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Response of DC and PAS to size fractionated particles

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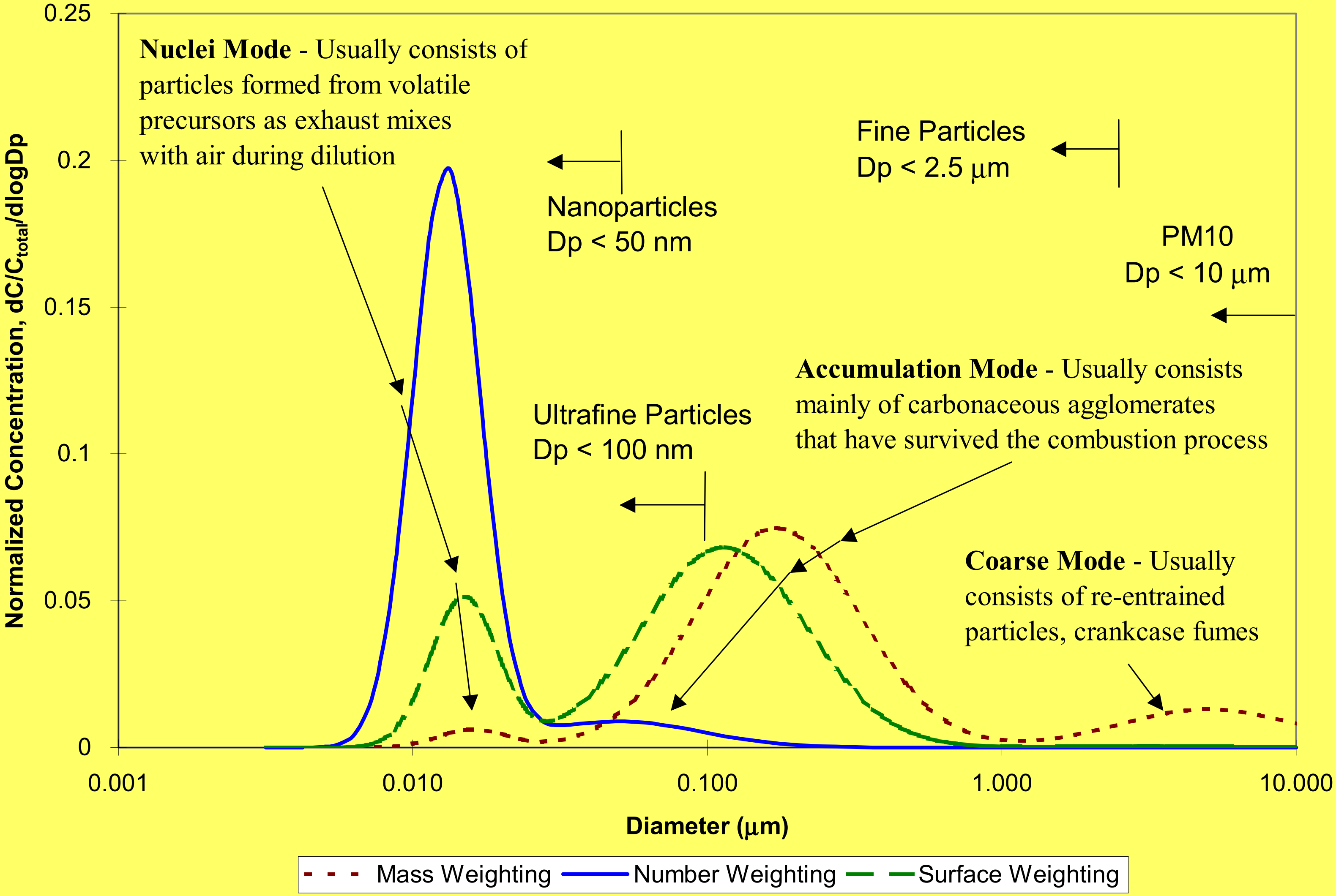
Typical Diesel Particle Size Distributions, Number, Surface Area, and Mass Weightings Are Shown



Surface area measurements

- Some health studies suggest that biological response is better correlated with surface area than with mass or number
- Most surface area instruments are relatively new and incompletely characterized
- The are currently no standard calibration methods or standards
- The work described here focuses on the Fuchs or “Active” surface area

Surface area instruments

- Epiphaniometer (EPI) – well characterized but slow response (≅ 5 minutes)
- Diffusion charger (DC)
  - Matter Engineering – conventional and portable instruments available
  - Dekati
  - TSI – calibrated in length, not surface (mm/cm^3)
- Photoemission aerosol sensor (PAS) – photoelectron emission – equivalent surface polycyclic response
- This presentation describes initial characterization of and comparison of Matter Engineering DC and PAS. Ongoing work includes portable DC and PAS, EPI, and TSI DC

Definition of Fuchs Surface

$$A_{Fuchs\_FM} = \pi \cdot D^2$$

$$A_{Fuchs\_CONT} = 2\pi \cdot I \cdot (A+Q) \cdot D$$

$$A_{Fuchs\_TR} = \frac{\pi (A+Q) \cdot D^2}{\frac{D}{2 \cdot I} + \left(A + Q \cdot \exp\left(\frac{-b \cdot D}{2 \cdot I} \right) \right)}$$

D	Mobility diameter
I	Mean free path of particle in gas(65nm for air)
A, b, Q	Cunningham fit parameters

$A = 1.257$

$Q = 0.40$

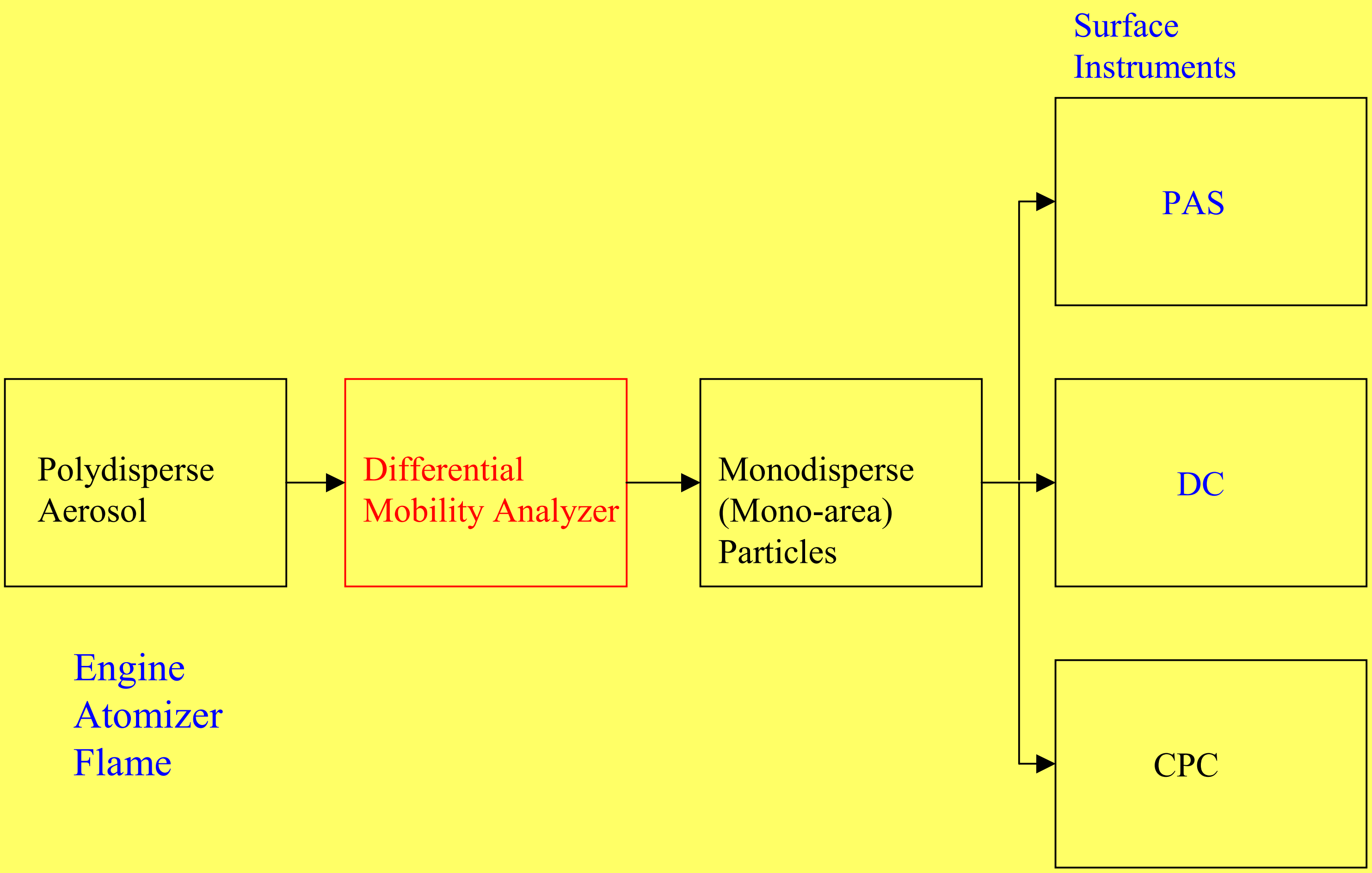
$b = 1.10$

Ref) Operation manual of LQ 1-DC

Objectives

- Characterize the response of a photoemission aerosol sensor (PAS) and a diffusion charger (DC) with *mono-area* selected particles from engine exhaust and standard laboratory aerosols.
- Determine if there are particle size effects to the response of the surface instruments.
- Influence of particle composition on the response of the surface instruments.

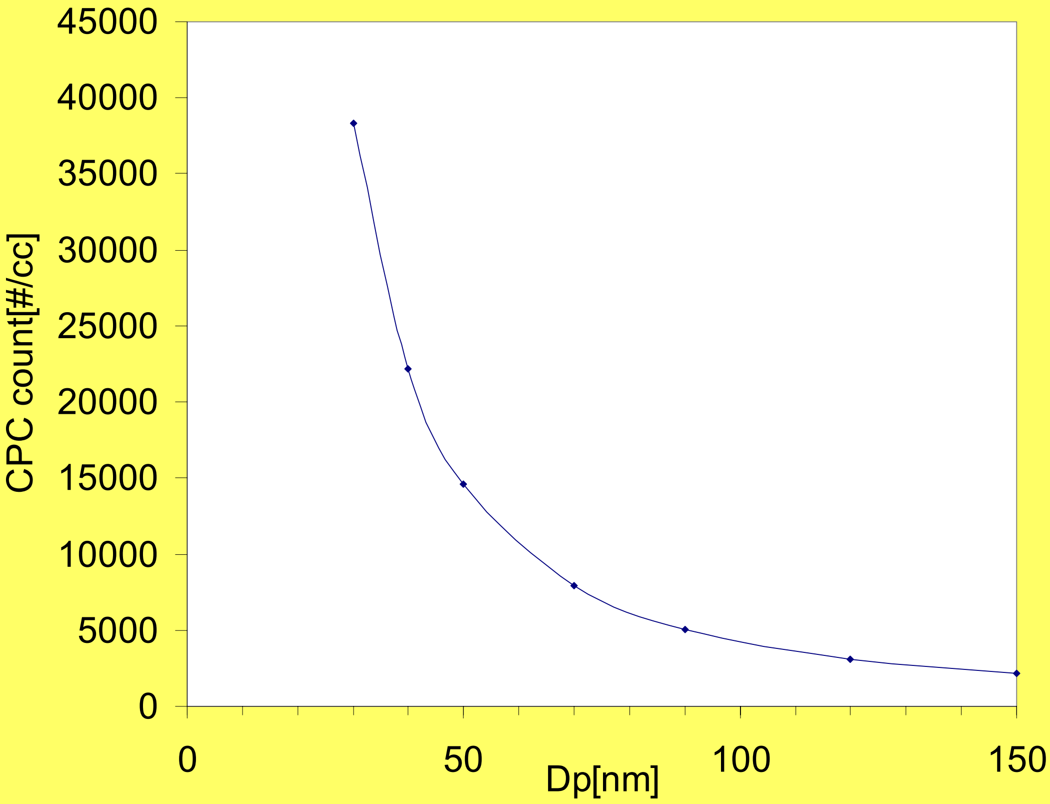
Experimental setup



Aerosol sources

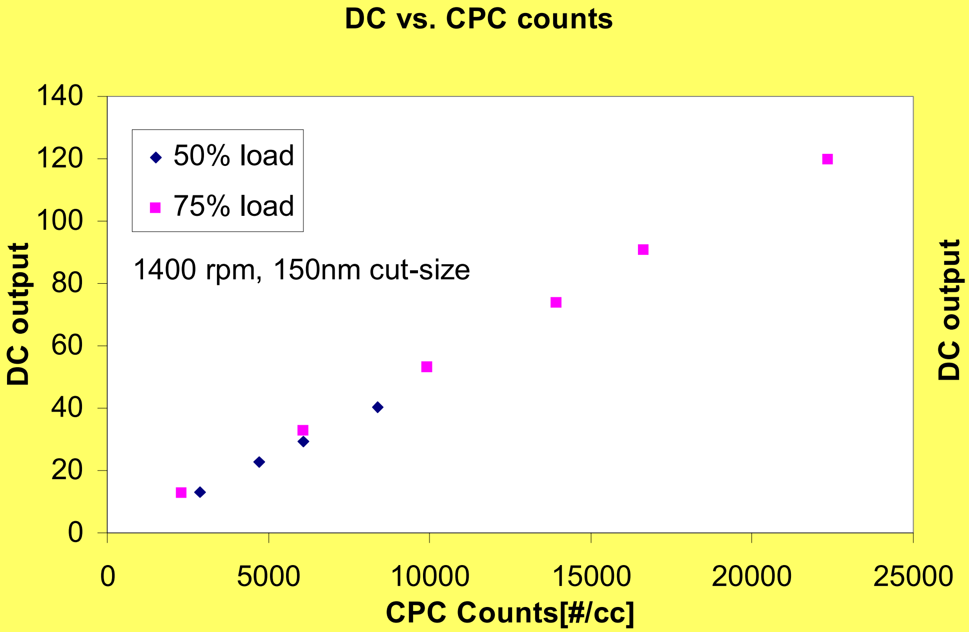
- Medium-duty, direct injection, turbocharged Diesel engine – all tests at 1400 rpm
  - 10% load, large nuclei mode, VOF $\cong$ 60%
  - 50% load, no nuclei mode, VOF $\cong$ 30%
  - 75% load, no nuclei mode, VOF $\cong$ 15%
- Collison atomizer
  - Ammonium sulfate
  - DOS
  - Engine oil
- Ethylene flame (ongoing)

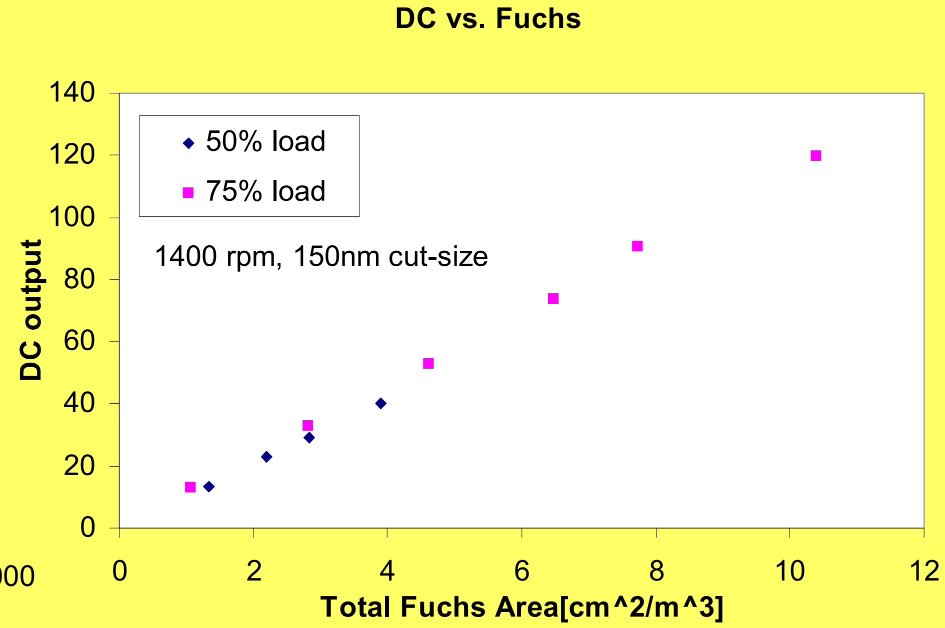
Detection limit of diffusion charger



- The claimed resolution of the instrument is 1cm^2/m^3- we have assumed that that is also the lower useful detection limit.
- It is often difficult to produce very high concentrations of monodisperse aerosols with a DMA
- All the measurement should be above the detection limit curve to yield meaningful data

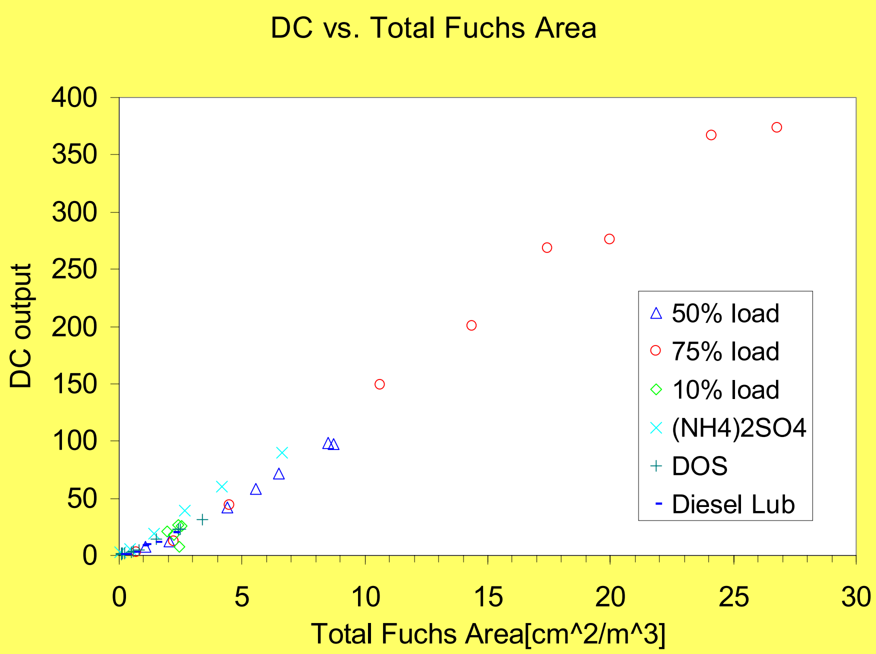
Linearity of the diffusion charger

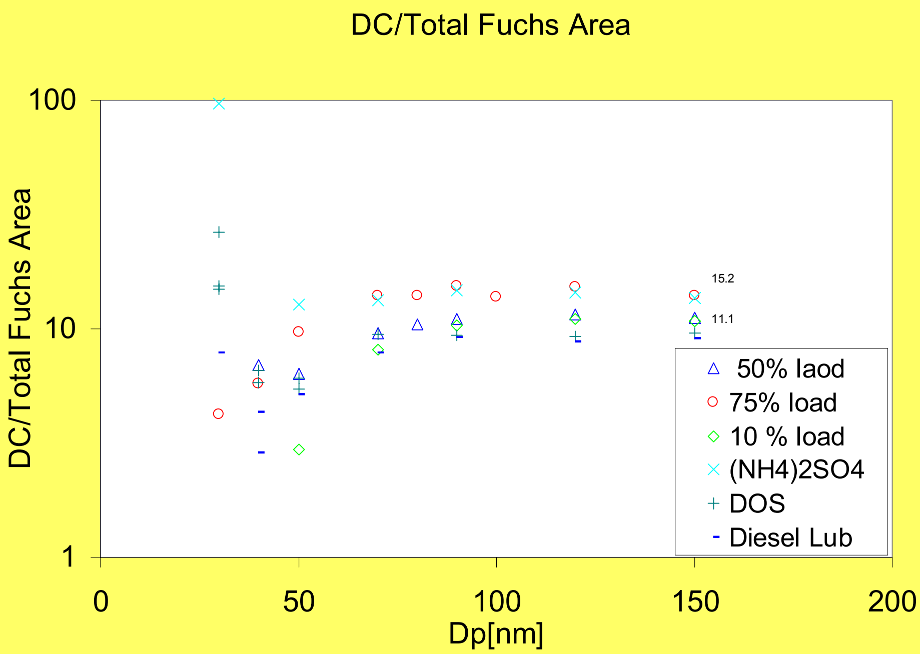




- Concentration was varied at a DMA fixed mobility diameter by changing the dilution ratio for the linearity check of the instrument.
- Two different engine loads were tested.

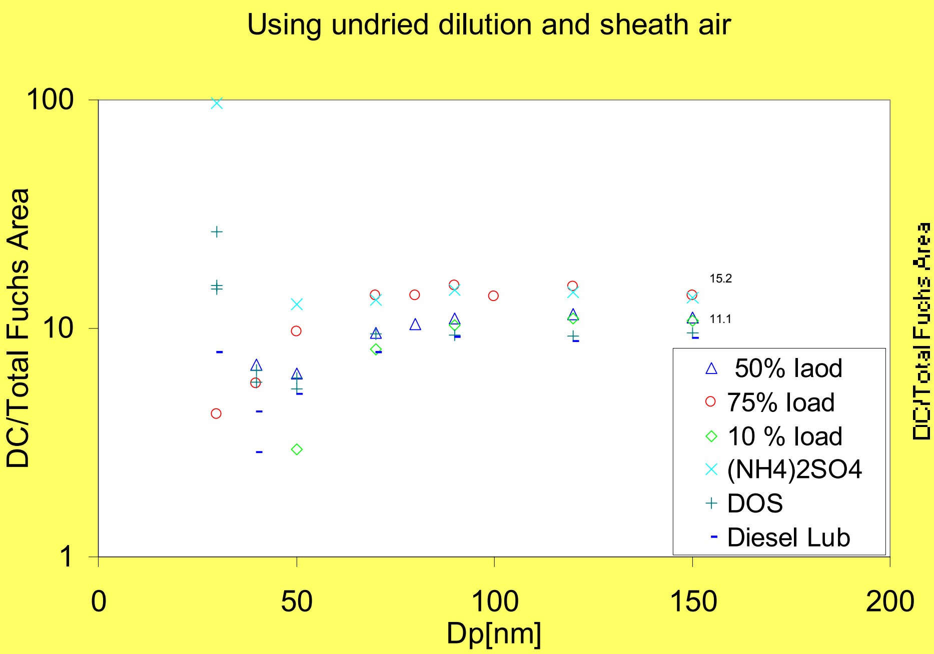
DC response to Total Fuchs Area (Fuchs Area(D_p) * CPC number)

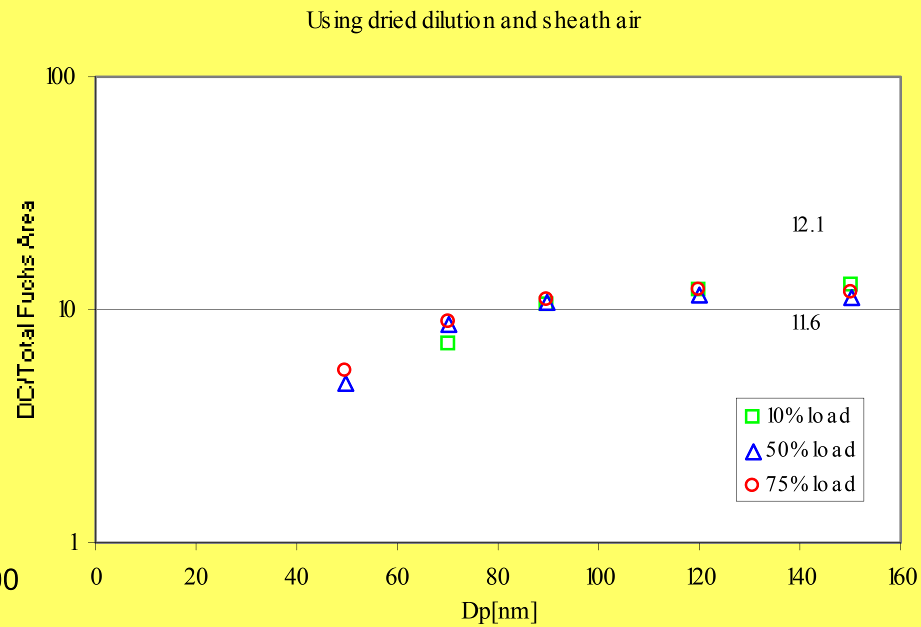




- DC/Total Fuchs Area plot contains more information on the instrument than DC vs. Fuchs plot.
- The output near the lower detection limit gives inconsistent data.

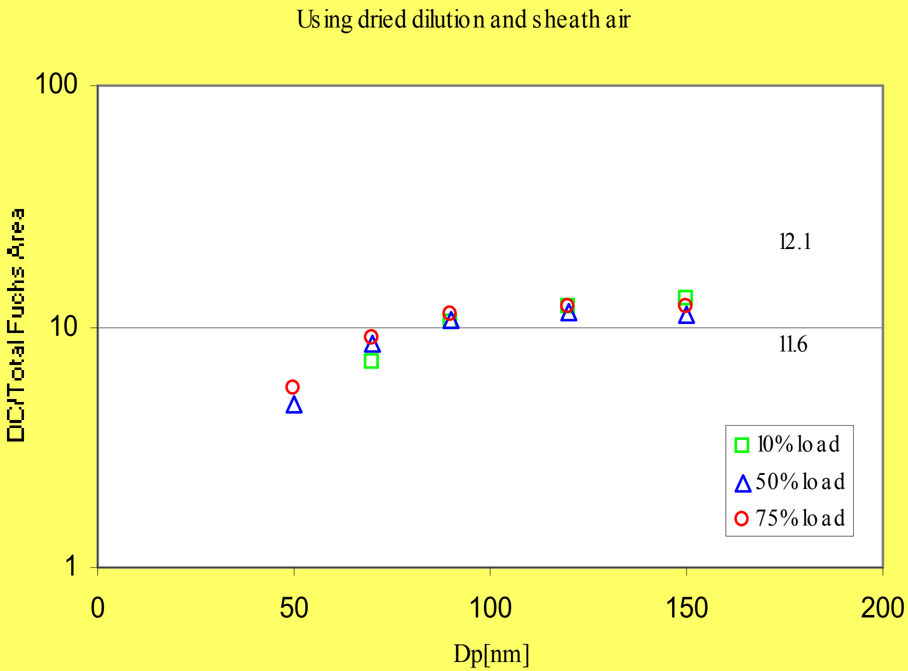
The effect of the humidity on the response of the DC

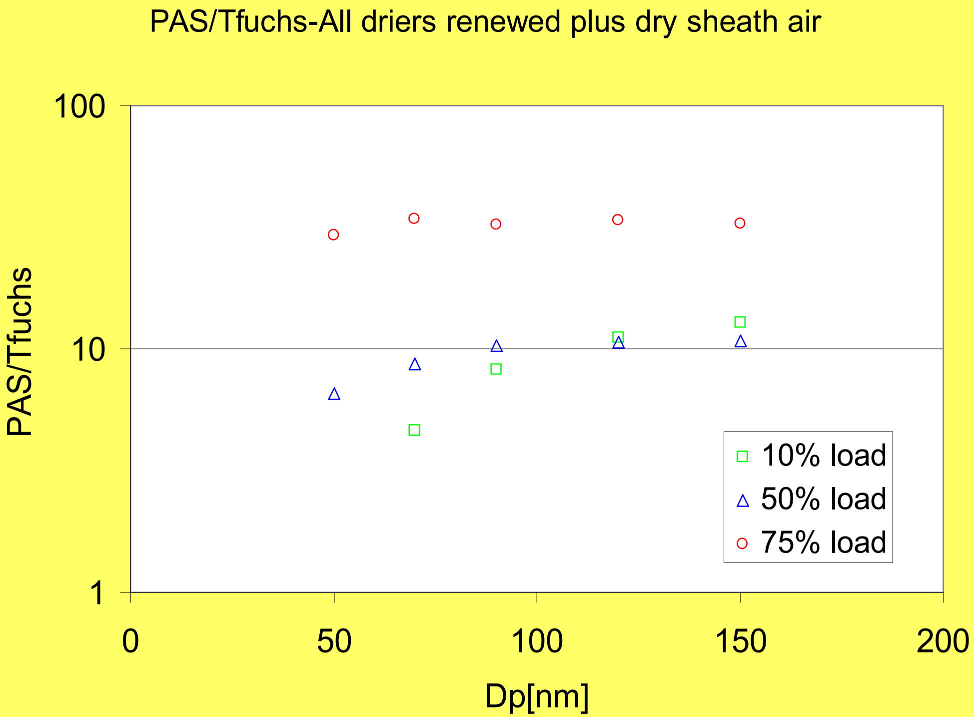


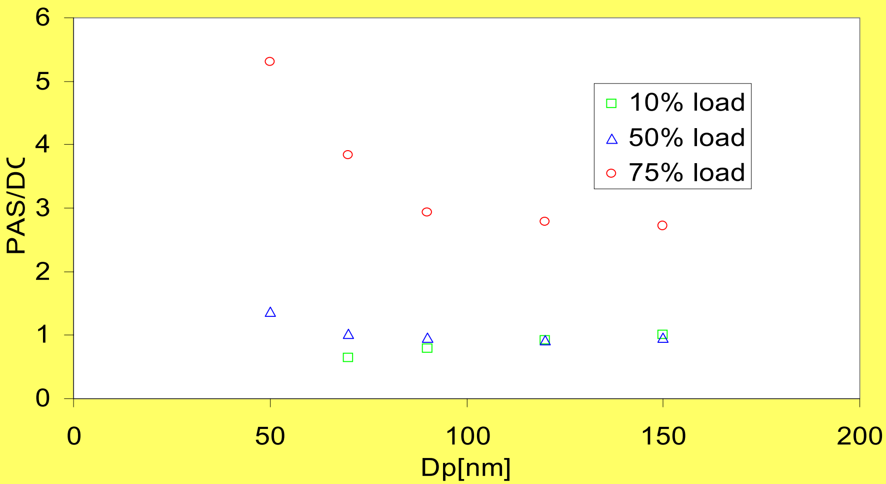


- Humidity of the carrier gas affects to the response of the diffusion charger.
- Additional study is needed for the particles below 80nm in diameter at higher concentration to clarify the effect of size on the response of DC.

PAS and DC response







- PAS response is dependent on engine load, i.e., on chemical composition while DC response is not.

Conclusions

- This is the first report on an ongoing study
- The DC showed a significant response to humidity – the conclusions below are for well dried dilution and DMA sheath air
- The DC response to Diesel particles is proportional to the Fuchs Surface and independent of size (above 80 nm) and composition.
- The PAS response to Diesel particles is proportional to the Fuchs Surface and independent of size (above 80 nm) but depends upon composition.

Future Studies

- The influence of humidity on instrument response must be resolved
- The apparent decrease in sensitivity below 50 nm needs further study
  - Electro spray
  - Condensation aerosols
  - Flame aerosols
- A neutralizer was not used between the DMA and the instruments – tests with neutralizer planned
- Continuing work will include the EPI and the TSI DC

Acknowledgements

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