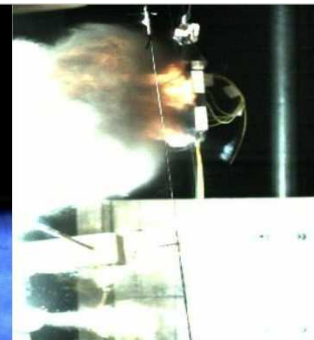
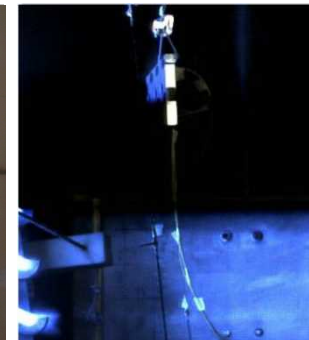
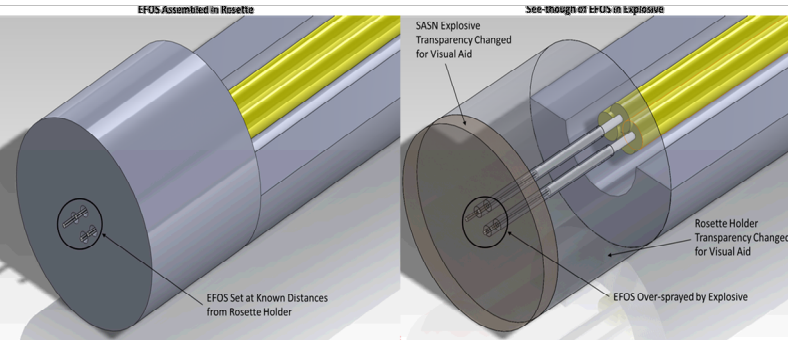


Translucent Explosive Encapsulated Fiber Optic Sensor (EFOS) Assembly

Explosive Encapsulated Fiber Optic Sensor (EFOS) Assembly



Embedded Fiber Optic Sensors for Measuring Transient Detonation/Shock Behavior

26th International Colloquium on the Dynamics of Explosions and Reactive Systems

July 30-August 4, 2017

Marcus A. Chavez, Michael D. Willis, and Timothy T. Covert



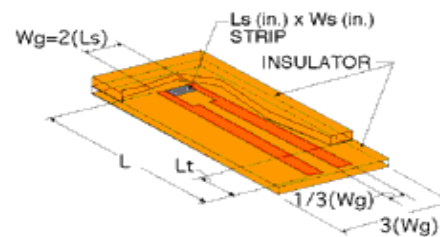
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Outline

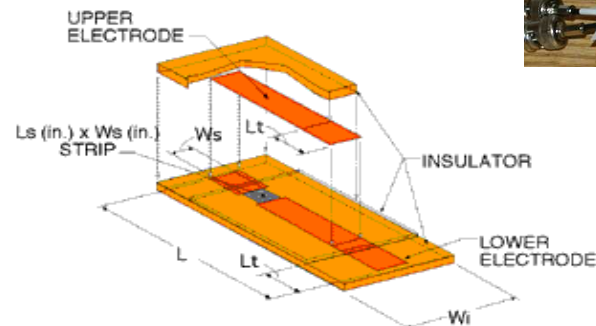
- Why does anyone care?
- Macroscale Interface Velocity Gauges
- Photonic Doppler Velocimetry
- Micro-energetic Experimental Considerations
- Miniaturized Interface Velocity Sensors: EFOS
- Hydrocode Simulation
- Measurements with EFOS
- Summary
- Acknowledgements
- Questions

Traditional Diagnostic Limitations

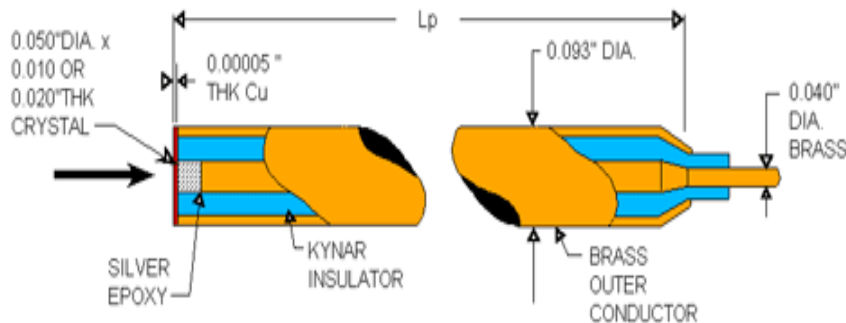
- Push for miniaturization due to smaller energetic packages
- Probes are obtrusive
 - Must account for this in experiments
- Electromagnetic noise
 - Carbon gauges
 - PVDF gauges
 - PZT pins



C300-50-EKRTE



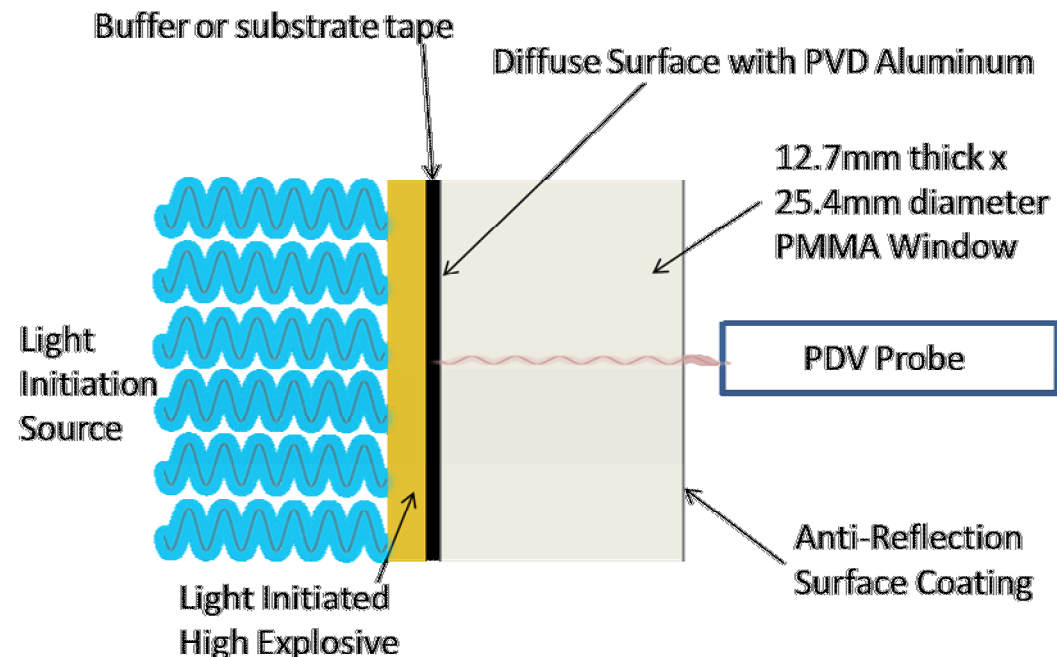
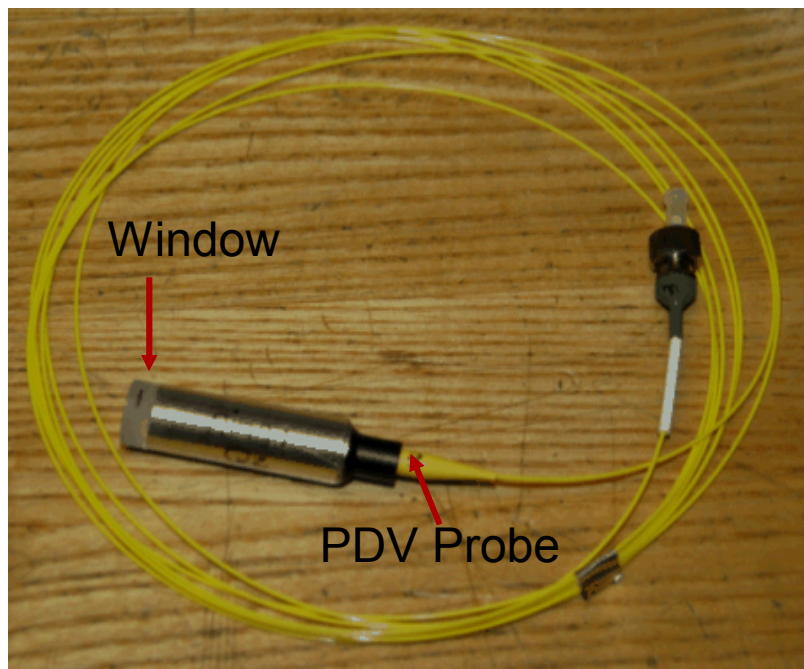
FC300-50-EKRTE



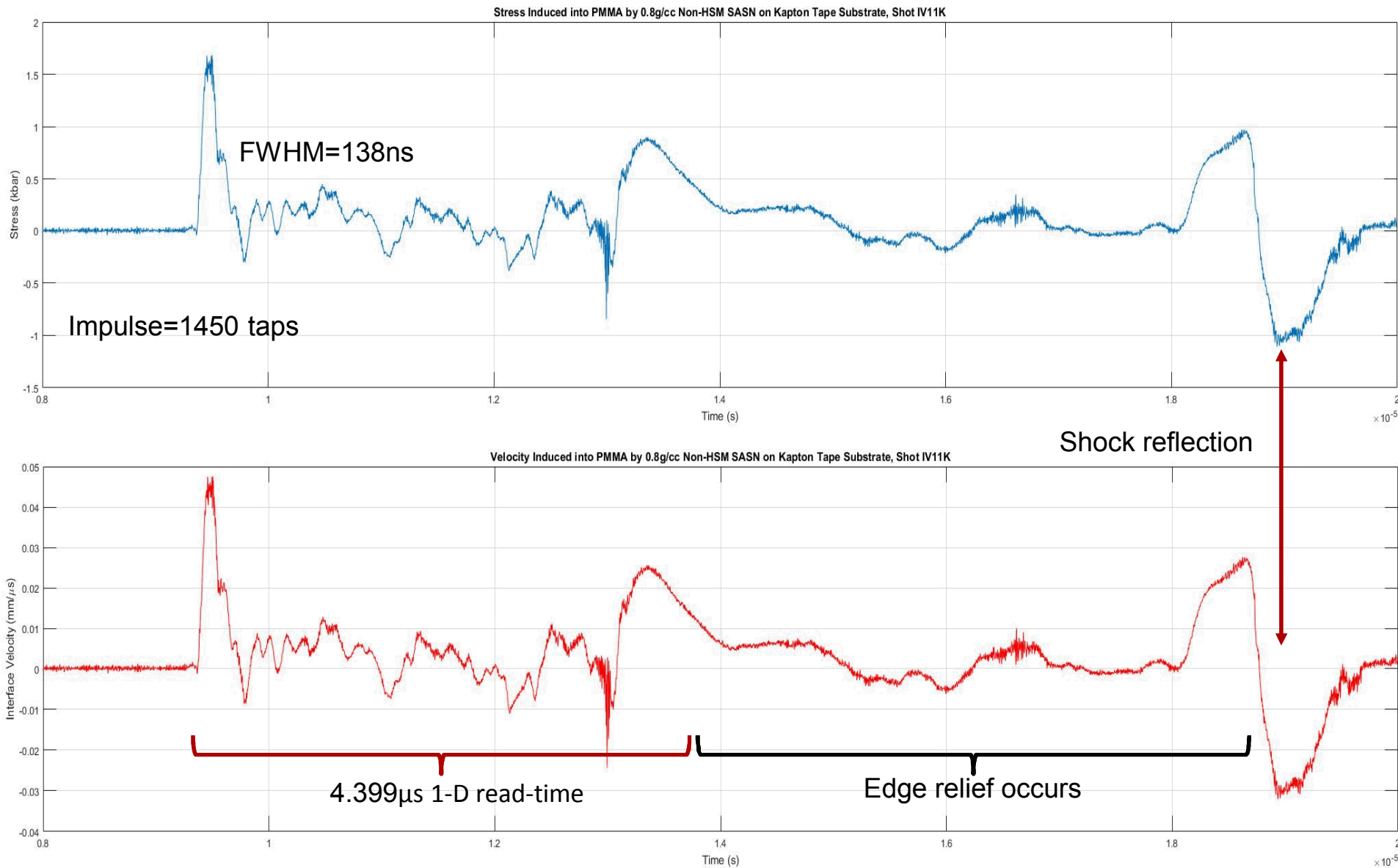
CA-1136

Macroscale Interface Velocity

- Interface velocity measurements are ubiquitous
- Noise is reduced from an electromagnetic standpoint
- Relatively large devices (order of centimeters)
- Several optical systems provide this type of data



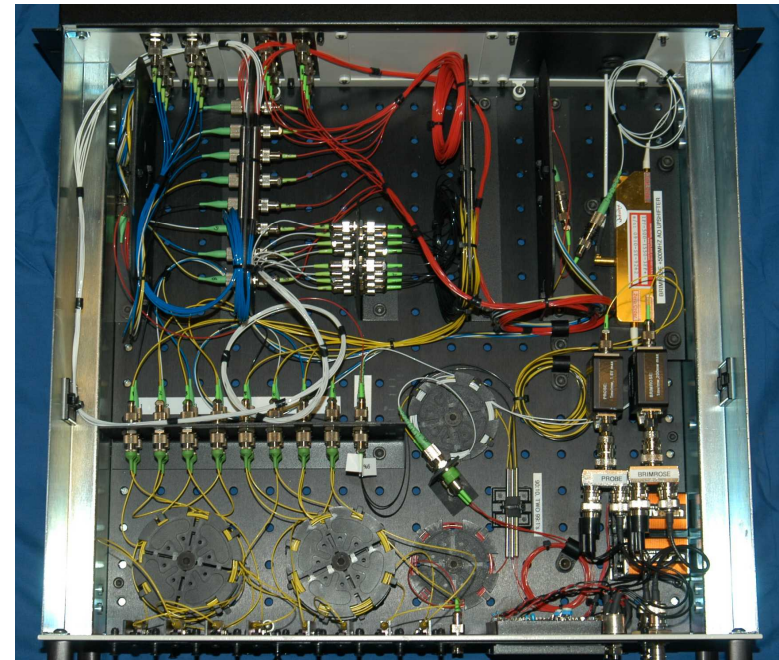
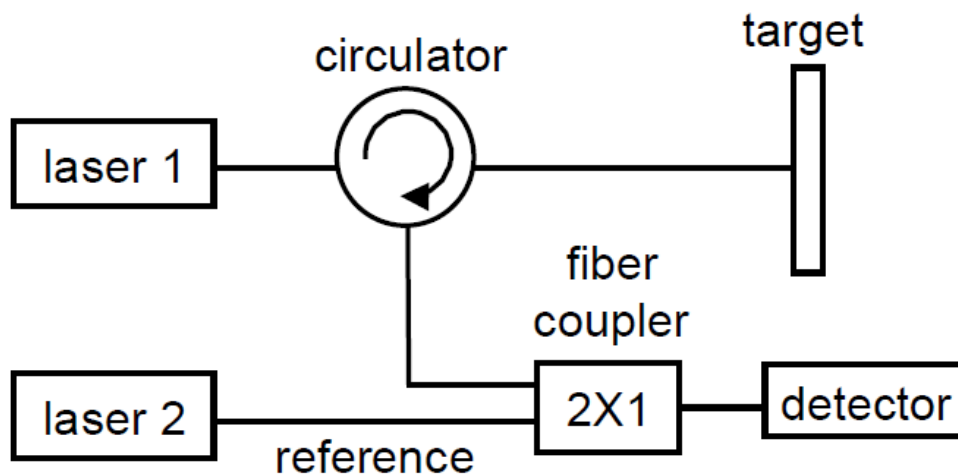
Macroscale Interface Velocity



Photonic Doppler Velocimetry

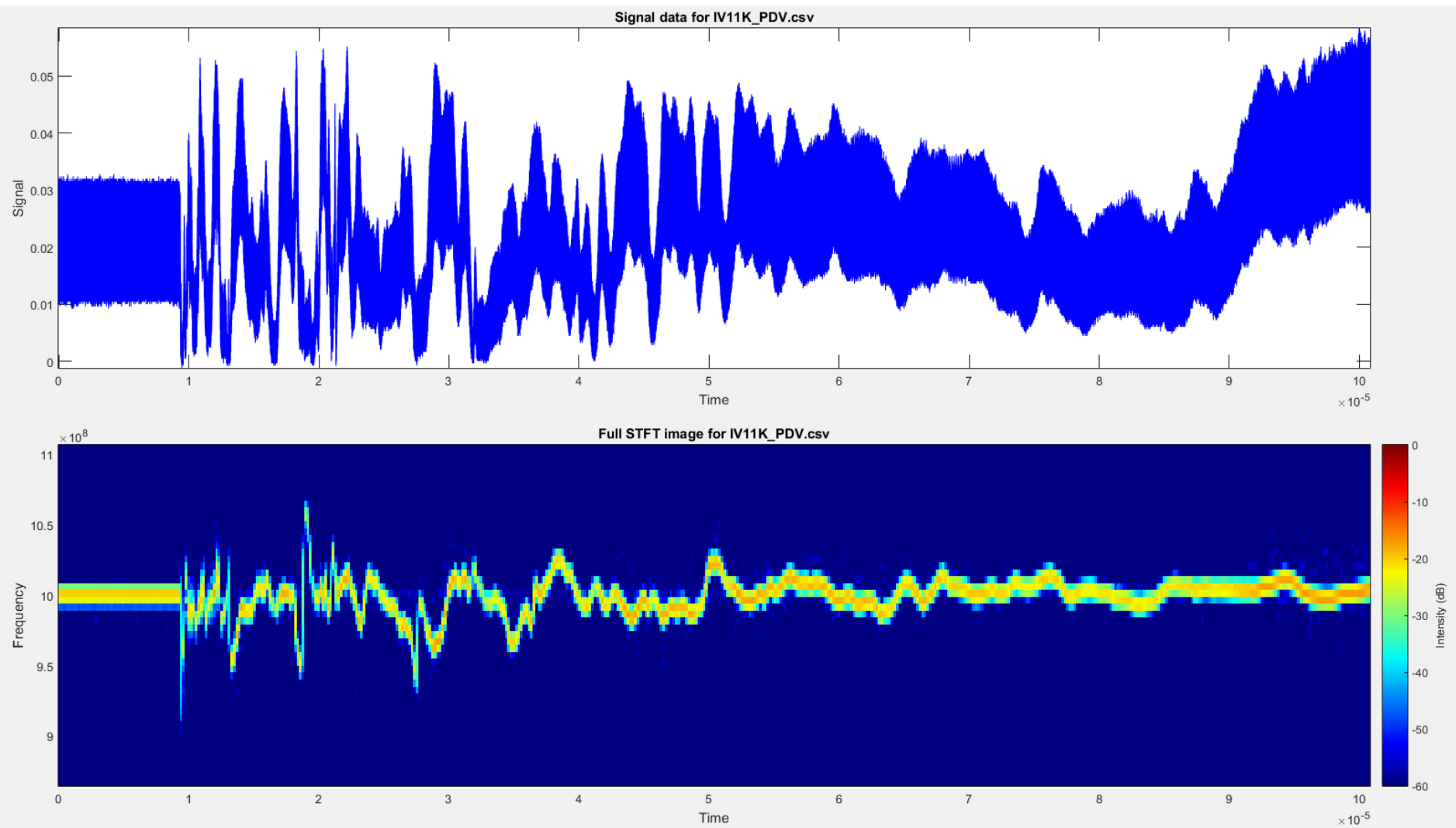
- Developed at Lawrence Livermore National Laboratories
- Short-time Fourier transform needed to transform beat frequency time history to apparent velocity

$$v_a = \frac{\lambda_0}{2} f$$



LIHE Facility PDV System 6

Photonic Doppler Velocimetry



Reduction of interface velocity in SIRHEN, MatLab based script

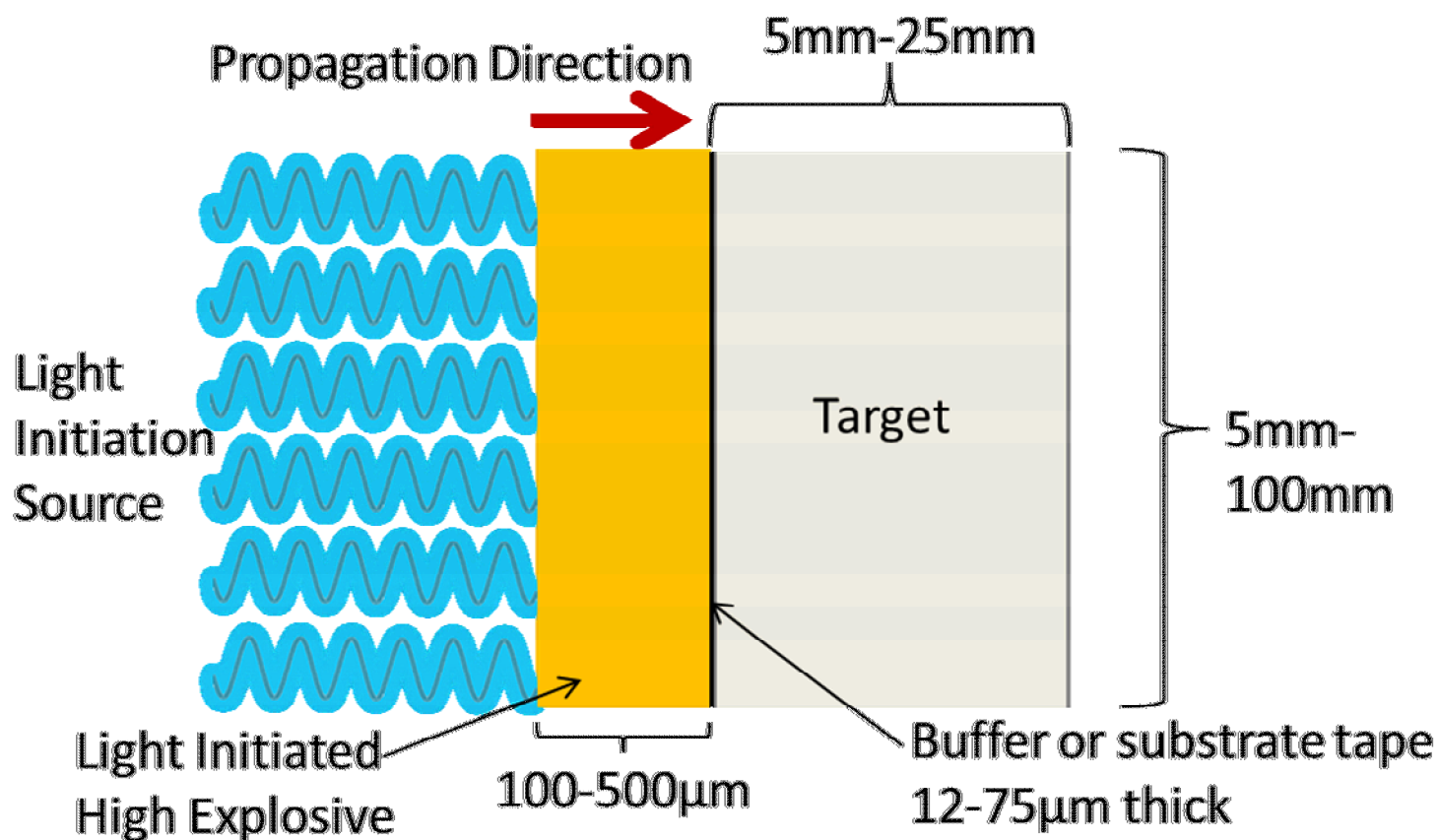
7

Experimental Considerations

- Micro-energetics pose many issues:
 - Diagnostic and the limited space available
 - Geometry influencing phenomena
 - Manufacture of micro-geometry difficult
- Measurements of interest:
 - Particle or interface velocity
 - Pressure
 - Temperature
 - Reaction wave propagation rate
- “Cut-back” one-dimensional experiments may get around some issues, but with caveats

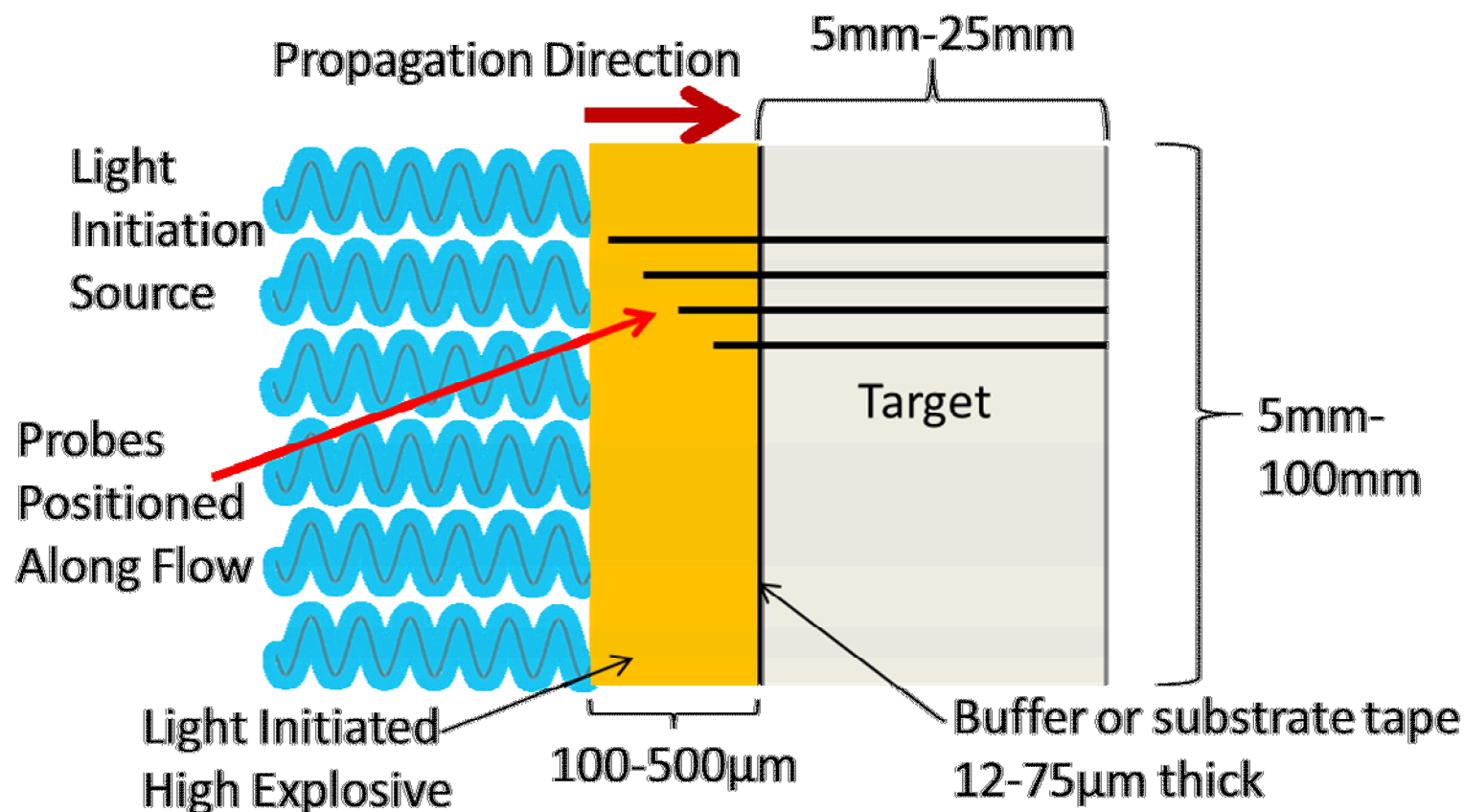
Experimental Considerations

- Silver acetylide-silver nitrate (SASN) explosive is light initiated for impulse testing

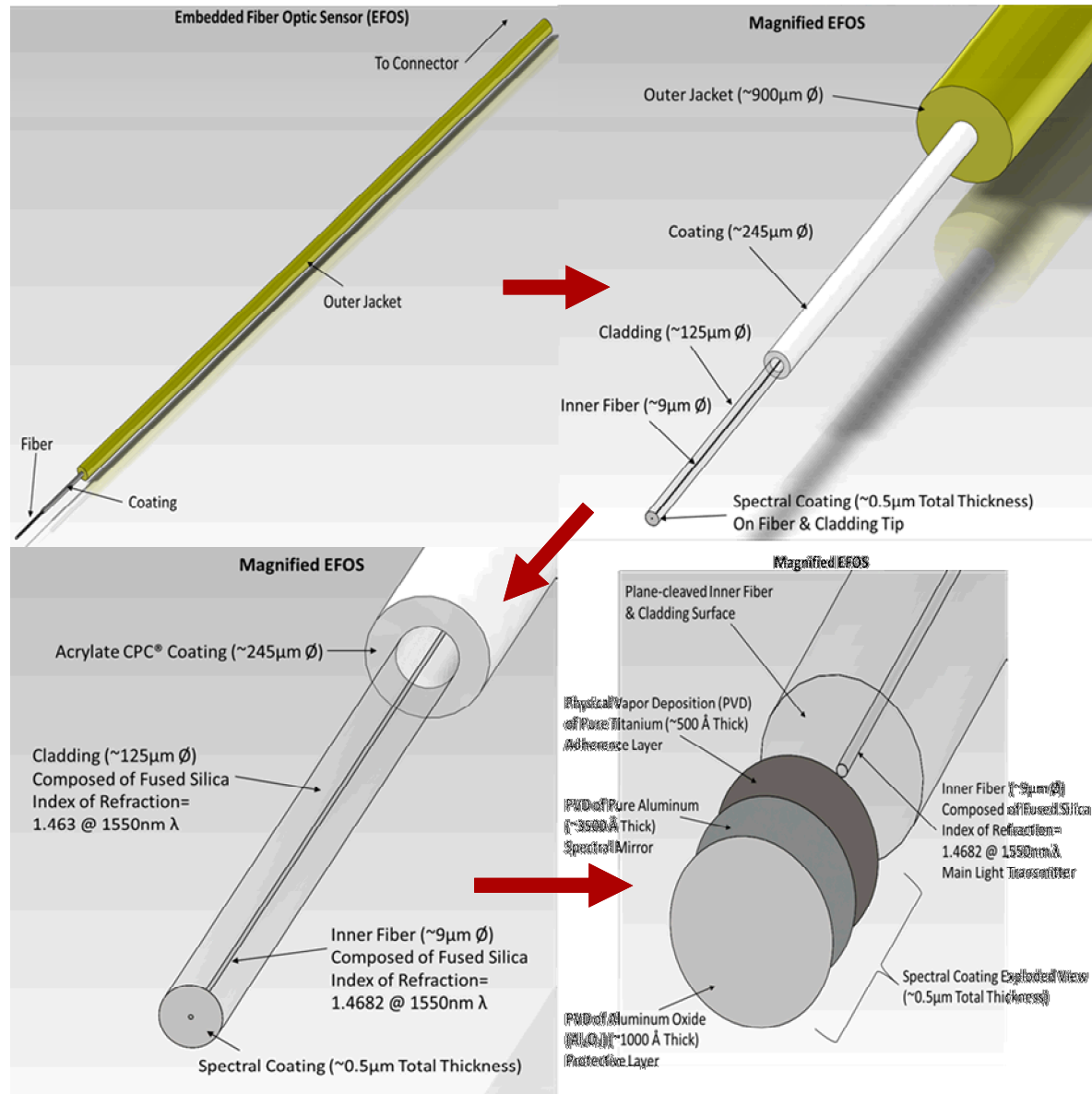


Miniature Interface Velocity

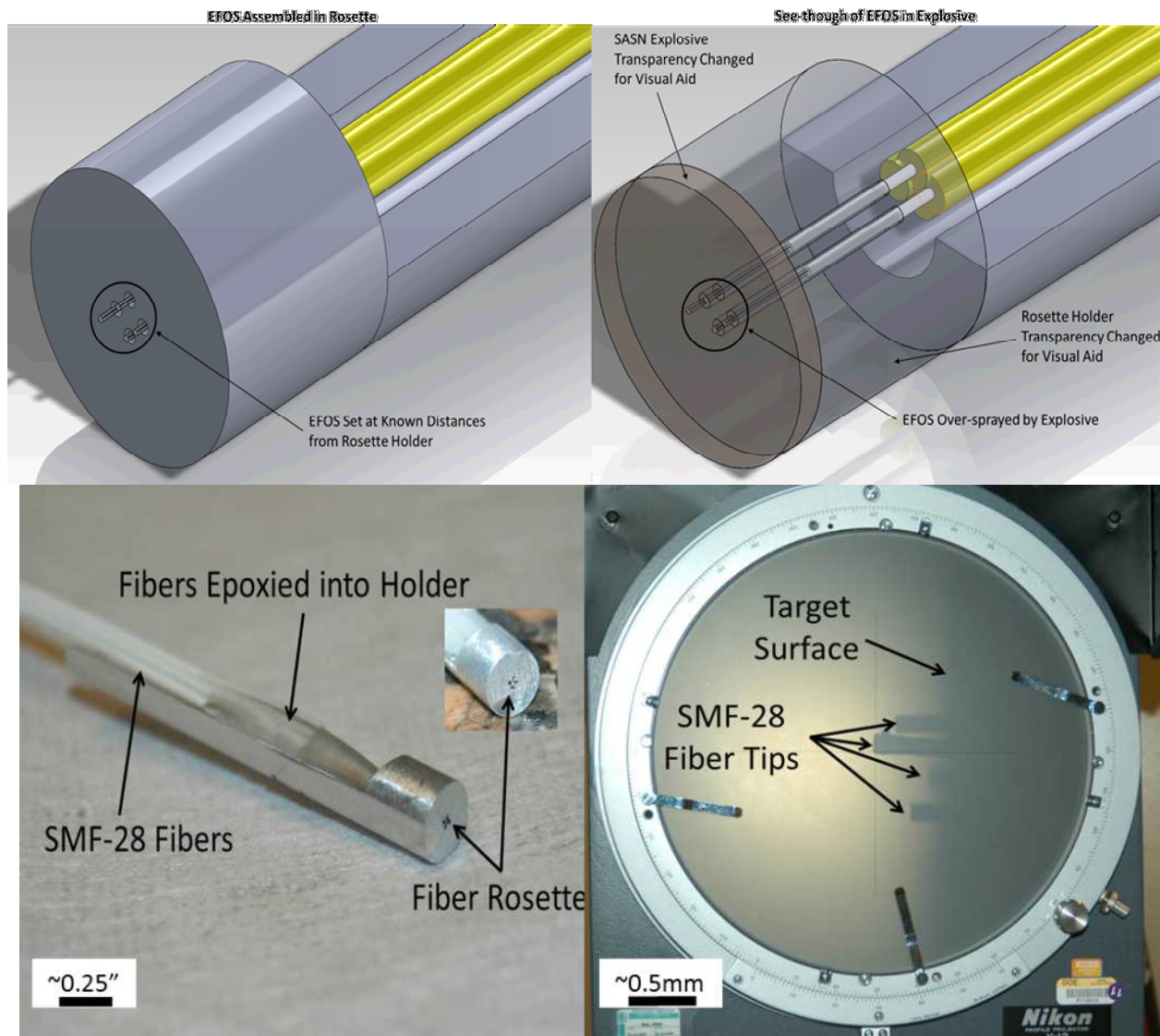
- Originally, time-of-arrival (TOA) pins were envisioned



Embedded Fiber Optic Sensors



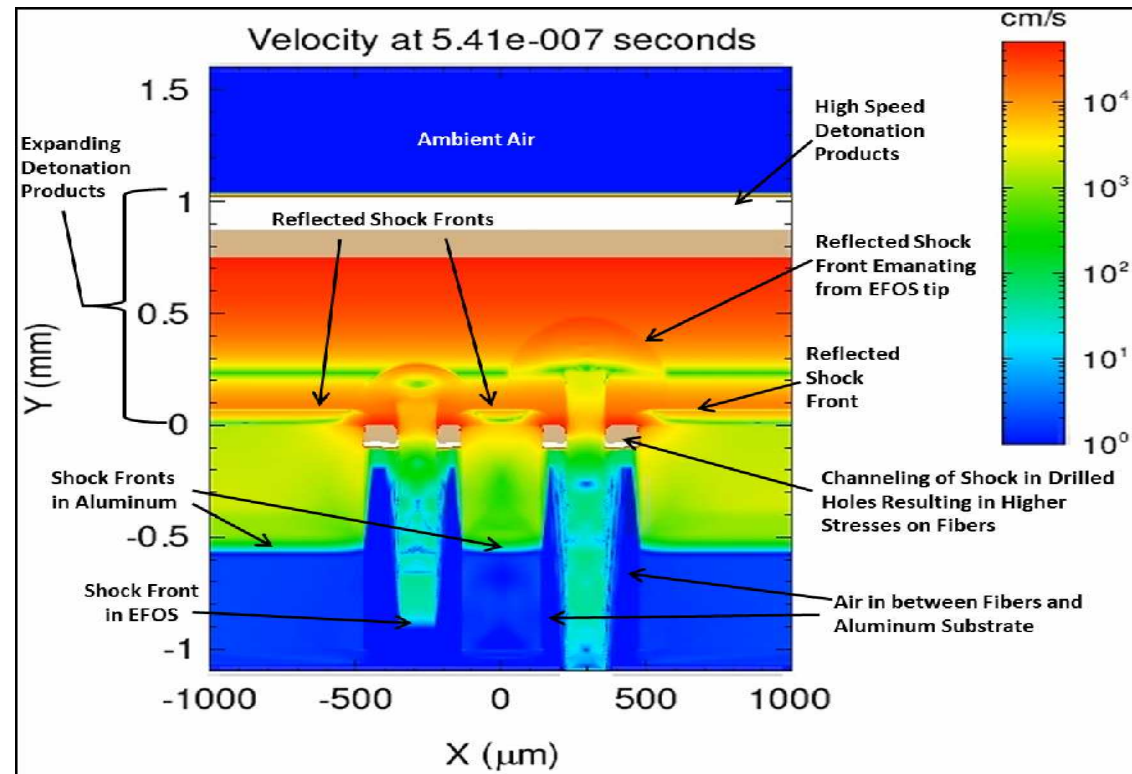
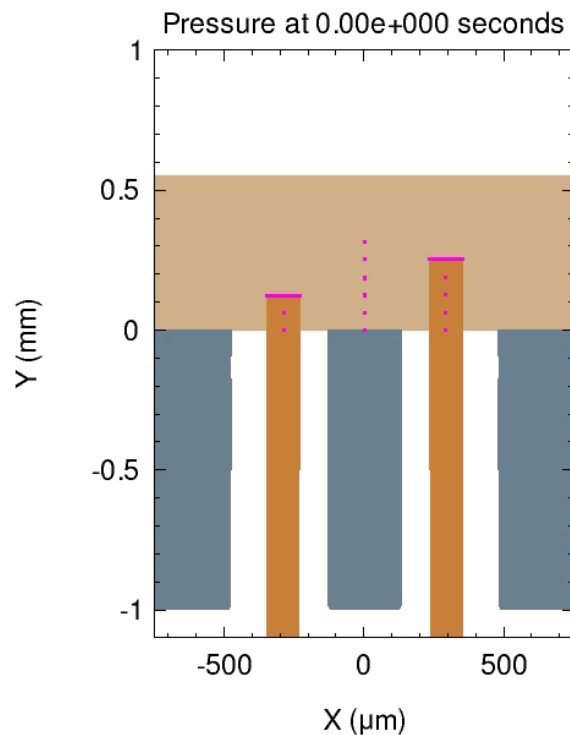
Embedded Fiber Optic Sensors



**Positioning
resolution
along flow:
 $\pm 2\mu\text{m}$**

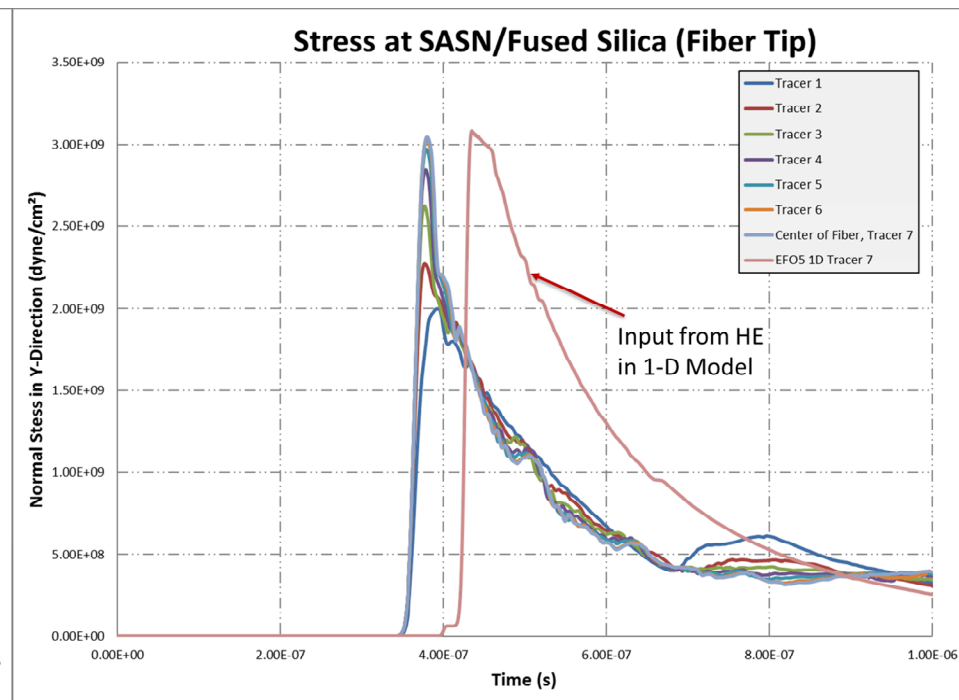
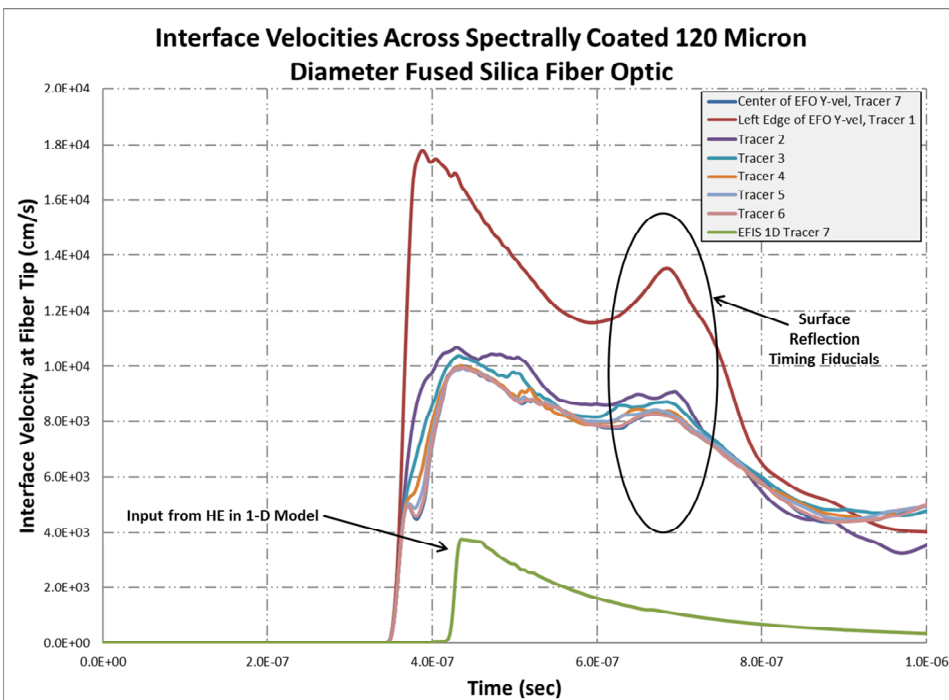
Hydrocode Simulation

- Advanced mesh refinement used in 2D rectangular model
- Arbitrary SASN JWL EOS with programmed HE burn
- Elementary model needs further refinement

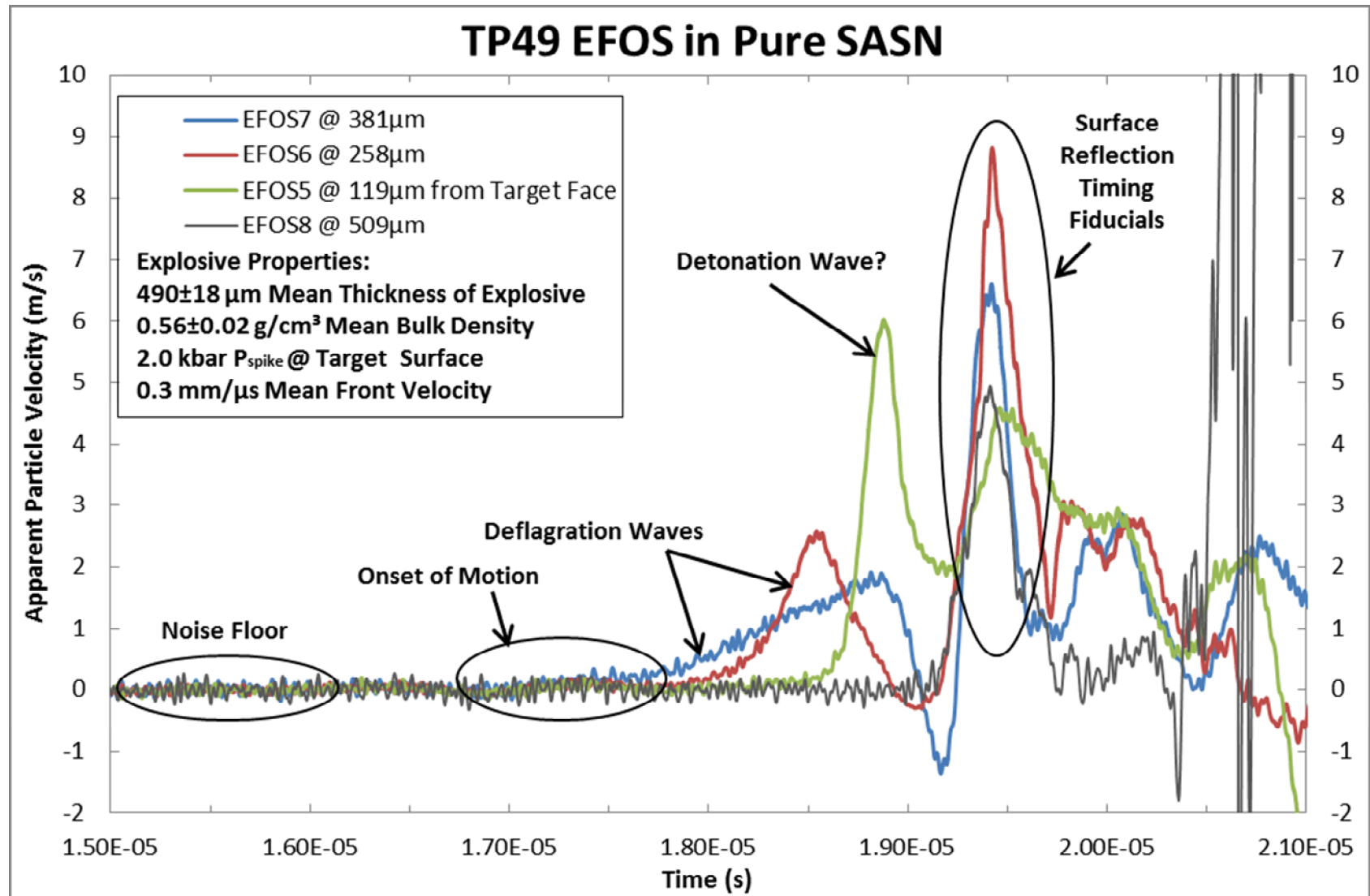


Hydrocode Simulation

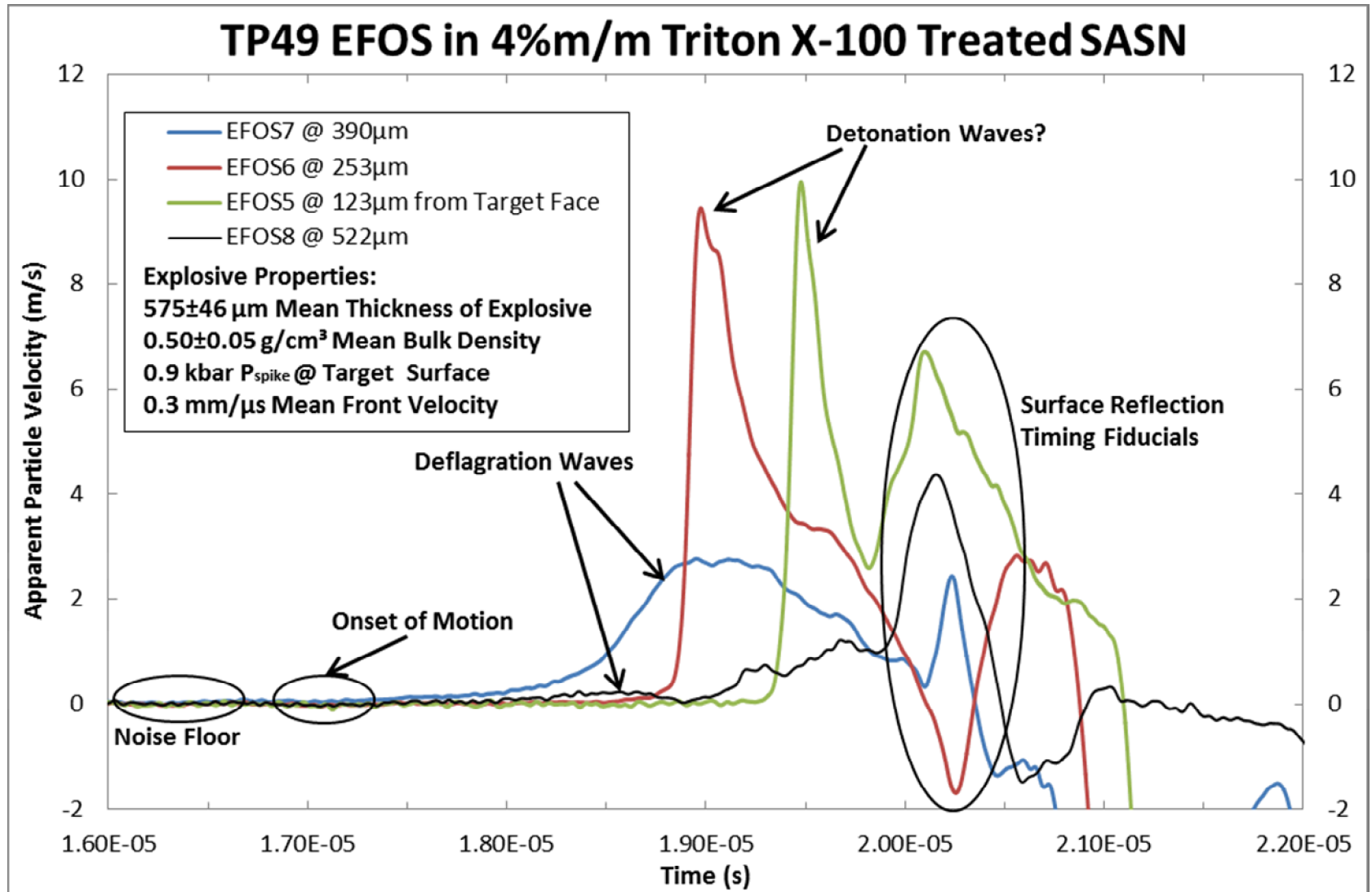
- Stress and velocity at center of fiber modified from original input pulse shape
- Aid in data analysis: surface reflection timing fiducials from experimental configuration



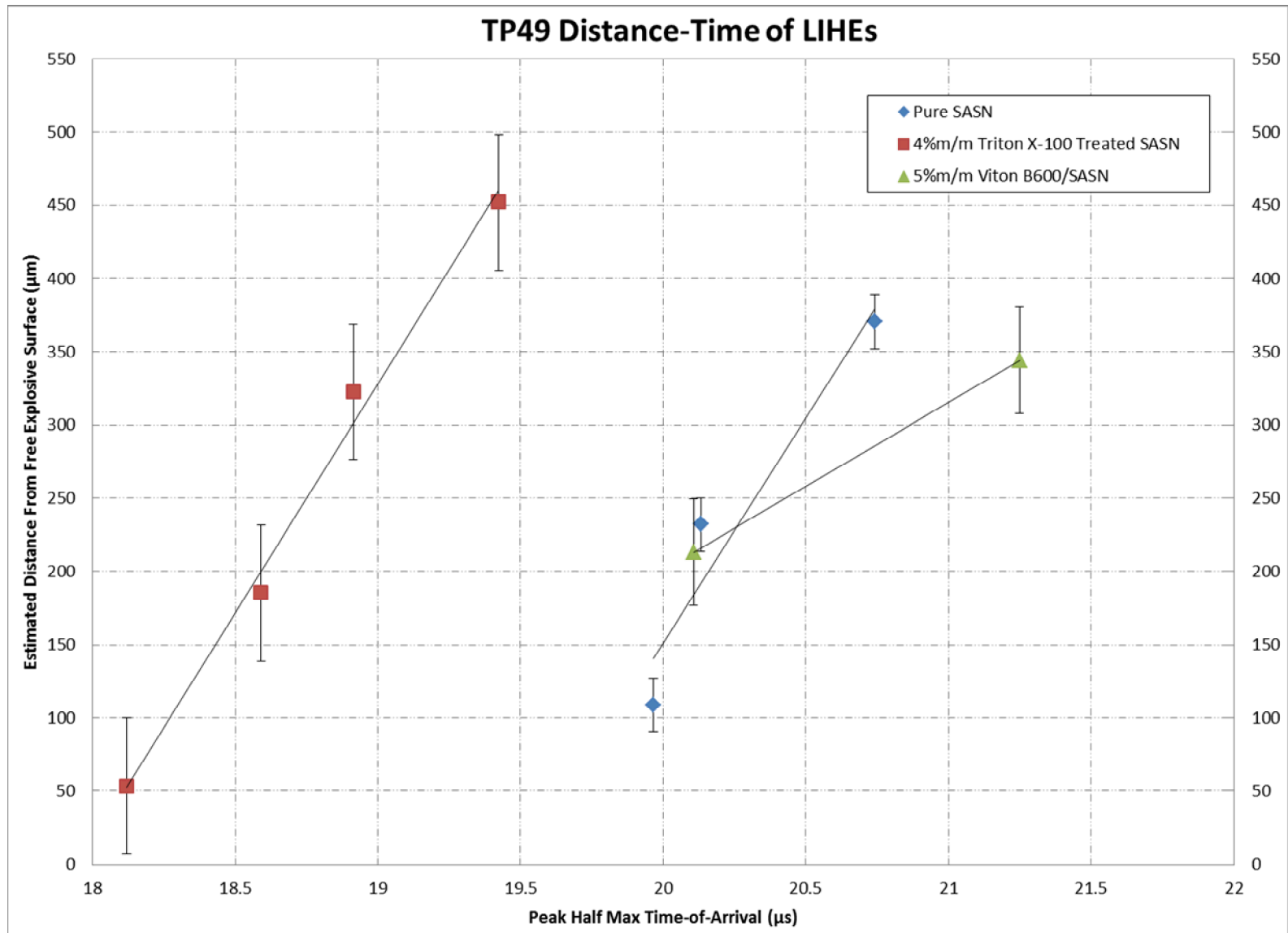
EFOS Measurements



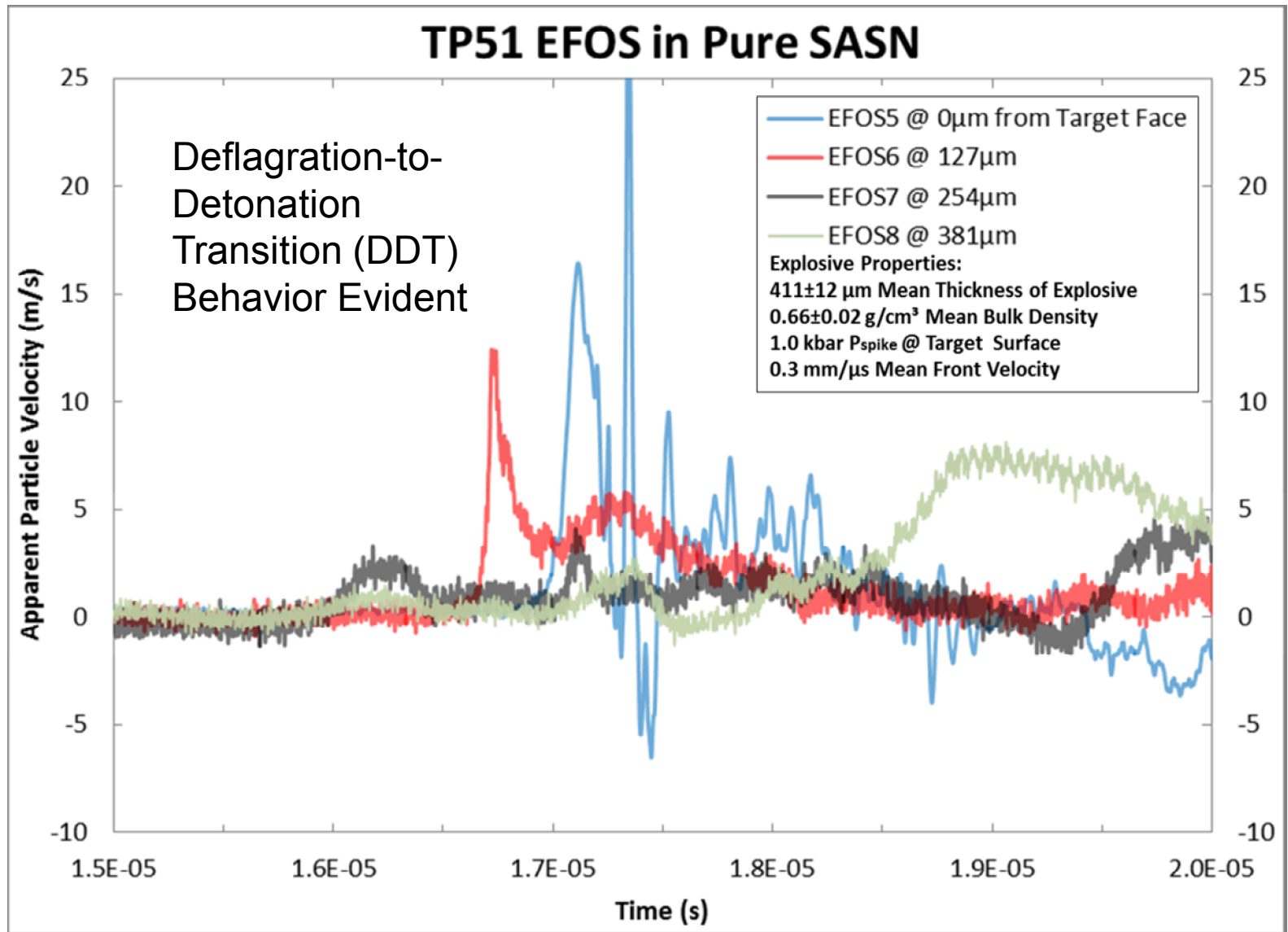
EFOS Measurements



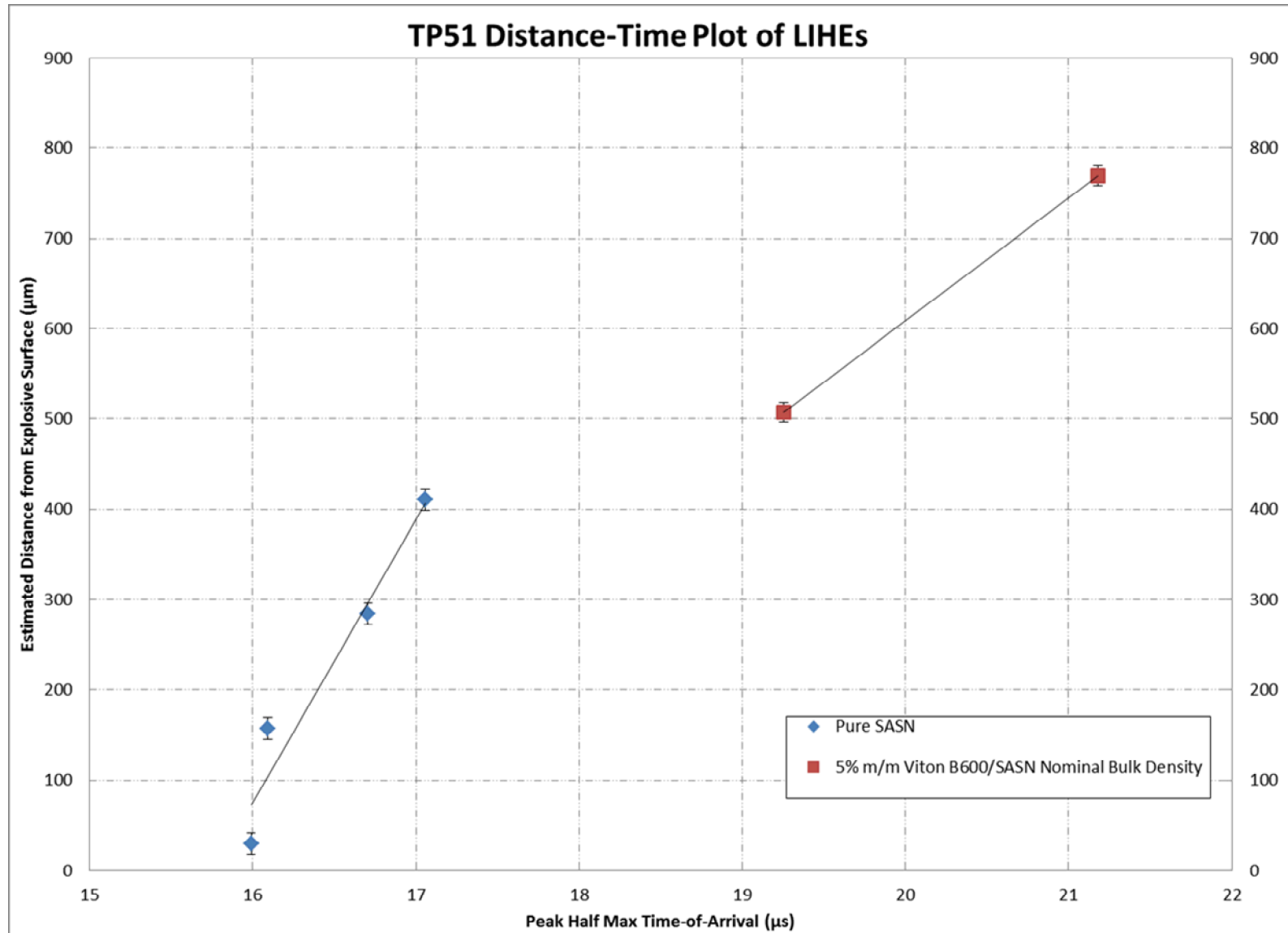
EFOS Measurements



EFOS Measurements



EFOS Measurements



Summary

- EFOS presented here are a miniature sensor for probing combustion phenomena in microscale settings
- EFOS employed in 100-500MPa pressure range and successfully acquired: TOA and apparent interface velocity data
- Deflagration-to-detonation behavior apparent in SASN HE
- Hydrocode simulations and experimental data show that a true velocity and stress transformation possible with more effort
- Uncertainty quantification necessary once true velocity and stress transformation achieved
- SNL Technical Advance (SD# 12638) with patent currently pursued

Acknowledgements

- Daniel Dow
 - Tom Pfeifle
 - John Liwski
 - John Pavlakos
-
- Sandia National Laboratories

■ Questions?