Development of a Motorized Telescope for the Pulse-Burst Laser System

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Objectives

- To control the beam divergence between plasma discharges by creating a motorized system to move one of the lens of the telescope in the Pulse Burst Laser System.
- Motorized system needs to overcome minimal footprint, reduction of friction, and accuracy of the positioning of the lens (sub-millimeter over 25-30 mm travel).

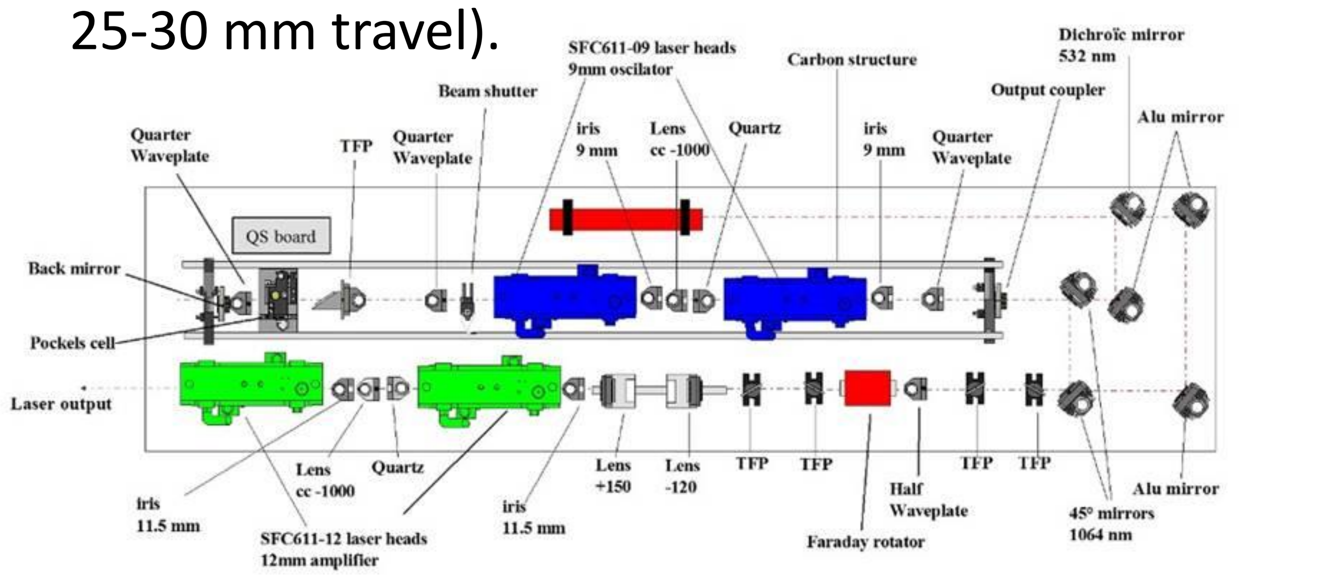

Figure 1: Schematic of the PBLS where the telescope is after the oscilloscope after a series of waveplates and mirrors.

Background on the Pulse Burst Laser System

The Pulse Burst Laser System (PBLS) has been installed and commissioned on the NSTX-U to measure the temperature and density of particles in the plasma. As the only technology currently available to measure these important parameters in plasma physics, it is imperative that the system is fully functional. As lasers propagate through space, the beam of light starts to diverge from its center. As a result, when the laser gets to the tokamak, the beam has diverged so far from its center that any data collected is inaccurate. The PBLS is part of the NSTX-U Thomson scattering system so the dependence of the scattering of light by the laser is a critical measurement.

Design Iterations

The telescope consists of two lens that are able to translate on two rods. To change the focal length of the laser beam, the screw has to be taken out so the lens can move.

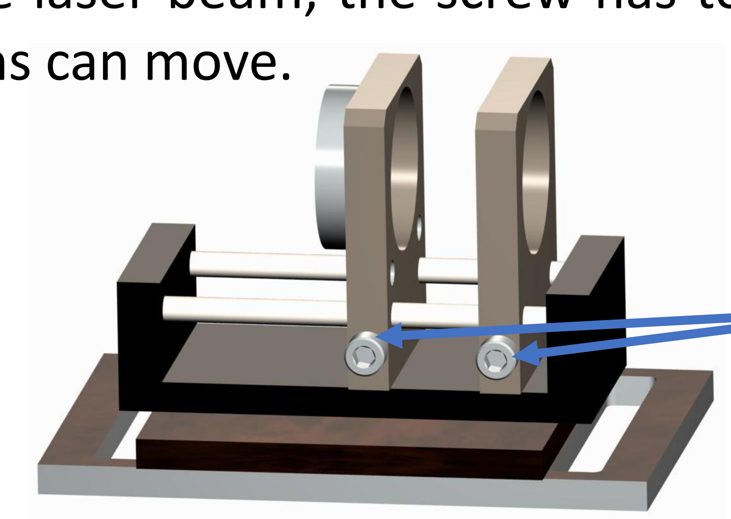

Figure 2: CAD Render of screws that prevent motion.

To increase the focus of the laser beam, only one of the lens needs to move. The distance from the laser cavity to the tokamak is 19 meters, so having the lens positioned accurately to the nearest sub-millimeter is imperative. With all of these conditions in mind, the first design iteration had a rod attached to a screw which was connected to the actuator (See Figure 2).

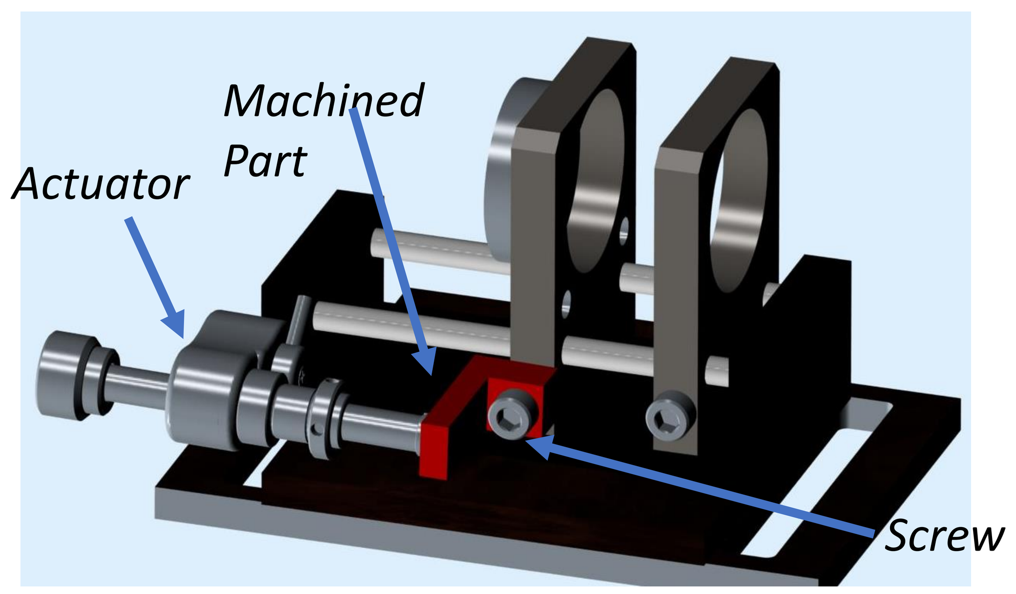

Figure 3: A machined part is attached to the lens and held together by a screw. This machined part is mounted to the actuator which moves the lens accordingly. This simple design accomplishes most of the design goals.

To ensure that the motorized system would move accurately and precisely, three actuators (Motorized Screw 8MS00-10-28 from *Standa*, Piezo Inertia Actuator PIA25 from *Thorlabs*, Compact Stepper Motor Actuator ZFS25B from *Thorlabs*) were chosen study in more detail to see which one would be the best for the system. Given the space constraints of the design, the motorized screw from *Standa* did not meet the requirements because it was very long (167.5 millimeters).

	Bidirectional repeatability	Locking Position	Closed Loop Operation	Step Size	Backlash	Temperature	Nominal Force (N)	Travel (mm)	Total Cost (including motor)
PIA Screw Motor	No	Yes	No but can manually program	0.46 nm	<15 µm	5-40°C	40	25	$1,517.18*
Compact Screw Motor	5 µm (~10-15µm)	Yes	No but can manually program	20 nm	None	10-40°C	25	25	$1,817.24*

Table 1: Comparing the characteristics of the two actuators.
**Price found on Thorlabs website on 8/8/2018[1]*

The maximum travel for both actuators is 25 millimeters, not 30 millimeters. Thus, the design had to be changed to make the machined part give a mechanical advantage.

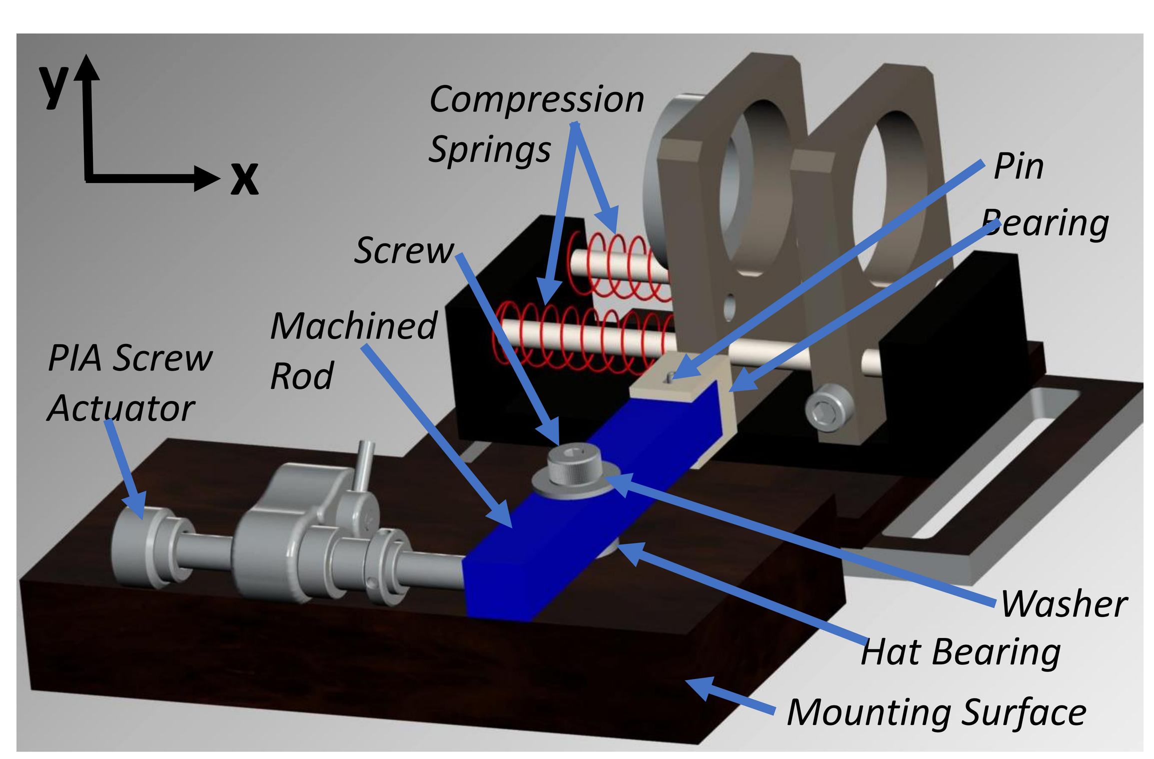

Figure 4: Final design with compression springs to move the lens backward, a bearing attached to the hole where the screw once was, and a rod which gives a 3:2 ratio advantage of the motor to allow it to travel more than 25 millimeters.

When the actuator moves a step size, the machined rod moves in the positive x-direction, sending the other side of the rod move in the negative x-direction causing the spring to compress, and the lens to translate to the position desired.

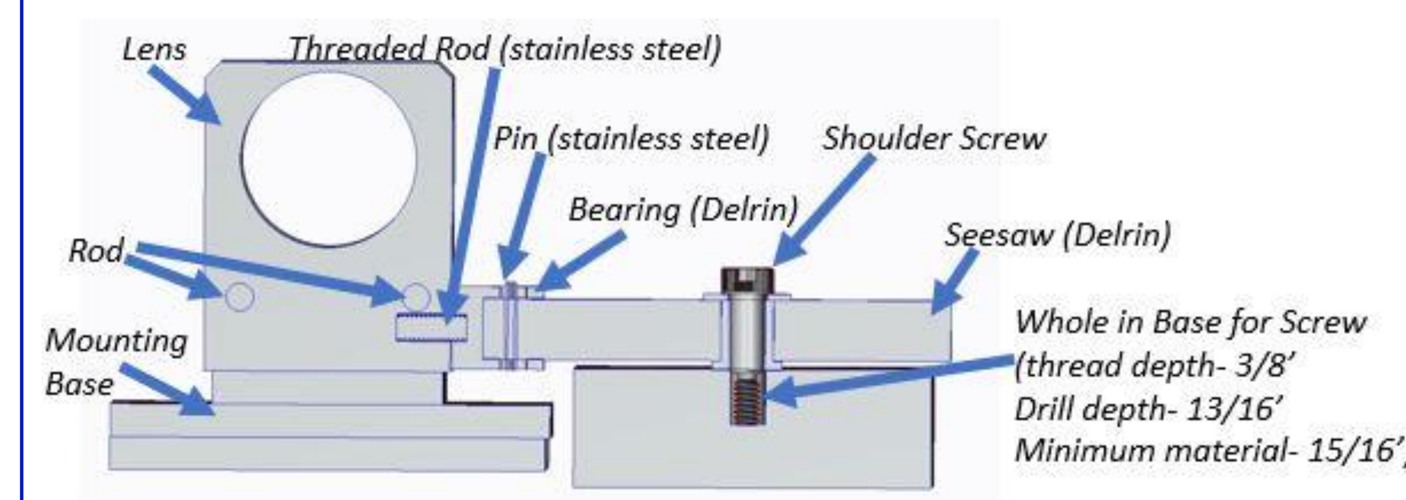

Figure 5: A cross section of the design.

Motion Study of Design

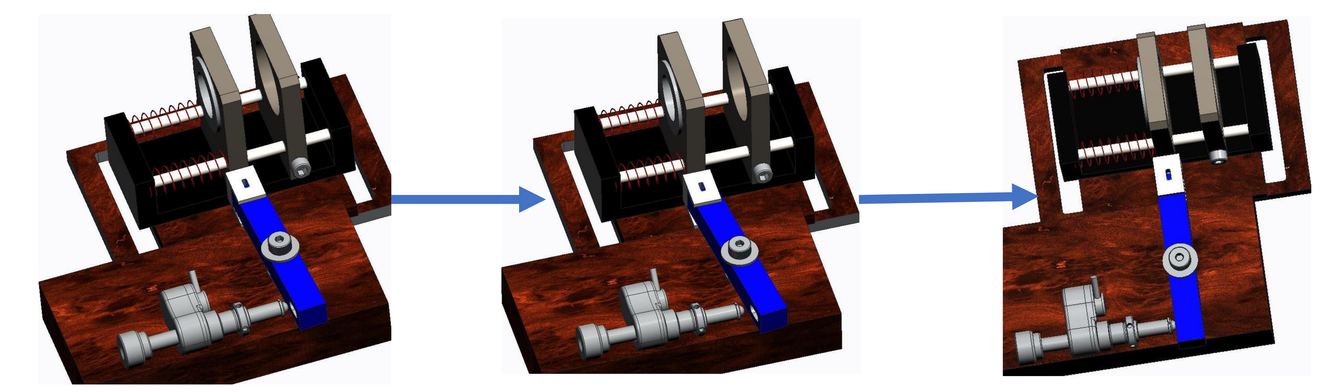

Figure 6: The figures above show how the design will move when the actuator move a step size.

Future Work

- Implement a safety lock on the design to ensure that in non-operation, the position is secured.
- Prototype and test the apparatus to ensure that it works within design guidelines.
- Have the motorized system software controlled so can it operate through a computerized system.
- Installing the design in the Pulse Burst Laser System in the NSTX-U.
- Implement on a three-lens system.

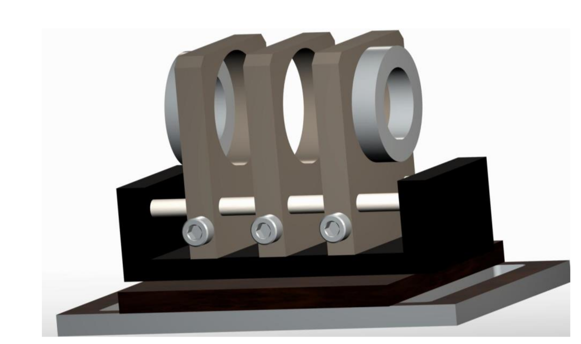

Figure 7: CAD Render of the three-lens system.

References

[1] https://www.thorlabs.com
[2] See link below for all references used:
https://docs.google.com/document/d/1hId88XX6RlkBTyOZZ7J4EjuYal-d7vE9HOyQG6MScWk/edit?usp=sharing

Acknowledgements

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