Optical Characterization of Energetic Materials at the Small Scale

S&T Campaign: Sciences for Lethality & Protection
Energetics

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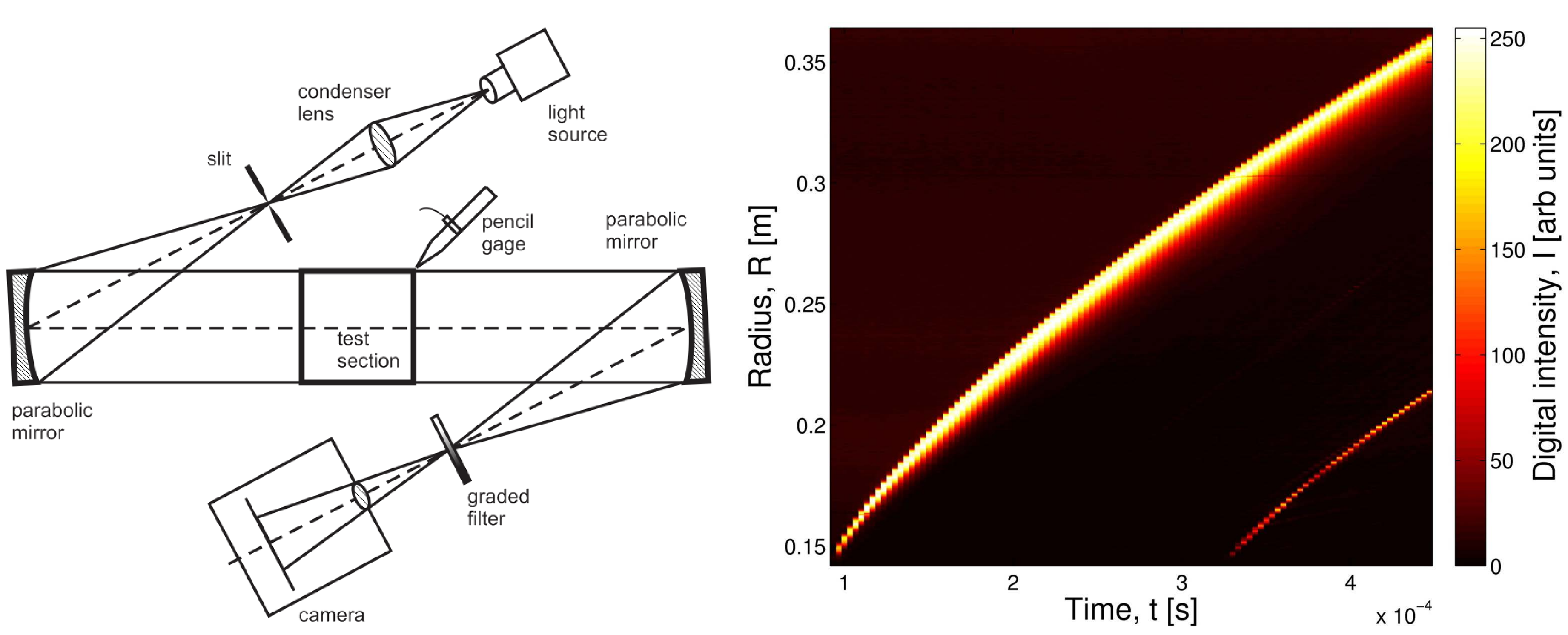
Research Objective

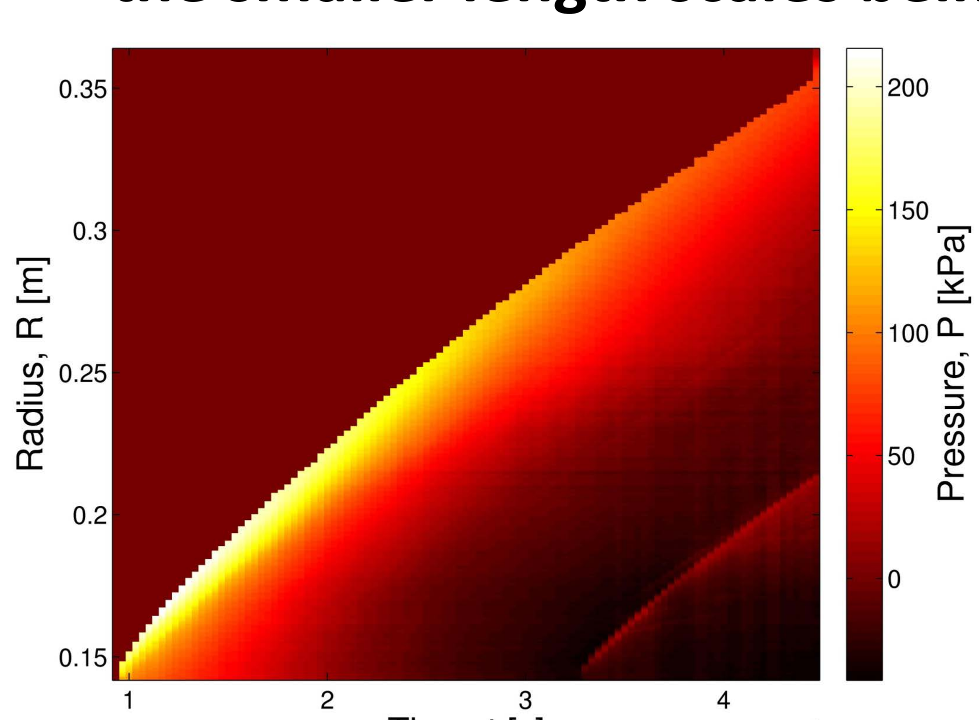
- Establish suite of small-scale (gram-range) advanced diagnostics for the characterization of novel energetic materials (EMs) that are material quantity limited.
- Current detonative and air-blast characterization techniques require kilograms of EMs and extensive man-hours to complete. Small-scale techniques, however, are capable of maximizing the information obtained per experiment while greatly reducing the cost, risk, and man-hours necessary to complete.



(Left) Quantitative high-speed digital schlieren system and (Right) Two-dimensional intensity map of shock wave flow field from 2 g charge of EM.

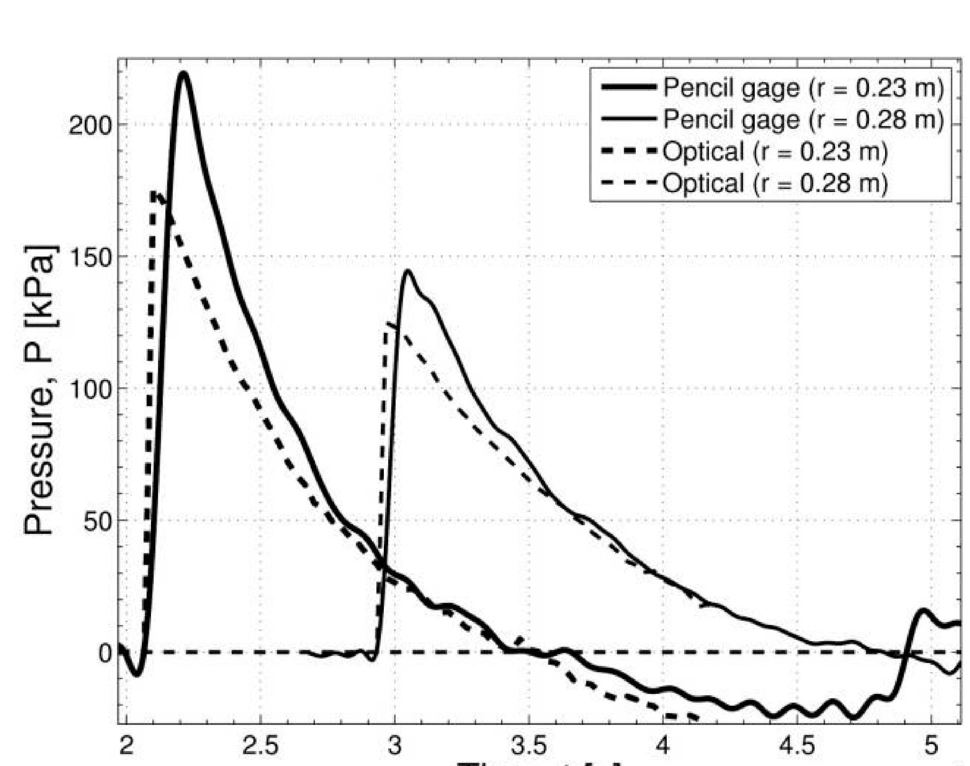
Challenges

- Extending validity of small-scale methods to include insensitive and non-CHNO EMs that possess larger energy fluence and run distance parameters.
- Increased spatiotemporal resolution necessary due to the smaller length scales being tackled (see below)



(Left) Two-dimensional, non-intrusive, optical map of the shock wave pressure flow field produced by the detonation of a 2 g spherical charge of EM. This particular experiment provided 832 temporal pressure traces for a radial standoff range of 0.14-0.36 m.

(Right) Non-intrusive optical pressure traces compared to intrusively measured pressure traces taken with pencil gages. As shown, the optical trace fails to fully resolve the initial pressure decay due to the camera's spatiotemporal resolution limitations.



ARL Facilities and Capabilities Available to Support Collaborative Research

- Outdoor experimental facility with 9 kg net explosive weight (NEW) limit (approval required for larger NEW)
- Indoor blast chambers with 2.3/6.8 kg NEW limit (open/closed optical access ports)
- Open-air gun room with 10 g NEW limit
- High-speed imaging systems:
  - 2.5 million frames/s high-resolution (4 MP) framing camera capable of capturing 74 images
  - Digital streak camera with 25 micron slit width (3.4 pixels) and 2.0 ns temporal resolution
  - Gated-intensified imaging spectrograph
  - Two- and single-camera imaging pyrometry
- ARL eXplosive Evaluation Utilizing Minimal Material (AXEUMM) experiment and optical impulse measurement capabilities for detonative and air-blast characterization.
  - AXEUMM technique: 1 experiment → 8 performance properties of interest
  - Optical impulse: radial profile characterization non-intrusively

- Biss, M.M. and McNesby K.L., "Optically measured explosive impulse," *Experiments in Fluids*, 55(6), 2014.
- Biss, M.M., et al., "Composite-charge extension of AXEUMM experiments to less-sensitive energetic formulations," ARL-TR-7610, APG, MD, 2013.
- Biss, M.M., "Energetic material detonation characterization: A laboratory-scale approach," *Propellants, Explosives, Pyrotechnics*, 38(4), 2013.

Complementary Expertise/Facilities/ Capabilities Sought in Collaboration

- Expertise sought in the areas of: advanced diagnostics for probing ultra-high-speed events, detonation physics, optics, or energetic material characterization
- Chirped Fiber Bragg Grating Testing, Spectrally Encoded Imaging Diagnostics, Furball Test
- Upcoming thrust is towards a small-scale Gurney energy experimental characterization technique and the measurement of JWL parameters without critical diameter limitations.

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