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# LIGO Advanced System Test Interferometer

LIGO Advanced R&D Review  
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8 October, 2002

# LASTI Mission

- Test LIGO components & systems at **full mechanical scale**
- Practice installation & commissioning
- Minimize delays & downtime for advanced LIGO upgrades
- *Qualify design mods & retrofits for initial LIGO*

## **Specific Advanced LIGO Program Tasks ('01 - '06+):**

- Qualify advanced isolation & suspension systems and associated controls at full scale
- Develop detailed SEI/SUS installation & commissioning handbook
- Look for unforeseen interactions & excess displacement noise
- Test LASER and Input Mode Cleaner together at full power

# LASTI Advanced R&D Program

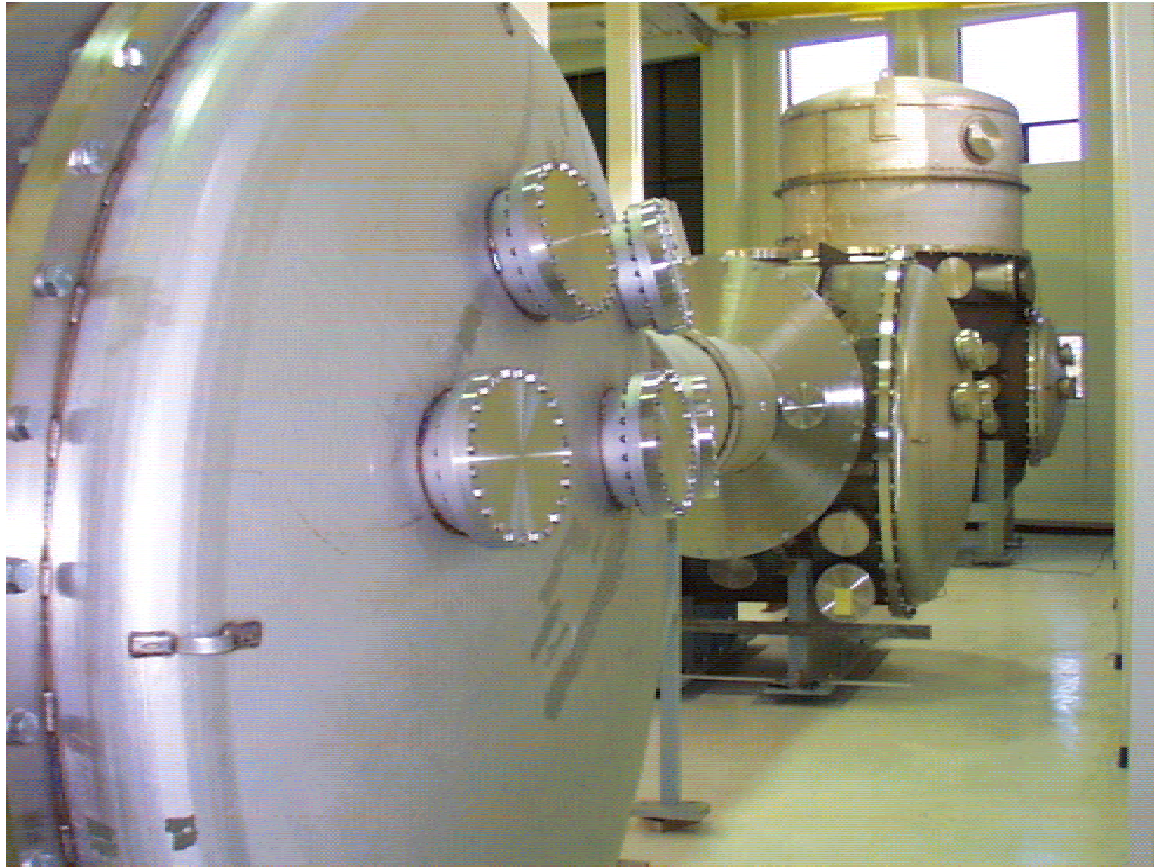
- Commission infrastructure (vacuum, cleanrooms, cranes...) ✓
- Commission PSL & controls ✓
- Commission initial seismic stack, suspensions & 1m test cavity in HAM chamber ✓
- ↓ Develop & test EPI for LLO seismic remediation
- ↓ Qualification test of early pre-prototype triple pendulum
- Integrate/test active HAM SEI pathfinder
- Integrate/test active BSC SEI pathfinder
- Integrate/test Quad and Triple suspensions
- Integrate/test sapphire & fused silica core optics
- Qualify for low displacement noise with sensitive interferometer system
- Integrate/test AdLIGO 180 Watt PSL & Mode Cleaner

*In each step, develop installation & test procedures to optimize AdLIGO upgrade*

# Status

- Infrastructure complete; mods considered/in work
  - » Now turbopumped; upgrade to IP's planned, not budgeted
  - » Relocation of TP and RGA stations to lower-traffic area
  - » Cleanroom “mezzanine” for integrated SEI/SUS cartridge assembly
  - » AWG hw/sw for stimulus/response test capability (on order)
  - » added DAQ channel capacity
- PSL complete, working well (supporting site PSL's)
- HAM SEI, SOS test cavity installed & under control
- Currently >90% effort on EPI
  - » MEPI (HAM) mechanically & electrically complete
  - » sensors/actuators in service for plant characterization & SysID; DSPACE controller ready for loop closure
  - » HEPI (BSC instance) components & installation tooling coming in

# Vacuum Envelope



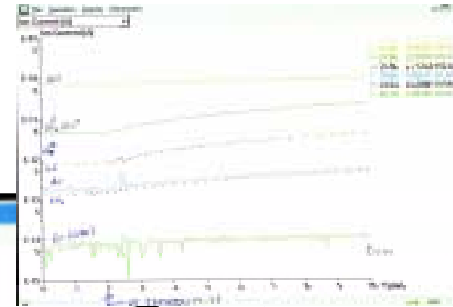
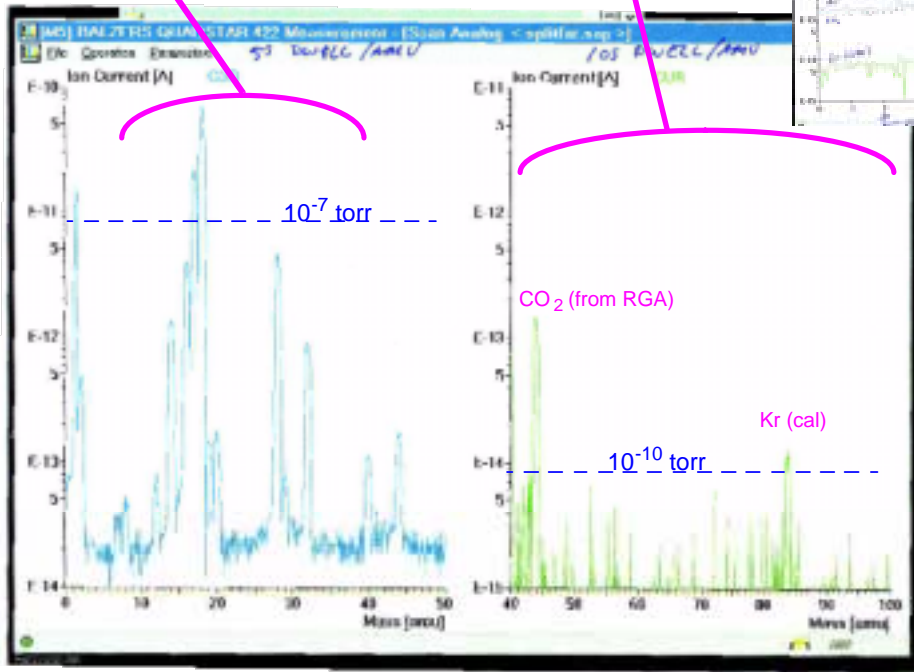
# Vacuum Performance

BSC0 stack + 2 SOS + stack + wiring in HAM13

H<sub>2</sub>O, N<sub>2</sub>, O<sub>2</sub>, Ar: consistent with degassing of Flourel

(sensitivity S~ 85 μA/torr)

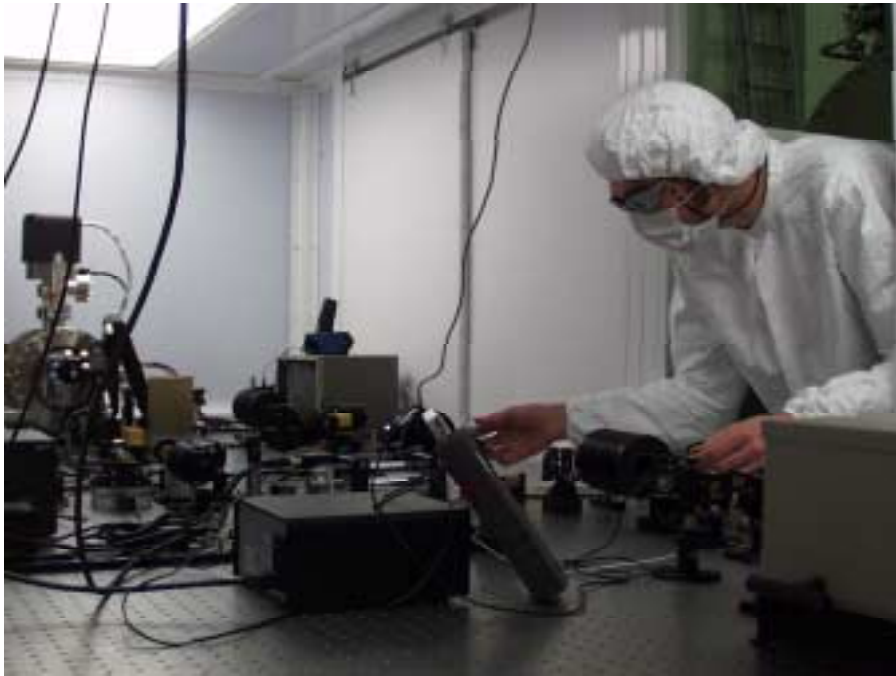
P(H<sub>x</sub>C<sub>y</sub>) < 2e-11 torr



Accumulation test on  
LASTI volume

(water diffusion is  
"interesting!")

# Prestabilized Laser (PSL)

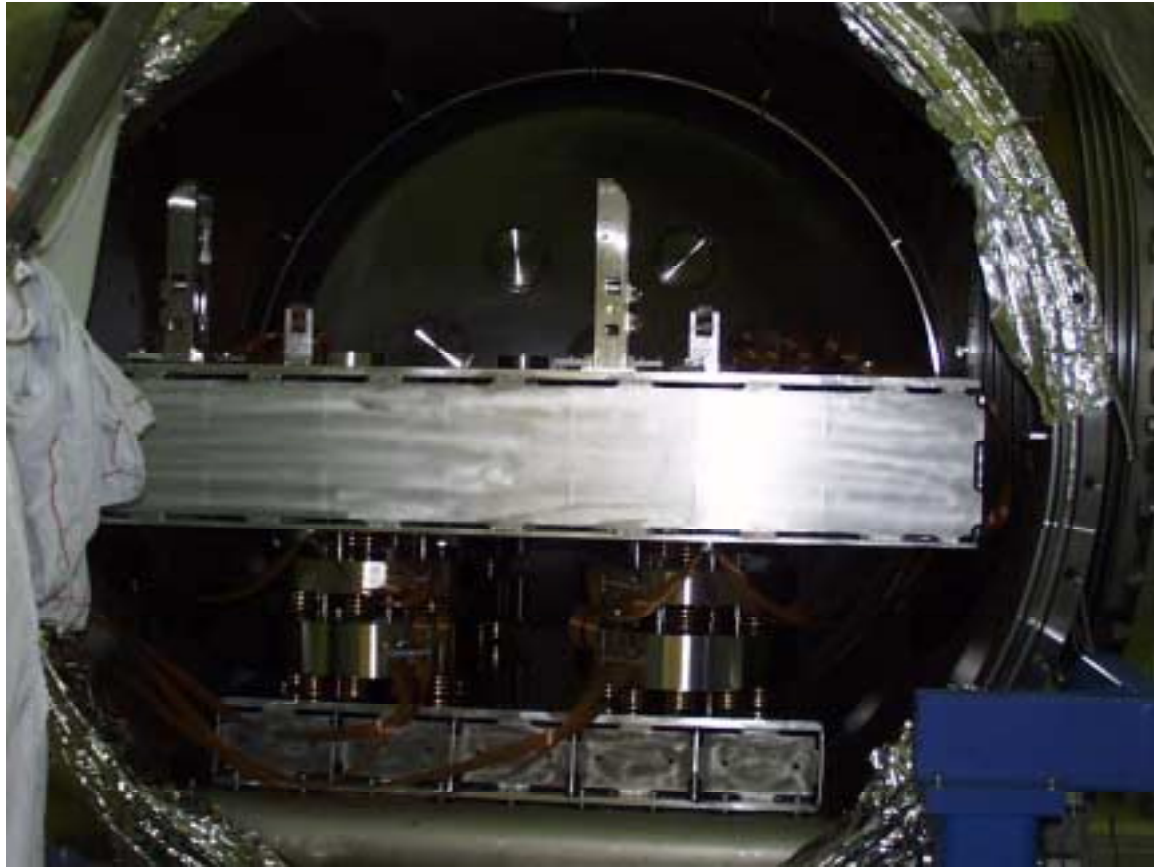


J. Rollins aligning PMC cavity



D. Ottaway (r.) w/ J. Rollins commissioning controls

# HAM Seismic Stack

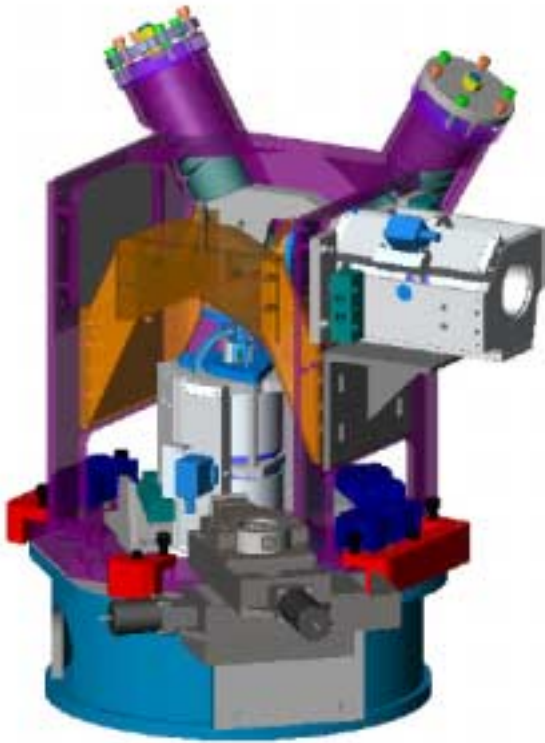




# 1m Suspended Test Cavity



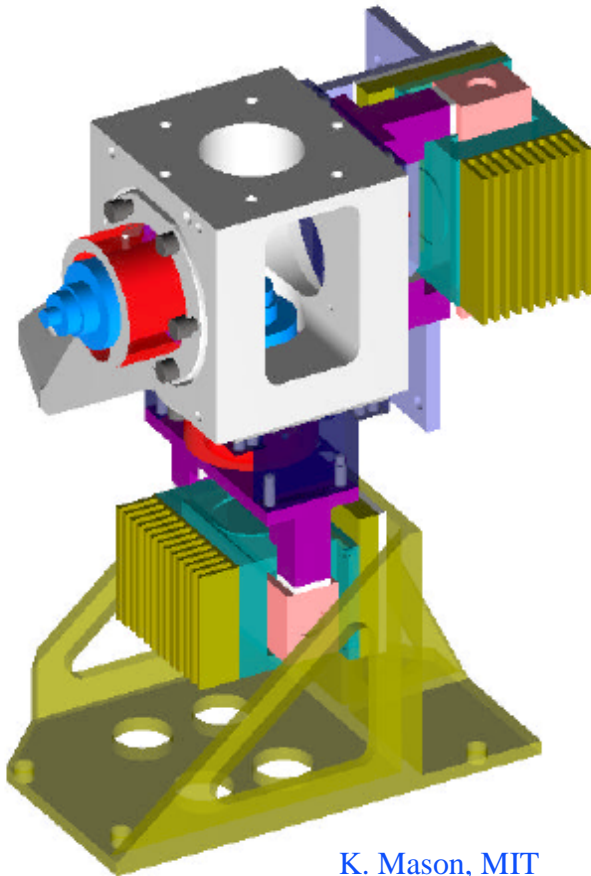
# Hydraulic External Pre-Isolators (HEPI)



K. Mason, MIT

- Working fluid is low-viscosity mineral oil
- Bellows hydraulic pistons apply force without sliding friction, moving seals
- Laminar-flow differential valves control forces
- Stabilized “power supply” is remote hydraulic pump with fluid-equivalent “RC” pressure filtering
- Technology adapted from precision machine tool applications

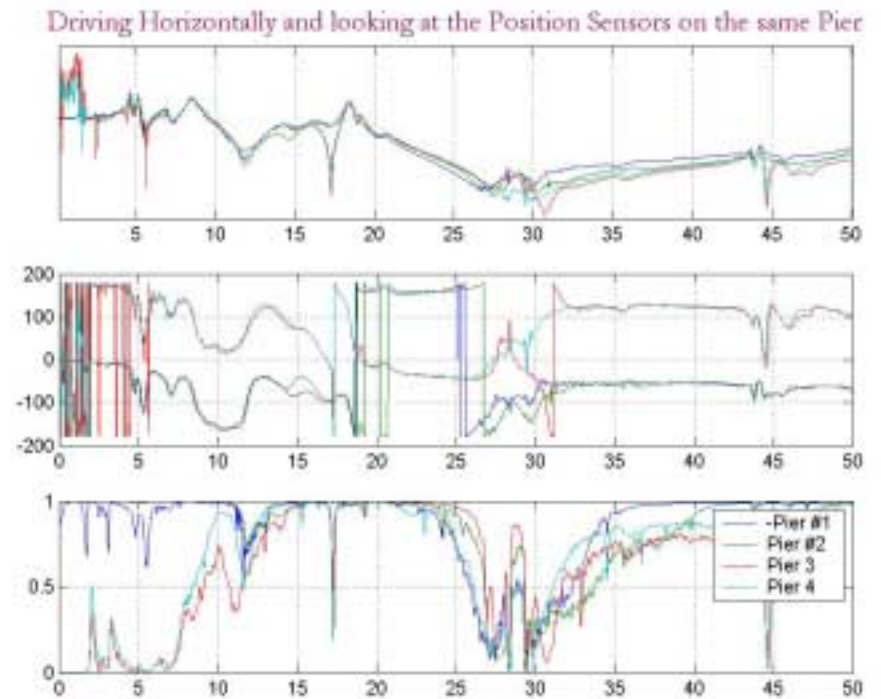
# Magnetic EPI (MEPI)



K. Mason, MIT

- Uses commercial voice-coil actuator
- ‘Pin-compatible’ mechanically
- Simpler electronics
- ‘Soft’ mechanical back impedance

# MEPI Installed on HAM13



# Technical Risks

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- All those inherited from subsystems under test, plus
- Added constraints from MIT lab environment
  - » installation & swing space, lifting capacities, etc.
  - » ambient vibration
  - » cleanliness/access
  - » mostly managed through intelligent engineering (so far...)

# AdLIGO Schedule Feeds/Constraints

- EPI testing (LIGO I LLO retrofit) was expected to finish 9/02, now anticipate completion ~ 1/03 - 2/03
- EPI pushes back integration of HAM SUS test (itself a new task w.r.t. baseline)
- Still shown finishing *before* earliest AdLIGO HAM SEI delivery (use float; PSL testing made concurrent)
- **No net impact** on subsequent milestones, *IF*
  - » EPI finishes OK and activity moves to site as planned
  - » HAM SUS control test finishes OK and moves into final design
  - » No further slip in AdLIGO SEI deliveries

# Updated schedule:

## LLO seismic remediation interleaved with Advanced LIGO R&D (ref. M020121-C, 9/25/02)

task	baseline	act/proj	comments
vacuum envelope commissioned	4Q99	4Q99	
SEI external structures installed	1Q00	3Q01	
infrastructure complete	3Q01	1Q02	(EPICS, DAQ, GDS, SEI, PSL, SOS)
BSC stack installed	N/A	4Q01	needed for EPI/LLO retrofit
EPI development for LLO seismic retrofit	N/A	1Q03	LIGO I support
PSL intensity noise/FSS testing	N/A	2Q03	LIGO I support
HAM triple pendulum "controls" proto test	N/A	3Q03	held off by EPI completion
AdL HAM SEI standalone test compl.	4Q02	1Q04	paced by earliest SEI delivery (AdL SEI delayed by LLO/EPI)
AdL BSC SEI standalone test compl.	3Q02	2Q04	paced by earliest delivery
AdL SUS standalone tests compl.	1Q04	4Q04	paced by triple SUS delivery
AdL TM optics integrated	2Q04	3Q05	paced by COC, quad SUS delivery
IFO noise testing compl.	2Q05	1Q06	
AdLIGO PSL/IO integration test compl.	3Q05	3Q06	next: SEI prod. first article tests

# Cost baseline and issues

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- FY '03 LASTI budget: all people, about \$10k for misc. supplies and expenses (bootie fund)
- Engineering, management, admin. support and certain M&S drawn from Operations
- MIT institute grant of ~\$0.5M was invested in EPI equipment during FY'01-'02; now exhausted
- Future material, equipment and infrastructure investments to be provided by R&D subsystem accounts ('users')
- Significant recycling of LIGO I site tooling & equipment has kept costs low & will continue



# '03 staffing baseline and issues

- Dedicated LASTI staff (per '03 work plan)
  - » .5 FTE scientist
  - » .5 FTE postdoc
  - » .5 FTE sr. tech specialist
  - » 2 FTE grad, 0-2 FTE undergrad
- Shared resources (per '03 work plan)
  - » EE, ME, SysAdmin, senior scientist shared within lab
  - » E-tech, M-tech < MIT CSR (about 0.1 FTE total, bridging peaks)
- Critically dependent on visitors
  - » Mechanical & installation: peaks sporadic, visits have worked well
  - » Electronics & software: continuous & unpredictable workload, competes with LIGO commissioning --> need to beef up
  - » Plan to increase shared EE from current 0.5 FTE to 1 FTE

# Summary: Plans for 2003

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- Complete EPI program & support LLO retrofit
- Complete PSL ISS/FSS support investigations
- Install “control test” triple pendulum prototype in HAM13 and begin characterization
  - » requires SOS test cavity removal, shortening of passive SEI stack
  - » also requires increase in electronics infrastructure
- Install AdLIGO HAM SEI & begin testing (if ready)