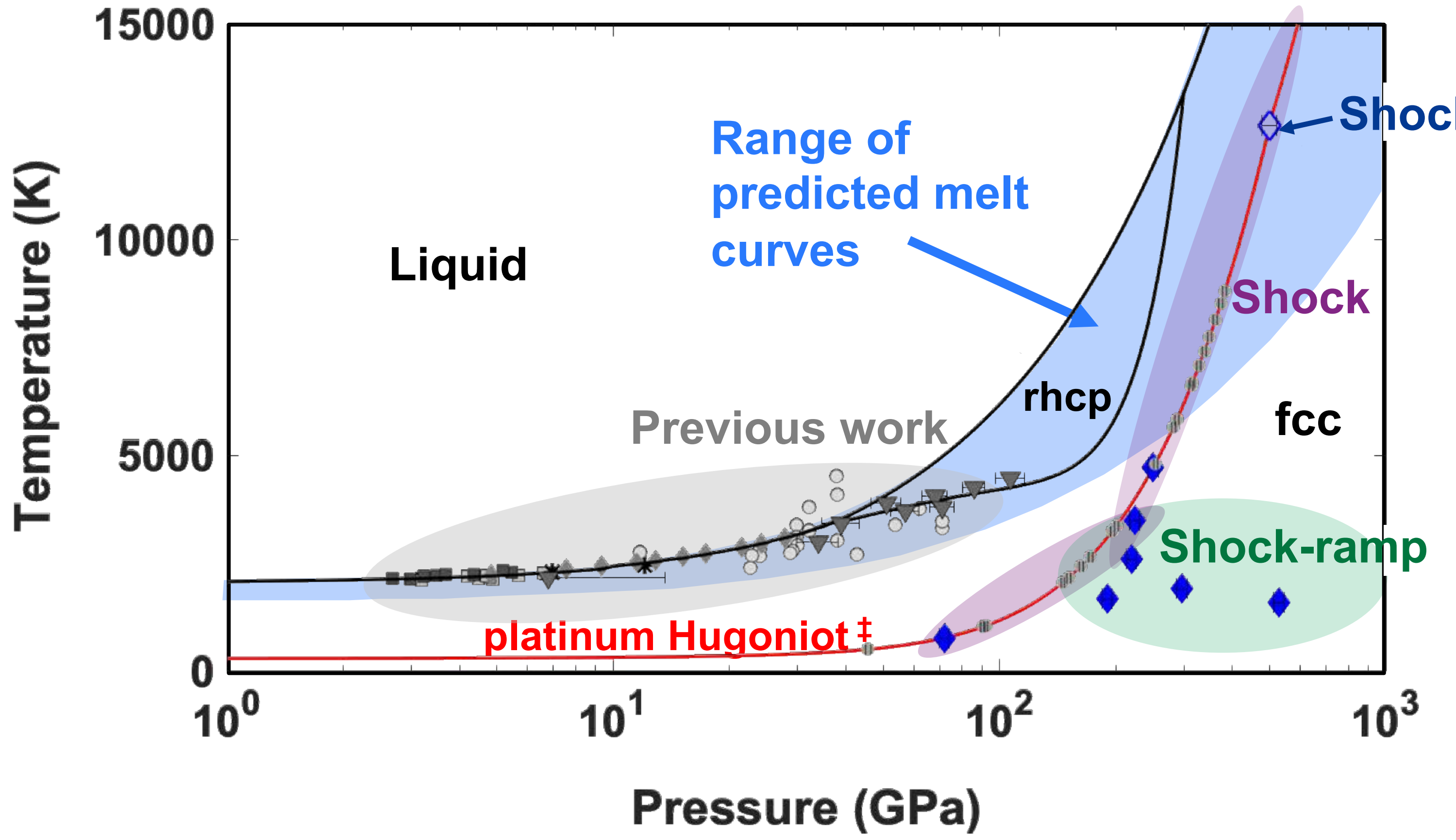
X-ray diffraction measurements of shocked and shock-ramped platinum



M. K. Ginnane
University of Rochester
Laboratory for Laser Energetics

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Division of Plasma Physics
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Collaborators

D. N. Polsin, X. Gong, M. C. Marshall, T. R. Boehly, J. R. Rygg, G. W. Collins

University of Rochester
Laboratory for Laser Energetics

A. Lazicki, R. Kraus, J. H. Eggert, D. E. Fratanduono

Lawrence Livermore National Laboratory

J.-P. Davis, C. A. McCoy, C. Seagle, S. Root

Sandia National Laboratories

Summary

X-ray diffraction is used to measure the phases and constrain the melt curve of Pt shock- and ramp- compressed to ~500 GPa

- **We investigate both a predicted phase transition and the melt curve of platinum**
- **Pt remains in the face-centered cubic (fcc) phase when ramp compressed to 530 GPa (with initial shocks between 72 – 250 GPa)**
- **The melt line is constrained with an observation of liquid platinum at 490 GPa on the principal Hugoniot**

Work shown on title slide:
S. Crockett, LANL
L. Burakovsky, *et al*., *J. Phys.*: Conf. Ser. 500 162001 (2014)
H. M. Strong and F. P. Bundy, Phys. Rev. 115, 278 (1959).
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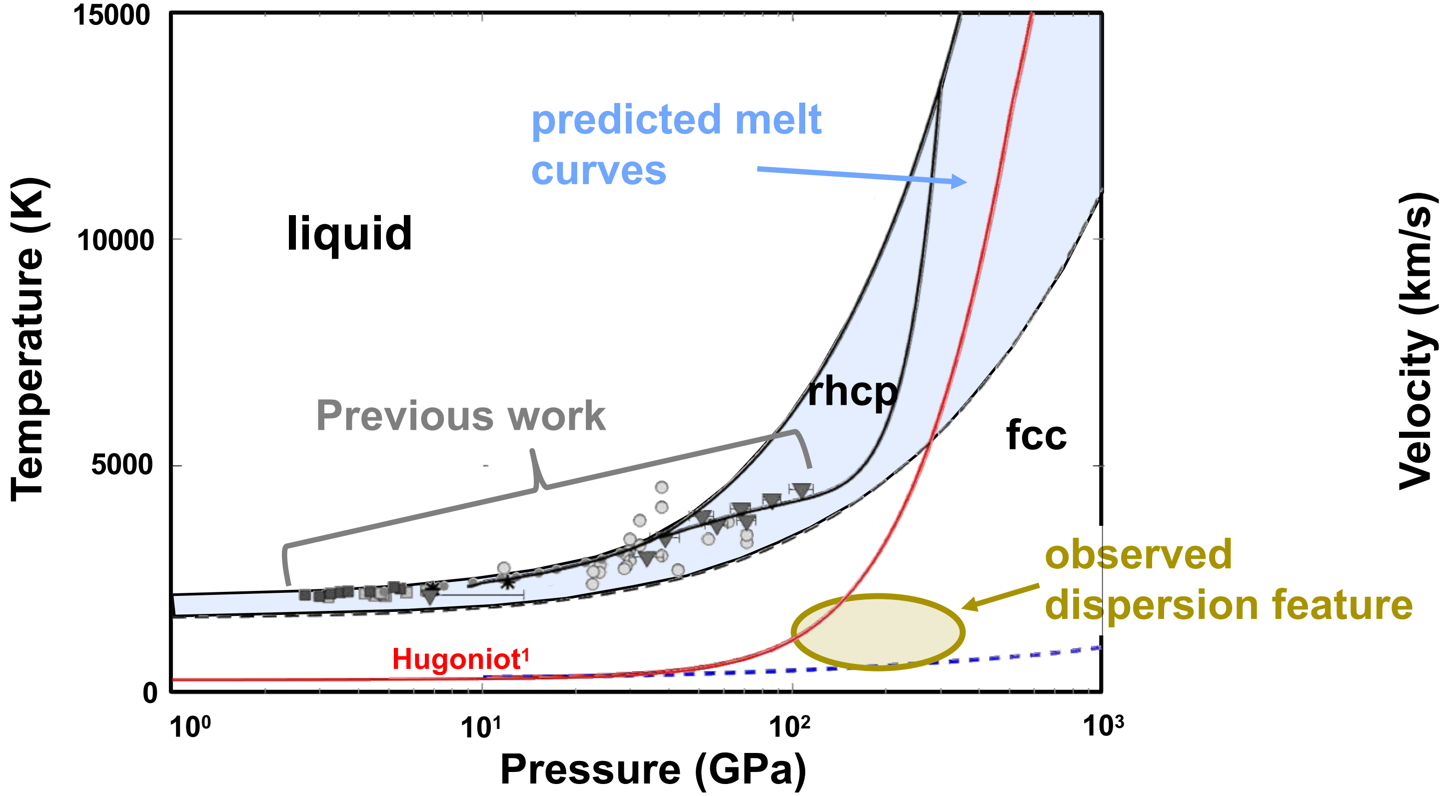
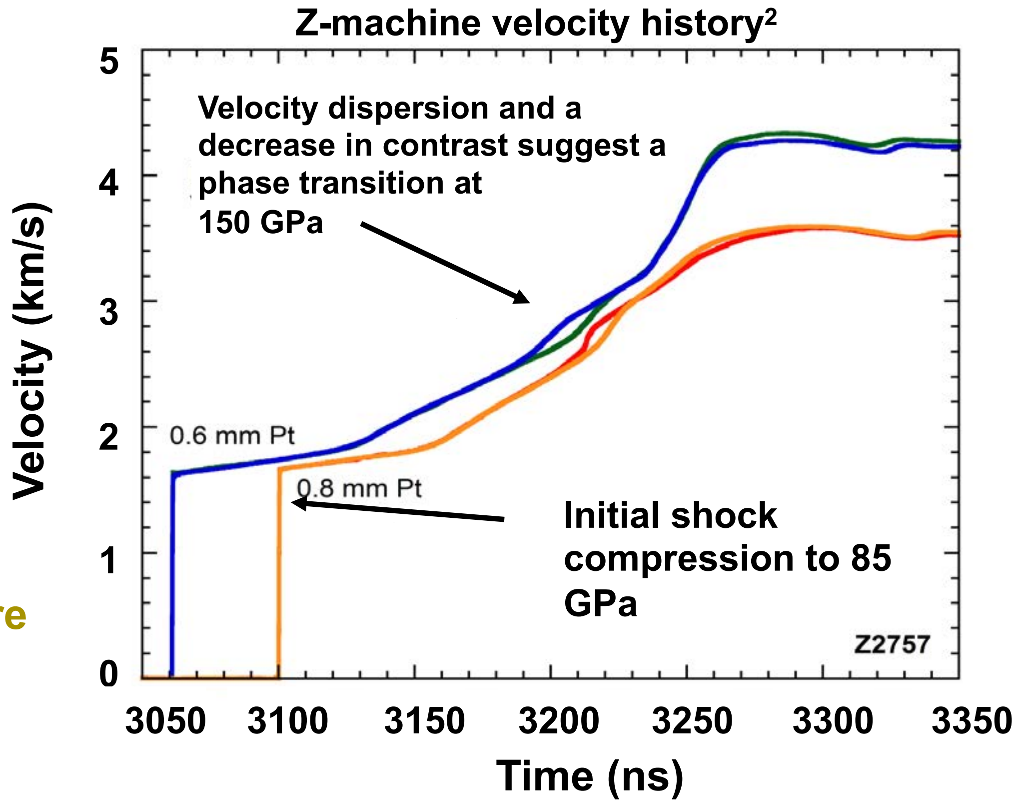
Zha, *et al., J. Appl. Phys.* 103, 054908 (2008)
Sharma, S. M., *et al.* Rev. Lett.124, 235701. (2020).
Z. Geballe *et al*. Phys. Rev. Mat. 5, 033803 (2021).

Motivation

We investigated two aspects of the platinum phase diagram: the melt curve and a possible solid-solid phase transition



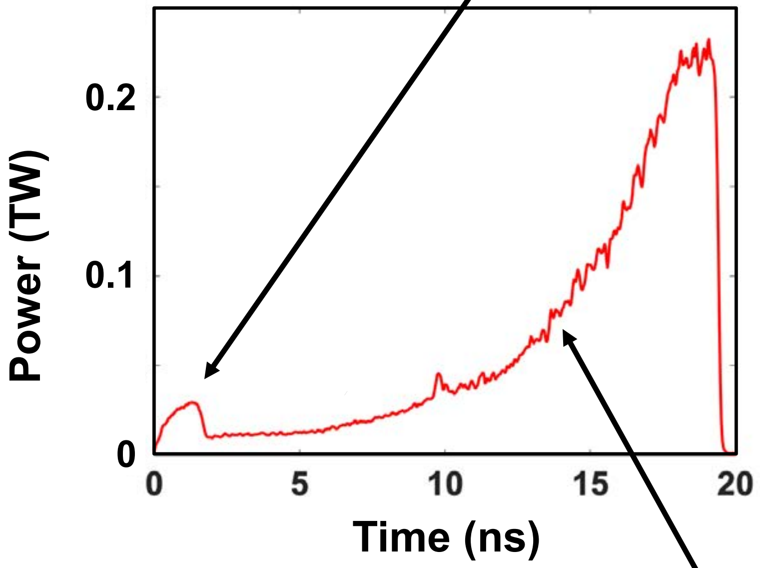


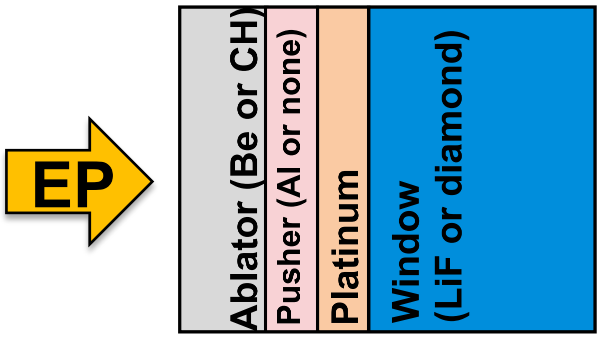
We will be exploring the Pt melt curve up to 490 GPa

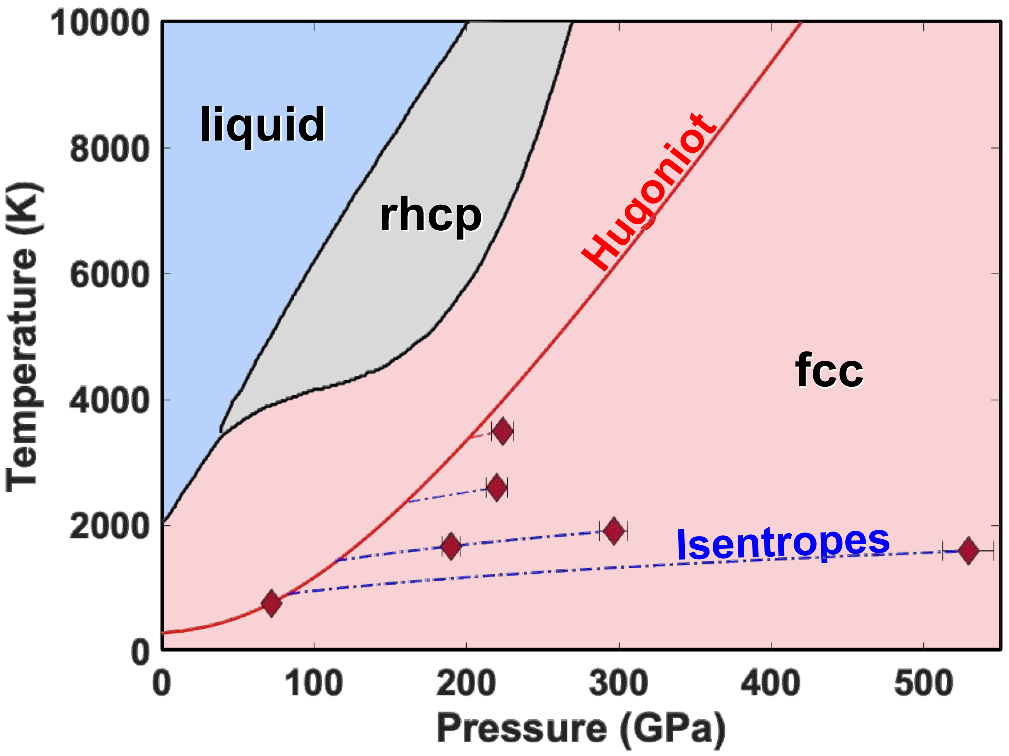
fcc: face-centered cubic
rhcp: randomly oriented hexagonal close packed
1. S. Crockett, LANL
2. C. Seagle, SNL

Precursor shocks are used to bring Pt into the region of interest of the SNL experiments

First shock sets the system entropy



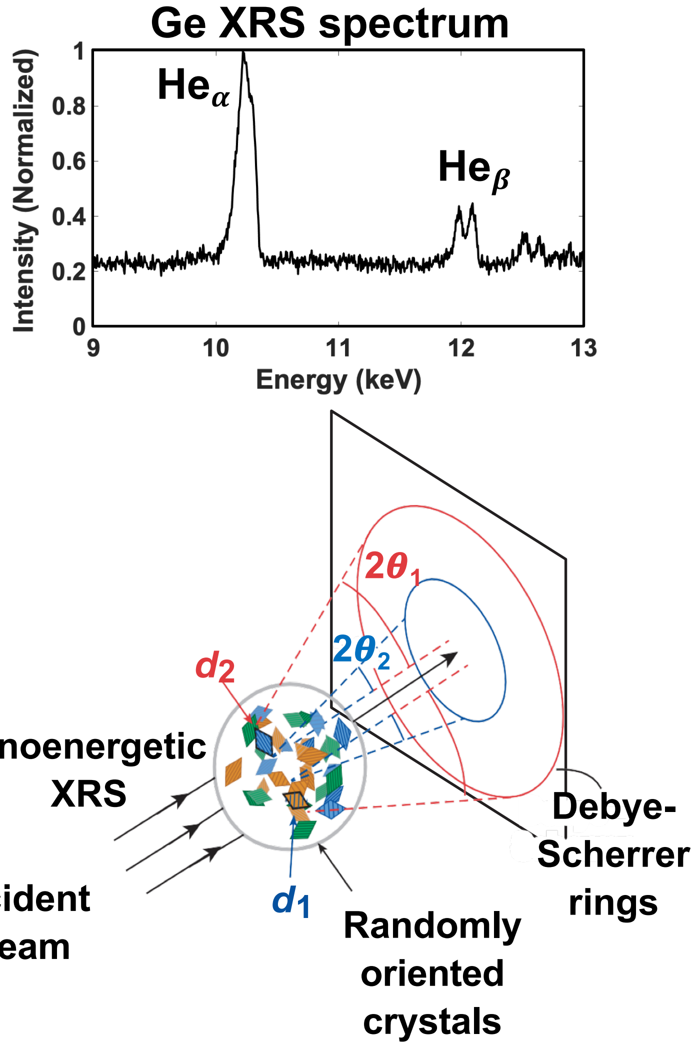


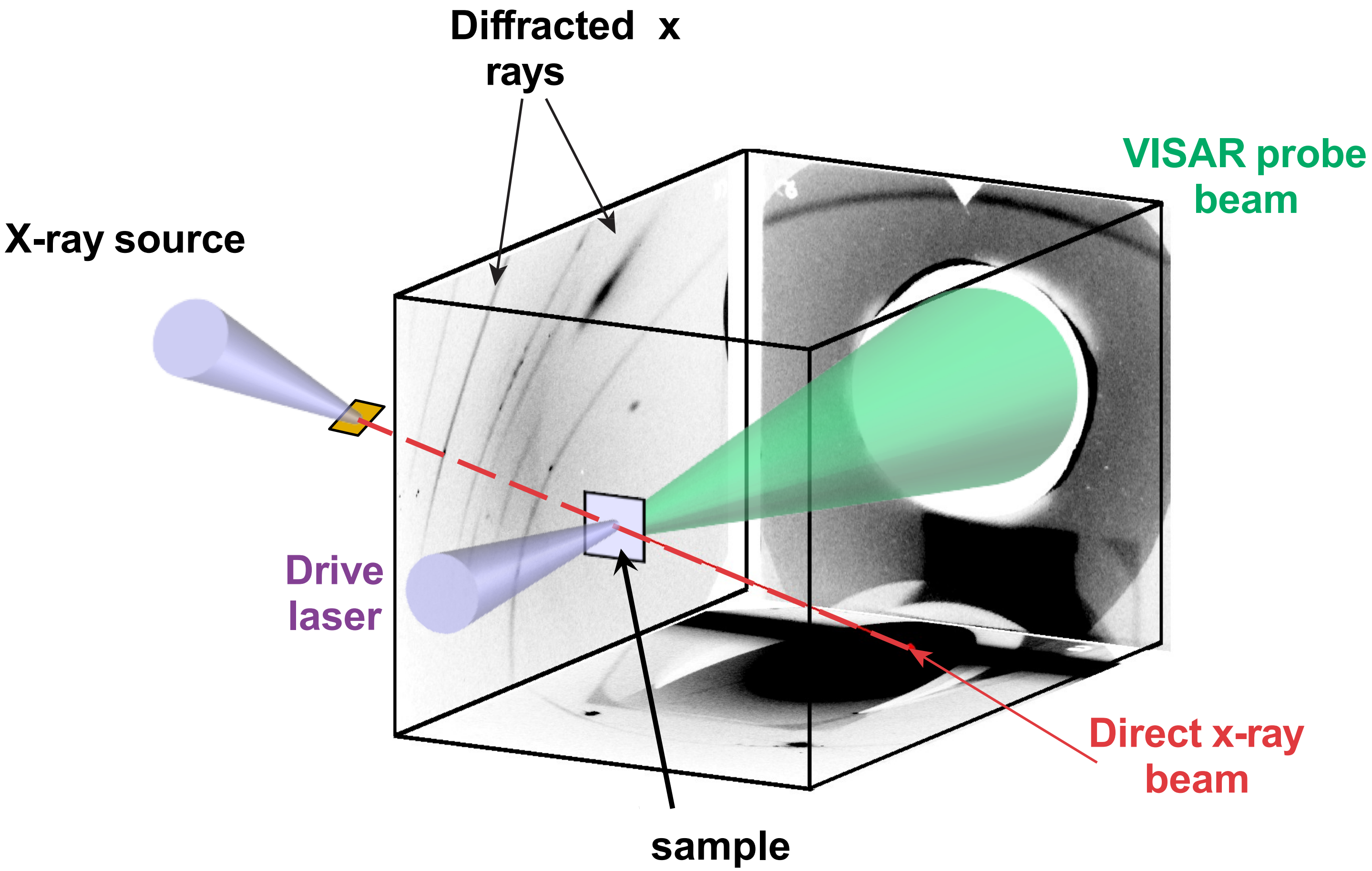


The ramp sets the final pressure

S. Crockett, LANL
L. Burakovsky, *et al.*, J. Phys.: Conf. Ser. 500 162001 (2014)
R. Kraus, LANL, pulse design
SNL: Sandia National Laboratory

The powder x-ray diffraction image plate platform (PXRDIP*) records the diffraction pattern of the compressed sample

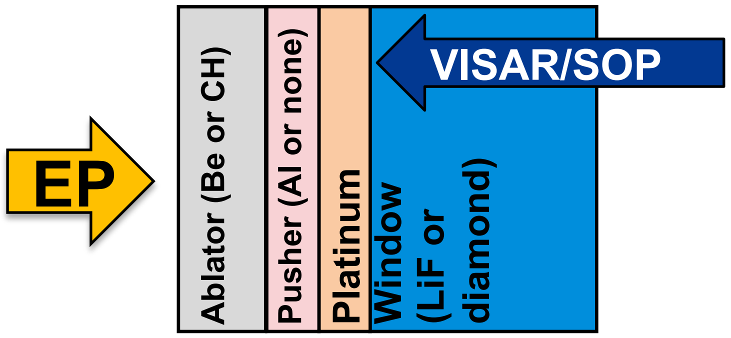




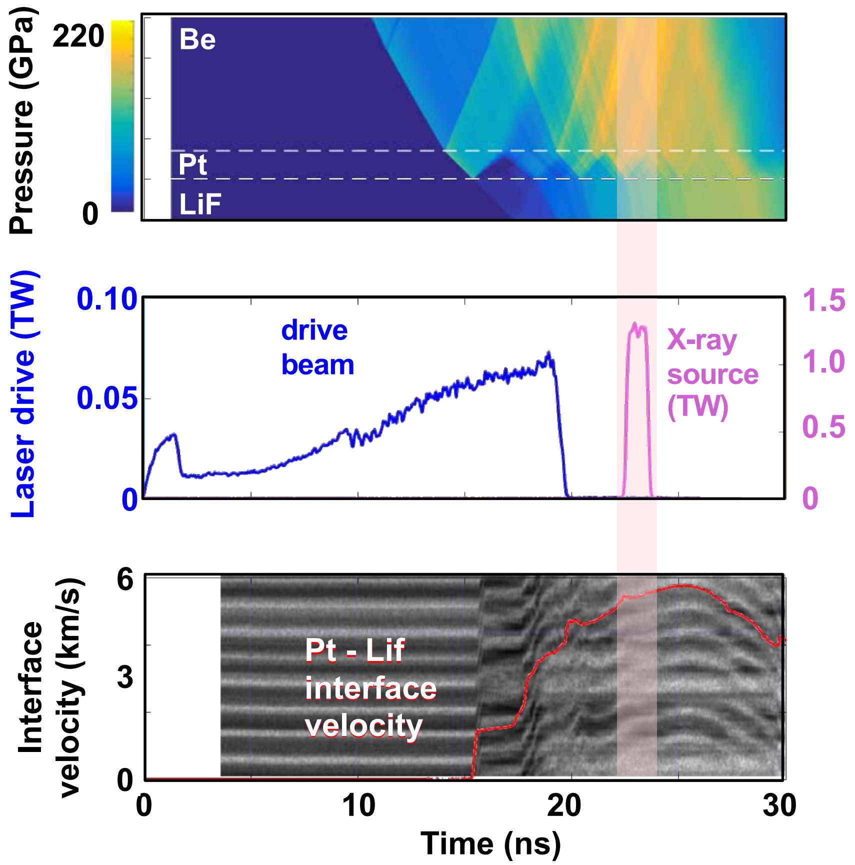
* J. R. Rygg *et al.*, Rev. Sci. Instrum. 83, 113904 (2012).

VISAR* tracks a particle or free surface velocity to infer the pressure in the sample at the time it is probed with x-rays

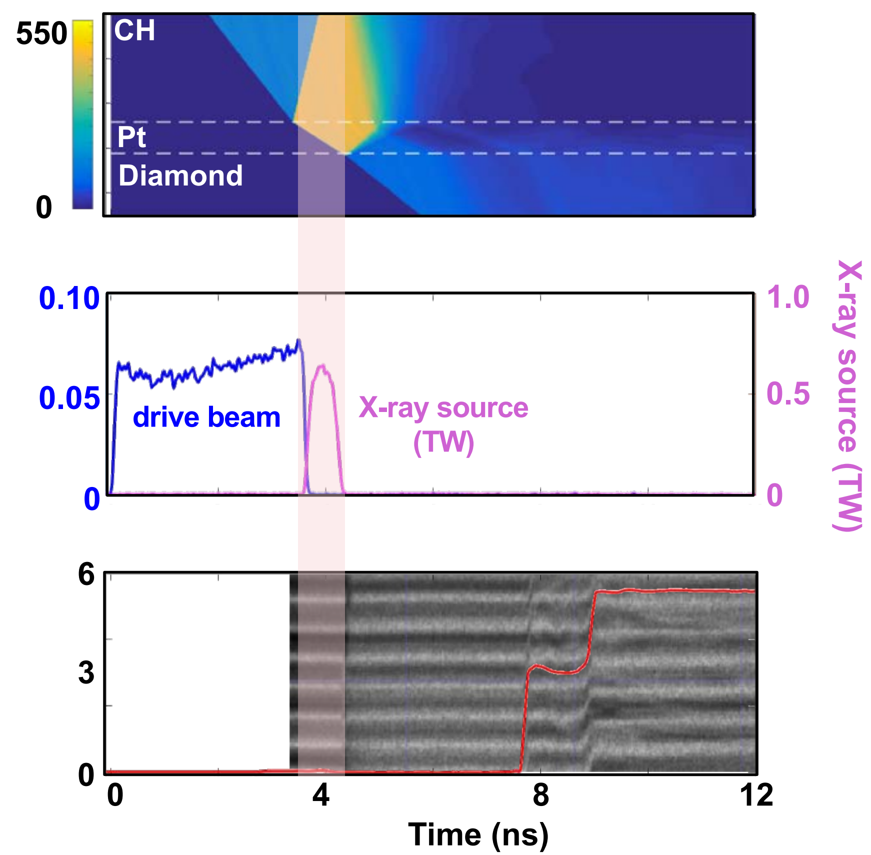
Target Package



Shock – Ramp Technique

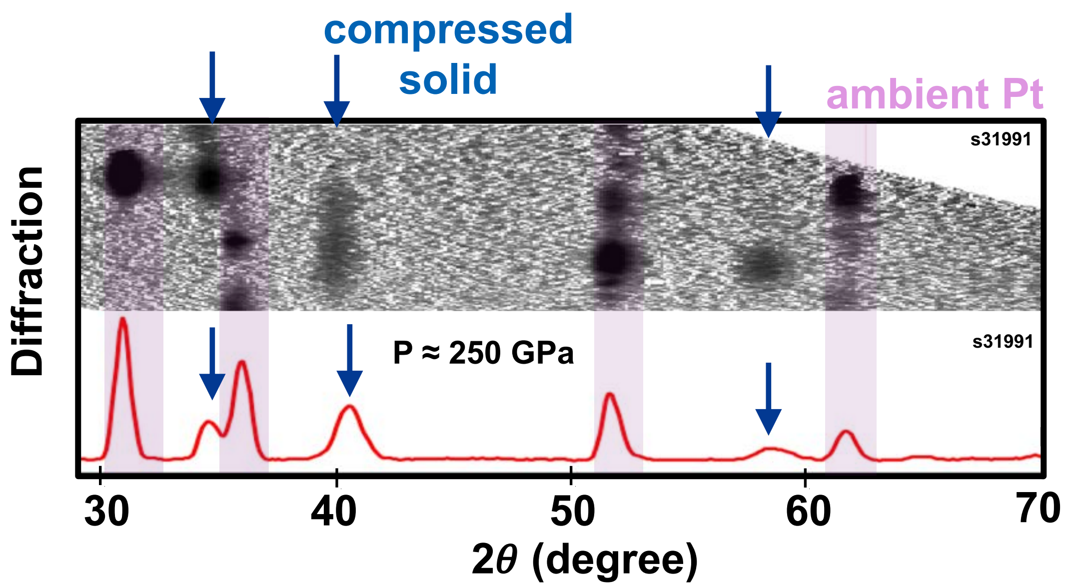


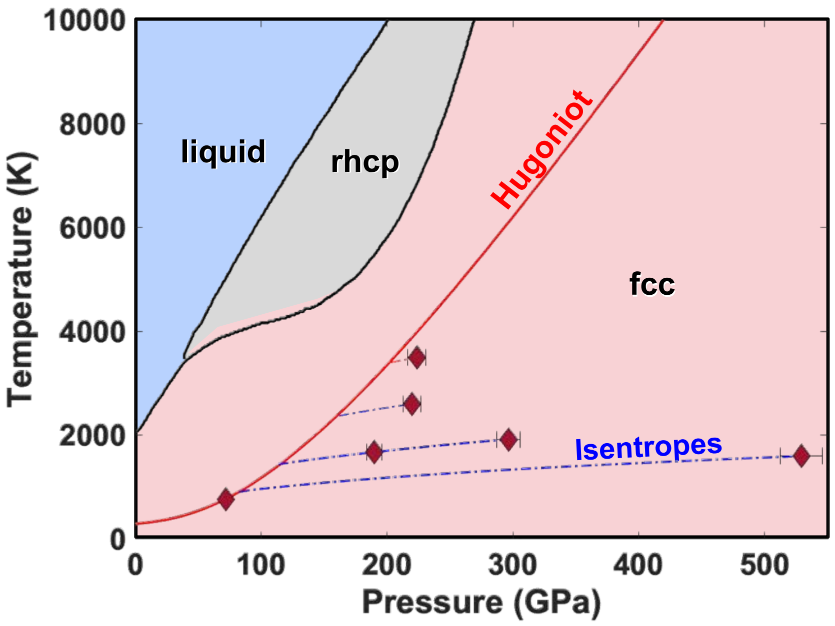
Shock Technique



* Velocity Interferometer System for Any Reflector

The crystal structure and density of the compressed solid platinum is obtained from the diffraction pattern



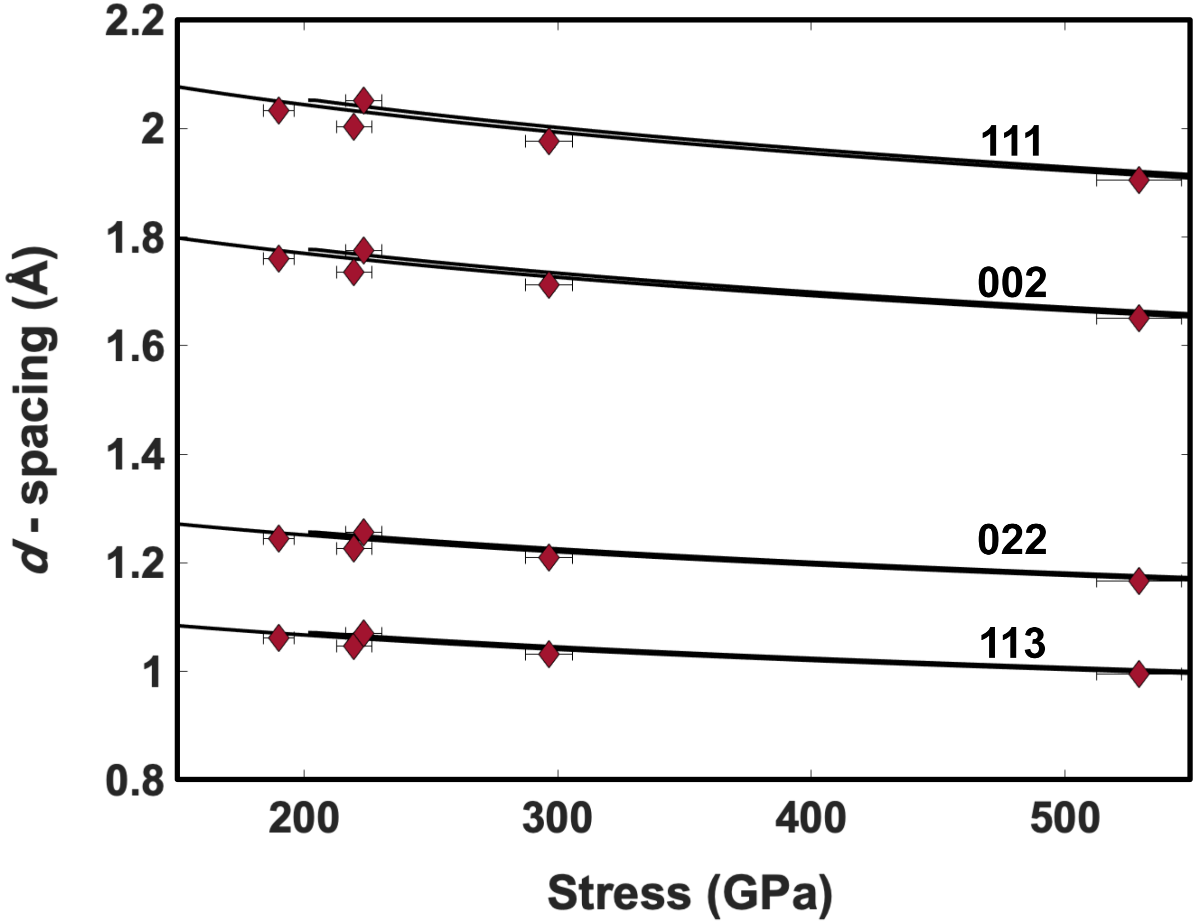


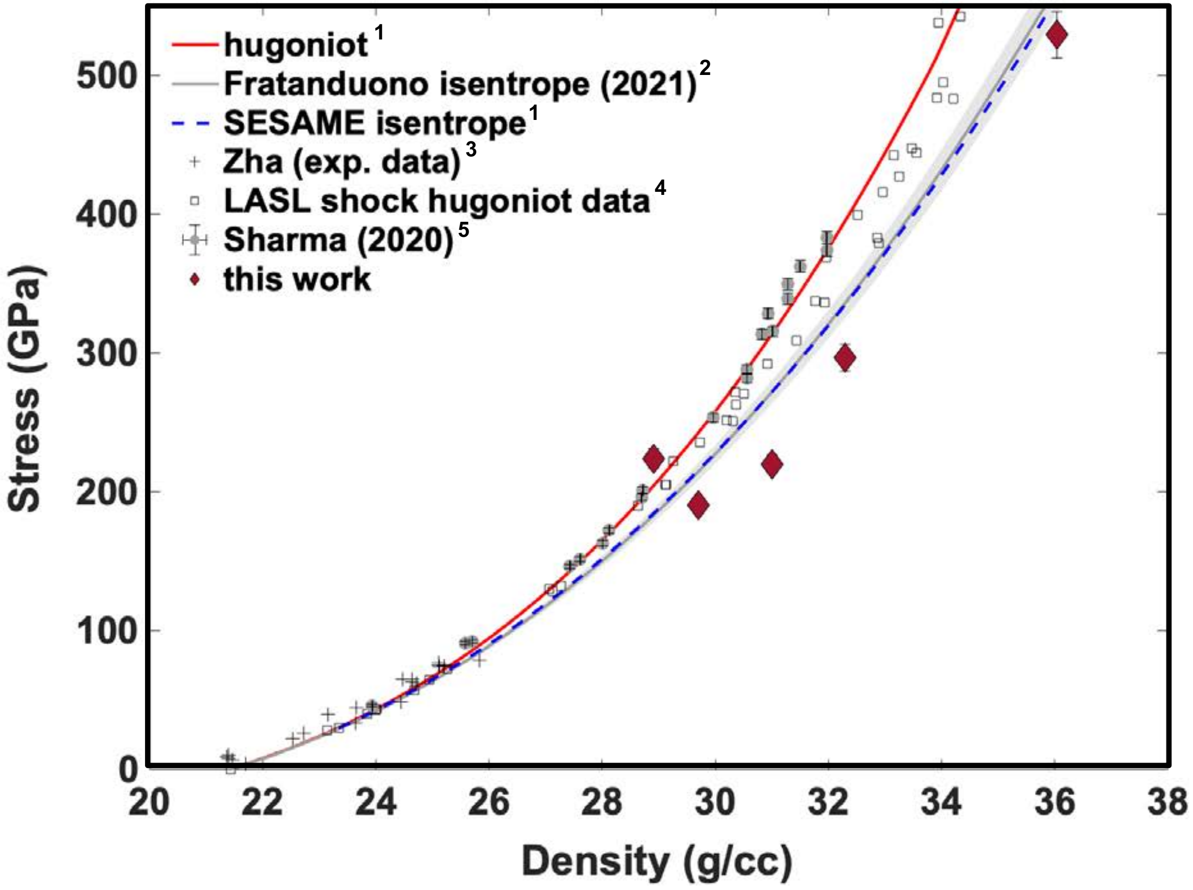
- Ambient Pt diffraction from the pinhole provides geometric calibration of the image plates
- Compressed Pt that remains solid produces a shift in the fcc pattern

- Temperature is obtained from the SESAME EOS isentrope at the pressures inferred from velocimetry measurements

fcc: face-centered cubic

We observed face-centered cubic platinum in the region of the Sandia experiment and no evidence of other solid structures

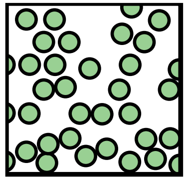




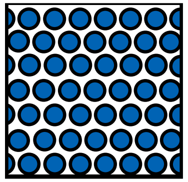
[1] S. Crockett, LANL
[2] Zha, *et al.,* J. Appl. Phys. 103, 054908 (2008)
[3] Marsh, S. P. *LASL Shock Hugoniot Data*. 5 Univ of California Press, (1980).
[4.] D. E. Fratanduono et al., Science 372, 1063 (2021).
[5] Sharma, S. M., *et al.* Rev. Lett.124, 235701. (2020).

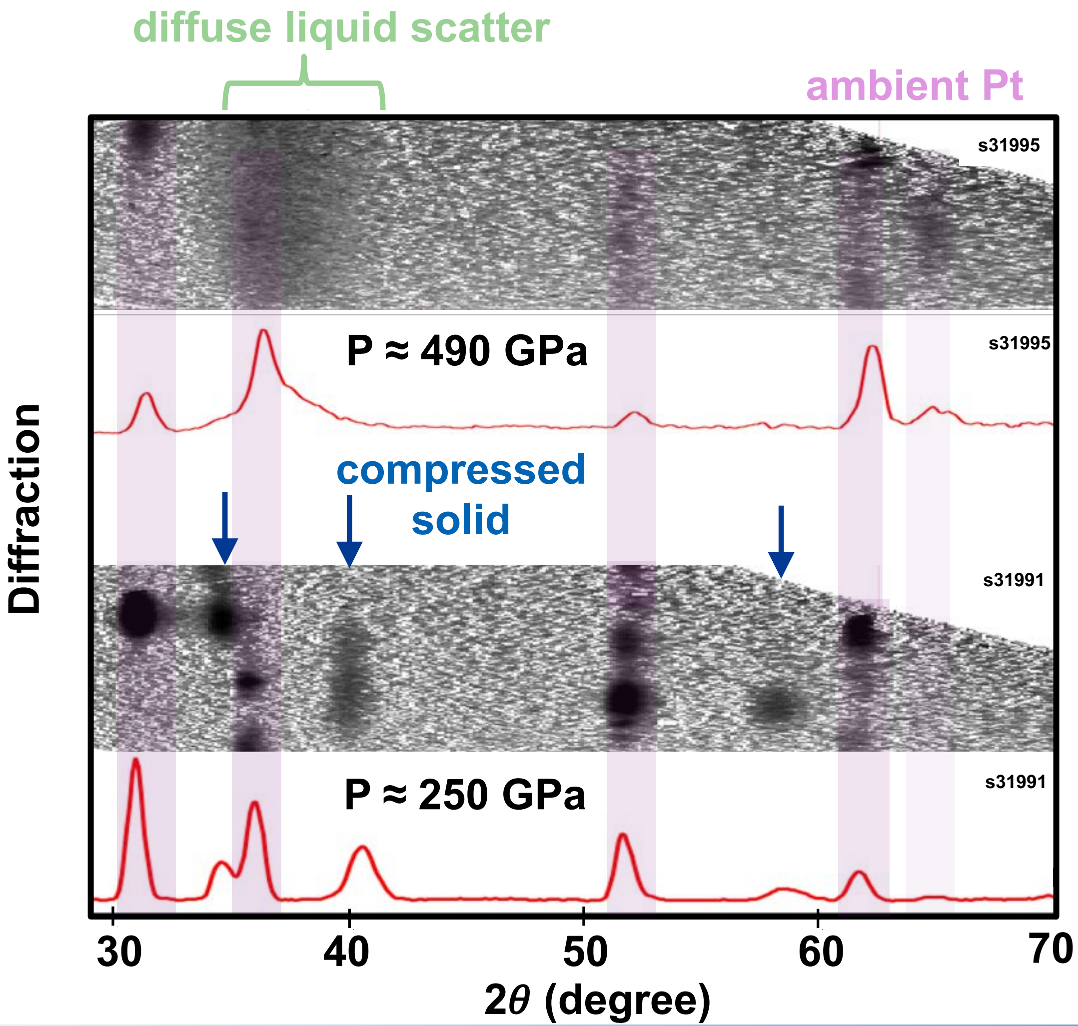
A single broad diffraction line, seen among the ambient platinum, is the signature of diffuse scattering from a liquid

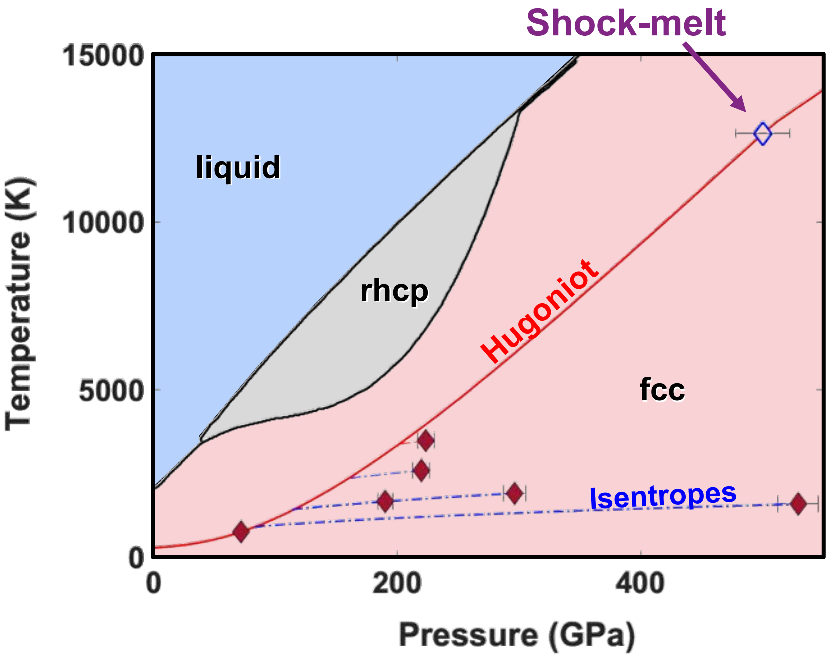
liquid



solid



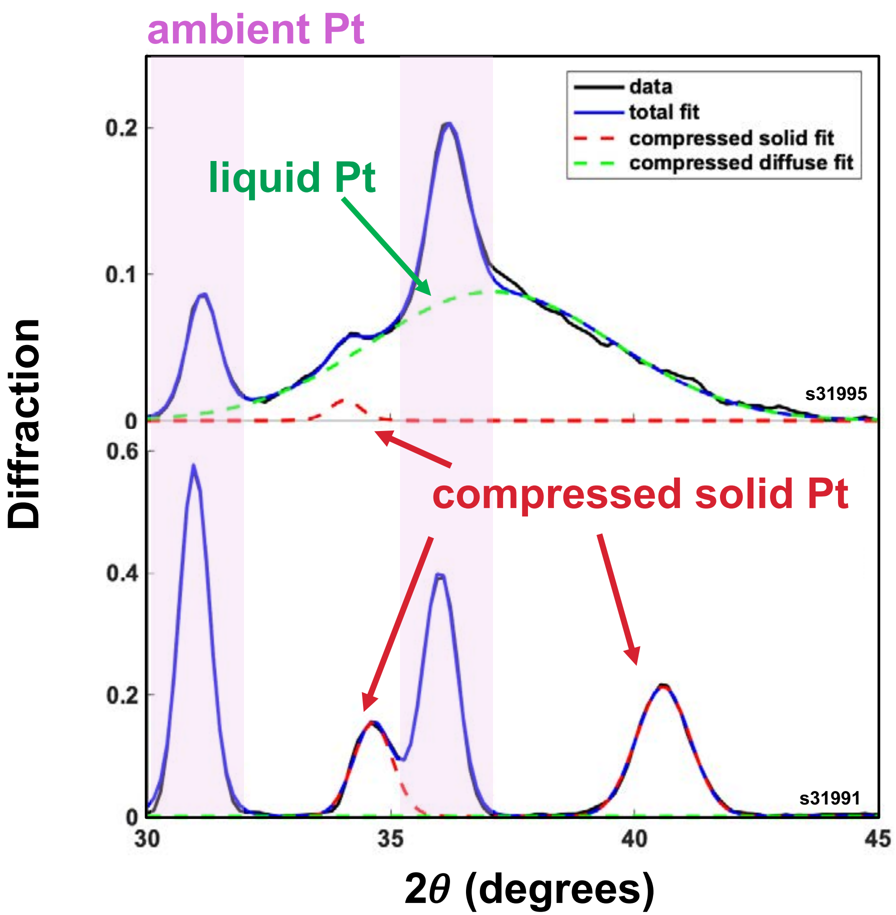




- Analysis of the liquid structure will provide density and coordination number of the liquid phase

fcc: face-centered cubic

The data was fit to a series of Gaussian functions to quantify liquid scattering*



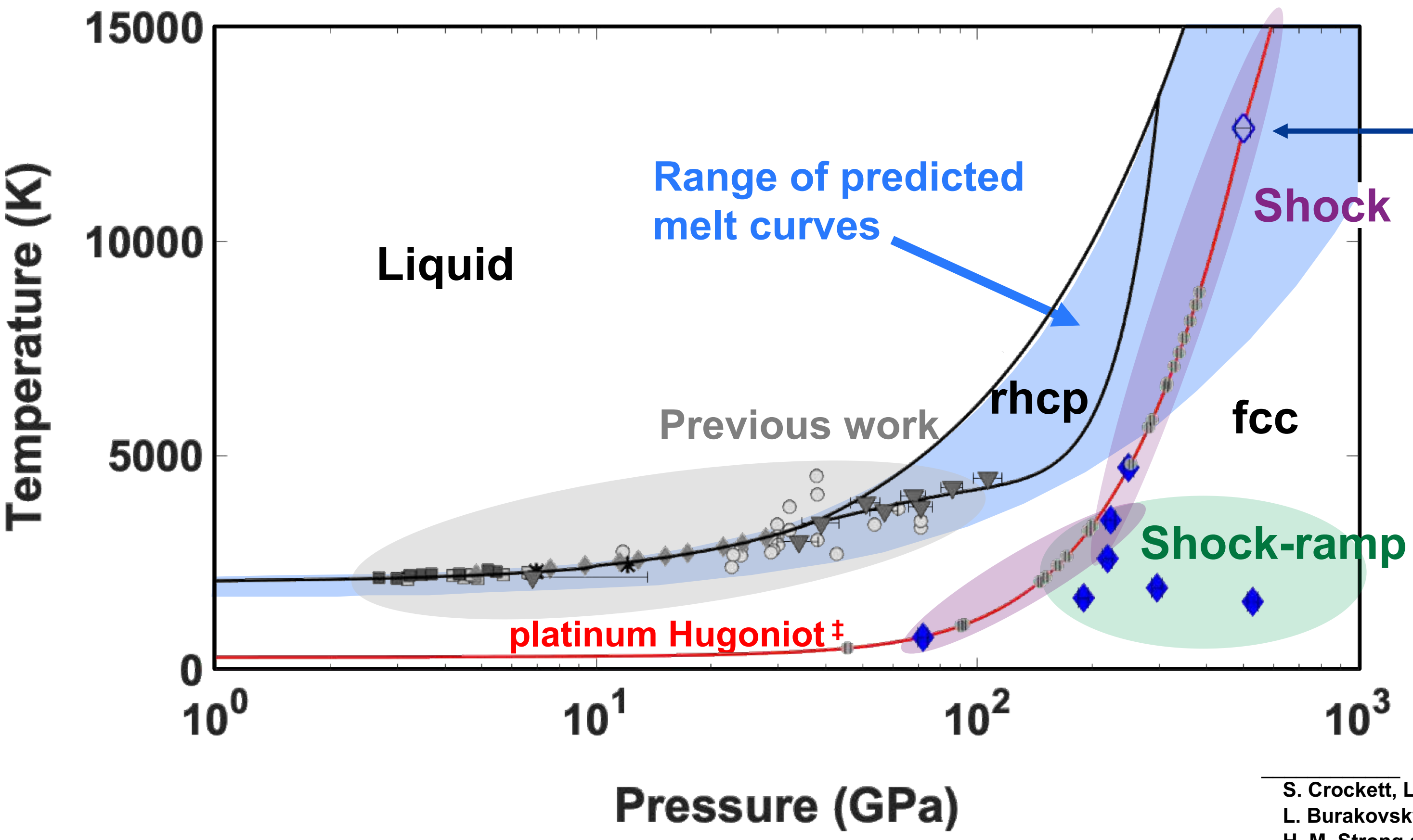
- Each solid peak can be described as two Gaussians with three free parameters: amplitude, centroid location, and width.

$$I = a_1 e^{-(x-a_2)^2/2a_3^2} + 0.2a_1 e^{-(x-a_2)^2/2(0.5)^2}$$

- A single Gaussian is used to fit the liquid scattering feature

* R. G. Kraus, *et al.* Phys. Rev. Lett. 126. 255701 (2021)

Strong shocks (~500 GPa) were used to observe melting along the Hugoniot



Liquid platinum was identified at 490 GPa

‡ S. Crockett, LANL
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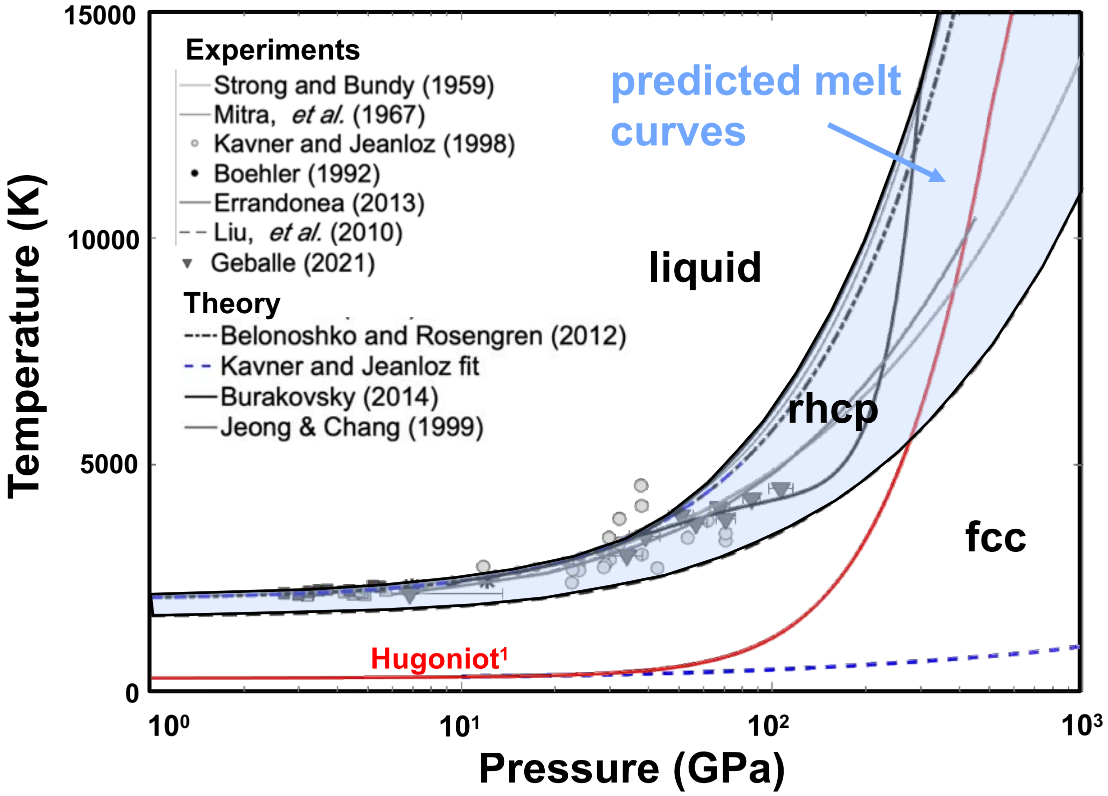
Backup slides

* First reference
** Second reference
† Third reference
‡ Fourth reference

Melt curves



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Extra Slides

The crystal structure of the compressed platinum is inferred from the diffraction pattern