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NIF and Omega Laser Ramp-Compression EOS on Tantalum

J. Eggert, R. Smith, D. Braun, R. Patterson, P. Celliers, G. Collins, R. Rygg, J. Hawreliak, T. Perry

July 11, 2011

Shock Compression of Condensed Matter
Chicago, IL, United States
June 26, 2011 through July 1, 2011

Disclaimer

HEDP

high energy density physics

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NIF and Omega Laser Ramp-Compression EOS on Tantalum

SCCM, Chicago, July 1, 2011

Jon Eggert,

Ray Smith, Dave Braun, Reed Patterson,
Peter Celliers, Gilbert Collins, Ryan Rygg, Jim Hawreliak
Ted Perry

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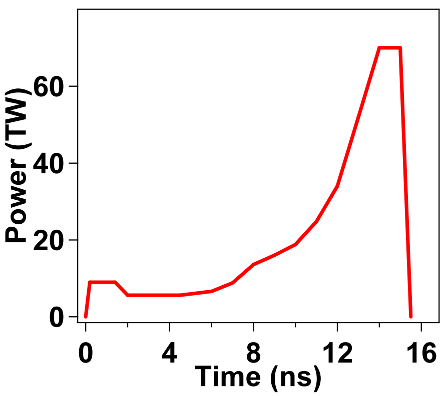
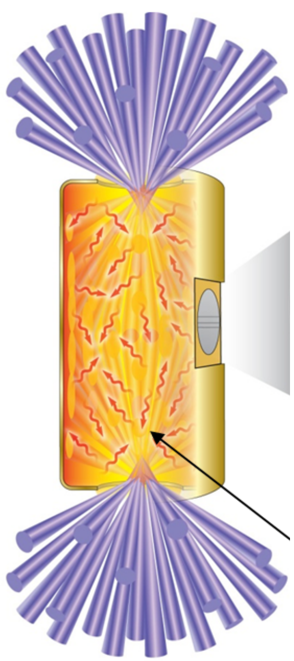
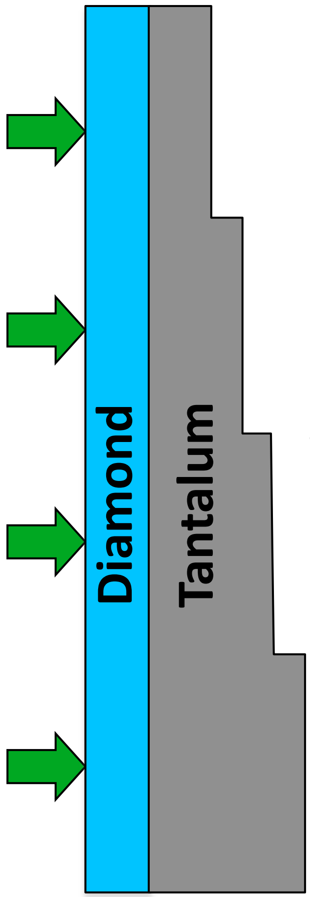
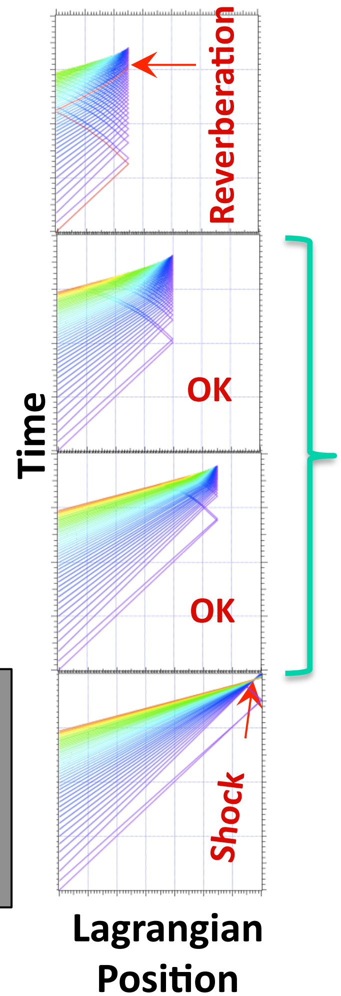
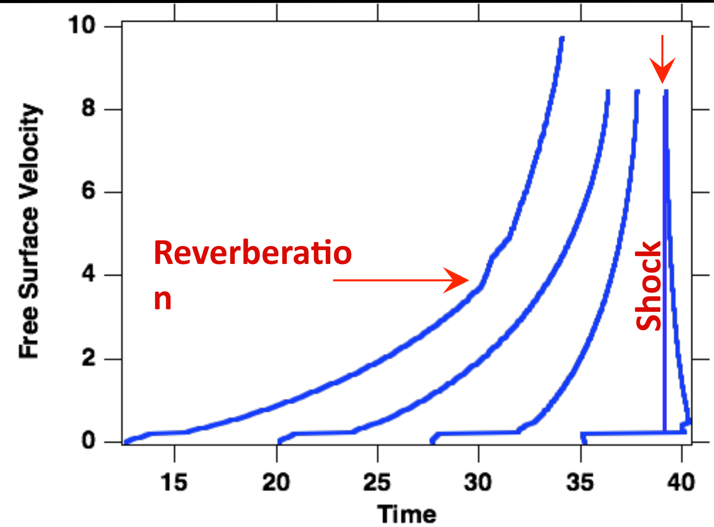
Under ramp loading, EOS (stress-density) can be determined from free-surface velocity measurements







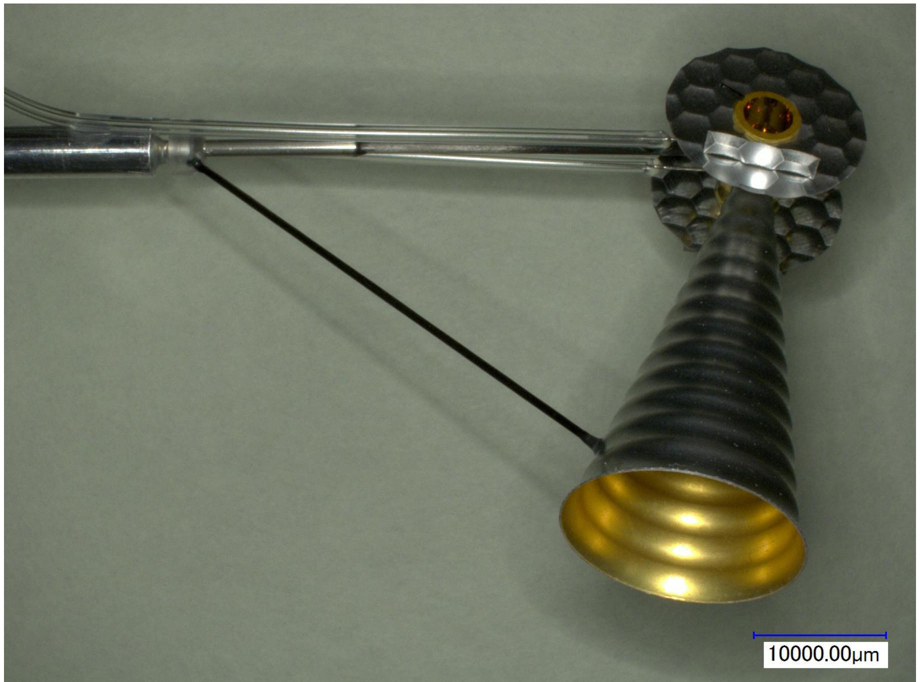


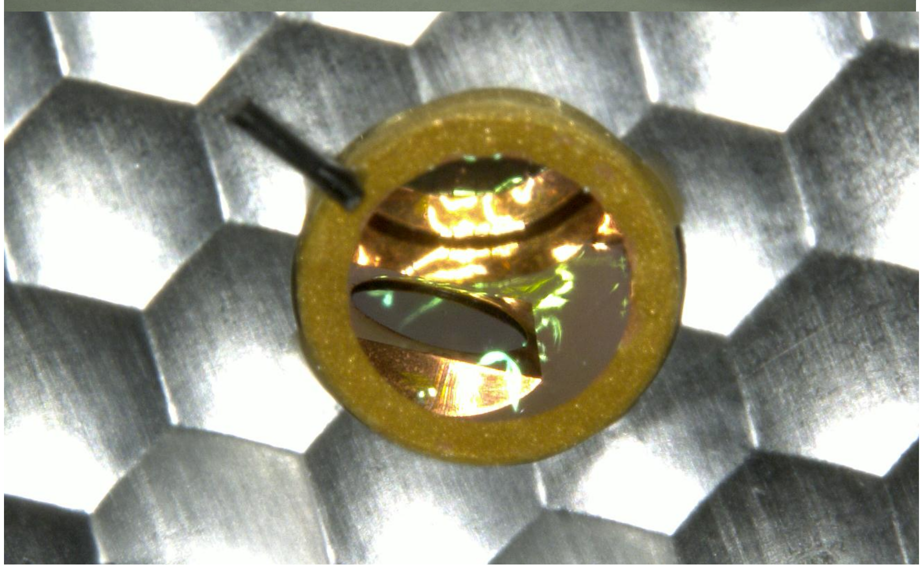


Design constraints:

No reverberation <u>and</u> no shock

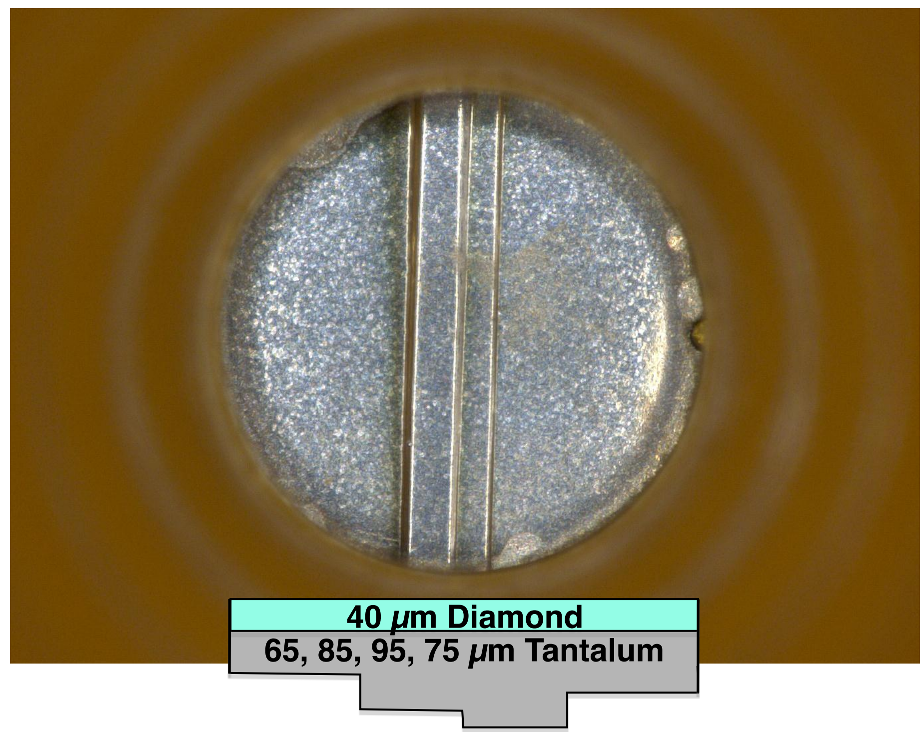
NIF: Materials EOS Drive targets





Gas-filled, room-temperature, stepped target mounted on side of Hohlraum with VISAR cone.

- **0.2 atm. Neopentane gas fill**
- ***L* = 11 mm**
- **ϕ = 6 mm**
- ***LEH* = 4.5 mm.**



Nano-crystalline diamond EOS on NIF

Ramp-compression EOS of nano-crystalline diamond to 50 Mbar.

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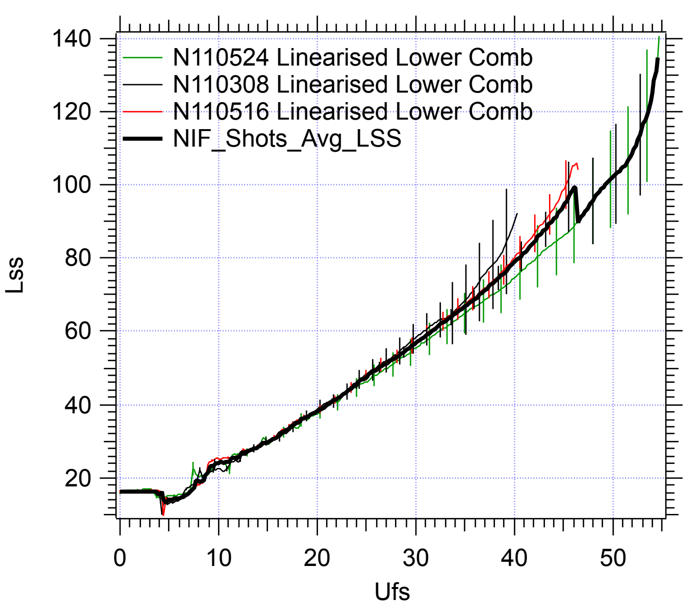
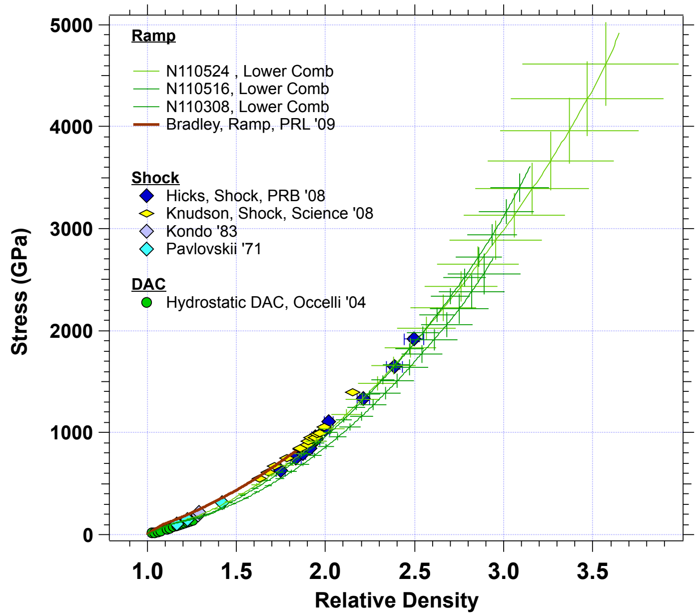
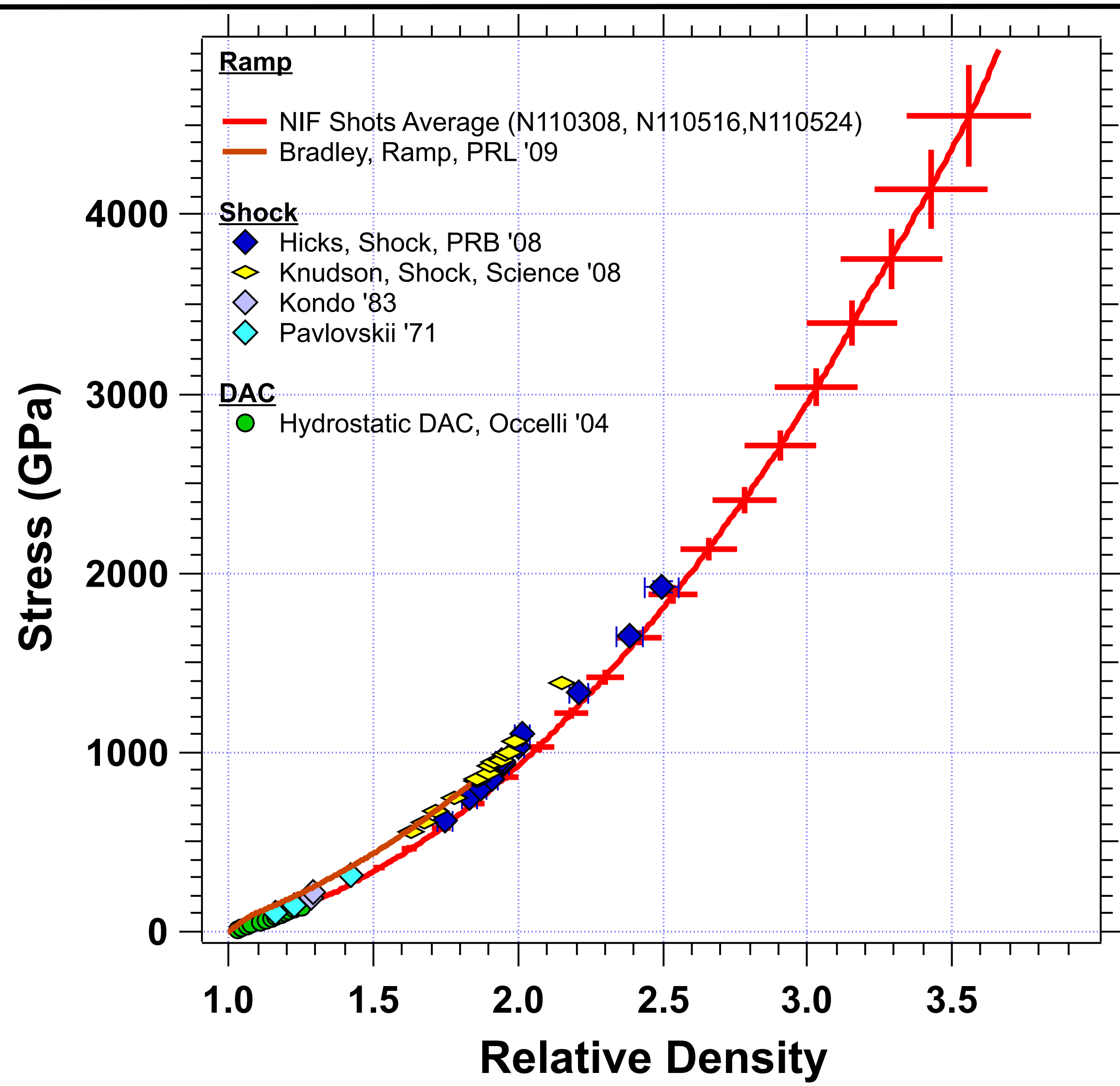


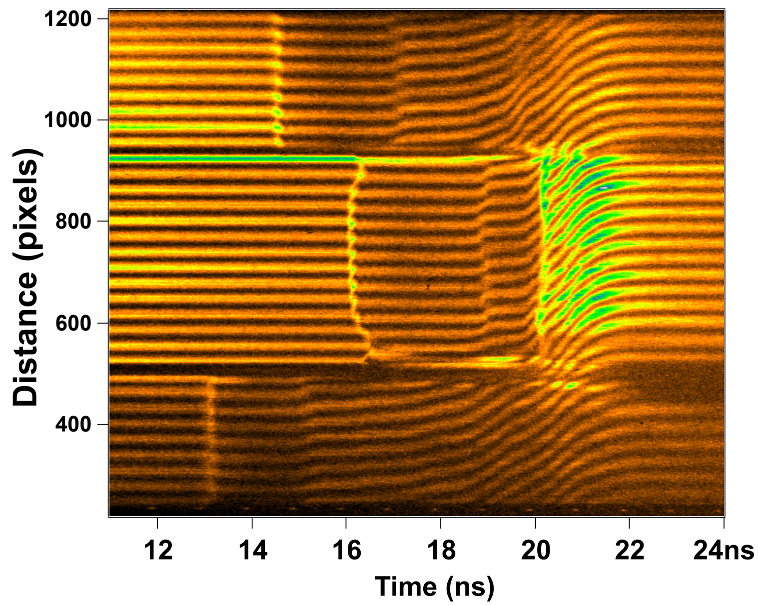


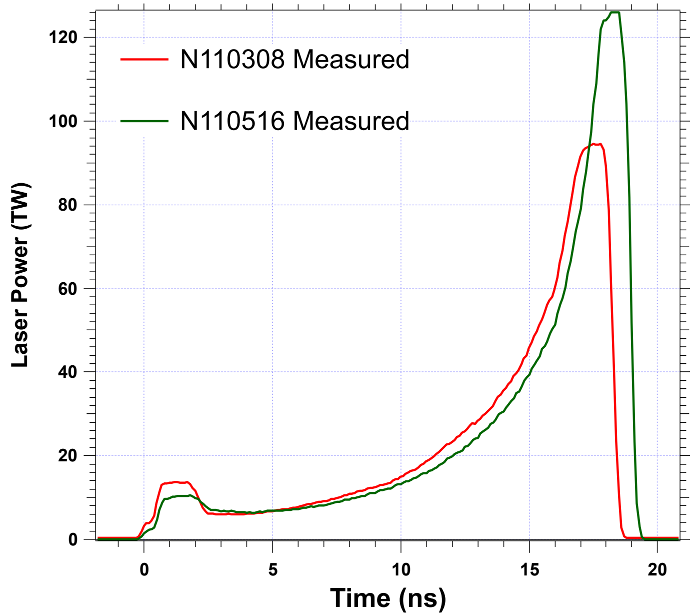


Average of three shots

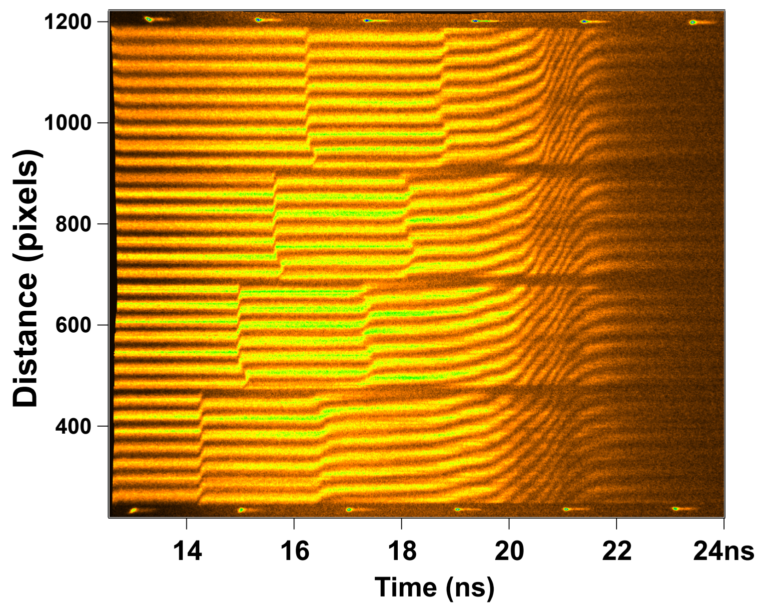
Pulse shaping required very small adjustments to laser-power drive: First two data shots.

27 Mbar
N110308



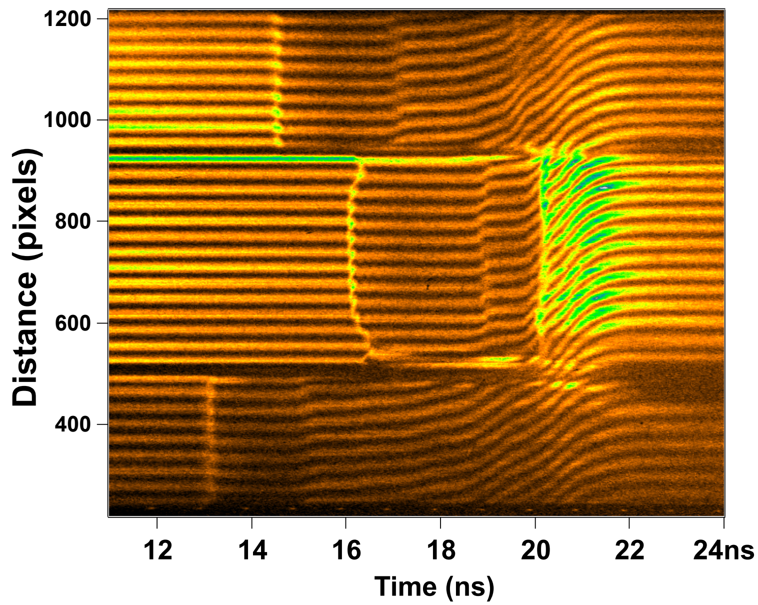


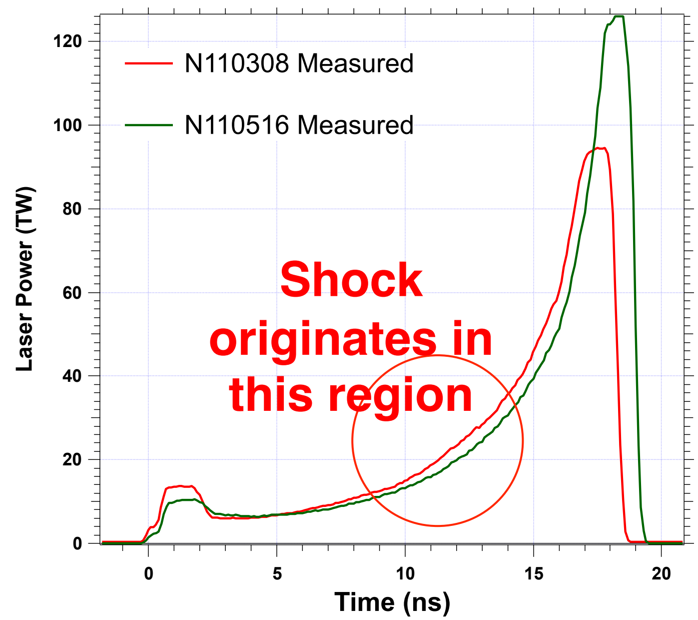
37 Mbar
N110516



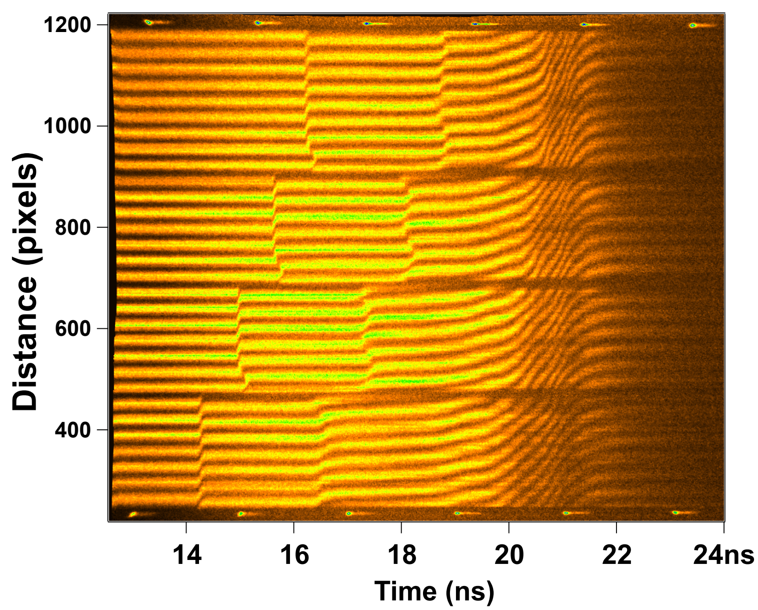
We were able to identify and correct regions responsible for growing shocks.

27 Mbar





37 Mbar



Pulse-shape correction worked extremely well.

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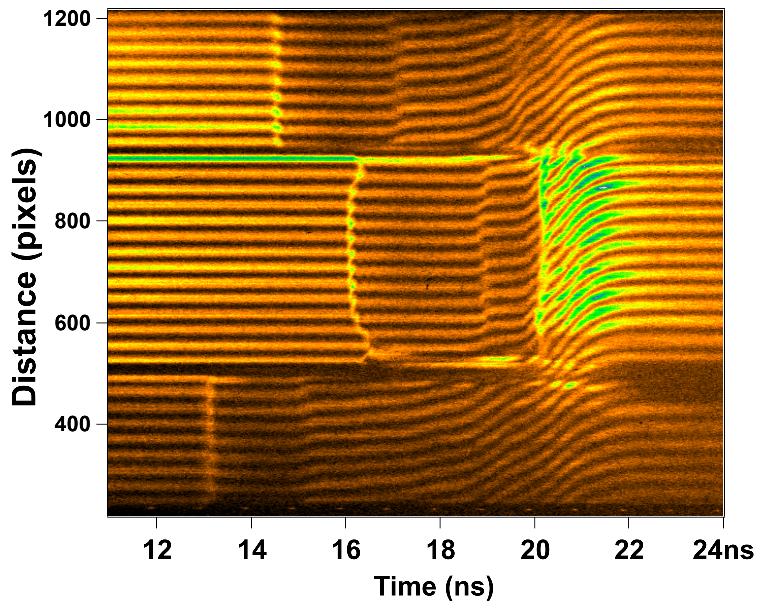
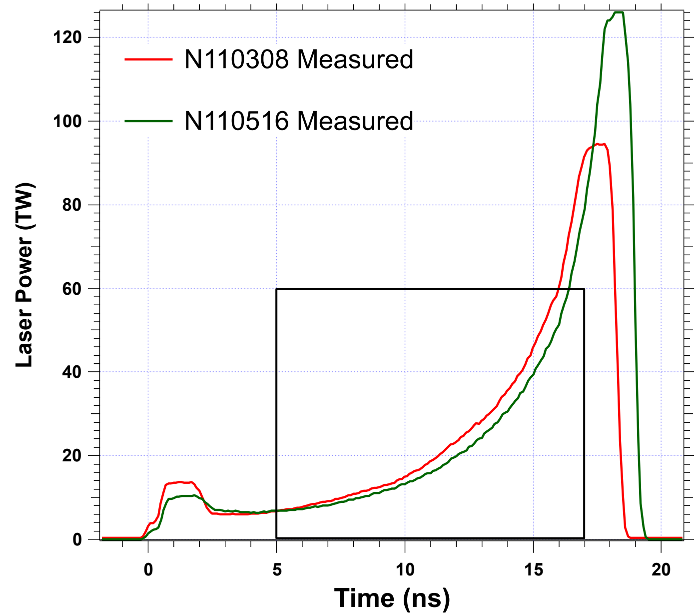
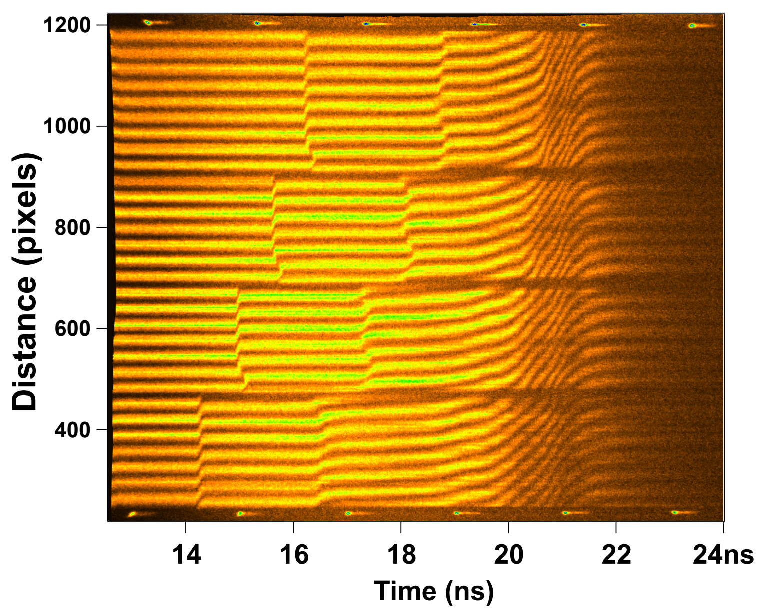
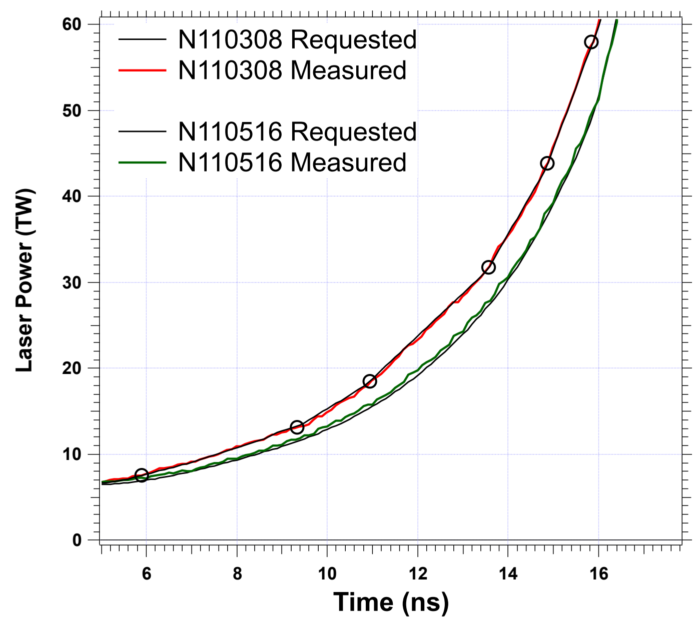
27 Mbar





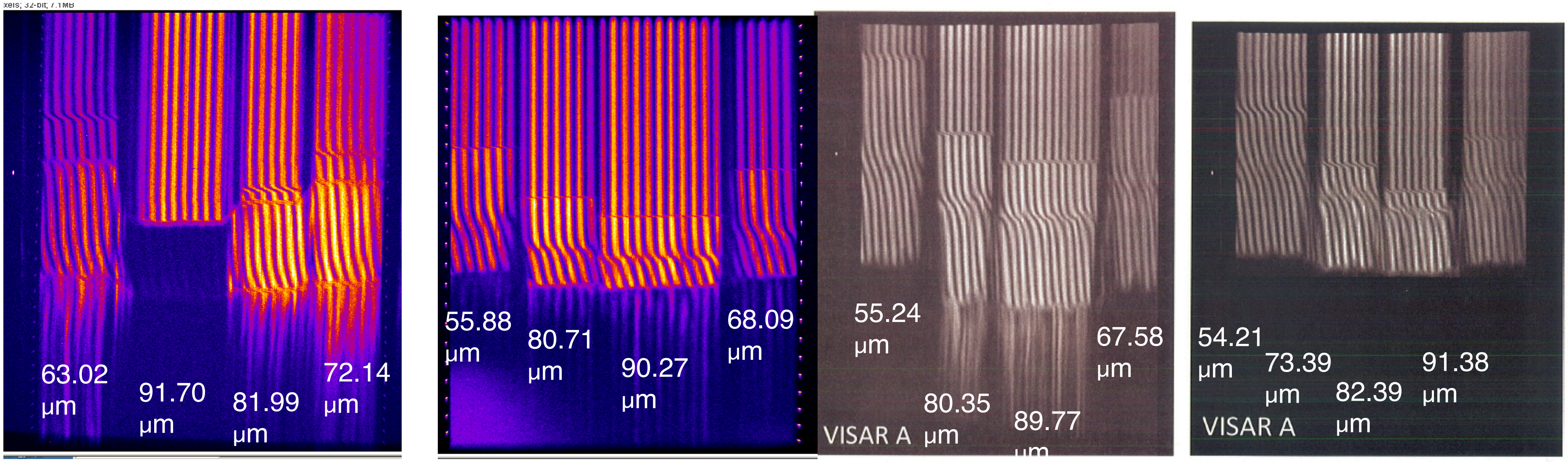
37 Mbar



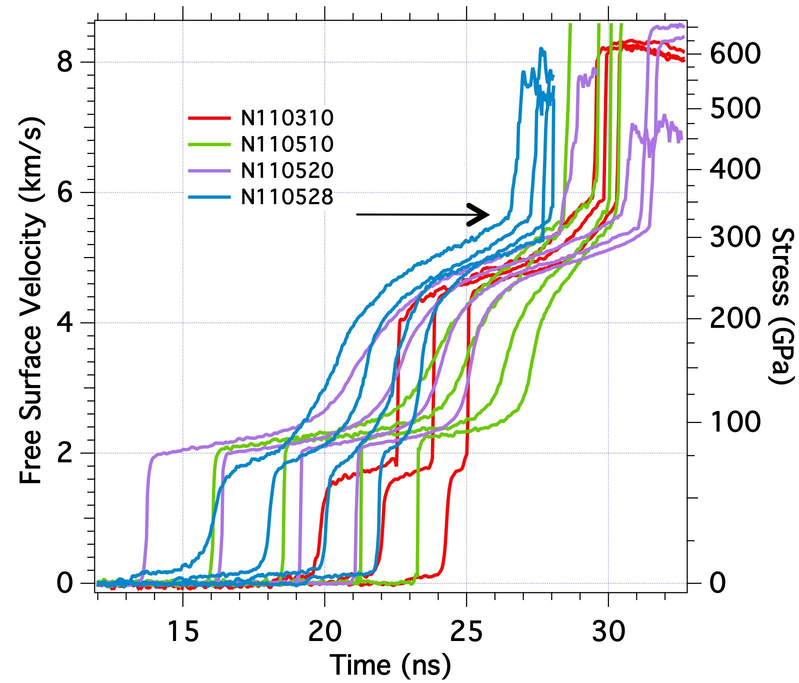


Vapor-deposited tantalum EOS on NIF

Tantalum on the NIF



Shock initiation at ~ 3.4 Mbar repeatedly with minor dependence on sample thickness or drive profile.



For tantalum shock initiation is independent of pressure-drive profile

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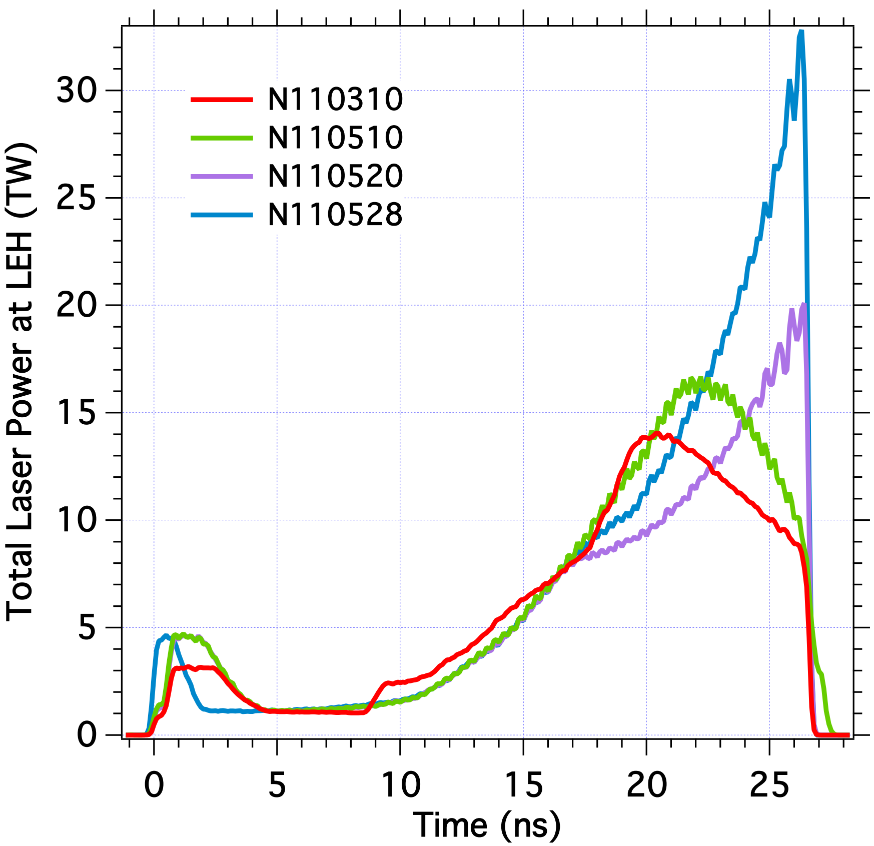
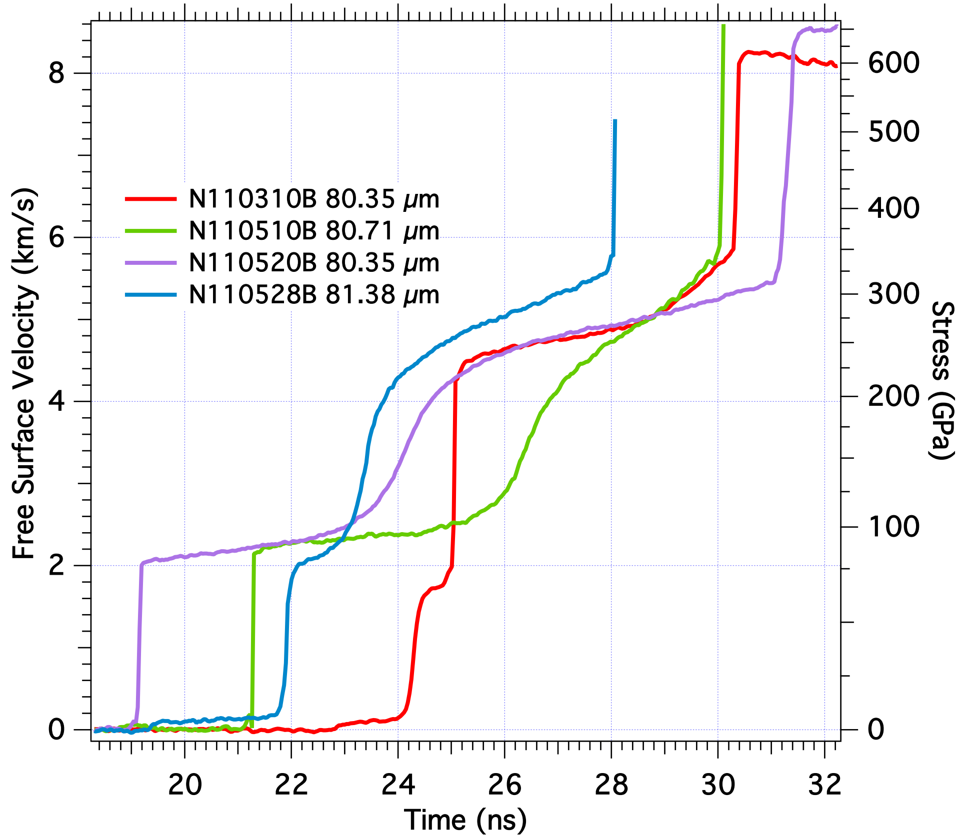
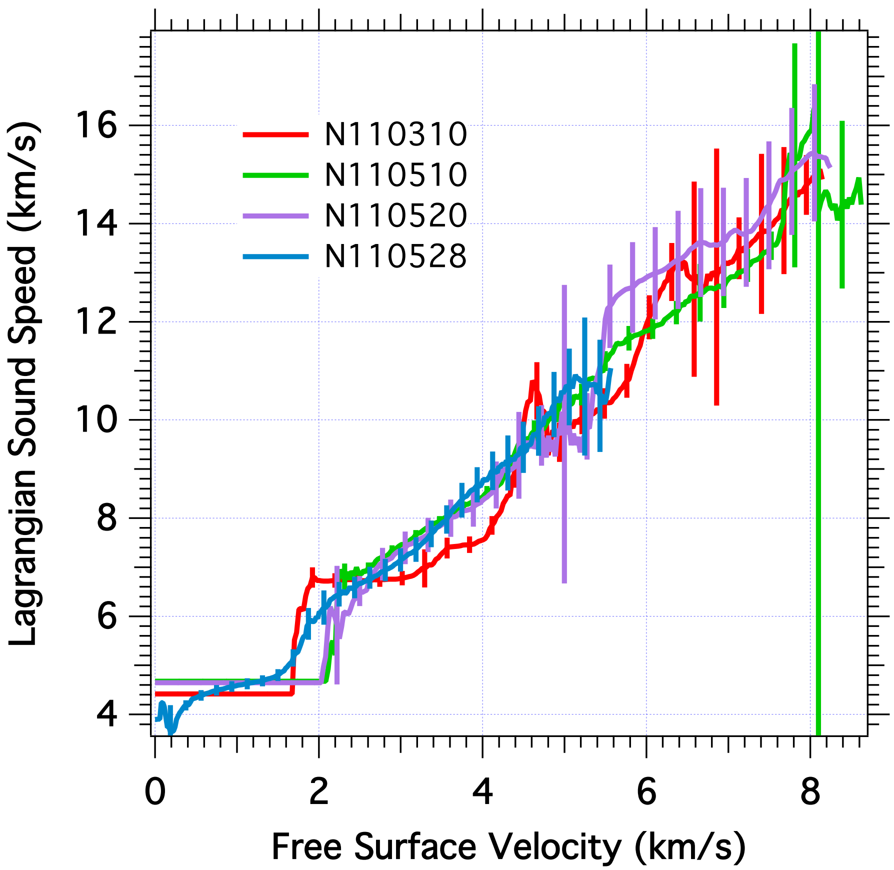
Variation of pressure drive is much larger than was needed for diamond. Shock does not appear due to hydrodynamic steepening.

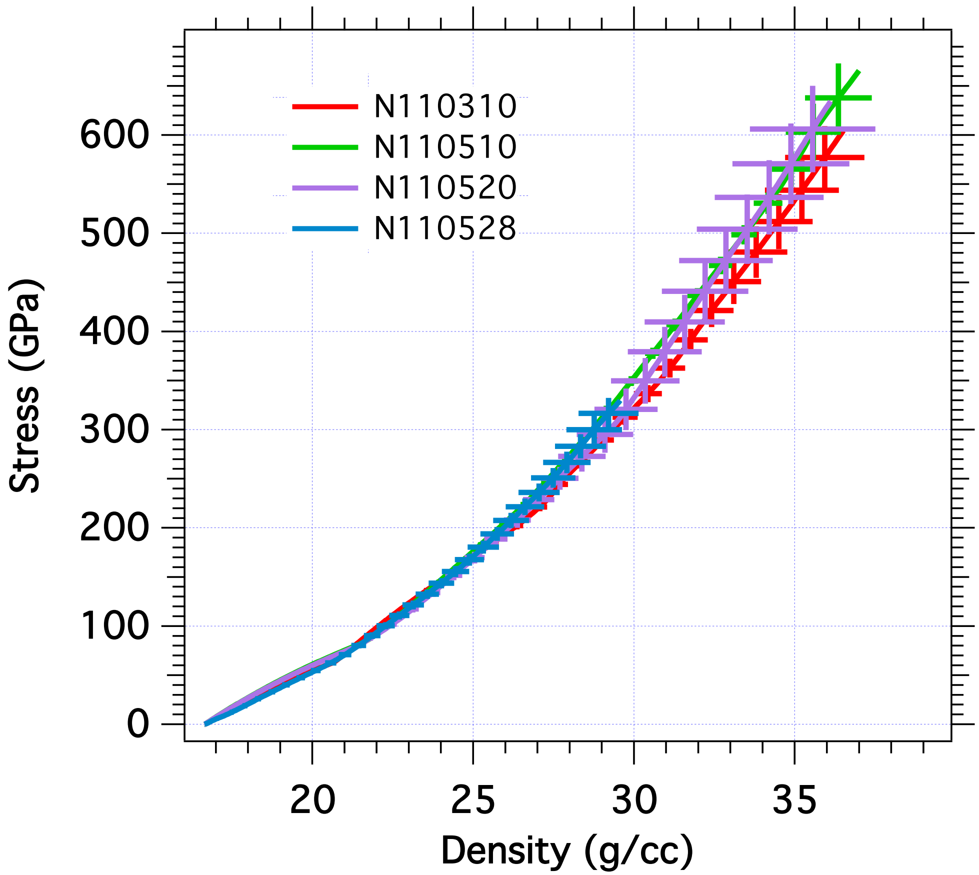




Since the shock was steady, we can extract an EOS to 6.7 Mbar

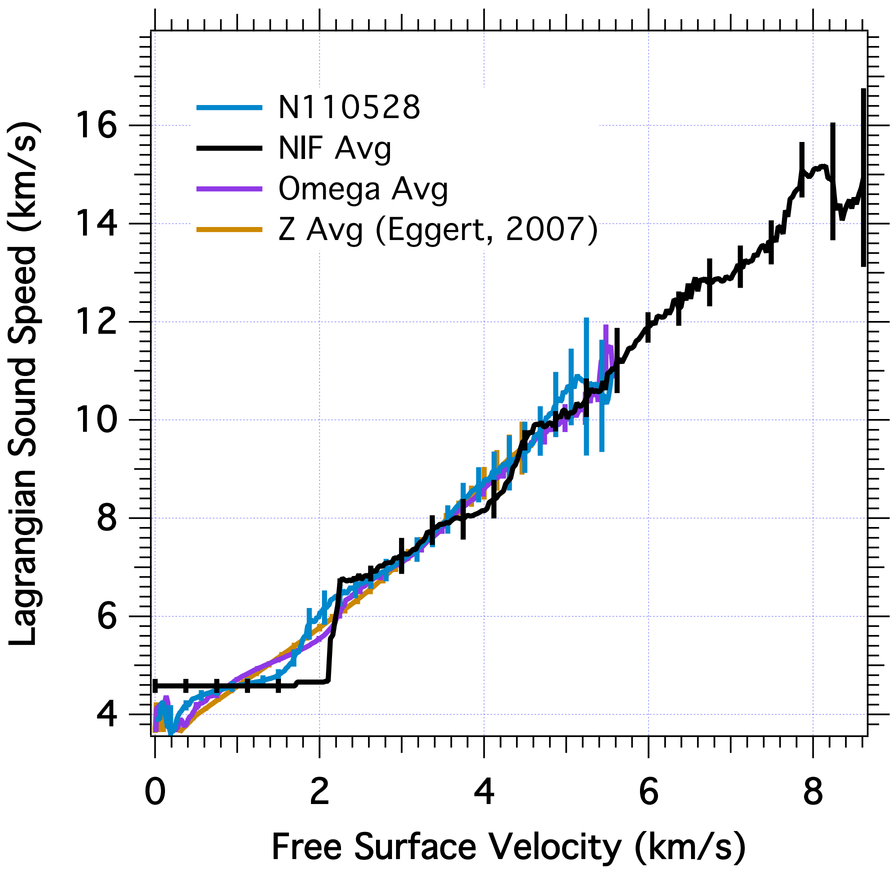
Independent analyses for each shot

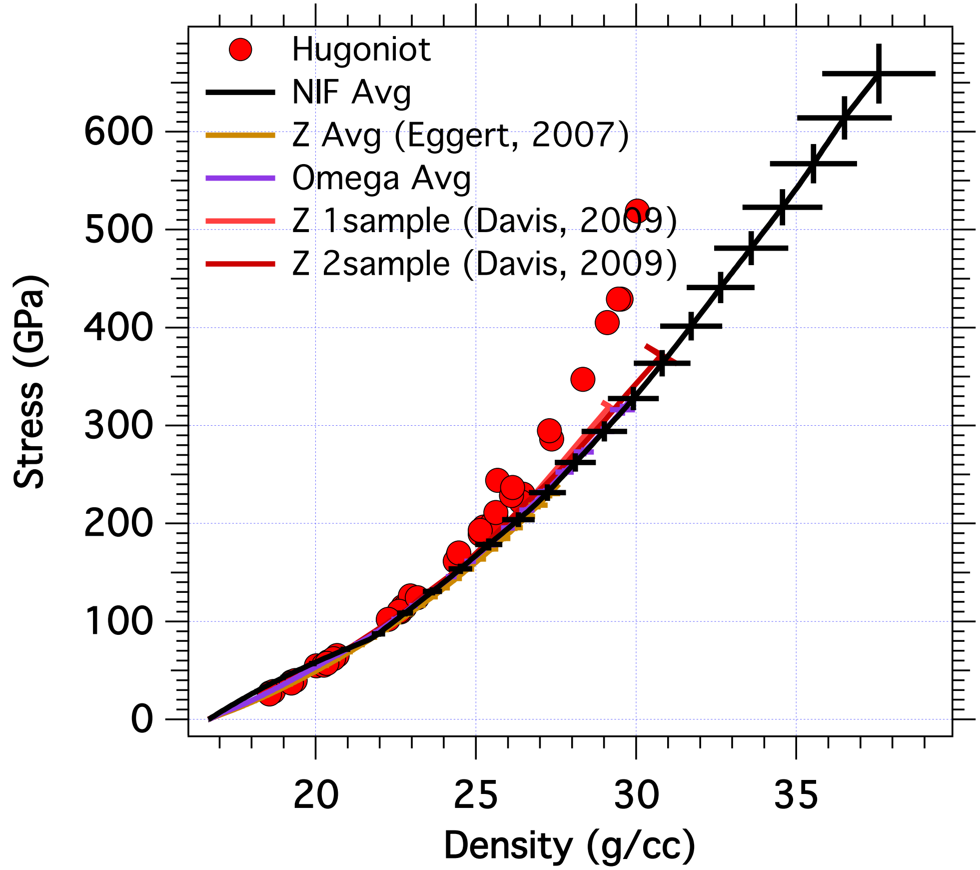




We average the sound speed for multiple shots

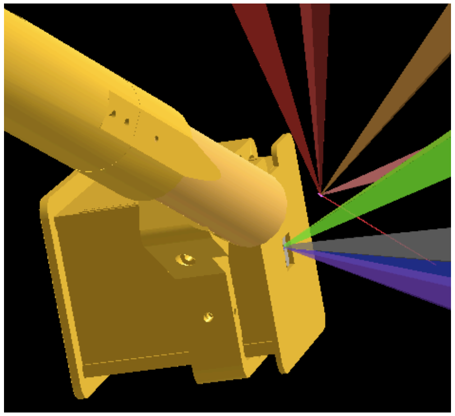
Excellent agreement with previous data from Z and Omega

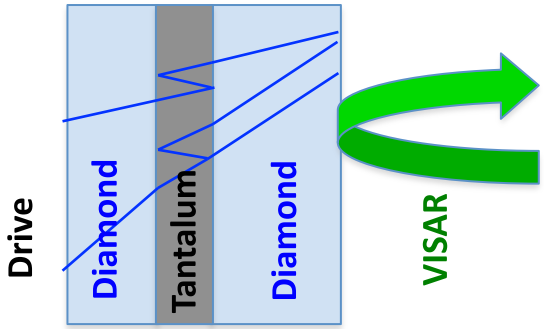




Powder x-ray diffraction of rolled tantalum on Omega

We have also performed high-pressure x-ray diffraction on tantalum at the Omega laser

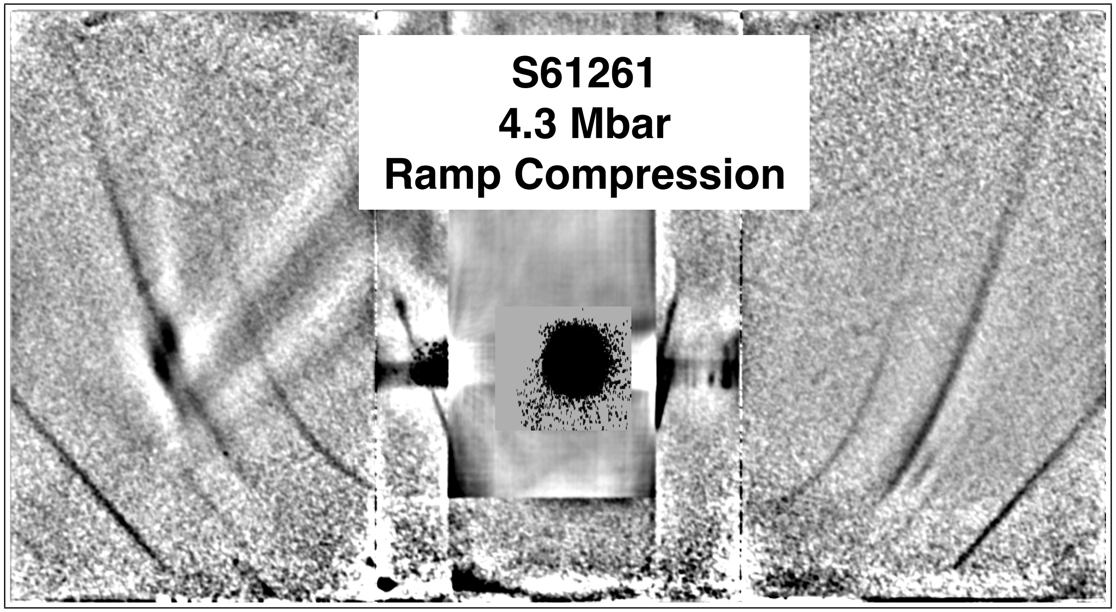


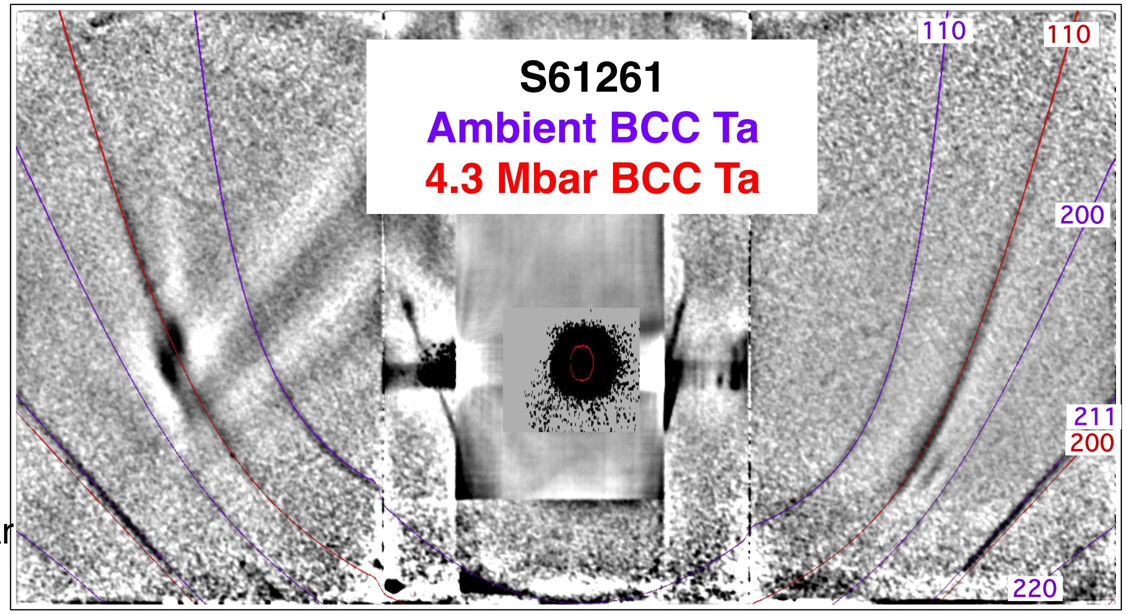


RampDiff-11B (Ta, ramp5)
Shot **61261,** OMEGA 2011-0223

Target: C[17]Ta[3]C[40], **BL: Fe**

Ramp drive: 246 J (t_{BL} = 4.6 ns)
$P_{expected}$: 5.0 Mbar, P_{max_exp} = 4.34±0.09 Mbar





We determine stress by backward integration of diamond free-surface velocity

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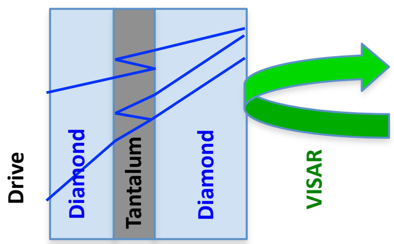
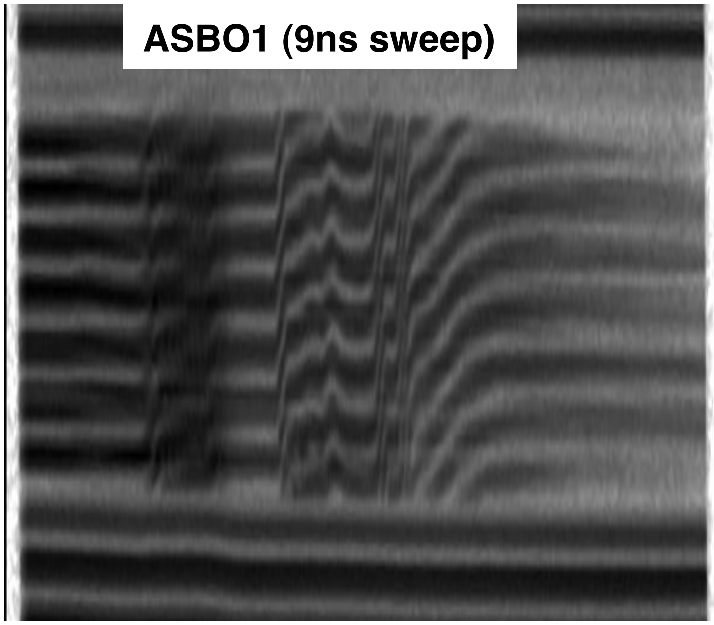
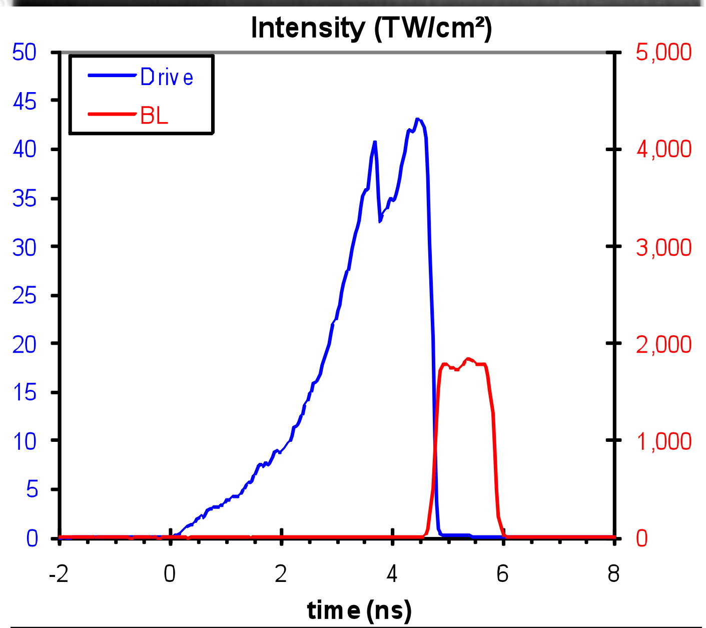
Shot **61261,**
OMEGA 2011-0223

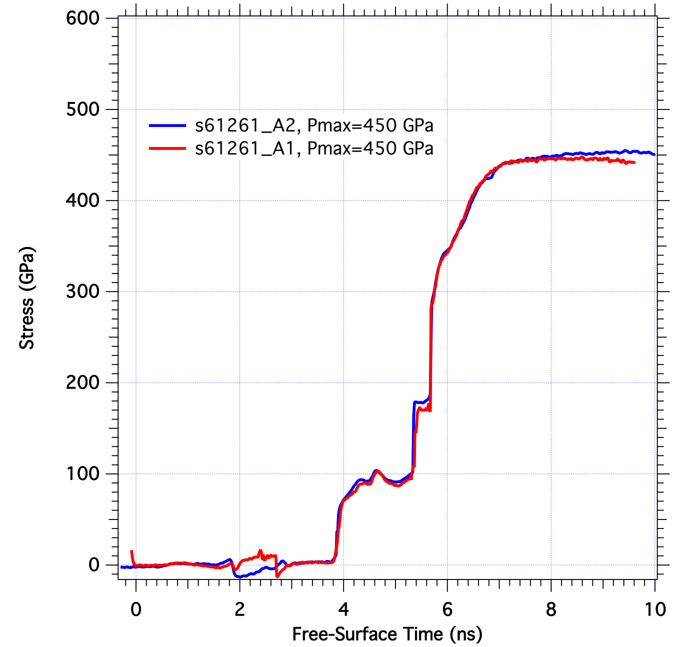
Target: C[17]**Ta**[3]C [40], **BL: Fe**

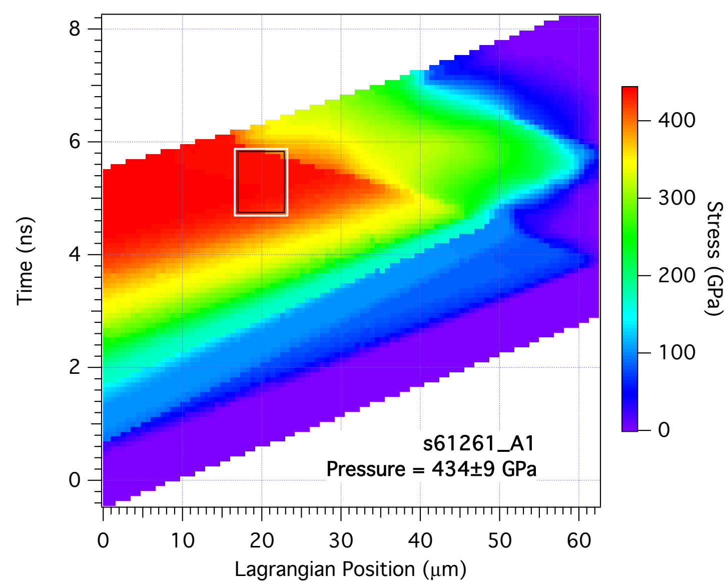




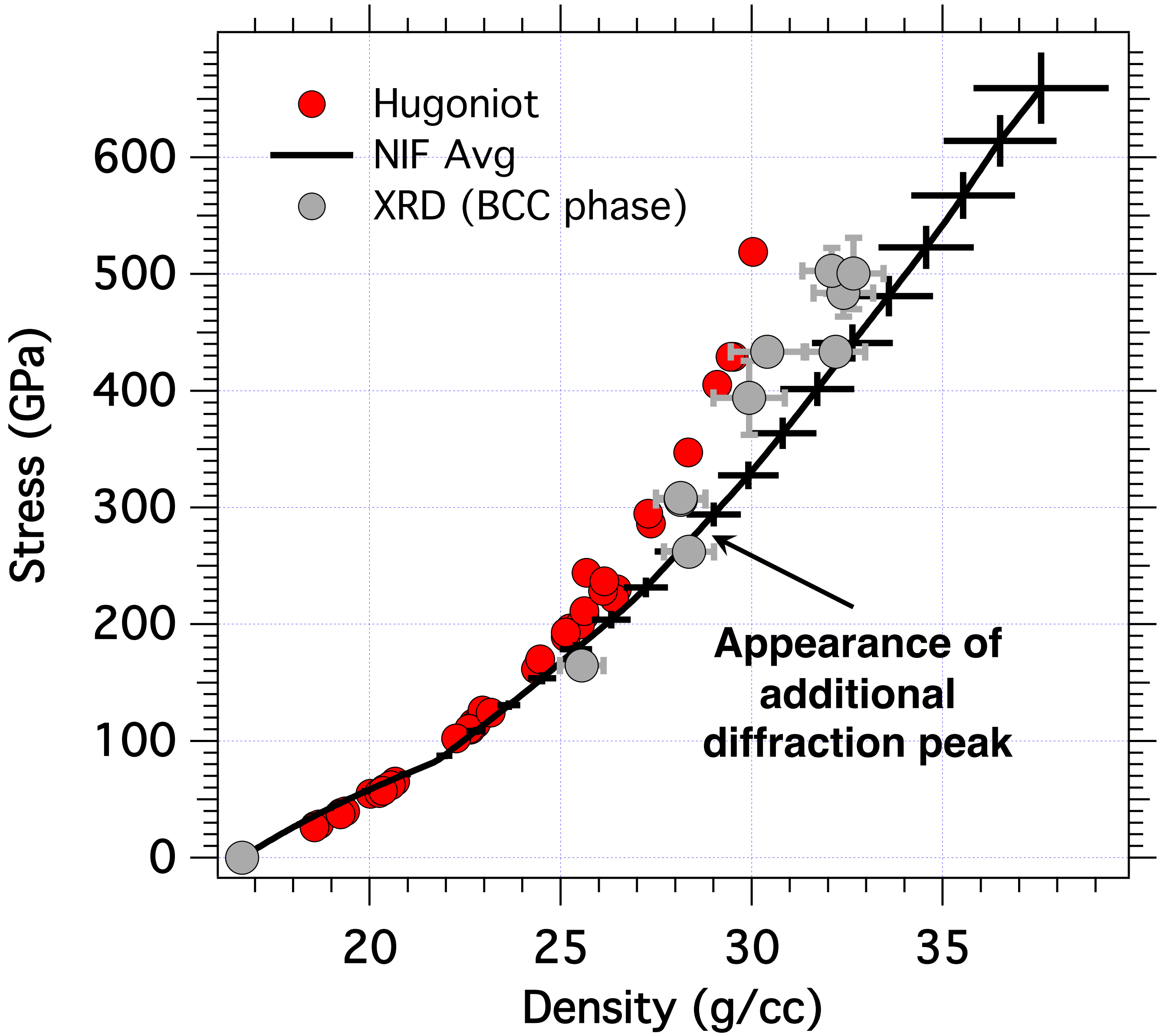
Ramp drive: 246 J
(t_{BL} = 4.6 ns)
P = 4.34±0.09 Mbar



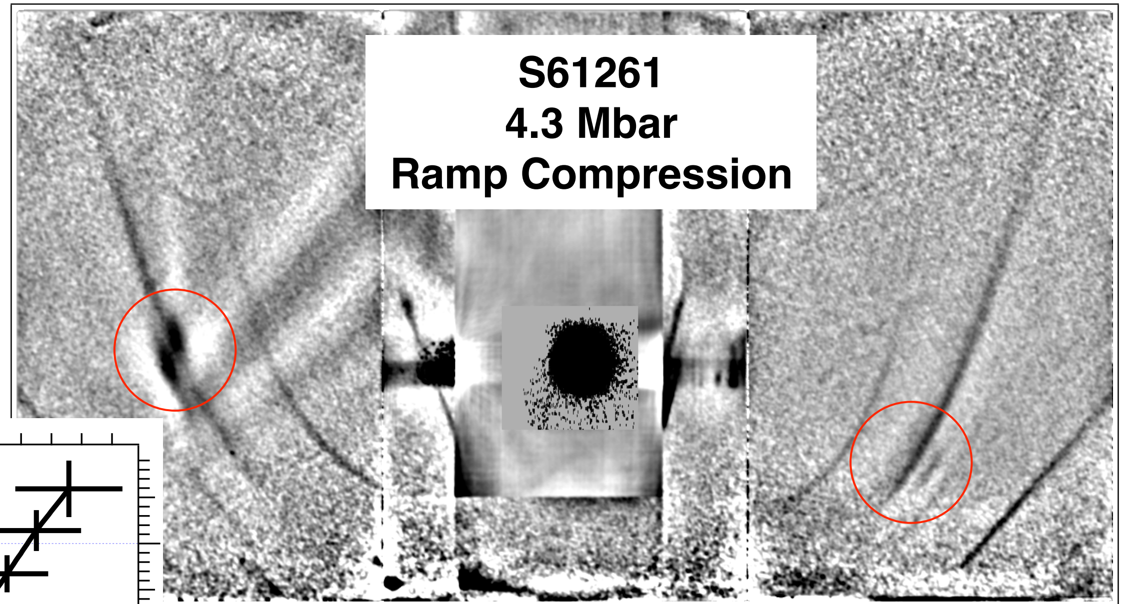


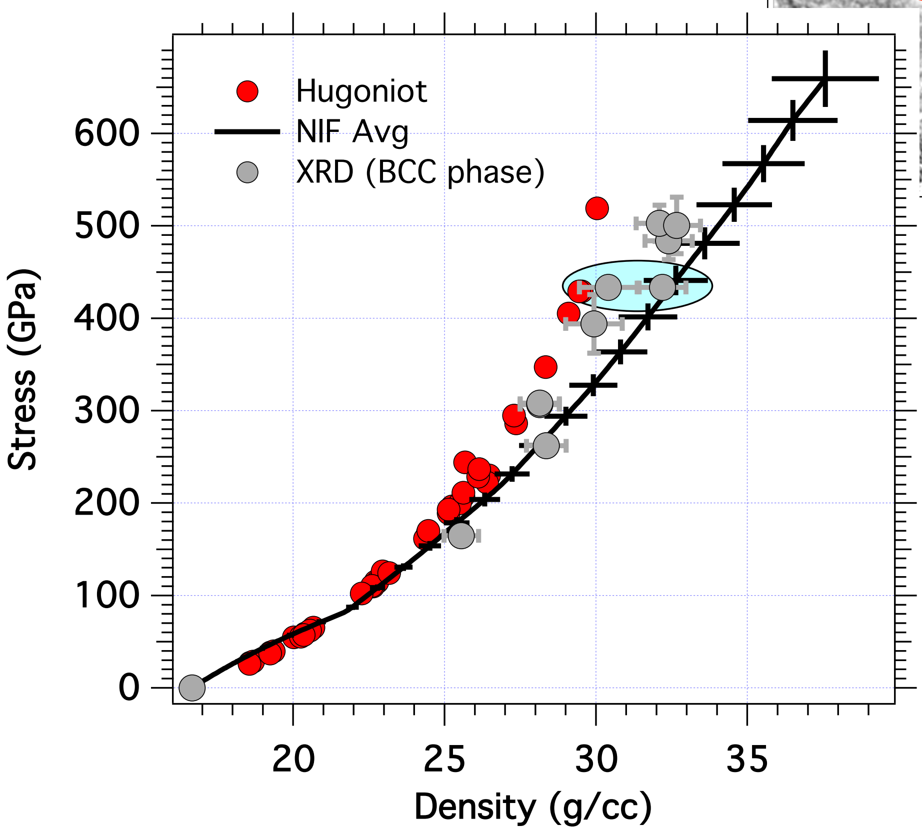


We have measured the (assumed) BCC density for 8 shots.



Diffraction for S61261 can be interpreted as two phase coexistence





A consistent understanding of both the NIF EOS and the Omega diffraction data can be had by positing a Ta phase transition near 3.4 Mbar.

e.g. Burakovski (2010) predict ω-phase.


About 30% of NIF’s capacity was needed to reach 50 Mbar on ramped diamond, and about 8% of capacity to reach 9 Mbar in Ta.
We need to continue to develop experimental techniques for this regime.