Advanced LIGO Optical Layout Status

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17 March 2004

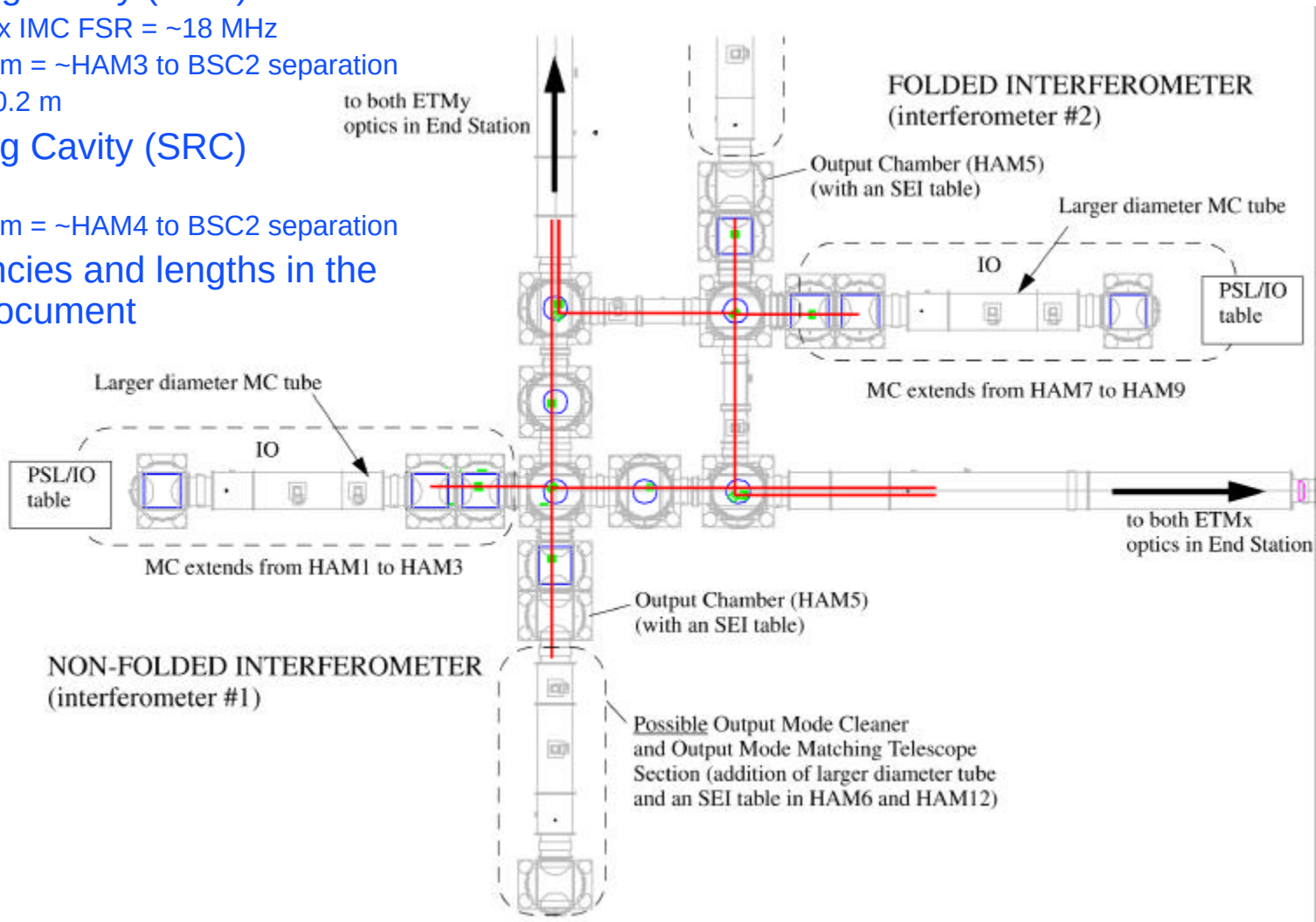
LSC Meeting at LLO

Summary, Issues, Limitations

- Folded interferometer layout pending
  - » Integrated FM/ITM is a challenge
- Active thermal compensation system
  - » Working baseline is CP incorporated into the ITM reaction chain
- Non-wedged ITMs?
  - » VIRGO's approach, but not (yet) established as OK
- Horizontal Wedges?
  - » May be possible if a single RC pick-off is sufficient
- Recycling cavity pick-off beams?
  - » 3 in initial LIGO: ITMx, ITMy, BS
  - » 2 possible for vertical wedges (ITMx, BS)
  - » 1 seems possible for horizontal wedges (need to complete the layout)
- Clearances & mass margins are tight!
  - » Requires close coordination between groups & iteration in layout & subsystem design; can't a' priori define a set of immutable requirements
  - » Requires coupled structural dynamics analysis of all payloads attached to the SEI
  - » Requires Systems maintenance of mass property contingency
  - » Planning to migrate from AutoCad (2D) to SolidWorks (3D) to facilitate

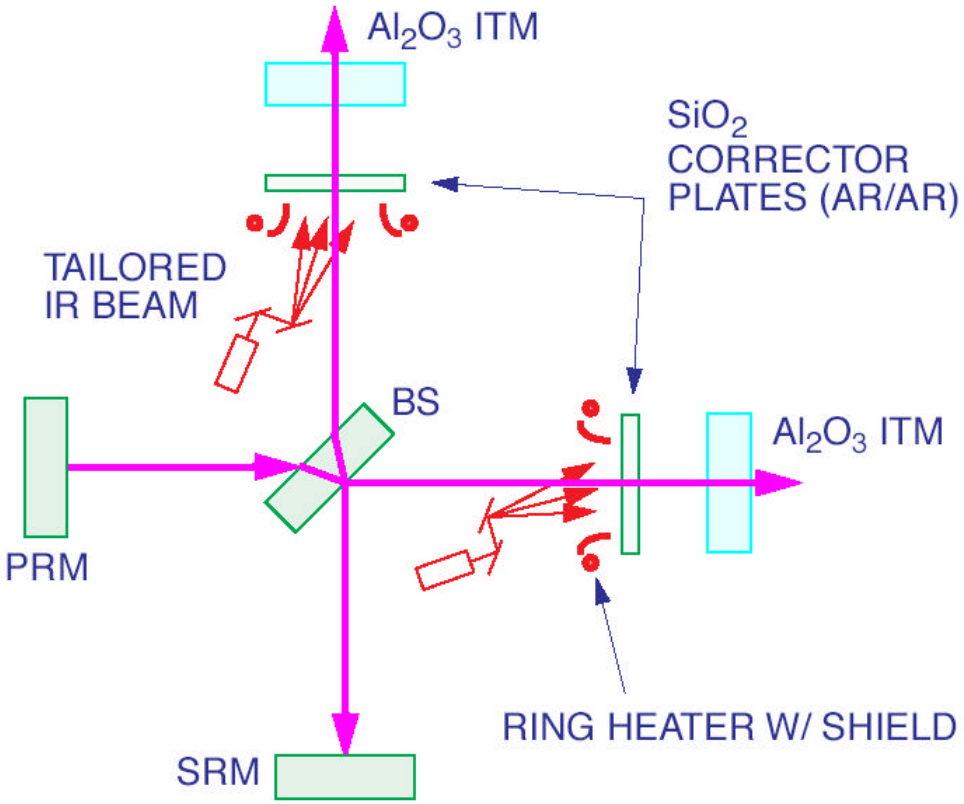
Optical Layout Plan View

- Input Mode Cleaner (IMC)
  - » IMC FSR = ~9 MHz
  - » Length = ~16.6 m = ~HAM1 to HAM3 separation
- Power Recycling Cavity (PRC)
  - » PRC FSR = 2 x IMC FSR = ~18 MHz
  - » Length = ~8.3 m = ~HAM3 to BSC2 separation
  - » Asymmetry = 0.2 m
- Signal Recycling Cavity (SRC)
  - » f = 180 MHz
  - » Length = ~8.4 m = ~HAM4 to BSC2 separation
- Precise frequencies and lengths in the optical layout document
  - » T010076-01



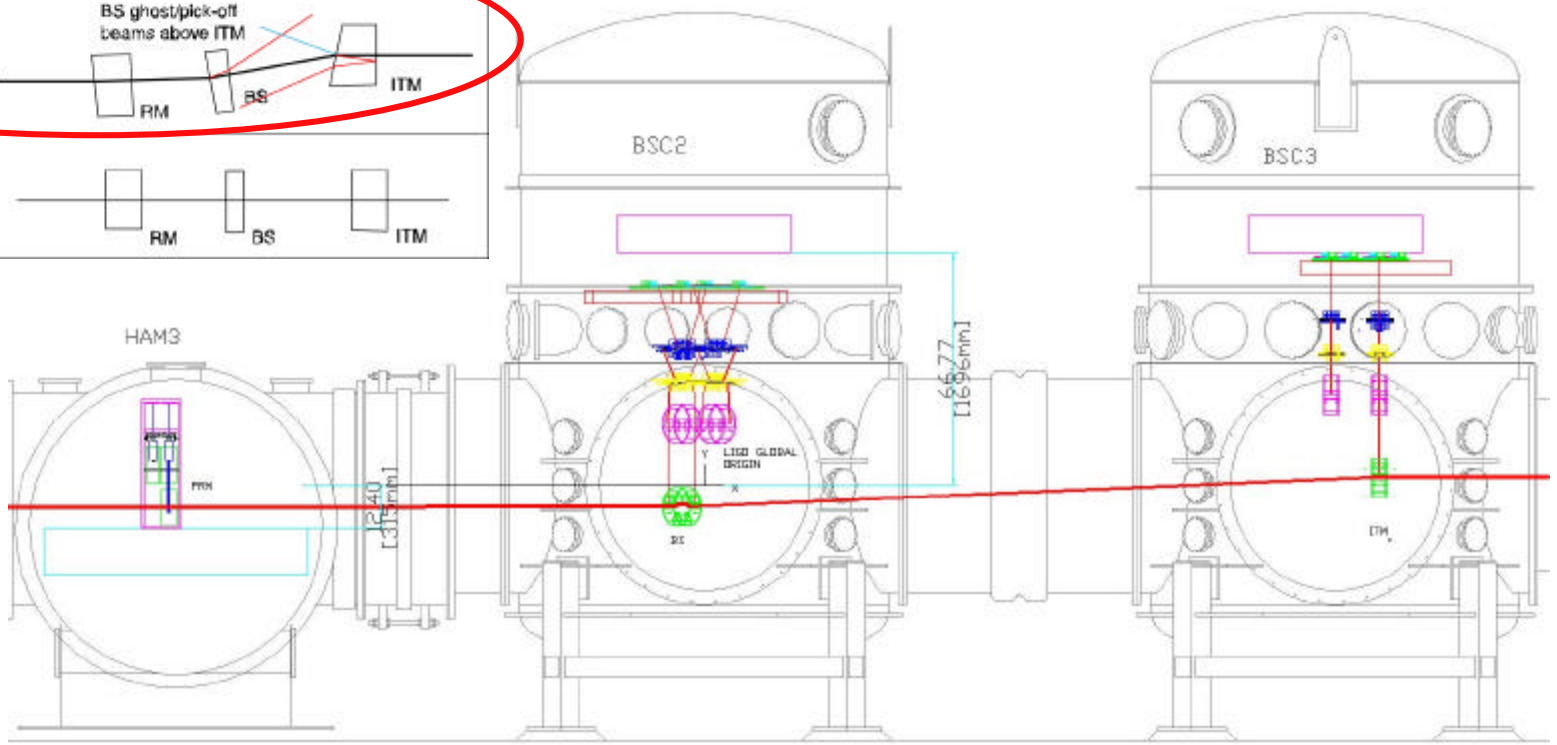
Active Thermal Compensation Configuration

- All ATC actuation on SiO2 Phase Plates
- May derive recycling cavity pickoff beams from wedged phase plates (rather than wedged ITMs)



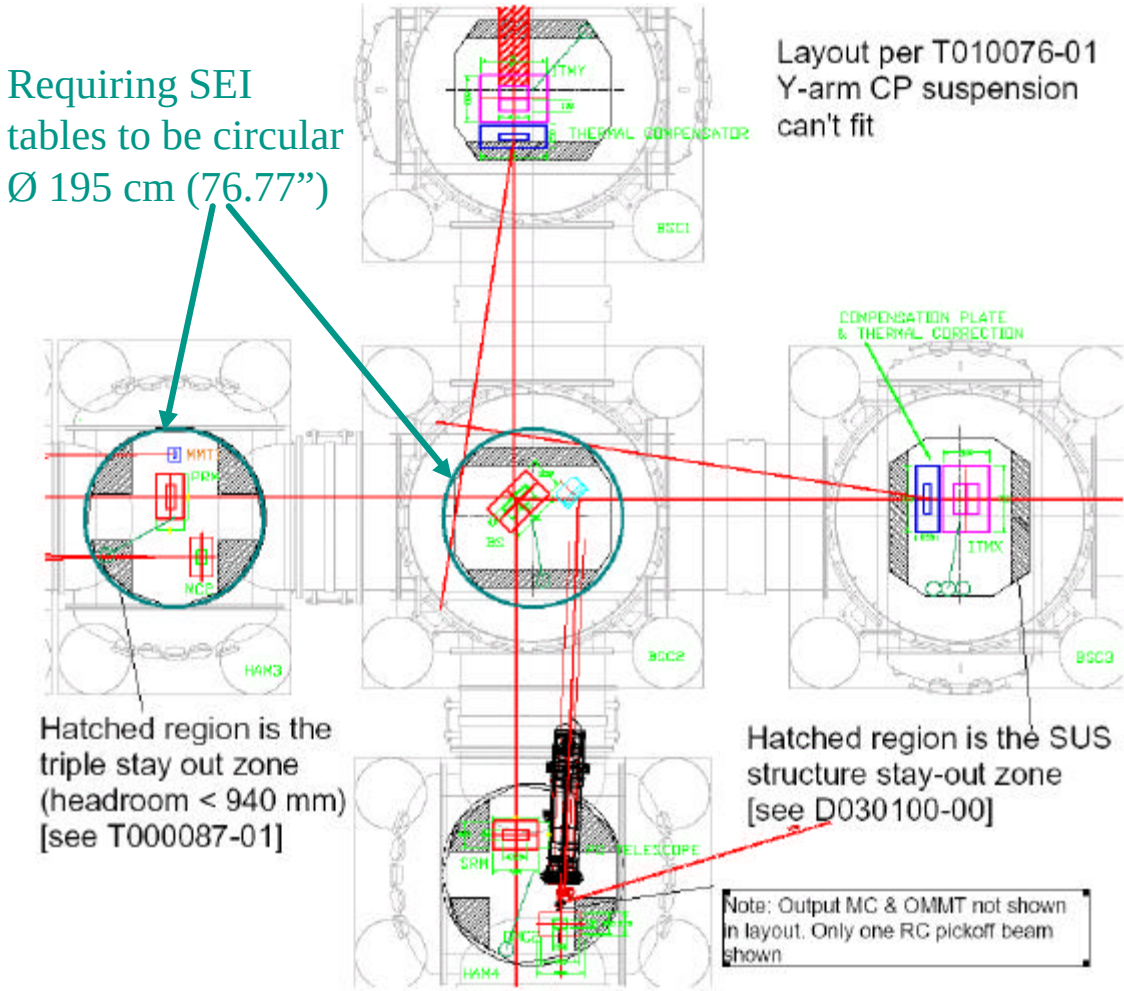
Vertical Wedge Options

#	Case	*Refracted Path Schematic, elevation view (BS rotated into the plane and angles exaggerated for clarity)*
1	Vertical Wedges: ITM & BS with thick sides up **(like LIGO-1)**	RM, BS, ITM
2	Vertical Wedges: ITM with thick side up, BS with thick side down	RM, BS, ITM; BS ghost/pick-off beams below ITM
3	Vertical Wedges: ITM and BS with thick sides down	RM, BS, ITM
4	Vertical Wedges: ITM with thick side down, BS with thick side up **(current baseline for advanced LIGO)**	BS ghost/pick-off beams above ITM; RM, BS, ITM
5	Horizontal Wedges (left/right orientation will matter due to handiness associated with the folded and non-folded interferometers)	RM, BS, ITM

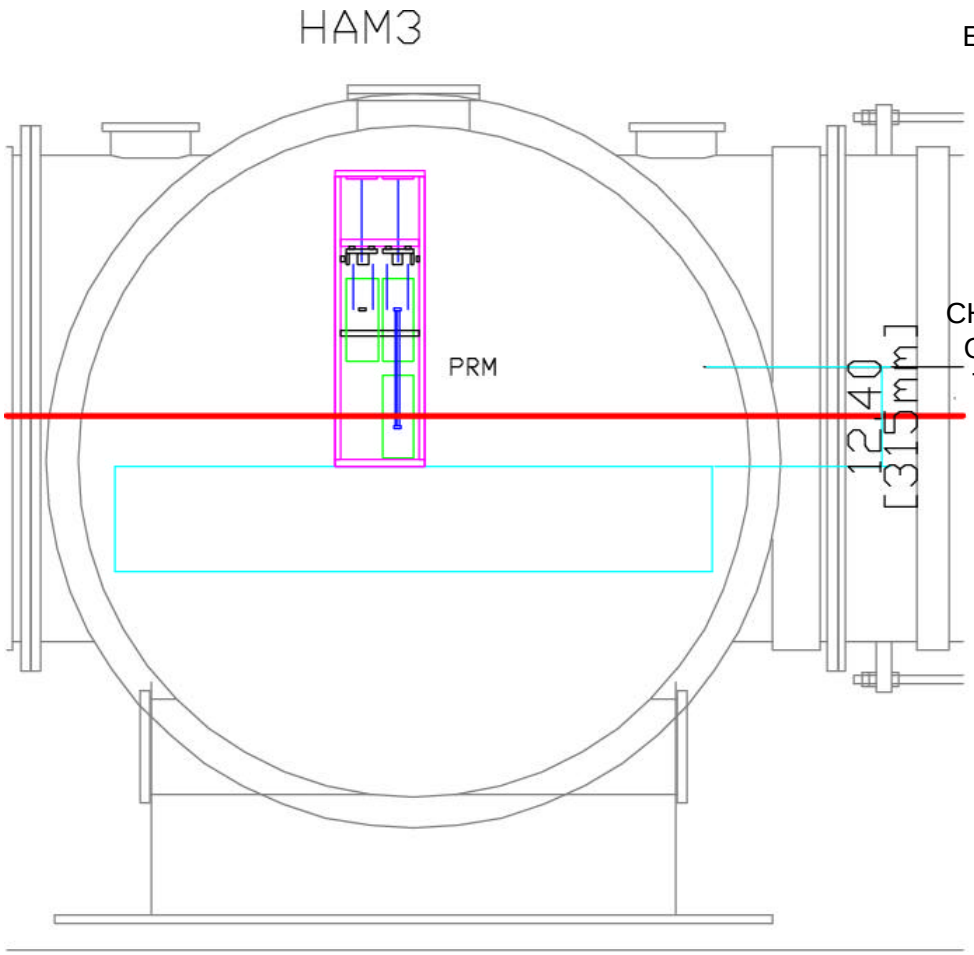


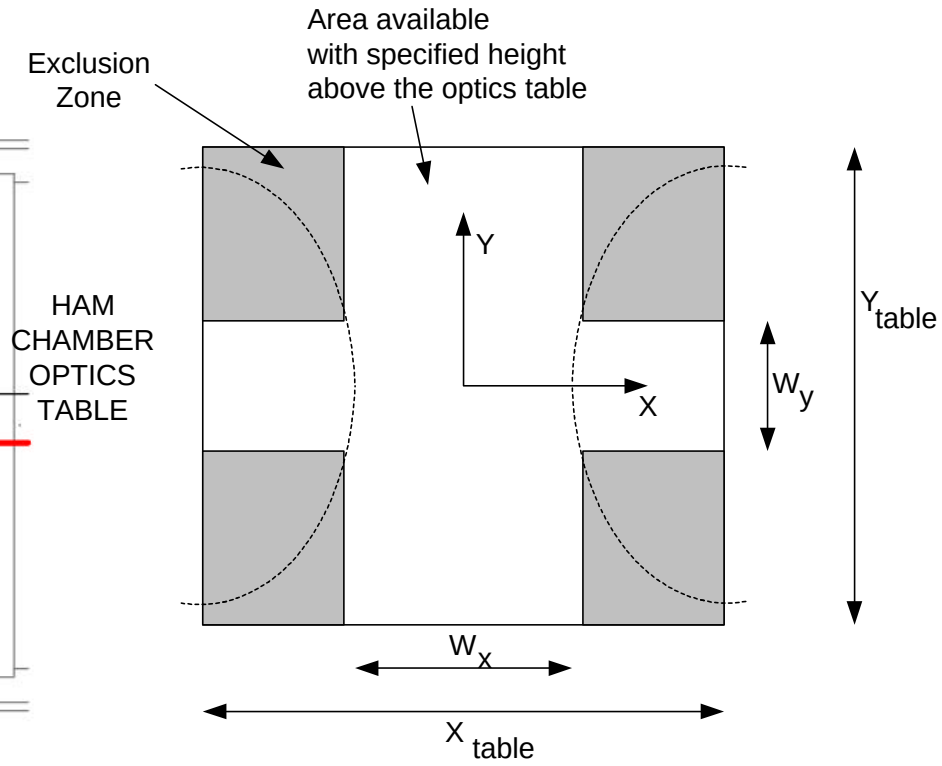
Recycling Cavities

- Separate Compensation Plate (CP) Suspensions
  - » Can move PRM & SRM closer to BS & ITMs farther from BS to accommodate
  - » Adds cost, weight and takes up precious table area
- CP integrated into ITM reaction chain (current "working baseline")
  - » Better layout; Permits Pickoff mirrors on ITMy table
  - » Derive pickoff beam from the (wedged) CP
  - » AOS group reviewing for technical viability
  - » Decision in April



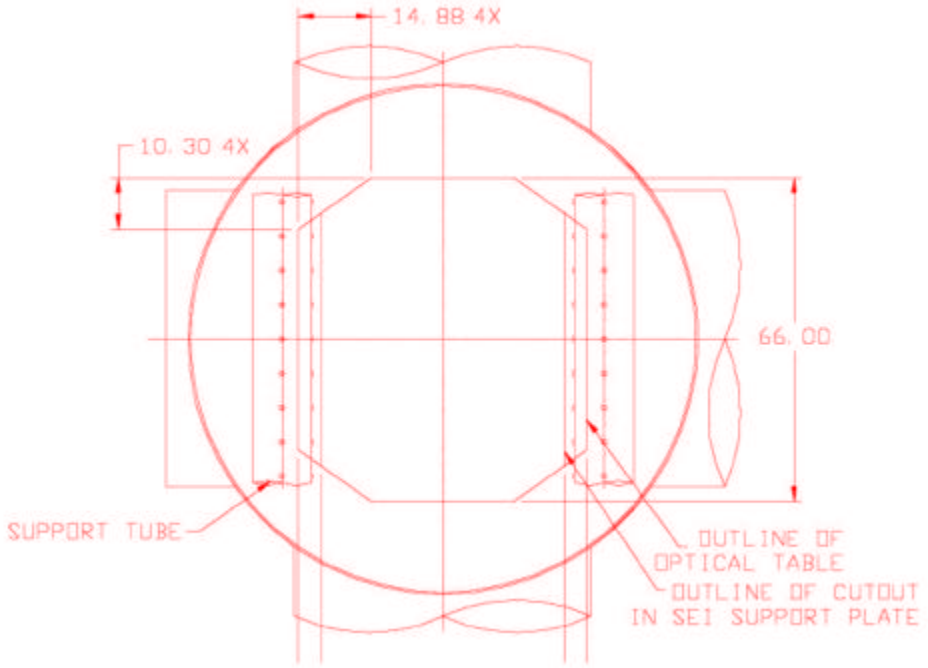
Headroom in HAM Chamber constrains MC, RM placement

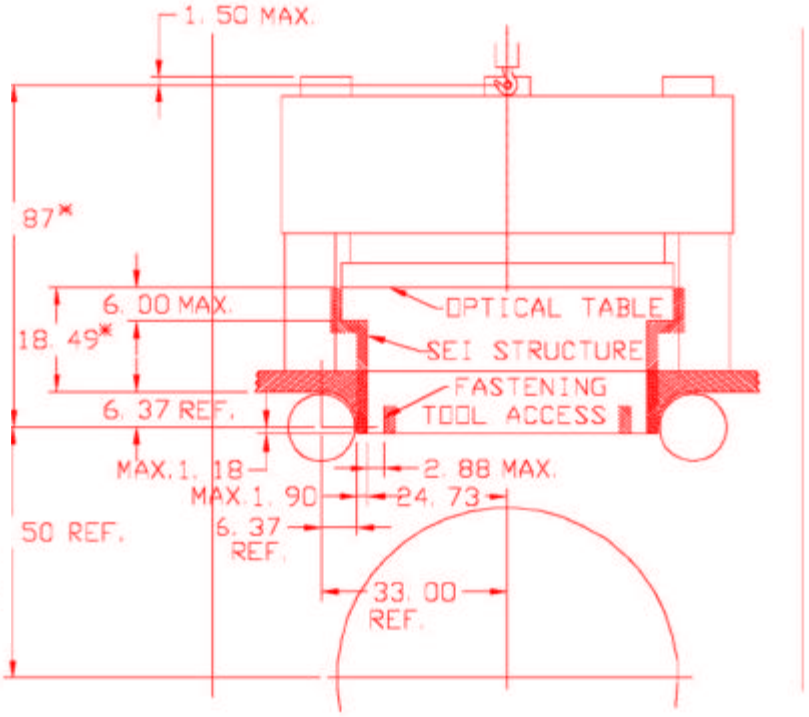




- Available area dimensions as a function of table & suspension heights are defined in T000087-01

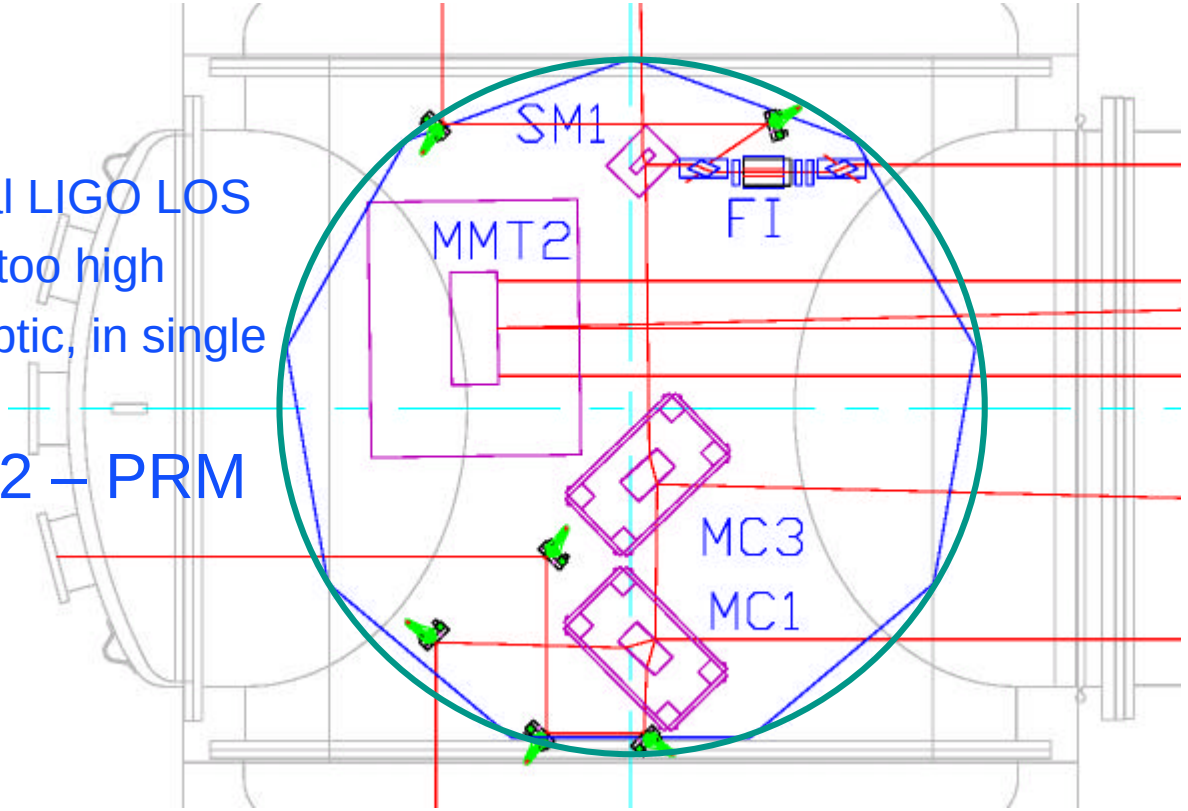
Support Tubes in BSC Constrain Payloads





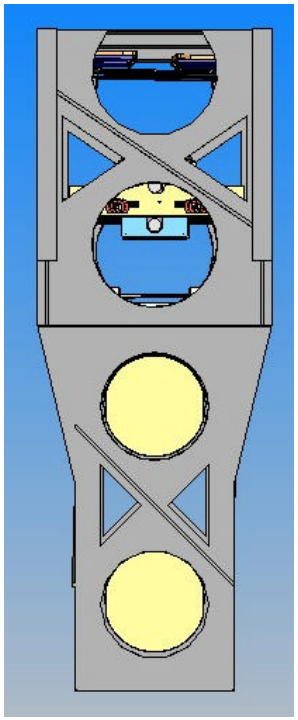
HAM1 Input Optics Layout

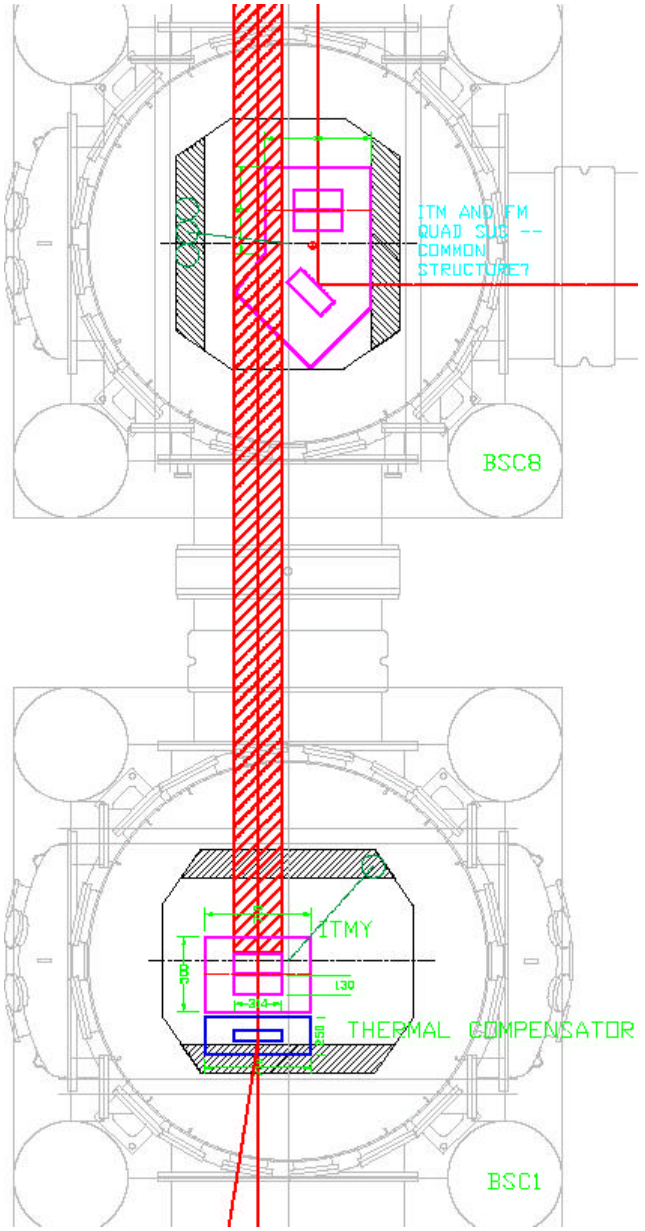
- UFL maintains/develops the IO layout
- MMT2
  - » Baselined as initial LIGO LOS
  - » Diffraction losses too high
  - » Need PRM size optic, in single suspension
- Tight fit for MMT2 – PRM beam and MC Suspensions



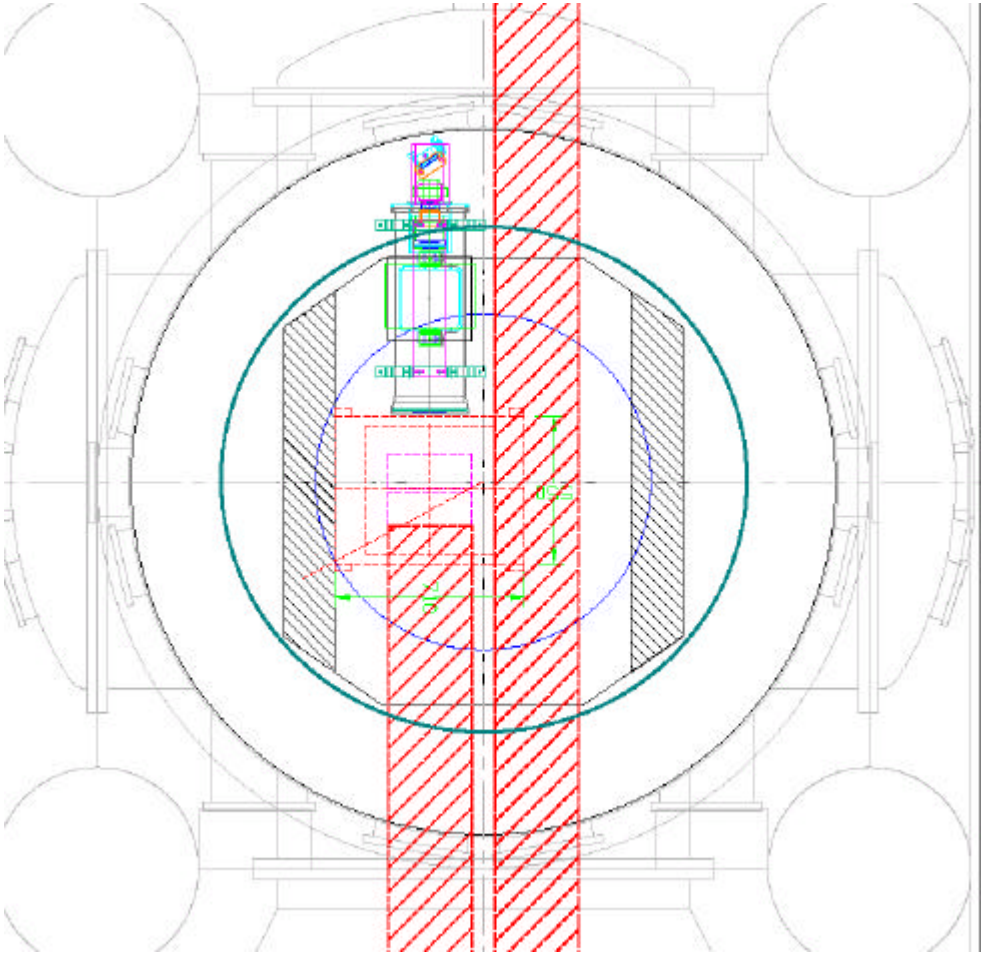
Shared Aperture – Corner Station

- FM & ITM for the Folded Interferometer require a integrated structure
- Clearance between interferometer beams
  - » Can't further separate folded & non-folded beams:
    - – Support tube physical constraints on Suspension structure
    - – HAM headroom constraint on SRM
    - – Beam clearance for the backscatter limit from BT baffles
- Suspension structure width at the optic height is limited to 440 mm





Shared Aperture – End Station



Payload Mass Properties for SEI

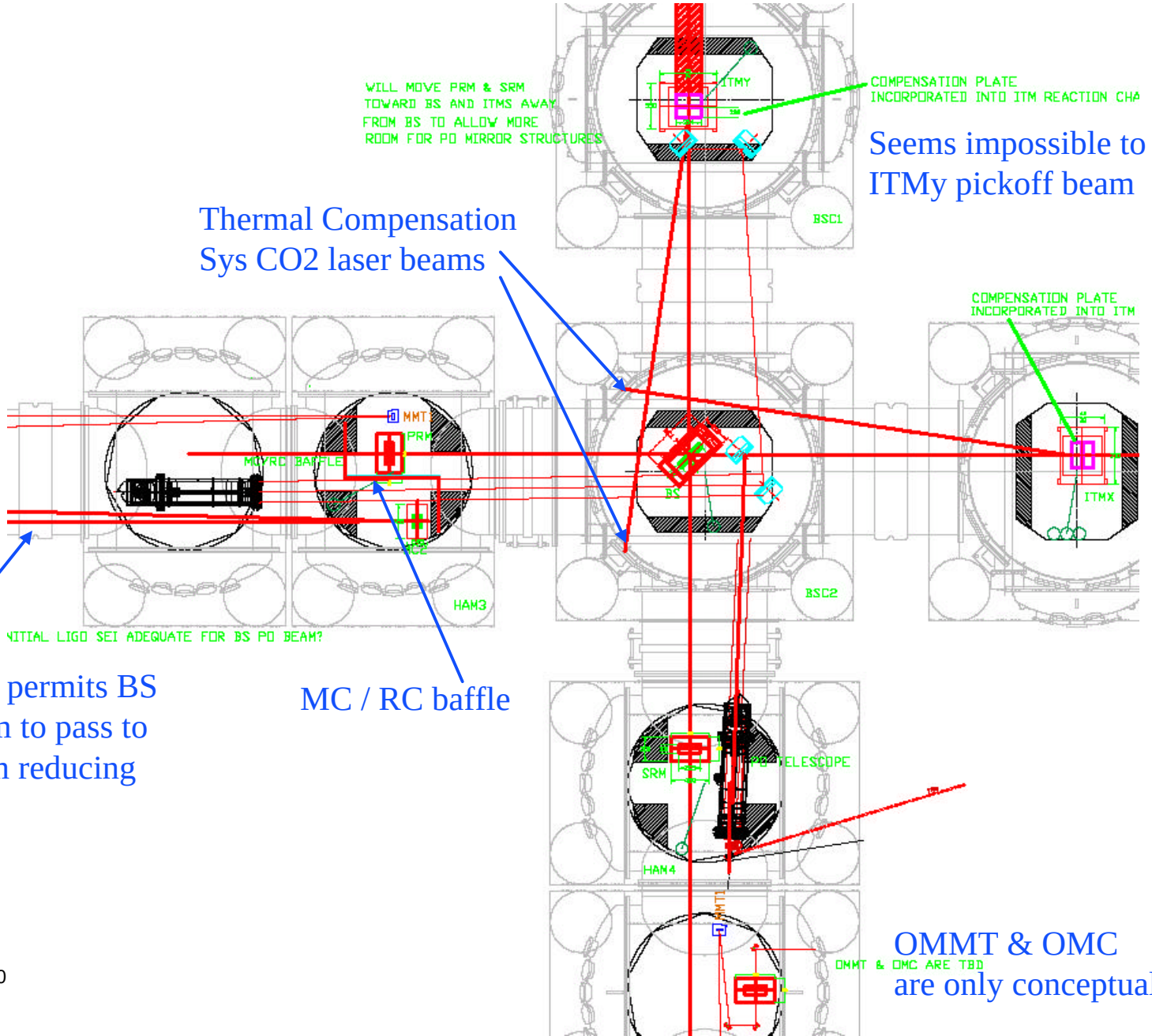
- Basic Layouts, plus a few scenarios
- Perturbations in positions to reflect possible relocations
- Includes estimate of all components, incl. Cabling
- Used to set SEI payload mass properties

HAM Payload Summary

			Payload							
			Total	Suspend	Non-Susp	Moments (kg-m)				
IFO	Chamber	COC	Mass (kg)	Mass (kg)	Mass (kg)	Mx	My	min Mz	max Mz	
Non-Folded	H1	IO	496.3	83.8	412.5	0.0	0.0	72.6	92.1	
	H3	PRM	345.5	72.3	273.2	0.0	0.0	55.0	70.2	
	H4	SRM	545.2	56.3	488.9	0.0	0.0	119.1	144.9	
	H5	Detector	TBD							
	H6	OO								
Folded	H7	IO								
	H9	PRM								
	H10	SRM								
	H11	Detector								
	H12	OO								
	"MAX"		545.2	83.8	488.9	0.0	0.0	55.0	144.9	
			510.0	75.0	435.0	kg		55.0	145.0	kg-m
			1124.4	165.3	959.0	lbm		4773.8	12585.4	lbm-in
			Requirements							

BSC Payload Summary

				Payload							
			Layout	Total	Suspend	Non-Susp	Moments (kg-m)				
IFO	Chamber	COC	#	Mass (kg)	Mass (kg)	Mass (kg)	Mx	My	min Mz	max Mz	
Non-Folded	B1	ITMy	1	659.0	304.0	355.0	101.9	179.2	-284.6	-178.7	
			2	755.5	299.2	456.3	166.0	270.6	-409.2	-247.8	
	B2	BS	1	525.9	131.9	393.9	46.9	90.3	-313.9	-195.4	
			2	525.9	131.9	393.9	131.7	70.8	-247.3	-159.5	
	B3	ITMx	1	495.7	258.0	237.7	26.7	124.5	-143.9	-99.5	
			2	755.5	299.2	456.3	36.8	195.2	-409.2	-247.8	
	B9	ETMx	1	580.5	285.7	294.8	249.2	107.1	-190.0	-145.6	
	B10	ETMy	1	580.5	285.7	294.8	131.0	110.6	-194.9	-120.9	
Folded	B4	BS	TBD								
	B7	ITMx, FMx	TBD								
	B8	ITMy, Fmy	1	806.4	348.0	458.4	145.5	169.0	-291.6	-199.5	
	B5	ETMx	TBD								
	B6	ETMy	TBD								
			"MAX"	806.4	348.0	458.4	249.2	270.6	-409.2	-99.5	
			kg	800.0	350.0	450.0	270.0	270.0	-410.0	-100.0	kg-m
			lbm	1763.7	771.6	992.1	23435.0	23435.0	-35586.4	-8679.6	lbm-in
			Requirements								



Seems impossible to get ITMy pickoff beam

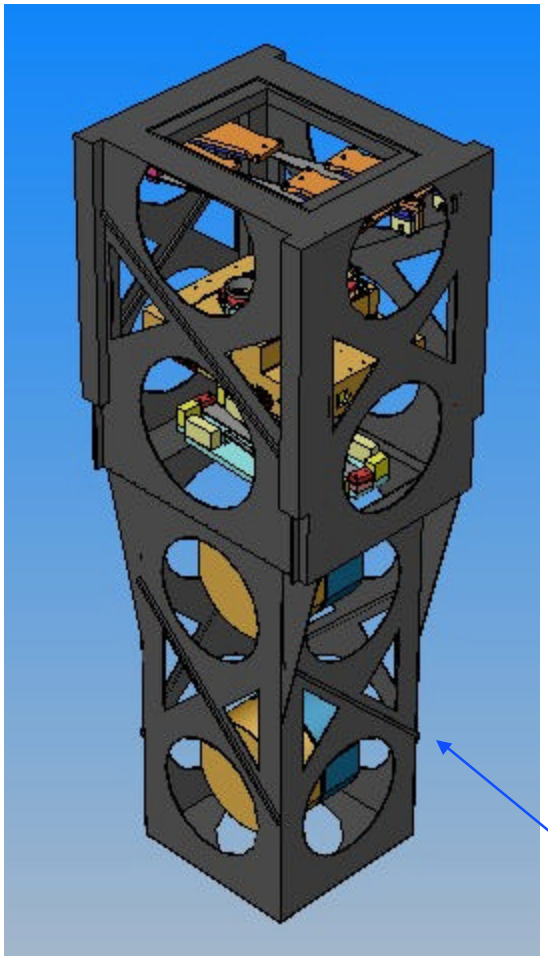
Thermal Compensation Sys CO2 laser beams

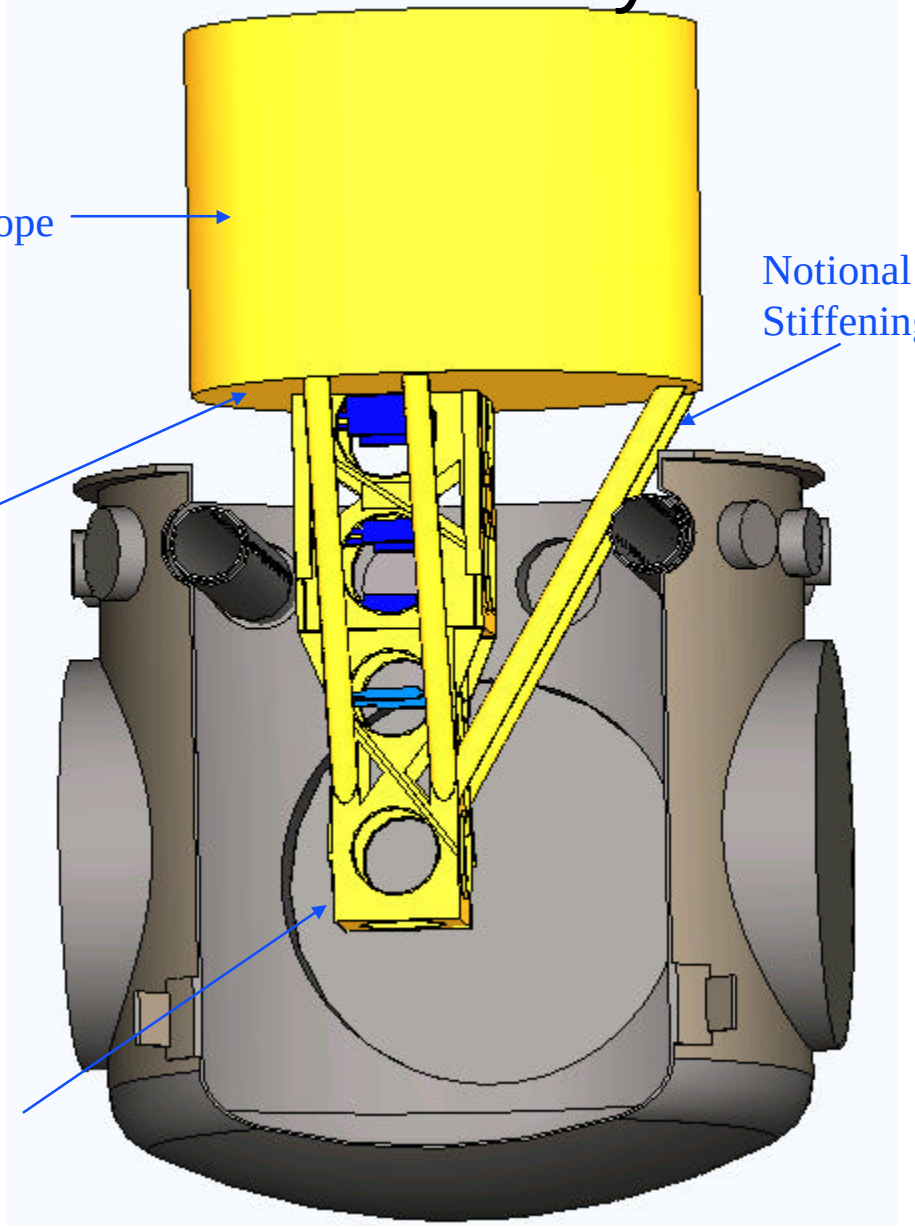
Rotated MC permits BS pickoff beam to pass to HAM2 beam reducing telescope

MC / RC baffle

OMMT & OMC are only conceptual

Coupled SUS-SEI Structural Dynamics





Cutaway view of the BSC ETM Chamber

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