In-use Particle Filter Inspection with Simple Electrical Particle Detectors

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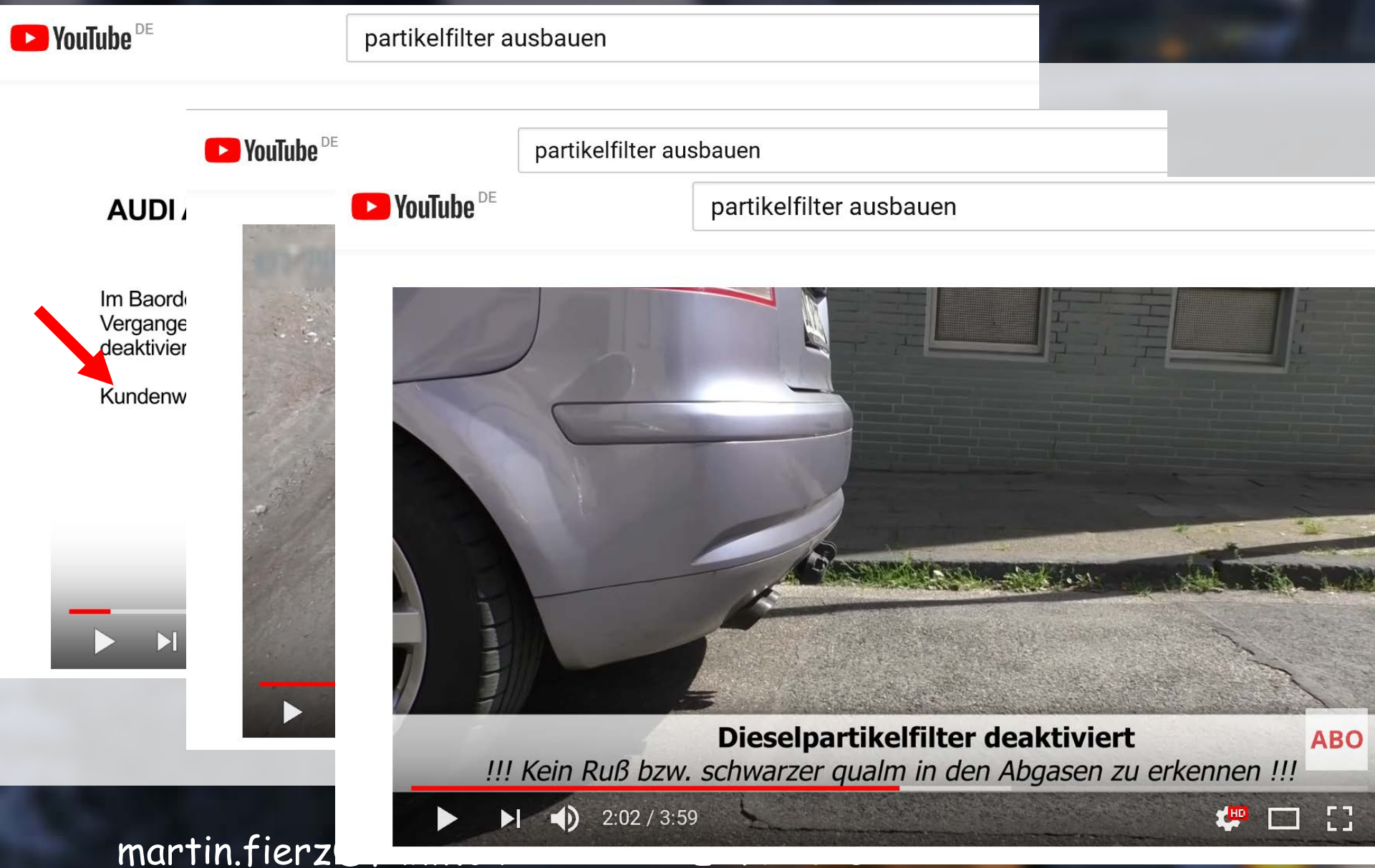
Motivation


YouTube DE
partikelfilter ausbauen
YouTube DE
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AUDI
Im Baord
Vergange
deaktivier
Kundenw
Dieselpartikelfilter deaktiviert
ABO
!!! Kein Ruß bzw. schwarzer qualm in den Abgasen zu erkennen !!!
2:02 / 3:59
HD

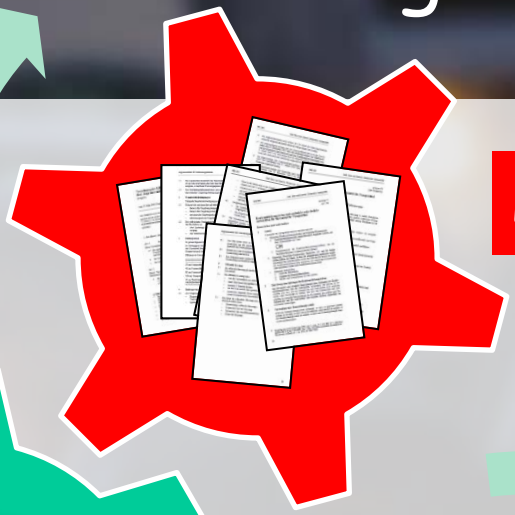
State of the art

- Complex devices mimicking PMP type approval protocol

- Simple sniffers (handheld CPC)

It's not only about the device!!

PTI is a package with 3 ingredients



Limit value

Procedure

Device

The key idea: the right procedure

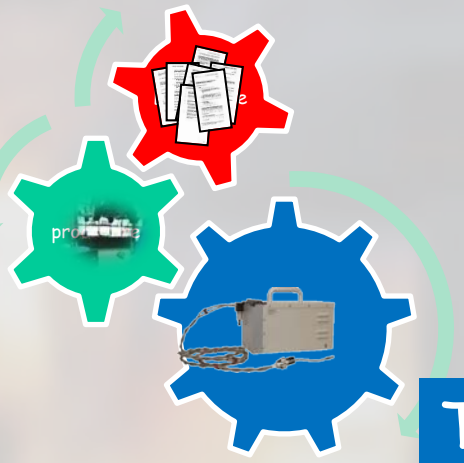
(see talk by Gerrit Kadijk this afternoon)

Measure at low idle with warm engine

- (Very easy in PTI)
- Automatic dilution for Diesel engines
  (λ ~10, much lower dewpoint than usual)

This allows a simpler device

Procedure leads to much lower dewpoint

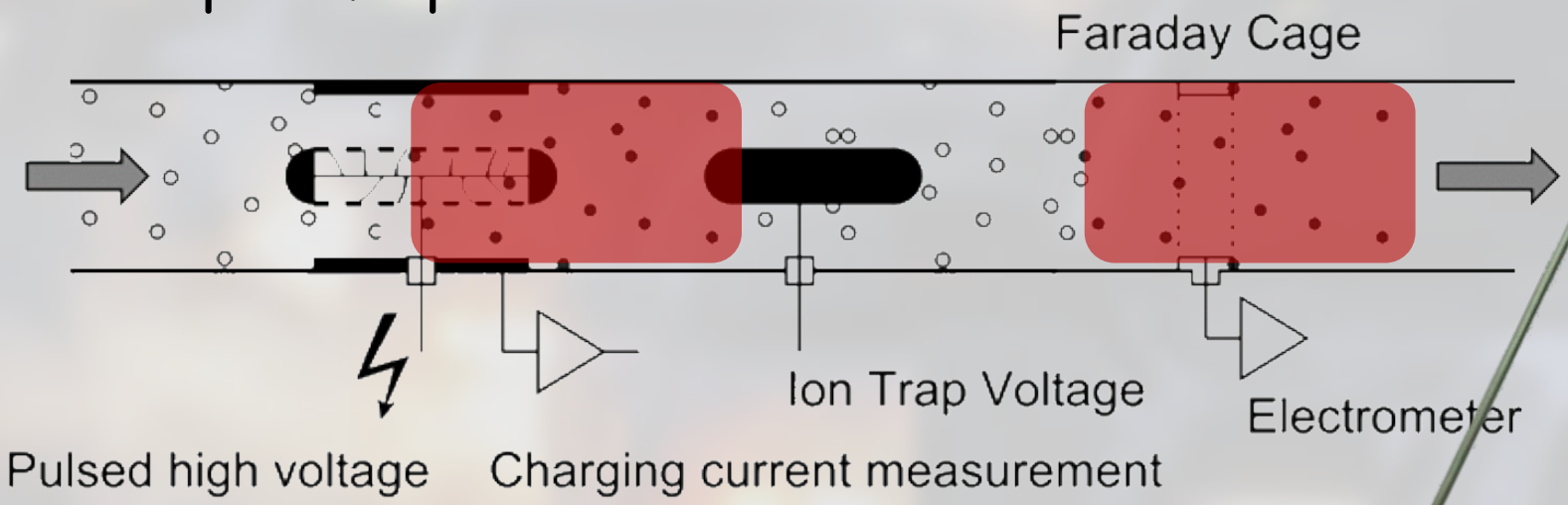


Therefore we can use a device with no dilution heated to ~40°C

Simpler device: The Partector

M. Fierz et al. Aerosol measurement by induced currents, Aerosol Science and Technology 48 (4), 350-357, 2014

- Principle of operation

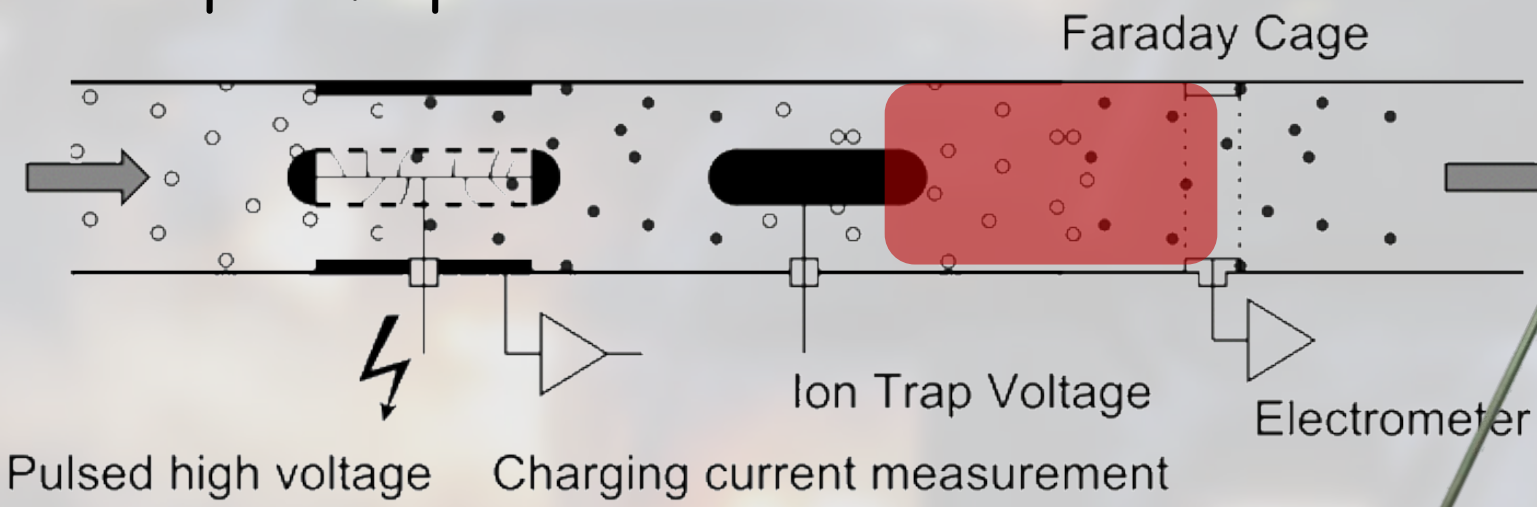


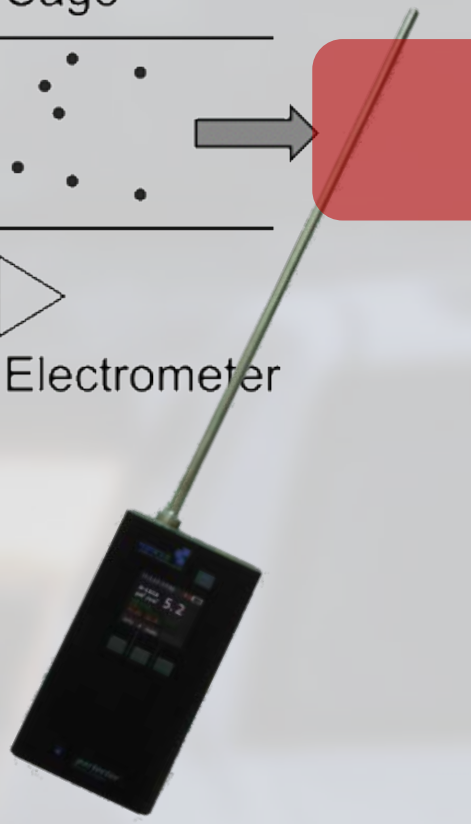
- Advantages vs. traditional DC:
  - Insensitive to electrometer offset drift
  - No filter, no clogging, little maintenance

Simpler device: The Partector

M. Fierz et al. Aerosol measurement by induced currents, Aerosol Science and Technology 48 (4), 350-357, 2014

- Principle of operation

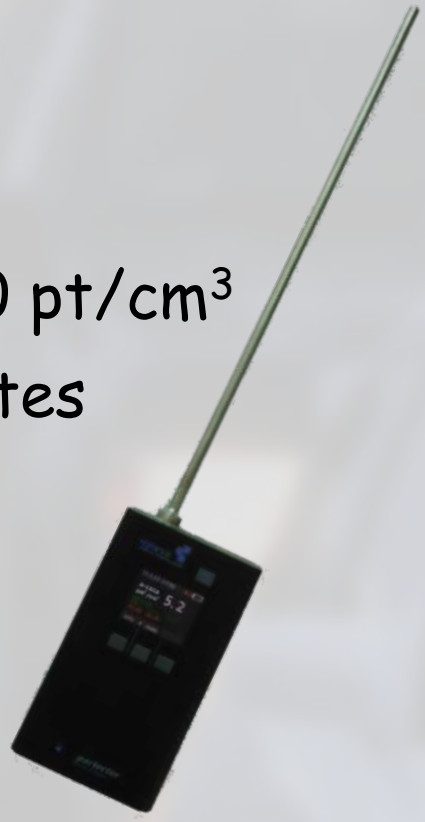




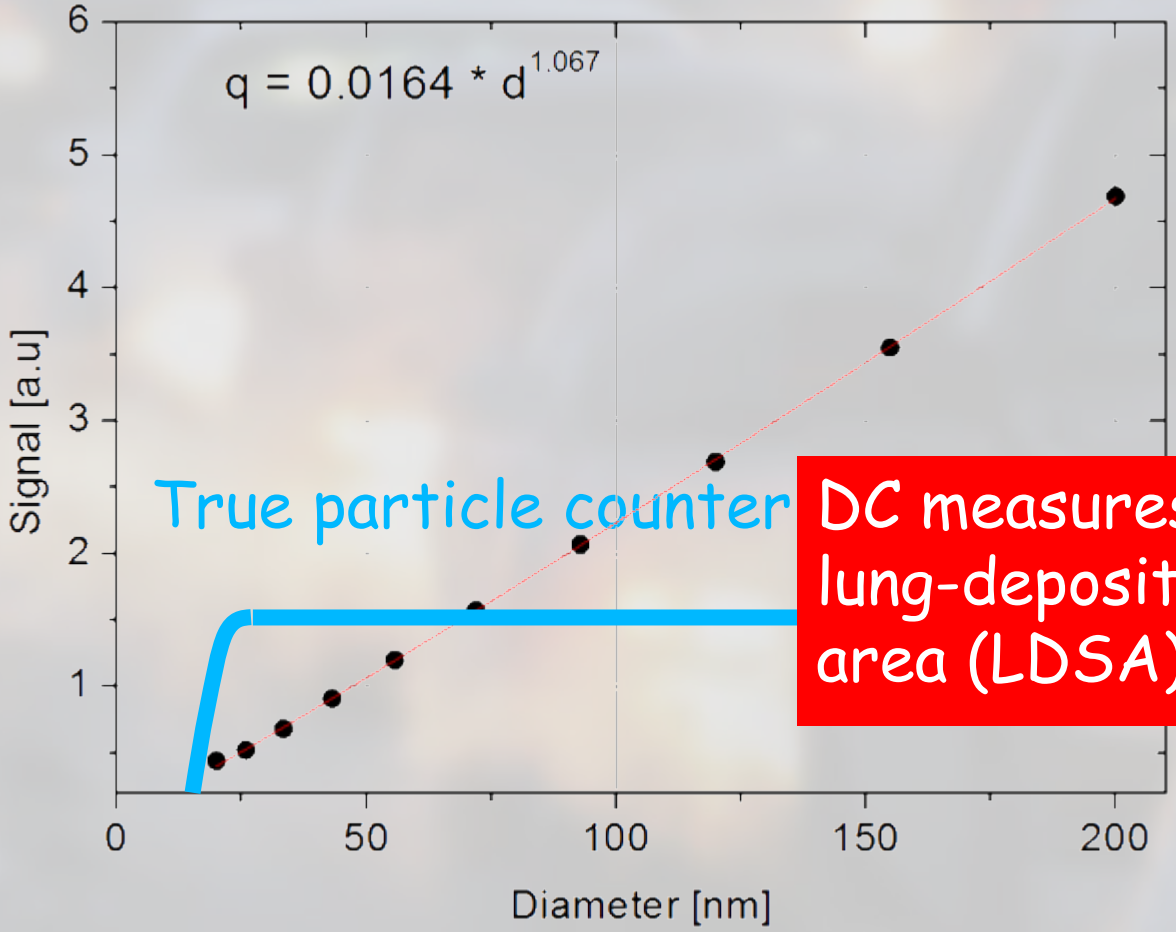
- Advantages vs. CPC
  - No working fluid, no hassle, no flooding
  - Short warmup time
  - Smaller + lighter
  - Better concentration range for this application
  - Can be heated to 60° to avoid condensation
  - Internal RH sensor

Partector DPFtester specifications

- Only change vs standard device: larger battery + heater
- Weight 700g, Size 13x8x6cm
- Battery lifetime ~6h
- Concentrations: 1'000 – 5'000'000 pt/cm^3
- ΔT vs ambient: 15-25°C, 5-10 Minutes warmup time



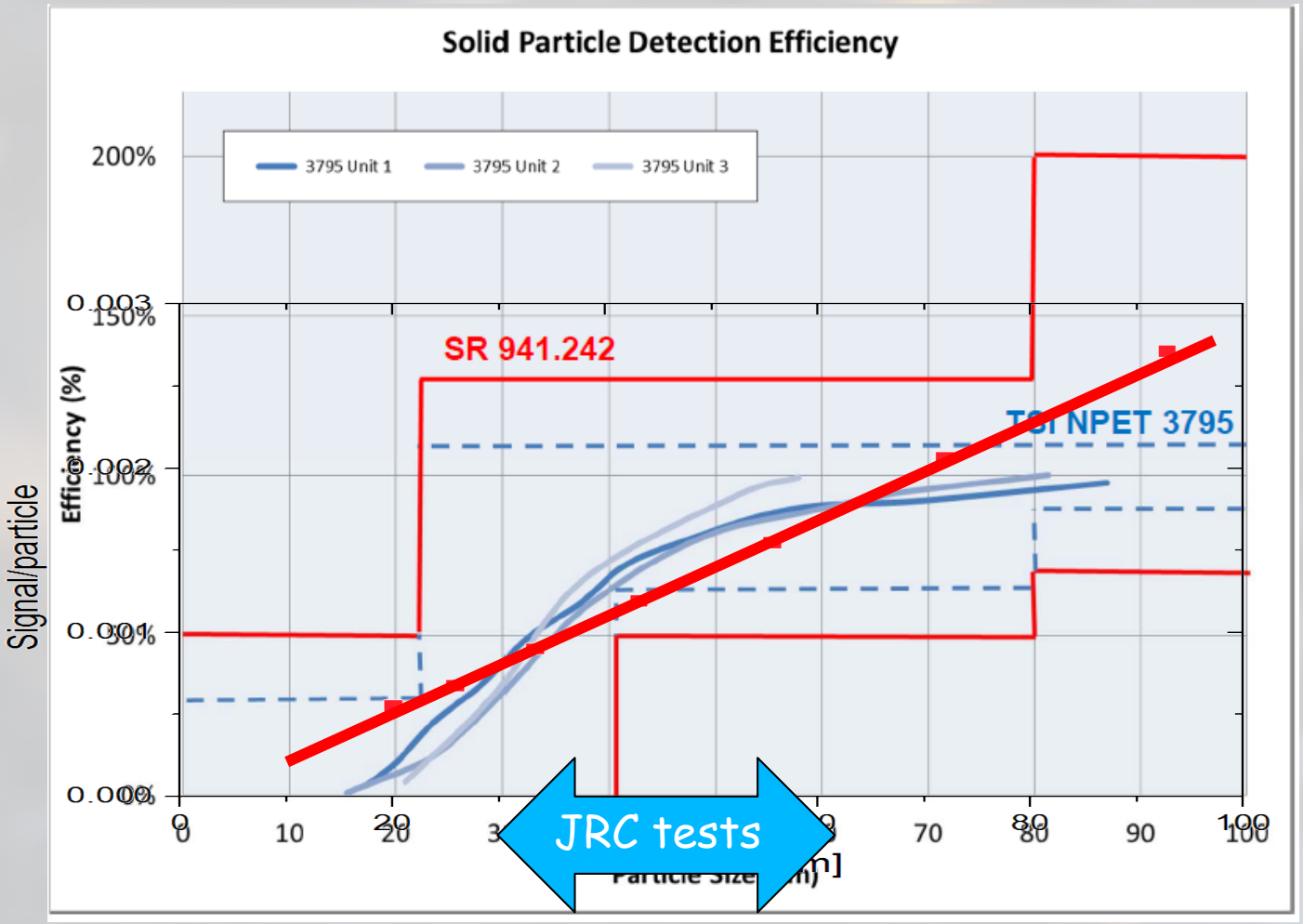
But it doesn't measure particle number!



DC measures $N \cdot d^1$, or lung-deposited surface area (LDSA)

But it doesn't measure particle number!

http://www.nanoparticles.ch/2014_ETH-NPC-18/FE2-3_Horn.pdf

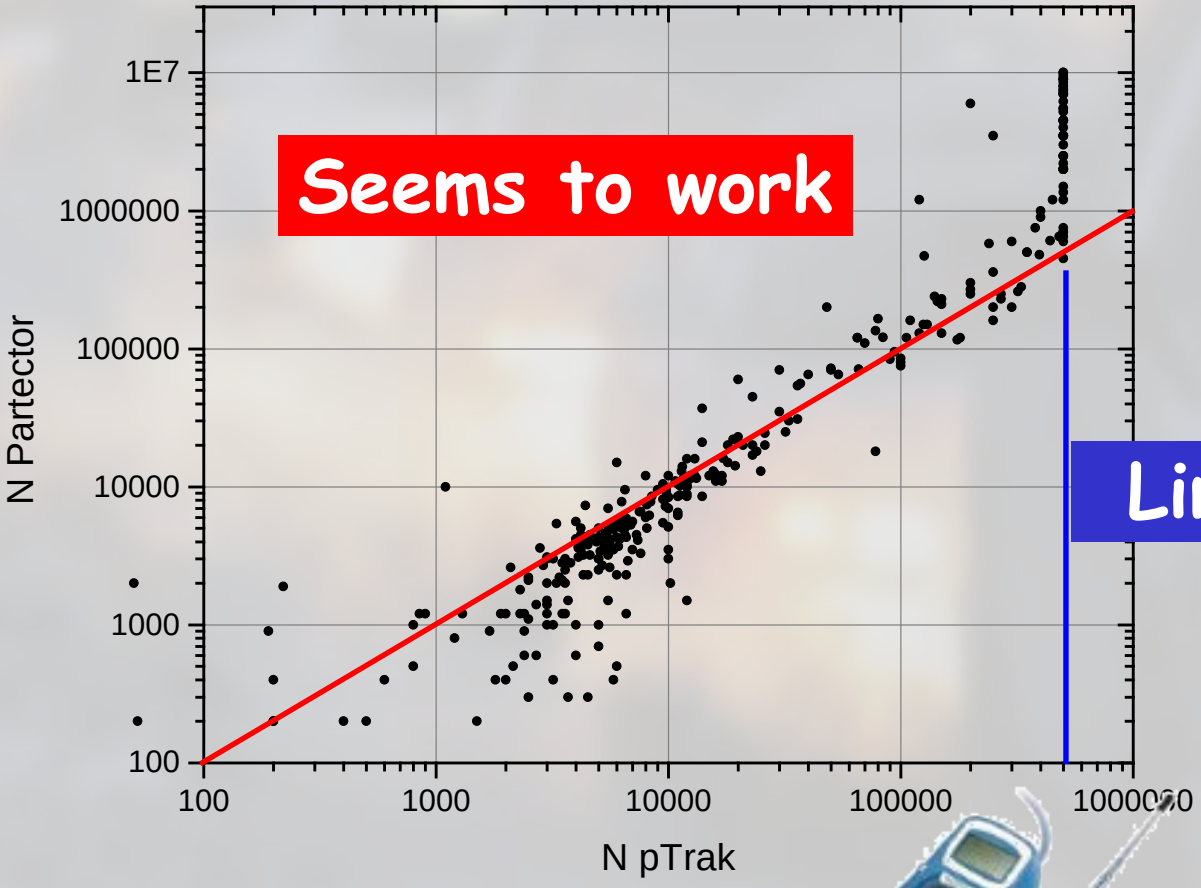


Results

- ~~Own testing~~
- ~~Testing at JRC (next presentation, R.Suarez)~~
- Real PTI data (more this afternoon, B.Gloor)

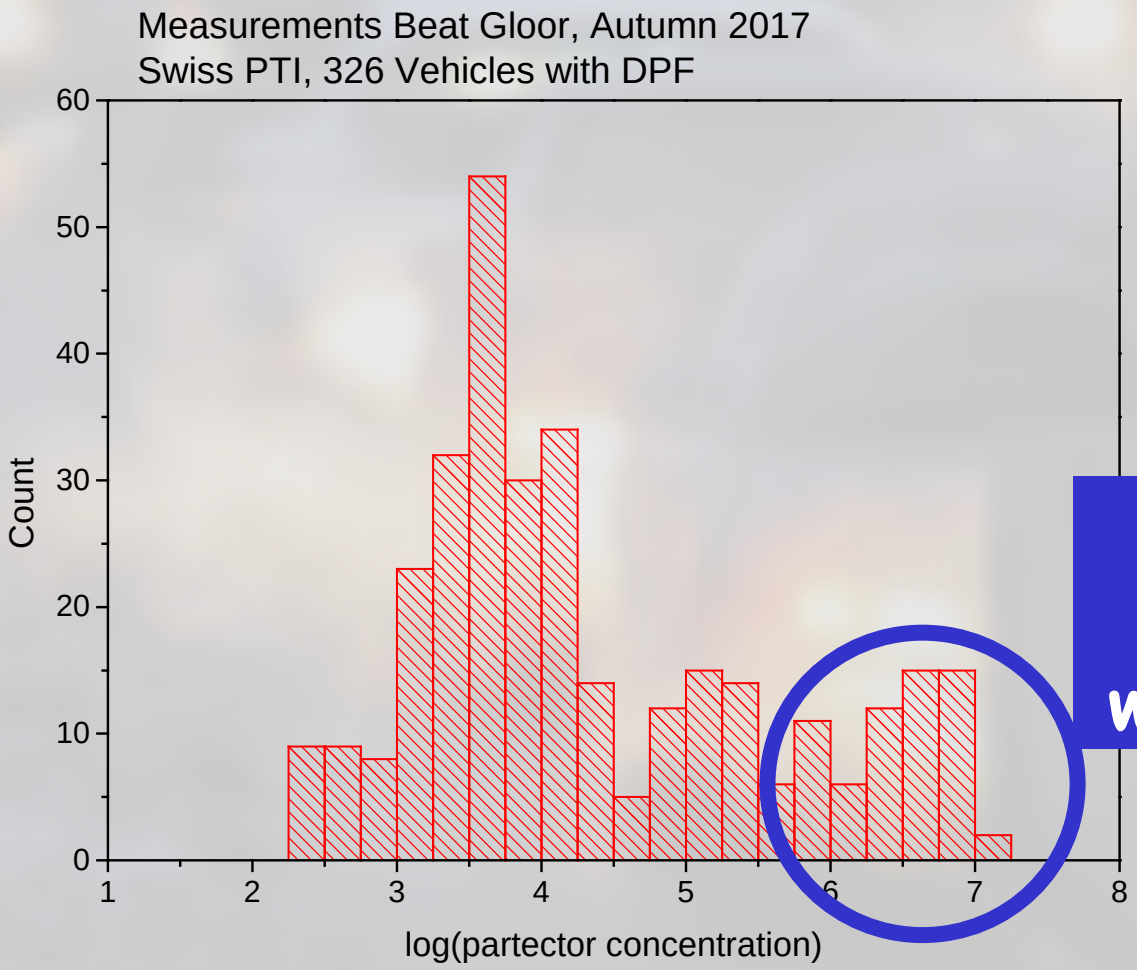
Result Beat Gloor

326 cars with DPF



Limit p-Trak

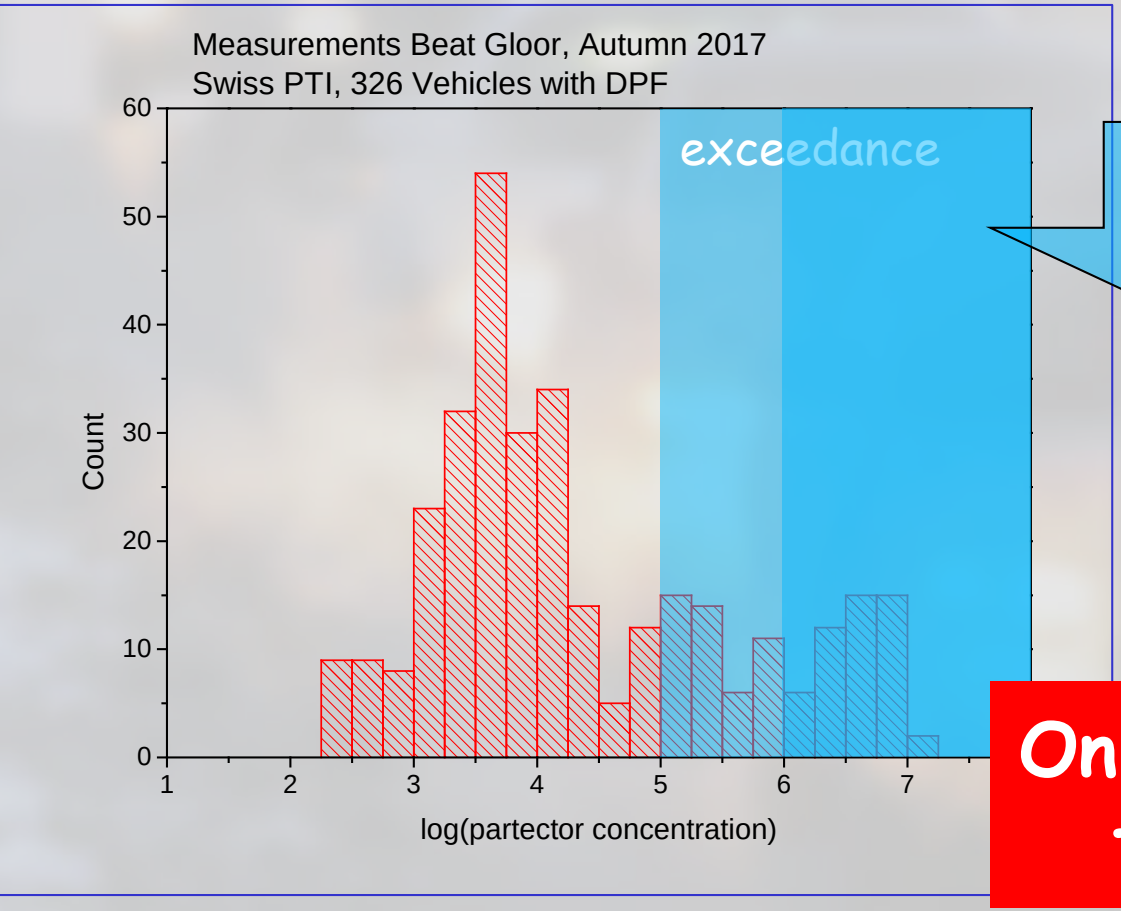
Result Beat Gloor



Cannot be resolved with p-Trak

Limit value?

What will a limit value achieve?



Limit	average
None	7.74e5
1e6	0.65e5
1e5	0.11 e5

-7.1e5

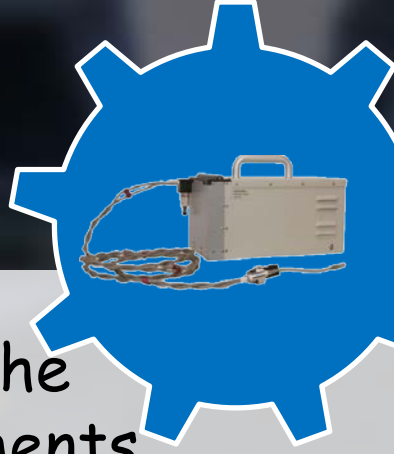
-7.6e5

Only 7% more reduction for 1e5 vs 1e6 (!)

Conclusions (procedure)

- low idle is a great candidate for new PTI for DPF
- Keep in mind:
  - Concentrations are generally low, use a strict limit value.
  - Procedure creates uncertainty even with perfect devices (EGR, filter loading state), perhaps a factor 2 = it's pointless to ask for highly accurate devices!
  - Lube oil peak relevant or not??

Conclusions (devices)



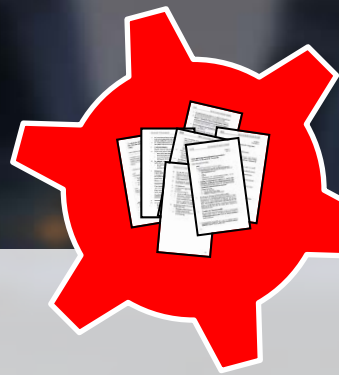
- It's very easy to detect damaged DPFs in the field with simple diffusion charging instruments
- DC devices are ideal for this application (much better than CPCs)

Ultra-simple version only works for Diesel + low sulfur fuel!

- More testing (1000s of vehicles) under way in Belgium – will prove or disprove this approach

If it doesn't work we have to make it more complex

Conclusions (legislation)



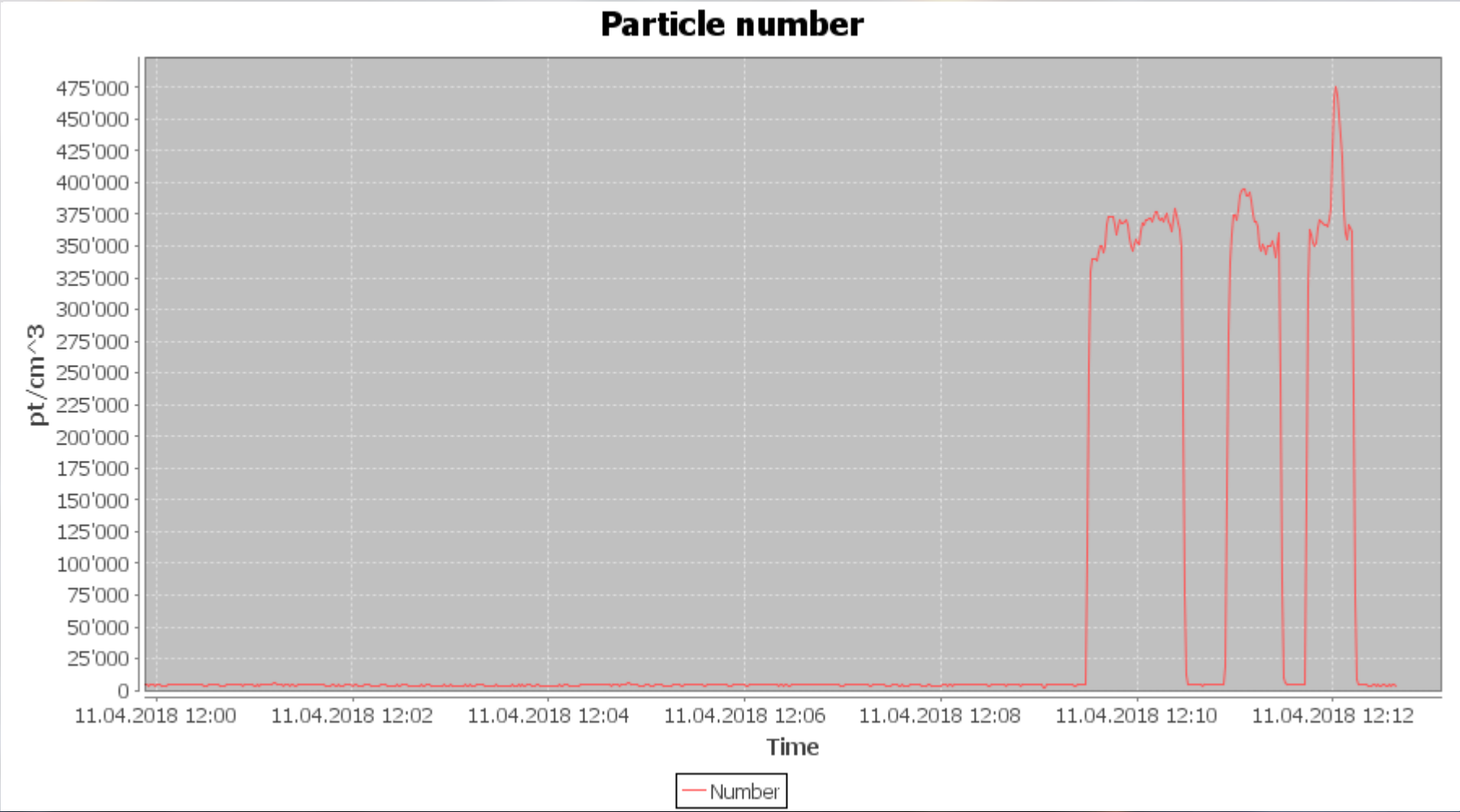
- The difference between an NPET (d^0) and a diffusion charger (d^1) is minimal in the size range of interest (allowing DCs does no harm).
- The exact limit value has little influence on final urban air quality.

Acknowledgements

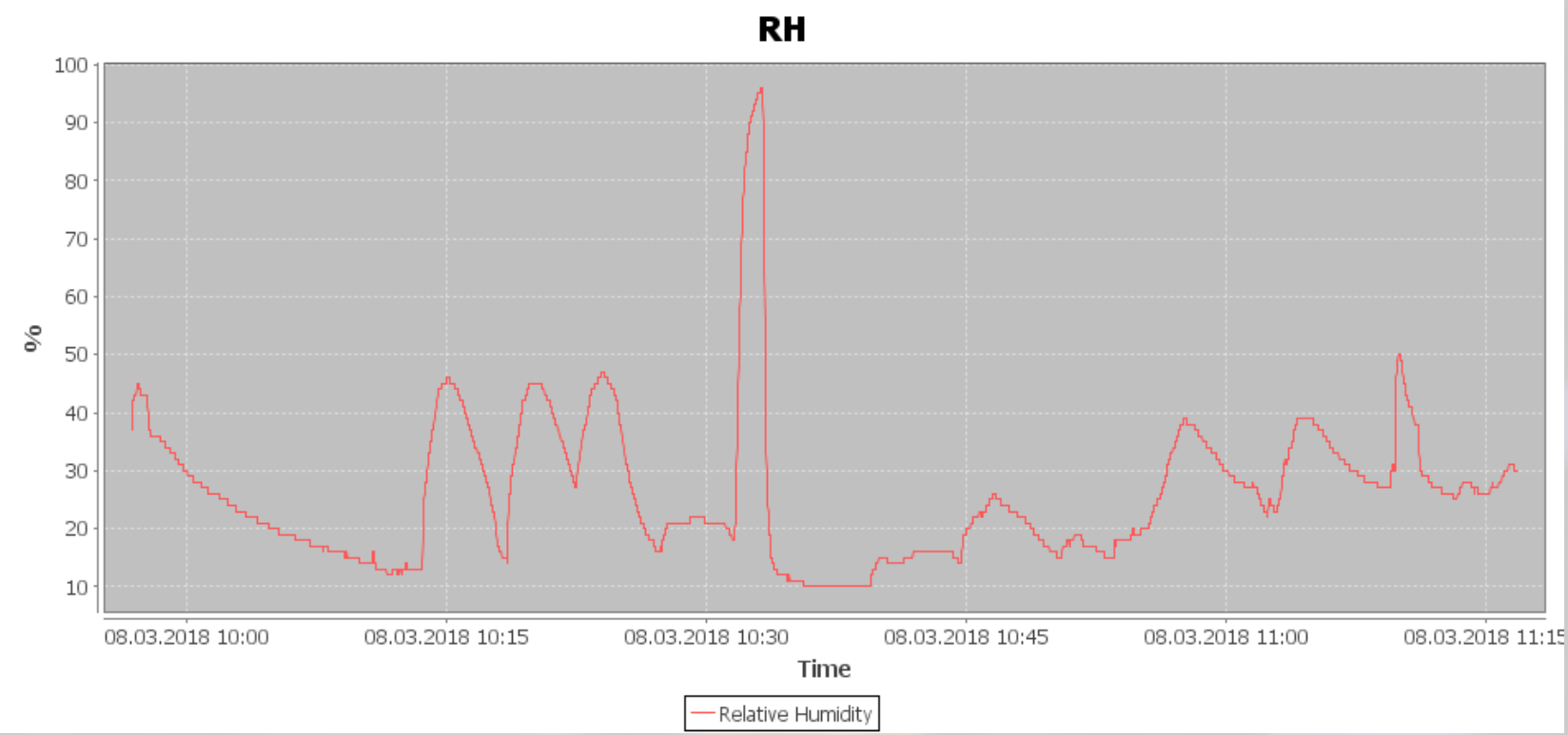
Beat Gloor (AWEL)

For sharing the data of his field campaign

Example: low idle measurement JRC



GDI?


RH
100
90
80
70
60
50
40
30
20
10
%
08.03.2018 10:00
08.03.2018 10:15
08.03.2018 10:30
08.03.2018 10:45
08.03.2018 11:00
08.03.2018 11:15
Time
Relative Humidity

But it doesn't measure particle number!

- Is this about §§§ or about protecting public health?

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Surface area is the biologically most effective dose metric for acute nanoparticle toxicity in the lung

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The Task

- Detect vehicles with broken or removed filters
- Measurement must be simple, fast, reliable, cheap, and be performed by non-aerosol-scientists