NIRCam Imaging Sensitivity

Exposure times vs. flux estimates at signal-to-noise ratio = 10 in NIRCam images can be obtained using the Pandeia JWST Exposure Time Calculator (ETC) Python engine.

Introduction

Parent page: NIRCam Predicted Performance

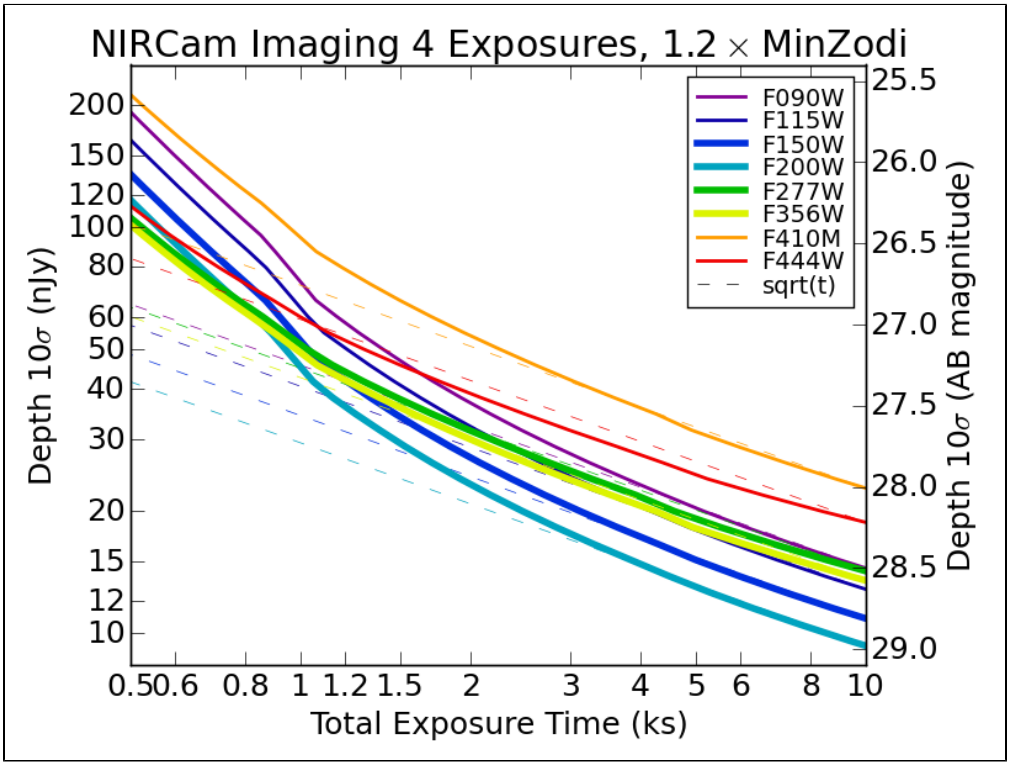
The Pandeia Exposure Time Calculator Old should be used for all observation planning. This article provides ETC results using the Python engine to loop through many calculations of signal-to-noise ratio (SNR) for various readout specifications and resulting exposure times, given assumptions detailed below. These calculations are then interpolated to determine depth (SNR = 10) vs. exposure time. The script is available on Github.

Depth vs. exposure time

The NIRCam Imagingoverview and NIRCam Sensitivity articles show SNR = 10 sensitivity estimates for imaging in all NIRCam filters given a total exposure time of 10 ks (166.7 minutes = 2.78 hours). Figure 1 shows similar estimates for a range of exposure times in seven wide filters and one medium filter.

⚠ Sensitivity estimates can vary significantly depending on the backgrounds and the assumed photometric aperture sizes as discussed below. Please use the Pandeia Exposure Time Calculator Old to plan your observations.

Figure 1. Depth vs. exposure time

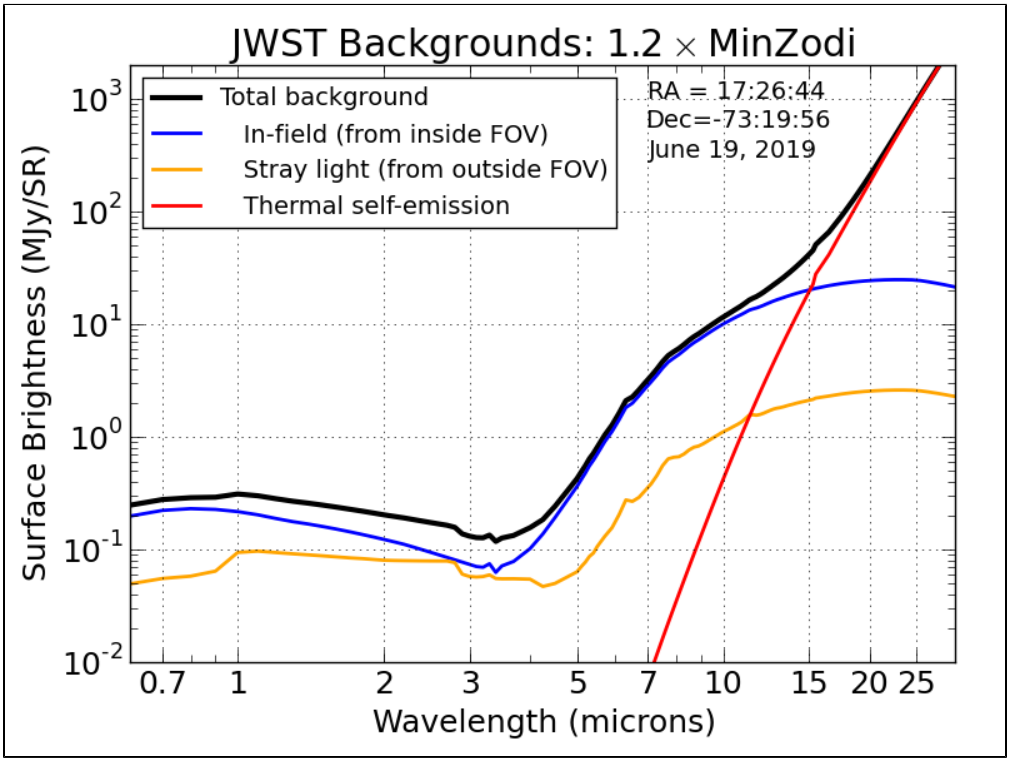


Depth (10-sigma) vs. total exposure time for four exposures of NIRCam imaging in seven wide filters and one medium-band filter, assuming the "1.2 × MinZodi" background defined below. Values are for point sources with photometric apertures of 0.08" (0.16") diameters with 0.6"–0.99" (1.2"–1.98") background sky annuli for the short (long) wavelength channel. Depths are interpolated from results obtained with the Pandeia JWST ETC Python engine. Dashed line extrapolations assume depth in units of flux goes as sqrt(t), or in magnitudes: depth = $depth_0$ + 1.25 * log(t / t_0). Note 5-sigma depth estimates are 0.75 mag fainter than the 10-sigma estimates shown here.

Background

JWST's background model varies with the target coordinates (RA, Dec) and time of year. These calculations assume the fiducial "1.2 × MinZodi" (1.2 times the minimum zodiacal light) background at RA = 17:26:44, Dec = -73:19:56 on June 19, 2019, as used in the NIRCam Imaging article. The background model for these observations must be generated using the online ETC GUI and then imported into the Python ETC engine.

Figure 2. Background vs. wavelength

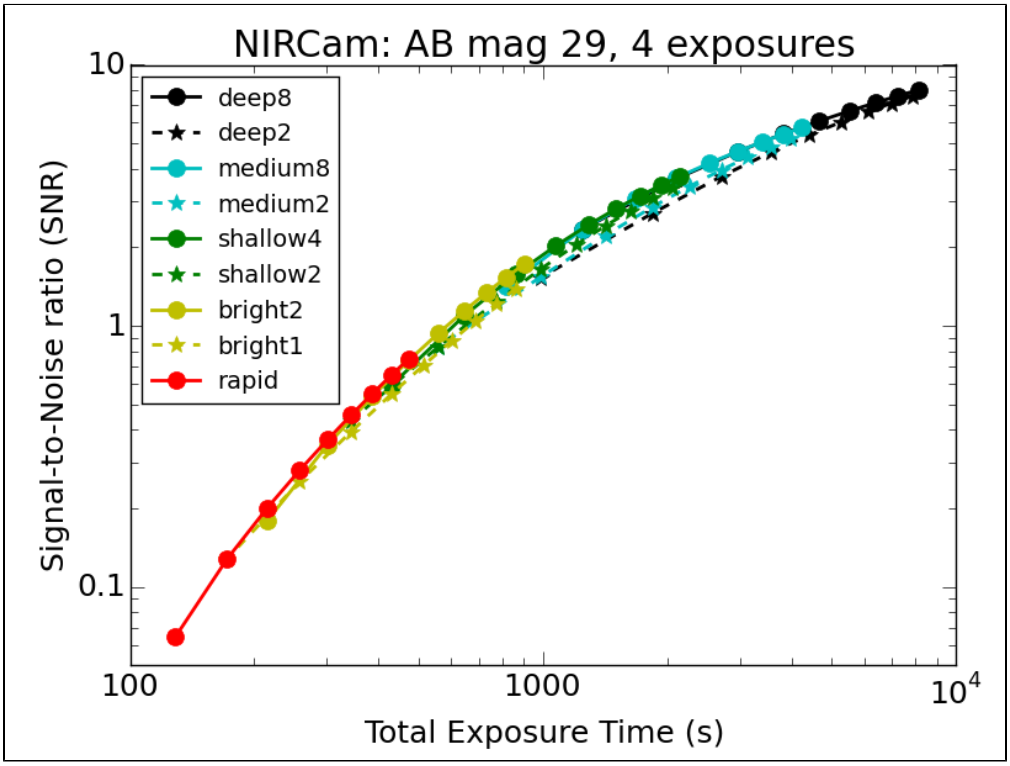


Background vs. wavelength assumed in these calculations, as generated by the online ETC GUI for "1.2 × MinZodi" at (RA = 17:26:44, Dec = -73:19:56) on June 19, 2019.

Exposure time

Recommended readout patterns and exposure times used for the calculations on this page are described below. They are based on ETC calculations that show these to yield optimal signal-to-noise ratios for a given exposure time. ***RAPID*** [1], ***BRIGHT2***, ***SHALLOW4***, ***MEDIUM8***, and ***DEEP8*** yield high signal-to-noise ratio most efficiently and are preferred to maximize depth. The other readout patterns (***BRIGHT1***, ***SHALLOW2***, ***MEDIUM2***, ***DEEP2***) may be preferred in some cases, for example, to provide a greater dynamic range (with a shorter first group) to sample bright stars before saturation.

Figure 3. Signal-to-noise ratio vs. exposure time for various readout patterns



Comparison of signal-to-noise ratio for various readout specifications for F200W imaging of an AB mag 29 point source. Each point shows the estimate given four exposures, each comprising a single integration that consists of multiple groups (between two and 10) of a given readout pattern. This analysis shows that RAPID, BRIGHT2, SHALLOW4, MEDIUM8, and DEEP8 yield higher signal-to-noise ratio than other patterns for a given exposure time. These are plotted as filled circles; the other patterns are plotted as stars. Note BRIGHT2 is restricted to a maximum of four groups when reading out the full detectors in both modules.

When reading out the full detectors in both modules, ***RAPID*** and ***BRIGHT2*** are limited to four groups, ***DEEP8*** is limited to 20 groups, and all other patterns are limited to 10 groups. The table below gives the full range of recommended readout specifications for exposure times between 42.9 and 4176.6 s. The final two columns assume four such exposures.

Table 1. Recommended readout specifications for maximal depth in a given exposure time

Readout pattern	NGROUPS	NINT	Exposure time (s)	NEXP	Total exposure time (s)
RAPID	2	1	32.2	4	128.8
RAPID	3	1	42.9	4	171.8
RAPID	4	1	53.7	4	214.7
BRIGHT2	4	1	96.6	4	386.5
BRIGHT1	5	1	107.4	4	429.5

BRIGHT1	6	1	128.8	4	515.4
BRIGHT1	7	1	150.3	4	601.3
BRIGHT1	8	1	171.8	4	687.2
BRIGHT1	9	1	193.3	4	773.0
BRIGHT1	10	1	214.7	4	858.9
SHALLOW4	5	1	268.4	4	1073.7
SHALLOW4	6	1	322.1	4	1288.4
SHALLOW4	7	1	375.8	4	1503.1
SHALLOW4	8	1	429.5	4	1717.9
SHALLOW4	9	1	483.2	4	1932.6
SHALLOW4	10	1	536.8	4	2147.4
MEDIUM8	6	1	633.5	4	2533.9
MEDIUM8	7	1	740.8	4	2963.3
MEDIUM8	8	1	848.2	4	3392.8
MEDIUM8	9	1	955.6	4	3822.3
MEDIUM8	10	1	1062.9	4	4251.8
DEEP8	6	1	1170.3	4	4681.2
DEEP8	7	1	1385.0	4	5540.2
DEEP8	8	1	1599.8	4	6399.1
DEEP8	9	1	1814.5	4	7258.0
DEEP8	10	1	2029.2	4	8117.0
DEEP8	11	1	2244.0	4	8975.9
DEEP8	12	1	2458.7	4	9834.9
DEEP8	13	1	2673.5	4	10693.8
DEEP8	14	1	2888.2	4	11552.8
DEEP8	15	1	3102.9	4	12411.7
DEEP8	16	1	3317.7	4	13270.6

DEEP8	17	1	3532.4	4	14129.6
DEEP8	18	1	3747.1	4	14988.5
DEEP8	19	1	3961.9	4	15847.5
DEEP8	20	1	4176.6	4	16706.4

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