SAND2011-4464C

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6/29/2011

Double Shock Experiments on the Sandia Z Machine

Off-Hugoniot Designs, Measurements, and Analysis

Heath L. Hanshaw and Marcus D. Knudson

acknowledgments to Mike Desjarlais, Ray Lemke, Jean-Paul Davis, Greg Sharp, Z teams

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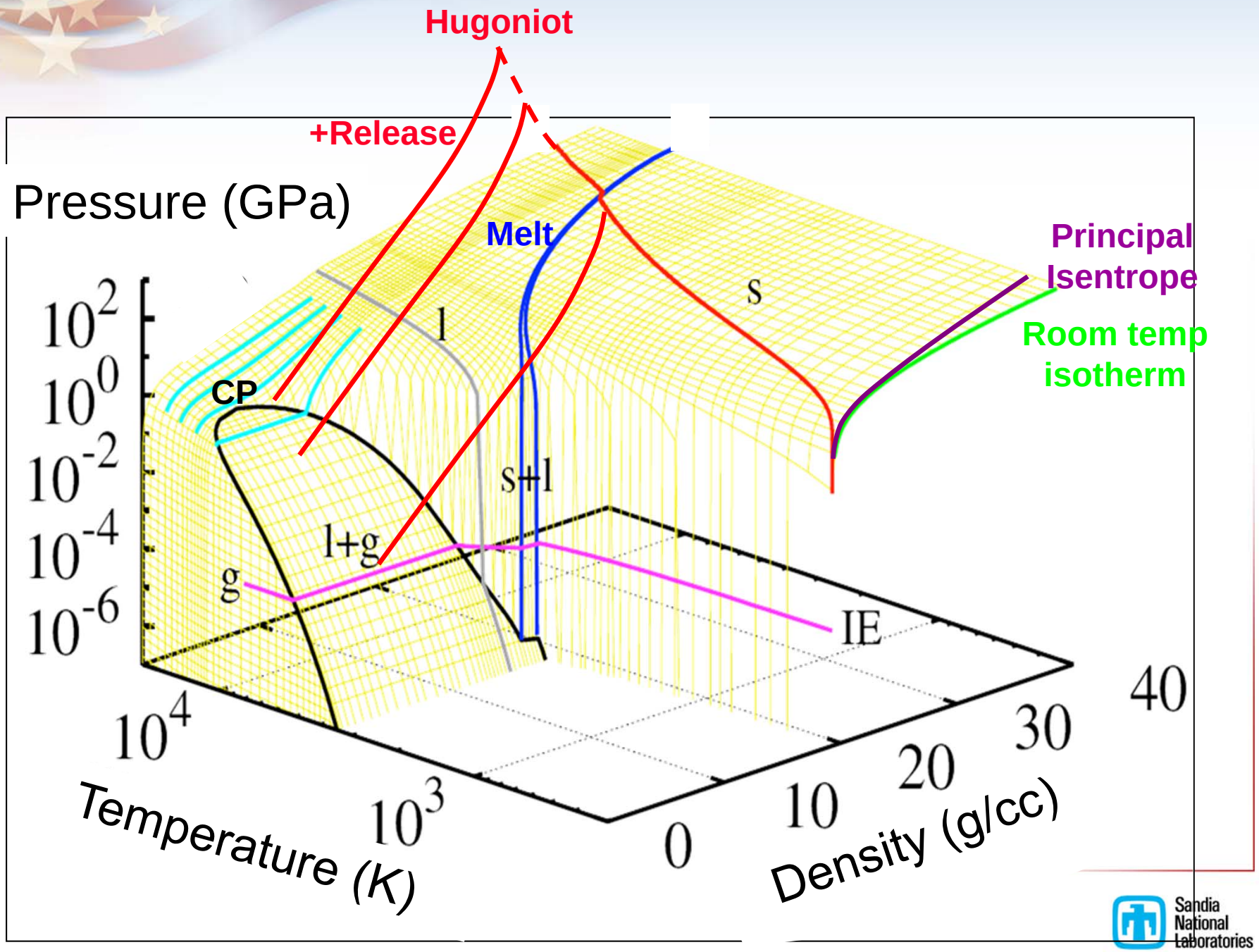

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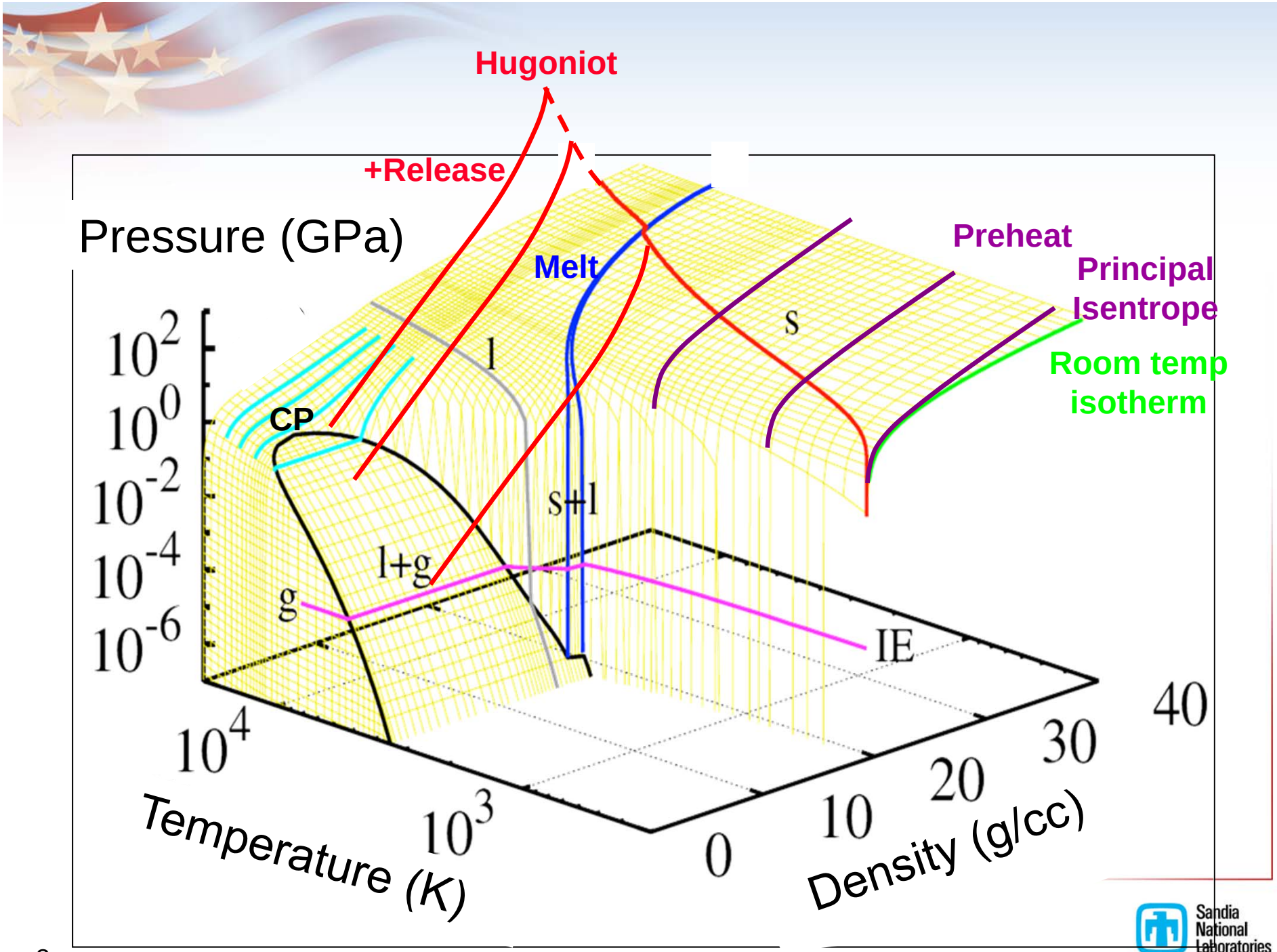

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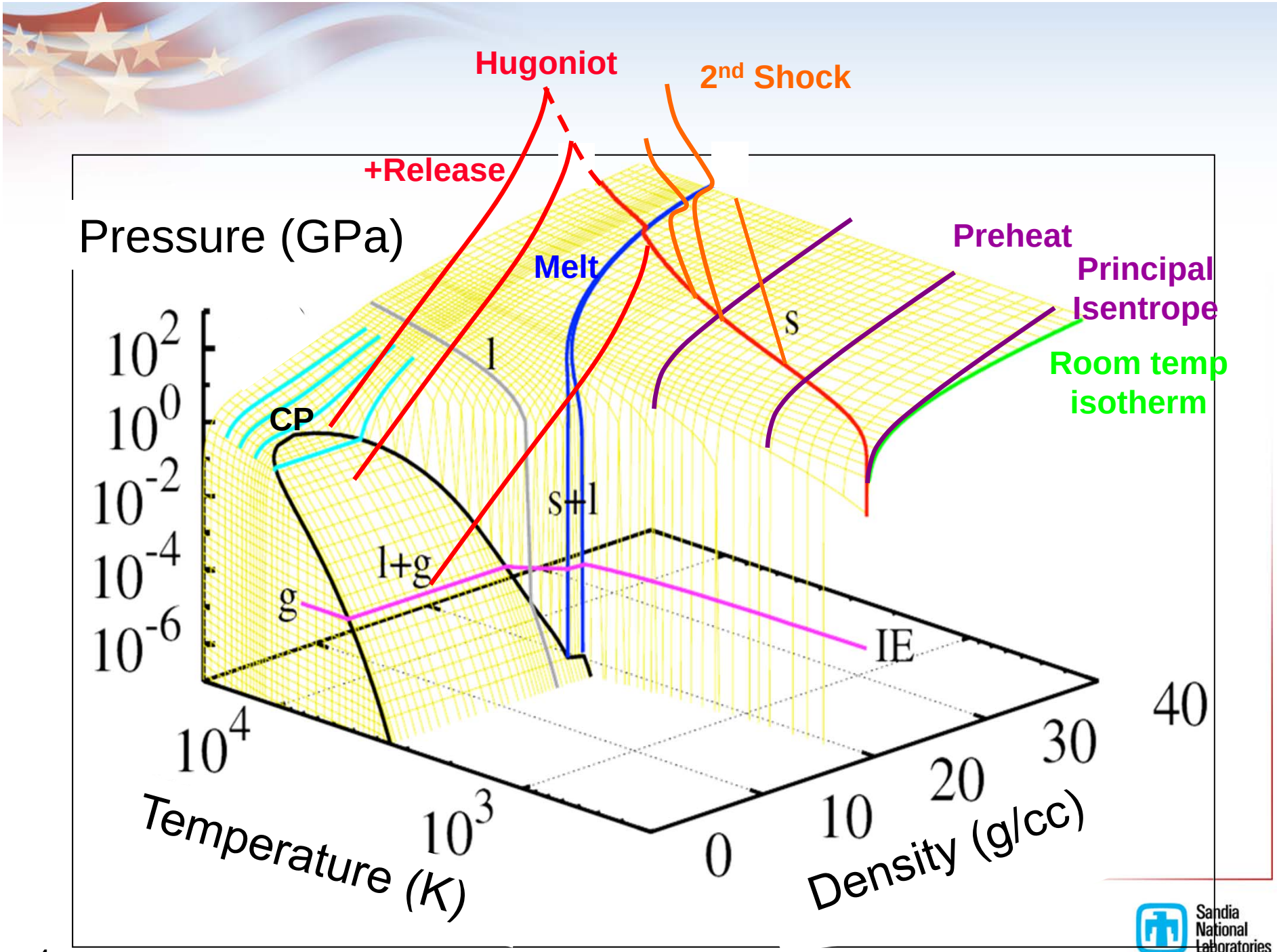

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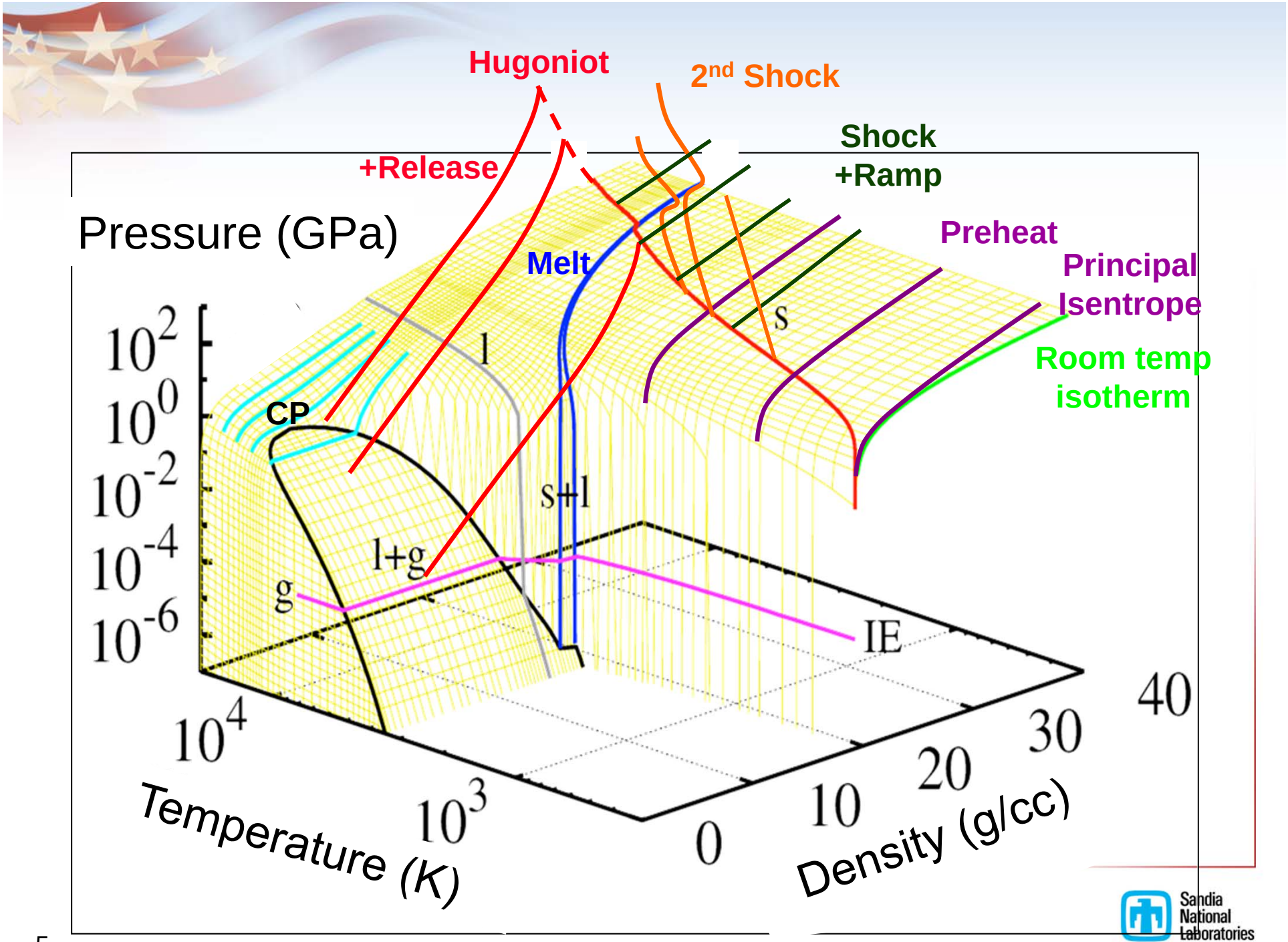

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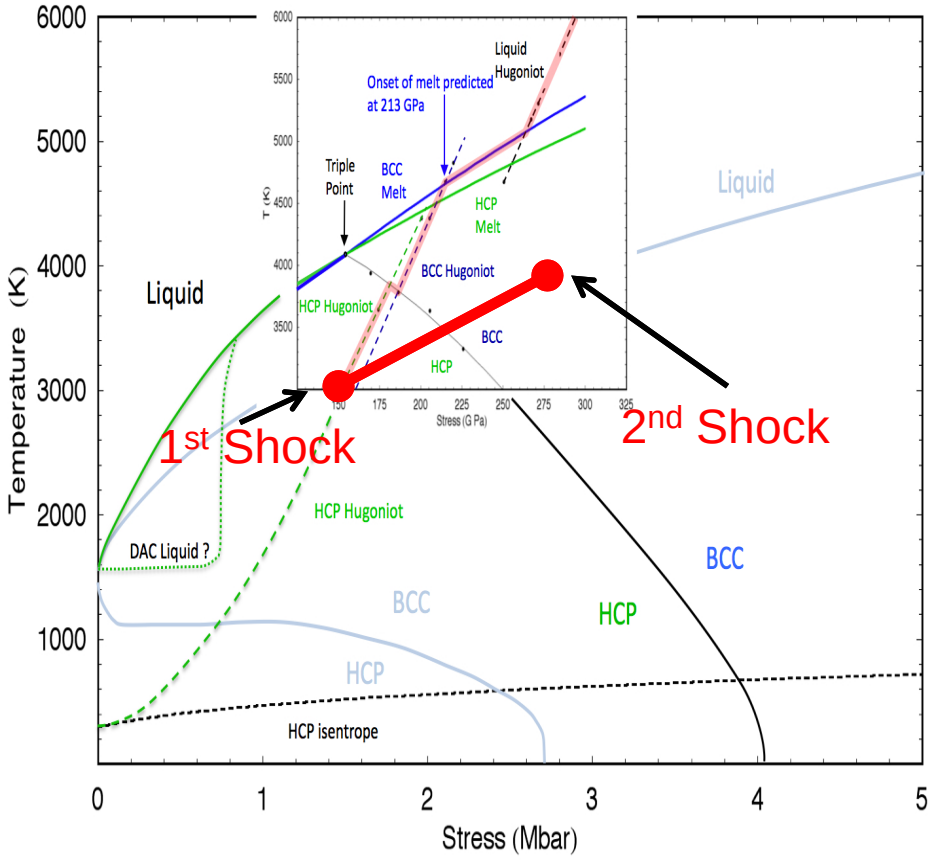

Beryllium HCP->BCC phase transition below melt

HP melt curve

Refreeze from shock melt (Be, Ta, …) ?

Reshock states, strength & damage from shock+reshock, and phase transitions on other materials

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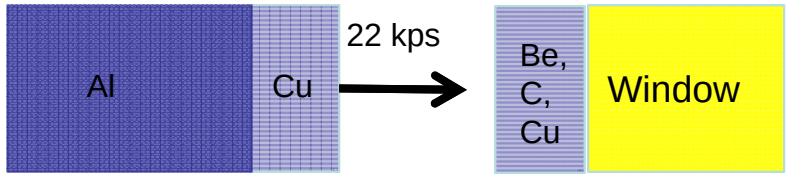
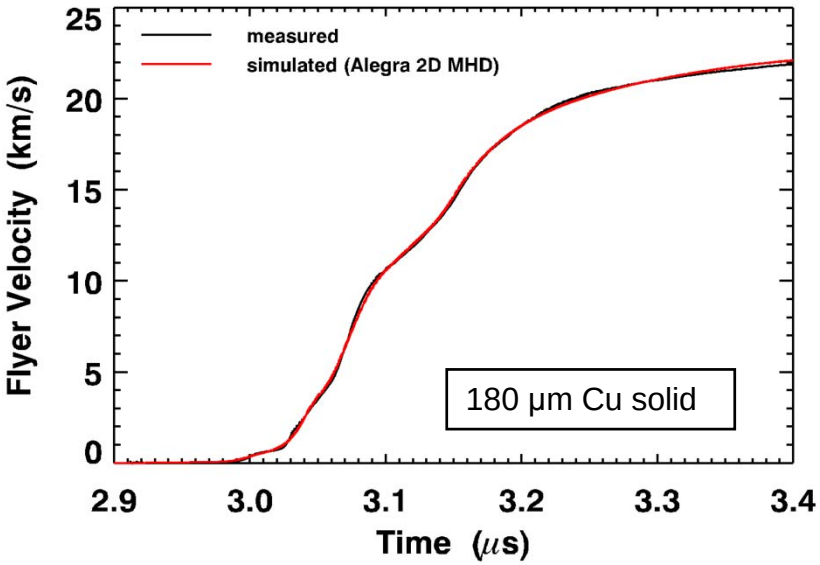
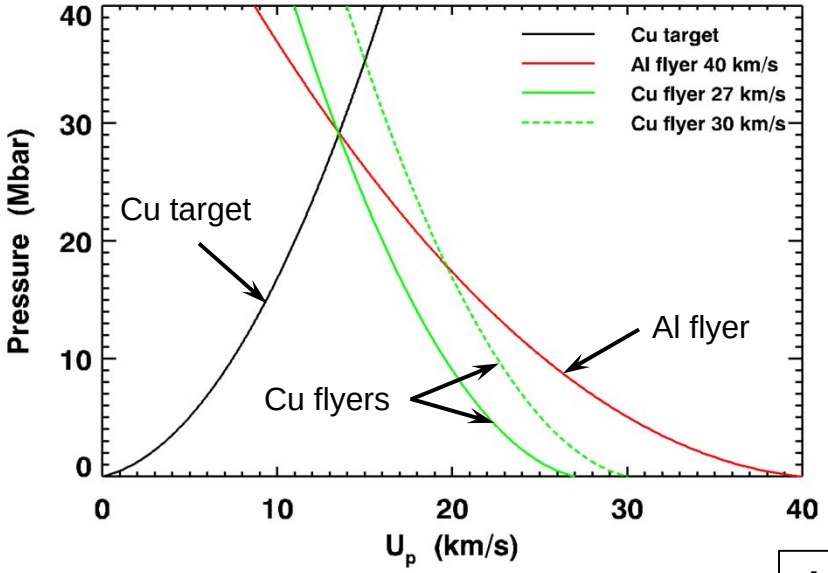
We have previously developed a micro-plating technique for forming layered flyers and used it to measure the shock melt transition of Be and diamond



Measured & Simulated Velocity vs. Time Composite Al / Cu Flyer Plate



Pressure vs. Particle Velocity for Al & Cu Flyers Impacting Cu Target



Lemke et al: IJIE v 38, 2011, 480-485

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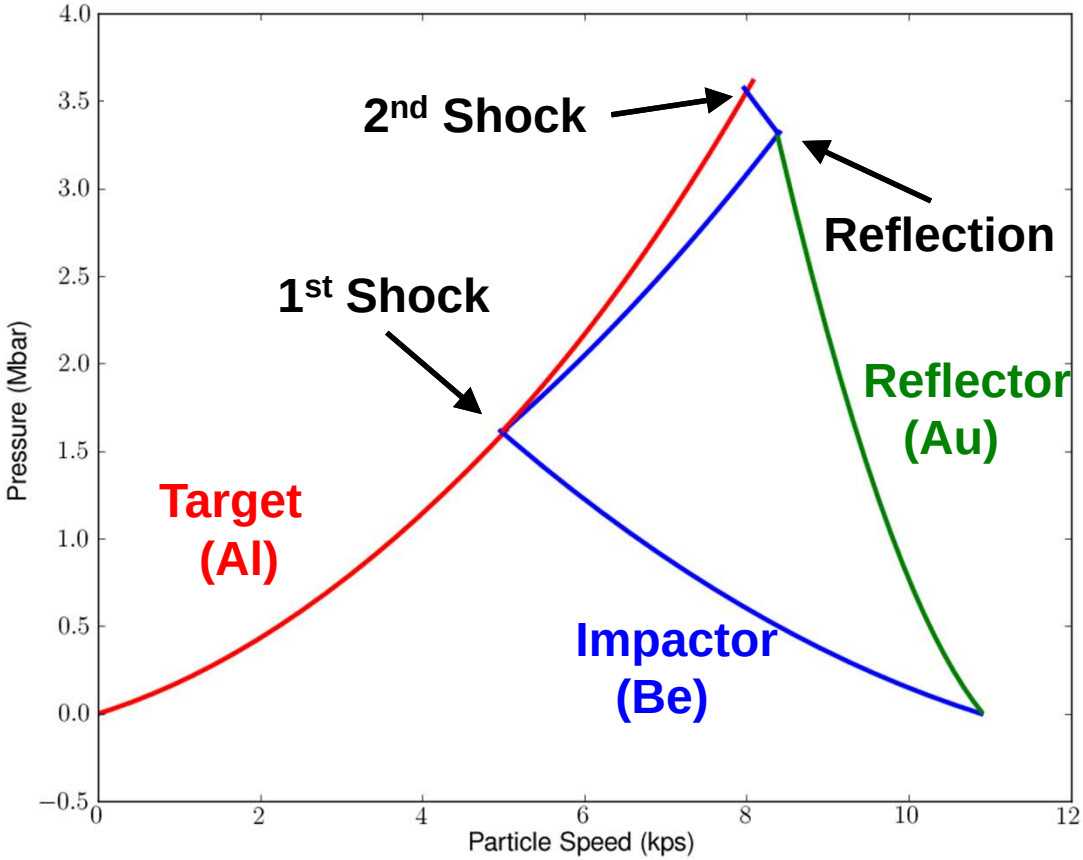
- **Impedances**
- **Fabrication**
- **Flyer magnetic drive design**
- **Quality Data Analysis**



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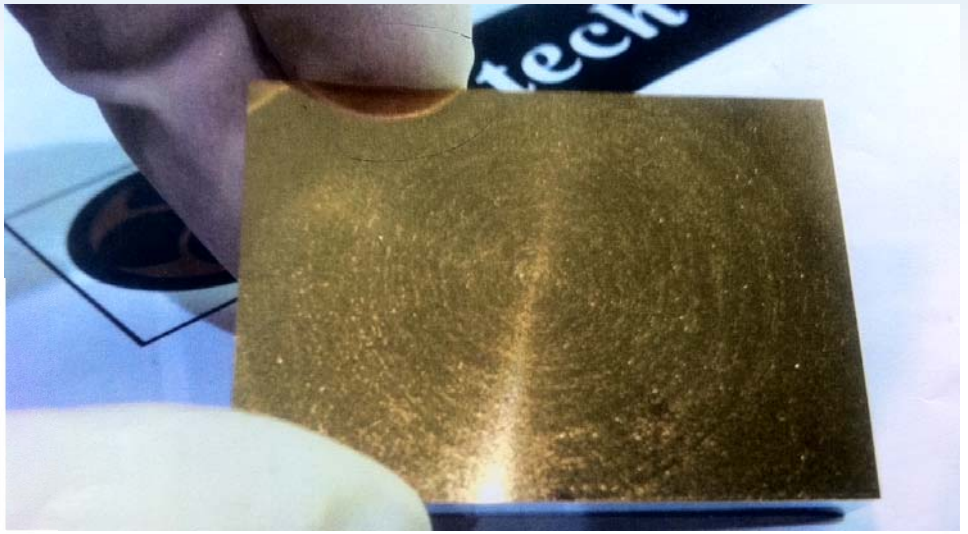
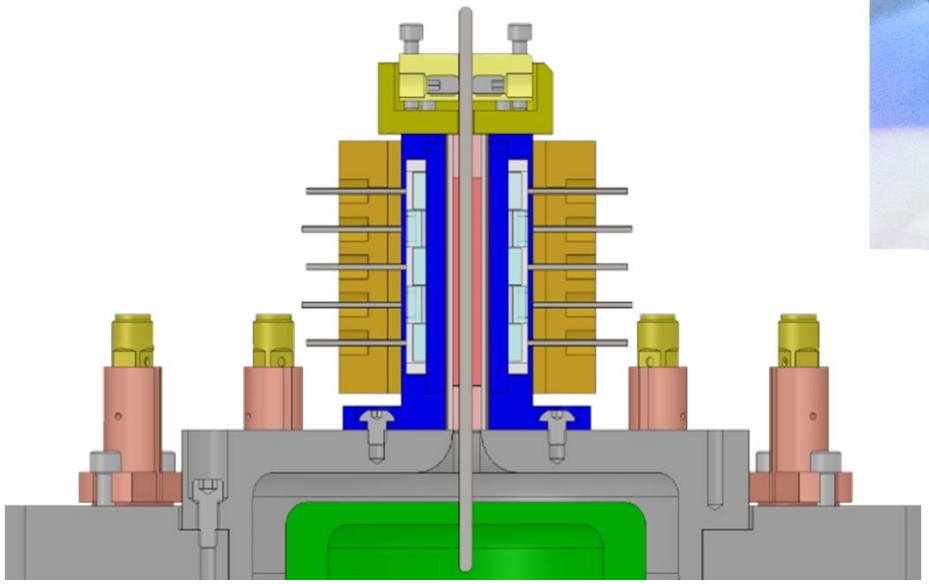
MPCL successfully electroplated and diamond turned solid density layers



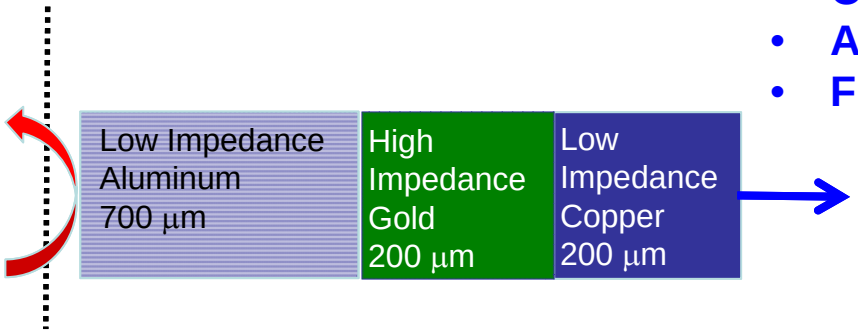


We select thicknesses allowing:

- **Long 1st and 2nd shock dwell times**
- **Observable release**
- **Ability to ramp accelerate**
- **Flyer fab w/o pancaking**

Offset cathode

- **2 flyer speeds per shot**



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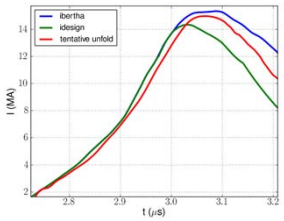
Z Shot

Velocity Data

Analysis

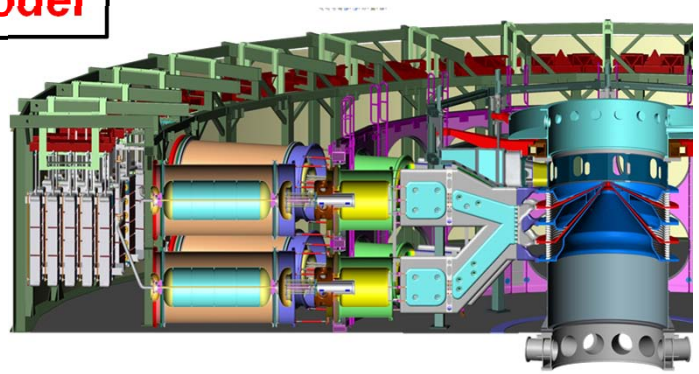
Current Data

Machine Settings
(voltage, 36 laser timings, 36 water switch gaps)

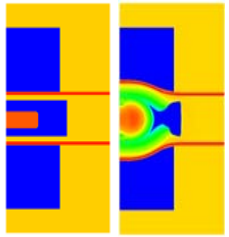


Tail Model

L3 Bertha Circuit Model



Loss Model



Load Current
(including 2D effects)

2D ALEGRA MHD

B(t) at AK gap

1D Design

1D Hydro, MHD

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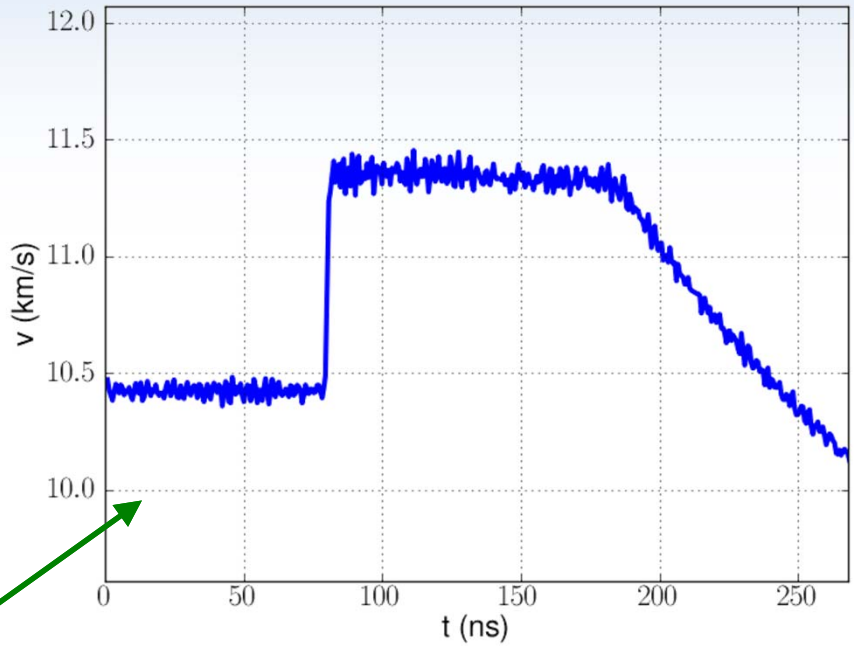
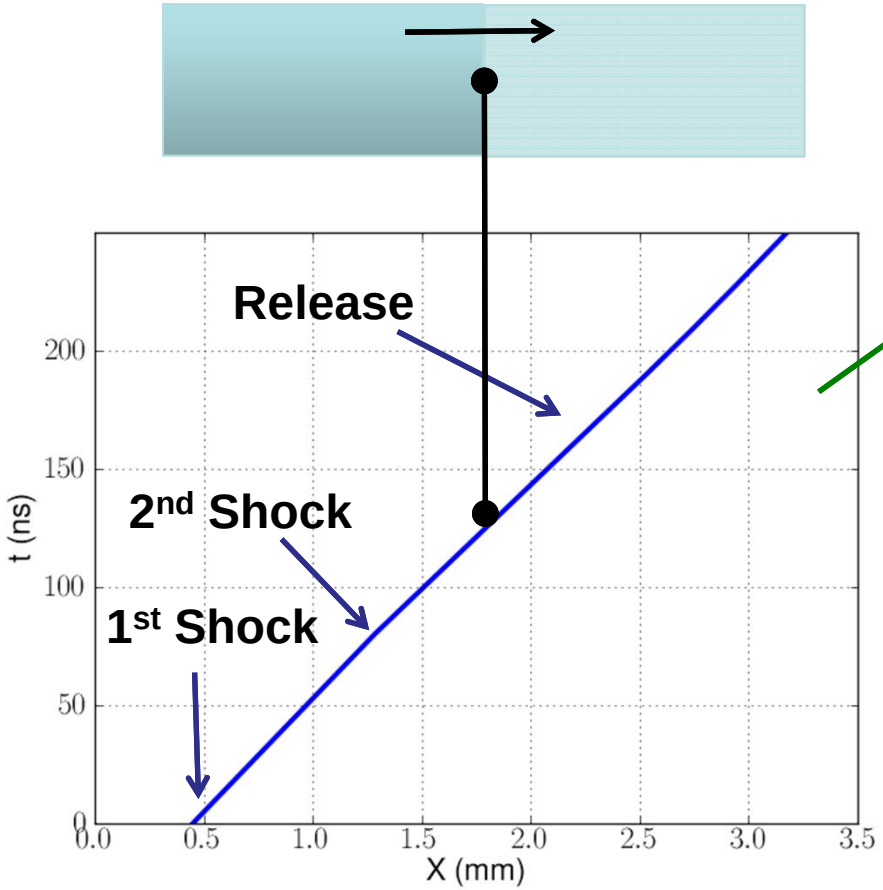
Simulated VISAR



Shock Front



Simulation of Ideal Impact

- Window is transparent in flight → flyer velocity at impact
- Post-impact VISAR tracks shock front in quartz
- In simulations, we use a "characteristic" tracer (u+c)

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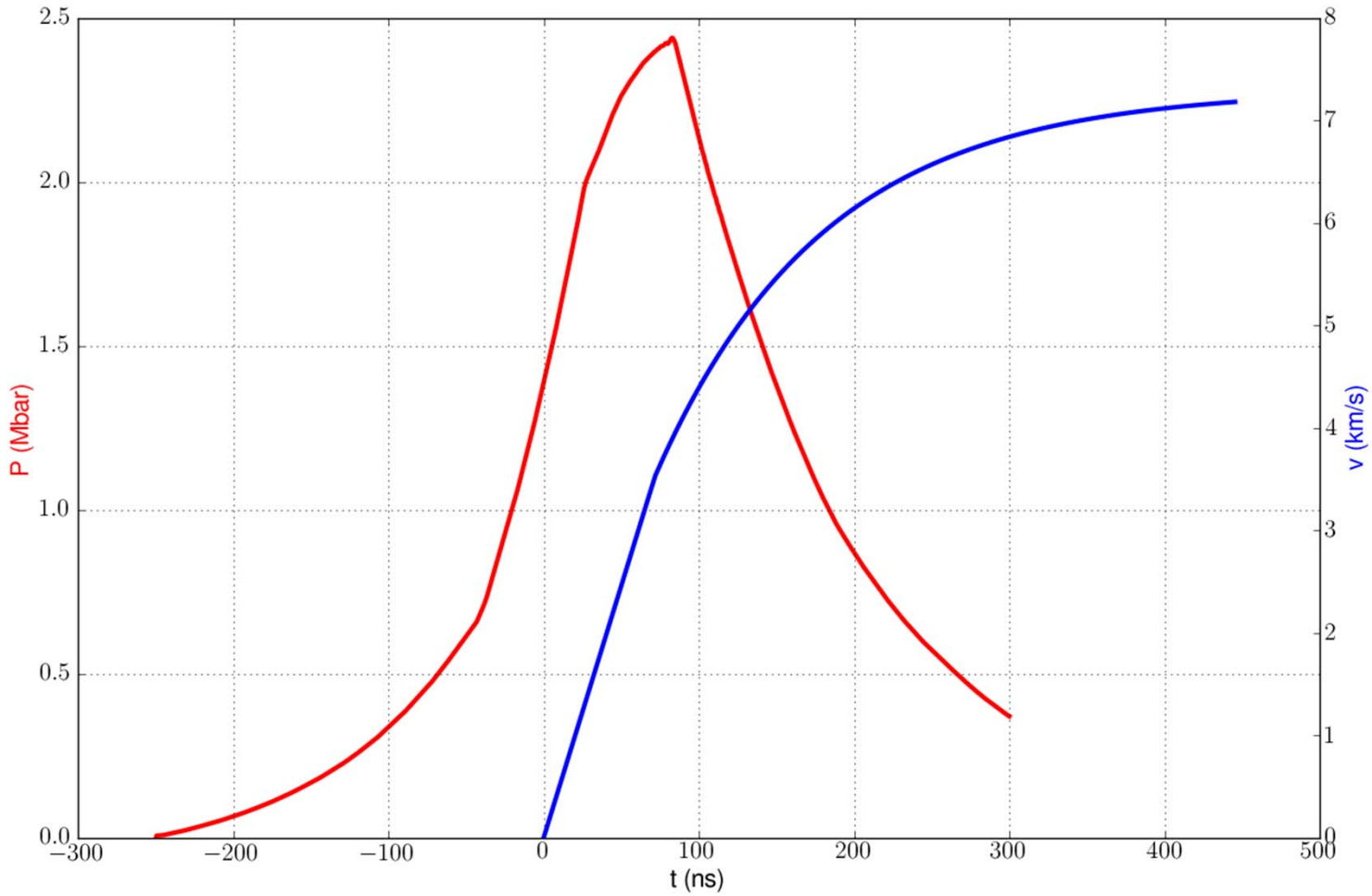
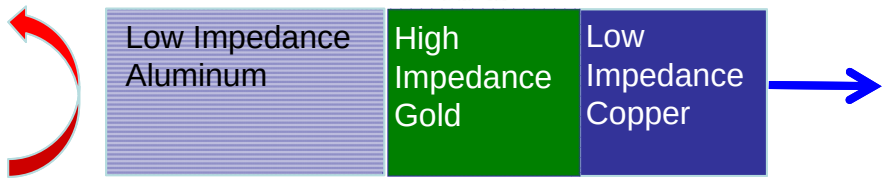
Ideal Drive From Backwards Integration





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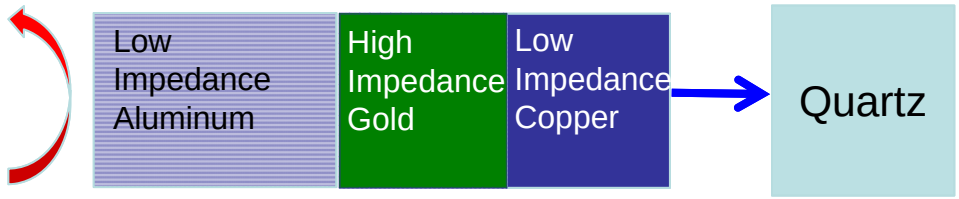
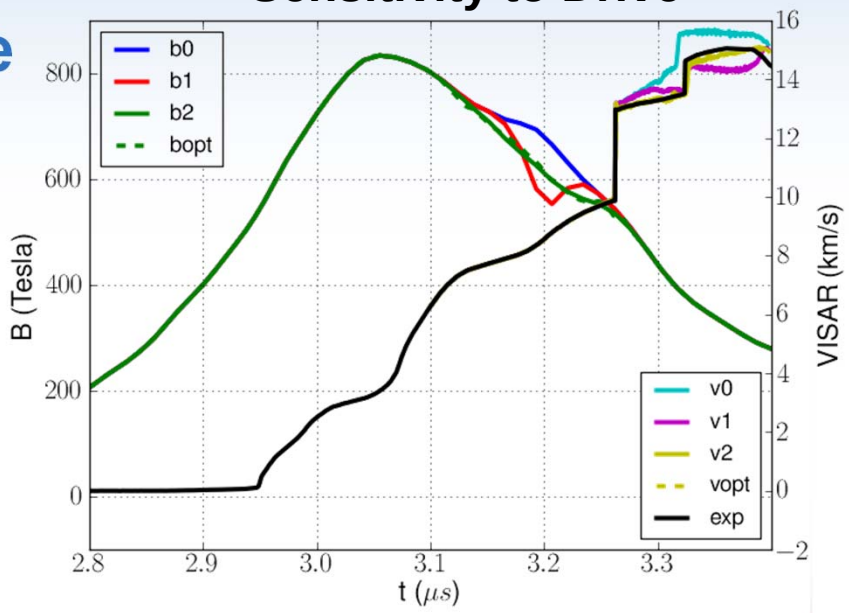
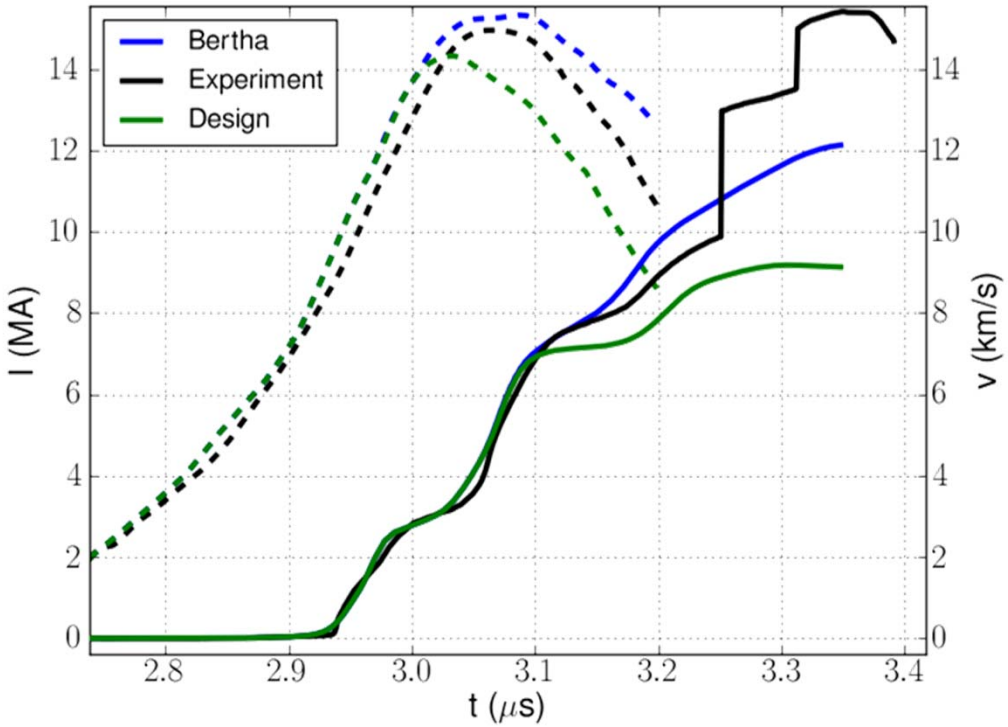
Our goal is to separate drive unfold from data analysis



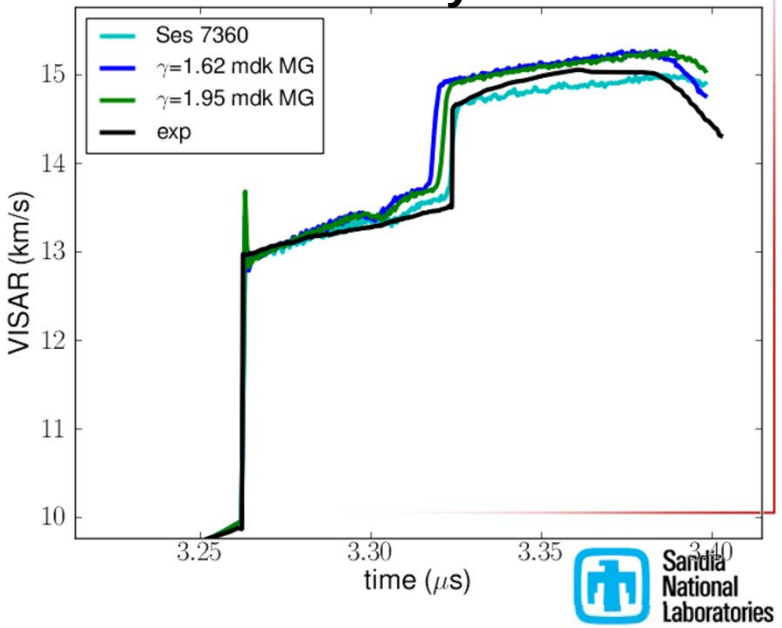
Sensitivity to Drive



Uncertainty in Drive Model



Sensitivity to EOS



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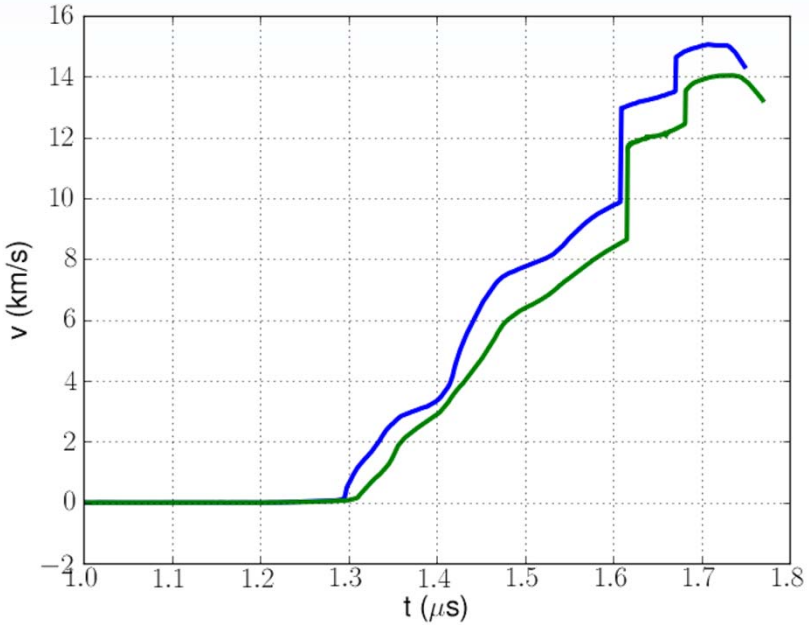
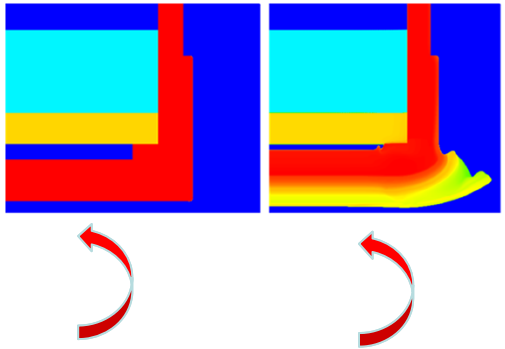
Summary

- **Successful 1st double shock on Z**
  - **No spall or separation issues with flyer**
  - **Good data for improving Z circuit model**
  - **Al and quartz data unfortunately coupled to MHD drive**
- **Goal to decouple drive from analysis on successive shots**
- **Simultaneously developing shock+ramp**





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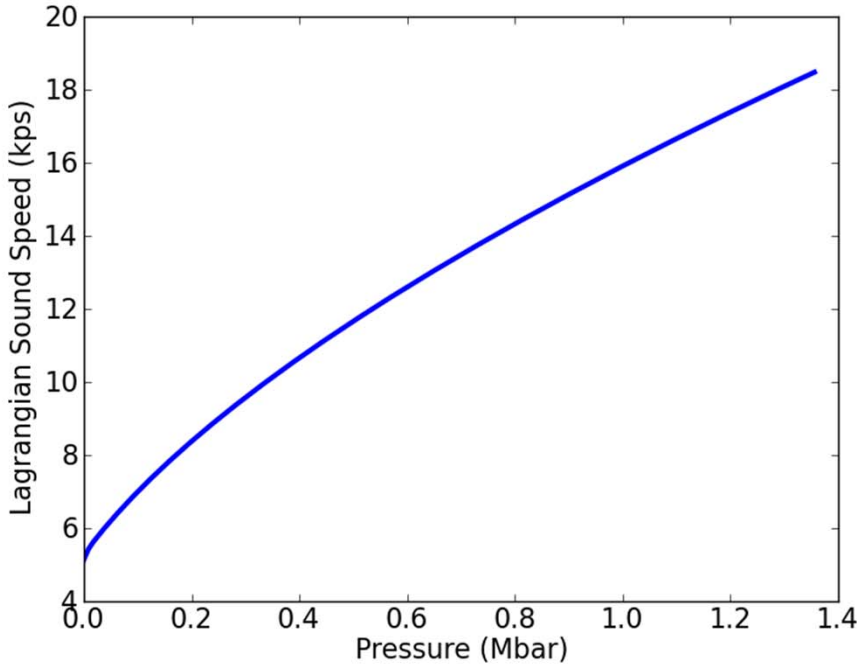
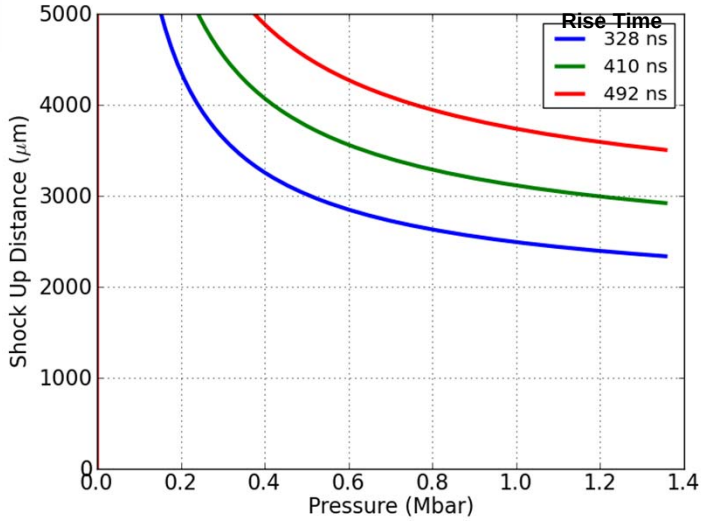
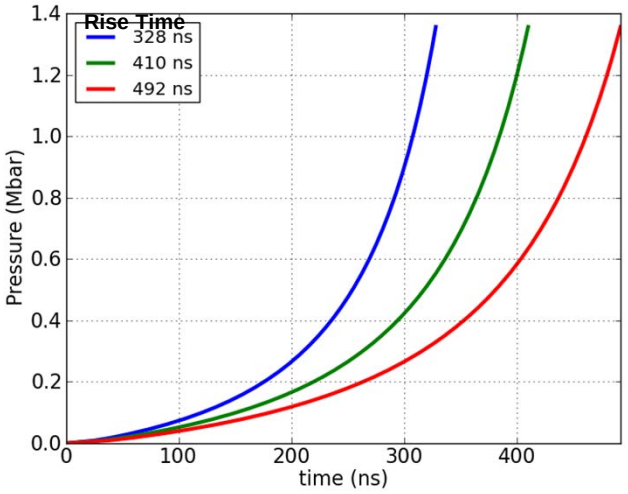
Backup Slides







$$v = \frac{P\Delta t}{\rho D} \qquad \Delta t = \frac{1}{I_{peak}^2}\int I^2(t)\,dt$$

-Lemke 2003,2003,2005,2011

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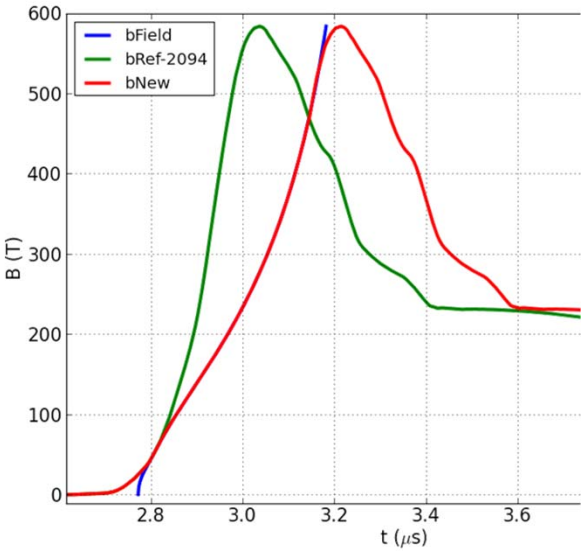

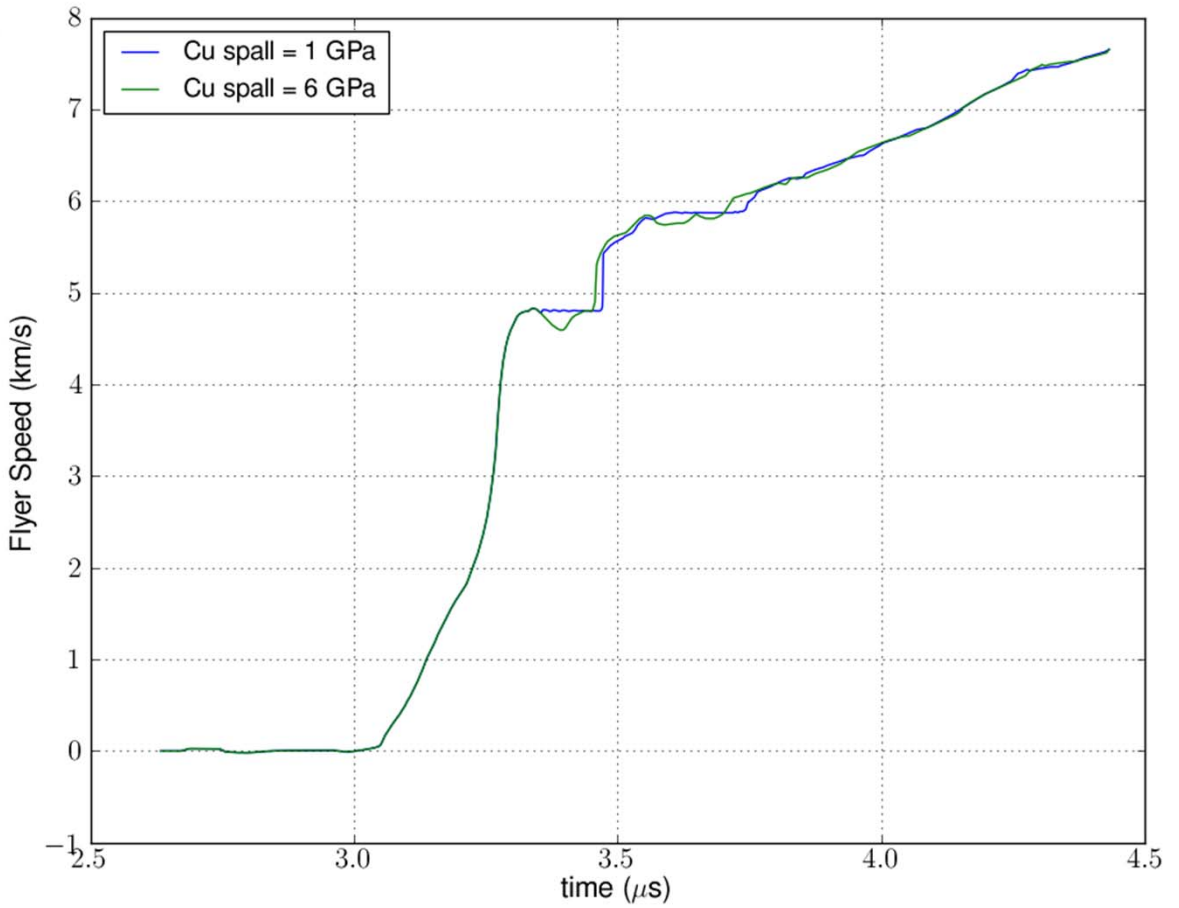

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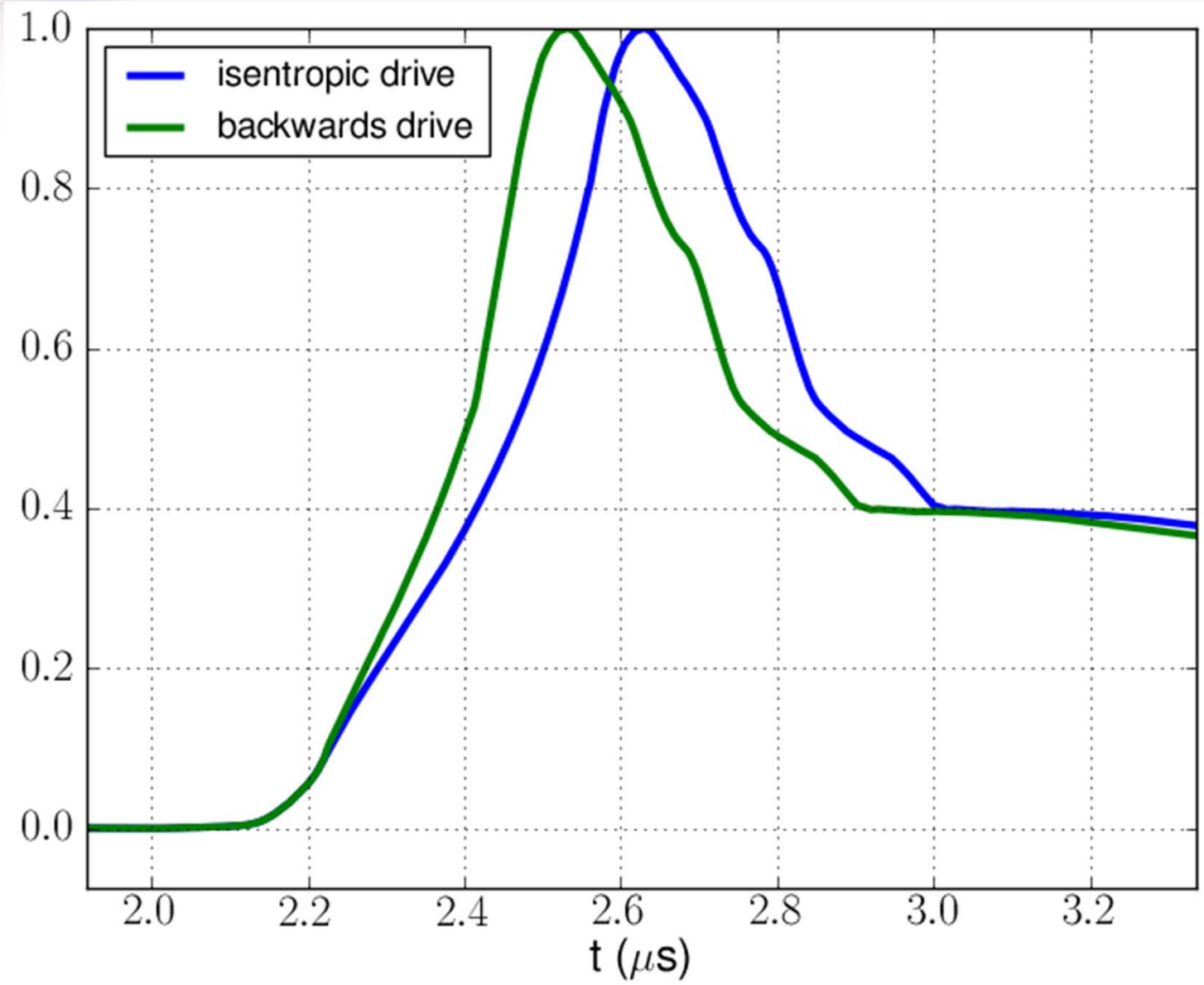

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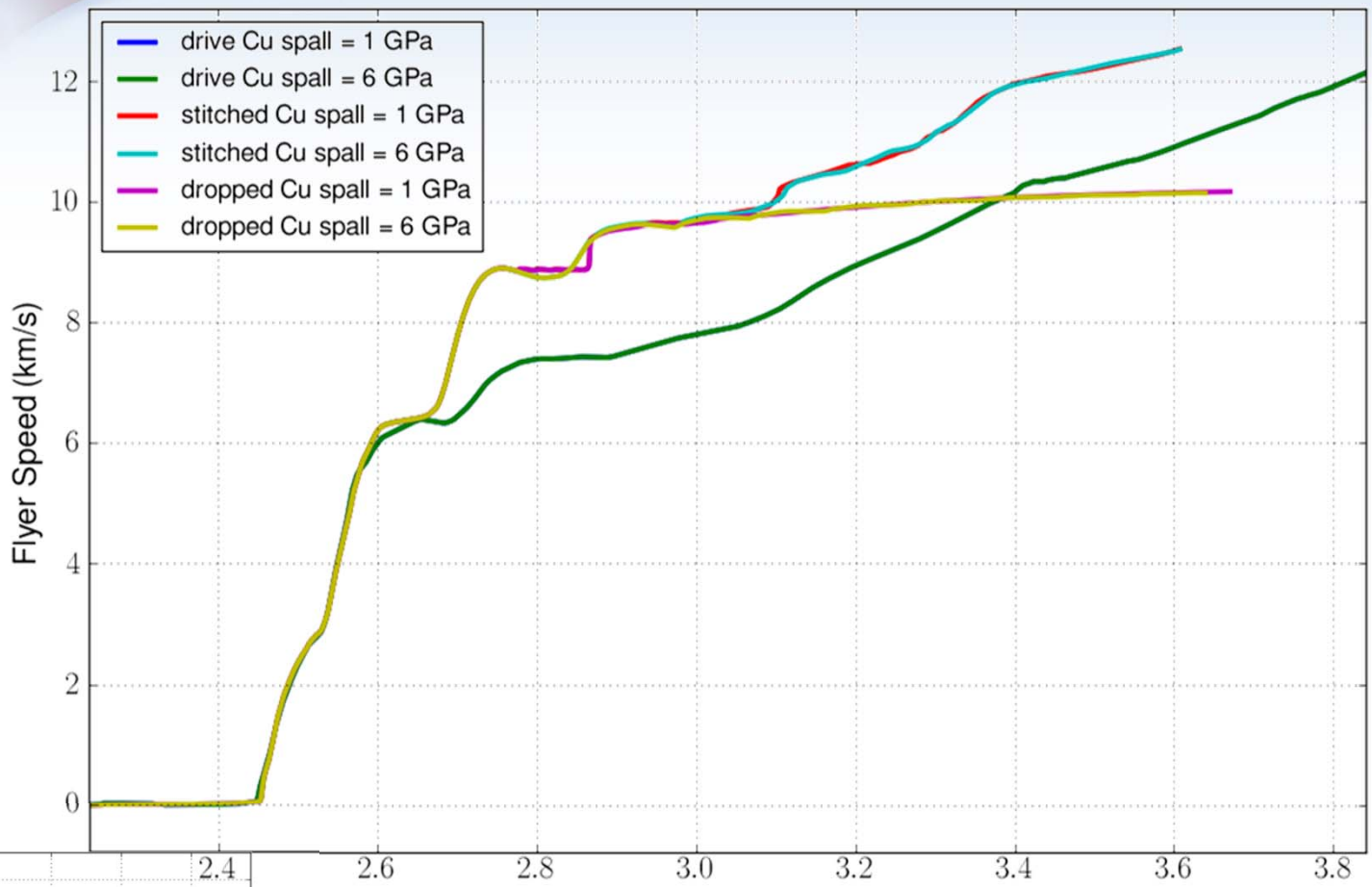

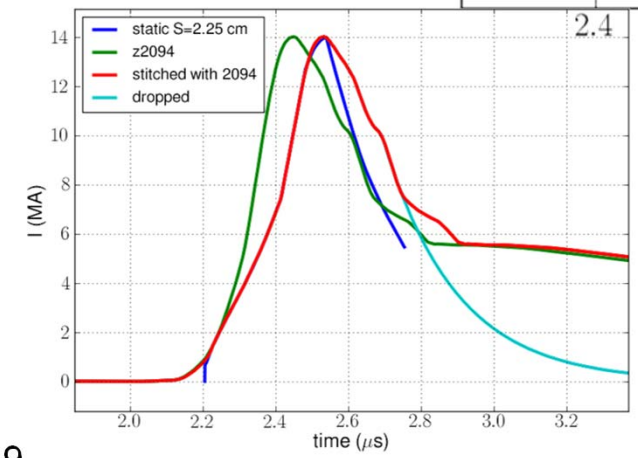

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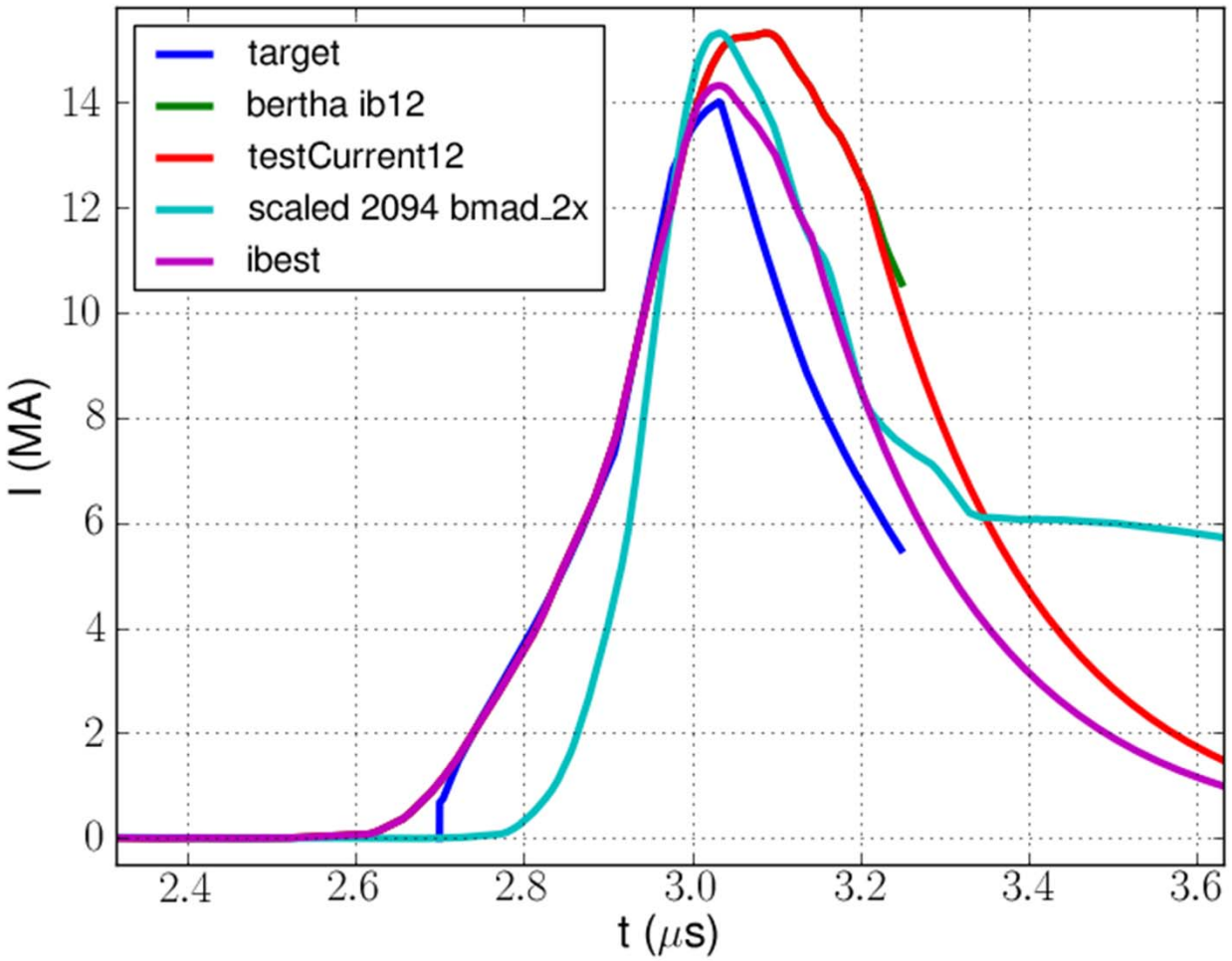

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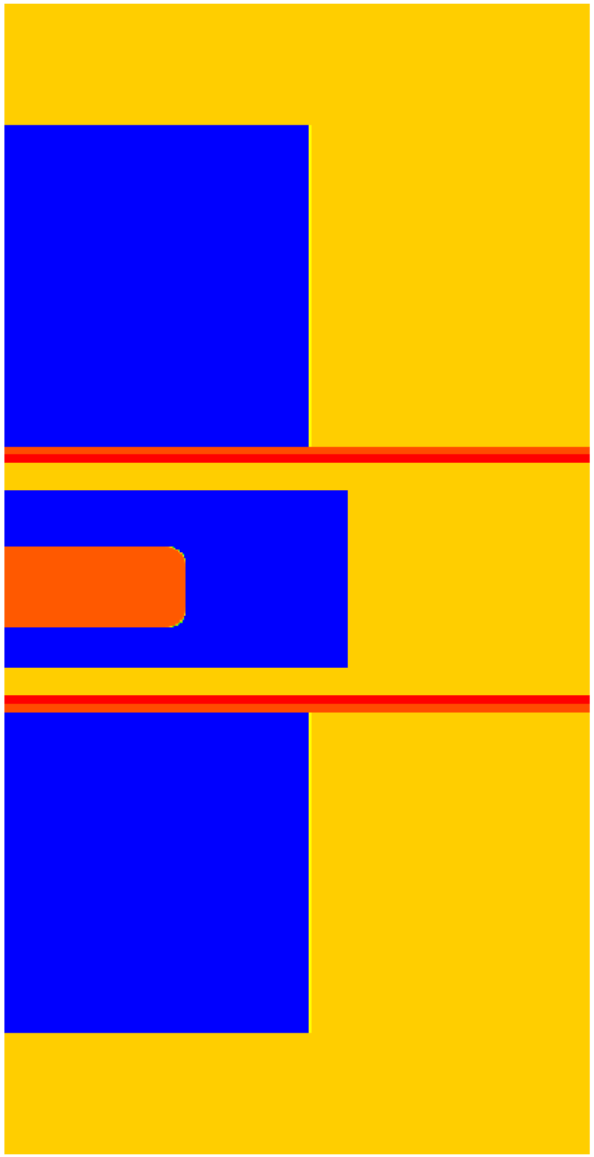

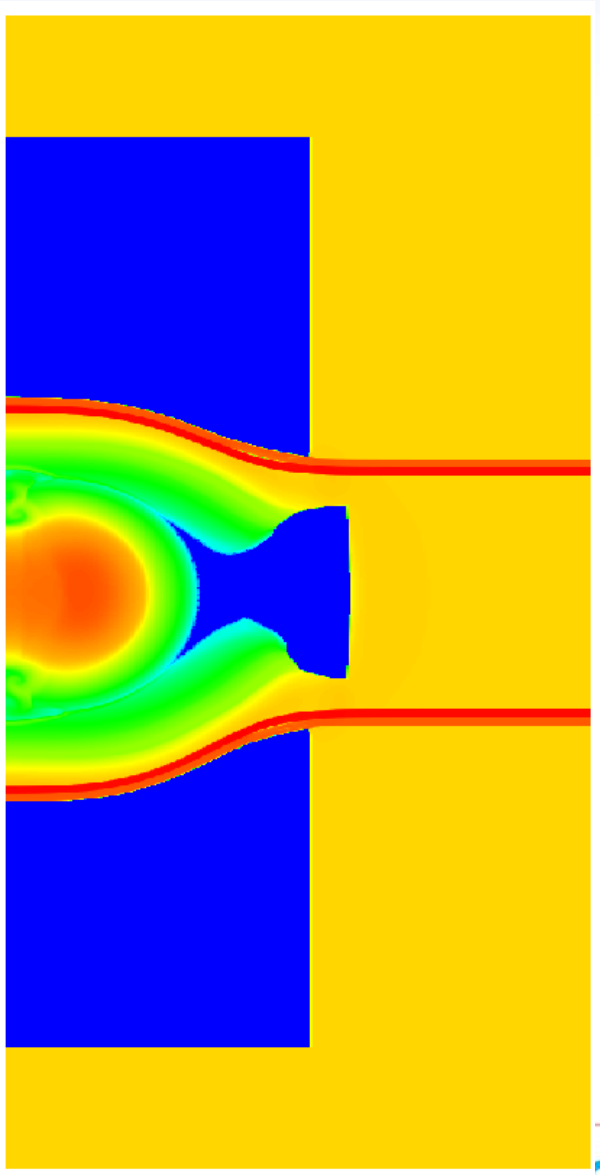

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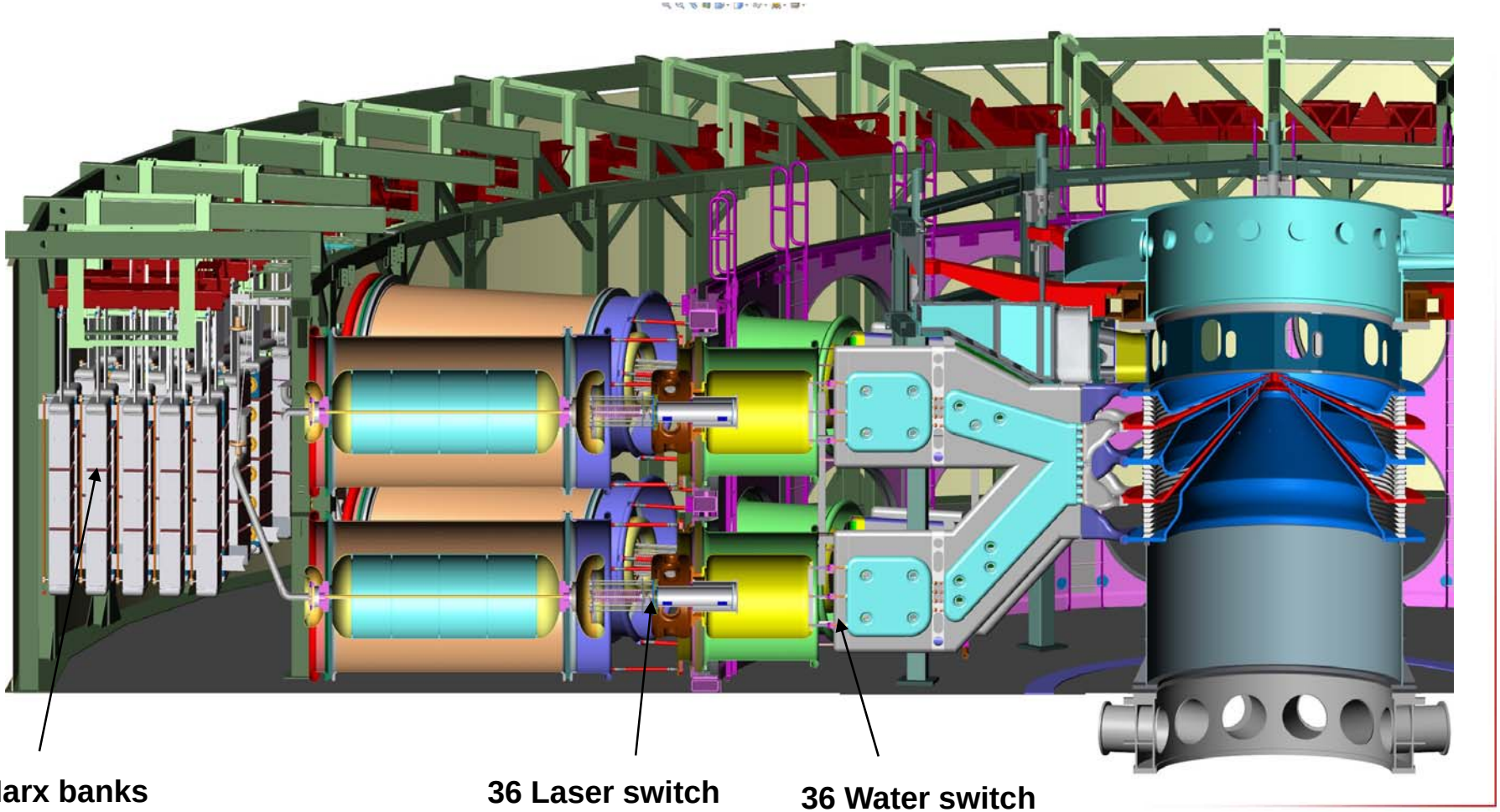

Marx banks triggered

36 Laser switch trigger times

36 Water switch gap settings

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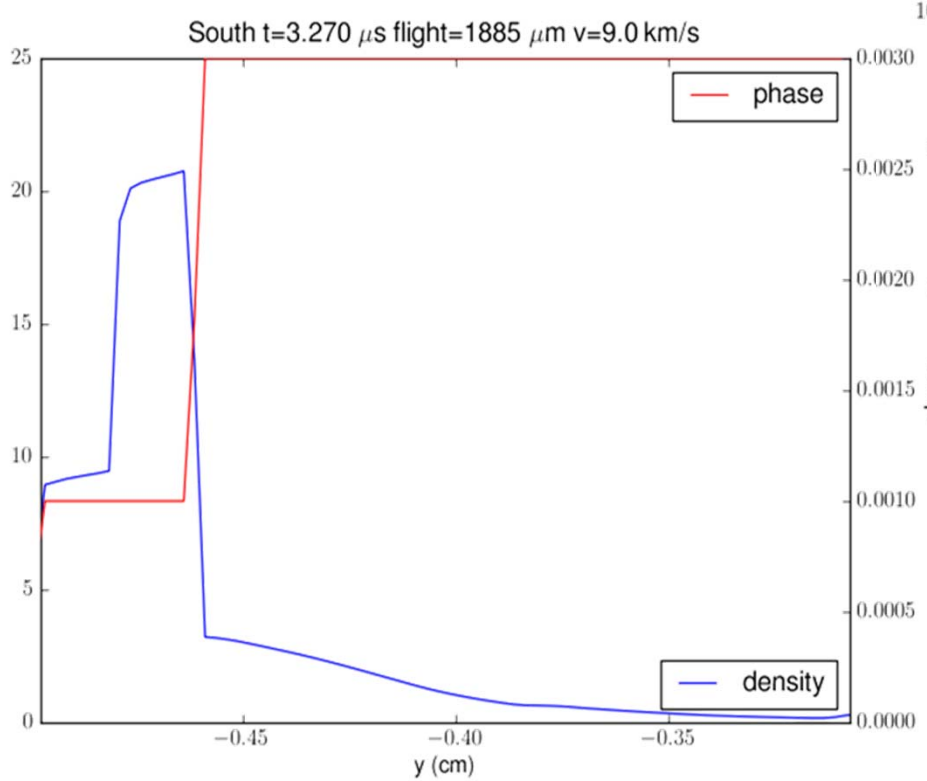

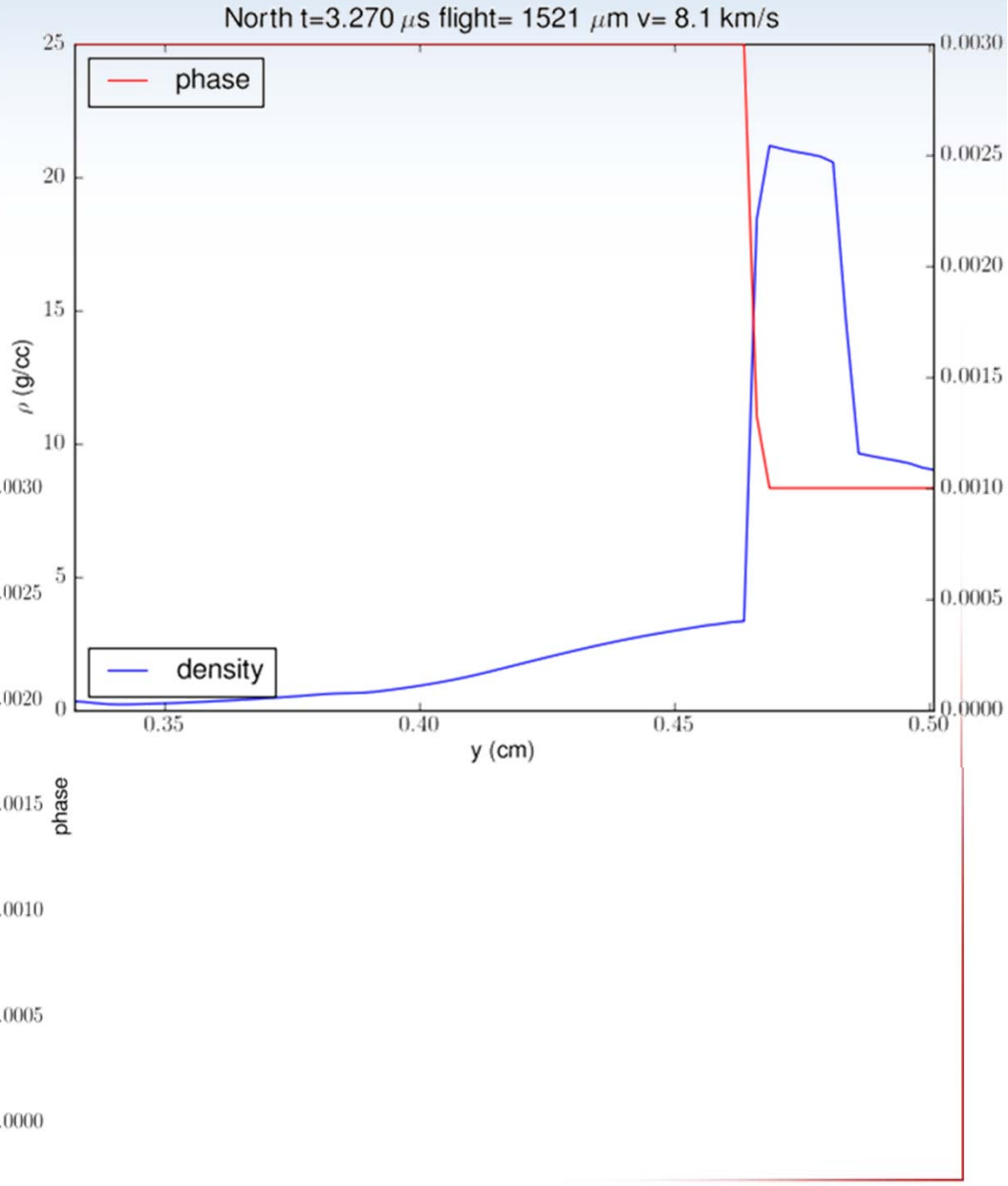

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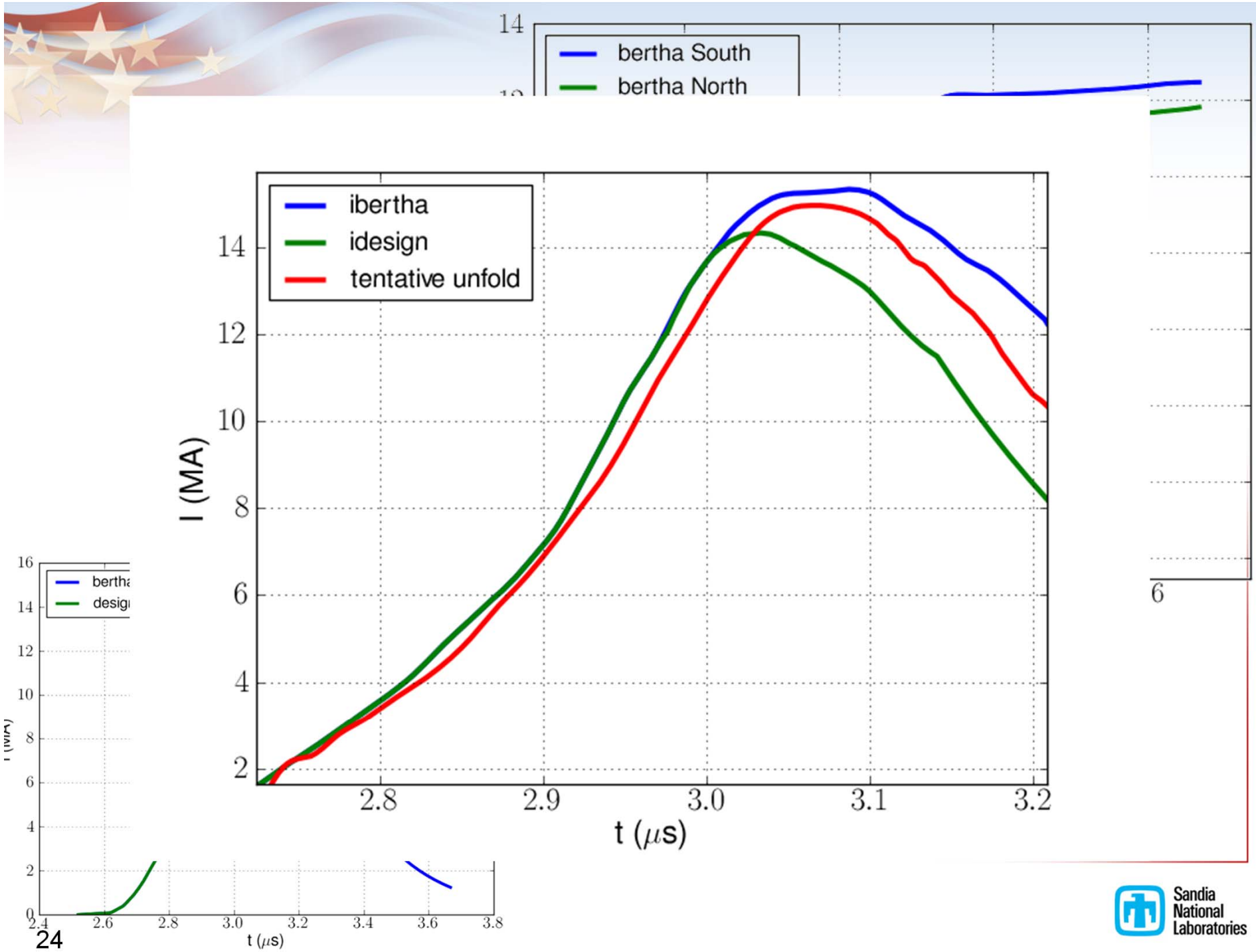

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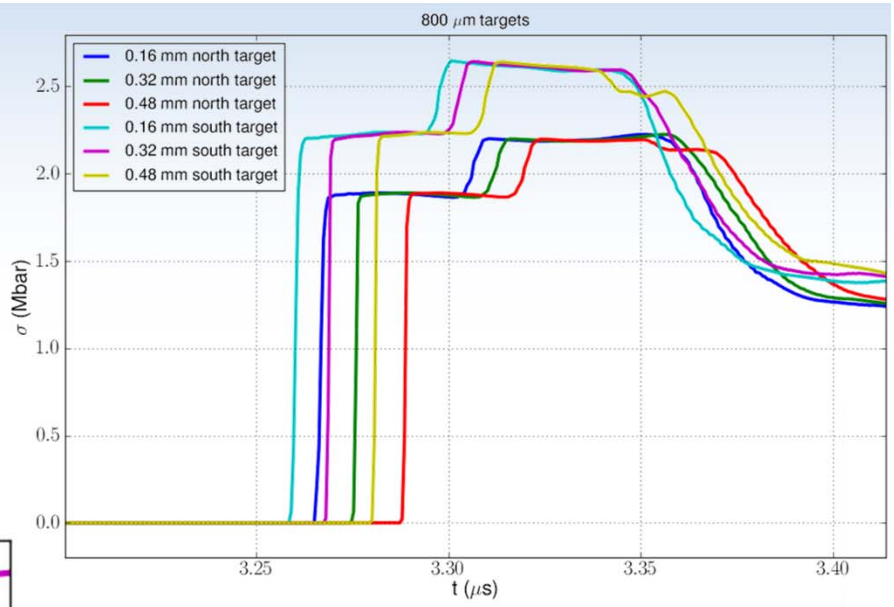

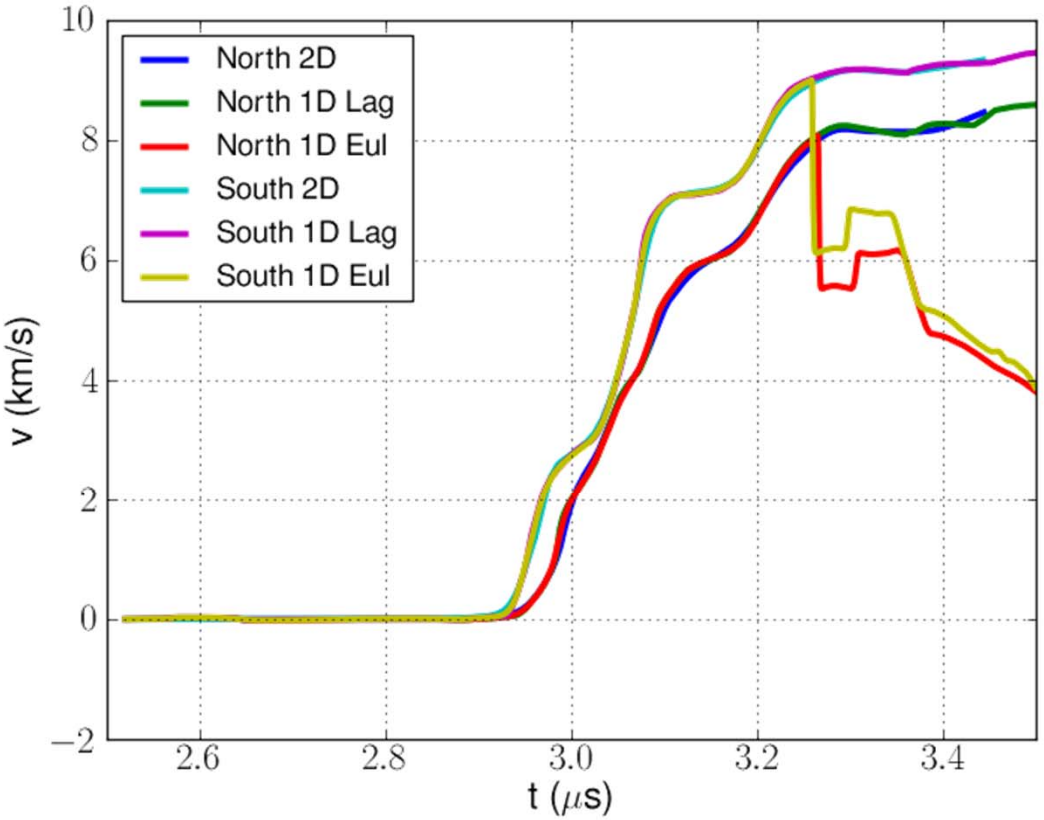

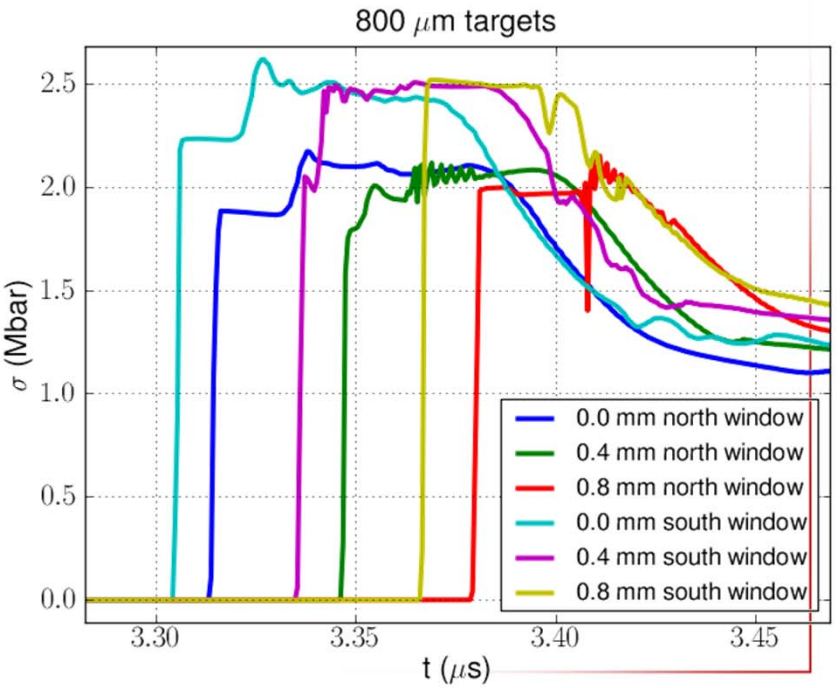

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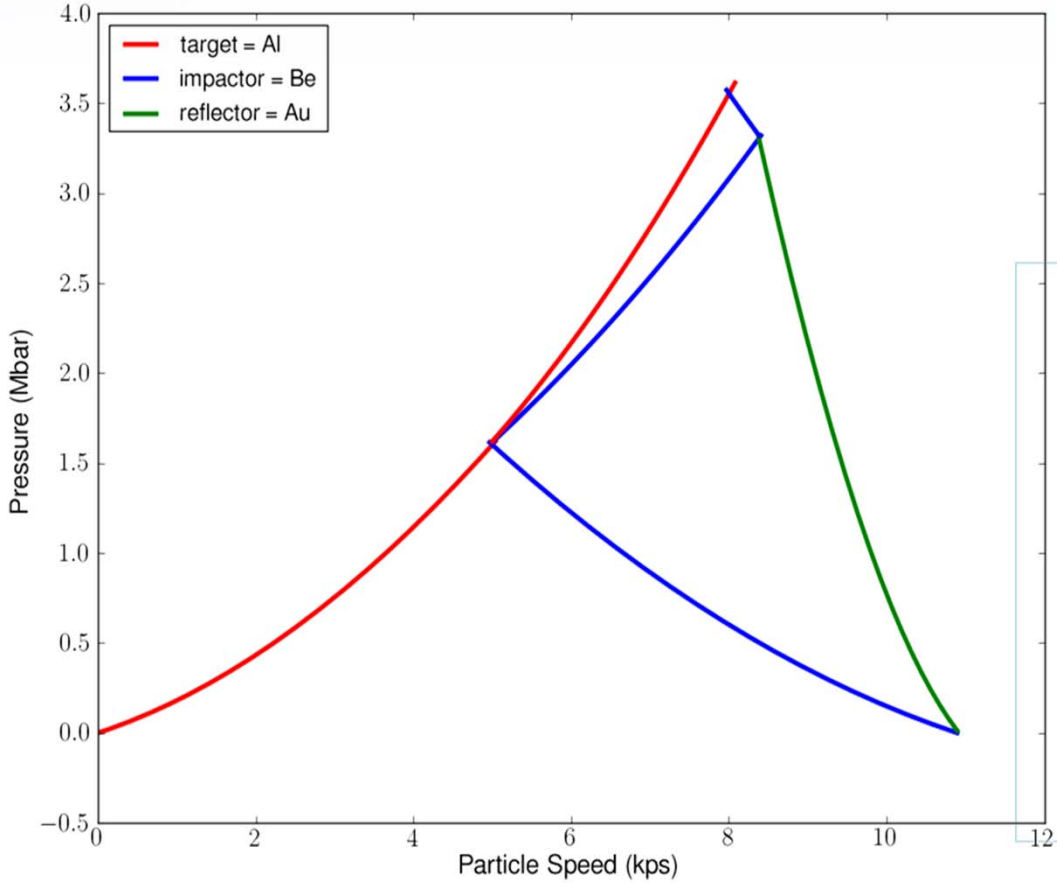

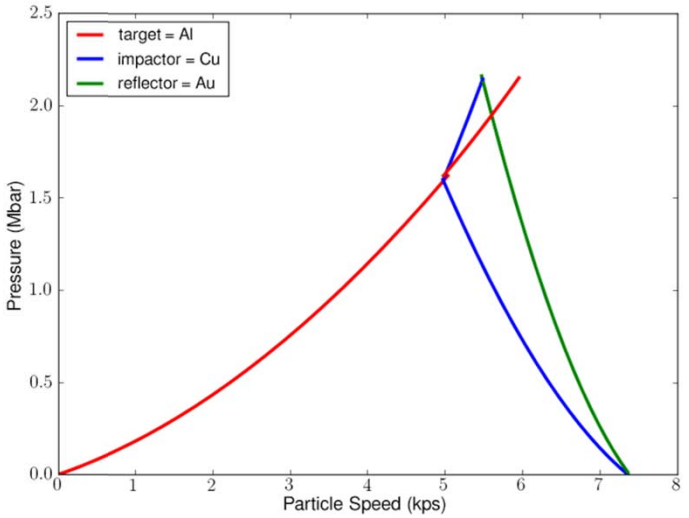

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