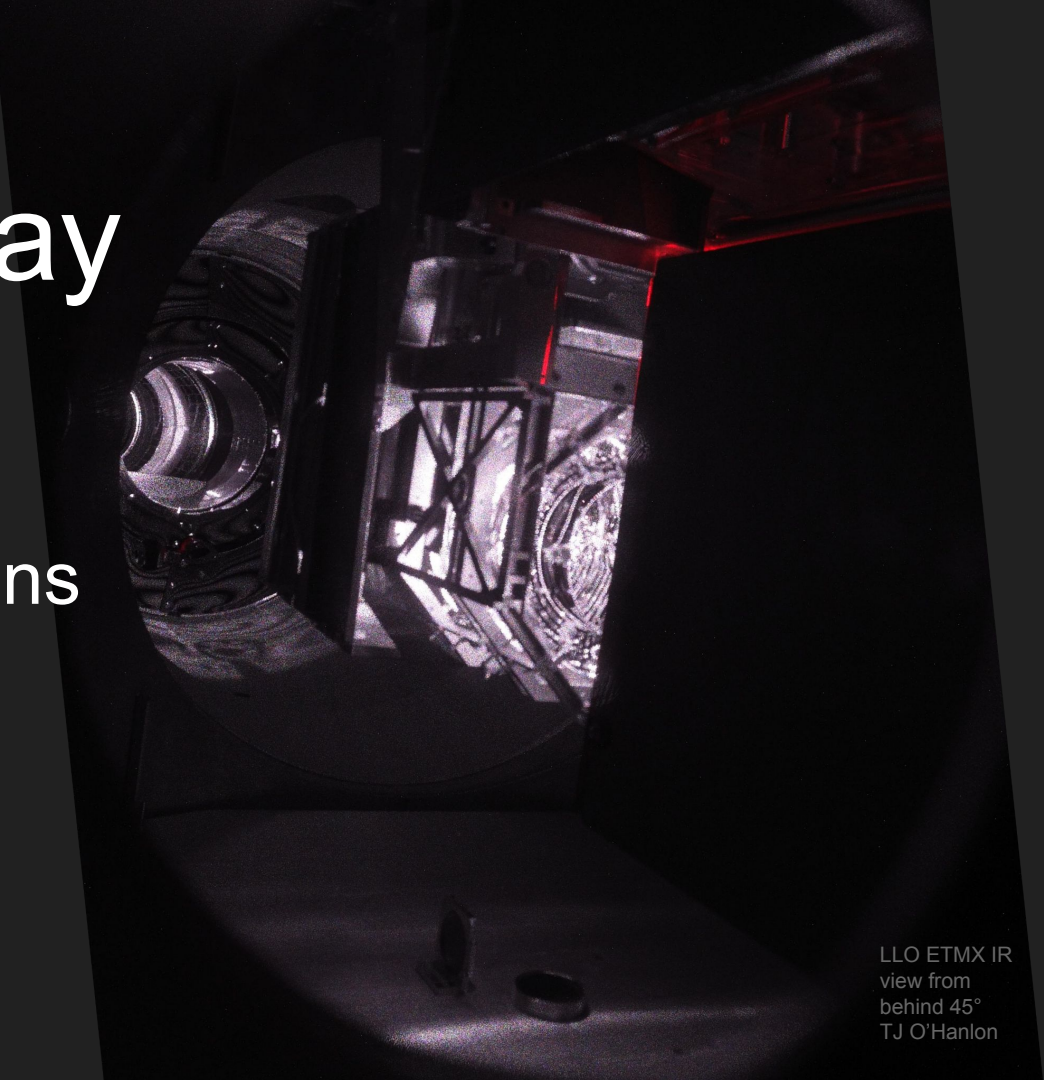


BTW3 WG3 Beam Tube Stray Light Control

and other baffling questions



LLO ETMX IR
view from
behind 45°
TJ O'Hanlon

Some conclusions

- Baffles, if vacuum fired, will not contribute to outgassing. However, attention should be paid to coatings, polymers (i.e., for damping) etc.
- Tube corrugation should be ok, though we should also calculate its impact.
- Dust might not be a driving factor, especially given the “divide and conquer” approach described below, but **to be confirmed**.
- Probably suspended baffled (i.e., with “quad-like suspensions”) will not be needed in large numbers. We might want 2 of these in each arm for other purposes (i.e., higher-order mode attenuation, alignment, stray light measurement, etc.)
- Mass produced baffles can probably use black nickel (easy, cheap), though baffles near the mirrors (or in the stations) may be more specialized (DLC)

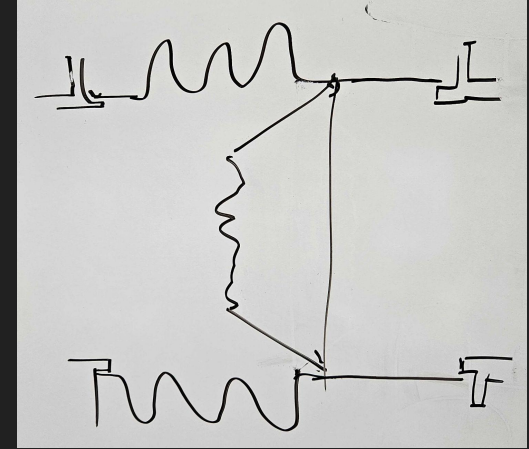
Some more conclusions

- For the optical point of view, we don't need "sub centimeter" alignment tolerances, so baffle location should not drive survey requirements
 - All designs should support mis-centering of the baffle (and/or the tube) of 1cm+
- We should make a small variety of short tube segments with baffles installed
 - These can be manufactured and cleaned/prepared off-site, and then installed with the adjacent tube sections already in place. This is done to
 - minimize actions that need to be taking in the field (i.e., welding/mounting baffles)
 - avoid coupling tube and baffle cleanliness requirements
 - These may include a
 - simple baffle with a bellow to provide compliance for installation
 - double baffle with pump-ports etc. for vacuum support. Baffles hide the vacuum parts, and their own mounting hardware
 - a standard length (e.g., 20m) segment with a baffle installed?
 - These could include hooks for accelerometers, shakers, etc.

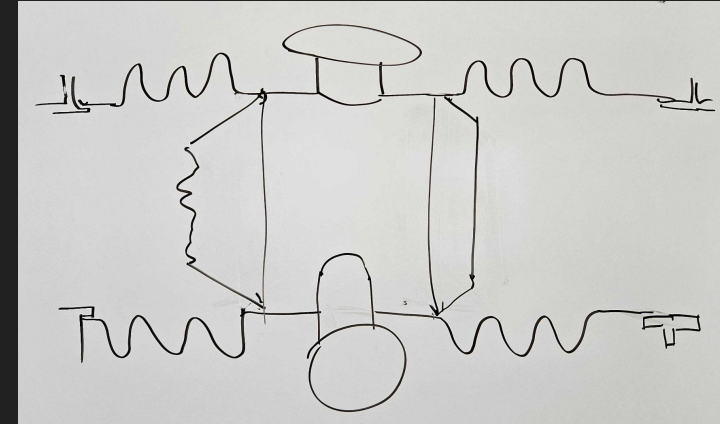
Standard Baffle Sections

- simple baffle with a bellow to provide compliance for installation
- double baffle with pump-ports etc. for vacuum support. Baffles hide the vacuum parts, and their own mounting hardware

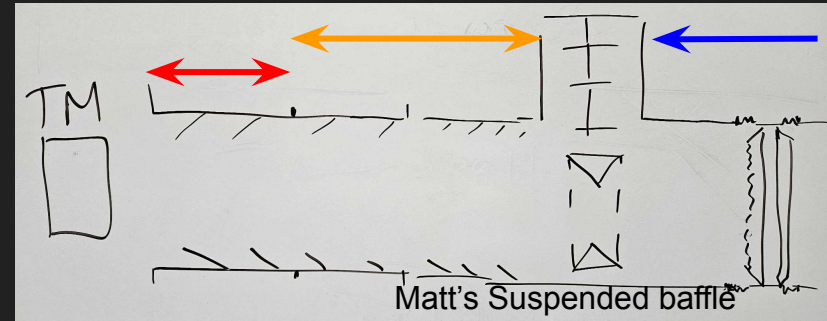
Just a baffle



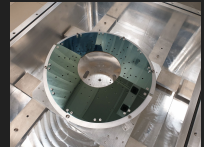
Baffle and vacuum ports



Overall Strategy



- Divide the baffling strategy into 3 regions
 - Very close to mirrors (first 100m) - tightly spaced, specialized baffles. Made in 5 to 20m tube sections.
 - Near the mirrors (100m to 1km) - baffle spacing as needed (conservative calculation based on “worst case” of geometric and wave calculations), but use “standard baffle sections”.
 - In the middle (from 1km to end - 1km) - baffle spacing is even, and integrated with vacuum hardware (pumping, instrumentation, etc.) again using standard sections that are manufactured off-site.
 - Symmetric around the middle of the arm
- Consider one suspended baffle (probably instrumented) at 1km
 - Instrumentation would provide info about baffle movement, beam position (on baffles with cameras), flashes/glitches due to particles in the beam (with PDs in the baffle), etc.
 - Potentially co-located with other systems (i.e., IMC and FC)



Open Questions

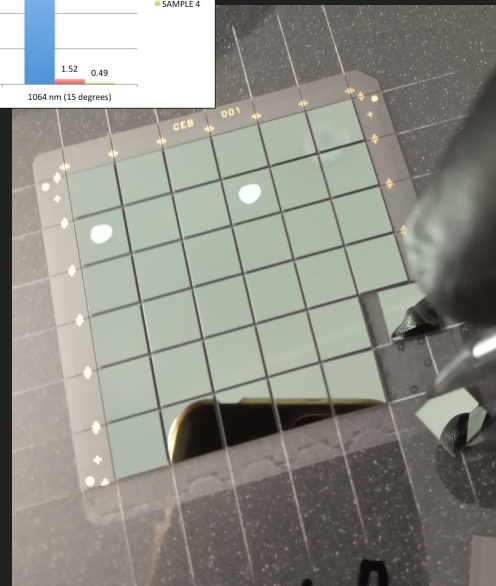
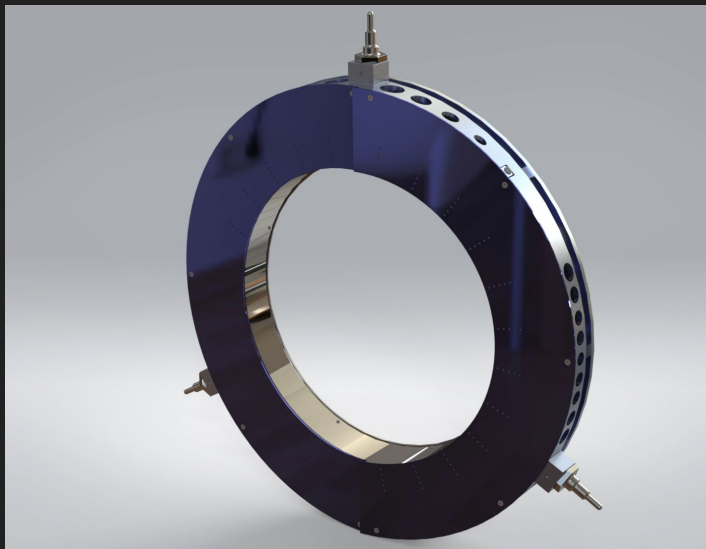
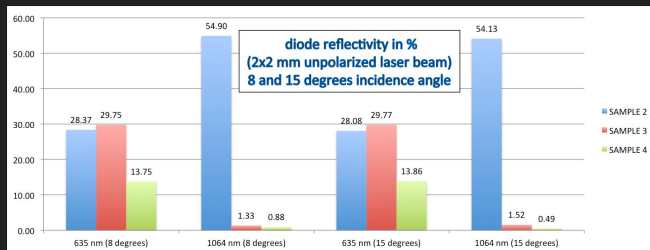
- Is a “safety margin” of 100 below the sensitivity curve good enough?
 - Likely yes, but need to work on simulations.
- How can we clearly support the tube diameter selection?
 - It seems that noise coupling is a soft function of aperture size for the standard 1.2 or 1m tube diameters. (What about loss? What about loss with mis-centering?) Is this correct? If the tube is smaller, what problems are encountered (e.g., 80cm)?
- Can we make an integrated model of coherent (wave propagation and mirror maps etc.) and incoherent (power tracking and BRDF) light propagation?
 - scattering on beam tube - FFT is notorious for calculating larger angle due to aliasing, good on baffle, bad on beam tube
 - mirror surface map on large mirrors - affects both small and large angle scattering
- Installation and mounting strategy: hard or soft? What TFs do we want? What will provide 50y longevity.
- Which way is best for the baffles? Trap or deflect into the opposite side?

Action Items

- Work on simulation validation
 - What prevents a good match with LLO data? (though match not awful, within factor of ~ 8)
 - What other tests could we do? Engage LIGO and Virgo instrumentalists
- Experimental verification of cleanliness requirements
 - And cleanliness implications of installation, especially welding of “standard baffle sections” into the tube sections (i.e., welding done in the field to install these sections)
- Simulations will need to move to the spaces closer to the mirror (see coherent vs incoherent open question)
 - large angle scattering - input is BRDF which has large uncertainty
 - Low-angle scattering - may depend on realization, so need statistics

Enabling Technology

- Low reflectivity UHV compatible sensors for instrumented baffles
- A dedicated R&D campaign could provide a $< 0.5\%$ reflectivity with reduced BRDF ($10E-3 \text{ str}^{-1}$)



Add references/talks here

- Calculations and Simulation tools being used:
<https://dcc.ligo.org/LIGO-G2502118>
- Mechanical/Optical Design Options for Baffles:
<https://dcc.ligo.org/LIGO-G2502118>
- Case for instrumentation
<https://dcc.ligo.org/G2502164>
-