



**SPECIFICATION**

TITLE

**LIGO Cavity Lengths and Core Optic Positions**

APPROVALS:	DATE	REV	DCN NO	BY	CHK	DCC	DATE
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CHECKED							
APPROVED:							
DCC RELEASE:							

*Version 1 change: Shifted the beamsplitter (BS) for the 4km interferometer so that the chief ray passes through the geometric center of the optic in order to maximize intrference contrast.*

**1.0 Scope**

This specification lists the locations of the LIGO core optics and cavity lengths for the as-built configuration. There are a number of technical documents which discuss the cavity length determination, ray tracing of the core optics and aproximate positions of the LIGO core optics. This is meant to e the definitive source of the final positions and cavity lengths.

**2.0 Reference Documents**

The following documents are reference information on the LIGO cavity lengths, modulation frequencies and core optic positions. This document superceeds these documents.

- T960122-00 M. Zucker, P. Fritschel, "Proposed initial detector MC and RC baseline lengths", 7/12/96.
- T960181-00 J. Camp, "Initial Length Precision of LIGO Suspended Cavities"
- T970068-00 D. Coyne, "recycling Cavity and Mode Cleaner Cavity Baseline Dimensions", 2/23/97.
- T970091-00 D. Coyne, "Determination of the Wedge Angles for the Core Optic Components", 3/28/97.
- T970156-03 D. Tanner, "LIGO Cavity Lengths and Modulation Frquencies", 3/17/98.
- E990083-A D. Rose, M. Smith, IFO COC and Beam Coordinate Data", 3/15/99.

**3.0 Core Optic Positions and Cavity Lengths**

The following pages contain the positions of the LIGO core optics in the global coordinae system. The notation is the same as in T970068 (in particular, see the layout sketches in the appendix).

COC positions from E990083-A and T970091-00:					<b>(OBSOLETE -- SEE AS_BUILT)</b>				
		positions (mm)				path			
description	point	x	y	z	n	reflection	refraction		
RM HR surface center	p3	12184	9060	43		0	0		
BS first surface center	p4	9162.6	9059.6	-14	1	3021.938	3021.938		
BS second surface center	p5	9116.1	9072.7	-14.8	1.44963		3091.979		
FMy HR surface center	p6	199.6	9072.4	-96.3	1		12008.85		
ITMy AR surface center	p7	199.6	9499.2	-98.2	1		12435.66	-0.00445	0.117304
ITMy HR surface center	p8	199.6	9598	-98.2	1.44963		12578.88		
FMx HR surface center	p9	9162.6	-199.6	-98.4	1	12281.52			
ITMx AR surface center	p10	9614.2	-199.6	-100.4	1	12733.13		-0.00443	0.116697
ITMx HR surface center	p11	9713	-199.6	-100.4	1.44963	12876.35			
						12876.35	12578.88	<b>error:</b>	
						<b>avg. RC cavity length =</b>	12727.61	2.61462	
						<b>RC asymmetry =</b>	297.4711	-2.5289	
Note: Compare to values in T970068-00. Lrc = 12725 mm and asymmetry = 300 mm.									

Revised ITMx_2k and ITMy_2k positions & ETM positions:						(AS_BUILT)				
ITM common correction	-27.6146									
ITM dif. correction	1.264448									
vertical correction	0.117304									
		positions (mm)				path				
<b>description</b>	<b>point</b>	<b>x</b>	<b>y</b>	<b>z</b>	<b>n</b>	<b>reflection</b>	<b>refraction</b>			
RM HR surface center	p3	12184.0	9060.0	43.0		0	0			
BS first surface center	p4	9162.6	9059.6	-14.0	1	3021.938	3021.938			
BS second surface center	p5	9116.1	9072.7	-14.8	1.44963		3091.979			
FMy HR surface center	p6	199.6	9072.4	-96.3	1		12008.85			
ITMy AR surface center	p7	199.6	<b>9470.3</b>	<b>-98.1</b>	1		12406.78			
ITMy HR surface center	p8	199.6	<b>9569.1</b>	<b>-98.1</b>	1.44963		12550			
FMx HR surface center	p9	9162.6	-199.6	-98.4	1	12281.52				
ITMx AR surface center	p10	<b>9587.8</b>	-199.6	<b>-100.3</b>	1	12706.78				
ITMx HR surface center	p11	<b>9686.6</b>	-199.6	<b>-100.3</b>	1.44963	12850				
						12850	12550			
						avg. RC cavity length =		12700		
						RC asymmetry =		300		
Note: Compare to recycling cavity length in P. Fritschel's 6/8/99 email, Lrc = 12700 mm										
Larm	2009120									
ETMy HR surface center		199.6	2018689.1	-98.1						
ETMx HR surface center		2018806.6	-199.6	-100.3						

COC positions from E990083-A for the 4km interferometer:						<b>(OBSOLETE -- SEE AS_BUILT)</b>			
		positions (mm)					path		
description	point	x	y	z	n	reflection	refraction		
RM HR surface center	p3	-4596	212	26		0	0		
BS first surface center	p4	-199.4	212.6	-57	1	4397.383	4397.383		
BS second surface center	p5	-152.9	199.5	-57.8	1.44963		4467.425		
ITMy AR surface center	p8	-199.4	4713.5	-98.2	1	8898.472		-0.00915	
ITMy HR surface center	p9	-199.4	4811	-98.2	1.44963	9039.811			
ITMx AR surface center	p6	4579.5	199.5	-101	1		9200.022	-0.00913	
ITMx HR surface center	p7	4677	199.5	-101	1.44963		9341.361		
						9039.811	9341.361	<b>error:</b>	
						<b>avg. RC cavity length =</b>	9190.586	6.55137	
						<b>RC asymmetry =</b>	301.5499	1.549895	
Notes: (1) Compares well (to within ~1mm) with T970091-00; E990083-A is a refinement of the calculations of T970091-00.									
(2) Compare to values in T970068-00. Lrc = 9191 mm and asymmetry = 300 mm.									
(3) Compare to values in T970156-03: Lrc = 9188 mm.									

Revised ITMx_4k and ITMy_4k positions and ETM positions:						(AS_BUILT)	
N.B.: These COC positions are for Lrc=9184.0 mm, Lmc=12245.4 mm, Larm=3995055 mm and f=24482 Hz							
ITM common correction	-6.55137						
ITM dif. correction	-0.77495						
vertical correction	0.067063						
		positions (mm)				path	
<b>description</b>	<b>point</b>	<b>x</b>	<b>y</b>	<b>z</b>	<b>n</b>	<b>reflection</b>	<b>refraction</b>
RM HR surface center	p3	-4596.0	212.0	26.0		0	0
BS first surface chief ray intercept	p4	-199.4	212.6	-57.0	1	4397.383	4397.383
BS second surface chief ray intercept	p5	-152.9	199.5	-57.8	1.44963		4467.425
<b>BS front face center</b>	<b>pc</b>	<b>-193.2</b>	<b>223.1</b>	<b>-57.2</b>			
ITMy AR surface center	p7	-199.4	<b>4707.7</b>	<b>-98.1</b>	1	8892.695	
ITMy HR surface center	p8	-199.4	<b>4805.2</b>	<b>-98.1</b>	1.44963	9034.034	
ITMx AR surface center	p10	<b>4572.2</b>	199.5	<b>-100.9</b>	1		9192.695
ITMx HR surface center	p11	<b>4669.7</b>	199.5	<b>-100.9</b>	1.44963		9334.034
						9034.034	9334.034
						avg. RC cavity length = 9184.034	
						RC asymmetry = 300.0001	
<b>Note: The BS is positioned so that the chief ray passes through the optic geometric center in order to maximize interference contrast.</b>							
Larm	3995055						
ETMy HR surface center		-199.4	3999860.2	-98.1			
ETMx HR surface center		3999724.7	199.5	-100.9			
BSCy center		0	4000000				
BSCx center		4000000	0				
(ETM-BSC center)y		-199.4	-139.8				
(ETM-BSC center)x		-275.3	199.5				
zero asymmetry:							
(ETM-BSC center)y		-199.4	10.2				
(ETM-BSC center)x		-425.3	199.5				
max asymmetry:	280	580					
(ETM-BSC center)y		-199.4	-419.8				
(ETM-BSC center)x		-145.3	199.5				

n	2								
k	1								
m	652								
Lrc	9184.034								
Lmc	12245.38								
f	24481.89								