SAND2016-6462PE

Exceptional service in the national interest

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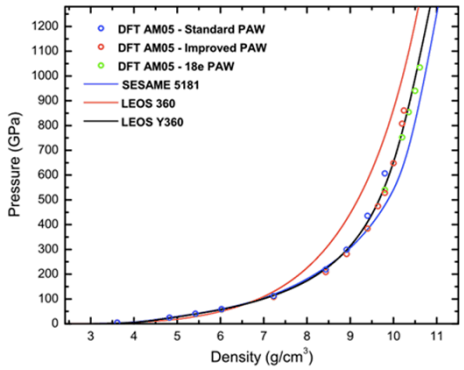

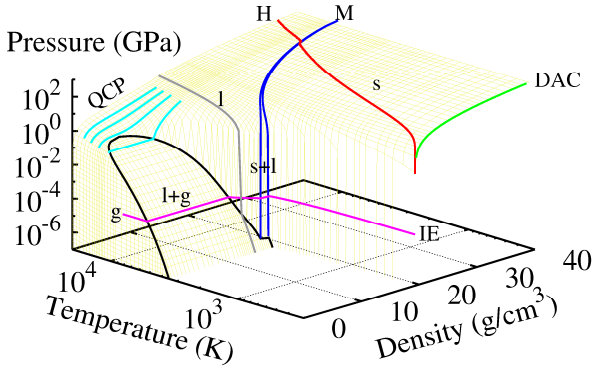

SNL EOS Program Overview

JOWOG32mat EOS Workshop

July 12, 2016

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Integrated EOS Program

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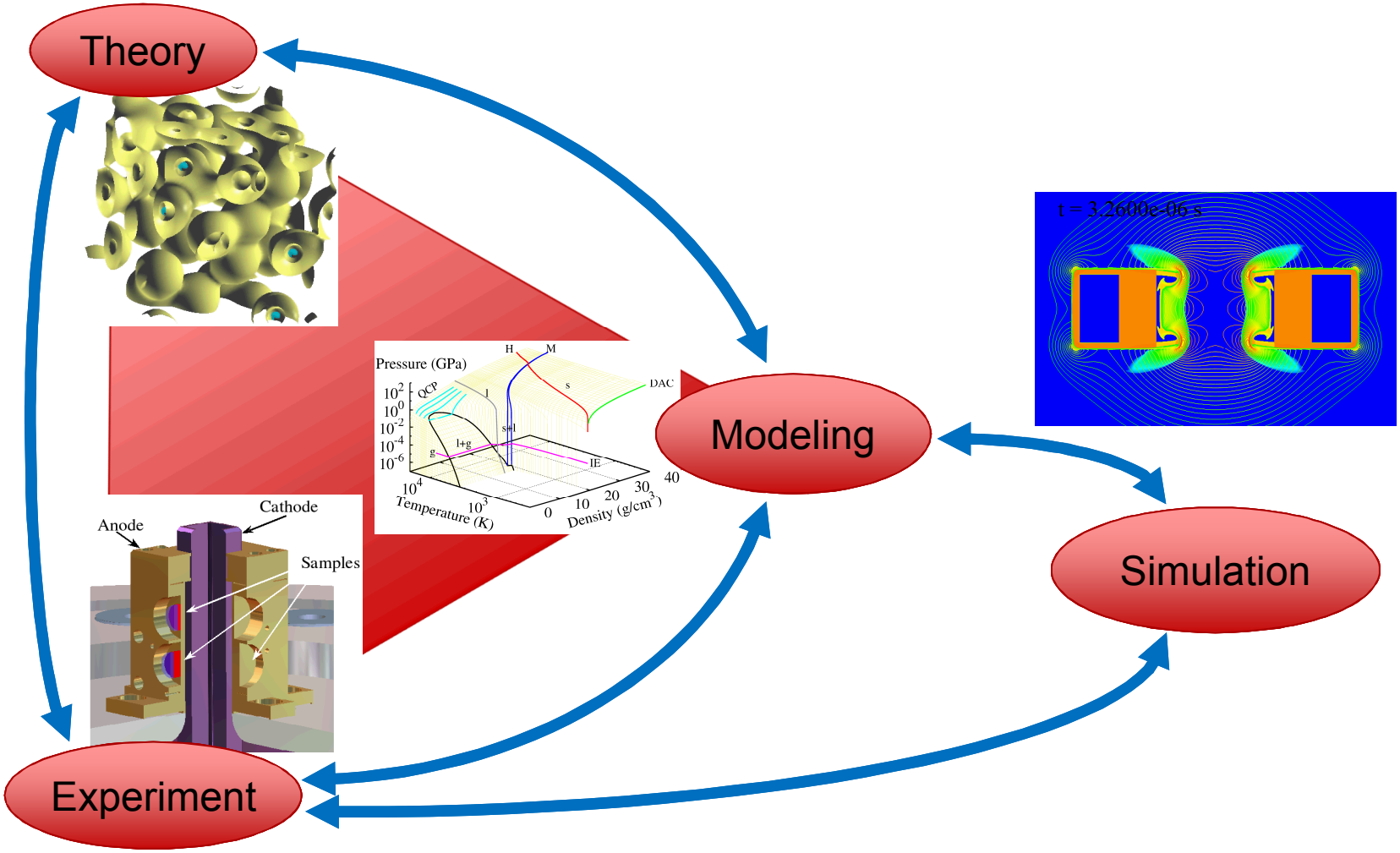

Experiments: Platforms, Capabilities

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Z Facility

Drivers:

26 MA drive → Wide range of phase space

Configurations: Ramp load (to 1 TPa)
Impact (to 40+ km/s)
Shock/Ramp
Cylindrical compr.

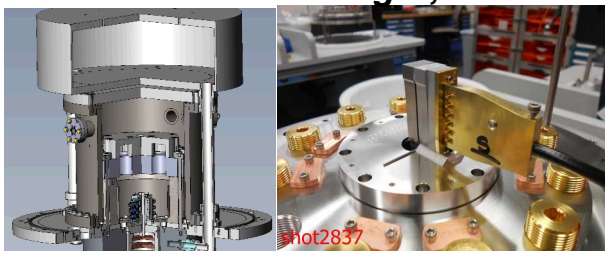
Tunable input waveforms
Containment in routine use

Diagnostics:

Velocimetry: 38 channels VISAR
16 channels PDV

Z Backlighter
X-ray Thomson Scattering
Streaked visible spectroscopy …

Well modeled in Alegra, Bertha



STAR Facility

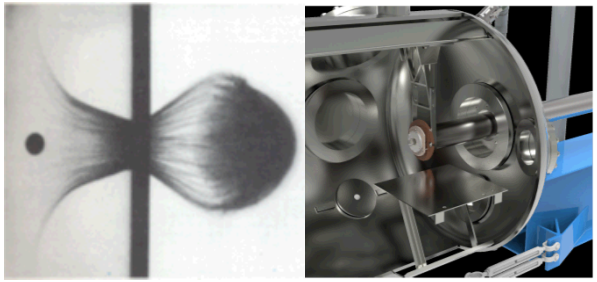
Drivers:

5 ranges: Gas gun (4”)
Oblique gas gun (4”0)
Powder gun (3.5”)
2-Stage LG gun (28 mm)
Hypervelocity add-ons
Ballistics 2S LGG

Diagnostics:

Velocimetry: 19+ channels VISAR
8 channels PDV

60-channel line VISAR
X-ray shadowgraphy
Have used holography, pyrometry
…



DICE

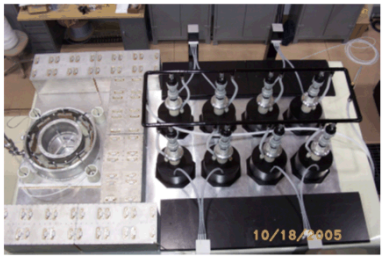
Drivers:

VELOCE pulser (to 20 GPa)
THOR pulser (under construction)
Gas gun (2.5”)

Diagnostics:

Velocimetry: 7 channels ultra-low VPF VISAR
8 channels PDV
Testbed for others

Sample recovery
…



Experiments: Getting at Physics (Z)

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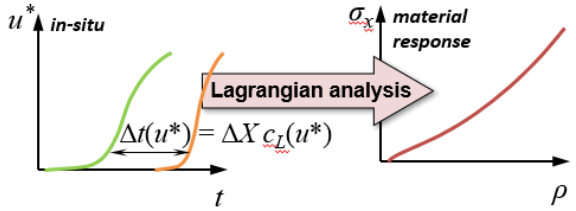
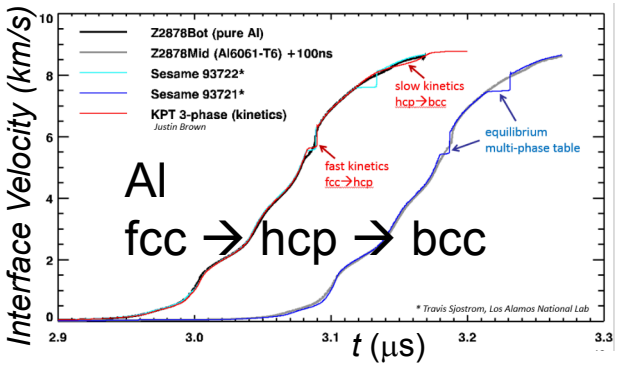
Adiabats:



u^* = "compression velocity" (mechanical-EOS variable)

Phase Transitions:



Cryogenic liquids

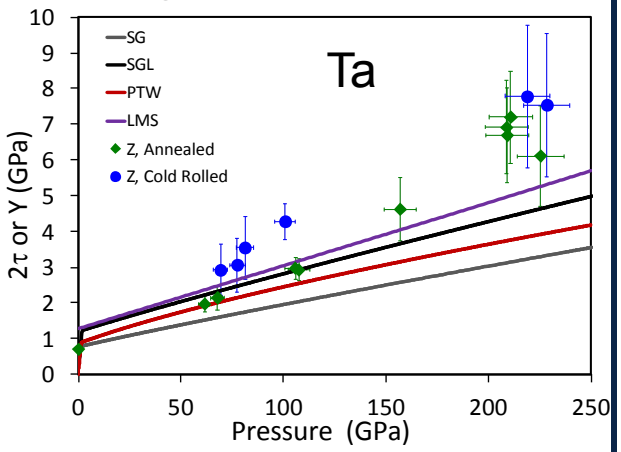
Preheated metals

Powder samples

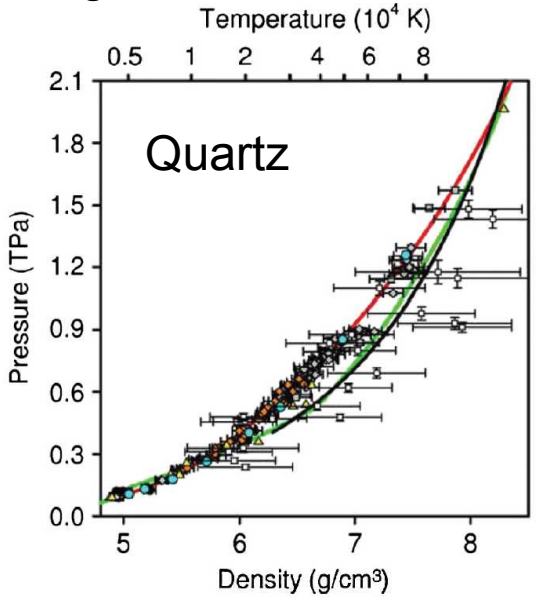
Energetic Materials

…

Strength:

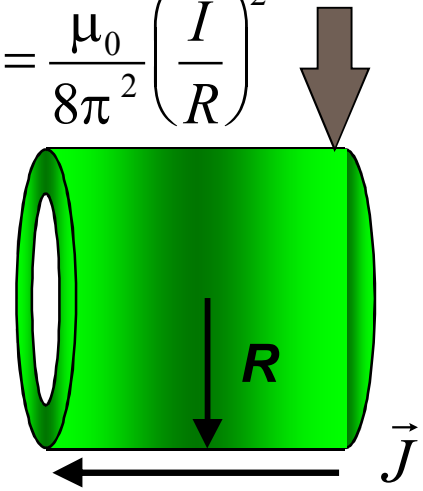


Hugoniots:

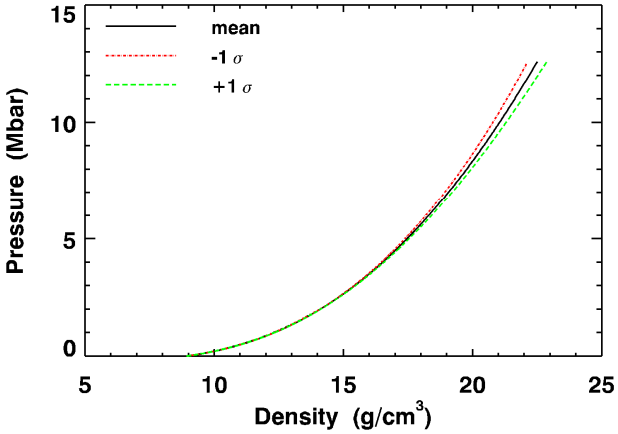


Cylindrical ramp to 10-20 Mbar:

$$P_B = \frac{\mu_0}{8\pi^2}\left(\frac{I}{R}\right)^2$$



Cu Calibrated P vs. ρ with Uncertainty



Experiments: Physics at DICE and

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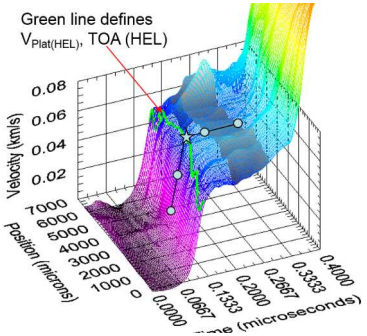
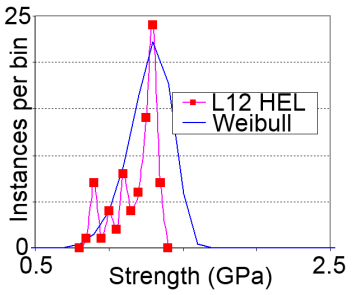
STAR Facility

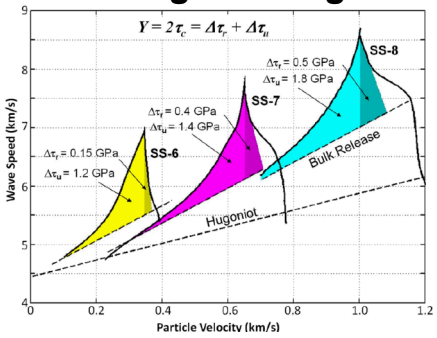
STAR — Shock Thermodynamics Applied Research

Tantalum elastic limit & spall:

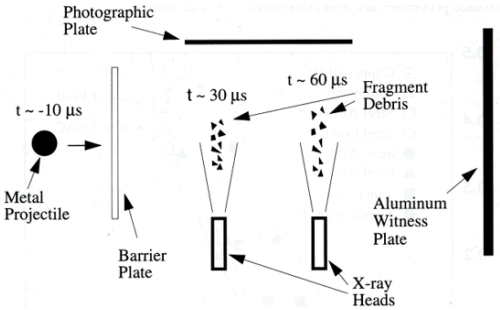




Steel strength & Hugoniot:



Fragmentation:



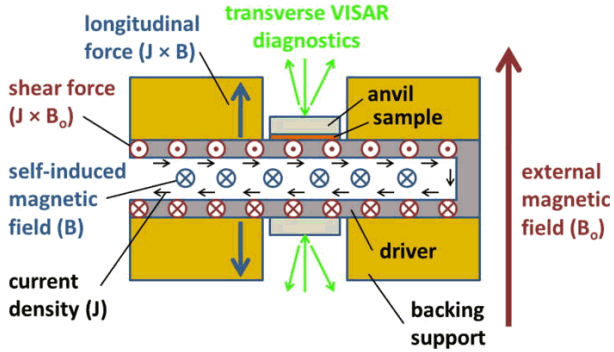
Powder & liquid samples

Energetic Materials

…

DICE

Shear strength (MAPS on VELOCE; technique testbed):



Spallation studies by Line VISAR and Recovery

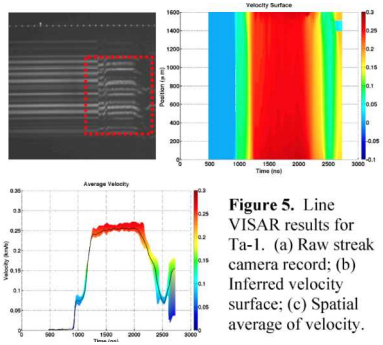


Figure 5. Line VISAR results for Ta-1. (a) Raw streak camera record; (b) Inferred velocity surface; (c) Spatial average of velocity.

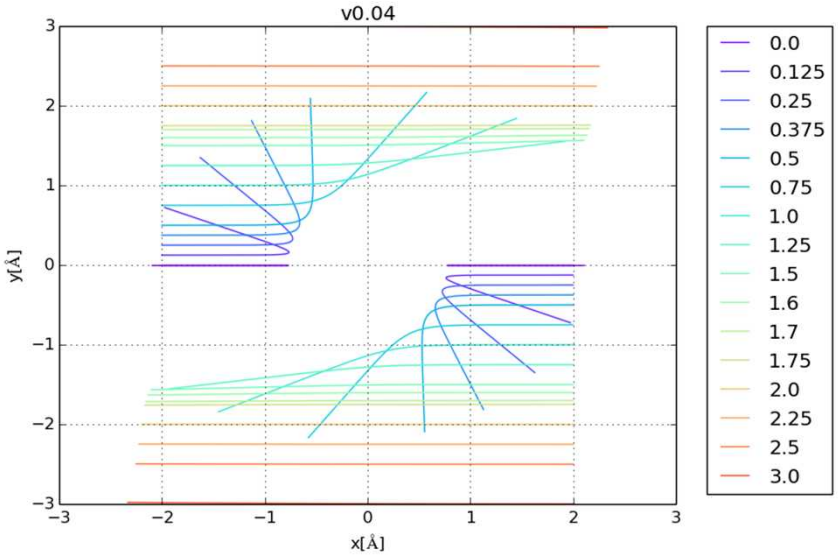
Post-shot metallography along line

Theory

Develop and deploy first-principle based computations:

- Warm-dense matter simulation
- DFT functionals and psuedo-potentials
- QMC and TD-DFT development
- Entropy/phase boundaries from first principles

Ar-Ar Collisions from TD-DFT



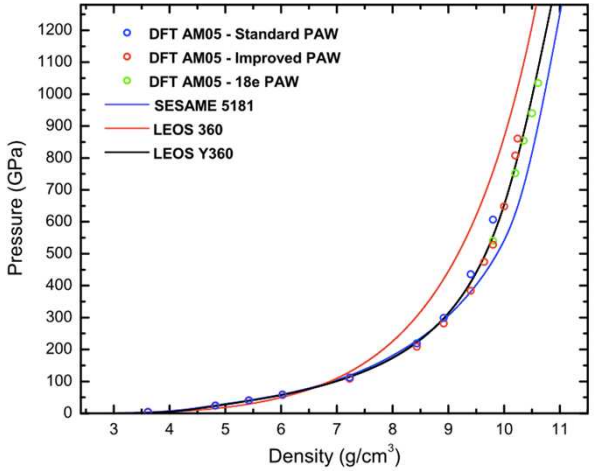
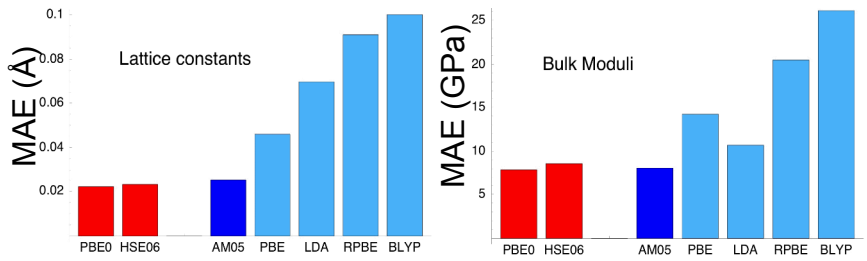


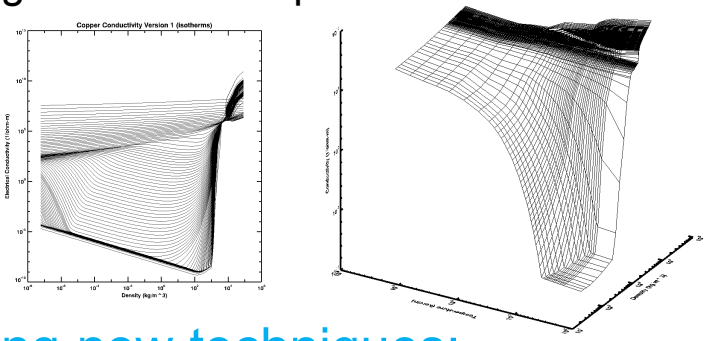
FIG. 3. Shock Hugoniot of liquid krypton calculated with different PAW potentials using the AM05 XC functional together with tabular equation of state models.

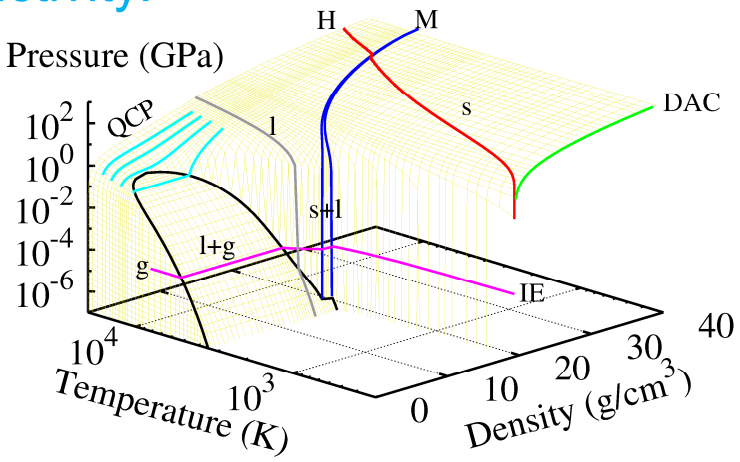


Modeling

Wide-range EOS and electrical conductivity:

- SESAME table creation
- Model development
- Stronger focus on expanded states





Exploring new techniques:

- Table formats
- Uncertainty quantification