Design of a near-/far-field monitor system for the petawatt laser system DRACO

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INTRODUCTION

In laser beam diagnostics, the following beam properties must be included:

1. Measurement of Laser Energy or Power
2. Spatial Intensity of
3. Propagation, Temporal Characteristics, and Spectral Analysis[1]

Spatial Intensity and Beam Propagation are typically defined and measured in two optical fields, Near and Far Fields

The Near Field of a Laser Beam is a region at or very close to the output aperture that is characterized by disordered phase fronts and often called the Frenzel Zone. In the Near Field, beam shape, size, profile and divergence can vary rapidly with distance.

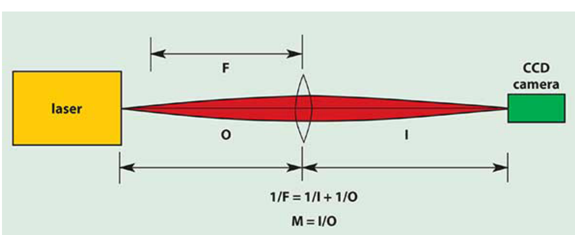

Fig 1 : Near-Field Optical Setup

OPTICAL SETUP REQUIREMENT

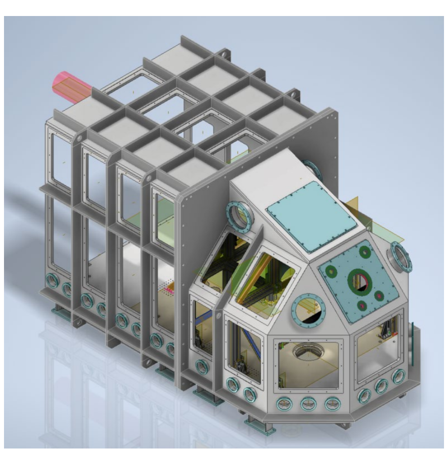

Fig 2 : Proton Accelerator

As shown in the Fig 2, the laser beam is directed in a large vacuum chamber. However, the laser beam characterization must be performed outside of the vacuum, e.g. using cameras and wavefront sensors.

The laser beam must be steered outside of the vacuum chamber. The setup must be very stable so that the beam parameters such as the near- and far-field can be measured.

To get the laser beam out of the vacuum chamber we need an extension of the vacuum chamber which can support the optical elements.

PROPOSED OPTICAL BEAM PATH

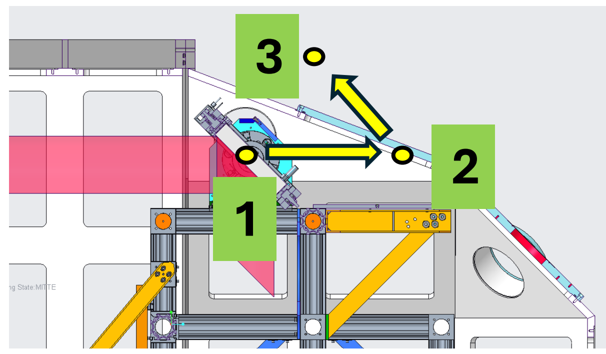

Fig 3 : Sectional View of Vacuum Chamber

As shown in Fig 3, some laser beam is getting leak from the Point 1, and we want to focus that beam on the Point 3 with the help of reflection.

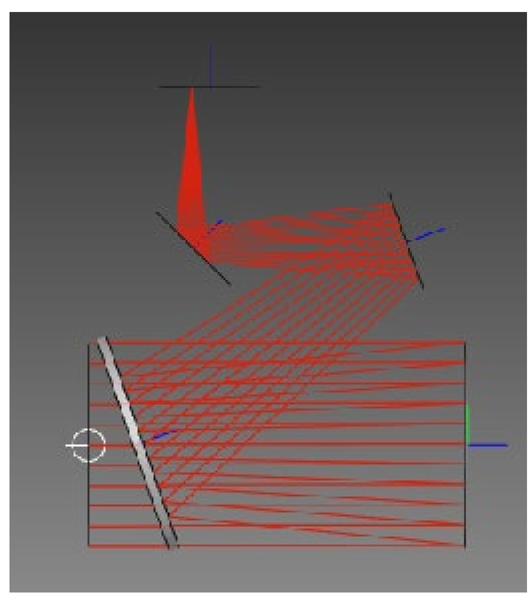

Fig 4 : Simulated Optical Beam Path using the Quadoa – Optical CAD Software

As shown in Fig. 4, the laser beam is transmitted through a beam splitter, then reflected and focused by a parabolic mirror.

The outer surface of the beam splitter will reflect the beam to the next pair of flat mirrors (turning mirrors). With the help of these mirrors, the beam is focused outside of the vacuum chamber.

SPECIFICATION OF THE OPTICAL DEVICES

1. Parabolic Mirror

Diameter:	203.20 mm
Effective Focal Length:	1625.60 mm
Edge Thickness:	34.80 mm
Surface Accuracy:	λ/8

2. Flat Mirrors

Diameter:	4 inch

3. Vacuum Compatible Mirror Mount for Flat

Mirror Diameter:	101.6mm
Motorized Axis:	2
Angular Range:	+/- 3.5°
Mechanism:	Picomotor Actuator

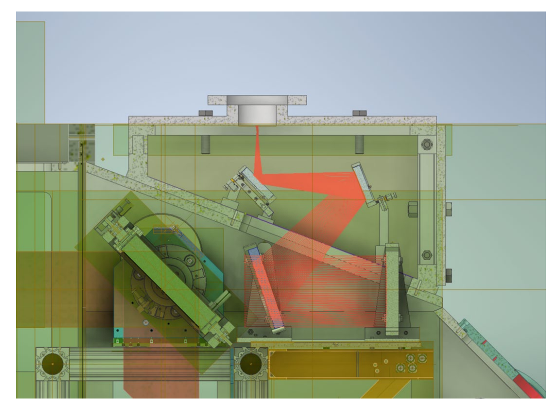

Fig 5 : CAD Design with the Mirror Mount and the Vacuum Chamber Extension

CUSTOM MADE 8” PARABOLIC MIRROR MOUNT

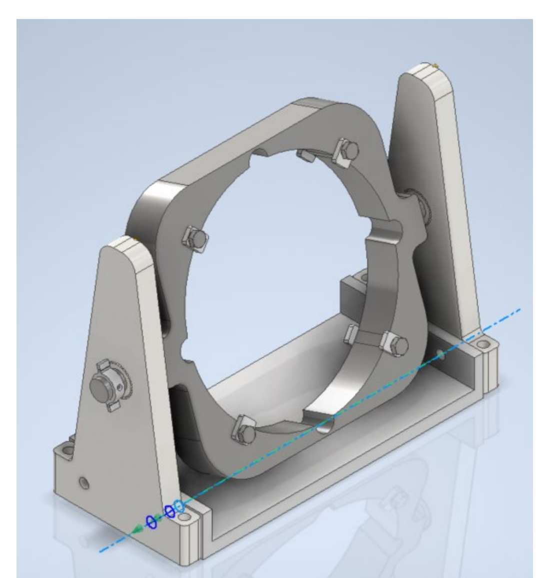

Fig 6 : CAD Design for Parabolic Mirror Mount

References:
[1]] Kroll et al., "Tumour irradiation in mice with a laser-accelerated proton beam“, Nature Physics 18(3), 316-322 (2022)
[2] https://www.edmundoptics.de/p/8-diameter-x-64-fl-protected-gold-parabolic-mirror/2148/
[3] https://www.newport.com/p/8824-AC