Step-by-Step ETC Guide for NIRCam Grism Time Series Science Use Case

A walk through of the JWST ETC for the NIRCam Grism Time Series Science Use Case is provided, demonstrating how to select exposure parameters for this observing program.

Exposure Time Calculator

Main article: Exposure Time Calculator Old

The ETC Scene

Main article: JWST ETC Defining a New Scene
See also: JWST ETC Defining a New Source

We use the JWST ETC to estimate the signal level of GJ 436 and determine the detector readout parameters. First we set up the source and observation into the ETC and determine the signal-to-noise (SNR) in a single integration, and then we will convert this to the SNR over the secondary eclipse observation time.

We open an ETC workbook and create a Scene that emulates GJ 436 with a M2V model Phoenix spectrum and renormalize it to K = 6.1 mag (Johnson). The observatory background is very low for these observations (~ 1 e- / s / pixel in F322W2 + grism and F444W + grism), and we pick an observing strategy that uses backgrounds in the regions 0.8″–1.6″ (13–25 pixels) above and below the target spectrum.

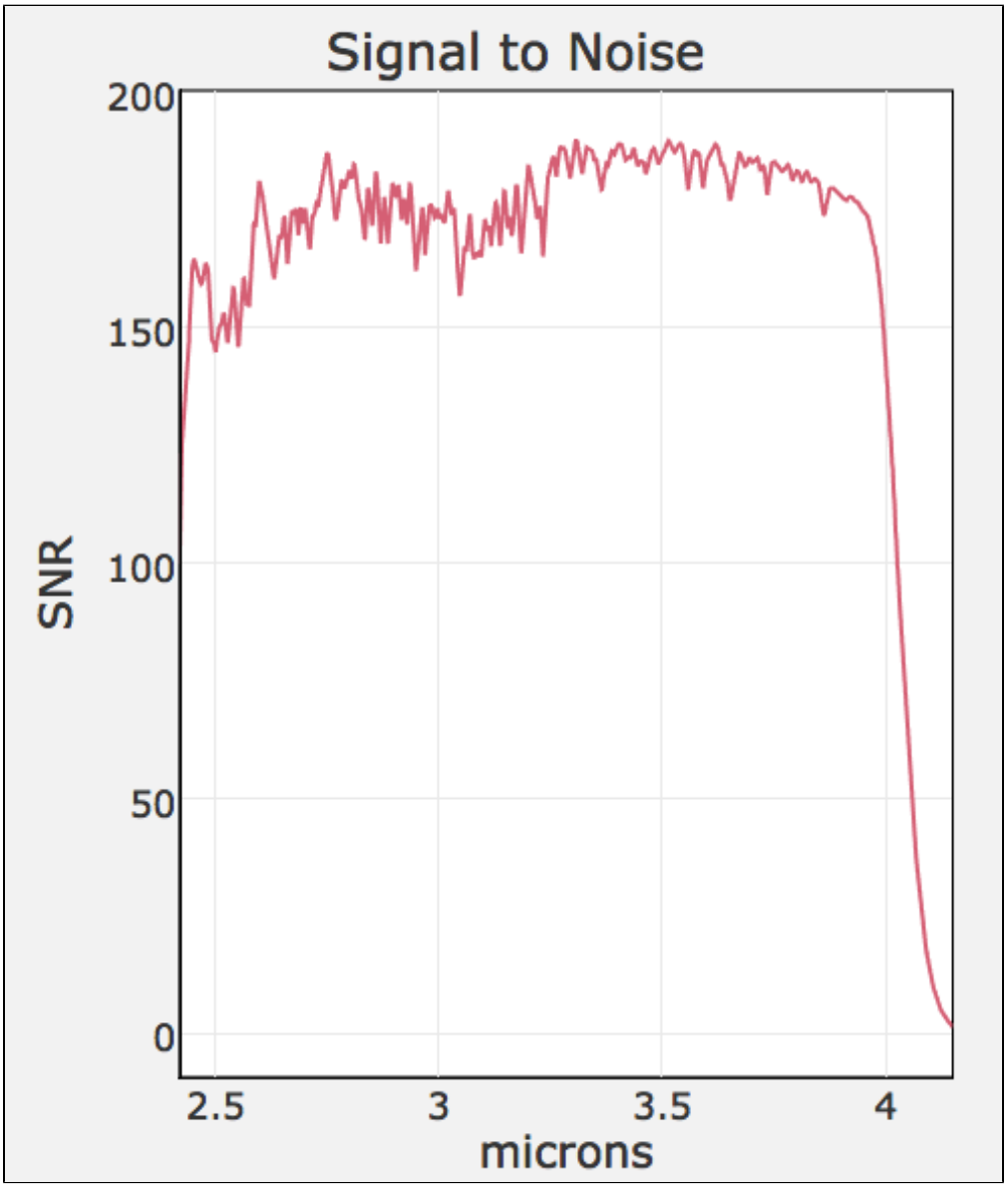
ETC Calculations

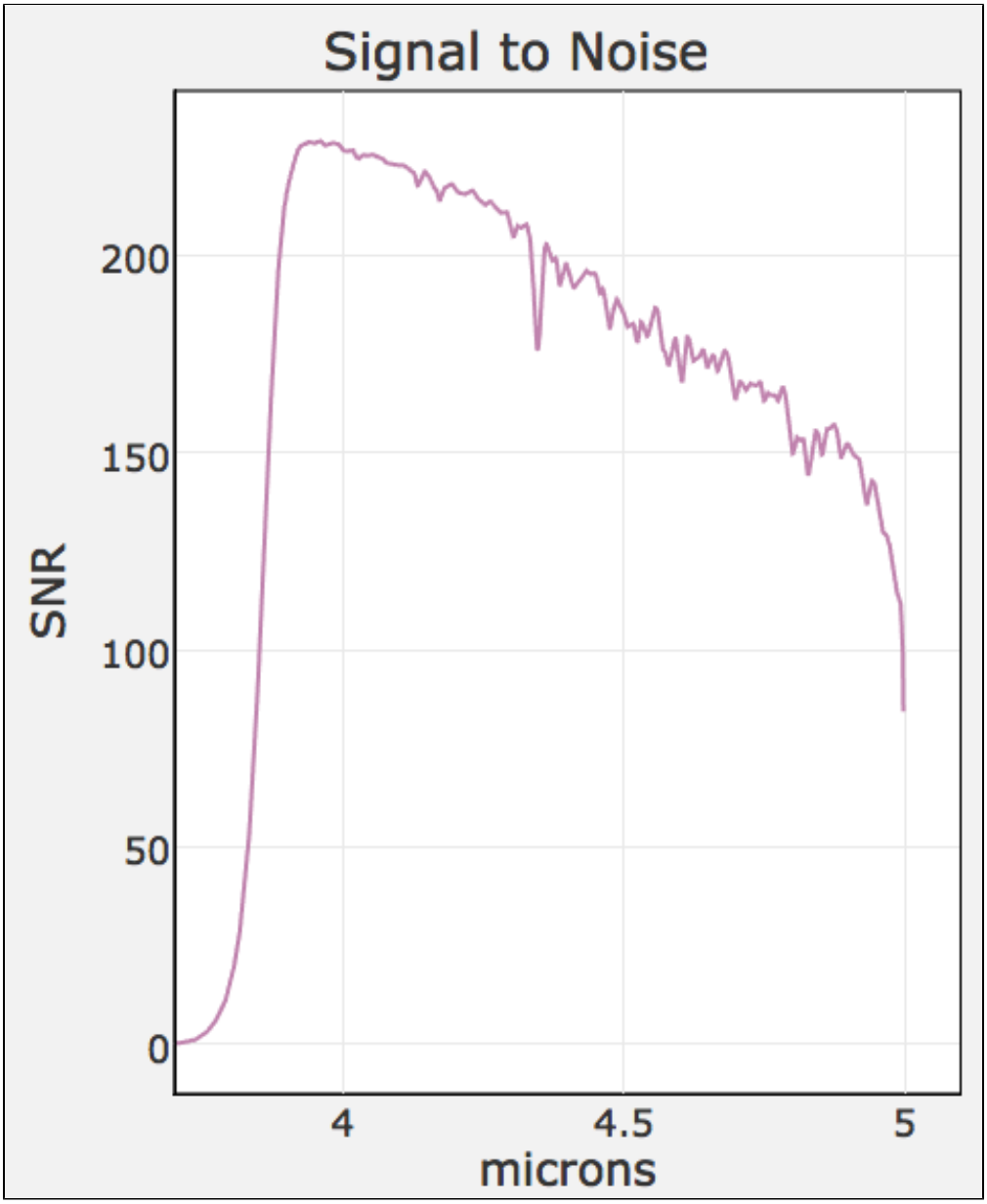
Main article: JWST ETC Creating a New Calculation

The ETC shows that the onset of saturation occurs in some pixels with 9 RAPID groups when using the SUBGRISM64 subarray with $N_{outputs} = 4$ and with the F322W2 filter. We chose the RAPID readout pattern with $N_{Group} = 5$ to allow significant saturation headroom, and this results in SNR = 180 per spectral pixel per 2.04 s integration at 3.5 μm (see Figure 1). This will allow 1341 integrations during each 0.76 hour (2736 s) secondary eclipse. Using this result and binning to 20 spectral pixels (R ~ 175) results in photon-limited SNR = 29,500 per secondary eclipse. This is reduced to SNR = 20,800 when subtracting the secondary eclipse from the out-of-eclipse data, yielding a photon-limited precision of 48 ppm. Dividing by the in-eclipse stellar spectrum will reduce this further (to ~70 ppm). We wish to achieve ~50 ppm or better, so we plan to observe 3 secondary eclipses.

Similarly, GJ 436 saturates in 17 RAPID groups using the SUBGRISM64 subarray with $N_{outputs}$ = 4 with the F444W filter. We chose 10 RAPID groups for some headroom in the observations. This produces SNR = 195 at 4.4 µm in the resultant 3.75 s integration time per spectral pixel (see Figure 1). This improves to SNR = 23,500 when binning 20 spectral pixels (R ~ 220) over the secondary eclipse. This is reduced to SNR = 16,660 when subtracting the secondary eclipse from the out-of-eclipse data, yielding a photon-limited precision of 60 ppm. Dividing by the in-eclipse stellar spectrum will reduce this further (to ~ 85 ppm). We wish to achieve ~50 ppm or better, so we plan to observe 3 secondary eclipses.

Figure 1. ETC SNR for single GJ 436 integrations

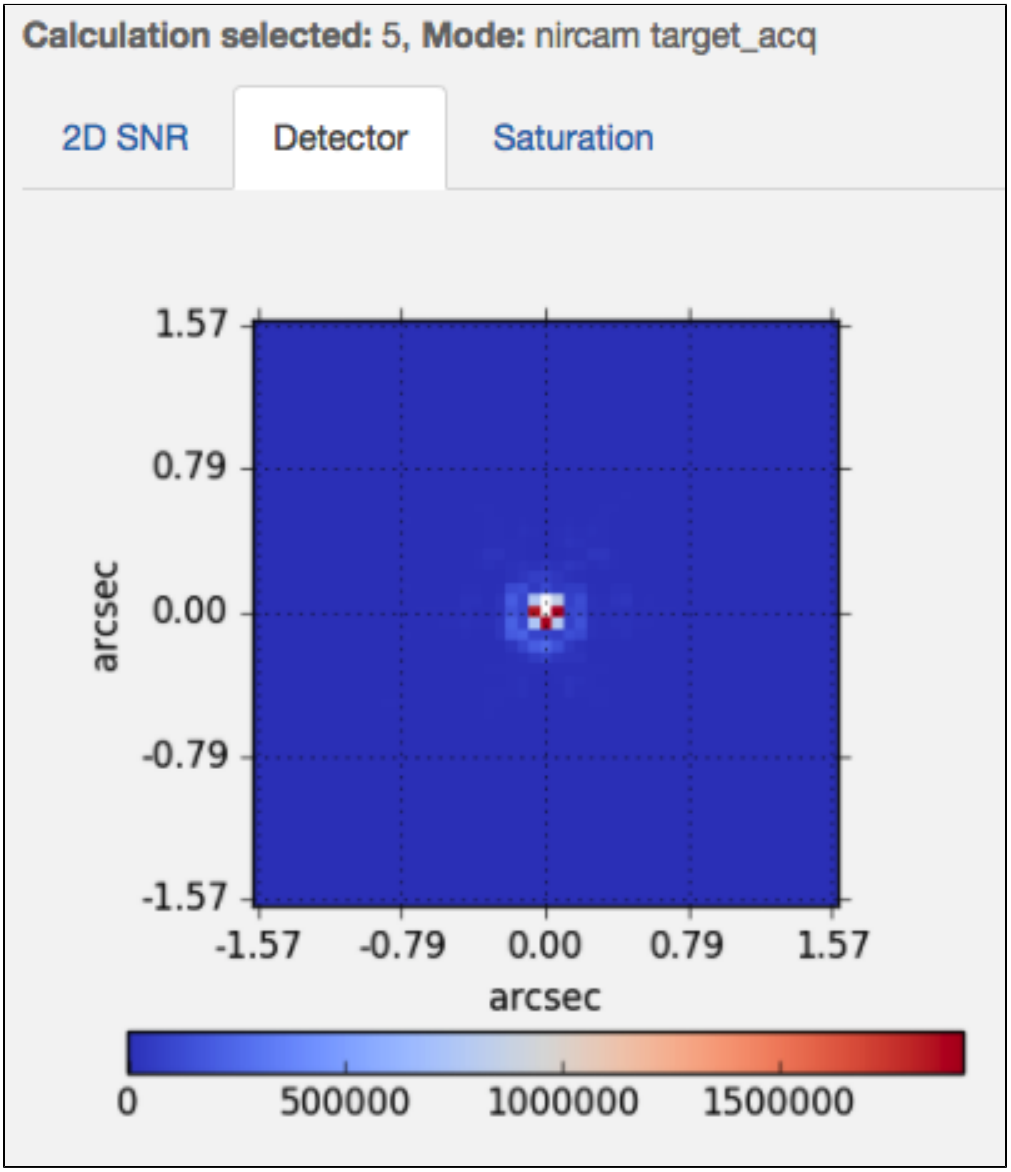




The SNR plots for F322W2 + grism and F444W + grism observations generated by JWST ETC 1.1.1. F322W2 + grism observations (upper panel) will have SNR ~ 180 per spectral pixel in each 2.04 s integration, while the F444W + grism observations (lower panel) have SNR = 195 per spectral pixel in each 3.75 s integration.

Cycle 1 Target acquisition for NIRCam grism time series observations are currently done only in the F335M filter with the SUB32 subarray. GJ 436 b images saturate in 3 pixels in only 3 RAPID groups (the minimum). Ideally a fainter nearby star should be used for target acquisition, but there are no suitable star within the 35″ visit splitting distance of GJ 436. Alternatively, target acquisition could be done in a narrowband filter that reduces signal levels (not yet implemented for cycle 1). The target acquisition detector image generated by the ETC is shown in Figure 2.

Figure 2. ETC Target acquisition of GJ 436



Three pixels are saturated in the shortest (RAPID readout, N_{Groups} = 3) target acquistion image of GJ 436. Using a narrow filter would prevent this, but that is not yet implemented for Cycle 1.