



# Initial LIGO Assembly and Alignment Techniques

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## Initial LIGO Assembly

Specifications on assembling and balancing and optic are detailed in:

Small Optic Suspension (SOS) Assembly Spec.,  
E970037-C

Large Optic Suspension Balancing Spec.,  
E970154-E

# Initial LIGO Assembly and Alignment Techniques

- Initial LIGO Assembly – in the optics lab

<b>DOF</b>	<b>Reqt.</b>	<b>Method</b>	<b>Tools</b>
Pitch	+/-0.5 mrad	Adjust wire standoff	PZT buzzer, Optical lever/Autocollimator
Yaw	Side osems	Move susp block	
Pos./Long/Axial/ Beam direction	Side osems	Move susp block	
Rotation/Roll	Back osems	By hand	
Side/Transverse	Back osems	Move susp block	
Vertical	Back osems/ +/- 0.5mm	Winch	Height gage

# Initial LIGO Assembly and Alignment Techniques

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- Initial LIGO Installation – from optics lab to chamber  
Specifications on installing the suspensions are detailed in:  
LOS Installation Procedures for HAM Chambers, E000061-C  
LOS Installation Procedures for BSC Chambers, E000062-C

# Initial LIGO Assembly and Alignment Techniques

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- Initial LIGO Alignment – the interferometer
  - » Determination of Global and Local Coordinate Axes for the LIGO Site, T980044.
    - monument and curvature of the earth info.
    - converting global to local coordinates
  - » Determination of the Wedge Angles for the Core Optics Components, T970091
    - beam vectors and wedge info
  - » ASC Initial Alignment Procedures, T970151
    - figure out where the optic is and move it to where it's supposed to be.



# Initial LIGO Assembly and Alignment Techniques

- Initial LIGO Alignment – on optical table

DOF	Requirement	Method	Tools
Pitch	+/- 0.1 mrad	PAM screws	autocollimator
Yaw	+/- 0.1 mrad	PAM screws pushers	autocollimator
Position/Longitudinal/Axial/Beam direction	+/- 3mm	PAM screws pushers	theodolite – electronic distance measurement
Rotation/Roll	N/a	N/a	N/a
Side/Transverse	+/- 1 or 5mm	Side PAMs pushers	theodolite
Vertical		shims	theodolite

# Initial LIGO Alignment Techniques

- Alignment Equipment

- » **Transit square** – extremely accurate optical square – within 1 arc second.
- » **Theodolite** – accurate angular positioning instrument. It uses a rotary encoder to provide angular positioning within 1 arc sec (5 microradians.) Also has an electronic distance measurement feature, - +/-3mm.
- » **Autocollimator** – for angular measurement. Includes a photodiode. Fancy optical lever.

# Initial LIGO Alignment Techniques

- Alignment Overview

- » Monuments in concrete directly under beam tubes (BTVE)
- » Transit square positioned over offset monuments
- » Theodolite from transit square to horiz. direction (x,y)
- » Use scribe on structure for x,y position of theodolite
- » Markers on side of beam tubes that indicate center of tube – used to pick up beam vertical position (z)
- » Calculated vectors for beam hitting middle of front face of each optic.
- » Autocollimator gets mounted and aligned to theodolite.
- » Position autocollimator/theodolite in direction of beam.
- » Adjust pitch/yaw/position with PAM screws.



# Advanced LIGO Assembly and Alignment Techniques

- Advanced LIGO Assy Techniques – in optics lab

DOF	Reqt.	Method	Tools
Pitch		Moving masses	Optical lever, autocoll.
Yaw		Blade rotation	
Pos./Long/Axial/ Beam direction		Blade rotation	
Rotation/Roll		Blade rotation	Metal - screw
Side/Transverse		Tablecloth holders	
Vertical		Wire length, added mass, library of clamps, winch	Height gage

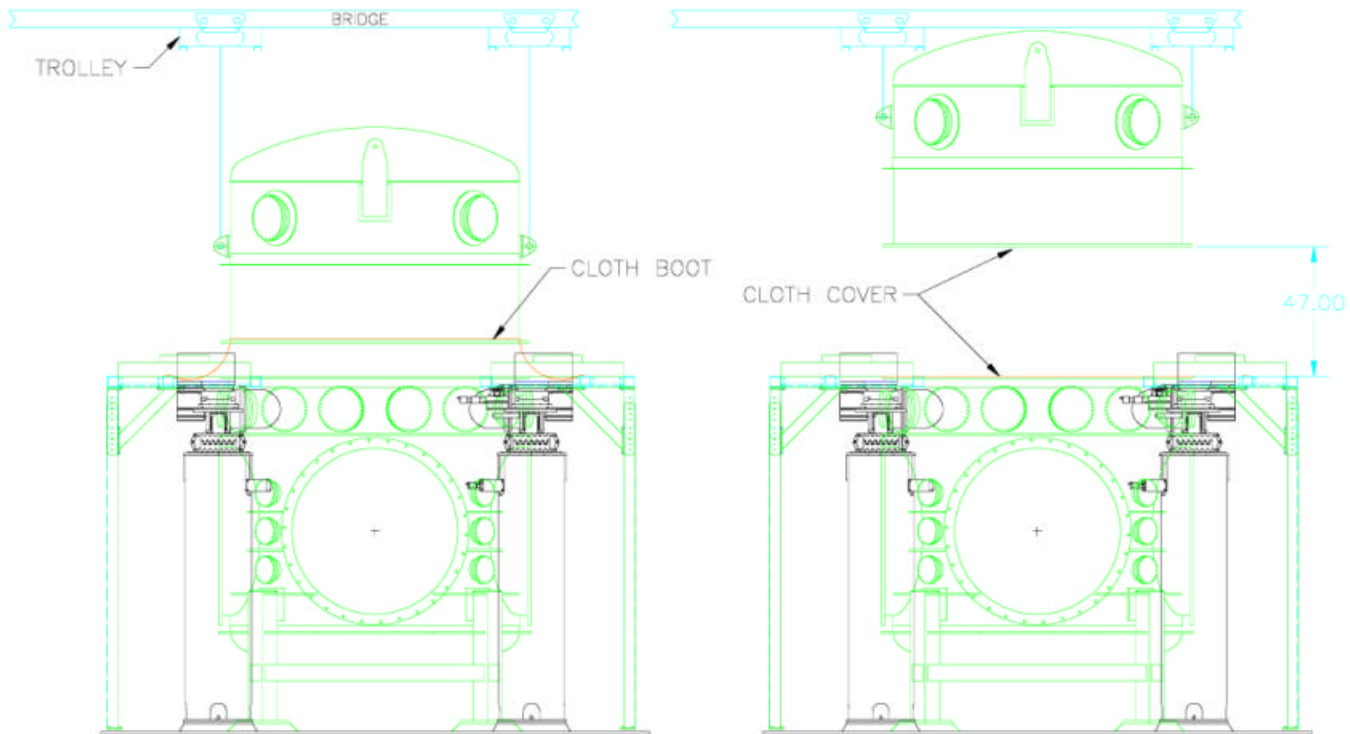


# Advanced LIGO Installation/Alignment Techniques

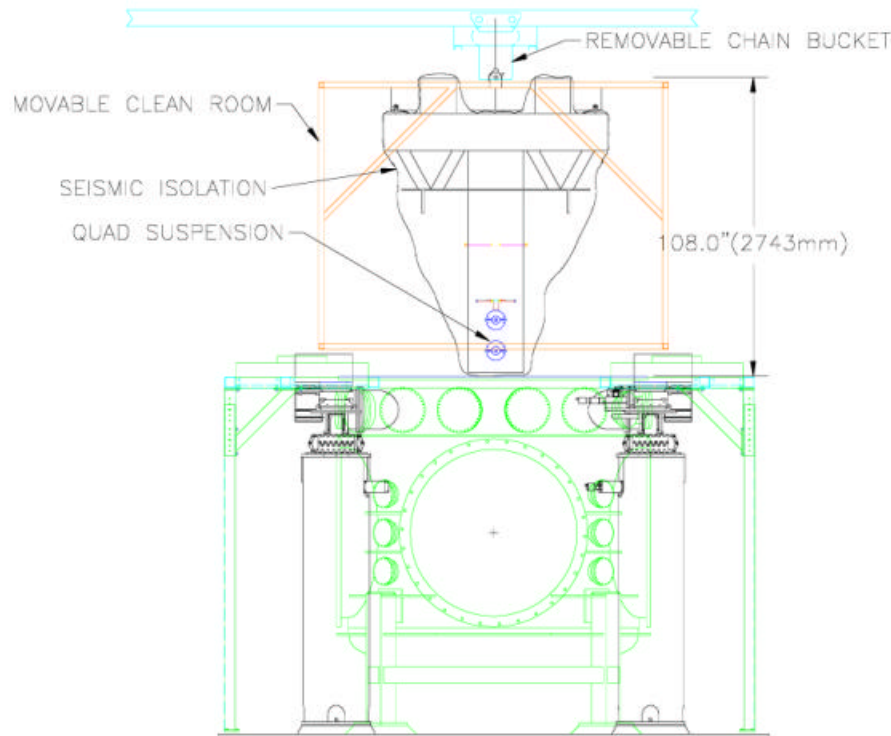
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- HAMS - Same as LIGO 1?
  - » Except triples will need additional feet mounted to bottom of structure to allow for removal of the teflon highway.
- BSC –
  - » Cartridge installation of upper part of quad only.
  - » How to install lower catcher?
    - Pushers on upper structure to move lower structure, or just move upper structure?

# Advanced LIGO Installation Techniques – Cartridge Install



# Advanced LIGO Installation Techniques – Cartridge Install



# Advanced LIGO Assembly and Alignment Techniques

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- Advanced LIGO Install. Techniques – on optical table
  - » Same as Initial LIGO?
  - » Quads – lower catcher mounts to upper structure – how to align one to another: dowel pins?
- Questions –
  - » How to do alignment if a fiber needs to be replaced
  - » How to do alignment if an osem needs replacing
  - » How to do alignment when a wire needs replacing.