SIM-Lite Update

M. Shao JPL

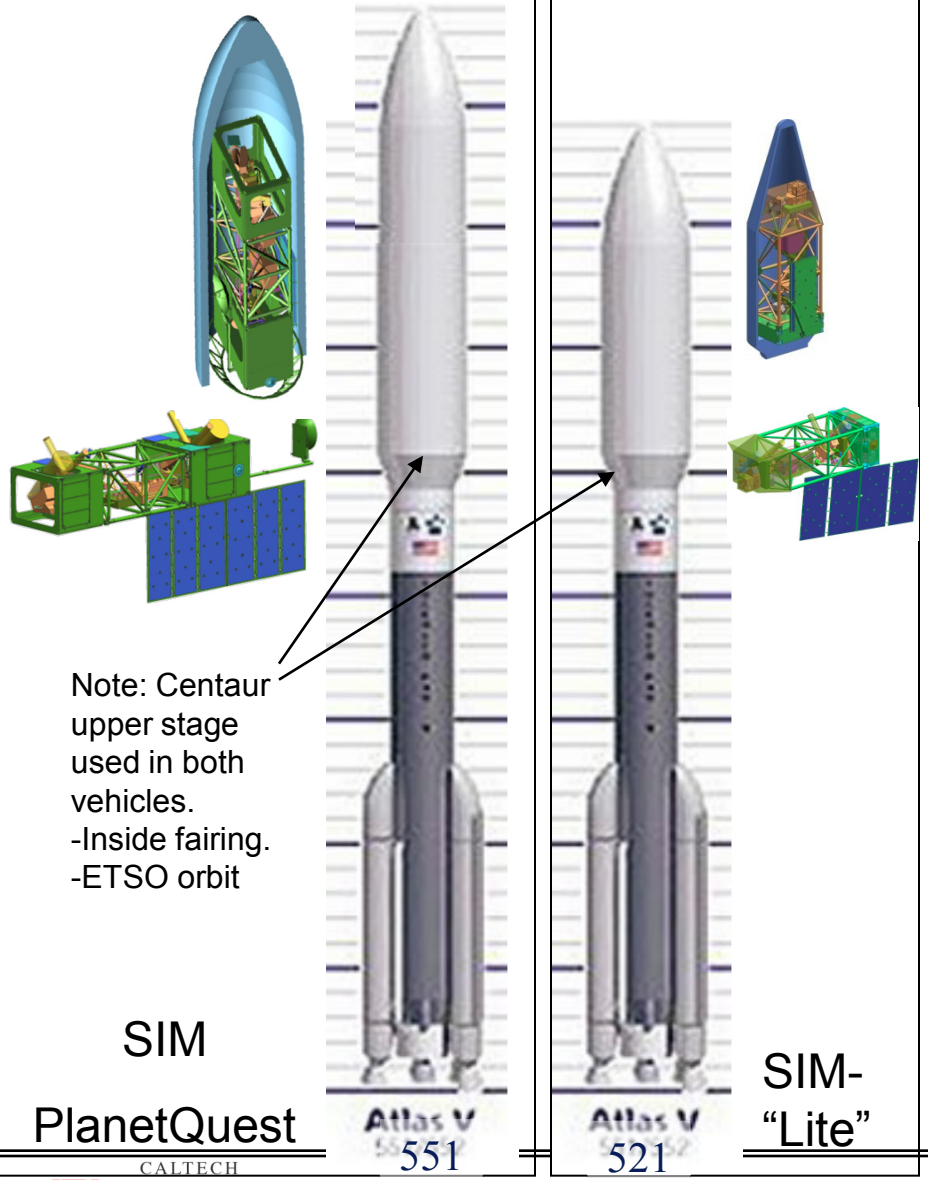
Outline

- SIM-Lite Instrument Update
  - 6m baseline, 50cm, ~900M cost
- Technology Update
  - Systematic errors and floor
- SIM-Lite terrestrial planet discovery capability
- Double blind multiple planet study summary
- The changing landscape of exoplanet science and the role of SIM-Lite

SIM and SIM-"Lite"

Parameter	SIM-PQ	SIM-LITE
Wide Angle (global) accuracy	2.4 uas	3.6 uas
Narrow Angle Accuracy	0.7 uas	1.0 uas
Mag limit	20 mag	20 mag
# Stars surveyed 1Mearth-HZ	~130	~60
Mass (with reserve)	6800 KG	4300 KG
Number of Interferometers	3	2
Science Baseline	9m	6m
Guide-1 Baseline	7.2m	4.2m
Guide-2	7.2m	0.3mTscope
Launch Vehicle Atlas V	551	521
Payload Risk Class	A	B
BCD schedule	77 mon	58 mon
BCD cost to go	1470 M	940 M
Mission Ops 5yrs	400M	170 M

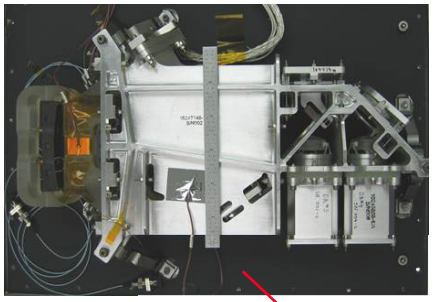
Smaller size also meant end to end performance test of flight hardware could be done in thermo-vac chamber at JPL, instead of S/C contractor.



SIM PlanetQuest

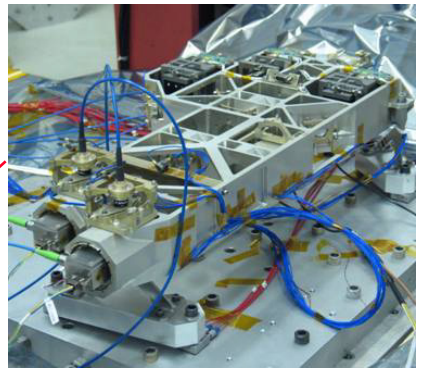
From Technology to Flight Component Engineering

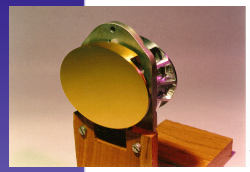
- Much of the SIM hardware for flight already exists in engineering model and brassboard form.



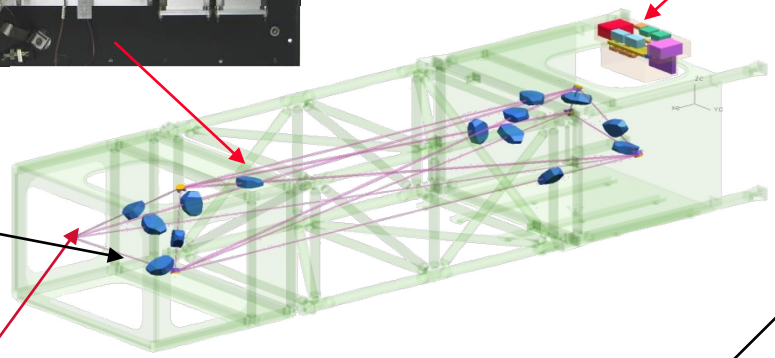
External Metrology Launcher

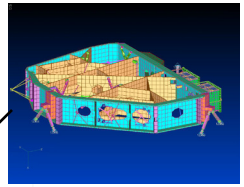
Metrology Source



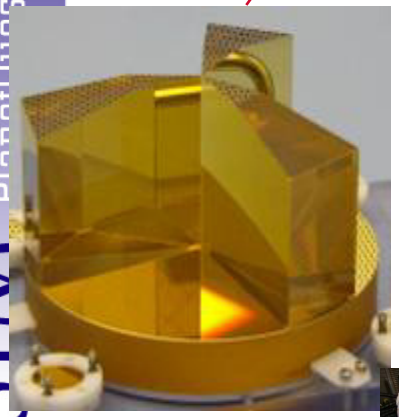


Fast Steering Mirror



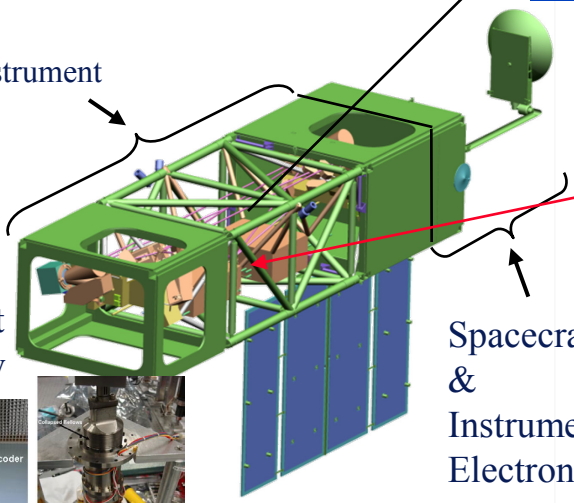


Astrometric Beam Combiner (Drawings released)

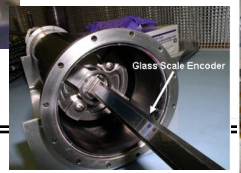


Double Corner Cube

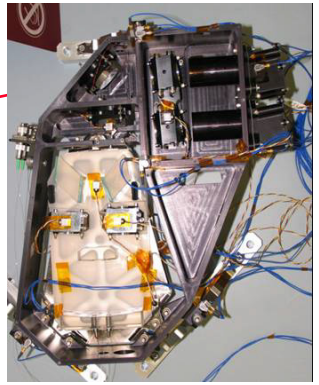
Instrument



Siderostat ball screw



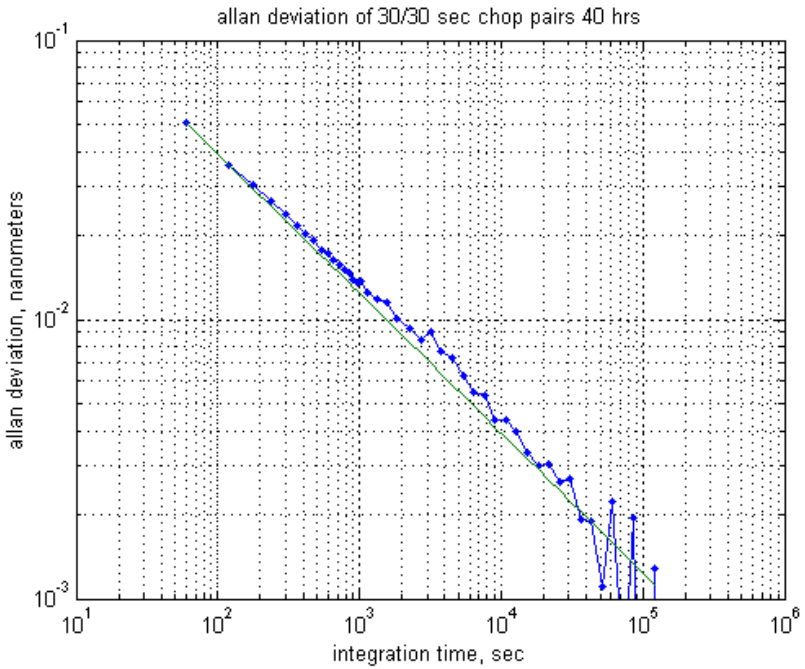
Spacecraft & Instrument Electronics



Internal Metrology Launcher

Instrumental Systematic Errors

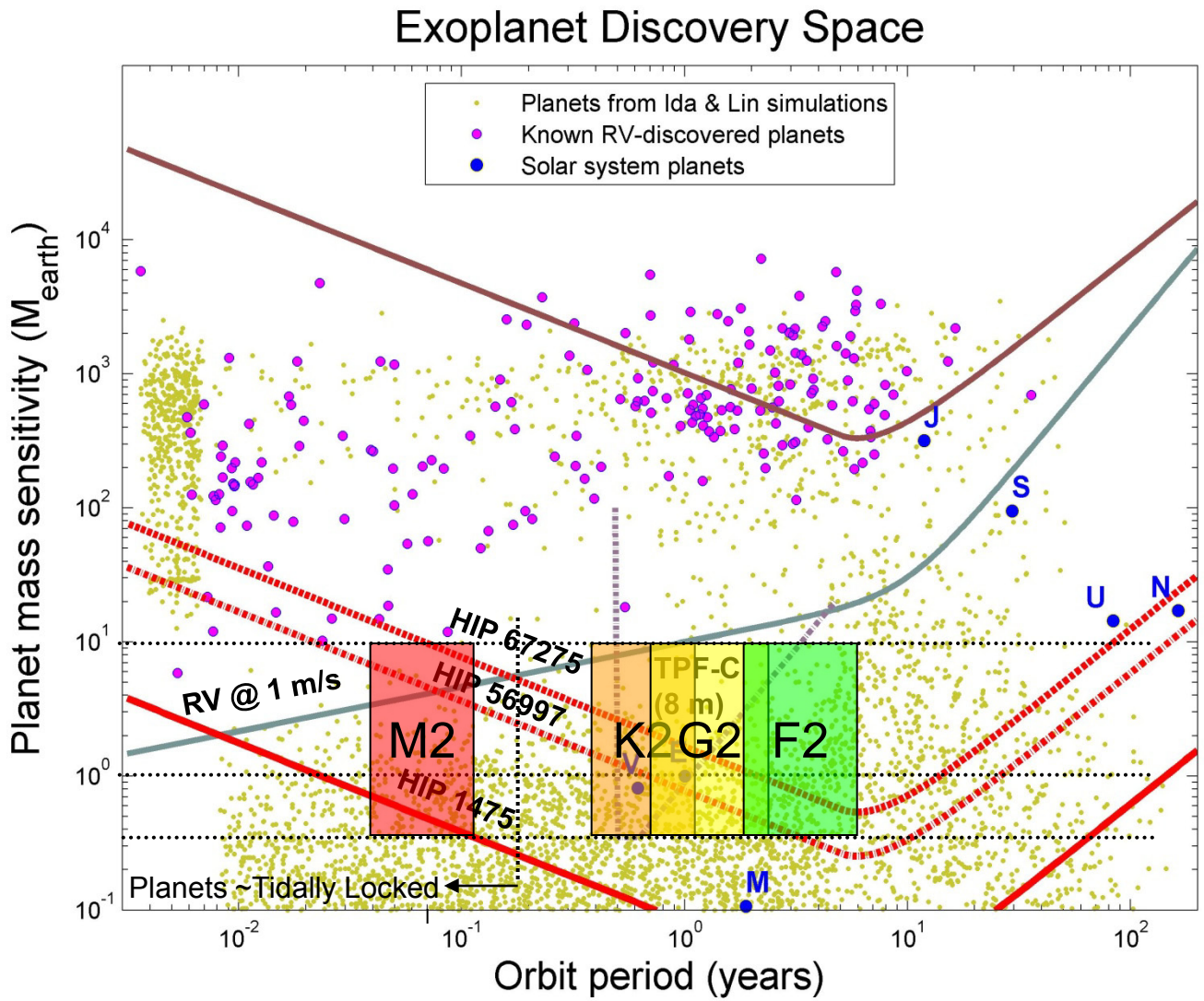
- Thermal drift affects all measurements
- For narrow angle observations, w "chop" between target and reference stars every 90 sec.
- When this observation procedure was tested in the MAM testbed w showed that thermal drift noise became "white" after chopping.
- The remaining question, is the thermal drift in the MAM testbed representative of the thermal stability we will see on SIM in orbit?
  - Detailed (>10^4 node) thermal model of SIM shows current design ~5 times more stable on orbit than testbed is in Lab.



1pm/6m = ~0.04uas

SIM PlanetQuest

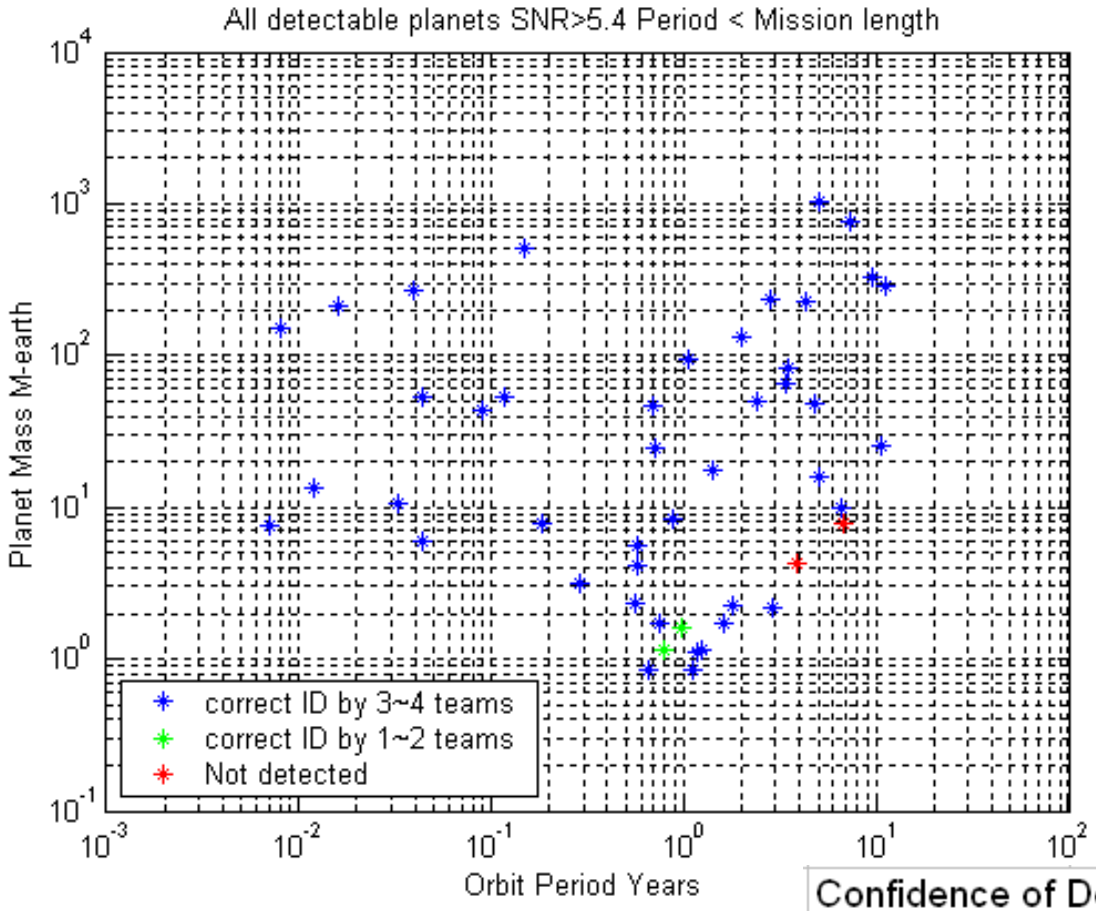
Ultra Deep Search for Earth Clones



Concentrate a lot of observing time 40% on a small number ~60 for SIM-Lite) over a 5 year mission.

To achieve sensitivity to 1 Mearth @ (1 AU) scaled to the luminosity of the star

Double Blind Test, Astrometric Detection of Earths in Multiplanet Systems



48 Planetary systems
95 planets & ~300 Asteroids
48 detectable planets (<5yr, SNR>5.8)
Threshold $1M_e$ @ 1AU

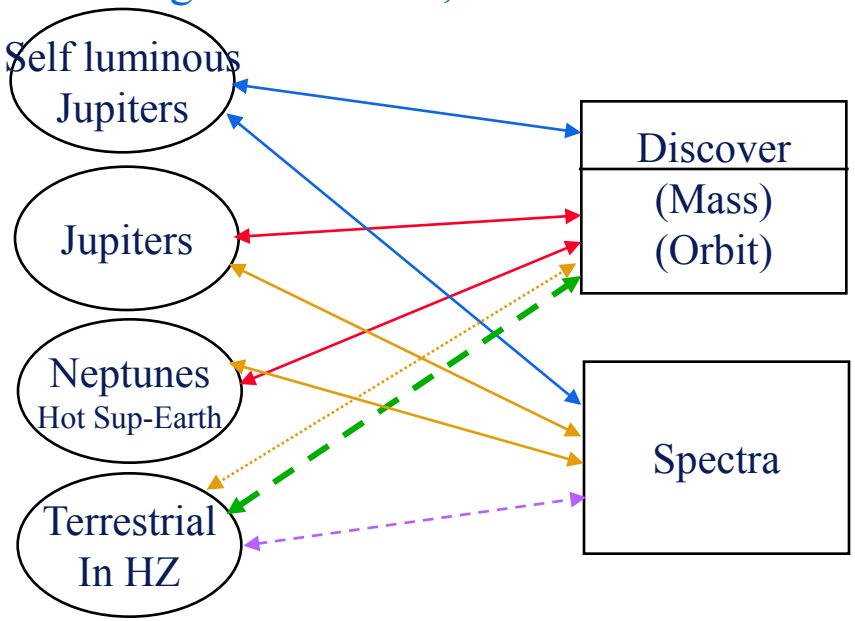
Two key metrics
- Confidence of detection
- Completeness

Confidence of Detection = # det/(#det + # false_positives)
Completeness = #det/(# detectable planet (solor))

	All planets	Hab Zone	0.3~10Me	Earths
Confidence	98%	100%	96%	100%
Completeness	96%	100%	91%	100%

The Current Era of Exoplanet Science (Where does SIM-Lite fit in?)

- Where are we now?
  - 300+ exoplanets have been found, Mostly RV (4.5 Mearth, in few day orbits)
  - Kepler is about to launch, coupled with JWST, get spectra of Jovians (100's)
  - TESS was selected for Phase A
  - Technology for an astrometric mission is complete
  - Considerable technology progress for direct imaging from space.
  - Extreme AO coronagraphs on 8~10m telescopes to come on-line in 2010/2011. Spectra of self luminous jupiters soon. Perhaps spectra of planets in reflected light with TMT, ELT



Simplified Diagram

Where we are.
Where are we going.

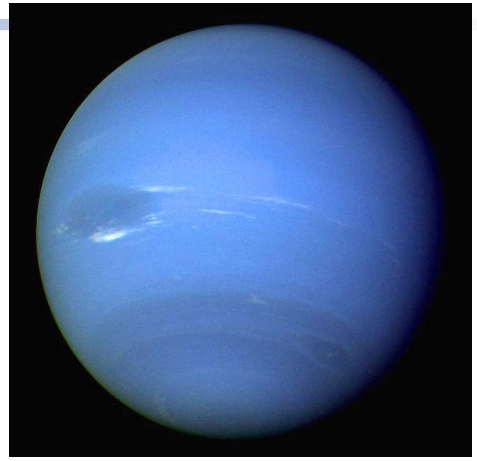
SIM PlanetQuest

Where is the next frontier, where does SIM-lit fit?

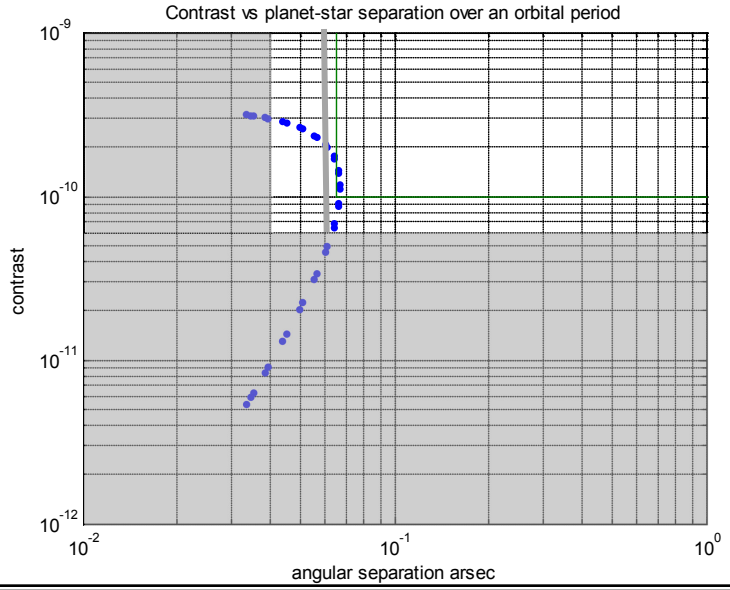
- The next Major (Space) advance in exoplanet research is the **discovery of Terrestrial planets in the habitable zone**.
  - SIM plays a pivotal and unique role
- After discovery, spectroscopic characterization Earth-clones with large space coronagraphs/interferometers

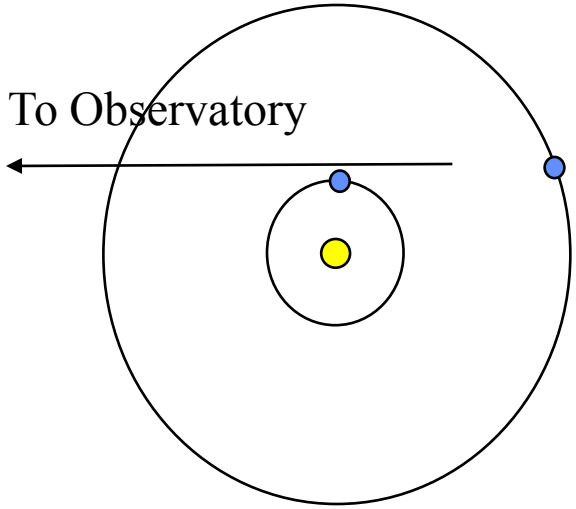
Discovering Earths, Why SIM is **Unique**

- The most important parameter, of a planet is its mass. We know a planet is a terrestrial planet **IF and ONLY IF** we know its mass.
  - We can't tell the mass of a planet from its color, and brightness.
- Neptune is 4X the diameter of Earth. A Neptune @ 4 AU has the same apparent magnitude as Earth @ 1 AU.
- The apparent brightness of a planet depends on the orbital phase angle.



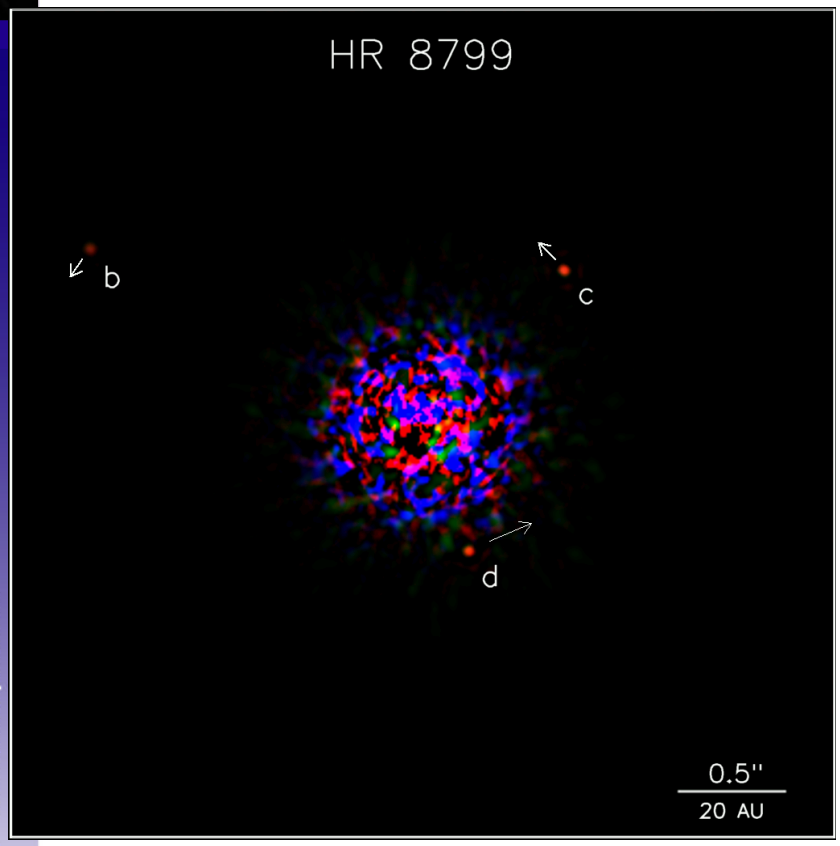
Pale blue dot, Neptune an ice giant





SIM PlanetQuest

Imaging: Planet Status Uncertain Without Masses and Ages



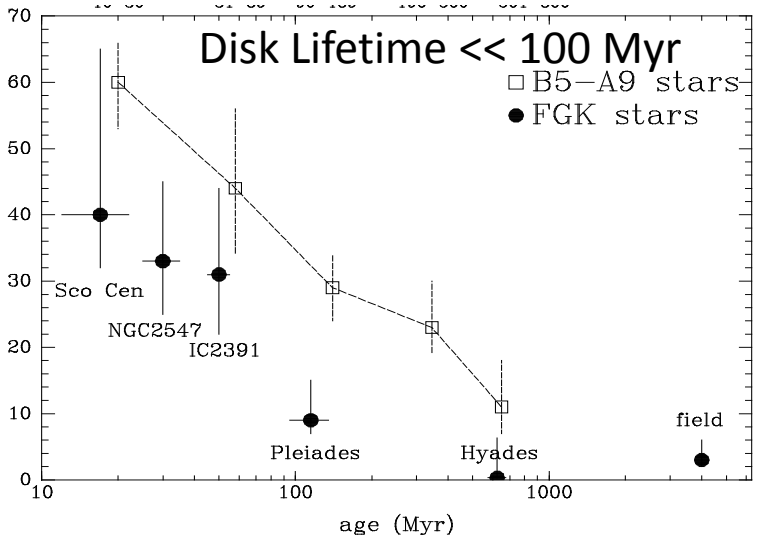
- Ages, Models, Masses uncertain
  - Assumed Age: 60 Myr ➔5-13 M_{JUP}
  - Age Range: 30 Myr-1.2 Gyr ➔ 40 M_{JUP}
  - Are these Planets or Brown Dwarfs?
- Orbits unstable
- SIM determines masses directly
- SIM will calibrate mass, luminosity, age relationships which make imaging studies so uncertain

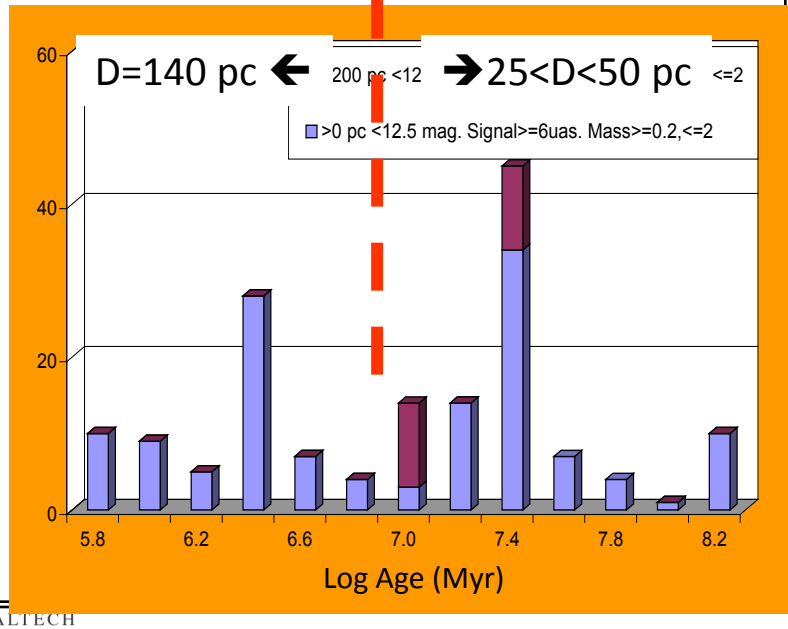
Three Planets Imaged Around HR 8799 masses of 5-13 M_{JUP}

SIM PlanetQuest

SIM Will Help Establish How Planetary Systems Form & Evolve

- Astrometry can find gas giants within 1-5 AU of parent stars
  - Mass measurements critical to evolutionary models
  - What fraction of young stars have gas-giant planets?
  - Do gas-giant planets form at the "water-condensation" line?
- AO imaging will find distant planets (>10 AU), but cannot determine mass, find inner planets
- Variability, spectral jitter, & rotation >>100 m/s preclude planet detection via RV, transit

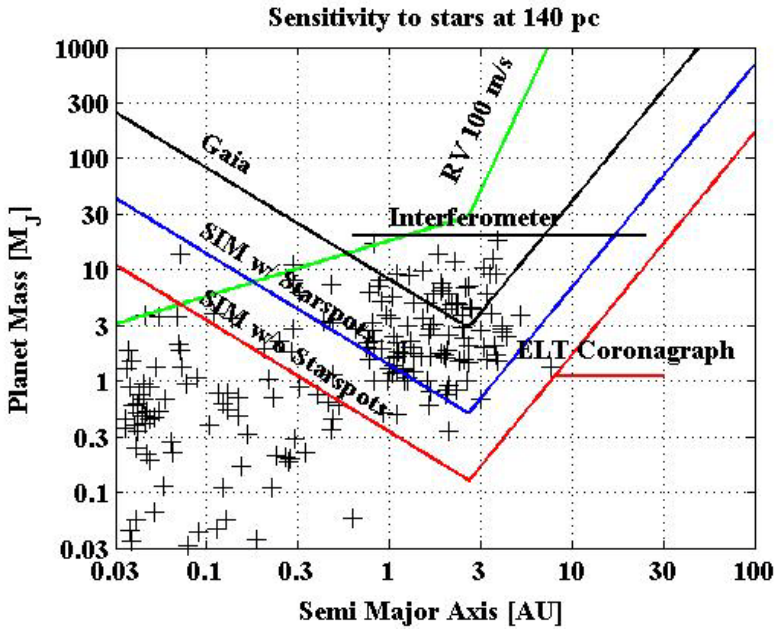


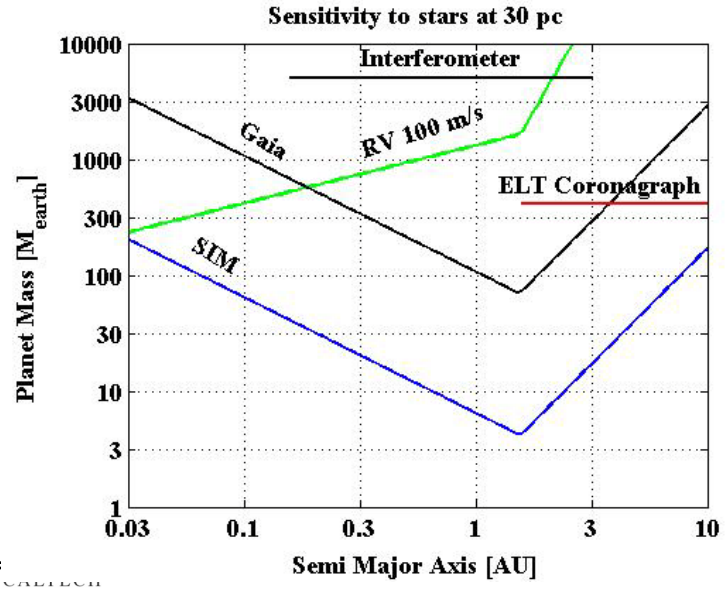


SIM PlanetQuest

SIM Probes the Broad Planet Mass Range Around Young Stars

- SIM surveys critical mass and age range
  - Gas giants around youngest stars (1-10 Myr at 140 pc)
  - Gas and icy giants around closest stars (>10 Myr at <50 pc)
  - Large rocky planets around nearby, young, low mass stars
- GAIA can find only Jupiters around the closest young stars (d<50 pc, ages >10 Myr)
- Star spots (<2 μas for ΔV=0.05 mag variability at 140 pc) will not prevent detection of gas giants





SIM PlanetQuest

Summary

- SIM-"lite" is much reduce cost version of SIM that still retains the potential to detect Earth Clones around ~ 60 of the nearest stars. (~1.1B in fy08 $, this includes 5 yrs of mission operations)
  - It's possible that we would get better science searching 160 stars for 2 Mearth planets, but the capability exists to get to 1 Mearth @ 1AU.
  - Find addresses for the nearest potentially habitable planets
  - SIM-Lite also has a strong astrophysics program, (Dark Matter, stellar physics, compact objects)
- The technology for SIM is ready. Flight designs and models exist for many flight picometer level precise components.