LIGO Systems Engineering and Integration

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LIGO Systems Engineering and Integration

Outline

- Documentation
- Progress on LIGO Interfaces
- Trade Studies and Analyses
- Modeling and Data Analysis
- Summary

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Documentation

- LIGO Science Requirements Document (SRD)
  - Preliminary version completed 15 May
  - Available for internal review
  - Document addresses:
    - LIGO Scientific Mission and Purpose
    - Detector Definition & Configuration
    - Initial and Ultimate Sensitivity Goals
    - Facilities Extensibility Requirements
    - Observational Modes and Availabilities
    - Data Formats and Data Products
    - Enabling Research and Long-Term Goals

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Documentation (cont.)

- LIGO System Specification
  - In progress
  - Ongoing Design Reviews within Detector Group are providing definitions which will be incorporated within the System Specification
  - Key element of the specification will be the interferometer baseline optical configuration -- being worked on at present.
- Technical Notes
  - LIGO coordinate system for facilities construction
  - LIGO vibration and acoustic noise level requirements during operation
  - Derivation of core optics coating specifications from requirements
  - Feasibility study of fabricating dual-wavelength core optics coatings for either 0.5145 μm (Ar^+) or 0.532 μm (2X Nd:YAG) laser lines

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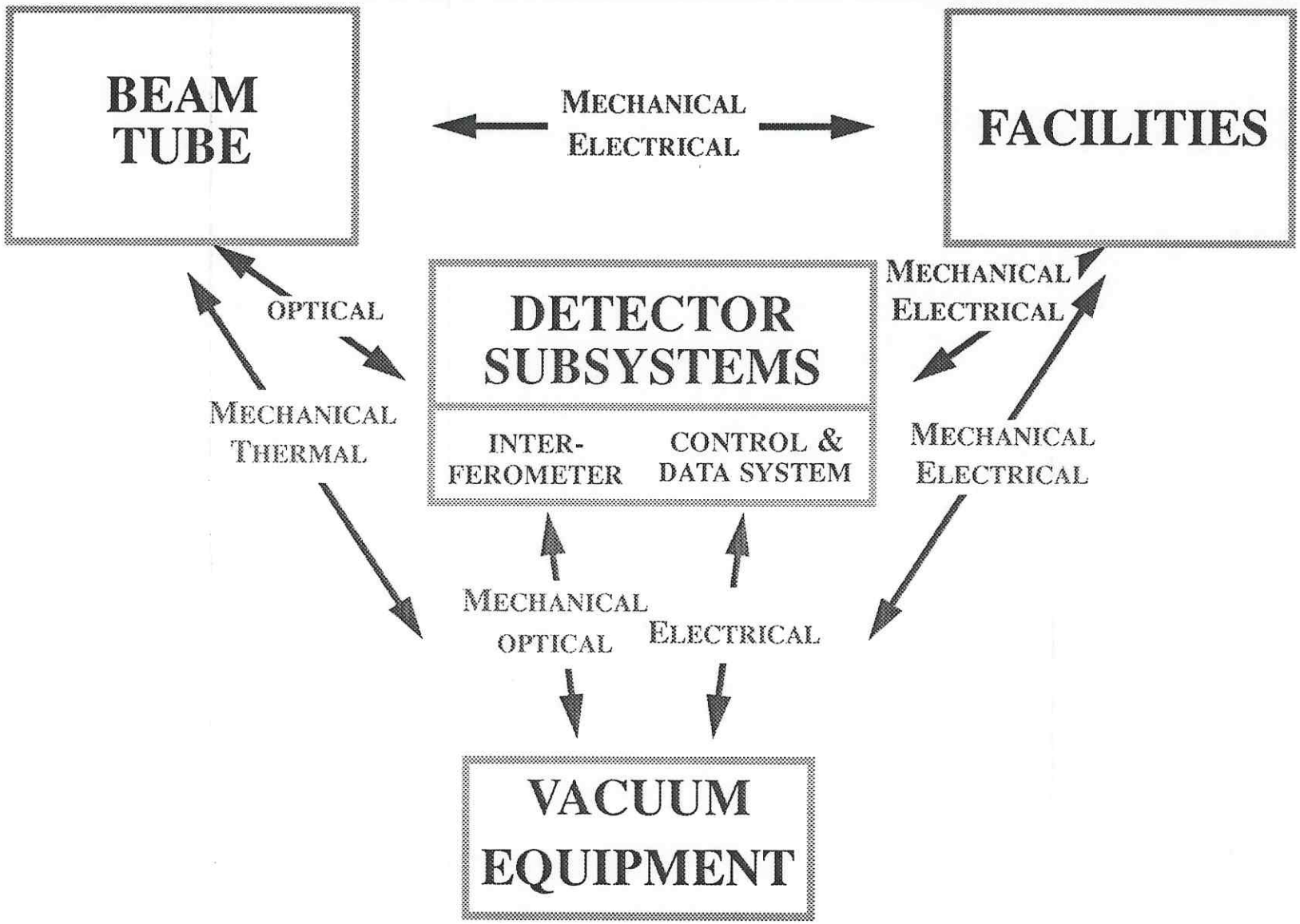
Interfaces

- System Interfaces have work in progress:

  - Vacuum Equipment - Beam Tube mechanical interfaces defined
  - Vacuum Equipment - Detector signal interfaces defined
  - Vacuum Equipment - Facility interfaces being defined
  - Facilities - Detector interfaces in progress
  - Beam tube - Detector interfaces in progress
  - Beam tube - Facilities interfaces in progress

Physical Interfaces Among LIGO Systems



Interface Classes & Types

INTERFACE CLASSES

TYPE	MECHANICAL	ELECTRICAL	THERMAL	GLOBAL
1	FOOTPRINT EXCLUSION OVERHEAD CLEARANCES	POWER	CONDUCTION	OPTICAL SCATTERING
2	CONNECTIONS APERTURES SUPPORTS	SIGNAL	RADIATION	VACUUM PRESSURE BURSTS OUTGASSING LEAKS
3				VIBRATION/ACOUSTIC
4				CONTAMINATION VOLATILES PARTICULATES
5				EMI/RFI
6				SCHEDULE AVAILABILITY

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Trade Studies and Analyses

- LIGO Interferometer Optical Configuration
  - Review baseline parameters:
    - number and locations of carrier/subcarriers
    - pick-off locations & servo topology
  - Parameter optimization:
    - mirror radii of curvature
    - arm asymmetry
    - reflectances
    - servo gains/frequency response
  - Modeling techniques
    - FFT propagation
    - Modal decomposition

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Trade Studies and Analyses (cont.)

- High reflectance coatings specifications and tolerancing
  - Phase fluctuations must be controlled to $\lambda/800$
  - Metrology issues -- center wavelength nonuniformity measurements to infer phase nonuniformities
- Coating designs for dual wavelength operation
  - Demonstrated the feasibility of using coatings which provide same performance for both Ar^+ (0.5145 μm) and Nd:YAG (0.532 μm)
  - Permits LIGO to switch from Ar^+ to Nd:YAG when solid state laser technology is available without re-fabricating core optics
  - AR coatings are the most sensitive
  - Caveats: A few mirrors need re-coating; surface electric field strength effects need to be understood; coating uniformity requirements are stringent

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Trade Studies and Analyses (cont.)

- Beam Tube baffle design
  - Baffling conceptual design review held jointly with European groups (GEO 600 & VIRGO)
  - Greater attenuation of stray scattered light required than original baffle design provided
  - Presently exploring different baffling materials and baffle designs
    - Oxidized cold rolled stainless
    - Martin Black (outgassing concerns)
    - Black glass (Breault Research Organiztion's recommendation - mechanical design concerns)
  - Effort to be completed by December 1995 in order to support scheduled detector PDRs

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LIGO Modeling and Simulation Environment

- Candidate environments considered
  - Khoros,AVS,Grid,SIESTA,LabView/CVI
- Factors considered:
  - Modular vs. Monolithic Coding Environment
  - Powerful software modules
  - Module can be written by C/Fortran/Mathematica/MATLAB
  - Automated Make, Graphical User Interface (GUI) and Man(on-line help)
    - Graphical Programming Interface
    - Good graphics viewer
  - Shared memory, Distributed processing
  - User recommendations

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LIGO Modeling and Simulation Environment (cont.)

- AVS (Advanced Visual System) based framework Modular, GUI, Graphics
- Start building LIGO modeling framework
  - ›› Define the structure components and information flow
- Port existing codes into AVS framework
  - ›› Integration of exisiting codes into more powerful modules
  - ›› Better GUI, data visualization, and maintenance capabilities
- Progressive modeling of details--modules enhanced as hardware designs evolve
- Develop applications within AVS for general use by project scientists and engineers
  - ›› Performance predictions, trade studies, error budget allocation
  - ›› Pseudo-data production and development of data analysis tools

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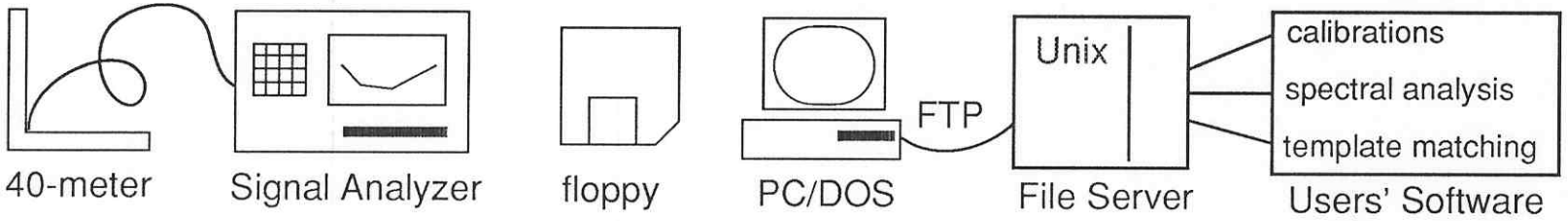
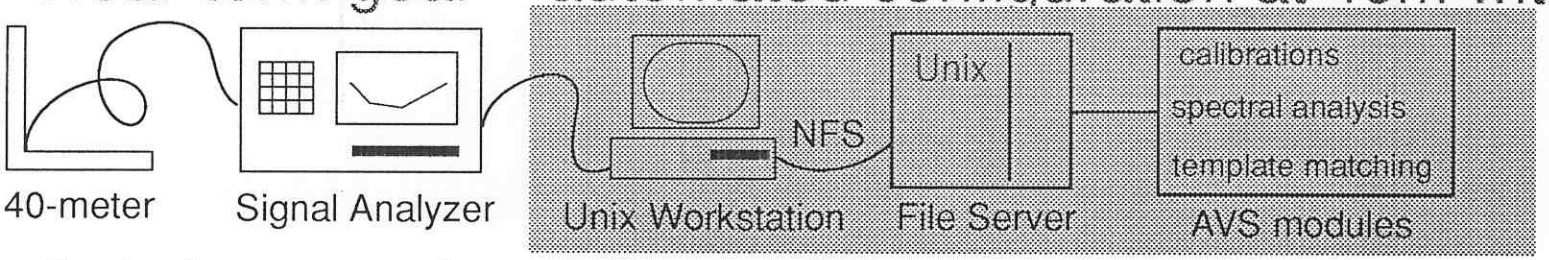
LIGO Modeling and Simulation Environment (cont.)

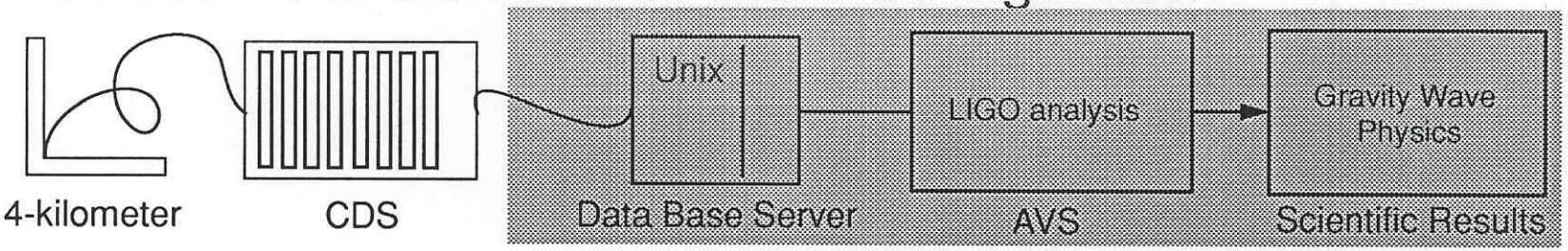
- 40m Data Acquisition & Analysis - presently using "Sneaker-Net"



- Near-term goal -- automated configuration at 40m with AVS



- Solution transferrable to LIGO configuration



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Summary

- Key LIGO system issues being addressed;
  - Working closely with all LIGO system groups (Detector, Vacuum Equipment, Beam Tube, Facilities)
  - Convening working groups to address interface issues
  - Active participation in weekly R&D and Detector meetings
  - Quarterly meetings in conjunction with science group to review project status, discuss issues and propose approaches
- Developing a LIGO end-to-end modeling environment with near-term support to 40m facility
- Group presently includes two scientists; planning to bring in at least one engineer with expertise in mechanical, control & electronic systems to expand group resources and to provide better support to all LIGO systems groups.