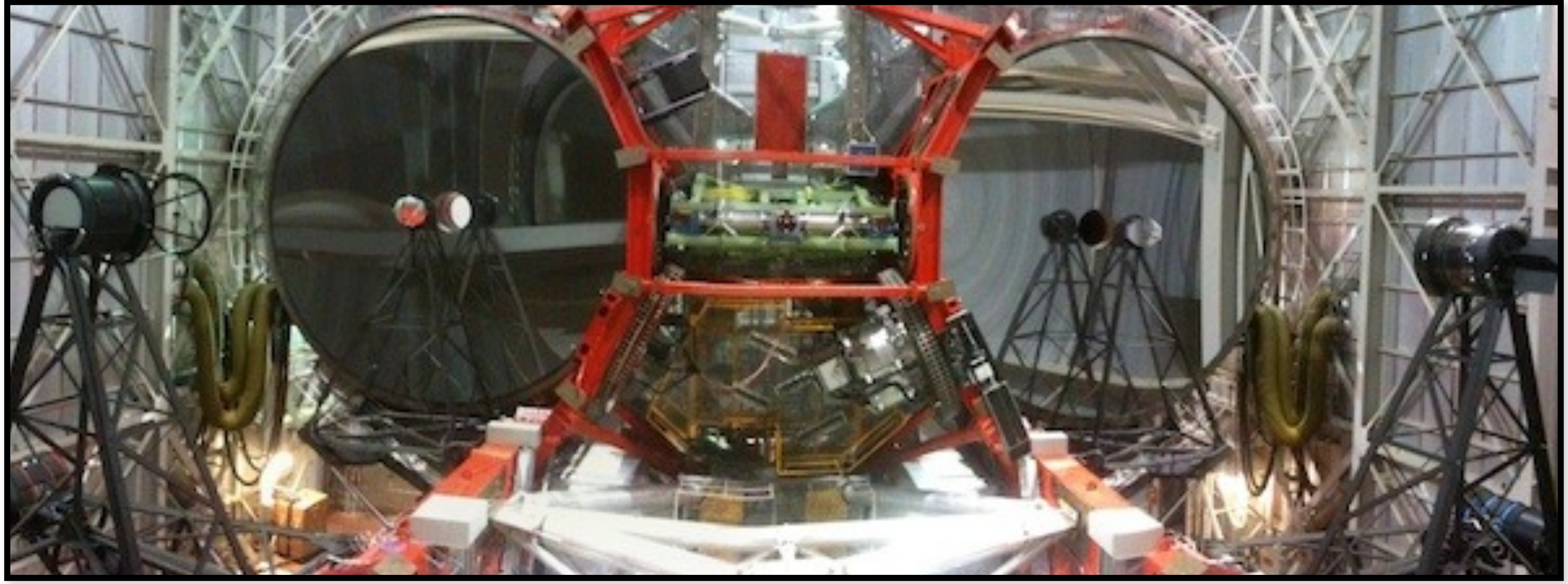
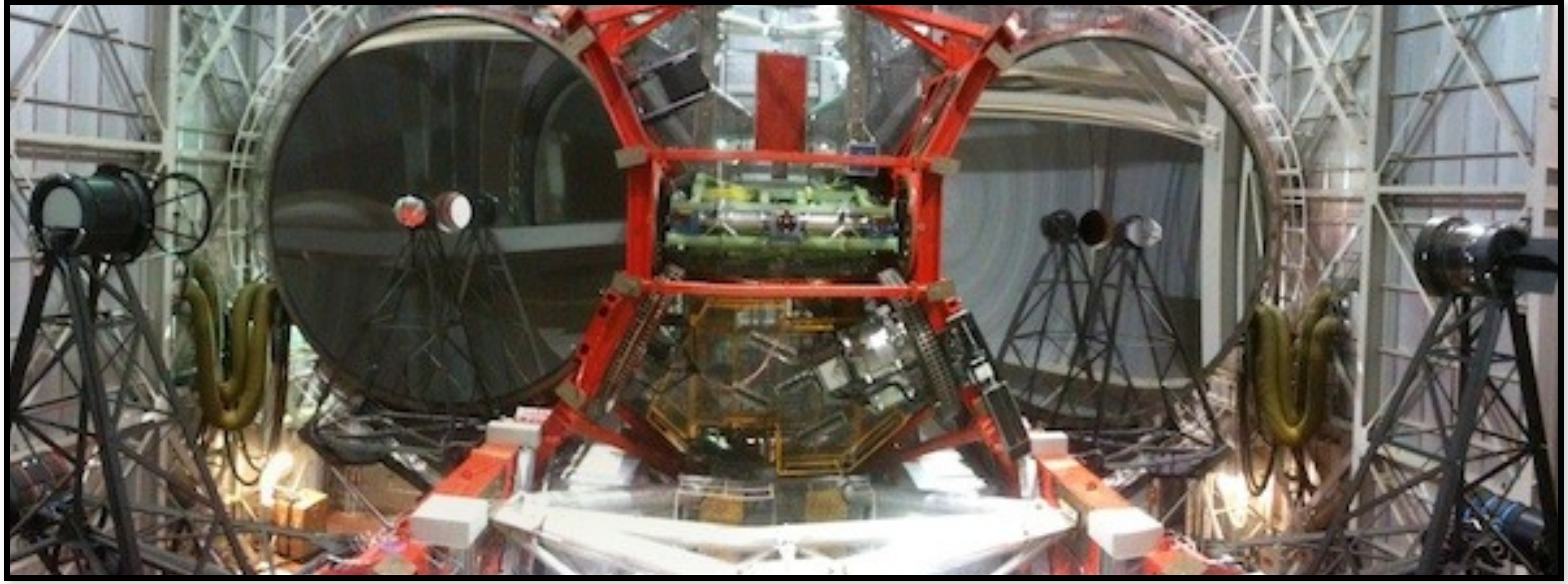


The LBT Interferometer:
Observing Disks and Planets in the thermal Infrared

Phil Hinz
May 2, 2011



The LBT Interferometer:

Observing Disks and Planets in the thermal Infrared

Phil Hinz

May 2, 2011

Outline:

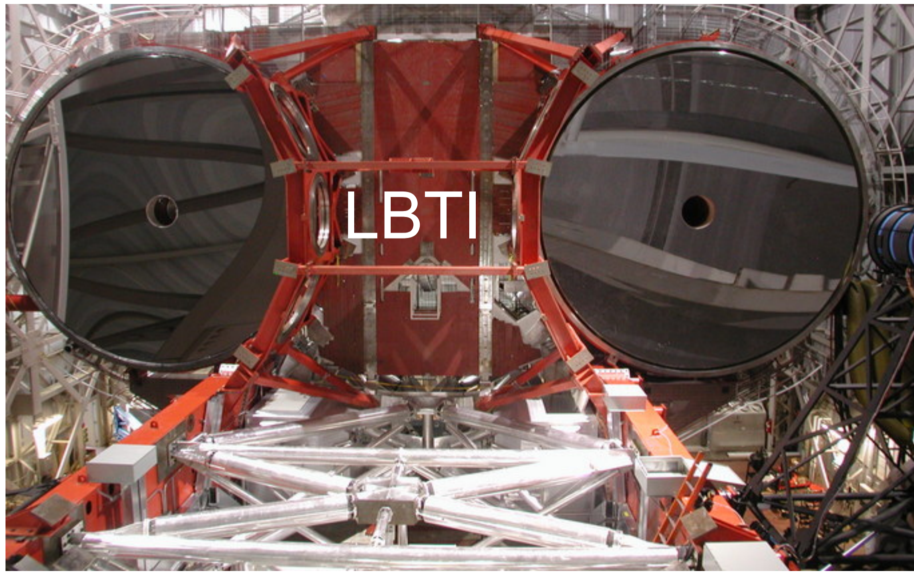
- Fall 2010 on-sky testing of LBTI
- Expected Capabilities

Key Parameters

Key Parameters

Sensitivity

LBTI has two 8.4 m mirrors mounted on a single structure.



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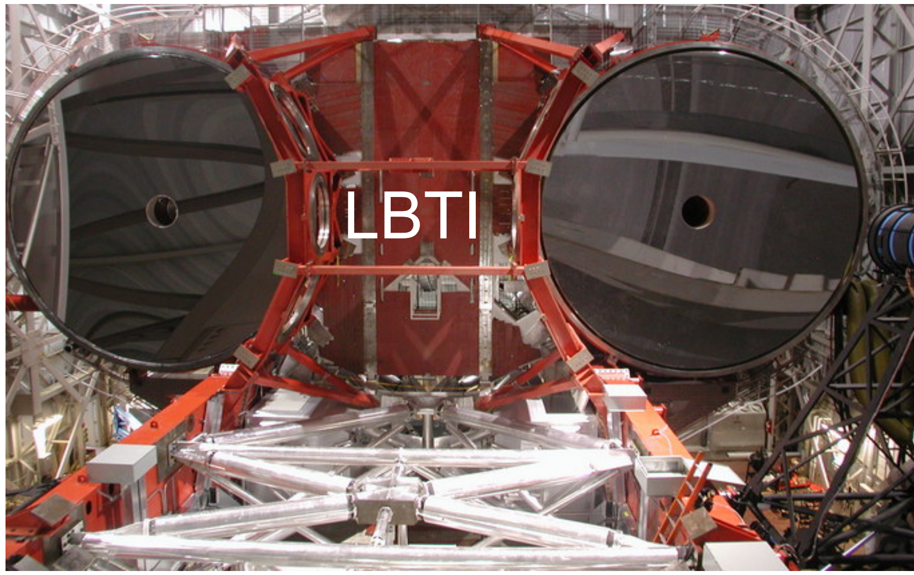

High Contrast

The AO system creates an image with a Strehl of >95% at increases at 3.8 μm.

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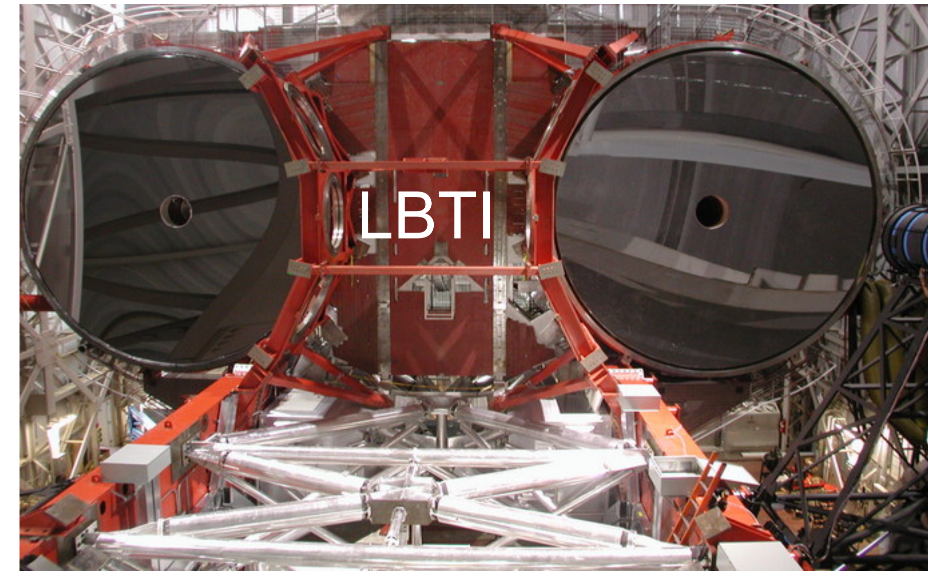

High Contrast

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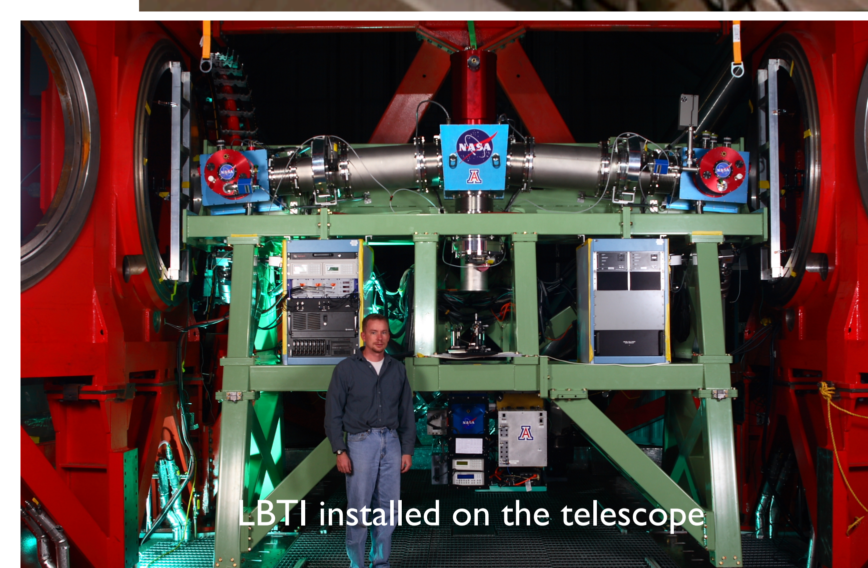
LBT Deformable Secondary Mirror

Resolution

Beam combination provides the equivalent resolution of a 22.7 m telescope.



LBTI installed on the telescope

LBTI by numbers

	LMIRcam	NOMIC
Wavelength Coverage (μm)	2.9-5.1	8-14 (8-25 goal)
Throughput	>30%	>20%
Pixel Size	0.011”	0.03”
FOV	10”	7.7”
minimum Strehl	85%	95%
Spectral Resolution	350	100
5 sigma detection, 1 hour	19.8 (3.4 μJy) @ L’	14.3 (70 μJy) @ N
Spatial Resolution	40 mas @ L’	100 mas @ N’

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at 1 Gyr

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0.4 AU
at 10 pc

1/3 zodi
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2 M_J planet
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0.4 AU
at 10 pc

1/3 zodi
debris disk

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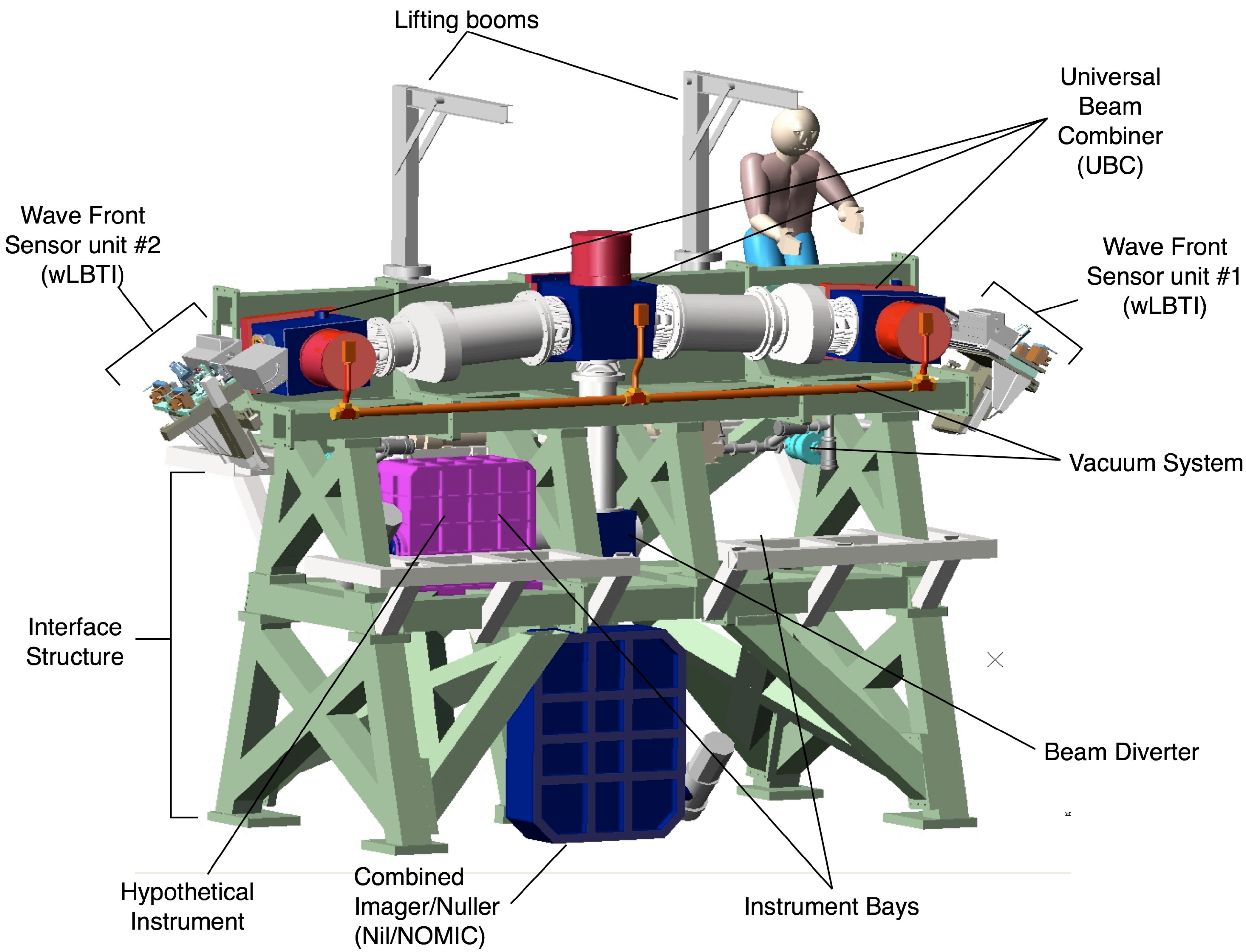
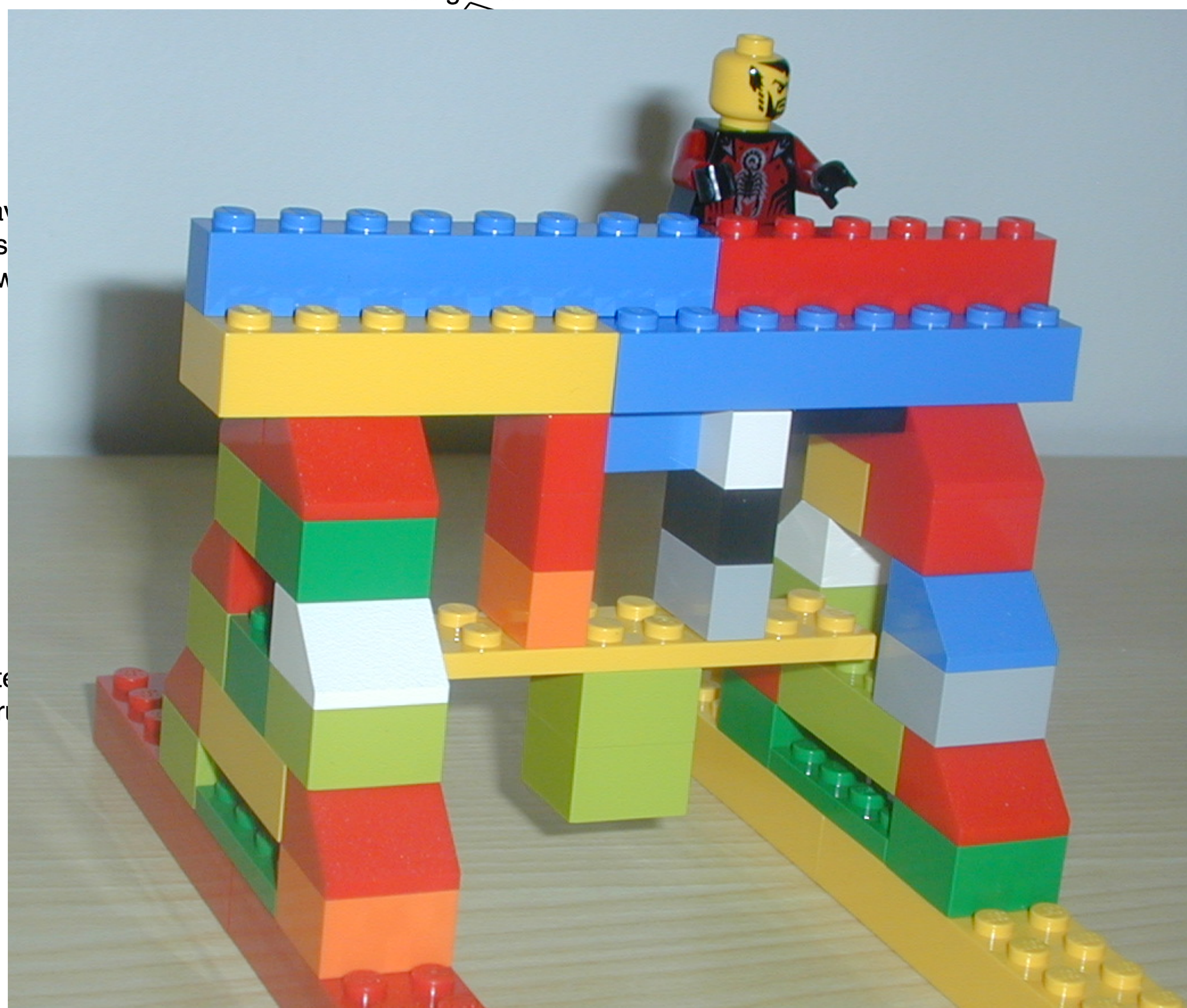
at 10 pc

LBTI Components



LBTI Components

Lifting booms



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Going onto the Telescope

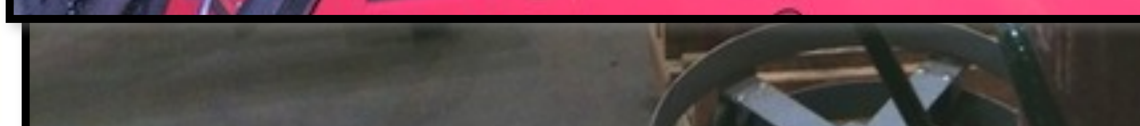
Large Binocular Telescope Interferometer (UA)

Lifting the beam combiner to the telescope

Sep. 2011

Going onto the Telescope

Large Binocular Telescope Interferometer (UA)



Lifting the beam combiner to the telescope

Lifting over the telescope. A very nervous 45 minutes

Sep. 2011

Going onto the Telescope

Large Binocular Telescope Interferometer (UA)

90 minutes later we are on the telescope!

Sep. 2011

Plugging everything in . . .

Early October

Large Binocular Telescope Interferometer (UA)

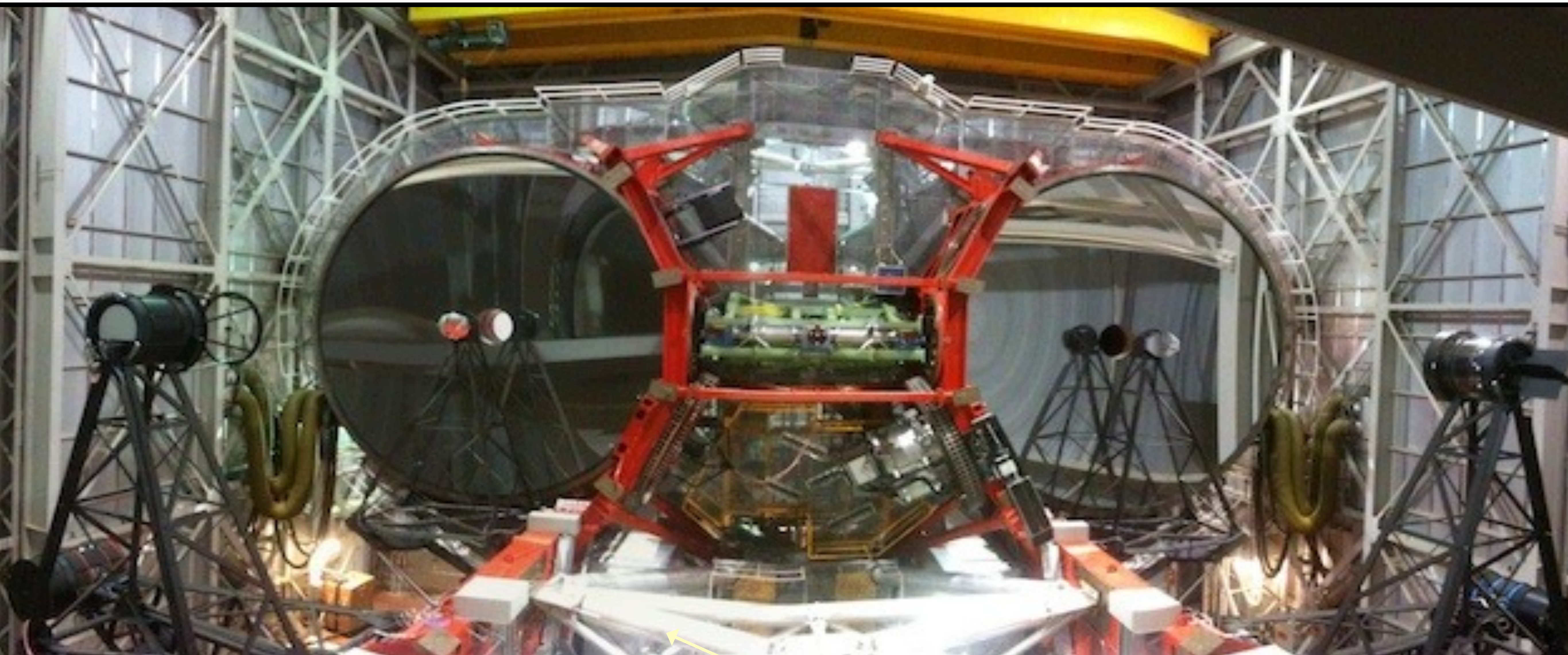
Activity on the telescope

Adjusting the DX wave front sensor

Completing the electrical system

Aligning the imager pupil to the system

Ready to Go . . .



Large Binocula
Interferomete

Oct 14… First Night of Observing

Here the telescope is horizon pointing giving the best vantage point of the instrument mounted on the telescope

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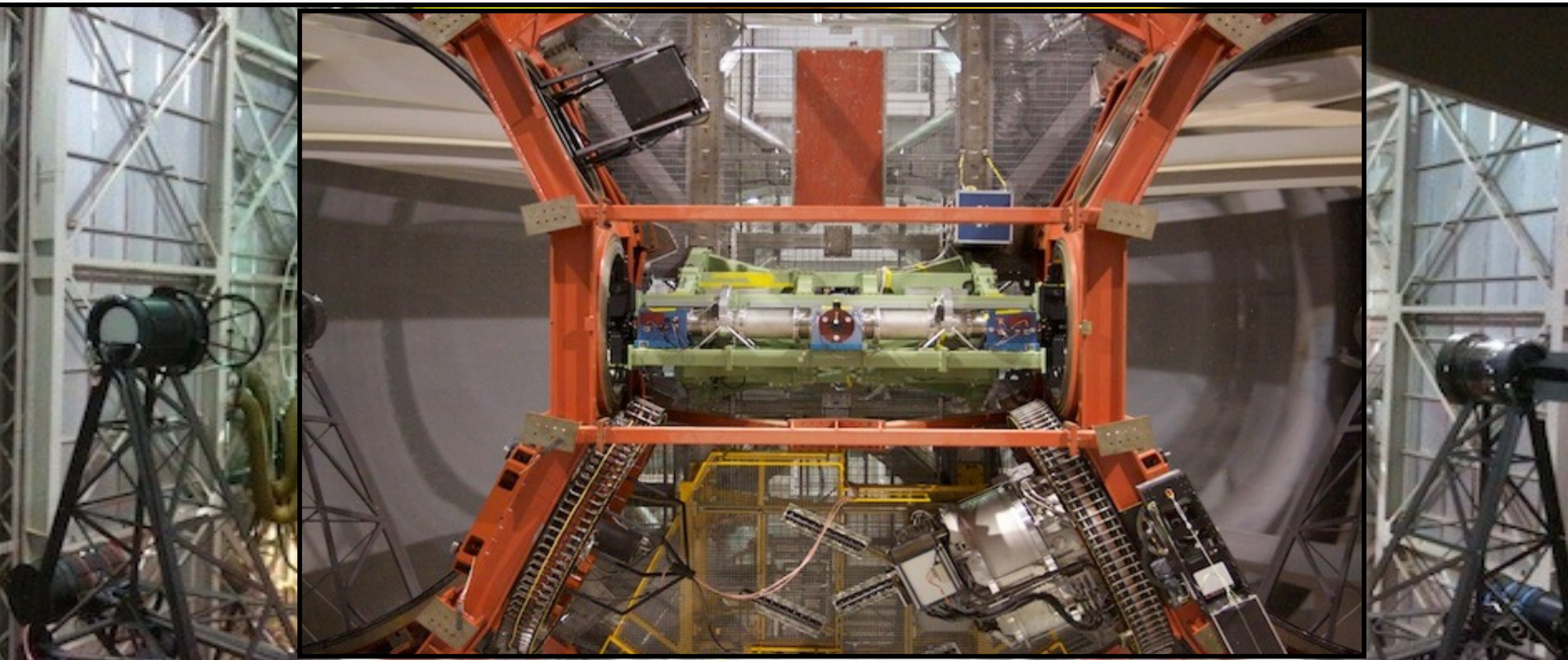

Large Binocula
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Oct 14… First Night of Observing

Here the telescope is horizon pointing giving the best vantage point of the instrument mounted on the telescope

Commissioning Plans

Three nights in October and another three in November:

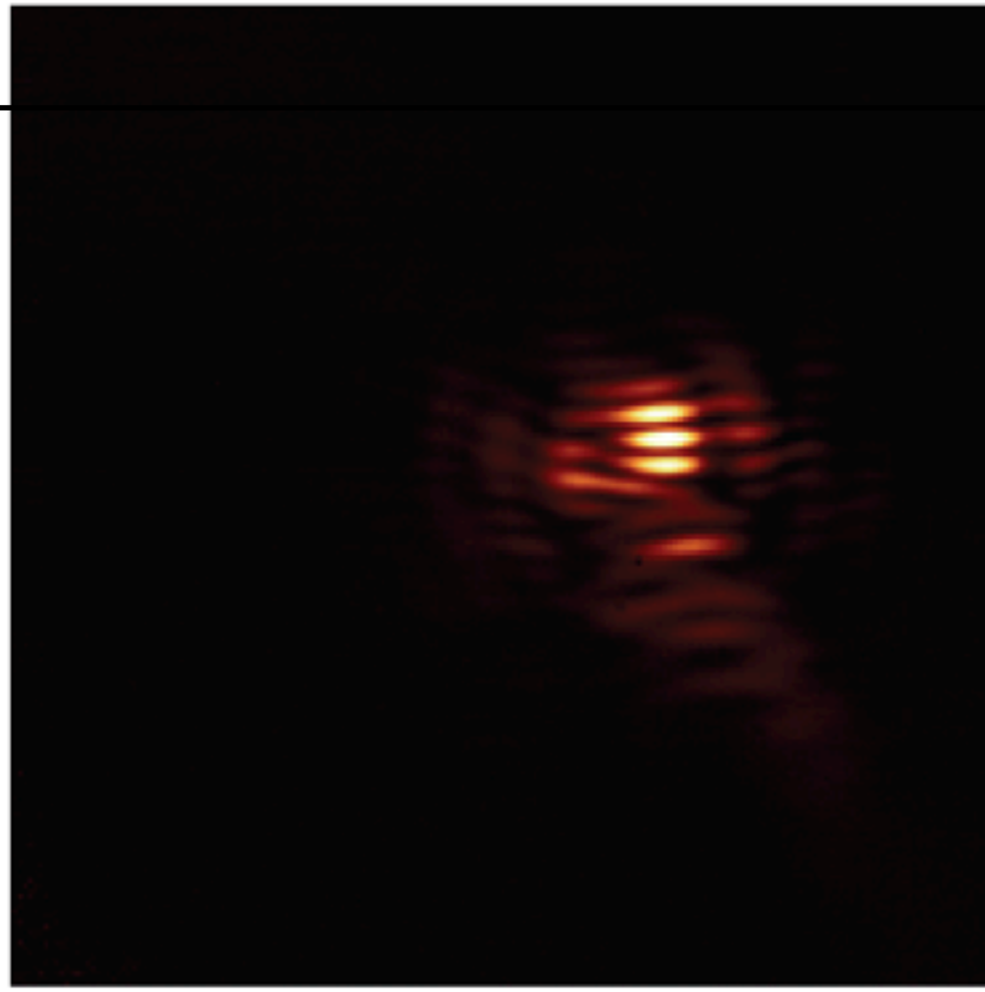
- Develop LBTI pointing model for each arm.
- Align and Characterize both WFS and Science Camera.
- Test Alignment and Phase Scanning of Interferometer.
- Detect Fringes between apertures and take test observations.

- Characterize the ASM aberrations and test communication.
- Test ability to maintain closed loop AO operation.
- Characterize limits to the AO correction.

First Fringes!

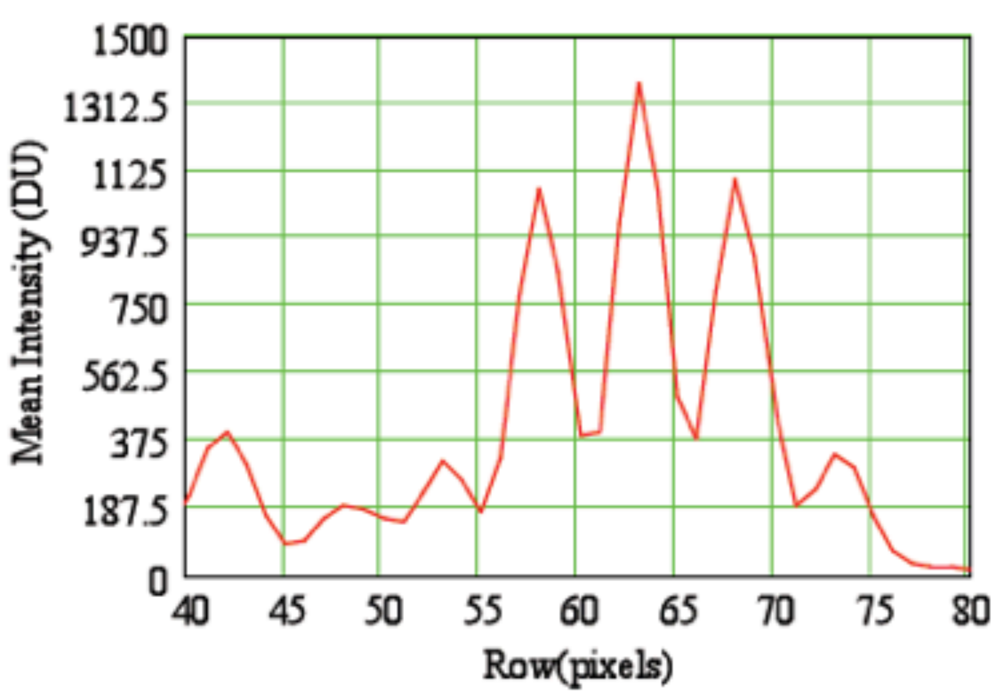
Large Binocular Telescope Interferometer (UA)

Oct 14… First Night of Observing



Beta Peg: Combined 10μm image from the LBTI imager. Image is "seeing limited" under poor weather conditions (seeing ~1.2 arc sec).

Text



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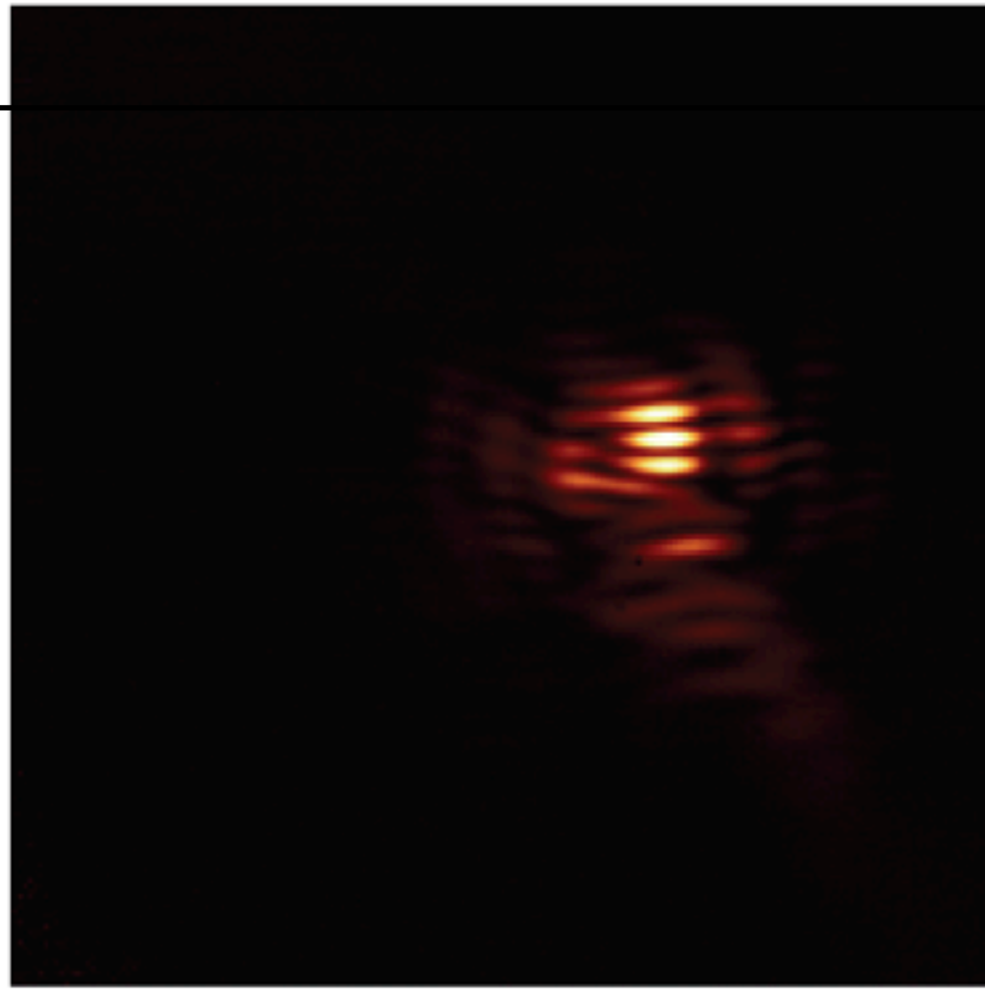
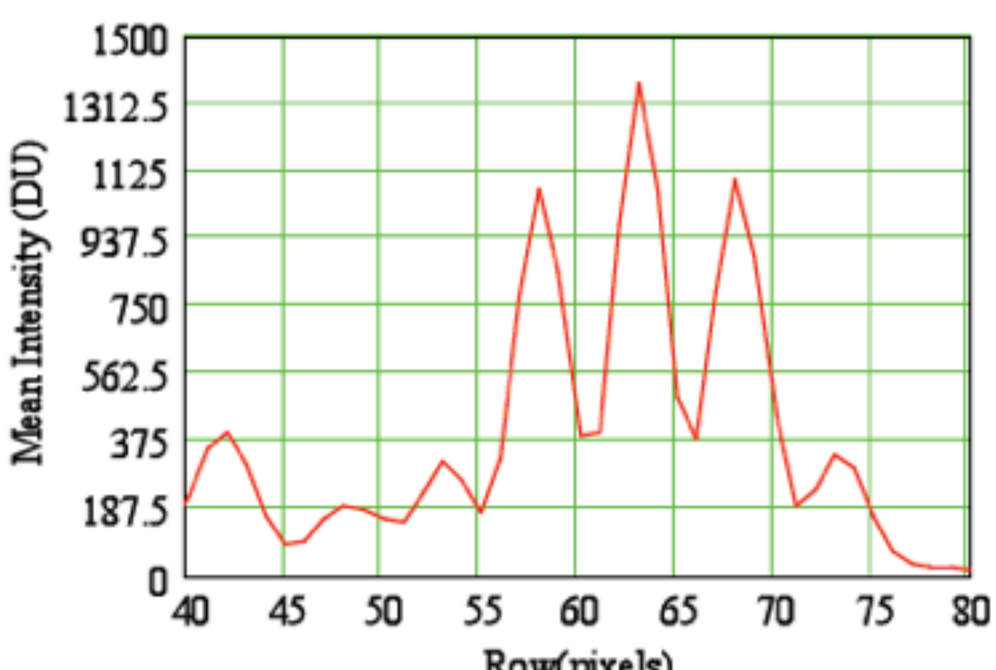
Large Binocular Telescope Interferometer (UA)

Oct 14… First Night of Observing





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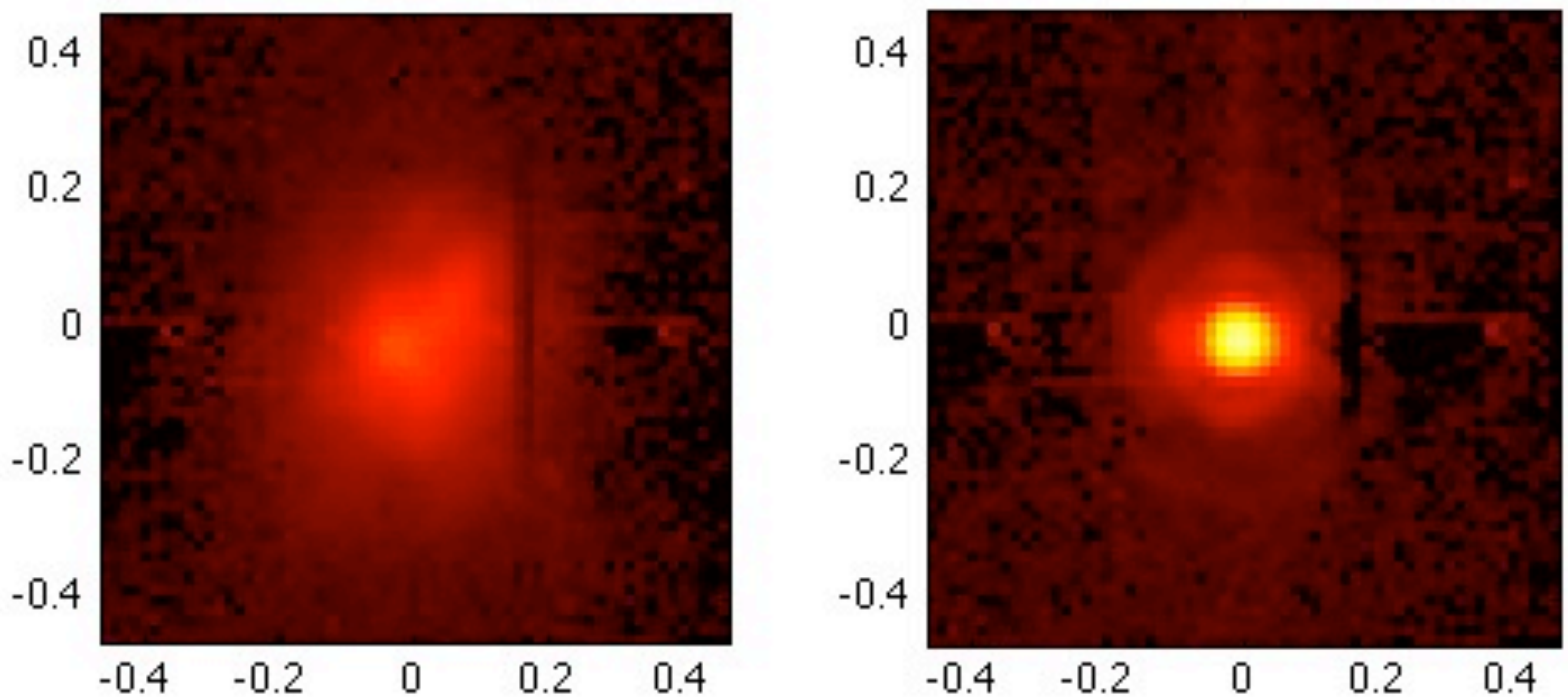
Text

The First Light on-site team:
Tom McMahon, Oli Durney, Vanessa Bailey, Vidhya Vaitheeswaran, and Bill Hoffmann

with the expert help of John Hill

First AO Closed Loop, Nov. 6.

Large Binocular Telescope Interferometer (UA)



5 s of off vs. on data at K band with the Right side LBT telescope.
Seeing was ~0.5” in V.
Strehl at K was 65%.
Short exposure Strehl was ~85%

What the AO system is capable of . . .

- Arcetri Observatory is commissioning a 1-2.5 micron AO system on the station next to LBTI
- They have demonstrated Strehls of 60-80% at H.

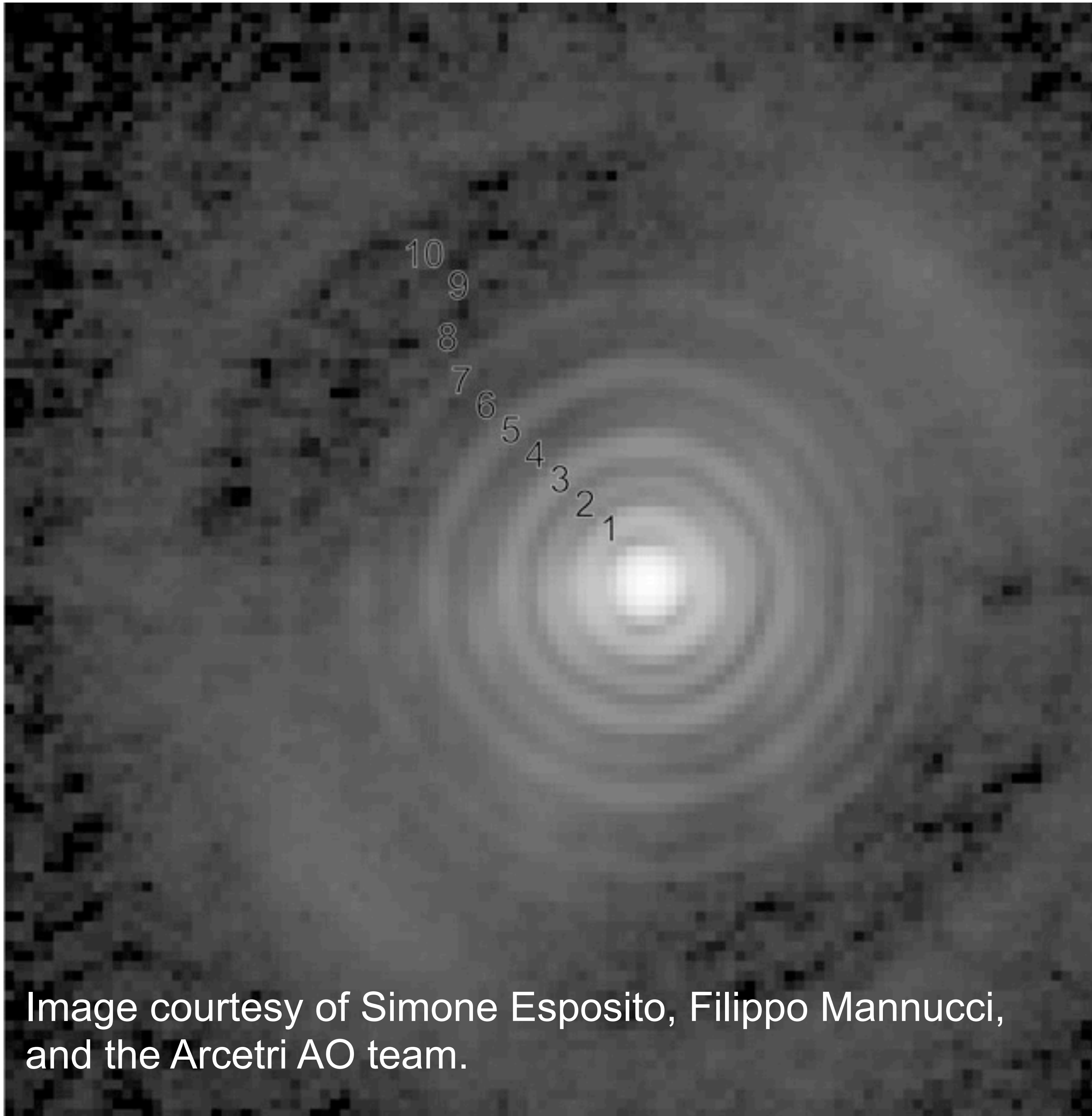


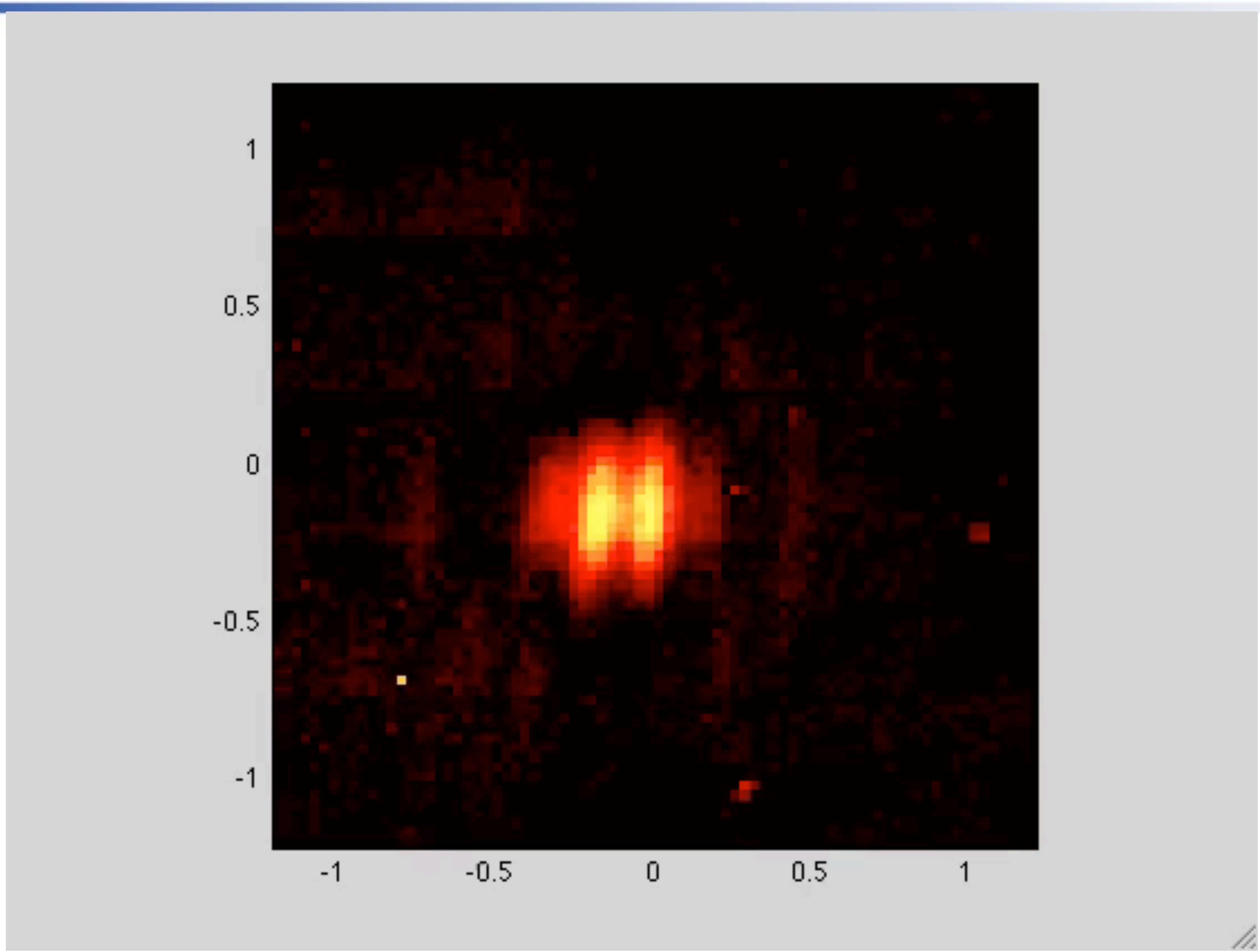
Image courtesy of Simone Esposito, Filippo Mannucci, and the Arcetri AO team.

Closed loop on one side. Fringes

Actual Frame rate is 10 Hz (displayed 5 Hz).
Wavelength is 12 µm

Closed loop on one side. Fringes

Large Binocular Telescope
Interferometer (UA)



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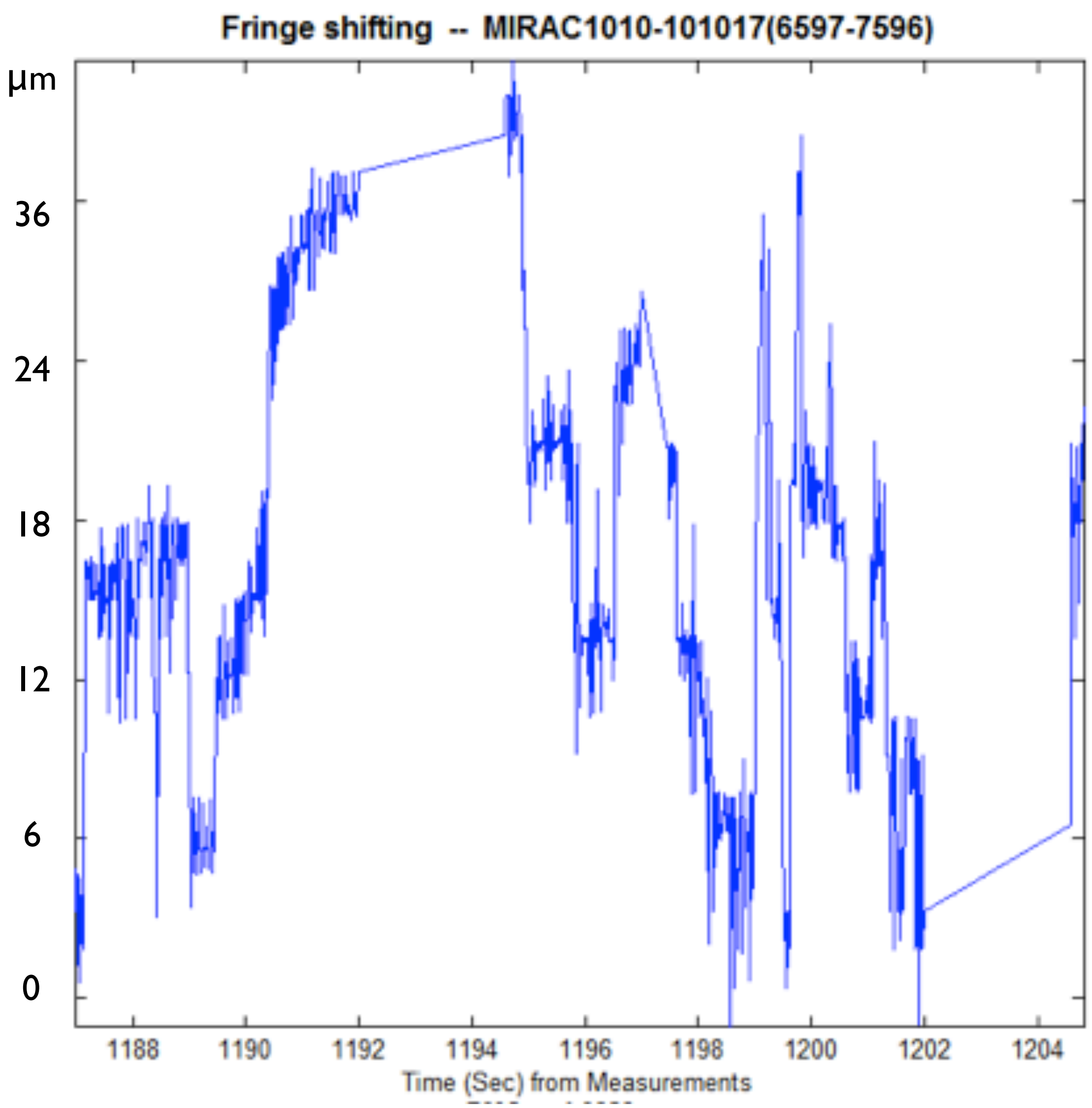
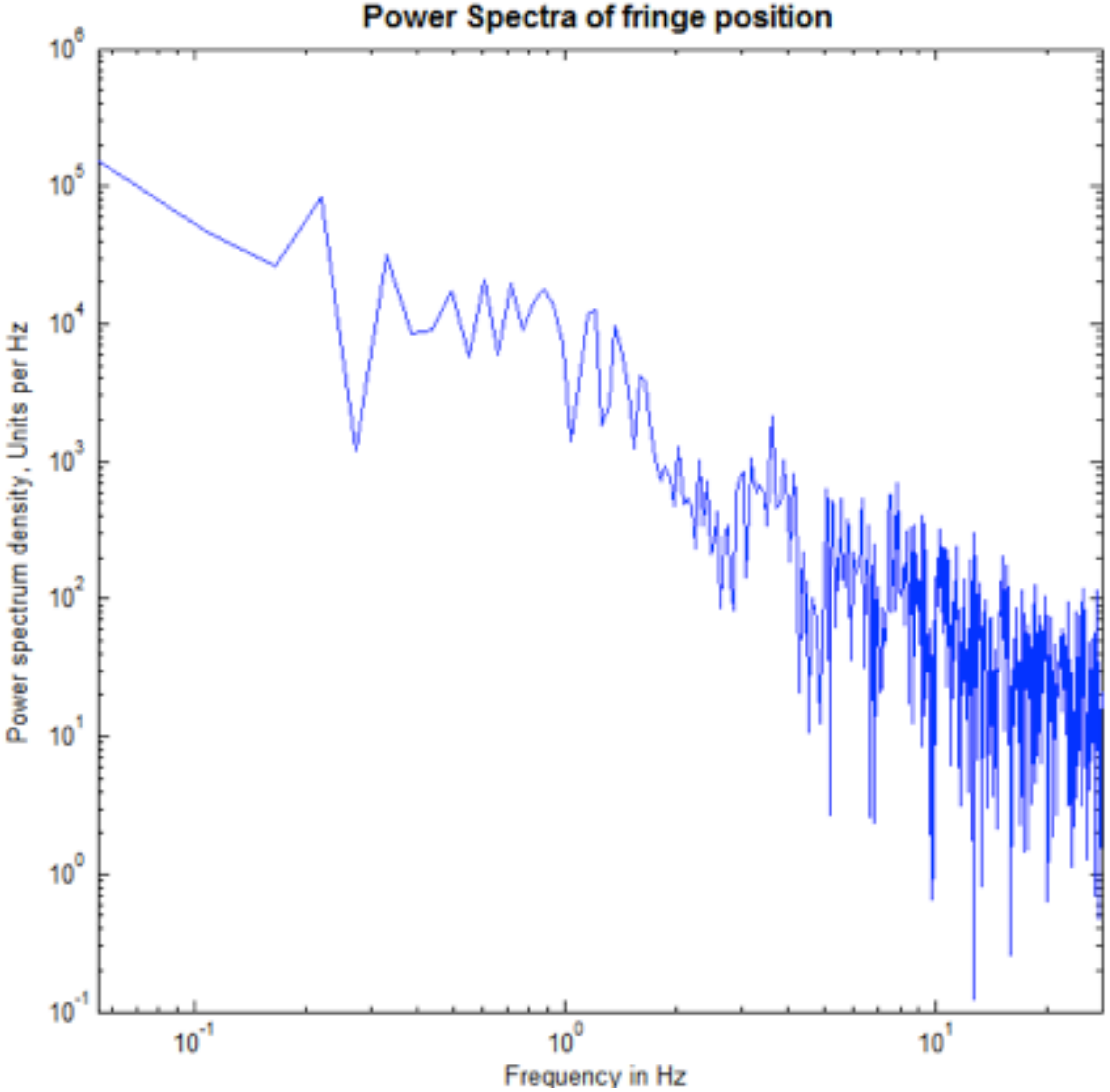
Fringe Sensing





RMS = 10.5 µm

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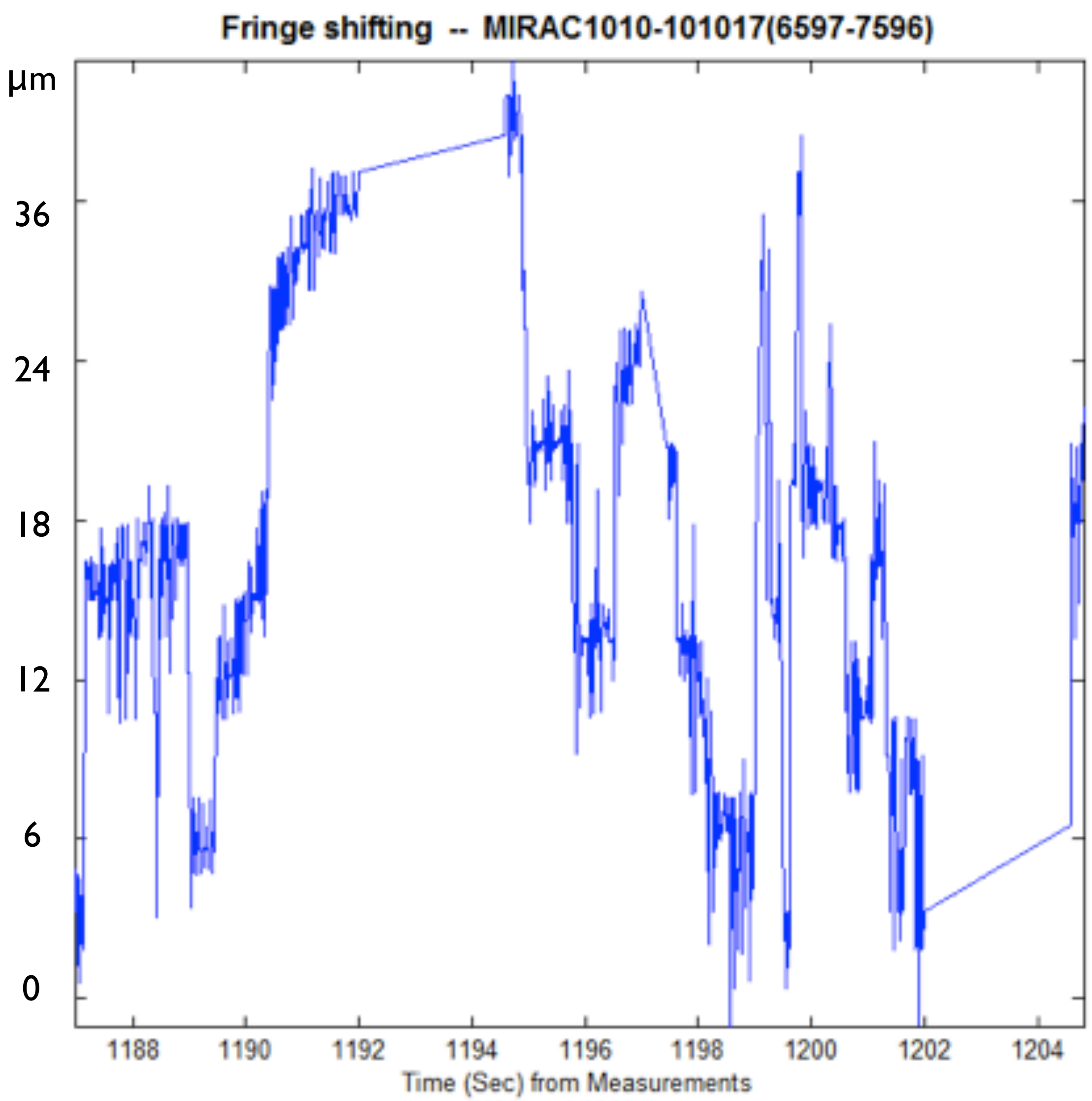

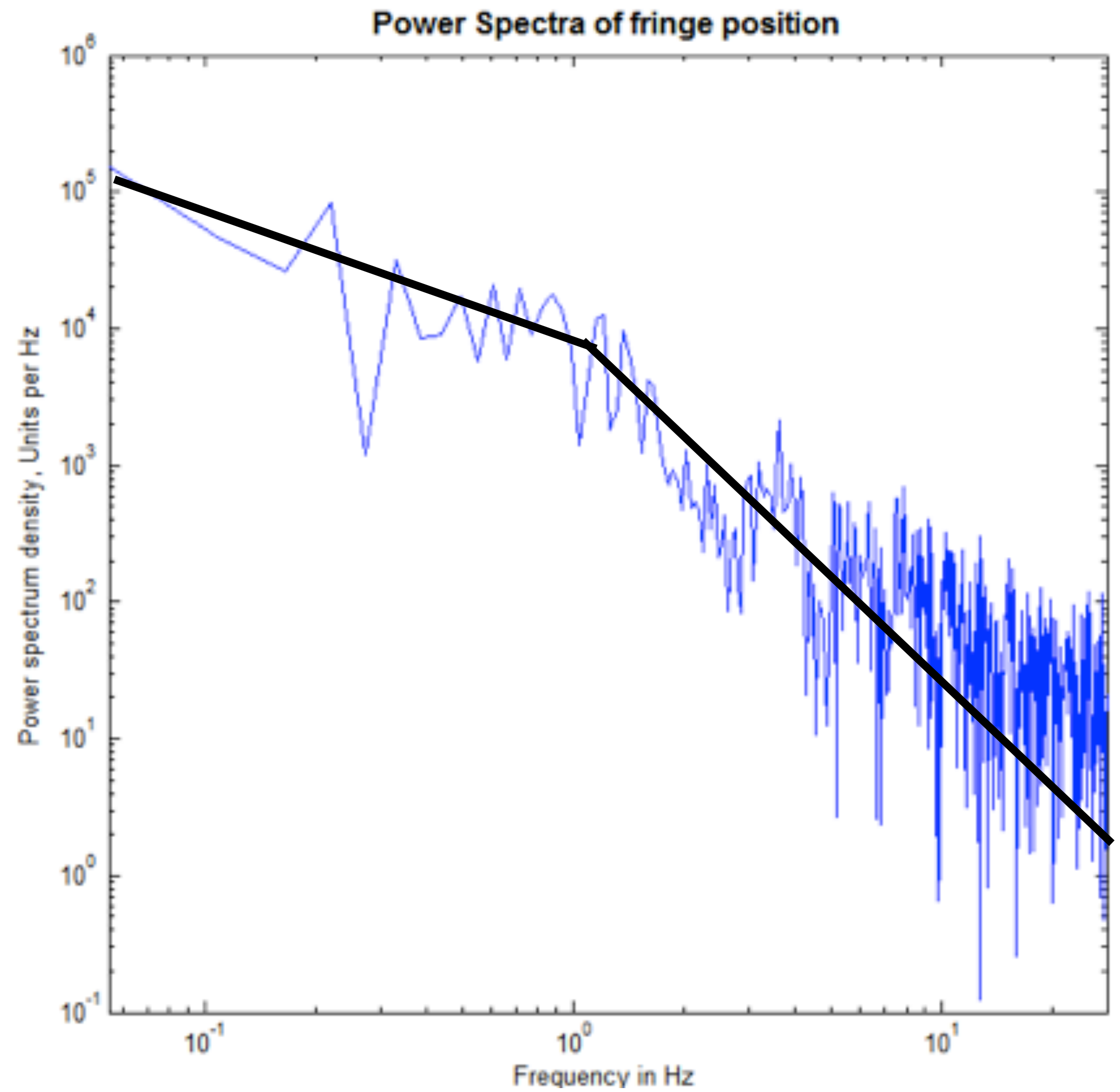

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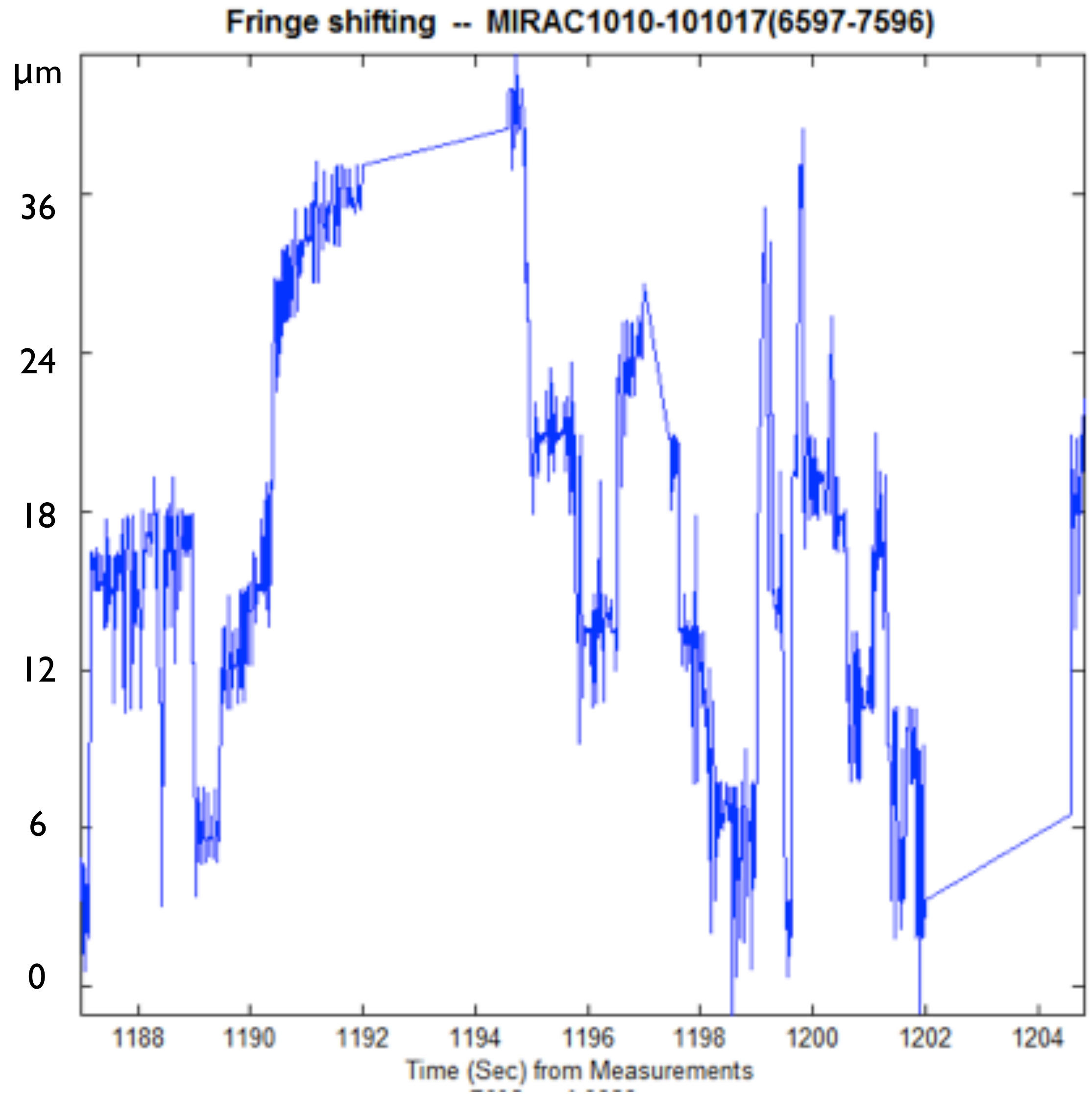
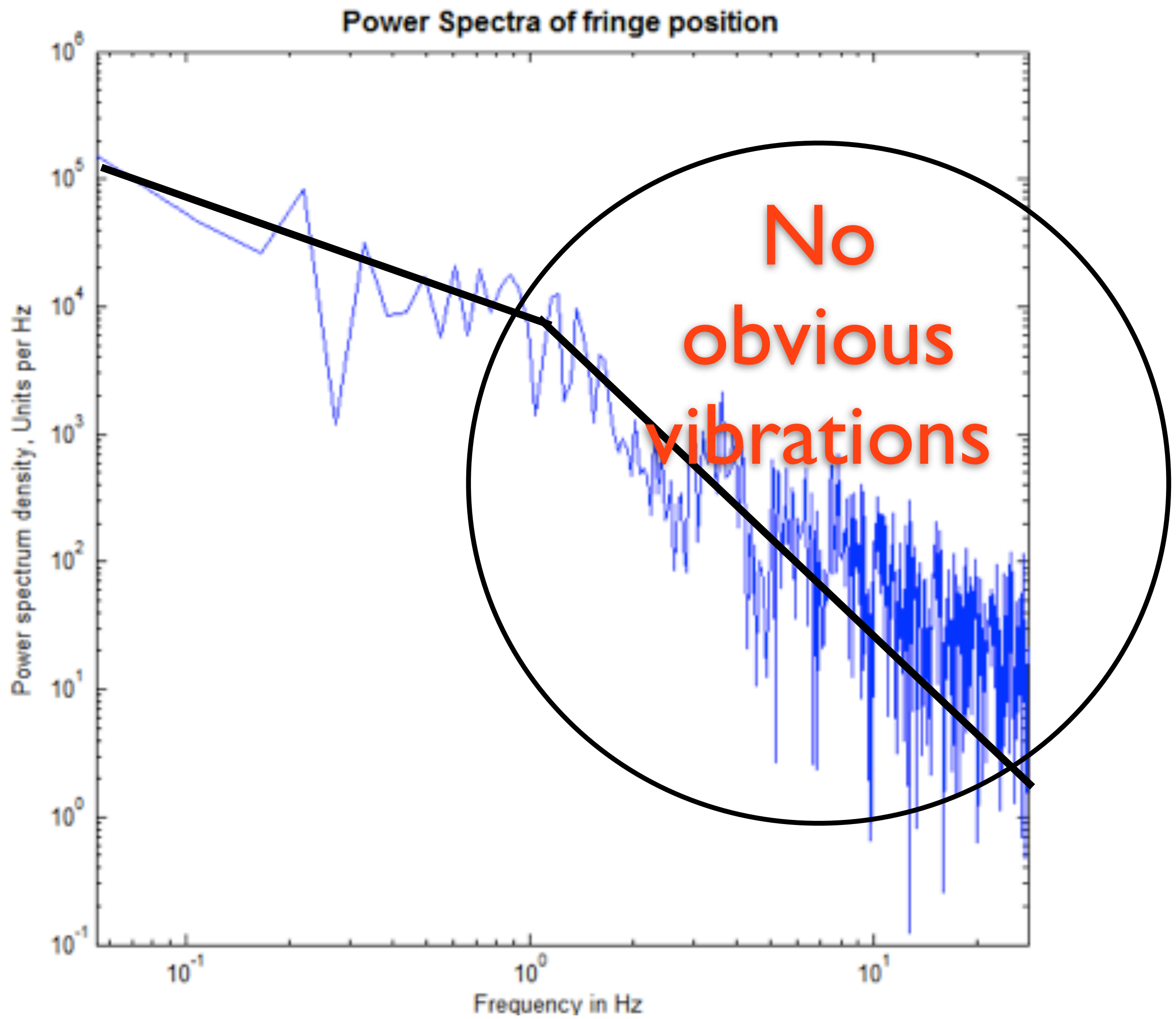


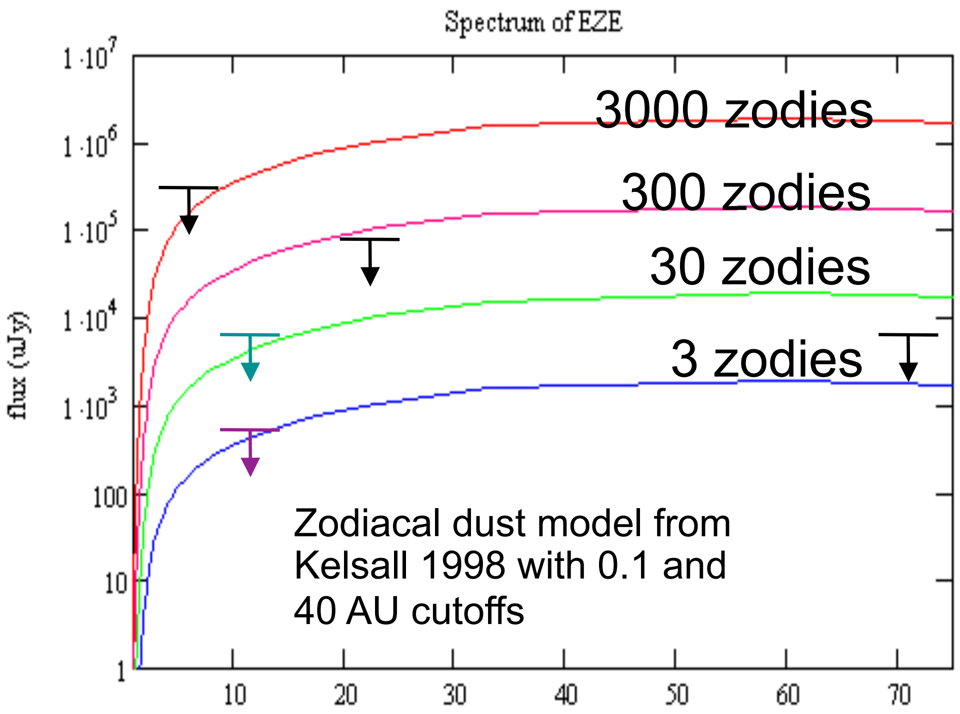


RMS = 10.5 µm

High Contrast Performance

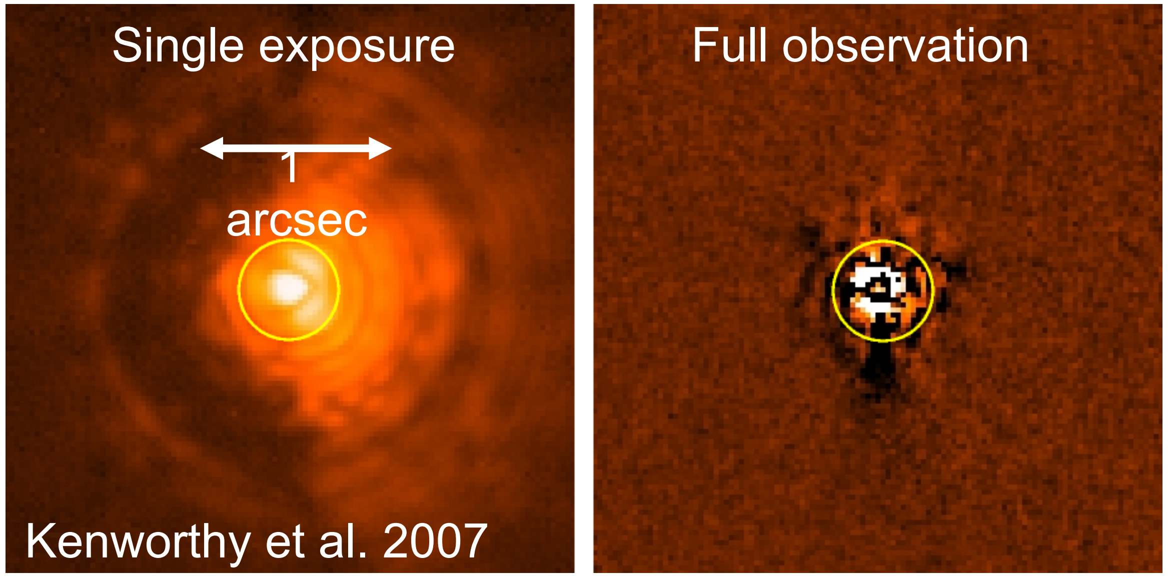
Disk Detection

- Nulling interferometry with the MMT: Currently have noise of ~50-70 zodies
  - Larger apertures will give 5x improvement.
  - Faster update will give 2x improvement.



Planet Detection

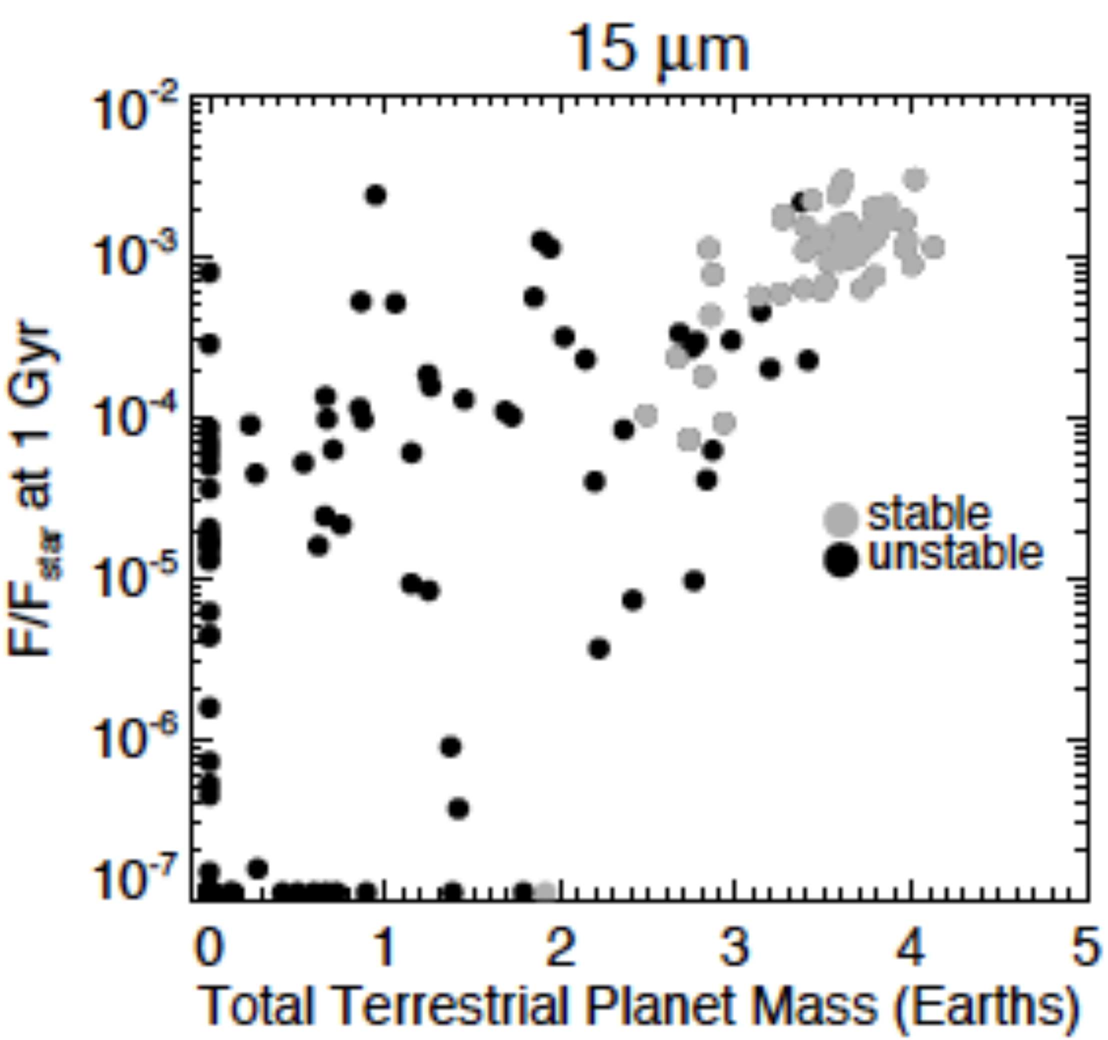
- Phase Apodization Coronagraphy with the MMT: 10^{-5} at 3 λ/D (Kenworthy et al. 2007)



Dust Detection: What might we expect?

•Raymond et al. (2011) have carried out an N body simulation of debris disks that predicts dust brightness.

•Results suggest that systems with stable giant planets will have bright debris disks.



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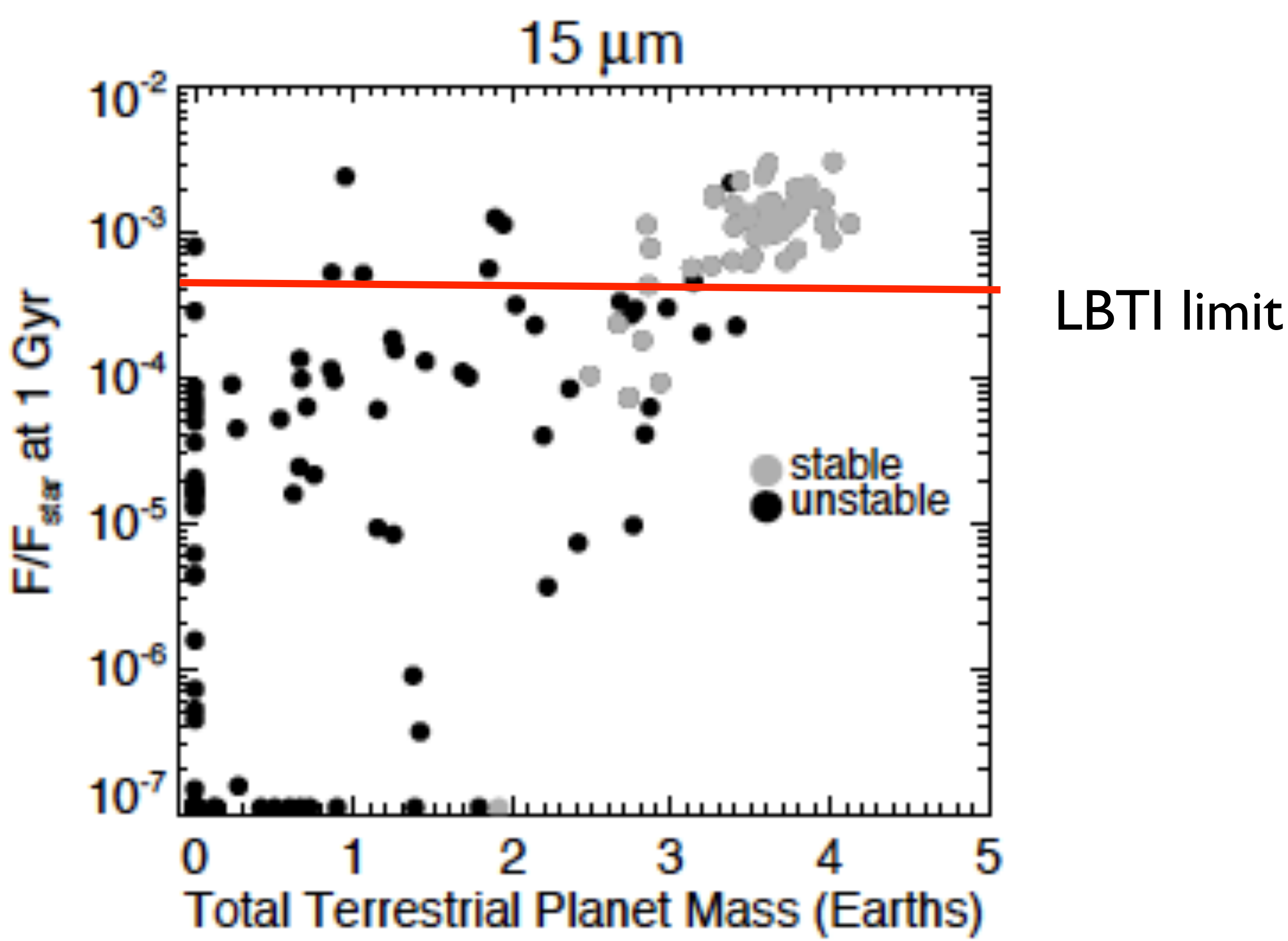
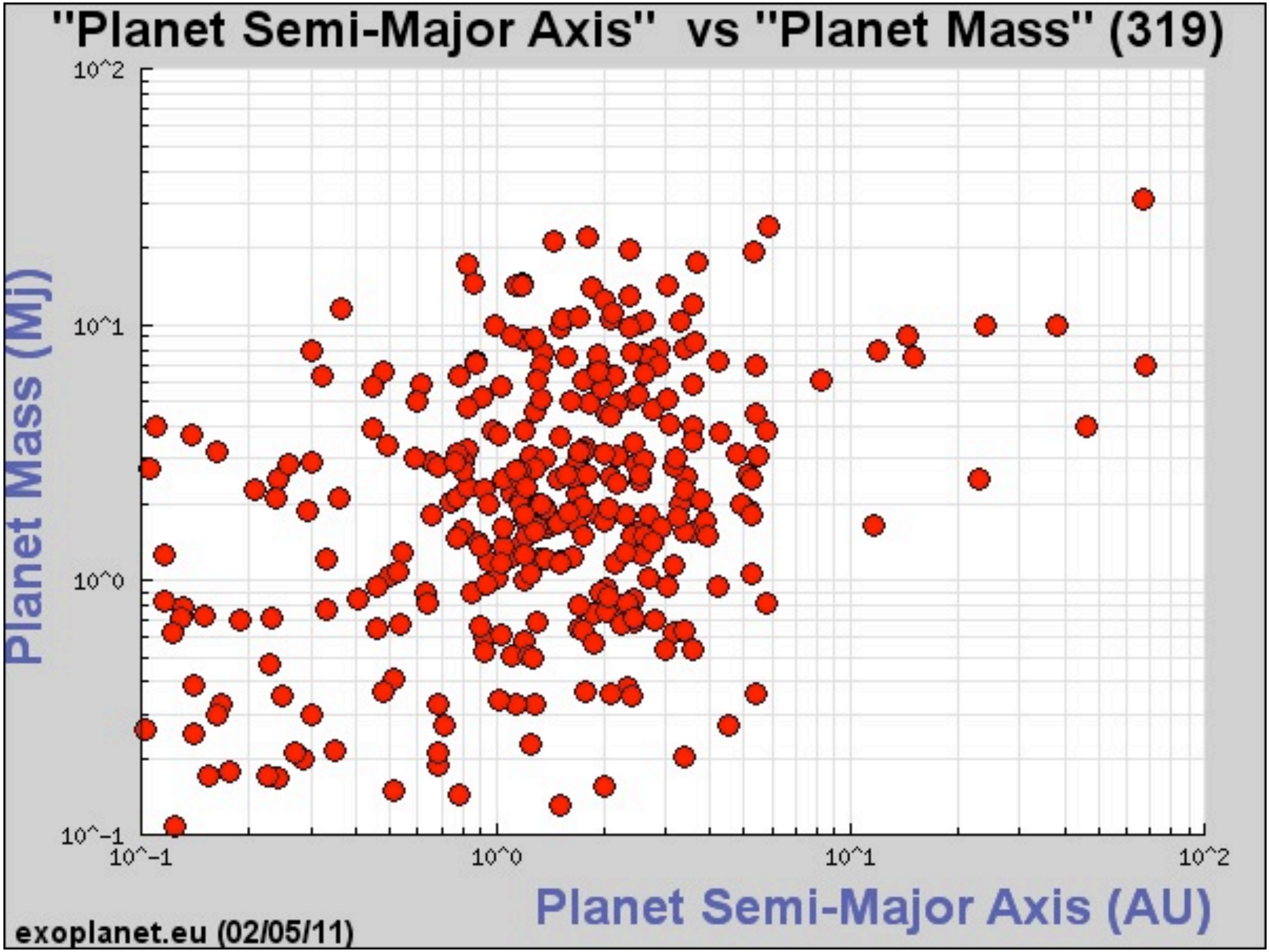


Phase space of planet detection with LBTI



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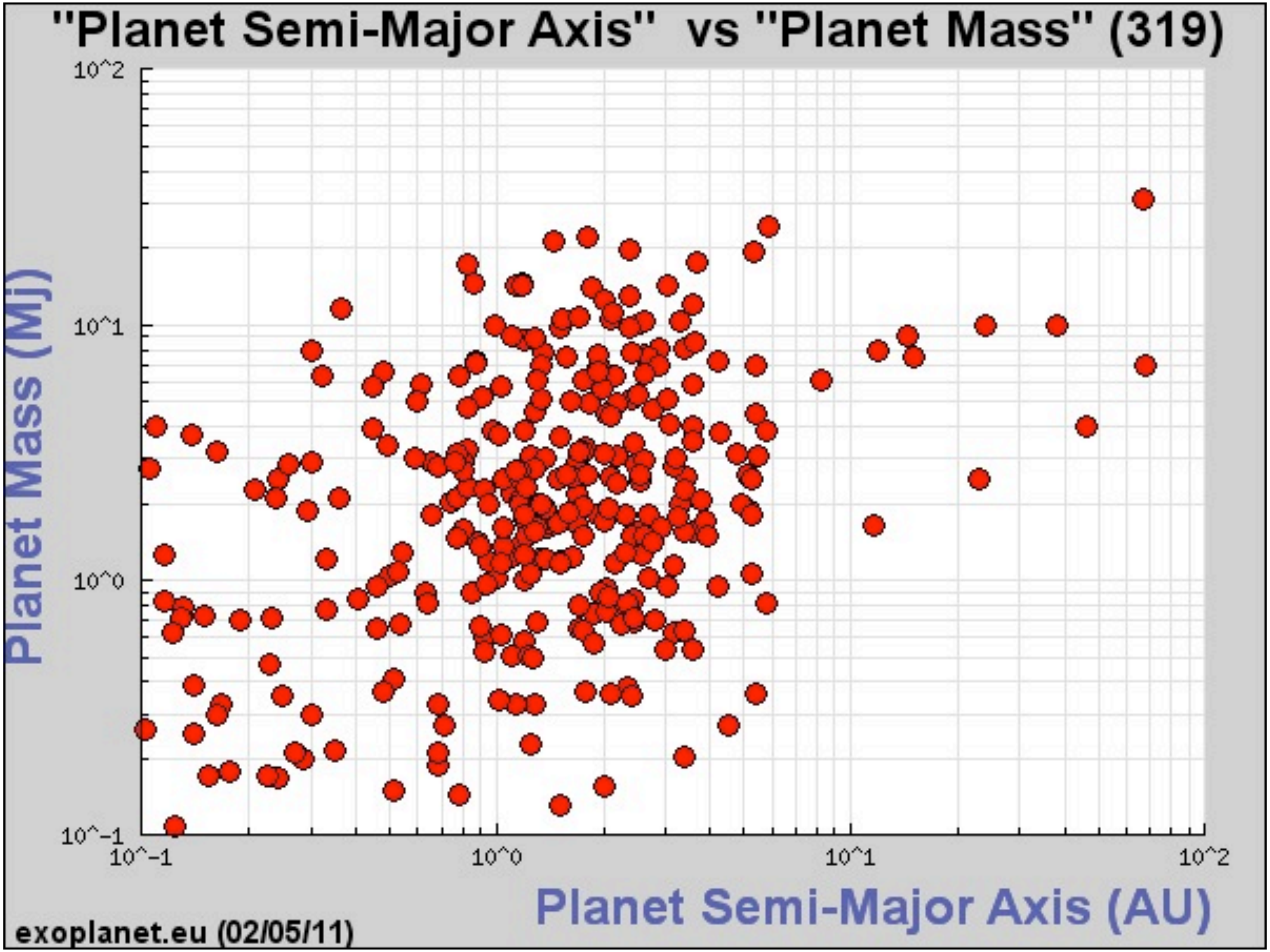

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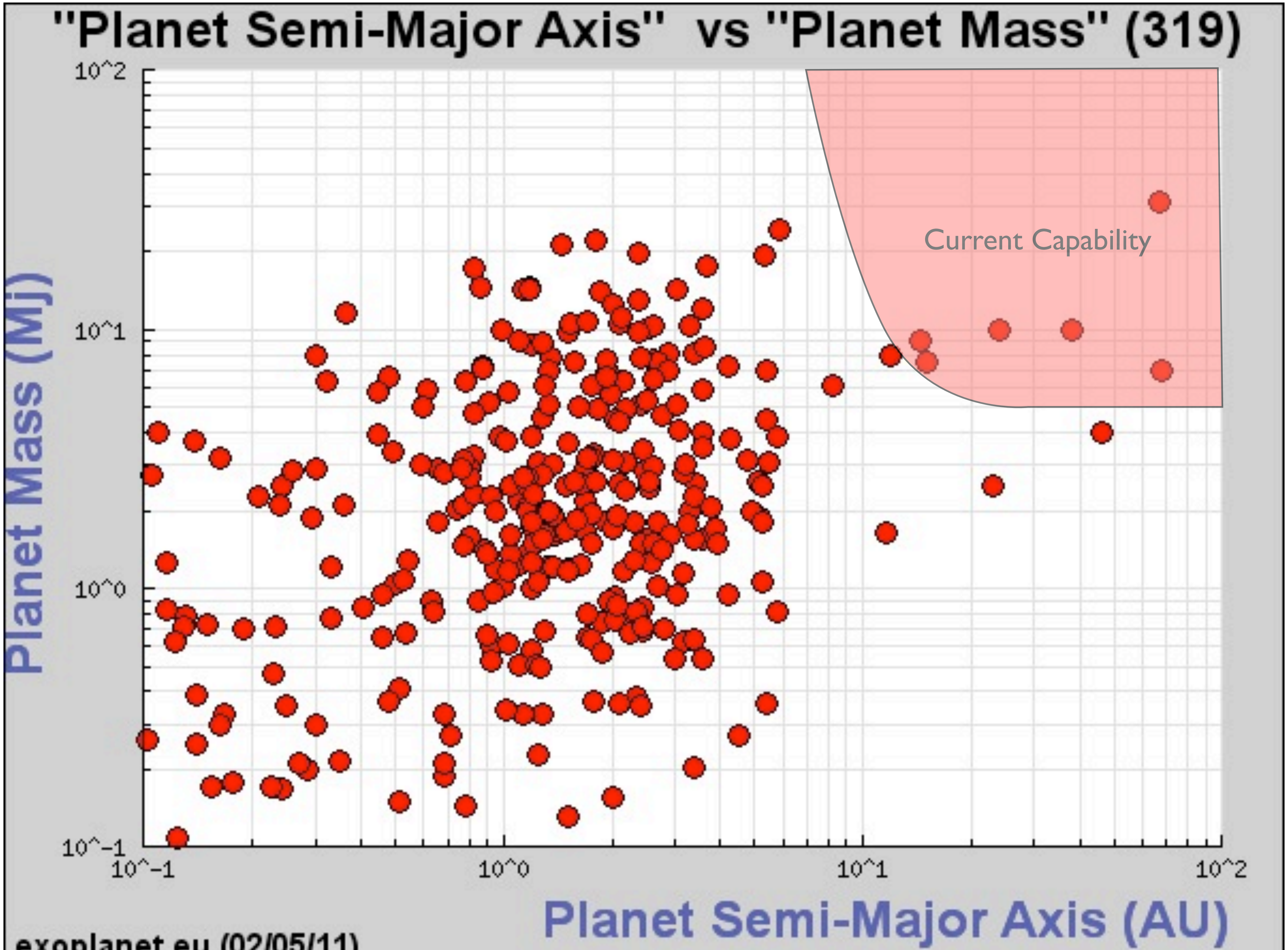

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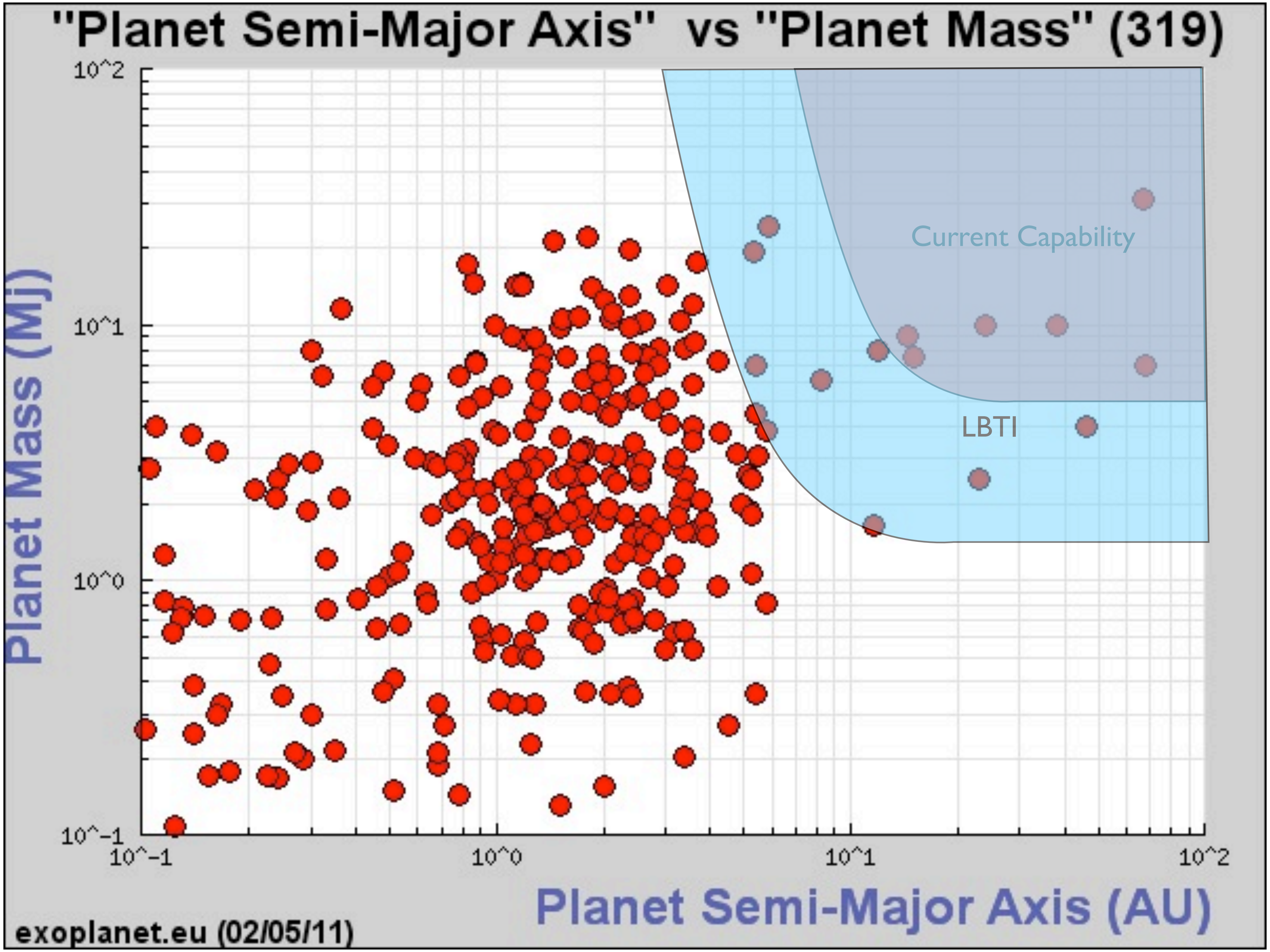
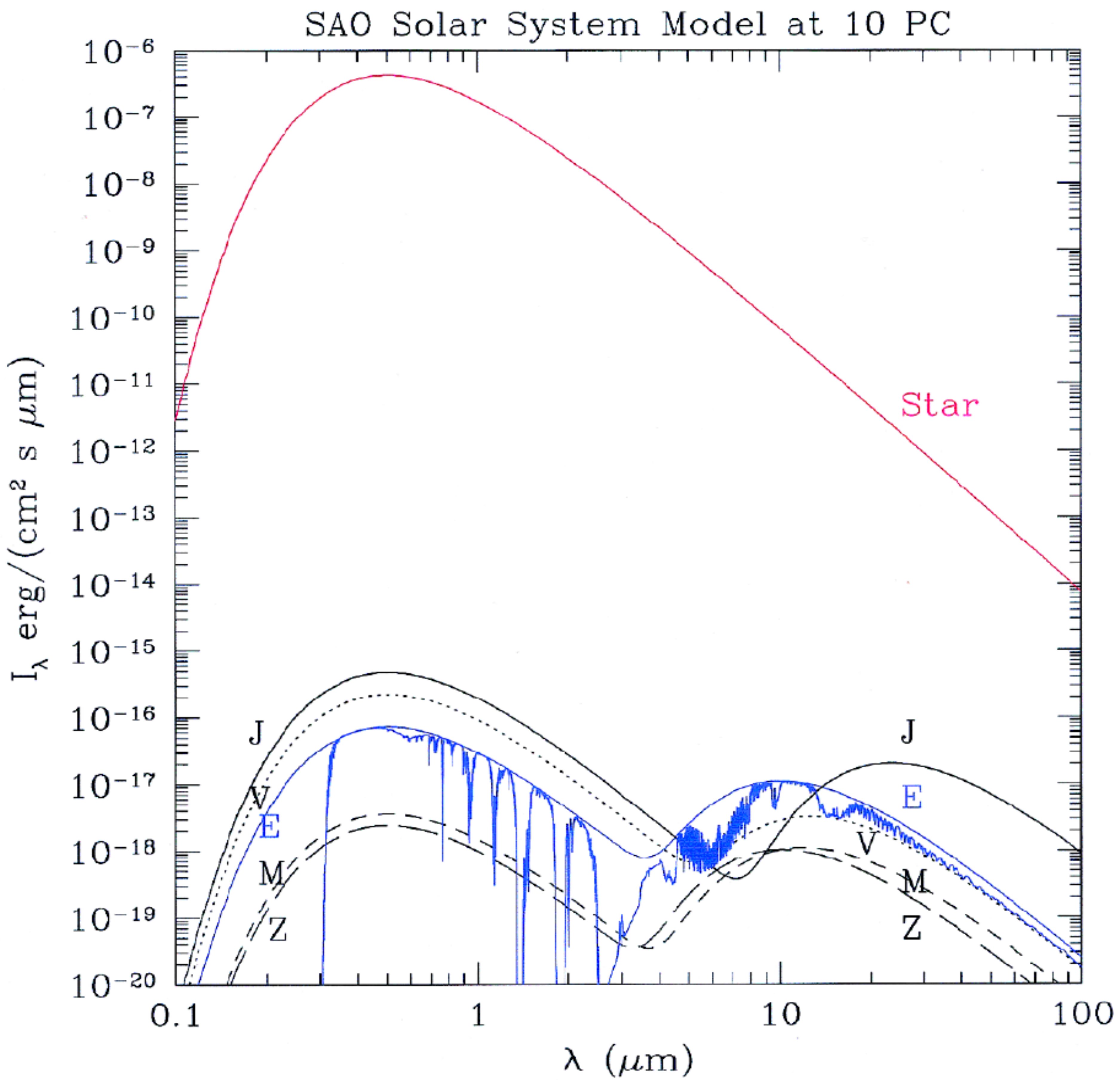


Backup Slides



SAO Solar System Model at 10 PC
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{-20}
I_λ erg/(cm^2 s μm)
Star
J
V
E
M
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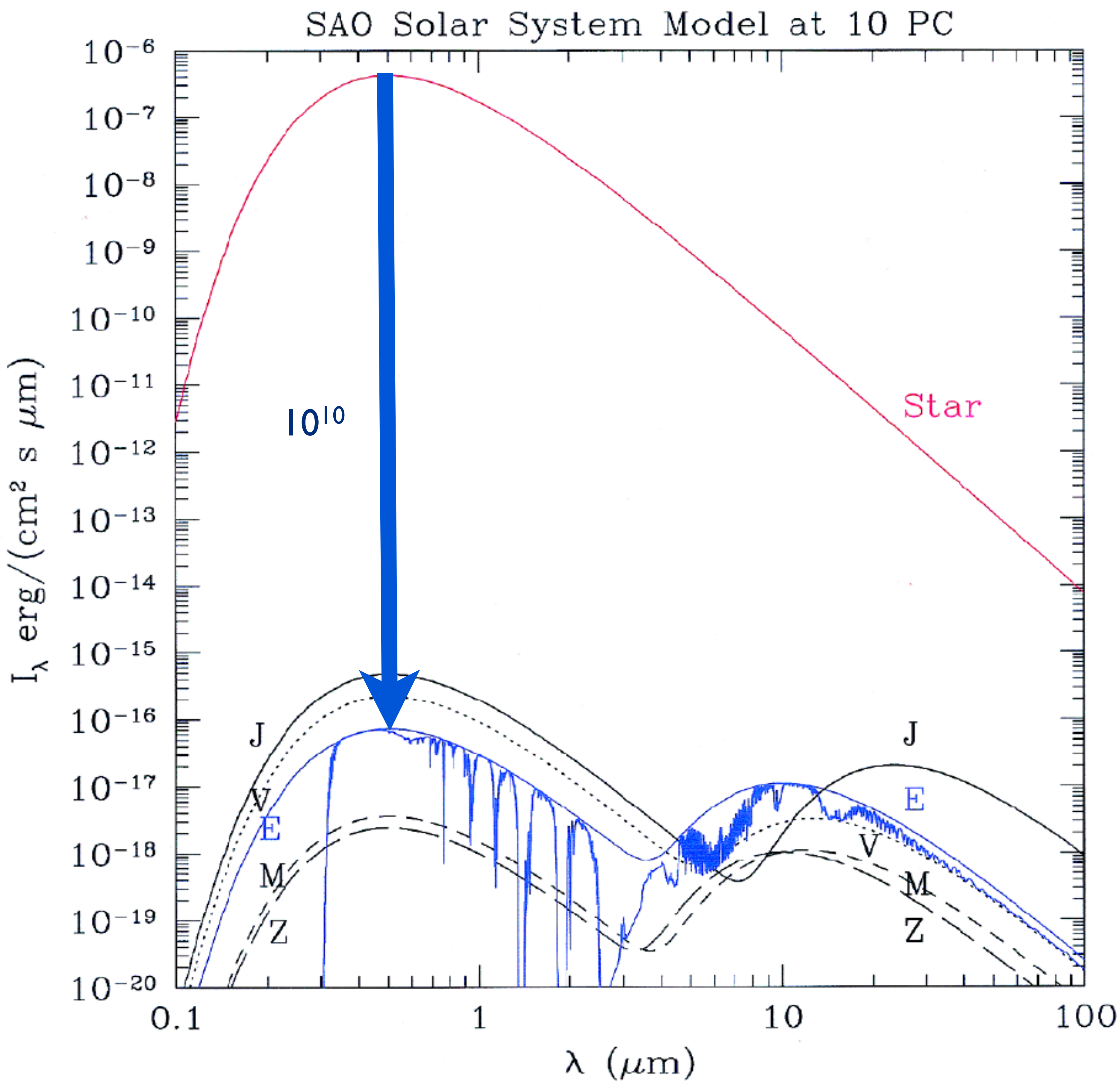
J
E
V
M
Z
0.1
1
10
100
λ (μm)


SAO Solar System Model at 10 PC
10^{10}
Star
J
V
E
M
Z
I_λ erg/(cm² s μm)
λ (μm)
0.1
1
10
100
10^{-6}
10^{-7}
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10^{-9}
10^{-10}
10^{-11}
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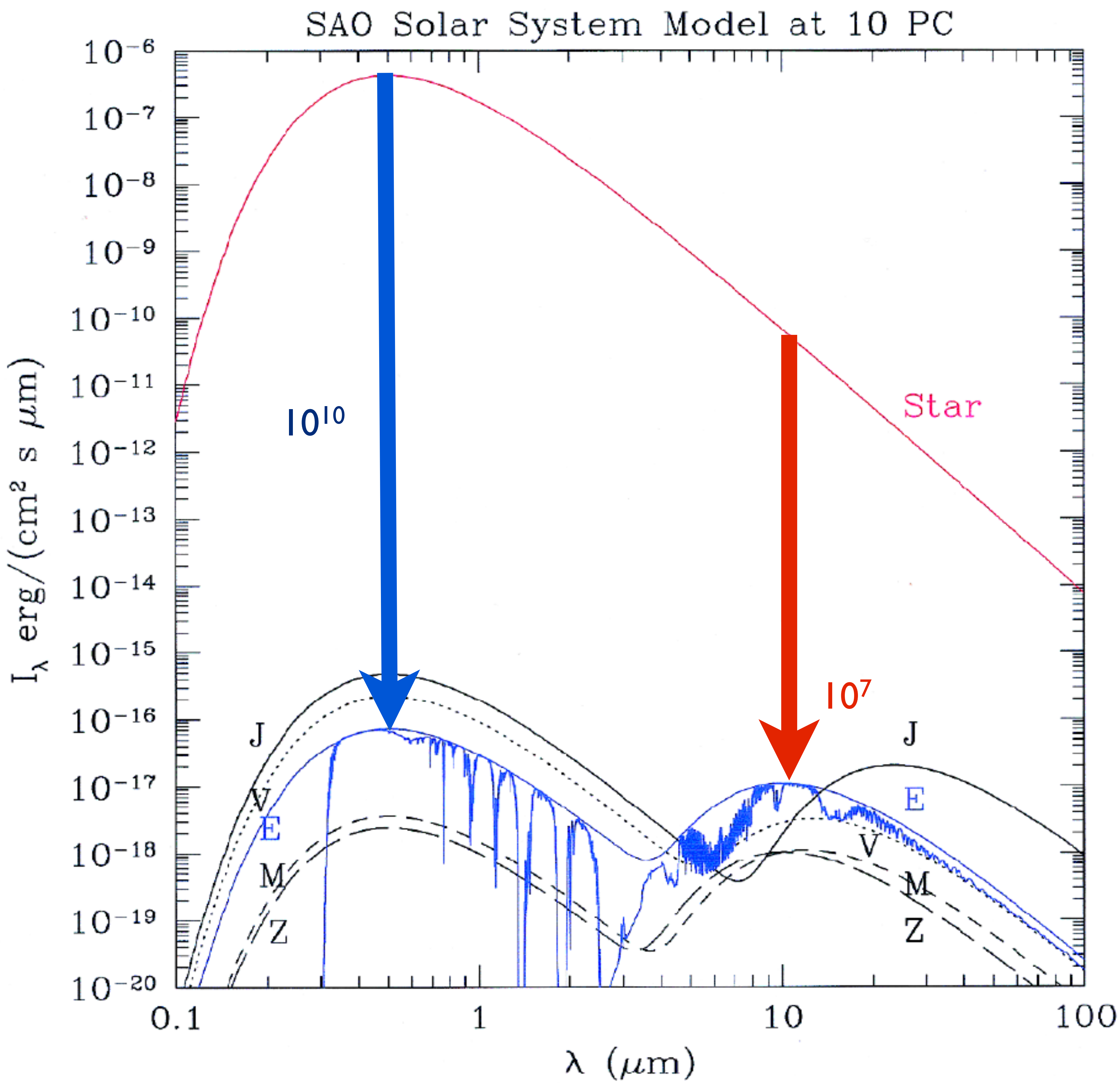
10^{-20}


SAO Solar System Model at 10 PC
10¹⁰
10⁷
Star
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V
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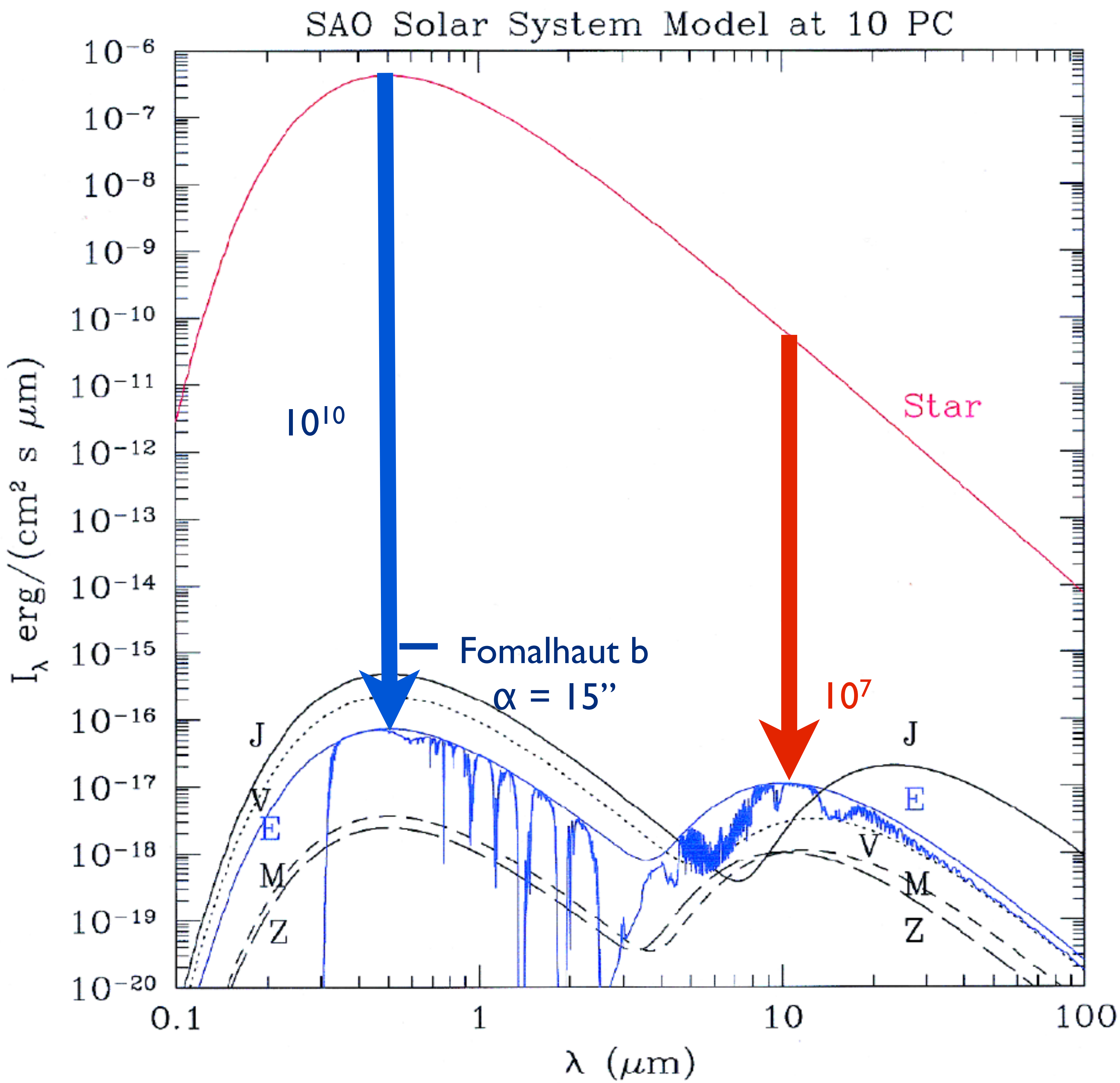
M
Z
0.1
1
10
100
λ (μm)
I_λ erg/(cm² s μm)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10^{-13}
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{-20}
I_λ erg/(cm^2 s μm)
0.1
1
10
100
λ (μm)
Star
10^{10}
10^{7}
Fomalhaut b
α = 15"
J
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J
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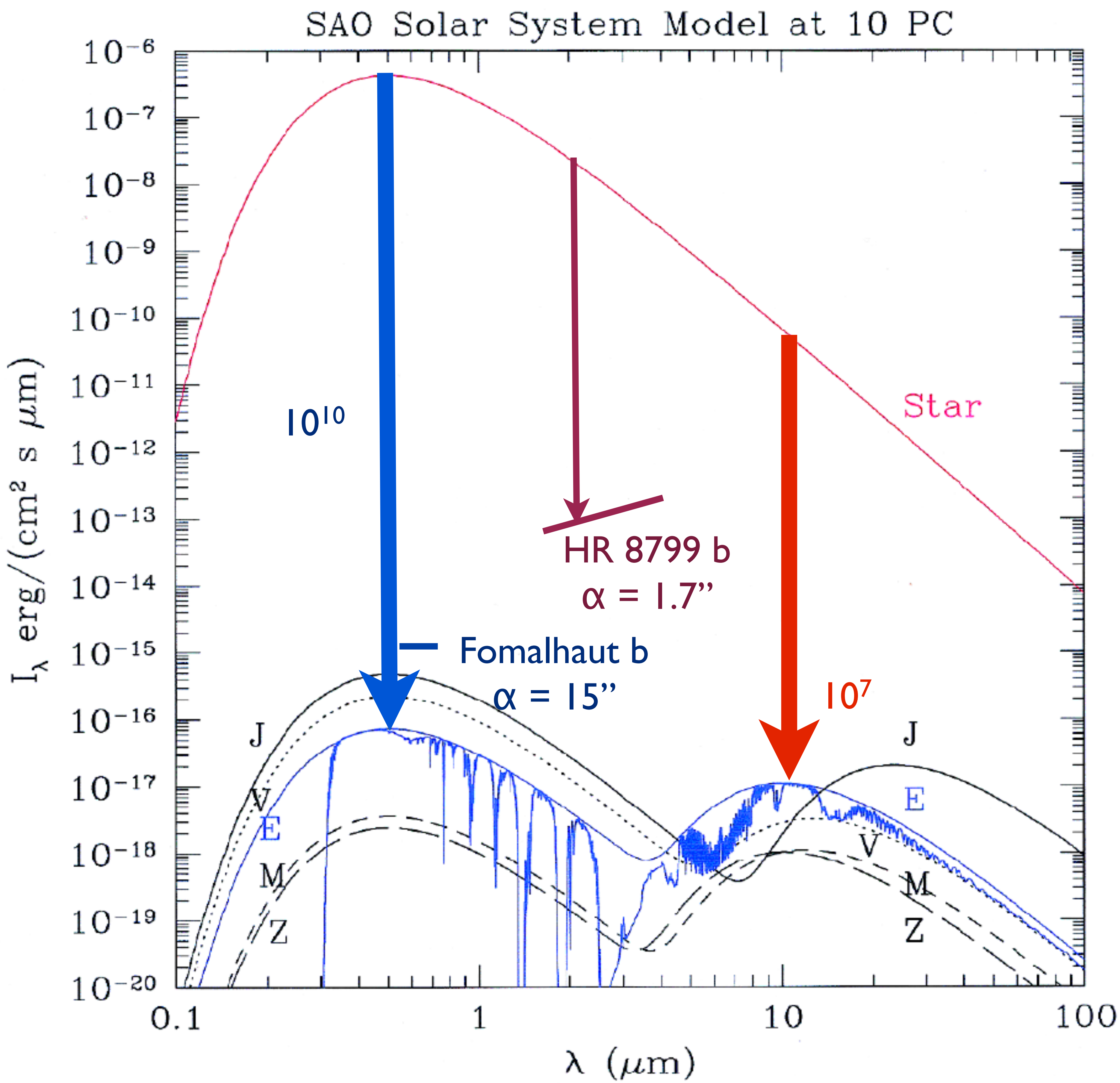
Z



SAO Solar System Model at 10 PC
I_λ erg/(cm^2 s μm)
λ (μm)
10^{10}
HR 8799 b
α = 1.7''
Fomalhaut b
α = 15''
10^7
Star
J
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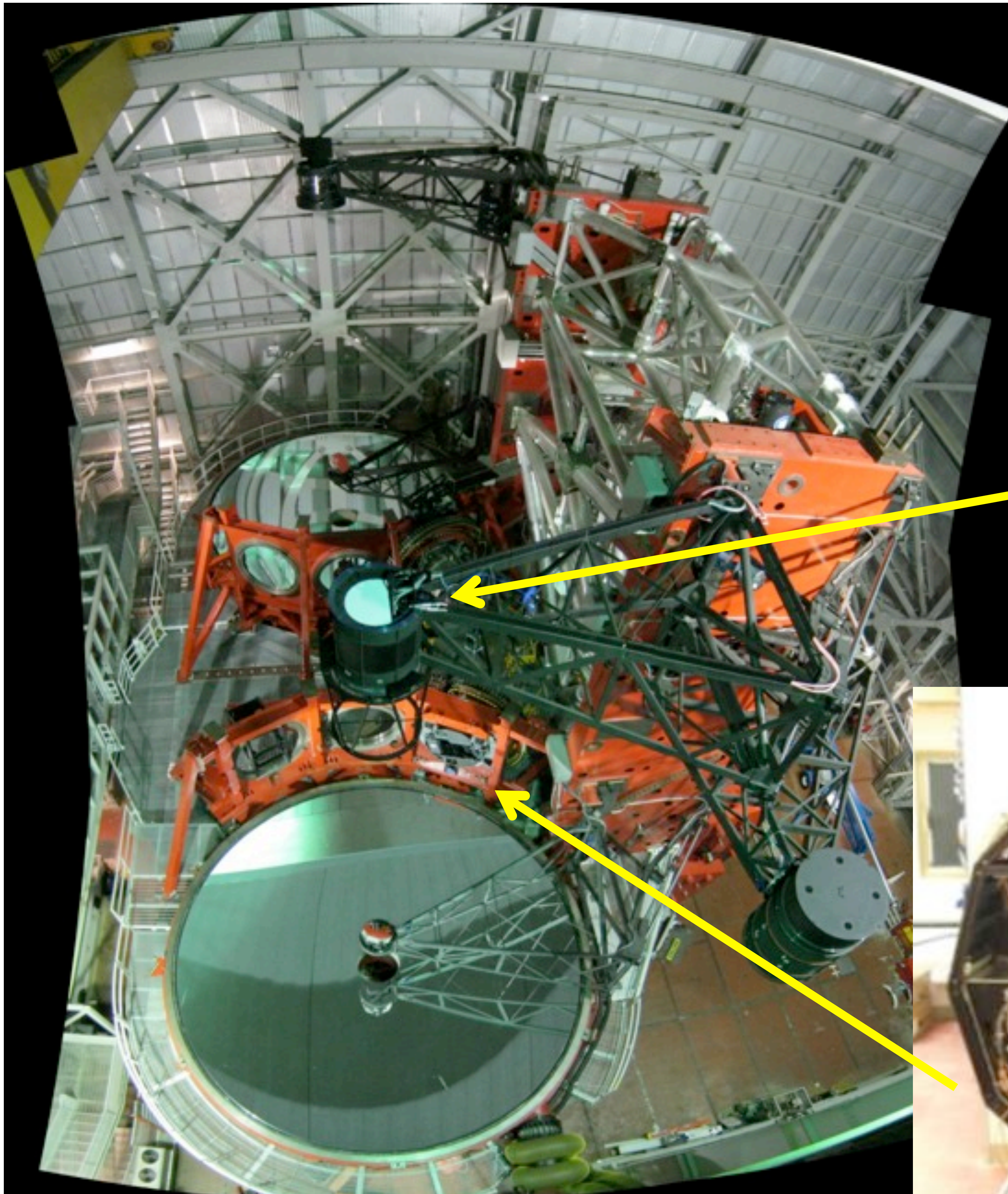
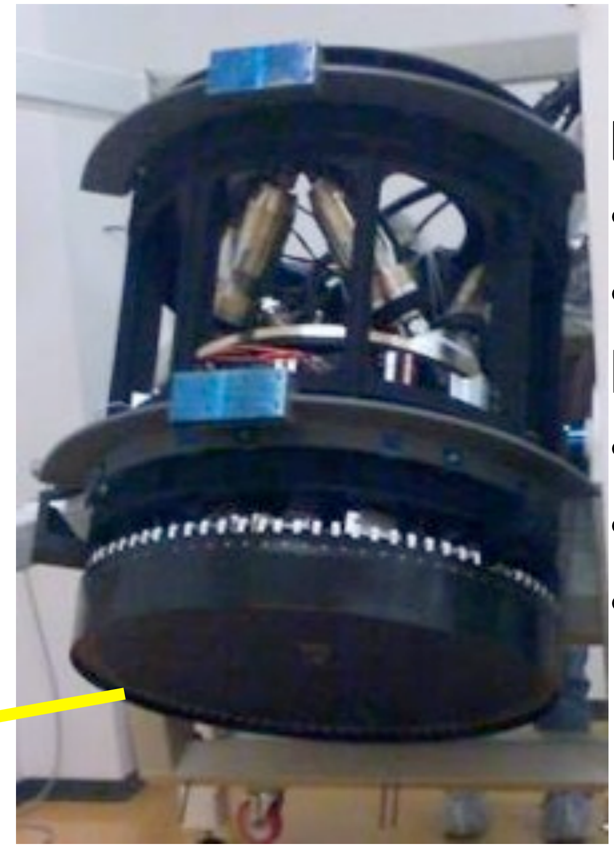
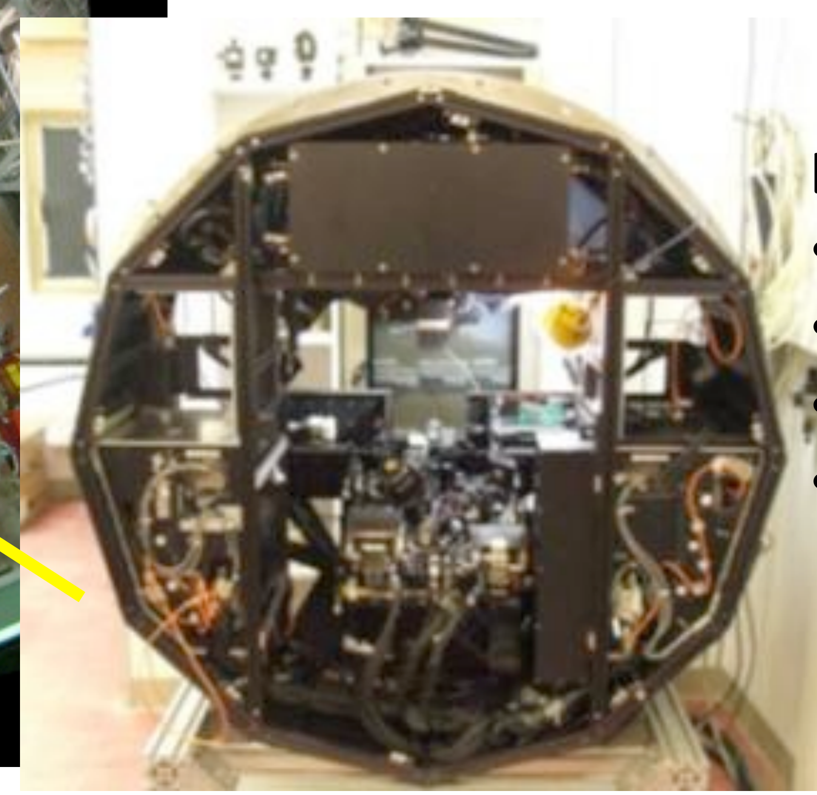
M
Z

FLAO system key components





LBT672a unit
- 911mm diameter
- 1.6mm thick, (Mirror lab)
- 672 actuators
- Settling time < 1ms
- 30nm WFE



LBT WFS unit
- Pyramid sensor
- 30x30 to 5x5 subap.
- Tilt mod. 2-6 λ/D
- 1Kfps max [30x30]

7736-12 **[7736-12]**