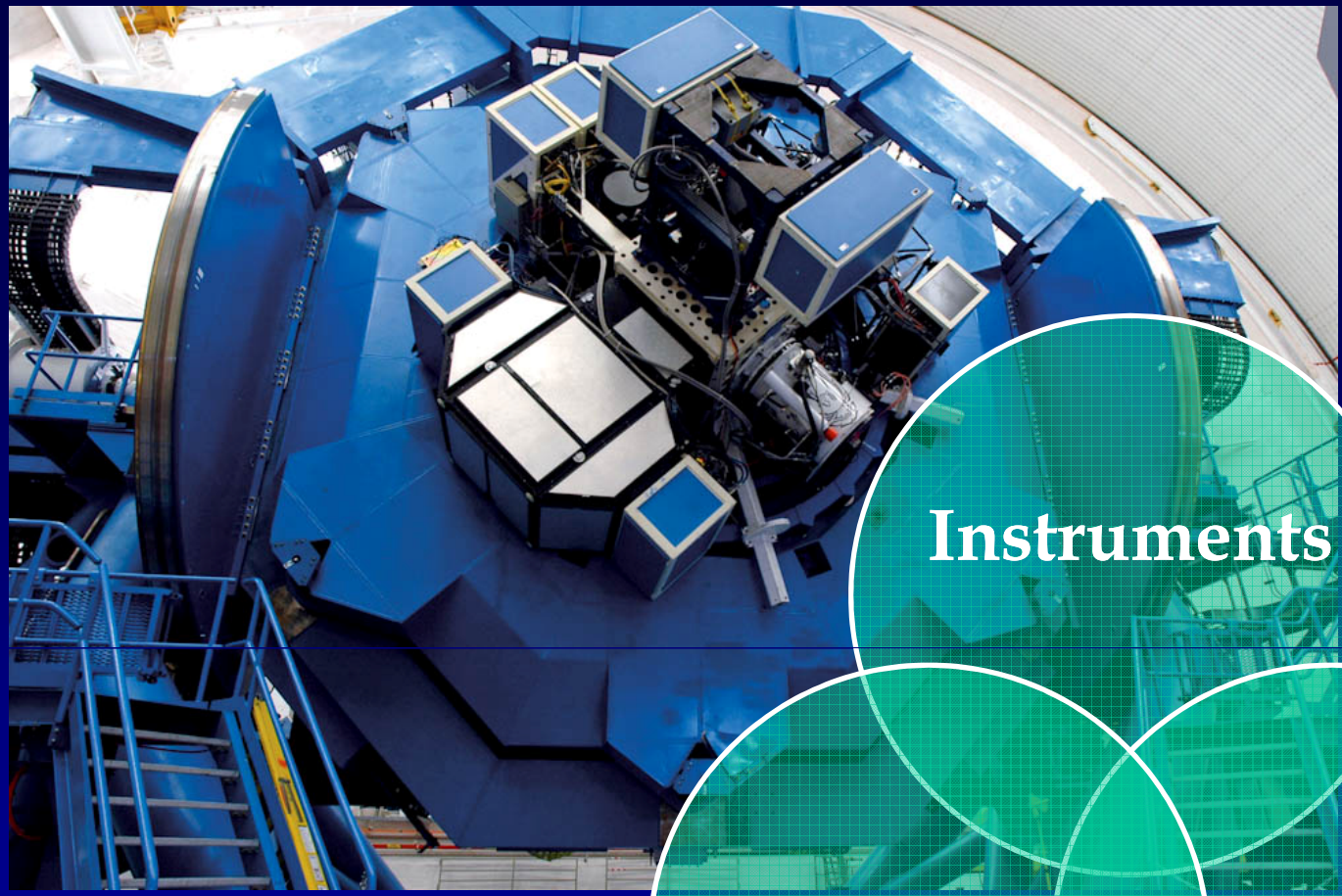
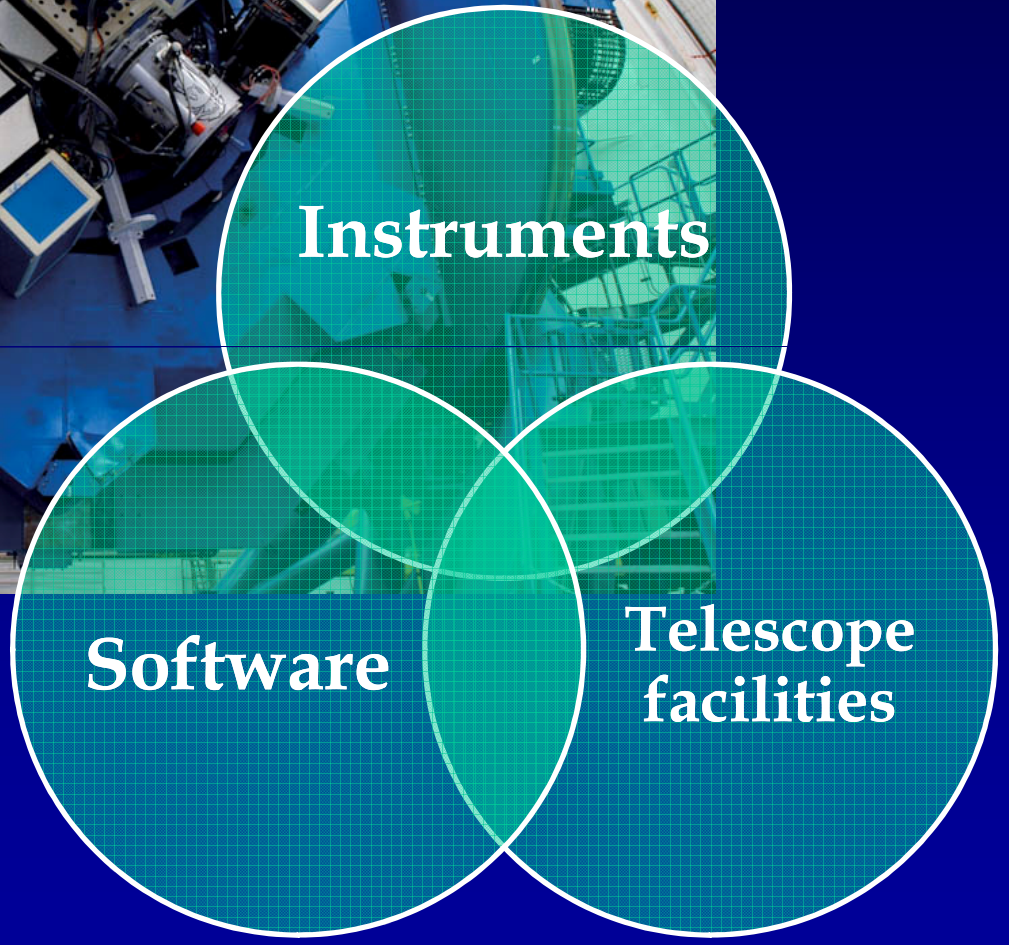
Gemini's Instrumentation

Joe Jensen

18 May 2009, Kyoto





Gemini's strengths:

- **Observing flexibility**
- **IR sensitivity**
- **Image quality**

Mauna Kea

- GMOS
- ALTAIR+LGS*
- NIRI*
- NIFS*
- MICHELLE
- GNIRS*

Cerro Pachón

- GMOS
- T-ReCS
- NICI*
- Phoenix
- FLAMINGOS-2*
- GeMS* (MCAO/Canopus)
- GSAOI*
- GPI*

*AO instrumentation

GMOS: Gemini Multi-Object Spectrograph (GN&GS)

NGC 3311 and 3309 in Eridanus

Optical Imaging

- 5.5'x5.5' FOV; 0.073” pixels
- Broad (ugriz) and NB filters

Spectroscopy

- R ~ 600 – 4400
- Long-slit: 0.25 – 5.0” wide slits; 108” and 330” long.
- Multi-slit: ~60 0.5”+ slits are possible.
- IFU: 5”x7” 1000 element science + 500 elements for sky.

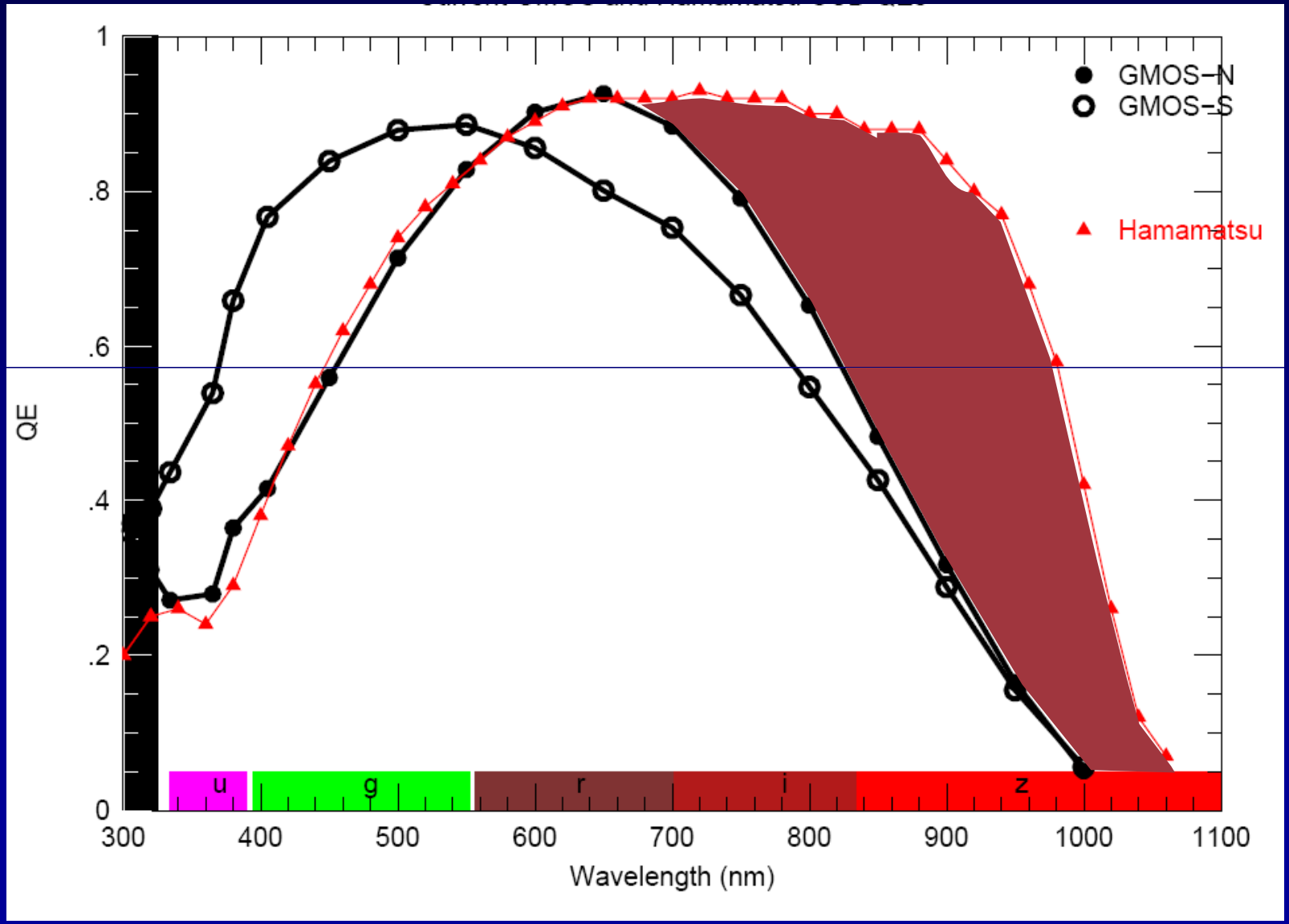
Detectors

- 3 E2V 2048x4608 pixels
- Planning now for GMOS-North upgrade to Hamamatsu CCDs in about 6 months.

Nod and Shuffle

- Improved sky subtraction
- Allows more (~200+) and shorter slits

Hamamatsu CCDs



NIRI: Near-IR Imager (GN)

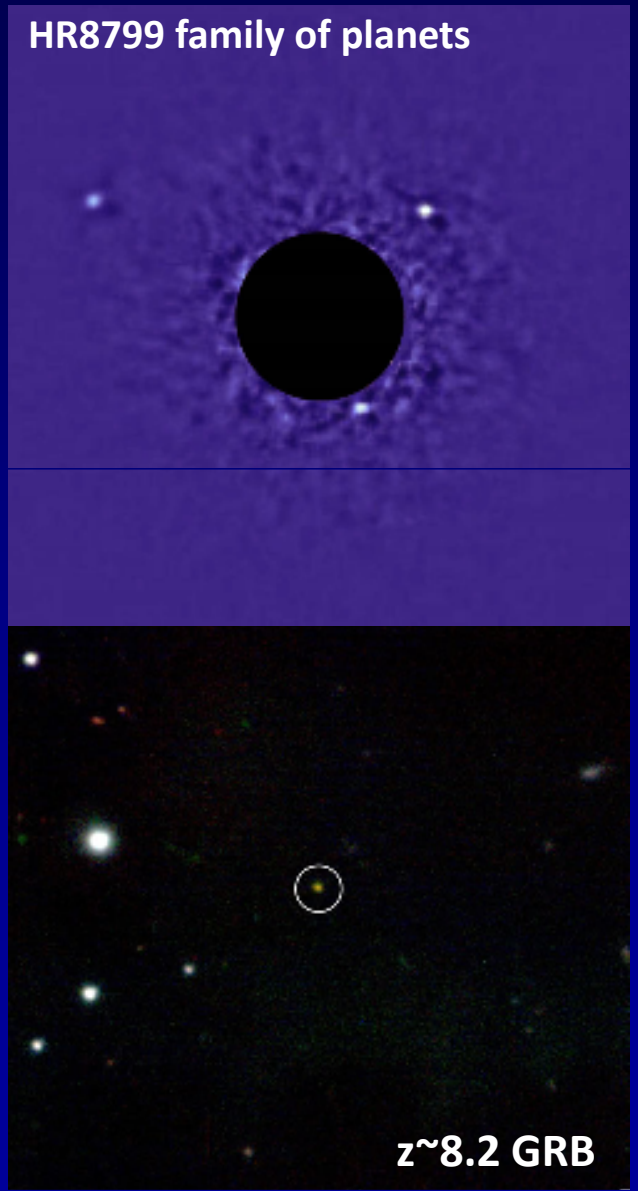
Imaging

- f/6 0.12”/pix 120” FOV (natural seeing)
- f/14 0.05”/pix 51” FOV (L band, AO)
- f/32 0.02”/pix 22” FOV (M band, AO)
- 1 to 5 µm Y,J,H,K,L,M +NB filters
- Seeing-limited and Altair NGS/LGS AO

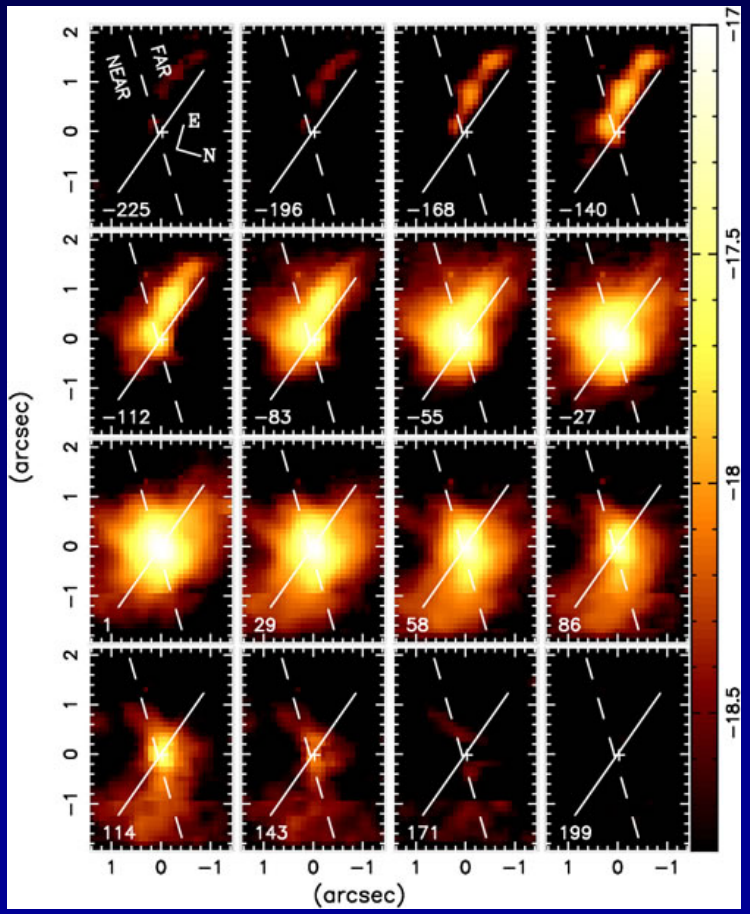
Spectroscopy

- R ~ 450-1650 single long slit
- f/6: 0.2-0.8” x 50-110” slits
- f/32: 0.1-0.2 x 22” slits
- ALADDIN-2 detector
- 1024x1024 pixels
- 0.9 to 5.5 µm

Spectroscopy to be phased out when GNIRS is re-commissioned on Gemini-North



NIFS: Near-IR Integral Field Spectrometer (GN)



NIFS detection of gas inflow in NGC 4051 with 42km/s velocity slices along the H_2 profile.

Integral Field Spectroscopy

- Image slicer w/ 29 slices
- 3”x3” field
- ~70 detector pixels along each slice
- Spaxels ~0.1”x0.04”
- R ~ 5000
- z ,J ,H, K bands

HAWAII-2RG detector

- 2048x2048 pixels
- 0.9 – 2.5µm
- Coronagraphic mode also available

Optimized for AO use with Altair

MICHELLE: Mid-IR Eschelle Spectrometer (GN)

Detector

- 7 – 26 µm
- 320x240 Si:As IBC array
- Chopping and nodding (15” chop throw)

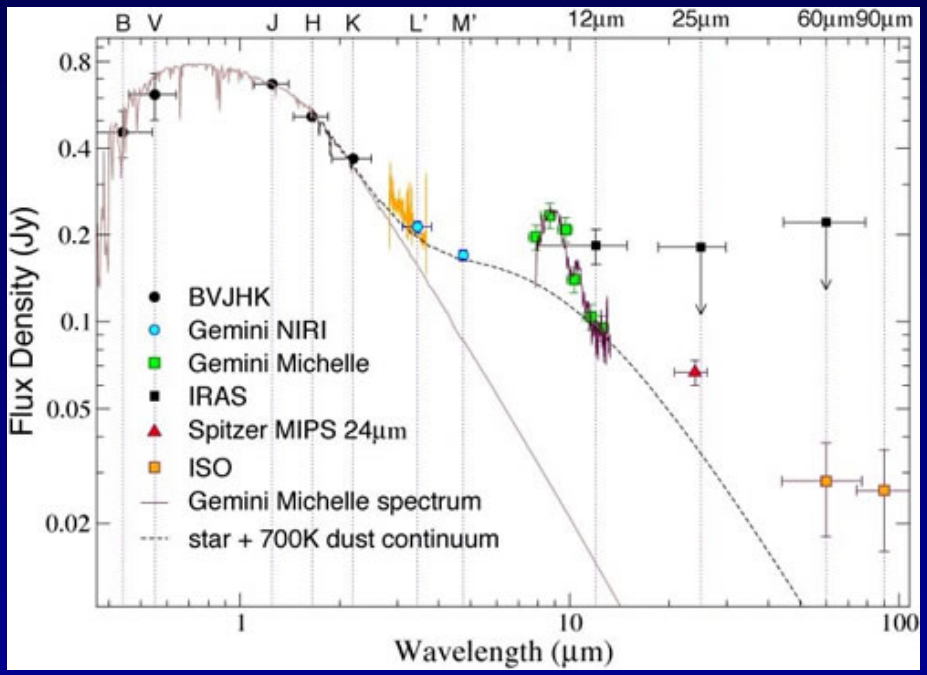
Imaging

- FOV 32”x24”; 0.1” pixels
- FWHM ~0.3” at 10 µm

Spectroscopy

- R ~100 – 3000 long slit
- R ~10,000 – 30,000 eschelle
- Slits 0.36”-1.3” wide x 43.2”

Imaging polarimetry available



Michelle (plus other spectra) of HD 23514, in the Pleiades, providing evidence for colliding proto-planets.

GNIRS: Gemini Near-IR Spectrograph (coming to GN)

- 2 scales: 0.l5” and 0.05”/pixel
- Aladdin-3 detector
- 1024x1024 pixels
- 0.9-5.5 µm

Long Slit spectroscopy

- 0.9 – 2.5µm, R~5900, 18000
- 1.1 – 2.5µm, R~1700
- 2.9 – 5.5µm, R~1700, 5900, 18000
- Δλ: R1700: 0.3*λ; R5900: 0.09*λ; R18000: 0.03* λ

Cross-Dispersed spectroscopy

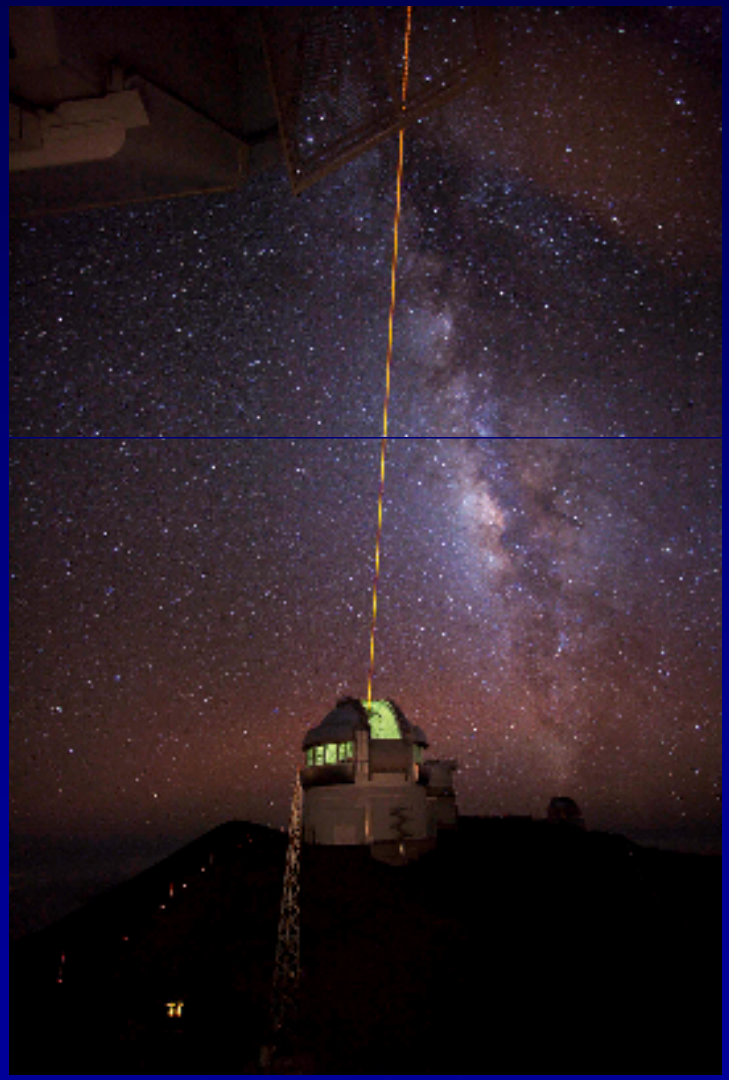
- 0.9 – 2.5µm, R=1700 full coverage
- R=5900, partial coverage

GNIRS is being refurbished in Hilo after accidentally overheating ~2 years ago

GNIRS will be commissioned at GN in 2009B

Will use Altair NGS/LGS AO

Altair Adaptive Optics (GN)



- 177 element DM, 10 W sodium laser
- LGS science operations ~1 to 2 weeks/month (resource limited)
- NGS Strehl 0.2 to 0.4 (best at H, K)
- LGS Strehl ~0.3 at 2.2 μm (FWHM = 0.083”), PSF stable for a month at a time
- LGS sky coverage ~40% (4% for NGS)
- Working to improve efficiency and reliability, and to increase sky coverage

SN 2008cs discovered with LGS AO

Mauna Kea

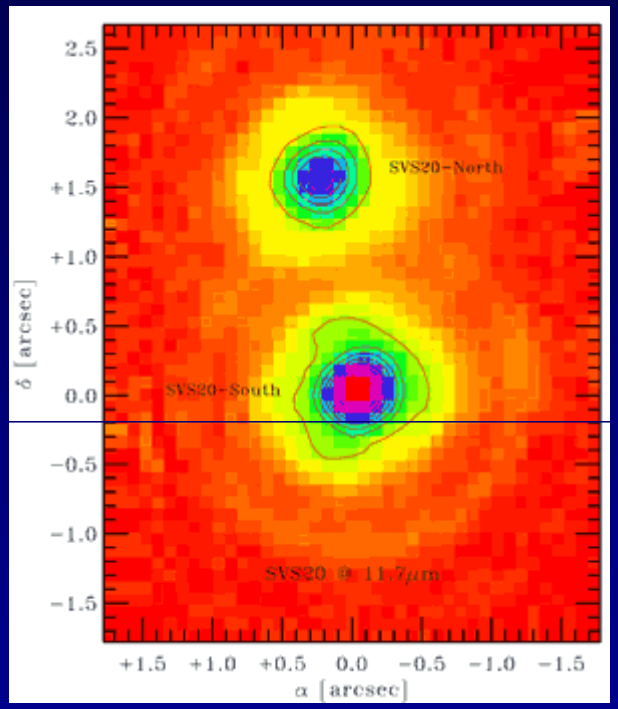
- GMOS
- ALTAIR+LGS*
- NIRI*
- NIFS*
- MICHELLE
- GNIRS*

Cerro Pachón

- GMOS
- T-ReCS
- NICI*
- Phoenix
- FLAMINGOS-2*
- GeMS* (MCAO/Canopus)
- GSAOI*
- GPI*

*AO instrumentation

T-ReCS: Thermal Region Camera+Spectrograph (GS)



Thermal emission from dust around a protostellar binary system

Detector

- 320x240 Raytheon SBRC
- 5-28μm
- Chop and Nod (15" chop throw)

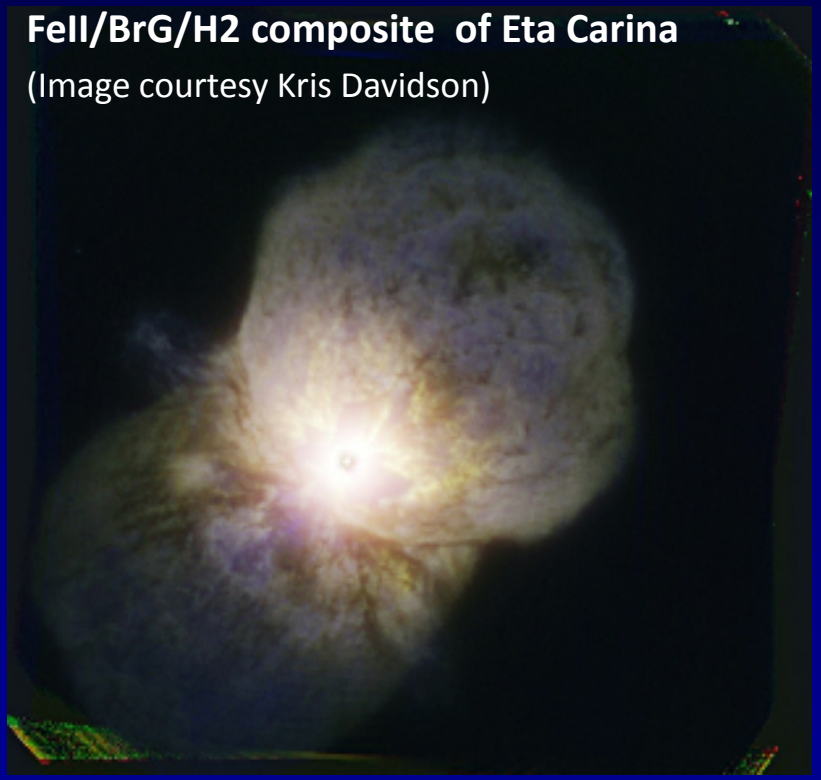
Imaging

- Filters: N, Q + NB
- FOV: 28.8"x21.6"
- 0.09"/pixel

Long-slit Spectrograph

- R~100, 1000 at 10μm
- Slits: 0.21"-1.32" x 21.6"

NICI: Near IR Coronagraphic Imager (GS)



FeII/BrG/H2 composite of Eta Carina
(Image courtesy Kris Davidson)

Planet search campaign has started (~120 targets observed already)

Open use in 2009B

85 element curvature AO system

- **Strehl ratio: up to 40% at 1.6µm**
- **Lyot coronagraph**

Dual channel imager

- **2 Aladdin-2 1024x1024 arrays**
- **FOV: 18”x18”; 18mas/pixel**
- **0.9 – 5.5µm**
- **Filters: J-M, NB, and specialized 1.6µm methane filters**
- **Spectral and angular differential imaging for planet searches**

Contrast >10^6 inside 1-2”

Phoenix Near-IR Spectrograph(GS)

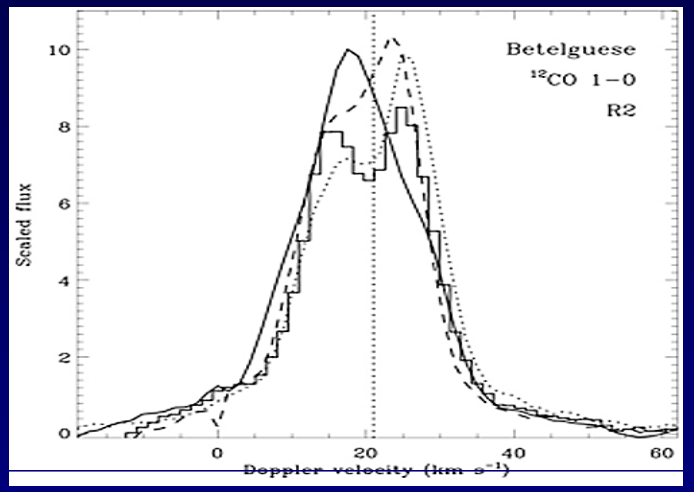
Long slit eschelle spectrograph

- 4 pix slit R~50,000
- 3 pix slit R~65,000
- 2 pix slit R~80,000
- Δλ: 0.005*λ, 1500 km/s (not cross-dispersed)
- 21 order sorting filters

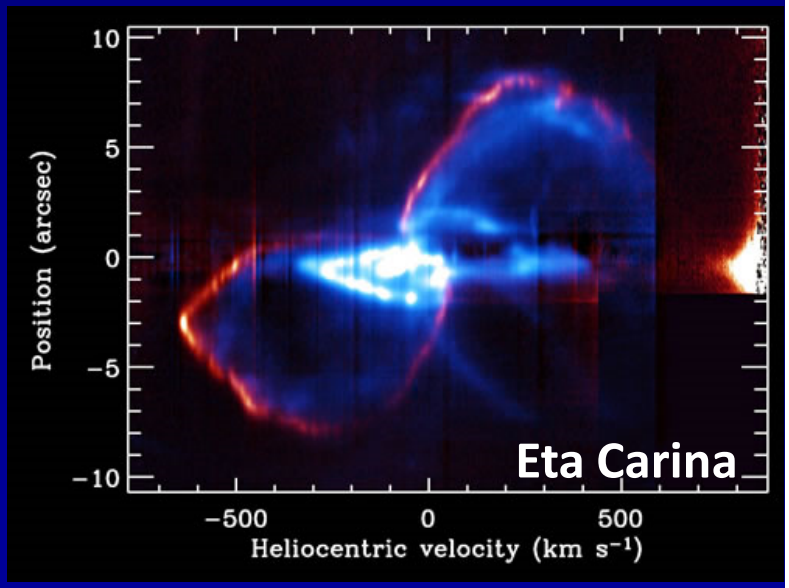
Aladdin-2 detector

- 1024x512 pixels
- 0.9-5.5 µm

Phoenix is on loan from NOAO, and will go to SOAR next year



Resolving velocity structure



FLAMINGOS-2: Near-IR Imager and MOS (GS)

Imaging

- 6.1’ FOV; 0.18”/pixel
- 2’ FOV; 0.09”/pixel (MCAO)
- Y, J, H, K filters
- ultra-narrow band, tunable filters for high-z searches

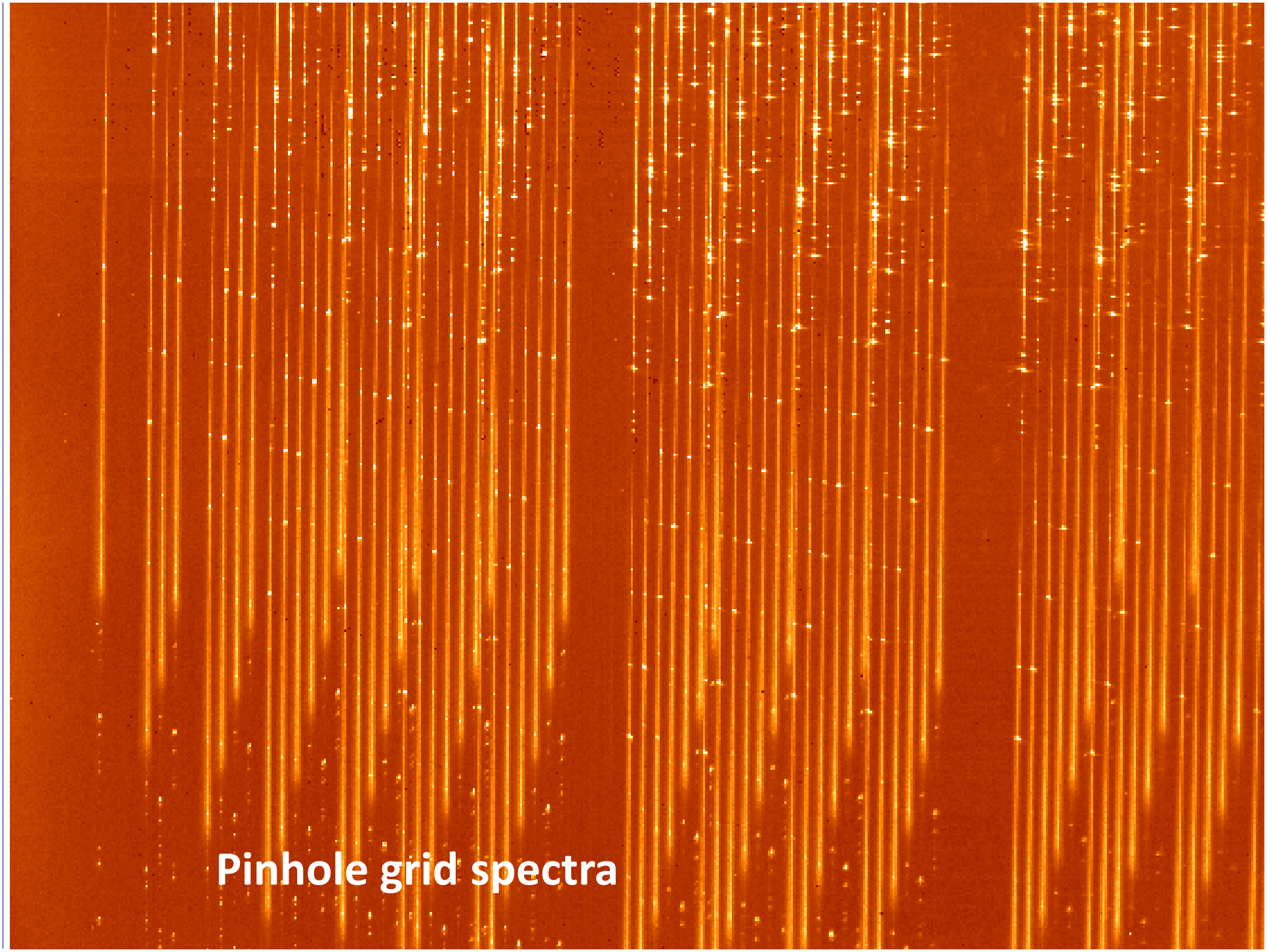
Spectroscopy

- R ~ 1200 – 3000
- FOV: 2'x6‘ (1’x2’ MCAO)
- Long-slit or custom multi-slit masks (9 cold at once, daytime swappable)
- HAWAII-2 Detector: 0.95 – 2.5µm

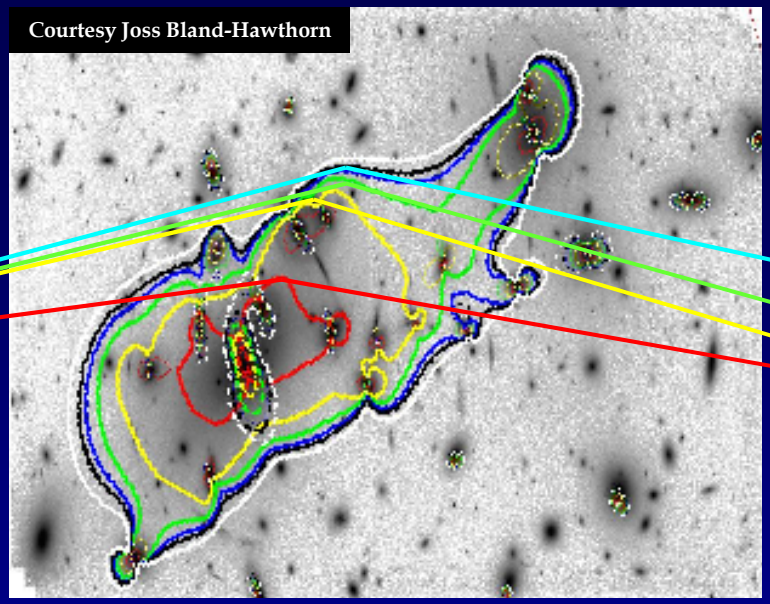
FLAMINGOS-2 pre-ship acceptance testing was completed 2 weeks ago

F-2 will be shipped to Cerro Pachon next month

Commissioning in 2009B


Pinhole grid spectra

High-z with FLAMINGOS-2



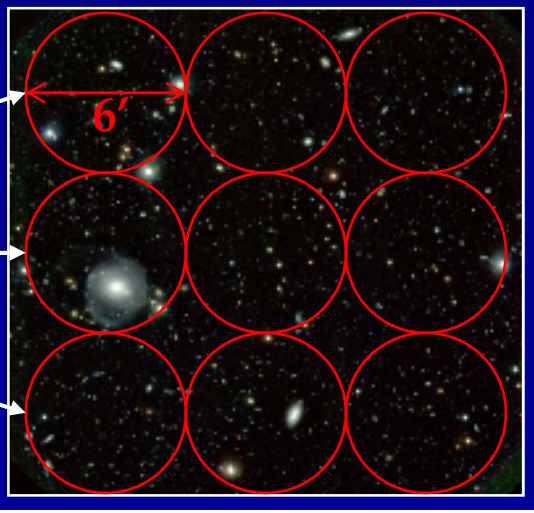
FLAMINGOS-2 + TF

Small search volume but large range in distances sampled

0.5 1 2 4

z

FLAMINGOS-2 + UNB Filter



Large search area but small range in distances sampled

GeMS + GSAOI (GS)

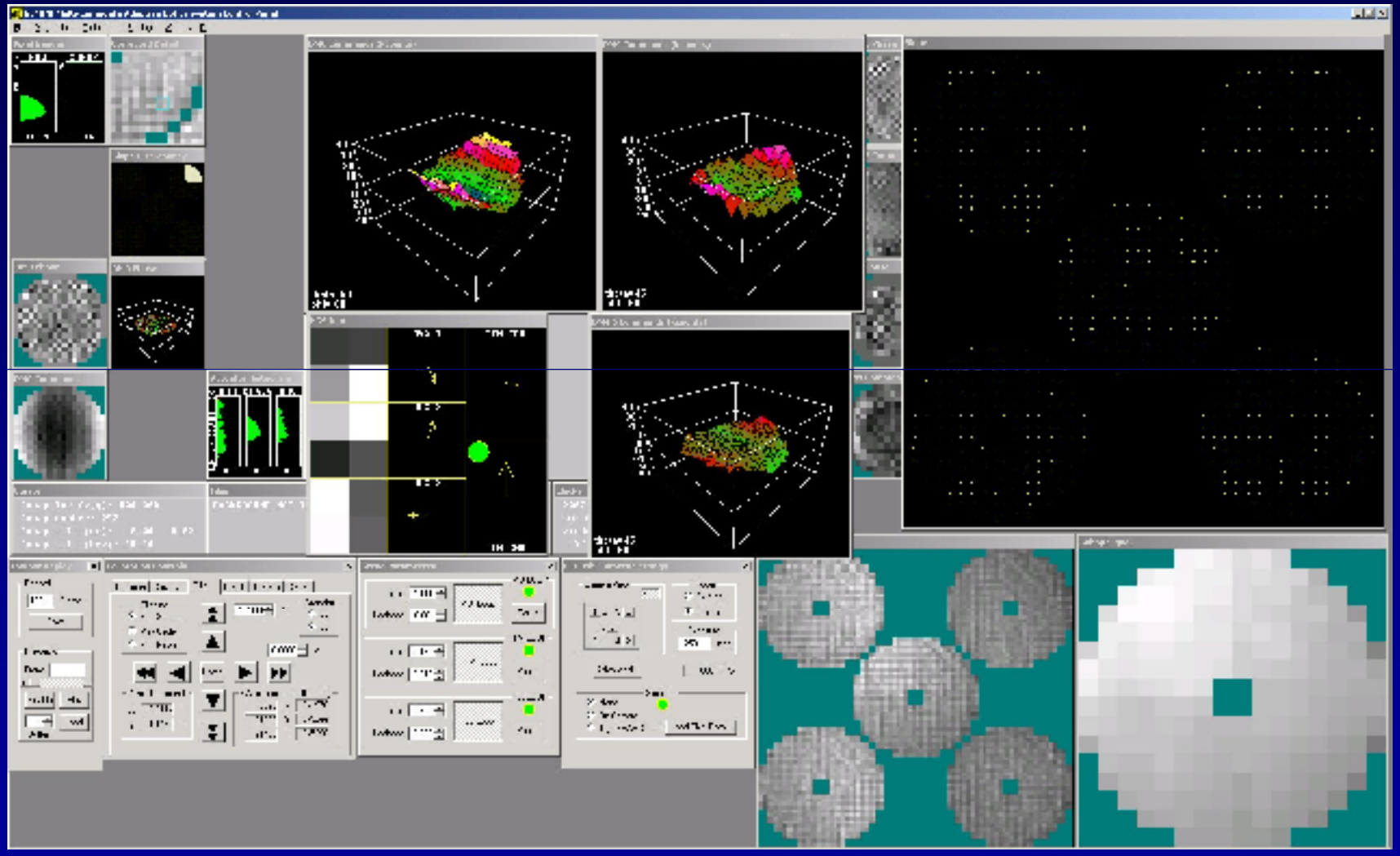
Multi-conjugate AO known as GeMS (Gemini MCAO System)

- AO bench = Canopus
- Laser enclosure and beam transfer optics installed
- Waiting on 50 W Na laser
- Uniform near diffraction limited PSF over 2' FOV

GSAOI imager:

- 1.4'x1.4' FOV; 0.02"/pixel
- 4 HAWAII-2RG detectors
- 0.9 – 2.5 µm JHK
- On-detector guide windows

Canopus Lab Tests



First tests of all the Canopus control loops in the lab

Mauna Kea

- GMOS
- ALTAIR+LGS*
- NIRI*
- NIFS*
- MICHELLE
- GNIRS*

Cerro Pachón

- GMOS
- T-ReCS
- NICI*
- Phoenix
- FLAMINGOS-2*
- GeMS* (MCAO/Canopus)
- GSAOI*
- GPI*

*AO instrumentation

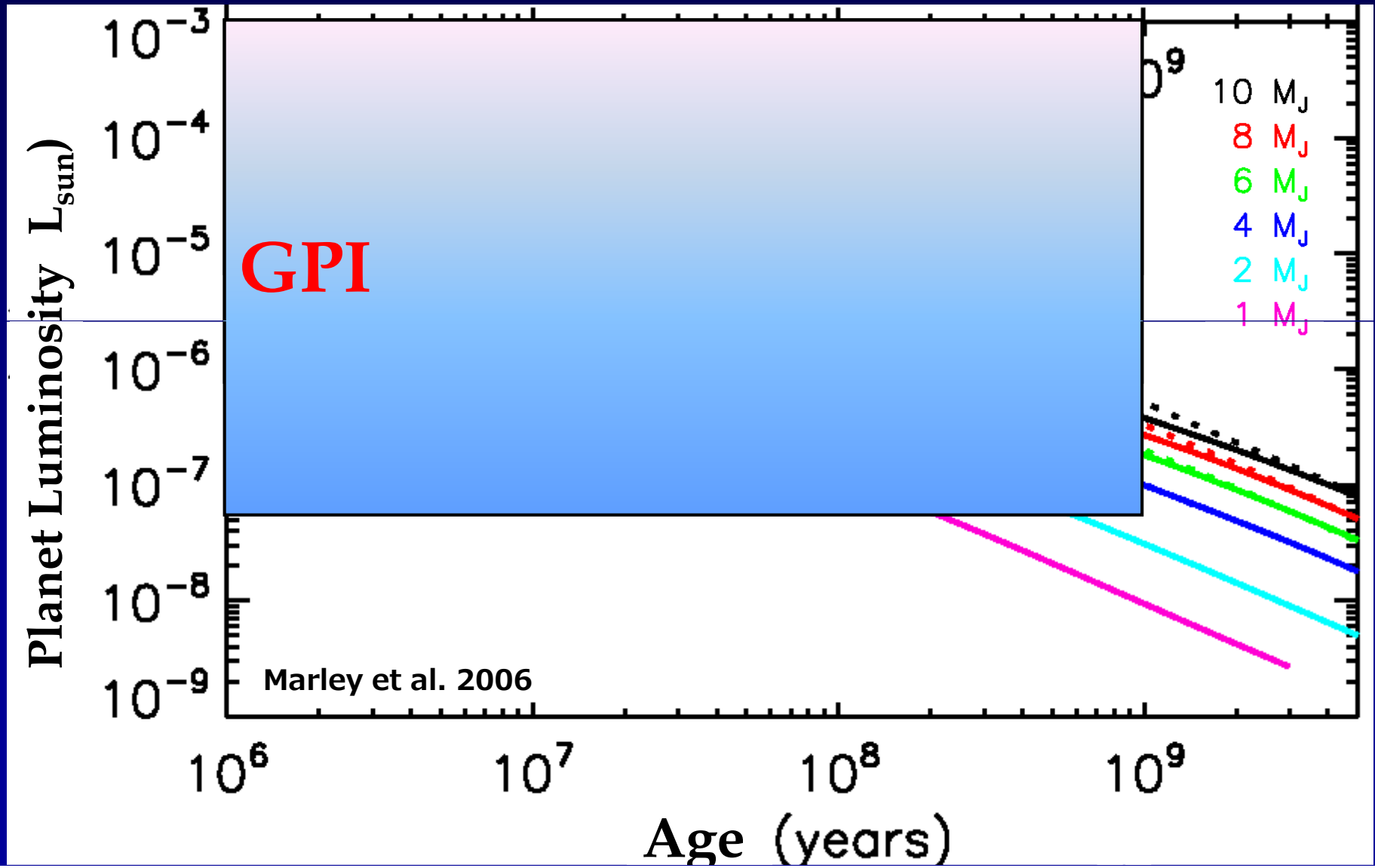
Gemini Planet Imager

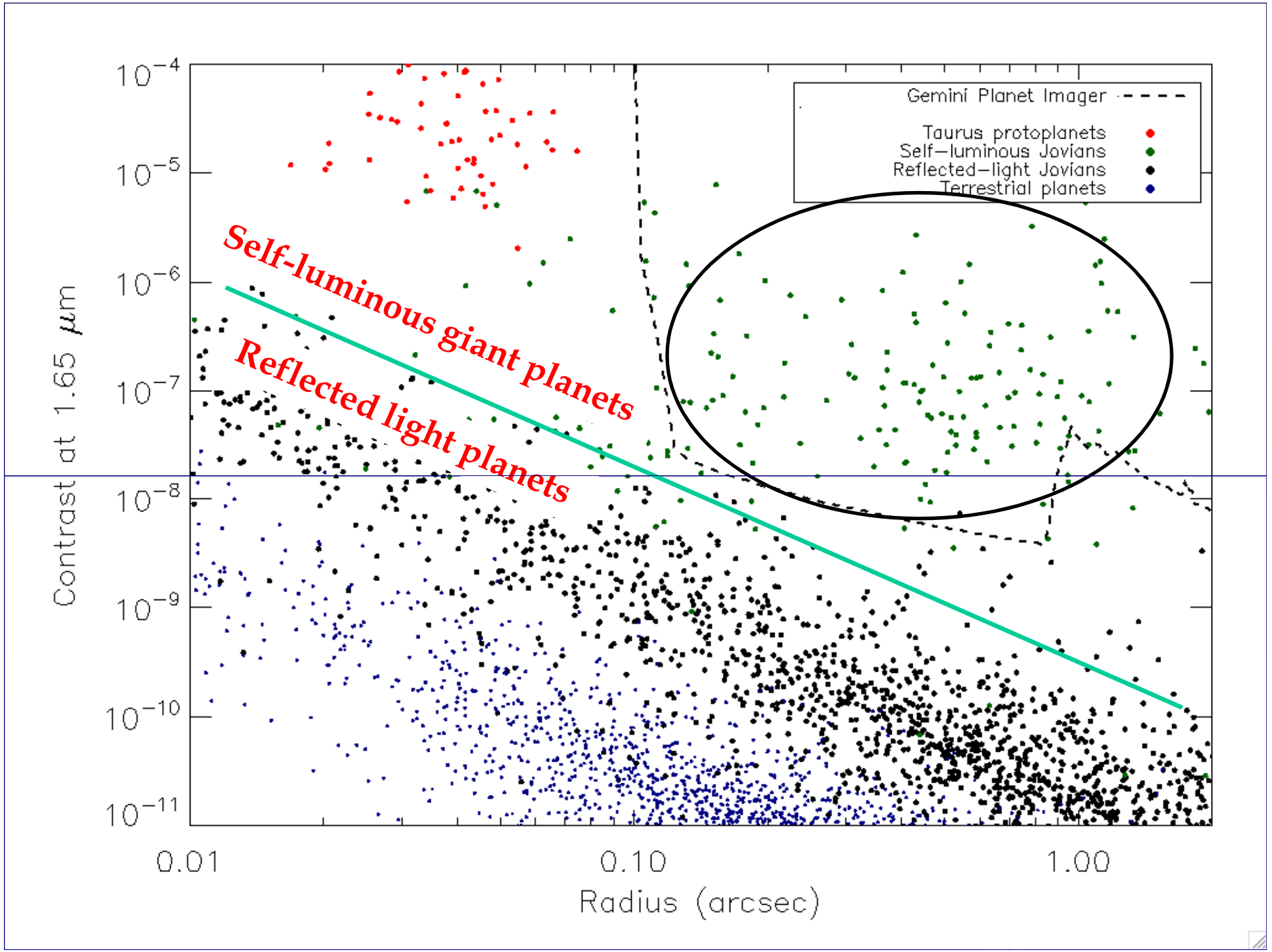
PI: Bruce Macintosh

Project Scientist: James Graham

AMNH, HIA, JPL, LLNL, UCLA, UCSC, U. Montreal

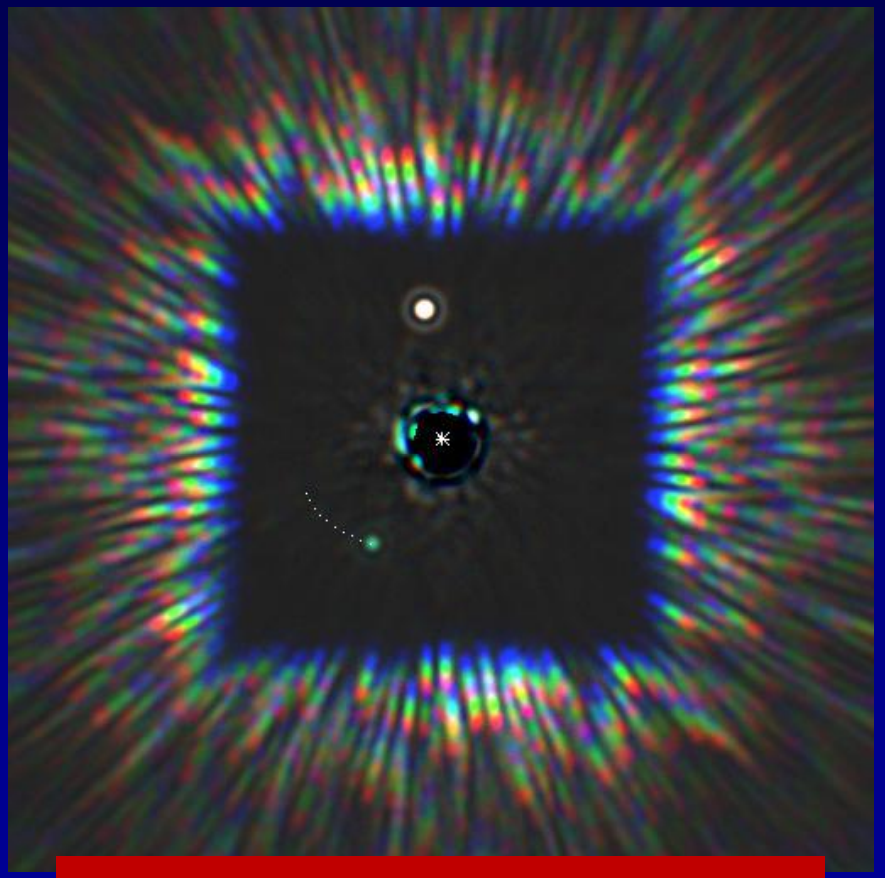
Models of Young Planet Luminosity




Gemini Planet Imager
Taurus protoplanets
Self–luminous Jovians
Reflected–light Jovians
Terrestrial planets
Self-luminous giant planets
Reflected light planets
Contrast at 1.65 μm
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
0.01
0.10
1.00
Radius (arcsec)

Gemini Planet Imager (GS)

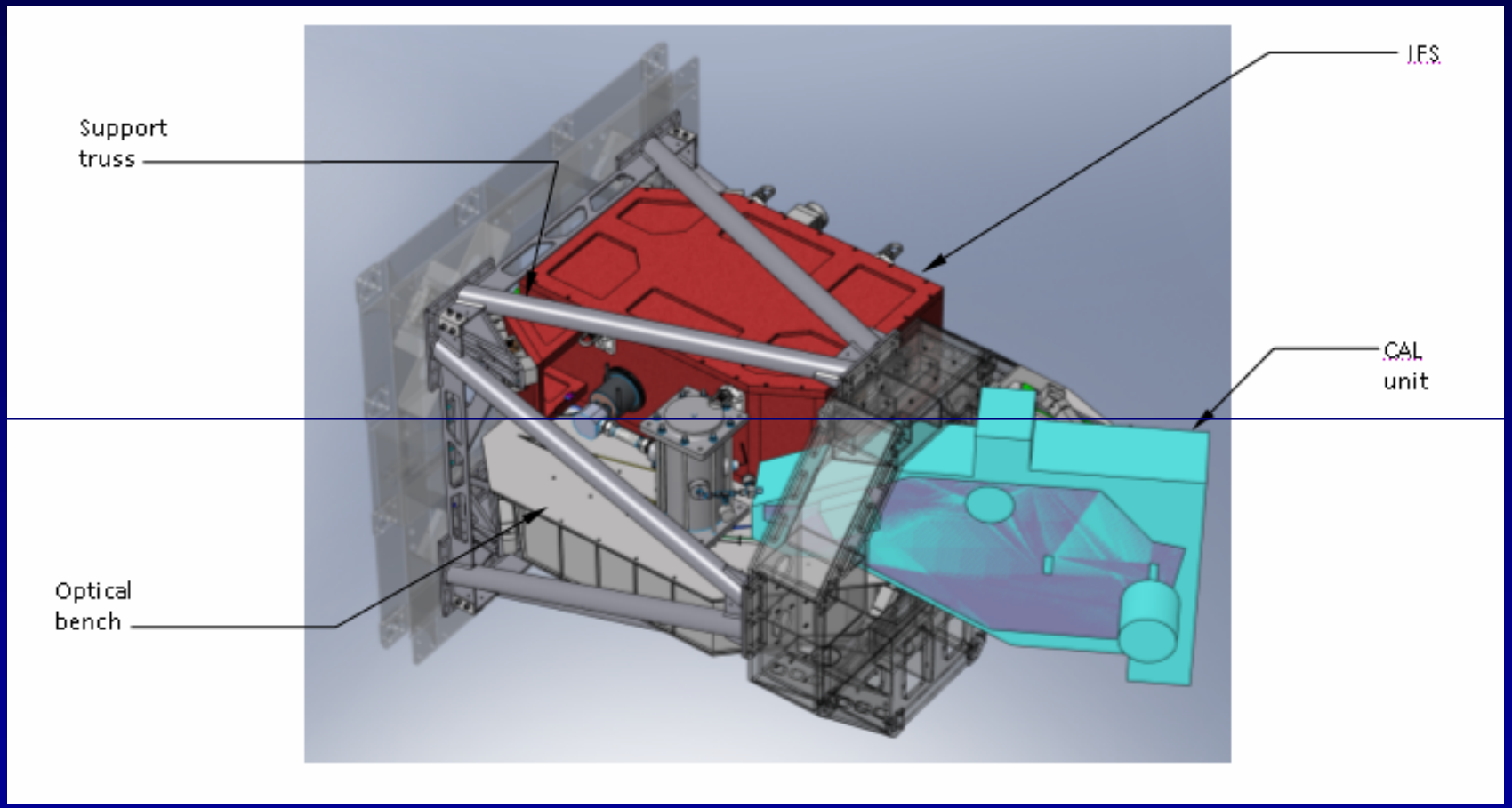
- "Extreme AO" Coronagraph designed for planet detection and characterization
- Specialized high-order AO system will produce Strehl ratios >80%
- High-order interferometric WFS to minimize NCP errors
- Sophisticated apodized Lyot coronagraph
- Low-resolution Integral field spectrograph



GPI passed CDR and is under construction now

Delivery expected in 2011

GPI Design



Final version of the GPI design, which is now more robust to vibrations.

Coming Soon…

Coming very soon:

- GNIRS
  - coming to GN this year
- NICI
  - Planet survey has started, open use starting in 2009B
- FLAMINGOS-2
  - Delivery to GS in 1 month
- MCAO+GSAOI
  - Subsystem integration and testing this year, commissioning on the telescope next year

New development:

- GPI
  - Now in construction; scheduled completion in 2011
- Next Generation
  - Planning for next round of instrument development starts soon!
  - GLAO: possible facility upgrade for Gemini-North