New Folder Name Access Considerations

LIGO-T920032-00-D

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INTERFEROMETER ACCESS CONSIDERATIONS

Component access for the initial interferometer
(in diagonal chambers and test mass chambers type 2):

1. Item description(s) (what is this that we need to access?):

   a. Mass and dimensions:

   The largest component to access would be the 25 cm dia. x 10 cm beamsplitter mirror (Pockels cells and polarizers may be as large, but would probably be installed in HAMs). Test mass and beamsplitter mirrors would be suspended, and may be doubly suspended, as a worst case. A modular assembly which would include the mirror, suspension, OSEM heads, earthquake stops and position locks appears to be the most appropriate design plan, especially for high stacks. Besides advantages in accessing (discussed elsewhere), most critical assembly tasks of a modular unit can be made on a workbench with better control, precision, and comfort.

   A modular design for a doubly suspended beamsplitter mirror is shown in Fig. 1. Basic dimensions are dictated by the 35 cm pendulum suspensions, 25 cm dia. mirror, post spacing to not interfere with large light beam, and post size (2" pipe) to give resonant frequencies well above 25 Hz (approx. 150 Hz)..

   These result in the following dimensions:
   doubly suspended beamsplitter module: 36"h x 17"w x 7.2"d; mass, 150 lb (68 kg);
   doubly suspended test mass module: 36"h x 12"w x 10"d; mass, 180 lb (82 kg).

   b. Details:

   Suspension, earthquake stops, position locks and OSEM heads would all be included in the modular design. The position locks and earthquake stops would be combined in fixture design, and would be applied to each of the masses in doubly suspended units. OSEM heads could be installed on either or both masses.

   Mounting the modules would be accomplished by means of strap clamps, to the bottom of a grid-tapped plate.

2. Environment description (where is it located, and what surrounds it?):

   a. Chamber details and component layouts

Chamber and component layouts are shown in Fig. 2. This shows one possible configuration for main beam components, as well as components to monitor and dump the reflected beams caused by mirror wedge angles.

b. Assumptions on intensity of reflections and size of optics:

- Assumed all optical reflections with intensity greater than 10 microwatt are to be dumped or detected.
- Detector dimensions were chosen to be 18 cm dia. x 2.5 cm thick. Beam dumps are conical, 20 cm dia. x 40 cm long (overkill).
- Assumed that detectors need to be suspended. Assumed the beam dumps were not necessarily suspended; could be bolted to the tank. Another thought is that the beam dumps need not be discrete elements but could appear as baffles at different points in the tanks; this is not explicit in the drawings.

c. Diagonal chamber:

- The diagonal chamber contains a beam splitter, and possibly a Mach Zender mirror
- Each test mass has 3 back reflections that need to be either dumped or detected in the diagonal chamber. We assumed that there are 2 needed for detection and 1 dumped.
- The recycling mirror in the adjoining input HAM chamber would have one forward reflection to a detector in the diagonal chamber.
- Total number of beam dumps in the diagonal chamber is 2 and total number of detectors (or pick-offs) is 5. (An element of the Mach Zender loop is shown on Fig. 2 for clearance purposes only.)

d. TMC-2 chamber:

- The TMC–2 chambers contain a test mass.
- The beam splitter mirror would have 2 reflections in the forward direction, and the Mach Zender mirror would have 1. Each of the reflections need to be either dumped or used as detectors. We assumed that for each optic 1 beam was to be detected and the extra beam splitter beam was to be dumped.
- The total number of beam dumps is 1 and the total number of detectors is 2 in a TMC–2 chamber.

e. TMC-1 chamber

- The TMC–1 chambers contain a test mass and a directing mirror
- The beam splitter mirror would have 2 reflections in the forward direction, and the Mach Zender mirror would have 1. Each of the reflections need to be either dumped or used as detectors. We assumed that for each optic 1 beam was to be detected and the extra beam splitter beam was to be dumped.
- The TMC–2 test mass has 1 reflection in the forward direction; this is to be dumped.

- The total number of reflections to be dumped is 2 and the total number to be detected is 2. The key feature of the TMC–1 chamber is the fact that the suspended optics have to fit through the 5 foot air lock. The other optics (i.e. beam dumps) are attached to the chamber and can not be reoriented after the initial installation unless a mechanism is designed for positioning the dumps from outside the vacuum.

3. Main concerns about optical configuration:

   a. Given the size of the beam dumps and detectors necessary for a 6'' beam, it will take some very clever placement of optics to feed 6 main beams through the 4' clear aperture. When we looked at possible configurations during the Tiger Team meeting we only looked at whether we could fit 6 test masses in the 4' aperture; not 6 test masses and a number of other rather large optical pieces.
   b. Upgrade to 100 kg test masses with reaction masses would be difficult.

4. Purpose of access (what do we do when we access, and why?):

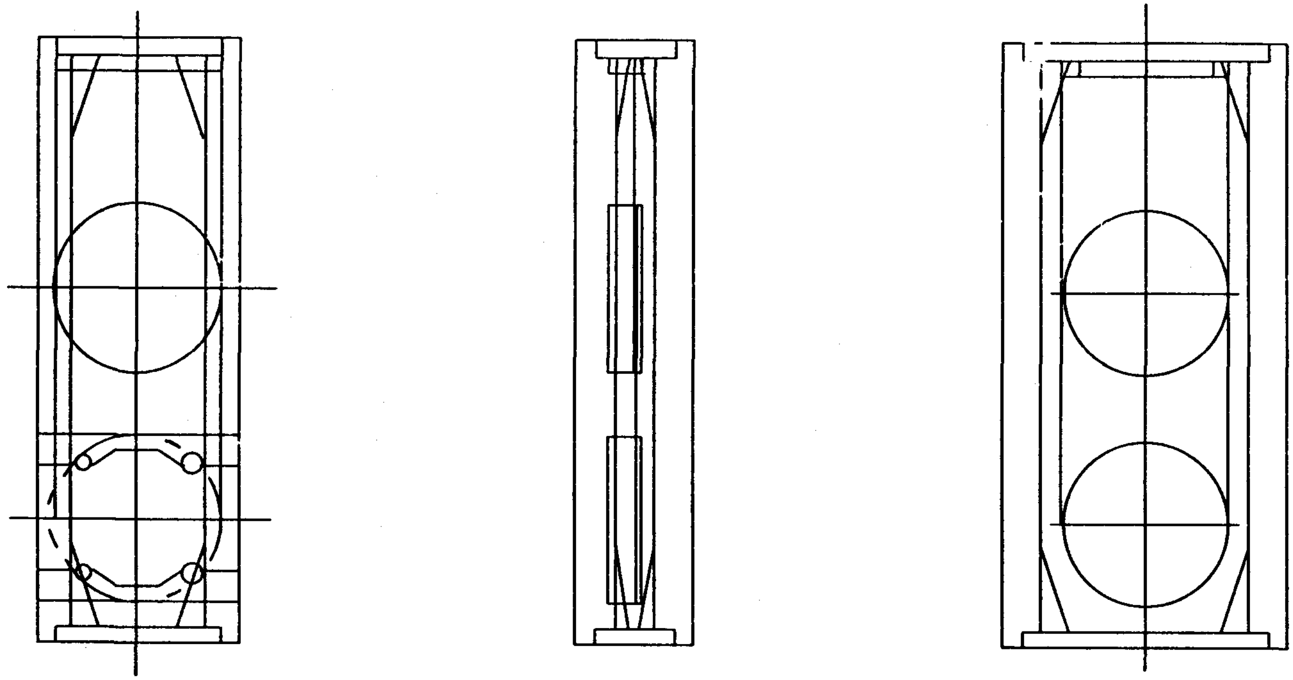
   a. Removal and installation: suspended components would be locked in position during transport and handling. This requires that access in the installed position is provided for the position locks. Access in this position is also required for installation and removal of the strap clamps which mount the module to the mounting plate. Lateral adjustments will be required as part of the mounting process. These may be made with adjustment screws (if space permits mounting a fixture alongside the module) or with a "pinch bar" for crowded installations.

      - Module movement route and method:

        - station shop to chamber area: a bridge crane would be used, with drip pan/umbrella for particle control. This crane switches between tracks as it moves through the different sections of the open bay.
        - chamber area to chamber port: a non-rider fork lift is appropriate for short distances, allowing maneuvering around isolation stack support pedestals, and transferring the module to the positioning jack inside of the chamber.
        - chamber port to mount position: a positioning jack is used to move the module around previously installed components and lift it against the mounting plate for attachment of the strap clamps (see Fig. 3).

   Beam line height relative to the floor is convenient for a worker on his back, working near the beam line (with or without a "creeper"), but tasks at the mounting plate requires that the worker is able to position himself alongside the module for proper reach, and that he is reach at least two opposite sides for clamping.

b. Service: this would include adjustment of OSEM heads after stack drift exceeds the OSEM range, inspection of suspensions after an earthquake, etc. Broken suspensions would probably necessitate removal for repairs at a workbench, but some in-place work may be required to lock the position of loose parts.



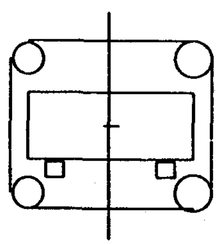
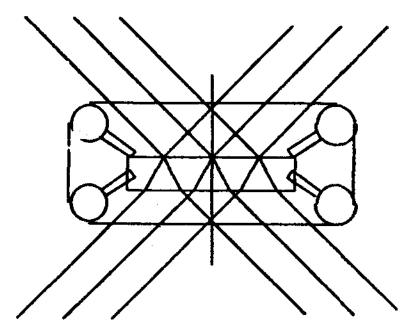


FIG. 1 COMPONENT MODULES



TEST MASS MODULE

BEAM SPLITTER MODULE

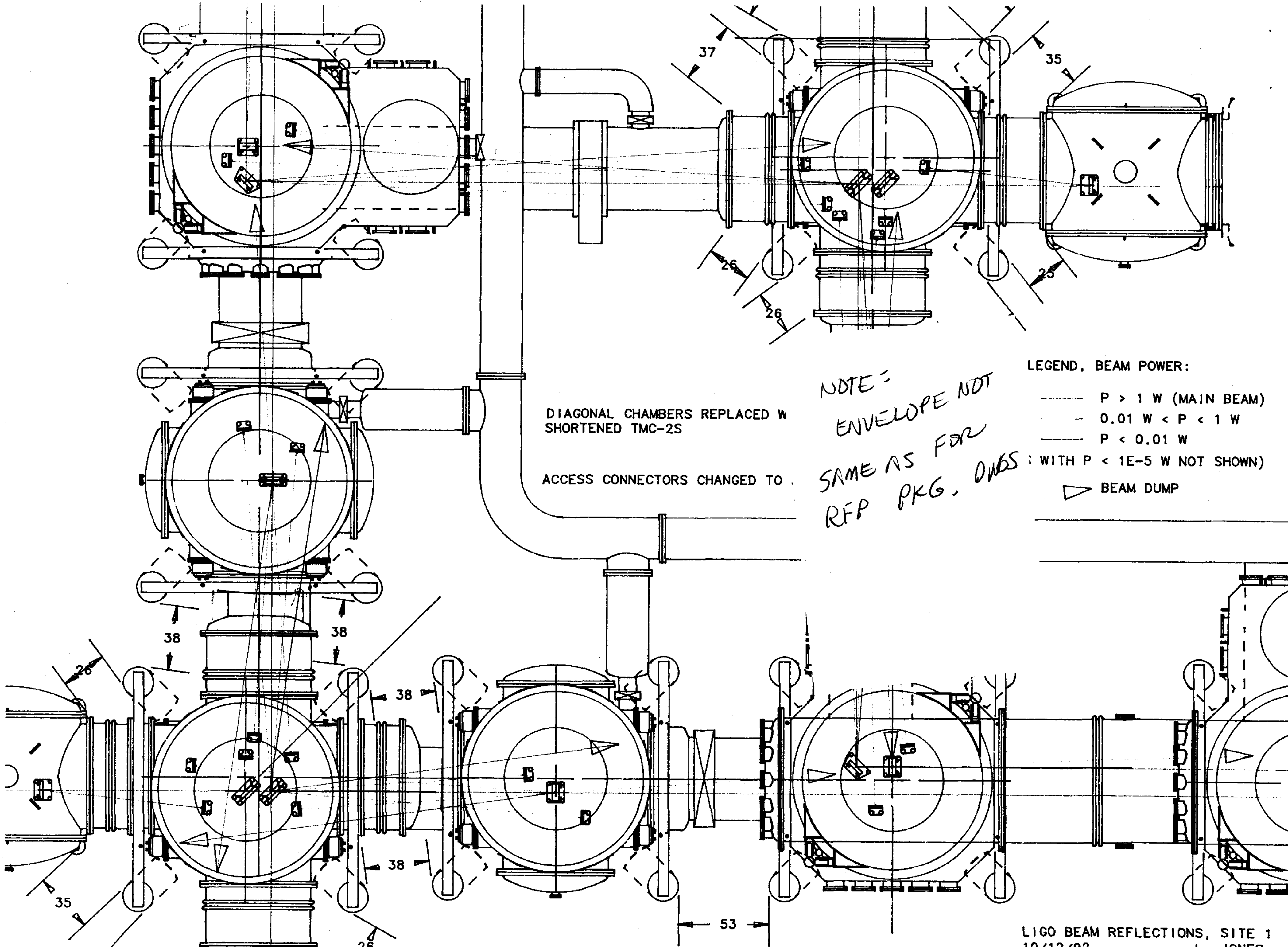


FIG. 2 REFLECTED BEAM LAYOUT

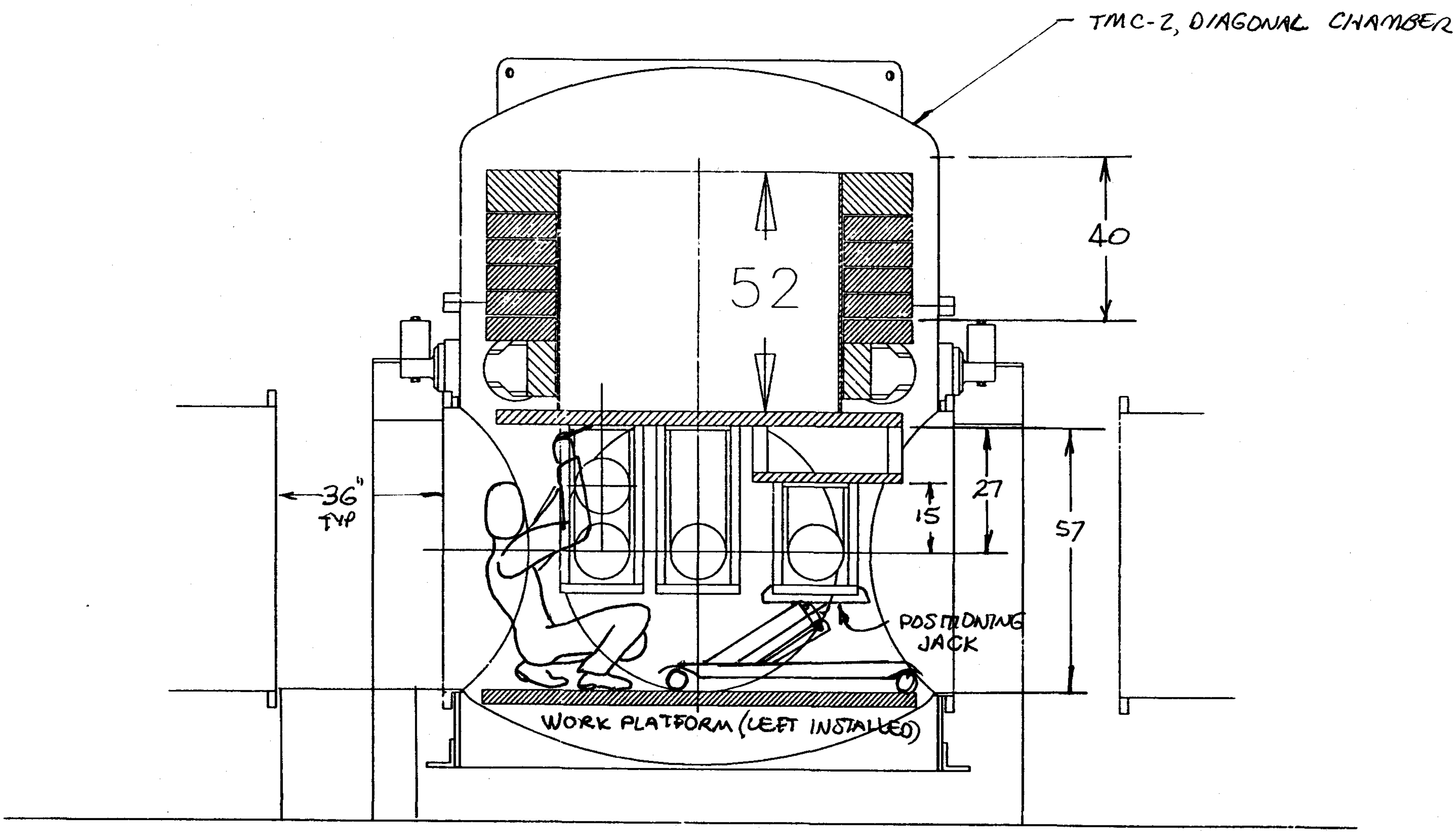


FIG. 3 INTERNAL ACCESS

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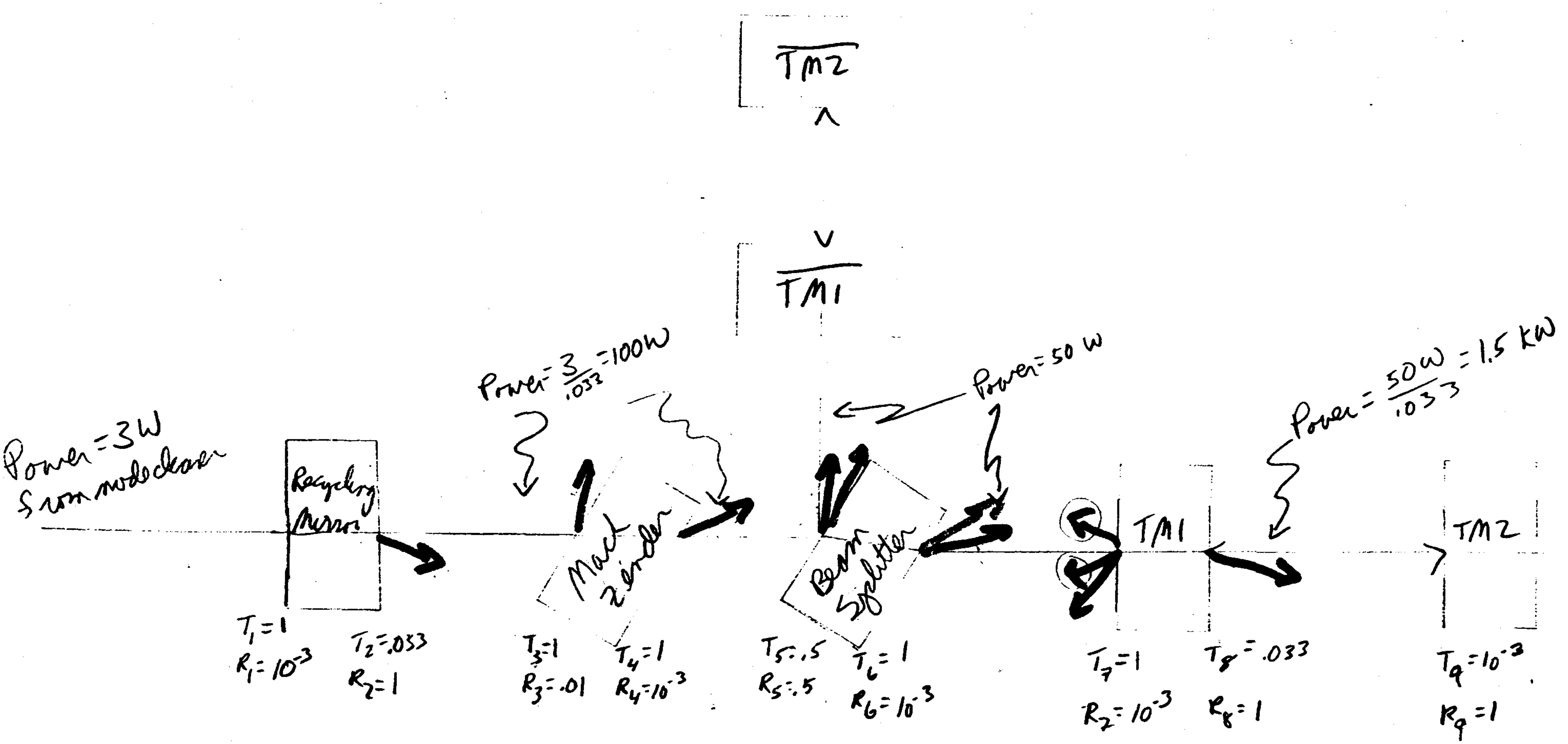
Possible Interferometer Layout For Ligo

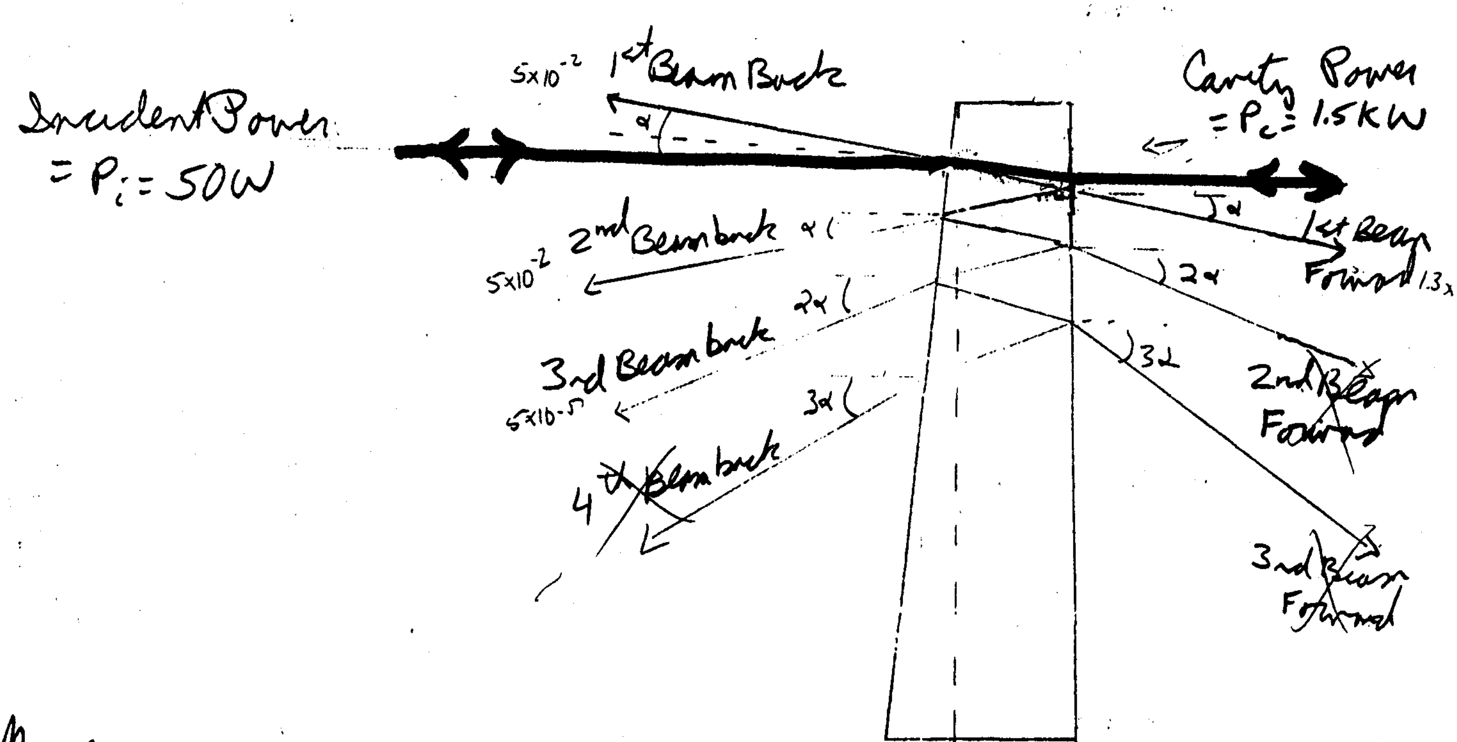


P ≮ 10 mwatts

<u>Assumptions</u>

1) All beams with $P < 10\,\mu$Watts are ignored
2) Power from mode cleaner is 3 watts
3) AR coating residual reflection: 10^{-3} (in power)
4) Input test mass transmission: 3.3%
5) Mach Zender pickoff R=1%

Test Mass 1 + Recycling Mirror



$T_7 = 1$ $\quad$ $T_8 = .033$

$R_7 = 10^{-3}$ $\quad$ $R_8 = 1$

Test Mass

Test Mass

1st Beam Back: $R_7 P_i = 10^{-3} \cdot 50 = 5\times10^{-2}W$

2nd Beam Back: $R_7 R_8 T_7 50 = 10^{-3} \cdot 50 = 5\times10^{-2}W$

3rd Beam Back: $R_7^2 R_8^2 T_7 50 = 10^{-6} \cdot 50 = 5\times10^{-5}W$

4th Beam Back: $R_7^3 R_8^8 T_7 50 = 10^{-9} \cdot 50 =$ ~~$5\times10^{-8}W$~~

$P_c = \frac{50W}{T_8}$

1st Beam Forward: $R_7 T_8 \cdot 50 = 10^{-3}(.033)50 = 1.7\times10^{-3}W$

2nd Beam Forward: $R_7^2 R_8 T_8 \cdot 50 = 10^{-6}(.033)50 = 1.7\times10^{-6}W$

3rd Beam Forward: $R_7^3 R_8^2 T_8 \cdot 50 = 10^{-9}(.033)50 = 1.7\times10^{-9}W$

Recycling Mirror:

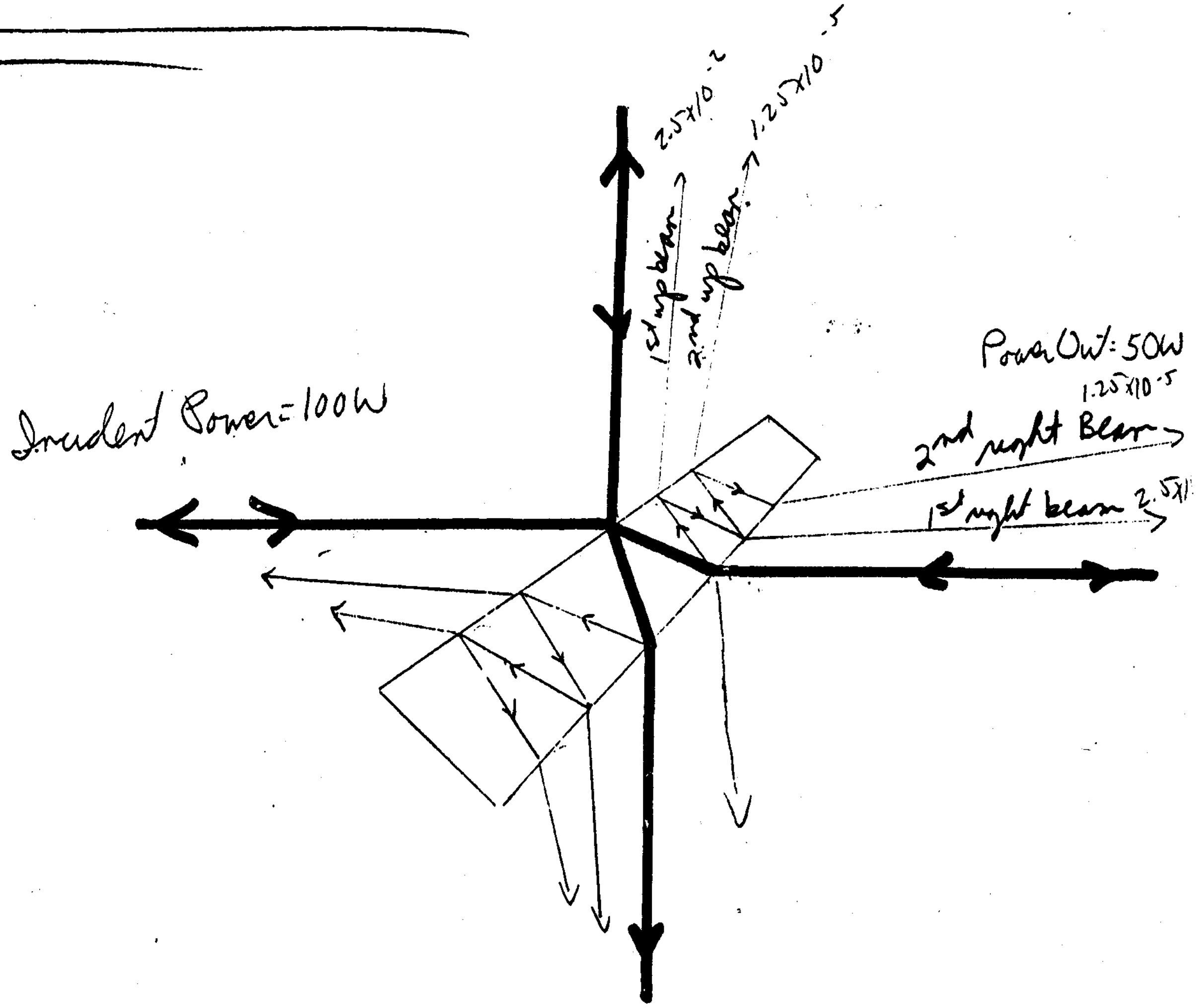
$T_1 = 1$ $\quad T_2 = .033$

$R_1 = 10^{-3}$ $\quad R_2 = 1.$

1st Beam Forward: $R_1 T_2^2 \cdot 100 = 10^{-3}(.033)^2 10^2 = 1 \times 10^{-4}$ W

2nd Beam Forward: $R_1^2 R_2 T_2^2 \cdot 100 = 10^{-6}(.033)^2 10^2 = 1 \times 10^{-8}$ W

Beam Splitter + Mach Zender



MZ: $T_3 = 1$ $T_4 = 1$

$R_3 = .01$ $R_4 = 10^{-3}$

B.S.: $T_5 = .5$ $T_6 = 1$

$R_5 = .5$ $R_6 = 10^{-3}$

Beam Splitter

1st up beam: $P = R_6 T_5^2 100 = \frac{10^{-3}}{4} 100 = 2.5 \times 10^{-2}$ W

2nd up beam: $P = R_6^2 T_5^2 R_5 100 = \frac{10^{-6}}{4 \cdot 2} 100 = 1.25 \times 10^{-5}$ W

1st beam right: $P = R_6 R_5 T_6 T_5 \cdot 100 = \frac{10^{-3}}{2 \cdot 2} \cdot 100 = 2.5 \times 10^{-2}$ W

2nd beam right: $P = R_6^2 R_5^2 T_6 T_5 \cdot 100 = \frac{10^{-6}}{4 \cdot 2} \cdot 100 = 1.25 \times 10^{-5}$ W

Mach Zender

1st up beam: $P = R_4 T_3^2 \cdot 100 = 10^{-3} \cdot 100 = 10^{-1}$ W

2nd up beam: $P = R_4^2 T_3^2 R_3 \cdot 100 = 10^{-6} \cdot 10^{-2} 10^{2} = ~~10^{-6}~~$ W

1st beam right: $P = R_4 R_3 T_4 T_3 \cdot 100 = 10^{-3} 10^{-2} 10^{2} = 10^{-3}$ W

2nd beam right: $P = R_4^2 R_3^2 T_4 T_3 100 = 10^{-6} 10^{-4} 10^{2} = ~~10^{-8}~~$ W