Small-scale shock experiments for characterizing the performance detonator materials

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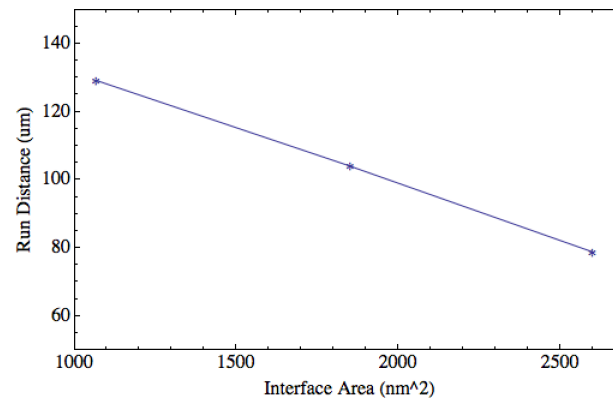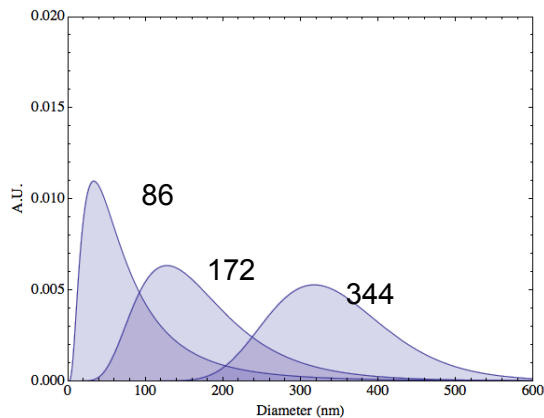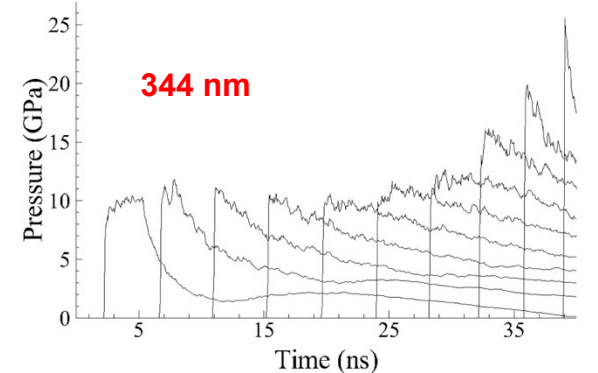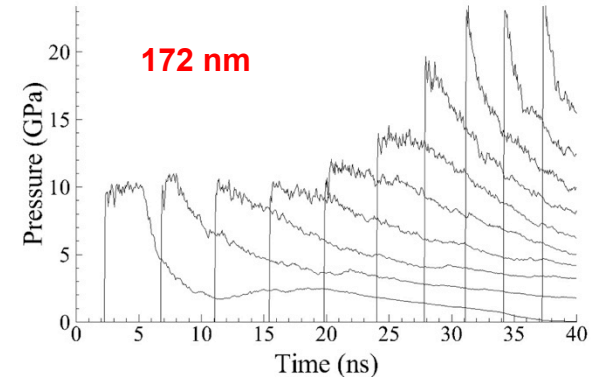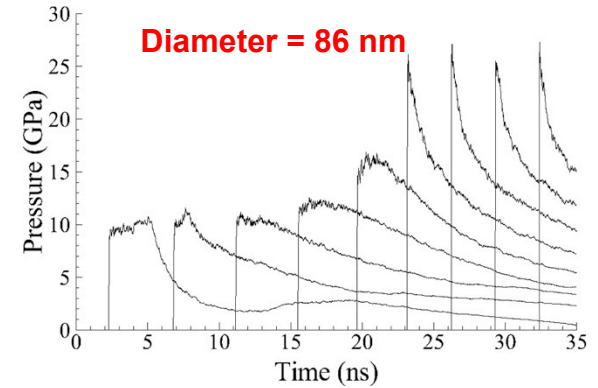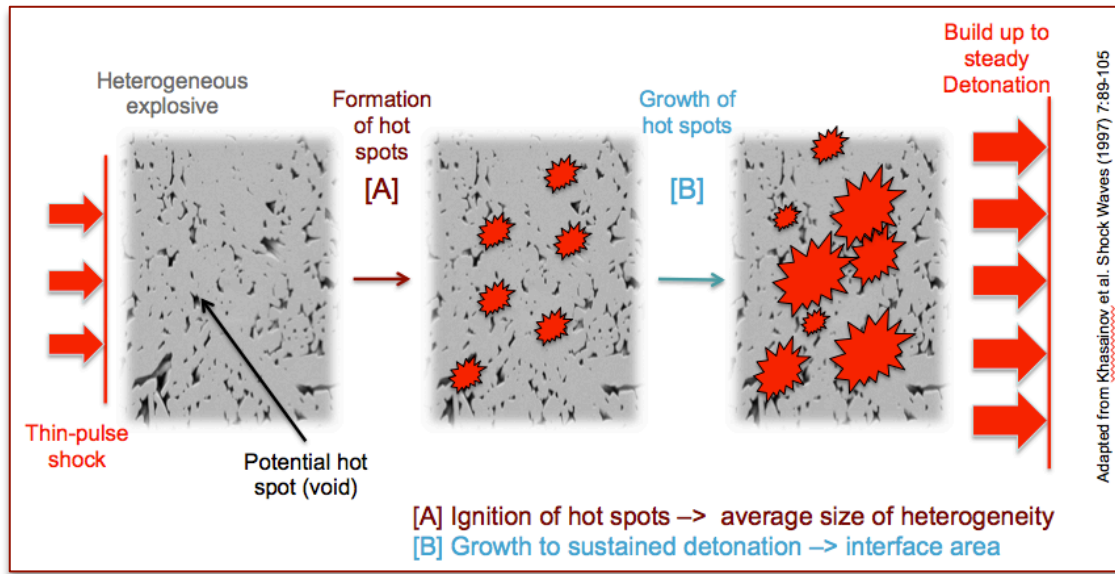
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Effects of pore size and interface area on run-distance

Heterogeneous explosive → Formation of hot spots [A] → Growth of hot spots [B] → Build up to steady Detonation

Thin-pulse shock

Potential hot spot (void)

Adapted from Khasainov et al. Shock Waves (1997) 7:89-105

[A] Ignition of hot spots –> average size of heterogeneity
[B] Growth to sustained detonation –> interface area
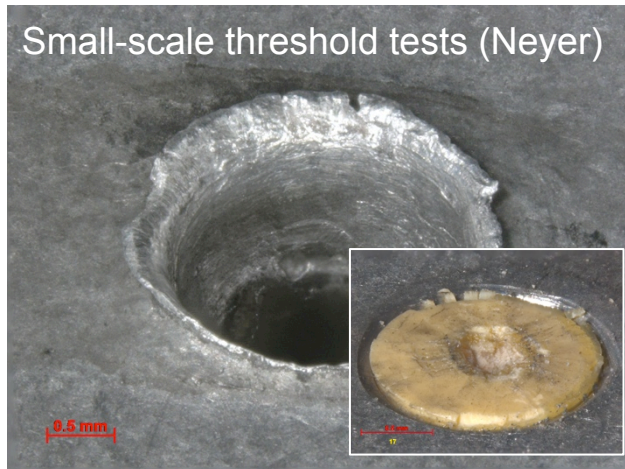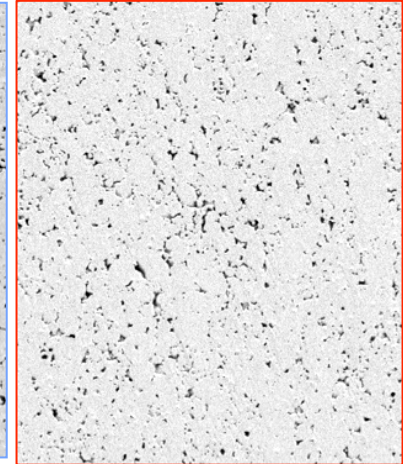
Diameter = 86 nm

172 nm

344 nm

Material with varying pore-size and interface area
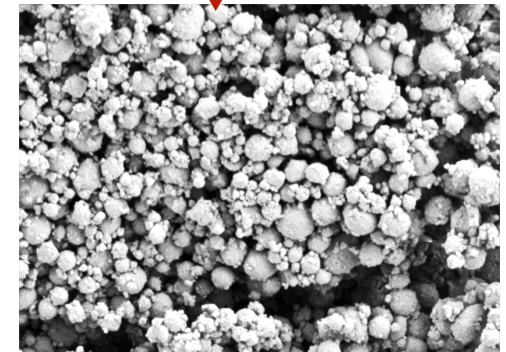
Decreasing Initiation Threshold

10 um

Engineered morphology

Small-scale threshold tests (Neyer)
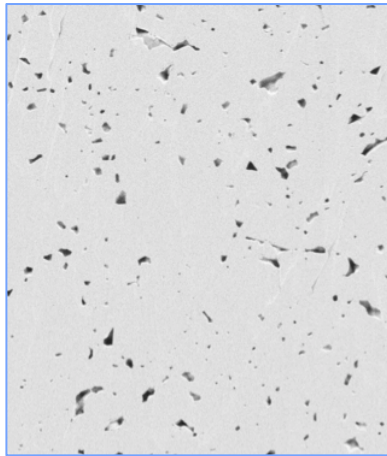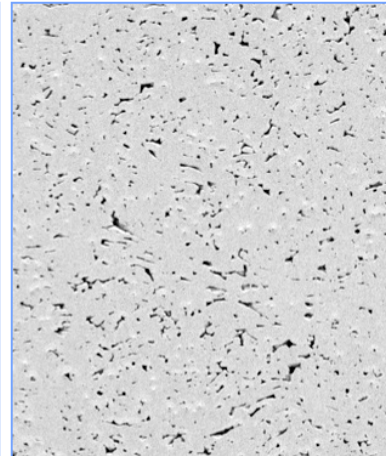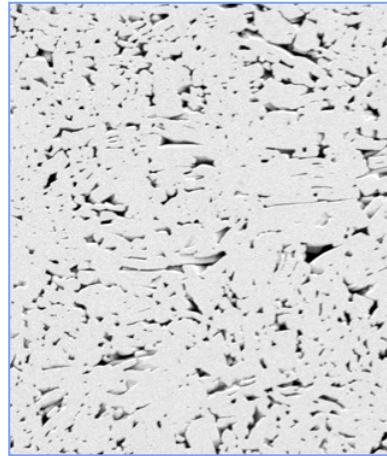
1 mm diameter pressing, chip-slapper initiated

Typical HNS powders

CO_2 assisted nebulization
Spherical particle HNS (dia = 300 nm)
Surface area ~ 12 m^2/g

Small-scale wedge shot
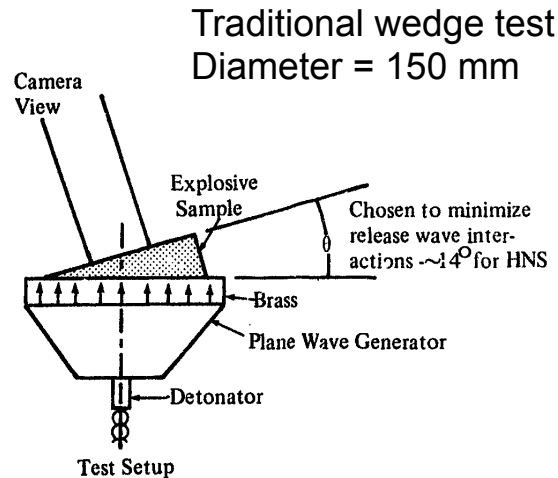
20 kV CDU
Flyer:
 2.5 - 6.35 mm square
 25 - 250 µm thick
Velocities up to 4.5 km/s

Wedges:
 Diameter: 3.1 mm
 Toe: 0.1 µm
 Heal: 1.8 µm

Traditional wedge test
Diameter = 150 mm

SAND80-2372 / A.C. Schwarz

Camera View

Explosive Sample

Chosen to minimize release wave inter-actions ~14° for HNS

Brass
Plane Wave Generator
Detonator

Test Setup

Time
Steady-State Detonation Velocity
Shock Velocity
2 GPa
3 GPa
Streaks shown for 2 GPa and 3 GPa input into explosive
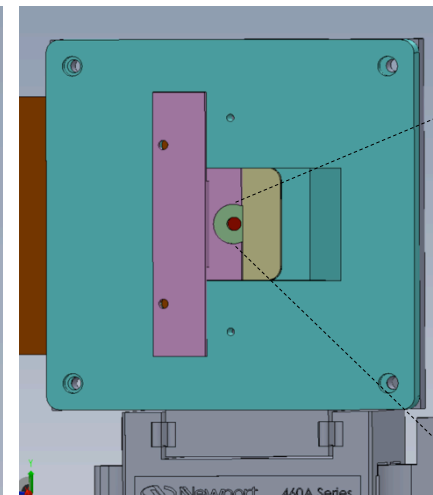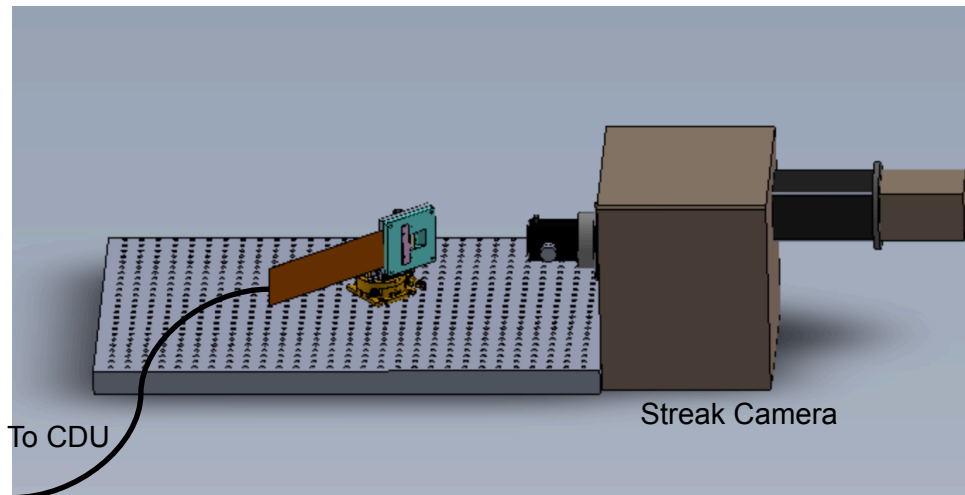xs Transit Time
GTDD for 2 GPa
x (mm)

Typical Streak Camera Records (x-t space)
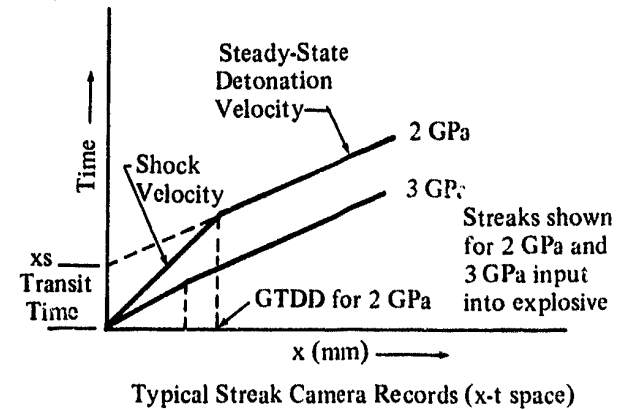
Figure 10.   Wedge Test Technique

To CDU

Streak Camera

fs-laser machined wedge
Vapor deposited Al reflector
Flash-lamp and filter

Streak
Lexan support
HNS wedge

4
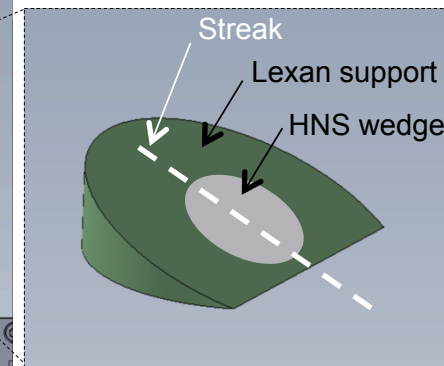
Small-scale wedge shot: Simulation
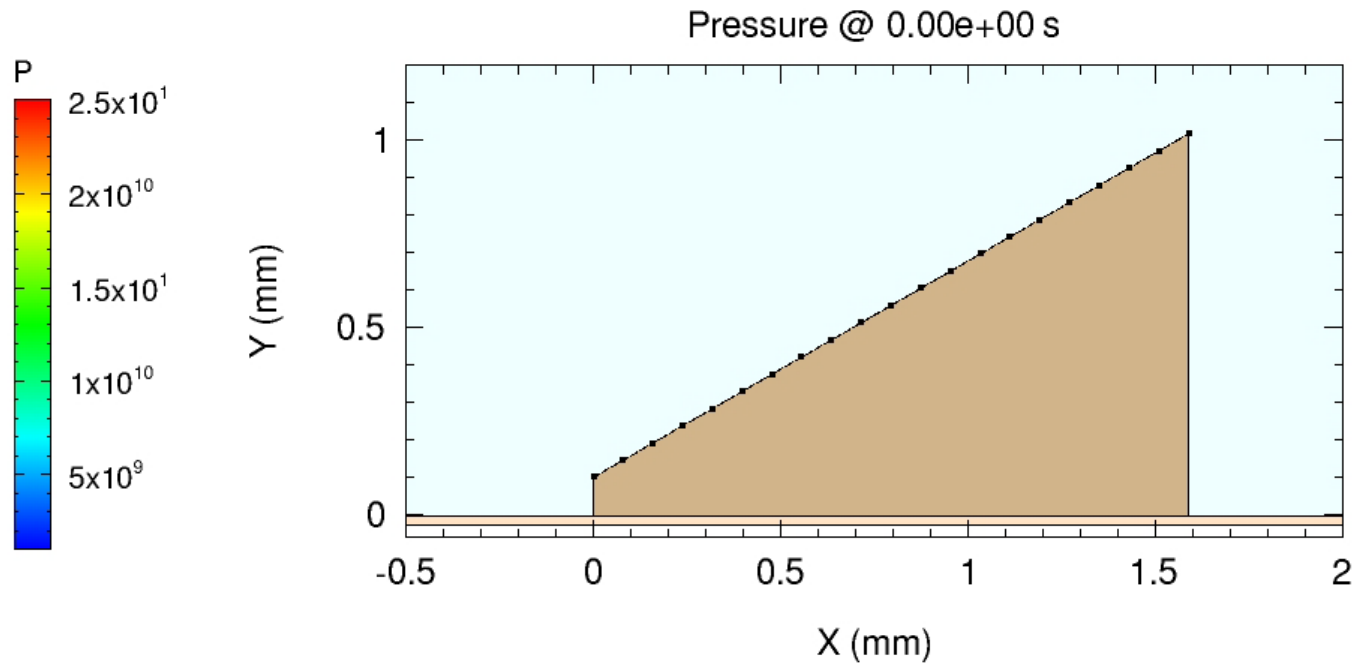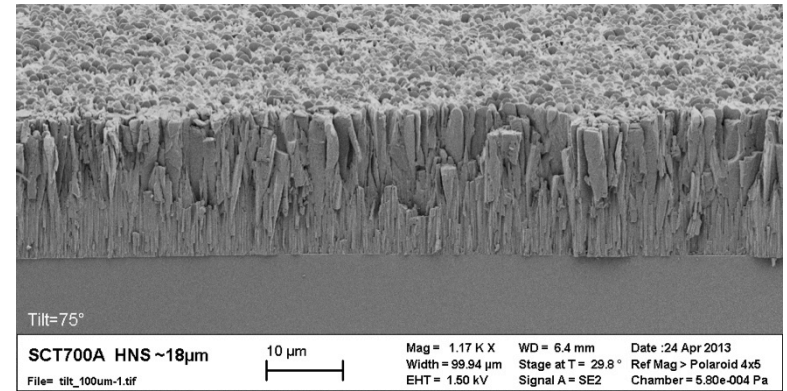
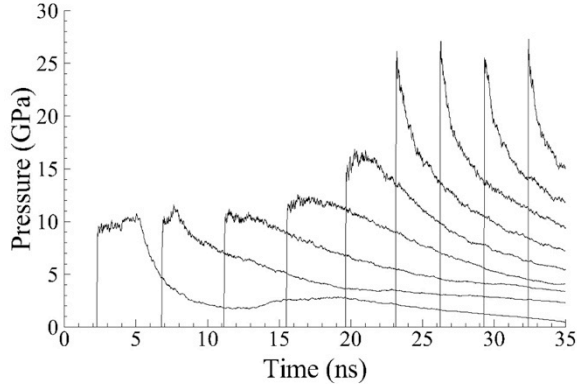# Small-scale wedge shot: Simulation
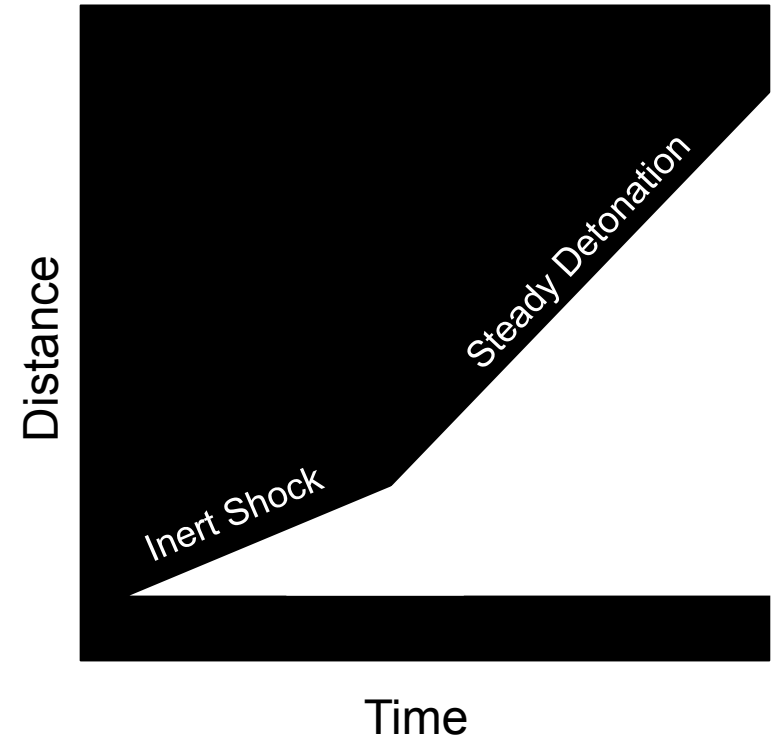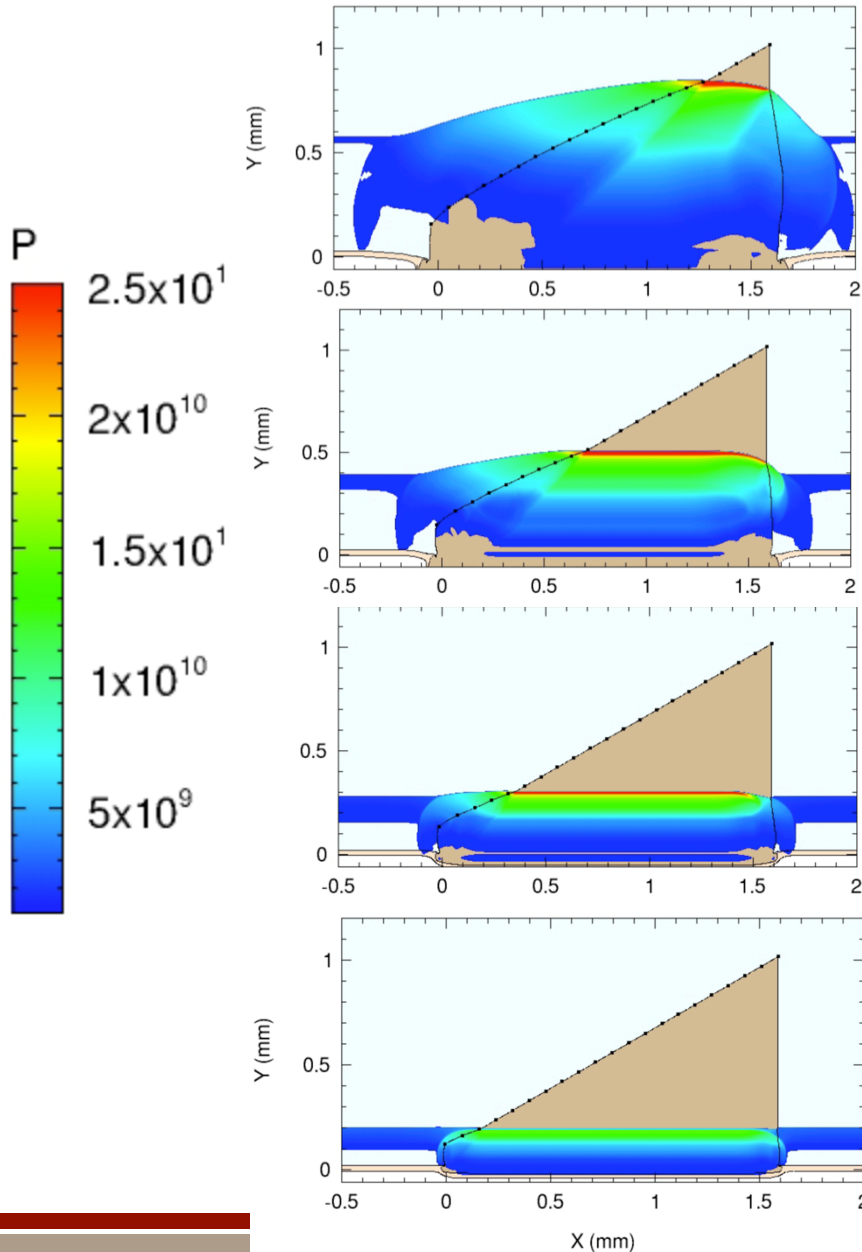
Pop-plot & unreacted Hugoniot

Vapor-deposited "cut-backs" 10 – 100 μm

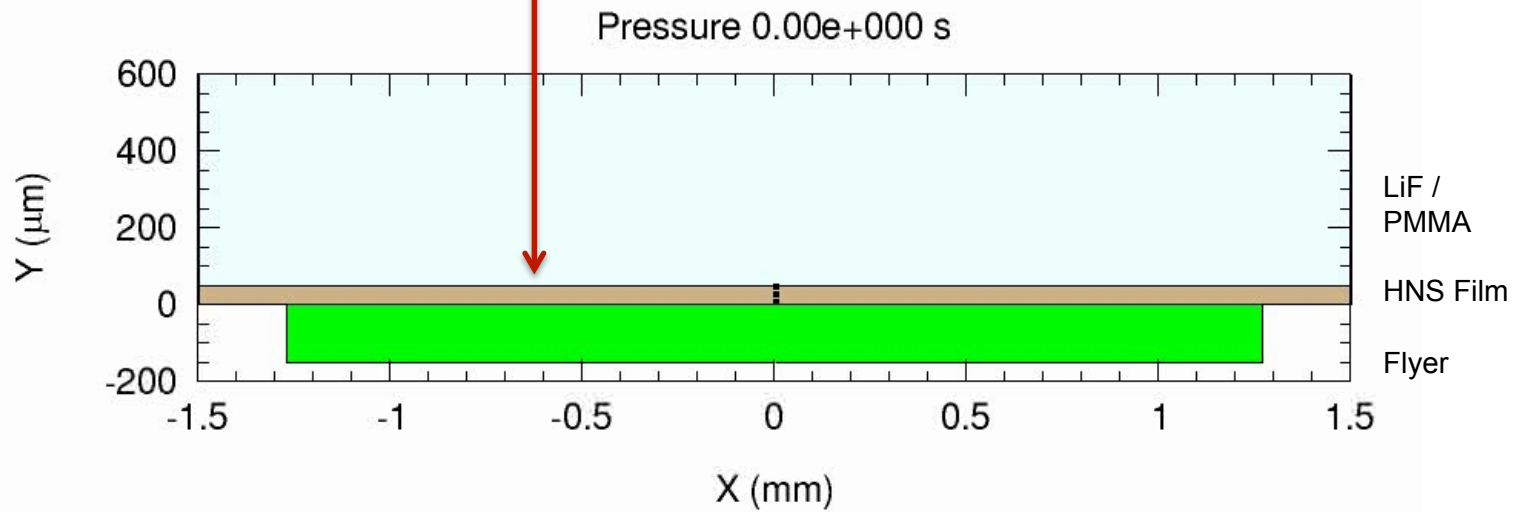## Pressure histories

Photonic Doppler
Velocimetry

Films courtesy by Rob Knepper and Alex Tappan
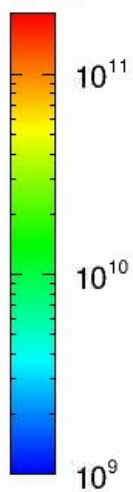
Summary

- Simulations and theory predict that threshold and run-distance are both correlated to details of the microstructure.
- We have developed a method (CAN-BD) making a unique and controllable morphology that is ideal for validating the predictions.
- We have collected threshold data for varying microstructures.
- Have developed a small-scale shock capability that allows for both mini-wedge tests and micro-scale cut-back studies.

Future Work

- Use our developed experimental capability to measure run-distance, unreacted Hugoniot, and pressure histories.
- Validate this model for other materials (CL-20, HMX, …).