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## Schematic design of the cryogenic baffles

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Riccardo DeSalvo

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***KAGRA* Large-scale Cryogenic Gravitational Wave Telescope Project.**

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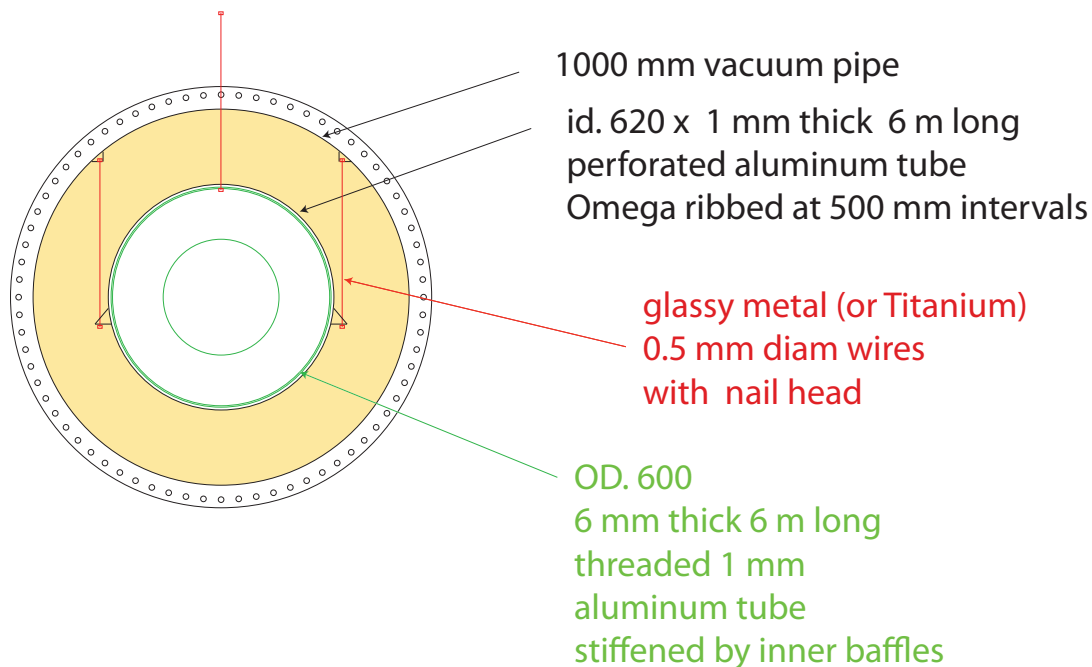
# 1 Introduction

I made a schematic design of the cryogenic baffles, following considerations from Mike Smith, myself, and my limited understanding of Thursday May 31<sup>st</sup> discussion. This scheme is intended for further discussion only, to assure that all critical requirements are satisfied, none is forgotten, and that we employ as much as possible only standard materials and processes, to minimize cost and maximize performance and reliability. Please read critically and feed back.

The cryogenic baffle section is divided into 3 sections, each shorter than 6 m, to allow use of standard size, cheaper, metal sheet to form the pipes.

As suggested in Thursday's meeting, one starts with a 1000 mm vacuum pipe and 200 mm thick super-insulation, to minimize transversal thermal losses, and allow for long, low loss, suspension wires. This scheme is shown in figure 1.

The super-insulation is kept in shape, and from scraping onto the suspended baffle tube, by a thin perforated aluminum tube. This perforated tube is simply supported from the inside wall of the vacuum pipe through 4 low thermal conductivity wires, each provided with two 4 mm nail heads, locking into keyholes in small shelves on the pipes, just like is done in the main suspensions.



Omega profile stiffening ring



superinsulation

Figure 1: Schematic front view of the cryogenic baffles.

The baffles are mounted inside a 6 mm thick suspended aluminum tube; suspension and alignment of this tube is performed from warm chambers above the tube, as illustrated in figure 2.

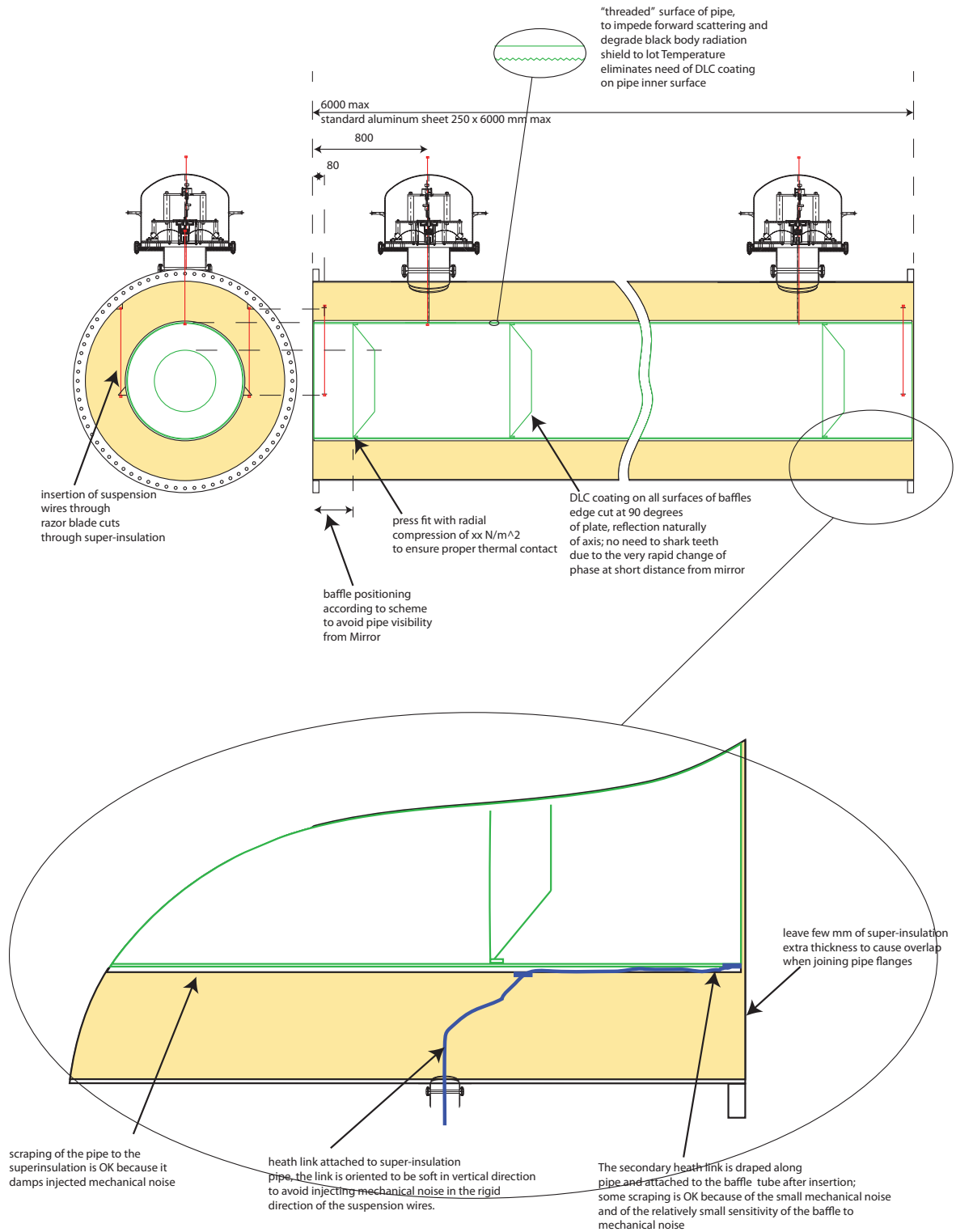


Figure 2: Schematic side view of the cryogenic baffle tubes.

Some scraping of the suspension wire to super-insulation is acceptable due to the softness of super-insulation foils and relatively reduced isolation requirements of the baffle tube.

The heat links first connect to the super-insulation pipe, then to the baffle tube. Some scraping of the secondary heat link between the super-insulation and the baffle tubes is acceptable.

The positioning of the suspension wires of the super-insulation pipe are chosen for easy attachment of the wires to their shelves, by hand, before closing the vacuum pipe sections. Similarly for the suspension wires of the cryogenic baffle tube. The minimum number of baffles in the tube, and their positioning, is dictated by the necessity to shield the pipe from view from the mirror surface according to the sketch of figure 3.

The number of baffles and their aperture still needs to be optimized.

An additional number of baffles can be added to further reduce the amount of thermal load from the external thermal bath to the mirror.

Only the baffles are DLC-coated, the inner surface of the suspended tube housing the baffles is “threaded” to stop thermal radiation skimming along the pipe and increase its effective black body emission coefficient by radiation trapping. DLC coating of the pipe would be expensive. The “threading” is suspended where the baffles connect to the tube, for good thermal connection. Good thermal connection is obtained by tight force fitting of the baffles inside their tube.

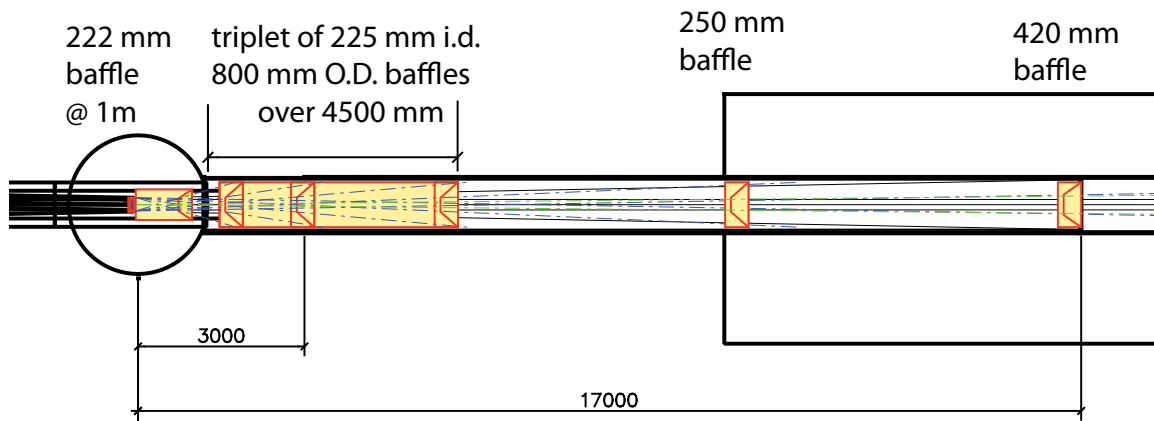


Figure 3: Schematic view of the minimum cryogenic baffle solid angle coverage to avoid exposing the mirror to the view of non-DLC coated, non-seismically insulated surfaces with large solid angle coverage.

Suitable windows are cut in the baffles, where needed, to allow the passage of the optical lever beams and of the photon calibration beams. The optical lever and photon calibration beam launching geometry is illustrated in figure 4 and figure 5.

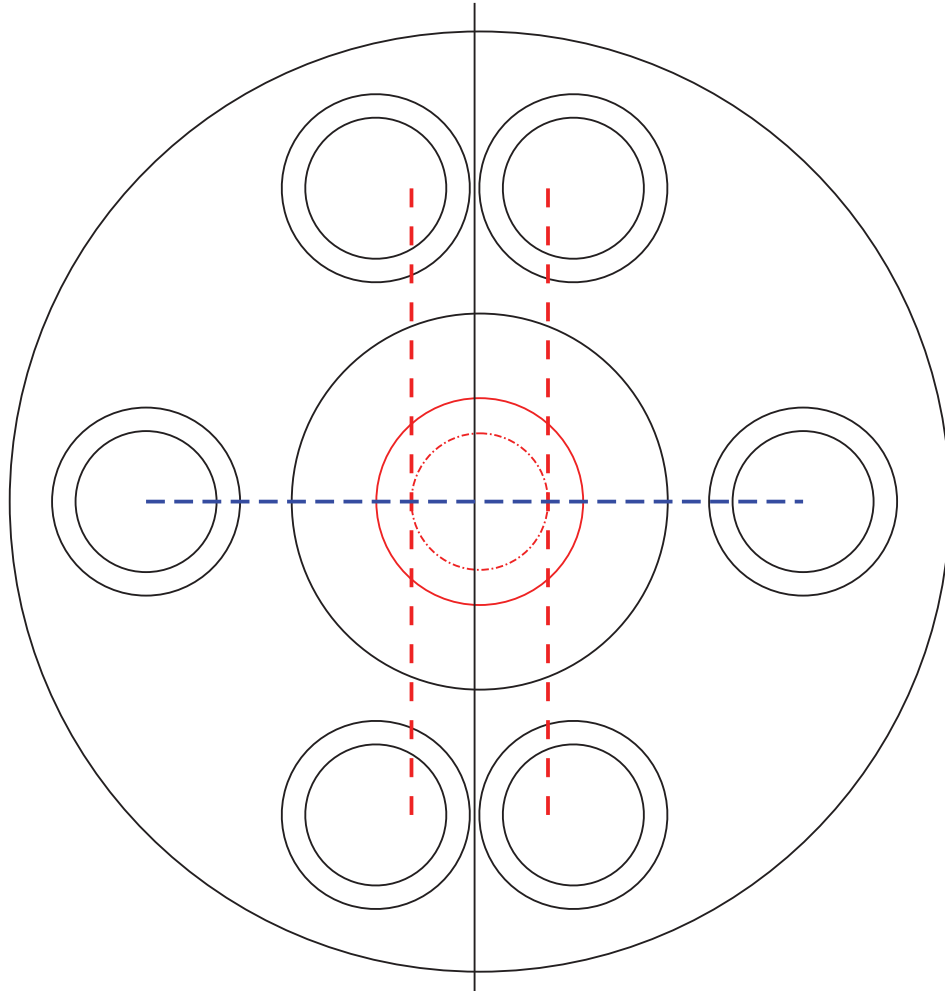


Figure 4: Front view scheme of the launching points of the optical lever and photon drive beams. The optical lever beam travel horizontally and hits the center of the mirror. The two Photon drive beams hit the mirror in the horizontal plane, at the specified separation for optimal calibration quality.

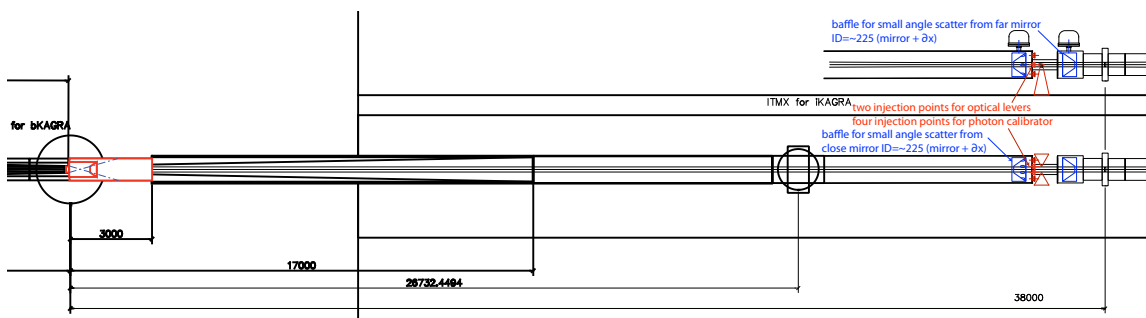


Figure 5: Side view scheme of the launching points of the optical lever and photon drive beams. Launching is done from a spool vacuum pipe restriction, 37 m from the test mass, near the gate valve. Thanks to the large distance, the opening of the beams is small, they are already close when getting inside the cryogenic section, and only few cryogenic baffles need windowing to allow passage of the beams.

Note: the optical lever requirements of KAGRA are substantially tighter than those of aLIGO, due to the fact that alignment must be conserved during the very long cryogenic cool-down process. The relay-mirror optical lever scheme initially proposed is not feasible for two reasons: during cool-down because the relay mirror supports are exposed to varying temperature load from the cold baffles, deform and lose alignment. During operation because non-suspended mirror supports generate non-seismically isolated light scattering back to the mirror. Even in the external scheme, the launching points need to be well shielded. In addition, it would be mechanically awkward to design the six-point mirror relay needed for photon drive and optical levers.