# LIGO ADVANCED SYSTEMS TEST INTERFEROMETER (LASTI)

Program Update:

LSC Meeting, Hanford

Dave Ottaway for the LASTI team

November 2003

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# Talk Overview

1. Short review of LASTI goals and timelines
2. Concerns raised at previous review
3. Overview of achievements since Aug 03
4. Predicted performance of Single Test Cavity LASTI
5. New issues and proposed solutions
6. Conclusions

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# LASTI Mission

- Test LIGO components & systems at full mechanical scale
- Practice installation & commissioning
- Minimize delays & downtime for advanced LIGO upgrades
- Qualify design modifications & 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 PSL and Input Mode Cleaner together at full power

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# LASTI People

Resident MIT Staff

- Students - Jamie Rollins, Laurent Ruet (Jan '04 INSA)
- Engineering - Myron MacInnis, Ken Mason, Jonathan Allen, Bill Rankin
- Scientists - Gregg Harry, Rich Mittleman, Dave Ottaway, David Shoemaker, Pradeep Sarin, Mike Zucker (Advice)
- Computers – Keith Bayer

Laboratory and LSC Visitors (to date)

- Initial SEI & SUS- Corey Gray, Hugh Radkins, Gary Traylor, Harry Overmier, Betsy Bland , Jonathan Kern, Marcel Hammond, Dennis Coyne…
- Advanced SEI - Joe Giaime, Brian Lantz, Wensheng Hua, Corwin Hardham…
- Advanced SUS - Norna Robertson, Calum Torrie, Janeen Romie, Phil Willems, Justin Greenhalgh, Ken Strain, Caroline Cantley, Mark Barton…
- CDS/DAQ - Jay Heefner, Rus Wooley, Paul Russel…

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# LASTI Advanced LIGO 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 (Delayed)
- Integrate/test active HAM SEI pathfinder (Delayed)
- Integrate/test active BSC SEI pathfinder (Delayed)
- Integrate/test Quad and Triple suspensions
- Integrate/test sapphire & fused silica core optics
- Qualify for low displacement noise with sensitive interferometer system
- Integrate and test full scale adaptive thermal compensation
- Integrate/test AdLIGO 180 Watt PSL & Mode Cleaner

# Concerns raised during at previous review

- LASTI has no graduate students working on it
  - » Have recruited a graduate student  Laurent Ruet from INSA
- LASTI exceeds seismic mass limit
  - » Completed feasibility study for single test cavity LASTI
  - » Results presented here

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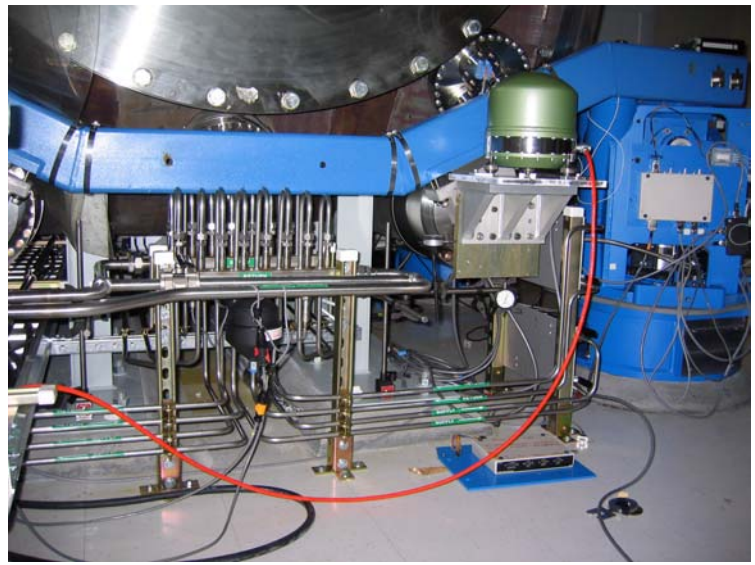
# Recent Progress –HEPI HAM

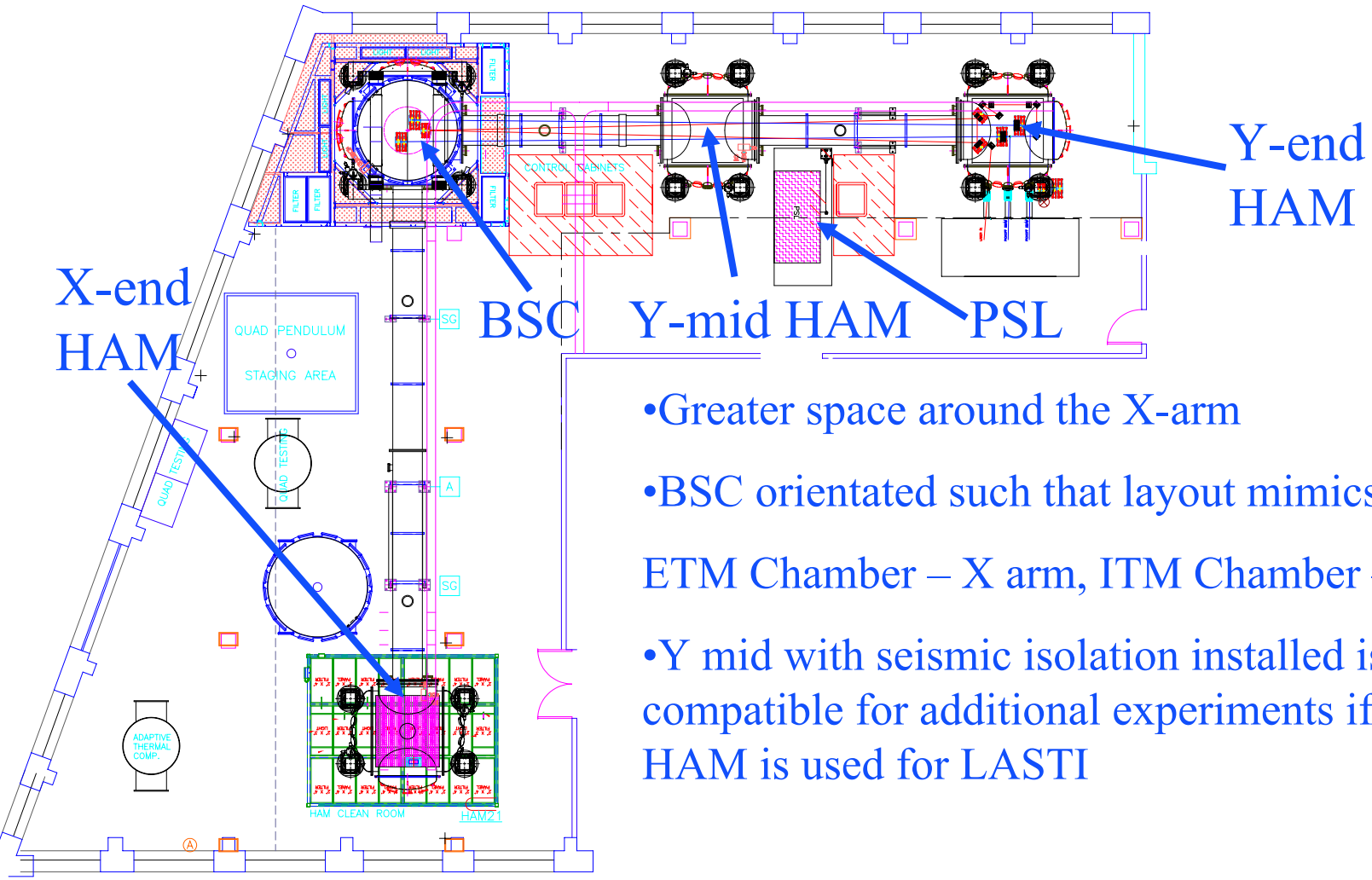
- Installed HEPI actuators on HAM
- Complete system ID completed
- 8 Modal loops closed
- See talk by Rich Mittleman
- Fit check still needed



# Recent Progress - (Vacuum Compatible Geophones and PDs)

- Problem
  - Impossible to clean geophones to ultra-high vacuum standards
- Solution
  - Place geophone in vacuum tank whose outside is vacuum compatible
  - Fill vacuum vessel with neon buffer gas, first article test with Argon was successful
  - Designed by summer student David Kaplan

# High Bay Schematic




- Greater space around the X-arm
- BSC orientated such that layout mimics:

  ETM Chamber – X arm, ITM Chamber – Y arm
- Y mid with seismic isolation installed is not compatible for additional experiments if Y-end HAM is used for LASTI

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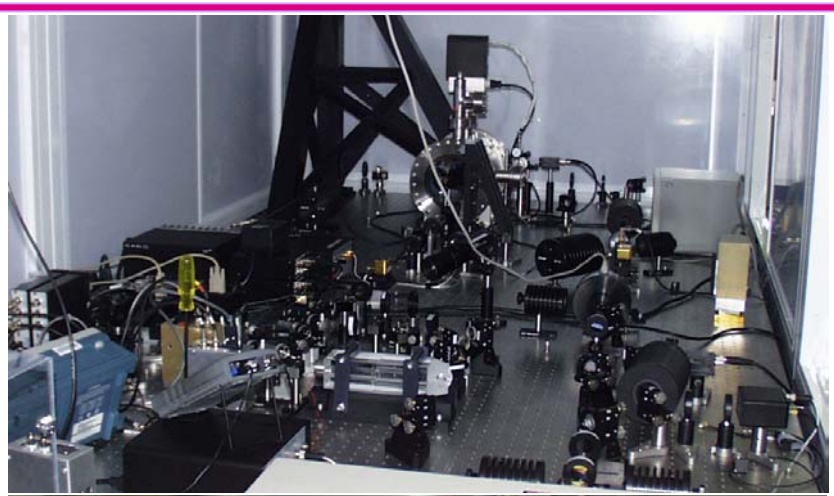
# LASTI Infrastructure and PSL

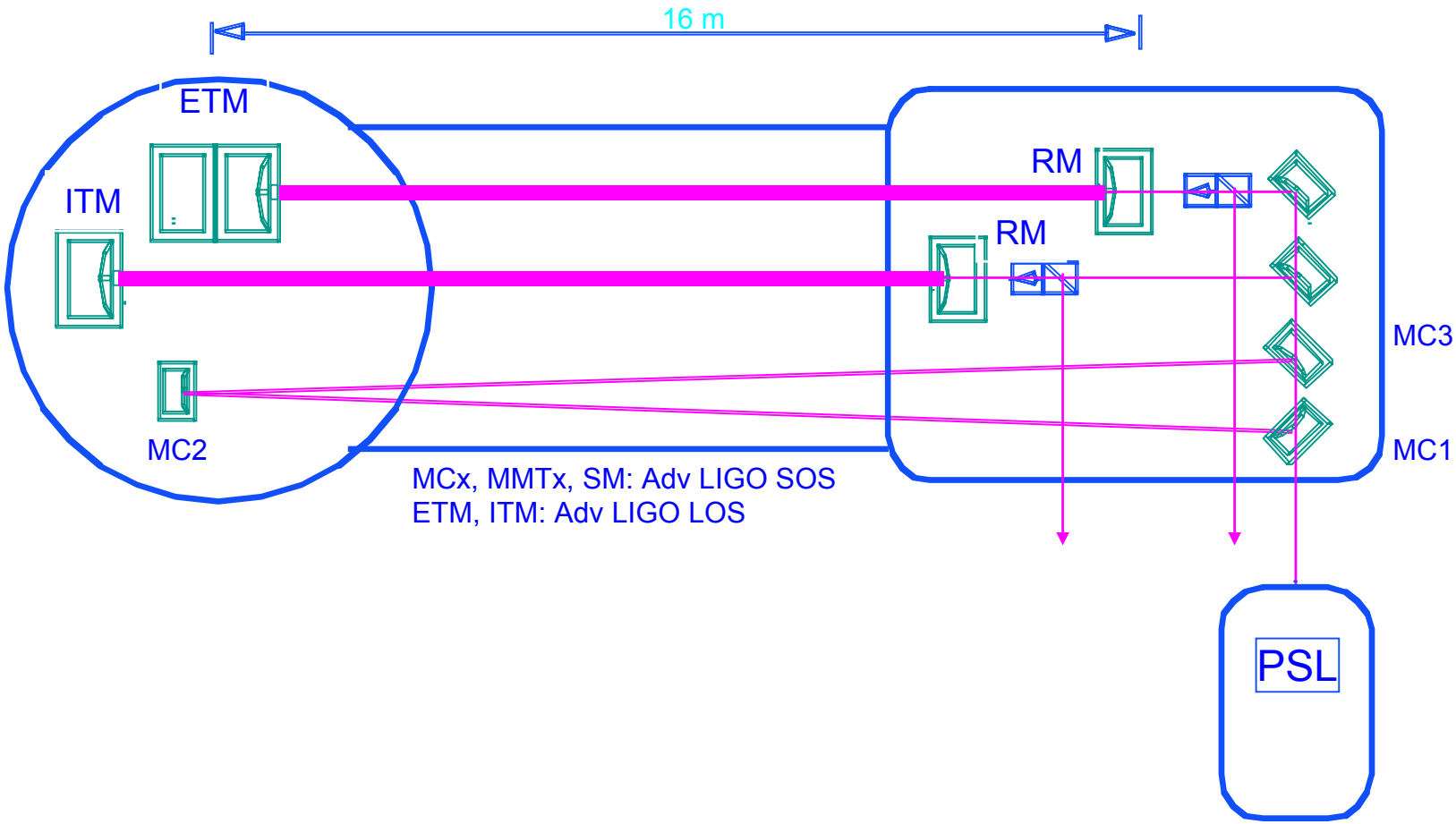


LASTI PSL

Mid Y HAM with MEPI

BSC chamber including cartridge clean room

# Initially proposed Interferometric Noise Test Configuration



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# Summary of Initial Solution

- Two cavities proposed to provide common mode rejection of mode cleaner frequency noise and technical radiation pressure noise
- Problem : Proposed payload exceeds seismic limits

  Seismic mass limit = 800 kg

  Current payload mass ~ 1000 kg

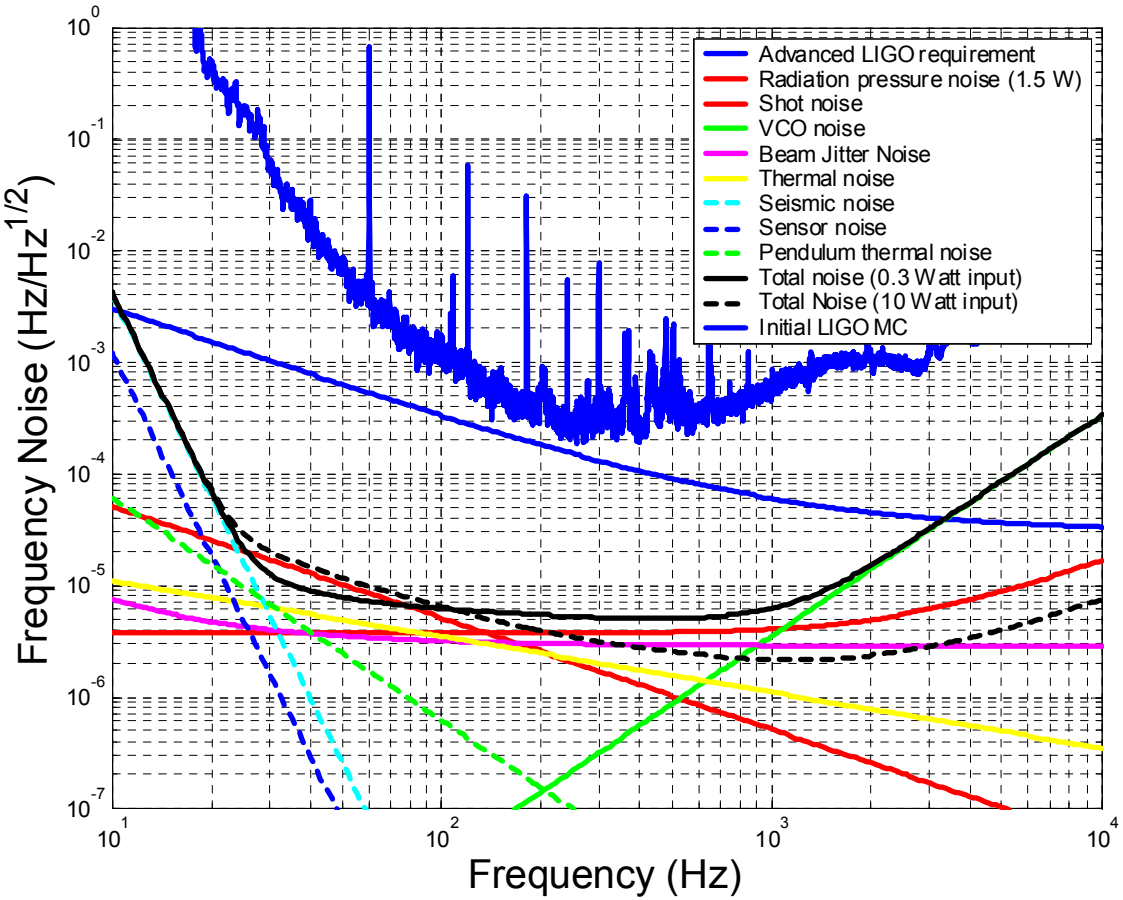
  ITM Suspension mass = 422.5 kg

  ETM Suspension mass = 472.5 kg

  MC Suspension mass = 81.3 kg +spacer
- Detailed alternative : Single test cavity LASTI

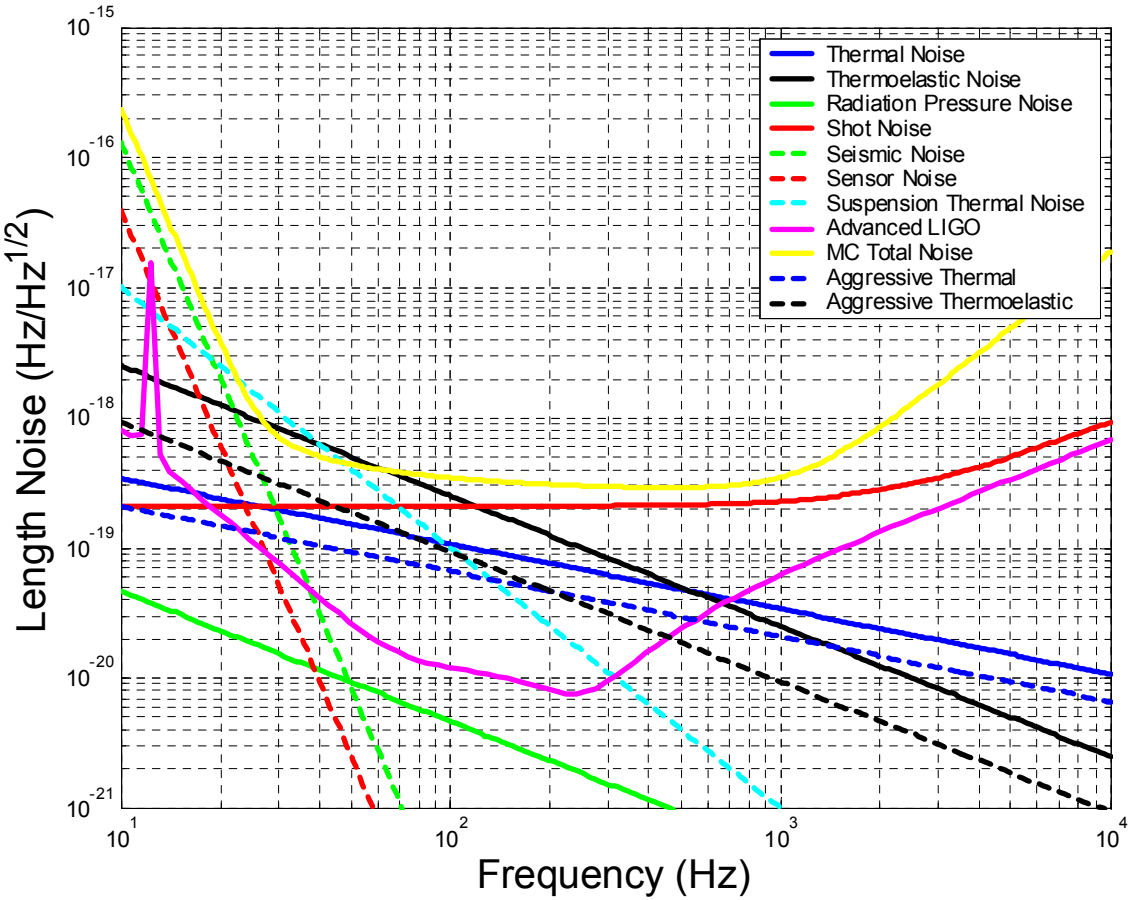
  Less schedule risk

# Predicted MC Operation



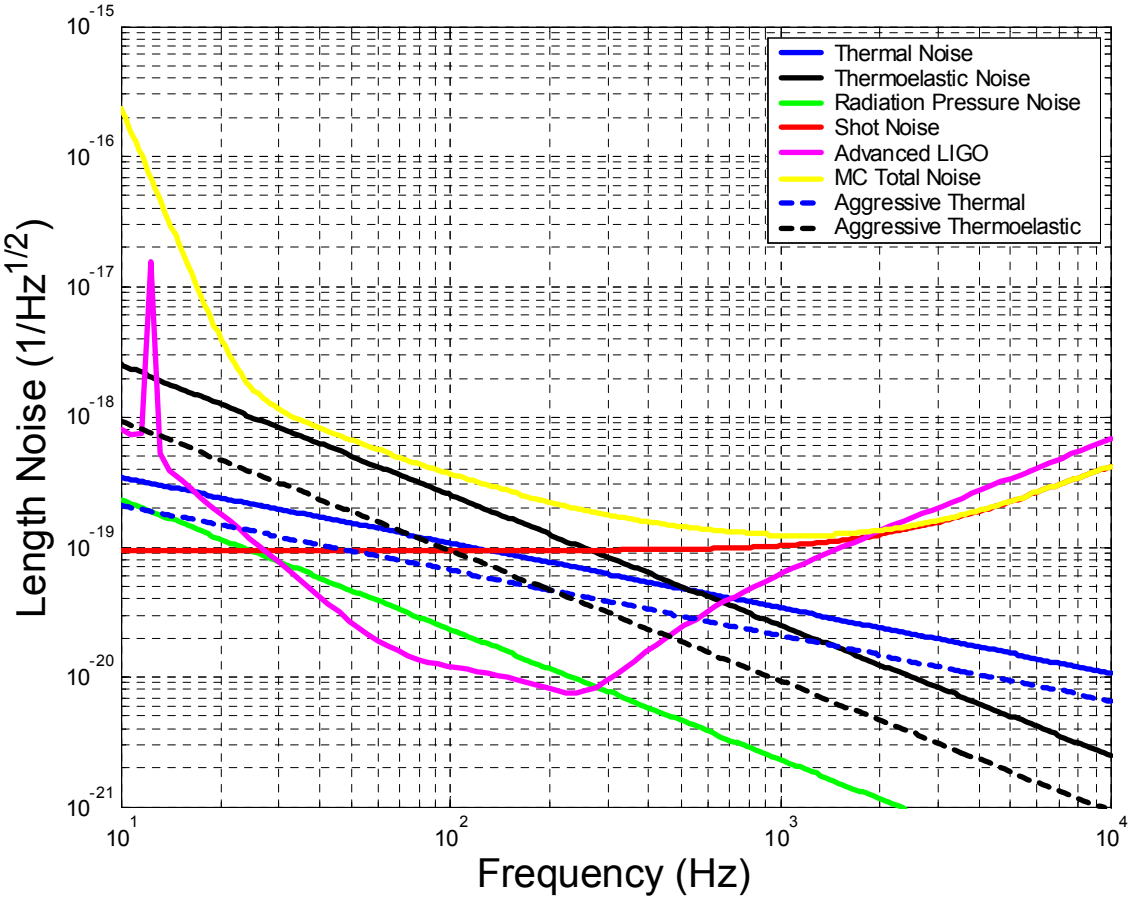

- Very important if single test cavity design is pursued
- Beam jitter only known to 100 Hz
- Calculated using AdvLIGO Parameters
- High power curve ignores VCO, beam jitter noise
- Low frequency end limited by Cambridge, MA seismic noise

# Predicted Single Arm LASTI Performance at 0.3 Watts



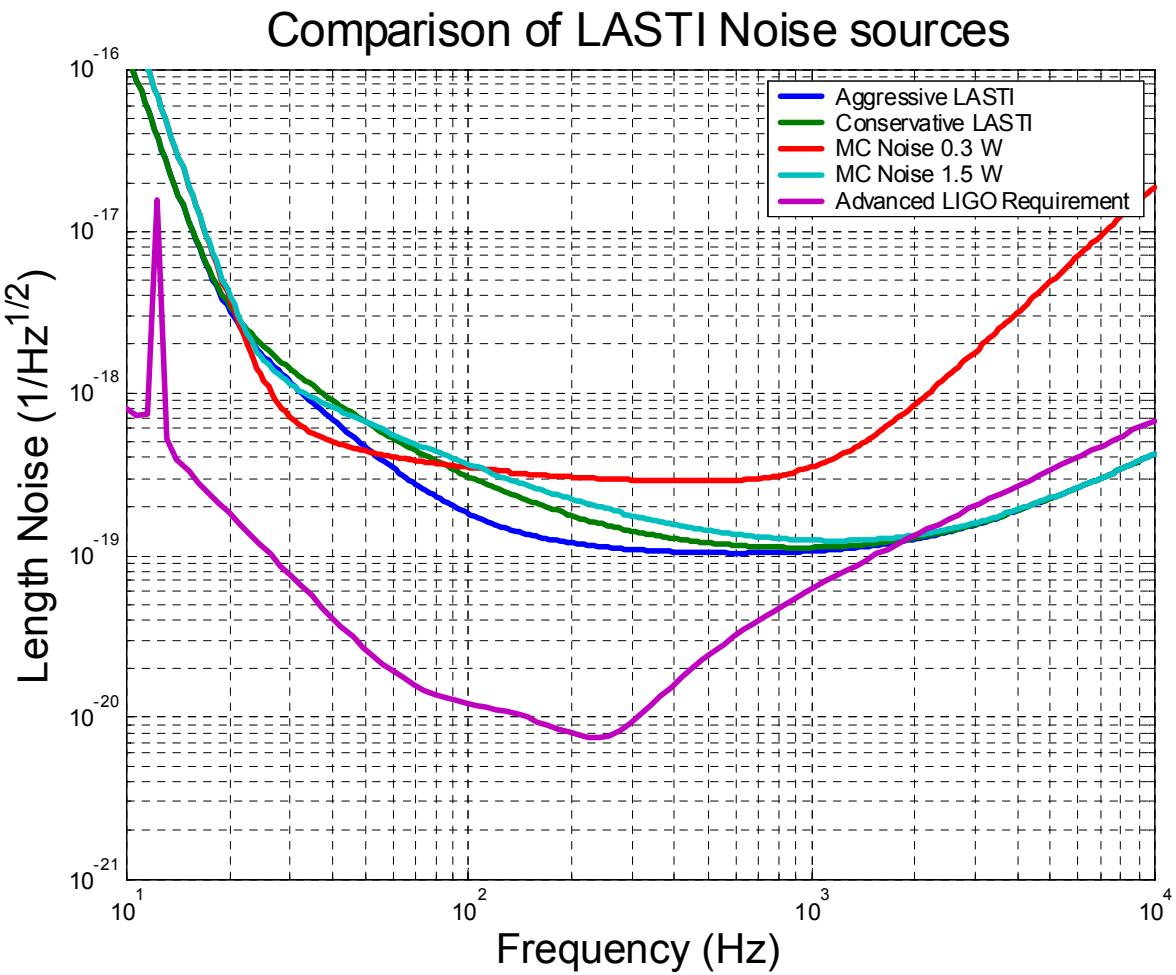

- Power incident on mode cleaner = 0.3 W
- Conservative LASTI not limited by MC noise
- Includes Seismic and Sensor noise coupling from T010103-03
- Seismic noise input at 1e-11 m/rtHz on optics table
- Aggressive LASTI 2km ROC end mirror, spot size = 7.7 mm
- Conservative LASTI 160m ROC end mirror, spot size =4.0 mm

# Predicted Single Arm LASTI Performance at 1.5 Watts

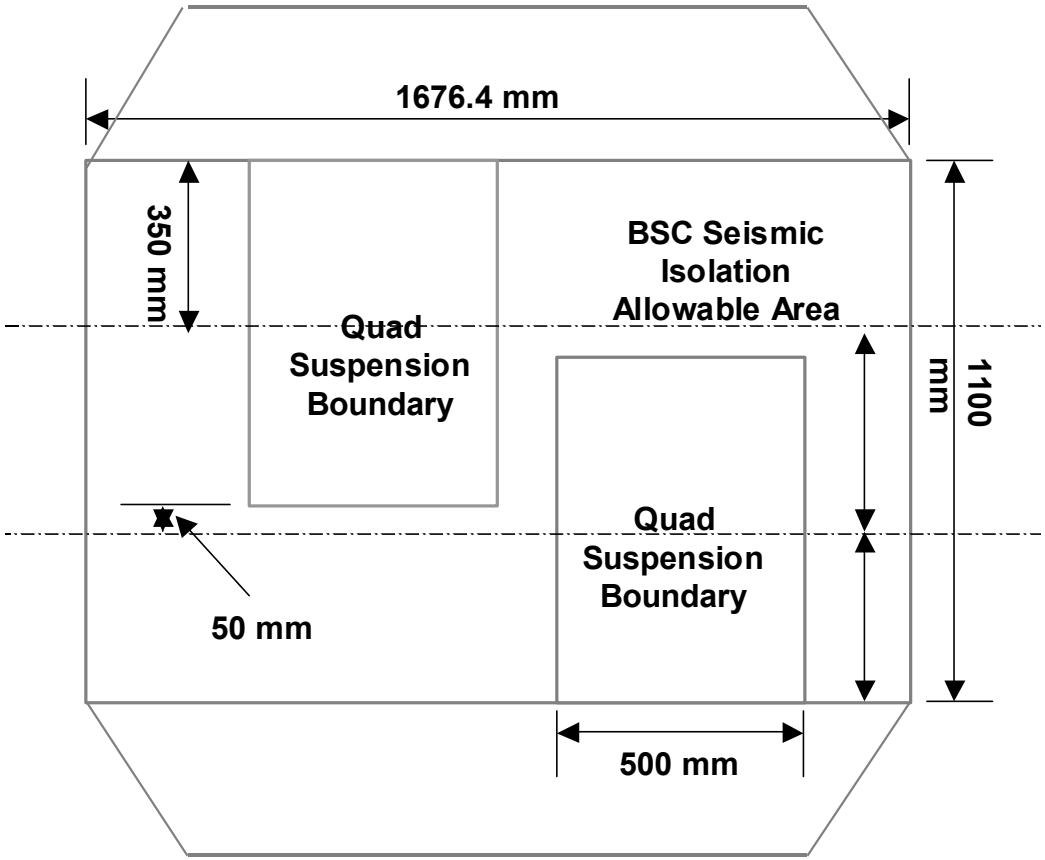



- Power incident on mode cleaner = 1.5 W
- Can reach AdvLIGO sensitivity at 1kHz with currently achieved intensity noise stability

# Comparison of Predicted Noise Curves

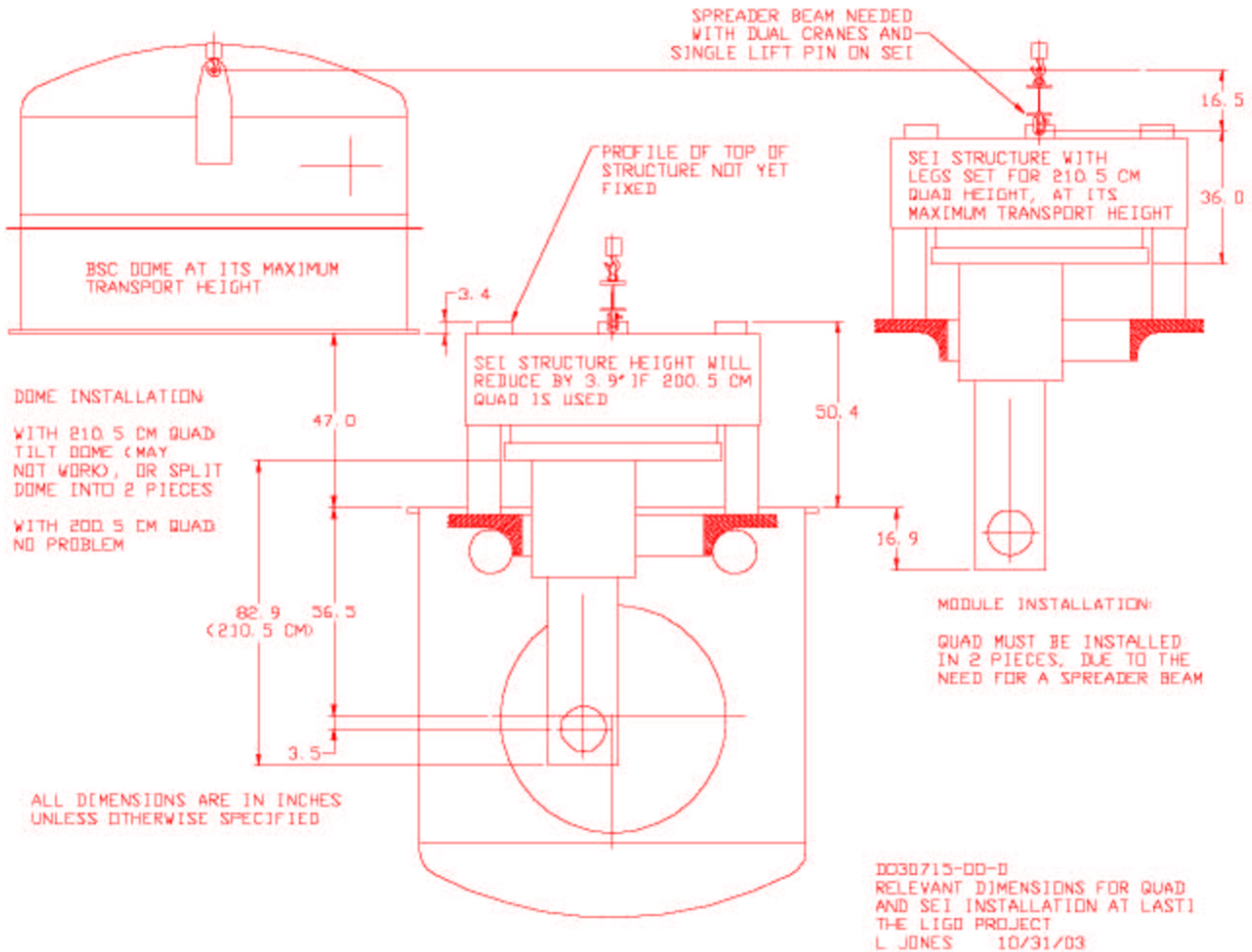


# X arm or Yarm ??




- Xarm
  - Two test cavities barely fit
  - Need to pass MC through Quad if two tc are required
  - Significantly better accessibility to HAM
  - Simulates ETMs stations
  - Probably need to move PSL
- Yarm
  - Simulates ITMs
  - PSL stays put

# LASTI Height Issues




- LASTI roof lower than observatory
- LASTI constraints should not drive AdvLIGO requirements and design
- Suspension height of 2100 mm will make putting dome back on impossible
- Possible solutions
  - Split dome ~ $37 K
  - Drop beam height

# Updated milestones:
## LLO seismic remediation interleaved with Advanced LIGO development

- 4Q99 (4Q99 act): LASTI vacuum envelope commissioned √
- 1Q00sch (3Q01 act): LASTI SEI external structures installed √
- 2Q00sch (4Q00 act): LASTI infrastructure design review √
- 3Q01sch (1Q02 act): LASTI infrastructure complete (DAQ, SEI, PSL, test cavity) √
- 4Q01: Fit LIGO I BSC stack (from spare parts) to support EPI qualification√
- 1Q02: External pre-isolator tests for LLO seismic retrofit underway
- 4Q02: PSL intensity stabilization experiment√
- 4Q02: MC triple suspension prototype installed for "controls" pre-test
- 1Q05: HAM SEI pathfinder installed for standalone testing
- 3Q04: BSC SEI pathfinder installed for standalone testing
- 2Q05: LASTI noise test begins; SUS prototypes installed
- 2Q05: Thermal compensation integration and test
- 4Q05: Interferometric displacement tests
- 1Q06: LASTI SUS/SEI test review
- 2Q06: Adv LIGO PSL/MC tests start (180 Watts)

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# Short term plans (ie 6months)

- HAM HEPI Work
  - » Complete controls testing
  - » First production fit check using Xend
  - » Finish conversion of controls from Dspace to VME
- Advanced LIGO
  - » Lull in activity in first quarter 2004
  - » Controls MC triple in HAM (Needs HEPI)
  - » Coincides with temporary staff re-allocation
    - – Middleman, Mason, McInnes, Sarin (HEPI Install LLO)
    - – Harry (Commissioning at LLO in January)
    - – Ottaway, Mason (Initial Thermal Compensation effort LHO)

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# Conclusions

- Change baseline design to a single test cavity approach
- List of required suspensions
  - » 1 ETM Quad, 1 RM Triple and 4 MC Mirrors
  - » Extra MC Suspension will get better performance at low end
- Change to using the Xarm
- Lull in activity for first quarter of 2003 due to schedule and staff re-allocation issues