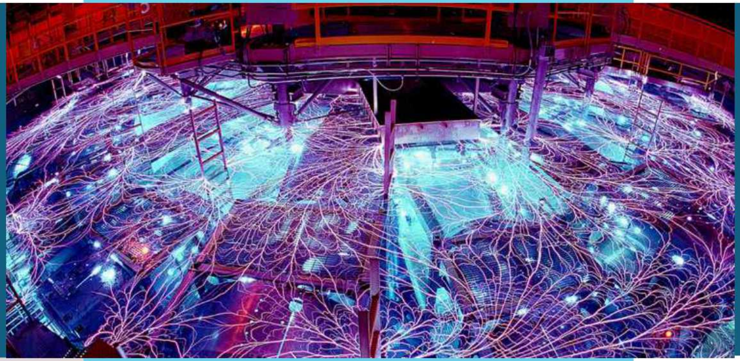
SAND2019-9397C

Developments of Ellipsometry on Z Shock-Ramp Experiments



Sean Grant[1,2], Todd Ditmire[1], Jung-Fu Lin[3], Aaron Bernstein[1], Tommy Ao[2], Kyle Cochrane[2], Jean-Paul Davis[2], Daniel Dolan[2], Andrew Porwitzky[2], Christopher Seagle[2], John Benage[2], Dawn Flicker[2]

[1]University of Texas at Austin, Center for High Energy Density Science

[2]Sandia National Laboratories

[3]University of Texas at Austin, Department of Geological Science

Sean Grant

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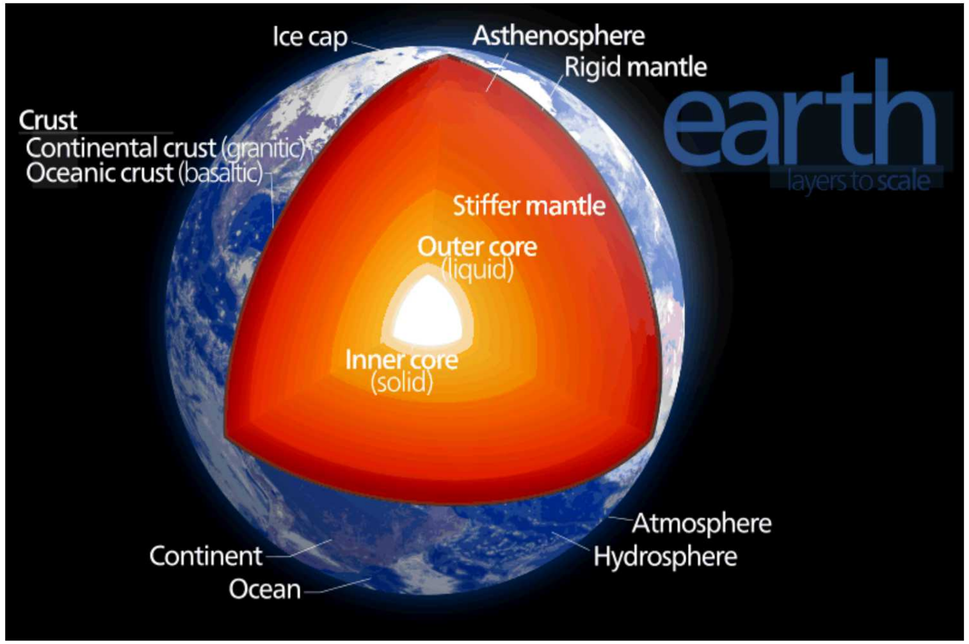
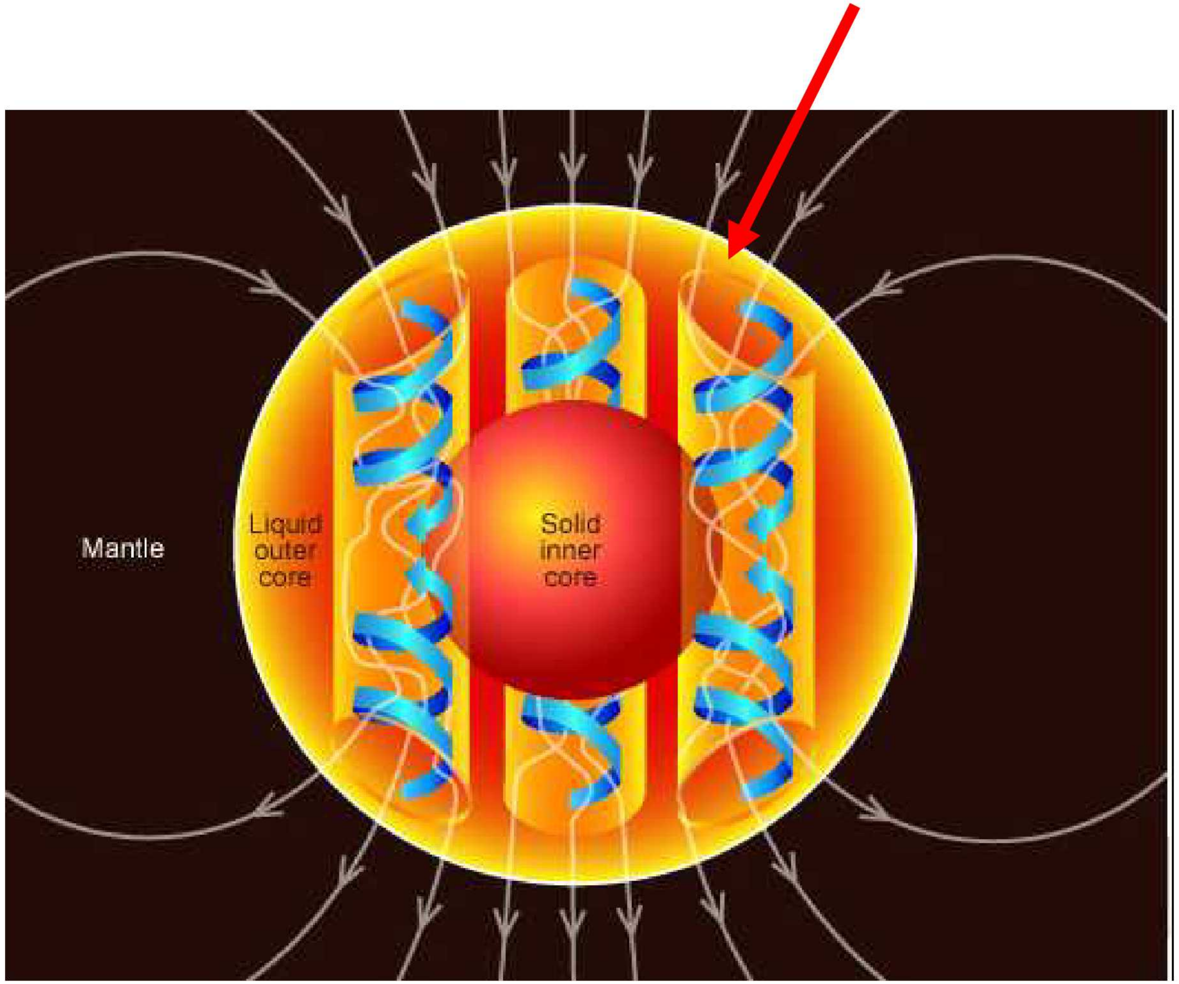
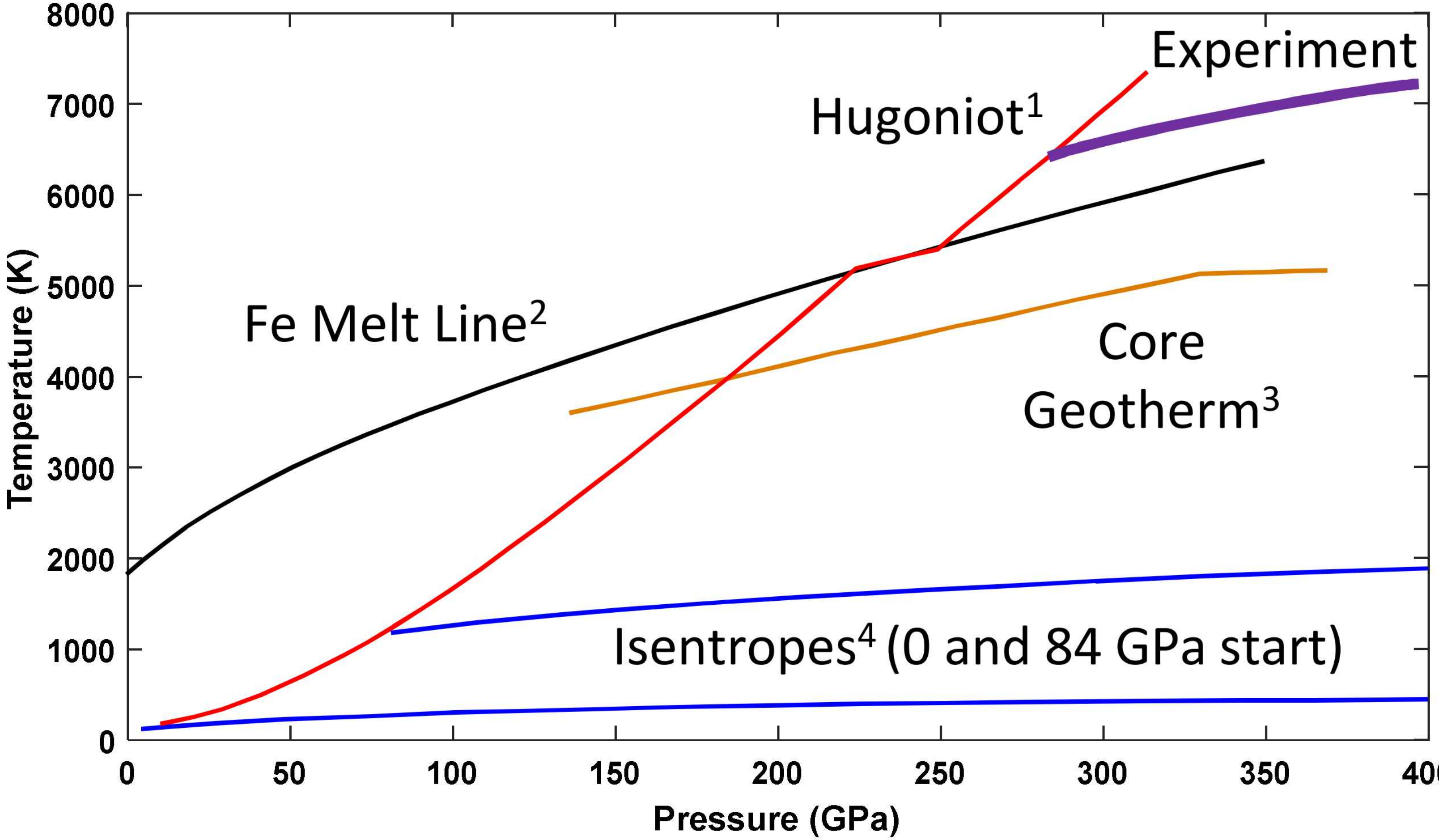
Iron is the primary component of rocky planet cores



Convection drives the magnetic field

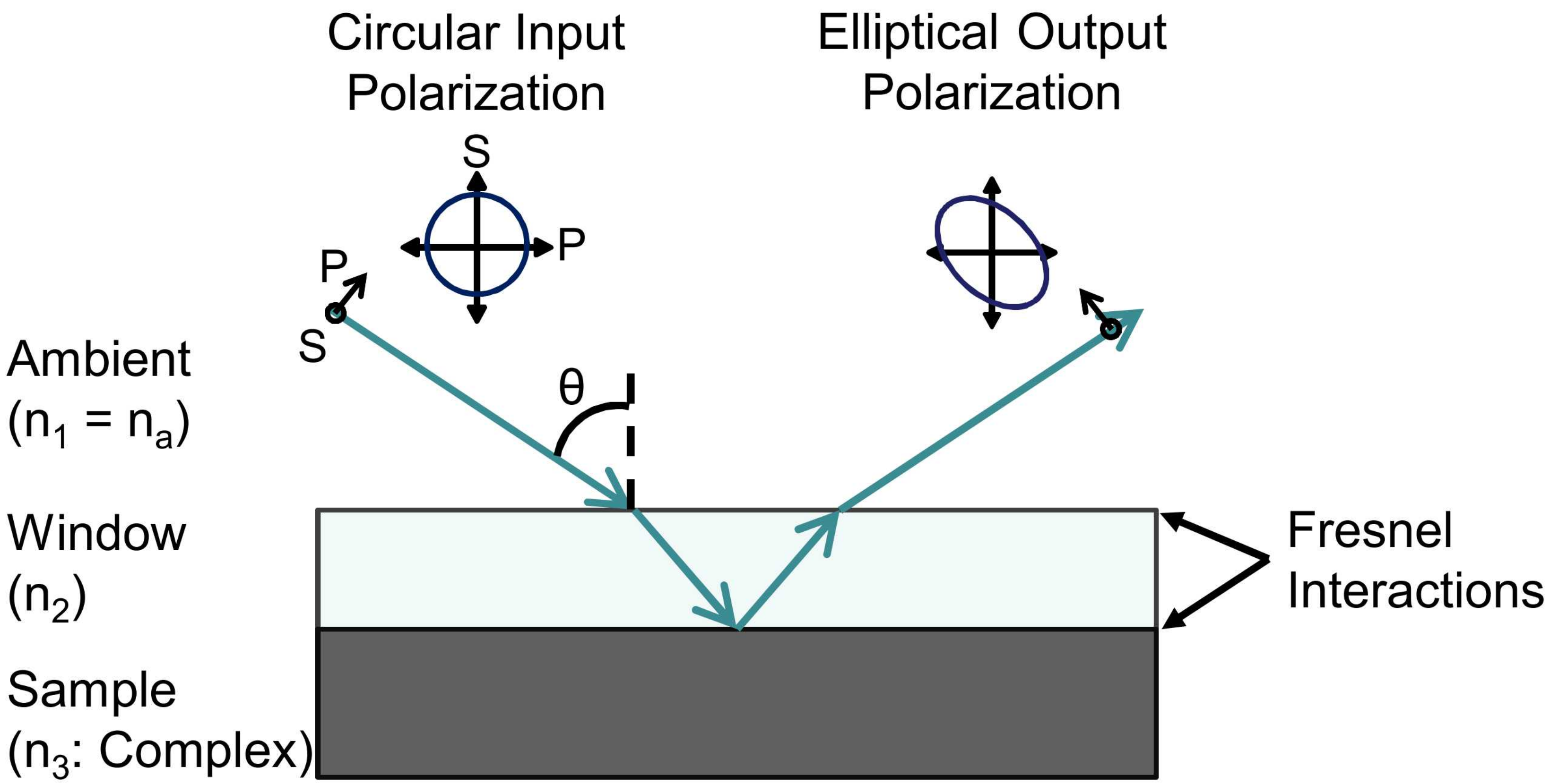


We designed an experimental path close to the conditions of the Earth's core

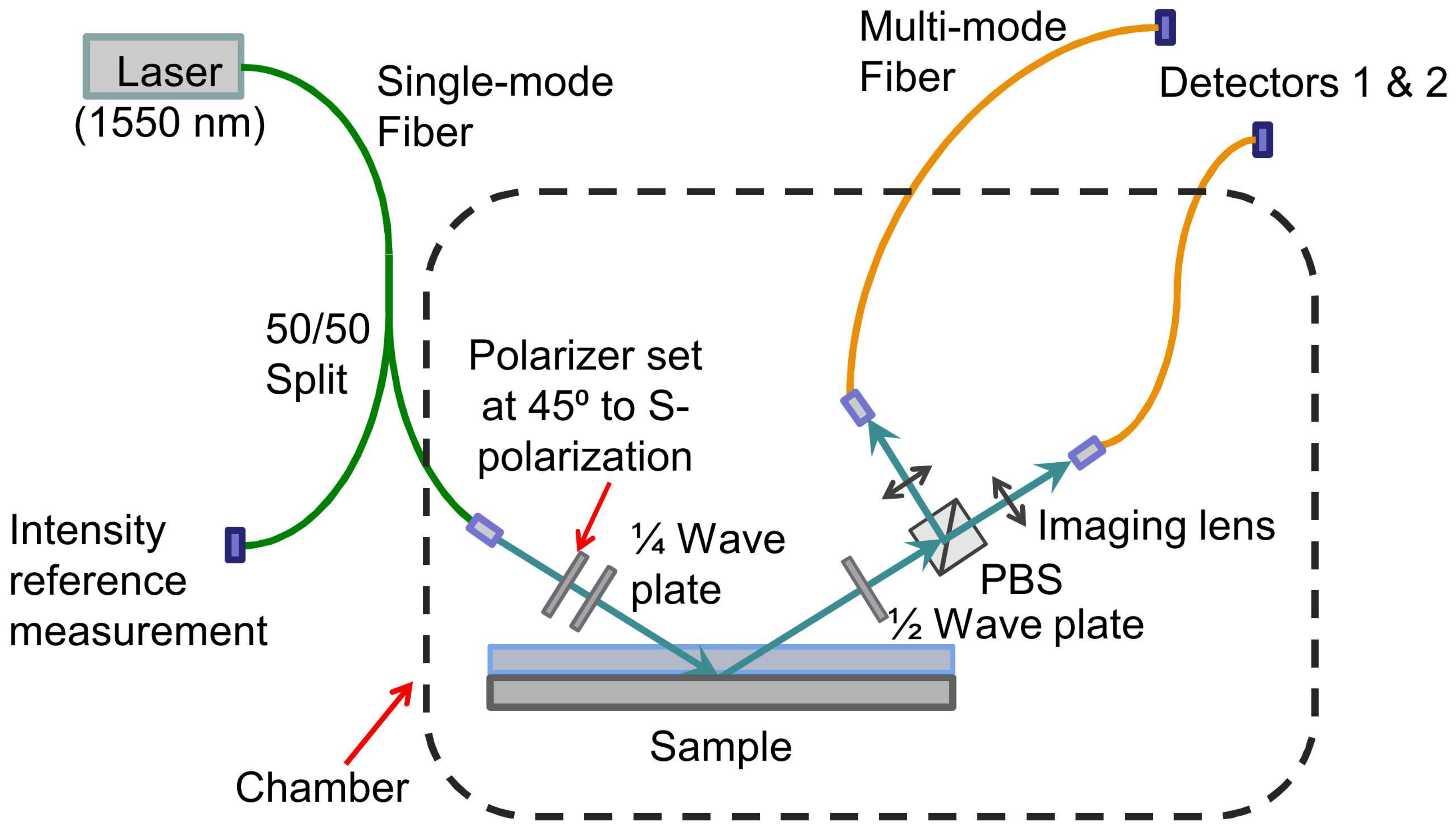


[1]J. M. Brown and R. G. McQueen, J. Geophys. Res. 91, 7485, doi:10.1029/ JB091iB07p07485 (1986).
[2]S. Anzellini, A. Dewaele, M. Mezouar, P. Loubeyre, & G. Morard, (2013). Science, 340(6131), 464-466.
[3]F. D. Stacey, *Physics of the Earth*, 4th ed. (Cambridge University Press, Cambridge, 2008).
[4]J. Wang, R. F. Smith, J. H. Eggert, D. G. Braun, T. R. Boehly, J. Reed Patterson, P. M. Celliers, R. Jeanloz, G. W. Collins, and T. S. Duffy. Journal of Applied Physics, 114(2), p.023513. doi.:10.1063/1.4813091 (2013).

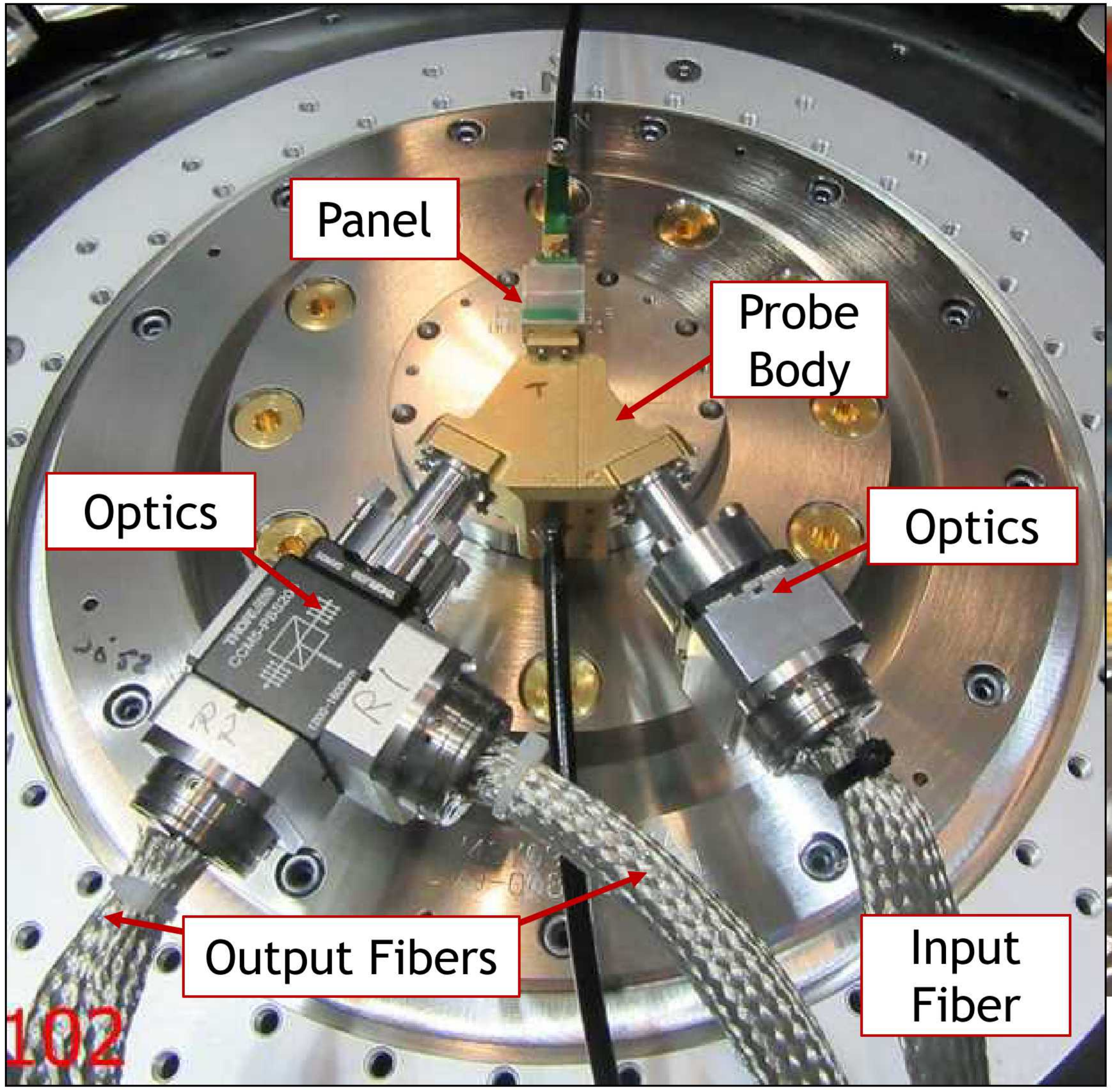
Ellipsometry uses a polarized laser to probe material dielectric properties at the laser wavelength



The basic design is a fiber/free-space hybrid



The Z hardware engineers made the fielding of this diagnostic possible



Obtaining specular reflections on dynamic experiments is difficult

Surface roughness and impactor tilt can severely hinder such measurements

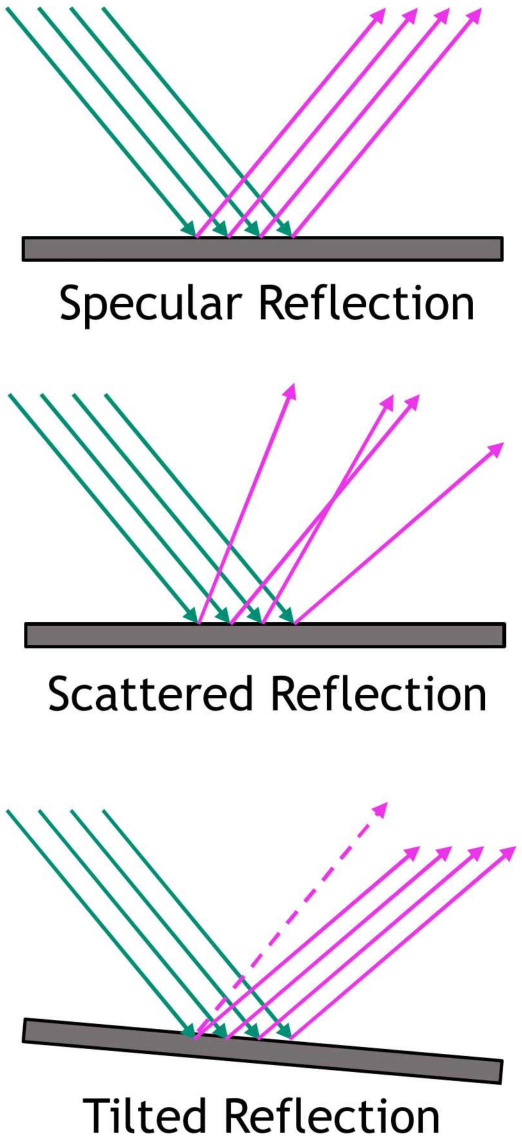
- Surface roughness can be propagated through the shock wave

Ellipsometry depends on AOI

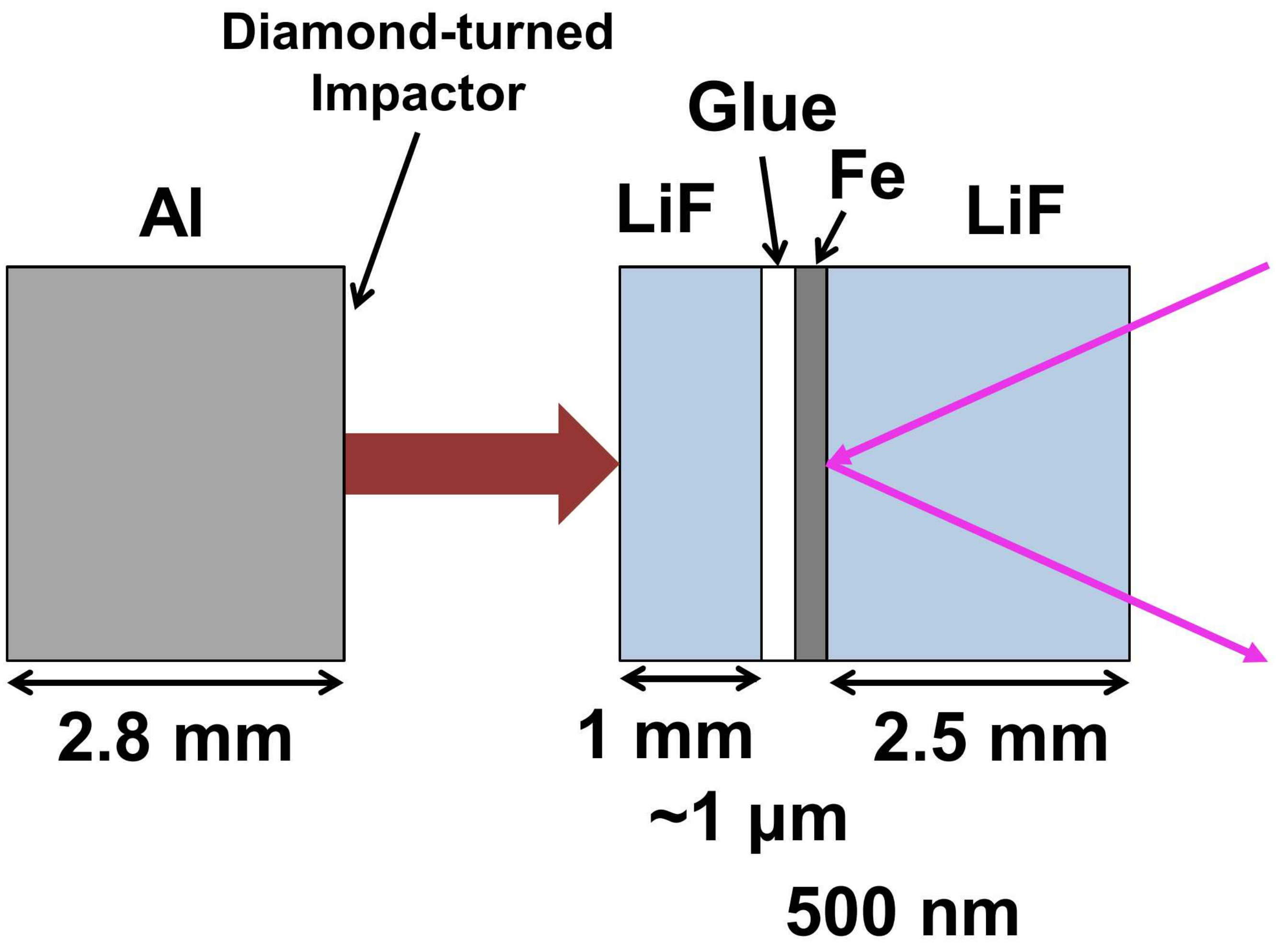
- cannot simply increase the collection

Ensure all surfaces are as smooth as possible

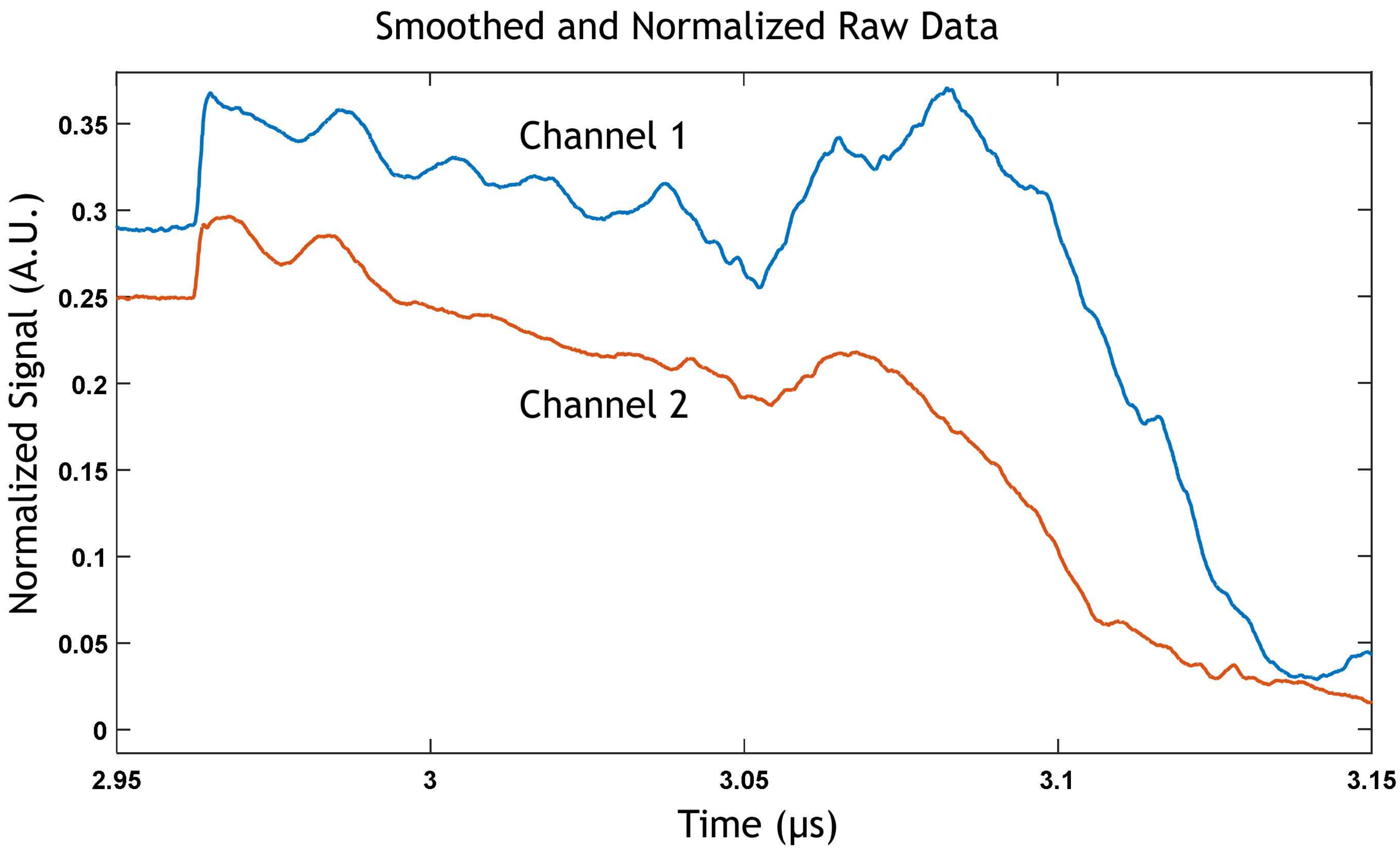
- Diamond turned metals (maybe lapping too)
  - 10-30 nm Ra
- Polished single crystal LiF
  - 20/10 scratch/dig



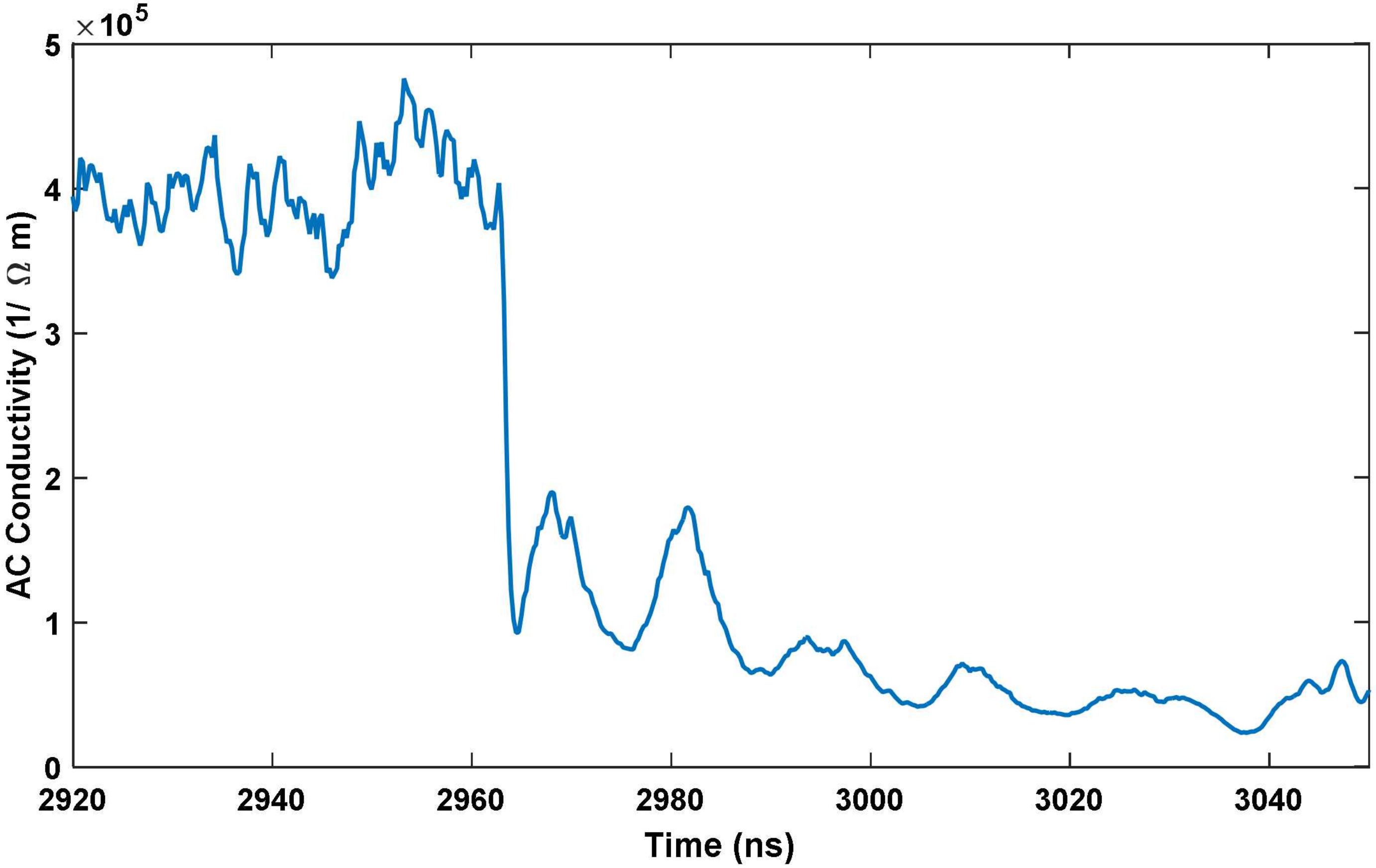
We previously tested the configuration with polished LiF



With this sample arrangement we obtained the best collection yet



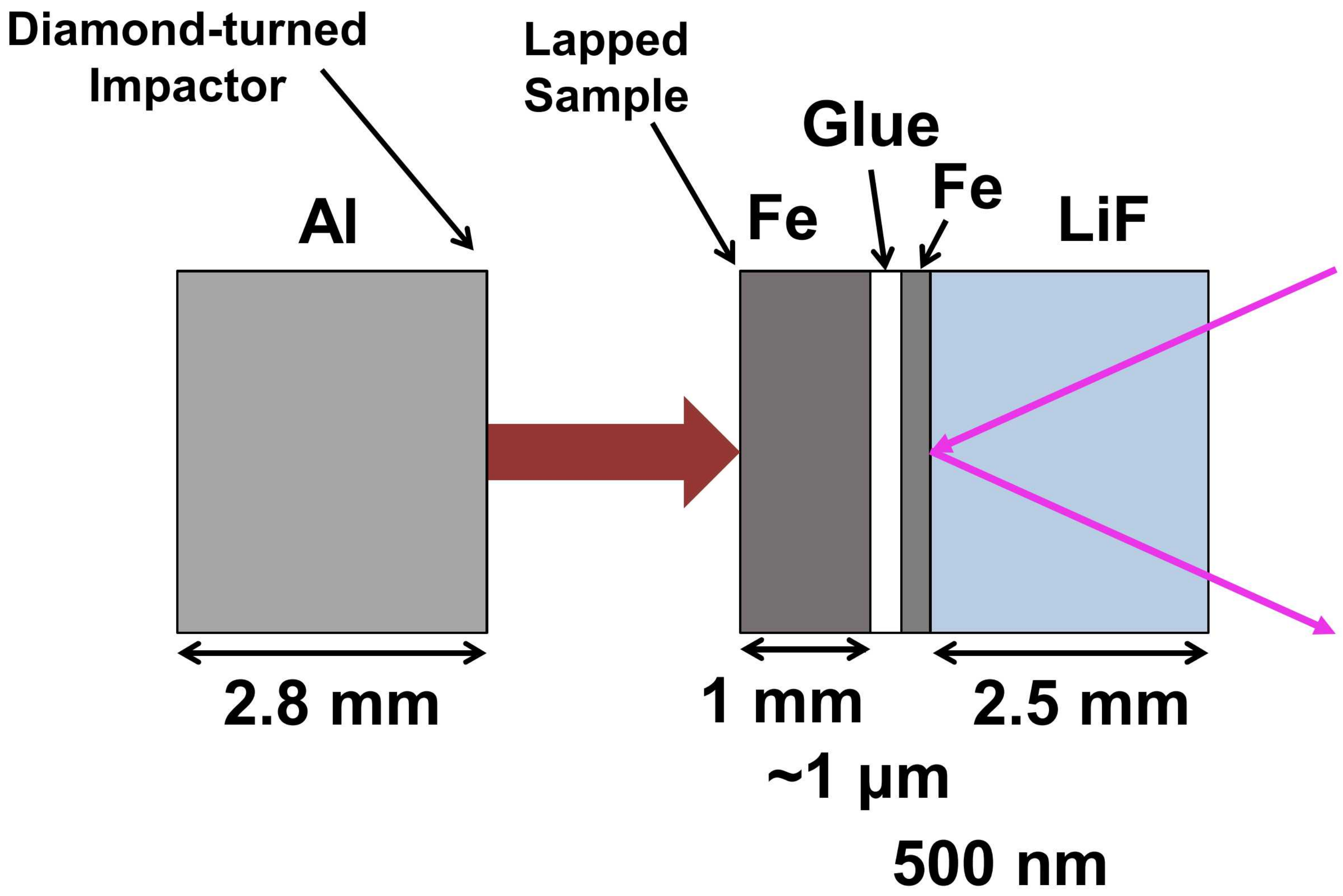
We calculate the AC electrical conductivity directly from the data



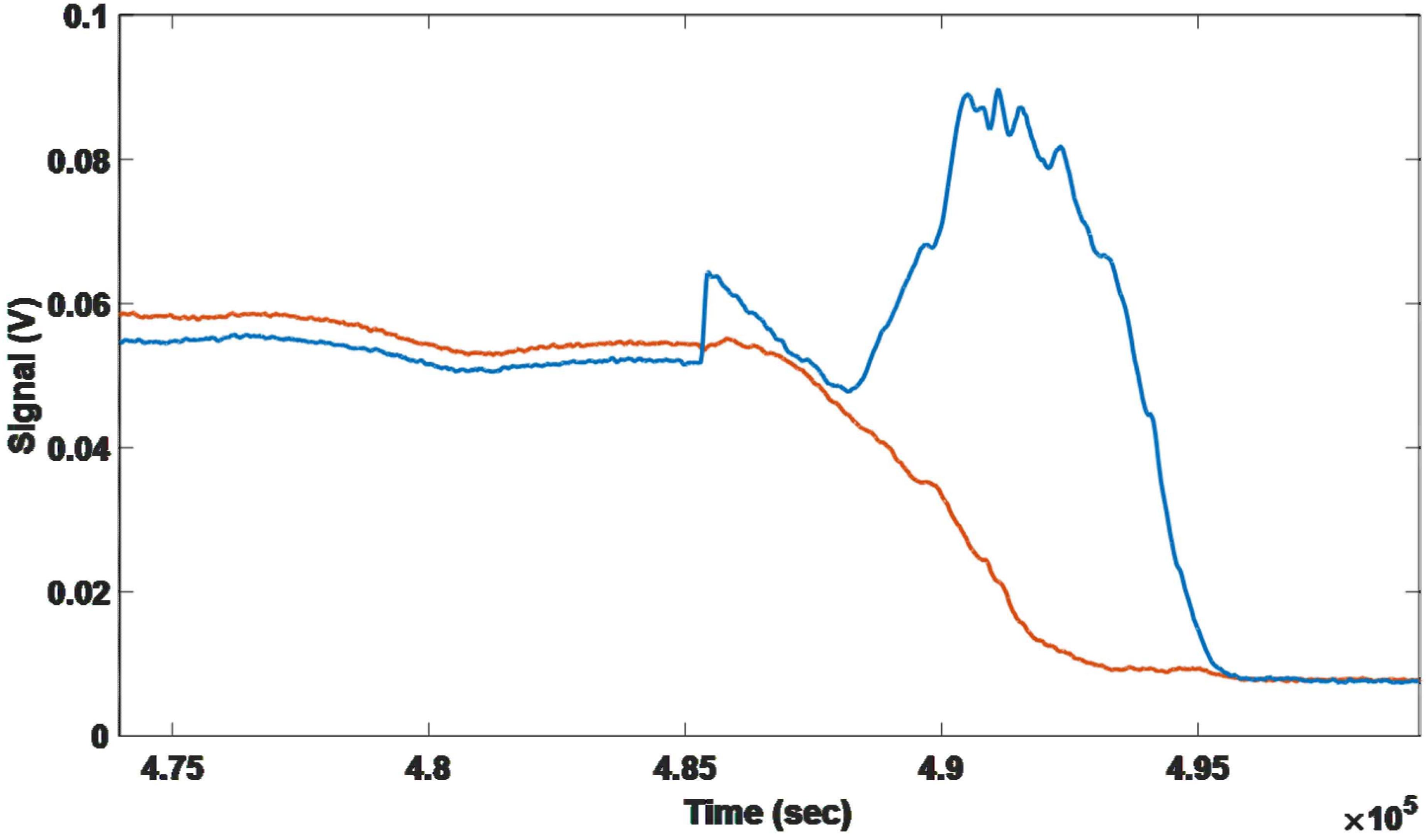
If we rely on Wiedemann-Franz Law and simulations that show a relatively flat DC-to-AC electrical conductivity (Pozzo 2013), we get a DC thermal conductivity of 15 +8/-5 W/m K.

This is lower even than the lower literature values (33 W/m K, Konopkova 2016), and significantly lower than the upper values (226 W/m K, Ohta 2016)

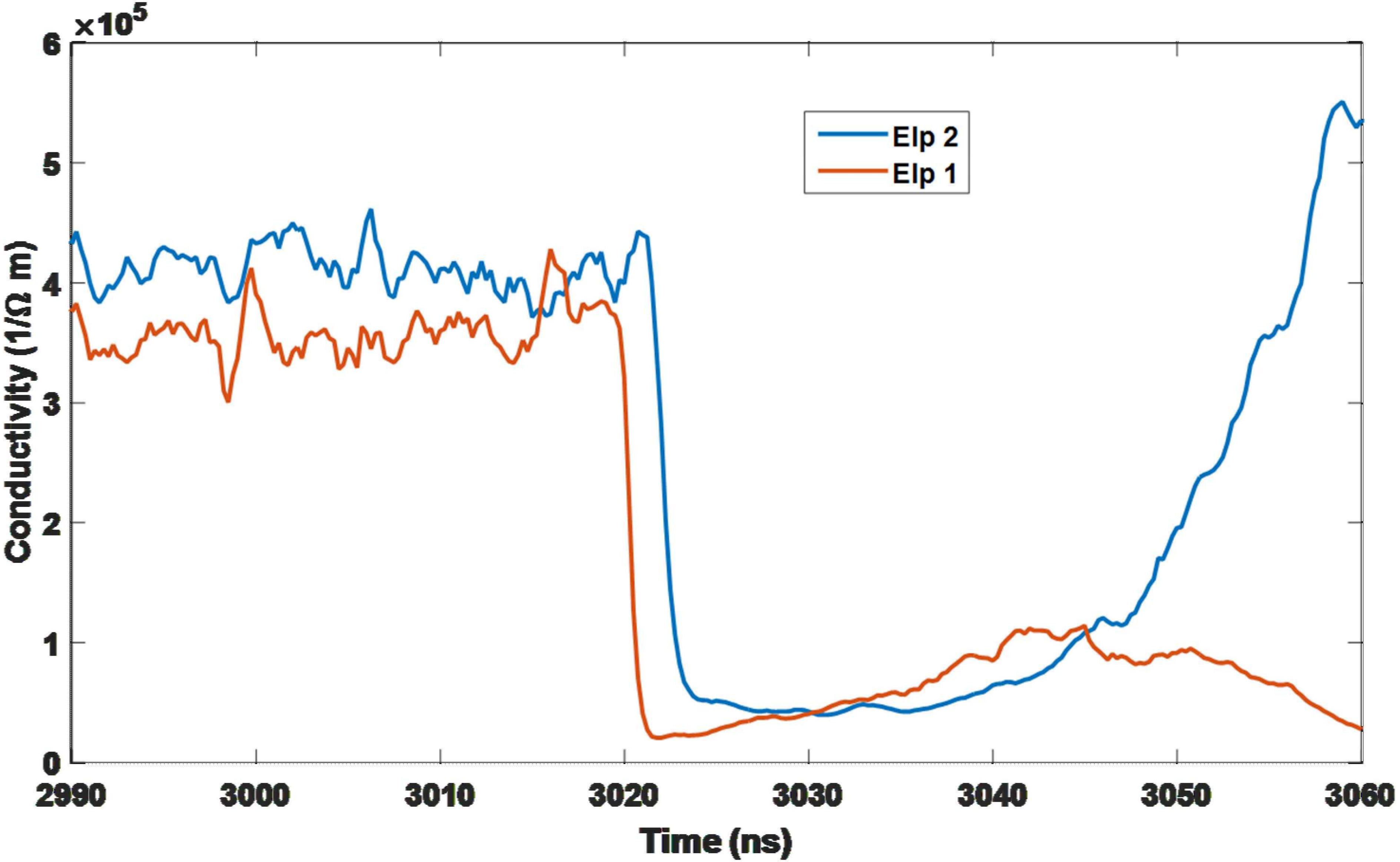
Our most recent experiment tested a smoothed metal sample



This experiment did see an increase in collected light, though not as much as for the LiF sample arrangement



Analyzing this data at ‘face value’ gives an even lower conductivity than the last experiment



Conclusions and Future Work

Conclusion:

- We have significantly improved light collection on this specular reflection diagnostic through systematic changes in procedures and hardware

Future Plans:

- We have expanded the openings within the probe body to widen the previous limiting aperture

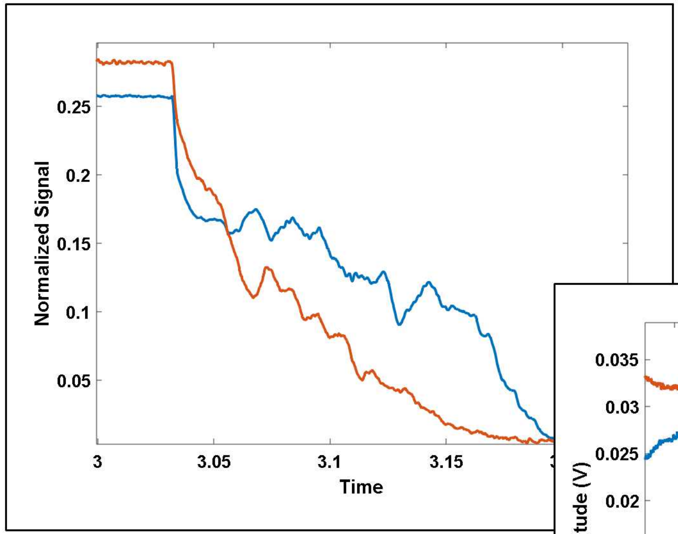
Acknowledgements

Sandia:

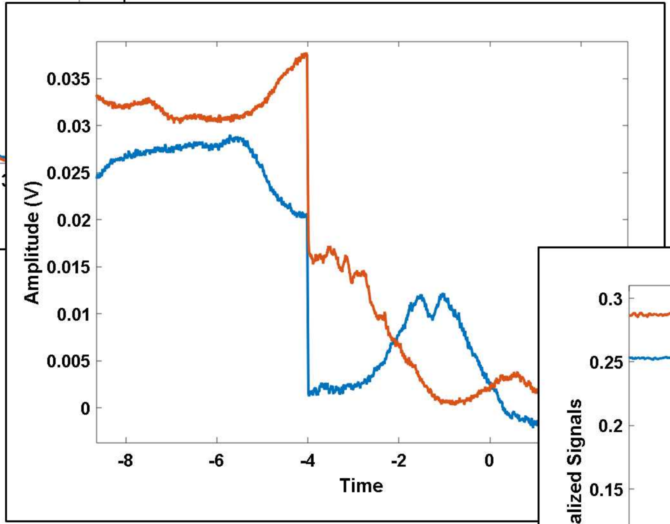
- **The many people of Z operations**
- **DICE team:** Randy Hickman, Nicole Cofer, Keith Hodge, and Josh Usher
- **MSTS:** Sheri Payne and Richard Hacking
- **Design Engineers:** Andrew Maurer, James Williams, Lynn Twyeffort, John Fisher
- **Managers:** Christopher Seagle, John Benage, and Dawn Flicker
- **SEERI Program:** Trish St. John and Kristy Martinez
- **Z Fundamental Science Program**

Past experiments have had variable success, but almost always saw significant losses at high shock speeds

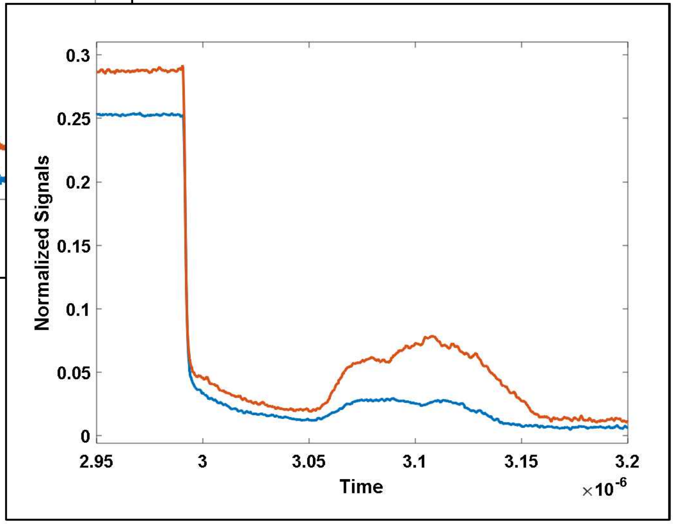
The “good”: ~20% loss



The bad: >50% loss



The ugly: 80% loss



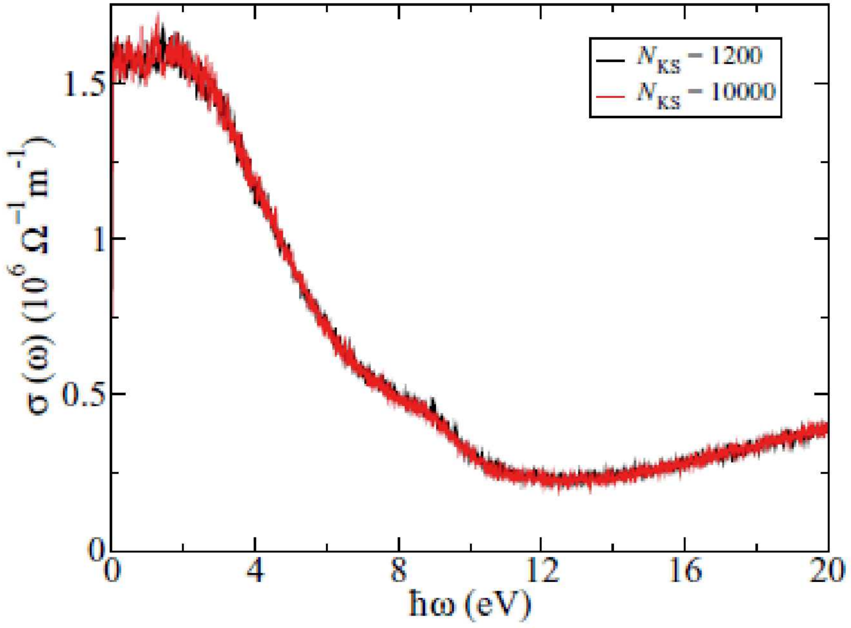
Using a few assumptions, we convert from AC electical to DC thermal conductivity

AC Electrical Conductivity

DC Electrical Conductivity

Wiedemann-Franz Law

DC Thermal Conductivity



Pozzo, 2013

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