NIRISS Bright Limits

The bright limits, above which saturation occurs, depends on subarray configurations for the various JWST NIRISS observing modes.

Introduction

Parent page: NIRISS Predicted Performance

The NIRISS single object slitless spectroscopy (SOSS) and aperture masking interferometry (AMI) modes are optimized to observe bright objects, where the target is centered on a pixel. For imaging, and to some degree for slitless spectroscopy, the bright limit in some filters is significantly affected by whether a star is centered on a pixel or is located at the pixel corner. This effect is larger for the NIRISS short wavelength imaging filters where the PSF sampling is sparse. Values given here are for stars centered on a pixel, and hence represent the worst case.

Users should ultimately use the Exposure Time Calculator (ETC) for all saturation/sensitivity calculations.

NIRISS SOSS bright limits

Main article: NIRISS Single Object Slitless Spectroscopy

The NIRISS single object slitless spectroscopy (SOSS) mode is optimized to obtain spectra from 0.6–2.8 μm of transiting exoplanets around bright stars. SOSS makes use of the GR700XD grism to disperse the light into three orders, two of which are useable, at a resolution of R ~ 700.

SOSS offers two subarrays, ***SUBSTRIP256*** [1], which covers 256 × 2048 pixels, and ***SUBSTRIP96***, which covers 96 × 2048 pixels. ***SUBSTRIP256*** captures both orders while ***SUBSTRIP96*** captures only the 1st order. Table 1 lists the bright limits for the two subarrays, where N_{groups} refer to integration length as specified by MULTIACCUM detector readout. Saturation is assumed to occur at an accumulated signal of 72,000 e^-/pixel.

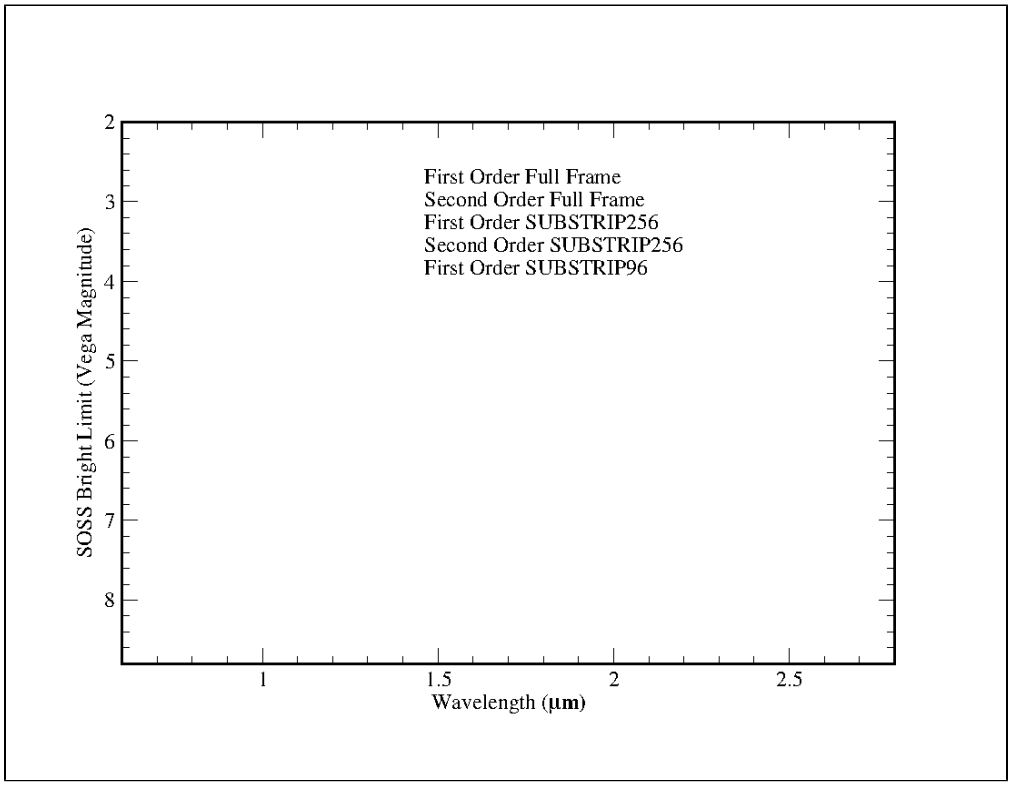
Table 1. Estimated bright limits for NIRISS SOSS mode (G2 V star[1])

Subarray	Subarray size	Order	N_{Groups}	J mag (Vega)
SUBSTRIP256	256 × 2048	1	2	8.5
SUBSTRIP256	256 × 2048	2	2	7.2
SUBSTRIP96	96 × 2048	1	2	7.5

[1]The bright limit varies by +0.15 magnitudes for an A0V star to -0.10 magnitudes for an M5V star.

The bright limit is a function of wavelength in each order for a given readout. Figure 1 shows the predicted single group saturation Vega magnitude as a function of wavelength for the assumed maximum signal level of 72,000 e^- /group and in ***NISRAPID*** detector readout pattern.

Figure 1. Bright limit as a function of wavelength for SOSS mode



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

NIRISS AMI bright limits

Main article: NIRISS Aperture Masking Interferometry

The NIRISS aperture masking interferometry (AMI) mode enables high spatial resolution imaging of bright objects and is optimized to identify close companions ~70–400 mas from their host stars. A non-redundant mask (NRM), consisting of seven holes, produces an interferogram in the image plane, sampling 21 unique baselines. The AMI mode is used in conjunction with three medium-band filters (F380M, F430M, F480M) or one wideband filter (F277W) in the filter wheel.

Most observations with AMI will make use of the ***SUB80*** subarray which covers 80 × 80 pixels on the detector. Table 2 lists the bright limits in A0V-based magnitudes, also called Vega magnitudes, for the various filters. Table 2 assumes a point source centered in a pixel. If the point source is placed at or near the corner of a pixel, the target could be about 1.5 magnitudes brighter because of the lower pixel response. For a full frame observation the bright limits will be about 5.4 magnitudes fainter than for a ***SUB80*** observation. Saturation is assumed to occur at 72000 e^-/pixel.

Table 2. Estimated bright limits for NIRISS AMI mode in Vega magnitudes (i.e., the average A0V star has colors of 0.0 between filters), for an A0V type spectrum, for the *SUB80* subarray

Filter	$N_{Groups} = 1$	$N_{Groups} = 2$
F277W	5.98	6.60
F380M	3.08	3.71
F430M	2.42	3.04
F480M	2.07	2.69

The bright limits for $N_{groups} = 2$ were calculated using the JWST ETC for an A0V star with no background and an aperture radius of 1". JWST ETC does not support $N_{groups} = 1$, so the detected flux from the $N_{groups} = 2$ calculation was scaled to estimate the bright limit for $N_{groups} = 1$.

NIRISS WFSS bright limits

Main article: NIRISS Wide Field Slitless Spectroscopy

The NIRISS wide field slitless spectroscopy (WFSS) mode enables low-resolution (R ≈ 150) spectroscopy over the wavelength range 0.8–2.2μm for all objects within the 2.2’ × 2.2’ field of view (FOV) of the NIRISS detector. WFSS observations are obtained using the GR150 grism with a blocking filter in the pupil wheel. Only full frame readout is supported.

The estimated bright limits for each filter are listed in Table 3. The magnitudes listed are Vega magnitudes in the NIRISS filters. For an average A0V star, the same magnitude applies in the 2MASS J, H, and K filters to within about 0.03 magnitudes. The wavelengths listed in Table 3 indicate the wavelength at which saturation is expected to first occur for an A0V star. Magnitudes and wavelengths at which saturation first occurs will be a bit different for a cool star or any other object of a distinctly different spectral shape.

Table 3. Estimated bright limits for NIRISS WFSS mode assuming a maximum signal of 72,000 e^- in the first *NISRAPID* group of an exposure

Filter	Wavelength (μm)	Magnitude
F090W	0.992	13.20
F115W	1.107	13.26
F150W	1.346	12.88
F200W	1.772	11.80
F140M	1.346	12.88
F158M	1.504	12.33

NIRISS imaging bright limits

Main article: NIRISS Imaging

NIRISS imaging is not supported as a prime observing mode, but can be used in parallel when another JWST instrument is primary. In the WFSS observing mode, direct images with NIRISS, using a filter in the pupil wheel, are required before and after a grism exposure sequence. Direct images can optionally be taken prior to an AMI observation with three medium-band filters (F380M, F430M, F480M) or one wideband filter (F277W) in the filter wheel.

Table 4 lists the estimated bright limits. The magnitude values listed are estimated Vega magnitudes in the NIRISS filters, so for an A0V star these magnitudes should match those of 2MASS or other filters in this wavelength range to with 0.03 magnitudes. These values are calculated for the case where a star is centered on the pixel; the bright limit will be higher for a star observed at the pixel corner where the peak signal is split about equally between four pixels.

Table 4. Estimated bright limits for NIRISS imaging mode, for a signal of 72,000 e^-/group in *NISRAPID* readout

Filter	Magnitude
Pupil wheel filters	
F090W	17.46
F115W	17.61
F140M	16.51
F150W	17.21
F158M	16.36
F200W	16.69
Filter wheel filters	
F277W	15.57
F356W	14.71
F380M	12.69
F430M	12.03
F444W	13.80
F480M	11.68