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Ellipsometry for Dynamic Material Studies

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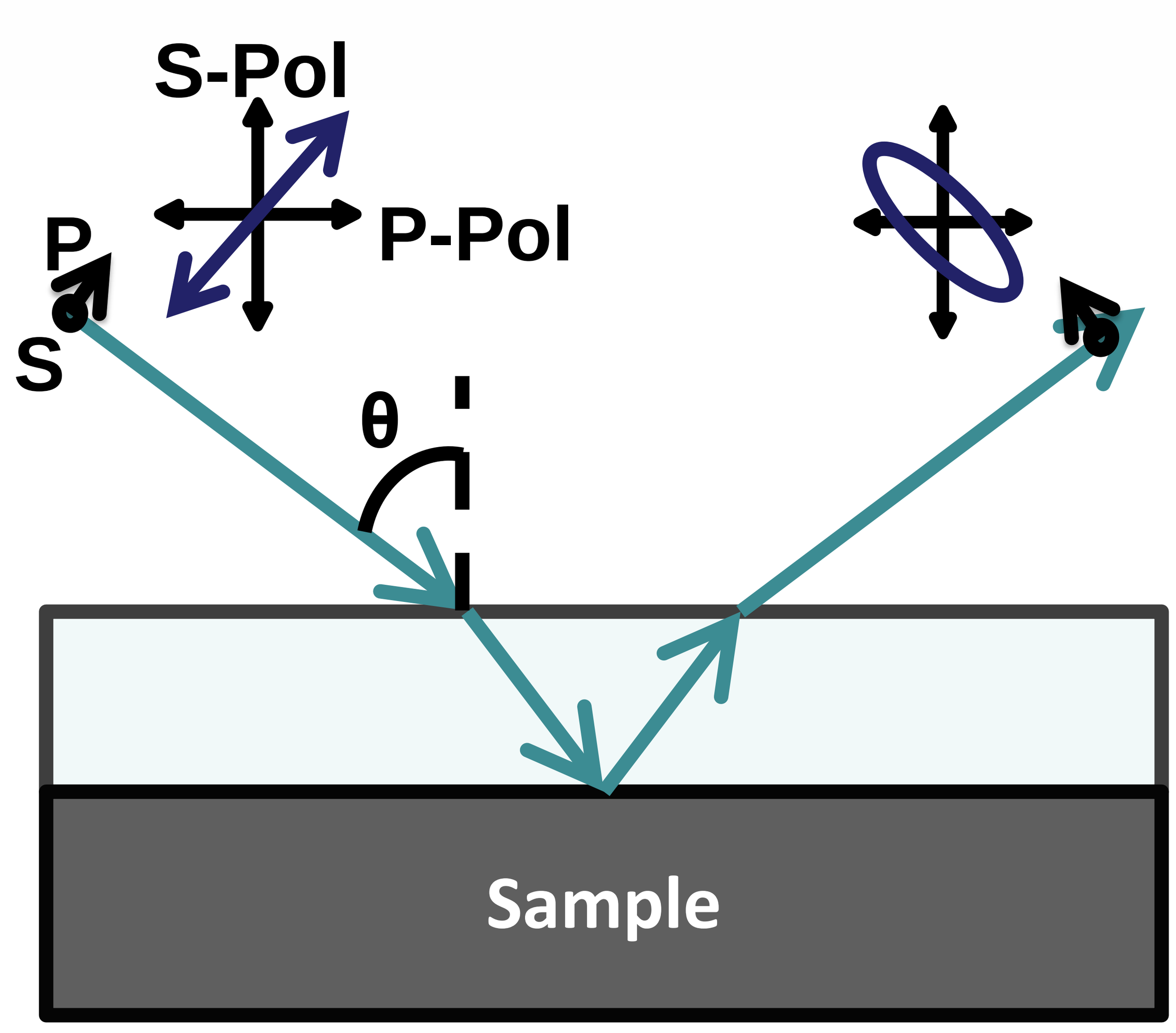
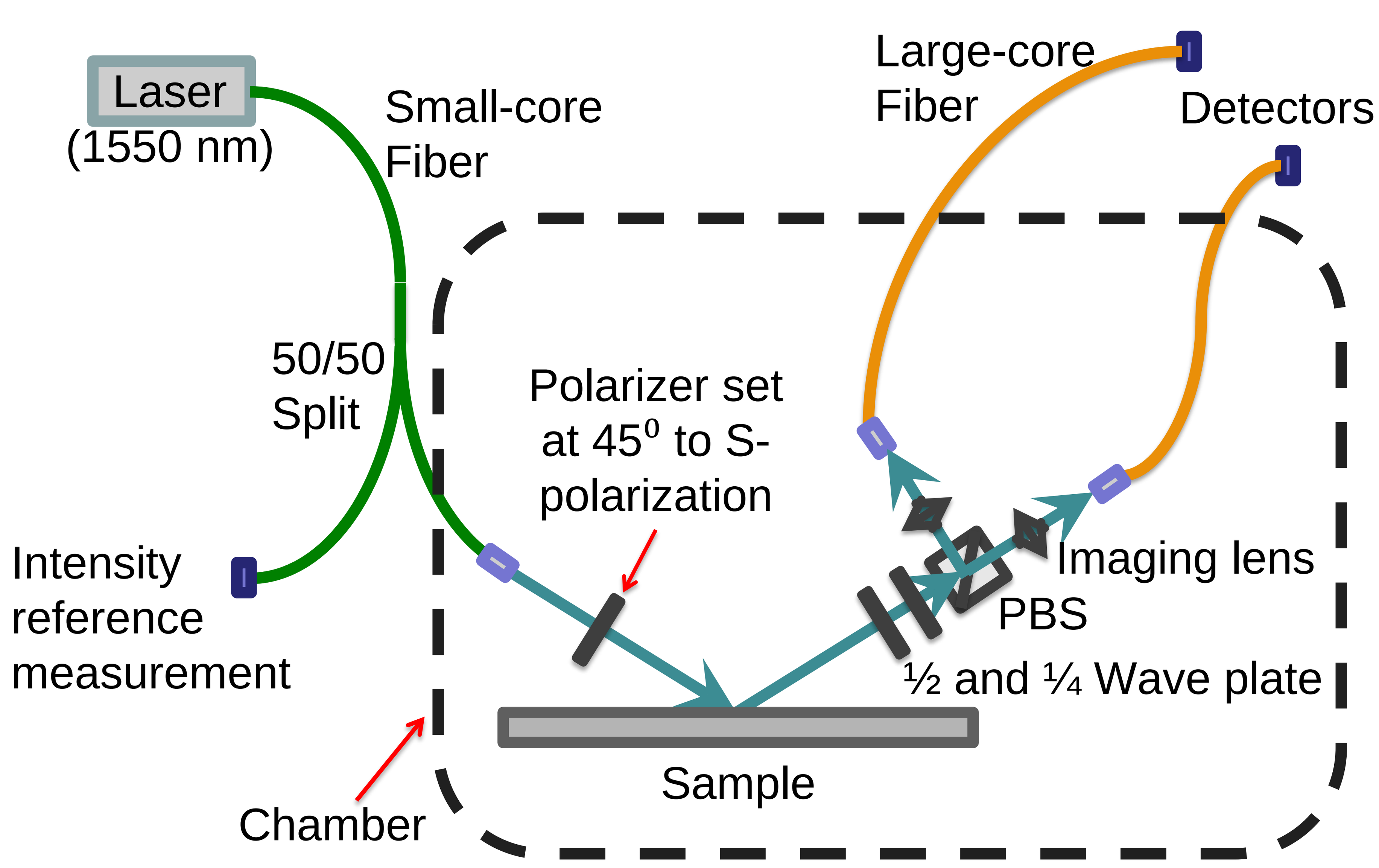
Abstract: We have built and implemented a time-resolved ellipsometry diagnostic for dynamic testing. This diagnostic measures refractive index of a sample under dynamic conditions. We present promising results from our dynamic experiments on a gas gun.

Introduction: Our goal is to enable time-resolved measurements of a sample's dielectric constant during dynamic experiments (gas gun, pulsed power, laser-driven, etc.). To achieve this we have been developing a time-resolved ellipsometry diagnostic. The design and results from our first gas gun experiments are presented below.

Methods: Ellipsometry reflects a polarized laser off the sample at non-normal incidence. The change in the polarization state gives information on the dielectric parameters of the sample through the Fresnel Equations.





Probe Design: Open-beam optics set and analyze the polarization state while the fibers transport the light into and out of the chamber.

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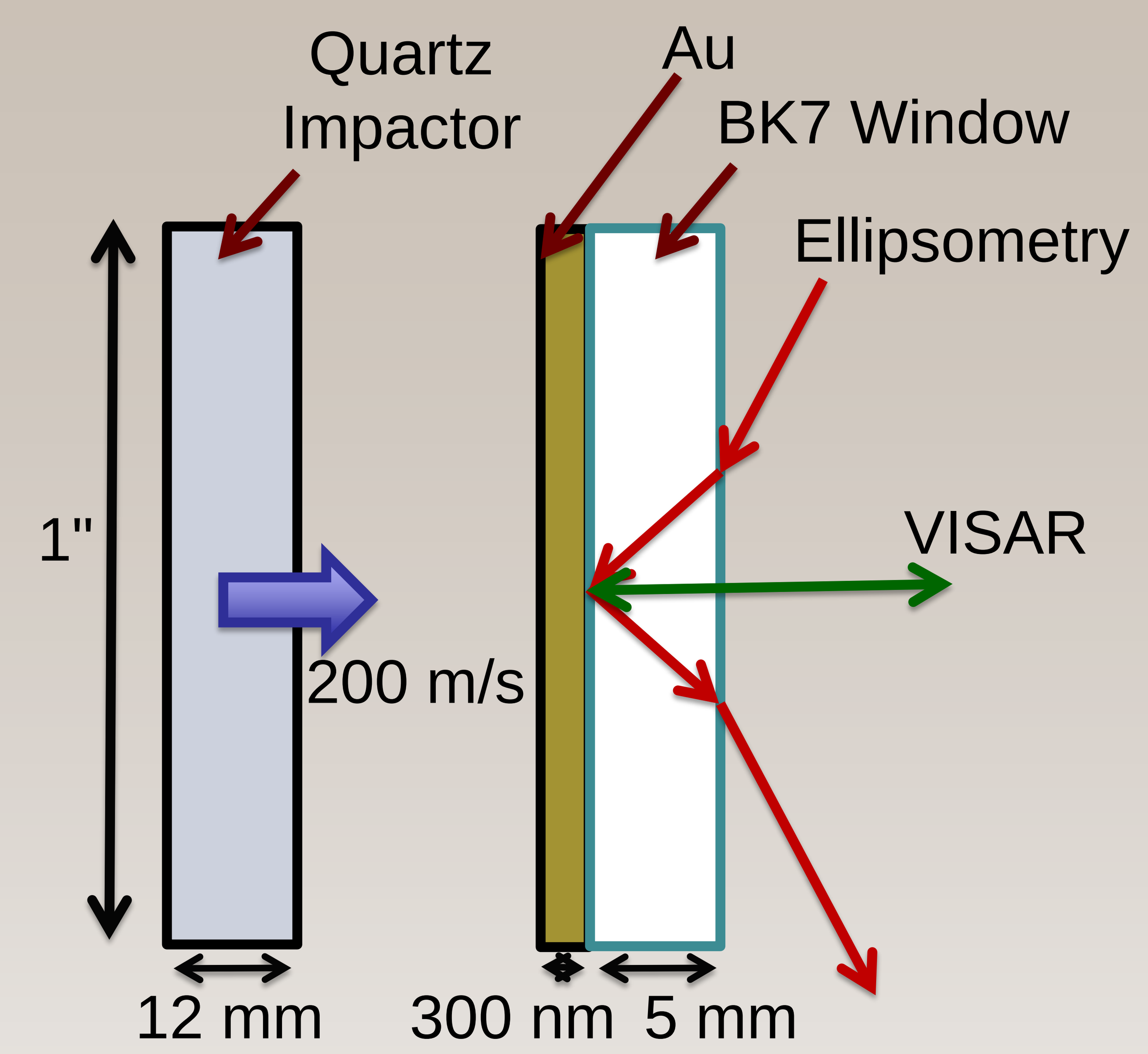
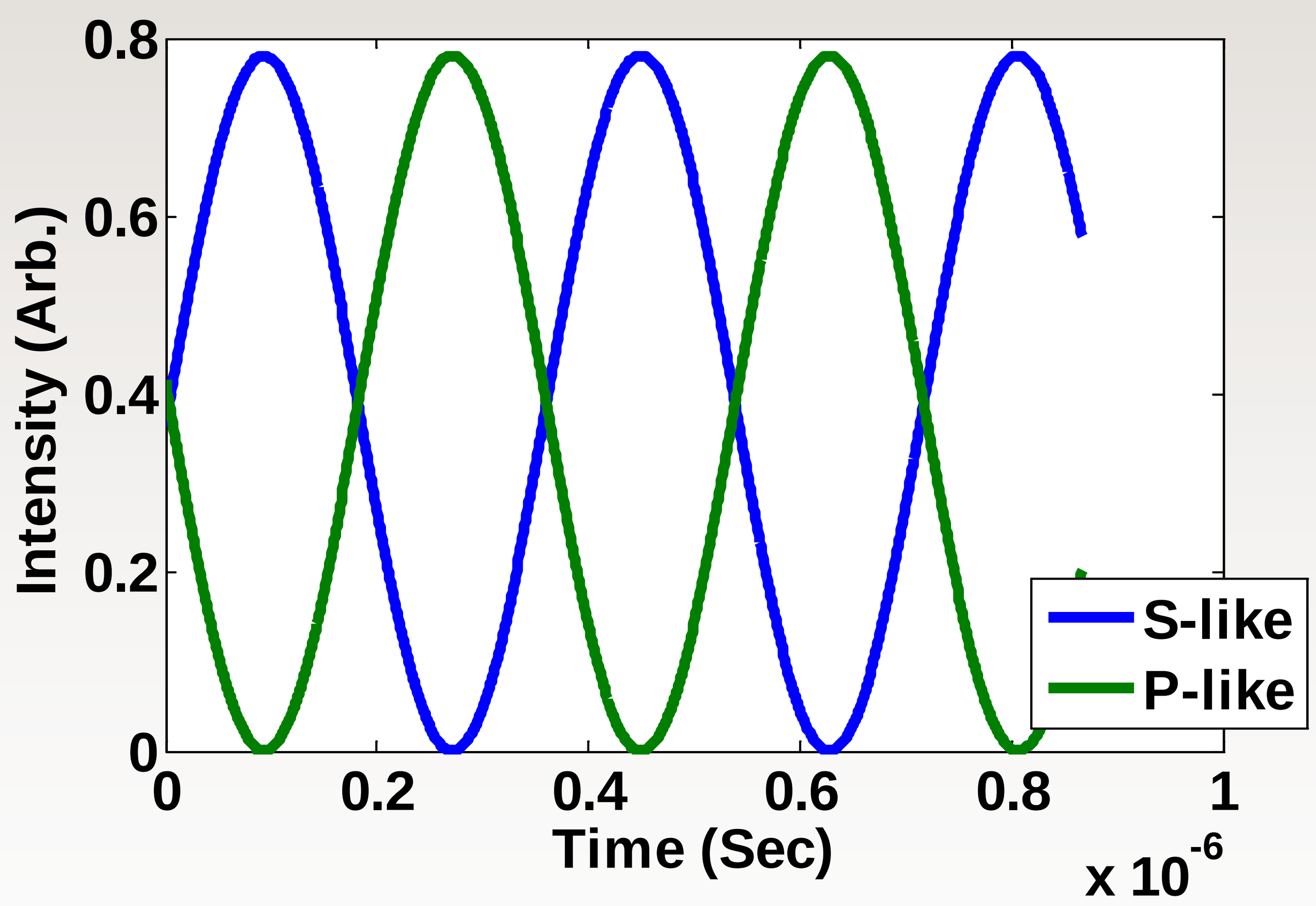
Experimental Setup: We tested the diagnostic on a standard gas gun experimental setup. The sample in this case was a gold coating on a BK7 (glass) substrate.

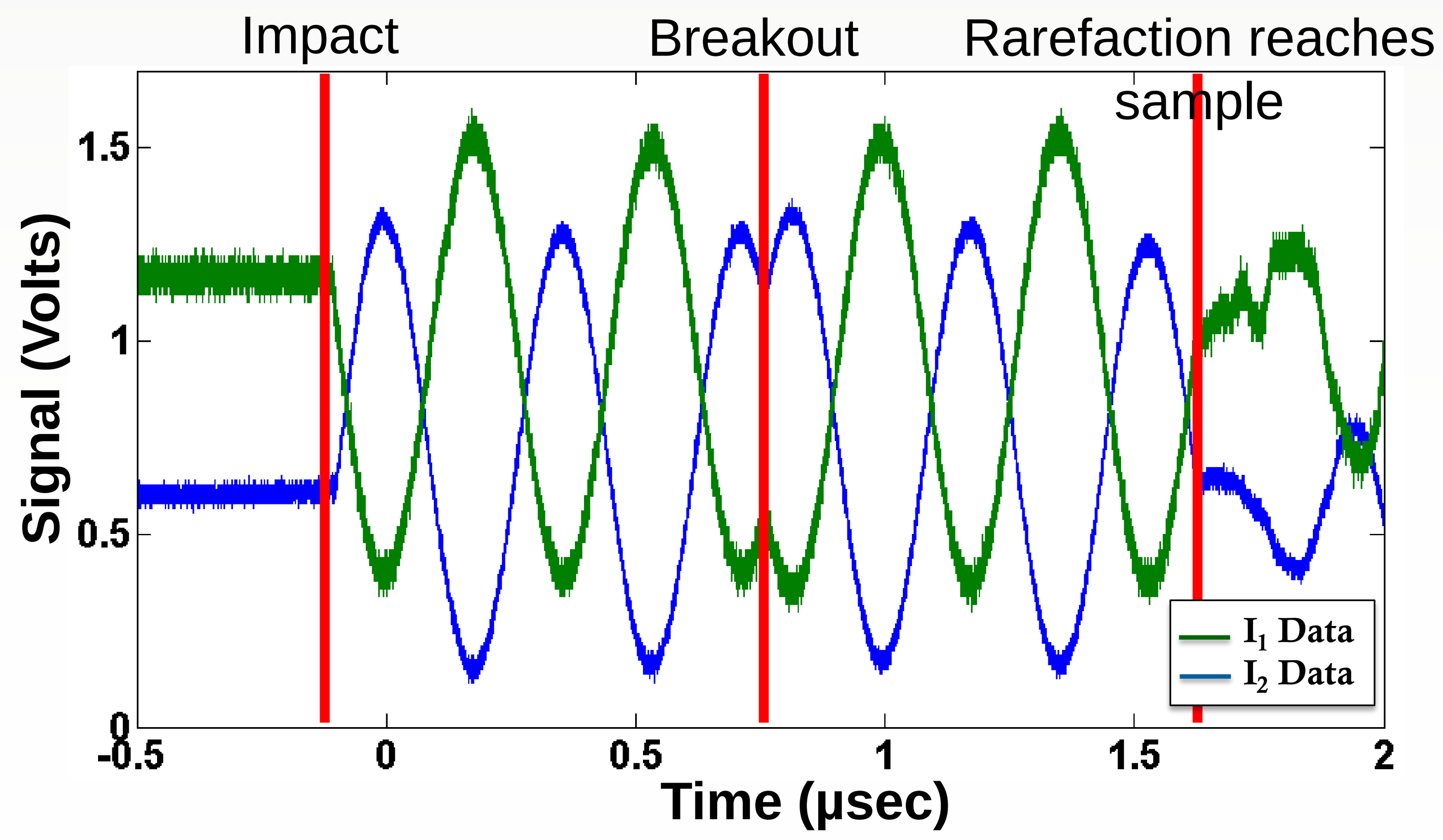
As the shock propagates through the window, it will uniaxially and elastically compress the material behind the shock front.

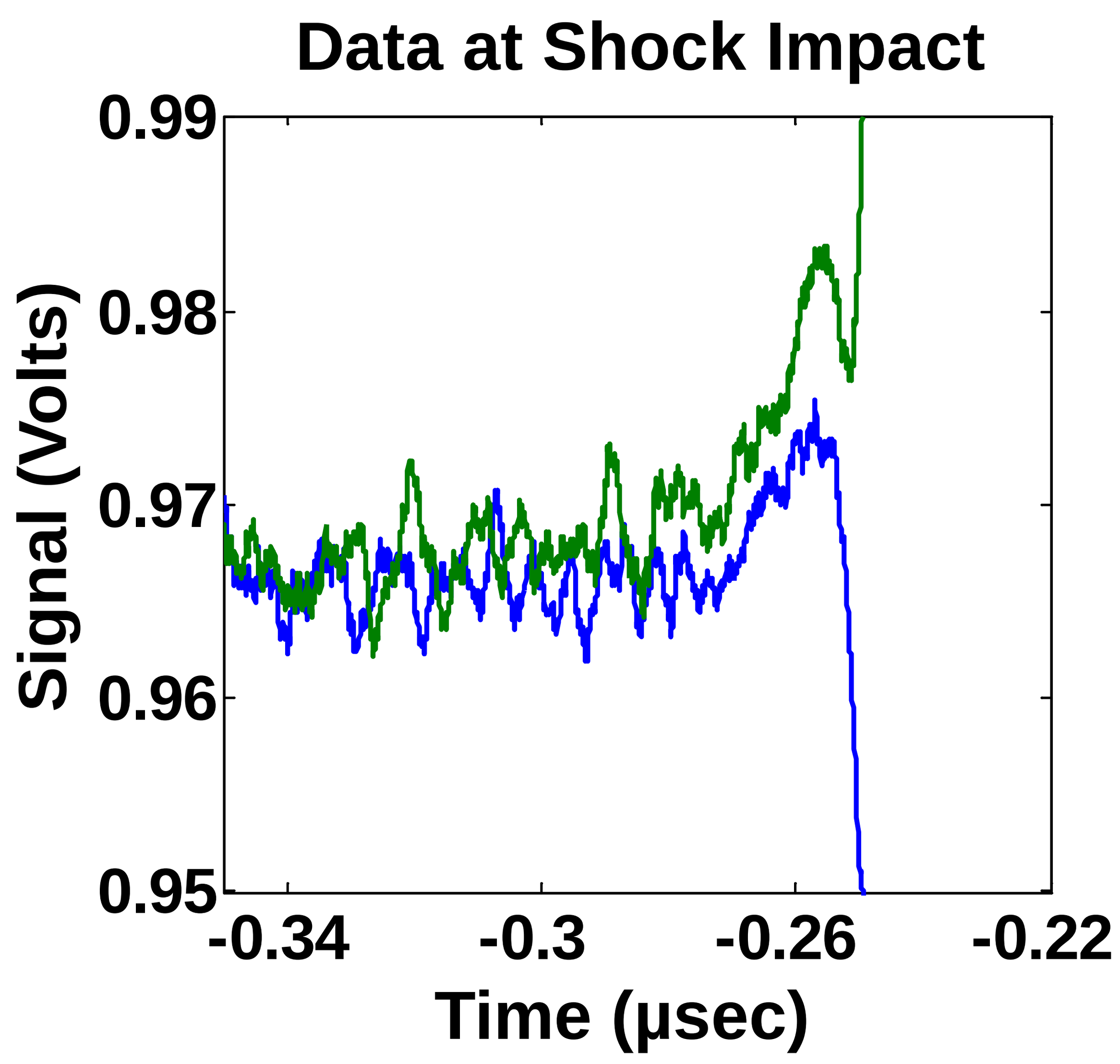




Modeling Signals: We model the anticipated results. In this case, a growing birefringent layer in the BK7 window due to the uniaxial compression causes a phase shift to steadily accumulate between the two independent polarization axis.

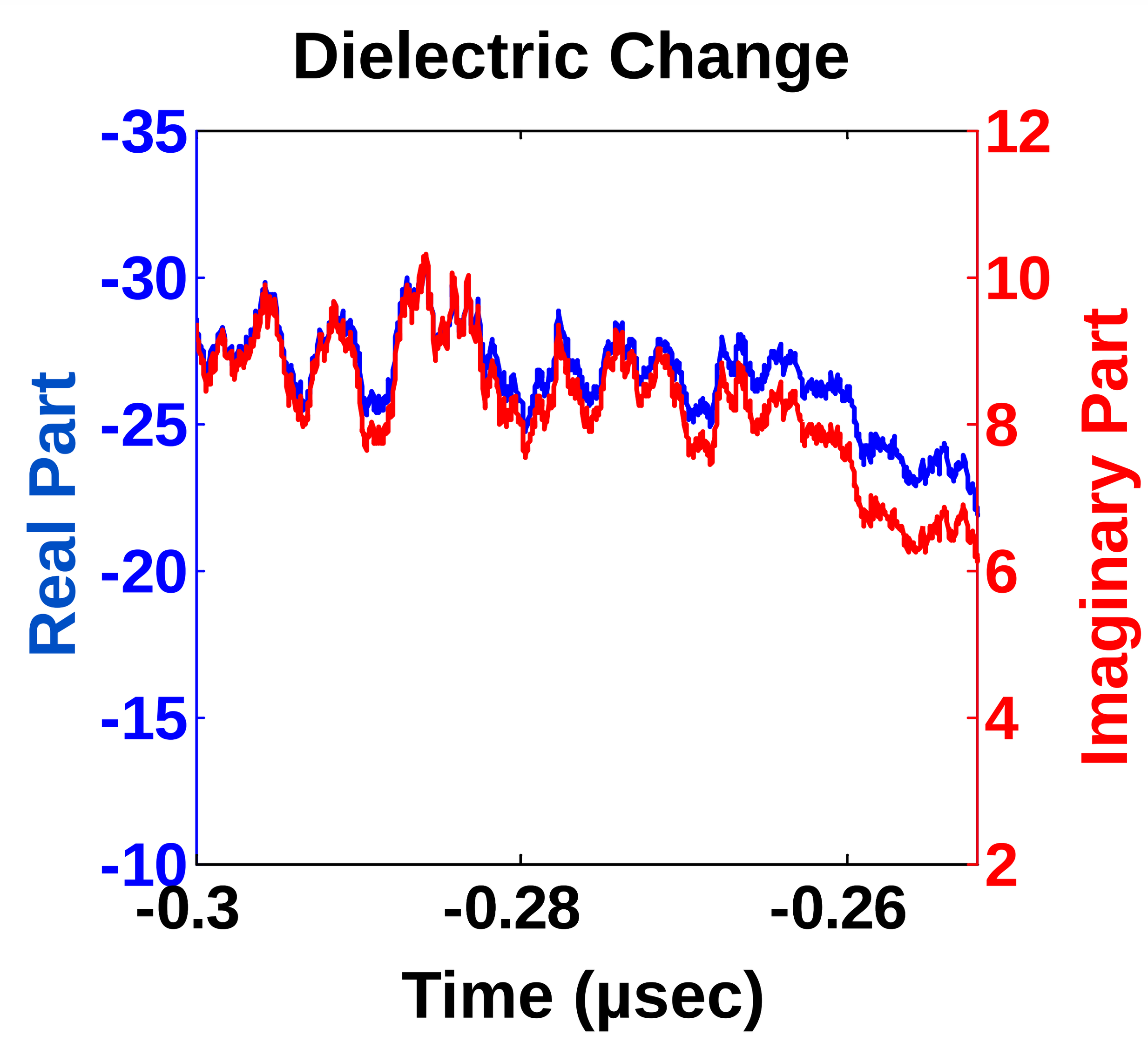
Results: Our experimental data resembles the modeled expected results, even showing a clear sign of the window birefringence being "erased" by the rarefaction wave after breakout (not included in model).





Results: Zooming in on initial impact, we see indication of a change in the gold dielectric.

We can analyze the data at each point in time to give a plot of the gold's dielectric as a function of time.



Conclusion: While these results are preliminary, they show a clear indication that the diagnostic can handle basic window birefringence as well as an ability to discern changes in the reflector's dielectric constant.

Future work will continue to improve upon the diagnostic design, as well as moving to higher shock conditions and probing material phase changes.

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