# Dual-View Imaging of Laser-Induced Plasma Expansion

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## Introduction

- A major area of research for laser-induced plasmas is for laser fusion (otherwise known as inertial confinement fusion) or magneto-inertial fusion for terrestrial energy and space propulsion.
- Magneto-inertial fusion uses a combination of magnetic and inertial confinement methods (lasers to ignite target/fuel and magnetic fields to push plasma axially out of the nozzle).
- In order to appropriately design a magnetic nozzle for future magneto-inertial fusion concepts, plasma expansion size must be determined.
- Multi-view imaging allows us to study the plasma expansion from multiple angles using a single camera, and leads into optical tomography

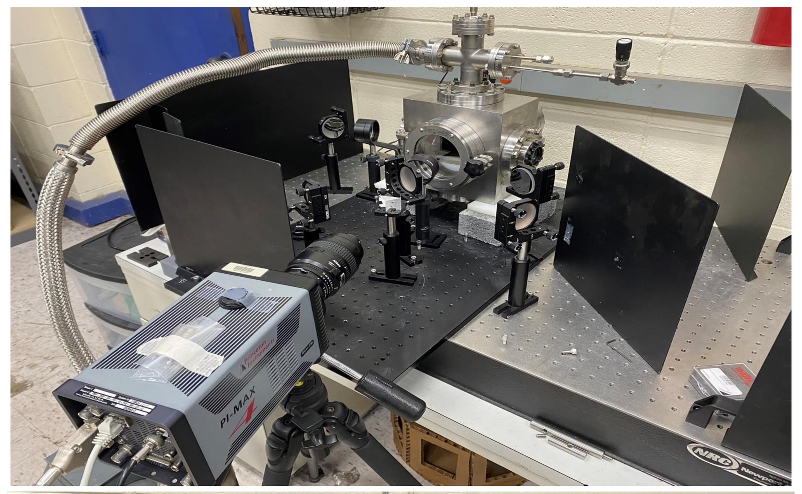

**Figure 1. Camera and Dual-View Setup with Vacuum Chamber.**

**Figure 2. Overall Experimental Apparatus.**

## Materials and Methods

- Plasma images were captured using a PI-MAX 4 ICCD camera.
- The camera was placed in front of a prism that split the image into front and side views of plasma expansion (see fig. 1).
- Neutral density and notch filters on the camera to prevent damage
- To create the plasma, a Nd: YAG laser (Quantel Brilliant b) was focused through a plano-convex lens and directed at a rectangular graphite target within the small vacuum chamber.
- The laser and camera were synchronized with the camera gate delay varied from 30 ns to 2,000 ns, with a 5 ns gate width, to gather time-resolved images of plasma expansion and contraction.
- MATLAB code was used once data is collected to produce time resolved images of plasma and graph area (in pixels) versus time.

## Materials and Methods

- Two pressures were tested (760 Torr and 100 mTorr) as well as two different energy levels (100 and 400 mJ).
- A neutral density filter plus two notch filters were mounted in front of the camera lens to protect the camera.

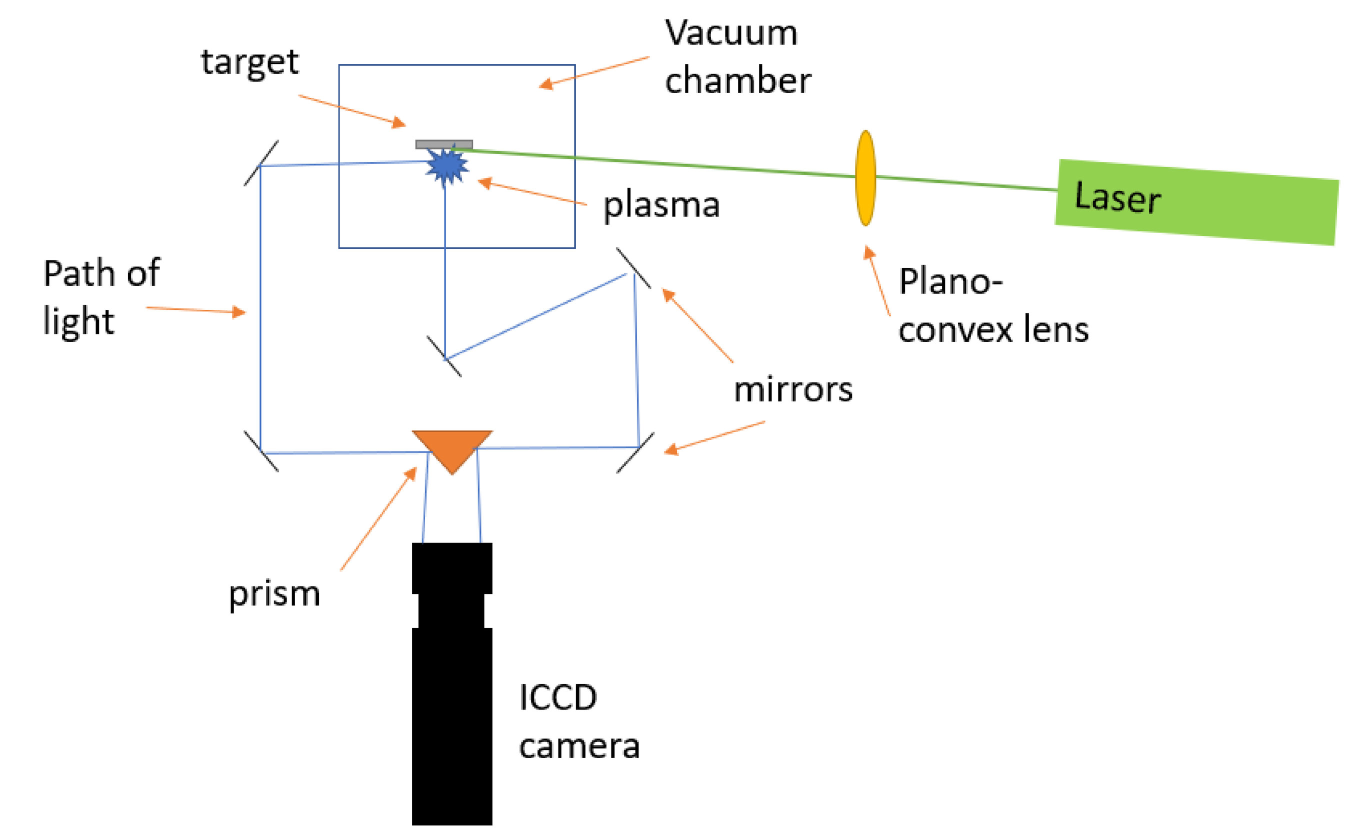


**Figure 3. Schematic of Dual-View Plasma Imaging Setup.**

## Results

- Plasma was more dispersed and scattered at lower pressure.
- Plasma was detectable for longer in higher pressure due to an increased number of collisions with air molecules causing more excitation and photon emission.
- At the higher laser energy level, the plasma expanded more rapidly and contracted more slowly compared to lower laser energy.
- At 150 mTorr of pressure and 100 mJ of laser energy, the side-view plasma was undetectable by the ICCD camera due to low signal and thus shows no change in area vs. time.

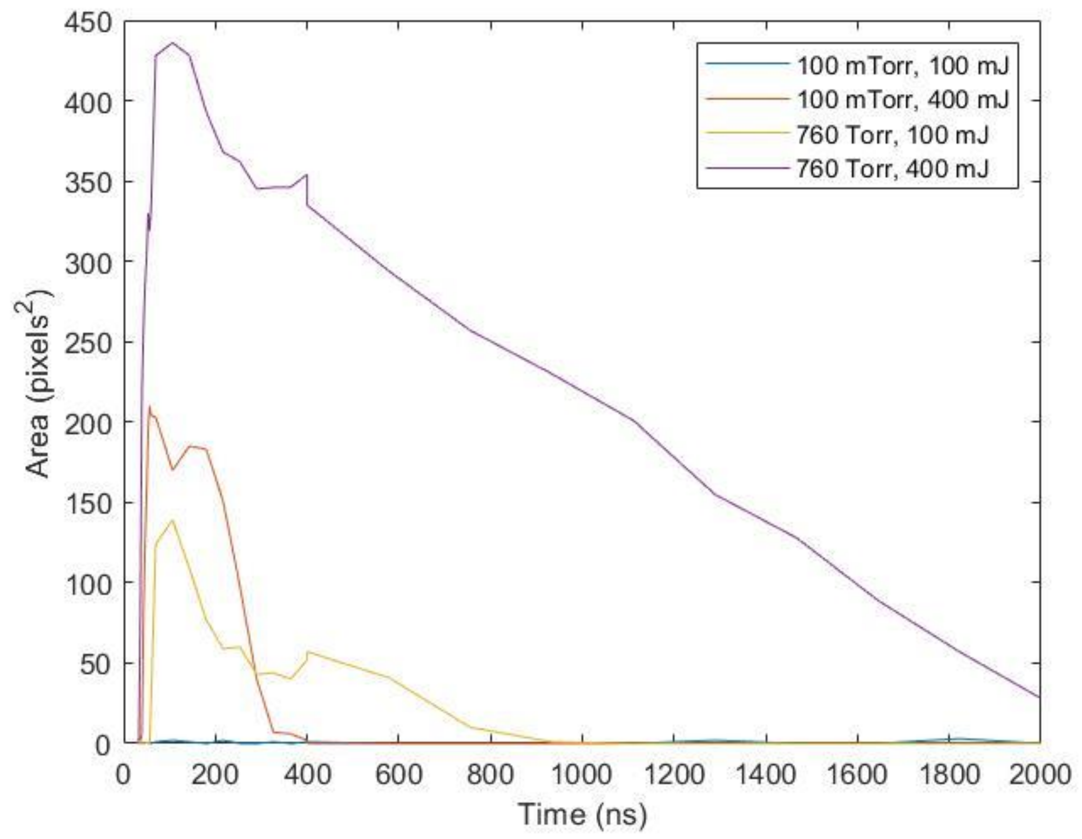


**Figure 4. Area vs. Time for Side View Plasma Expansion.**

## Results

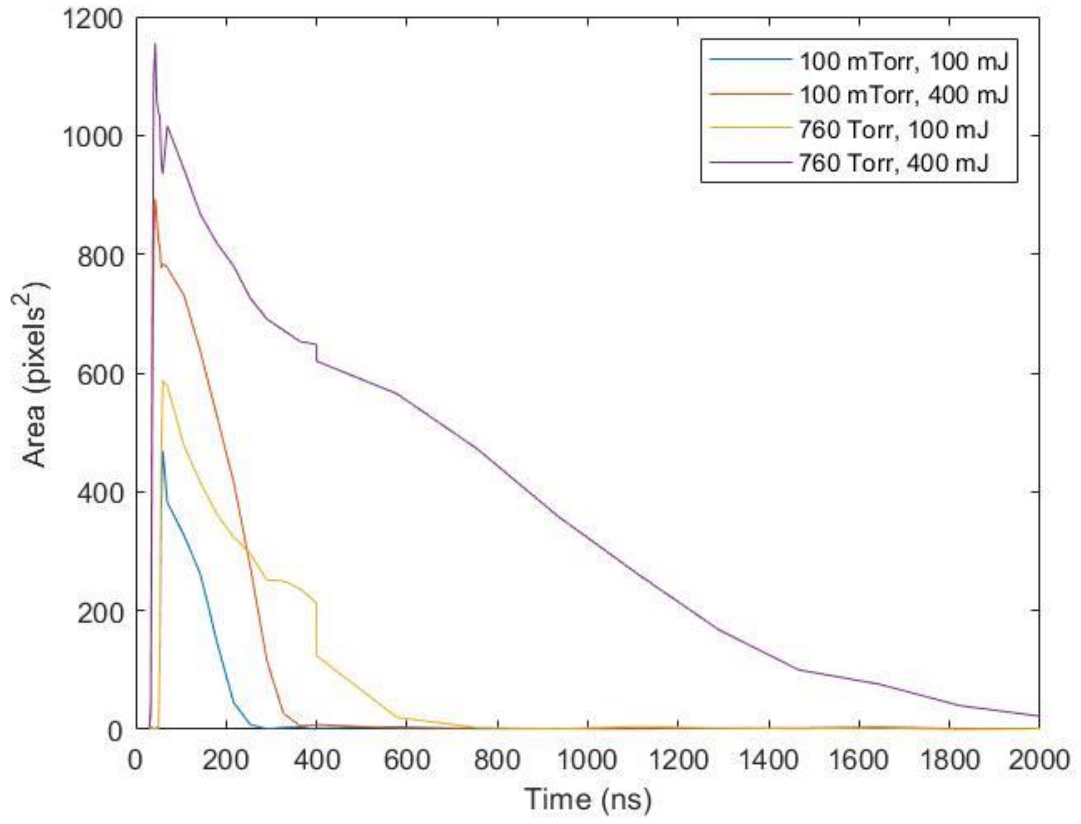


**Figure 5. Area vs. Time for Front View Plasma Expansion.**

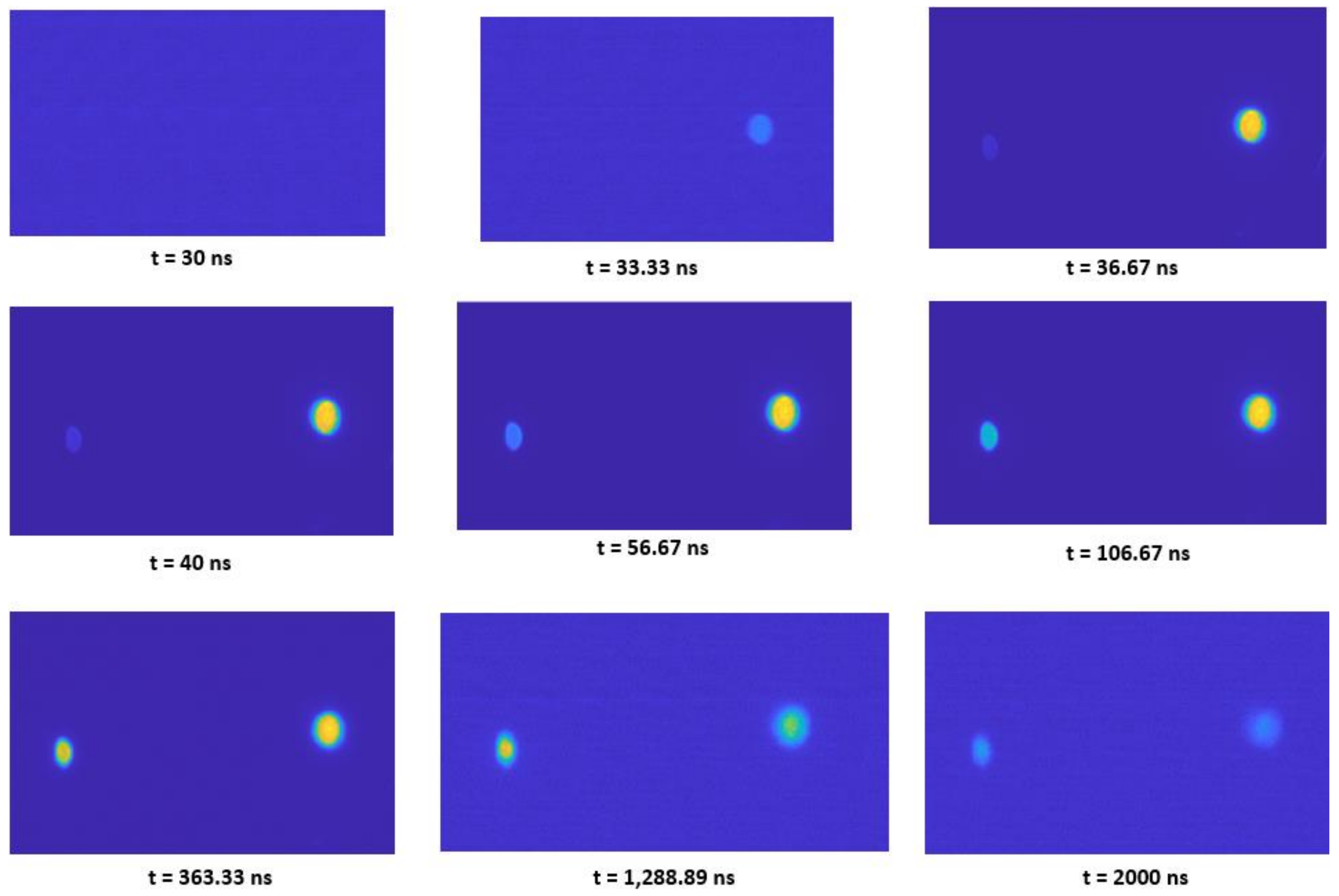


**Figure 6. Time-Elapsed Plasma Expansion (760 Torr, 400 mJ). Front view on the right, side view on the left side of each image.**

## Conclusions

Altering pressure and laser energy had clear effects. Higher laser energies caused more rapid expansion behavior of the plasma. At 100 mTorr, the plasma dispersed and scattered more than the plasma at 760 Torr due to less collisions with ambient gas. This makes the lower pressure plasma short-lived. Higher laser energy also increased plasma expansion compared to lower laser energy. The plasma appears sooners in the front view. The dual-view technique can be useful, however, difficulties arise due to inability to selectively increase focus of one view or the other.