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Experimental investigation of the breakup of a round liquid jet in a shock-induced crossflow

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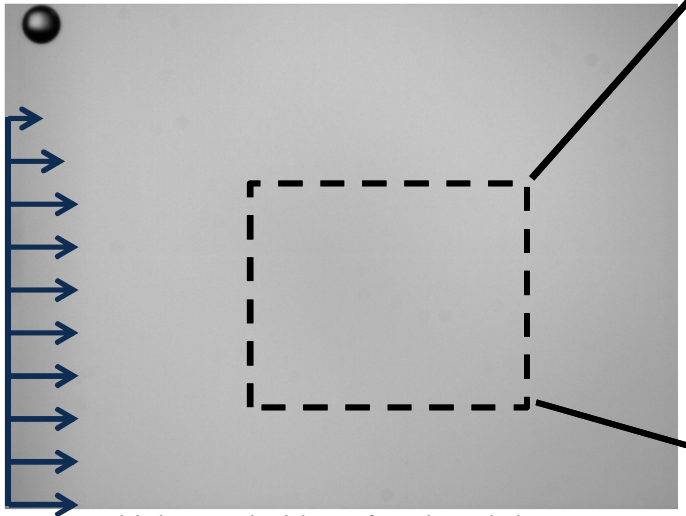
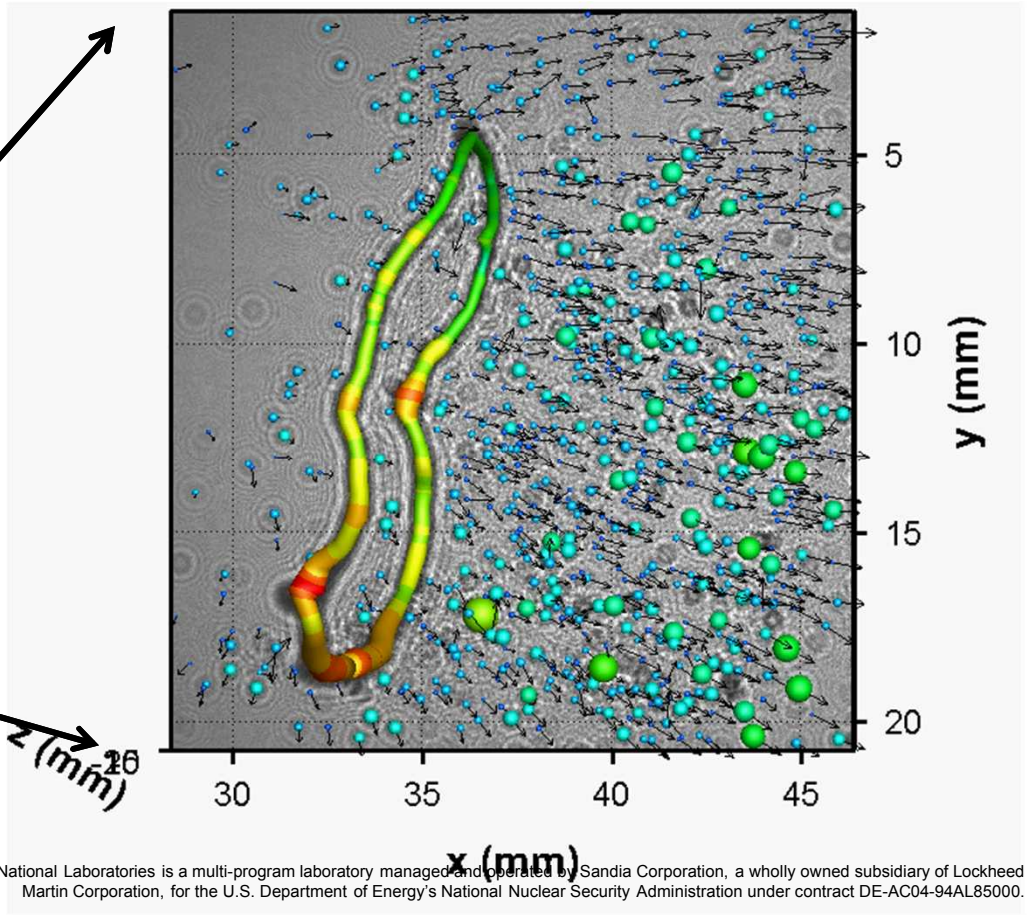
Motivation

- Large effort in modeling of liquid breakup
  - Shocked jet is easier to produce vs. drops
- Reproducible experiment with well defined conditions
- Liquid subjected to crossflow with diagnostics to increase resolution
- Validation experiments with advanced diagnostics
- Instabilities



high-speed video of a ethanol drop in an air-stream



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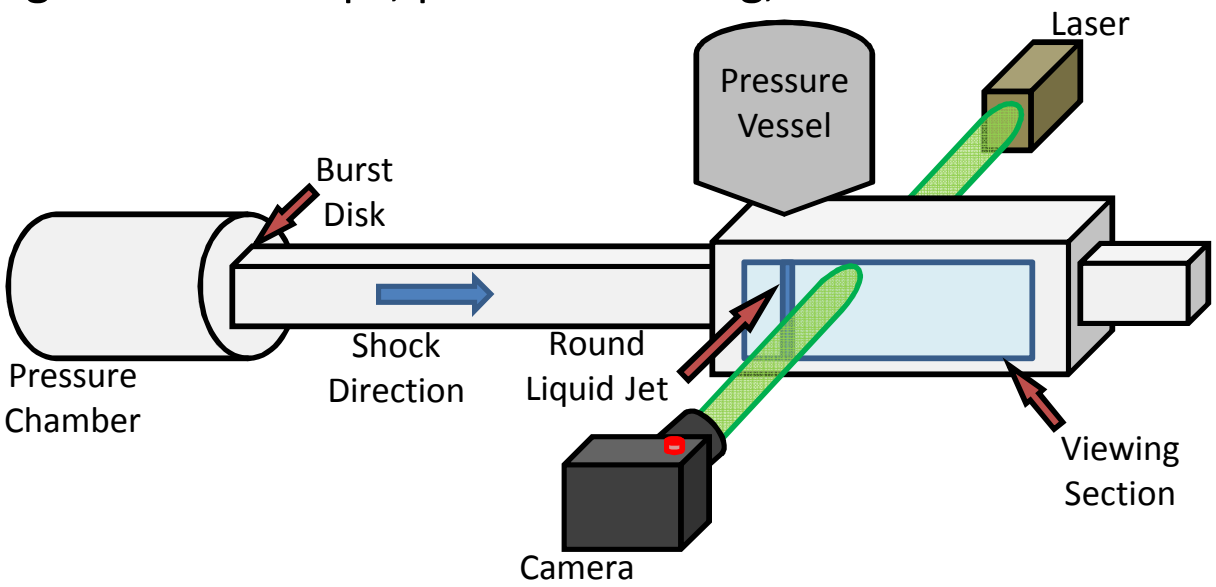
Experimental setup

- Liquid jet – pressure vessel driven
- Shock tube –velocity measured with PIV
- Imaging/holography
- Parameter space – backlit @ 40k fps, length of visualization (3+inches), FoV (measure from image), burst disk pressures (velocity)
- R-T instability – planar result, cylindrical measured results
- Holograms – 100k fps, particle tracking, velocities



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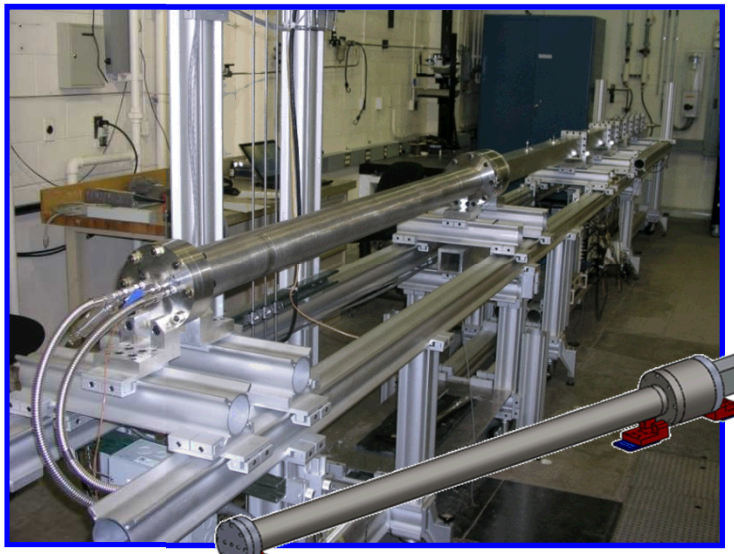
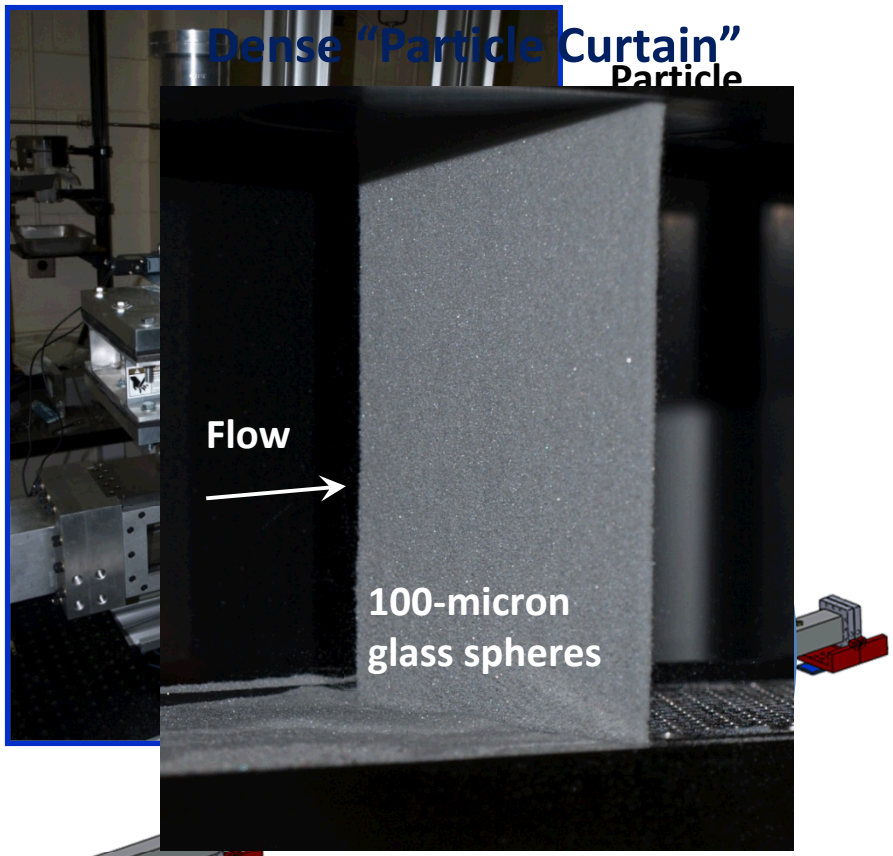
Shock tube characterization

Multiphase shock tube facility

- Allows study of shock-particle interactions in dense gas-solid flows.
- Shock Mach #s up to about 2, driven section at atmosphere
- 76 mm × 76 mm test section





Particle volume fraction ≈ 20%

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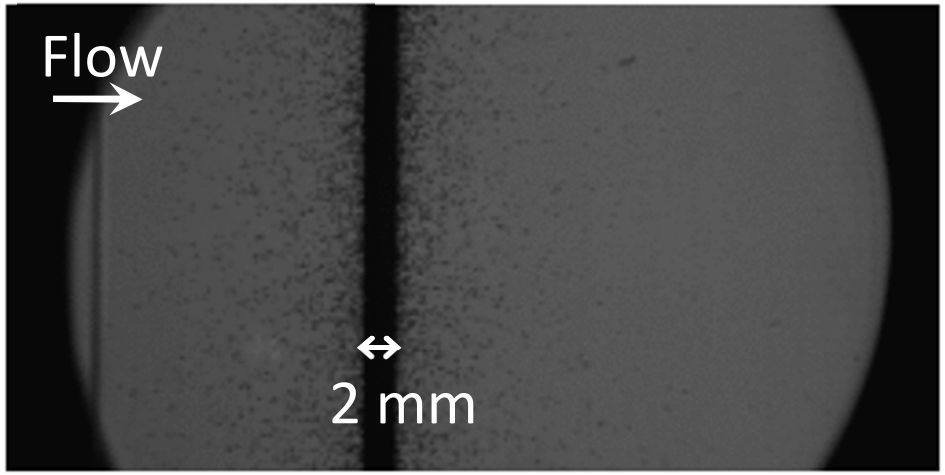
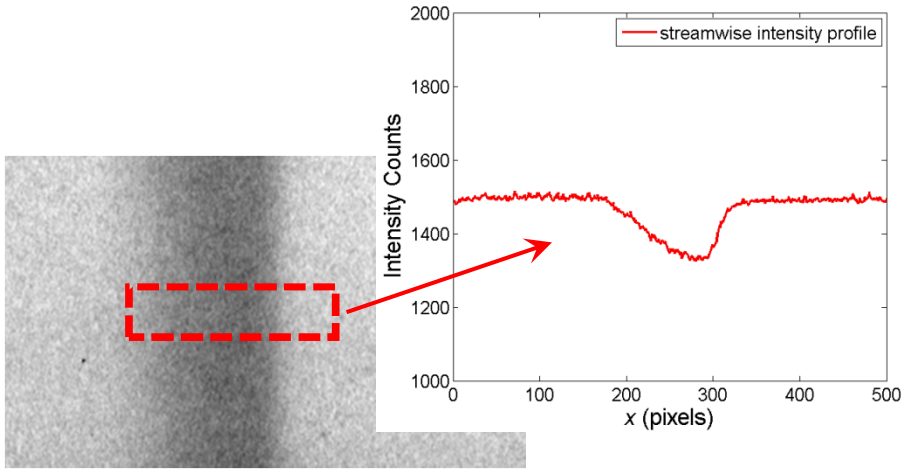
Shock tube characterization

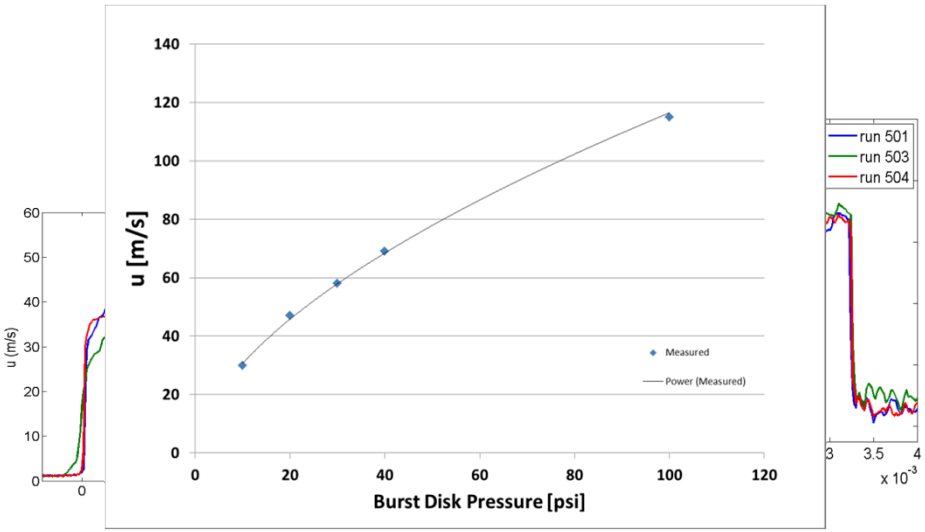
Interaction at shock
Mach number = 1.67



Interaction Radiographs (Flash X-Ray)



Extract Convective Flow Velocities



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High speed backlit images

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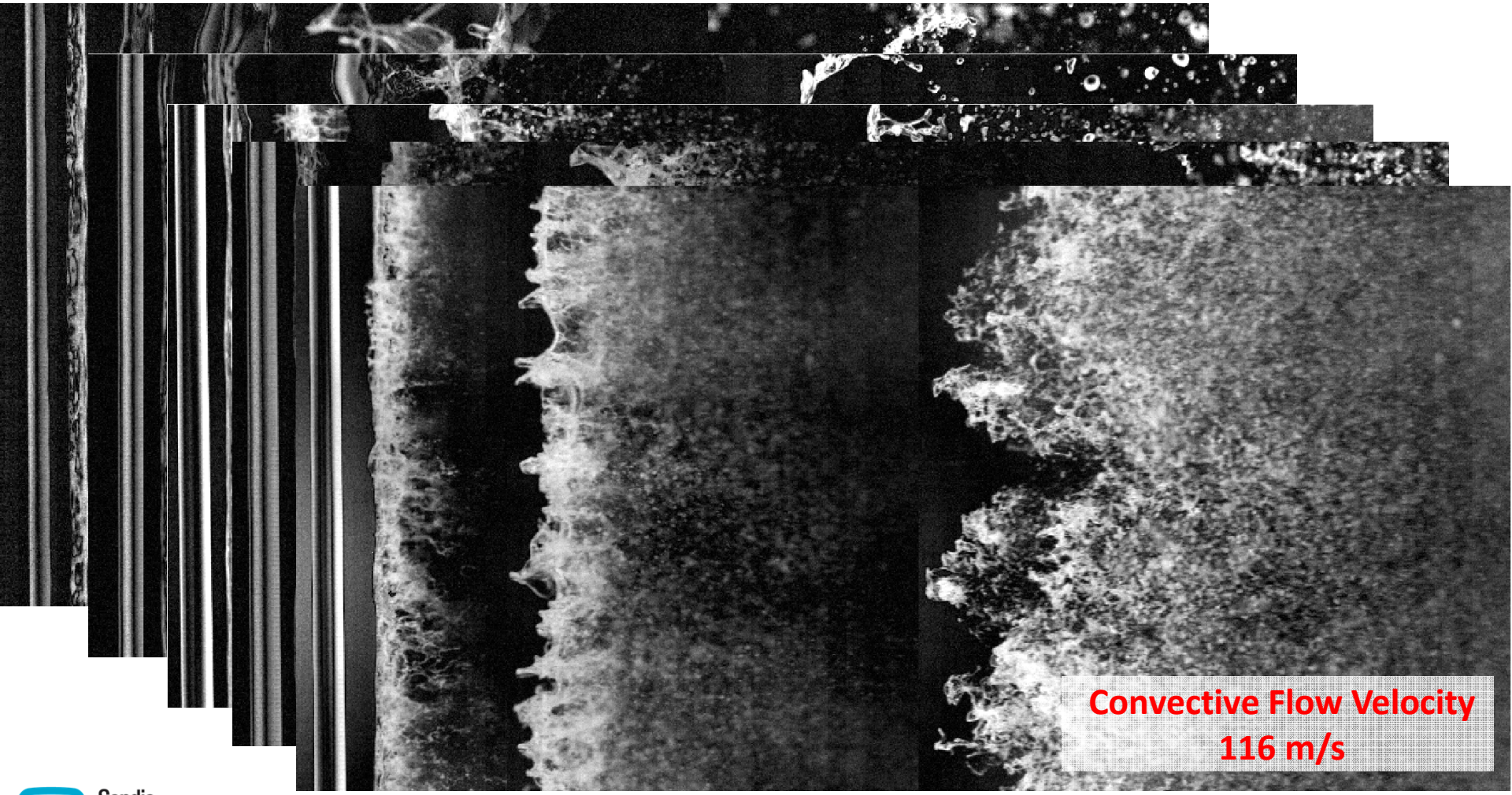
High speed backlit images

- Progression of jet, varying input velocity



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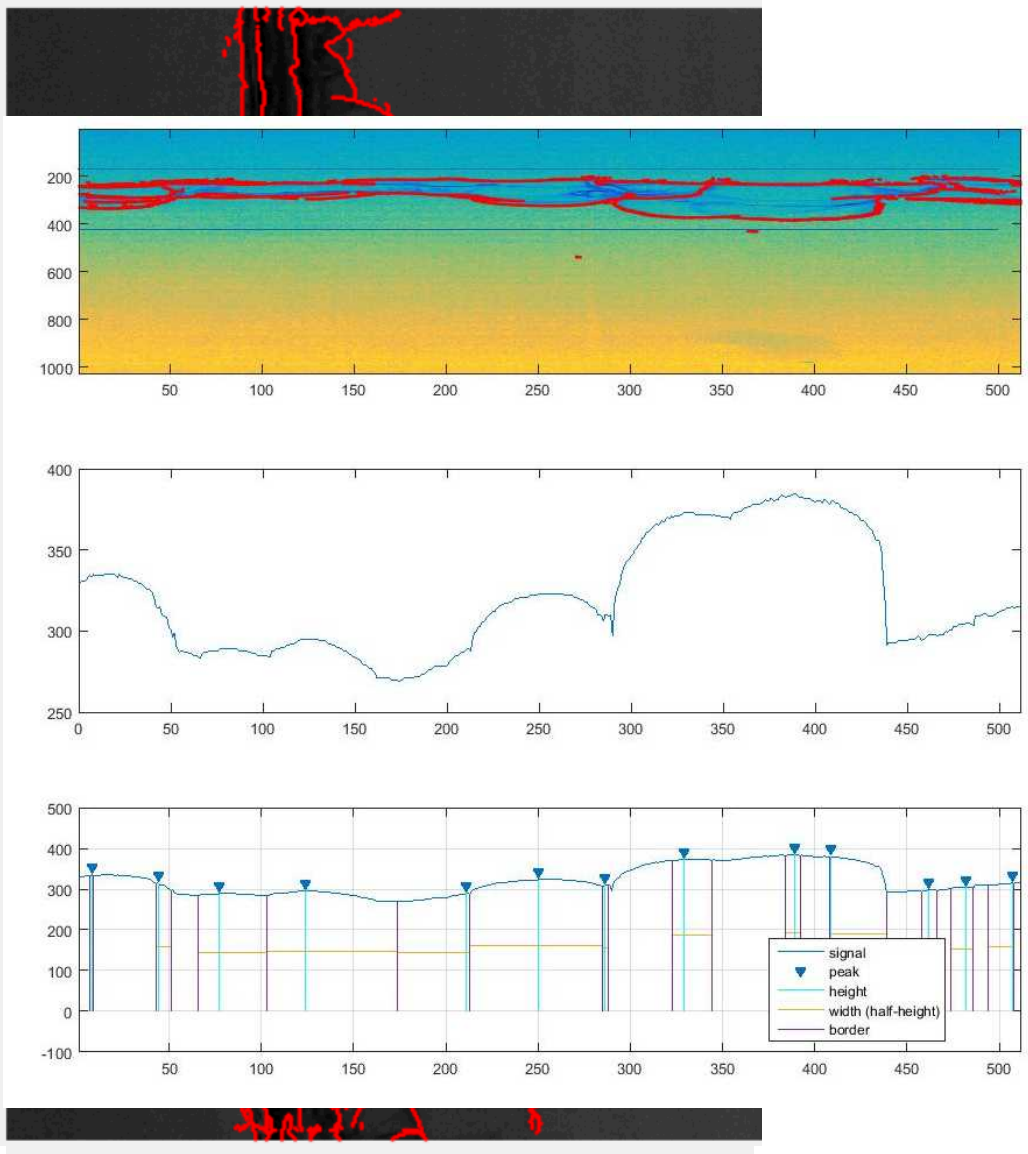
Rayleigh-Taylor Instability

- Taking node spacing as the bag/ligament point
  - MATLAB image processing along with findpeaks



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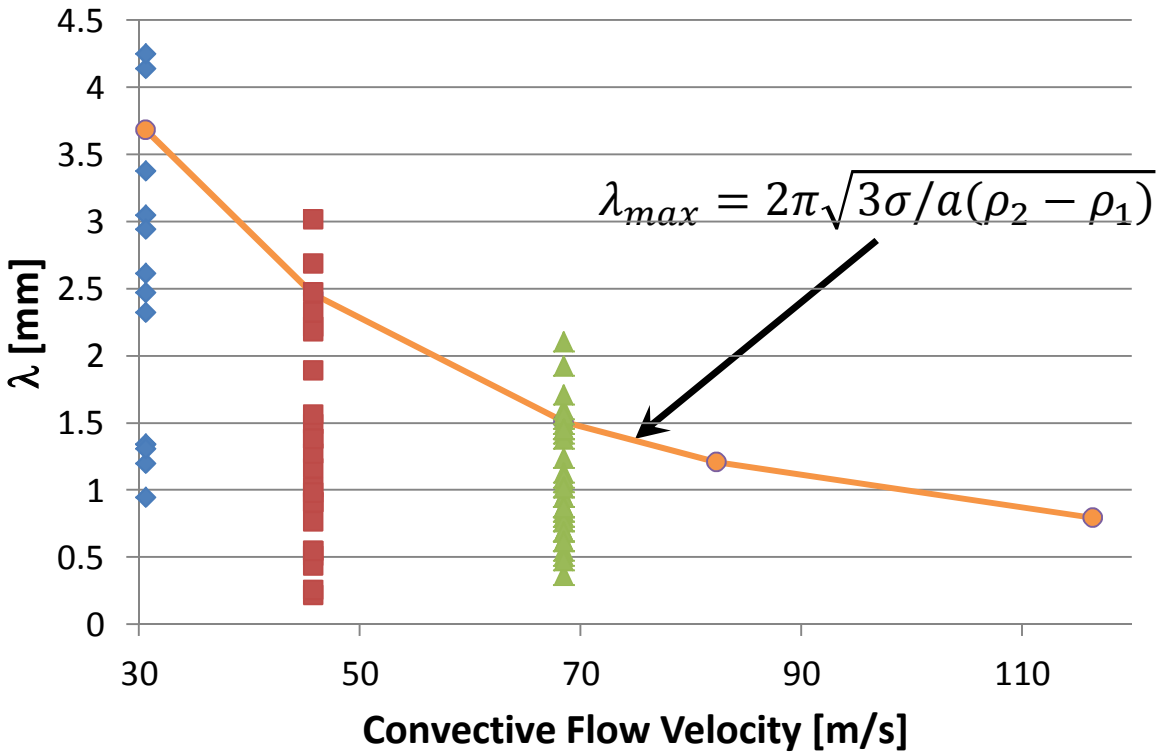
Rayleigh-Taylor Instability

- λ_{max} from planar instability theory
  - Higher velocities breakup too quickly to analyze



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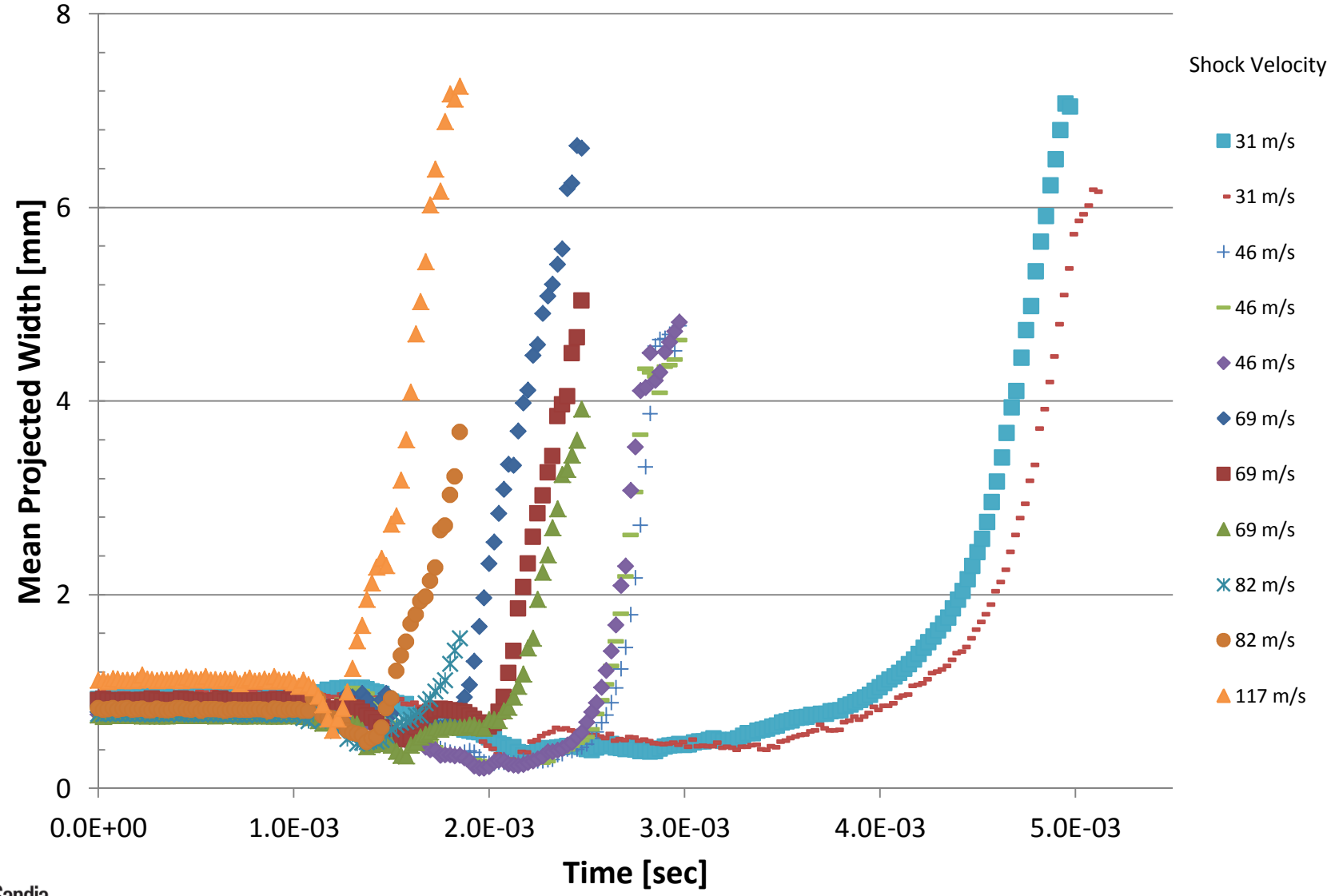
Column Growth in Time



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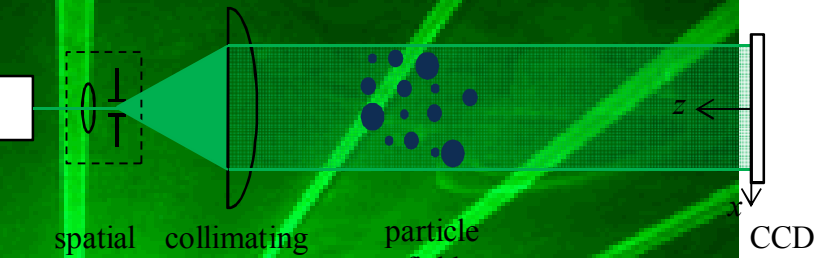
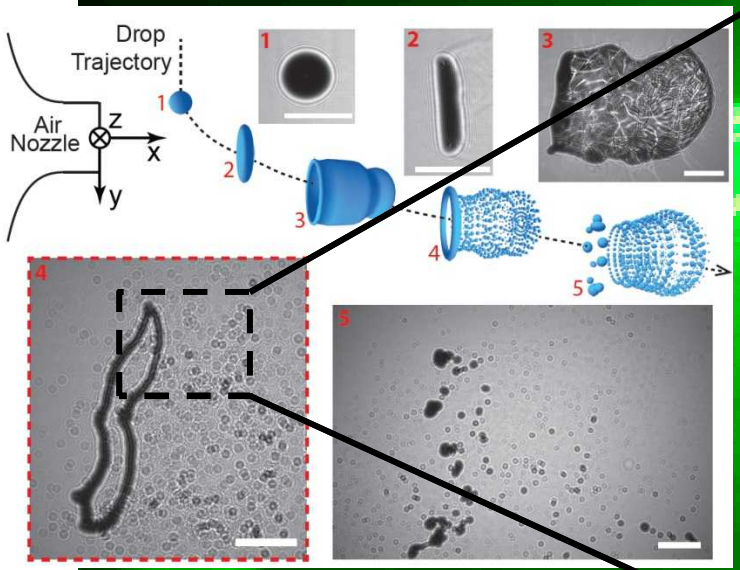
What is holography?

Digital In-line Holography

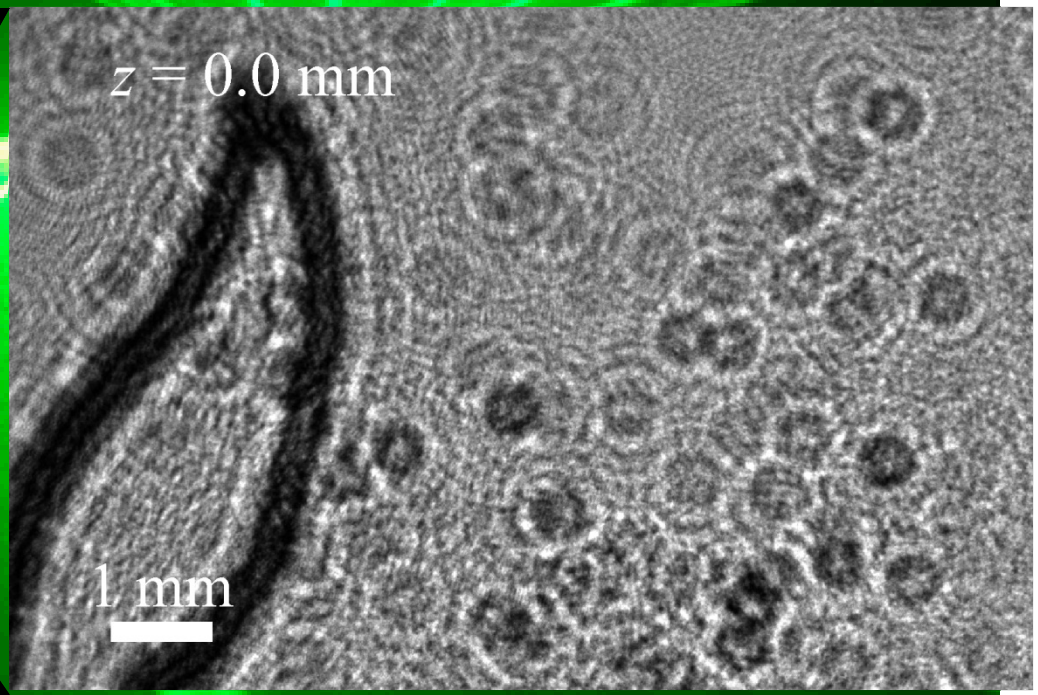
Advantages: (1) no darkroom, (2) temporal resolution (3) numeric refocusing and post-processed

Challenge: Resolution of sensors (order 100 line pairs/mm; compared to photograph, order 5,000 line pairs/mm)





digital holograms of an ethanol drop breakup in an air stream



reconstructed depth through hologram, z

Guildenbecher et al 2013, *Appl. Opt.;* Gao et al 2013, *Opt. Express;* Gao et al 2014, *Appl. Opt.*

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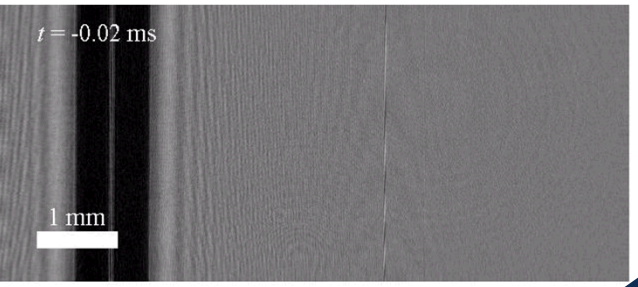
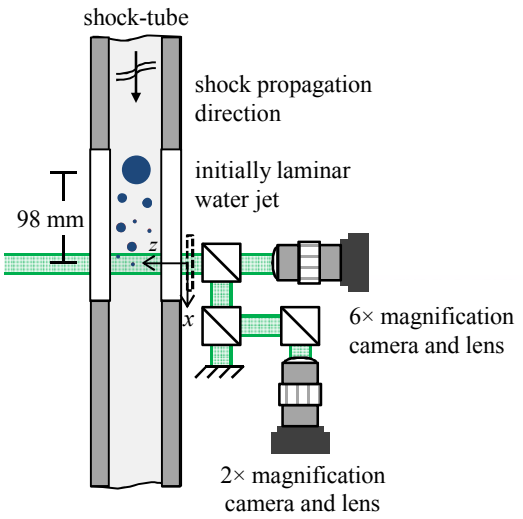
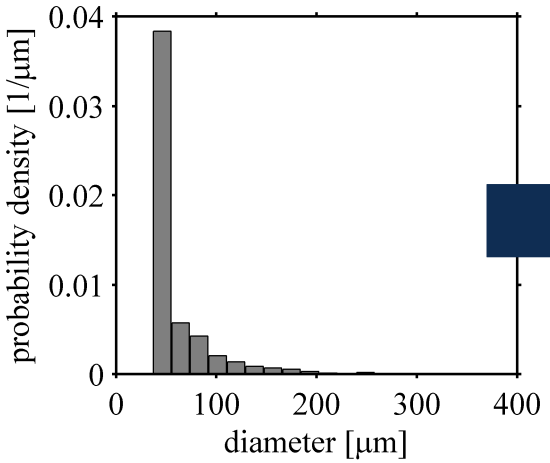
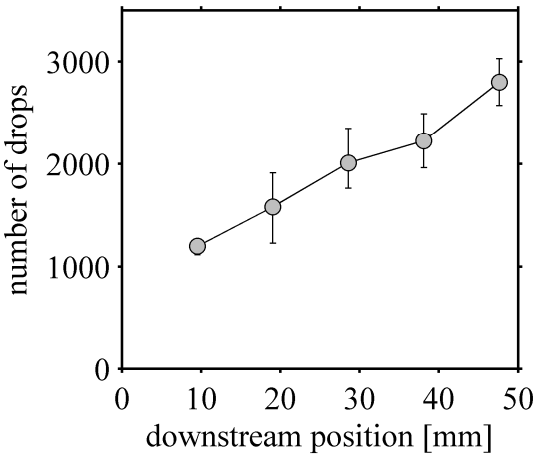
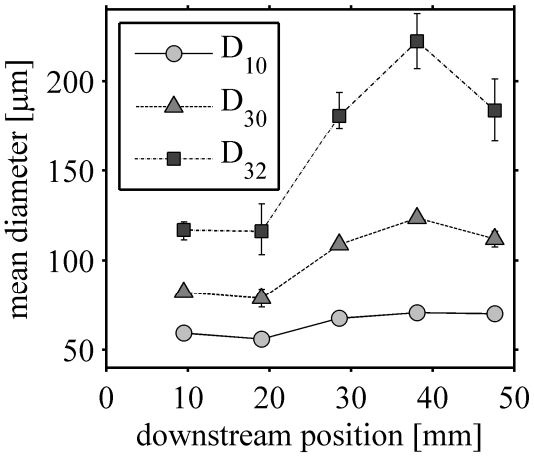
Reconstructed Holograms of Breakup











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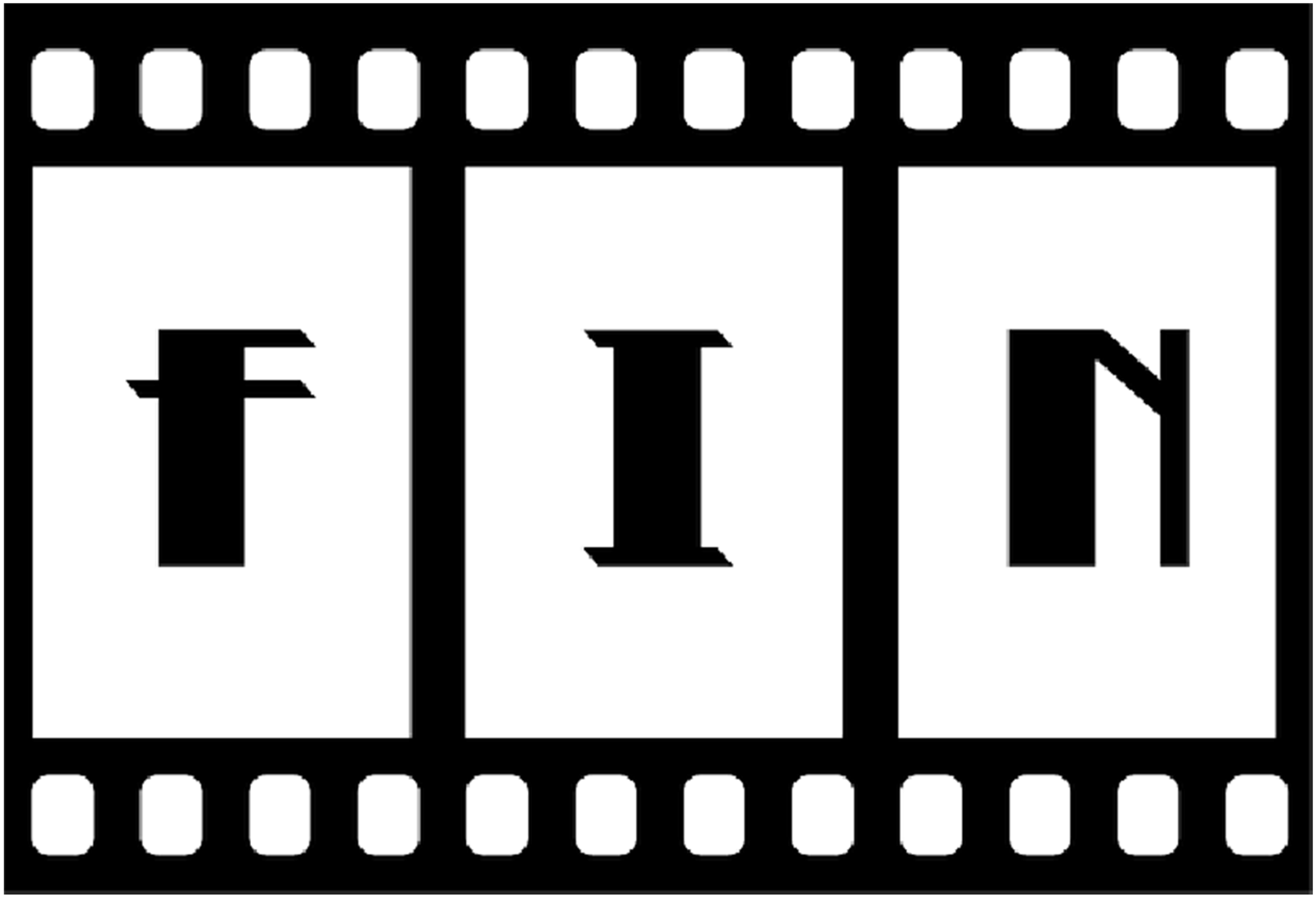
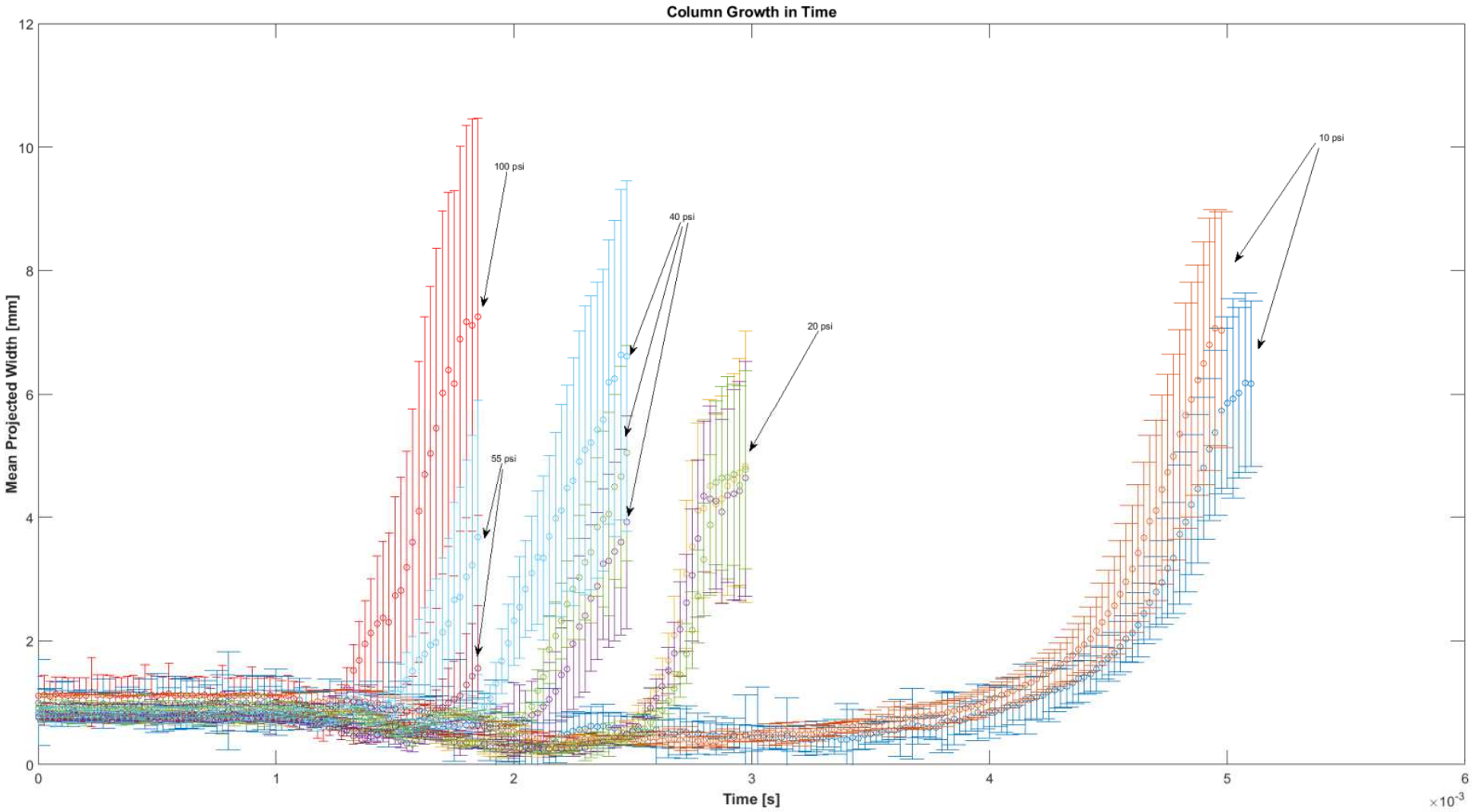

FIN


Column Growth in Time
Mean Projected Width [mm]
Time [s]
×10-3
100 psi
55 psi
40 psi
20 psi
10 psi
0
2
4
6
8
10
12
0
1
2
3
4
5
6