

Characterization of Hypervelocity Fragments and Subsequent HE Initiation



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#High Explosives Science and Technology

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PRESENTED BY

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Motivation: HE initiation by fragment impact

$t = 0.2 \mu\text{s}$

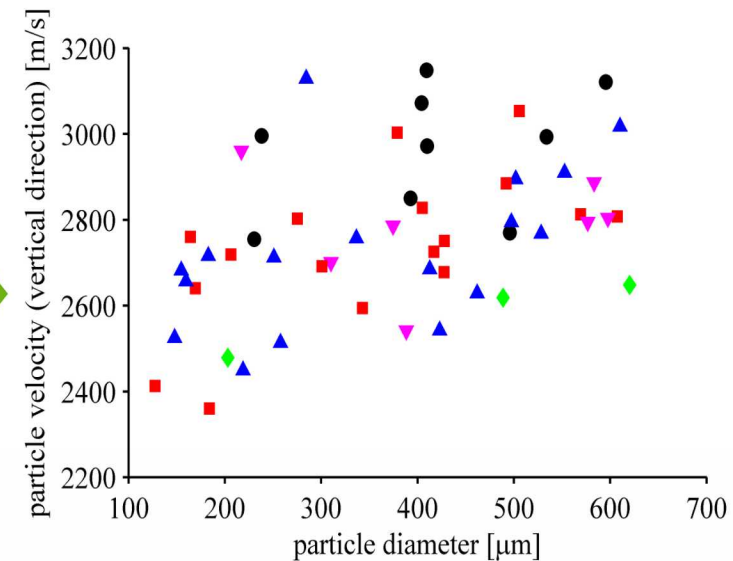
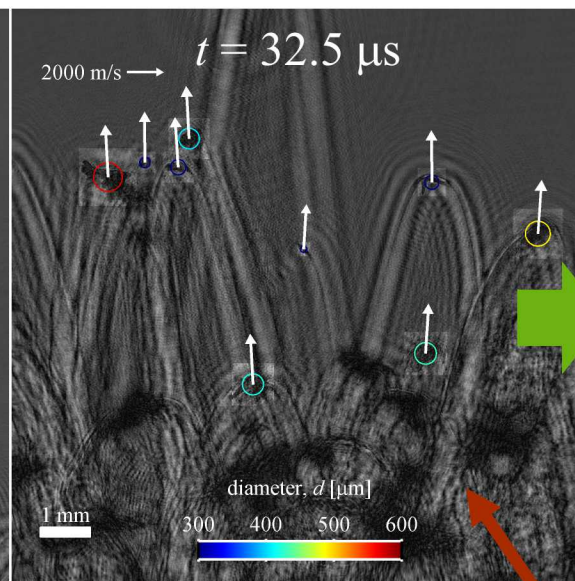
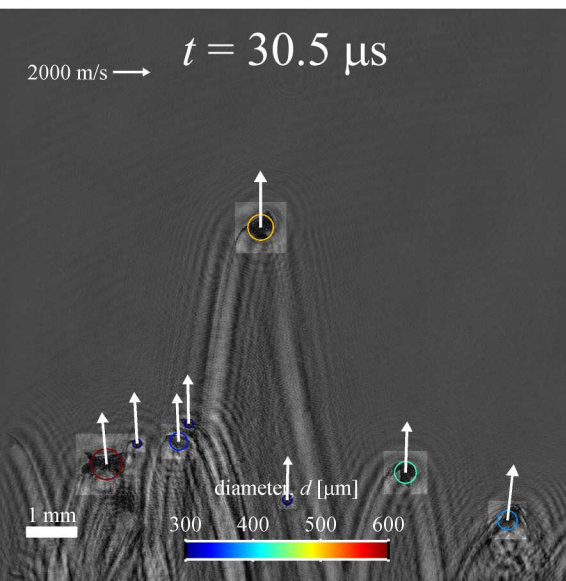
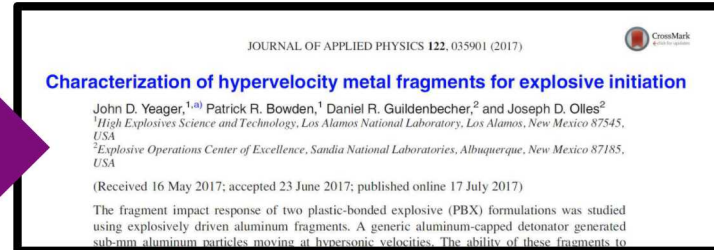
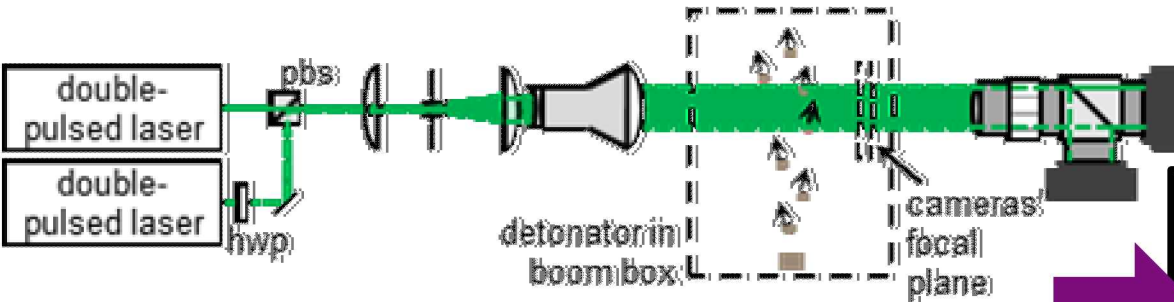
Fragmenting detonator



Recorded at 5 MHz using
Shimadzu HPVX backlit
with pulsed laser diode

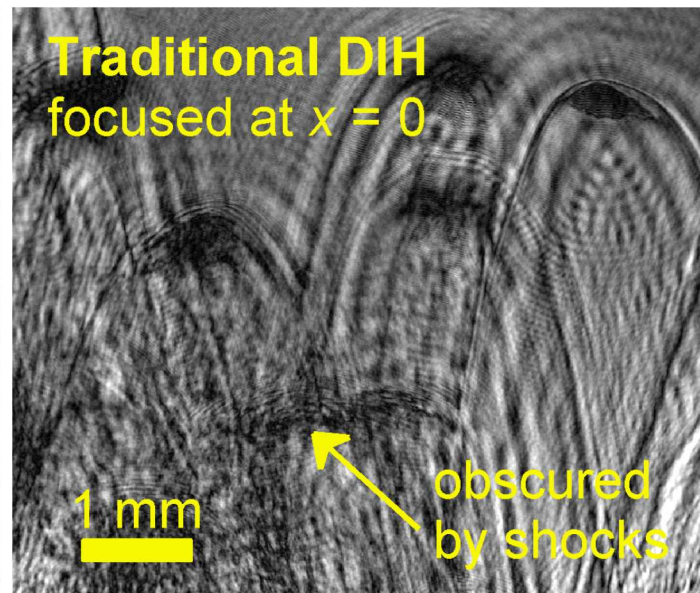
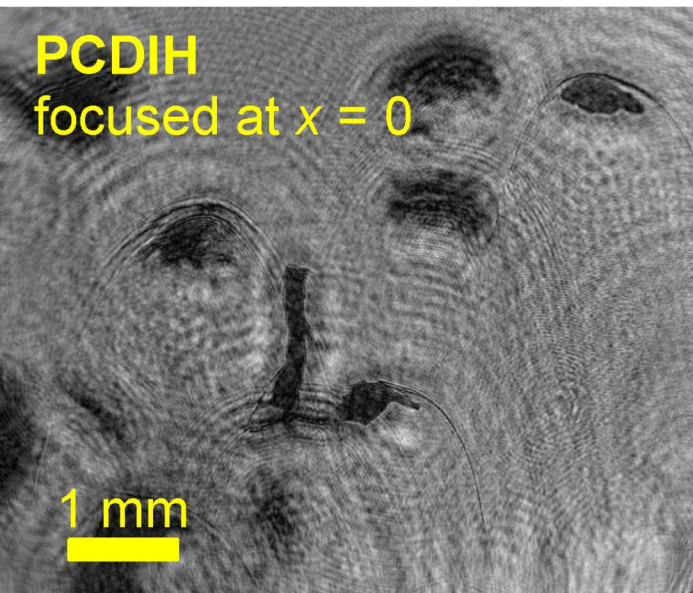
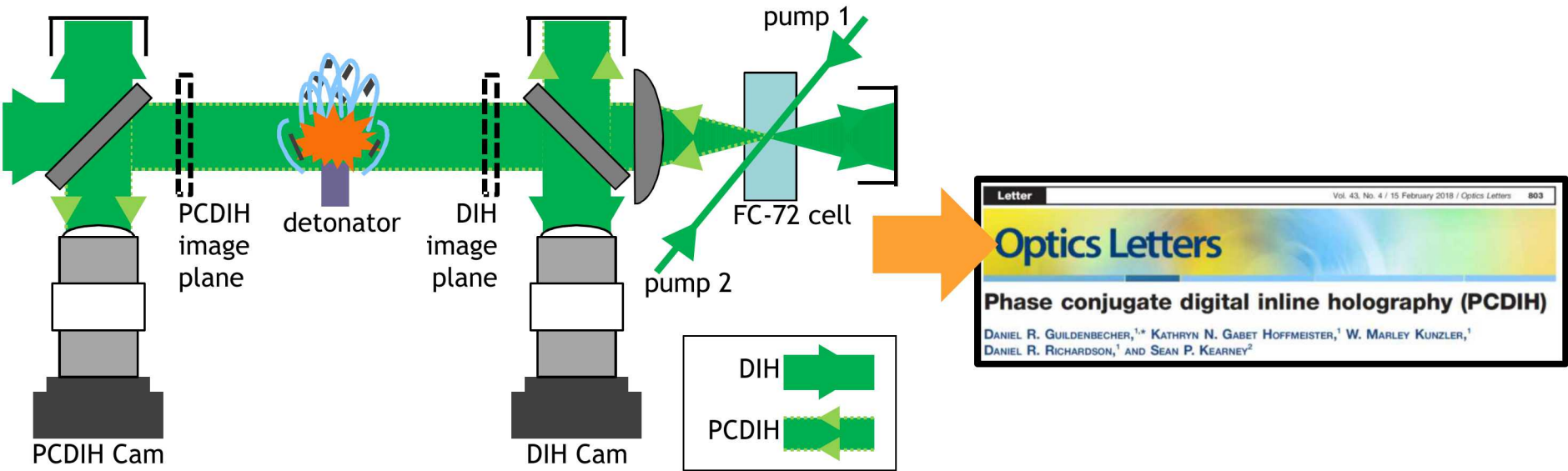
PBX 9407

Previous work: Digital Inline Holography (DIH)



Challenge: downstream particles obscured by shock-waves

Previous work: Phase conjugate DIH



Challenge: time resolution requires new laser sources

$$t = 31.2 \mu\text{s}$$

Advantages:

1. Time resolution (up to 10 MHz)
2. Limited susceptibility to shock-waves
3. Relatively simple optical configuration

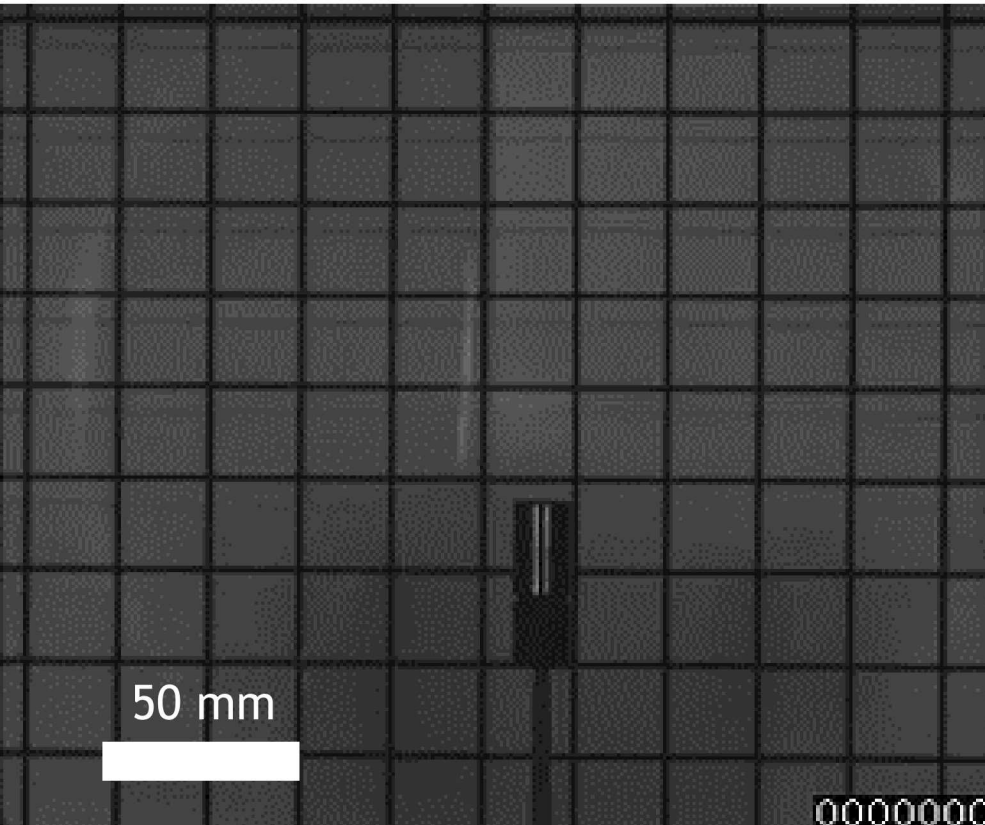
Goals:

1. Quantify strain and fragmentation
2. Study PBX initiation
3. Explore larger scales

6 Process statistics must be captured

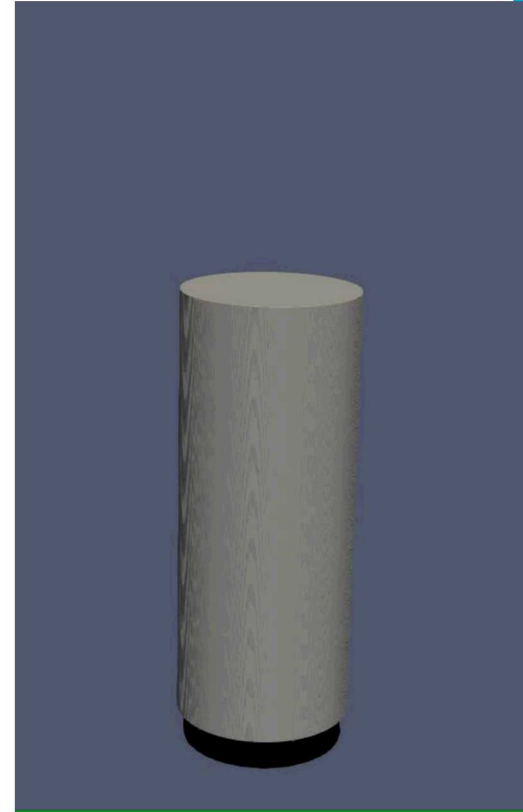
Fragmentation and impact are highly stochastic:

- Experiments on all relevant conditions is impossible
- Models of fragmentation and impact are needed
- Commercial dets are cost-effective for model V&V



RISI RP-80

Video courtesy A. Baca, SNL
CTH sim courtesy F Perez, SNL

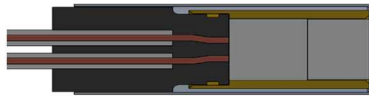


7 Case strain at 5 MHz

Digital Image Correlation (DIC)

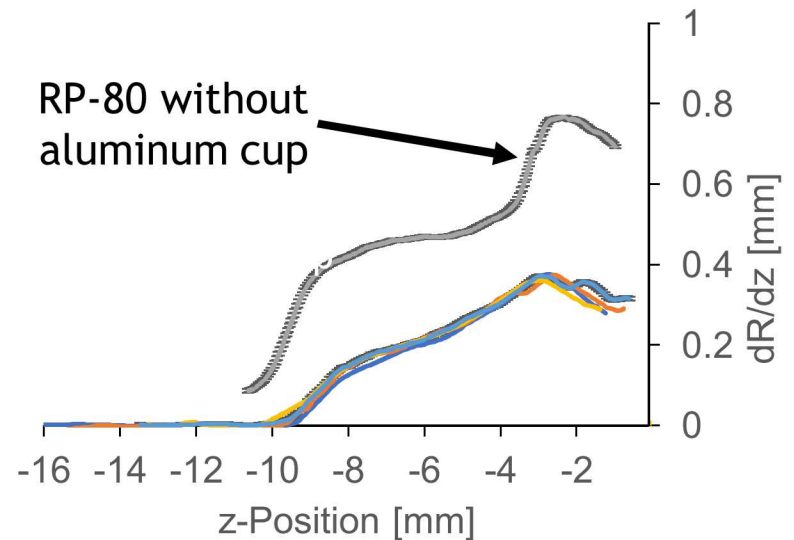
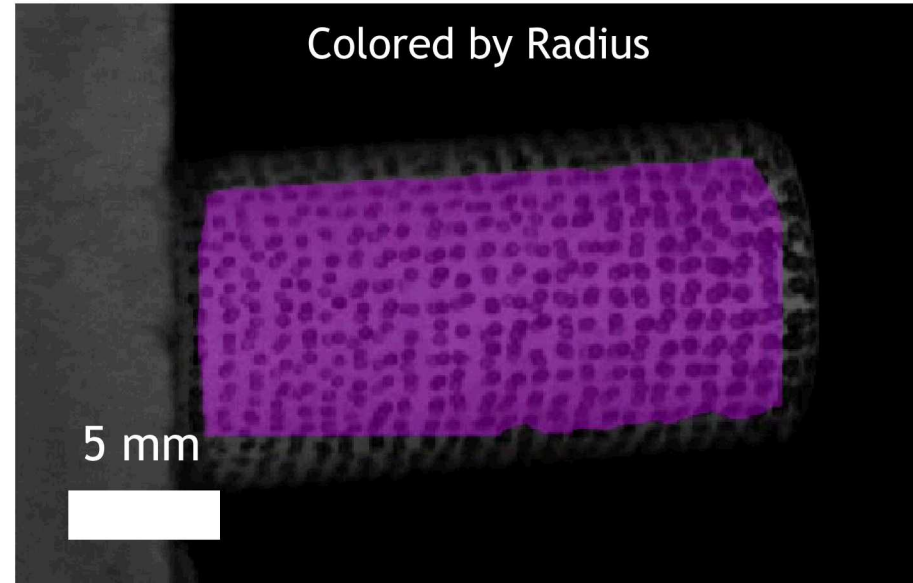
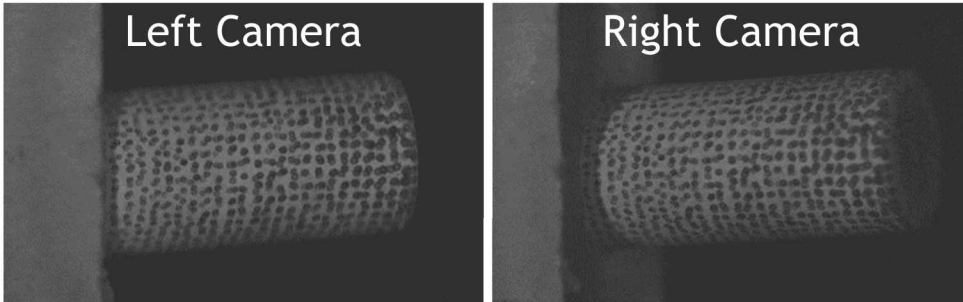
Full-field surface tracking for solid mechanics investigations

RP-80 Detonator



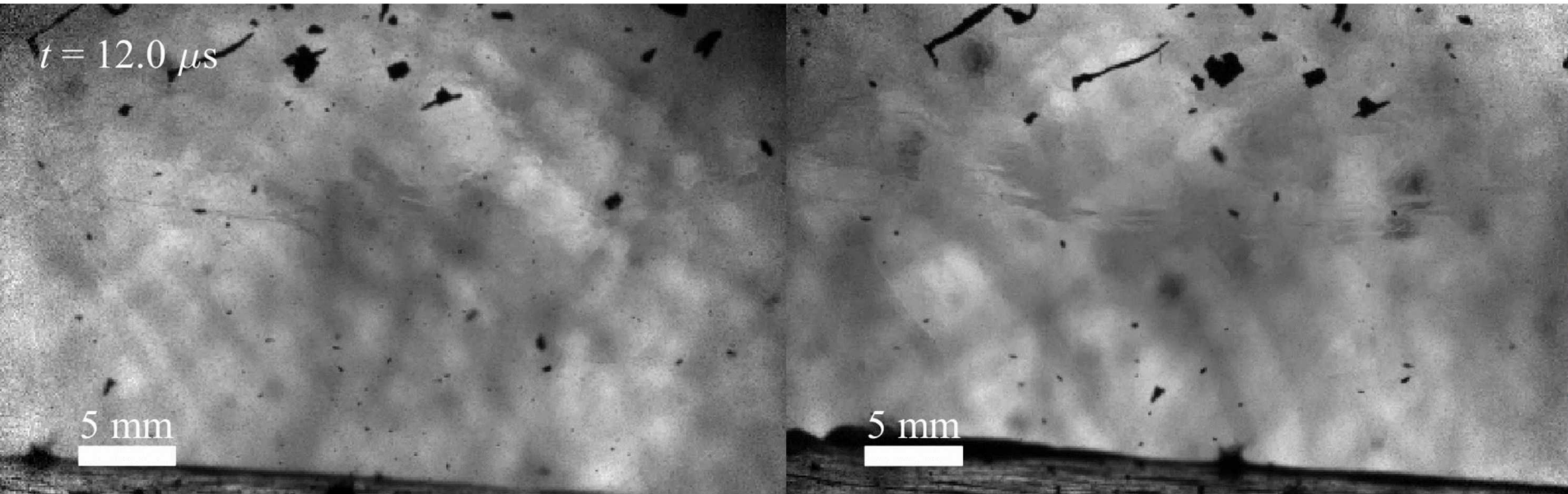
Left Camera

Right Camera



8 Fragment tracking at 2 MHz

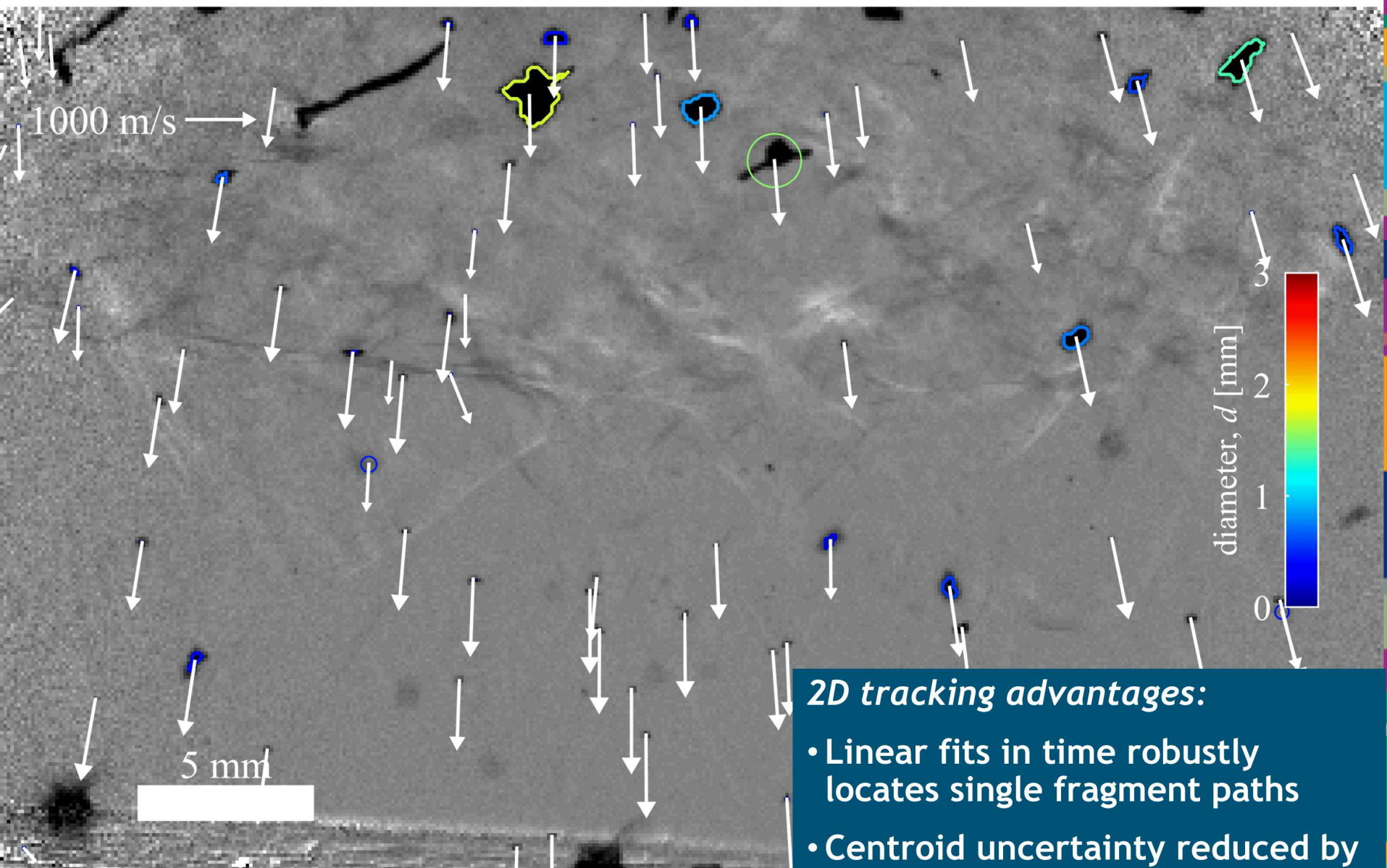
Experimental configuration: Stereo camera setup essentially identical to DIC



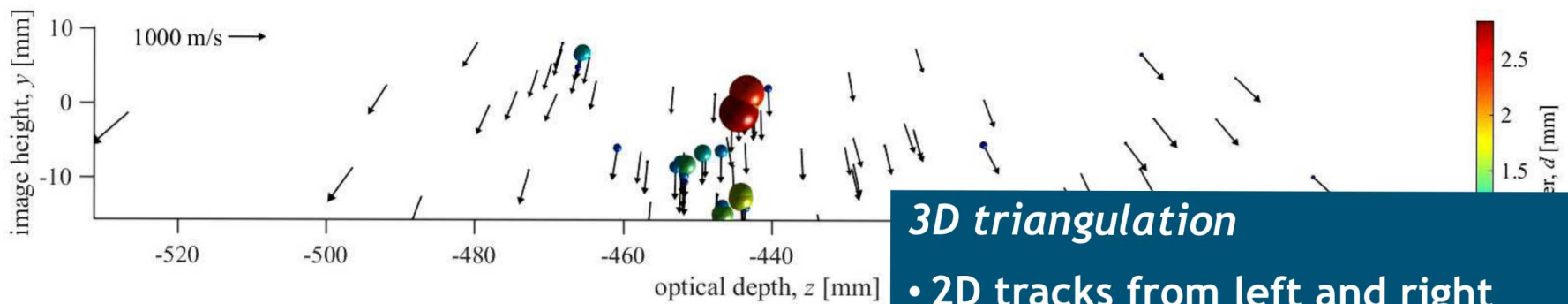
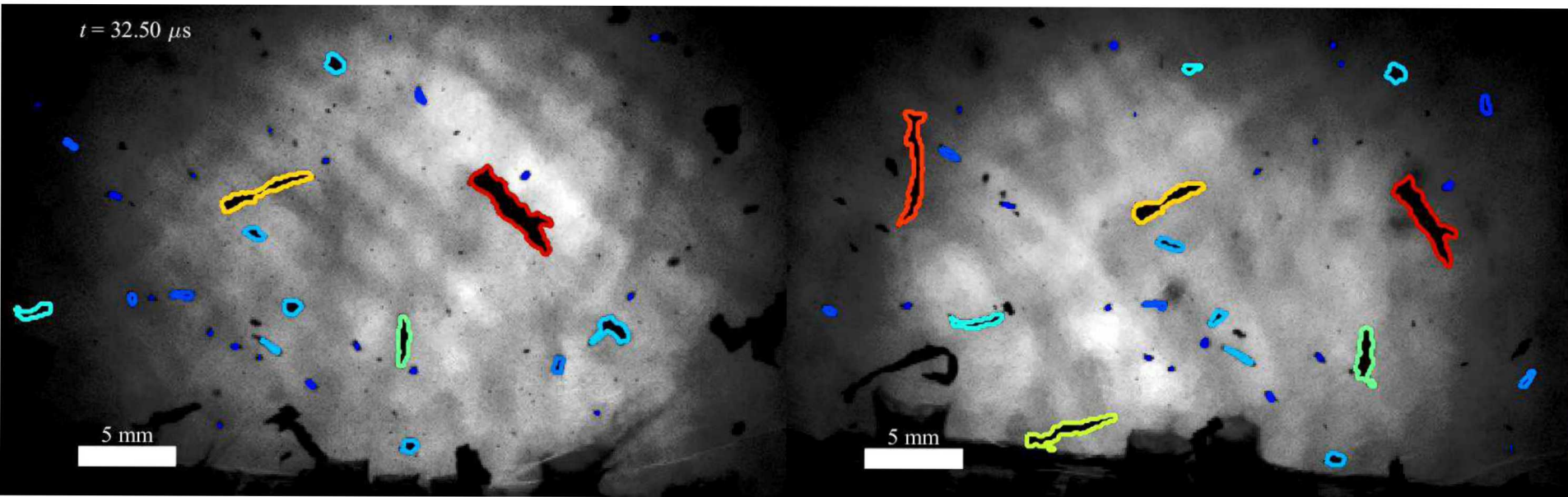
Three-step custom data processing:

1. Image segmentation using typical image processing routines
2. 2D tracking (next slide)
3. 3D triangulation

Fragment tracking at 2 MHz



Fragment tracking at 2 MHz

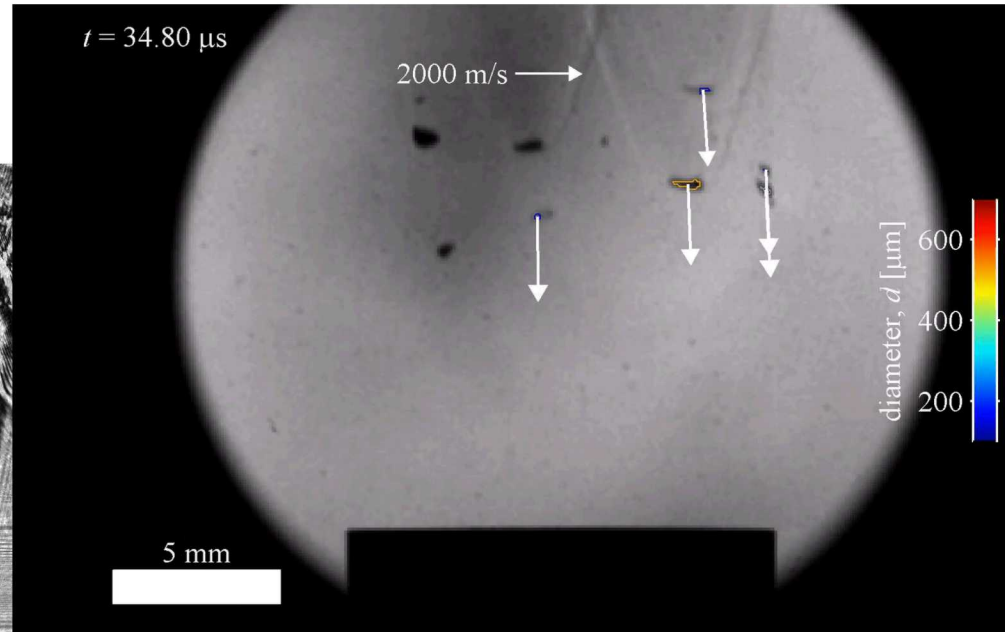
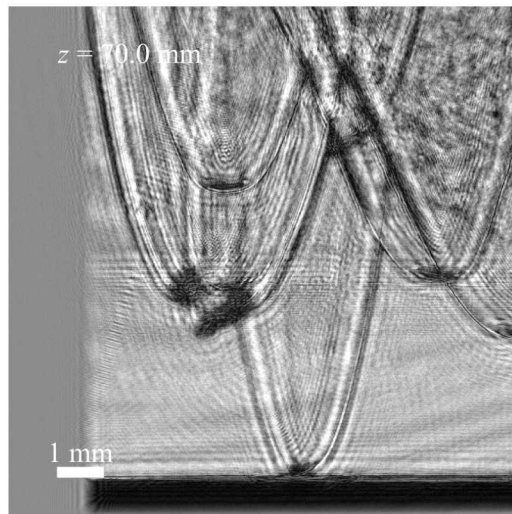
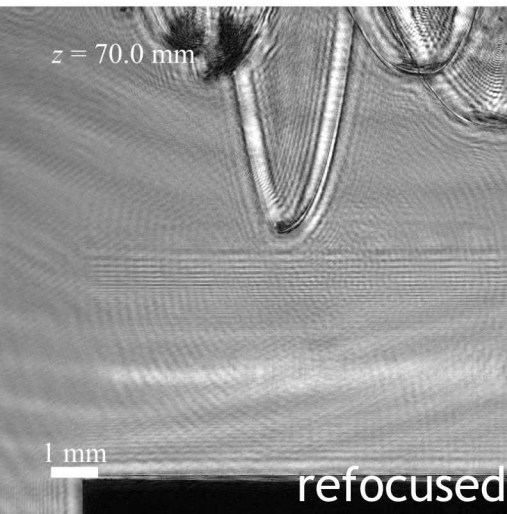
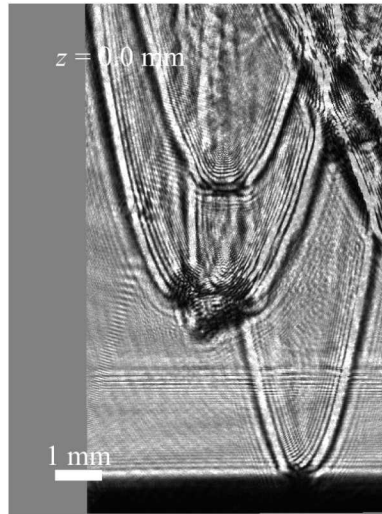
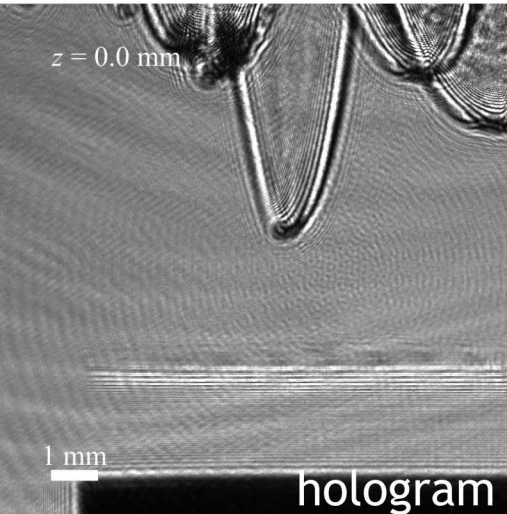


3D triangulation

- 2D tracks from left and right cameras triangulated to get 3D
- Trajectories eliminated which do not extrapolate back to start

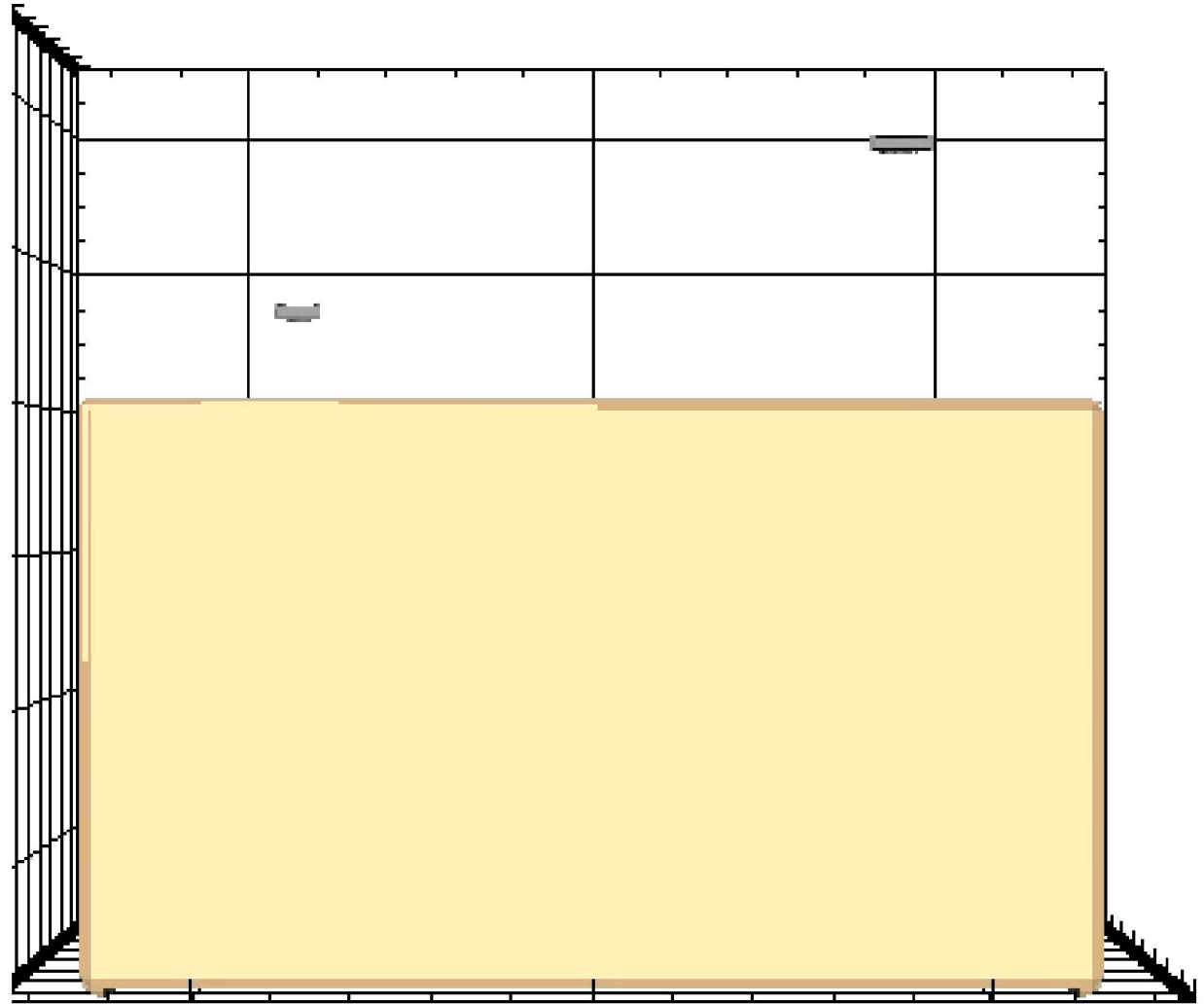
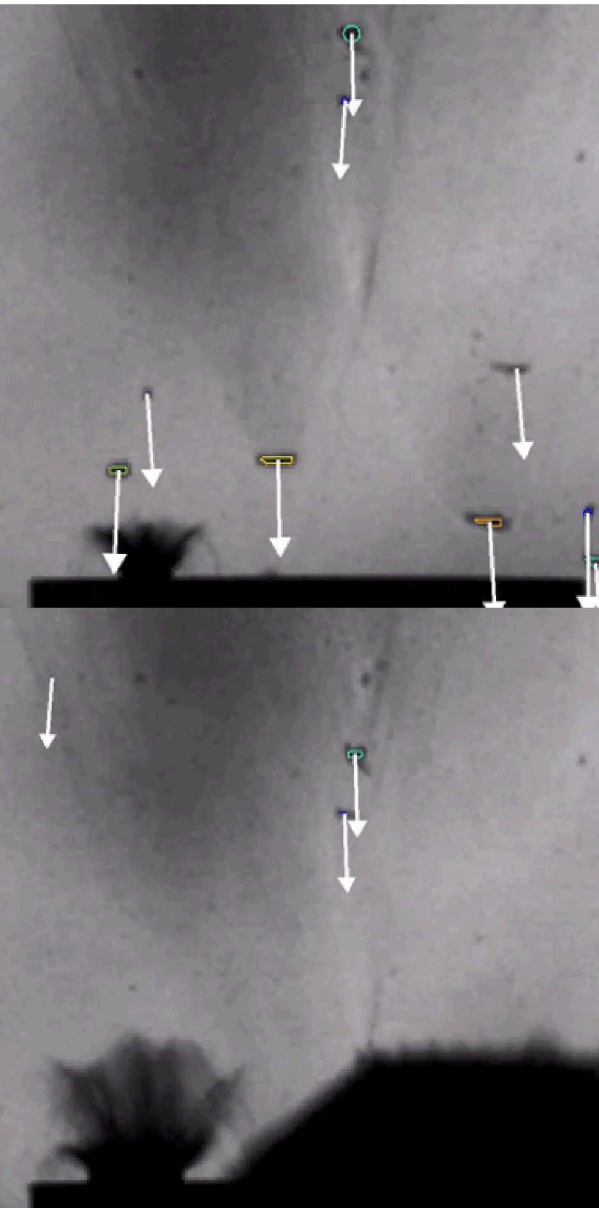
Integration for HE impact experiments

Simultaneous DIH and high-speed imaging



Next Steps:

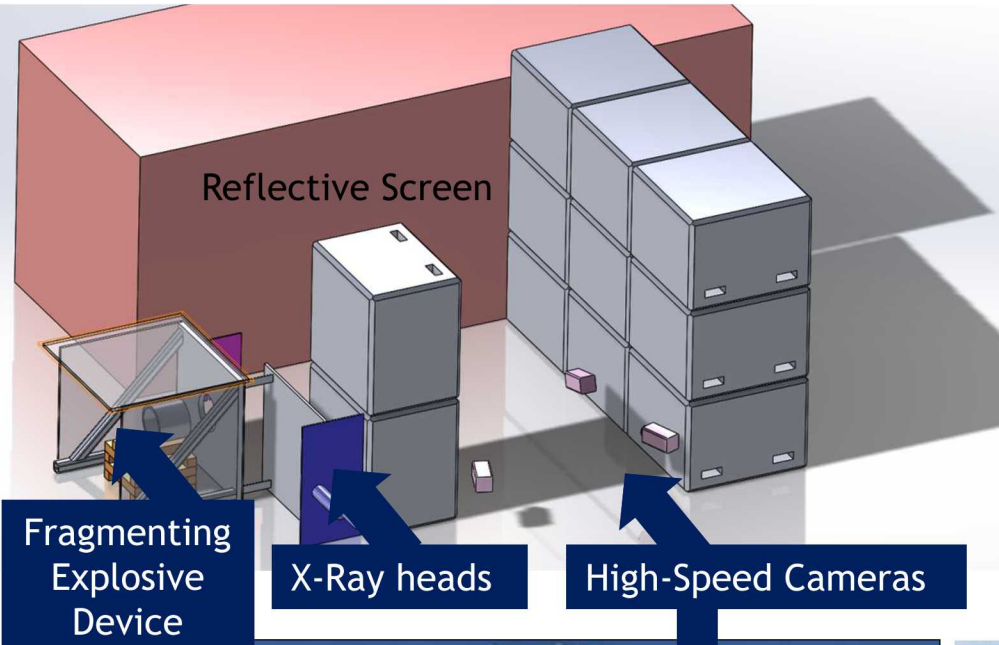
1. Stereo tracking to pinpoint multi-fragment initiation
2. Repeat RP-80 experiments to explore fragmentation statistics
3. Exploring other ideas to quantify shock-convergence within the PBX



Initial CTH simulation captures the observed go/no-go of this shot (courtesy A. R. Garcia, SNL)

Towards Full-scale Fragmentation Experiments

~10 pound fragmenting explosive device at SNL



~10 pound fragmenting explosive device at SNL

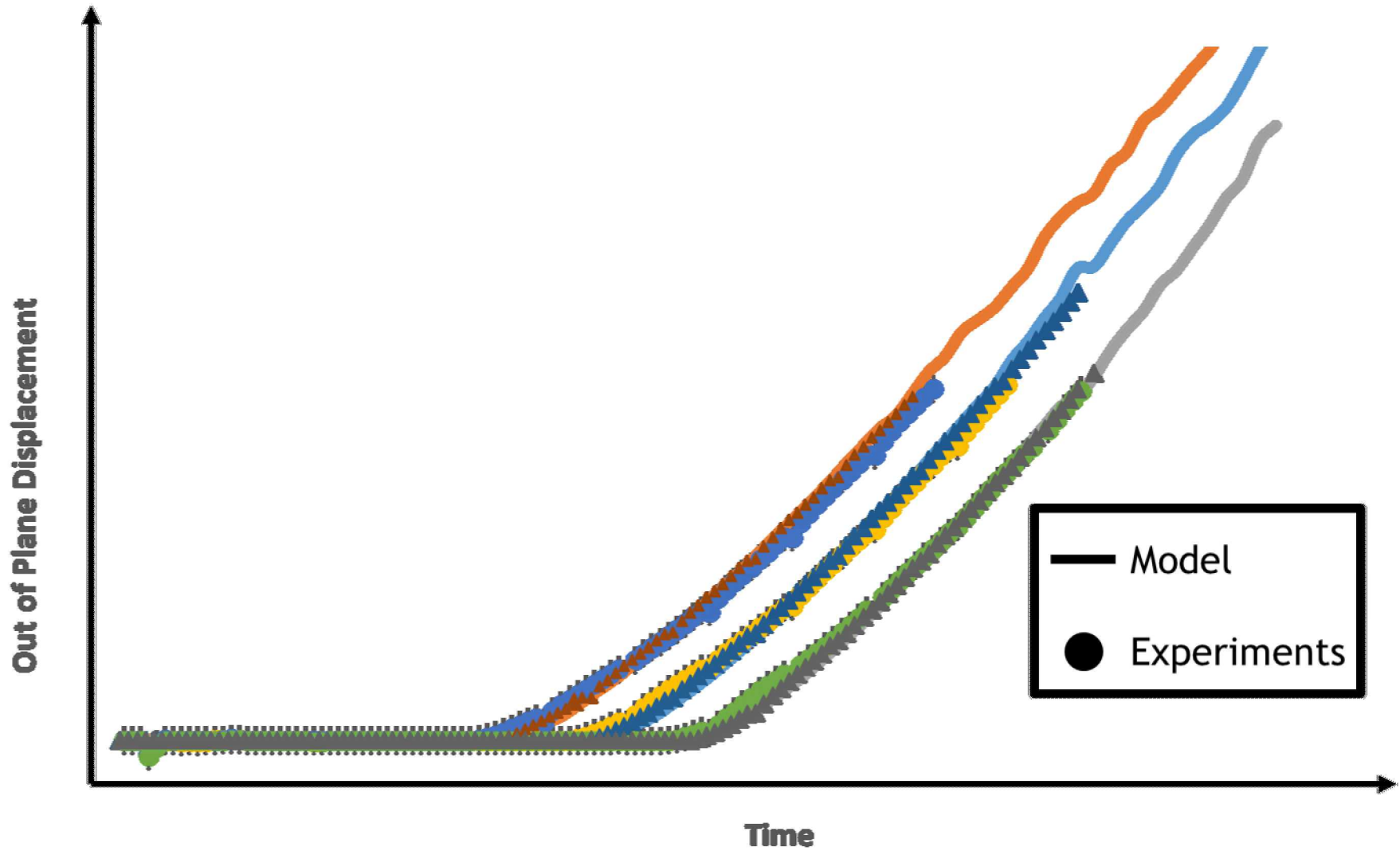
DIC Imaging (P. Reu, T. Miller)



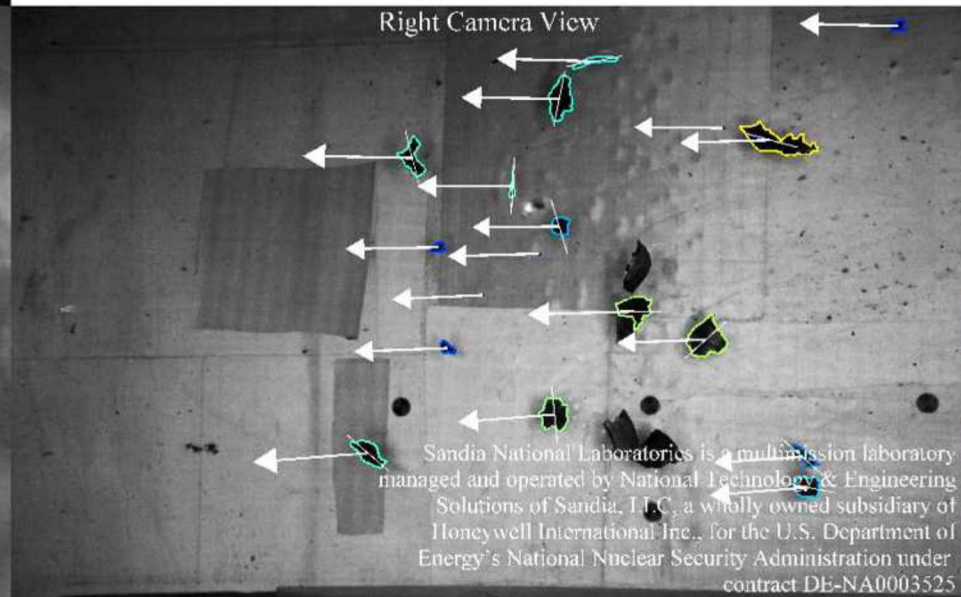
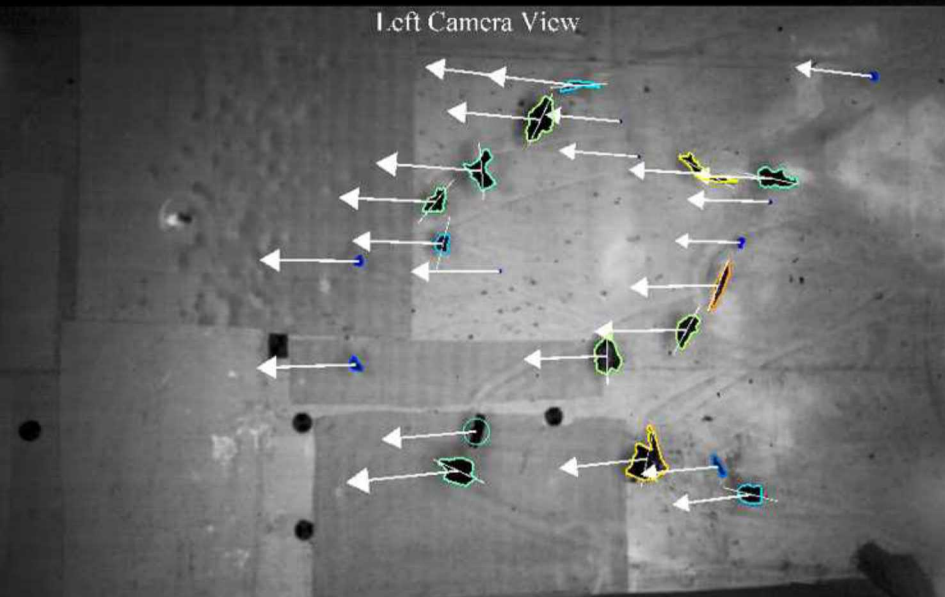
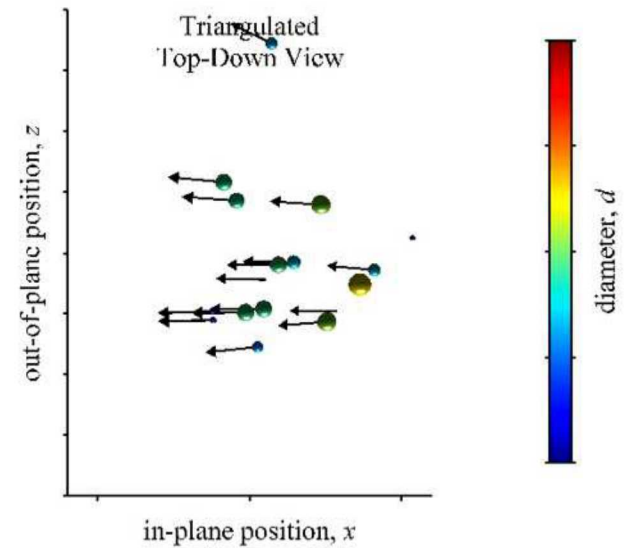
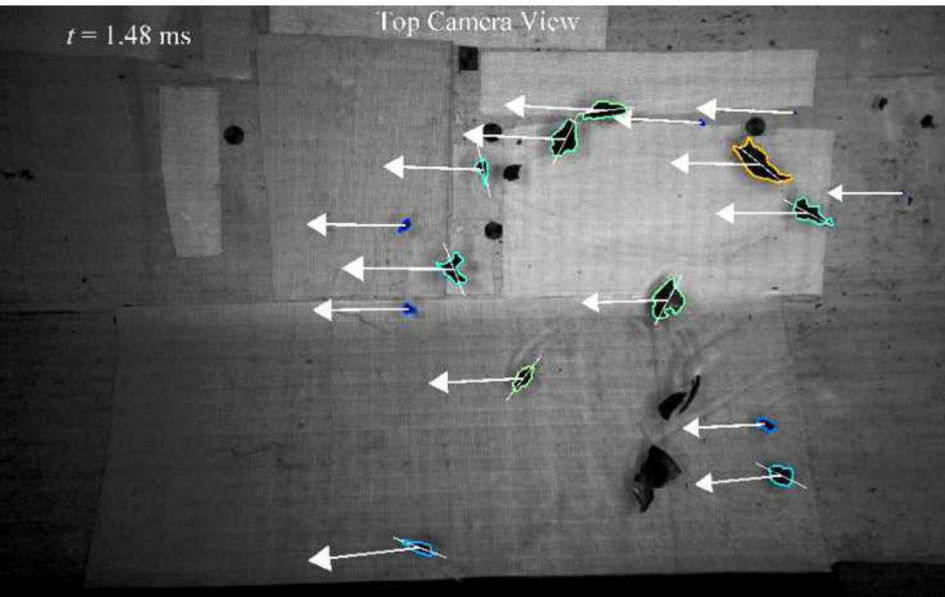
Simulation (R. Teeter)
Hydrocode + solid mechanics



~10 pound fragmenting explosive device at SNL



~10 pound fragmenting explosive device at SNL



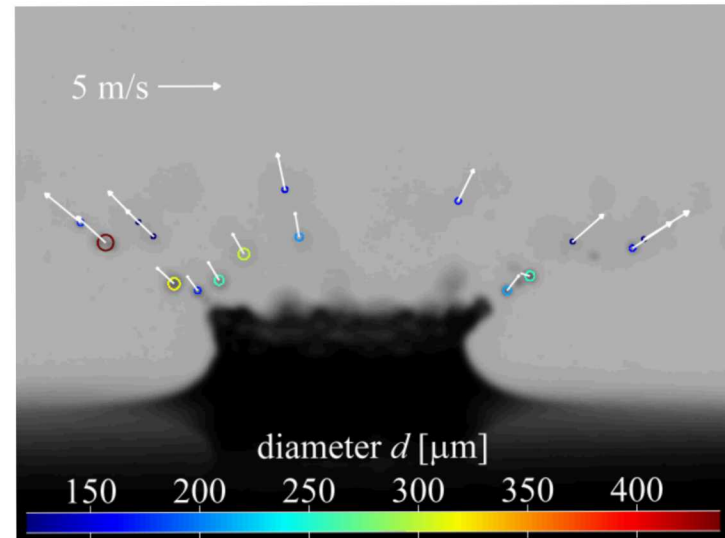
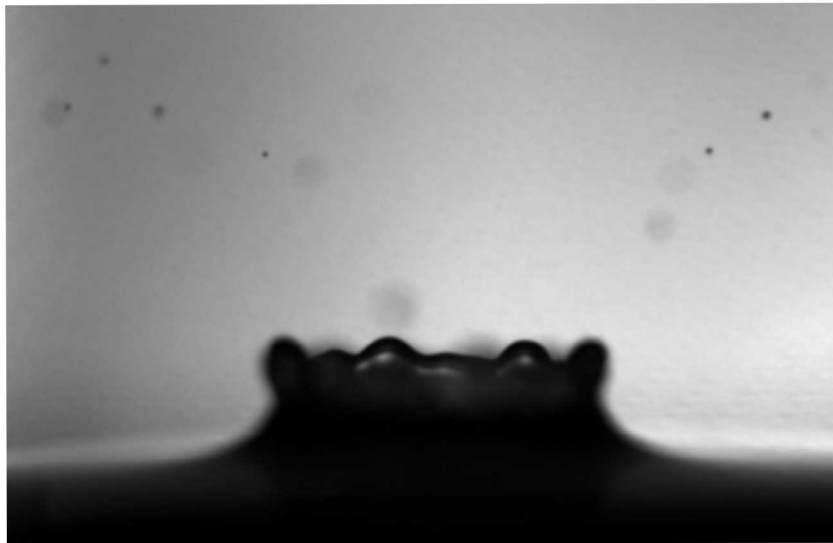
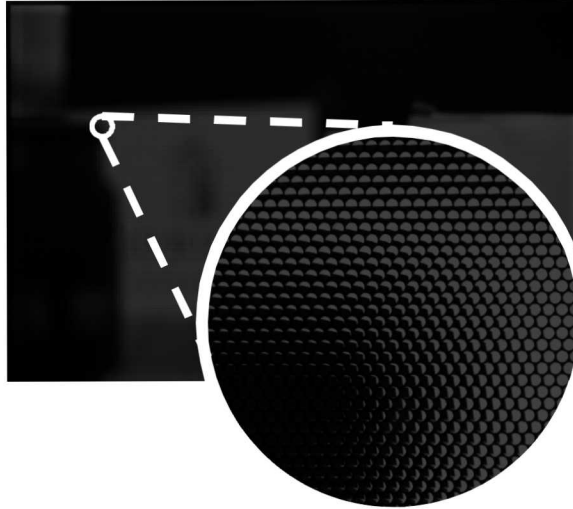
A black and white photograph of a hand holding a lit flare. The flare is bright and glowing, with a large amount of sparks and light radiating from its tip. The word "Questions?" is overlaid in white text in the center of the image.

Questions?

Backup

Alternative 3D diagnostics?

Plenoptic cameras use micro-lens arrays and white light to create a 3D image



Plenoptic Imaging of a RP-80 detonator

$t = 52 \mu\text{s}$

10 mm

3D plenoptic image at $t = 52 \mu\text{s}$

10 mm