Relevant nanoparticle properties and how to measure them

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Vert focus event March 16, 2018

questions

What: what is the best metric to use? PM10, PM2.5, number, surface, EC,….???

Where: few supersites …personal monitoring

How: What is the best instrumentation

What is a reasonable limit

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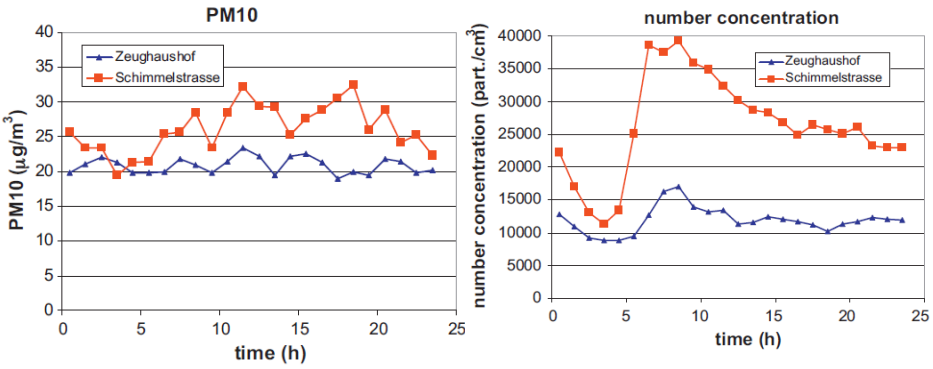
time series of PM10 and number concentration



orange: busy street
blue: urban background

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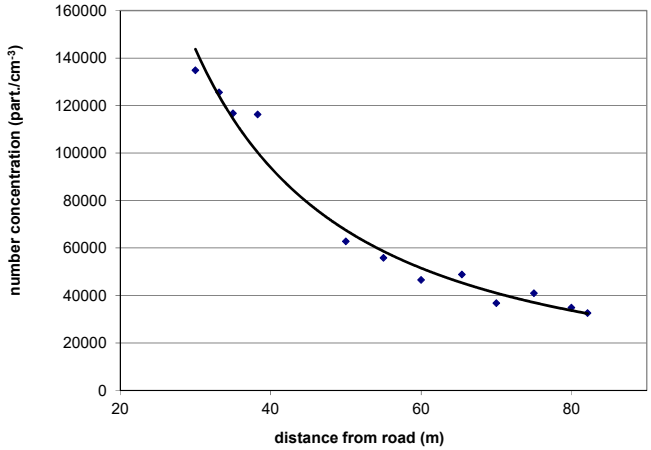
number concentration as function of distance from a road



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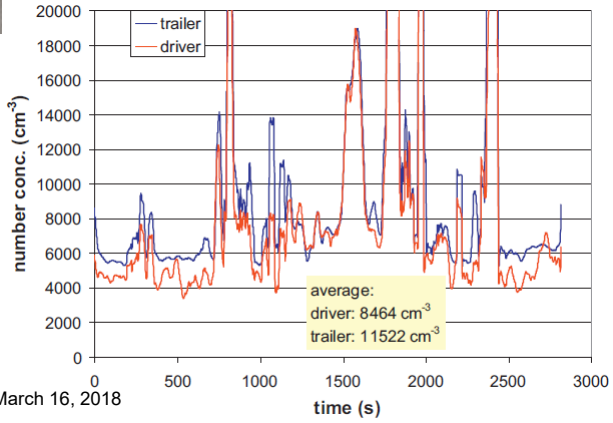
influence of height



weshalb es falsch ist, nur auf die Feinstaub-Konzentration zu schauen:

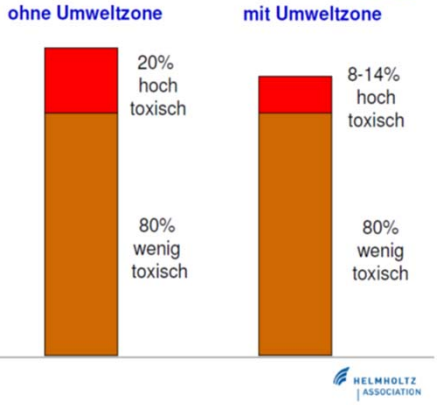
4

Entscheidend:

Nur ca. 20% des Feinstaubs sind hochtoxischer Dieselruß

wenn dieser Anteil um 6-12% reduziert wird, sinkt das Gesundheitsrisiko um 30-60%,

aber die Feinstaubkonzentration sinkt nur um 6-12%!

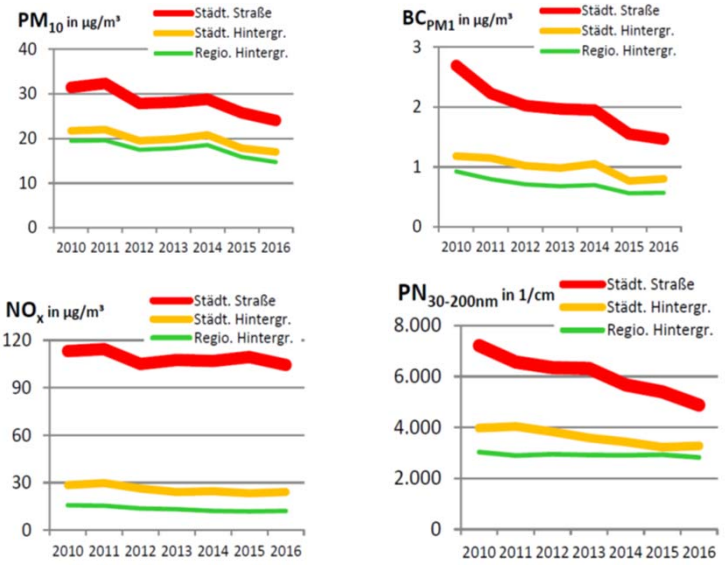


HelmholtzZentrum münchen
German Research Center for Environmental Health

HELMHOLTZ ASSOCIATION

From Wichmann

Results from low emission zone Leipzig

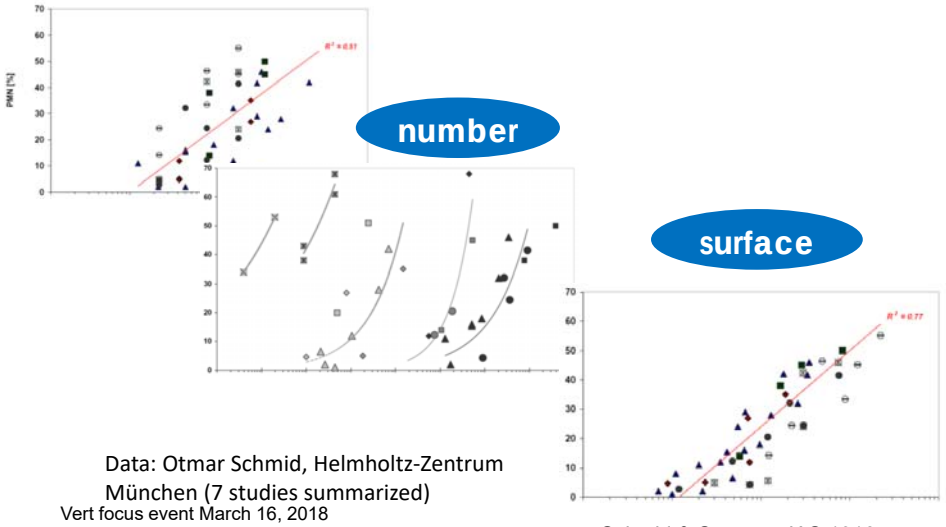


Particles and health effects

mass

number

surface



Data: Otmar Schmid, Helmholtz-Zentrum München (7 studies summarized)

Schmid & Stoeger, JAS 1916

Current legislation

ambient air:	**PM10, PM2.5**
occupational health:	**EC**
combustion engines:	**PM, number conc., solid >23nm**
biomass combustion	**PM**

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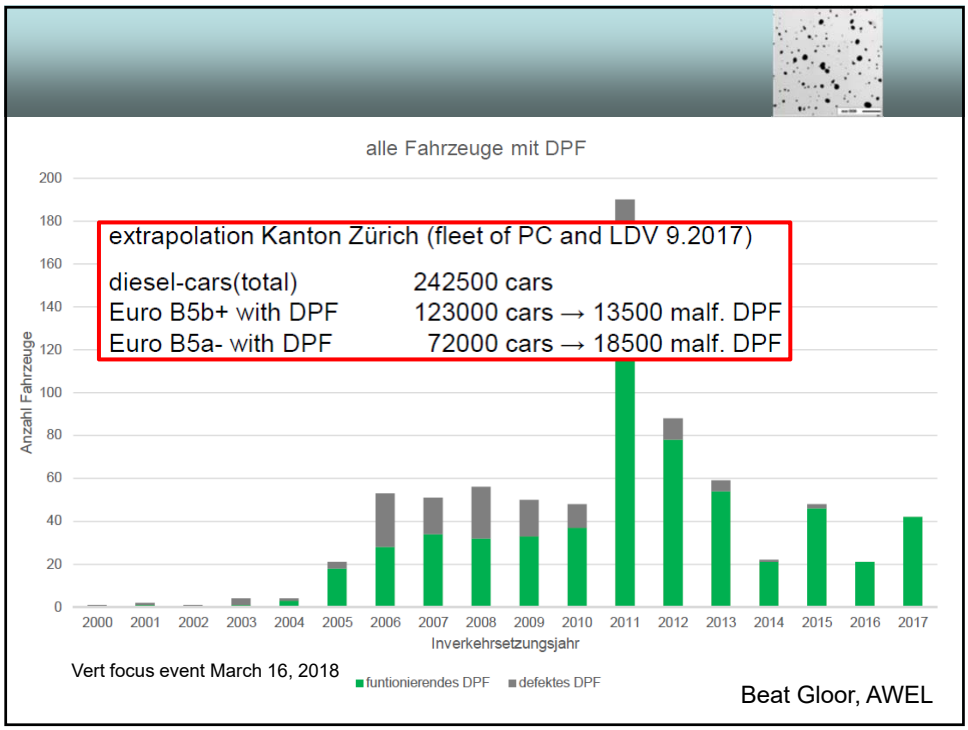

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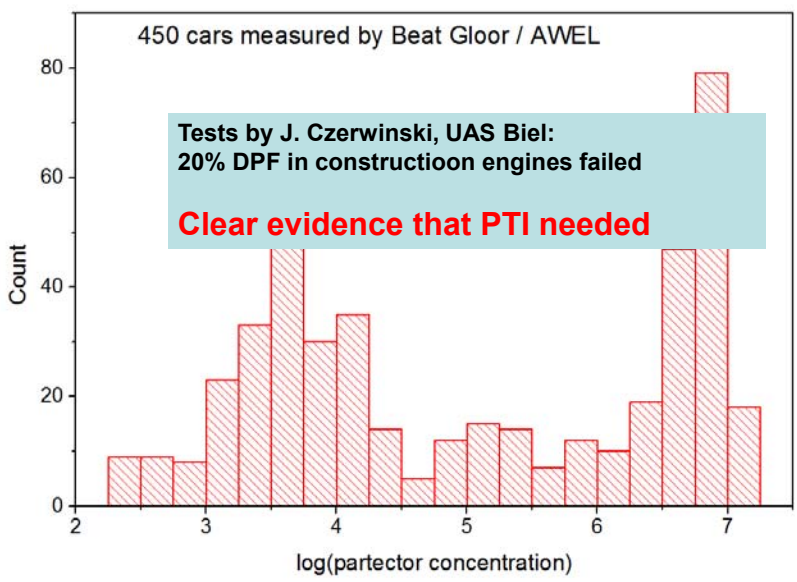
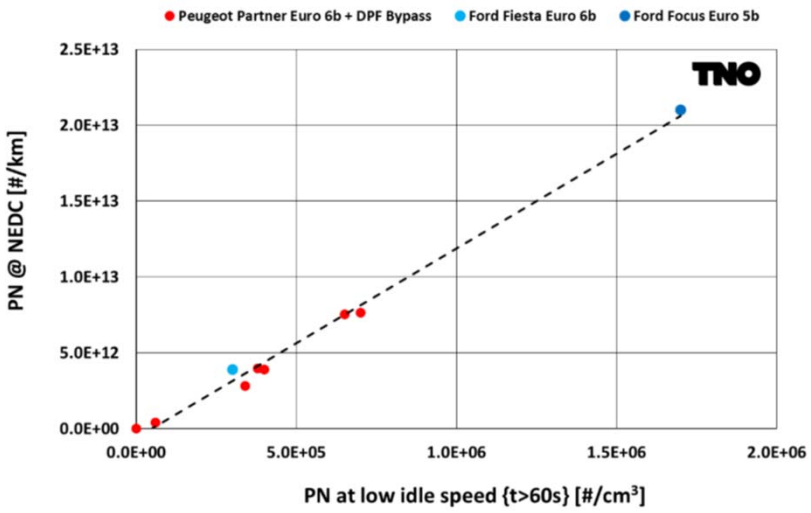
Beat Gloor, AWEL



How to do PTI

free acceleration
low idle
high idle



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From G. Kadjik, TNO

First Conclusions

- For ambient air measurements with weight on nanoparticles the location is crucial.
- Possible metrics therefore are number, surface or elemental carbon concentrations
- Several studies indicate that surface has the best correlation to health effects
- Periodic inspection is needed to ensure proper operation of particle filters

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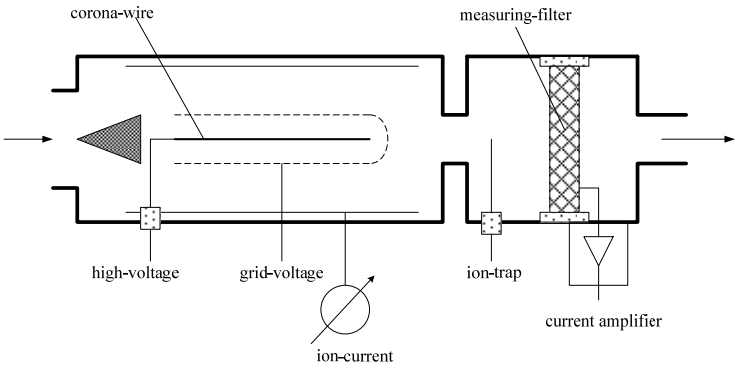
One focus of our work:

developing small instruments
not only ‚portable‘
but ‚wearable‘
for ambient air and emission measurements

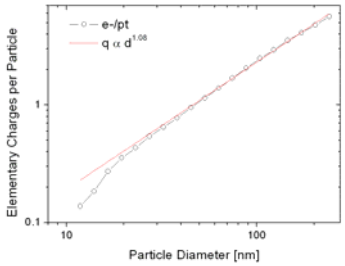
Unipolar Diffusion Charger



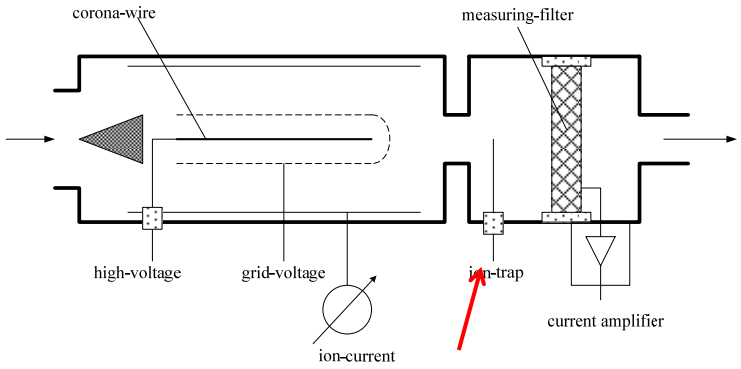
charging mainly material independent

Charging is tunable

- Diffusion charging leads to a charge proportional to d^x
- Exact value of x depends on charger; typically 1.0…1.4
- Can be tuned to achieve signal
  ~ number concentration
  ~ LDSA

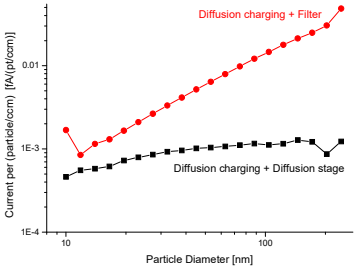


size dependence can be tuned by ion trap voltage



Size selective detection

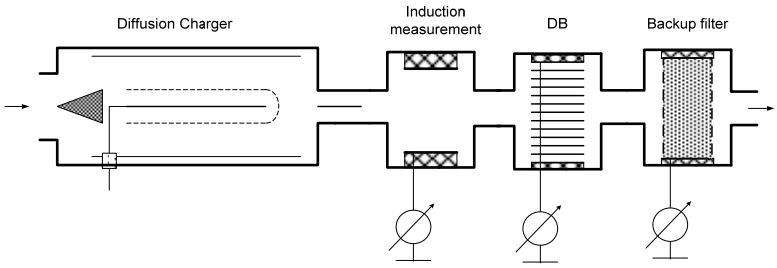
- by Diffusion: instrument response is nearly independent of particle size
  „electrical particle counter“



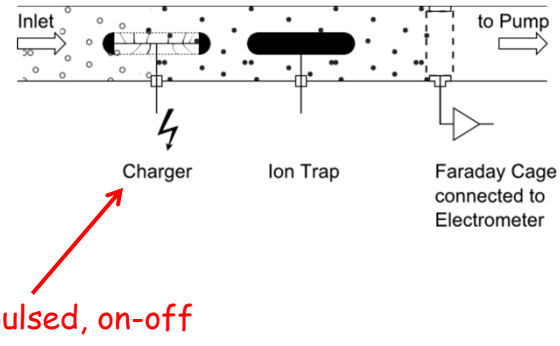
Why do we need this tunability’?

- Fulfill legal requirements, e.g. measure number concentration(PMP-Protocol)
- Considering health effects

Diffusion Size classifier (DiSC)



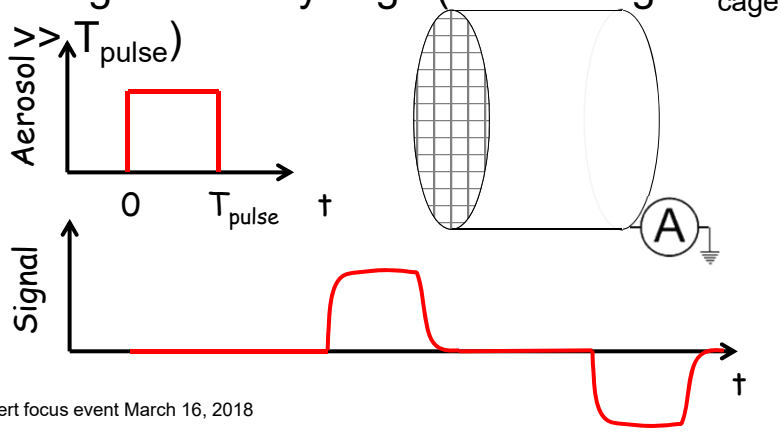
Aerosol detection with induced currents



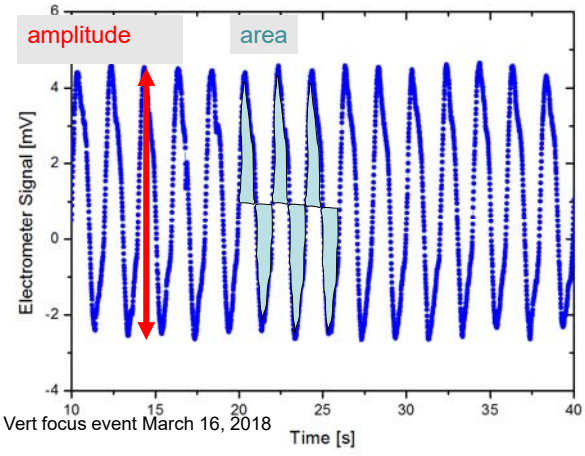
pulsed, on-off

Aerosol detection with induced currents

- "Large" Faraday cage (time in cage $T_{cage} >> T_{pulse}$)

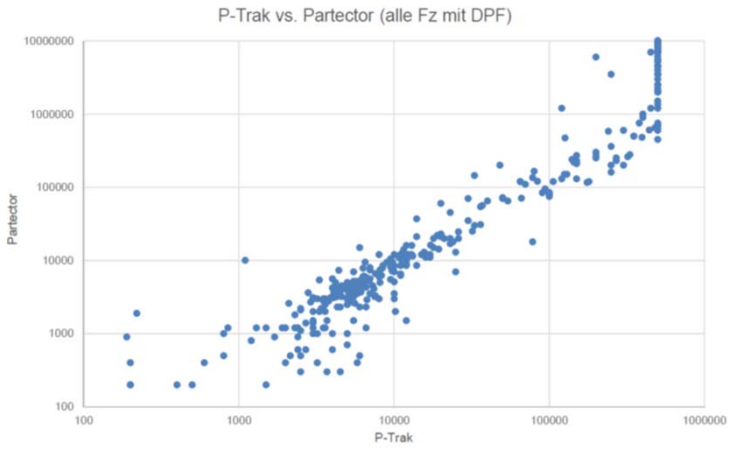


Signals in the iDC



- no filter necessary ⇨ no exchanges ⇨ little maintenance
- particles available after measurement
- automatic 0 offset compensation & short warmup time
- you get a nonzero signal from noise alone

- can be miniaturized!
- 300 cm^3 / 460 g battery-powered
- world's smallest nanoparticle detector!?



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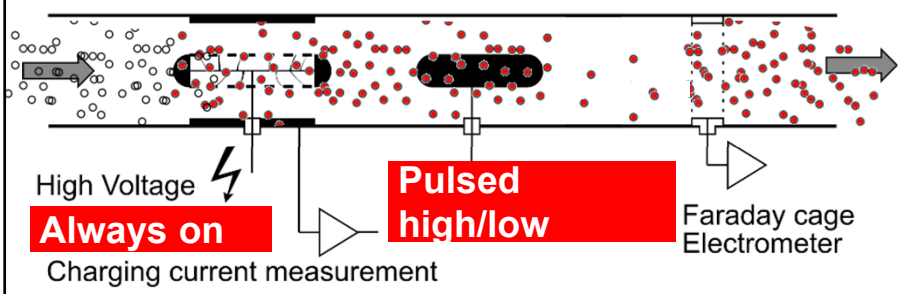
From Beat Gloor

Influencing size dependence



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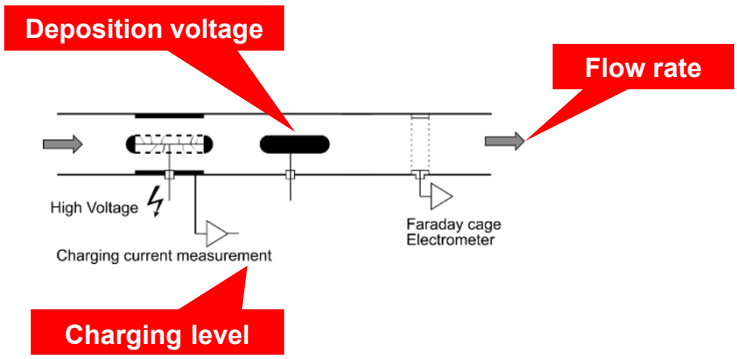
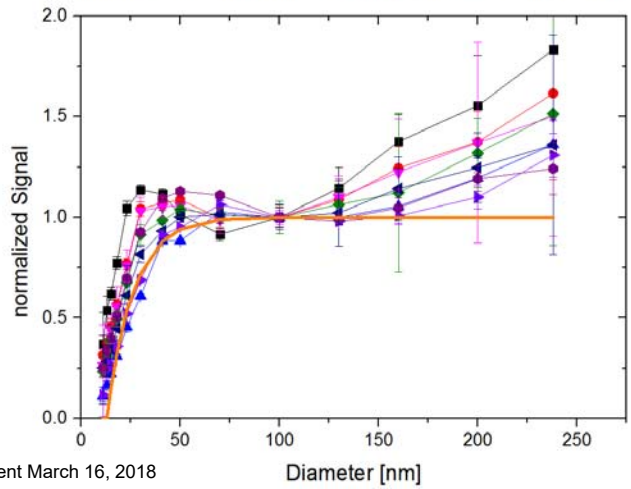
- Parameters that influence the instrument response:



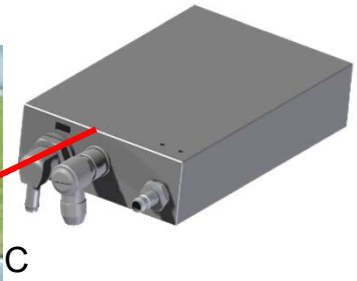
instrument response

Different SUREAL candidate settings, normalized@100nm



automotive partector

- Limits of detection: ~500 – $1.5 \cdot 10^6$ pt/cm^3
- Particle size range: 15-200 nm
- Size: 16.5 x 8.8 x 3.2 cm

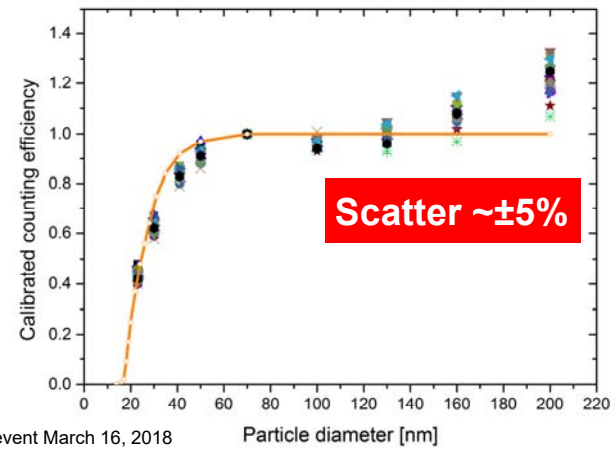


C

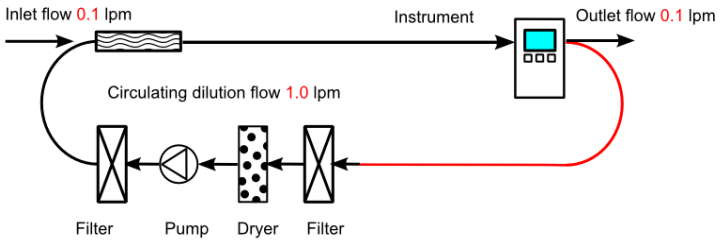
Measuring 'real driving' Emissions (AVL PN-PEMS)

Comparability for multiple instruments (initial calibration only! NaCl)

24 AP devices calibrated with NaCl



Exhaust conditioning for portable instrument



- Hot dilution
- small flow rates

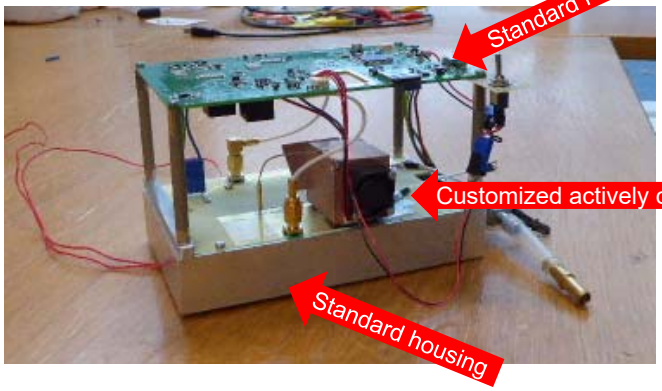
  ⇒ smaller pump, less power, less contamination

- Prototype! built to prove feasibility
- Handheld
- 1.5kg
- BATTERY OPERATED
- 1:10-dilution at 200°C (0.1/1lpm)
- range 10^4 – 10^8 pt/ccm

Next step: avoid dilution and heat sensor

(for <23nm device)

- 150°C tested



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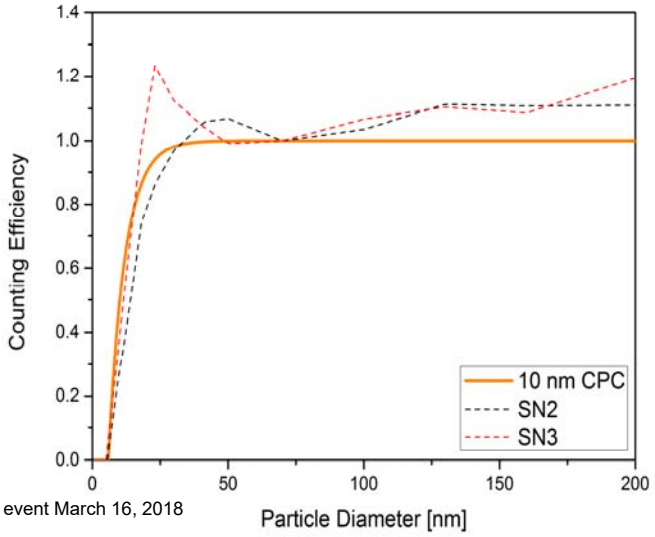
instrument response optimized for 10nm



System for In vitro toxicity tests

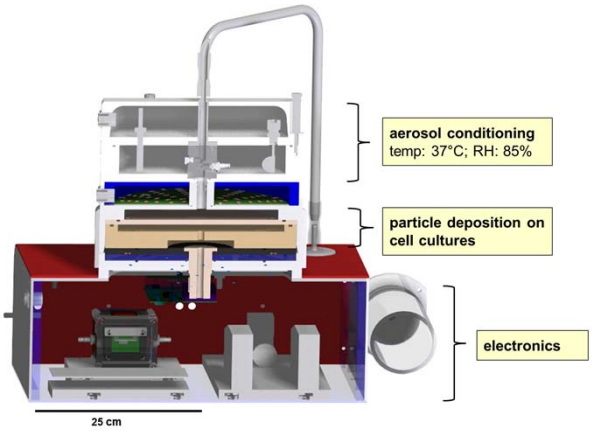
Once particles are electrically charged, they can be deposited in a well defined way

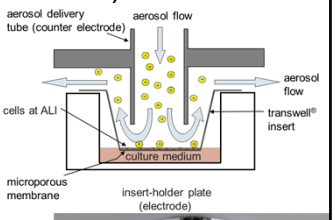
For example for analysis in the electron microscope
or on cell cultures to study there effects on the cells

In collaboration with M. Geiser from Uni Berne we developed such a 'deposition chamber', based in the same basic components:

- particle charger,
- particle 'manipulator' for deposition

Nano Aerosol Chamber for In-Vitro Tixicity (NACIVT)





Conclusions

- Charge based techniques offer a wide range od possibilites for particle characterization.
- They allow to built small, fast and easy to use devices
- Cannot replace lab Techniques, mainly for monitoring purposes