



## CONTENTS

- PM 10 vs. NP
- PM and PN from engines
- Nuclei mode
- Examples of PN emissions
- PN health effects
- What to do ? – exhaust gas filtration
- Conclusions

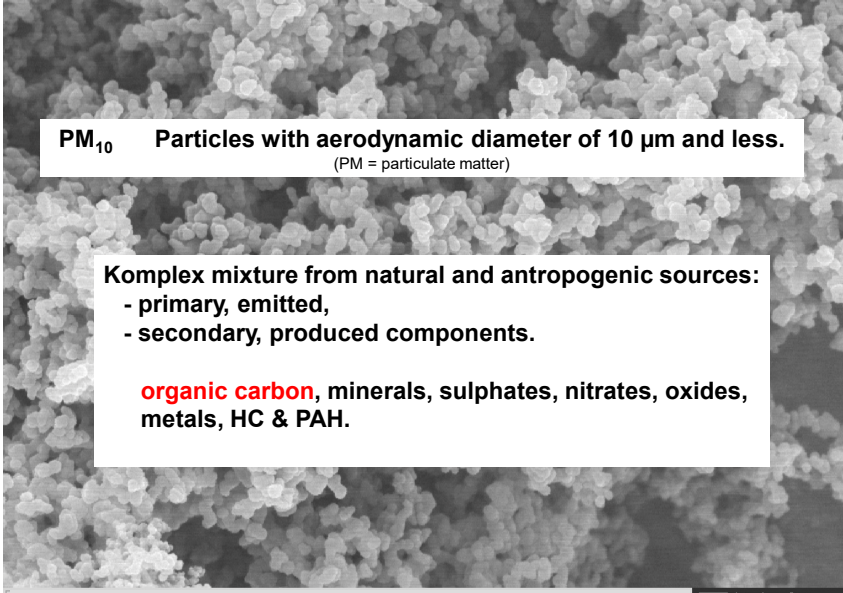
# PM 10 Versus Nanoparticles

## PM-10 MEASUREMENT EMPA

(Nabel Network)



## WHAT IS FINE DUST?




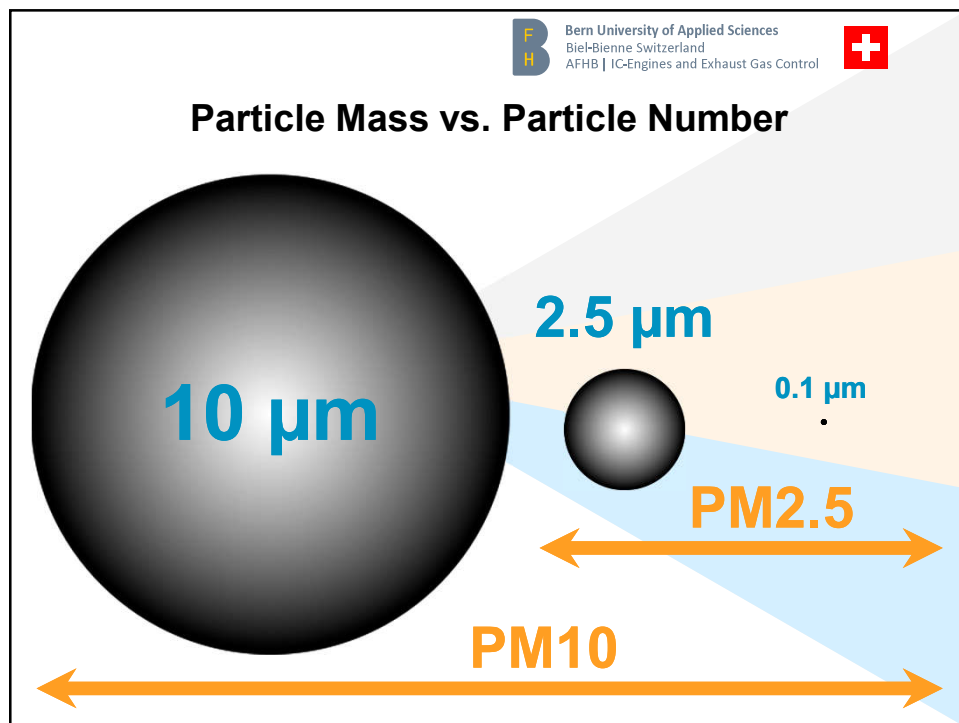
**PM<sub>10</sub>**    Particles with aerodynamic diameter of 10  $\mu\text{m}$  and less.  
(PM = particulate matter)

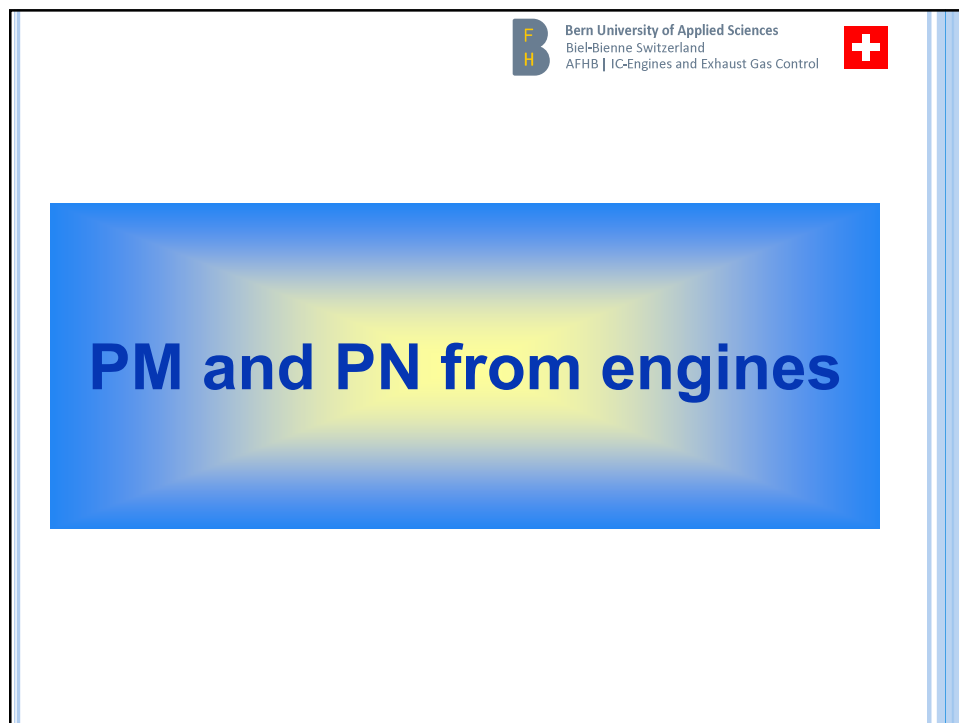
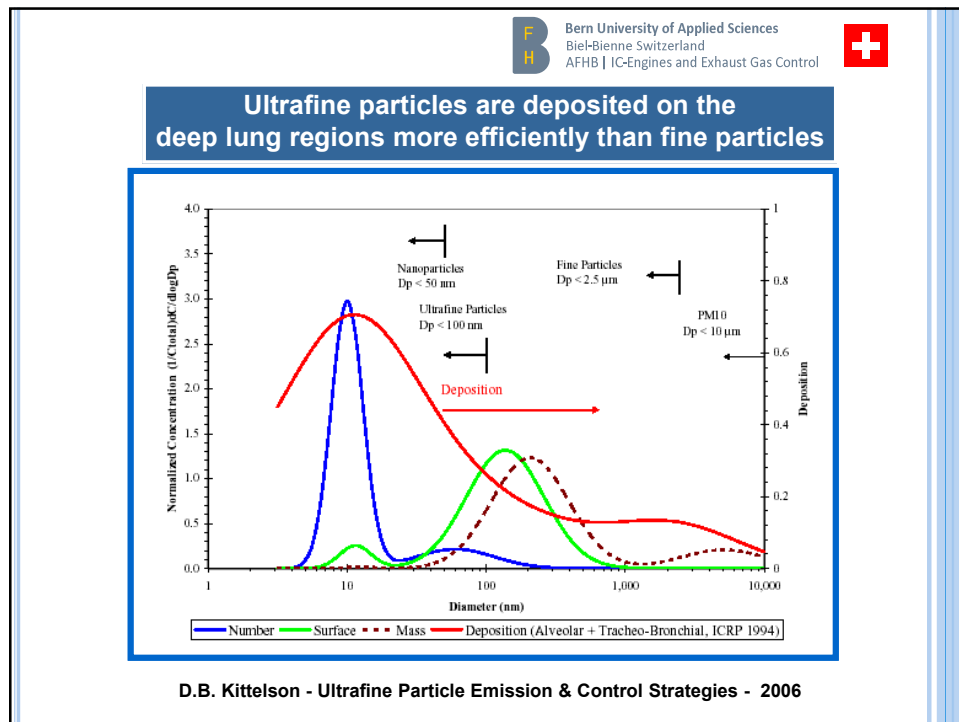
Komplex mixture from natural and antropogenic sources:

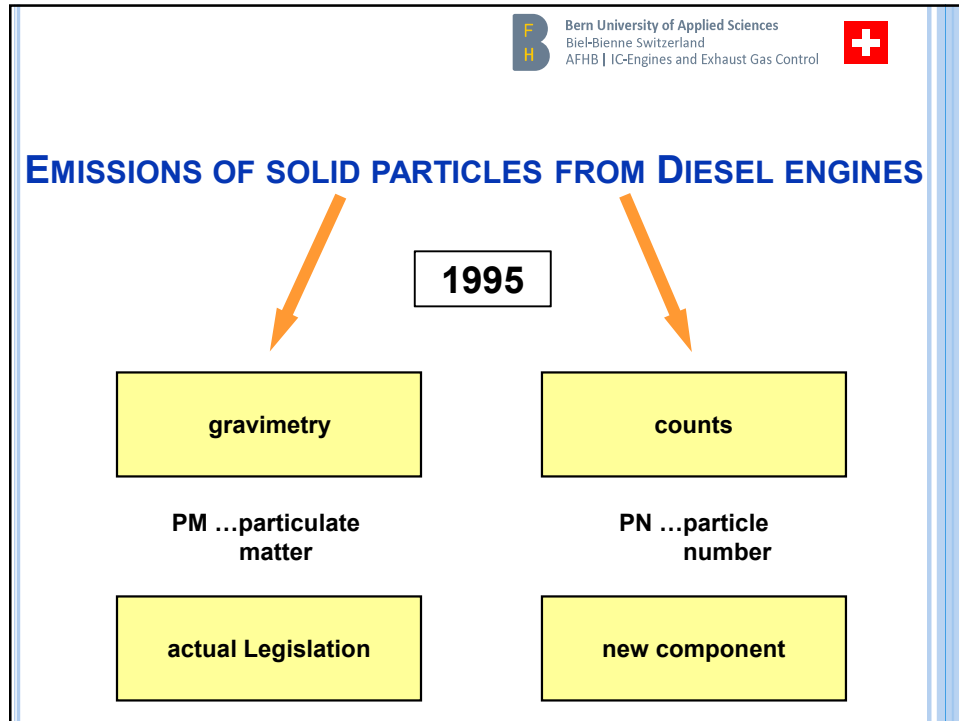
- primary, emitted,
- secondary, produced components.

**organic carbon**, minerals, sulphates, nitrates, oxides, metals, HC & PAH.

Med. Univ. Wien – W. Bursch    

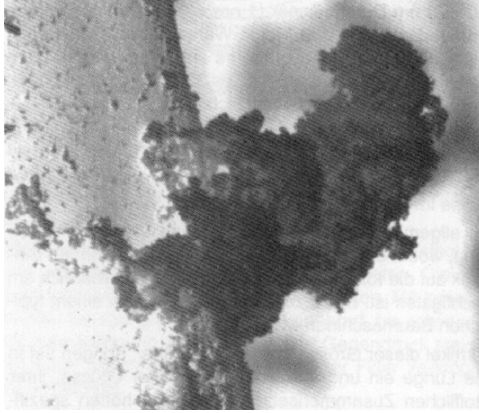








**(PN)<sub>max</sub>**



Soot deposition on a 10  $\mu$ m filter fiber;  
a large agglomerate, formed on the fiber and  
many ultrafine particles in the size range of 100 nm

**Diesel:**

$$10^6 - 10^7 = \left[ \frac{1}{\text{cm}^3} \right]$$

**Ambient air:**

$$\sim 2,5 \times 10^4 \left[ \frac{1}{\text{cm}^3} \right]$$

**$\sim 2,5 \times 10^{13}$  Molecules**

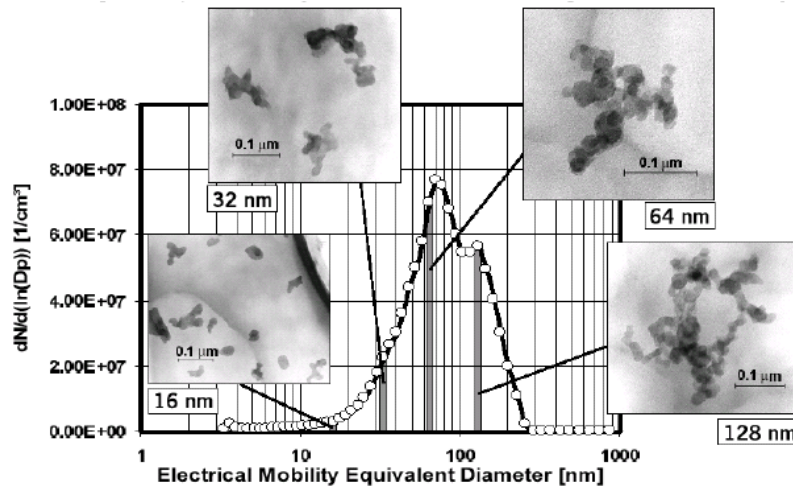


## **NANOPARTICLES**

- negligible mass
- astronomically high numbers
- penetration like gases



## MORPHOLOGY OF NANOPARTICLES

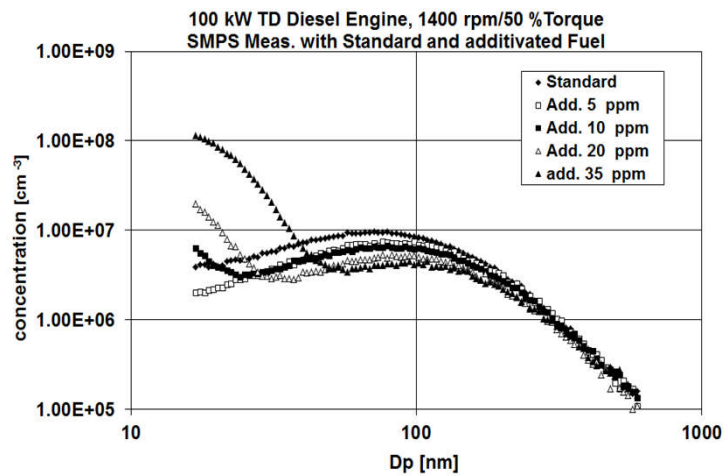


**Nuclei mode –  
what composition ?**



## Additive ash particle formation depending on concentration

[Kasper et al. SAE 2000-01-1998]



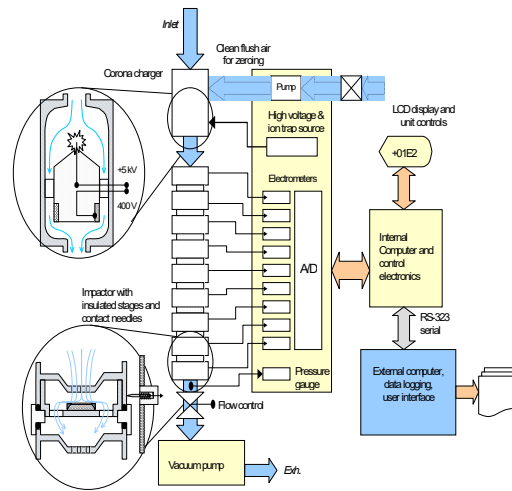
## Elements used as tracer indicators in the tested lube oils

	Engine lube oil	Addition to the fuel		
		Motorex	DEA	FBC
Ca [ppm]	2630	3680	-	-
Zn [ppm]	1200	1010	-	-
Fe [ppm]	-	-	-	40

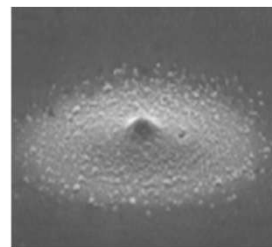
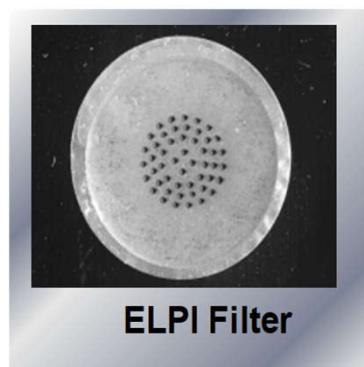




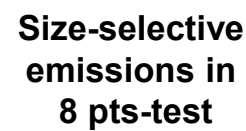
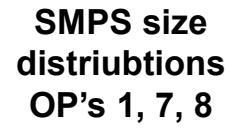
## ELPI block diagram (DEKATI)



## Typical appearance of particles deposits on ELPI filter plates



SEM/EDX



## CONCLUSIONS



### Market lube oil

- highest nuclei mode < 30 nm
- combined effects of metal oxides & SOF

### In the size range < 100 nm were found:

- 79% Fe mass & 77% Zn mass
- Ca inappropriate tracer; comes also from lube oil

### From dosed elements summary masses were found:

43.5% Fe; 36.6 Zn & 65.5% Ca

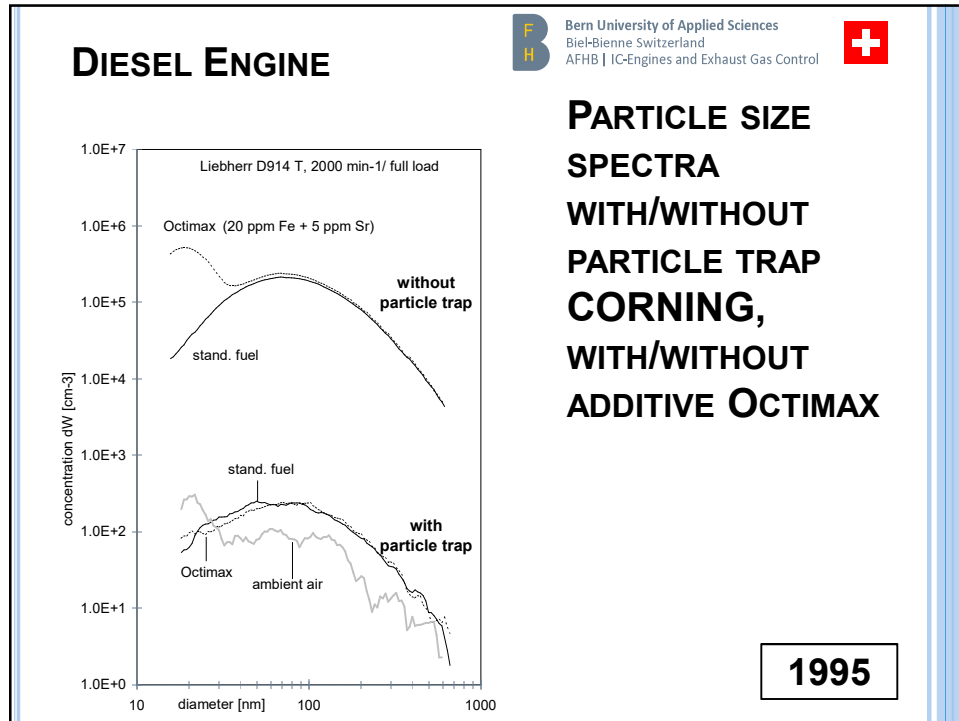
### It was confirmed that:

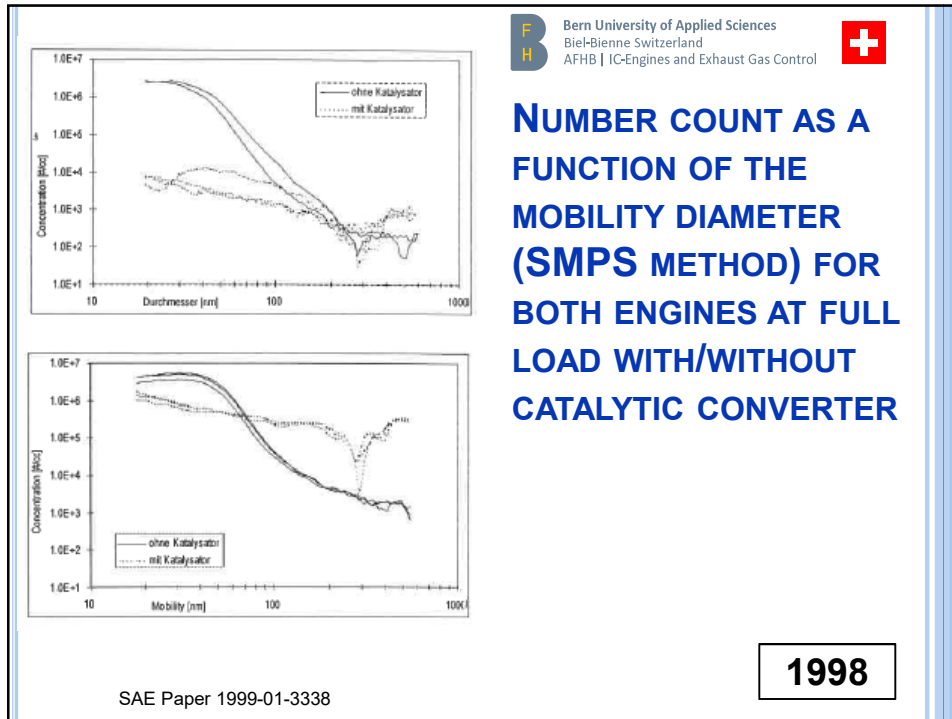
- the dosed metals are emitted mostly below 100nm
- 1/2 to 2/3 of the the dosed metals stay in the system.

Czerwinski Jan et al., PTNSS Comb. Engines, No1/2015(160)



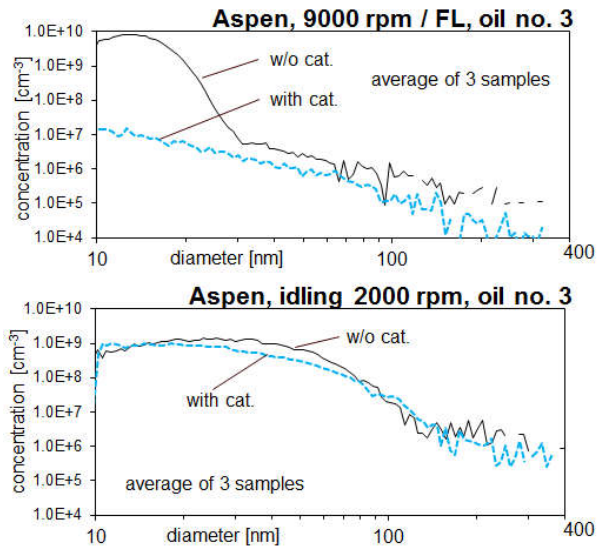
## Examples of PN emissions



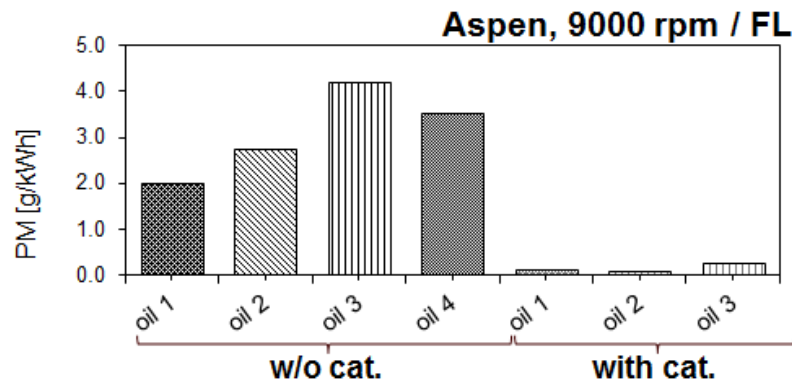




## INFLUENCES OF OXIDATION CATALYST ON PARTICLE SIZE DISTRIBUTIONS (PSD) AT FULL LOAD & IDLING



## PARTICLE MASS (PM) WITH DIFFERENT LUBE OILS AT FULL LOAD



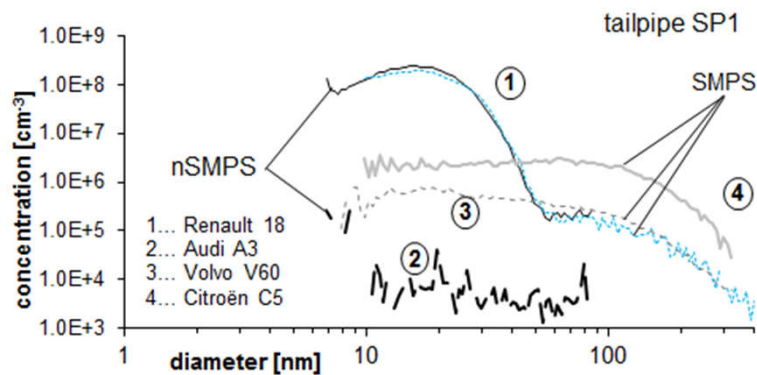


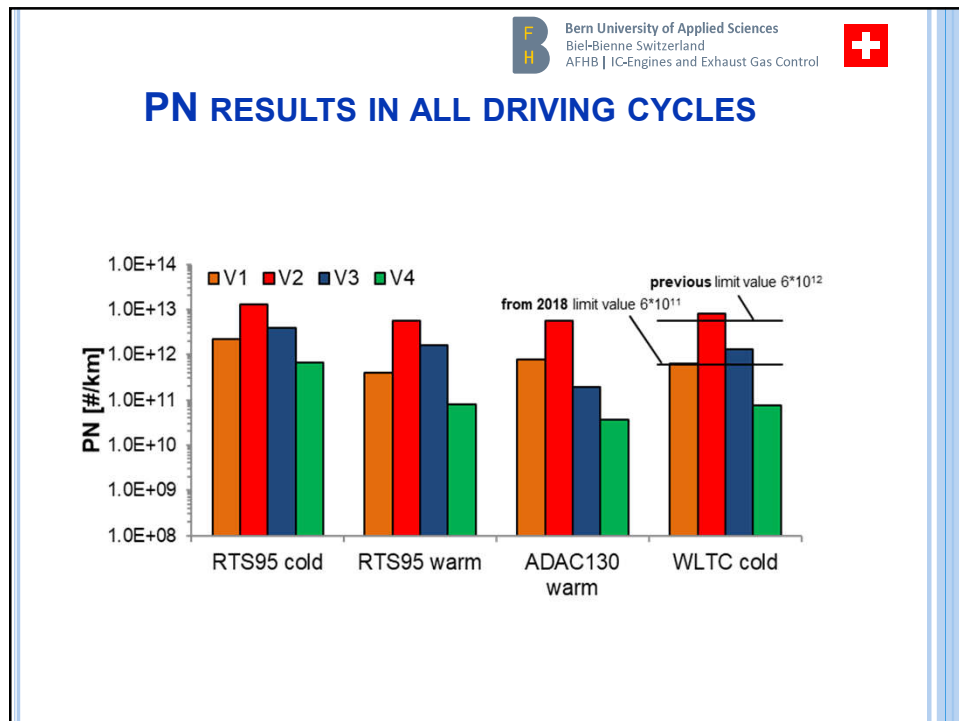
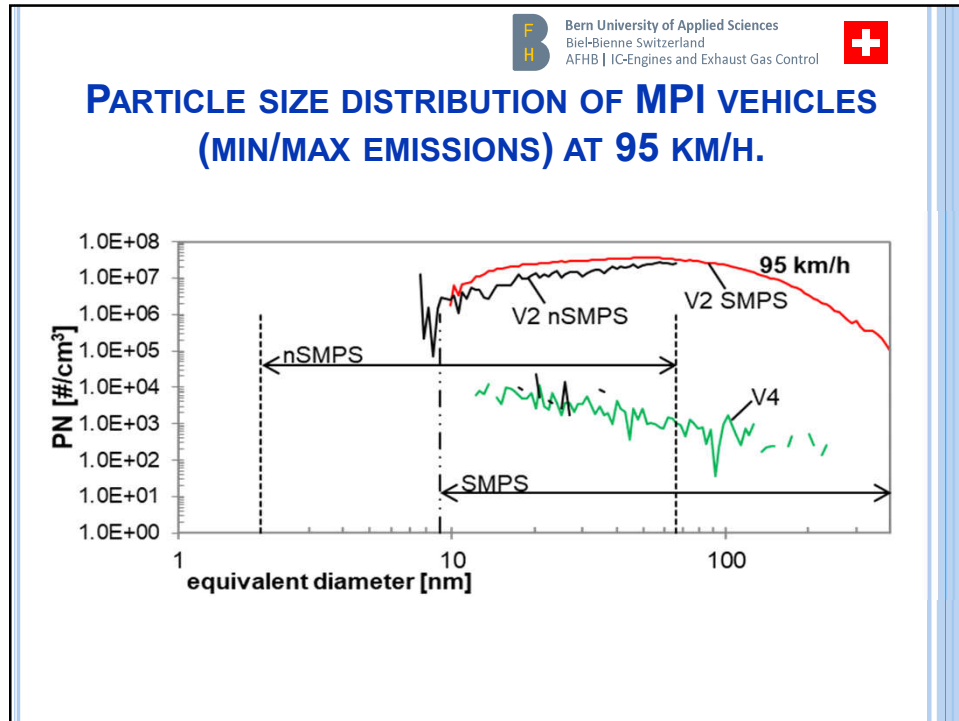
## GASOLINE CARS

GDI & MPI  
Since 2013



## PARTICLE SIZE DISTRIBUTIONS OF DIFFERENT VEHICLES AT TAILPIPE & 40 KM/H





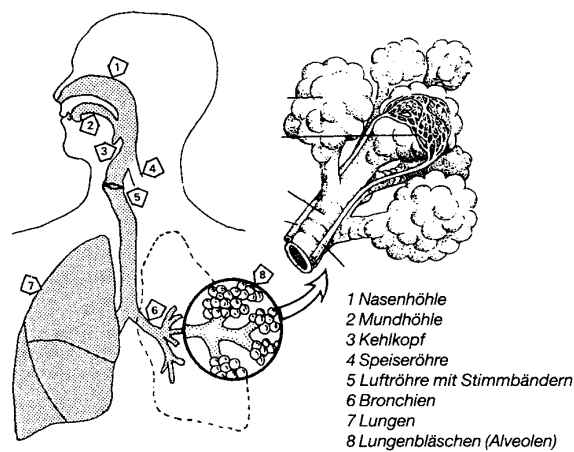




# PN Health effects



## HUMAN LUNGS

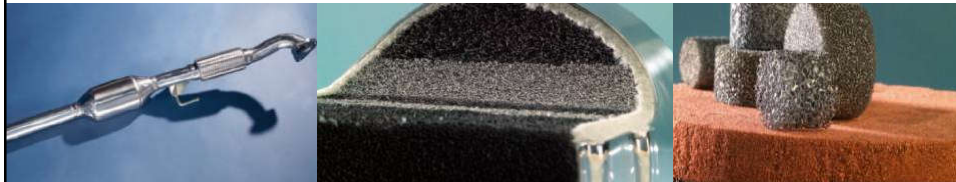
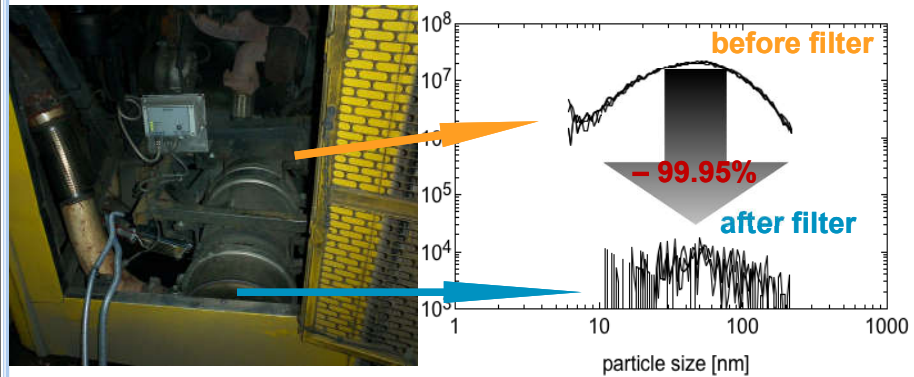




## Exhaust gas filtration



## FILTER EFFICIENCY MEASUREMENT

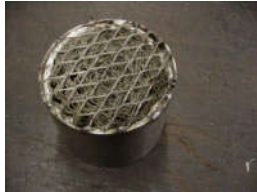


**PM – cat**  
**(cat. yes, filter no!!!)**



## BUCK - WFC

Wiremesh filter-catalyst - for scooter application

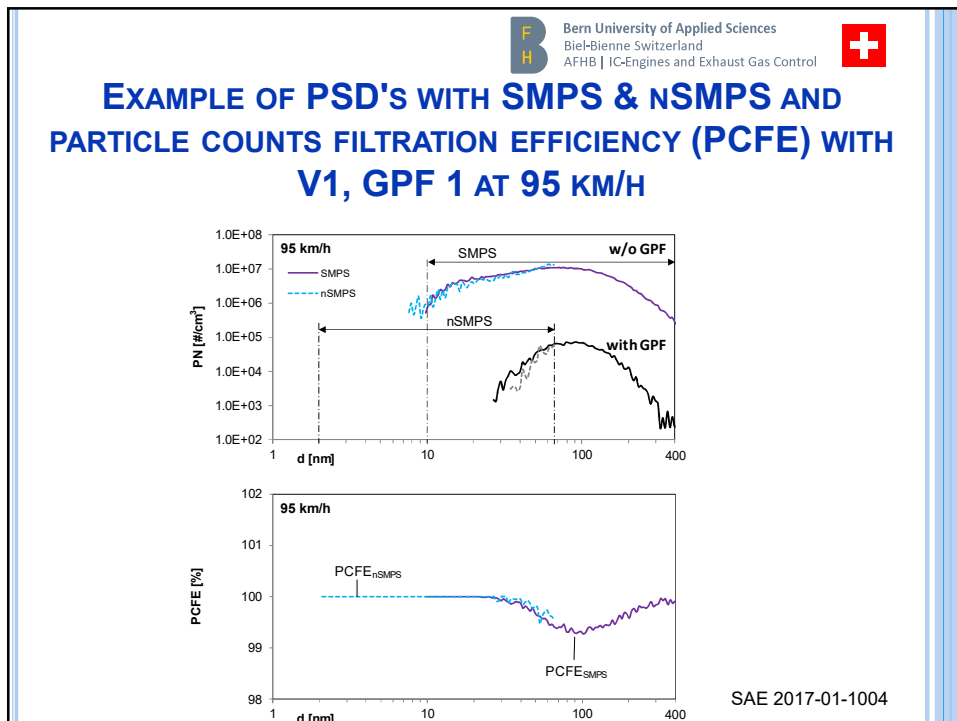
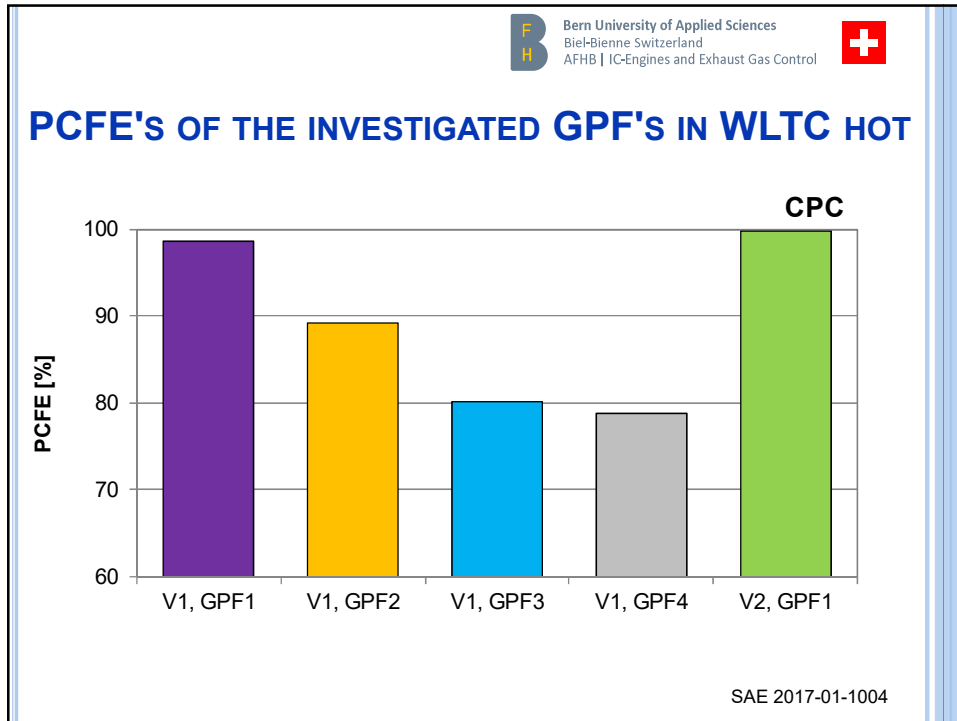


WFC  
For chain saw →



## Cells structure with shovels for partial particle filtration (Pcars - retrofitting)



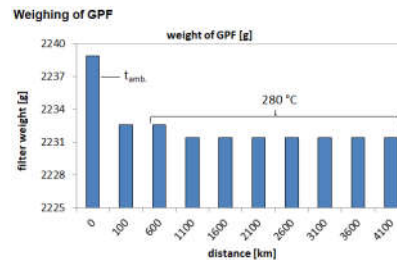




Bern University of Applied Sciences  
Biel-Bienne Switzerland  
AFHB | IC-Engines and Exhaust Gas Control



## ATTEMPT OF SOOT-LOADING OVER 4100 KM IN REAL DRIVING; ADD-ON-GPF (UNCOATED); V2



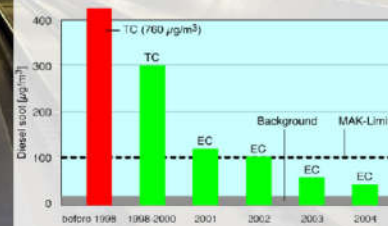
GPF entrance after 2100 km



## St. Gotthard Tunnel (NEAT)

- **SUVA: Air quality in tunnel (1998-2004)**
- Impressive results
  - Filter reducing 99.99% of particles
  - Reduction of burden from elementary carbon by factor 20 after implementation of DPFs
- Since 2002 all diesel combustion machines in Switzerland need a filter
- Scientists like Gehr, Rothen et. al. researching biological evidence; Peters and others require PN control also in ambient air

SUVA: Air quality in tunnel (1998-2004)





## Conclusions

- Ambient PM 10, PM 2.5 are far from NP (size, composition, penetration)
- Engine PM  $\neq$  PN
- PN is a very sensitive parameter
- Nearly all engines have operating conditions with high PN
- ... and not only engines
- Filtration helps a lot
- Nanoparticles penetrate easily in the human body and have different toxic influences.

