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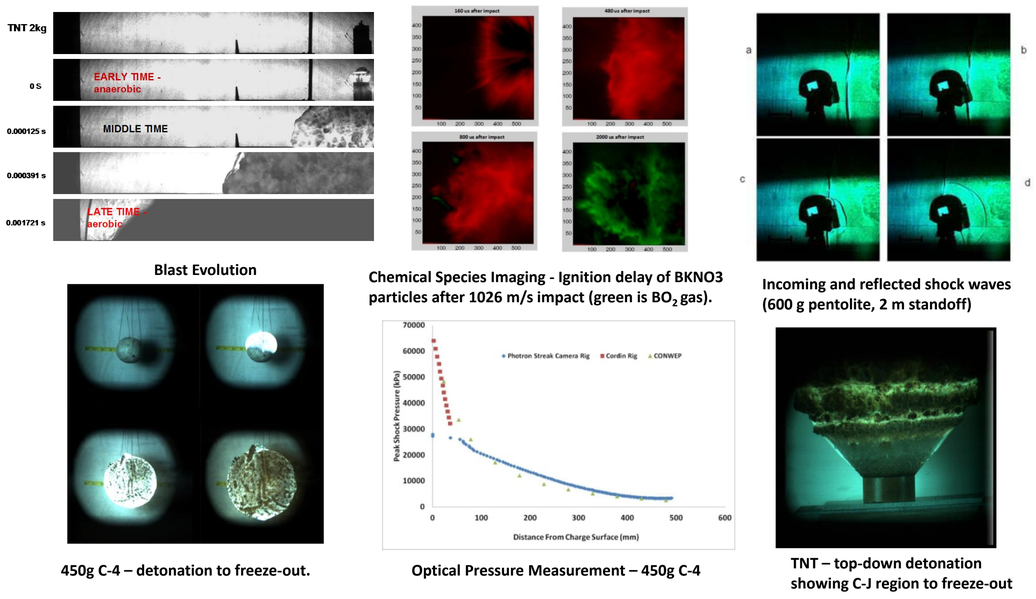
High Speed Imaging for Detonation Science

S&T Campaign: Sciences for Lethality & Protection
Tier 2 Subtopic: Detonation Science

Kevin McNesby, RDRL-WML-C, (410) 306-1383
kevin.l.mcnesby.civ@mail.mil

Research Objective

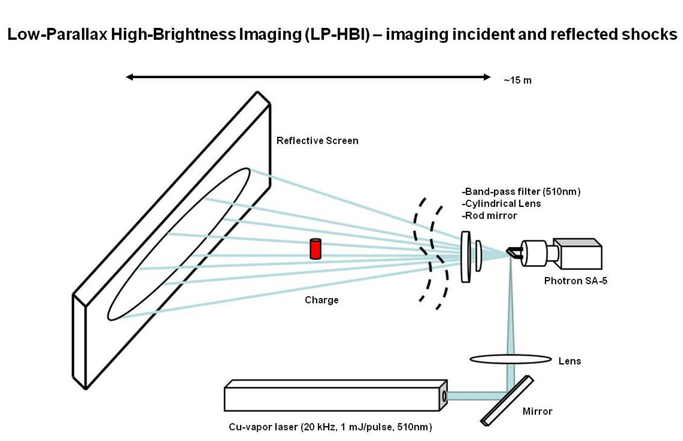
- **Utilize high speed imaging to measure optically pressure, temperature, and chemical species during explosive events.**
- **Use shockwave imaging to measure blast energy deposited on target.**



Examples of high speed imaging techniques applied to explosive events.

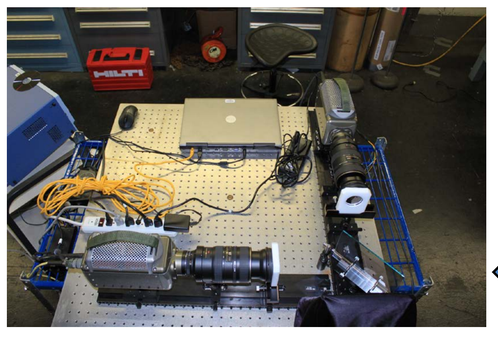
Challenges

- **Single shot mapping of all explosive parameters at real scale (several kg) to include peak shock pressure, surface temperature, chemical species at fireball surface**
- **Moving imaging frame rate from tens of kHz to MHz**
- **Active imaging (laser sheet probing at large scale)**
- **Ultra-high brightness femtosecond imaging**
- **Forcing metals to react in vicinity of detonation front**



LP-HBI

Two-camera imaging rig for mapping temperature, species.

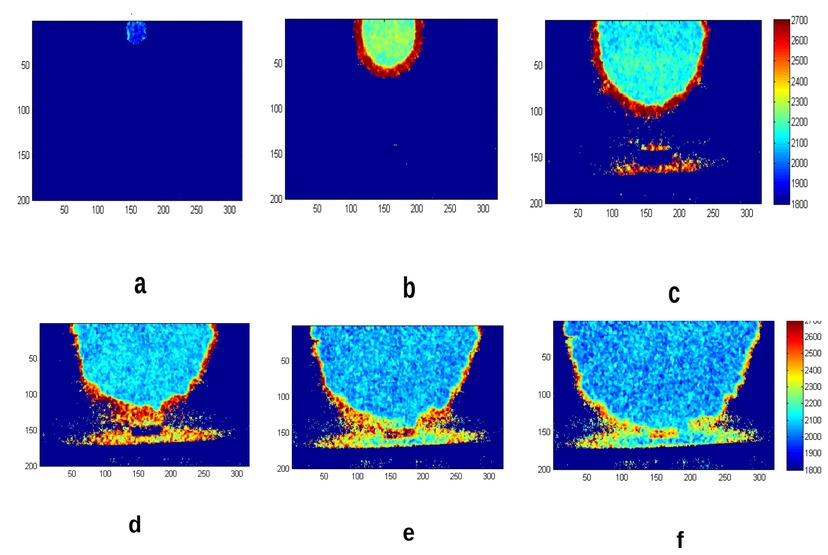


event

ARL rigs for characterizing explosives range from large outdoor facilities (schematic of LP-HBI at top) to portable table-top two-camera imaging systems

ARL Facilities and Capabilities Available to Support Collaborative Research

- **Detonation Science Facility, Indoor/Outdoor Ranges, NEW to 20 kg.**
- **Low-parallax High Brightness Imaging Facility (unique to US).**
- **High Speed, High Definition framing cameras to 2.5 Mfps.**
- **Imaging emission spectroscopy.**
- **Charge formulation, manufacture, testing.**
- **Small scale testing of novel energetics.**
- **All classical explosive characterization tests (wedge, cylex, detonation velocity, etc.) performed.**
- **4-channel Photonic Doppler Velocimetry (PDV) rig on site.**
- **Digital and film-based streak cameras.**
- **Full color, two-color imaging pyrometry**



Full-color imaging pyrometry measurements for a 227 g charge of C-4 at 63.5 cm standoff from a table used to simulate an armor surface. Time sequence: a<b<c<d<e<f with a time interval of 71 μs. Note the hot outer surface of the fireball indicating the primary shock wave location.

Example Publications (full list on request)

[1] J.M. Densmore, M.M. Biss, K.L. McNesby, B.E. Homan, "High Speed Digital Color Imaging Pyrometry," Applied Optics, Vol. 50, pages 2659-2665 (2011).
[2] "Time Resolved Optically-Based Temperature and Pressure Measurements of Suspended C-4 Spheres During and After Detonation," John Densmore, Matthew Biss, John Ritter, Brendan McAndrew, Barrie Homan, Kevin McNesby; ARL-TR-5667, August 2011.
[3] J.M. Densmore, M.M. Biss, B.E. Homan, K.L. McNesby, "Thermal imaging of nickel-aluminum and aluminum-polytetrafluoroethylene impact initiated combustion," Journal of Applied Physics, Volume 112 Issue 8; Pages: 084911 - 084911-5 (2012).
[4] "Modeling of Near-Field Blast Performance," by Barrie E. Homan, Matthew M. Biss, and Kevin L. McNesby, ARL-TR-6711 November 2013
[5] "Optical Measurement of Peak Air Shock Pressures Following Explosions," Kevin L. McNesby*, Matthew M. Biss, Richard A. Benjamin and Ronnie A. Thompson,Propellants, Explosives, Pyrotechnics; Volume 39, Issue 1, pages 59–64, February 2014
[6] "Optically Measured Explosive Impulse," Matthew M. Biss and Kevin L. McNesby, Exp Fluids (2014) 55:1749
[7] "Impact Initiated Combustion of Nickel-Aluminum and Aluminum-Polytetrafluoroethylene Reactive Materials," John Densmore, MatthewBiss, Kevin McNesby; proceedings of 2014 International Detonation Symposium, San Francisco, CA.
[8] "Imaging Metals Participation in Ballistic Events in Real Time," K.L. McNesby, M.M. Biss, R.A. Benjamin, proceedings of 38th JANNAF PEDCS, 19-22 May 2014, Charleston, SC.

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