SAND2012-7405C

Megaamps, Megagauss and Megabars: Using the Sandia Z Machine to Perform Extreme Material Dynamics Experiments

Physics of Non-Ideal Plasmas
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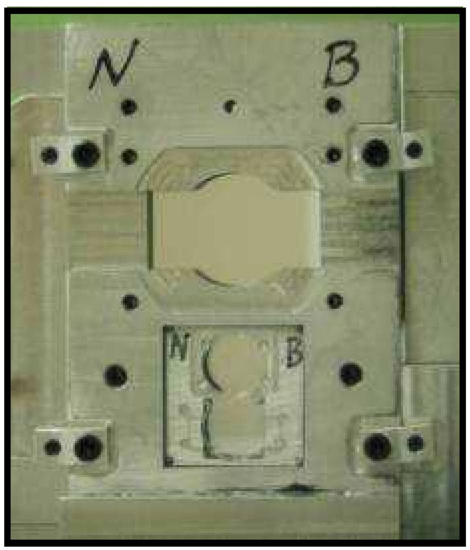
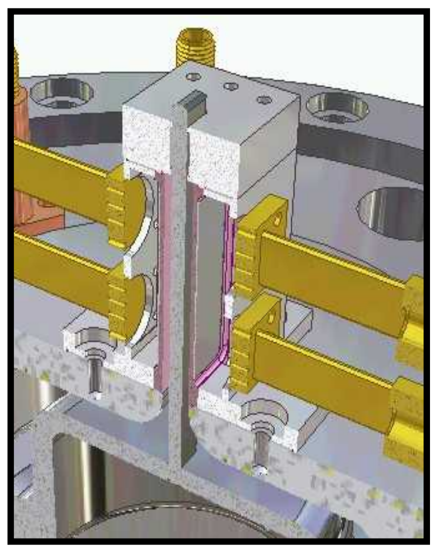
Marcus D. Knudson
Sandia National Laboratories, Albuquerque, NM





Marcus D. Knudson, (505) 845-7796, mdknuds@sandia.gov

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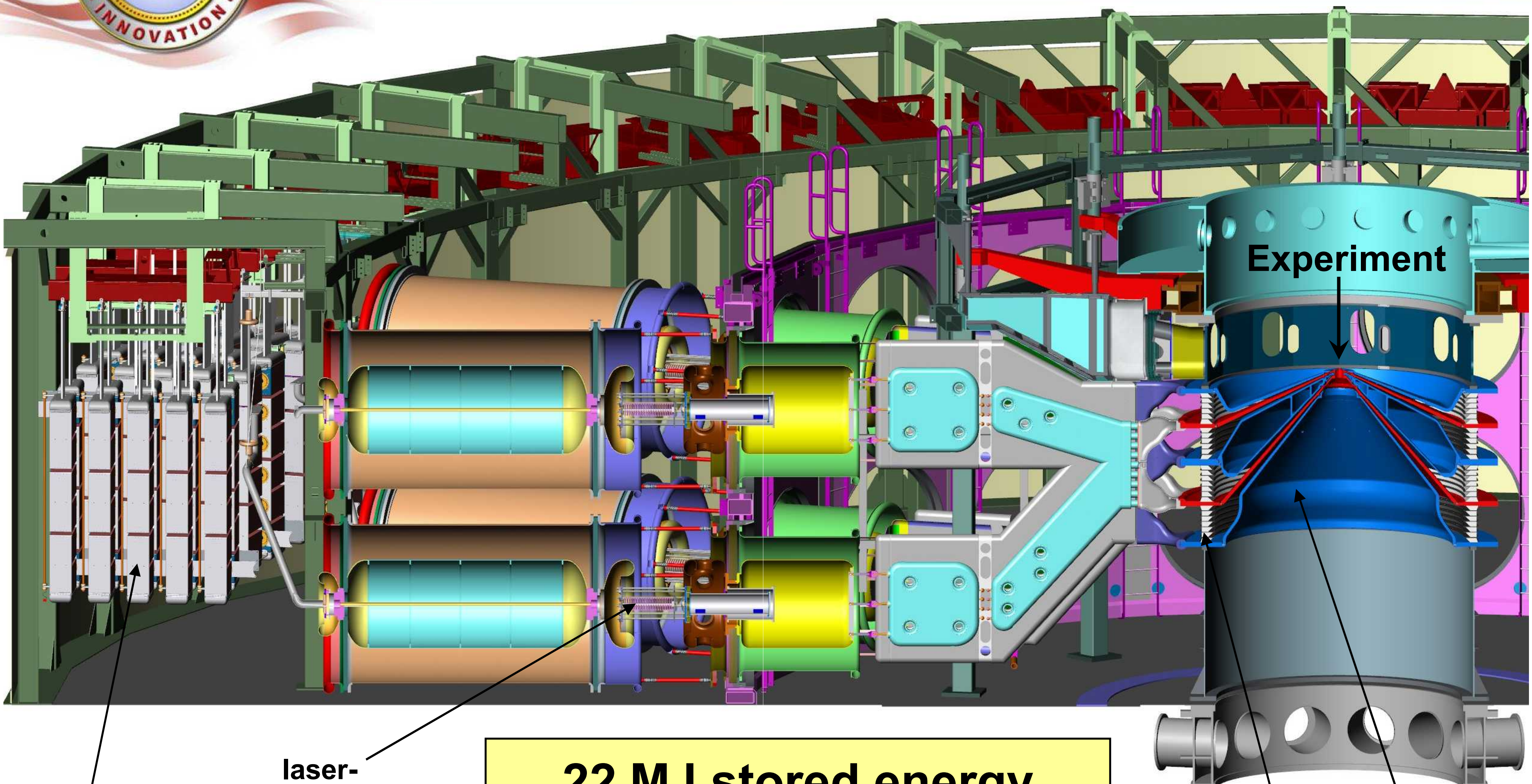
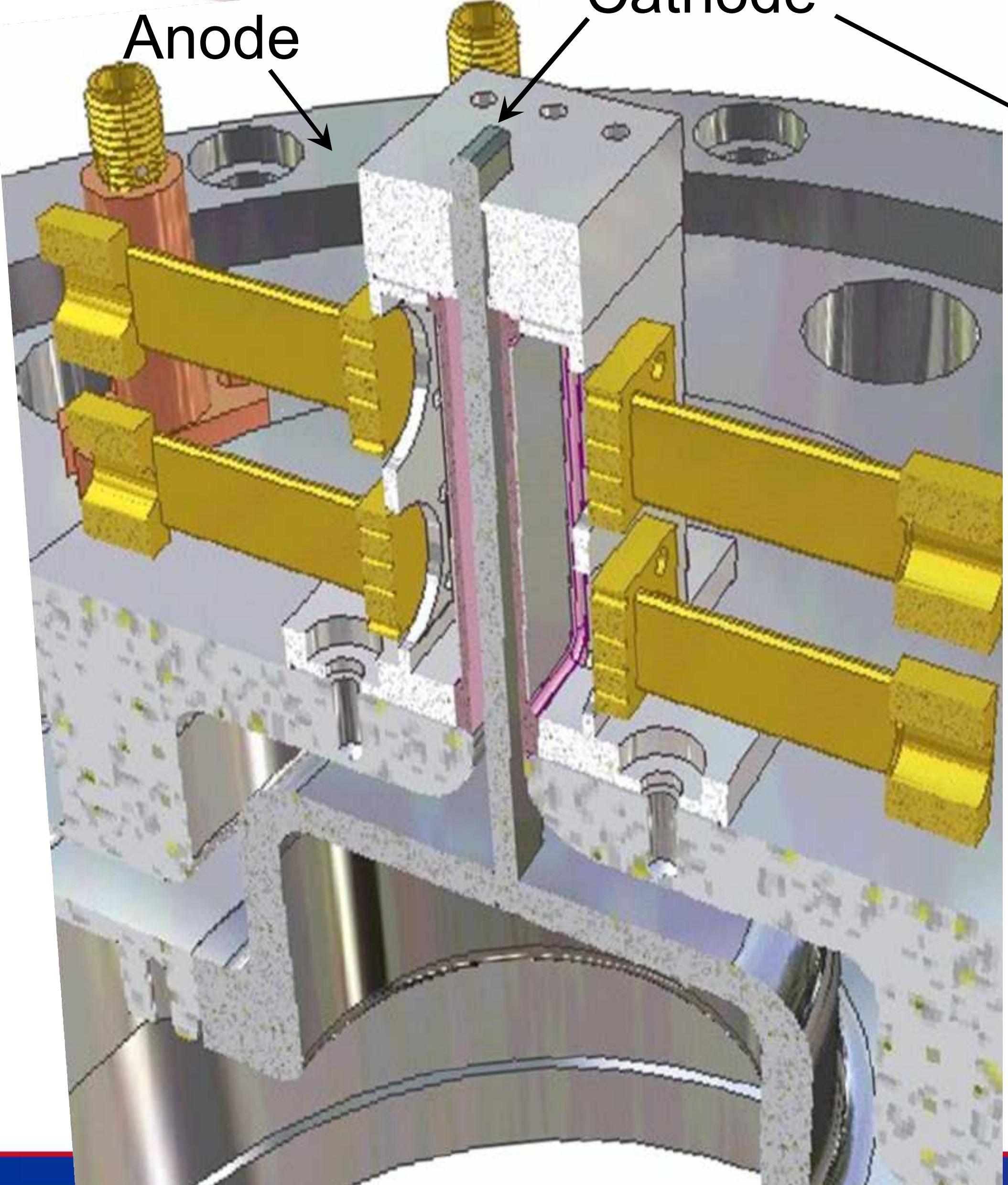
  - Quantum Molecular Dynamics (QMD) calculations
- Ray Lemke
  - Flyer plate design and MHD simulations
- Jean-Paul Davis, Devon Dalton, Ken Struve, Mark Savage, Keith LeChien, Brian Stoltzfus, Dave Hinshelwood
  - Bertha model, pulse shaping
- Charlie Meyer, Devon Dalton, Dustin Romero, Anthony Romero, entire Z crew…
  - Experiment support

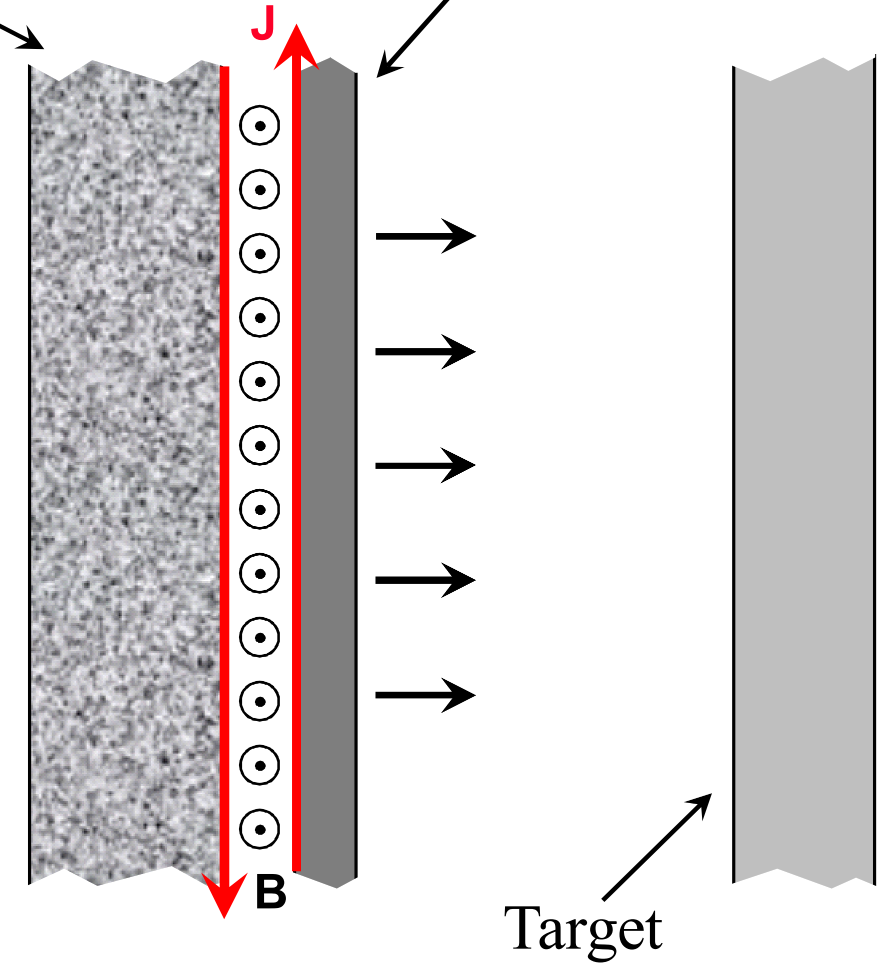
The Sandia Z Machine



22 MJ stored energy
~25 MA peak current
~200-600 ns rise time

With proper pulse shape and design the anode can be launched as an effective high-velocity flyer plate





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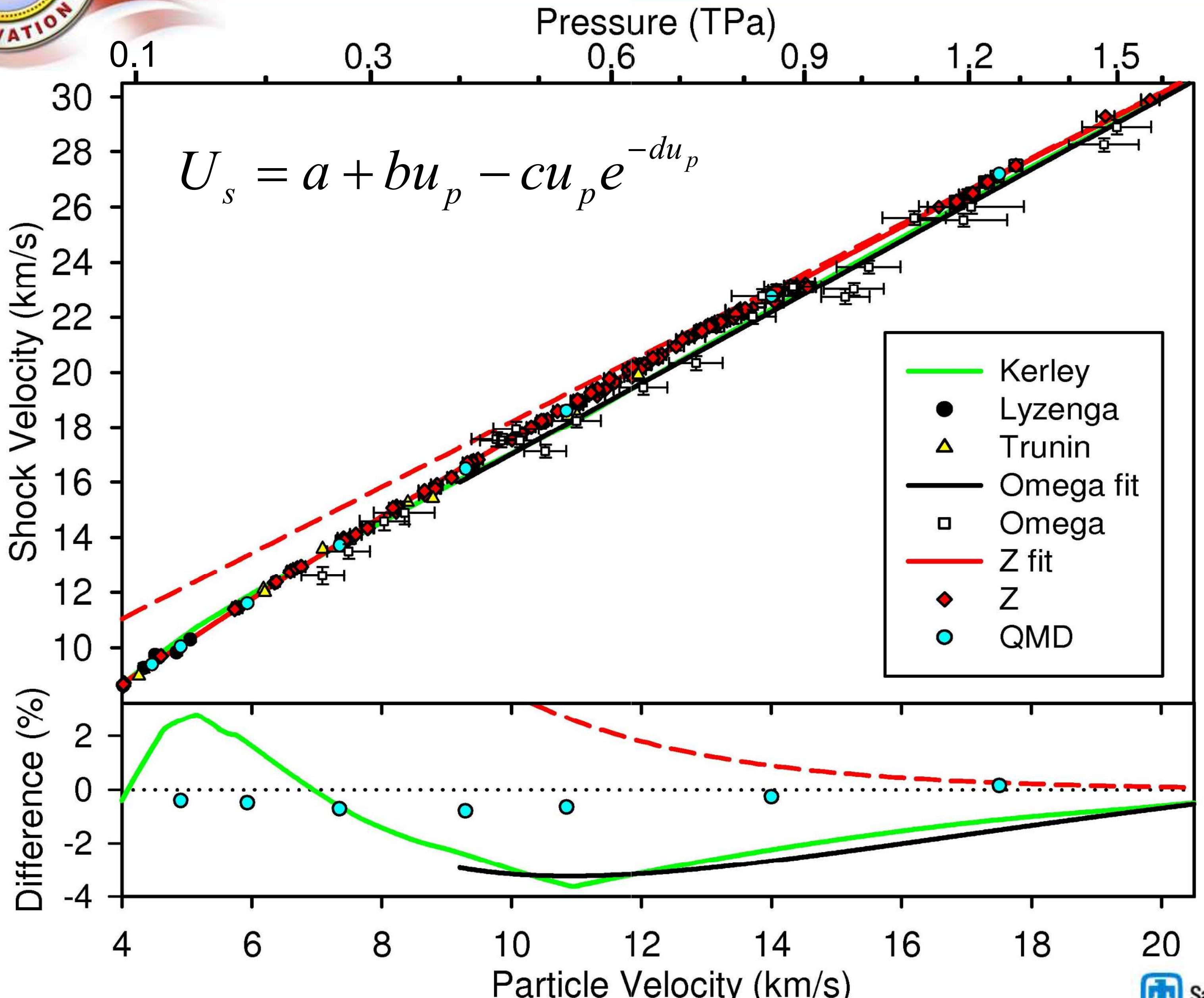
U_s-u_p Hugoniot for α-Quartz



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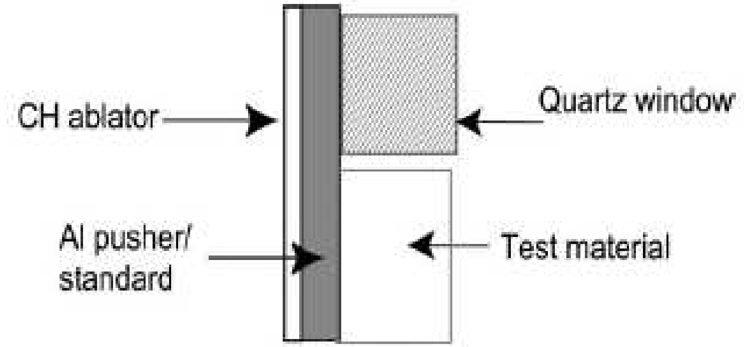
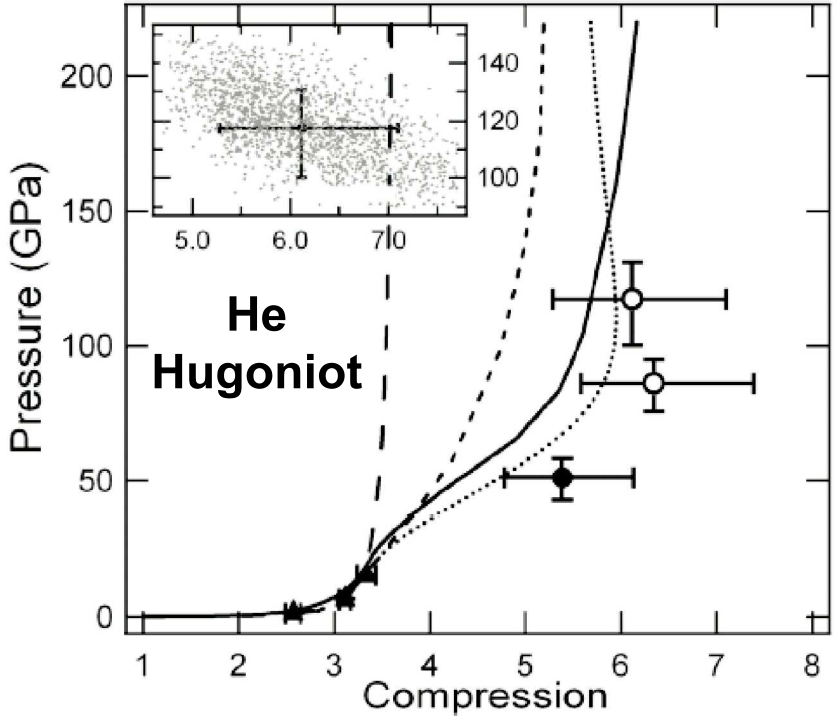
Motivation for α-Quartz measurements

- Quartz melts at ~100 GPa into a conducting fluid
  - Shock front becomes reflective
- Quartz is quickly becoming a high pressure shock wave standard
  - Helium, diamond, deuterium, water, xenon, krypton, carbon dioxde, …
- For accurate results there is a need to understand the off-Hugoniot response of quartz
  - In particular the quartz release response is needed for use with lower impedance materials

APPENDIX: DEVELOPMENT OF QUARTZ AS AN IMPEDANCE-MATCH STANDARD





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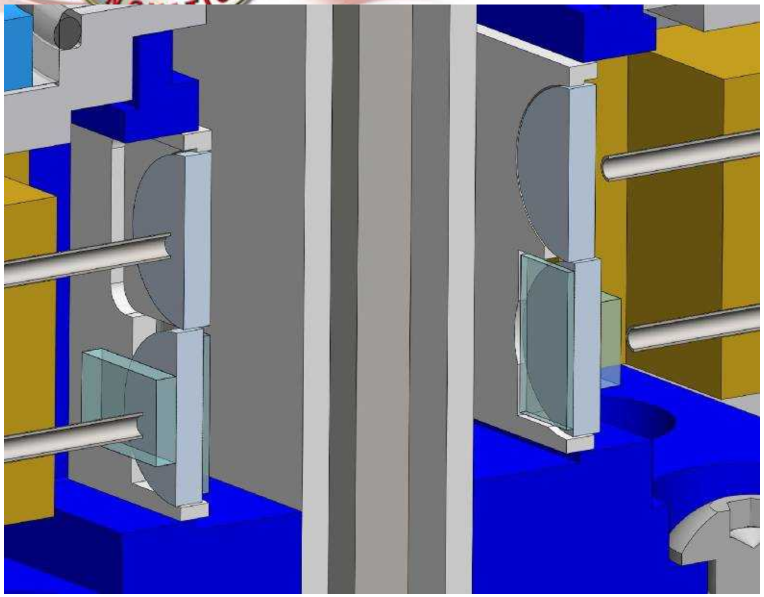
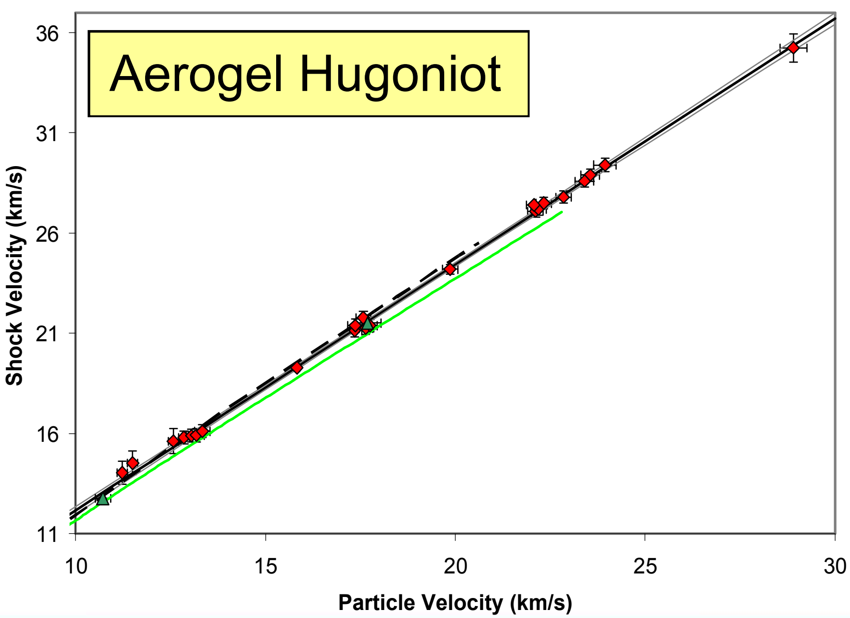
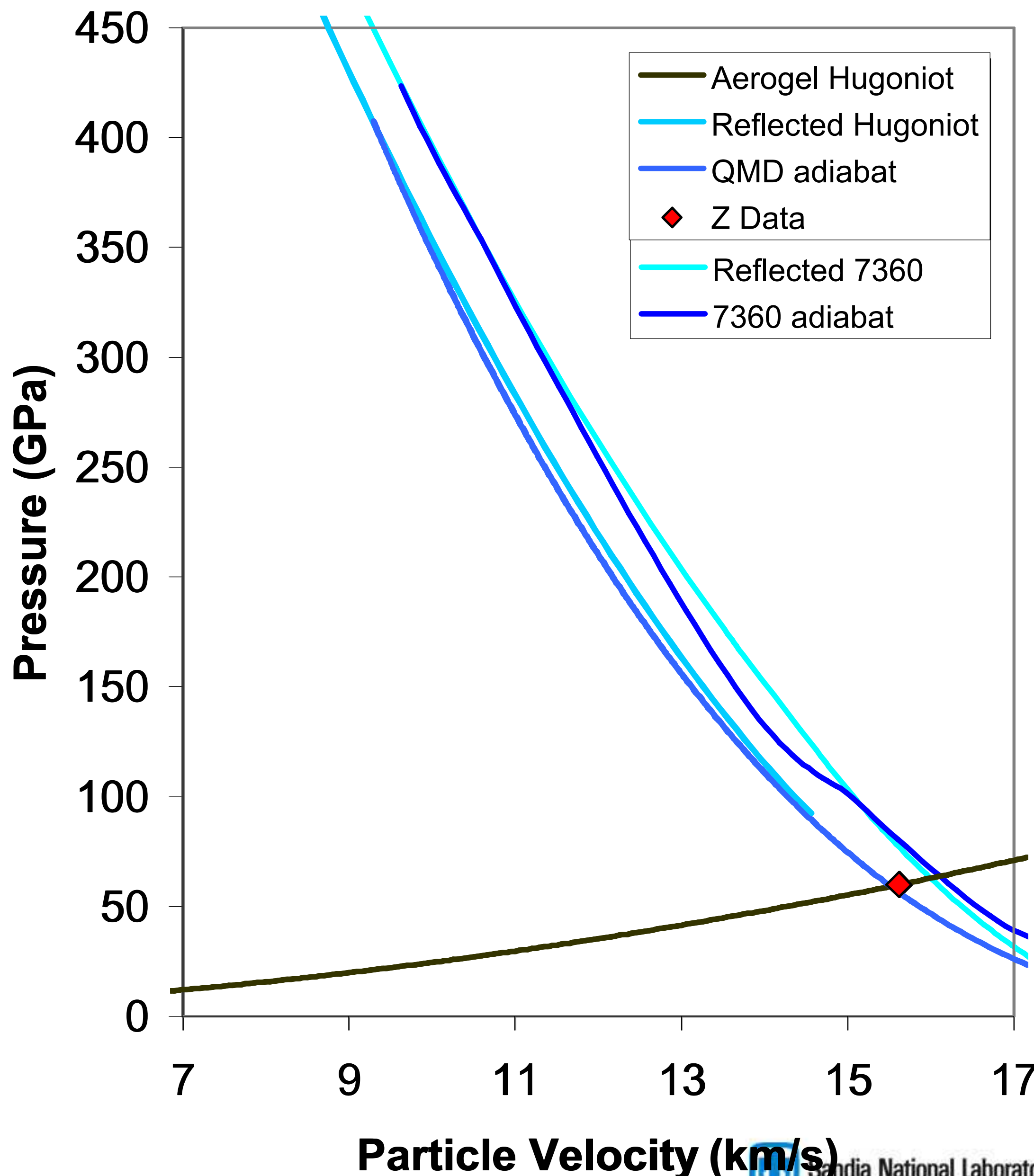
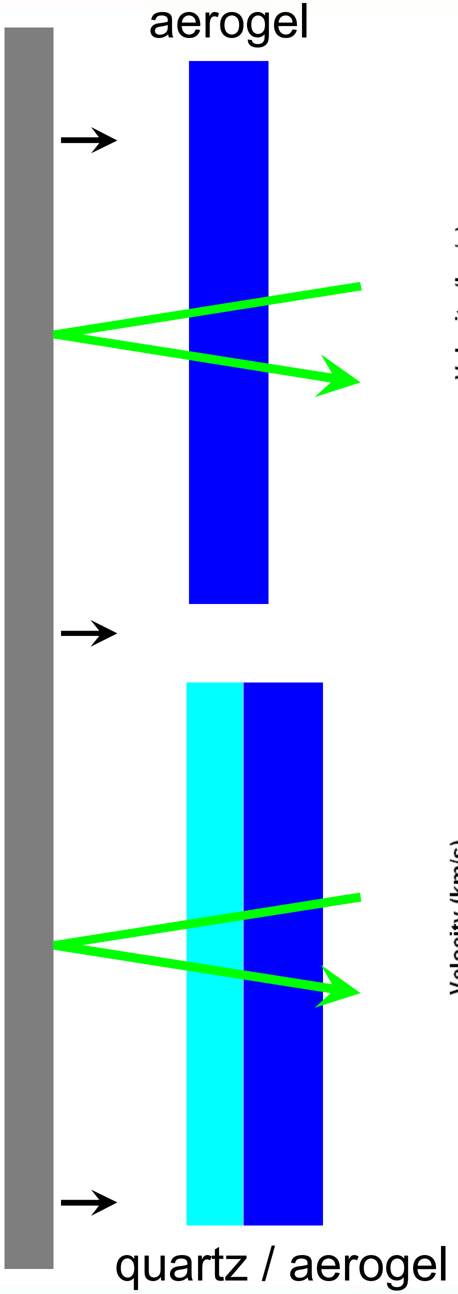
We have performed a series of experiments to measure release from 300 – 800 GPa states

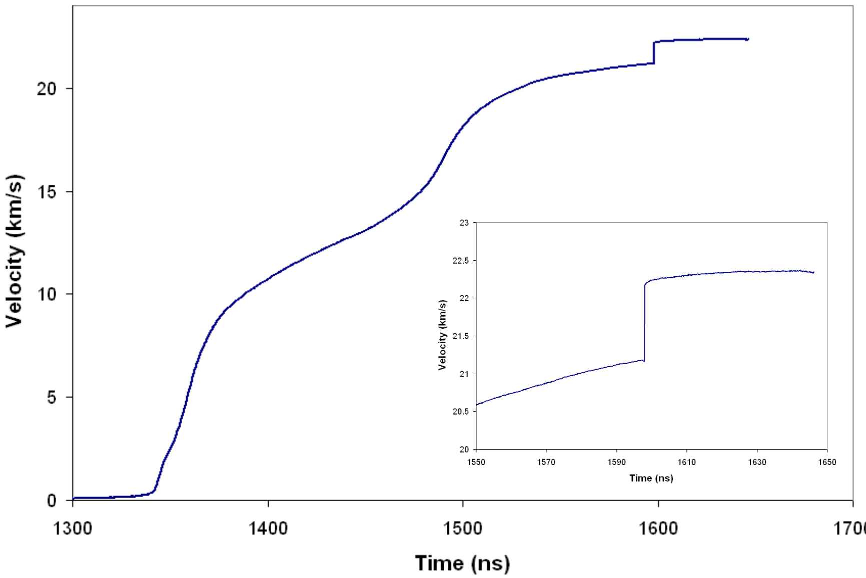


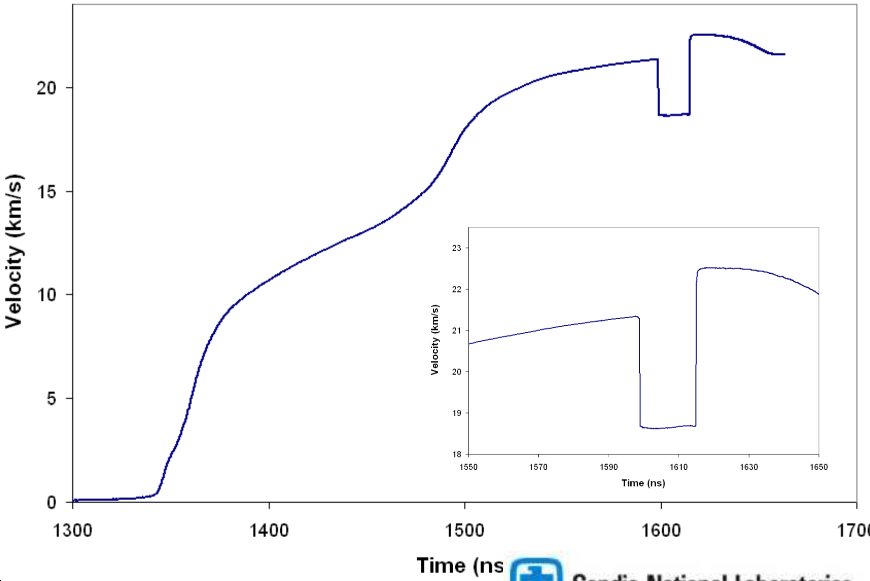




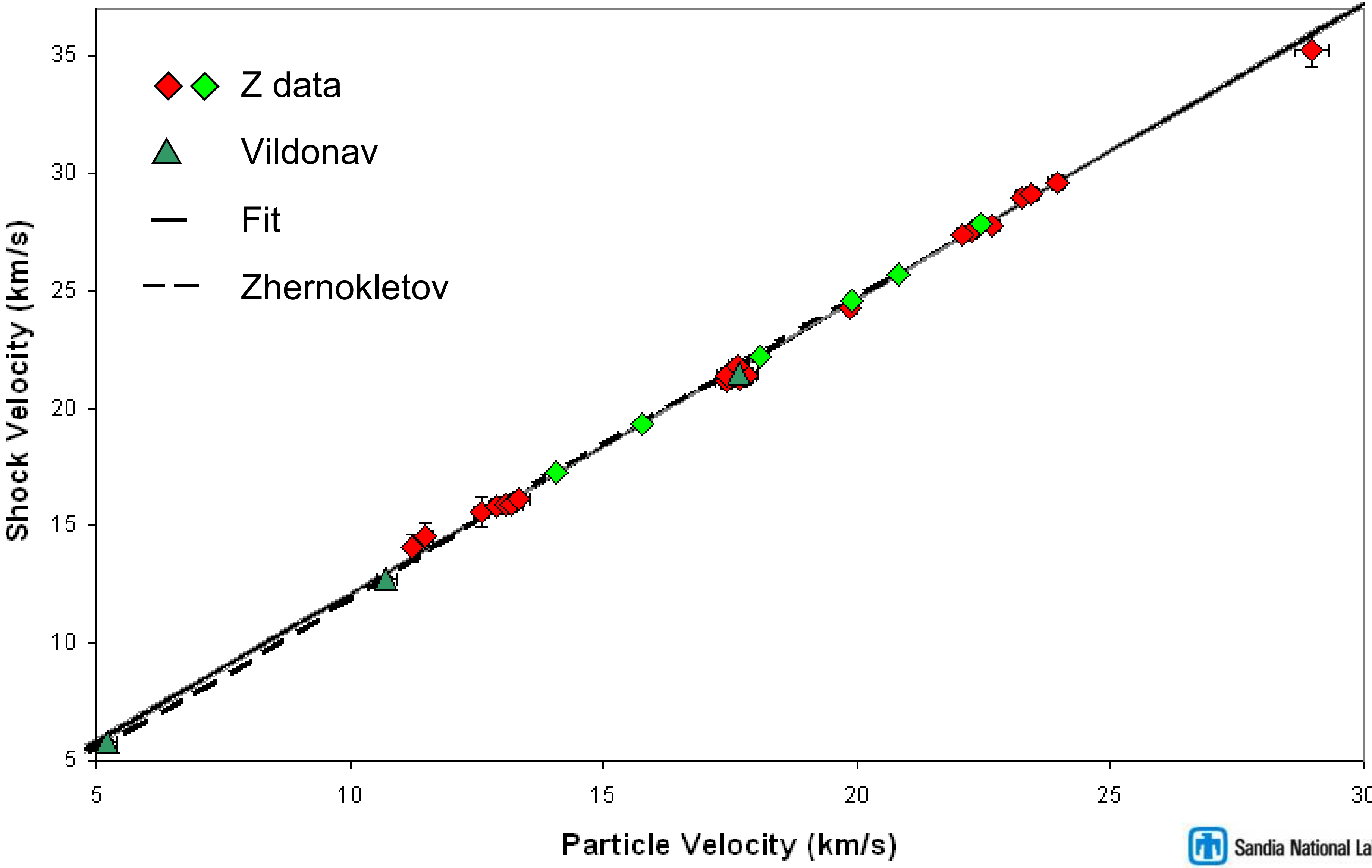
The same experiment provides Hugoniot and release measurement via velocity interferometry



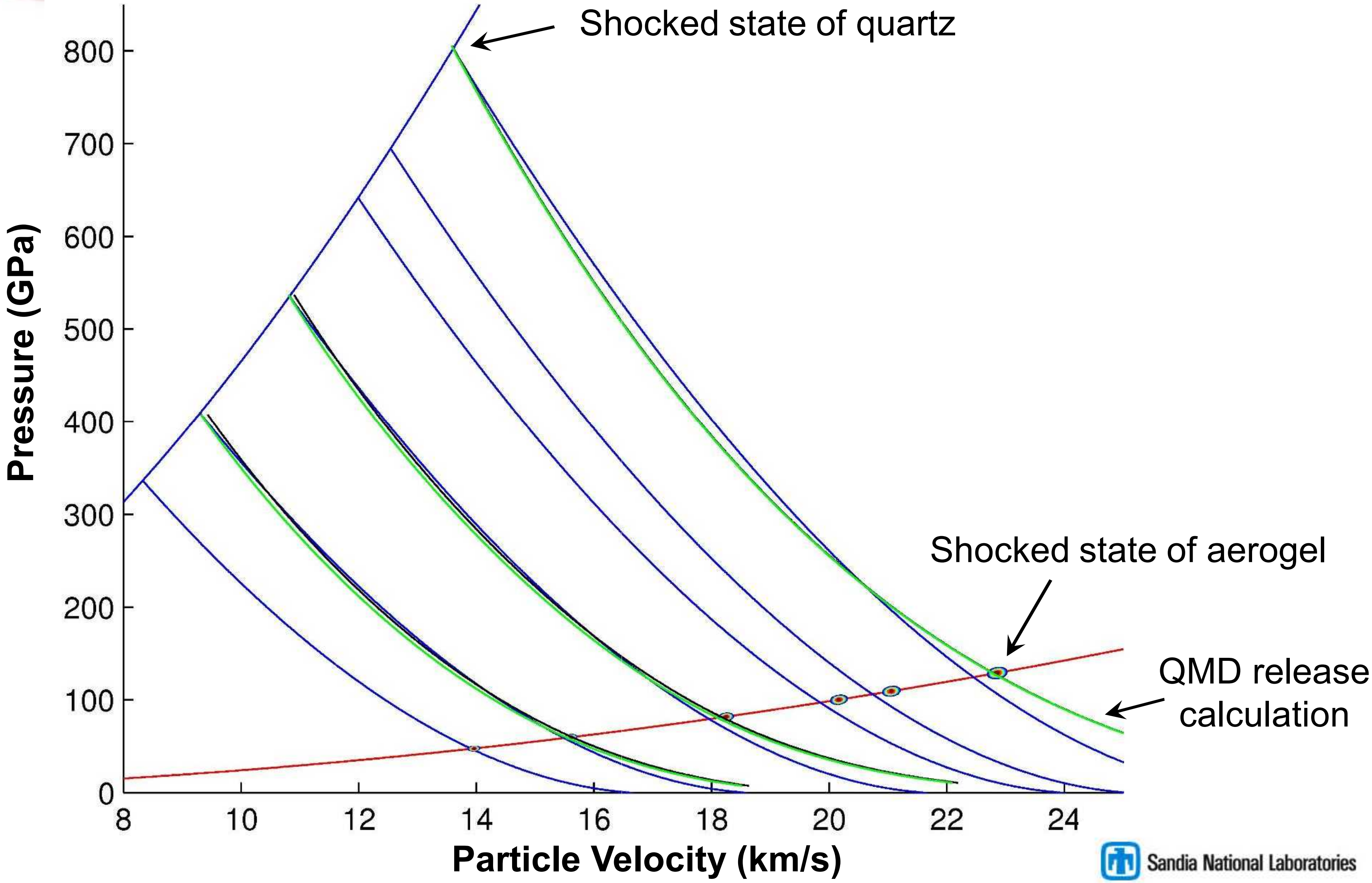




Hugoniot of ~200 mg/cc aergoel has been well characterized



Six release experiments have been performed from 300 – 800 GPa Hugoniot states



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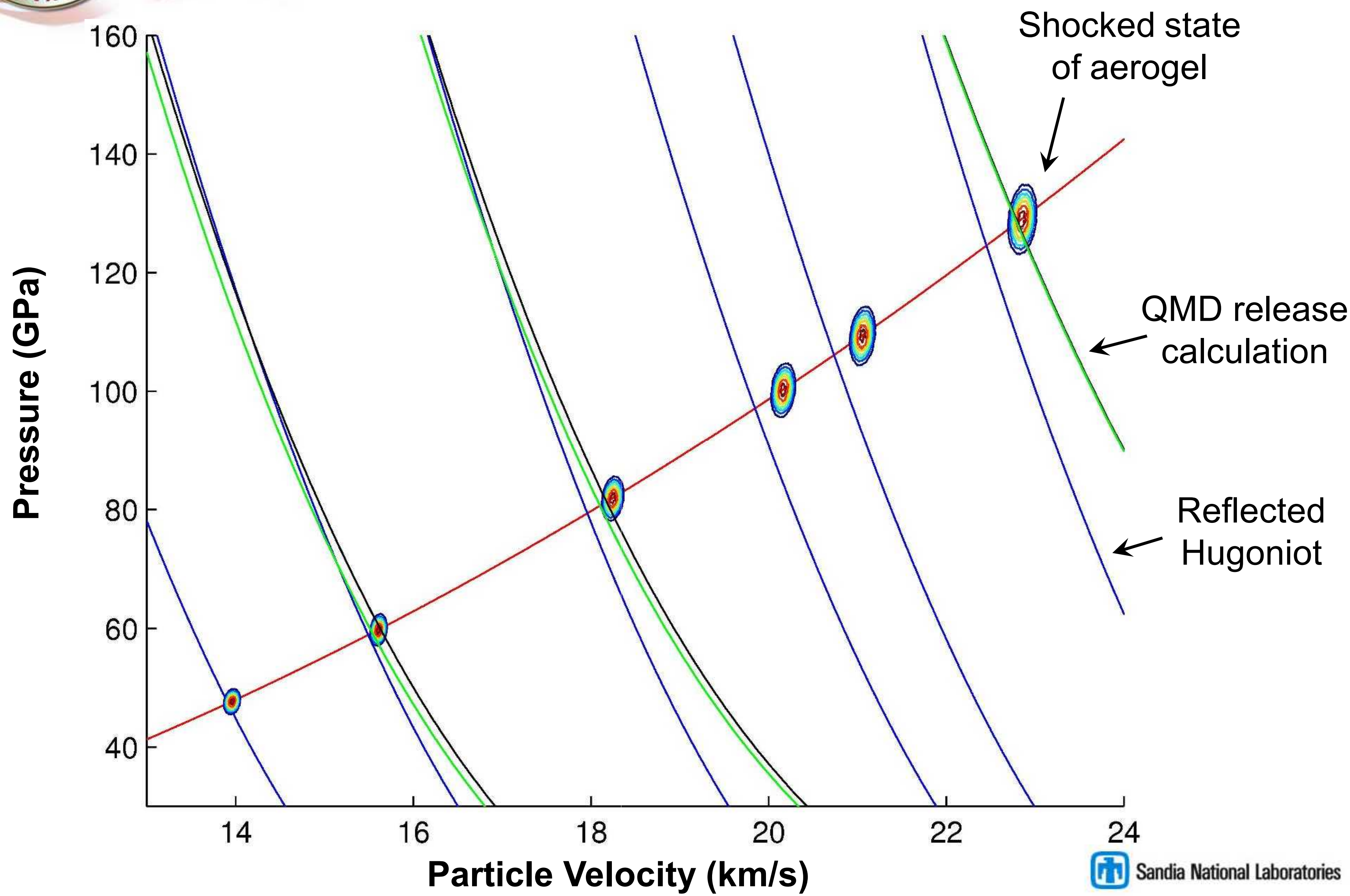
Quantum Molecular Dynamics calculations in good agreement with experiment



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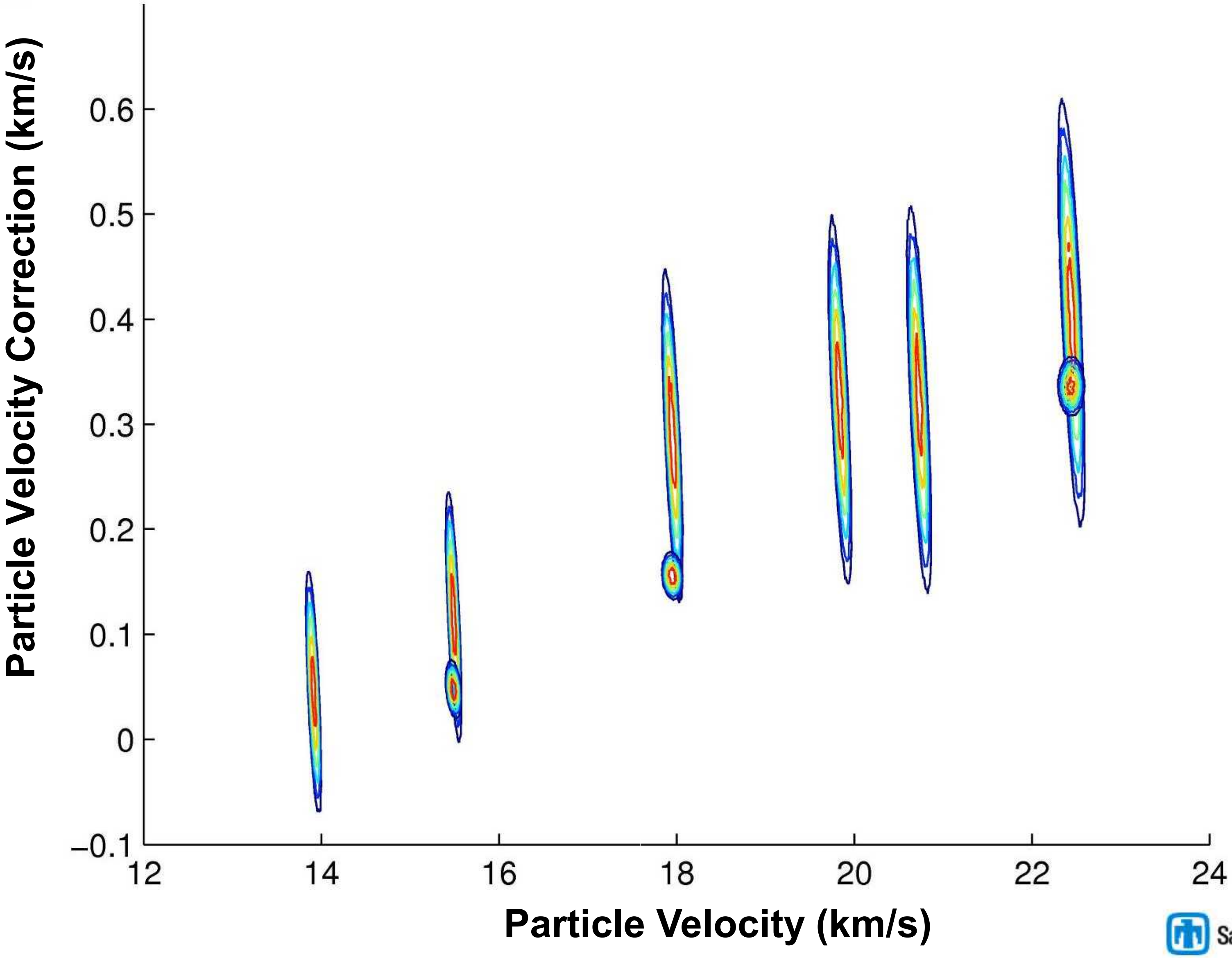
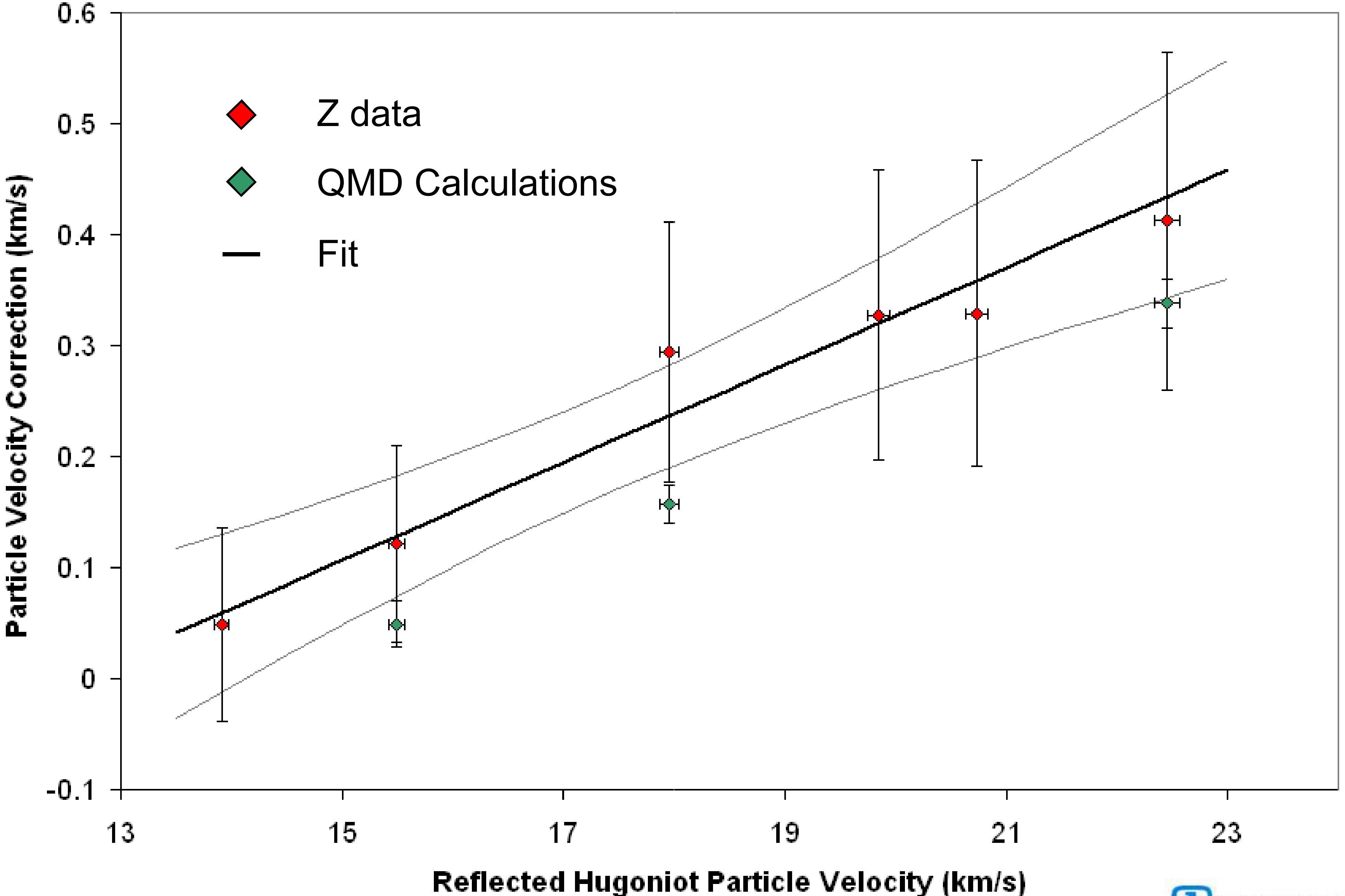
Quantum Molecular Dynamics matches trend in, but slightly underestimates, the correction to the RH



The absolute correction appears to increase linearly with the Reflected Hugoniot particle velocity



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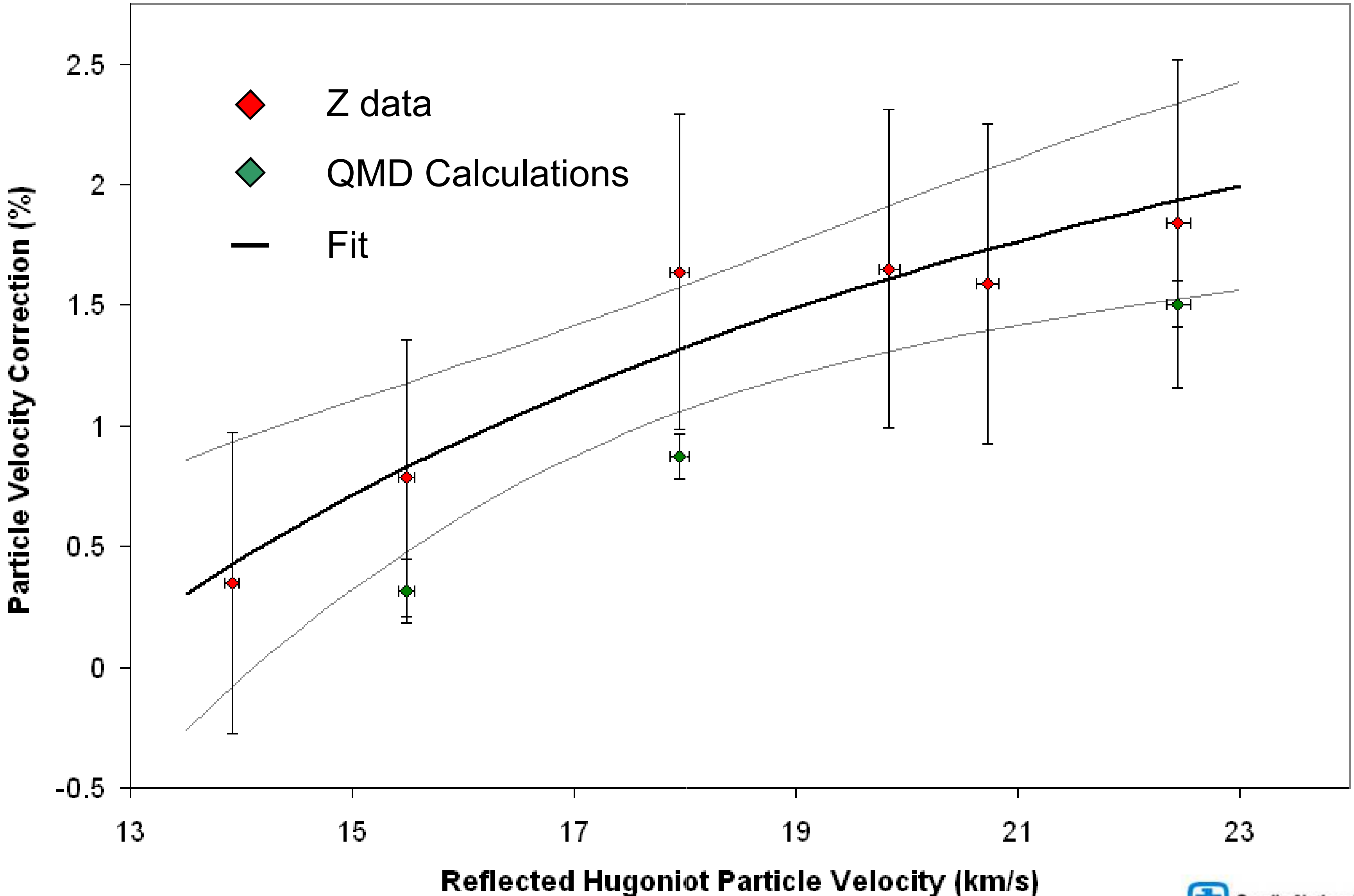
Expressed as a percentage, the correction appears to saturate at ~ 2 – 2.5 %



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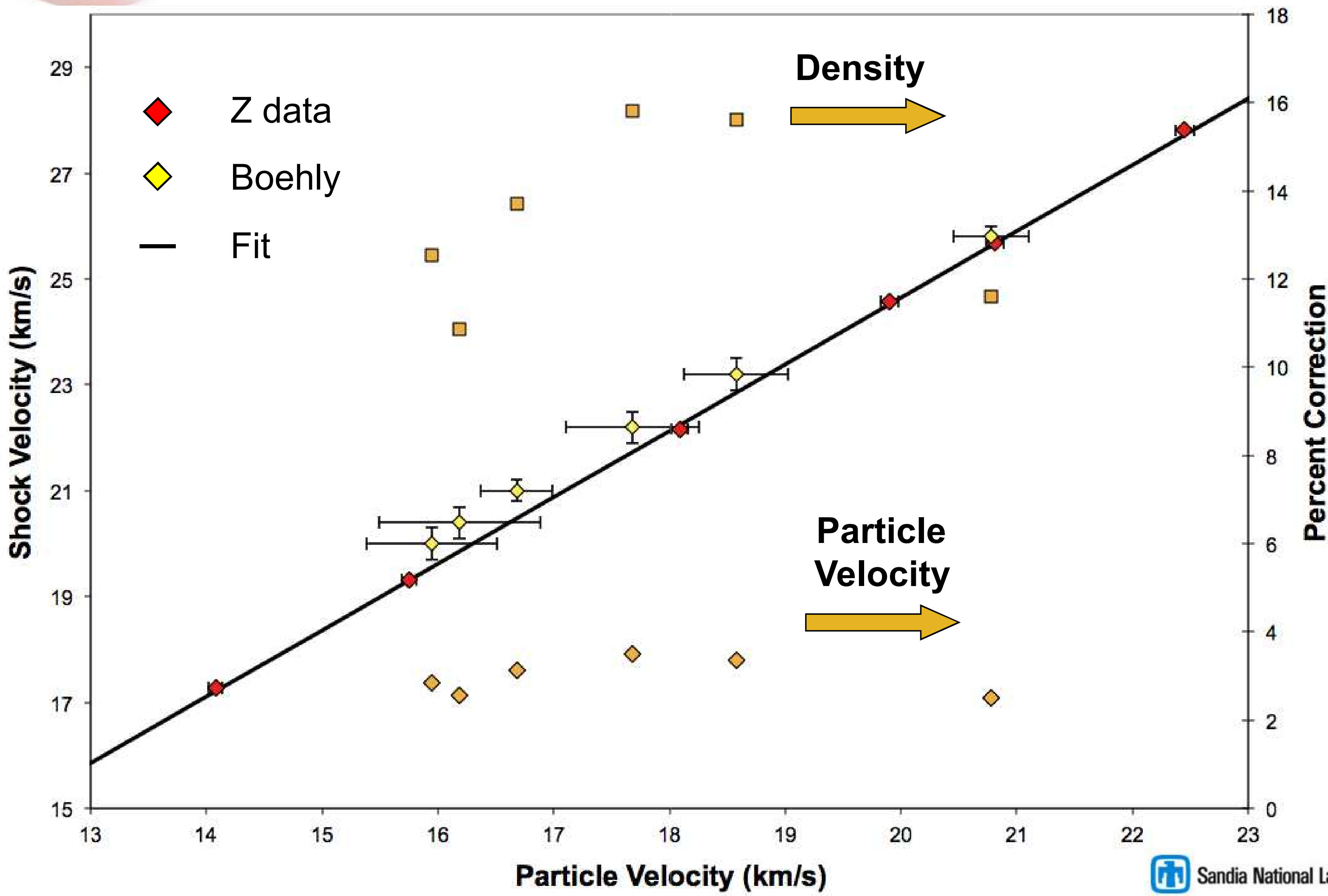
Recent results from Boehly, et al., demonstrate that potential errors can be significant



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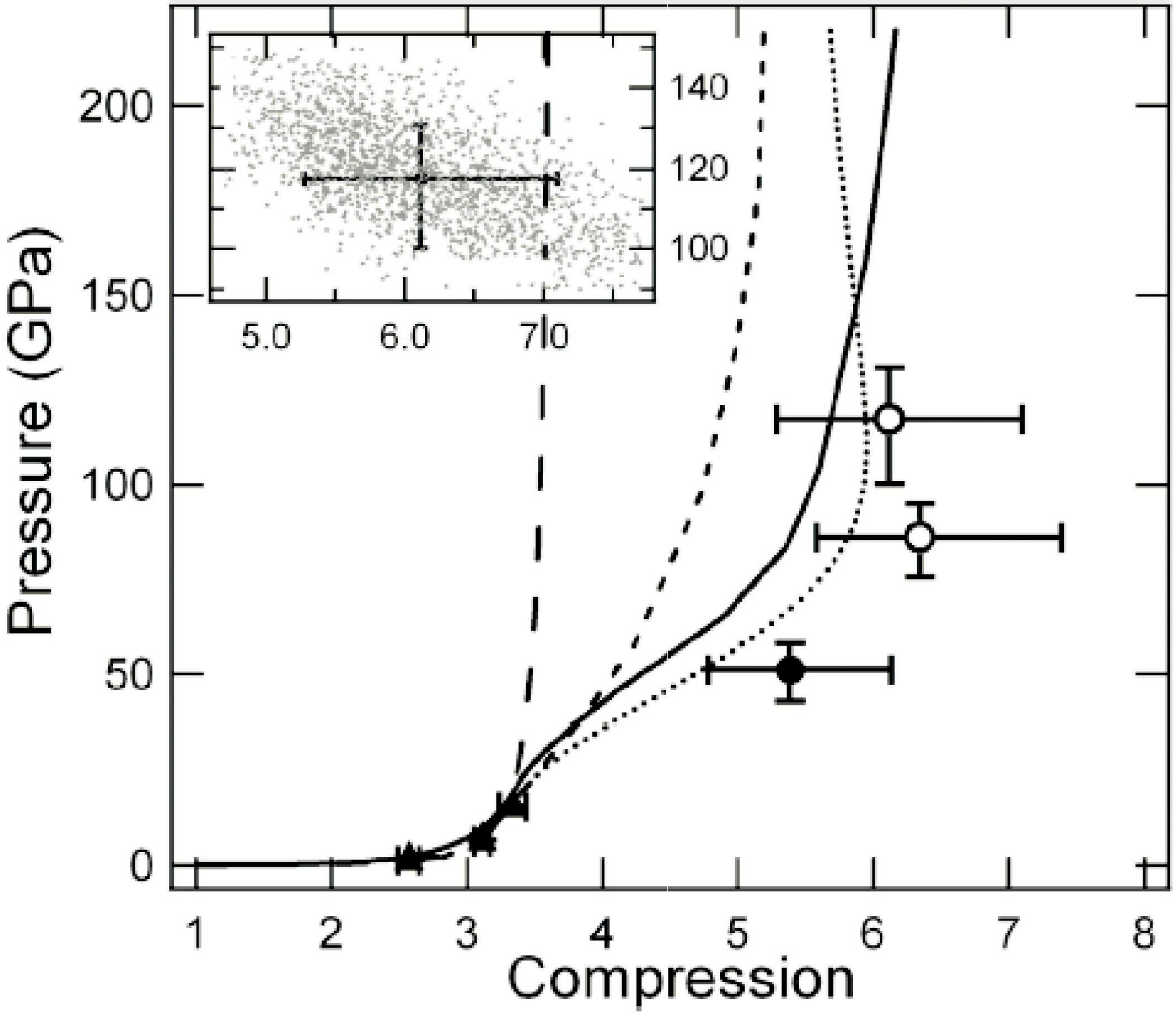
These results should provide better constraints for measurements made with quartz standard



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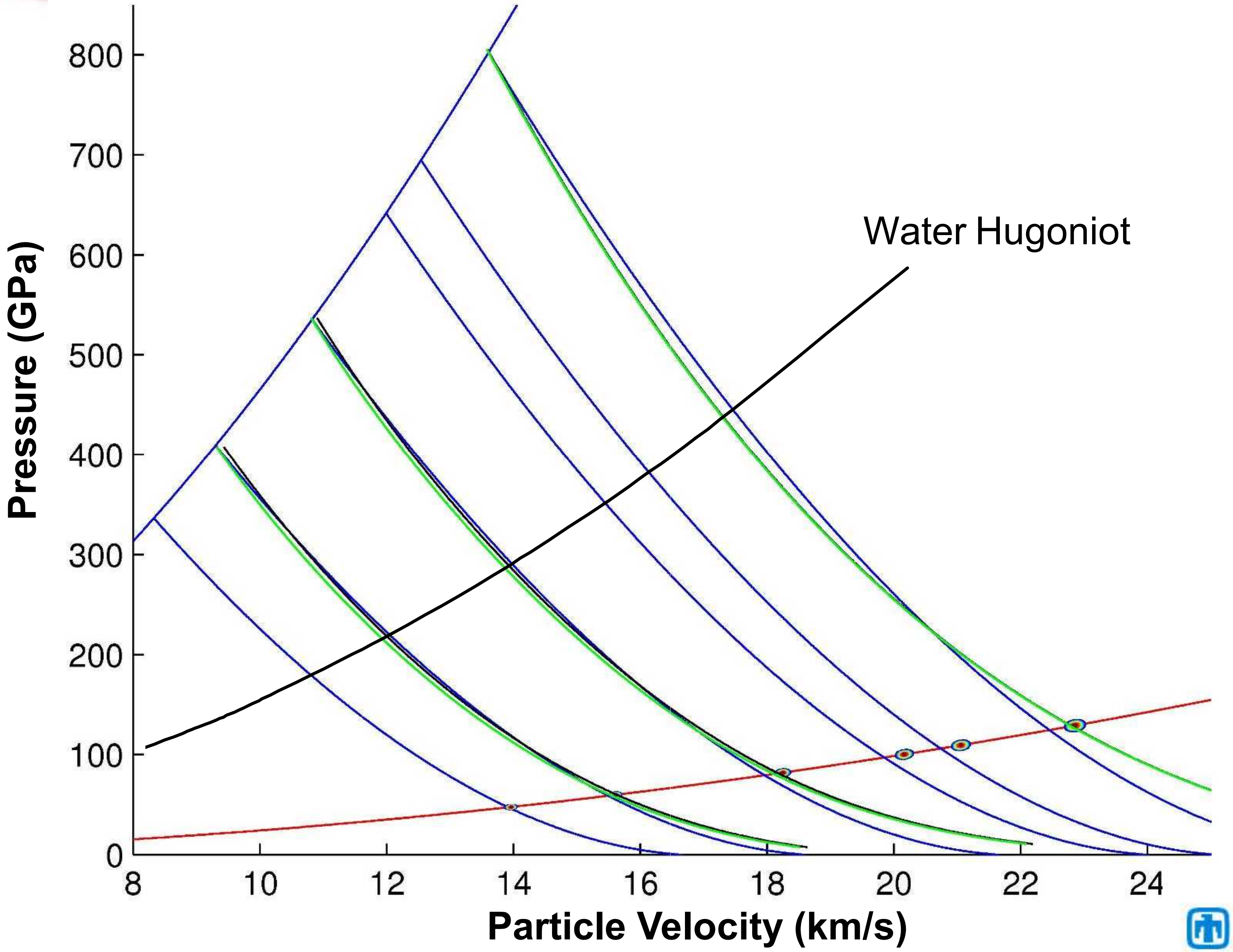
Recent experiments on water test the QMD release calculations at higher pressure



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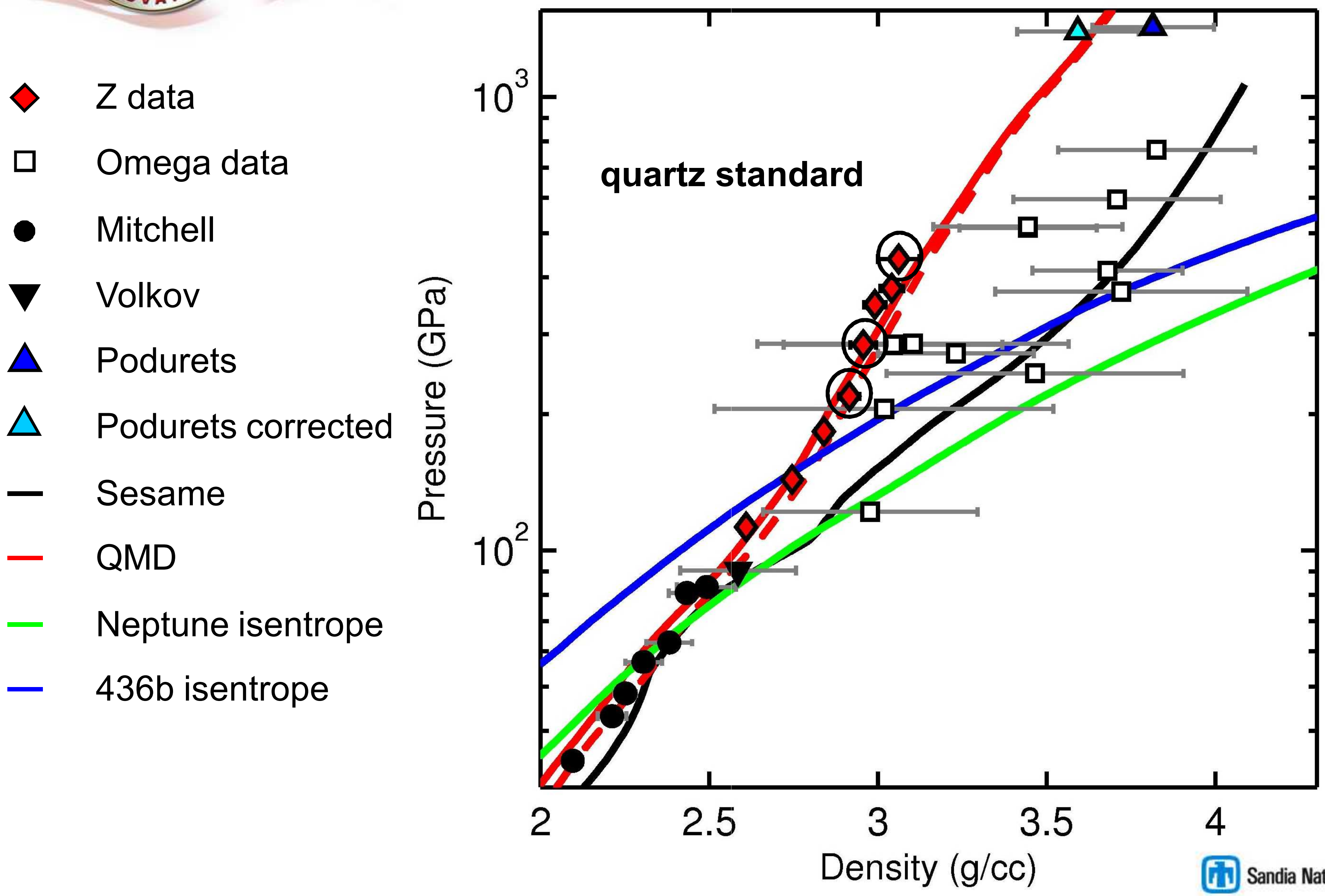
Consistent results found between quartz and aluminum standard with Z fit and QMD correction



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Conclusions

- The quartz Hugoniot has been determined with very high precision to ~1.6 TPa
  - » Enables quartz to be used as a standard in shock wave experiments with moderate impedance materials
- Deep release measurements of quartz have provided data to characterize the adiabatic expansion
  - » Enables quartz to be used as a standard in shock wave experiments with low impedance materials
- Recent experiments on water suggest the QMD release calculations are accurate
- These results have significant implications for recently published impedance match data using quartz standard
  - » Correction scales with (η – 1)