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

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
GPI will:
Achieve $10^{-8} - 10^{-7}$ contrast from 0.15''-2'' for stars brighter than $I = 9$

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

Measure $T_{\text{eff}}$ & $g$ via spectra
Models indicate $R \sim 40$ 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

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

GPI will:
Image polarized scattered light from disks as faint as $t \sim 3 \times 10^{-5}$ (1/50 AU Mic)
Be sensitive to the majority of known IRAS-detected debris disks
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

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

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)
Apodized Prolate Lyot Coronagraph

Soummer et al. 2003, 2005, 2006

Microdot apodizers

AMNH Coronagraph Testbed Data
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

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

- 22.5 pixels
- >41,000 lenslets, >82,000 spots
- Prism Slide
- Lenslet Rows
- Lenslet Columns
- 2 Polarizations for each lenslet
- Lenslet-based IFS
- Gemini GPI ICD 1.9.x/1.9.x.1/1.9.x.5
“Integral Field Polarimetry” with GPI

Prism Slide

>41,000 lenslets, >82,000 spots

7 pixels

2 Polarizations for each lenslet

22.5 pixels

>41,000 lenslets, >82,000 spots

Lenslet-based Differential Polarimetry
Perrin et al. 2008
DATA REDUCTION PIPELINE

Input data:
Objects (star, disk, planets)
AO PSF
IFS/Pol optical model
Detector properties
Noise sources

GPI Data Simulator

Data Pipeline

Simulated Raw Data

Simulated Reduced Data

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!
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.

Thanks to: Gemini Observatory, AURA, National Science Foundation, CfA0 & many others, too!