

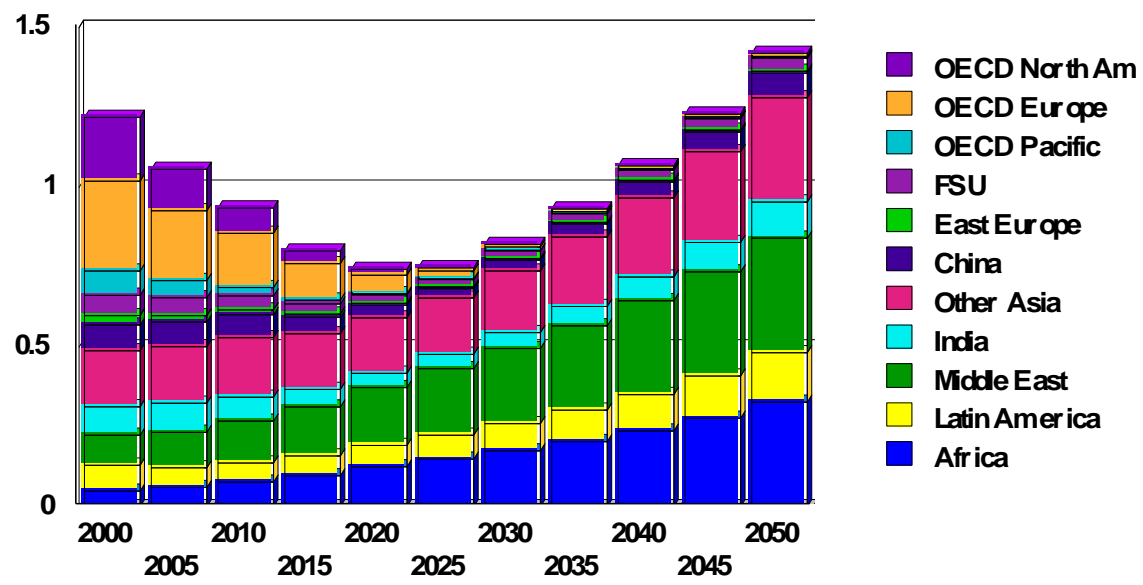
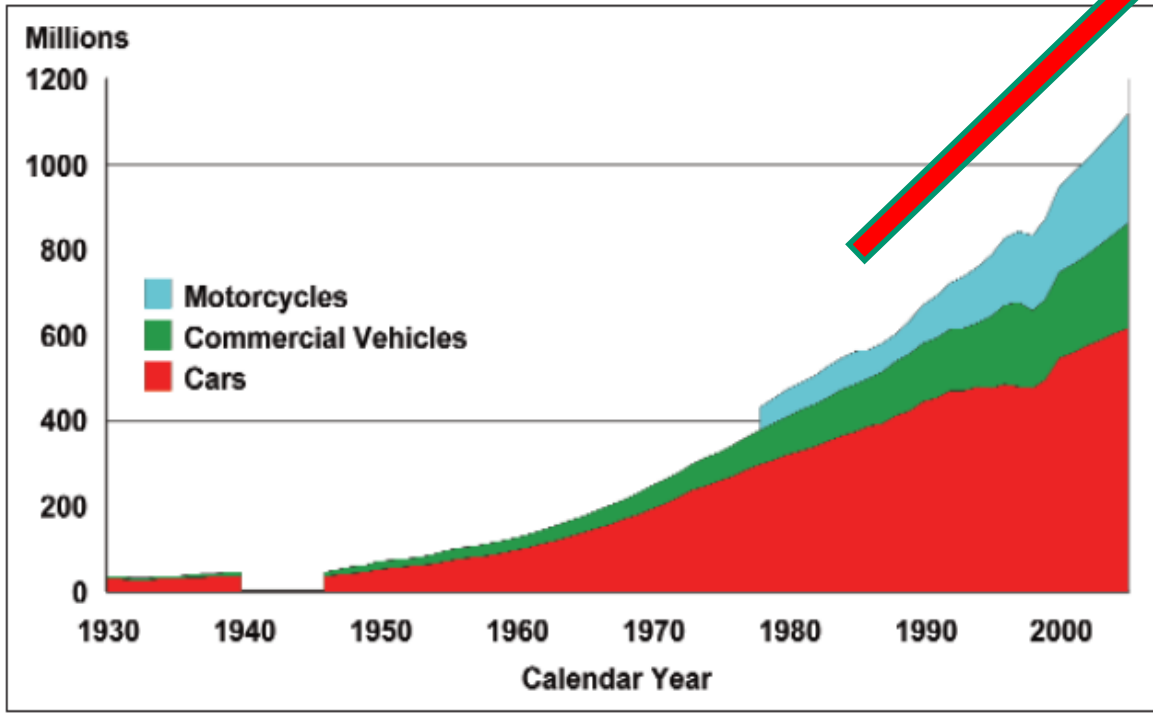
First Iranian PPP Forum for Clean Diesel - Tehran

# **Diesel Exhaust Detoxification by VERT-standard Particle Filters Why and How**

A.Mayer

# Society needs Mobility

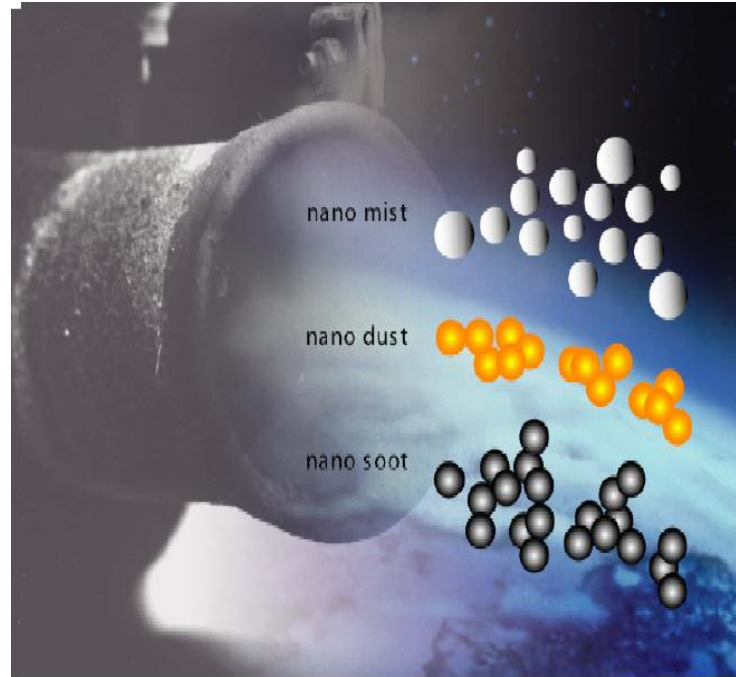
Toxics Air  
Contaminants  
TAC from Traffic  
will increasingly  
pollute Megacities  
→ need to act



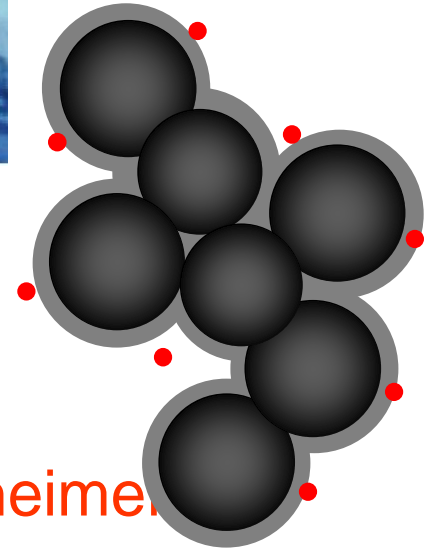
# Engine Exhaust Gas contains

**Soot Particles**  
**Ash Particles**  
**Liquid Droplets**

**Gases:**  
**CO, HC, NOx**  
**PAH, Nitro-PAH**



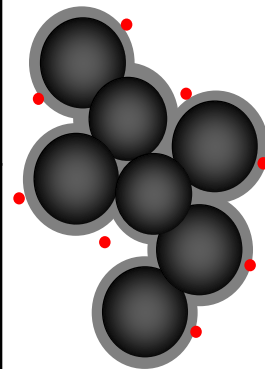
**Highest Toxicity:**  
**solid soot particles, PAH, metal oxides**  
→ Asthma, Heart Attacks, Cancer, Parkinson, Alzheimer



# Which inhaled Substance may be toxic ?

Health Effect Equivalence Analysis HEQ,  
a tool to answer this question. Simplified Example:

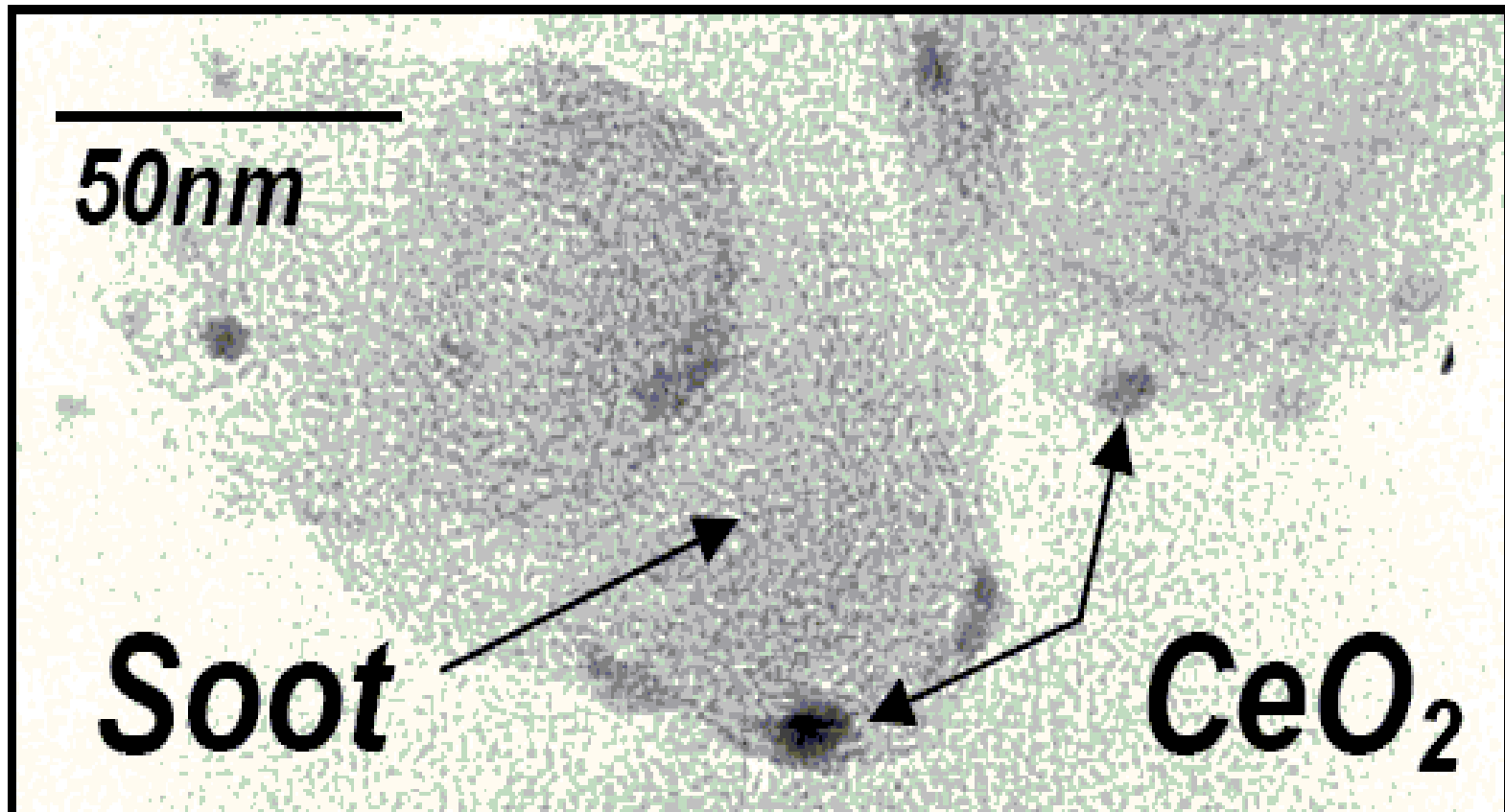
| Toxicity -Parameters                                | Sulfates<br>Nitrates | Mineral<br>Dust | Solid<br>Nano-<br>Particles |
|---|----------------------|-----------------|-----------------------------|
| <b>invasive (mobility)</b><br>penetrate membranes ? | ☹️<br>1              | 😊<br>< 0.1      |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



Particles coated by PAH  
and decorated by metal oxides



*The Trojan Horse Effect*



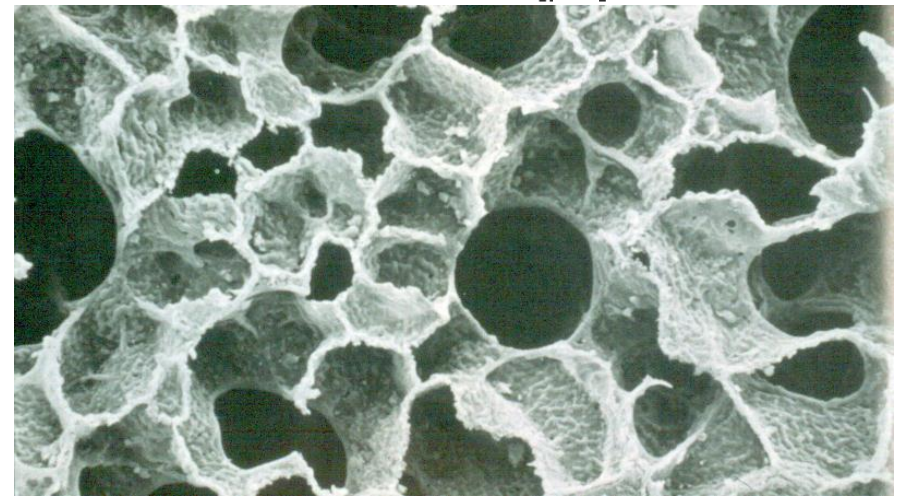
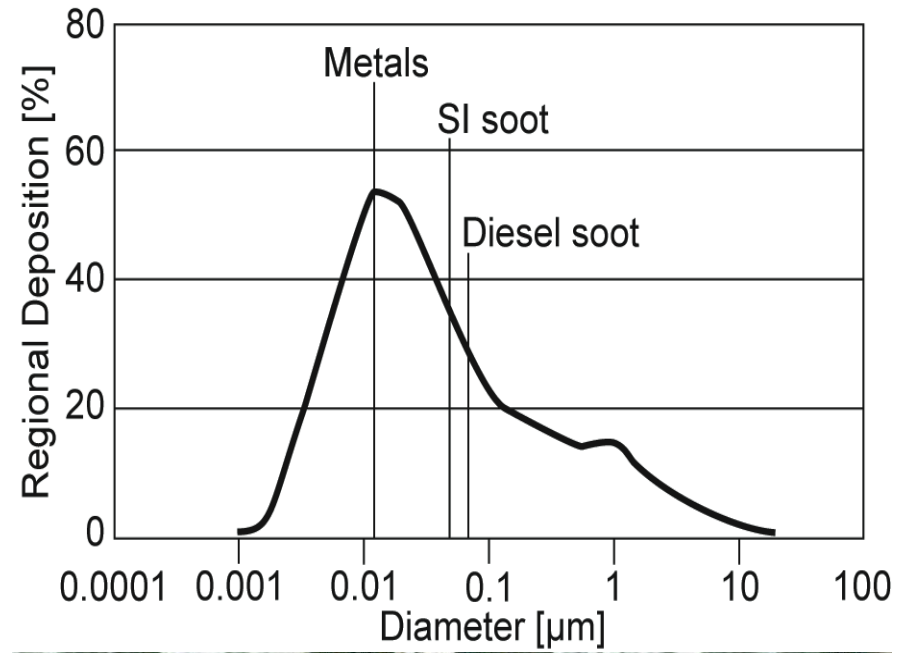
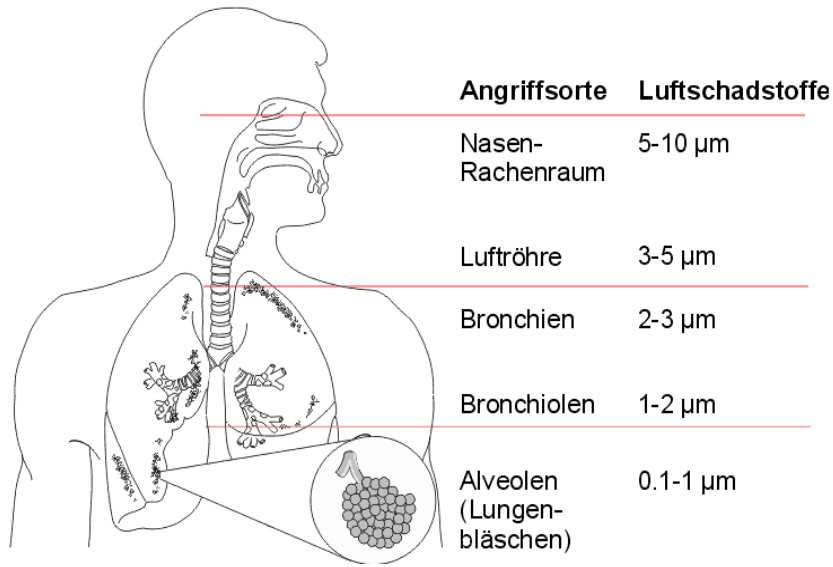
# Soot Particle

- black
- small
- anywhere
- unavoidable
- carcinogenic
- difficult to control
- mass of one particle is  
0.000 000 000 001 mg = 1 fg
- up to 10 Mio particles in one cm<sup>3</sup>
- 100 P in each alveoli at each breath



# Why is particle size decisive for health risk considerations

Ablagerungen von Feinpartikeln im menschlichen Atemtrakt



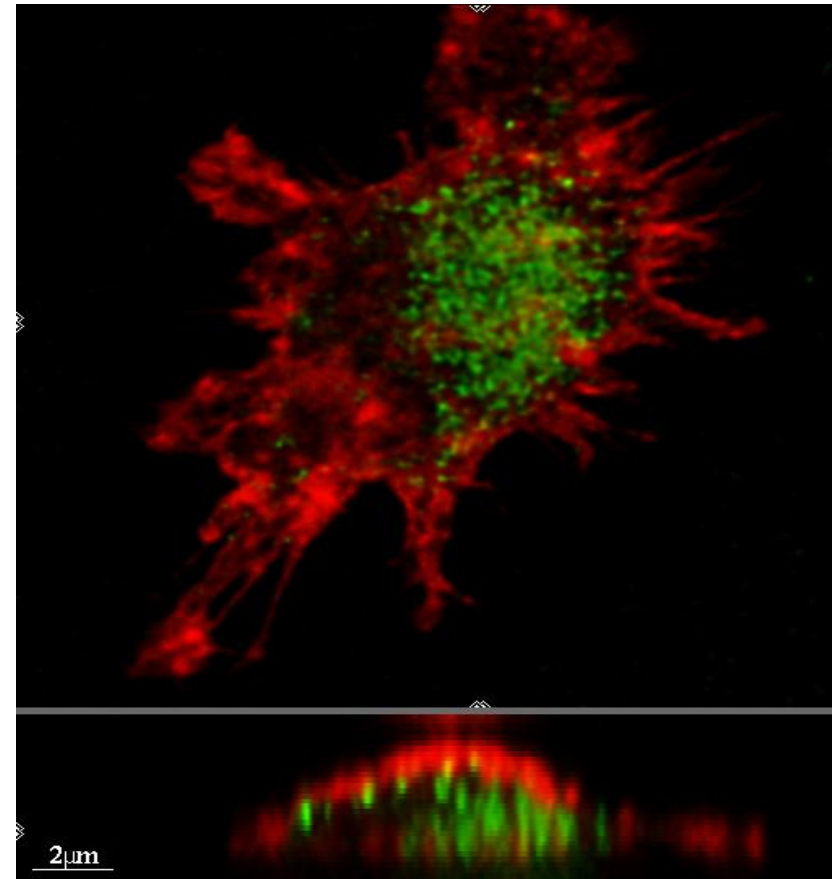
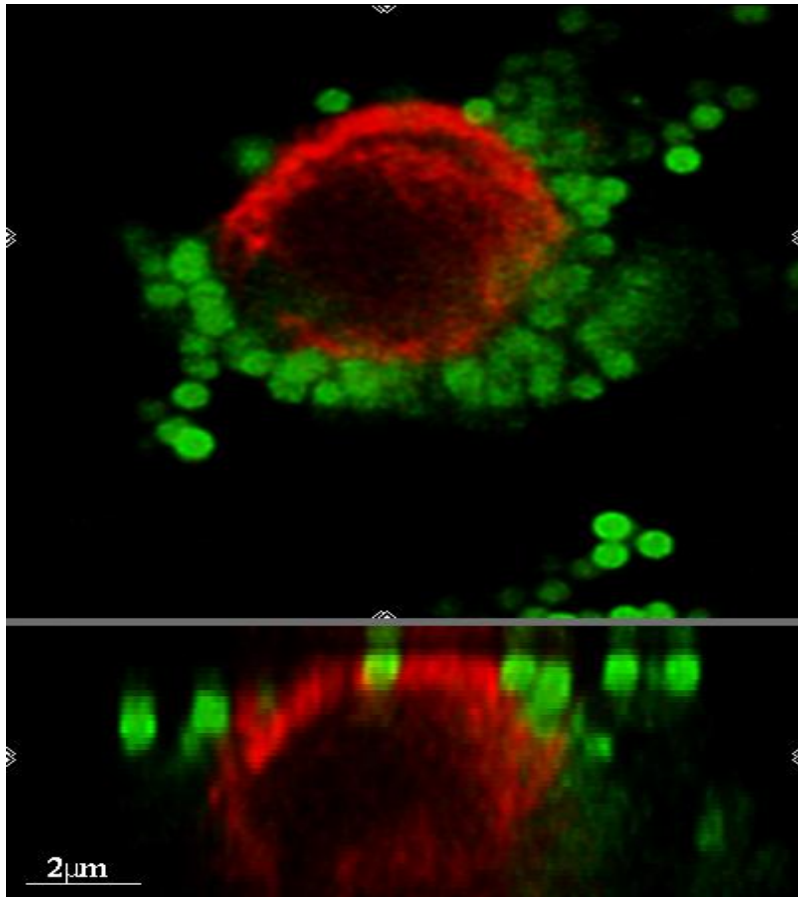
Ultrathin alveoli tissue permits penetration of gases and UFP into blood vessels

# Particle Size Penetrating Membranes

1000 nm  
Polystyrene Particles

+

78 nm  
Polystyrene Particles



Laser Scanning Microscopy

B. Rothen-Rutishauser, University Berne



# Particle Emission of ICE

## Diesel

Sootpeak: 80 nm;  $10^6$

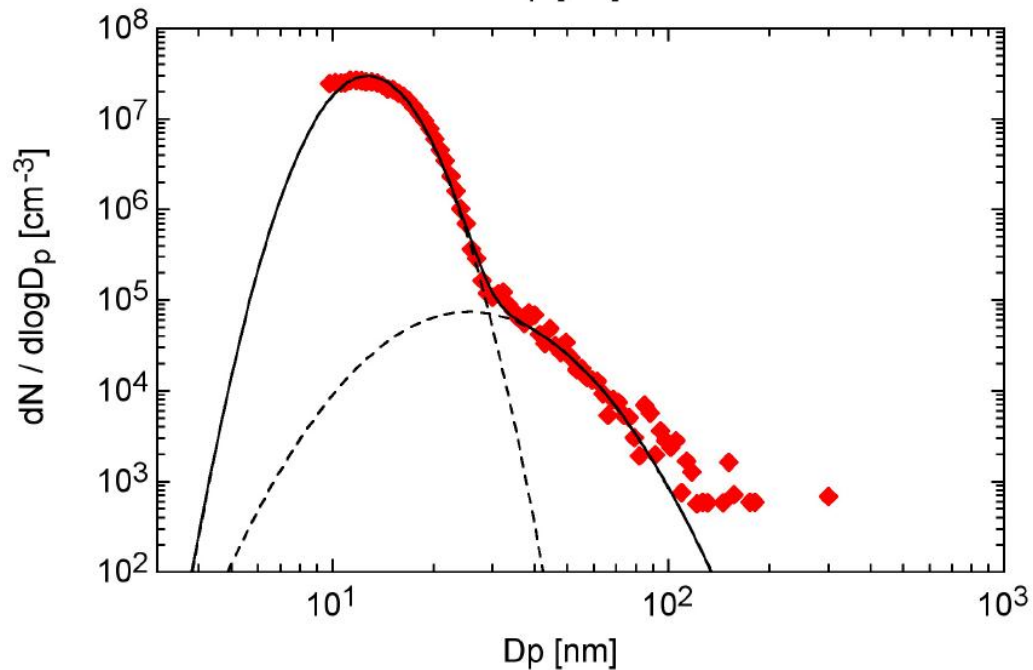
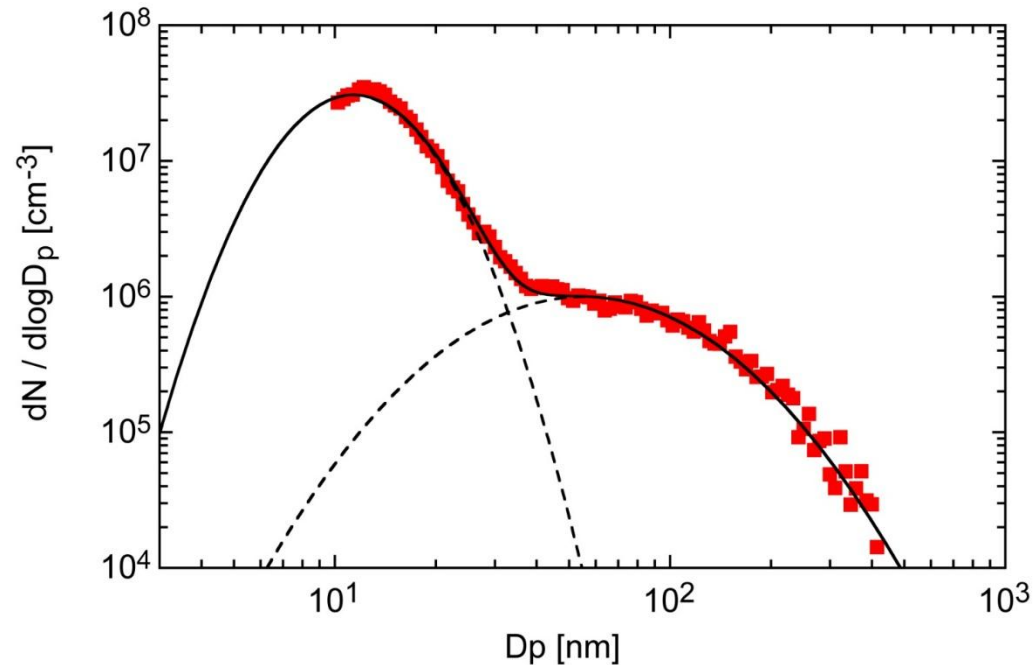
Ashpeak: 10 nm;  $10^7$

## Petrol

Sootpeak: 40 nm;  $10^5$

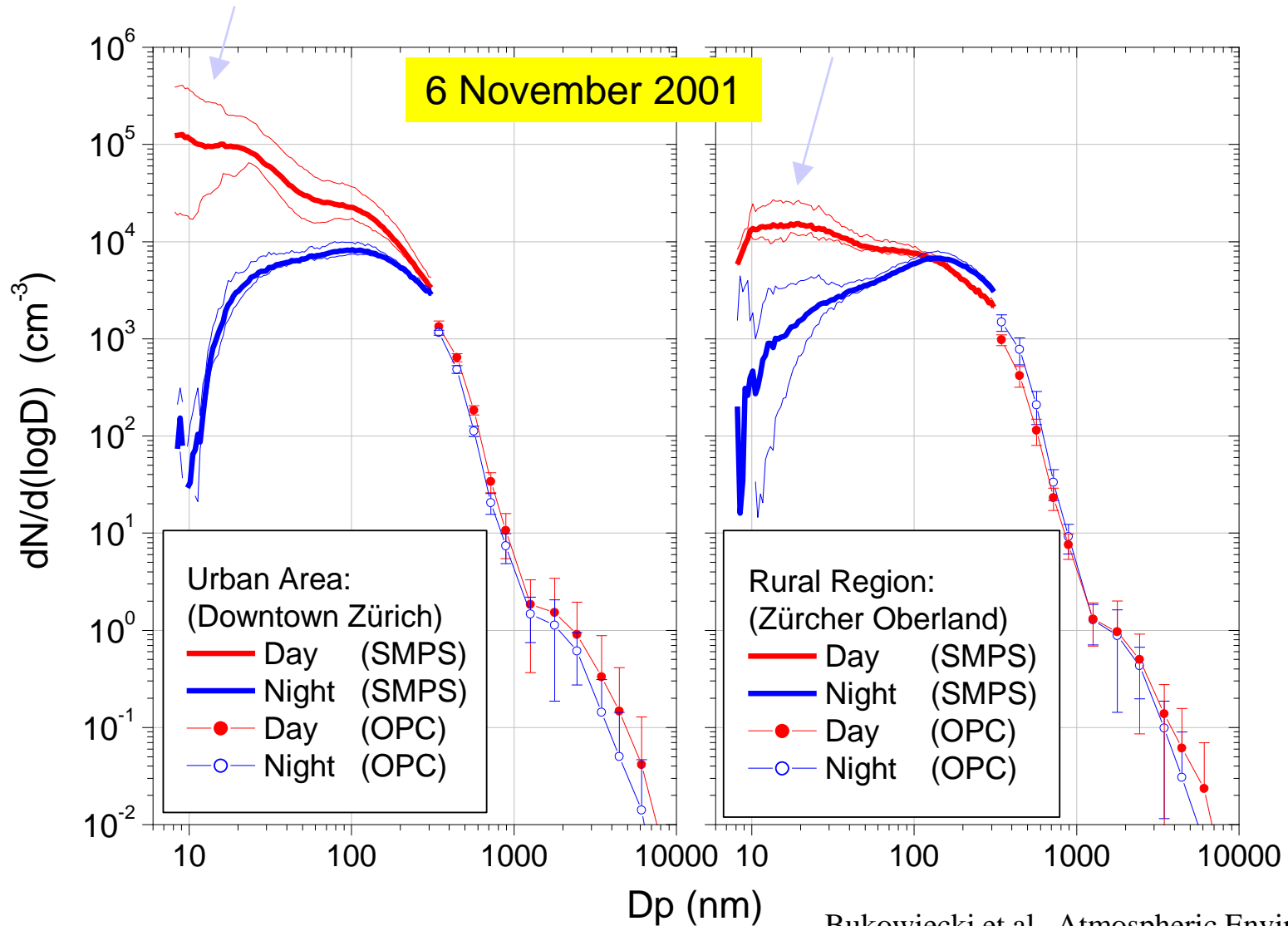
Ashpeak: 10 nm;  $10^7$

*Soot and Ash Peaks*



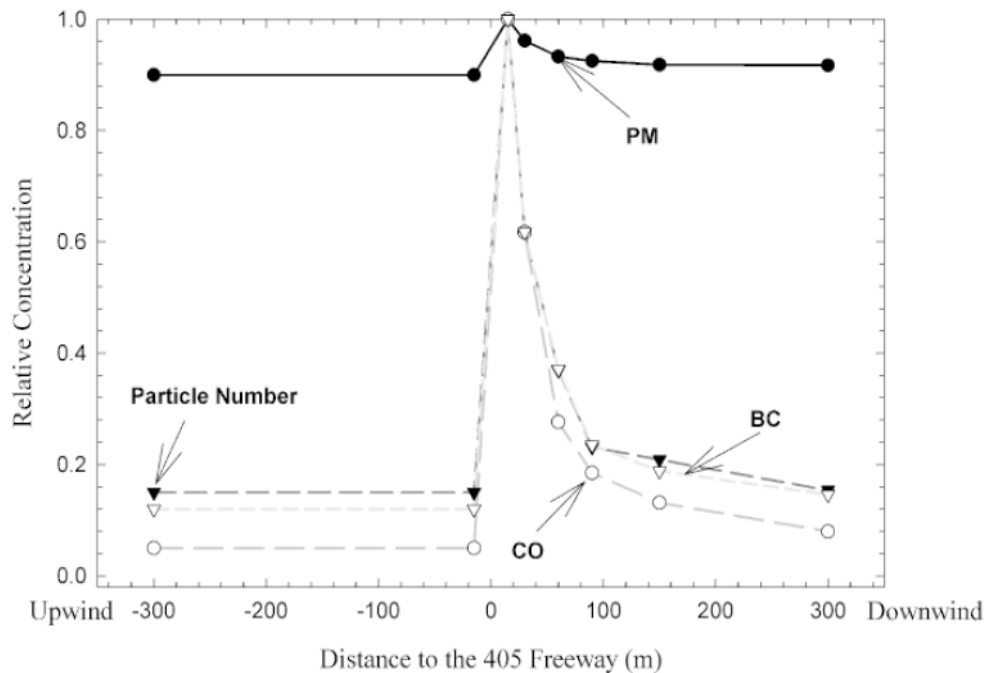
# Ambient Aerosol Number/Size – Distribution

## City (Zürich) and Coutry (Zürcher Oberland)



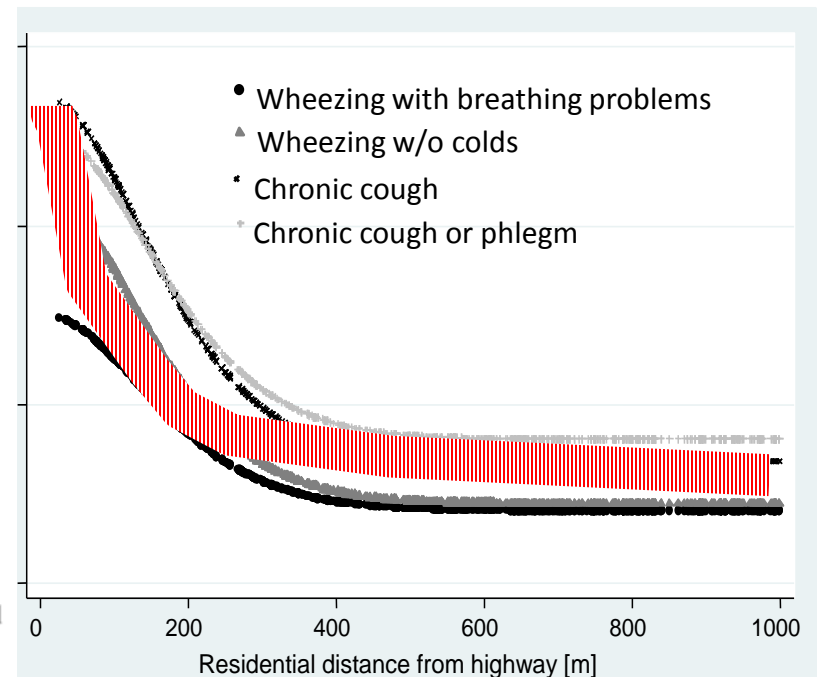
# UFP-Concentration and Health Impact depend strongly on distance to high traffic roads

## Particle Number Distribution near Roads



Hinds, Zhu et al  
University of California, L.A.  
Size distribution of UFP near Los Angeles 405  
Air & waste management Sept. 2002

## Respiratory Health Impact near Roads



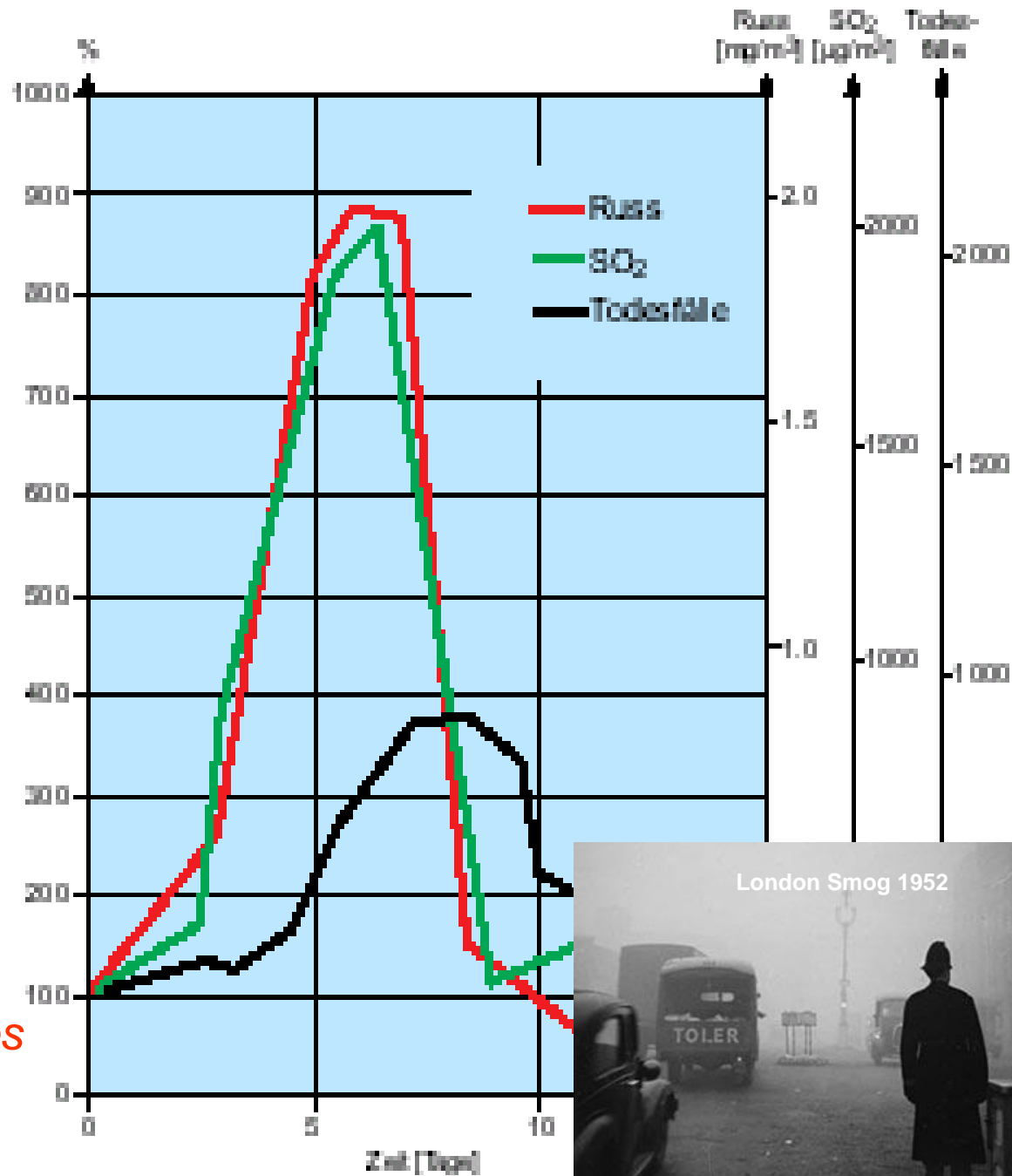
Hazenkamp, Künzli et al  
Swiss Tropical and Public Health Institute, TPH  
Impact of highway traffic on respiratory health in adults  
Environmental Health 10/2011

# 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*

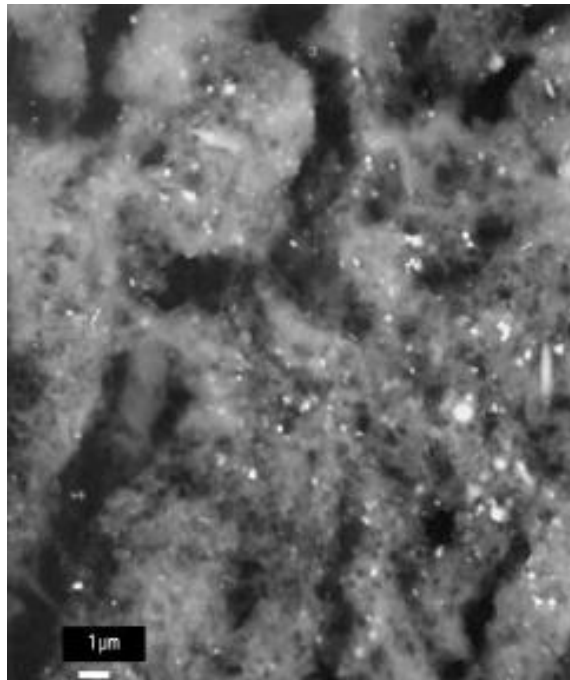
*The famous medical doctor  
Sir Percival Pott found 1775  
that soot is the reason for  
carcinoms in chimney sweeps*



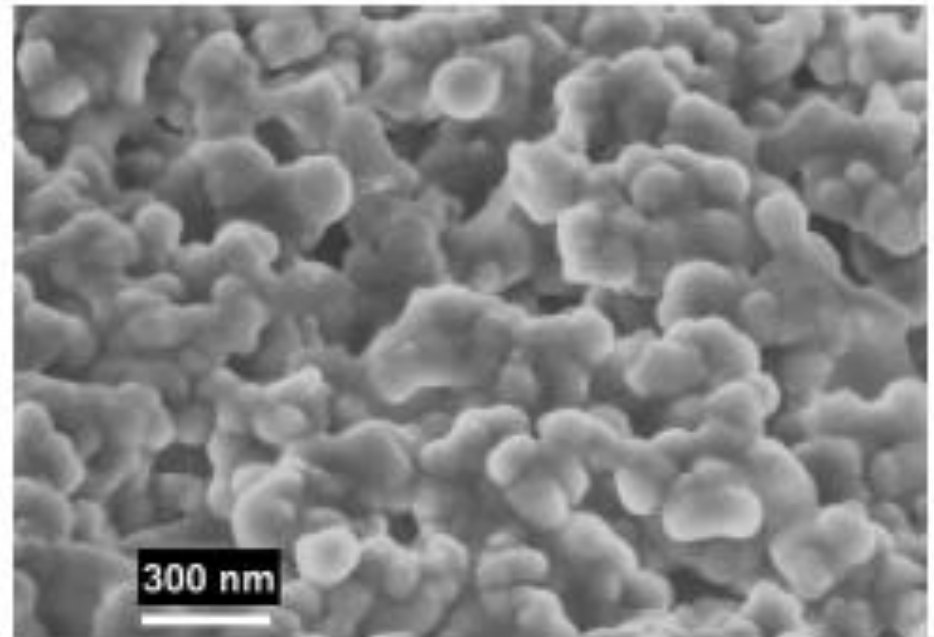
# Histological Research

## 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



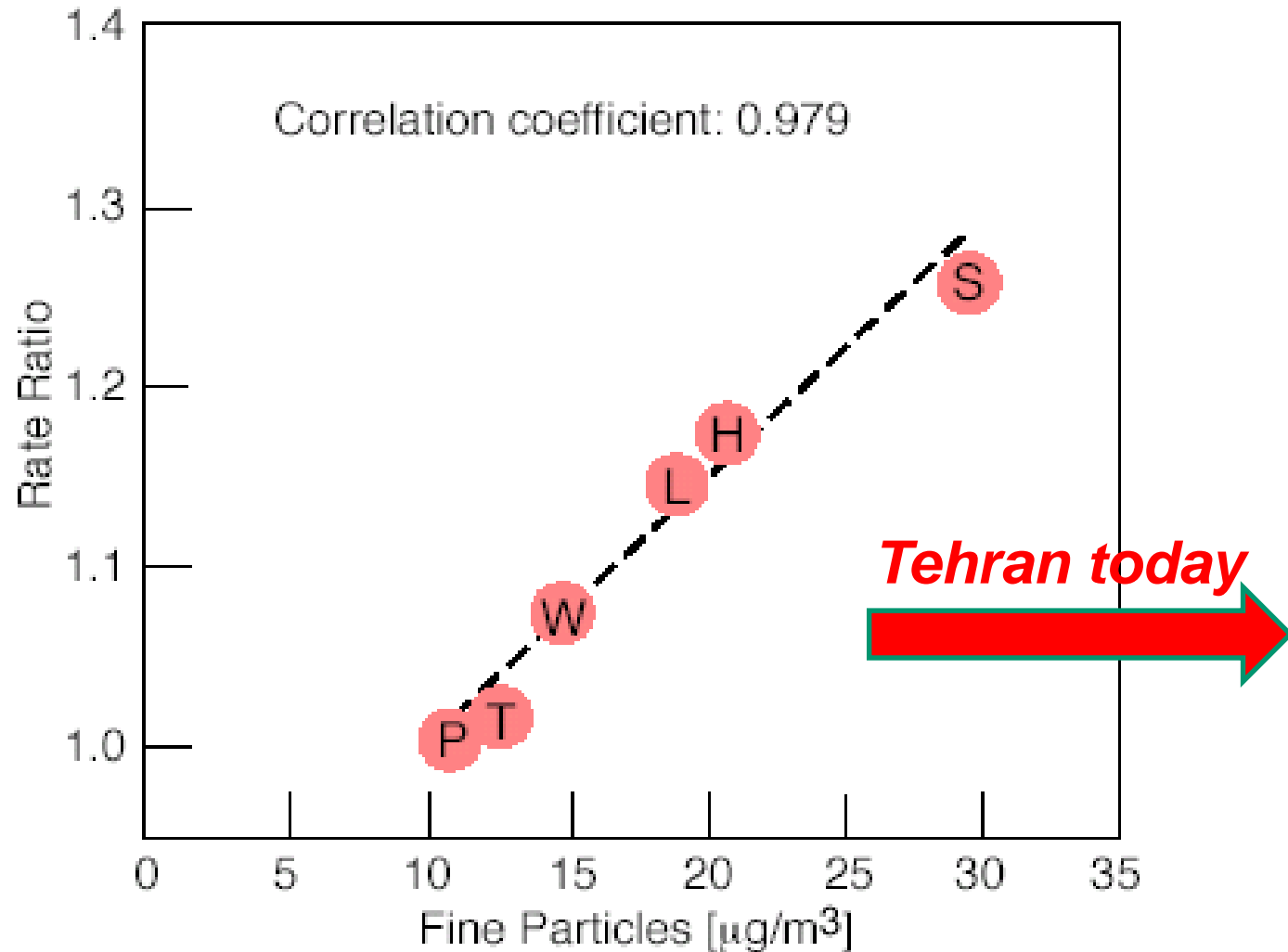
**Figure 2.** BE micrograph of section of airway aggregate from case 2 revealing abundant sub-micrometer inorganic (bright) particles.



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



# Linear Dose/Effect-Relation of Mortality with Ultrafine Particles



6 cities study  
USA 1970-1990  
Dockery D.W

# Mortality and Health Cost global 2012

due to traffic [per year]

|            | Inhabitants<br>Mio | Mortality<br>Traffic<br>x1000 | Related<br>Health Cost<br>Mio € | Mortality<br>per 1 Mio<br>and year | Cost<br>€/Pers |
|------------|--------------------|-------------------------------|---------------------------------|------------------------------------|----------------|
| USA        | 313                | 200                           | ?                               | 638                                | ?              |
| California | 38                 | 9                             | ?                               | 236                                | ?              |
| London     | 8.1                | 4                             | 234                             | 493                                | 2800           |
| Schweiz    | 7.8                | 4.5                           | 6.5                             | 576                                | 833            |
| EU28       | 501                | 400                           | 650                             | 798                                | 1390           |
| World      | 7000               | 4500                          | ?                               | 642                                | 15?            |

Benefit/Cost > 10  
 Cost for Filters 10 times lower  
 than Health-Cost

# **IARC-WHO 1988 / 2012**

*International Agency for Research on Cancer  
World Health Organization*

***Diesel Exhaust Carcinogen Class 3→1***

## **Legal Consequences:**

- apply BAT
- establish AQL

# ***Diesel Particle Filter***

***eliminate solid particles  
and if catalysed also CO, HC, PAH***

***detoxifies exhaust gas***

***which leaves the endpipe cleaner than the  
ambient air***

***DPF is the only cost-effective tool for  
in-use Diesels and for all new  
Diesel Vehicles***

# What counts is clean exhaust gas much cleaner than intake air



City Bus Exhaust  
after 85'000 km

Picture A.Mayer 2006