U.S. ARMY RDECOM

Computational Fluid Dynamics of Reacting Flows for Propulsion

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S&T Campaign: Sciences for Lethality and Protection
Kinetic Lethality
Propulsion and Launch

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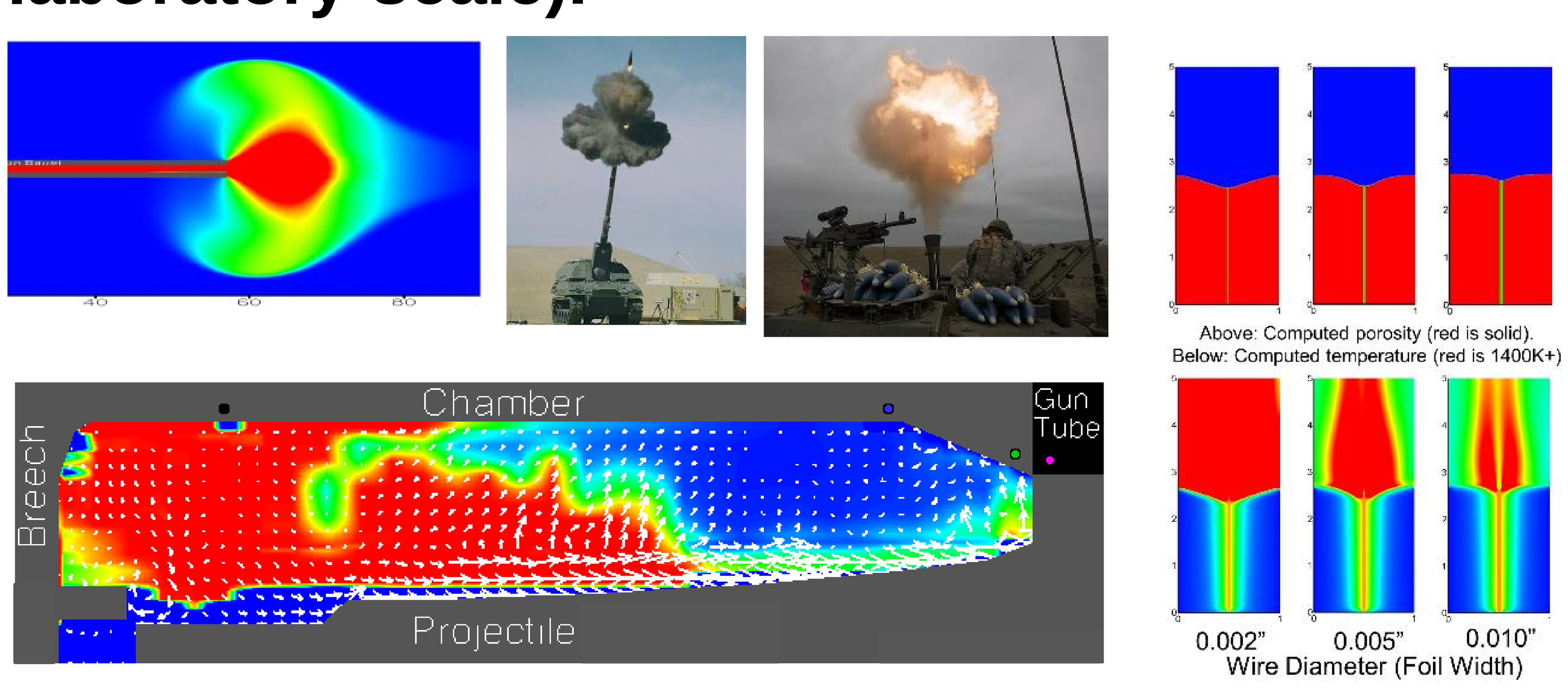
Research Objective

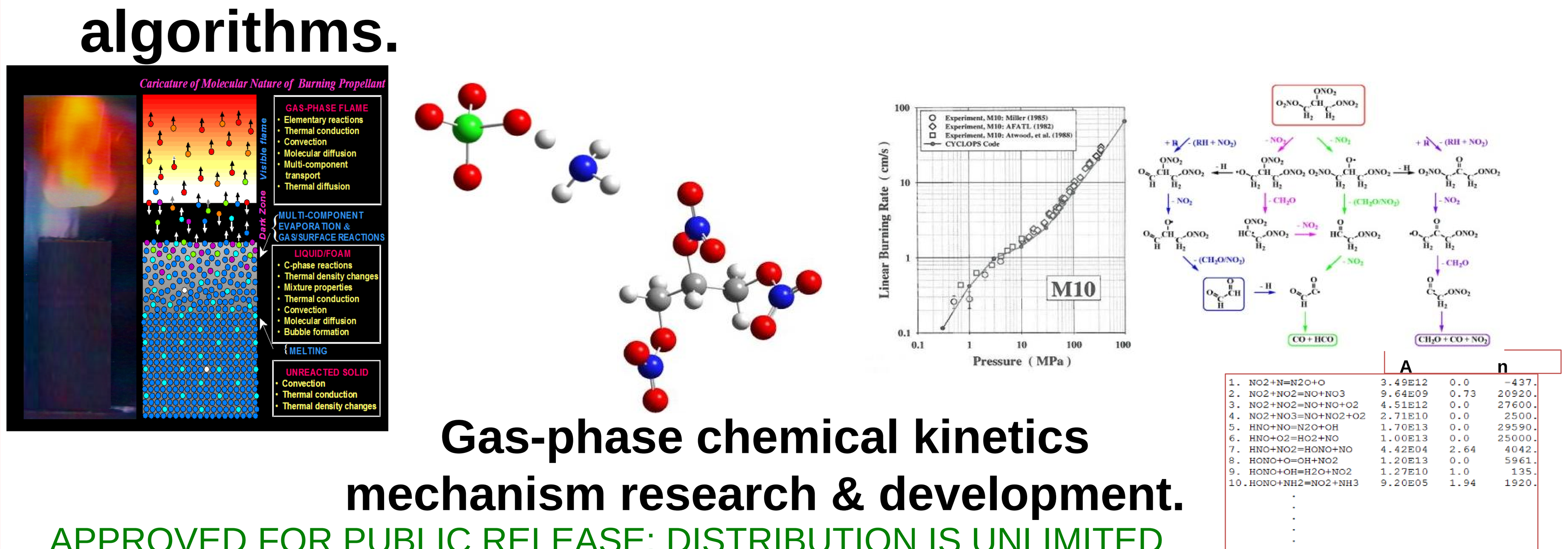
- **Understanding the physics of gun interior ballistics, gun muzzle blast/flash, and rocket internal ballistics.**
- **Develop and validate high-fidelity modeling capabilities to predict multidimensional, multiphase, chemically-reacting flow fields for solid propellant gun charges and rocket engines used for tactical armament propulsion.**
- **Develop and validate chemical kinetics mechanisms for solid propellants used in Army guns as well as minimum-smoke and composite propellants used in Army missiles.**
- **Create synergism between computational physics-based models and experimental facilities (full- and laboratory-scale).**



Gun muzzle blast/flash with model; gun charge modeling; strand model.

Challenges

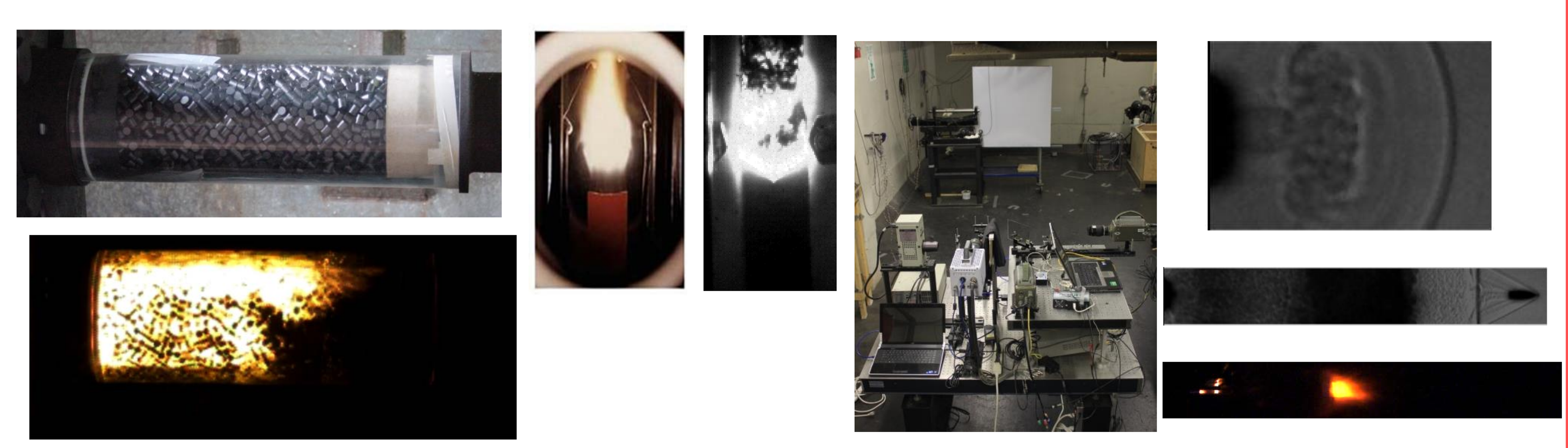
- **Mitigating high-pressure fields associated with gun muzzle blast (pressure, temperature, signature).**
- **Fundamental understanding of the interaction of reaction kinetics and high-pressure, multi-phase fluid dynamics in propulsion systems (guns, rocket engines).**
- **Reducing kinetics mechanisms to computationally tractable sizes while maintaining accuracy over wide range of pressures, temperatures, and compositions.**
- **Difficult obtaining quality validation data over range of conditions for strand-burners and small rocket engines.**
- **Developing efficient computational methods and algorithms.**



Gas-phase chemical kinetics mechanism research & development.

ARL Facilities and Capabilities Available to Support Collaborative Research

- **Expertise in physics-based computational model development (lumped-parameter, CFD, burnrate models) for gun charges and tactical rocket engines.**
- **Expertise in gas-phase chemical kinetics mechanism generation/customization for solid propellants developed for use in gun charges, igniters, and rockets.**
- **Complementary computational and experimental resources for gun interior ballistics, gun muzzle blast, and solid propellant strand burn visualization and rate data.**
- **Gun ballistic ranges and laboratory-scale test facilities.**
- **DOD Supercomputing Resource Center (DSRC).**



Select experimental facilities (CW from upper left: windowed strand burner, muzzle blast/flash Schlieren, gun interior ballistics simulator.

Complementary Expertise / Facilities / Capabilities Sought in Collaboration

- **Mitigation techniques for high-pressure fields produced by blast from propulsion systems (e.g., gun muzzle blast).**
- **Precision bench-level experiments for the measurement of gun charge dynamics during ignition-phase.**
- **High-quality validation data (propellant strand burnrate and chemical composition, engine internal pressure and temperature) over wide range of operating conditions (10,000+ psi) and propellant compositions.**
- **Shock tube data to support gas-phase chemical kinetics mechanism development for specific critical reactions.**
- **Solid (condensed) phase kinetics for high-pressure, multi-phase, chemically-reacting flows.**