

DPF- Success-Story to clean the air

From a small retrofit pilot fleet
with 10 vehicles in Switzerland 1995
to 125 million DPF-vehicles 2017

CONTENTS

- Health and certification criteria
- VERT – Emission Control Success based on Quality
- The Swiss Case
- EU adopts Swiss emission control criteria
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- Euro VI
- DPF for Nonroad
- GPF for Petrol Vehicles
- Air Quality Improvement - Overall Success
- Technology Transfer to IRAN

Teheran



Bogotá



Foto tomada el 20 de abril de 2006 a las 8:30 a.m. (smog fotoquímico)

Beijing



Systems for all Diesel Engines / Tips for Selection, Installation and Operation

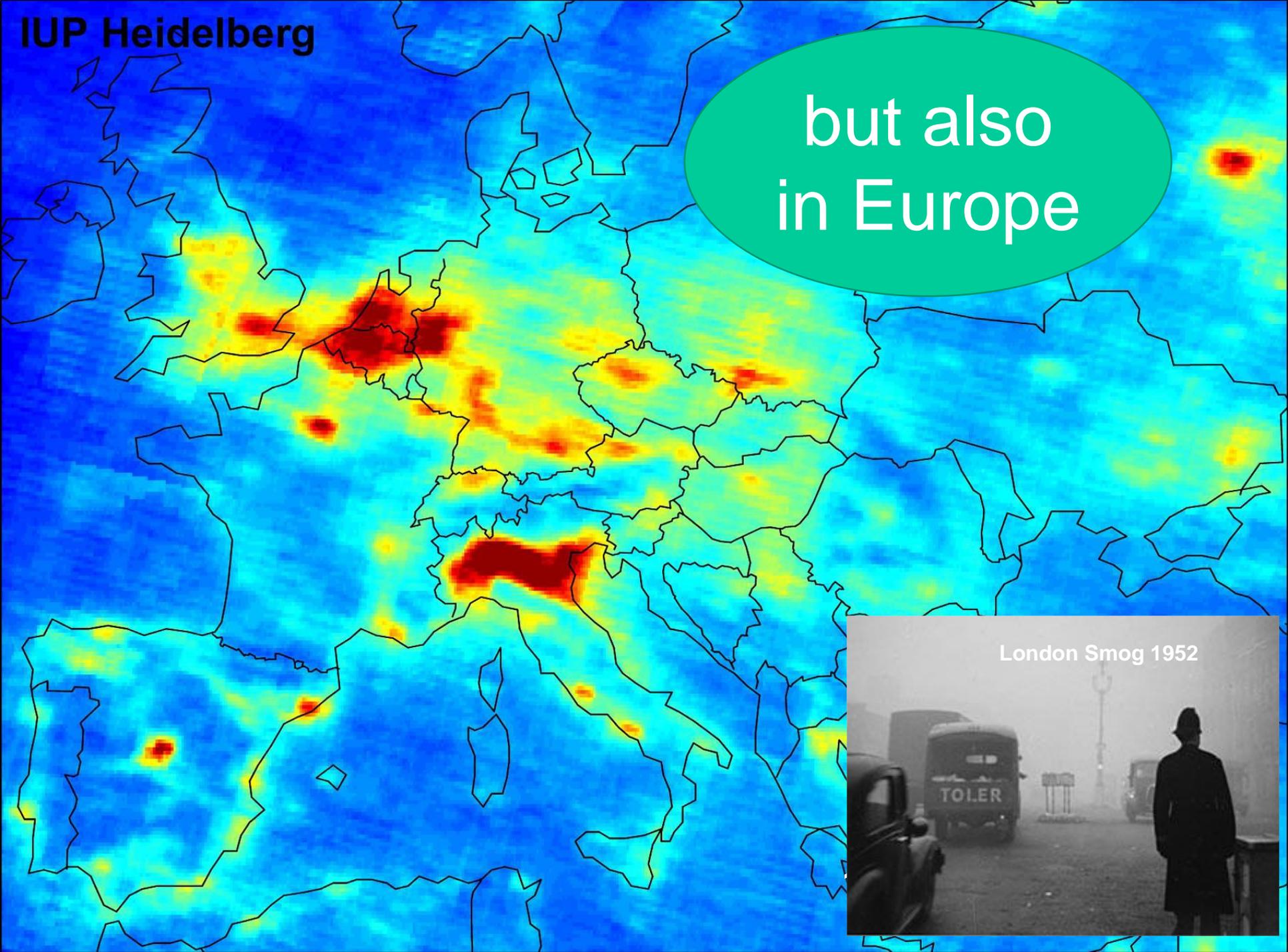
All Megacities have the same
pollution problem due to size
and traffic and VERT is
everywhere active

Last night in the taxi: >300000 P/cc

VERT

BEST AVAILABLE TECHNOLOGY
IN EMISSION REDUCTION

but also
in Europe



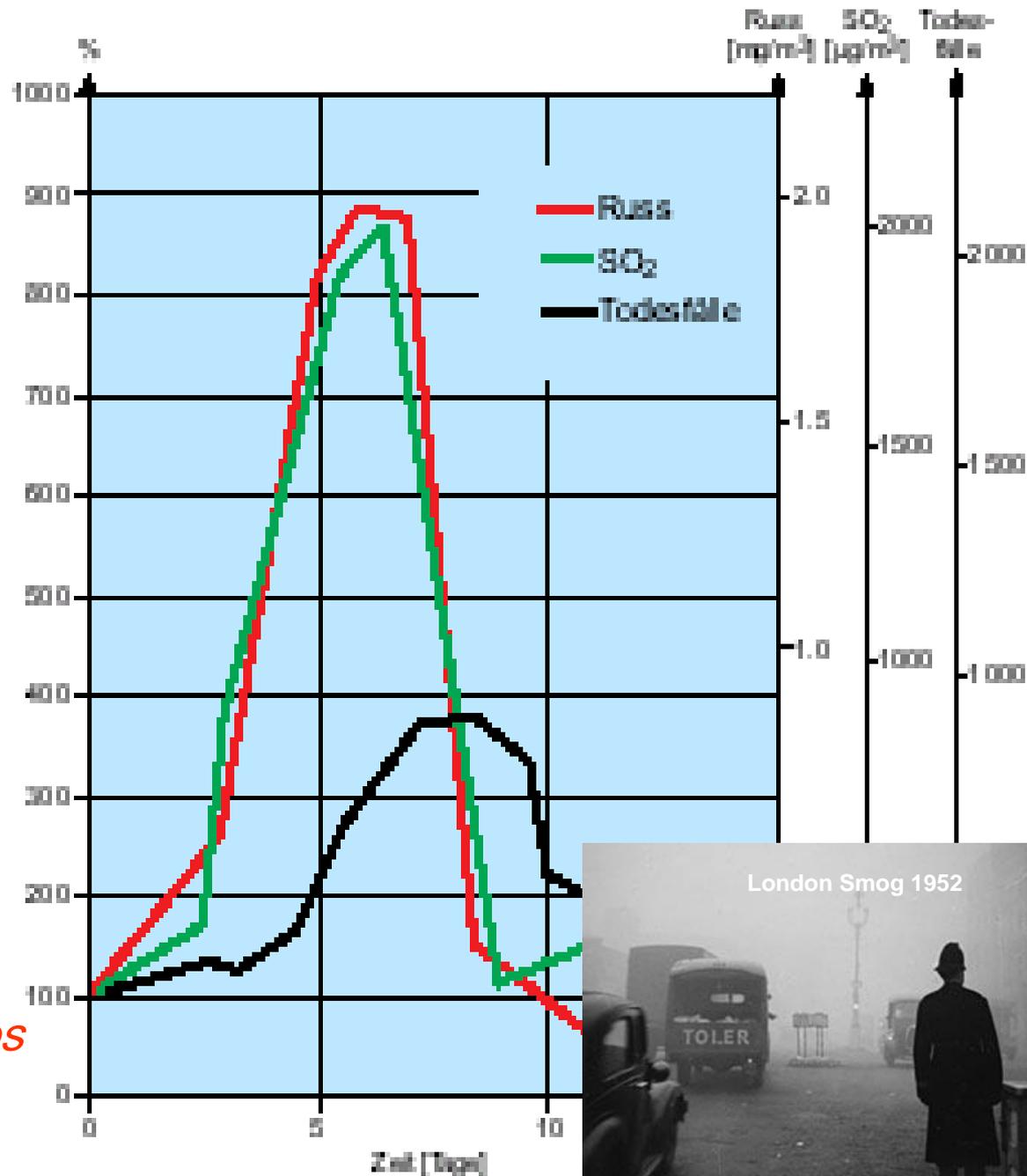
London Smog 1952

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*

*The famous medical doctor
Sir Percival Pott found 1775
that soot is the reason for
carcinoms in chimney sweeps*

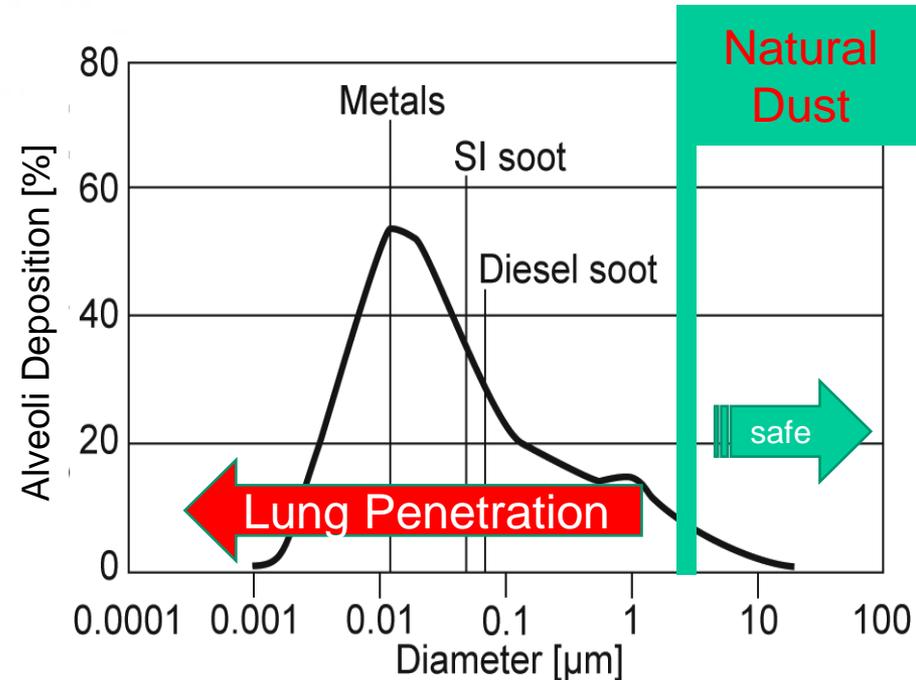
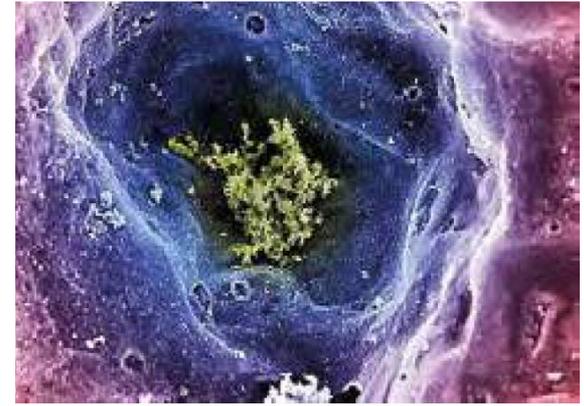
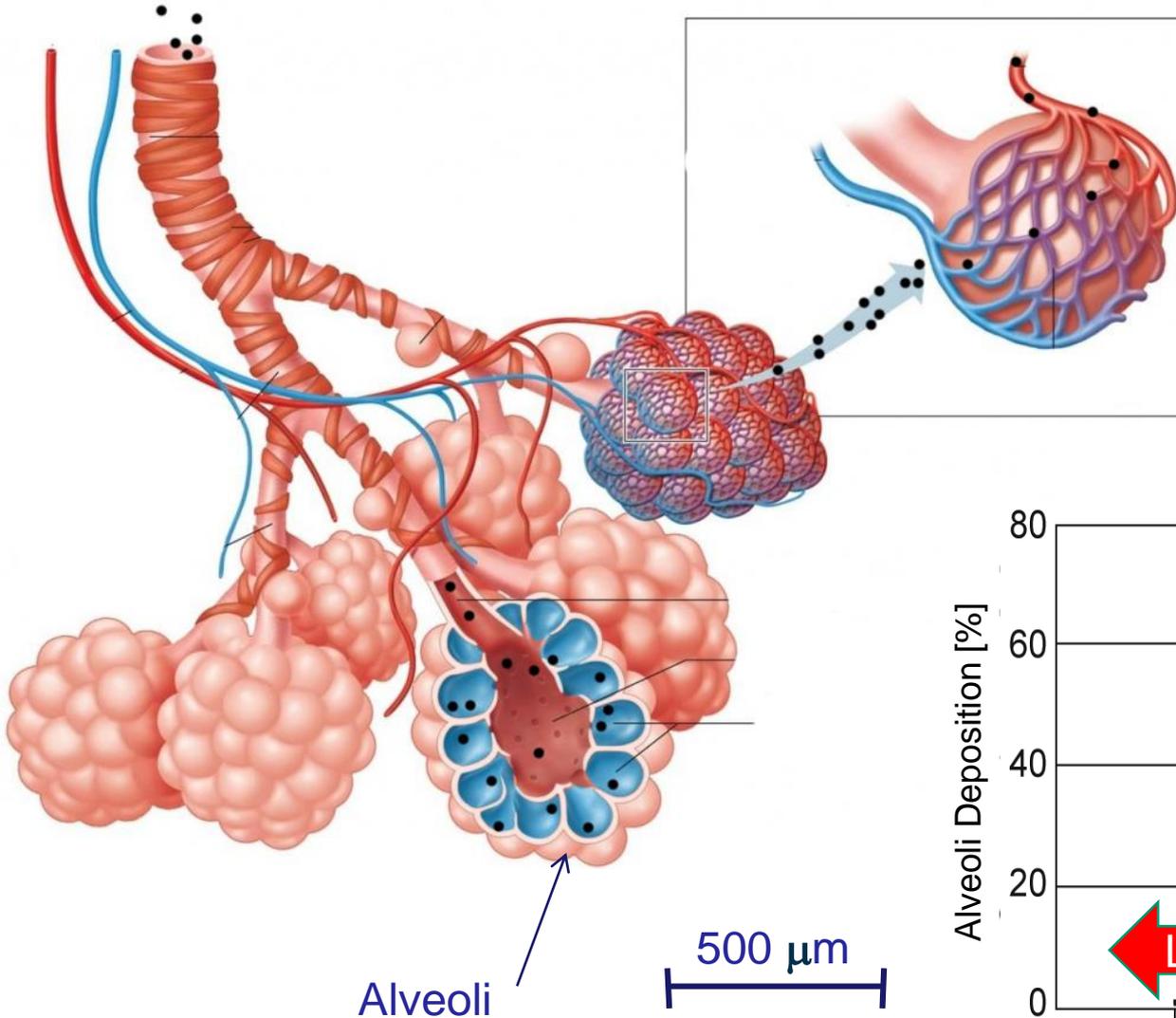


The Lung are an open door for toxics to enter our body since we cannot stop breathing

Respiratory volume/day:
10 – 20 m³

150 000 000 000
particles/day

Translocation into blood circulation is only possible for solid particles < 500 nm

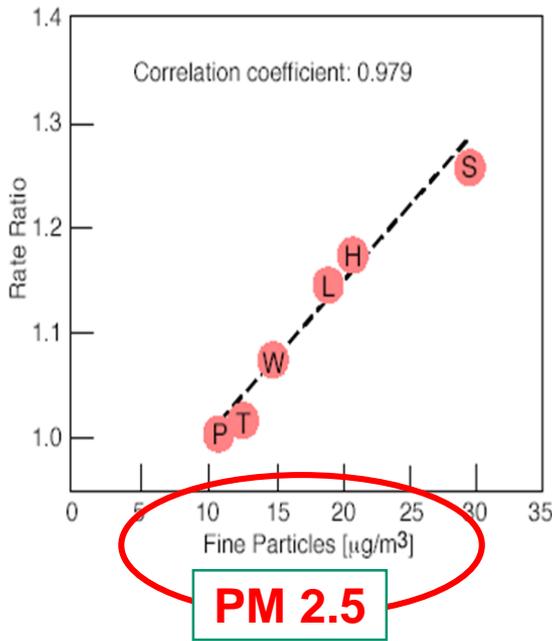


After a 15 years epidemiology study with 15'000 persons in 6 US-cities this man identified 1993 the most important toxic air contaminant as "PM2.5"

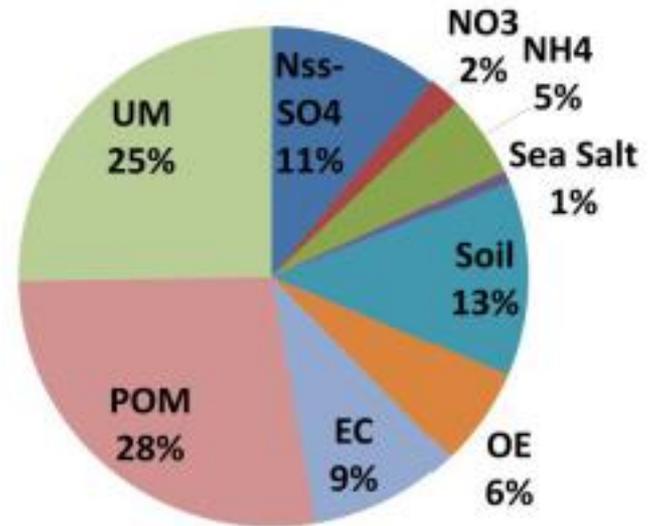
Dock Dockery
Boston



Only PM 2.5 correlates with mortality



Yearly



This is PM2.5 in Tehran but which of these substances is the most toxic ?

what makes an Air Contaminant toxic ?

Toxicity -Parameters	Gases	Sulfates Nitrates	Mineral Dust	Solid Nano- Particles
invasive (mobility) penetrate membranes ?	☹️	☹️ 1	☺️ < 0.1	☹️ 1
Insoluble Solids	☺️	☺️ 0.01	☹️ 1	☹️ 1
persistant collected and stored ?	☺️	☺️ 0.01	☹️ 1	☹️ 1
carcinogen mutagene, genotoxic ?	☹️	☺️ 0.01	☺️ 0.01	☹️ 1

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

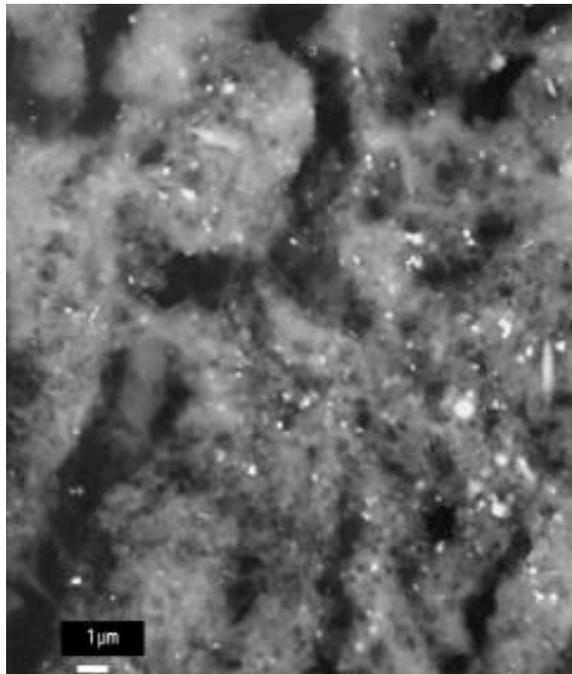


Figure 2. BE micrograph of section of airway aggregate from case 2 revealing abundant submicrometer inorganic (bright) particles.

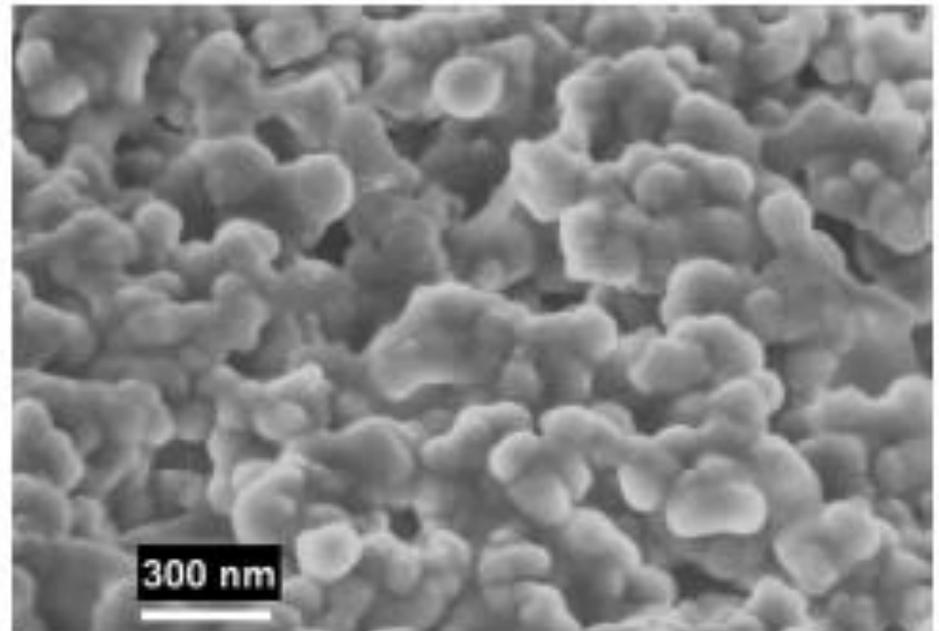
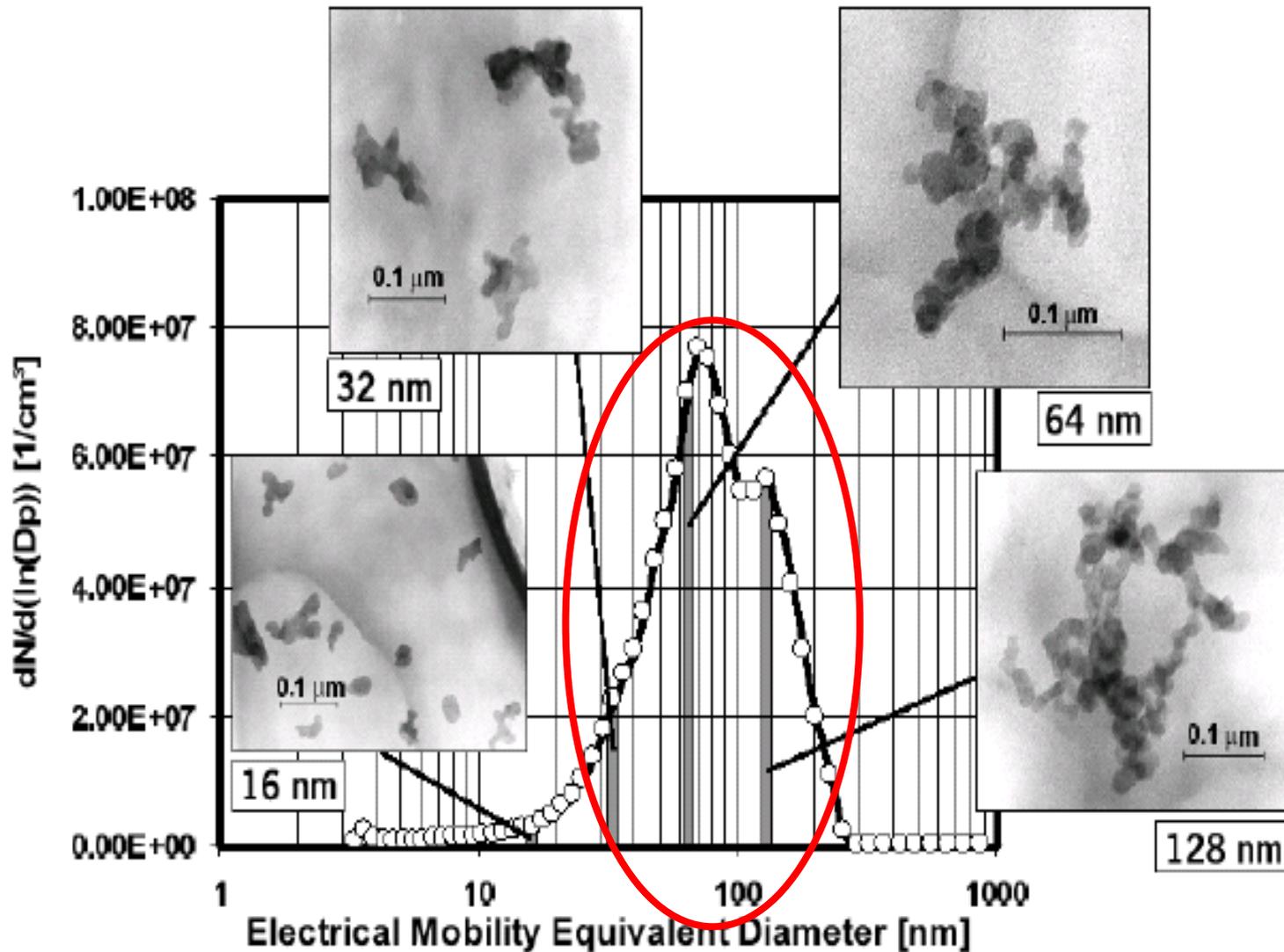


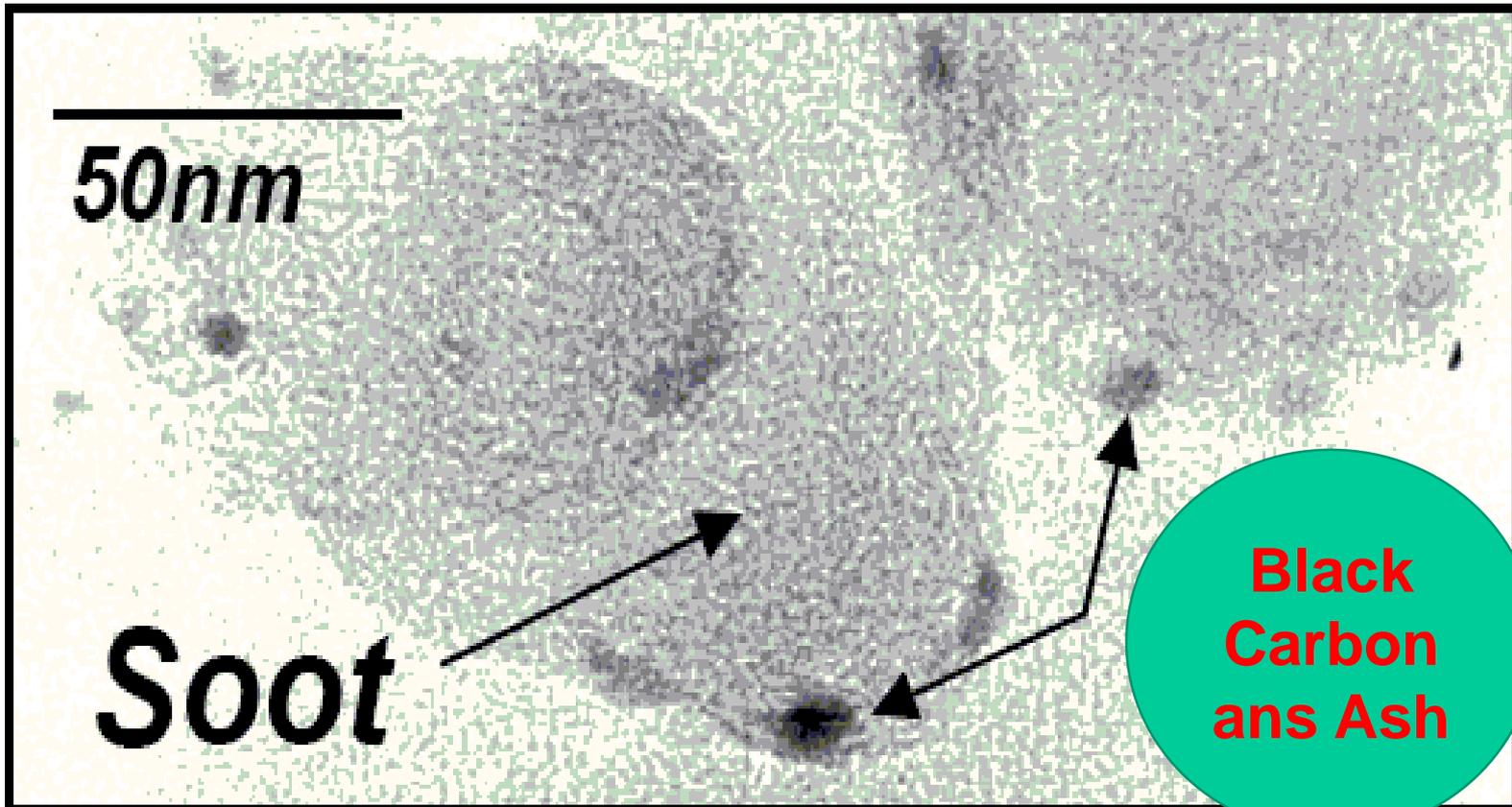
Figure 3. High-magnification field emission scanning electron micrograph of airway aggregate from case 2 showing ultrafine PM structure.

Particles emitted by combustion engines are solid and smaller than 500 nm (0.5 μm)

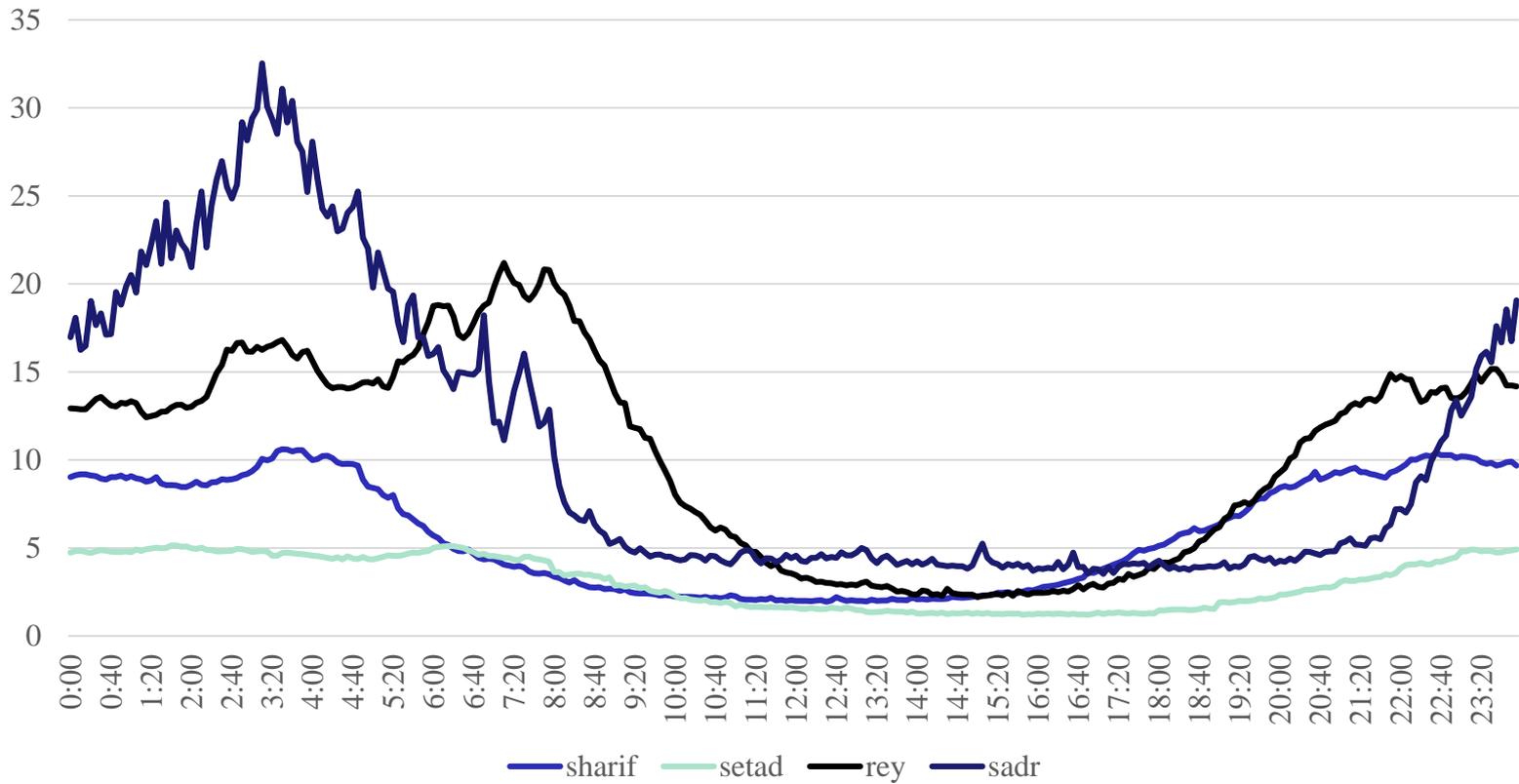


Particles coated by PAH
and decorated by metal oxides

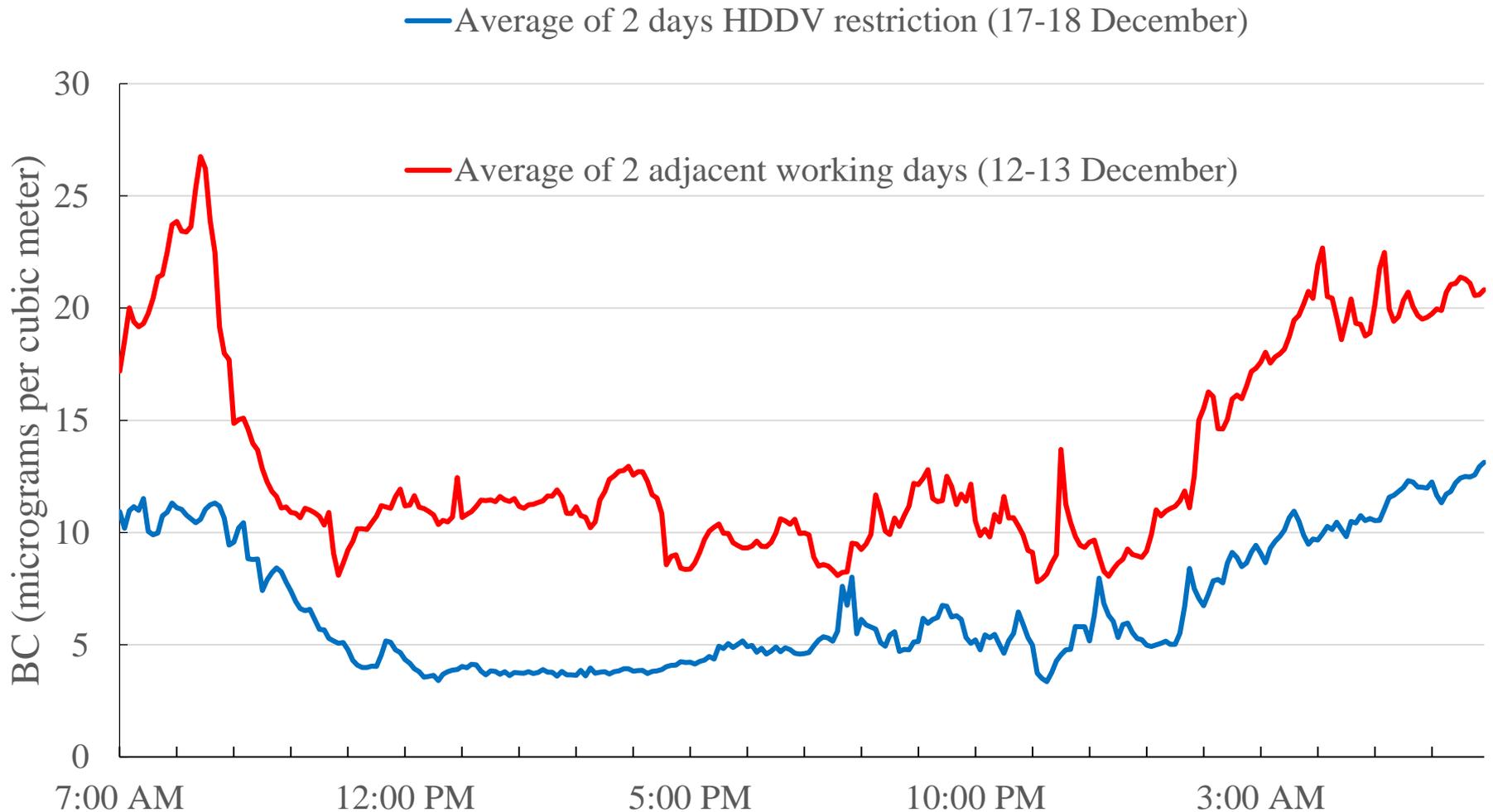
The Trojan Horse Effect



Teheran BC concentration averaged for 2017



BC at Setad-Station in December 2017



Particle Emission by all combustion engines

Diesel

Sootpeak: 80 nm; 10^6

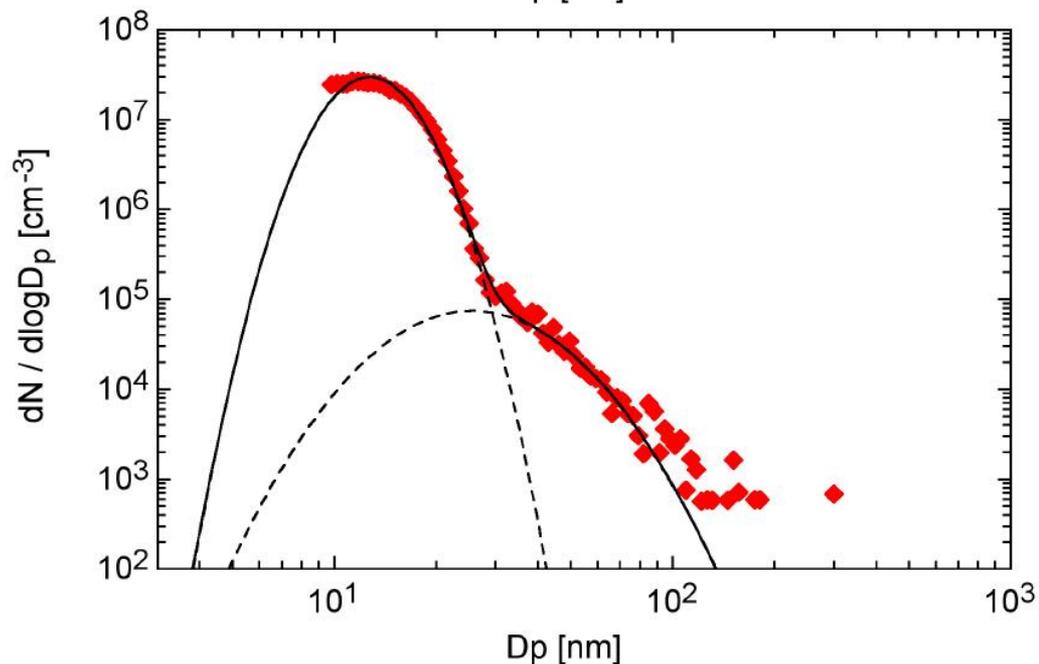
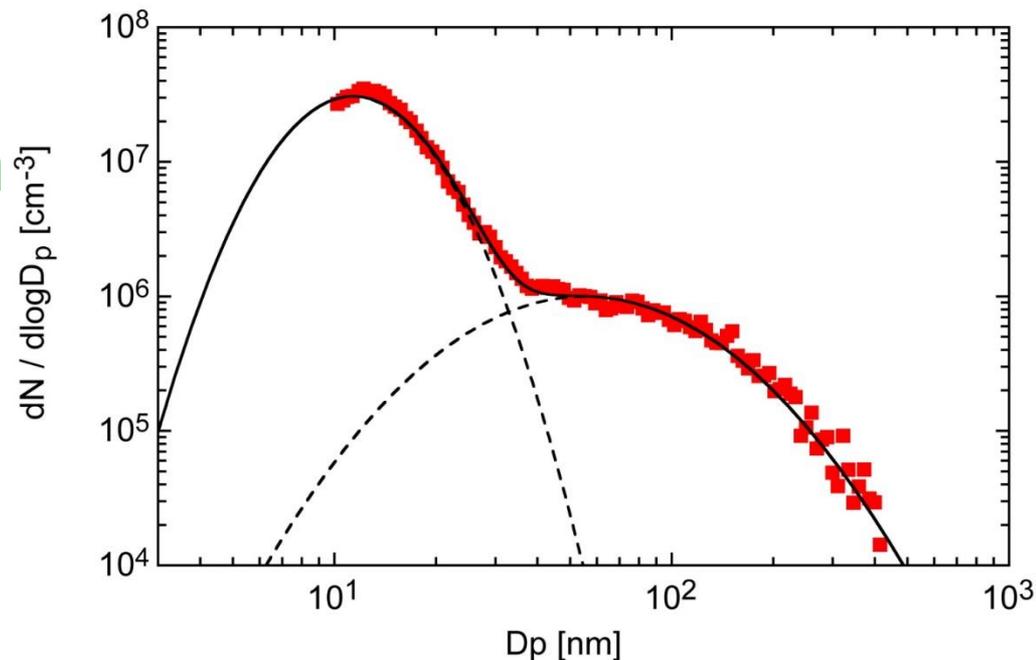
Ashpeak: 10 nm; 10^7

Petrol

Sootpeak: 40 nm; 10^5

Ashpeak: 10 nm; 10^7

Soot and Ash Peaks



IARC-WHO 1988 / 2012

*International Agency for Research on Cancer
World Health Organization*

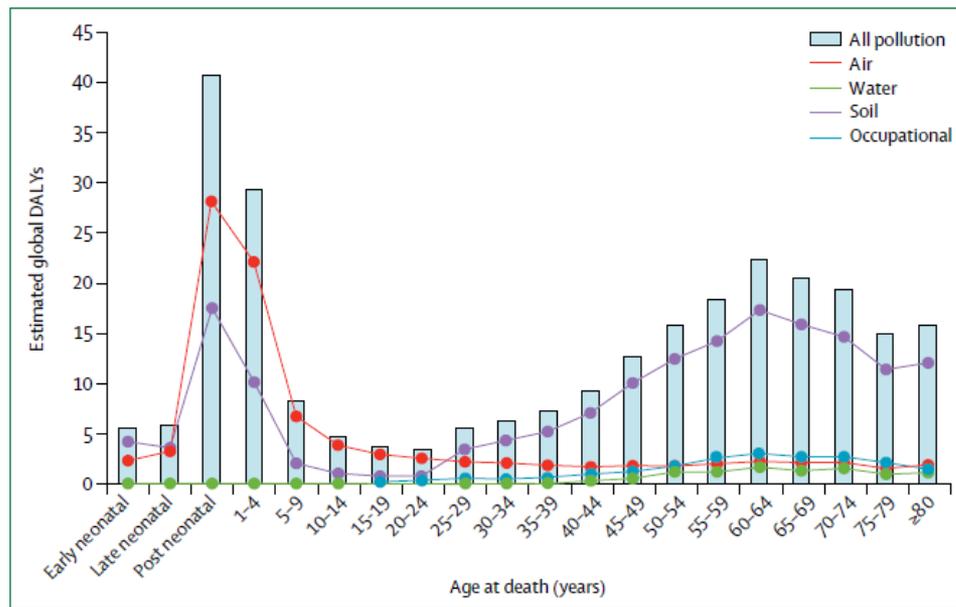
Diesel Exhaust Carcinogen Class 3 / 1

The *Lancet*-Commission on pollution & health published a very large meta study Oct 2017

	GBD study best estimate (95% CI)	WHO best estimate (95% CI)
Air (total)	6.5 (5.7-7.3)	6.5 (5.4-7.4)
Household air	2.9 (2.2-3.6)	4.3 (3.7-4.8)
Ambient particulate	4.2 (3.7-4.8)	3.0 (3.7-4.8)
Ambient ozone	0.3 (0.1-0.4)	..
Water (total)	1.8 (1.4-2.2)	0.8 (0.7-1.0)
Unsafe sanitation	0.8 (0.7-0.9)	0.3 (0.1-0.4)
Unsafe source	1.3 (1.0-1.4)	0.5 (0.2-0.7)
Occupational	0.8 (0.8-0.9)	0.4 (0.3-0.4)
Carcinogens	0.5 (0.5-0.5)	0.1 (0.1-0.1)
Particulates	0.4 (0.3-0.4)	0.2 (0.2-0.3)
Soil, heavy metals, and chemicals	0.5 (0.2-0.8)	0.7 (0.2-0.8)
Lead	0.5 (0.2-0.8)	0.7 (0.2-0.8)
Total	9.0	8.4

Note that the totals for air pollution, water pollution, and all pollution are less than the arithmetic sum of the individual risk factors within each of these categories because these have overlapping contributions—eg, household air pollution also contributes to ambient air pollution and vice versa.

Table 1: Global estimated deaths (millions) due to pollution risk factors from the Global Burden of Disease study (GBD; 2015)⁹⁷ versus WHO data (2012)^{99,101}



3 x more death by pollution than from AIDS, tuberculosis and malaria combined

15 x more than from all wars - in Iran 1 death in four

Financial Losses due to pollution are estimated 6 trillion US\$

But we have a perfect Solution: highly efficient Filters are available



Corning 1982



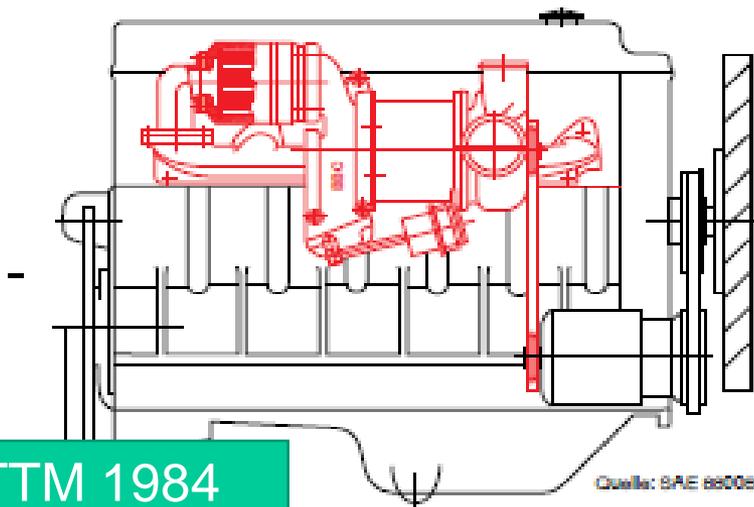
IBIDEN 1998

NGK 1986



HJS 2004

TTM 1984



Quelle: SAE 8800e

Switzerland startet with Tunneling 1993

„VERT-Filter for each Diesel“



VERT-Certificate

- Filtration > 98%
- for solid particles 20-500 nm
- no secondary emission
- complete detoxification
- reliability
- endurance tests > 2000 hrs
- benefit/cost > 10
- guarantee 2 years
- electronic control



Valid only with VERT-stamp and validity dates

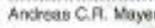
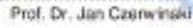
VERT[®]-Certificate

No	B15W03.05	
Product	HJS	
	Particle-Filter System: Filter Module	SMF [®] -CRT [®] HJS Sinter metal filter with upstream DOC
Regeneration Electr. Filter Control	NO _x from oxidation catalytic converter HJS-ECU V1.43ae; E13 030618	
	Manufacturer	
HJS Fahrzeugtechnik GmbH & Co KG Düsselweg 12 D - 58705 Menden		

We herewith apply to be listed in the VERT[®] filter-list and accept the rules and conditions

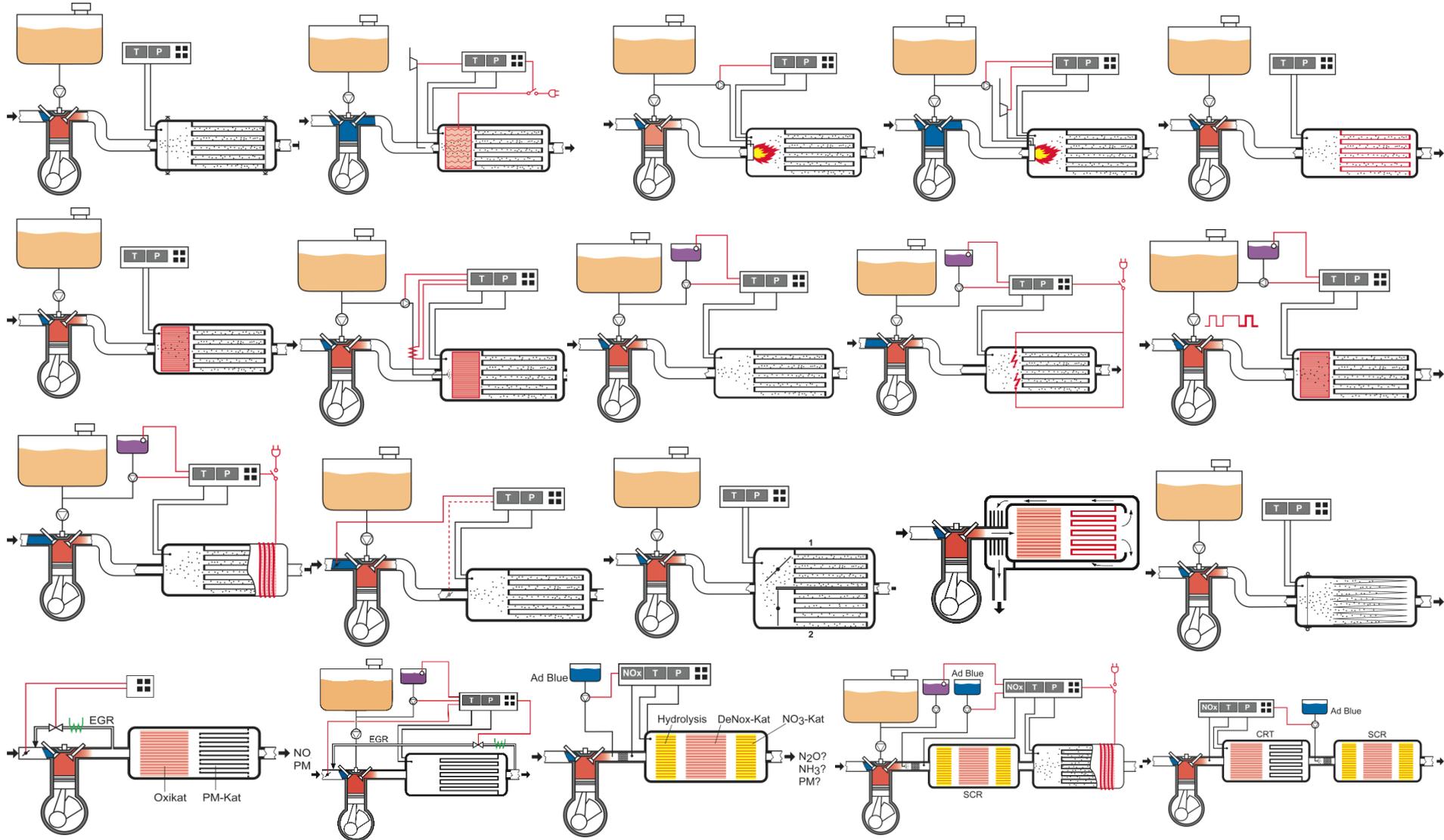
Manufacturer	Date	Signature
HJS Fahrzeugtechnik GmbH & Co KG	March 03 2010	 Klaus Schrewe

Certified by the VERT[®]-Scientific Committee

 Andreas C.R. Mayer	 Prof. Dr. Jan Czerwinski	 Jacques Lemaire
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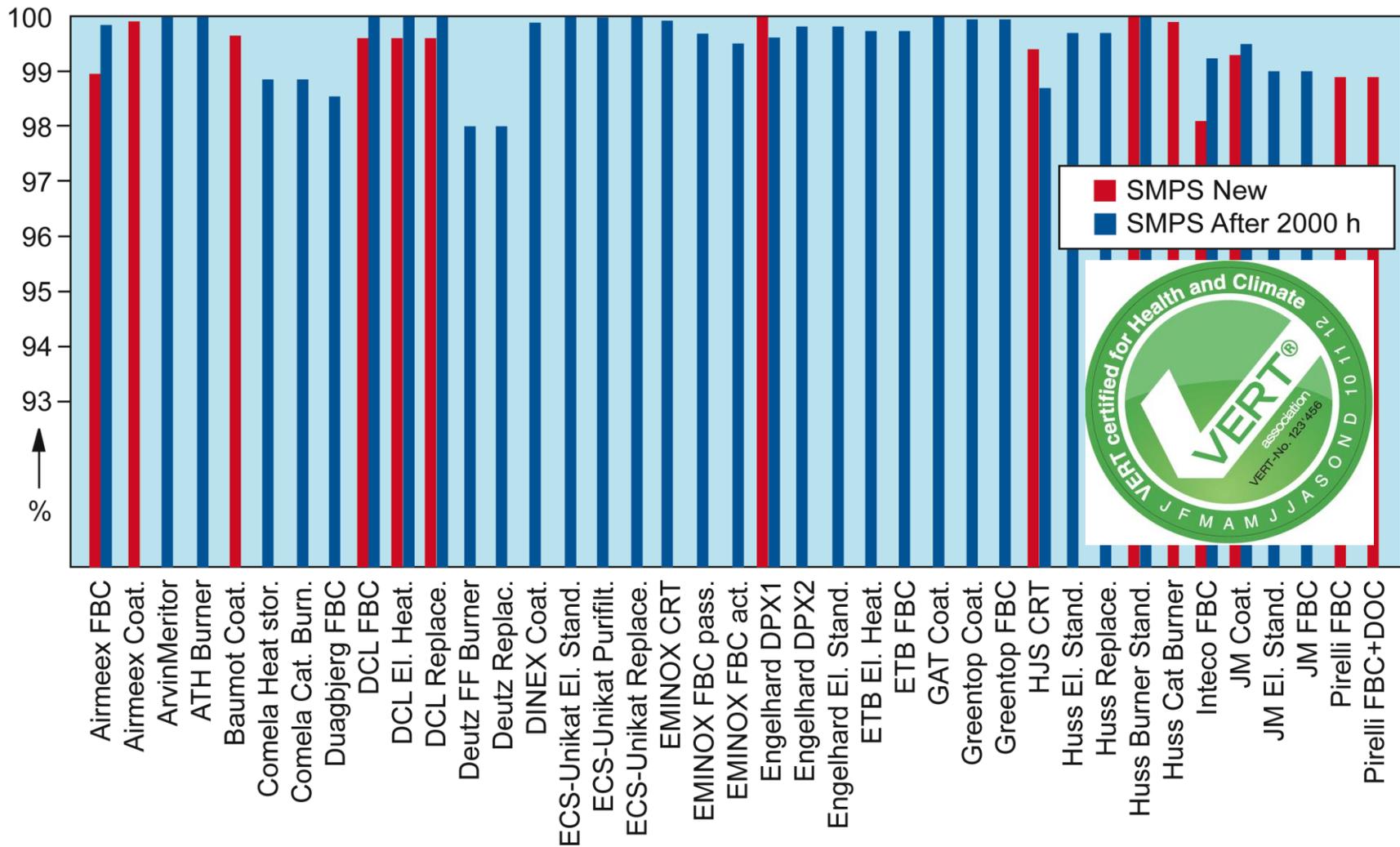
VERT-certified DPF Systems

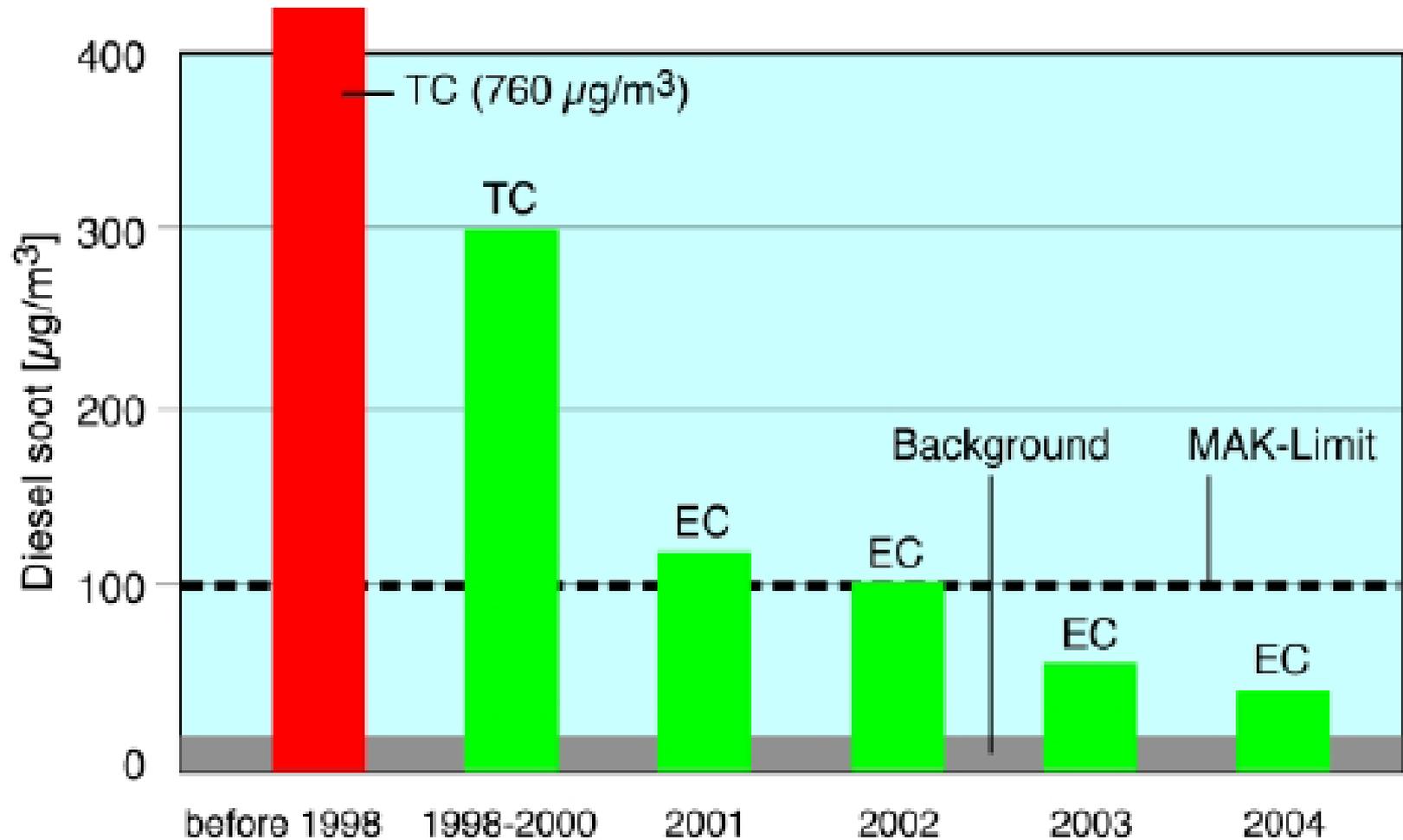
for different targets and applications



Filtration - 65 DPF VERT tested

25 % > 99.8 % within size range 20-300 nm





Improvement of Air Quality in Swiss Tunneling

"no Diesel without filter" since 1997

Learning Curve in Switzerland

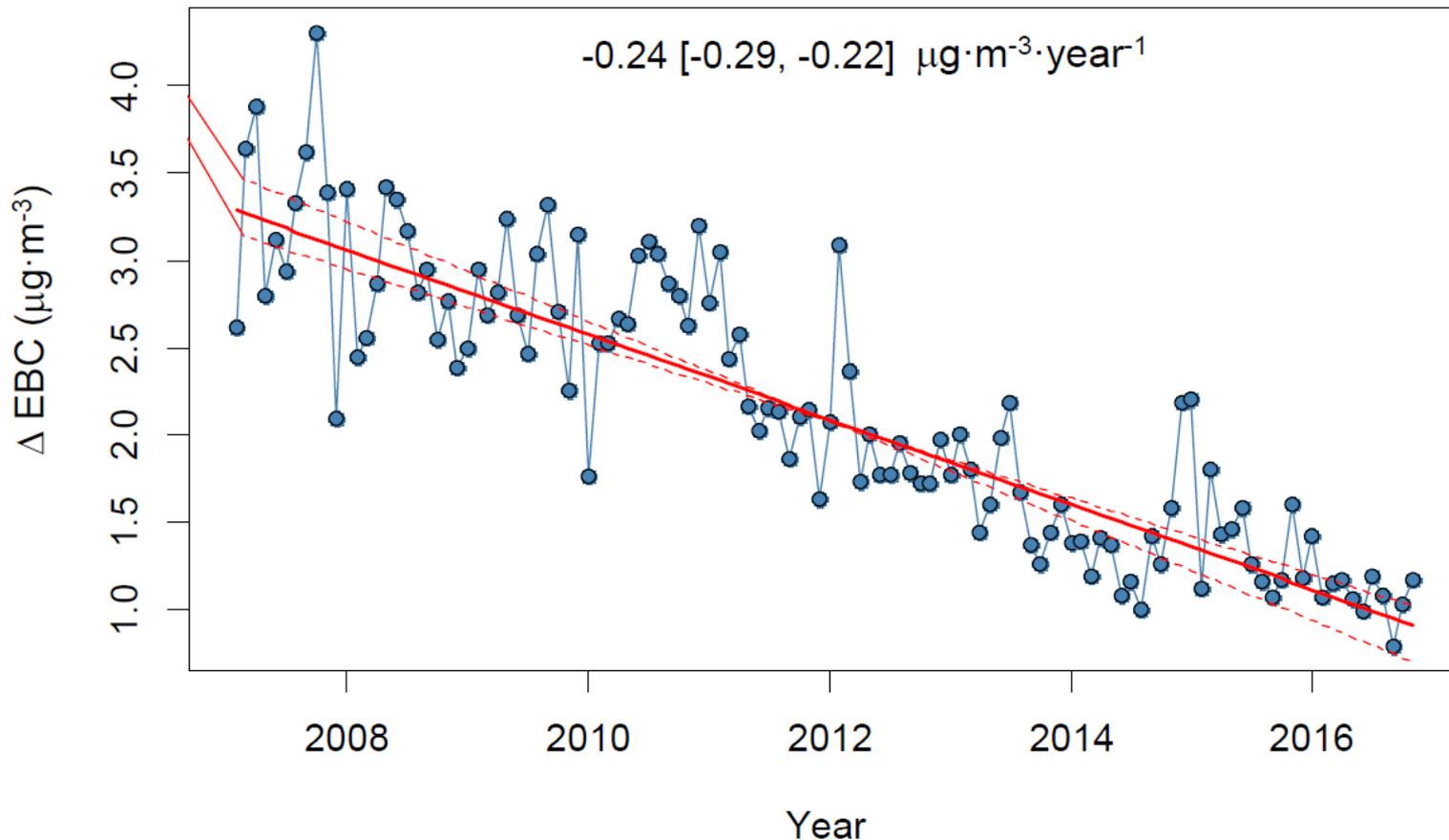
Success need a Vision and Persistence

Inspiration & Transpiration

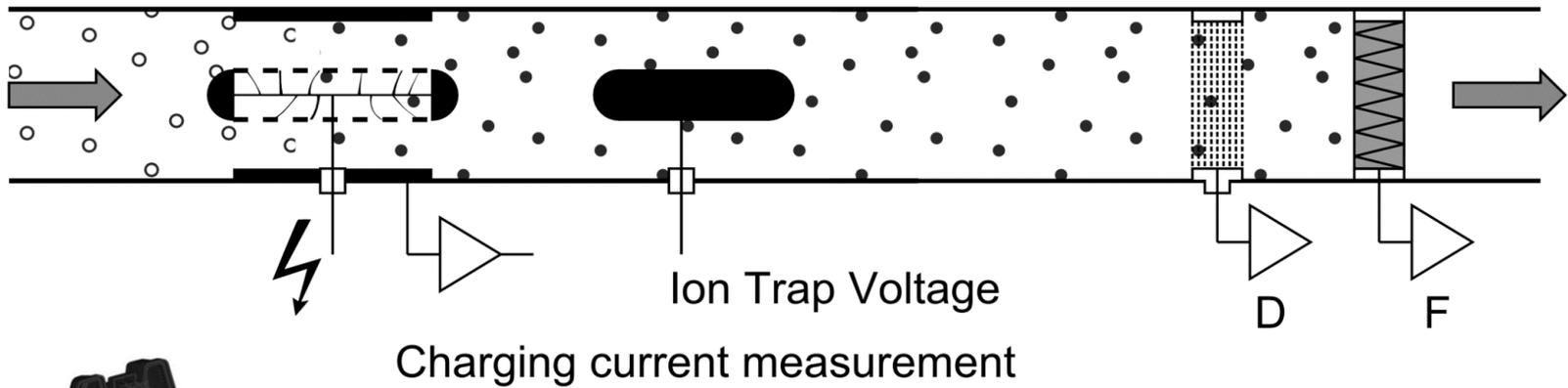
Year	Fuel Sulfur ppm	Retrofit total	Retro-Fitters	Failures % p.a.	VERT Certified
1988	2'000	100	2	>10	-
1992	2'000	350	2	>10	-
1995	500	500	3	>10	5
1998	500	900	8	10	16
2000	350	2'500	12	8	23
2002	50	4'900	7	3	8
2003	50	6'500	11	2	22
2005	10	11'500	21	2	30
2007	10	17'500	26	2	50
2010	10	25'000	30	<2	71
2012	10	35'000	30	<2	75
2015	10	46'000	32	<2	80
2020	10	55'000	35	<1	85

Y 2000: failure rate too high, 15 manufacturer deverified, 2000 hrs endurance introduced

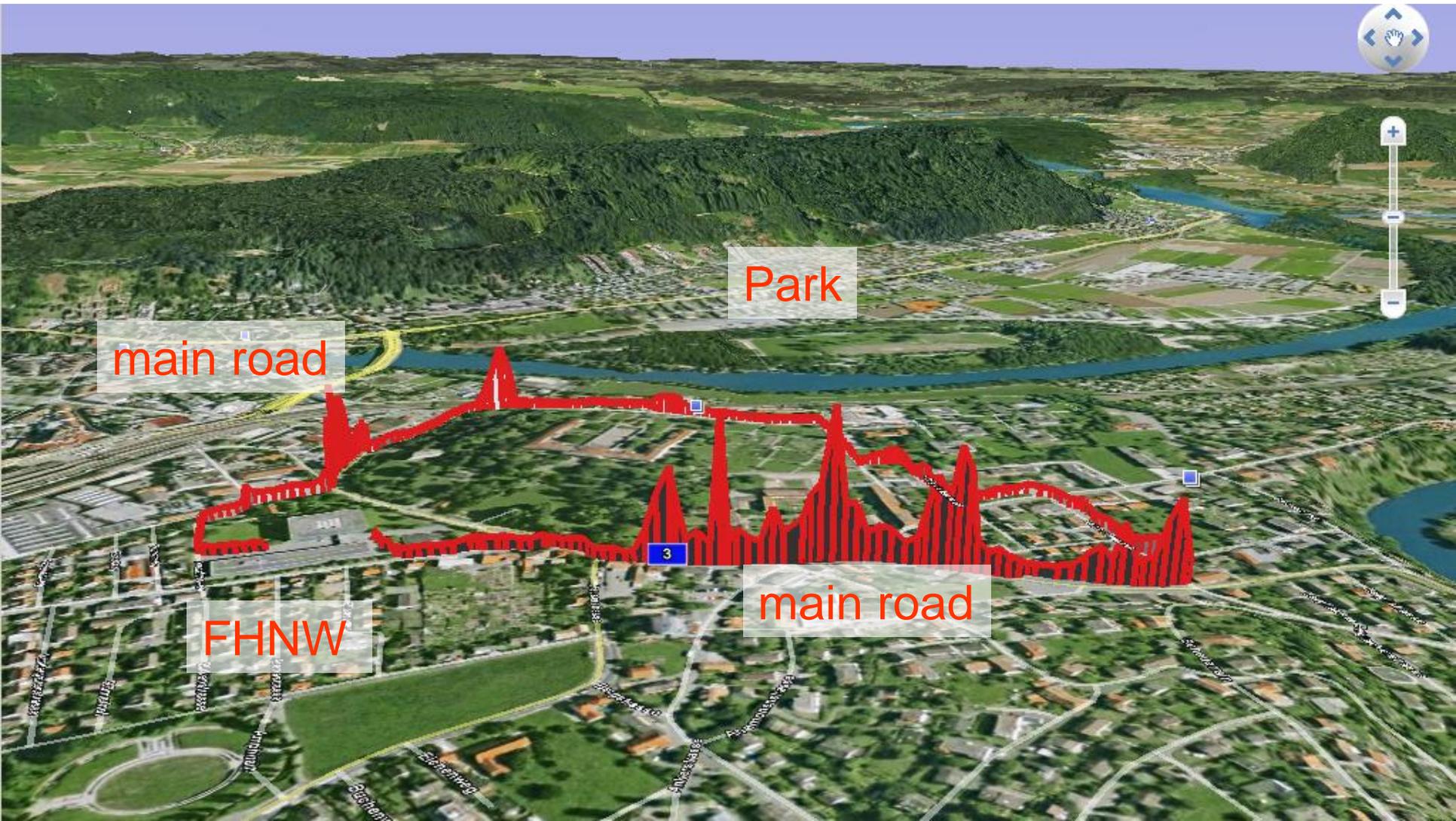
Proof of Success: PN and BC reduced by 60% at a very busy motorway in Switzerland although traffic increased by 30 %



Portable Particle Counting instruments are available



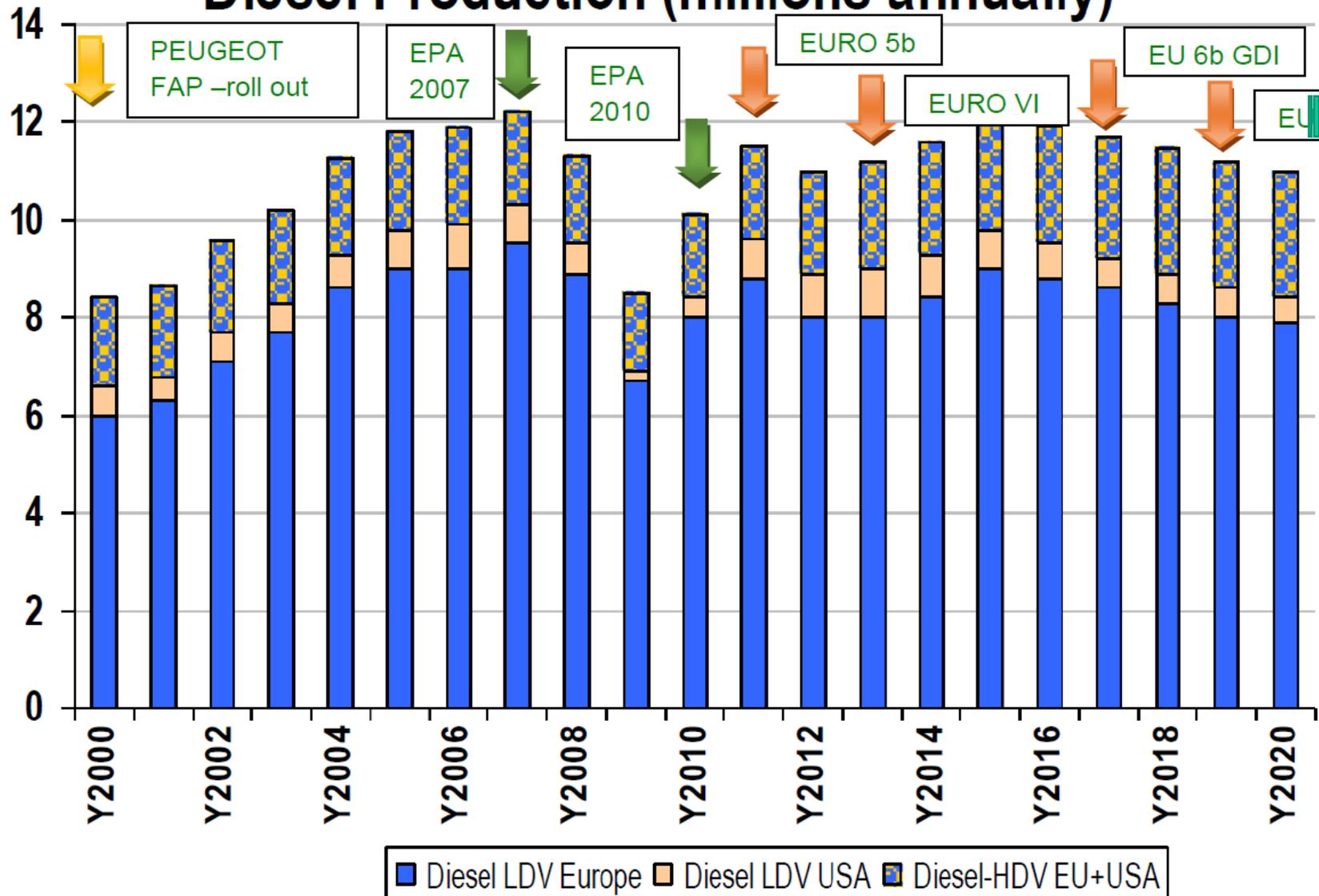
Walk through the city and monitor pollution by PN



EU adopts VERT Criteria in 2006 for Euro 6 - EU Co-Decision (Art.12, Rec.15)

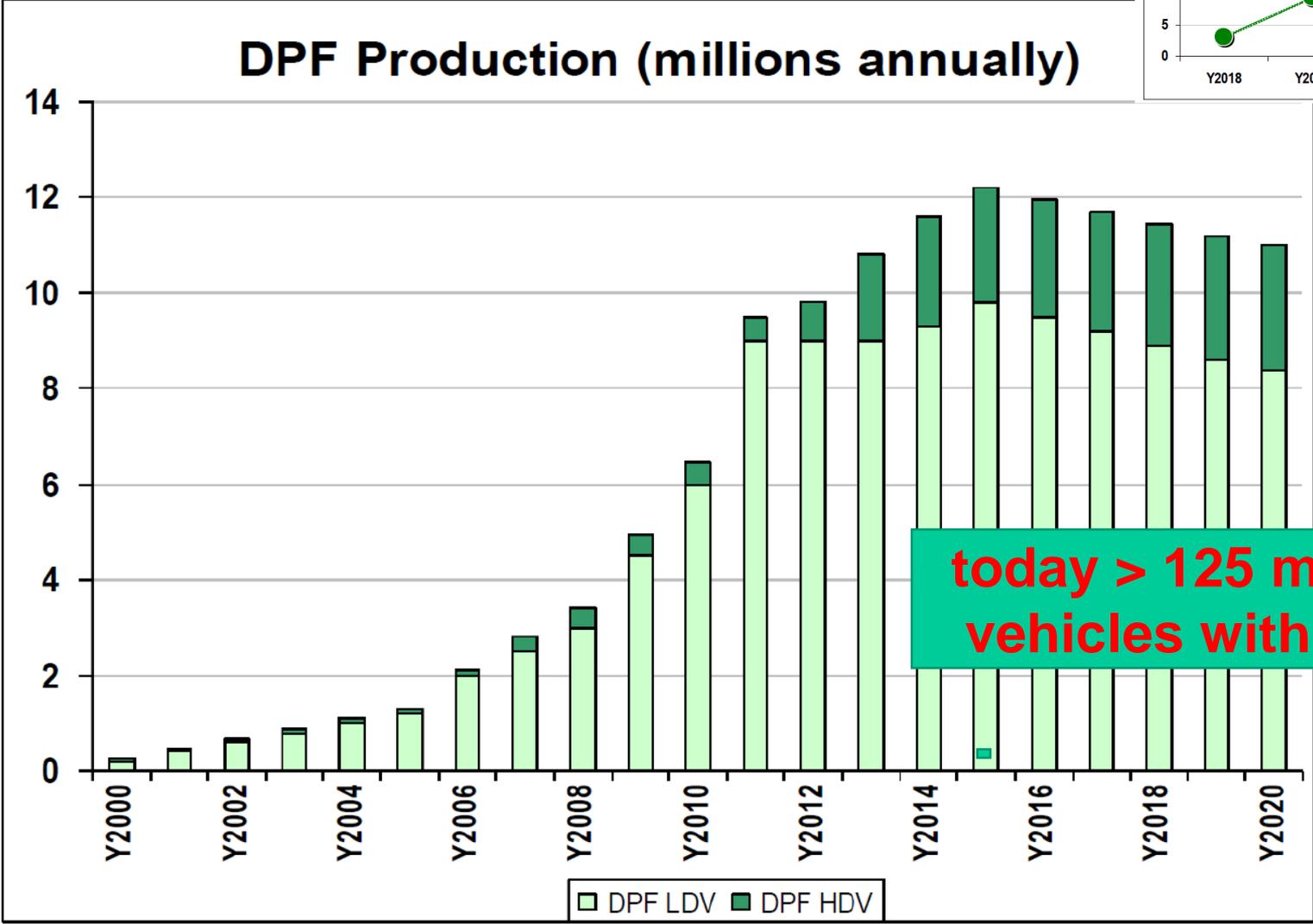
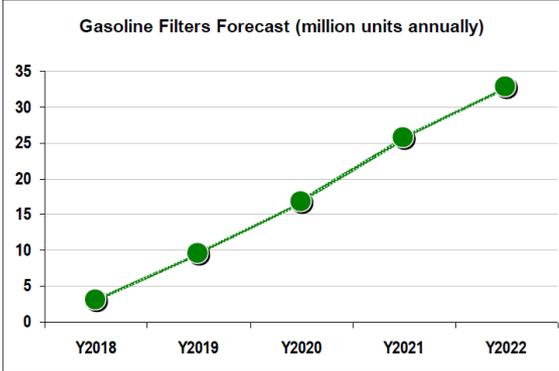
- In order to achieve these environmental objectives it is appropriate to indicate that **particle number limits** are likely to reflect the **highest level of performance** with **particle filters** using **best available technology**
- .. the commission shall introduce **particle number based limit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

Diesel Production (millions annually)



DPF-Installations in Europe

and GPF to come



today > 125 million vehicles with DPF

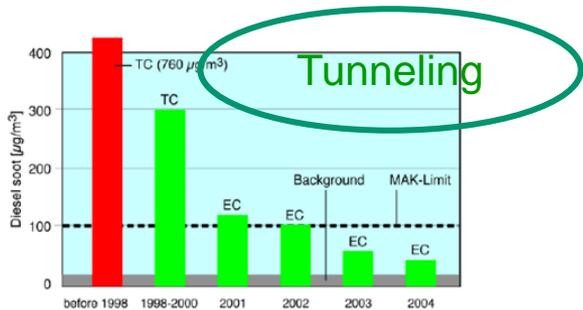
DPF Retrofit worldwide

- **EUROPE: 540'000 (2001-2015)**
- **USA : 120'000**
- **ASIA : 545'000 mainly Korea and Japan**

	Y2001-Y2005			Y2006-Y2010			Y2011-Y2015			Y2016-Y2020			Total x 1000
	Bus	Truck	NR	Bus	Truck	NR	Bus	Truck	NR	Bus	Truck	NR	
Switzerland	3	1	7	2	1	11	3	2	16	-	1	8	55
Germany	20			25	50		5	50				40	190
Italy	10			20			15						45
France	7			3			2					10	22
G.Britian	9	11			12			10	1			5	48
EU-Rest	15			15			15						45
EU Indoor			50			75			75			50	250
USA	20	10		12	22	2	20	28	7	10	20	10	161
Latin Amer.				3			1			10	40	10	64
Iran										8	35	2	45
Israel										4	5	2	11
Korea	10	20		20	130		20	80		20	70		370
Japan	30	30		30	30		30	30		-	-		180?
China				4	4		15	10	1	50	30	50	164?
Asia-Rest	15			15			15			25			70
Sum	139	72	57	149	249	88	141	210	100	127	201	187	
Total	268			486			451			515			
Total	1'205 (Europe: 541)												1'720

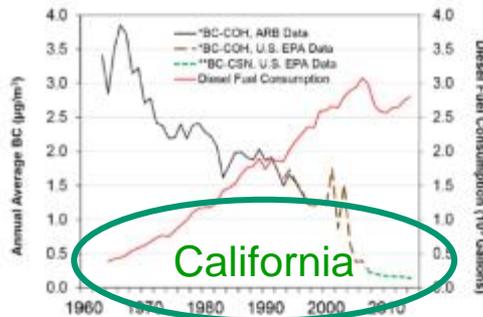
Table 2: Retrofits worldwide (x 1000)

Success for Clean Air in all LEZ



Improvement of Air Quality in Swiss Tunneling

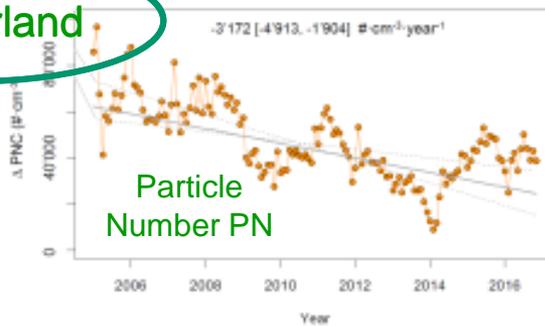
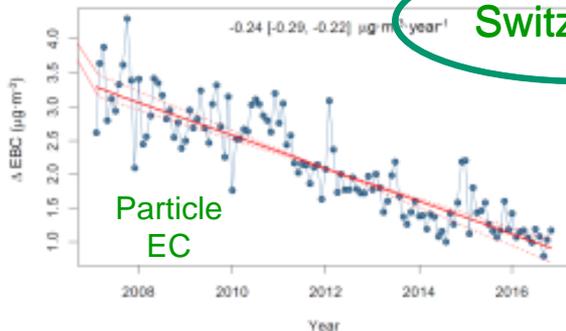
"no Diesel without filter" since 1997



Source: California Air Resources Board, 2015¹

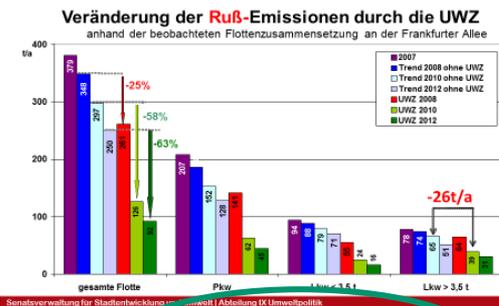
Pollutant	Overall trend	2005–2009	2010–2014
ΔNO_x	$\mu g m^{-3} year^{-1}$	0.87 [0.07, 1.68]	-1.11 [-2.27, 0.04]
	% year ⁻¹	1.02 [0.07, 1.96]	-0.95 [0.04, -1.94]
ΔNO_2	$\mu g m^{-3} year^{-1}$	1.63 [1.25, 2.01]	-1.65 [-2.27, -1.03]
	% year ⁻¹	10.56 [8.08, 13.04]	-4.84 [-2.98, -6.69]
ΔPM_{10}	$\mu g m^{-3} year^{-1}$	-0.19 [-0.34, -0.03]	0.07 [-0.13, 0.27]
	% year ⁻¹	-3.92 [-0.69, -7.15]	1.11 [-2.06, 4.27]
$\Delta PM_{2.5}$	$\mu g m^{-3} year^{-1}$	-	-0.70 [-0.97, -0.42]
	% year ⁻¹	-	28.34 [-14.65, -42.03]
ΔCO_2	$\mu g m^{-3} year^{-1}$	-	0.55 [-0.42, 1.11]
	% year ⁻¹	-	2.93 [-1.00, 9.85]
$\Delta CBLK$	$\mu g m^{-3} year^{-1}$	-	-0.59 [-0.93, -0.23]
	% year ⁻¹	-	-11.30 [-3.74, -19.16]

Switzerland



Relevanz von Baumaschinen

Herkunft der Feinstaub Emissionen 2009



Berlin

traffic related 'black' carbon particle concentration in Berlin

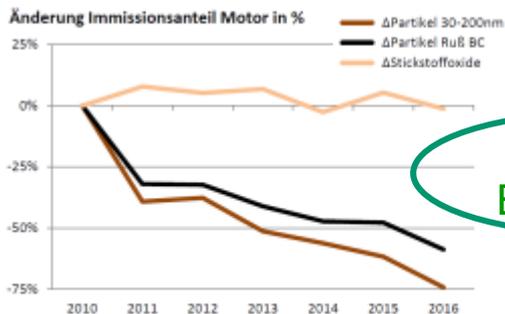
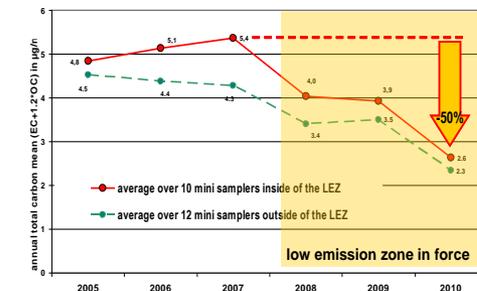


Abbildung 15: Relative Änderung des Immissionsanteils durch die Kfz-Motoremissionen an der Messstation Leipzig-Mitte von 2010 bis 2016

Leipzig
EC and PN

¹ local BC increment at traffic sites, adjusted to traffic volumes trend relative to 2007 before LEZ came into force
² elemental carbon (EC) particles plus other deposited organic compounds (OC)

Iran is well on the learning curve

- HD-Diesel-Vehicles: 9'500 !
with DPF growing fast
- and starting Retrofit of buses in 8 cities

We will clean the air from carcinogenic
engine emitted nanoparticles
within 10 years

SUMMARY

- Worldwide > 9 million death per year by pollution
- Mortality by Air Pollution is 95% by EC-Particles
- Main source of EC particles are vehicle engines
- LDV & HDV / Diesel & Petrol / on-road & off-road
- EC-particle emissions eliminated by DPF/GPF
- DPF/GPF are applicable for in-use vehicles and OE
- EU enforces DPF/GPF for all new vehicles
- > 100 million DPF/GPF guarantee reliability

IRAN has already an excellent policy

and will succeed to clean the air within 10 years

Exhaust End Pipe stays clean !

onroad > 85'000 km

offroad > 1000 h



