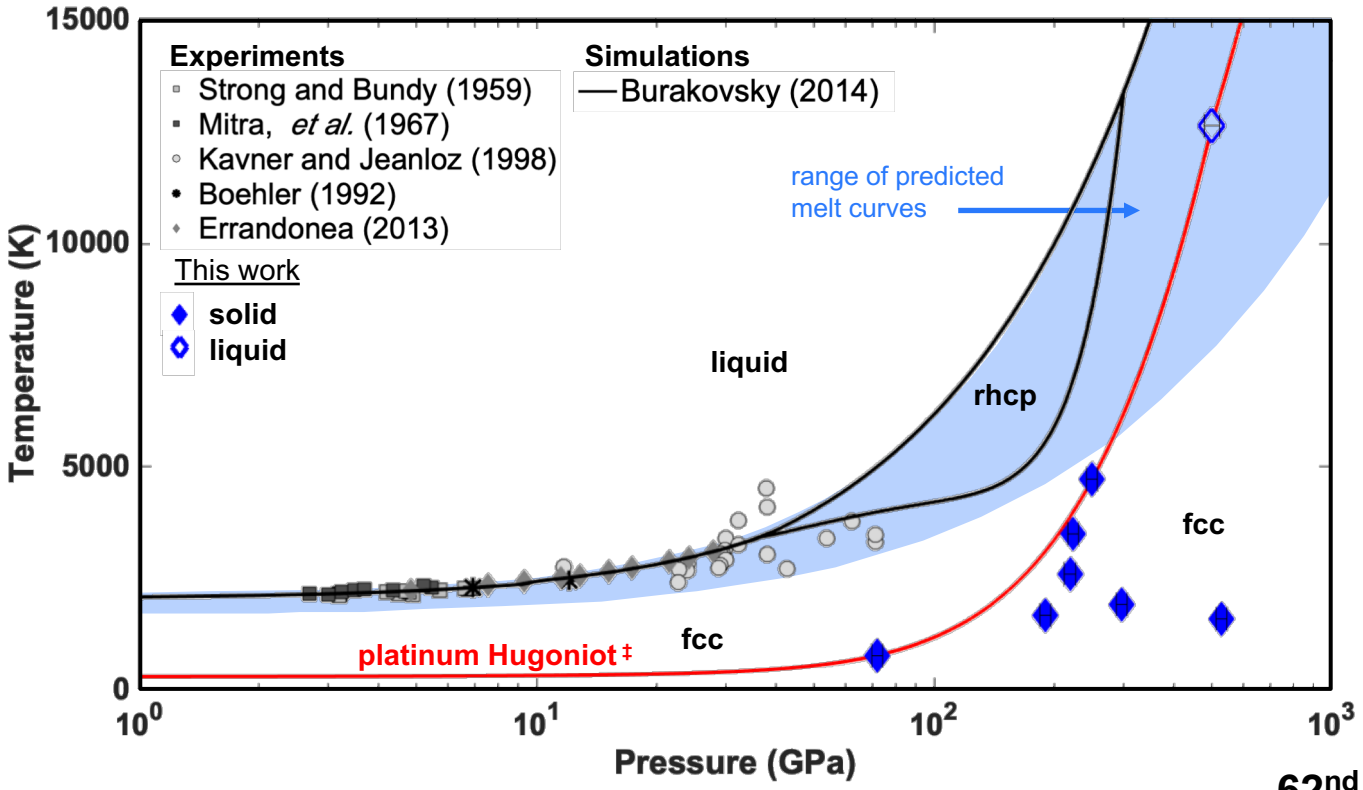
X-ray diffraction measurements of dynamically compressed platinum



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

62nd Annual Meeting of the APS
Division of Plasma Physics
Virtual Meeting
November 9-13, 2020

Collaborators

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

University of Rochester
Laboratory for Laser Energetics

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

Lawrence Livermore National Laboratory

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

Sandia National Laboratories

Summary

In this work, we extended the pressure – temperature range of the platinum phase diagram covered by previous experiments

- Single- shocked platinum (Pt) was observed to be liquid at 490 GPa
- Shock-ramp measurements confirmed the stability of the face-centered cubic (fcc) phase in Pt through pressures greater than 300 GPa
- Analysis of the liquid structure will provide density and coordination number of the liquid phase

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).

N. R. Mitra, D. L. Decker, and H. V. Vanfleet, Phys.Rev.B 161, 613 (1967).

A. Kavner & R. Jeanloz, *J. Appl. Phys.*, 83(12), 7553-7559 (1998)

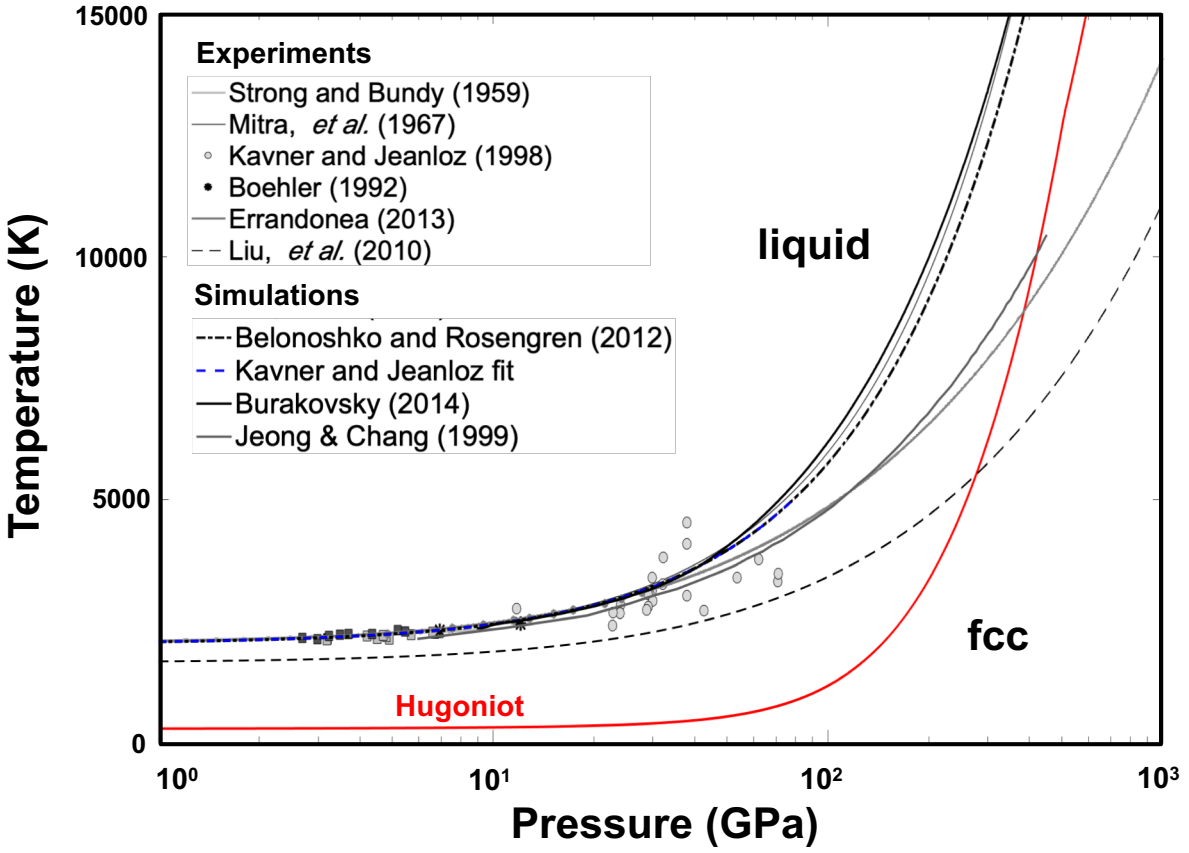
Errandonea, D. *Phys. Rev. B* 87(5): 1–5. (2013)

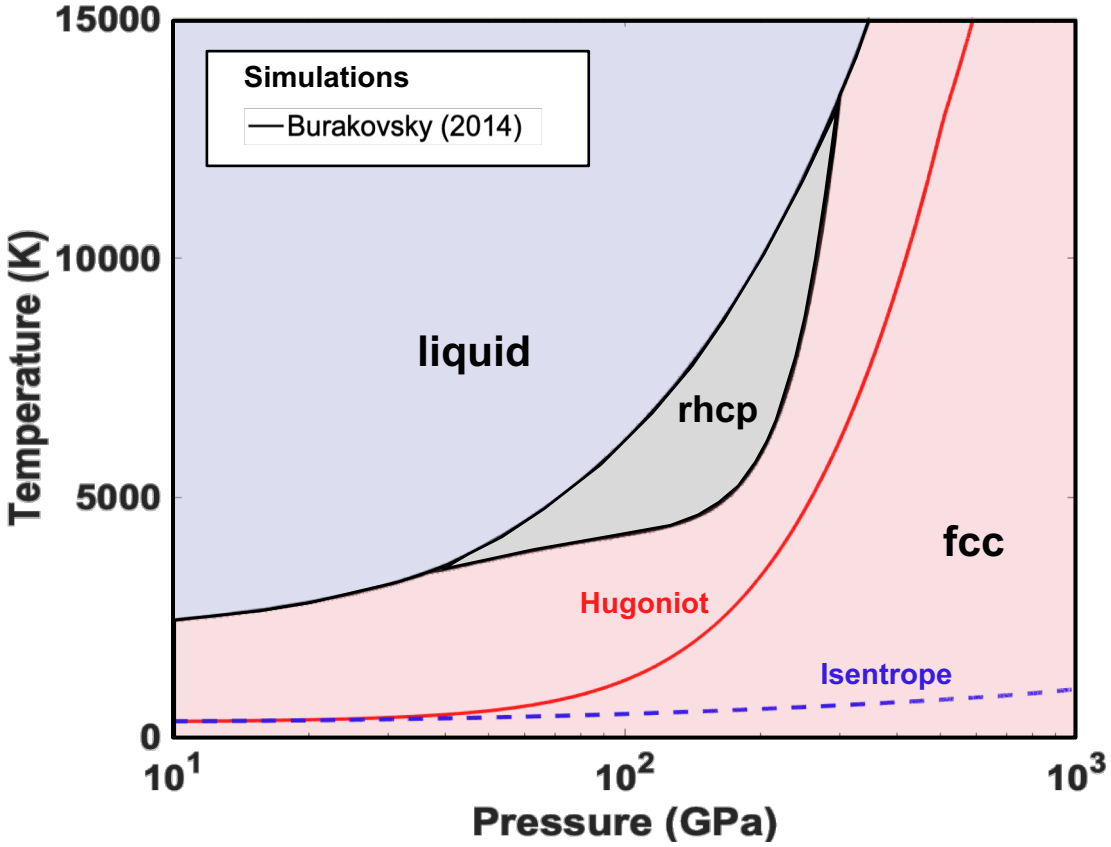
R. Boehler, in Recent Trend in High Pressure Research, edited by A. K. Singh, Proc. of AIRAPT XIII (International Science, New York, 1992), p. 591.

Zha, *et al., J. Appl. Phys.* 103, 054908 (2008)

Motivation

Platinum has a predicted solid-solid phase transition and an anomalously high melt line

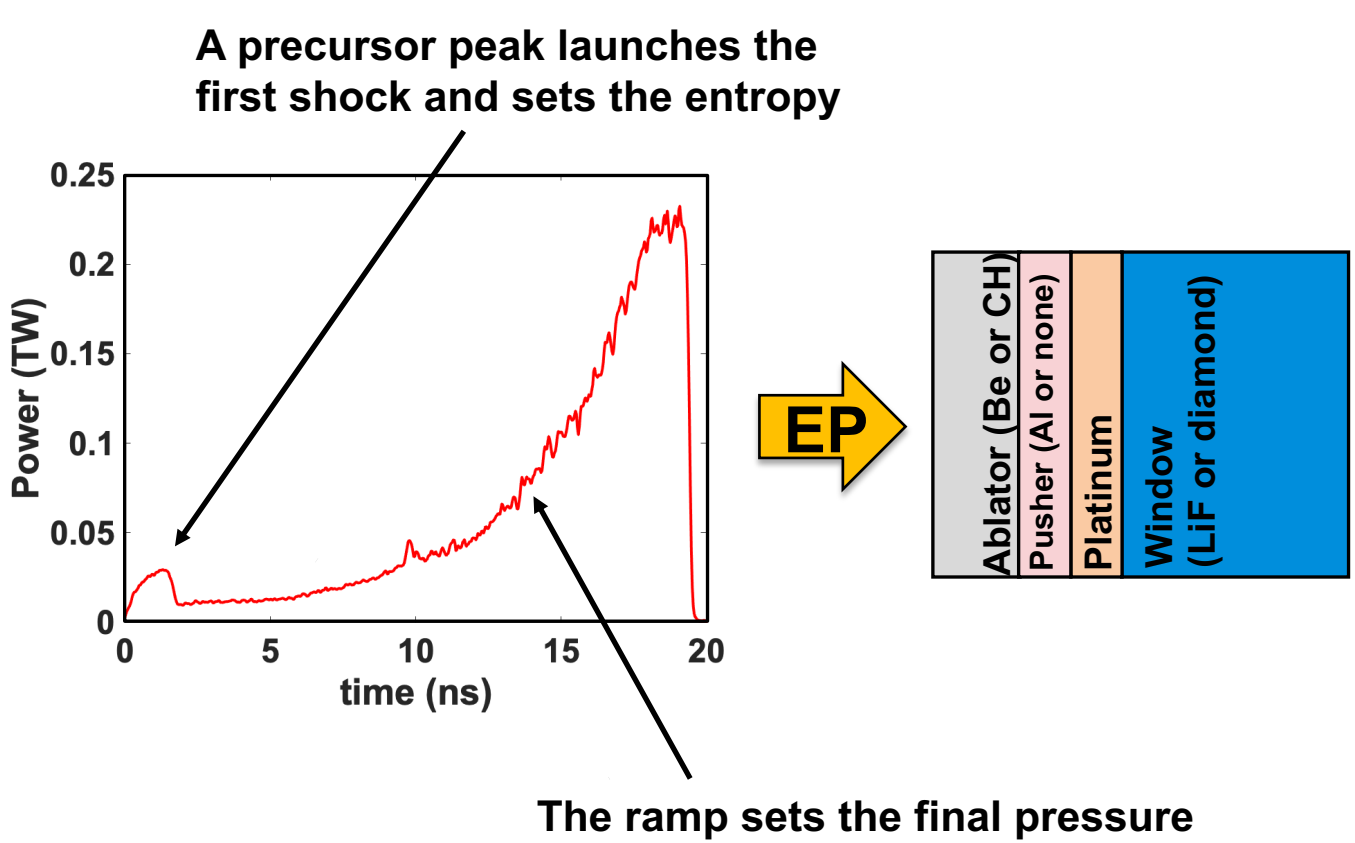


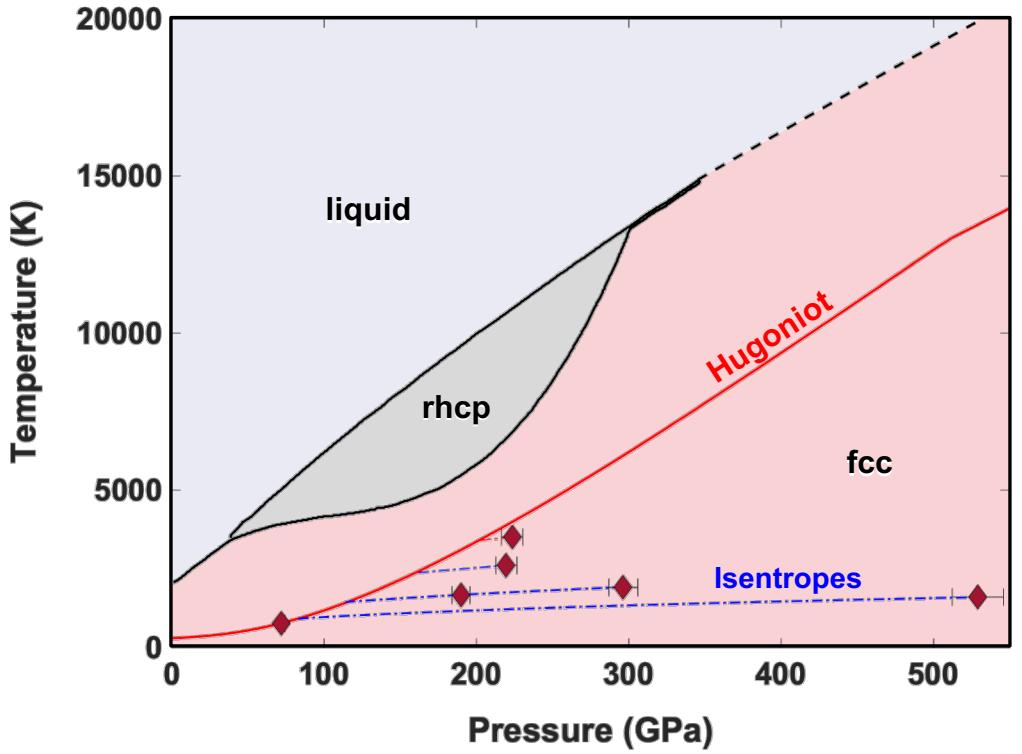


There is no experimental data for the melting curve of platinum above 90 GPa

fcc: face-centered cubic
rhcp: randomly oriented hexagonal close packed
S. Crockett, LANL

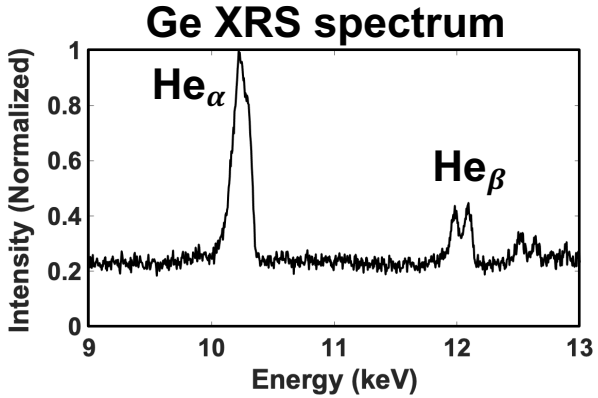
Platinum was compressed to high pressures and temperatures on OMEGA EP

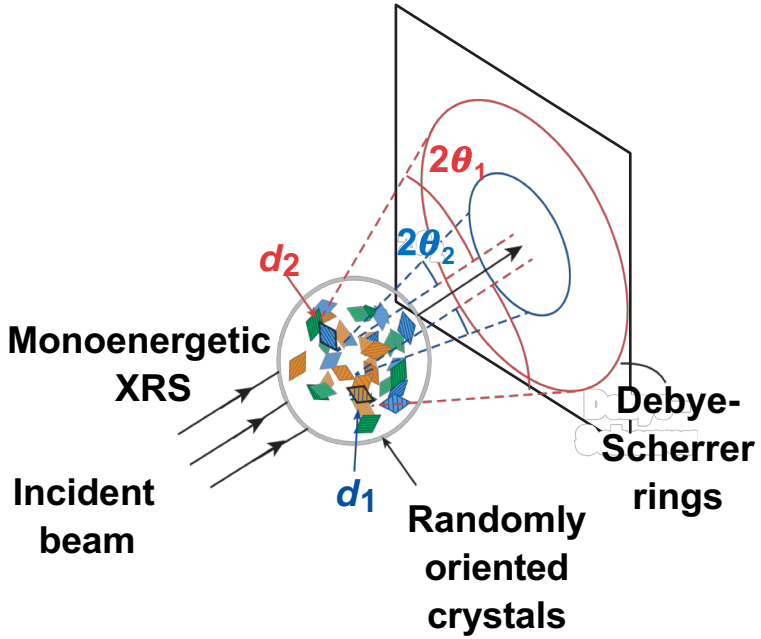


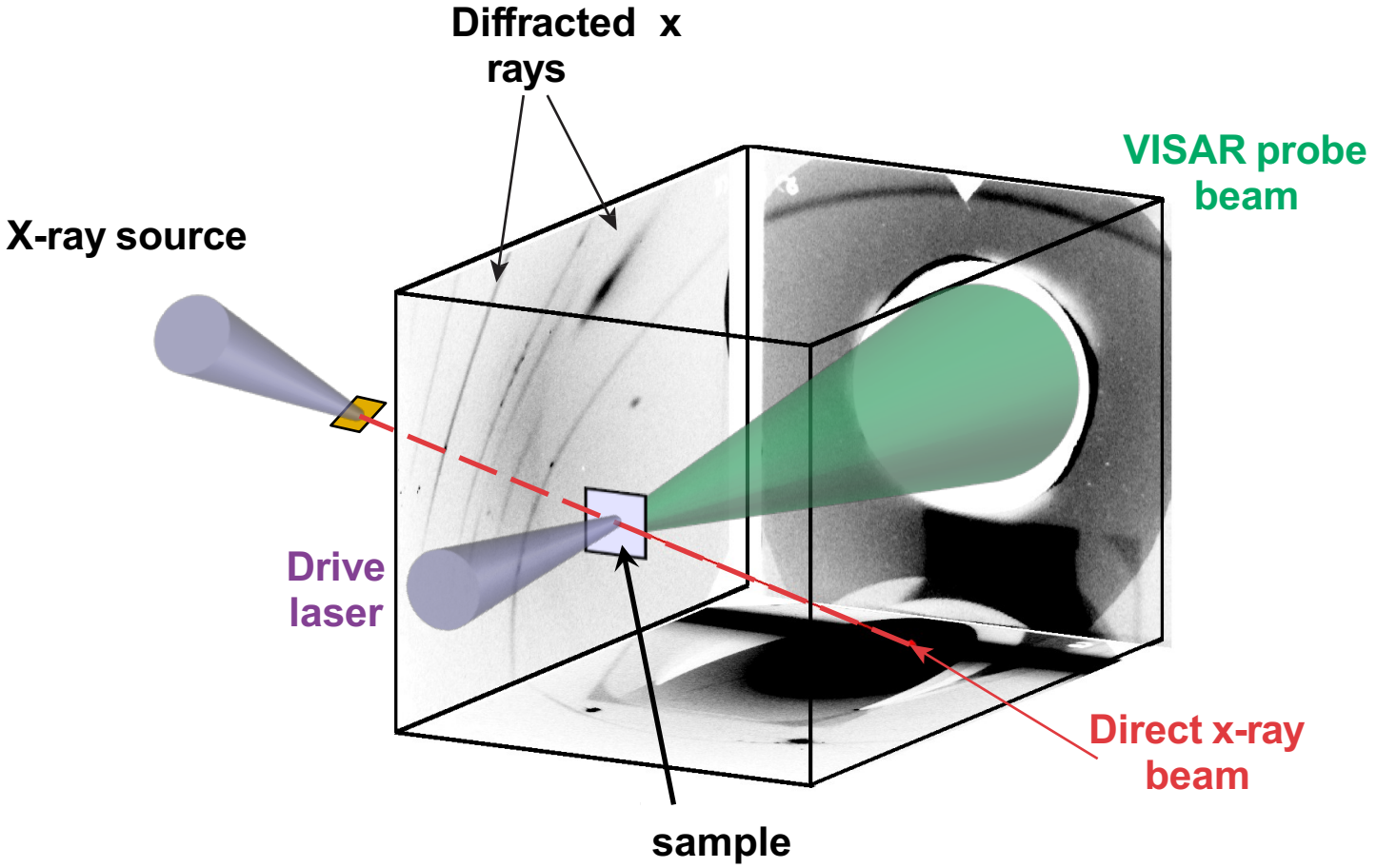


S. Crockett, LANL
L. Burakovsky, *et al.*, J. Phys.: Conf. Ser. 500 162001 (2014)
R. Kraus, LANL, pulse design

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



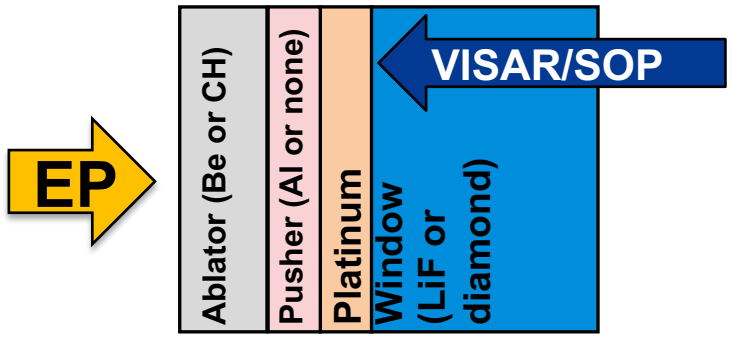




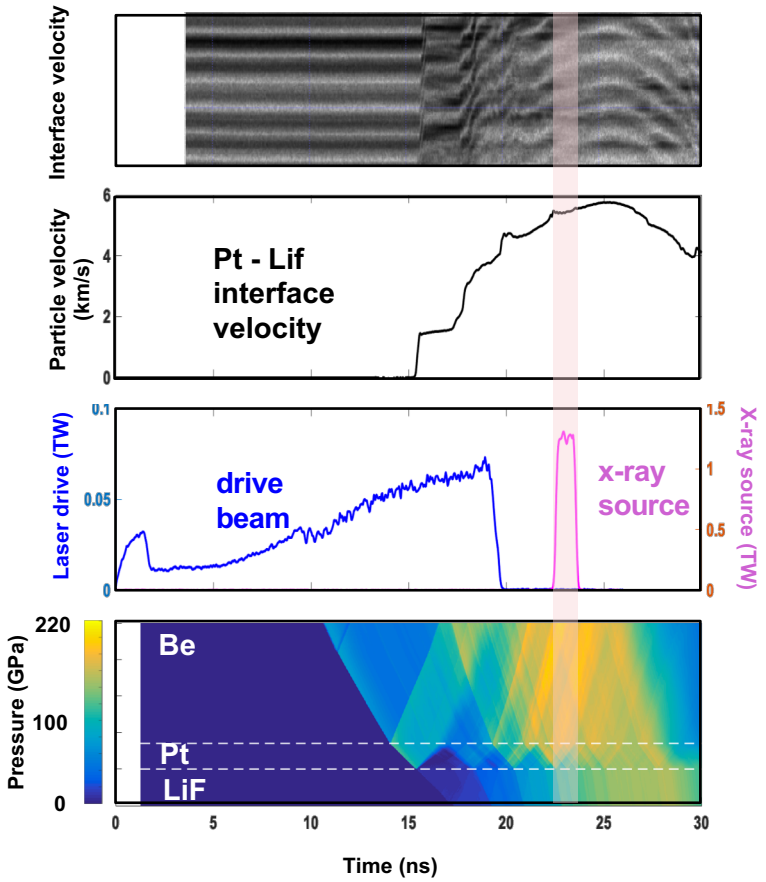
* J. R. Rygg *et al.*, Rev. Sci. Instrum. 83, 113904 (2012).

VISAR* tracks a particle or free surface velocity for an inferred pressure measurement in the sample

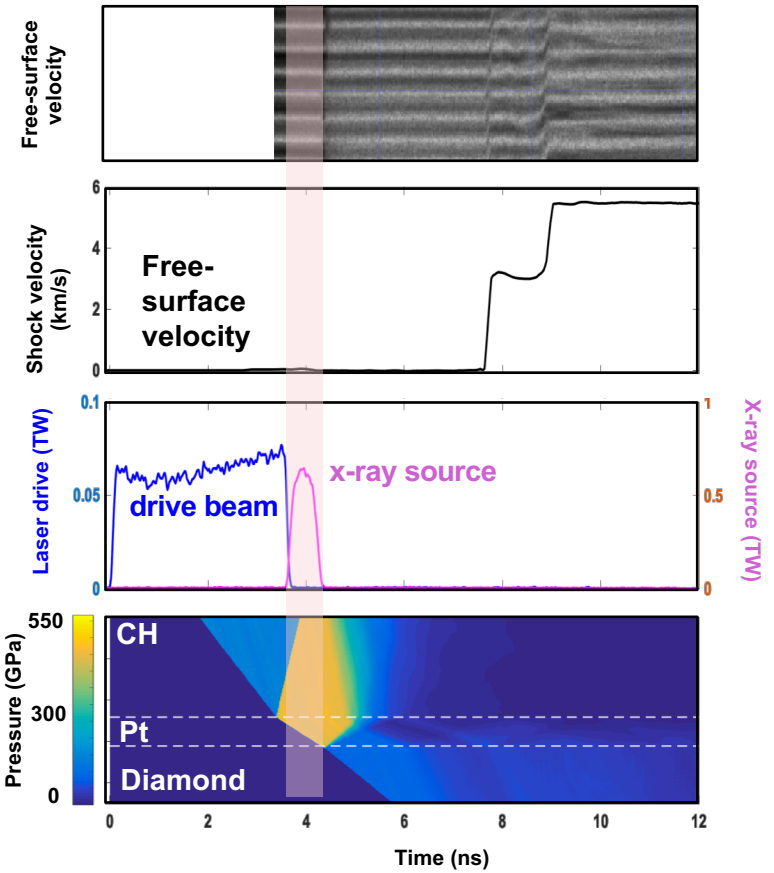
Target package



Shock – ramp technique



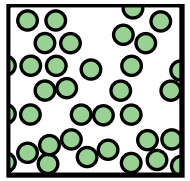
Shock technique



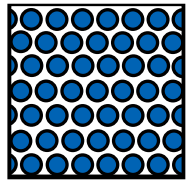
* Velocity Interferometer System for Any Reflector

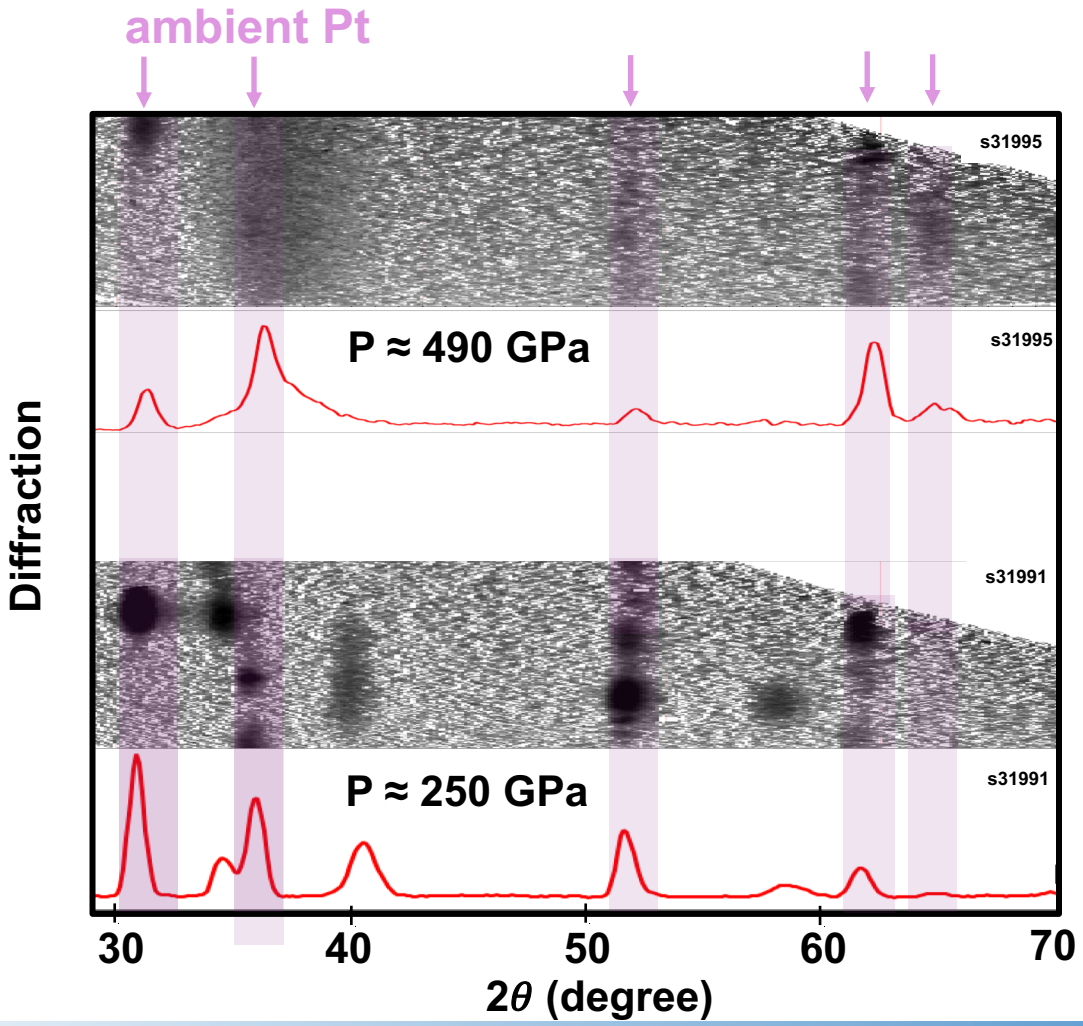
A single, broad diffraction line seen among the ambient platinum is the signature of diffuse scattering from a liquid

liquid

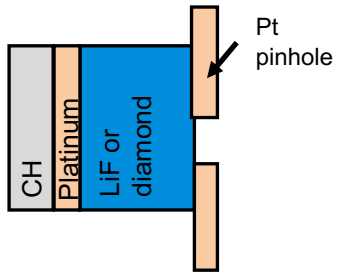


solid





Target:

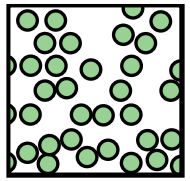


- Analysis of the liquid structure will provide density and coordination number of the liquid phase
- Ambient Pt diffraction from both the pinhole and uncompressed Pt provide geometric calibration of the image plates
- Compressed Pt that remains solid sees a shift in the fcc pattern

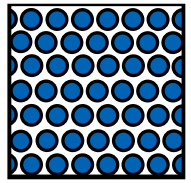
fcc: face-centered cubic

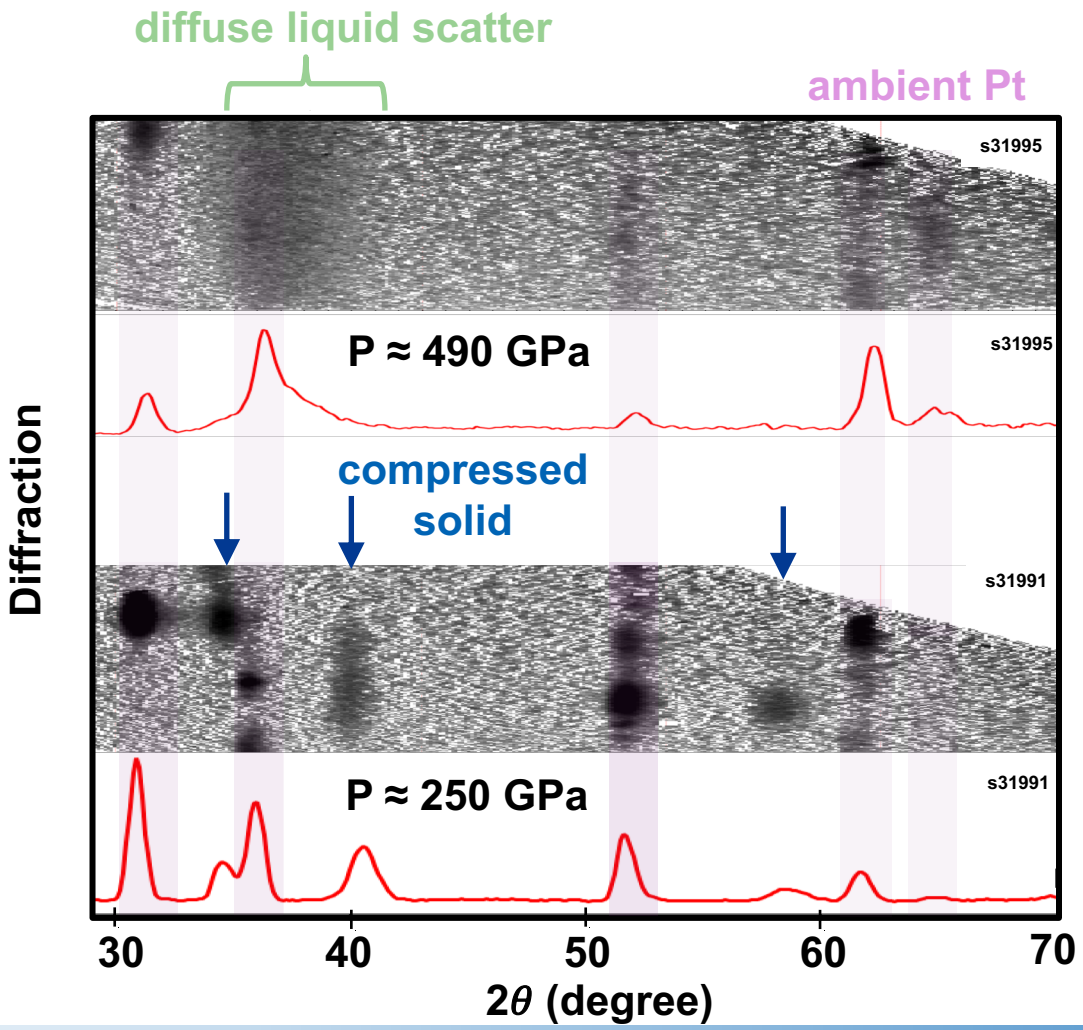
A single, broad diffraction line seen among the ambient platinum is the signature of diffuse scattering from a liquid

liquid

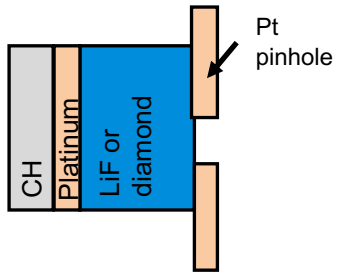


solid





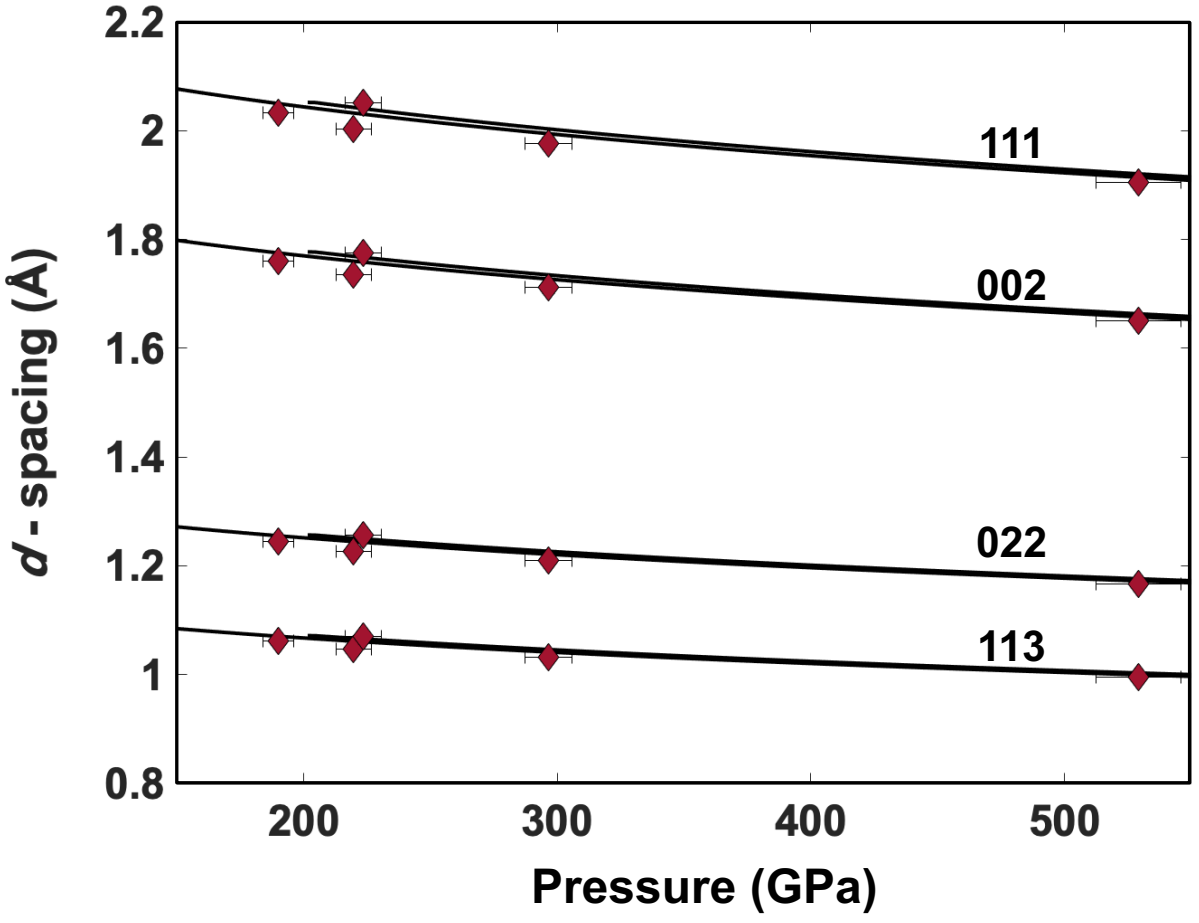
Target:

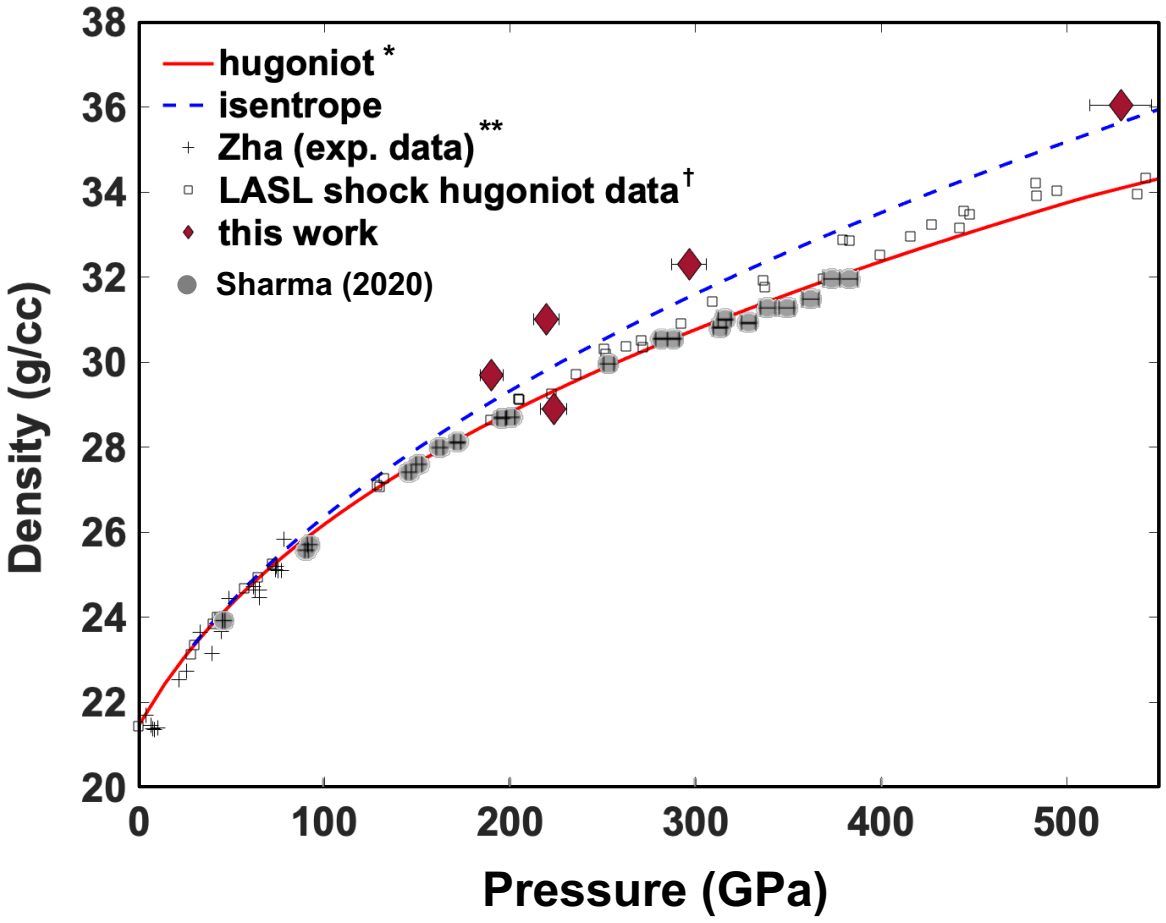


- Analysis of the liquid structure will provide density and coordination number of the liquid phase
- Ambient Pt diffraction from both the pinhole and uncompressed Pt provide geometric calibration of the image plates
- Compressed Pt that remains solid sees a shift in the fcc pattern

fcc: face-centered cubic

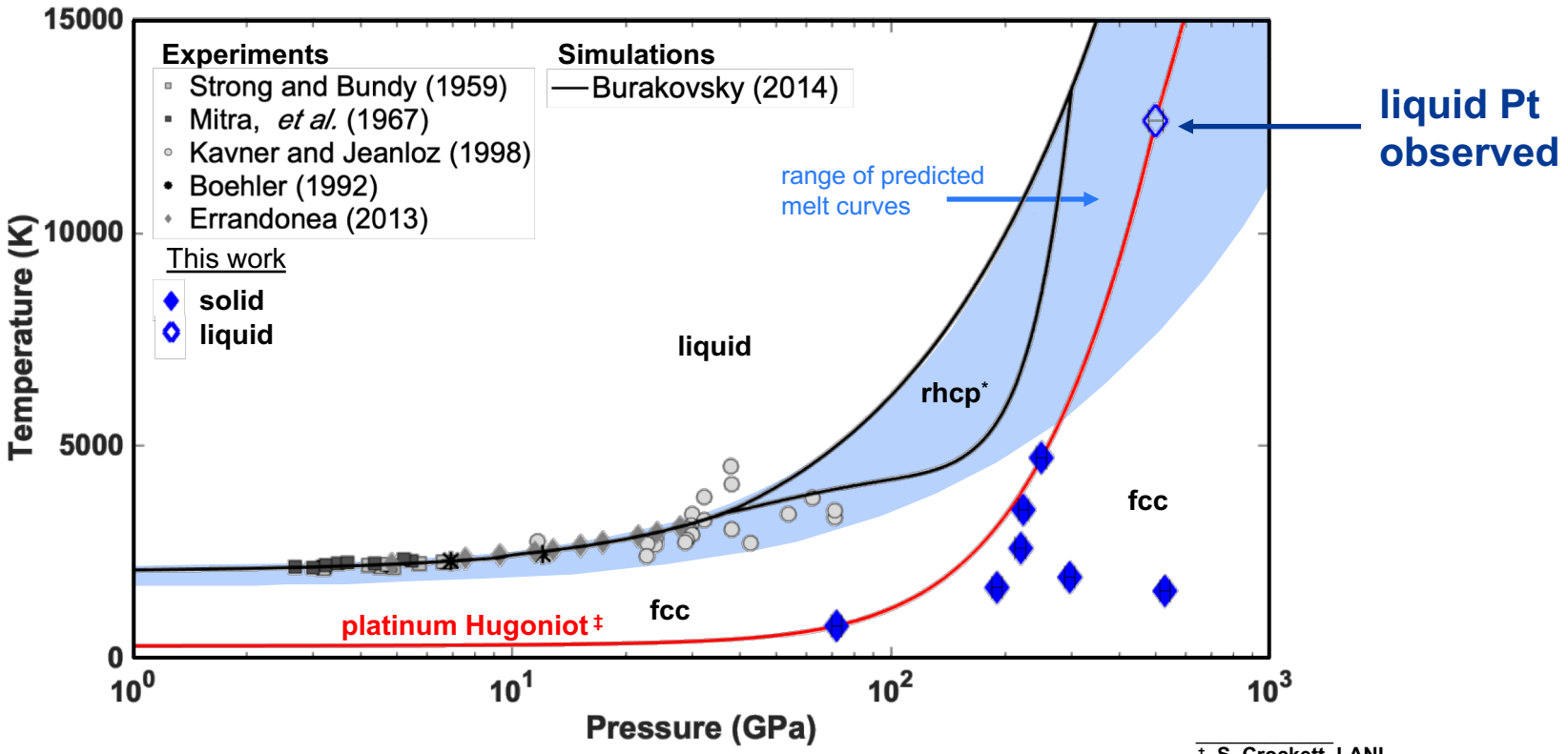
We observed fcc platinum and did not see evidence of other solid structures





* S. Crockett, LANL
** Zha, *et al.*, J. Appl. Phys. 103, 054908 (2008)
† Marsh, S. P. *LASL Shock Hugoniot Data*. 5 Univ of California Press, 1980.

Platinum was shocked in order to identify the intersection of the Hugoniot and melt curve.



Liquid platinum was identified at 490 GPa

‡ 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).
N. R. Mitra, D. L. Decker, and H. V. Vanfleet, Phys.Rev.B 161, 613 (1967).
A. Kavner & R. Jeanloz, *J. Appl. Phys.*, 83(12), 7553-7559 (1998)
Errandonea, D. *Phys. Rev. B* 87(5): 1–5. (2013)
R. Boehler, in Recent Trend in High Pressure Research, edited by A. K. Singh, Proc. of AIRAPT XIII (International Science, New York, 1992), p. 591.
Zha, *et al., J. Appl. Phys.* 103, 054908 (2008)

Summary

In this work, we extended the pressure – temperature range of the platinum phase diagram covered by previous experiments

- Single- shocked platinum (Pt) was observed to be liquid at 490 GPa
- Shock-ramp measurements confirmed the stability of the face-centered cubic (fcc) phase in Pt through pressures greater than 300 GPa
- Analysis of the liquid structure will provide density and coordination number of the liquid phase

Summary

Extra slides

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

Extra Slides

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