

Nanoparticle Measurement

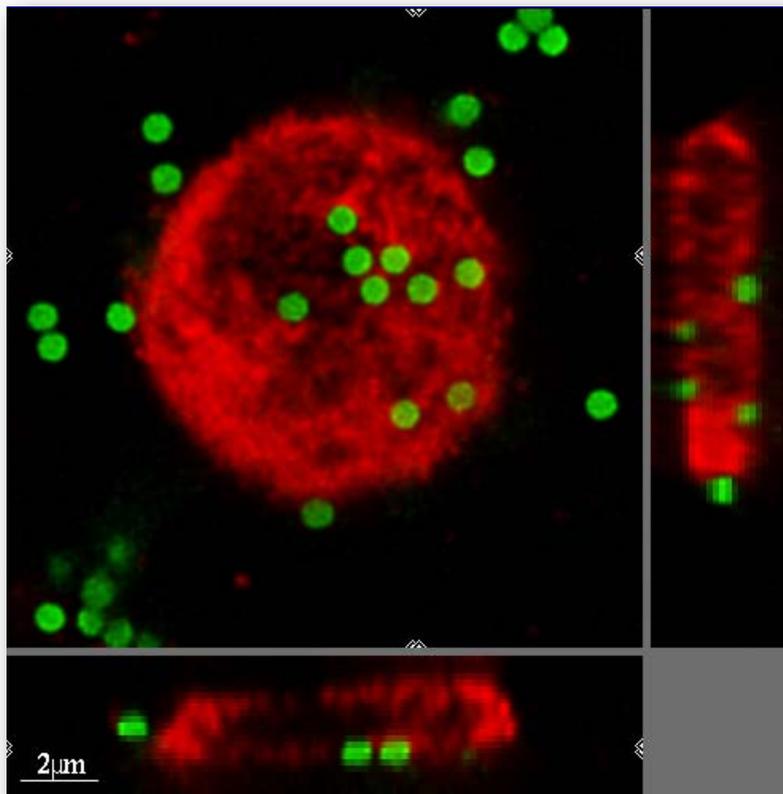
Markus Kasper
Matter Engineering AG

Ultrafine Particles - The Science, Technology, and Policy Issues.
Los Angeles CA, 1st May, 2006

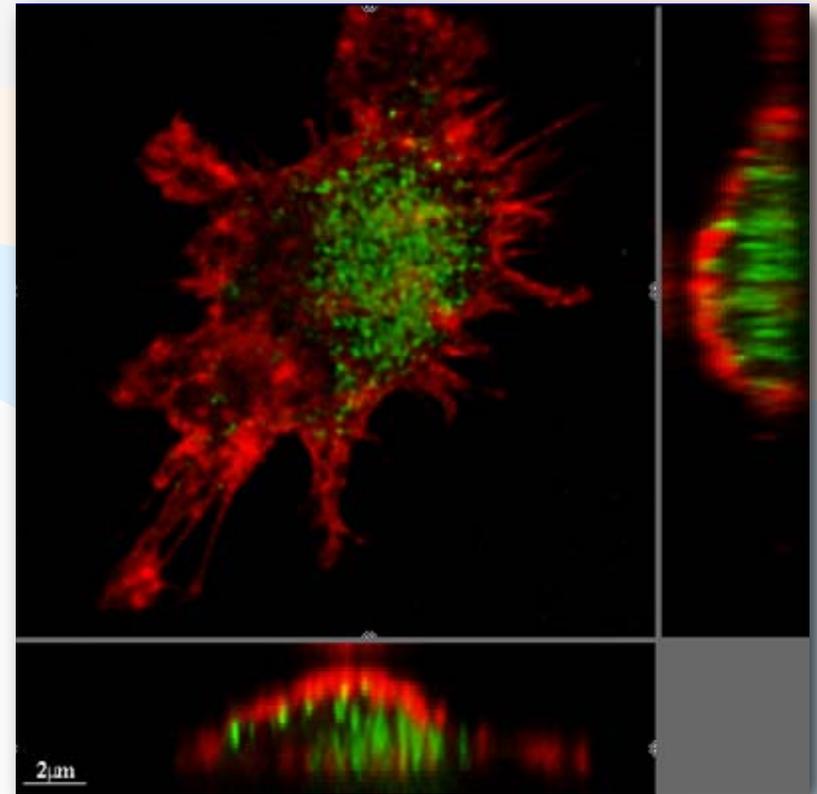
Small & Insoluble = Health Hazard

Human Macrophages Exposed to Polystyrene Particles

1 μm particles



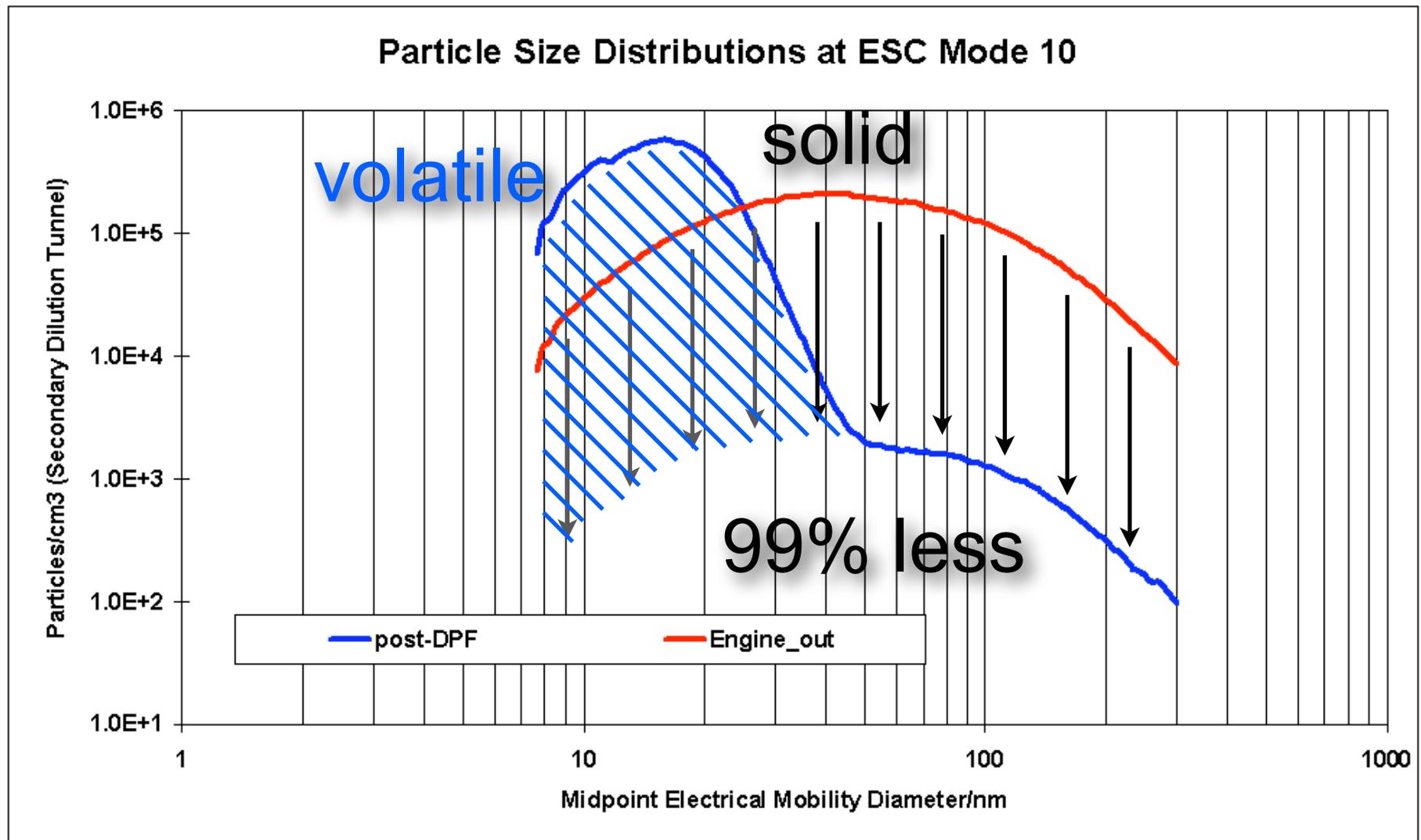
0.078 μm particles



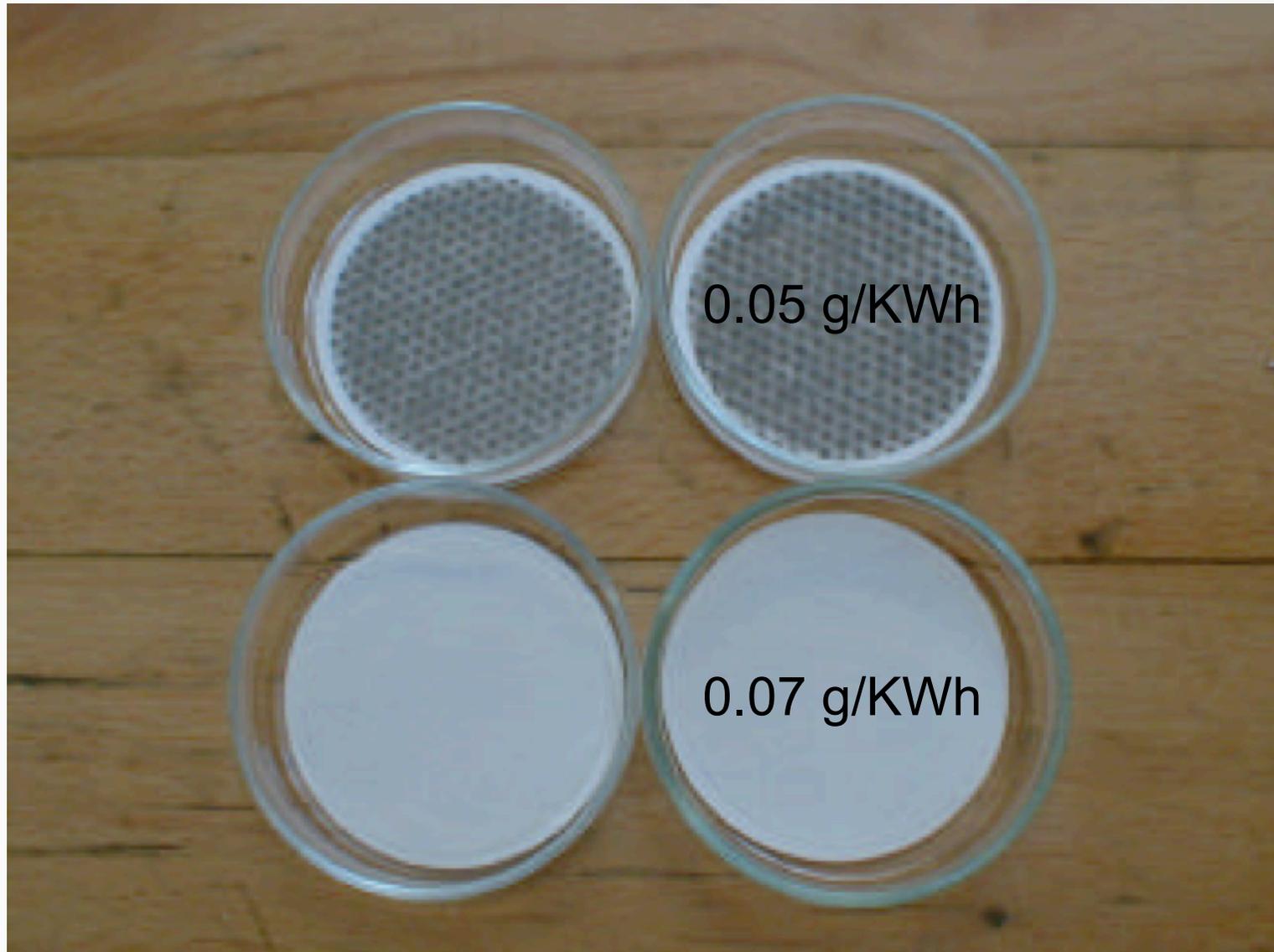
Nanoparticle Emission Measurement

- Prepare Particle Sample: Separate Droplets from Solids
- Characterise Sample: Focus on Nanoparticles
- Application Example: DPF Characterisation & PMP

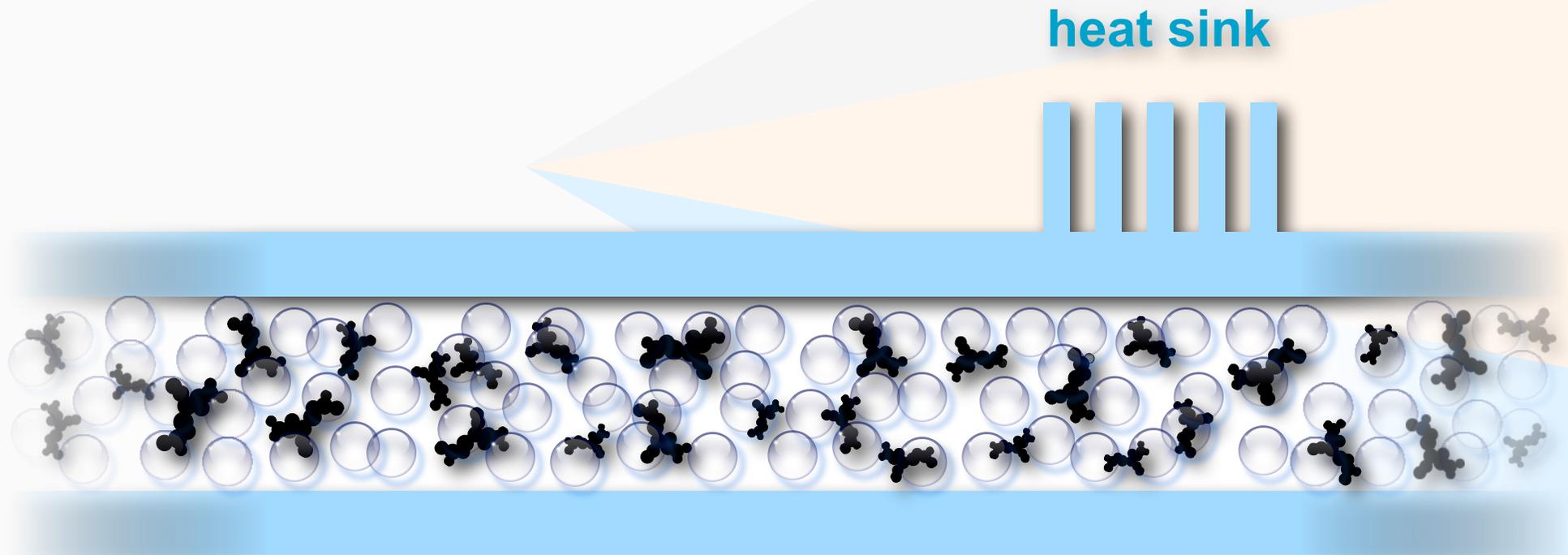
Nucleation after DPF



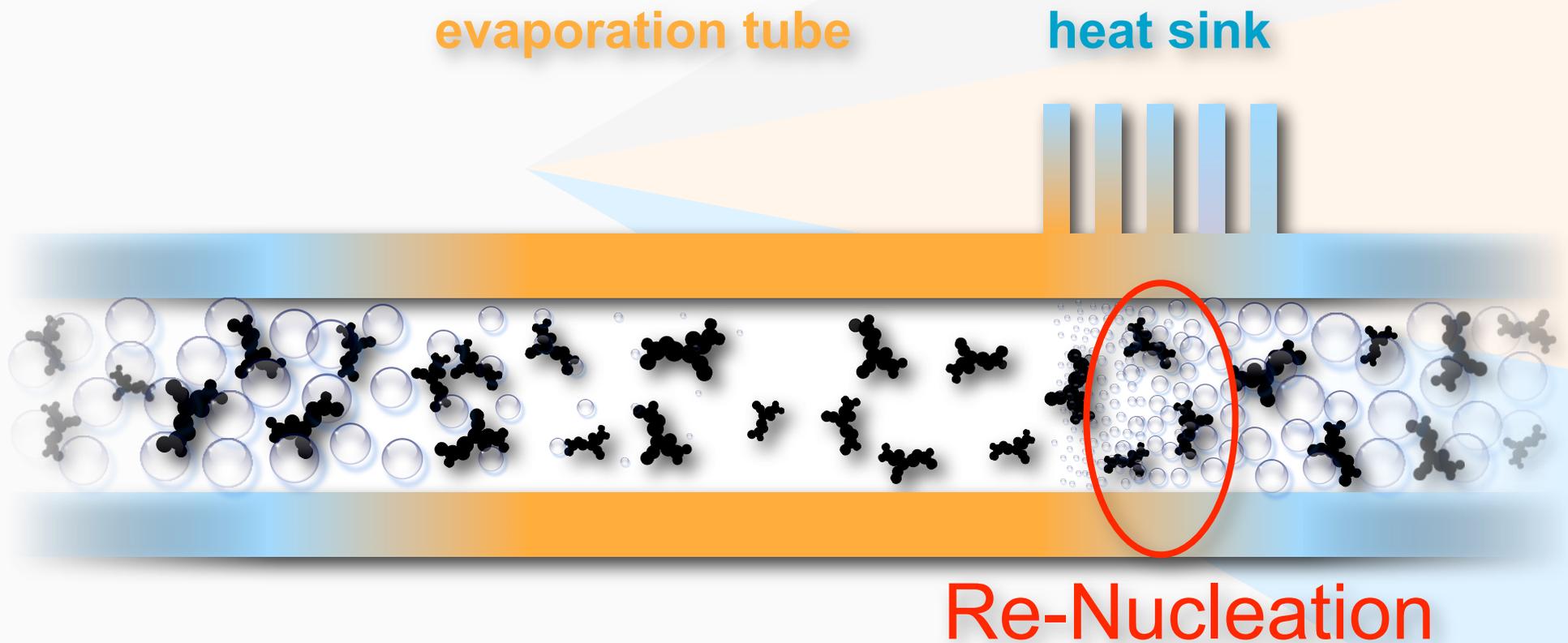
Gravimetric Samples Before/After Trap



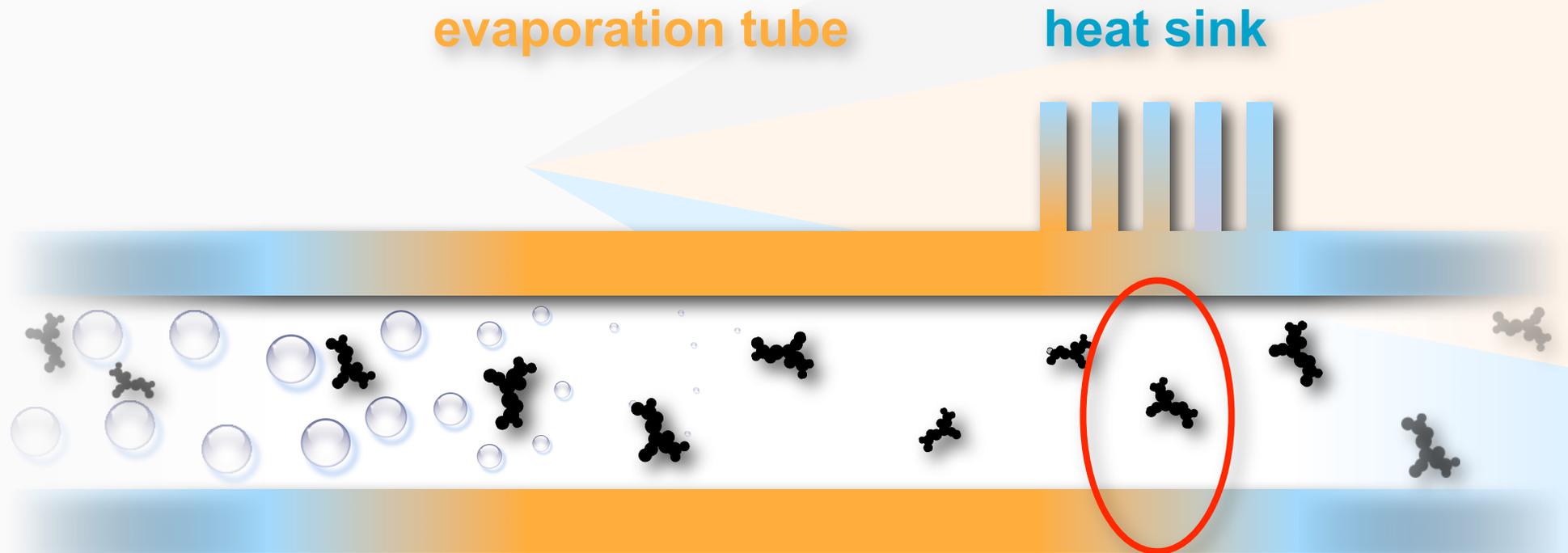
Flow of Droplets Through Cold Tube



Evaporation of Volatiles in Heated Section

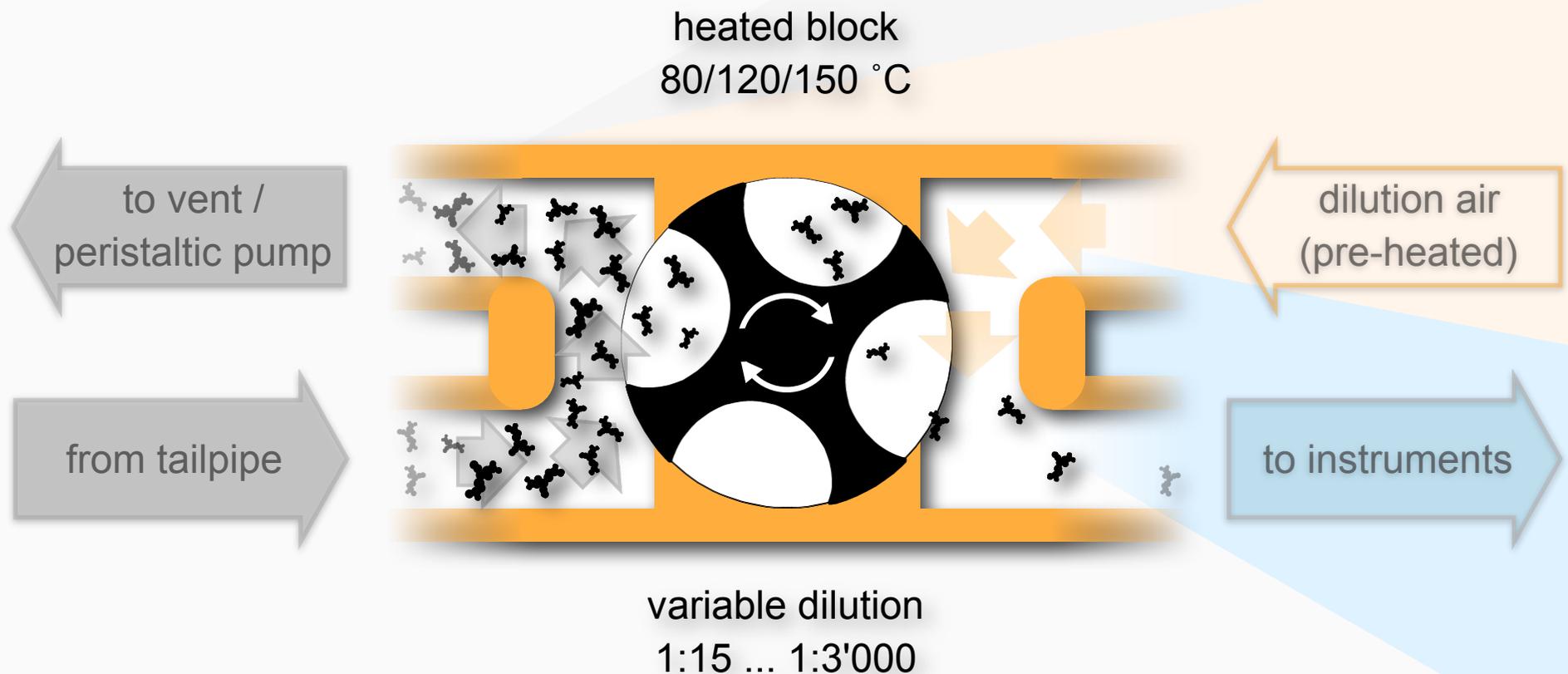


No Re-Nucleation if Droplet Concentration is Low



volatile material
remains in gas phase

Rotating Disc Diluter Revolving Door for Aerosol Particles



Combine Diluter+Heater to Remove Droplets from Aerosol Sample



exhaust with
nano-droplets

dilute

sample with nano-
droplets

evaporate

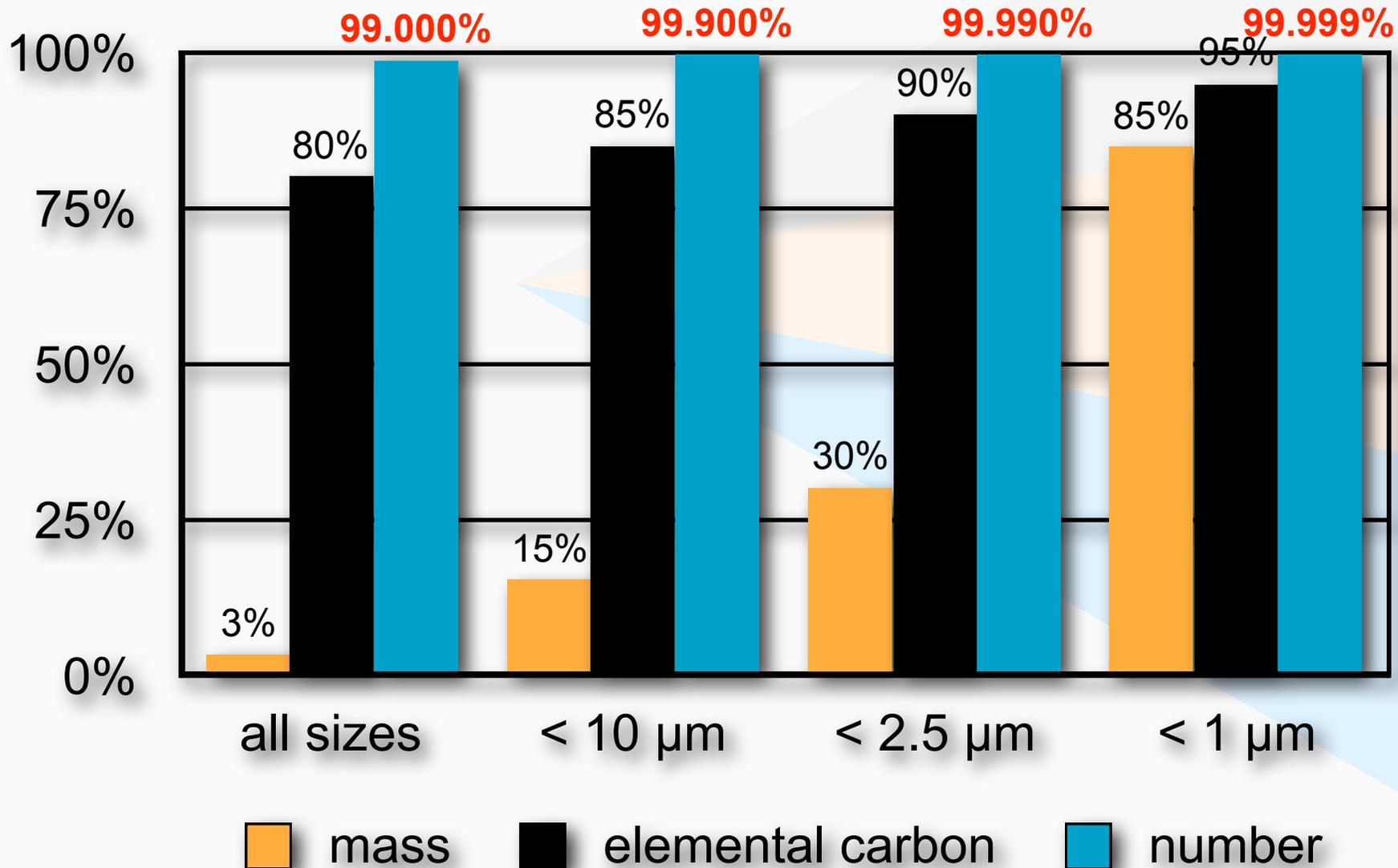
only solid
particles left

Nanoparticle Emission Measurement

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- **Characterise Sample: Focus on Nanoparticles**
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Contribution of Combustion PM to Ambient PM

Dependence on Cut-Off Diameter and Metric



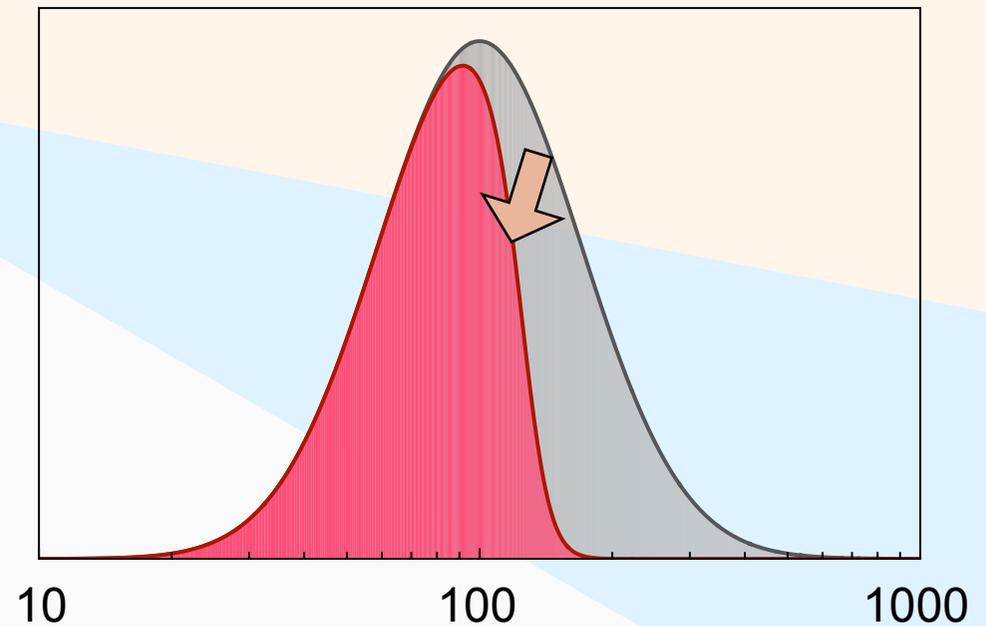
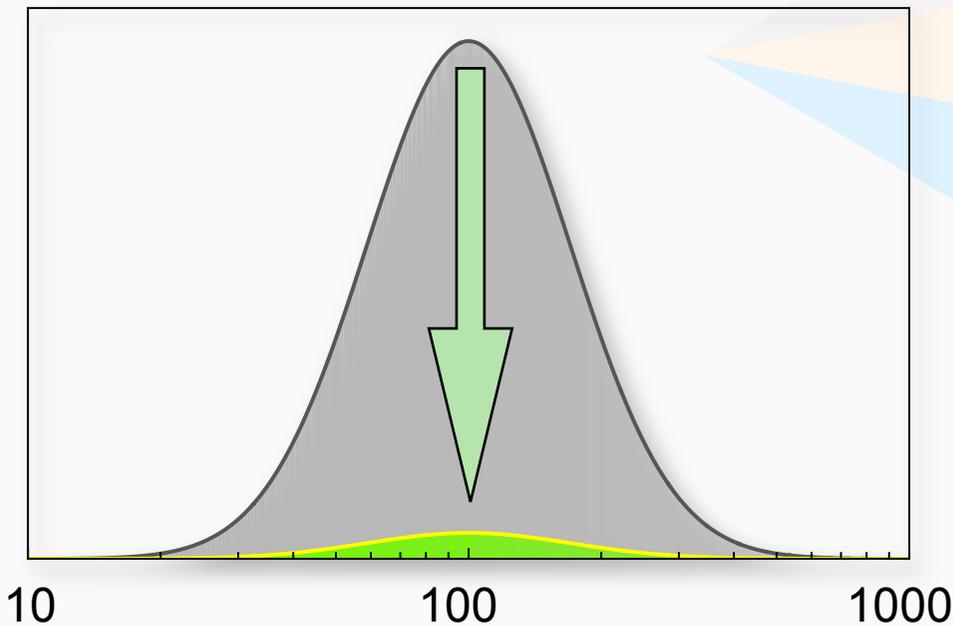
Toxicity: Dose–Response Relation

- classical approach: dose = mass intake
 - hidden assumption: all mass is accessible/bio-available
 - examples: gases, liquids, soluble particles
- exhaust particles are insoluble - consequence??
 - carbonaceous soot
 - metal (abrasion, additives etc.)
- bio-availability of insoluble particles
 - adsorbed toxic chemicals >> **dose = surface**
 - physical toxicity / presence >> **dose = number**

Good Particle Trap \Leftrightarrow Appropriate Methods

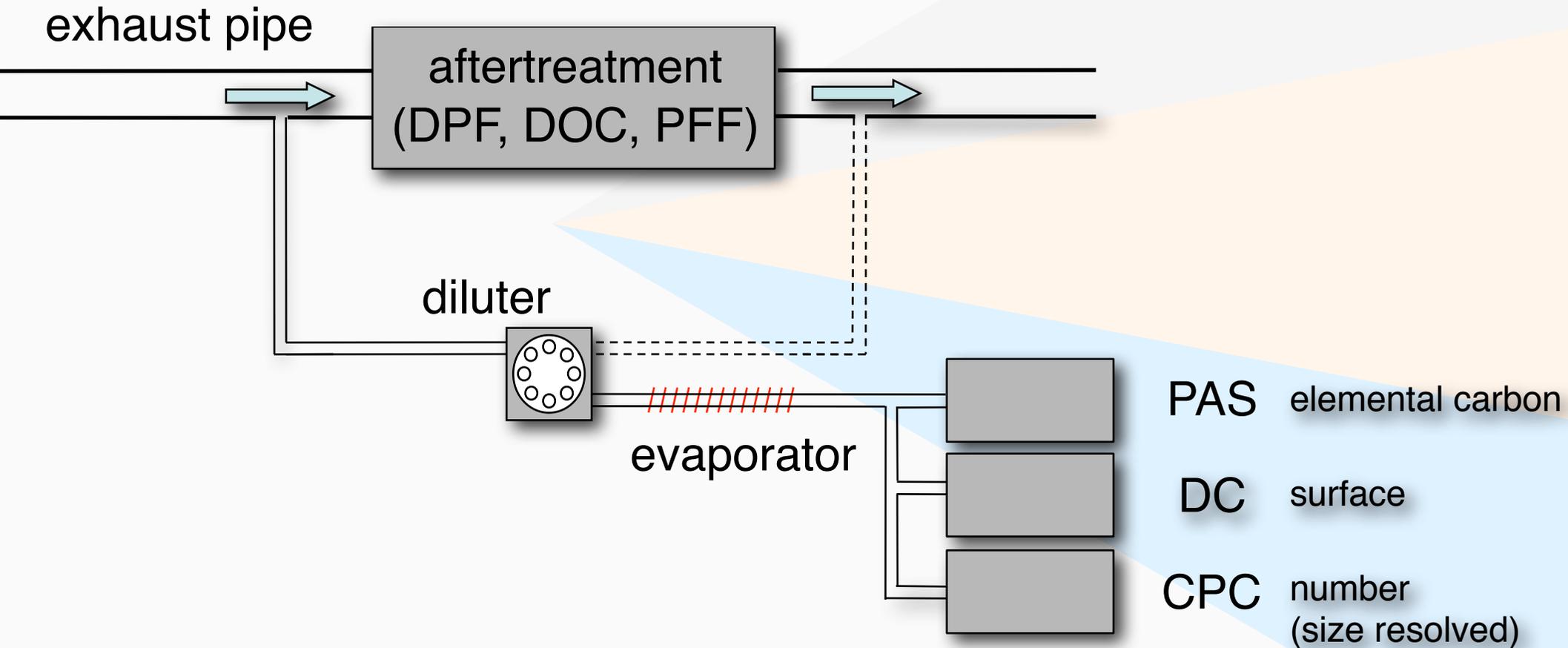
Mass: -95%
Number: -95%

Mass: -95%
Number: -55%



mobility diameter [nm]

Emission Testing Equipment - Set-Up

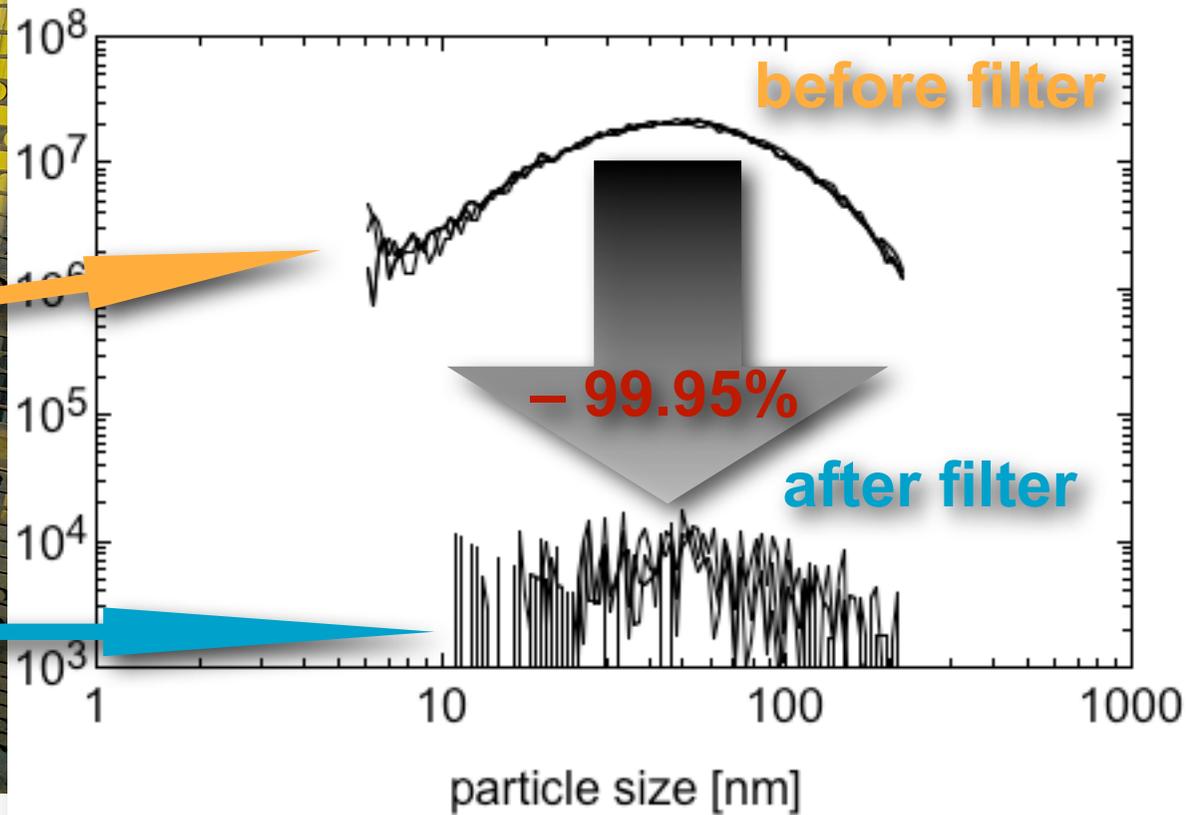


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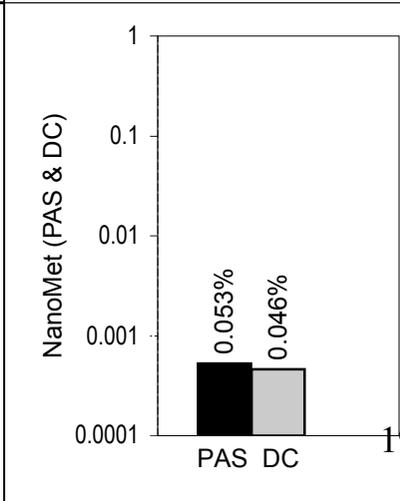
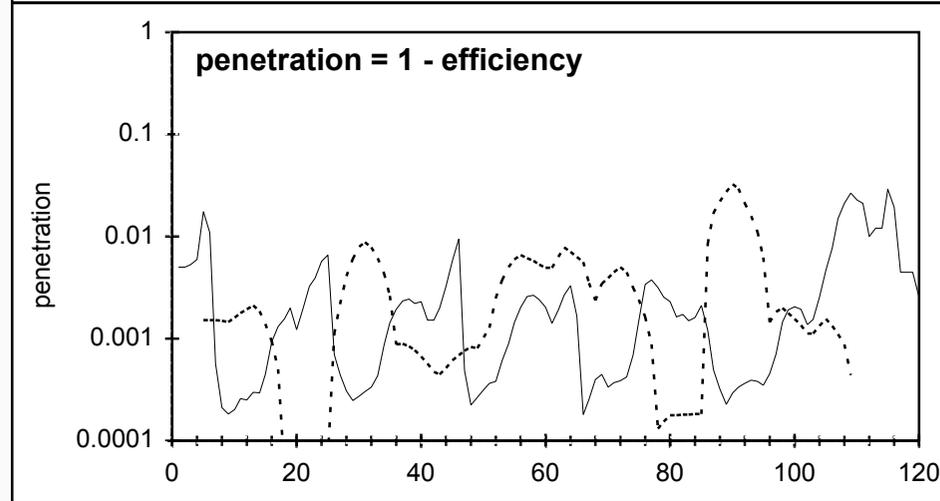
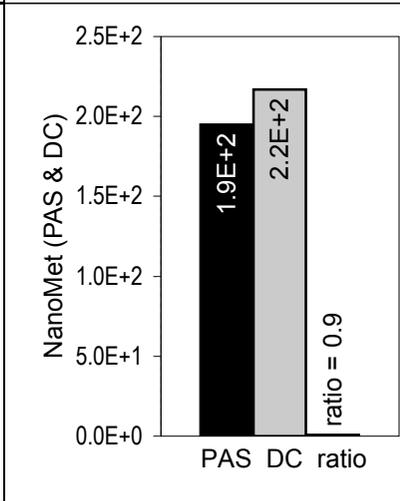
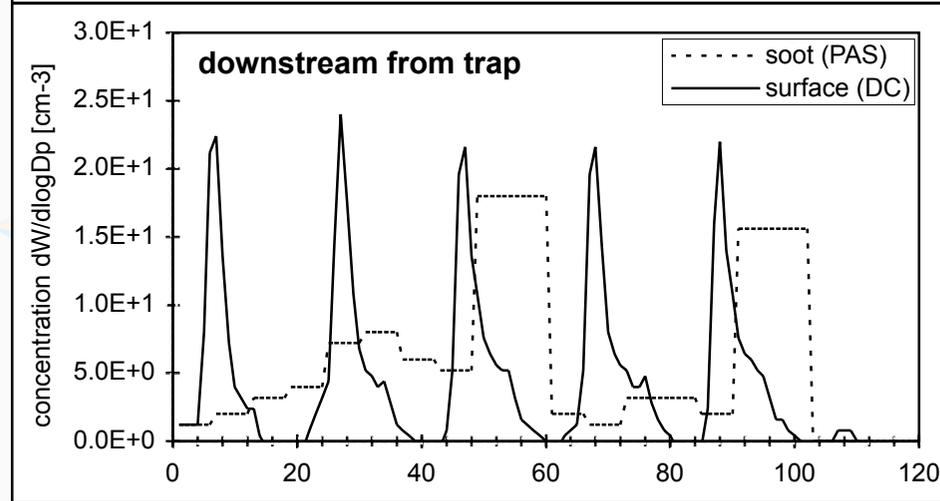
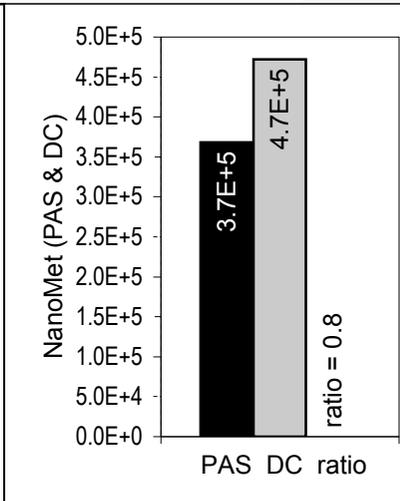
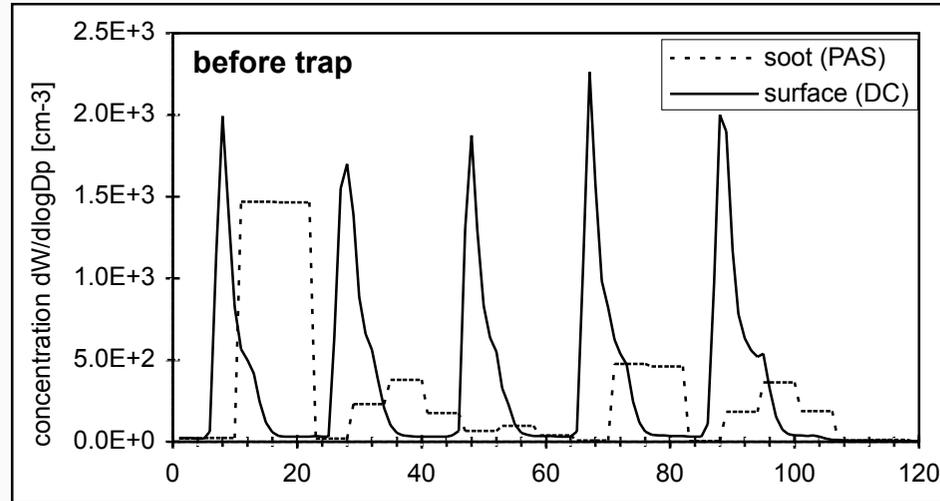
Filter Efficiency Measurement



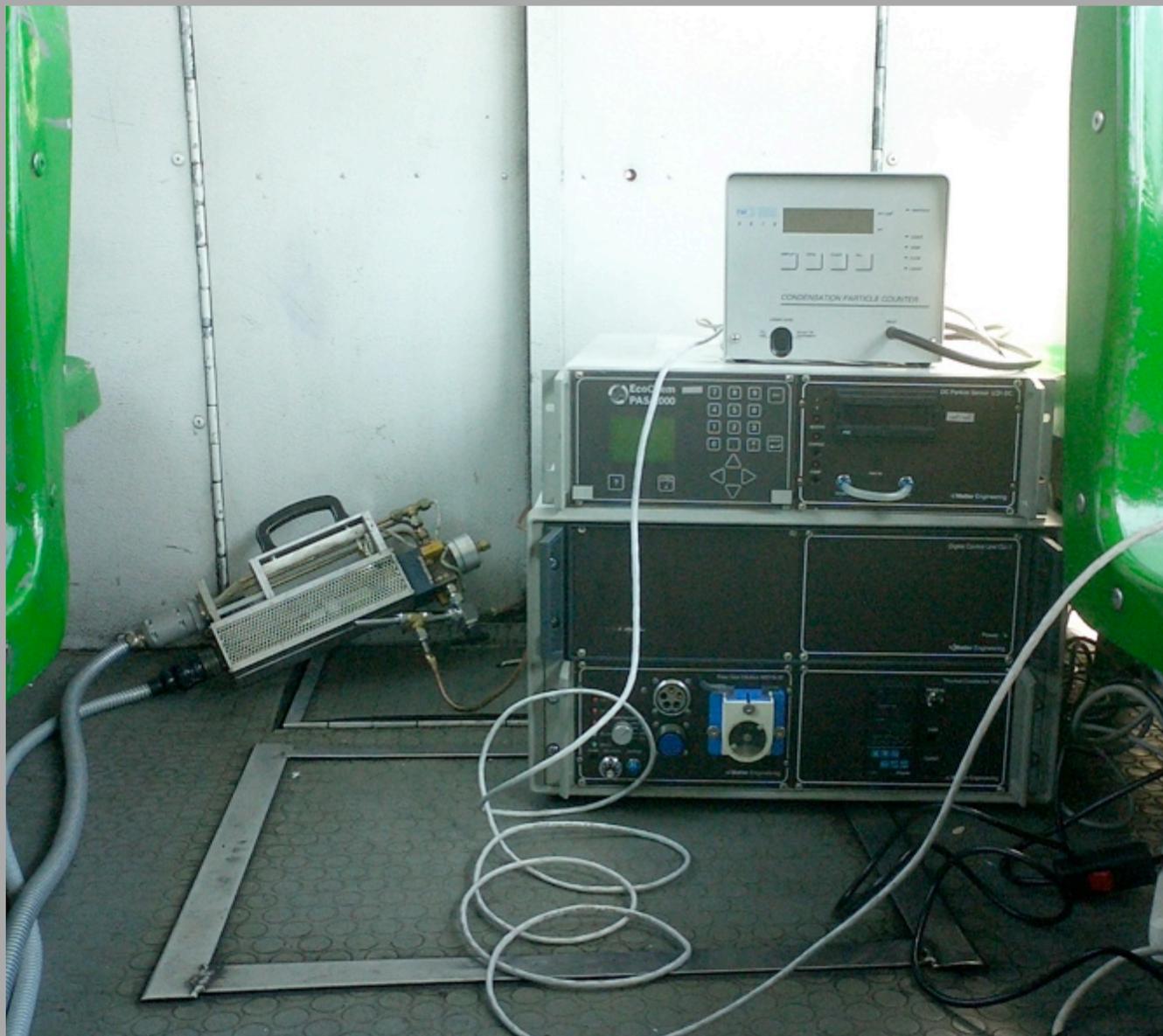
DPF Efficiency -

Snap Acceleration

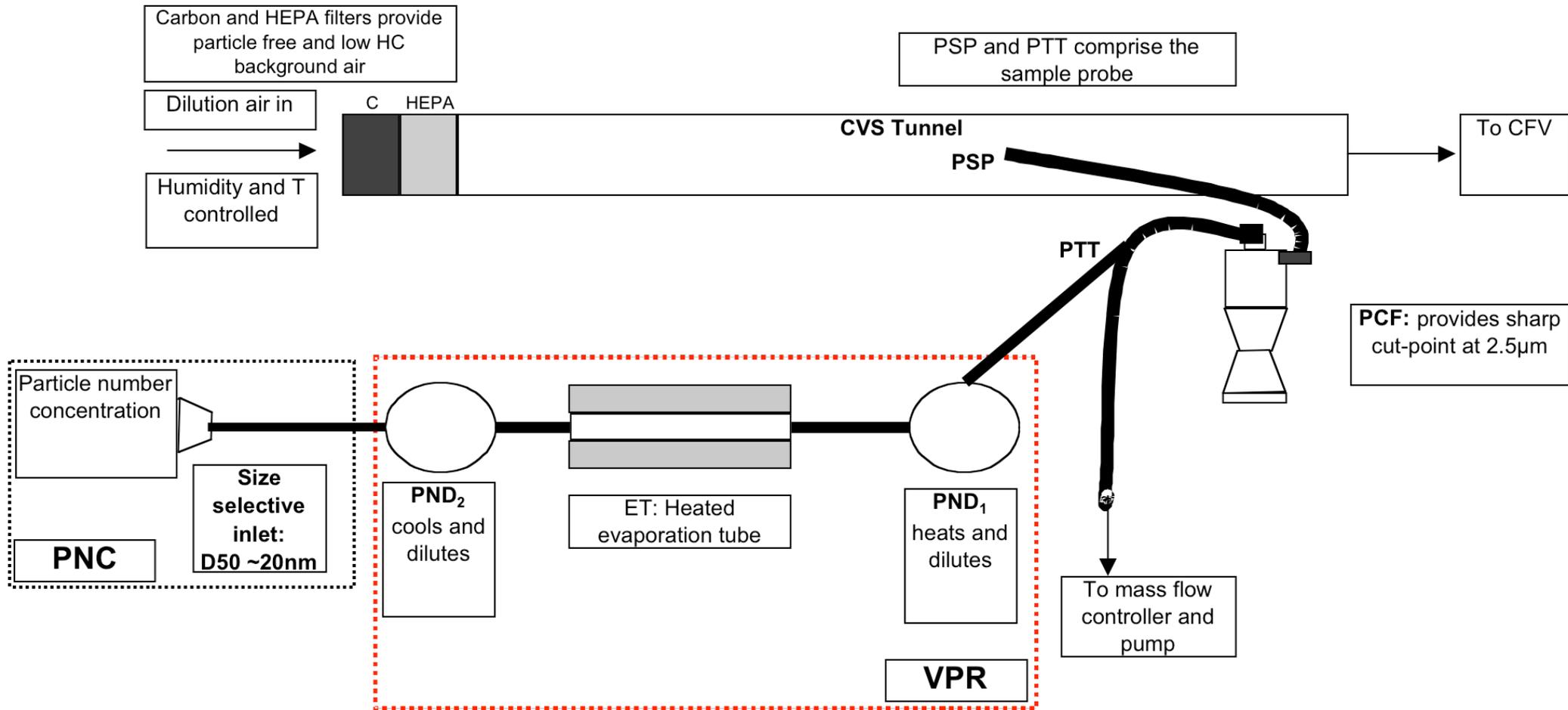
=> 99.95%



Mobile Measurement (Mexico City Buses)

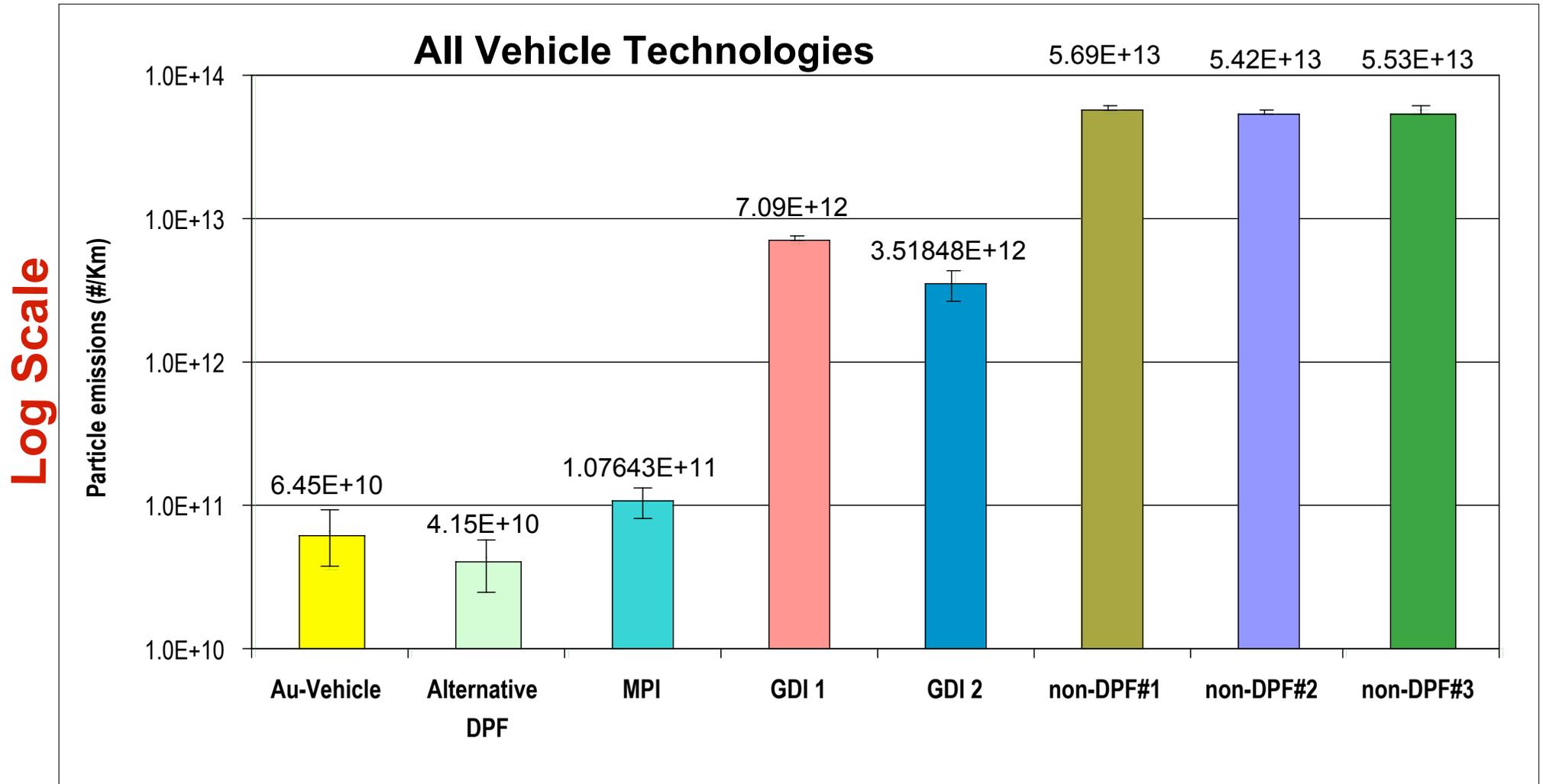


PMP Set-up for Particle Number Count

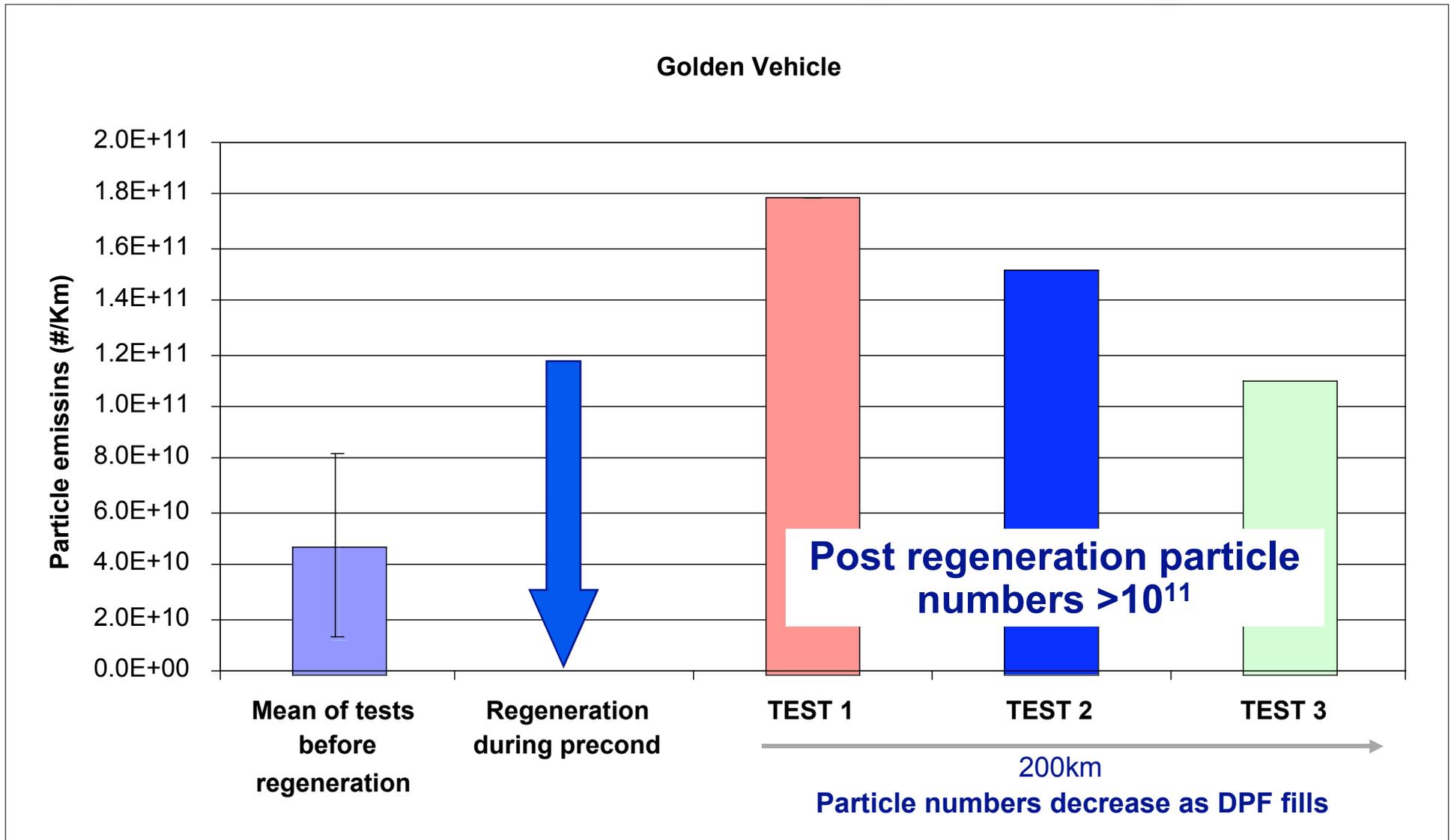


PMP: NEDC Particle Numbers (#/km)

Factor of 500 –1000 between DPF & Non-DPF Diesels



PMP: DPF fill state influences NEDC particle numbers – and repeatability!



Summary

- Controlled sampling is essential for particle measurement
 - separate solid from volatile particles
 - use filtered dilution air ($< 0.1 \text{ prt/cm}^3$)
- high-quality DPF require appropriate method
 - simple mass measurement leads to incomplete/wrong conclusions
 - size resolved number measurement provides valuable information
- PMP has demonstrated reliability of number measurement
 - method stable and robust (**variation only 1-3% !!** PM gravimetric: 4-8%)
- Equipment for stationary and mobile use is available
 - applicable to any kind of particle measurement