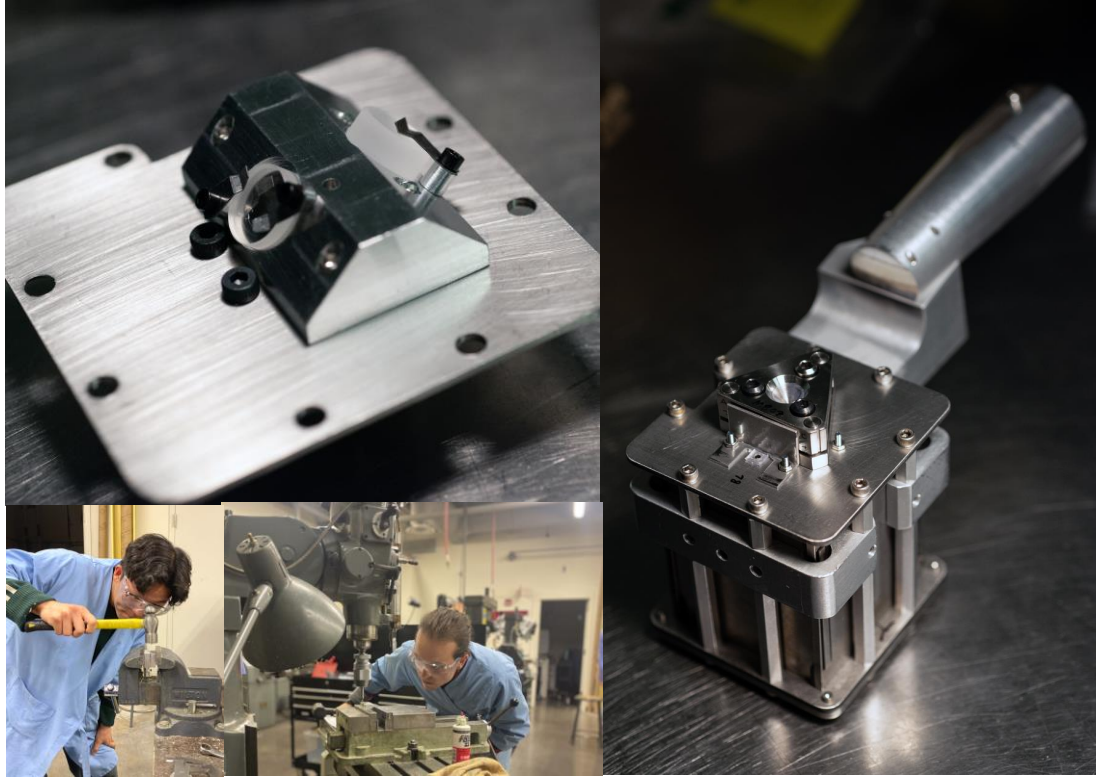
Light Relay Apparatus For The Laboratory of Laser Energetics



Team Members:
Adam Cummings
Julie Hernandez
Alex Kulvivat
Mokin Lee
Edban Watt

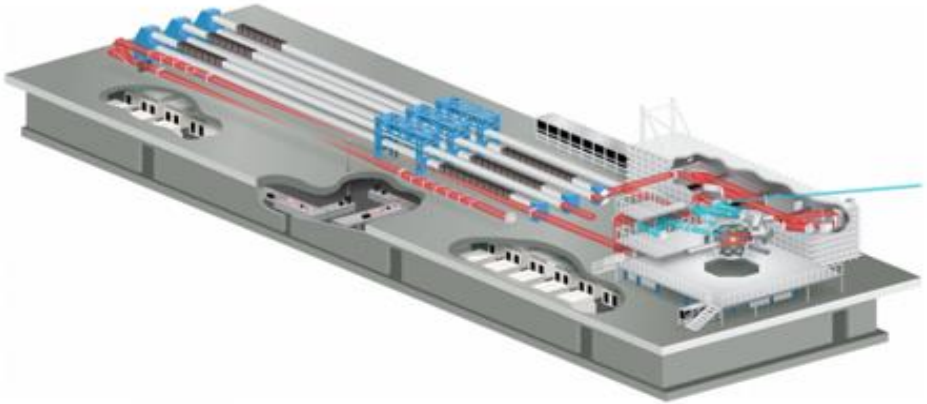
Customer:
Dr. Neel Kabadi

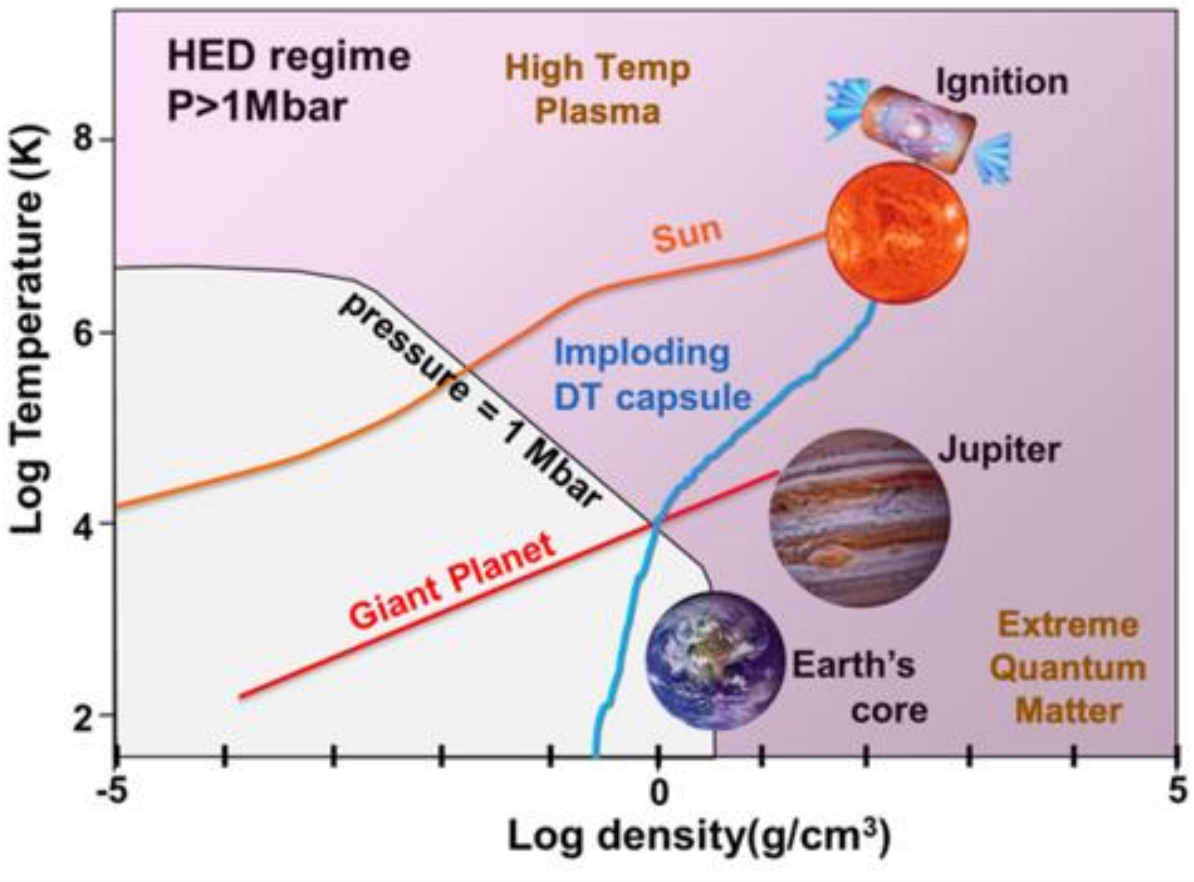
Project Overview

Design, manufacture, and test a light relay system intended for measuring the optical reflectivity spectrum for high-energy-density samples in experiments at the Laboratory for Laser Energetics.

Problem Statement

- The Laboratory for Laser Energetics (LLE) is a scientific research facility that operates lasers to conduct a variety of experiments. The LLE studies high-energy-density (HED) substances to gain insights into material properties under high pressure and temperatures.
- The team was tasked with developing a mechanical apparatus to relay the light from a back-lighter to a HED sample so that the reflected light can be measured to understand the reflectivity of the sample.
- The success of this experiment will provide a better understanding of hydrogen's transition from opaque to metallic reflective properties.





Deliverables, Requirements and Specifications

Deliverables:

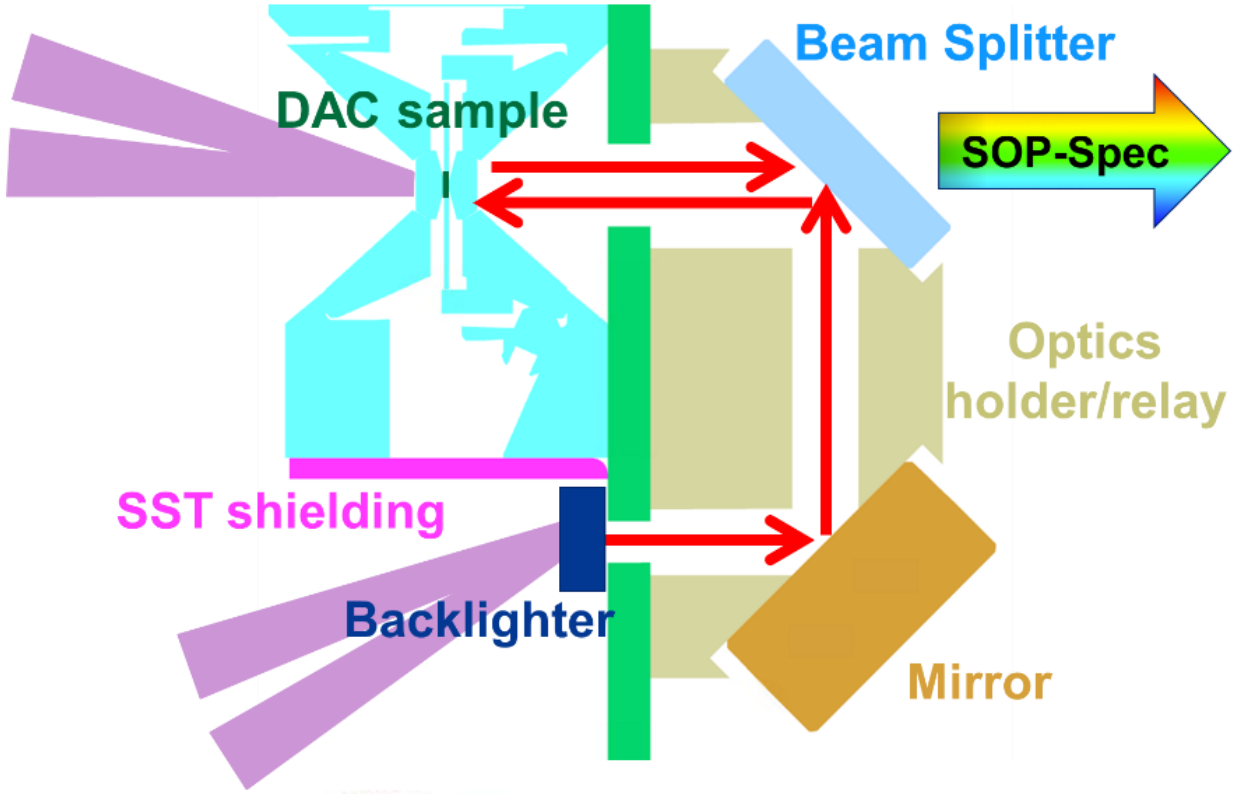
- 8 sets of functional assemblies
- Theory of use Manual
- Final Design Report

Requirements:

- Mountable on the existing PXRDIP box
- Compatible with both glue-on samples and screw-on DACs
- Allows light a path out to the spectrometer.
- Alignable within the OMEGA-EP chamber.
- Vacuum compatible.
- Must relay light from backlighter sample to target sample.
- Must fit into the space envelope defined by CAD of the PXRDIP box

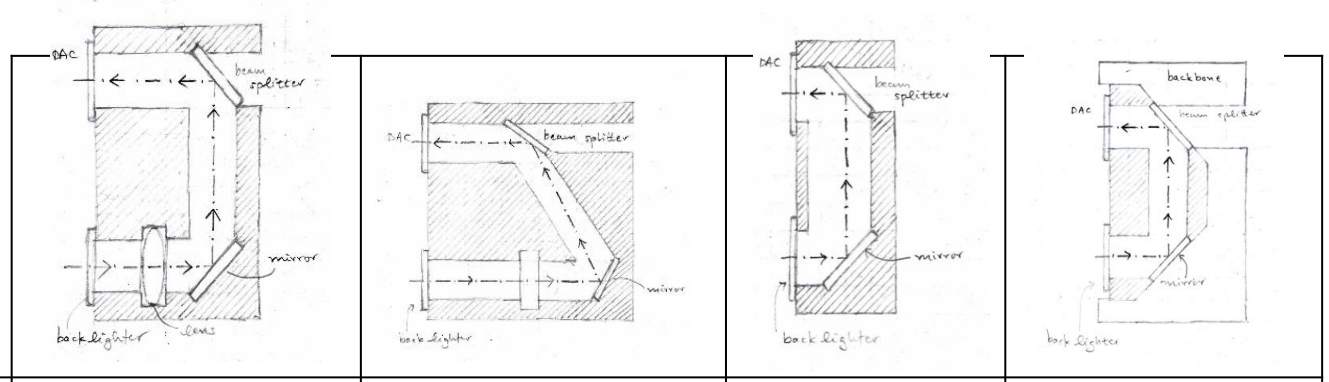
Specifications:

- A minimum of 0.01% of the light emitted by the backlighter sample must reach the target sample.
- The device must be operation within the wavelength range of 450-750 nm.



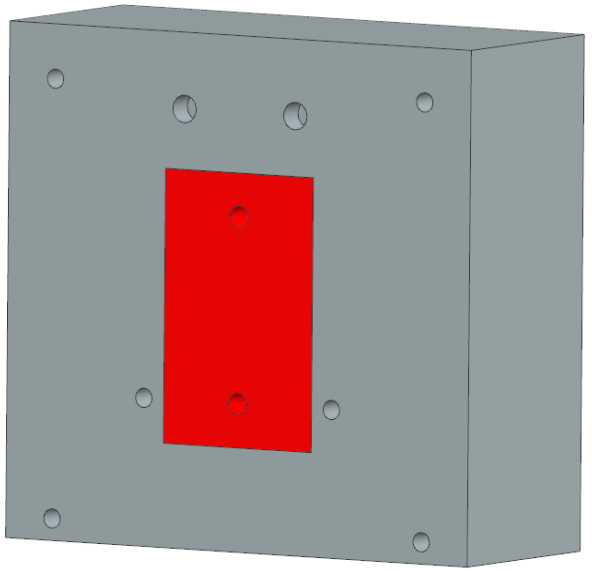
Current Project Status

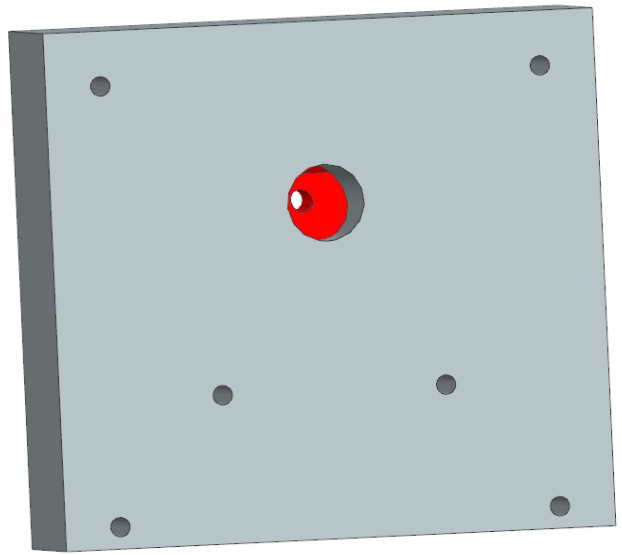
As the core component of the design, the reflectivity box used to relay the light had various concepts developed, varying primarily in their geometry.



	Concept 1	Concept 2	Concept 3	Concept 4
Ease of Manufacture	0	-	0	+
Expected Light Efficiency	0	+	+	0
Ease of Assembly	0	-	0	+
Debris Protection	0	0	-	-
Total	0	-	0	+

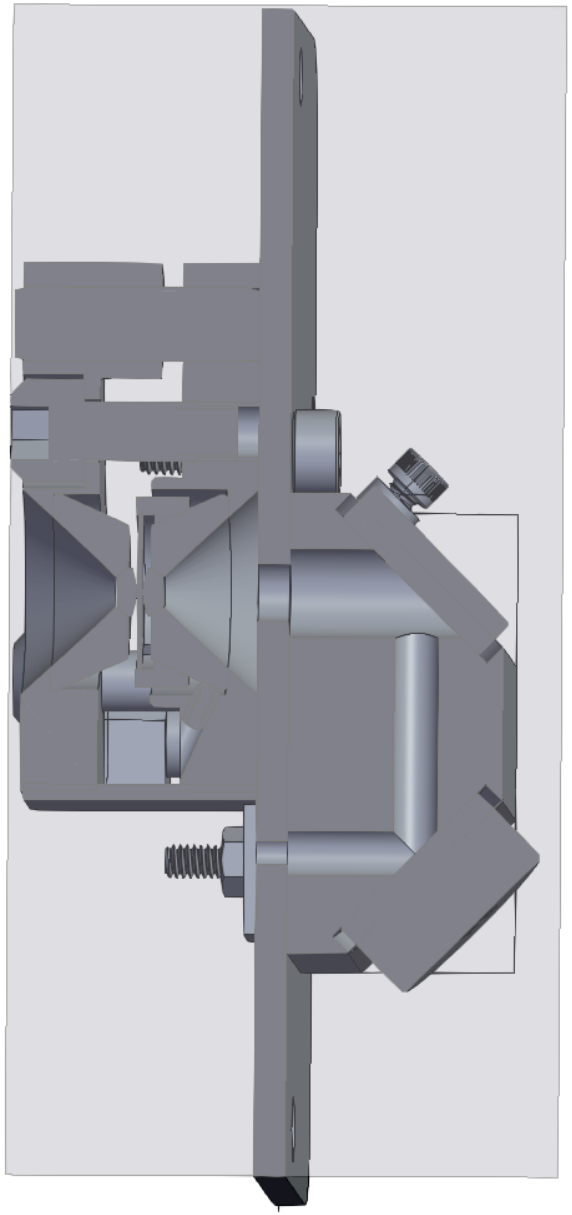
Concept 4 was selected, which utilized a backbone to hold the reflectivity box (in red) to the front plate.

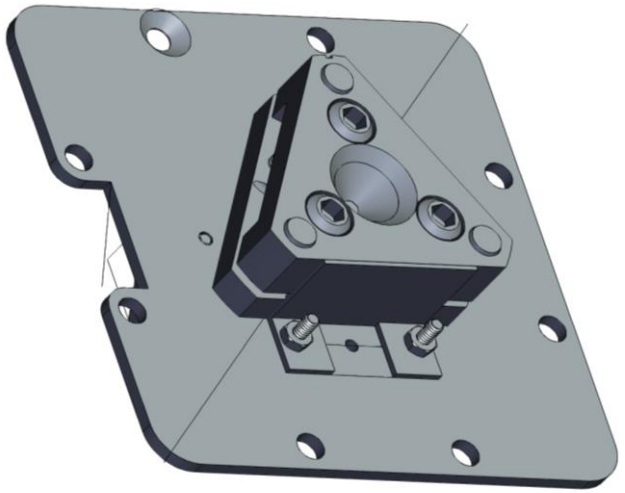


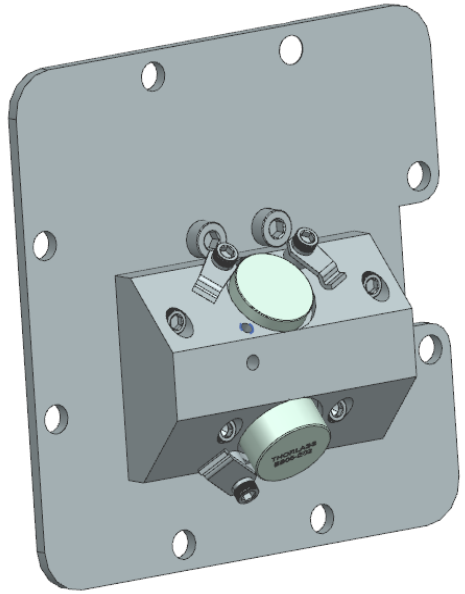


Current Project Status

After receiving feedback from the LLE engineers, a final design was developed. The reflectivity box was modified so it could be directly mounted to the front plate, and tabs were to hold the optics in place instead of a backbone.



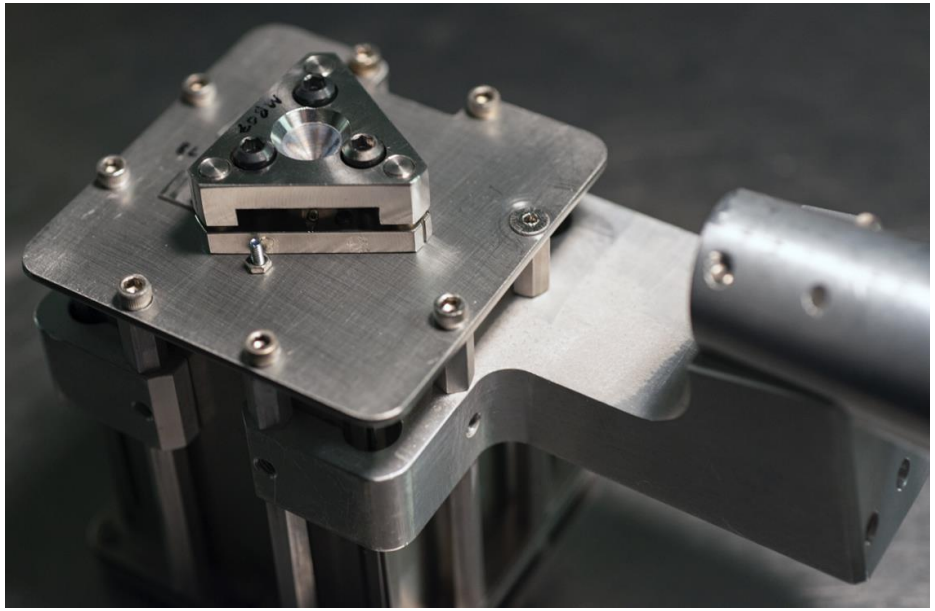


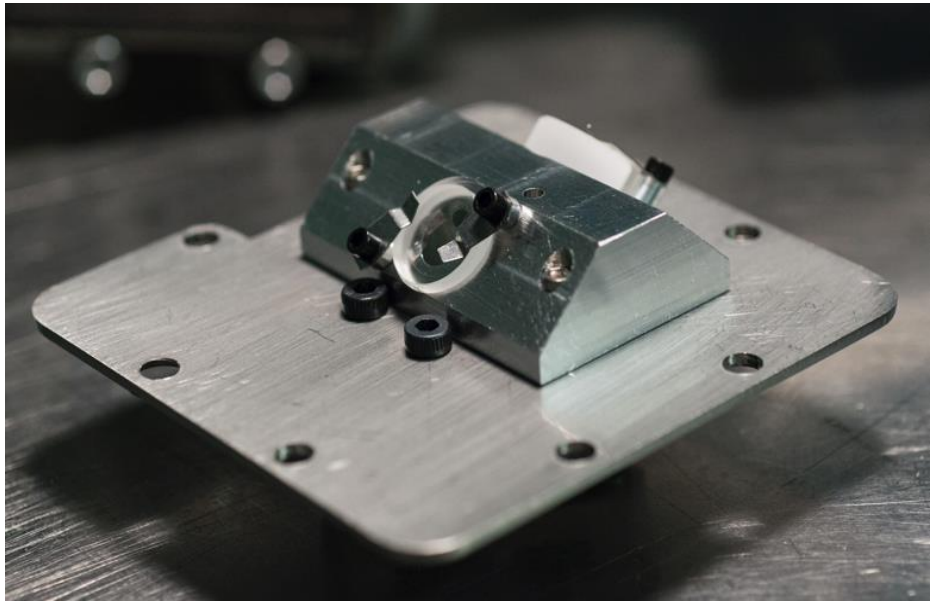


Current Project Status

- 8 sets of functional assemblies were successfully manufactured.

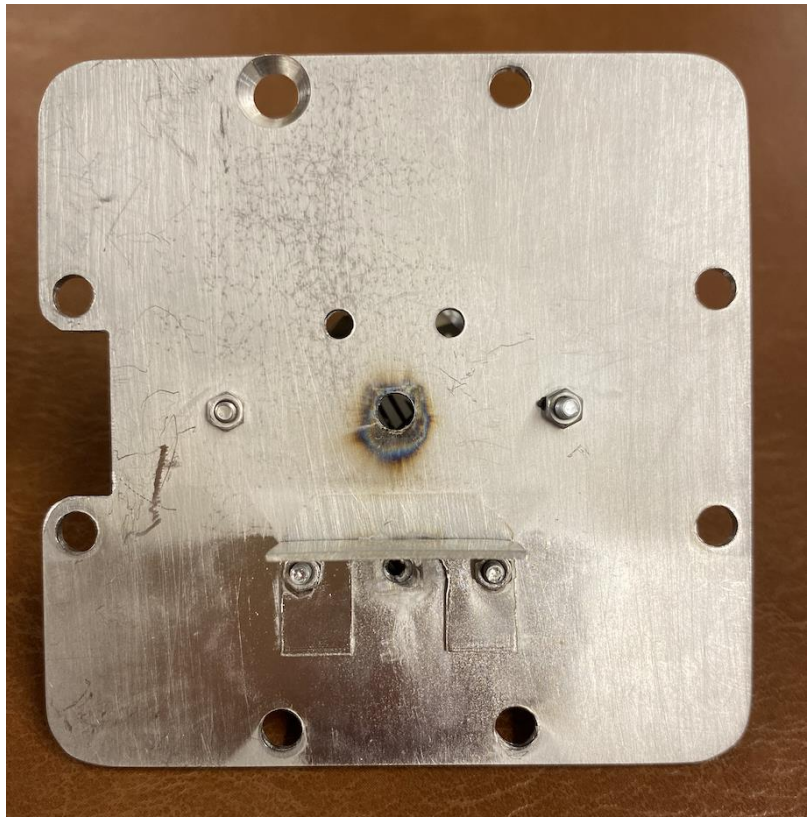
- All assemblies passed the fit and function test performed at the LLE, conducted by the LLE engineers.
  - Vacuum compatibility testing
  - Target chamber alignment

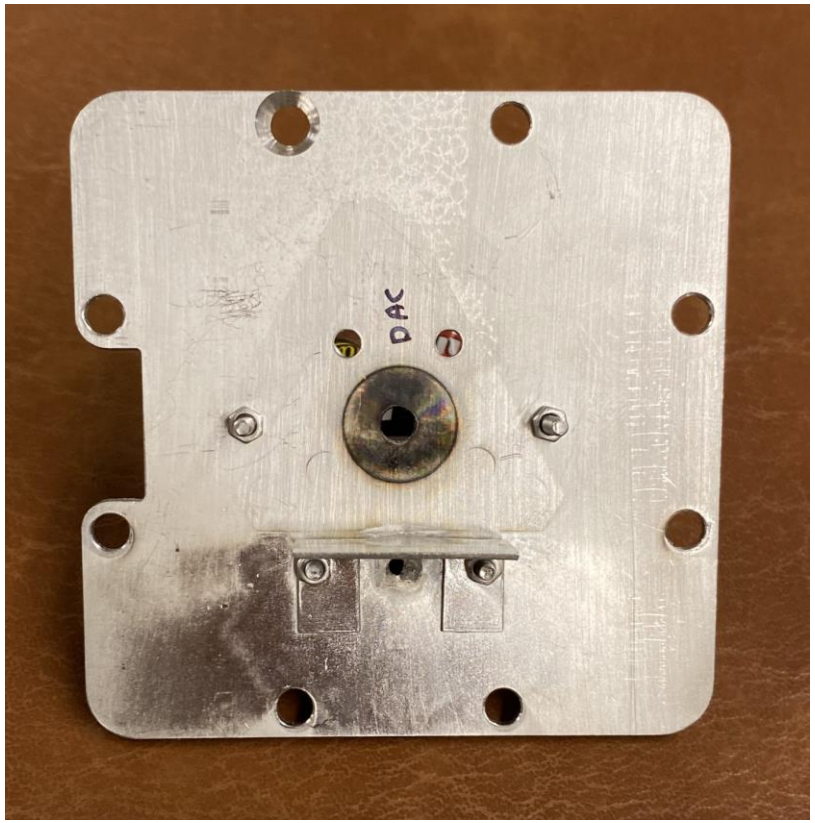




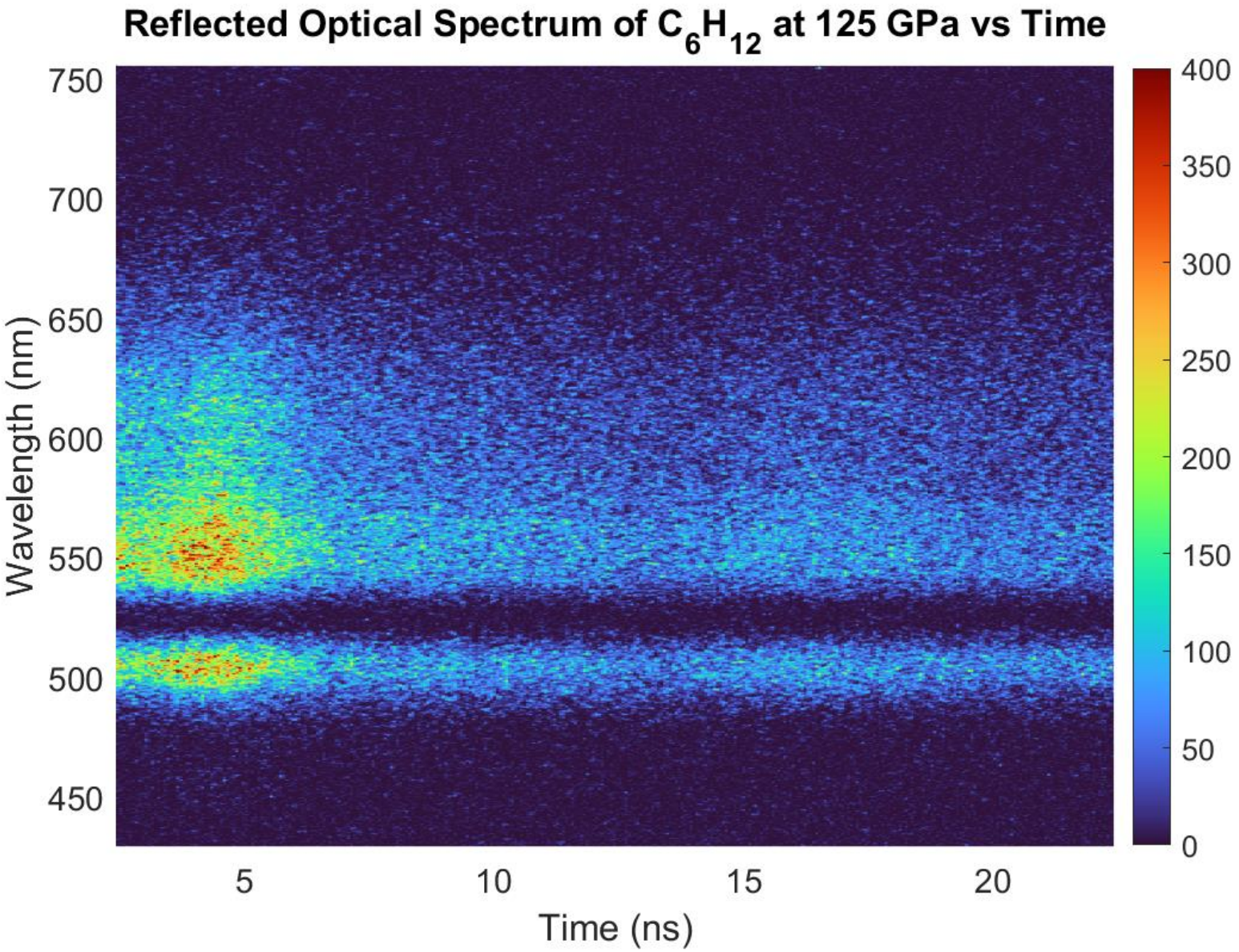
Current Project Status

All group members attended the shot day on April 16, 2024. The experiment was successfully conducted.





Current Project Status



Results from LLE Shot Day

- Hardware was operable within the specified range of wavelengths (450 – 750 nm)
  - The efficiency drop at the edges is due to the diagnostic response
- The signal being clearly detected also indicates that the hardware successfully delivered its target light efficiency (10E-4)
  - The specific 10E-4 value was determined based on the efficiency of the diagnostics

Conclusions/Future Work

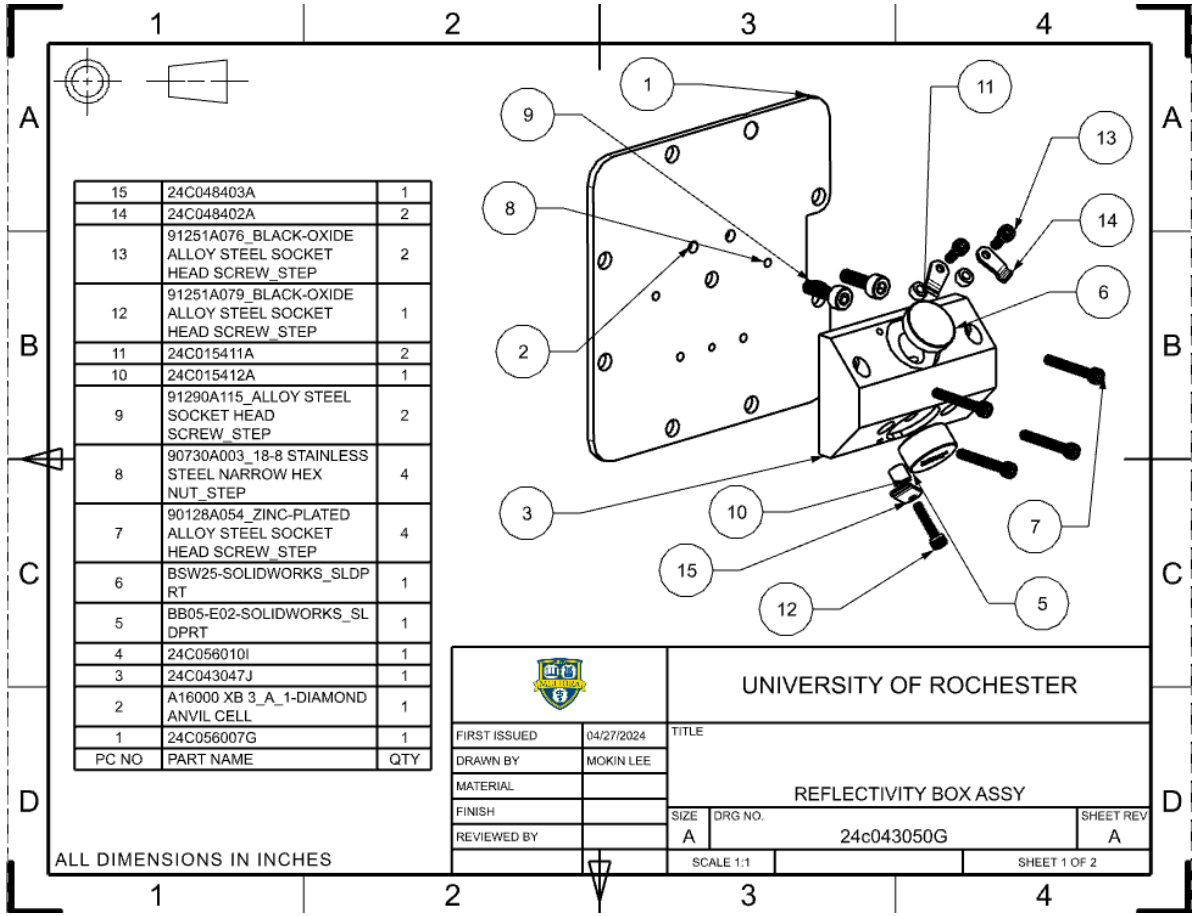
- Manufacturing time can be reduced if the shield is redesigned as a flat sheet that slots through the front plate and screws into the bottom of the reflectivity box.

- The tabs can be simplified into flat pieces that depend on the force of being screwed in instead of the spring force generated by the shim stock.

- For larger scale production, greater quality control methods can be undertaken to ensure that manufactured assemblies stay within tolerances.

- Research could be undertaken to develop methods to reduce pressure and damage to the optics.

Acknowledgements:
We would like to thank Professor Muir, Professor Mohammad, and Dr. Neel Kabadi for their guidance, Jarret Shamlian for his engineering advice, as well as Jim Alkins, Chris Pratt and Bill Mildenberger for their help with manufacturing.



PC NO	PART NAME	QTY
15	24C048403A	1
14	24C048402A	2
13	91251A076_BLACK-OXIDE ALLOY STEEL SOCKET HEAD SCREW_STEP	2
12	91251A079_BLACK-OXIDE ALLOY STEEL SOCKET HEAD SCREW_STEP	1
11	24C015411A	2
10	24C015412A	1
9	91290A115_ALLOY STEEL SOCKET HEAD SCREW_STEP	2
8	90730A003_18-8 STAINLESS STEEL NARROW HEX NUT_STEP	4
7	90128A054_ZINC-PLATED ALLOY STEEL SOCKET HEAD SCREW_STEP	4
6	BSW25-SOLIDWORKS_SLDPRT	1
5	BB05-E02-SOLIDWORKS_SLDPRT	1
4	24C056010I	1
3	24C043047J	1
2	A16000 XB 3_A_1-DIAMOND ANVIL CELL	1
1	24C056007G	1