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Adiabatic Release of alpha-Quartz from Multi-Mbar States on the Principal Hugoniot

17th Biennial APS Shock Compression Of Condensed Matter Conference
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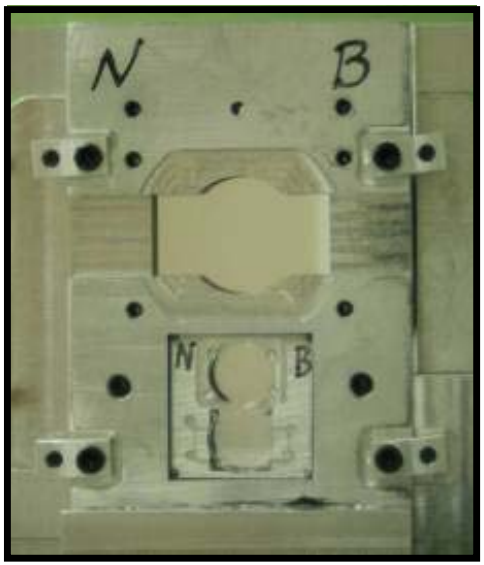

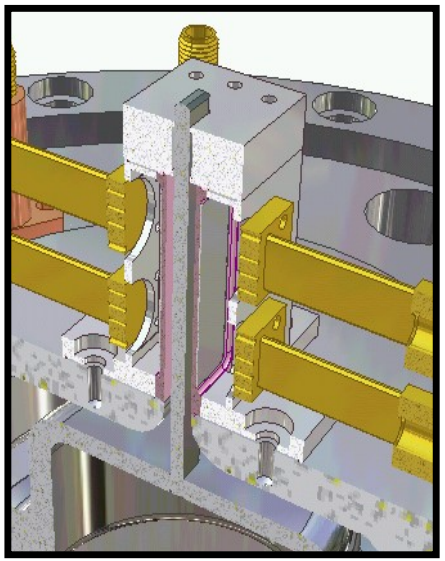

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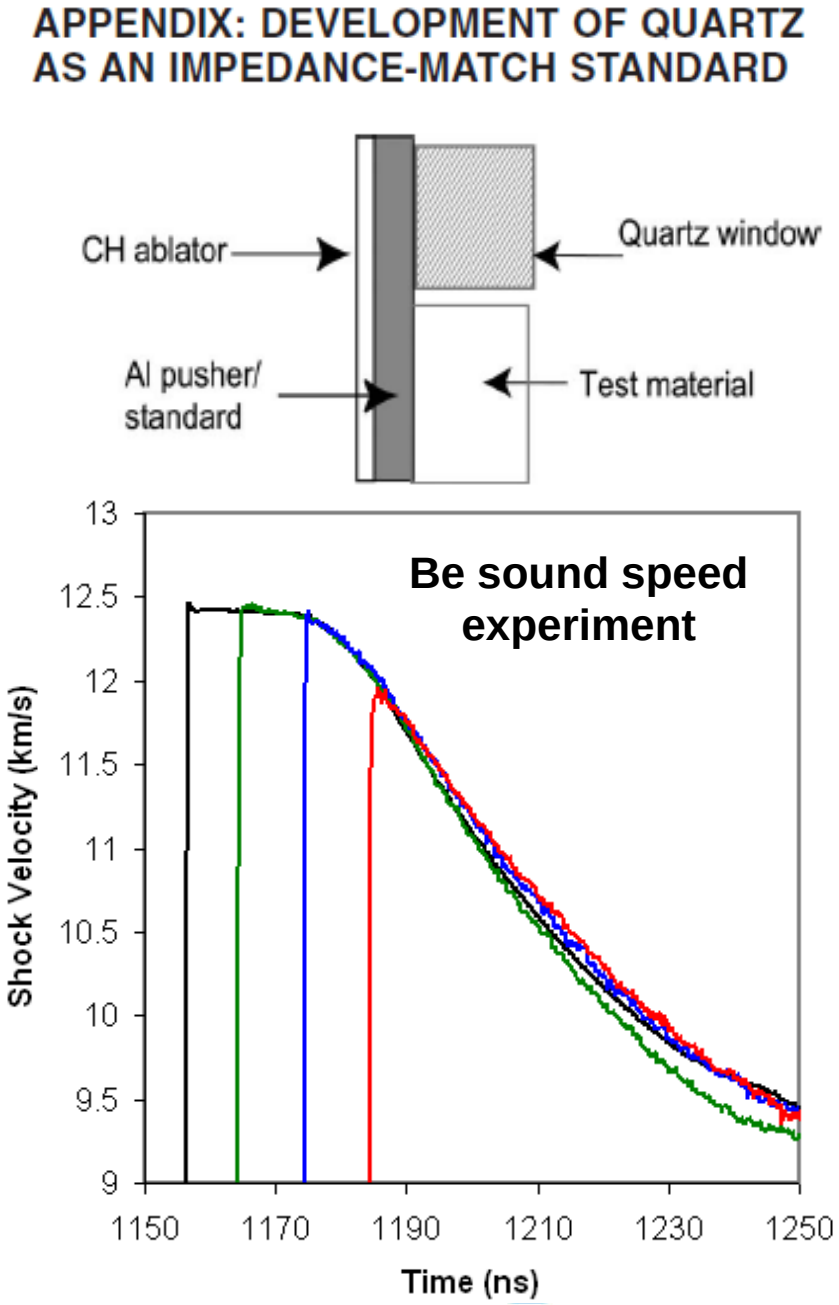
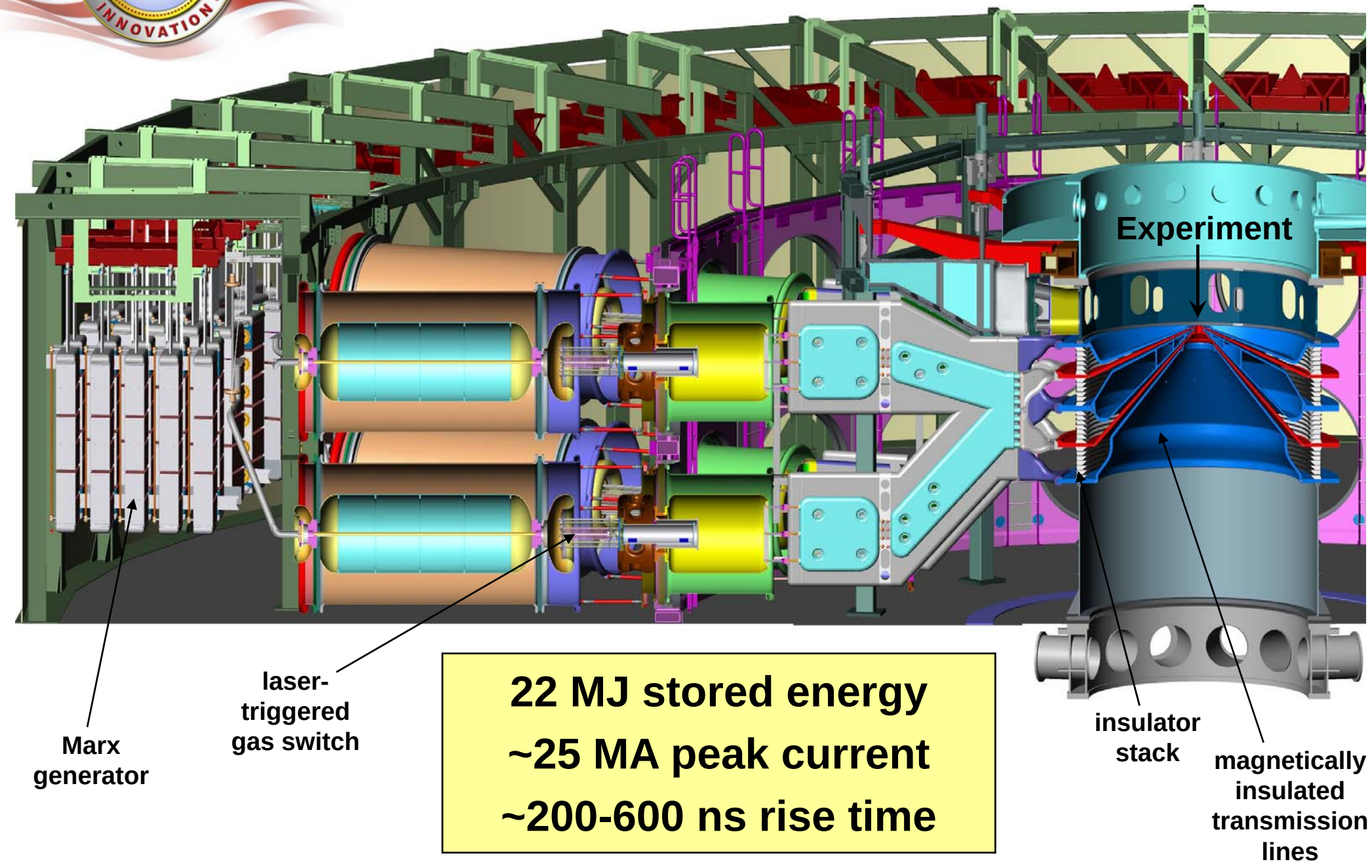
  - **Quantum Molecular Dynamics (QMD) calculations**
- **Ray Lemke**
  - **Flyer plate design and MHD simulations**
- **Jean-Paul Davis, Devon Dalton, Ken Struve, Mark Savage, Keith LeChien, Brian Stoltzfus, Dave Hinshelwood**
  - **Bertha model, pulse shaping**
- **Charlie Meyer, Devon Dalton, Dustin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

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, …
- Quartz has recently been used as a "window" for sound speed and Hugoniot melt experiments
- Quartz data has large uncertainty and scatter, and U_s-u_p exhibits significant curvature in the several 100 GPa regime
  - Attributed to dissociation



The Sandia Z Machine

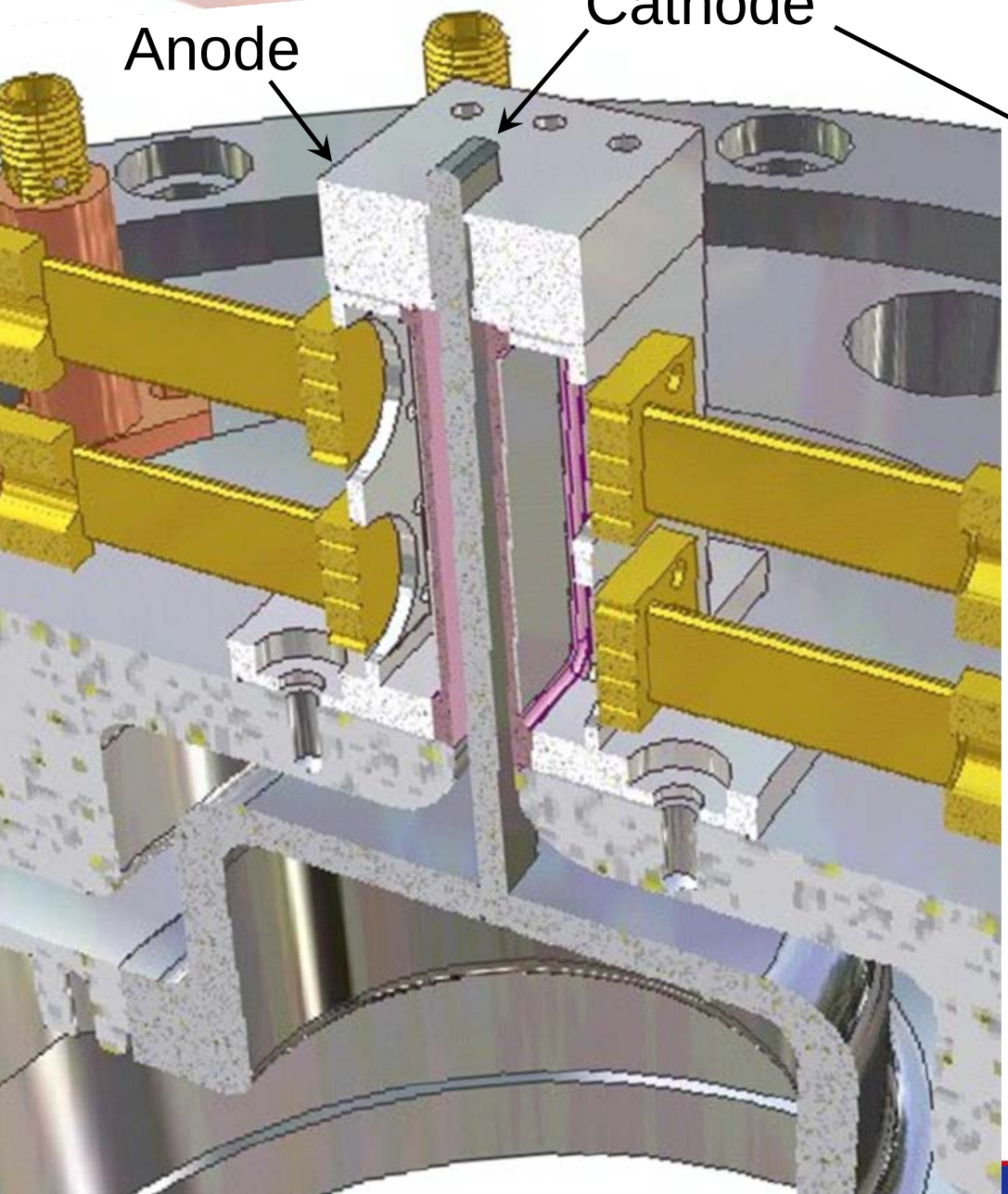


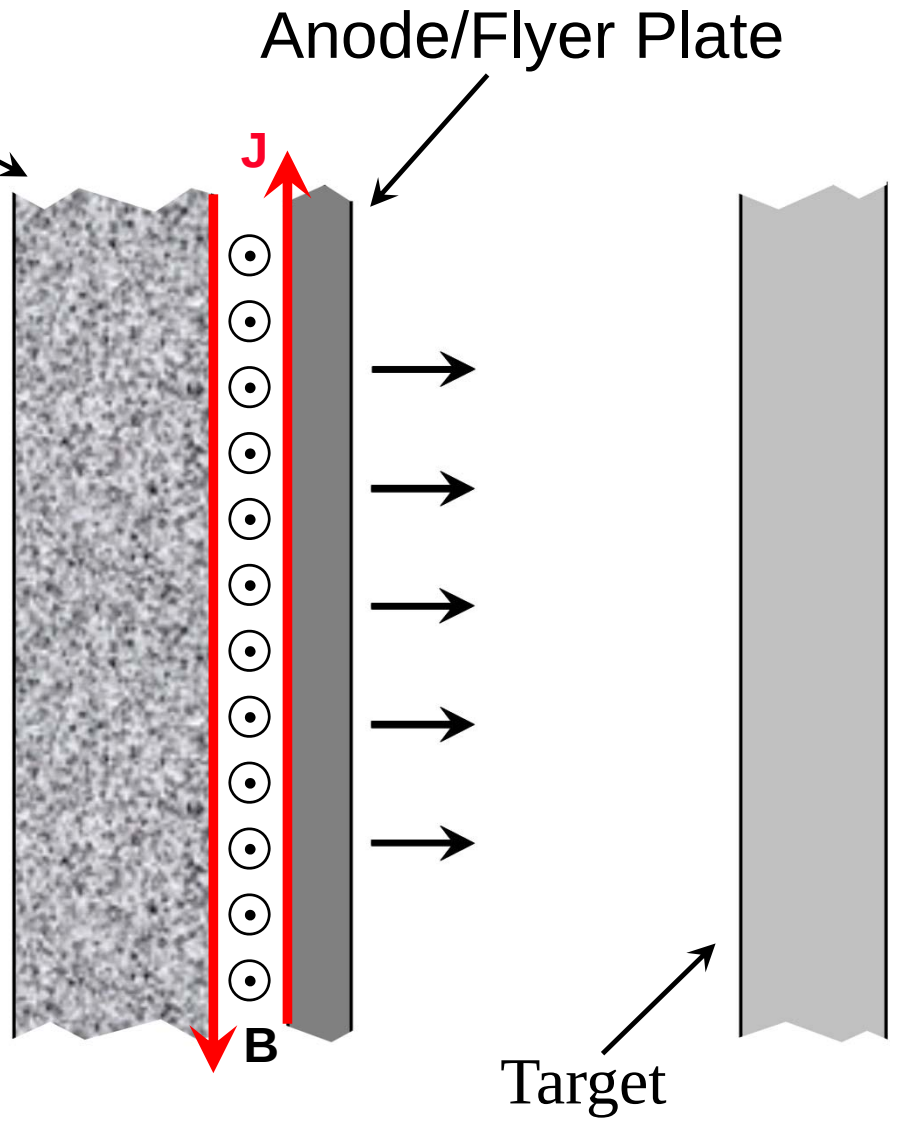
22 MJ stored energy

~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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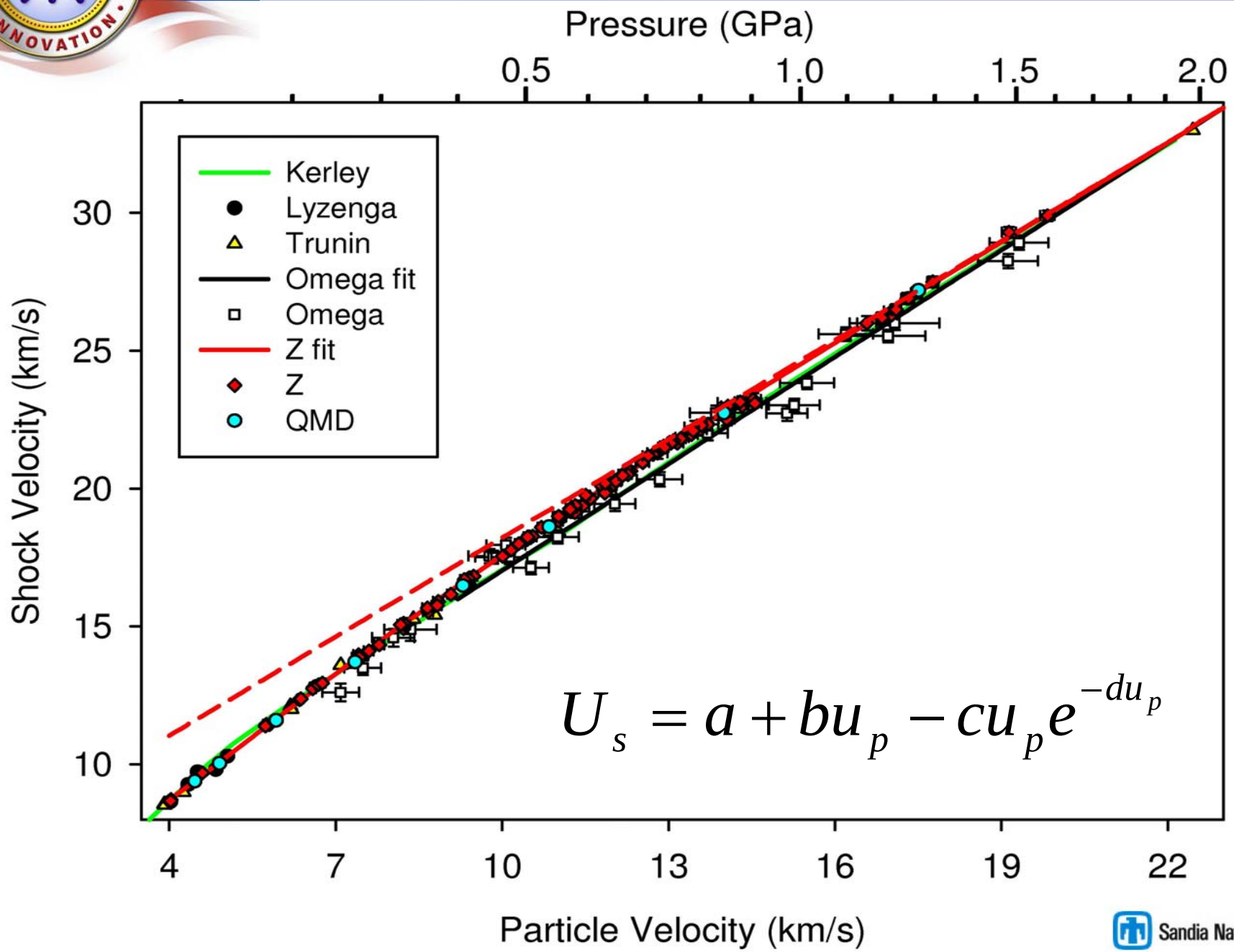
U_s-u_p Hugoniot for α-Quartz



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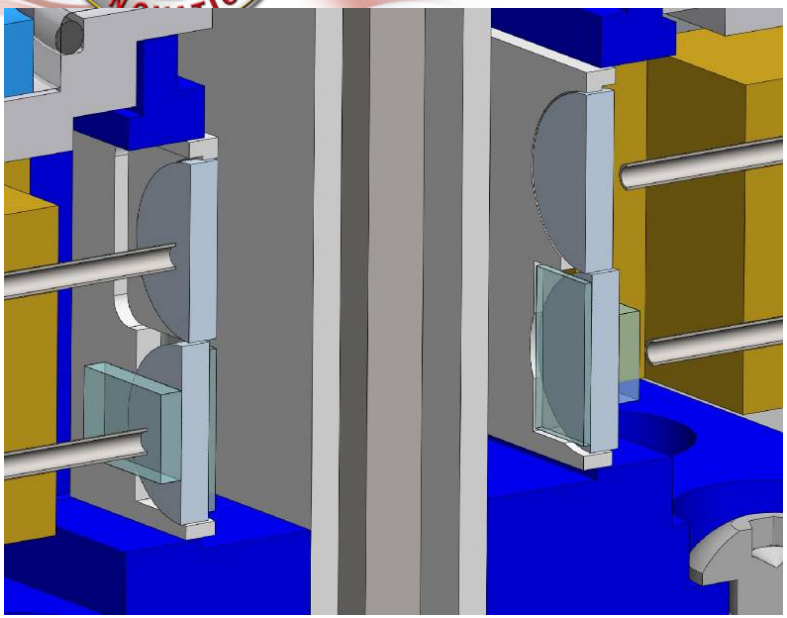
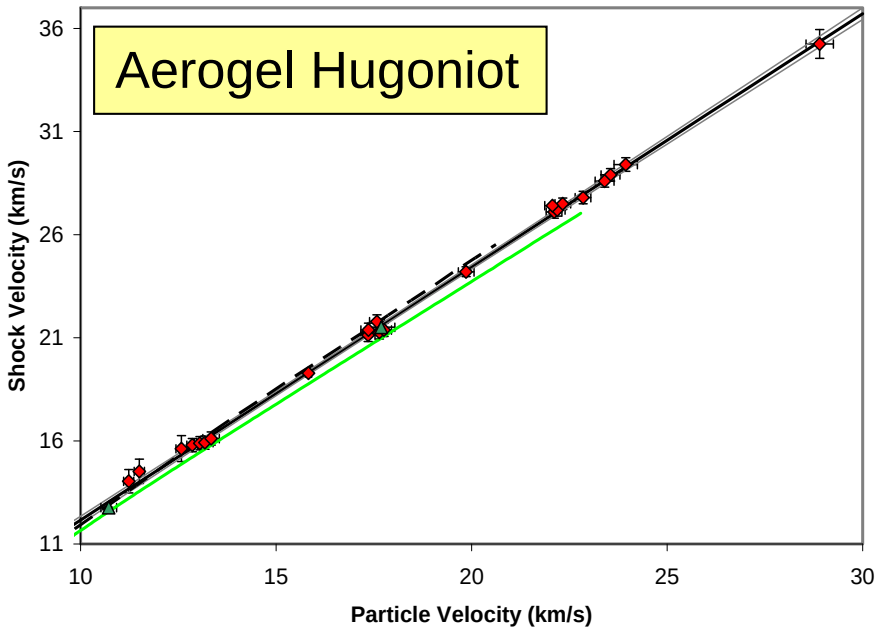
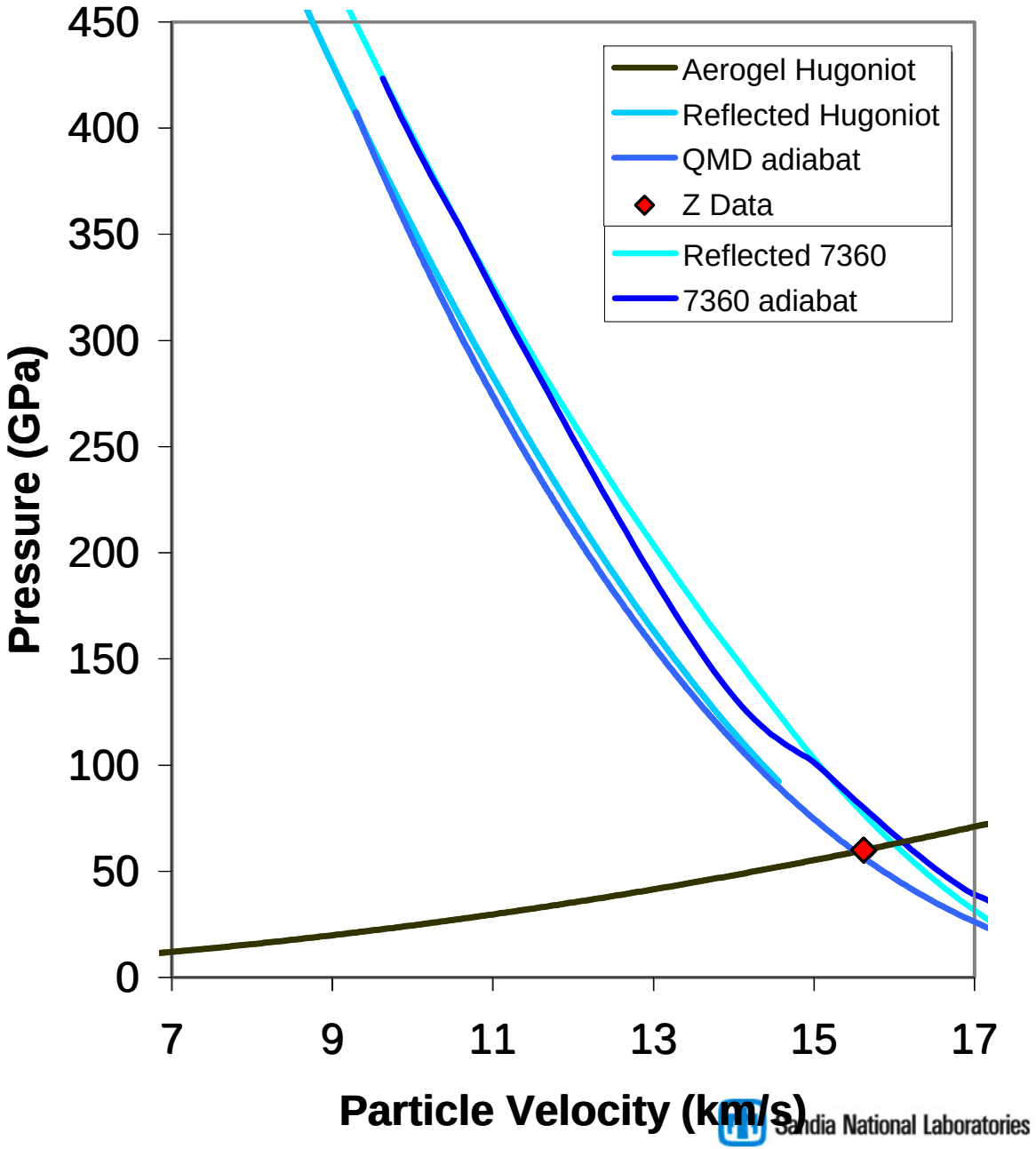
We have performed a series of experiments to measure release from 300 – 800 GPa states







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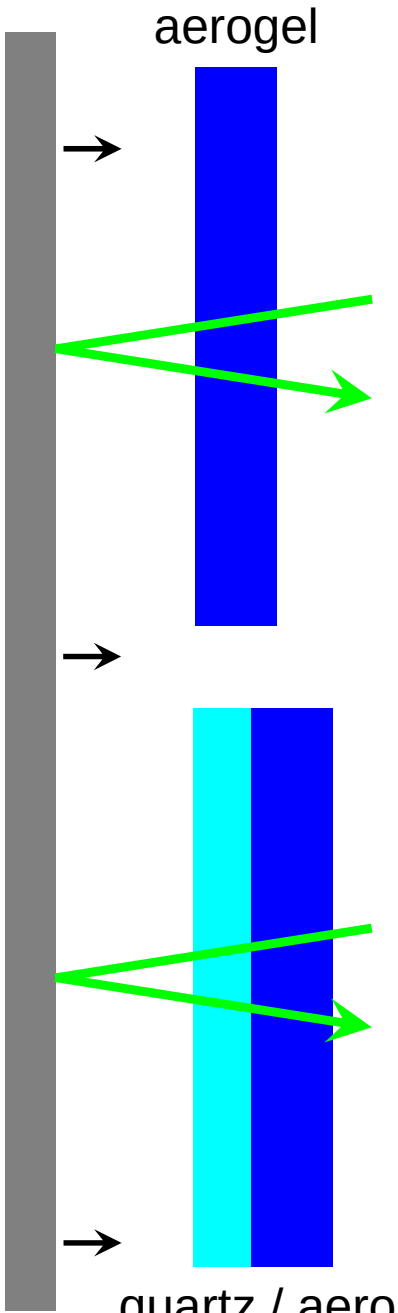
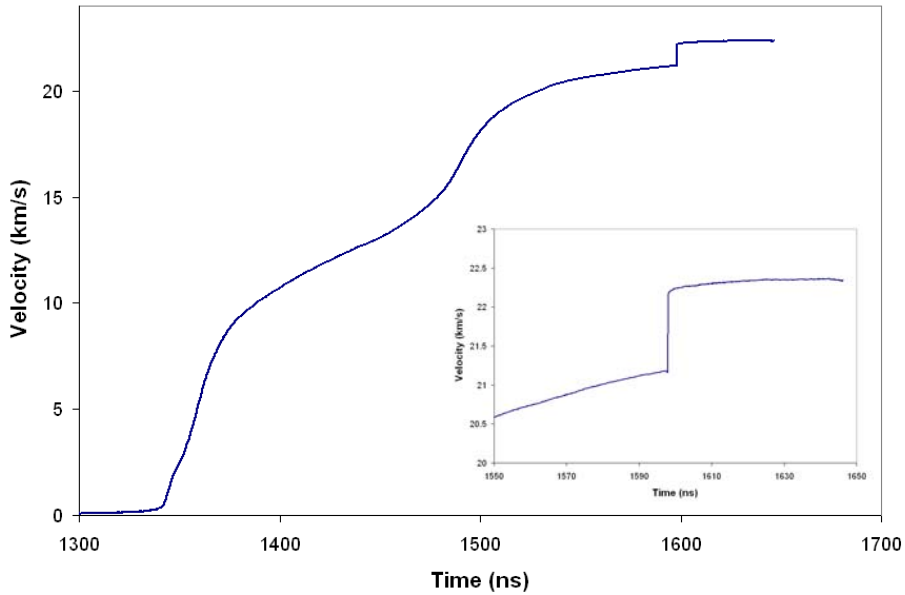
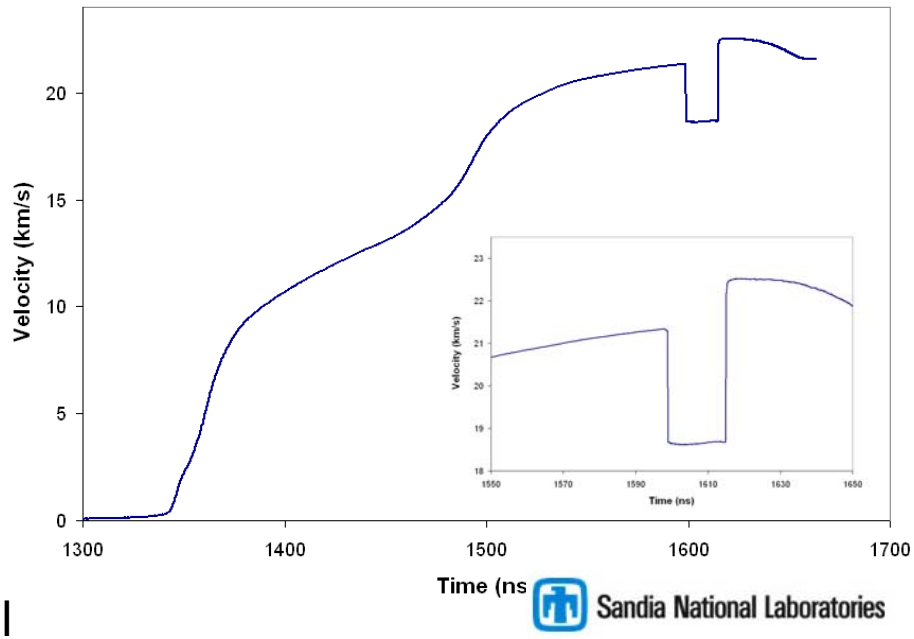
The same experiment provides Hugoniot and release measurement via velocity interferometry







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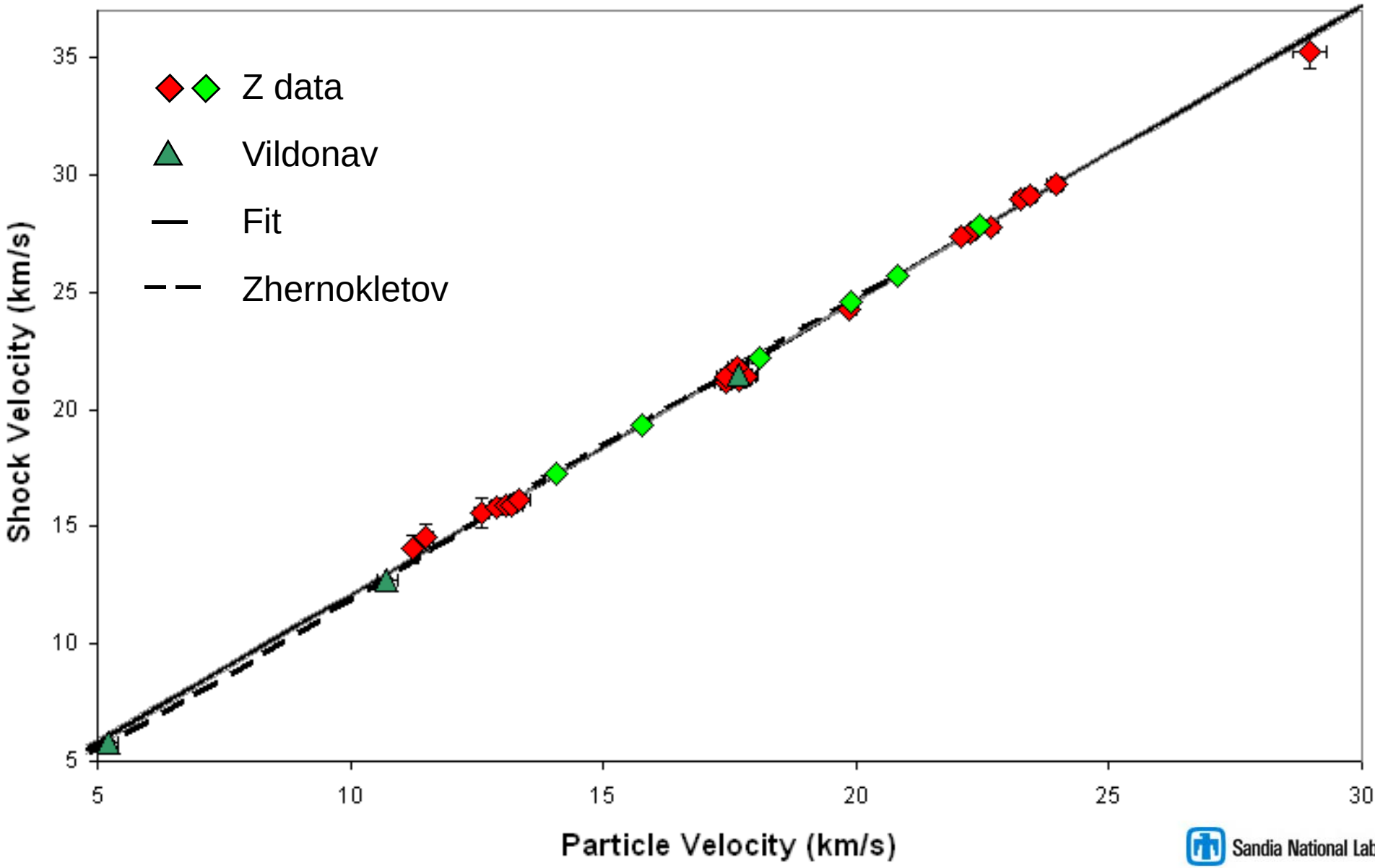
Hugoniot of ~200 mg/cc aergoel has been well characterized



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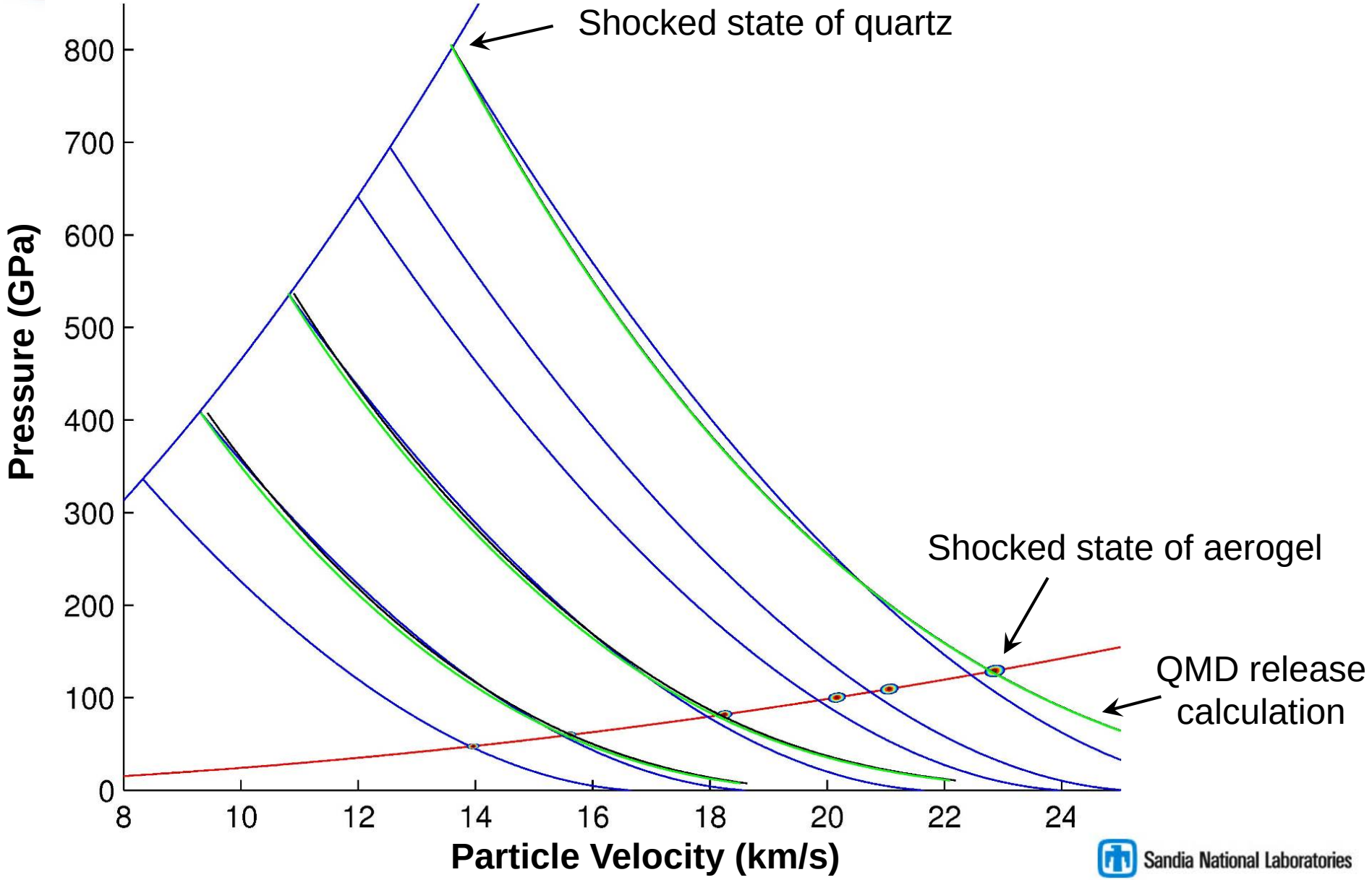
Six release experiments have been performed from 300 – 800 GPa Hugoniot states



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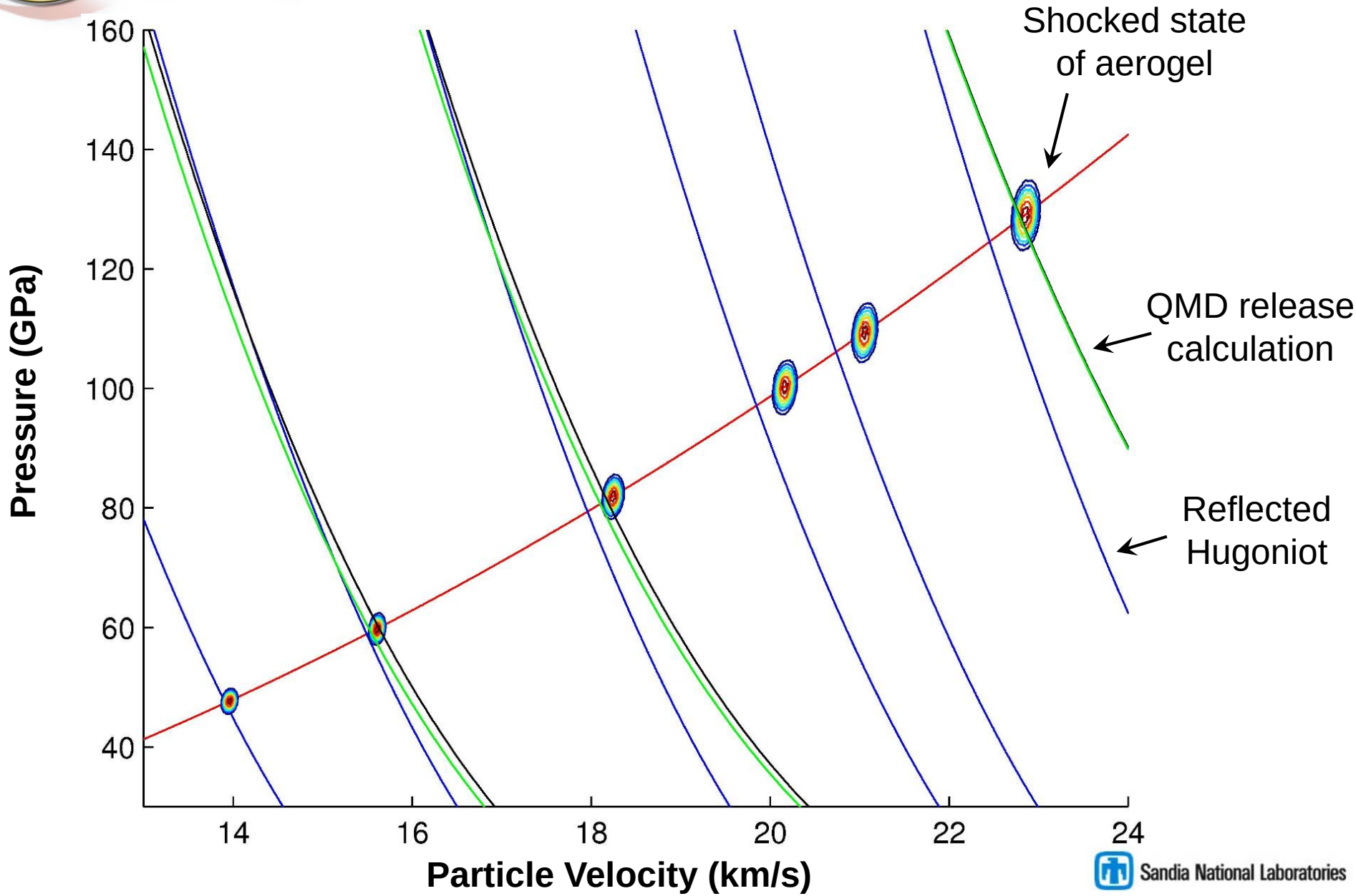
Quantum Molecular Dynamics calculations in good agreement with experiment



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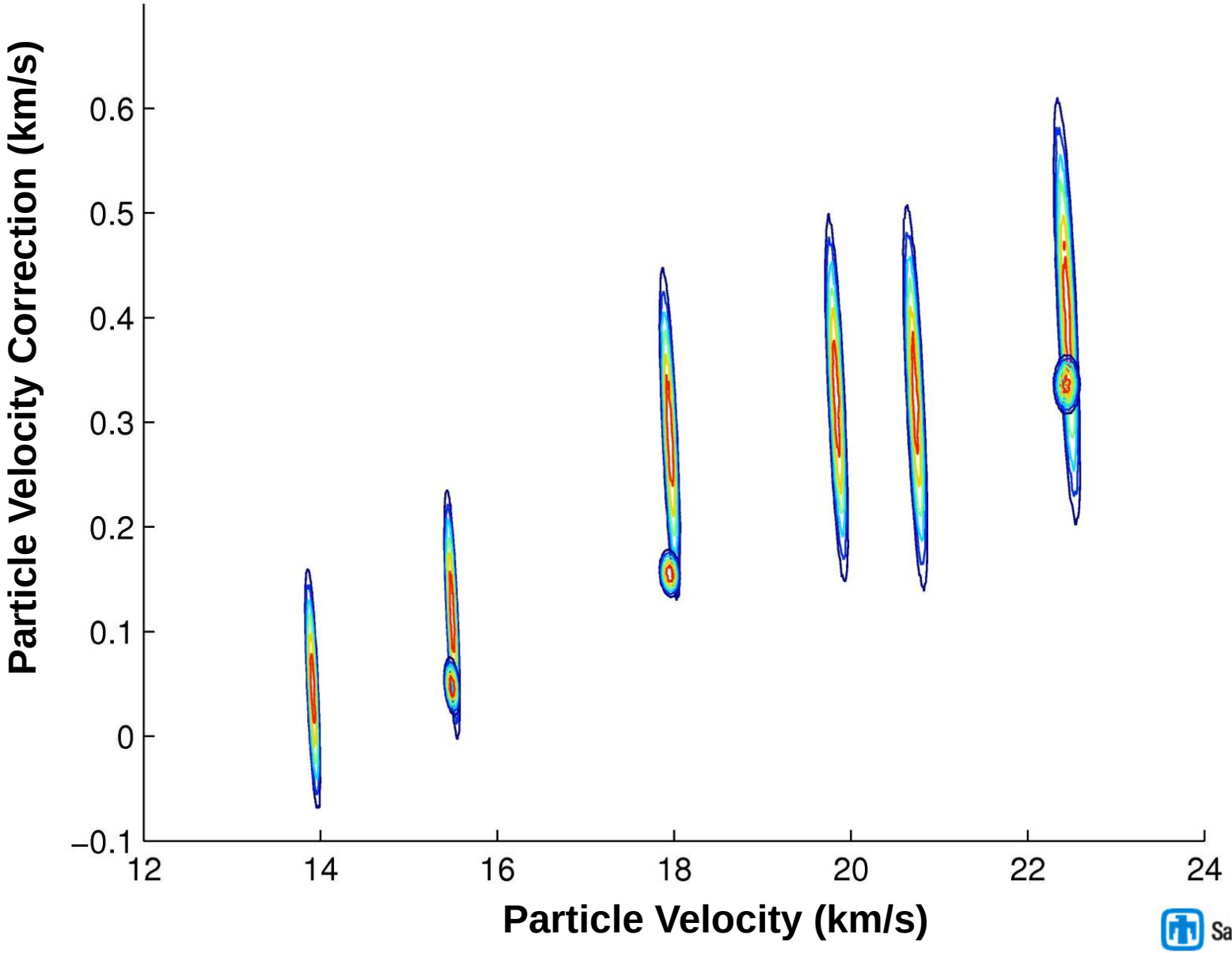
Quantum Molecular Dynamics matches trend in, but slightly underestimates, the correction to the RH



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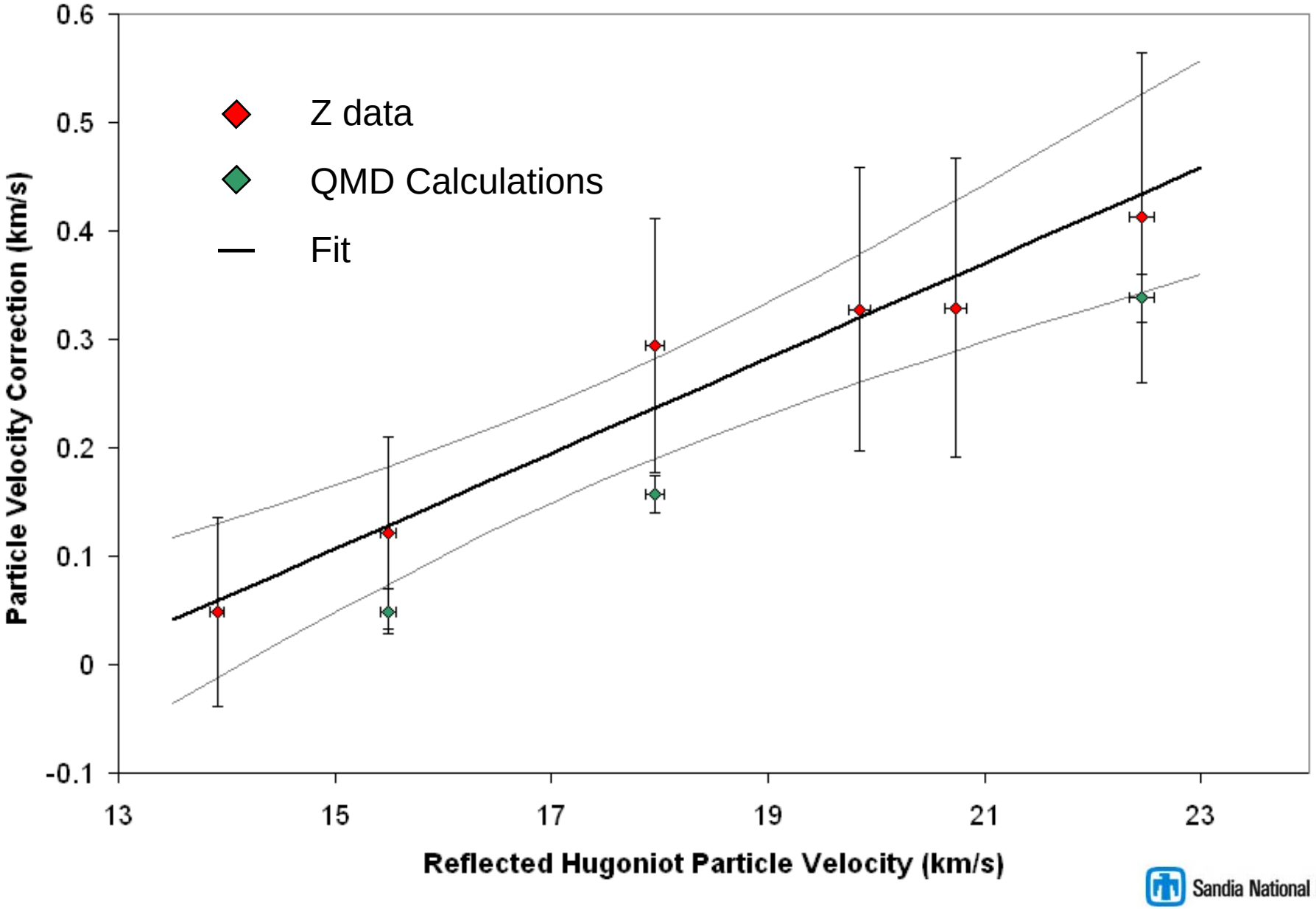
The absolute correction appears to increase linearly with the RH particle velocity



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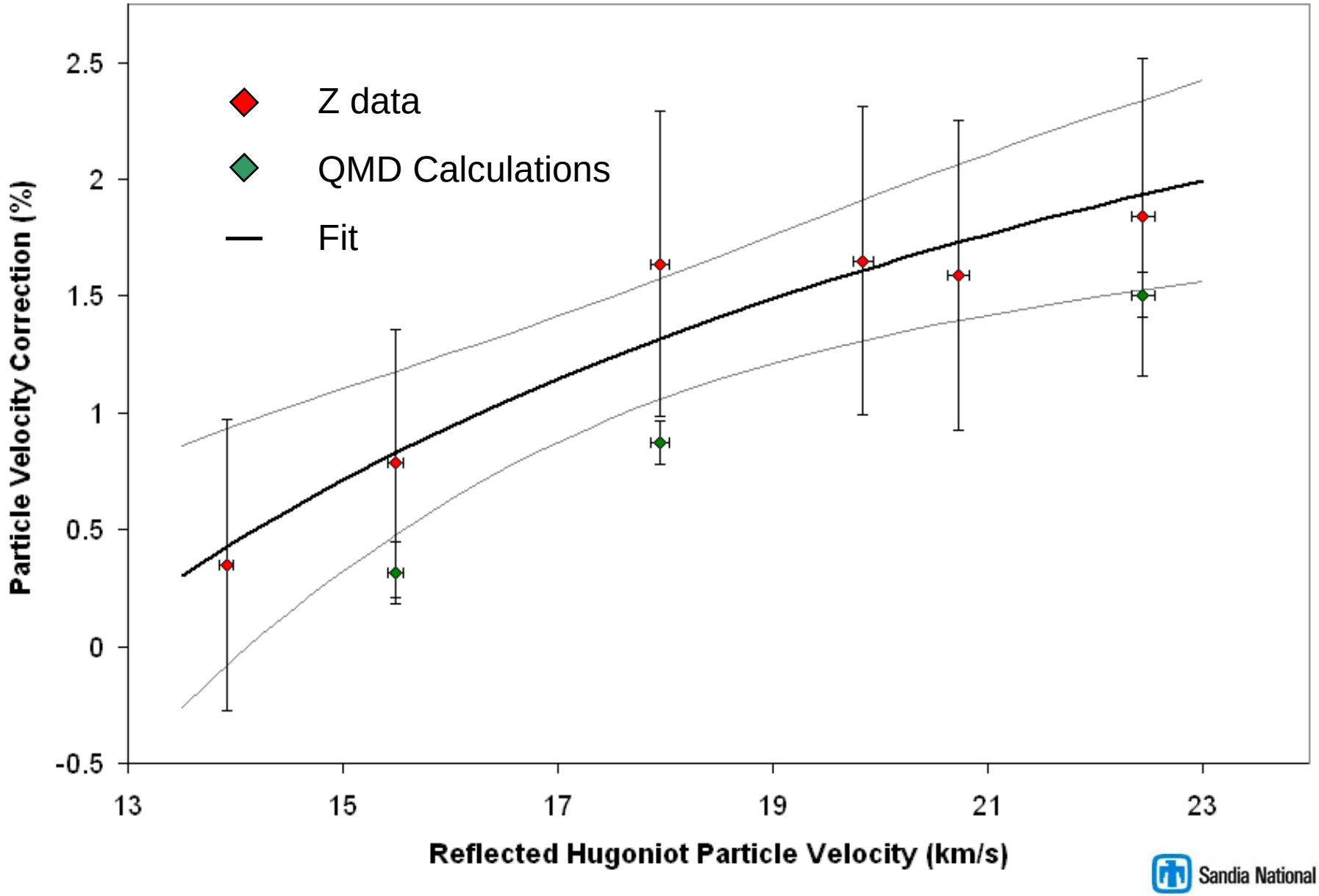
Expressed as a percentage, the correction appears to saturate at ~ 2 – 2.5 %



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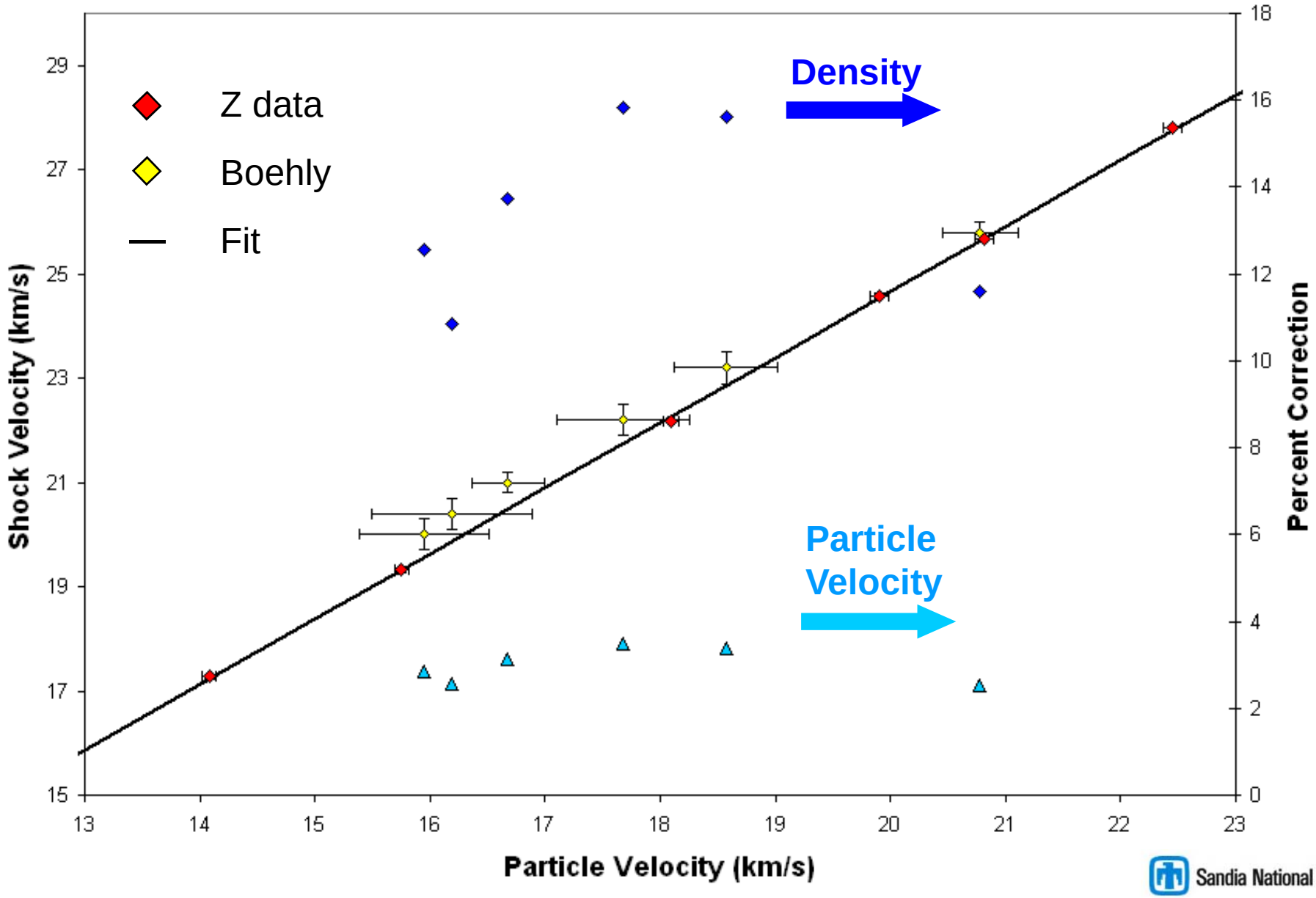
Recent Results from Boehly, et al., demonstrate that potential errors can be significant



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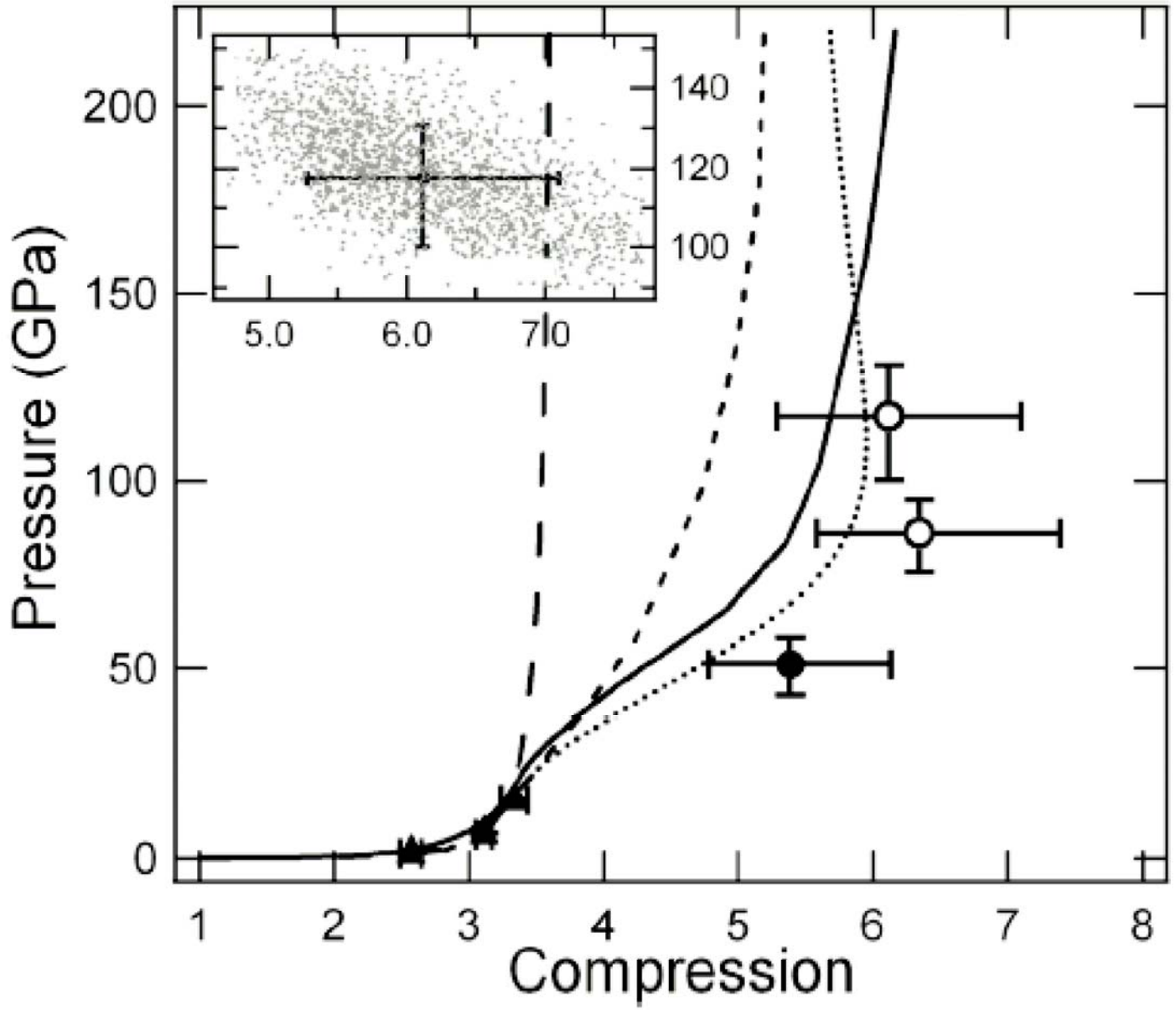
These results should provide better constraints for measurements made with quartz standard



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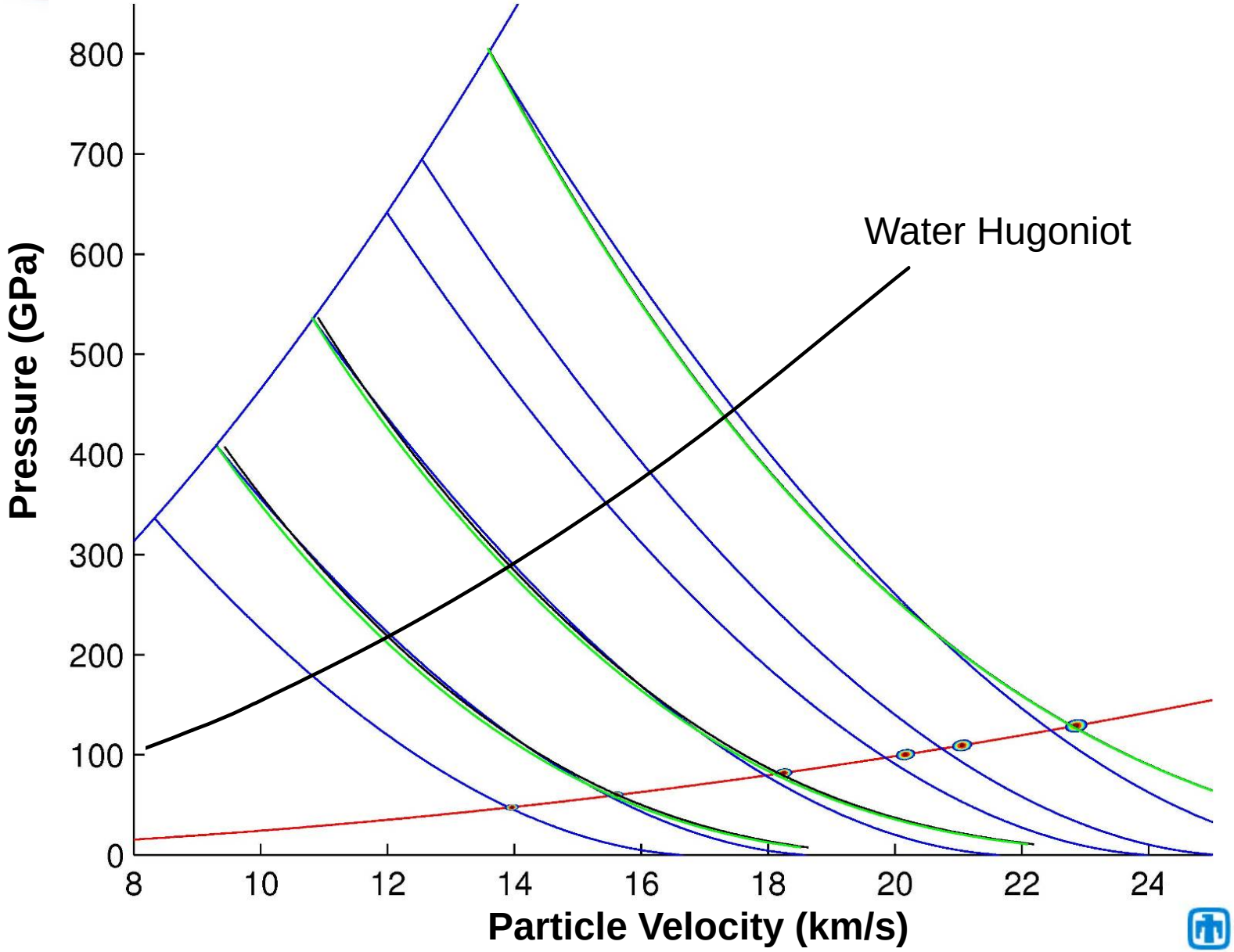
Recent experiments on water test the QMD release calculations at higher pressure



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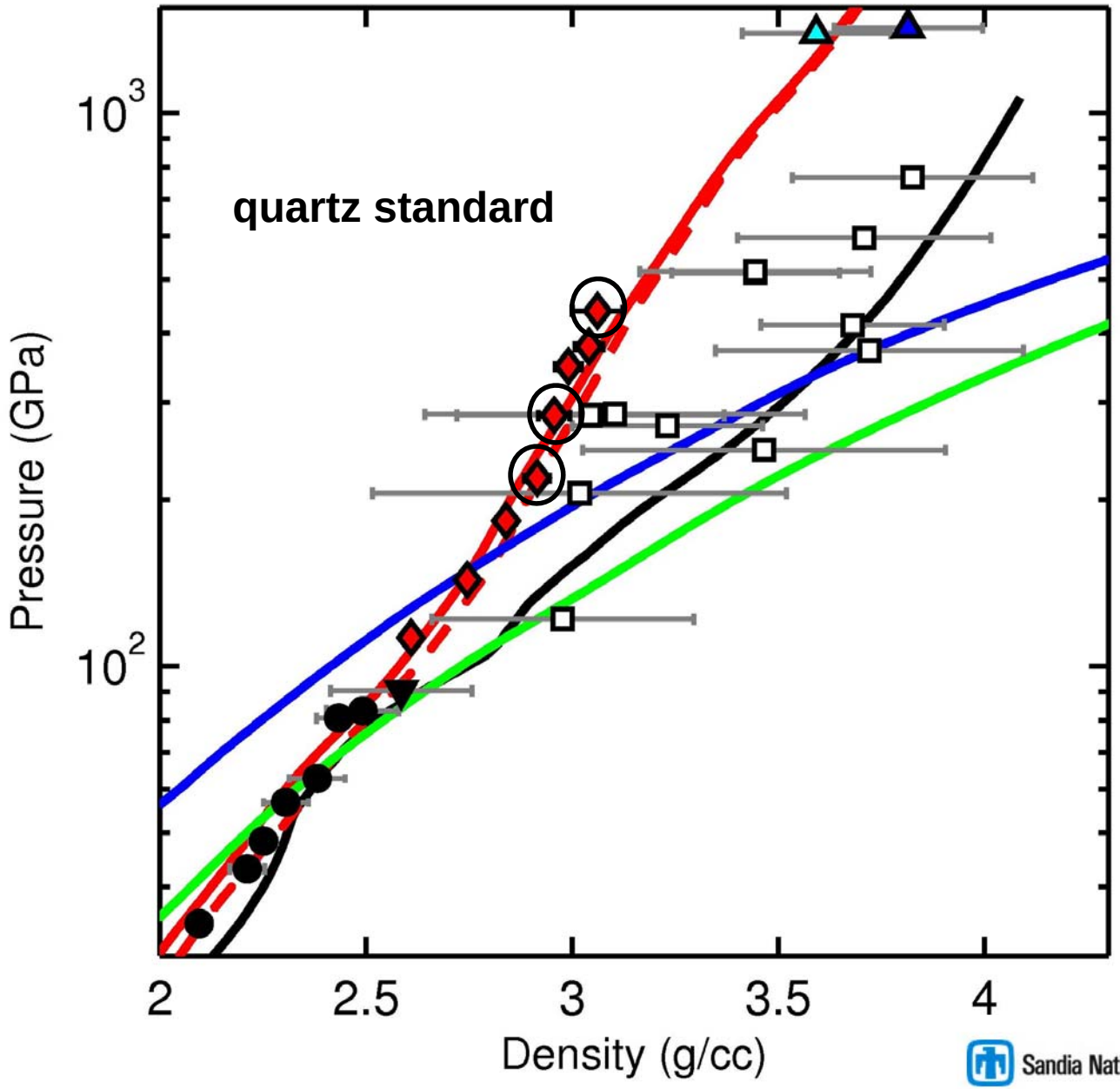
Consistent results found between quartz and aluminum standard with Z fit and QMD correction

- Z data
- Omega data
- Mitchell
- Volkov
- Podurets
- Podurets corrected
- Sesame
- QMD
- Neptune isentrope
- 436b isentrope



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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 $(\eta - 1)$