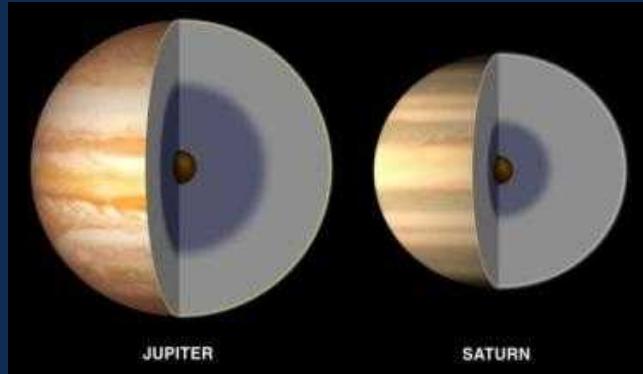
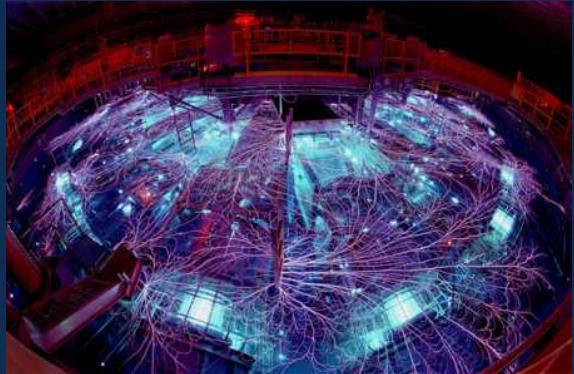


Exceptional service in the national interest



Direct observation of an abrupt Insulator-to-Metal transition in dense liquid deuterium

Marcus D. Knudson

**Sandia National Laboratories
Albuquerque, NM**



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Experiment Design/Analysis

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Ray Lemke

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Diagnostics

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Acknowledgements

QMD Calculations

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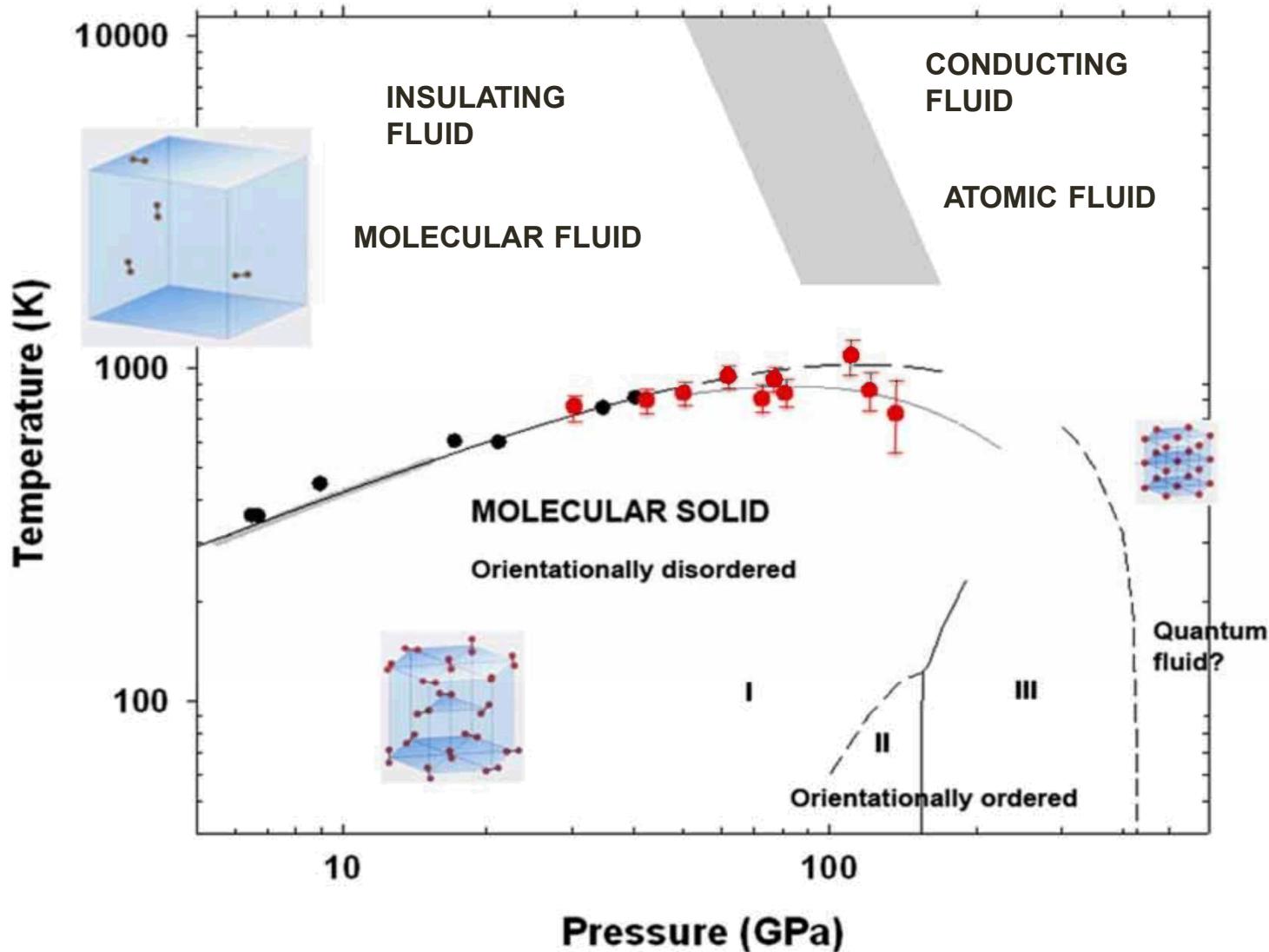
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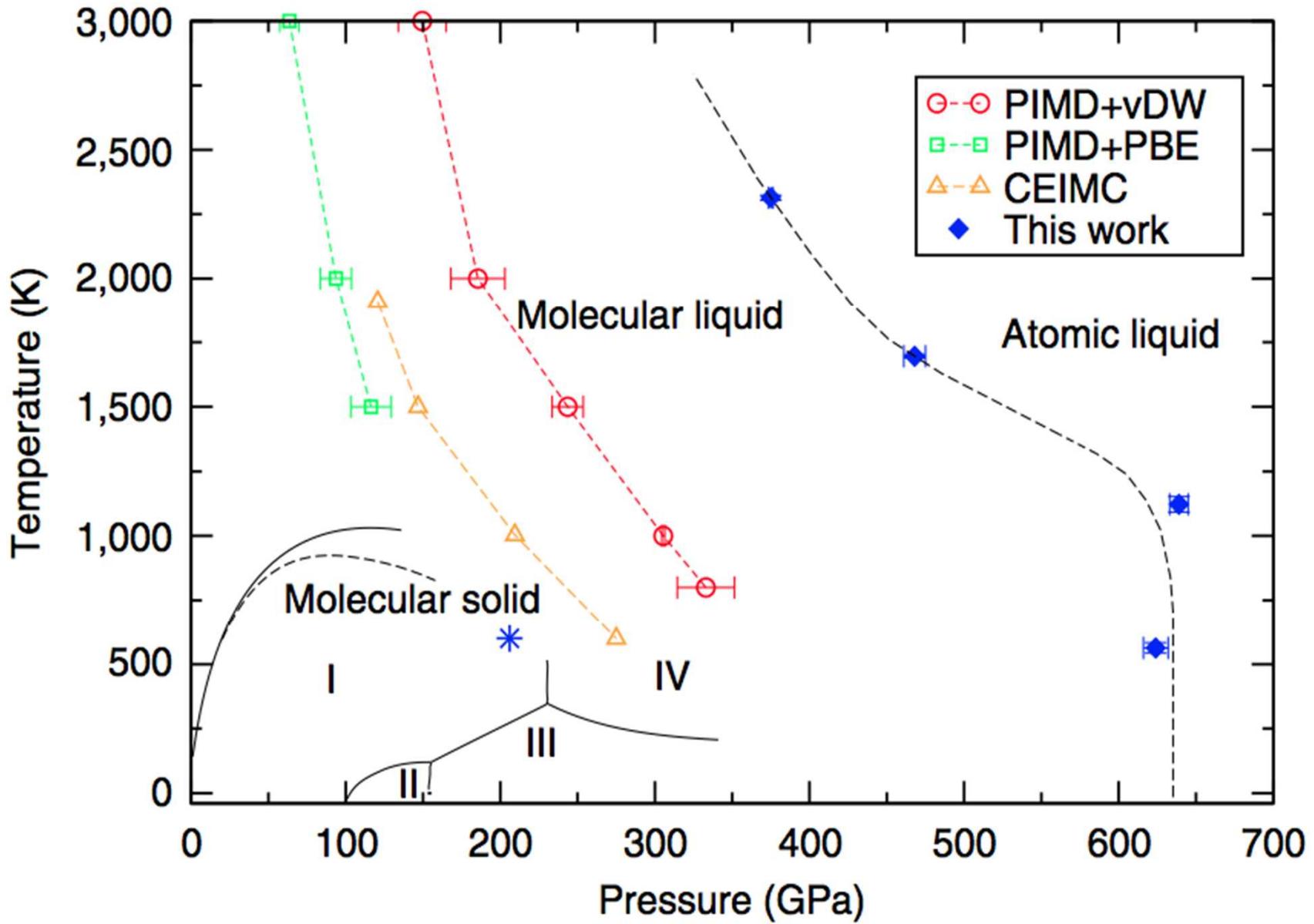
Entire Z crew

University of Rostock

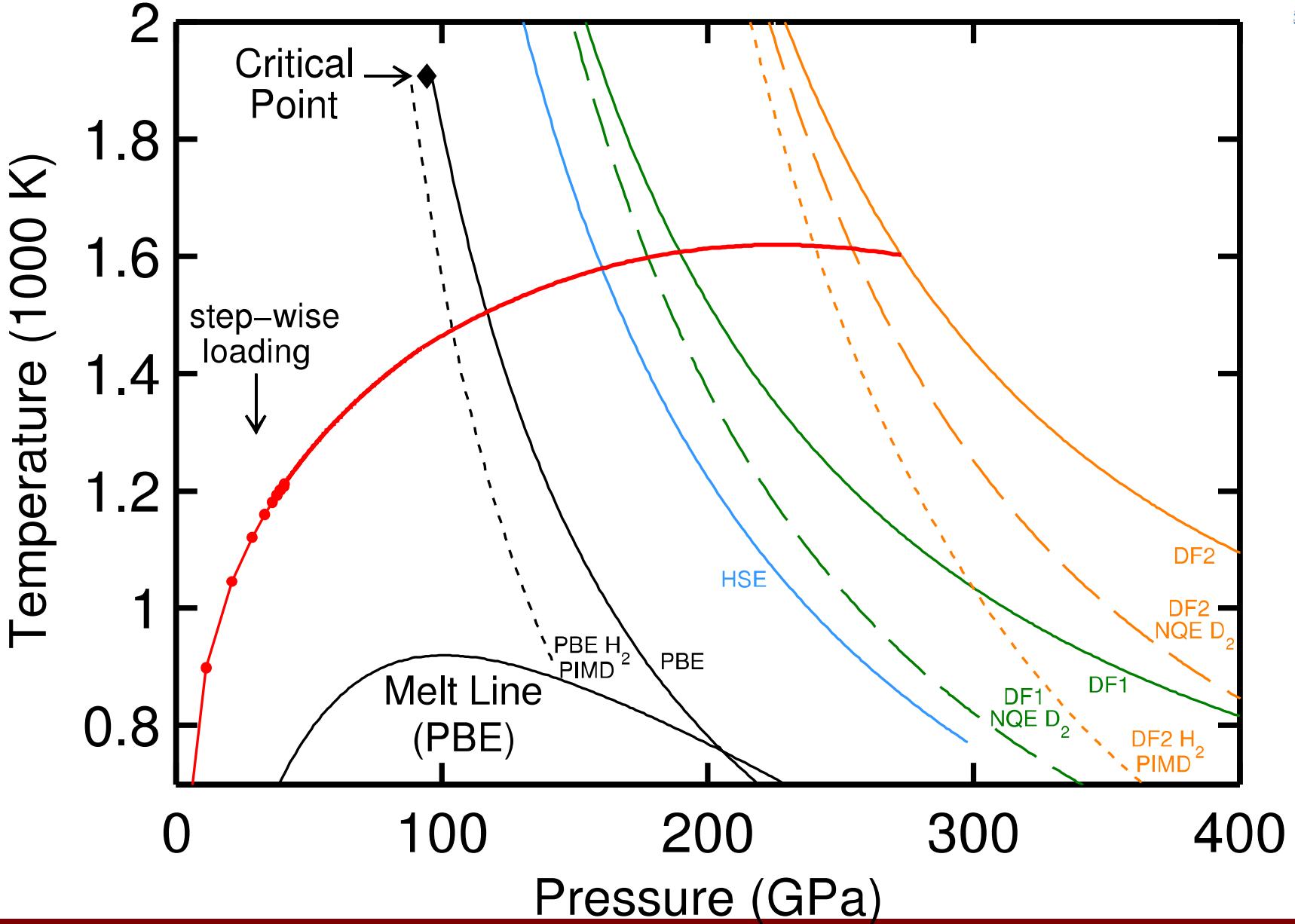
Hydrogen at high pressures – the known phase diagram so far



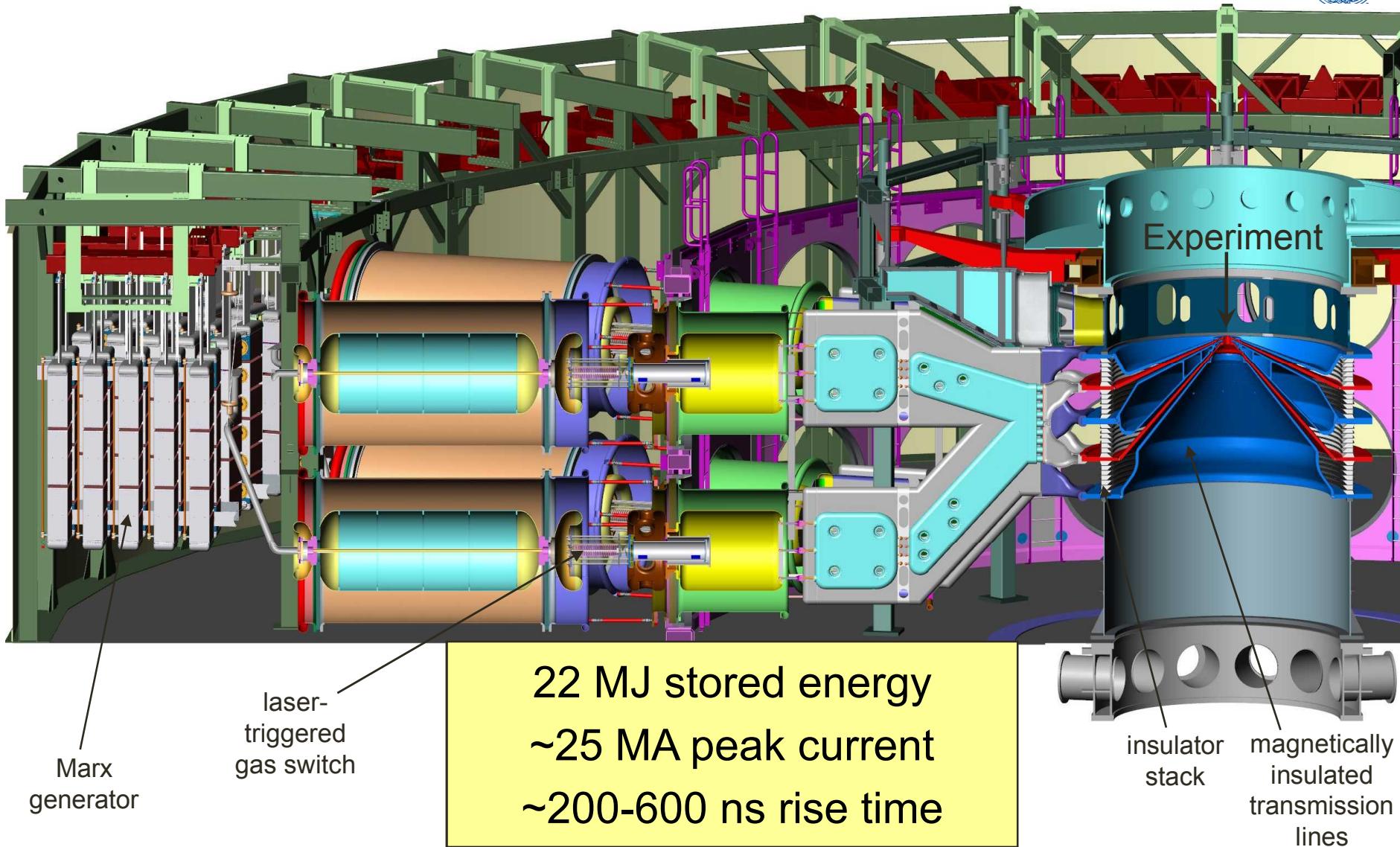
Recent predictions of the LL-IMT in hydrogen



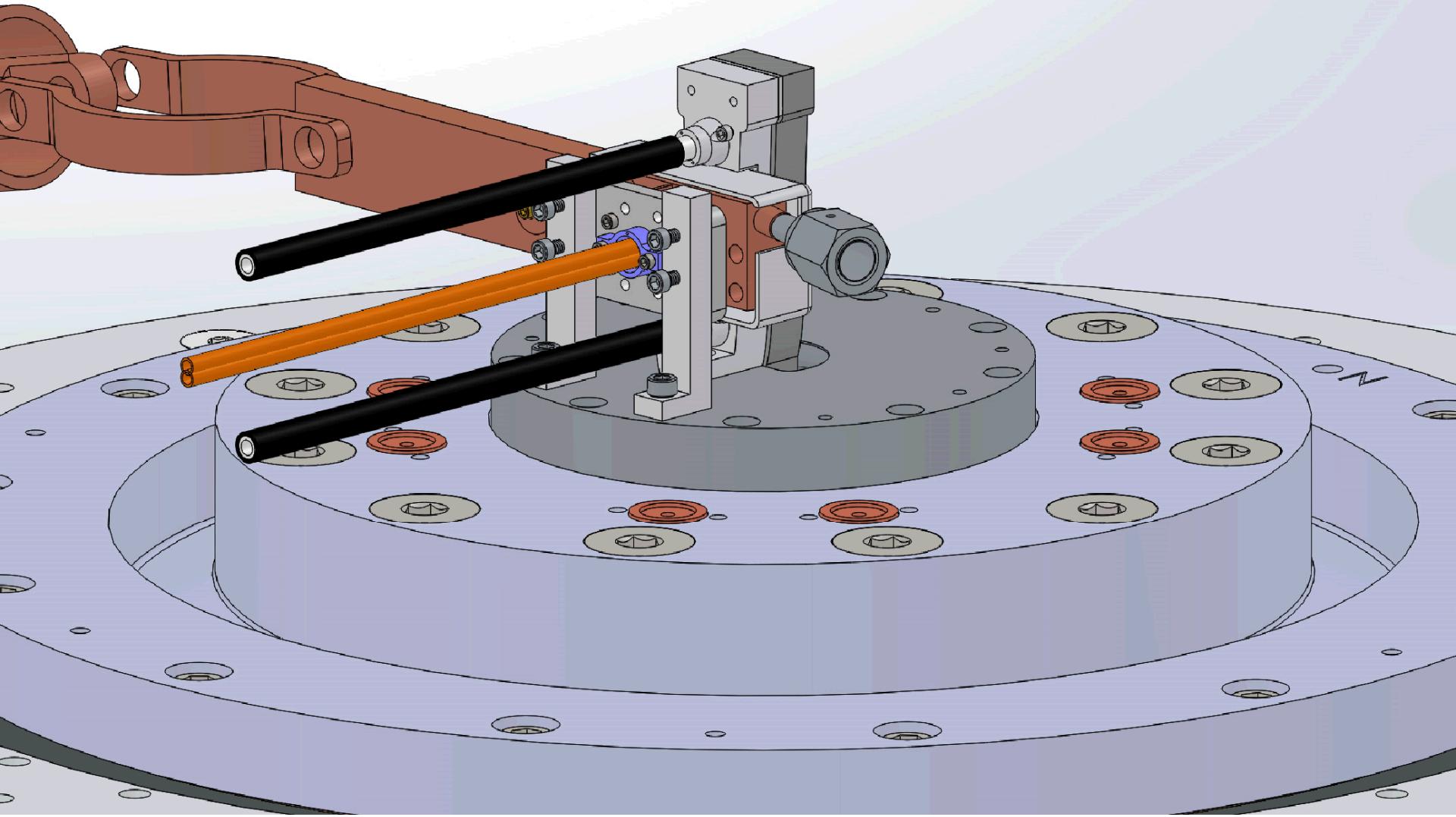
Proposed Experiment: Shock - Ramp



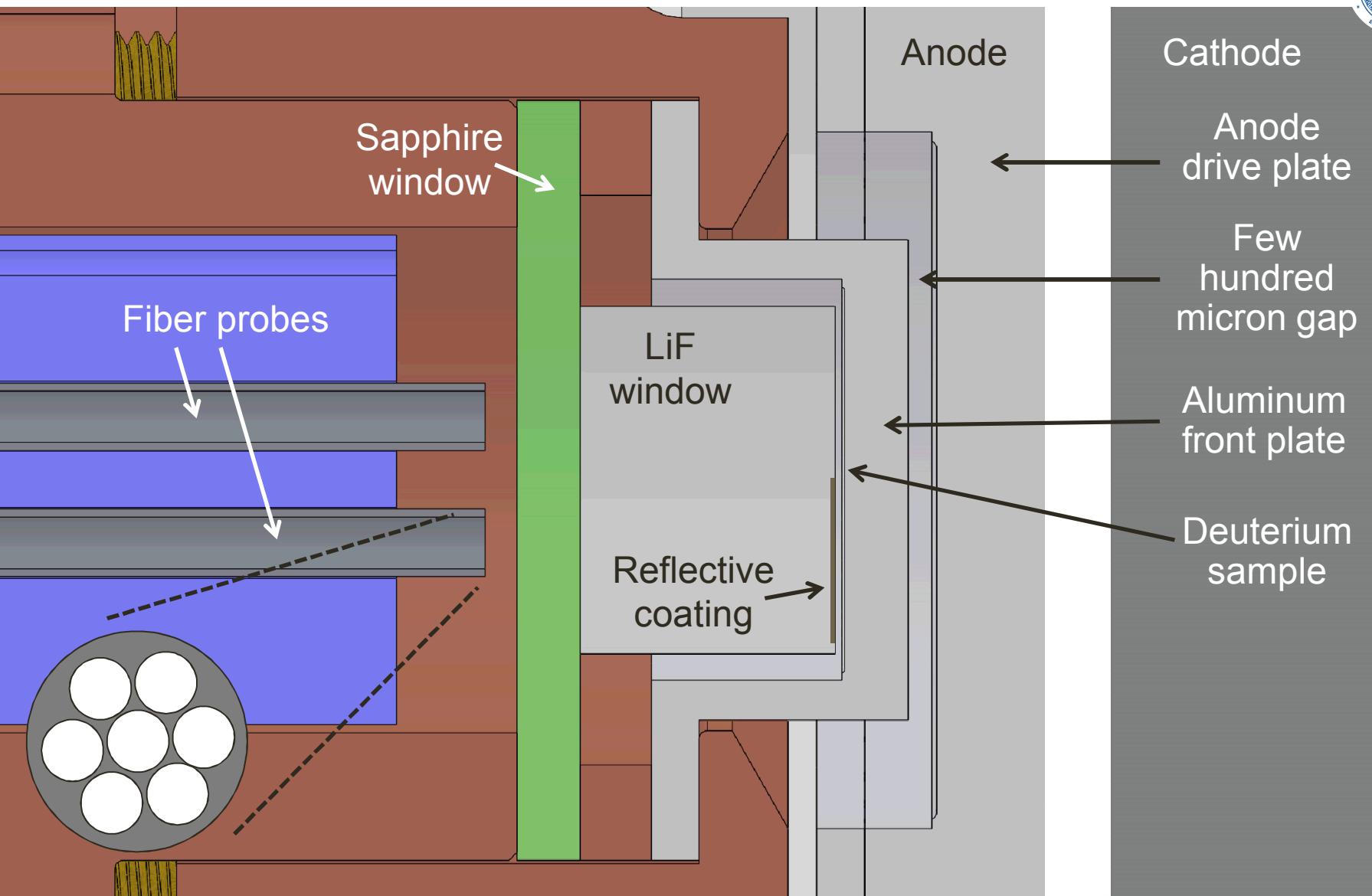
Sandia Z Machine



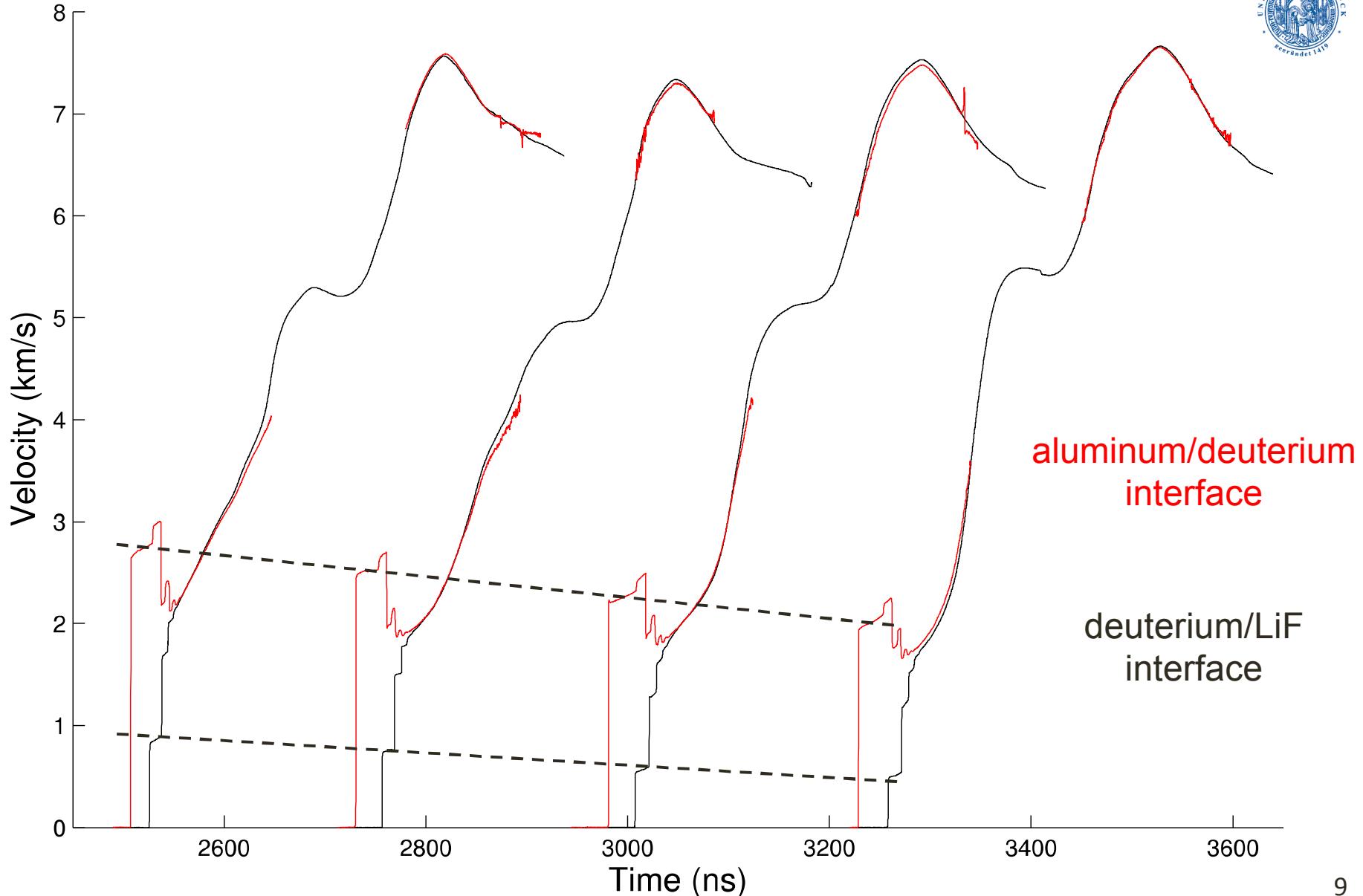
Stripline experimental configuration



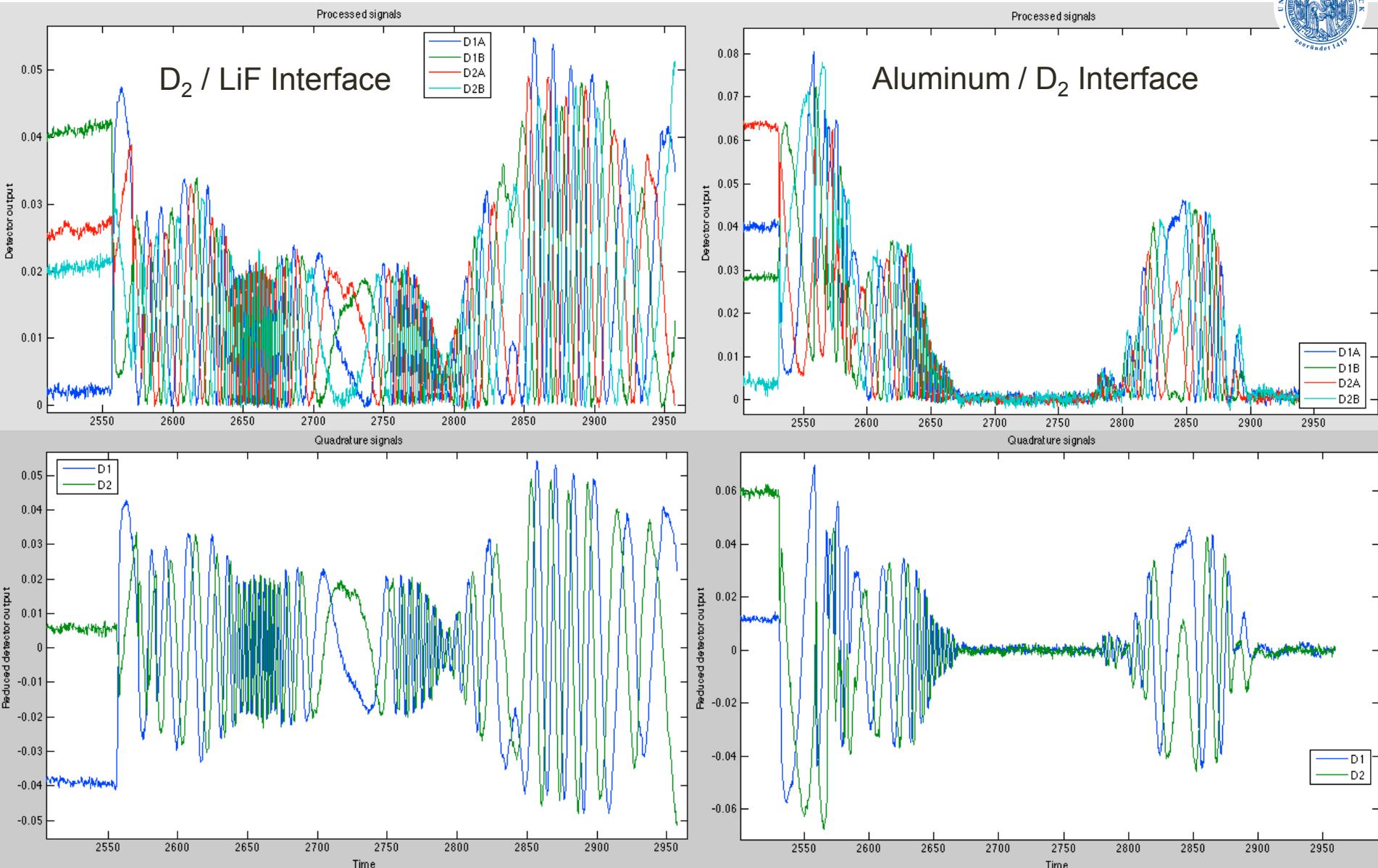
Experimental configuration



Stripline experimental profiles

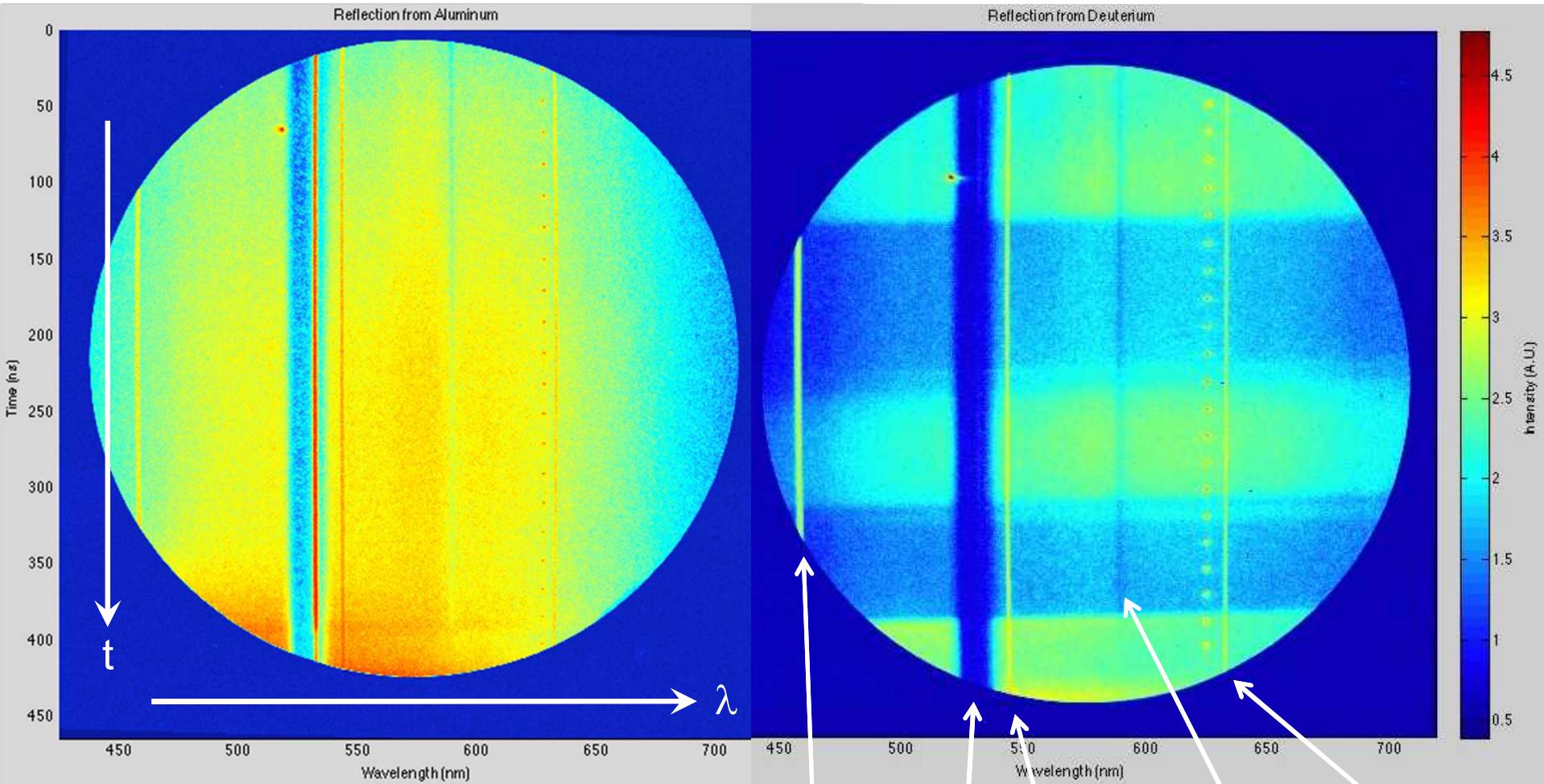


Processed VISAR signals



SVS system provides data to infer reflectivity

Reflection from aluminum coating



Wavelength range ~450-700 nm

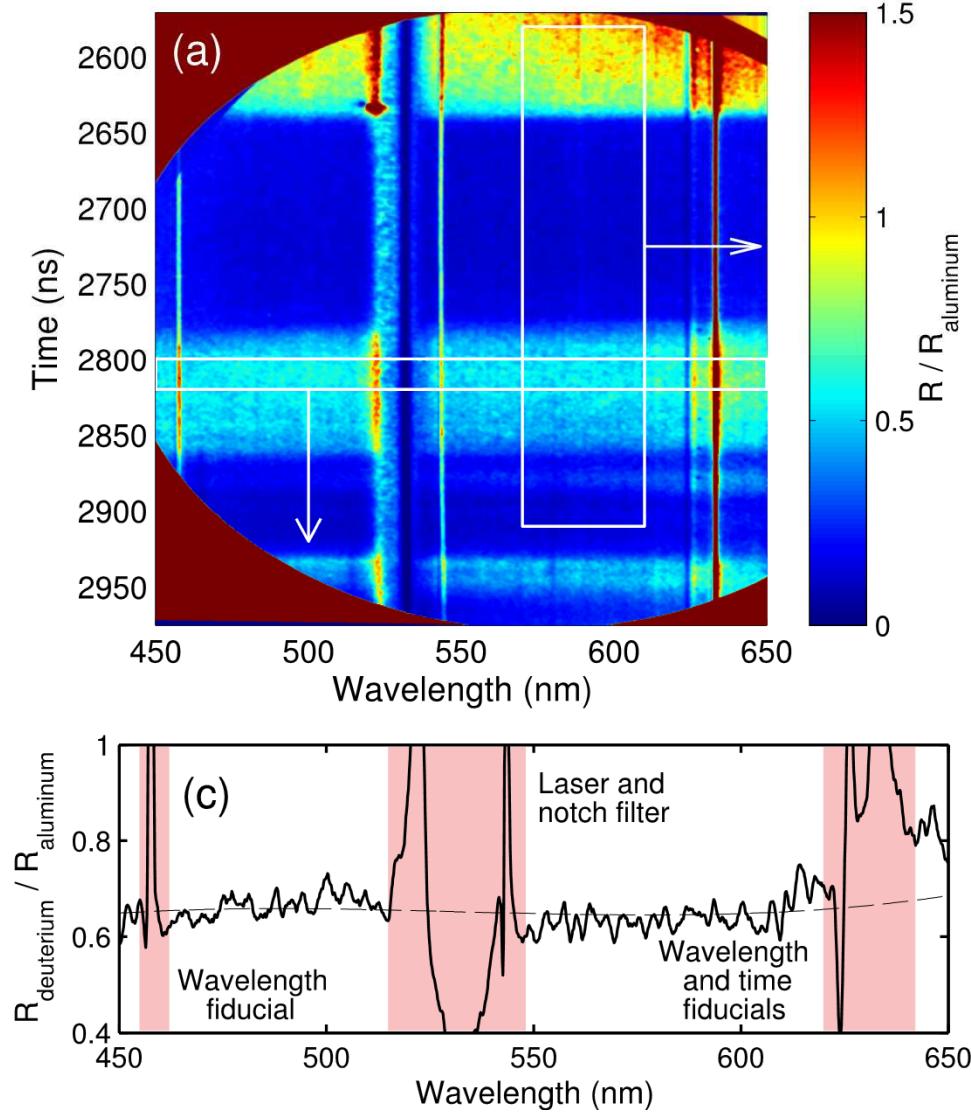
457.9 nm

532 / 543.5 nm

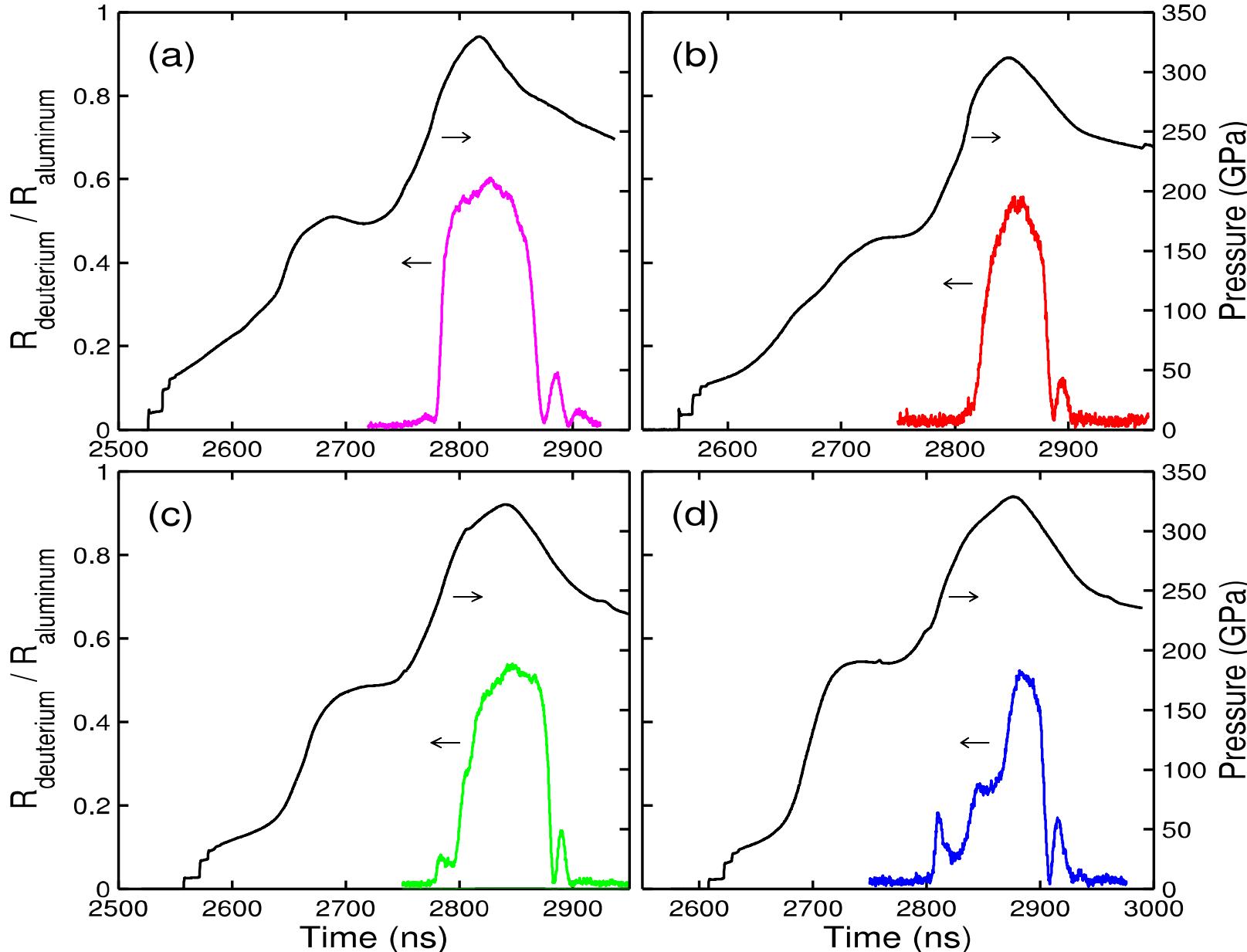
589.3 nm

633 nm

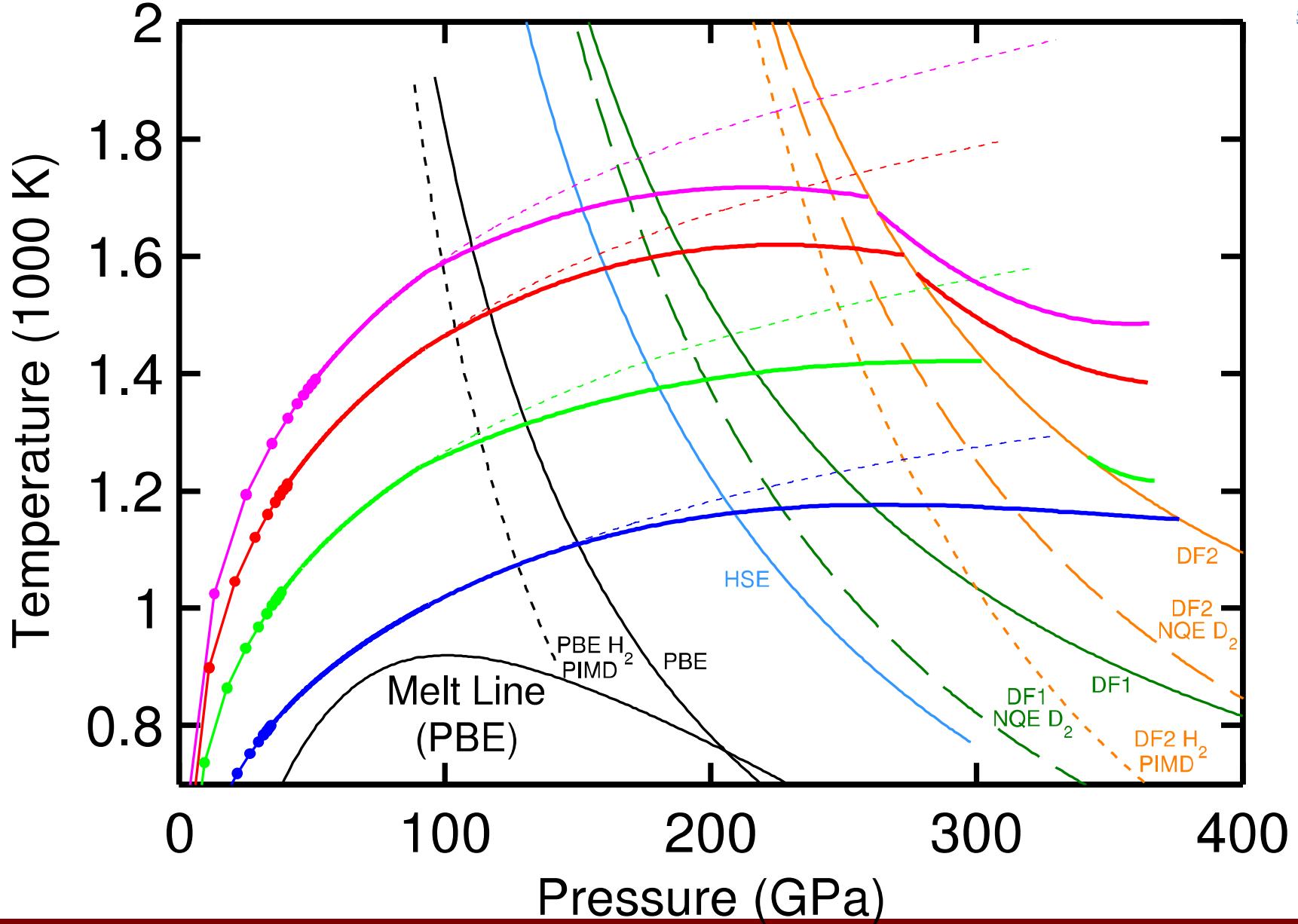
SVS system provides data to infer reflectivity



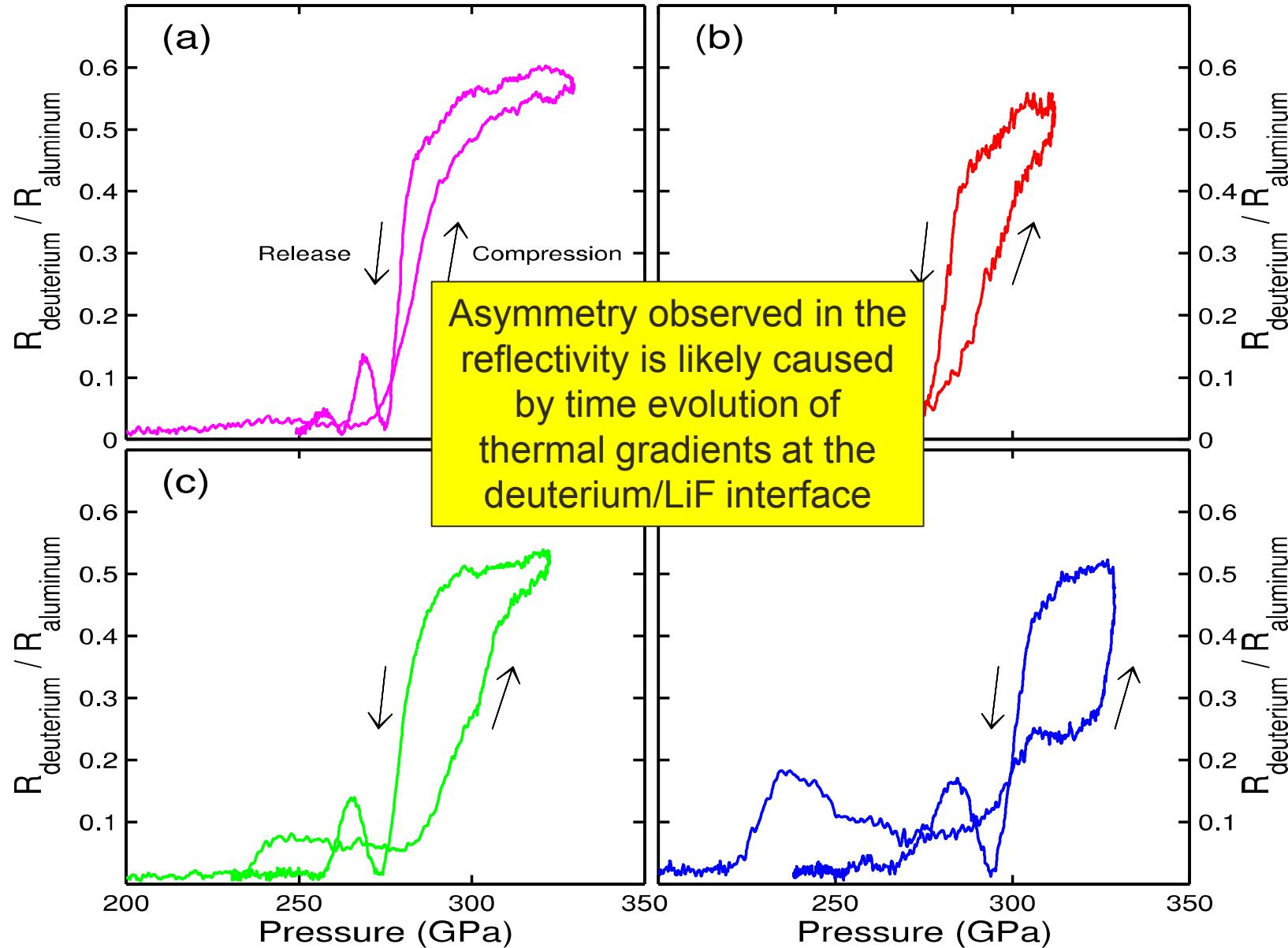
Reflectivity and pressure vs. time from VISAR



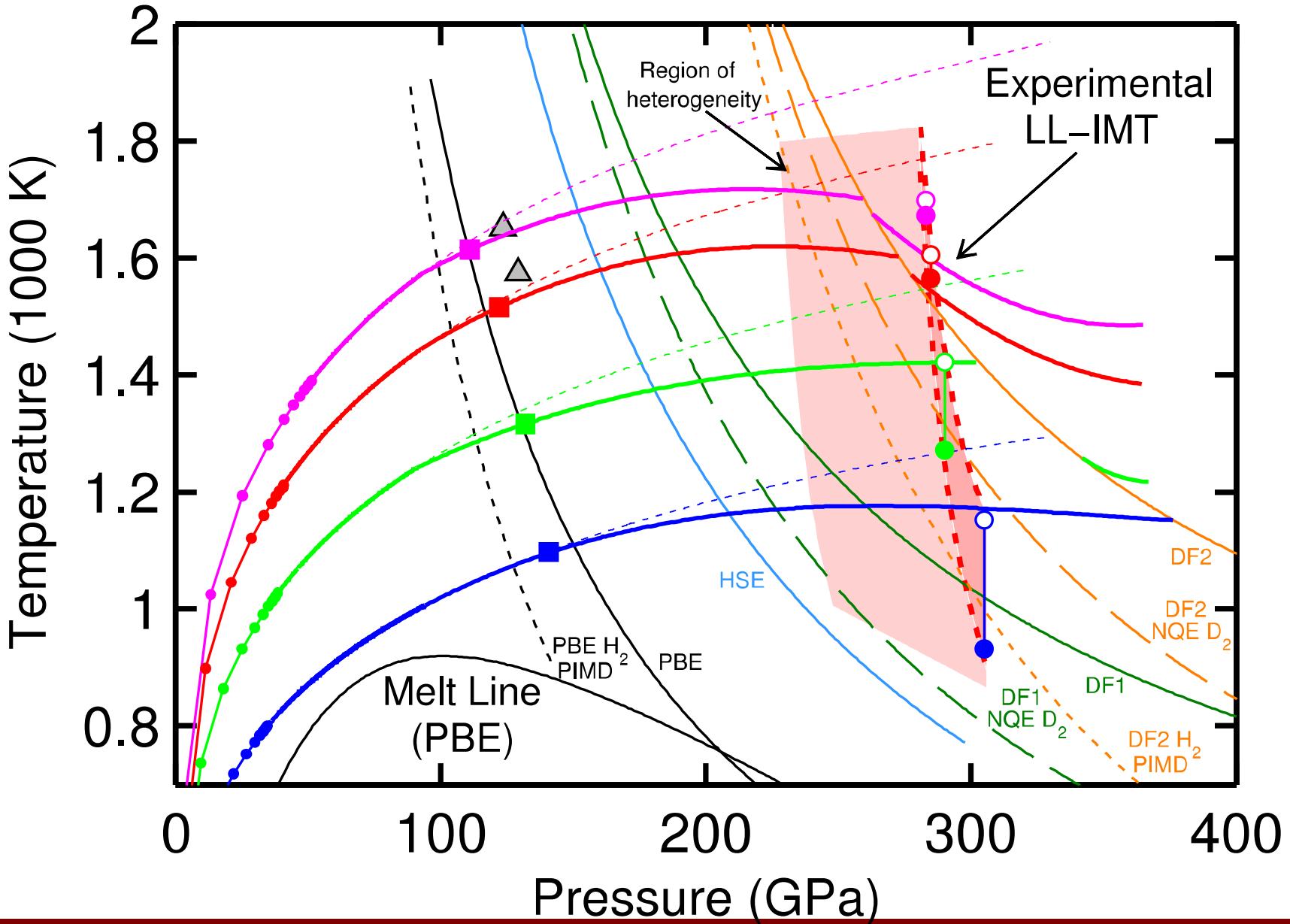
Experimental PT Paths



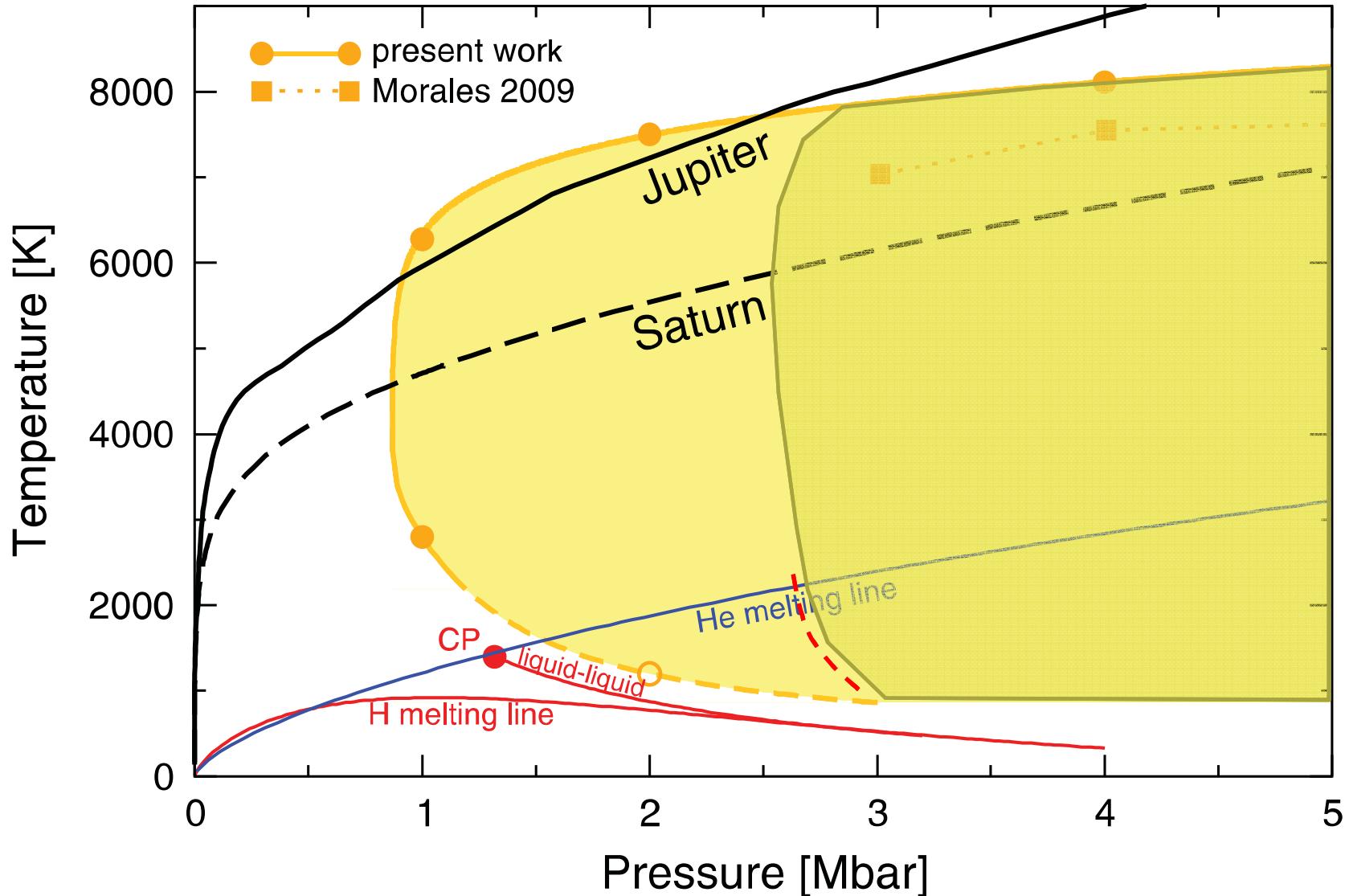
Reflectivity signals mapped to pressure



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
- Relative insensitivity to T suggests this is a ρ -driven transition
 - ρ at the transition is inferred to be $\sim 2\text{-}2.1$ g/cc in deuterium

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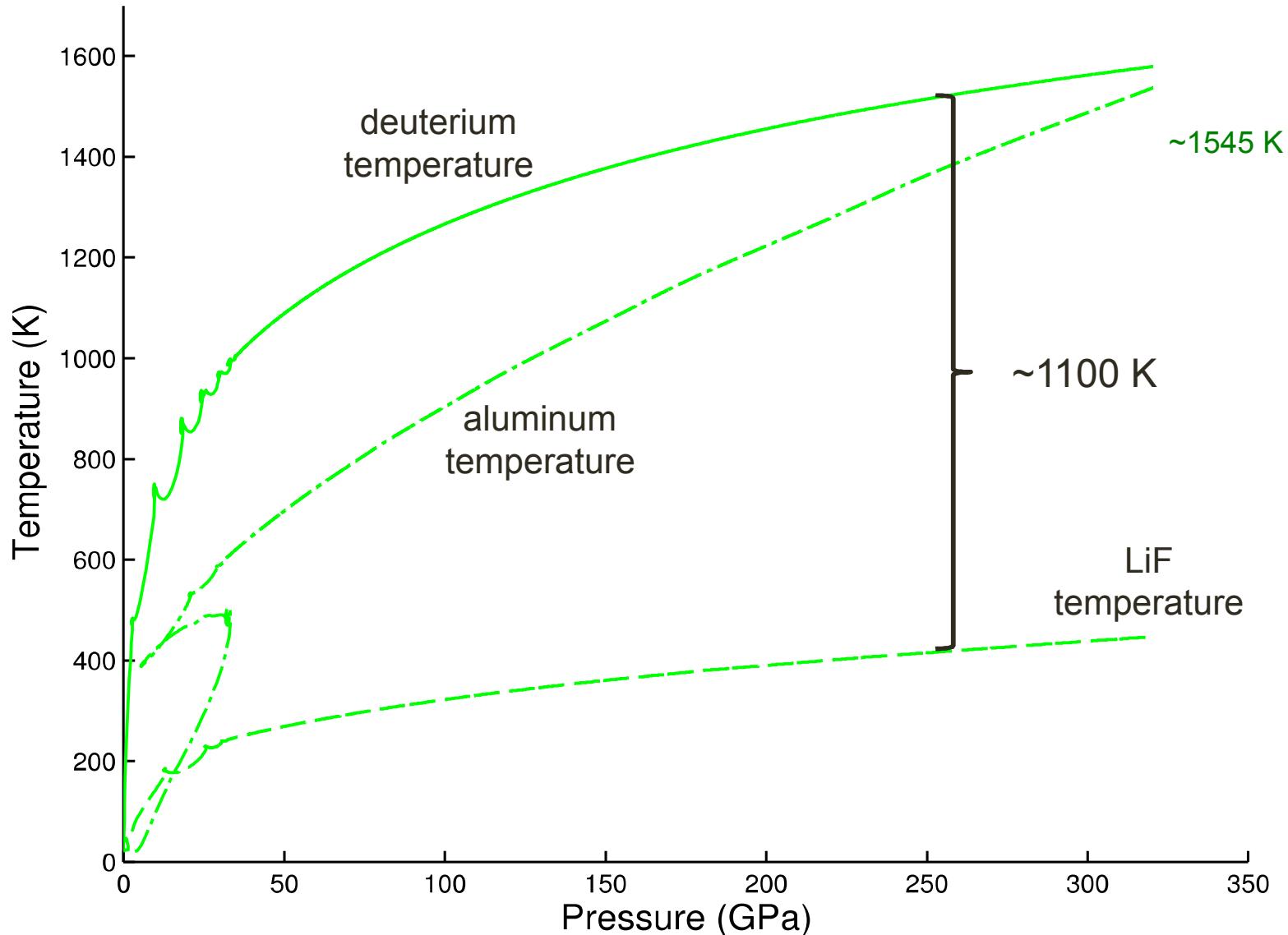
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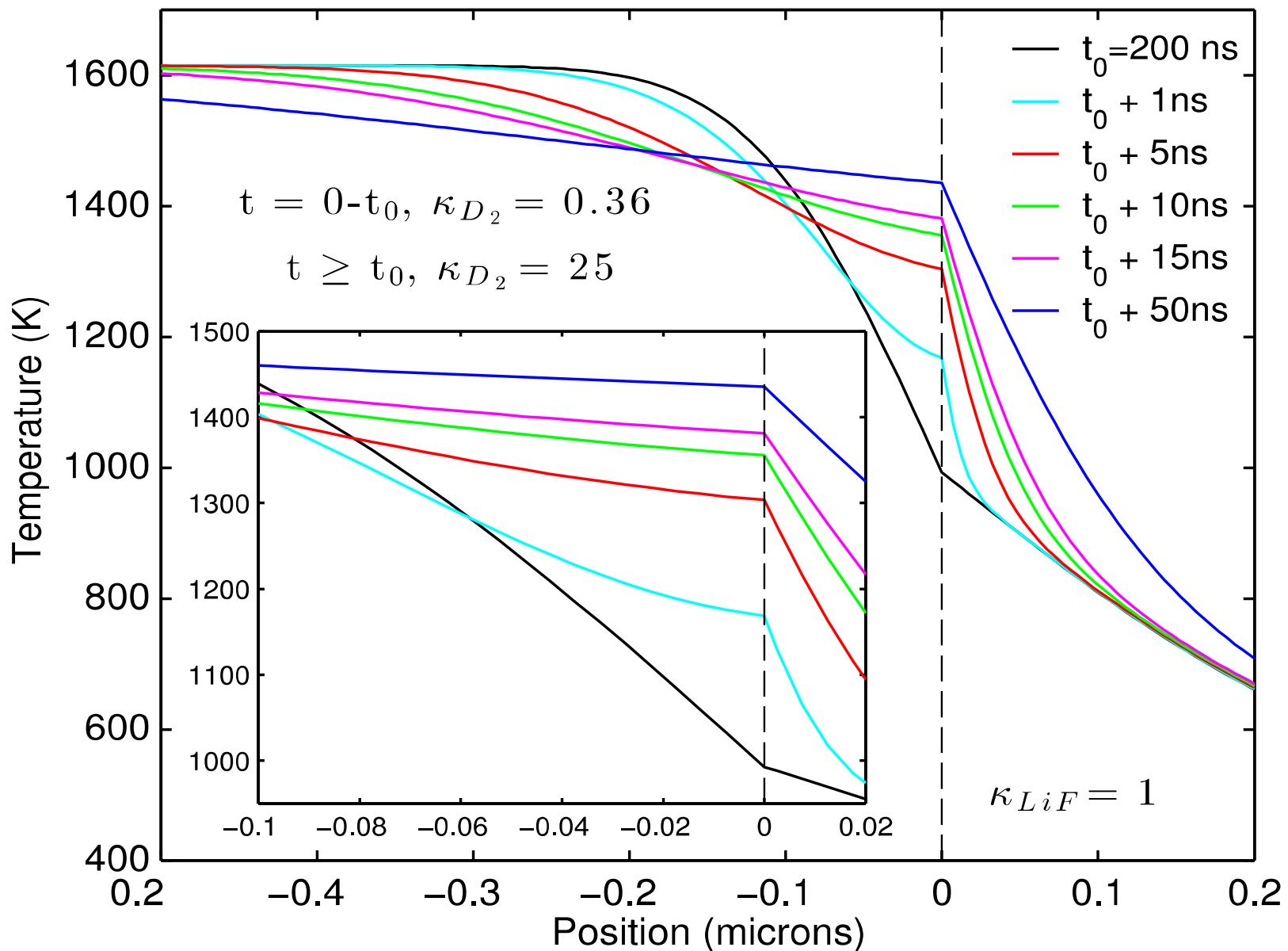
Entire Z crew

University of Rostock

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



Thermal conduction simulations



Reflectivity signals mapped to pressure

