Astronomical Telescopes
and Instrumentation

JPL

SIM Science Operations

Stephen Unwin

Deputy Project Scientist
Space Interferometry Mission

August 26, 2002

Summary

- How does SIM make science measurements?
  - SIM science is derived from precision astrometry
  - SIM is fundamentally a differential instrument
- Instrument field of regard: the *tile*
- Building the all-sky *astrometric grid*
  - Covering the sky with tiles
  - Frame tie using quasars
- Design of observations for global astrometry
  - Parallax and proper motion
- Design of observations for narrow-angle astrometry
  - Astrometric planet searches
- Science scheduling
  - SIM is a pointed instrument
    - but is not scheduled like an 'observatory' mission
  - Shares features in common with astrometric surveys

SIM Science Team

Key Science Projects

Names	Institutions	Topic
Dr. Geoffrey Marcy	University of California, Berkeley	Planetary Systems
Dr. Michael Shao	NASA/JPL	Extrasolar Planets
Dr. Charles Beichman	NASA/JPL	Young Planetary Systems and Stars
Dr. Andrew Gould	Ohio State University	Astrometric Micro-Lensing
Dr. Edward Shaya	Raytheon ITSS Corporation	Dynamic Observations of Galaxies
Dr. Kenneth Johnston	U.S. Naval Observatory	Reference Frame-Tie Objects
Dr. Brian Chaboyer	Dartmouth College	Population II Distances & Globular Cluster Ages
Dr. Todd Henry	Georgia State University	Stellar Mass-Luminosity Relation
Dr. Steven Majewski	University of Virginia	Measuring the Milky Way
Dr. Ann Wehrle	NASA/JPL	Active Galactic Nuclei

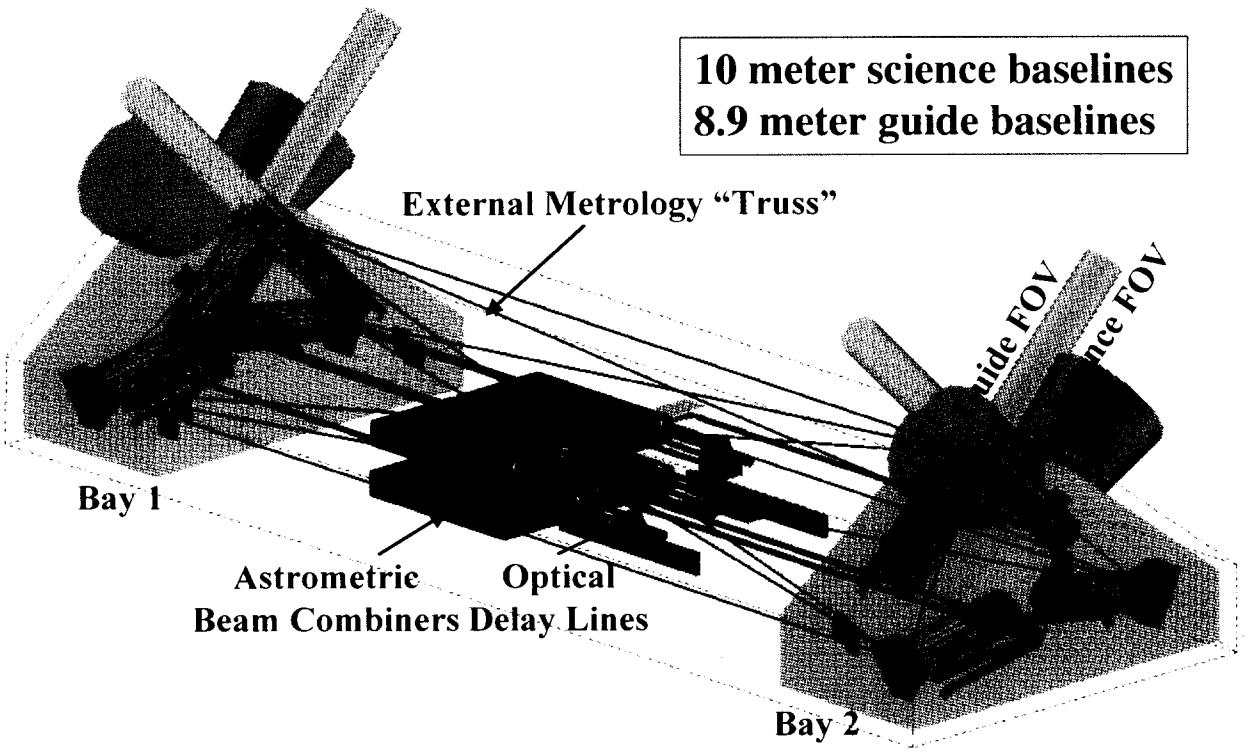
Mission Scientists

Dr. Guy Worthey	University of Washington	Education & Public Outreach Scientist
Dr. Andreas Quirrenbach	University of California, San Diego	Data Scientist
Dr. Stuart Shaklan	NASA/JPL	Instrument Scientist
Dr. Shrinivas Kulkarni	California Institute of Technology	Interdisciplinary Scientist
Dr. Ronald Allen	Space Telescope Science Institute	Synthesis Imaging Scientist

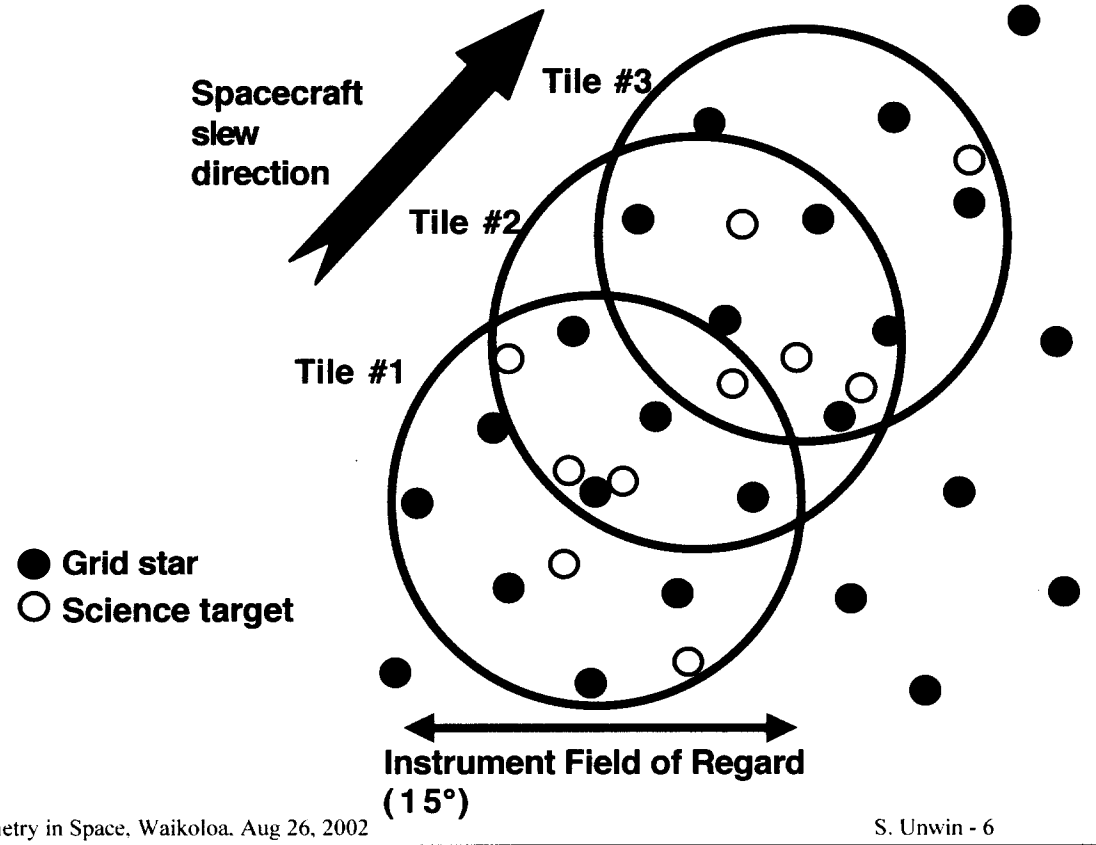
SIM Science Program

- Visit the SIM display at the "Planet Quest" booth
- More information on SIM at:
  `http://sim.jpl.nasa.gov`
- See *"Science with SIM"* handout
  - Excellent 2-3 page summaries of each Key Project
  - PDF version at: **`http://sim.jpl.nasa.gov/library`**

SIM instrument layout



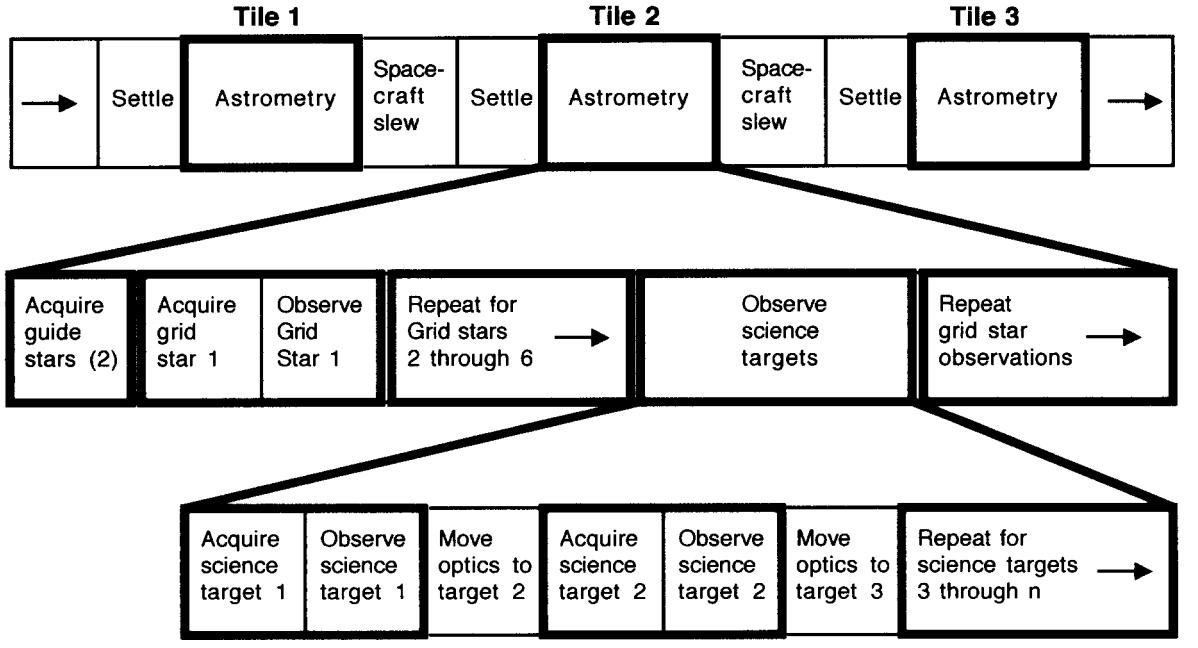
Wide-angle observing scenario



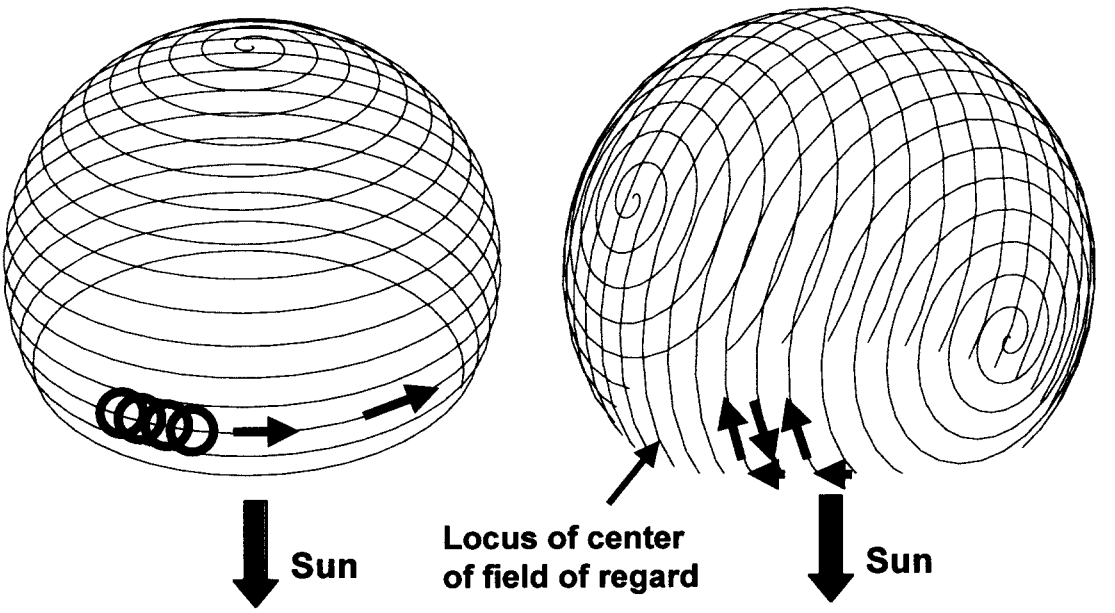
Wide-angle Astrometric Measurements

- Two-dimensional position measurements
- Measured (ideally) in an *inertial* reference frame
- (most) science is in *time-variability* of positions
  - Hence need long mission lifetime (>= 5 years)
- 5 basic astrometric parameters
  - Position in RA and declination
  - Proper motion in RA and dec
  - Parallax
  - (optional: accelerations in RA and dec)
- Challenge:
  - Astrometric accuracy depends on a very large number of measurements
  - Control of systematic errors:
    - Angular ('zonal errors')
    - Instrument thermal drifts

Wide-angle (global) observation timeline



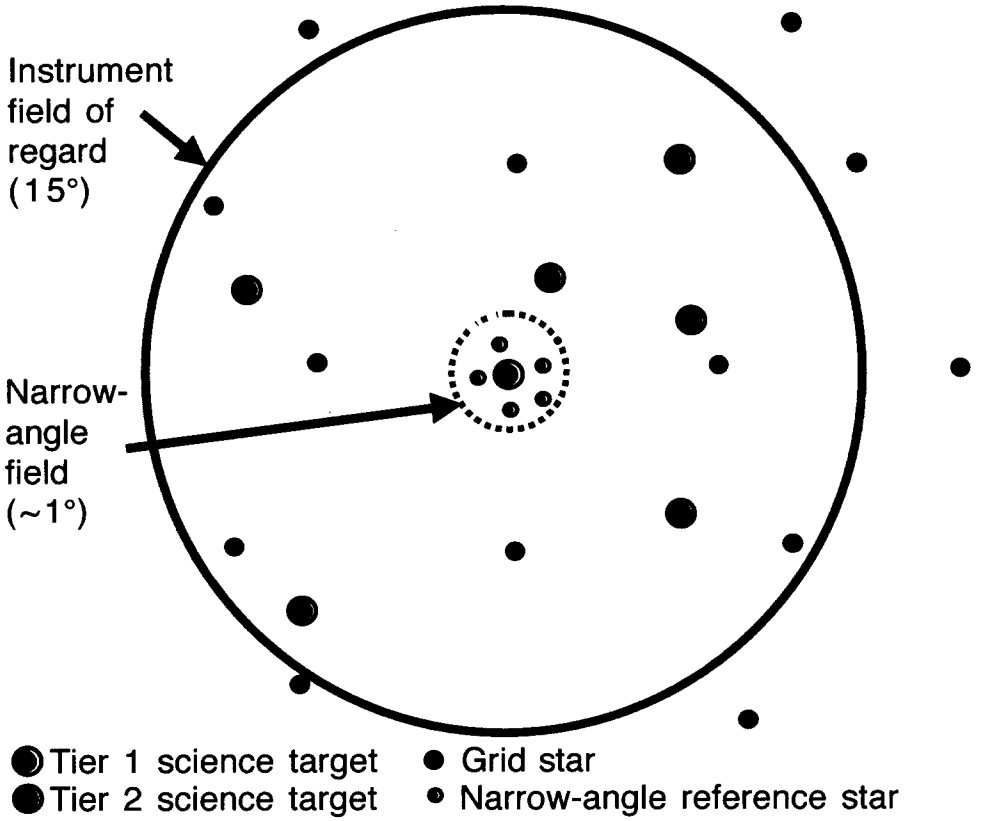
Covering the sky with tiles



Narrow-angle Astrometric Measurements

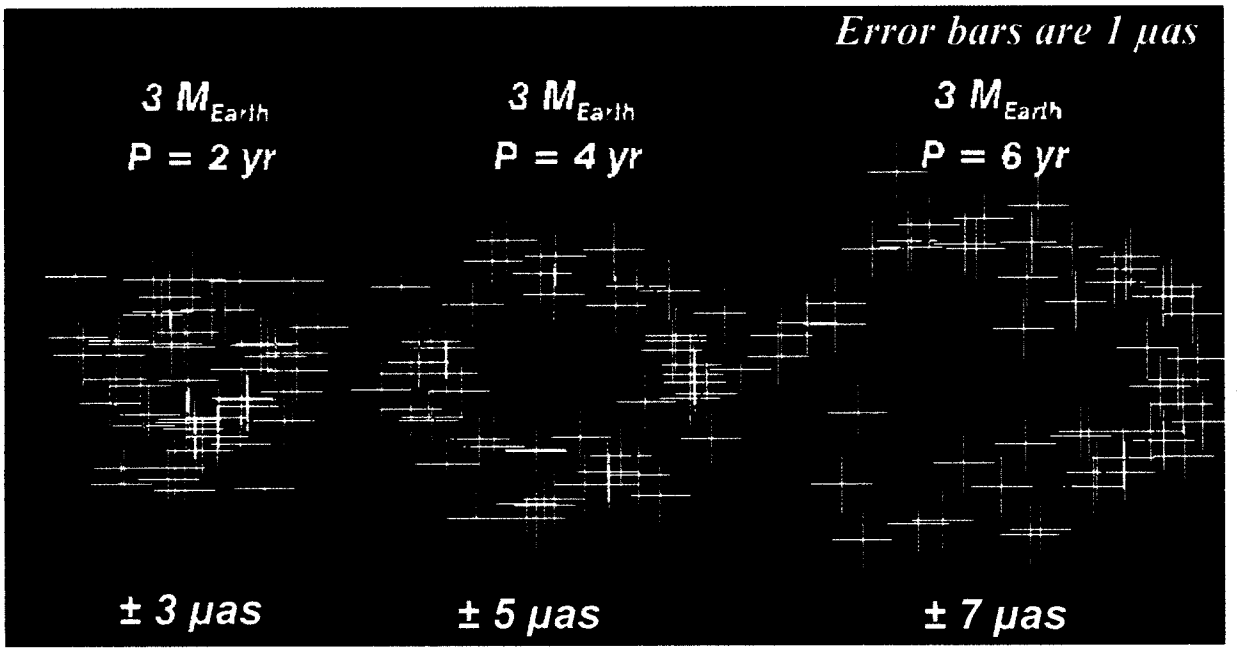
- Two-dimensional position measurements
  - Measured in a *local* reference frame
- For planet searches, science is in *time-variability* of positions
  - Position, parallax and proper motion are 'nuisance parameters'
- For Quasar astrometry, science is in the *proper motions*
  - Parallax is unmeasurably small
  - Absolute positions not significant
  - Hence can do relative astrometry (but over selected quasars over the whole tile) Some timeline are more constrained Some timeline are more constrained Some timeline are more constrained

Narrow-angle tile



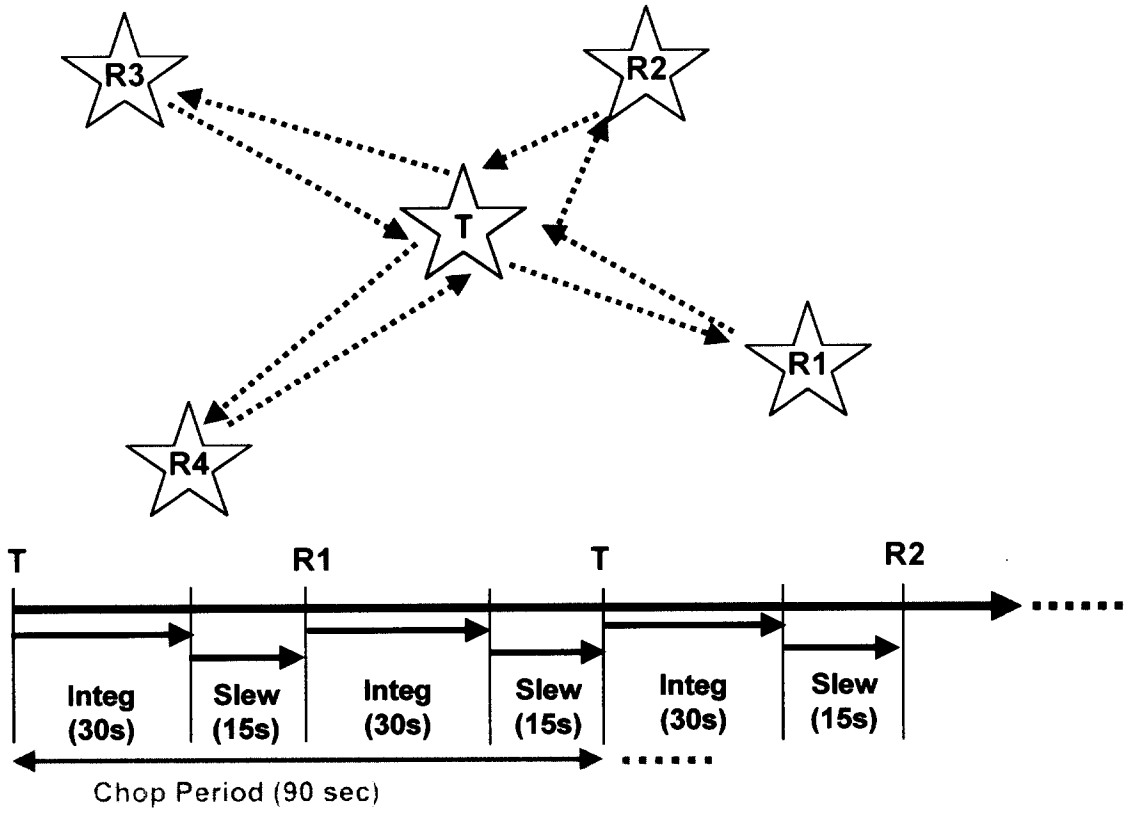
Astrometry at 1 μas precision

Performance worth waiting for…
dynamical masses of terrestrial planets

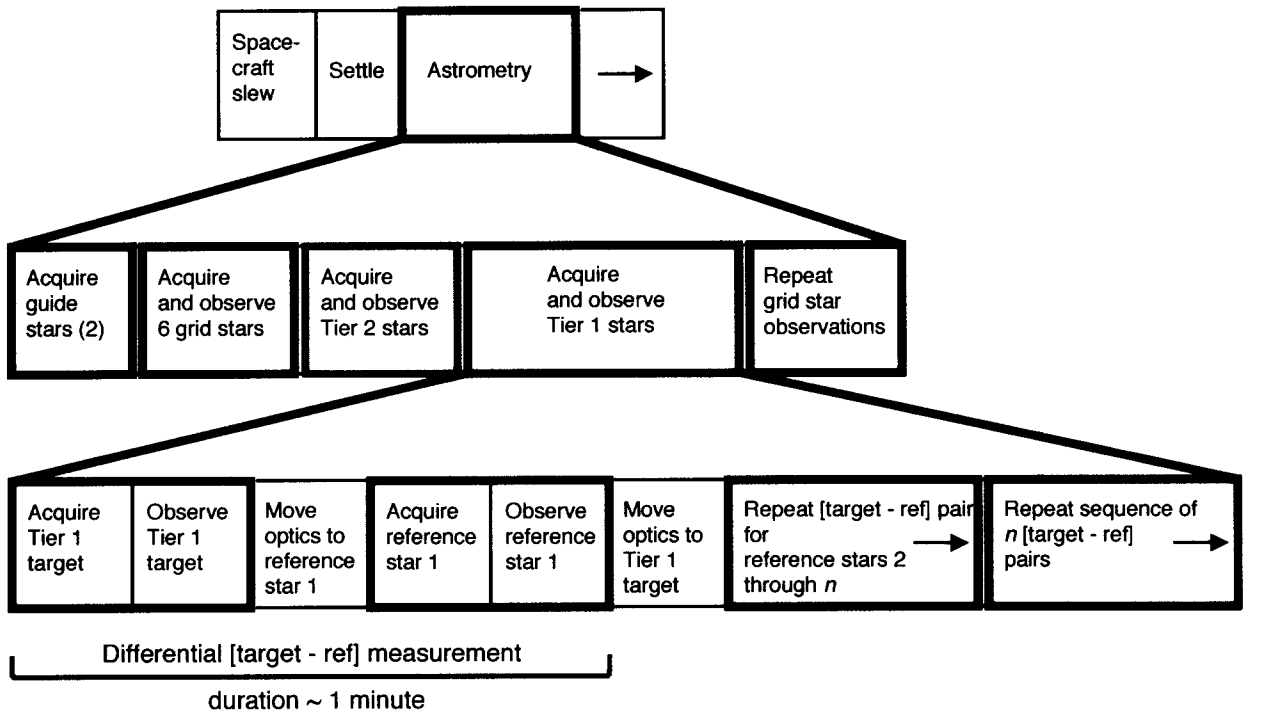


Simulation of detection of terrestrial planets around stars at 5 pc

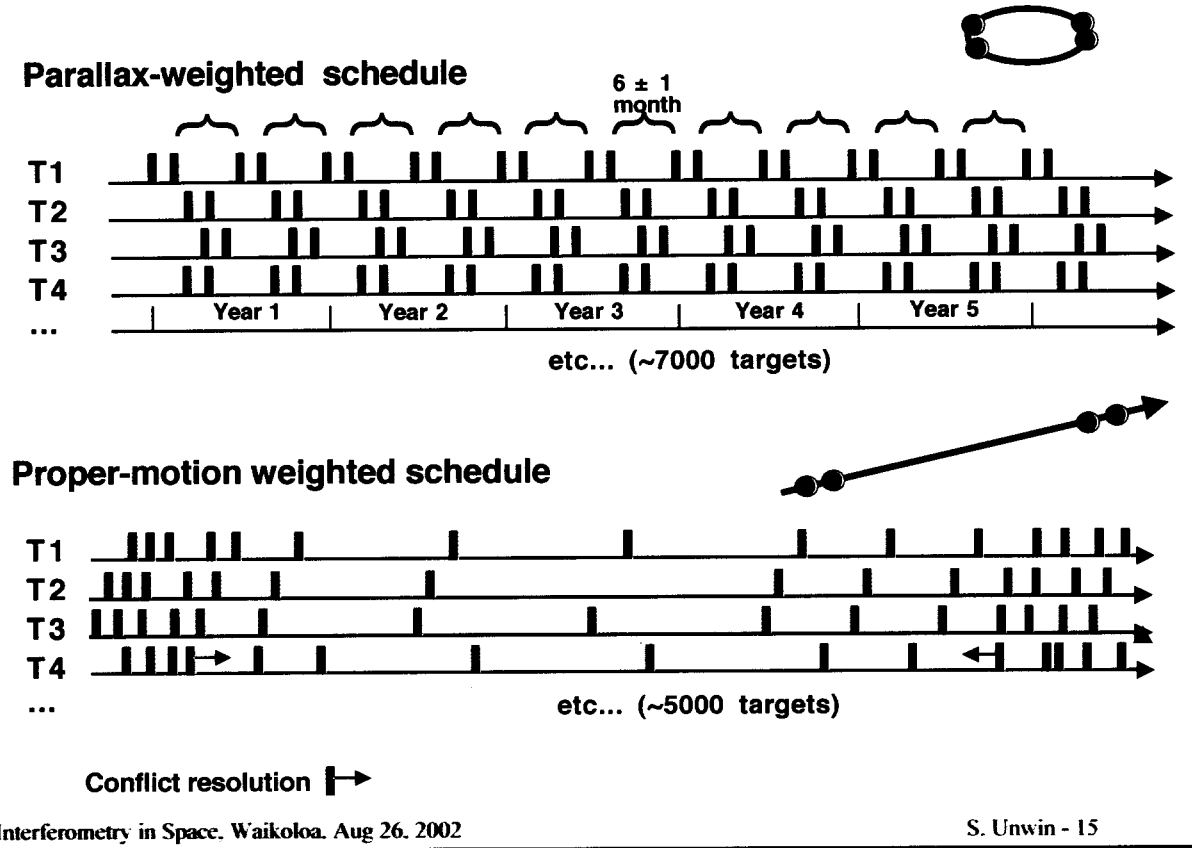
Narrow angle 'chopping'



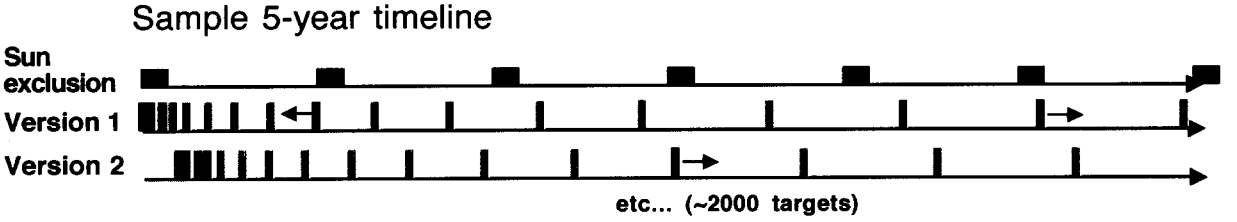
Narrow-angle observation timeline



Long-term Timeline



Planet-search Timeline



- Some timelines are more constrained:
  - Planet searches over a wide period range (logarithmic sampling)
  - Binary star orbits
  - Microlensing events
- May be easier to 'slide' the entire timeline for a target to avoid major conflicts
- Many planet-search targets will be scheduled by grouping on the sky
  - Tile-oriented scheduling of ~10 targets with same sampling

Conclusions

- SIM science experiment design is driven by the instrument operation and observing mode
  - 'Tile'-oriented design
- Science scheduling
  - SIM is a pointed instrument
    - But is not scheduled like an 'observatory' mission
  - Shares features in common with astrometric surveys
- Efficient scheduling requires the merging of > 15000 individual timelines, each with its own preferred time sampling and constraints
  - Minimize slews by a 'Traveling Salesman' approach