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Comparison of detonation spreading in pressed ultra-fine and nano-TATB

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Motivation

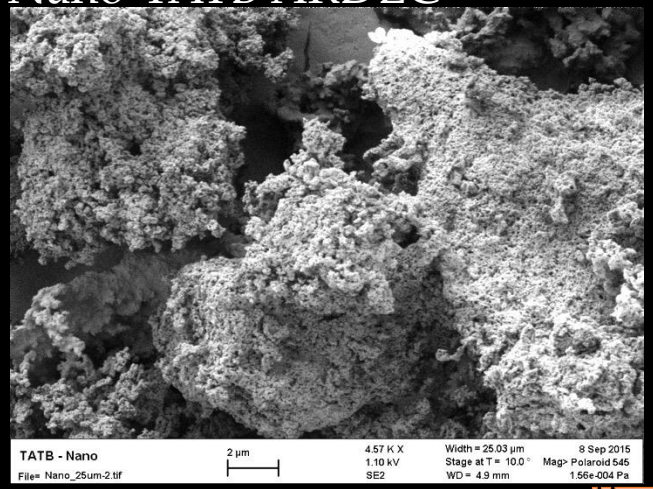
Insensitive high explosive performance is important in initiation-train design

Quantify new particle size/morphology

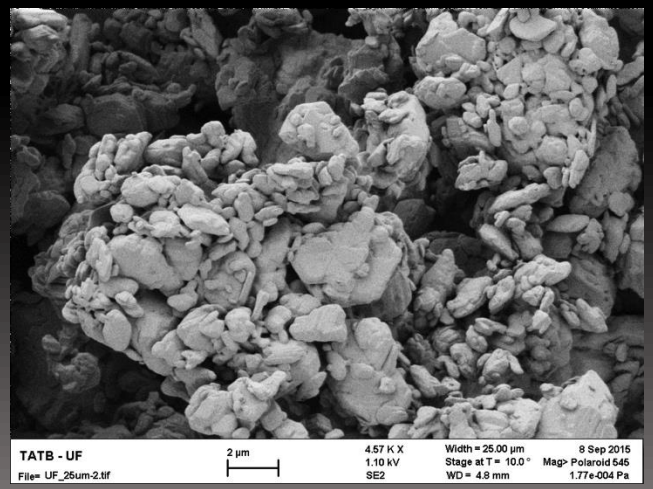
What is the value added from this data?

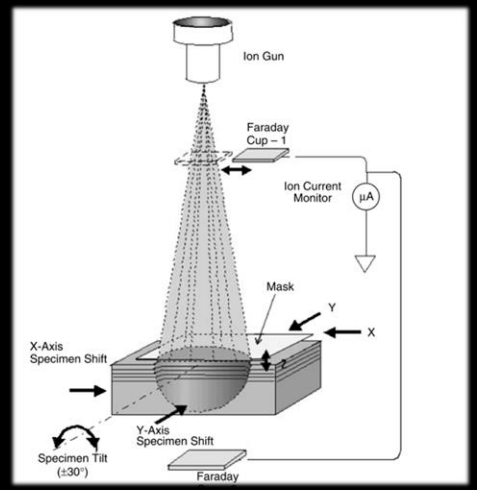
TATB Powders Microstucture Characterization

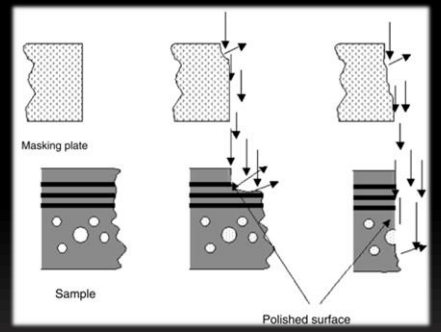
Nano-TATB ARDEC



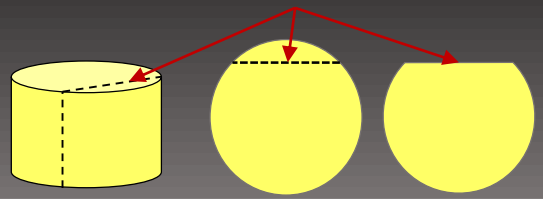
Ultra-fine TATB PANTEX



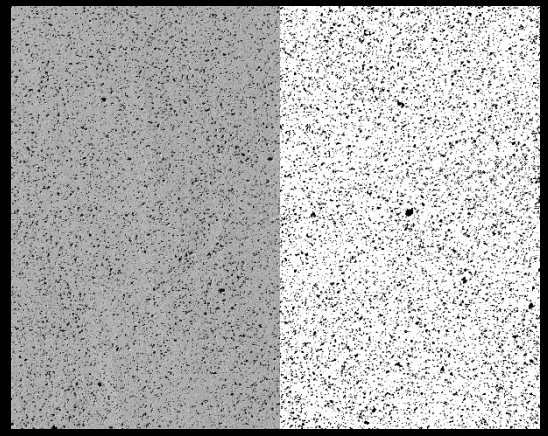




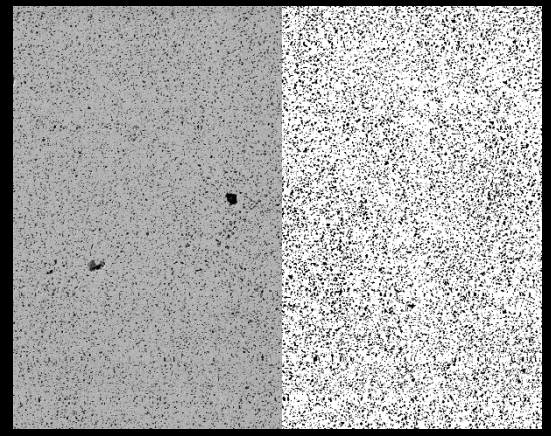
cross-section plane

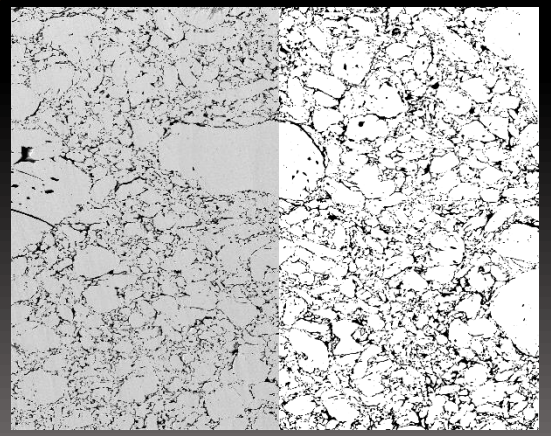


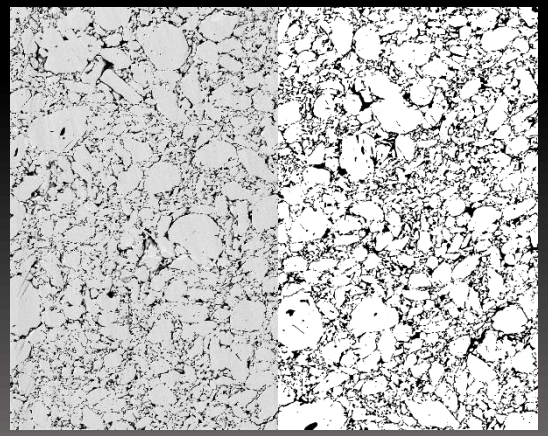
88% TMD



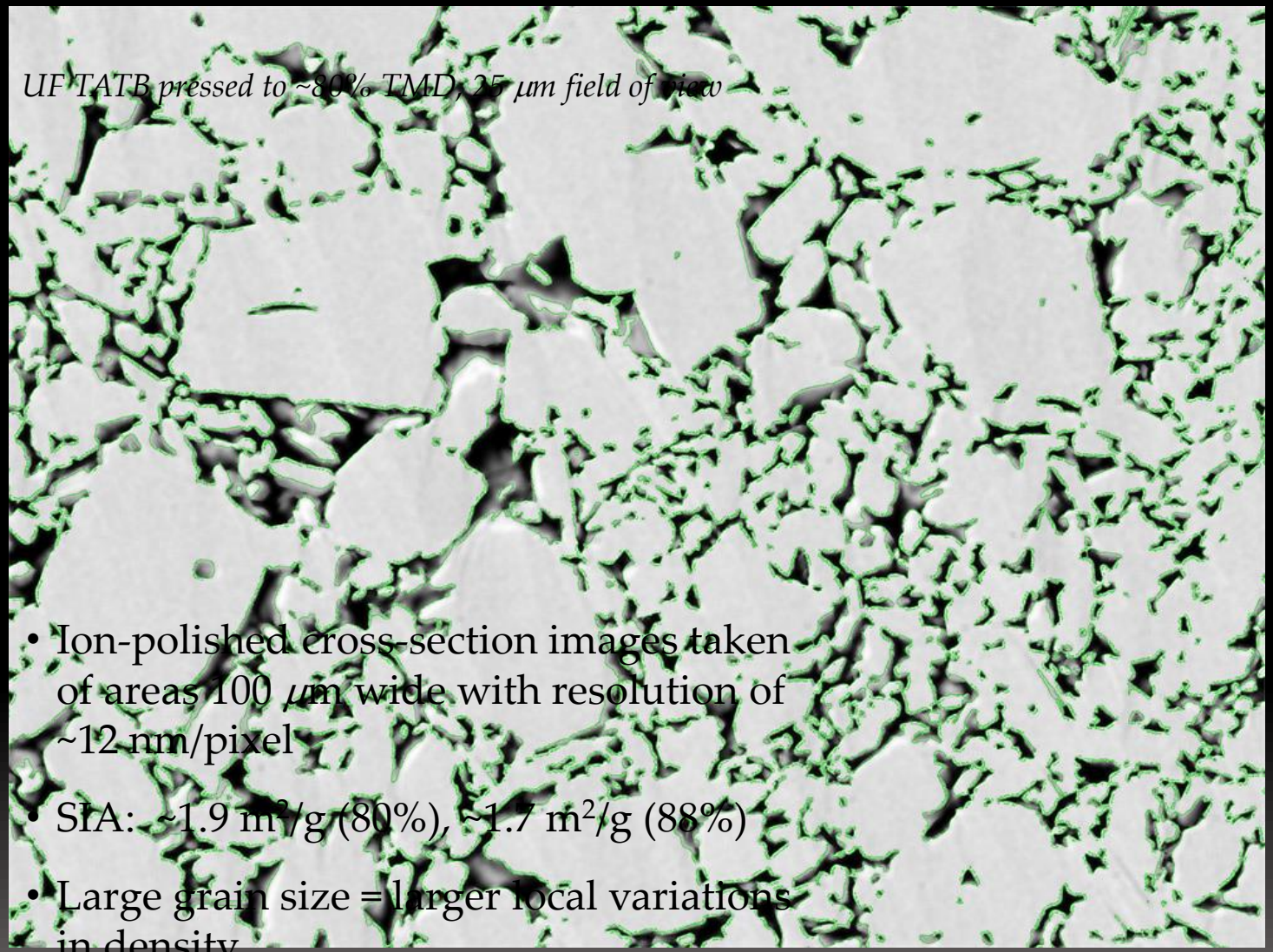
80% TMD





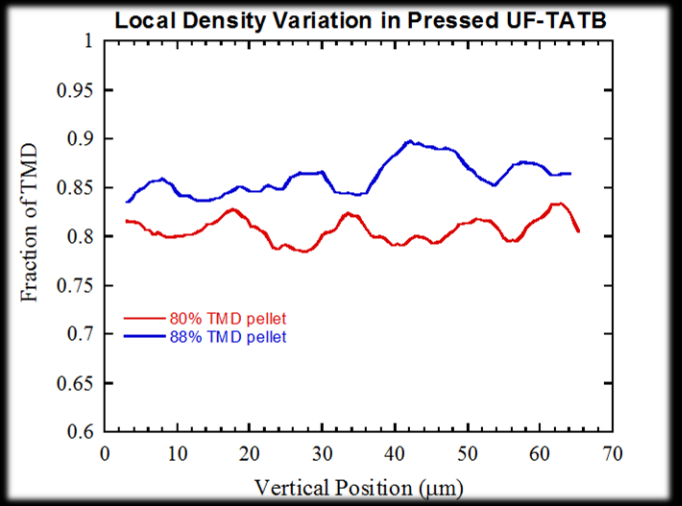


Ultra-fine TATB

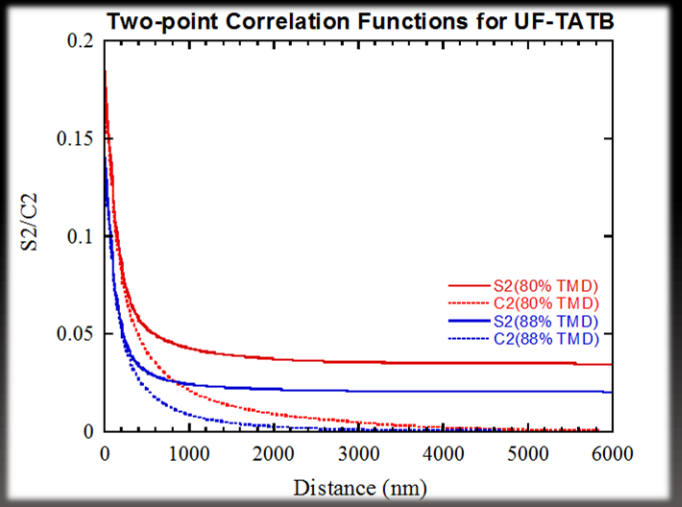


UF-TATB pressed to ~80% TMD, 25 μm field of view

- Ion-polished cross-section images taken of areas 100 μm wide with resolution of ~12 nm/pixel
- SIA: ~1.9 m^2/g (80%), ~1.7 m^2/g (88%)
- Large grain size = larger local variations in density

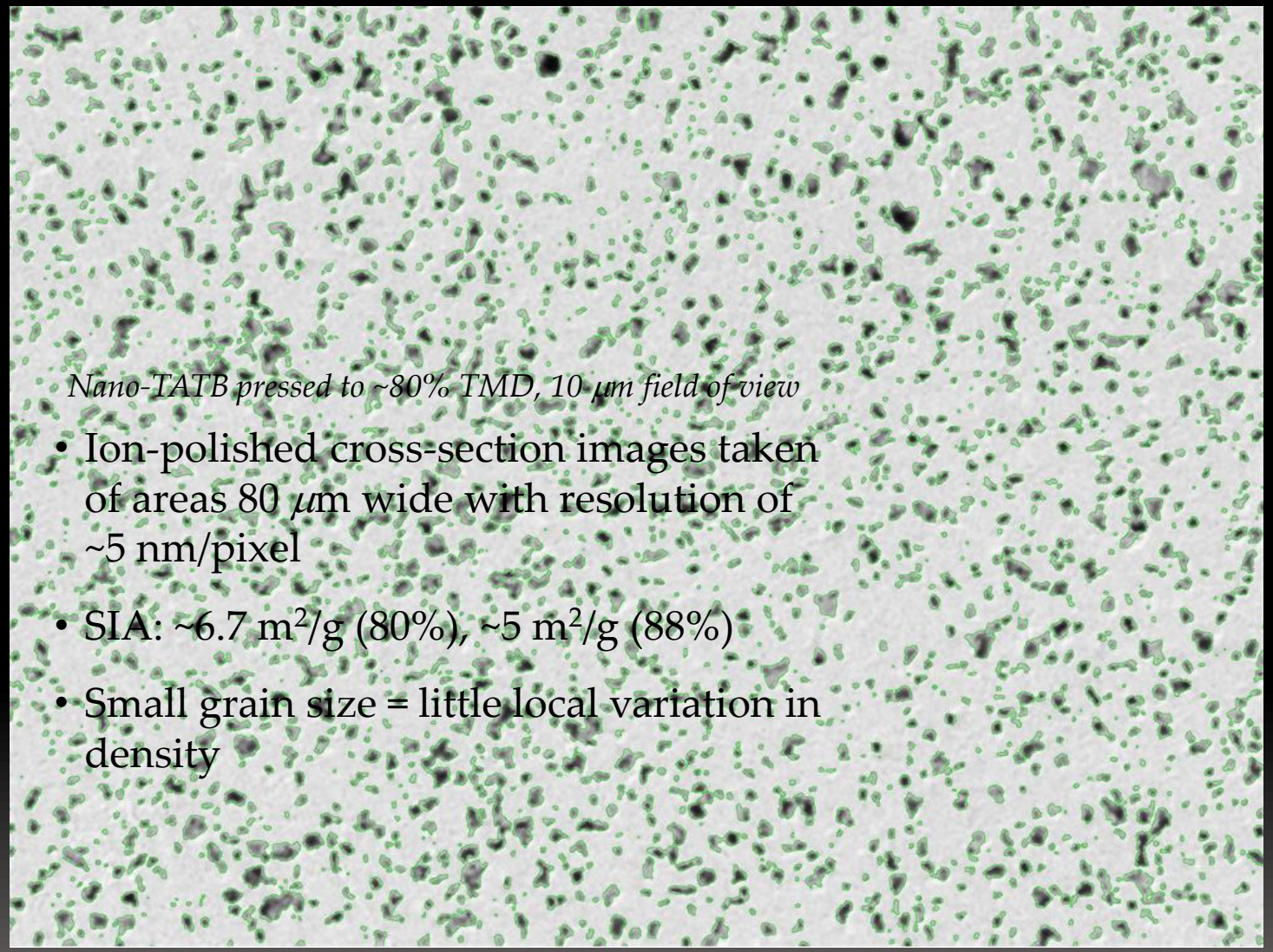


Local density variation with position in pressed UF-TATB pellets



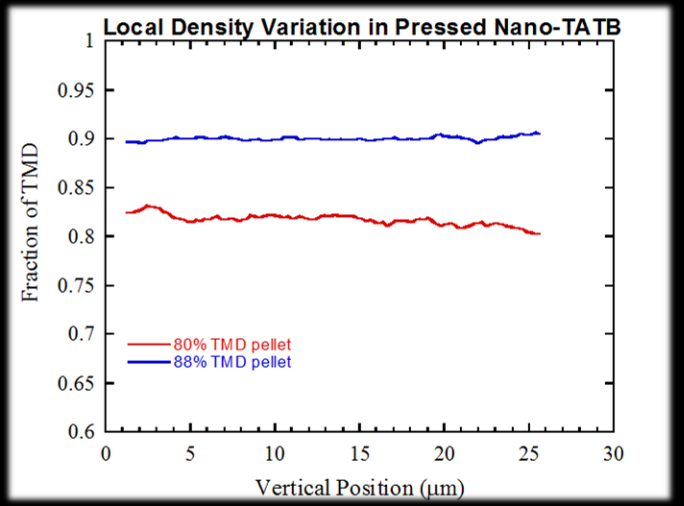
Two-point correlation function and cluster function data for UF-TATB pellets

Nano-TATB

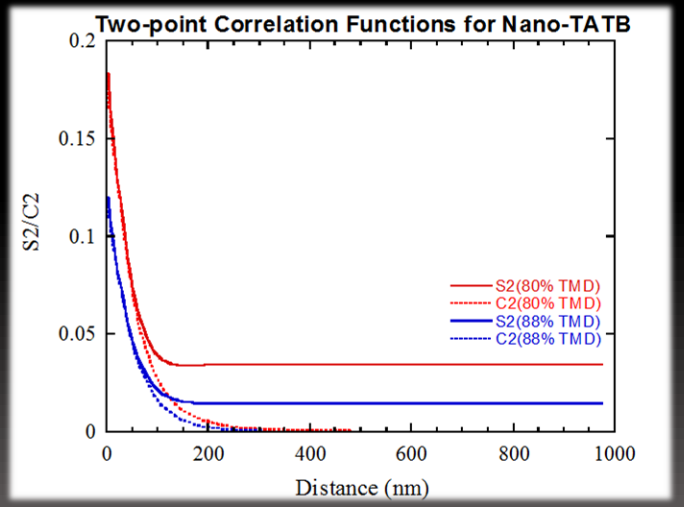


Nano-TATB pressed to ~80% TMD, 10 μm field of view

- Ion-polished cross-section images taken of areas 80 μm wide with resolution of ~5 nm/pixel
- SIA: ~6.7 m^2/g (80%), ~5 m^2/g (88%)
- Small grain size = little local variation in density



Local density variation with position in pressed nano-TATB pellets



Two-point correlation function and cluster function data for nano-TATB pellets

Previous Work
Kennedy/Plaksin on LLM-105

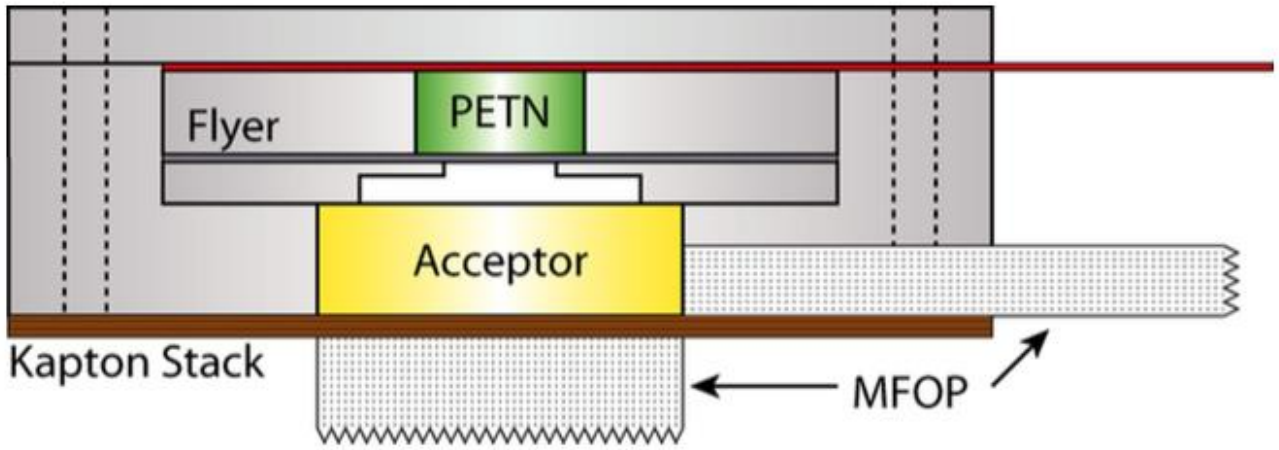


FIGURE 1. Instrumented floret test configuration with kapton stack multi-fiber optical probe.

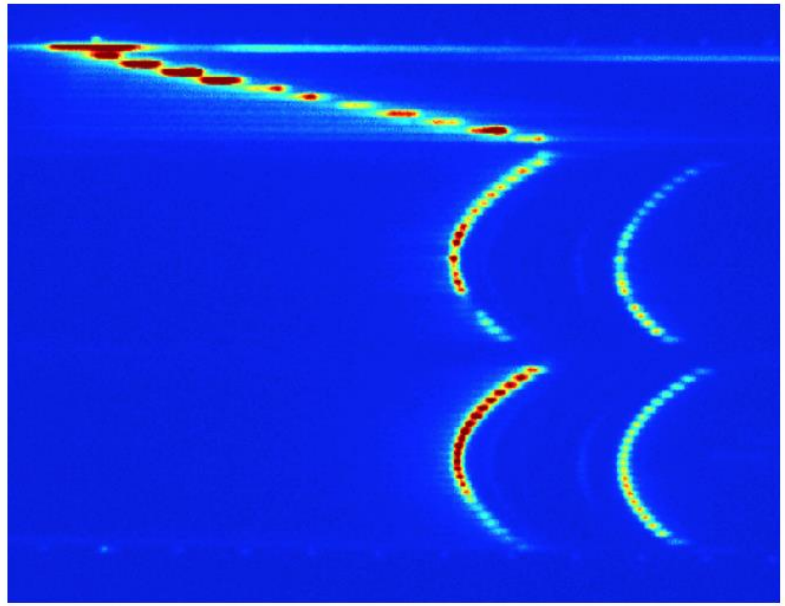


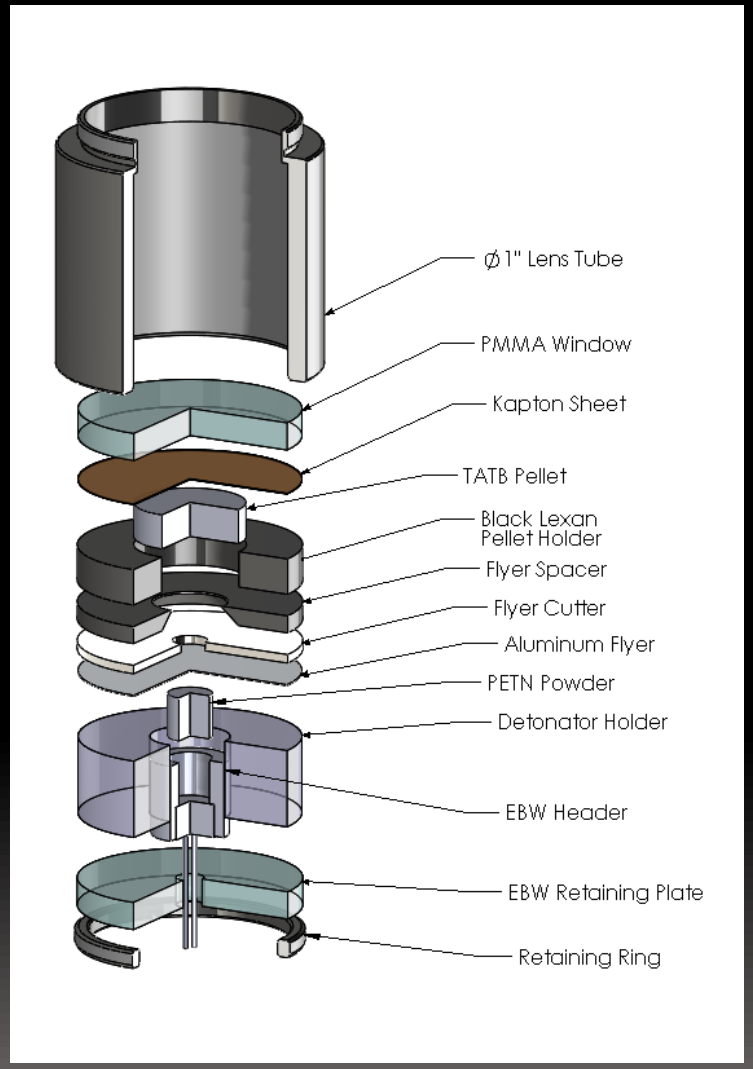
FIGURE 2. 6-mm-diameter x 6-mm LLM-105 shot, with two diametric fiber strips and side fiber strip (top). Time increases to the right.

Instrumented Floret Tests of Detonation Spreading

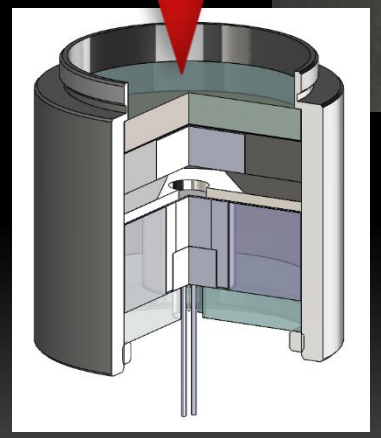
Kennedy *et al.*, AIP Conference Proceedings. Eds. Furnish, and Gupta. Vol. 706. No. 1. AIP, 2004

Experimental Setup

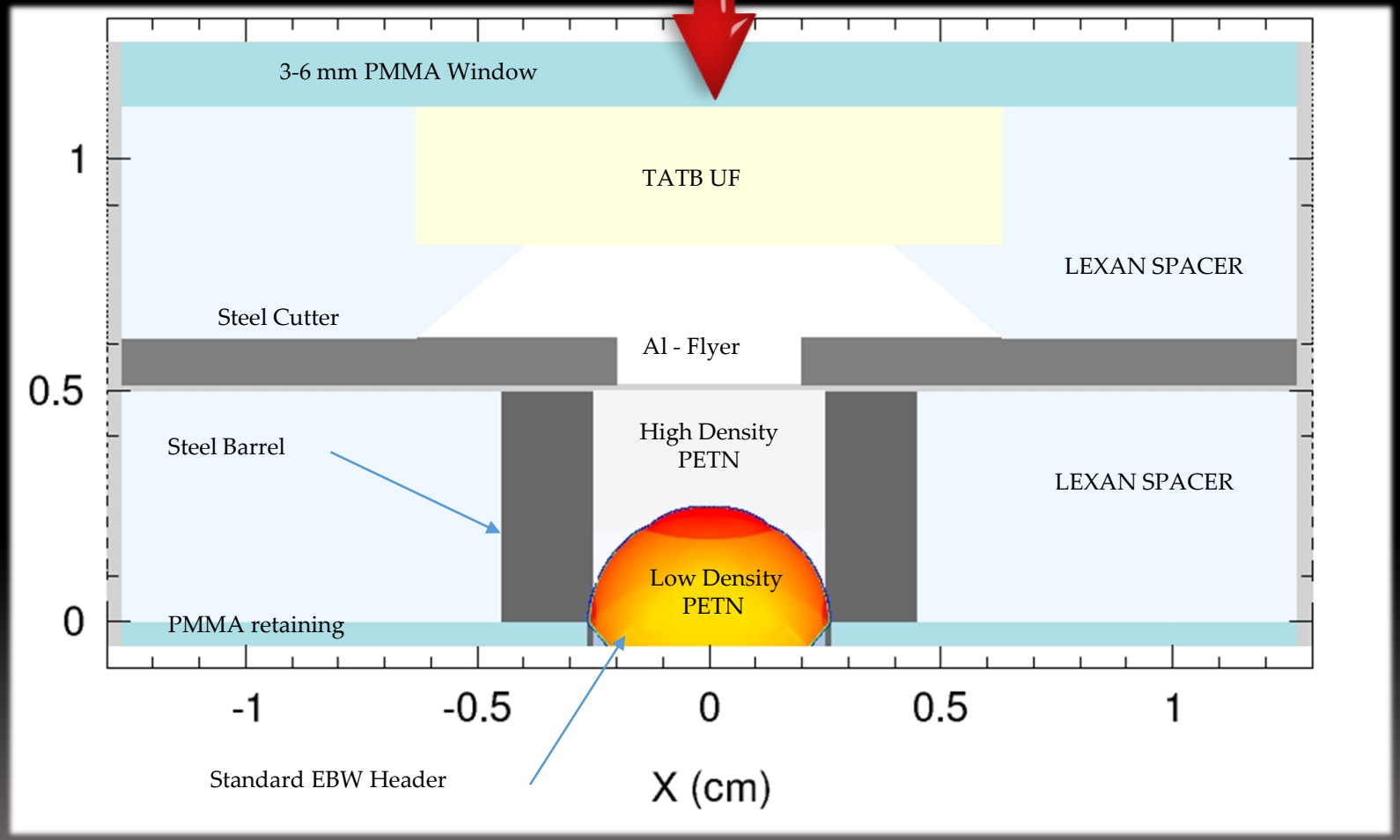
- Standard EBW header
  - 0.001 inch dia Au wire raised 0.0014″
  - 0.020″ length
  - Dual PETN pressing
- 127µm thick Al flyer
  - Cutter used to make Ø4mm
  - 3mm standoff from pellet
- TATB pressed pellets
  - Ø1/2″ X 3mm tall
  - Ultra-fine and nano 80 & 88% TMD
- Ø1/2″ X 127µm thick Kapton at output
  - 10µm Sylgard/GMB spin coat (for enhanced output lighting)

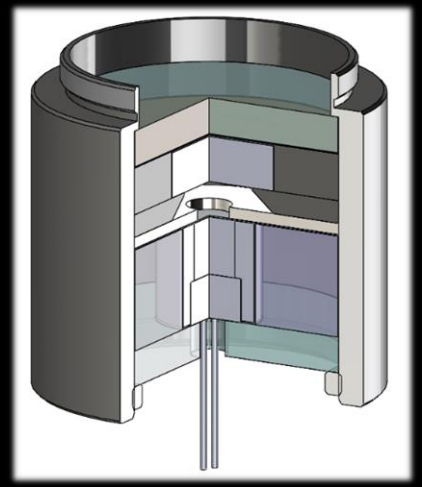


Streak/ PDV



Computational Setup



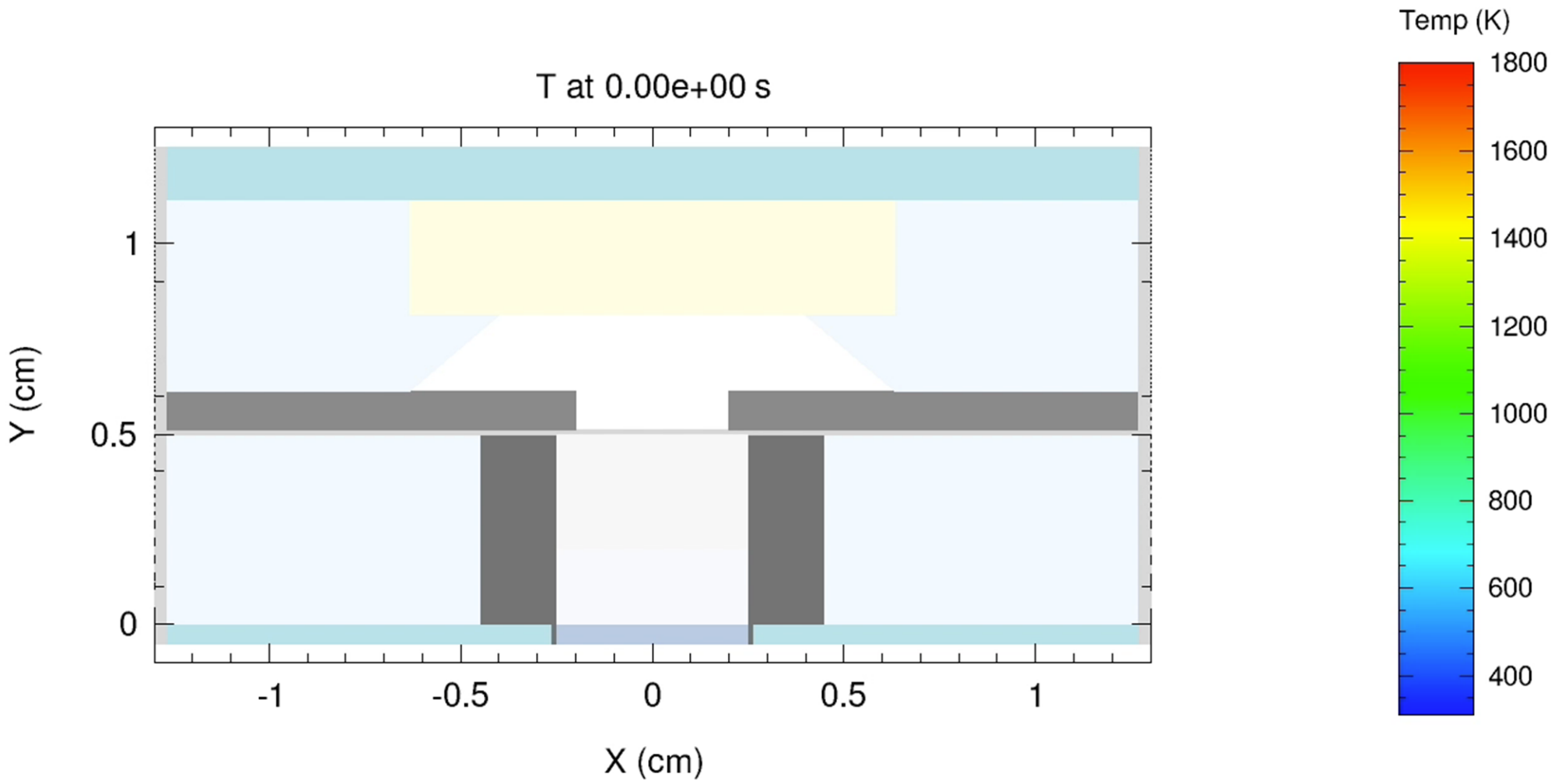


PETN IP is initiated with HEBURN on a 400um line

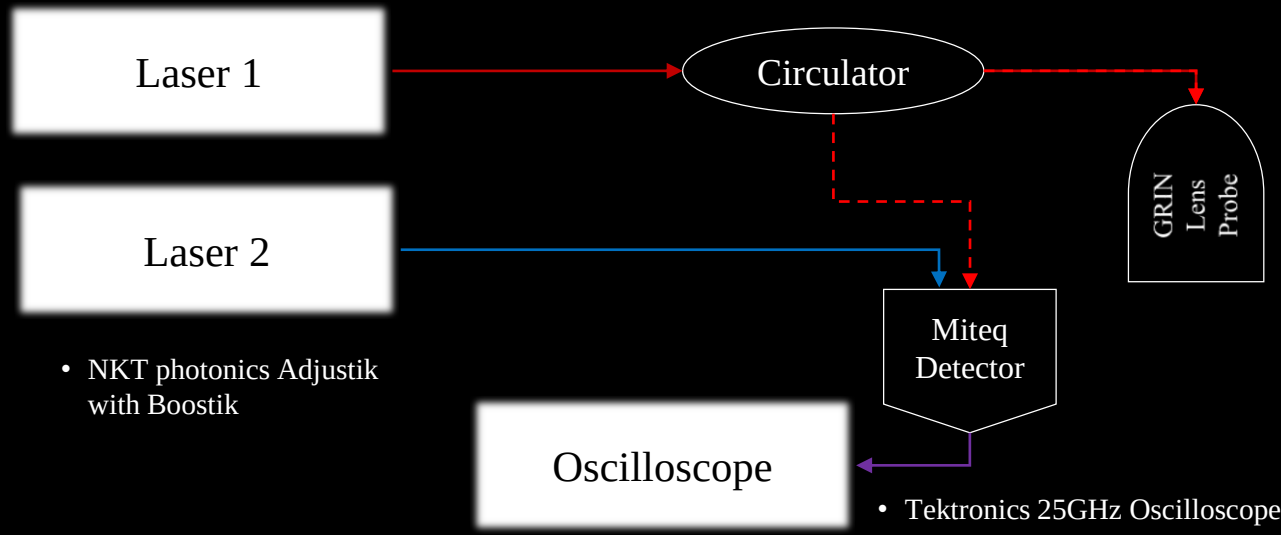
PETN OP is modeled with ARB and Mie-Gruneisen (very sensitive)

TATB ARB parameters from Kerley

Simulation


T at 0.00e+00 s
Y (cm)
1
0.5
0
-1
-0.5
0
0.5
1
X (cm)
Temp (K)
1800
1600
1400
1200
1000
800
600
400

How do we measure the velocity?

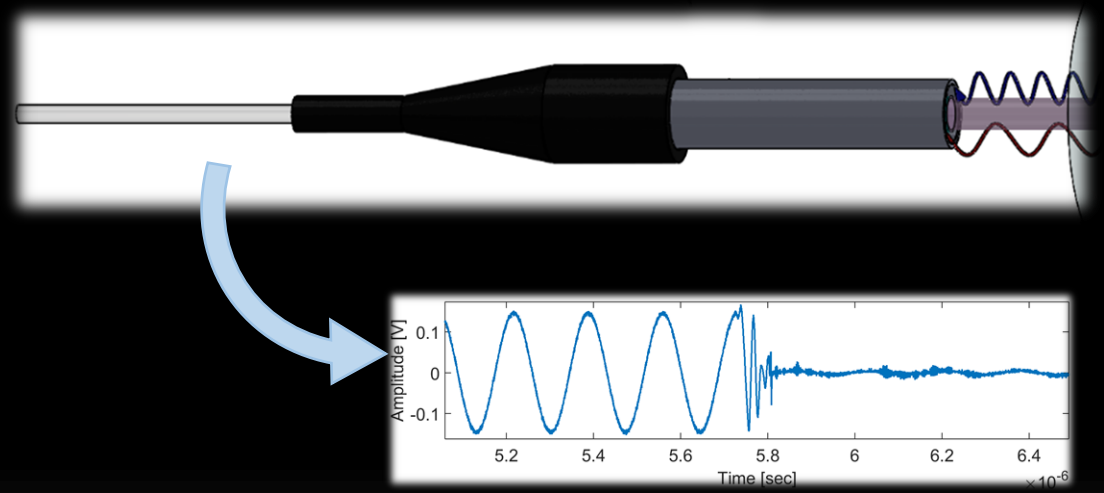


- NKT photonics Adjustik with Boostik

- Tektronics 25GHz Oscilloscope

Thor Labs

- Single Mode GRIN Fiber Collimator, 1550 nm, FC/APC Connector
- Mounted in a kinematic mount on a 60mm cage base

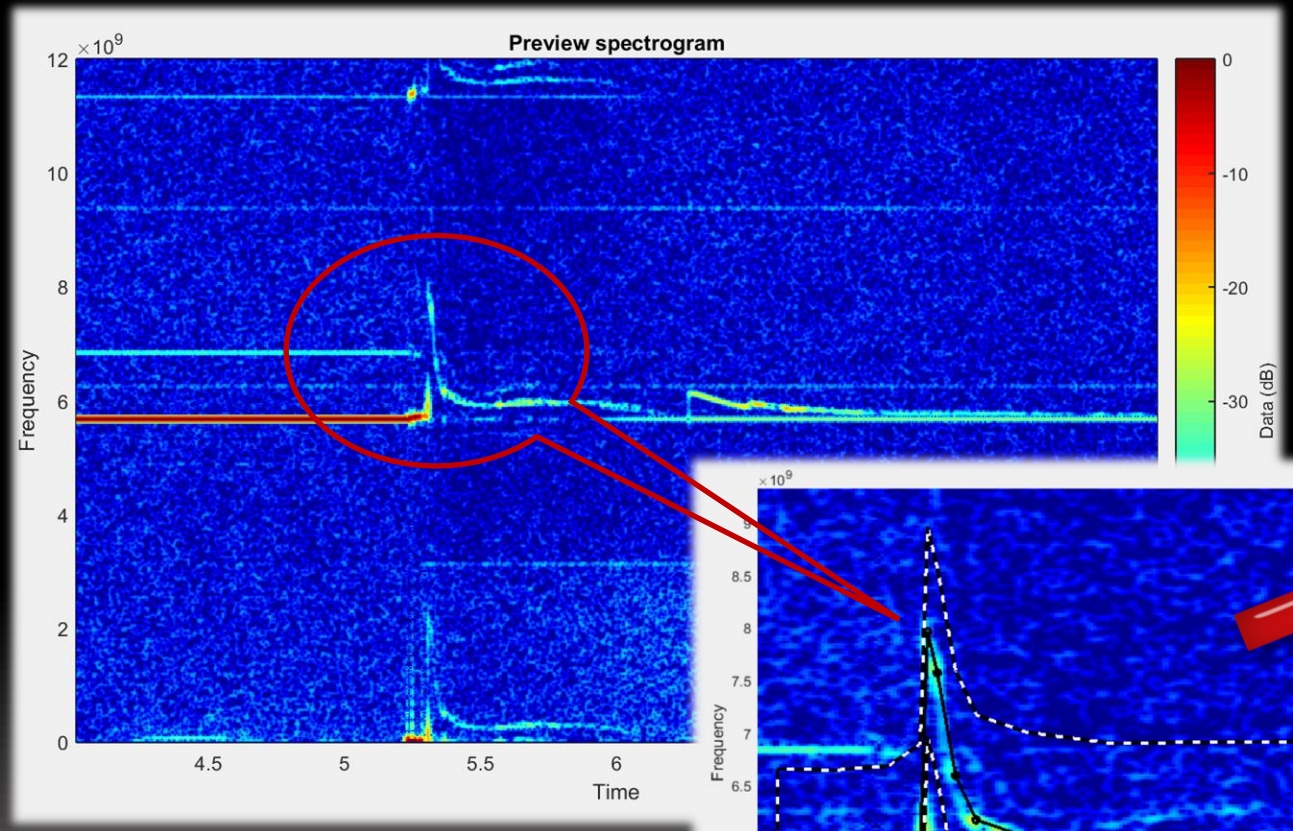


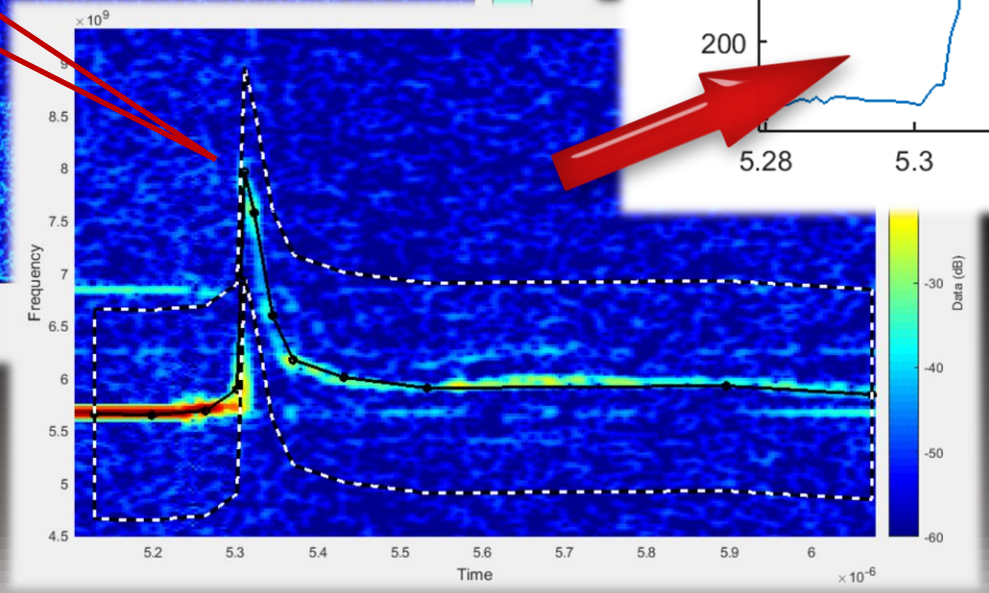
Upshifted PDV (1550nm)

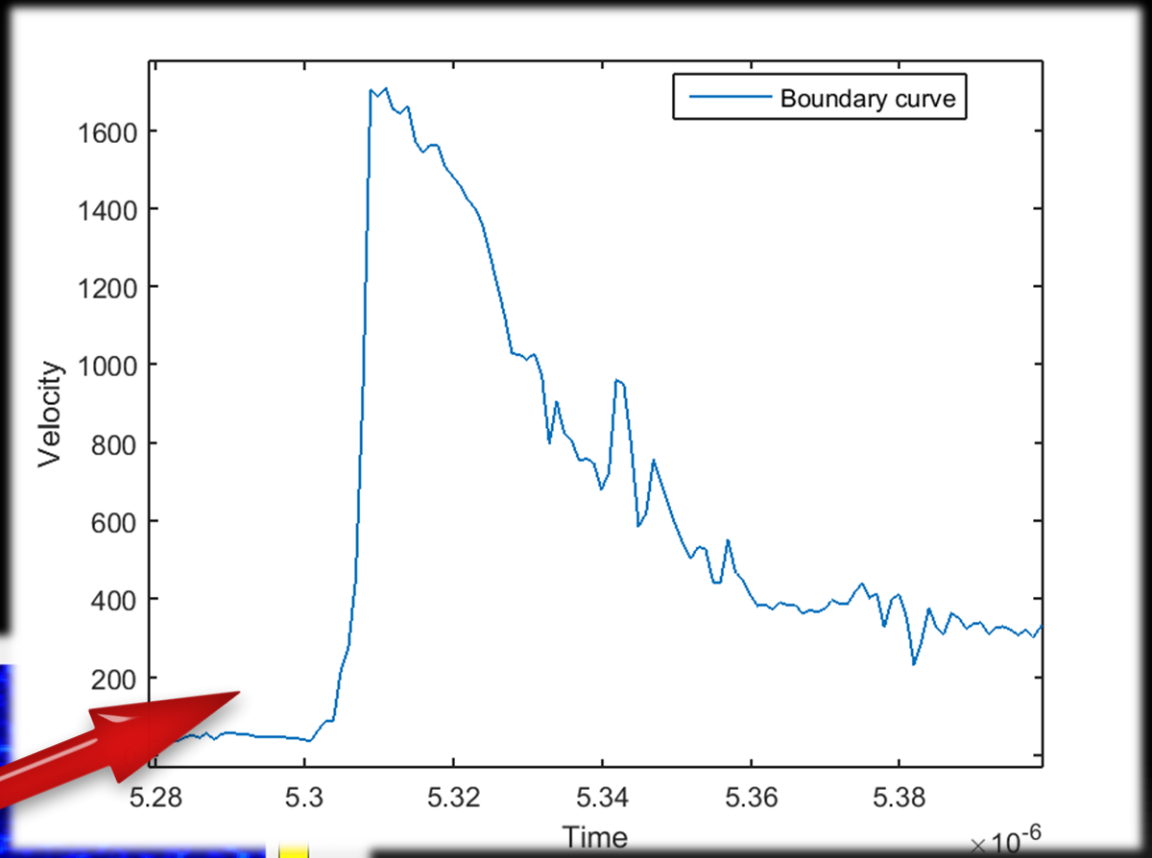
- One laser is used as a reference beam and the other is sent to the target, beat frequency is produced and measured with the oscilloscope
- Single mode collimated Graded-Index (GRIN) lens probe sends and receives light from target
- Post processing of signal is done using Short-time Fourier Transform (STFT)

PDV Analysis Process

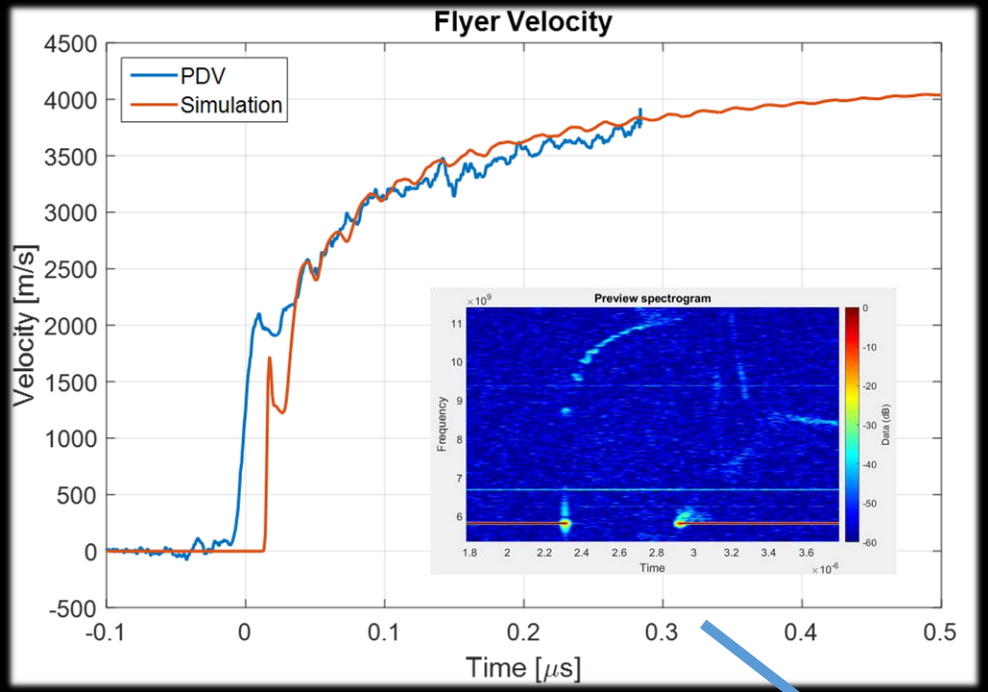
Interactive Spectrogram and Analysis

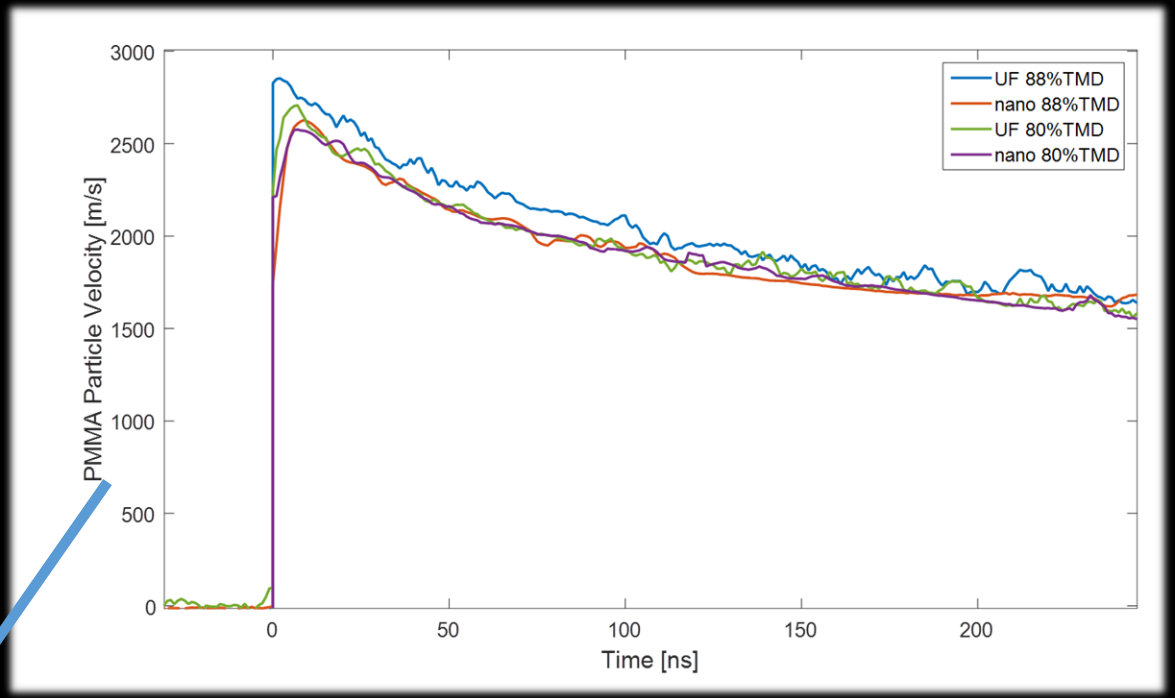


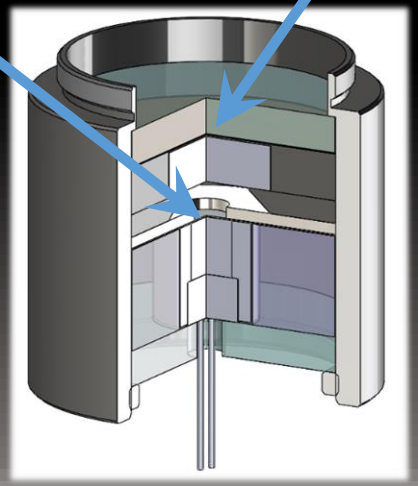




Velocimetry







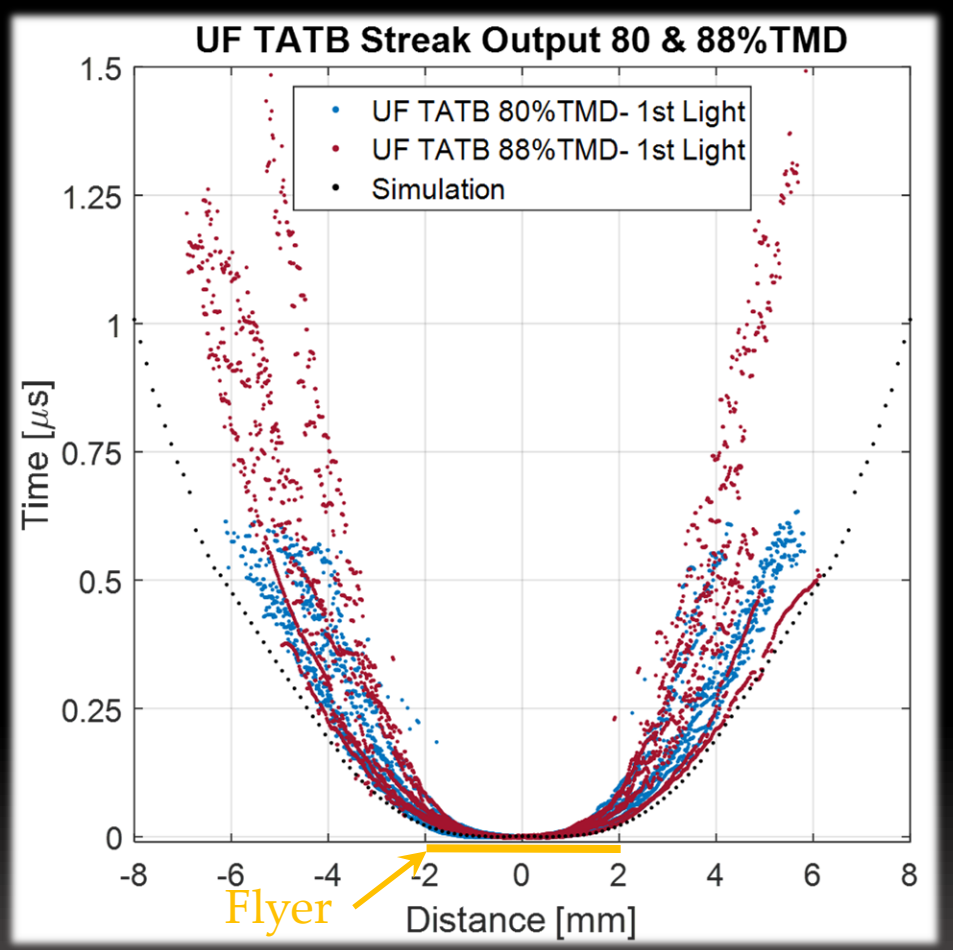
Flyer Velocity

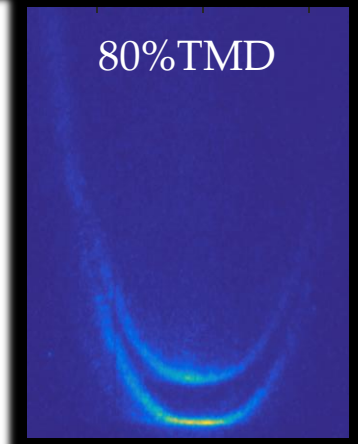
- Aluminum flyer driven by PETN Ø4mm
- PMMA window placed at pellet distance

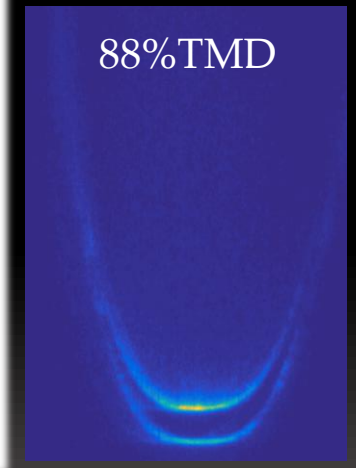
Breakout Interface Particle Velocity

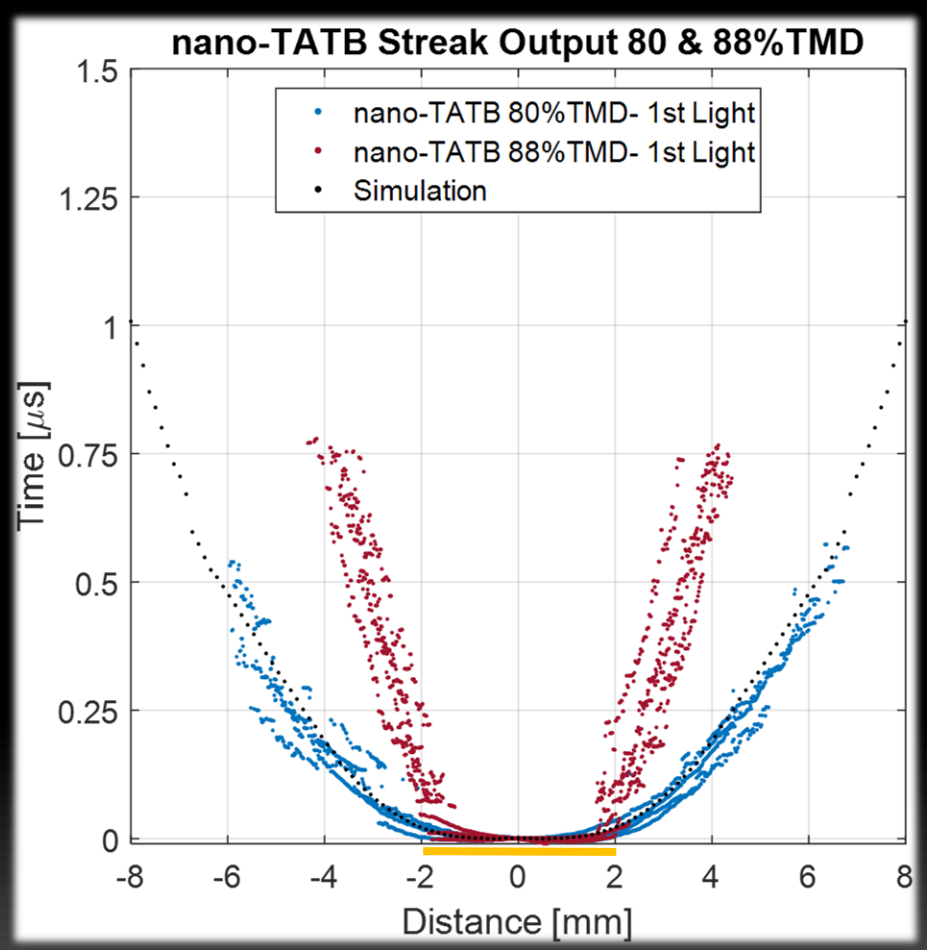
- PDV traces from the Kapton/GMB–PMMA interface
- Within 300m/s of each other

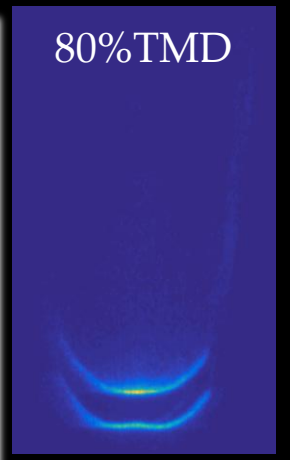
Detonation spreading

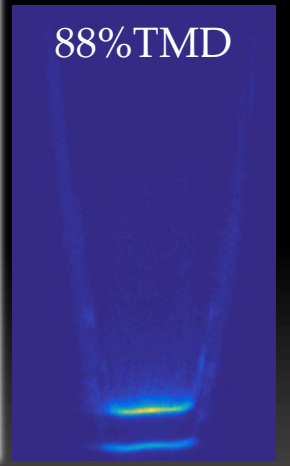






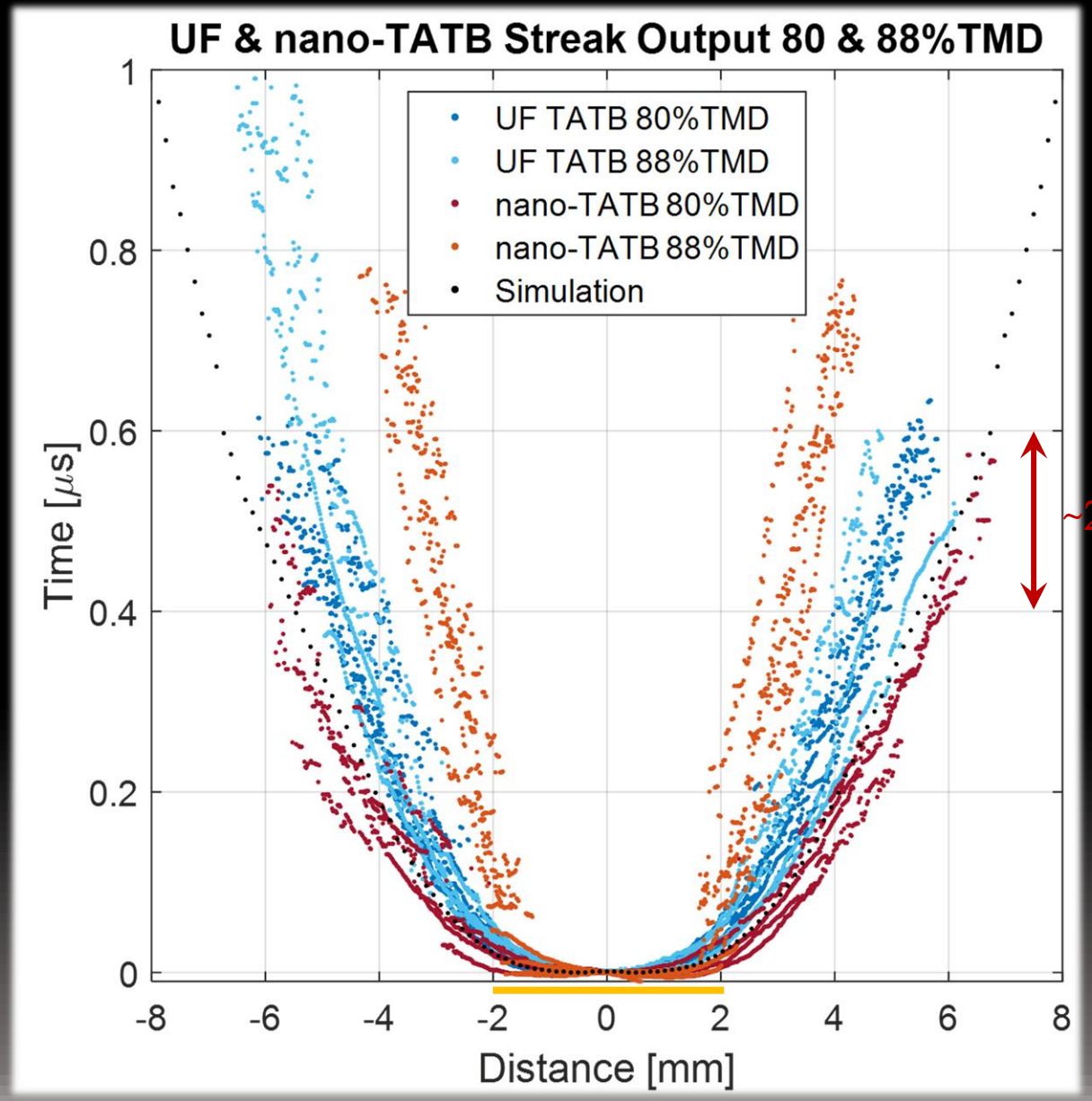




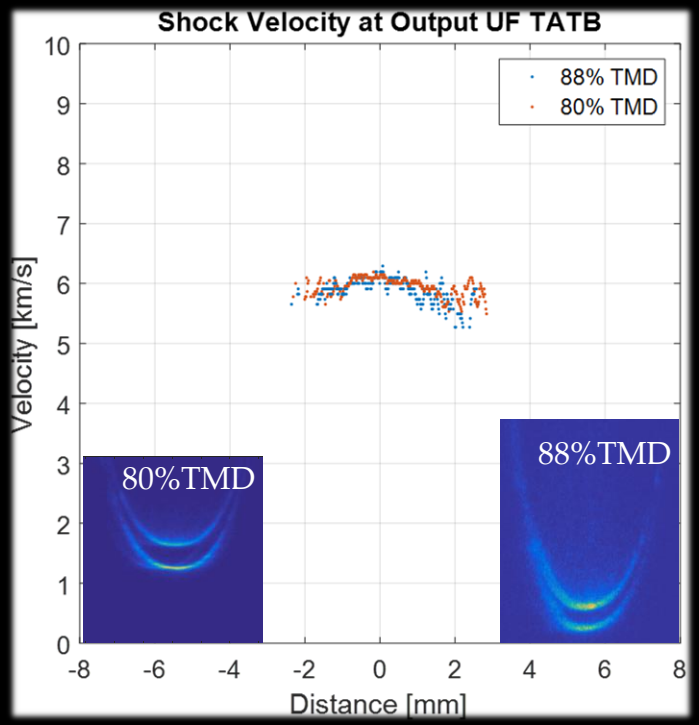


Peak extracted from Gaussian fit. 1st and 2nd light were found

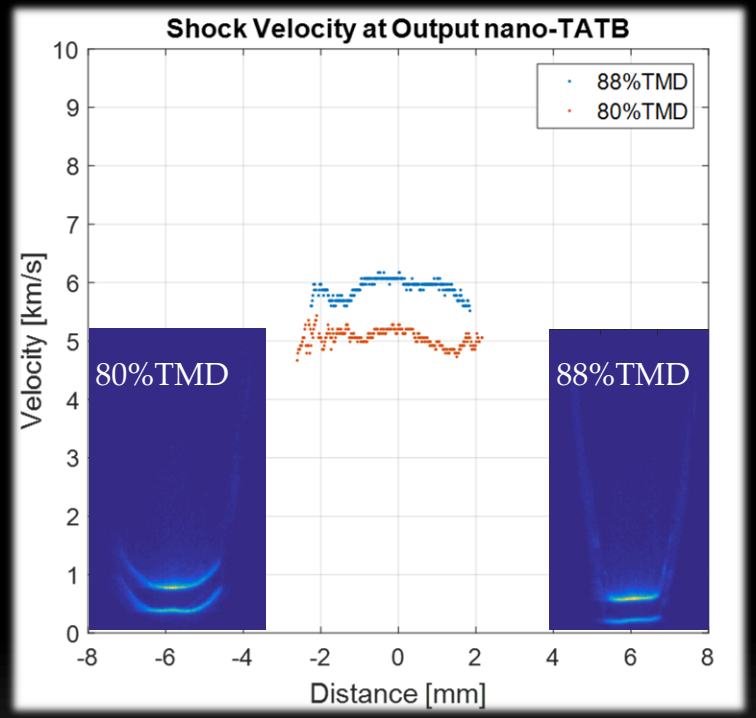
Comparison of detonation spreading



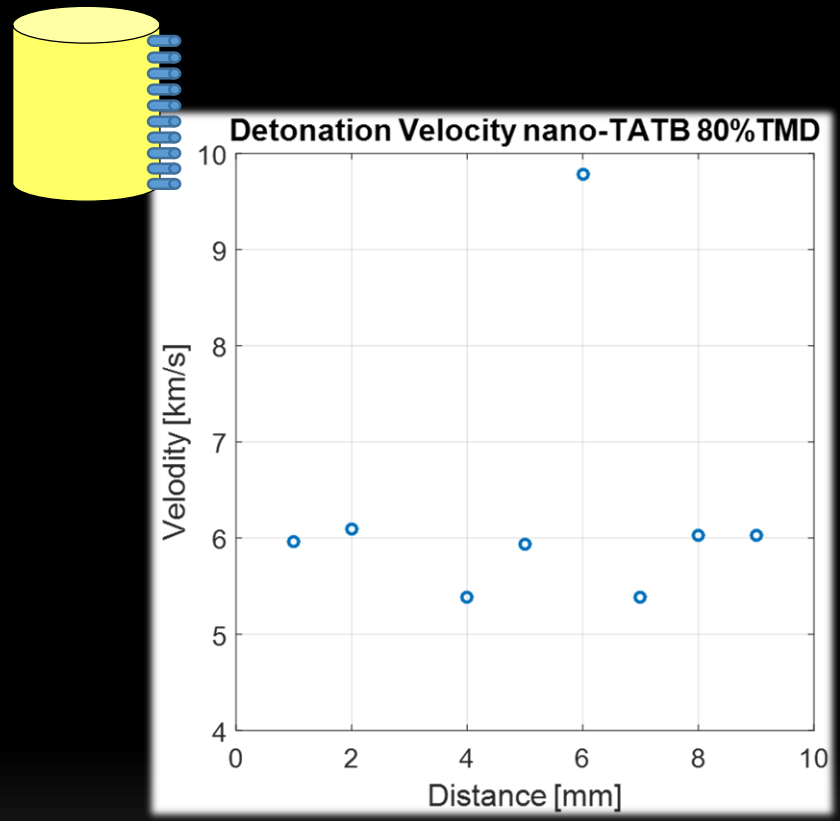
Comparison of Shock Velocity



Mean shock velocity 88%TMD=5.83km/s
80%TMD=5.93km/s



Mean shock velocity 88%TMD=6.32km/s
80%TMD=5.41km/s



Mean det. velocity =5.8318km/s
(excluding outlier)

TATB - U_S
80% TMD = 6.27km/s
88% TMD = 6.8613

LLNL Explosives Handbook Properties of Chemical Explosives and Explosive Simulants
Dobratz and Crawford, UCRL—52997, Jan. 1985

Error is due to inconsistency of film thickness.

Summary

Able to make large enough quantity to test nano-TATB

Characterized microstructure of pressed pellets

Setup floret test, similar to previous work, to measure detonation spreading

Currently tuning burn model parameters based on experimental results