Characterization Techniques for Flight and Impact of Electrically Driven Flyers

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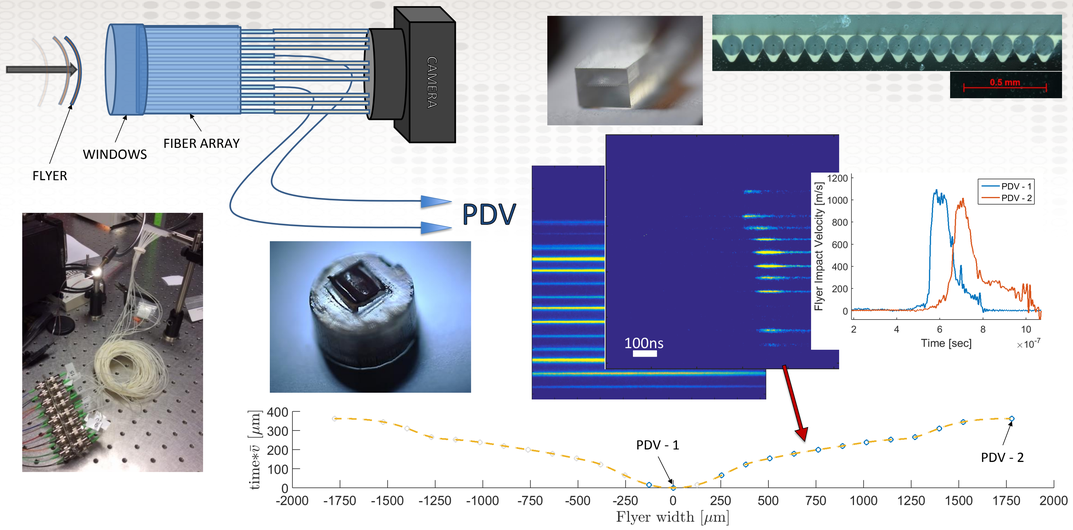
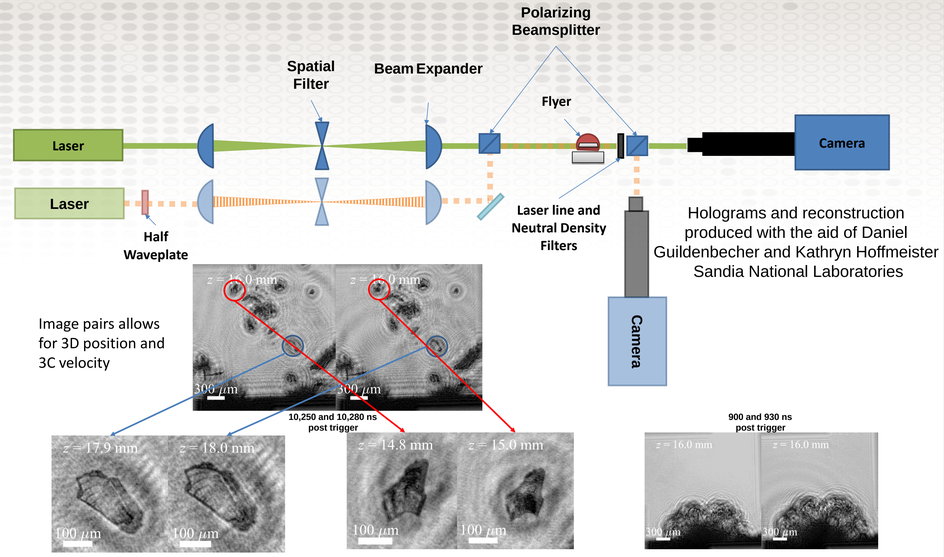
Dual Streak/PDV impact



- Characterization of a flyer upon impact of an energetic is of interest in understanding initiation and detonation spreading.
- 16 single mode bare fiber array, 14 are used for time of arrival with streak imaging and 2 are used for particle velocity via PDV
- Impact of a 5x5mm, 0.127mm thick, Kapton flyer, standoff 2.184mm into an 2μm thick aluminized PMMA window
- Assuming symmetry the profile is shown above, where the velocity of the center is 835m/s and 1.778mm away from the center measures 775m/s.
- Post mortem inspection of the flyer reveals a solidified curvature is present corroborating the fiber array results

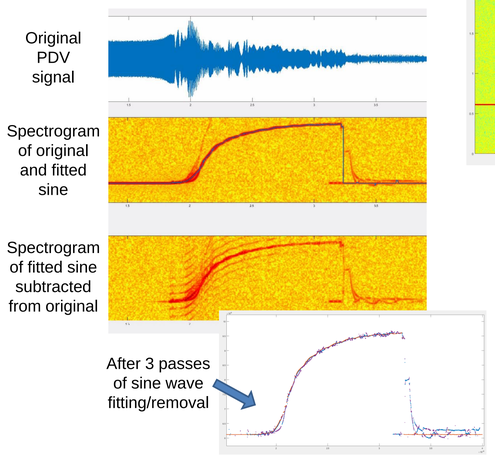
Holography



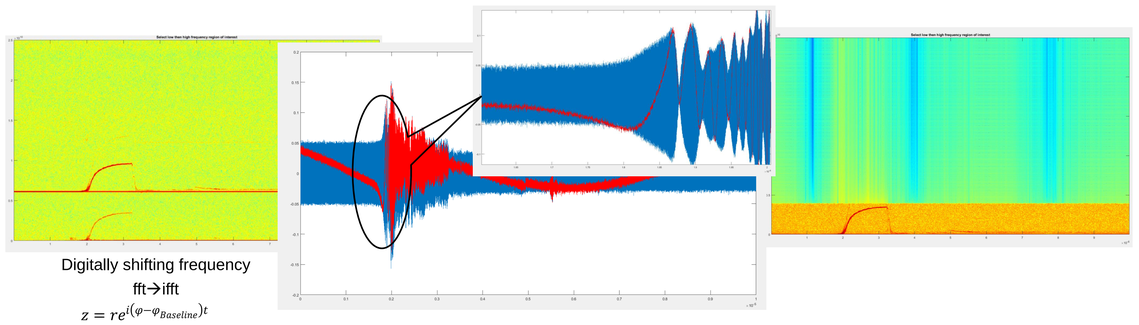
Holograms and reconstruction produced with the aid of Daniel Guildenbecher and Kathryn Hoffmeister Sandia National Laboratories

- Digital In-line Holography (DIH) allows for 3D reconstruction of an object. Using a microscope objective and two pulsed lasers, image pairs are generated allowing for reconstruction of all 3 components of velocity as well.
- Plasma tends to distort collimated light and obscure the flyer launch. Expansion of cloud was between 3500-5000m/s.
- Late time pieces are travel a few hundred m/s. Resolution shows striations in plastic flyer (Parylene-C), leading to a brittle failure conclusion.

PDV Analysis and Simulation Correlation

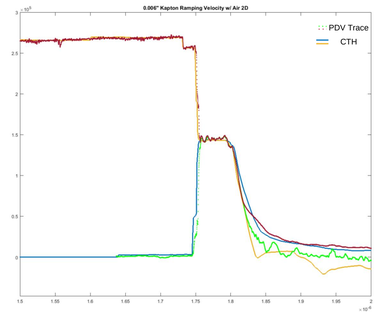


Short Time Sine Fitting



Digitally shifting frequency
fft→ifft
$z = re^{i(\varphi - \varphi_{Baseline})t}$

- Use of open source MATLAB class; Sandia MATLAB AnalysiS Hierarchy (SMASH) toolbox allows for integration of scripts
- PDV analysis is typically performed with Short Time Fast Fourier Transforms (STFT) and extracting a single largest magnitude frequency. Here an STFT is used in conjunction with a sine wave fitting algorithm (Short Time Sine Fitting - STSF), where multiple frequencies/velocities relatively close to one another are extracted.
- Current PDV systems use two disparate frequency lasers to “upshift” the signal and resolution during analysis. Digitally shifting a PDV trace allows for the operator to visually focus on specific events such as initial motion. The conjugate technique can also allow for higher quality analysis if non-upshifted PDV is performed.



CTH Comparison

- Kapton flyer measured with PDV and simulated with CTH
- Bow shock from the flyer is shown to decrease impact velocity and displace the window interface.
- CTH material properties agree well with measured data.

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