A portable Diffusion Size Classifier

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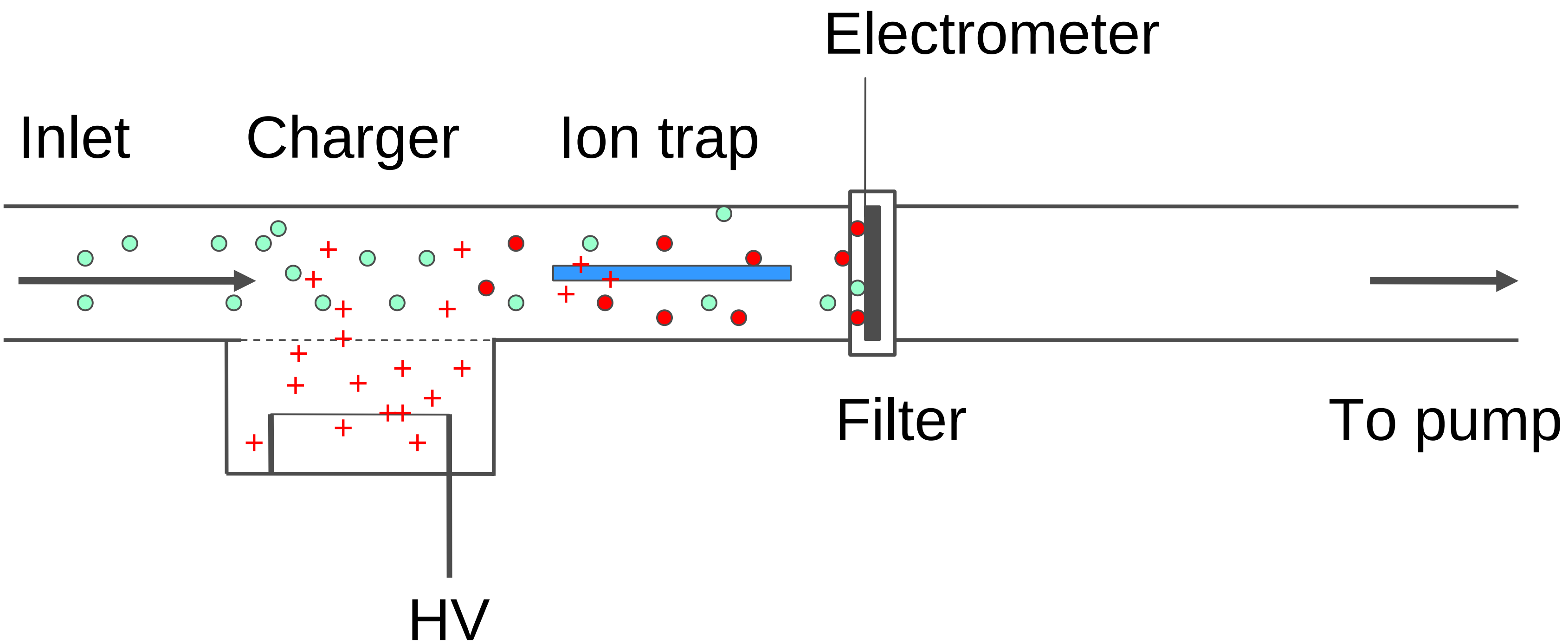
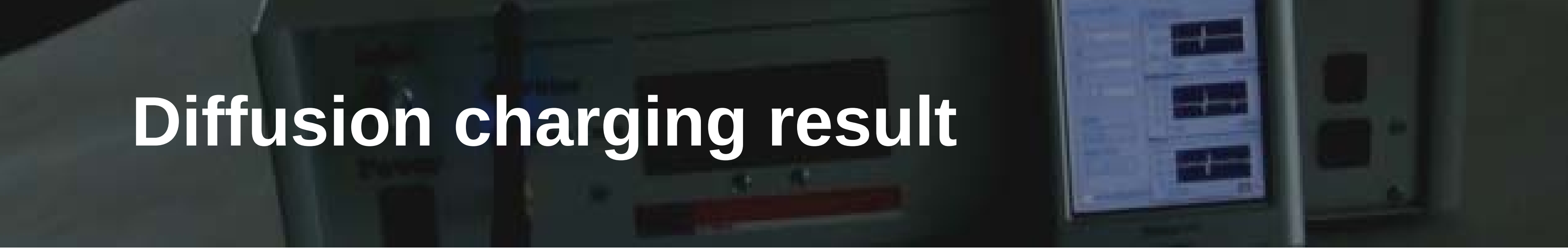
Motivation

- The current generation of particle measurement instruments is large, heavy and expensive (for example SMPS, ELPI, EEPS, DMS).
- Portable instruments exist: CPCs, personal samplers, optical instruments, DC/PAS – however, none of these gives nanoparticle **size** and **number** information **online**

Diffusion charging (DC) principle

Particles are charged, then trapped in a filter. The current flowing from the filter is measured – a very simple instrument.





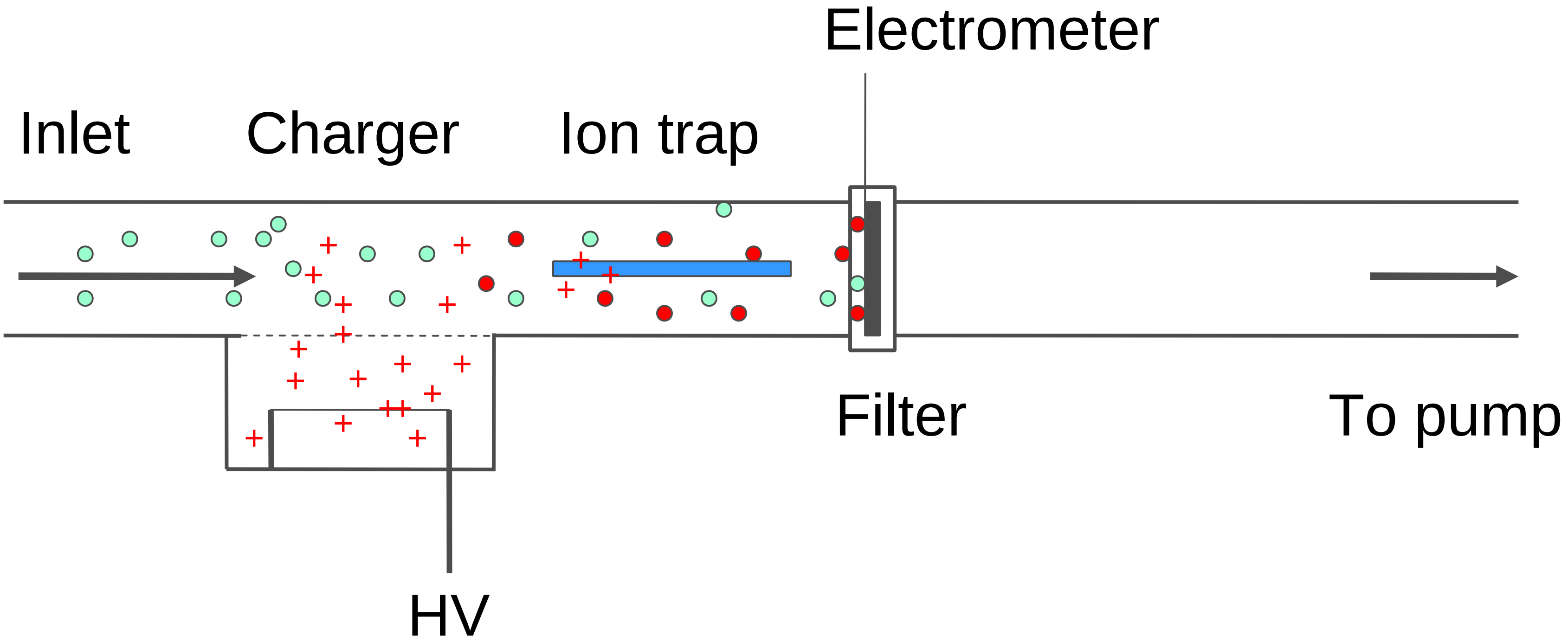
Diffusion charging result

- Typically, the average charge carried by a particle of diameter d after diffusion charging is well described by a power law

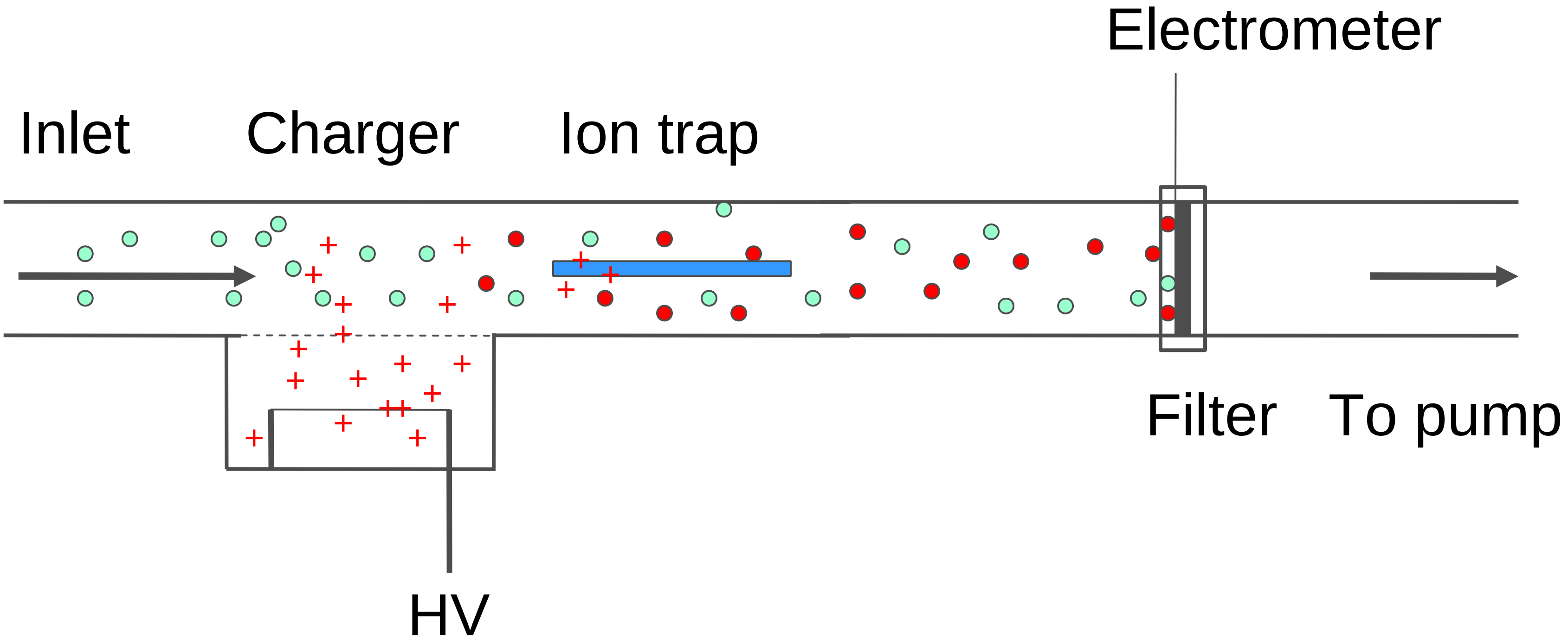
  $q \sim d^b$

- The exponent b is usually in the range of 1.1...1.6
- A diffusion charger measures something like „total aerosol length“ (small b) or „total active surface“ (large b). It gives no information on the particle size!

Improving the simple DC

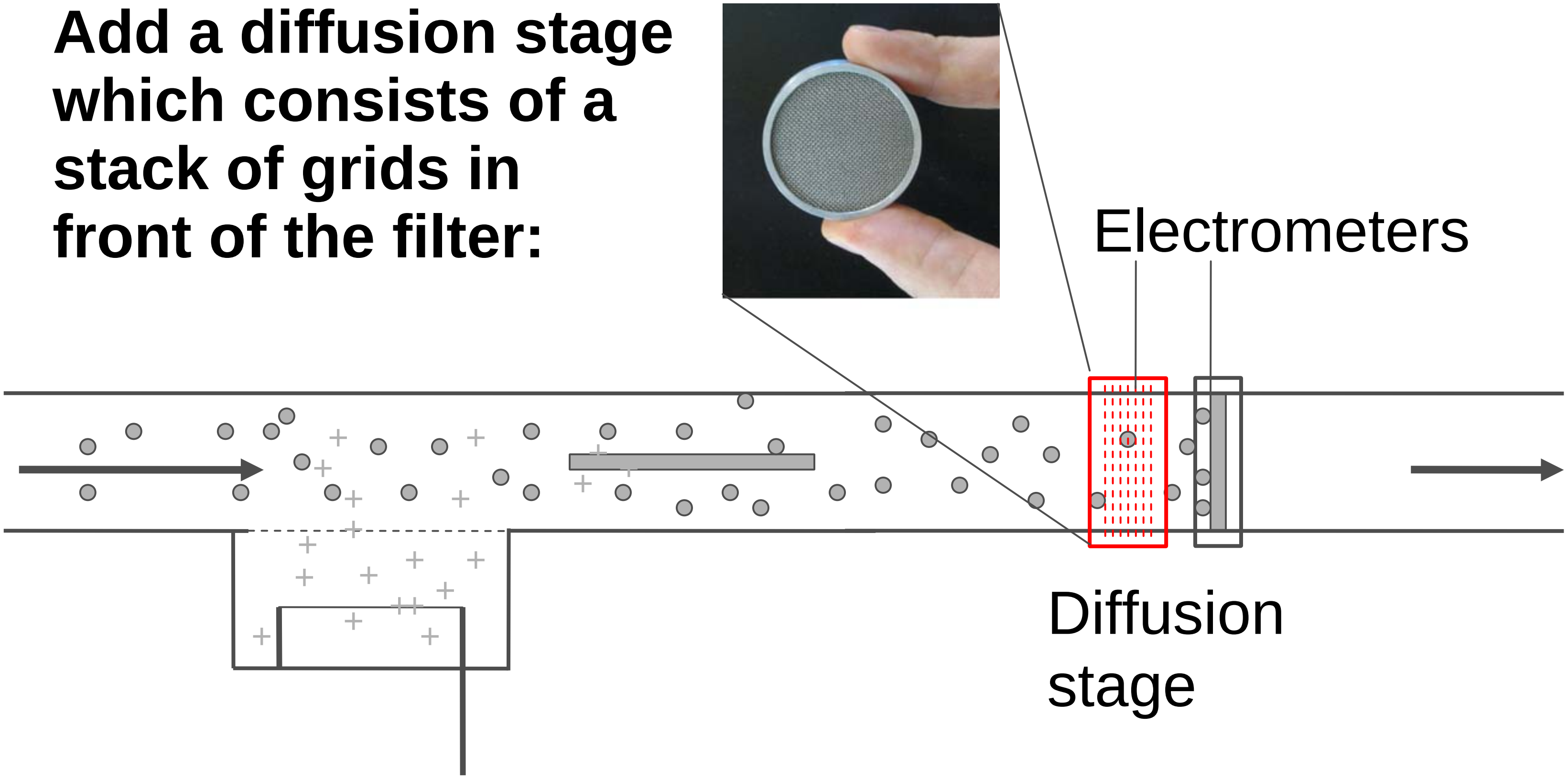


Improving the simple DC



Improving the simple DC

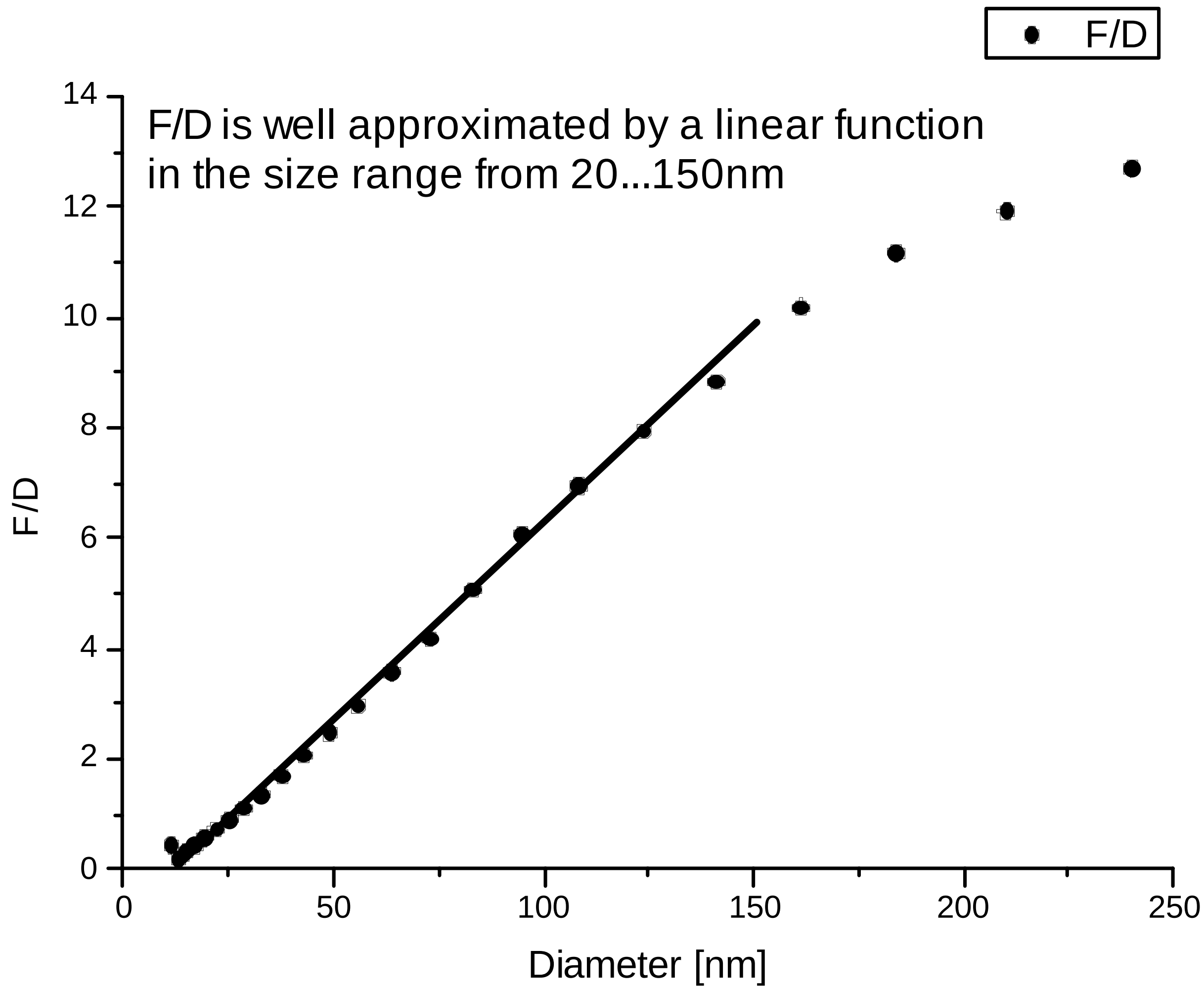
Add a diffusion stage which consists of a stack of grids in front of the filter:

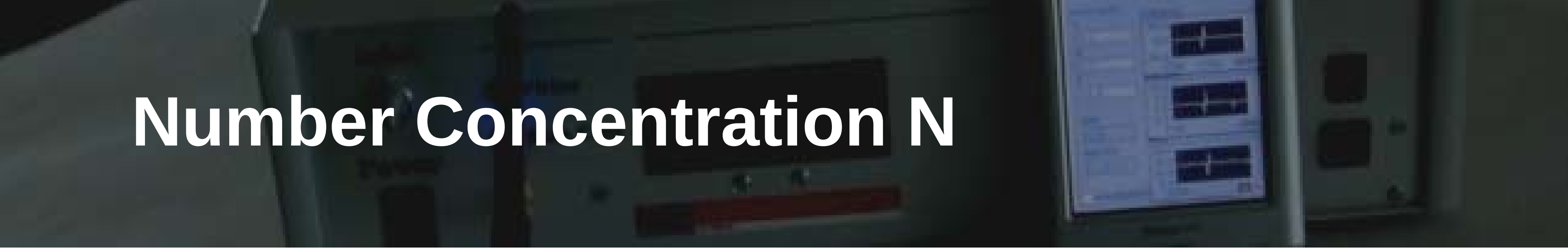


The diffusion stage

- Small particles are deposited preferentially in the diffusion stage (since they have a high diffusion coefficient and move about a lot)
- Large particles are deposited preferentially in the filter stage
- => The ratio of the filter stage current F divided by the diffusion stage current D is related to the particle size
- Calibration with monodisperse Aerosol:

Size determination with F/D





Number Concentration N

- Diameter is determined via F/D
- Total current measured is

  $j = F+D \sim N\ q(d) = N\ c\ d^b$

- => N can be determined from total current and charger characteristics:

  $N \sim (F+D)/(d^b)$

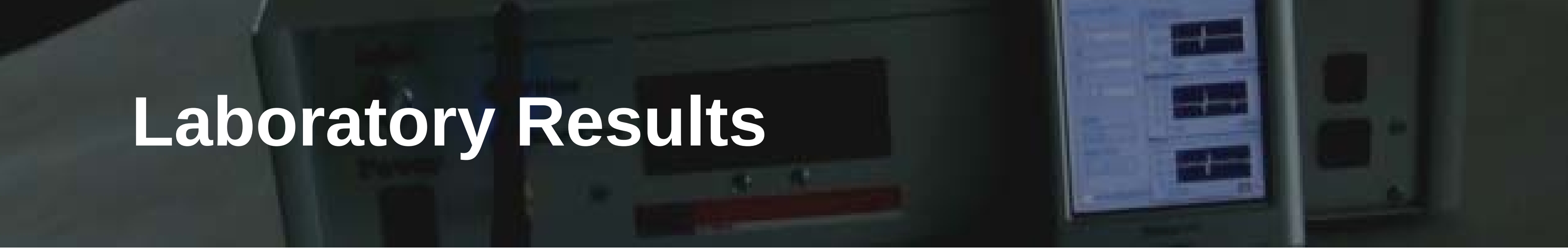
- => measuring two currents, you get N+d!?

Polydisperse Aerosol – a Problem?

- Calibration with monodisperse aerosol
- In polydisperse aerosol, larger particles carry more charge and contribute more to the measured currents
- => The measured F/D overestimates the diameter
- => The calculated number turns out too low
- However, for a known size distribution, correction factors can be applied
- Correction factors are „small“, i.e. 20-30% for a lognormal size distribution with $\sigma = 1.7$

Example Implementation

- Battery powered (12h)
- Size: 2 laptop computers
- Weight: 5.5 kg
- Transmits data via Bluetooth to PDA or PC
- Potentially smaller & lighter



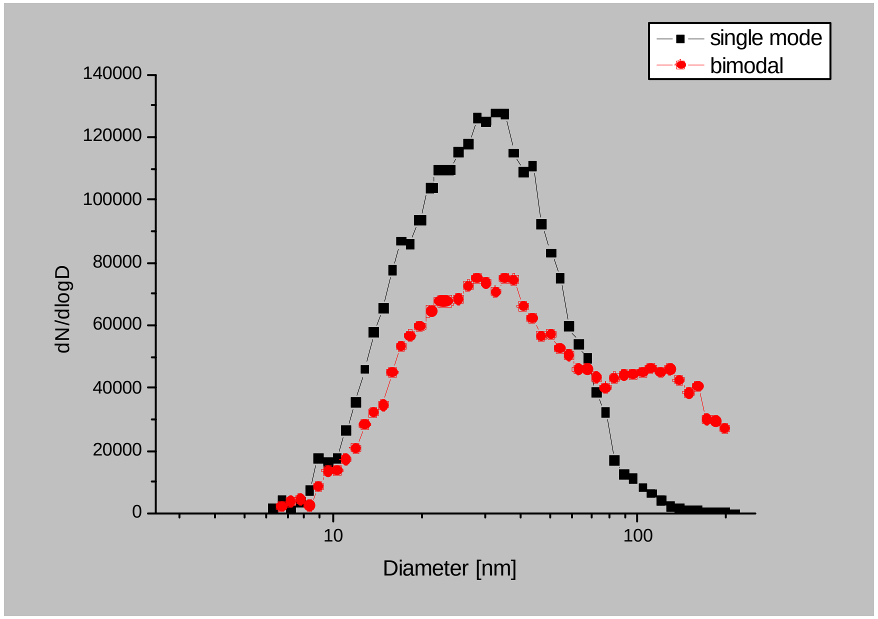
Laboratory Results

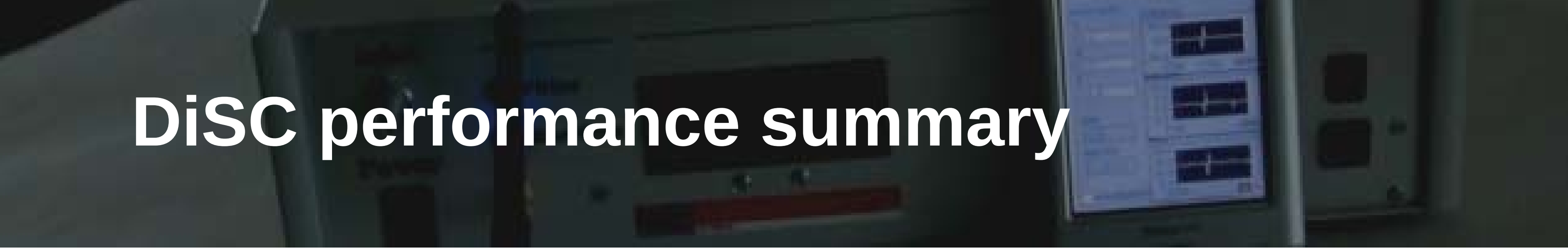
	SMPS d	DiSC d	SMPS N	DiSC N
NaCl	47.6	51.9	3.4E5	3.0E5
WOx	15.6	17.4	3.7E5	3.3E5
CAST 1	24.3	23.1	2.7E5	2.3E5
CAST 2	47.8	45.5	3.0E5	2.7E5
CAST 3	86.1	77.6	4.1E5	3.7E5

Too good to be true?

Bimodal Aerosol - a Problem!

- Results on last slide: for aerosol with $\sigma = 1.7$
- For bimodal aerosol larger errors occur
- Example: with $\sigma = 2.2$, diameter is 40% too large





DiSC performance summary

- Number concentration and average diameter measurement with an accuracy of ~30% (but can be worse in case of very broad size distributions)
- Fast time response (~2s)
- Detection limits: from 10^3 to 10^6 pt/ccm; upper limit depends on particle size

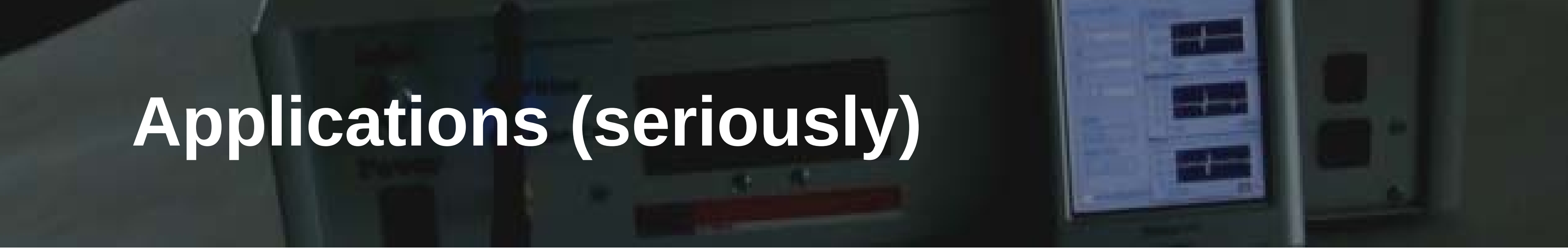
Applications

Mobile Lab:

U of M:

PSI:

FHA:



Applications (seriously)

- Any type of measurement which doesn‘t have to be very accurate like...
- Workplace pollution monitoring
- Mobile measurements & personal monitoring
- Regular DPF testing (good/not good)
- Process monitoring (Stability of an aerosol source, for example)

Conclusions

- DiSC is a very simple device
- DiSC measures size and number with reasonable accuracy
- DiSC is ideal for applications with low accuracy and high mobility requirements
- DC signal (F+D) is also available

Yesterday, late at night:

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Martin's uncertainty principle for aerosols:

- **The more precise your measurement is, the less relevant it gets!**