Detector System
PDR and Installation RR

AGENDA

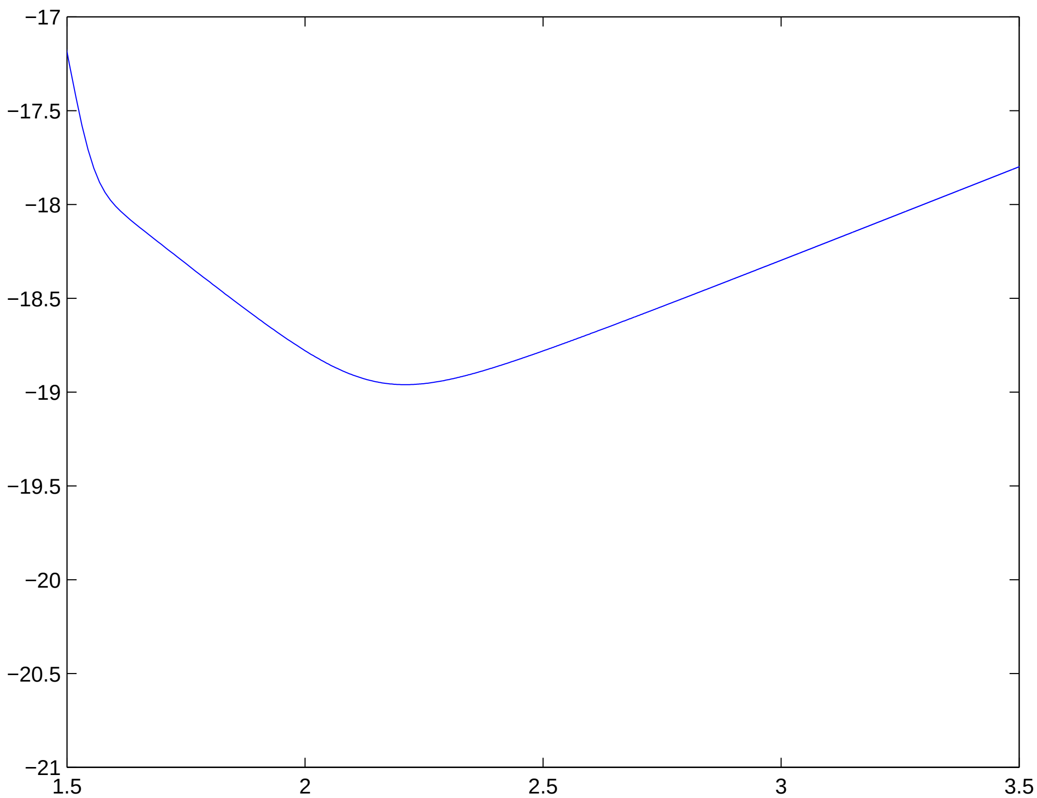
1	Requirements Update	8:30-8:45
2	Design Summary/Status	8:45-9:00
3	Installation Plan	9:00-9:45
4	Integration Testing	9:45-10:15
5	Installation Schedule	10:15-10:30
6	Installation Organization/Staffing	10:30-10:45
7	Practicalities & Policies	10:45-11:00

Requirements update

dhs 1 Oct 98

Top level performance requirement: the ‘SRD’ (Science Requirements Document performance curve)

- **seismic noise**: ‘typical site’ ground motion, and a technically feasible passive isolation system
- **thermal noise**: based on a naive estimate (and spectral form) for pendulum thermal noise
- **shot noise:** Fabry-Perot transfer function and a guess at possible power levels



Top-level requirements

Seismic noise

- ground noise at sites as input (with some measurements)
- baseline design of single pendulum suspension gives nominal final attenuation of isolation system
- require passive isolation stack to make up the difference

Thermal noise

- choose available, familiar technology of a wire loop around a fused silica substrate
- require attachments to not significantly compromize the material properties
- find that resulting anticipated noise is consistent with SRD

Shot noise

- choose readout system which makes good use of light
- place requirements on mirror substrate, polish, coating
- leads to laser power requirement, efficiency to reach required sensitivity

Bottom line: have core system which can deliver the SRD.

Non-principal noise contributors

Each source allowed to contribute 0.5% to SRD

- point of departure, and in general followed

Compromizes to shot noise

- non-optimized modulation and/or asymmetry
- angular alignment non-optimal
- lengths of cavities not on precisely on resonance (real limit for l_+)
- excess RF noise at modulation frequency
  - not really a shot noise excess, but indistinguishable

Sources of excess noise

- must in general lie at SRD/10
- assume they add incoherently ($\sqrt{1^2 + (0.1)^2} = 1.005$)

Only gaussian noise sources worked through in detail

- creaking, stress-releasing, non-stationary noise sources all TBD
- some comfort, some discomfort from measurements of suspension wire noise
- no serious effort to understand non-stationary environmental noise

Mechanical technical noise sources

- thermal noise from seismic stack elements
- thermal noise from pitch and yaw
  - › limits product of thermal noise and beam centering
  - › new analysis (Yuri Levin et al.) shows centering requirement incorrect; pendulum and test mass pitch motion correlated
  - › can still find optimum (competing noise sources)
- seismic fine actuator
- coil driver noise
  - › Exception; 9, rather than $5\times10^{-20}\left(\frac{f}{40}\right)^2$
  - › 1/5 SRD, so contributes 2% in limited noise region
  - › trade of actuation range vs. noise performance
  - › feedforward of seismometer signals to fine actuator can help
- radiometer effect: technical fluctuations in power at baseband
  - › weaker requirement than that due to direct detection of flucuations at interferometer output

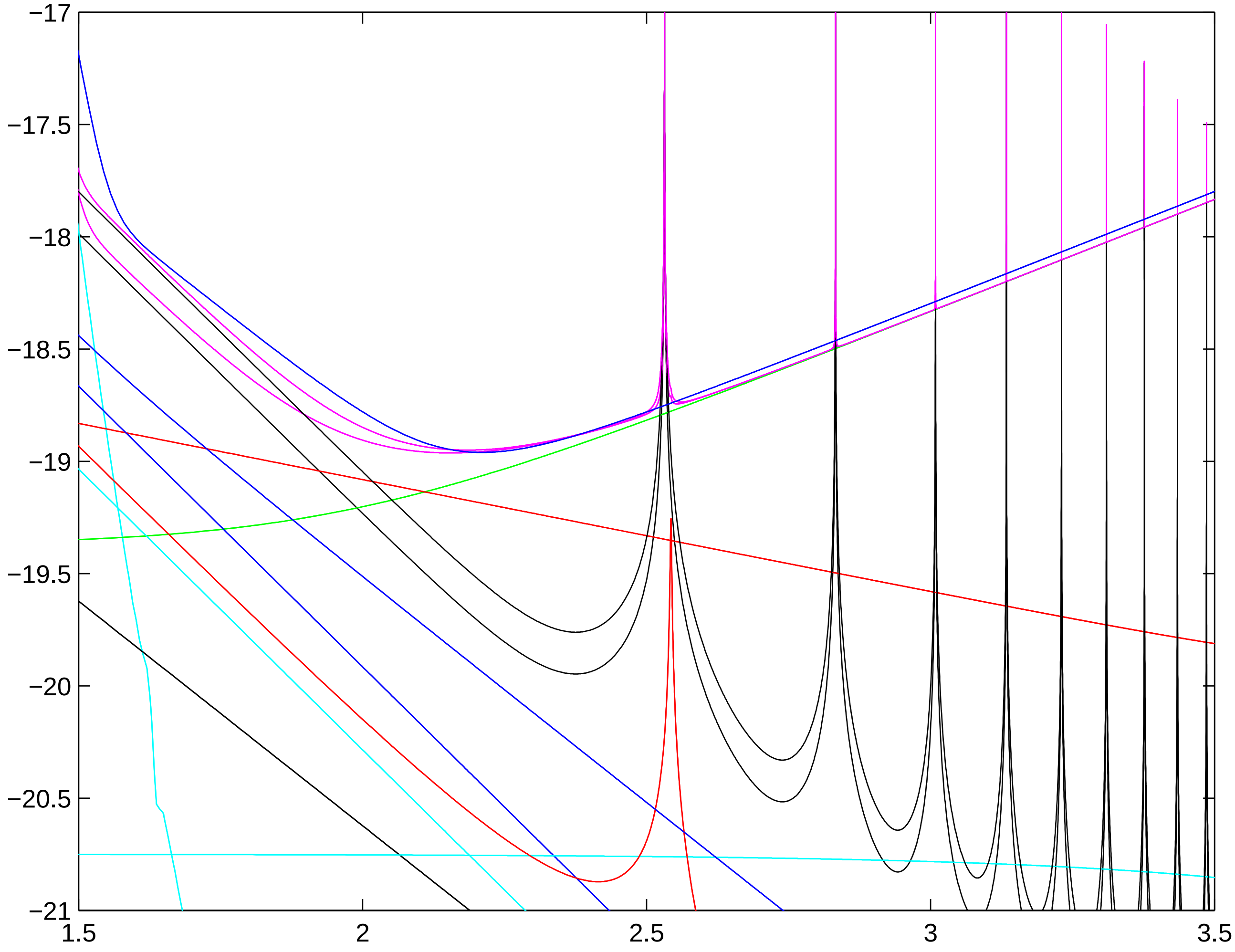
Sensing technical noise sources

Often requires balance of effort by several subsystems

- Light power baseband fluctuations (LSC, PSL, IOO) at antisymmetric port
  - PSL: input noise spectrum
  - IOO: low-pass filtering of mode cleaner
  - LSC: servo gain to limit deviations from minimum of interference fringe
- Light frequency fluctuations (COC, PSL, IOO)
- Light beam geometry fluctuations (ASC, IOO, PSL)
- Main 'L_-' photodetection system (e.g., photodector/amplifier noise)
- Auxiliary sensing systems (L_+, l_-, l_+)
  - Exception: Michelson l_- sensing from ~20-30 Hz
  - lies at ~0.15 of SRD (rather than required 0.10)
  - options to reduce gain, use alternative sensing point
- Angular DOF sensing/control
- Parasitic interferometers (SUS, COC, IOO, PSL)
- Scattered light (COC, COS, IOO, PSL, LSC)

Projected performance

- roughly 10 sources of noise which roll off quickly with frequency
- roughly 10 sources which can contribute at mid and high frequencies
- $\sqrt{(1^2 + [10(0.01)]^2)} = 1.05$ or about 5% excess above fundamental sources



Subsystem design status

Quick Review of subsystems

- interesting/late design aspects
- schedule/readiness from a technical standpoint

PSL

- prototype becomes first article
- decision to use AO at output to control intensity
- reliability of lasers improved; commercial item now at 20W
- status: performance and availability tests made;
  - › first article delivered, in installation

IO

- bullseye sensor for measuring matching developed, integrated into design
- overall efficiency anticipated higher (84% instead of required 75%)
- status: designs complete, parts in fabrication and installation

Subsystem design status con’t

COC

- pathfinder program a strong success
- polishing, metrology, and coating all meeting specifications
- some accidents requiring repolish/recoat; coating is still an art
- in-house metrology late due to difficulties with commercial interferometer
- contamination/absorption experiments very reassuring
  - several of our biggest contamination concerns put to rest
- status: many parts complete

COS

- made a significant transition from a set of concerns to a set of solutions
- phase flatness requirements for ASC present challenge
- also a challenge to make large in-vacuum assemblies affordable
- detailed design still in process
- final design review for later this year

Subsystem design status con’t

IAS

- tests indicate will meet precision requirements
- ISC still in flux on exact requirements for required alignment for a stable lockable length control system; difficult modeling challenge
- status: delivered or in fabrication

ASC

- completion of table top model, use on PNI and 40m all confirms functionality AND utility
- status: physics design complete, hardware defined, software in design

LSC

- PNI gives reassurance on phase noise performance of concepts, digital servoloop approach
- locking modeling nicely advanced (caveat above on initial alignment!)
- status: physics design complete, many hardware choices made, software in design

Subsystem design status con't

SEI

- design challenges: spring, actuator, bellows, scissors table, cleanliness
- air bearing now under study, may need tweaking
- a complicated system, also complicated developement/procurement
- first article tests on HAM (complete) and BSC (in process):
  - found a number of practical problems (thread tolerances, clearances, etc.)
  - taught a number of people how the system goes together
  - taught us a great deal about how to install/commission/organize...
  - fine actuator tests not yet started
- status: design mostly complete, first articles tested or in test; some remaining prototyping required

SUS

- indium bonding of magnets a possibility; higher Q?
- status: design complete, in fab, or installing (SOS IO)

Subsystem design status con't

PEM

- trial in SEI first article tests: shakers, seismometers, data acquisition
- status: almost all design complete (muon detector to do, some electronics); much in house, delivered, or installed

GDS

- trial on PNI:
  - › lots of the right technology (shared memory) tested
  - › remote interrogation and data collection demonstrated
- needs manpower, but all physcists will pitch in soon by default
- status: preliminary physics design, first articles of soft/hardware

CDS

- backbone in use at Hanford
- subsystems reported above; very intensive detailed design activities
- tests of DAQ system, reflected memory, acquisition (and real time loops)
- status: most designs complete, much of the infrastructure installed, real quantities of hardware lining up on shelves; a great deal of CDS activity is now installation at the observatories!

LIGO-G980115-00-R

Miscellaneous Design Status

- Optical Layouts completed in conjunction with COS design
  - › need to check ASC Optical Lever beams
- Integrated Layout Drawings:
  - › Optomechanical
  - › Equipment Arrangement
  - › Cable Tray Layout
  - › To be released (Rev. A) with incorporation of latest ISC layout

Installation Plan

- Overview
- Subsystem Prerequisites
- Documentation
- Sequence
- Installation by Subsystem

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

- Boundary Conditions:
  — Management Plan:
    - Initiate Interferometer Installation 07/98
    - First Coincidence Run ($h < 10^{-20}$) 12/00
    - Design Sensitivity ($h < 10^{-21}$) 11/01

  — Vacuum Equipment Completion Dates:
    - LIGO Hanford Observatory (LHO) 9/98
    - LIGO Livingston Observatory (LLO) 1/99

  — Detector Subsystem Delivery Dates
  — No reliance upon the BT Availability (due to BT bakeout) for alignment of Core Optics

- Guidelines:
  — Need ~12 months for Debug & Commissioning of Interferometers (Operations Proposal)
  — Use Observatory Staff as Much as Possible
  — Team Approach

Installation Plan: Subsystem Prerequisites

- Configuration Controlled Drawings
  - ››parts & assemblies
  - ››installed configuration (as appropriate)
- Assembly Procedure(s)
- Data Package:
  - ››defined & compiled by the subsystem cognizant engineer (cogE)
  - ››inspection reports (as needed)
  - ››material certifications (as needed)
  - ››not ‘delivered’ until installation is complete; but available & growing/maintained during fab & installation periods

Installation Plan: Subsystem Prerequisites (continued)

- Installation Procedure(s)
  - ››generally required for:
    - –assemblies to be performed by personnel not familiar with the assembly tasks &/or design
    - –assemblies which benefit from the QA that a well thought out procedure offers (e.g. conflat bolting)
  - ››exceptions include the PSL
- Subsystem Component/AssemblyTraveler(s)
  - ››a "traveler" is a set of paperwork which travels with a component and assembly through it's fabrication or assembly steps and defines the processing steps; in LIGO it is used to capture essential data (as defined by the cogE with concurrence by the Chief Engineer) for a component or assembly
  - ››required for all in-vacuum hardware with RGA scans
  - ››required for all critical or significant assembly & subsystem testing/characterization
- Test Plan (not a procedure)

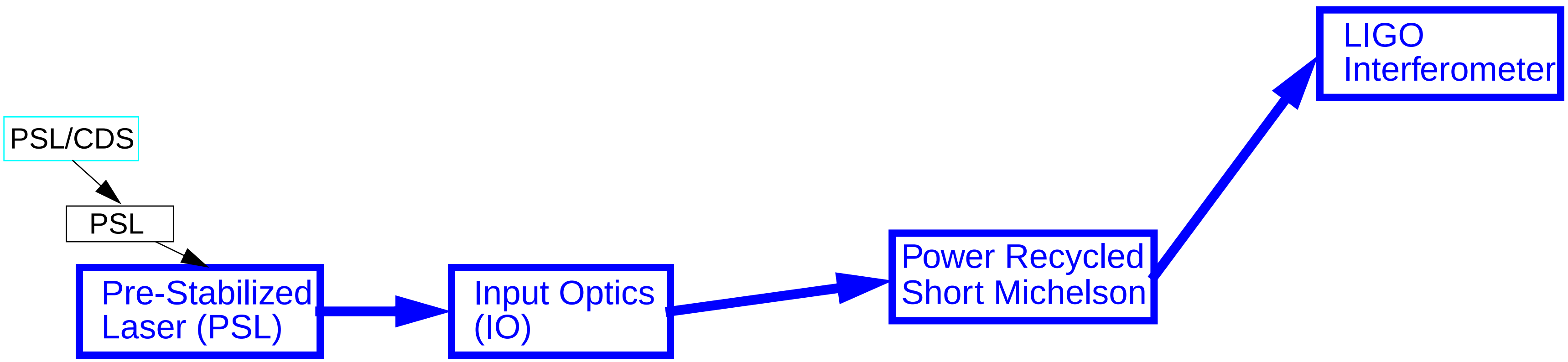
Installation Plan: Documentation

- 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)

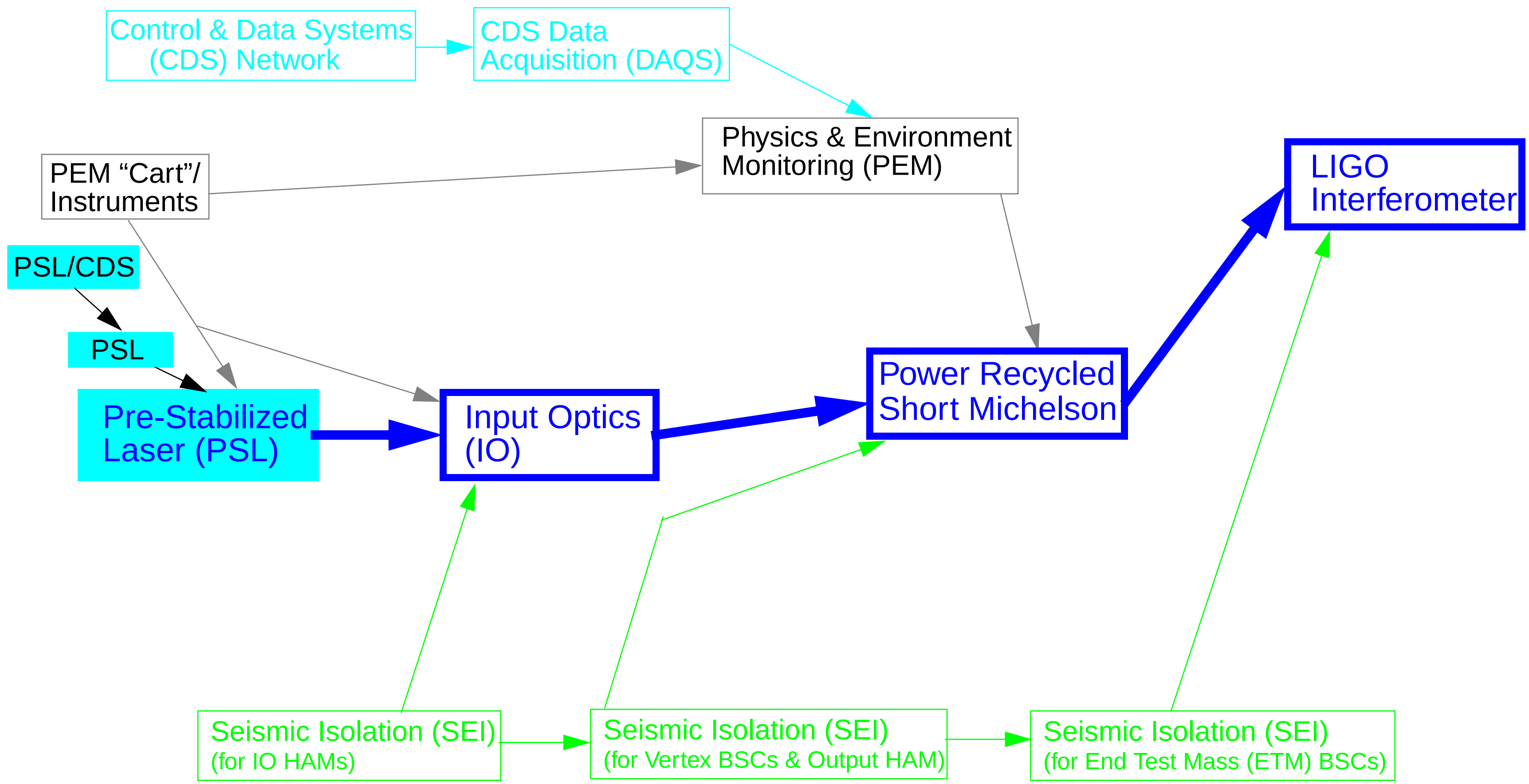
Installation Plan: Documentation (continued)

- 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 Director (or designee)
  - ››Process for obtaining permits by the site 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



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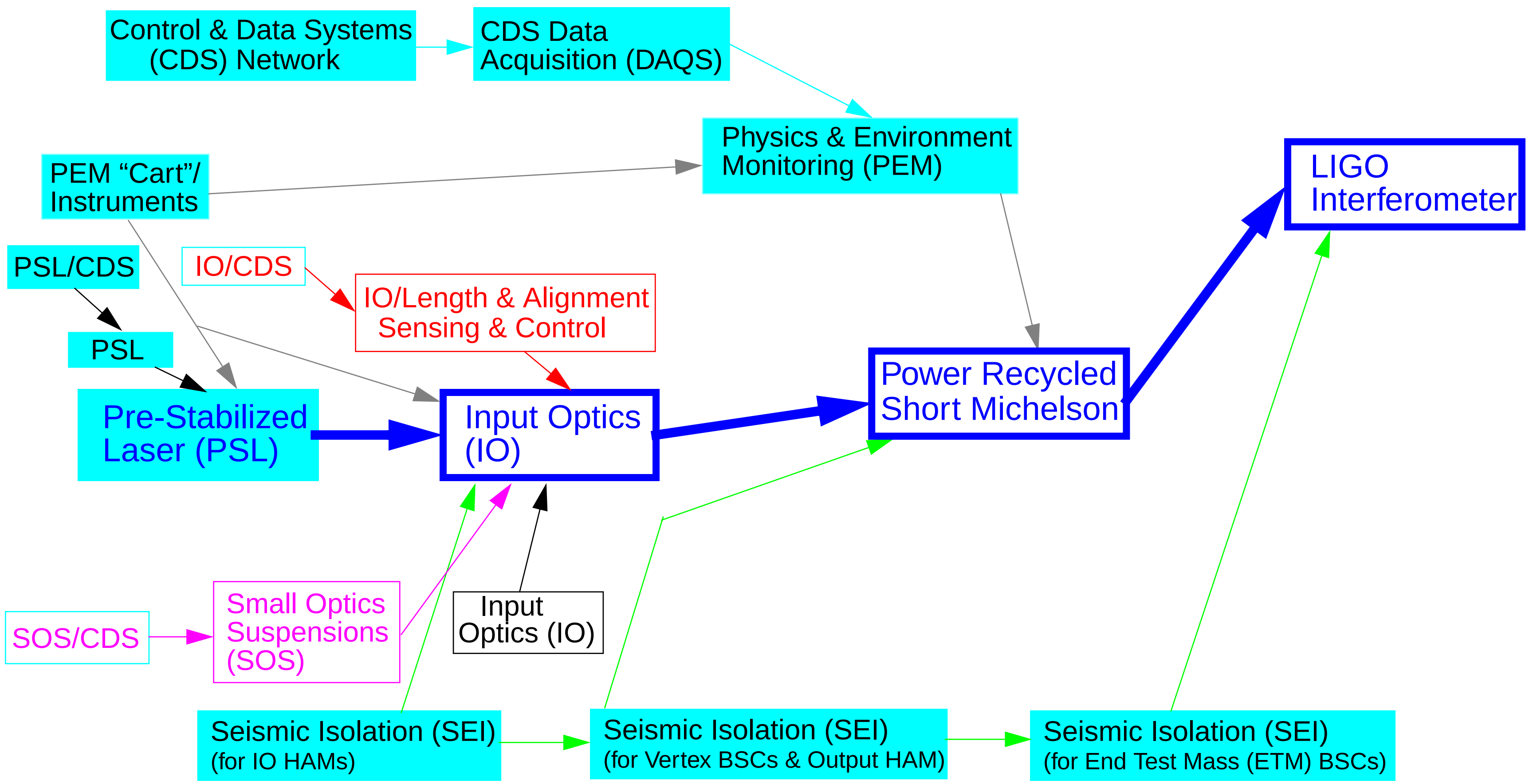
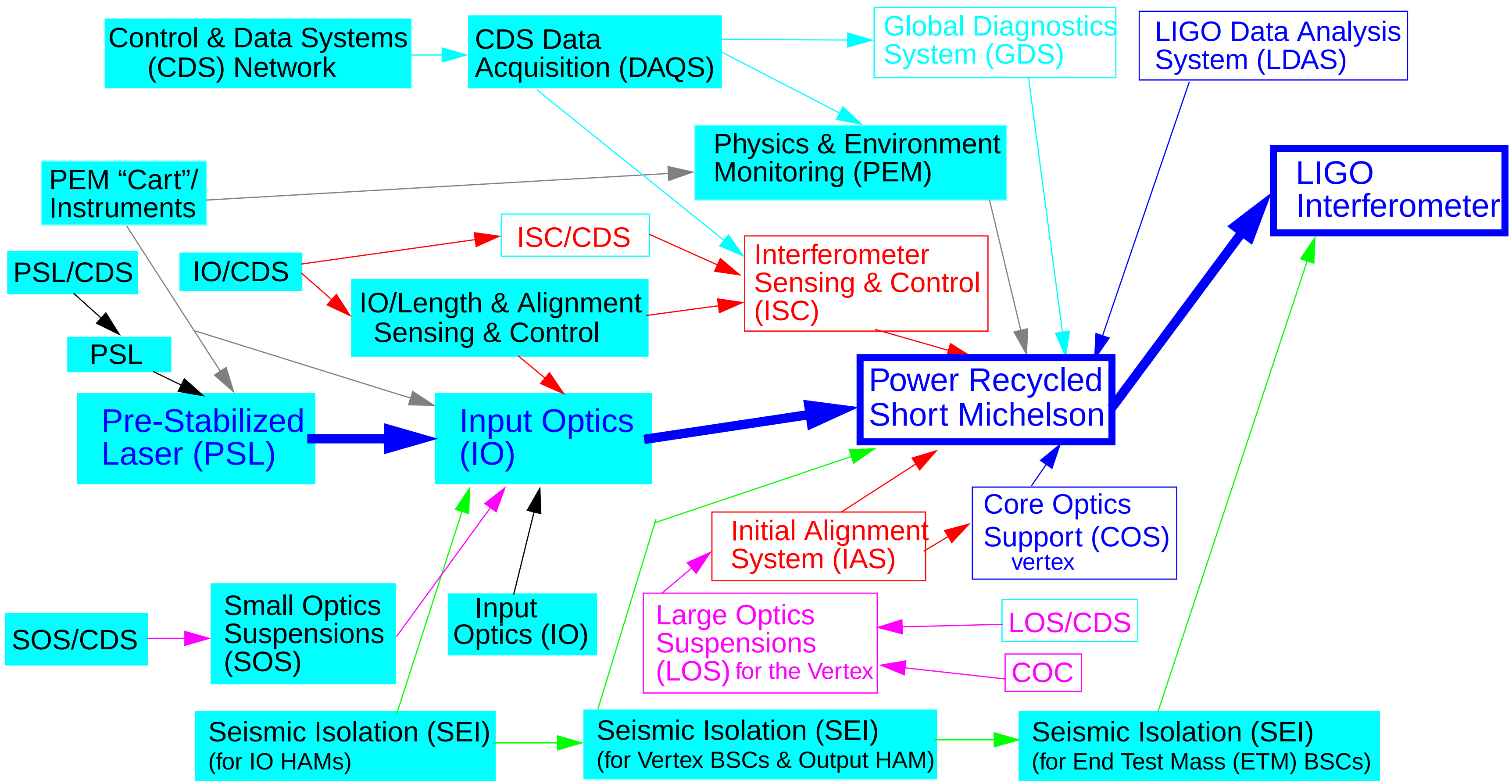
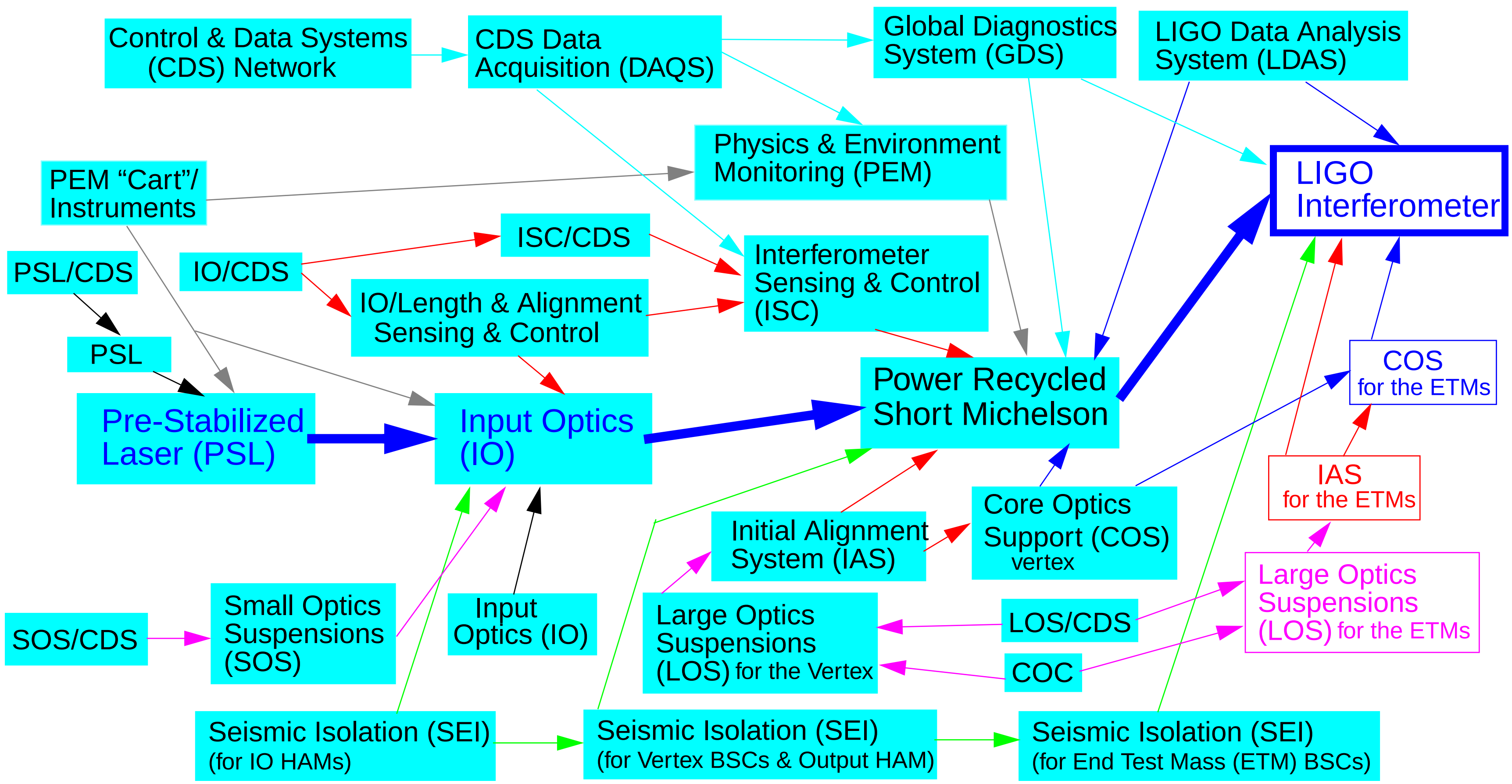
Detector Installation Sequence
Input Optics Threads



Detector Installation Sequence
Short Michelson Threads



Detector Installation Plan
Sequence Threads



Detector Installation Plan By Subsystem

- CDS (DAQS, CM, Network; sans subsystem CDS)
  - — Control Room furniture installed @ LHO
  - — Network fiber installed @ LHO; Fiber bids requested @ LLO
  - — DAQS SW integration & check-out on HW @CIT; Ships to LHO for installation 10/12/98
  - — All CDS racks located in the LVEA and VEAs early (unstuffed)
  - — Cable Tray installation prior to SEI installation (starting 10/1 @ LHO)
  - — Cabling pulled as needed to install subsystems as integration proceeds
  - — DAQS installation is incremental in support of subsystems as they are installed (esp. PEM)
- Pre-Stabilized Laser (PSL)
  - — informal installation plan (incl. obs. support) submitted by the PSL team for the 2km IFO installation (~8 wk period started 9/7/98) FIRST LIGHT!
  - — PSL for the 2km Interferometer is a First Article
revised pre-mode cleaner & earth tide compensation pending
  - — Initial Assembly & Check-out at CIT; Dis-assembled and shipped to Obs.
  - — Characterization and Subsystem Testing in parallel with IO installation
  - — Stand-alone characterization for the initial PSL subsystem
(no PEM and DAQ required)
  - — Final Design Follows 2km PSL Installation
  - — 4km LLO Interferometer Installation Begins 1/99

Detector Installation Plan By Subsystem (continued)

- Seismic Isolation System (SEI)
  - First Article Testing:
    - SEI/HAM (without actuation system) @ LHO4/98-8/98
    - SEI/BSC (with coarse and then fine actuation) @ Hytec4/98-10/98
  - Simultaneous Installation of:
    - Feedthrus & Viewports
    - in-vacuum cabling & cable clamps
    - counter-balance weights
  - Initial 2km SEI/HAM Systems are re-worked first article units
  - Installation in 3 phases:
    - piers
    - support structure
    - isolation stacks
    - detailed characterization on one instance of SEI/BSC later
  - Contractor Support for concrete work (drilling & installing embedded bolts & grouting)
  - Installation Procedures written; comprehensive plan pending production lag & rate information

Detector Installation Plan By Subsystem (continued)

- Input Optics (IO)
  - — Component Assembly at the Observatories:
    - SOS assembly (like LOS)
    - Fixed Mirror Mounts, periscope, etc.
  - — LOS/CDS Satellite Electronics Module & Controller Board Assembly & Check-out @ CIT
  - — Installation includes:
    - physical placement & alignment (with PSL beam) of the IO components on the PSL/ IO optics table
    - physical placement & alignment (ultimately with the PSL beam) of the IO components on the HAM/SEI optics tables
    - integration of the suspension control rack and cabling
    - Functional Check-out & tuning with SOS/CDS controllers
- Interferometer Sensing & Control (ISC)
  - — IO/ISC:
    - Early delivery & installation of electronics to support the IO subsystem
    - Includes integrated/aligned IO Table (IOT7 for the 2km IFO, etc.) & 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 ISC 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

Detector Installation Plan By Subsystem (continued)

- Suspension System/Core Optics Components (SUS/COC) & Initial Alignment System (IAS)
  - SUS/COC Assembly at the Observatories:
    - LOS assembly fixtures
    - SUS/CDS Test Stand for hanging/alignment
    - Obs. Vacuum Bake Oven
    - Obs. Optics Lab for Pre- & Post-Bake Cleaning
  - LOS/CDS Satellite Electronics Module & Controller Board Assembly & Check-out @ CIT
  - Optical Lever Xmit & Rec Module Assembly & Check-out @ MIT
  - LOS/COC Installation dictated by IAS Co-alignment Sequence[1]:
    - MMT3_2k, RM_2k
    - BS_2k, ITMx_2k, FMx, ITMy_2k, FMy
    - ETMx_2k, ETMy_2k
    - etc. for 4k IFO
  - Installation includes:
    - physical placement & alignment (with IAS) of the SUS/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

1. Availability of a view through the X- &/or Y-BT would alter the alignment procedure, and perhaps open the possibility to integrate one long FP cavity before even completion of the vertex Michelson.

Detector Installation Plan By Subsystem (continued)

- Core Optics Support (COS)
  - Includes beam reducing telescopes for ISC optical signals (and associated large and small relay optics), beam dumps and baffles
  - Installation enabled by vertex core optic installation & alignment[1]
  - Requires removal of manifoild spools for entry to install large baffles
  - Component assembly can be done either at Observatories or CIT

1. according to current installation & alignment plan the COS generates ghost beams with an autocolimator for alignment of it's optical elements; May consider early installation by dead reckoning the positions for COS elements which are not critical in alignment & then check later

Testing

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Subsystem testing: Tests which demonstrate that internal subsystem requirements have been met

- giving information on part performance
  - e.g., PSL servo error signals reasonable
- showing internal interfaces correct
  - e.g., internal PSL loops lock up correctly

Integration testing: Tests which span subsystems

- giving information on subsystem performance
  - e.g., PSL frequency noise measured with IO mode cleaner
- giving information on combined performance
  - e.g., frequency control system using cascaded servos (PSL, IO, ISC)

Commissioning

- phase of overall system testing to verify LIGO performance
- emphasis is on meeting performance goals of the overall LIGO system with a system known to function (thanks to earlier testing)
- to be addressed in detail later

LDAS - a central, integrated part of testing

Pre-requisite: individual subsystem tests

Each subsystem to prepare a plan

- take list of significant requirements
- make matrix: how will each be verified?
  - › demonstration
  - › modeling
  - › may be obvious
  - › may not be possible until more of system present (e.g., COC losses)
- CDS aspects of the system tested with all else (integrated whole)
- plan will be informally reviewed before installation starts
- (PSL, SEI ASAP)
-

Upon completion of installation, test review

- for each, have we demonstrated requirement?
- some times means more work; hopefully parallel with other advances
- provides basis, point of departure for system tests

First integration test series: PSL, IO, ISC, SEI

Availability issues

- required warmup time for both systems
- locking time for both systems
- time between loss of lock

Power

- stability in short time (spectral density) and long (drift); watts

Frequency

- stability in short time (PSL measured by IOMC) and long

Servo element performance

- response to inputs as anticipated from LSC

Acoustic ‘microphonic’ sensitivity

- is the ambient noise ‘printing through’ to the output?

Transfer function of the isolation system

- basic combined stack/SOS attenuation

Remote control/monitoring

- a limited GDS capability will be available for Diagnostics testing

Second integration test series: Recycled Michelson

- some initial tests un-recycled, but focus on recycled configuration

Principal thrust: tools

- ensure that the means are in place and the answers in the ball park

Availability issues

- locking time
- time until system usable (violin string, substrate modes)
- time between loss of lock
- any interaction in startup (this knocks that out of lock)

Power

- power buildup; matching from IO
- contrast defect, reflected light power (modal decomposition)

Servo performance

- gains/margins of loops as anticipated
- saturation, noise limits
- offsets due to pick up

Recycled Michelson (con't)

Acoustic 'microphonic' sensitivity

Isolation system

- basic combined BSC stack/LOS transfer function
- no short circuits
- ambient noise as perceived by stack
- common mode/differential mode motions

Global Diagnostics System

- monitoring: test points, visualization
- stimulus/response: transfer functions
- ability to identify status of machine, evaluation of tools to date

Intermediate configurations

- may pursue some of these
- depends on what works, what doesn't, what is available when
- most possible also in complete system (if well behaved...)

Single 2km Fabry-Perot cavity

- reveals many aspects unique to site
  - › pointing/bootstrap alignment
  - › light transit (and storage time)
  - › longitudinal and angular noise over 2km baseline
- frequency noise, locking dynamics, alignment dynamics once locked

Non-recycled long (2km) Michelson

- to measure differential noise over a 2km baseline
  - › interesting for diagnosis if cavities difficult/impossible to lock
- testing 'fine actuators'

Three mirror system (Recyc mirror, BS, one ITM, one ETM)

- very low finesse coupled mirror system
  - › again, interesting if more complete system intractable

Complete interferometer

Stress on getting basic functionality of underlying systems, not performance

- save for the commissioning effort

Availability issues

- success of locking strategy
- locking time
- time until system usable
- time between loss of lock
- any interaction in startup (‘this’ knocks ‘that’ out of lock)

Power

- power buildup
- contrast defect (and modal decomposition)
- reflected light power, modal decomposition
- pick off modal decomposition

Servo performance

- gains/margins of loops as anticipated
- saturation, noise limits
- offsets due to pick up

Complete interferometer (cont't)

Acoustic 'microphonic' sensitivity

Isolation system

- high-sensitivity combined BSC stack/LOS transfer function
- ambient noise as perceived by stack
- common mode/differential mode motions

Global Diagnostics System

- monitoring: test points, visualization
- stimulus/response: transfer functions
- ability to identify status of machine, evaluation of tools to date

Strain cross-spectrum characterization

Not the focus of planned integration testing

- careful strain studies and searches for performance belong in Commissioning
- May prove to be important for debugging to a ‘functional state’

Some examples:

- laser frequency modulation to antisymm output
- laser intensity modulation to antisymm output
- laser frequency noise as inferred from symm output
- test for quadratic dependence of operation around operating point
- identification of lines in spectrum: power, mech resonances, etc.
  - › mag field
- comparison of control signal spectrum/rms with models
- comparions of GW-band spectrum with models
  - › shot noise (at whatever level); modulation depth dependence
  - › seismic feedthrough
- time series: statistics
  - › identification of non-seismic impulse input (correlation MC/laser)

Timeframes and Personnel

When does this start?

- IO-PSL: Mode Cleaner locked 4/99
- Recycled Michelson: 7/99
- Single Long FP Cavity 7/99
- 2k Interferometer: 9/99

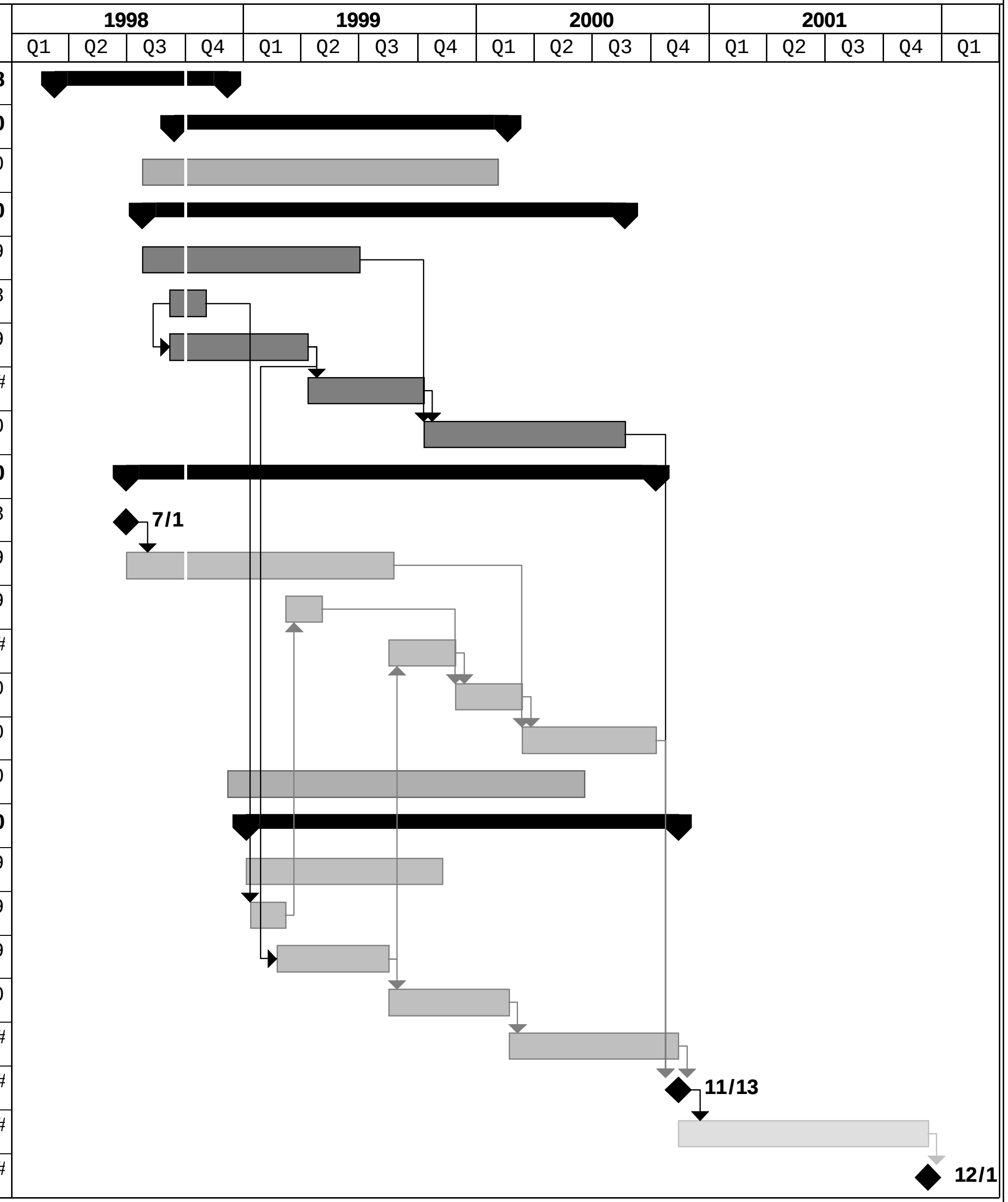
Who does it?

- all subsystem teams have valuable experience
- those with suspended interferometer experience particularly critical
- GDS plays a special role giving access to system
- Stan to assemble System Tests Team

10/1/98, 5:43 AM

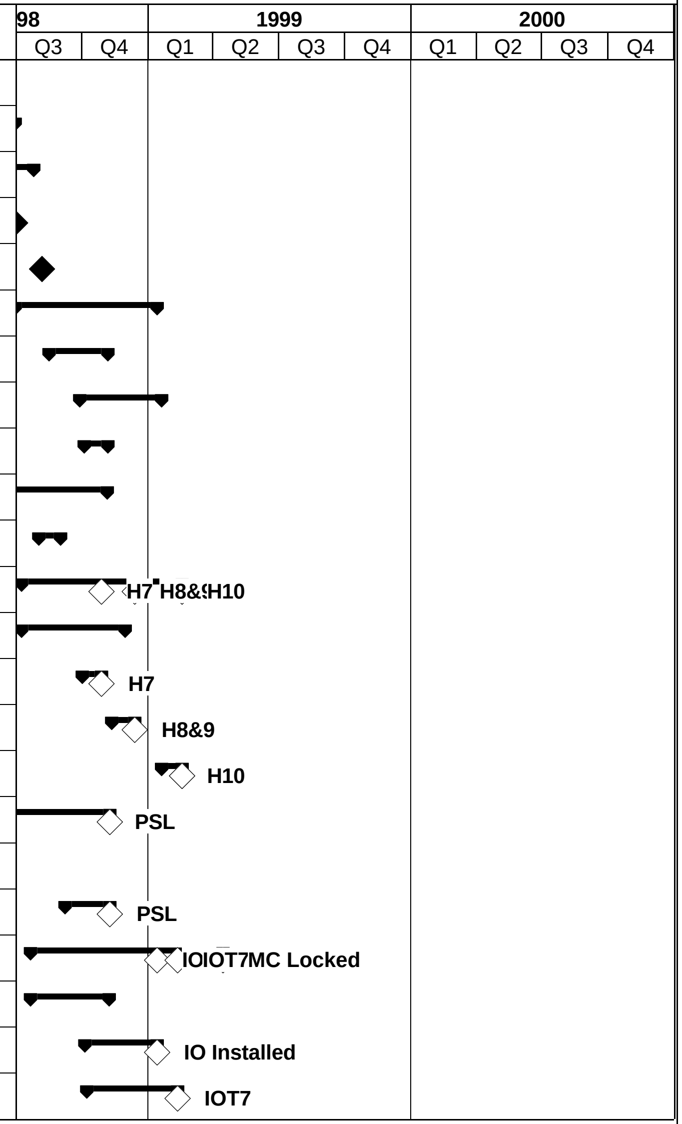
LIGO DETECTOR INSTALLATION -- TOP LEVEL

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**	**541 days**	**7/27/98**	**8/21/00**
23	Install SEI, SUS, COS, ISC	49 wks	7/27/98	7/2/99
24	PSL	8 wks	9/8/98	11/2/98
25	Input Optics	31 wks	9/8/98	4/12/99
26	PR Near Michelson	26 wks	4/13/99	########
27	PR Michelson w/ FP Arms	45 wks	########	8/21/00
28	**LHO 4km IFO**	**594 days**	**7/1/98**	**10/9/00**
29	Start Detector Integration	0 days	7/1/98	7/1/98
30	Install SEI, SUS, COS, ISC	60 wks	7/1/98	8/24/99
31	PSL	8 wks	3/9/99	5/3/99
32	Input Optics	15 wks	8/17/99	########
33	PR Near Michelson	15 wks	########	3/13/00
34	PR Michelson w/ FP Arms	30 wks	3/14/00	10/9/00
35	**LLO Detector Infrastructure**	80 wks	12/8/98	6/19/00
36	**LLO 4km IFO**	**484 days**	**1/6/99**	**11/13/00**
37	Install SEI, SUS, COS, ISC	44 wks	1/6/99	11/9/99
38	PSL	8 wks	1/12/99	3/8/99
39	Input Optics	25 wks	2/23/99	8/16/99
40	PR Near Michelson	27 wks	8/17/99	2/21/00
41	PR Michelson w/ FP Arms	38 wks	2/22/00	########
42	**Detector Commissioned (h<10^-20)**	0 days	########	########
43	Observatory Operations & improveme	56 wks	########	########
44	**Design Sensitivity (h<10^-21)**	0 days	########	########



LIGO Detector Installation and Commissioning Schedule

ID		Task Name	Duration	Start	Finish
1		*1 2km PR Near-Michelson*	*571.88 da*	*7/1/97*	*10/8/99*
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*
14		*1.3 Start IFO Install*	0 days	7/1/98	7/1/98
15		**1.4 IAS Monument Survey completed**	0 days	8/7/98	8/7/98
16		*1.5 PEM System Installation*	*132 days*	*7/1/98*	*1/13/99*
34		*1.6 Install SEI Phase 1*	*59 days*	*8/17/98*	*11/6/98*
55		*1.7 Cable Tray Installation*	*75 days*	*9/29/98*	*1/20/99*
61		*1.8 In-Vacuum Cable Assembly*	*25 days*	*10/5/98*	*11/6/98*
68		*1.9 Cleaning*	*341 days*	*7/1/97*	*11/5/98*
75		*1.10 Viewport & Feedthru Installation*	*22 days*	*8/3/98*	*9/1/98*
84		*1.11 SEI/HAM Phase 2&3 Installation*	*150.95 da*	*7/10/98*	*2/17/99*
85		*1.11.1 SEI Phase 2&3 Deliveries*	*99 days*	*7/10/98*	*12/1/98*
96		*1.11.2 WHAM7 SEI Ph 2&3 Installation*	*19.45 day*	*10/2/98*	*10/29/98*
105		*1.11.3 WHAM9 & WHAM8 SEI Ph 2&3 Installation*	*20.95 day*	*11/12/98*	*12/14/98*
117		*1.11.4 WHAM10 SEI Ph 2&3 Installation*	*19.95 day*	*1/21/99*	*2/17/99*
129		*1.12 PSL INSTALLATION*	*148 days*	*4/13/98*	*11/9/98*
130		*1.12.1 Setup*	*16 days*	*4/13/98*	*5/4/98*
135		*1.12.2 PSL Installation*	*45 days*	*9/8/98*	*11/9/98*
144		*1.13 IO Installation & MC Lock*	*183.95 da*	*7/22/98*	*4/15/99*
145		*1.13.1 IO Deliveries*	*77 days*	*7/22/98*	*11/9/98*
152		*1.13.2 Install Input Optics (IO)*	*65.95 day*	*10/6/98*	*1/14/99*
163		*1.13.3 IO ISC Table Installation (IOT7)*	*82.95 day*	*10/9/98*	*2/11/99*

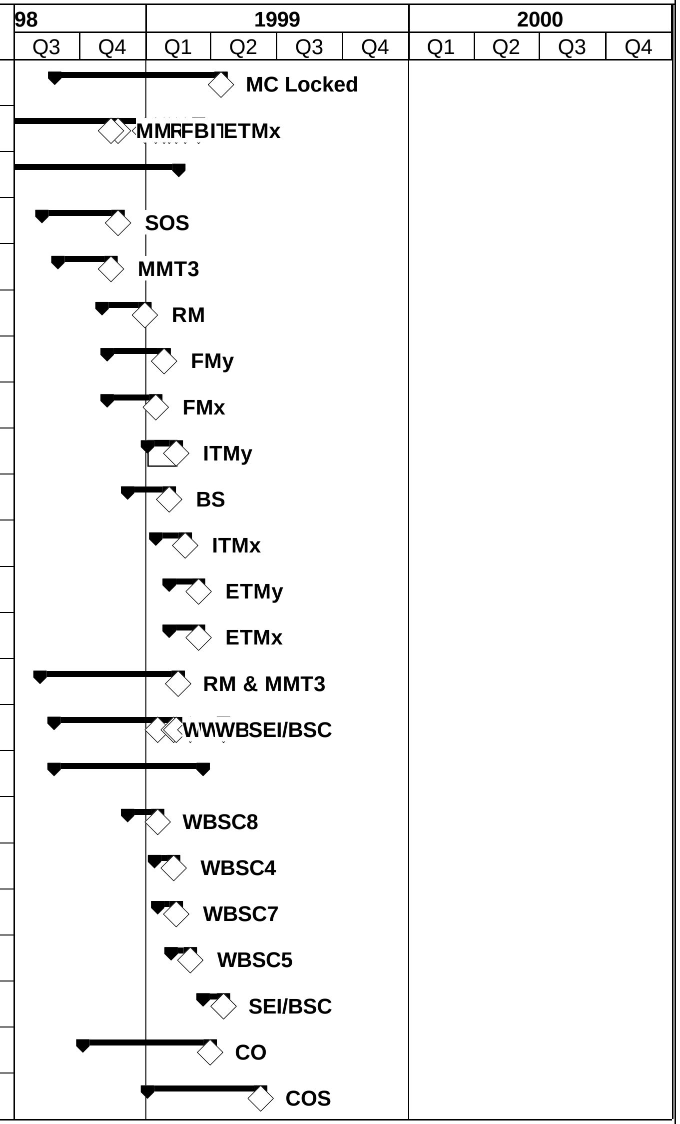


Project: WA 2km IFO Installation
Date: 10/1/98

Task | Critical | Progress | Milestone
Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress
External Tasks | Project Summary | Split | Rolled Up Split

LIGO Detector Installation and Commissioning Schedule

ID		Task Name	Duration	Start	Finish
168		*1.13.4 Input OpticsCommissioning*	*156.95 day*	*8/28/98*	*4/15/99*
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*	*53 days*	*9/1/98*	*11/13/98*
216		*1.14.4 SUSPEND Recycling Mirror (RM)*	*38 days*	*11/2/98*	*12/30/98*
221		*1.14.5 SUSPEND Fold Mirror Y (FM-Y)*	*50 days*	*11/9/98*	*1/26/99*
226		*1.14.6 SUSPEND Fold Mirror X (FM-X)*	*42 days*	*11/9/98*	*1/14/99*
231		*1.14.7 SUSPEND Inner Test Mass-Y (ITM-Y)*	*30 days*	*1/4/99*	*2/12/99*
236		*1.14.8 SUSPEND Beam Splitter (BS)*	*37 days*	*12/7/98*	*2/2/99*
241		*1.14.9 SUSPEND Inner Test Mass X (ITM-X)*	*29 days*	*1/15/99*	*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*	*128.25 day*	*8/7/98*	*2/15/99*
290		*1.16 SEI/BSC Phase 2&3 Installation*	*159.2 days*	*8/27/98*	*4/19/99*
291		*1.16.1 WBS SEIPh2/3 Deliverables*	*139 days*	*8/27/98*	*3/22/99*
308		*1.16.2 WBSC8 SEI Installation*	*25.15 days*	*12/7/98*	*1/18/99*
318		*1.16.3 WBSC4 SEI Installation*	*19.2 days*	*1/13/99*	*2/9/99*
328		*1.16.4 WBSC7 SEI Installation*	*19.2 days*	*1/18/99*	*2/12/99*
337		*1.16.5 WBSC5 SEI Installation (X-Arm Mid-Station)*	*19.2 days*	*2/5/99*	*3/4/99*
347		1.16.6 WBSC6 SEI Installation (in Y-Arm Mid-Station	20.2 days	3/22/99	4/19/99
359		*1.17 Install & Align CO*	*119.88 day*	*10/6/98*	*3/31/99*
420		*1.18 INSTALL COS*	*111.88 day*	*1/4/99*	*6/9/99*

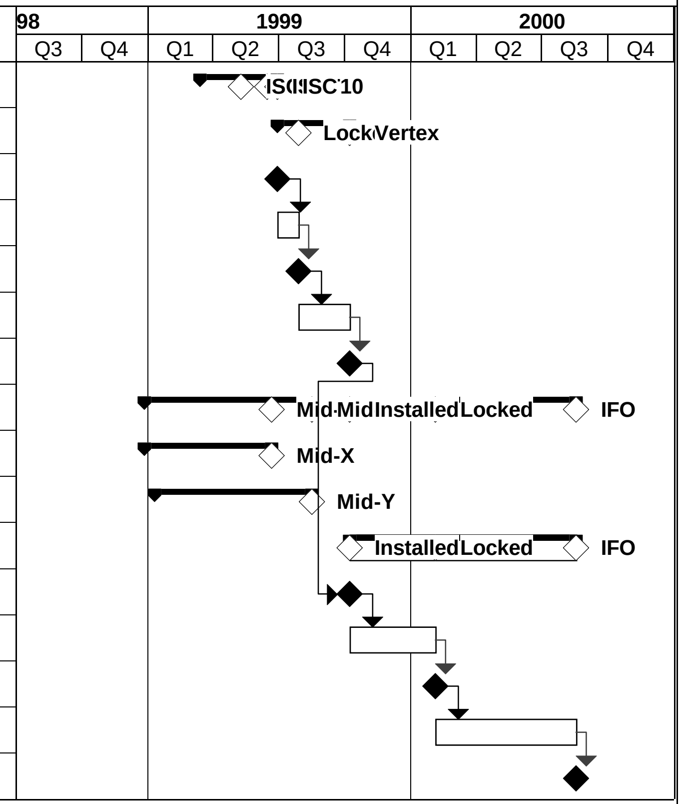


Project: WA 2km IFO Installation
Date: 10/1/98

Task		Summary		External Tasks	
Critical		Rolled Up Task		Project Summary	
Progress		Rolled Up Milestone	◇	Split	
Milestone	◆	Rolled Up Progress		Rolled Up Split	

LIGO Detector Installation and Commissioning Schedule

ID	ℹ	Task Name	Duration	Start	Finish
485		***1.19 ISC Installation***	***76.88 days***	***3/15/99***	***6/30/99***
508		***1.20 Vertex Michelson Shakedown***	***70 days***	***6/30/99***	***10/8/99***
509		1.20.1 All Vertex Michelson Equipment Installed	0 days	6/30/99	6/30/99
510		1.20.2 Align/Lock Vertex Michelson	4 wks	6/30/99	7/29/99
511		1.20.3 Vertex Michelson Locked	0 days	7/29/99	7/29/99
512		1.20.4 Characterize Vertex Michelson	10 wks	7/29/99	10/8/99
513		1.20.5 Vertex Michelson Characterization Complete	0 days	10/8/99	10/8/99
516		***2 LIGO 2k PRM with F-P Arms***	***419.88 days***	***12/28/98***	***8/18/00***
517		***2.1 Install Detector in X-Arm Mid-Station***	***123.2 days***	***12/28/98***	***6/22/99***
554		***2.2 Install Detector in Y-Arm Mid-Station***	***154.2 days***	***1/11/99***	***8/17/99***
589		***2.3 Shakedown 2k PRM w/ F-P Arms***	***220 days***	***10/8/99***	***8/18/00***
590		2.3.1 All 2k Michelson Equipment Installed	0 days	10/8/99	10/8/99
591		2.3.2 Align/Lock 2k IFO	16 wks	10/8/99	2/4/00
592		2.3.3 2km IFO Locked	0 days	2/4/00	2/4/00
593		2.3.4 Characterize 2k IFO	28 wks	2/4/00	8/18/00
594		2.3.5 2k IFO Characterization Complete	0 days	8/18/00	8/18/00

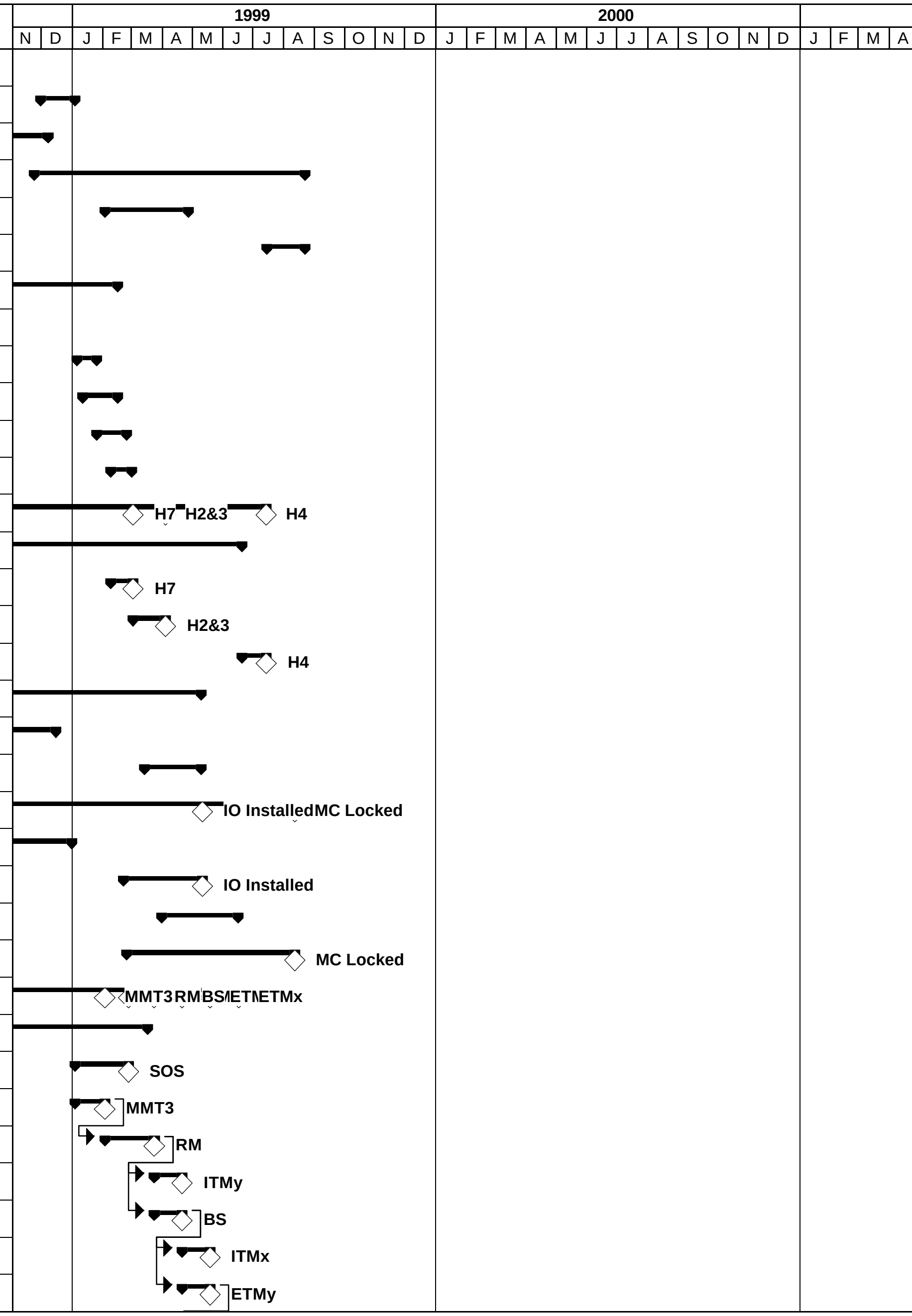


Project: WA 2km IFO Installation
Date: 10/1/98

Task		Summary		External Tasks	
Critical		Rolled Up Task		Project Summary	
Progress		Rolled Up Milestone		Split	
Milestone		Rolled Up Progress		Rolled Up Split	

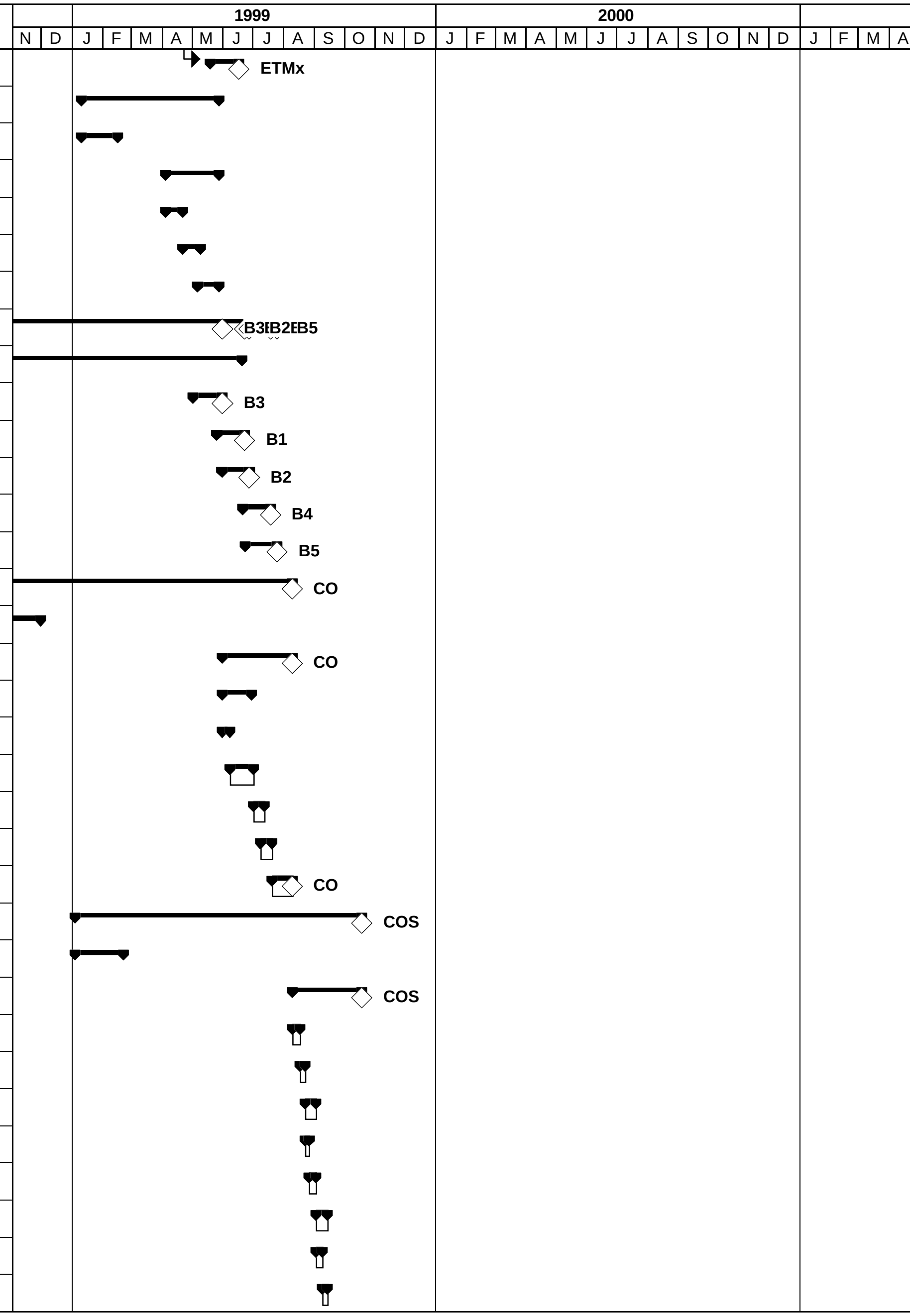
LIGO Livingston Observatory (LLO) Detector Installation and Commissioning Schedule

ID		Task Name	Duration	Start	Finish
1		*1 LA 4km PR Near-Michelson*	*463.2 days*	*4/20/98*	*2/22/00*
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	185.4 days	11/24/98	8/23/99
17		1.5.4 Install PEM in Corner Station	60 days	2/3/99	4/27/99
22		1.5.5 Install PEM in End-Stations	26.4 days	7/16/99	8/23/99
28		*1.6 Install SEI Phase 1*	*104 days*	*9/14/98*	*2/15/99*
29		*1.6.1 SEI Phase 1 Deliveries*	*20 days*	*9/14/98*	*10/12/98*
32		*1.6.2 4km IFO SEI (LHAMs 1-4)*	*14 days*	*1/6/99*	*1/25/99*
41		*1.6.3 4km IFO SEI (LBSCs 1-5)*	*25 days*	*1/12/99*	*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*	*239.75 days*	*7/31/98*	*7/15/99*
67		*1.9.1 SEI/HAM Ph 2&3 Deliveries*	*222 days*	*7/31/98*	*6/21/99*
73		*1.9.2 Install LHAM1 SEI (Ph 2 & 3)*	*16.45 days*	*2/9/99*	*3/3/99*
82		*1.9.3 Install LHAM2 & 3 SEI (Ph 2 & 3)*	*22.95 days*	*3/3/99*	*4/5/99*
95		*1.9.4 Install LHAM4 SEI (Ph 2 & 3)*	*17.75 days*	*6/21/99*	*7/15/99*
106		*1.10 PSL Installation*	*266 days*	*4/20/98*	*5/10/99*
107		*1.10.1 PSL Deliveries*	*167 days*	*4/20/98*	*12/16/98*
111		*1.10.2 PSL Installation*	*41 days*	*3/15/99*	*5/10/99*
121		*1.11 IO Installation & Mode Cleaner (MC) Lock*	*205 days*	*10/19/98*	*8/12/99*
122		*1.11.1 IO Deliveries*	*48 days*	*10/19/98*	*1/1/99*
127		*1.11.2 Install Input Optics (IO)*	*57 days*	*2/22/99*	*5/11/99*
140		*1.11.3 IO ISC Table Installation (LIOTH1)*	*54 days*	*4/1/99*	*6/16/99*
147		*1.11.4 Mode Cleaner Commissioning*	*119 days*	*2/25/99*	*8/12/99*
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*



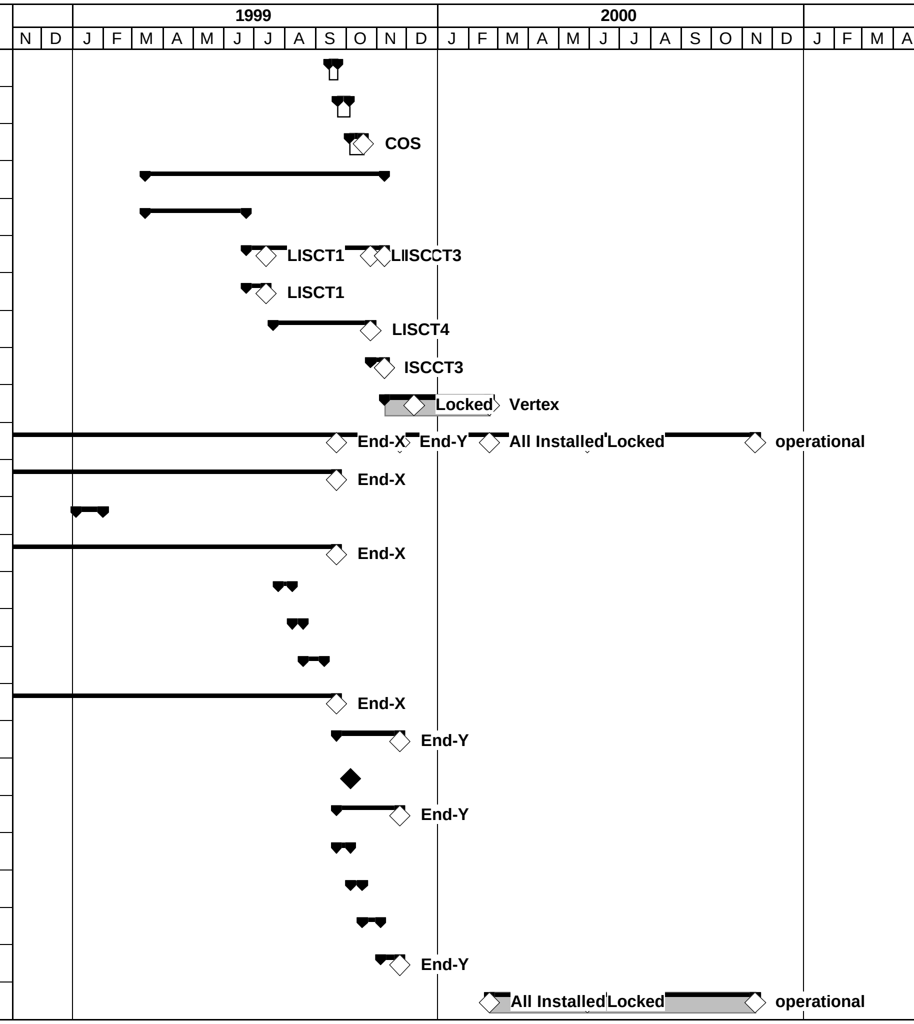
LIGO Livingston Observatory (LLO) Detector Installation and Commissioning Schedule

ID		Task Name	Duration	Start	Finish
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***
215		*1.13.1 Deliveries*	*26 days*	*1/11/99*	*2/16/99*
219		*1.13.2 Install RM & MMTE*	*39.3 days*	*4/5/99*	*5/28/99*
220		*1.13.2.1 VE & Clean Room Preps*	*13.3 days*	*4/5/99*	*4/22/99*
231		*1.13.2.2 Install & Align MMT3 & Optical Leve*	*12 days*	*4/22/99*	*5/10/99*
240		*1.13.2.3 Install & Align RM & Optical Lever*	*15 days*	*5/7/99*	*5/28/99*
248		***1.14 SEI/BSC Phase 2&3 Installation***	***274.4 days***	***6/22/98***	***7/26/99***
249		*1.14.1 SEI/BSC Deliveries (Ph 2 & 3)*	*250 days*	*6/22/98*	*6/21/99*
261		*1.14.2 Install LBSC3 SE*	*20.2 days*	*5/3/99*	*6/1/99*
271		*1.14.3 Install LBSC1 SEI*	*19.2 days*	*5/26/99*	*6/23/99*
282		*1.14.4 Install LBSC2 SEI*	*19.2 days*	*6/1/99*	*6/28/99*
292		*1.14.5 Install LBSC4 SEI (X-Arm End-Station)*	*19.2 days*	*6/21/99*	*7/19/99*
303		1.14.6 Install LBSC5 SEI (Y-Arm End-Station)	21.2 days	6/24/99	7/26/99
314		***1.15 Install & Align SUS/COC Assemblies***	***202.2 days***	***10/19/98***	***8/10/99***
315		*1.15.1 IAS & CDS Deliveries*	*29 days*	*10/19/98*	*12/1/98*
318		*1.15.2 Install & Align SUS/COC Assemblies*	*49 days*	*6/1/99*	*8/10/99*
319		*1.15.2.1 Install COC Opt Lev & SUS Electron*	*21 days*	*6/1/99*	*6/30/99*
326		*1.15.2.2 Install & Align OFx & ITMx in LBSC:*	*5.63 days*	*6/1/99*	*6/8/99*
334		*1.15.2.3 Install & Align Optical Flat OFy & Oi*	*18.38 days*	*6/8/99*	*7/2/99*
343		*1.15.2.4 Install and Align ITMx in LBSC3*	*5.5 days*	*7/2/99*	*7/13/99*
352		*1.15.2.5 Install & Align BS (LBSC2)*	*7.5 days*	*7/9/99*	*7/21/99*
363		*1.15.2.6 Close Up Vacuum System*	*14 days*	*7/21/99*	*8/10/99*
369		***1.16 INSTALL COS***	***203.2 days***	***1/4/99***	***10/19/99***
370		*1.16.1 COS Deliveries*	*35 days*	*1/4/99*	*2/22/99*
376		*1.16.2 Install COS*	*49 days*	*8/10/99*	*10/19/99*
377		*1.16.2.1 Install COS Alignment Laser*	*6 days*	*8/10/99*	*8/18/99*
383		*1.16.2.2 Install Alignment Targets*	*3 days*	*8/18/99*	*8/23/99*
386		*1.16.2.3 Install Pick Off Mirrors*	*9 days*	*8/23/99*	*9/3/99*
387		*1.16.2.3.1 LBSC3*	*4 days*	*8/23/99*	*8/27/99*
392		*1.16.2.3.2 LBSC2*	*5 days*	*8/27/99*	*9/3/99*
398		*1.16.2.4 Install COS Teles*	*6 days*	*9/3/99*	*9/14/99*
399		*1.16.2.4.1 LHAM4*	*3 days*	*9/3/99*	*9/9/99*
403		*1.16.2.4.2 LHAM3*	*3 days*	*9/9/99*	*9/14/99*



LIGO Livingston Observatory (LLO) Detector Installation and Commissioning Schedule

ID		Task Name	Duration	Start	Finish
407		*1.16.2.5 Install Beam Dumps/Baffles in Cha*	*7 days*	*9/14/99*	*9/23/99*
414		*1.16.2.6 X-Manifold Installations*	*8 days*	*9/23/99*	*10/5/99*
423		*1.16.2.7 Y-Manifold Installations*	*10 days*	*10/5/99*	*10/19/99*
434		*1.17 ISC Installation*	*168.2 days*	*3/15/99*	*11/9/99*
435		*1.17.1 ISC Deliveries*	*72 days*	*3/15/99*	*6/24/99*
441		*1.17.2 Install ISC*	*96.2 days*	*6/24/99*	*11/9/99*
442		*1.17.2.1 Install ISC Table (LISCTH1)*	*13 days*	*6/24/99*	*7/13/99*
447		*1.17.2.2 Install ISC Table (LISCTH4)*	*68.2 days*	*7/21/99*	*10/26/99*
453		*1.17.2.3 Install ISC Table (LISCTH3)*	*10 days*	*10/26/99*	*11/9/99*
459		*1.18 Vertex Michelson Shakedown*	*70 days*	*11/9/99*	*2/22/00*
465		*2 LA 4k PRM with F-P Arms*	*853.2 days*	*7/1/97*	*11/14/00*
466		*2.1 Install Detector in X-Arm End-Station*	*559.4 days*	*7/1/97*	*9/22/99*
467		*2.1.1 X-End Station Deliveries*	*19 days*	*1/5/99*	*2/1/99*
471		*2.1.2 X-End Station Installation*	*559.4 days*	*7/1/97*	*9/22/99*
472		*2.1.2.1 Install & Align ETMx in LBSC4*	*10 days*	*7/26/99*	*8/9/99*
481		*2.1.2.2 Install COS in X-Arm End-Station*	*9 days*	*8/9/99*	*8/20/99*
491		*2.1.2.3 Close LBSC4*	*14 days*	*8/20/99*	*9/10/99*
496		*2.1.2.4 Install ISC Table (LISCTB4)*	*559.4 days*	*7/1/97*	*9/22/99*
502		*2.2 Install Detector in Y-Arm End-Station*	*45 days*	*9/22/99*	*11/24/99*
503		*2.2.1 Y-End Station Deliveries*	*0 days*	*10/6/99*	*10/6/99*
505		*2.2.2 Y-End Station Installation*	*45 days*	*9/22/99*	*11/24/99*
506		*2.2.2.1 Install & Align ETMy in LBSC5*	*10 days*	*9/22/99*	*10/6/99*
515		*2.2.2.2 Install COS in Y-Arm Mid-Station*	*8 days*	*10/6/99*	*10/18/99*
524		*2.2.2.3 Close LBSC5*	*14 days*	*10/18/99*	*11/5/99*
529		*2.2.2.4 Install ISC Table (LISCTB5)*	*13 days*	*11/5/99*	*11/24/99*
535		*2.3 Shakedown LA 4k PRM w/ F-P Arms*	*190 days*	*2/22/00*	*11/14/00*

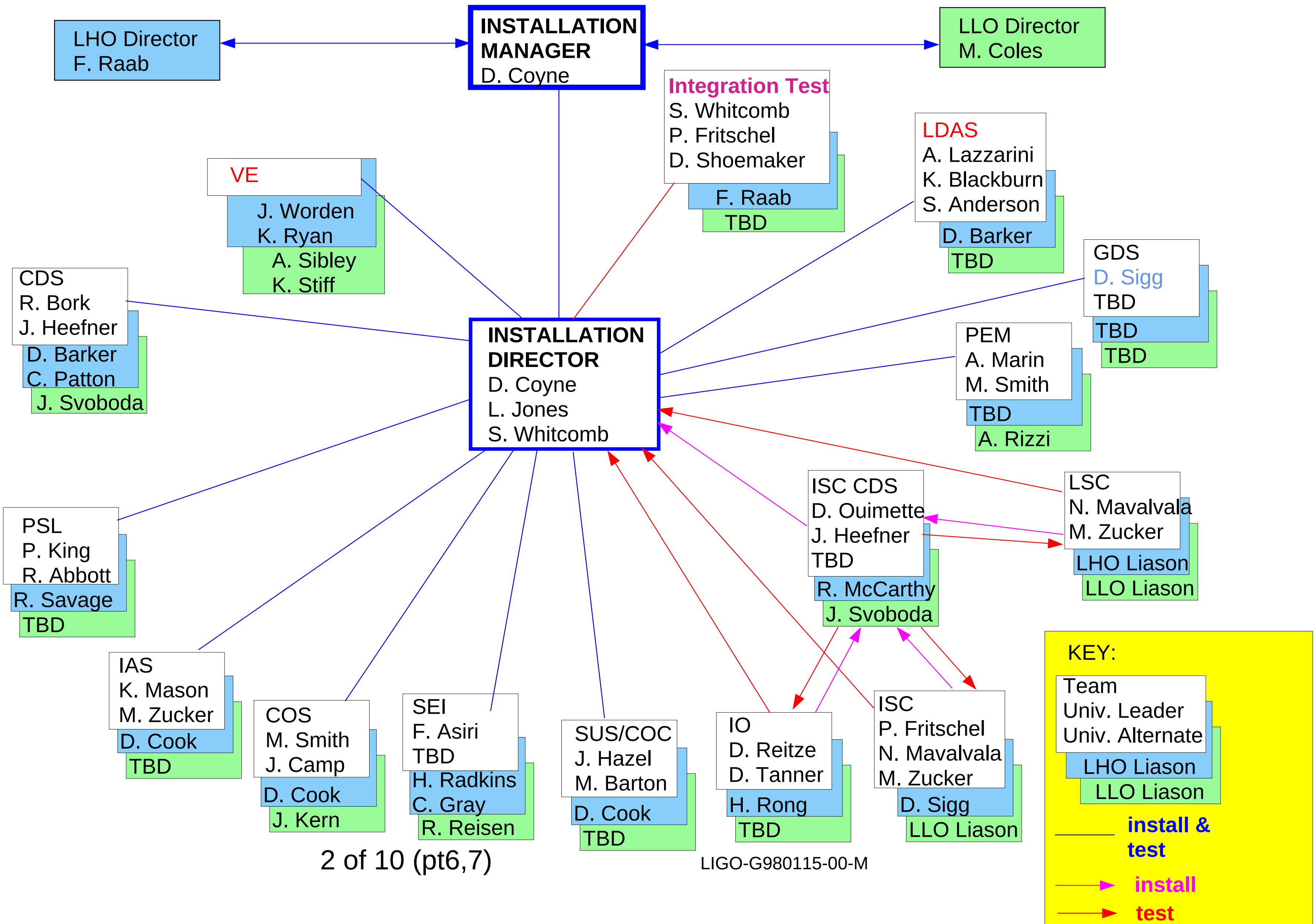


Installation Organization & Staffing

- Detector Integration and Test Organization
  - ››The Detector Group Manages to the Deliverable Definition & Schedule (Detector's "interface" with Installation)
  - ››Detector Installation is "Observatory-Centric"
    - EXECUTION:
      Day-to-Day On-Site Staff Direction & Tracking (per the installation plan) is the designated Installation Director's responsibility
    - PLANNING/COORDINATION:
      Detector Chief Engineer/Integration Manager's Responsibility (D. Coyne):
      - Work-Around Planning
      - Technical/Scientific Integration Support Staff Coordination
- Support to Detector Installation and Test
  - ››Detector Design Staff Migrates to Support the Installation Effort
    - During Integration peaks, ~1/2 the Detector Staff will be on-site at the observatories
    - Detector Staff Continues to Support the Detector Design, Fabrication, Assembly & Test
  - ››Subsystem Teams (with Observatory Site members) Execute the Installation
    - Teaming Helps Technology Transfer & Training of Observatory Staff
    - Teaming Helps Relieve Travel burden of University-based Detector Staff

Installation Organization

PRELIMINARY



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Installation Organization & Staffing (continued)

- Need Commitments by Technical Staff to support Installation and Test
- Individuals can be conscripted, but we prefer volunteers
- “Sign-up” is a committment for a % time at the Observatories (in a general timeframe) to support specific Subsystem/System Teams
- Virtually all staff will be asked to perform “service work”:

  ››one cannot always choose the work you’ll do

  ››you cannot always choose the date at which you will do the work, though we will try to accommodate personal limitations and needs

  ››we need a staff at the site at all times to support installation, i.e. expect to plan to arrive for a given week(s) and then do what is required, as opposed to what may have been planned months before

Installation Teams
Example 1

• PSL Team:

Team	Personnel	Role	% Time at Observatory	LHO 2km IFO Installation Timeframe[a]	LLO IFO Installation Timeframe
PSL 1.9 FTE	Peter King	Team Leader	50%	9/10 - 11/10/98	
	Rich Abbott	Alt. Team Leader; electronics	50%	9/10 - 11/10/98	
	Rick Savage	LHO liaison member; Alt. Team Leader	50%	9/10 - 11/10/98	
	Dave Barker	LHO member; software	20%	10/15 - 11/10/98	
	Lee Cardenas	member	20%	9/10 - 11/10/98	
	Virginnio Sanni-bale	member	50%	9/10 - 11/10/98	
	Peter Csatorday	member	50%	9/10 - 11/10/98	
	TBD	LLO liaison	50%		
	TBD	LLO member; software	20%		

a. The installation timeframe does not cover the debug, characterization and maintenance/support phases; These are expected to require considerably less labor time commitment.

Installation Teams Example 2

- SEI Team:
  - 2 teams (HAM and BSC), one overall team leader

Team	Personnel	Role	% Time at Observatory	LHO 2km IFO Installation Timeframe[a]	LLO IFO Installation Timeframe
SEI 7.1 FTE	Fred Asiri	Team Leader (& SEI installation director)	30%	9/98 - 2/99	1/99-5/99
	Mark Barton	member	30%	9/98 - 2/99	1/99-5/99
	Dennis Coyne	Alt. Team Leader	30%	9/98 - 2/99	1/99-5/99
	Larry Jones	Alt. Team Leader	30%	9/98 - 2/99	1/99-5/99
	Rick Savage	LHO member	50%	9/98 - 2/99	1/99-5/99
	Hugh Radkins	LHO liaison member; Team Leader & alignment	100%	9/98 - 2/99	1/99-5/99
	Corey Gray	LHO member	100%	9/98 - 2/99	1/99-5/99
	Stan Whitcomb	Alt. Team Leader	30%	9/98 - 2/99	1/99-5/99
	Lee Cardenas	member	30%	9/98 - 2/99	1/99-5/99
	Other Volunteers	members	1 FTE	9/98 - 2/99	1/99-5/99
	contractor	grouting	25%	9/25 ->11/15/98	
	Apollo	pier embedded bolts	80%	8/15 - 11/1/98	

a. The installation timeframe does not cover the debug, characterization and maintenance/support phases; These are expected to require considerably less labor time commitment.

Practicalities & Policies: Travel

- Expectation:
  - ››The technical staff at MIT and CIT, as a group, are expected to spend 25% of their time at the Observatories on average during operations
  - ››During the initial phases of installation (first 9 mo. of 1999), approximately 50% time at the Observatories
  - ››Travel to a site in support of installation should generally allow for at least 4.5 working days (Monday thru Friday) at the Observatory, for efficiency
- Lodging
  - ››a limited number of LIGO apts (4 beds currently) are available for sharing, for those who desire them
  - ››Hotels (government rate) are fine as well
- Per diem for 1998 & 1999:
  - ››Standard Gvm't per diem as governed by NSF and University rules

Practicalities & Policies: Travel (continued)

- Car Rentals

  ›› Travelers to the sites must make a good faith attempt to ride share with other visitors; A list of travelers, dates of travel, who has rental cars, etc. will be made available on the LAN to facilitate linking up with others

  ›› Leasing may be an option for long term stays or high duty cycle travelers (> 1/2 time)

- Relocation (~> 1 yr):

  ›› Depends on each individual and institution & applicable University and Federal Rules

Practicalities & Policies:
Observatory Visitor Accommodations

- Computers

  ››General use computers will be made available for visitors

  ››No dedicated desktop computers will be assigned to visiting staff

  ››Additional needs for workstations will be filled with temporary transfers from the campuses

  ››A few project-owned laptop computers can be made available (& IP addresses at the Obs.) for frequent travelers

- Desks/Offices

  ››Desks and offices will be temporarily assigned (as available) to visiting staff for the period of their stay

- Communications

  ››Phone lines will not be dedicated to visitors, but phones are available for general use

  ››900 MHz phones will be made available for installation teams

  ››A message board will be established at each Observatory

  ››Pagers can be made available as req'd (by CIT and MIT)

Practicalities & Policies: Logistics

- Daily Observatory Coordination Mtg
  - ››Run by Observatory Directors (Otto Matherny and Mark Coles)
- Installation Director at Observatory at all times:
  - ››Dennis Coyne, Larry Jones, Stan Whitcomb,...
- Team Leader
  - ››designated for each subsystem (being actively installed or commissioned)
  - ››means for contacting (24 hrs. a day) the “on-duty team leader” always posted on the message board
  - ››responsible to coordinate support staff for installation and commissioning with the Installation Director
- Purchase Approval Authority
  - ››Detector fab accounts unchanged
  - ››Operations accounts for support equipment & supplies is requested of the Observatory Director or designee

Installation/Commissioning Opportunities!

- The time has come for all great men and women to rise to the need of their project!
- Opportunities abound:
  - ››to be involved in the physical assembly & installation of the various subsystems (not just the one(s) that you may have designed)
  - ››to be involved in the commissioning and debugging of various subsystems
  - ››to be involved in system testing, instrument characterization and performance assessment
- Staffing Needs:
  - ››commitments to spend significant blocks of time (at reasonable duty cycles) at the Observatories
  - ››commitments to support specific activities for which you have needed skills

Remember: It's not just a job, it's an adventure!