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Quantitative Details of ExplodingWires with Application to Single Pore Collapse Validation

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Motivation

EoS and conductivity for bursting metals was based on 1970's data performed in air

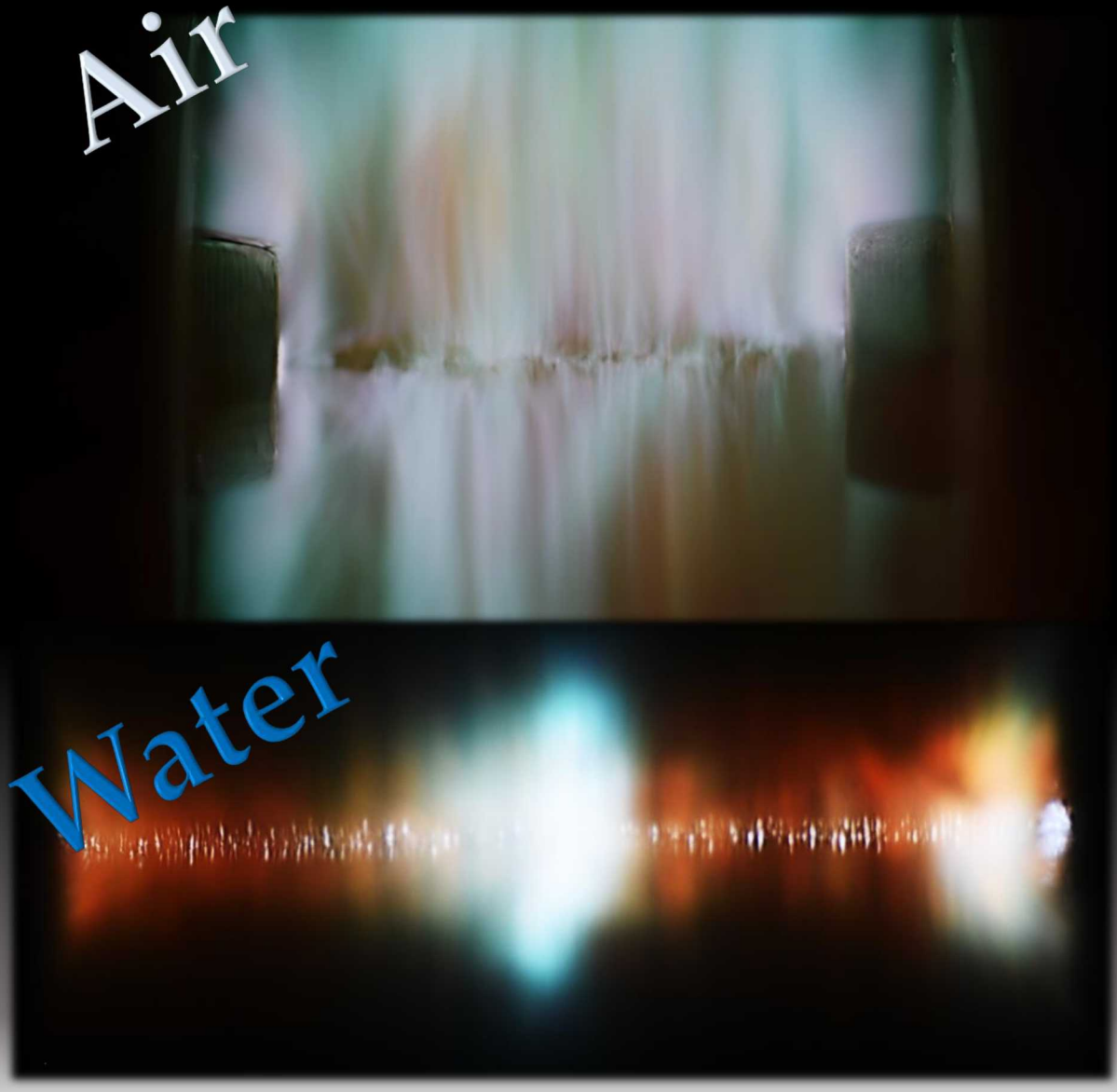
Capture phase transitions with moderately high energy deposition

Utilize high fidelity diagnostics to update/expand knowledge

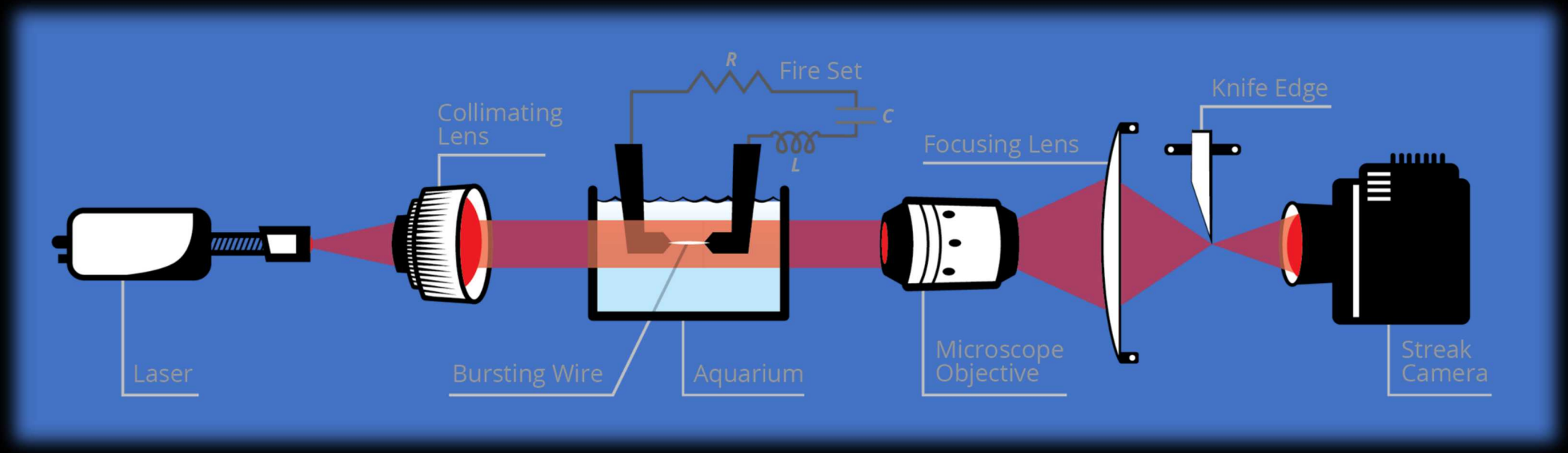
Dielectric water mitigates high voltage breakdown events as compared with wire bursts in air.

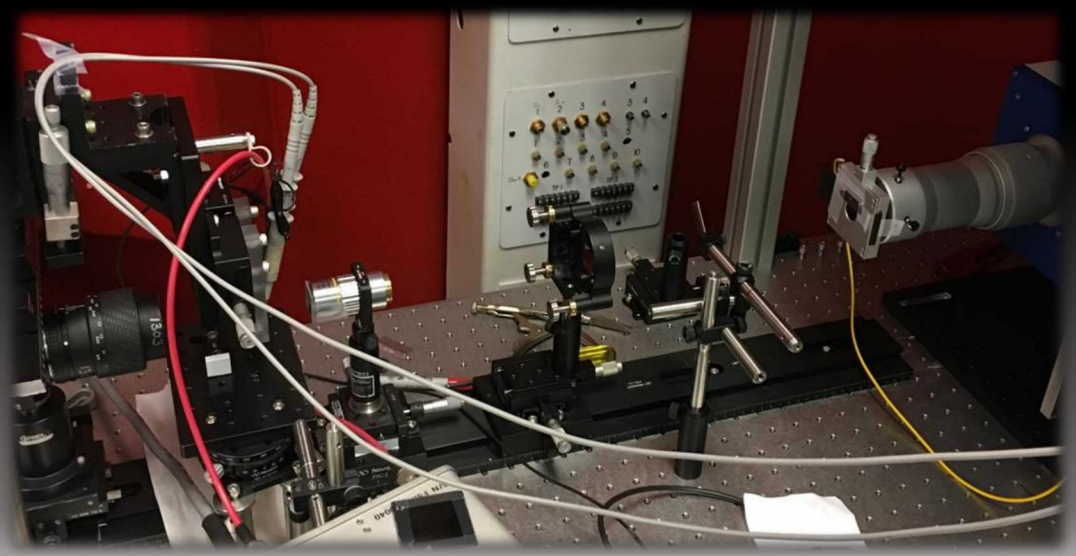
Simultaneous pieces of data from exploding wire experiments for code validation.

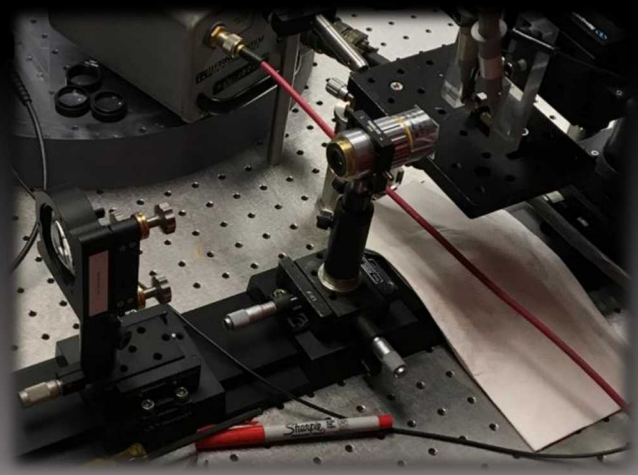
Current and voltage waveforms, and time-correlated spatial variation.

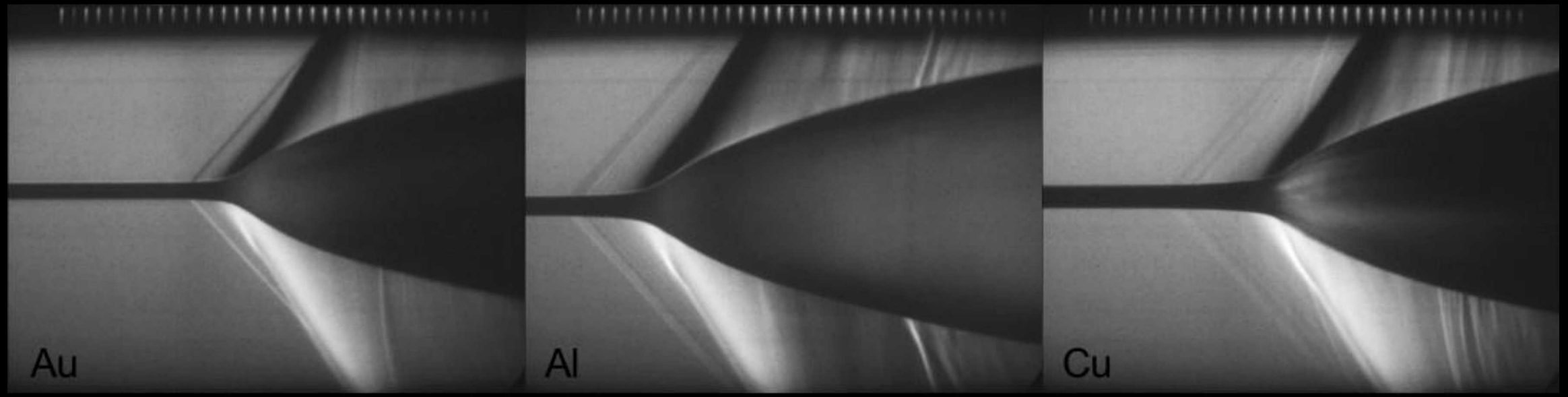


Experimental Setup

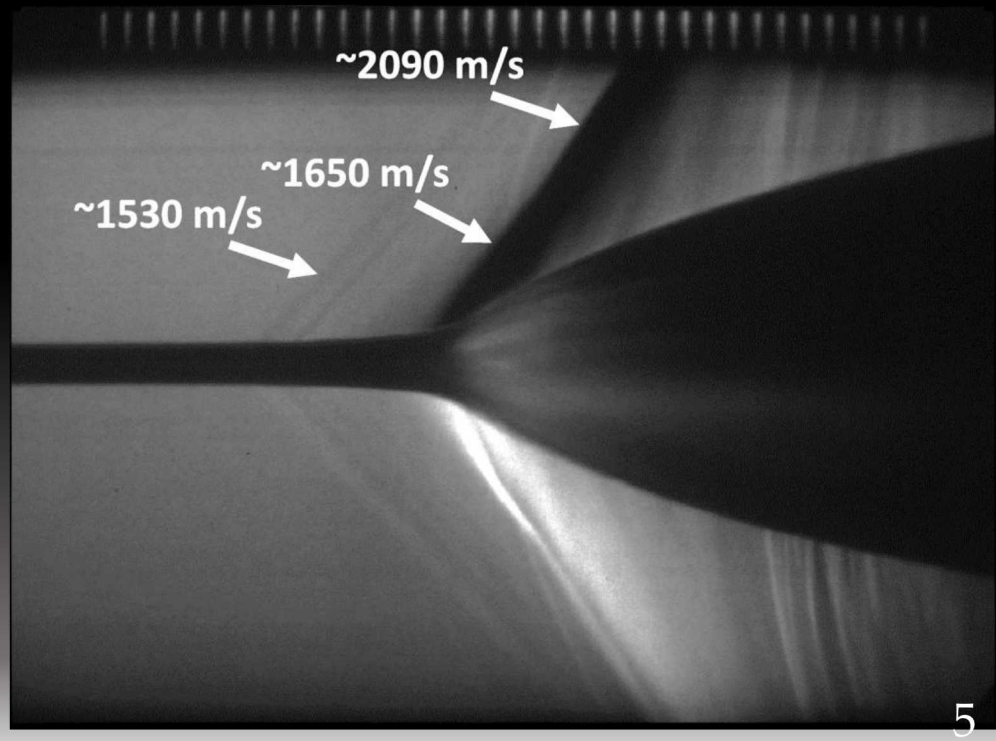






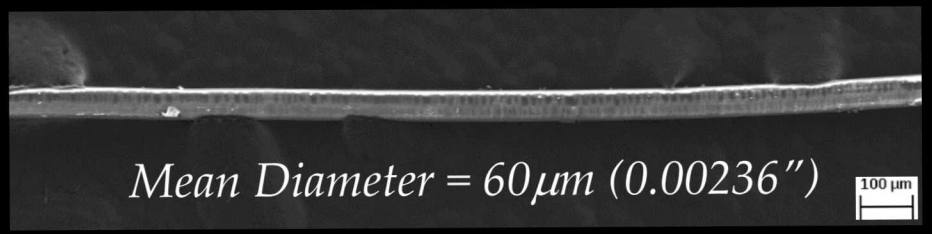


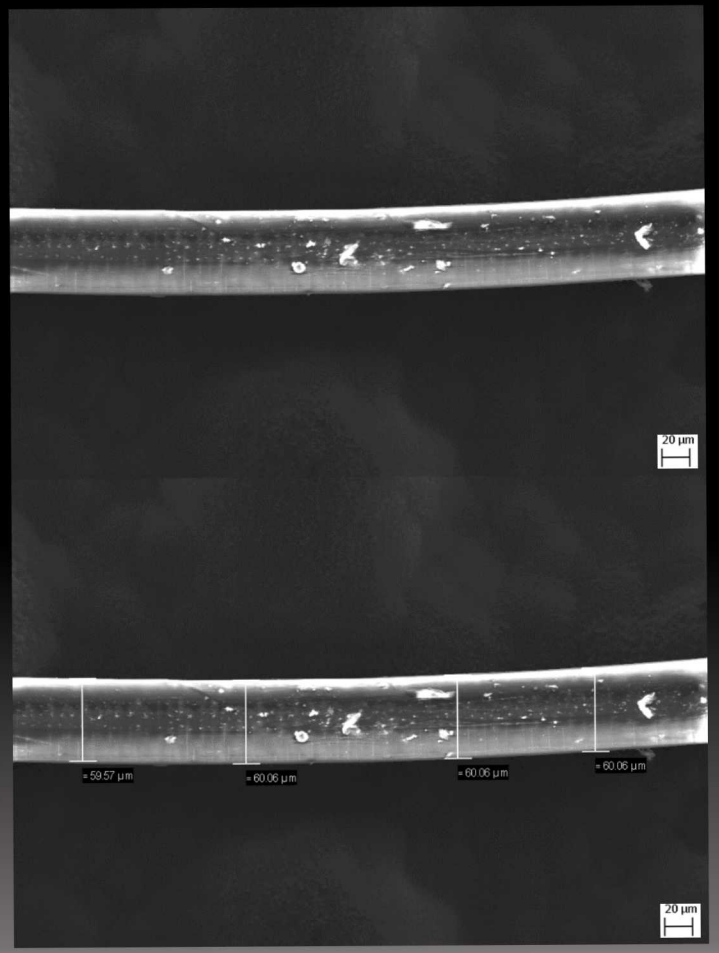
Micro-Schlieren streak image array in water of three metals: gold, aluminum, and copper. These were all fired at a charge voltage of 2000 Volts and wire length between wire holding fixture was 2.54 mm. The wire diameters are between 43-60 microns in diameter, measured with the SEM.

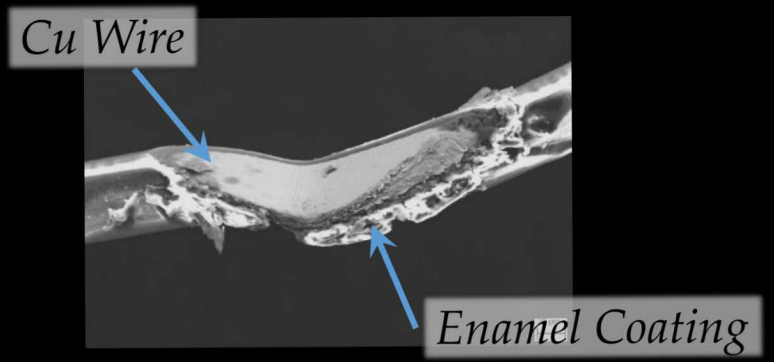


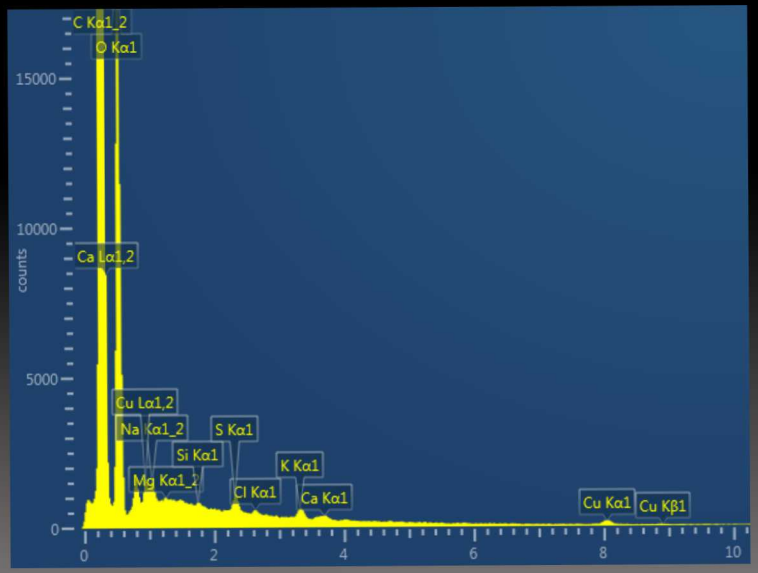
Shock wave velocity extracted from a bursting copper wire in water (Shot 163). The wire is 60 μm in diameter, 2.54 mm in length, and the firing set is charged to 2000 V.

SEM and EDS of Cu Wire



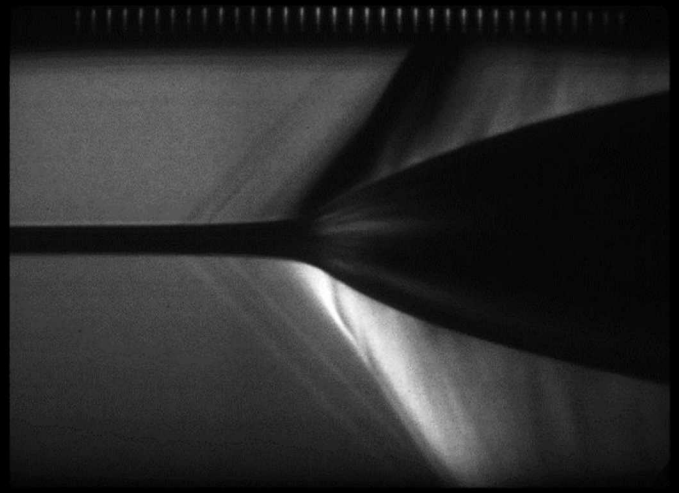




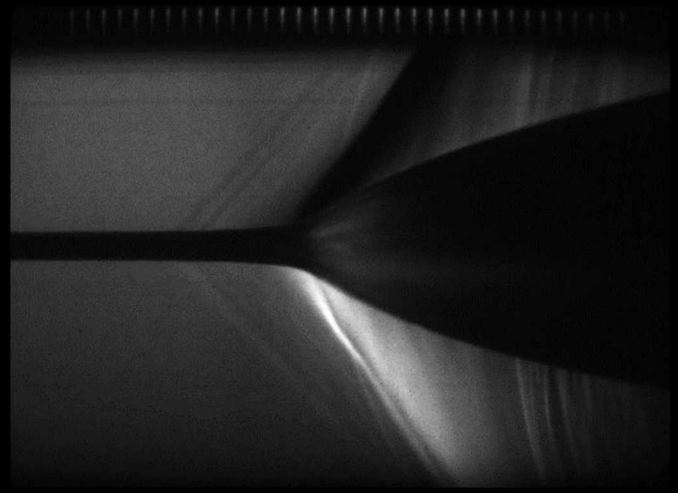


Bursting Copper Wire

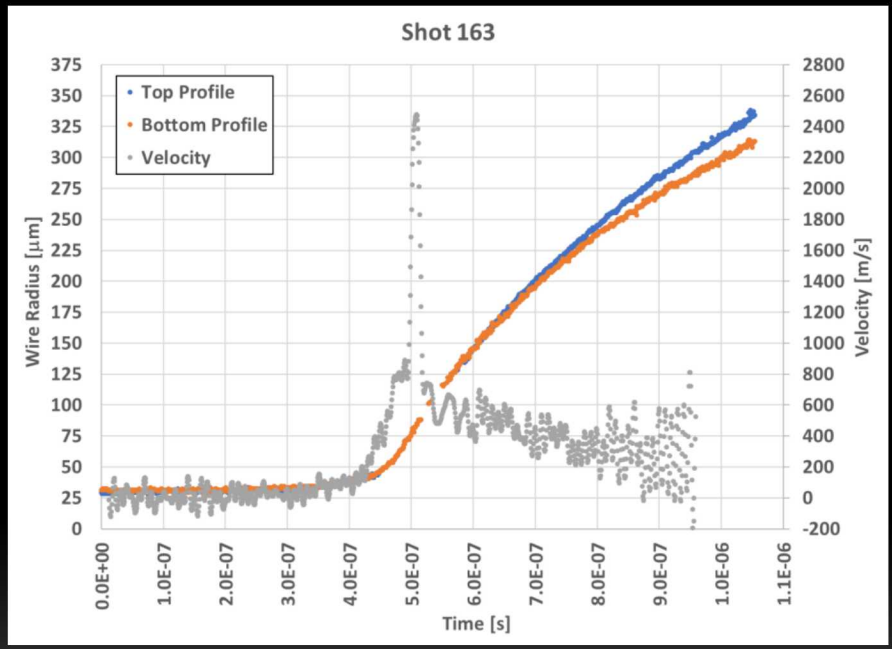
Shot 162

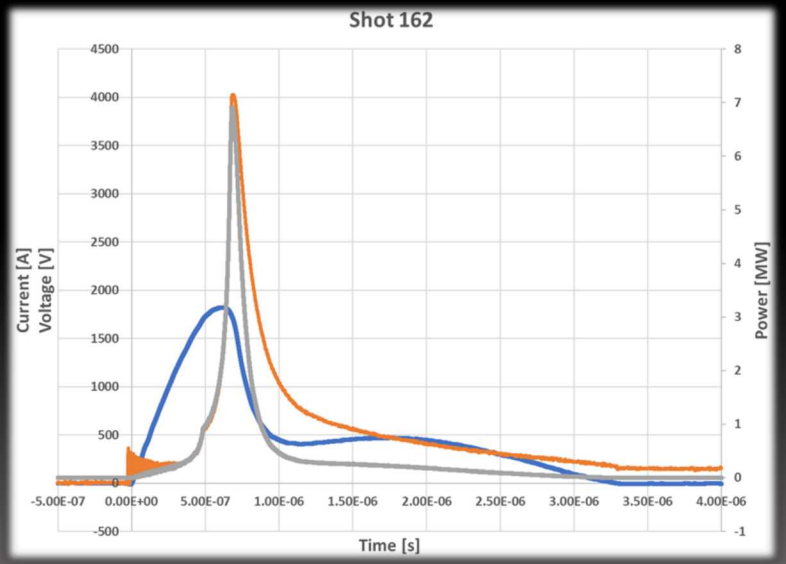


Shot 163

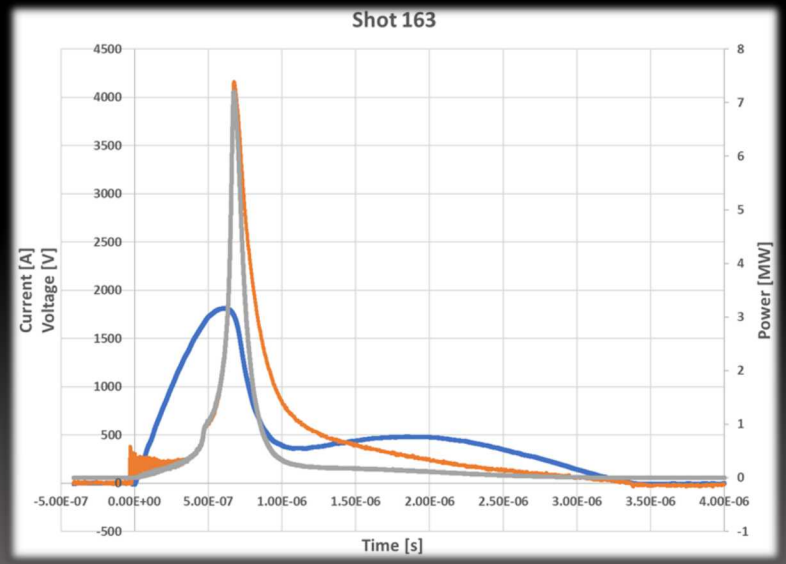


Wire radius in time





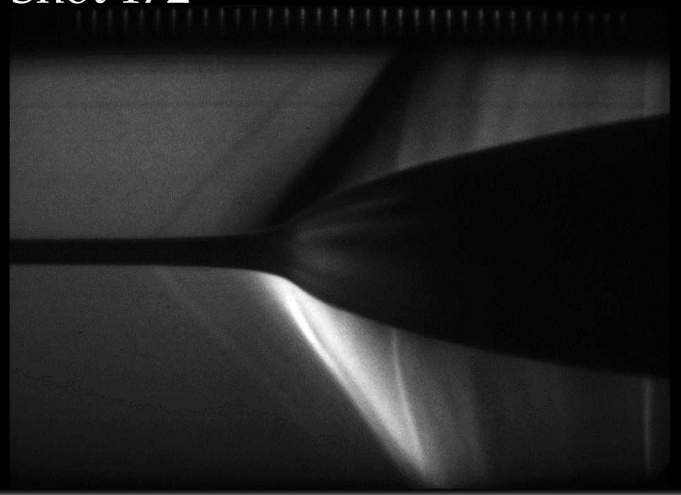
Length =0.100″
Charge Voltage = 2000V
Streak Window = 1µs



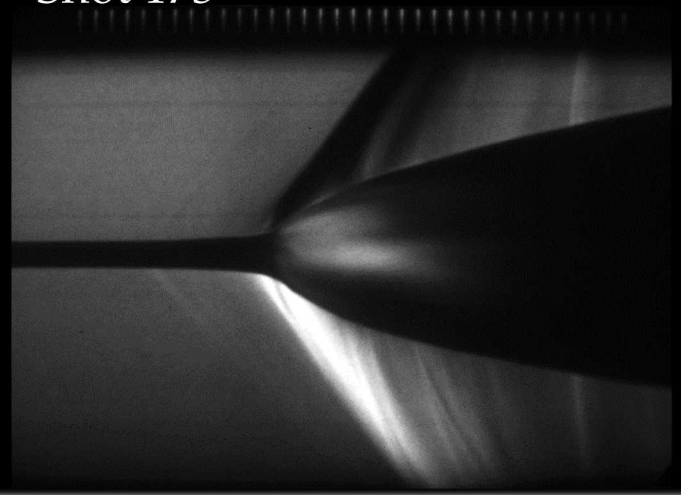
Length =0.100″
Charge Voltage = 2000V
Streak Window = 1µs

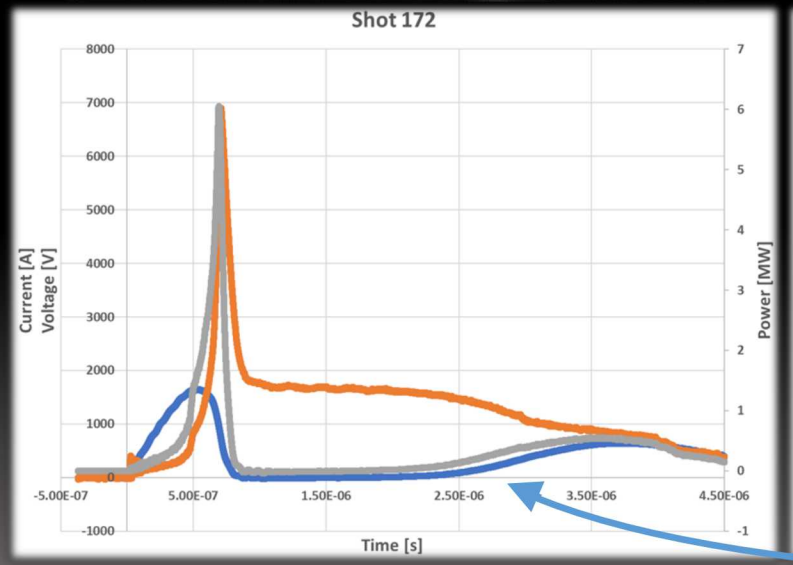
Bursting Copper Wire

Shot 172

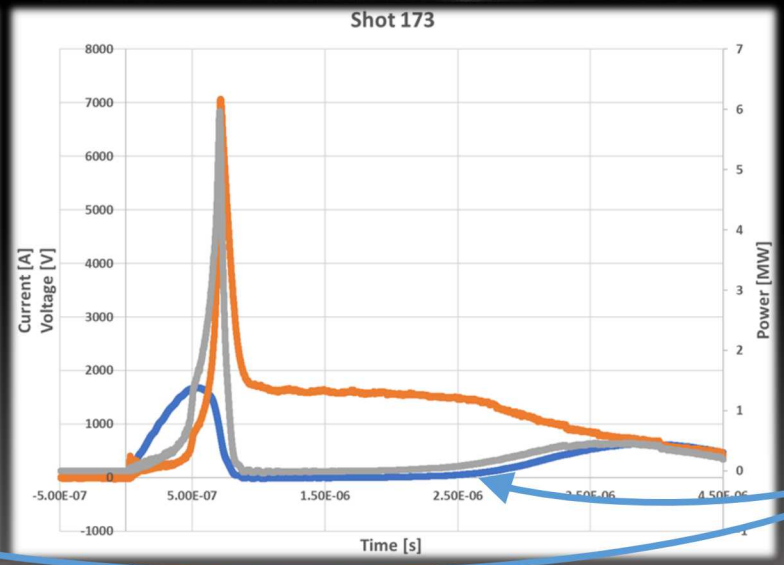


Shot 173



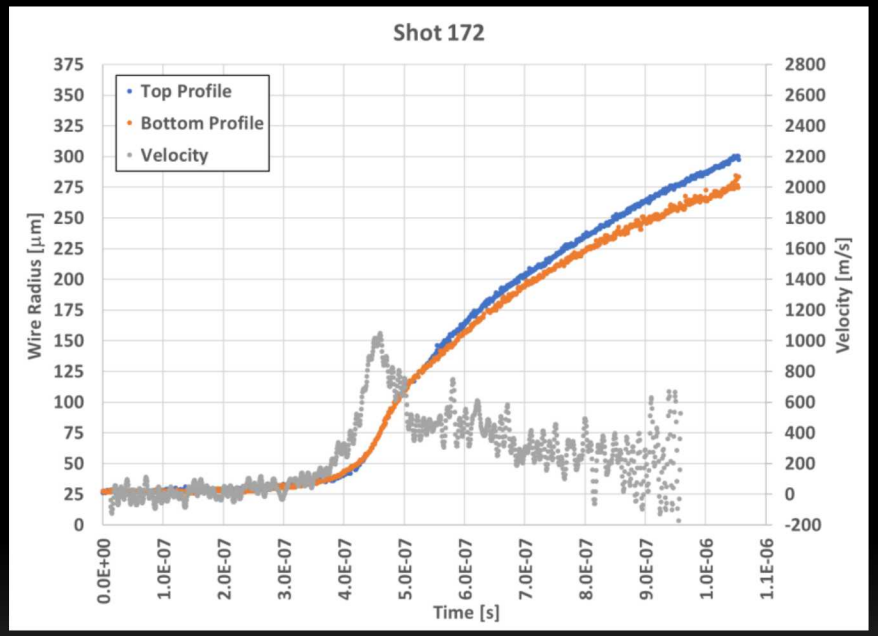


Length =0.200″
Charge Voltage = 2000V
Streak Window = 1μs



Length =0.200″
Charge Voltage = 2000V
Streak Window = 1μs

Wire radius in time

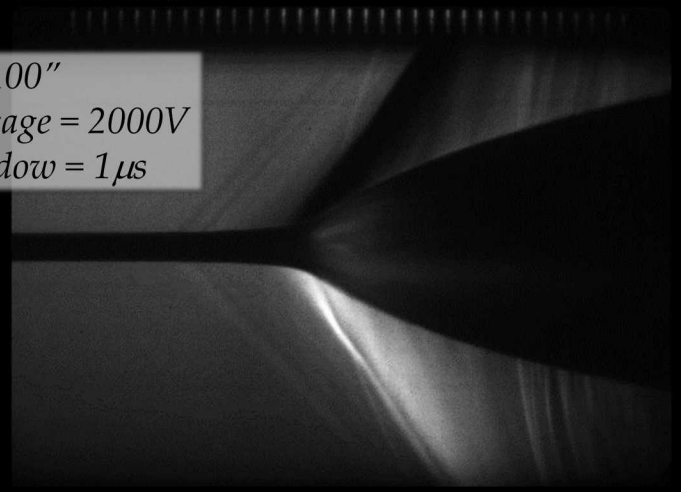


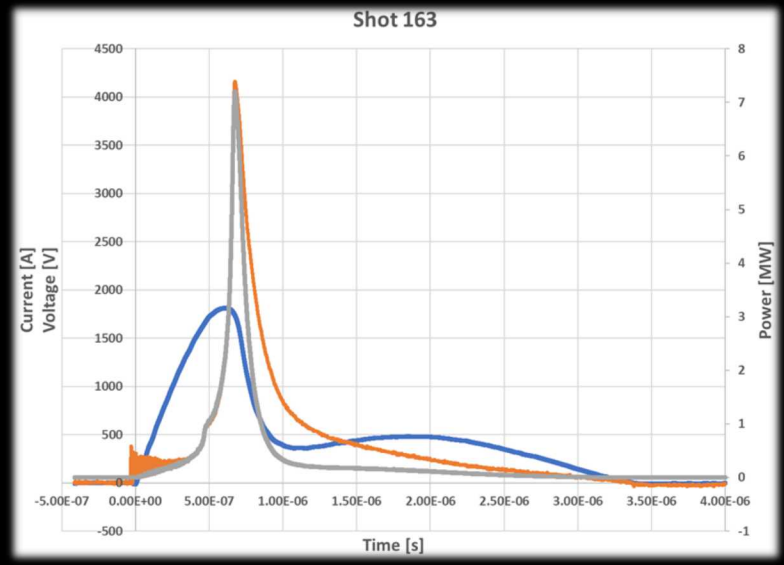
Wire during dwell event

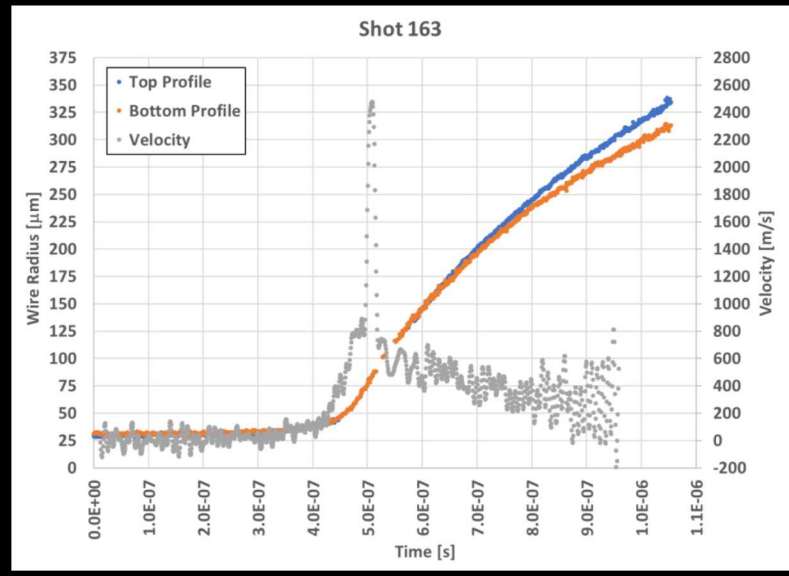
Bursting Copper Wire

Shot 163

Length =0.100″
Charge Voltage = 2000V
Streak Window = 1μs

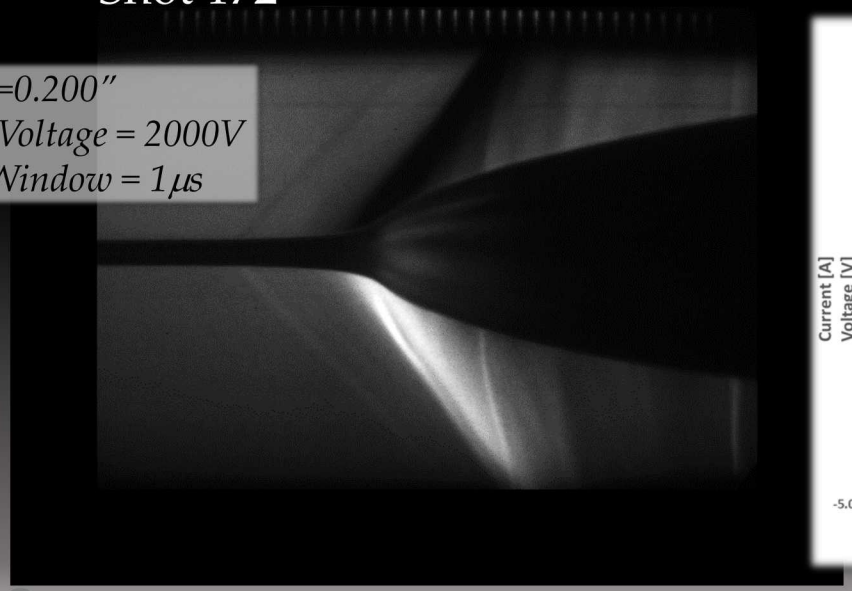


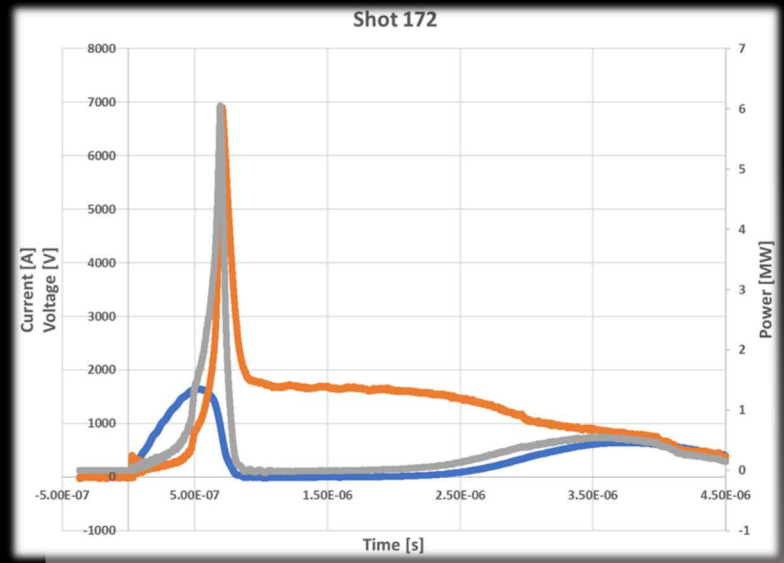


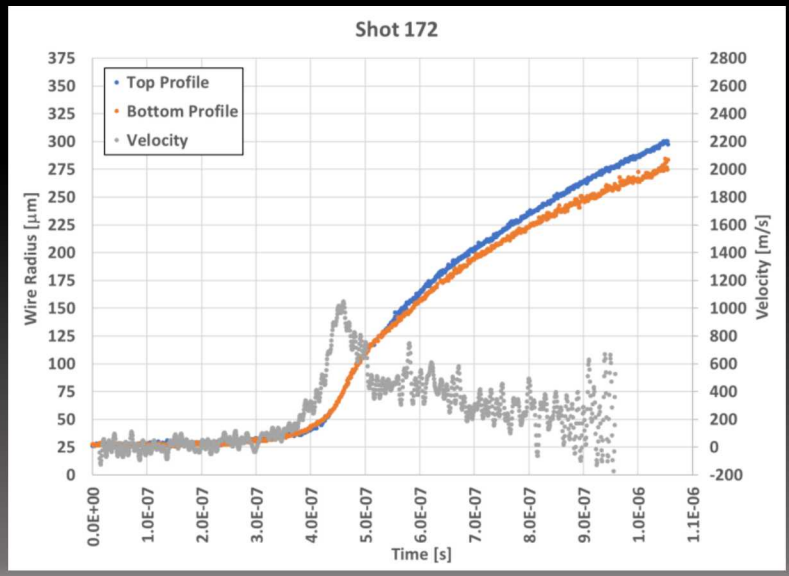


Shot 172

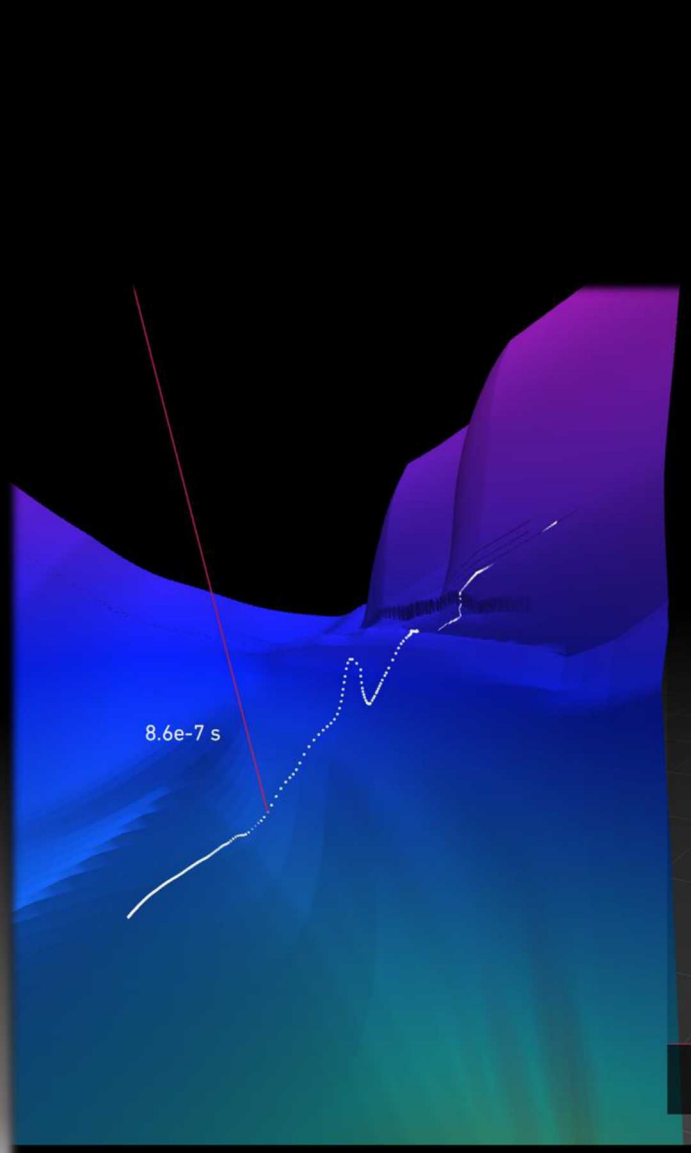
Length =0.200″
Charge Voltage = 2000V
Streak Window = 1μs

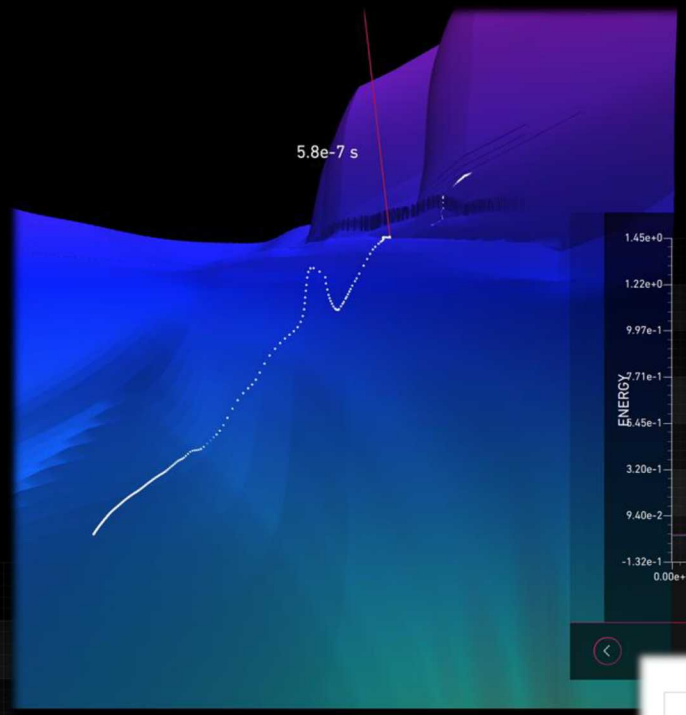


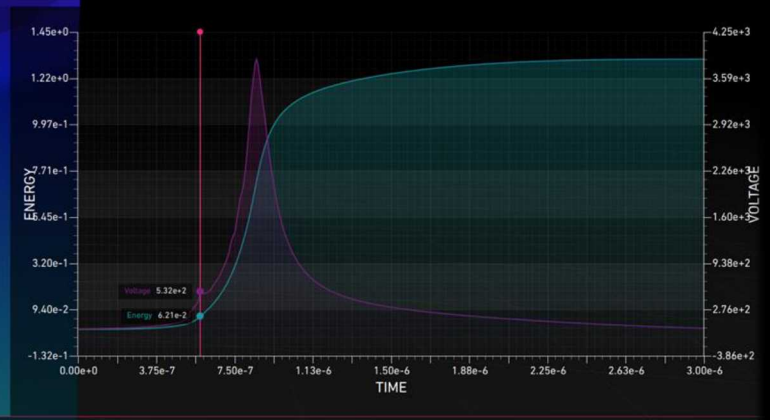


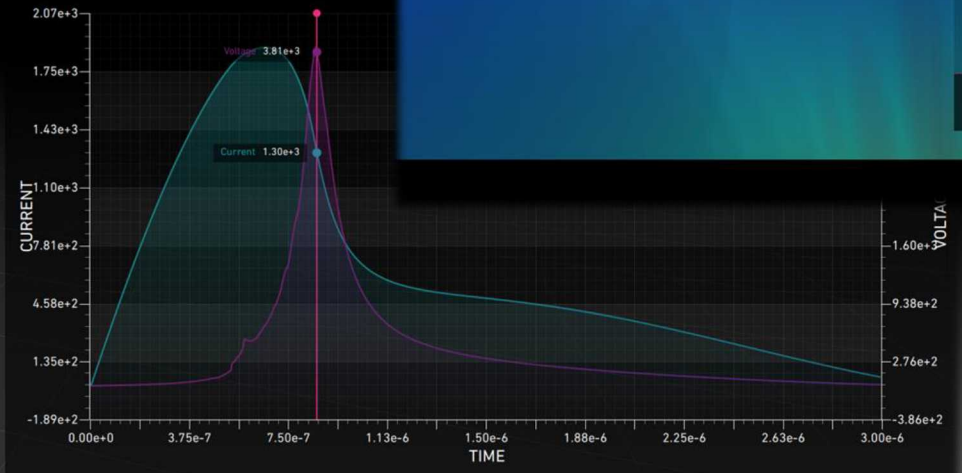


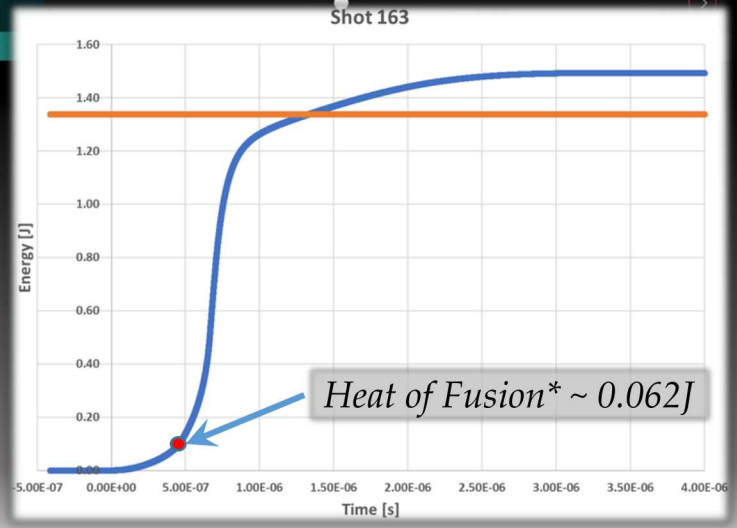
Simulation


8.6e-7 s

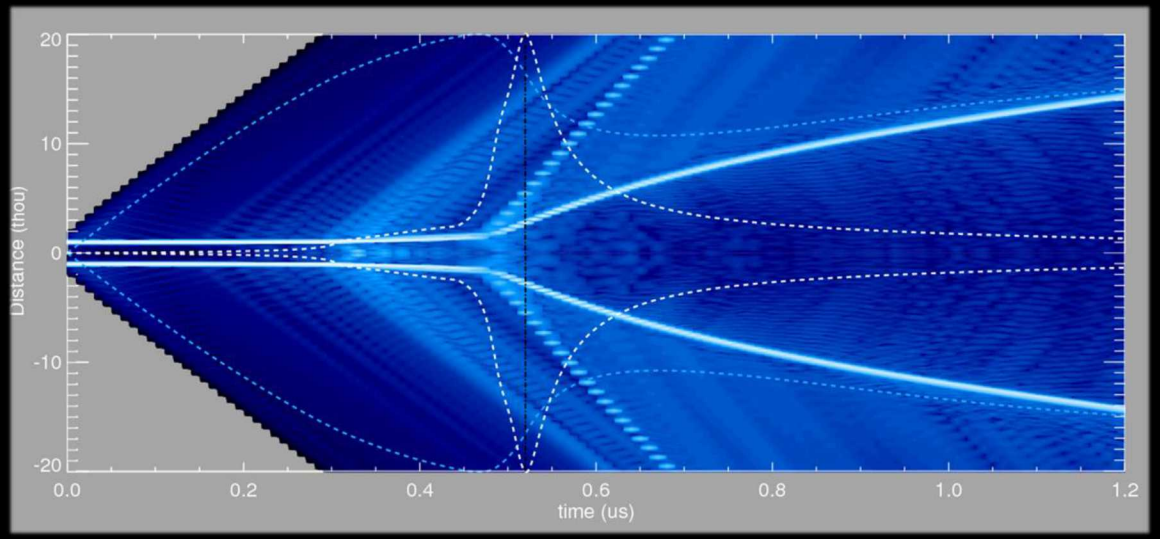

5.8e-7 s


ENERGY
VOLTAGE
TIME
0.00e+0
3.75e-7
7.50e-7
1.13e-6
1.50e-6
1.88e-6
2.25e-6
2.63e-6
3.00e-6


CURRENT
TIME
Voltage 3.81e+3
Current 1.30e+3
0.00e+0
3.75e-7
7.50e-7
1.13e-6
1.50e-6
1.88e-6
2.25e-6
2.63e-6
3.00e-6

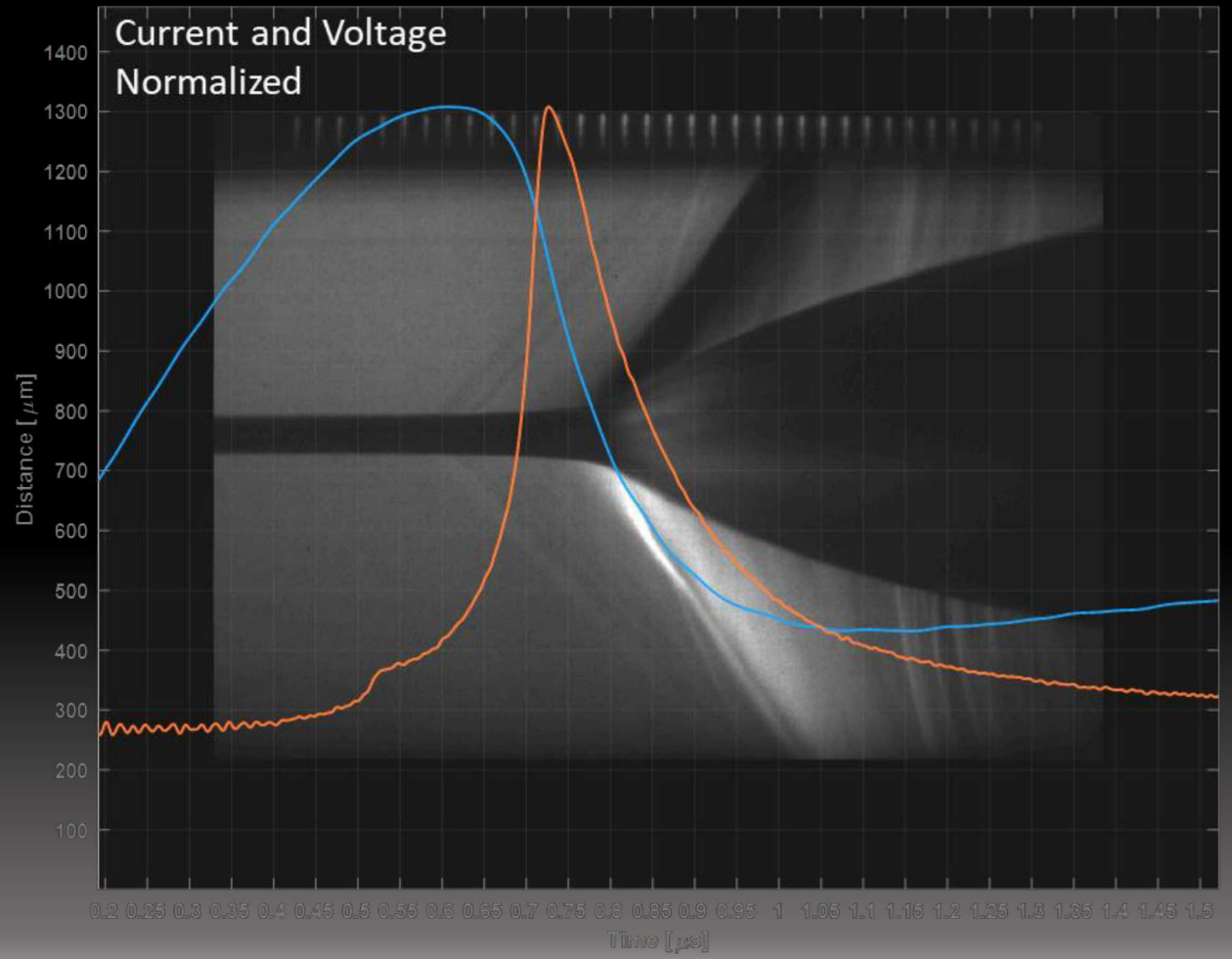

Shot 163
Energy [J]
Time [s]
Heat of Fusion* ~ 0.062J

Simulation/Experiment



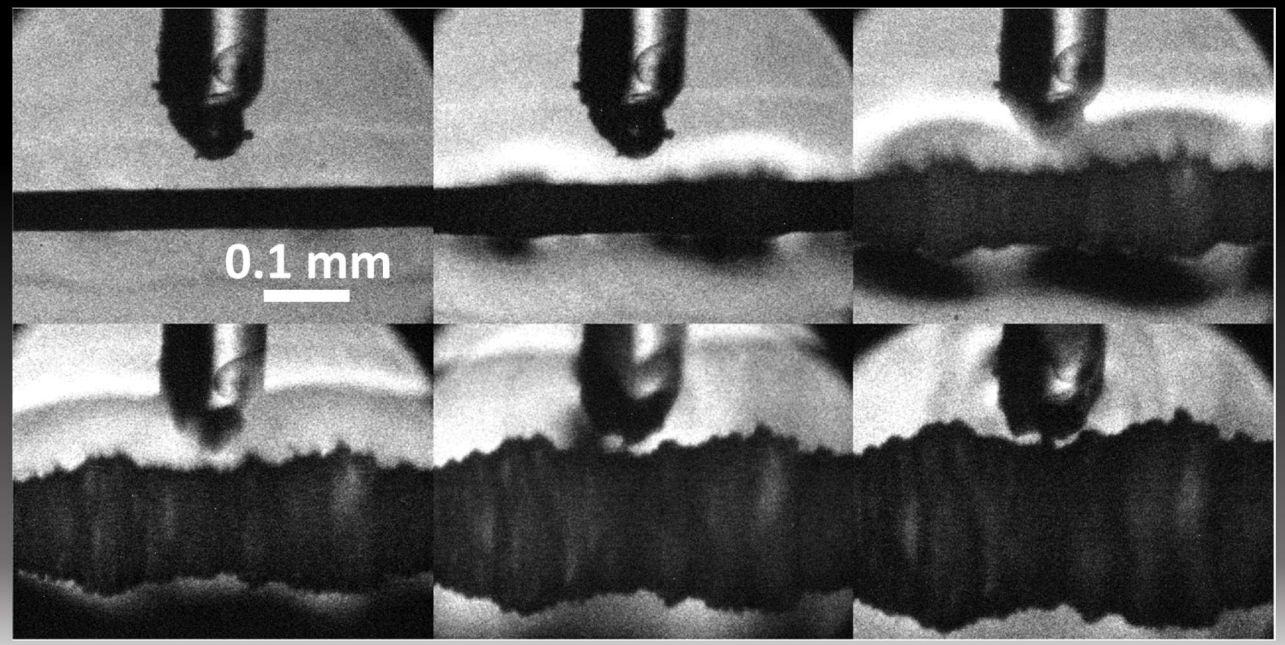
Electrical traces overalyed onto image/simulation

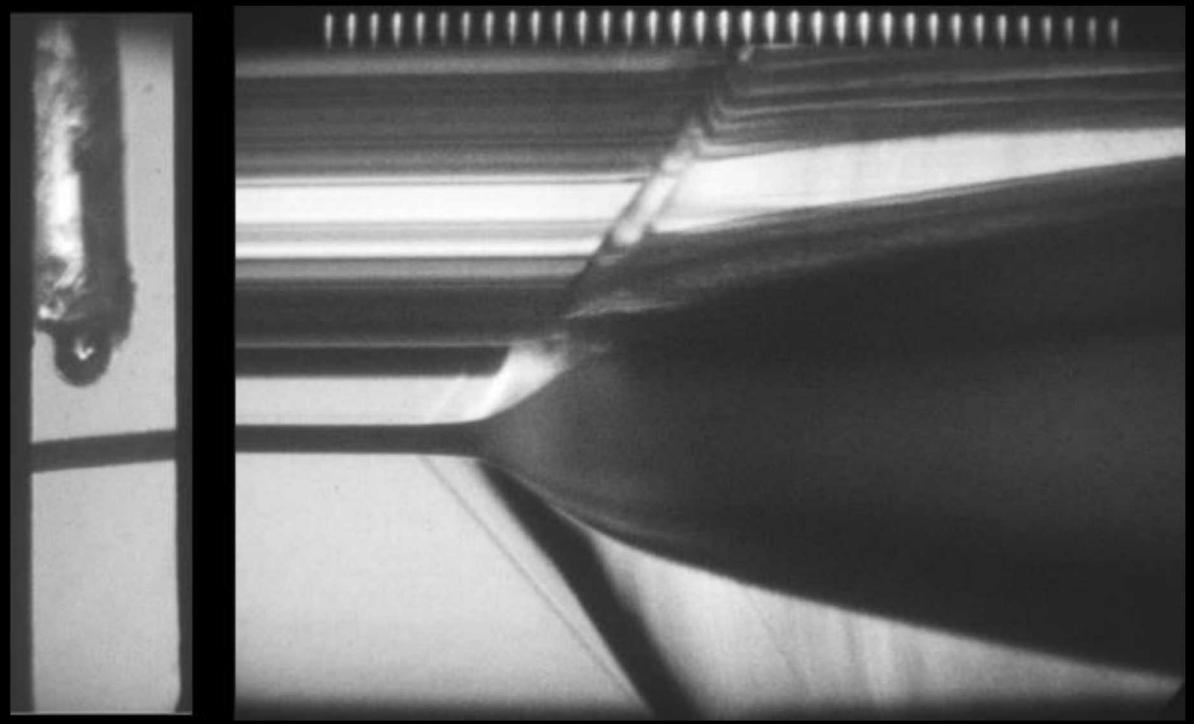
Pressure field from simulation overlayed onto experimental image



Simulation/Experiment

Sequence of images of a bursting gold wire in the vicinity of a hollow GMB. Images have a 10 ns exposure time and a 20 ns interframe time. Images were taken in the same lighting configuration as the μSSI with a Specialized Imaging SIMD framing camera.





(Left) Static 2-D image of gold wire with a ~70 micron hollow GMB held above the wire via glue on a 125 micron diameter glass fiber. (Right) μSSI of the bursting gold wire in proximity to the GMB. The first weak shock interacts with the GMB without any destructive outcome, while the second stronger shock is shown to collapse the GMB and continue to transition into the glass fiber.

Summary

Electrical burst of metal wires in water using time-correlated current and voltage waveforms with μSSI.

Used to collapse a GMB inserted into the water to examine the dynamics of shock on a single pore collapse.

Work is being done to simulate in 2-D and 3-D, with wire holding apparatus, and with density/impurity perturbations in the wire.