ALIGNMENT: WAVEFRONT SENSING
INTRODUCTION

Nergis Mavalvala
March 20, 1996

- For the LIGO interferometer, rms mirror misalignment or jitter of the input beam pointing of ~10^{-8} radians causes a 10% degradation of the GW signal
- 10^{-8} radians corresponds to 0.04 mm on a 4 km baseline
- Difficult to maintain in laboratory frame
- Alignment sensing and control (ASC) system needed

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DESCRIPTION

- Wavefront sensing
  - misalignment causes excitation of higher-order spatial modes
  - spatial sampling of the light using the same demodulation scheme as the length sensing and control (LSC) system
- Particularly attractive scheme since
  - reference axis is defined by the laser light incident on the interferometer
  - uses same optical modulation configuration as the LSC system
- But
  - requires LSC system to be operational

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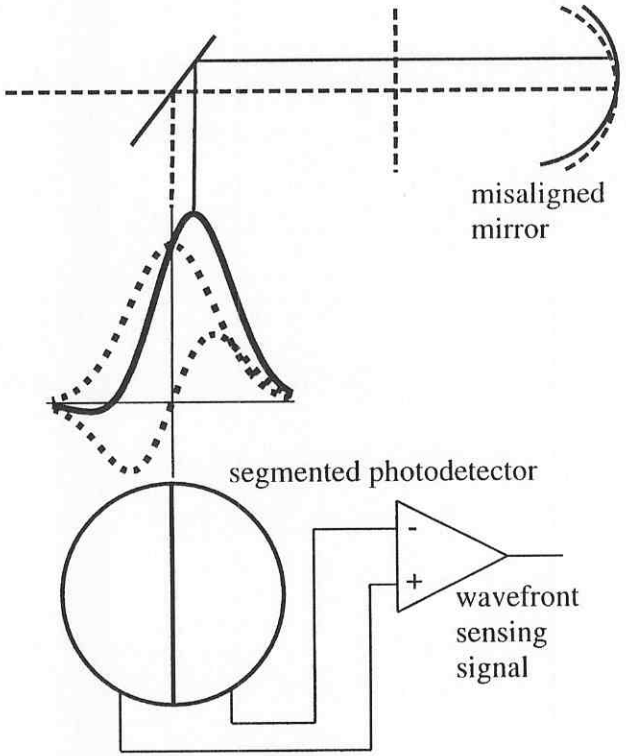
SCHEMATIC DESCRIPTION



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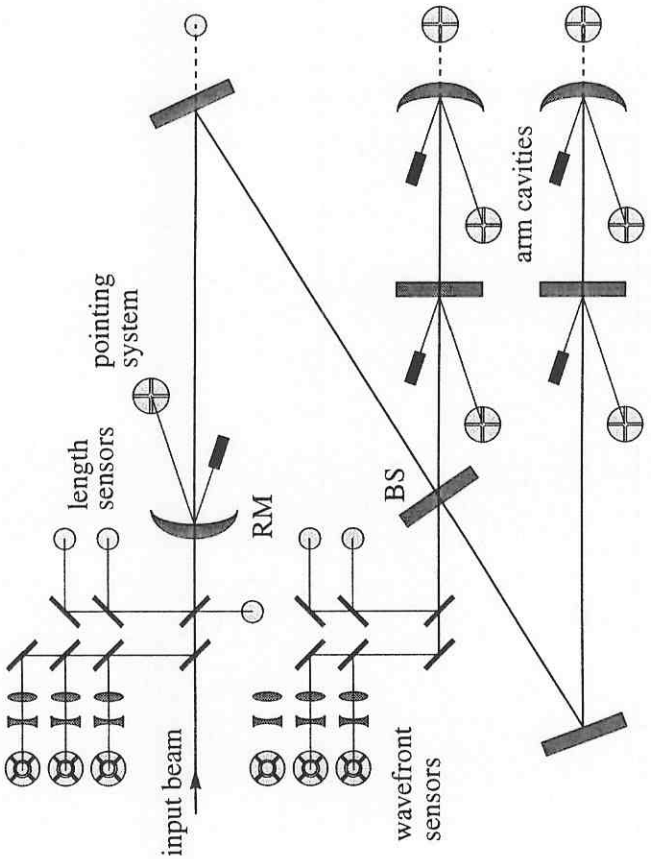
OBJECTIVES OF R&D PROGRAM

- **Modal model**
  - Simulation of interferometer response to misalignment
  - Design of ASC and LSC systems strongly coupled
- **Wavefront sensor prototype**
  - Design and fabrication of wavefront sensing prototype hardware
- **Testing/validation**
  - Fixed Mass Interferometer (FMI) experiment: table-top prototype interferometer using LIGO optical configuration
  - Test and characterize wavefront sensing system prototype
  - Quantitative verification of modeling results



FMI SCHEMATIC LAYOUT

ALIGNMENT: WAVEFRONT SENSING

PEOPLE

- **Modal model**
  - (Yaron Hefetz)
  - Nergis Mavalvala
  - Peter Fritschel
  - Daniel Sigg
- **Wavefront sensor prototype**
  - Daniel Sigg
  - LIGO CDS
  - BU electronics
- **FMI experiment**
  - Daniel Sigg
  - Nergis Mavalvala
  - LIGO CDS

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CURRENT STATUS OF RESEARCH

- **Modal model**
  - Small angle model (10^{-7} radians) of interferometer completed and used to design interferometer configuration
  - Large angle model (10^{-5} radians) being developed
- **Wavefront sensor prototype development**
  - Segmented detector head and demodulation electronics design complete
  - First boards fabricated and currently being tested
- **FMI experiment**
  - Input optics, modulation system, interferometer construction and locking electronics completed
  - Currently testing longitudinal lock acquisition sequence

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CURRENT STATUS OF RESEARCH (contd.)

- **Publications/Technical Reports**
  - Draft of paper on theory of mode decomposition (LIGO-T96005-00-R)
  - Report on design of optical configuration for the FMI (LIGO-T952109-00-I)
  - Specifications for measurement of wavefront sensing signals (LIGO-T950136-00-D)
  - Specifications for electronics design for the FMI experiment (LIGO-T950137-00-D)

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FUTURE PLANS

- **Modal model**
  - Used to design LIGO interferometer optical and modulation configuration
- **Wavefront sensor prototype**
  - Fabricate, test and install wavefront sensors (FMI and PNI)
- **FMI experiment**
  - Fully characterize interferometer locking sequence
  - Interface and program the VME data acquisition system
  - Install wavefront sensors
  - Measurement of alignment matrix
  - Deliver fully characterized wavefront sensing system
  - Validation of mode decomposition model
  - Quantitative results completed by December, 1996
  - Doctoral thesis