New X-Pinch Platform and Diagnostics for the MAIZE Facility

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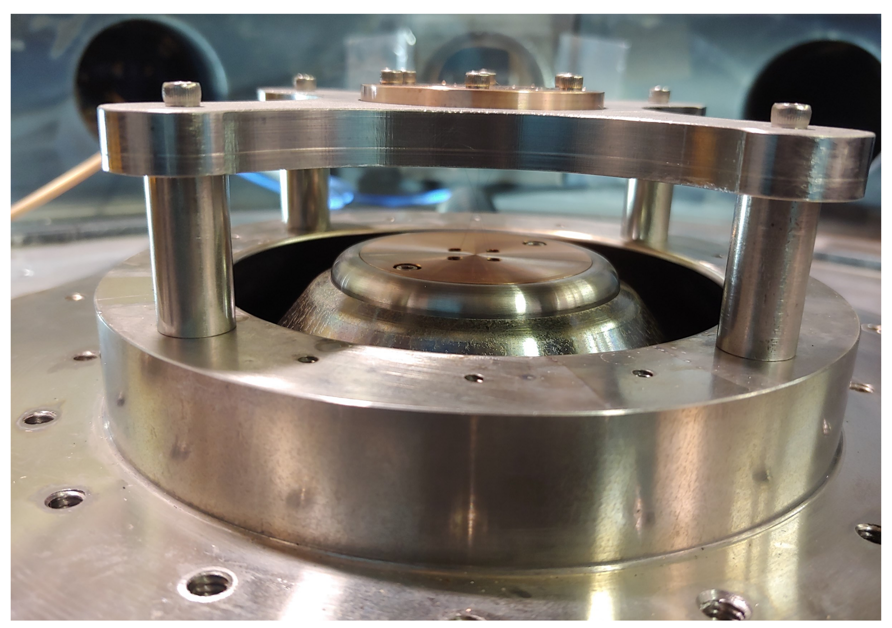
Motivation

X-pinches, formed by driving intense current through the crossing of 2 or more wires, provide an excellent platform for the study of "micro-pinches" due to their propensity to generate a single micro-pinch at a predetermined location in space (i.e., where the wires cross) [1, 2]. Ideally, micro-pinches compress to very small radii (~1 μm) leading to pressures on the order of ~1 Gbar for currents on the order of ~0.1 MA. However, the fraction of the total current that is driven through the dense micro-pinch plasma at small radii versus that being shunted through the surrounding coronal plasma at larger radii is not well known. To allow for the study of micro-pinches and their current distribution on the 1-MA MAIZE facility, an imaging Faraday rotation diagnostic, as well as corresponding X-pinch load and diagnostic hardware, are being developed [3].

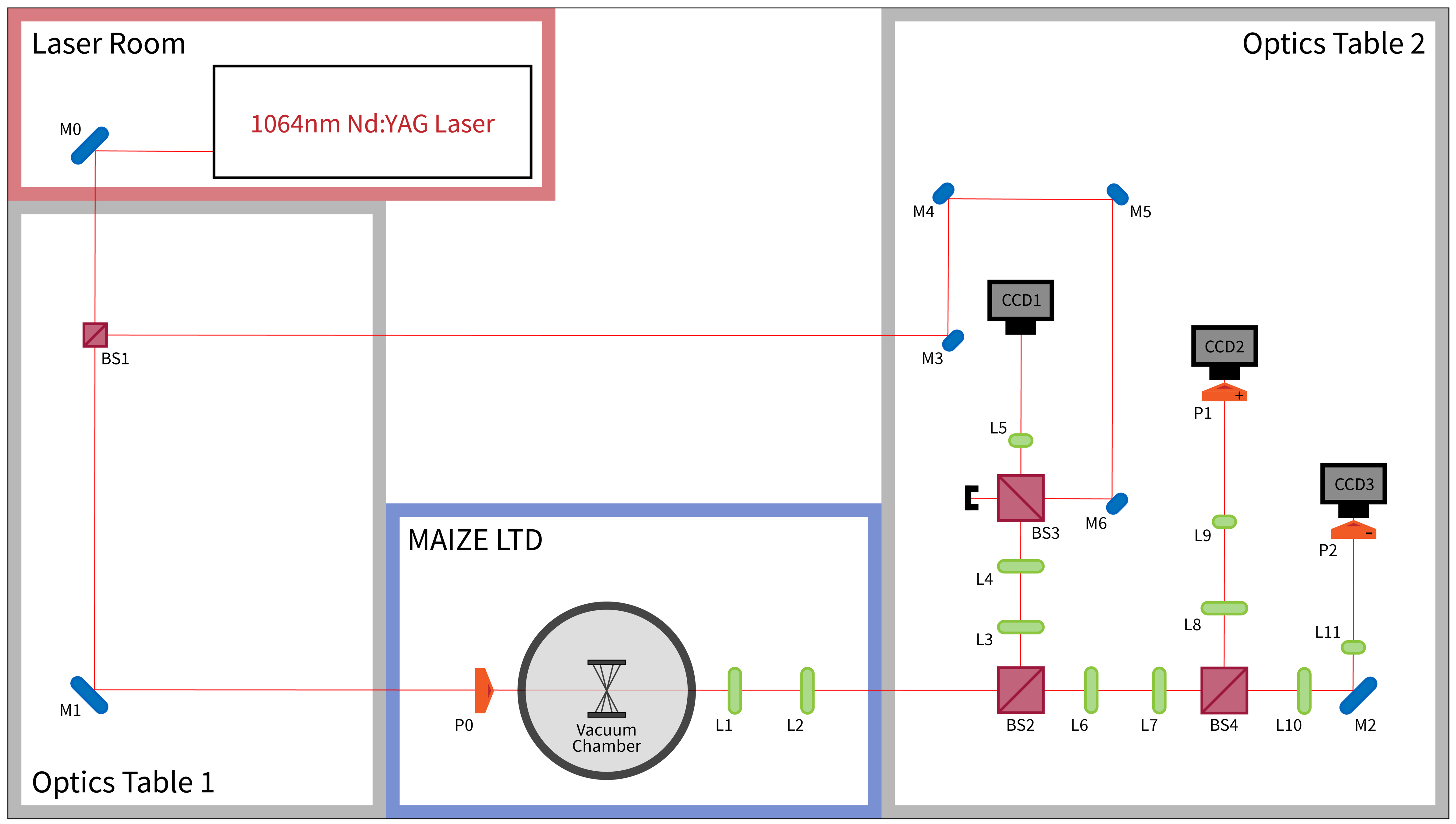
Main Load Hardware

Main load hardware with interchangeable x-pinch mounts was developed and fielded on the MAIZE LTD, and was the platform on which the presented data was collected.



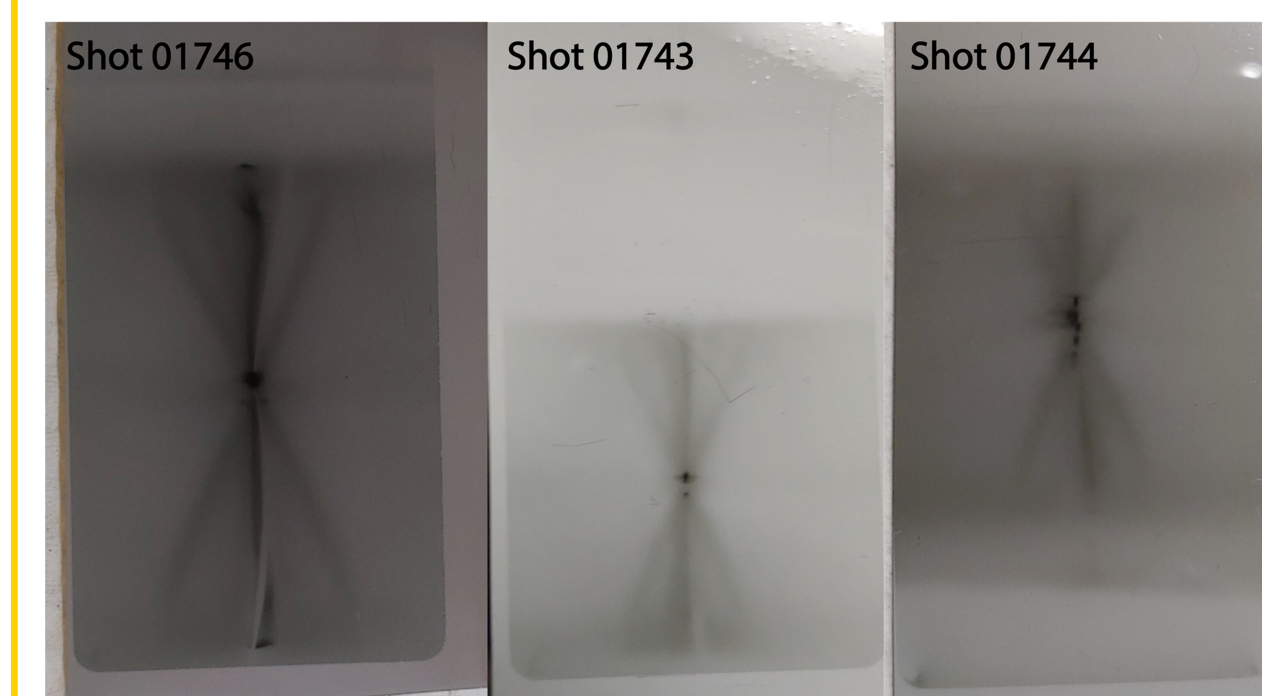
Faraday Rotation Diagnostic

A new Faraday rotation diagnostic has been designed for use with the MAIZE LTD to examine x-pinch current distributions and is now awaiting integration. The design, shown in the figure below, consists of a p-polarized probe beam of ~180 mJ at 1064 nm from a Nd:YAG laser which is split into an interferometric reference beam and combined interferometry and polarimetry probe beam. The probe beam is then split further to recombine on the interferometry leg, while the polarimetry line is equally split between two counter-rotated polarization analyzers to better improve noise reduction.



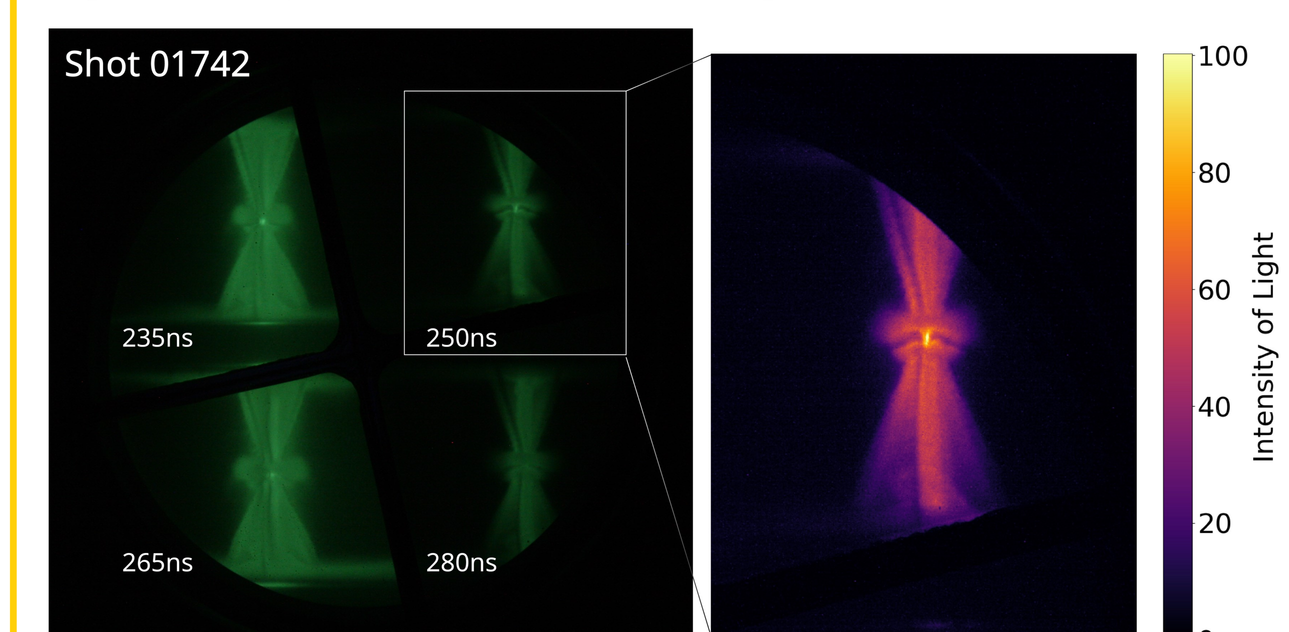
Pinhole Camera Radiographs

A sample of radiographs produced by a time-integrated, pinhole camera with a pinhole diameter of 50 microns and a 20 micron polyethylene filter showing a variety of structures produced during pinching.

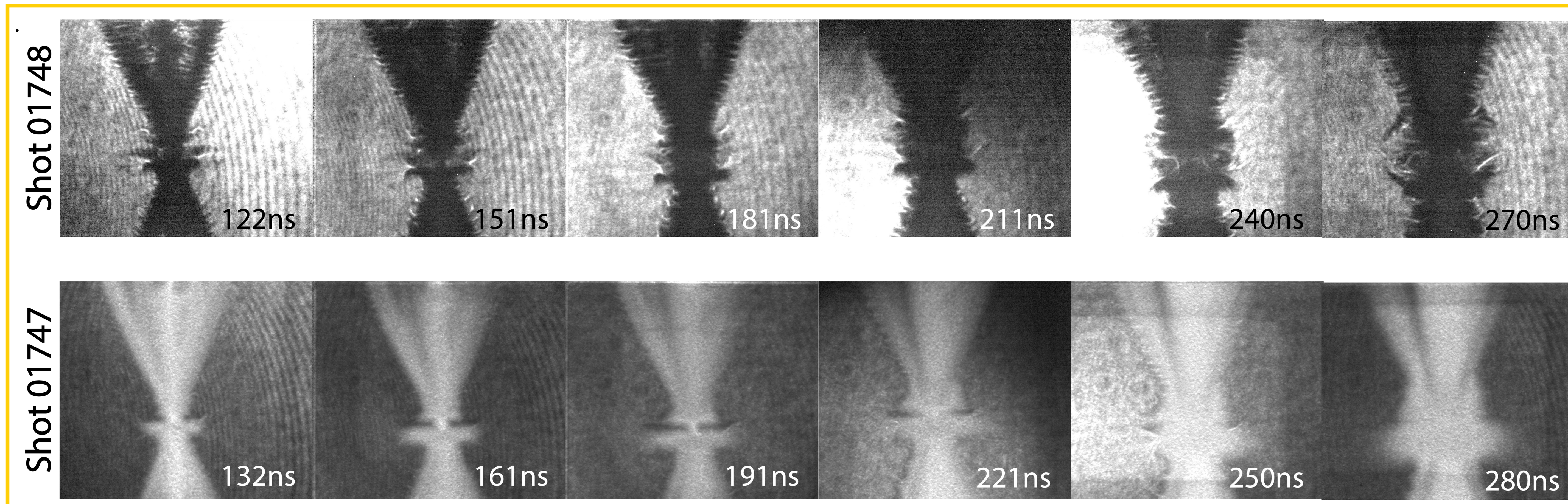


XUV Images

A 4-frame MCP XUV camera collected further images of the x-pinch. The figure below shows an example of a shot where the XUV camera captured a clear image of the x-pinch neck. The inset is contrast enhanced to better show the higher intensity of emission from the neck region.



Shadowgraphy and Self-Emission Images



Future Work

Near Future:

- Calibrate Si diodes and Photoconductive Detectors (PCDs) for better timing of pinching and hot-spot formation
- Integration and testing of the Faraday rotation diagnostic and first test shots with x-pinches to align and calibrate optics and sensors

Further Goals:

- Track possible sequential neck formations using a 12 image fast framing camera using both shadowgraphy and self-emission
- Design of Ross filters to collect time-resolved x-ray emission data

References

[1]G. F. Swadling et al., "Diagnosing collisions of magnetized, high energy density plasma flows using a combination of collective Thomson scattering, Faraday rotation, and interferometry (invited)," Review of Science Instruments, vol. 85, no. 11, p. 11E502, Nov. 2014.

[2]S. A. Pikuz, T. A. Shelkovenko, and D. A. Hammer, "X-pinch. Part I," Plasma Physics Reports, vol. 41, no. 4, pp. 291–342, Apr. 2015.

[3]S. A. Pikuz, T. A. Shelkovenko, and D. A. Hammer, "X-pinch. Part II," Plasma Physics Reports, vol. 41, no. 6, pp. 445–491, Jun. 2015.

This work was supported by the DOE Early Career Research Program under Grant DE-SC0020239 and by the NNSA SSAP under Cooperative Agreement DE-NA0003764.