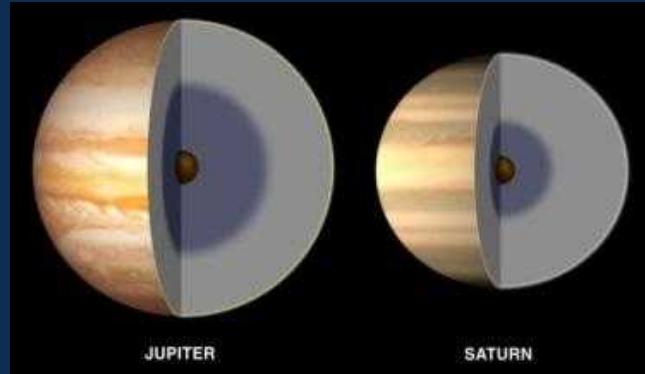
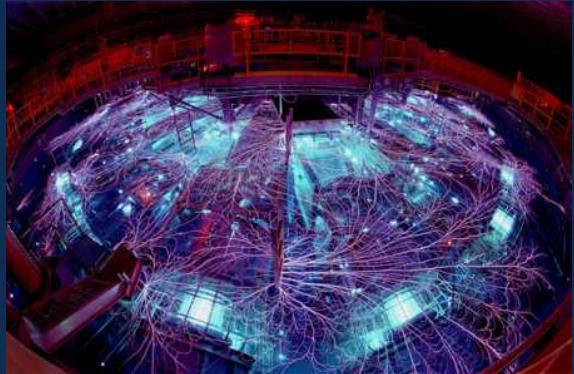


Exceptional service in the national interest



Dynamic compression experiments on liquid deuterium above the melt boundary

Marcus D. Knudson

**Sandia National Laboratories
Albuquerque, NM**



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Experiment Design/Analysis

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Ray Lemke

Kyle Cochrane

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Acknowledgements

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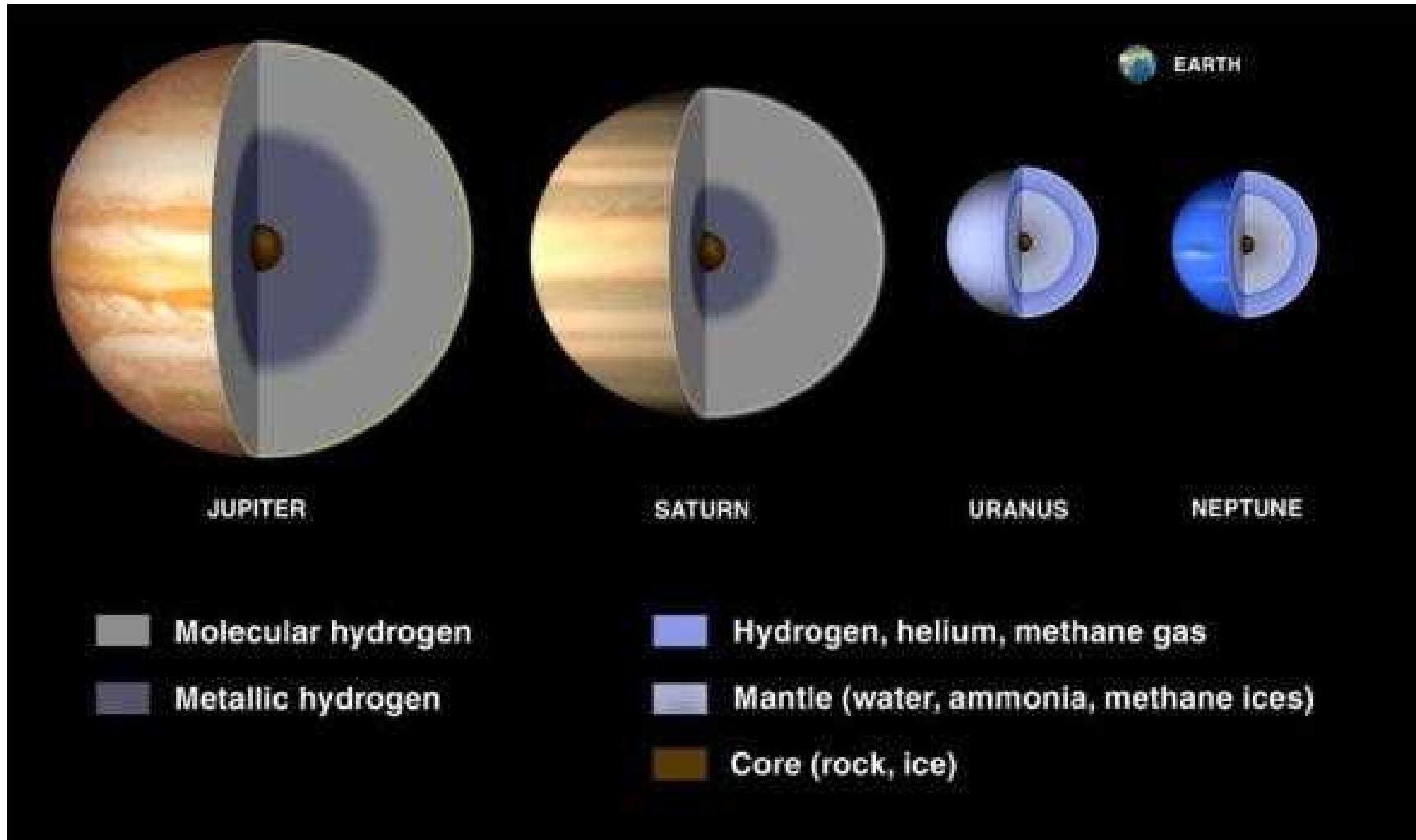
Dave Hinshelwood

Entire Z crew

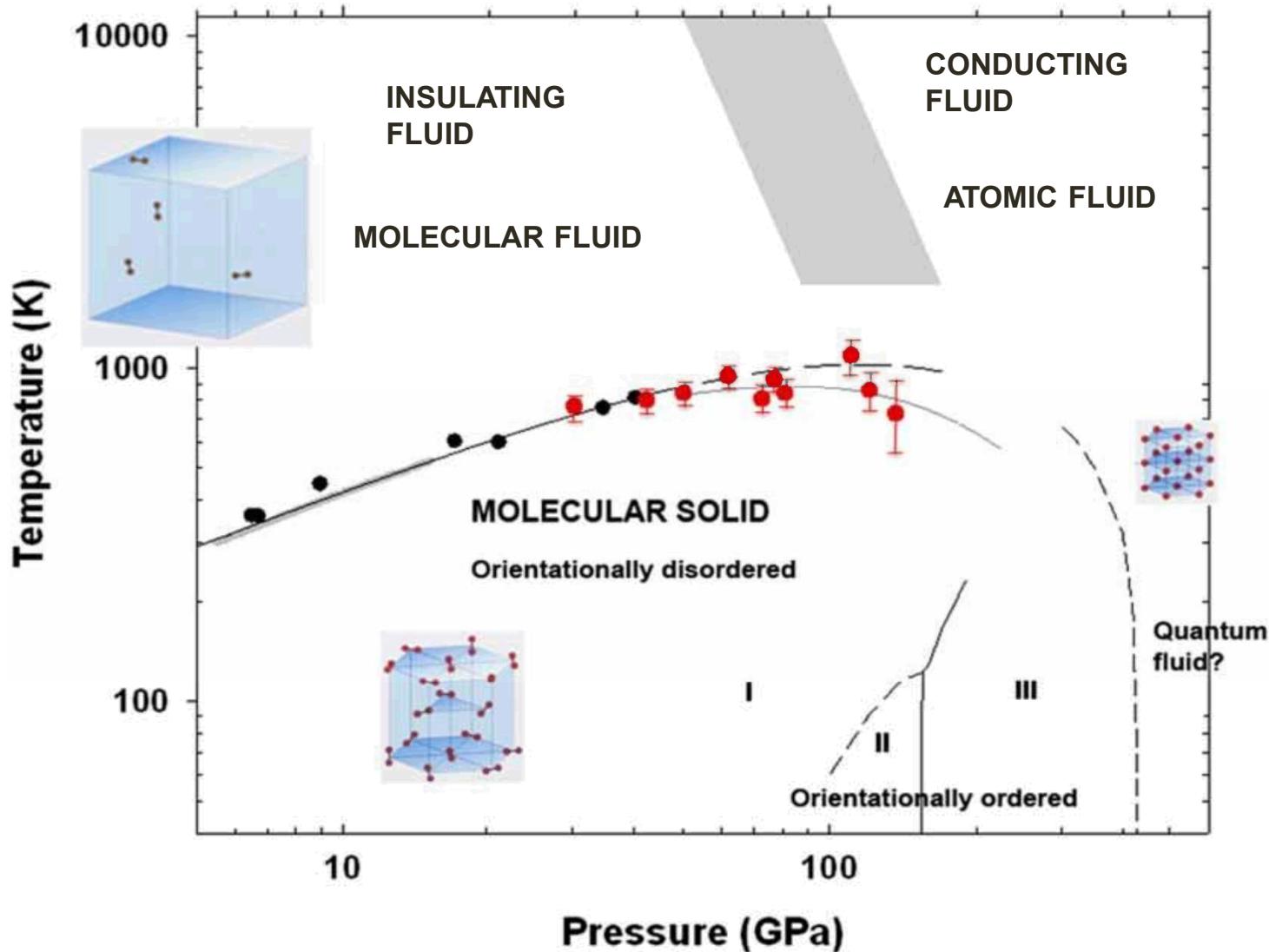
University of Rostock

Giant planets in the Solar system

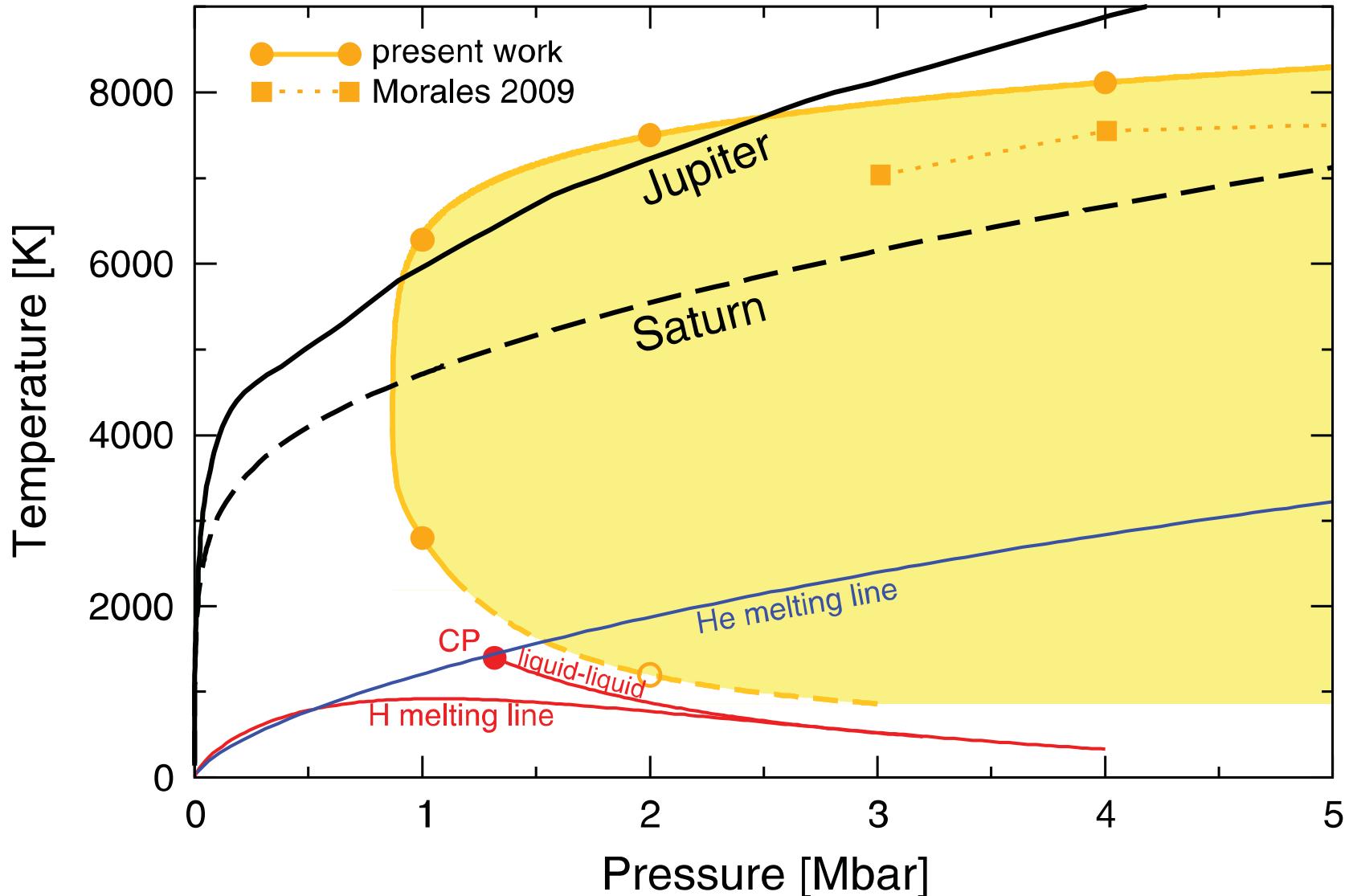
Interior composed of the lightest elements H & He, hydrides NH₃, OH₂, CH₄ (ices) and small amounts of heavier elements (cores)



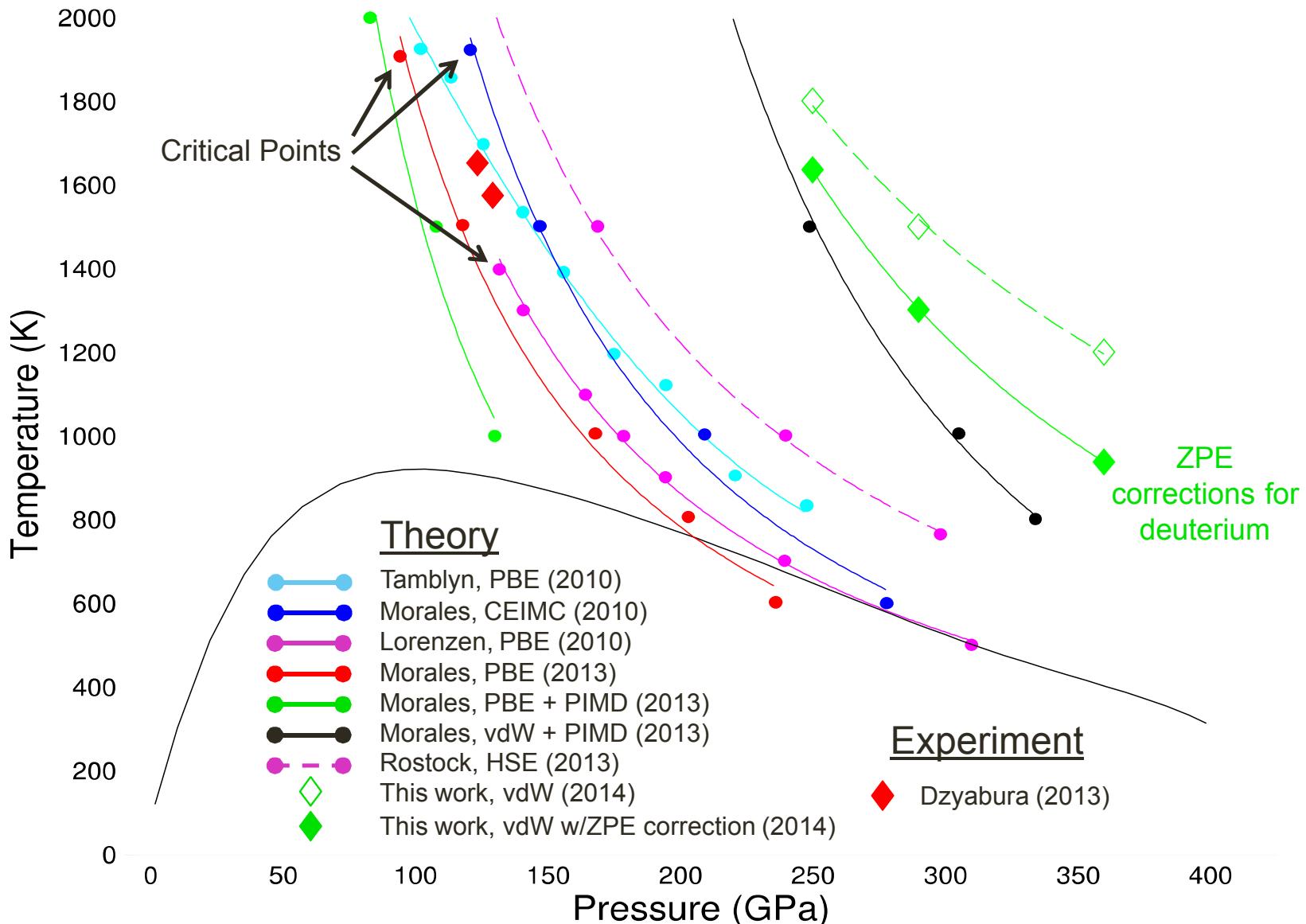
Hydrogen at high pressures – the known phase diagram so far



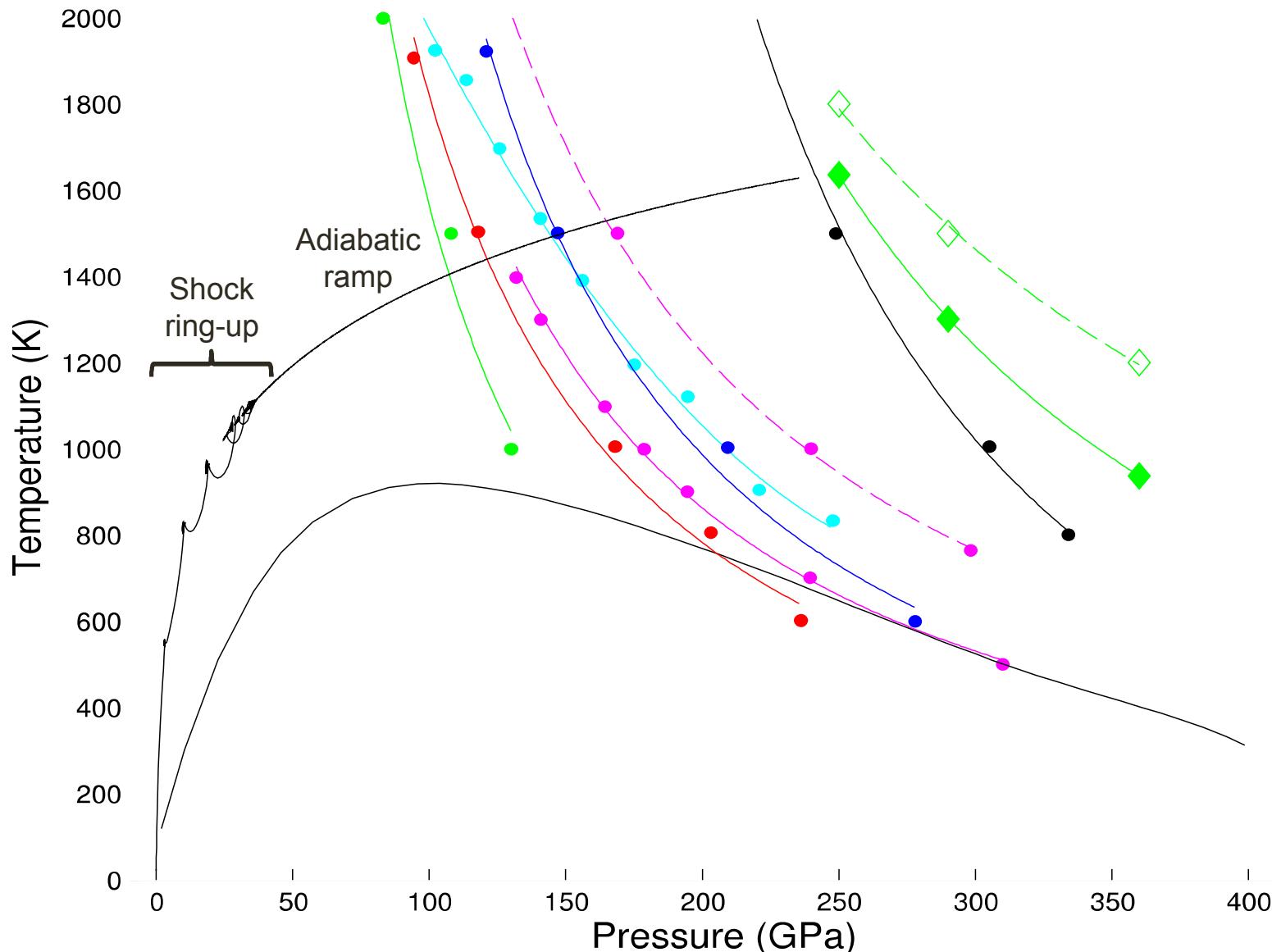
H-He de-mixing appears to be precipitated at low T and P by metallization in hydrogen



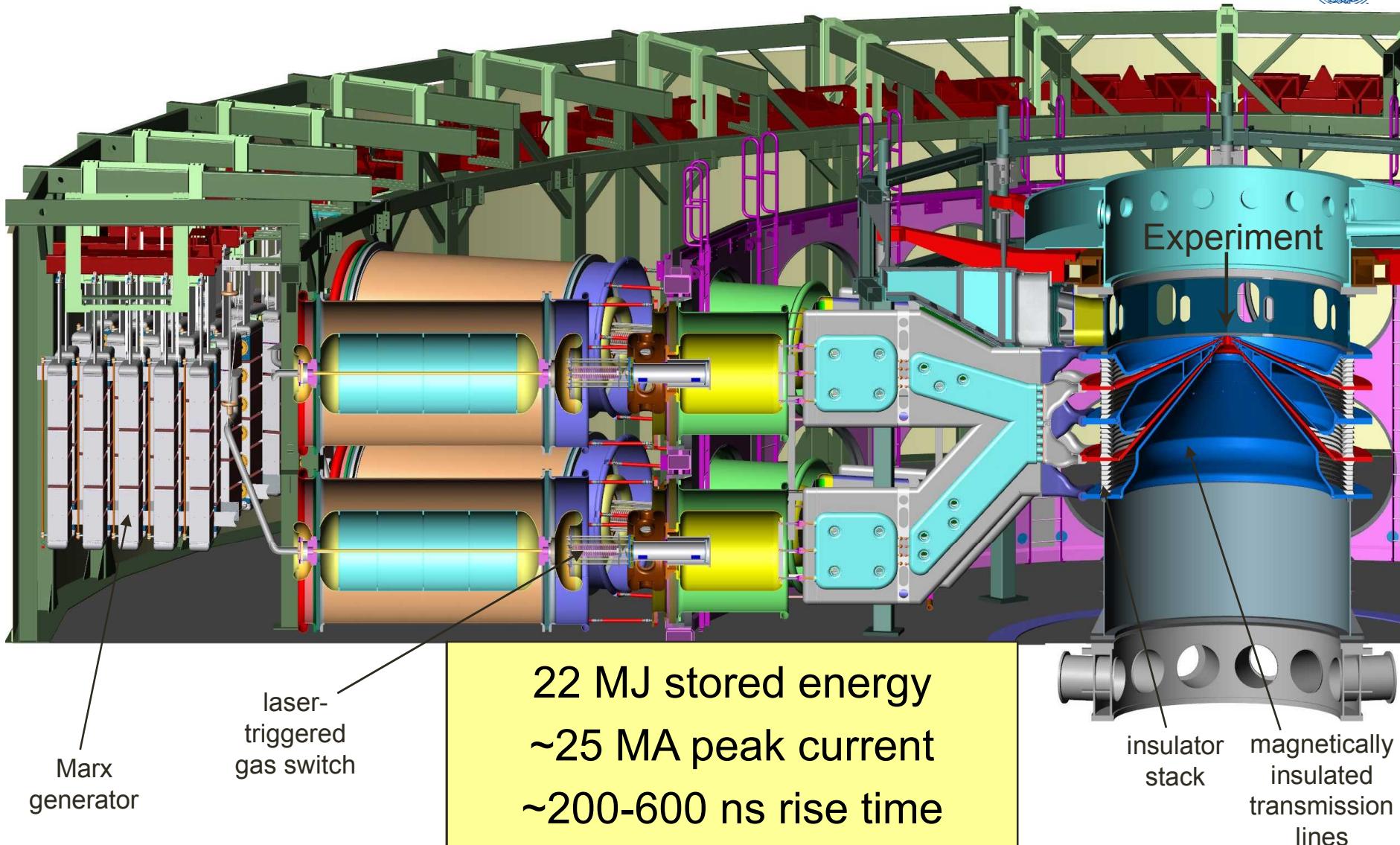
Recent predictions for LL-IMT in H



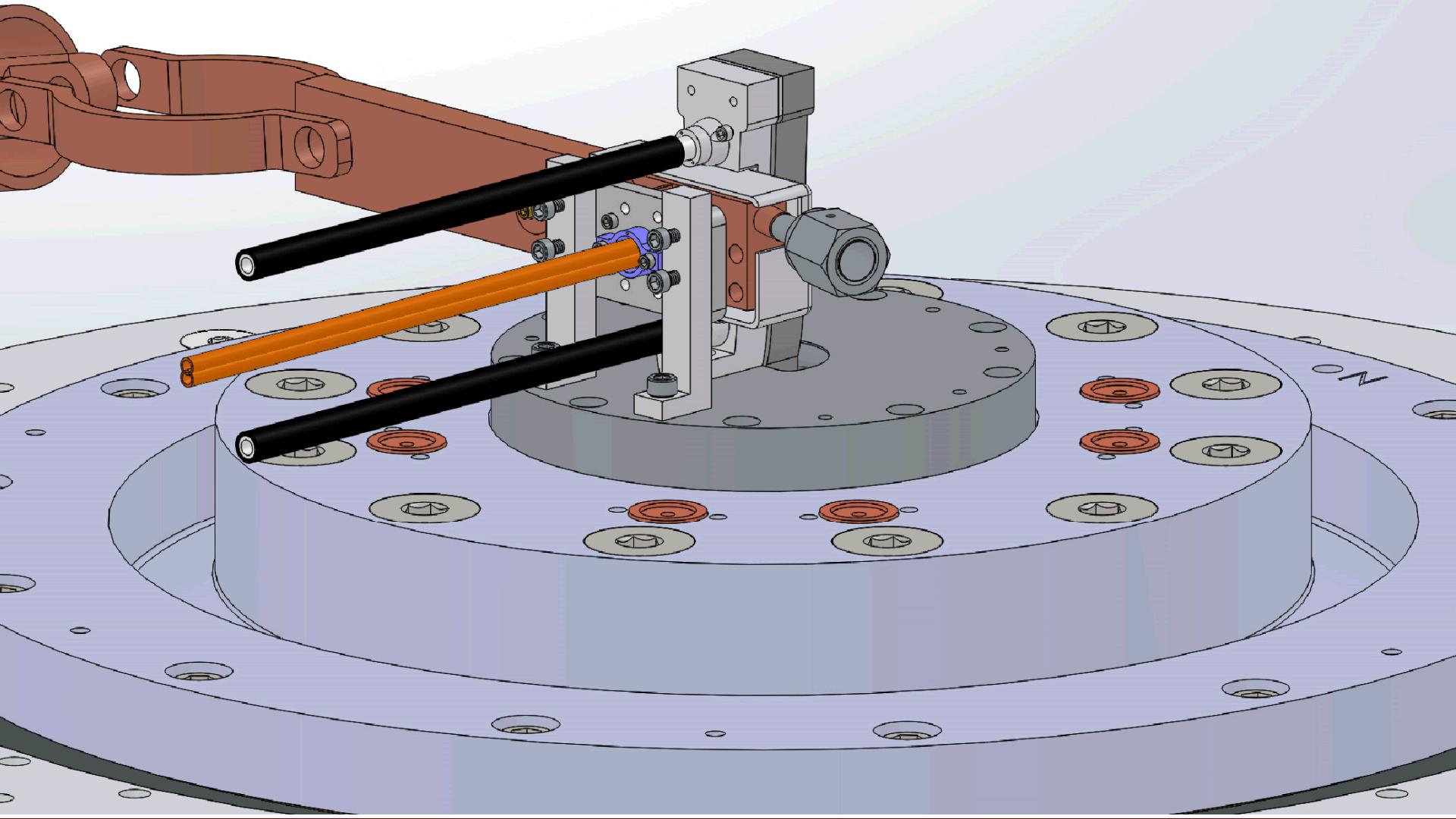
Proposed Experiment



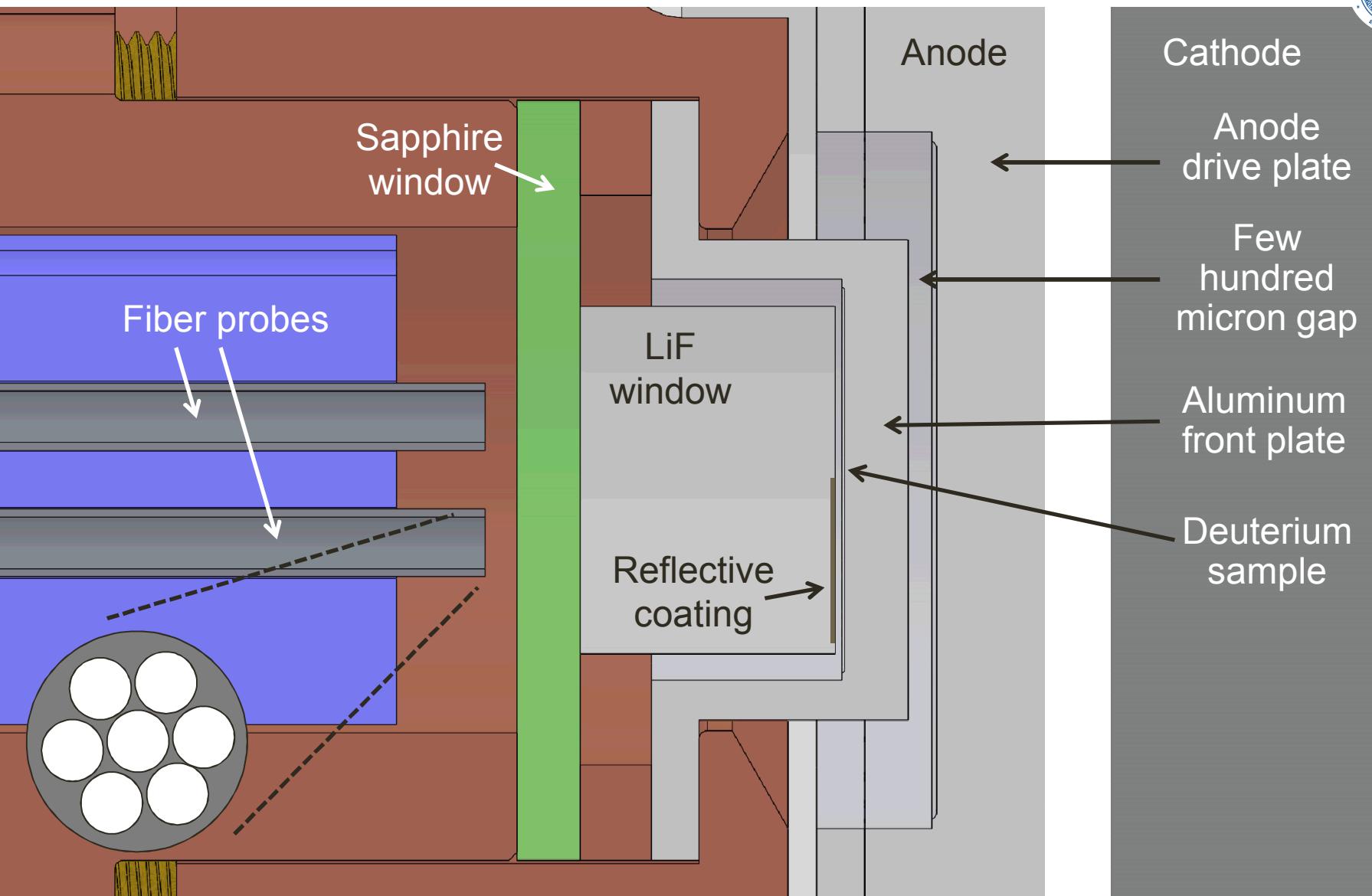
Sandia Z Machine



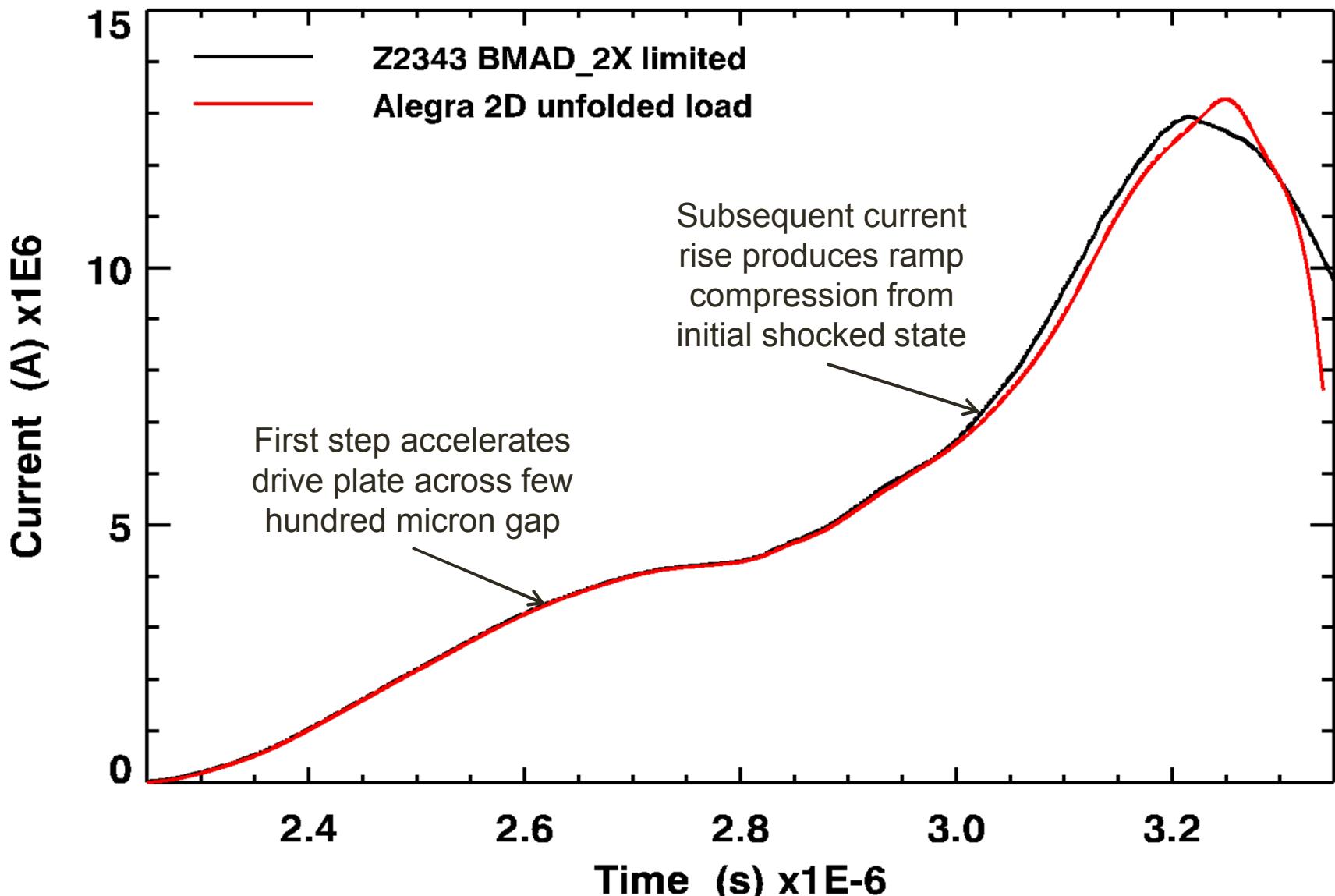
Stripline experimental configuration



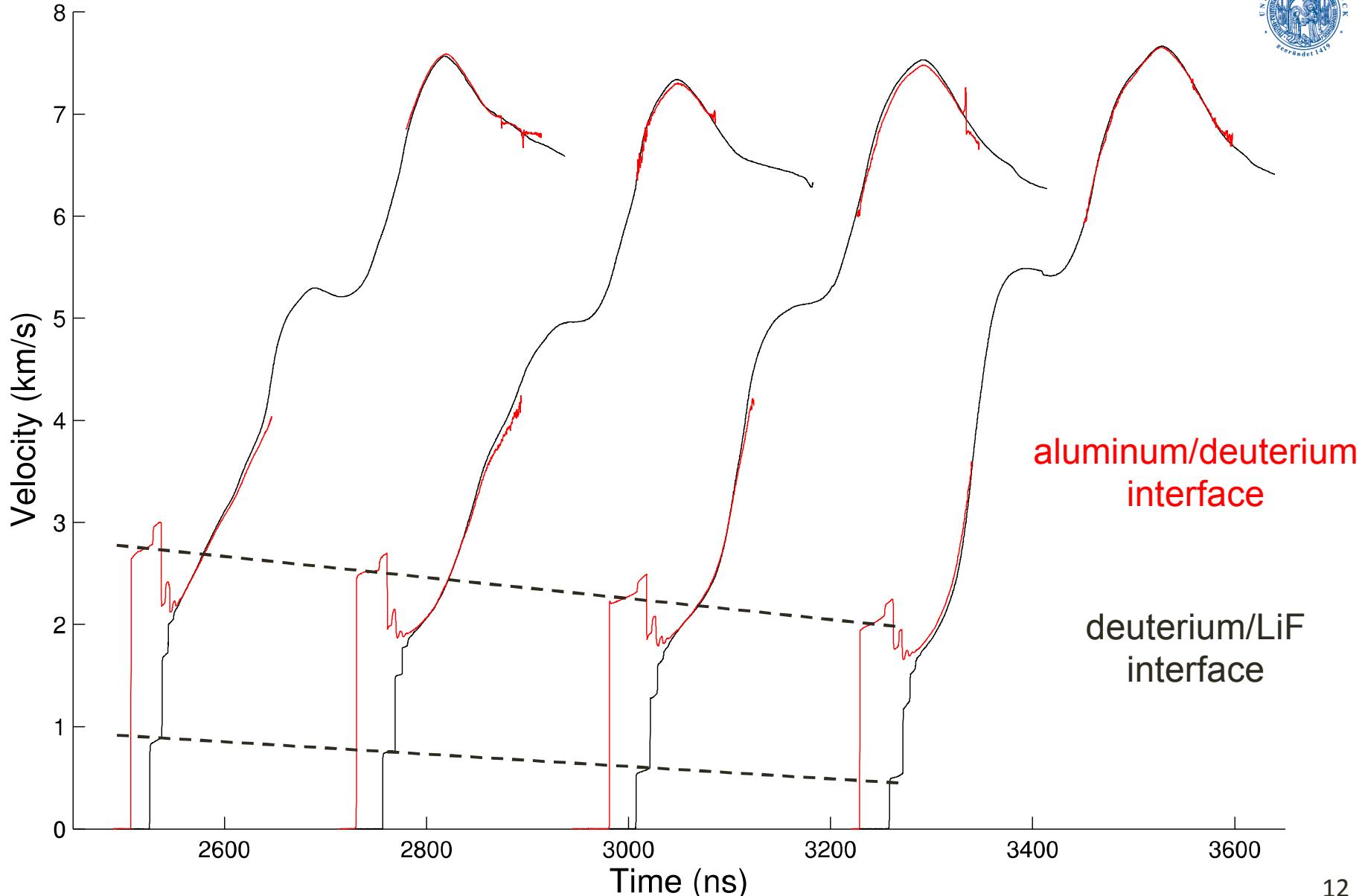
Experimental configuration



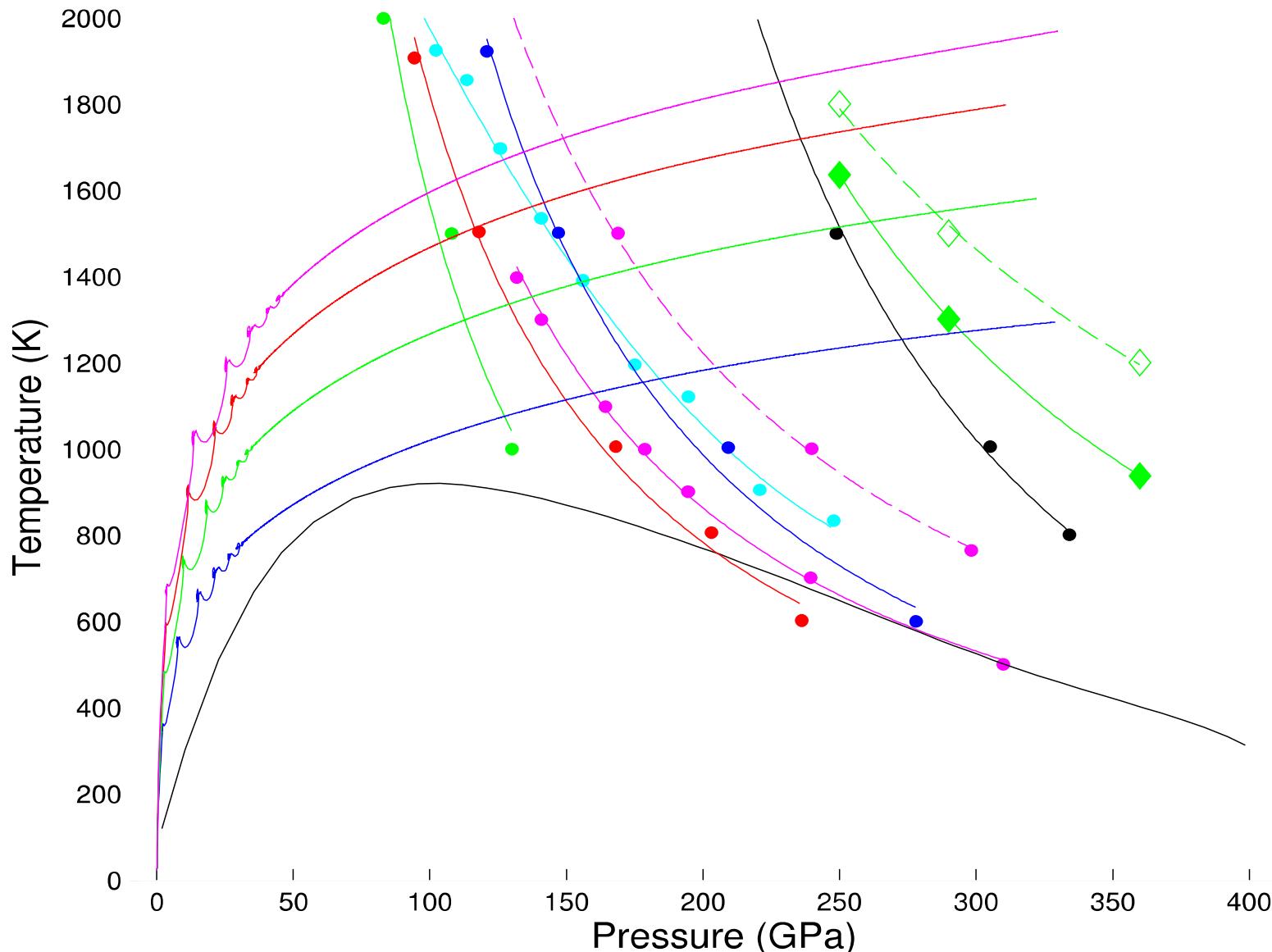
Two-step pulse shape provides shock-ramp profile



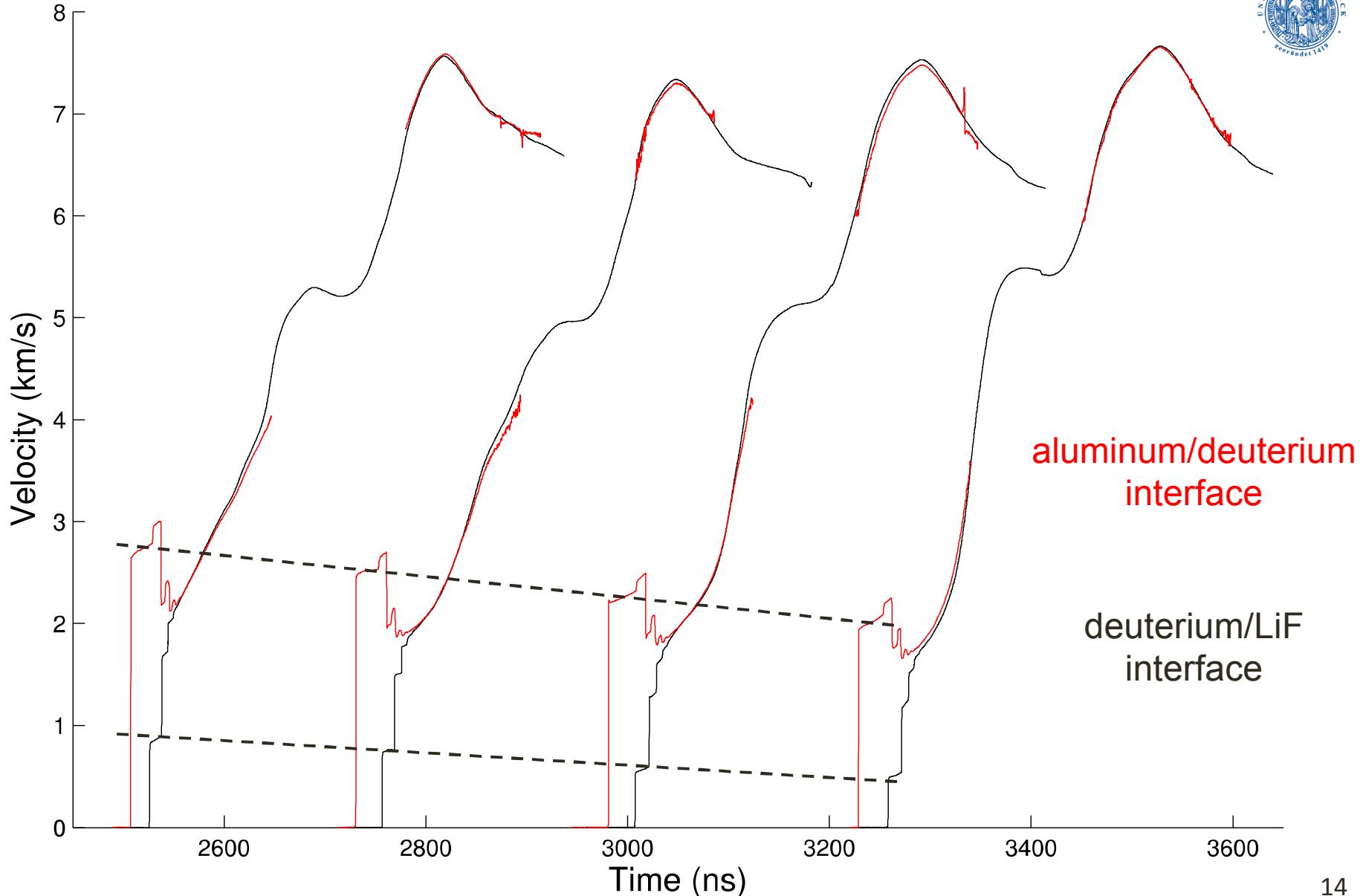
Stripline experimental profiles



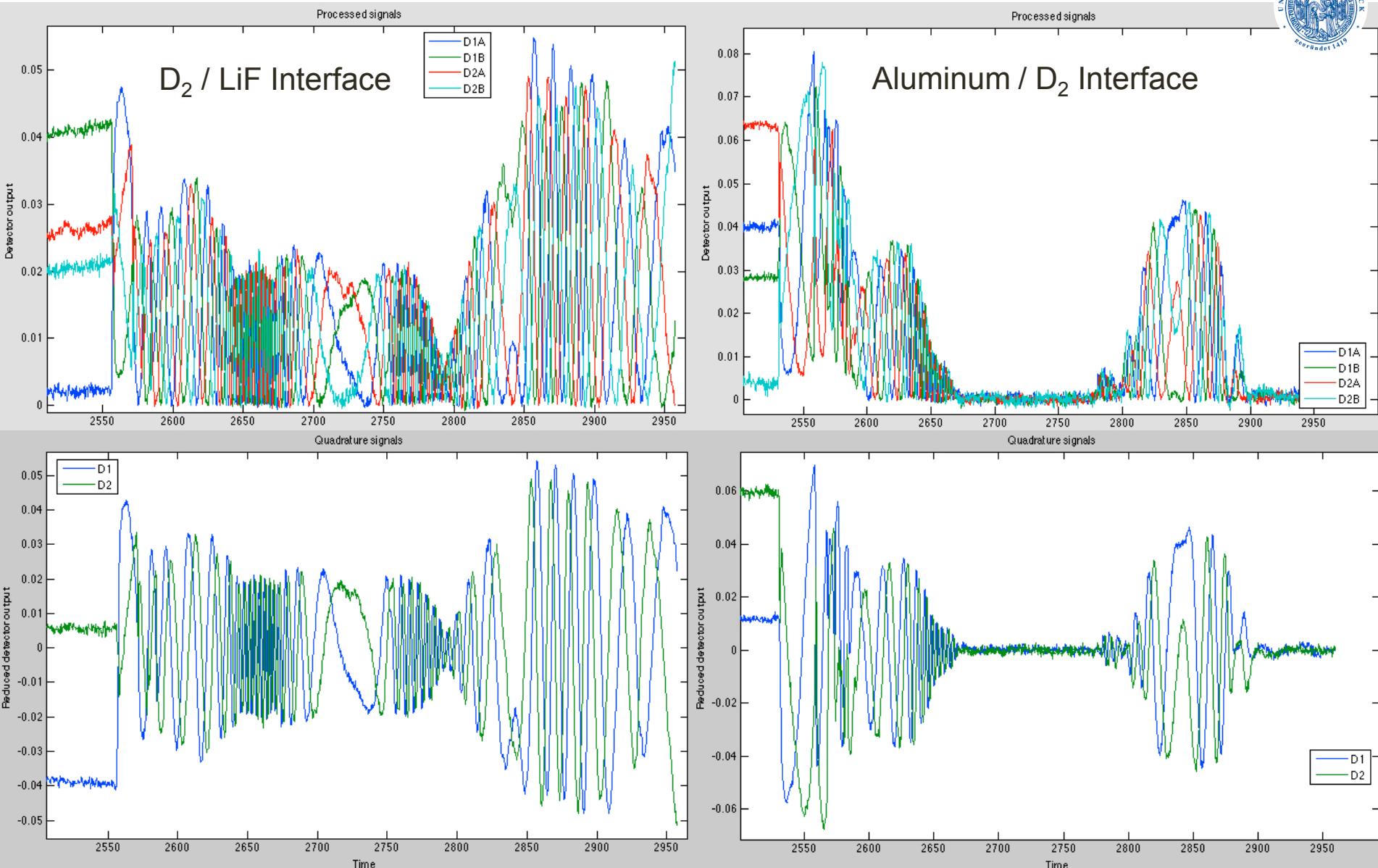
Stripline experiment PT paths



Stripline experimental profiles

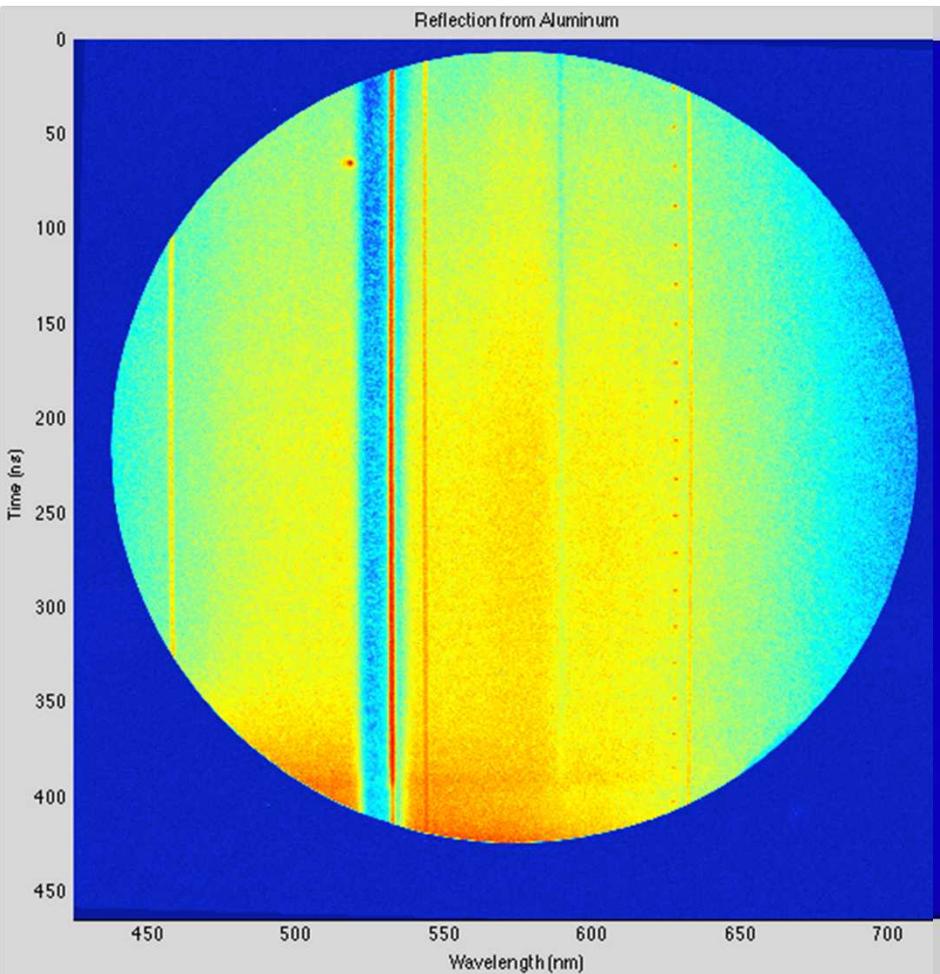


Processed VISAR signals

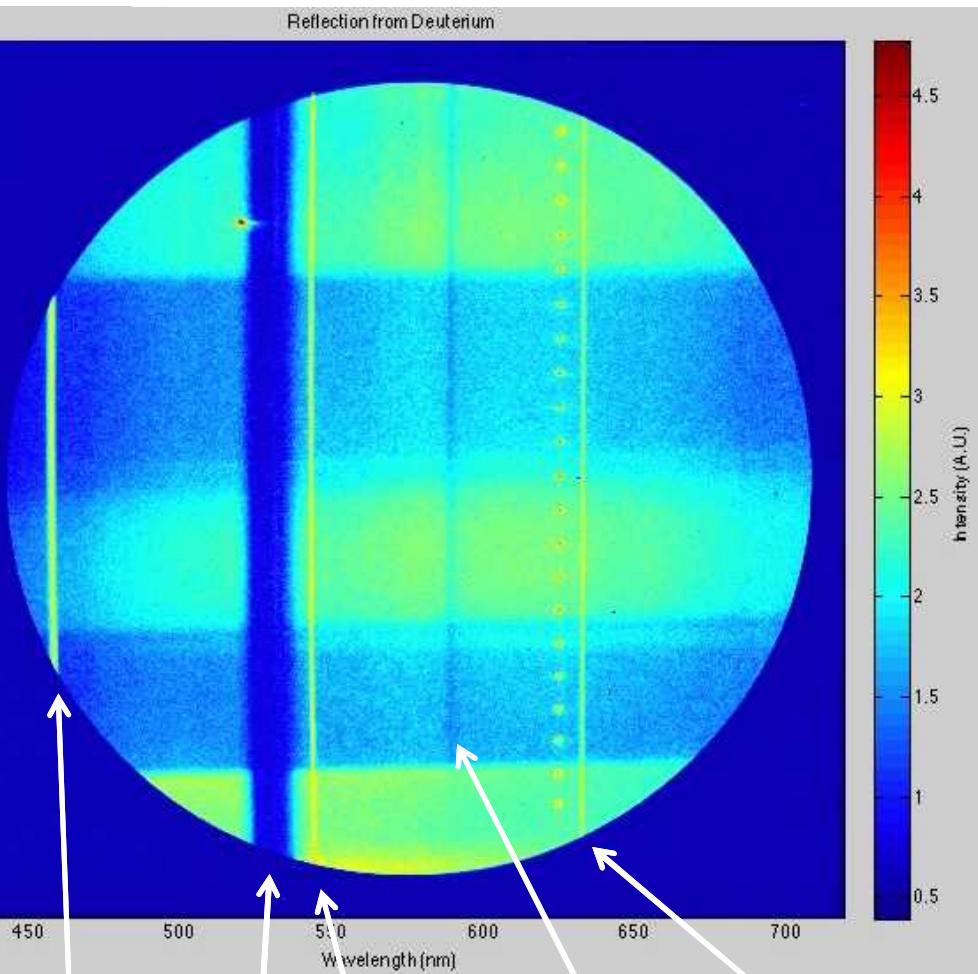


SVS system provides data to infer reflectivity

Reflection from aluminum coating



Reflection from deuterium



Wavelength range ~450-700 nm

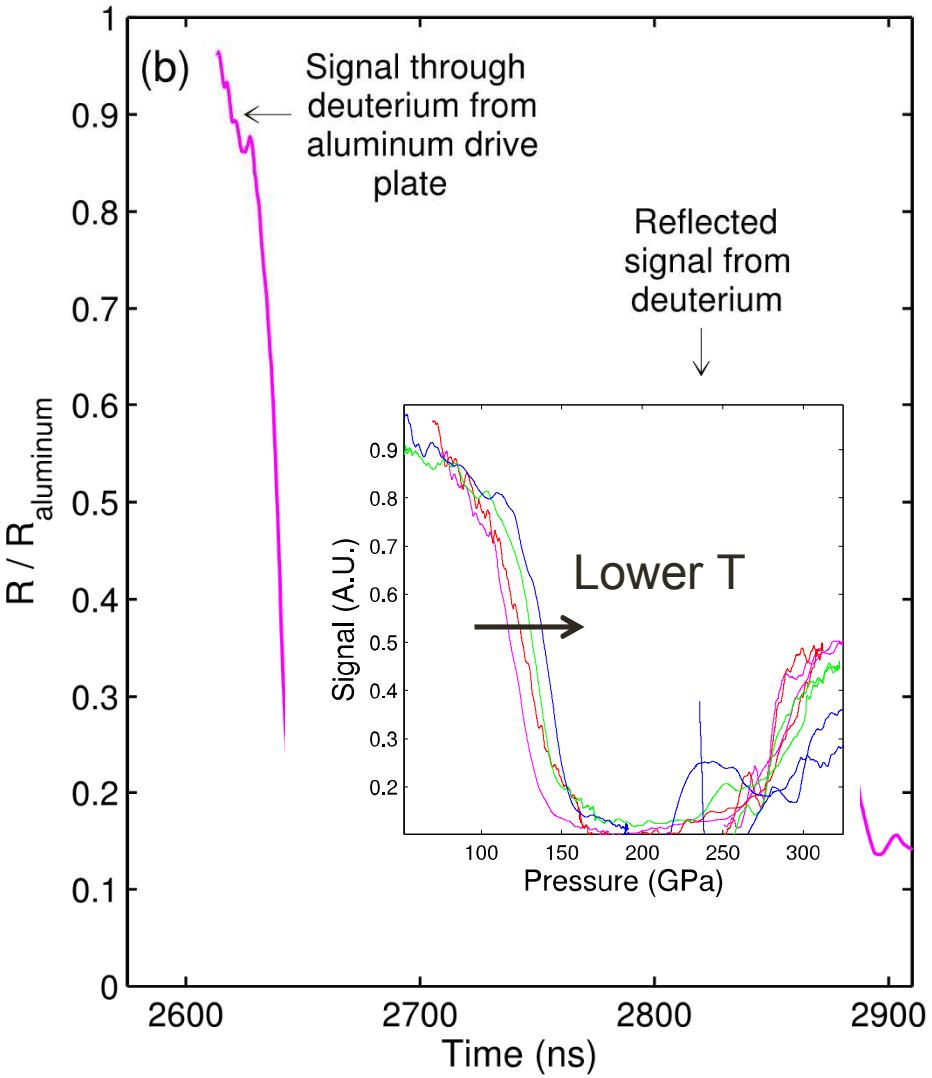
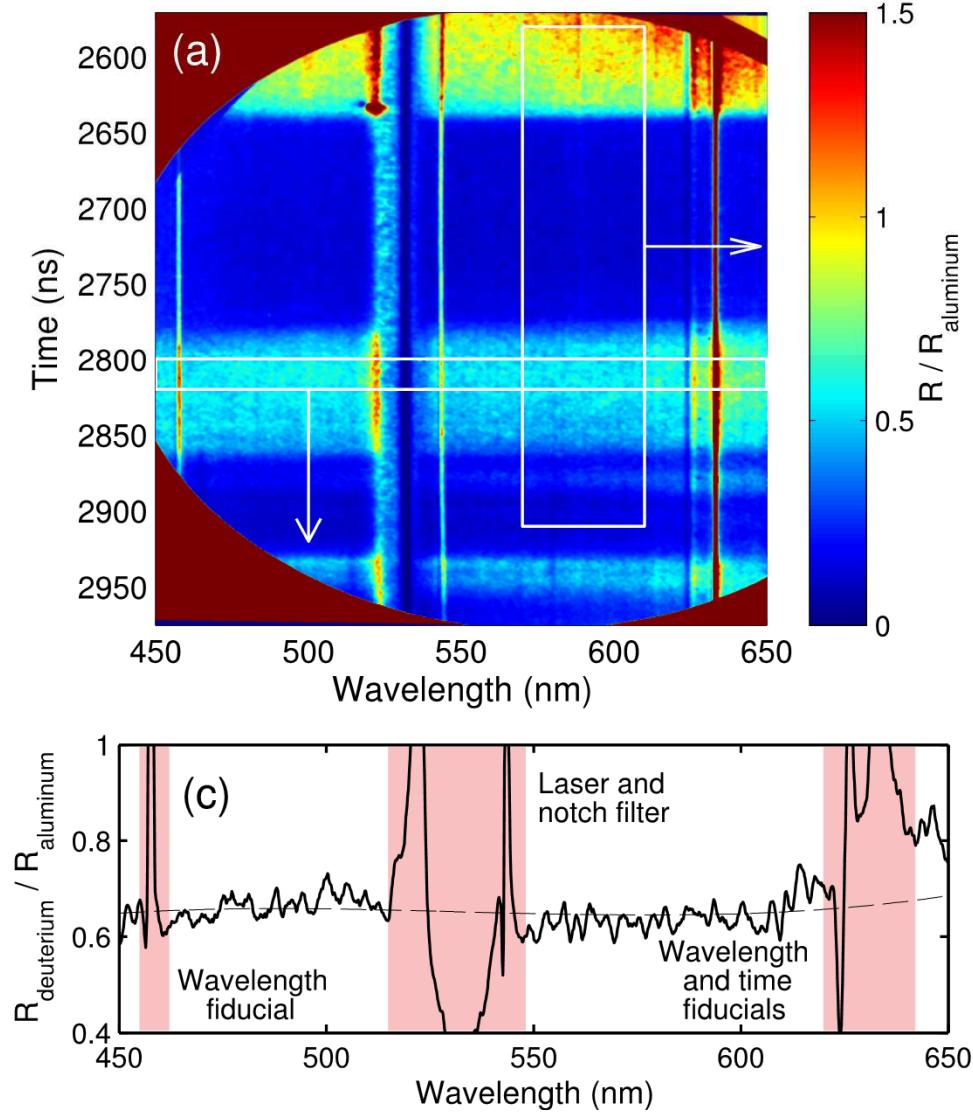
457.9 nm

532 / 543.5 nm

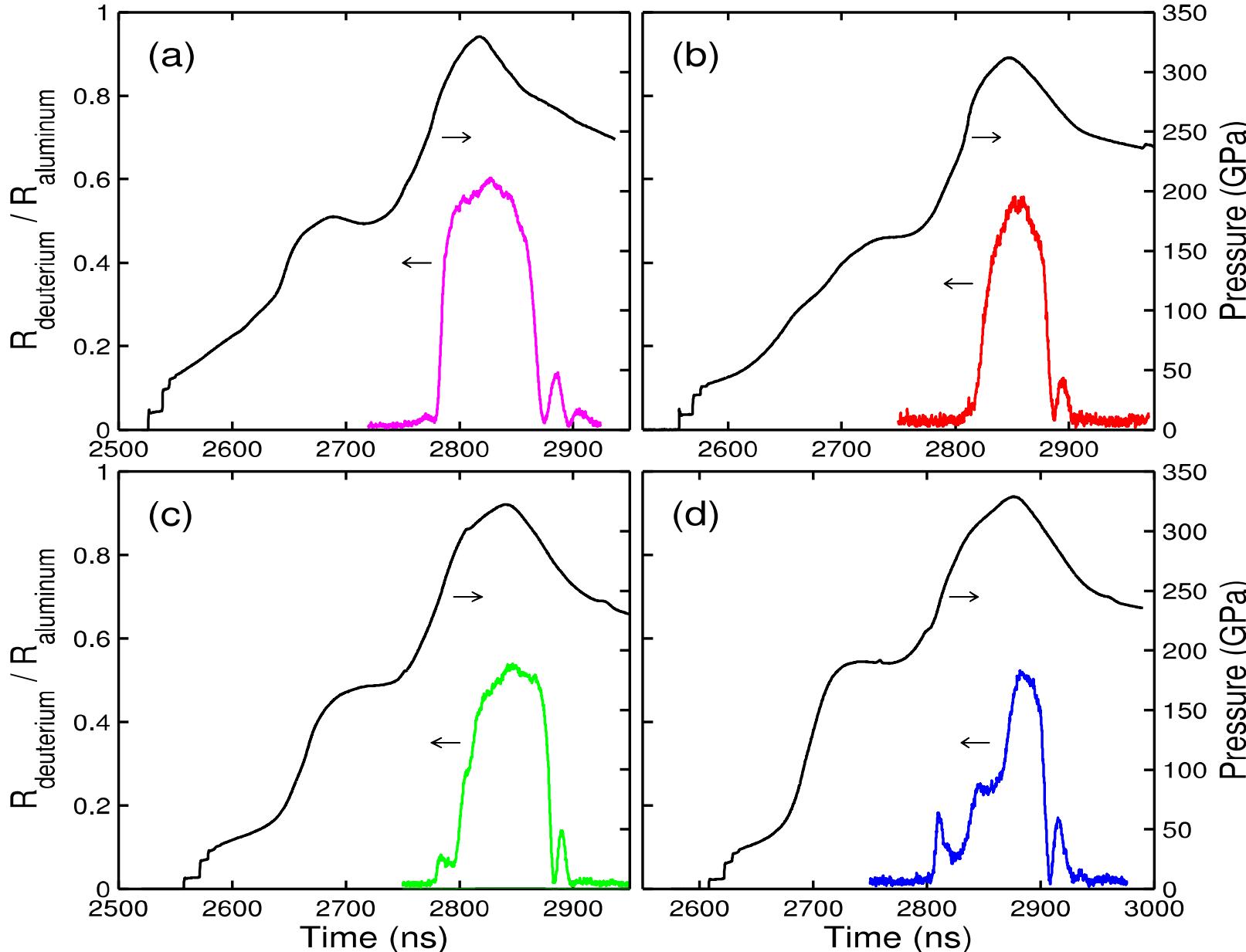
589.3 nm

633 nm

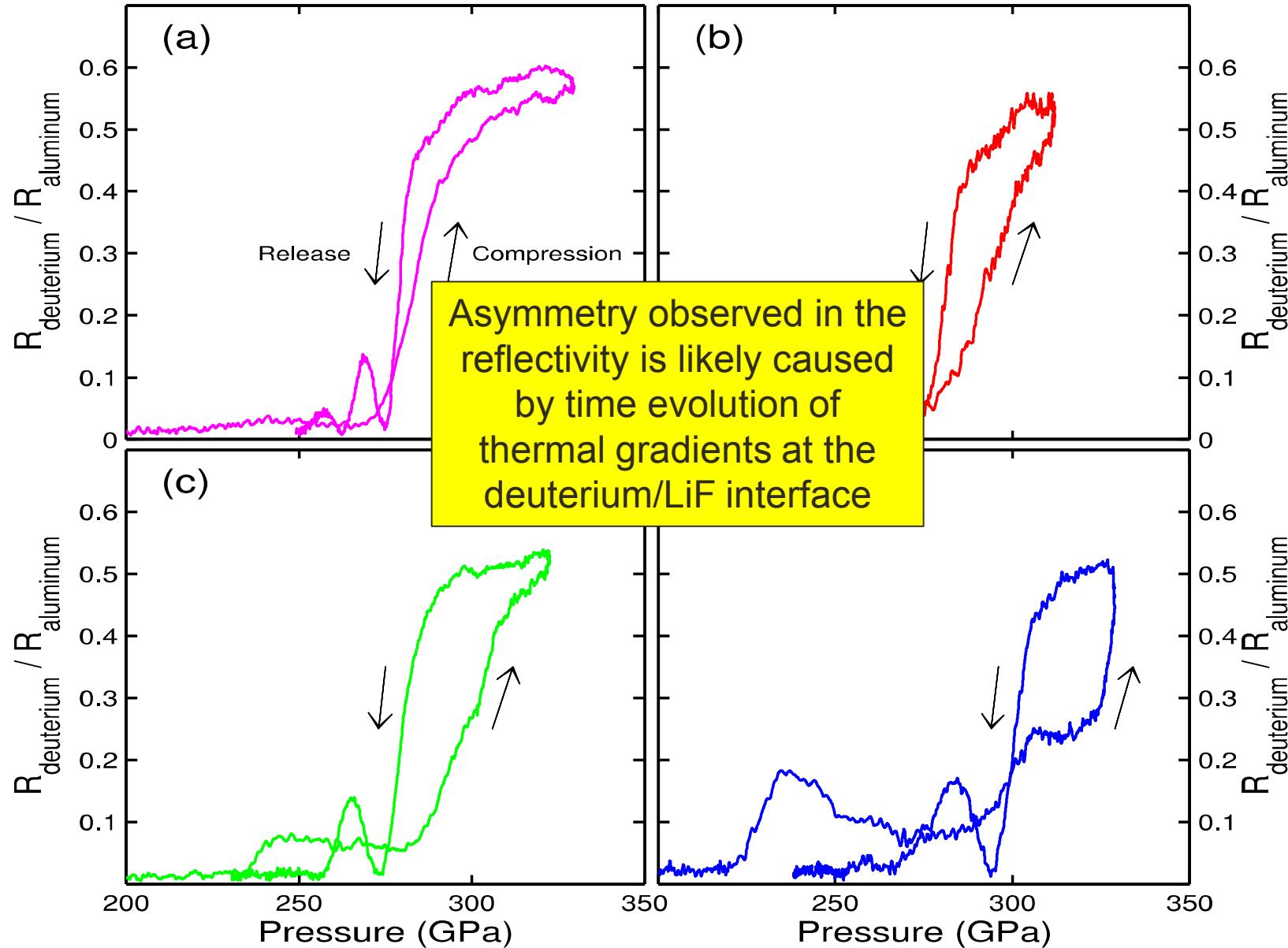
SVS system provides data to infer reflectivity



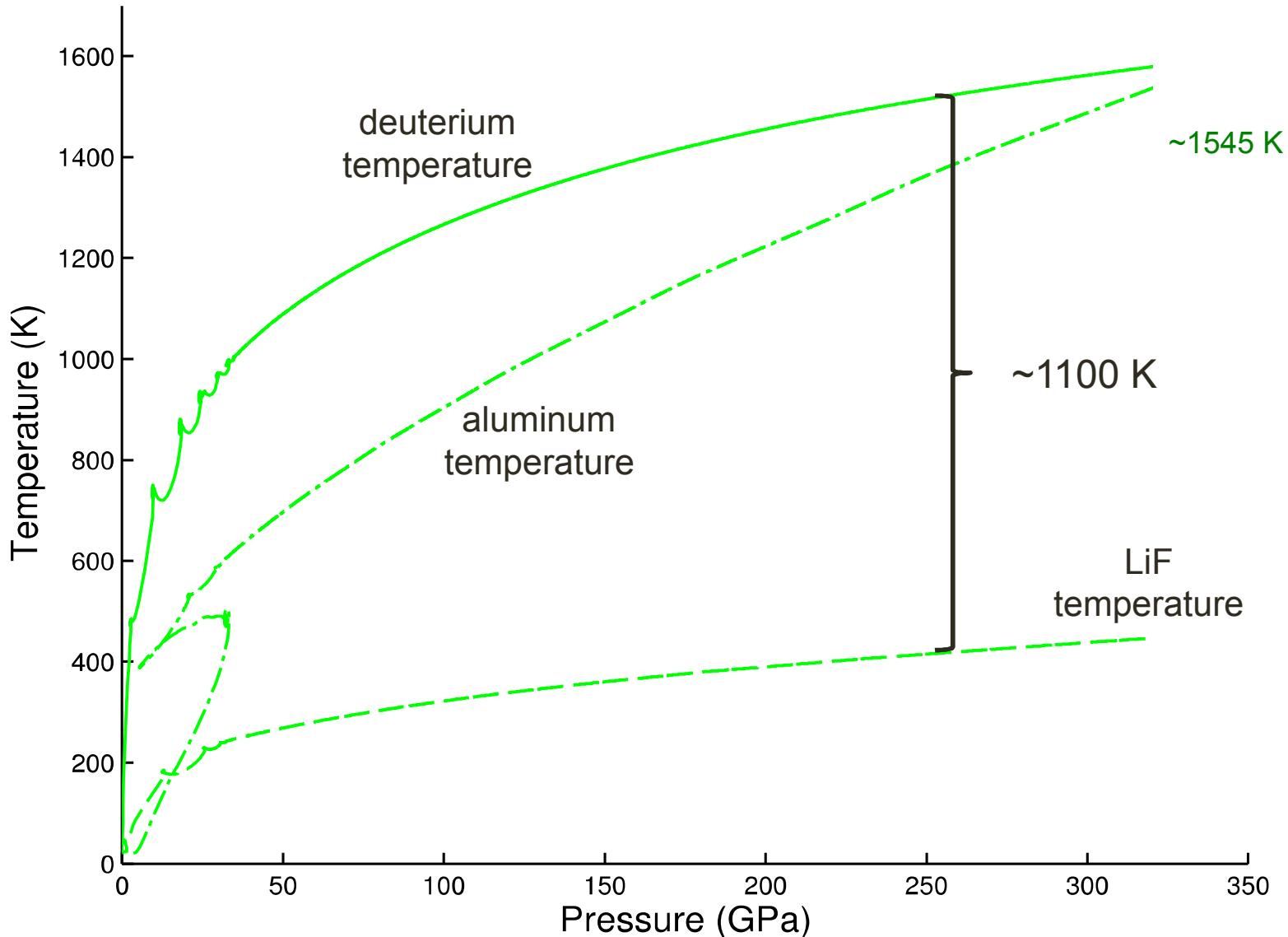
Reflectivity and pressure vs. time from VISAR



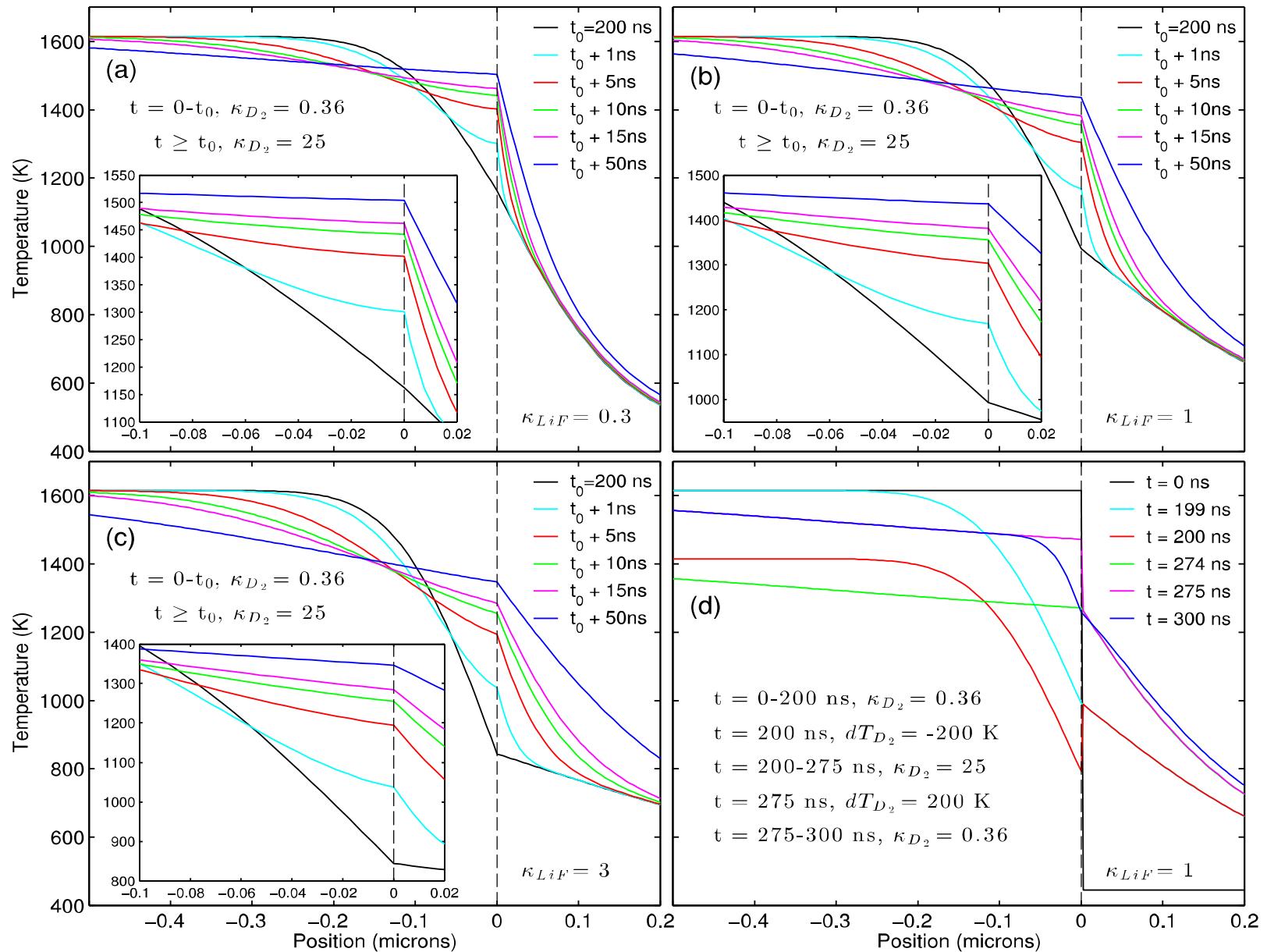
Reflectivity signals mapped to pressure



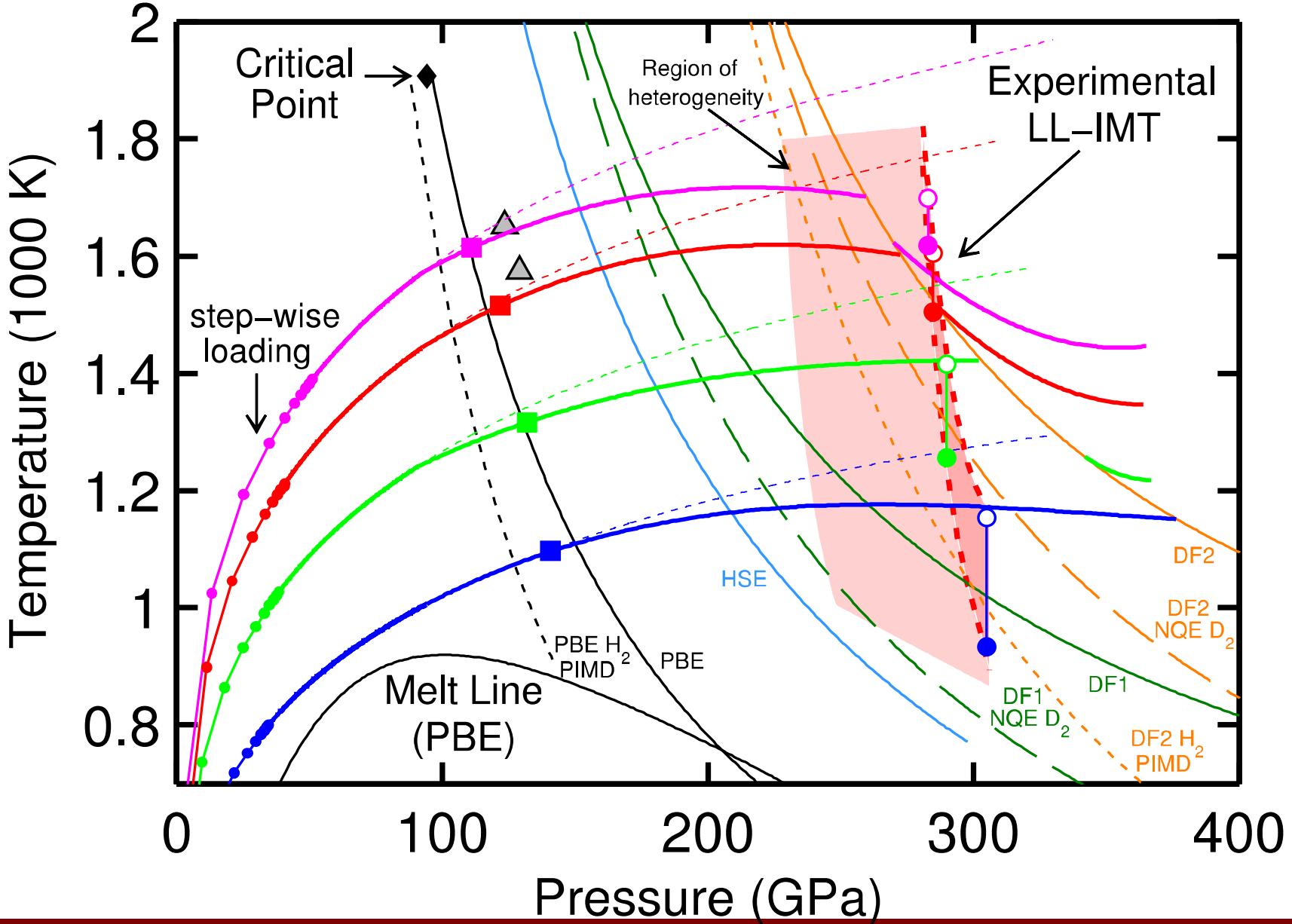
There is a significant temperature difference at the deuterium/LiF interface



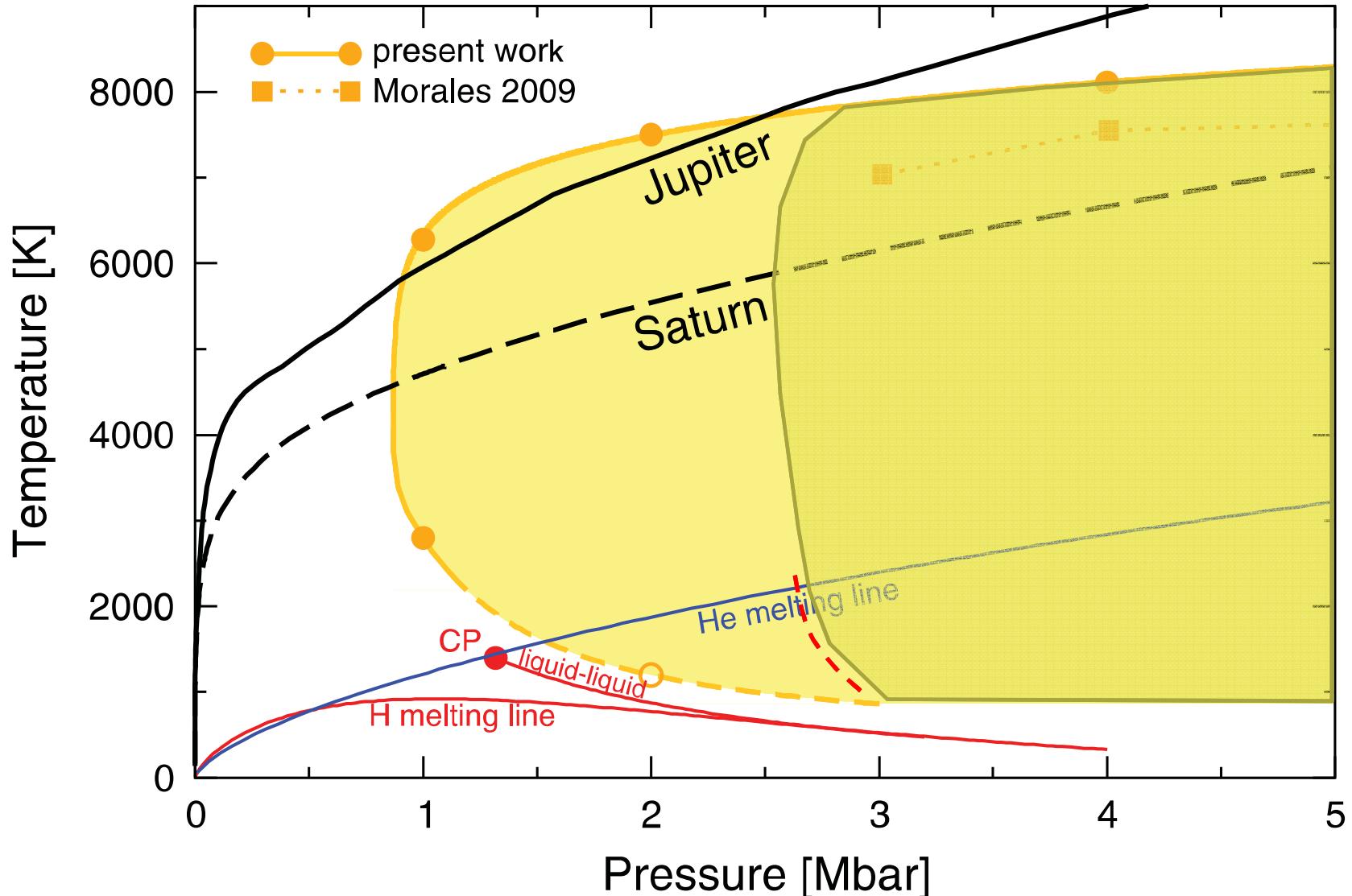
Thermal conduction simulations



Possible location of the LL-IMT in deuterium



H-He de-mixing appears to be precipitated at low T and P by metallization in hydrogen



Conclusions

- Shock-ramp technique enables experimental access to the region of phase space where the liquid-liquid, insulator-metal transition (LL-IMT) has been proposed for hydrogen
 - Temperature of the adiabat controlled by magnitude of initial shock
 - $P(t)$ in the experiments determined from the LiF equation on state
- Experiments above ~ 250 GPa show clear evidence of metallization of deuterium
 - Very abrupt increase in reflectivity to $\sim 40\text{-}50\%$
 - Pressure state well above numerous first principles predictions
 - Indications suggest that the transition is first order
- Interpretation of the experimental results is complicated
 - Thermal conduction likely very important at the deuterium / LiF interface

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