Experimental measurements of shock conditions at the exit of a 1 TPa shock amplification system

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First Light Fusion

First Light Fusion Ltd. (FLF) is a privately funded company researching ICF target designs that are driven by strong shocks from high velocity projectile impacts.

FLF has developed a shock amplification system which increases the impact pressure provided by the projectile by up to ~ 15 times.

The amplifier produces TPa pressures over mm spatial scales.

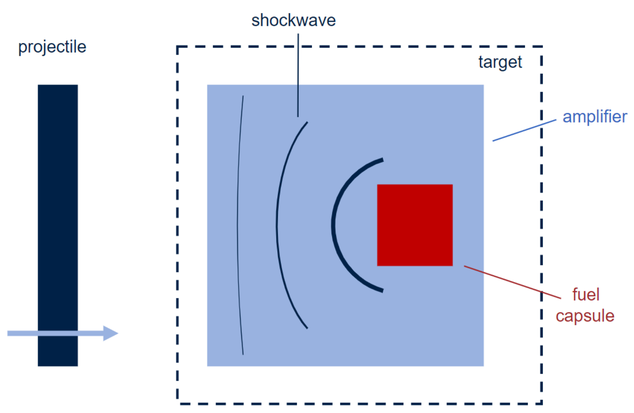

Fig. 1: Schematic of fusion method.

Planar amplifiers

Planar amplifiers amplify the velocity and pressure of a planar input shock, producing a planar output shock.

The velocity, and temporal and spatial release profile of the planar shock exiting the amplifier was measured and compared to simulations in B2, an in-house multi-material parallel resistive MHD code.

Side on laser backlighting

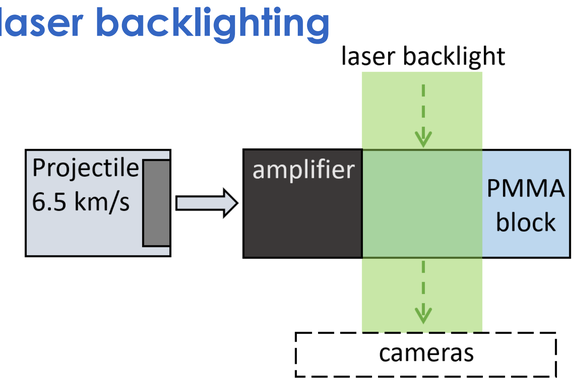

Fig. 2 (left): Diagram of the shock velocity and pressure experiment. As the shock exits the amplifier and travels through the plastic, the plastic becomes opaque to the laser light.

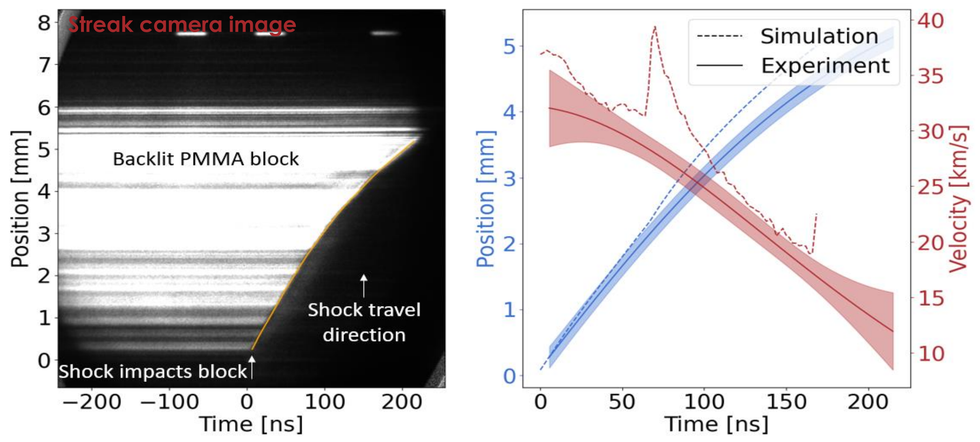

Fig. 3: Experimental measurement of the position of a shock from an amplifier entering a plastic block. Positions have been differentiated to obtain a velocity. Experimental data is compared to simulated results from code B2.

End on emission imaging

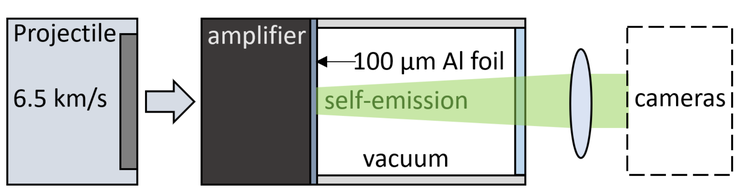

Fig. 4 (left): Diagram of the shock planarity experiment. As the shock breaks out of the foil, the self emission is captured by an imaging system.

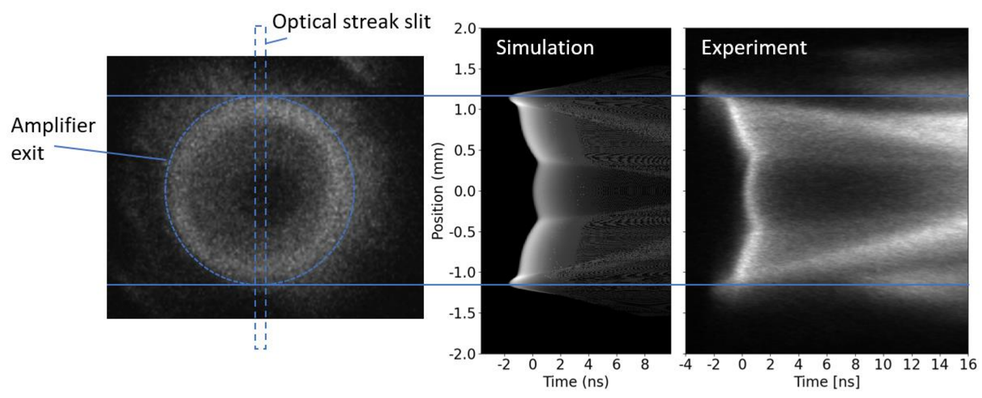

Fig. 5: Shot 58 experimental results. Left: end on 2D view of the circular amplifier exit releasing. Right: end on 1D streak data of an amplifier releasing showing the shock releases at the edges before the centre, Experimental streak data is compared to synthetic streak data from in house code B2.

References

[1] J. D. Moody, H. F. Robey, P. M. Celliers et al. : Phys. Plasmas 21, 092702 (2014); https://doi.org/10.1063/1.4893136

Spherically converging amplifiers

FLF is developing amplifiers which take a planar input shock and produce a spherically converging output shock.

New diagnostics are required to diagnose the spherical shock release.

Fisheye lens diagnostic

Several fish eye lenses were investigated including CCTV lenses and medical sinuscopes. Fish eye lenses are damaged during an experiment so are replaced for every shot.

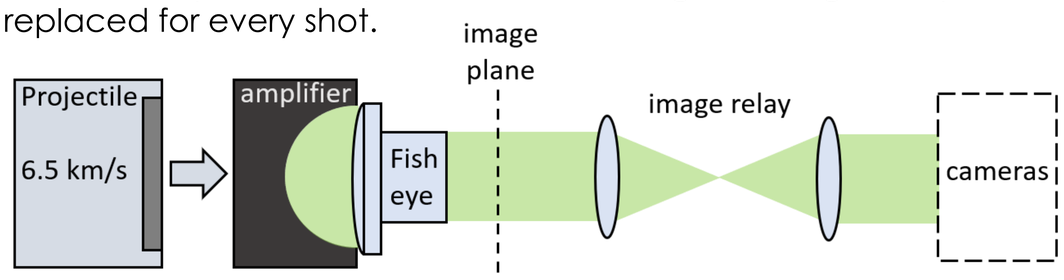

Fig. 6: Diagram of the fish eye lens system measuring the temporal and spatial release profile of a spherically imploding shock releasing from an amplifier.

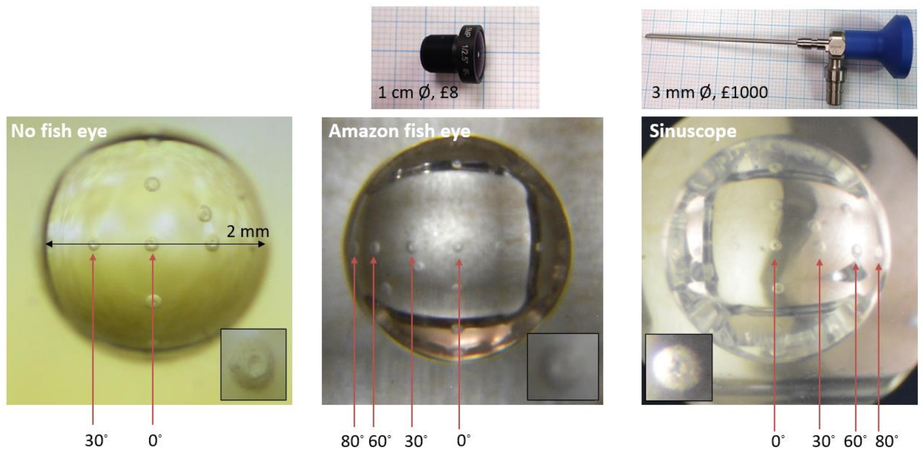

Fig. 7: Experimental comparison of different fish eye lens options: no fish eye lens, an Amazon cctv lens and a medical sinuscope manufactured by Henke Sass Wolf. A test 2 mm diameter hemispherical target is imaged with fiducial markers to indicate the field of view achieved.

Multi-axis mirror diagnostic

FLF has developed a mirror diagnostic that collects light from 2 areas of the amplifier exit. This is based on the two-axis shock timing measurements at the National Ignition Facility [1]. This can be adapted for 3 axis measurements.

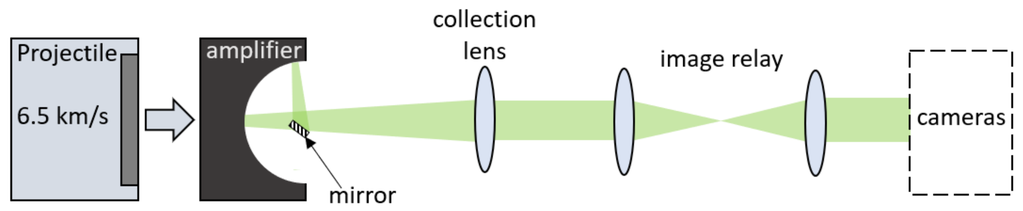

Fig. 8: Diagram of the multi-axis mirror diagnostic designed to image light from 2 regions of the imploding spherical shock.

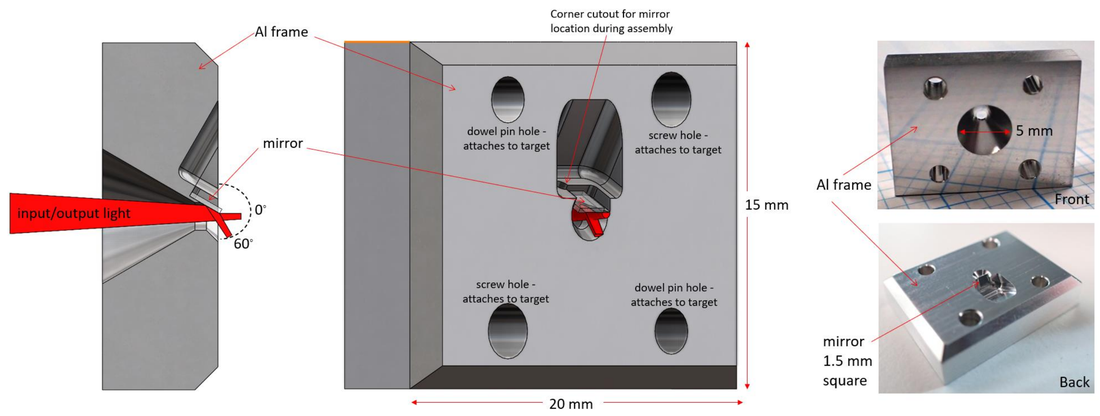

Fig. 9: CAD (left) and photos (right) of the multi axis mirror diagnostic manufactured at First Light Fusion. This has been successfully tested on test targets in the lab.

Summary and Future Work

- First Light Fusion has developed 2 new diagnostics to measure the spatial and temporal release profiles of a spherically converging shock exiting an amplifier.
- These diagnostics will now be tested in experiments on FLF's two stage large light gas gun.
- These diagnostics can be adapted to make VISAR measurements of the shock in water or quartz, enabling a velocity and pressure measurement.