High Contrast Imaging and Spectroscopy: Lessons Learned

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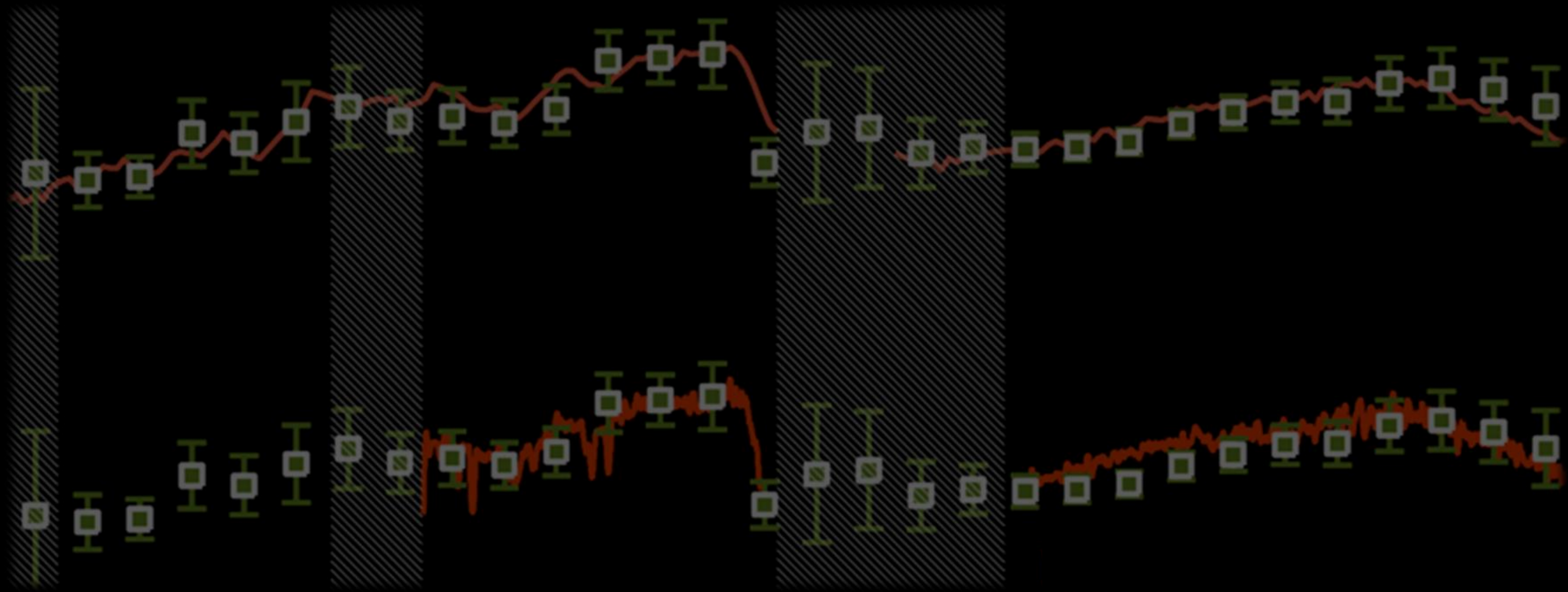
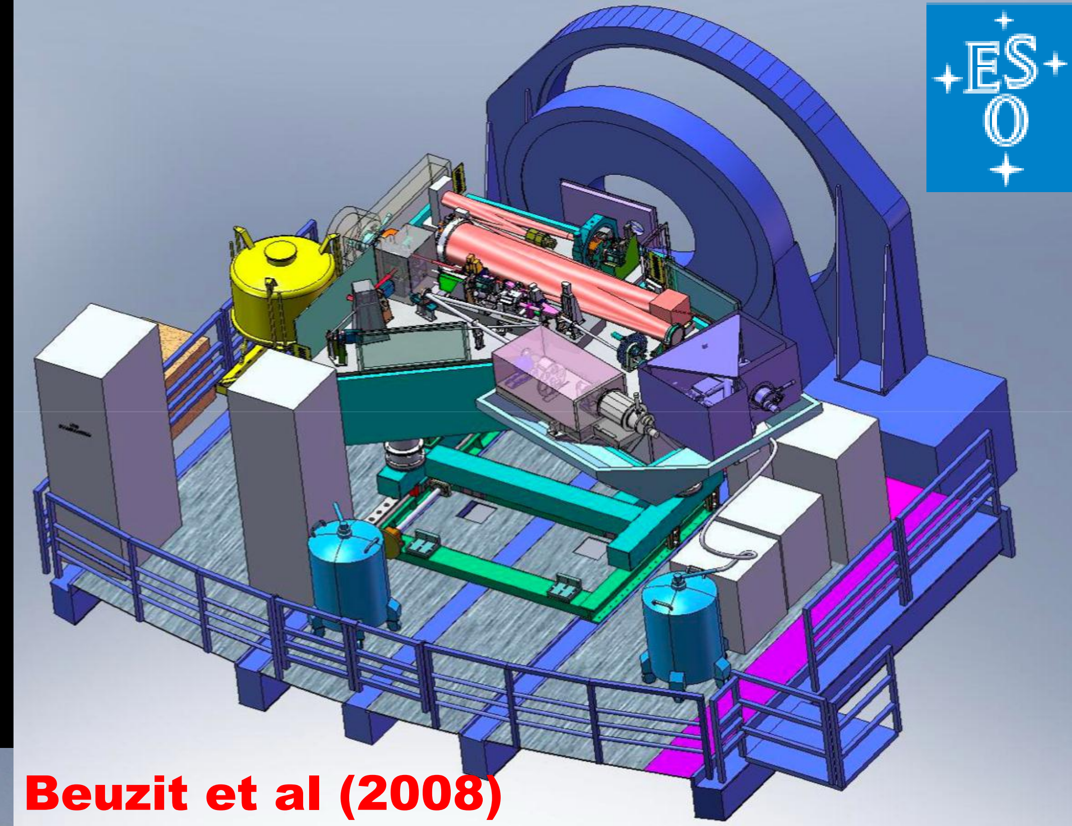
Garching, 05 February 2014

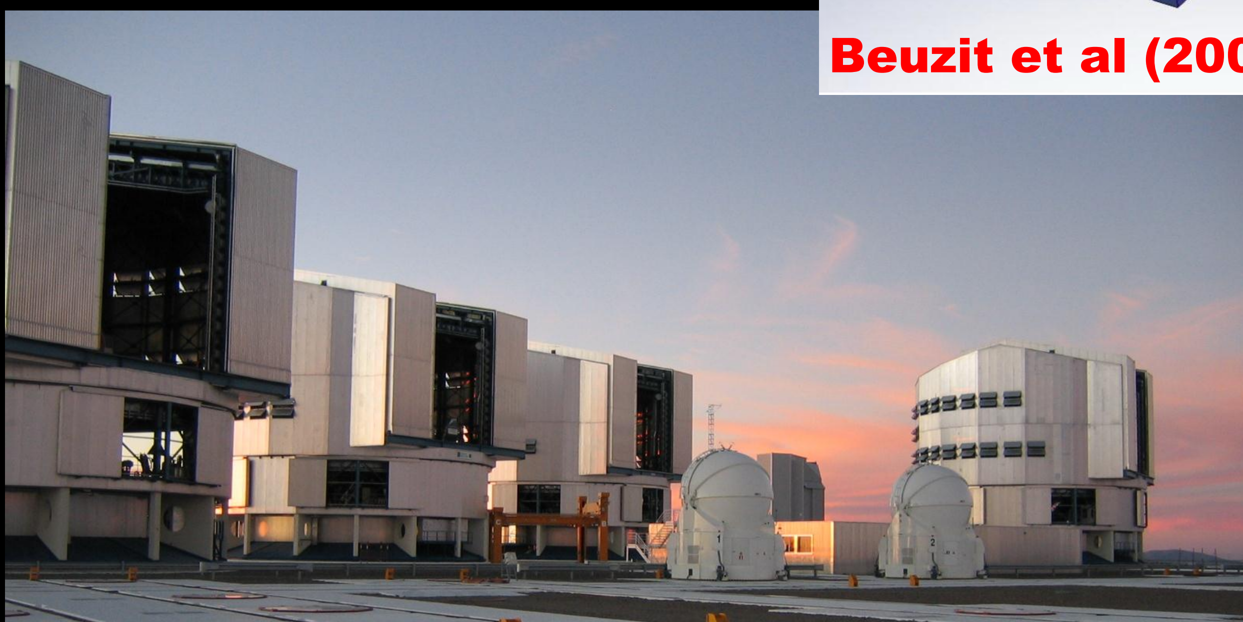
Thanks to: Bruce Macintosh (Stanford) and the rest of the GPI team, Dimitri Mawet (ESO), Laurent Pueyo (STScI), Ben Oppenheimer (AMNH),



VLT-SPHERE

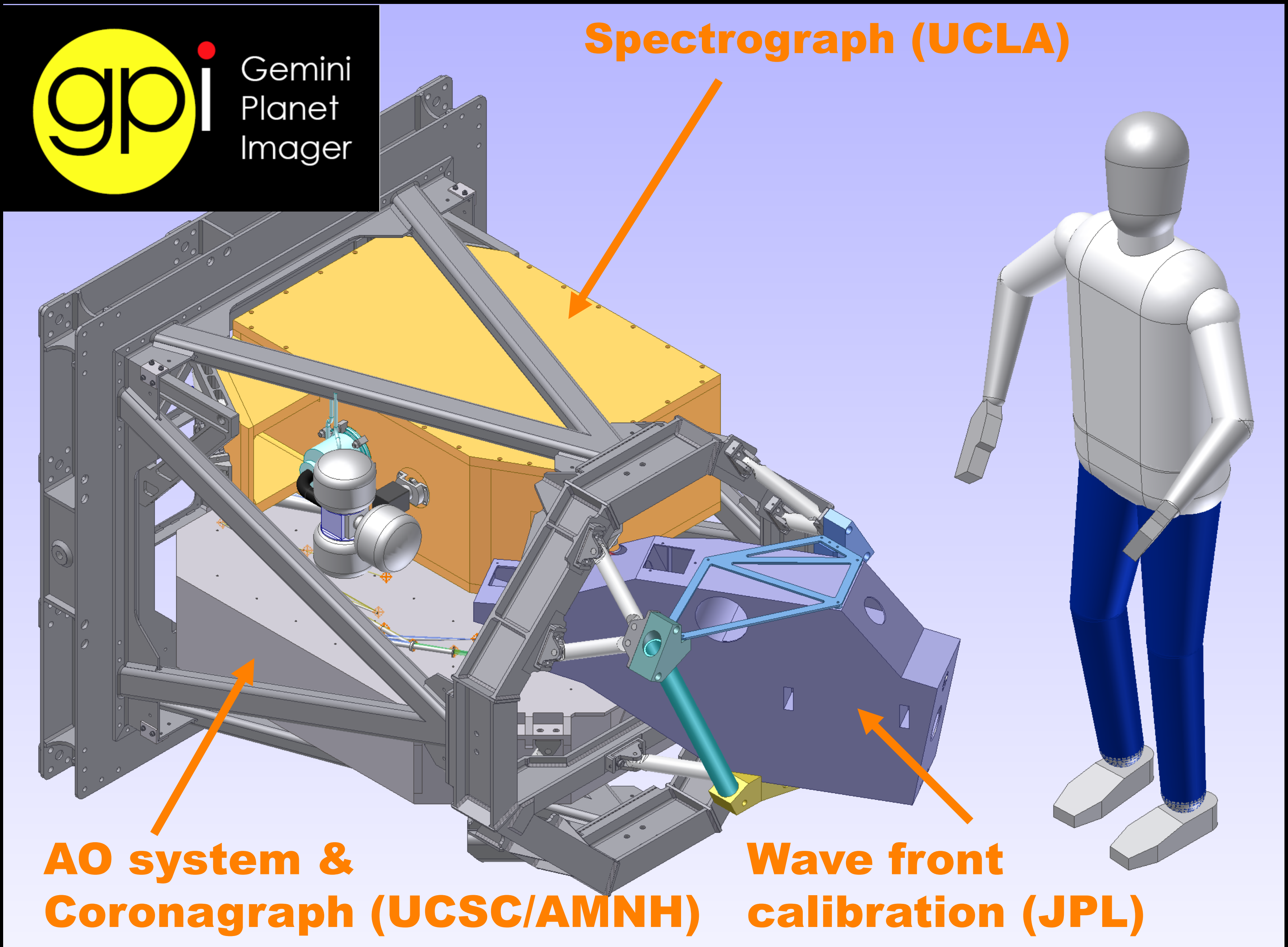


Beuzit et al (2008)



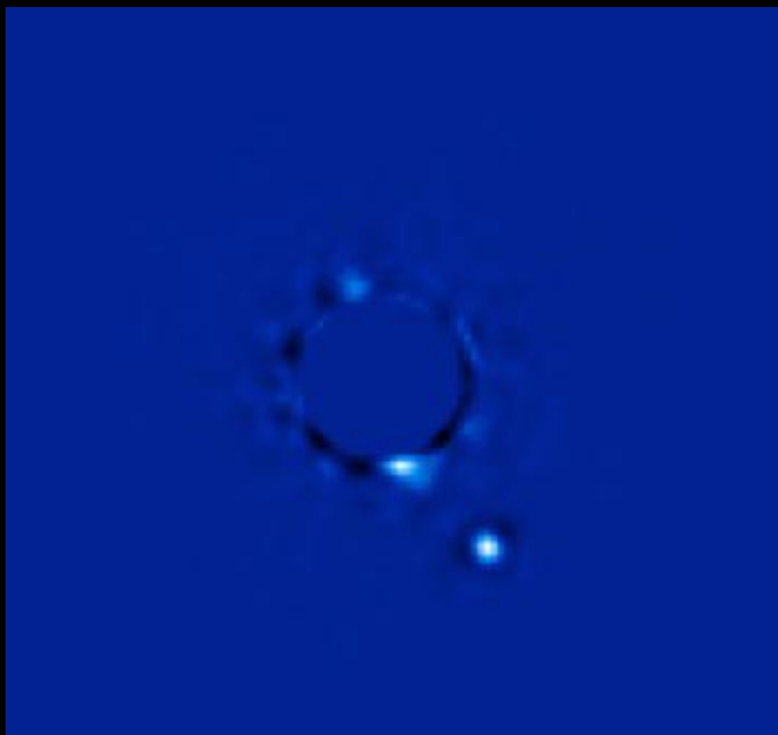
First light: 2014

Gemini Planet Imager



New GPI images of β Pictoris b

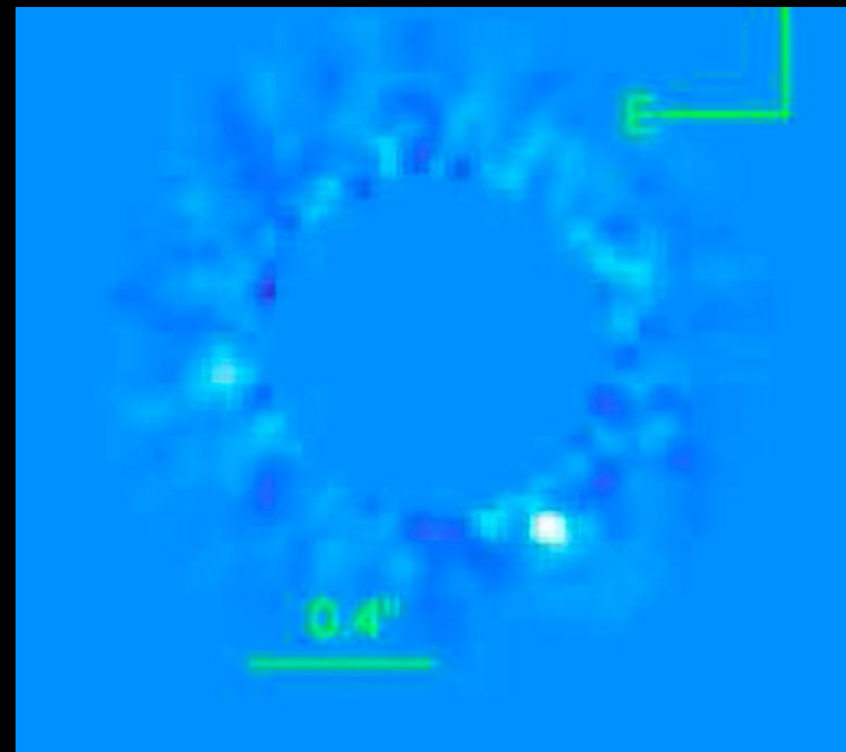
H-band November 2013



Gemini Planet Imager

1980 seconds

H-band December 2010

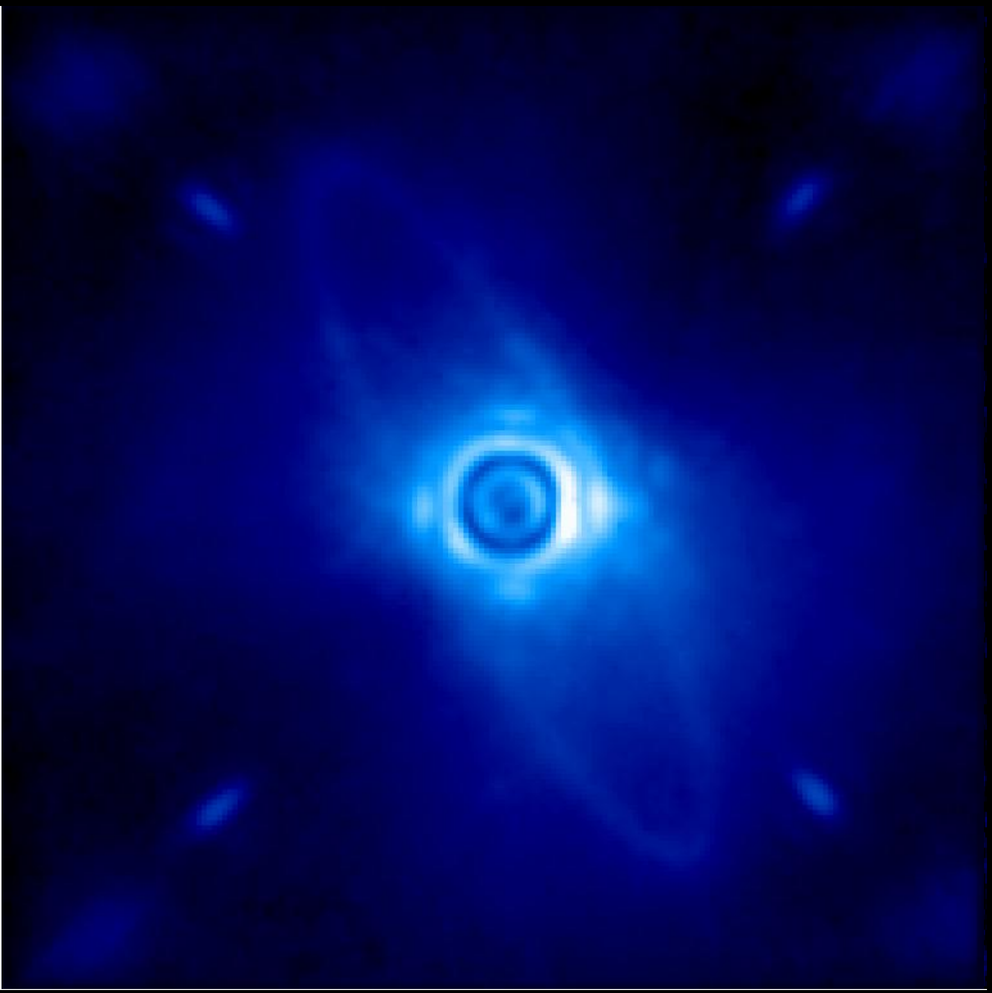


Gemini NICI (Currie et al. 2013)

1400 seconds

Slide courtesy of Bruce Macintosh and the rest of the GPI team

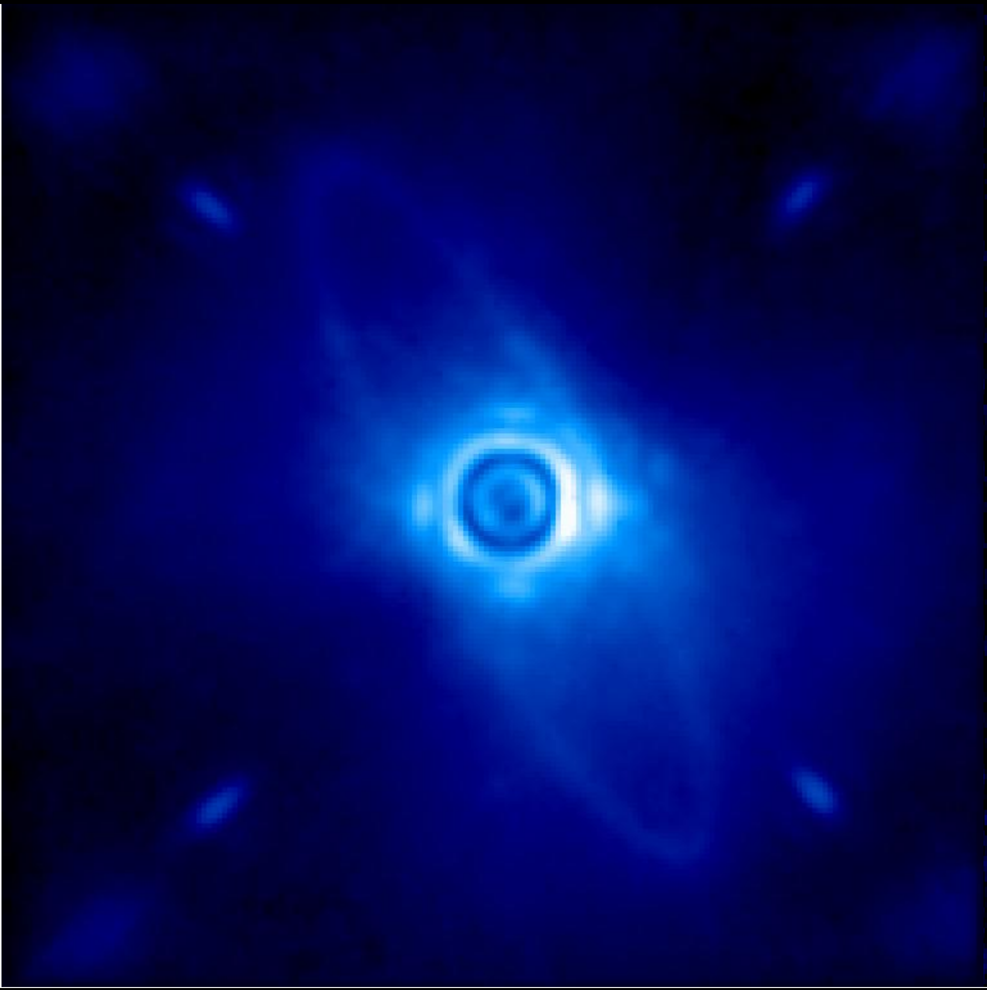
HR 4796A

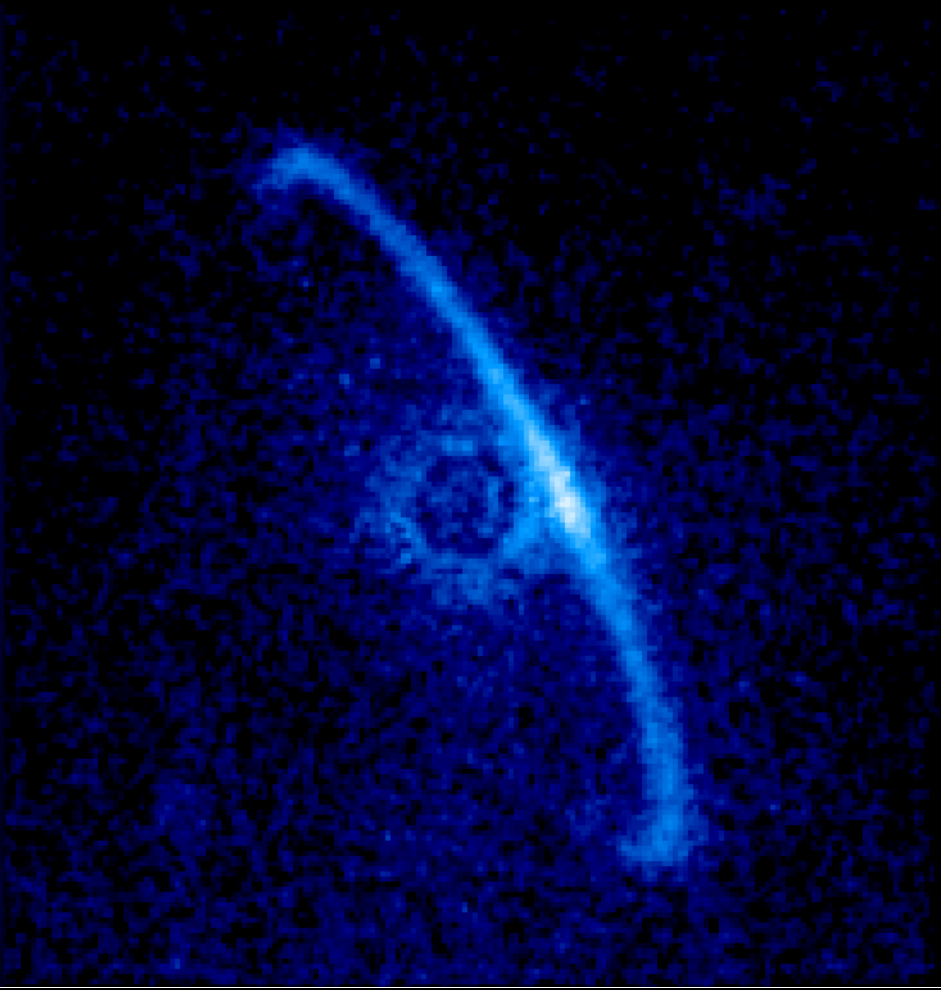


Total light intensity

Slide courtesy of Bruce Macintosh and the rest of the GPI team

HR 4796A





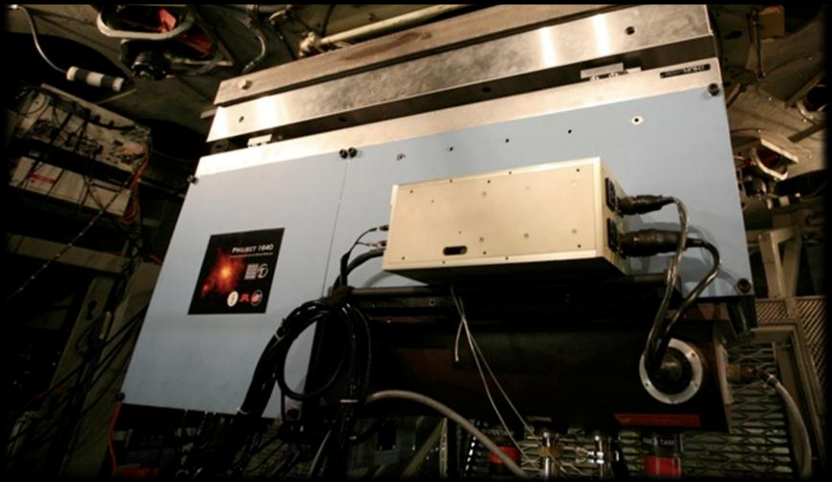
Total light intensity **Polarized light**

Slide courtesy of Bruce Macintosh and the rest of the GPI team

Project 1640: Palomar AO, Coronagraph & Integral Field Spectrograph

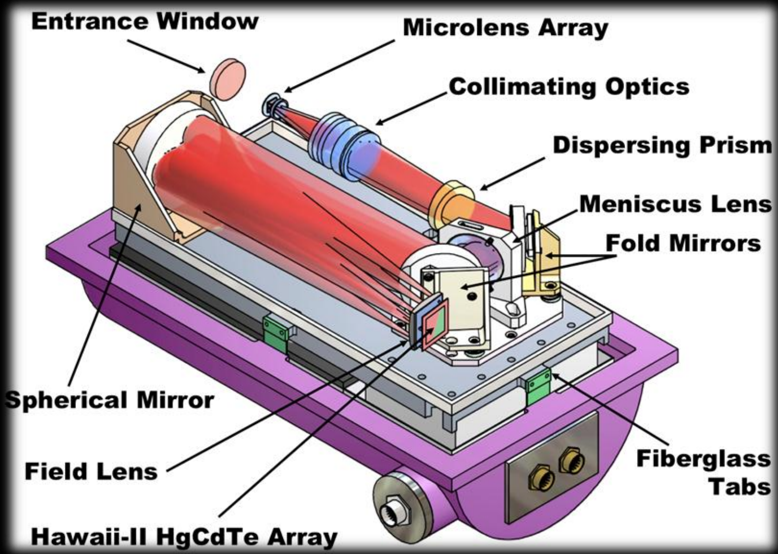
Hinkley et al., 2011b (PASP, 123, 74)

Project 1640: Palomar AO, Coronagraph & Integral Field Spectrograph



Key Features:

- 3,388 actuator AO system
- Wave Front Calibration Interferometer (JPL)
- YJH Imaging Spectrograph

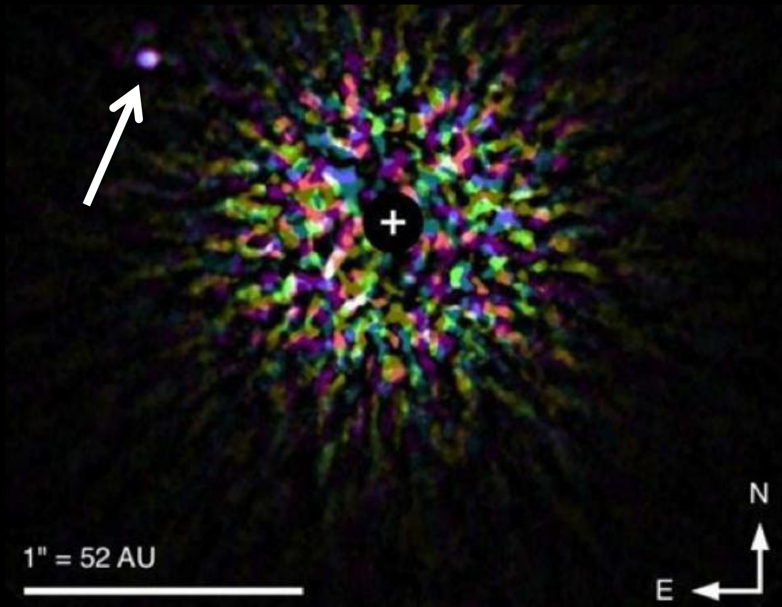


MKID Technology being integrated

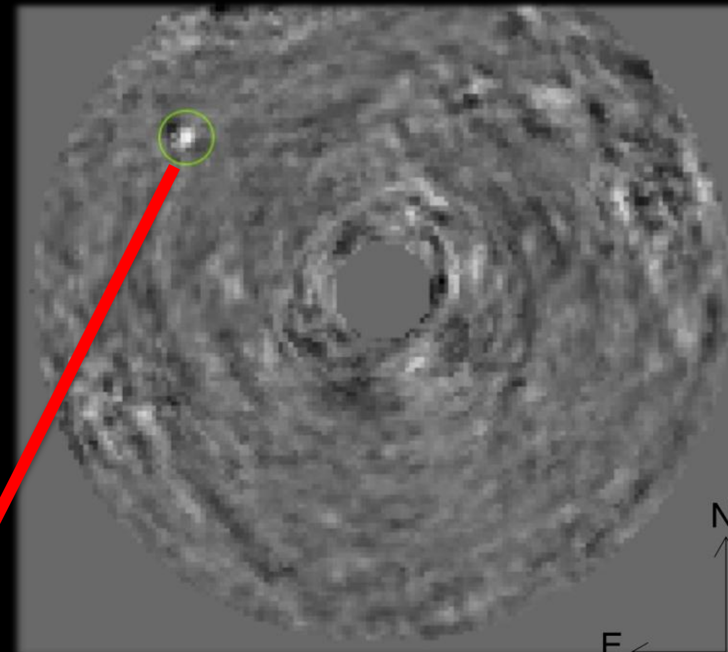
Hinkley et al., 2011b (PASP, 123, 74)

Kappa Andromedae

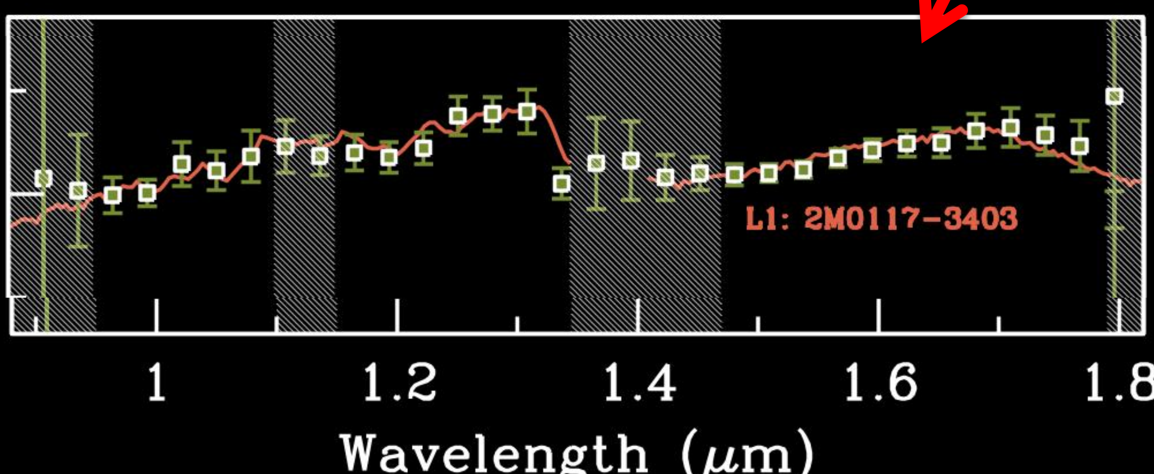
Subaru Discovery Image:
Carson et al (2013)



Project 1640 Imaging



Project 1640 Spectrum



Hinkley et al. (2013)

Lessons Learned

1. Post-Coronagraph Wavefront Calibration: Crucial.

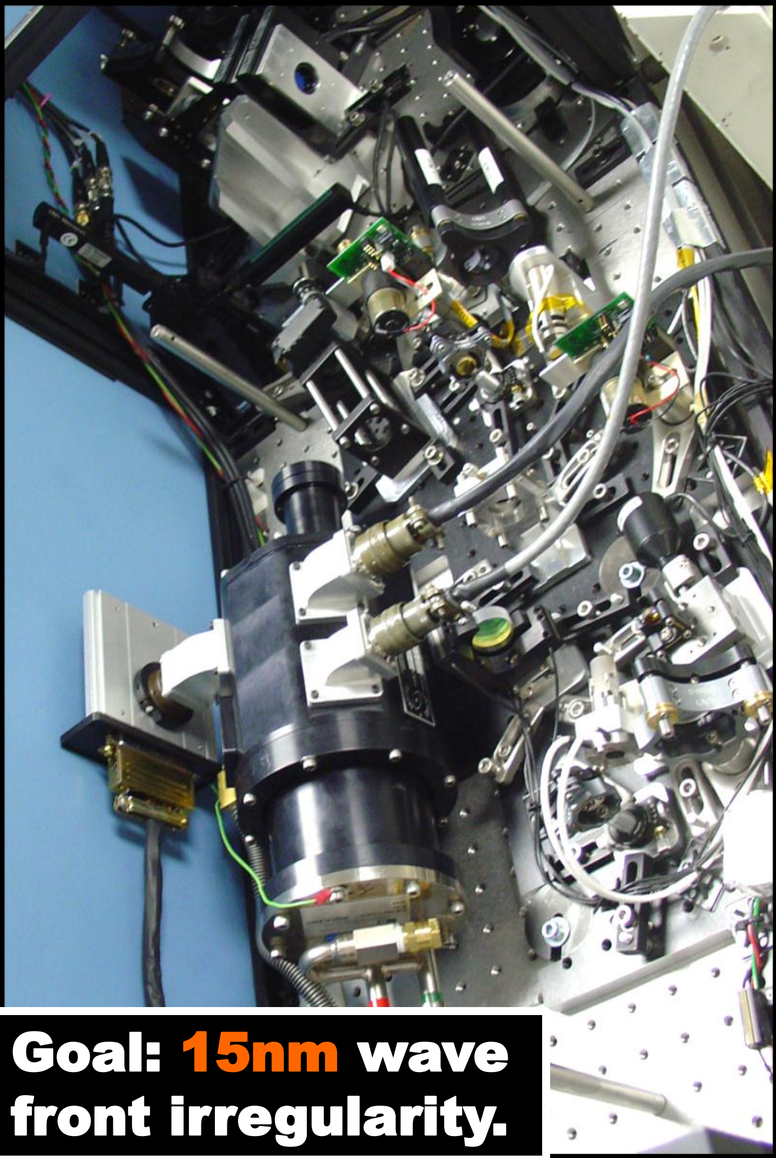
2. High or Low Spectral Resolution: Pros and Cons.

3. The Importance of 3-5 μm Data.

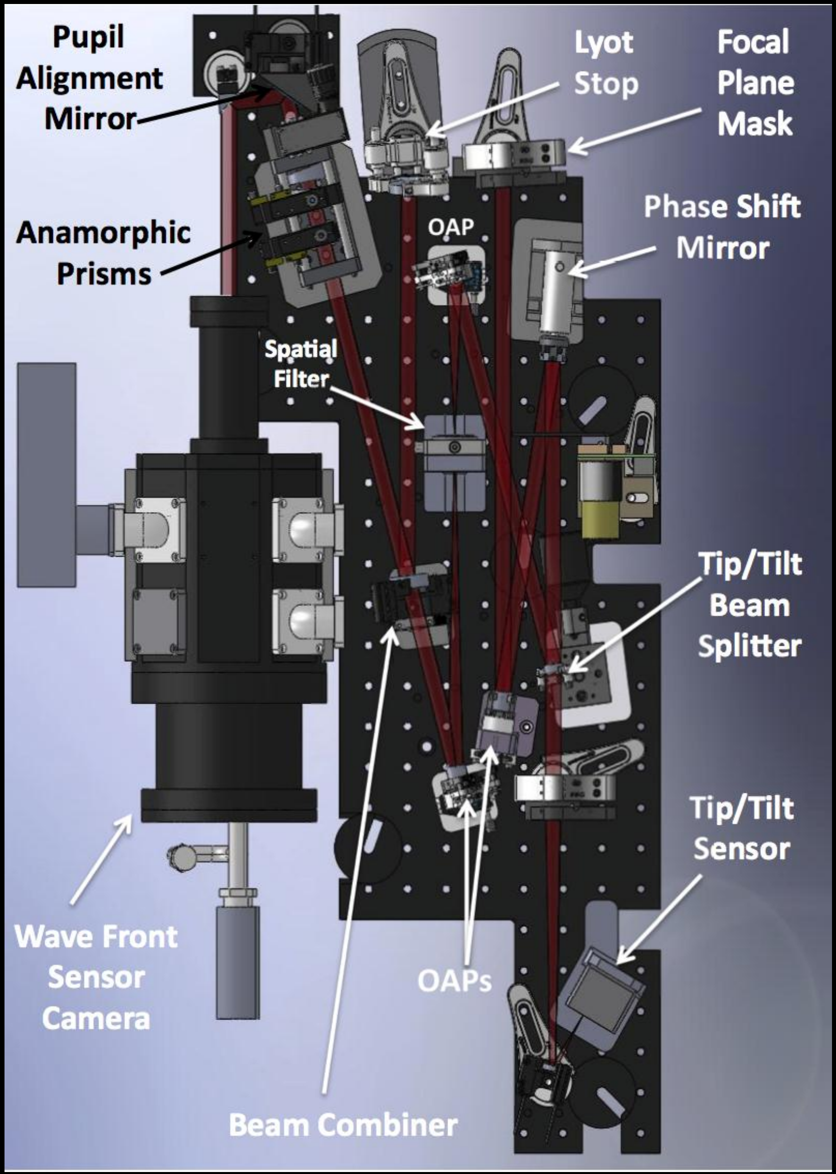
4. RV Trend Systems: Dynamical Masses.

5. PSF Library: Boosts Small Angle Sensitivity.

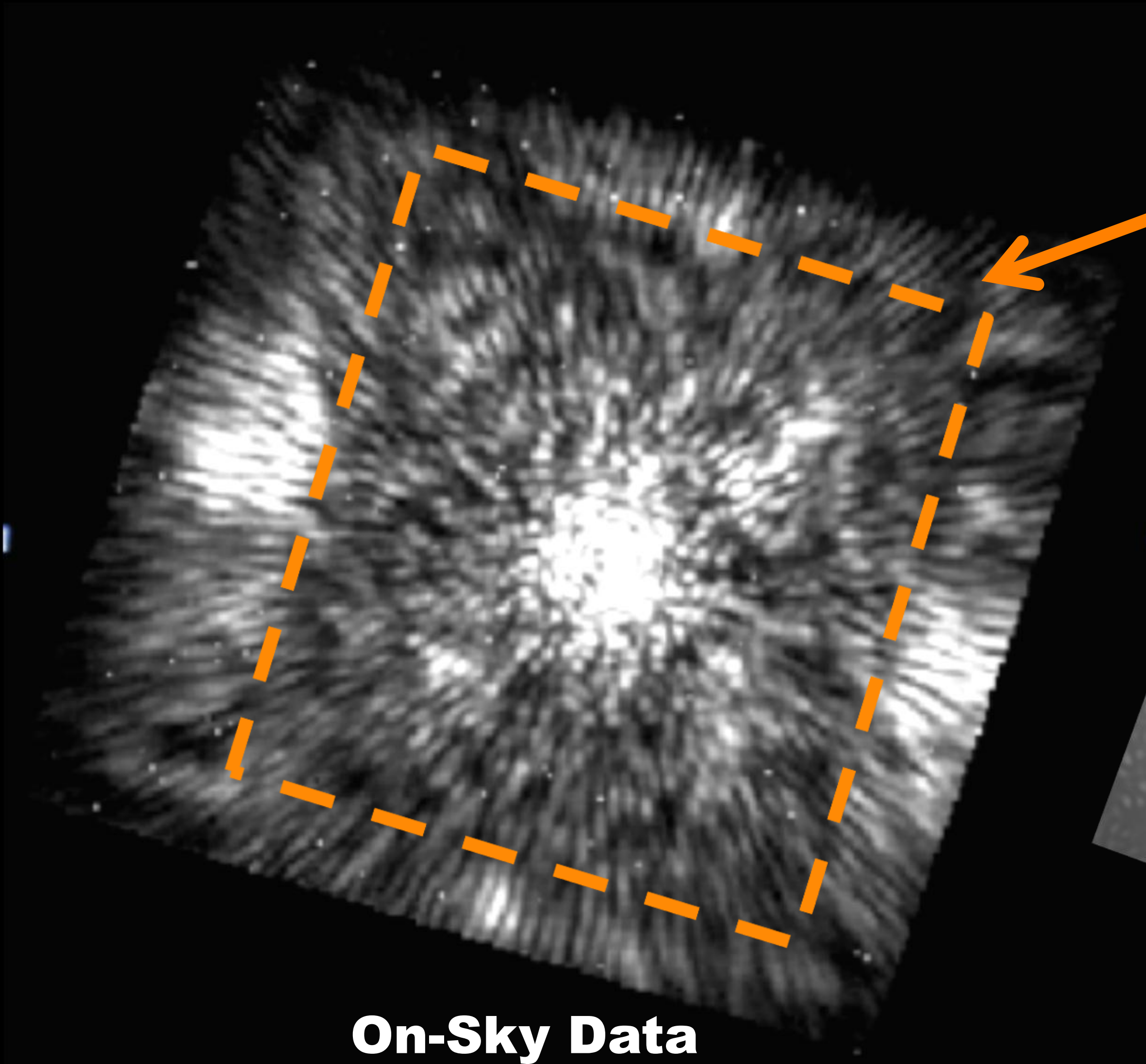
Phase 2: JPL Internal Wave Front Calibration Interferometer



Goal: 15nm wave front irregularity.

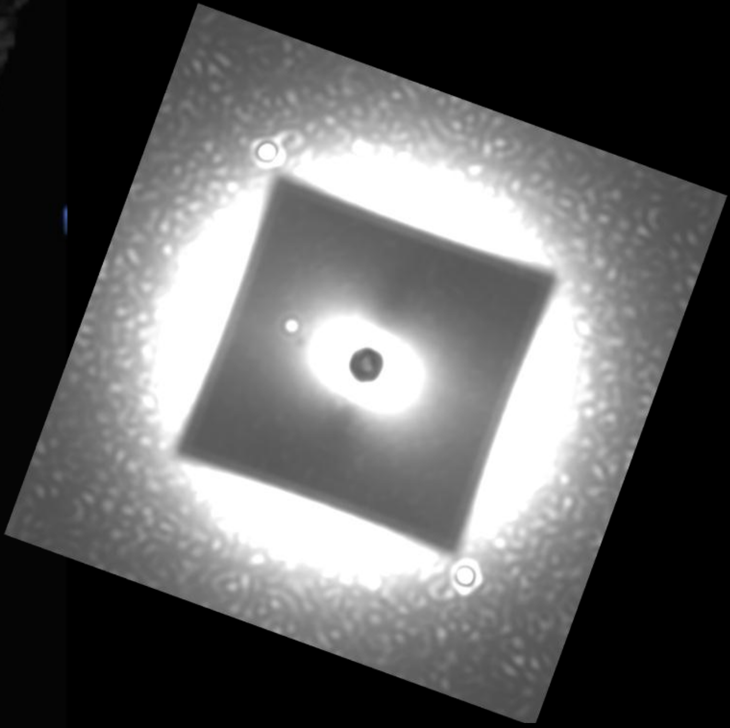


Lesson 1: Post-Coronagraph Wave Front Calibration is Essential



On-Sky Data

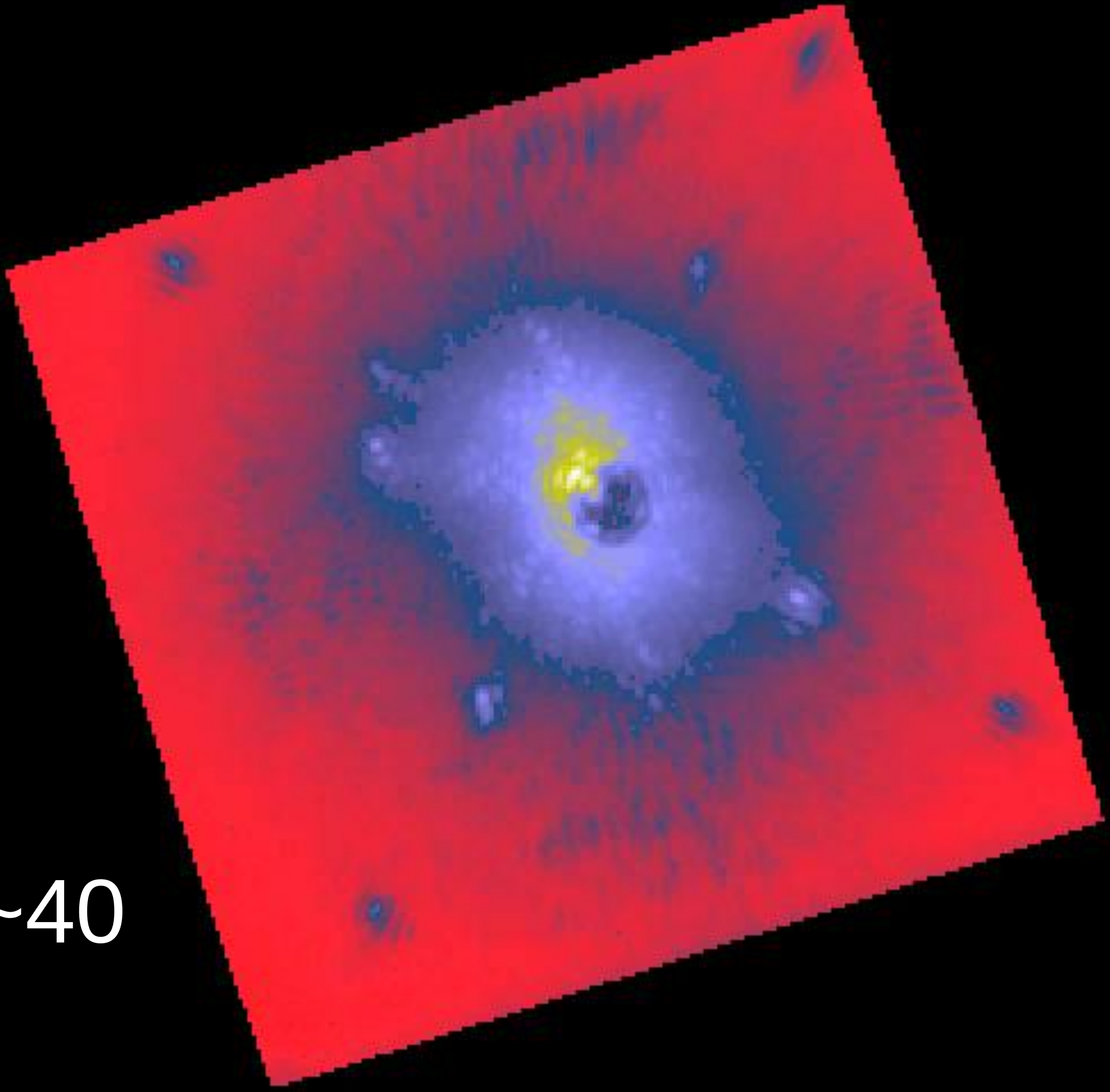
$$\frac{N_{act}\,\lambda}{2D}$$



GPI Simulation

On Sky Data

32 channels over 1.0 – 1.8 μm.



λ/Δλ ~40

← 4 arcseconds →

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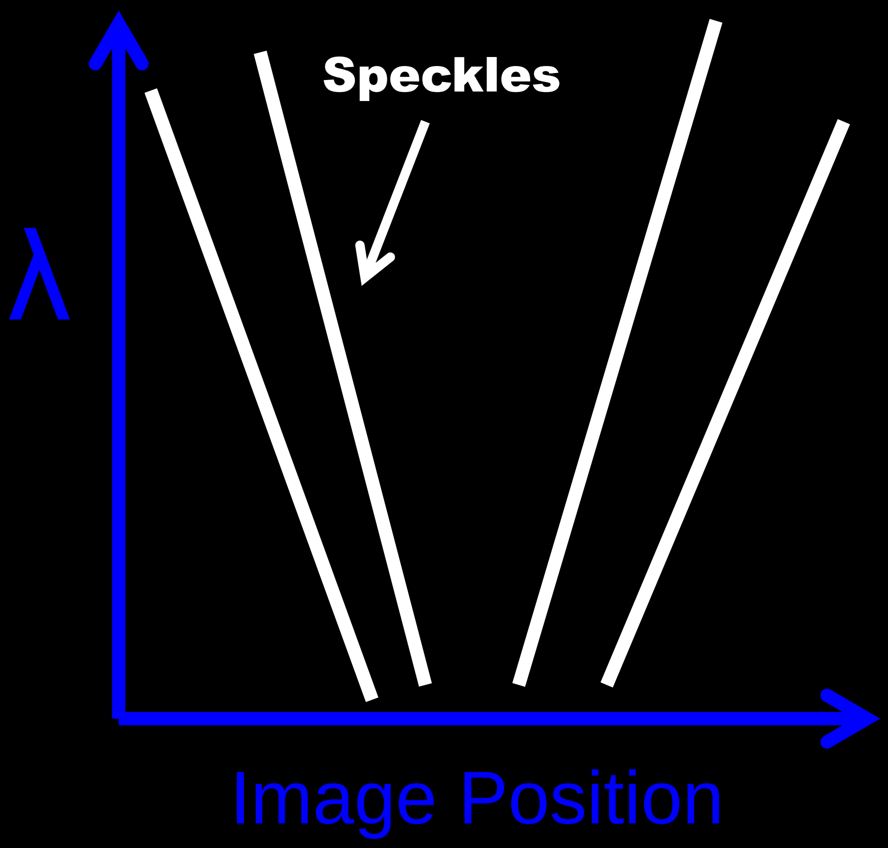
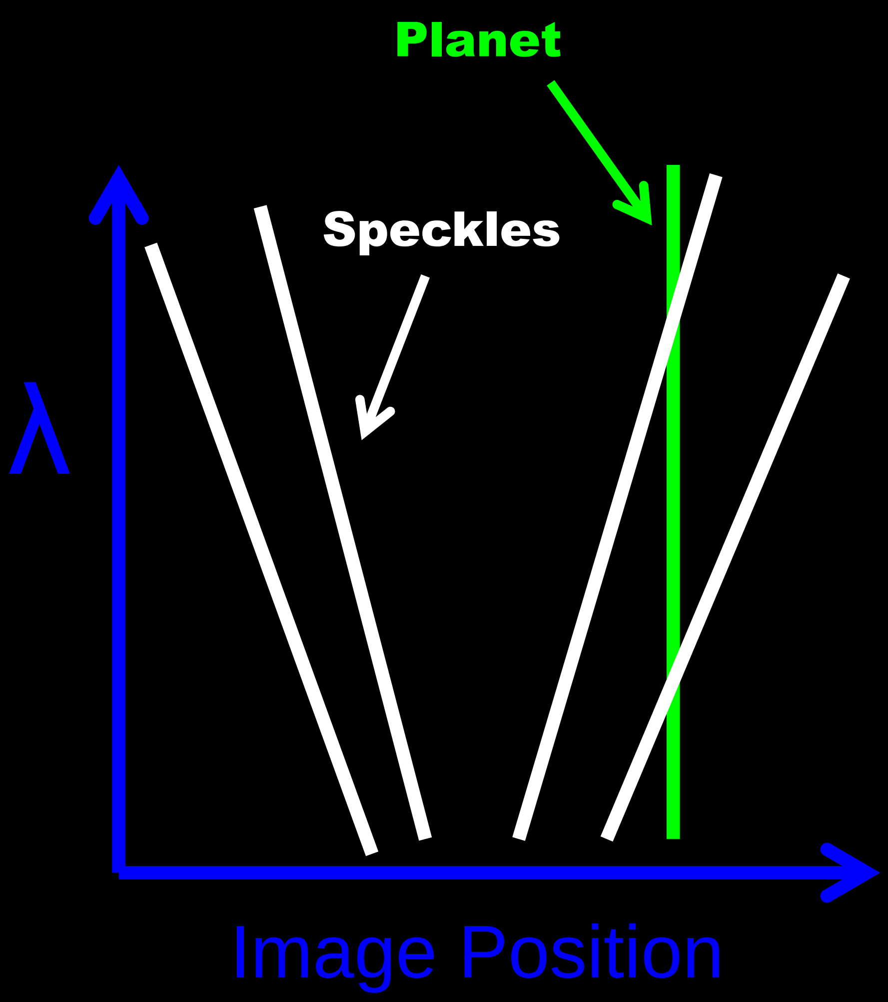
5. PSF Library: Boosts Small Angle Sensitivity.

Speckle-Planets Interaction in a Data Cube (λ/Δλ~40)

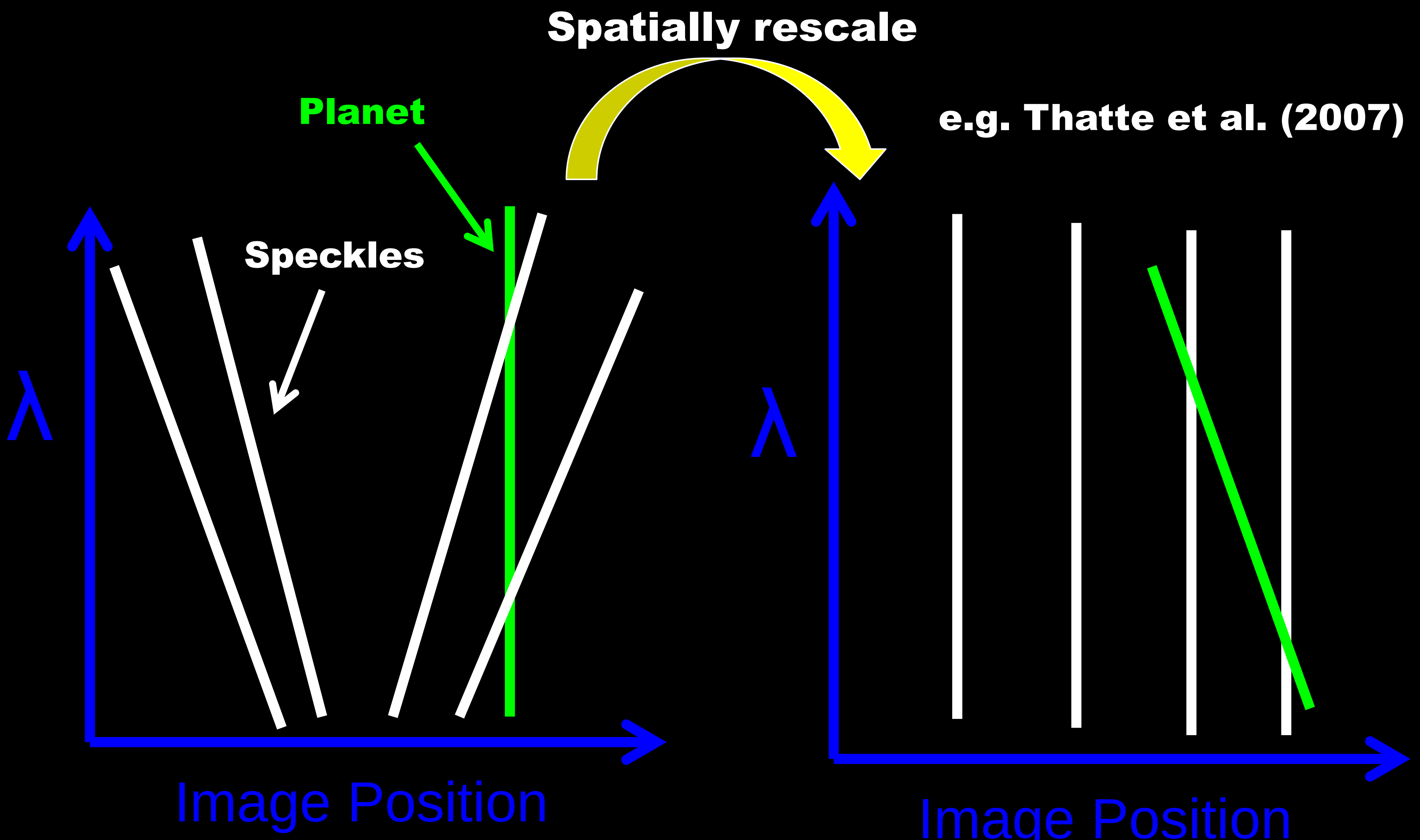


Speckle-Planets Interaction in a Data Cube (λ/Δλ~40)

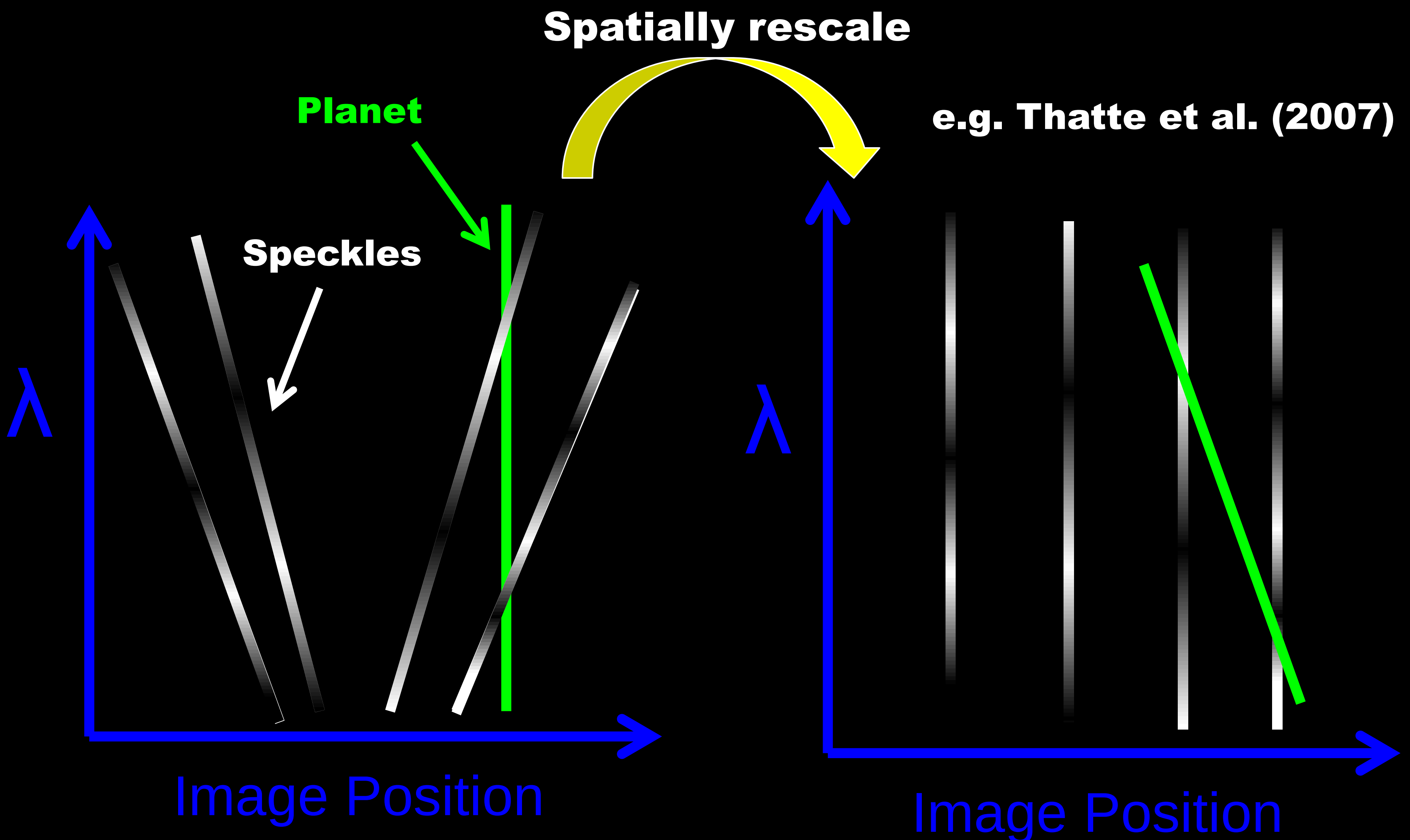


	Pro	**Con**
$\lambda/\Delta\lambda \sim 40$ **(GPI/SPHERE/P1640)**	Long λ baseline for Speckle suppression	

Speckle-Planets Interaction in a Data Cube (λ/Δλ~40)

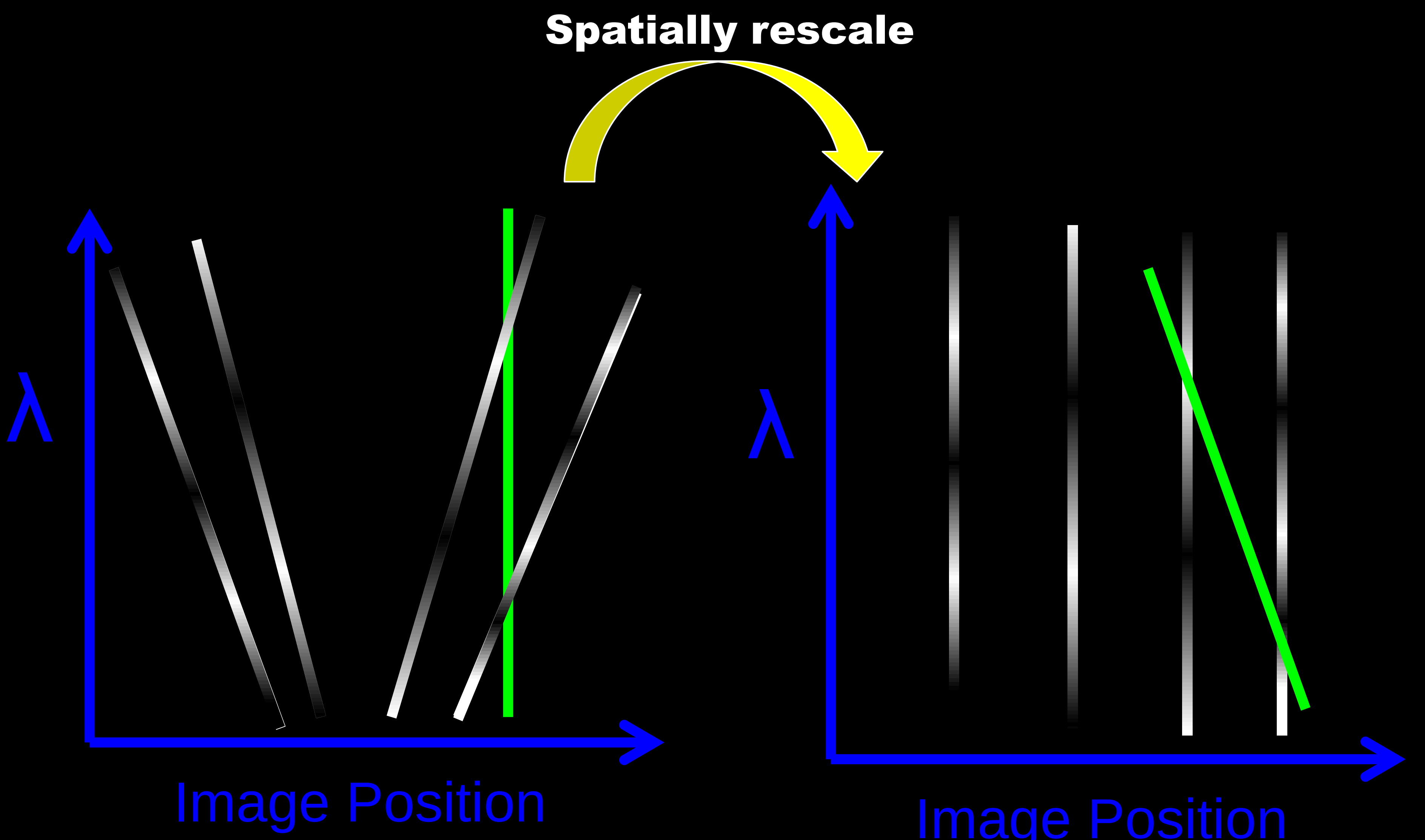


Speckle-Planets Interaction in a Data Cube (λ/Δλ~40)

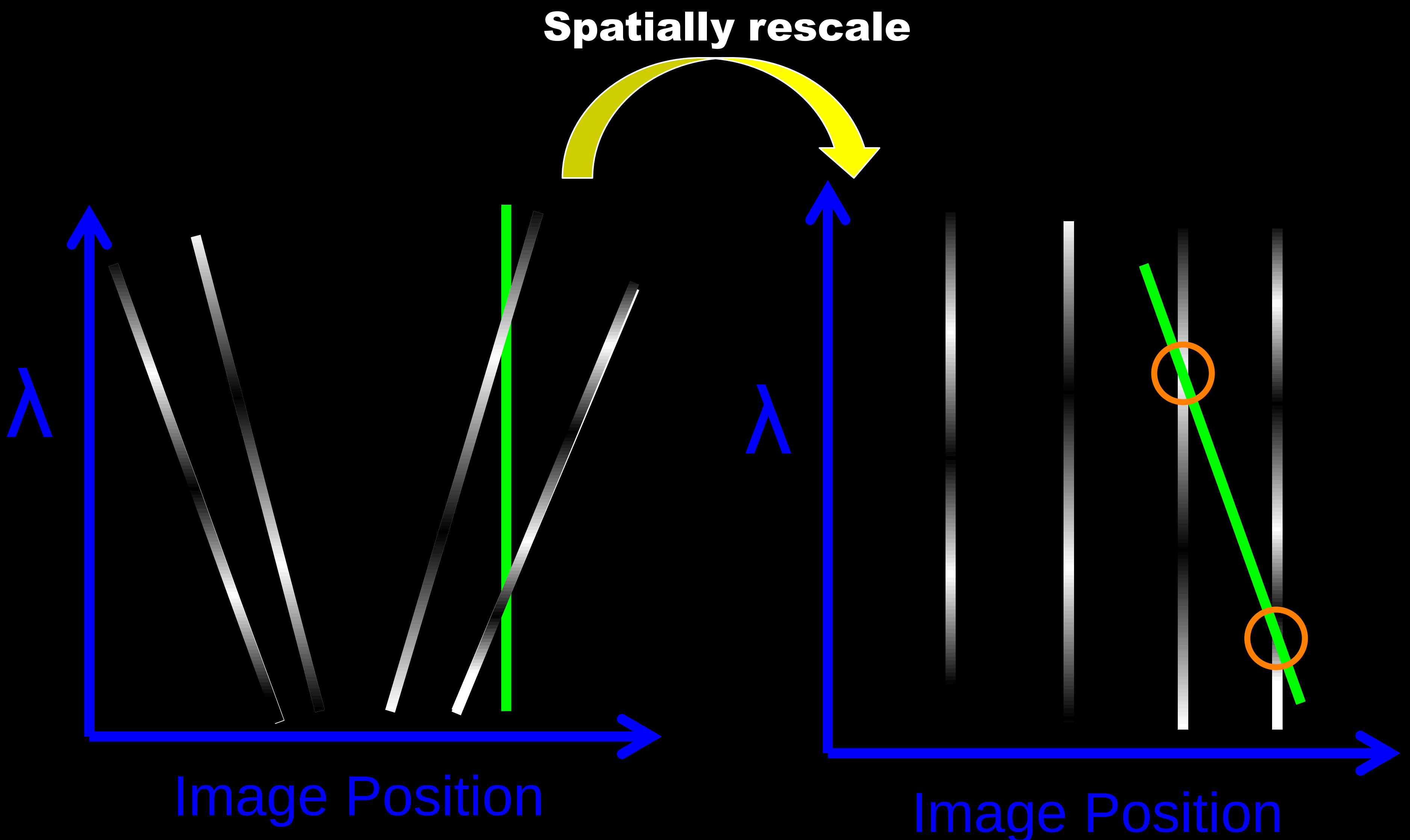


	Pro	Con
$\lambda/\Delta\lambda \sim 40$ **(GPI/SPHERE/P1640)**	Long λ baseline for Speckle suppression	Speckle Chromaticity

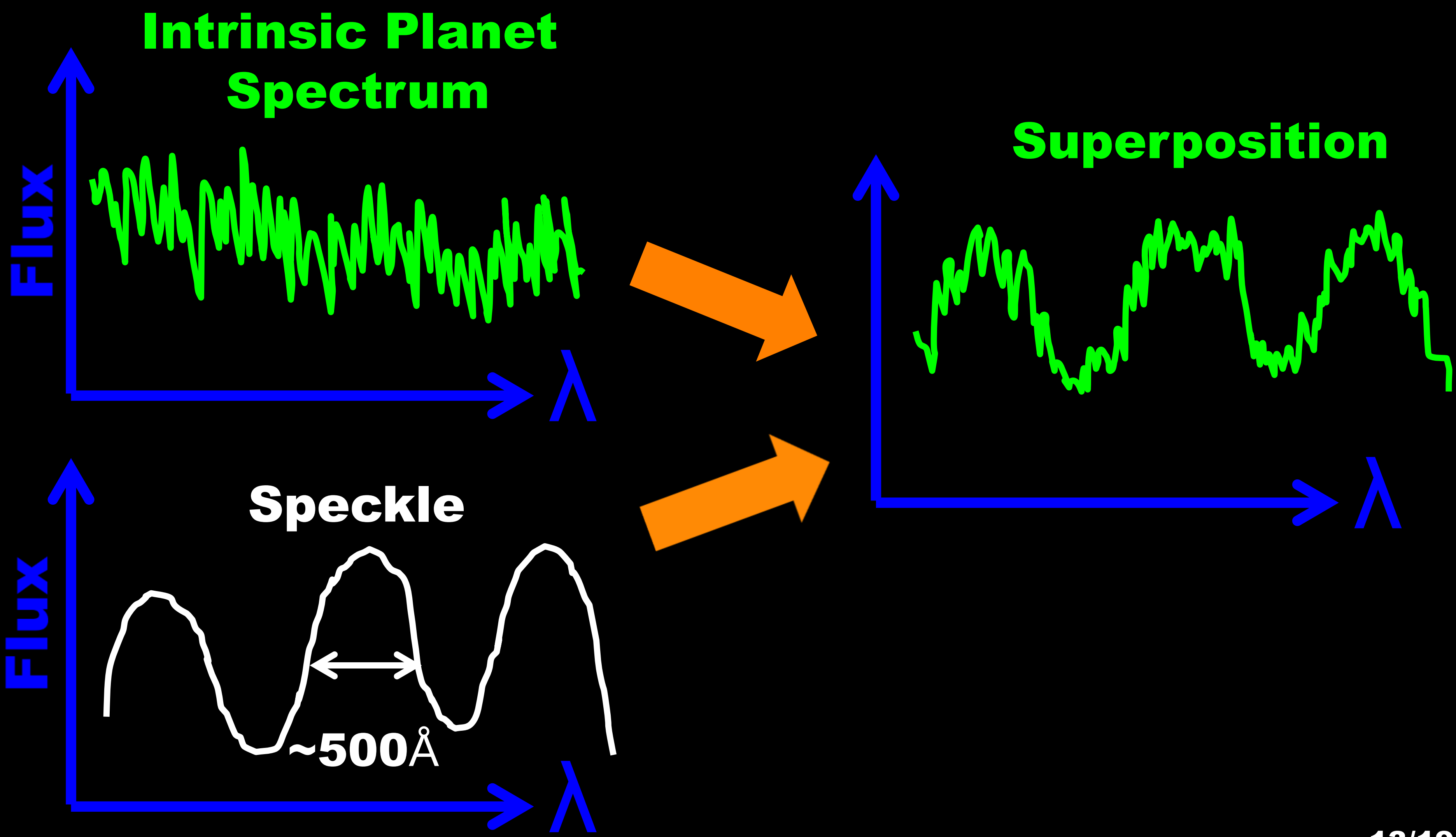
Speckle-Planets Interaction in a Data Cube (λ/Δλ~40)



Speckle-Planets Interaction in a Data Cube (λ/Δλ~40)

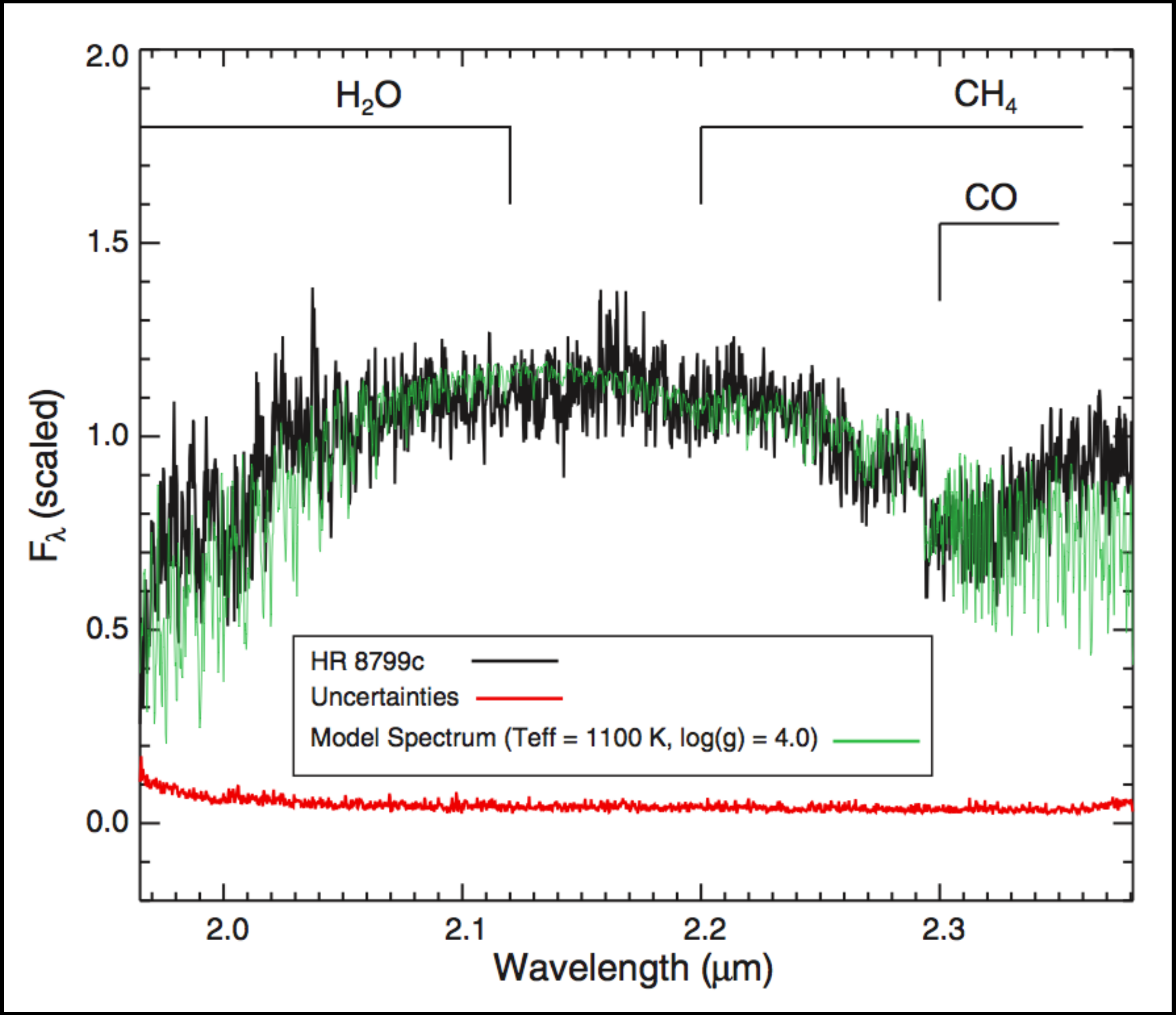


Speckle-Planets Interaction in a Data Cube ($\lambda/\Delta\lambda \sim 4000$)



Bottom Line: Line Ratios Less affected by Speckle Noise for λ/Δλ~4000

HR 8799c: Keck OSIRIS spectra



(Konopacky et al 2013)

Lesson 2: Pros and Cons to Spectral Resolution

	Pro	Con
$\lambda/\Delta\lambda \sim 40$ **(GPI/SPHERE/P1640)**	Long λ baseline for Speckle suppression	Speckle Chromaticity
$\lambda/\Delta\lambda \sim 4000$ **(OSIRIS/SINFONI)**	Line ratios insensitive to speckle noise	Narrow λ Coverage, smaller field of view

Lessons Learned

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2. High or Low Spectral Resolution: Pros and Cons.
3. The Importance of 3-5 μm Data.
4. RV Trend Systems: Dynamical Masses.
5. PSF Library: Boosts Small Angle Sensitivity.

Lesson 3: Data at 3-5 μm Can Disentangle Synthetic Models

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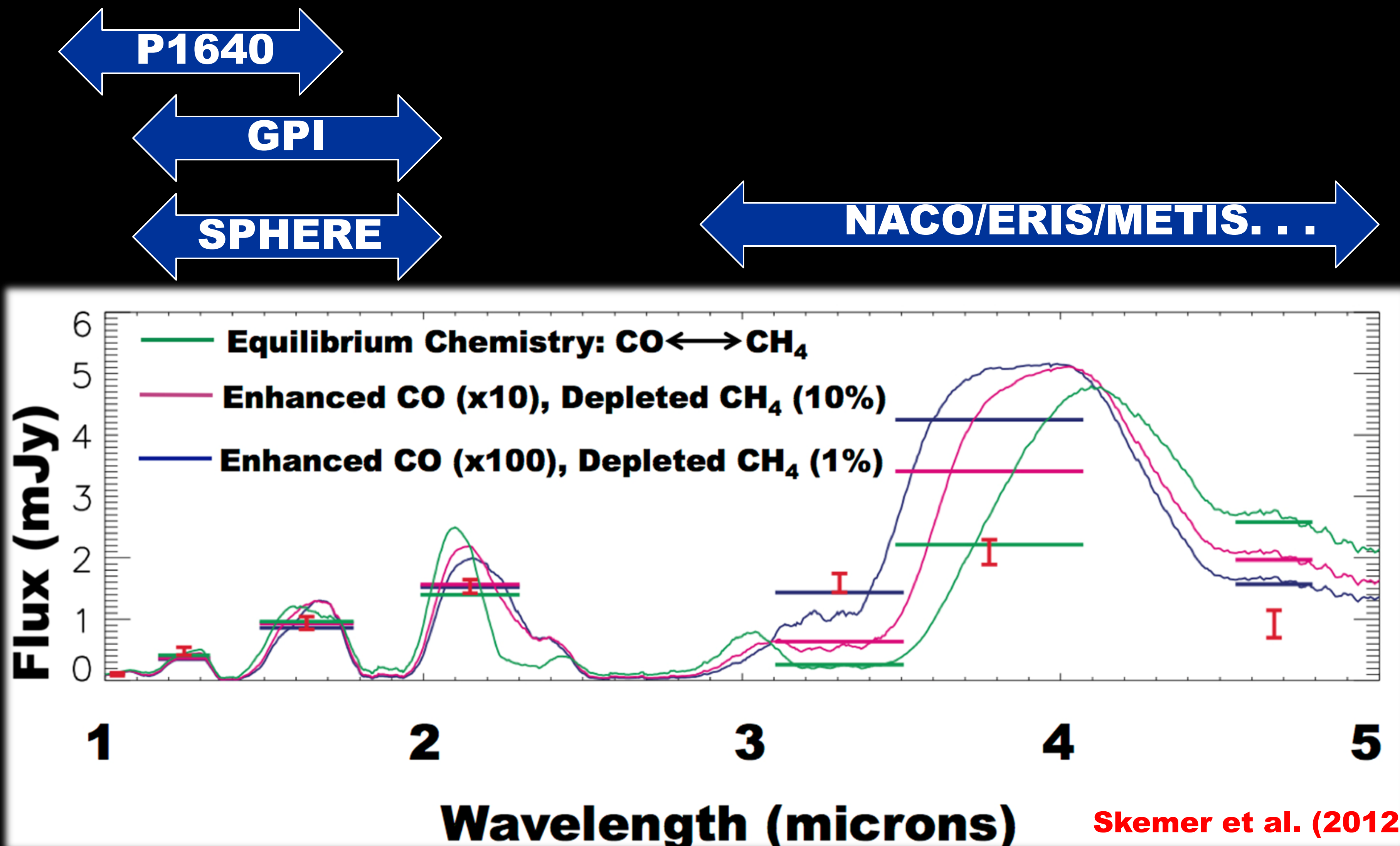

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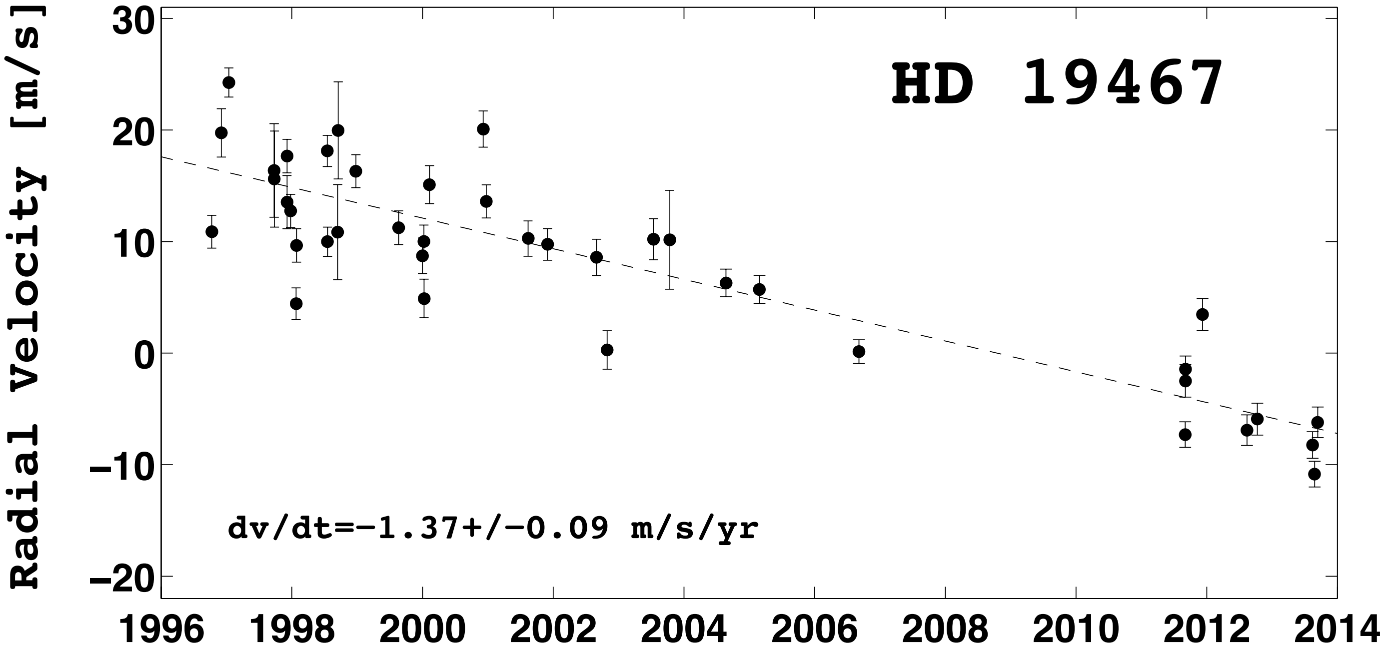
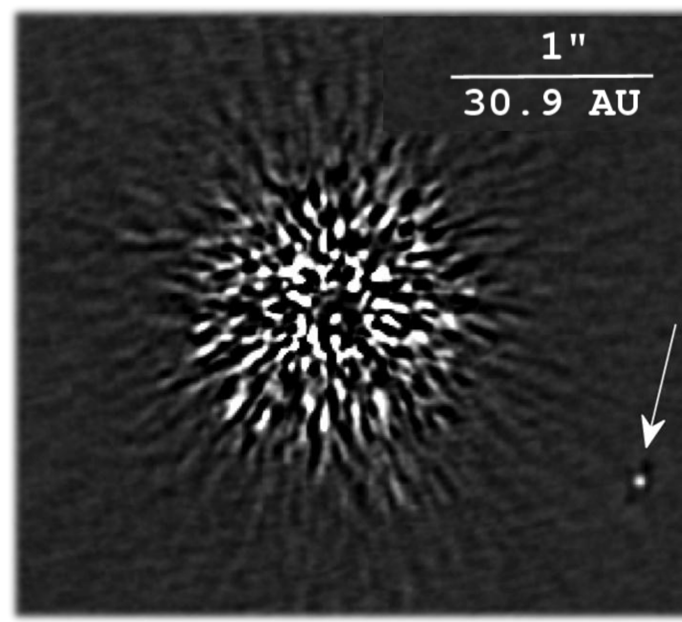
Lesson 4: Long Term RV Trends give Dynamical Masses



Crepp et al. (2013)



- **RVs + Astrometry gives a dynamical mass**
- **17 year time baseline**
- **P1640 Spectroscopy will constraint T_{eff}**

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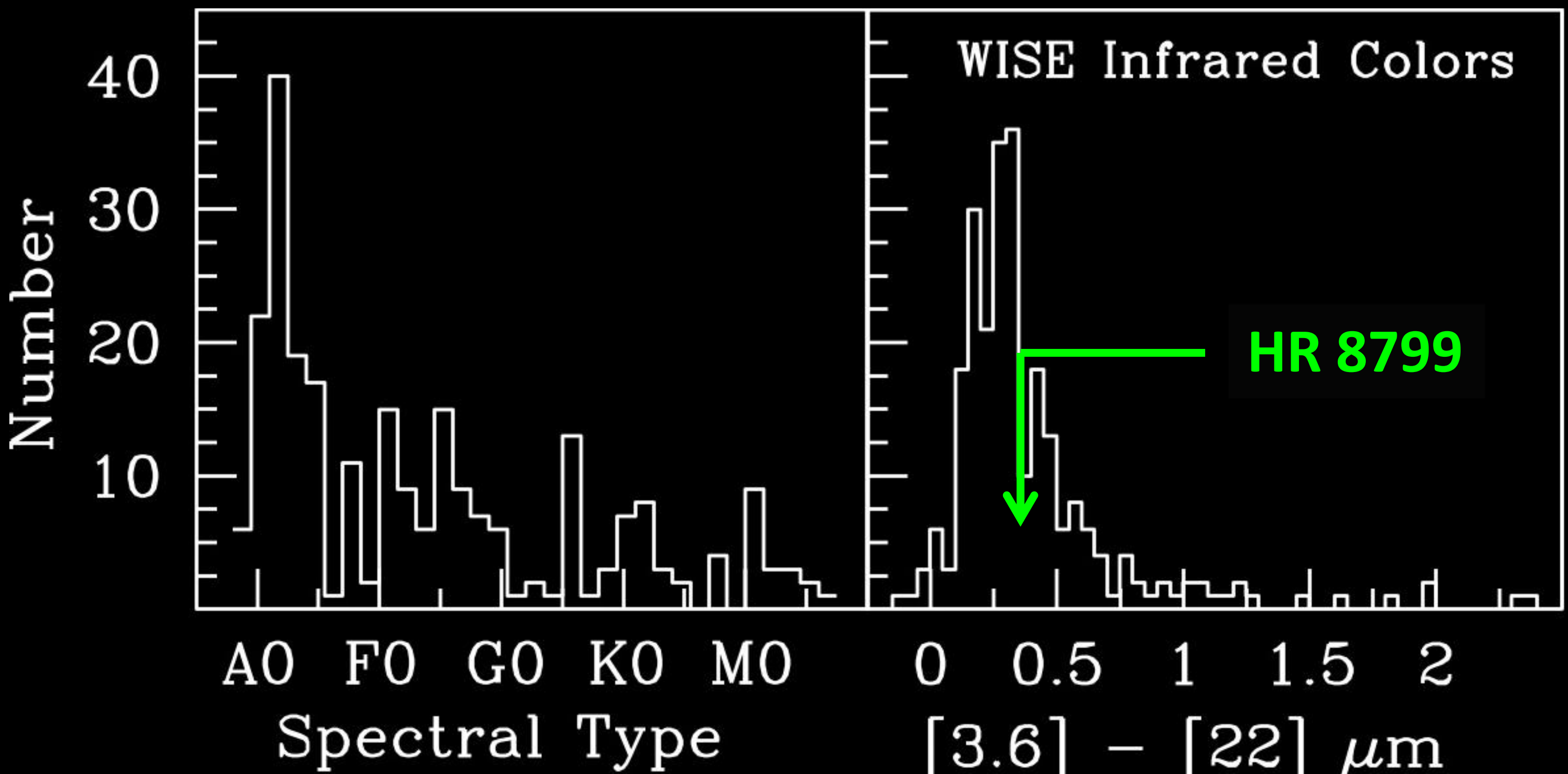
A VLT/Keck Survey of Newly Identified WISE Debris Disk Stars

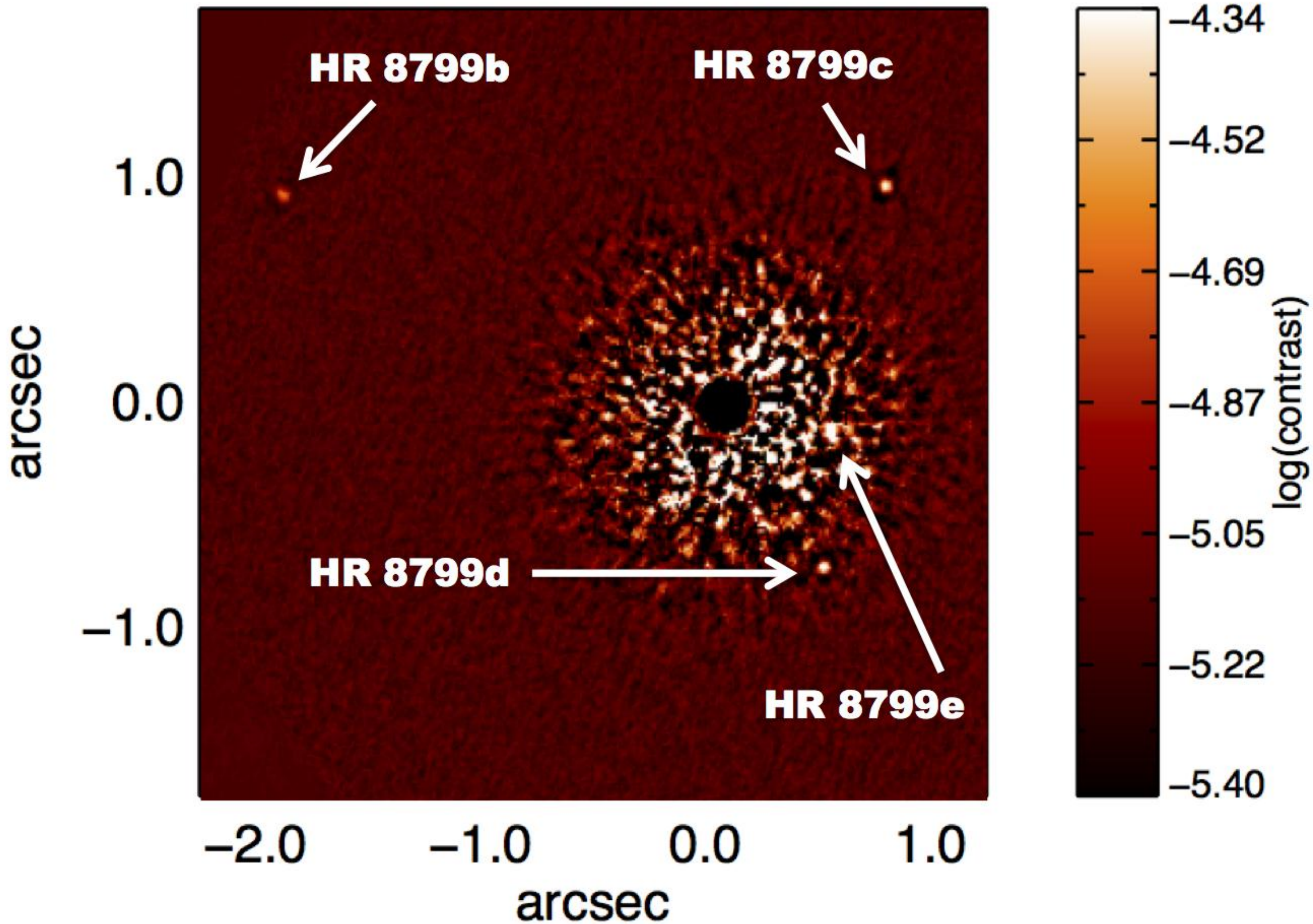
- **203 Stars** observed at Keck (Hinkley)
- **31 Stars** observed only at VLT (Mawet)
- **14 Stars** observed only at Palomar (Hinkley)

248 Stars



Lesson 5: A PSF Library Increases Sensitivity at the Smallest Inner Working Angles

HR8799 at Keck: Only 8 minutes of integration time



VLT: L-band Reference Star Subtraction (RDI)

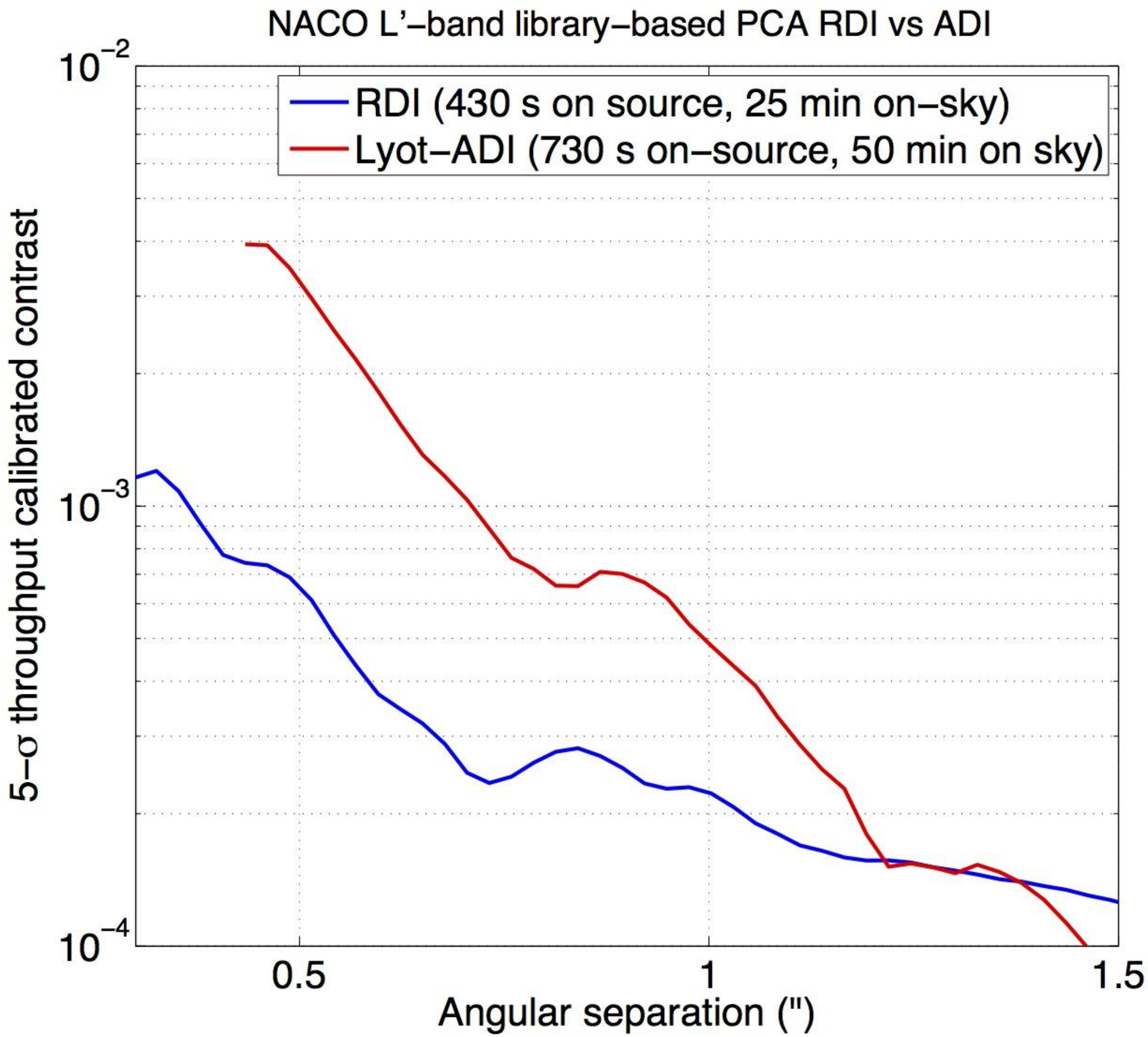
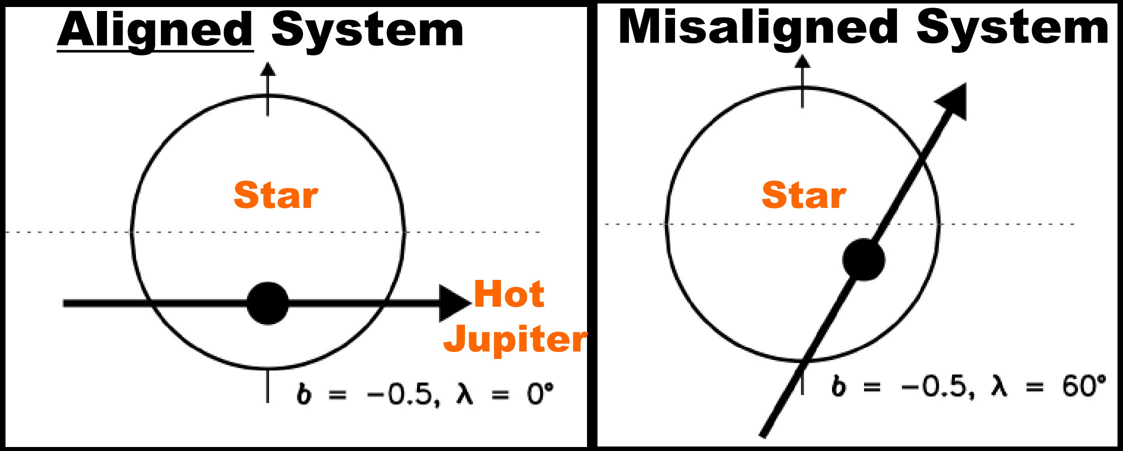
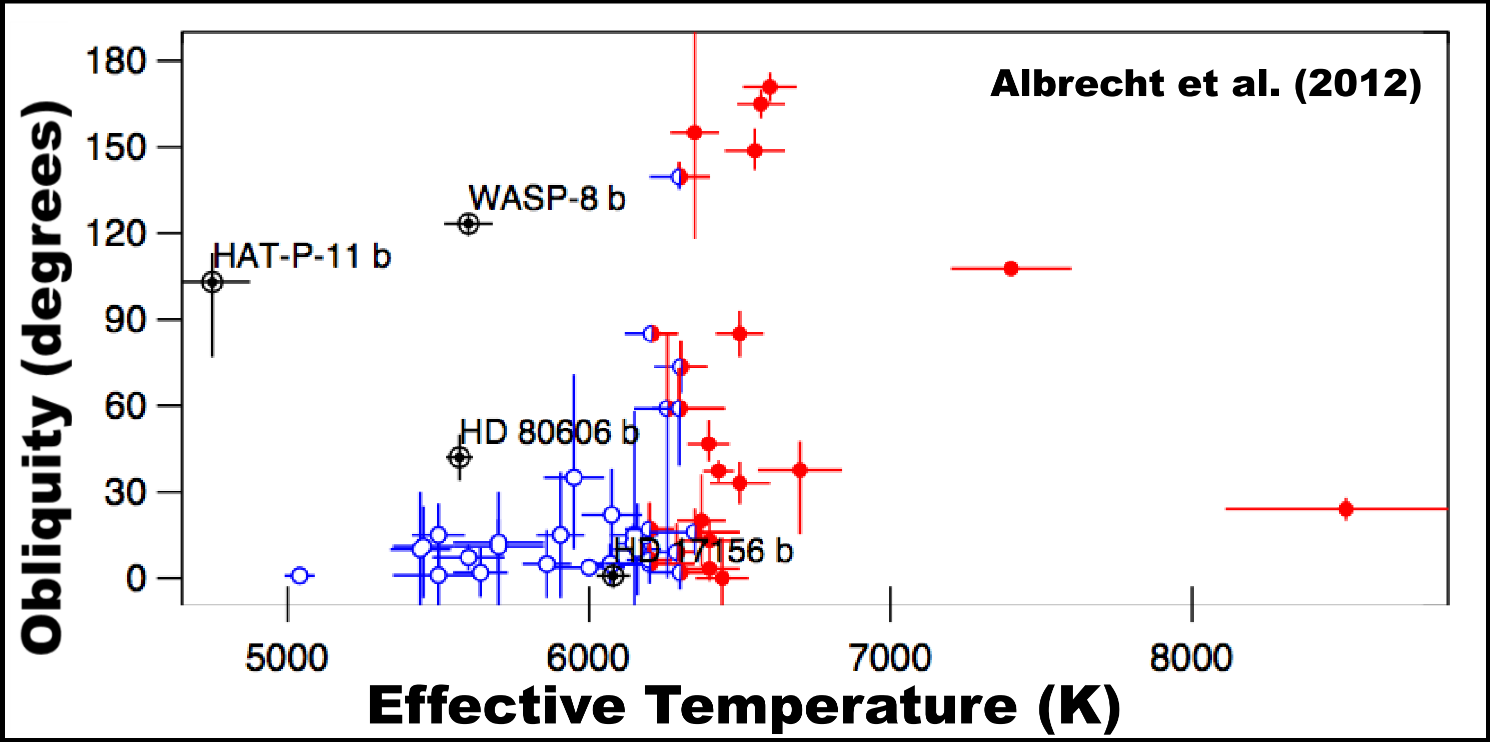


Figure courtesy of Dimitri Mawet (ESO)

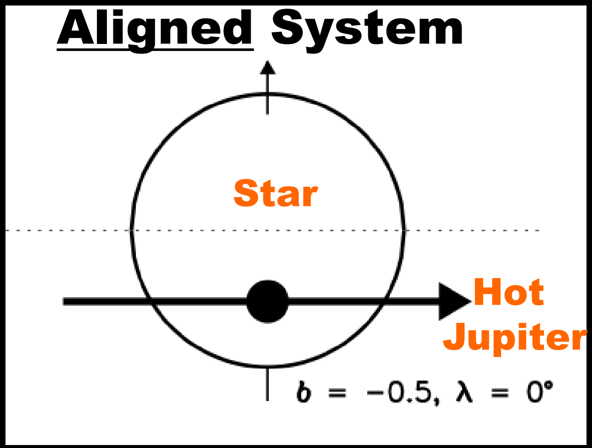
Companions to Transiting Hot Jupiters

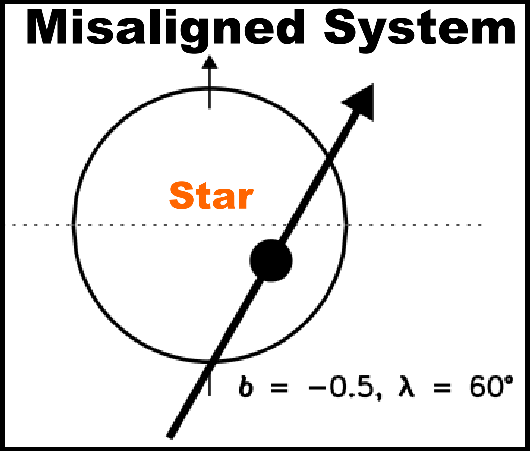


Winn (2006)



Companions to Transiting Hot Jupiters

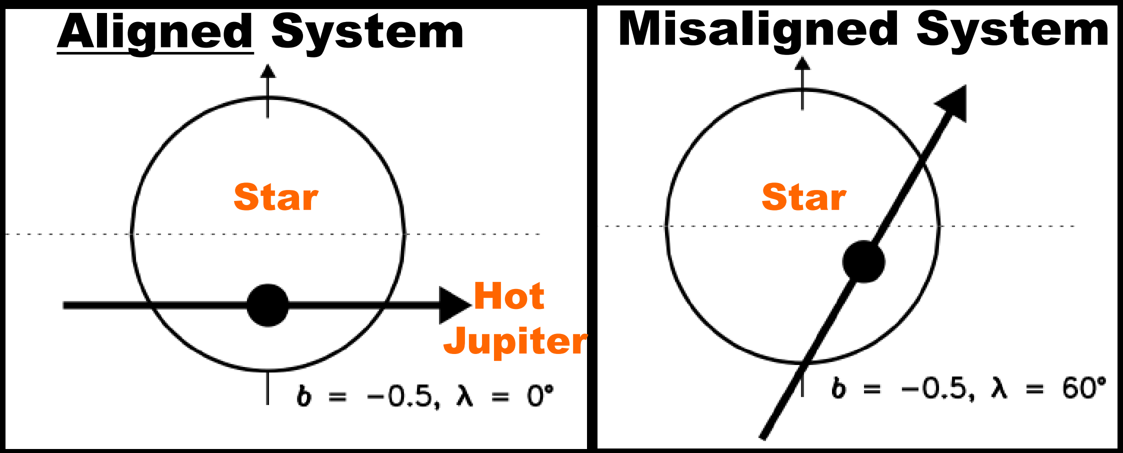




Winn (2006)

Keck Adaptive Optics Imaging

Companions to Transiting Hot Jupiters



Winn (2006)

Keck Adaptive Optics Imaging

Collaborators: H. Knutson, H. Ngo, K. Piskorz

Summary of Lessons Learned

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