## A THREE-DIMENSIONAL BEAM RAY TRACING OF LASER TRANSPORTATION SYSTEM

## Hongliang Shi, Daniele Spiga, Kai Nicholas Lafortune, Joseph Robinson, Alan Fry SLAC National Accelerator Laboratory Stanford University Menlo Park, CA 94025

## ABSTRACT

The vast majority of pump/probe experiments explore timescales of femtoseconds to picoseconds, requiring optical sources to have a welldefined spatial overlap. Currently in Linac Coherent Light Source at SLAC National Accelerator Laboratory, a beam transportation system is under development for transferring the pump laser to the end station. Considering the vibration and thermal drift, the pump laser is required to spatially overlap with a probe soft X-ray within 500 nanometer after about 20-meter transportation. In this work, we present an analytical model to analyze three-dimensional beam ray tracing in the transportation. It features module of reflected beam from a single mirror considering the spatial position error in 6 Degree of Freedom (DOF). A 3dimensional beam ray trace of multiple mirrors is further developed based on the module method.



FIGURE 1. Laser system overview.

The layout of the transportation beam pipe is illustrated in Fig. 2.



FIGURE 2. Beam transport of the laser system.

As shown in Fig. 3, a mirror is to be placed at a target position, Plane 1, from the original position Plane 0, where the global coordinate is defined. Plane 1' is denoted as the real position of the mirror. The difference between real position and target position is due to static and dynamic errors. The static errors include machining tolerance of mechanical part, assembly error, etc. The dynamic errors include vibration, thermal drift, etc. The transformation from Plane 1 to Plane 1' is modeled with 6 DOF in the local coordinate of Plane 1. Further, the real reflected beam O' and ideal reflected beam O is derived from the incident beam in the originate coordinate.



FIGURE 3. Analytical model of beam ray trace of 6DOF mirror position.

Based on the module method, the threedimensional beam ray tracing is further derived for multi-mirror reflection in space in Fig. 4.



FIGURE 4. 3 dimensional beam ray trace of multiple mirrors.