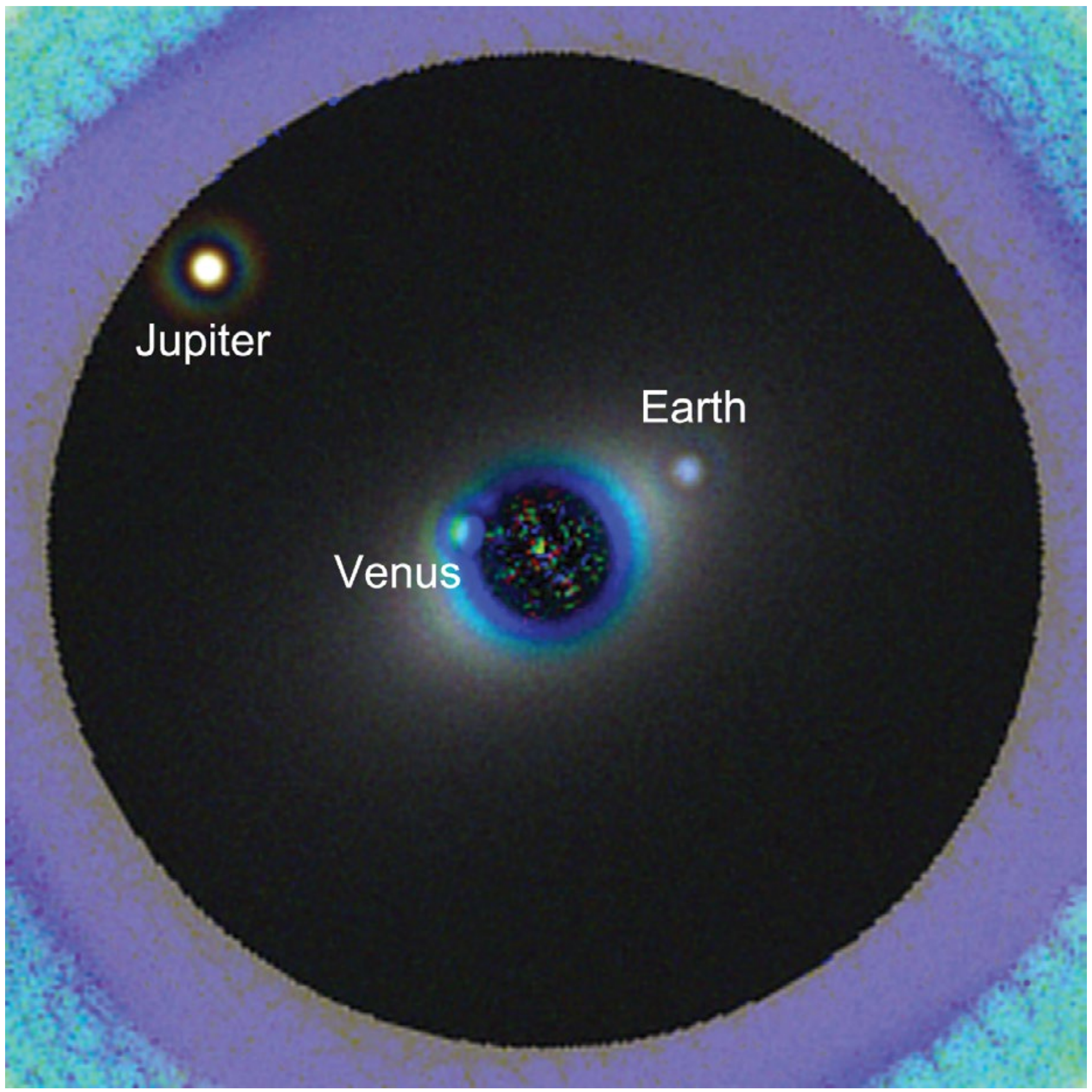
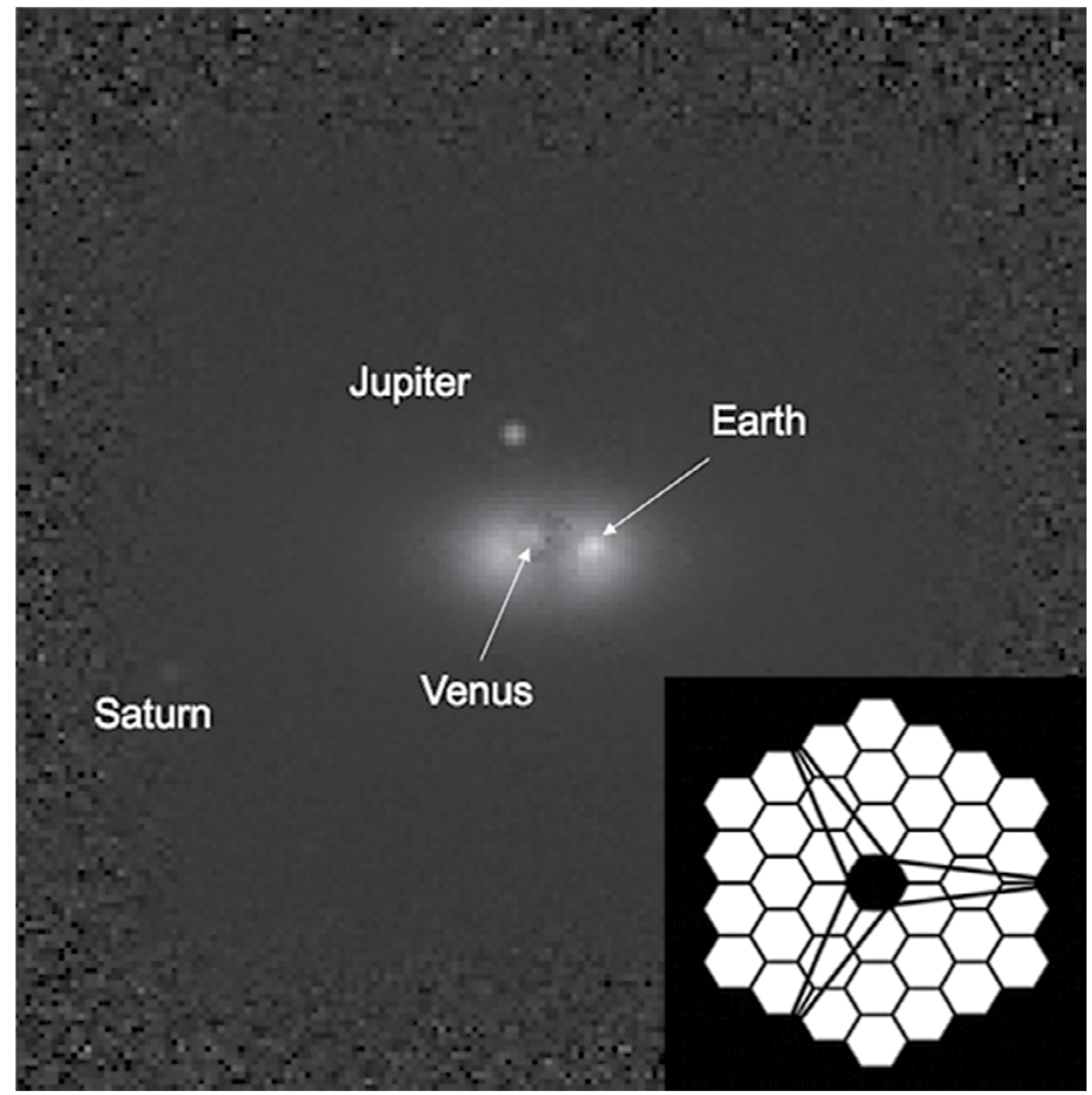
LUVOIR coronagraph Status Update

LUVOIR STDT f2f meeting, Nov 9 th 2016.

Laurent Pueyo

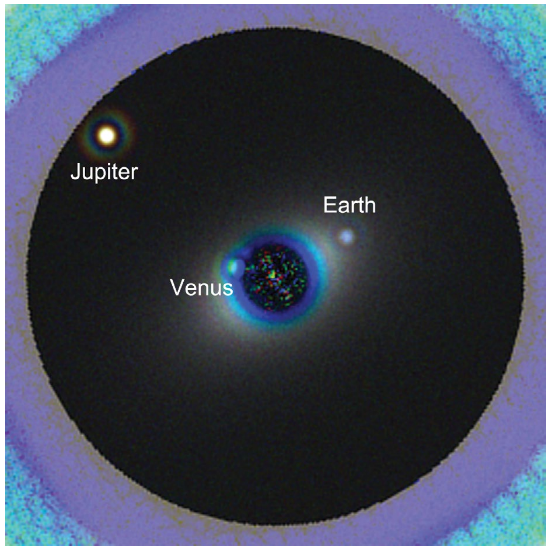
How to build instruments that yield these images.





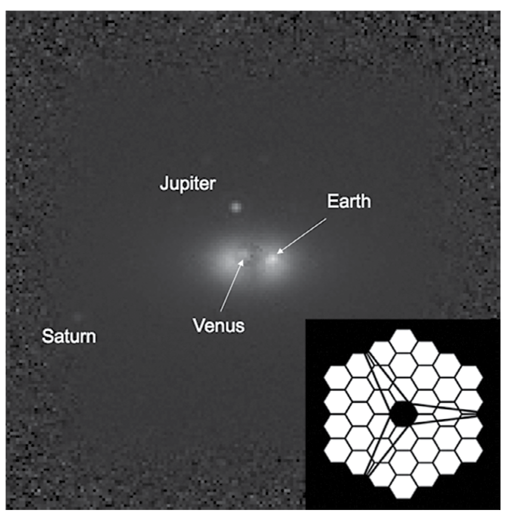
HDST report (2015)

Missing from simulations:



- What are the band passes, what is the resolution?

- What is the yield? How to increase the yield?

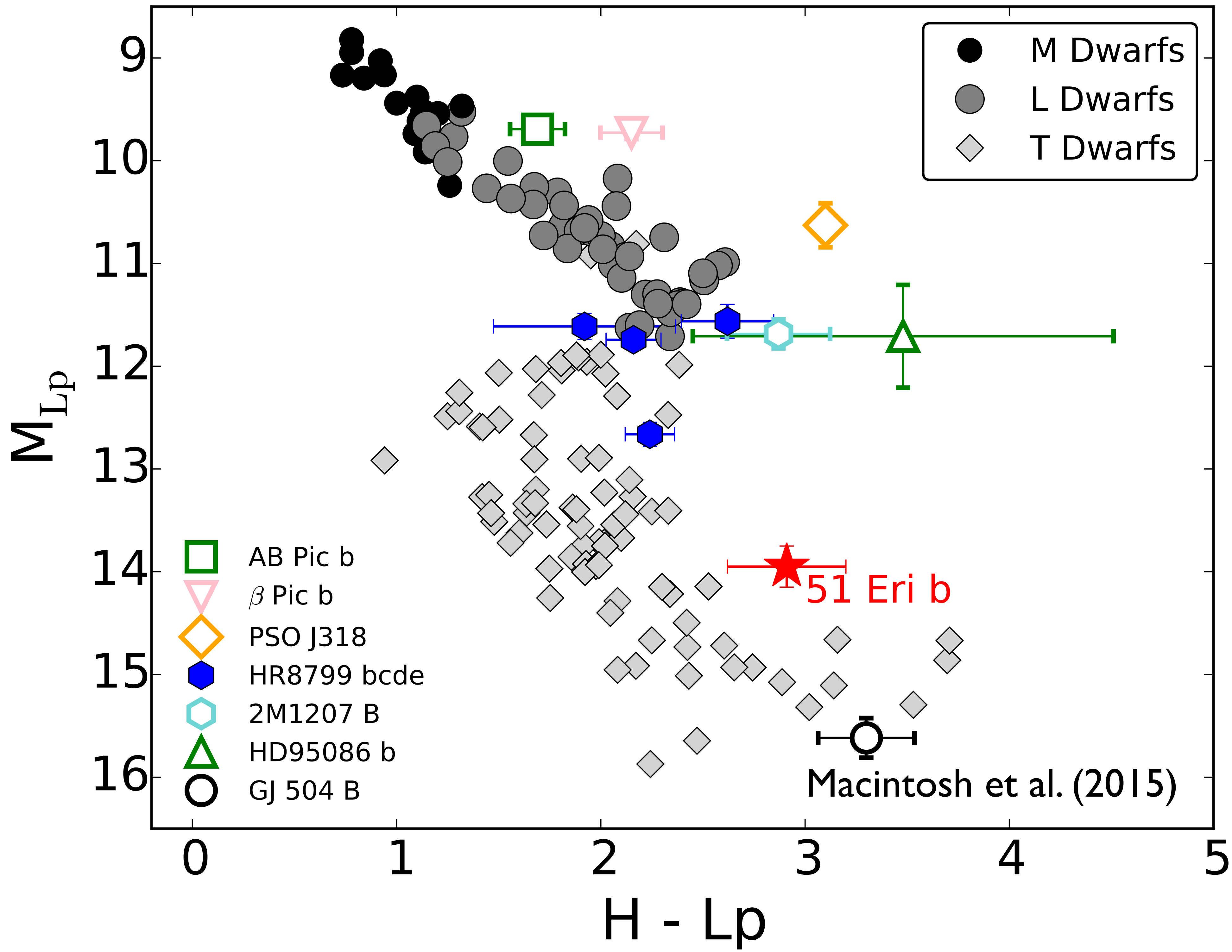


- How do we reach the wavefront stability?

Back end instrument decisions

Resolution for charaterization

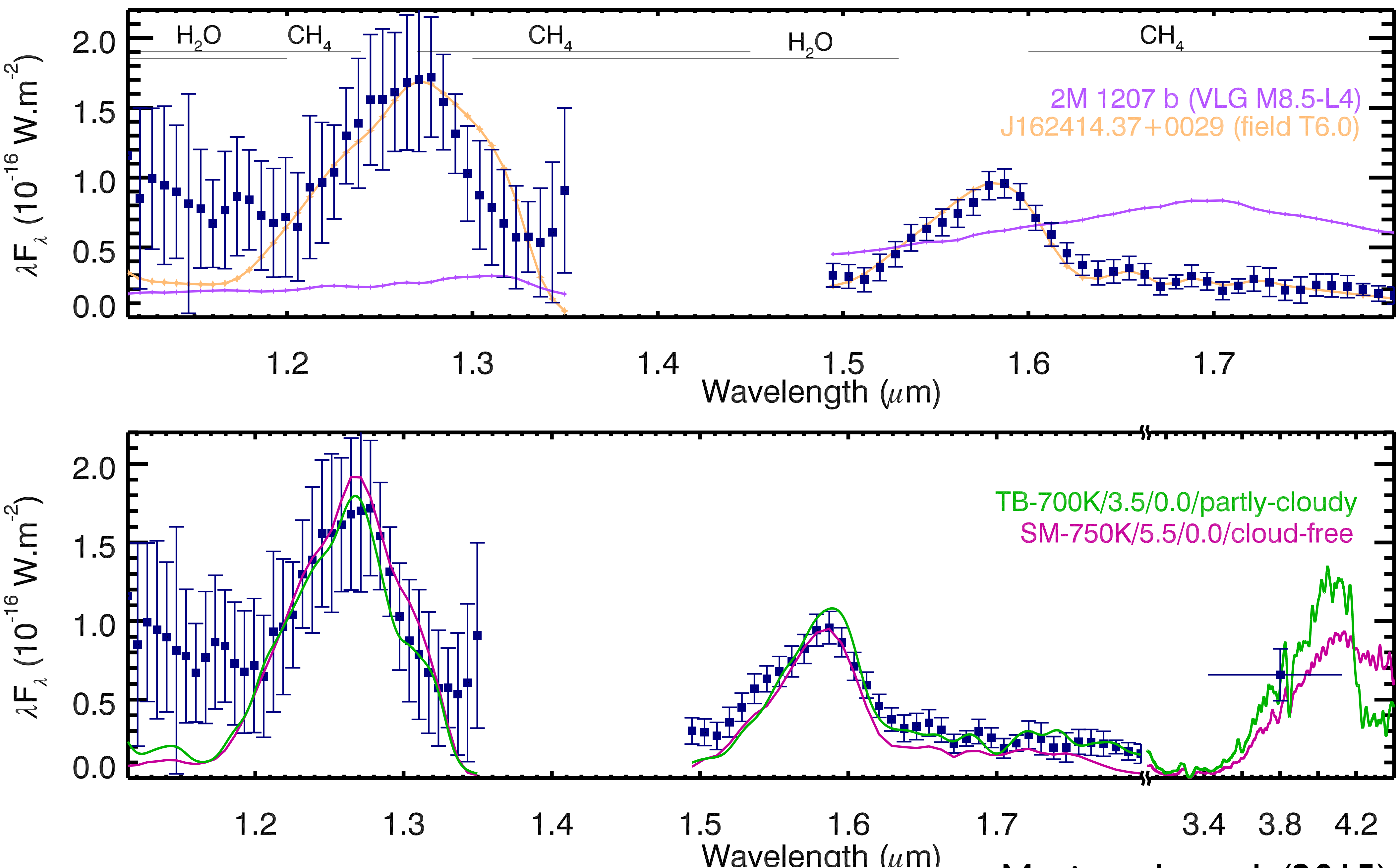
Photometry



Back end instrument decisions

Resolution for charaterization

R~50-100



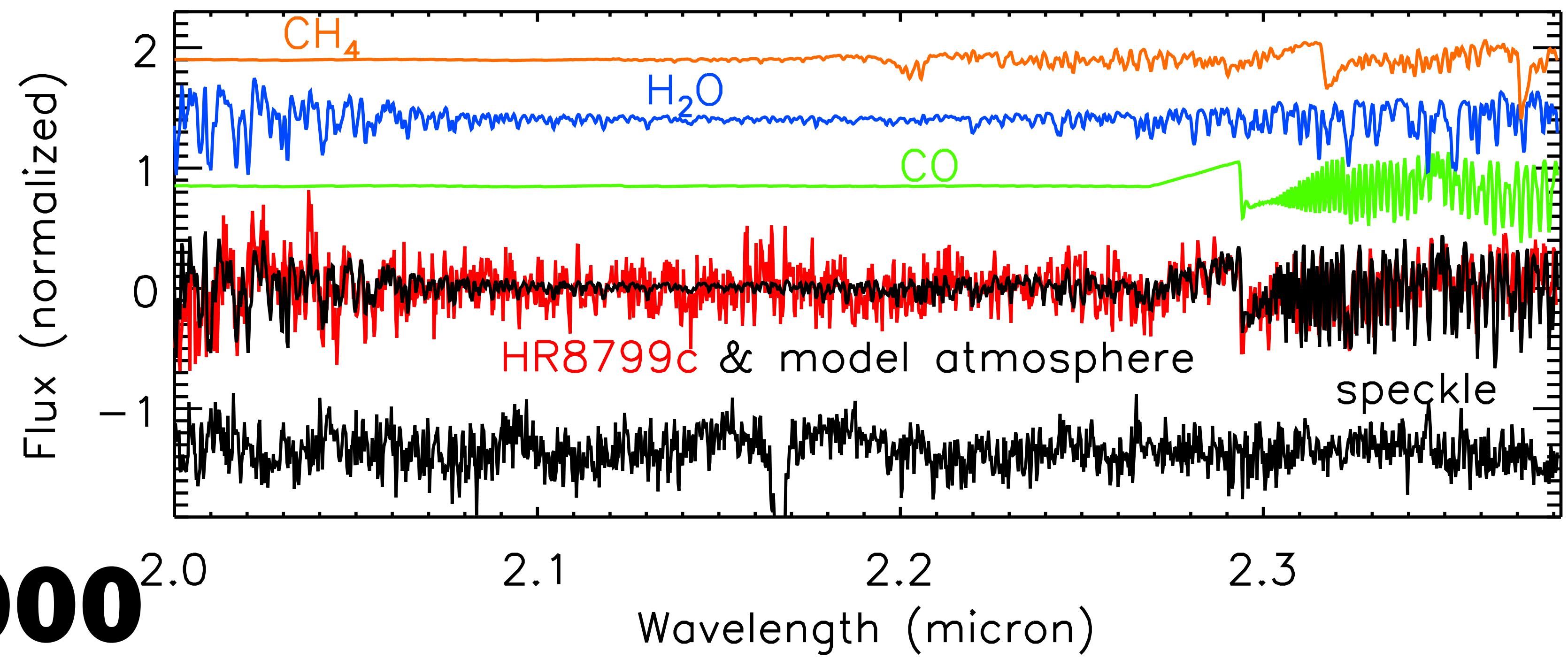
Macintosh et al. (2015)

Back end instrument decisions

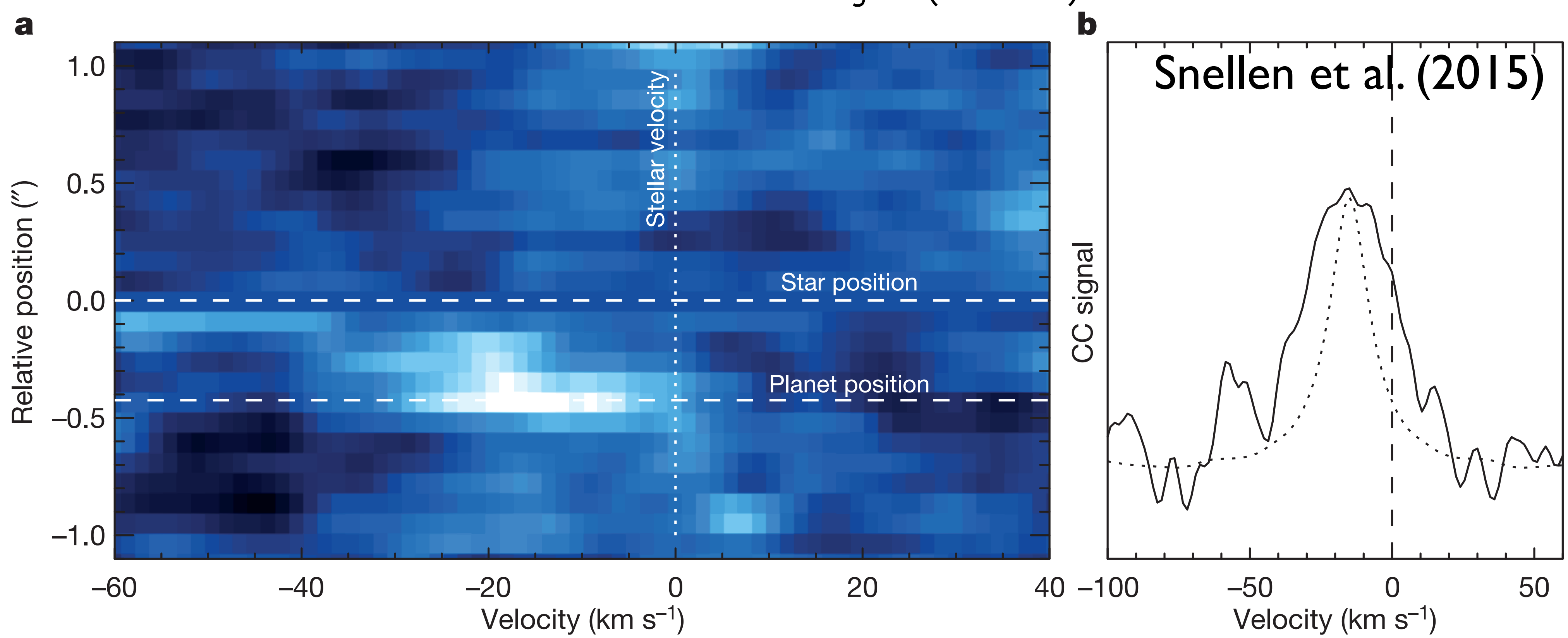
Resolution for charaterization

R~1000

Konopacky et al. (2013)



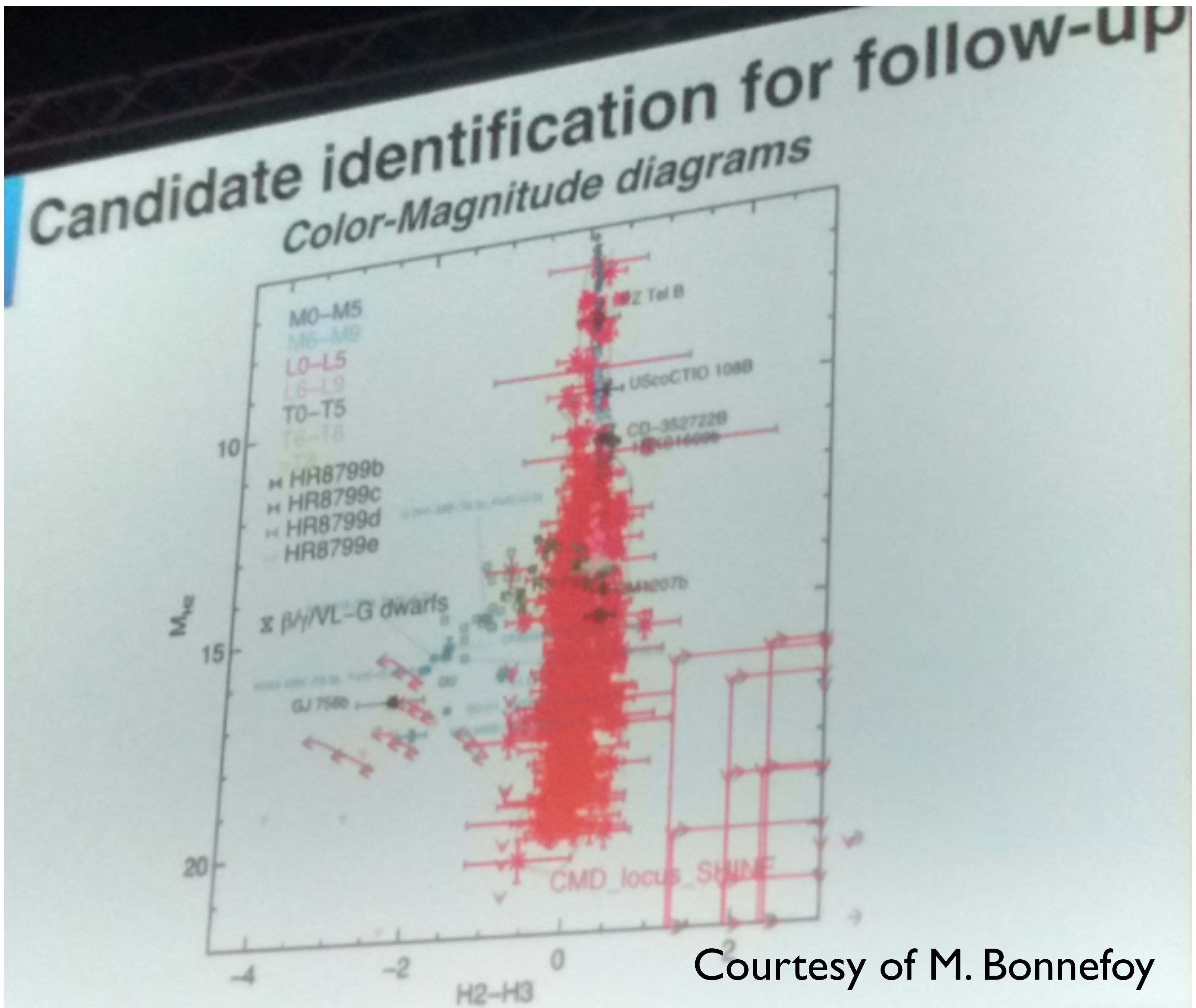
R~100000



Back end instrument decisions

Resolution for detection

Large fov, photometry only.

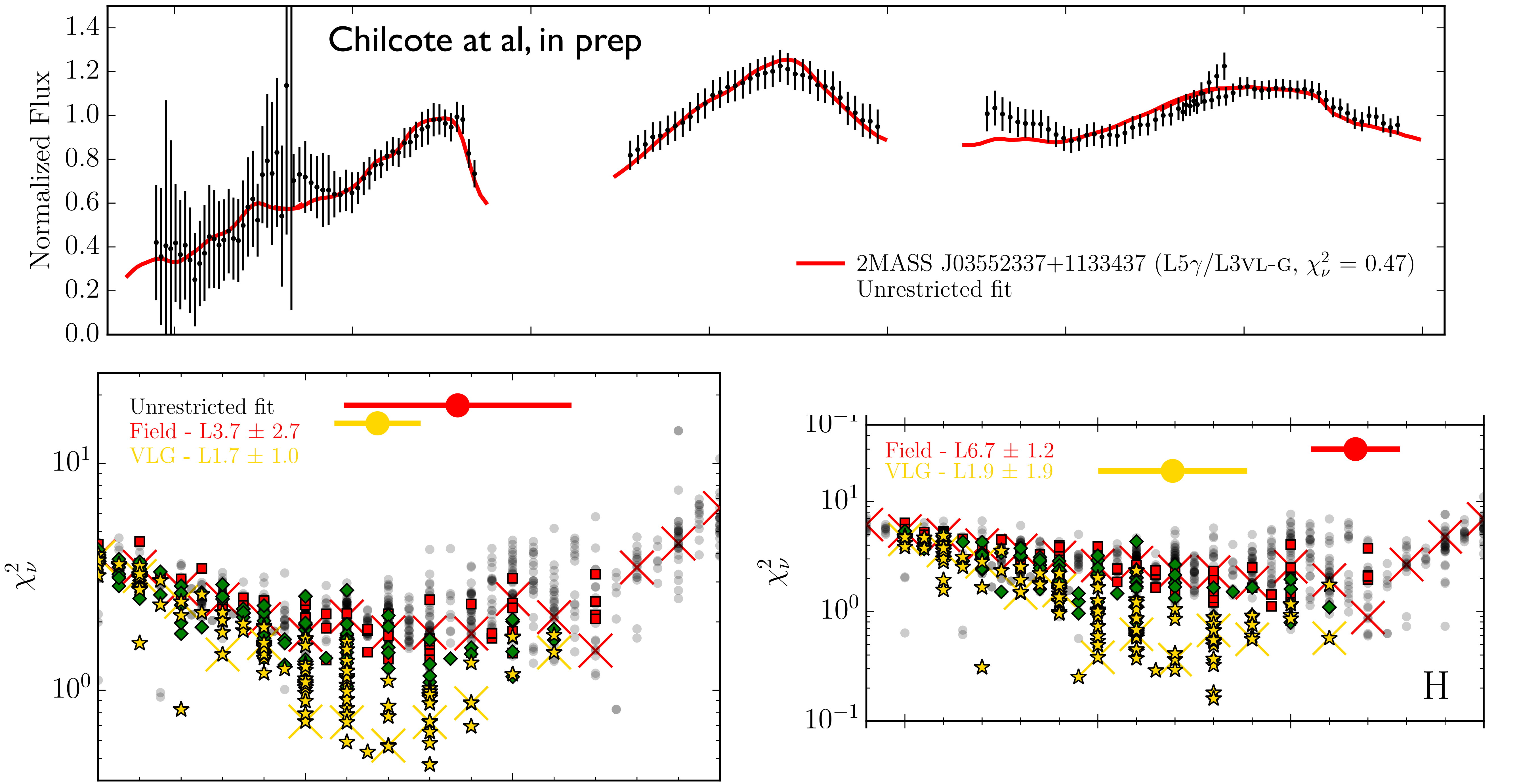


Courtesy of M. Bonnefoy

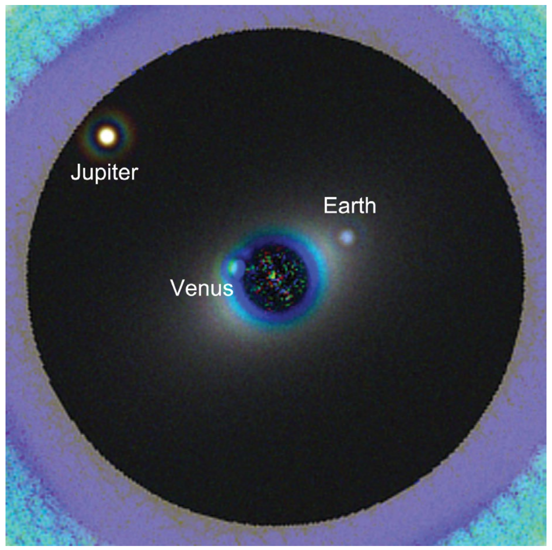
Back end instrument decisions

Resolution for detection

Small fov, spectrum.



Recap



- What are the band passes, what is the resolution?
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  - **How many parallel channels?**
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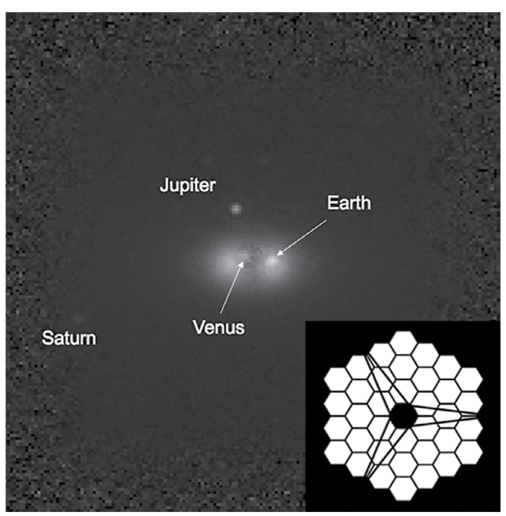
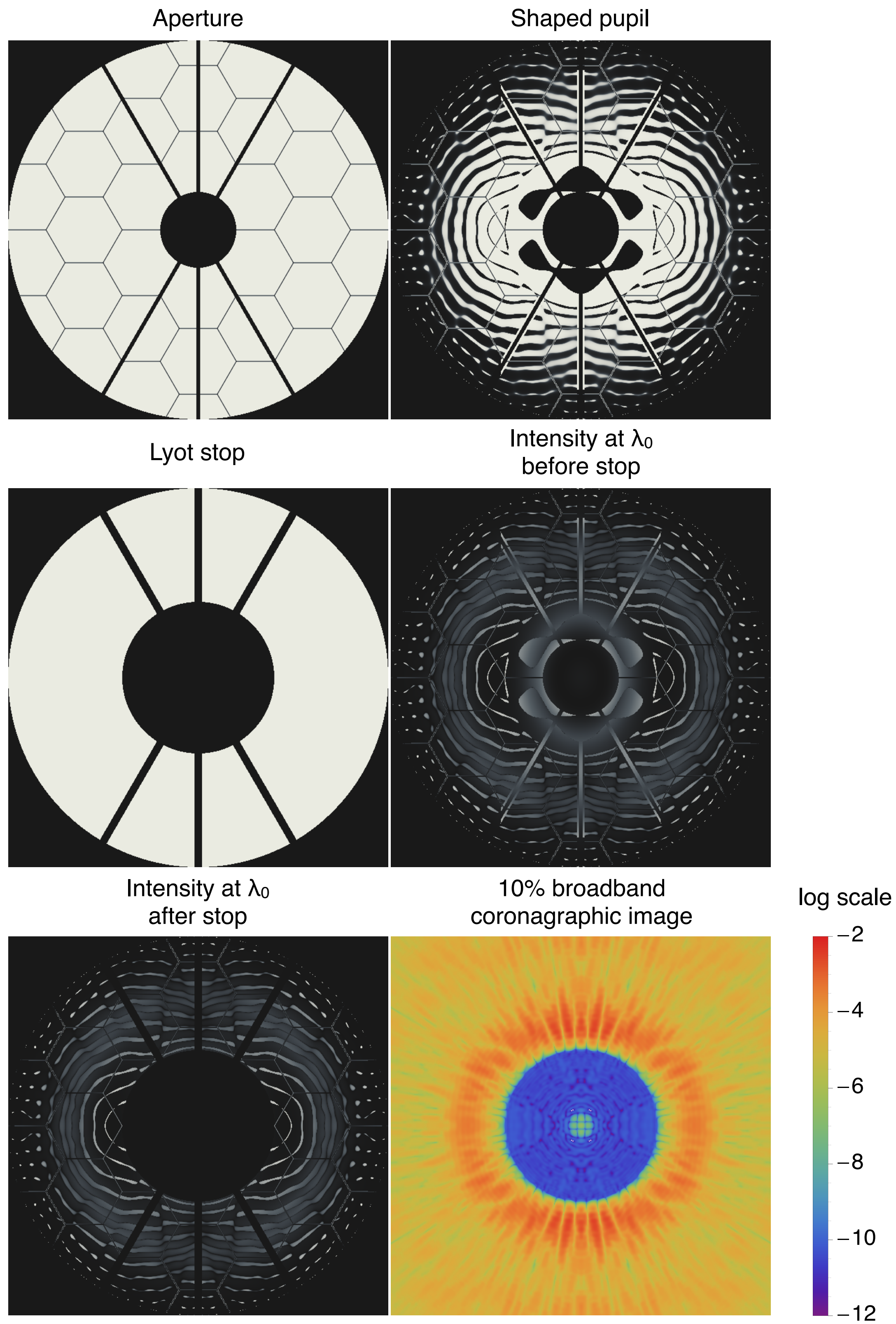
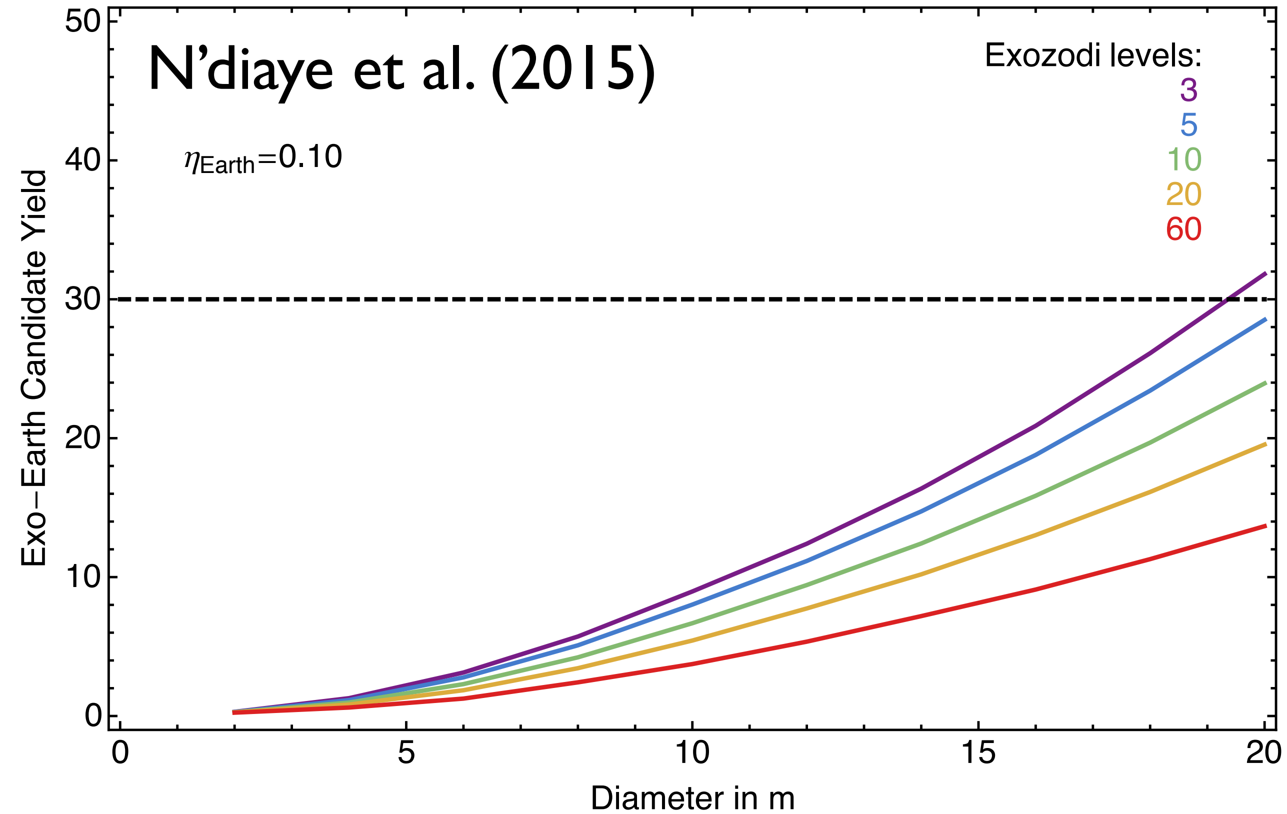
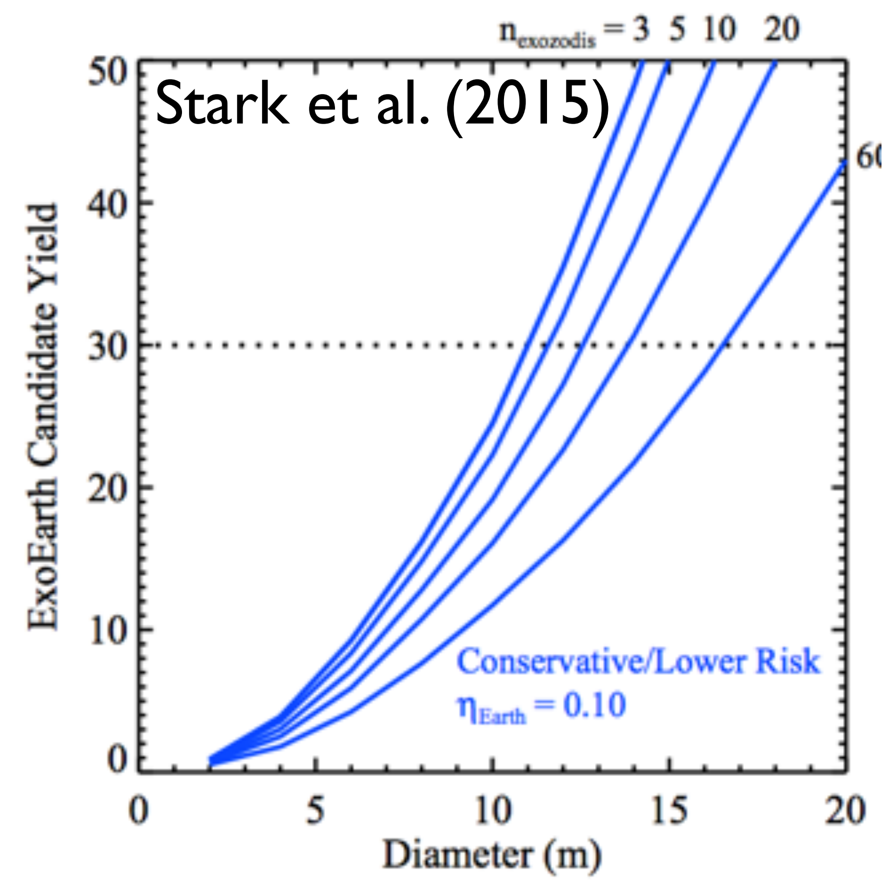


- How do we reach the wavefront stability?

Coronagraphs: starting point



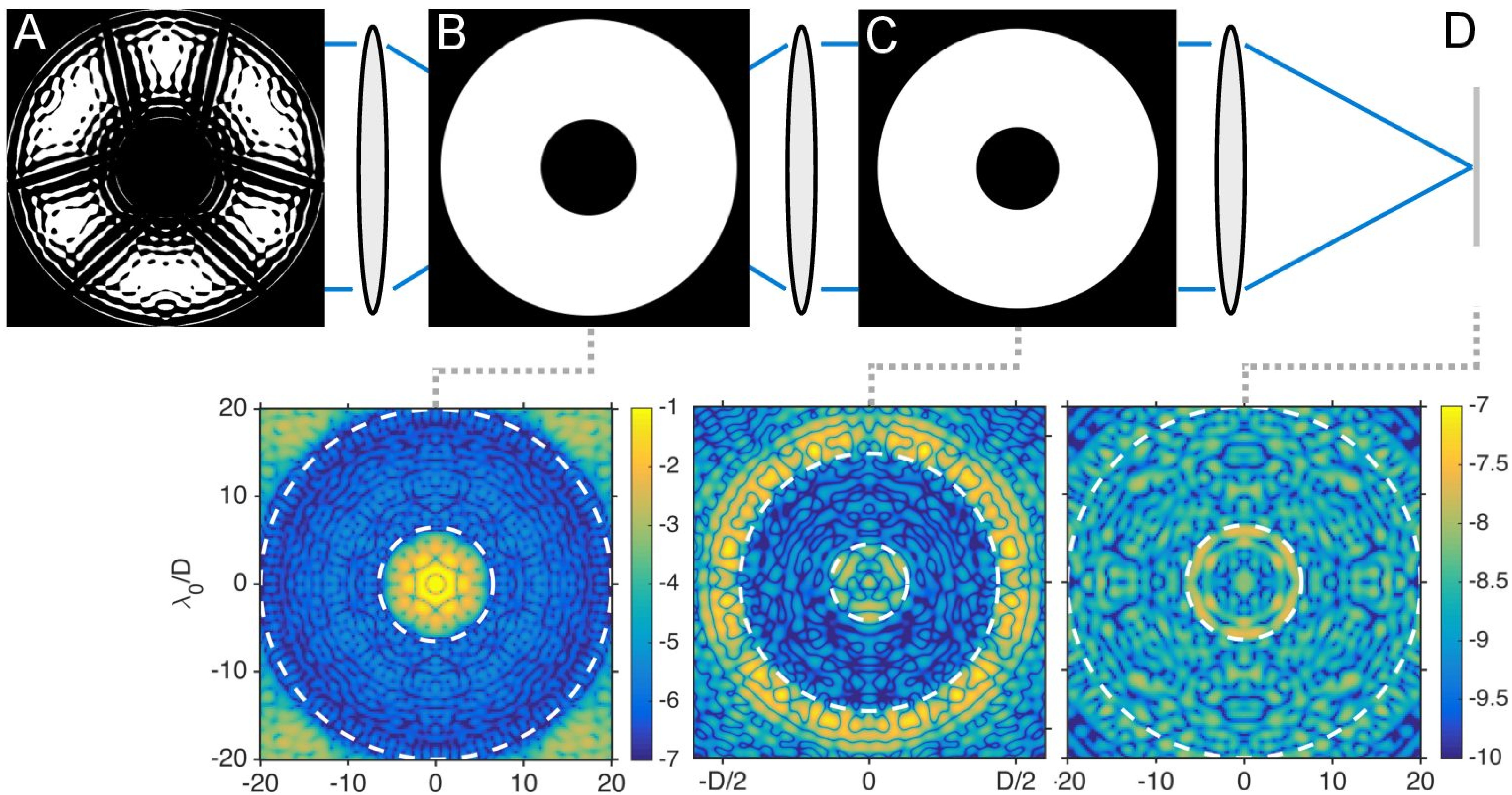




How to design higher performance coronagraphs?

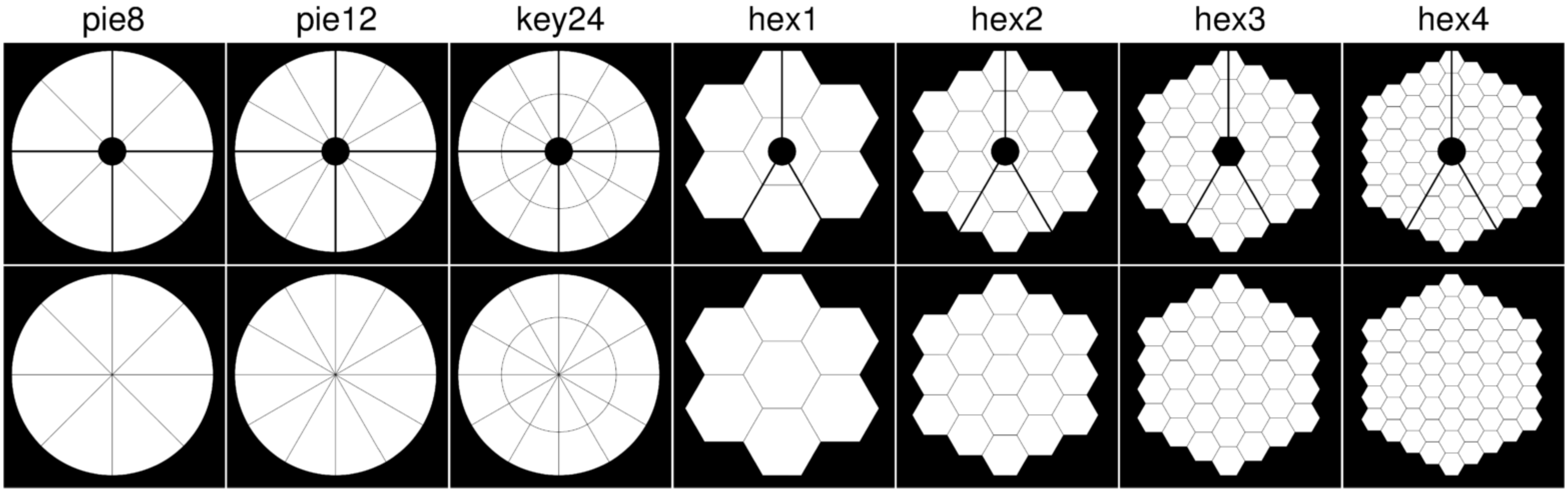
Coronagraphs: starting point

Zimmerman et al. (2014)



This is the technology that will fly with WFIRST

Coronagraphs: SCDA study



- Telescope builders choose possible architectures.
- Coronagraph designers do their homework
- Coronagraph design propagated through PROPER code.
- Agreed upon metrics for yield calculations are estimated.
- Yield calculation.

SCDA results SP/APLC

Courtesy of Neill Zimmerman

August-Sep 2016: New APLC design survey with expanded parameter range

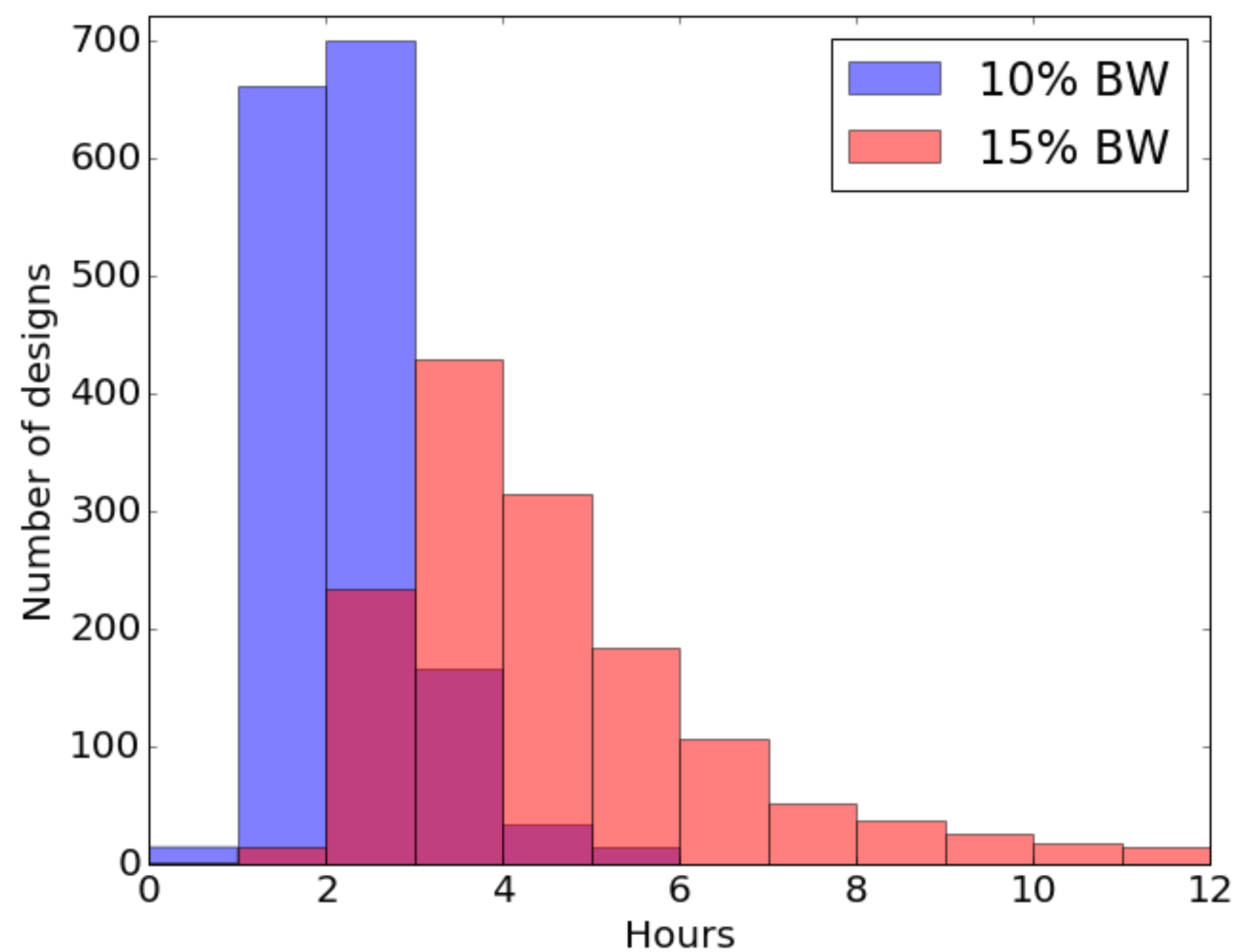
- 3100 new designs optimized on NCCS Discover supercomputer
- All SCDA reference apertures (hexagonal, pie, and keystone primaries)
- Inner working angles down to 2.5 λ/D
- With and without central obscuration (on-axis versus off-axis)
- Contrast fixed at 10^{-10} throughout

NCCS Discover is an efficient tool for running many linear optimization programs to survey the APLC design parameter space.

Up to 50 optimization jobs run concurrently, with typical completion times < 6 hours.

STScI team has submitted a proposal to renew the NCCS allocation in November (~25k run hours)

Optimization completion time per design



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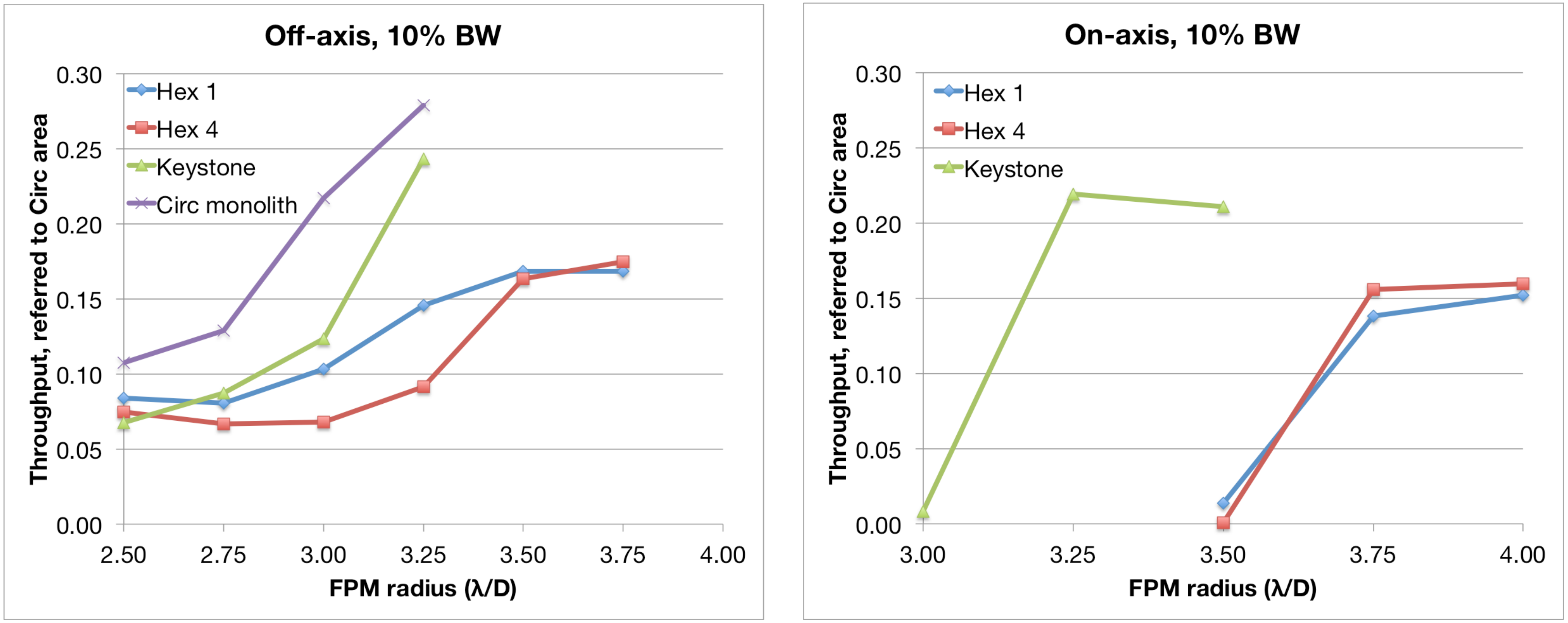
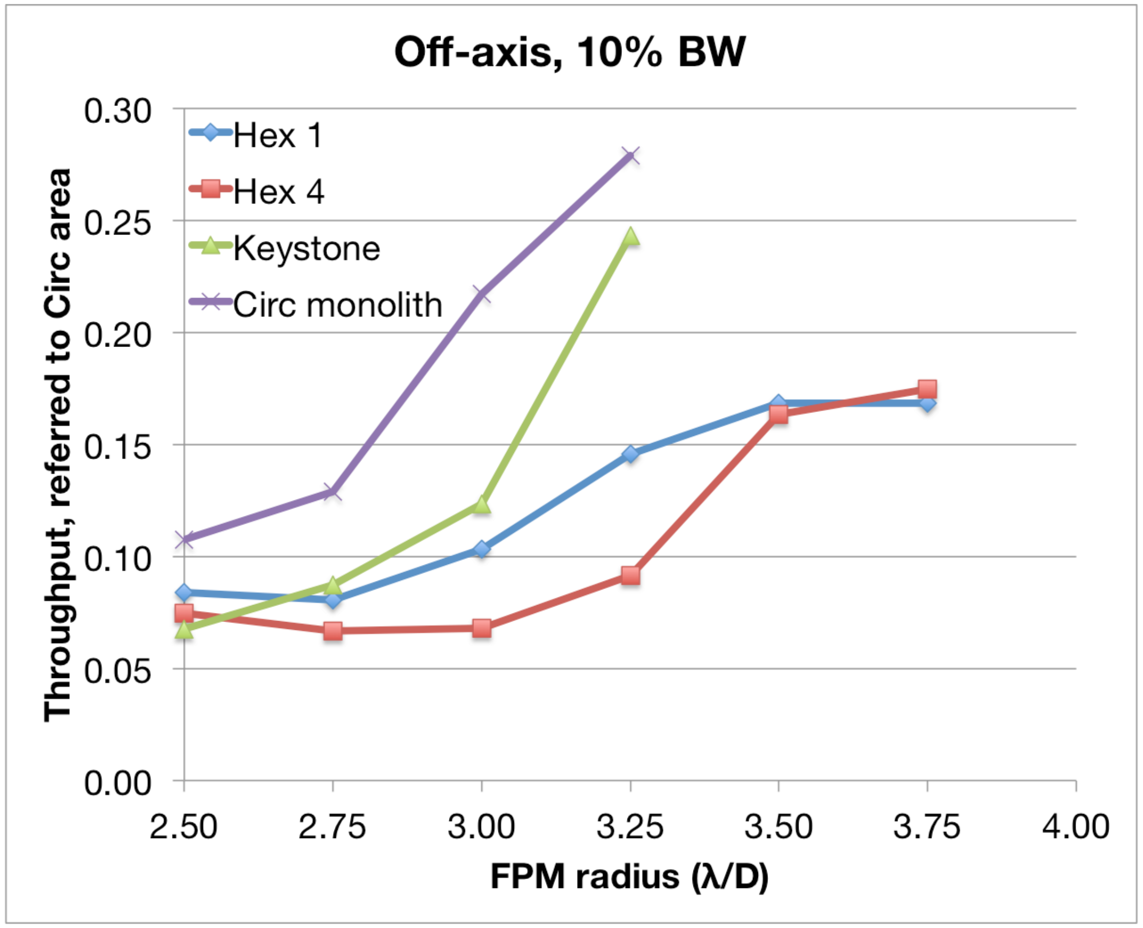
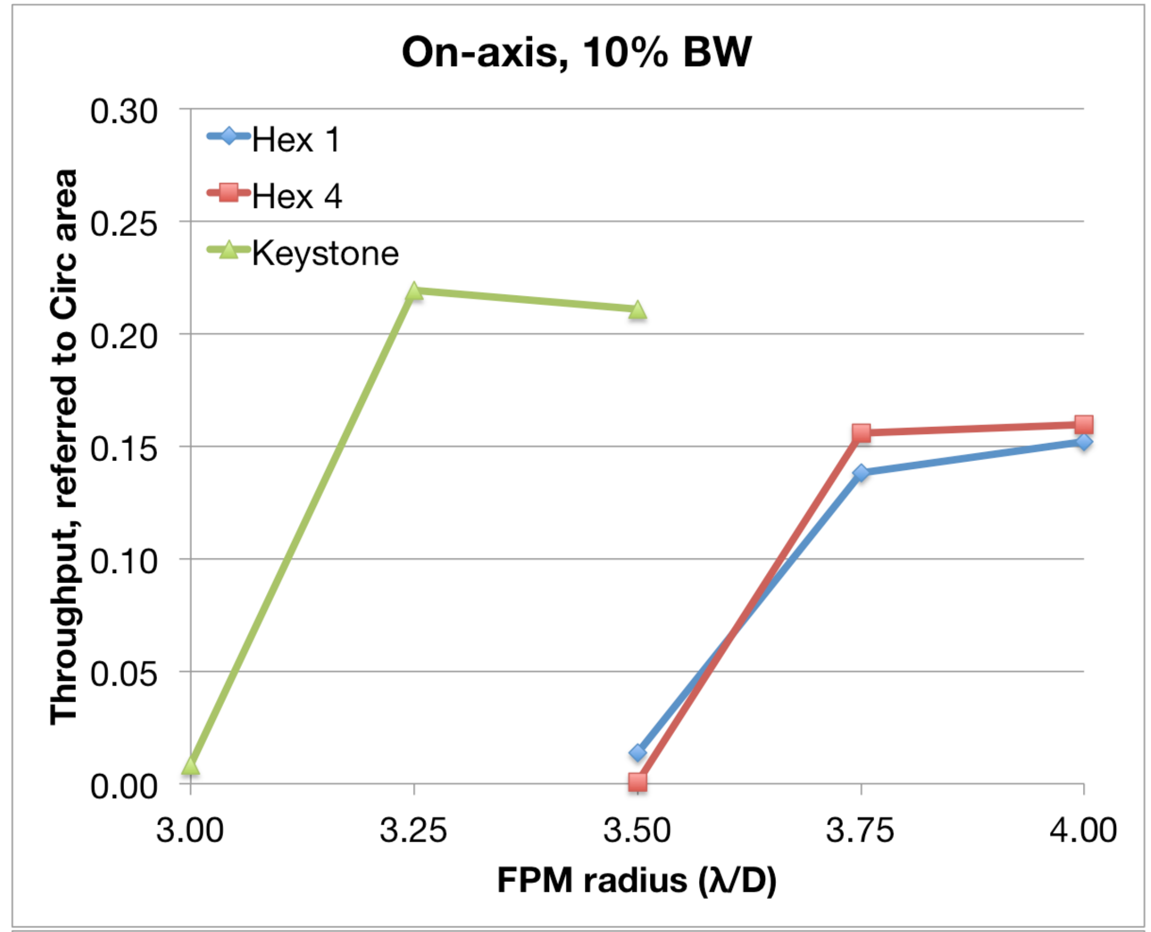
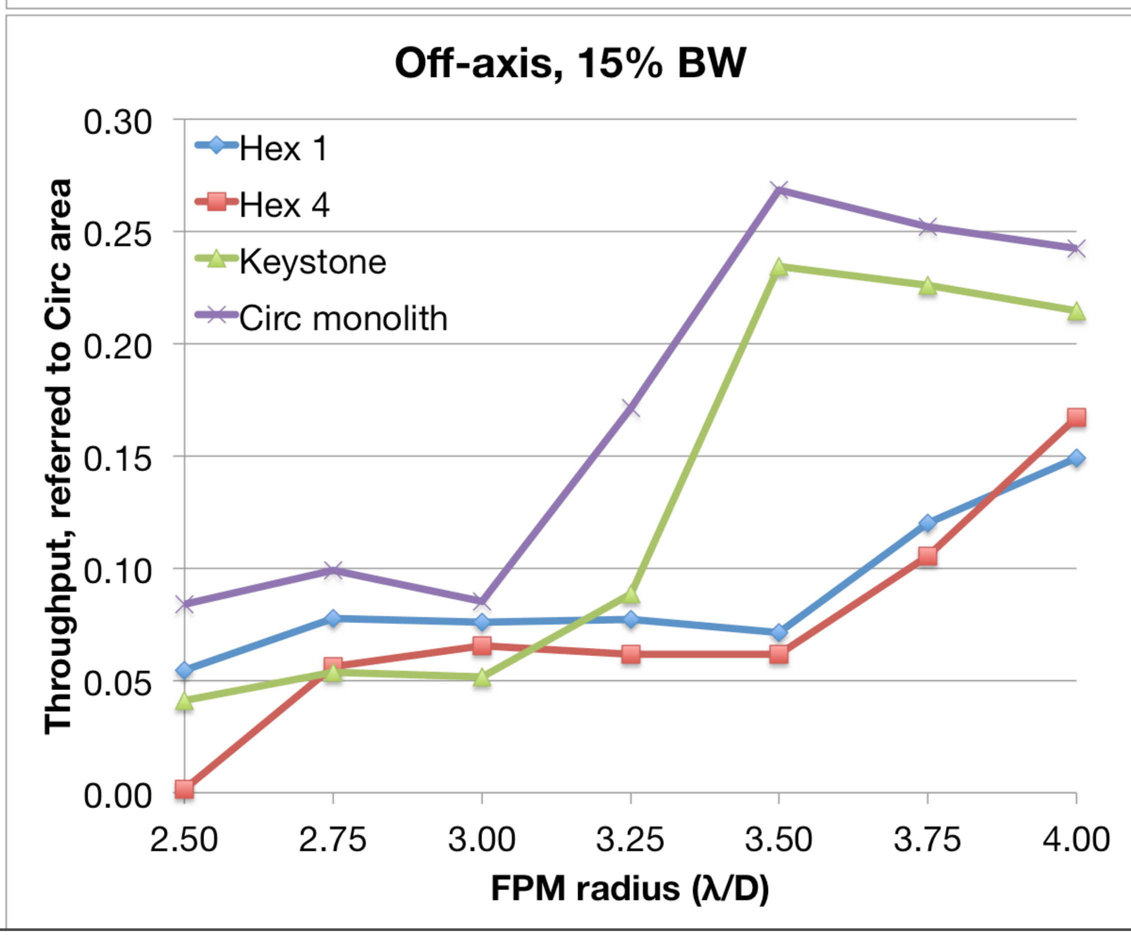
Throughput of best designs as a function of IWA

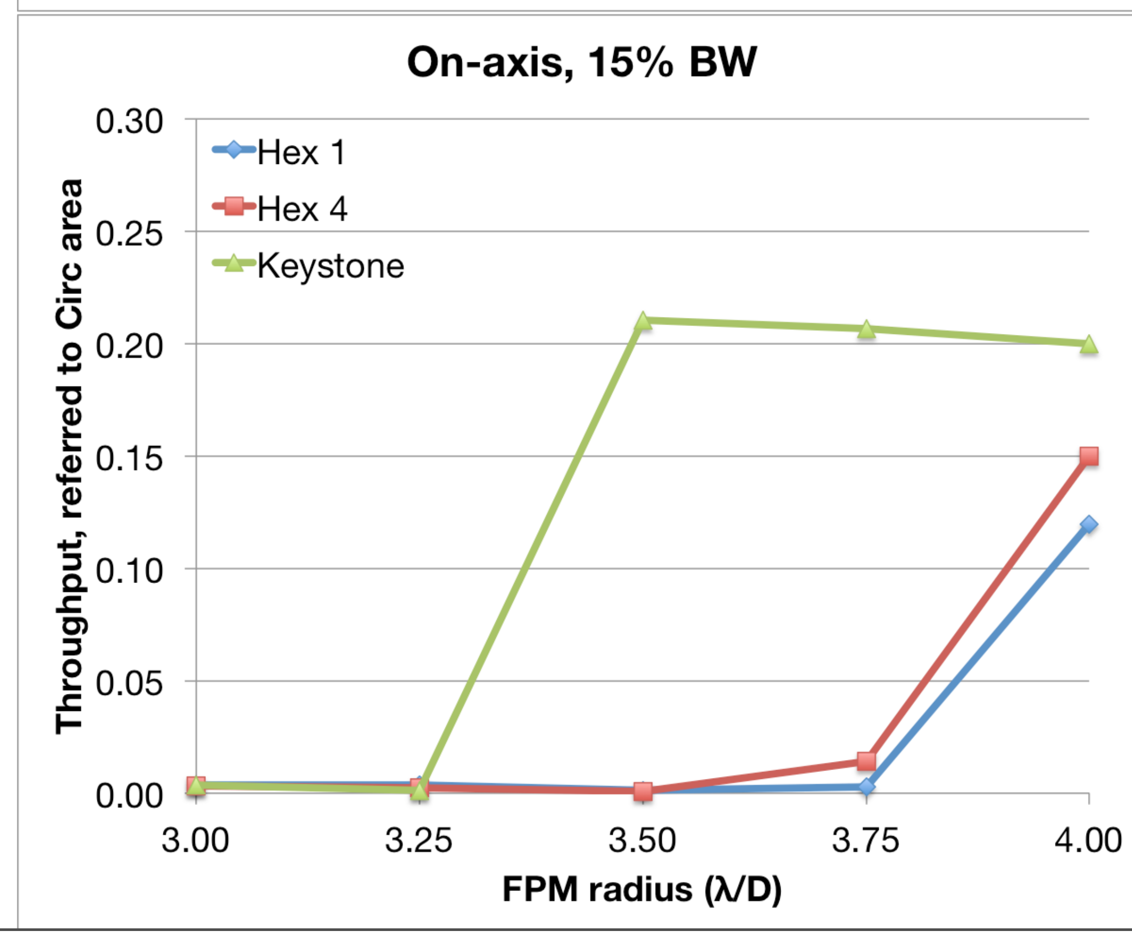


SCDA results SP/APLC

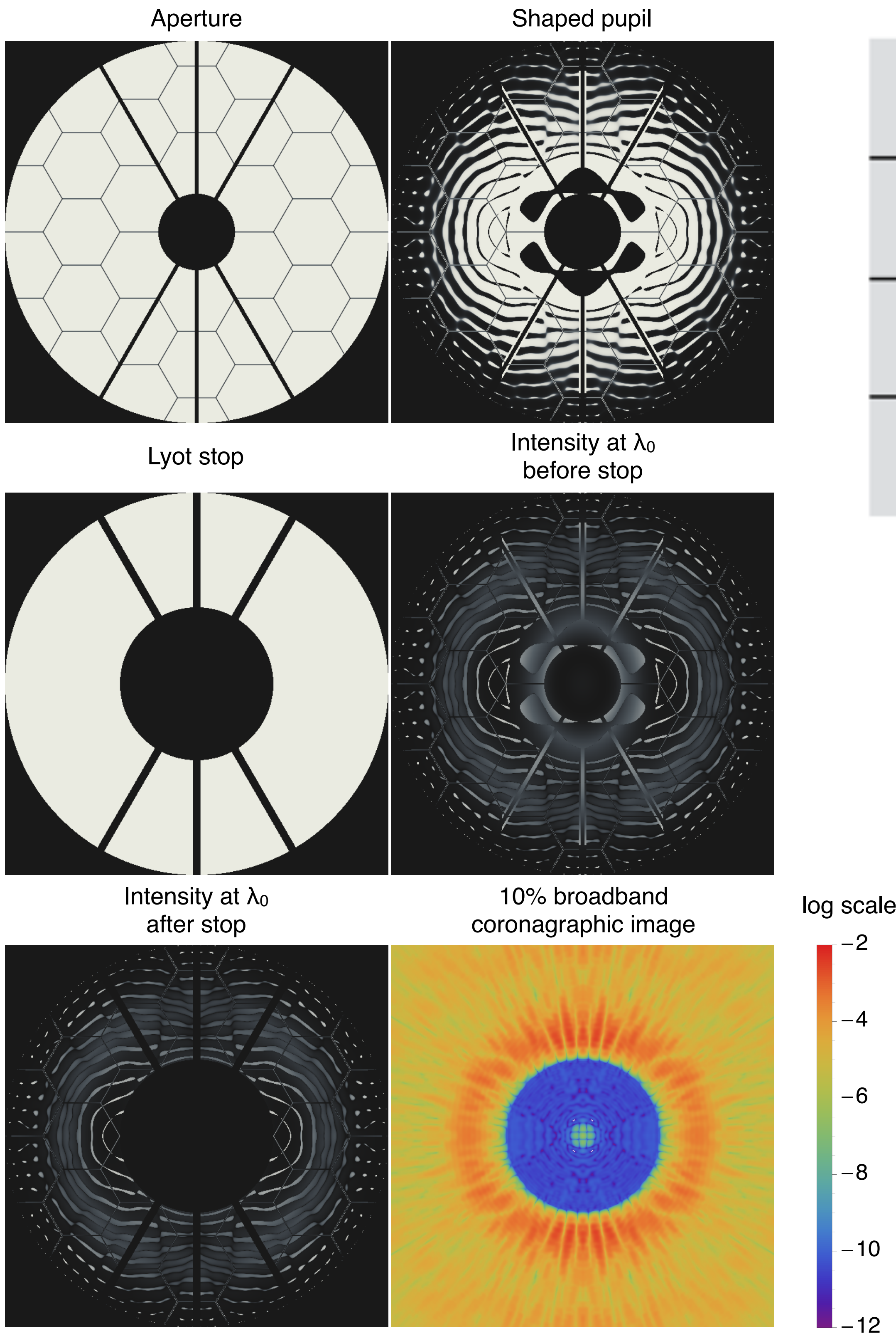






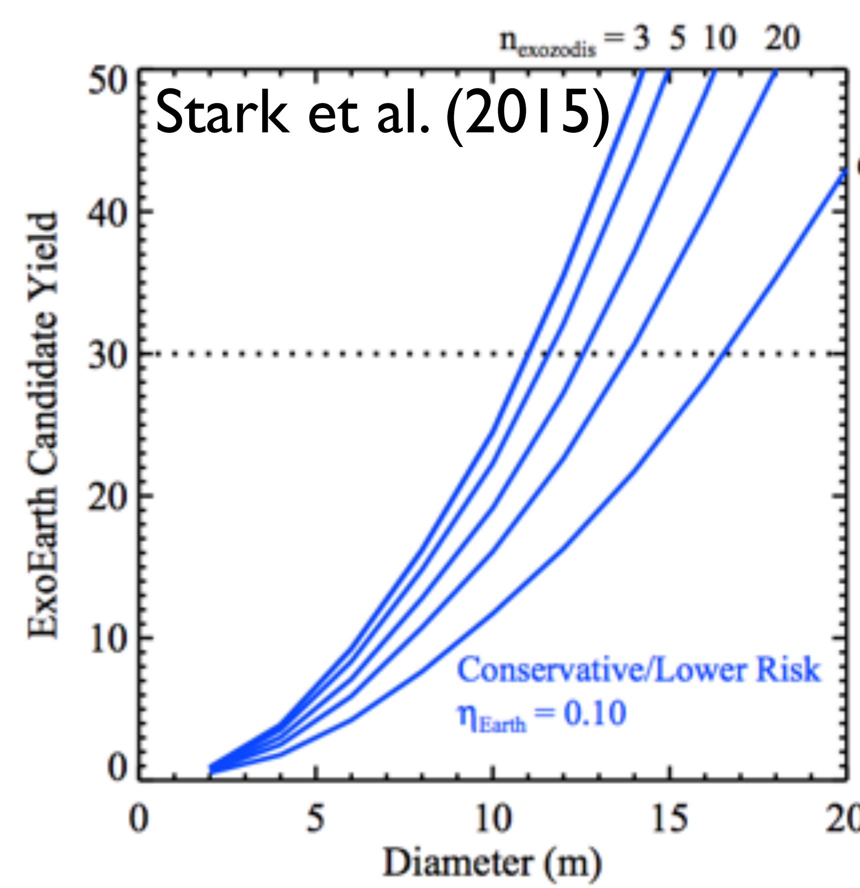


SCDA results SP/APLC



Aperture	Obscured	Unobscured
Hex 1	22	31
Hex 4	26	28
Keystone 24	31	36

Courtesy of Neill Zimmerman

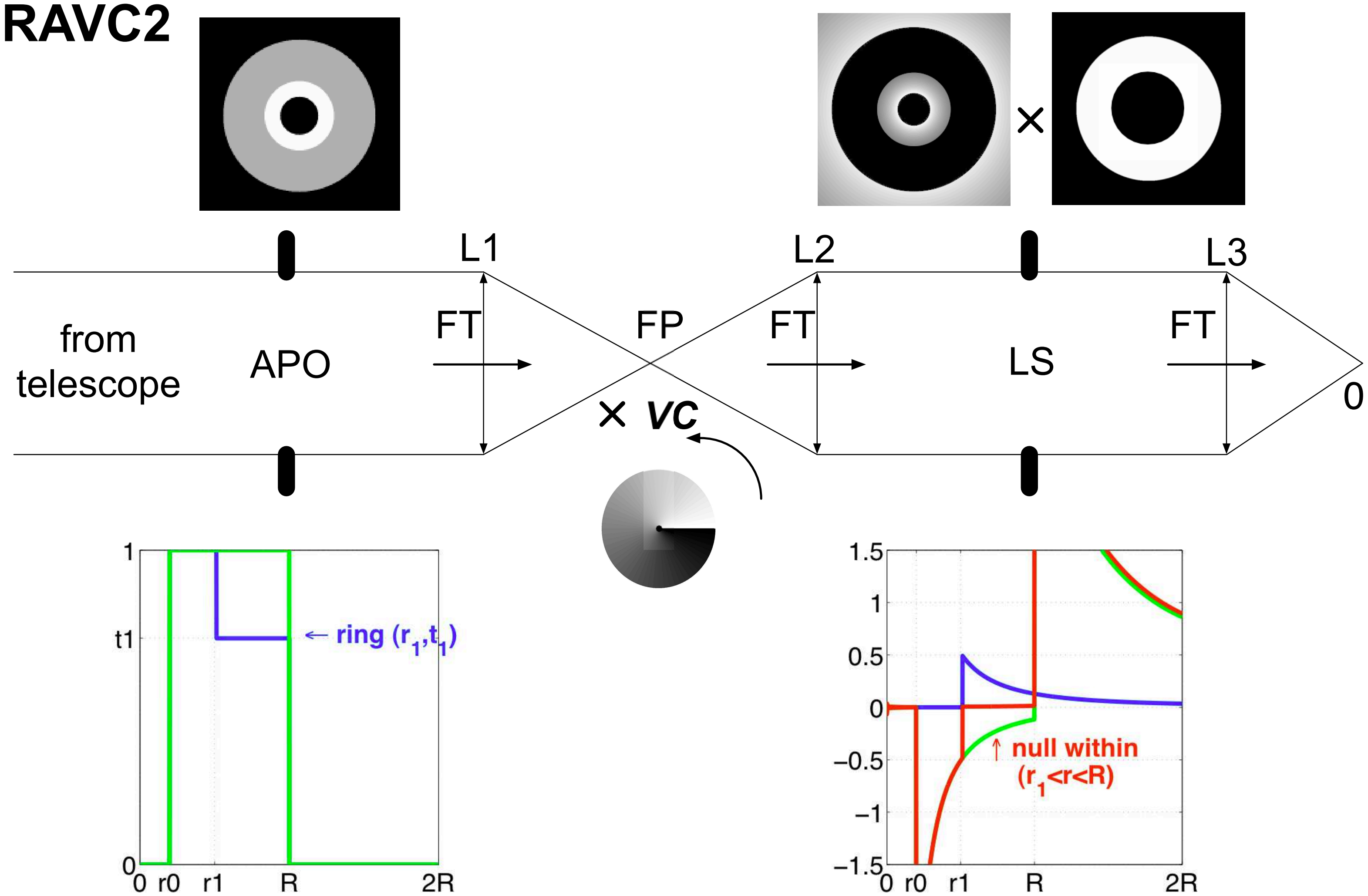


How to better design coronagraph.

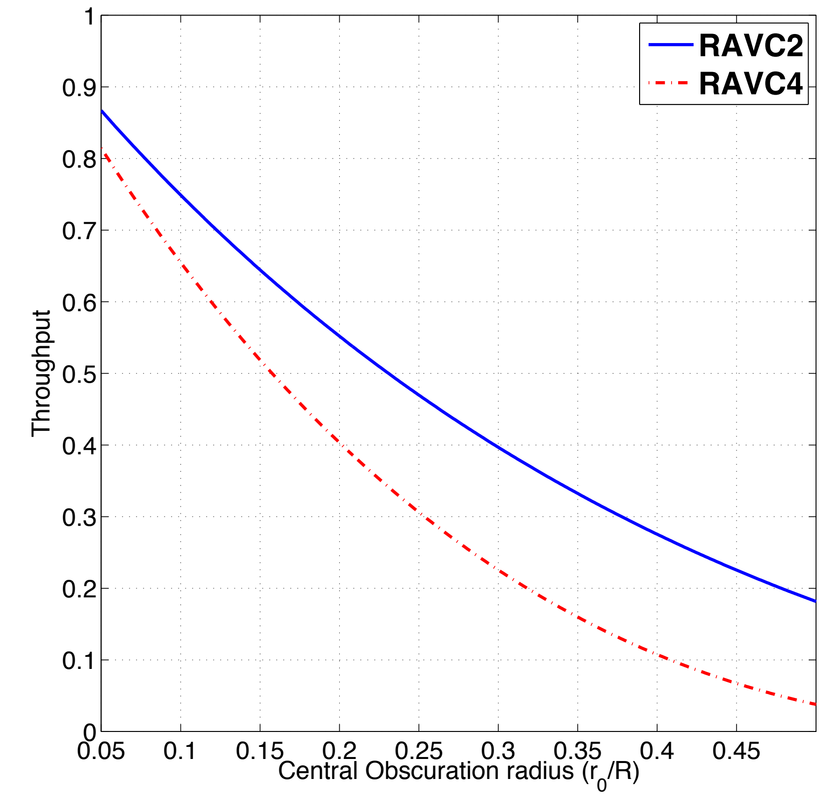
SCDA results: Vortex

Mawet et al. (2013)

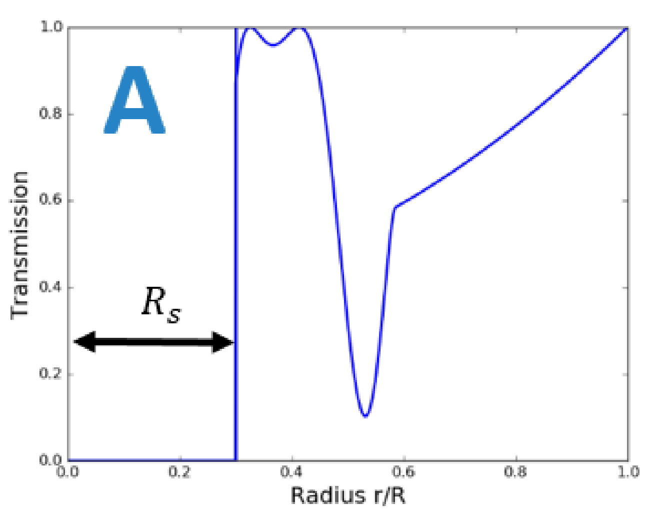
B. RAVC2

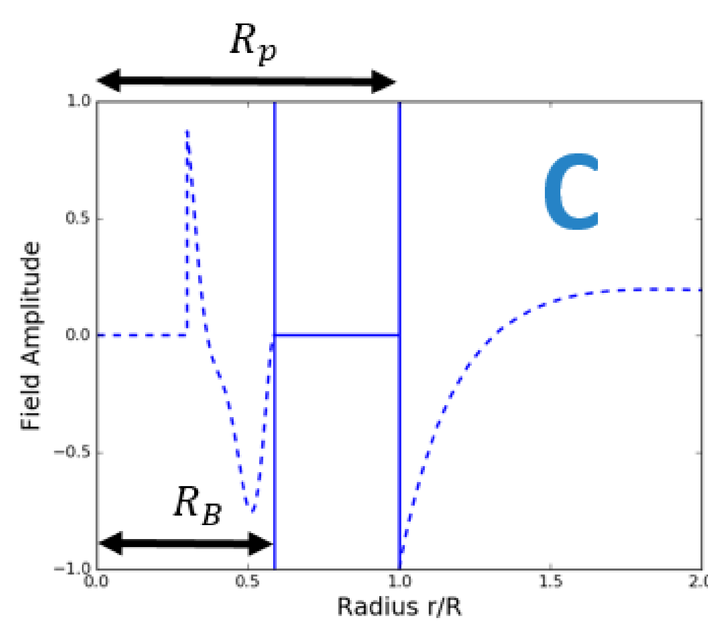


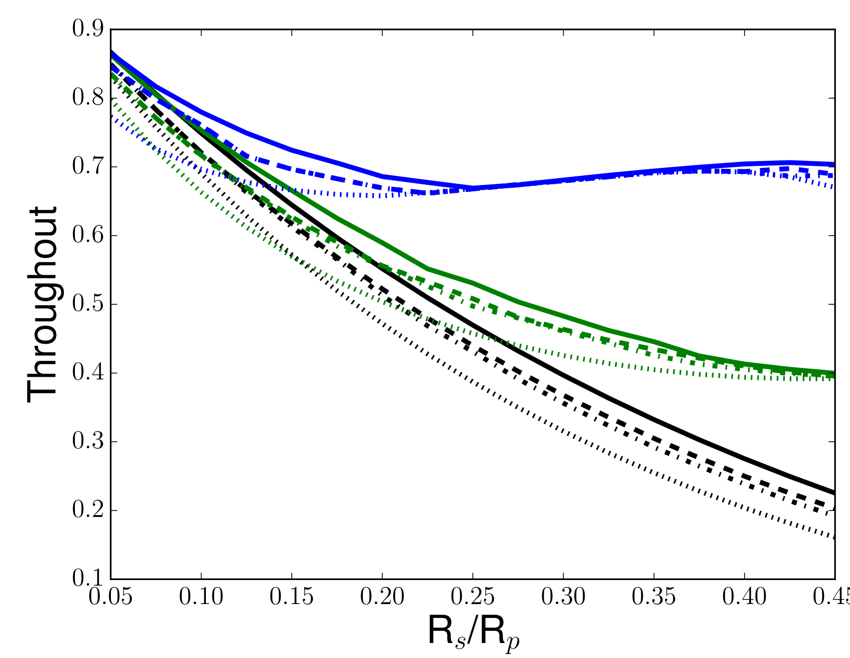
Throughput



Fogarty et al. (in prep)

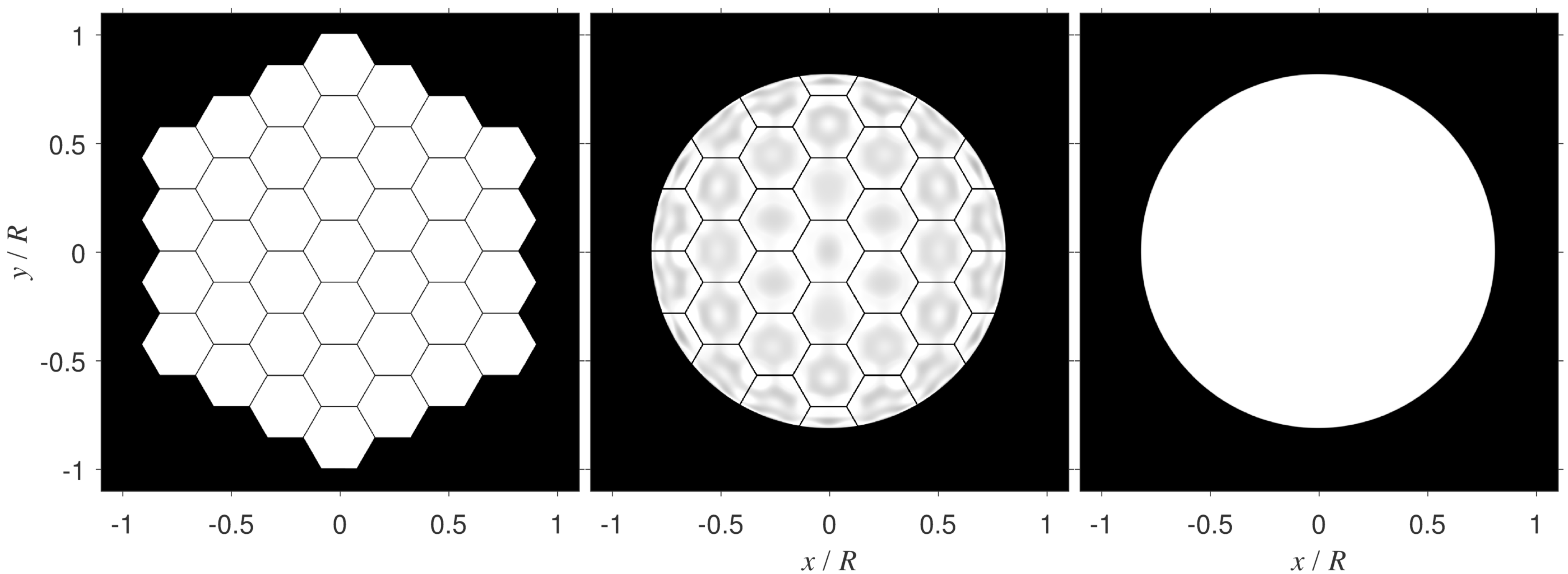


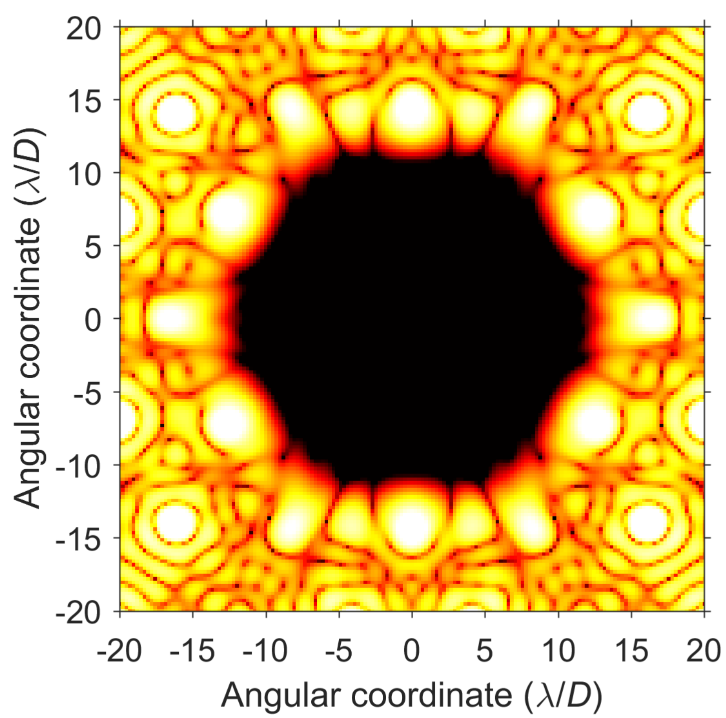




SCDA results: Vortex

Grayscale apodized vortex coronagraph

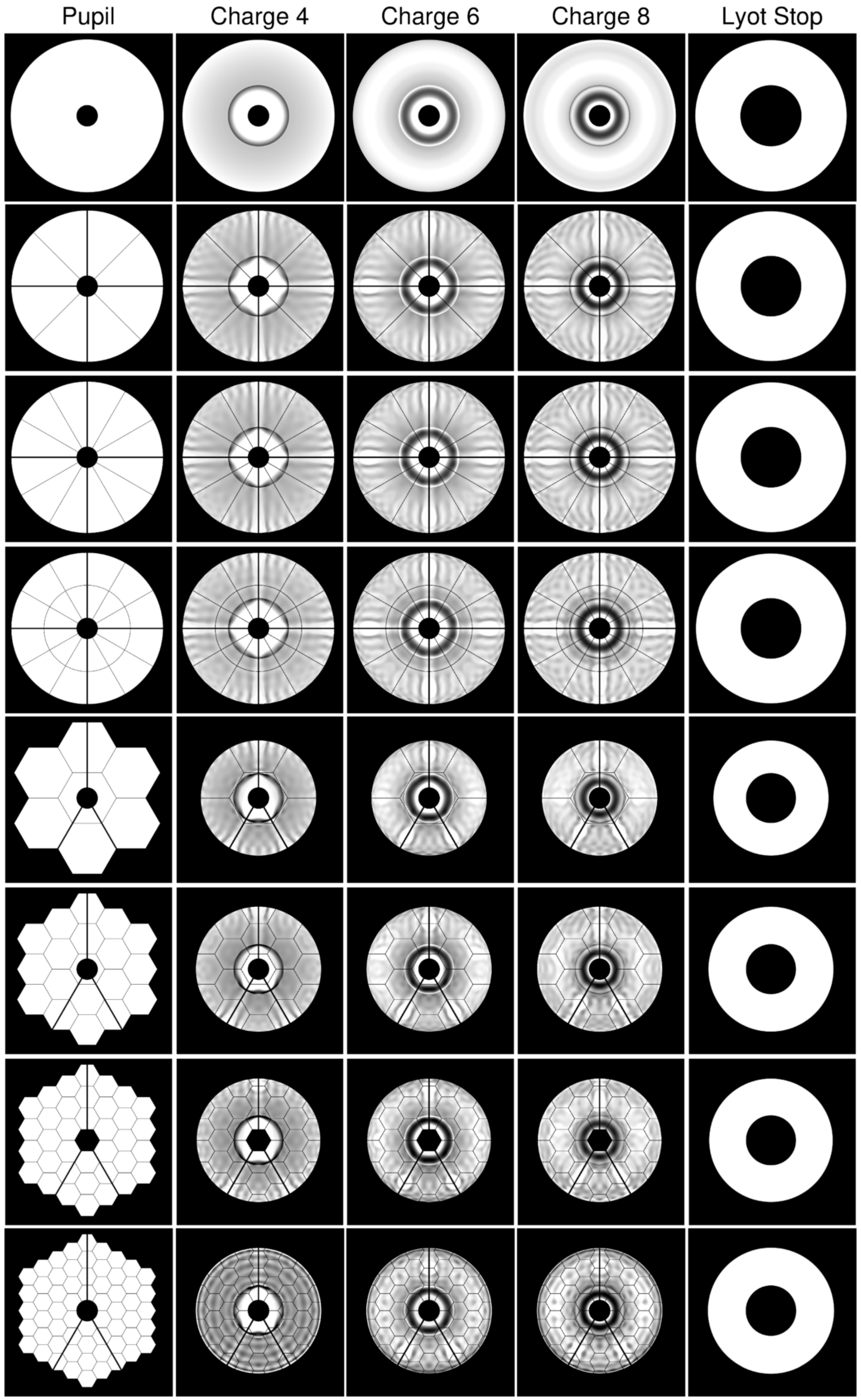




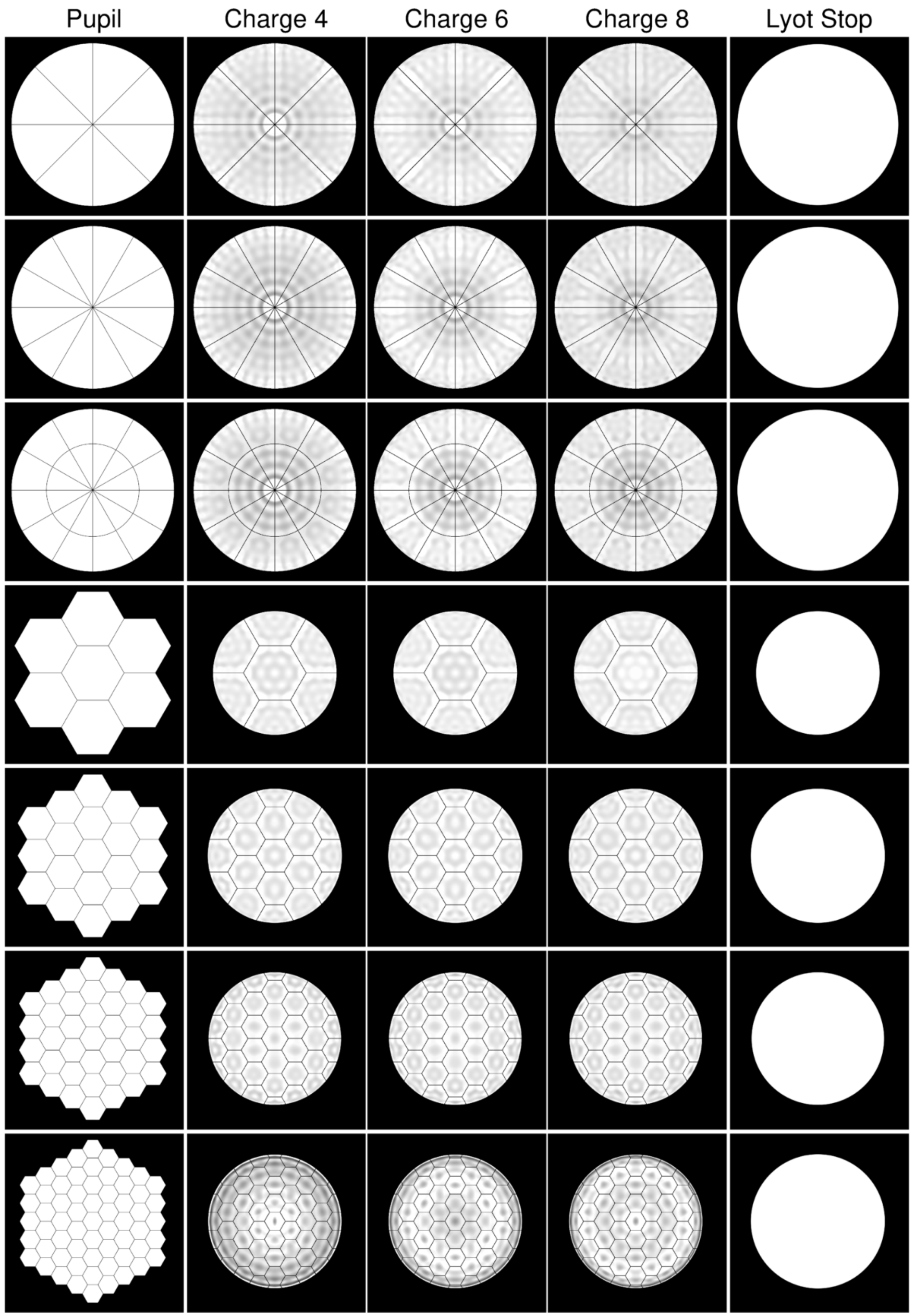
Ruane et al. (2015)

Courtesy of
Garreth Ruane

SCDA results: Vortex

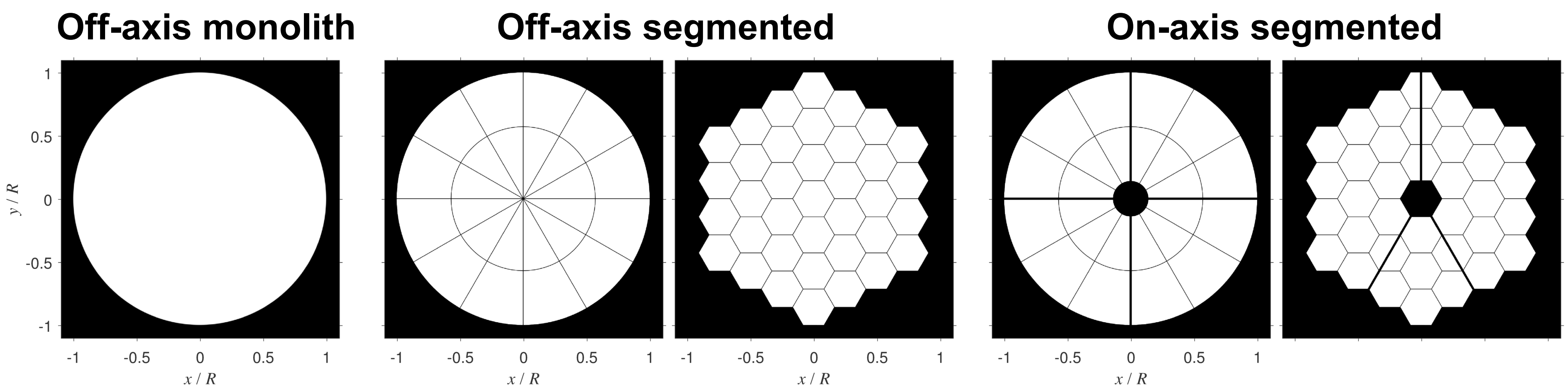


Courtesy of Garreth Ruane

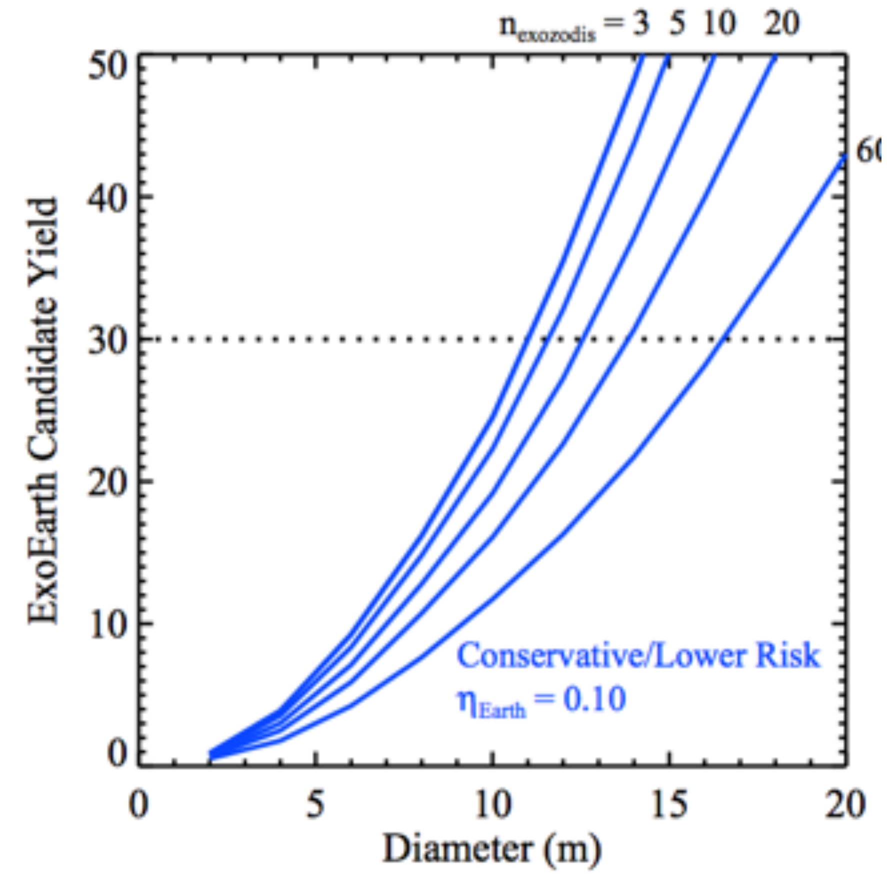


SCDA results: Vortex

ExoEarth Candidate Yield Calculations

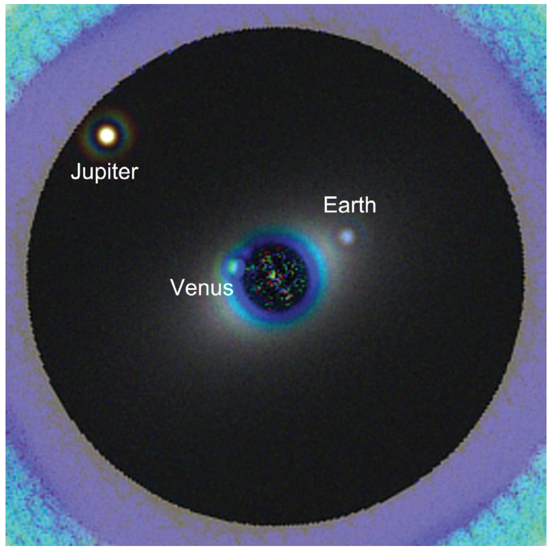


Telescope	ExoEarth Yield
4.0-m off-axis monolith	***5-8***
4.0-m off-axis segmented	3-4
6.5-m off-axis segmented	***8-11***
12-m on-axis segmented	2-8
12-m off-axis segmented	22-28



Courtesy of Garreth Ruane

Recap



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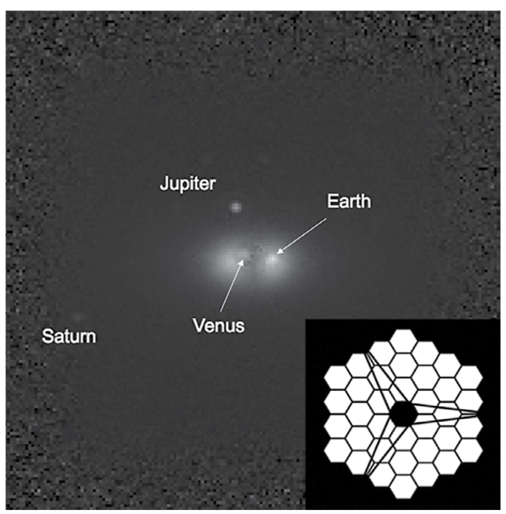
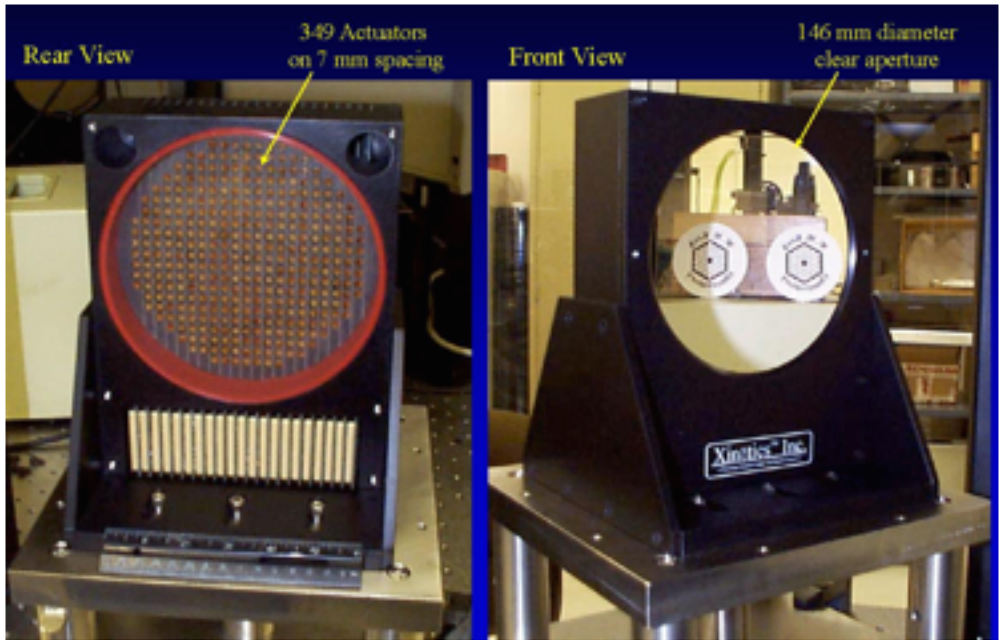


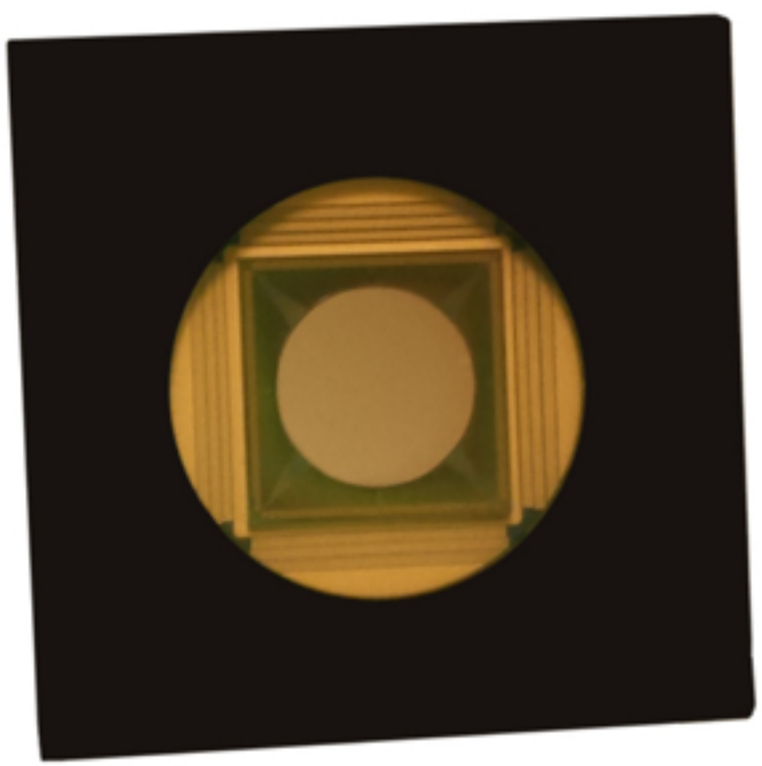
- What is the yield? How to increase the yield?
    - Yield is now on par with Stark et al. (2015)
    - Progress is happening quickly
- How do we reach the wavefront stability?

Wavefront stability

Wavefront actuation

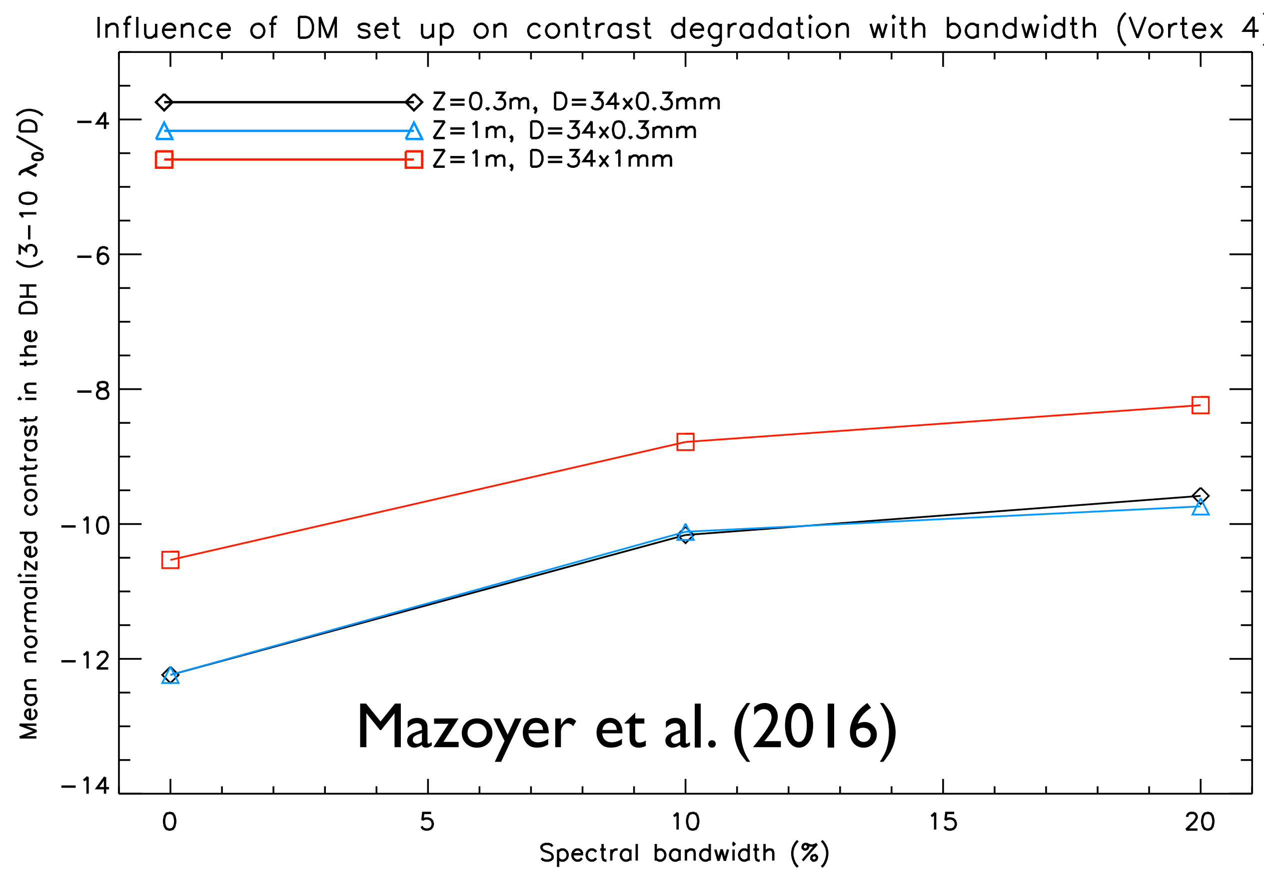


WFIRST like DM: 1 mm pitch



GPI like DM: 0.3 mm pitch

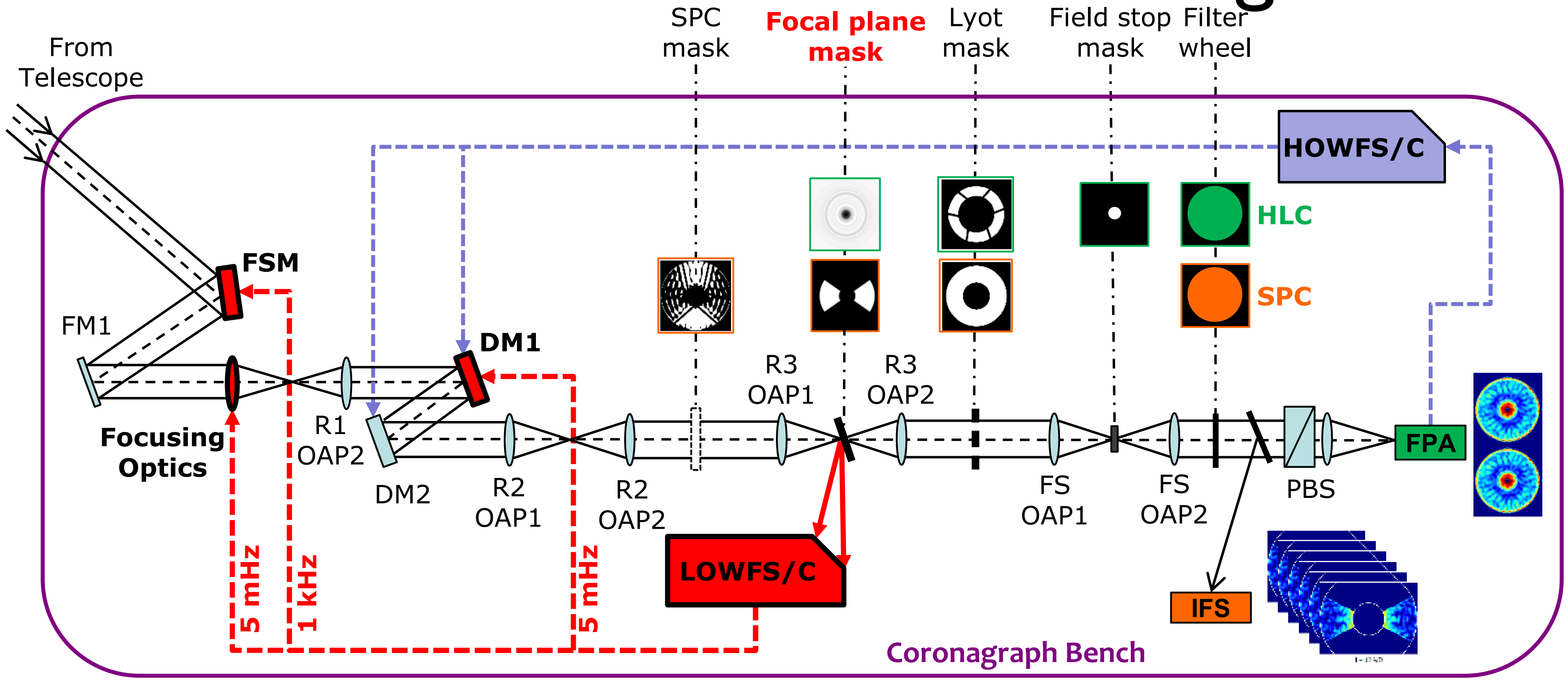
When using 2 DMs actuator pitch impact performance.



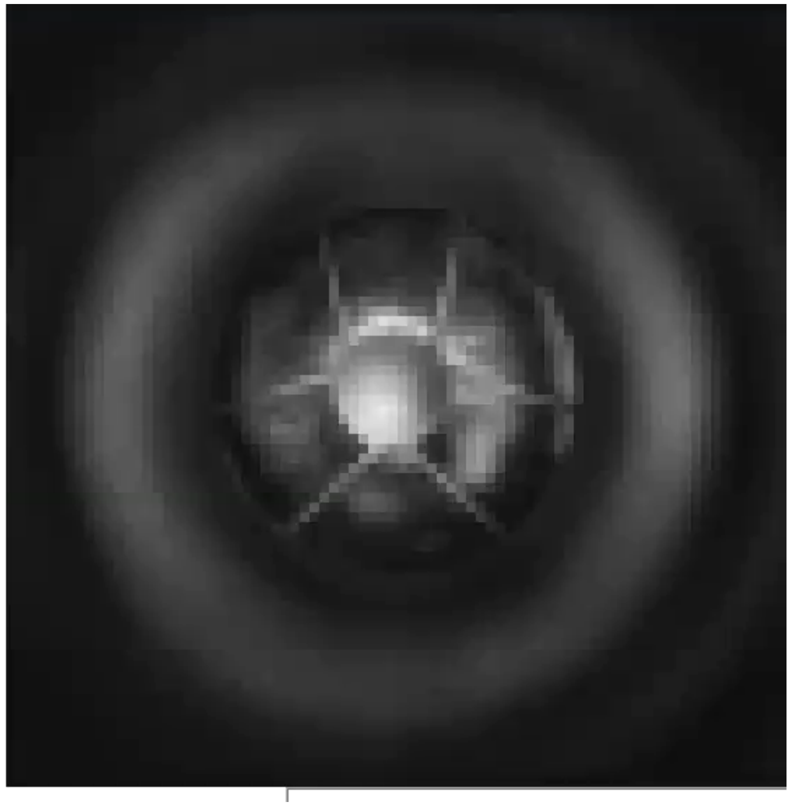
Other solutions include active primary, segmented DM.

Technology trades

Wavefront sensing



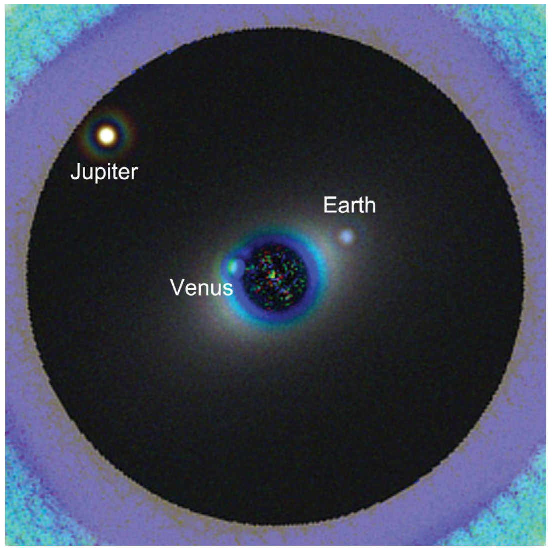
Shi et al. (2015)



Questions:

- Will we need a LOWFS?
- Will we need a HOWFS?
- Copy LOWFS architecture of WFIRST?

Recap



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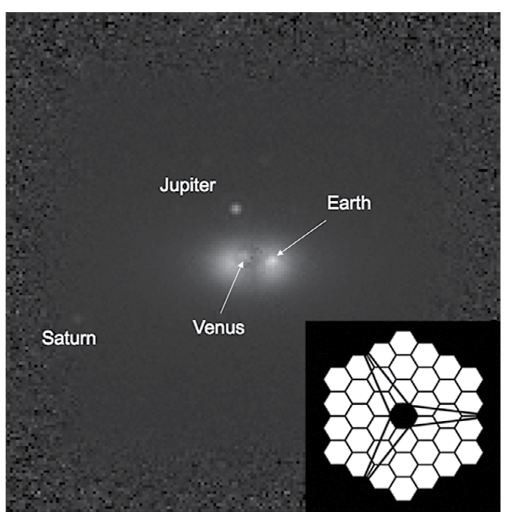
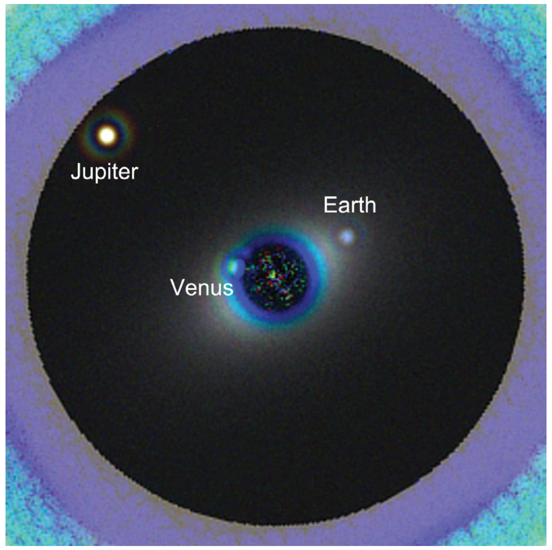
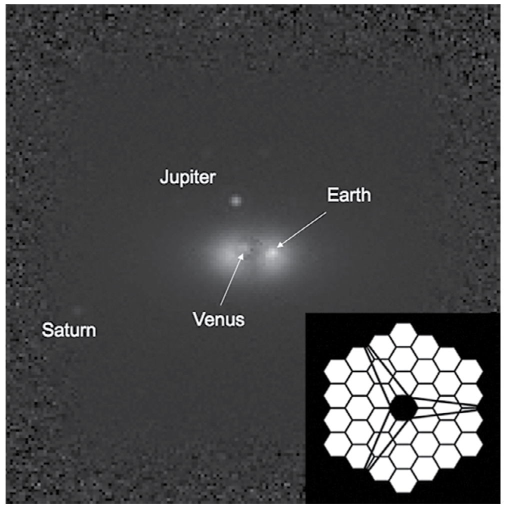


- How do we reach the wavefront stability?
    - Ongoing work on technology trades.
    - Most likely will not impact instrument mass volume.

Moving forward





- Oct 20 th 2016: Kick Off meeting.
- Nov 3 rd: Discussions on preliminary input sheet.
- Dec 1 st: In depth discussion filters, wavelength coverage. Inputs from ExoWG.
- Dec 15 th: In depth discussion on back end instrument architectures/detector technologies.
- Jan 12 th: In depth discussion on wavefront sensing and control architecture.
- Jan 19 th: In depth discussion on coronagraph design and optical design considerations.
- Feb 2 th: Finalize input sheets. Finalize documentation package to help GSFC design team.