Projects and Missions Using Nulling and/or Calibration Wavefront Sensing

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

- PICTURE
- Gemini/GPI
- TMT/PFI
- EPIC

Mission/ Instrument	Starlight Suppression	Calibration Wavefront Sensor
PICTURE	Single Nuller	Y
GPI	APLC	Y
PFI	Double Nuller	Y
EPIC	Double Nuller	N

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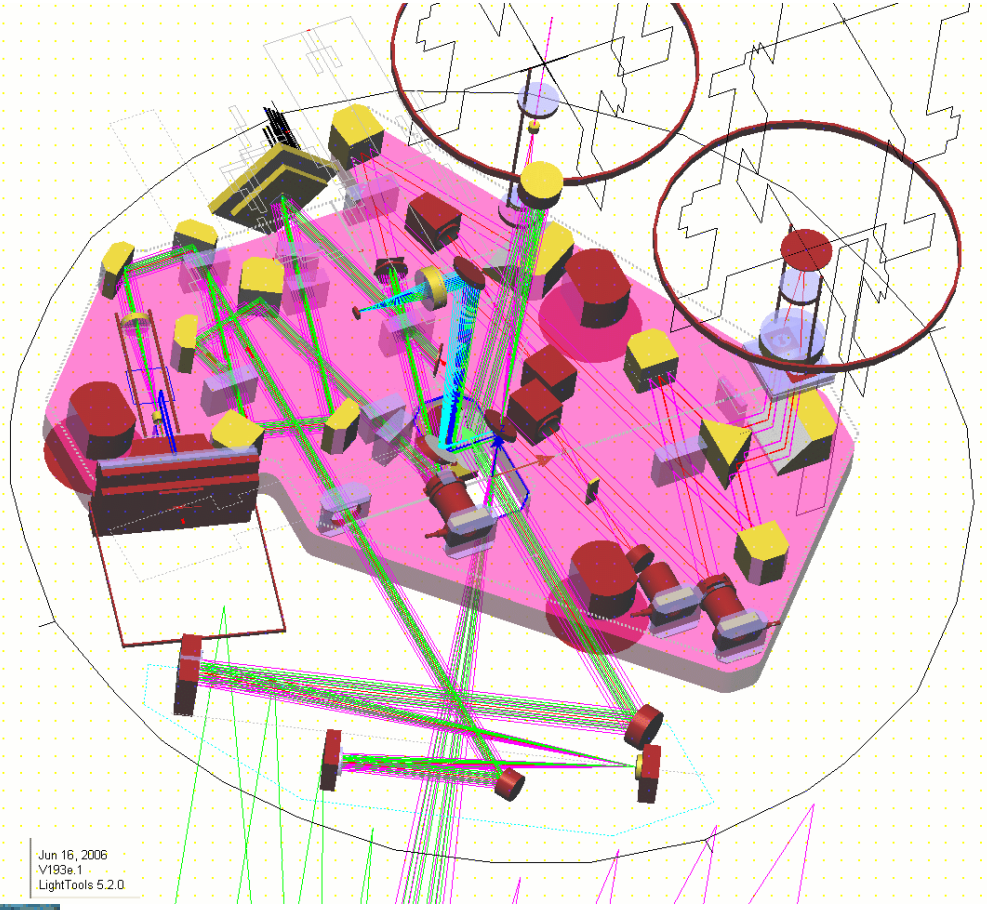
PICTURE

- Planet Imaging Concept Testbed Using a Rocket Experiment (PICTURE)
- Team:
  - BU (PI)- I&T, Operations
  - JPL-Instrument & Analysis
  - MIT-Cameras,
  - GSFC-Telescope,
  - BMC- DM
- Star List
  - Rigel-Calibration
  - ε-Eridani b- Target Star
- Mission Duration
  - 640 sec total
  - 400 sec on target
- Instrument
  - 0.5m Telescope
  - Single Nuller 1.2l/D
  - 1000 actuator DM
  - Calibration Unit



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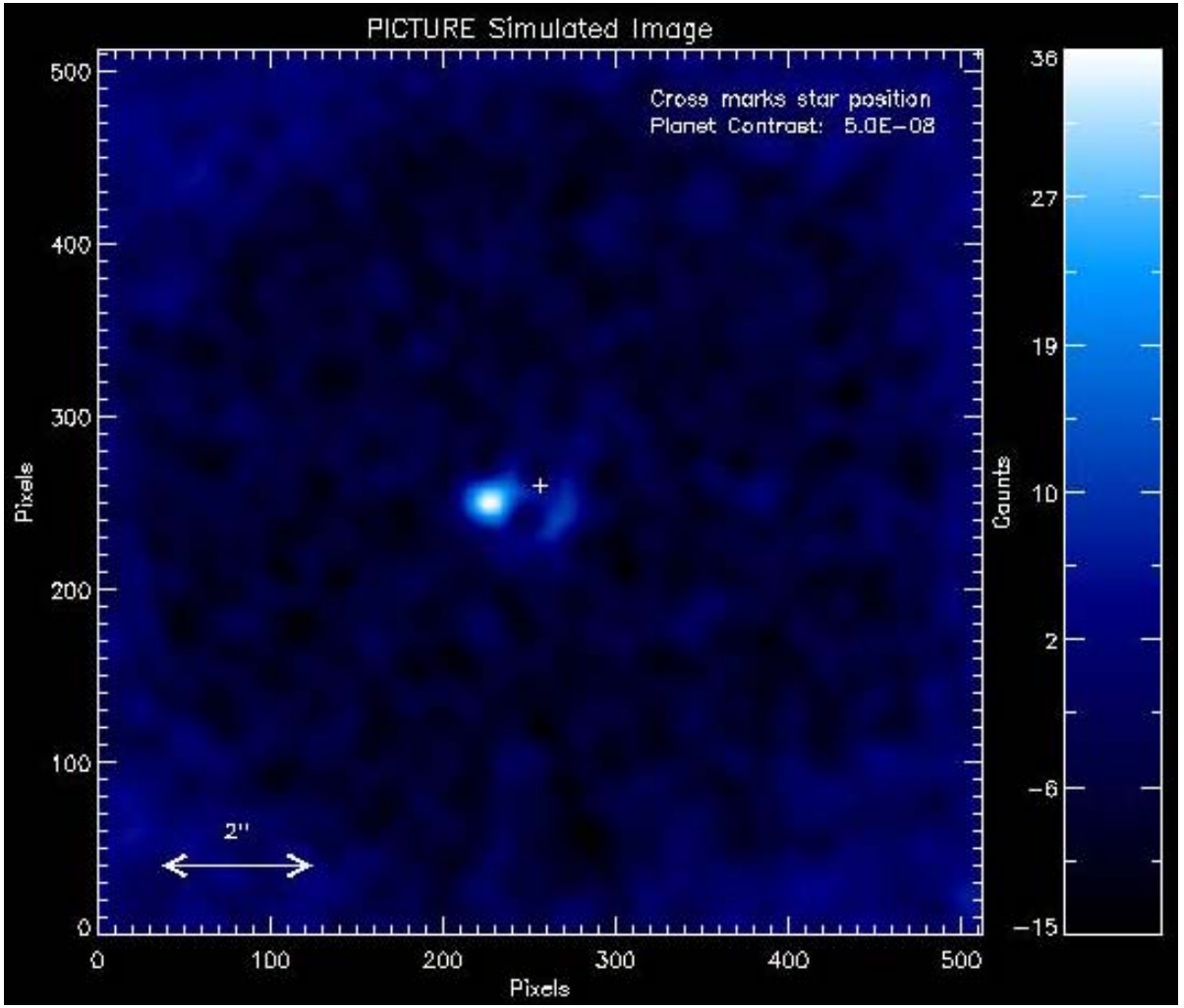
Simulated PICTURE Picture



- SNR~11 with PSF subtraction

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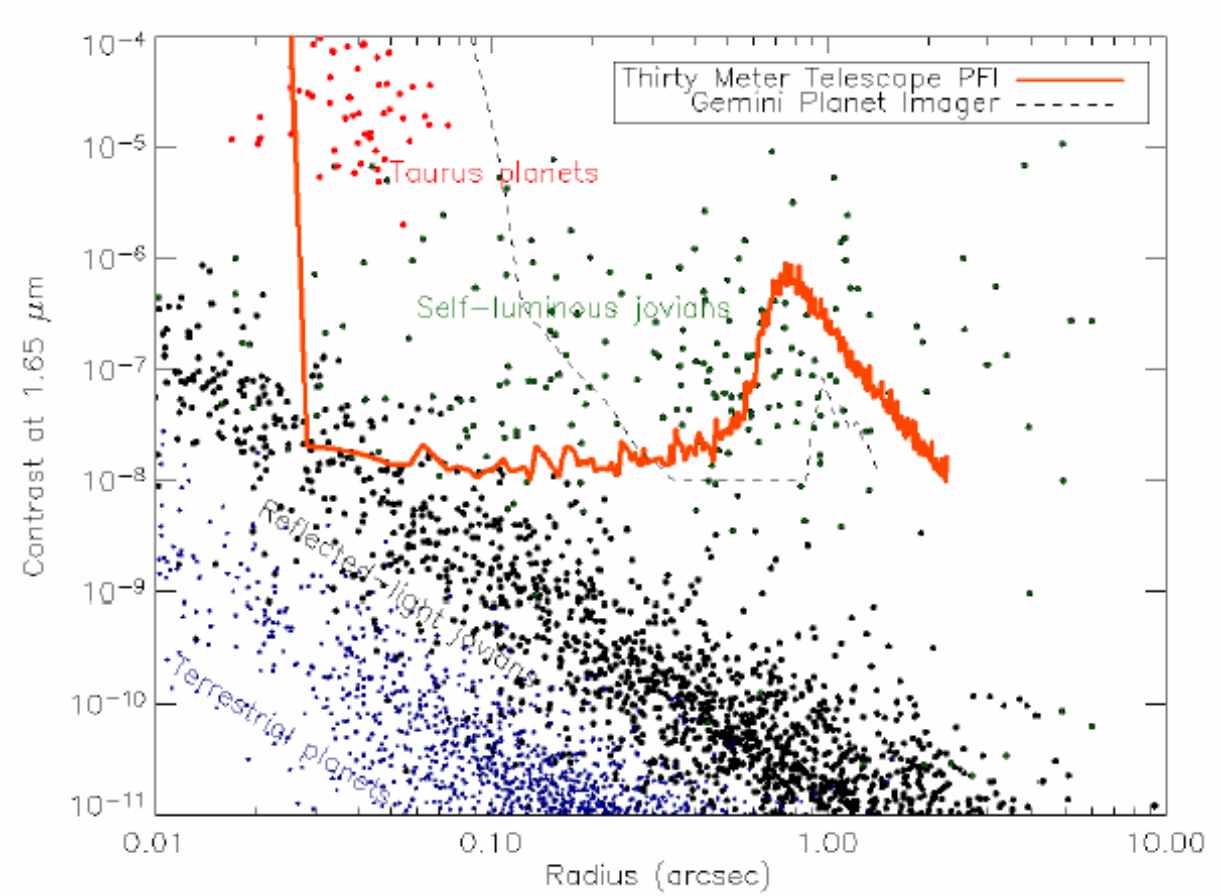
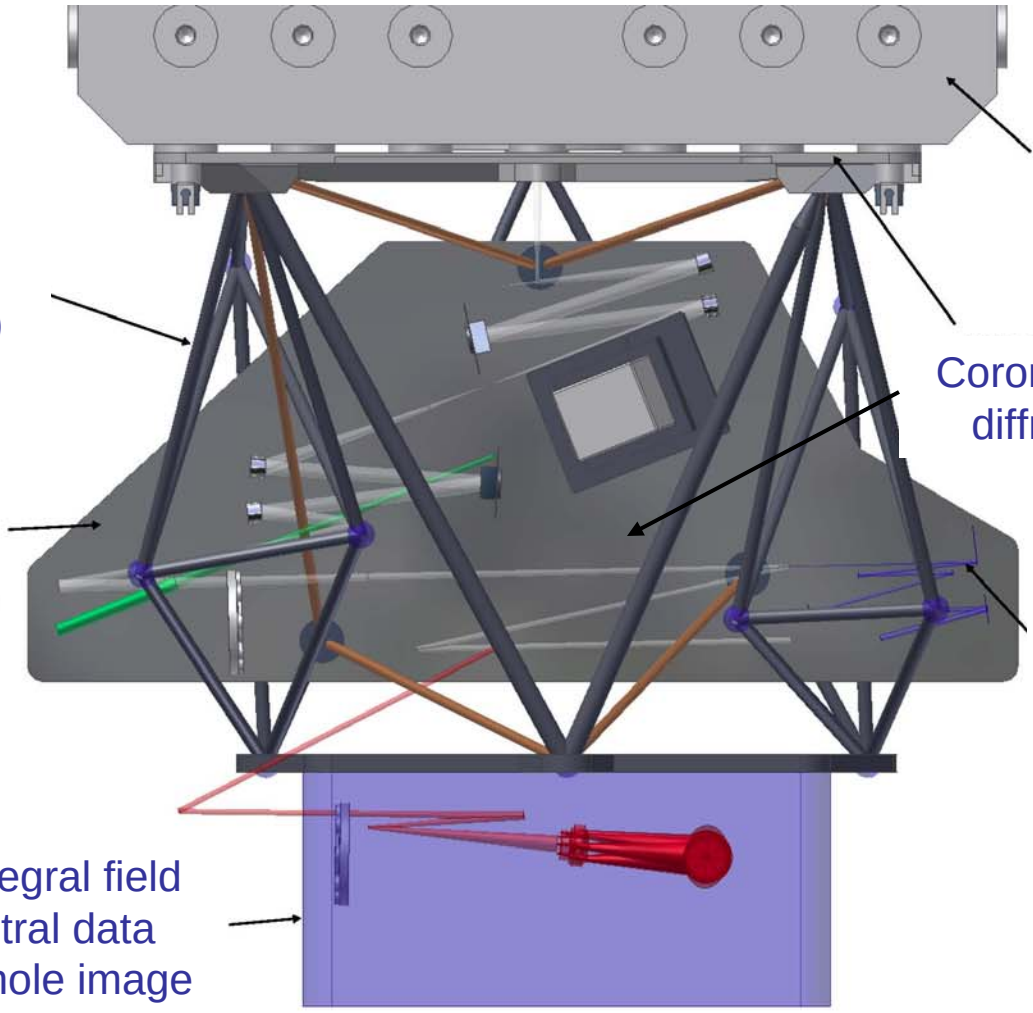
Limits of Ground Based Science



Taken from TMT OCDD

- **Contrast-separation plot for a Monte Carlo simulation of a variety of targets in the solar neighborhood.**
  - **Blue dots are rocky planets, beyond the reach of even TMT.**
  - **Black dots are mature Jovian planets reflecting sunlight.**
  - **Green dots are self-luminuous Jovian planets, typically those with masses of 3-10 Jupiter masses and ages < 1 Gyr.**
  - **Red dots are extremely young planets, recently formed or still accreting, in the Taurus star forming region.**

Gemini Planet Imager on the Gemini telescope (original UCSC design – Chris Lockwood)



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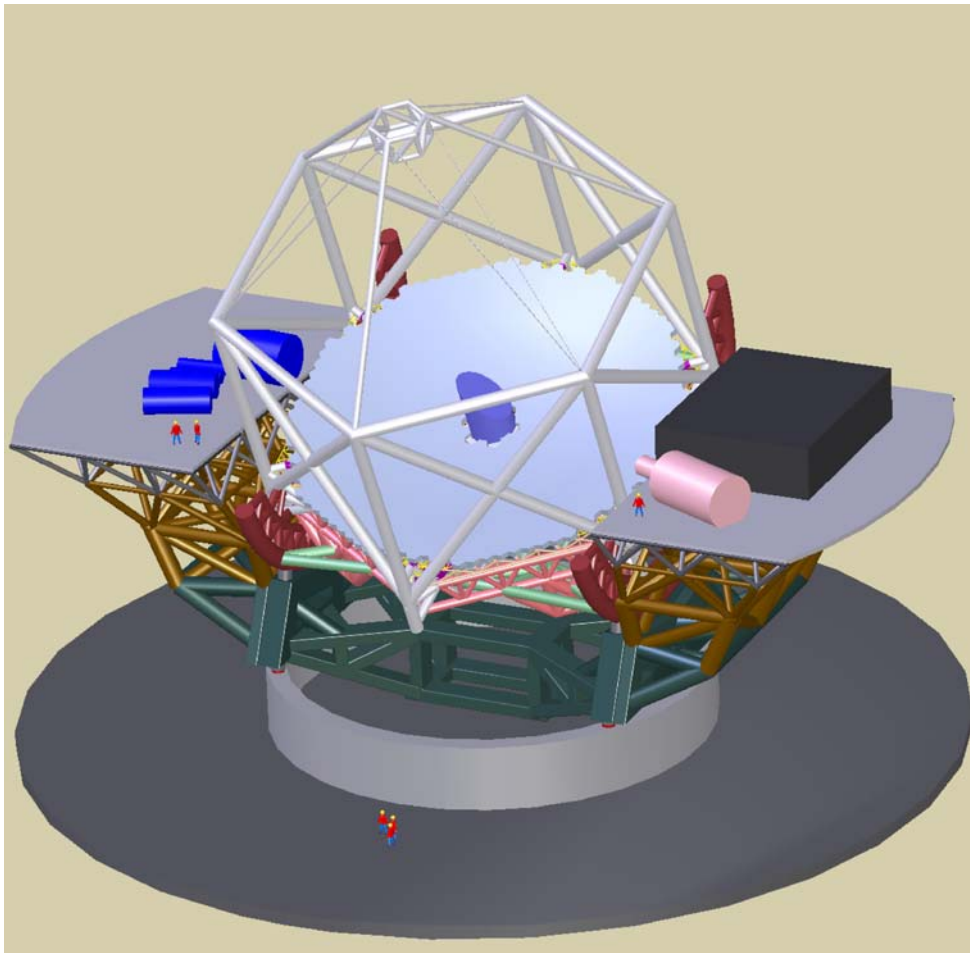
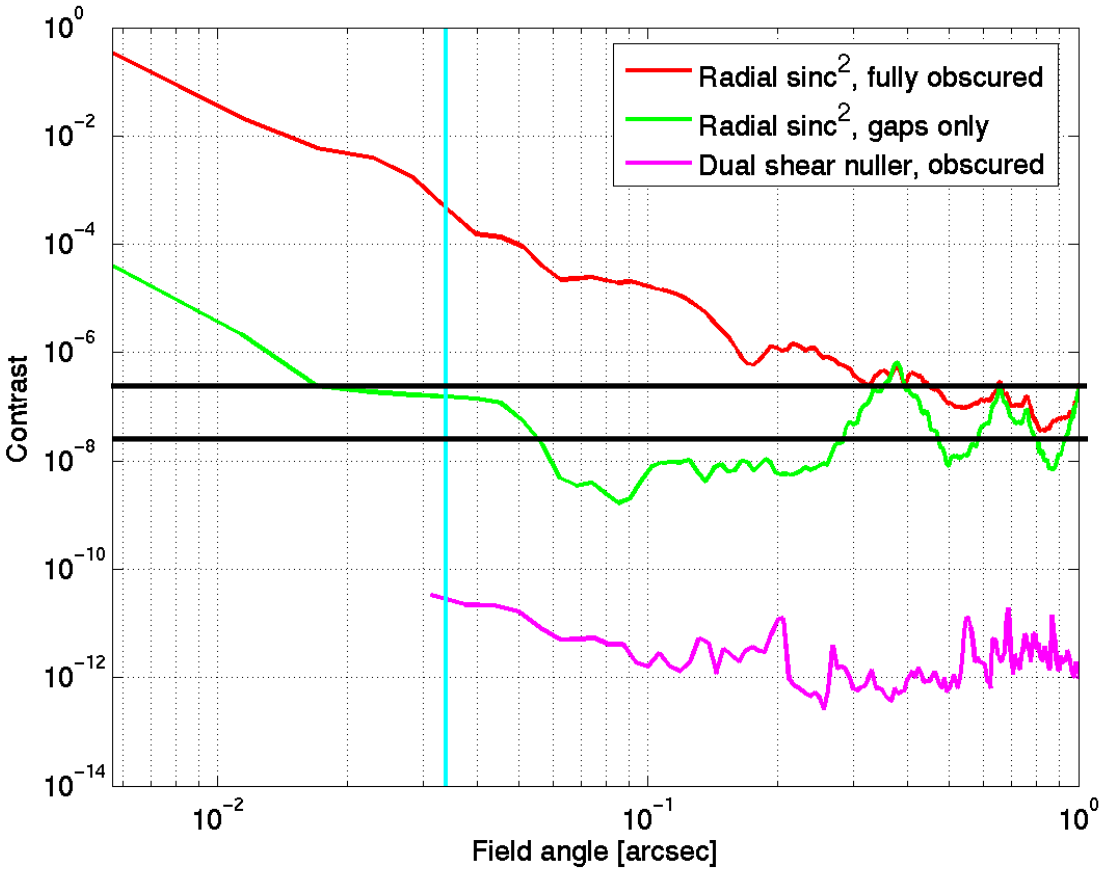
TMT Reference Design and Program

THIRTY METER TELESCOPE

- Telescope Architecture:
  - 30m filled aperture, highly segmented (~800) telescope
  - Wavelength coverage 0.31 – 28 µm
  - Both seeing-limited and adaptive optics observing modes
  - AO system requirements and architecture defined
  - First generation instrument requirements defined
- TMT Schedule (High Level)
  - Design and Development Phase (DDP) – (2004 – 2008)
    - Includes Feasibility Study RFP
  - Construction Phase – (2009 – 2014)
  - Early Operations Phase – (2012 – 2016)
  - Operations Phase – (2016 – 2024)
- High-level science objectives (PFI)
  - 1. Systematic studies of the extrasolar planet population in the solar neighborhood
  - 2. Imaging very young planets (0 – 15 Myr) in the process of forming or migrating >100 pc distances
  - 3. High-SNR studies of planetary atmospheres and their astrophysics
  - 4. The studies of circumstellar disks ranging from young protoplanetary disks through debris disks to high-density extrasolar zodiacal debris in inner solar systems.



Contrast from Segmentation and Obscuration of Pupil



- Nuller exceeds contrast goals at all field angles