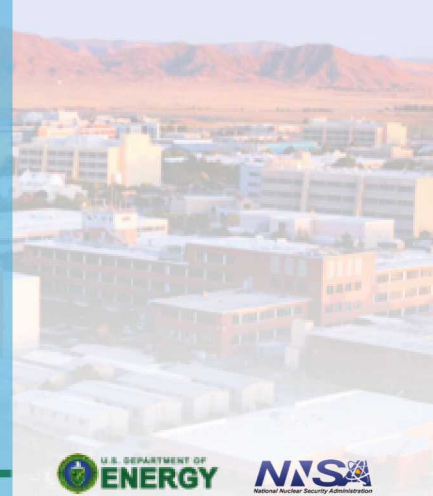
SAND2020-2047PE

Thor pulseshaping

Presented by:

Justin Brown



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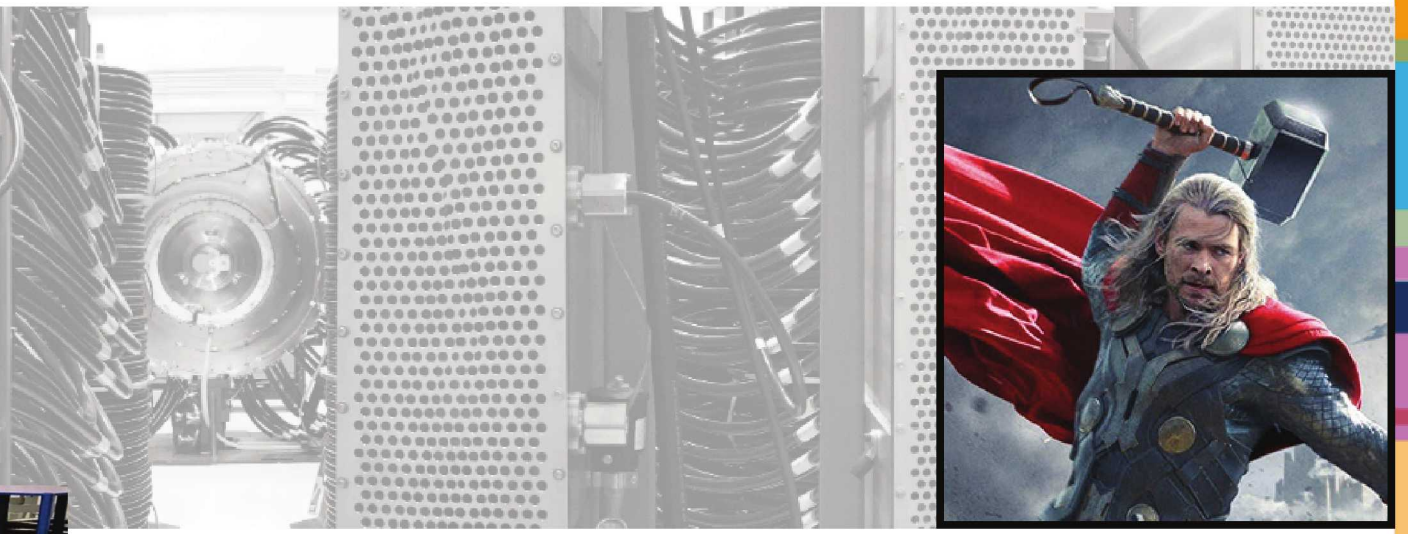
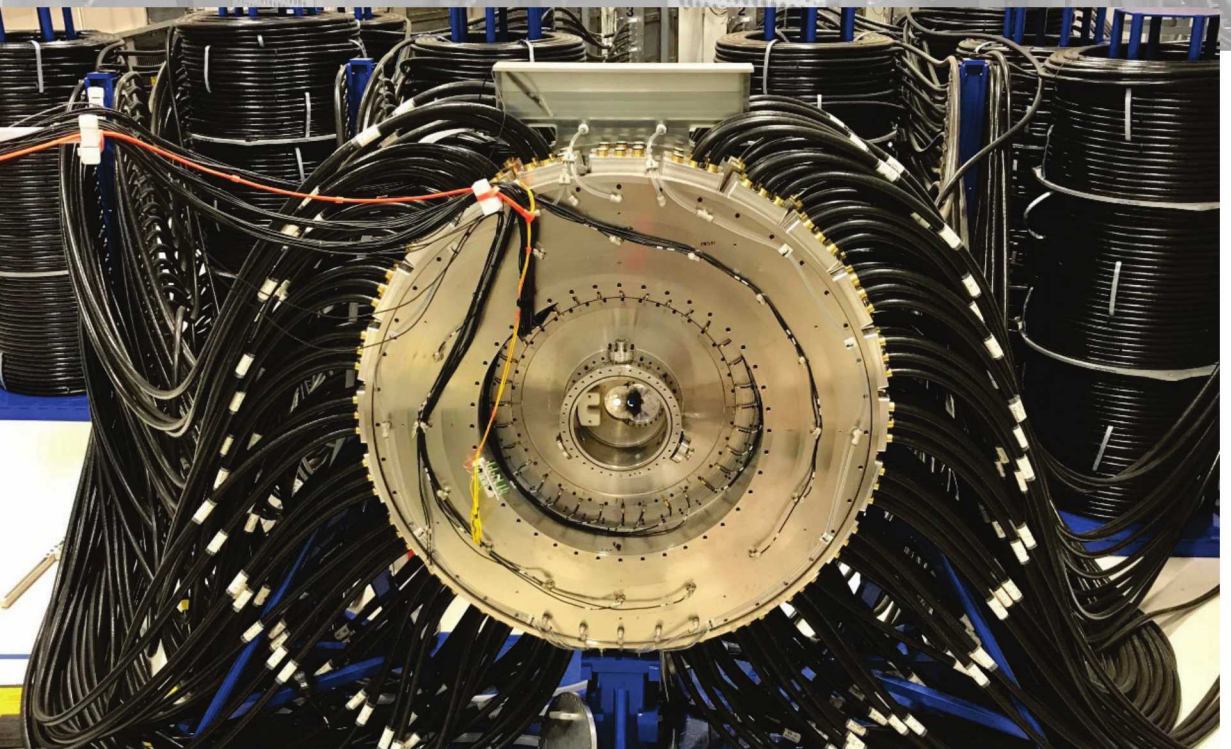
Thor provides a unique ability to produce different loading rates



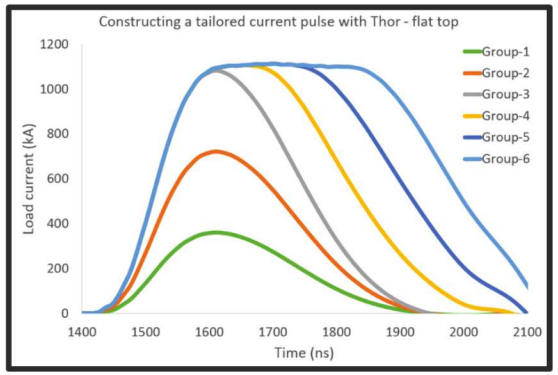


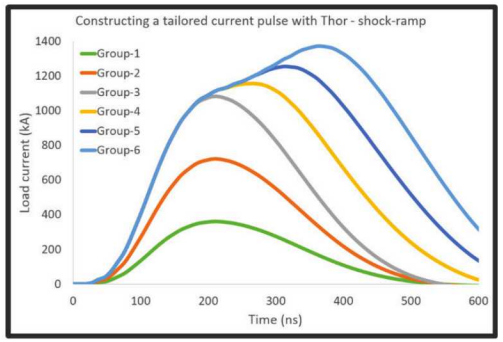
Stores 51 kJ of electrical energy with exquisite current pulseshaping

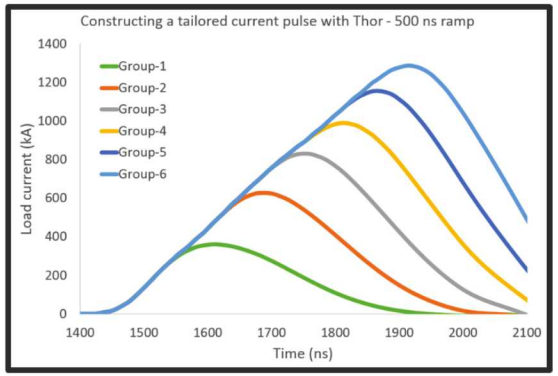
- Loading rates of ~10^6 – 10^7 /s
- Peak stresses of ~ 20 – 40 GPa

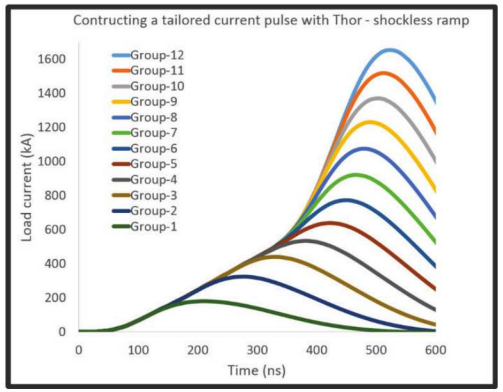
Relatively inexpensive and can be fired multiple times per day.

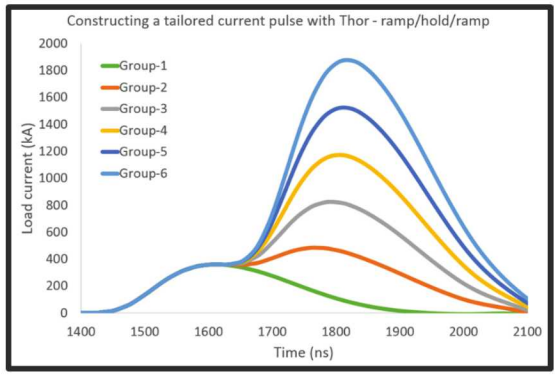
Thor was designed to deliver a wide range of current pulses

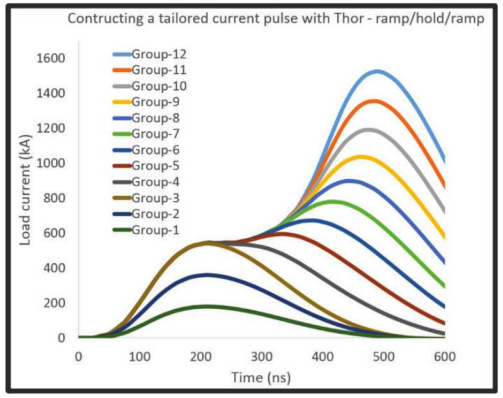












Pulseshape is a simple superposition of basis functions

- No complicated circuit-model like Z

High accuracy and precision

- Pre-fires are relatively rare
- Low timing jitter:

The rest of this talk will be a summary of a variety of projects making use of Thor's pulseshaping capabilities

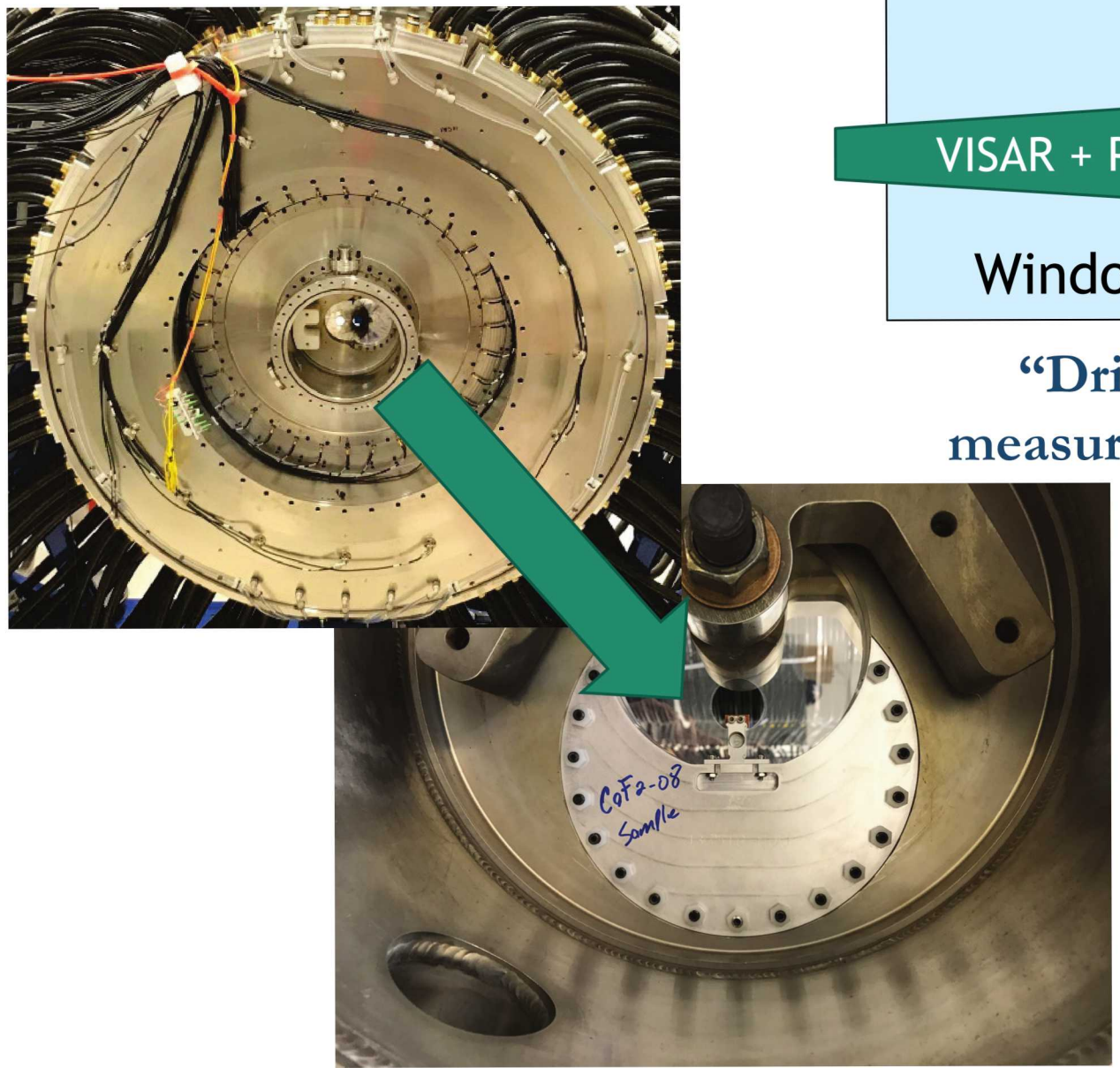
CaF_2 (S. Root, P. Kalita)
- Effect of rate on elastic-plastic transition

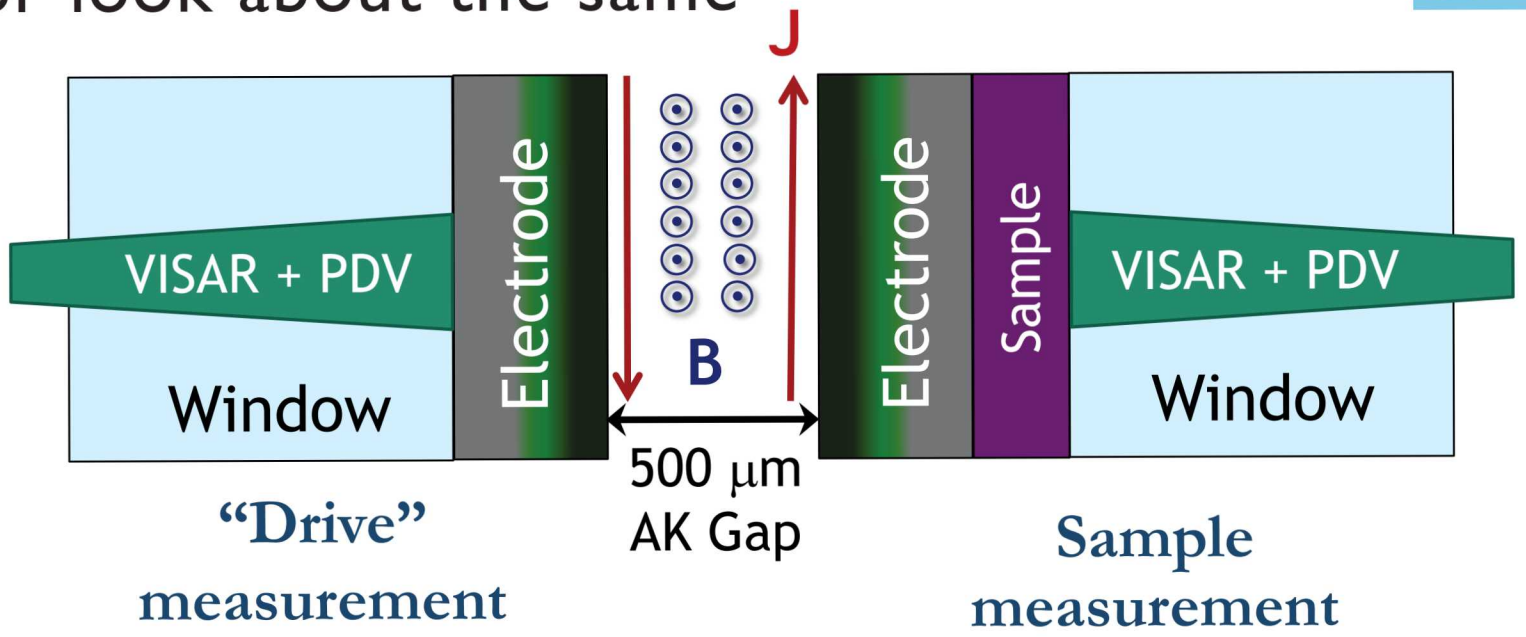
Tin single crystals (J. Scharff, S. Fensin, D.J. Luscher)
- Constitutive response of different orientations

Ga solidification(B. Stoltzfus, J.Belof, P. Myint)
- Nanosecond freezing

Tri-lab strength
- Ta flat top ramp-release
- Tin phase transitions
- Rayleigh-Taylor instability

Most experiments on Thor look about the same





"Drive" measurement

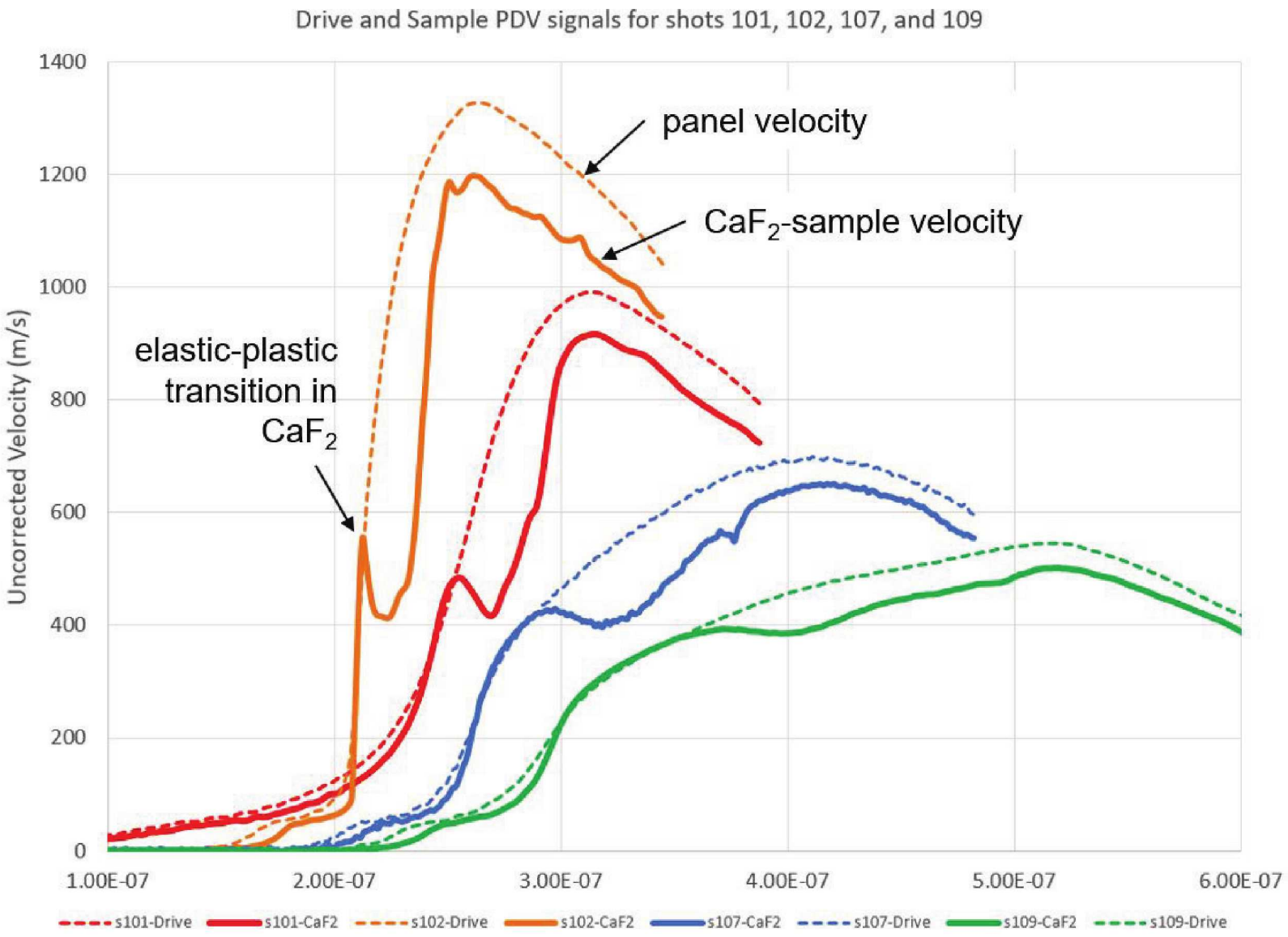
Sample measurement

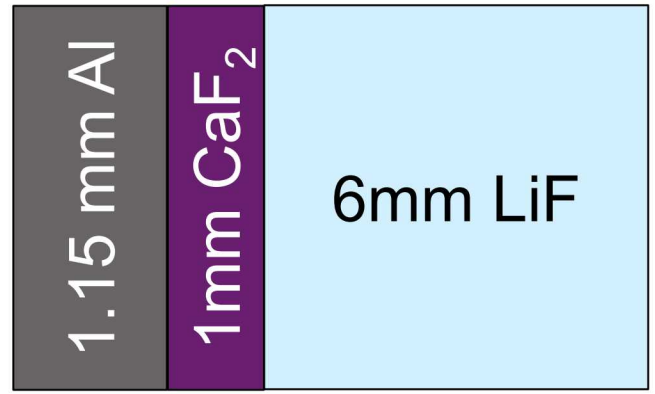
Short-circuit stripline load

Drive on one side and sample measurement on the other

Also well suited to 'AB' experiments

CaF_2 Single Crystals (S. Root, P. Kalita)

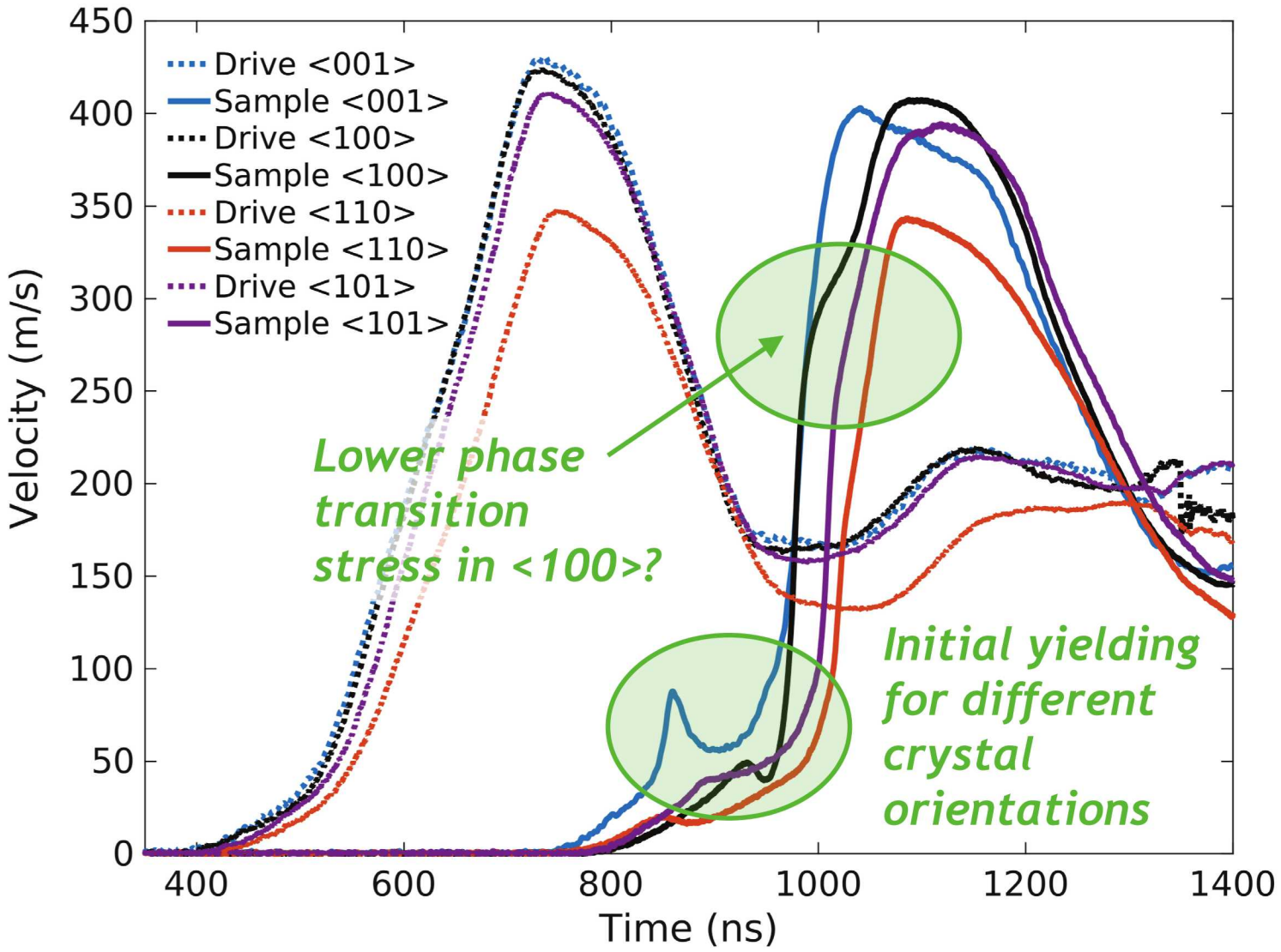


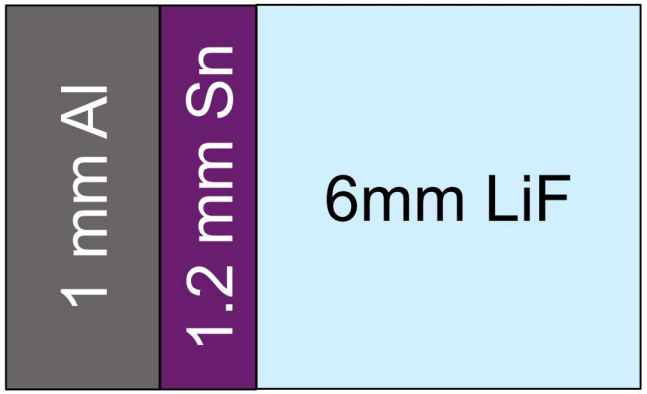


Loading rate was varied by ~40X, resulting in dramatically different signatures of the elastic-plastic transition.

- Data can be used to constrain the time-dependent nature of the constitutive response.

Tin single crystals (J. Scharff, S. Fensin, D.J. Luscher)

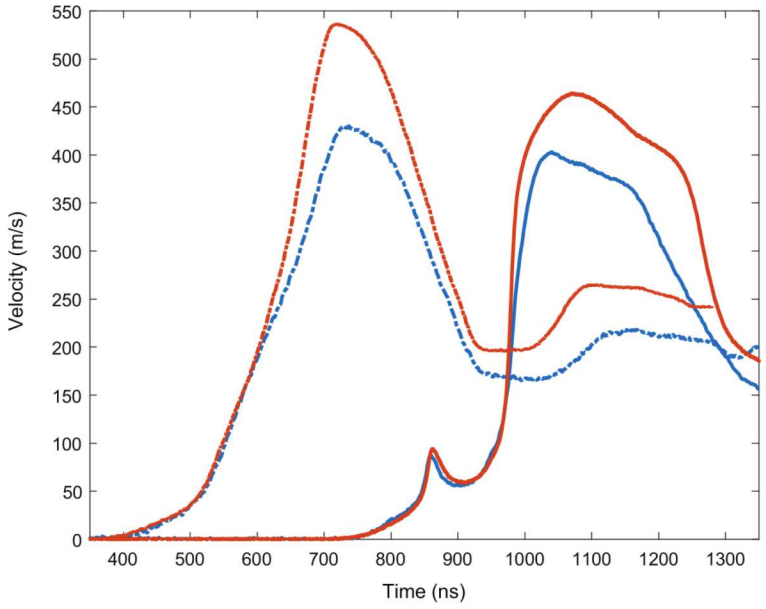




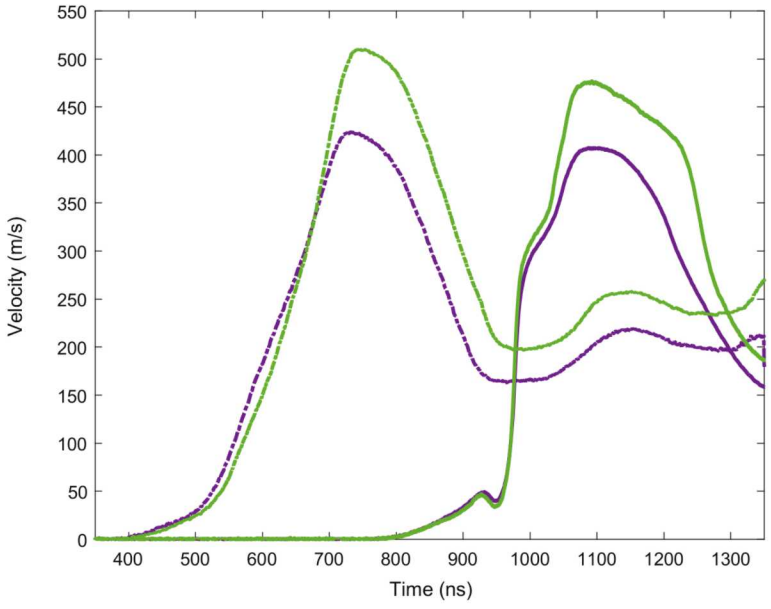
Same machine configuration results in very different sample responses

A second series on the Sn single crystals was conducted to see if the transition could be observed in other orientations

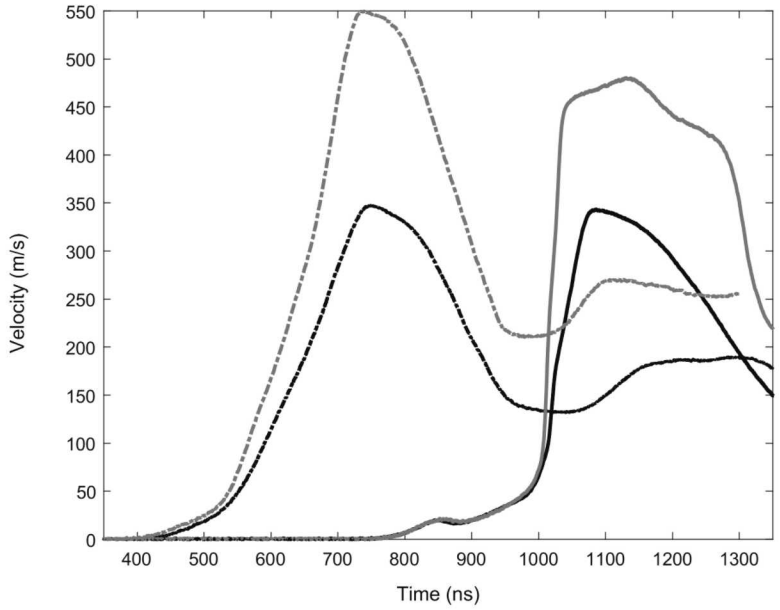
001



100



110

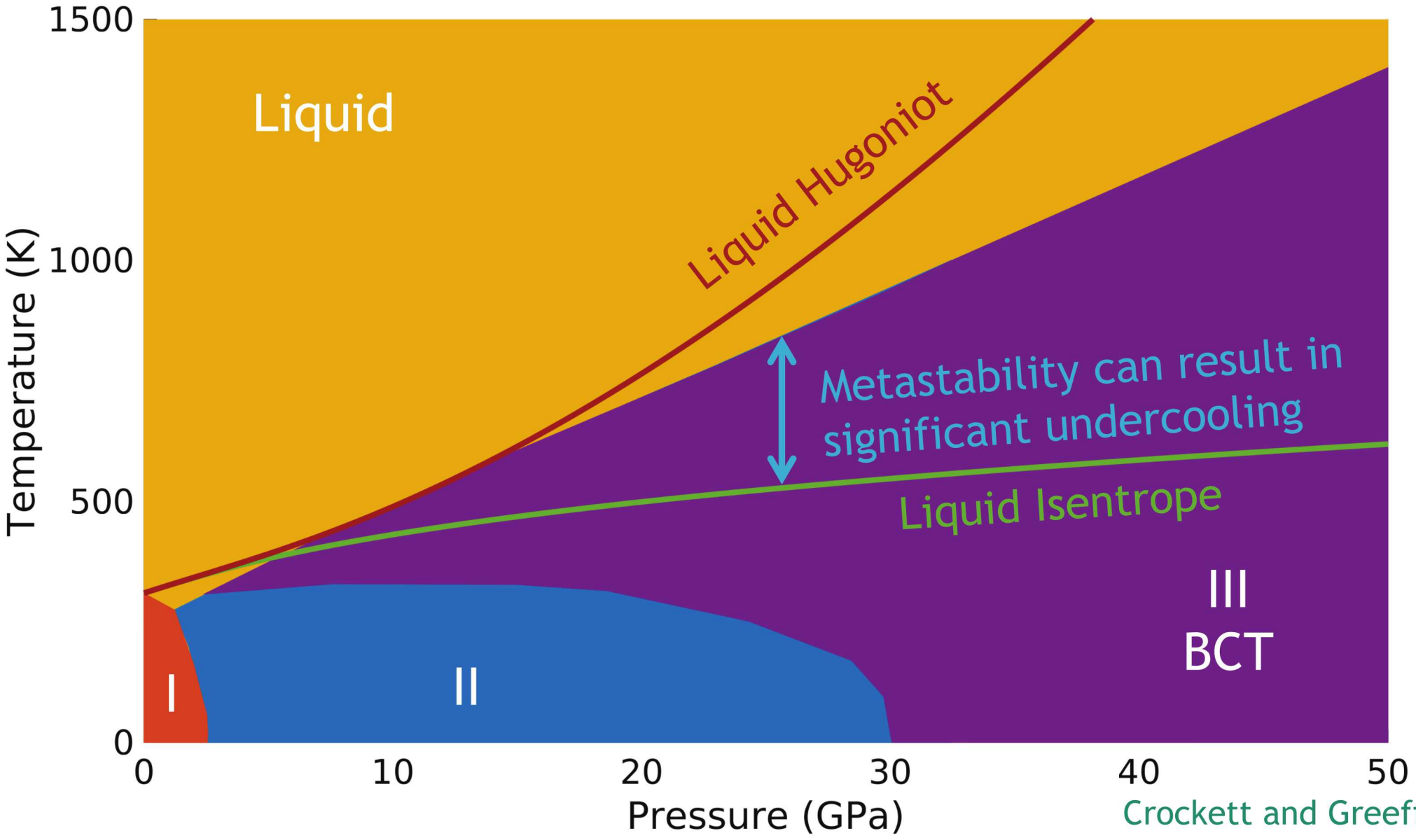


Designed to repeat the loading rate but go to higher pressures

Observed elastic-plastic transition is highly repeatable

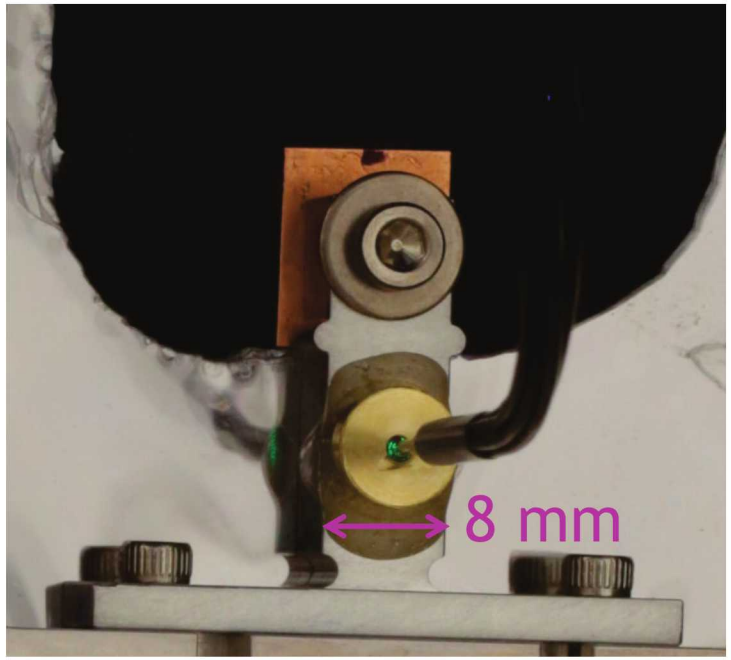
Nothing distinct at higher pressures in <001> and <110> but the behavior near peak is suggestive of something odd happening

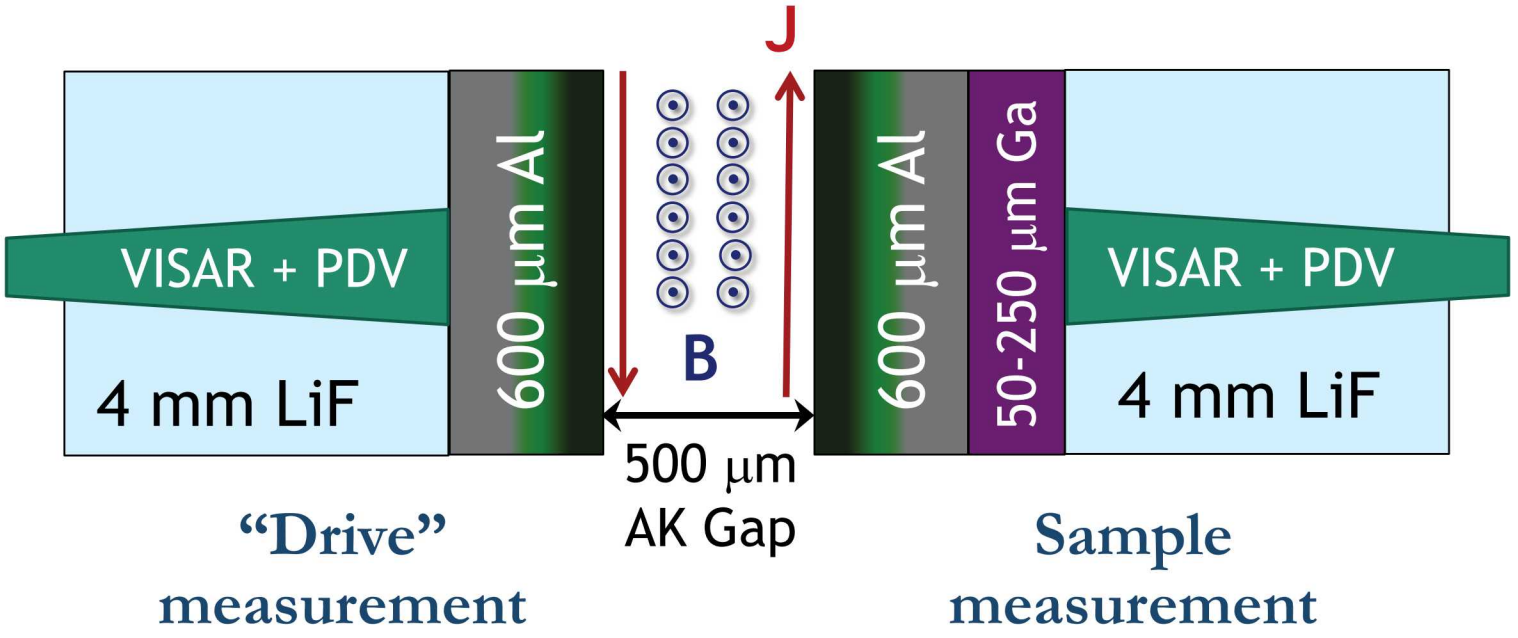
Ga solidification (B. Stoltzfus, J. Belof, P. Myint)



Crockett and Greeff, SCCM, 2009

Experimental configuration is different from typical experiment



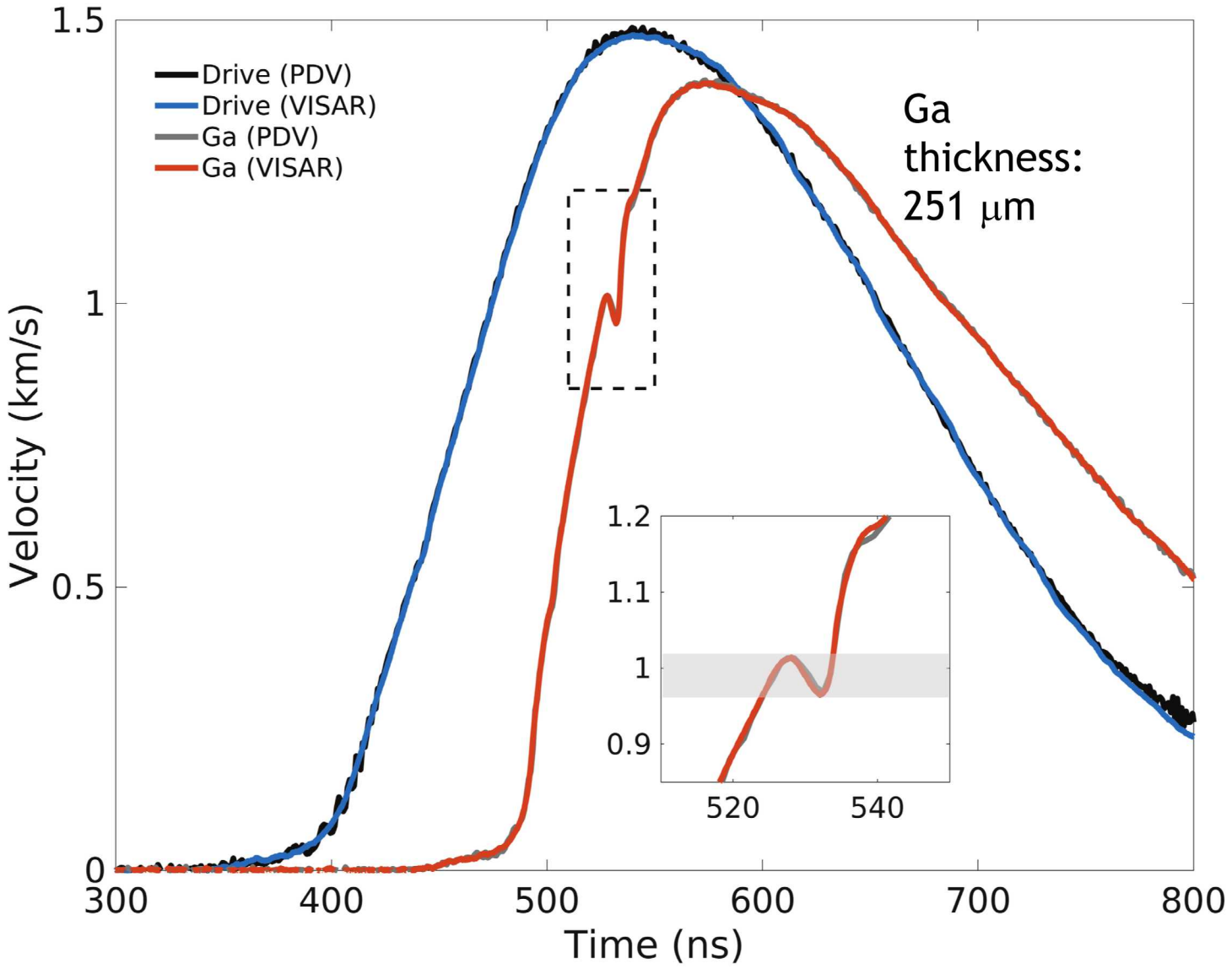


Aluminum electrodes and LiF windows
- Impedance matched for uniform sample loading
- Anodized Al panel to avoid liquid Ga embrittlement
  - Type IIB (<20 μm thick)

Panels heated to ~34°C
- Well controlled initial temperature

Shot variations:
- Current pulse (loading rate and peak pressure)
- Ga sample thickness

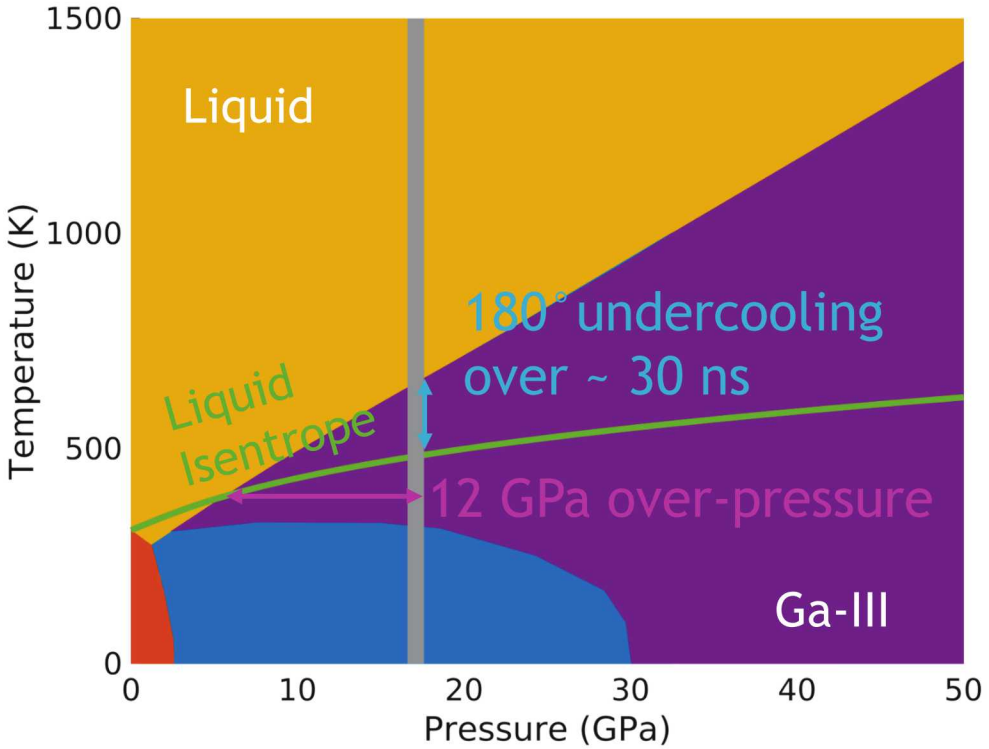
Example of a typical experiment



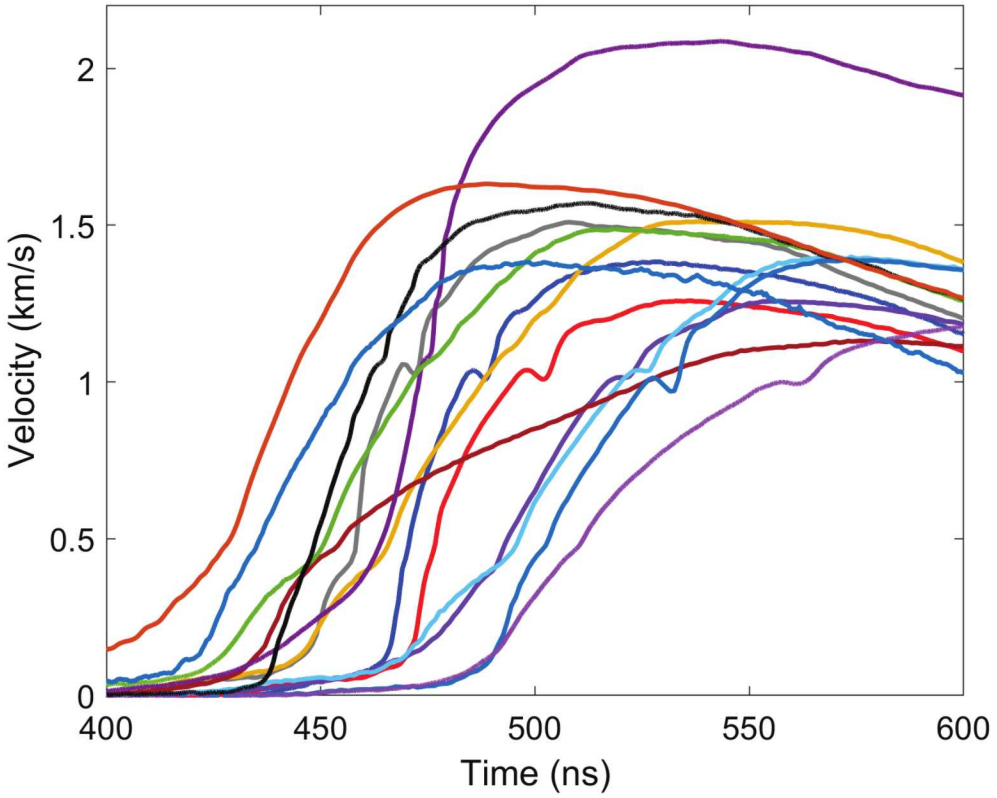
VISAR and PDV agree to within expected errors

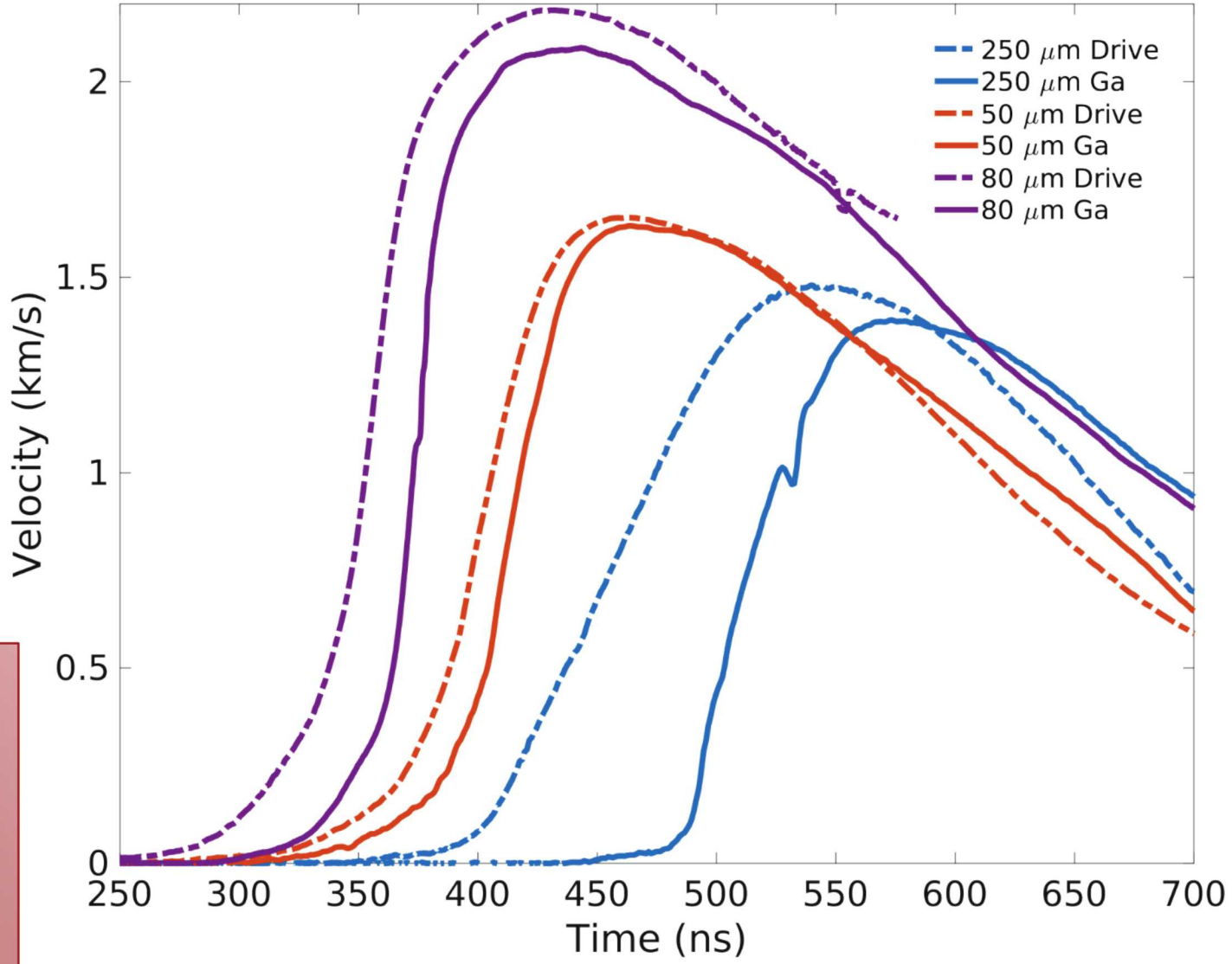
Signature in velocity profile suggests solidification in ~5 ns

No obvious evidence of re-melting on release



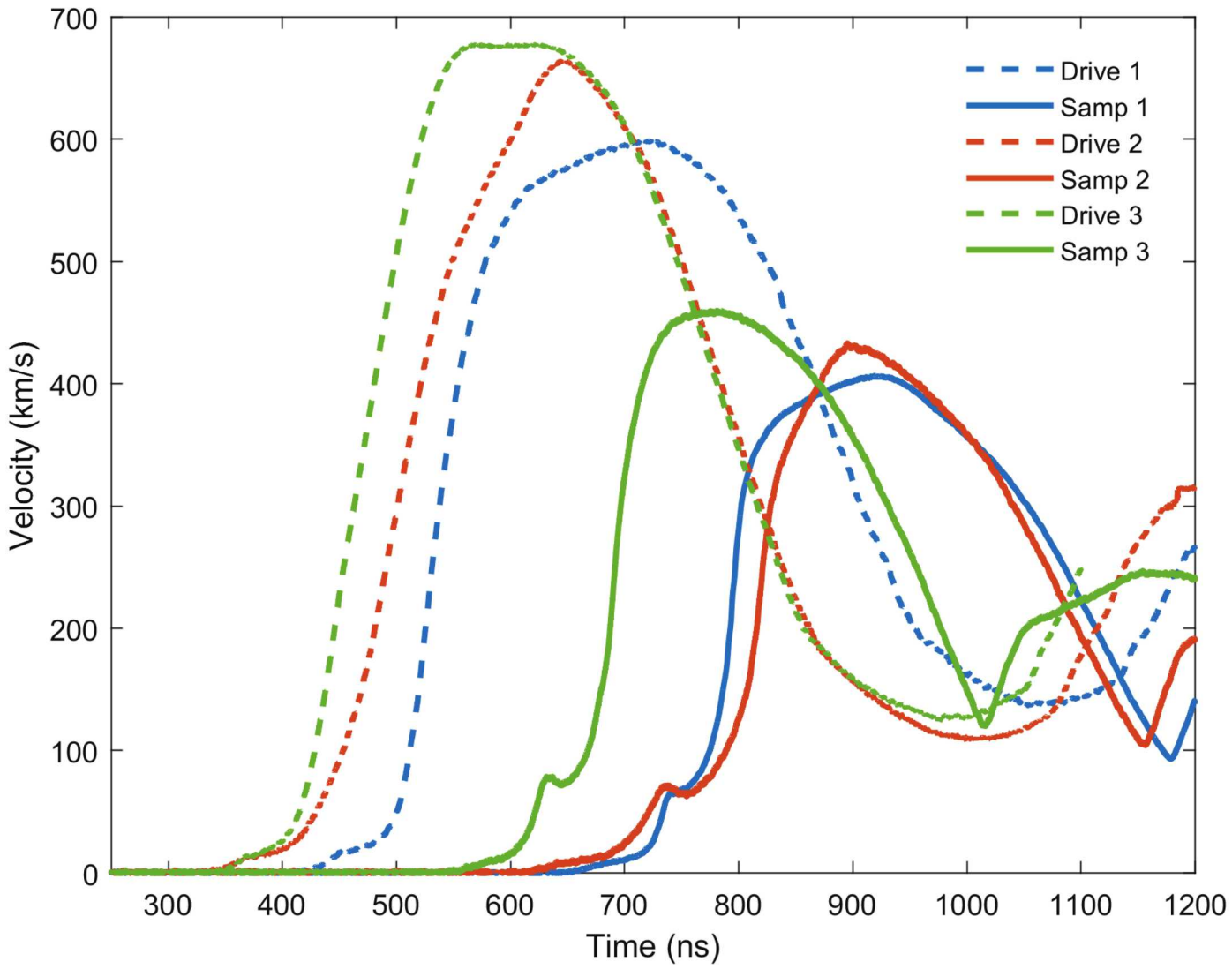
We have conducted 13 experiments which suggest a complicated coupling between the kinetics, cell size, and applied loading

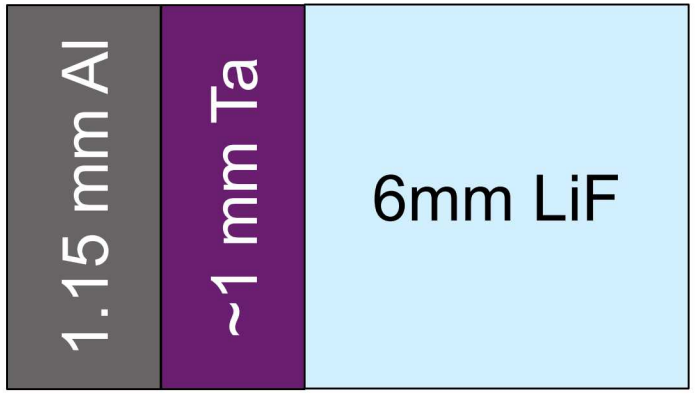




Only through the modeling presented in the next talk have we been able to put together a comprehensive picture of what is happening in these experiments.

Ta strength (tri-lab)



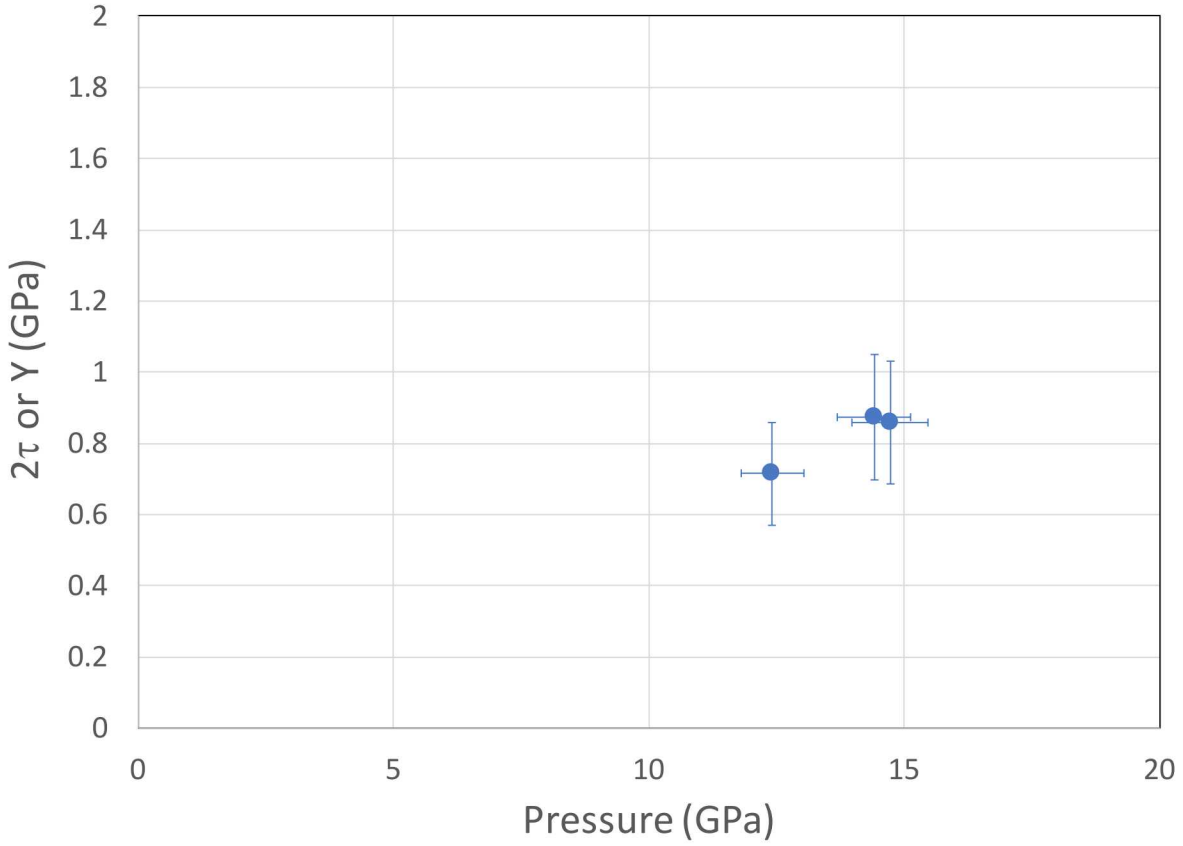


Ramp-release experiments can be used to infer strength near the peak state

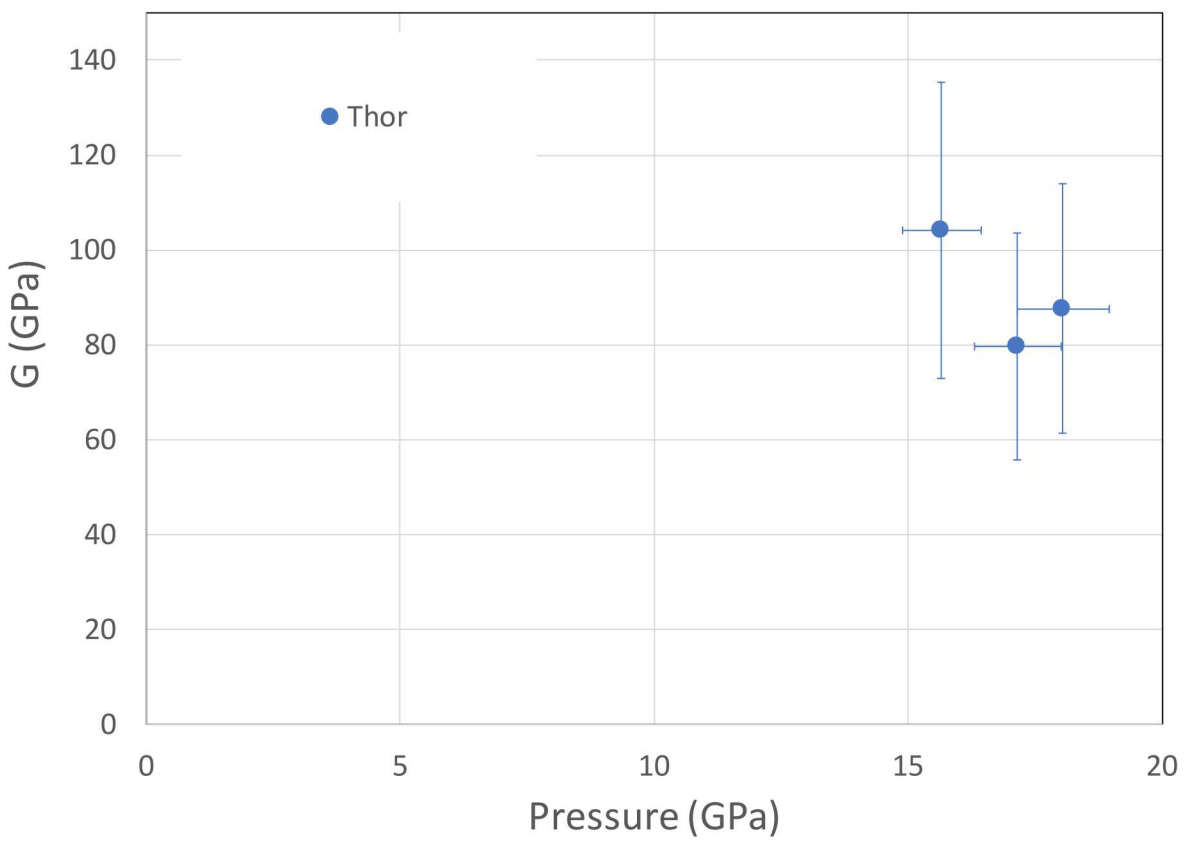
- Conventional wisdom states "flat tops" are required for the most precise estimates

There doesn't appear to be a significant advantage to using flat-tops for strength experiments

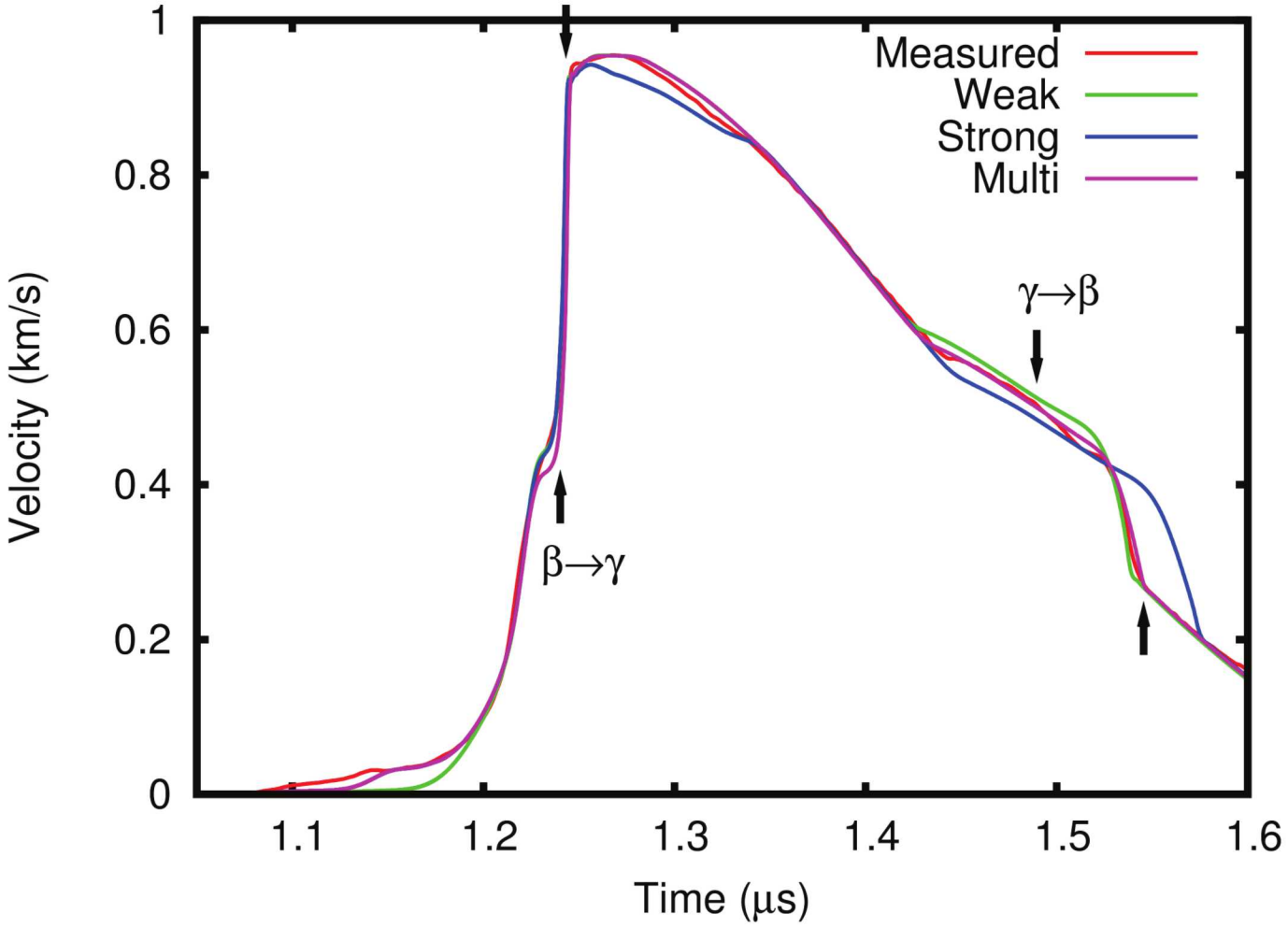
Strength



Shear Modulus



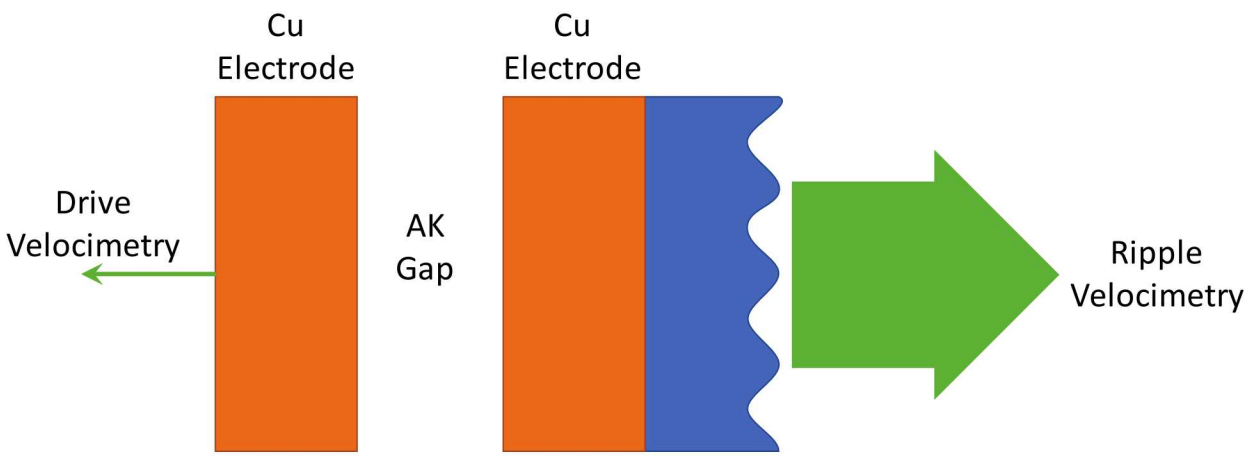
Tin: strength through phase transitions (Tri-lab, J. Carpenter)

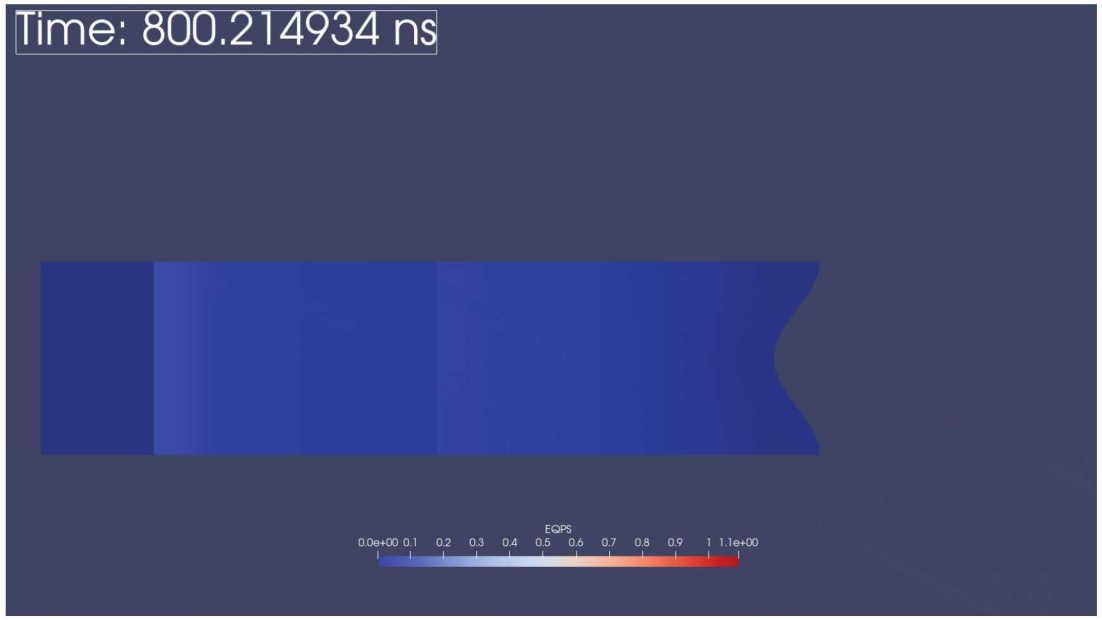


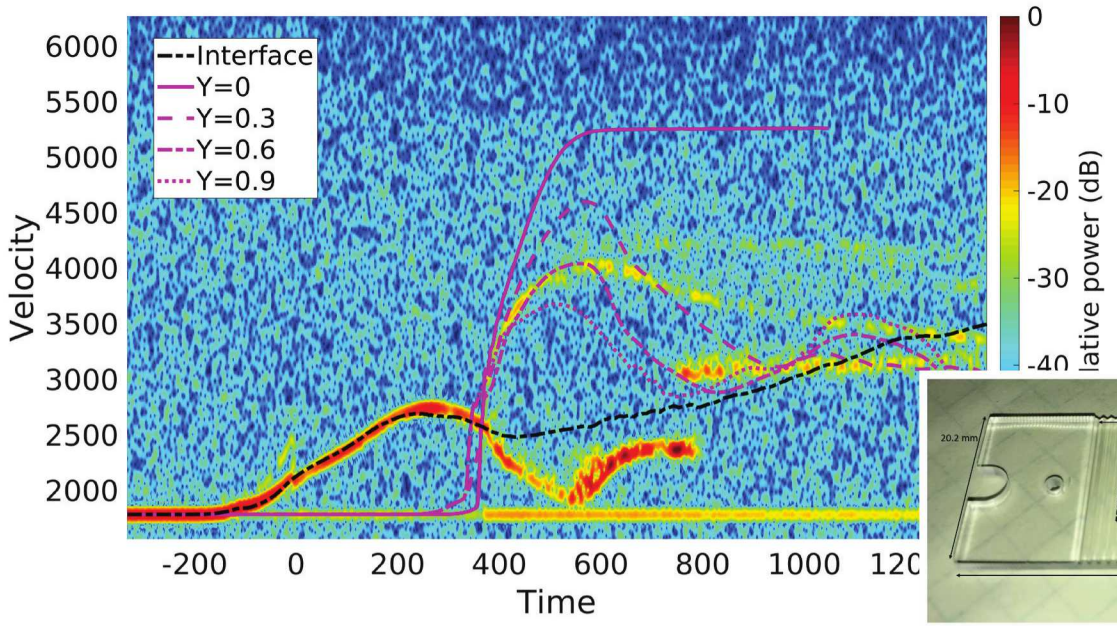
Measured velocity is a combination of EOS, phase transition kinetics, and strength.

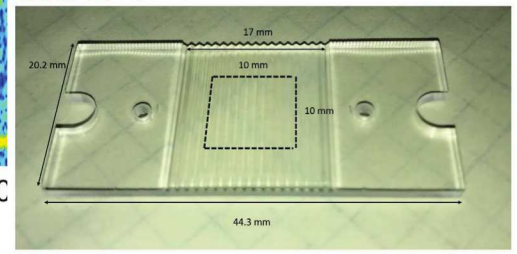
- With different loading rates on Thor we may be able to uniquely identify these different aspects

Rayleigh-Taylor Instability Experiments









Scoping experiments were conducted on PMMA (P. Specht, J. Olles)

- Easy to machine
- PDV sees both electrode and free surface

Conclusions

Unique pulseshaping on Thor has translated to a variety of relevant experiments

- Well suited to studying time-dependence
  - Phase transition kinetics, plasticity, etc.
- In some cases we can study materials of interest directly (Ta, Sn)
- In others, we choose a material with the physics of interest well matched to the driver (Ga)
- We're still innovating!