The Bleeding Wedge: *JWST* Coronagraphy at the Limits of Believability

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On behalf of the JWST-TST High Contrast GTO team

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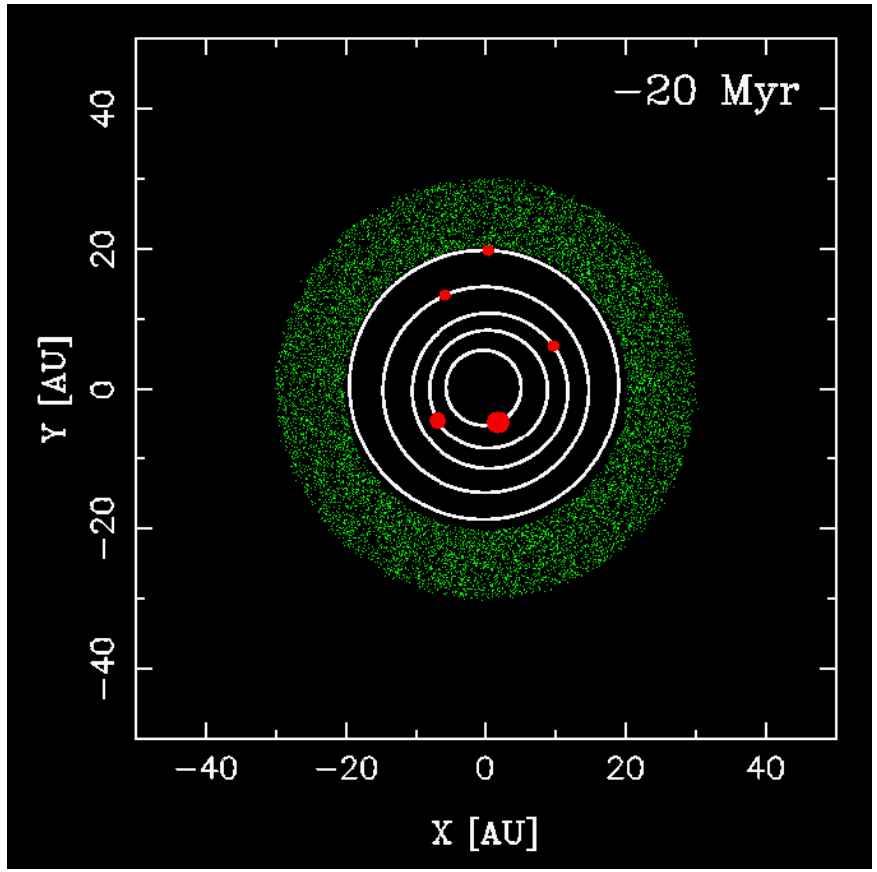
How did we get here?

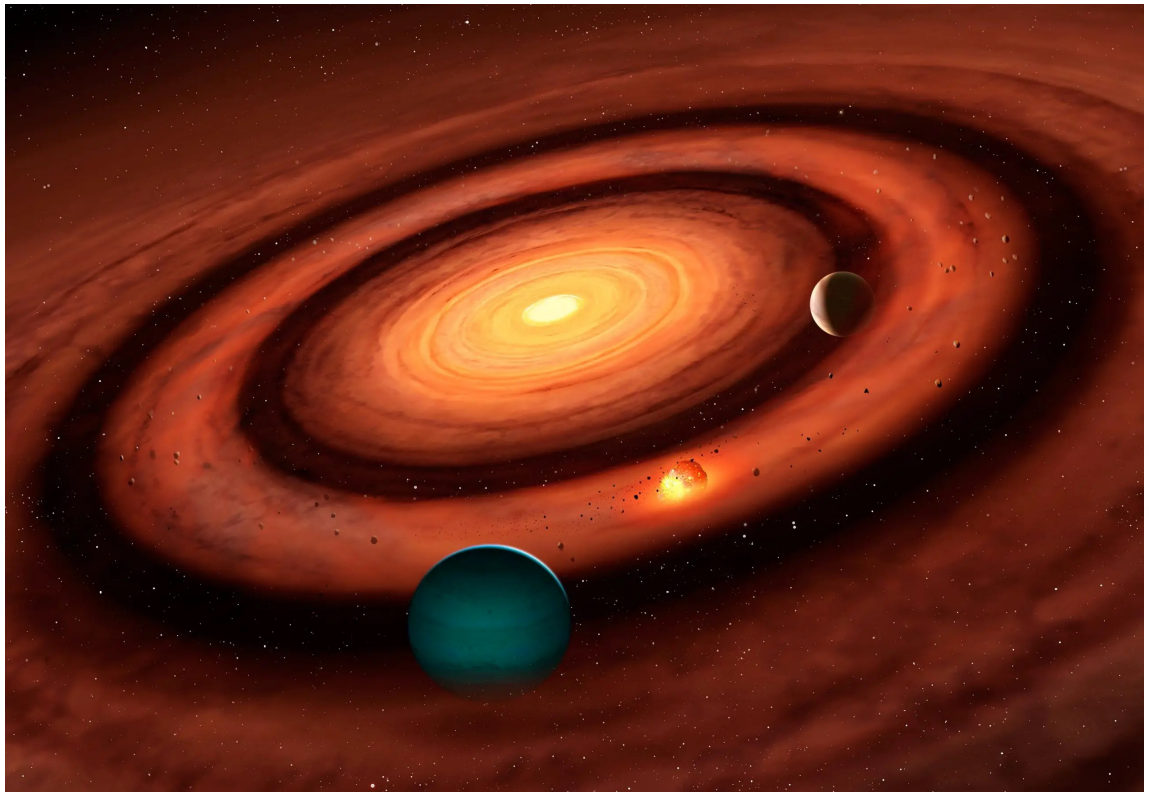
- Understanding our own Solar System (and therefore life) in context means understanding:
  - How do giant planets form and dynamically evolve?
  - How do giant planet frequencies change as functions of ___ (stellar metallicity, stellar mass, galactic location, galactic time)?
  - How unusual is the Solar System's architecture?

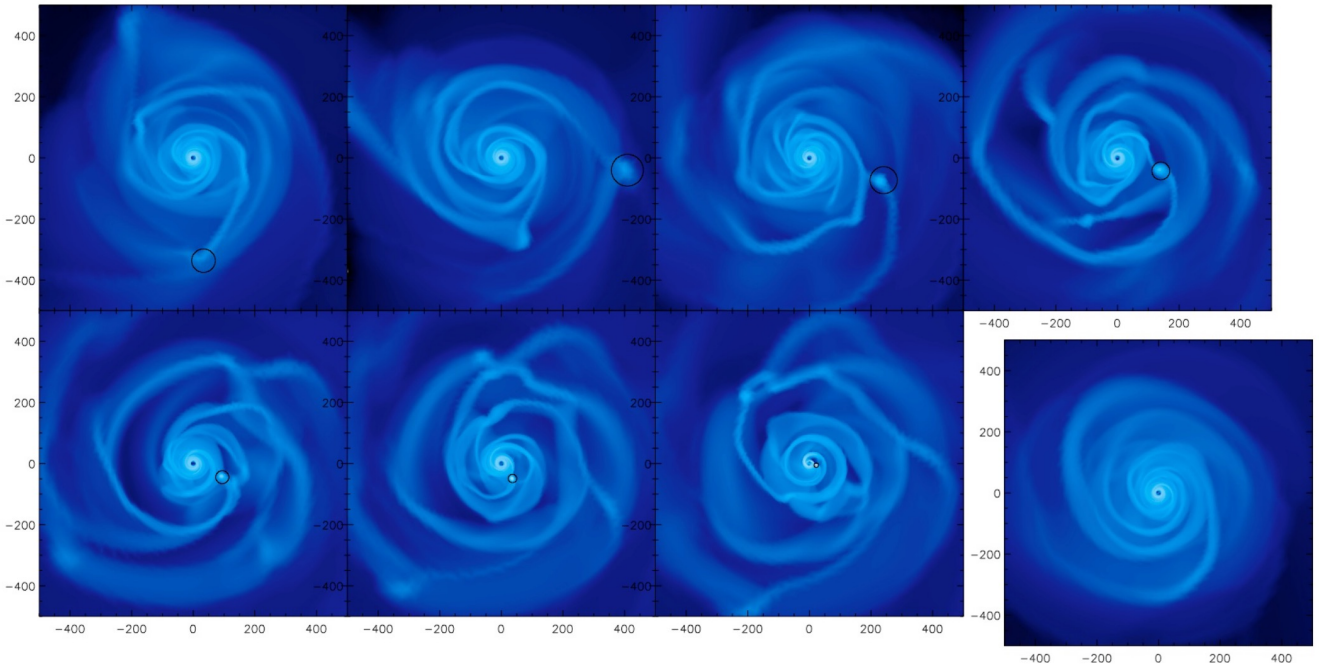


Scattering of a 5th solar system giant
David Nesvorny / SWRI

How can GPs form?

Core accretion rendition,
Garlick/University of Warwick





Disk instability SPH sim., Zhu+2011

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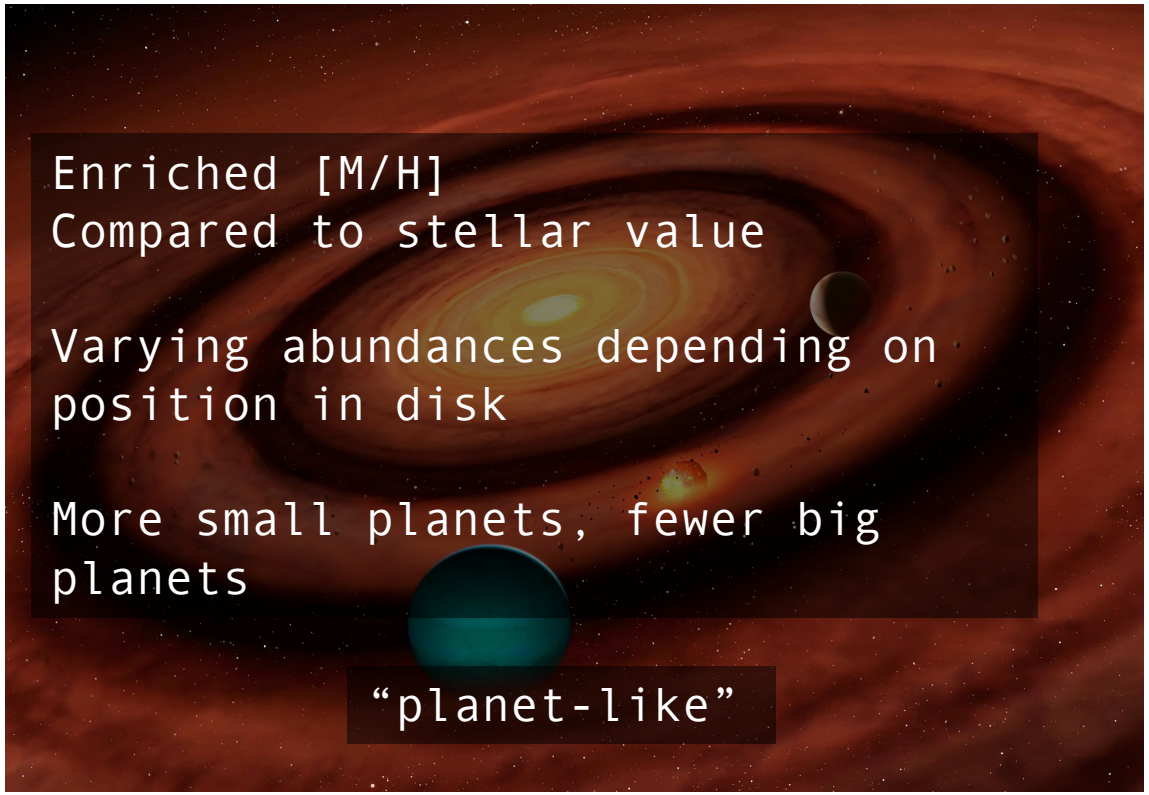
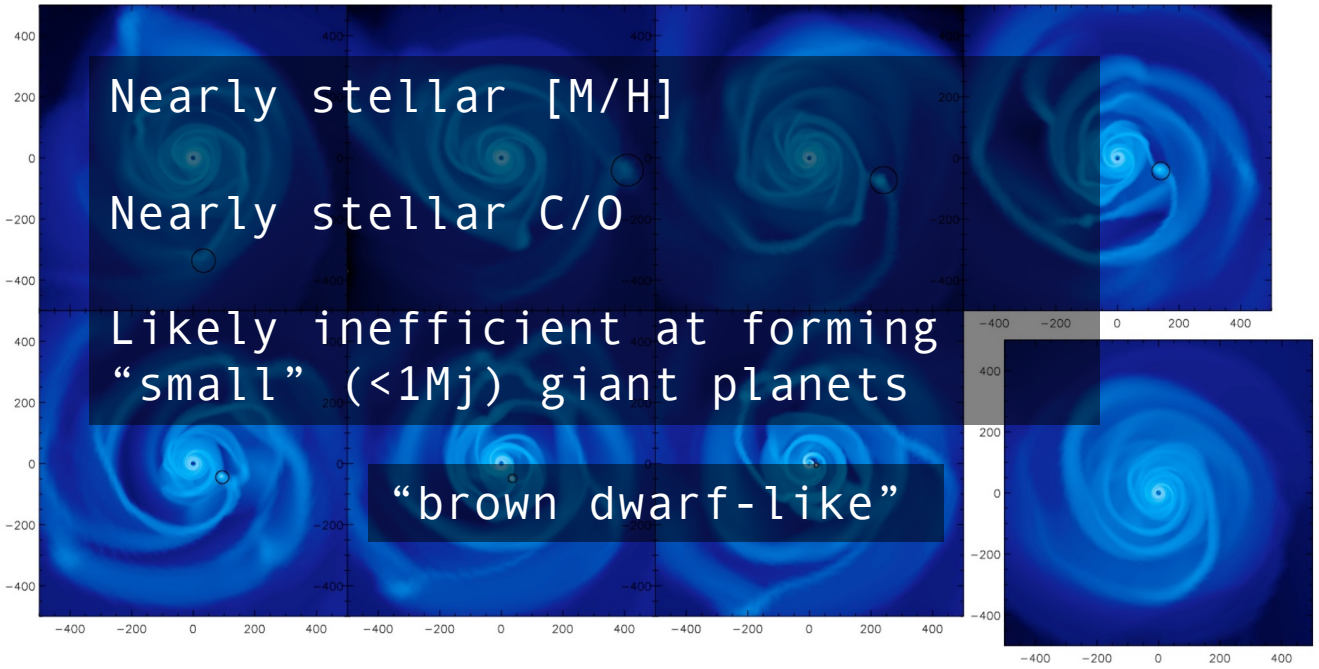




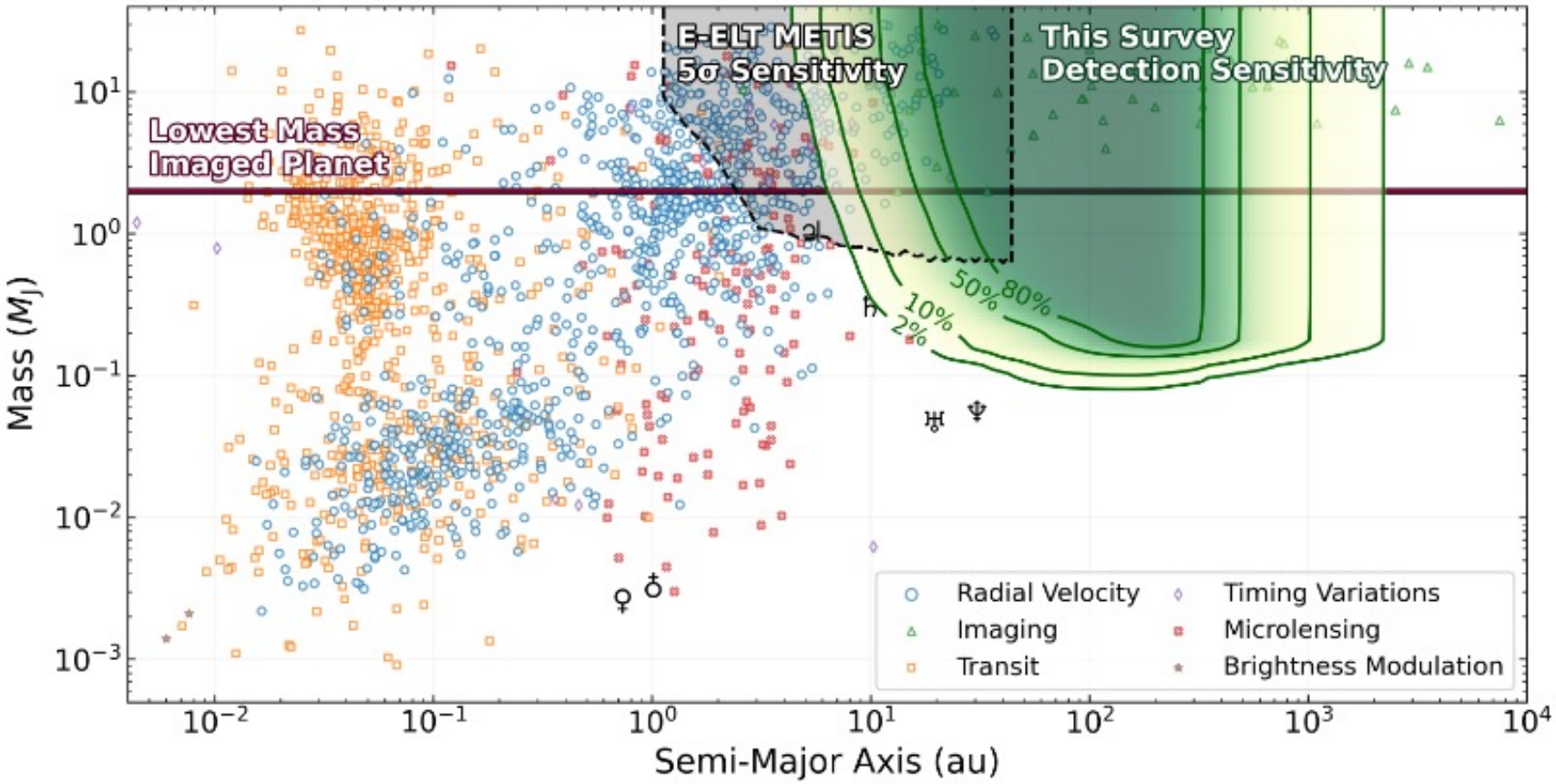
Disk instability SPH sim., Zhu+2011

Why go to space?

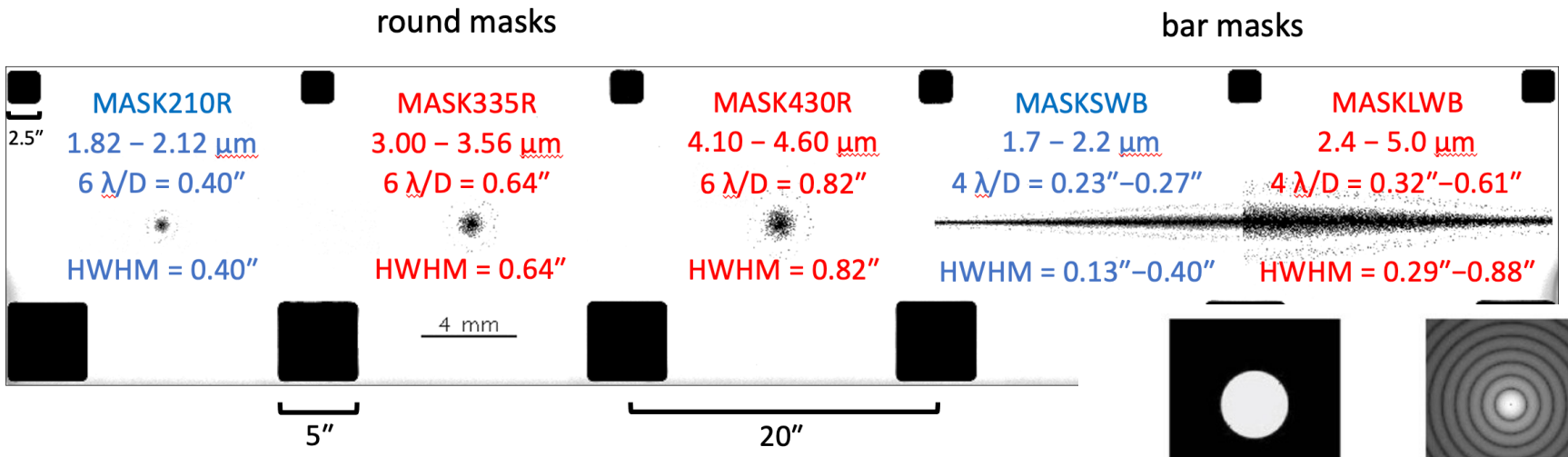
Figure courtesy A. Carter

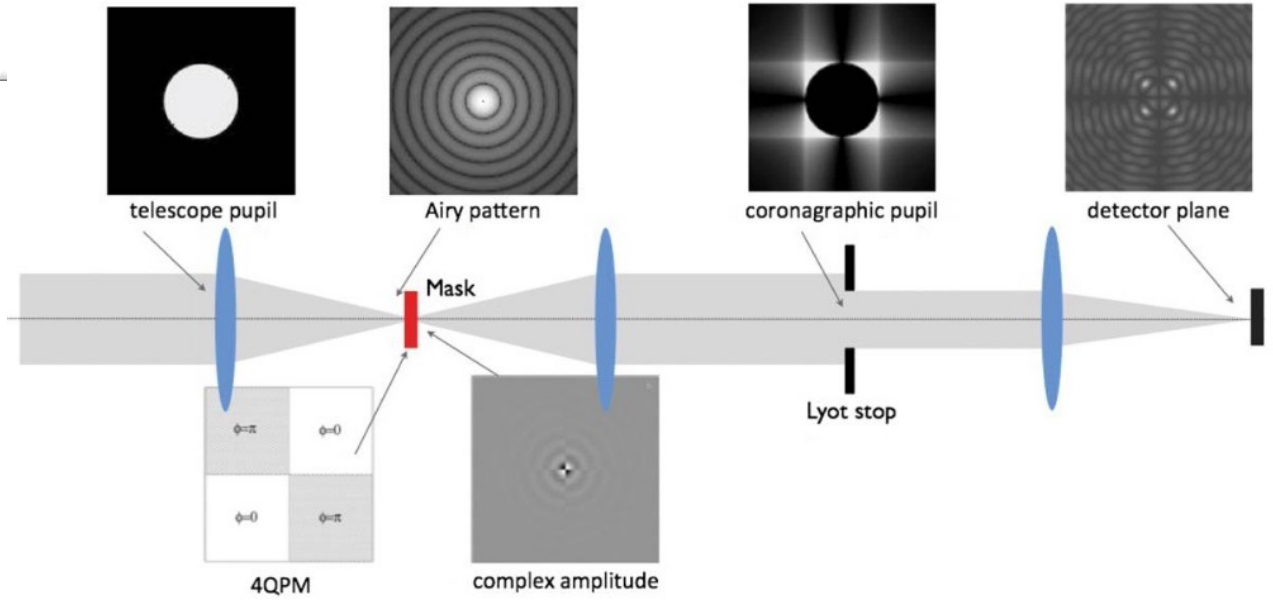
Mid-IR wavelengths are sensitive to 1) colder temperature planets, meaning either lower masses or older ages and 2) new molecules than can be studied from the ground in the near-IR.

Relative to 8-10m class imaging: Wavefront stability improves, telescope diameter decreases, lambda increases



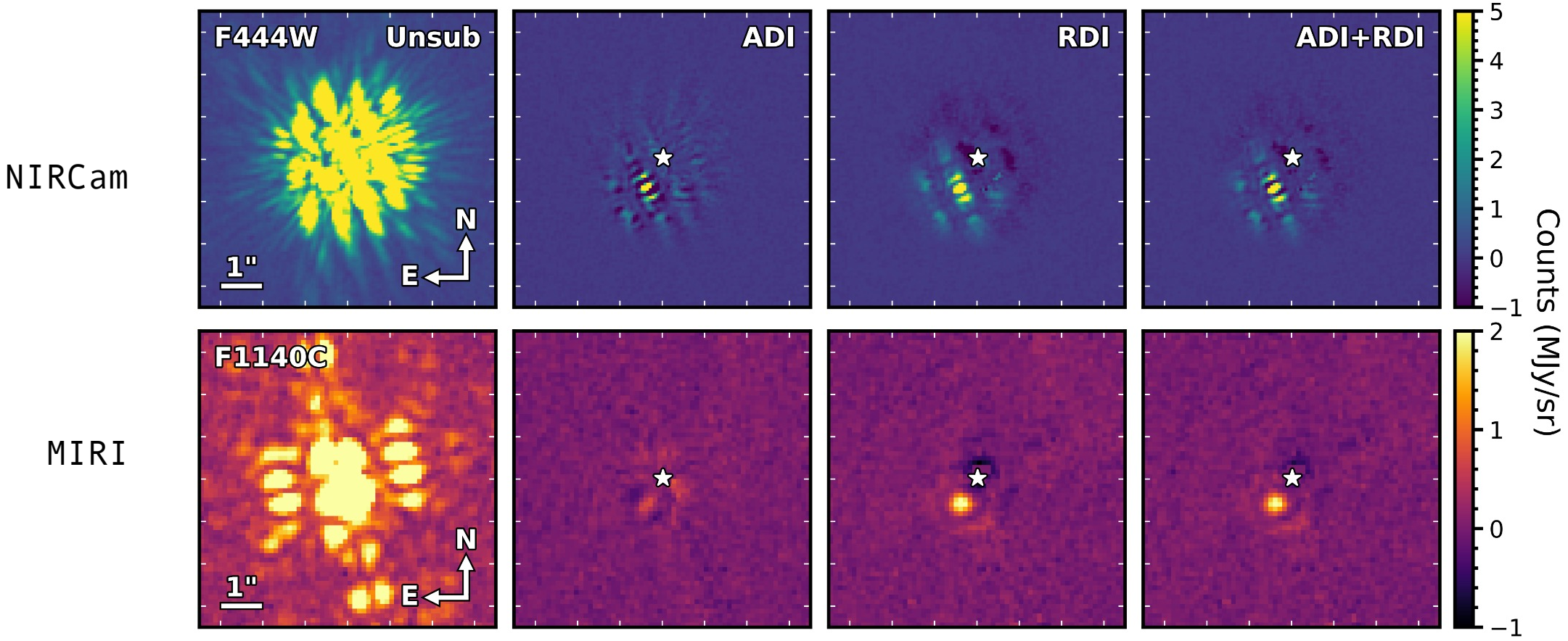
JWST Coronagraphs





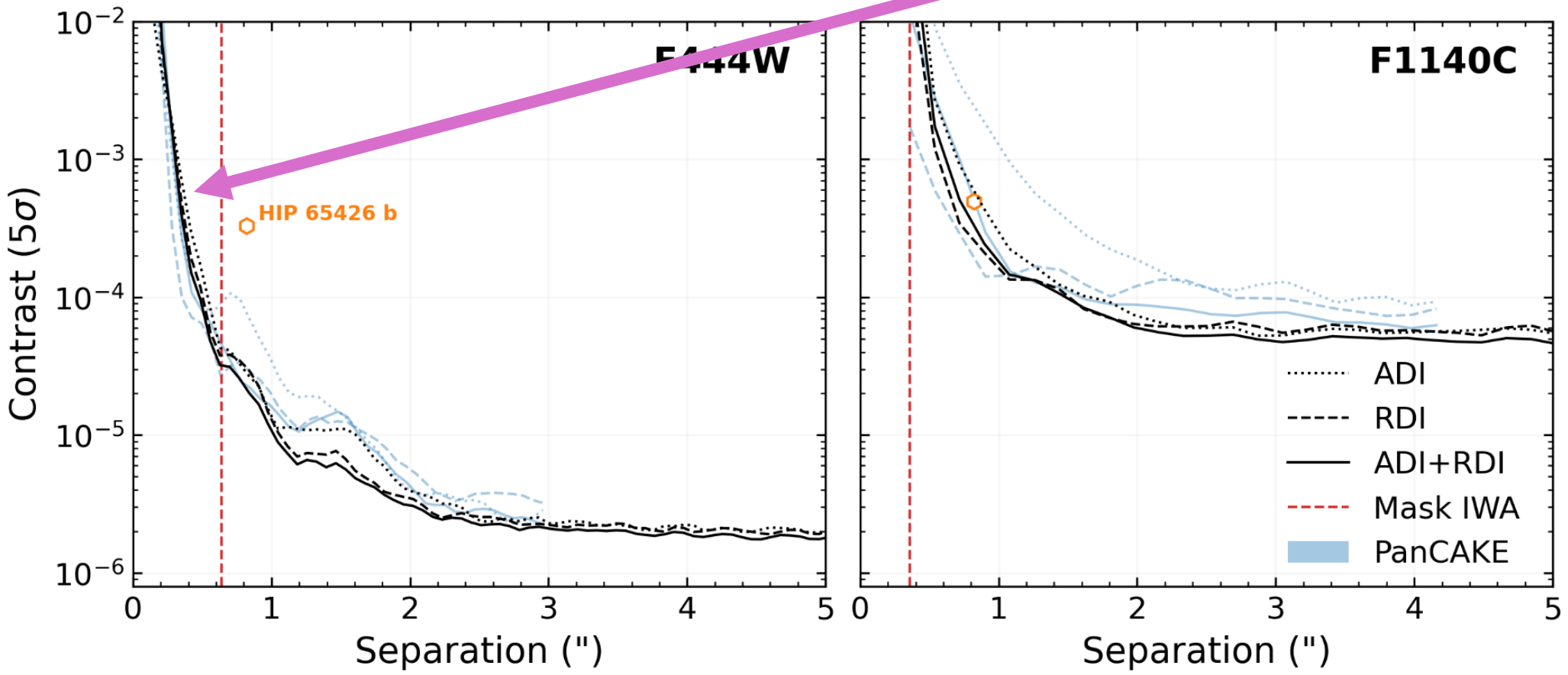
NIRCam coronagraphs (above)
MIRI coronagraph (right)
jwst-docs

ERS result (Carter+ 2023)

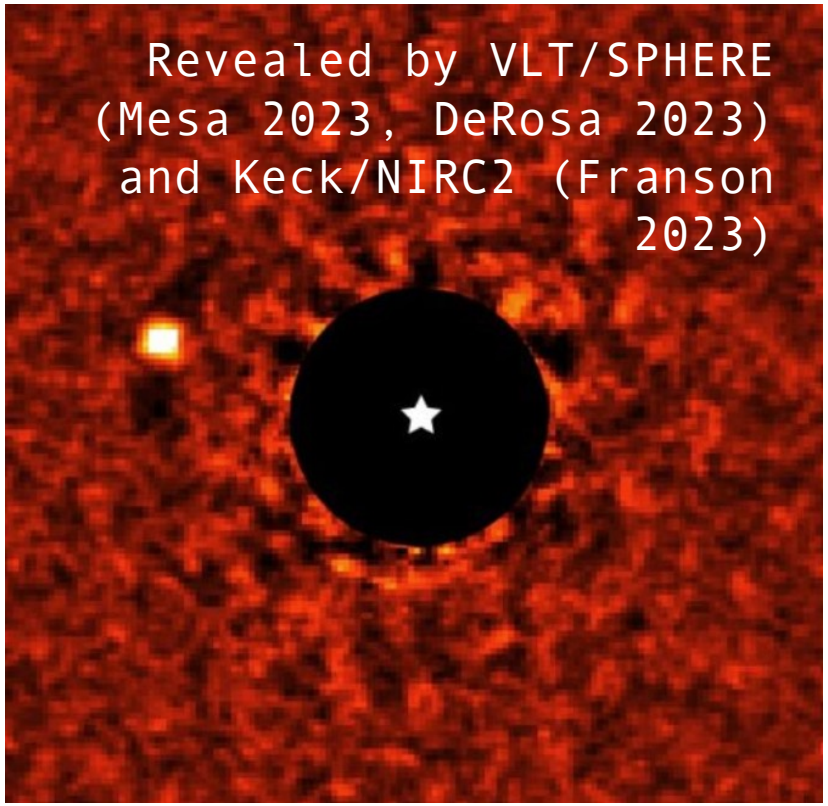


ERS contrast curve

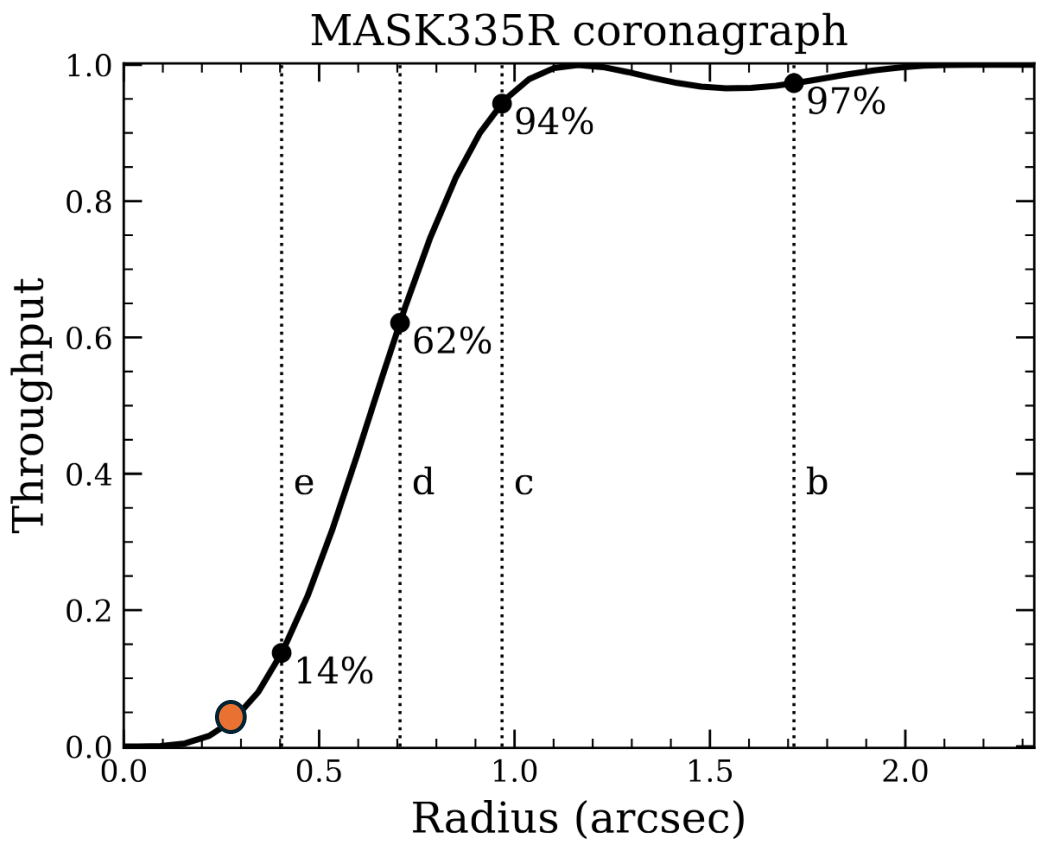
These NIRCam BLCs are not hard edged! Still throughput at seps << IWA



DD AF Lep b – NIRCam round

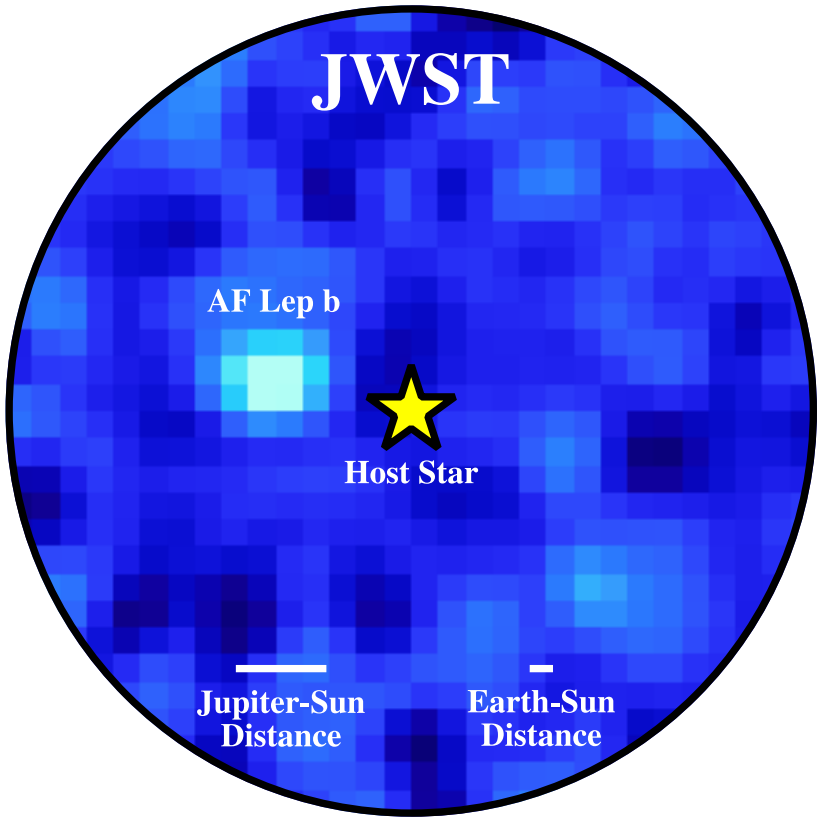


Franson, Balmer+ (in press)



800K planet at 0.31” => 7% throughput

DD AF Lep b – NIRCam round



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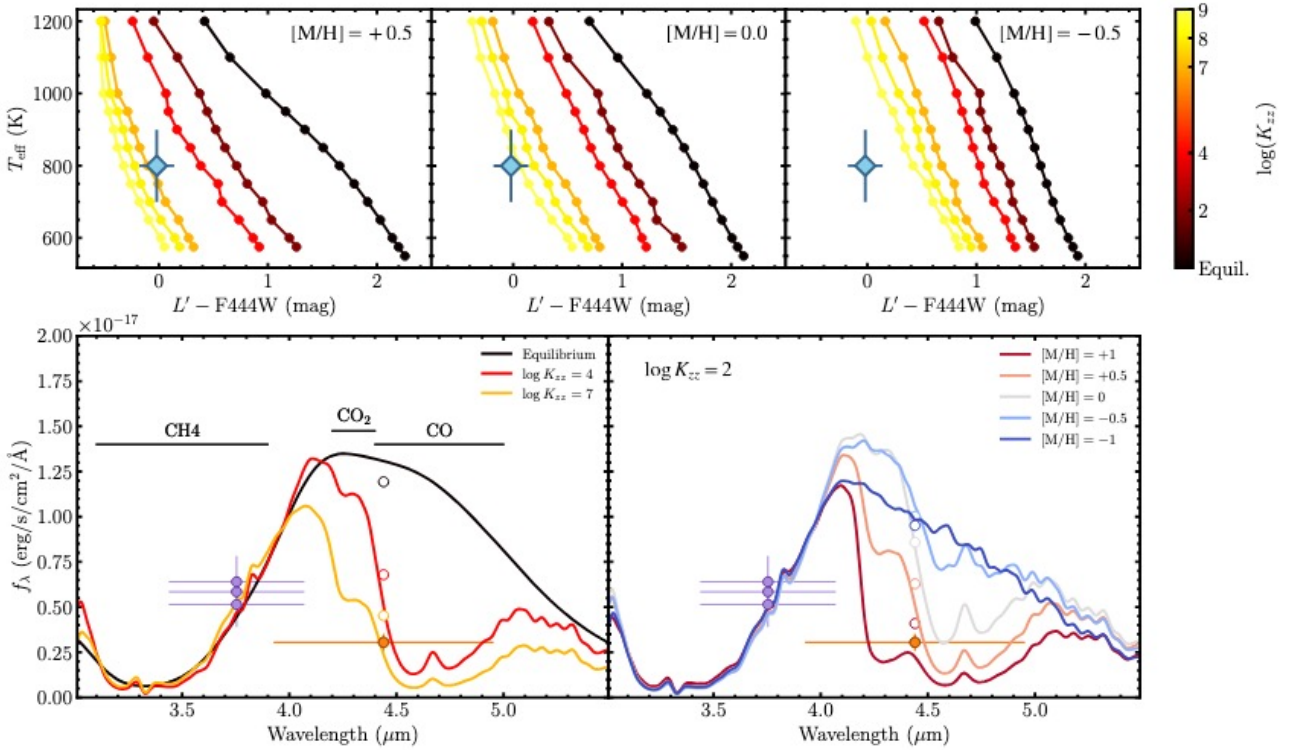
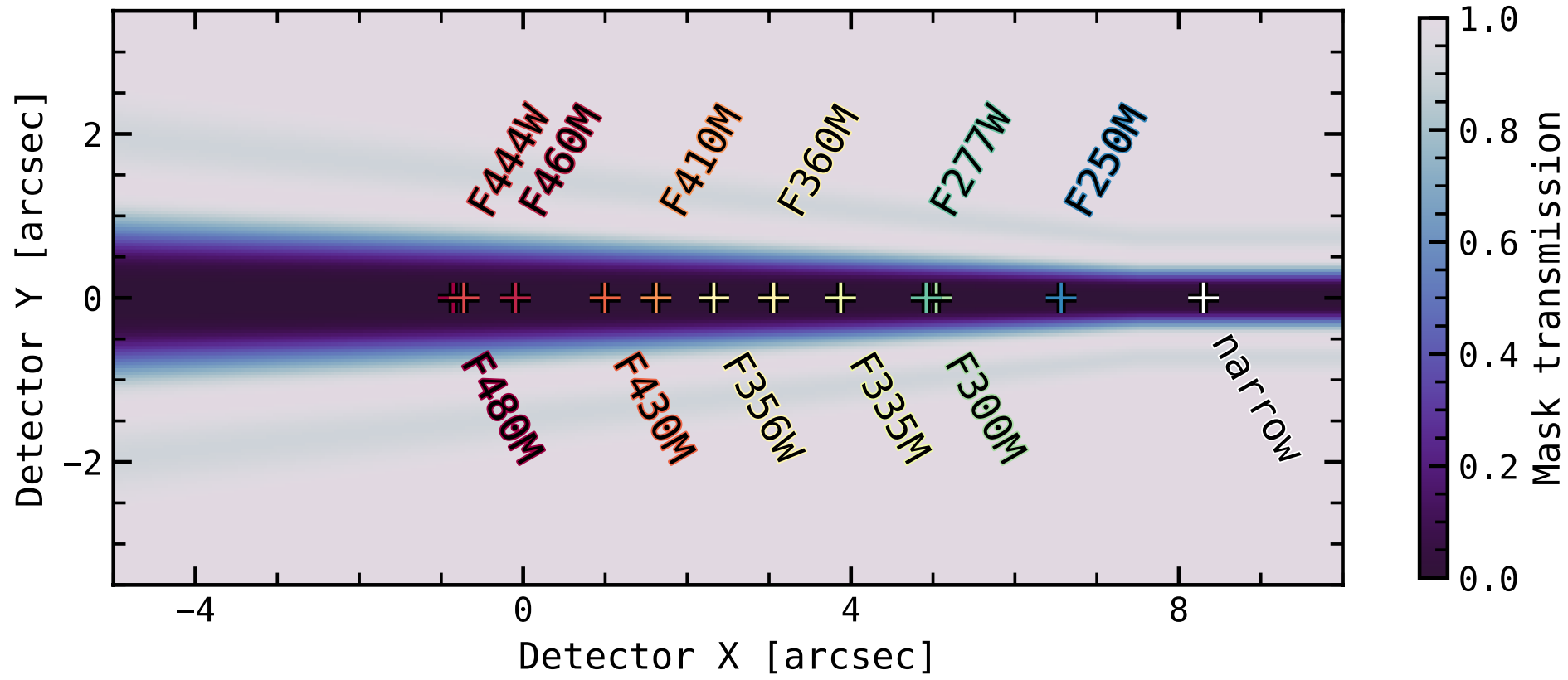
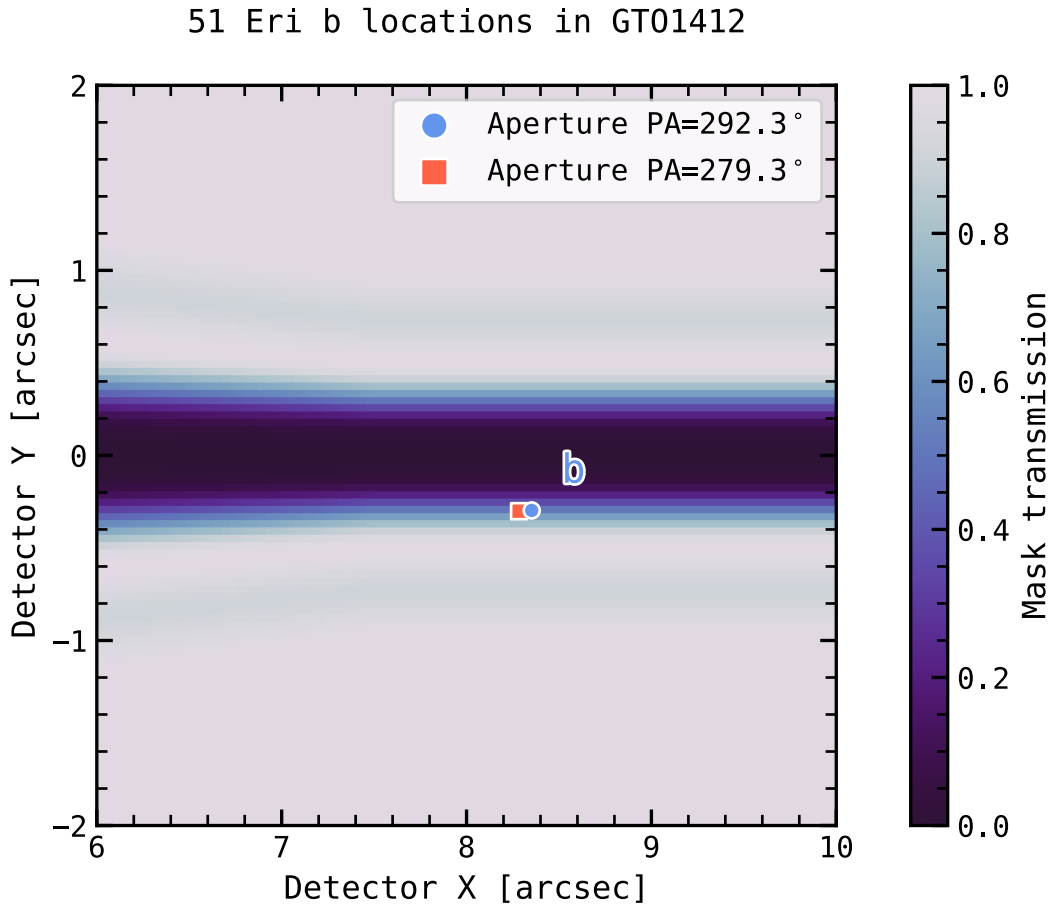


800K planet at 0.31”
5 pixels from star!

How to get better throughput this close in?

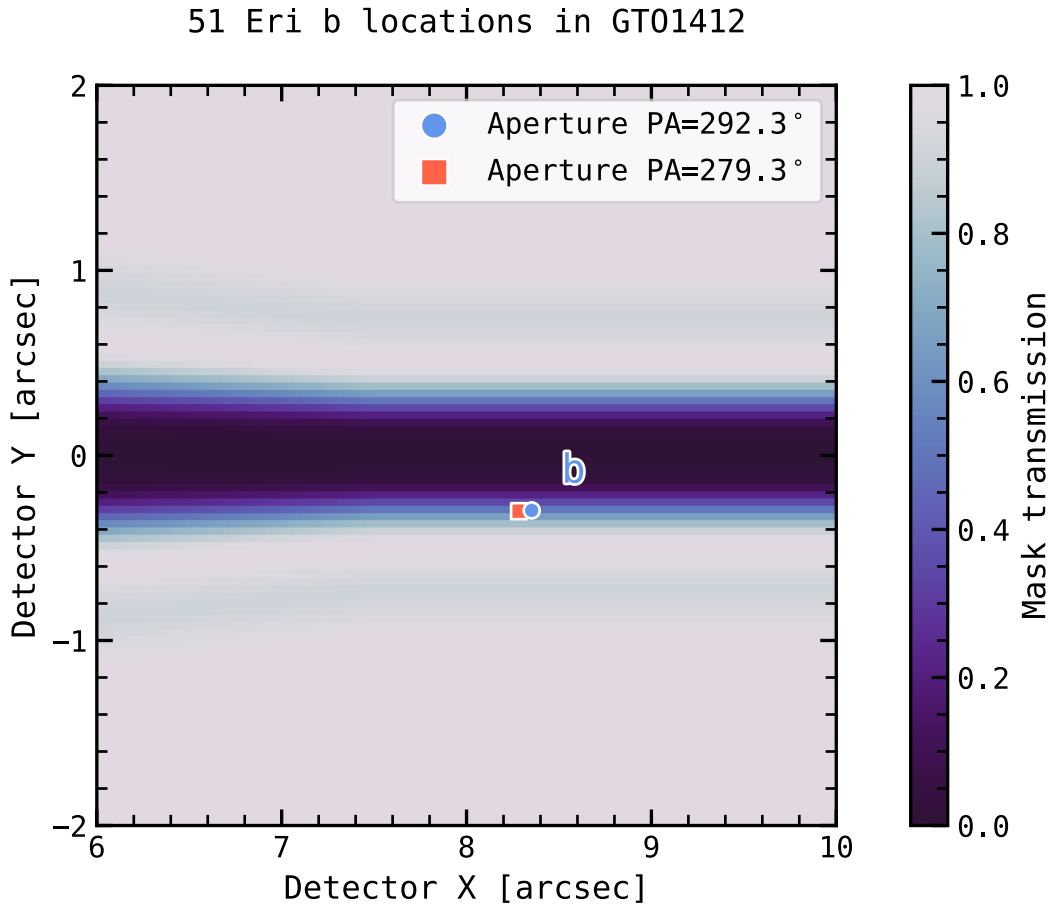


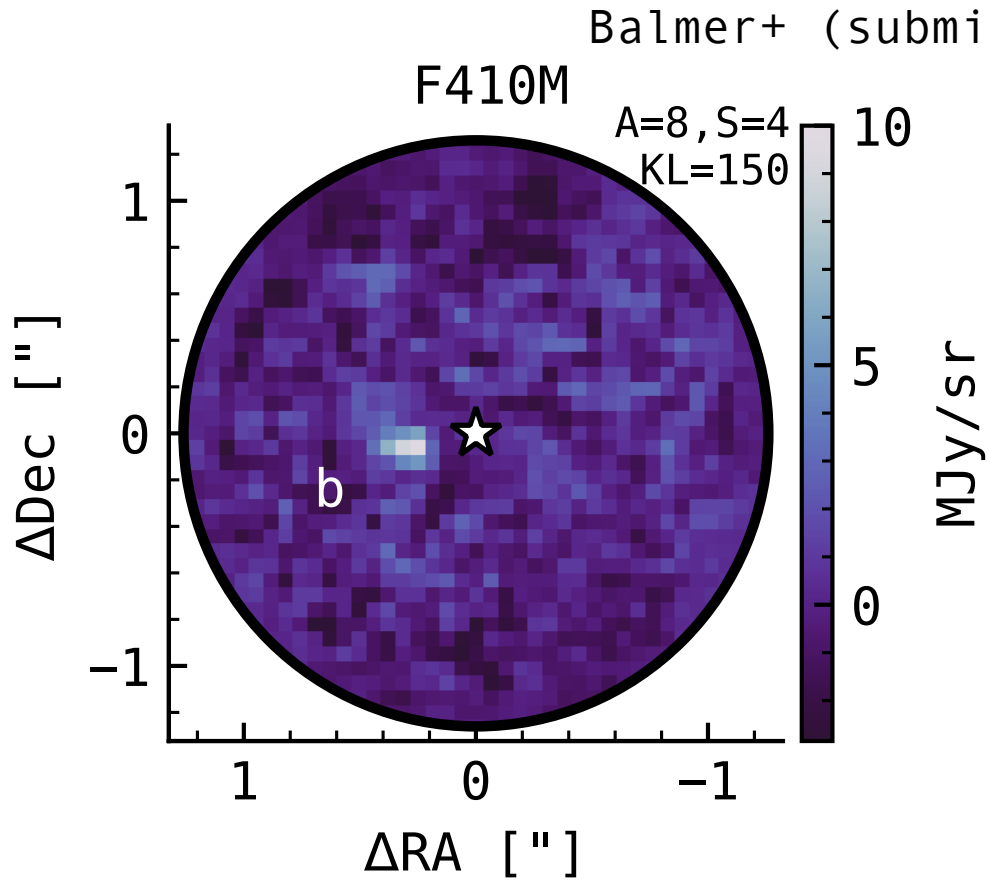
GTO 51 Eri - NIRCam bar mask



Balmer+ (submitted)

GTO 51 Eri - NIRCam bar mask

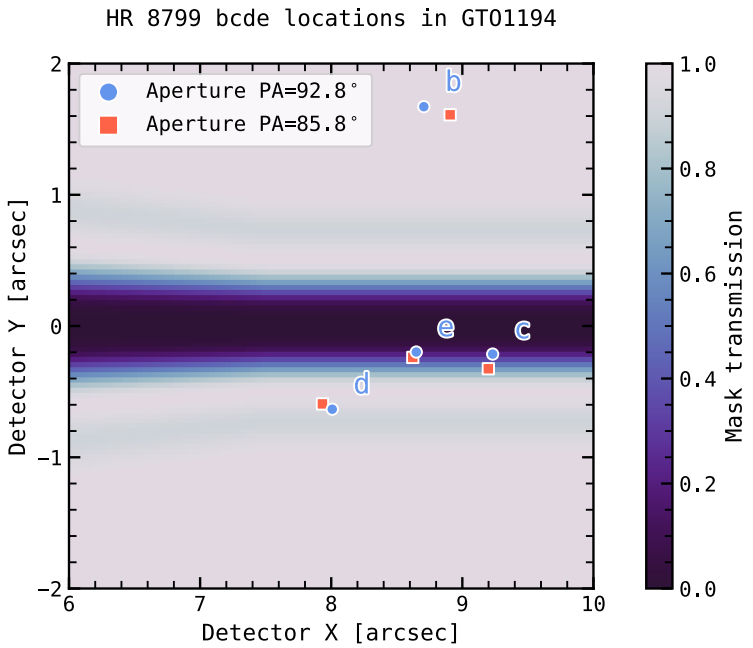




Detected a 700K planet at 0.28” => closest planet yet imaged with JWST

GTO HR 8799 - NIRCam bar mask

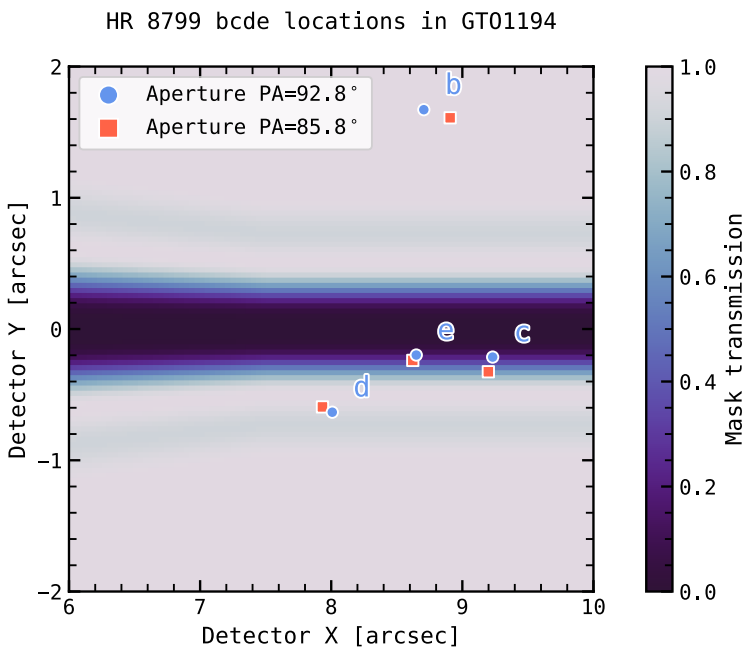
Balmer+ (submitted)

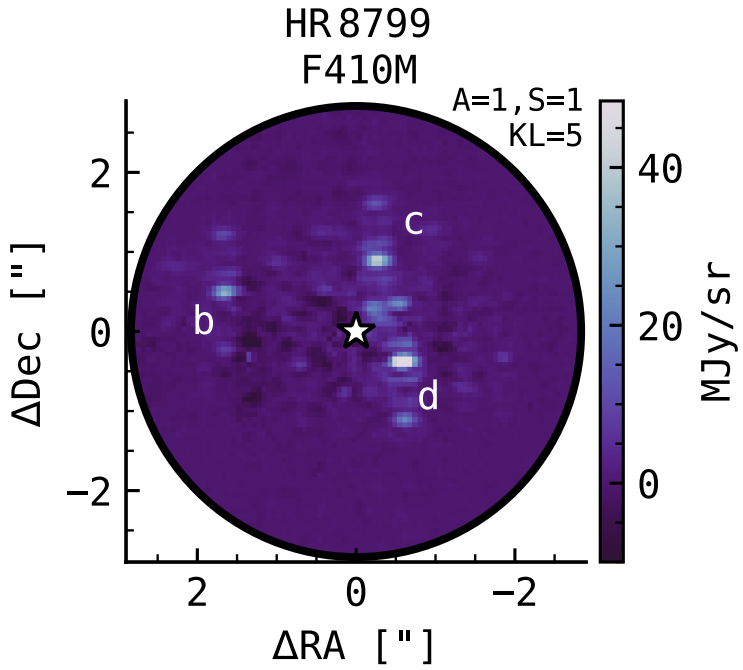


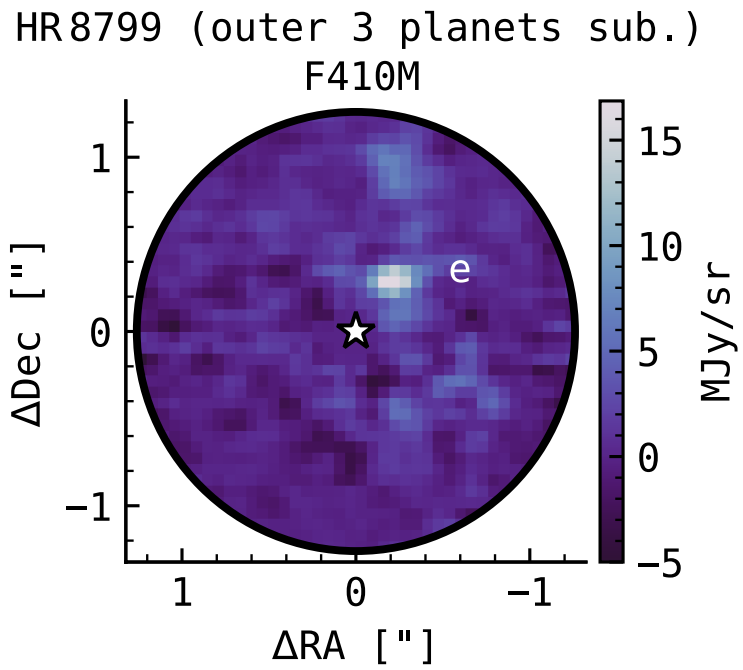
Better throughput than round mask!

GTO HR 8799 - NIRCam bar mask

Balmer+ (submitted)





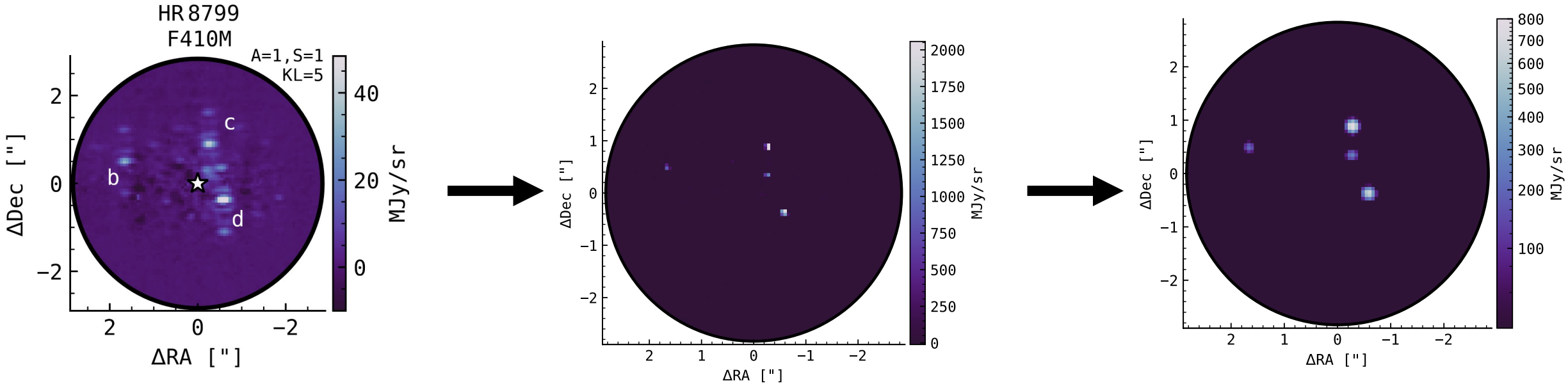


Better throughput than round mask!

GTO HR 8799 - NIRCam bar mask

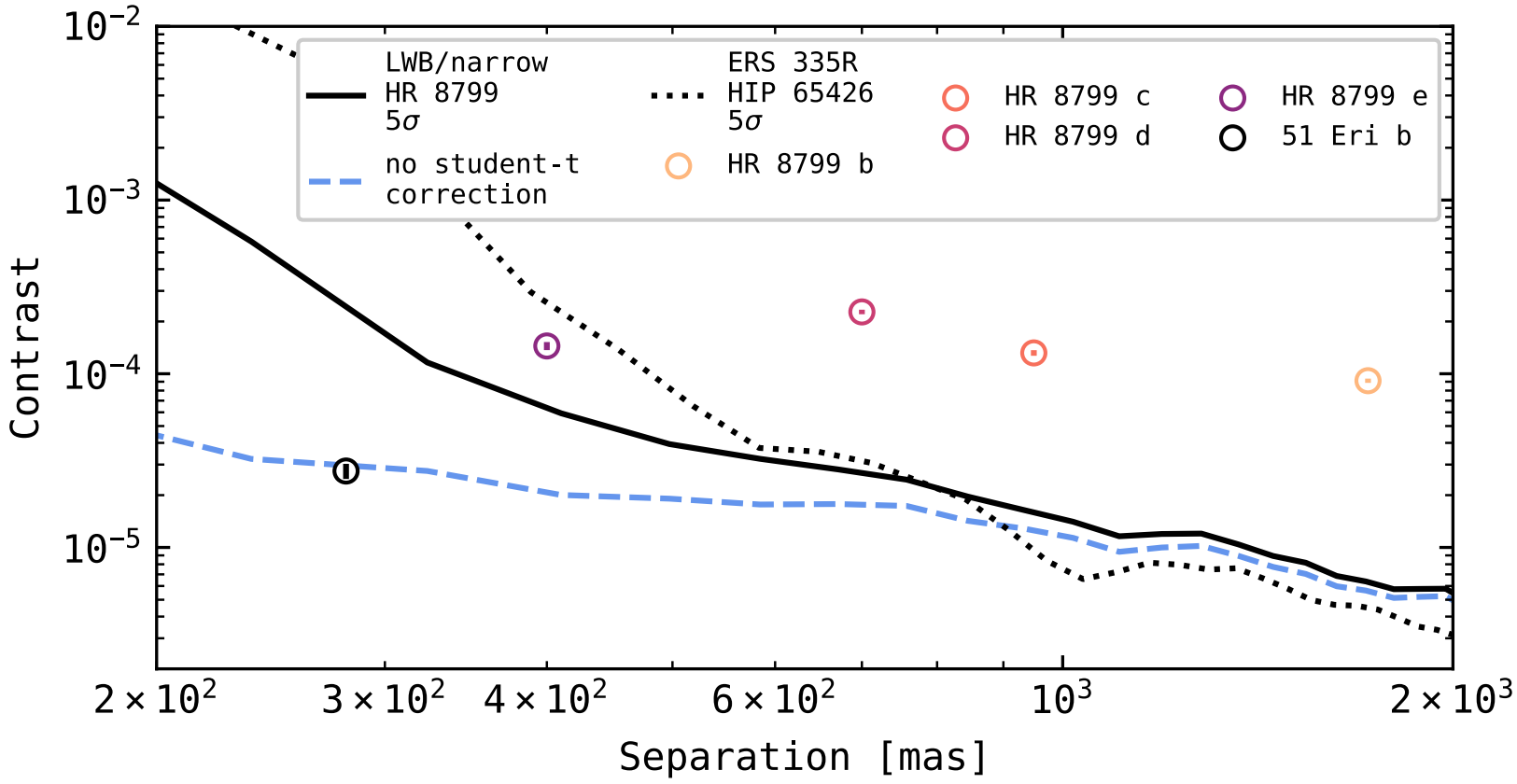
Lucy-Richardson deconvolution

Resmooth by Gaussian



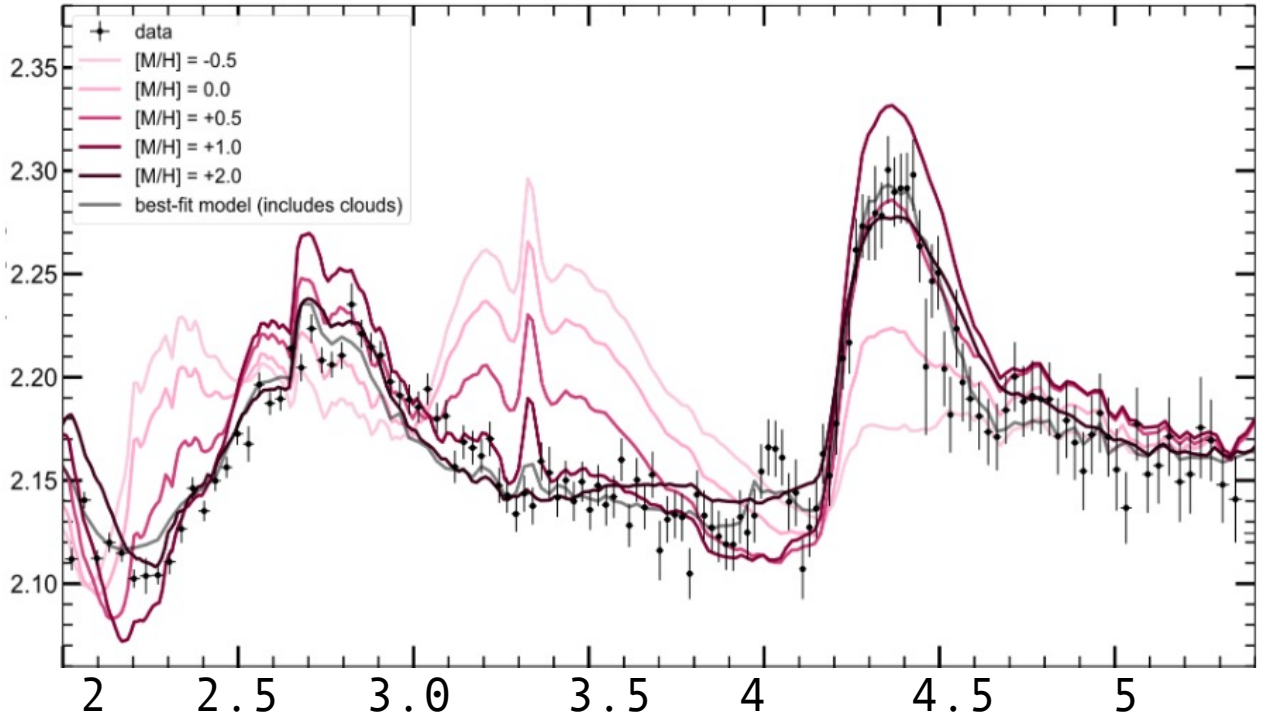
Balmer+ (submitted), deconv. work by Kellen Lawson @ Goddard

GTO - NIRCam bar mask contrasts

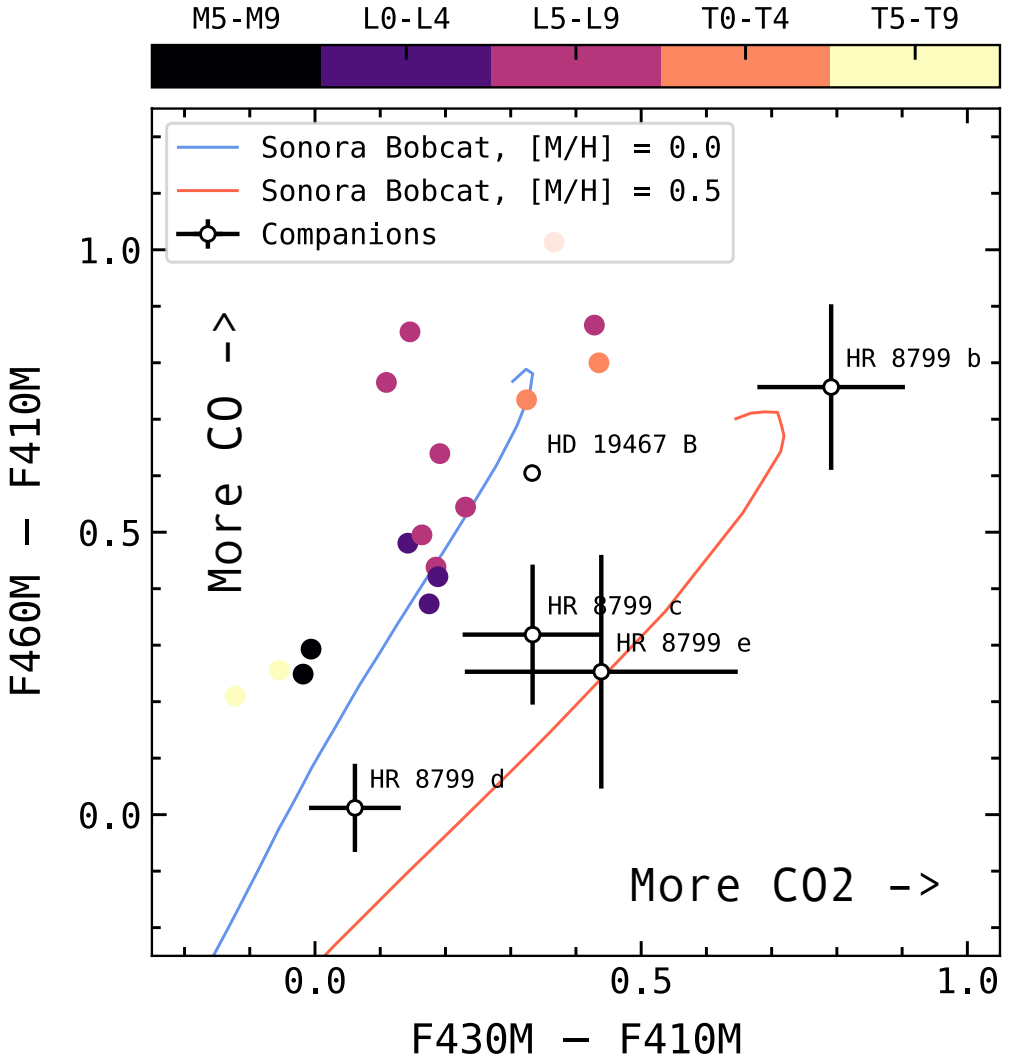


Balmer+ (submitted)

Constraining planetary metallicity “unambiguously”



Rustamkulov+ (2023)



Balmer+ (submitted)

Takeaways:

- In the era of JWST we have access to precise photometry that covers the metallicity dependent CO2 feature at closer separations and deeper contrasts than previously expected

- This allows us to finally discern between “brown dwarf-like” companions and “planet-like” companions relatively unambiguously

- This could be applied to both the current sample of imaged companions (C4 proposal), and potentially a subsample of new, massive Gaia discovered exoplanets in young moving groups in the future

- Chat with me about this project, JWST coronagraphy of cold (<500K) exoplanets, or optical interferometry at the VLT during the rest of the meeting! Thank you :~)