DC-instruments for PN at idle PTI in workshops and roadside

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Overview

Type approval lab

Only CPC

Type approval RDE

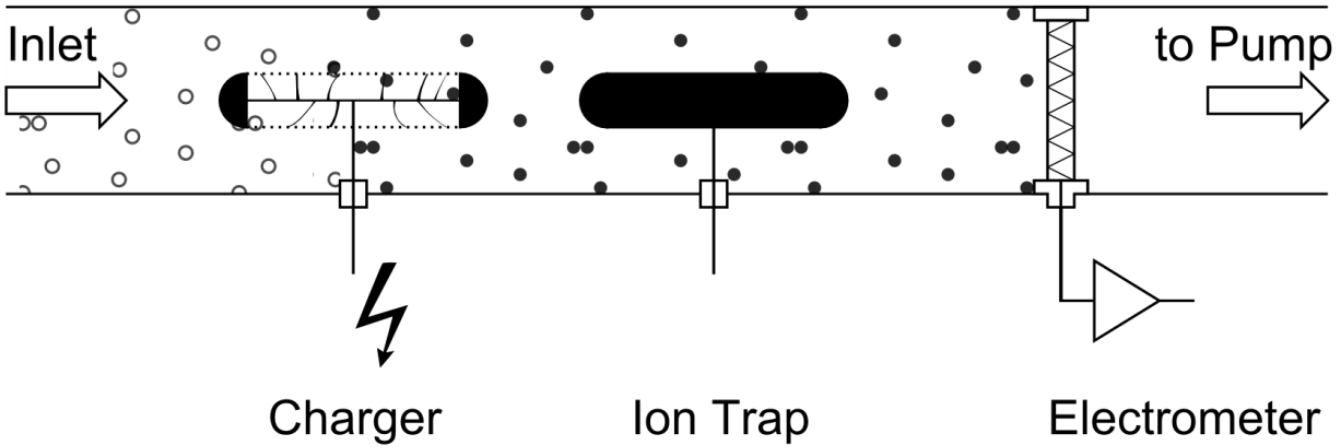
CPC/DC mix

periodic inspection

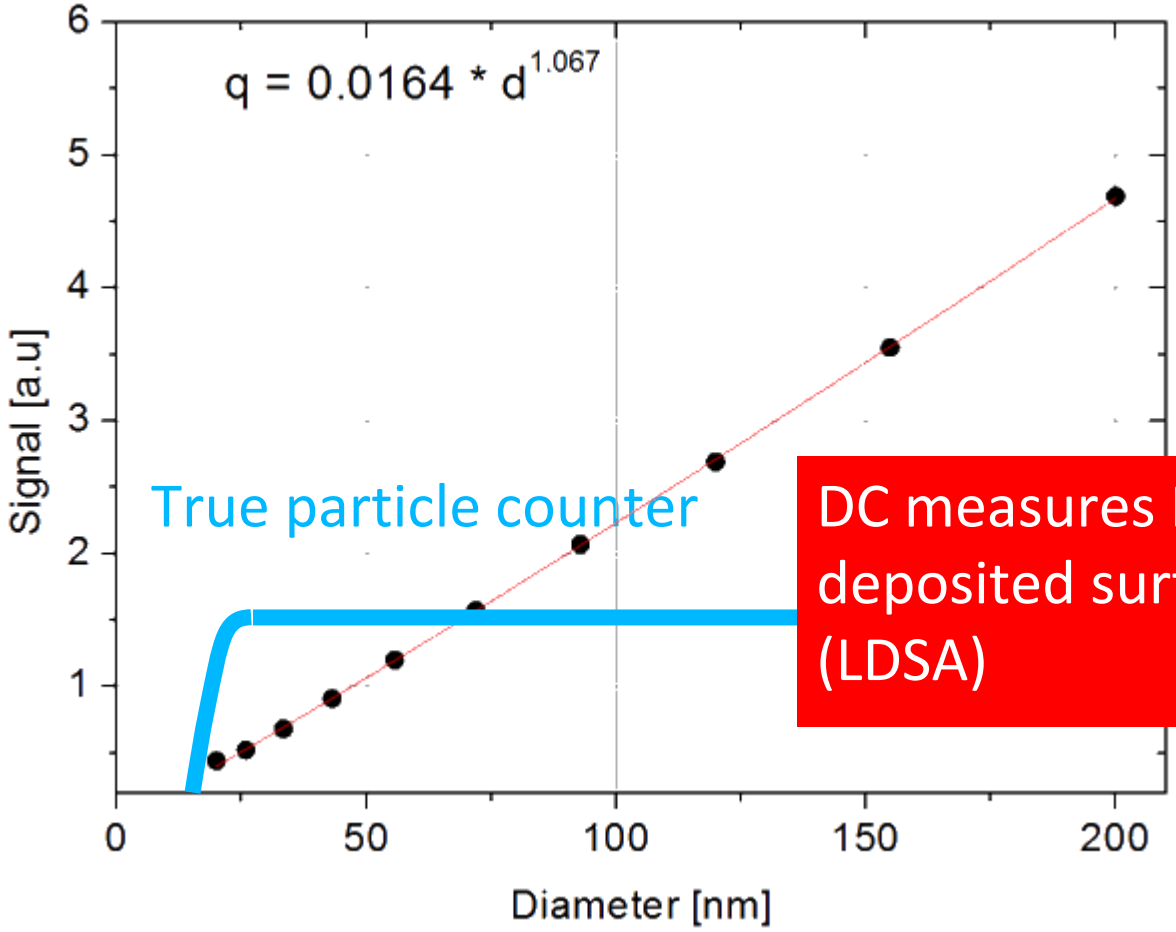
More DC than CPC?

Diffusion charging: the principle

- Simple technique (just 3 elements)
- No consumables (filter needs periodic exchange)
- Sensitive to nanoparticles (unlike light scattering)
- Unspecific (no material dependence)



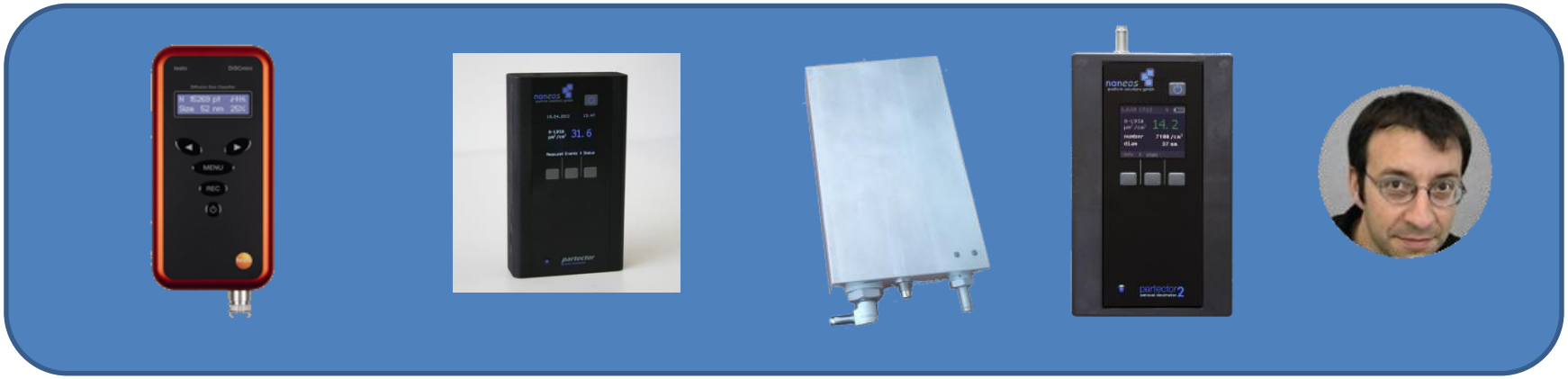
Instrument response (linear in particle diameter)

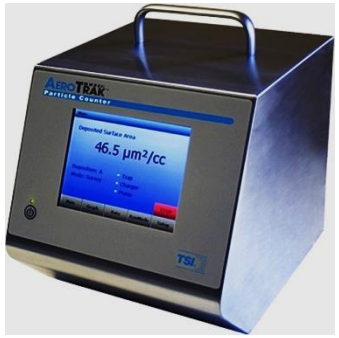


DC measures $N \cdot d^1$, or lung-deposited surface area (LDSA)

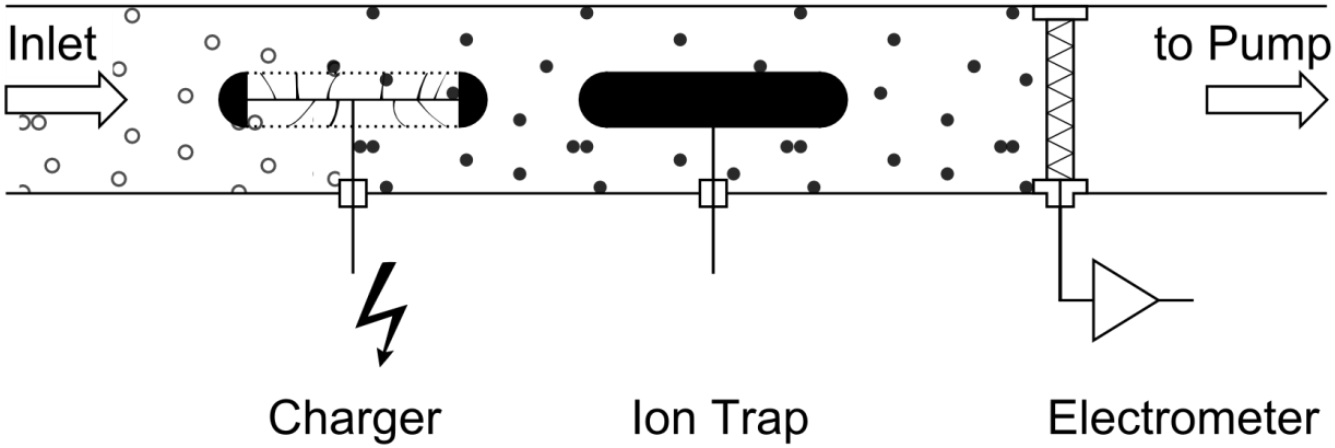
Many suppliers, even more devices

- The basic principle is simple and robust
- Many different implementations have been realized





Why are DCs more attractive for PTI than CPCs?



- Simpler, more robust, more cost effective
- No working fluid, no consumables, no hassle
- Better concentration range: no or low dilution required
- Heatable above exhaust dewpoint

Technology variations

- **Standard** diffusion charging
- **Escaping current** technology
- **Induced current** technology

- Each of these has specific benefits and drawbacks
- The implementation is more important than the principle!

Standard technology

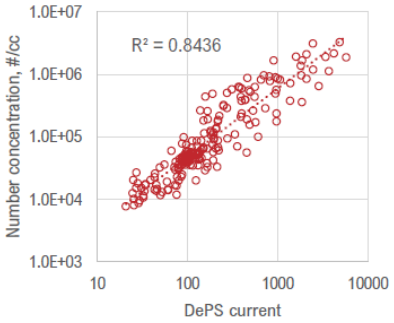
- **Particles are collected on a filter (or something else), currents measured – measures charge state of particles**

DEKATI

DePS™ – Dekati electrical Particle Sensor

- Portable maintenance free particle sensor
- LDSA, Number and Mass concentration
- Available also as customizable OEM module

Specifications



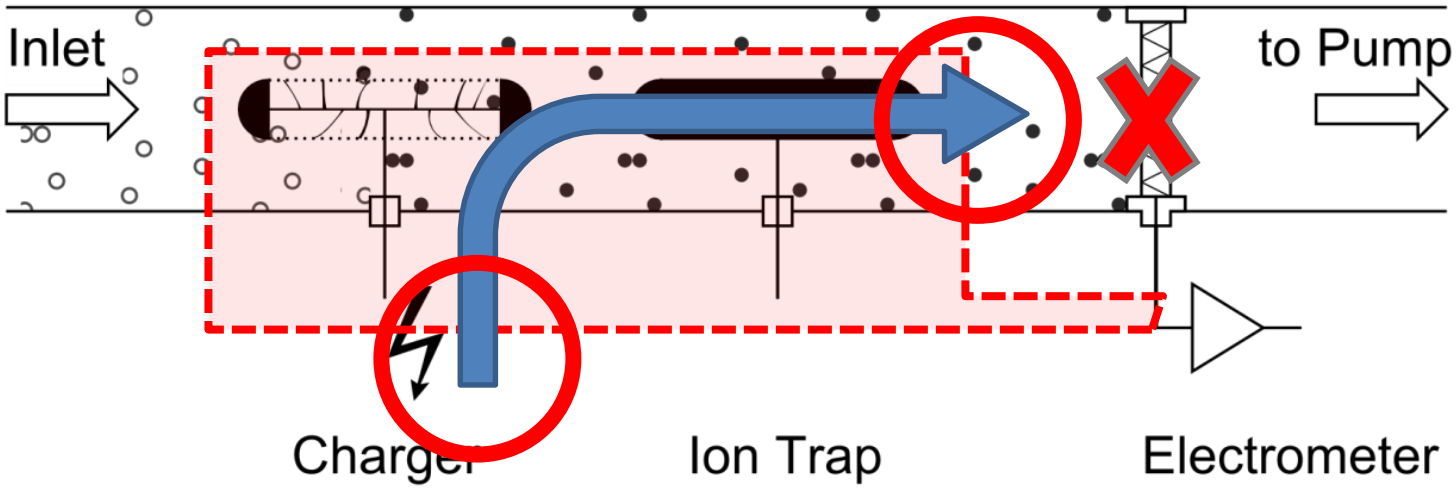
https://www.dekati.com/products/deps/

M. Fierz , C. Houle , P. Steigmeier & H. Burtscher (2011) Design, Calibration, and Field Performance of a Miniature Diffusion Size Classifier, Aerosol Science and Technology, 45:1, 1-10, DOI: 10.1080/02786826.2010.516283

Non-contact detection 1: escaping currents

1. Remove filter
2. Insulate everything
3. Measure ingoing current, equal to "escaping current" on particles

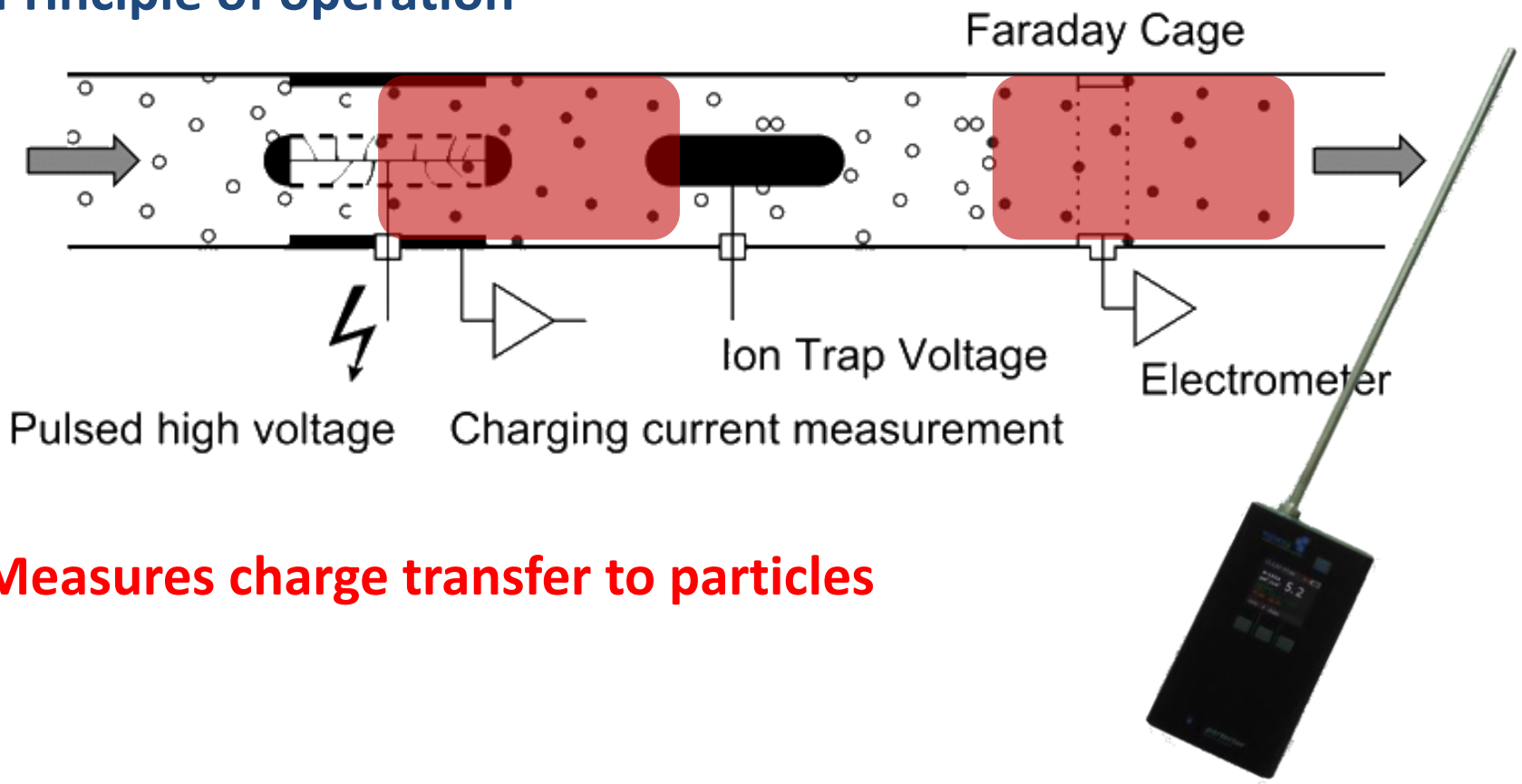
Measures charge transfer to particles



Pegasor, https://pegasor.fi/site/attachments/Pegasor_PPS_M_web_2.pdf

Non-contact detection 2: induced currents (naneos)

- **Principle of operation**



Measures charge transfer to particles

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

Summary on diffusion charging

- Multiple devices from multiple suppliers available
- Different twists in terms of technology, but general idea always similar
- Diffusion chargers do not measure particle number, but give a signal proportional to $N \cdot d^1$

- Can fulfil current NPTI specifications
- The appropriate technology for cost effective, simple and fast filter checks! (Example: Talk by M.Demski 15:15)

How about particle number?

- It is possible to add bells and whistles to diffusion chargers, and to measure particle number

But

- this adds cost + complexity to the device, decreases the robustness, and increases maintenance requirements. It is a mistake for this particular application!

Testo DiscMini

I have already made it 3 times!

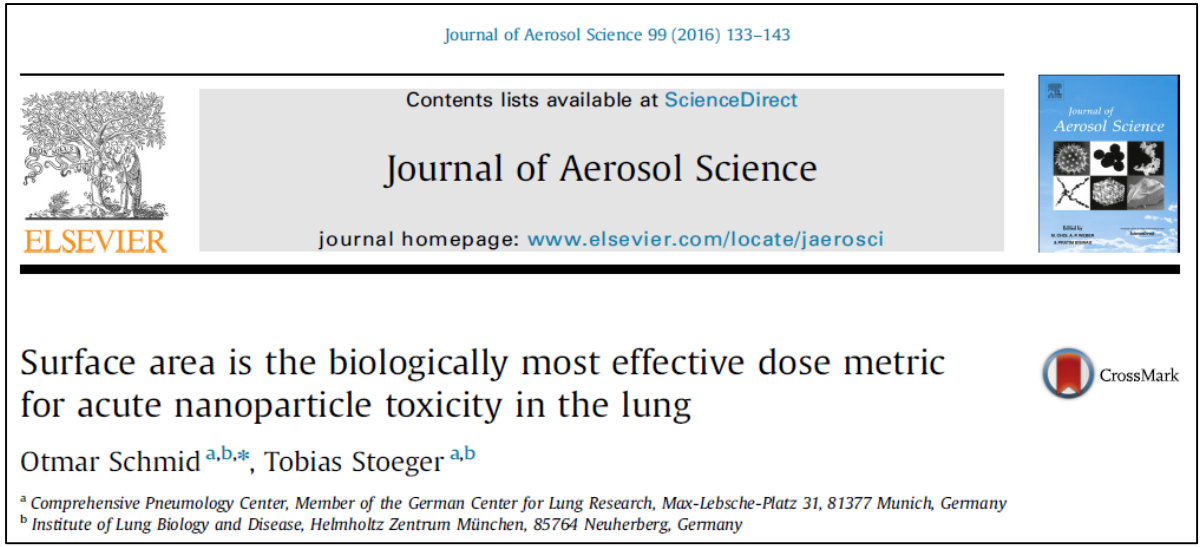
Naneos automotive partector

Naneos Partector 2

1. Number is the wrong metric

Particle number is the wrong metric

- We know (and have known for a long time…) that lung-deposited surface area (which is measured by DCs) is a more health relevant metric than particle number
- We should declare LDSA as equivalent for this application rather than pretend that we are measuring particle number with DCs
- More information:



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

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2. The NPTI specification is too strict

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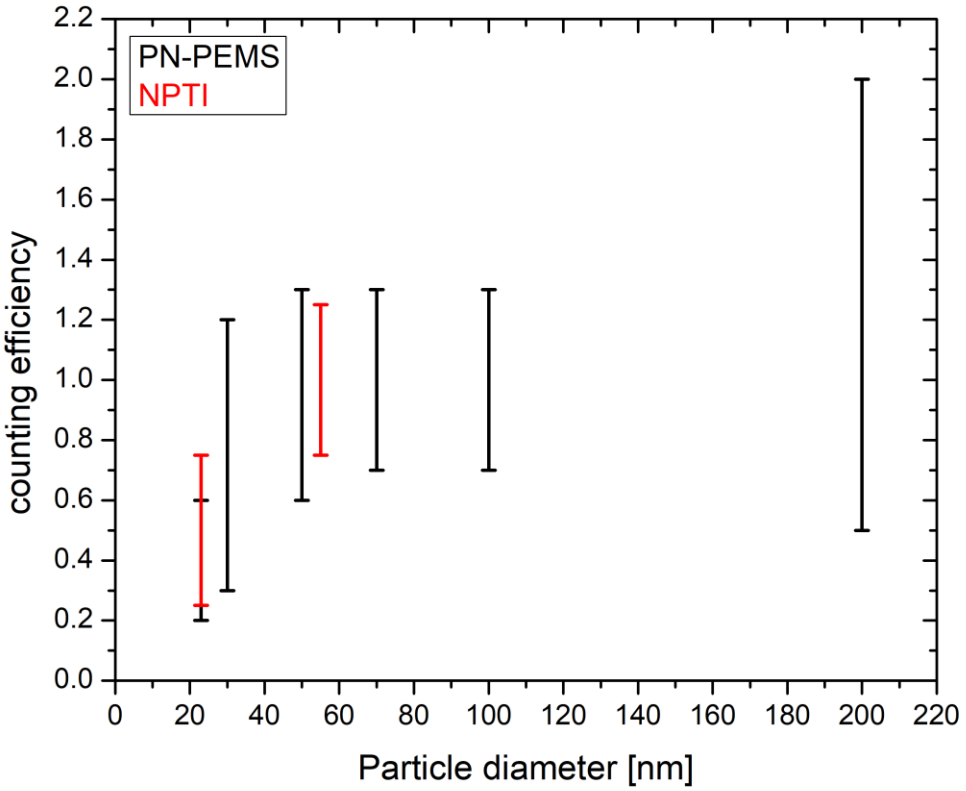
At least 10x lower cost (!)

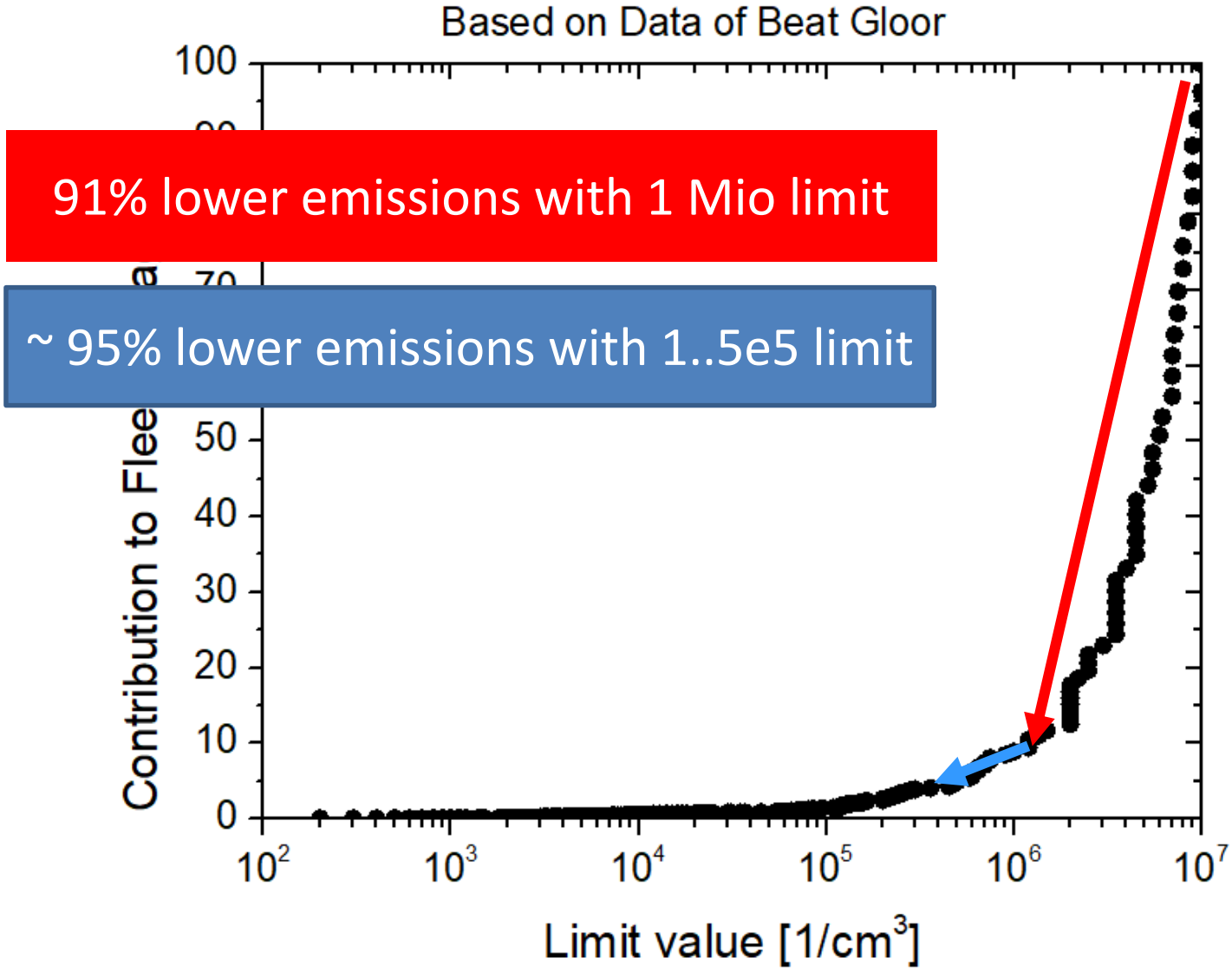


Despite >10x lower cost and less controlled environment, the same accuracy is required in NPTI (red) as in PN-PEMS type approval (black)

3. Accuracy is not important

(Accuracy is of course always good, but in this specific application it is not necessary to achieve a huge improvement in air quality)

Effect of the limit value (Talk of Heinz Burtscher)



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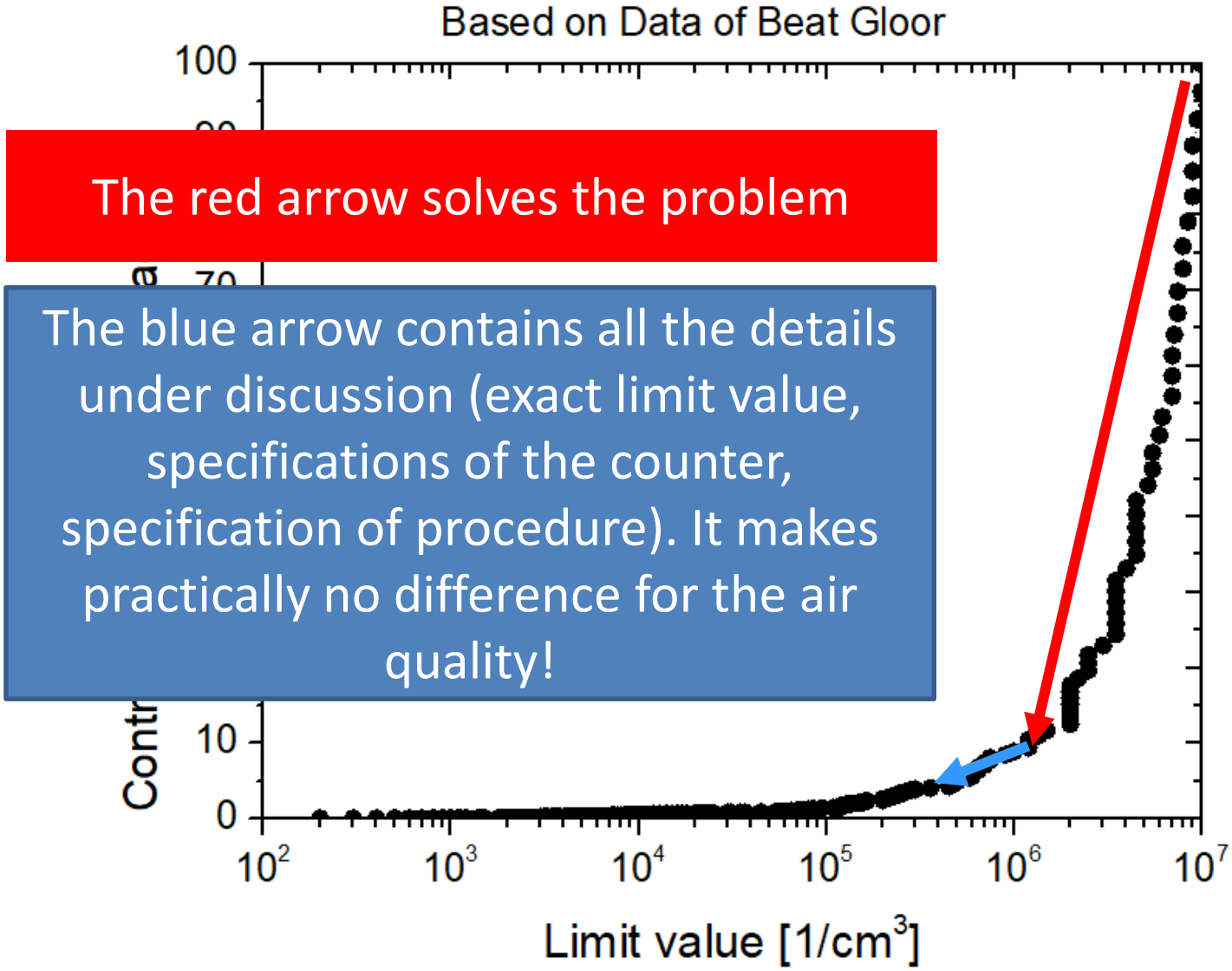
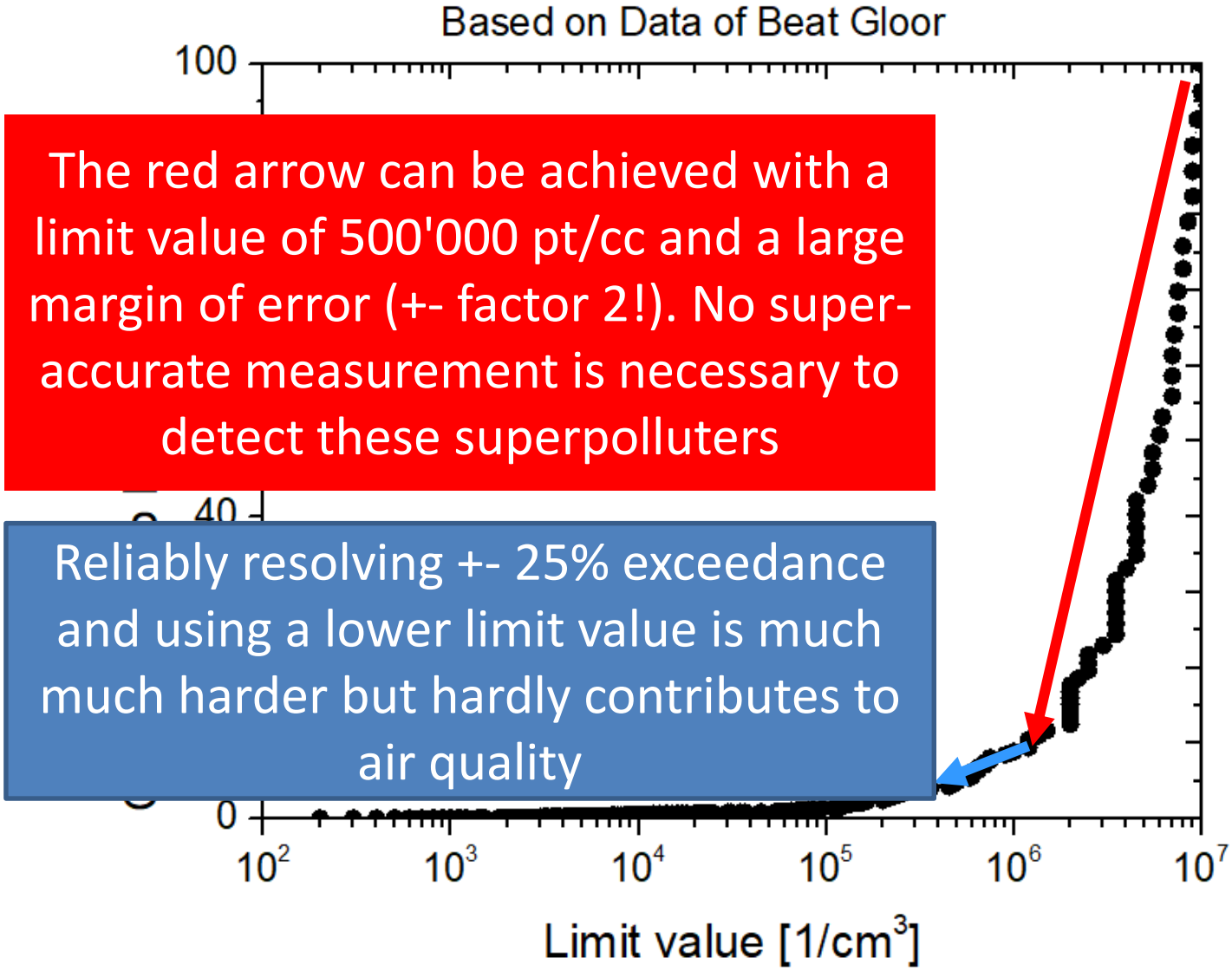


The red arrow solves the problem

The blue arrow contains all the details under discussion (exact limit value, specifications of the counter, specification of procedure). It makes practically no difference for the air quality!

Effect of the limit value (Talk of Heinz Burtscher)



The red arrow can be achieved with a limit value of 500'000 pt/cc and a large margin of error (+- factor 2!). No super-accurate measurement is necessary to detect these superpolluters

Reliably resolving +- 25% exceedance and using a lower limit value is much much harder but hardly contributes to air quality