Building the Gemini Planet Imager

Current Status and Future Plans

Marshall Perrin - on behalf of many others!

The GPI Team

GPI Science Goals

Instrument Design & Construction Status

What's Next?

Bruce Macintosh (Principal Investigator)
Dave Palmer (Project Manager) James Graham (Project Scientist)

AMNH: Ben Oppenheimer, Anand Sivaramakrishnan. STScI: Remi Soummer

HIA: Les Saddlemyer, Jean-Pierre Veran, Darren Erikson, Jennifer Dunn, Christian Marois, Joeleff Fitzsimmons, Alexis Hill, Marcel Pennington, Vlad Reshetov

JPL: Kent Wallace, John Angione, Randall Bartos, Bijan Nemati, Chris Shelton

LLNL: Lisa Poyneer, Brian Bauman, Julia Evans, Steve Jones

UCB: Sloane Wictorowicz, James McBride

UCLA: James Larkin, Marshall Perrin, Jeff Chilcote, Jason Weiss, Evan Kress

UCSC LAO: Don Gavel, Katie Morzinski, Daren Dillion, Scott Severson

U. Montreal: Rene Doyon, Jerome Marie. Immervision: Simon Thibault

Science team: Adam Burrows, Mike Fitzgerald, Paul Kalas, Geoff Marcy, Stan Metchev, Jenny Patience, Gene Serabyn, Mike Shao, Inseok Song

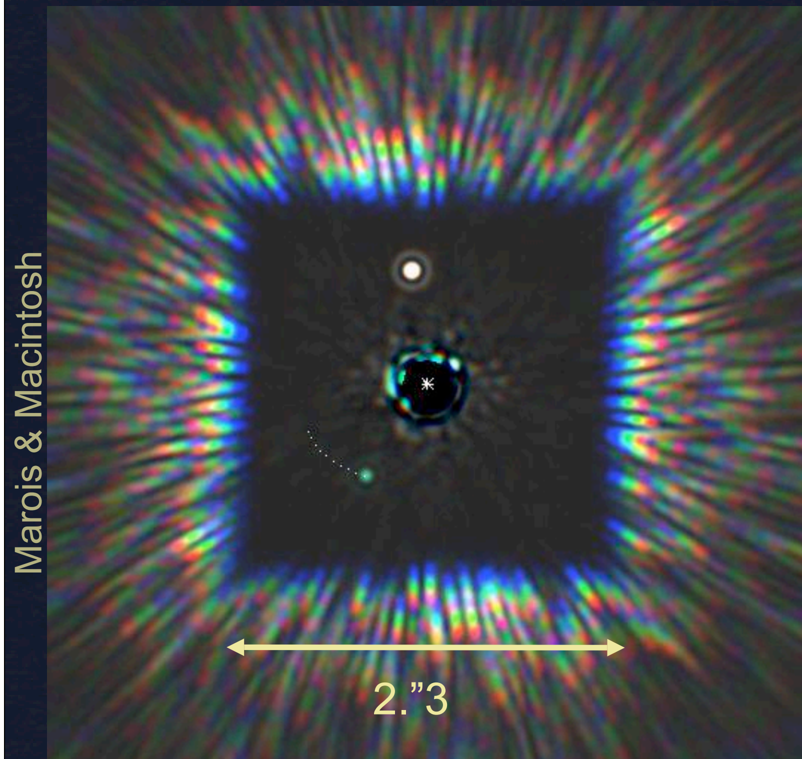
Michelson Fellows and GPI

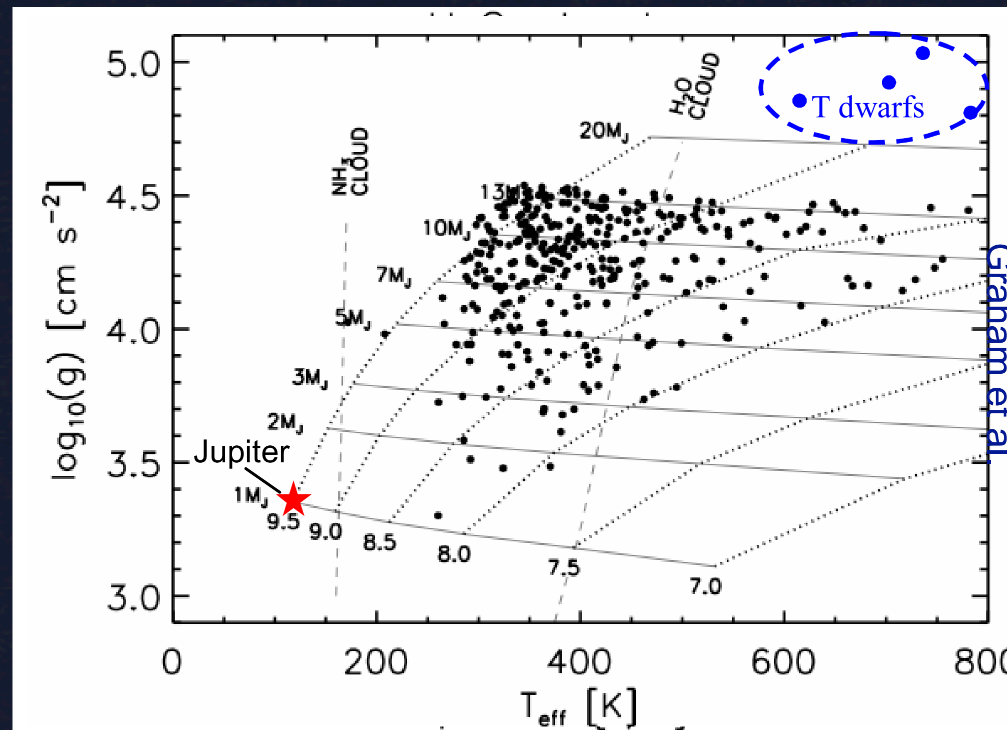
Graduate:	Marshall Perrin	2003
	Katie Morzinski	2007
Postdoc:	Rémi Soummer	2003
	Jenny Patience	2004
	Mike Fitzgerald	2007

08

GPI Science Meeting October 2009

GPI Science: Direct Imaging of Exoplanets





GPI will:

Achieve 10^{-8} - 10^{-7} contrast from 0.15”-2” for stars brighter than I = 9

Directly image 1-10 M_{Jup} planets around stars < 2 Gyr old

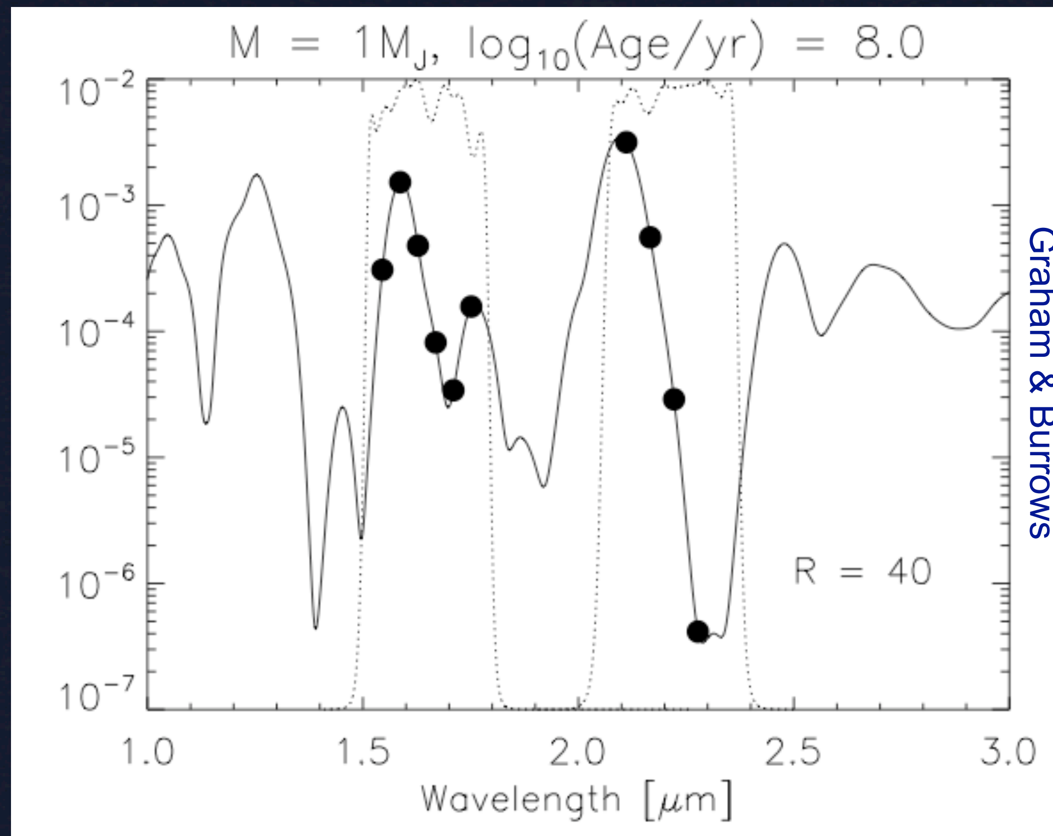
Measure T_{eff} & g via spectra

GPI Science: Spectroscopy of Exoplanets

Models indicate R ~ 40 is suitable for measuring atmospheric parameters

- [1.5] – [1.6] is a good effective temperature indicator

- [1.5] – [2.2] is a good gravity indicator

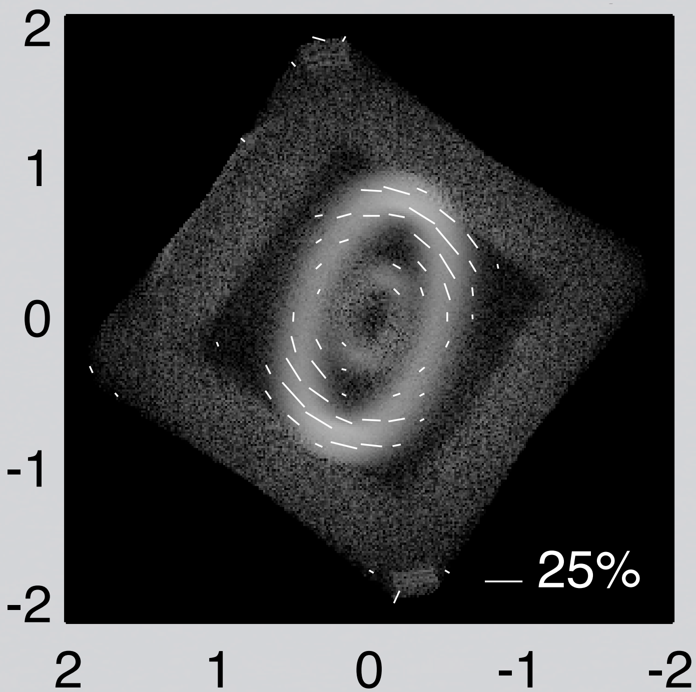


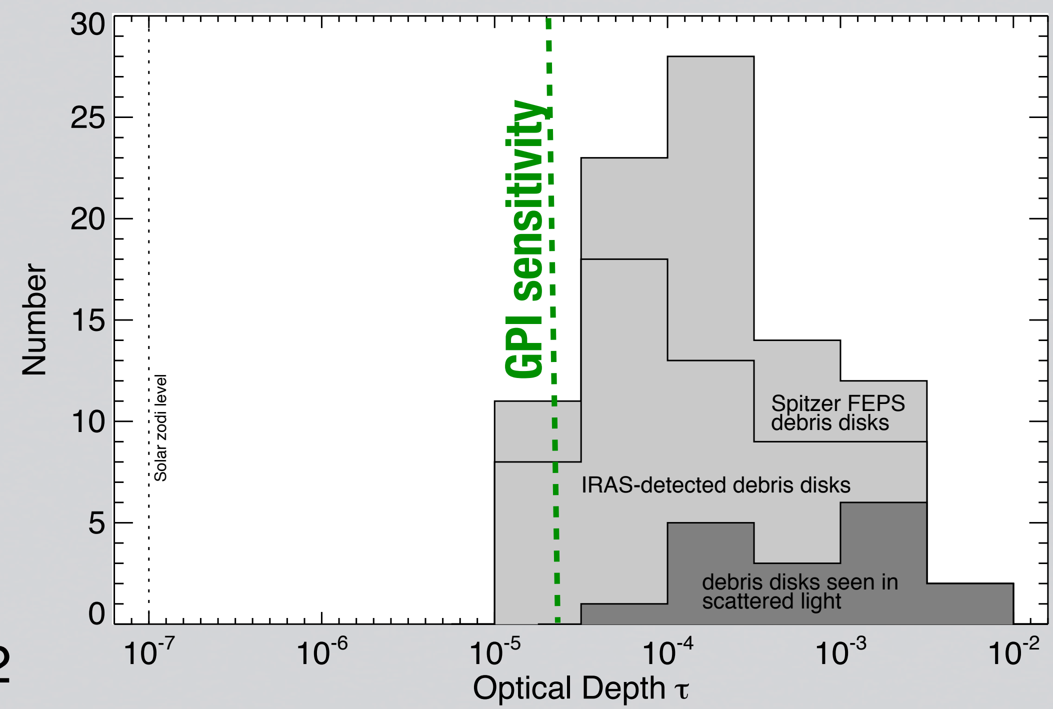
Graham & Burrows

A key project science campaign should target several hundred nearby stars to detect a large population of planets. Statistics, not single objects!

GPI Science: Direct Imaging of Circumstellar Disks

Perrin, Marois, Poyneer



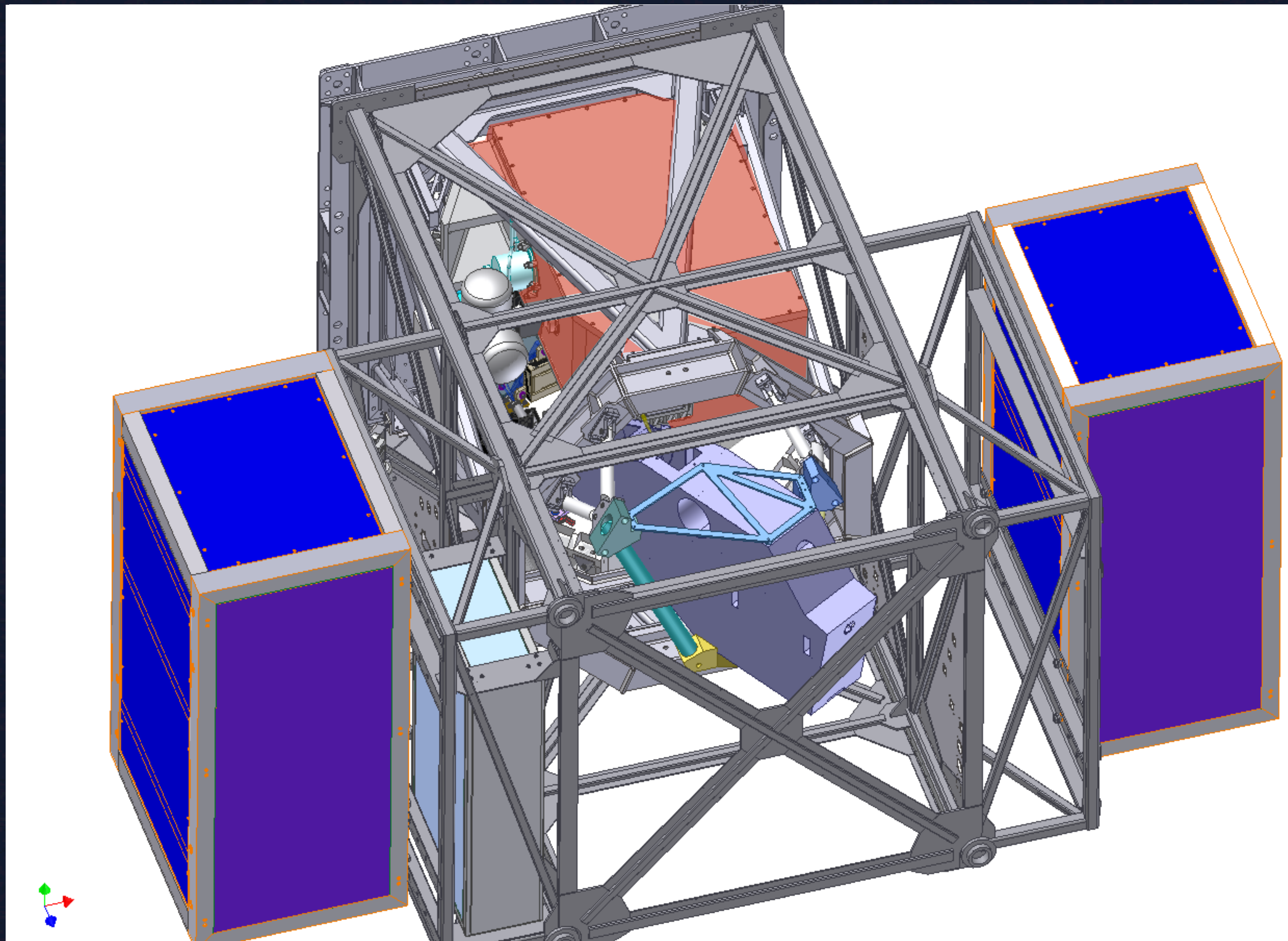


data from Hillenbrand 1998, Zuckerman & Song 2004, Kalas 2007, circumstellardisks.org

GPI will:

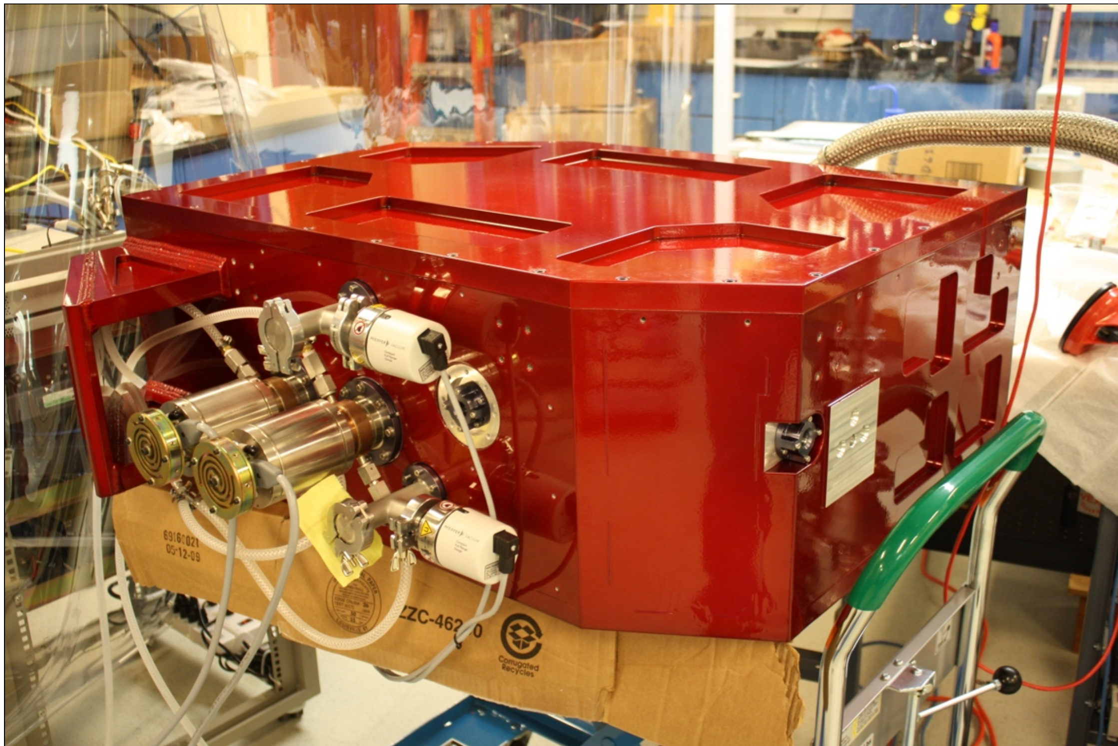
Image polarized scattered light from disks as faint as t~3x10-5 (1/50 AU Mic)

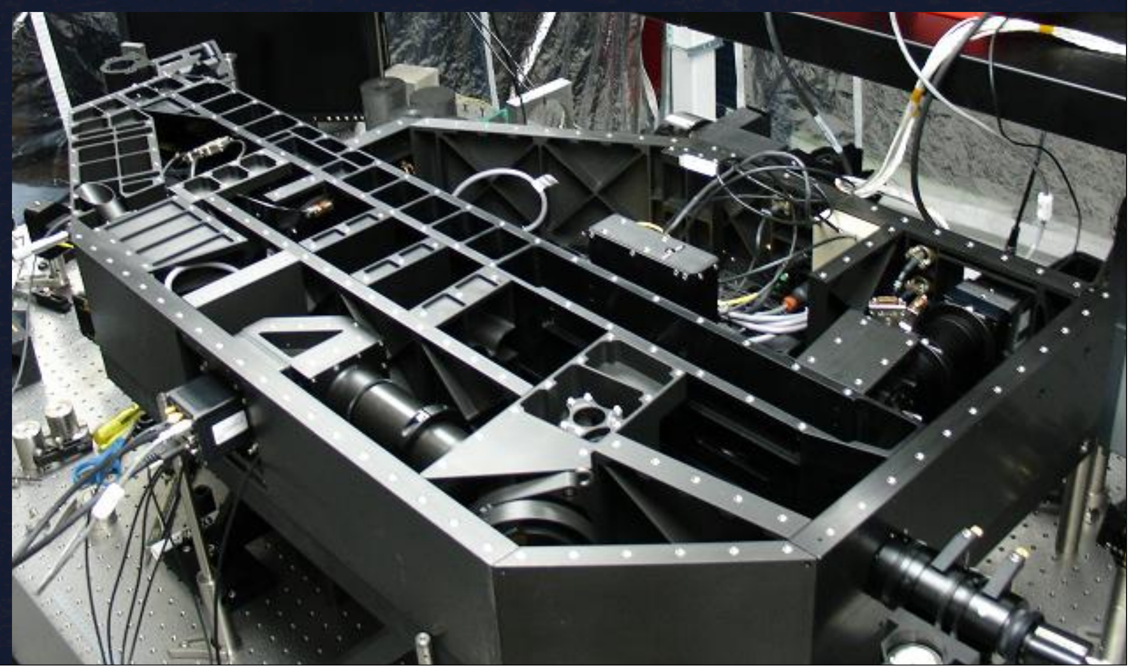
Be sensitive to the majority of known IRAS-detected debris disks



LLNL: Wavefront Control. *B. Macintosh*
UCB: Science lead. *J. Graham*
UCSC: Test & Integration. *D. Gavel*
UCLA: IFS. *J. Larkin, M. Perrin*

Montreal: IFS, data pipeline. *R. Doyon*
HIA: Optomechanics. *L. Saddlemeyer, J-P. Veran.*
JPL: Precision IR WFS. *K. Wallace*
AMNH: Coronagraph. *B. Oppenheimer, R. Soummer*



ADAPTIVE OPTICS

LLNL, UCSC, HIA

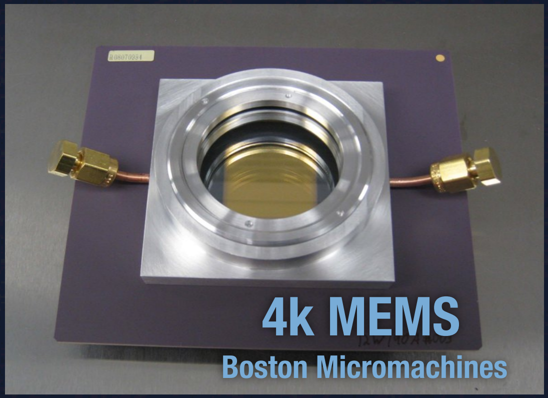
High order, High speed AO:

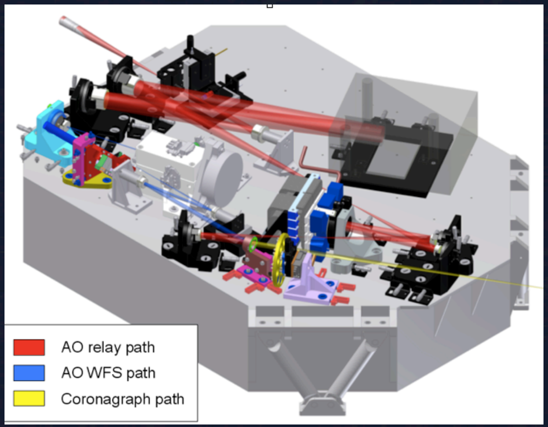
- Woofer/Tweeter design
- 1809 active actuators (44 across)
- 18 cm subapertures
- 1500 Hz control
- Strehl > 0.9 for I < 9 guide star

Spatially Filtered WFS (Poyneer & Macintosh 2003)

4k MEMS DM (Morzinski et al. 2007)

Fourier predictive control (Poyneer et al. 2007)



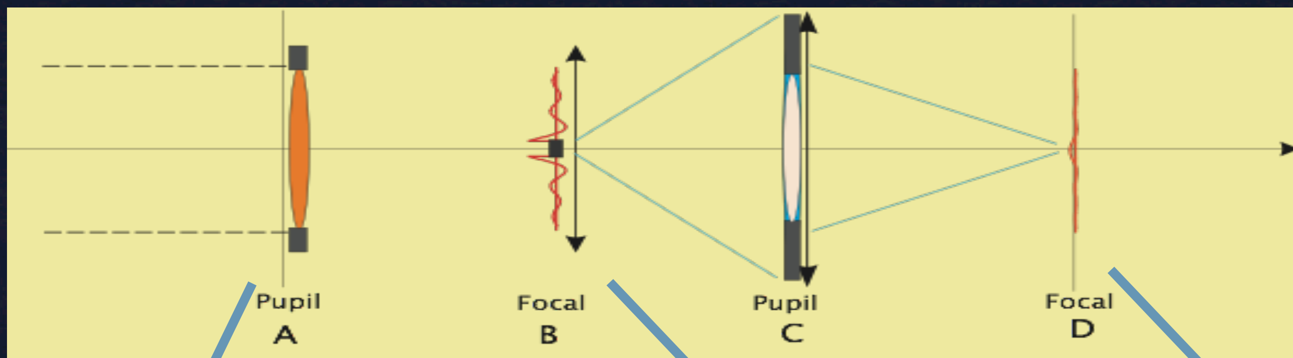


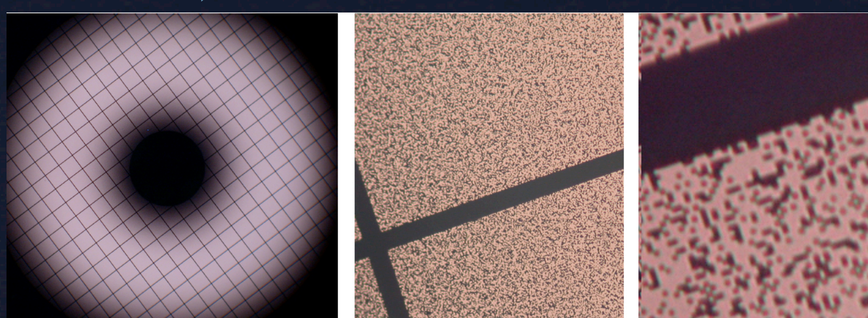
CORONAGRAPH

AMNH, STSCI

Apodized Prolate Lyot Coronagraph

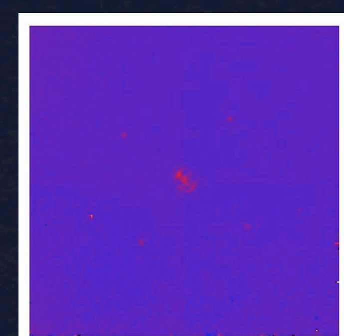
Soummer et al. 2003,2005,2006





Microdot apodizers

Microdot apodizers



AMNH Coronagraph Testbed Data

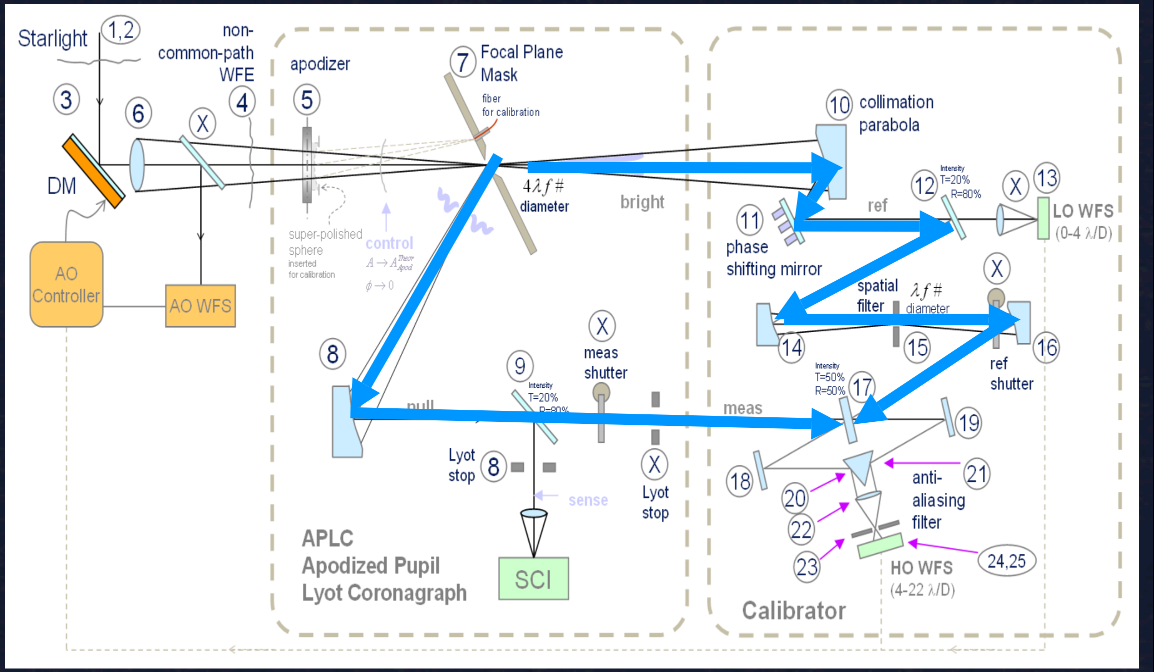
CALIBRATION UNIT

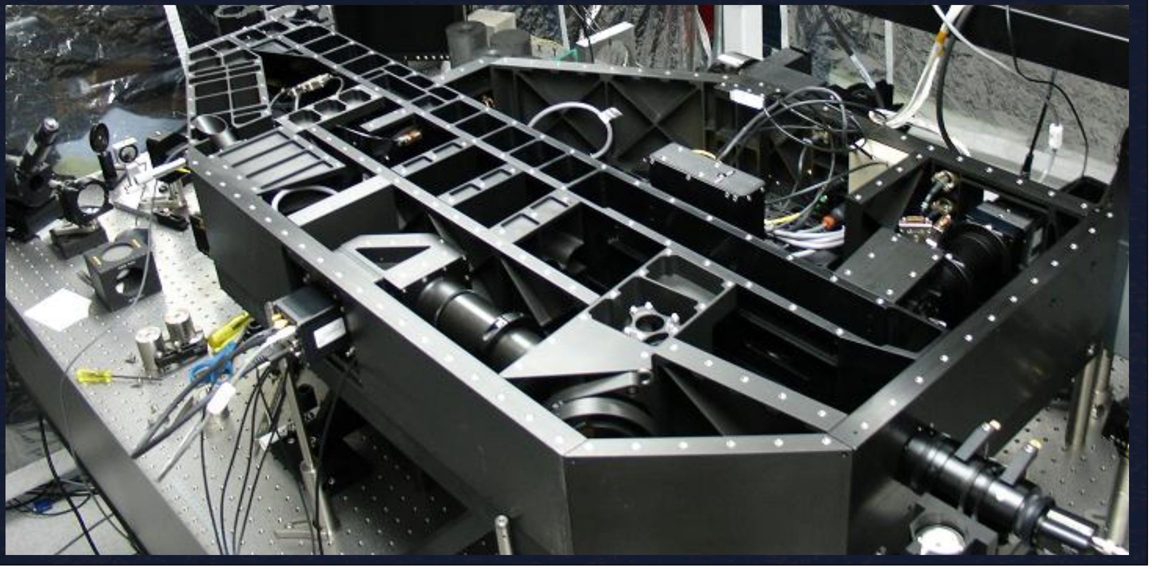
JPL

Post-coronagraph, phase errors are mixed into amplitude errors

Interferometric WFS

- Senses at coronagraph focal plane
- 1.7 µm
- <5 nm precision
- 1 nm goal





INTEGRAL FIELD SPECTROGRAPH

UCLA, U. MONTREAL

Lenslet-based IFU

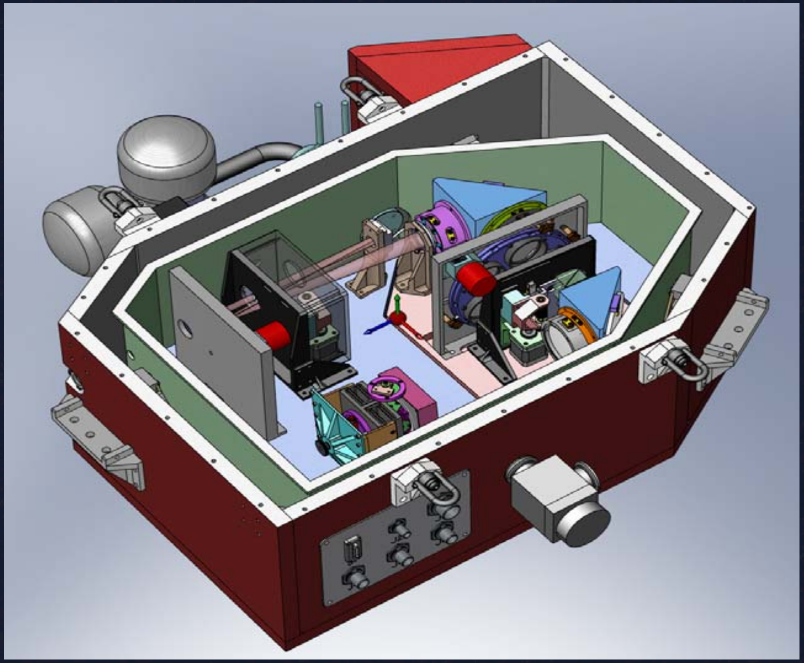
- Y, J, H, K1, K2 filters
- 0.014 arcsec/pixel
- 2.8 x 2.8 arcsec FOV (200x200 pix)

Spectral Mode

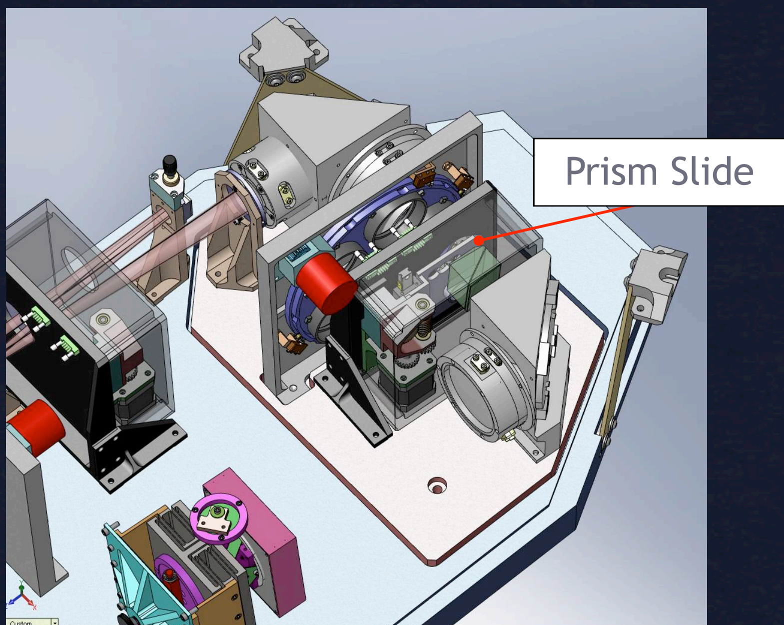
- R ~ 34 at 1 μm to 80 at 2.3 μm

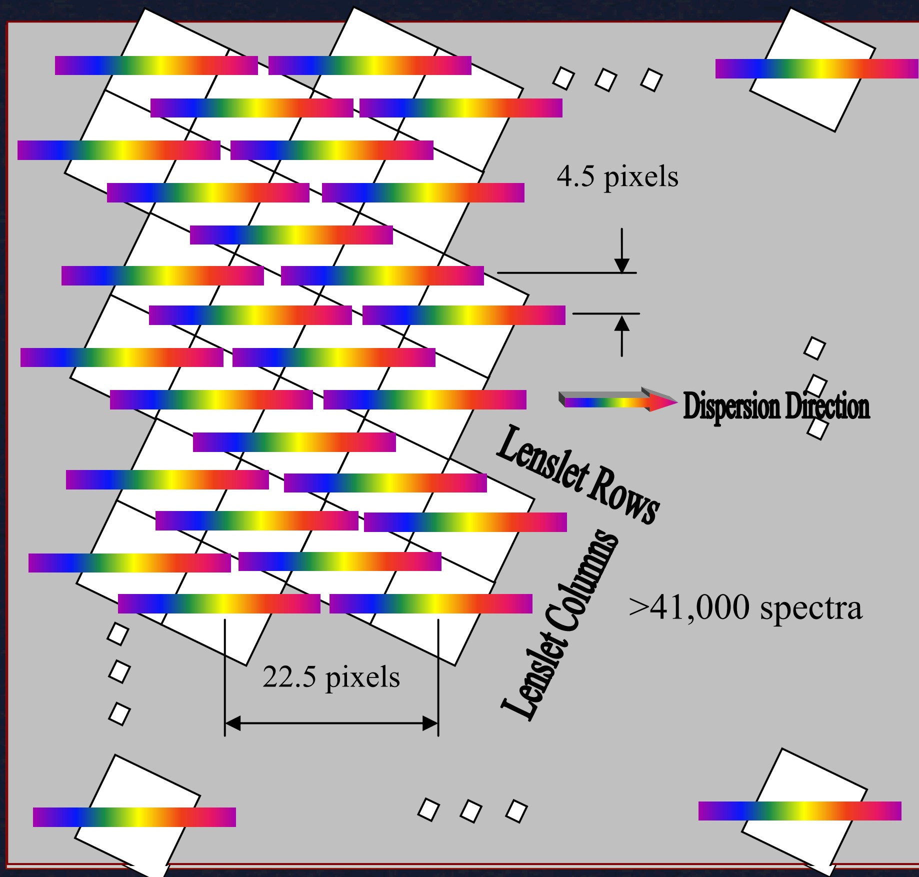
Polarimetric Mode

- Simultaneous dual linear pol.



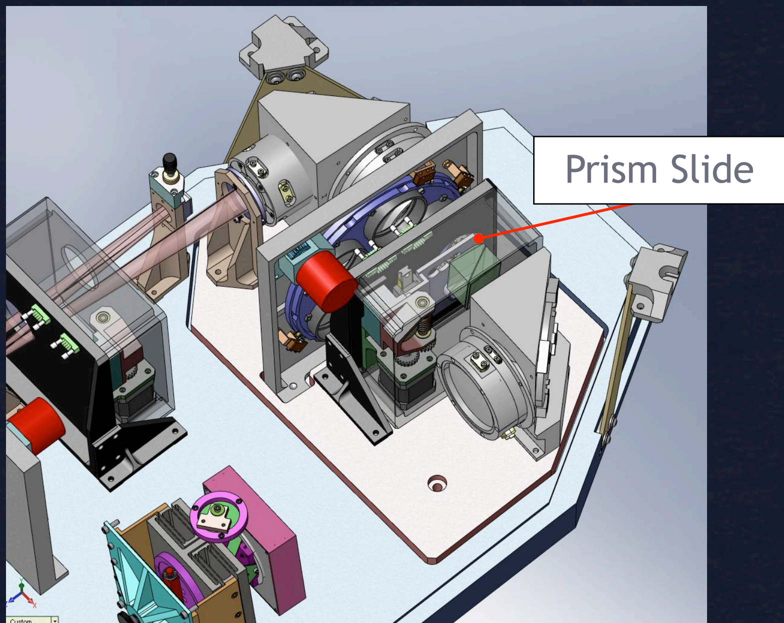
Integral Field Spectroscopy with GPI

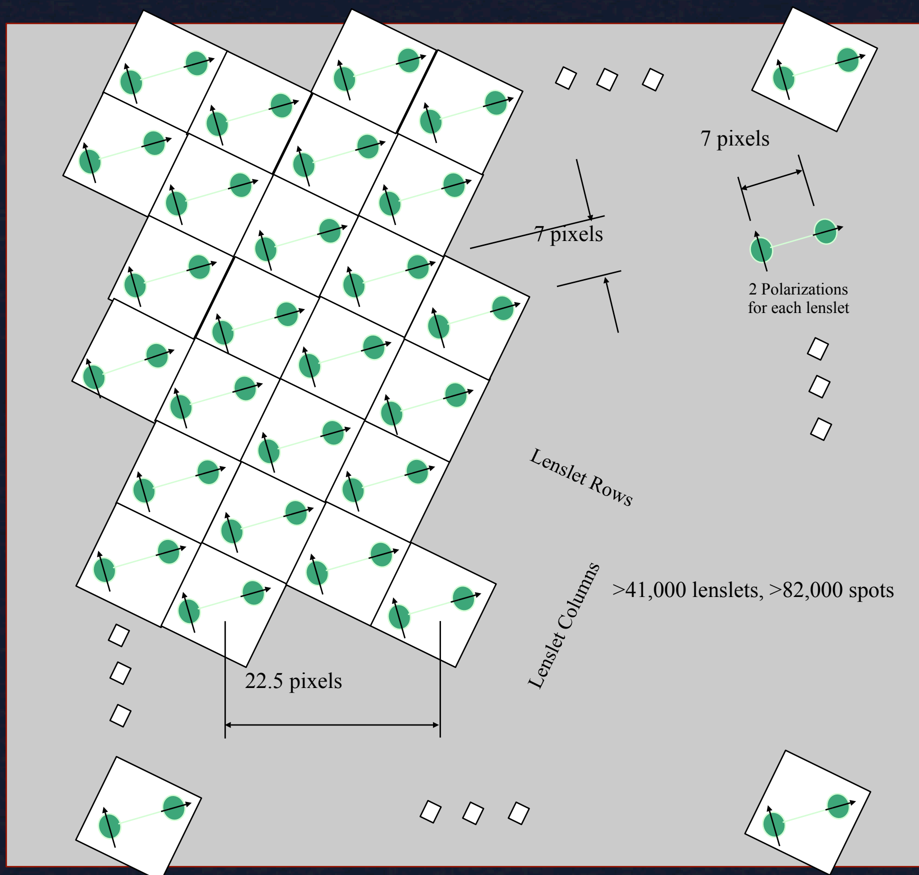




Lenslet-based IFS

“Integral Field Polarimetry” with GPI

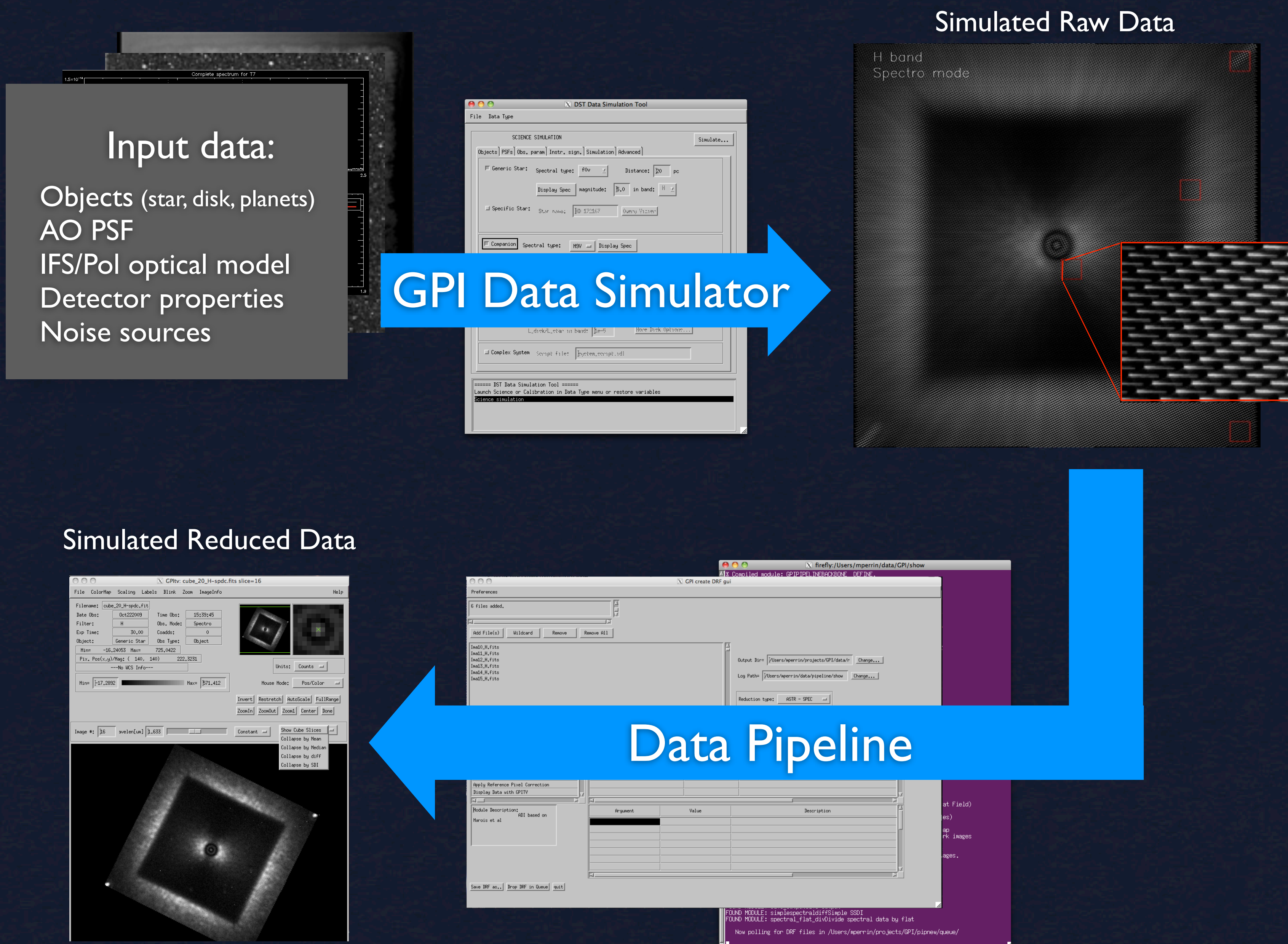




Lenslet-based Differential Polarimetry
Perrin et al. 2008

DATA REDUCTION PIPELINE

U. MONTREAL, UCLA



WHAT *HASN'T* GONE QUITE RIGHT

Vendor Delays

- Many optics
- OMSS fabrication
- Cryocooler
- Science grade DM!

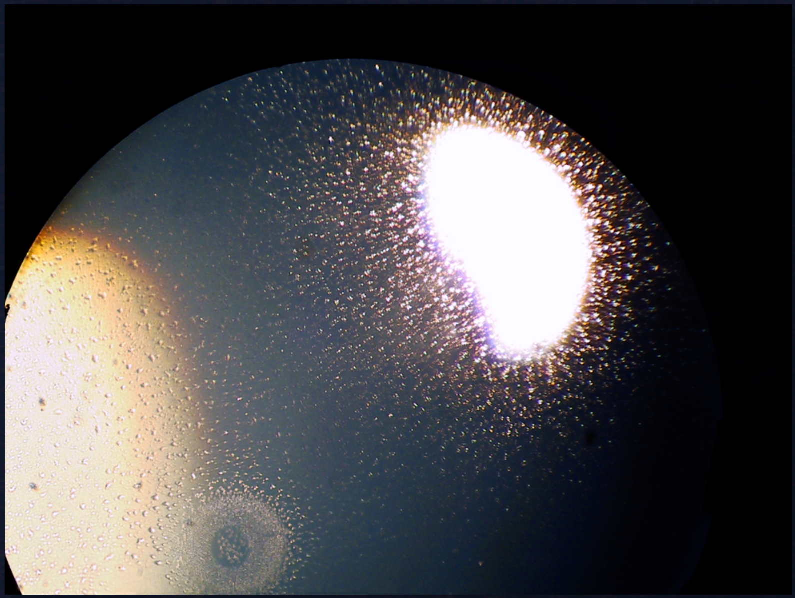
Optics coating failures

- now redone successfully

Mask fabrication problems

- now using new processes

Schedule slip (~3 mo. in 5 yrs)



LESSONS LEARNED

Contrast depends primarily on controlling static non-common-path residual WFE at mid spatial frequencies. It's not about the atmosphere!

- Initial concept: 10k actuators at 2 kHz; final design: 1800 act at 1.5 kHz
- Buy good optics!

Reaching high contrast requires pursuing many paths at once.

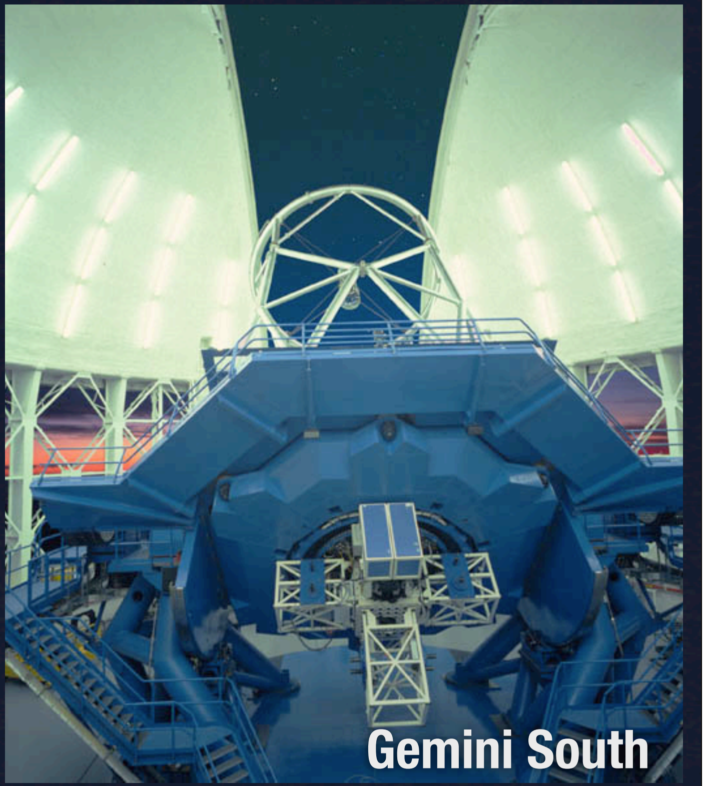
- Better wavefront control, algorithms, calibration, coronagraph, differential imaging science camera, observing techniques, & more.

Integrated systems modeling is key.

- Fresnel propagation, dust, scattered light, flexure, chromaticity, vibration...
- Detailed error budgets are a must!

GPI SCHEDULE

2001-2004:	Design studies & modeling
August 2005:	Gemini selects GPI
June 2006:	Official kickoff
May 2007:	PDR - passed!
May 2008:	CDR - passed!
February 2010:	Integration starts at UCSC
~Dec 2010:	Ship to Gemini South
~March 2011:	First light!



gpi Gemini Planet Imager

Starting in early 2011,
the Gemini Planet Imager will study
young Jovian planets and circumstellar disks
around many nearby stars.

Atmospheres, orbits, masses, dynamics & more.

1hr simulation, SDI processed
4 MJ/580K + 1 MJ/330K planet

Thanks to: Gemini Observatory, AURA,
National Science Foundation, CfAO

[redacted]