

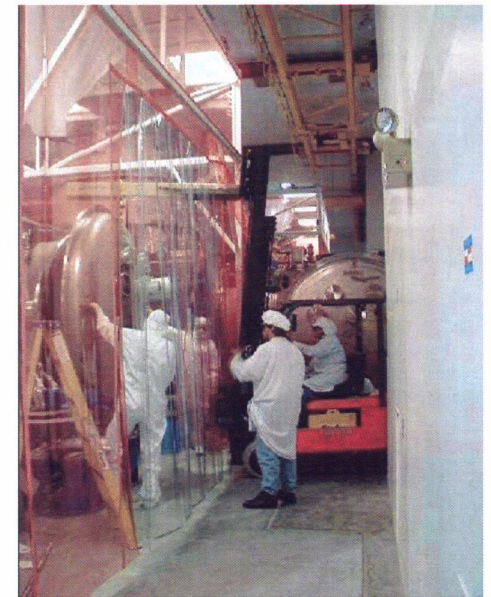
Installation (INS)

Requirements and Design Breakout Presentation NSF Review of Advanced LIGO Project

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INS is the project phase between subsystem assembly & project completion

Includes:

- **Removal**
 - » Removal of existing detector equipment
 - » Disposition or storage of equipment
 - » Particulate clean up of vacuum chambers
- **Installation**
 - » Installation of Vacuum Equipment
 - » Installation of all Detector Equipment
 - External to vacuum system
 - Internal to vacuum system
- **Testing**
 - » In-situ Unit/subsystem Testing
 - » Integrated System-Level Testing

Does not include:

- Installation Planning (FMP scope)
- Installation Staging (FMP scope)
- Assembly (subsystem scope)
- Unit Acceptance testing (subsystem scope)
- Installation Fixtures (subsystem & FMP scope)
- Commissioning (beyond project scope) – Commissioning starts on a subsystem-by-subsystem basis in parallel with continued installation/integration
- Data & Computing System (DCS) installation & test



- Start with Livingston (L1) to minimize impact of initial problem discovery
- LIGO Staff employed principally
 - » Skilled in UHV, subsystem install, interferometer testing, etc.
- LIGO manages all INS activities
 - » No subcontracted effort
 - » Skilled trade labor all directed by LIGO staff
- Prior to INS start:
 - » All production/fabrication and assembly are completed per interferometer (reduce labor distraction and delays from late deliveries)
 - » Integrated Testing & Training at LASTI Lab (@MIT) & 40m Lab (@Caltech)
 - Significant participation & support from observatory staff (training)
 - Pre-Stabilized Laser + Input Optics + Data Acquisition/Networking (PSL+IO+DAQ)
 - Seismic Isolation System + Suspension Assemblies + partial Interferometer Sensing & Control + Data Acquisition/Networking (SEI+SUS+~ISC+~DAQ)

INS Procedure Development & Training at the MIT LASTI Facility

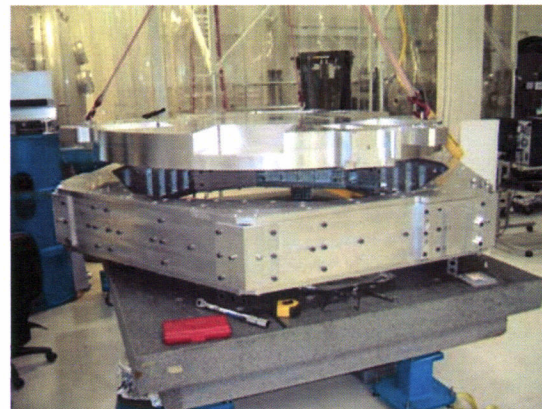
- **Large Full-Scale Prototype Assemblies are Installed & Tested in the LASTI Facility Chambers**



Mode Cleaner, Triple Suspension
Installation in a HAM Chamber at LASTI



Quadruple Suspension Installation
on Temporary Optics Table at LASTI



Internal Seismic Isolation (ISI) Assembly at LASTI
(to be installed in BSC Chamber in 2006)

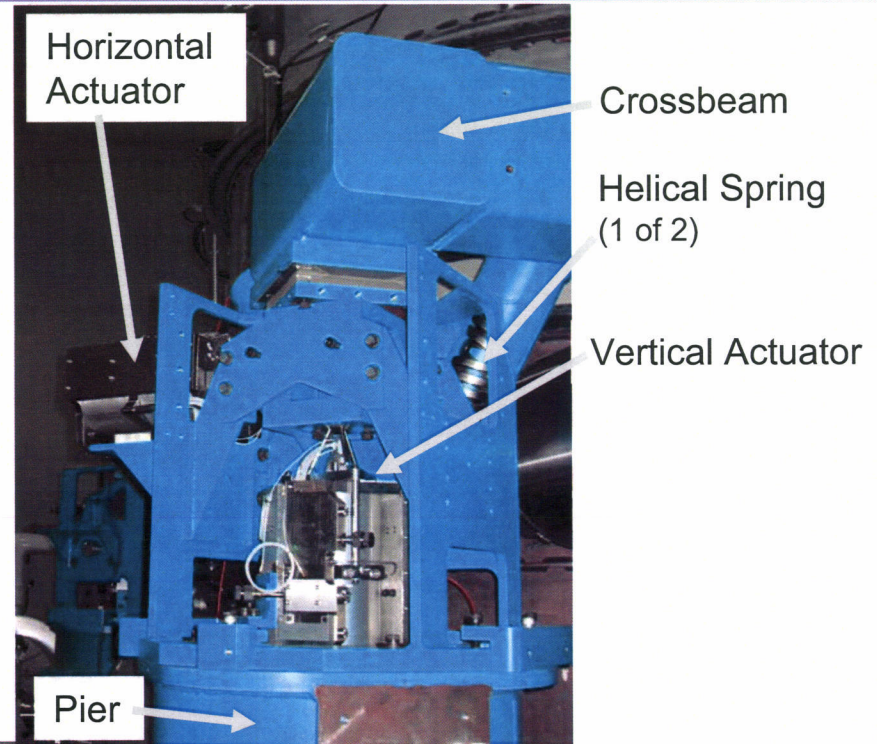
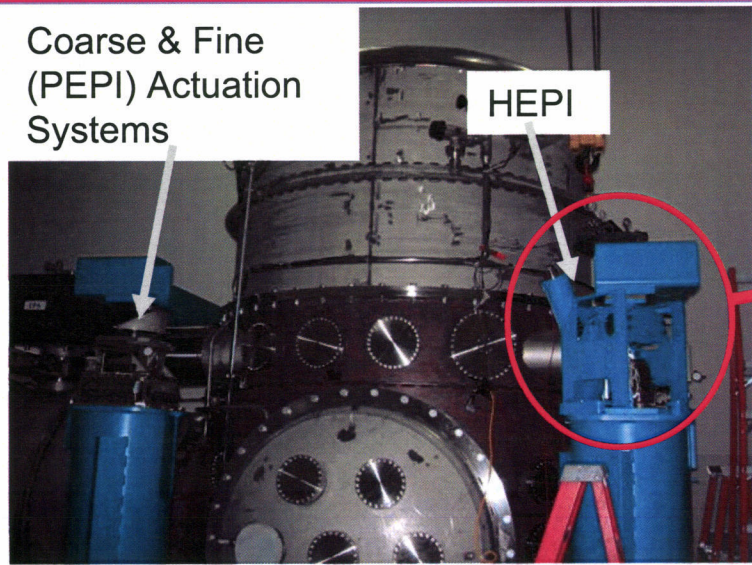
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- After INS Start:
 - » Simultaneous installation at both observatories (optimum staff utilization)
 - » Time phased installation of subsystems (leveling load on experts)
 - Sufficient to transfer/re-direct expertise to support 2nd observatory installation
 - Some time to rework or work-around in response to problems
 - » Installation & Integrated Testing are parallel activities
 - emphasis on early discovery of problems at integrated systems level
 - emphasis on installation of in-vacuum components ASAP

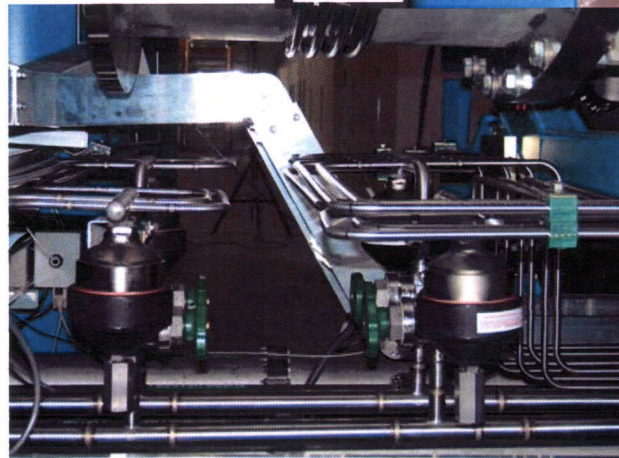
- **Installation Readiness Review to be held prior to switching off an Operating Observatory**
- **Litmus Test for Readiness:**
 - » **Re-affirm readiness with LSC & LIGO Lab**
 - » **All Installation Procedures Approved**
 - **Note that many procedures developed for Initial LIGO are common to AdL**
 - » **Critical Installation Activities & Tooling have been Tested (LASTI testbed)**
 - » **Sufficient assembly, check-out and delivery of subsystem components completed, so that installation will not be supply chain limited**

Seismic Isolation, HEPI Subsystem Installation at LIGO Livingston Observatory



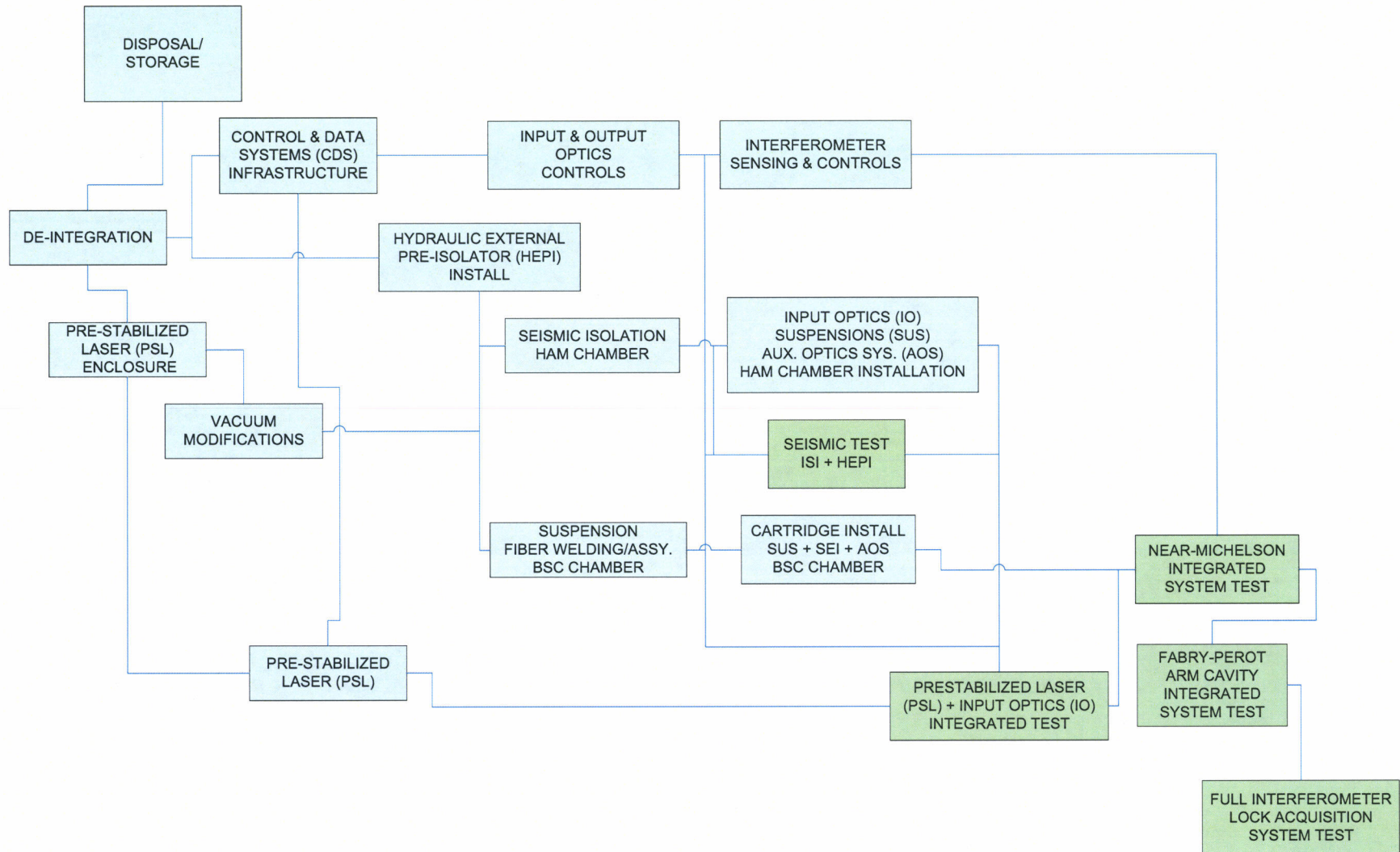
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- Organization:
 - » Separate organization (subsystems matrix into INS organization)
 - » Project Manager directs INS effort
 - » Separate on-site management for Installation and Integrated System Test
- Teams:
 - » Subsystem focused
 - » Installation teams comprised of the subsystem staff (designed & fabricated the hardware)
 - » Plus observatory staff (assembled & tested the hardware)
 - » Plus hired temporary (contract) staff (particularly skilled trade labor and technicians) as needed

INS Basic Tasks/Sequence for a single Interferometer

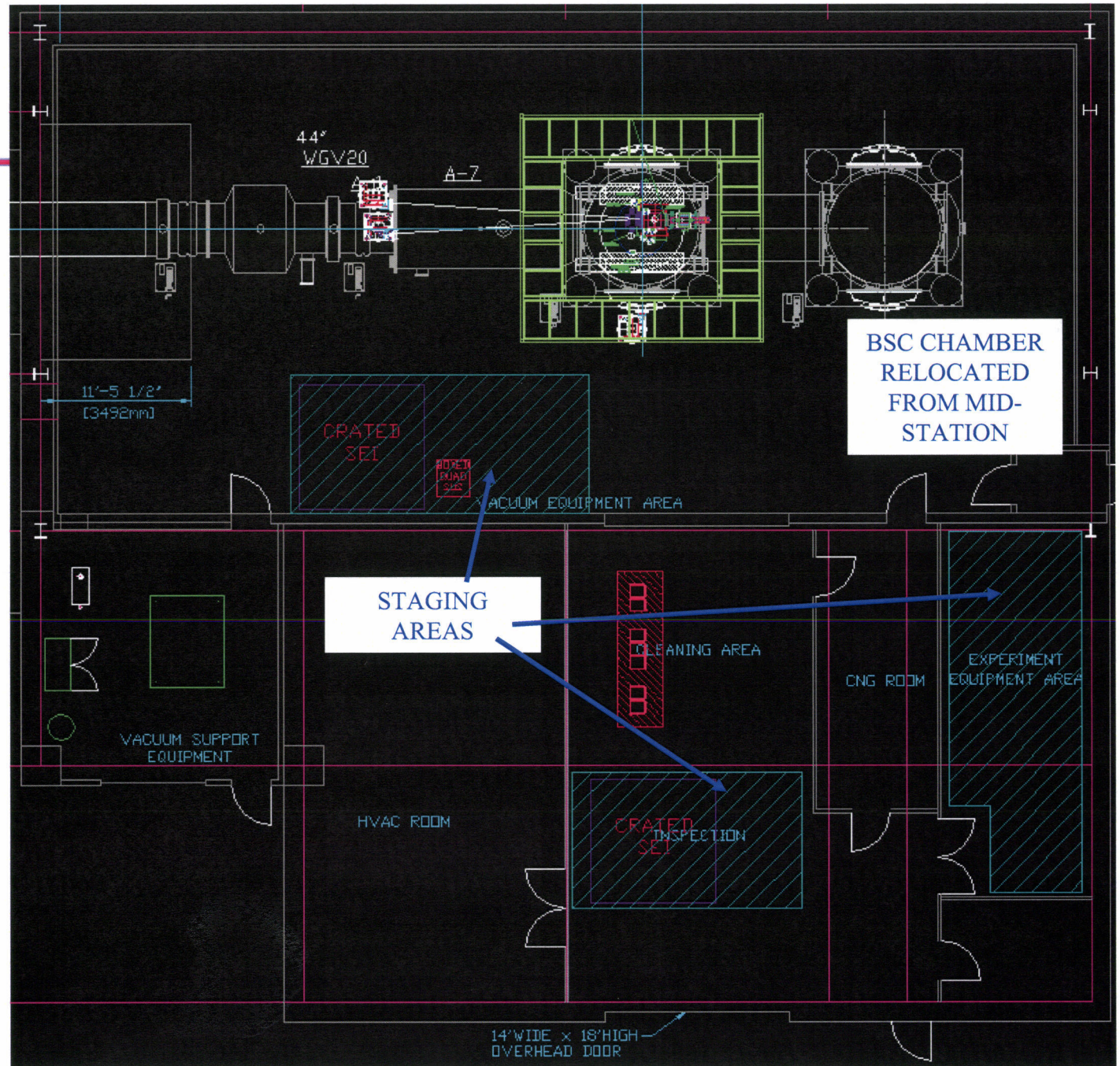


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End Station

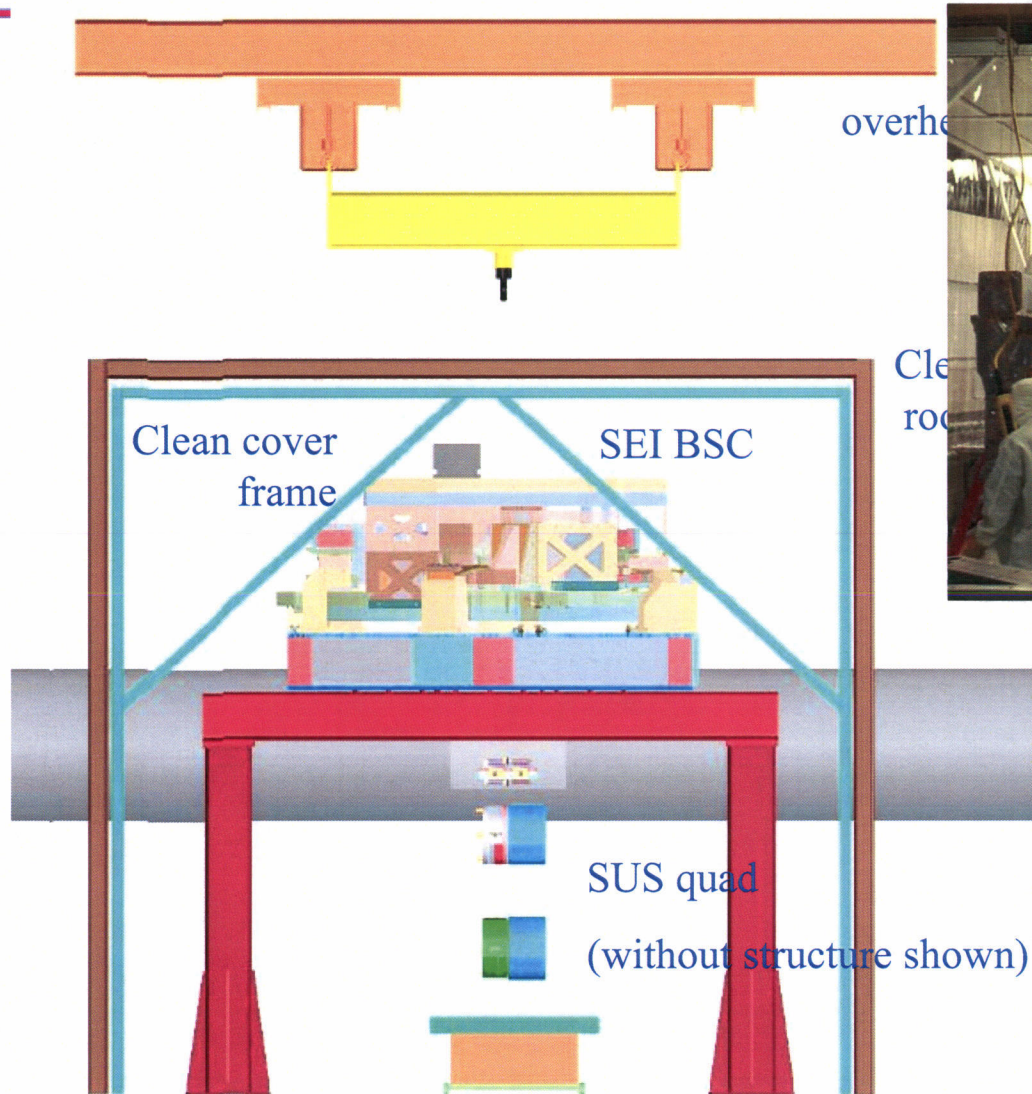
Revise to show
cartridge
assembly clean
room



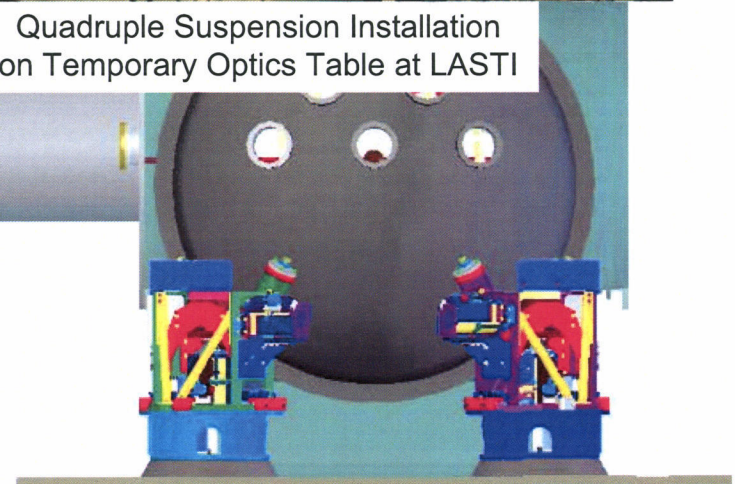
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BSC "Cartridge" Installation on Test Stand

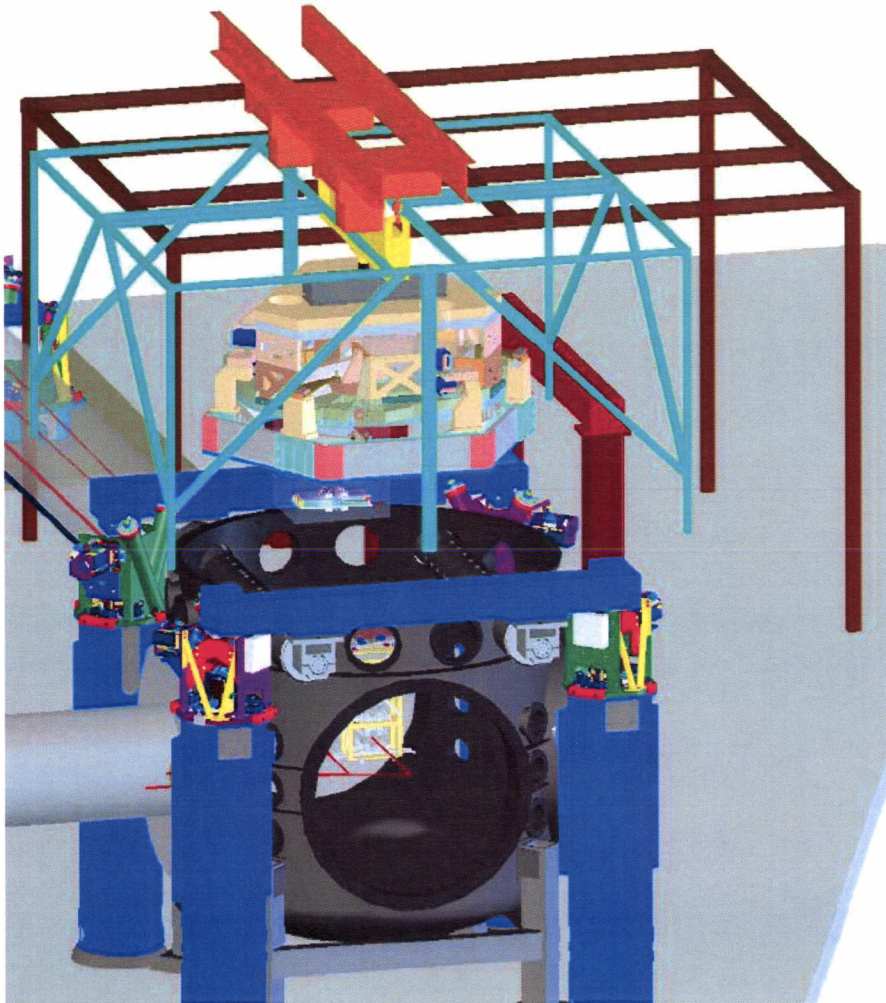


Quadruple Suspension Installation on Temporary Optics Table at LASTI



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- **Subsystem deliveries may be late**
 - » Readiness Review to decide whether to start or delay
- **Safety**
 - » Tight procedures & training (as was done in Initial LIGO)
 - » Light Source Physically “locked” within PSL Enclosure during most of the Installation effort
 - » Strict adherence to Safety Plan
- **Timely Transfer of “Lessons Learned” from 1st Interferometer to 2nd & 3rd**
 - » Staggered Starts (9 months)
 - » Common management & key staff
- **Quality Assurance**
 - » In-situ Subsystem Testing for acceptance is mandatory