Hardware Updates

- Light Scattering developments
  *External trigger and software for ToF system*

- Black carbon detection module
  *SP2-AMS black carbon mass measurement.*

- Lens Modeling and Testing
Particle Lens Work

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Aerodynamic Lens Systems Investigated Models and Measurements

- Standard lens
- High Pressure lenses (PM2.5)
- Nano-particle lenses (Wang/McMurray design)
- Inlet design, pin hole
- Valve assembly design
Model Studies Have Investigated:

**Standard lens**
- Effect of the lens pressure through a change of inlet pressure or a change of the critical orifice size

**High Pressure lens**
- Effect of different valve assembly system
- Effect of the lens aperture and nozzle diameter

**Nano-particle lens** *(Wang et al 2005)*
- Effect of carrier gas molecular weight

**For each of the 3 lens systems**
- Effect of laminar vs. turbulent model
- Effect of different Brownian methods
- FLUENT used for CFD calculations
Particle Transmission versus Collection in Aerodynamic Lens

Small particle losses are controlled by geometry and Brownian diffusion.

Large particle losses are controlled by the pin-hole.

No Transmission or Collection
Results for Standard Lens

Figure 10. Experimental results for DEHS (solid circles), NH$_4$NO$_3$ (triangles) and NaNO$_3$ (squares) at an ambient pressure of 585 torr. The solid line is the Fluent modeling result for 585 torr and is re-plotted from Figure 7.

Standard Lens System

Figure 1a. Drawing of the lens system which is composed of the pinhole assembly, the valve body and the lens assembly.

Figure 1b. Structure used in the Fluent simulations, including the lens system, particle flight chamber and vaporizer. The diameters of the apertures are given in Table 1.

Must model the “System”

Liu et al. (2006)
HP Lens requires constant bore

Constant bore of 4.4 mm from orifice to lens entrance. “New Inlet”

Diameter of pinhole is 80/100/120 microns.
Diameters of connection and lens tube are 4.4mm.
Diameter of the nozzle is 1.0mm.
Good agreement between calculated and measured transmission efficiency.
Effect of lens pressure for High Pressure lens

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Transmission Efficiency vs. dp [nm]
Small Particle lens
Nano-particle lens geometries

Four lenses
Collection efficiency

- Standard lenses
- High-Pressure lenses
- Nano-particle lenses

CE vs. Dp (m)
Effect of different Brownian models

McMurry “Nano” Lens Geometry
Effect of carrier gas for nano-particle lens performance

- Carrier gas: Air
- Carrier gas: Helium
“Spot Measurements” for Visual Characterization of Lens Performance
Keith and Frank....

We have gotten really good at measuring spots!
Another way to look at focusing: BWP Data for HPLv2 SN5 and Standard Lens

Red circle is projection of vaporizer on plexiglass surface.
Photographs of “Spots”

Polydisperse NH₄NO₃ with different “Identical” HP lenses

Machining tolerances are critical
Lens #3, turned whole lens
Lens SN#3, NH$_4$NO$_3$

poly  
100nm  
150nm  
200nm  
250nm  
300nm  
350nm  
400nm  
450nm  
500nm
Trajectories for 3000 nm particles for HPLv2.

Impaction losses predicted on low pressure side of 100um pin hole

13 torr lens pressure
Particle loss on the back plane of the critical orifice 
(NH₄NO₃, varied particle size, 5min)
Summary

• Small particles focusing ultimately limited by Brownian diffusion.

• Large particle TE and CE limited by impaction.

• Agreement between model and measurement is not perfect but agrees qualitatively. Need to refine calculations.

• HP lens cuts off too soon on small size end for ambient work.

• Overall goal is to “widen” the transmission window. Can we combine Standard and HP lens?

• Lens development is an ongoing effort.