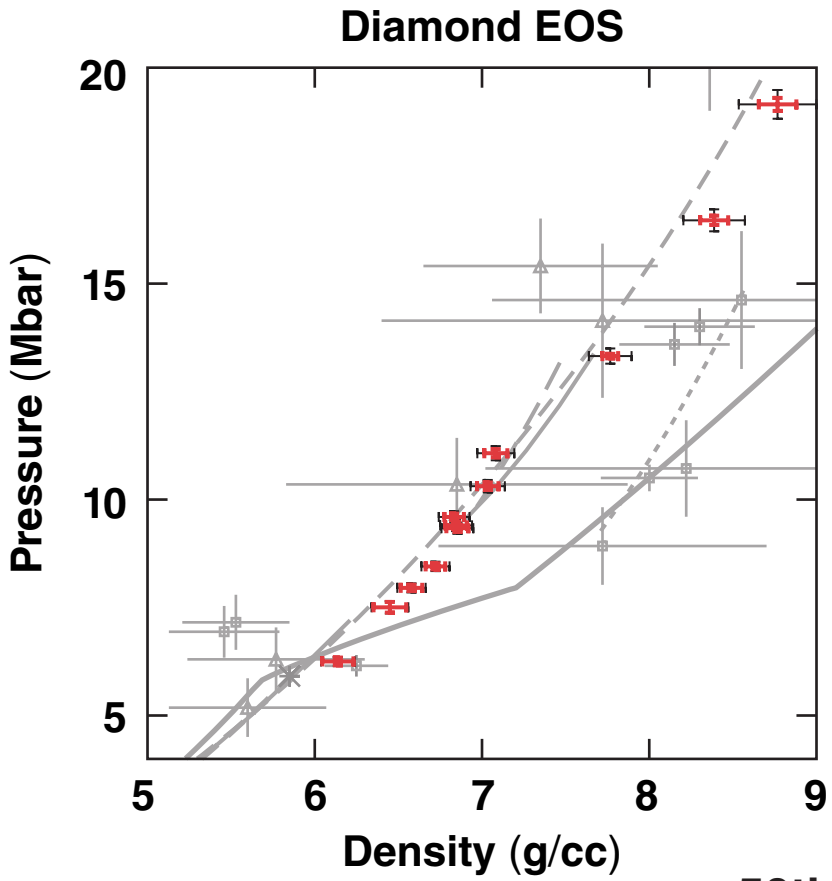
Precision Equation-of-State (EOS) Measurements Using Laser-Driven Shock Waves On the OMEGA Laser



M. A. Barrios
University of Rochester
Laboratory for Laser Energetics

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Summary

Precision equation-of-state (EOS) measurements are obtained using quartz as a standard

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- The impedance-matching (IM) technique has been used for decades to obtain EOS measurements, mainly using opaque standards.
- Both random *and* systematic errors, inherent in IM, must be addressed.
- Transparent standards (quartz) allow one to measure the shock velocity (U_S) within the standard, reducing random errors.
- This high-precision technique applied to diamond EOS resolved an ambiguity in existing data.

Collaborators

D. E. Fratanduono

T. R. Boehly

D. D. Meyerhofer

University of Rochester
Laboratory for Laser Energetics

D. G. Hicks

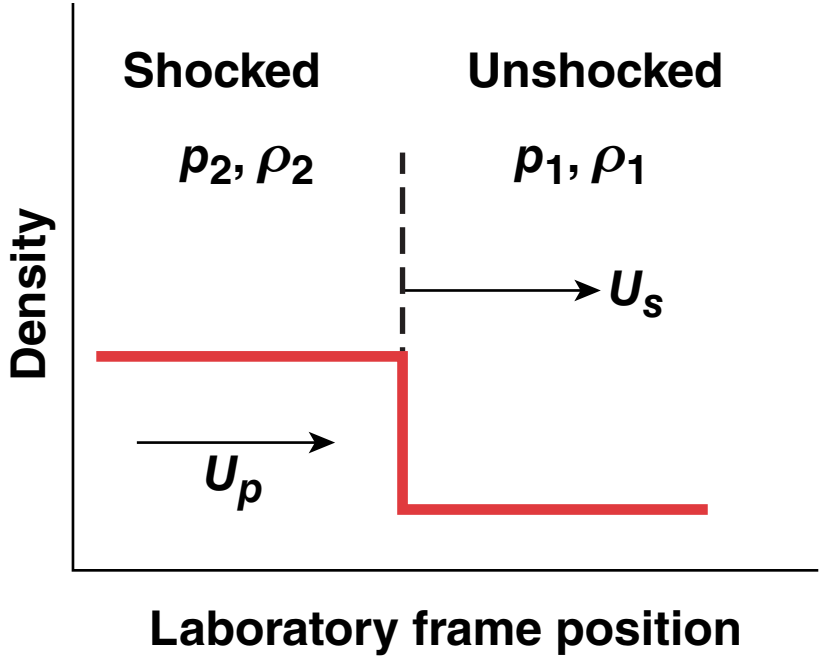
P. M. Celliers

J. Eggert

Lawrence Livermore National Laboratory

EOS Measurements

Laser-driven shocks are used to study materials at high pressure



Rankine–Hugoniot equations

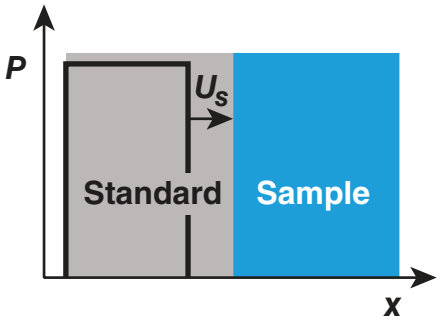
$$\rho_0 U_s = \rho_1 (U_s - U_p)$$

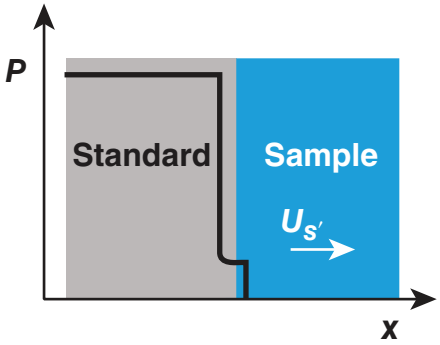
$$P_1 - P_0 = \rho_0 U_s U_p$$

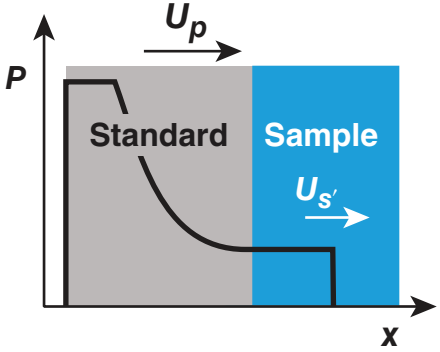
The measurement of two variables is needed to close these equations; e.g., $U_s = F(U_p)$.

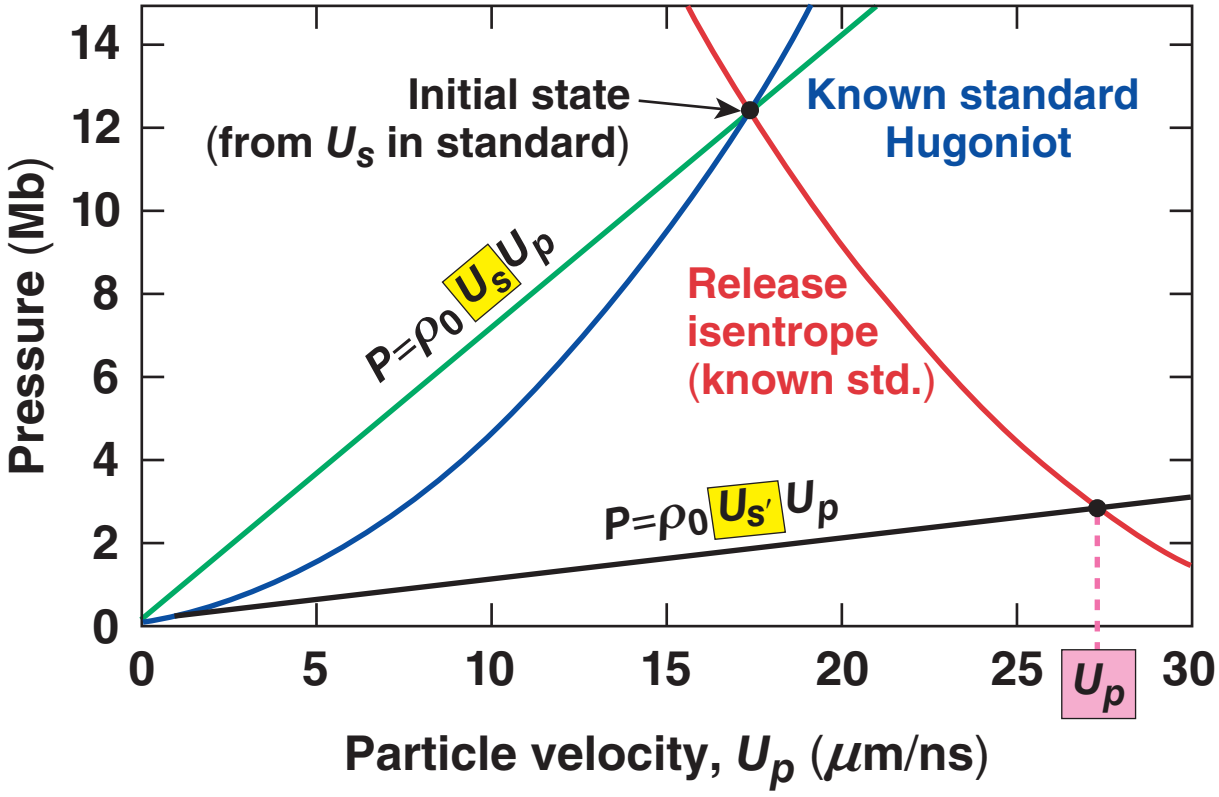
Impedance Match $U_s = F(U_p)$

The particle velocity and pressure are conserved across a contact interface









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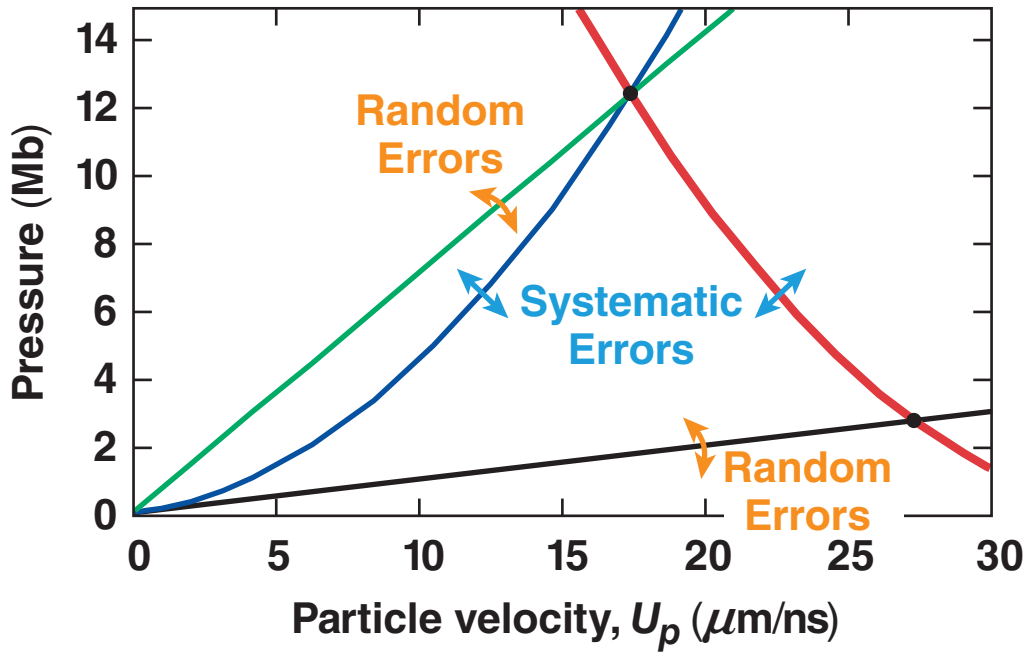
Need to minimize experimental error and address systematic errors for precision EOS measurements



- Measurement accuracy depends on knowledge of standard.
- Most IM studies quote only random errors.
- Cannot propagate systematic errors using theoretical EOS.

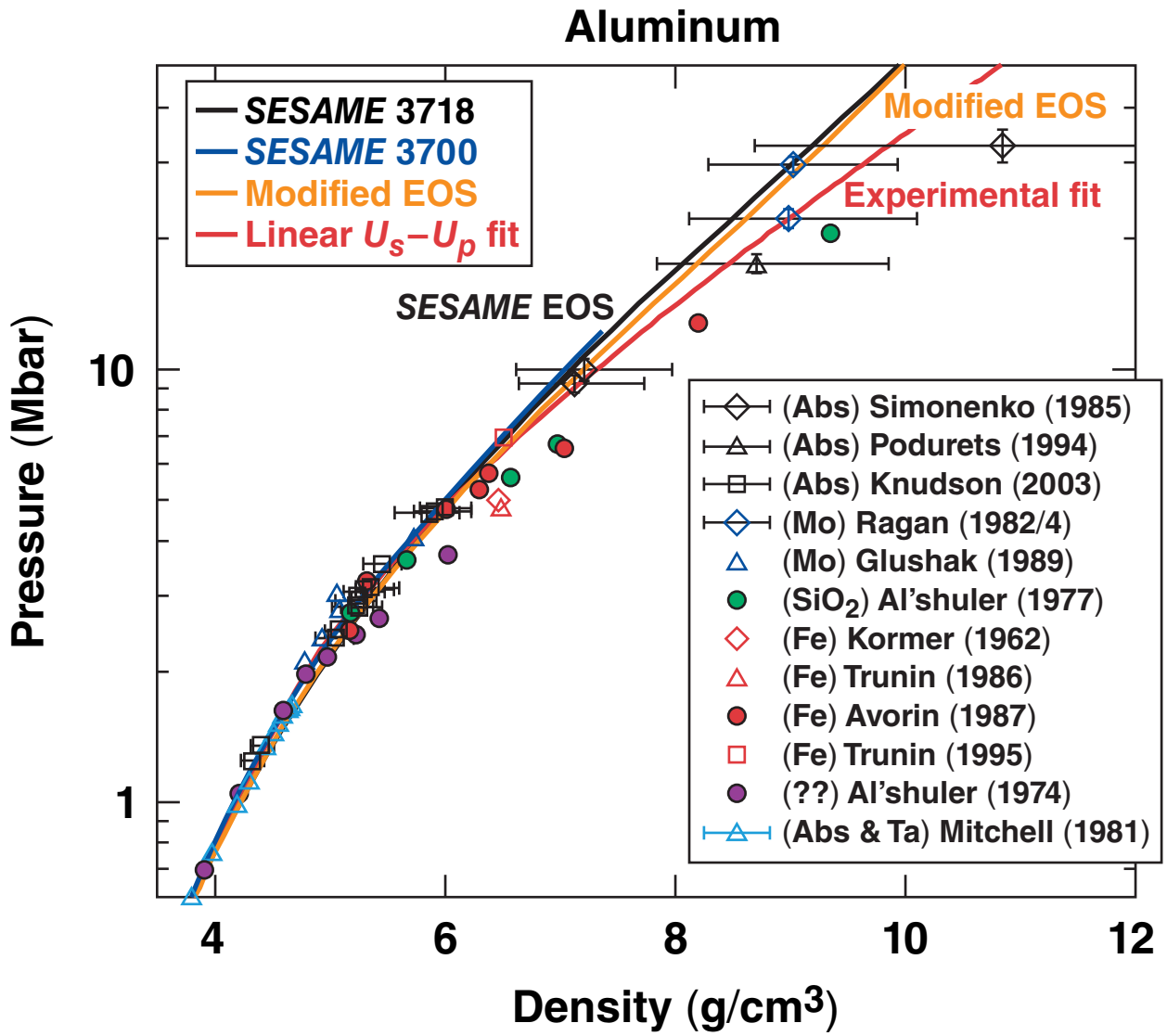
- Random errors

$$\frac{\delta\rho}{\rho} \simeq (\eta - 1), \quad \eta = \frac{\rho}{\rho_0}; \quad \eta \simeq 4 - 6 \rightarrow \frac{\delta\rho}{\rho} \propto (3 - 5) \times \delta u_s$$

E13920b

Systematic Errors

At high pressures inconsistencies exist between EOS models and data for aluminum



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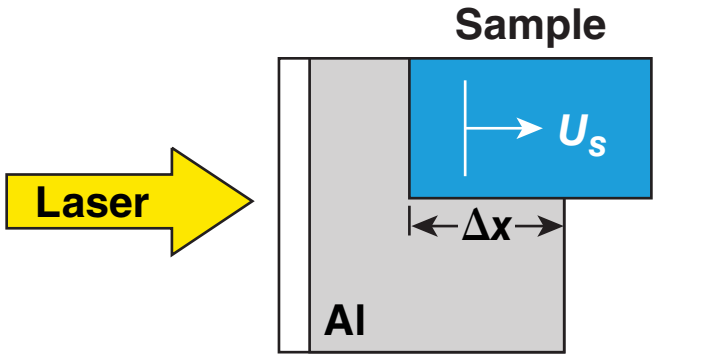
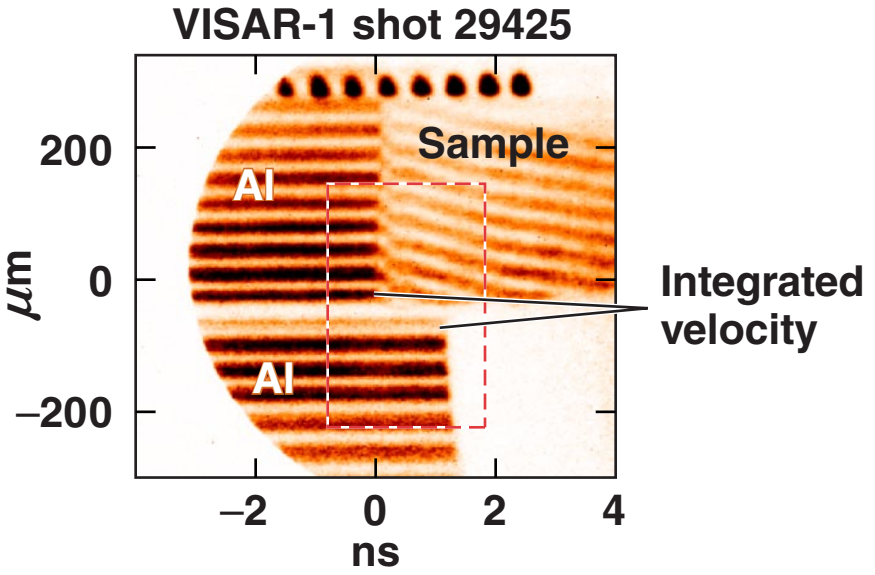
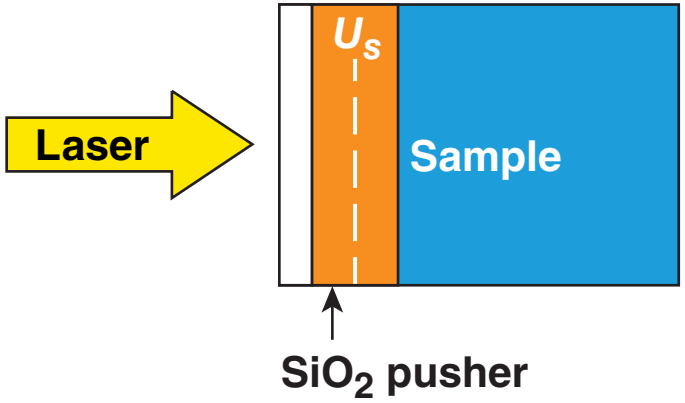
Random Errors

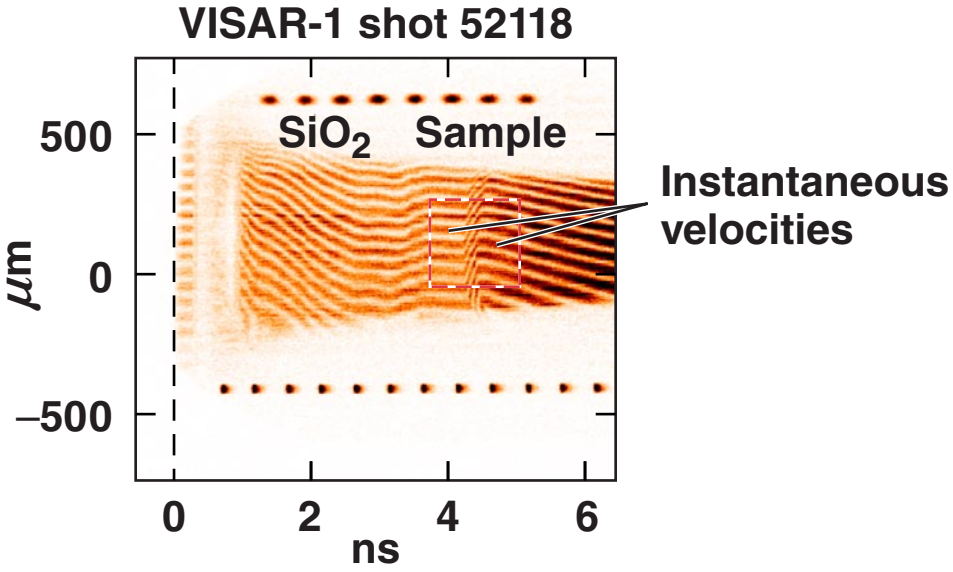
Higher precision is achieved using a transparent standard



U_s is inferred from transit times







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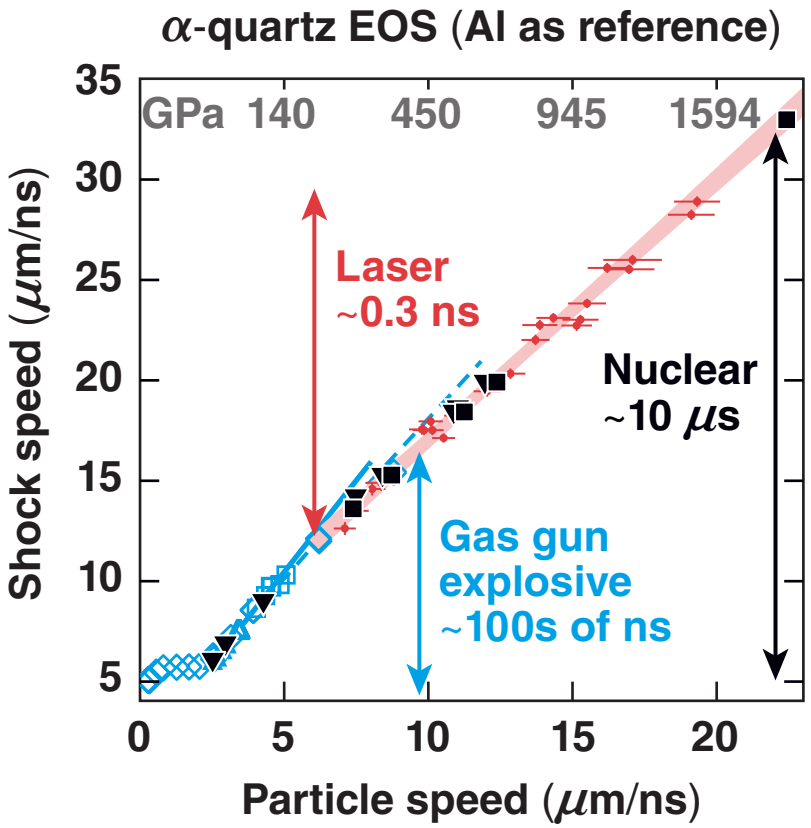
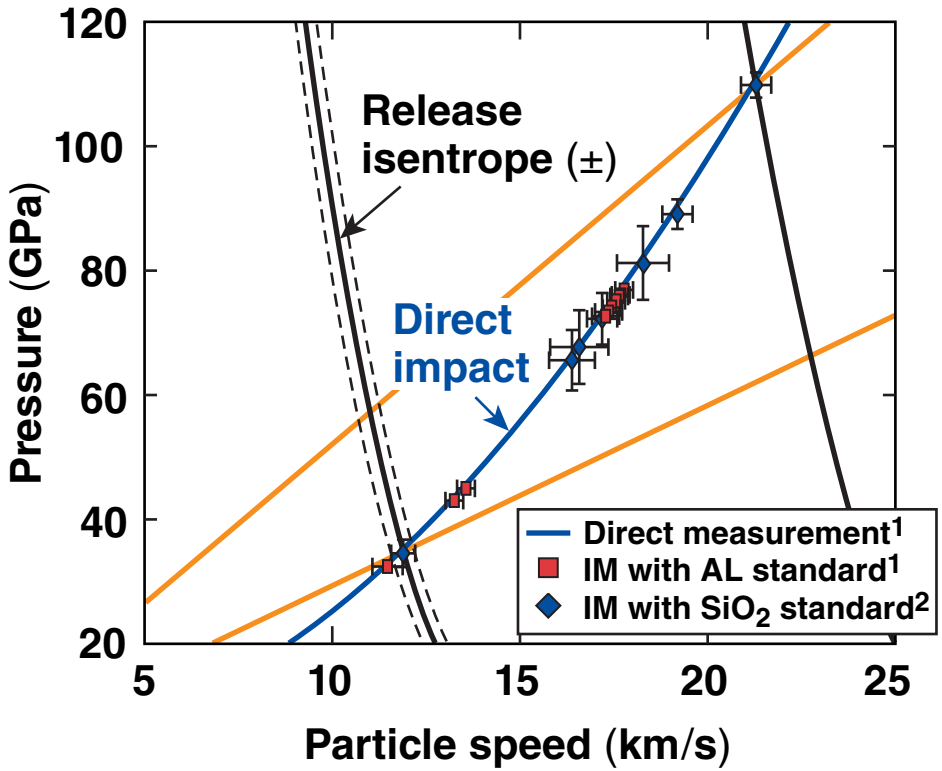
Quartz validity as a standard is established through ample study of its EOS and agreement with previous results



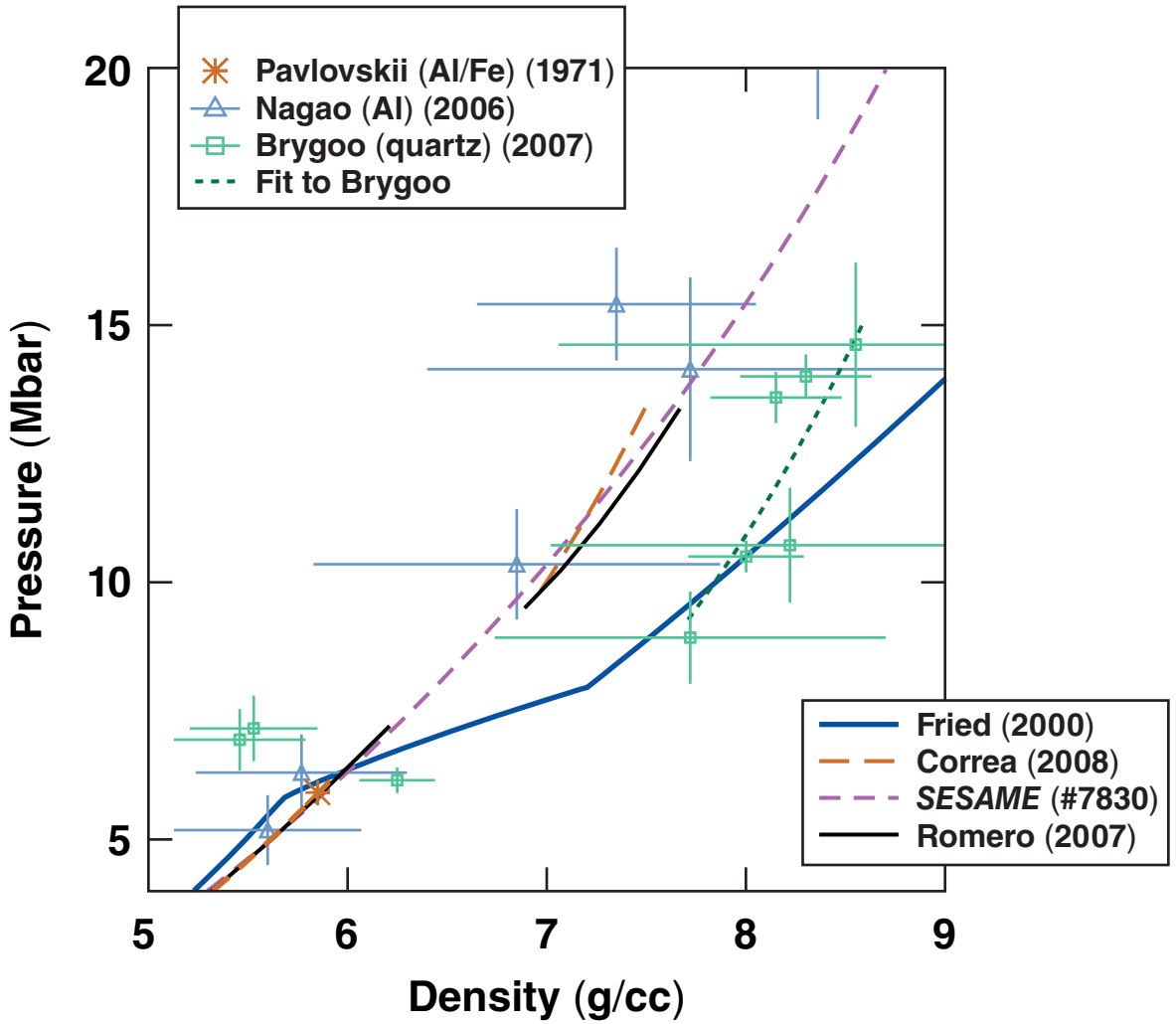


D. G. Hicks *et al.*, Phys. Plasmas 12, 082702 (2005).

[1] M. D. Knudson *et al.*, J. Appl. Phys. 97, 073514 (2005).

[2] T. R. Boehly *et al.*, in *Shock Compression of Conducted Matter–2007*, Vol. 955, p 19–22.

Discrepancies in diamond EOS were resolved with high-precision data



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D. G. Hicks *et al.*, Phys. Rev. B 78, 174102 (2008).

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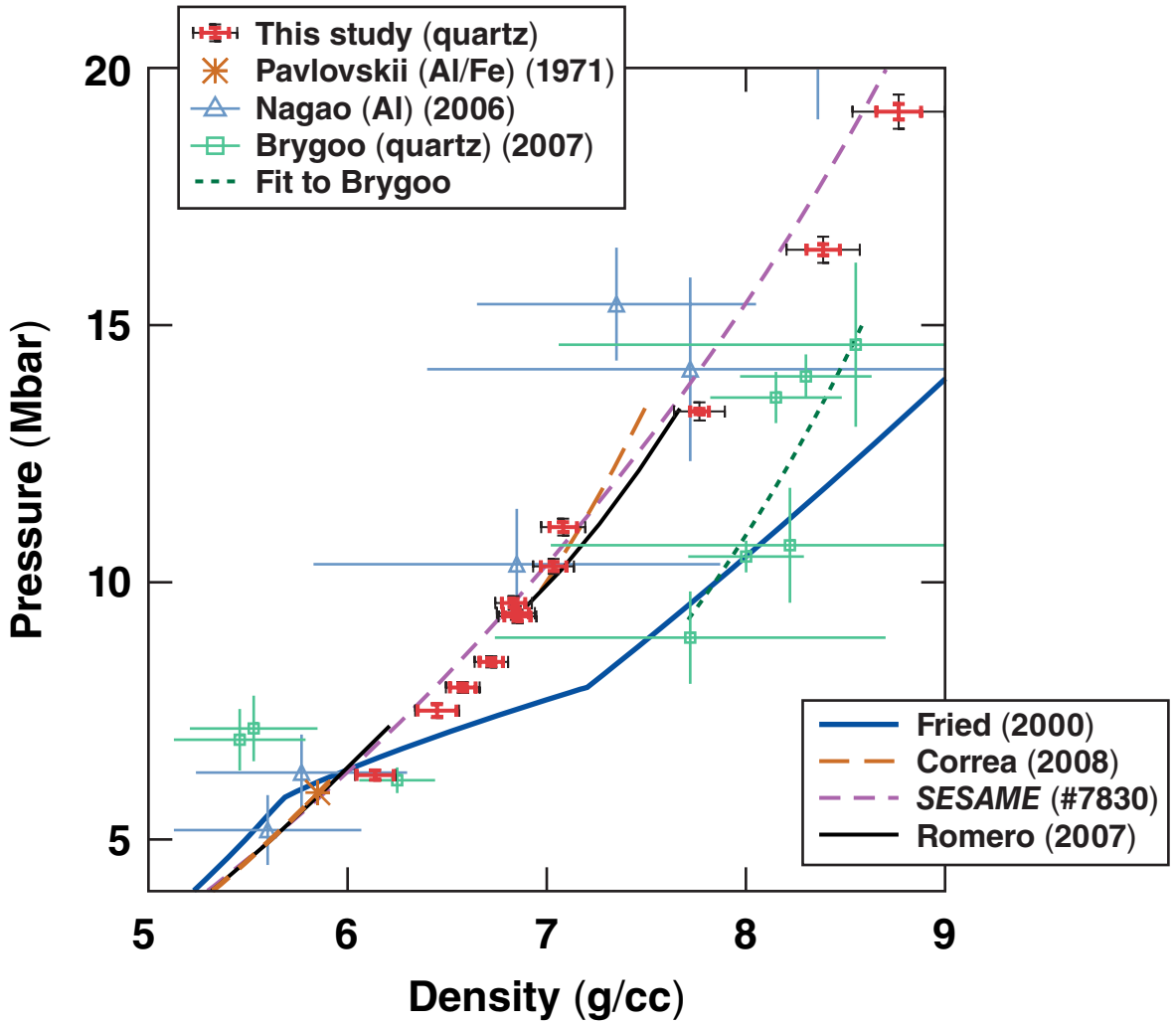

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- This high-precision technique applied to diamond EOS resolved an ambiguity in existing data.
- This technique will be applied to: CH, LiF, Al_2O_3, and GGG.