



Laser Metrology for Segmented Telescopes

CCAT

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Laser Metrology at JPL



- ◆ Metrology enables
 - Stellar interferometry
 - ◆ Space Interferometry Mission
 - ◆ 10^{-12} m resolution, ~2 m range
 - ◆ New designs
 - For next-generation segmented telescopes
 - ◆ Terrestrial Planet Finder
 - ◆ SAFIR, SMLS, ...
 - ◆ CCAT
 - Absolute distance measurement

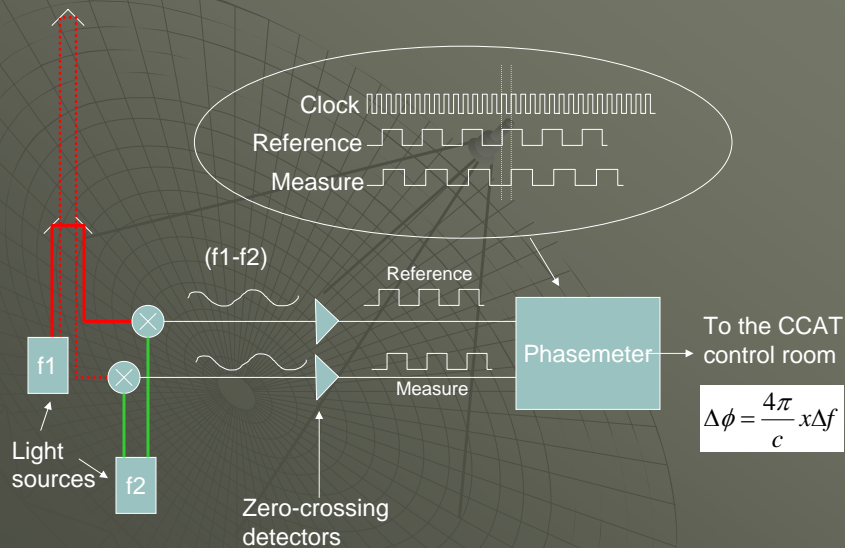
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- ◆ Working prototypes
 - Hardware
 - ◆ Optics, mounts, electronics
 - Procedures
 - ◆ Assembly, alignment, calibration
- ◆ CCAT
 - Cost estimates and risk assessment
 - Integration
 - ◆ Software, implementation plan, manufacturing approaches

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Relative Distance Measurement



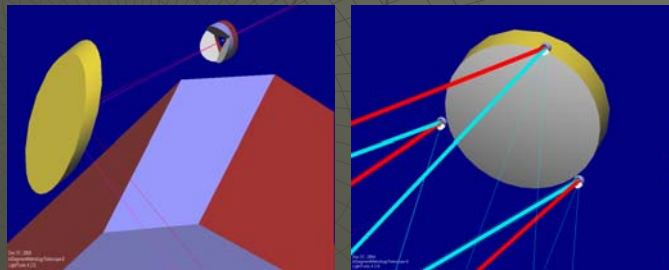
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CoPHI for Accurate Differential Displacement



◆ Common Path Heterodyne Interferometer

- Two concentric beams
 - ◆ “Near” reference point – outside, at the primary
 - ◆ “Far” reference point – inside, at the secondary
- Drill a hole in a corner cube on the primary mirror
- Reflect off a corner cube on the secondary mirror



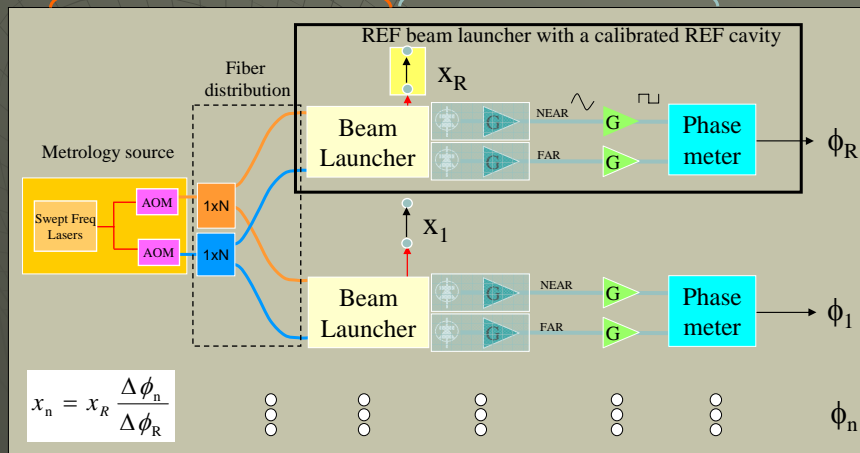
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Swept Frequency Laser for Absolute Distance



Optical Domain

Electrical Domain

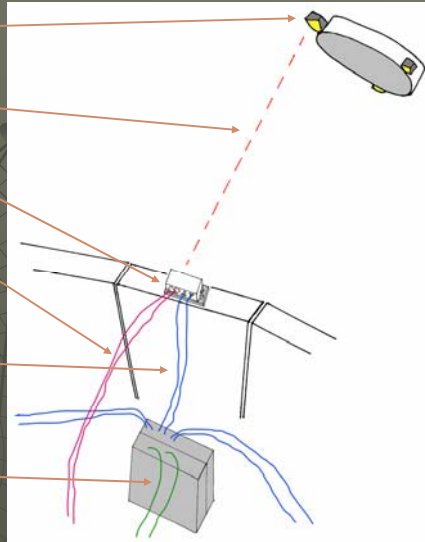


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Concept Design



- ◆ Three corner cubes attach to the secondary mirror.
- ◆ The collimated visible beam doesn't interfere with astronomy.
- ◆ Beam launchers attach to the primary mirror segments.
- ◆ Each beam launcher needs two fiber optic cables. Light comes from a laser in the control room.
- ◆ Photodiodes are powered by low-power phasemeter boxes throughout the telescope truss.
- ◆ Minimal cabling connects the phasemeter boxes with the control room.

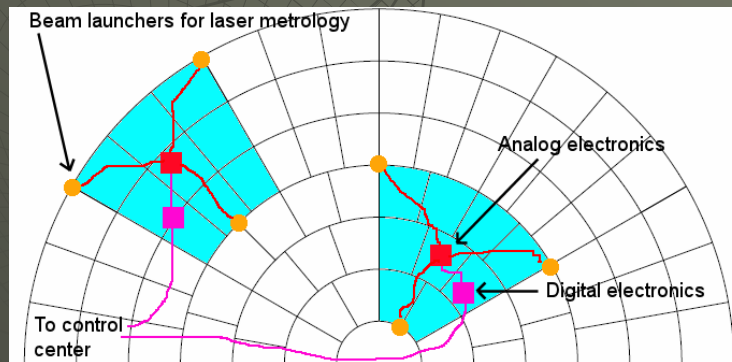


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Concept Deployment



- ◆ **How many beams?**
 - **Probably between 6 and 120**



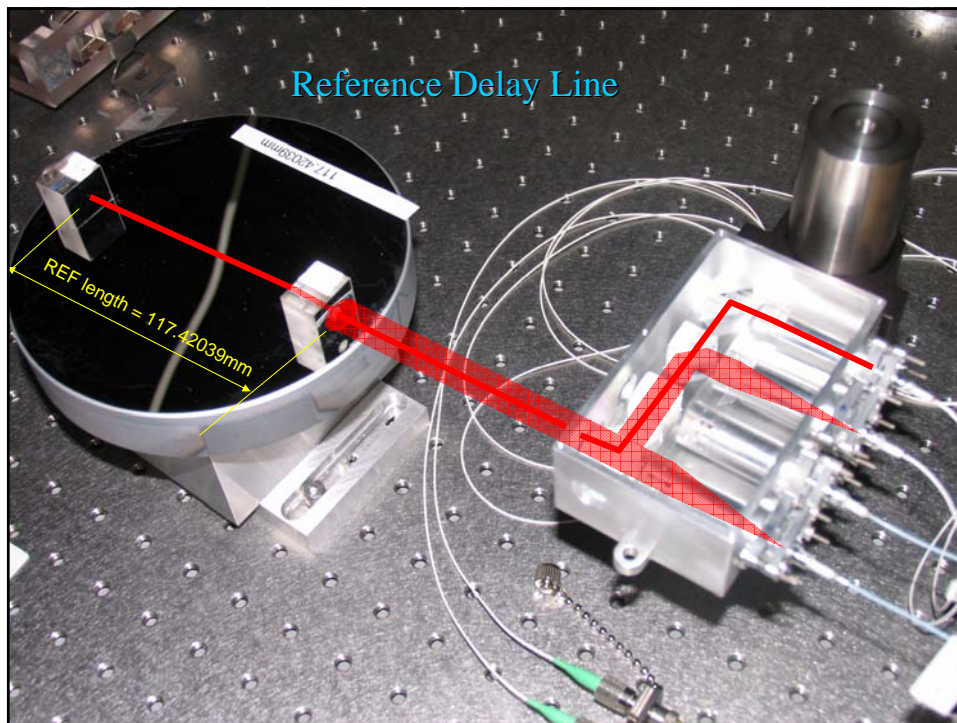
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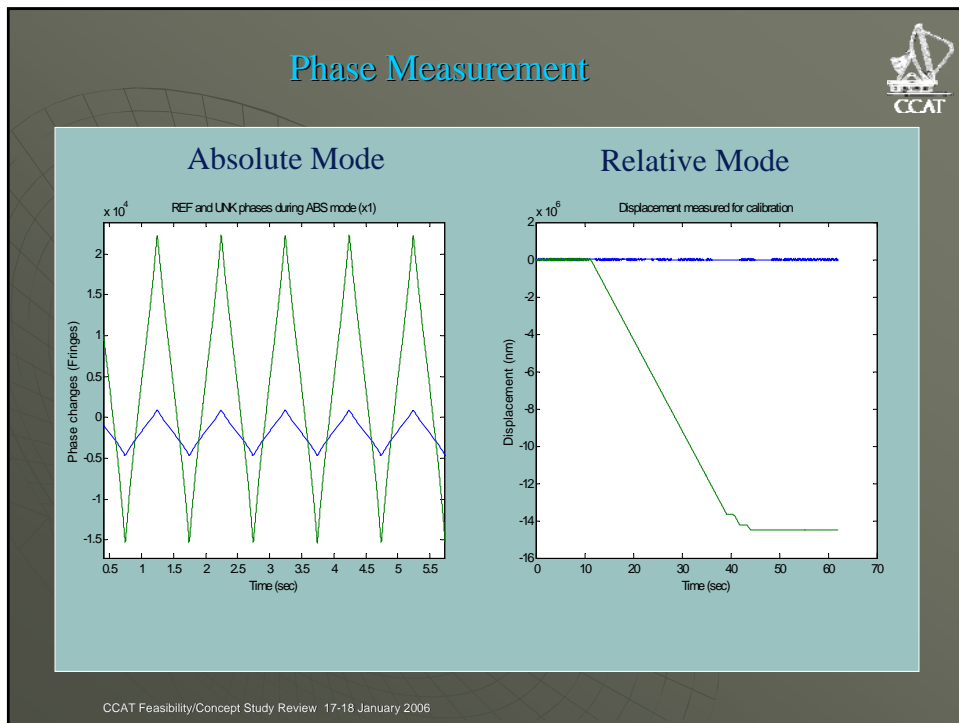
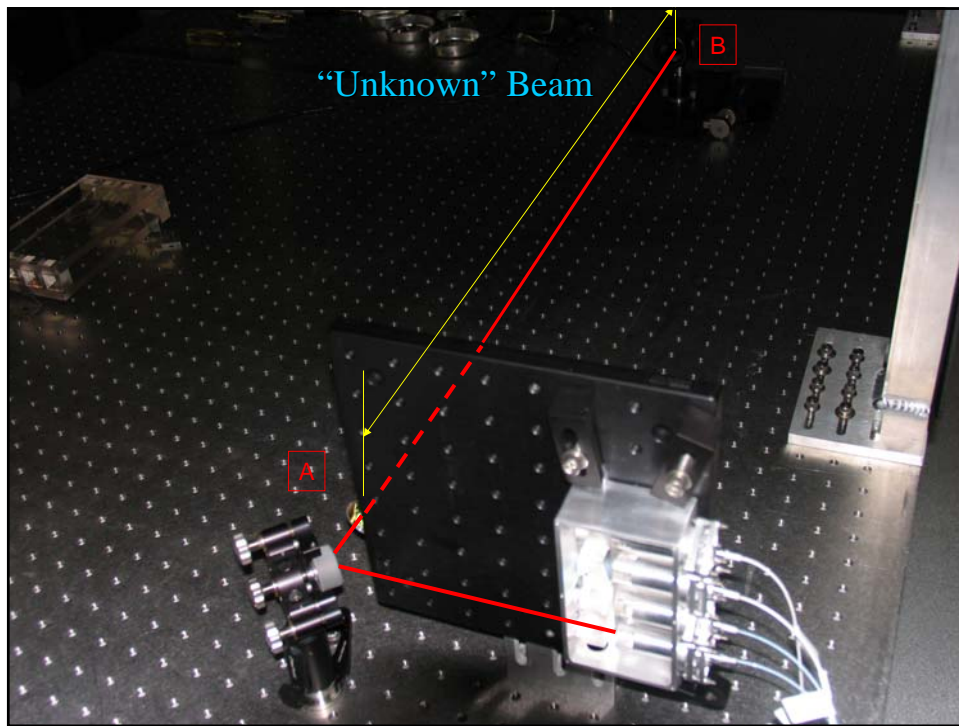
Key Tradeoffs



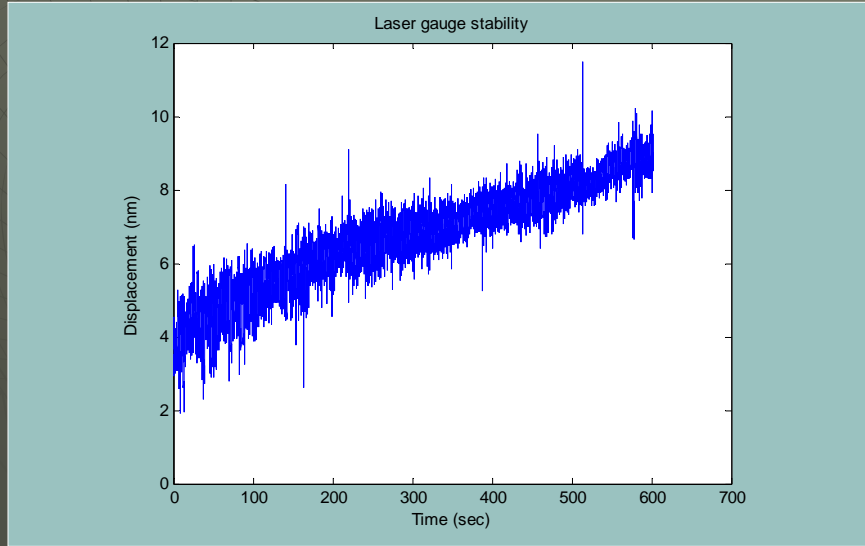
- ◆ **How many beam launchers?**
 - Trade with edge sensors.
- ◆ **Beam launcher manufacturing**
 - Assembly is difficult. Can JPL teach CCAT how to do it?
- ◆ **Beam launcher pointing**
 - Toleranced interface plates or adjustable fold mirrors?

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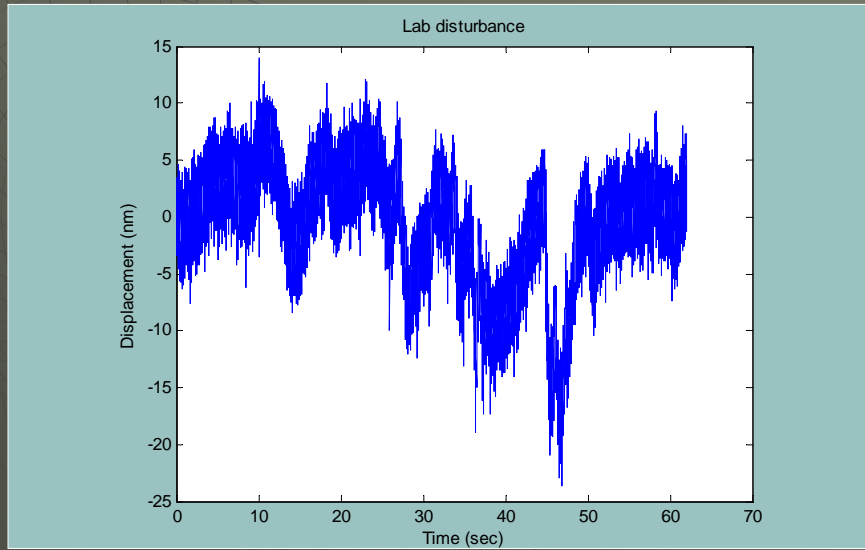


Background Noise

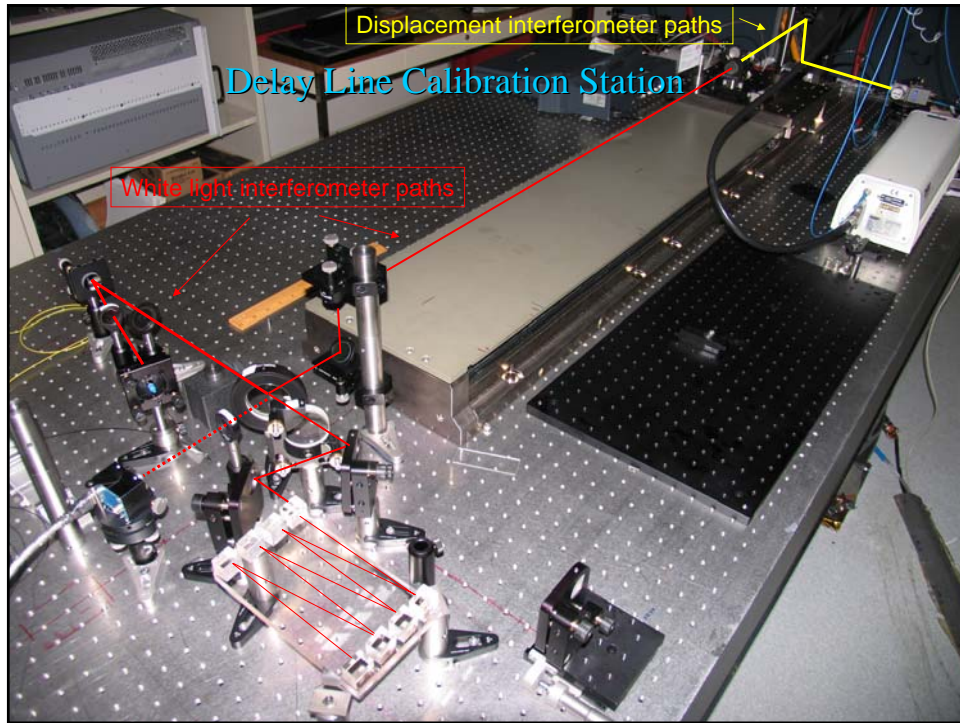


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Background Noise (linear fit subtracted)




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R&D Progress



- ◆ Working testbed.
 - 10^{-7} m resolution.
- ◆ External cavity controlled laser.



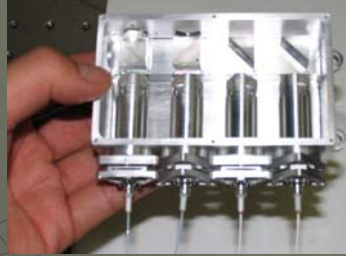
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The slide features a dark background with a grid pattern. It includes a logo for CCAT (Canadian Centre for Advanced Technology) in the top right corner. The main content consists of two bullet points describing the R&D progress. Below the text are two photographs: one showing a hand holding a green printed circuit board (PCB) with a white component, and another showing a server rack with a laptop and various cables.

R&D Progress



- ◆ **Beam launchers**
 - Fiber-fed
 - COTS optics
 - Thermally stable mounts and housing
- ◆ **Detector circuits**
 - Line noise filters
 - Automatic gain control

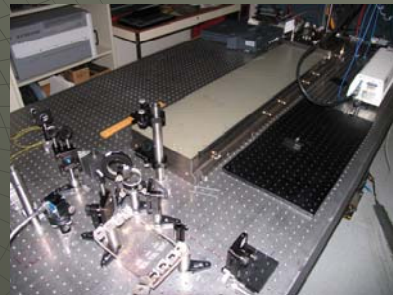


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R&D Progress



- ◆ **Phasemeter**
 - Re-implement SIM algorithms in low-cost FPGAs.
 - Communicate via ethernet.
- ◆ **Reference cavity**
 - Calibrated with white light to 10^{-6} .



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R&D Progress



◆ Software

- LabView panels track a phasemeter as the laser frequency sweeps
- Wrote C code for listening to next-generation ethernet-based phasemeters



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Moderate Risks



- ◆ Thermal stability
 - Needs further study
- ◆ Beam launcher assembly
 - Need more practice
- ◆ Software development
 - Integration into the CCAT servos
- ◆ Calibration
 - Define calibration requirements
- ◆ Air turbulence?

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