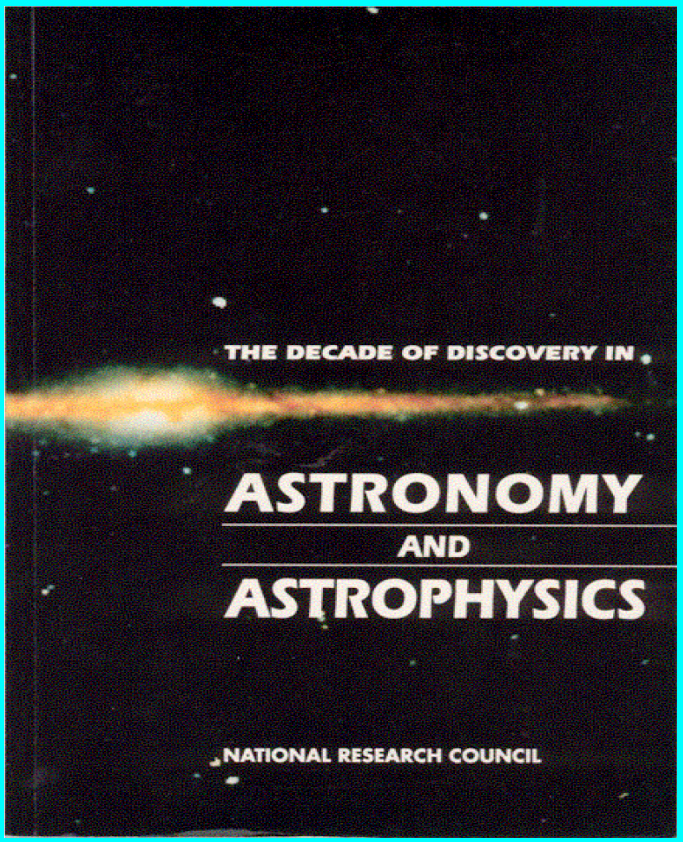

Taking the Measure of the Universe…
Space
Interferometry
Mission

"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.*"

“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

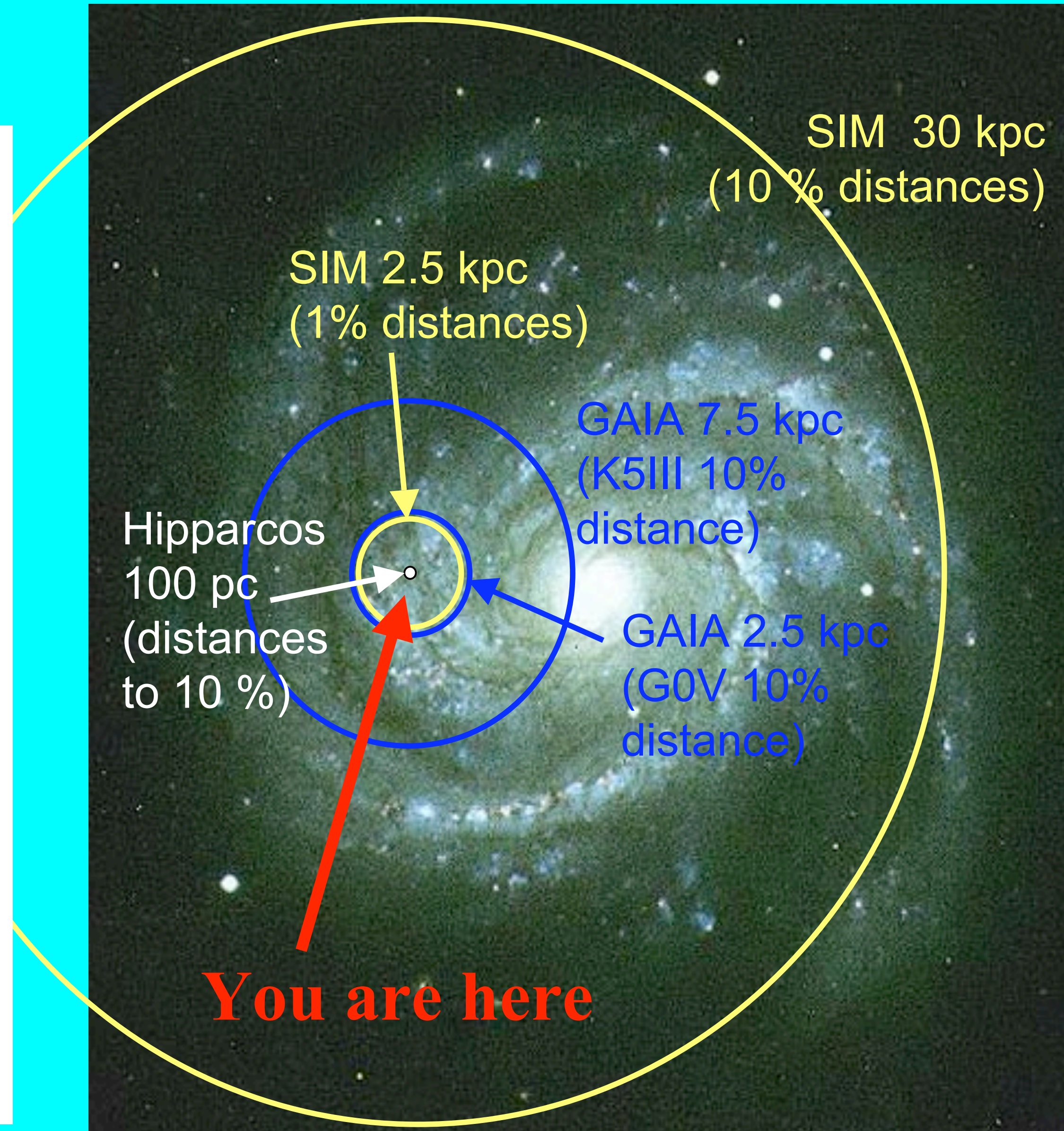
- SIM is a “distance measuring” machine
  - Poorly understood objects
  - New classes of objects, transients (e.g. PanSTARRS, LSST)
  - Rare objects (Neutron Star Systems, Black Hole Systems)
- A “Distance Determination” Key Project will constitute a powerful legacy to astronomy

SIM & Gaia: Synergy

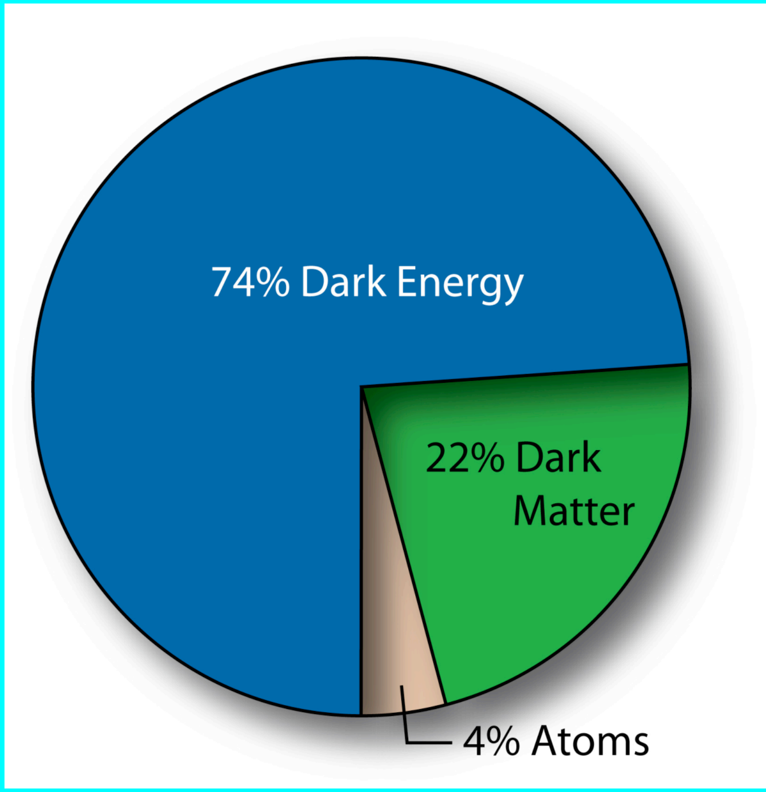
- Gaia is the Survey Machine
  - E.g. the Palomar Sky Survey
  - E.g. Sloan Digital Sky Survey
- SIM is the Observatory
  - E.g. Keck Observatory
    Hubble Space Telescope

SIM's Reach: the Galaxy

- Extreme astrometric precision
  - 4 μas
  - 4 μas/yr
  - 1 μas differential
- Ability to observe faint targets
  - V <~ 20
- Flexible scheduling



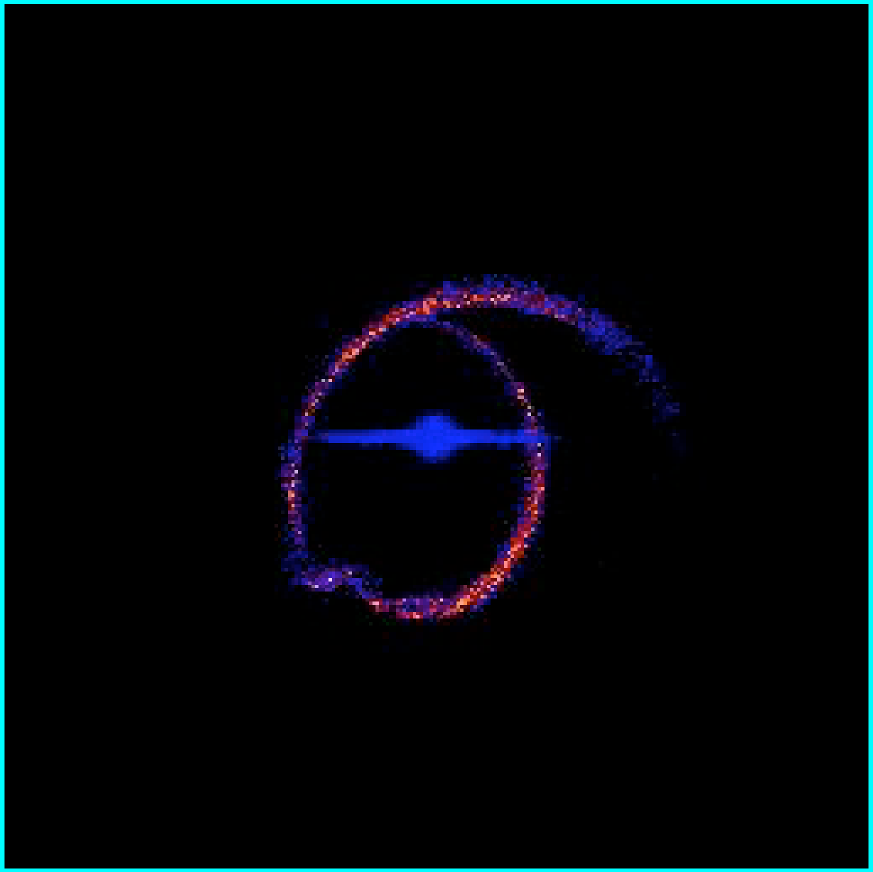
A COSMIC PROBLEM: The Ghost of Hubble (7% is not good enough)

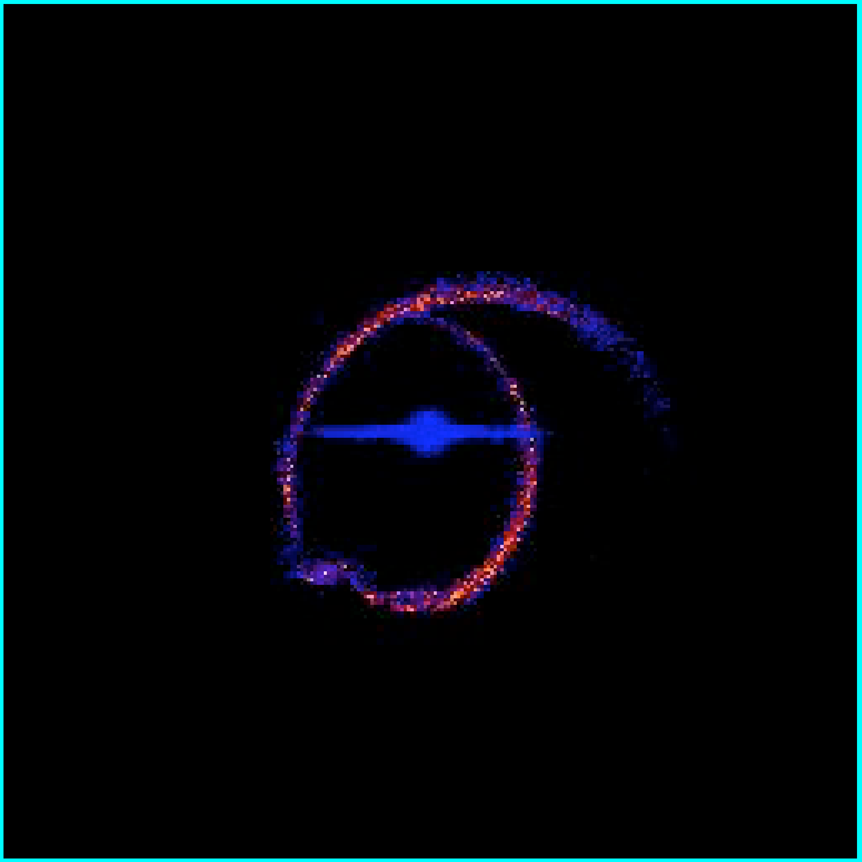


Precision cosmology is limited by precision (and accuracy) of Hubble's constant

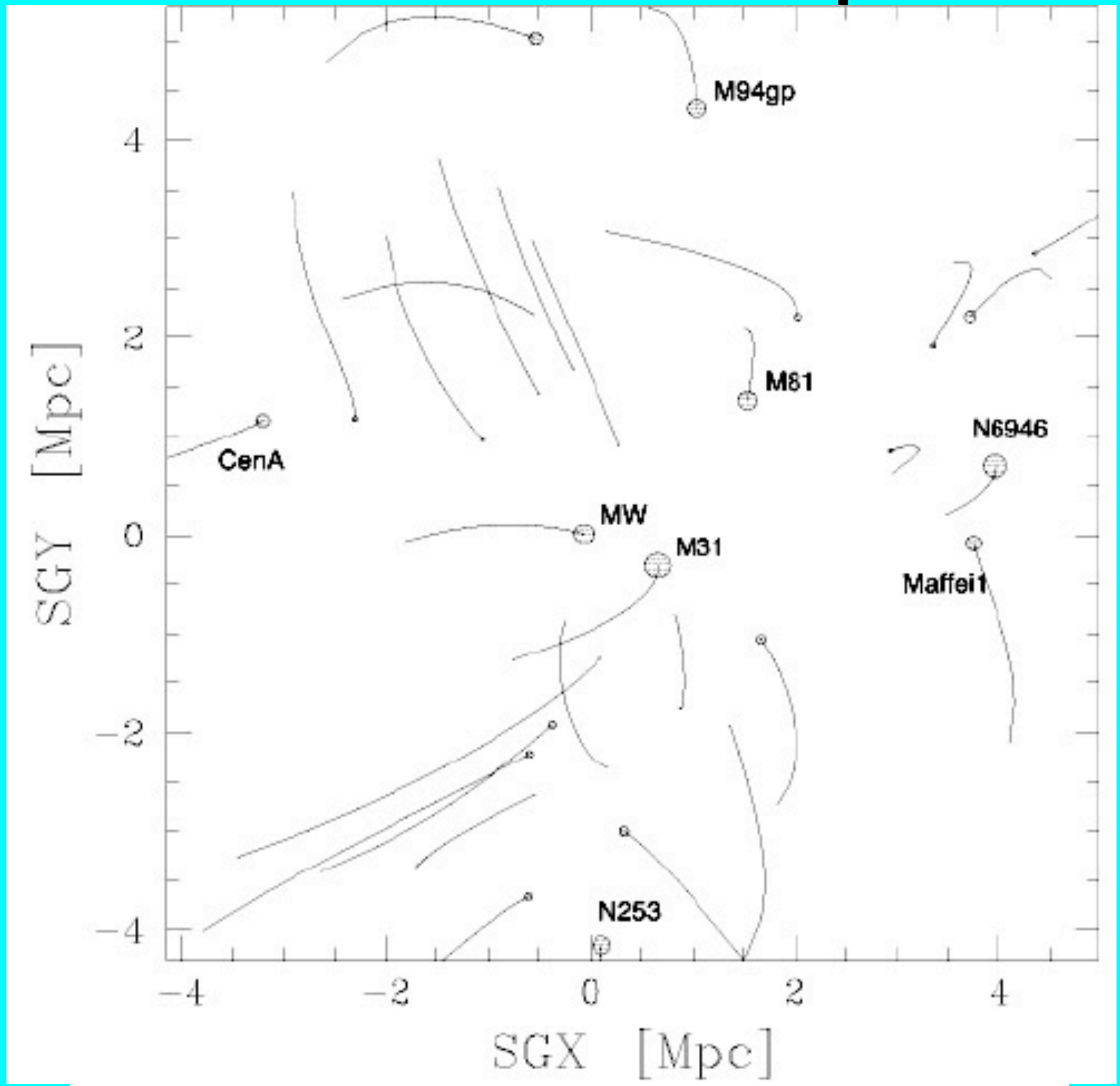
•SIM can undertake a thorough calibration of Galactic Cepheids
•SIM can measure the distances to M31 and M33 (rotational parallax)

Shape of our Galaxy



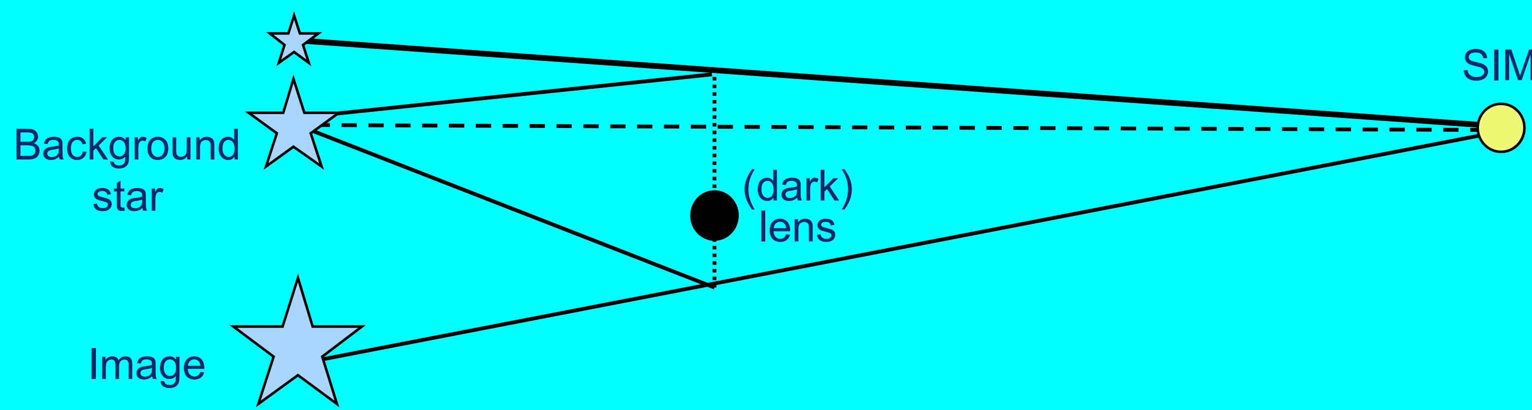


Matter Distribution of the Local Group



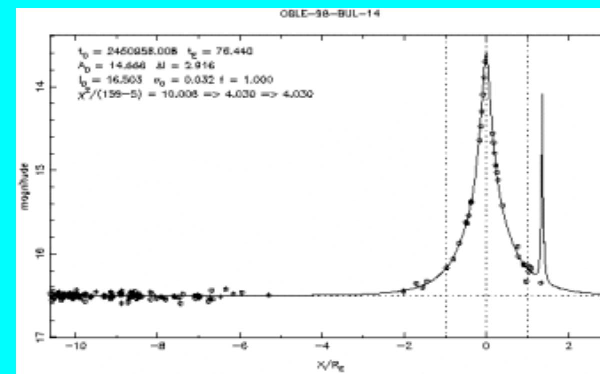
Simulated 1 Gyr trajectories of our neighbours

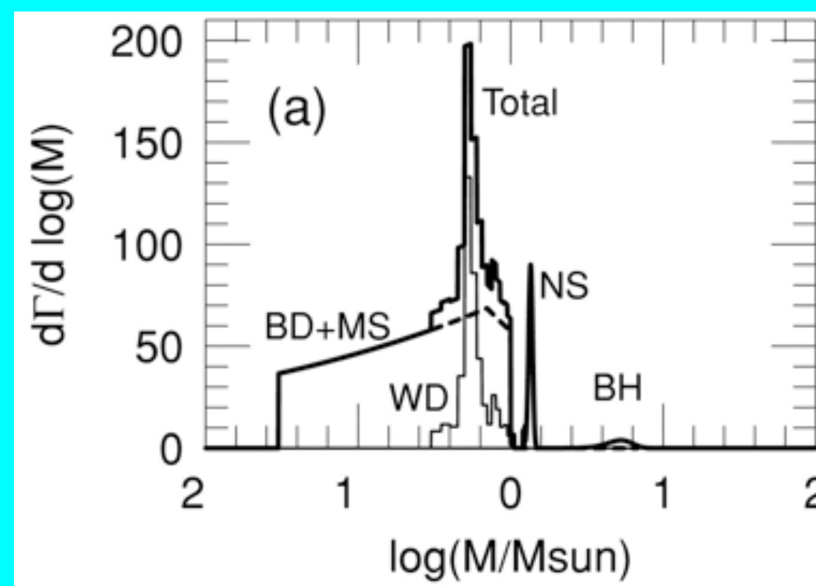
Using Gravitational Lenses to Probe 'Dark Matter'



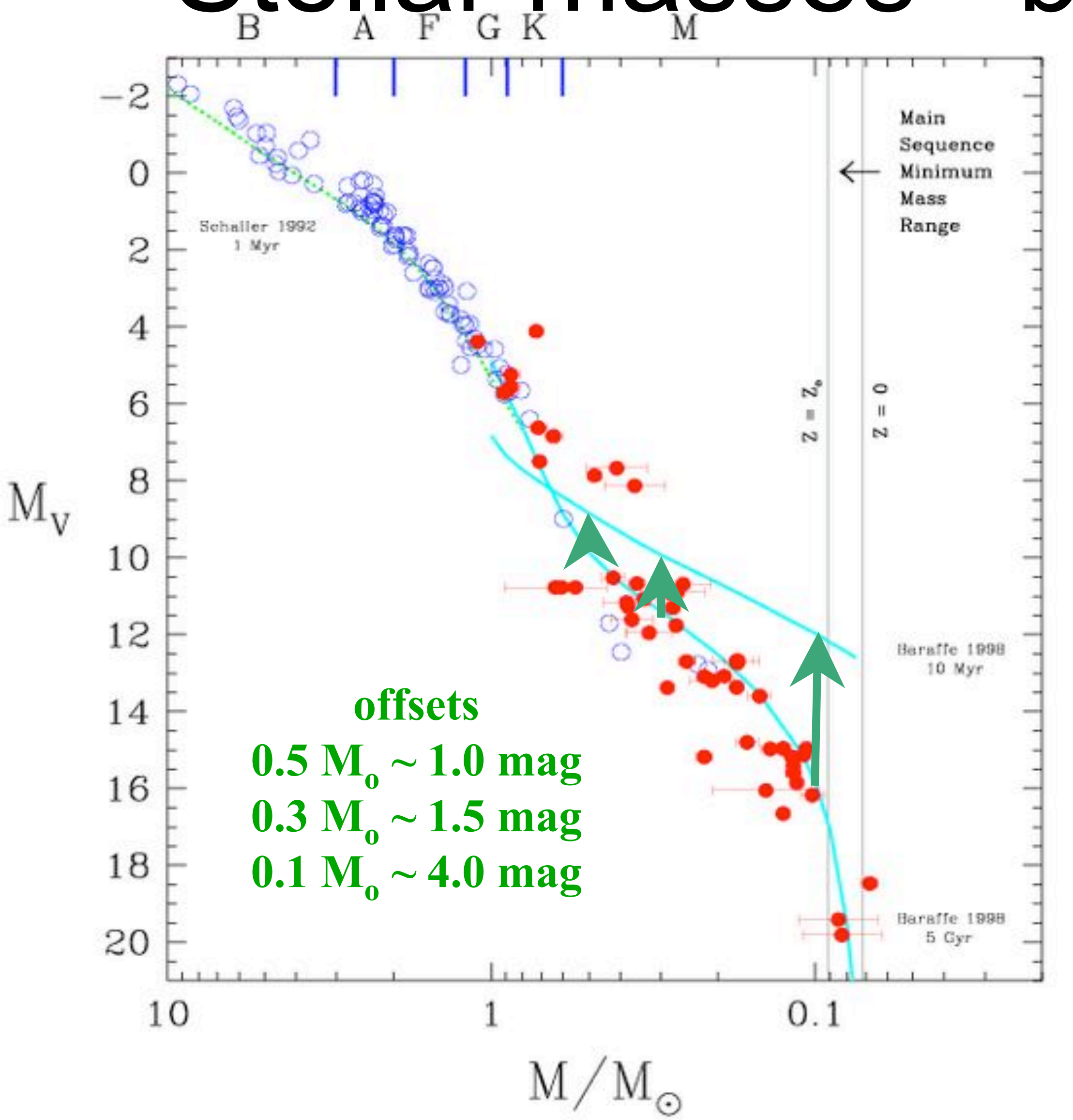
Using Gravitational Lenses to Probe 'Dark Matter'

- Events are detected by
  - Brightness enhancement (~days) – ground based
  - Astrometric perturbation (~weeks to months) – SIM, ~100 μas
- Symmetry of astrometric track 'broken' by Earth orbit motion due to lens parallax
  - Hence: distance to lens
- Derive:
  - mass, distance, and velocity of the lensing object
  - Mass function in the Galactic Bulge of (mostly) dark remnants





Stellar masses - big and small

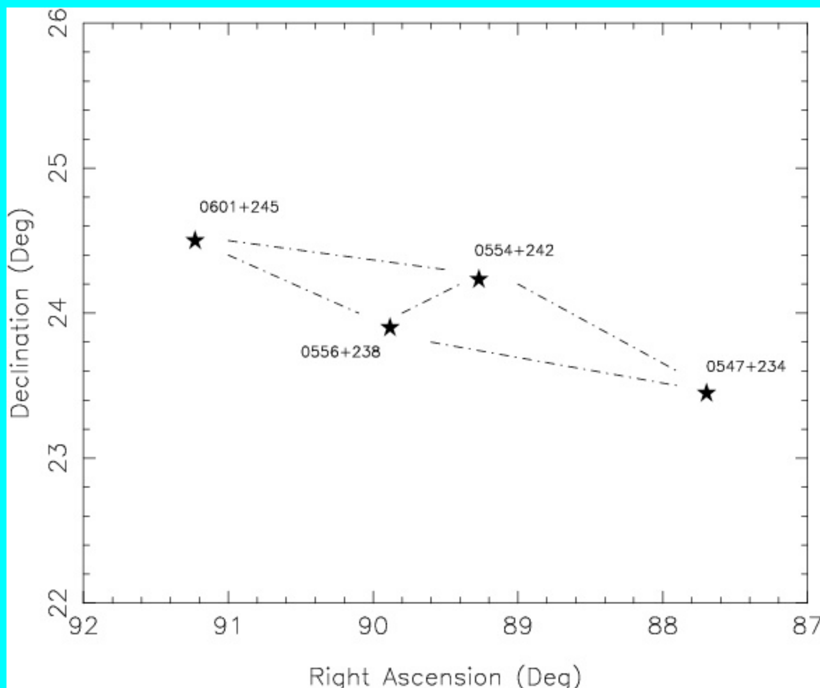


- O/B stars
  - quick evolution = lots of action
  - distances generally beyond GAIA reach
  - answers … what is the biggest star?
- Red dwarfs
  - age tells all
  - faint for GAIA, but not too faint for SIM
    - subdwarfs for metallicity axis
    - substellar is new territory
  - answers … what is the smallest star?

Fundamental Astronomy & Fundamental Physics

- 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
    - Determine the mass scale for QPOs
  - Neutron stars … Lab for dense matter (e.g. Vela X-1 and equation of state)

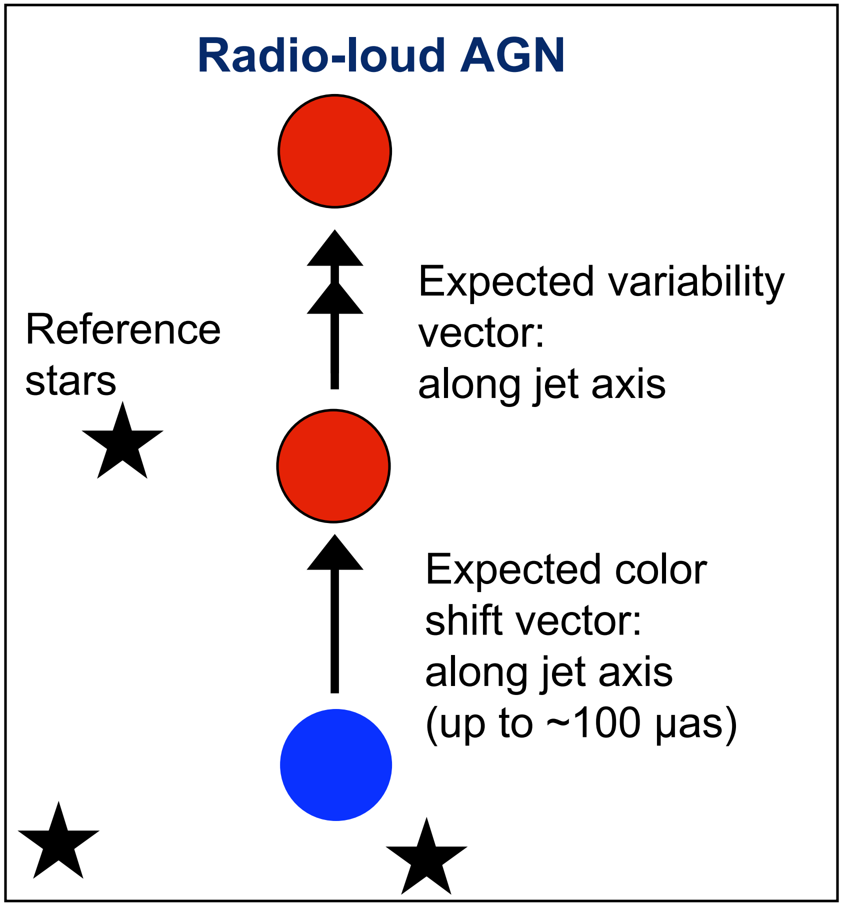
Quasar Reference Frame: SIM & ICRF

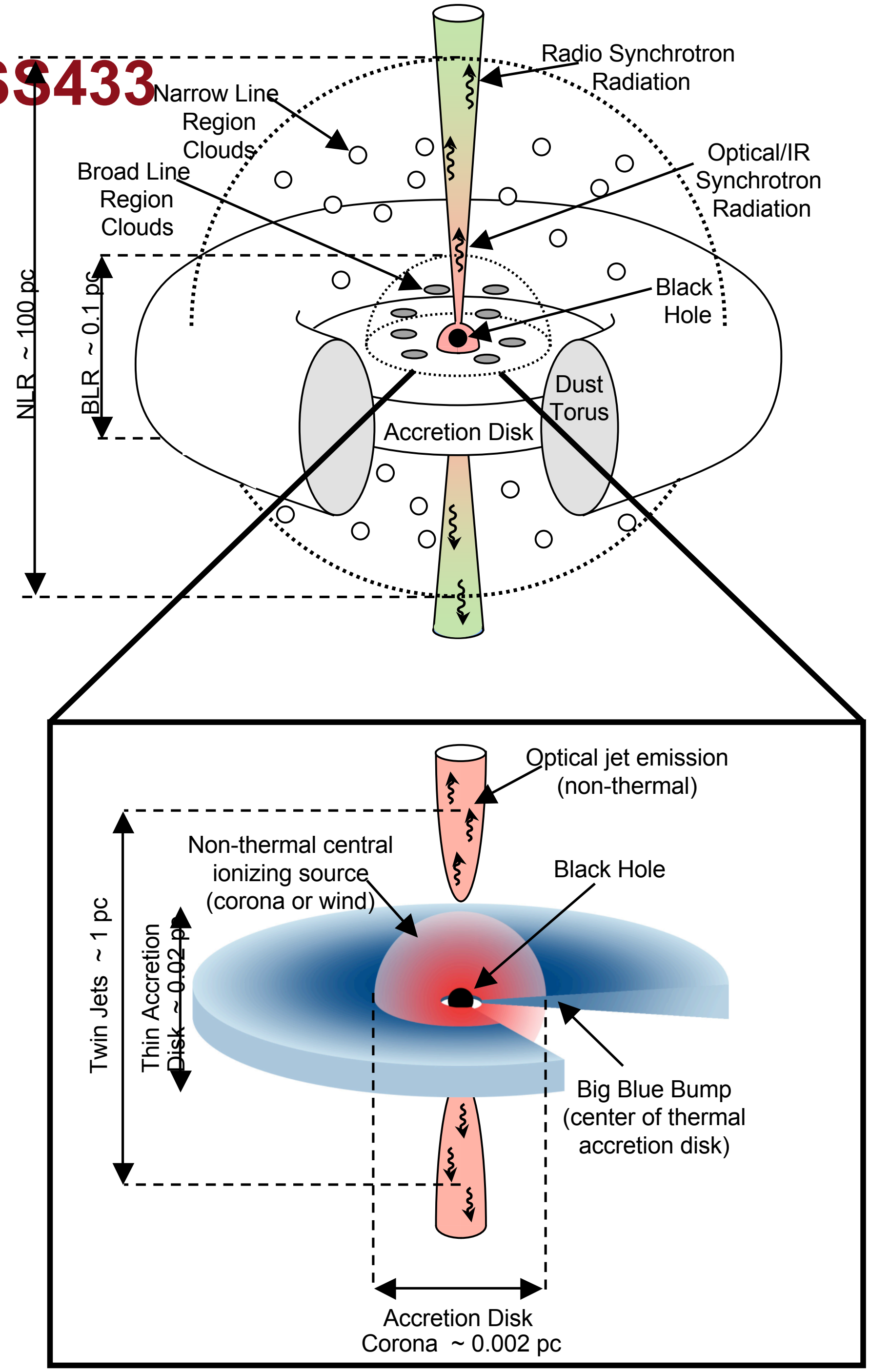


Relative quasar positions on the sky

- SIM will observe 50-100 quasars to define an inertial frame to 2 μas/yr
- Radio-loud (ICRF) quasars will provide registration to the ICRF to < 20 μas

Launching of Jets: Quasars & SS433

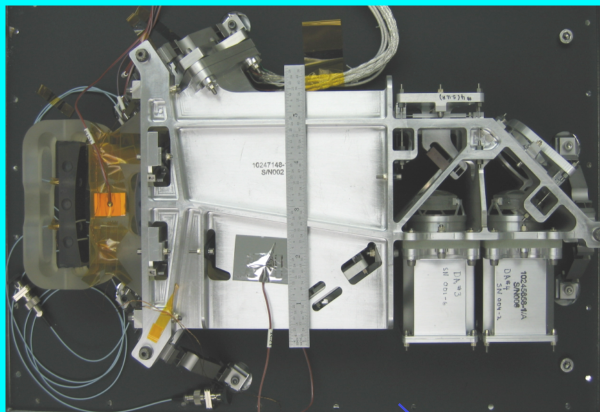




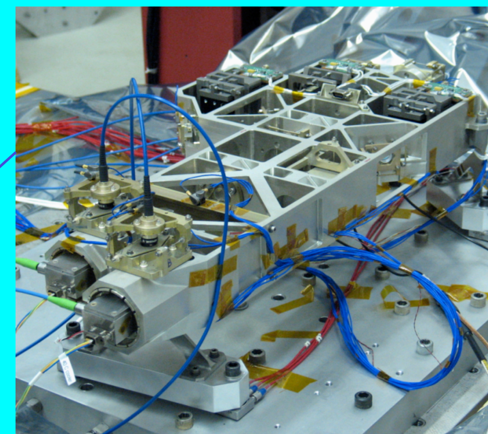
Emerging Applications

- Realize the full potential of Kepler Mission
  - Radius of target stars
  - Precision Mass-radius relation for white dwarfs
- Physics of newly discovered classes of objects and transients
- High Velocity Stars as probes of our Galactic Halo
- Determine whether CDM is cusped or not

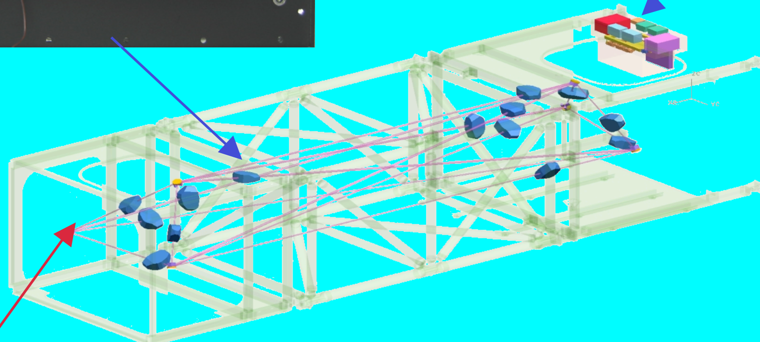
2005: We were ready!

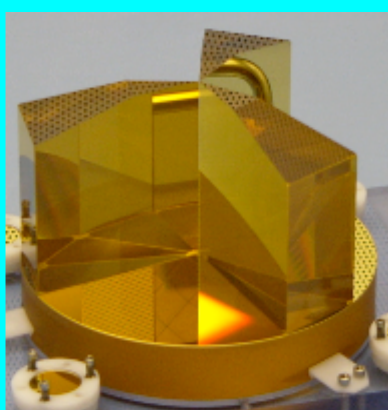


External Metrology Launcher

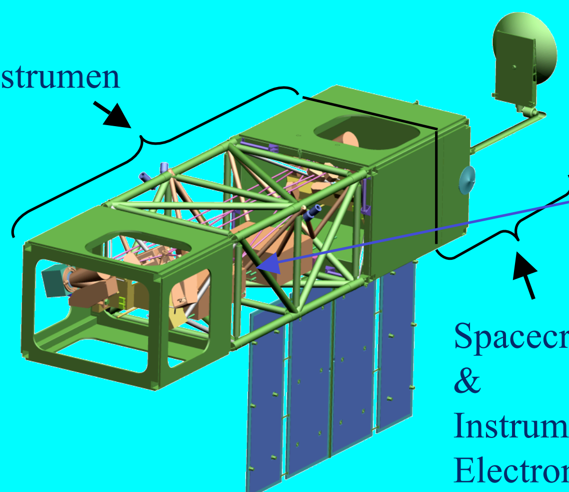


Metrology Source



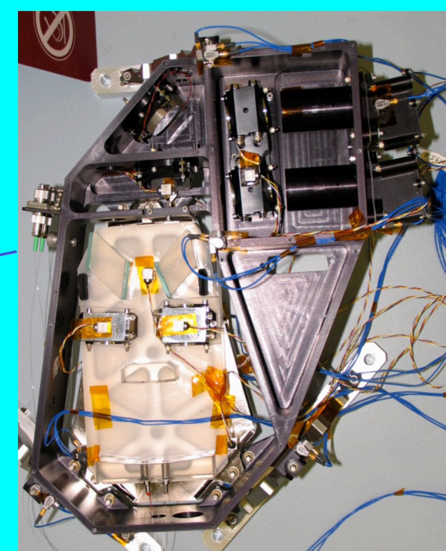


Double Corner Cube



Instrumen
t

Spacecraft
&
Instrument
Electronics



Internal Metrology Launcher

Nanometer Control & Picometer Knowledge: Flight Ready Hardware

THE END