



LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1300598-V1

Advanced LIGO

12 JUL. 2013

**BSC4-L1 & BSC9-H1, Requirements & Procedure, Cartridge Flight
& Insertion into BSC Chambers, aLIGO**

Sam Barnum, Calum Torrie, Eduardo Chavez

Distribution of this document:
LIGO Science Collaboration

This is an internal working note
of the LIGO Project.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW17-161
175 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland, WA 99352
Phone (509) 372-8106
Fax (509) 372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone (225) 686-3100
Fax (225) 686-7189

<http://www.ligo.caltech.edu/>

1. Reference Documents

BSC4-L1 D0900471, BSC9-H1 D0901150, Top Level Chamber Assembly

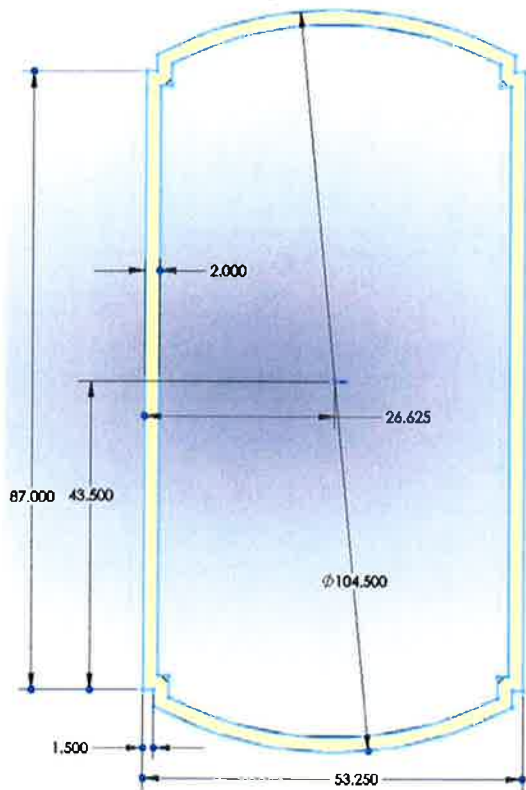
2. Rules about constructing BSC Installation Cartridges:

1. Items hung from the BSC-ISI that break the following rules will need to be removed, Or the cartridge will needed to be maneuvered such that rules are maintained.
 - a. Items must fit within support tubes. See Clearance Zone On P2
 - b. Items must fit within all 4 Beams on the Test-Stand. Also see P2
2. MAX Cartridge weight without 3PT Lifter is 9,500 lbs. See detailed mass budget *E1000202*.
3. CG of the Cartridge in X and Y, must be in the adjustable range of the lifting bar, or masses will need to be added back on, to balance the cartridge (Keel Mass will be removed). Balance may be achieved with temp mass on sidewalls if needed. (In this case, go below 9,500 lbs/4310 kg, then add back on to achieve XY balance).
4. Listing of items on ISI, ITM, ETM, BS/FM, TMS, that will need to be locked down when the cartridge is moved. And Cartridge Install procedure.

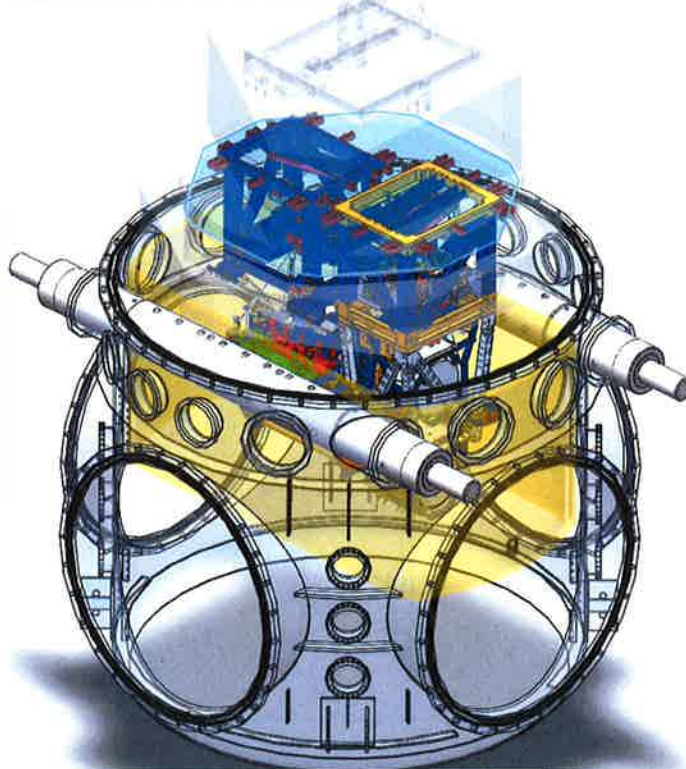
Conventions:

1. Views Labeled TOP are viewed from above looking down
2. Views Labeled Bottom are from bellow looking up.
3. Views Labeled Front are looking forwards from behind, so you see the back of the Cartridge.
4. Views Labeled Left are looking left from right side of the cartridge, so you see the right side.
5. All View Names correspond to the Views used in SolidWorks.
6. X-Y-Z Triad in each figure is relative to *G1000125*.
7. Cranes, and the direction of movement, are referred to by their compass orientation. At LHO: +X=North, +Y=West, LLO: +X=West, +Y=South.

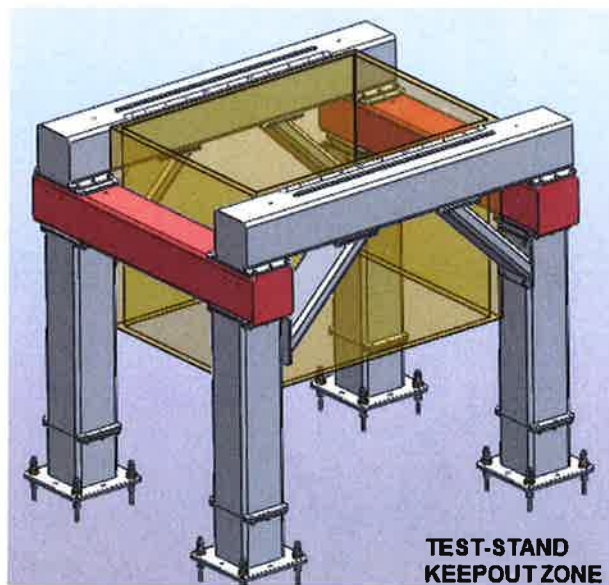
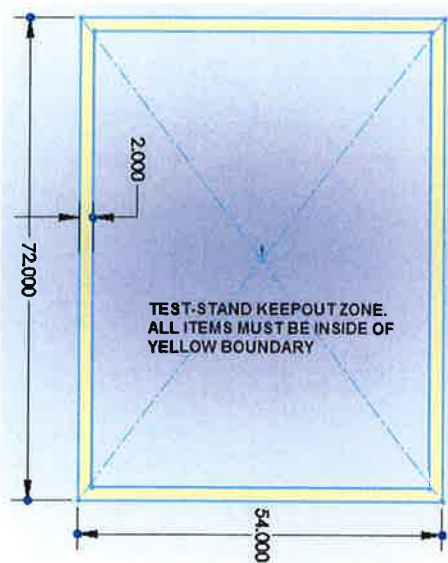
Clearance zone layout for BSC



BSC5-L1 D0900506, BSC10-H1 D0901154

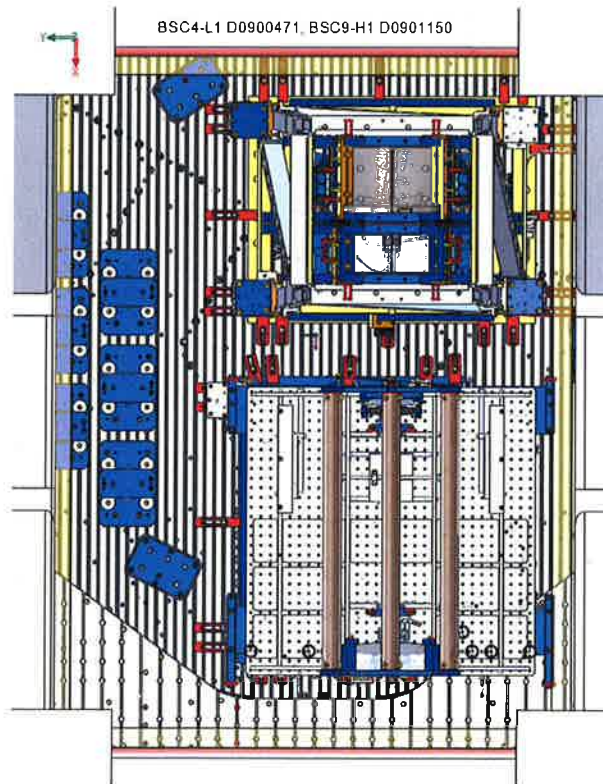
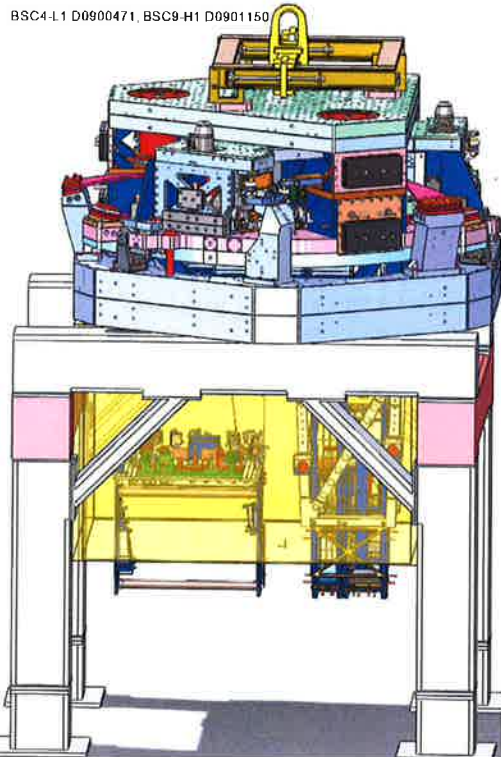
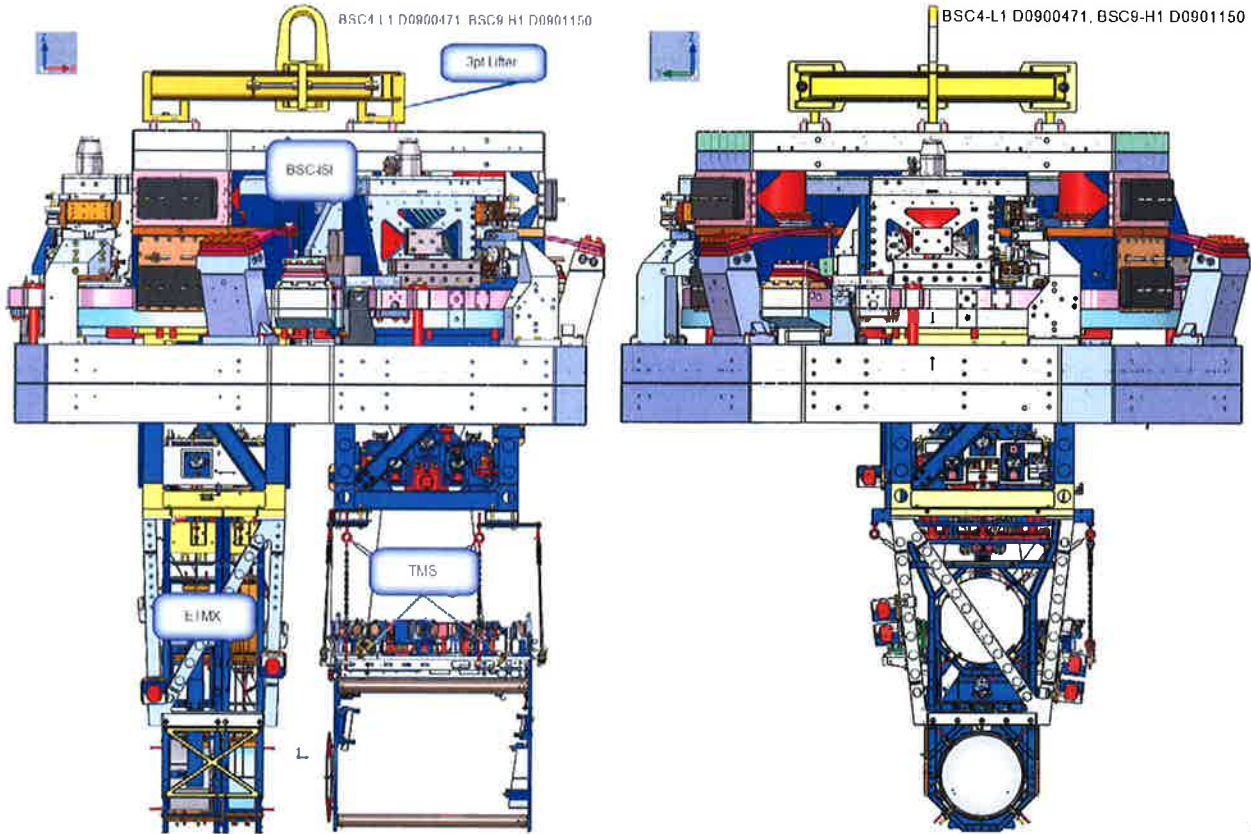


The Clearance Zone is a 2 inch wide area defined between the support tubes, and by the chamber shell. Any items on the cartridge that protrude partly into this zone should be considered for alteration or removal during install. **ANY ITEMS THAT PROTRUDE ALL THE WAY INTO, OR THRU, THE ZONE, MUST EITHER BE REMOVED OR ALTERED SO AS TO STAY CLEAR OF THE ZONE FOR INSTALL.**



The following pages show the current expected configuration of the BSC cartridge. Any issues with items violating the Clearance Zone are flagged, and possible cartridge maneuvering with the crane during install is suggested. The locations of the CGs is also shown with reference to the lifting bar on top of the cartridge.

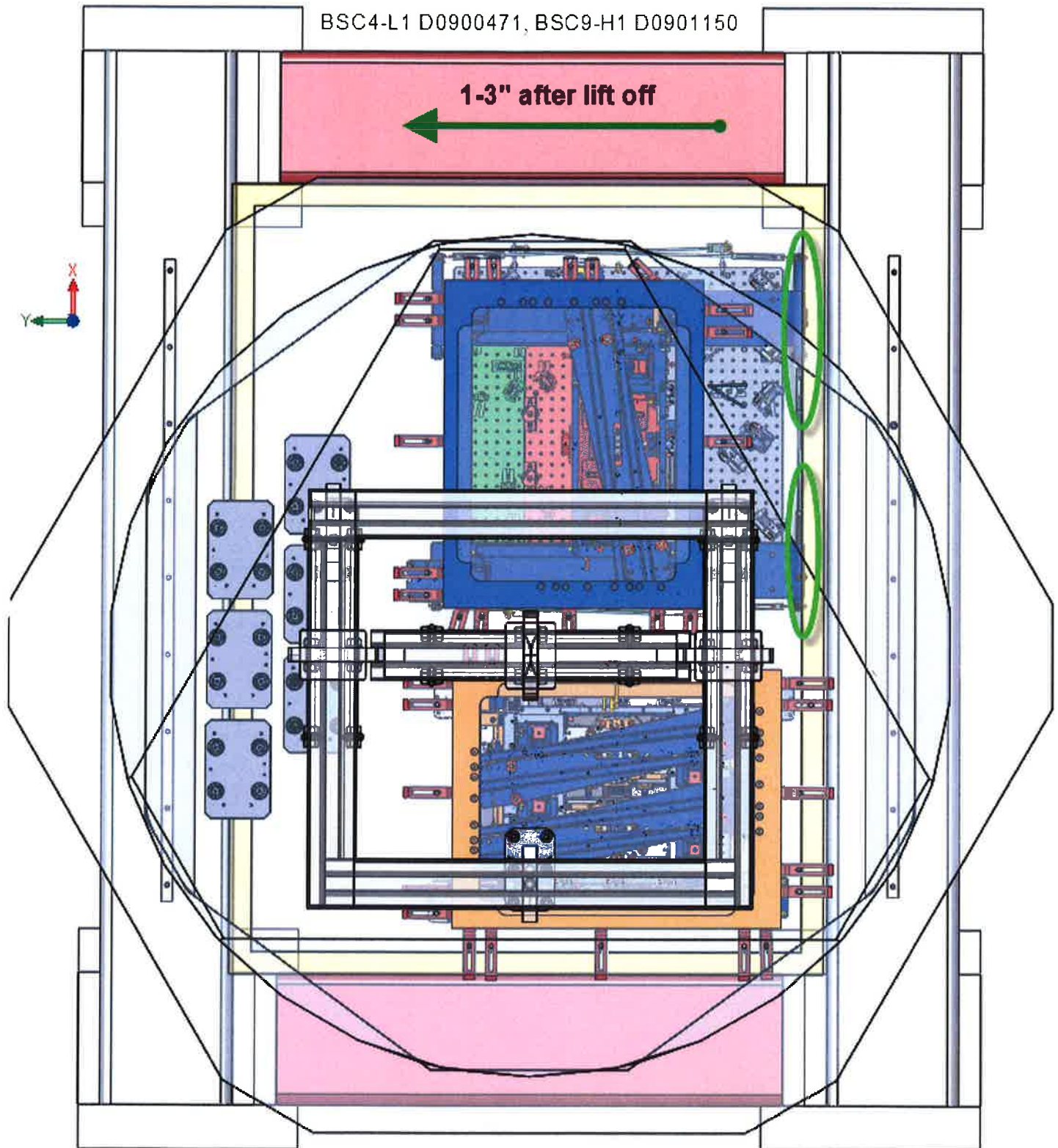
Start BSC4-L1 D0900471, BSC9-H1 D0901150, Considerations



Cartridge will be offset on the Test Stand.

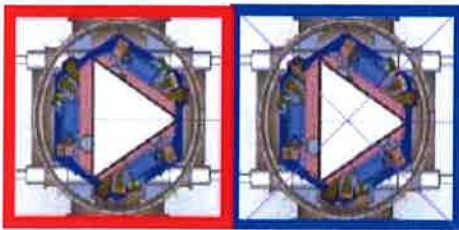
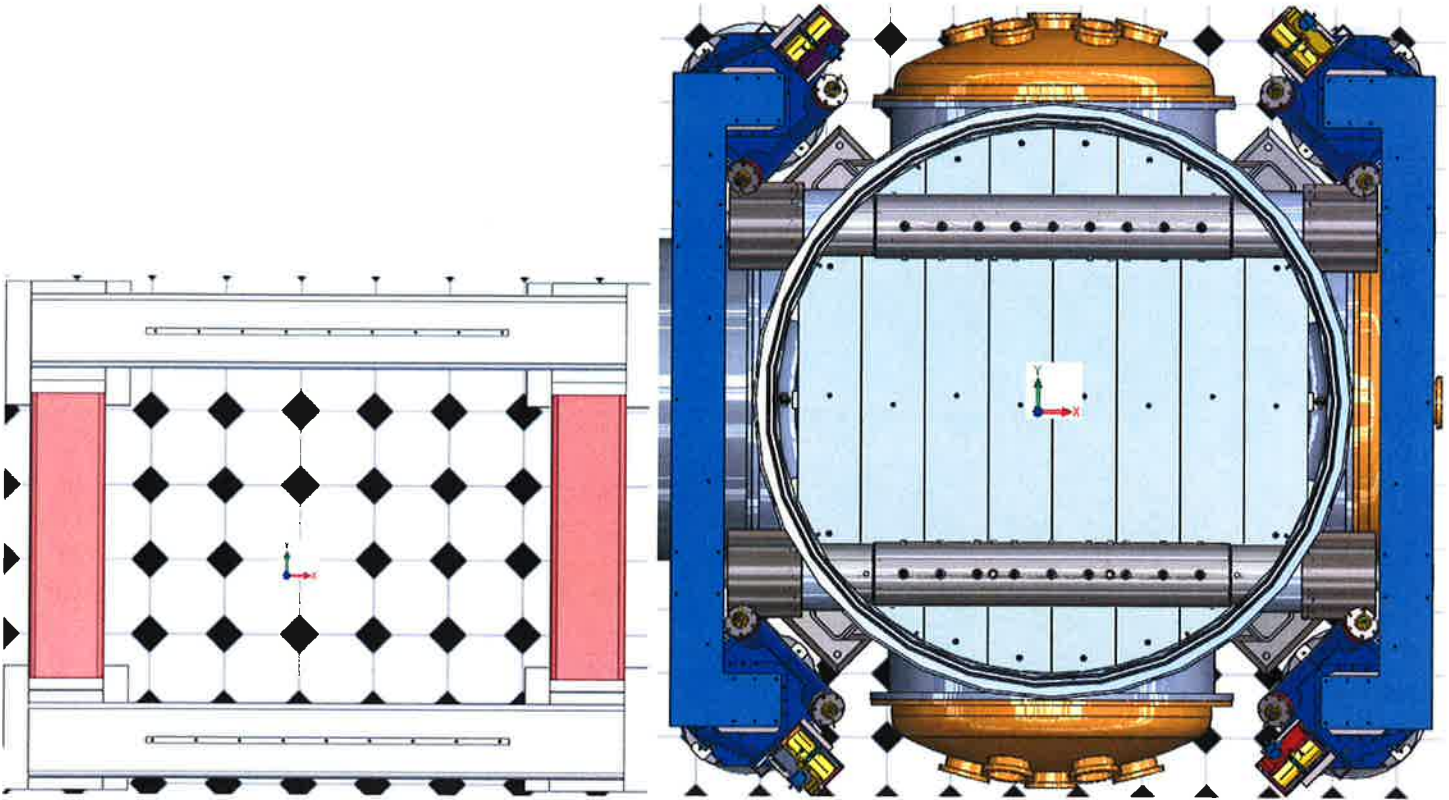
Cartridge installation of BSC. 3pt Lifting bar can cover the range of locations for the XY CG

BSC4-L1 D0900471, BSC9-H1 D0901150, Crane moves need to clear the Test Stand Clearance Zone. (NONE)



Circles in green indicate any protrusion into the keep out zone. Any global XY moves relative to the Test-Stand will depend on the orientation of the Test-Stand.

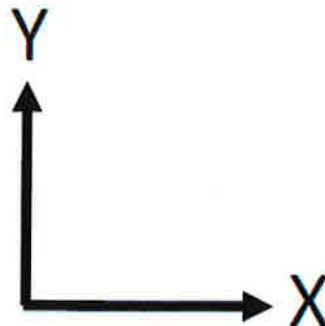
BSC4-L1 D0900471, BSC9-H1 D0901150, will not need to be rotated before insertion into the camber because the test stand is oriented parallel to the support tubes in the BSC chamber.



BSC9
 H1:ISI-ETMX
 h1isietmx.mdl
 BSC-ISI/H1/ETMX/

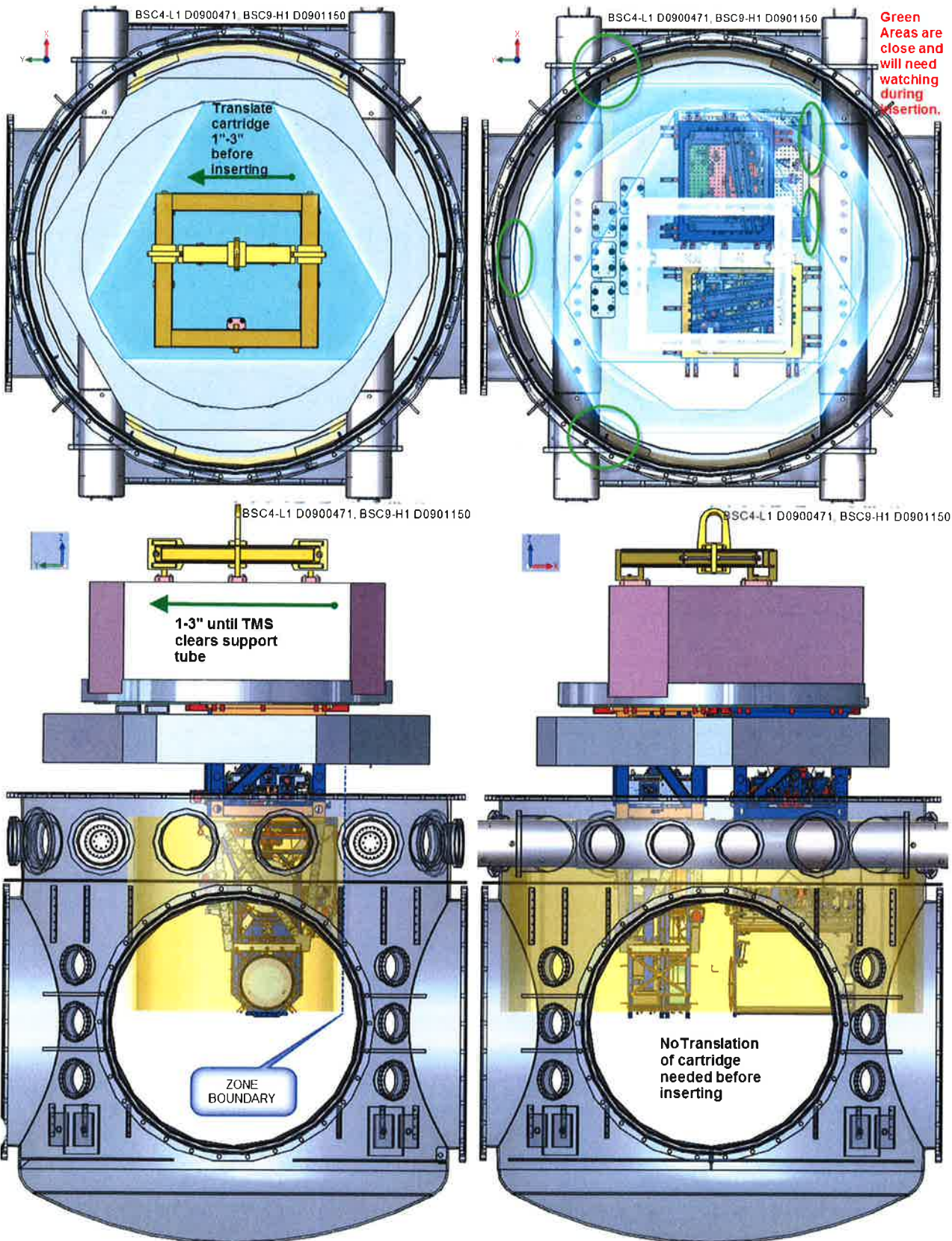
~~BSC5~~
~~H2:ISI-ETMX~~
~~h2isietmx.mdl~~
~~BSC-ISI/H2/ETMX/~~

BSC4
 L1:ISI-ETMX
 l1isietmx.mdl
 BSC-ISI/L1/ETMX/

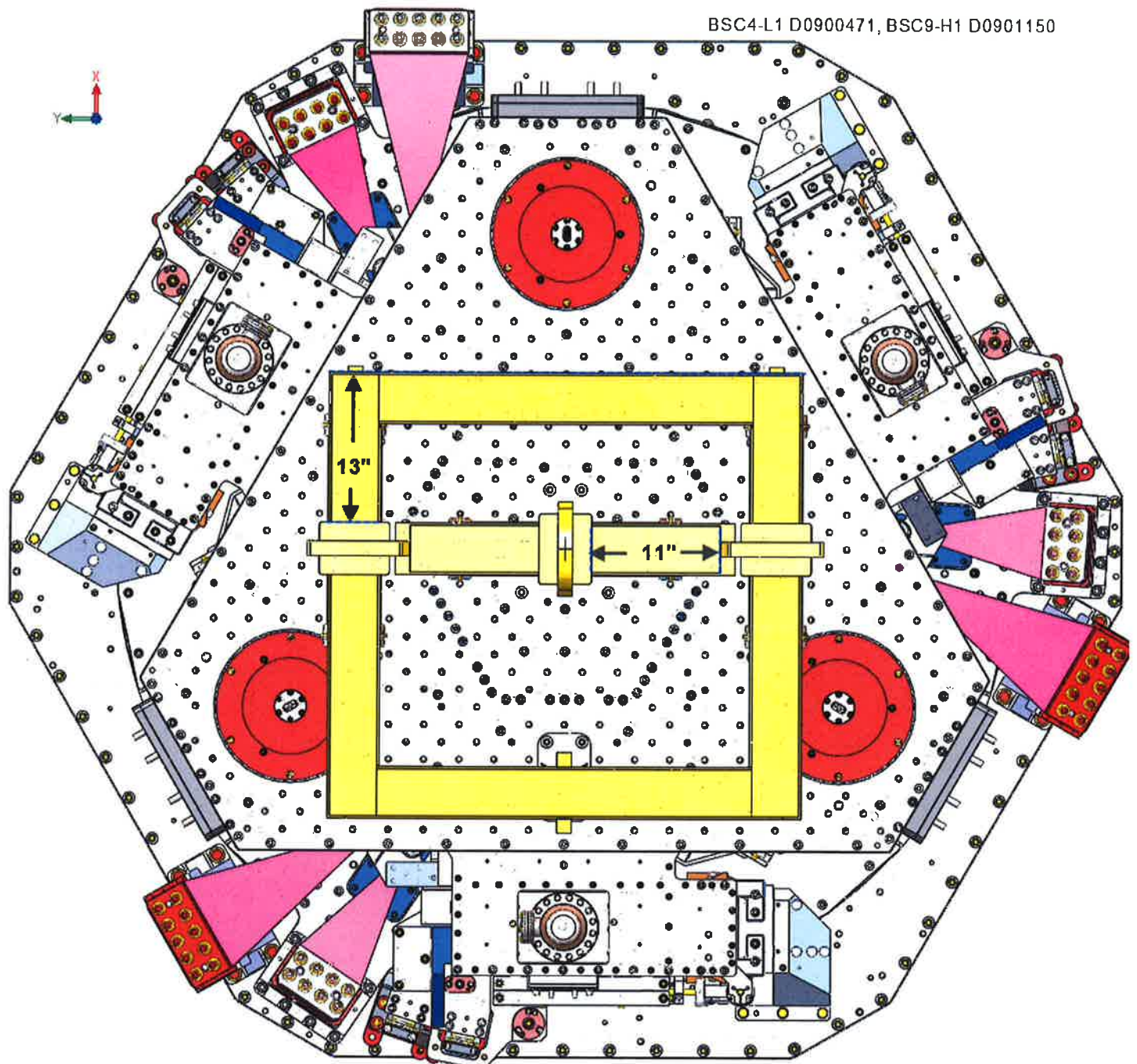


Orientations are from G1000125

BSC4-L1 D0900471, BSC9-H1 D0901150,, Crane moves need to clear the Chamber Clearance Zone. (NONE)



Locating the Bale pre-lift of the cartridge (Some adjustment will be needed)



Items that will need to be locked down when the cartridge is moved:

1. **BSC-ISI:** (see [E1200344](#) sections 4.2)

completed, approved or checked by:
date:
comments (optional):

2. **ITMY:** Final checks before moving ([T1100406](#)):

completed, approved or checked by:
date:
comments (optional):

Cartridge: Preparation for, and installation into Chamber:

aLIGO BSC ISI/Quad Install Procedure: (see [E1200344](#))

completed, approved or checked by:
date:
comments (optional):



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO- E1200925-v3

Advanced LIGO

29 Apr 2013

**BSC Cartridge Installation
Hazard Analysis**

Sam Barnum, Dennis Coyne, M. Landry, Brian O'Reilly, Norna Robertson, Calum Torrie

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This is an internal working note
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California Institute of Technology
LIGO Project – MS 100-36
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland, WA 99352
Phone (509) 372-8106
Fax (509) 372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone (225) 686-3100
Fax (225) 686-7189

<http://www.ligo.caltech.edu/>

APPROVAL SIGNATURES

Dennis Coyne, LIGO Chief Engineer Date

David Nolting, LIGO Lab Safety Officer Date

Richard Oram, LLO Site Safety Responsible Date

John Worden, LHO Site Safety Responsible Date

Brian O'Reilly, Advanced LIGO LLO Installation Lead Date

Michael Landry, Advanced LIGO LHO Installation Lead Date

David Shoemaker, Advanced LIGO Leader Date

Albert Lazzarini, LIGO Directorate Date

CHANGE LOG

Date, version	Summary of Changes
18 Oct 2012	Initial release for comment (modified from E1200327 BSC2-L1)
25 Oct 2012	<p>1) BIG ONE - is this is now a general HA for ALL Cartridge installs. 2 have now been completed at LHO and one at LLO.</p> <p>As part of this change to general we clarified, noted and identified the following: -</p> <p>2) Identified risk for damage to Gate-Valve Plumbing and Gate Valve (section 2 and hazard 9)</p> <p>3) Noted that some keel plate hole patterns are rotated by 120deg from the that shown in the assembly documentation, adjust x-y of the lifter bale position to compensate for rotation. (section 3.4)</p> <p>4) Spelled out that there is a need to rotate Cartridge to align with chamber, if a rotation of the cartridge is required to align it to the chamber (BSC1,2). (Section 3.5)</p> <p>5) Updated related documents (section 4)</p> <p>6) Identified clearly that the cleanroom will be fitted with a 4" spacer between the two halves to provide clearance for the gate-valve motor box. A narrower version of Platform-C will be used in place of the original Platform-C to avoid contact with the gate-valve plumbing (Section 5.9)</p> <p>7) walking Plate railings will not be reinstalled, due to lack of clearance between them and the incoming Cartridge. (3.8)</p>
26 Apr 2013	Added hazard associated with moving cleanroom while people are resident on work platforms.
29 April 2013	Modified signature page as per D. Nolting

1) Scope

This document covers safety concerns related to the installation of the BSC cartridge from the Test/Assembly stand into the BSC Chamber. The cartridge is comprised of the BSC Internal Seismic Isolation (ISI) with all of the optics table payloads which can be lifted and inserted without interference into the chamber.

The scope includes:

- 1) Preparation and liftoff of cartridge from the Test/Assembly Stand.
- 2) Flight of the cartridge from the Test/Assembly stand to the Chamber.
- 3) Insertion of the Cartridge into the chamber.

This document does not cover the issues associated with the individual suspension and seismic systems that are part of the cartridge. Nor does it cover aspects specific to the crane, or handling of optics. These are covered by other documents.

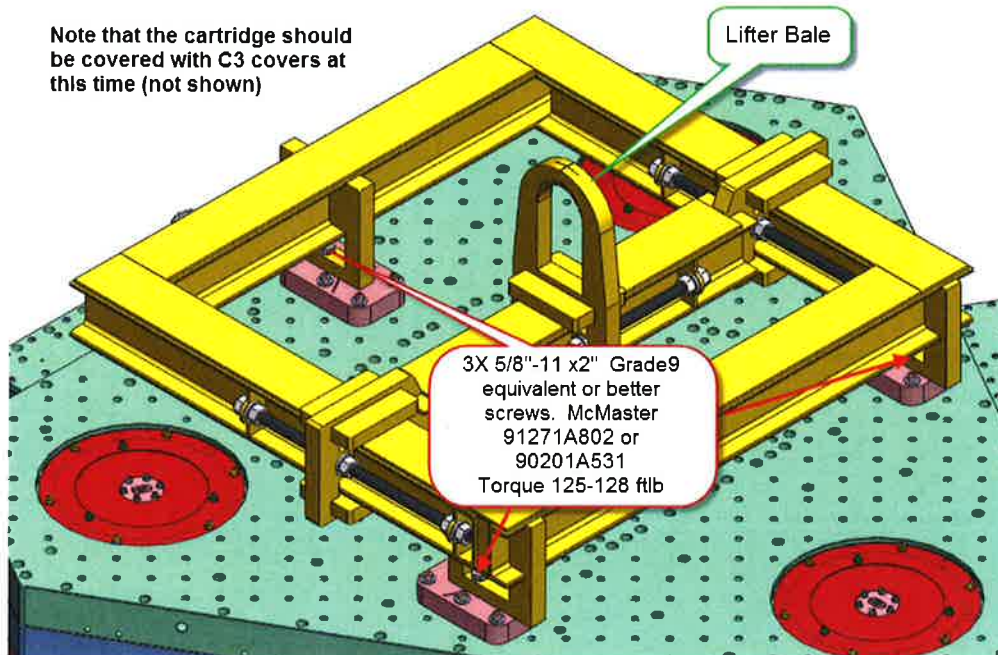
2) Summary of Hazards

The hazards in this work can be broadly divided into the following areas:

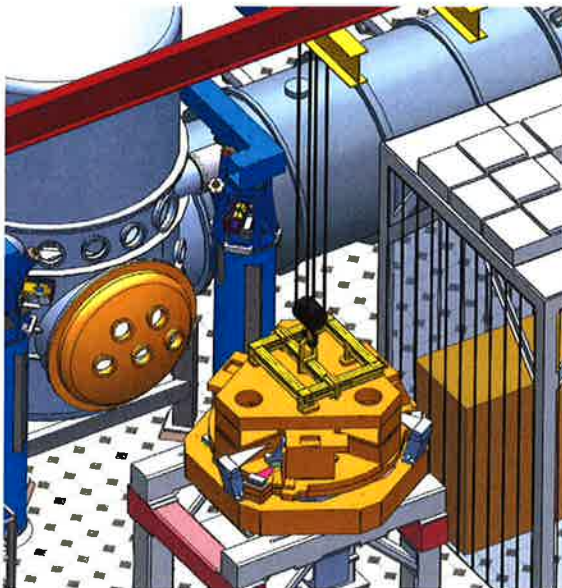
- 1) Moving of heavy, delicate and valuable structures with lifting and moving equipment, with potential for shock/impact if dropped or bumped, leading to the following potential failures/hazards:
 - a) Personnel injury (crushing, pinching, falling).
 - b) Damage to equipment, such as:
 - failure/stretching of wires and/or fibers.
 - misalignment of suspension elements.
- 2) Damage to the suspensions or isolation system,
 - a) Impact against the Test/Assembly Stand.
 - b) Impact against the BSC Chamber and Support Tubes.
- 3) Particulate contamination,
- 4) Cartridge dropped,
- 5) Crane failure (without drop) or Power Failure during operation,
- 6) Crane/Structural failure (Overload crane),
- 7) Drop/fall hazard of tools, etc. due to assembly of components at height,
 - a) While putting covers over cartridge.
 - b) During attachment of 3pt Lifter to cartridge.
 - c) When attaching Cartridge to Chamber support tubes
- 8) Crane rotation failure while cartridge suspended.

3.2 Attach 3pt Lifter to Lift Hook Receivers (D1003140), use 5/8"-11 Grade9, equivalent or better (91271A802, 90201A531), 125-128 ft-lb

Note that the cartridge should be covered with C3 covers at this time (not shown)



3.3 Crane In position above Cartridge and Test Stand



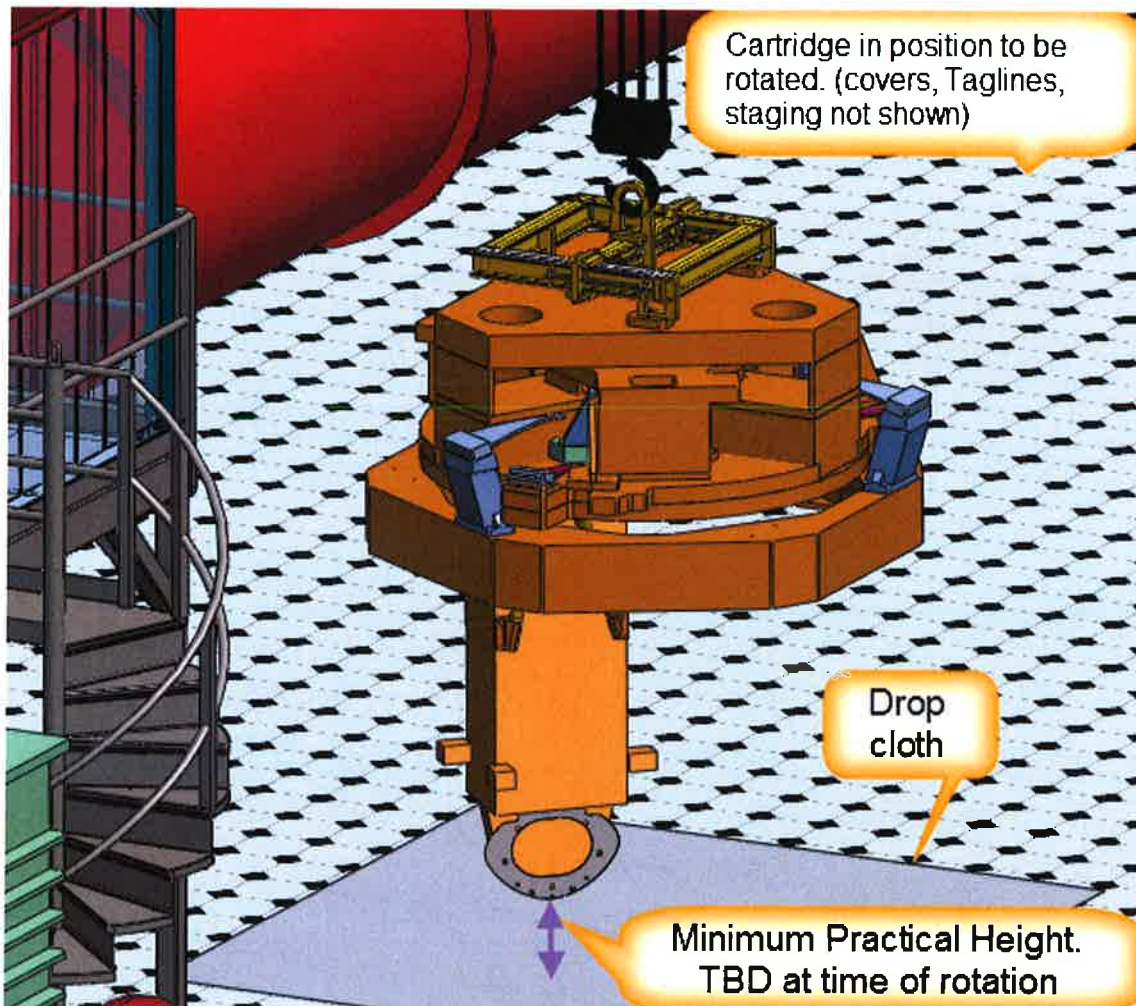
3.4 Adjust 3pt lifter bale (shown below with load cell attached) to predicted X-Y CG location (some keel plate hole patterns are rotated by 120deg from the that shown in the assembly documentation, adjust x-y of the lifter bale to compensate for rotation.) Then **Check Cartridge weight**: Lift cartridge from

test-stand with load cell and crane, If load-cell starts to exceed 10,000lb, stop, and set cartridge back down. Reduce cartridge weight and try again. Record the final total weight, set back down and remove load cell. Record the specific load cell and any needed deviations in the intended payload for the cartridge. If there is a 2" or more gap at any point between the mounting surface of the Test Stand and the mounting surface of the cartridge, the cartridge must be re-leveled. Target gap at any point will be ~ 1/4"

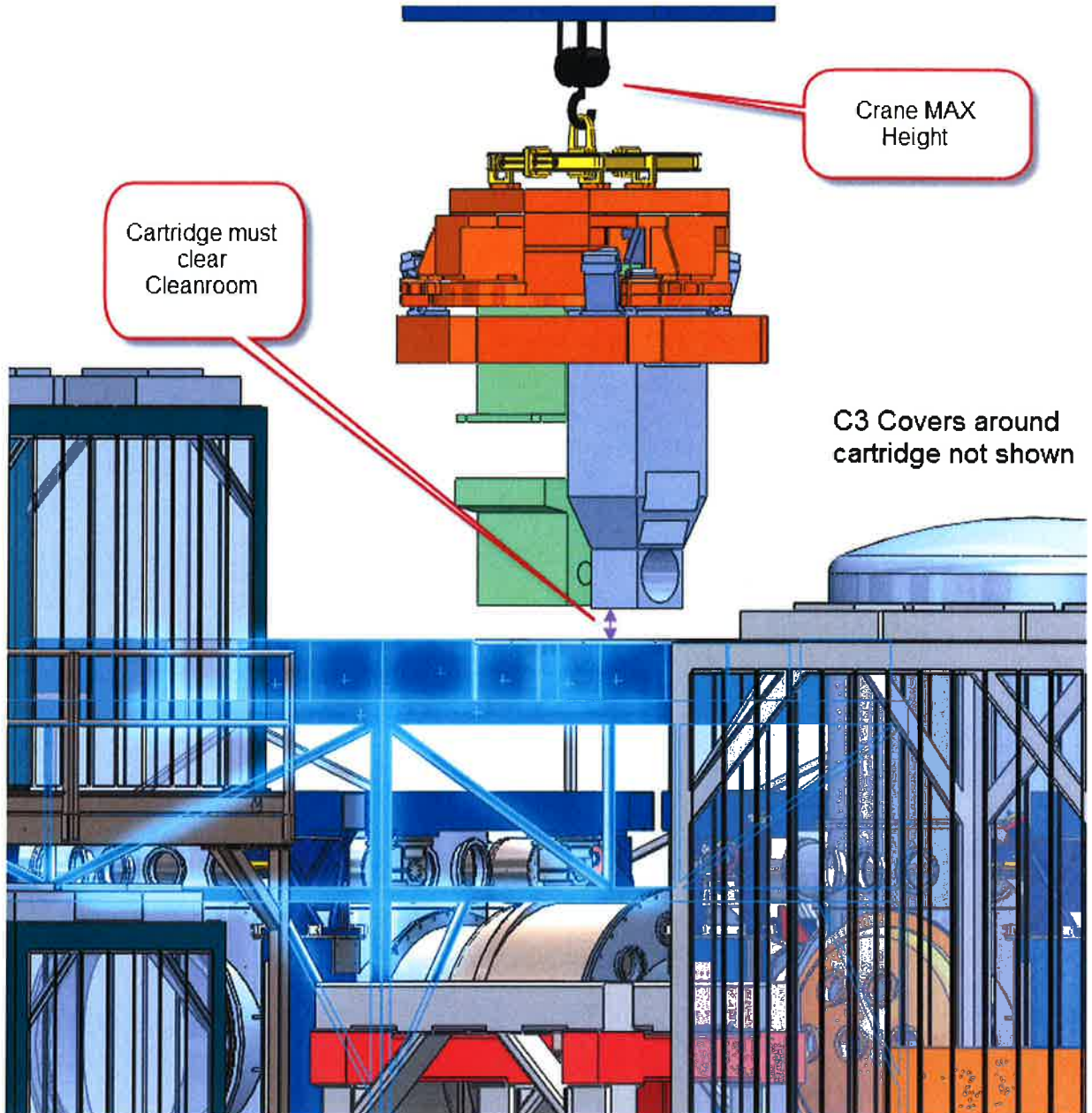


(3pt. Lifter & Load Cell, shown while not attached to cartridge)

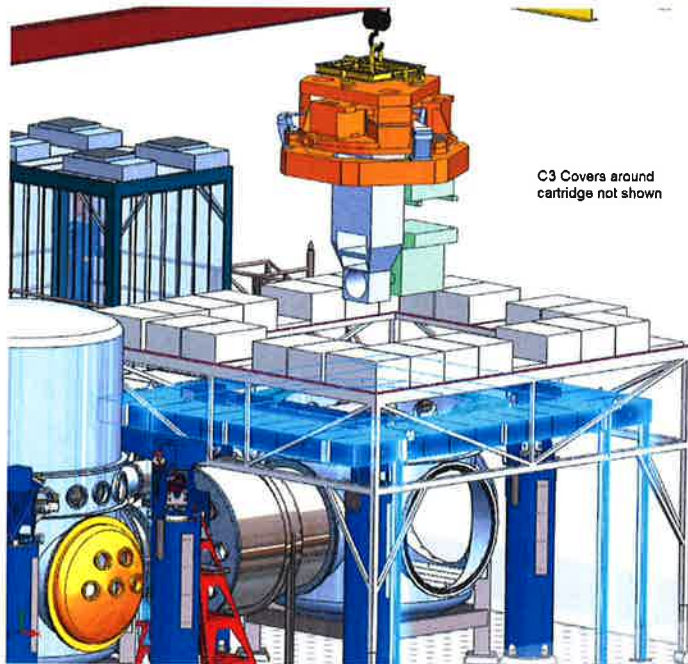
- 3.5 Rotate Cartridge to align with chamber,** if a rotation of the cartridge is required to align it to the chamber (BSC1,2): Insure a protective tarp with clean side up has been placed on the floor in the area where the cartridge rotation will take place (cartridge cover may contact floor otherwise). Attach 2 to 4 taglines to 3pt lifter (to rotate cartridge or serve as backup) Lift cartridge to clear Test Stand and move to designated area over tarp. Lower cartridge to minimum practical height without suspensions contacting the floor. Move staging from around test stand, into place to access stage0 if rotation "by hand" is to be done. Using either taglines or the "by hand" method, rotate cartridge to align with chamber orientation. If pivot on hook becomes jammed, return cartridge to test stand. There is clearance to allow this.



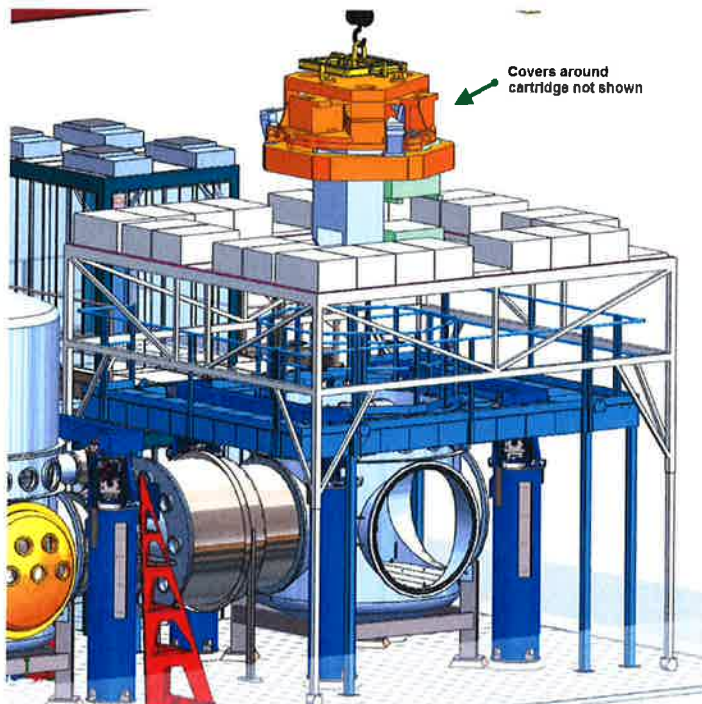
- 3.6** Lift cartridge up to height to clear BSC Clean-room (max height). BSC Clean-room should already be at minimum height (just above spools), Walking Plates (D1002410) and Platforms (D1001990) should be in place without railings, around chambers (See install procedure E1101051). Clean-room clearance ~8"



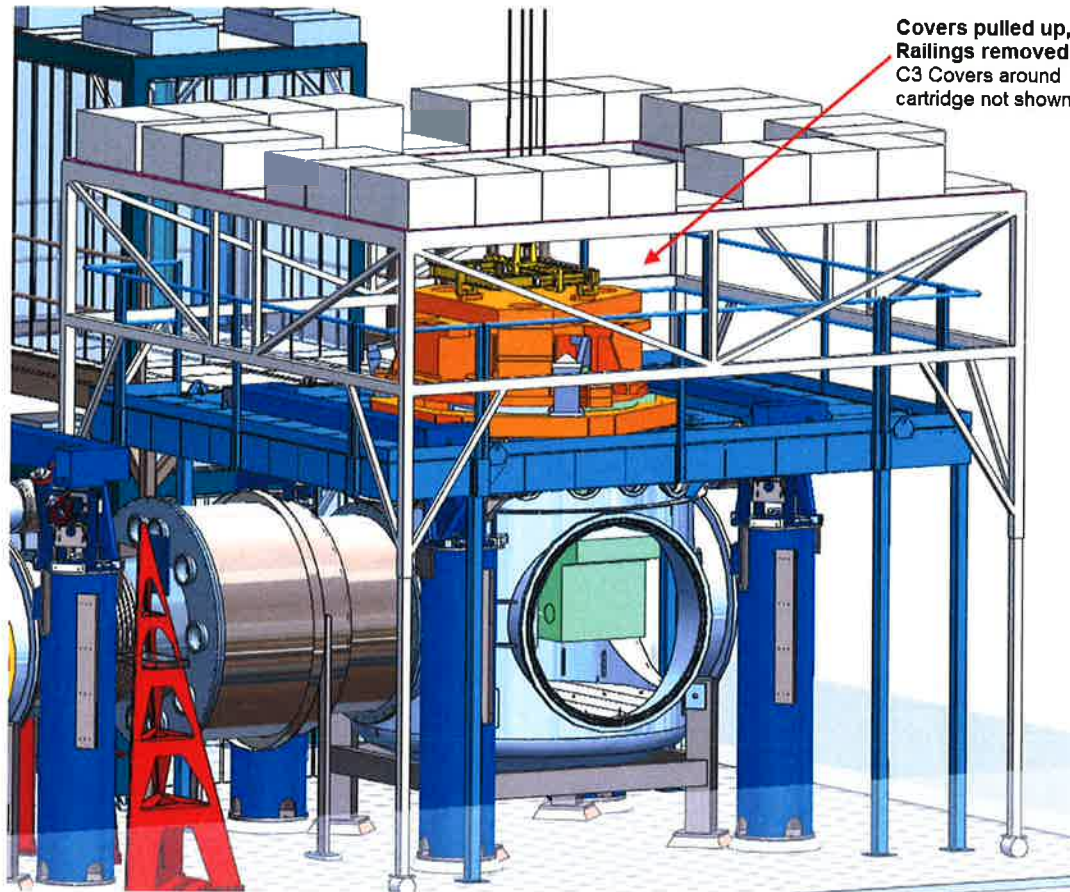
3.7 Move crane to a point centered above target BSC chamber, and BSC Clean-room



3.8 Raise BSC Clean-room back up to max height, Walking Plate railings will not be reinstalled, due to lack of clearance between them and the incoming Cartridge. Fall arrest system will be used (personal harness, lanyard, anchor points,) to prevent falls.



3.9 Lower cartridge to just above chamber, and roll up outside cover to expose stage0, remove fabric cover from chamber. Continue to lower cartridge onto support tubes in chamber.



3.10 Insert 3/8"-24 x 2" screws into all 14 holes. Torque 21 ft.lb, Then remove 3pt Lifter, close up clean room, finish removing C3 covers.

4) Related Documents

- [LIGO-E1200023](#): aLIGO Chamber Installation Procedures.
(See related documents specific to the BSC Cartridge being installed)
- [LIGO-E1200900](#): BSC Installation Procedures (from sub-systems)
- [LIGO-E1200901](#): BSC Safety Procedures(associated with install)
- [LIGO-E1101051](#): BSC Work Platforms Assembly Instructions
- [LIGO-E1200344](#): All BSC, Basic Cartridge Install, aLIGO
- [LIGO-E1101017](#): Cartridge Lifting Hardware, Loading Analysis.

5) Hazard Analysis

Each hazard, and mitigation approach or measure, is listed in the severity table in the next section

5.1 While moving heavy, delicate and valuable structures using lifting and moving equipment, there is potential for injury, shock and/or impact if structures are dropped or bumped.

- Personnel injury (crushing, pinching, falling)
A minimum number (4) of personnel must be trained for, and follow safety rules of the lifting equipment to be used. Safety glasses, shoes, and hardhats must be worn by personnel involved in the lifting and transporting of the Cartridge. At no time should work be done above head height while people are directly below.
- At no time should any person be beneath a suspended cartridge.
- Damage to equipment (from shifting or vibrations)
- Vibrations, Accelerations and Decelerations during liftoff, transport, and placement have the potential to damage items held in the suspensions or between the stages of the ISI. Therefore the ISI and items in the SUS frames must be locked down per the checklists and references in [LIGO-E1200900](#) & [LIGO-E1200344](#)

5.2 Damage to the suspensions or isolation system from Impact

- Impact can cause damage directly to the suspension frames, Test Stand, or Chamber. Resulting movement of the suspended items in the frames during an impact can cause secondary damage. Chances of contact with optics table payload is significantly reduced by removing any items that might interfere with the Support Tubes or Chamber. In addition there are lateral moves (laid-out in BSC Requirements and procedures.. in: [LIGO-E1200900](#)) to avoid contact with potentially interfering items. The ISI and items in the SUS frames must be locked down per applicable checklists and references in [LIGO-E1200900](#) & [LIGO-E1200344](#).

5.3 Particulate contamination

- To protect delicate optics and other components, all guards, covers and caps, must be in place. All personnel must be trained and follow the detailed procedure and checklist to ensure all of the required items are in place
- Fabric covers are used over the entire cartridge assembly to catch particulates generated by the crane.

5.4 Cartridge Drop

- Failure of the lifting apparatus causing the cartridge to drop, could result in serious injury and loss of a significant portion of the cartridge hardware. Thus no person will be allowed below the cartridge or within a safety radius of it during liftoff, transport or

set-down. Only the crane operator and persons watching for close encounters and/or providing hand signals, shall be allowed in the area where the lift is being made. All others shall stay at a safe distance (20-foot minimum) away from lift activities. The exception to this is in the very early and late stages of liftoff and set-down while the cartridge is only a few inches away from the support tubes, which would shield anyone from the short drop of the cartridge. The cartridge will need to be inspected and guided at these two times. The dropping hazard is mitigated overall by the use of lifting hardware that has a 3 times yield, designed-in, safety factor. It should also be noted that it is recommended that bystanders refrain from talking/making noise that may disturb the concentration and communication of the personnel involved in the lift.

5.5 Failure of crane to operate or power failure during operation

- A failure of the crane lifting mechanism, or power loss during transport will result in the crane locking in place. This is not a safety problem, and covers will prevent contamination. See critical lift plan in [LIGO-E1200901](#).

5.6 Structural failure of Crane

- The crane will not be operated beyond rated capacity. All items will be pre weighed, and must only be the ones expected per plans ([LIGO-E1200900](#) and [LIGO-E1101017](#)) to be part of the cartridge (no additional unexpected parts).

5.7 Drop/fall hazard due to assembly of components at height

- To prevent falls and dropped items from height, platforms and walking plates with kick panels and railings will be in place as needed around the BSC chamber. Also a Fall Arrest System will be used when railings cannot be used.

5.8 Crane does not allow cartridge to rotate, or jams at partial rotation

- Cartridge can be returned to test stand if hook pivot becomes stuck.

5.9 Cleanroom or platforms impact the Gate-Valve or plumbing.

- The cleanroom will be fitted with a 4" spacer between the two halves to provide clearance for the gate-valve motor box. A narrower version of Platform-C will be used in place of the original Platform-C to avoid contact with the gate-valve plumbing. Reference [LIGO-E1101051](#) (BSC Work Platforms), for setup and configuration of the platforms round the BSC Chambers.

5.10 Personnel strike hazard while moving cleanroom when people are resident on test stand work platforms.

- The test stand cleanroom is moved to allow crane access to the 3pt lifter and cartridge, when readying the system to be checked with a load cell and subsequently flown to chamber for install. Workers on test stand work platforms will typically hold curtains open to ensure the clear plastic drapes do not touch the ISI. However, cleanroom gussets

(cross-bracing) located at the corner of the ceiling (where the legs are affixed) has some chance to strike a worker when the cleanroom begins to clear the test stand. This puts the worker at risk for injury due to the strike, and due to a potential fall from the test stand that could follow (see Fig 5.10). The risk can be exacerbated if the cleanroom sits off-center relative to the test stand (which may happen owing to nearby interferences).

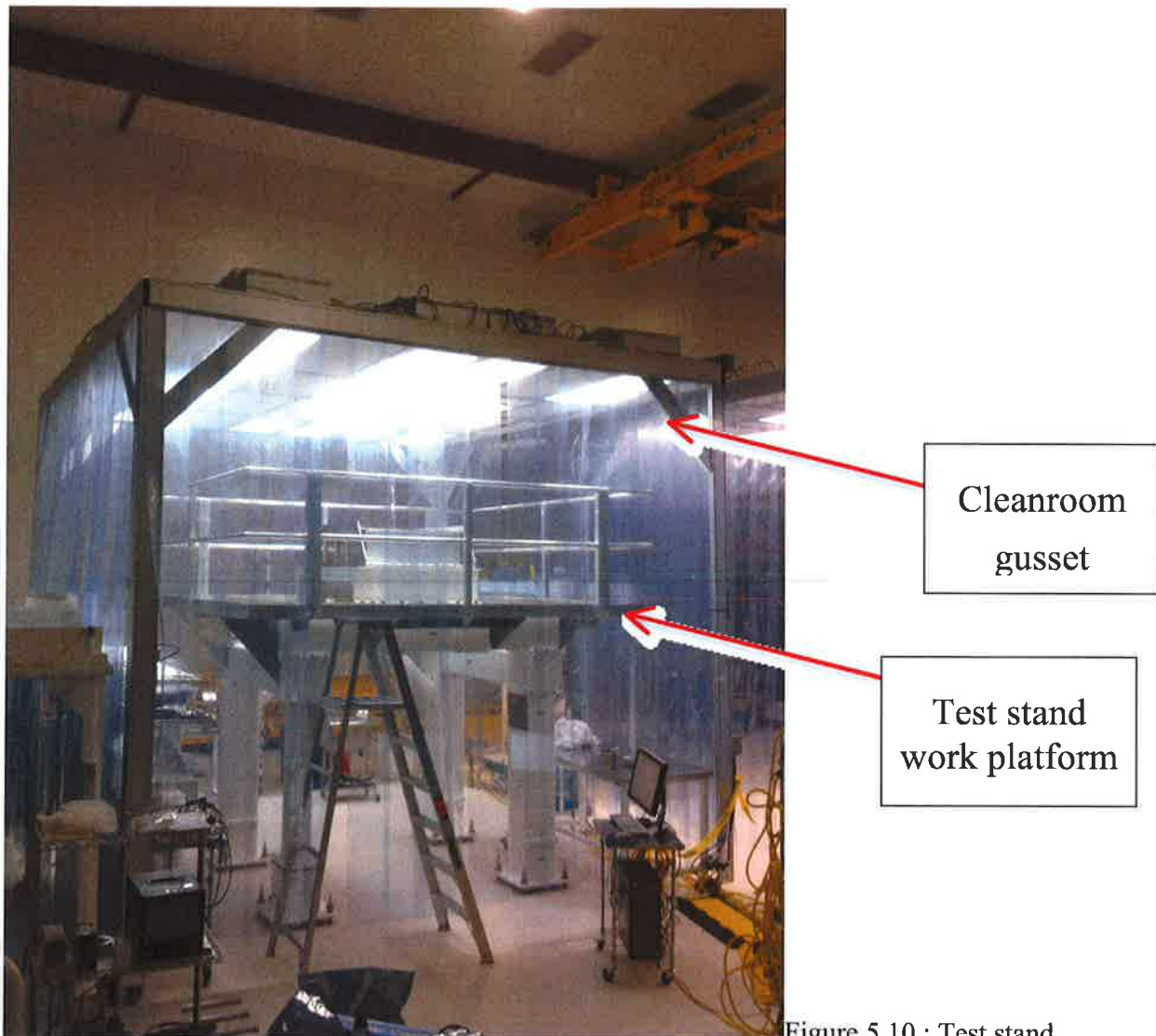


Figure 5.10 : Test stand equipped with work platform. When being moved for crane access, gussets on cleanroom can interfere with workers on platform (in particular, if the cleanroom is offset from test stand center).



6) Hazard Analysis Severity Table (The number in brackets is a reference back to section 2 summarizing the hazard)

Item (Ref)*	Hazard	Cause	Effect	Unmitigated Severity	Unmitigated Probability Level	Unmitigated Risk Index	Comment	Mitigation	Mitigated Severity	Mitigated Probability Level	Mitigated Risk Index
1 (2.1)	Fingers/hand/arm pinching/crushing hazard	Between Cartridge and Support tubes on Test Stand or in Chamber	Injury to personnel	Critical	Occasional	2C		A minimum number (4) of personnel must be trained for and follow safety rules of lifting equipment being used	Negligible	Remote	4D
2 (2.2)	Cartridge impact anywhere other than mounting surfaces.	Interference with support tubes, Test Stand or chambers	Damage to mostly suspended items.	Critical	Probable	2B	Damage concern mostly to suspensions during lift or lower, to stand or chamber	Remove interfering items & lateral moves of cartridge to clear obstacles.	Marginal	Remote	3D
3 (2.3)	Particulate contamination	Debris falling from above: crane etc. Removal of covers/caps	damage to environment	Marginal	Probable	3B		C4 Cloth covers for cartridge and suspended components	Marginal	Remote	3D
4 (2.4)	Payload drop hazard	Improper use of interface tooling, linkages, crane	Injury to personnel; damage to equipment	Critical	Remote	2D	3X or better safety factor on all lifting equipment (industry standard)	Personnel must be trained and follow detailed procedure and checklist.	Critical	Improbable	2E
5 (2.5)	Failure of lifting mechanism, power outage	Lifting equipment not serviced or used as per instructions, power outage	Nuisance, lost time	Marginal	Remote	3D	Final weight of cartridge measured, insure crane within operating spec. at all times.	lifting equipment should be inspected and maintained, so that a failure is unlikely. Do not operate at time when a power outage is likely.	Negligible	Improbable	4E
6 (2.6)	Crane, structural failure	Overloaded crane, poor crane related maintenance	Injury to personnel; damage to equipment	Critical	Remote	2D		All items to be lifted pre weighed, Test lift, Proper crane maintenance	Critical	Improbable	2E
7 (2.7)	Assembly of components at height	On top of, or below Cartridge and above Support tubes	Injury to personnel; damage to equipment	Critical	Remote	2D		Use barrier plates and railings as instructed, and personnel must wear safety glasses ,shoes ,hard hats	Critical	Improbable	2E
8 (2.8)	Crane rotation failure	Hook Blinds	Wrong orientation	Marginal	Remote	3D		Return cartridge to test stand, repair crane	Negligible	Improbable	4E

Item (Ref)*	Hazard	Cause	Effect	Unmitigated Severity	Unmitigated Probability Level	Unmitigated Risk Index	Comment	Mitigation	Mitigated Severity	Mitigated Probability Level	Mitigated Risk Index
9 (2.9)	Gate Valve or plumbing damage	Impact with cleanroom/platfom	X/Y arm Vacuum leak	Critical	Remote	2D	Spacer added to cleanroom to clear gatevalve	New platform -C to clear plumbing/wave, close gatevalve at cryo/pump	Marginal	Remote	3D
10 (2.10)	Strike from cleanroom when on test stand	Moving cleanroom without alerting workers on test stand	Injury to personnel	Critical	Occasional	2C	Risk is exacerbated by off-center cleanroom	Good communication from crew moving cleanroom to personnel on test stand	Marginal	Improbable	3E

7) Key

Key to table in section 6

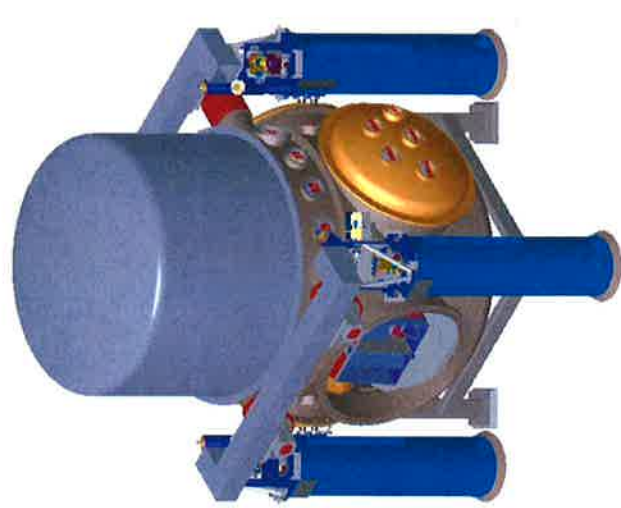
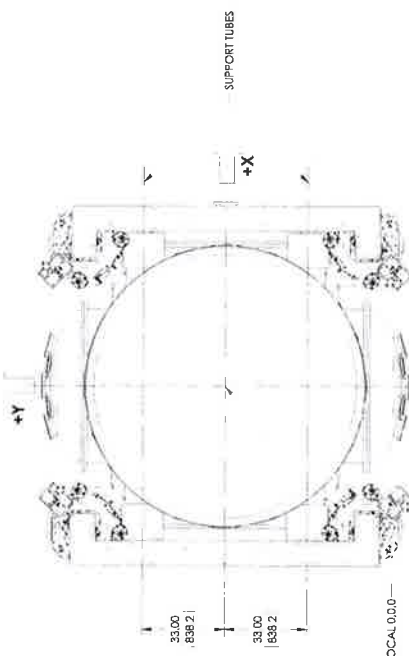
Severity	Category	Definition
Catastrophic	1	Death or permanent total disability, system loss, major property damage or severe environmental damage
Critical	2	Severe injury, severe occupational illness, major system or environmental damage
Marginal	3	Minor injury, lost workday accident, minor occupational illness, or minor system or environmental damage
Minor	4	Less than minor injury, first aid or minor supportive medical treatment type of occupational illness, or less than minor system or environmental damage.

Probability	Level	Definition
Frequent	A	Likely to occur frequently or continuously experienced
Probable	B	Will occur several times in the life of an item
Occasional	C	Likely to occur some time in the life of an item
Remote	D	Unlikely but possible to occur in the life of an item
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced.

SEVERITY OF CONSEQUENCE	PROBABILITY				
	E Improbable	D Remote	C Occasional	B Probable	A Frequent
1 Catastrophic					
2 Critical					
3 Marginal					
4 Negligible					
Hazard Risk Index	Risk Code Criteria Unacceptable (Directorate decision required) Undesirable (Directorate decision required) Acceptable with review by Directorate Acceptable without review				
1A, 1B, 1C, 2A, 2B, 3A 1D, 2C, 2D, 3B, 3C 1E, 2E, 3D, 3E, 4A, 4B 4C, 4D, 4E					

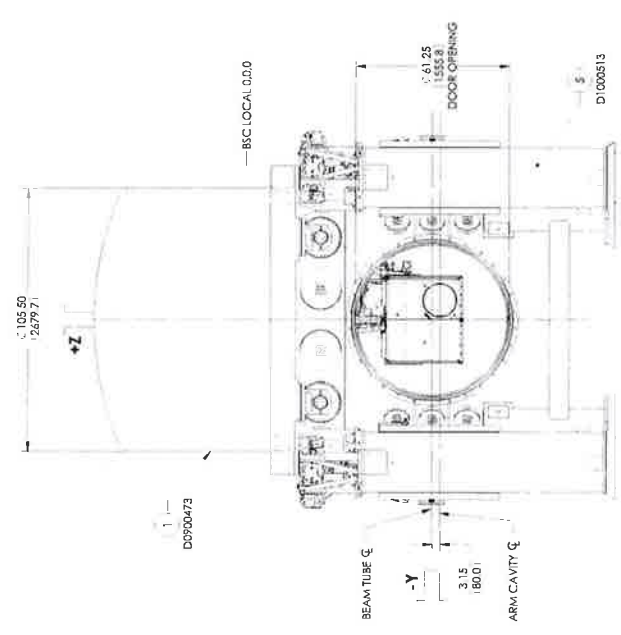
REV
 V4 25 JAN 2012
 V5 30 NOV 2012

- 5 REFER TO DOCUMENT D10721 FOR OPTICAL TABLE
- 6 REFER TO DOCUMENT D10028 FOR S1 NAMING AND ORIENTATION CONVENTION
- 7 REFER TO I1100292 FOR VIEW PORT DEFINITION
- 8 REFER TO E1200655 FOR LOCAL COORDINATES OF SUPPORT TUBES END.

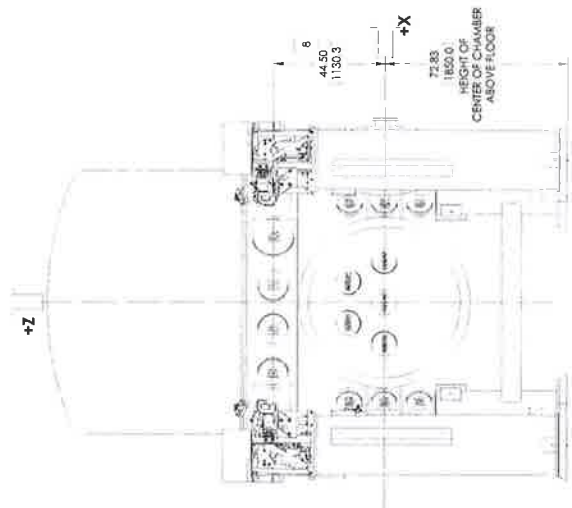


SUPPORT TUBES

TOP VIEW



LEFT VIEW



FRONT VIEW

GLOBAL COORDINATES (mm)		
X	450000.0	
Y	0.0	
Z	0.0	

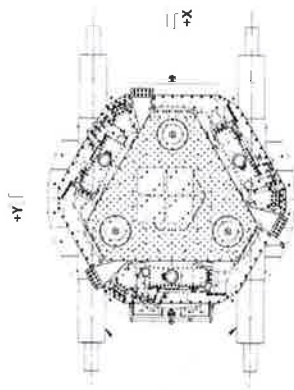
PART NAME	BSC4-L1 AdvLIGO Systems, Top Level Chamber Assembly
DESIGNER	D0900471
CHECKER	
APPROVAL	
SCALE	1:1
SHEET	1 OF 3

LOGS AND CHECKLISTS (REFER TO DRAWING SPECIFICATIONS)

- REMOVE ALL SWAP PEGS AND ALL SWAP PEG HOLES FROM MACHINED PARTS
- ALL EDGES APPROXIMATE R0.02 FOR SHEET METAL PARTS
- ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SILICON, SULFONE AND CHLORINE MATERIAL

DIMENSIONS ARE IN INCHES (MM)
 TOLERANCES
 XX01
 XXX005
 ANGULAR: 0.5

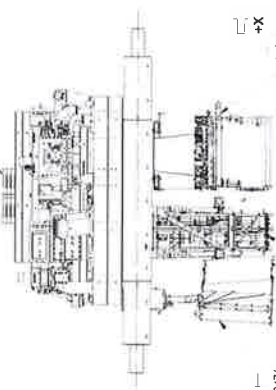
LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY
 SYSTEM: ADVANCED LIGO SUS
 SUB-SYSTEM: SUS
 PART: BSC4-L1
 PART NO: D0900471
 REV: V5



D092121
SUPPORT
TUBES

TOP VIEW

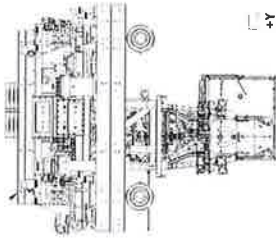
+Z
7
D:201035



6
D:1100476

FRONT VIEW

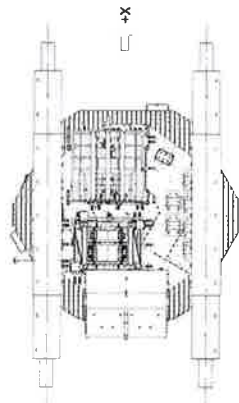
3
D:1100476



+Z
2
D:0900477

RIGHT VIEW

1.5
D:061115

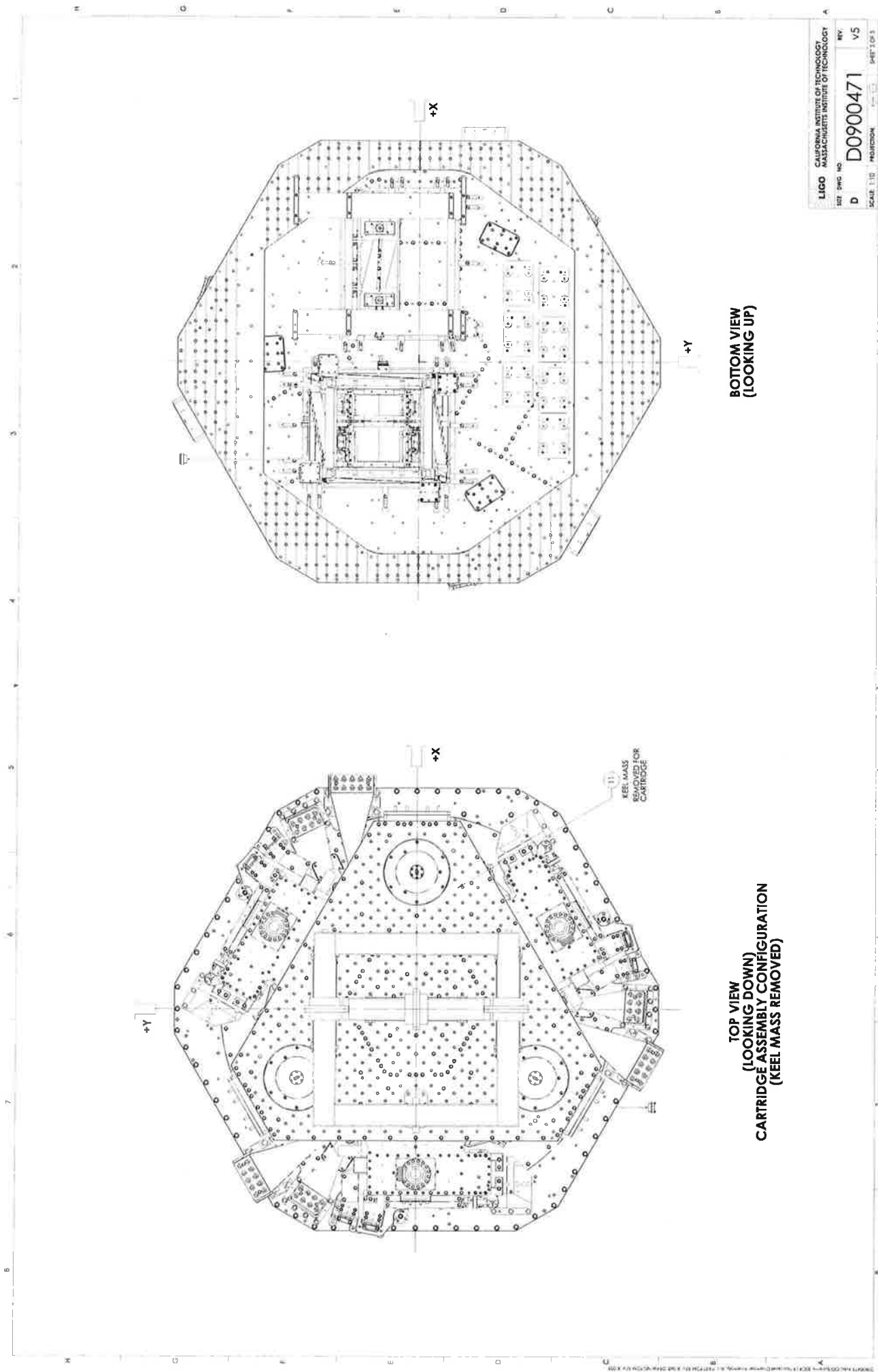


BOTTOM VIEW

+Y

ITEM NO	PART NUMBER	DESCRIPTION	QUANTITY	UNIT
7	D:201035	ADALIGO BECAL - 18, 20mm, 18mm Field & Supplemented	1	
8	D:1100476	ADALIGO SLS BECAL - XYZ Locus CS for SLC Arm	1	
9	D:000511	HWP ASSEMBLY BEC BECAL	1	
4	D:0900477	ADALIGO SLS BECAL - XYZ Locus CS for PWT In Assy	1	
3	D:0900478	ADALIGO SLS BECAL - XYZ Locus CS for PWT	1	
2	D:0900471	ADALIGO SLS BECAL - XYZ Locus CS for SLC Tube	1	
1	D:0900471	ADALIGO SLS BECAL - Vacuum Equipment Assembly	1	
		ASSEMBLY	1	Component

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY
 SIZE DWG NO **D0900471** REV **V5**
 SCALE 1:25 PROJECTION 3-REF 2 OF 3



**BOTTOM VIEW
(LOOKING UP)**

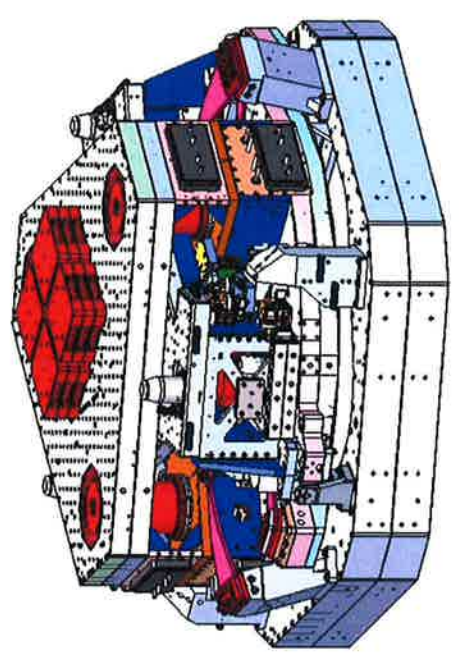
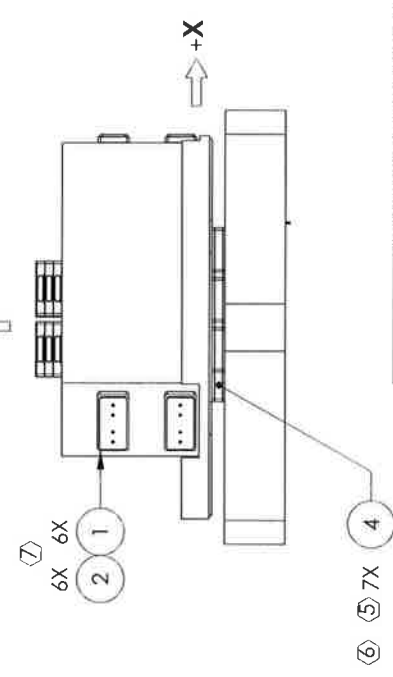
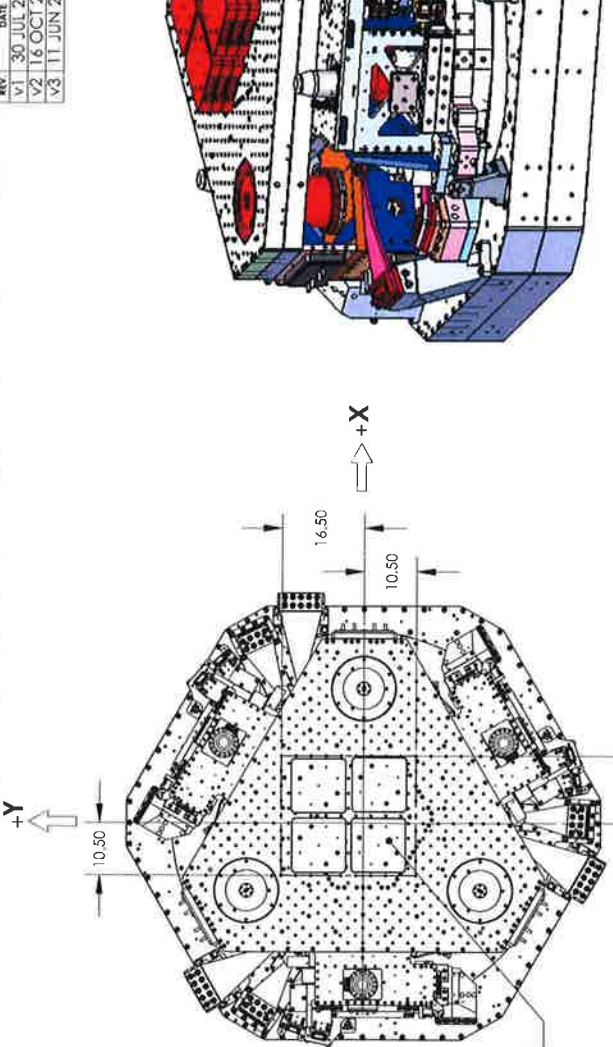
**TOP VIEW
(LOOKING DOWN)
CARTRIDGE ASSEMBLY CONFIGURATION
(KEEL MASS REMOVED)**

LIGO		CALIFORNIA INSTITUTE OF TECHNOLOGY		PASADENA, CALIFORNIA	
REV:	D	DWG NO:	D0900471	REV:	V5
SCALE: 1:10			REVISION:	SHEET 1 OF 1	

1 2 3 4 5 6 7 8

REV	DATE	DCN #	DRAWING TREE #
V1	30 JUL 2012	-	-
V2	16 OCT 2012	-	-
V3	11 JUN 2013	-	-

- NOTES:**
- ⑤ A MINIMUM OF 3X FASTENERS SHOULD BE USED WITH EACH MASS ASSEMBLY D1003161.
 - ⑥ FOR HARDWARE REQUIREMENTS REFER TO DRAWINGS: D1003161 TRIM MASS & DAMPING ASSY., BSC ISI D1003143 BALLAST MASS ASSEMBLY, ALIGO BSC-ISI
 - ⑦ HARDWARE REQUIRED ON ITEMS 1 & 2: HEX NUT, D0900304 WASHER, UCC-WFV-50
 - ⑧ FOR DEFINITIONS ABOUT THE ORIENTATION OF THE BSC ISI SYSTEMS WITH RESPECT TO THEIR VACUUM AND/TO GLOBAL COORDINATED SYSTEMS SEE THE FOLLOWING DOCUMENTS:
D1101271 ALIGO, AOS, BSC CHAMBER, OPTICAL TABLE TABULATION
G1000125 ADVANCED LIGO BSC AND HAM ISI CONVENTIONS

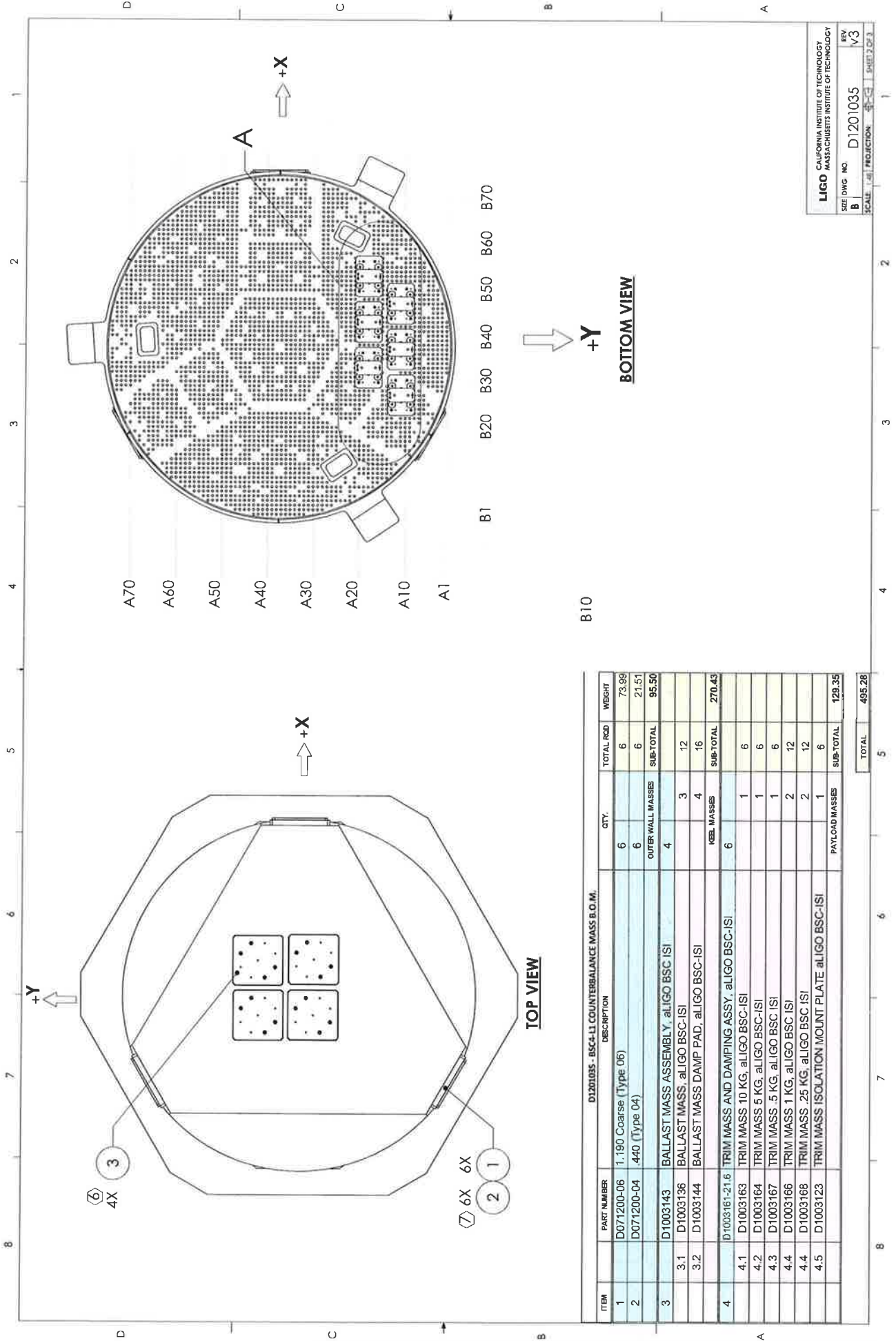


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
4	D1003161-21.6	TRIM MASS & DAMPING ASSY, aLIGO BSC-ISI [21.6kg]	6
3	D1003143	BALLAST MASS ASSEMBLY, aLIGO BSC ISI	4
2	D071200-04	.440 (Type 04)	6
1	D071200-06	1.190 Coarse (Type 06)	6

PARTS LIST			
PART NAME			
CALIFORNIA INSTITUTE OF TECHNOLOGY			
LIGO MASSACHUSETTS INSTITUTE OF TECHNOLOGY			
SYSTEM ADVANCED LIGO SEI			
DESIGNER	ED CLAVEZ (20-MAY-2012)	SIZE DWG. NO	D1201035
CHECKER	SEE DCC	REV	V3
APPROVAL	SEE DCC	SCALE	1:32/ PROJECTION: 1ST ANGLE
REV.			

MATERIAL	
N/A	N/A

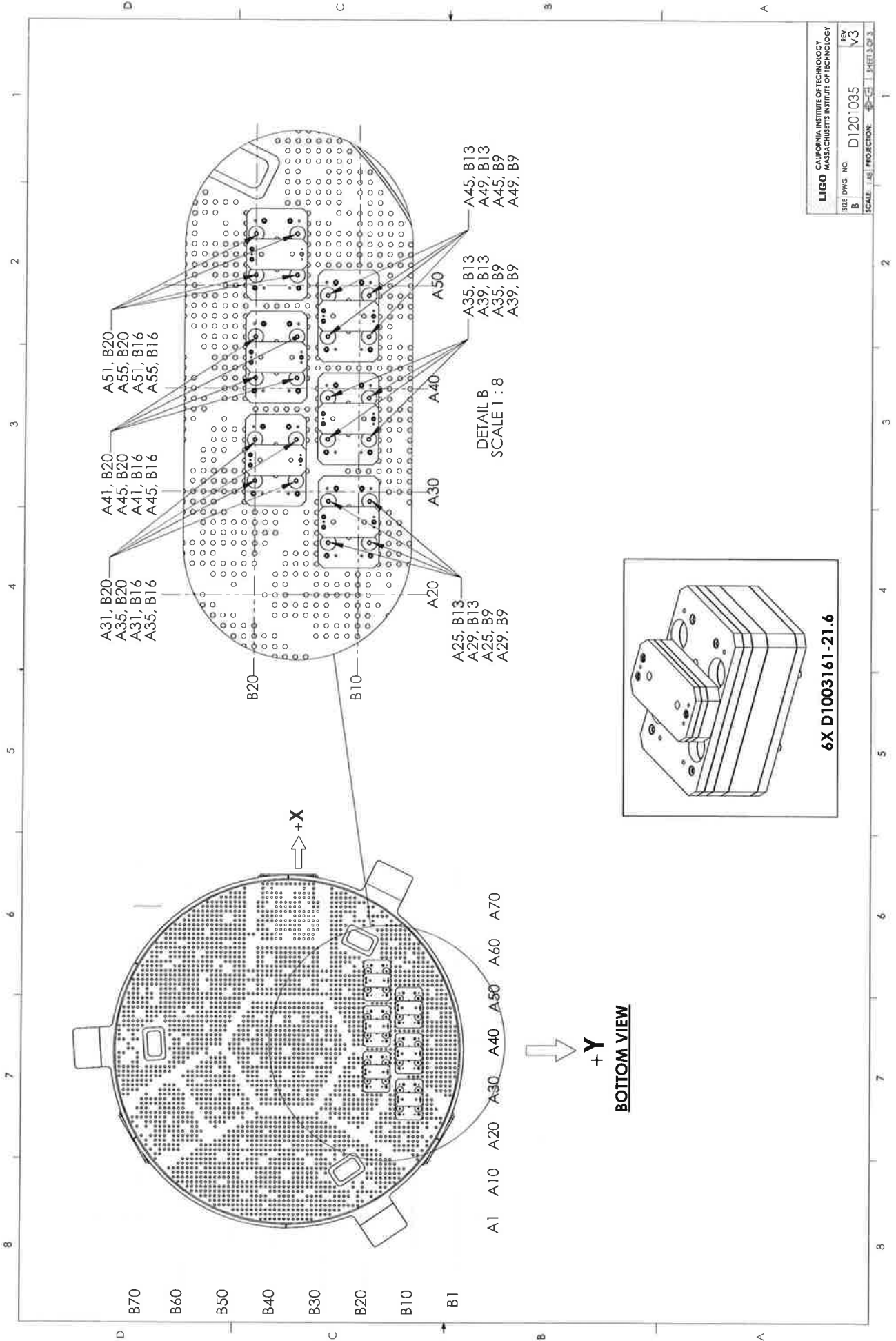
FINISH AND TOLERANCES (UNLESS OTHERWISE SPECIFIED)	
N/A	N/A



ITEM	PART NUMBER	DESCRIPTION	QTY.	TOTAL ROD	WEIGHT
1	D071200-06	1.190 Coarse (Type 06)	6	6	73.99
2	D071200-04	440 (Type 04)	6	6	21.51
		OUTER WALL MASSES		SUB-TOTAL	95.50
3	D1003143	BALLAST MASS ASSEMBLY, aLIGO BSC-ISI	4		
3.1	D1003136	BALLAST MASS, aLIGO BSC-ISI	3	12	
3.2	D1003144	BALLAST MASS DAMP PAD, aLIGO BSC-ISI	4	16	
		KEEL MASSES		SUB-TOTAL	270.43
4	D1003161-21.6	TRIM MASS AND DAMPING ASSY, aLIGO BSC-ISI	6		
4.1	D1003163	TRIM MASS 10 KG, aLIGO BSC-ISI	1	6	
4.2	D1003164	TRIM MASS 5 KG, aLIGO BSC-ISI	1	6	
4.3	D1003167	TRIM MASS .5 KG, aLIGO BSC-ISI	1	6	
4.4	D1003166	TRIM MASS 1 KG, aLIGO BSC-ISI	2	12	
4.4	D1003168	TRIM MASS .25 KG, aLIGO BSC-ISI	2	12	
4.5	D1003123	TRIM MASS ISOLATION MOUNT PLATE aLIGO BSC-ISI	1	6	
		PAYLOAD MASSES		SUB-TOTAL	129.35
		TOTAL			495.28

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SIZE DWG NO D1201035 REV V3
 B
 SCALE 1:1 PROJECTION SHEET 2 OF 3



LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SIZE DWG. NO.	D1201035
REV	V3
B	SCALE: 1:8 PROJECTION: 1st ANGLE SHEET 3 OF 3



LIGO Laboratory / LIGO Scientific Collaboration

LIGO-E1101063

Advanced LIGO

28 Oct. 2011

Clean Room Heights, Cartridge Install, BSC Chamber,
aLIGO

Sam Barnum

Distribution of this document:
LIGO Science Collaboration

This is an internal working note
of the LIGO Project.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW17-161
175 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland, WA 99352
Phone (509) 372-8106
Fax (509) 372-8137

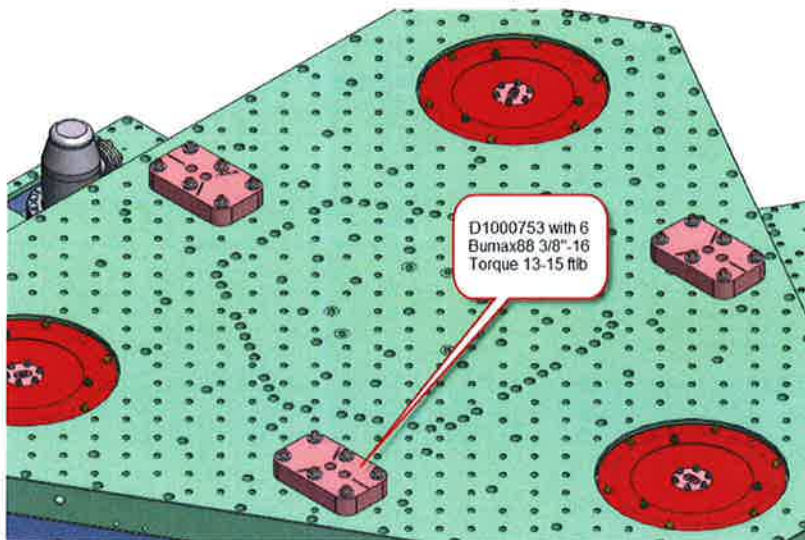
LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone (225) 686-3100
Fax (225) 686-7189

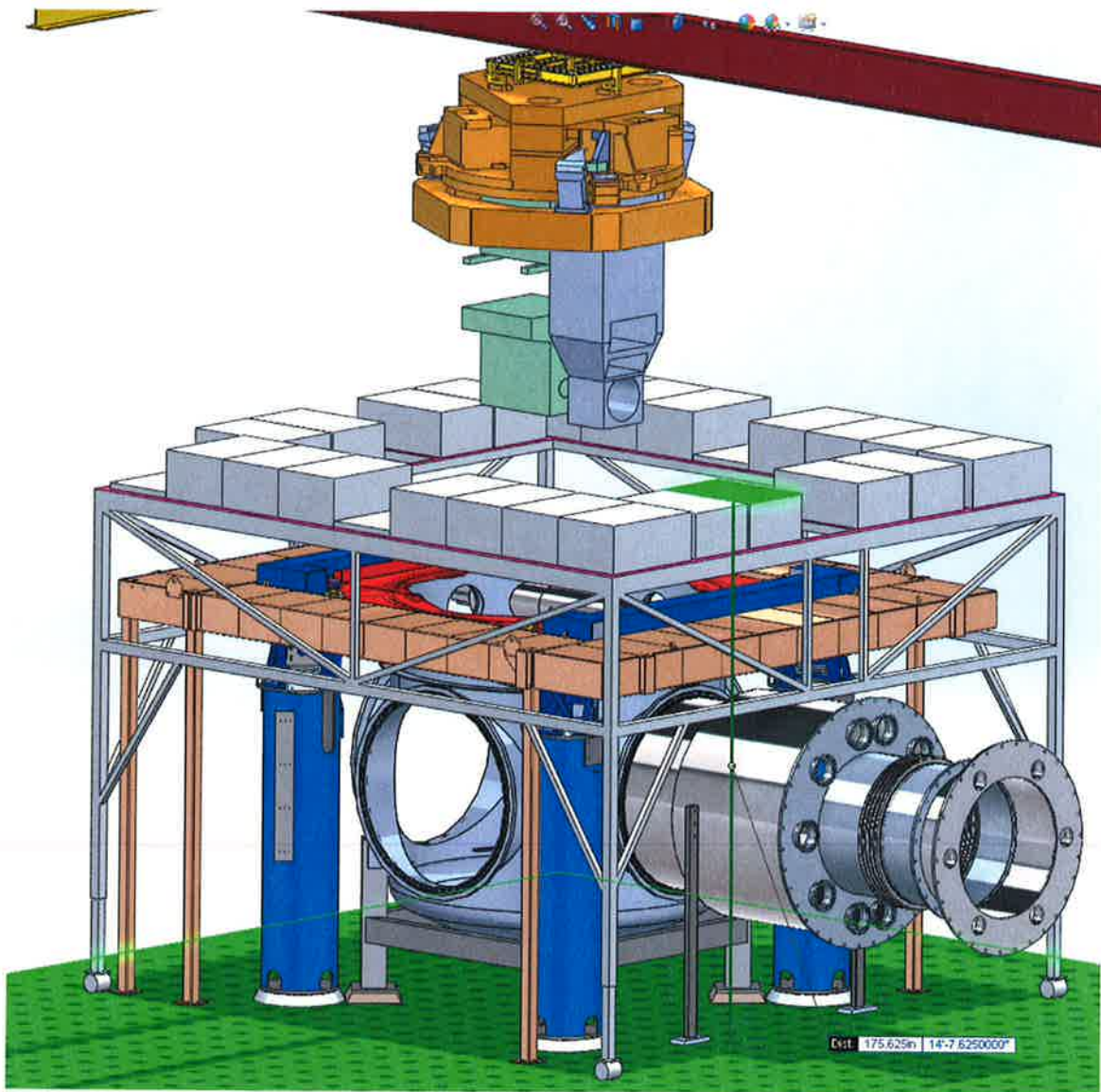
<http://www.ligo.caltech.edu/>

- 9) Damage to Gate-Valve Plumbing and Gate Valve.
- 10) Personnel injury (strike or fall) when working on test stand platforms while cleanroom is moved away from test stand area.

3) Overview (Note: all pictures are examples from BSC6, but are applicable to BSC2)

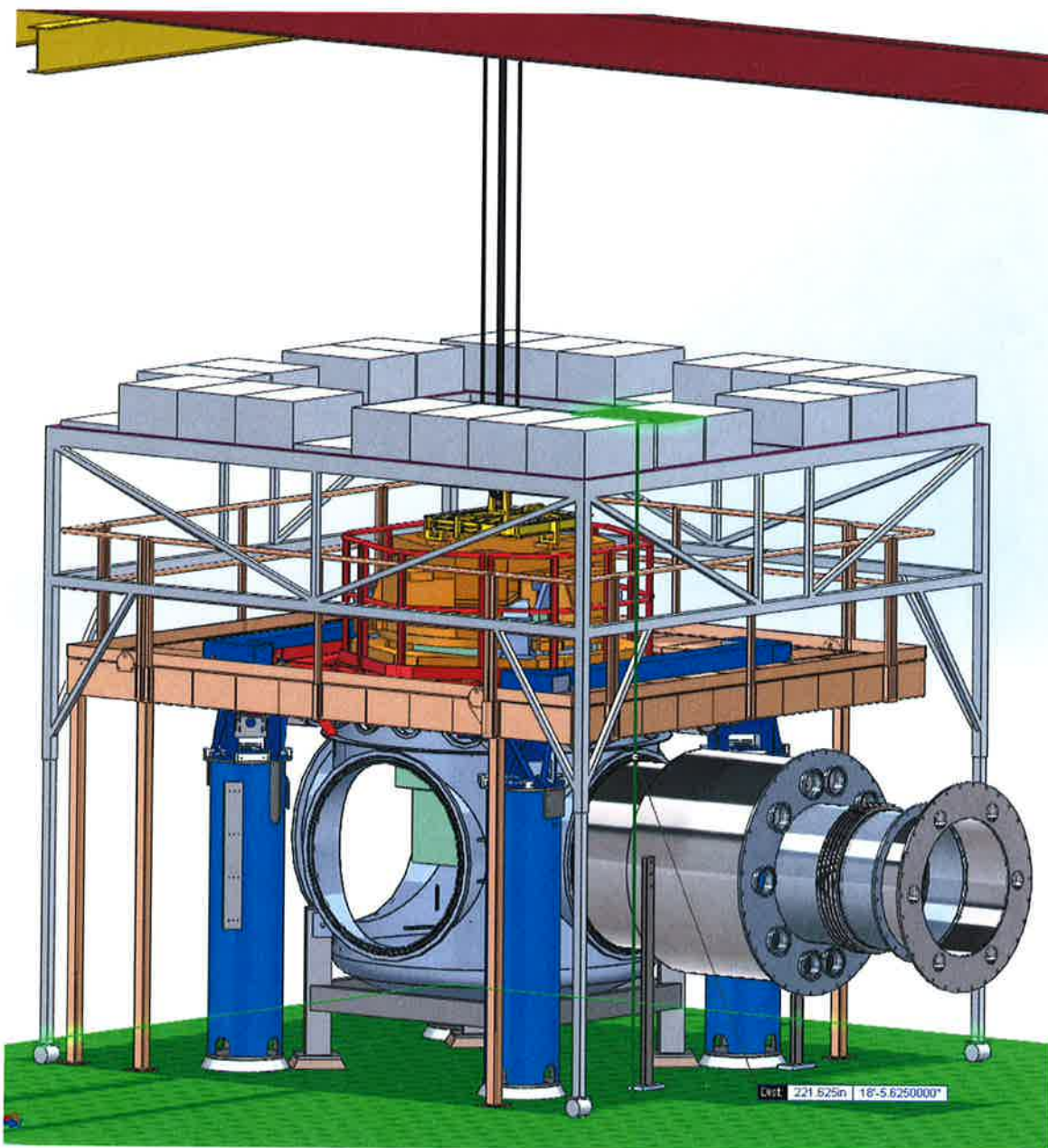
- 3.1 Attach the three (3) Lift Hook Receivers (D1000753) on the ISI Keel-plate, if not already present (See *D1000756* for layout and use *Bumax-88 3/8"-16* Screws, Torque, 13-15 ft-lb).

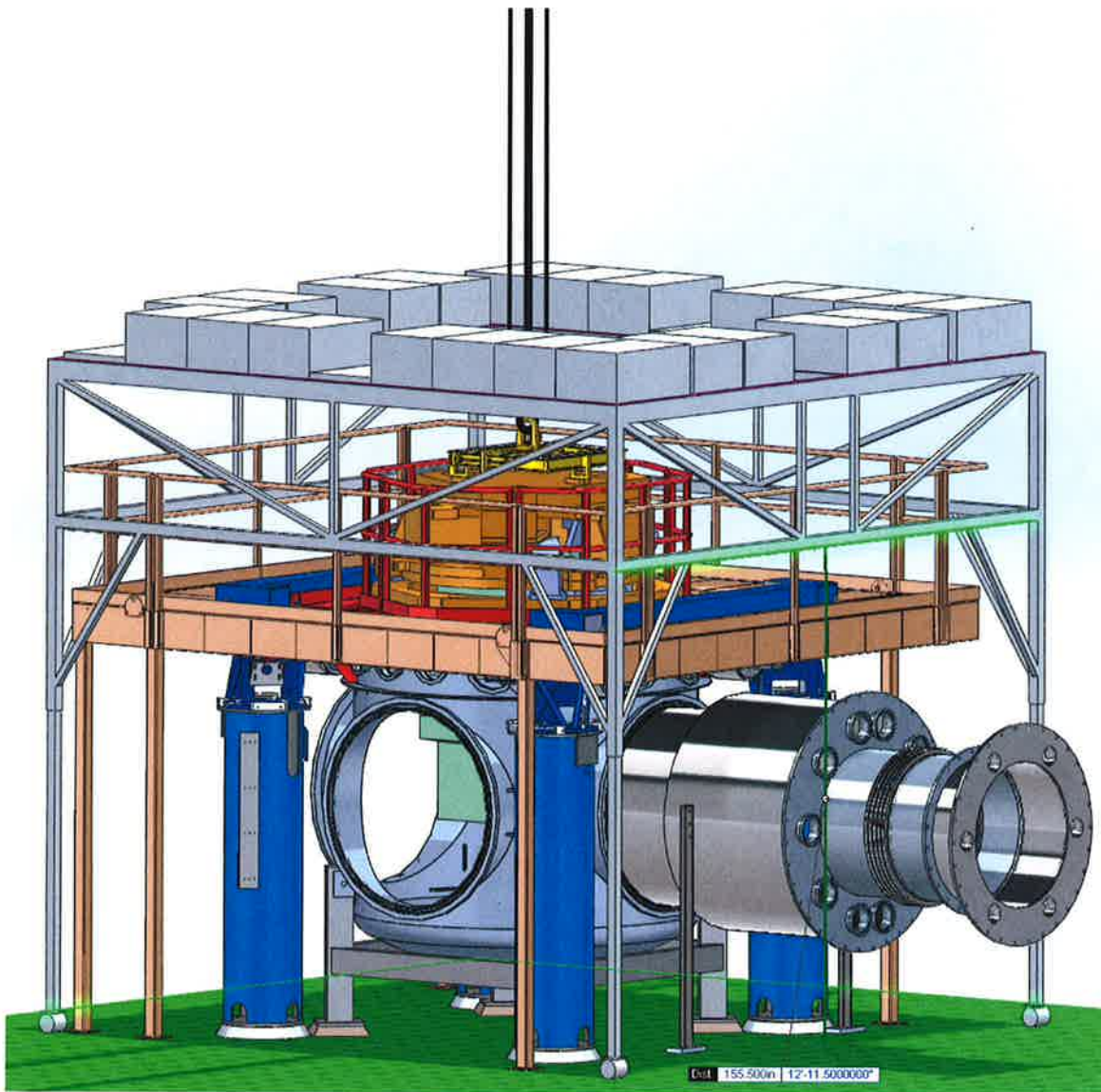




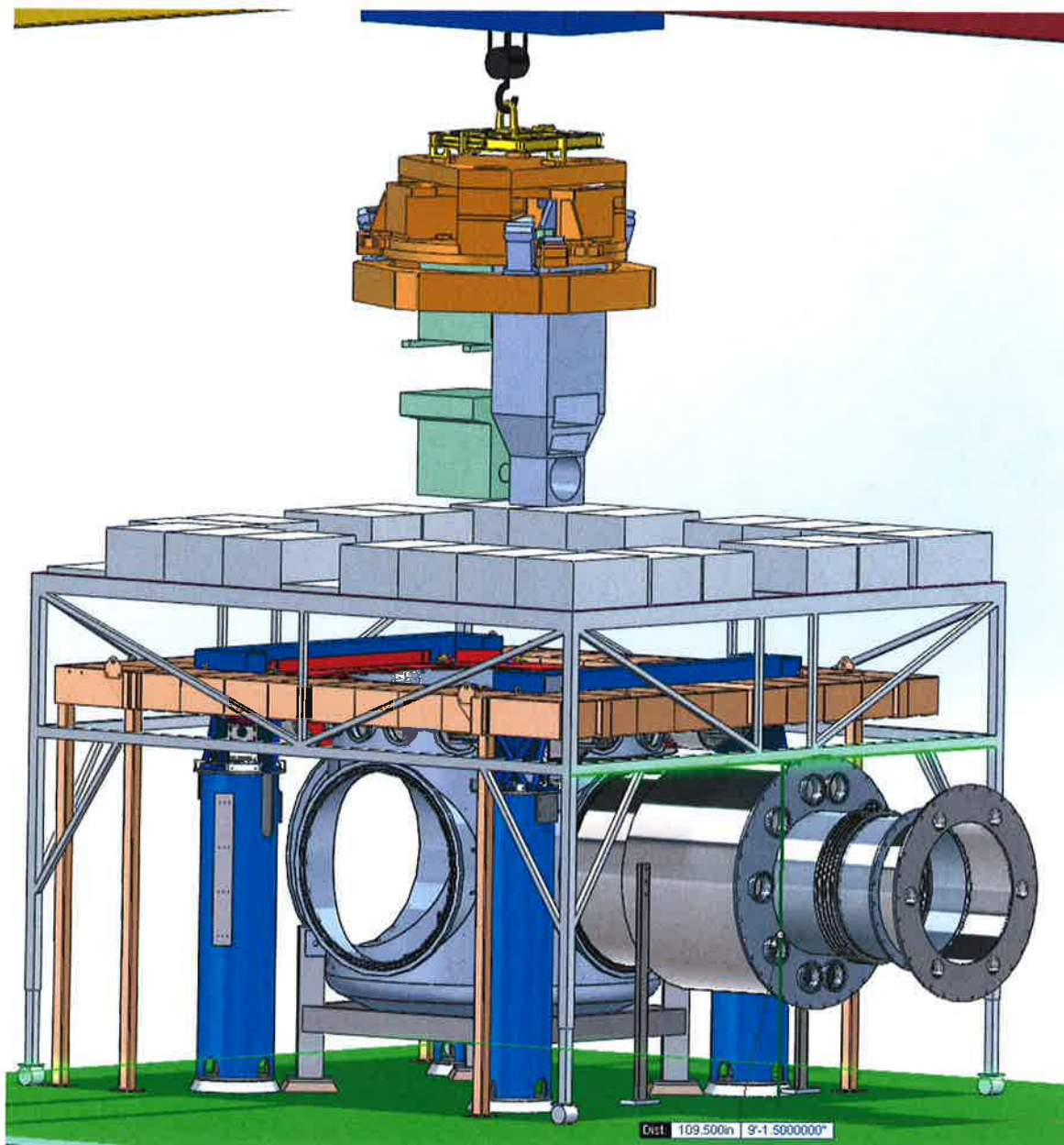
Enhanced minimum height bellow original design, VO49-4-133, VO49-4-135

2) Maximum Raised height, VO49-4-133, VO49-4-135





1) Minimum Lowered height



Enhanced minimum height bellow original design, V049-4-133, V049-4-135

193

183
106
 127 299

Hook heights at LHO:

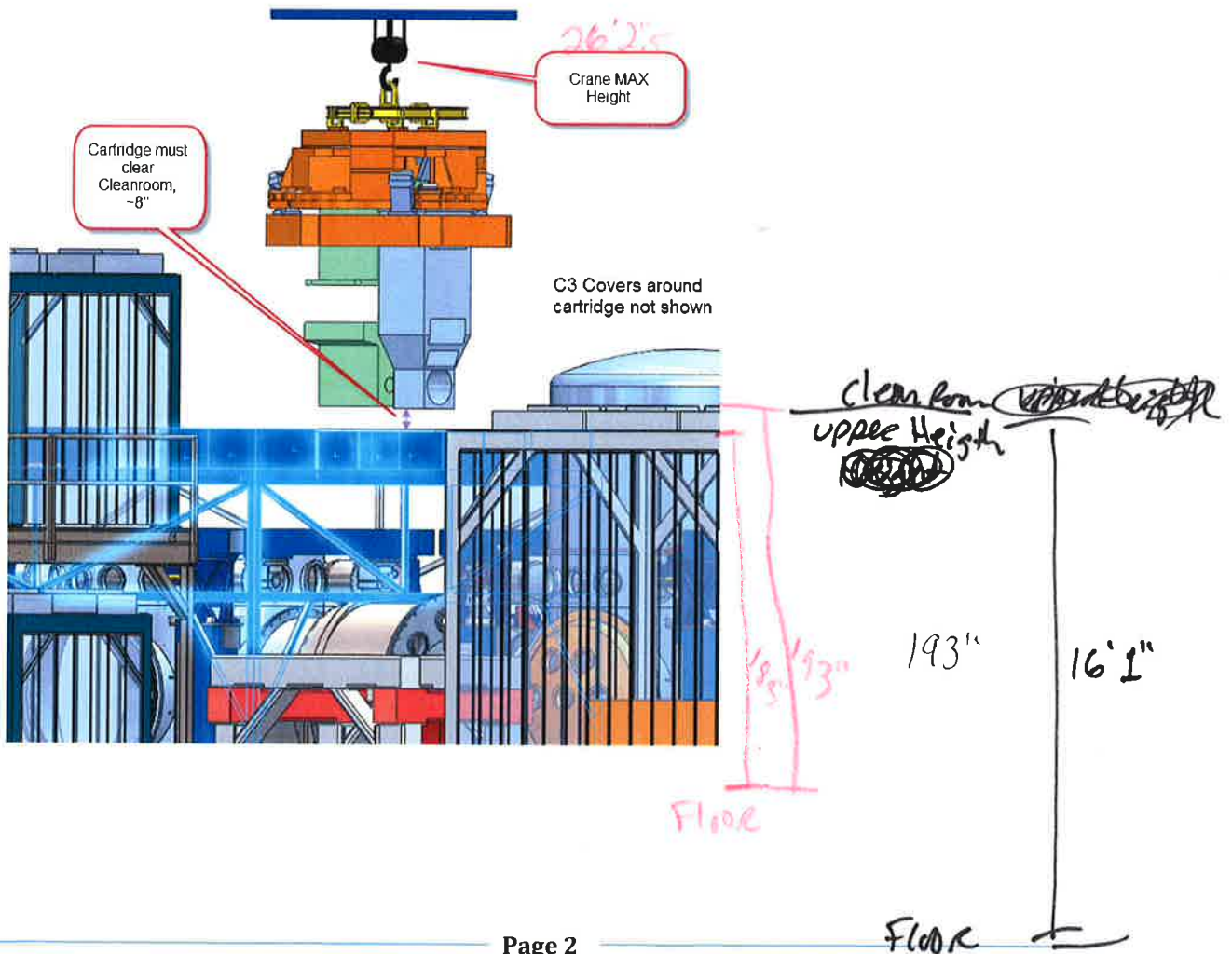
- Y-end = 26' 4 1/2",
- X-end = 25' 9 1/2",
- Main North-0 = 26' 5",
- Main North-1 = 26' 5",
- Main North-2 = 26' 5",
- Main North-3 = 26' 4 1/2".

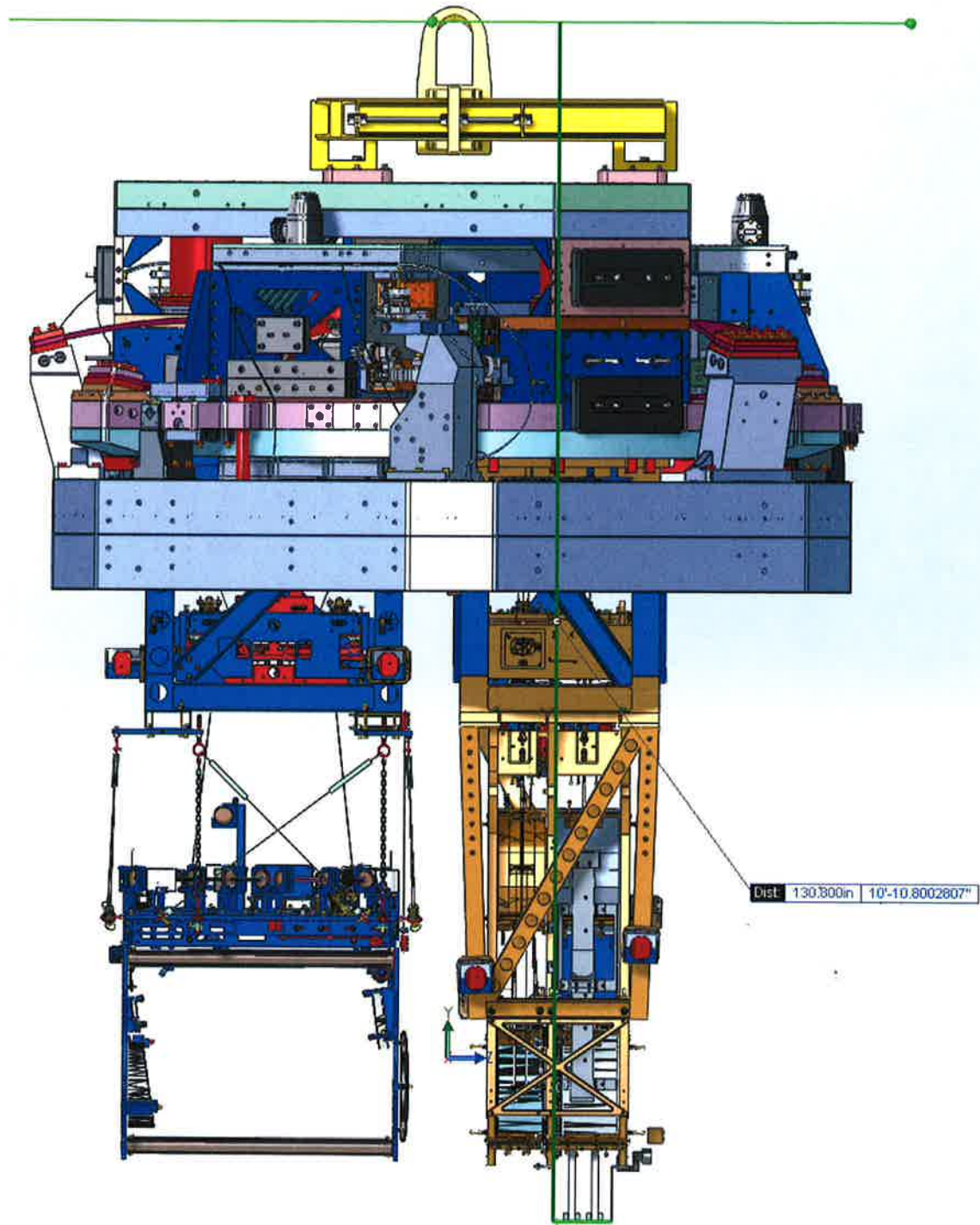
17

25'

Hook heights at LLO:

- Y-End - 26' 8"
- X-End - 26' 2"
- LVEA North - 26' 3"
- LVEA East - 26' 1"
- LVEA South - 26' 8"
- LVEA West - 26' 5"





o CRANE inspection / install BS down fall

o ~~MOVE CRANE~~ / Install DeBeir catch

o ~~attach LIFT on ISI / with cable / set cover~~

o ~~start lift / open soft cover / add 2nd cover~~

o ~~Bring ISI into clean room / Leg Crane Start / Remove Dome Cover~~

Move Top Stand from into position

1055 > 35 min
1130

o ~~cover ISI by lapping cover ASAP~~

o ~~at last Move up; Inside + Top team get ready / Particle~~ Purge air up

o ~~Plate between e-roof + room~~

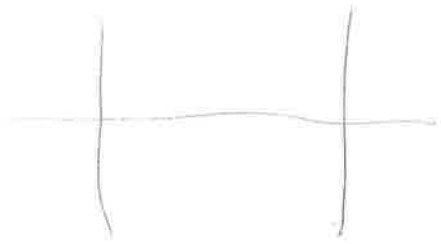
o ~~ISI go Down / Belt in~~

782 }
18 }
asuc
11.55
up

Counts
in Room: 11
up 200 : 0/0

o ~~Remove lift / bring in install clean room cover / BELT-30~~

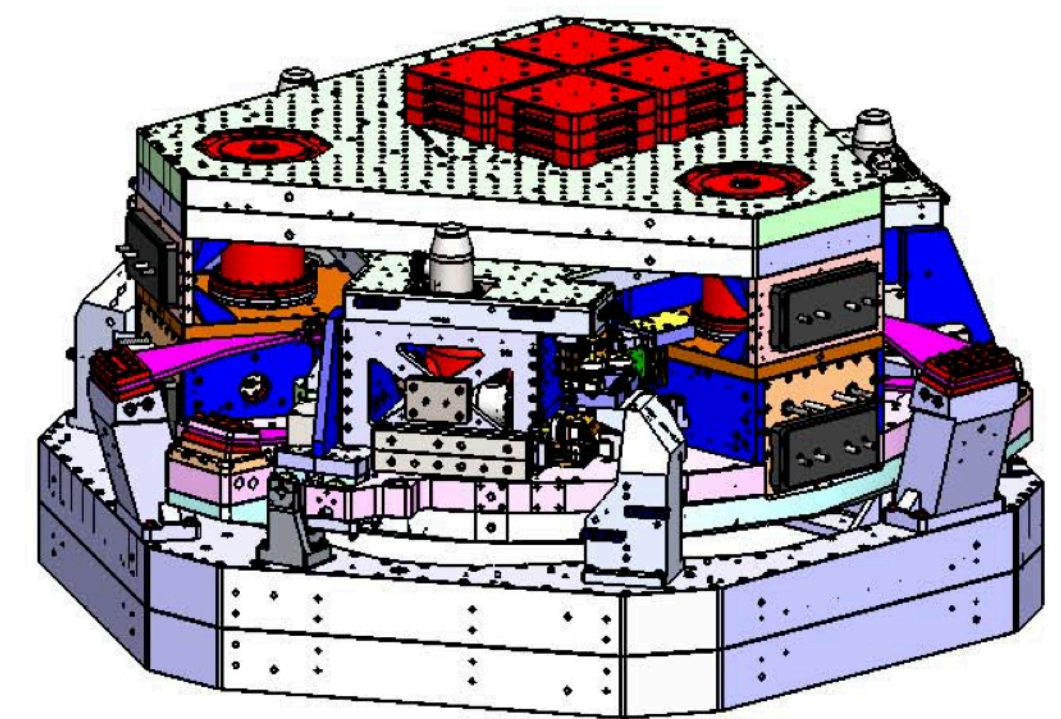
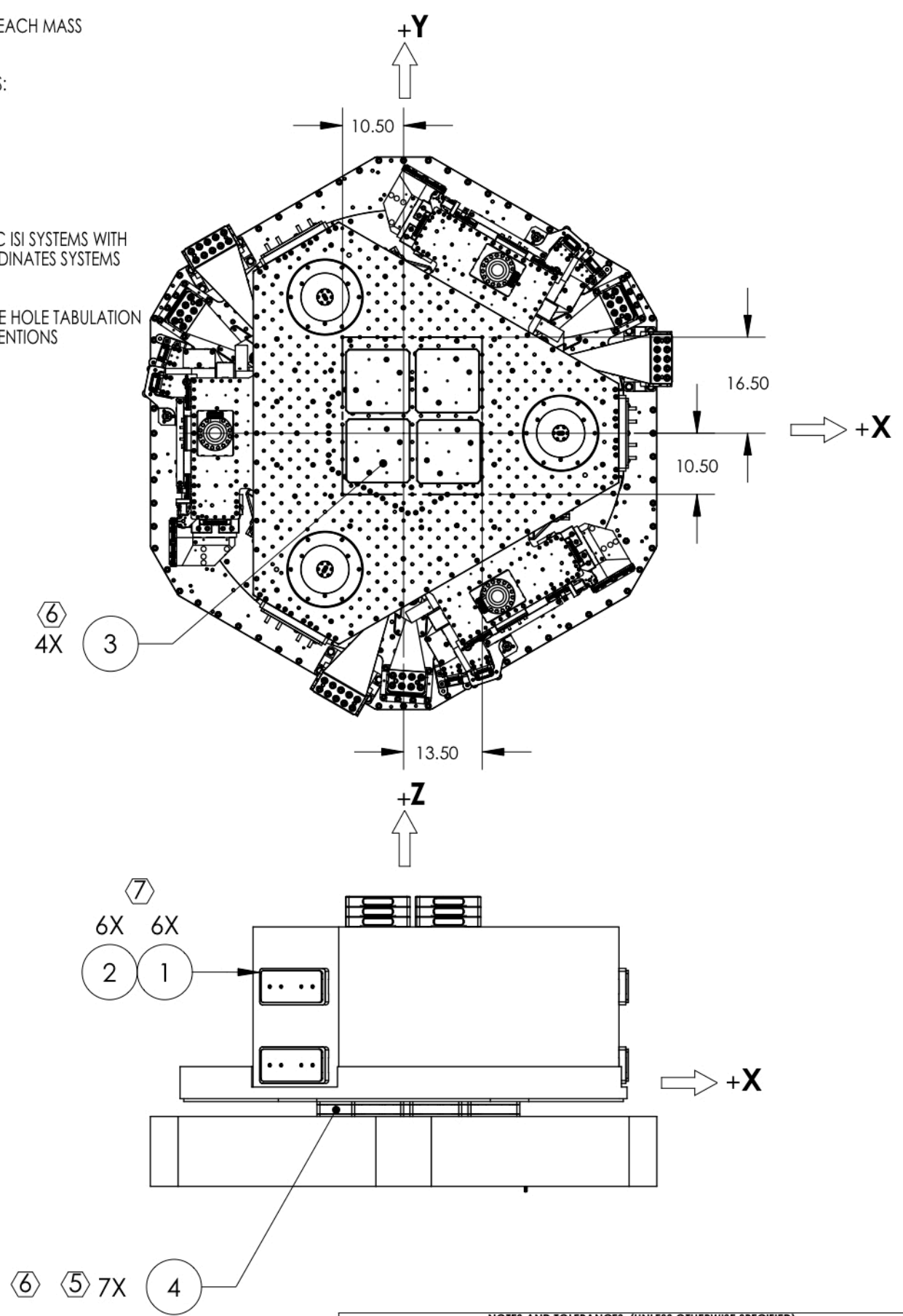
183
130
313



D1201035 AdvLIGO BSC4-L1 ISI Table, Payload & Suspended Mass Assembly, PART PDM REV: X-013, DRAWING PDM REV: X-002

- NOTES:
- ⑤ A MINIMUM OF 3X FASTENERS SHOULD BE USED WITH EACH MASS ASSEMBLY D1003161.
 - ⑥ FOR HARDWARE REQUIREMENTS REFER TO DRAWINGS: D1003161 TRIM MASS & DAMPING ASSY., BSC ISI D1003143 BALLAST MASS ASSEMBLY, ALIGO BSC-ISI
 - ⑦ HARDWARE REQUIRED ON ITEMS 1 & 2: HEX NUT, D0900504 WASHER, UCC-WFV-50
 - ⑧ FOR DEFINITIONS ABOUT THE ORIENTATION OF THE BSC ISI SYSTEMS WITH RESPECT TO THEIR VACUUM AND IFO GLOBAL COORDINATES SYSTEMS SEE THE FOLLOWING DOCUMENTS.
D1101271 ALIGO, AOS, BSC CHAMEBR, OPTICAL TABLE HOLE TABULATION
G1000125 ADVANCED LIGO BSC AND HAM ISI CONVENTIONS

REV.	DATE	DCN #	DRAWING TREE #
v1	30 JUL 2012	-	-
v2	16 OCT 2012	-	-
v3	11 JUN 2013	-	-



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
4	D1003161-21.6	TRIM MASS & DAMPING ASSY, αLIGO BSC-ISI (21.6Kg)	6
3	D1003143	BALLAST MASS ASSEMBLY, αLIGO BSC ISI	4
2	D071200-04	.440 (Type 04)	6
1	D071200-06	1.190 Coarse (Type 06)	6

PARTS LIST			
LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME	
ADVANCED LIGO		AdvLIGO BSC4-L1 ISI Table, Payload & Suspended Masses Assy	
DESIGNER	ED CHAVEZ	30 MAY 2012	SIZE DWG. NO.
DRAFTER	SEE DCC	SEE DCC	B D1201035
CHECKER	SEE DCC	SEE DCC	REV.
APPROVAL	SEE DCC	SEE DCC	v3
SCALE: 1:32		PROJECTION:	
SHEET 1 OF 3			

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)	
MATERIAL	N/A
FINISH	N/A μinch
NEXT ASSY	D0900471

95.00

LBS

RON 2000

10t

CE

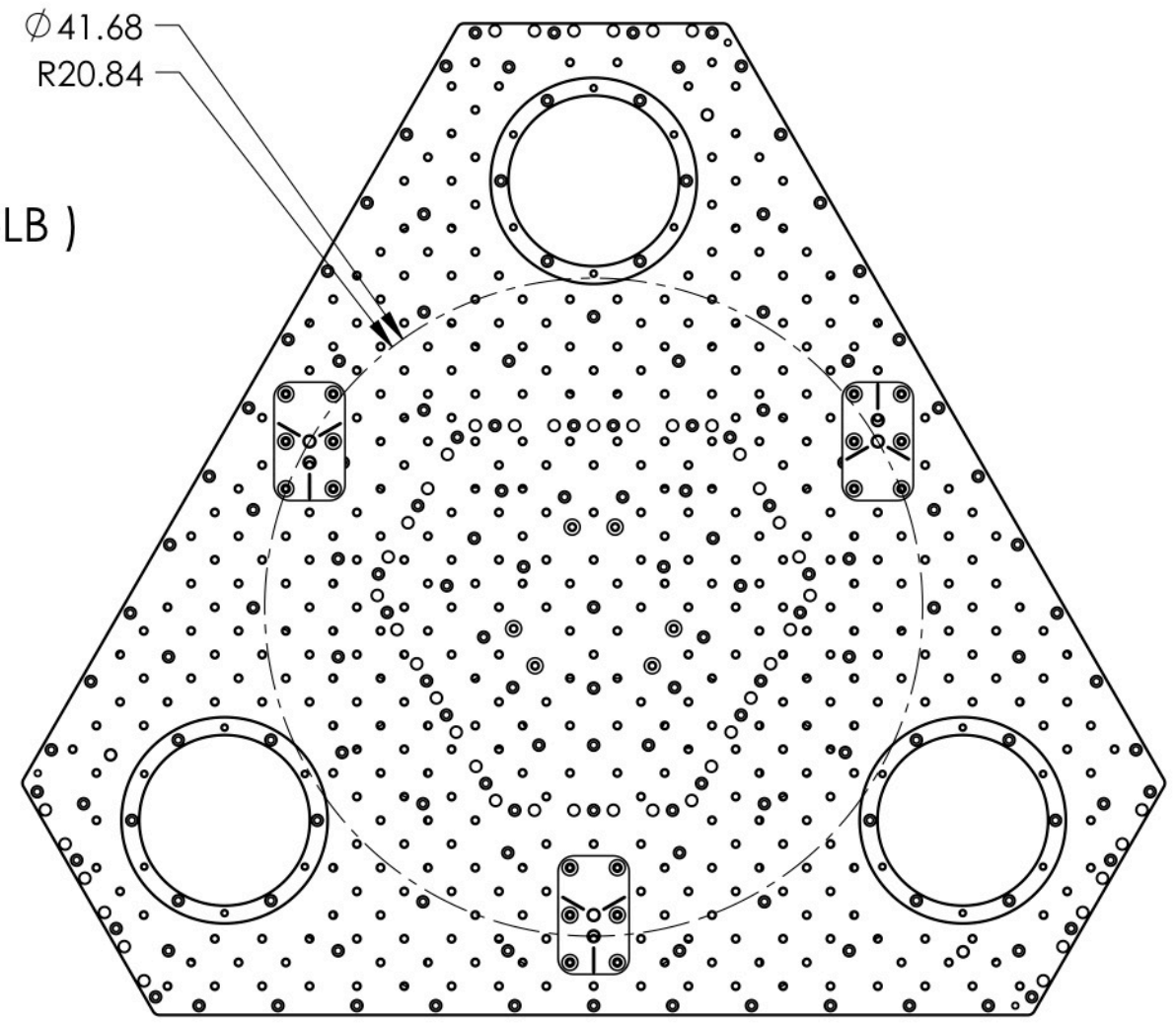
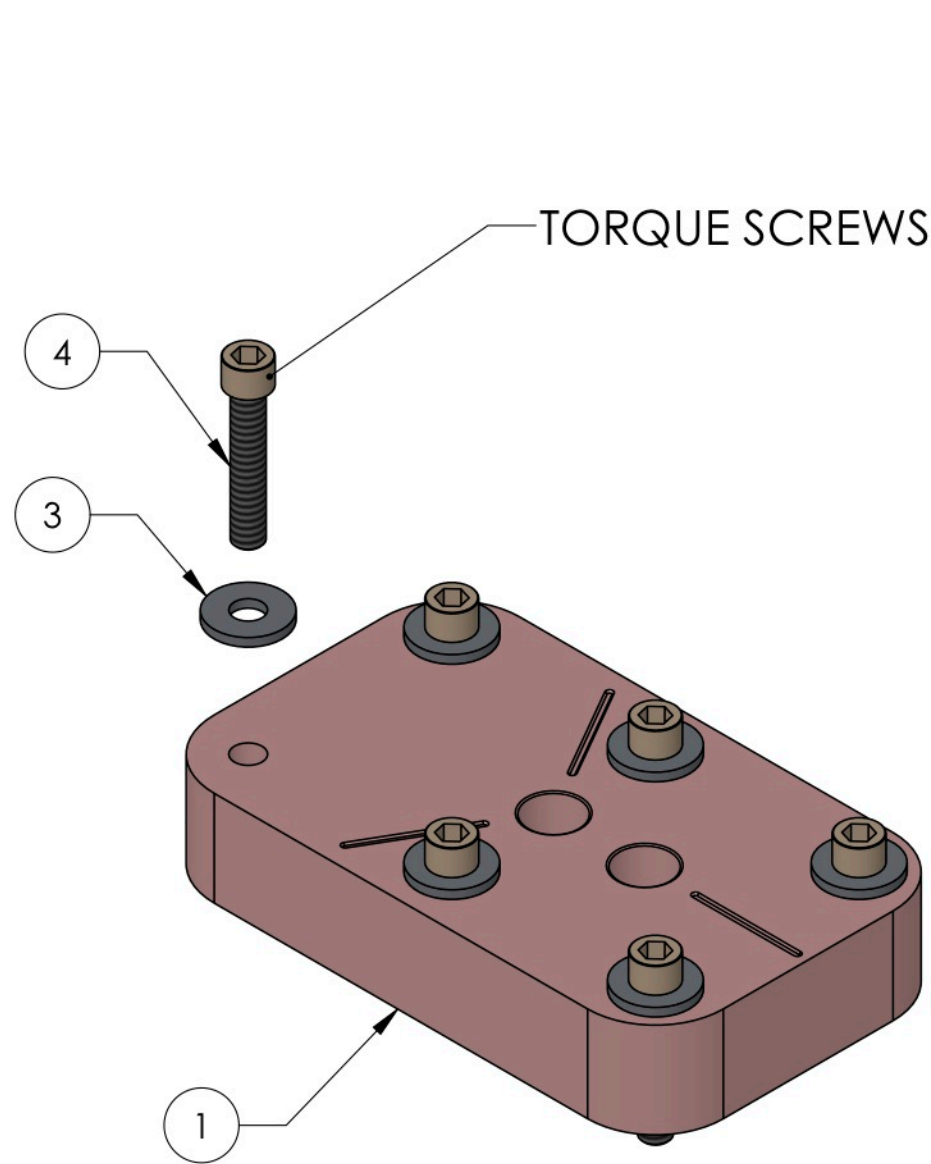
© Eilon Engineering
Industrial Weighing
© Systems Ltd.

ESC

8 7 6 5 4 3 2 1

NOTES CONTINUED:
 5. VENDOR REFERENCES ARE PROVIDED AS EXAMPLES OF PARTS MEETING ALL REQUIRED SPECIFICATIONS. EQUIVALENTS ARE ALWAYS ACCEPTABLE UNLESS OTHERWISE SPECIFIED.
 6. REFER TO LIGO E0900357 FOR ASSEMBLY AND LOADING PROCEDURE.

REV.	DATE	DCN #	DRAWING TREE #
v1	20 Apr. 2010	E1000152	E1000025
v2	19 SEPT 2011		



3X SETS OF LIFTHOOK RECEIVERS AND HARDWARE ARE NEEDED PER ISI

4	McMASTER_92488A302	SHCS, 3/8"-16 x 2.0" BUMAX-88 SST	BUMAX-88	6
3	MCMaster_98370A021	Flat Washer, 3/8"	18-8 SS	6
1	D1000753	BASE, SAFTEY, LIFT HOOK RECIEVER, aLIGO BSC ISI	304 SSTL	1
ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

DIMENSIONS ARE IN INCHES
 TOLERANCES:
 .XX ± N/A
 .XXX ± N/A
 ANGULAR ± N/A*

1. INTERPRET DRAWING PER ASME Y14.5-1994.
 2. BREAK ALL EDGES AND CORNERS .03 X 45°.
 3. DO NOT SCALE FROM DRAWING.
 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

MATERIAL N/A **FINISH** N/A μinch

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SYSTEM ADVANCED LIGO **SUB-SYSTEM** SEI
NEXT ASSY D0908211

PART NAME SAFTEY, LIFT HOOK RECIEVER, aLIGO BSC ISI
DESIGNER S.BARNUM 20 Apr. 2010 **SIZE** DWG. NO. B **D1000756**
DRAFTER S.BARNUM 20 Apr. 2010
CHECKER F.MATICHERD 20 Apr. 2010
APPROVAL K.MASON 20 Apr. 2010 **SCALE:** 1:2 **PROJECTION:** **SHEET 1 OF 1**

8 7 6 5 4 3 2 1

D1000756 Safety, Lift Hook Receiver, BSC-ISI, aLIGO, PART PDM REV: X-008, DRAWING PDM REV: X-008