# MIRI-Specific Treatment of Limiting Contrast

Treatment of limiting contrast ($C_{limit}$) is based on current information about telescope aberrations and the expected performance of JWST MIRI.

## Introduction

> *Parent article: JWST High-Contrast Imaging*
> *Main articles: MIRI Coronagraphic Imaging, MIRI Bright Source Limits*
> *See also: MIRI Coronagraph Masks*

Limiting contrast ($C_{limit}(s)$) is the companion-to-host flux ratio of the minimum detectable companion. It is the detection limit and the best that can be done.

The article Contrast Considerations for JWST High-Contrast Imaging provides a general treatment of "contrast" ($C$), including $C_{limit}(s)$ in particular.

$C_{limit}(s)$ is a function of essentially everything related to high contrast imaging (HCI): myriad eclectic technical factors and procedures, end-to-end.

This treatment of $C_{limit}(s)$ for MIRI is based on Boccaletti, A., et al 2015.

## Limiting contrast, $C_{limit}(s)$, for MIRI

Figure 1 shows the best available treatment of various contrasts for a MIRI 4QPM2 coronagraph, as adapted from Figure 10 (upper right) in Boccaletti, A., et al 2015.

The "technical factors" behind the curves include:

- 4QPM2 inner working angle (IWA), filter, and nominal wavelength (0.49", F1140C, 11.30 μm)
- Stellar distance and spectral type of host source (10 pc, M0V)
- Exposure time (3,600 s)
- Telescope area and transmission (25 $m^2$, 85%)
- Detector quantum efficiency and noise (80%, readout 20 $e^-$ rms, 0.001 flat-field stability)
- Lyot-stop transmission (62% for 4QPM)
- A random positional error of 10 mas and a wavefront error of 10 nm between rolls
- Reference star subtraction strategy

- False-alarm probability of $3 \times 10^{-3}$ (3-sigma), which assumes normally distributed errors with zero mean after reference-star subtraction
- Currently available estimates of JWST aberrations

Under those assumptions, Figure 1 shows the approximate minimum contrast ratio for 3-sigma detection of a faint companion near a bright host, as a function of their apparent separation s in arcseconds.

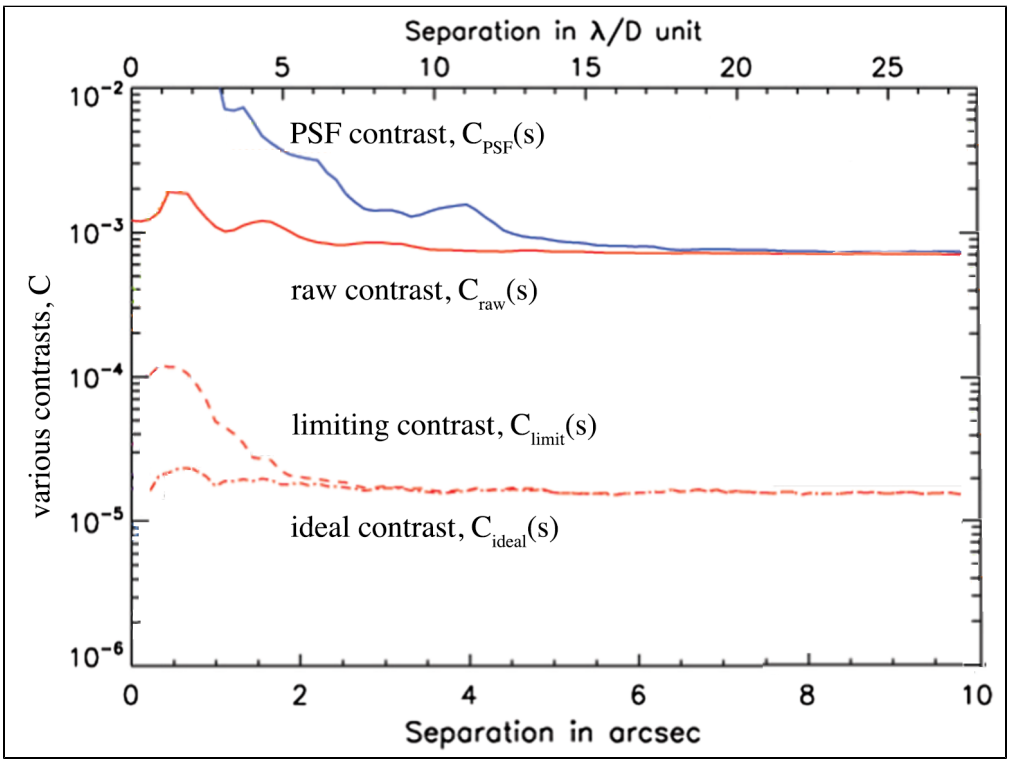
Boccaletti et al. (2015) also present variants of three particular technical assumptions: the 4QPM coronagraph (1 of 3), filter, and the spectral type of the host source.

If the user's operating point ($s$, $C_{flux}$) lies above the red-dashed curve, that source is detectable under the technical and procedural assumptions of Boccaletti, A., et al 2015.

This is the best information on limiting coronagraphic performance for MIRI at the current time. In the future, with a better understanding of wavefront errors and other technical factors—or when users become interested in different combinations of technical factors—improved calculations of $C_{limit}(s)$ will be made available for MIRI coronagraphs.

Meanwhile, users may be able to extrapolated estimates of $C_{limit}(s)$ using the Exposure Time Calculator (ETC) and other proposal tools.

**Figure 1. MIRI limiting contrast example**




***Example of estimating limiting contrast for MIRI. Adapted from Boccaletti, A., et al 2015, Figure 10, top-right panel, showing $C_{PSF}(s)$, $C_{raw}(s)$, $C_{limit}(s)$, and $C_{ideal}(s)$ for Boccaletti, A., et al 2015, set of technical and procedural assumptions.***

# References

Boccaletti, A., et al. 2015, PASP, 127, 633
The Mid-Infrared Instrument for the James Webb Space Telescope, V: Predicted Performance of the MIRI Coronagraphs