

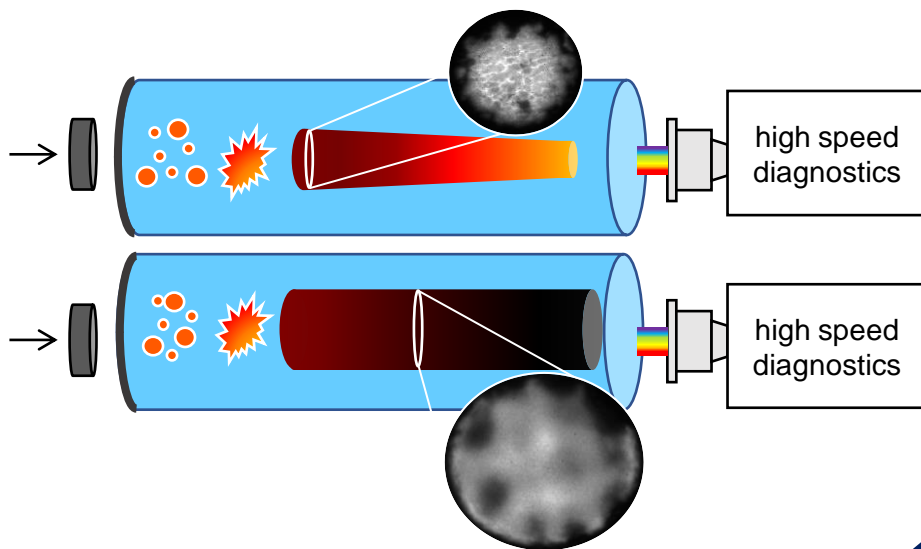
Investigating the Reactive Nature of Nitromethane, an Explosive Liquid, Under Tabletop Shock Compression

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Professor Dana D. Dlott

School of Chemical Sciences

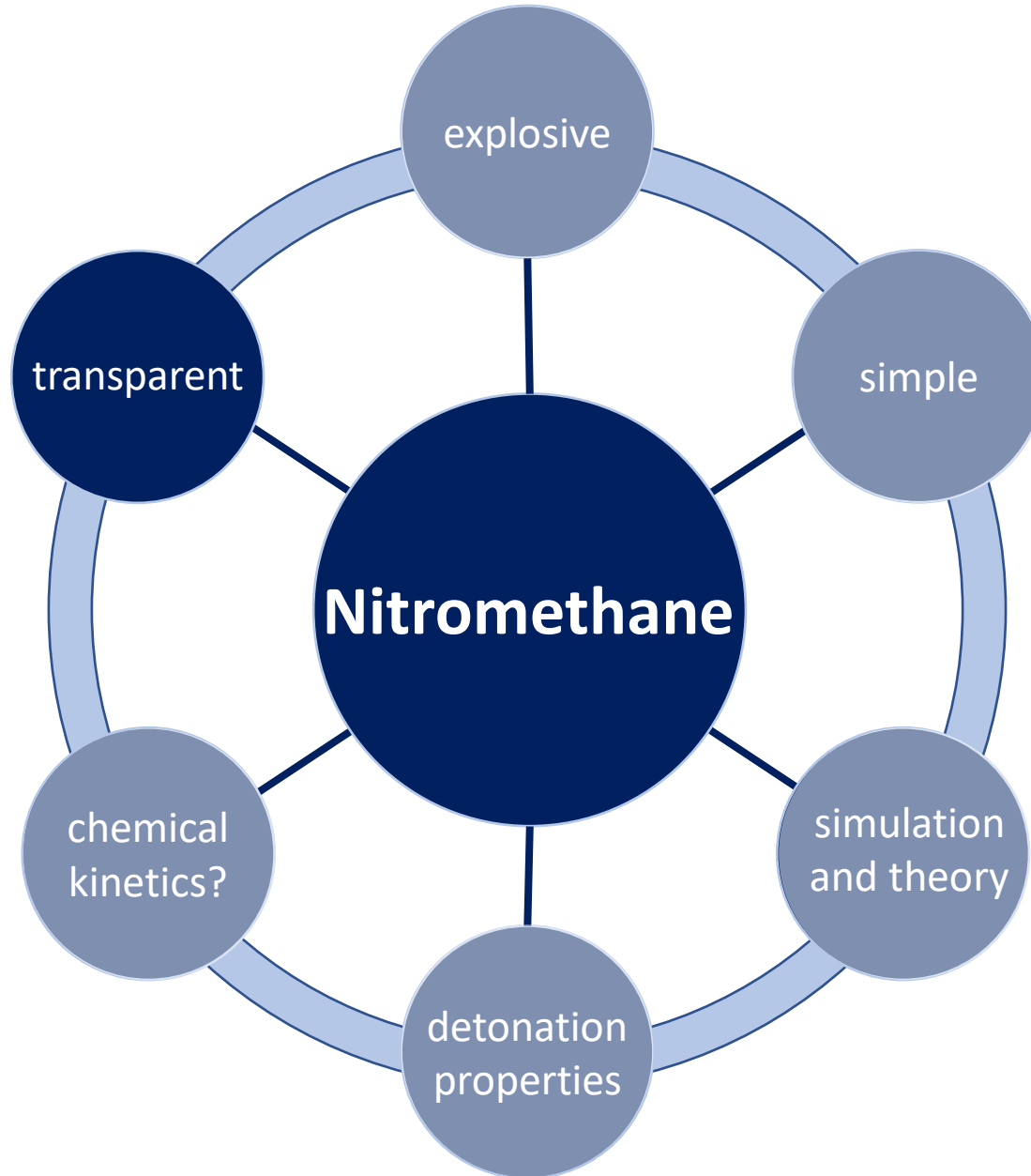
University of Illinois, Urbana-Champaign



Introduction and Overview of The Tabletop Shock Compression Microscope



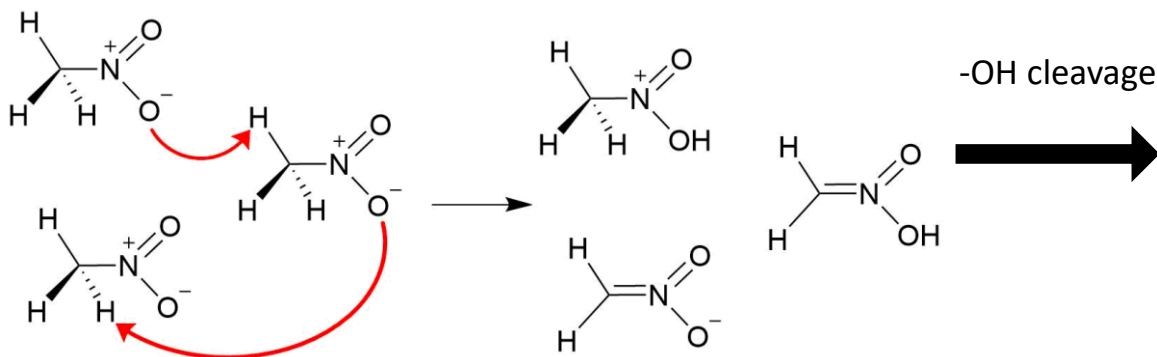
Why Study Nitromethane?



Chemical Kinetics of a Two-Stage Explosion in Liquid Nitromethane

First Explosion:

intermolecular proton transfer



H_2O
*water marks the beginning of exothermic chemistry

Second Explosion:

Break up the 40-70% of C and N-atoms tied up in large molecular fragments



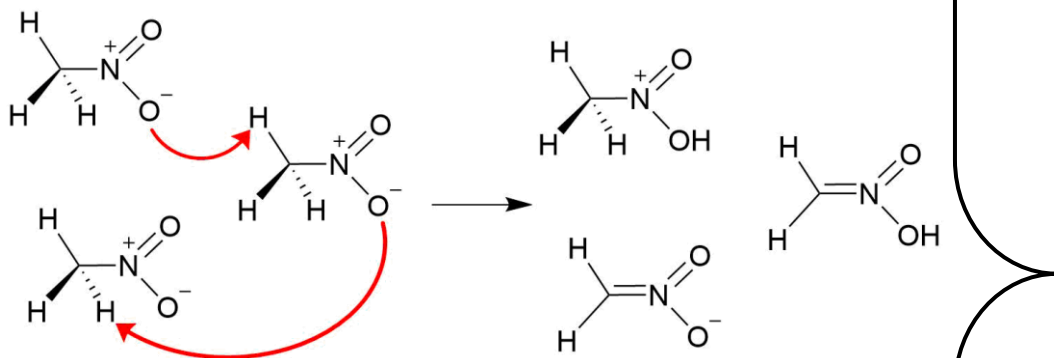
Stable products: H_2O , H_2 , N_2 , CO_2 , and NH_3

*using density functional molecular dynamic simulations

Chemical Kinetics of a Two-Stage Explosion in Liquid Nitromethane

Alternative Approach

First Explosion:
intermolecular proton transfer

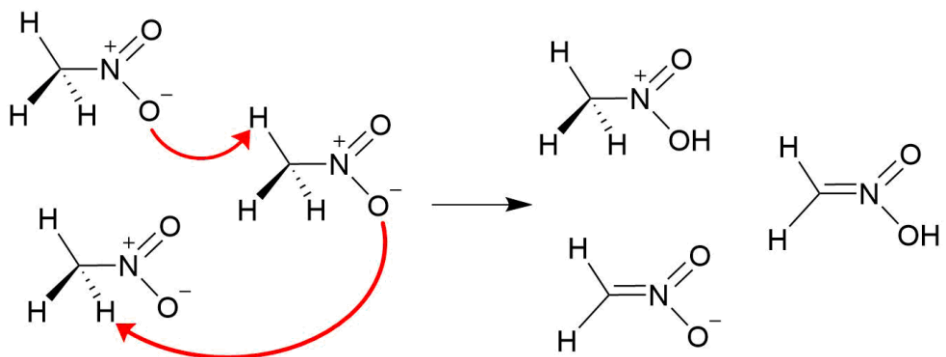


Second Explosion:
Break up the 40-70% of C and N-atoms
tied up in large molecular fragments

Chemical Kinetics of a Two-Stage Explosion in Liquid Nitromethane

First Explosion:

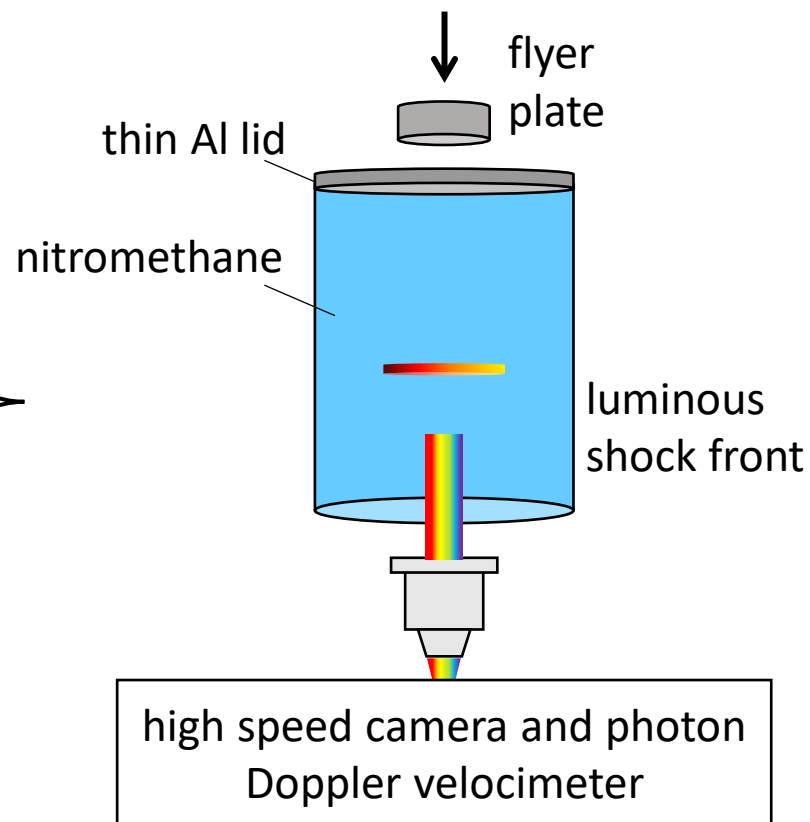
intermolecular proton transfer



Second Explosion:

Break up the 40-70% of C and N-atoms tied up in large molecular fragments

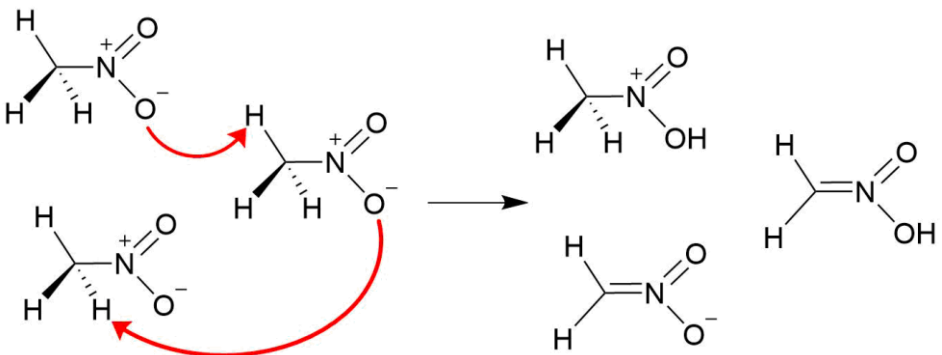
Alternative Approach



Chemical Kinetics of a Two-Stage Explosion in Liquid Nitromethane

First Explosion:

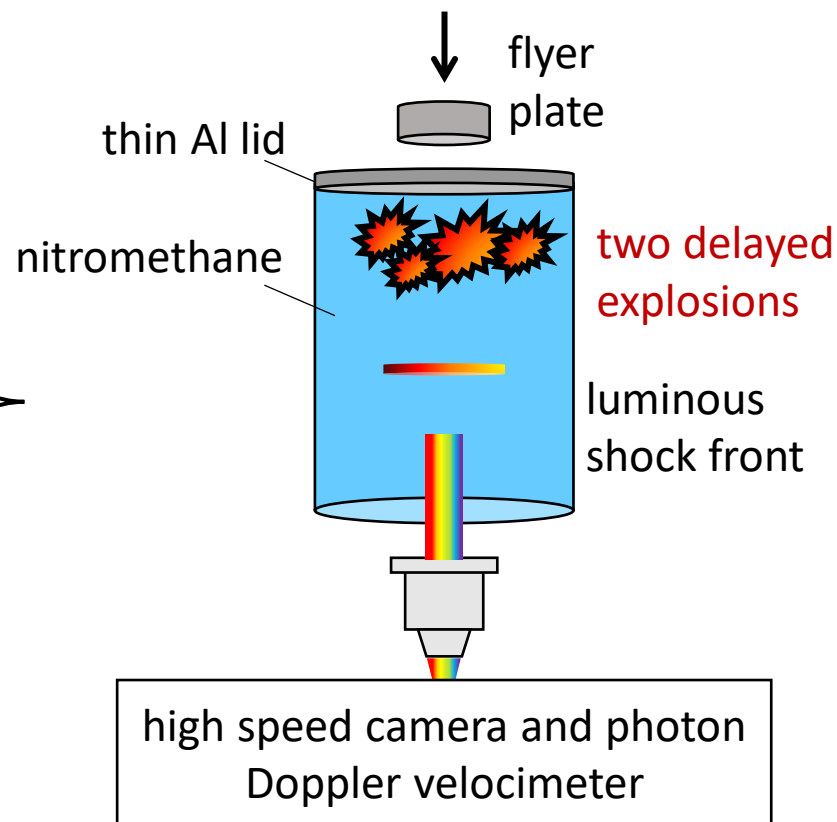
intermolecular proton transfer



Second Explosion:

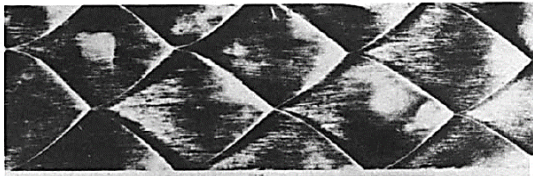
Break up the 40-70% of C and N-atoms tied up in large molecular fragments

Alternative Approach

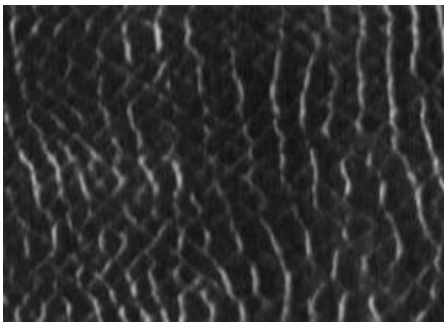


Chemical Kinetics of a Two-Stage Explosion in Liquid Nitromethane

Detonation tube filled with stoichiometric hydrogen-oxygen mixture with 70% Ar

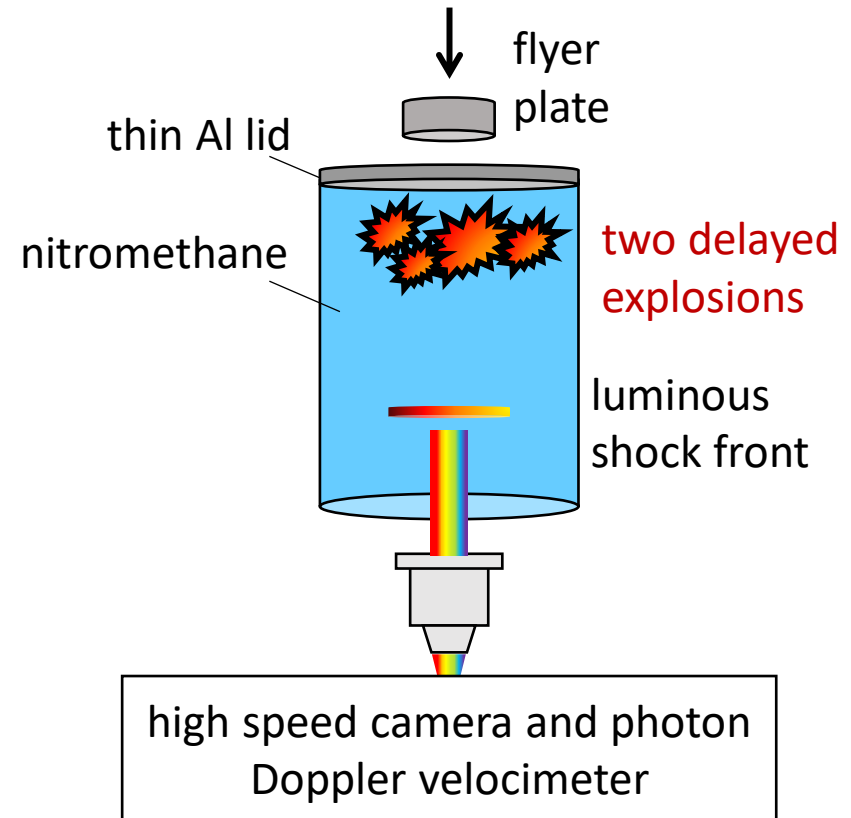


Wall traces of a detonation wave propagating through equimolar hydrogen-oxygen mixture.



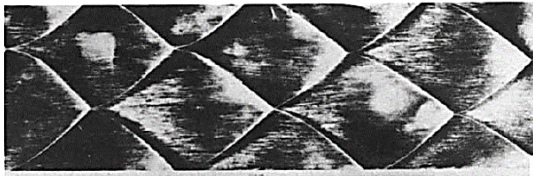
Cellular Structures

Alternative Approach

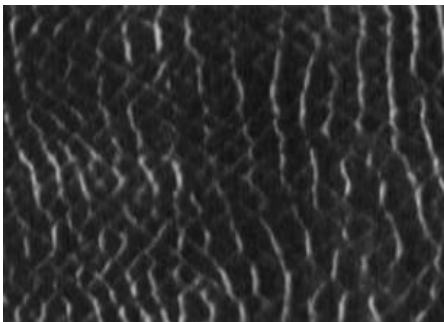


Chemical Kinetics of a Two-Stage Explosion in Liquid Nitromethane

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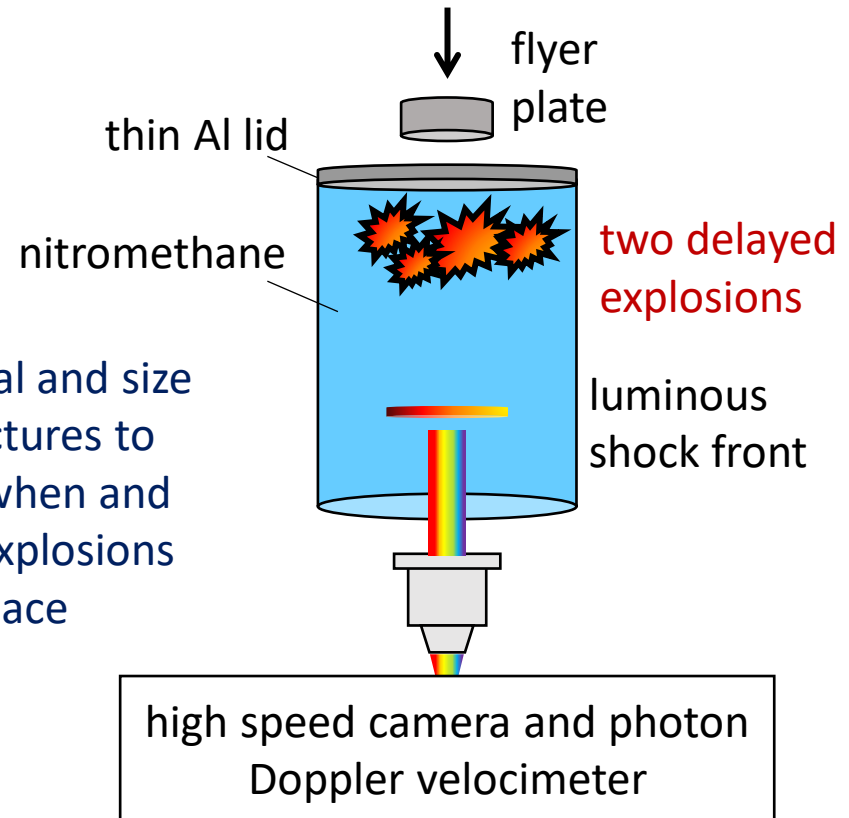


Wall traces of a detonation wave propagating through equimolar hydrogen-oxygen mixture.

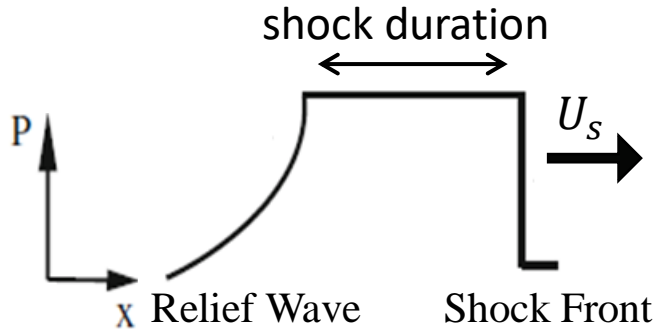


Use the arrival and size of the structures to determine when and where the explosions took place

Alternative Approach

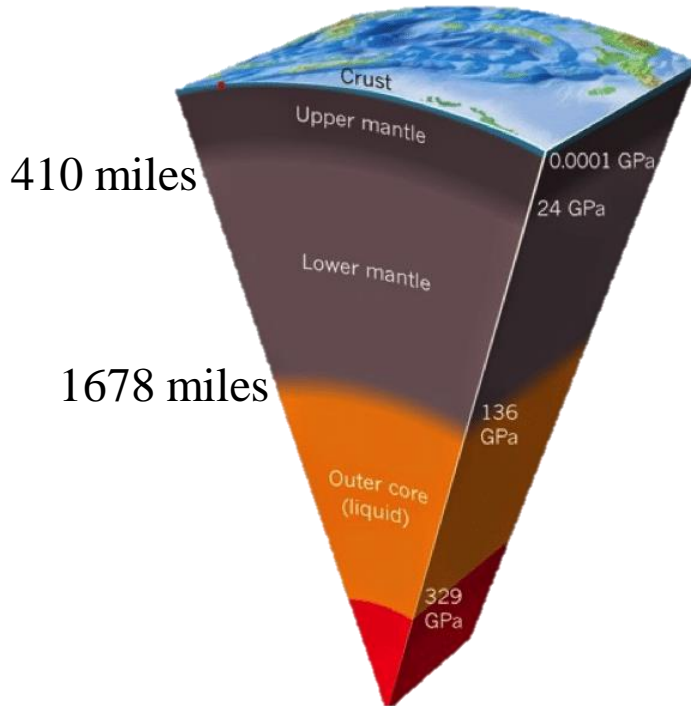
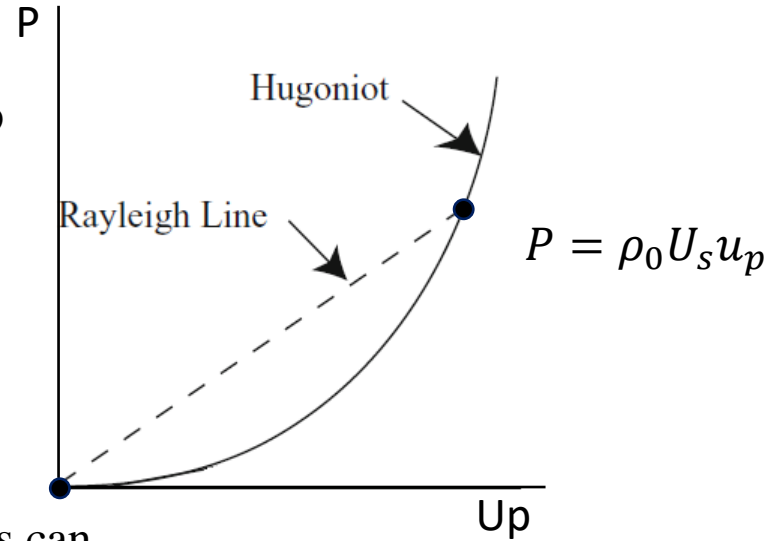


Shock Wave Propagation in Explosives



Linear Relationship
for Nitromethane

$$U_s = A + bu_p$$

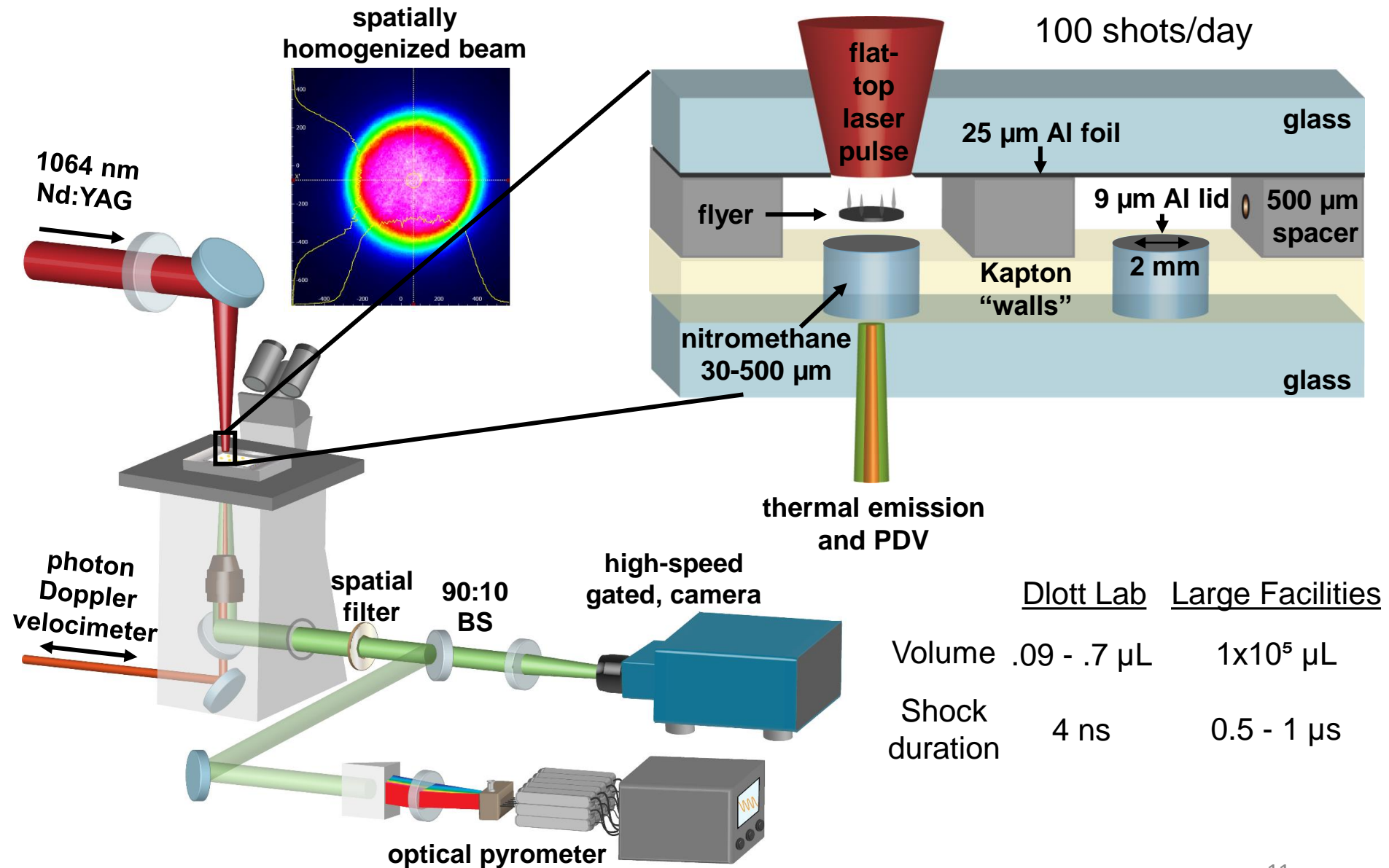


our apparatus can
probe ~ 1 – 30 GPa

$$\text{Mach 1} = 767 \text{ mph} = 0.331 \text{ km/s}$$

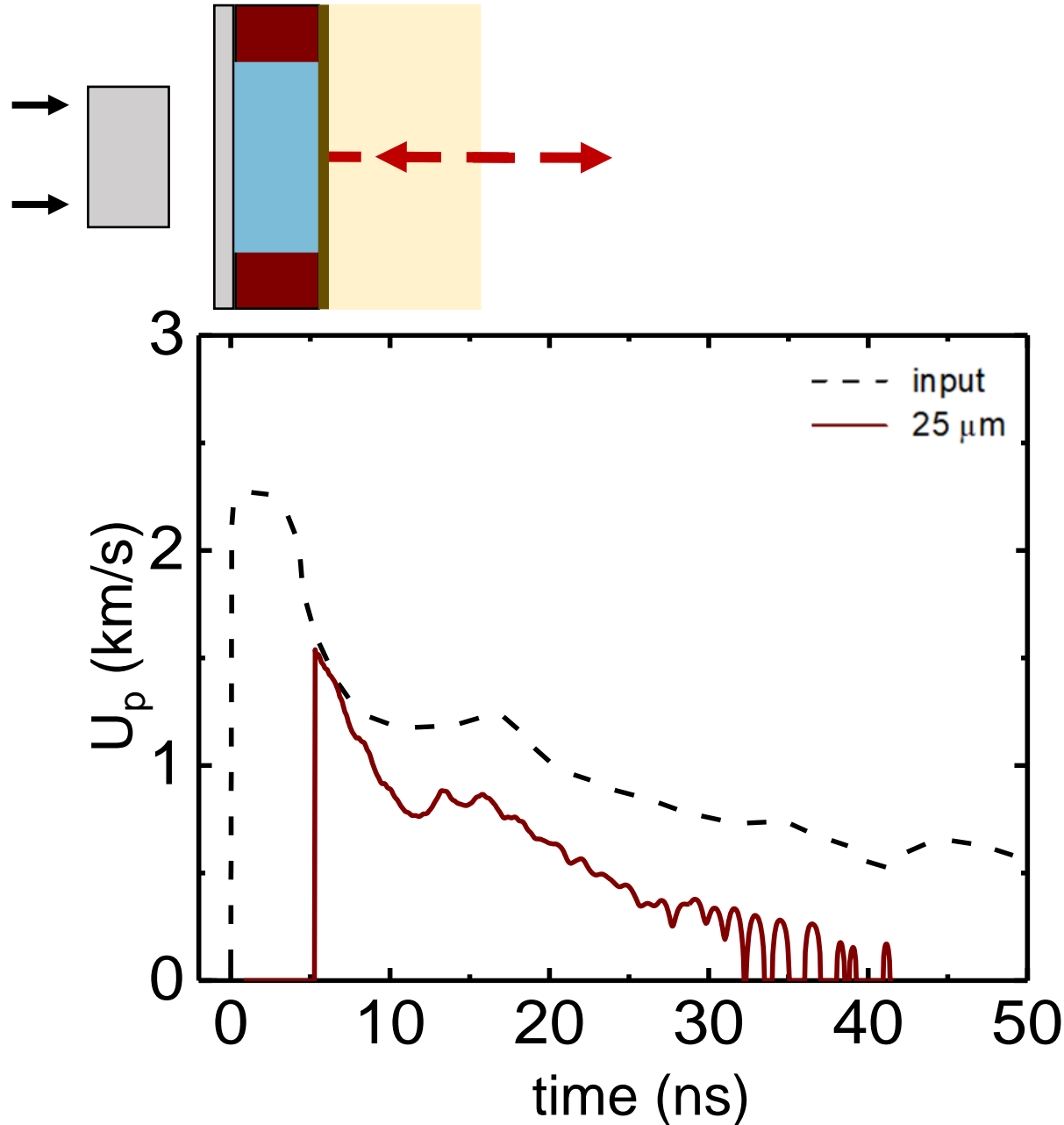
$$1 - 6 \text{ km/s} = 2000 - 13,500 \text{ mph}$$

Tabletop Shock Compression Microscope

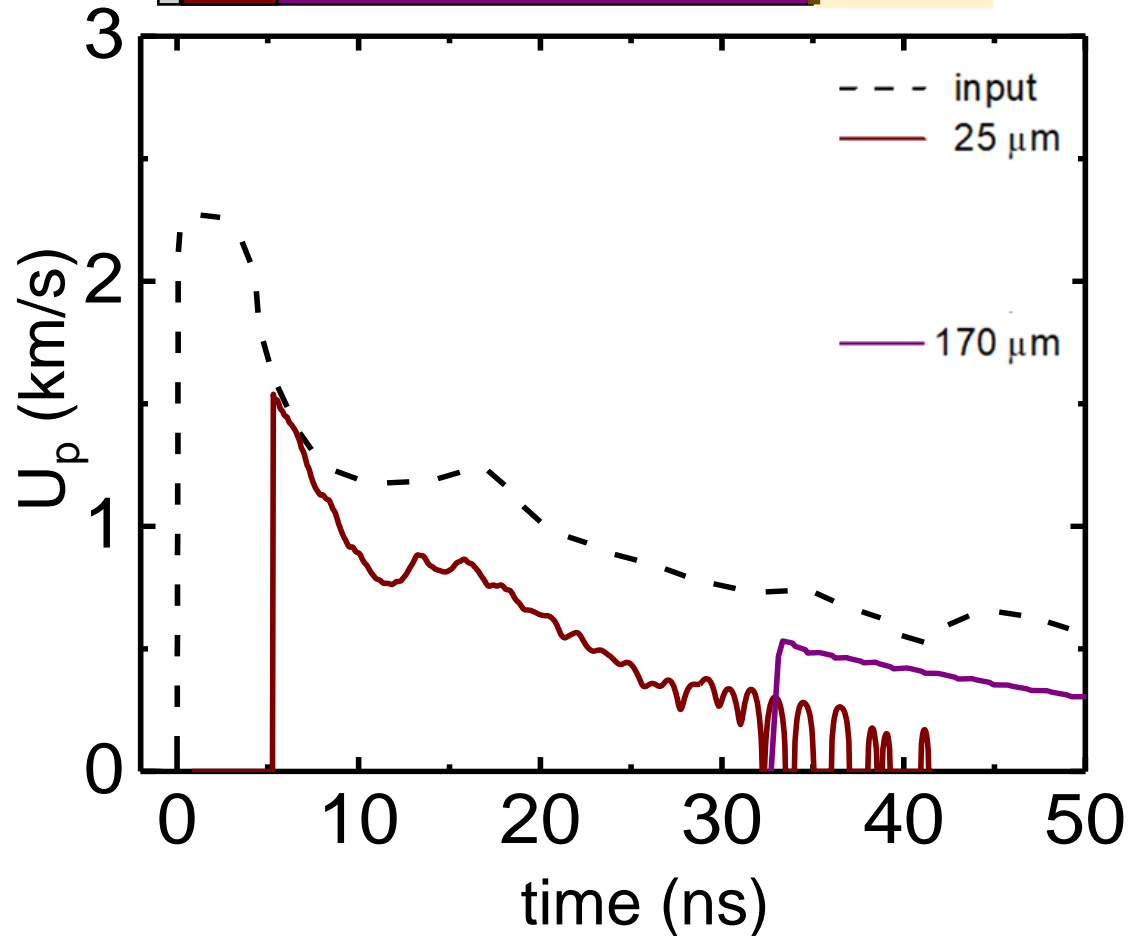
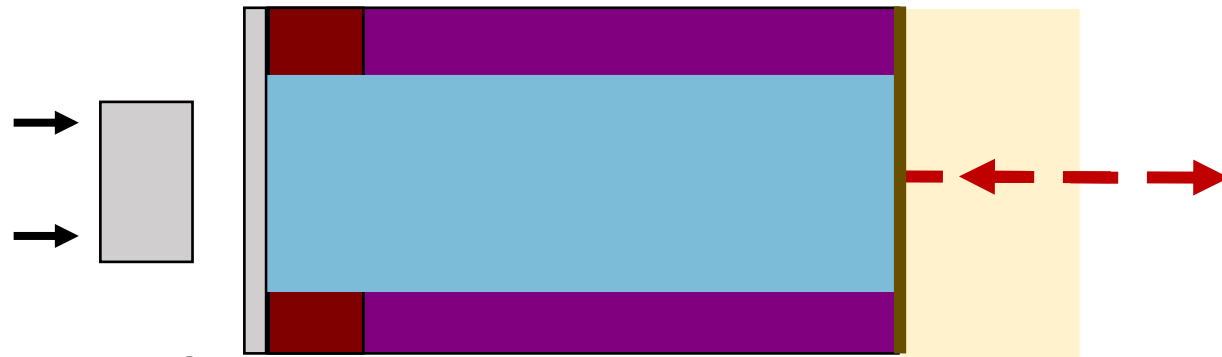


The Detonation Properties of
Shock Compressed Nitromethane with
High Temporal and Spatial Resolution

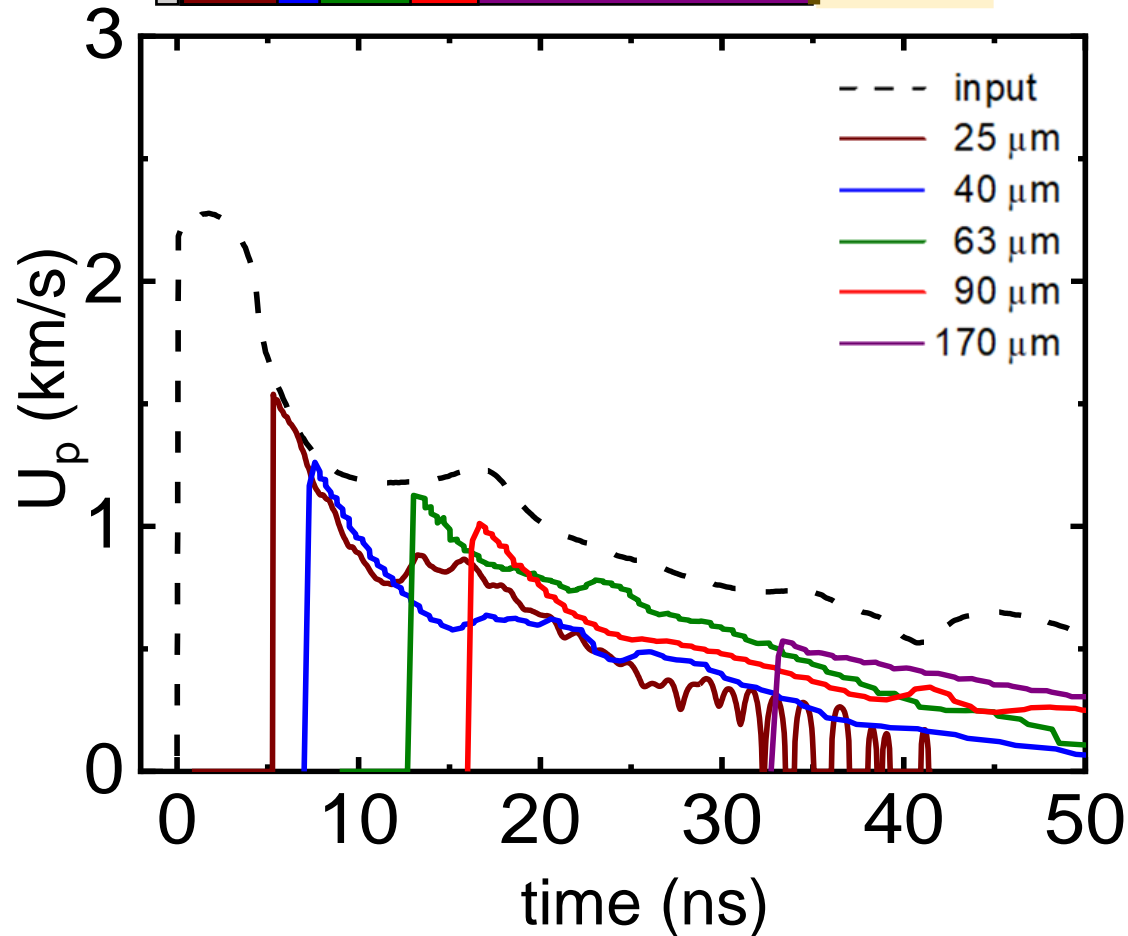
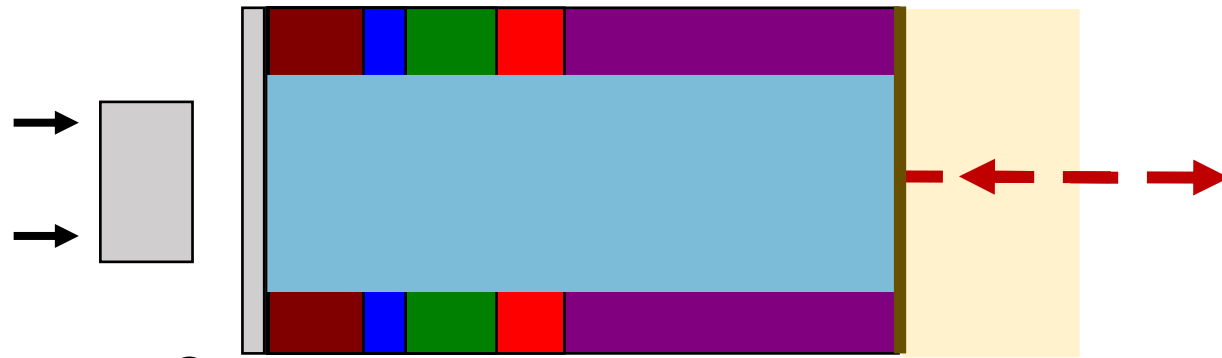
Shock Waveforms as a Function of Distance



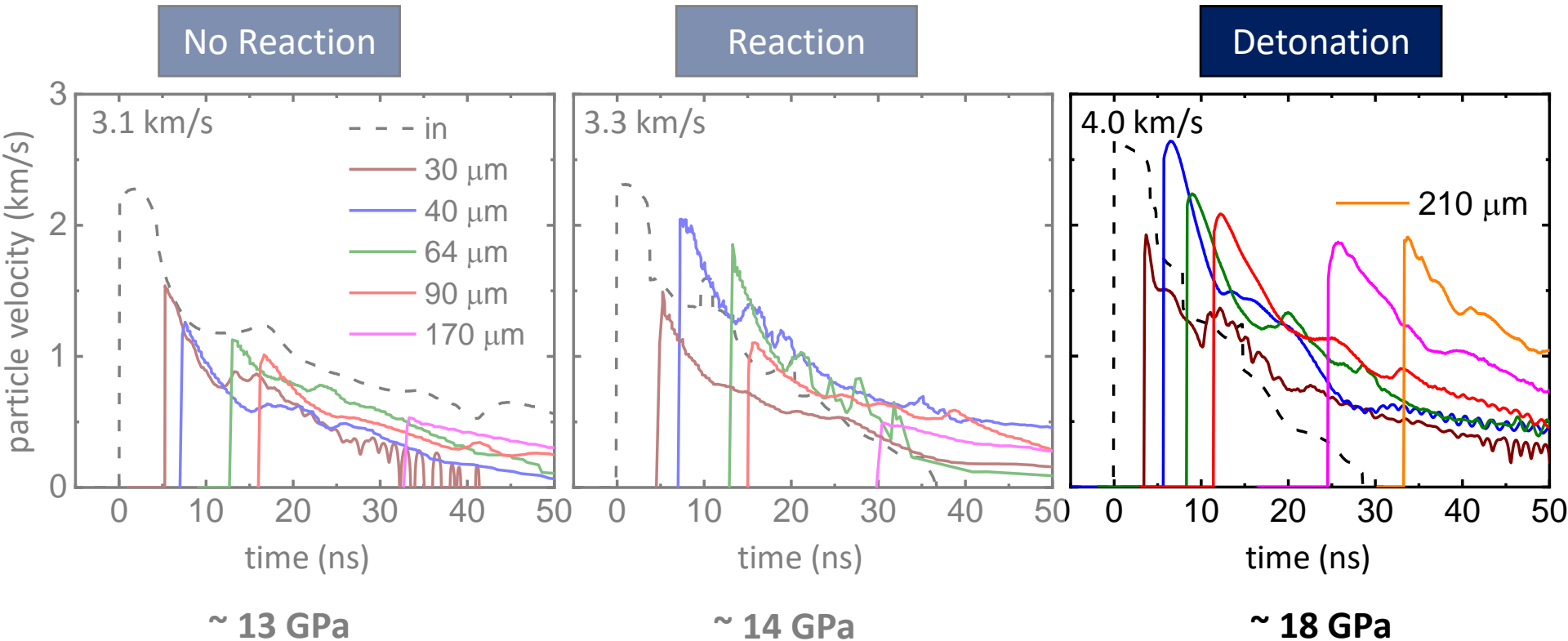
Shock Waveforms as a Function of Distance



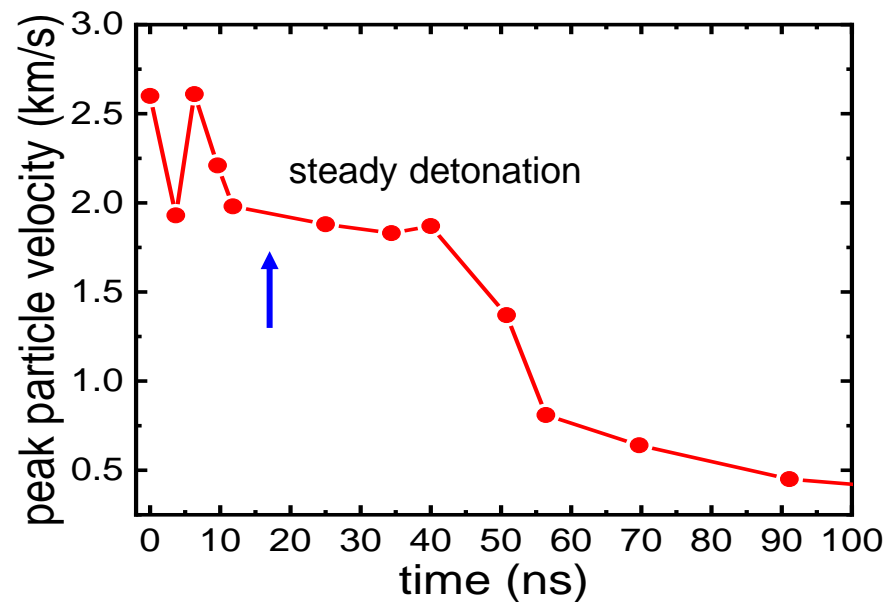
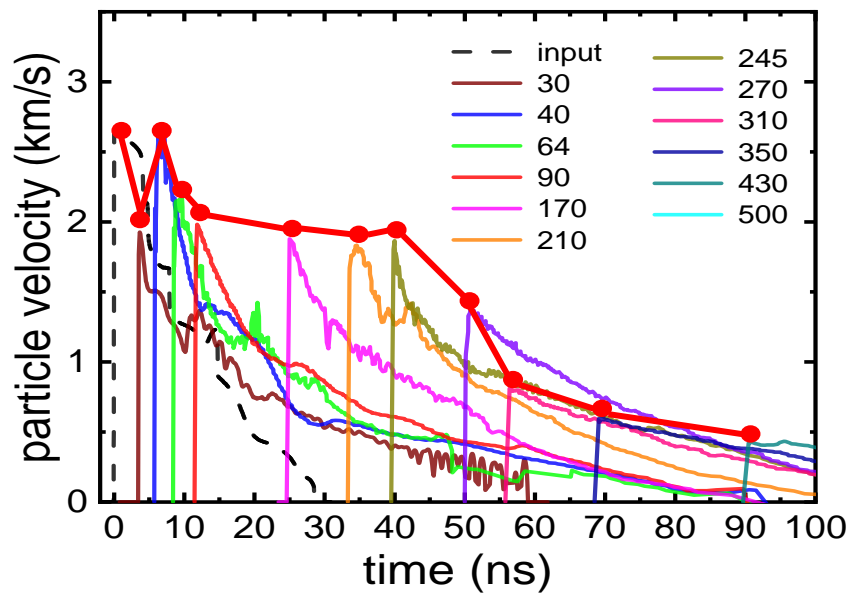
Shock Waveforms as a Function of Distance



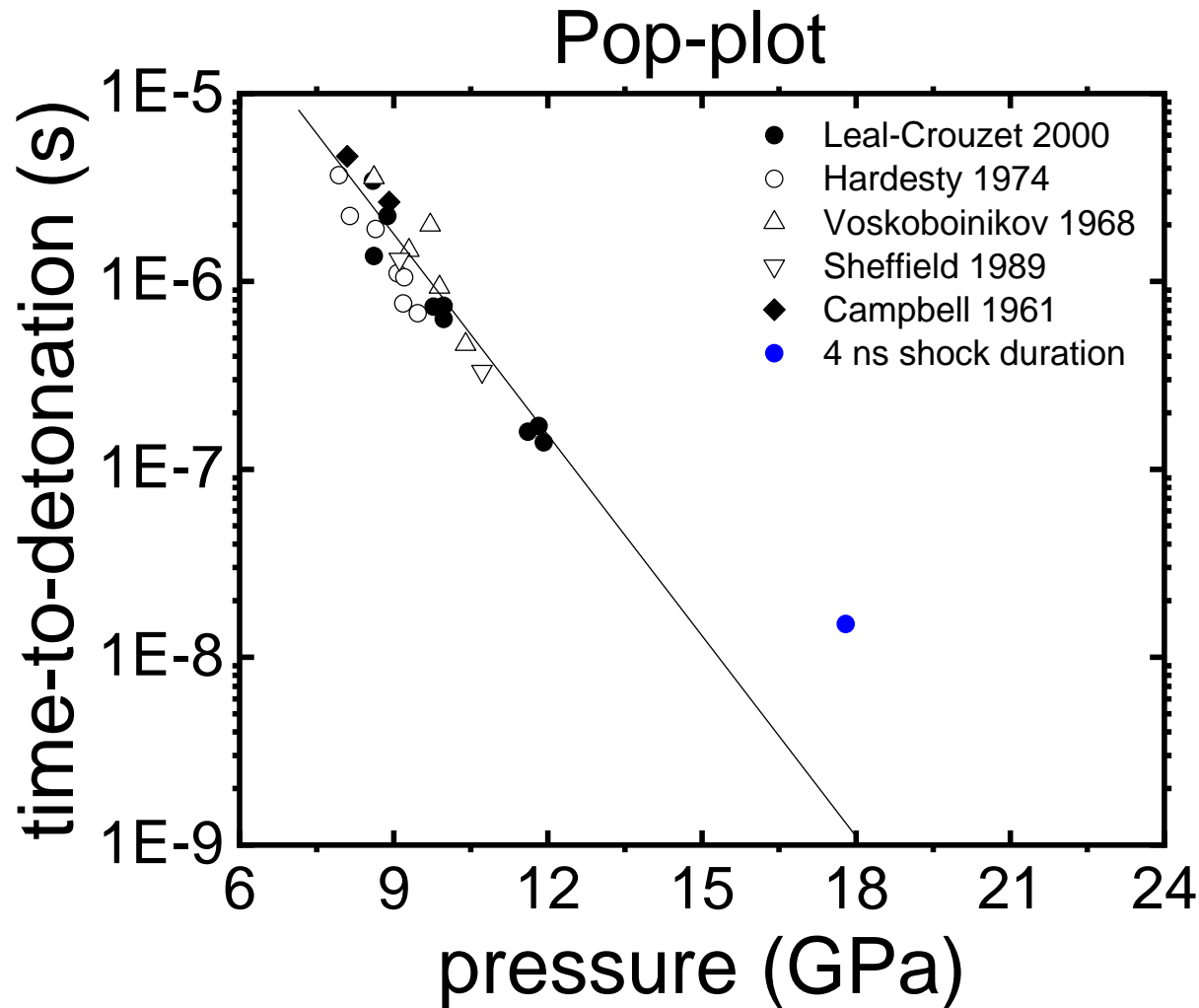
Shock Waveforms as a Function of Increased Input Energy



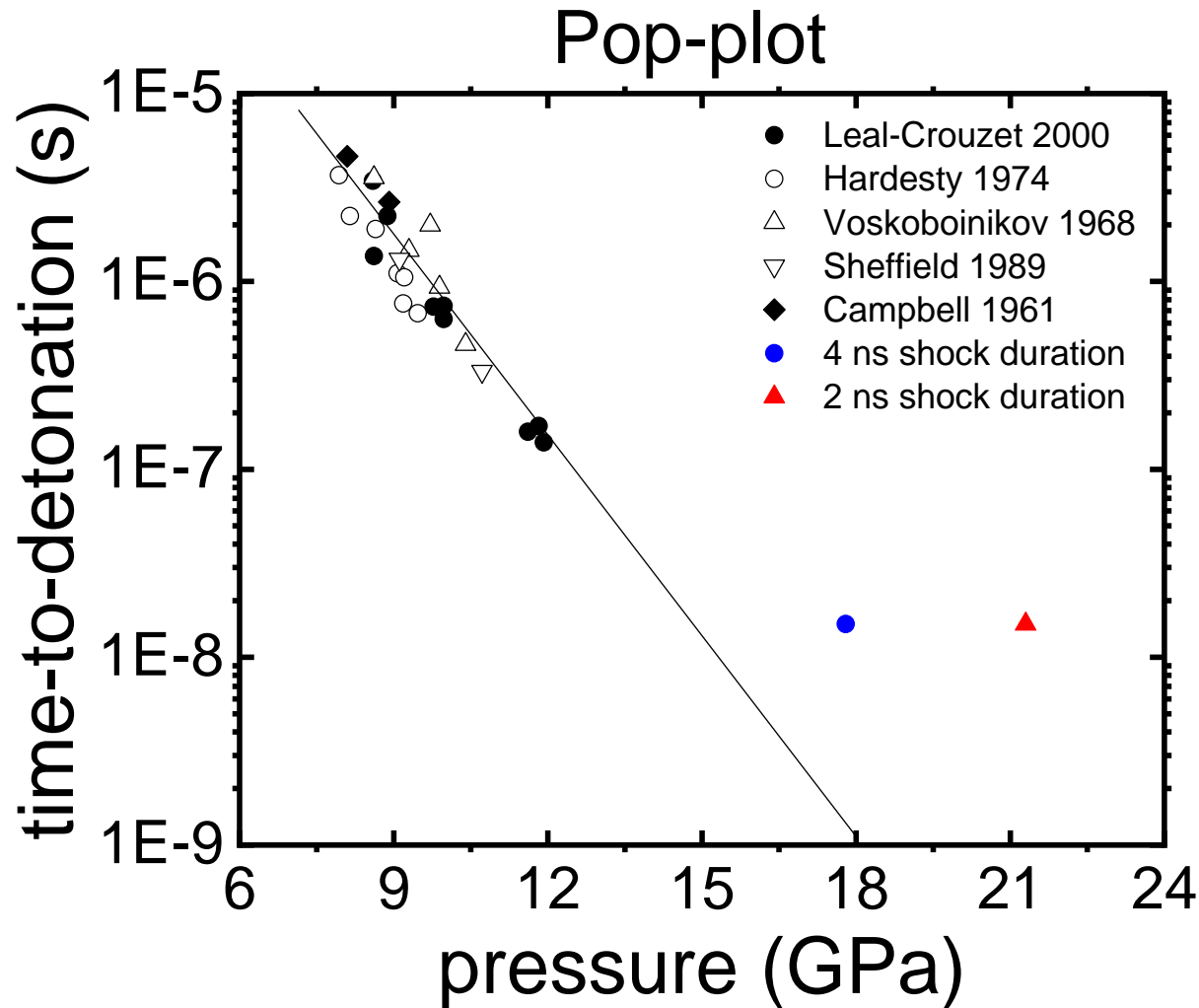
Detonation Properties of Liquid Nitromethane



Detonation Properties of Liquid Nitromethane



Detonation Properties of Liquid Nitromethane

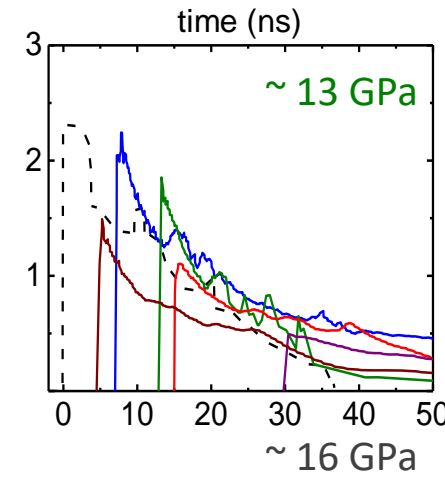
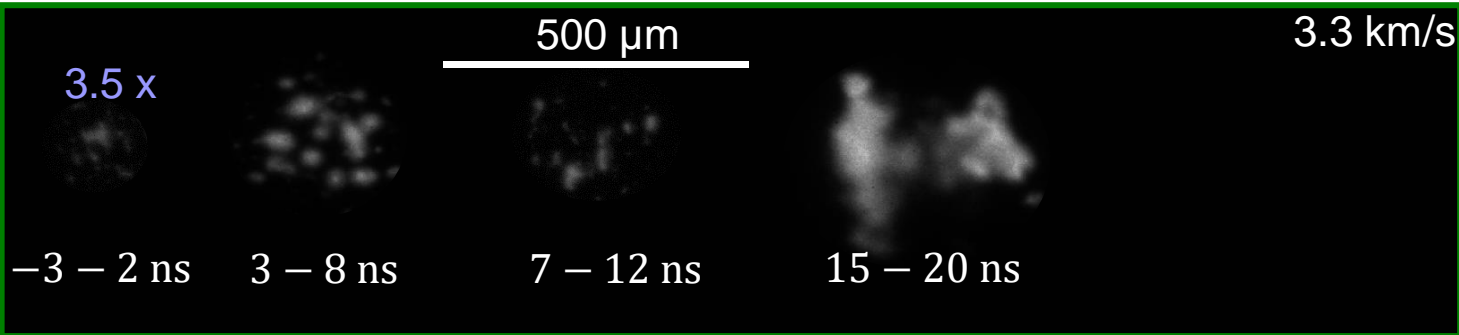
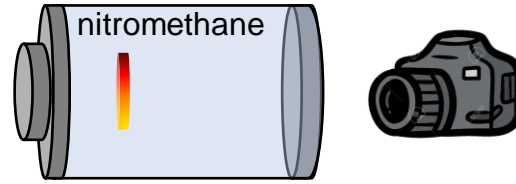


The Fluid Dynamics of Shock Compressed Nitromethane: 3 Regions of Reaction



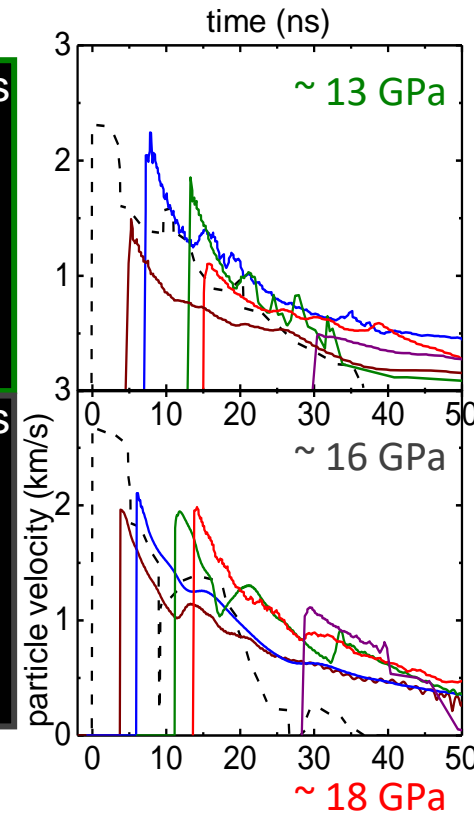
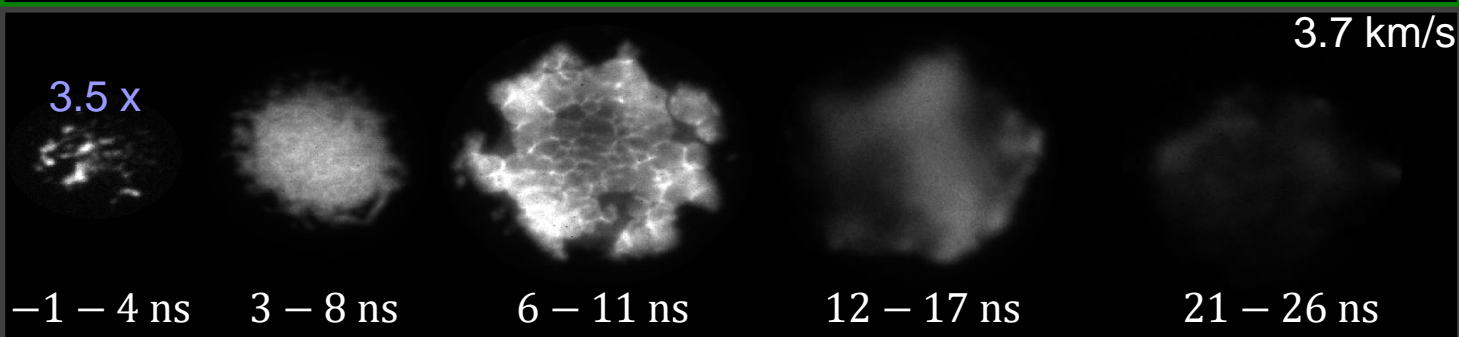
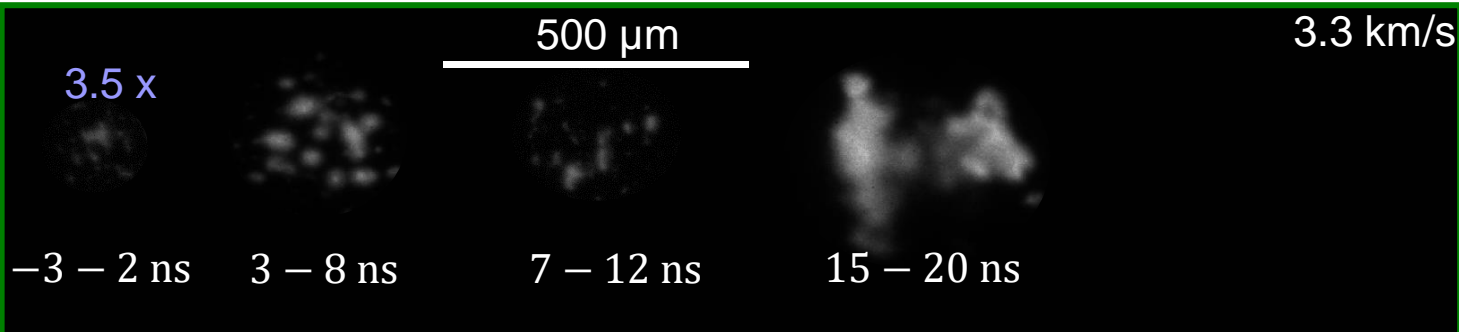
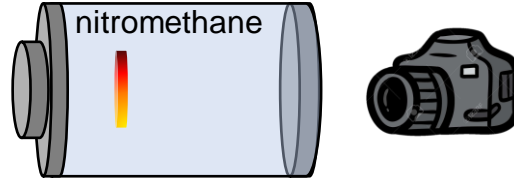
High-Speed Images of Pure Nitromethane

ignition



High-Speed Images of Pure Nitromethane

ignition
subdetonation

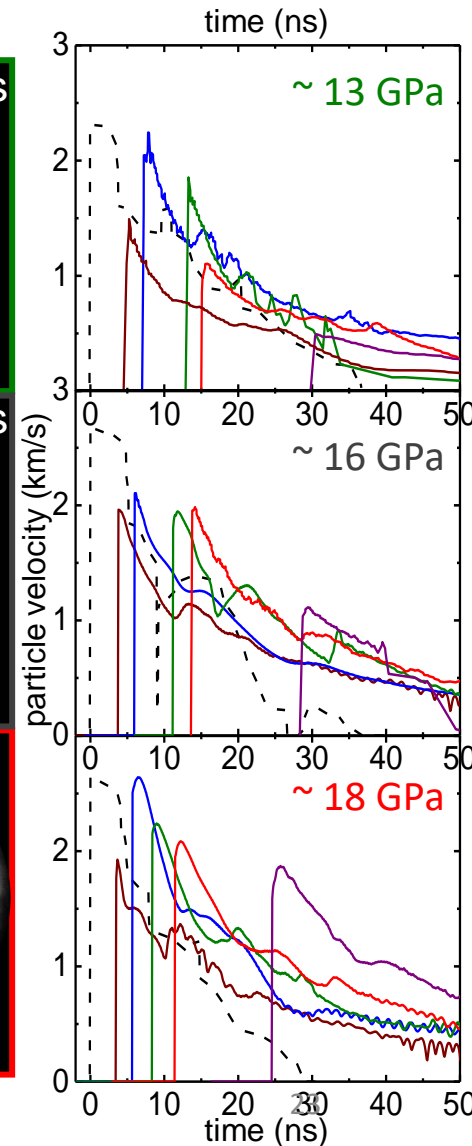
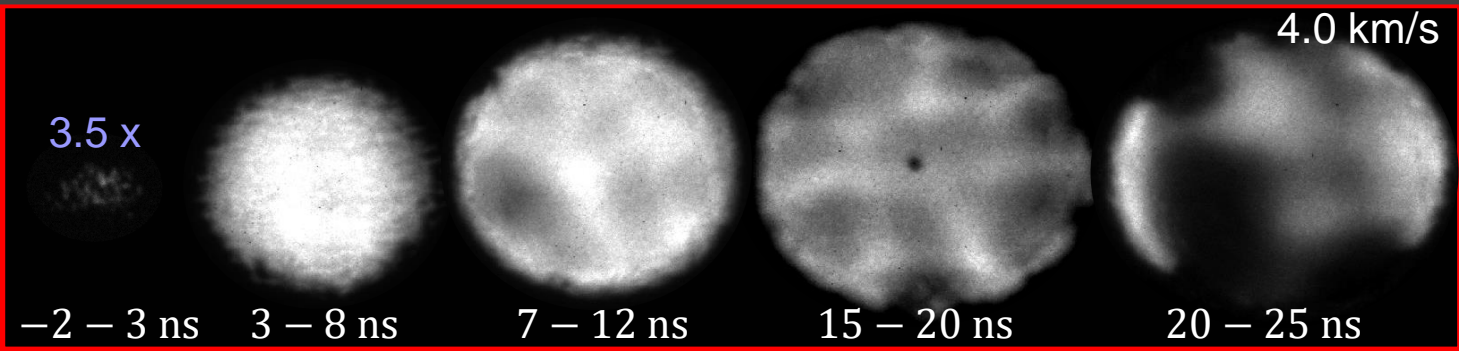
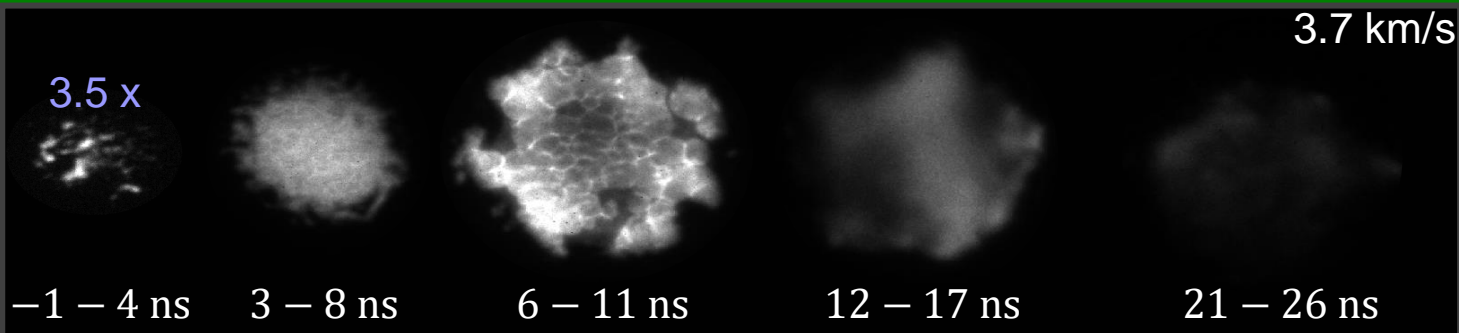
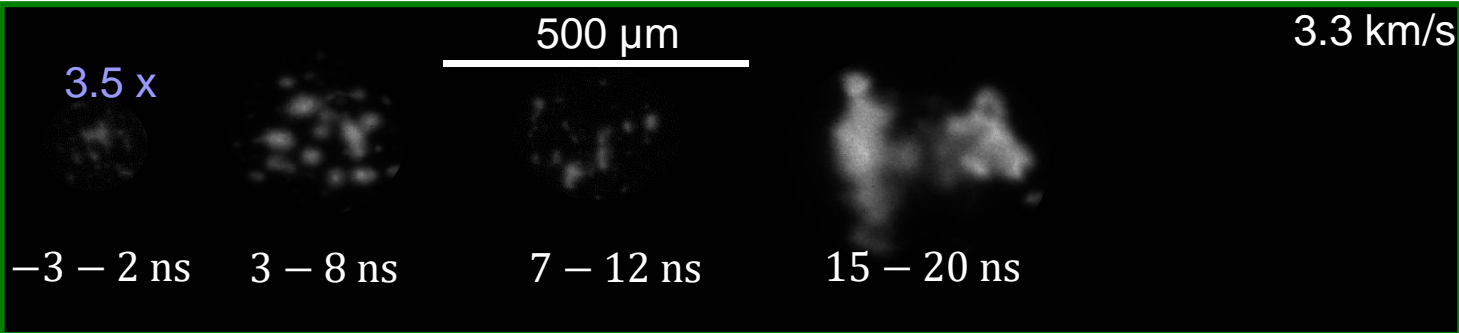
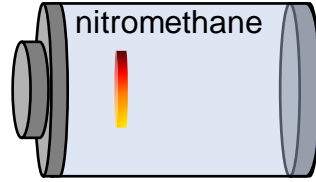


High-Speed Images of Pure Nitromethane

ignition

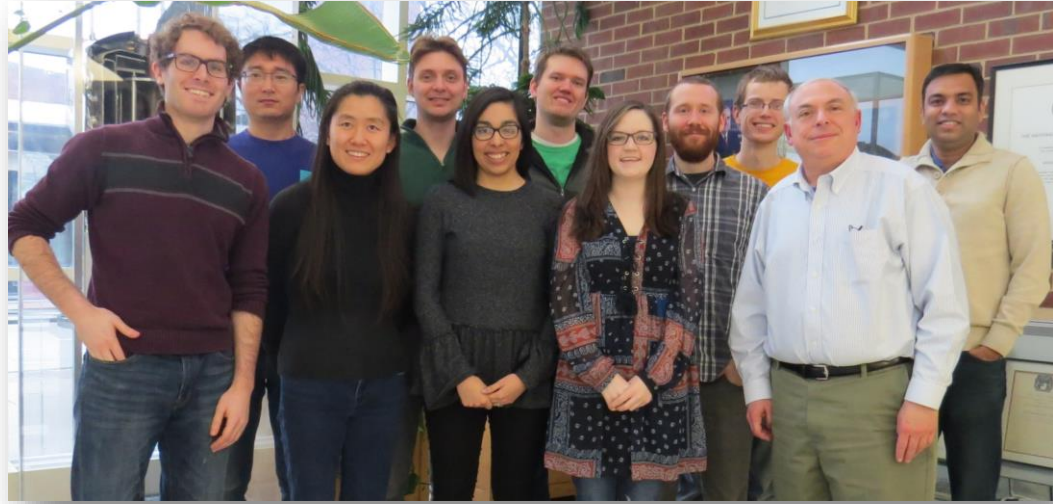
subdetonation

detonation



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