

LIGO DETECTOR

R. VOGT

May 22, 1995



DETECTOR

- Concept and Cost Estimate: June - September 1994
- Implementation Plan: September - December 1994
- Design Activities: Start December 1994

DETECTOR IMPLEMENTATION STRATEGY

- Detector activities governed by implementation plan and Project Management Control System
- Detector work organized into tasks (according to WBS), each under a Task Leader
- Detector program implementation consistent with Sept. 94 Cost Book
- Technical basis of Detector program:
 - ›› conceptual design based upon past R&D activities
 - ›› design evolution utilizes:
 - on-going R&D activities
 - modeling
 - engineering optimization



DETECTOR GROUP

- Group Leader: R. Vogt
- Deputy Group Leader: W. Althouse

- CDS Task Leader: V. Schmidt
- IFO Task Leader: TBD
- Systems Task Leader: R. Spero

- PEM Task Leader: R. Weiss
- SUP Task Leader: F. Raab

SCIENTISTS (8):

J. Camp
P. Fritschel
S. Kawamura
R. Savage
D. Shoemaker
N. Solomonson
TBD (Optics)
TBD (General)

ENGINEERS (12):

CDS:

R. Abbott (6/5/95)
D. Barker (6/1/95)
R. Bork
J. Heefner
TBD (Analog) (O/P)
TBD (Digital)

Optics:

G. Billingsley
S. Elieson
D. Jungwirth

Mechanical:

J. Hazel

Project:

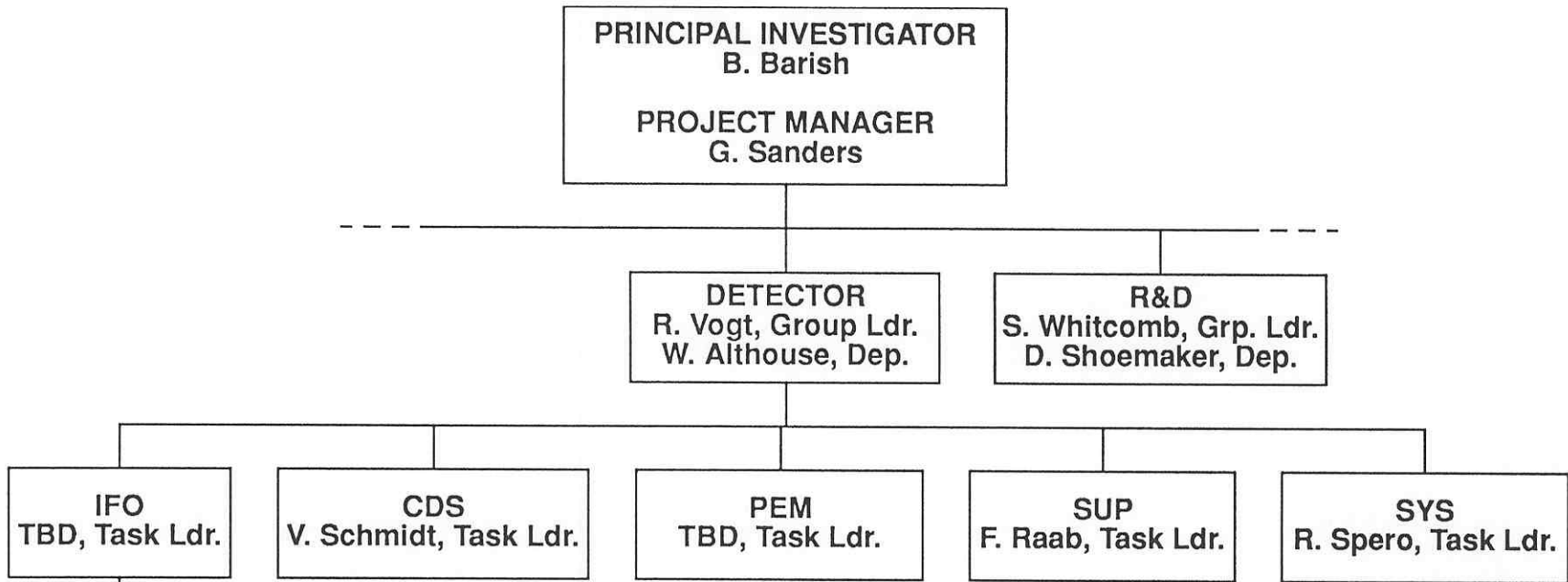
TBD
TBD

TECHNICIANS:

XX

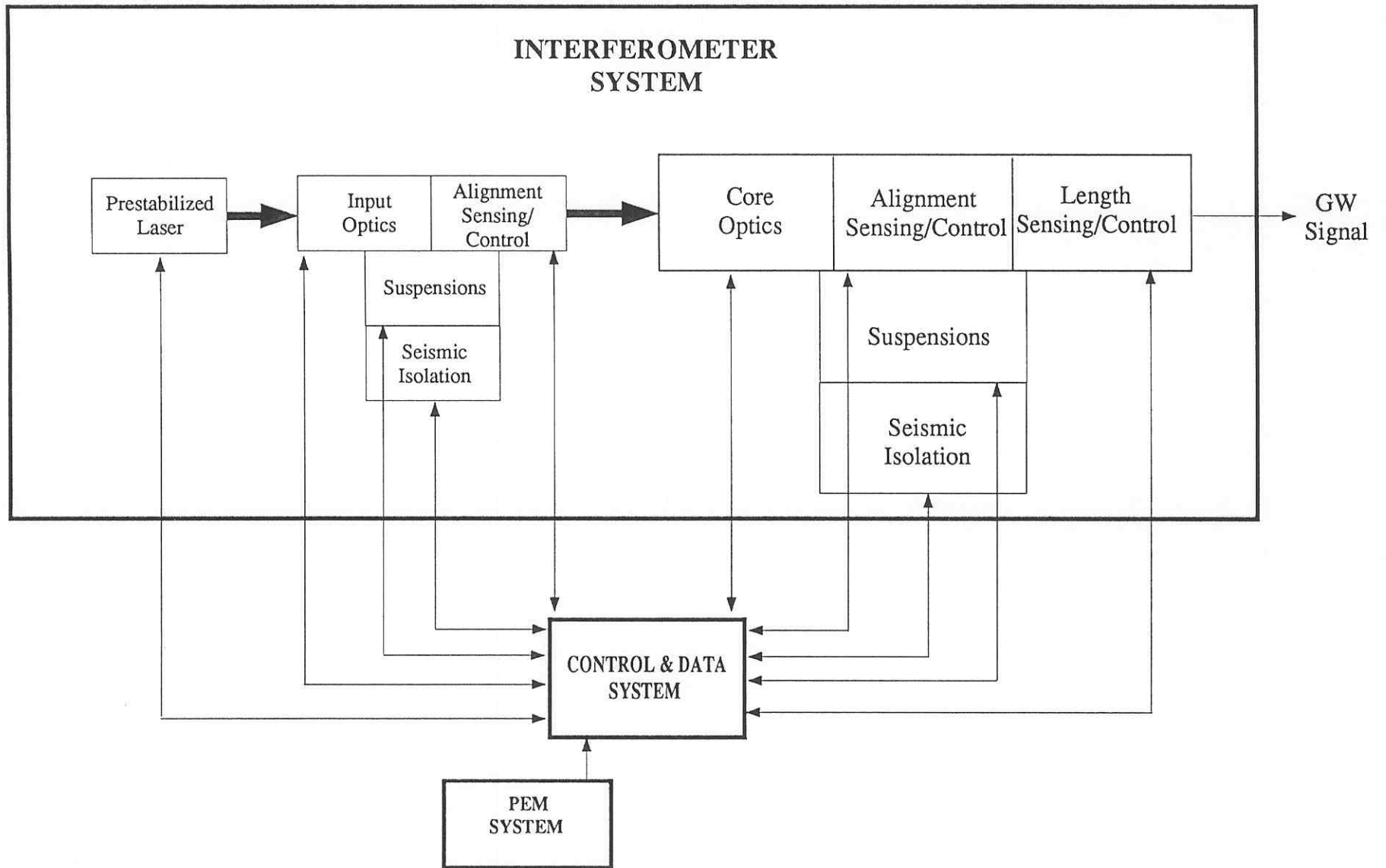
(R&D STAFF)

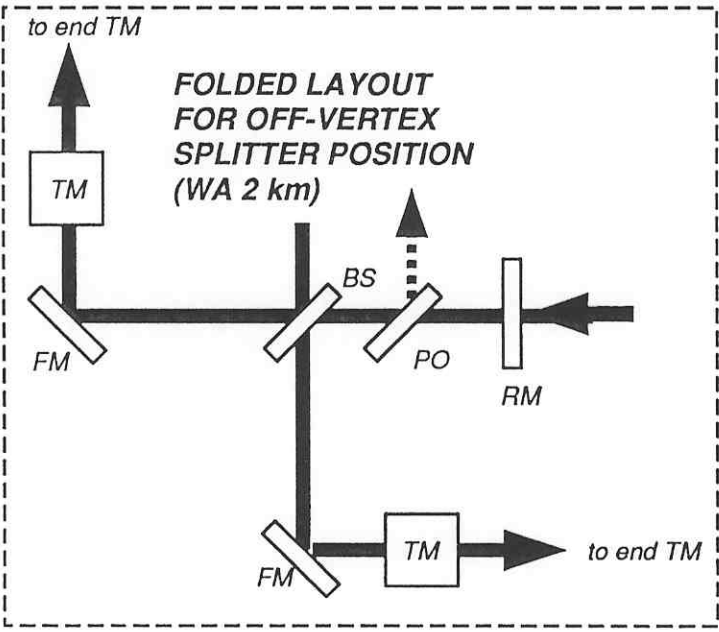
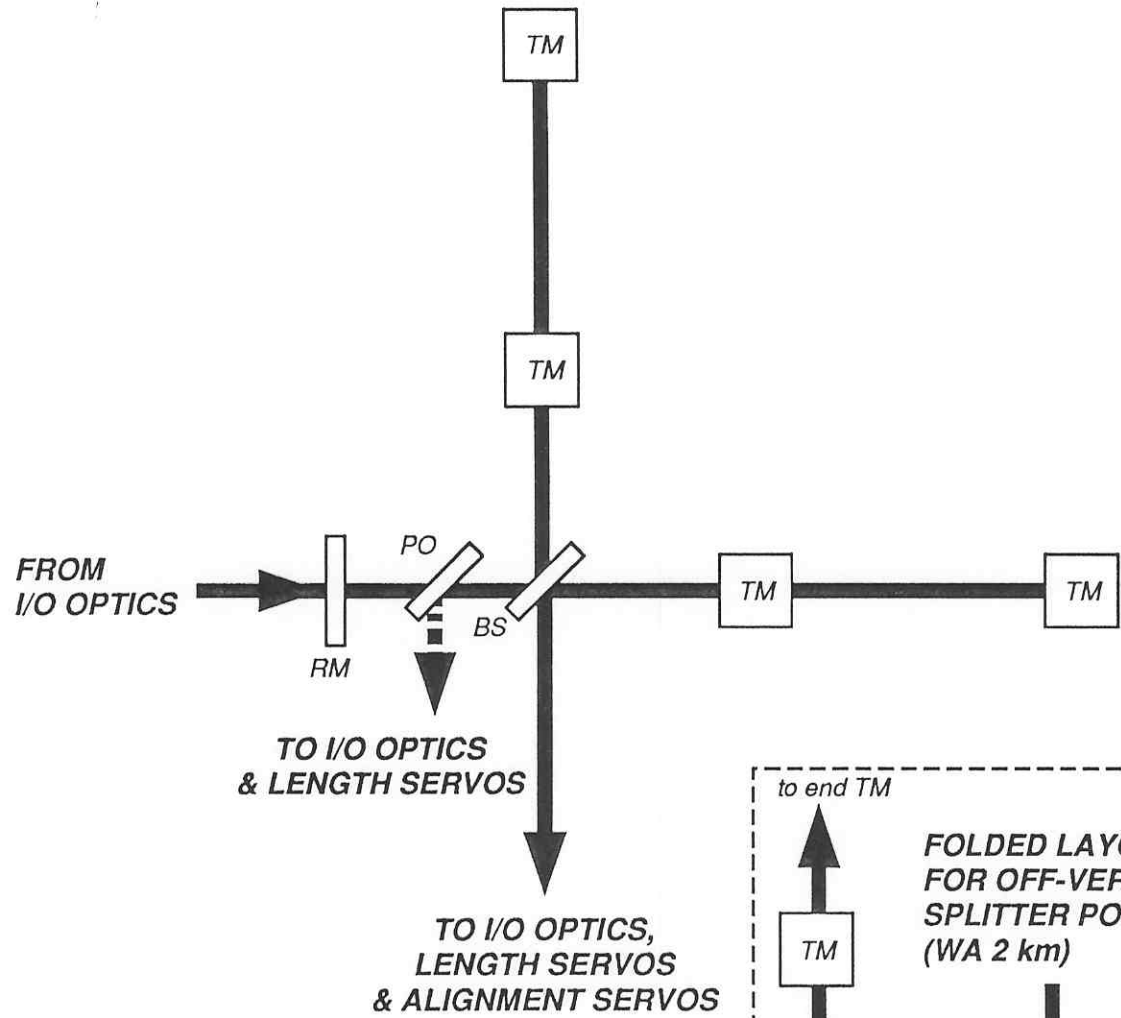




- IFO Subsystem Task Leaders:
- Seismic Isolation, N. Solomonson
 - Prestabilized Laser, J. Camp
 - I/O Optics, J. Camp
 - Core Optics Components, R. Savage
 - Core Optics Support, R. Savage
 - Alignment Sensing and Control, D. Shoemaker
 - Length Sensing and Control, P. Fritschel
 - Suspension Design, S. Kawamura

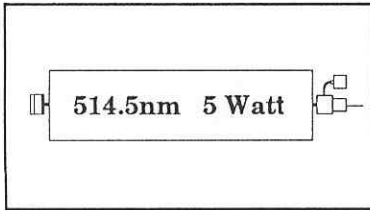






Vertex Station

Primary Laser Table

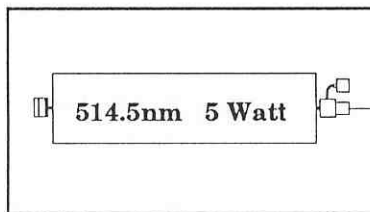


Laser Source for Interferometer

$$\frac{\Delta f}{f} = 10^{-11} / \sqrt{\text{Hz}}$$

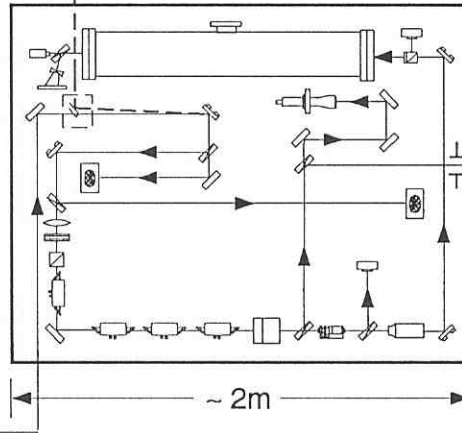
$$\frac{\Delta P}{P} = 10^{-4} / \sqrt{\text{Hz}}$$

Secondary Laser Table



Back-up Source for Interferometer

PSL Optical Table

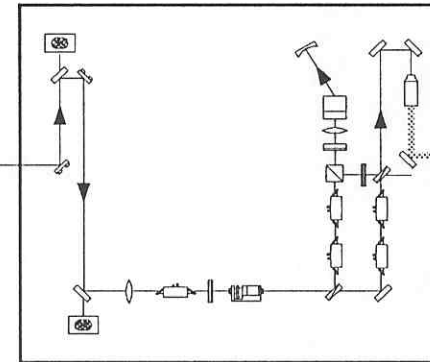


Applies reference cavity lock modulation (~10MHz)

Stabilizes power $\frac{\Delta P}{P} = 10^{-7} / \sqrt{\text{Hz}}$

Provides frequency stabilization $\frac{\Delta f}{f} = 10^{-16} / \sqrt{\text{Hz}}$

Optics Table No. 1

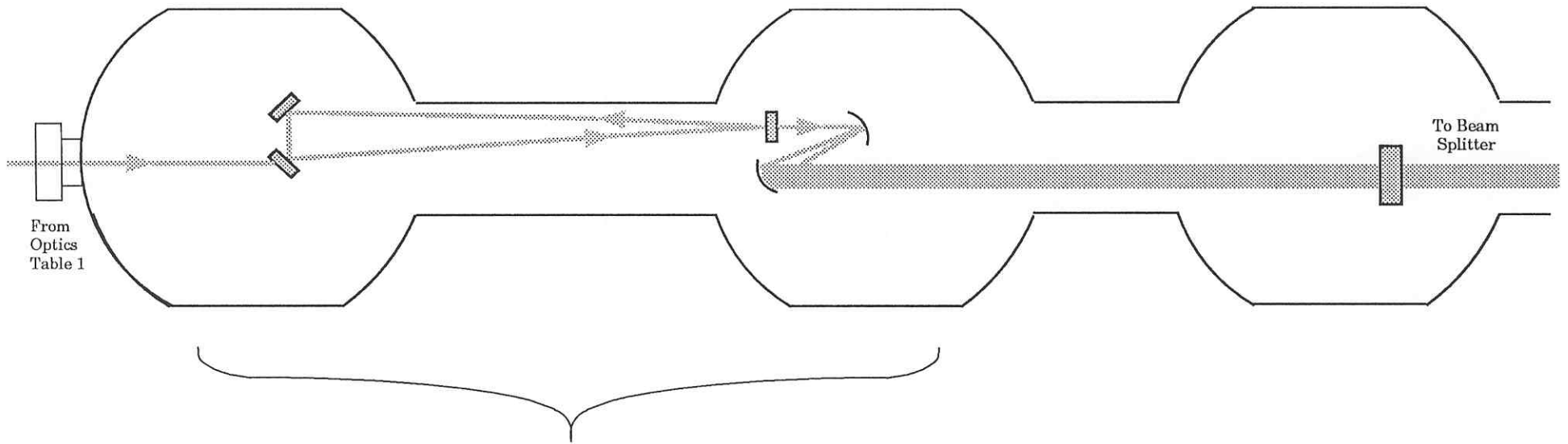


Applies interferometer length control modulation

Expands beams

Provides optical isolation

Vertex Station



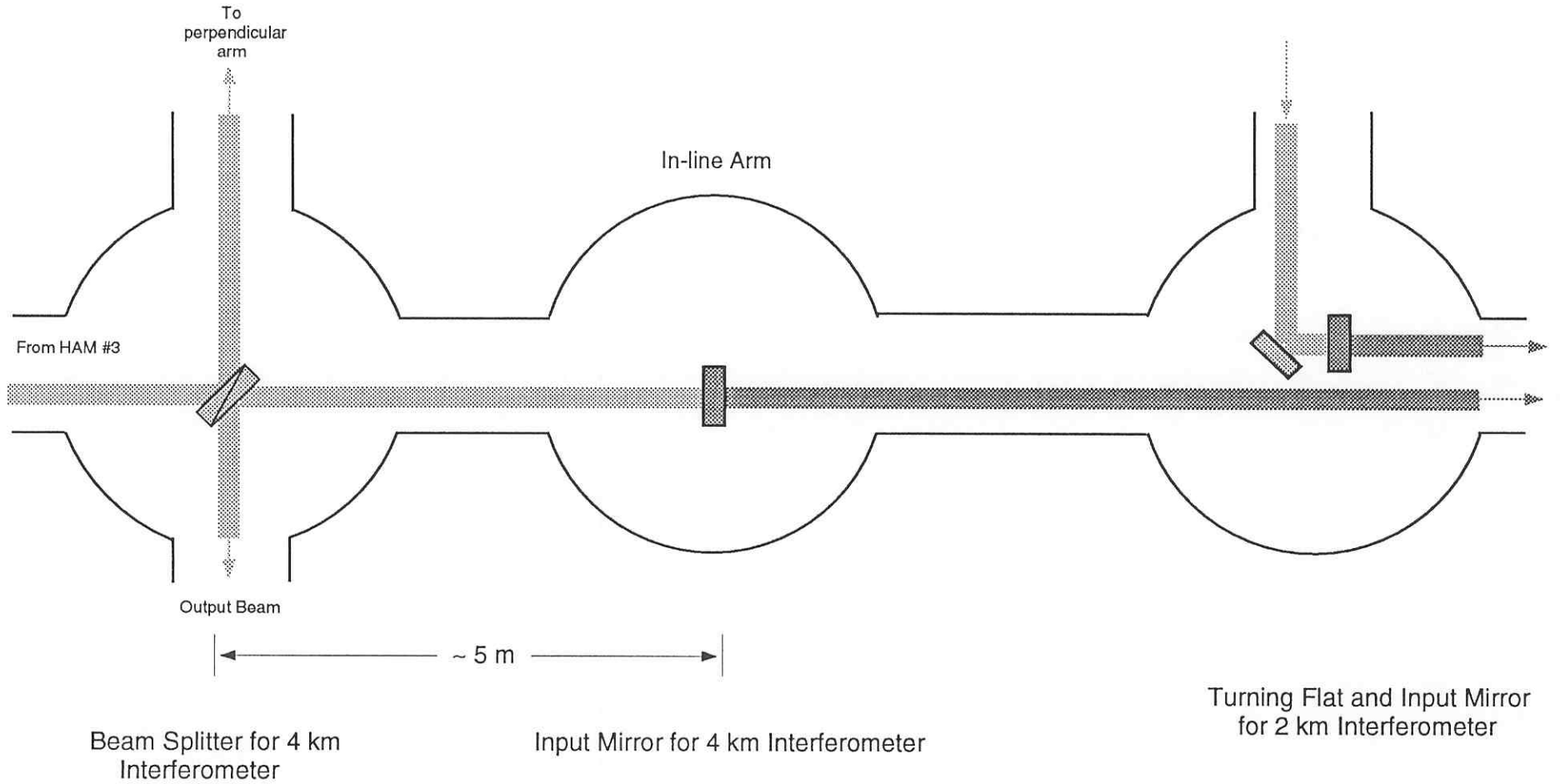
Triangular Mode Cleaner (12 m length)

- * Suppresses backscatter ($P_{back} / P_{In} < 10^{-6}$)
- * Reduces Pointing jitter ($\Delta\theta_{out} / \Delta\theta_{In} < 10^{-3}$)
- * Provides additional frequency stabilization, by a factor of 1000, to $\frac{\Delta f}{f} = 10^{-19} / \sqrt{Hz}$

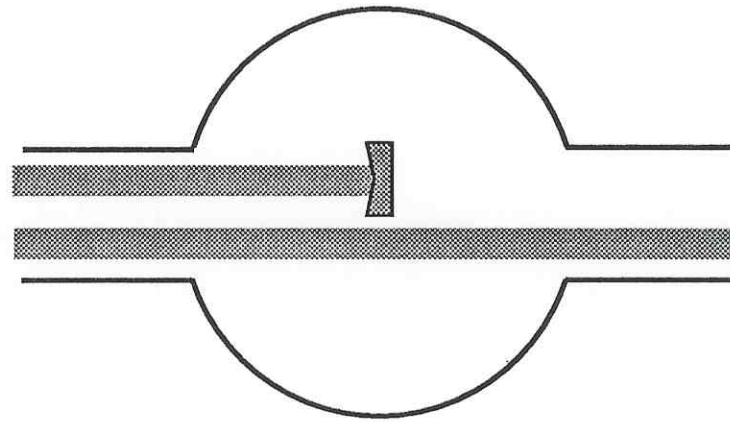
Beam expander

Recycling Mirror for 4 Km Interferometer

Vertex Station

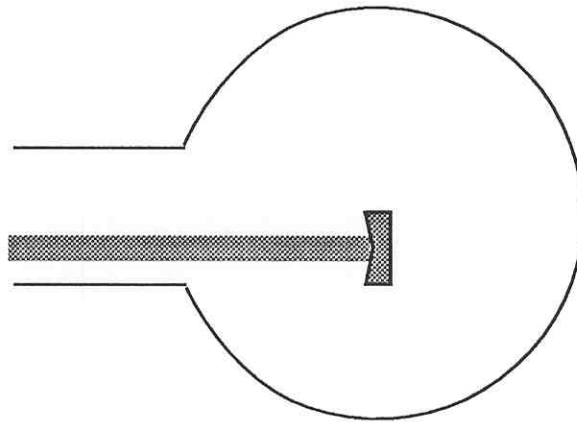


Mid Station

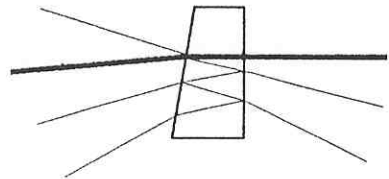


End Mirror for 2 km Interferometer









End Station

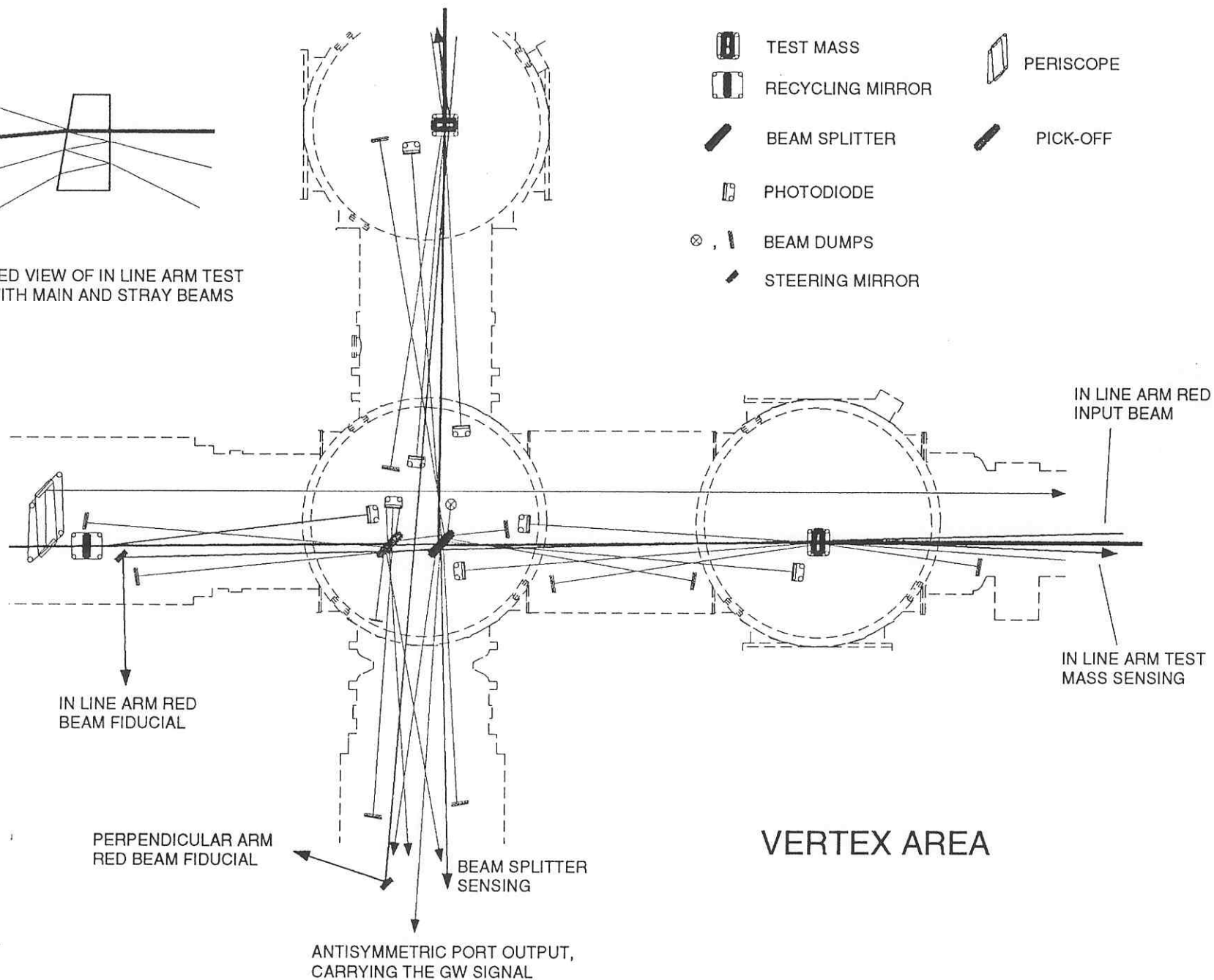


End Mirror for 4 km Interferometer



ENLARGED VIEW OF IN LINE ARM TEST MASS, WITH MAIN AND STRAY BEAMS

-  TEST MASS
-  RECYCLING MIRROR
-  BEAM SPLITTER
-  PHOTODIODE
-  BEAM DUMPS
-  STEERING MIRROR
-  PERISCOPE
-  PICK-OFF



DESIGN CONTRACT,
OPTICAL RESEARCH ASSOCIATES
(ORA)
(Code V, Light Tools)

PILOT PROJECT (3 mos)

1. Optical layout (geometric/Gaussian ray tracing) of main interferometer components and beams (3D)
2. Conceptual optical design for mode matching telescope (PSL to mode cleaner)
3. Beam splitter designs (multiple reflections)
4. Wedge angle design for main optics, including stray and monitor beams
5. System and subsystem response analysis to drifts, aberrations, and other imperfections.



DETECTOR EFFORT MANAGEMENT

- Implementation Plan (Detector Workbook)
 - ›› Policies and Procedures
 - ›› WBS
 - ›› Schedules, Cost Baselines (derived from integrated project cost/schedule system)
- Detector Handbook
- Technical Reports
- Milestones / Documentation
 - ›› Design Requirements Reviews (DRRs)
 - Design Requirements Document (DRD)
 - ›› Preliminary Design Reviews (PDRs)
 - ›› Proto Test Reviews
 - ›› Final Design Reviews (FDRs)
 - ›› Ist Article Test Reviews
 - ›› Preship Reviews

- Weekly Reports
- Weekly Detector Group Meetings
- Weekly meetings with Subsystem Task Leaders

- Weekly Project Control Meetings (3-mo. rolling status report)
- Project Management Control System

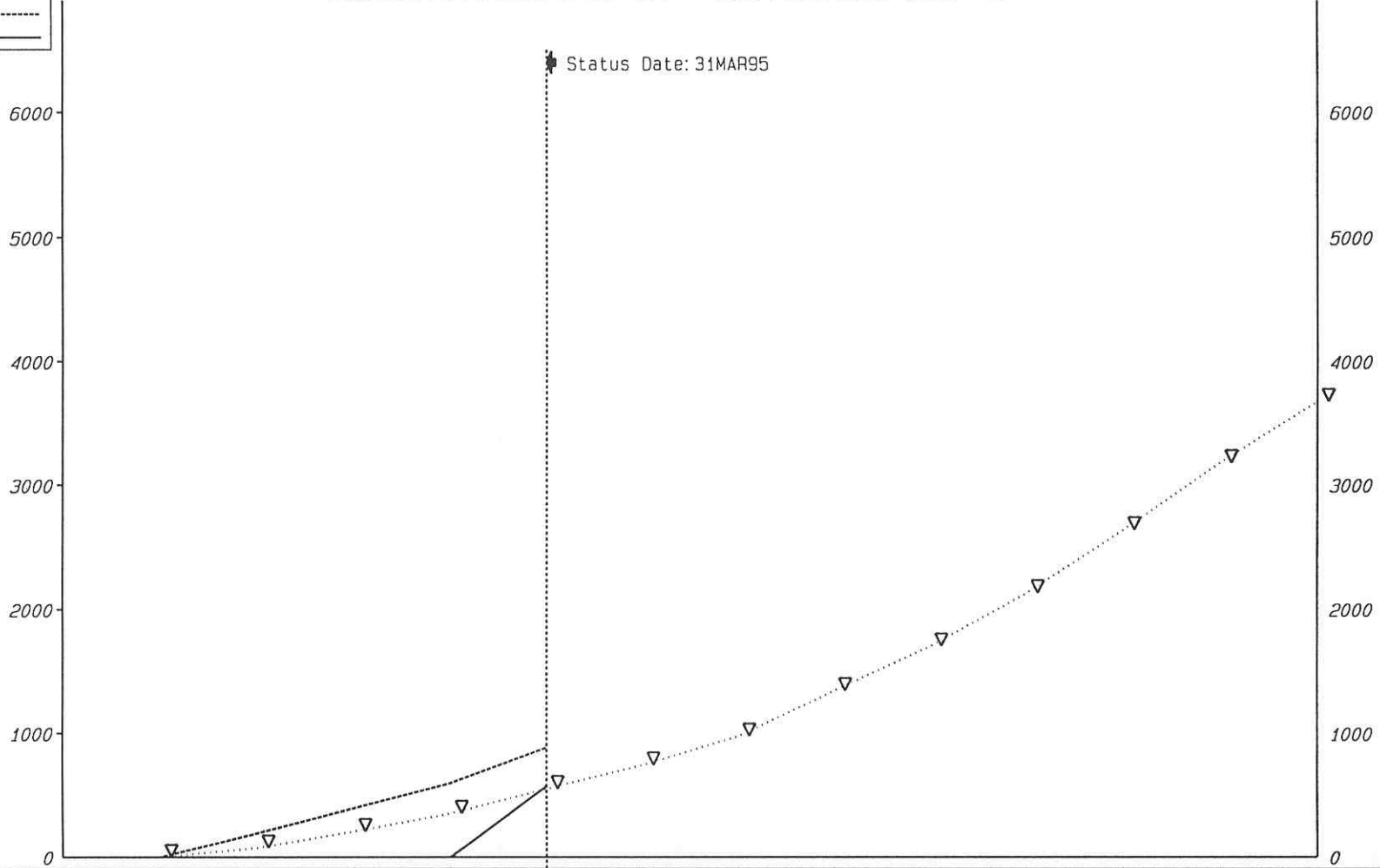


LEGEND

Bud▽.....▽.....▽.....▽
Per	—————
Act	—————
ETC	—————

Budget vs Performance vs Actual

Schedule Performance Index= 104 Cost Performance Index= 65



	FY94	DEC94	JAN95	FEB95	MAR95	APR95	MAY95	JUN95	JUL95	AUG95	SEP95	OCT95	NOV95	SCALE
Budget	0	75	211	354	553	745	978	1,342	1,704	2,132	2,635	3,179	3,675	K\$
Performance	0	0	0	0	577									K\$
Actual/Forecast	0	194	397	599	887									K\$
Schedule Variance	0	-75	-211	-354	24									K\$
Cost Variance	0	-194	-397	-599	-310									K\$

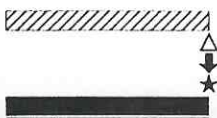
Schedule Variance = Perf-Budg Cost Variance = Perf-Actual Schedule Performance Index= Perf/Budg Cost Performance Index= Perf/Actual

*** Prepared by LIGO Project Controls Group ***

MILESTONE	SCHEDULED DATE ¹	LATE DATE ²
Imposed Project Milestones:		
WA Buildings Joint Occupancy		9/97
LA Buildings Joint Occupancy		3/98
WA Facility Ready	7/98	
LA Facility Ready	1/99	
Significant Detector Milestones:		
Detector Implementation Plan Approved	1/95	
CDS Design Requirements Review	10/95	
PSL Final Design Review	4/96	8/97
BSC/TMC Seismic Isolation Final Design Review	11/96	11/96
CDS Vacuum Controls Final Design Review	1/97	
HAM Seismic Isolation Final Design Review	11/96	12/96
Core Optics Support Final Design Review	10/96	11/96
Core Optics Components Final Design Review	12/96	1/97
Detector System Preliminary Design Review	7/97	1/97 ³
Input/Output Optics Final Design Review	1/97	6/97
CDS Data Acquisition Final Design Review	7/97	4/98
Length Sensing/Control Final Design Review	5/97	5/98
Alignment (Wavefront System) Final Design Review	9/97	11/97
CDS WA Site Vacuum/Control Area & Networking Systems Ready for Installation	9/97	9/97
Physical Environmental Monitor Final Design Review	6/98	6/98
Begin WA IFO Installation	7/98	7/98
Begin LA IFO Installation	1/99	1/99
¹ March 1995 baseline ² From LIGO Project Management Plan, LIGO-M950001-13-M, February 1995 ³ Change Request in process		

Table V-1: Detector Milestones

Finish: 01Apr95
 Time Now: 01Apr95
 Project: Untitled #1
 Run: 03May95
 Page: 1 of 1

Critical Milestone BaselineMS Progress


Prestabilized Laser Milestones



Open Plan Professional by Welcom Software

Activity ID	Activity Desc.	WBS	1994			1995				1996				1997				1998				1999				
			Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct	Jan
21120103	PSL DRR	1.2.1.1.2				▲06Feb95																				
						★06Feb95																				
22112015	PSL CDS DRR	1.2.2.1.01.02				▲06Feb95																				
						★06Feb95																				
21120107	PSL PDR	1.2.1.1.2					△04May95																			
							★04May95																			
22112025	PSL CDS PROTO INSTALLED IN OL	1.2.2.1.01.02					△01Jun95																			
							★01Jun95																			
22112050	PSL CDS PDR	1.2.2.1.01.02						△01Aug95																		
								★01Aug95																		
21120106	PSL PROTOTYPE TEST REVIEW	1.2.1.1.2						△01Nov95																		
								★01Nov95																		
22112036	PSL 40m TESTS COMPLETE	1.2.2.1.01.02							△26Jan96																	
									★26Jan96																	
21120109	PSL FDR	1.2.1.1.2							△17Apr96																	
									★17Apr96																	
22112065	PSL CDS FDR	1.2.2.1.01.02							△17Apr96																	
									★17Apr96																	
21120112	PSL 1ST ART. TEST REVIEW	1.2.1.1.2																△15Sep97								
																		★15Sep97								
21212114	WA4K PSL PRESHP REVIEW	1.2.1.2.1.2																	△02Mar98							
																			★02Mar98							
21222115	WA2K PSL PRESHP REVIEW	1.2.1.2.2.2																	△02Mar98							
																			★02Mar98							
21312116	LA4K PSL PRESHP REVIEW	1.2.1.3.1.2																	△02Mar98							
																			★02Mar98							

FSS Mode Select

OFF Auto Scan

LIA Mode Select

Auto Wideband Bypass

RCSM #1 X Correction

0 0 1

RCSM #1 Y Correction

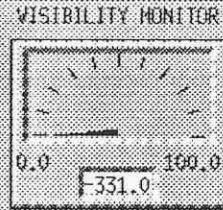
0 0 1

RCSM #2 X Correction

0 0 1

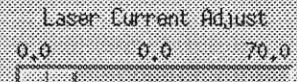
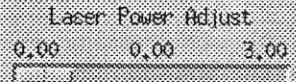
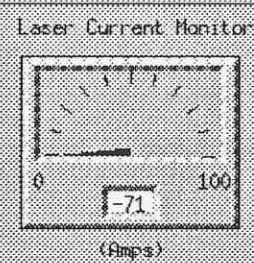
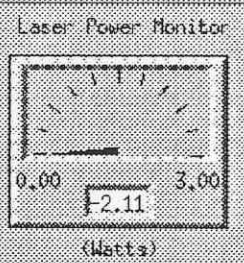
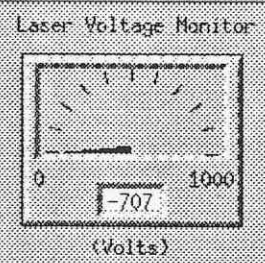
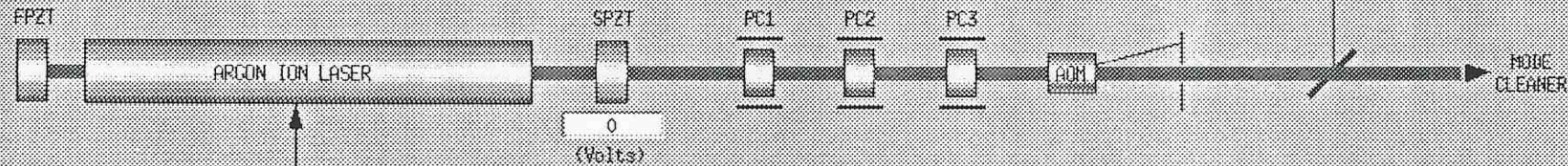
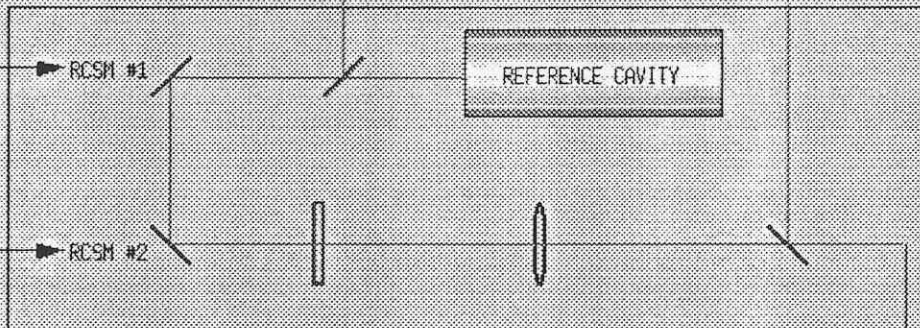
RCSM #2 Y Correction

0 0 1



RF PI

Reference PI



Laser Plasma

OFF ON

Control Mode

Power Current

PSA Mode Select

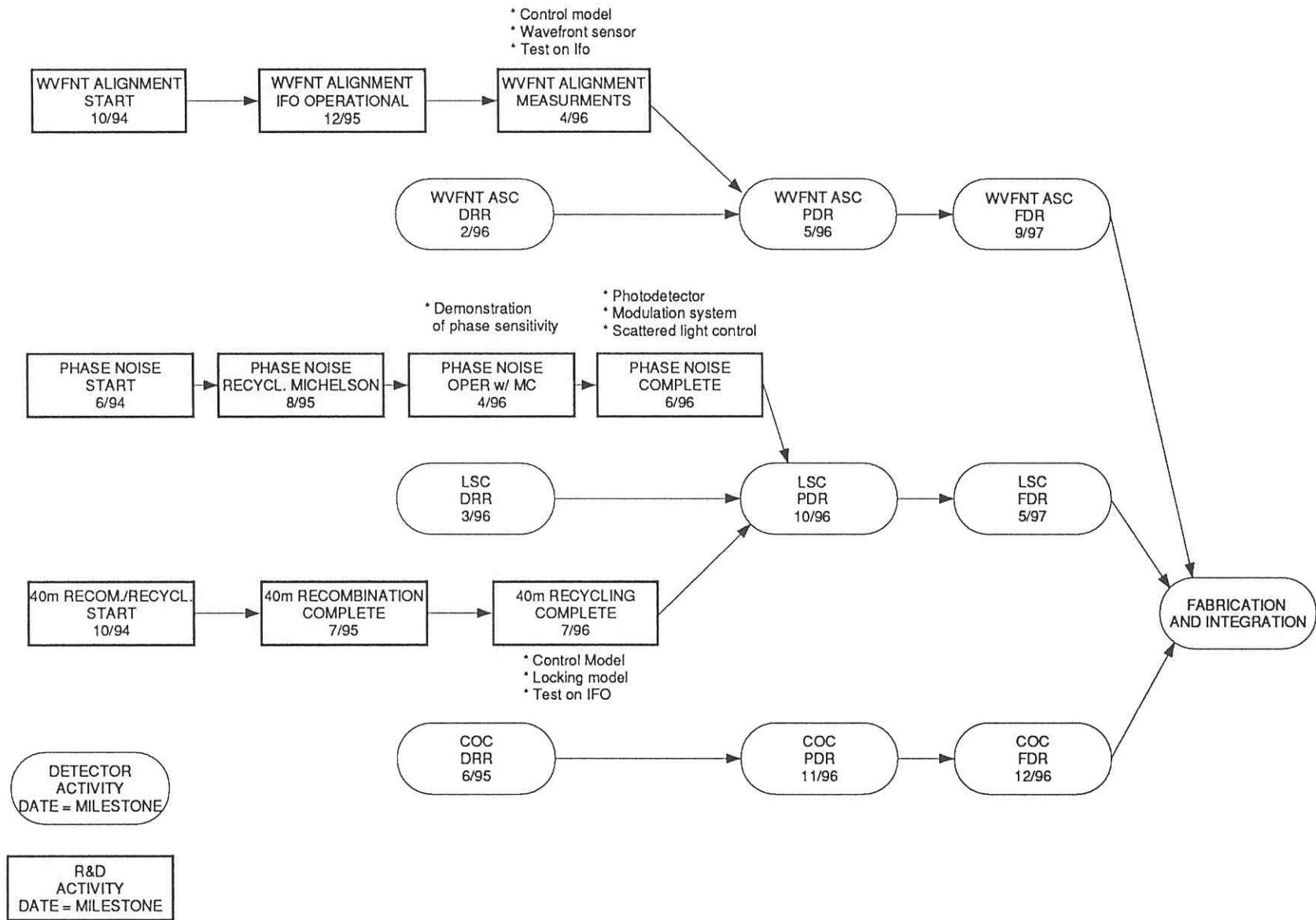
OFF ON Ringdown

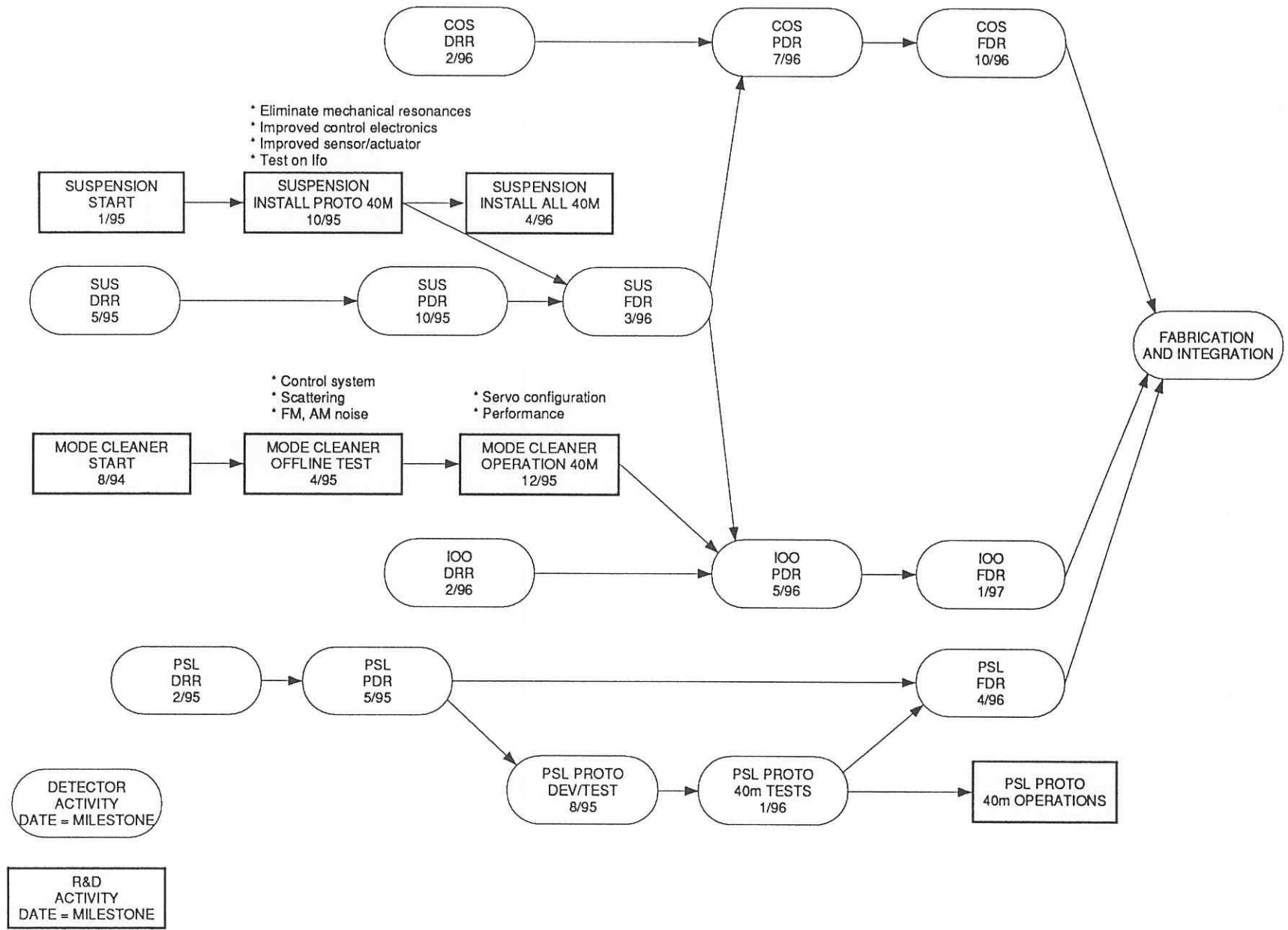
PSA Power Level Select

1	10	7	4
12	9	6	3
11	8	5	2

PSA Output Monitor

- Head Cover Intlk.
- Laser Low Water Flow
- Tube Fill Status
- Laser Key Switch
- Laser High H2O Temp.
- Regulator Fault





DETECTOR OPTIMIZATION INITIATIVES

- Seismic Isolation Design Optimization
 - ›› Weight reduction
 - ›› Replacement of viton springs with compound metal springs
- Substitution of frequency-doubled Nd-YAG laser for A⁺ laser (intermediate wavelength coating of optics?)
- Substitution of electrostatic control of suspended optics for magnetic control

DETECTOR STATUS

- Implementation Plan approved
- PSL & ASC Design Requirements Reviews completed
- SUS Design Requirements Review and PSL Preliminary Design Review imminent
- PSL prototype implementation on schedule
- Major optics subcontracts with industry initiated:
 - ››REO (coating)
 - ››CSIRO, HDOS (polishing)
- Seismic isolation stack optimization initiated
- Detector program continues on a schedule meeting installation milestones