

LIGO Laboratory / LIGO Scientific Collaboration

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Advanced LIGO

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Degenerate RC Core Optics Position & Orientation
(Some revisions to T010076)

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Abstract

The positions and orientations of the Core Optical components for Advanced LIGO non-folded and folded degenerate recycling cavity interferometers have been determined using ZEMAX optical design program. For the non-folded IFO, a symmetric wedge angle of 2.0000 deg was placed on the BS optic in order to achieve the required clearance between the closest extent of the BS PO mirror assembly and the 100ppm radius of the main interferometer beam within the recycling cavity.

1 Introduction

The positions and orientations of the Core Optical components for Advanced LIGO degenerate recycling cavity have been determined using ZEMAX optical design program.

1.1 Background

Coyne has previously established the positions and orientations of the optical elements in the optical train of the Advanced LIGO interferometer. The driving parameter that determines the required wedge angle on the BS optic is the clearance of the BS PO beam above the main beam at the location of the BS PO mirror on BSC3 chamber. A symmetric wedge angle of 2.0000 deg was placed on the BS optic In order to achieve a required clearance $> 30\text{mm}$ measured between the closest extent of the BS PO mirror assembly and the 100ppm radius of the main interferometer beam within the recycling cavity, which is 128.8 mm. The prior BS wedge angle assumed by Coyne was 1.3000 deg.

1.2 Scope

The wedge angles, positions, and orientations of the optical elements listed in this document are based on the following assumptions:

Degenerate recycling cavity

Minimum clearance between BS PO assembly and main RC beam @ 100 ppm radius	30 mm
Global height of x-arm beam	80 mm
Wedge of compensation plate	negligible
Height of MMT3 and PRM	nominally equal
Length of PRC	8341 mm
Length of SRC	8327 mm
Schnoop asymmetry	400 mm

1.3 Referenced Documents

T010076-01 Optical Layout for Advanced LIGO, D. Coyne

2 Non-folded IFO

2.1 RC Optics Position & Orientation, Degenerate Cavity

Table 5: RC Core Optics Position & Orientation, Degenerate Cavity

CHAMBER	Optic	SURFACE	CENTERLINE COORDINATE				SURFACE ORIENTATION			
			Pt	X (mm)	Y (mm)	Z (mm)	n	i	j	k
non-fold #1										
HAM1	DLC2 OPTLEV SM1	HR	p18	22691.9	-77.8	100.7	n18	0.769400	0.638768	0.000000
HAM2	DLC1	HR	p01	20356.9	-413.5	100.2	n01	0.707042	0.707172	0.000000
	DLC2	HR	p02	20356.8	-905.1	100.2	n02	0.707107	0.707107	0.000000
	DLC3	HR	p03	20085.1	-905.1	100.2	n03	0.693398	0.720555	0.000061
	MC1	AR	p04	20079.1	-749.3	100.2	n04	0.685864	0.727730	0.000436
	MC1	HR	p05	20055.4	-668.5	100.2	n05	0.710844	0.703350	0.000436
	MC3	HR	p06	20050.0	-219.3	100.2	n06	0.693590	0.720369	0.000436
	MC3	AR	p07	20071.7	-138.0	100.2	n07	0.668027	0.744137	0.000436
	SM1	HR	p08	20084.3	764.4	100.3	n08	0.378487	0.925607	0.000000
	SM2	HR	p09	19645.3	304.8	100.4	n09	0.870402	0.492342	0.000000
	MMT1	HR	p010	20740.9	551.1	100.5	n010	0.994461	0.105110	0.000367
	MMT3	HR	p011	19338.7	221.5	156.5	n011	0.999920	0.012430	0.002147
	MMT3	AR	p012	19238.7	221.6	156.4	n012	0.999991	0.003744	0.002147
	DLC1 OPTLEV SM1	HR	p013	19890.5	442.4	100.7	n013	0.913545	0.406737	0.000000
	DLC OPTLEV MC1	HR	p014	20634.8	-761.7	-95.0	n014	0.719340	0.694658	0.000438
	DLC MCR	HR	p015	20559.5	-680.8	100.5	n015	0.850811	0.525472	0.000000
	DLC1 OPTLEV MC3	HR	p016	19703.8	-294.3	-94.0	n016	0.882948	0.469472	0.000438

	DLC2 OPTLEV MC3	HR	p017	-	19614.3	-414.3	-93.8	n017	0.770513	-	0.637424	0.000000
	DLC3 OPTLEV MC3	HR	p018	-	19904.7	-512.8	-92.6	n018	0.543942	-	0.837597	0.050593
	DLC REFL	HR	p019	-	19813.8	238.4	100.4	n019	0.767165	-	0.641450	0.000438
	DLC1 MON1	HR	p020	-	19926.2	903.5	100.4	n020	0.642788	-	0.766044	0.000438
	DLC2 MON1	HR	p021	-	19635.9	797.5	100.2	n021	0.972776	-	0.231748	0.000438
	DLC3 MON1	HR	p022	-	20598.5	-230.1	-99.3	n022	0.398749	-	0.917060	0.000000
	DLC1 MON2	HR	p023	-	20488.9	385.1	100.5	n023	0.461749	-	0.887011	0.000438
	DLC1 MON3	HR	p024	-	20233.7	755.1	100.4	n024	0.887815	-	0.460200	0.000438
	DLC2 MON3	HR	p025	-	20588.9	754.3	100.6	n025	0.707107	-	0.707107	0.000438
	DLC3 MON3	HR	p026	-	20590.3	149.4	100.7	n026	0.707107	-	0.707107	0.000438
	DLC1 OPTLEV MMT1	HR	p027	-	19448.3	219.7	161.9	n027	0.614873	-	0.787002	0.050593
	DLC2 OPTLEV MMT1	HR	p028	-	19443.6	549.3	146.5	n028	0.707973	-	0.704030	0.055822
	DLC HEAT MMT2	HR	p029	-	20480.1	656.9	-91.3	n029	0.620819	-	0.783954	0.000070
HAM3	MC2	HR	p030	-	-3588.5	-643.0	-88.4	n030	0.999927	-	0.012098	0.000611
	MMT2	HR	p031	-	-3893.0	728.0	-90.0	n031	0.999762	-	0.021658	0.002443
	PRM1	AR	p2	-	-3809.0	219.3	156.7	n2	0.999979	-	0.000152	0.006418
	PRM1	HR	p3	-	-3709.0	219.3	156.9	n3	0.999998	-	0.000152	0.002003
	DLC1 OPTLEV MC2	HR	p032	-	-4289.9	-716.4	100.9	n032	0.999048	-	0.043619	0.000438
	DLC2 OPTLEV MC2	HR	p033	-	-3845.3	-716.6	101.0	n033	0.998365	-	0.054594	0.016929
	DLC1 OPTLEV SM2	HR	p034	-	19725.6	471.3	-94.2	n034	0.172961	-	0.980909	0.088894

	DLC2 OPTLEV SM2	HR	p035	-	22382.7	-74.3	-98.1	n035	0.804894	-	0.593419	0.000000
	DLC1 OPTLEV MMT2	HR	p036	-4382.3	769.3	110.4	-	n036	0.698767	-	0.713558	0.050593
	DLC2 OPTLEV MMT2	HR	p037	-4376.0	-500.8	241.7	-	n037	0.717542	-	0.694133	0.057564
	DLC HEAT MMT3	HR	p038	-3554.7	551.9	-91.3	-	n038	0.804894	-	0.593419	0.000070
	ITMY HARTMANN M1	HR	p039	-2685.2	-234.5	148.8	-	n039	0.700534	-	0.695660	0.159089
	ITMY HARTMANN M2	HR	p040	-2677.6	162.1	58.1	-	n040	0.706161	-	0.701542	0.095794
	ITMY HART TELE M1	HR	p041	-4550.0	-248.7	101.2	-	n041	1.000000	-	0.000000	0.000000
	ITMY HART TELE M2	HR	p042	-4607.1	-248.9	101.3	-	n042	0.706922	-	0.707292	0.000436
	ITMY HART STEER 1	HR	p043	-4366.4	60.1	106.6	-	n043	0.707107	-	0.707107	0.000000
	ITMY HART STEER 2	HR	p044	-4708.5	-252.2	101.5	-	n044	0.865919	-	0.499938	0.015707
	ITMY HART STEER 3	HR	p045	-4366.5	60.0	100.8	-	n045	0.707107	-	0.707107	0.000000
	BD BSHR3P MIRROR	HR	p046	-4705.8	-247.6	100.8	-	n046	0.865919	-	0.499938	0.015707
HAM4	SRM1	HR	p10	-180.9	-3536.0	157.8	-	n10	0.000151	-	0.999998	0.001982
	SRM1	AR	p11	-180.9	-3636.0	157.6	-	n11	0.000152	-	0.999980	0.006398
	OMMT2	HR	p21	204.1	-3670.0	156.3	-	n21	0.015800	-	0.999874	0.001586
	OMMT3	HR	p22	80.0	20600.0	101.1	-	n22	0.047455	-	0.998872	0.001693
	OMMT3	AR	p23	80.5	20650.0	100.9	-	n23	0.047455	-	0.998872	0.001693
	BS PO MIRROR2	HR	p047	598.3	-4316.0	101.3	-	n047	0.043500	-	0.998813	0.021900
	BSPO STEER M1	HR	p048	597.6	-3214.6	-99.7	-	n048	0.707107	-	0.707107	0.000000
	BSPO STEER M2	HR	p049	448.9	-3214.5	-99.7	-	n049	0.703395	-	0.710799	0.000000

	ITMX HARTMANN M1	HR	p050	-597.1	-2695.1	148.1	n050	0.000111	0.707107	0.707107
	ITMX HARTMANN M2	HR	p051	-597.2	-2695.2	416.8	n051	0.707107	0.000000	0.707107
	ITMX HARTMANN M3	HR	p052	-144.2	-2695.2	416.7	n052	0.705828	0.705754	0.060979
	ITMXPO TELE M1	HR	p053	-598.5	-4288.2	148.5	n053	0.000098	0.996149	0.087680
	ITMXPO TELE M2	HR	p054	-598.6	-2889.3	-99.8	n054	0.000724	0.996188	0.087228
	ITMXPO STEER M1	HR	p055	-598.1	-4514.5	100.8	n055	0.706693	0.707520	0.000000
	ITMX HART STEER M1	HR	p056	-346.8	-3833.2	101.0	n056	0.707107	0.707107	0.000000
	ITMX HART STEER M2	HR	p057	-345.3	-4514.3	101.0	n057	0.708155	0.706057	0.000454
	ITMXPO STEER M2	HR	p058	491.7	-4516.5	101.6	n058	0.712026	0.702153	0.000000
HAM5	OMMT1	HR	p20	-178.5	19430.0	157.7	n20	0.012061	0.999927	0.000047
BSC1	BS PO MIRROR1	HR	p059	-131.5	4123.1	251.1	n059	0.000000	0.000000	0.000000
	CPy	front	p18	-200.2	4610.4	-86.9	n18	0.000000	0.999840	0.017889
	CPy	back	p19	-200.2	4675.4	-85.8	n19	0.000000	0.999813	0.019342
	ITMY	AR	p8	-200.2	4731.1	-84.8	n8	0.000000	0.999298	0.037465
	ITMY	HR	p9	-200.2	4931.2	-84.8	n9	0.000000	1.000000	0.000000
BSC2	BS1	BS	p4	-200.2	218.8	163.9	n4	0.707039	0.707039	0.013812
	BS1	AR-x	p5	-134.1	200.0	164.4	n5	0.706268	0.706268	0.048700
	BS1	AR-aps	p5p	-134.1	200.0	164.4	n5n	0.706268	0.706268	0.048700
BSC3	CPx	front	p16	4558.0	200.0	-82.1	n16	0.999840	0.000000	0.017889
	CPx	back	p17	4623.0	200.0	-80.9	n17	0.999813	0.000000	0.019342

	ITMX	AR	p6	4678.7	200.0	-80.0	n6	0.999298	0.000000	0.037465
	ITMX	HR	p7	4878.8	200.0	-80.0	n7	1.000000	0.000000	0.000000
BSC9	ETMX	HR	p12	18100.0	200.0	-80.0	n12	1.000000	0.000000	0.000000
	ETMX	AR	p13	18200.0	200.0	-80.0	n13	0.999962	0.000000	0.008727
BSC10	ETMY	HR	p14	-200.2	18000.0	-84.8	n14	0.000000	1.000000	0.000000
	ETMY	AR	p15	-200.2	18200.0	-84.8	n15	0.000000	0.999962	0.008727

2.2 RC Core Optics Ray Parameters, Degenerate Cavity

Table 6: RC Core Optics Ray Parameters

CHAMBER	Description	Surface	Ray	RAY UNIT VECTOR (direction cosines)		
				i	j	k
HAM2	MC1	AR	u04	0.038215	0.999270	-0.000084
	MC1	HR	u05	0.012137	0.999926	-0.000092
	MC3	HR	u06	0.012137	0.999926	-0.000092
	MC3	AR	u07	-0.013952	0.999903	-0.000100
	MMT3	HR	u011	-0.999452	-0.032828	-0.004309
	MMT3	AR	u012	1.000000	-0.000151	-0.000017
HAM3	MMT2	HR	u031	-0.999562	-0.029361	-0.003730
	PRM1	AR	u2	1.000000	-0.000151	-0.000017
	PRM1	HR	u3	0.999998	-0.000151	-0.002004
HAM4	SRM1	HR	u10	0.000152	-0.999998	0.001983
	SRM1	AR	u11	0.000152	-1.000000	-0.000004
HAM5	CPy	front	u18	0.000000	0.999846	0.017531
	CPy	back	u19	0.000000	0.999858	0.016877
	ITMY	AR	u8	0.000000	0.999858	0.016877
	ITMY	HR	u9	0.000000	1.000000	-0.000001
BSC2	BS1	BS	u4	0.999998	-0.000151	-0.002004
	BS1	AR-x	u5	0.999846	0.000000	0.017532
	BS1	AR-aps	u5u	0.000152	-0.999998	0.001983
BSC3	CPx	front	u16	0.999846	0.000000	0.017532
	CPx	back	u17	0.999858	0.000000	0.016877
	ITMX	AR	u6	0.999858	0.000000	0.016877
	ITMX	HR	u7	1.000000	0.000000	0.000000
BSC9	ETMX	HR	u12	1.000000	0.000000	0.000000
	ETMX	AR	u13	0.999992	0.000000	0.003927
BSC10	ETMY	HR	u14	0.000000	1.000000	-0.000001
	ETMY	AR	u15	0.000000	0.999992	0.003927

2.3 RC Core Optics Wedge Angles, Degenerate Cavity

Table 6: RC Core Optics Wedge Angles

Interferometer	Optic	WEDGE	
		Angle (Deg)	Orientation of thick side
Non-folded, unstable (#1)			
	MC1	2.0000 symmetric	away from MC2
	MC3	2.0000 symmetric	away from MC2
	MMT3	0.5000 symmetric	+y direction
	PRM1	0.2530 symmetric	down
	SRM1	0.2530 symmetric	down
	BS1	2.0000 symmetric	up
	ITM1	2.14708 symmetric	down
	CP	0.0833 single sided	down
	ETM	0.5000 single sided	up

3 Folded IFO

3.1 RC Optics Position & Orientation, Degenerate Cavity

3.2 RC Core Optics Ray Parameters, Degenerate Cavity

3.3 RC Core Optics Wedge Angles, Degenerate Cavity