If any of the three grism subarrays is chosen, a slew places the target on one of the lower two yellow stars, depending on the science filter. If full array exposures are selected, the target is positioned at one of the upper two yellow stars, depending on the selected filter.

Target acquisition saturation and sensitivity limits

See also: NIRCam Bright Source Limits

The TA subarray frame time is 0.015 s. It is recommended that users choose a TA exposure time that achieves a total integrated signal-to-noise ratio (SNR) of >30, which enables a centroid accuracy of <0.15 pixel. Any readout pattern is available for TA, with N_{groups} = 3, 5, 9, 17, 33, or 65. The saturation and sensitivity limits for the TA subarray are summarized in Table 1. Sensitivity assumes SNR ~ 30 with N_{groups} = 65. Saturation limits are derived for N_{groups} = 3. All calculations use the F335M filter. Users should use the Exposure Time Calculator (ETC) to estimate saturation and sensitivity for their targets.

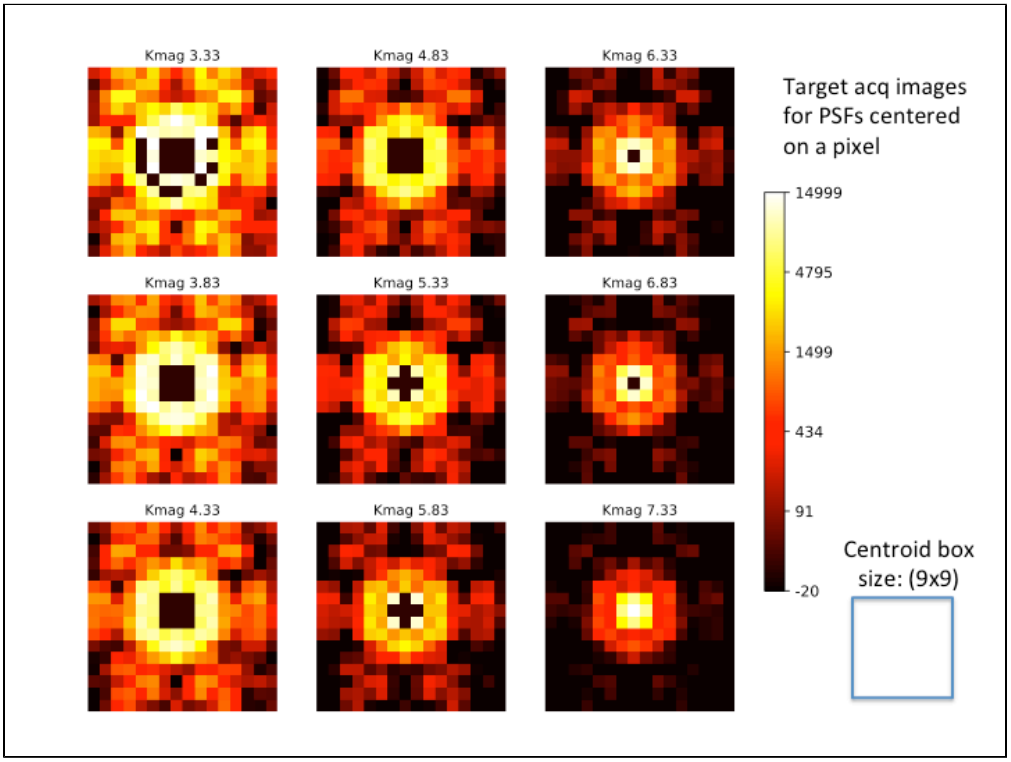
Table 1. Bright source saturation limits and sensitivity for the TSO target acquisition sub-array (*SUB32*)

Readout Pattern	Saturation (Vega Mags) K_{sat} (G2V)	Sensitivity (Vega Mags) K_{sat} (G2V)
RAPID [1]	7.20	14.57
BRIGHT1	7.75	15.32
BRIGHT2	7.95	15.65
SHALLOW2	8.70	15.64
SHALLOW4	8.87	16.95
MEDIUM2	9.36	17.39
MEDIUM8	9.62	17.98
DEEP2	10.06	18.14
DEEP8	10.21	18.71

[1] ***Bold italics*** font style is used to indicate parameters, parameter values, and/or special requirements that are set in the APT GUI.

TA centroid accuracy is a function of the source brightness as well as the location of the source within a pixel. Pixels that saturate prior to the second group of the three that are used to create the target location algorithm input image will appear with little or no signal, as seen in Figure 2. This will negatively impact the centroiding results of the algorithm.

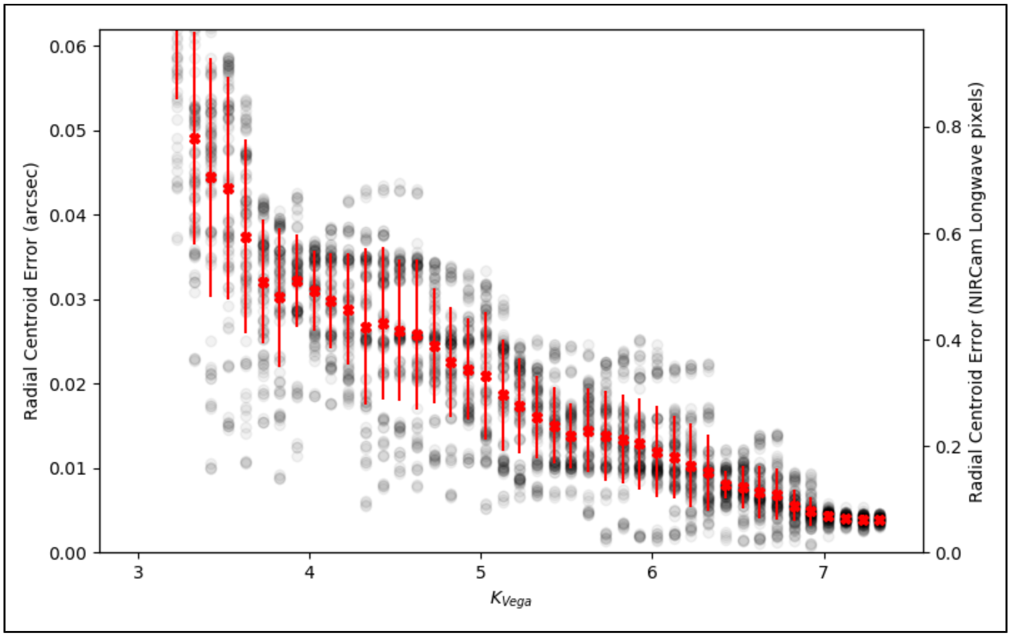
Figure 2. TA images



These TA images were produced from sources with K band magnitudes of 3.33 to 7.33. Pixels that saturate prior to or during the second group used to create the TA image will contain no signal (modulo noise) and appear dark in the images. In this case, no more signal can accumulate between the second and third groups, leading to a group 3 and group 2 difference close to zero. This value then propagates into the final TA image. The blue box to the lower right shows the 9 × 9 pixel box used in the centroid calculations.

Figure 3 shows the centroiding accuracy of the target location algorithm versus the K band Vega Magnitude of a G2V source. These calculations were performed using a dataset of simulated point sources located within a grid of subpixel locations and with several Poisson noise realizations at each location. The gray points show the accuracy of the calculated centroid compared for all observations. The red points and error bars show the mean accuracy and standard deviation at each magnitude.

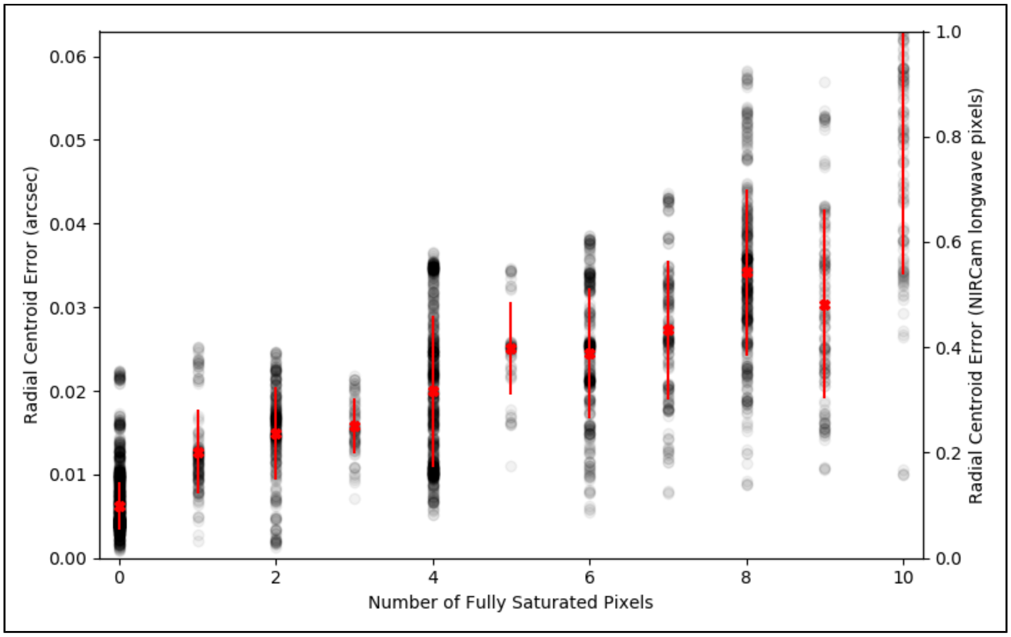
Figure 3. Centroiding error versus source brightness



Accuracy of the target location algorithm results for NIRCam time-series and grism time-series observations versus the K band Vega magnitude of a G2V source. The accuracy is calculated for a grid of subpixel locations and Poisson noise realizations. Individual results are shown as gray points. Red points and error bars show the mean and standard deviation over all pixel phases and noise realizations at each magnitude.

Figure 4 shows the centroiding accuracy versus the number of fully saturated pixels in the scene. These are pixels that are saturated in all three of the groups used to create the TA image. The ETC also uses this definition when reporting the number of pixels that have reached "full saturation".

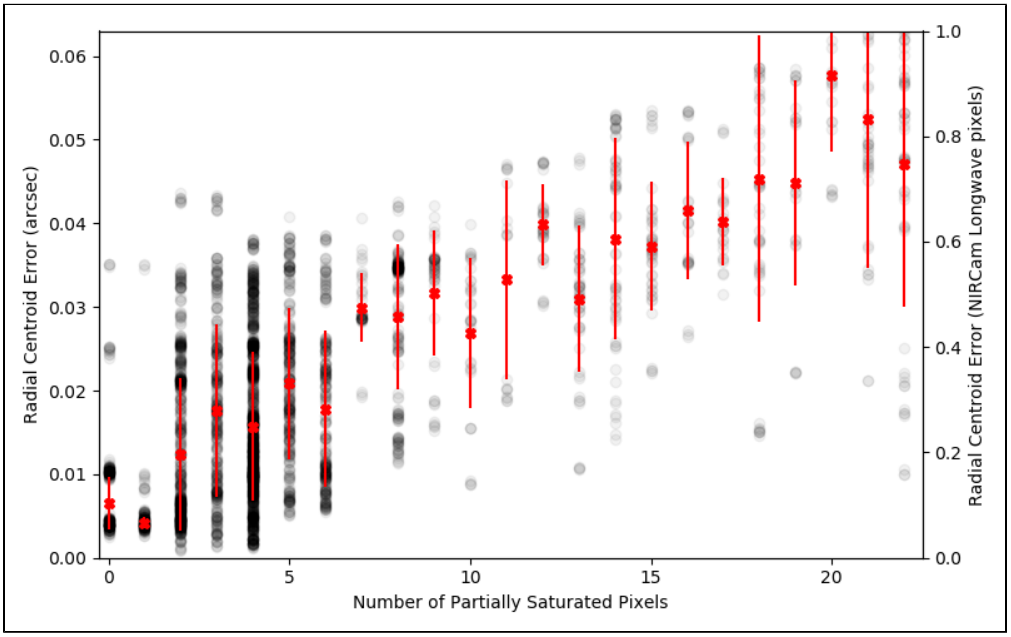
Figure 4. Centroiding error versus the number of fully saturated pixels.



The number of pixels on the X axis is equivalent to the number of fully saturated pixels reported by the ETC. The red x's and error bars show the mean and standard deviation of the centroiding error.

Figure 5 shows the centroiding accuracy plotted against the number of pixels that saturate in groups 2 or 3 of the 3 groups used to produce the TA image. This is equivalent to the number of "partially saturated" pixels reported by the ETC.

Figure 5. Centroiding error versus the number of partially saturated pixels.



The number of pixels on the X axis is equivalent to the number of partially saturated pixels reported by the ETC. The red x's and error bars show the mean and standard deviation of the centroiding error. Note that fully saturated pixels begin to occur at limits described on the ETC NIRCam Target Acquisition article.