

## Detector Technical Update

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David Shoemaker

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### Progress over last half-year

- Detector implementation
- Detector research and development

### Organized by task groups, then subsystems

- Isolation
  - > Seismic stacks
  - > Suspensions
- Lasers/Optics
  - > Nd:YAG laser
  - > Core Optics
- Interferometer Sensing/Control
  - > Length
  - > Alignment
- Control and Data System

## Isolation: Seismic stacks

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**Challenge:** make seismic noise negligible above 40 Hz;  
attenuation of  $<10^4$  at 40Hz,  $Q < 30$ , materials constraints

### Requirements/Interfaces

- basic requirements determined
- new measurements of Livingston ground noise
- detailed requirements under development
- Design Requirements Review: 29 April

### Design Study

- contract with Hytec, Inc. to study passive stacks
- refinements to initial LIGO-generated design
  - > lowering cutoff frequency
  - > reducing weight
- detailed models, trial designs for springs, overall structure
- single-layer prototype tests to come

## Isolation: Suspension

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**Requirement:** actuation and attenuation without  $Q$  compromise

### Off-line $Q$ measurements on full-scale substrates

- measured values of  $6 \times 10^6$ ; still refining hanging procedure

### 40m: first article complete, in off-line tests

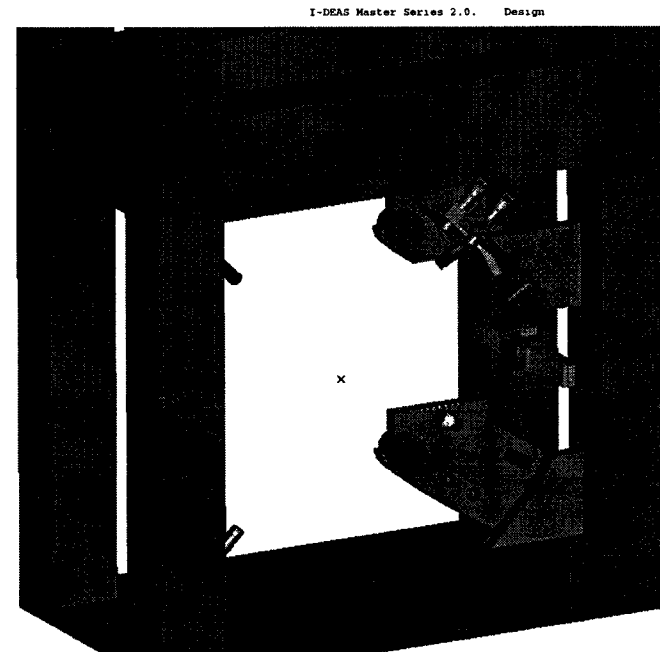
- hanging practice
- controller tuning
- installation mid-summer

### LIGO: refinement of design

- Design Requirement Document, Review: June 95
- dynamic range of controller, attention to wire attachment
- interfaces with Seismic Isolation, Core Optics
- Preliminary Design Review: May 96

## LIGO Suspension Design

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## Lasers/Optics: Nd:YAG

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**Challenge:** 10 cw output, very low frequency & intensity noise, good spatial quality, high reliability and efficiency

### Development of 10 W LIGO laser

- requirements developed (from Argon Laser Reqs)
- Request for Proposals issued, responses received
- presently evaluating proposals; selection in mid-April
- vendors propose to meet LIGO schedule (16 month cycle)

### In-house development

- need for a moderate-power near-term Nd:YAG source
- use 700 mW commercial laser
- initial frequency stabilization for characterization of actuators
- serves several purposes
  - > experience with Nd:YAG for LIGO controls design
  - > near-term application in Phase Noise Interferometer
  - > loss, scatter, contamination tests at 1.06  $\mu\text{m}$
  - > 40m conversion
- parallel build-up of 1.06  $\mu\text{m}$  optics, tools

## Lasers/Optics: Core Optics

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**Challenge:** <1 nm rms over 8cm radius net phase front

### Requirements/Interfaces/Conceptual Design

- refinement of models, exploration of design space
- incorporation of constraints/advantages of 1.06  $\mu\text{m}$ 
  - > curved/curved arm cavity geometry
  - > allows 25cm  $\times$  10 cm substrates (as before)
- DRR 23 Feb 96

### Polishing

- very good responses from vendors
- CSIRO, HDOS show we can meet or exceeded requirements

### Metrology

- putting independent program in place with NIST
- polished substrates to be evaluated

### Coating

- interactive development with vendor (REO)
- measurements of uniformity of coating underway
  - > REO: center frequency measurements
  - > LIGO: anti-reflective coating variations
- meets requirement radially, but shows azimuthal variations

## ISC: Length Sensing/Control

**Challenge:**  $10^{-10} \text{ rad}/\sqrt{\text{Hz}}$ ,  $10^{-19} \text{ m}/\sqrt{\text{Hz}}$ ,  $>10^{-6} \text{ m}$  input motion

### Adoption of single-frequency readout

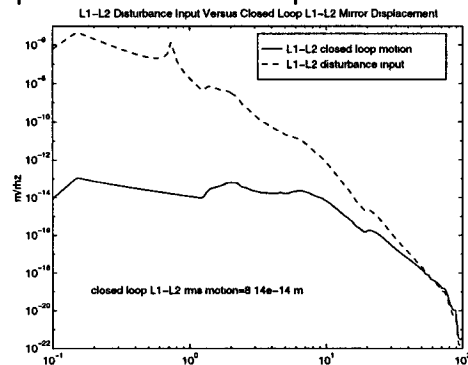
- simpler than carrier/subcarrier scheme
- greater confidence in design due to modeling results

### Linear-regime modeling

- complete small-signal analysis completed
  - > detailed shot-noise inputs for all sensor
  - > up-to-date seismic noise model
  - > coupling of laser noise (frequency, intensity)

### Acquisition modeling

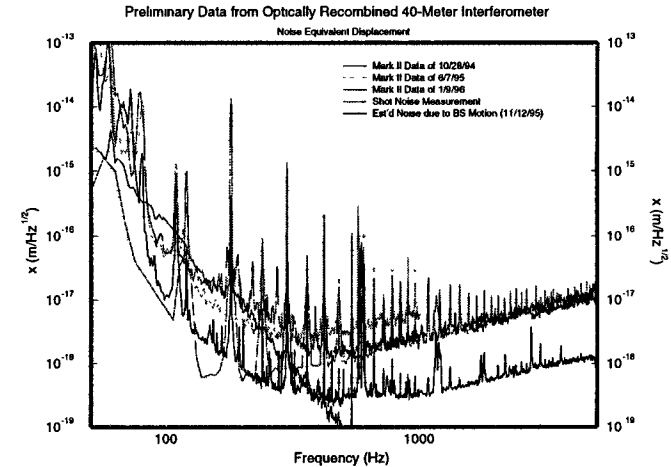
- extension of present model to complete interferometer



## ISC: Suspended Ifo tests

### Program to test optical/sensing configuration on 40m

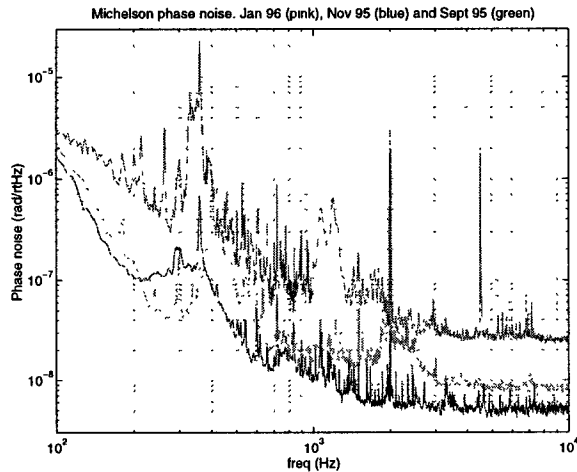
- non-recycled Fabry-Perot Michelson interferometer
  - > extensive effort to understand noise at high frequencies
  - > incremental improvements in noise floor
  - > much more known about noise propagation in system
- preparations for recycling in parallel
  - > optics specified, ordered
  - > servos/sensors specified, in design
- plan to start conversion to recycling in July



## ISC: Suspended Ifo tests

### Phase Noise Research on the PNI

- commissioning and first stage of measurements completed
- non-recycled Michelson, Argon laser
  - > noise sources explained at present sensitivity level



- recycling mirror installed, servo systems being tested
- measurements during next quarter
- conversion to 1.06  $\mu\text{m}$  in mid-summer

## ISC: Alignment Sensing/Control

**Challenge:**  $<10^{-8}$  rad rms operational alignment

### Alignment design refinement

- greater use of Wavefront Sensing (bandwidth, dynamic range)
  - > simplicity
  - > direct measurement/control
  - > less dependence on facility mechanical stability
- additional modulation on carrier
  - > outcome of Length Sensing working group studies
  - > leads to more robust alignment signals
- Design Requirements Review: June 96

### Wavefront Sensor R&D

- experiment length control in shakedown
  - > all degrees of freedom controlled, but for short times
- wavefront sensor and demodulator development
  - > requirements, design, prototype, layout complete
  - > first articles finished
  - > to be installed also on PNI, 40m

## Control and Data System

**Challenge:** architecture, design, fabrication of all electronics; data and control hard- and soft-ware

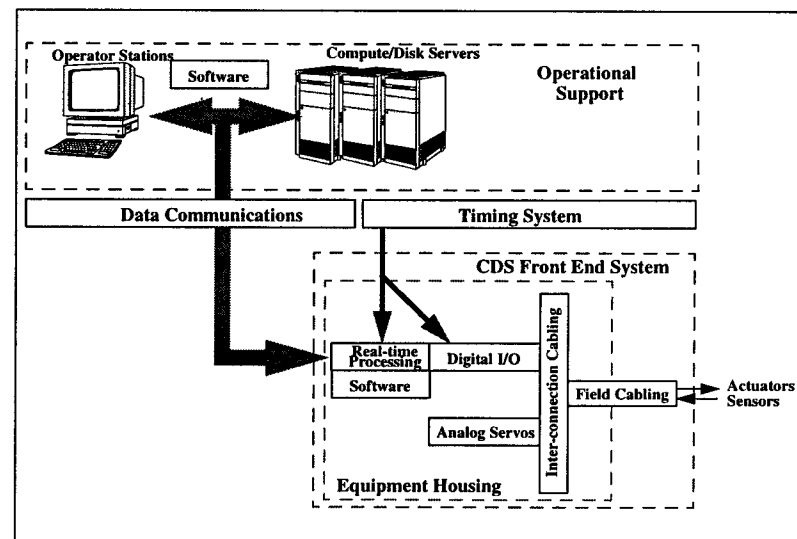
### Support of laboratory activities

- jump-start on field tests of engineering, human interface
- current lab projects
  - > integration of CDS Argon laser into 40m
  - > 40m recycling including LIGO reference source
  - > monitoring acquisition in 40m lab
  - > programming for Wavefront data acquisition
  - > layout and fab of Wavefront demodulator boards

### Design Requirements/Conceptual Design

- strong effort to collect requirements from Detector
- basic choices in backbone, protocols, topologies
- Control and Monitor Design Requirements Review: Feb 96
- Vacuum Controls Design Requirements Review: 1 May 96

## CDS: Conceptual Design



# Technical Update

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## **Detector subsystems well into design process**

- learning curve for scientists leveling off
- Design Requirement Documents and Reviews:
  - > Alignment, Suspension, Core Optics, Ar Laser, CDS
  - > Seismic, Length, additional CDS in coming months
- Preliminary Design Review for Suspension in June

## **Detector Systems flowdown operative in Design process**

- allocation of noise sources
- resolution of interfaces
- noise modeling of resulting flowdown starting

## **Outside contractors helping keep the pace**

- Hytec (Seismic isolation stacks)
- CSIRO, HDOS, NIST, REO (Core Optics polishing, coating, measurement)
- JPL (Length Sense/Control), Cygnus (Alignment Sense/Control)
- Soon: Nd:YAG 10W Laser