

Tutorial : Observation of eps Ind Ab with JWST

Context :

eps Ind Ab is a planet recently imaged with MIRI by Matthews et al. 2024 (10.1038/s41586-024-07837-8)

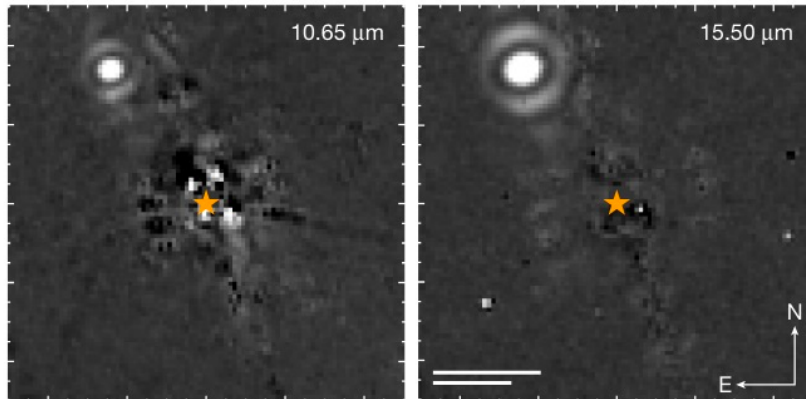


Fig. 1 | Point source detected in JWST/MIRI coronagraphic images of Eps Ind A. The target was observed at 10.65 and 15.50 μm . Starlight was removed with RDI. Only the central portion of the field of view is shown. The stellar position is marked with an orange star. A bright point source was detected in the upper left corner of these images at a projected separation 4.11" (15.0 au at the distance of Eps Ind A). Top scale bar, 2.75" = 10.0 au; bottom scale bar, 2" = 7.28 au.

few facts :

distance system 3.64pc

Eps Ind A (HD209100) : $T_{\text{eff}} = 4,760 \pm 15 \text{ K}$, $\log(g) = 5.25 - 0.34 + 0.18$, $[\text{Fe}/\text{H}] = 0.22 \pm 0.12$ and $R = 0.679 \pm 0.004 R_{\odot}$

Eps Ind Ab : Separation is 4.11" $T = 275\text{K}$

Fluxes : - F1065C : 13.16mag or 119.6 micro Jy

- F1550C : 11.20mag or 525.1 microJy

Purpose of the tutorial :

Test the detectability of the planet with the ETC, comparing various observing modes :

NIRCAM imaging, MIRI imaging, NIRCAM corono, MIRI corono.

determine the best parameters for the detector (Ngroup, Nint)

measure S/N of the planet in the "star+planet" and "planet alone" configuration

prepare the corresponding APT

1- ETC :

Login at <https://jwst.etc.stsci.edu/>

create New Workbook, rename Workbook => "Eps Ind Ab"

– create 2 sources, the star and the planet. associate the 2 sources with 1 scene. create another scene to associate the planet only

– flux of the star : simplest is to use a spectral type and renormalize it to the K band magnitude for instance. the ETC will scale it for all filters. but not always precise for mid IR. we can instead use the flux retrieved from Vizier using 2MASS and WISE photometry

– flux of the planet : simplest is to use a BB temperature of 275K and renormalize it to F1065C magnitude... but not very precise. Can we use one magnitude for each filter (would require to create one target for each filter and same for the scene). offset the planet at 4.11".

– observations:

- start with MIRI coronagraph.
 - select configuration F1065C.
 - determine the Ngroup Nint to avoid saturation and reach S/N >10 on the planet
 - configure the strategy to subtract the optimal PSF and extract the flux on eps Ind Ab
 - repeat for F1550C
- repeat for with MIRI imaging F1000W
 - use small window
 - conclude on feasibility
 - compare with the scene "planet alone"
- repeat for NIRCAM coronagraph with MASK430 and F444W
- repeat for NIRCAM imaging F480M

2- APT :

Note : It is convenient to check the configuration in other approved programs. The list of GO, GTO, ERS programs can be checked here :

<https://www.stsci.edu/jwst/science-execution/approved-programs>

and APT file can be either downloaded or directly opened in APT with the menu "Retrieve from STScI".

- define targets
 - fixed target resolver : eps Ind and DI Tuc (reference star)
 - background for MIRI corono : to make it simple just duplicate the targets eps Ind and DI Tuc and rename it with "bgd" at the end, but change category to calibration and description to telescope sky background. link target to their background

- create observation folder "MIRI imaging"
 - label the observation : for instance "MIRI imaging target"
 - select eps Ind
 - set subarray
 - select a dither strategy : 4 points, point source ...
 - select filters : F1000W
 - specify ngroup, nint, ndither find in the ETC
 - duplicate the observation and change the target to DI Tuc
 - in Observation Links : link all templates to non interruptible sequence

- create observation folder "MIRI coronagraphy"
 - select Targ acq parameters (should be defined with the ETC). Acq filter is ND and Quadrant is 1
 - corono params : F1065C, specify ngroup, nint, ndither find in the ETC
 - dither type is none (reserved the reference star only)
 - duplicate for the background template, select the target eps Ind bgd
 - duplicate for the reference and change to DI Tuc
 - duplicate for the background template, select the target DI Ind bgd
 - indicate DI Tuc is the PSF reference, and link in the target observation template
 - in Observation Links : link all templates to non interruptible sequence

- create observation folder "NIRCAM imaging"
 - readout pattern = Bright2
 - sub array : SUB400P in module B
 - dither pattern = subarray dither
 - filters : F210M/F480M
 - repeat for the reference star
 - link all templates to non interruptible sequence

- create observation folder "NIRCAM coronagraphy"
 - same strategy as for MIRI coronagraphy but no need to make backgrounds
 - readout pattern = Bright2
 - sub array : sub320A335R
 - dither pattern = 9pt circle
 - filters : F210M/F480M
 - repeat for the reference star
 - link all templates to non interruptible sequence

when finish run smart accounting to estimate the observing windows and the charged time

