Space Interferometry Mission
SIM PlanetQuest

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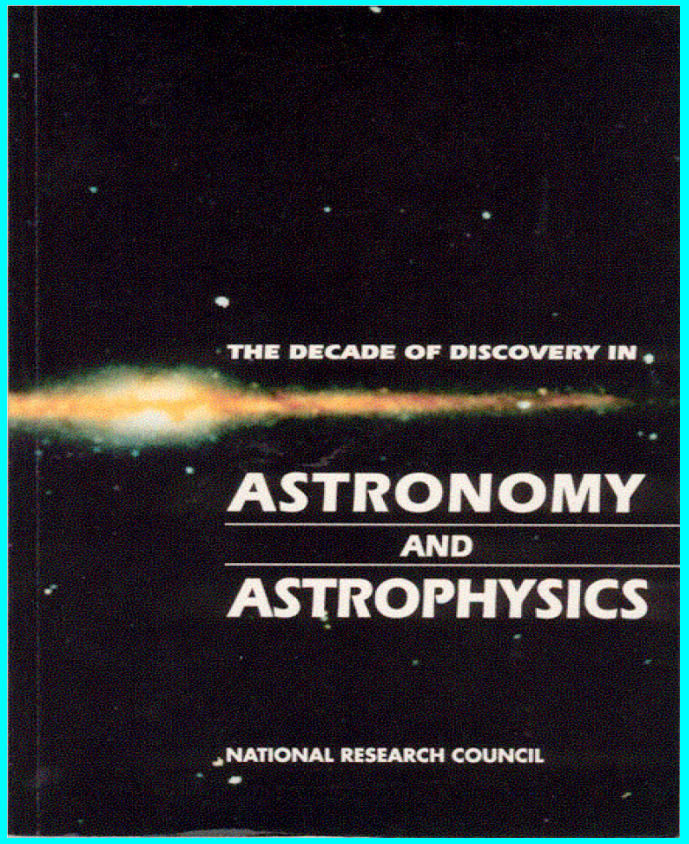
Chairman SIM Science Team

"You understand something truly only when you can measure it precisely." Lord Kelvin

- Measure precise distances -- the basis to physics of stars and physics of the Universe
- Determine the mass makeup of our Galaxy and the Local Group
- Detect earth mass planets in the habitable zone of nearby Sun-like stars
- Direct insight into the formation & diversity of other planetary systems though orbit measurements

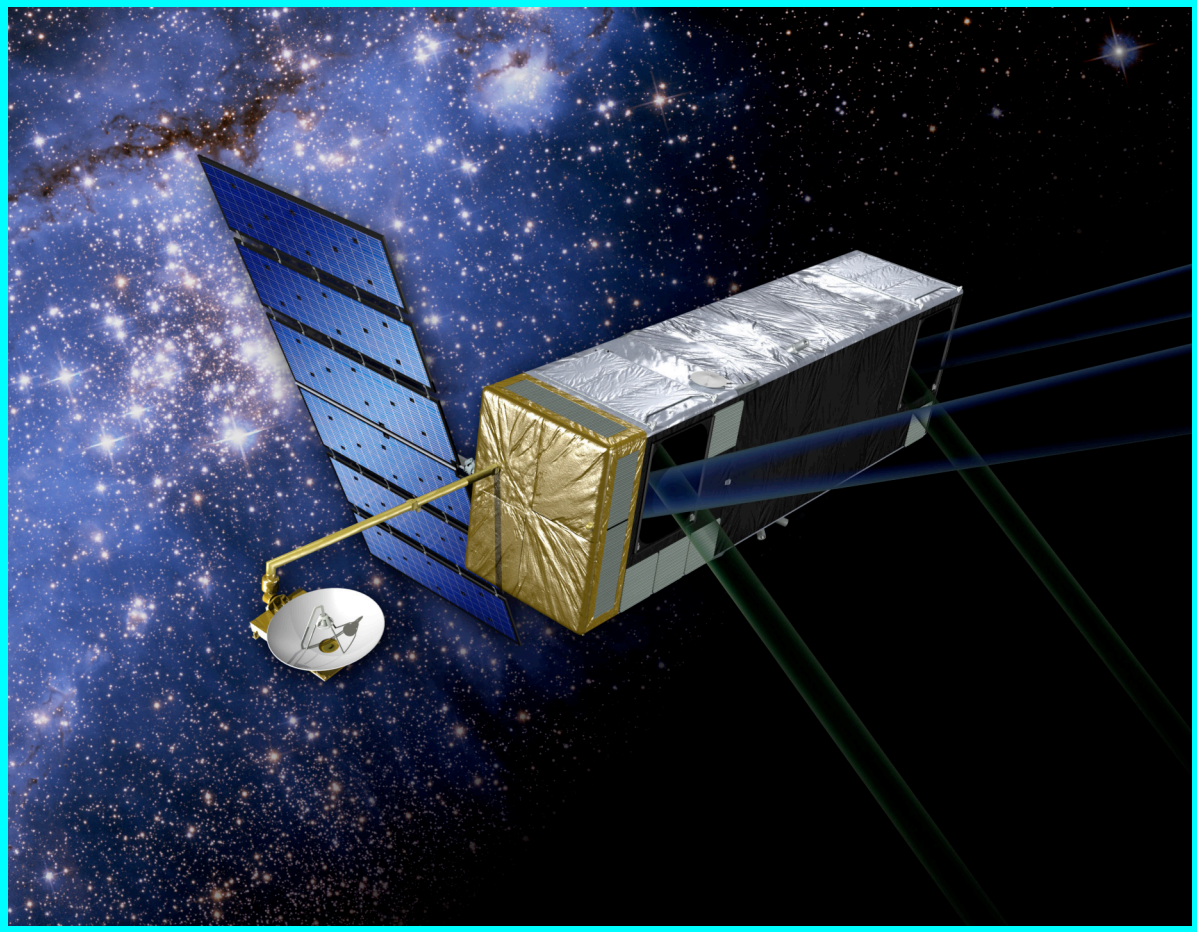
Confucius says "One excellent measurement is better than many mediocre measurements."

1990 & 2000 Decadal Reviews Endorse SIM



"…emphasized the dual capability of SIM, noting that this capability would enable "…*both… detecting planets and … mapping the structure of the Milky Way and other nearby galaxies*."

SIM: An Optical Michelson Interferometer



Global astrometry (5yr mission)

- 4 μas position (inertial)
- **2.5 μas/yr** proper motion
- **4 μas** parallax

Narrow angle astrometry, **1 μas**

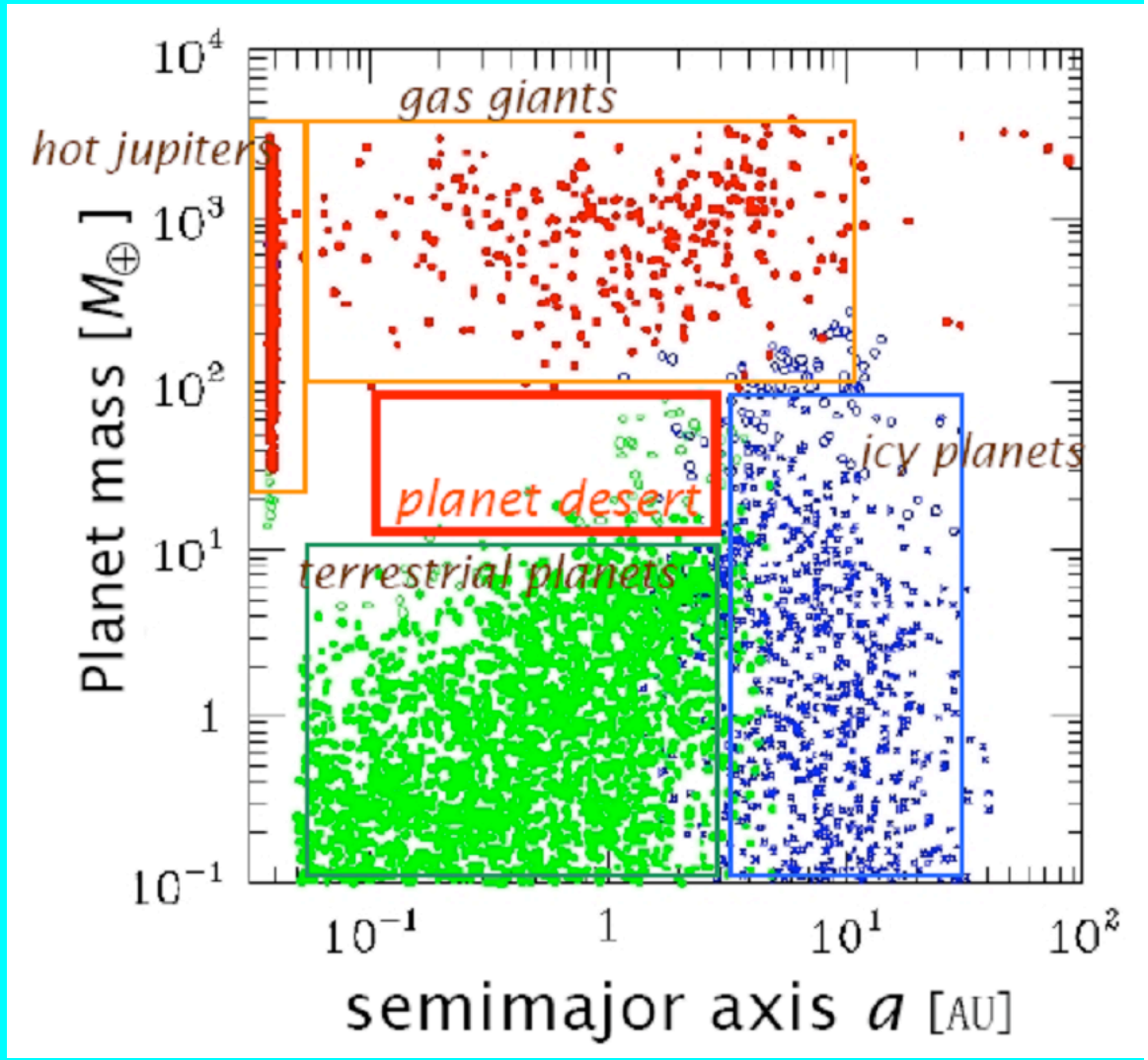
Extra-solar Planets Continues to be a Frontier Area

- Is our solar system rare or common?
- How are planets formed? (bottom up or top down)
- Are there earth-like planets around nearby stars?
- What sorts of planets exist around stars different from our Sun?

Extrasolar Planet Phase Space

Current harvest of 200 planets (RV): empirical constraints to planetary system formation.

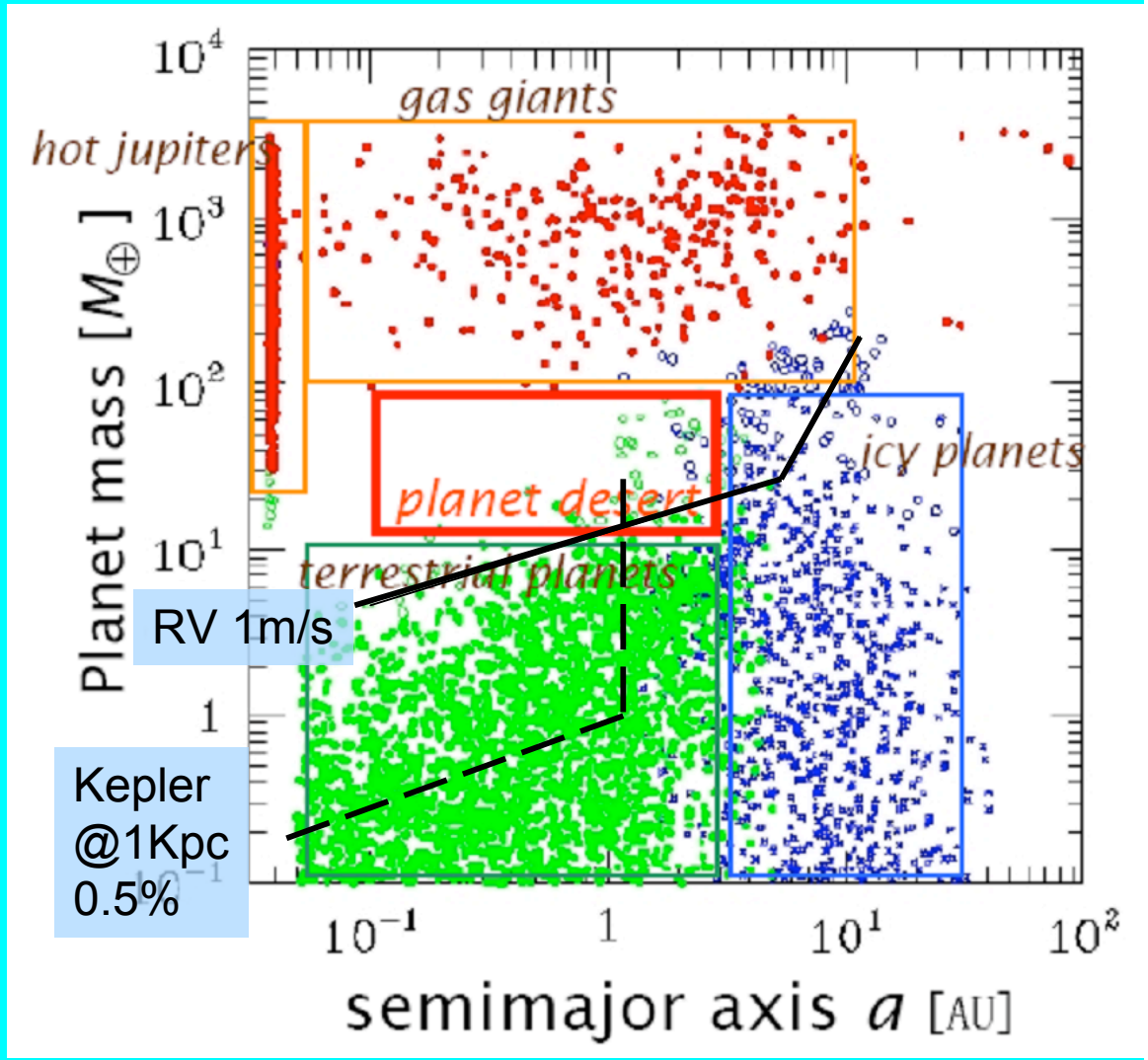
Jupiter & Neptune appear to be the tip of the "planetary iceberg"



Discovery Space

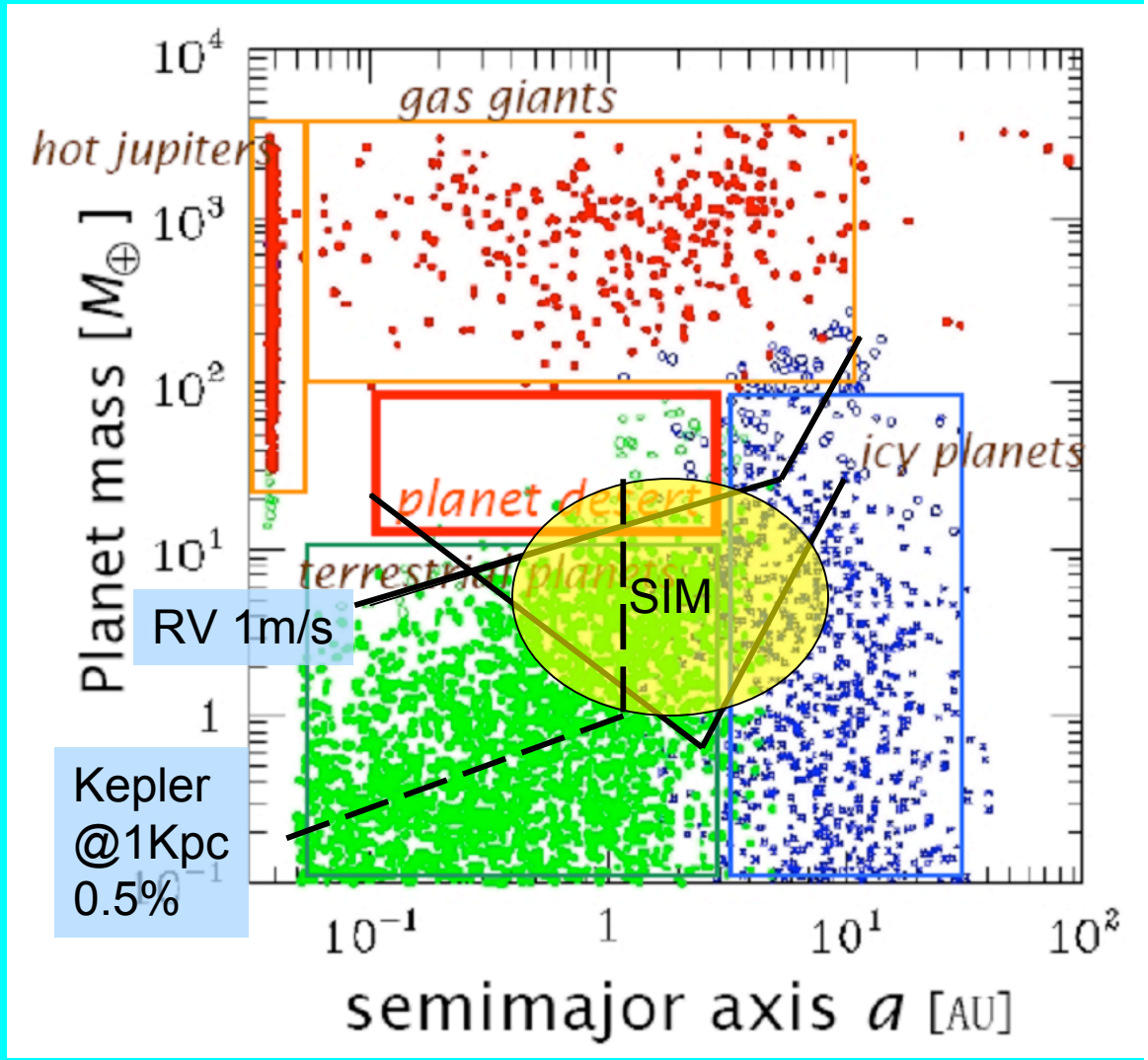
RV will press on icy planets and close-in planets

Transit & Microlensing will provide statistical census of rocky planets

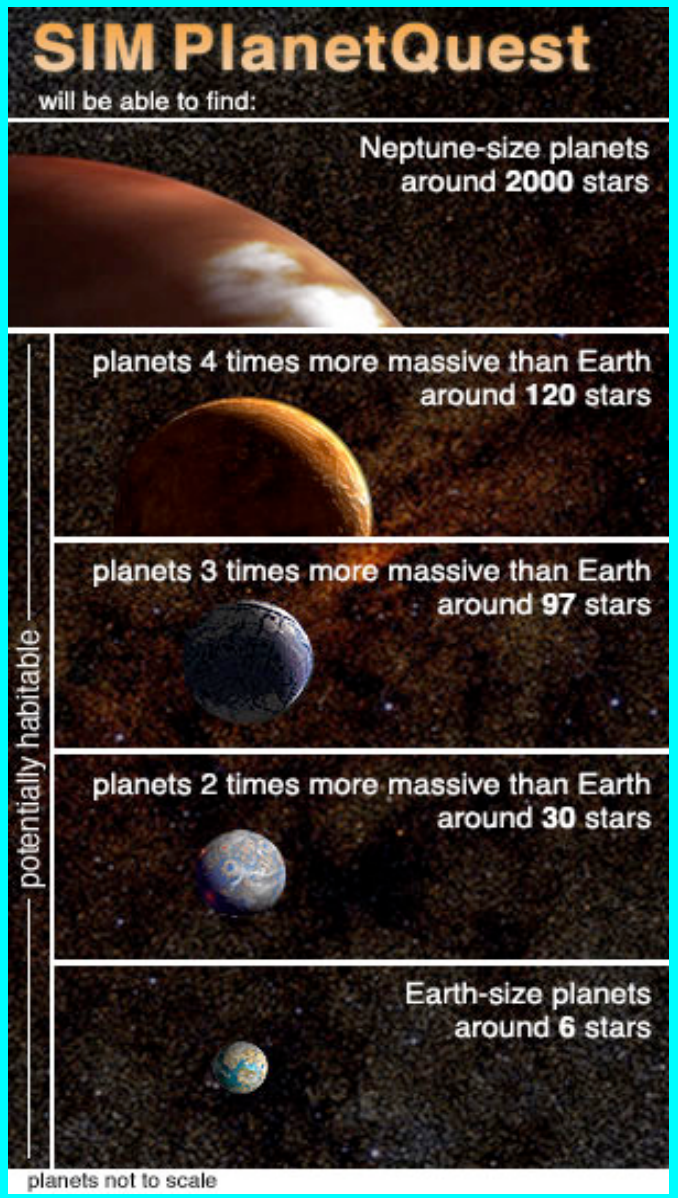


SIM Discovery Space

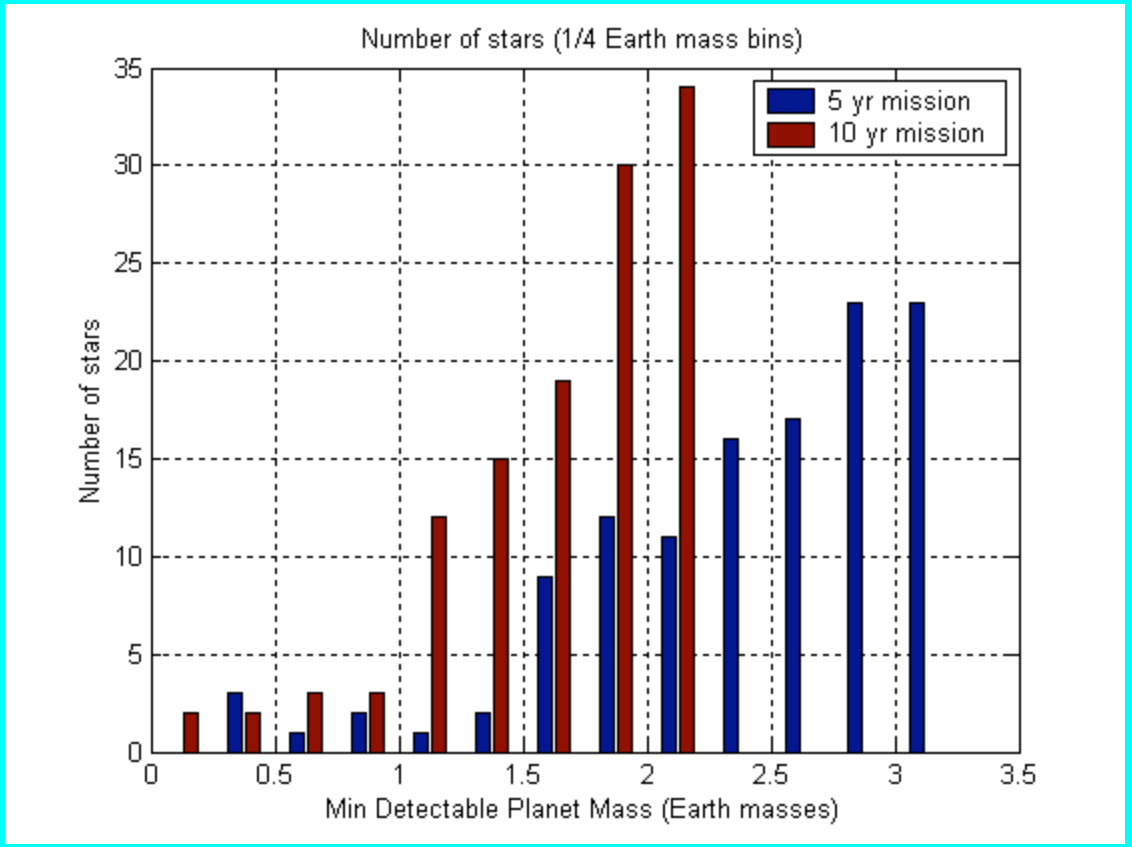
SIM: uniquely probes
1~10 M_{earth} (0.4~6.0AU)
(for nearby stars)



Deep Search of 120 nearby stars

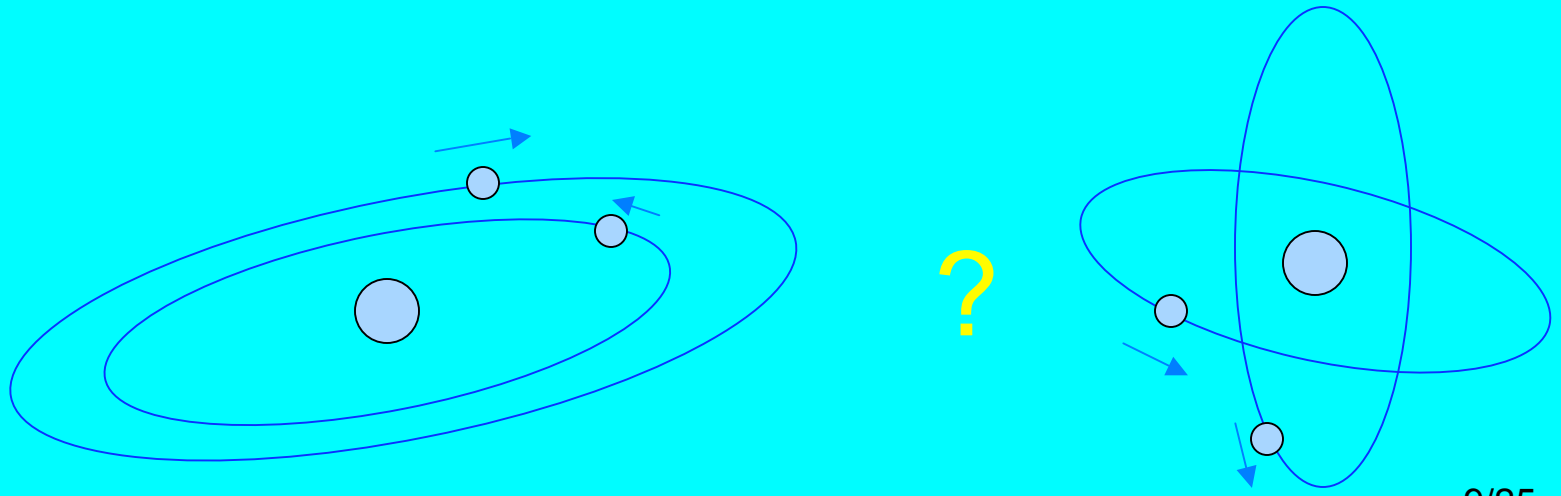


For the nearest solar-type stars hundred stars SIM has the capacity to detect earth mass planets in the Habitable zone



Planetary System Architectures & Diversity

- Comprehensive survey of 2000 stars to probe Jovian/Neptunian planets (metalicity, debris disks, binary systems)
- Search for planets around stars not probed by any other technique (O, B, A, early F, white dwarfs).
- Uniquely probe for planets around young stars and thus provide insight into evolution of planetary systems
- Measure planet masses, eccentricities, orbital direction and mutual orbital inclinations of multiple planet systems



“No Distance, no physics”

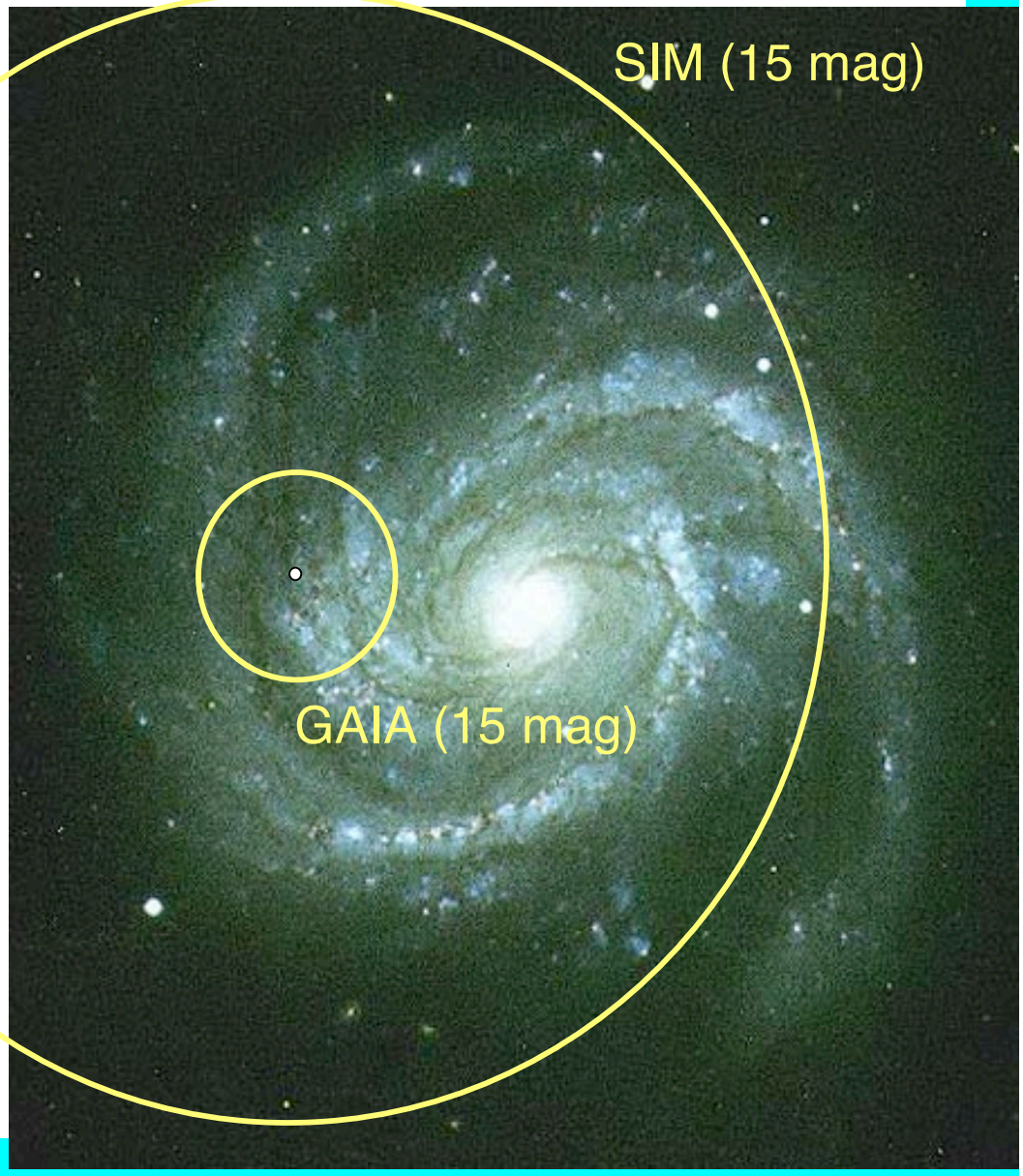
The history of astronomy is entwined with the determination of reliable distances

- Size of the Galaxy
- Size of the Local Group
- Size of the Universe
- Origin of Gamma-ray bursts

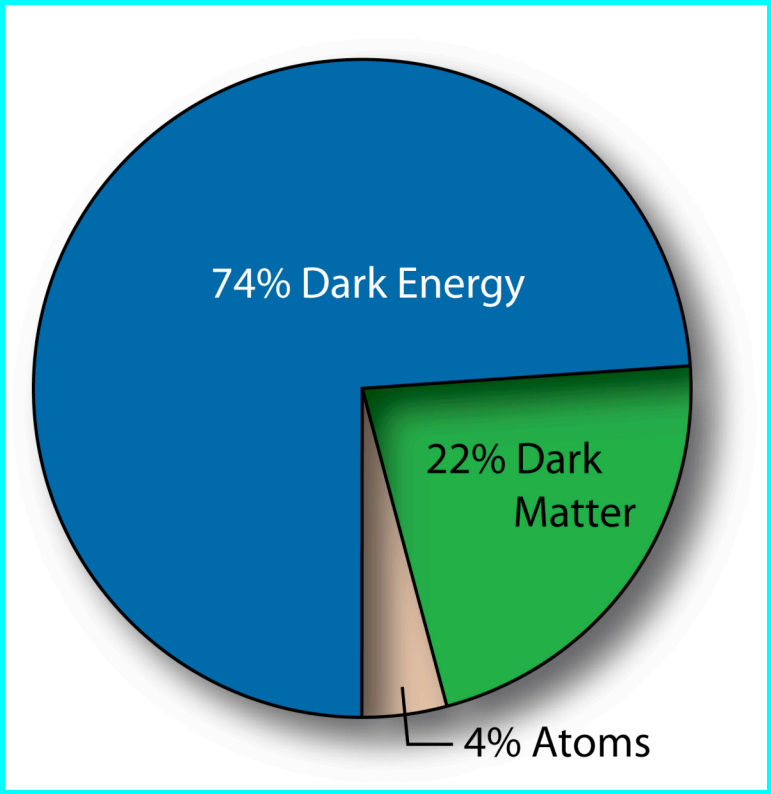
- SIM is a “distance measuring” machine
  - Poorly understood objects
  - New classes of objects, transients (e.g. PanSTARRS, LSST)
  - Rare objects (Neutron Star Systems, Black Hole Systems)
- A “Distance Determination” Key Project will constitute a powerful legacy to astronomy

SIM has a Galactic Reach

	1%		10%
SIM	2.5	kpc	25 kpc
GAIA	0.4	kpc	4 kpc
Hipparcos	0.010	kpc	0.1 kpc



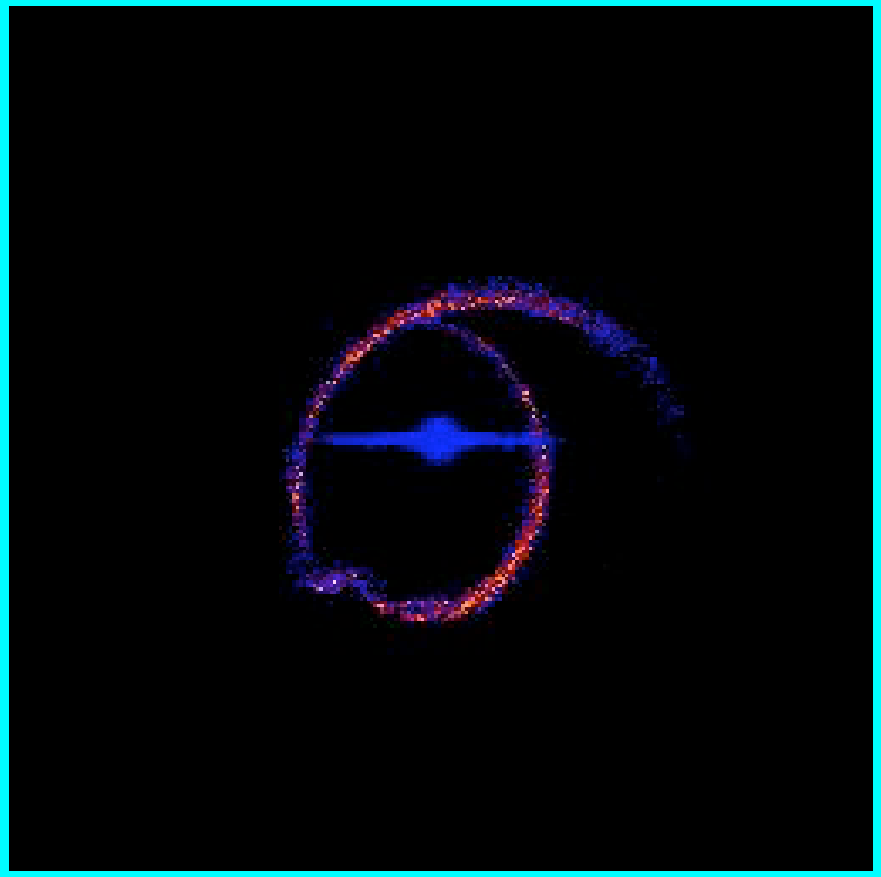
A COSMIC PROBLEM: The Ghost of Hubble (7% is not good enough)

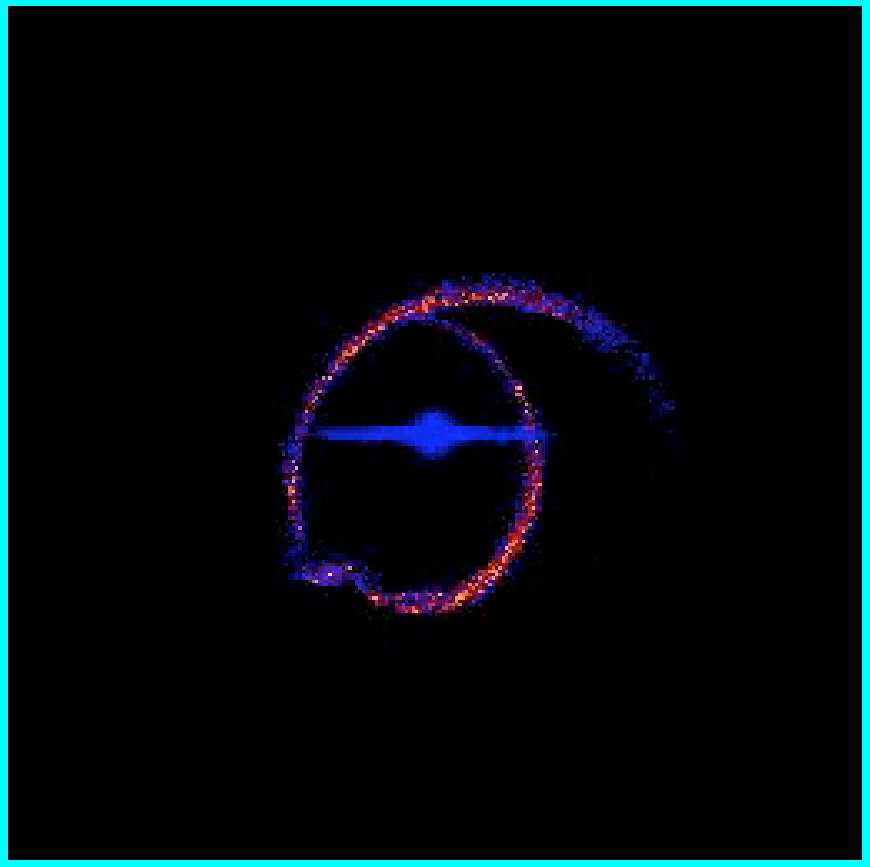


Precision cosmology is limited by precision (and accuracy) of Hubble's constant

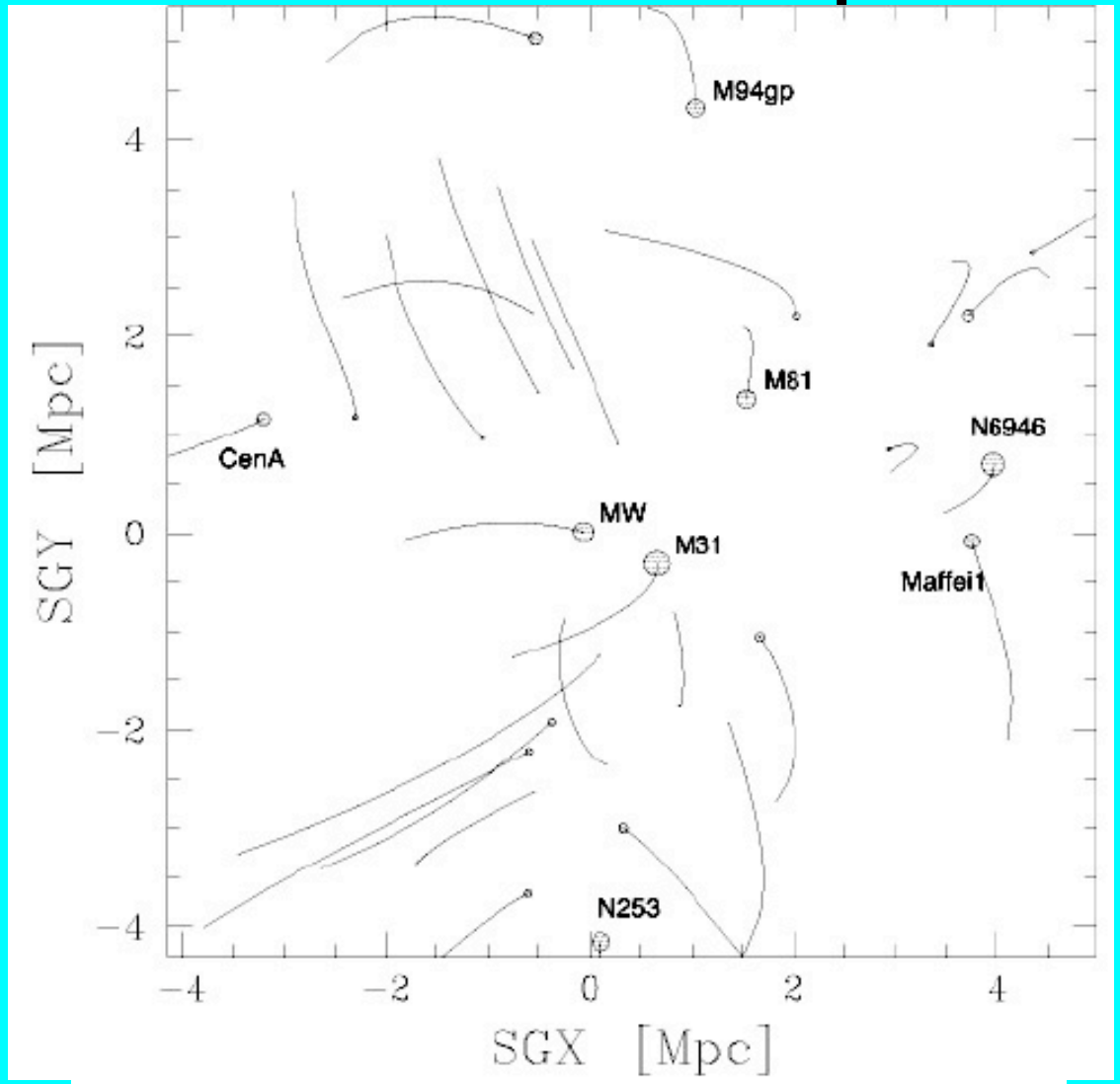
- SIM can undertake a thorough calibration of Galactic Cepheids
- SIM can measure the distances to M31 and M33 (rotational parallax)

Shape of our Galaxy





Matter Distribution of the Local Group

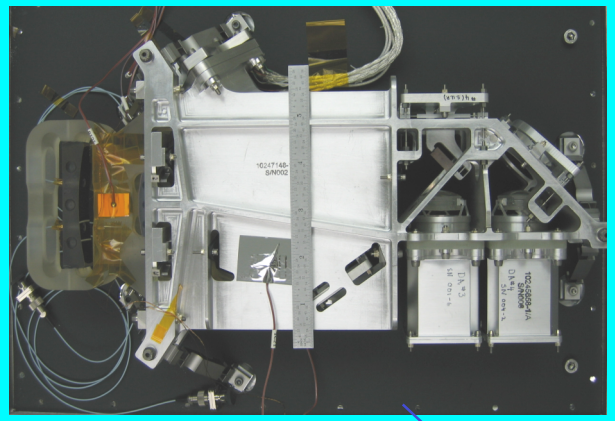


Simulated 1 Gyr trajectories of our neighbours

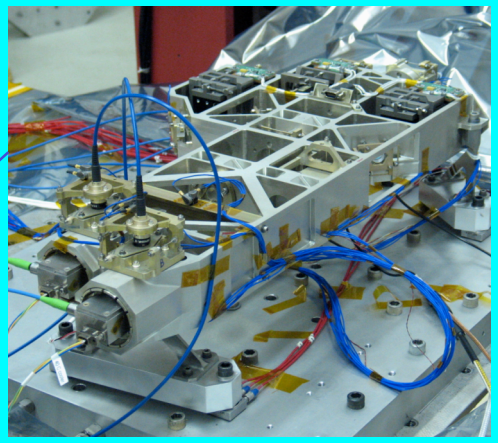
Fundamental Astronomy & Fundamental Physics

- SIM is uniquely suited to probe the true mass spectrum of our Galaxy
  - Microlensing+SIM = mass spectrum
- SIM has the ability to determine masses of neutron stars and black holes
  - Stellar black holes .. Lab for strong gravity and lab for jet formation
  - Neutron stars … Lab for dense matter (e.g. Vela X-1 and equation of state)

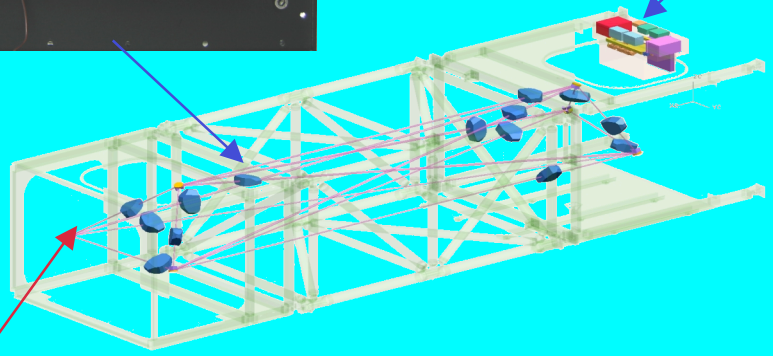
2005: We were ready!

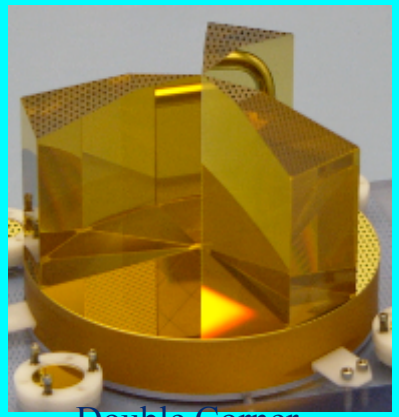


External Metrology Launcher



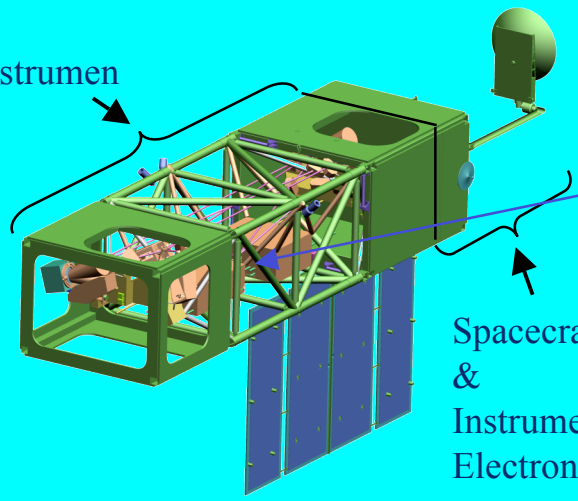
Metrology Source



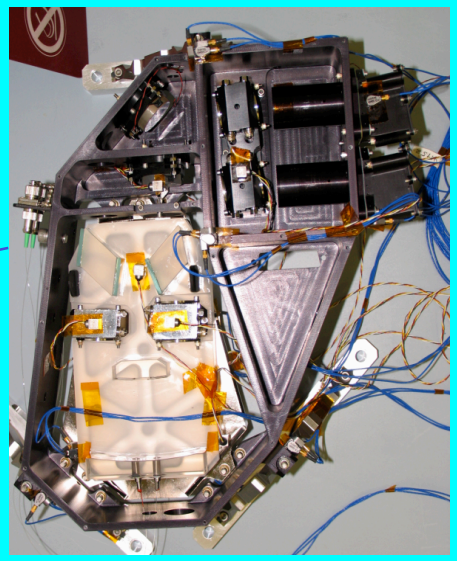


Double Corner Cube

Instrumen t



Spacecraft & Instrument Electronics



Internal Metrology Launcher

Nanometer Control & Picometer Knowledge: Flight Ready Hardware

2006: SIM Hits a Block

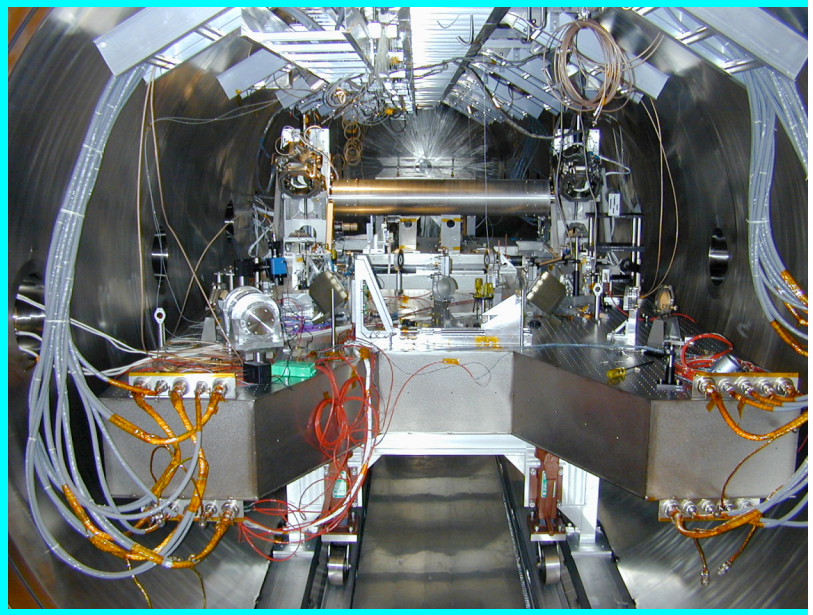
- Cost of Mission to launch: $1.5B
- Severe cost over-runs on practically all NASA missions (especially some more than others) made SIM unaffordable

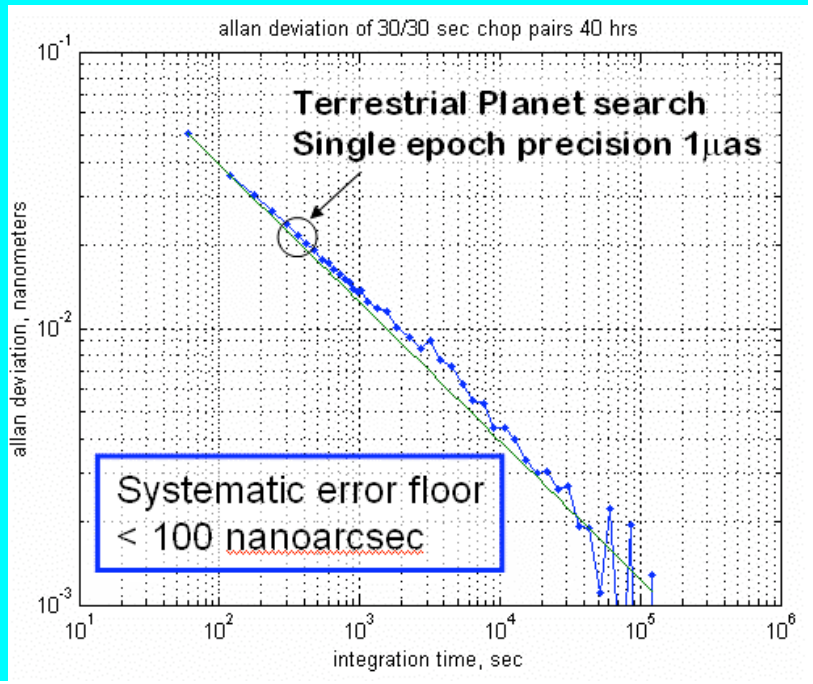
Rescue

- Technological Breakthrough
- Readiness of the mission
- Public Appeal of extra-solar Planets

- Technology program demonstrated

  systematic error floor of < 1 picometer!
- ***Thus baseline can be reduced with corresponding reduction of mass and thus cost***
- Narrow angle astrometry of 1 uas still retained
- Throughput reduced but can be made up with fewer targets or mission duration
- Wide angle astrometry limit now 1 magnitude worse (19 mag)

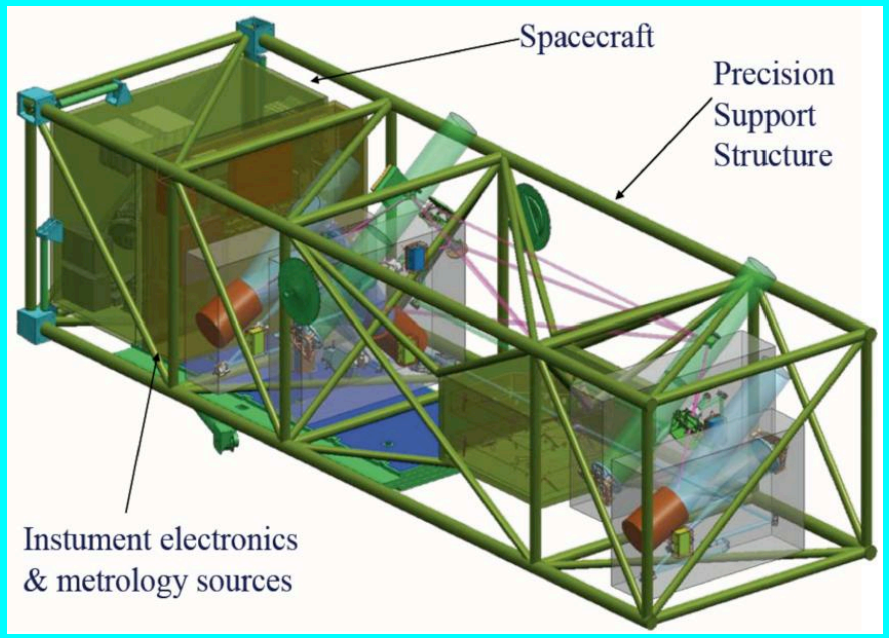




SIM-Lite

- Replaced one Guide MSI with much simpler 30 cm telescope.
- Simplified many elements of the design and used common hardware.
- Shorter baseline, simpler packaging, smaller volume & lower mass.
- Smaller launch vehicle and smaller faring.
- Simpler design allows shorter schedule and smaller team.
- Simpler observation planning, sequencing & data reduction.

SIM Lite Overview



Salient Features

- **6 meter science Michelson Stellar Interferometer (MSI)**
- **Guide: One 4m MSI and one 30cm telescope**
- **Visible wavelength**
- **Earth-trailing solar orbit**
- **5 year mission**
- **SIM is a JPL, Caltech, NGST, KSC, and SIM Science Team partnership**

Major Elements in Cost Reduction

	SIM-PQ	SIM-Lite
Science Baseline	9m	6m
Number of Interferometers	3	2
optics, mounts, actuators		
computers, cableing		
heaters for thermal control		
solar panels	6KW	4.5KW
Mass	6800kg	4470kg
Atlas V		
Launch Vehicle fairing	5*19m	4*11m
BCD schedule	77 months	58 months

- 30% reduction in mass
- Greatly reduced mechanisms (due to removal of second guide interferometer)
- Reduction in instrument complexity

SIM “Lite” satisfies Decadal Goals

Option	WA Perf	NA Perf
NRC Decadal	*10 μas (4 μas)*	*3 μas (1 μas)*
SIM Planet Quest	2.4 μas	0.7 μas
SIM Lite	4.0 μas	1.0 μas

SIM: Mature, Robust, Affordable

- SIM is technically ready to enter Phase C/D now
  - Result of $500M/10-year investment to complete technology and design
- New technological gains make it possible to achieve previous goals but at reduced cost
- SIM is non-pareil in astrometry
  - Earth-mass planets in Habitable Zone
  - Measure of the Galaxy
  - Dynamics of the Local Group
- SIM and GAIA can make the next decade the “Decade of Astrometry”

THE END