



# aLIGO Installation Status

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NSF Review

LIGO Livingston Observatory

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LIGO-G1100511-V5





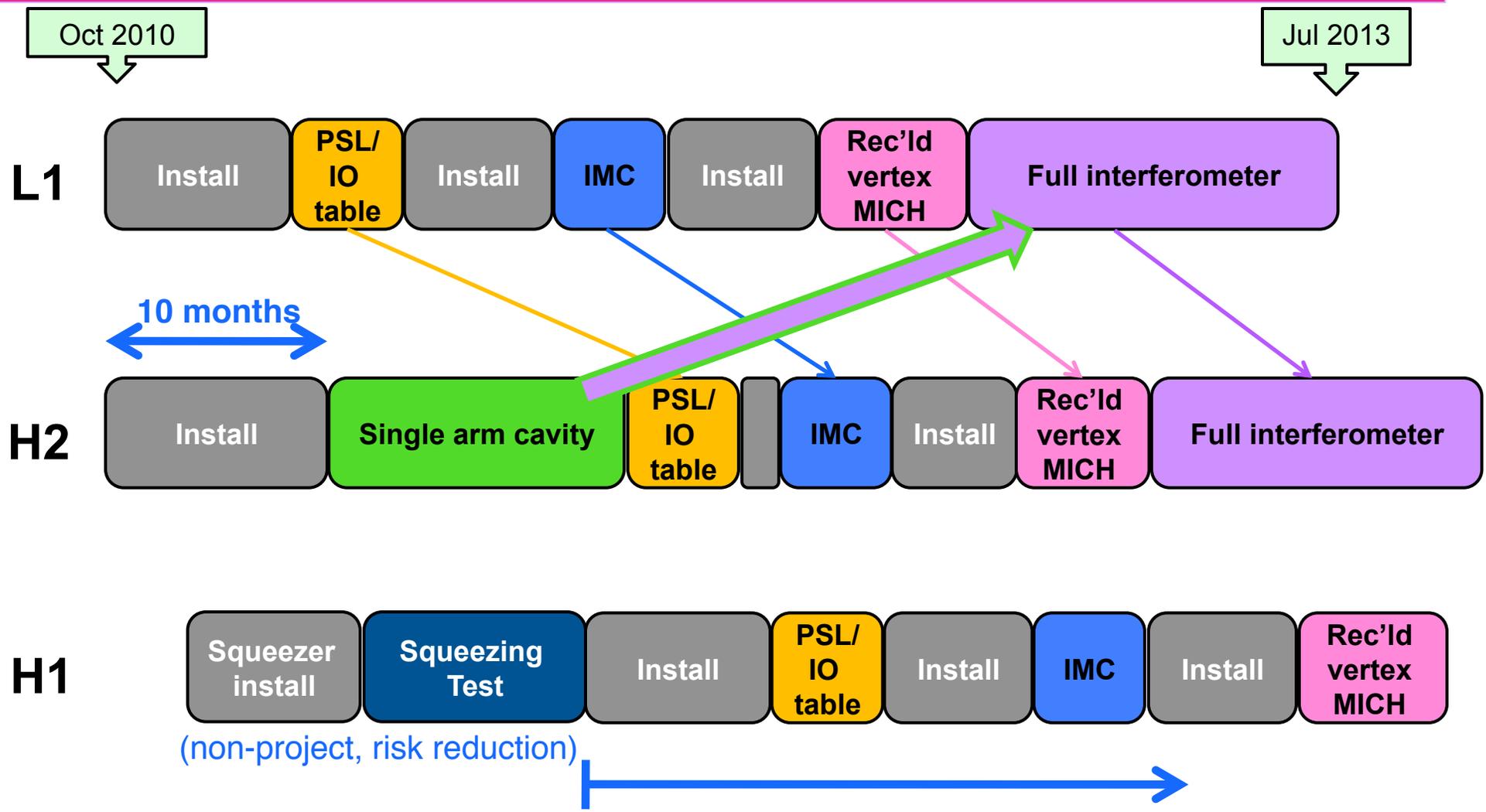
# Installation Plan

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- The Livingston detector is the pathfinder for aLIGO.
- Plan is to build this detector from the laser up.
- The installation follows the natural flow of the interferometer:  
Laser  $\Rightarrow$  IMC  $\Rightarrow$  Michelson  $\Rightarrow$  PRM  $\Rightarrow$  Full Interferometer
- At Hanford where there are two interferometers the situation is more complicated:
  - » H1 is still intact and is being used for a squeezing experiment.
  - » H2 will do a full install in the Y-arm of the instrument in order to test the new auxiliary locking scheme.



# Install sequence



H1 follows L1 sequence

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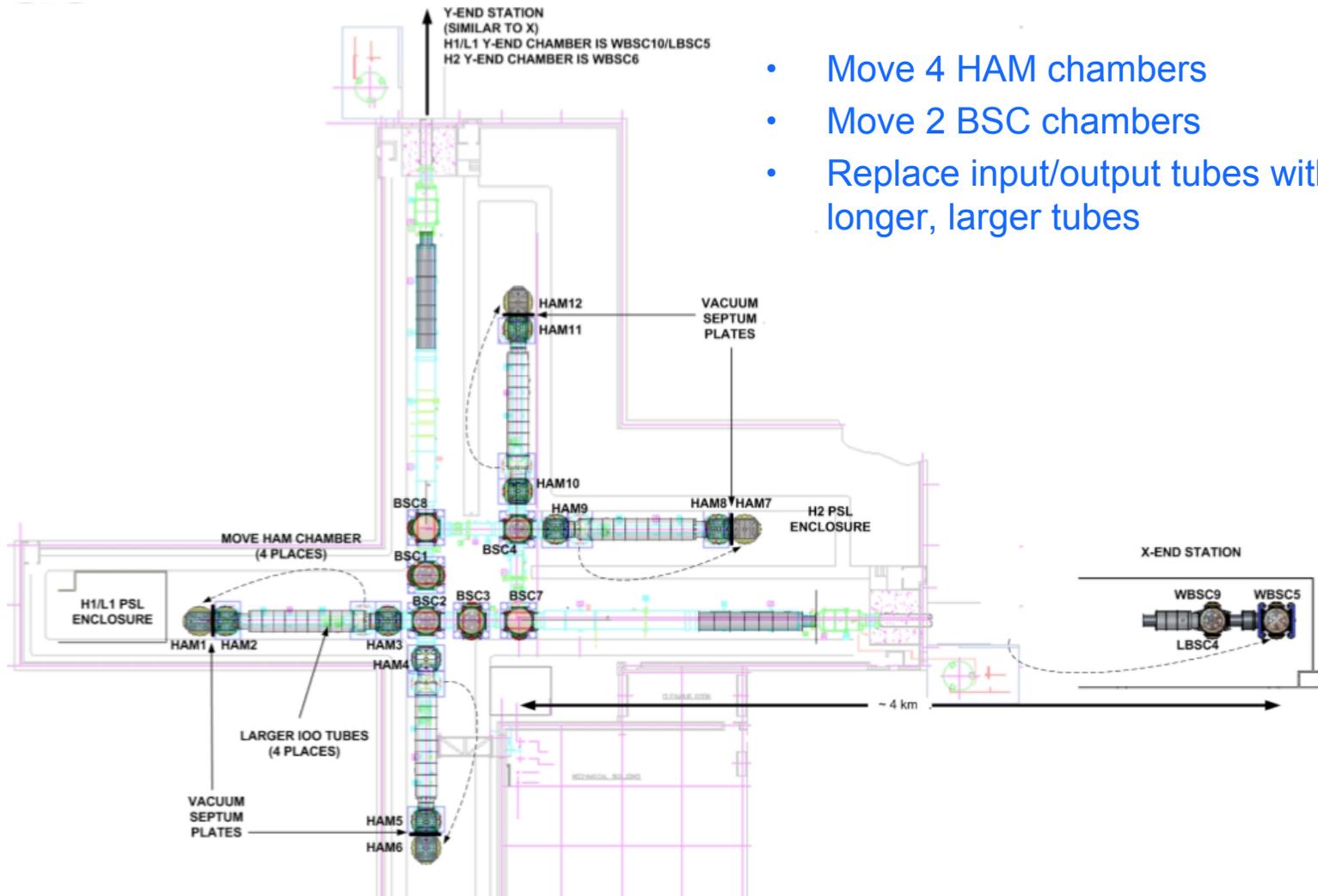
# LHO Staffing

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- aLIGO safety officer to assist with hazard analysis, training and orientation of new personnel and contractors, documentation and general on the job safety.
- Time & Materials contract with Apollo engineering used to supplement staff numbers and expertise:
  - » Started late January 2011
  - » Presently 10 Apollo people on site (1 foreman, 4 millwrights, 2 apprentices, 3 laborers); adding 3 for SEI work as of May 2
  - » Work packages include major vacuum modifications (HAM and BSC moves, IO tube removal, removal of grout), in-chamber cleaning support, HEPI installation and machined parts, survey work, and critical lifts.



# LHO Vacuum equipment modification



- Move 4 HAM chambers
- Move 2 BSC chambers
- Replace input/output tubes with longer, larger tubes

# LHO Activities



- All BSC and HAM stacks removed from H2 diagonal section.
- One HAM stack saved for re-use on aLIGO.
- Remainder recycled. Some H1 units will be donated to LSC member institutions.

# LHO Activities

- Input and Output tubes removed and recycled.
- HAM7 has been moved and is set in its final location.
- HAM12 has been moved, still needs to be fixed in place.



LIGO-G1100511-V5

# LHO HEPI

- HEPI installation on HAM11 and BSC7 (H2 ITMX).
- Minor fit issues were resolved during install.
- Using temporary plumbing in corner station for single-arm test. End station will have permanent plumbing.
- Considerable effort was expended to understand support tube positioning.
- Work has begun on BSC8 (H2 ITMY).



# H2 Electronics

- Initial LIGO electronics removed.
- New building arriving in early May.
- Installation expected 5/5/11



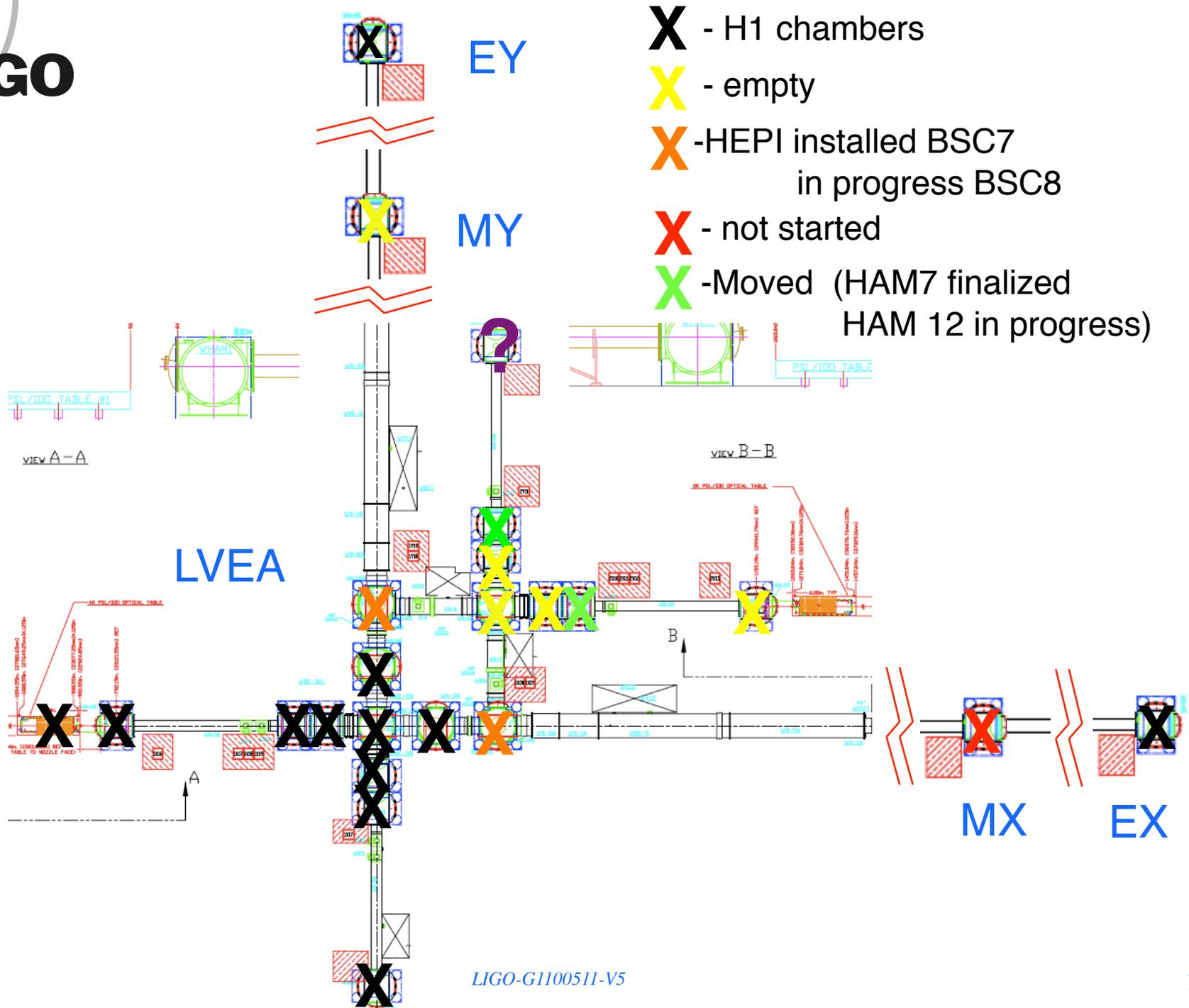


# LHO Laser Area Enclosure

PSL table has been installed and glued in place.



Construction of the acoustic enclosure about halfway complete.



## LHO: MX and MY

- MY is empty except for support tube and table
- BSC prepared for move to Y end-station.
- Move contingent upon arrival of replacement spool piece.
- Optics and isolation stack being removed from MX this week.
- Will move MX after MY, with low latency.



# LHO:Single-Arm Test

- ITM optic has had ear bonding at LHO.
  - » Will ship to CIT for metrology. Then back to LHO for fiber welding.
- End station labs being prepared for Transmission monitor assembly.
  - » Parts in bake queue.
- First BSC-ISI assembly in progress:
  - » Stage 0 on assembly stand.
  - » Heli-coiling of optical table in progress.
- H2 DAQ assembled on test stand.
- Detailed single-arm punchlist:
  - » assessing readiness of all subsystems: lots of work to do.
  - » Want to ensure any easy-to-overlook items (such as cables, feed-thrus, viewports etc.) are addressed



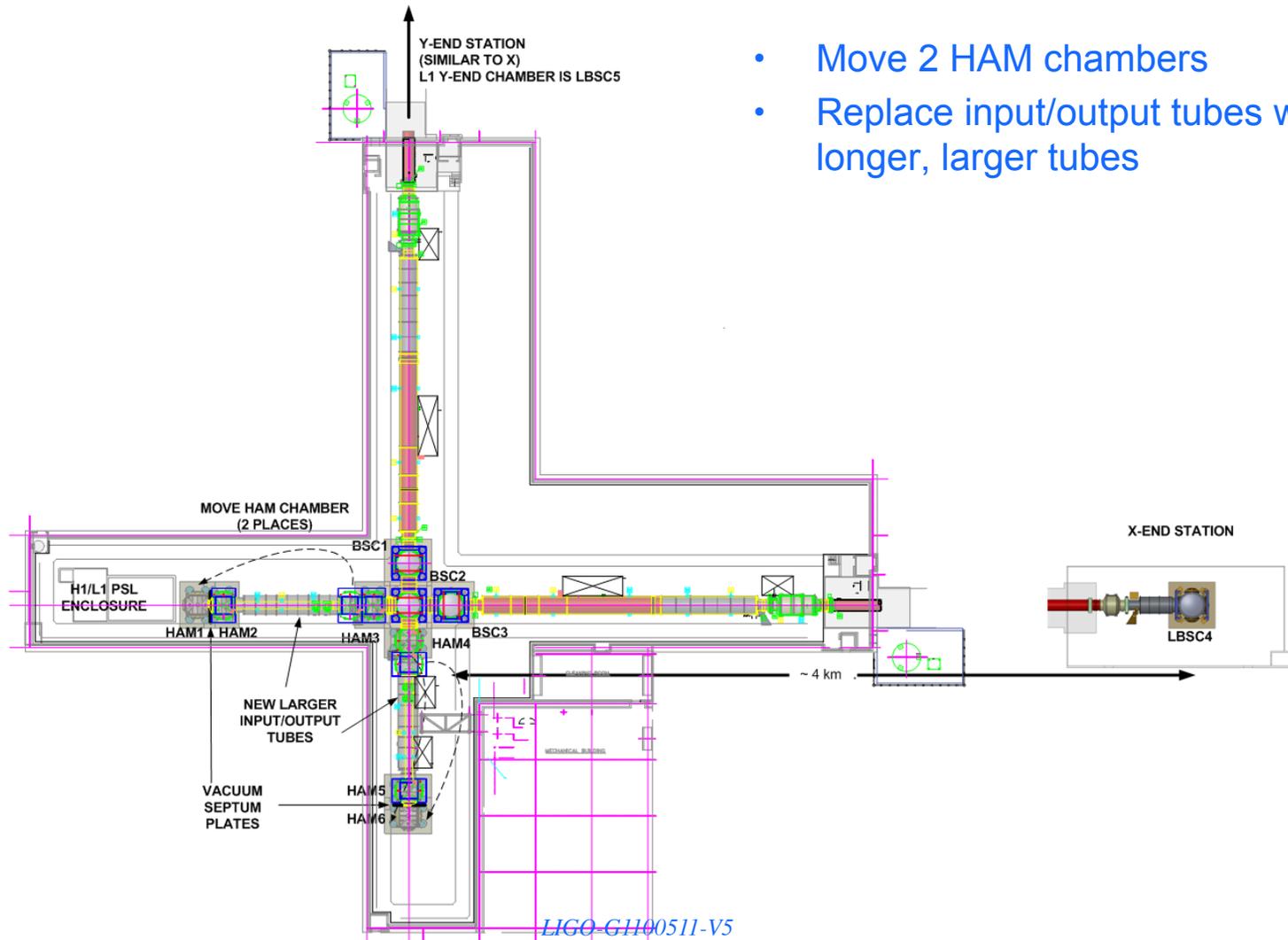


# LLO Staffing

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- aLIGO safety officer assists with hazard analyses, training and orientation of new personnel and contractors and general on the job safety.
- Time & Materials contract with Excel
  - » Started in mid-January 2011.
  - » Average of 6-7 workers on-site.
  - » Supplement local staff labor during de-install
  - » Electricians for new DC power supplies and racks, electrical work for Laser Area Enclosure etc.
  - » Skilled labor to assist in chamber cleaning and vacuum modifications.
  - » Use this contract to obtain specialized services if needed
    - Surveyors
    - Scaffolding

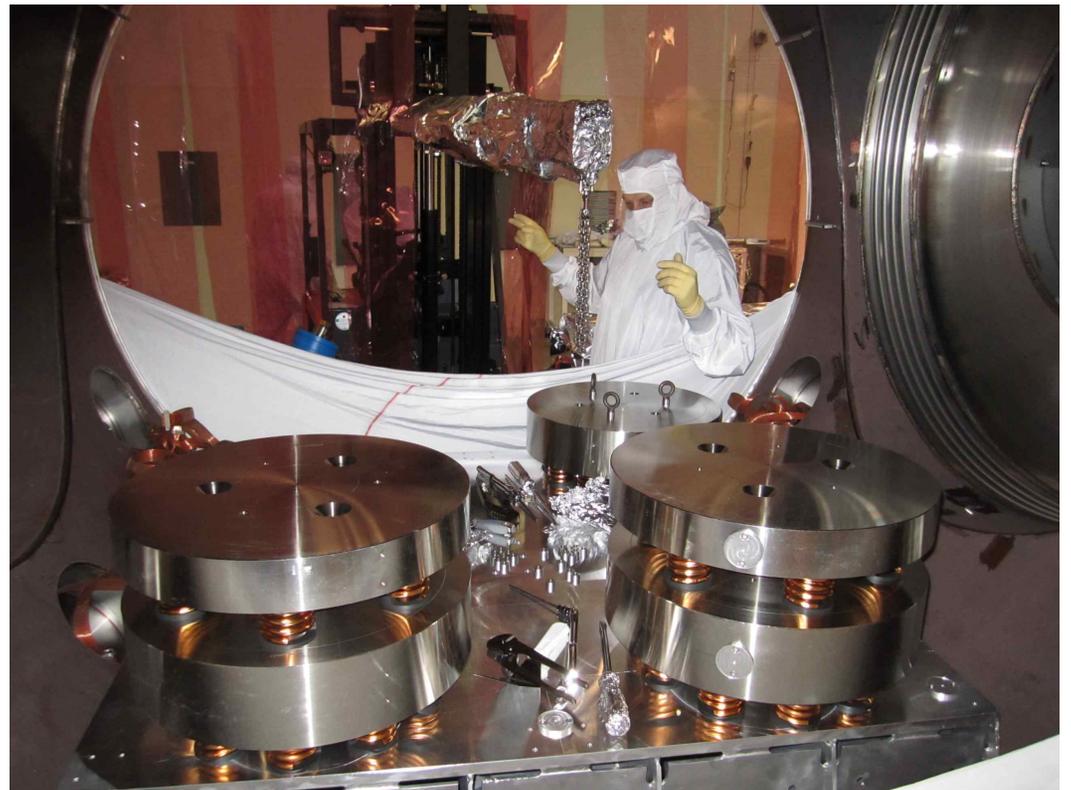
# LL0 Vacuum equipment modification



- Move 2 HAM chambers
- Replace input/output tubes with longer, larger tubes

# LLO Activities

- Optics and isolation stacks removed from all chambers in the vertex region.
- Stacks either saved for re-use in aLIGO, donated to LSC member institutions or recycled.



# LLO Activities

- Input/Output tubes removed and recycled.



# LLO HEPI

- Existing HEPI plumbing flushed clean.
- Had to remove a lot of plumbing to allow for vacuum modifications.
- Existing HAM HEPI will be modified to a stiffer design. Old housings ship to LHO for use on their BSC chambers





# LLO Laser Area Enclosure



- Enclosure build essentially complete.
- Needs cameras and an access control system.

# LLO Laser work

- Visitors from LZH and AEI-Hannover are working on commissioning the laser.
- Already working on the high-power stage.
- We will use 35W for initial phases of aLIGO



# LLO Electronics

- All electronics removed from corner station.
- Preserved vacuum monitoring and environmental monitoring channels at corner and ends.
- In process of build out of aLIGO electronics racks and DC power supplies.



# DAQ Progress

- LHO:
  - » Front ends for the corner station are installed and being tested this week.
  - » Performing tests at X-end station using PEM channels.
- LHO:
  - » H2 DAQ assembled and running in temporary location.
  - » Will be moved to H2 electronics building in late May.
  - » Orders placed for H1 computers (expect May delivery).





# Disposition of iLIGO hardware

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- Components extracted from Initial and Enhanced LIGO interferometers are:
  - » Re-used in aLIGO e.g. Output Mode Cleaner, 35W laser
  - » Sent to LIGO Laboratory sites for R&D or outreach usage
    - Some electronics sent to 40m at CIT
    - Two Isolation stacks from LLO HAM chambers sent to UF.
    - Old TCS chillers to MIT
  - » Sent to LSC sites for R&D or outreach usage
    - As requested by individual institutions.
  - » Retained at observatories for future use
    - Optic tables, hardware, Optical Lever lasers and receivers etc.
  - » Recycled
    - Scrap metal contracts in place at each observatory.
    - Mainly Aluminum, Stainless Steel and cast Iron.
  - » Discarded
    - In general we endeavor to minimize this aspect and have been quite successful.



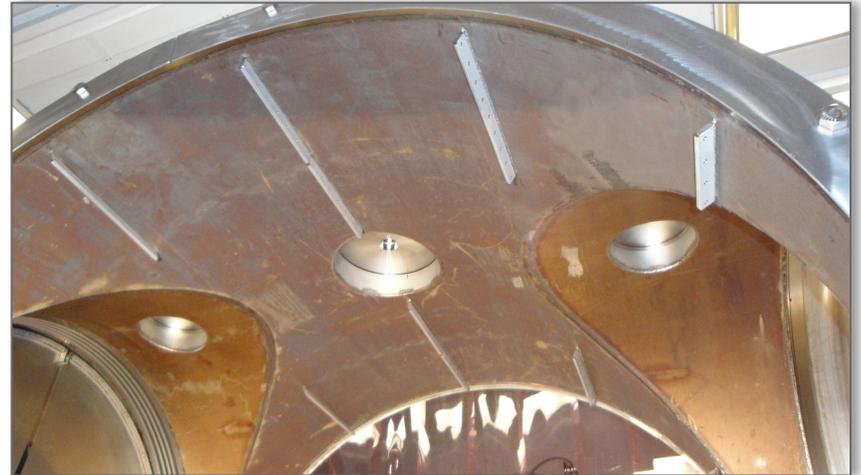
# Disposition of iLIGO Hardware

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- At both LLO and LHO, master lists of extracted components and their subsequent disposition were assembled:
  - » Documented items as they were removed from the chamber.
  - » Integrated individual lists into master lists.
  - » Major dispositions were individually recorded (UF, CIT etc.)
- These lists were forwarded to R. Luna at CIT, and ultimately to the NSF.
- We can account for the disposition and current location of all iLIGO hardware and electronics.

# Chamber Cleaning

- Ongoing R&D effort at LHO since early December 2010.
- Now have tooling and techniques for oxide removal and cleanliness sampling of surfaces.
- Technology now being transferred to LLO.
- Cleaning has already started at LHO.





# HAM 11 Contamination

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- Contamination occurred from use of an oil-based compressor.
- See D. Coyne's talk for details.
- Chamber will require cleaning and baking to bring it back to LIGO spec.
- Limited schedule impact if cleaning is done by contractors.
- Can parallel remaining chamber cleaning.



# LLO: Future activities

LIGO-1.4.13.2.2.3.2 IN PSL/IO/IMC Install & Testing L1				356	255	20-Oct-10 A	06-Apr-12		24
LIGO-1.4.13.2.2.3.2.1 IN PSL & Table Install Enclosure L1				123	123	01-Apr-11	23-Sep-11		96
IN-L1-P1400	INS L1: Install/Assemble PSL on Table	NSF	53	53	01-Apr-11	15-Jun-11	0%		93
IN-L1-P1410	INS L1: Install IO for PSL on Table	NSF	10	10	16-Jun-11	29-Jun-11	0%		93
IN-L1-P1450	INS L1: PSL/IO Table Testing	NSF	60	60	30-Jun-11	23-Sep-11	0%		93

- The pre-stabilized laser effort is on schedule and has ample time to be complete before input mode cleaner commissioning.
- May use Laser Area Enclosure for some assembly and testing of input optic components.



# LLO: Vacuum Modifications and Chamber Cleaning

LIGO-1.4.13.2.2.3.2.2 IN Install Vertex L1			253	144	20-Oct-10 A	24-Oct-11		46	
IN-L1-P1500	INS L1: Remove/Move Existing Equip in Vertex & Clean (LOE)	NSF	109	55	20-Oct-10 A	17-Jun-11	75%	14	
IN-L1-P1310	INS L1: Install New PSL Enclosure	NSF	30	21	19-Jan-11 A	29-Apr-11	95%	125	
IN-L1-P1699	INS L1: Relocate Vac Equip (LOE)	NSF	82	75	22-Feb-11 A	18-Jul-11	3%	16	
IN-L1-P1629	INS L1: Install/Modify all HEPI (LOE)	NSF	44	47	22-Feb-11 A	07-Jun-11	10%	84	
IN-L1-P1611	INS L1: CDS Install (LVEA Chambers)	NSF	68	26	22-Feb-11 A	06-May-11	20%	135	
IN-L1-P1355	INS L1: String Cables & Install CDS Racks (All HAM's and All...)	NSF	180	144	22-Feb-11 A	24-Oct-11	20%	43	
IN-L1-P1620	INS L1: Install HEPI (HAM 1)/INS L1: Modify HEPI (HAM 2, 3)	NSF	25	47	28-Feb-11 A	07-Jun-11	25%	84	
IN-L1-P1630	INS L1: Install HEPI (HAM 5, 6)/Modify HEPI (HAM 4)	NSF	24	47	28-Feb-11 A	07-Jun-11	25%	84	
IN-L1-P1600	INS L1: Relocate HAM 1	NSF	10	25	21-Mar-11 A	05-May-11	10%	44	
IN-L1-P1750	INS L1: Clean Vertex, Chambers, Beam Tubes	NSF	30	55	21-Mar-11 A	17-Jun-11	5%	14	
IN-L1-P1610	INS L1: Relocate HAM 6	NSF	5	20	21-Mar-11 A	28-Apr-11	25%	49	
IN-L1-P1700	INS L1: Install I/O Tubes	NSF	17	17	20-Jun-11	13-Jul-11	0%	14	

- HAM1 and HAM6 are ready to move. Will pull the trigger once we are ready to start cleaning chambers.
- New Input/Output tubes should arrive in June.



# LLO: IMC Testing

LIGO-1.4.13.2.2.3.2.3 IN Install IMC L1			175	175	26-Jul-11	06-Apr-12		24
IN-L1-P1900	INS L1: Install Passive Stack/HAM ISI (HAM 1,2,3) (LOE)	NSF	30	22	26-Jul-11	24-Aug-11	0%	14
IN-L1-P1950	INS L1: Install Passive Stack (HAM 1)	NSF	10	10	26-Jul-11	08-Aug-11	0%	16
IN-L1-P1930	INS L1: Install HAM ISI (HAM 3)	NSF	10	10	11-Aug-11	24-Aug-11	0%	14
IN-L1-P1905	INS L1: Install HAM ISI (HAM 2)	NSF	10	10	25-Aug-11	08-Sep-11	0%	19
IN-L1-P2200	INS L1: Install SUS/Optics (HAM 3)	NSF	15	15	31-Aug-11	22-Sep-11	0%	9
IN-L1-P2100	INS L1: Install Small IO/SUS/ISC/AOS (HAM 1,2,3) (LOE)	NSF	50	12	06-Sep-11	22-Sep-11	0%	9
IN-L1-P2103	INS L1: Install Optics (HAM 1)	NSF	10	10	06-Sep-11	20-Sep-11	0%	11
IN-L1-P2110	INS L1: Checkout/test HEPI/ISI/SUS (HAM 1,2,3) (LOE)	NSF	80	27	20-Sep-11	27-Oct-11	0%	54
IN-L1-P2170	INS L1: Checkout/test HEPI (HAM 1)	NSF	10	10	20-Sep-11	04-Oct-11	0%	41
IN-L1-P2220	INS L1: Checkout/test HEPI (HAM 3)	NSF	10	10	22-Sep-11	06-Oct-11	0%	54
IN-L1-P2105	INS L1: Install SUS/Optics (HAM 2)	NSF	25	25	23-Sep-11	27-Oct-11	0%	9
IN-L1-P2180	INS L1: Acceptance of HAM 1	NSF	40	40	04-Oct-11	01-Dec-11	0%	106
IN-L1-P2230	INS L1: Checkout/test ISI (HAM 3)	NSF	10	10	06-Oct-11	20-Oct-11	0%	54
IN-L1-P2240	INS L1: Checkout/test SUS (HAM 3)	NSF	10	10	13-Oct-11	27-Oct-11	0%	54
IN-L1-P2210	INS L1: Acceptance of HAM 3	NSF	40	40	27-Oct-11	04-Jan-12	0%	89
IN-L1-P2140	INS L1: Checkout/test HEPI (HAM 2)	NSF	10	10	28-Oct-11	10-Nov-11	0%	24
IN-L1-P2150	INS L1: Checkout/test ISI (HAM 2)	NSF	15	15	11-Nov-11	05-Dec-11	0%	24
IN-L1-P2160	INS L1: Checkout/test SUS (HAM 2)	NSF	15	15	13-Dec-11	11-Jan-12	0%	24
IN-L1-P2300	INS L1: PSL/IO/IMC Testing	NSF	60	60	12-Jan-12	06-Apr-12	0%	24

- Installation into HAM chambers begins in late July.
- Testing of the Input Mode Cleaner is scheduled for early 2012.



## LLO

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- Intend to get to Power Recycled Michelson Testing by May 2012.
  - Requires parallel efforts of installation and testing in corner station.
  - May require overlapping shifts. Will require multiple installation teams.
  - End station decommissioning will be a target of opportunity between now and June.
  - Installation in end chambers will happen during PRM commissioning effort.



# LHO Future Activities

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- Near Term:
  - » MY (BSC6) move to the Y-end station ~ May 9<sup>th</sup> 2011
  - » Empty MX (BSC5) this week to prepare for move to the X-end.
  - » First HAM is being cleaned at present. ITMY (BSC8) is next.
  - » Finish PSL enclosure and clean room in the interior.
  - » Complete H2 HEPI installations in advance of the single-arm test.
  - » H2 electronics building to be set on slab ~May 5<sup>th</sup>



# Squeezer Experiment

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- Squeezer
- Non-project squeezer will soon go into vacuum
- Early May (after H2 electronics building): in-vacuum work to unlock all optics
- Relock H1 Michelson
- Install squeezer table, in-vacuum Faraday isolator, in-vacuum beam-splitter .
- Alignment work in HAM6
- Add arms and relock at  $\sim 20$ Mpc.
- Squeeze the vacuum.

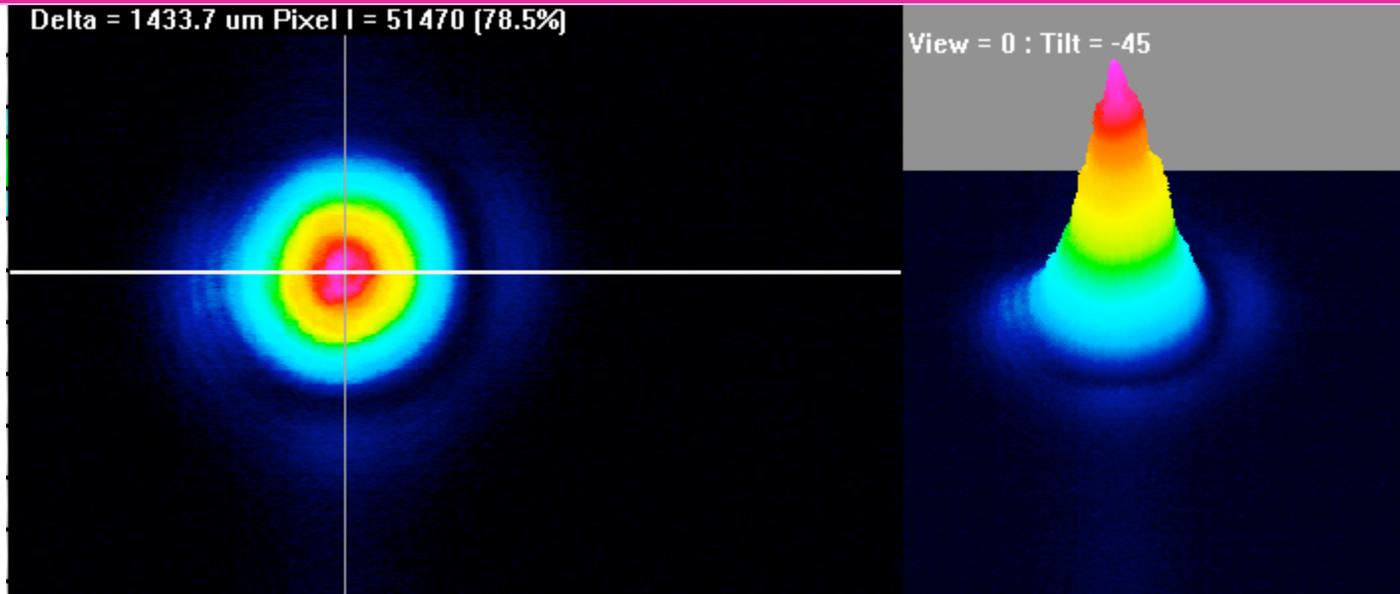


# LHO Future Activities

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- Longer Term:
  - » Single-Arm test on H2 Y-arm begins 10/14/11
  - » Squeezer experiment on H1 to run concurrently
  - » Single-Arm test continues into 2012, but squeezer experiment finishes at end of 2011. These activities are now decoupled (*cf. C. Wilkinson's talk*).

# Installation



- Both sites are transitioning from decommissioning iLIGO to installation of aLIGO components.
- The next six months promise to be very exciting as we get a first look at the installation and performance of a lot of our new technology and instrumentation.