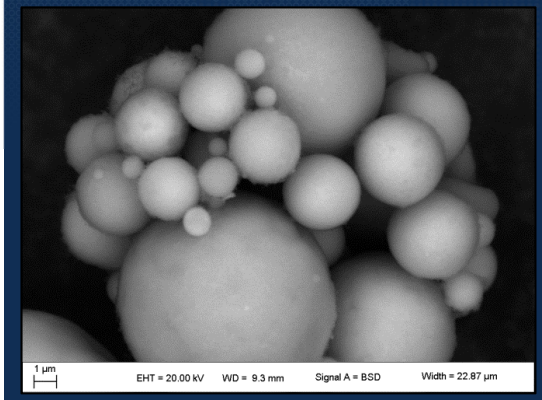
SAND2016-0423PE

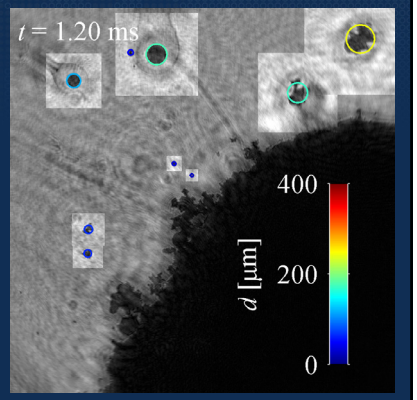
Exceptional service in the national interest

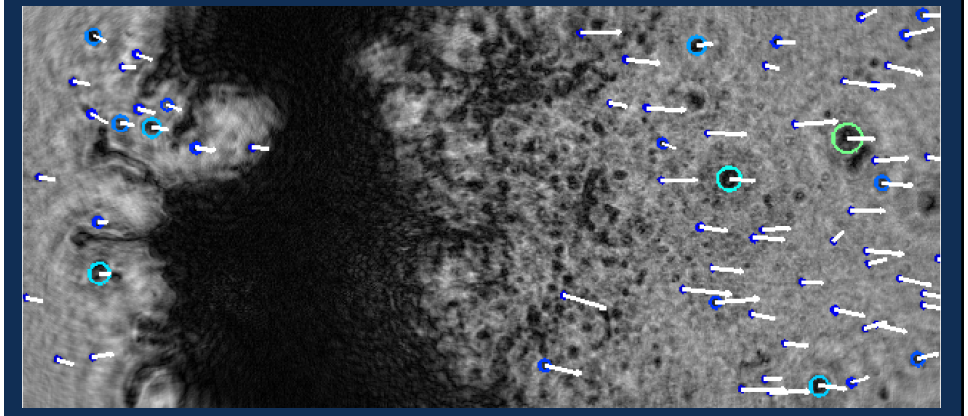
Sandia National Laboratories

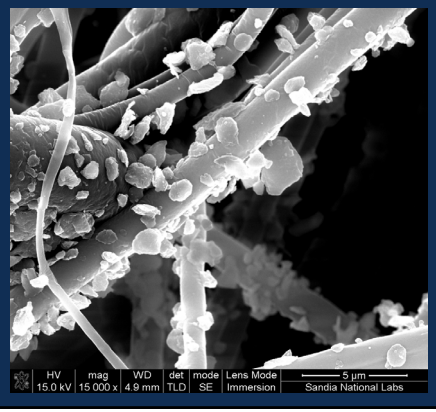
Experimental validation of microparticle physics models

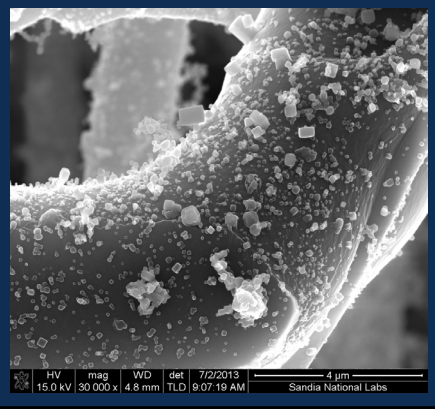
Josh Hubbard, Dan Guildenbecher, Justin Wagner, and Pylin Sarobol











U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Ensemble measurements

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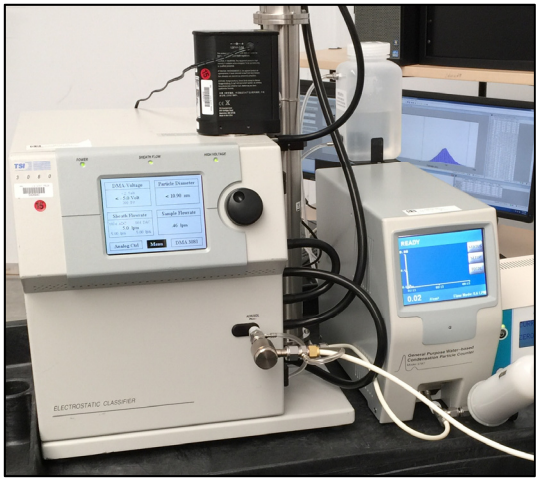
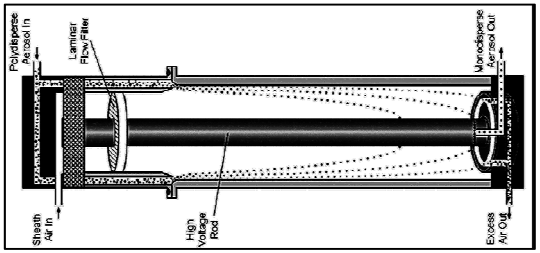
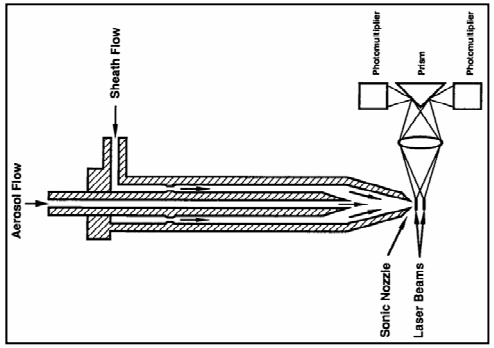
- Electrical mobility
  - 1-1000 nm

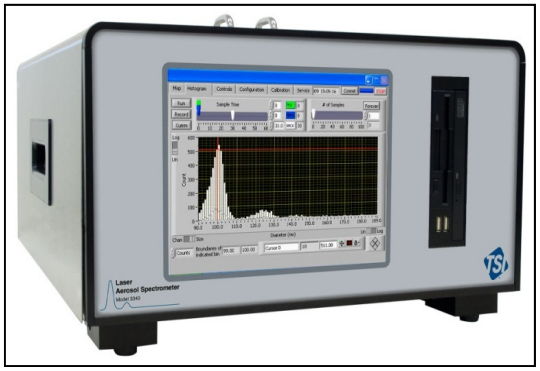


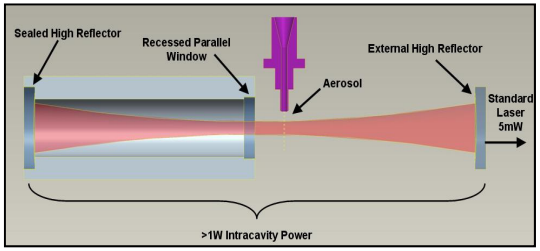


- Mechanical mobility
  - 0.4-20.0 μm



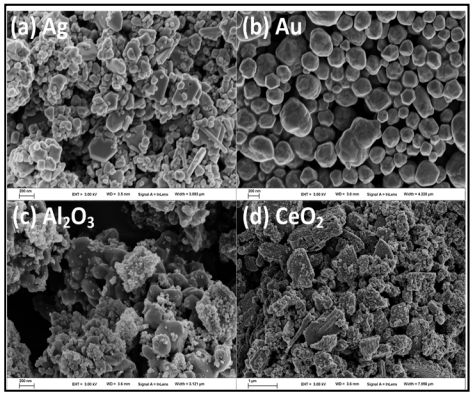
- Light scattering
  - 0.09-7.5 μm

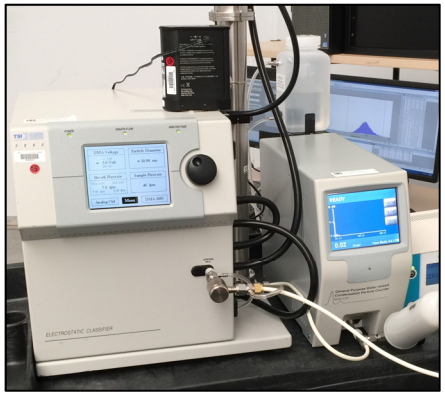


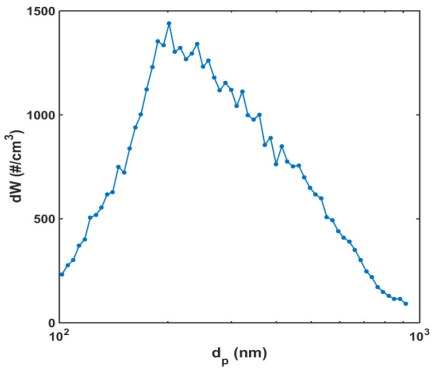


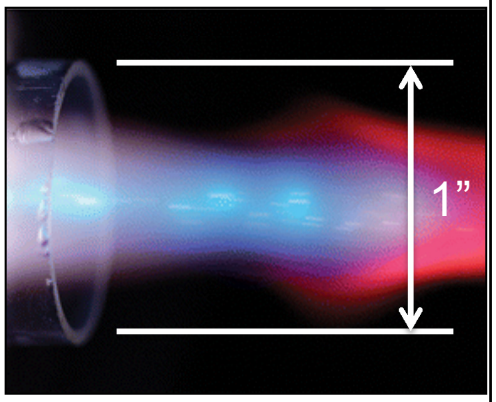
- Ensemble measurements provide: particle size, shape, density, refractive index, total number concentration

Nanoparticle vaporization









- Particles of known composition aerosolized
- Aerosol size distribution measured
- Monodisperse aerosol injected into inductively coupled plasma
- Atomization efficiencies calculated from initial particle size distribution and ions detected with mass spectrometer
- Image (right) adapted from Aeschliman et al. (2003) showing optical emission from vaporizing Y_2O_3

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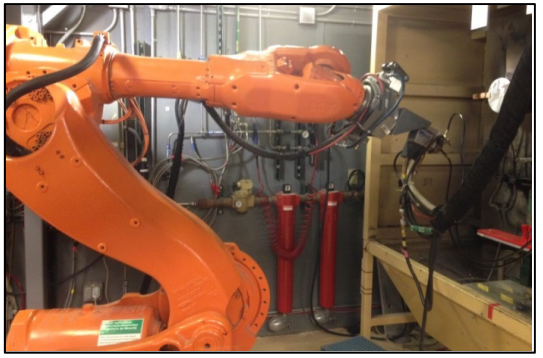
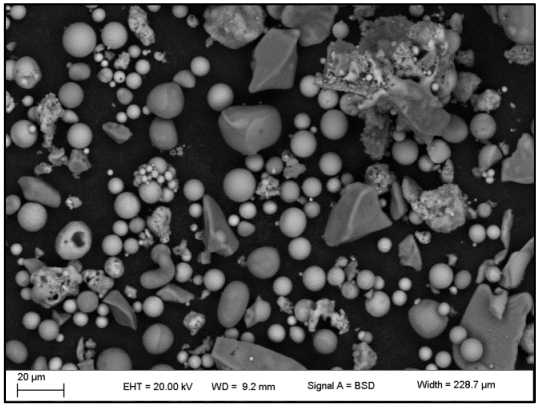
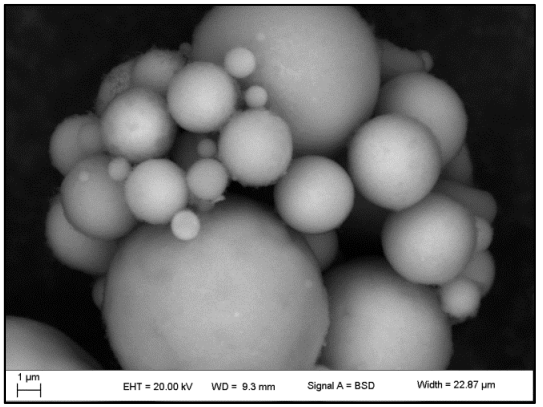
Microparticle vaporization

- Surrogate Debris for Nuclear Detonations in Urban Environments
- Urban background matrix cement
- Rare-earth and precious-metal dopants
- Processed in DC plasma
- *DPV eVOLUTION*
  - Temperature measurements from 1000 to 4000°C (± 2.5%)
  - Velocity measurements from 5 to 1200 m/s (± 0.5%)
  - Diameter measurements from 10 to 300 µm (± 6.0%)
- Initial and resultant chemical composition, particle morphology, particle size







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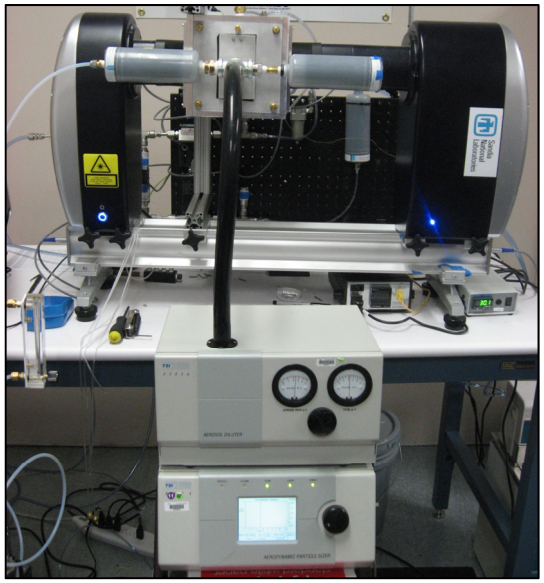
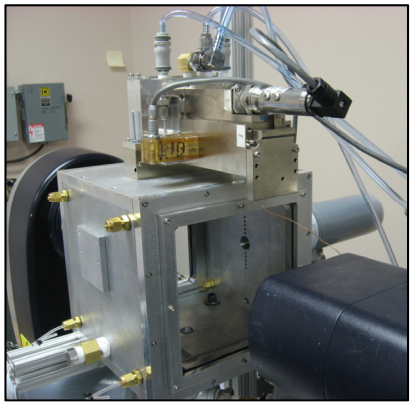
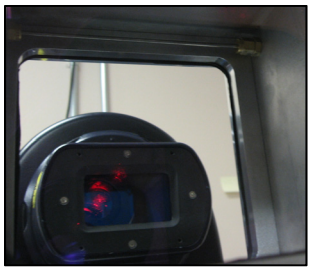
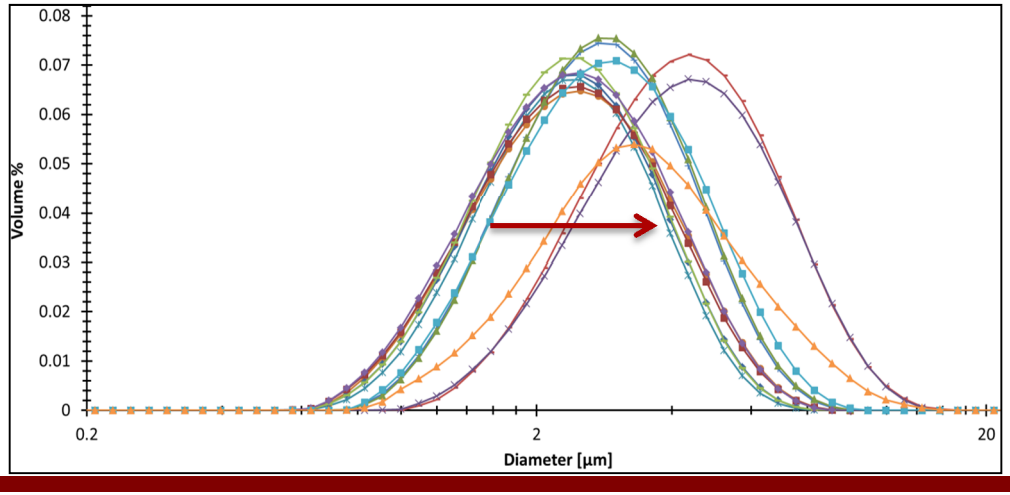
Droplets and sprays

- Malvern Spraytec
  - Mie Scattering
  - Dense Sprays
  - Deformable droplets
  - Measurement across a wide size range (0.1 – 2000 µm)
  - Resolve rapid changes in droplet size over time, 10,000 measurements/sec
  - Multiple scattering analysis
  - Characterize wide spray plumes
  - Dynamic changes in spray particle size









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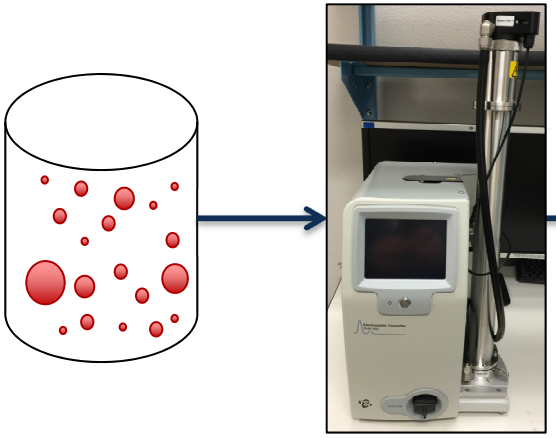
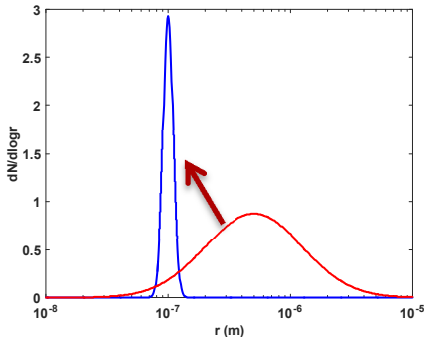
Nanoparticle growth

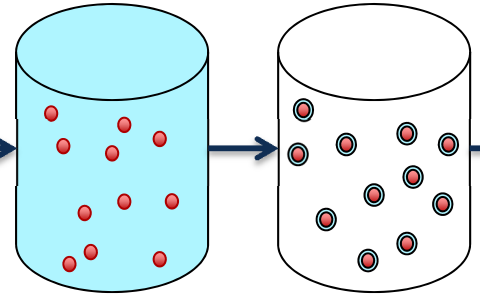
- Nucleation, coagulation, hygroscopic growth, Tandem Differential Mobility Analysis (TDMA)

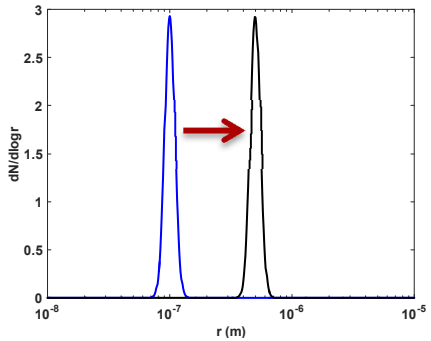




Polydisperse aerosol generated

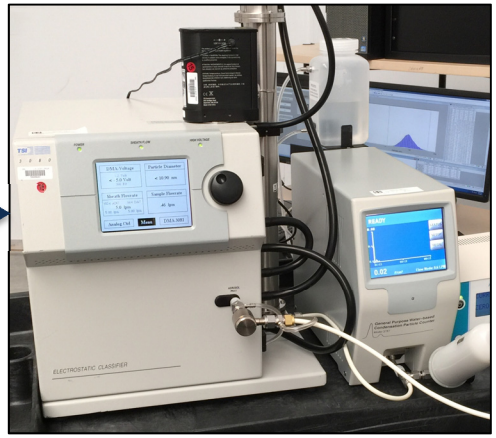
Particles size segregated with DMA





Aerosol exposed to specific environment (e.g., RH)

Aerosol dynamics



Resultant particle size distribution measured with Scanning Mobility Particle Sizer (SMPS)

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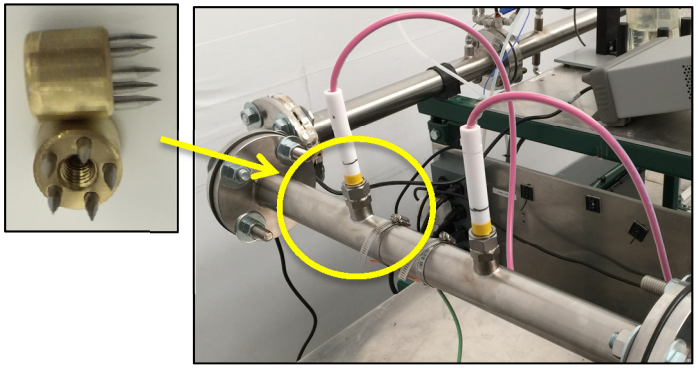
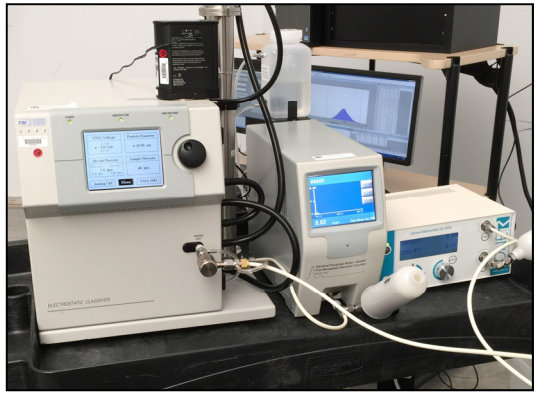
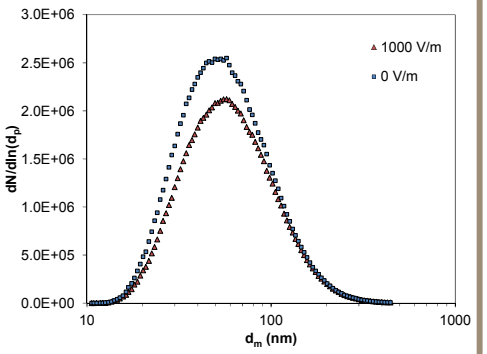
Electrostatic charging



Charge aerosols in corona

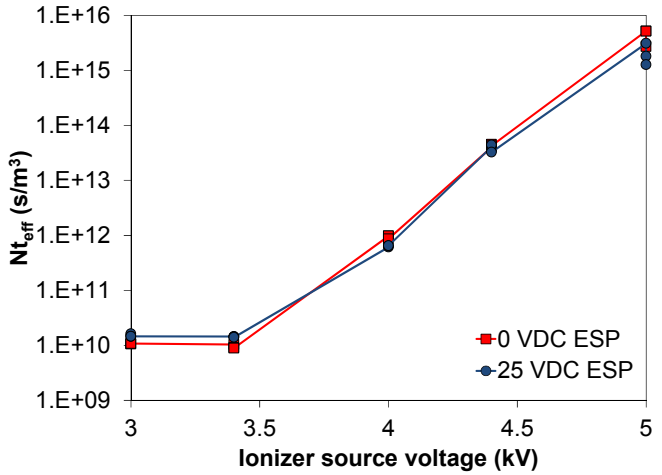




Measure particle size distribution and total current carried on aerosol

Calculate diffusion and field charging parameters

$$n(d_p) = \frac{d_p k_B T}{2 K_E e^2} \ln\left[1 + \frac{\pi K_E d_p c_i e^2 Nt}{2 k_B T}\right]$$



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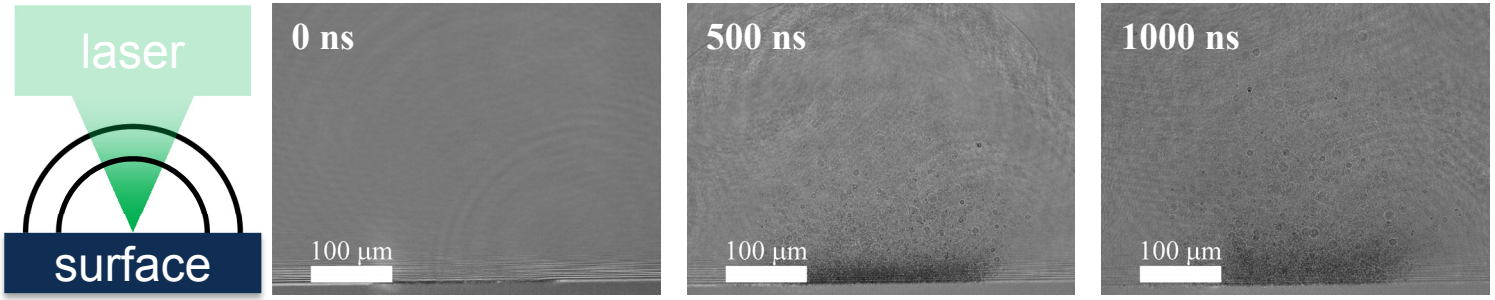
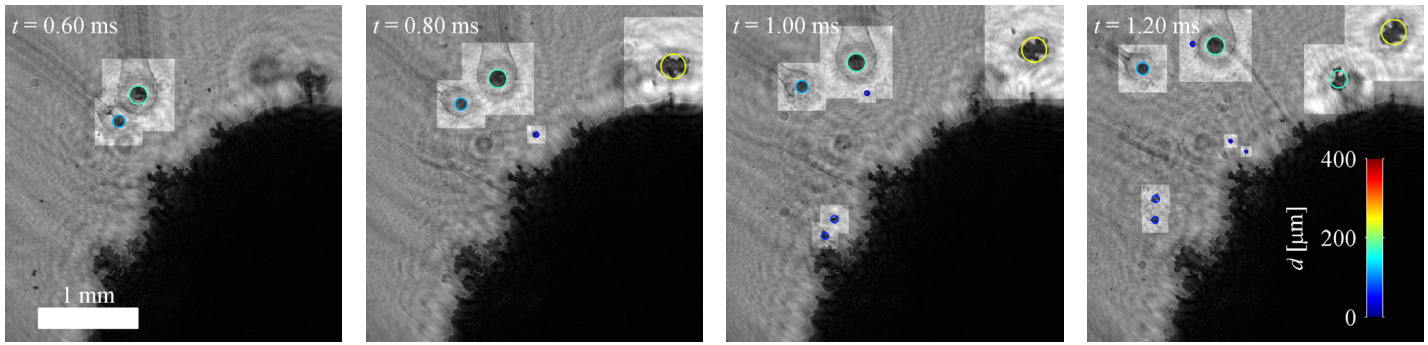
Flow field visualization

- Laser ablation particle physics
  - Microscale investigation of particles generated by rapid energy deposition



- Particle diagnostic development
  - Holographic methods quantify 3D, temporal phenomena of μm-particles



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Flow field visualization

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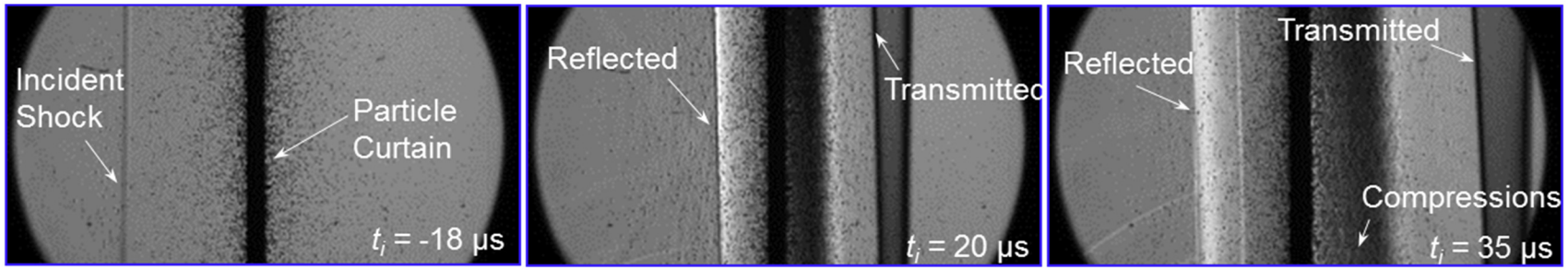
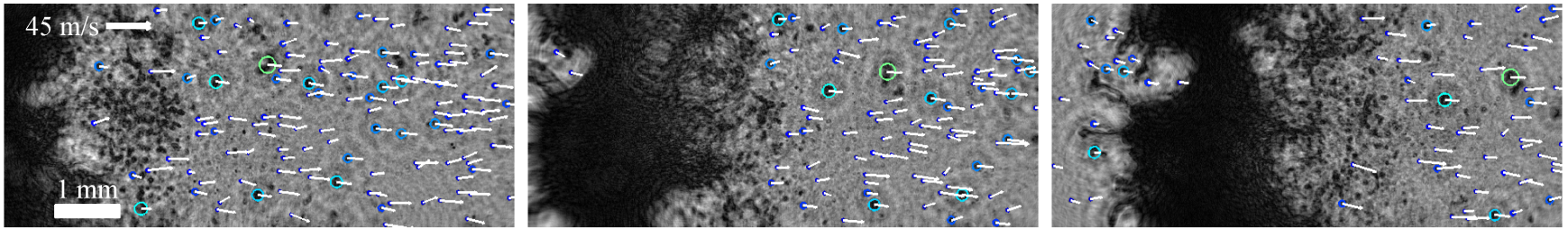
- Shock tube investigation of dense particle interactions
  - Quantification of shock-driven particle dispersal at intermediate densities



- Characterization of high-speed liquid atomization
  - Detailed investigation of particle production due to shock interactions with liquids (to include molten metals)



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