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Laser Interferometer Gravitational Wave Observatory (LIGO) Project

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IOT1 LAYOUT AND MODE CLEANER REFLECTION PORT

Summary:

This is a proposal to remove the EO shutter at the mode cleaner reflection port (IOT1 and IOT7). This should allow for a simpler beam path with reduced acoustic couplings and for reliable operations with higher laser power.

Current State:

Figure 1 presents the current layout of IOT1. For H1 about 80% of the light is dumped ahead of the EO shutter. The EO shutter is operated with a high and low transmission state selected by the amount of light detected on the trigger photodetector. During lock acquisition the EO shutter lets

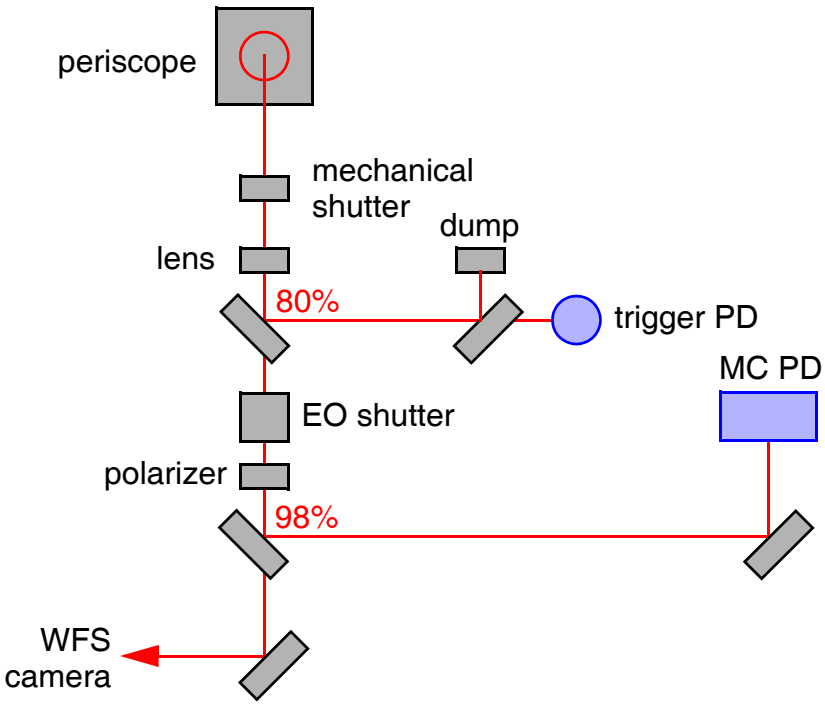

Figure 1: Schematic view of current H1 IOT1 layout.

about 10% of the light through. With 800 mW available on the PSL table this yields about 16 mW of light on the mode cleaner length sensor. When the mode cleaner is locked the reflected light decreases by a about a factor of 30 and the EO shutter switches into its high transmission state letting 100% of the light through. With the same 800 mW on the PSL table this gives about 5 mW of light on the MC length sensor. During the switch to common mode the light into the mode cleaner is slowly increased while reducing the EO shutter transmission accordingly. This keeps the optical gain of the mode cleaner length and alignment servos constant during the transition. One problem when going to higher power is that the trigger level has to be set low enough to allow for the switching during lock acquisition. A reasonable trigger level corresponds to about 100 mW–200 mW of light at the periscope. However, at full 8 W input power this level is exceeded even when in lock.

Proposed Layout:

As it turns out the EO shutter isn't really required and the mode cleaner could equally well be operated without it—as long as a mechanical shutter is installed to prevent high light levels to burn out the MC length sensor. Figure 2 presents the proposed new layout of IOT1. To allow for higher input power 90%–95% of the light is dumped at the head of the beam path. The EO shutter has been eliminated and the mechanical shutter has been installed in its place. The mechanical shutter is controlled from the trigger photodetector to close down when the power at the MC length sensor exceeds ~30 mW. To lock the mode cleaner the power at the PSL table is reduced to approximately 50 mW–100 mW. This guarantees that the light power on the MC length sensor does not exceed 10 mW. When the mode cleaner locks, the power at the PSL table is set back to its

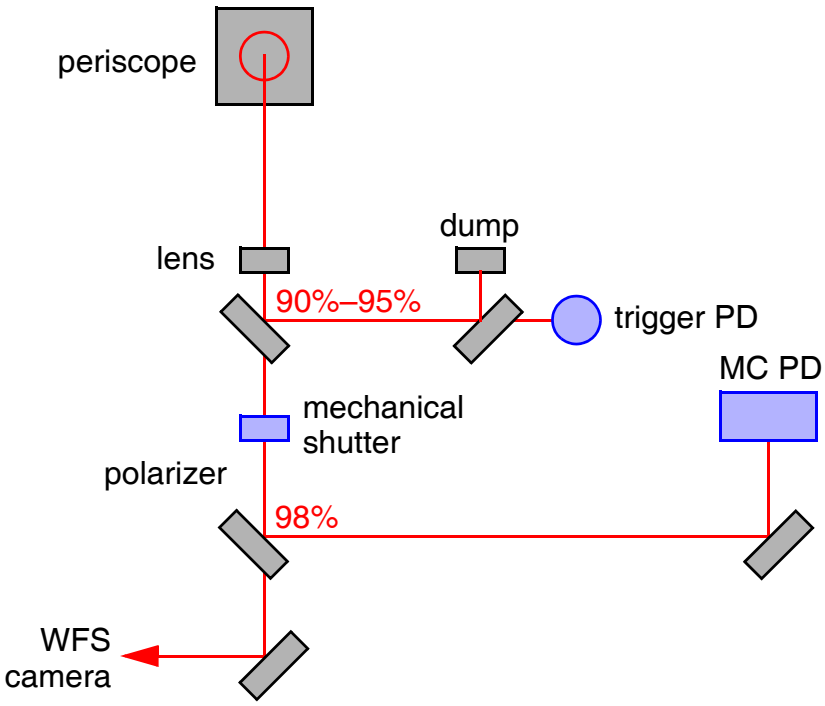

Figure 2: Schematic view of proposed new IOT1 layout.

normal value—800 mW in the case of H1. This will yield about 2.5 mW of light on the MC length sensor. During the transition into common mode the power could be increased to as high as 8 W. This will give 25 mW of light with the 90% dump, or 12.5 mW with the 95% dump. To account for the increased optical gain the electronics gain of the MC length and alignment systems have to be reduced correspondingly. If the mode cleaner looses lock at nominal input power of 0.8 W or higher, the mechanical shutter will be closed automatically. The shutter will open again, if the power on the PSL table is reduced below ~300 mW.

Currently, about 2% of the light going to the MC length sensor is used for the auto-alignment system. This results in roughly 0.1% of the incoming light for each of the two wavefront sensors. When locked with the full 8 W of laser power, this gives no more than 0.25 mW. The trigger level would correspond to about 0.3 mW. The light on the wavefront sensors can easily be increased by an order of magnitude by replacing the 98% beamsplitter with a 80% one. This will then give ~2.5 mW for each wavefront sensor when locked at full power. This change would reduce the power available on the MC length sensor by about 20% to 20 mW (90% dump).