ELECOMP CAPSTONE SUMMIT
FRIDAY, MAY 10, 2019

THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Laser Simulation and Optimization

“LASIMO”

Team Members: Bennett Lallo (CPE), Jonathan Fasano (ELE)

IRADiON Ceramic Core CO_2 Lasers

Technical Directors: Dr. Mike Mielke, Adam Card

Project Motivation

The Laser Simulation and Optimization, or commonly referred to by the acronym, LASIMO, is a project that has been established and intended for use with Iradion’s patented CO2 lasers. Construction of a laser resonator relies heavily on both experimentation and optical modeling. At this time, there are few resources that provide easy to use modeling software which caters to this type of laser despite its popularity within the industry. Due to the absence of a concrete theoretical modeling approach, design modifications inevitably result in extensive lead times and significant economic impacts. The LASIMO project aims to reduce necessary time and resources by providing an optical modeling platform that can efficiently and accurately predict the optical performance of these industrial lasers. With access to such a platform, it is anticipated that modification times will be reduced by up to 70%. This has the potential to be a key factor in Iradion’s projected growth and expansion.

Key Accomplishments

- **Basic Knowledge Acquisition of Laser Optics:** Developed a basic knowledge and foundational understanding of laser science and optics.
- **Light Diffraction:** Research of diffraction and its mathematical representations for modeling applications.
- **Laser Safety:** Learned about laser safety when it comes to working with and around high power CO2 lasers at the Iradion facility.
- **Far Field Waveform:** Through use of the *Fraunhofer* integral, successfully modeled far field waveforms for both rectangular and circular apertures.
- **Near Field Waveform:** Through use of the *Fresnel* equation, successfully modeled near field waveforms for both rectangular aperture and a circular apertures.
- **Lens Propagation:** Modeled the waveform for a frequency passing through a lens, the format serving as a basis for current and future work.
- **Field Intensity:** Modeled field intensity using *Fourier* convolution, including variations for multi-lens with single point source.
- **Galilean Telescope:** Modeled the *Galilean Telescope* in a for various applications, as well as for a variety of wave-front propagation techniques.
- **Holes and Grating:** Modeled square grating and other types of periodic transparency functions in Matlab. These problems experimented with placing forms of obstructions such as diffraction grating patterns and verify expected final field intensity outputs.
- **Model the Laser Cavity:** Briefed on how to model the laser cavity and managed to attain a basic model and idea that was on the correct track by the end of the fall semester.
- **Complete Laser Resonator Model:** The laser cavity was developed through many trials and versions consisting of different approaches and techniques. Upon a successful methodology, additional functionalities were implemented until the resonator was a robust and accurate modeling platform. Many refinements were implemented into the resonator model, such as a shifting function that allows output data to be more intuitively understood prior to intrinsic analysis, and optimizations for the application to be execute with high levels of efficiency.
- **Enable Wavefront Incidence Angle:** Integrated functionality that allows for analysis of the beam’s output with the mirrors at differing angles than their neutral position. This allows for relative checks for power loss and was key for checking measurement competency.
- **Output Beam Quality Data Analysis:** Perform output beam sampling to define the figures of interest such as the beam radius and beam divergence which enable industry standard quantitative beam quality definitions, such as *“M^2”* or beam cross sectional distributions.
- **Develop Hands-On Laser Measurement Competency and Build Portfolio of Data:** Working with the Iradion R&D team, we were able to development data sets (shown in ***figure 1***) to tune and validate the simulation outputs. The particular data of interest was namely the power and it’s mirror angle dependence, as well as the beam waist as a function of propagation distance.
- **Compare Theoretical Model Results to Experimental Output:** Using the collected data, the optical model was tuned (seen in ***figure 2***) for efficiency and accuracy . Using a trial and error method, we performed rigorous testing to minimize errors and discrepancies, resulting in improved accuracy. This ensured the simulation outputs converge to the actual laser beam parameters. This process also enabled the ability to perform identical analysis procedures in the simulation as performed in actual laser data development.
- **Design and Implement Graphical User Interface with Supporting Documentation:** Using MATLAB, we packaged the complete optical modeling platform into an easy to use and intuitive application (shown in ***figure 3***). The App is easily accessible and mounted within the MATLAB editor toolbar next to other stock applications provided by Mathworks. A user manual/documentation to accompany this final deliverable has been provided to Iradion.

Anticipated Best Outcome

The anticipated best outcome of the LASIMO project is to accurately and efficiently model the negative branch, confocal unstable resonator that Iradion uses in their CO2 lasers. Through use of MATLAB coding software, the project designers will develop a platform that matches the output of an Iradion laser. A number of values, such as cavity geometries and optical wavelength of light, will be entered as input to a GUI to produce modeling outputs. A manual will be provided alongside the program detailing how it is used and how it works. Overall implementation should be done in a way that is simple for the employees to understand.

Project Outcome

We have met and exceeded the Anticipated Best Outcome of the *laser simulation and optimization* project.

Figures

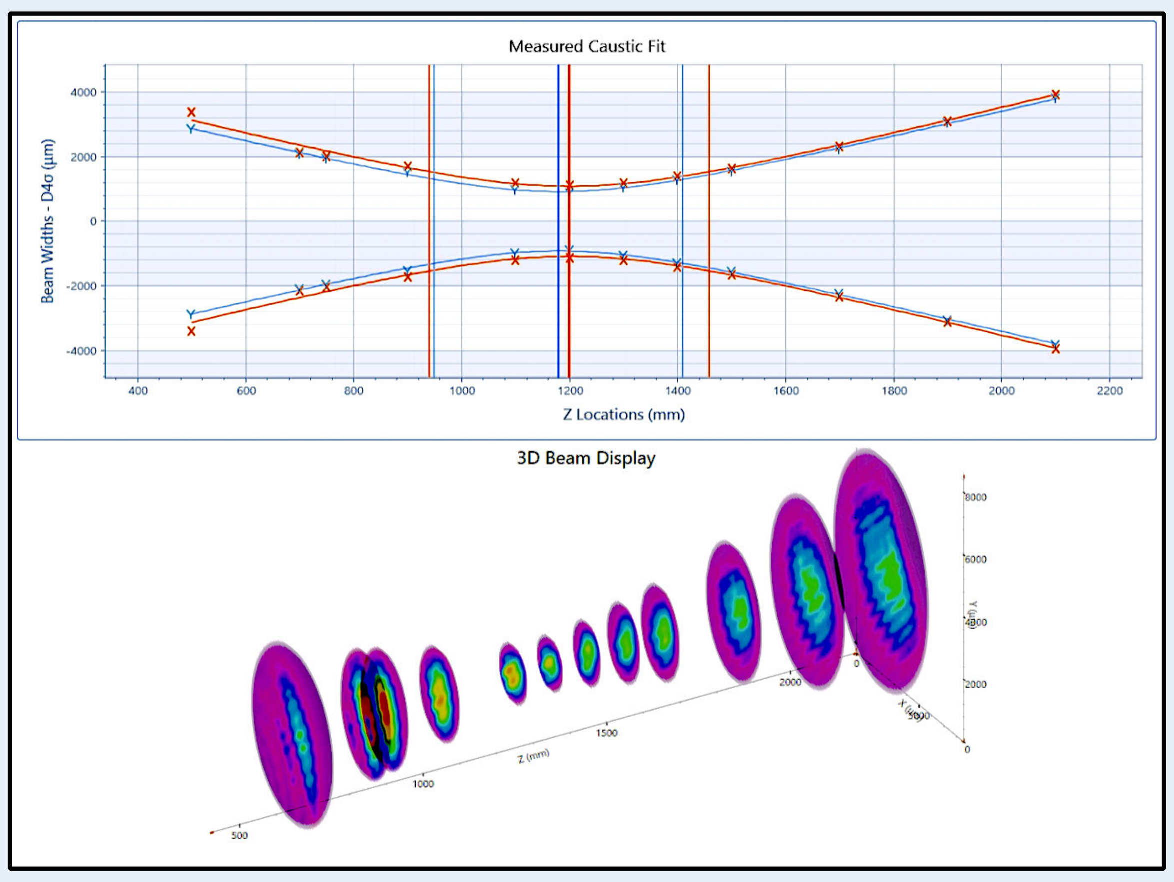

Figure 1: Actual measured laser data from Iradion facility

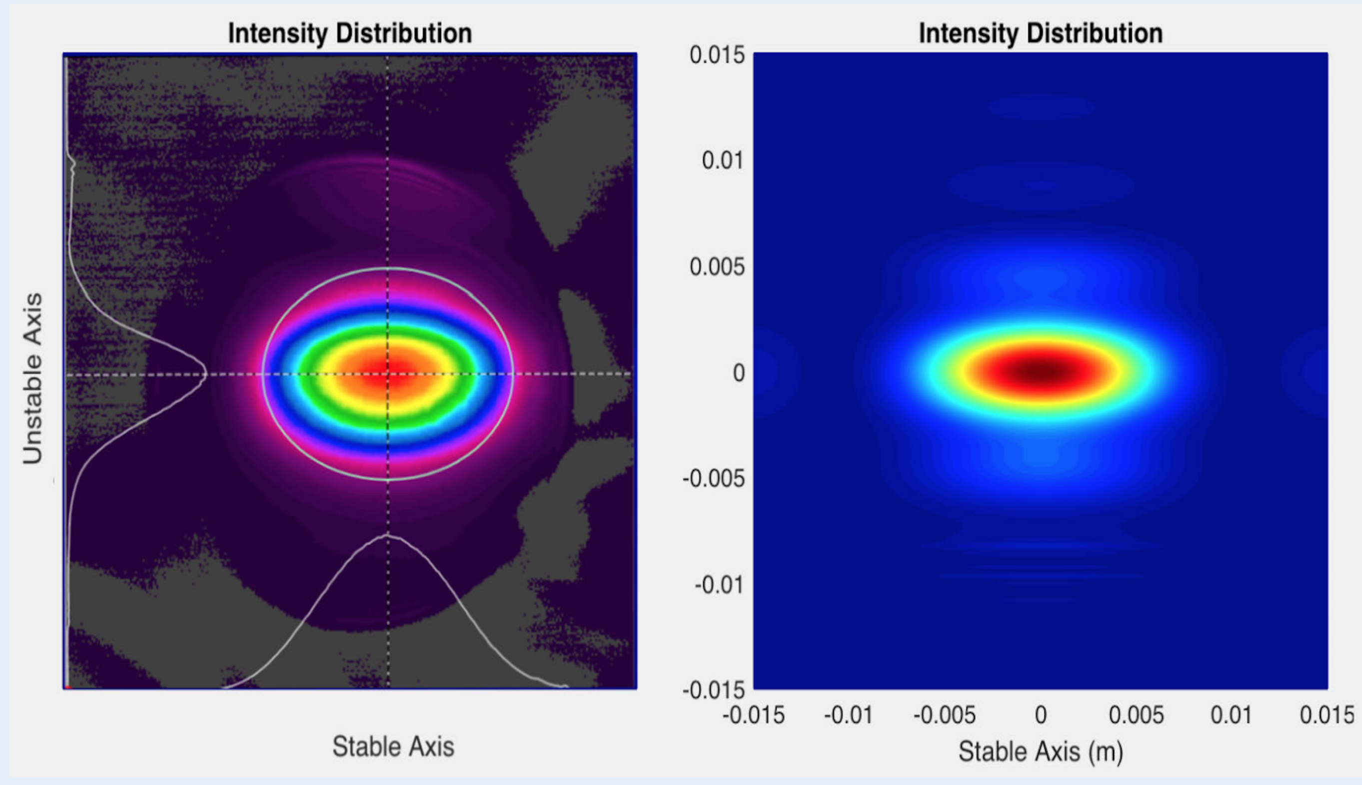

Figure 2: Comparing actual vs. theoretical beam output data.

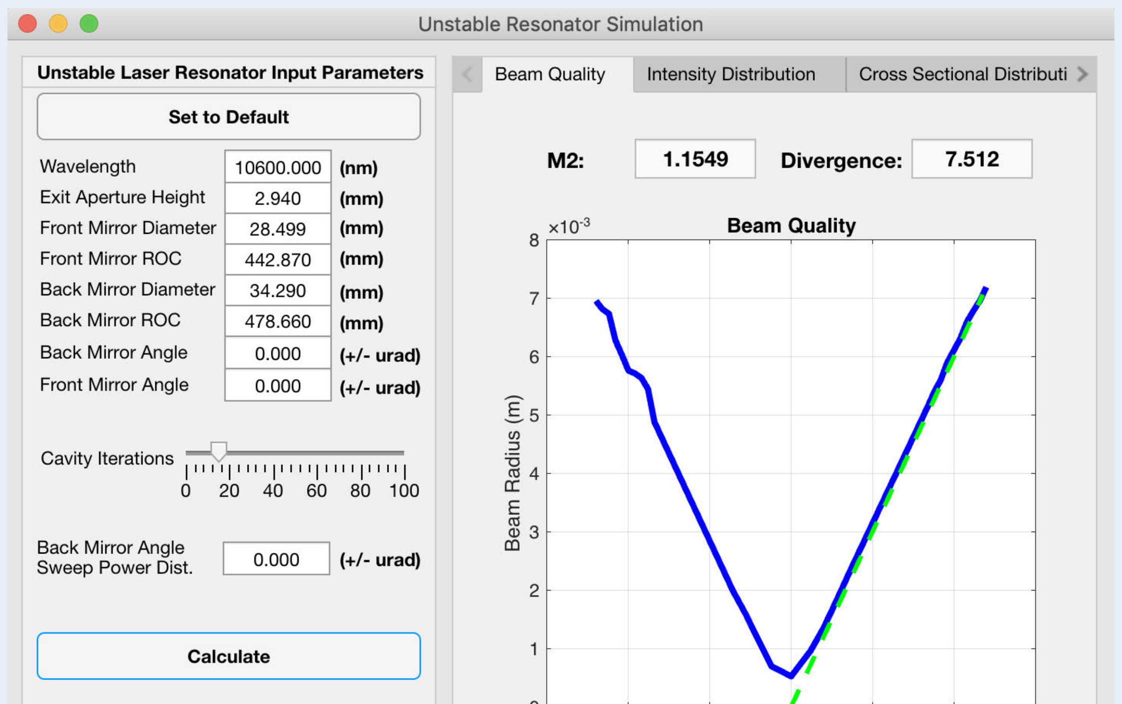

Figure 3: Beam quality characterization is one of many functionalities of the Unstable Resonator Simulation graphical user interface.

ELECOMP Capstone Program Director: Professor Harish R D Sunak

email: sunak@ele.uri.edu telephone: 401-874-5859

ELECOMP Website: http://web.uri.edu/elecomp-capstone