

CALAC+ Conferencia sobre emisión de nanopartículas –
Virtual Meeting 25.November 2021

Eliminate Nanoparticles and Bio-Aerosols outdoor and indoor by VERT Tools

Andreas C.R.Mayer / VERT

This is not a new story

but we only started late to learn our lessons



- **1775:** Percival Pott proves the correlation between cancer and soot at chimney sweeps scrotum
- **1928:** Lawther proves correlation between traffic in London/Wales and lung cancer
- **1936:** first assumption in the German journal “DUST” correlates diseases to particles < 1 μm
- **1959:** OSH Convention in Johannesburg defines the submicron fraction which penetrates bronchi and alveoli
- **1980:** Dough Dockery: Mortality due to PM2.5 quantified in the Six Cities Study USA 1978-1993
- **1978:** John J. Mooney introduces aftertreatment for the petrol engine, the TWC – three way catalyst
- **1982:** CARB introduces the first limit value for Diesel PM
- **1989:** WHO declares Diesel exhaust probably carcinogenic

Who is VERT

an association of manufacturers
and research institutions
to certify and introduce

**Best Available Technology
for Emission Reduction**

for Health and Global Warming

founded 1994, active worldwide

What are Nanoparticles

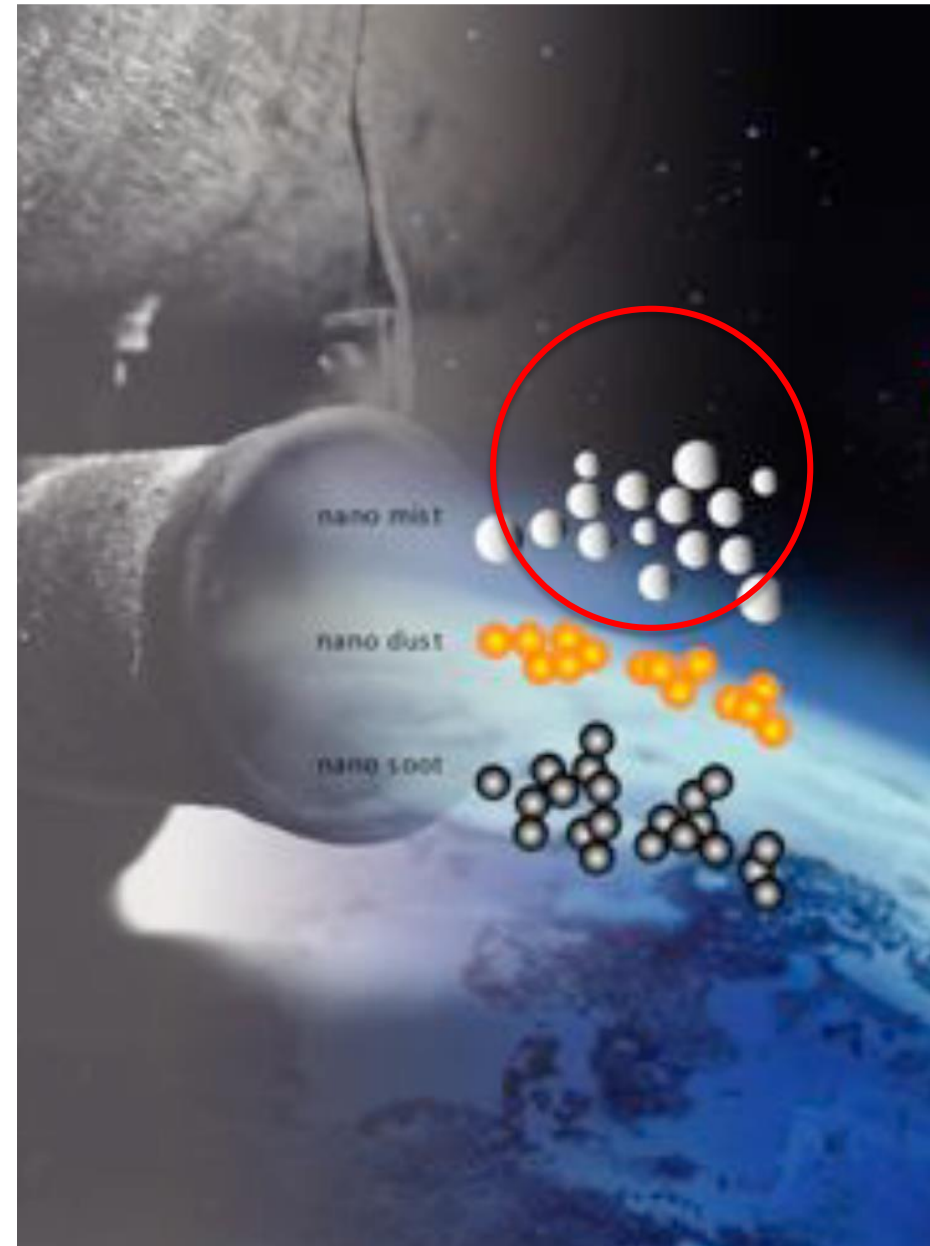
and why and how impacting health

- **Non volatile particles < 1000 nm**, VERT defines 10-500nm
- **Form a stable aerosol inhalable for hours**
- **Penetrate membranes (alveoli, brain, placenta)**
- **Translocate to other organs within hours**
- **Carry other toxins (PAH) on their surface**
- **Most toxic air contaminant – carcinogen (WHO 2012)**
- **Depending on the source: soot or metal oxides**
- **Metric is not mass but size and number concentration**

Most Important Source: traffic related nanoparticles

Definitions

- not overall mass PM
- no water/oil droplets
- not EC only
- **Solid particles count PN**
(soot+metal oxides)
- **Size: 10nm - 500nm**



Other Nanoparticle Sources

- Brakes
- Tires
- Road and Rails
- Handheld tools (chainsaws etc)
- Industrial Combustion
- Indoor Combustion
- Wildfires



and what about Bio-Aerosols ?
Virus, Bacteria, Fungus

Aerosol Research

strange coincidence:

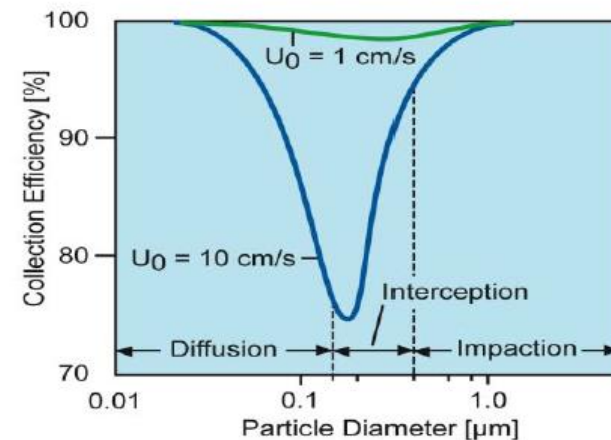
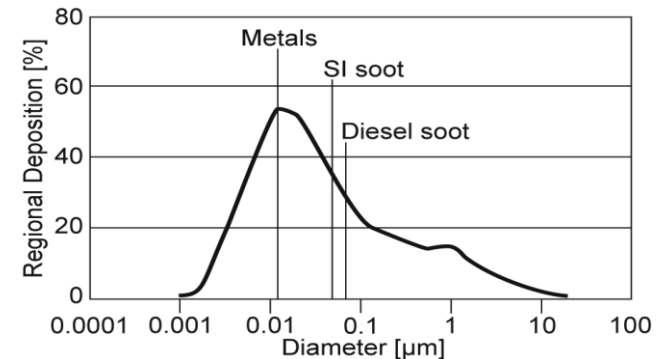
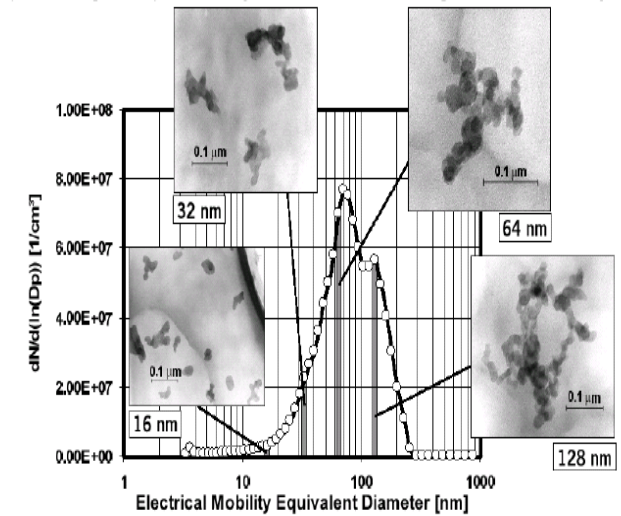
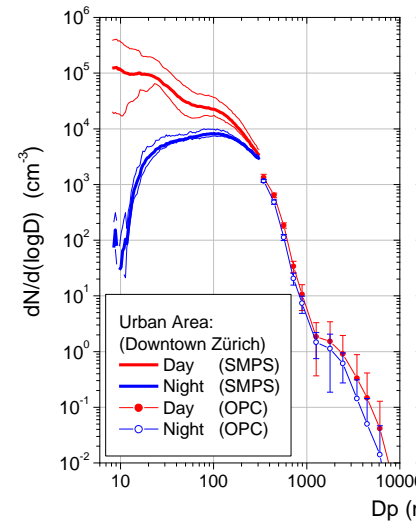
the most intensive emission range of the Engines

=

The most sensitive size range of the Lungs

=

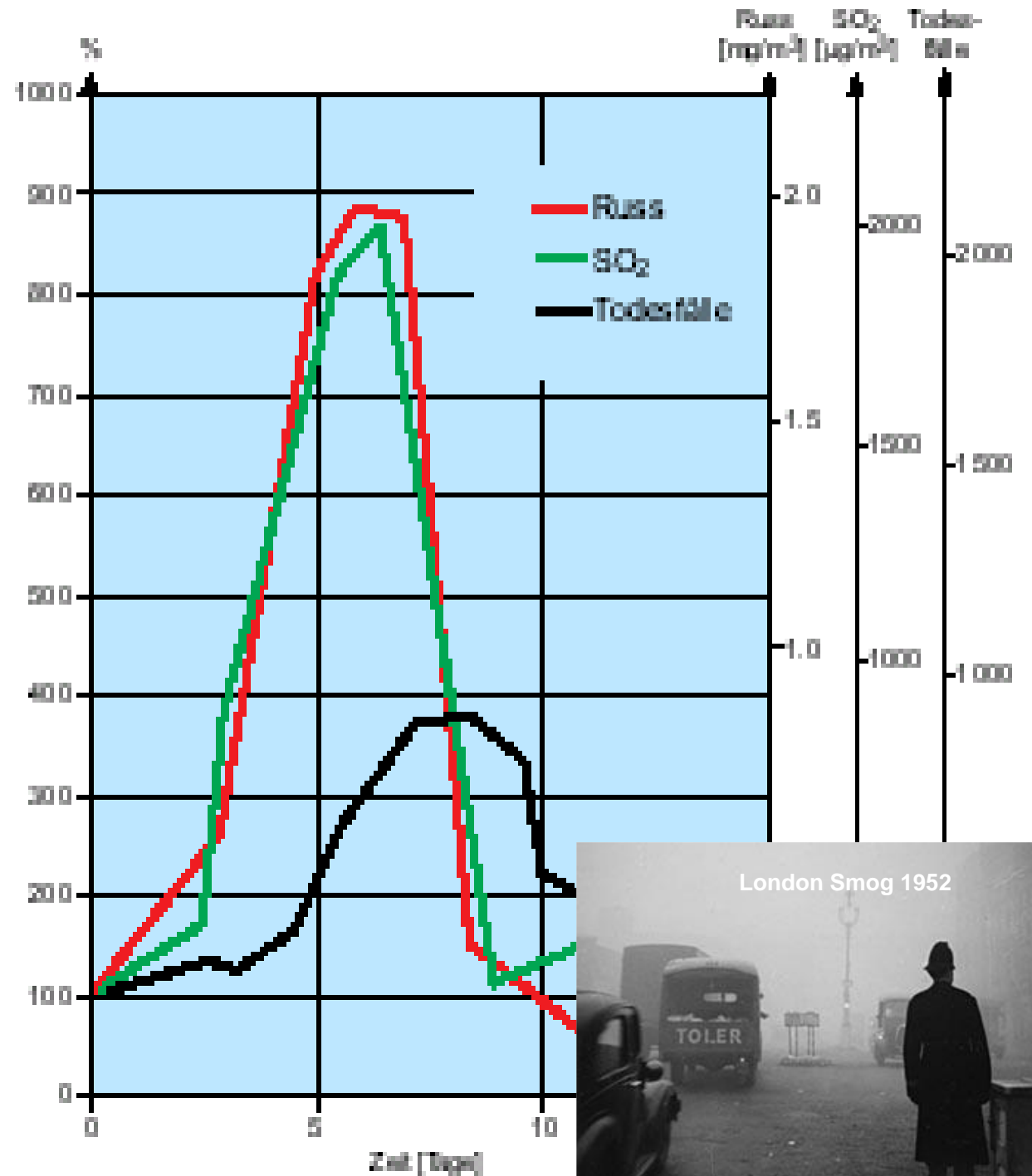
and the weakest size range of Filtration



London Smog 1952

during one week died
6'000 persons
6'000 more next month

*London had replaced the
electric tram by Diesel
buses 6 month before*



Histological Research

of lungs compartments from 50 year old autopsies

Electron microscopic analyses revealed the dominance of retained soot and a surfeit of other particle types. A variety of metal-bearing particle types were found in all compartments, but Pb, Zn, and SnZn types appeared the least biopersistent. The results support the acute toxicologic importance of ultrafine carbonaceous and metal PM. *Key words:* 1952 London smog, autopsy, lung

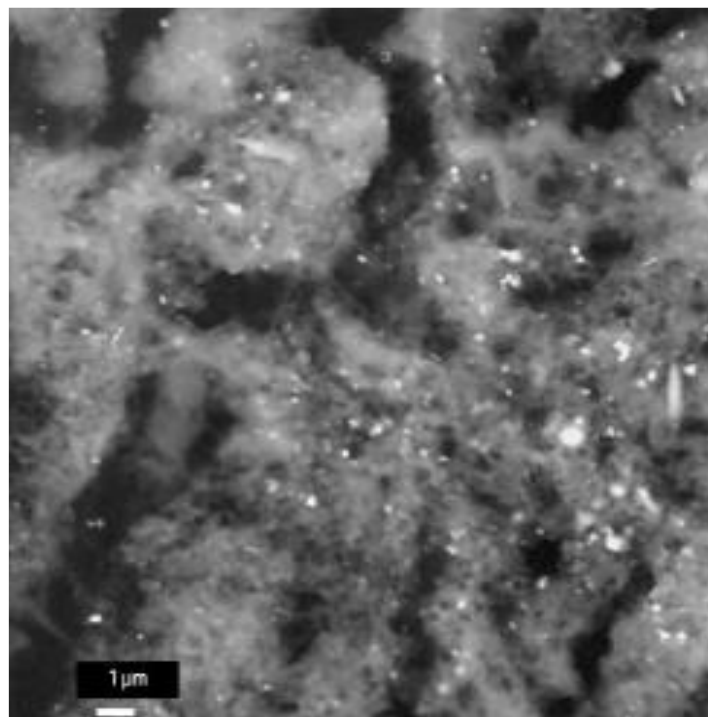


Figure 2. BE micrograph of section of airway aggregate from case 2 revealing abundant submicrometer inorganic (bright) particles.

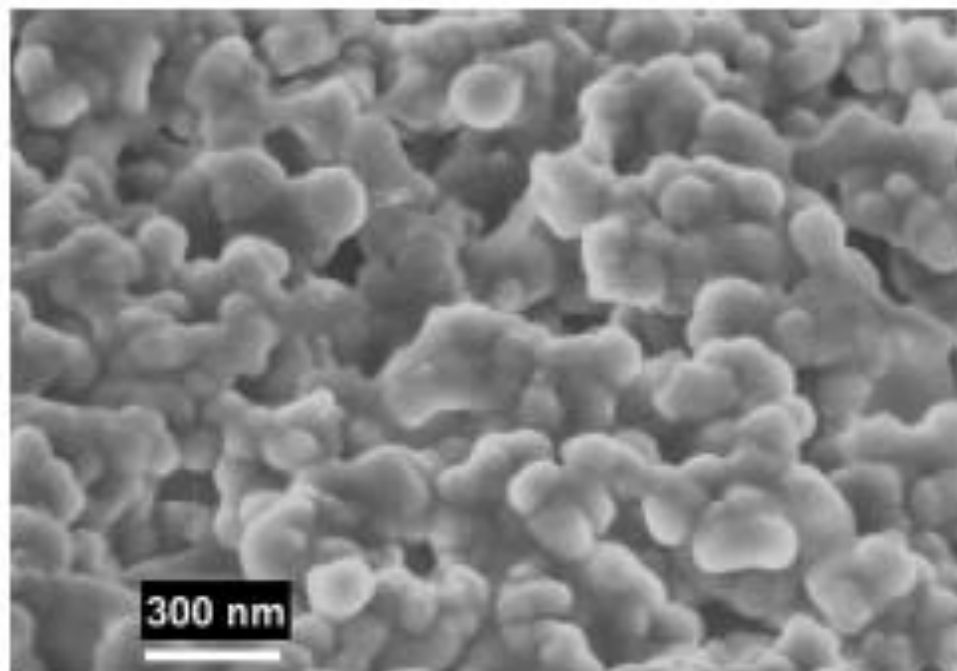


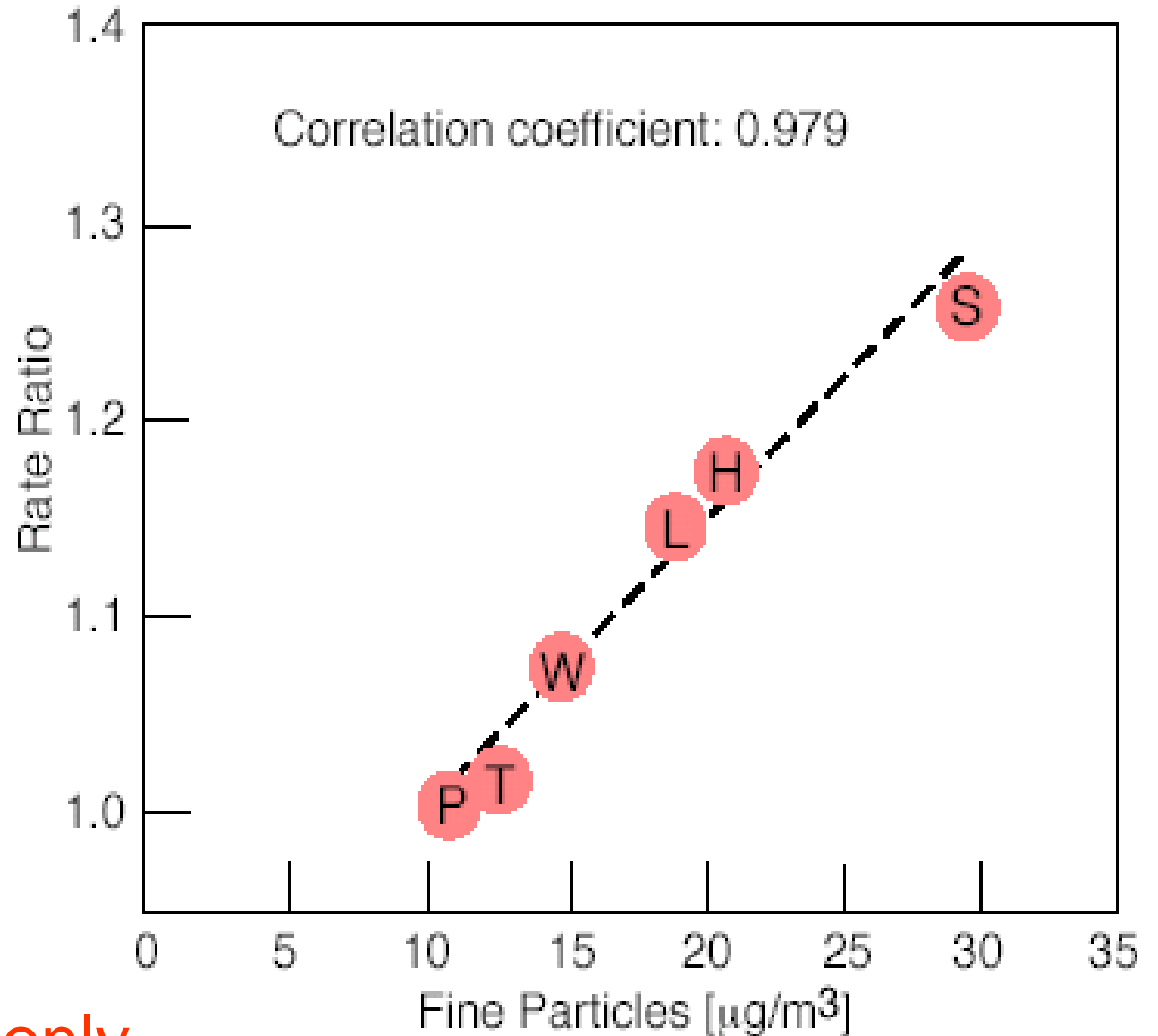
Figure 3. High-magnification field emission scanning electron micrograph of airway aggregate from case 2 showing ultrafine PM structure.

1993

Mortality due to Fine Particle Exposition

**6-Cities-Study
USA 1978-93
15'000 cases**

Correlation with Ultrafine Particles only not with large Particles, nor with Sulfur, nor with NO₂

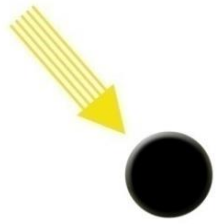


Very steep effect/dose - high correlation
Scientific confirmations 2006 / 2012

Health Impact due to fossil fuel related PM 2.5 Harvard 2021

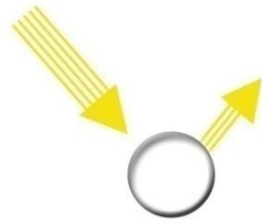
GEOS-Chem spatial grid resolution ^a	Region ^b		Total deaths >14 years old, in thousands	Population-weighted annual mean PM _{2.5} concentration, $\mu\text{g m}^{-3}$			Mean attributable fraction of deaths, % (95% CI) ^d	Deaths attributable to fossil-fuel related PM _{2.5} , in thousands (95% CI) ^c
				PM _{2.5} from all emission sources	PM _{2.5} without fossil fuel	Estimated PM _{2.5} from fossil fuel, %		
Fine	North America	Central America & the Caribbean	1,148	10.06	3.03	7.03 (69.9)	8.2 (4.5-11.6)	94 (52-133)
		USA	2,705	11.81	2.15	9.66 (81.8)	13.1 (7.8-18.1)	355 (212-490)
		Canada	250	12.01	1.76	10.25 (85.4)	13.6 (8.0-18.7)	34 (20-47)
Coarse	South America		2,389	8.66	3.02	5.65 (65.2)	7.8 (4.5-11.0)	187 (107-263)
Fine	Europe		8,626	19.22	4.68	14.54 (75.7)	16.8 (10.4-22.6)	1,447 (896-1,952)
Fine	Asia	Eastern Asia	25,468	51.72	8.68	43.05 (83.2)	30.7 (-189.1-52.9)	7,821 (-48,150-13,478)
Coarse		Western Asia & the Middle East	1,456	26.95	20.73	6.22 (23.1)	6.5 (3.0-9.9)	95 (44-144)
Fine	Africa		5,274	32.98	28.98	4.00 (12.1)	3.7 (-4.5-8.7)	194 (-237-457)
Coarse	Australia & Oceania		189	4.17	2.19	1.98 (47.4)	3.2 (1.6-4.8)	6.0 (2.9-9.0)
	Global		47,506	38.01	11.14	26.87 (70.7)	21.5 (-99.0-35.7)	10,235 (-47,054-16,972)

Warming Effect
of Black Carbon Aerosols



“Low albedo”

Cooling Effect
of Organic & Sulfate Aerosols



“High Albedo”

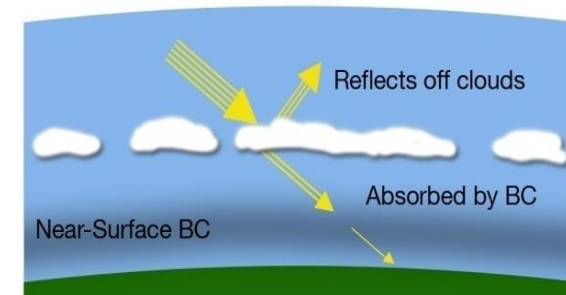
Multiplying Effect
When Mixed Together



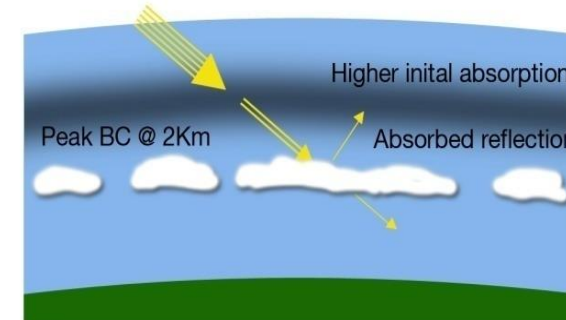
“Very Low Albedo”

Higher in atmosphere

Traditional View: Peak Black Carbon Close to Surface



New Findings: Peak Black Carbon at 2Km



Science Daily, United Nations Environment Program Nov 2008

BC on snow
decreases
albedo,
turning to
water..
further
lowering
albedo



Minimum extent
of ice cover 2005

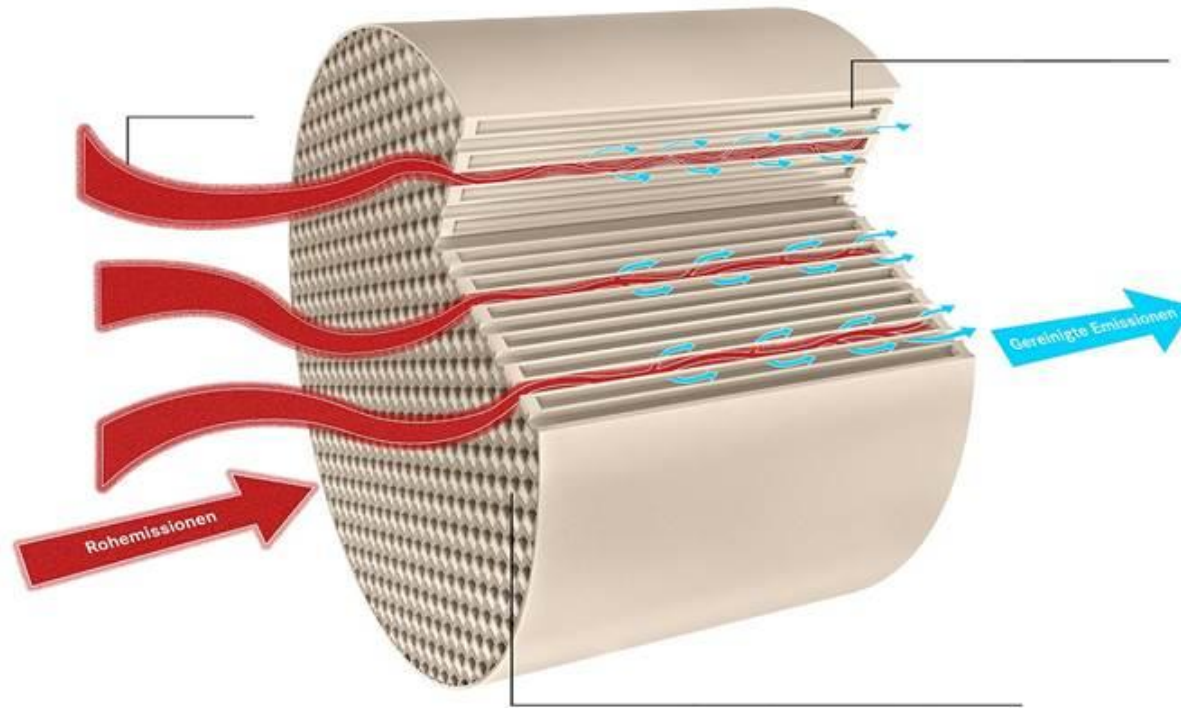
Median minimum extent
of ice cover (1979-2000)

Journal of Geophysics Res.2007

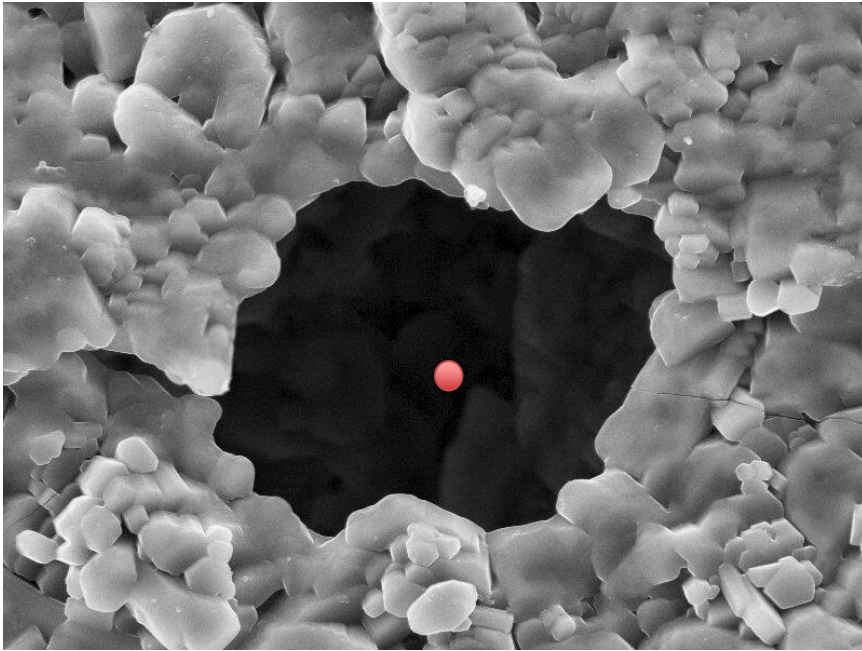
Source: UNEP/GRID Arendal & EPA

**Global Warming
by BC-Particles**

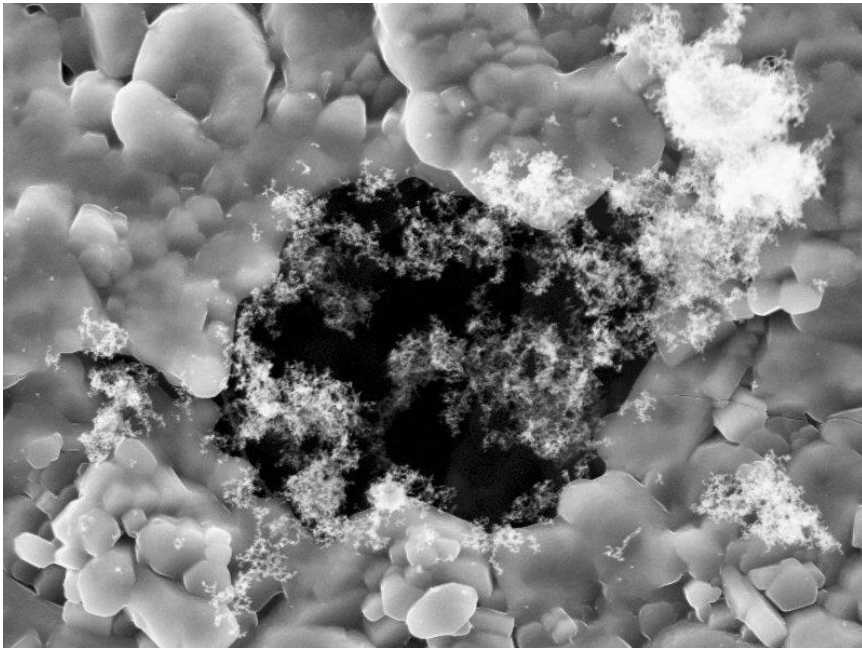
Nanofilter (wall flow) 1982 Corning



- Very large active surface in relation to bulk volume
- Particle trapping efficiency 99.99 from 10 nm
- Cell filter (wall flow) 200 cpsi, 10 μm Poren
- High temperature regeneration, no aging, easy cleaning
- Virus trapping > 99.9999, passive deactivation / therm. desinfektion



**Die Partikel sind 100
mal kleiner als die
Filterporen**

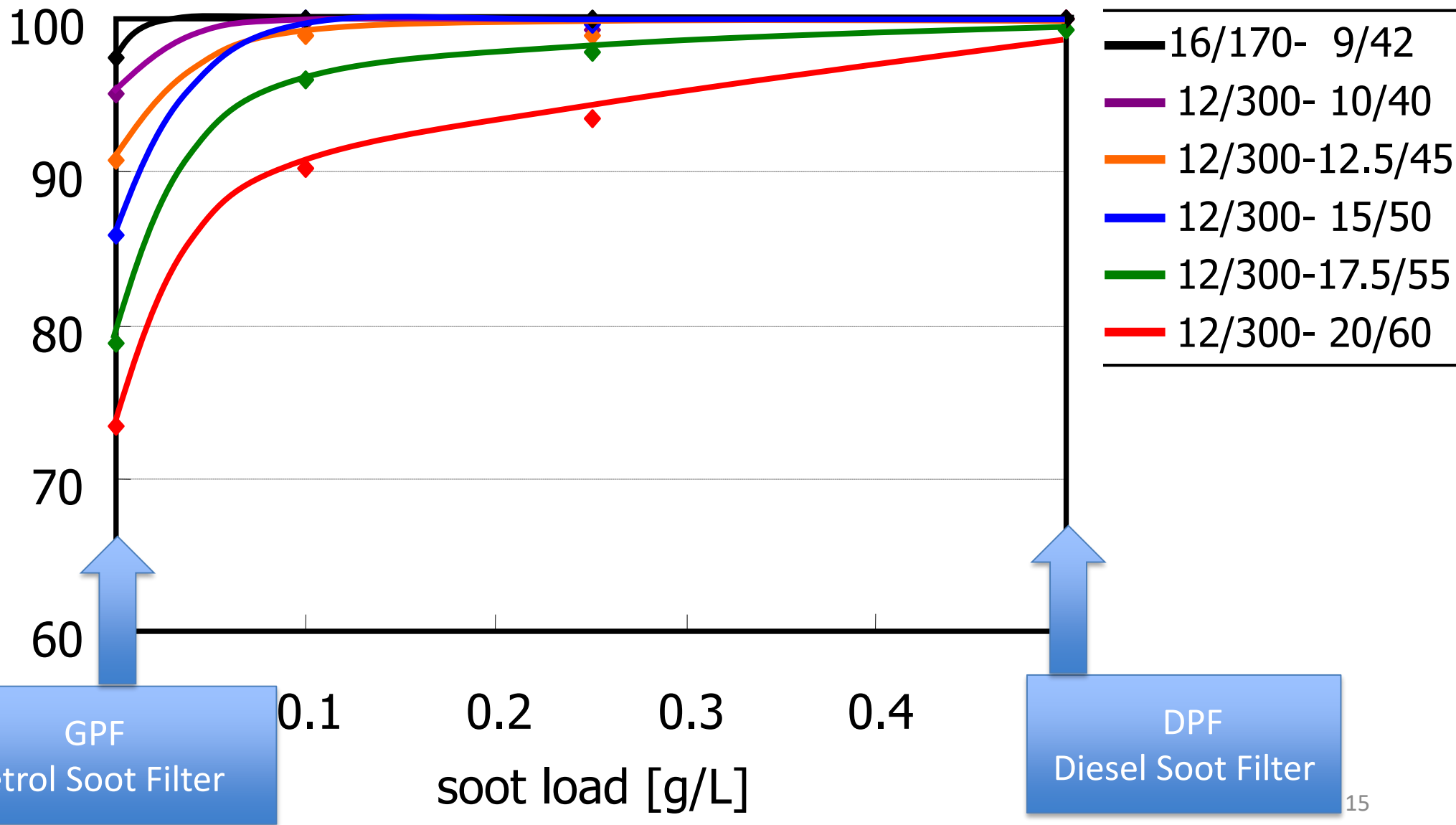


**Das Prinzip der
Verbesserung der
Abscheidung**

Simon Payne, ETH-NPC 2012

Filtration [%] = f (Time, Soot-Loading)

Source: IBIDEN HDT-Seminar 2006



Swiss Tunneling requires „VERT-Filter for each Diesel“ since 1996



Vert-Filter Efficiency > 98% for particles 10-500 nm

VERT had defined solid PN 10-500 nm in 1996 adopted by EU 2008

EU CO-Decision (Art.12, Rec.15 - 2008)

- In order to achieve these environmental objectives it is appropriate to indicate that **particle number limits** are likely to reflect the **highest level of performance** with particle filters using **best available technology**
- .. the commission shall introduce **particle number based limit values** at a level appropriate to the technologies actually being used.

→ 2011/14 Euro VI/6

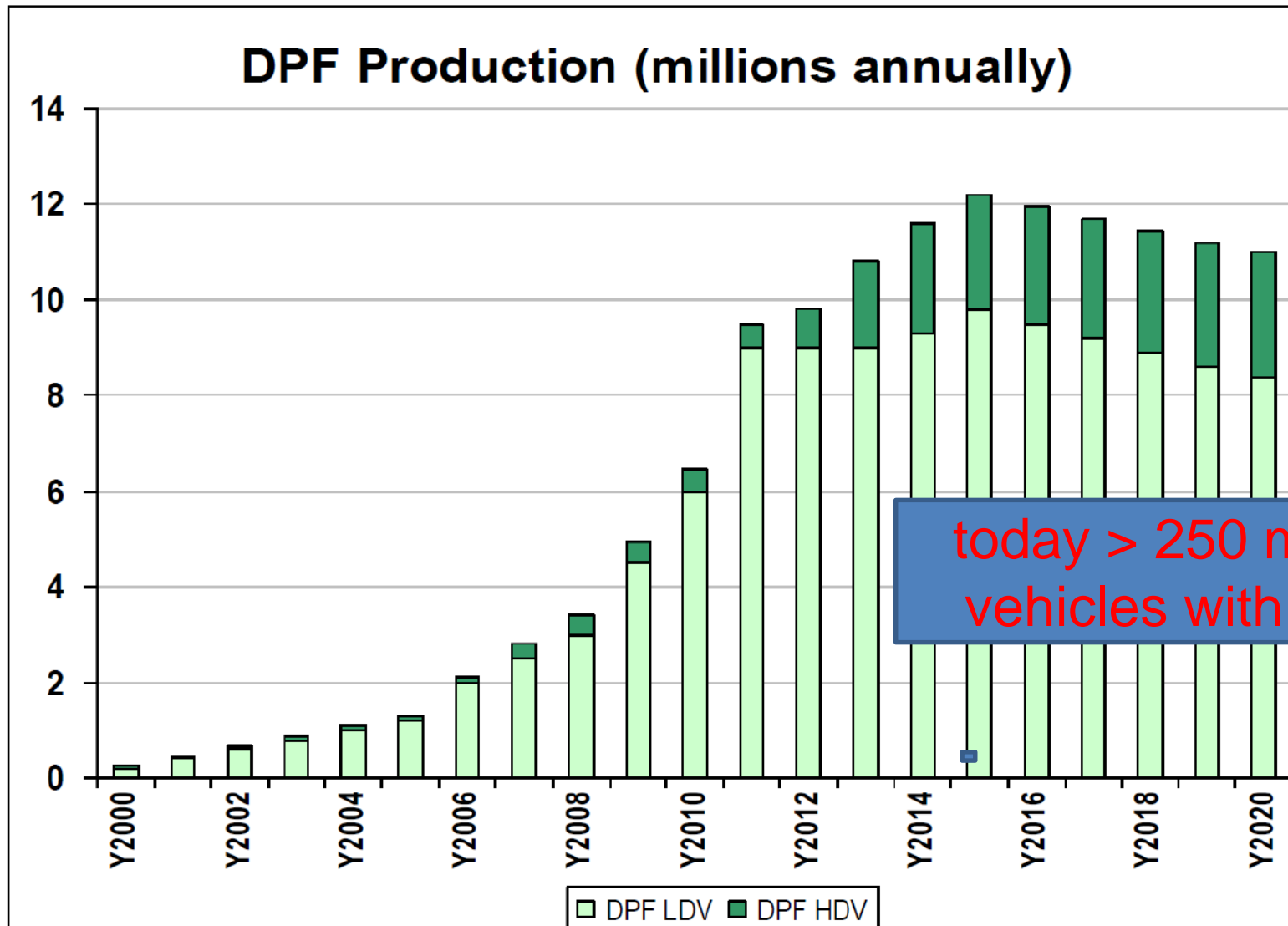
PN < 0.6x10¹² P/kWh in addition to 10 mg/kWh (mass DL)

where 0.6x10¹² represents only a mass of 0.2 mg/kWh

DPF-Installations in Europe

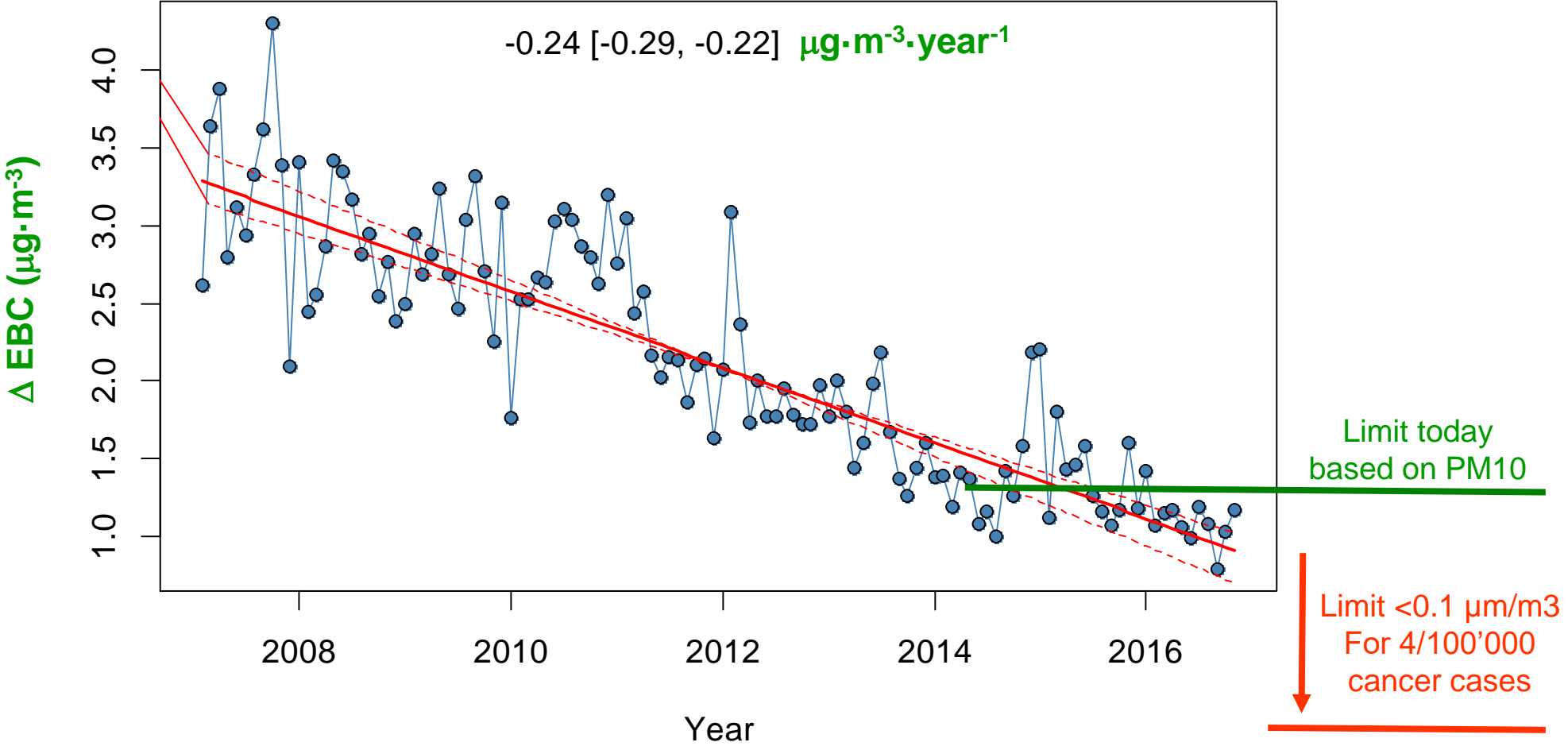
+ China 2016 + India 2020

and GPF to come



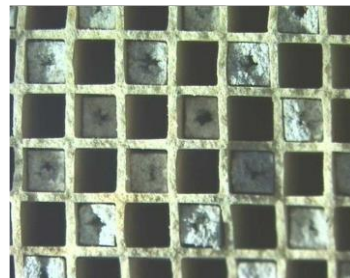
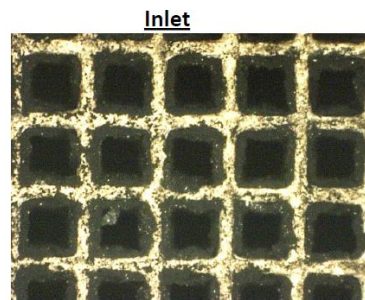
And the Result: Cleaning the Air by DPF in Switzerland

Monitoring BC



VW-Scandal Manipulation with DPF & DeNOx

→ Emission increases by x 1000

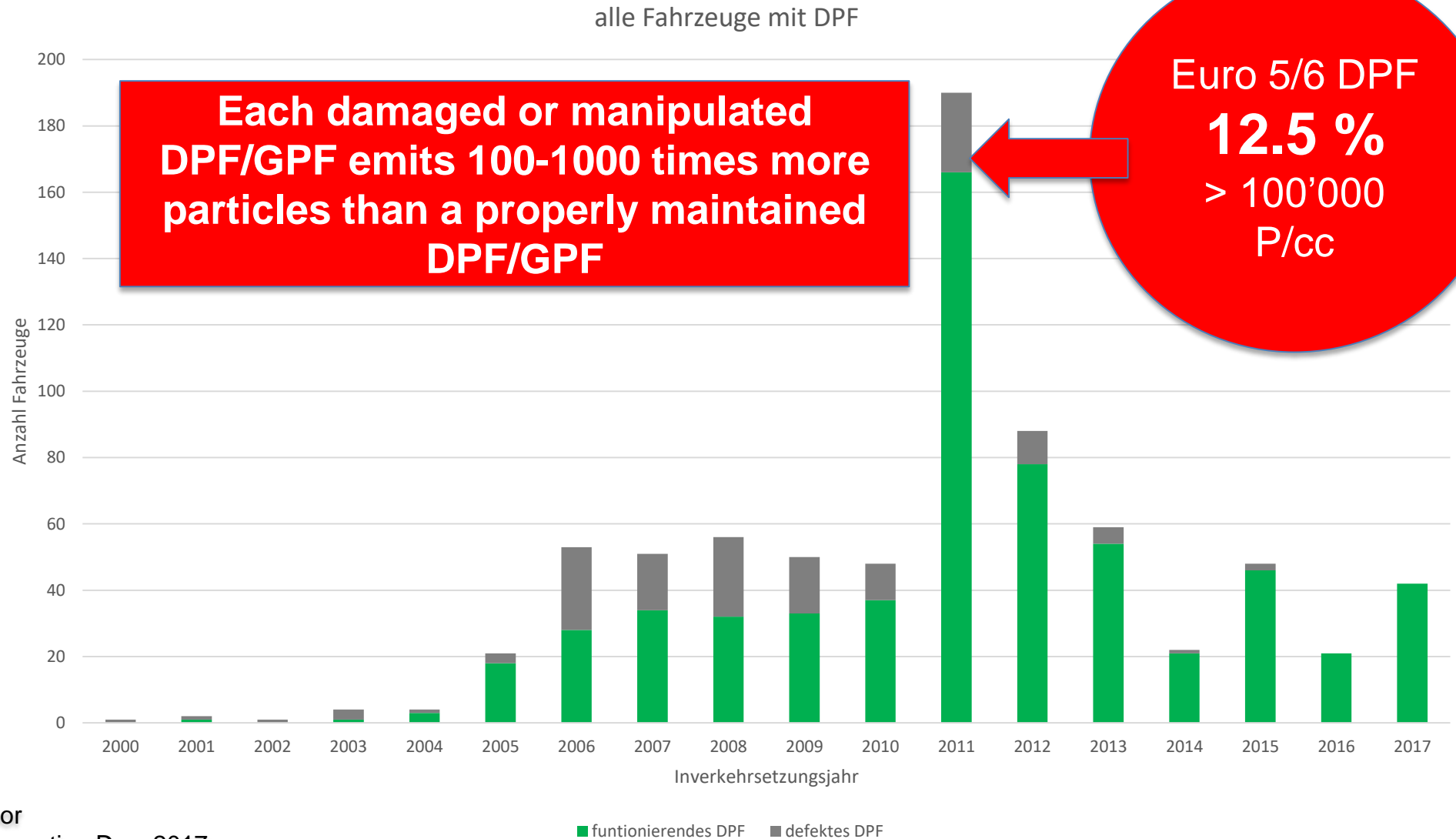


because they want to avoid cost
for proper repair or cleaning

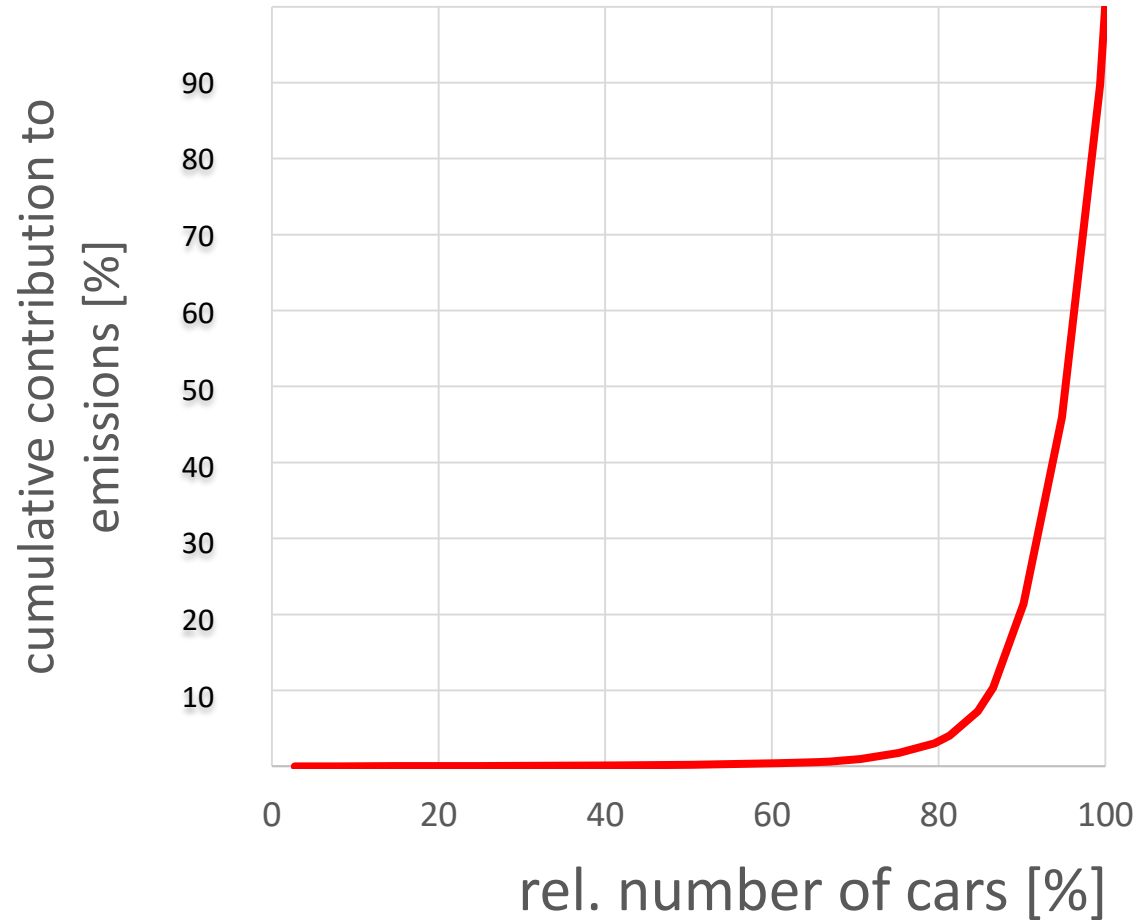


LDV DPF Failure Statistics Switzerland

1000 vehicles tested PN at idle 2017



Cumulative Contribution of High Emitters to Fleet Emission



VERT Internation Working Group NPTI 2016

for a very efficient and cost effective 100% in-use periodic emission control for DPF equipped vehicles

- **PN-Test at low idle**
- PN with DPF; $< 10^3$
- PN with failure $> 10^6$
- Pass/Fail: 100'000 1/cc
- VERT 2012

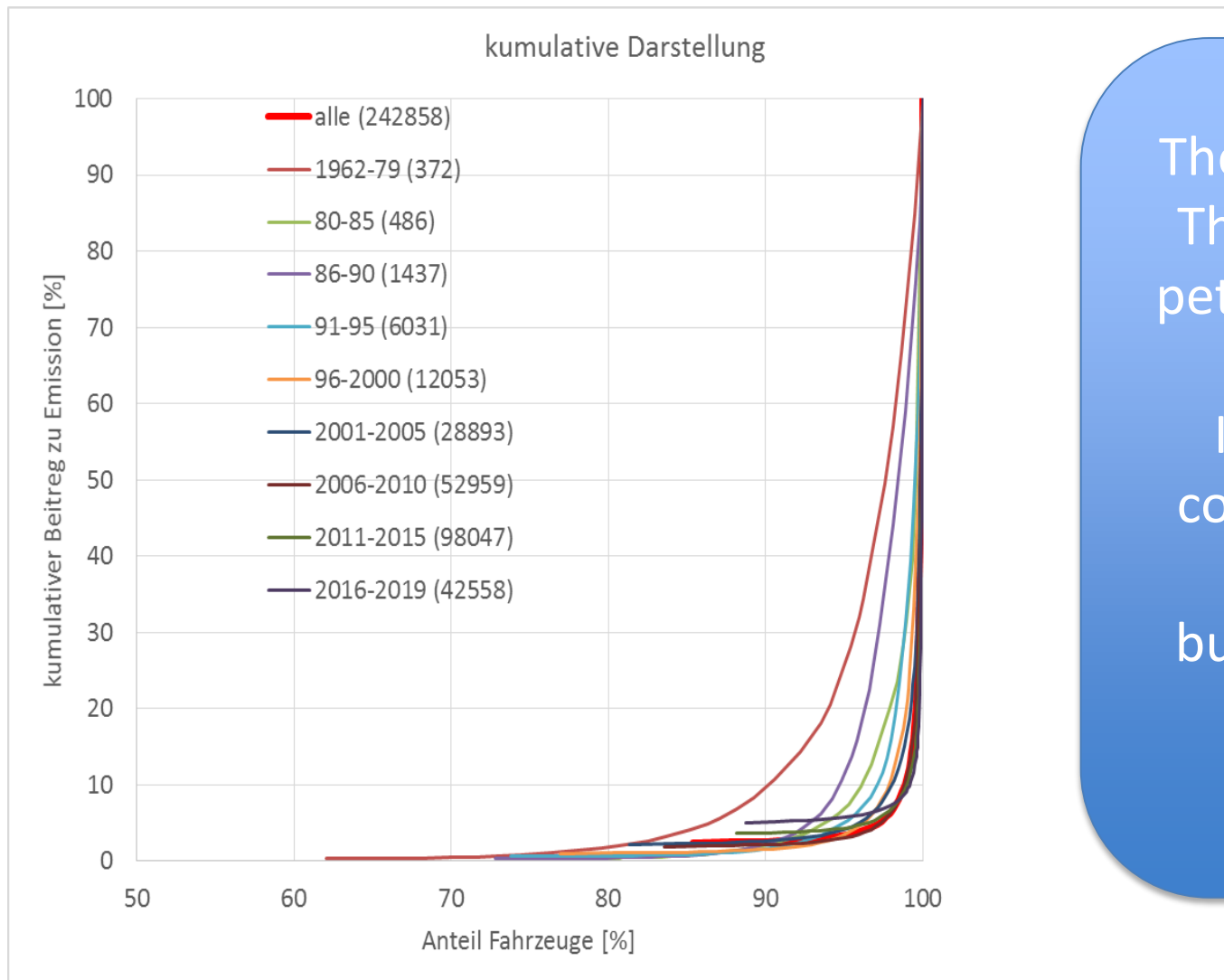


This Test is more than Pass/Fail

It supplies **quantitative diagnostic** information for the **functionality** of each emission control component and the engine as well and permits **preventive repair and maintenance.**

But what about Petrol Engines ?

→ need Filters ? But GPF efficiency is $< 80\%$
since soot is burned away, no soot layer build up



The High Polluter Problem
This „dirty tail“ of today's petrol fleets is everywhere underestimated
It is by far the highest contribution to urban air contamination
but it can be cleaned out fast and cheap by consequent PN-PTI

V10

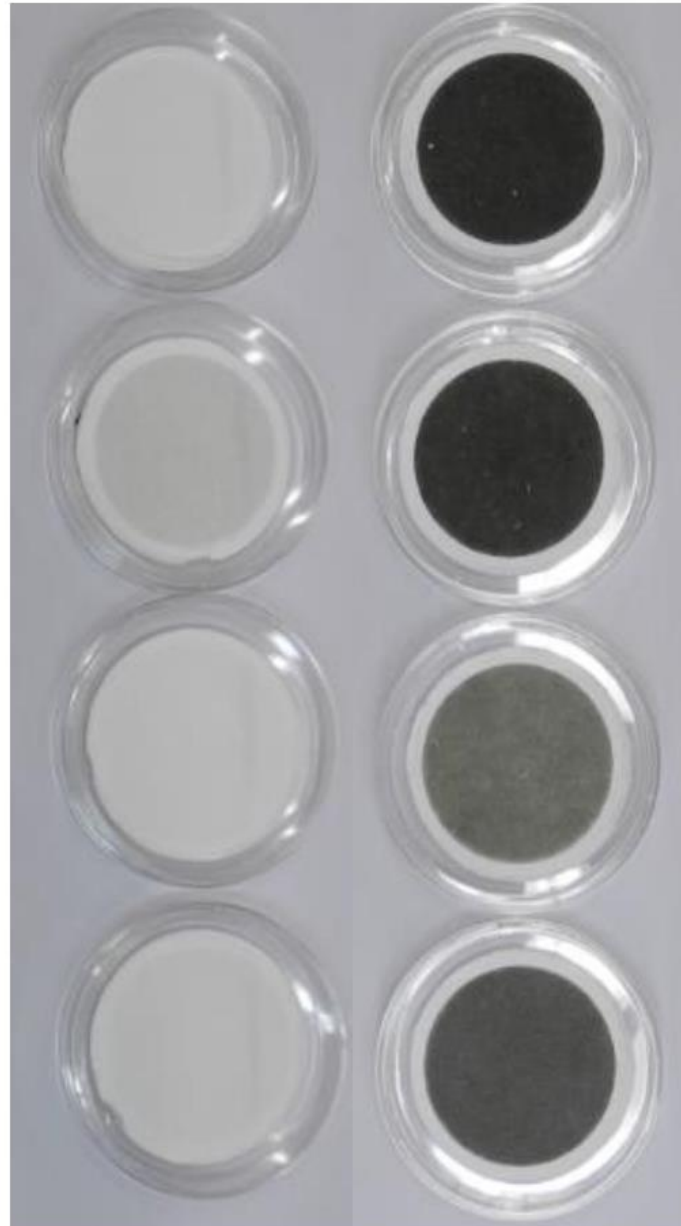
V8

WLTC cold

RTS95 cold

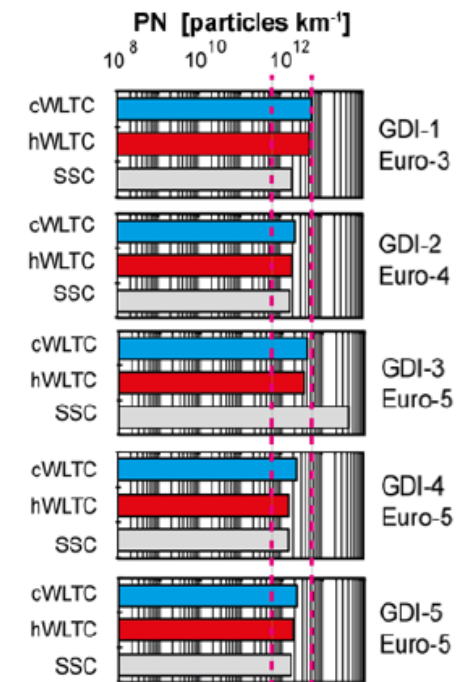
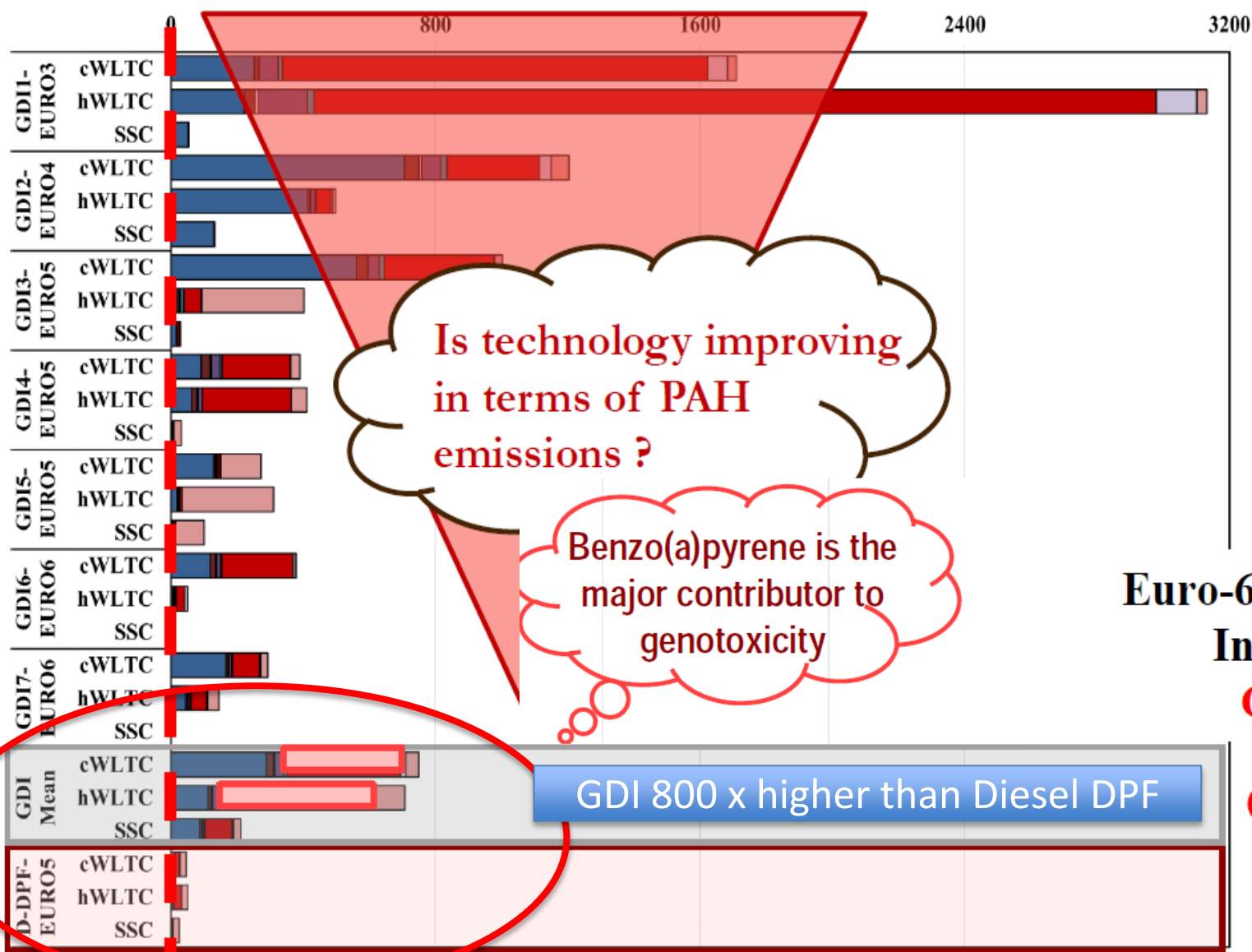
RTS95 warm

ADAC130 warm

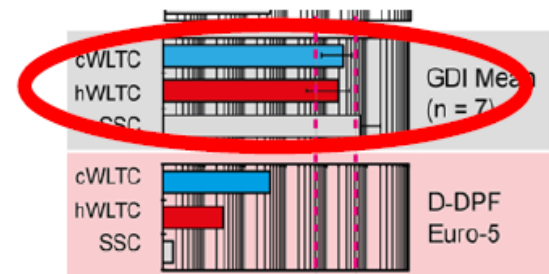


**Test
with Petrol
Vehicles
DI and PFI**

**some are
extremely
high PN
polluters**



Euro-6 PN limit: 6×10^{11} #/km
Initial limit: 6×10^{12} #/km
GDI much higher

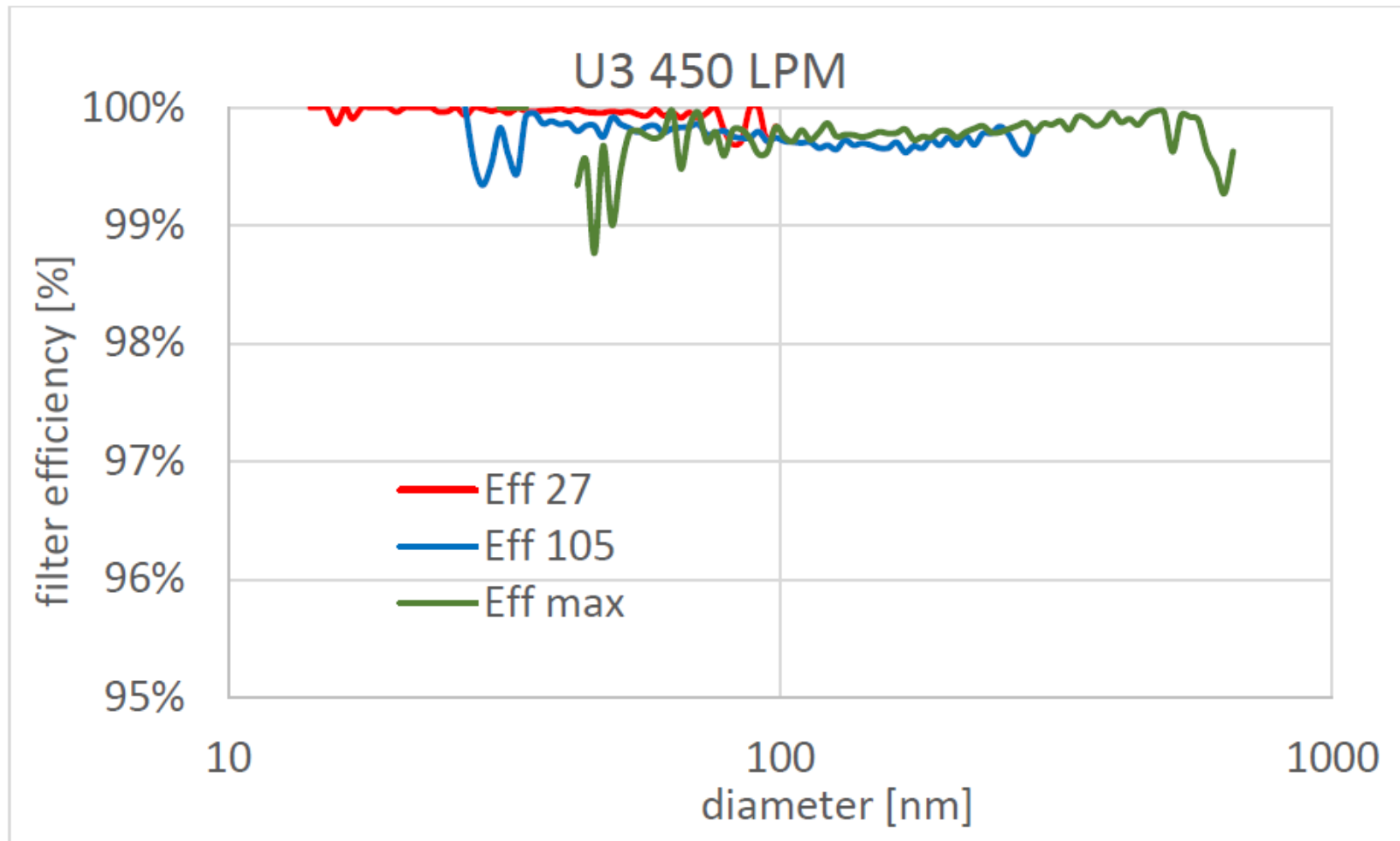


EU - air limit value:
1 ng/m³ benzo(a)pyrene (2014/107/EC Directive)

GDI fleet emits 64-, 700- and 39000-fold higher PN emissions than the Euro-5 diesel vehicle

New Technology for Petrol Engines

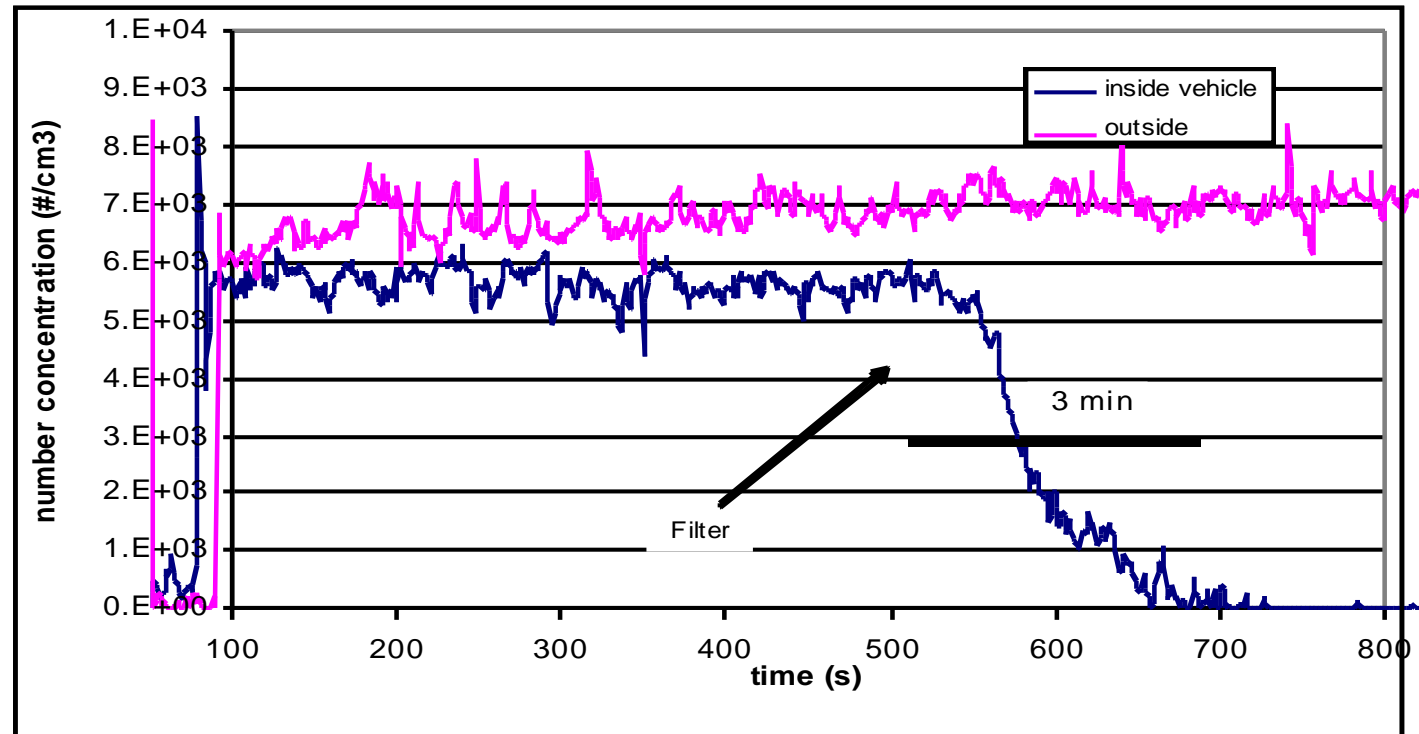
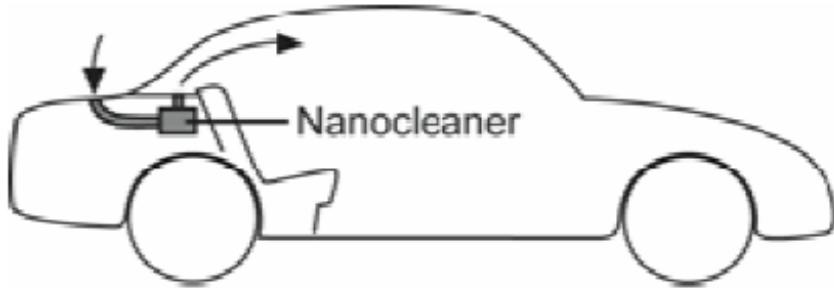
without deficits in the Alveoli critical size range (99.9 %)



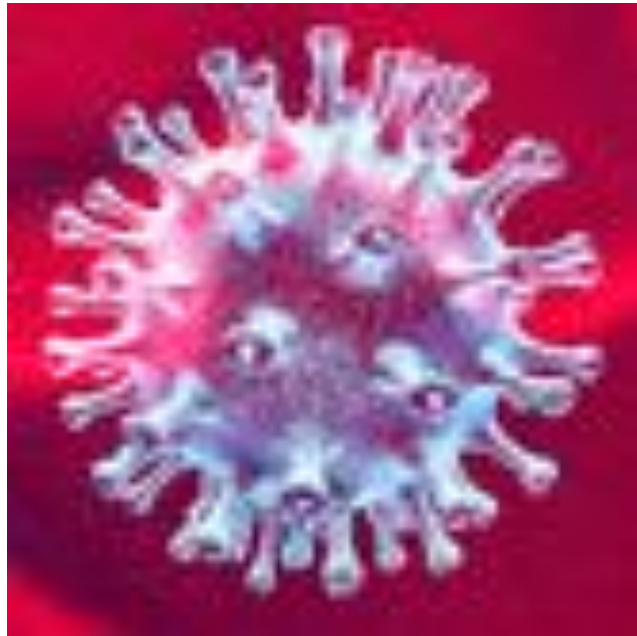
Handheld Machines
Contributions to the occupational health
protection by new VERT-Fuels (benzene
free) and Lubricants (metal free)



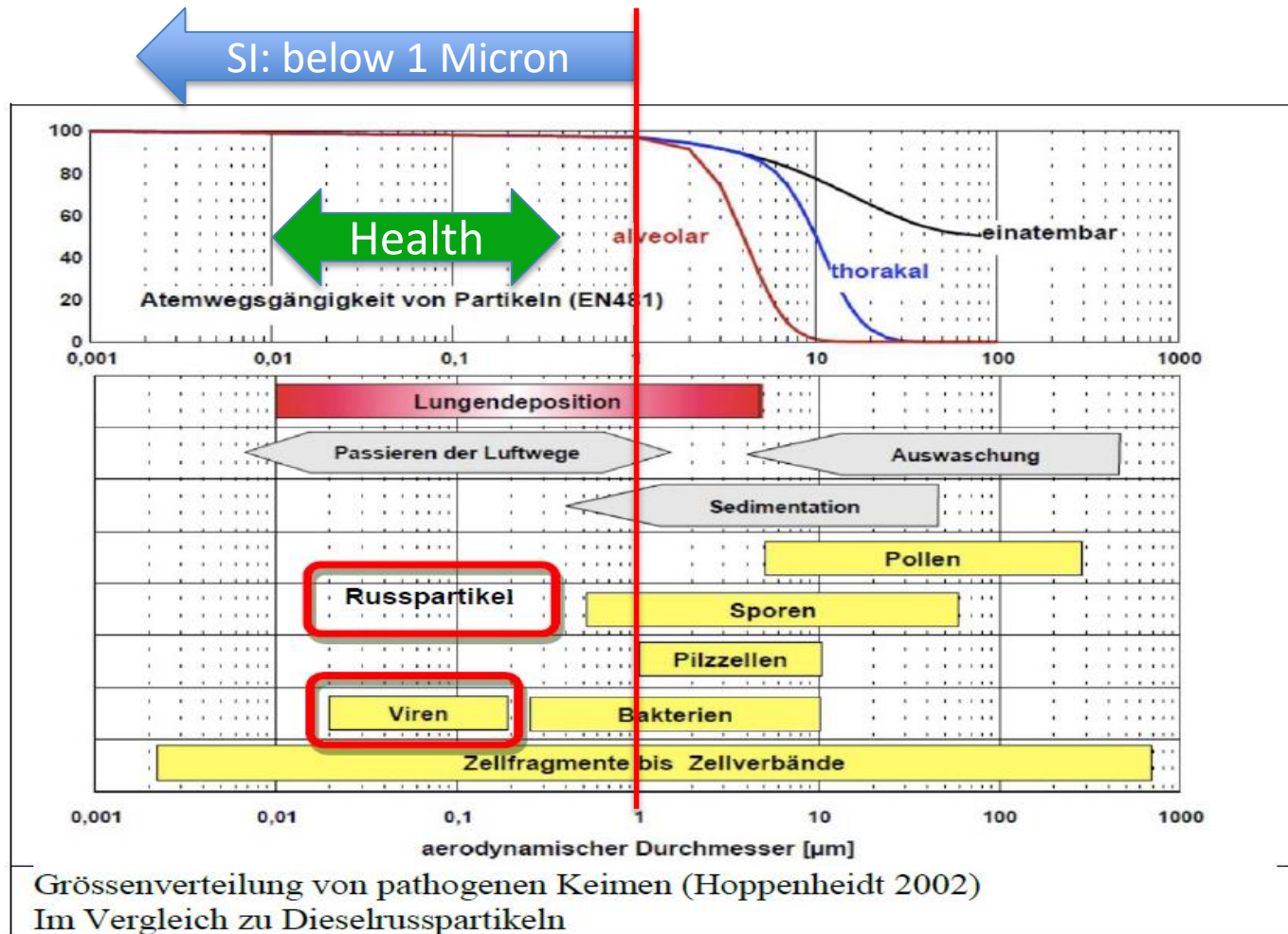
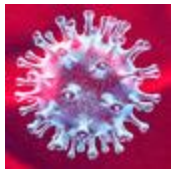
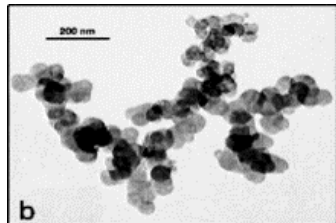
Vehicle Cabin Filters



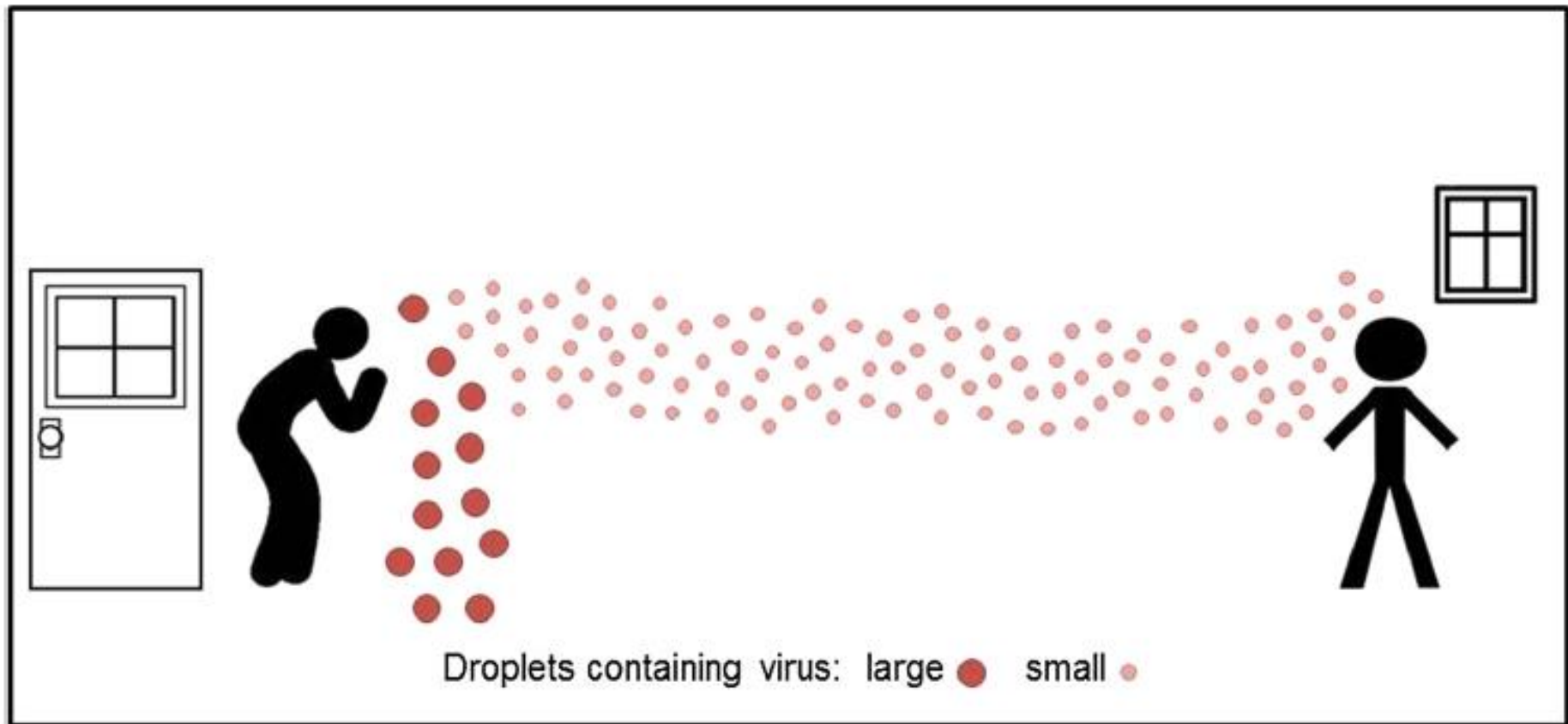
and what about Bio-Aerosols ?



„The smaller the more important“ Blaise Pascal

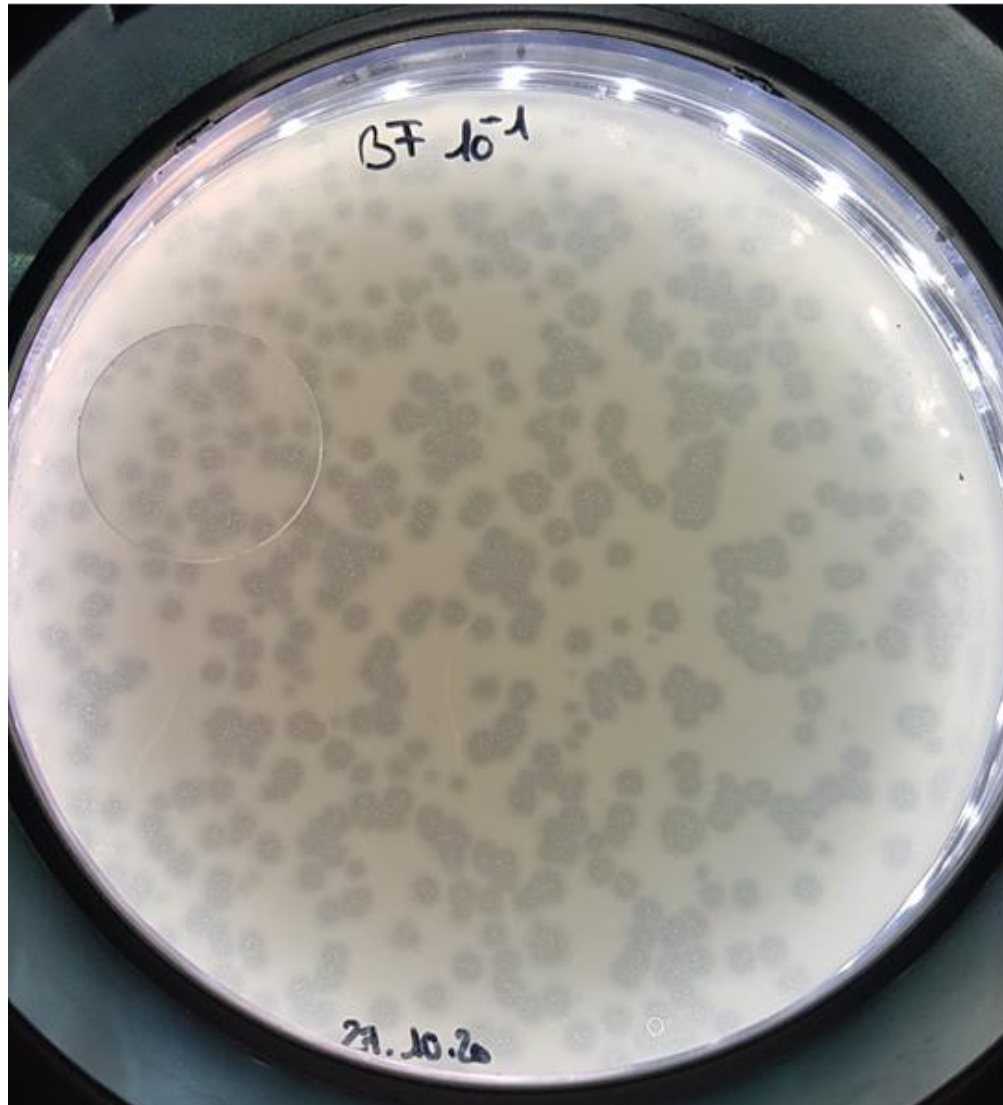


Simplified but true

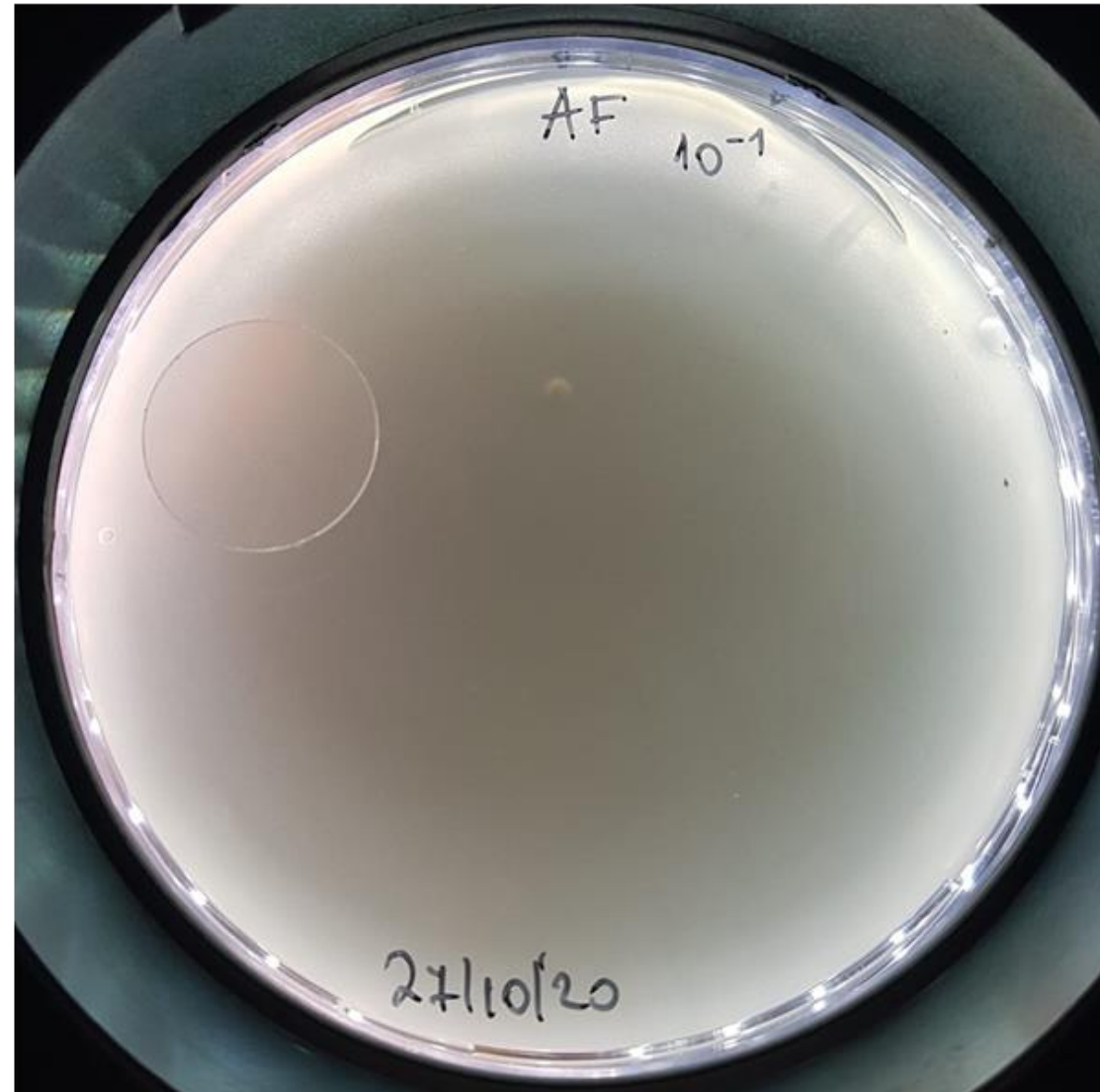


VERT Virus Filtration > 99.99 %

Before Filter



After Filter



VERT

**we can control
and eliminate
Nanoparticles**

