LIGO Laboratory / LIGO Scientific Collaboration

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The mirror installation cleanliness, solving the problem the cheap way.

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1 Introduction

It has been pointed out[1] that it is impossible to maintain the cleanliness of the mirrors unless their assembly is completely made under complete clean air laminar flow conditions.
Mirrors that have few dust particles at production, are covered with thousands of particle per cm^2 after returning from a beam line installation.
Recently the problem of mirror surface pollutions made itself evident in the LIGO interferometer operations.
It has been proven possible to produce, package and unpackage mirrors and maintain their cleanliness, at the condition of performing all of those operations in class 100 or better environment.
It is clear that in Advanced LIGO we need to generate a benign environment that will allow us to install and perform maintenance on the mirrors without compromising their cleanliness. This is an overriding requirement, without which the Advanced LIGO requirements cannot be satisfied.

2 Solving the problem

The LIGO vacuum chambers are all stainless steel and aluminum, in principle compatible with clean air conditions.

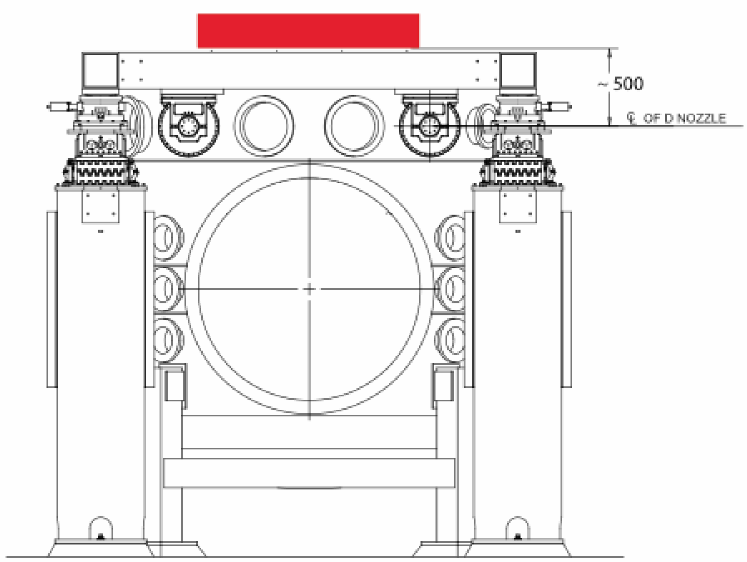

Figure 1: BSC and Adv-LIGO optical bench.

[1] Jean Marie Mackowski, 1995

The difficult part is to establish a good laminar flow of air around the suspension mechanics during mirror installation.
In order to establish a good laminar flow it is necessary to build a clean box with sieved bottom to generate the air shower above the optics, and a similar box, with sieved top should be placed below to suck out the air flow. Then a filtered flow of air must be established between the two boxes.
The sketch of a BSC chamber (without its cap) and its optical bench are shown in figure 1, all the optics and their mechanical supports (not shown) are suspended below the optical bench.
There is obviously no problem in installing the sucking box below the optics, plenty of space is available below the entrance level over the entire BSC floor.
The real problem is how to build the upper box, which cannot be a temporary, removable box. A removeable box cannot be inserted in between the Optics structure and would not provide flow just where it is needed. Also the process of removing the box would introduce lots of dust. The upper box generating the clean air laminar flow must be a fixed structure.

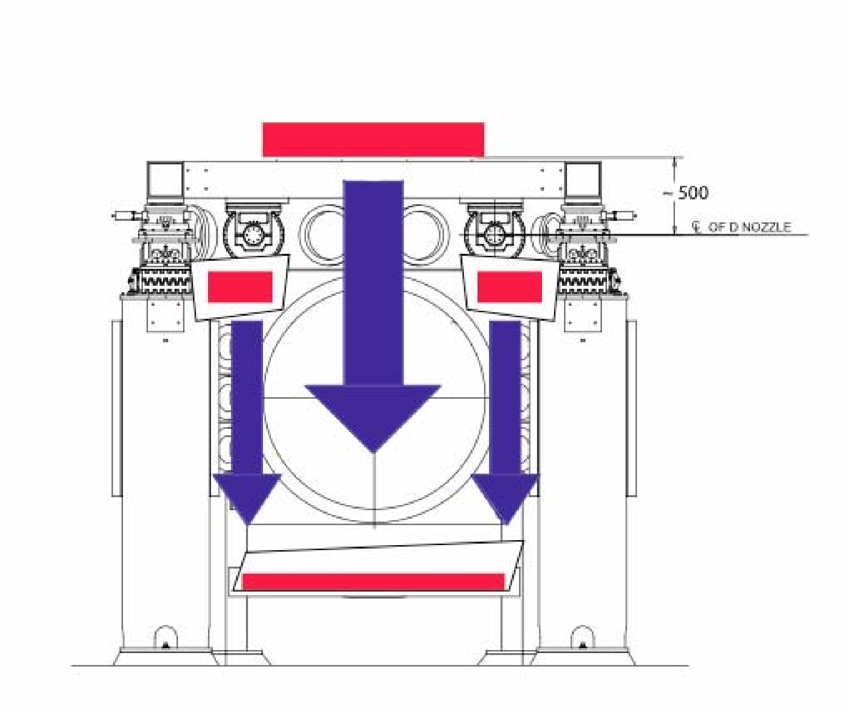

Figure 2: Laminar flow (blue) from the Optical bench and the anular box to the bottom receiving box.

It may appear to be a difficult geometrical problem to solve. Fortunately the answer is obvious and simple, we can build the box, or at least part of it, out of the optical bench itself.
The optical bench is already a box like structure with many holes (the 1/4-20 tapped holes), all we have to do is make the box air tight and add another set of interleaved 6 mm diameter holes.

Then simply pumping clean air through a temporary piping system would generate the required flow around the optics.
A small proble remains, the optical bench is only about 1.5 m diameter, and does not generate flow over the entire BSC cross section, a requirement probably necessary to allow human access and maintenance.
An additional anular air shower box can then be implemented below the cross tubes, as illustrated in figure 2.

The proposed structure would then generate the desired clean air laminar flow without introducing unacceptable structures inside the BSC chambers.