Bin Ren (bin.ren@oca.eu), Nice, 2023-06-27

European Research Council
Established by the European Commission

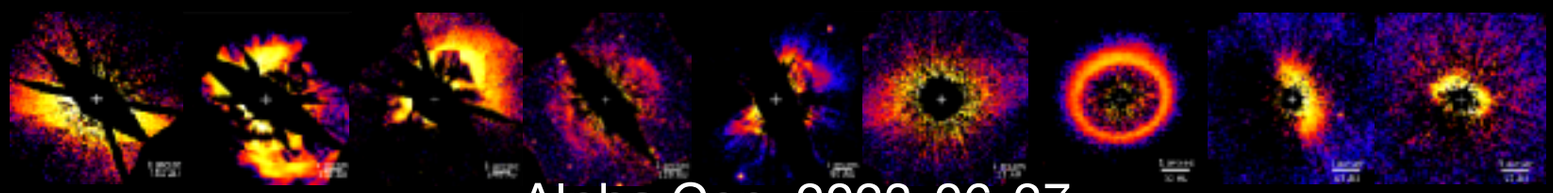
MARIE CURIE ACTIONS

Imaging “Behind” *Hubble* Coronagraph

(STIS calibration program GO-17135)

Bin Ren

Marie S.-Curie Fellow, hosted at Observatoire de la Côte d’Azur (OCA)



Alpha Cen, 2023-06-27

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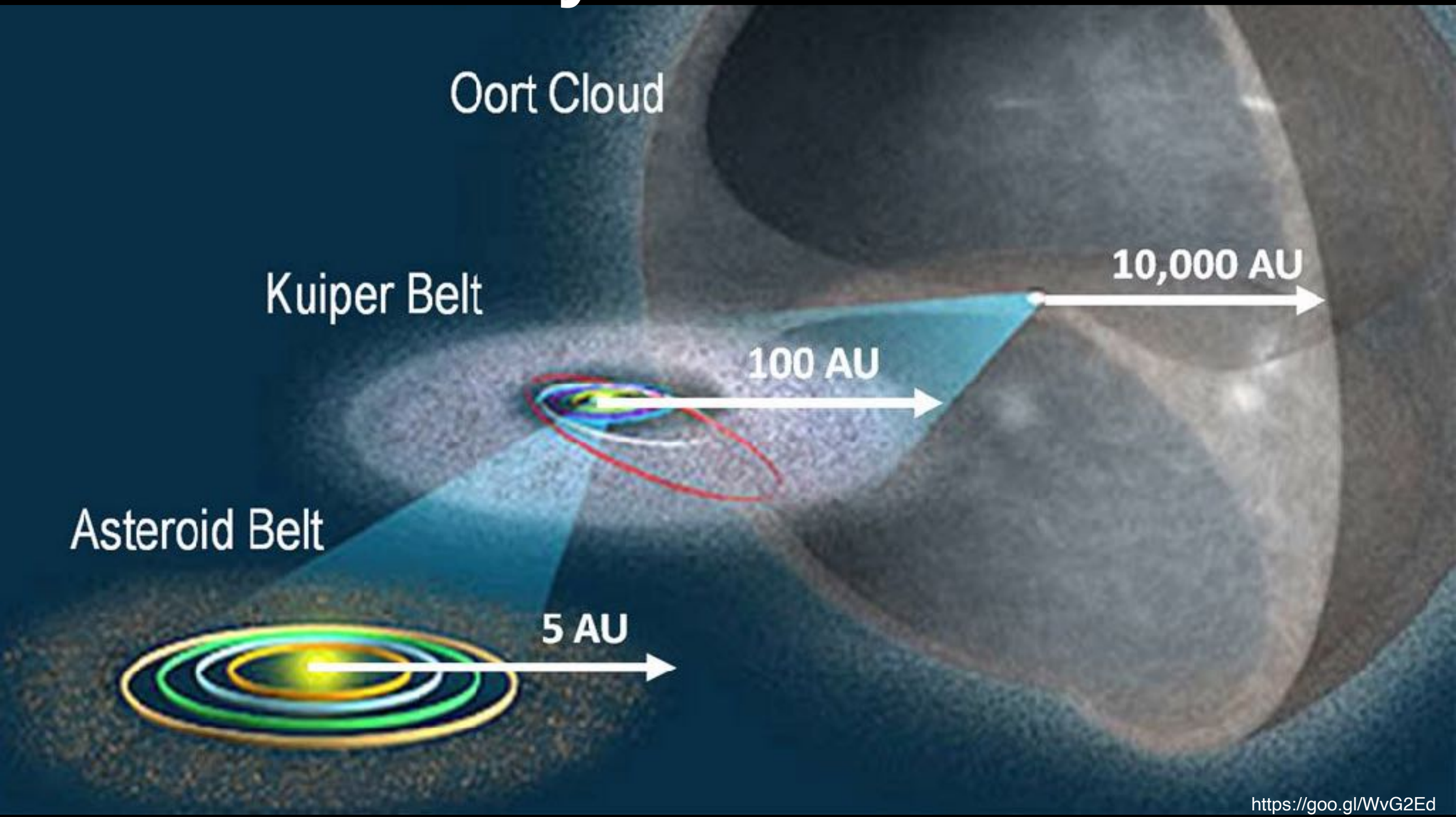
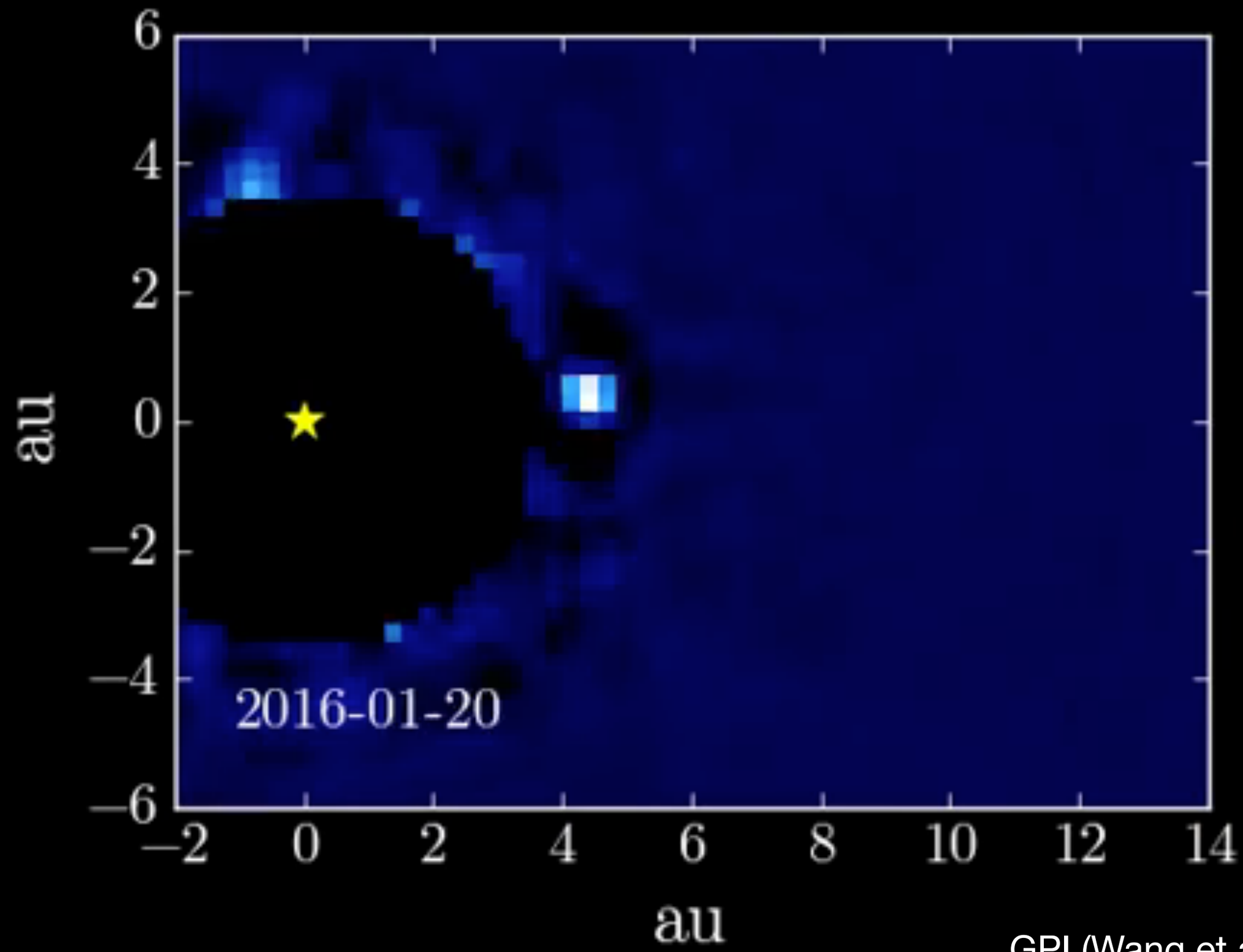
Solar System Structure



https://goo.gl/WvG2Ed

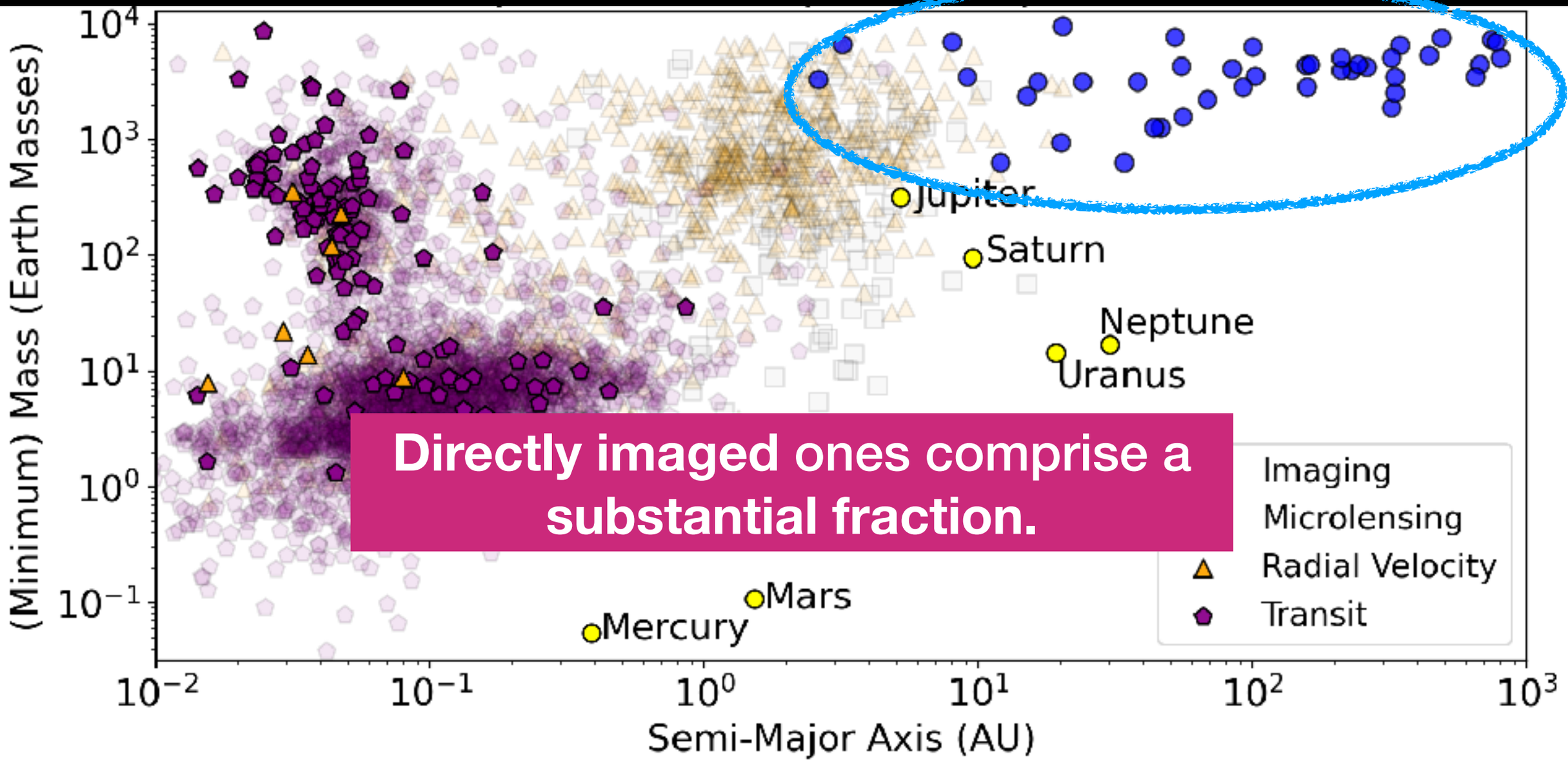
J. Bock et al.

N



GPI (Wang et al. 2016)

Direct imaging: 20-25 among 5000+ planets



Directly imaged ones comprise a substantial fraction.

Solid symbols: **175** spectroscopically characterized

Currie et al. (2022)

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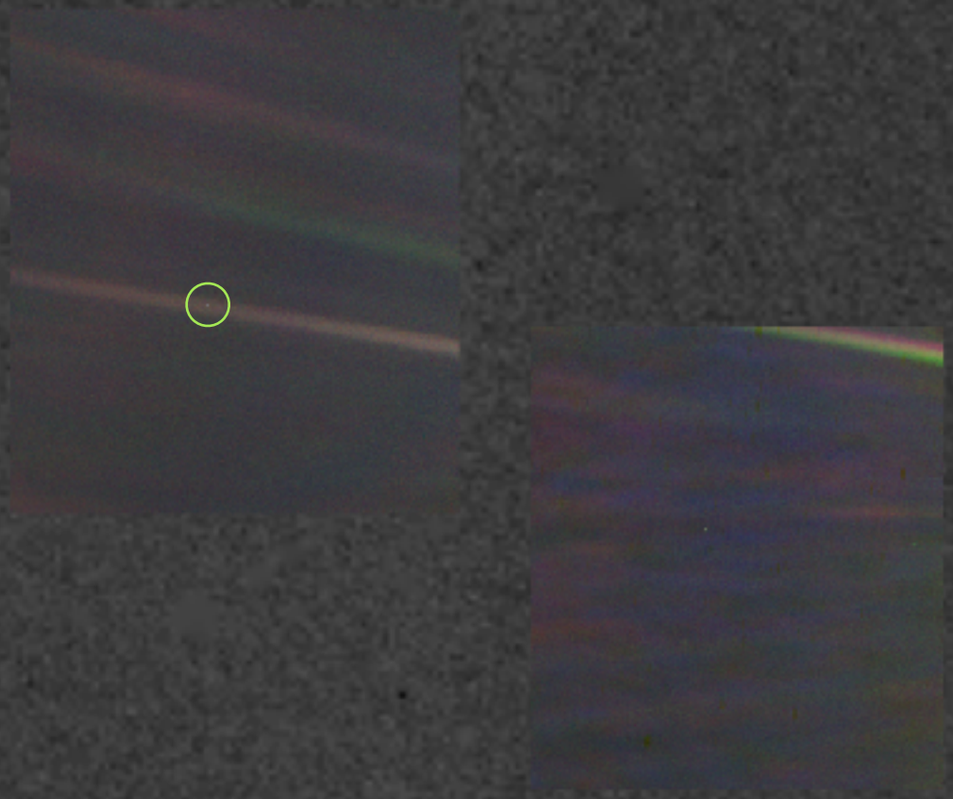
Planet/disk Imaging is Difficult



Close-in (~0.1”) and faint (10^6 to 10^{10})

“Pale blue dot”: Voyager 1, in 1990: link

Lighthouse & firefly: link

High Contrast Imaging

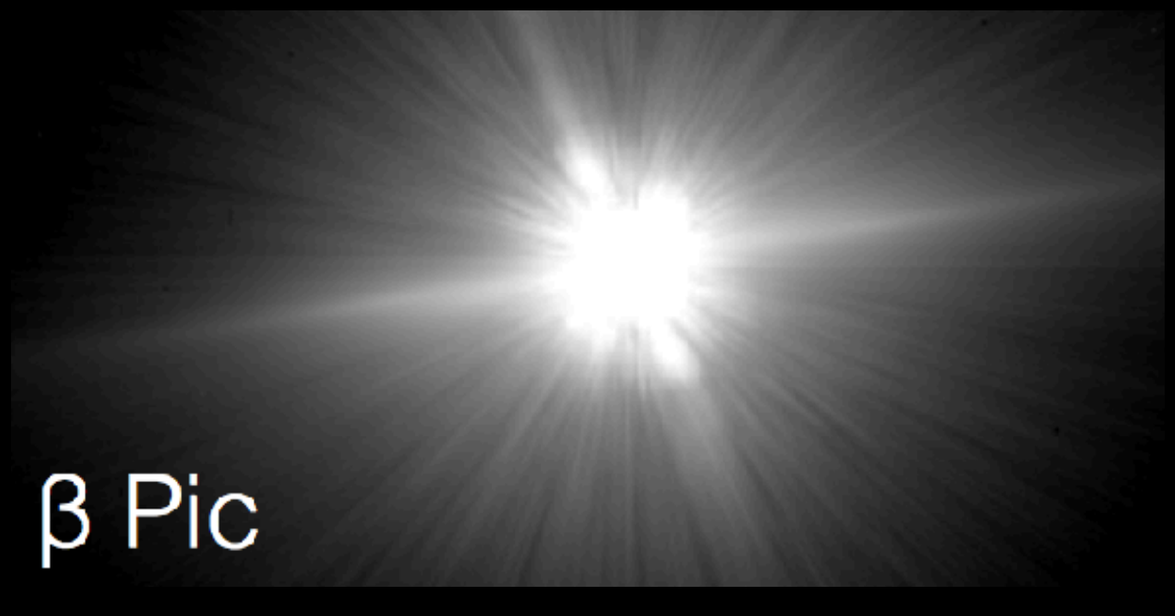
*——See faint things **near** bright sources.*

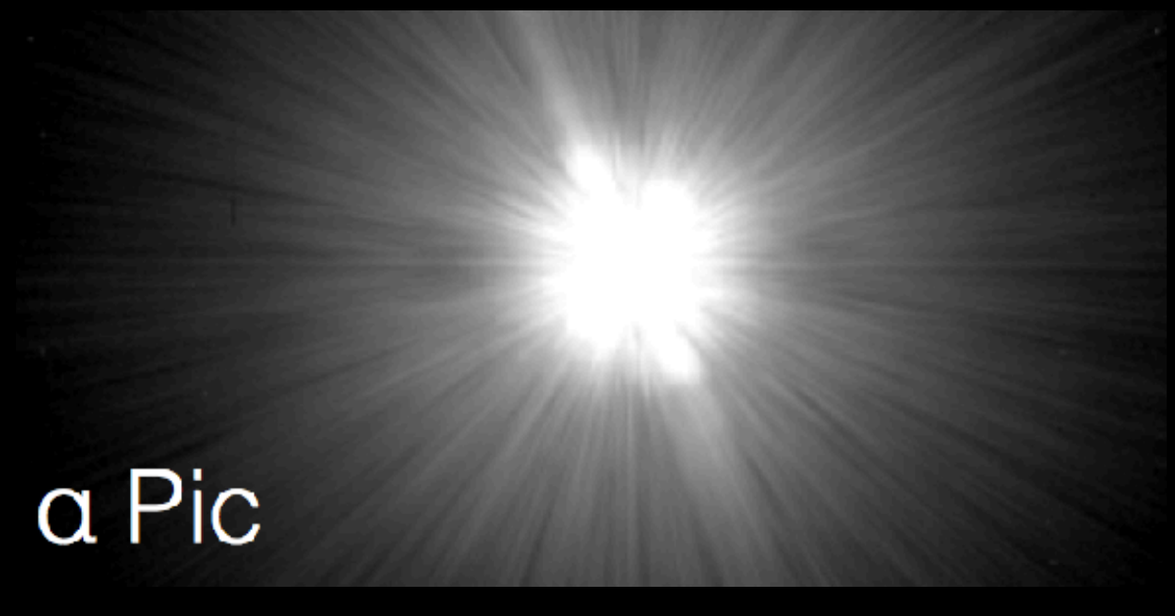
1. Use coronagraph to block some star light.
2. Use post-processing to remove residual light.

Reference Differential Imaging

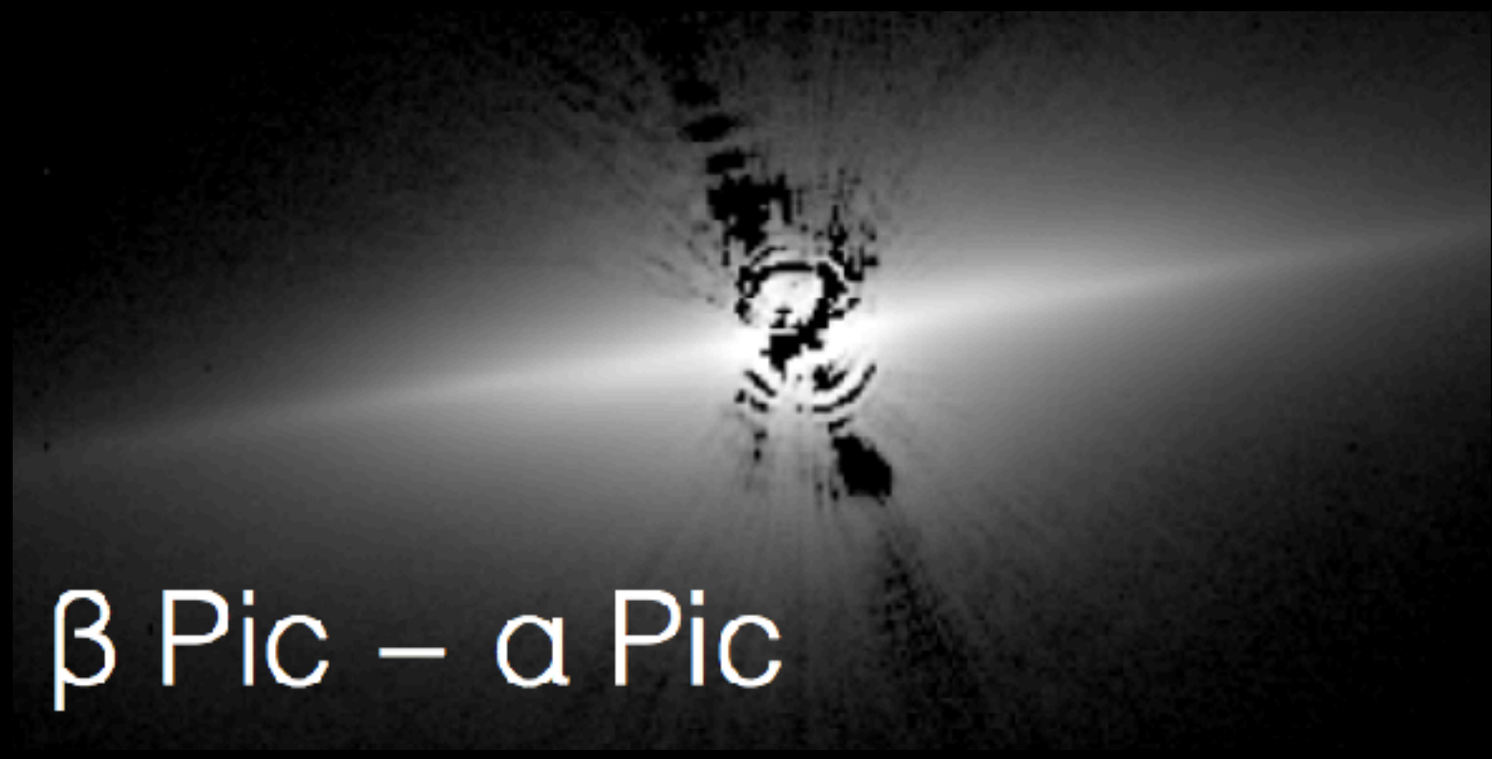
Target

Reference



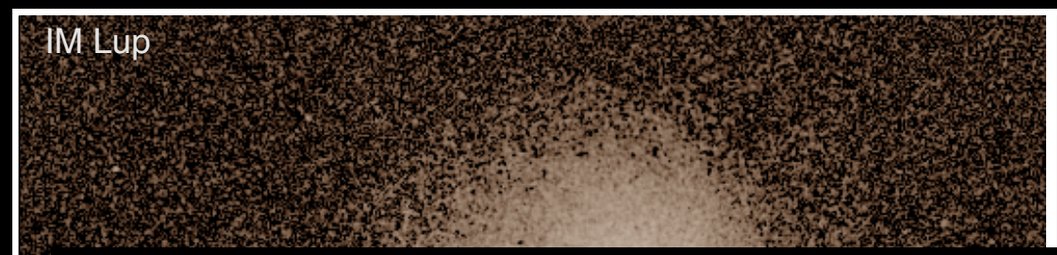


Result

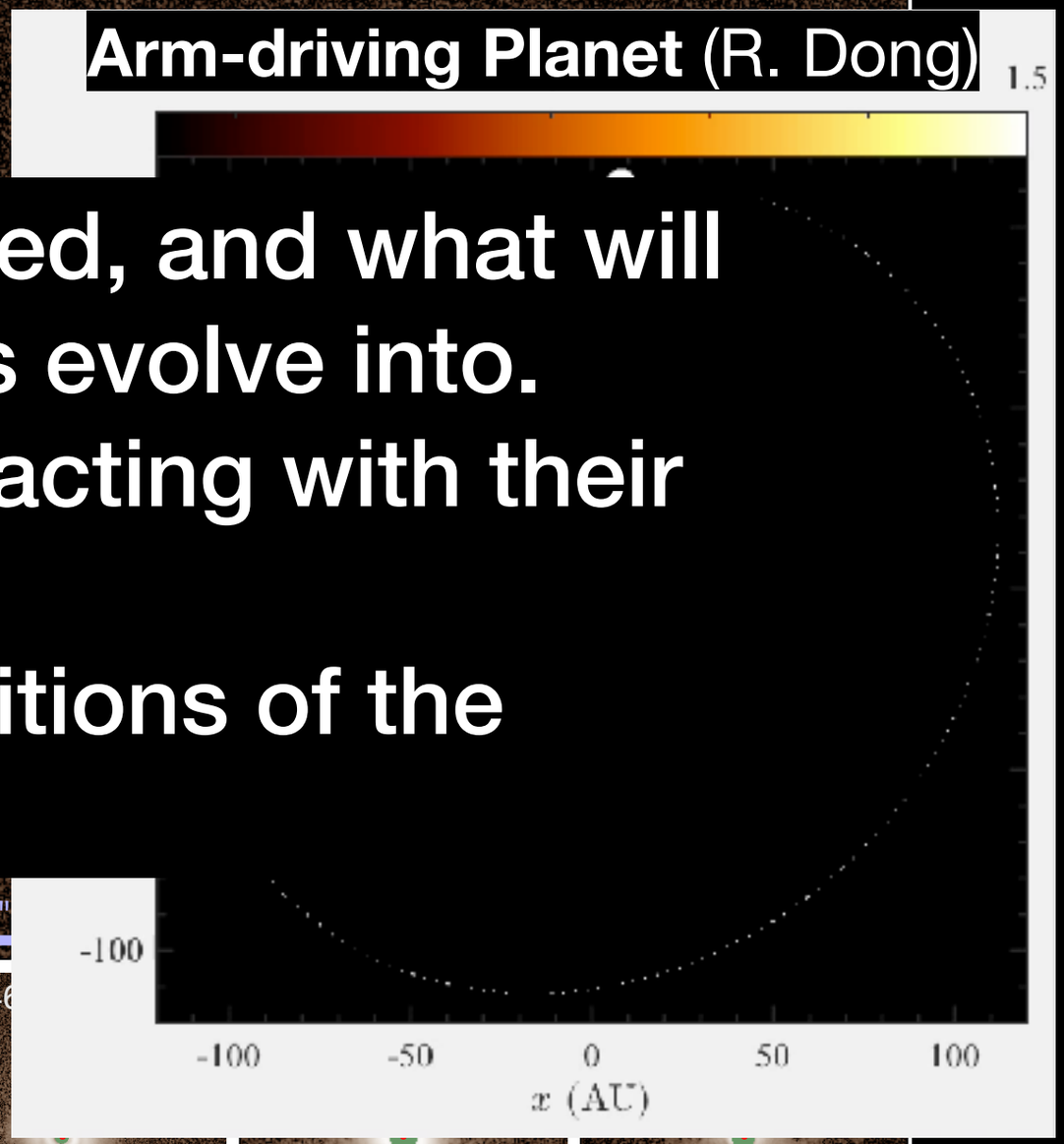


O. Absil

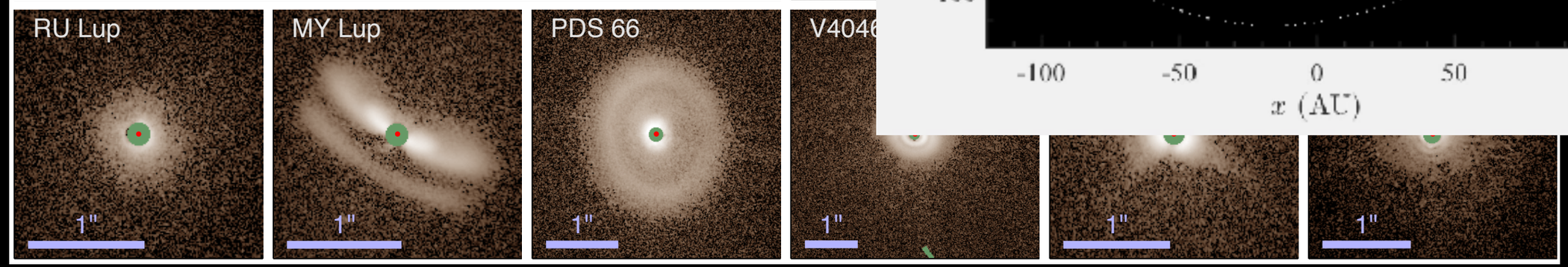
Answer Questions with Imaging



Arm-driving Planet (R. Dong)



1. How are planets formed, and what will the planetary systems evolve into.
2. How are planets interacting with their birthplace.
3. What are the compositions of the circumstellar dust.



Avenhaus et al. (2018)

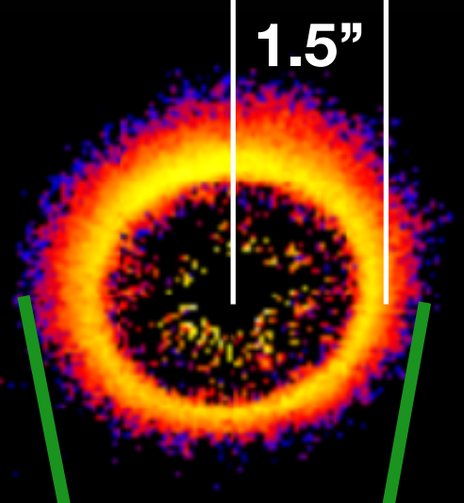
Hubble Space Telescope

Space Telescope Imaging Spectrograph (STIS)

Image: NASA

Bin Ren (bin.ren@oca.eu), Nice, 2023-06-27

STIS Resolution



d ≈ 6 km mountain

1 pixel ≈ 90 m

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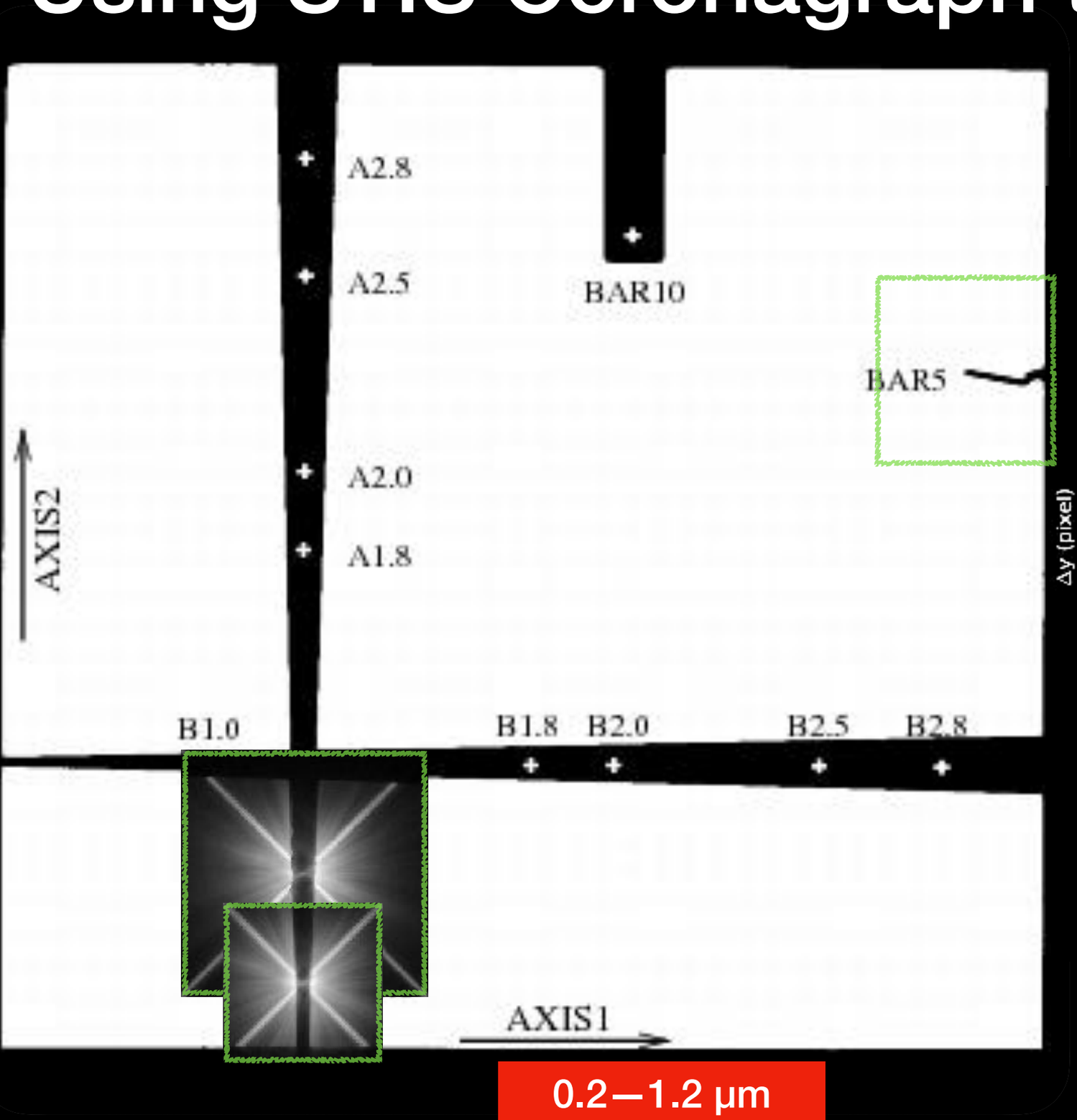
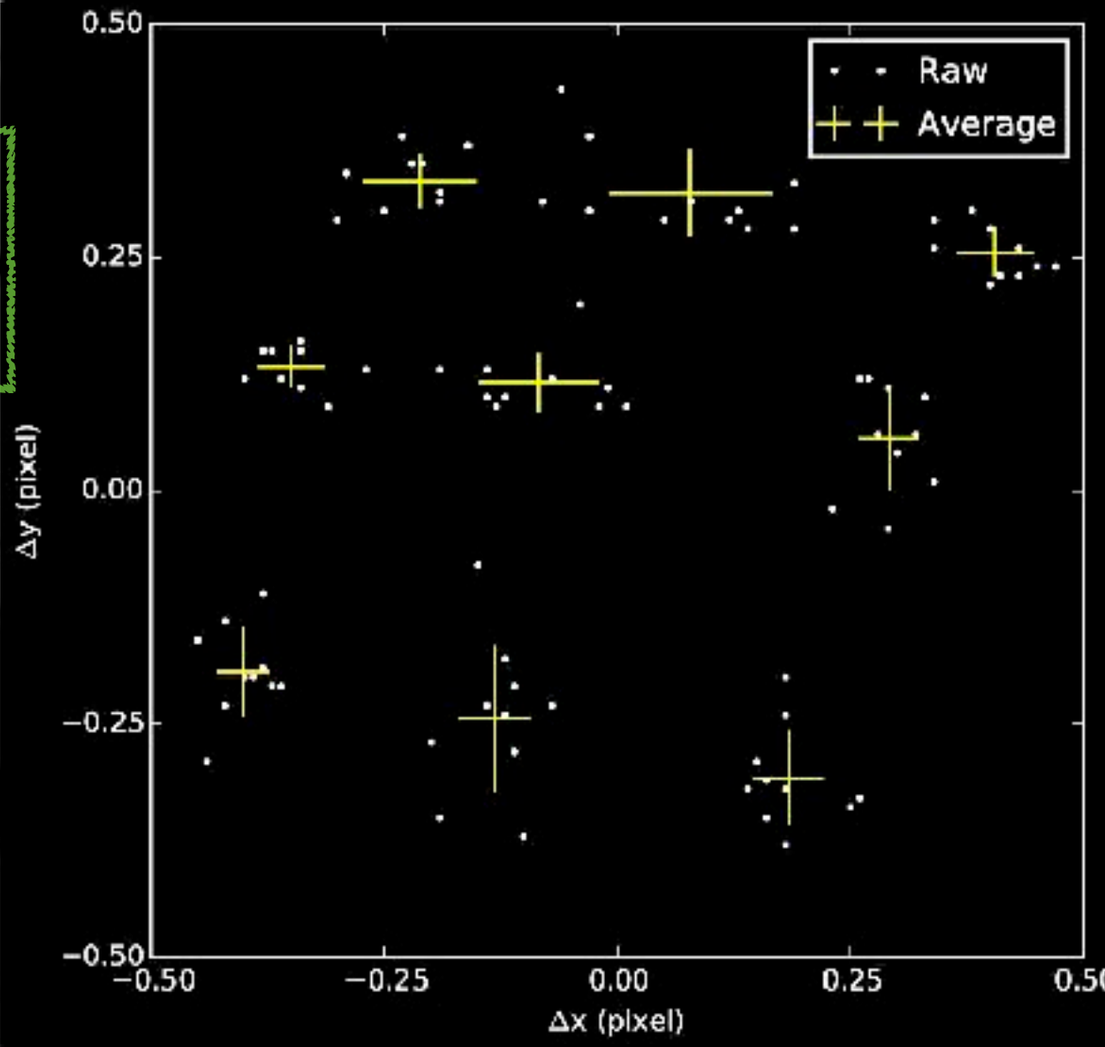
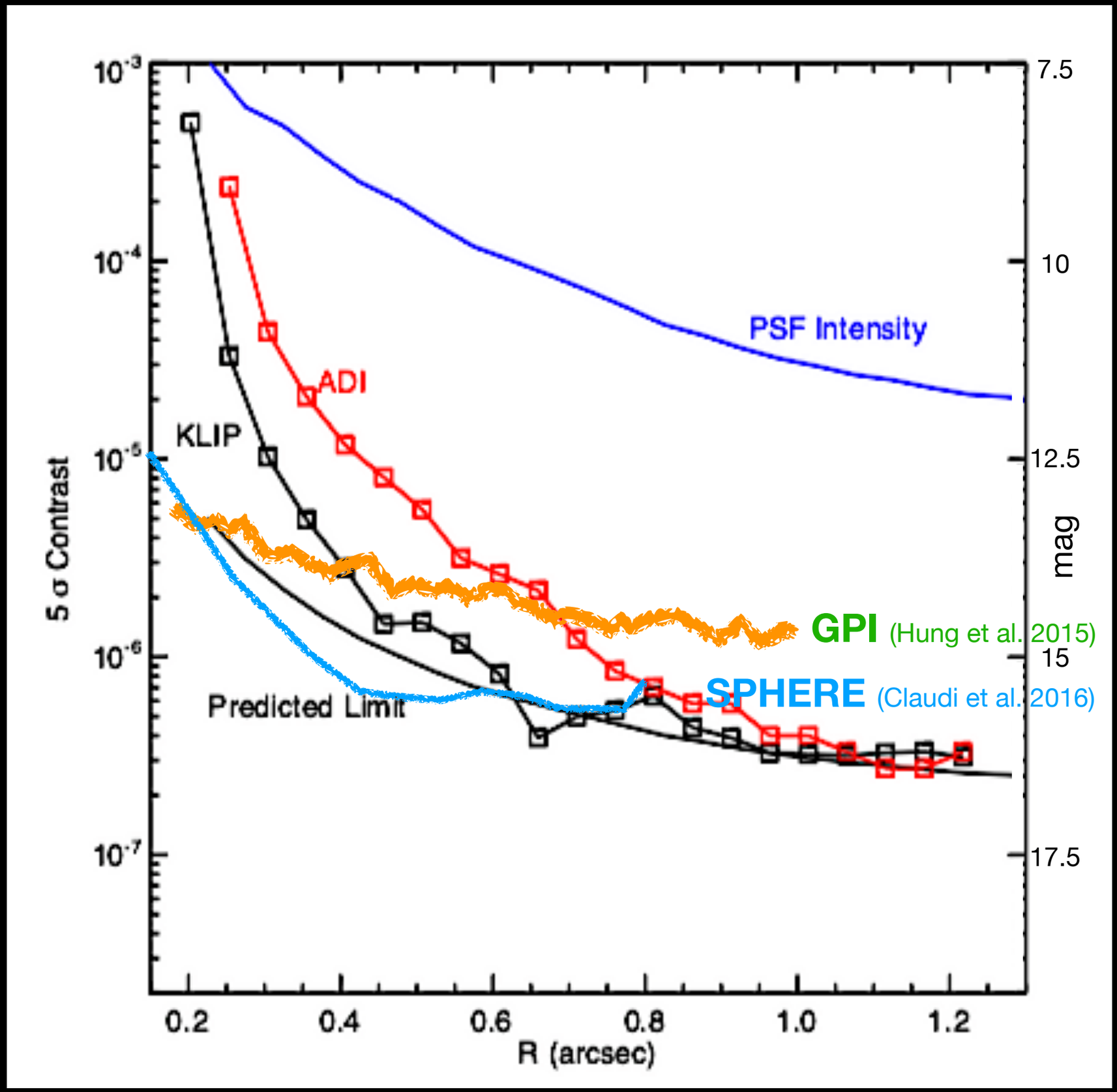
Using STIS Coronagraph to Block Star Light





0.2—1.2 μm
1024x1024 pixel
50.72 mas pixel^{-1}

Ren et al. (2017)

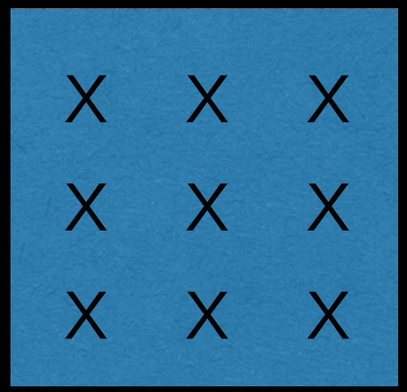


exoplanet searching machine

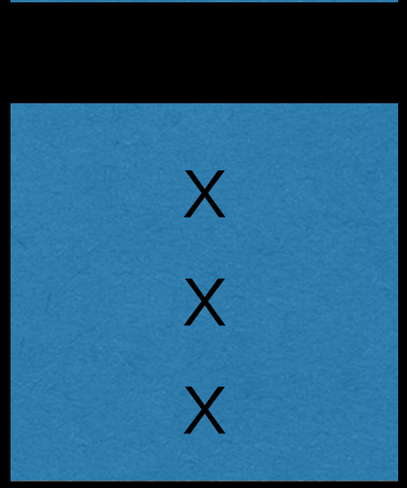
Ren et al. (2017); Debes, Ren & Schneider (2019)

Sub-Pixel Dithering Improves Contrast

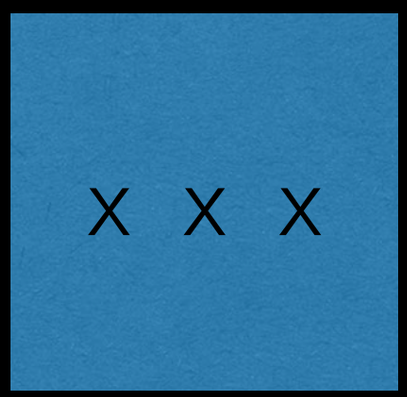
3x3

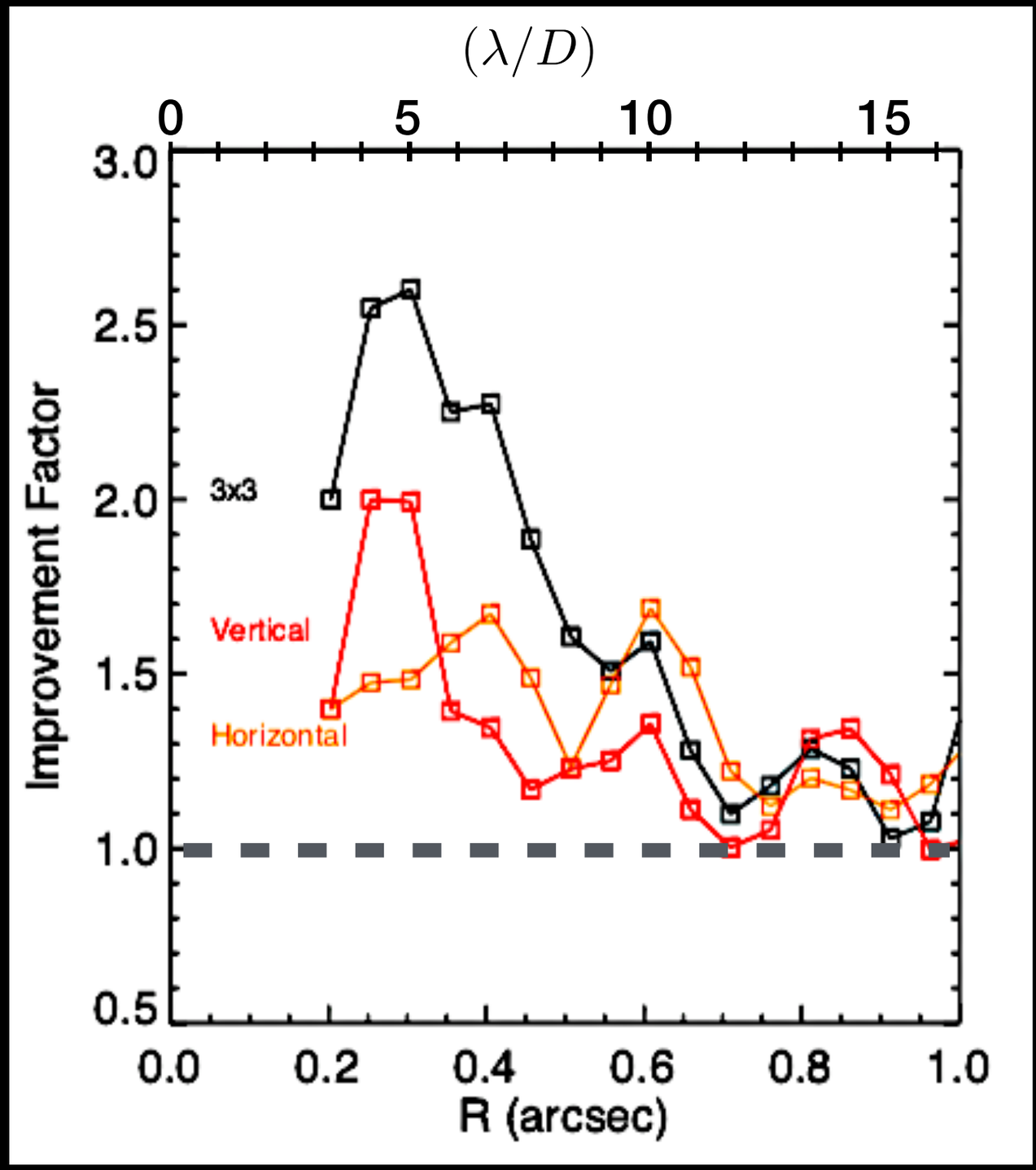


3x1



1x3

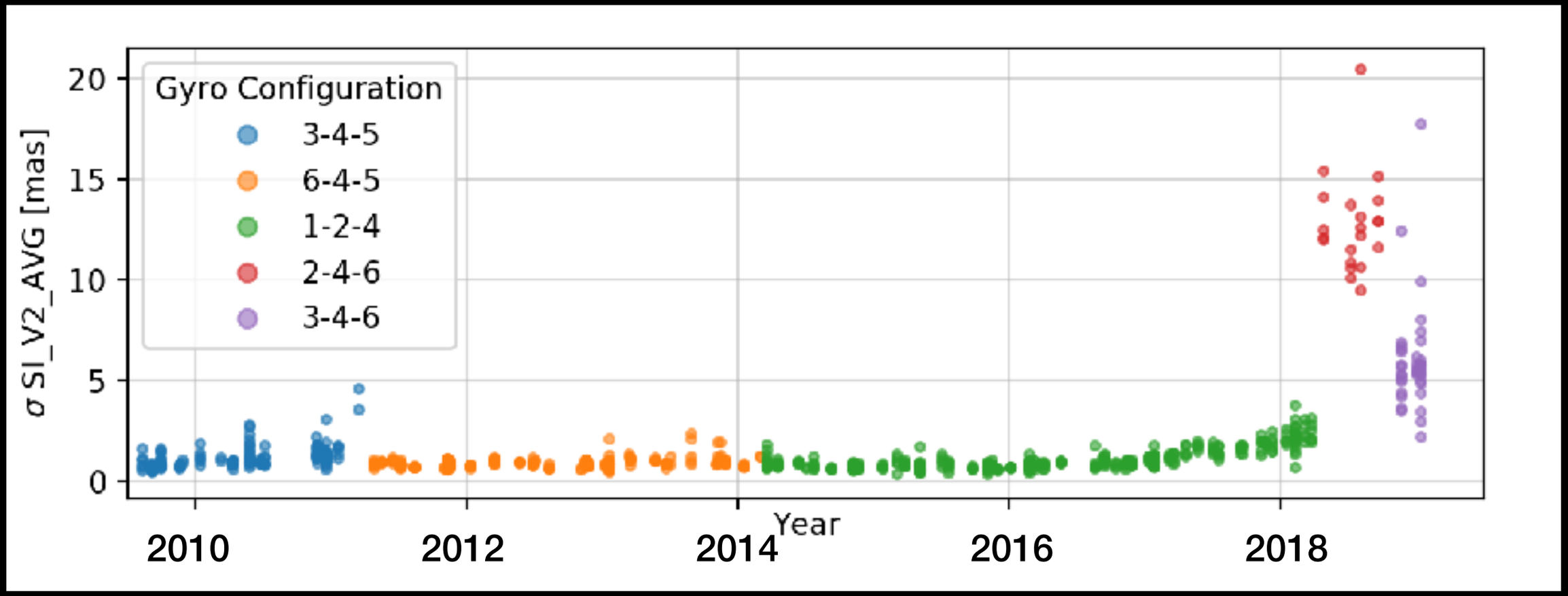




Debes, Ren & Schneider (2019)

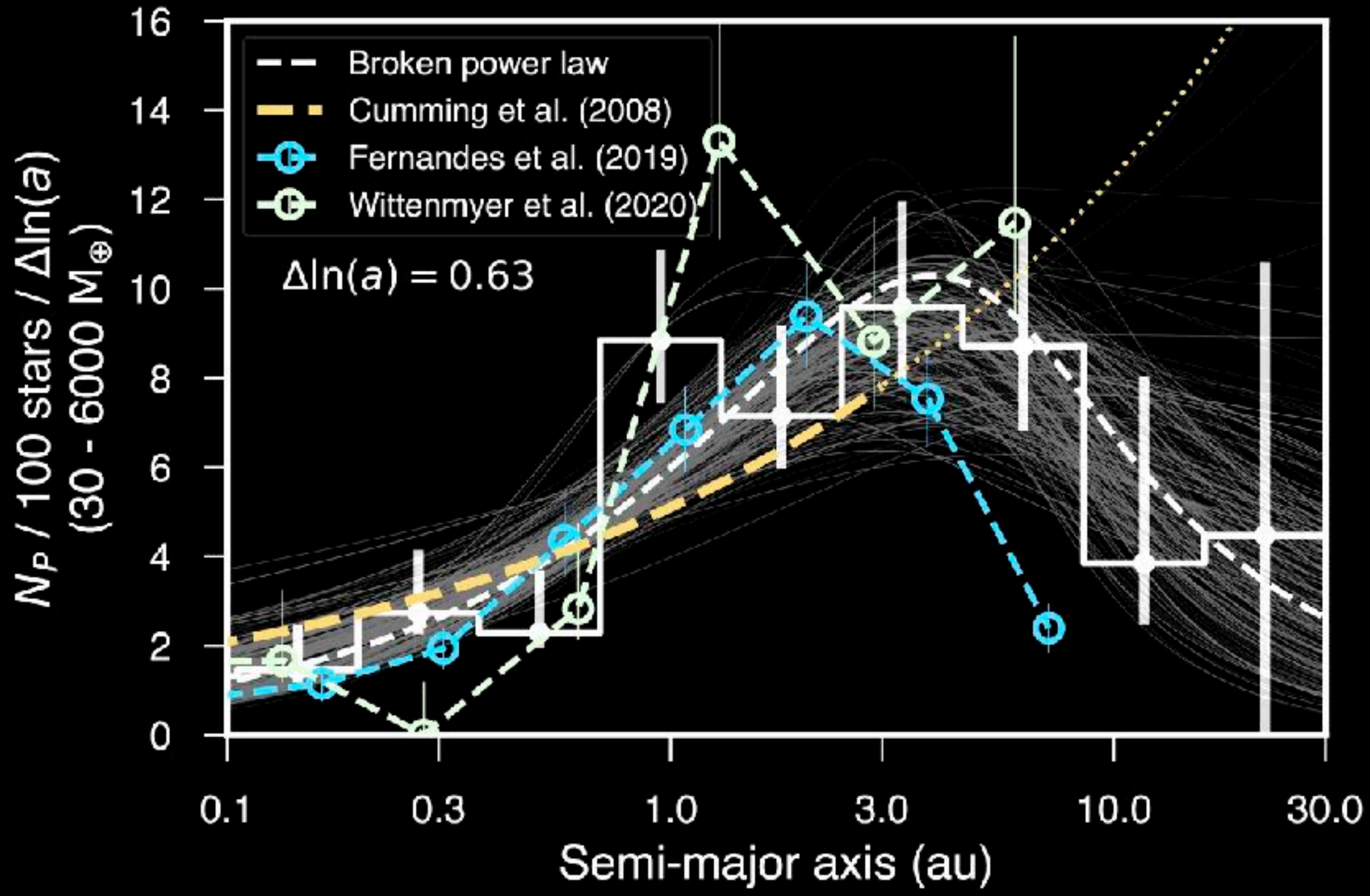
MIRI (~10): Soummer et al. (2014a)
NIRCam (~4): Lajoie et al. (2016)

STIS pointing accuracy



3mas **7mas**

Planet occurrence: most populous at 1 - 10 au



Fulton et al. (2021)

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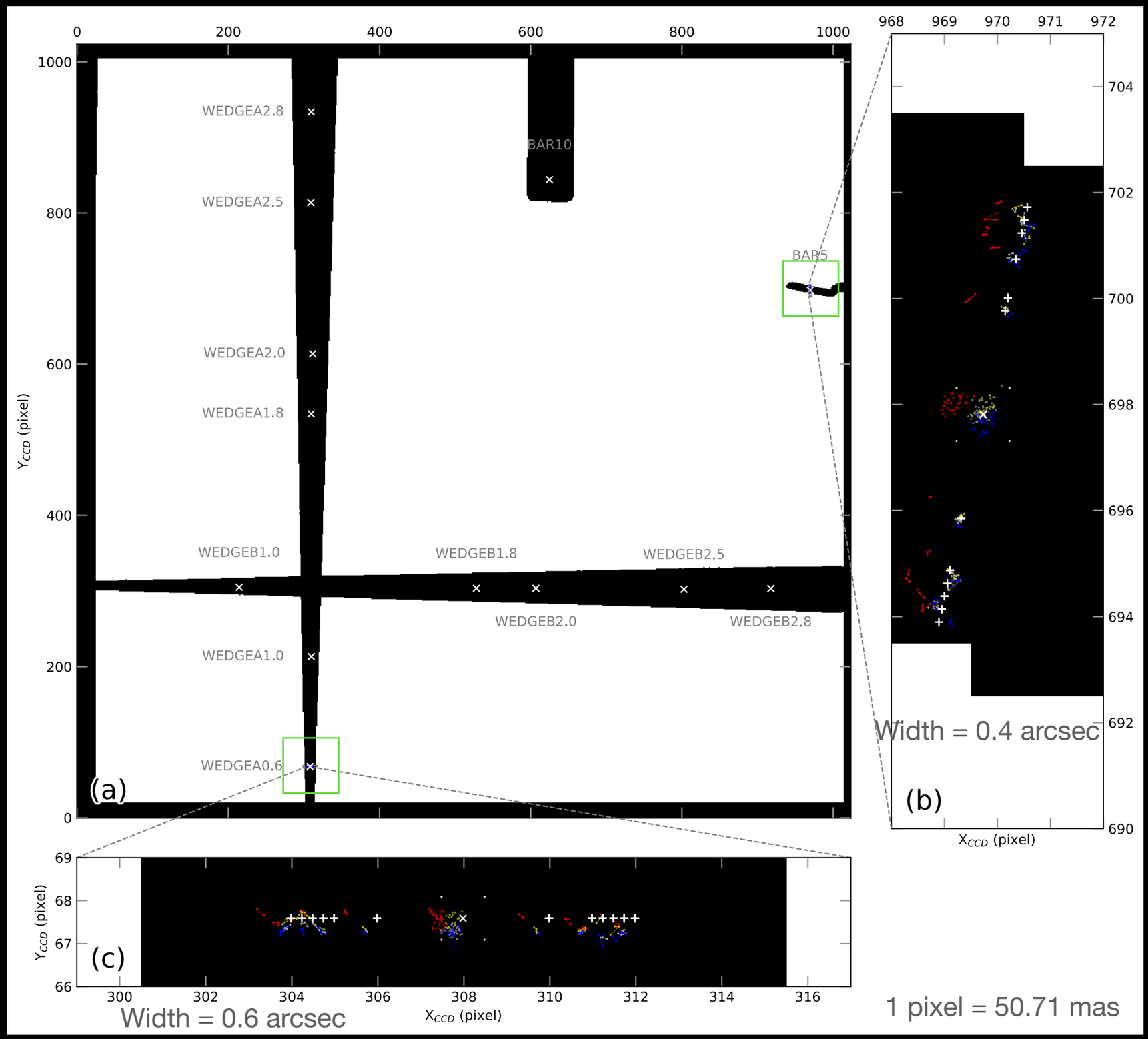
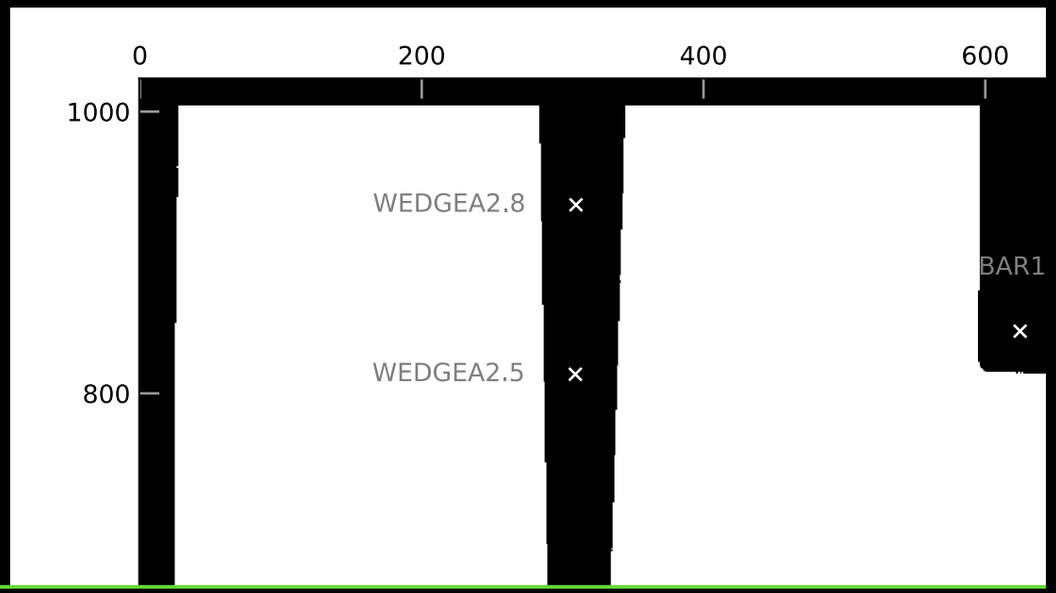
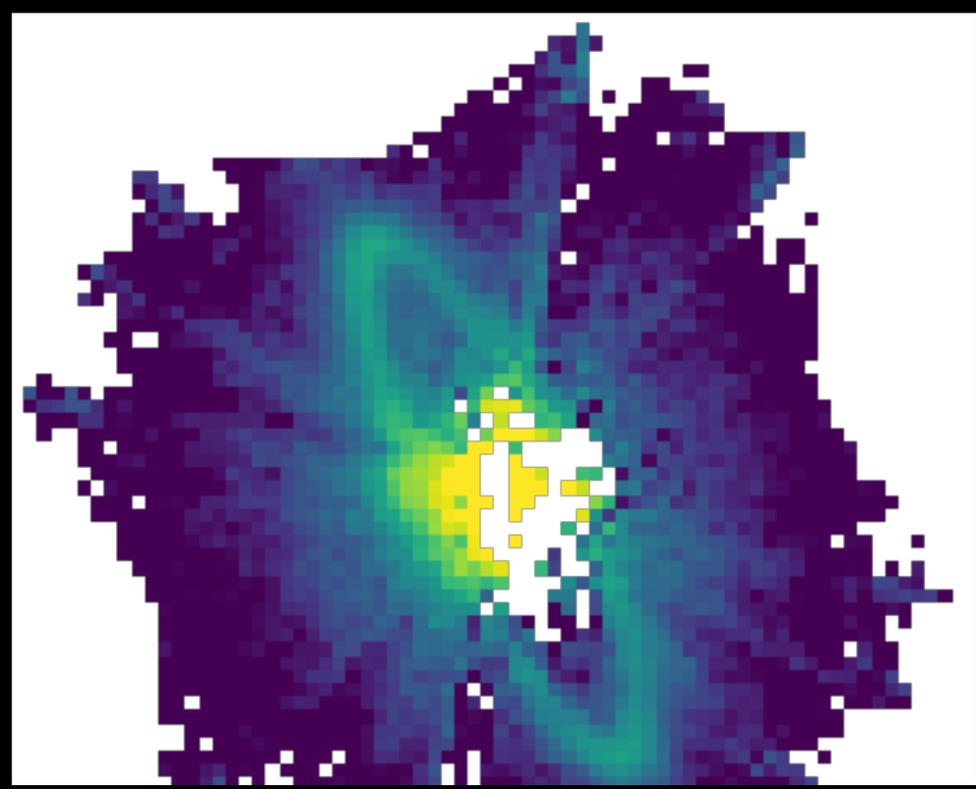
Calibration Program GO-17135

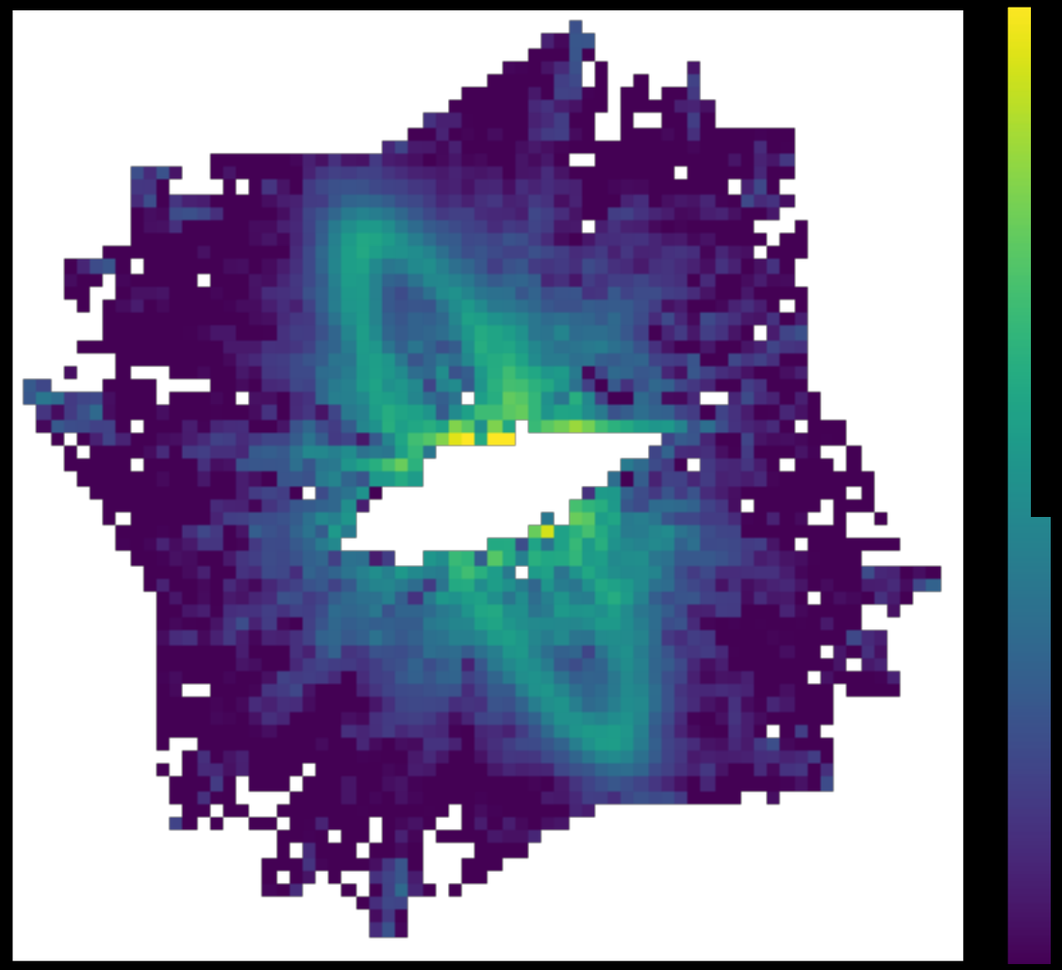


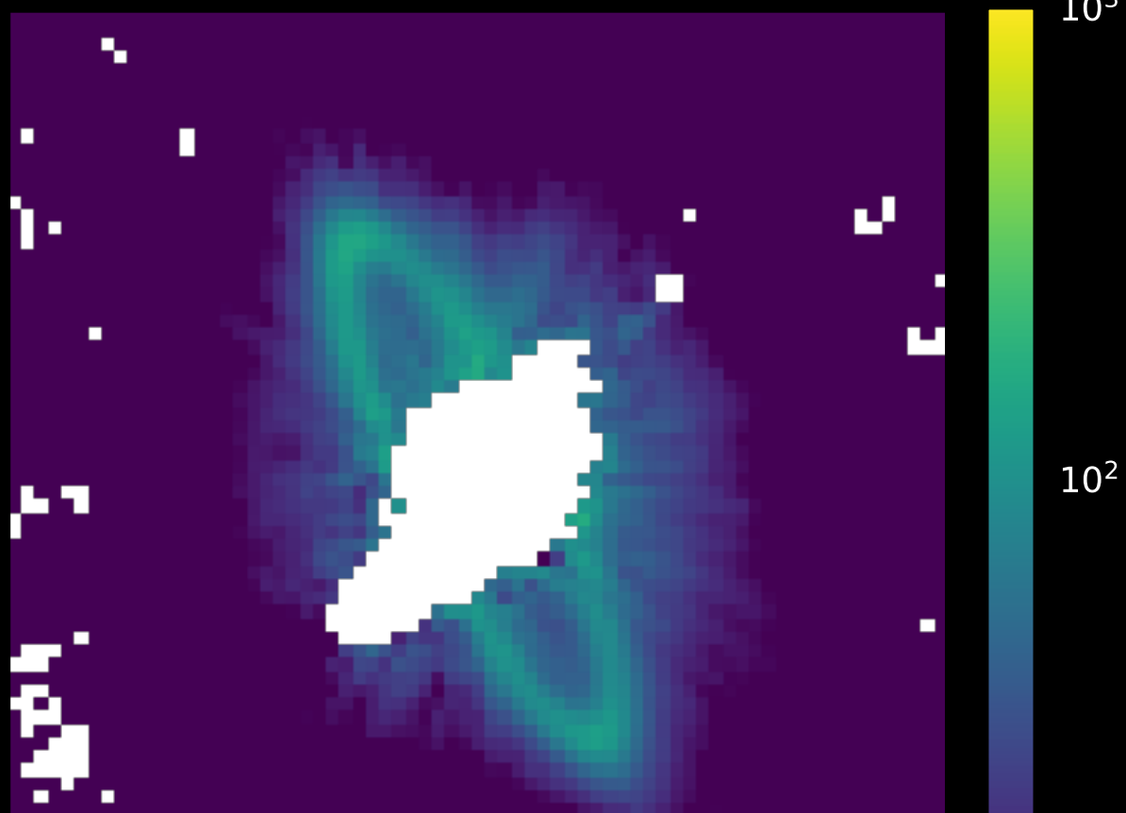




bar5 (previous)

wa06



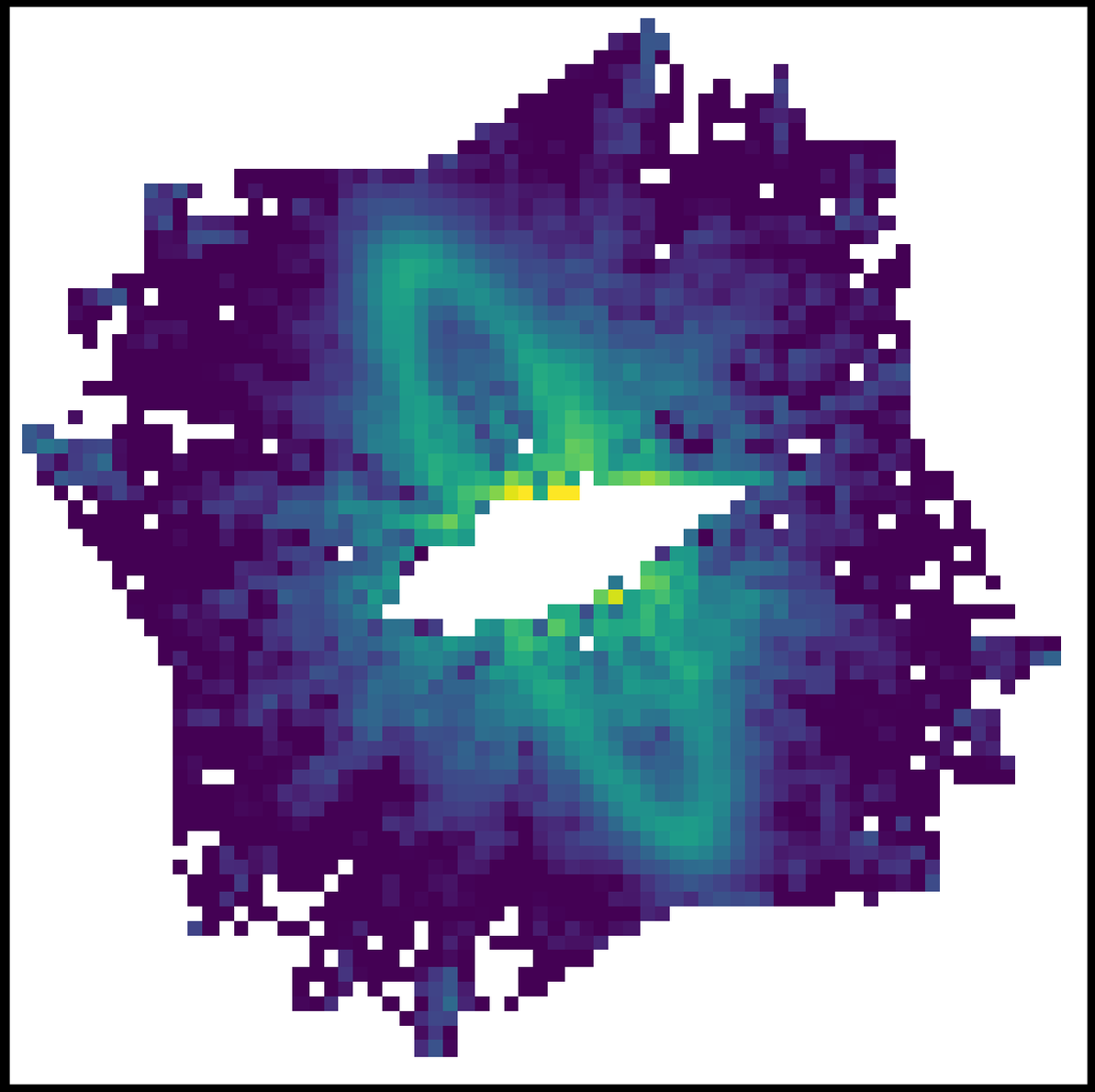


Width = 0.6 arcsec

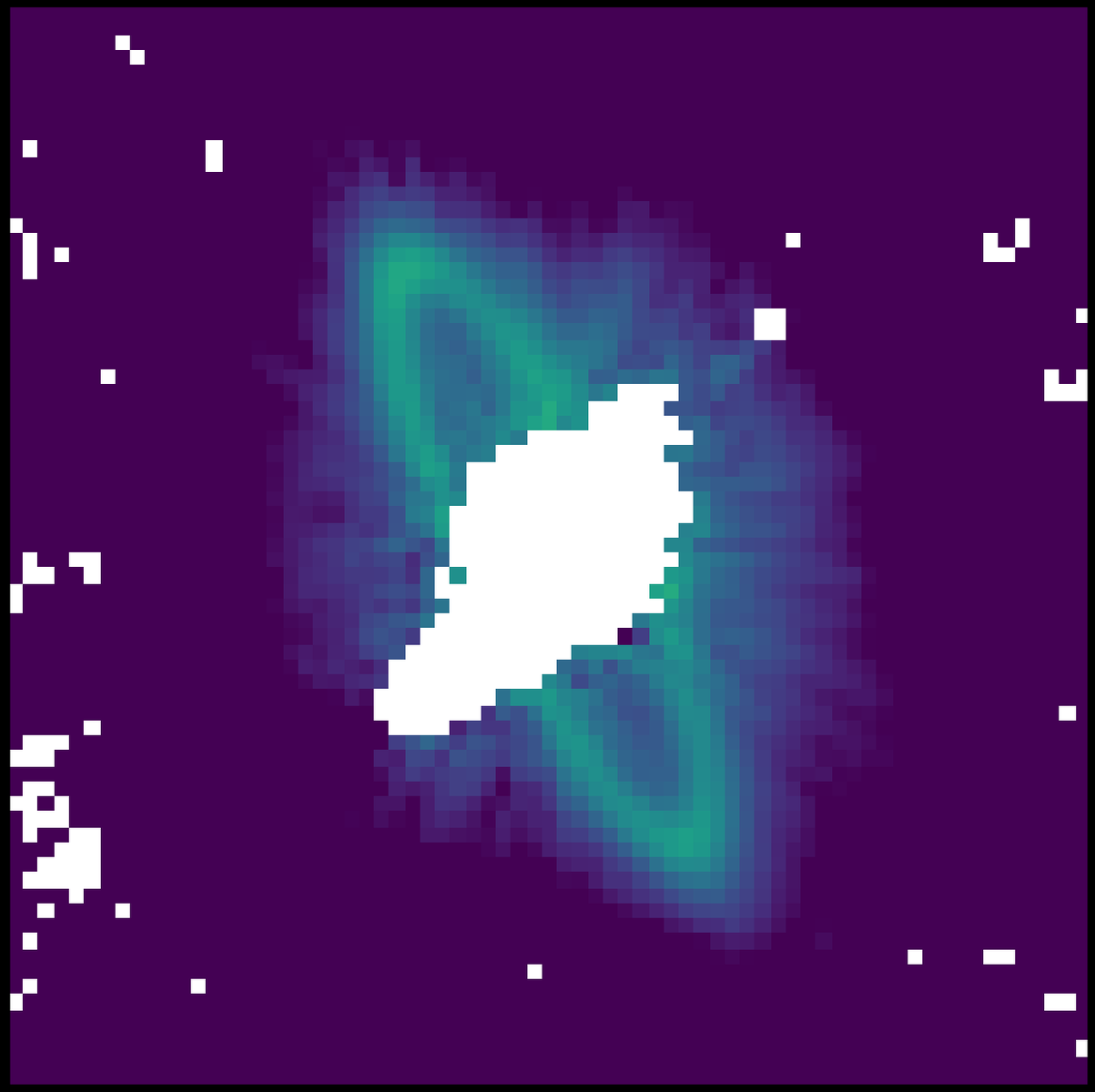
X_{CCD} (pixel)

Bin Ren (bin.ren@oca.eu), Nice, 2023-06-27

wa06



bar5 (previous)



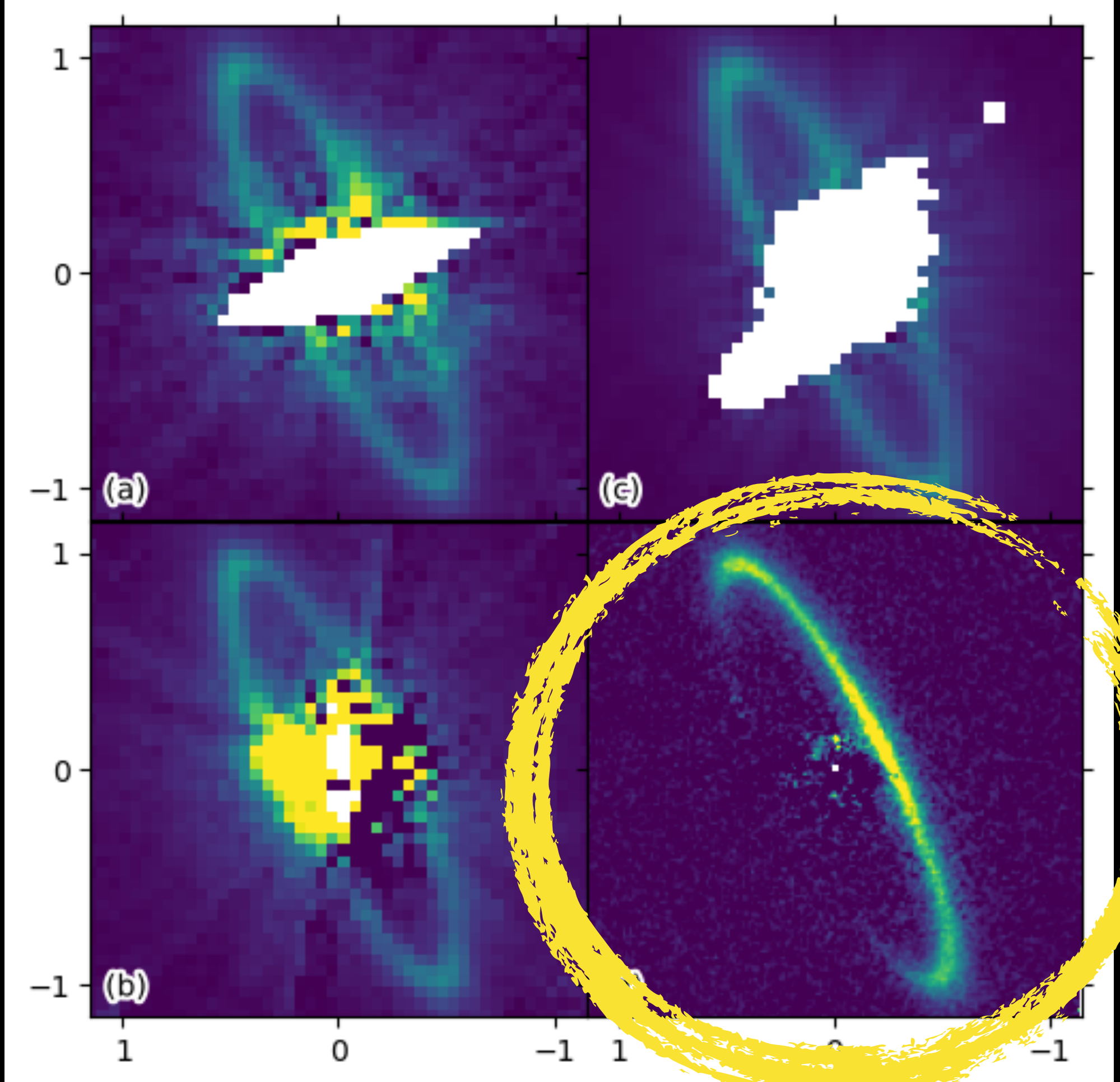
Closer-in regions with occulter 50% larger.

GO-17135

Schneider et al. (2018)

WedgeA0.6

BAR5



Schneider et al. (2018)

Perrin et al. (2015)

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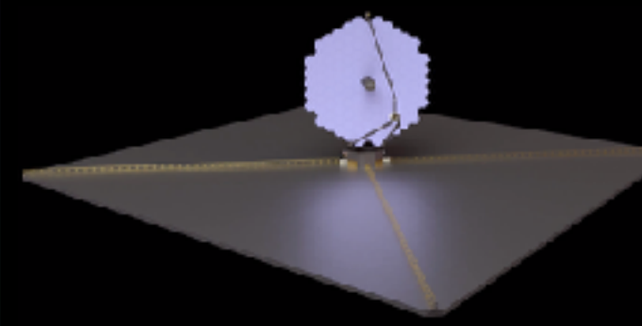
Jupiter

Venus

Earth

LUVOIR simulation



First images arrived only ~15 years ago.

Summary

- *HST*/STIS: GO-17135
  - **Enabled** closer-in region imaging by imaging the regions behind the WedgeA0.6 occulter (nominal inner working angle ~ 0.3 arcsec) down to ~0.2 arcsec.
    - The BAR5 occulter (nominal inner working angle ~ 0.2 arcsec): **need** to reach ~0.1 arcsec.
- Precise telescope control enables this approach.
- *JWST*/NIRCam: in Cycle 2 (GO-3087).