Detector Installation

Dennis Coyne

27 Oct 98

- Progress Overview
- Organization
- Plan
- Schedule
- Subsystem Installation or Readiness Status

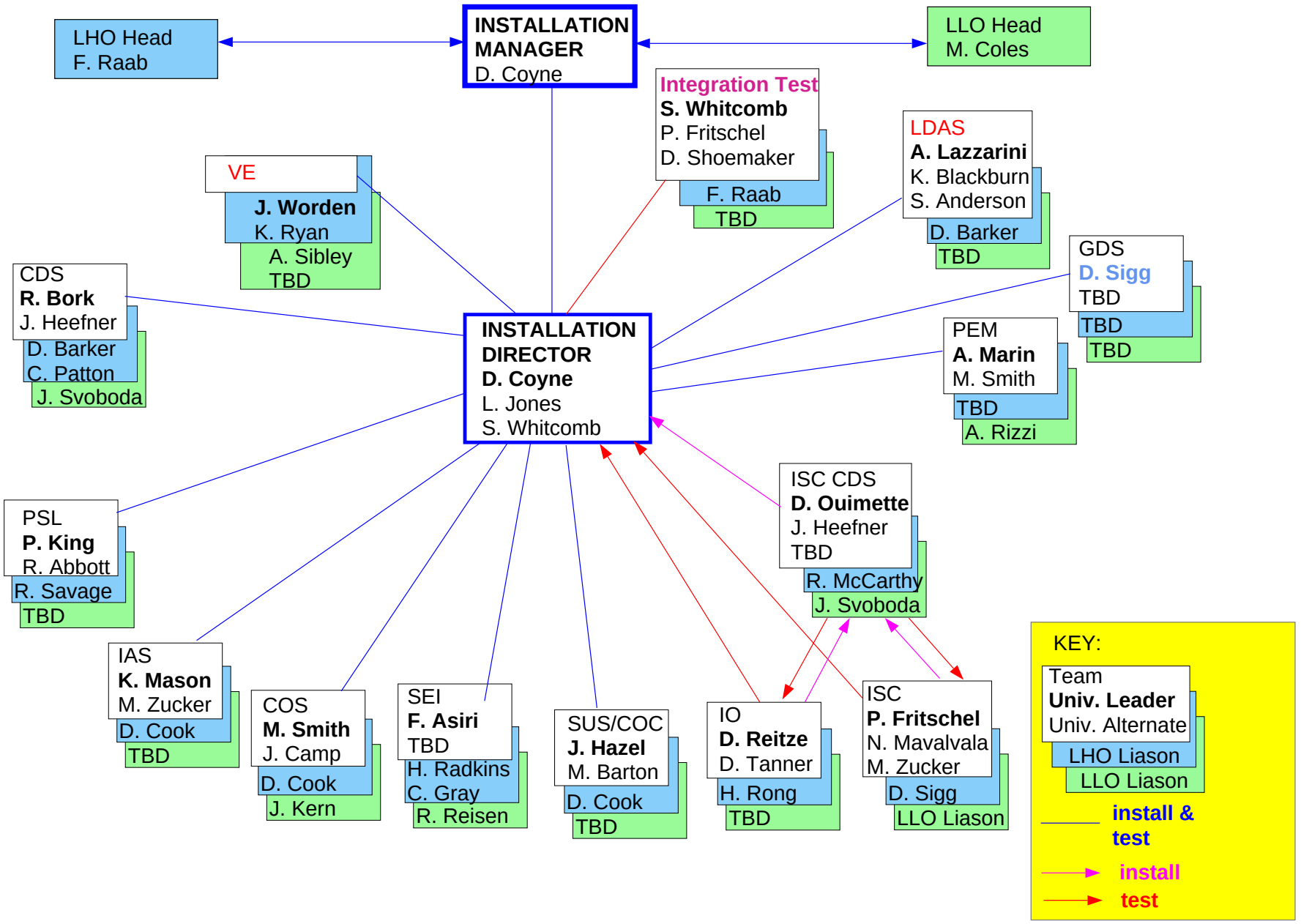
Installation Progress Overview

- Detector System PDR and Installation Readiness Review (9/98)
- Initiated Installation @ LHO!
  - ››Pre-Stabilized Laser (PSL)
  - ››Input Optics (IO)
  - ››Seismic Isolation System (SEI)
  - ››Physics Environment Monitoring (PEM)
  - ››Data Acquisition System (DAQS)
  - ››Control & Monitoring (CM) System
  - ››Cable Trays
- PSL Installation is Progressing Well!
  - ››Locked to pre-mode cleaner
  - ››Control Room Display is Functional
- Installing In-Vacuum Components!
  - ››WHAM7 SEI Bellows & All Diagonal Section Electrical Feedthrus are Leak Tight
- All HAM Piers are Installed!
  - ››Completed Virtually all Drilling for Embedded Bolts @ LHO

Installation Organization & Staffing

- EXECUTION:
  Day-to-Day On-Site Staff Direction & Tracking is the Designated Installation Director's Responsibility
- PLANNING/COORDINATION:
  Work-Around Planning & Technical/Scientific Support Staff Coordination is the Integration Manager's Responsibility
- Detector Design Staff Migrates to Support the Installation Effort
- Subsystem Teams (with Observatory members) Execute the Installation

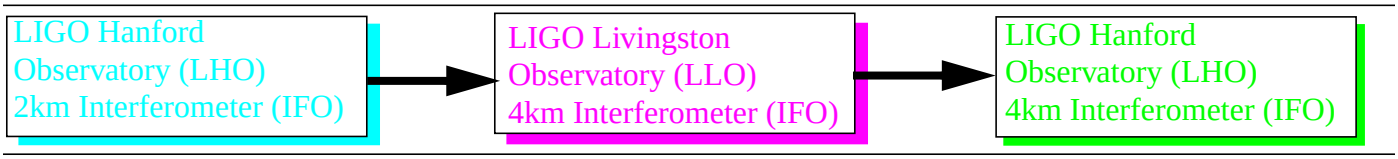
Installation Organization



LIGO-G980119-00-D

Detector Installation Plan Overview

- Interferometer Sequence:



  - 2km IFO is First Since It's Easier to Align & Can be Debugged in Parallel with 4km IFO Installation
  - LLO 4km IFO is Second Since Facility and Staff are Available
  - 2nd and 3rd IFOs benefit from Debug/Commissioning on the Earlier IFOs

- Initiate Interferometer Installation 07/98
- First Coincidence Run ($h < 10^{-20}$) 12/00
- Design Sensitivity ($h < 10^{-21}$) 11/01
- Need ~12 months for Debug & Commissioning of Interferometers (Operations Proposal)

NOTES:

1. ANNULUS ION PUMPS ARE NOT SHOWN IN PROPER LOCATIONS (TO BE MOVED TO +Y SIDE OF VACUUM MANIFOLD).
2. MOVABLE CROSS-OVER STILE NOT SHOWN.
3. DETECTOR ASC SUBSYSTEM COMPONENTS NOT SHOWN.
4. MID-STATION ALONG Y-ARM IS A MIRROR REFLECTION OF THE MID-STATION ALONG THE X-ARM.
5. NOT SHOWN YET IN ELEVATION:
   - CLEAN ROOM
   - PIPING UNDER VACUUM MANIFOLD

4K BEAM SPLITTER AND
PICKOFF TELESCOPES-ENLARGED

2K BEAM SPLITTER AND
PICKOFF TELESCOPES-ENLARGED

DWG. NO.	DESCRIPTION	DWG. NO.	DESCRIPTION
REFERENCE DRAWINGS			

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN FEET (cm)
TOLERANCES:
FRACTIONAL ±
ANGULAR MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
FINISHED SURFACE RMS
BREAK CORNERS ON OUT:
REMOVE ALL BURRS

DO NOT SCALE THIS DRAWING

USED ON:

NEXT ASS'Y:

REV	DESCRIPTION	DCN NUMBER	-	DRWN	DATE
A	RELEASE	E980260	-	KABDT	9/29/98
01	PRE-RELEASE	-	-	KABDT	3/6/98
00	PRE-RELEASE	-	-	KABDT	6/20/97

ISSUE DESCRIPTION

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTERFEROMETER OPTOMECHANICAL LAYOUT
HANFORD SITE
LASER VACUUM EQUIPMENT AREA (LVEA)
PLAN VIEW

CAD FILE	SIZE	DWG. NO.
D970308-A	E	D970308-A

SCALE	SHEET
NTS	1 OF 5

Installation Plan: Subsystem Prerequisites

- Configuration Controlled Drawings
- Assembly Procedure(s)
- Data Package
- Installation Procedure(s)
- Subsystem Component/AssemblyTraveler(s)
- Test Plan

Installation Plan: Documentation

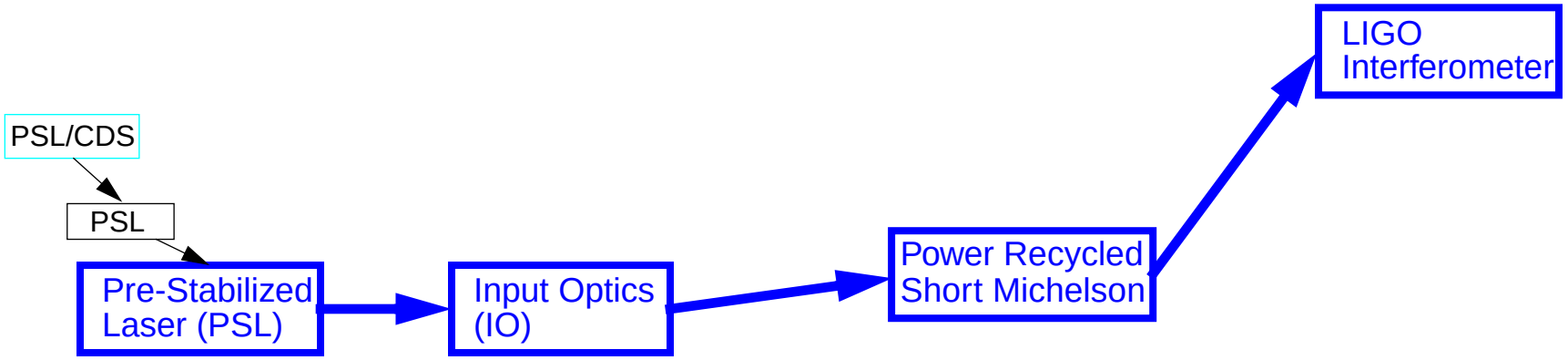
- Installation Logbook
  - ››Record of the system configuration as it is assembled
  - ››Maintained by the Installation Director
  - ››One logbook per Observatory
  - ››Completed installation procedures are incorporated
  - ››Record of daily activities
  - ››Record of all installed components/assemblies by Dwg # and Revision
  - ››Record all waivers
- As-Built Engineering Change Logbook
  - ››Capture as-built deviations, discrepancies (responsibility of the subsystem team leader)
  - ››Reviewed periodically by the Installation Manager for disposition (Technical Review Board, Material Review Board or Document Change Notice)

Installation Plan: Documentation (continued)

- Test Results
  - responsibility of the test director/conductor(s)
  - logbook or report
  - presentation
- Schedule
  - maintained at two levels by the Installation Director with input from the subsystem team leaders:
    - overall per interferometer, and
    - via task lists for current and near-term activities (~2-4 week span sliding window)
- Work Orders
  - Maintained/managed by the Observatory Head (or designee)
  - Process for obtaining permits by the observatory for work which has a safety impact/concern or could interfere with or limit other activities at the site

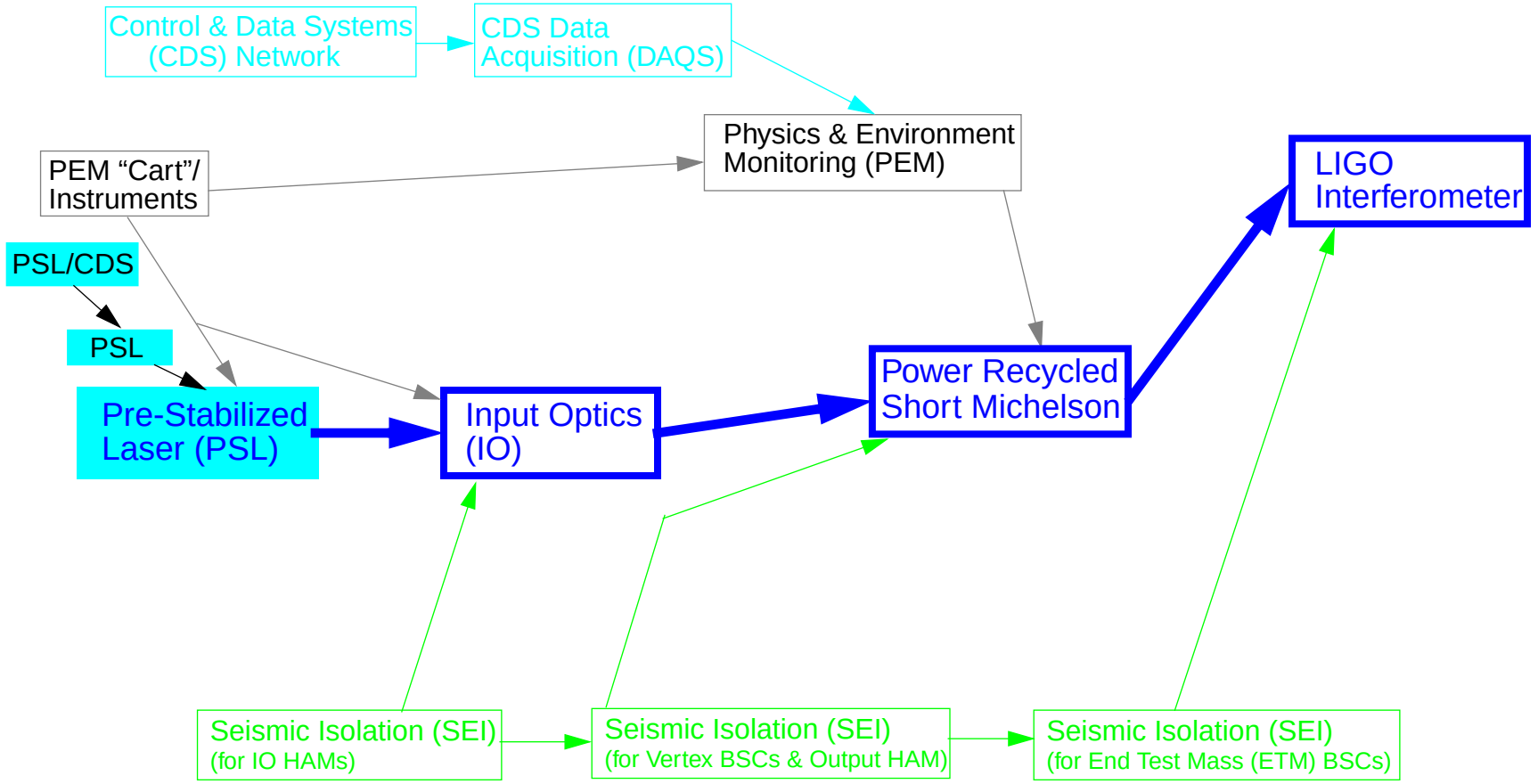
Detector Installation Sequence

Core Thread



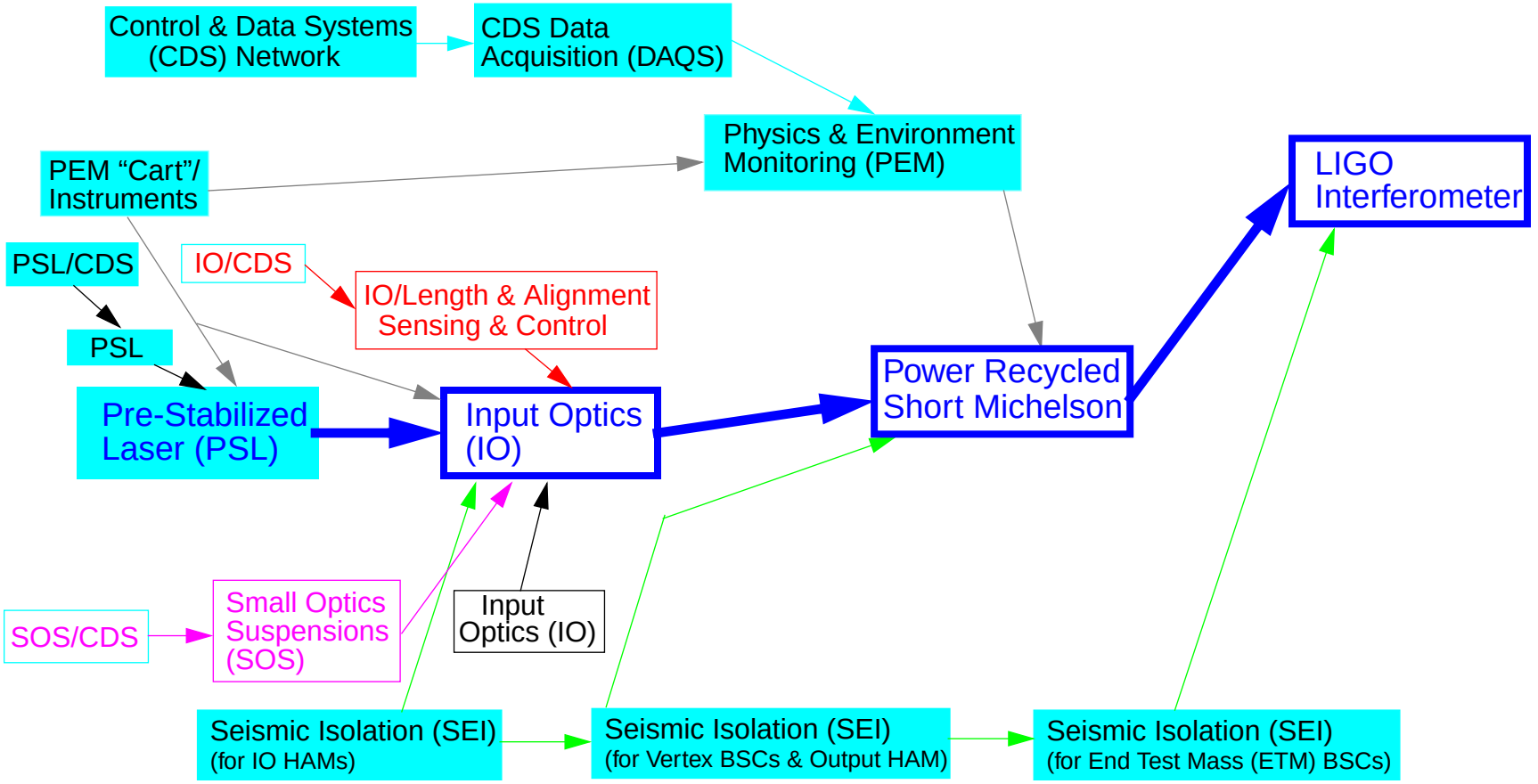
Detector Installation Sequence

Infrastructure Threads



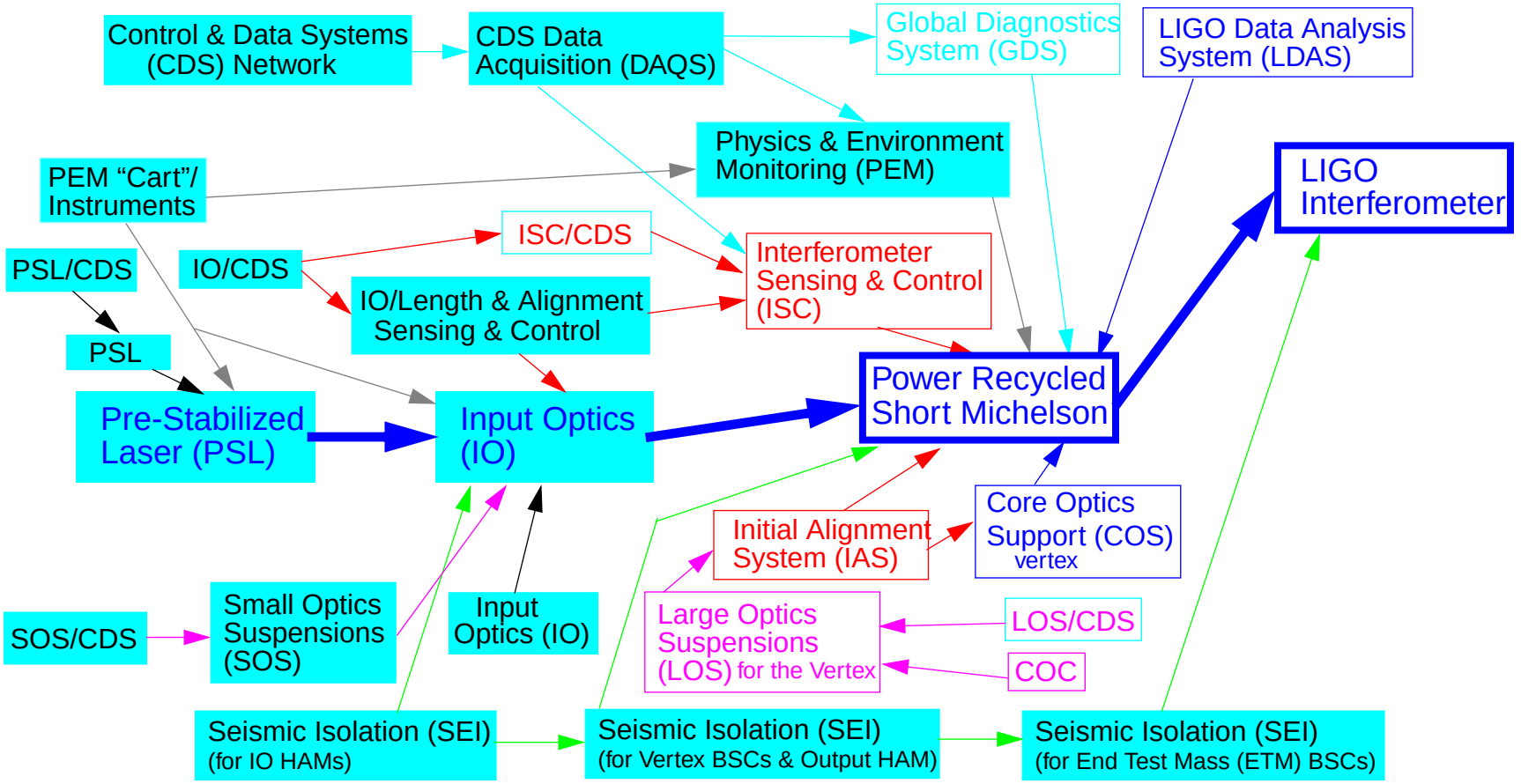
Detector Installation Sequence

Input Optics Threads

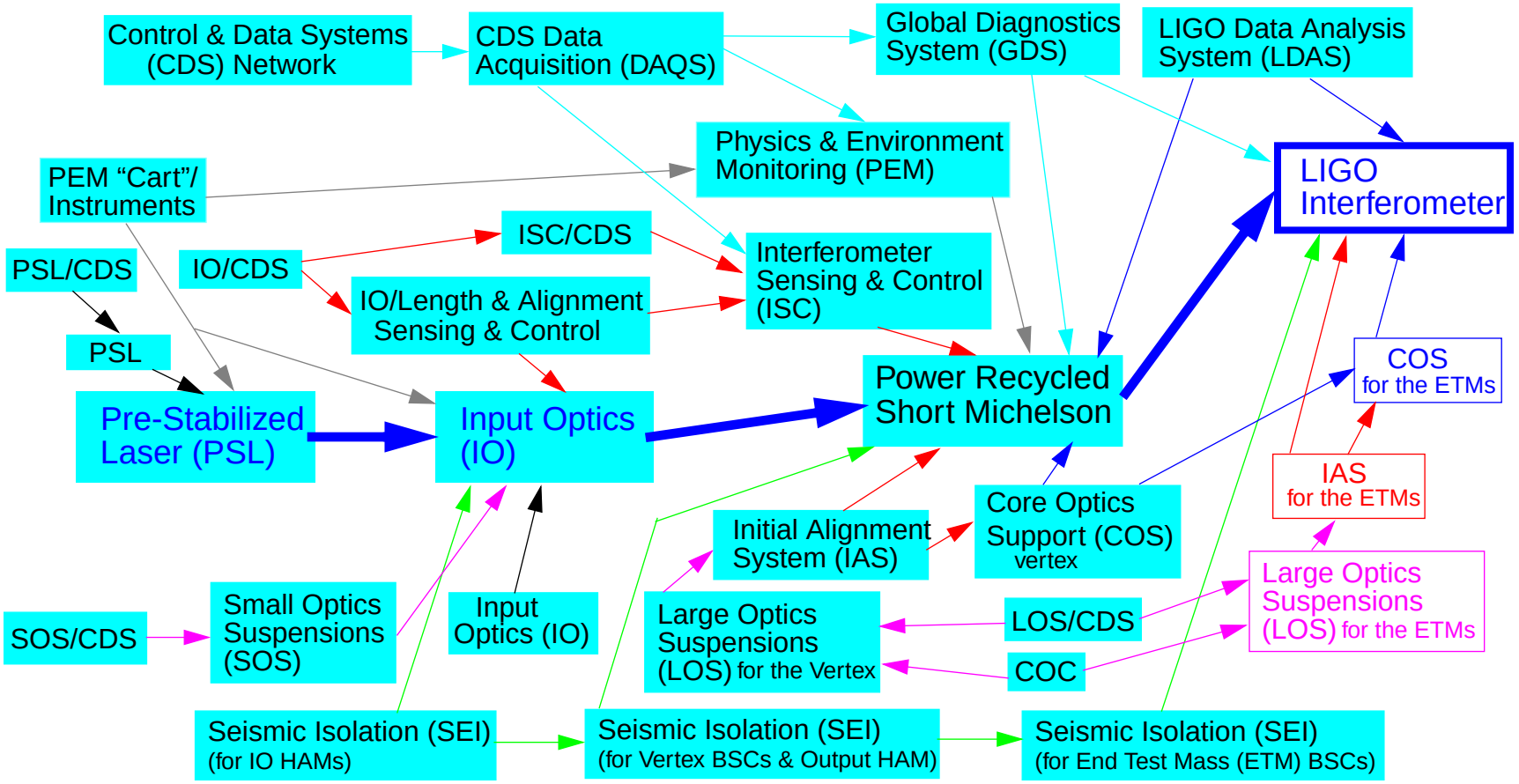


Detector Installation Sequence

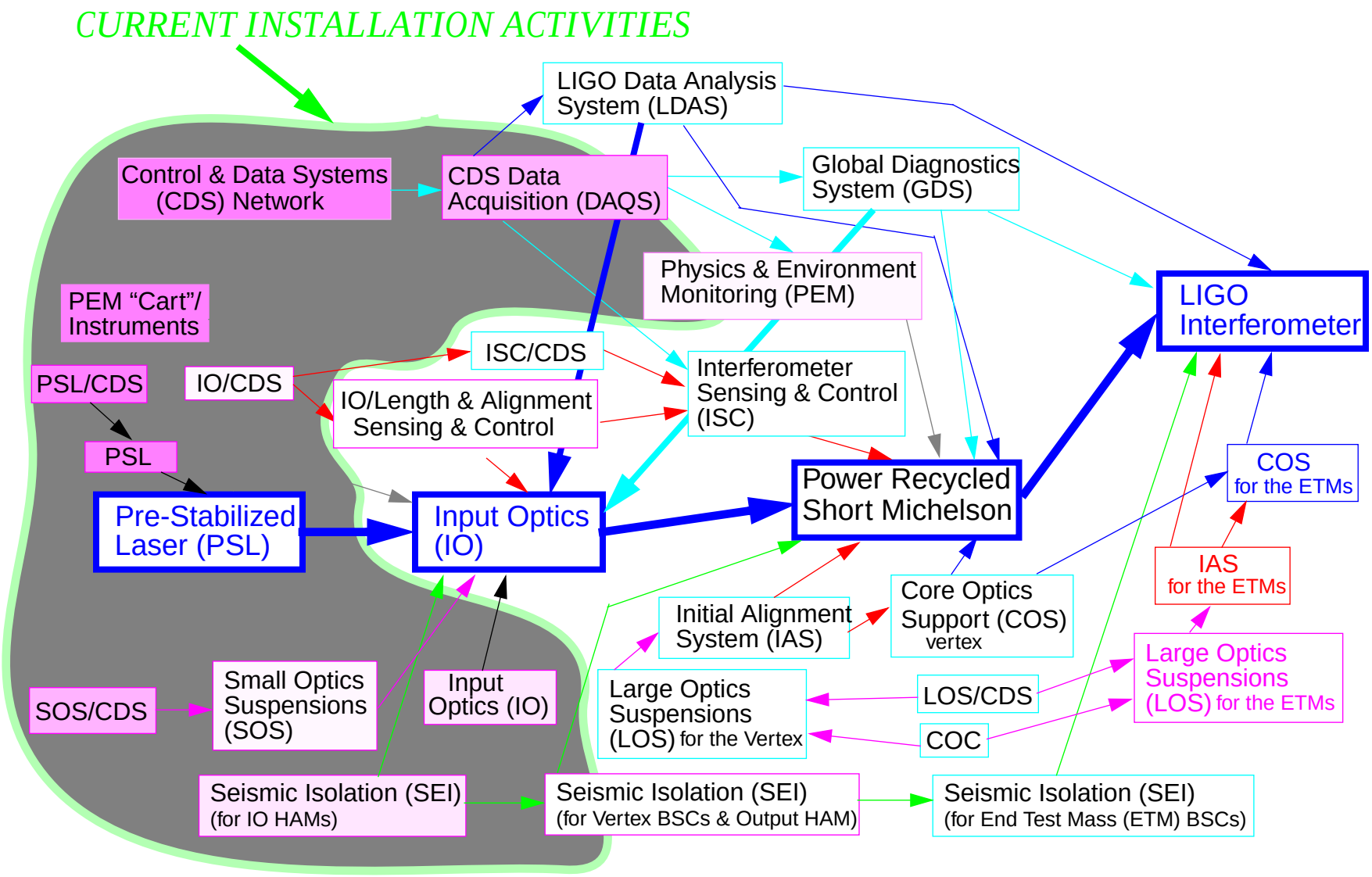
Short Michelson Threads



Detector Installation Plan
Sequence Threads



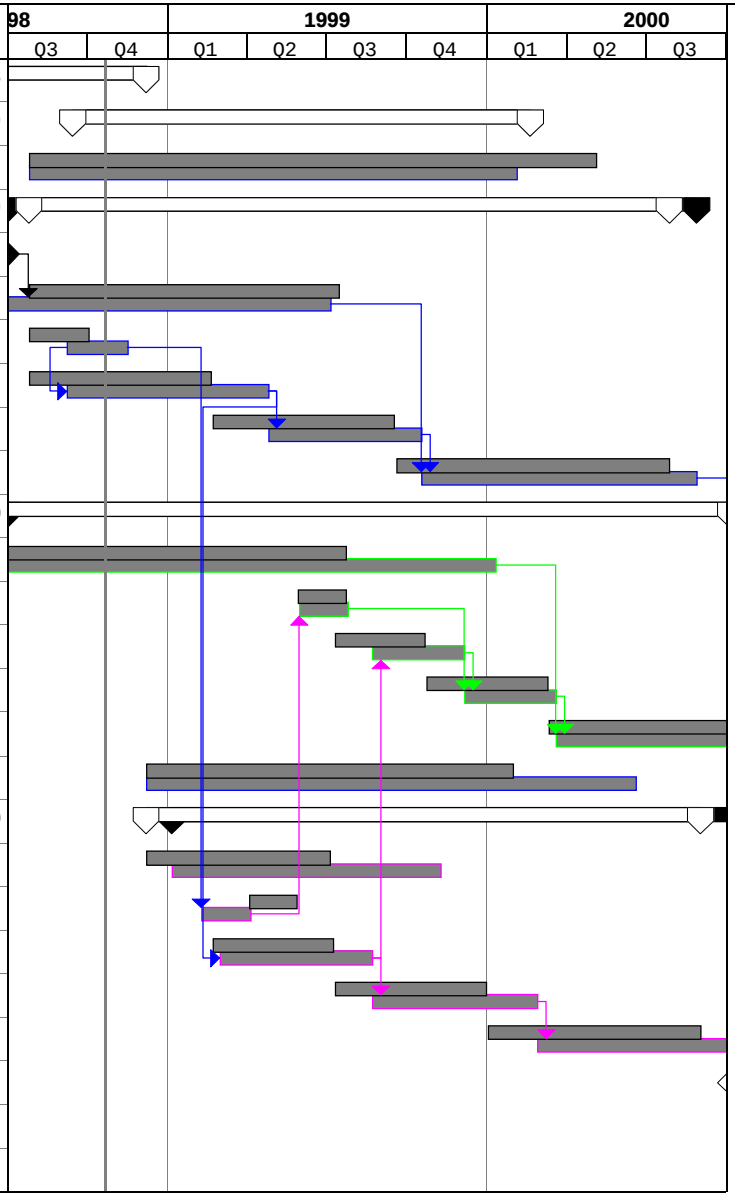
Detector Installation Status



10/21/98

LIGO DETECTOR INSTALLATION -- TOP LEVEL

ID	Task Name	Duration	Start	Finish
1	**VE Completion**	**194 days**	**3/11/98**	**12/8/98**
11	**BT Bake Out**	**374 days**	**9/15/98**	**2/21/00**
21	**LHO Detector Infrastructure**	80 wks	7/27/98	2/4/00
22	**LHO 2km IFO**	**564 days**	**7/1/98**	**8/28/00**
23	Start Detector Integration	0 days	7/1/98	7/1/98
24	Install SEI, SUS, COS, ISC	53 wks	7/1/98	7/6/99
25	PSL	10 wks	9/8/98	11/16/98
26	Input Optics	33 wks	9/8/98	4/26/99
27	PR Near Michelson	25 wks	4/27/99	10/18/99
28	PR Michelson w/ FP Arms	45 wks	10/19/99	8/28/00
29	**LHO 4km IFO**	**599 days**	**7/1/98**	**10/16/00**
30	Install SEI, SUS, COS, ISC	80 wks	7/1/98	1/11/00
31	PSL	8 wks	6/1/99	7/26/99
32	Input Optics	15 wks	8/24/99	12/6/99
33	PR Near Michelson	15 wks	12/7/99	3/20/00
34	PR Michelson w/ FP Arms	30 wks	3/21/00	10/16/00
35	**LLO Detector Infrastructure**	80 wks	12/8/98	6/19/00
36	**LLO 4km IFO**	**489 days**	**1/6/99**	**11/20/00**
37	Install SEI, SUS, COS, ISC	44 wks	1/6/99	11/9/99
38	PSL	8 wks	2/9/99	4/5/99
39	Input Optics	25 wks	3/2/99	8/23/99
40	PR Near Michelson	27 wks	8/24/99	2/28/00
41	PR Michelson w/ FP Arms	38 wks	2/29/00	11/20/00
42	**Detector Commissioned (h<10^-20)**	0 days	11/20/00	11/20/00
43	Observatory Operations & improvemer	50 wks	11/21/00	11/5/01
44	**Design Sensitivity (h<10^-21)**	0 days	11/5/01	11/5/01

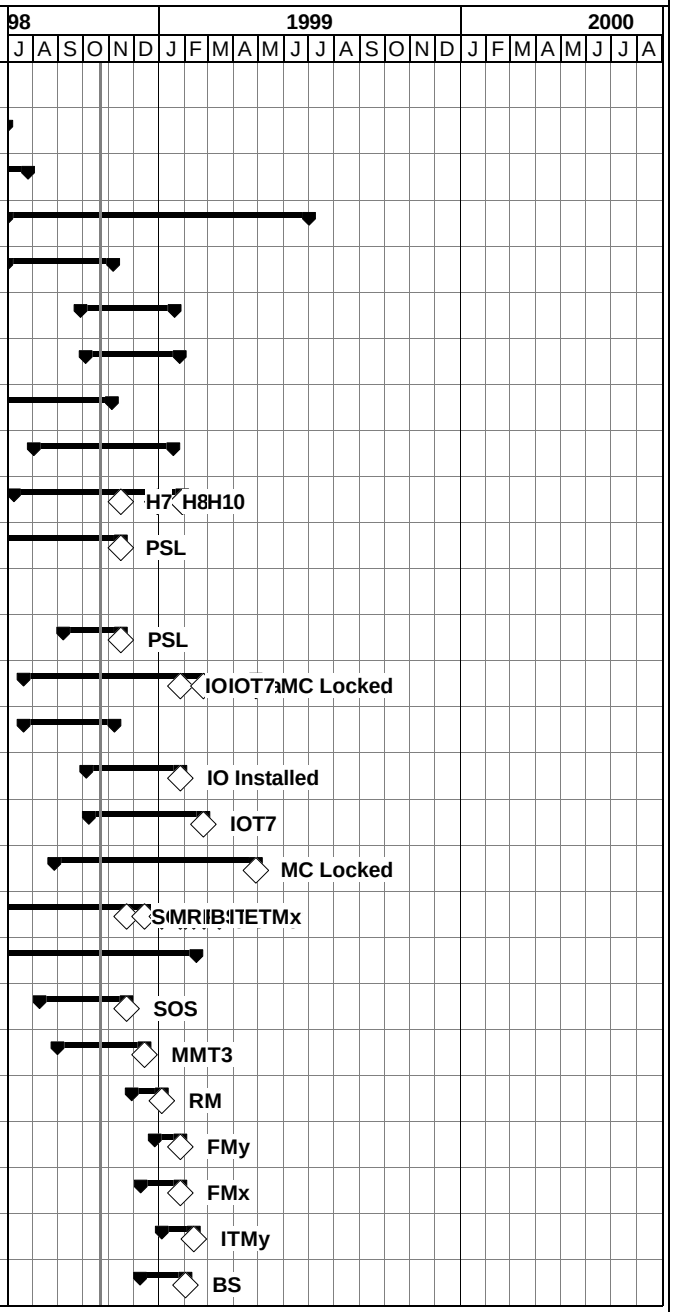


integ_2k_15dc.mpp non-milestone

LIGO Hanford Observatory (LHO) 2km IFO Detector Installation Schedule

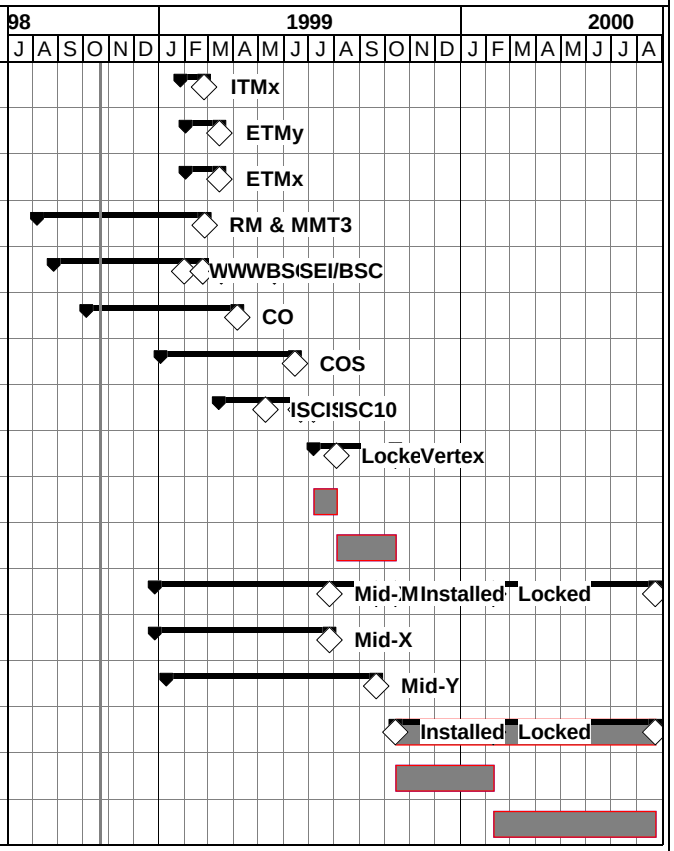
10/21/98

ID	Task Name	Duration	Start	Finish
1	*1 2km PR Near-Michelson*	575.9 days	7/1/97	10/14/99
2	*1.1 Setup Labs*	22 days	6/1/98	7/1/98
7	*1.2 Accept Vacuum Equipment*	96 days	3/11/98	7/27/98
16	*1.5 PEM System Installation*	252 days	7/1/98	7/1/99
34	*1.6 Install SEI Phase 1*	91 days	7/1/98	11/6/98
55	*1.7 Cable Tray Installation*	75 days	9/29/98	1/20/99
61	*1.8 In-Vacuum Cable Assembly*	75 days	10/5/98	1/26/99
68	*1.9 Cleaning*	341 days	7/1/97	11/5/98
75	*1.10 Viewport & Feedthru Installation*	113 days	8/3/98	1/18/99
84	*1.11 SEI/HAM Phase 2&3 Installation*	137.9 days	7/10/98	1/29/99
129	*1.12 PSL INSTALLATION*	153 days	4/13/98	11/16/98
130	*1.12.1 Setup*	16 days	4/13/98	5/4/98
135	*1.12.2 PSL Installation*	50 days	9/8/98	11/16/98
144	*1.13 IO Installation & MC Lock*	192.95 day	7/22/98	4/28/99
145	*1.13.1 IO Deliveries*	77 days	7/22/98	11/9/98
152	*1.13.2 Install Input Optics (IO)*	74.95 days	10/6/98	1/27/99
163	*1.13.3 IO ISC Table Installation (IOT7)*	91.95 days	10/9/98	2/24/99
168	*1.13.4 Input OpticsCommissioning*	165.95 day	8/28/98	4/28/99
180	*1.14 SUS Assembly*	229 days	4/15/98	3/15/99
181	*1.14.1 SUS/COC Deliveries*	209 days	4/15/98	2/16/99
204	*1.14.2 SUSPEND Small Optics*	75 days	8/10/98	11/23/98
210	*1.14.3 SUSPEND MMT3*	72 days	9/1/98	12/14/98
216	*1.14.4 SUSPEND Recycling Mirror (RM)*	21 days	11/30/98	1/4/99
221	*1.14.5 SUSPEND Fold Mirror Y (FM-Y)*	21 days	12/28/98	1/27/99
226	*1.14.6 SUSPEND Fold Mirror X (FM-X)*	29 days	12/11/98	1/27/99
231	*1.14.7 SUSPEND Inner Test Mass-Y (ITM-Y)*	29 days	1/5/99	2/12/99
236	*1.14.8 SUSPEND Beam Splitter (BS)*	34 days	12/10/98	2/2/99



LIGO Hanford Observatory (LHO) 2km IFO Detector Installation Schedule

ID	Task Name	Duration	Start	Finish
241	*1.14.9 SUSPEND Inner Test Mass X (ITM-X)*	*20 days*	*1/28/99*	*2/24/99*
246	*1.14.10 SUSPEND End Test Mass Y (ETM-Y)*	*29 days*	*2/3/99*	*3/15/99*
251	*1.14.11 SUSPEND End Test Mass X-Arm (ETM-X)*	*29 days*	*2/3/99*	*3/15/99*
257	*1.15 Install RM & MMT3*	*137.25 day*	*8/7/98*	*2/26/99*
290	*1.16 SEI/BSC Phase 2&3 Installation*	*183.2 days*	*8/27/98*	*5/21/99*
359	*1.17 Install & Align CO*	*123.9 days*	*10/6/98*	*4/6/99*
420	*1.18 INSTALL COS*	*115.9 days*	*1/4/99*	*6/15/99*
485	*1.19 ISC Installation*	*80.9 days*	*3/15/99*	*7/7/99*
508	*1.20 Vertex Michelson Shakedown*	*70 days*	*7/7/99*	*10/14/99*
510	1.20.2 Align/Lock Vertex Michelson	4 wks	7/7/99	8/4/99
512	1.20.4 Characterize Vertex Michelson	10 wks	8/4/99	10/14/99
516	*2 LIGO 2k PRM with F-P Arms*	*423.9 days*	*12/28/98*	*8/24/00*
517	*2.1 Install Detector in X-Arm Mid-Station*	*147.2 days*	*12/28/98*	*7/27/99*
554	*2.2 Install Detector in Y-Arm Mid-Station*	*178.2 days*	*1/11/99*	*9/21/99*
589	*2.3 Shakedown 2k PRM w/ F-P Arms*	*220 days*	*10/14/99*	*8/24/00*
591	2.3.2 Align/Lock 2k IFO	16 wks	10/14/99	2/10/00
593	2.3.4 Characterize 2k IFO	28 wks	2/10/00	8/24/00

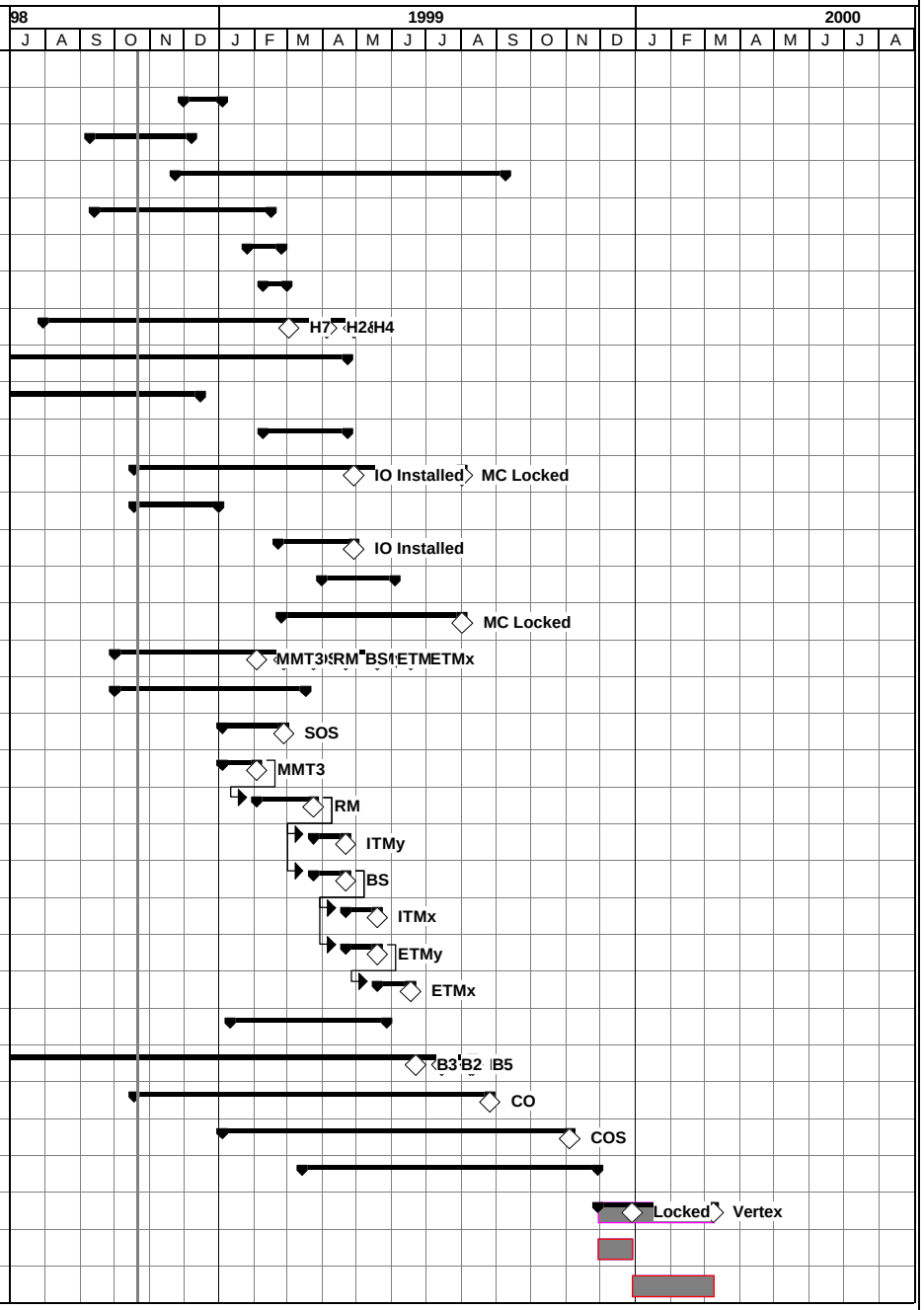


LLO_4dc.MPP non-milestone tasks

LIGO Livingston Observatory (LLO) Detector Installation Schedule

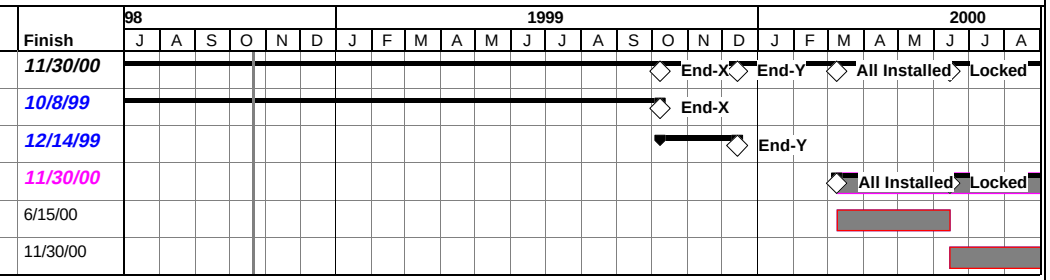
10/21/98

ID	Task Name	Duration	Start	Finish
1	*1 LA 4km PR Near-Michelson*	*475.4 days*	*4/20/98*	*3/9/00*
2	*1.1 Setup Labs*	*19 days*	*12/1/98*	*1/4/99*
7	*1.2 Accept Vacuum Equipment*	*61 days*	*9/10/98*	*12/8/98*
13	1.5 PEM System Installation	197.6 days	11/24/98	9/9/99
28	*1.6 Install SEI Phase 1*	*104 days*	*9/14/98*	*2/15/99*
52	*1.7 Cable Tray Installation*	*22 days*	*1/26/99*	*2/24/99*
60	*1.8 Cleaning*	*15 days*	*2/9/99*	*3/1/99*
66	*1.9 SEI/HAM Phase 2&3 Installation*	*186.15 days*	*7/31/98*	*4/29/99*
106	*1.10 PSL Installation*	*255 days*	*4/20/98*	*4/23/99*
107	*1.10.1 PSL Deliveries*	*167 days*	*4/20/98*	*12/16/98*
111	*1.10.2 PSL Installation*	*54 days*	*2/9/99*	*4/23/99*
121	*1.11 IO Installation & Mode Cleaner (MC) Lock*	*196.4 days*	*10/19/98*	*8/2/99*
122	*1.11.1 IO Deliveries*	*48 days*	*10/19/98*	*1/1/99*
127	*1.11.2 Install Input Optics (IO)*	*48.4 days*	*2/22/99*	*4/29/99*
140	*1.11.3 IO ISC Table Installation (LIOTH1)*	*45.4 days*	*4/1/99*	*6/4/99*
147	*1.11.4 Mode Cleaner Commissioning*	*110.4 days*	*2/25/99*	*8/2/99*
155	*1.12 SUS/COC Assembly*	*177 days*	*10/1/98*	*6/17/99*
156	*1.12.1 SUS/COC Deliveries*	*112 days*	*10/1/98*	*3/18/99*
174	*1.12.2 SUSPEND Small Optics*	*40 days*	*1/4/99*	*2/26/99*
179	*1.12.3 SUSPEND Mode Match Telescope Mirror-*	*22 days*	*1/4/99*	*2/2/99*
184	*1.12.4 SUSPEND Recycling Mirror (RM)*	*36 days*	*2/3/99*	*3/24/99*
189	*1.12.5 SUSPEND Inner Test Mass-Y (ITM-Y)*	*20 days*	*3/25/99*	*4/21/99*
194	*1.12.6 SUSPEND Beam Splitter (BS)*	*20 days*	*3/25/99*	*4/21/99*
199	*1.12.7 SUSPEND Inner Test Mass X (ITM-X)*	*20 days*	*4/22/99*	*5/19/99*
204	*1.12.8 SUSPEND End Test Mass Y (ETM-Y)*	*20 days*	*4/22/99*	*5/19/99*
209	*1.12.9 SUSPEND End Test Mass X-Arm (ETM-X)*	*20 days*	*5/20/99*	*6/17/99*
214	*1.13 RM & MMT3 Installation*	*99.7 days*	*1/11/99*	*5/28/99*
248	*1.14 SEI/BSC Phase 2&3 Installation*	*286.6 days*	*6/22/98*	*8/11/99*
314	*1.15 Install & Align SUS/COC Assemblies*	*214.4 days*	*10/19/98*	*8/26/99*
369	*1.16 INSTALL COS*	*215.4 days*	*1/4/99*	*11/4/99*
434	*1.17 ISC Installation*	*180.4 days*	*3/15/99*	*11/29/99*
459	*1.18 Vertex Michelson Shakedown*	*70 days*	*11/29/99*	*3/9/00*
461	1.18.2 Align/Lock Vertex Michelson	4 wks	11/29/99	12/29/99
463	1.18.4 Characterize Vertex Michelson	10 wks	12/29/99	3/9/00



LIGO Livingston Observatory (LLO) Detector Installation Schedule

ID	Task Name	Duration	Start	Finish
465	*2 LA 4k PRM with F-P Arms*	*865.4 days*	*7/1/97*	*11/30/00*
466	*2.1 Install Detector in X-Arm End-Station*	*571.6 days*	*7/1/97*	*10/8/99*
502	*2.2 Install Detector in Y-Arm End-Station*	*45 days*	*10/8/99*	*12/14/99*
535	*2.3 Shakedown LA 4k PRM w/ F-P Arms*	*190 days*	*3/9/00*	*11/30/00*
537	2.3.2 Align/Lock LA 4k Michelson	14 wks	3/9/00	6/15/00
539	2.3.4 Characterize LA 4k Michelson	24 wks	6/15/00	11/30/00



Subsystem Installation Status: Control & Data System (CDS)

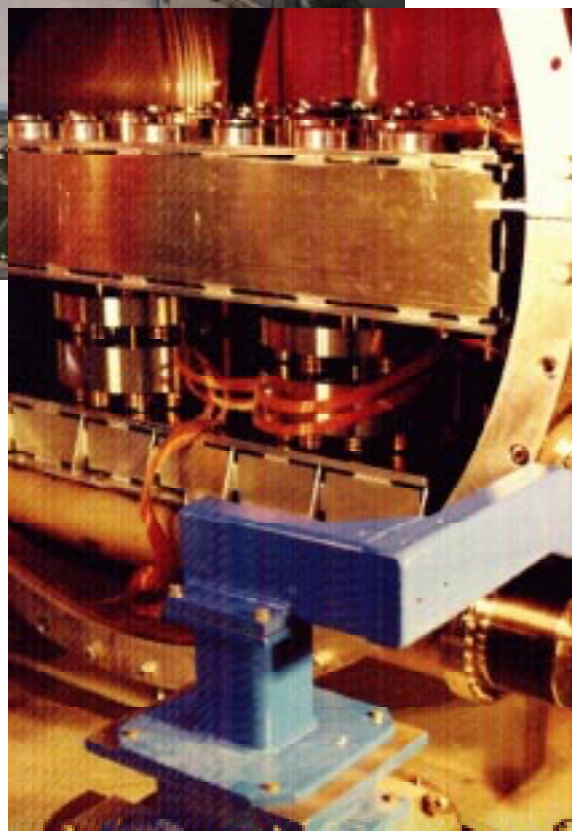
- Network fiber installed @ LHO;
  LLO fibre optic bid awarded; installation to occur in Nov 98
- CDS network ATM switching system & Servers are installed and operational at both observatories
- CDS controls for Vacuum Equipment (VE) are operational at both observatories
- Control Room furniture & some CM computers are installed @ LHO
- DAQS Installation @LHO started 10/13/98
- Cabling:
  - — All CDS racks located in the LVEA and VEAs early (unstuffed)
  - — Cable Tray installation prior to SEI installation; started 10/1 @ LHO
  - — Cabling pulled as needed to install subsystems as integration proceeds

Subsystem Installation Status: Pre-Stabilized Laser (PSL)

- Initial Assembly & Check-out at CIT; Dis-assembled and shipped to Obs.
- 2km Interferometer PSL installation started 9/7/98
- Completion expected by 12/98
- Characterization and Subsystem Testing in parallel with IO installation
- 4km LLO Interferometer Installation Begins 2/99

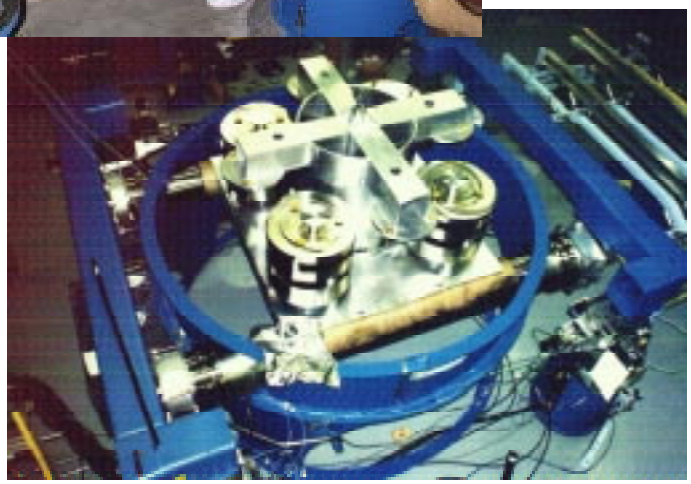
Subsystem Installation Status: Seismic Isolation System (SEI)

- First Article Testing:
  - SEI/HAM (without actuation system) @ LHO4/98-8/98
  - SEI/BSC (with coarse and then fine actuation) @ Hytec4/98-11/98
- Simultaneous Installation of Feedthrus & Viewports, in-vacuum cabling & cable clamps and counter-balance weights
- All HAM Piers Installed @ LHO; BSC Pier Installation Underway



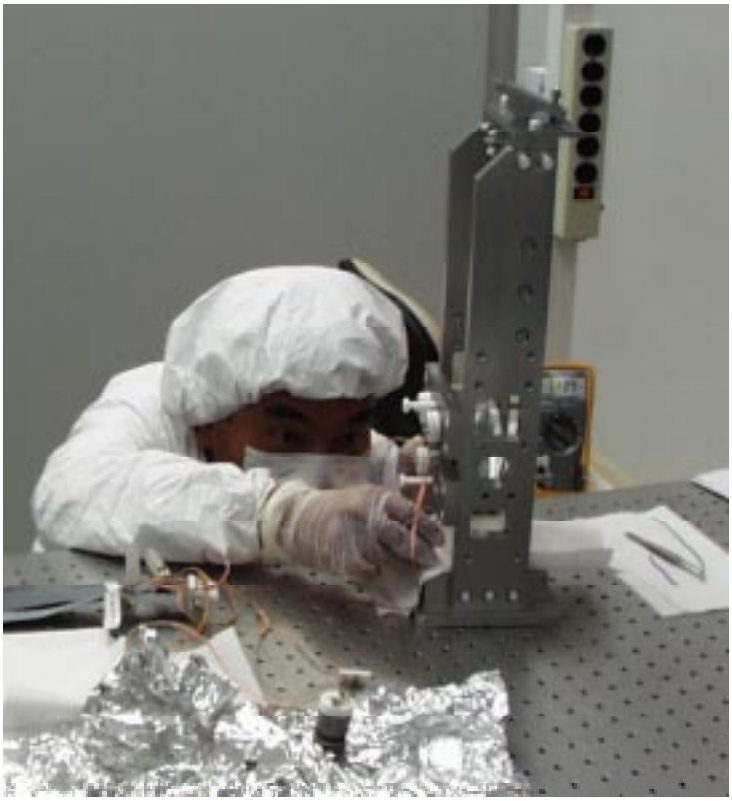
Subsystem Installation Status: Seismic Isolation System (SEI)

- First HAM Chamber (WHAM7)
  - — leak tested
  - — scissors tables, air bearings and cross beams about to be done (10/21)
  - — isolation stack to be installed early to mid-Nov
- Next HAM Chambers (WHAM8 and WHAM9) to have their support structures installed and leak tested by early Nov
- First SEI installation in a BSC chamber is scheduled for 1/99 in LHO



Subsystem Installation Status: Input Optics (IO)

- CDS SUS Test Stand Installed in the Optics Lab
- SOS Structures Assembled
- Small Optics Cleaning and Hanging/Alignment Training & Trials
- Staging UHV Parts and assemblies
- Some IOO components mounted on the PSL table
- in-vacuum, non-suspended mirrors to be cleaned and mounted week of 10/26



Subsystem Installation Status:
Interferometer Sensing & Control (ISC)

- IO/ISC:
  - ››Includes Integrated/Aligned Wavefront Alignment & Length Sensing Optics Table (IOT7 for the 2km IFO) & Optical Lever for the 3rd Mode Match Telescope Mirror (MMT3)
  - ››Installation occurs after basic optical elements have been installed by the IO group in the IO HAM chambers
  - ››FIRST MAJOR INTEGRATED SYSTEM TEST!
- ISC for CO (ASC and LSC):
  - ››Currently performing HW/SW test stand check-out
  - ››Includes Installation of Pre-Integrated Sensing Tables to Support ISC optical signals from COS (ISCT7, ISCT9 & ISCT10 for the 2km IFO)
  - ››To be Installed after CO/SUS and COS
  - ››Supporting electronics (demod, opt-lev, shutter control, digital servo control, etc.) to be installed in racks just prior to ISCTs

Subsystem Installation Status:

Suspension System (SUS), Core Optics Components (COC) and Initial Alignment System (IAS)

- Large Optics Suspension (LOS)/COC Assembly at the Observatories
- LOS/CDS Satellite Electronics Module & Controller Board Assembly & Check-out @ CIT
- Optical Lever Module Assembly & Check-out @ MIT
- Installation includes:
  - — physical placement & alignment (with IAS) of the LOS/COC
  - — physical installation of the SUS/CDS Satellite Electronics, Controller Board and interconnecting Cabling (exo-vacuum)
  - — Functional Check-out & tuning with SUS/CDS controller
  - — Optical Lever installation, cabling, alignment & check-out
  - — Requires simultaneous opening of 3 BSC chambers including interconnecting spools
- SUS & IAS Installation Field Trial to be Conducted in Y-End Station BSC week of 11/16

Subsystem Installation Status: Core Optics Support (COS)

- Fabrication Bids in Nov-Dec 98
- Installation enabled by vertex core optic installation & alignment
- IR Autocolimator used to generate ghost beams from the Core Optics
- Requires removal of manifoild spools for entry to install large baffles