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High Throughput Initiation: Agile Testing for Microscale Explosives

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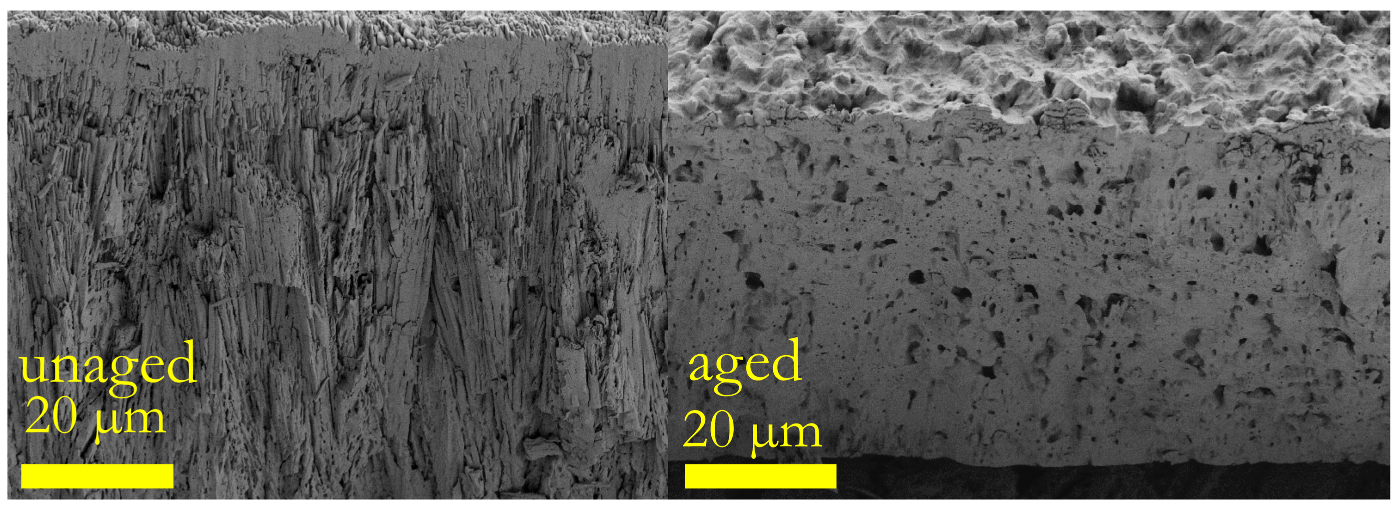
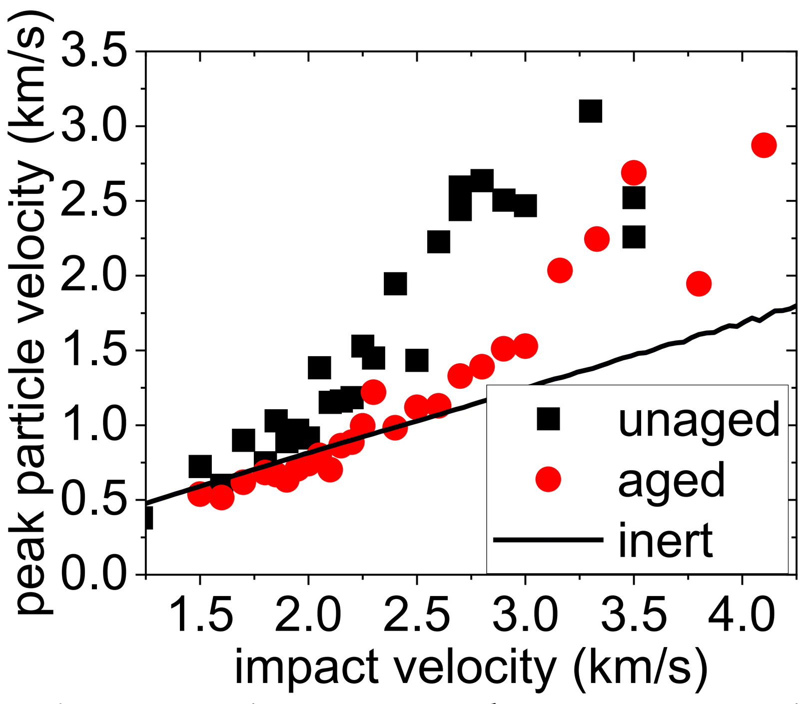
Abstract

In order to test a statistically significant experimental array of explosives, an agile platform for diagnostics and novel experiments is required. Towards this end, recent improvements have been implemented on the High Throughput Initiation (HTI) experimental platform. Laser-driven flyer experiments use an incident laser that has been spatially homogenized to propel a planar flyer at speeds ranging from 500 – 5000 m/s. In the present case, the flyer is made of parylene C, typically 25 µm thick, deposited onto glass substrates using physical vapor deposition techniques. The system is designed for rapidly exploring a variety of sample types while interrogating them using different spectroscopic and imaging techniques with simultaneous photon doppler velocimetry (PDV). Exemplar cases of initiation threshold tests and variable flyer designs are presented.

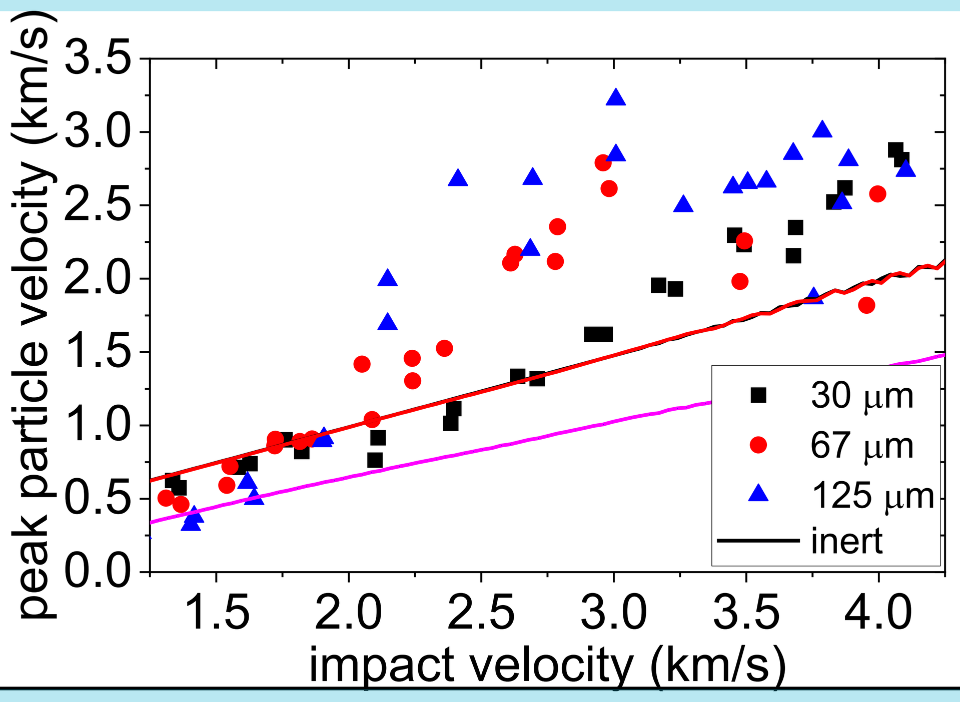
Initiation Threshold Suppression in Aged PETN



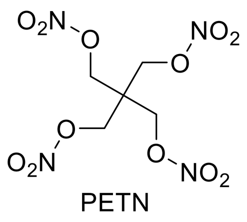


Pentaerythritol Tetranitrate (PETN) is seen to coarsen and coalesce with increased porosity with thermal aging. This microstructural effect is shown to decrease sensitivity, increasing the impact velocity required to force a deviation from a simulated inert response. The large variance in peak particle velocity near 2.5 km/s is indicative of detonation. Such sampling using > 100 explosive targets is made possible due to the high-throughput nature of the experimental platform.

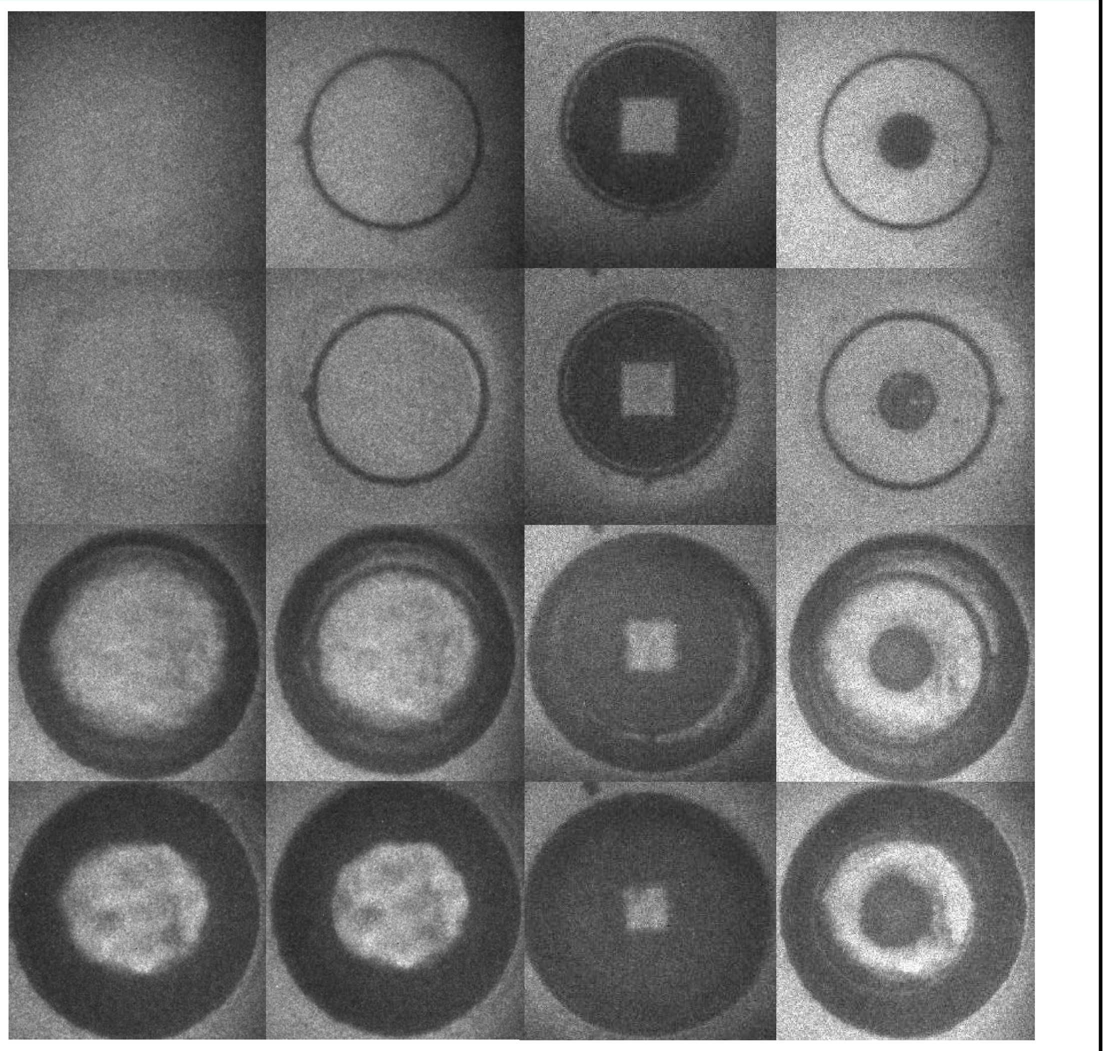
Initiation Threshold Cutback Experiments in PETN



Utilizing multiple samples of varying thickness, allows for measurement of buildup to detonation similar to cutback experiments. PETN is seen to be just beginning to react at a depth of 30 µm, with deviation from inert simulation gradually beginning at 3 km/s. Initiation threshold is determined to be around 2.4 km/s by the 125 µm thickness.

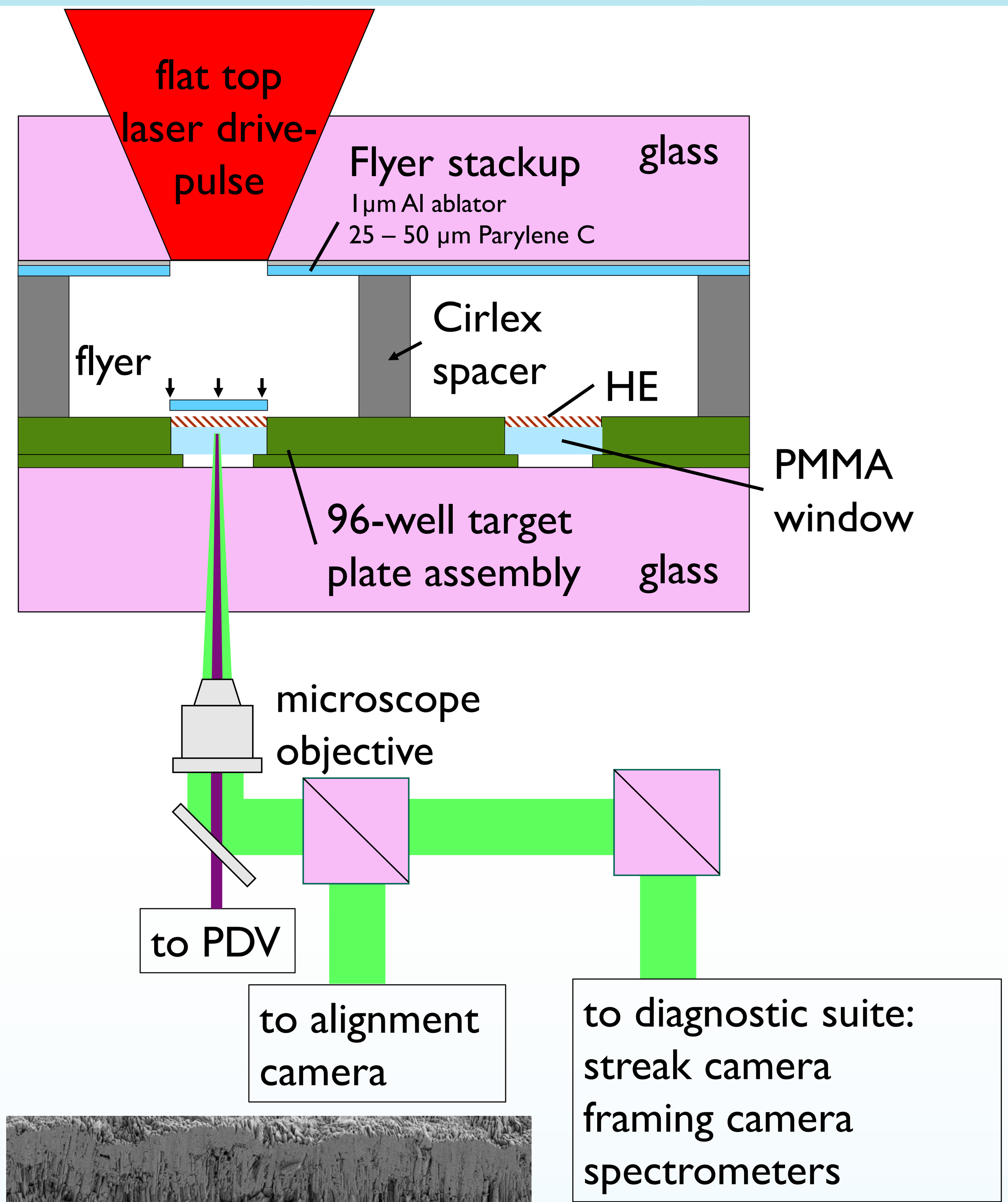


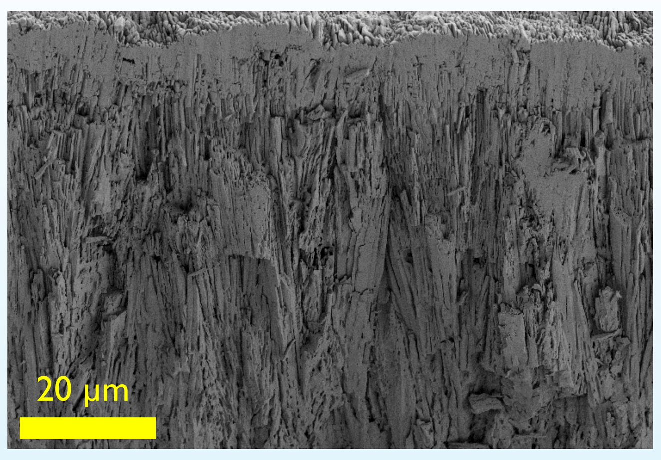
Imaging Parylene C Flyer Launch



Imaging of parylene C flyer launch with various cut-outs for flyer shaping. Frame exposure is 10 ns with 25 ns interframe time. PDV shows no difference between non-cutout and cutout flyers, indicating tensile strength plays little role in these plastic flyers.

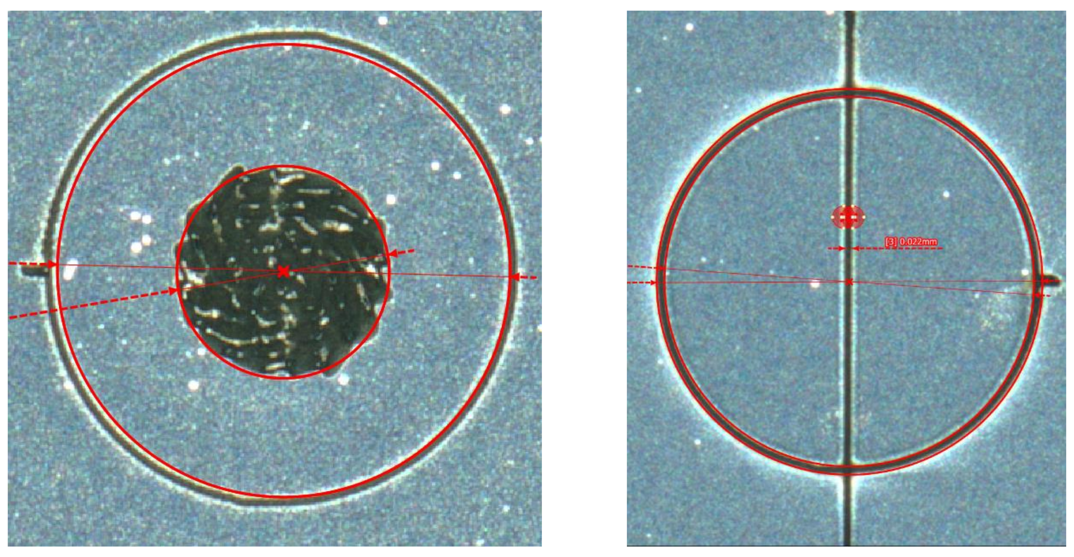
Experimental Diagram

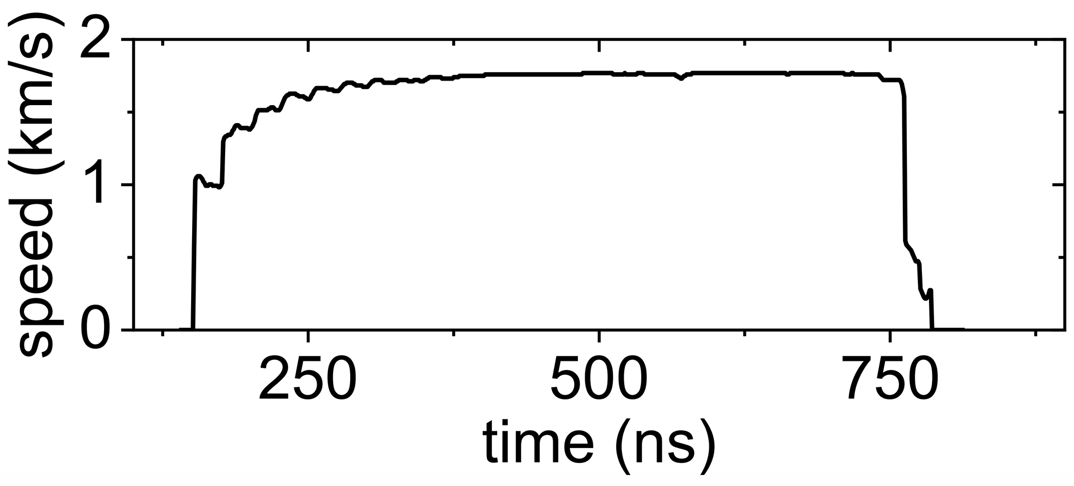




Physical vapor deposition creates uniform thickness microscale HE samples for statistical testing

Variable Flyer Designs





Femtosecond laser cutting of flyer optic allows for custom shapes including arbitrary shock geometries and fragmentation arrays. PDV trace is representative for annular section of "donut" flyer. No signal is present when centered on donut hole. Imaging of both bisected and donut flyers show parylene C launch of pre-cut shapes.

Conclusions

Improvements to the data collection and analysis algorithms in Sandia's HTI system allow for rapid iteration in experimental design for statistical analysis of microscale explosive samples. Initiation threshold testing with vapor-deposited PETN samples of various thicknesses was conducted to determine growth to detonation in a cut-back style experiment. Additionally, the effects of aging on PETN thin-film samples was explored. Femtosecond laser cutting of the flyer optics allow for custom flyer plates for generating arbitrary shock geometries in 2D.

Acknowledgments

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