Towards handheld DPF inspection

M.Fierz[1,2], S.Sjögren[1], P.Steigmeier[1], D.Egli[1], D.Meier[2] and H. Burtscher[1]

[1] Fachhochschule Nordwestschweiz, Windisch, Switzerland

[2] naneos particle solutions llc. (www.naneos.ch)

Motivation

a simple question

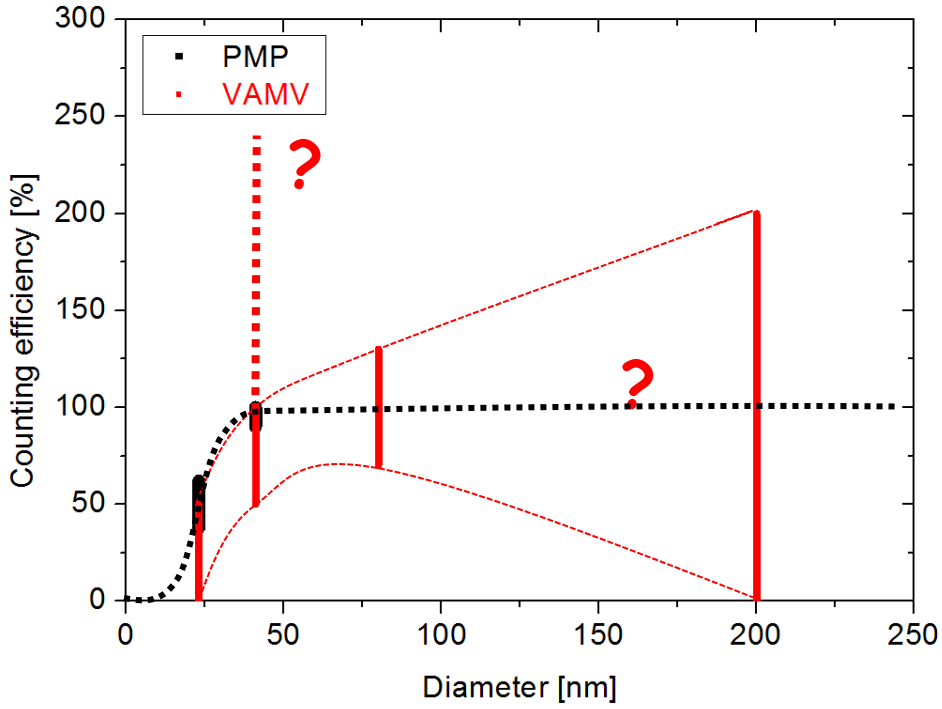
DPF ok?

a simple answer

yes / no

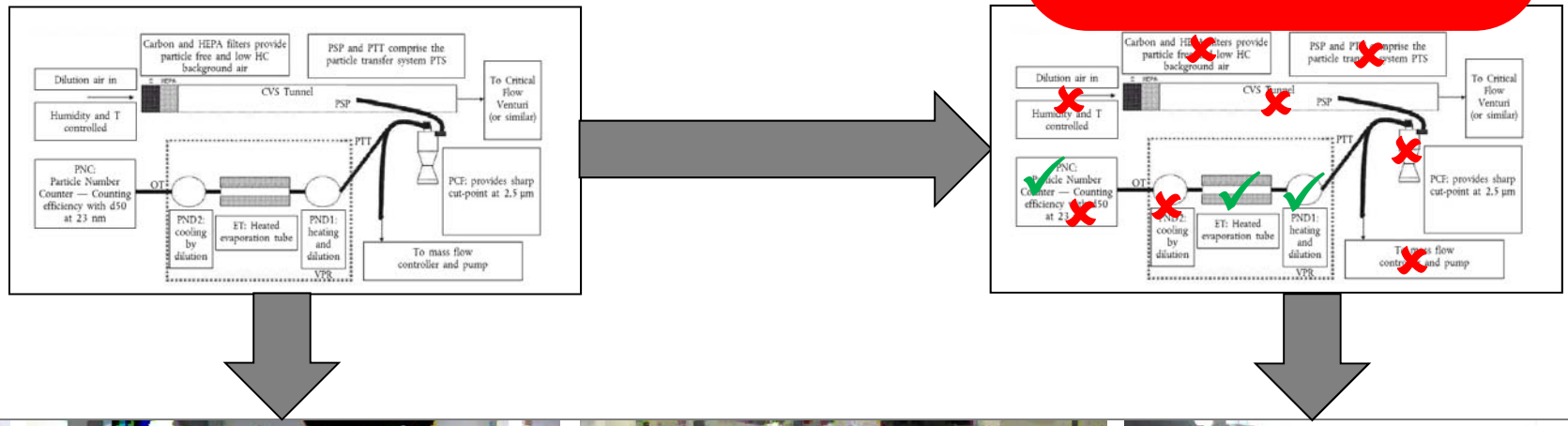
Swiss field test

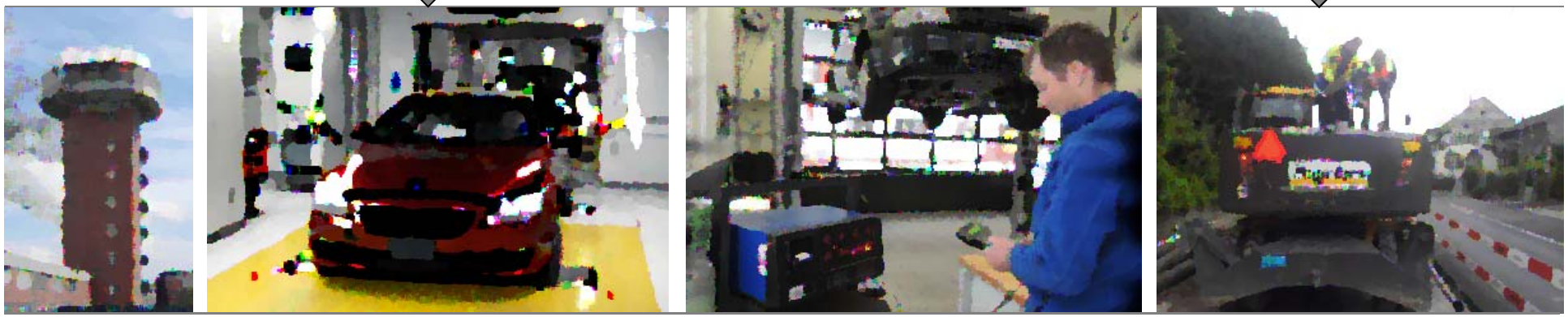
- Number based standard loosely based on PMP (but "relaxed PMP")



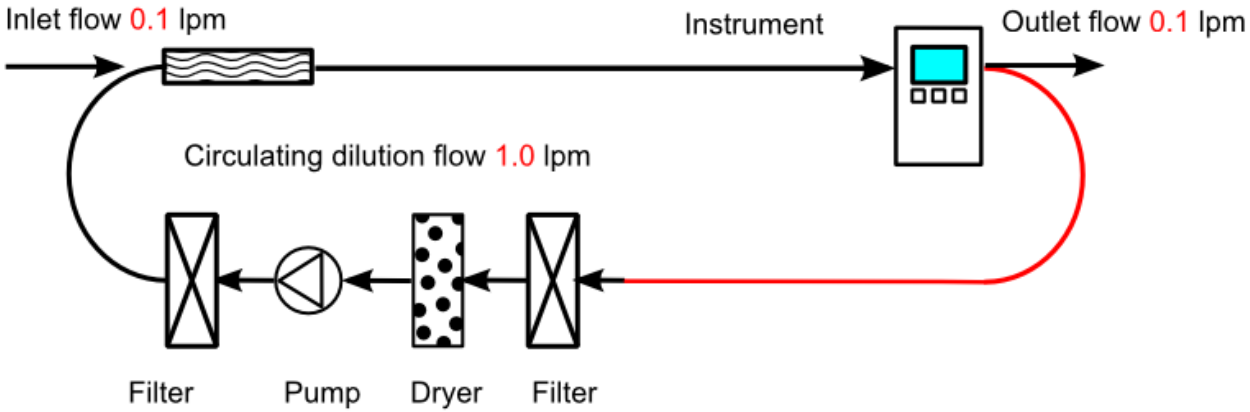
Swiss field test

- PMP is far too complex for field use





What's new in the 2014 version?



- Hot dilution instead of cold dilution followed by heating stage
- Partector as detector
- 10x lower flows than 2010

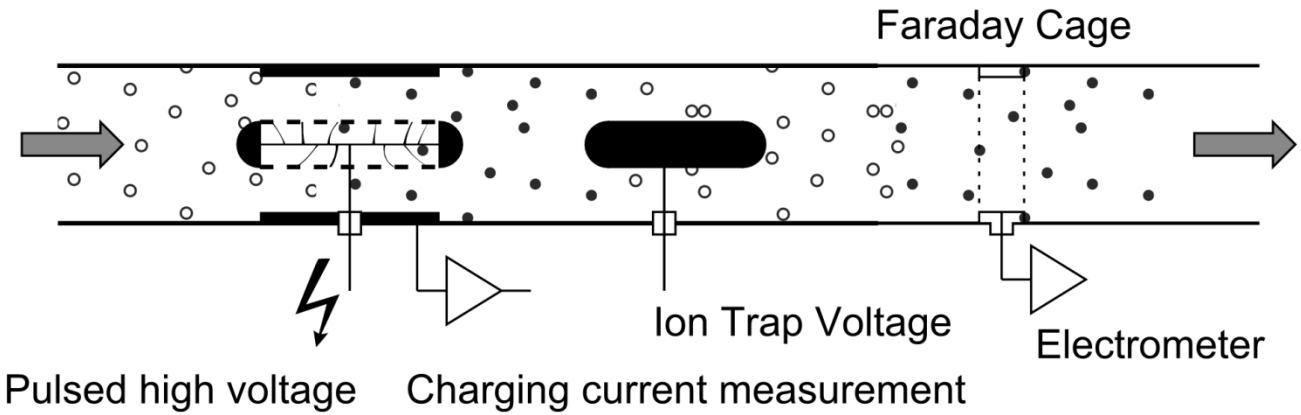
Instrument specs

- Handheld
- 1.5kg
- battery powered
- 10-fold dilution @ 200°C
- Concentration range
  10^4 – 10^8 pt/ccm

- A prototype, not a finished instrument like TSI 3795

Partector instrument response

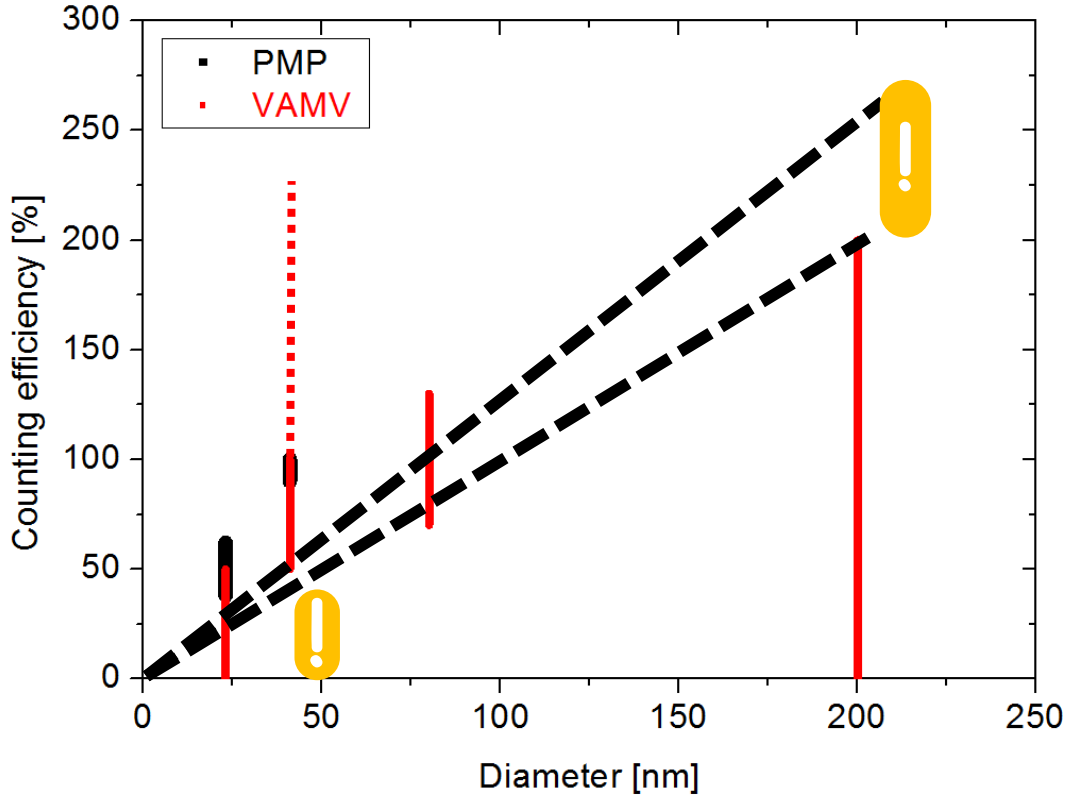
M.Fierz et al.: Aerosol measurement by induced currents, Aerosol Science and Technology 48:4 350-357.



- Partector is simple, small and robust but...
- ...instrument linear in particle diameter (which can be interpreted as LDSA, lung-deposited surface area) – this is not a particle number counter!
- Does this still fit into VAMV-window?

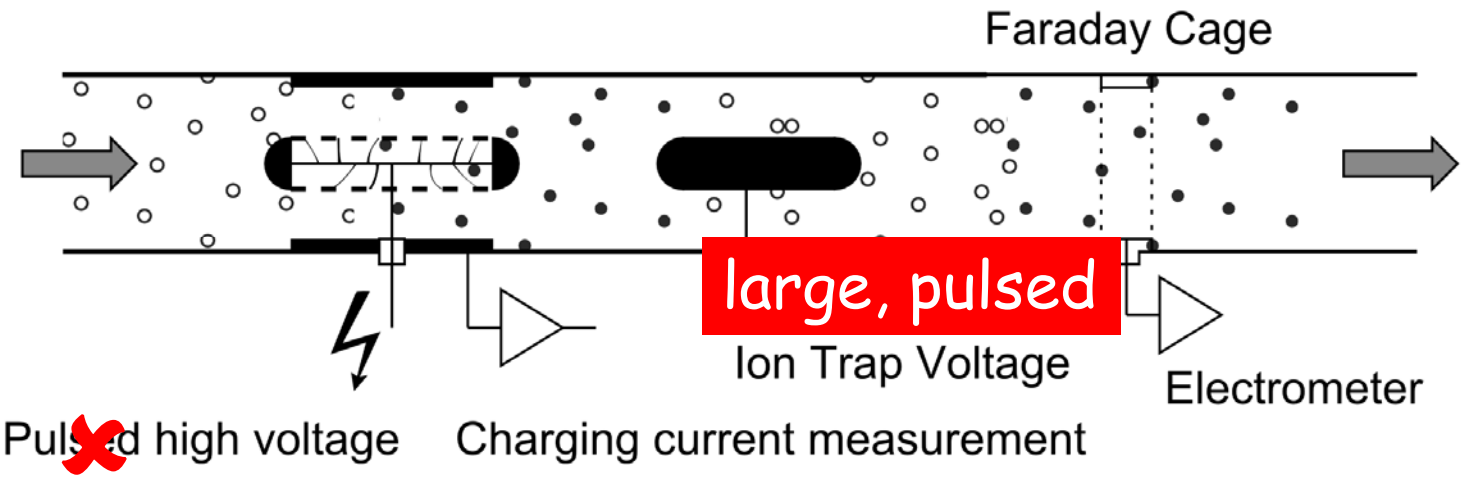
Instrument response

- It nearly fits – but not quite! we need to do something!



Adapt instrument to meet VAMV

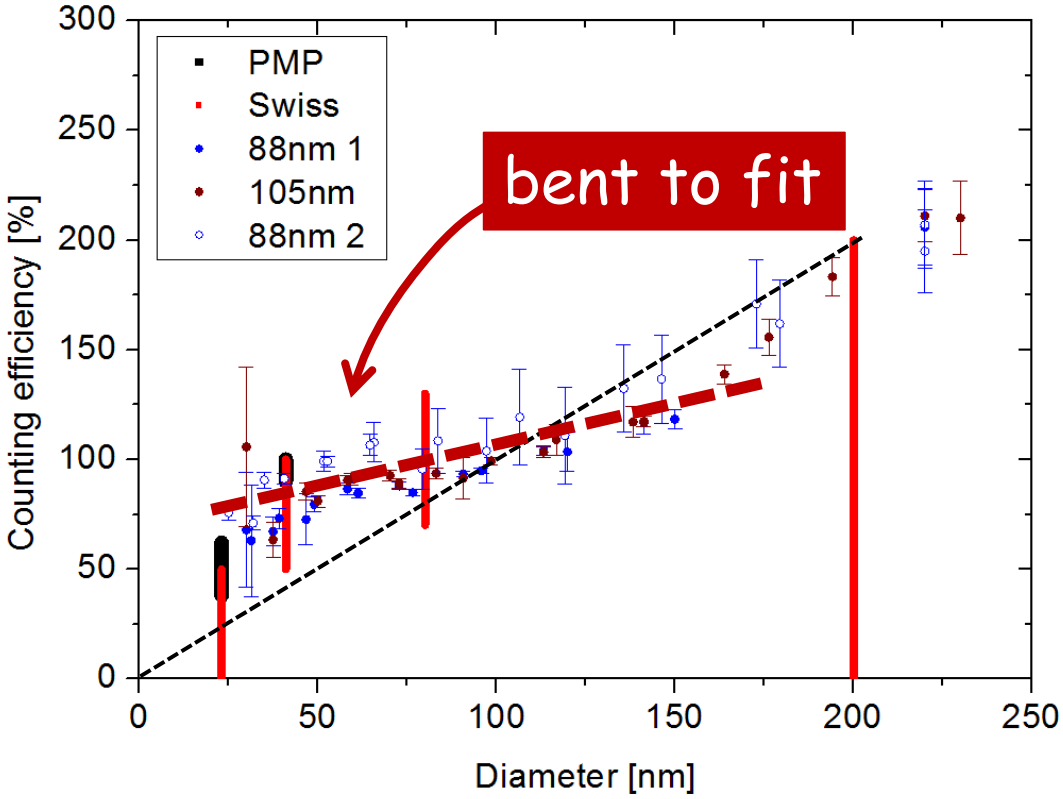
- Selectively remove smaller particles more efficiently with pulsed E-field



Modified partector response

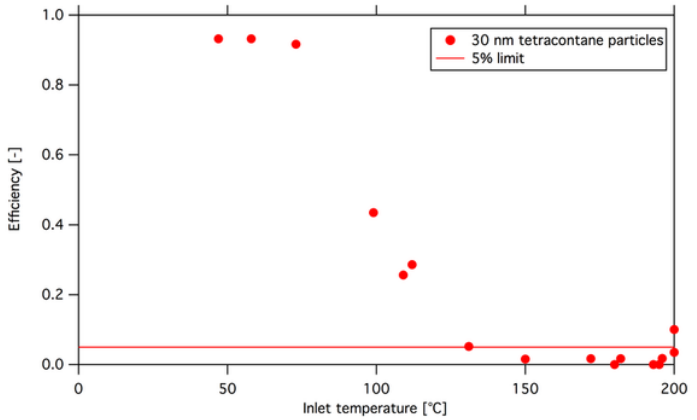
better proportionality to N, but lower overall sensitivity

- Calibration measurements with modified partector



Own tests

- Tetracontane evaporation ok

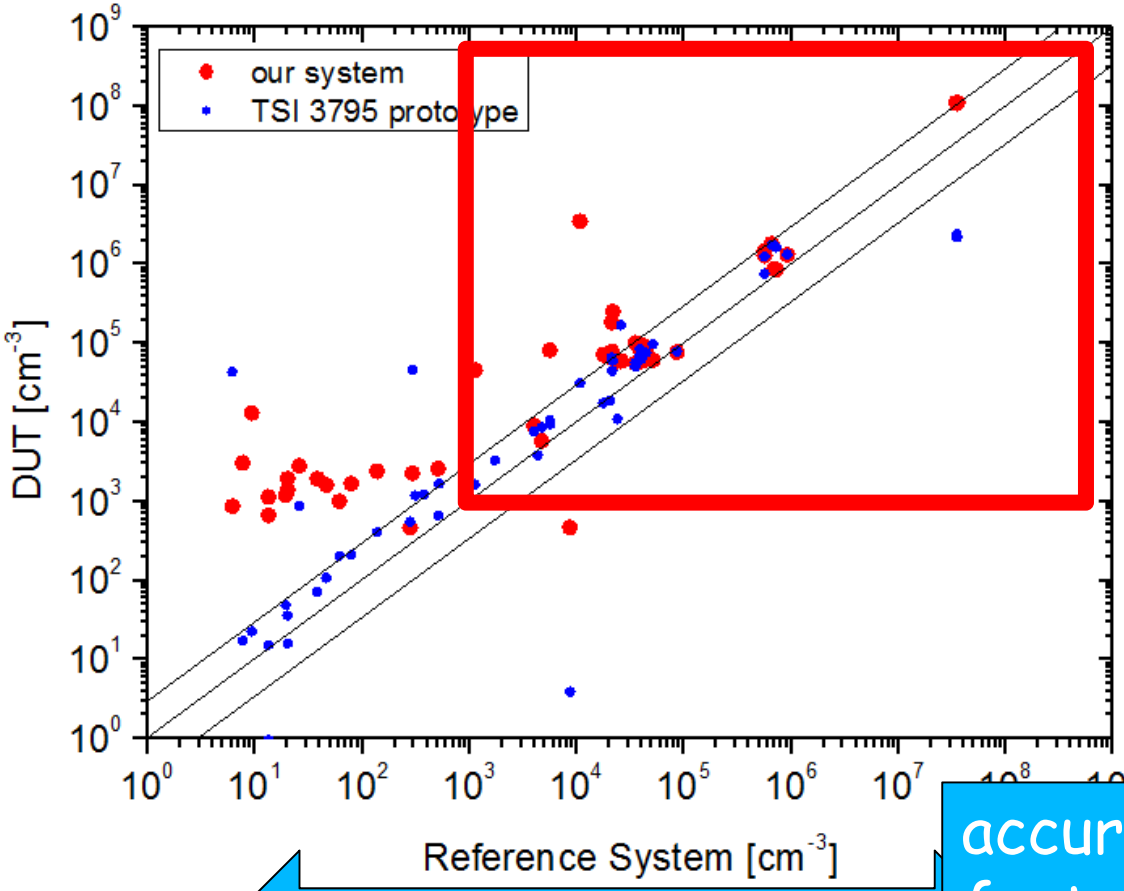


- The usual lab tests with Palas soot and CAST soot, all seem ok
- Field tests to check usability

Field tests

- Usability is essential!
- Fast startup times, battery power, small size, low weight and no working fluid contribute to usability

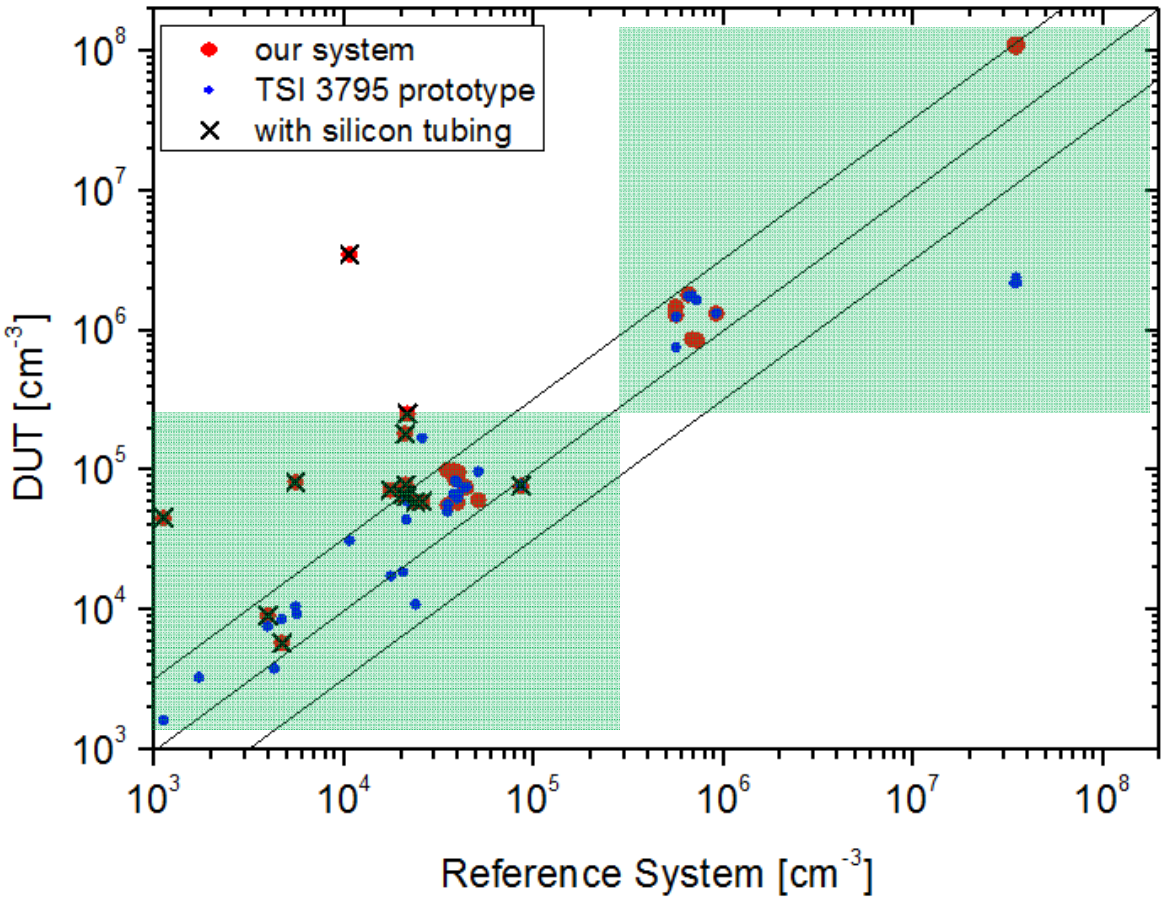
BAFU tests



7 orders of magnitude!

accuracy to within a factor of 3 seems good enough! (black lines)

The interesting part



Conclusions (sunshine)

- We have developed a prototype instrument for field inspection of DPF
- Own lab tests, independent tests by BAFU, field tests on construction sites confirmed that this device works and is easy to use
- According to our tests it also fulfils most of the measurement requirements of VAMV – we have not tested at -10...+40°C, we have not tested at 860-1060 mbar, we don't print official documents etc. (it's just a feasability study)

What is PMP?

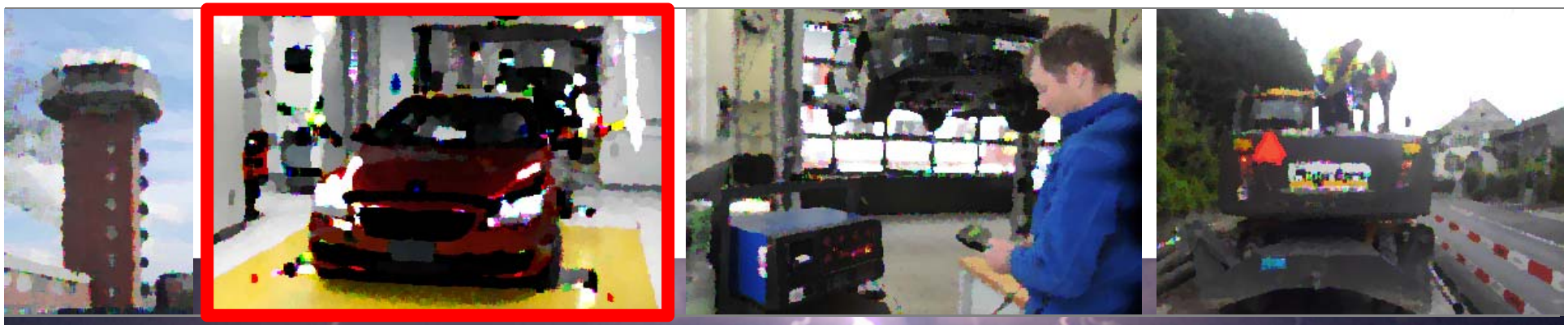
particle number

23nm cutoff

solid particles only

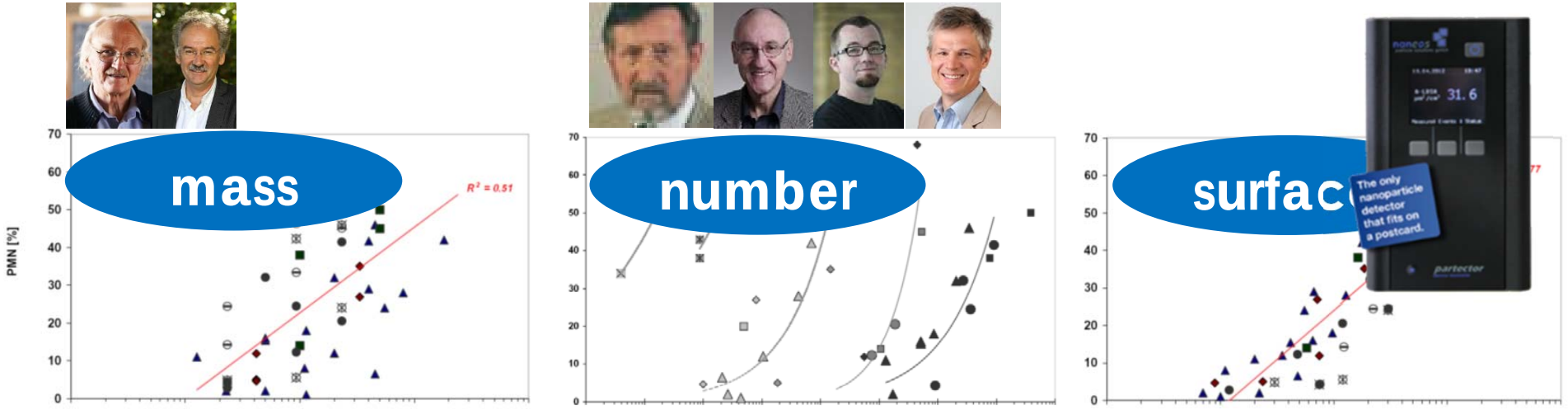
The essence of PMP

- PMP is about giving ultrafine particles a larger weight
- Metric chosen (PN) based on proven technology, high sensitivity to ultrafines, appropriateness for measurement environment (lab)
- PMP is a very pragmatic approach which leads to the emissions reductions that Nino Künzli wants to see



Particle number and health effects

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

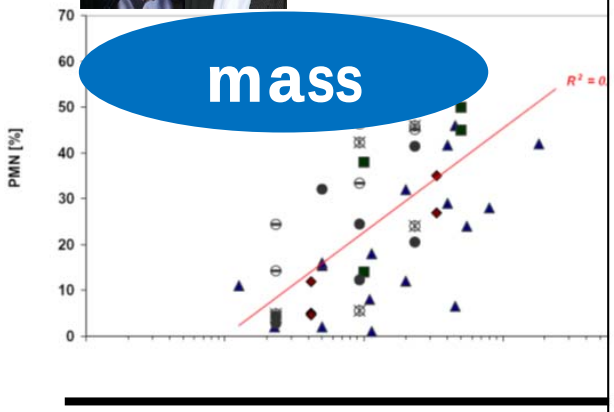


log scales

Particle number is worst metric possible!

- Data: Otmar … gy, Helmholtz-Z … marized)

mass



Reference	Particle	Size Range [nm]	
Oberdörster-2005	TiO_2	20-250	mouse
Stoeger-2006	CNP-lowOC	9-50	
Stoeger-2006	CNP-highOC	12-25	
Brown-2001	Polystyrene	65-535	
Dick-2003	Carbon Black	14	
Dick-2003	TiO_2	20	rat
Höhr-2002	TiO_2	25-180	
Oberdörster-2005	TiO_2	20-250	
Wahlheit-2006	TiO		
Warheit-2007	Quarz (N		

during/after original PMP decision to measure particle number

The essence of PMP

particle number

23nm cutoff

solid particles only

pragmatic approach

proven technology

sensitive to ultrafines

appropriate for application

Conclusions VAMV

VAMV prevents elegant solutions for DPF inspection in the field

- We could build a simple, elegant DPF inspection instrument (diluting partector) in the spirit of PMP
- Because of VAMV, we need to modify it and...
  - ...make it more complex
  - ...make it less sensitive
  - ....make it more susceptible to nucleation particles
  - ....make it measure something less health relevant than it would on its own

If I could choose

- Allow use of diffusion chargers ($d^{\sim 1.1}$) instead of CPCs for filter inspection and PN-PEMS
- Link them to PMP: calibrate them so that they give a particle number for typical exhaust aerosol (mean diameter 70nm, GSD 1.7; Hatch-Choate: simply 82nm monodisperse)
- Let these instruments perform the way they do naturally for the remaining size range – it's not a bug, it's a feature

Acknowledgements

Staffan Sjögren, Peter Steigmeier, Daniel Egli
(FHNW, instrument development + testing)

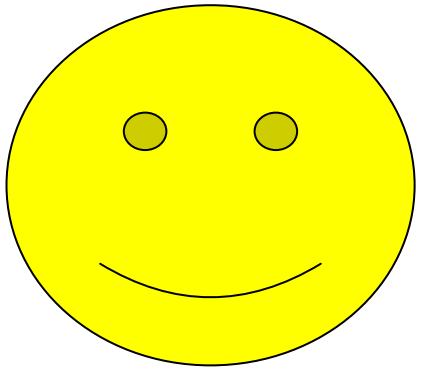
Kingsley Reavell (Cambustion)
(improved dilution concept)

Simone Krähenbühl (BAFU) and Pierre Comte (AFHB)
(Measurement campaign)

Beat Gloor (AWEL)
(Help with field measurements)

Otmar Schmid (Helmholtz München)
(Toxicology slides)

Index



Contents