Exposure Assessment

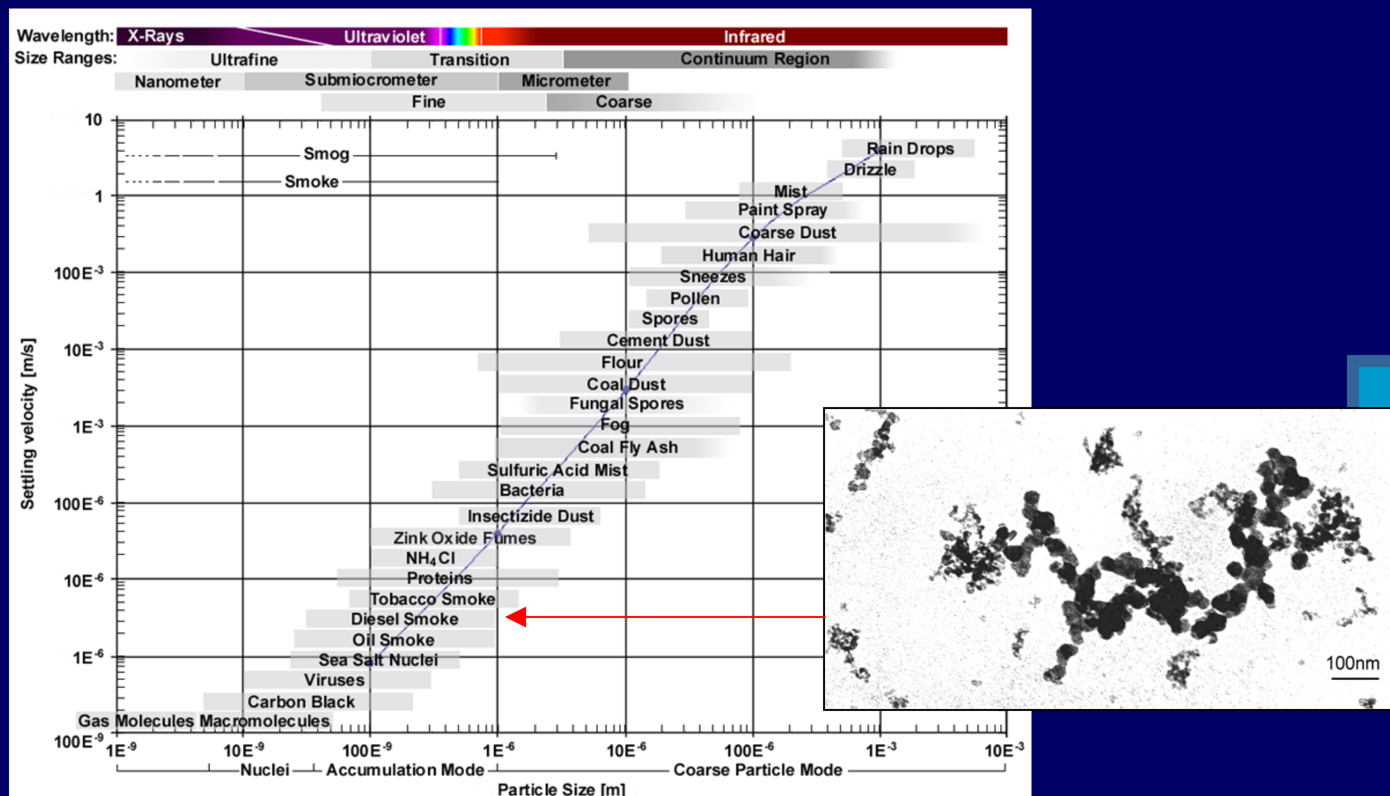
Salzburg University
Institute of Physics and Biophysics
Salzburg, Austria
(Ass. Prof. W. Hofmann)

Queensland University of Technology
Center for Medical and Health Physics
School of Physical Sciences
Brisbane, Australia
(Dr. A. Wiegand, Ass. Prof. L. Morawska)

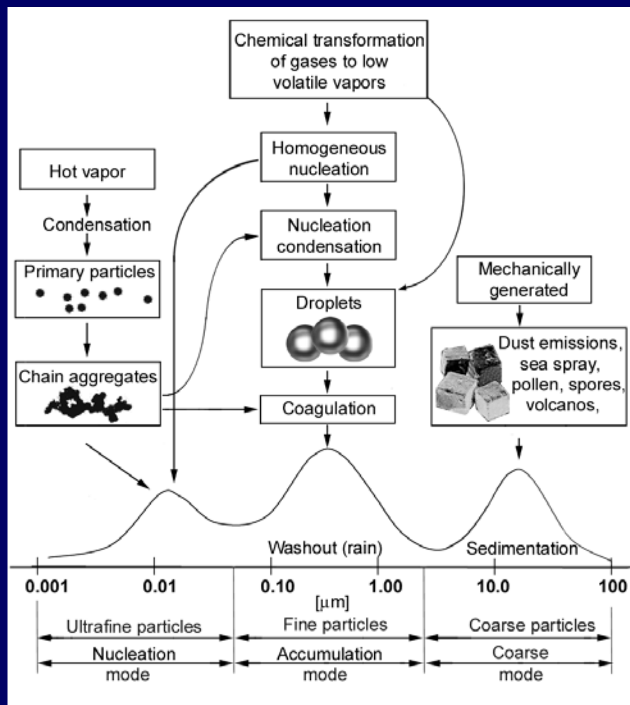
Presenter: Maricela Yip

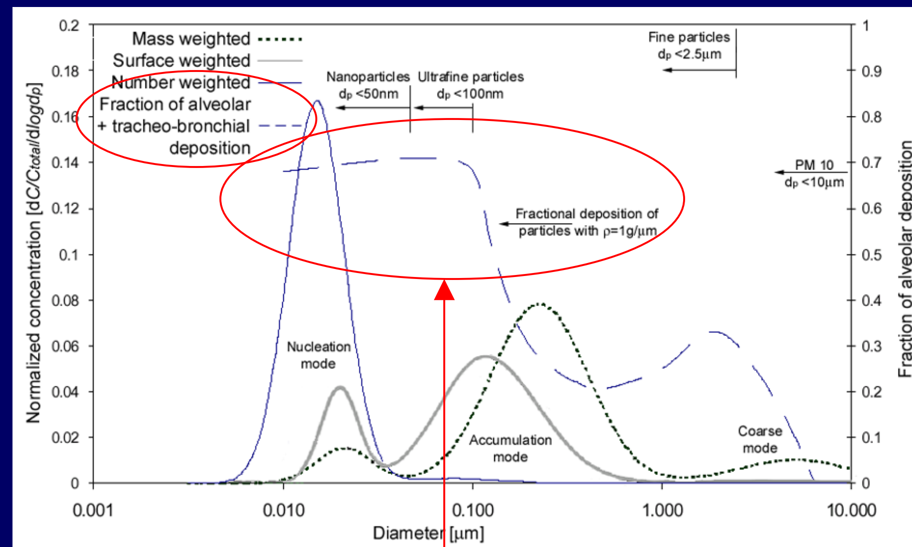
Intro - Exhaust Particles (1/4)

- Diesel Exhaust
- Petrol Exhaust



Intro - Particle Dynamics (2/4)

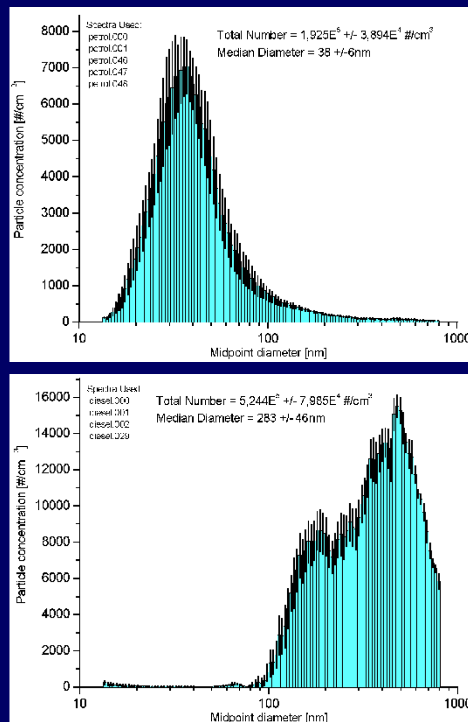


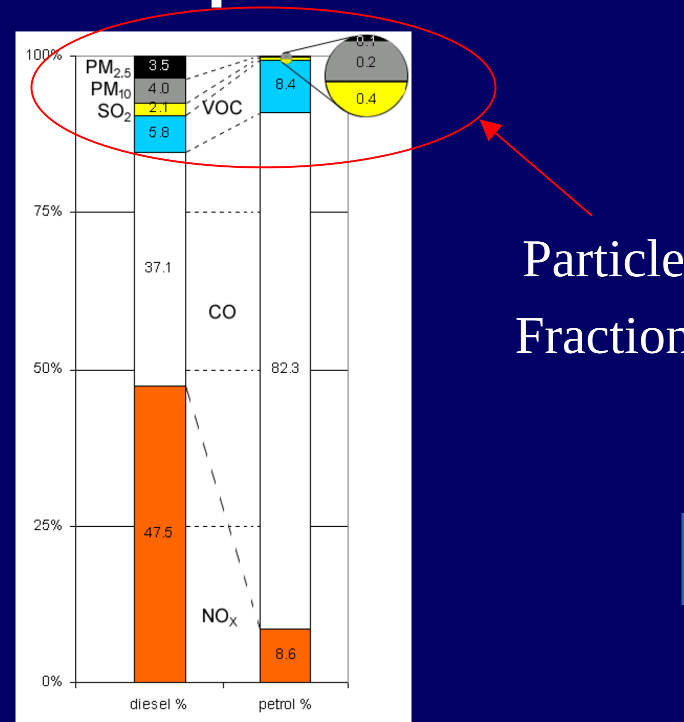


Combustion aerosols

- Primary particles (nucleation mode)
- Coagulation (accumulation mode)
- Particles of mechanical origin (coarse mode)

Intro - Exhaust composition (3/4)

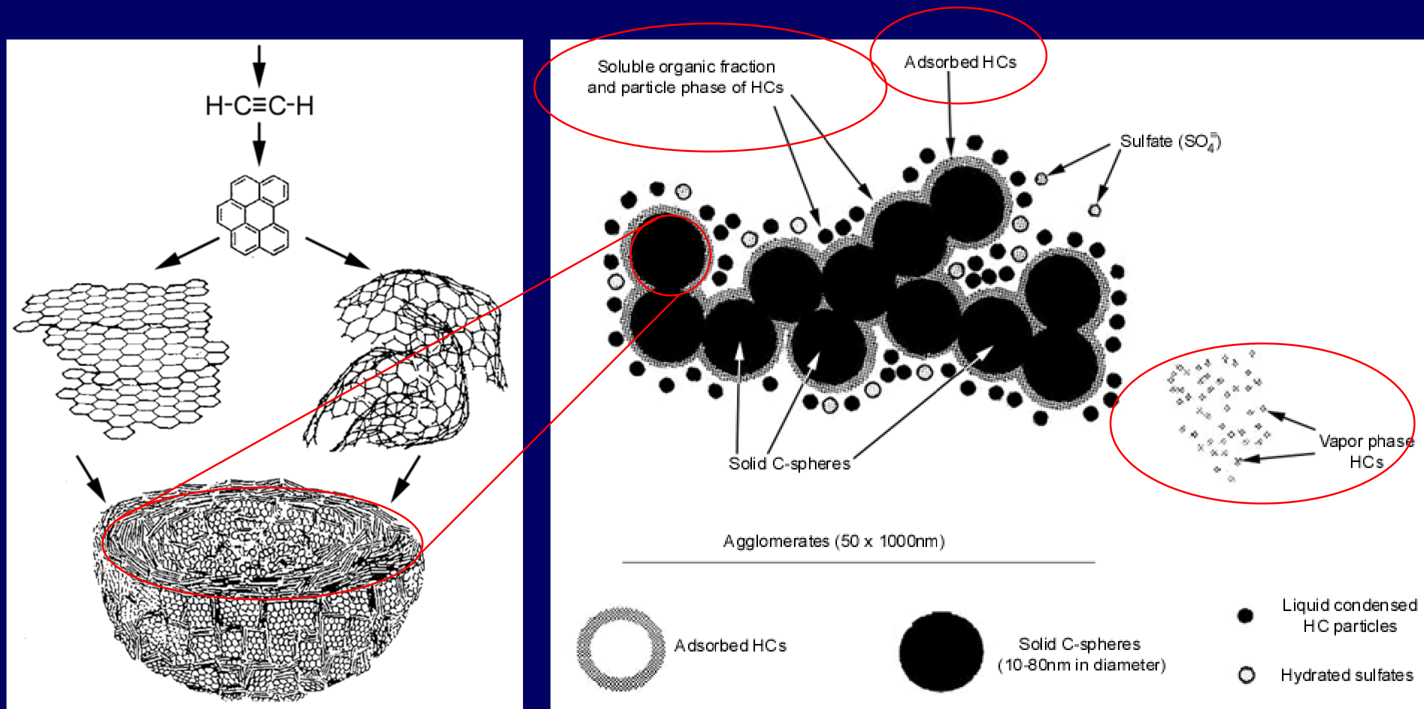




- Petrol exhaust consists predominantly of short-chained HCs
- Diesel exhaust consists of approx. 450 different combustion products (incl. PAHs)

Intro - Diesel soot

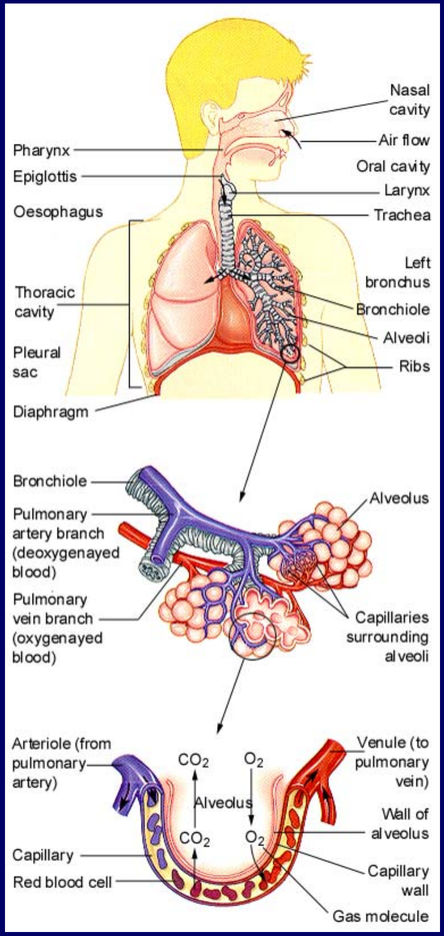
(4/4)



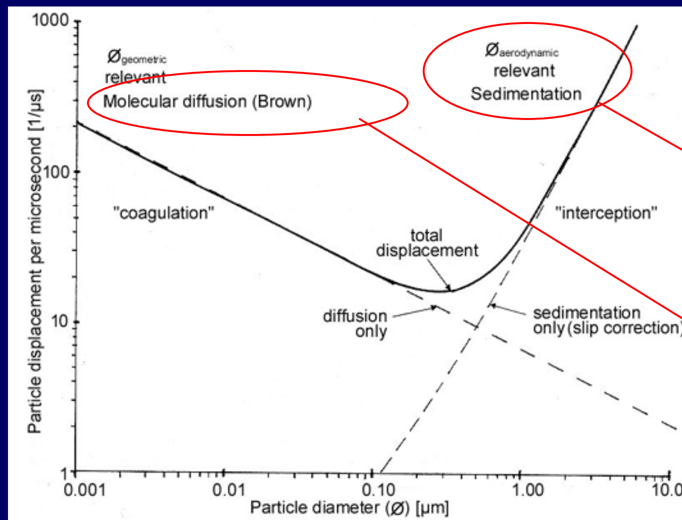
- At least 40 are toxic contaminants like arsenic, benzene, cadmium, dioxins, toluene, formaldehyde and even some major chemical carcinogens like 3-nitrobenzanthrone ($C_{16}H_9NO_3$) and 1,8-dinitropyrene ($C_{16}H_8N_2O_4$) are found in either as gas or as particle form.

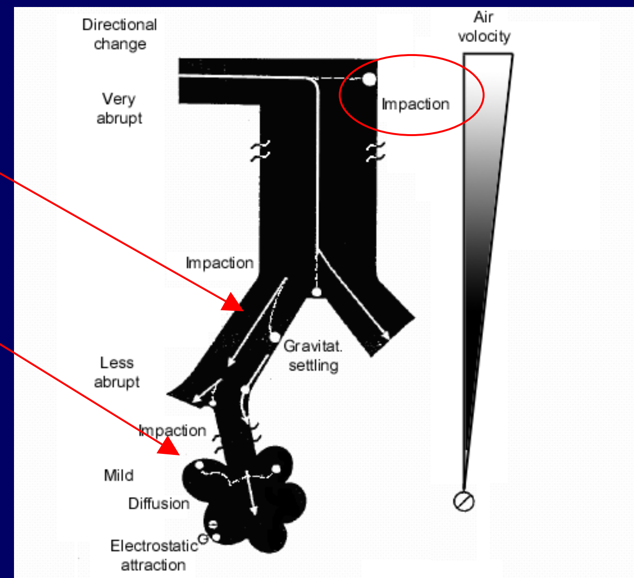
Respiratory System (1/3)

- The human respiratory system
- Structured like a up-side-down tree
- With decreasing thinning of the conductive branches (from bronchi, bronchioli, to alveoli)
- Gas exchange occurs at the alveolar-capillar interface



Particle Deposition (2/3)

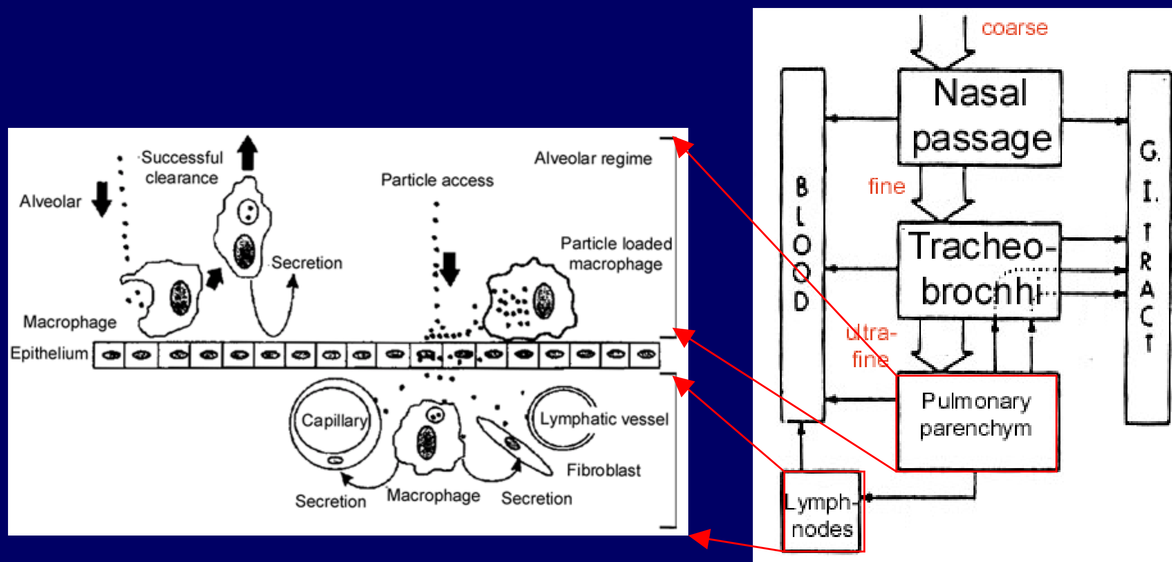




- Exposure occurs when an aerosol particle enter a person's nose or mouth (for respiratory deposition) or the skin (for dermal adsorption).
- The dynamic size of aerosol particles provides a direct relationship to the deposition of such particles in the respiratory system.

Clearance

(3/3)



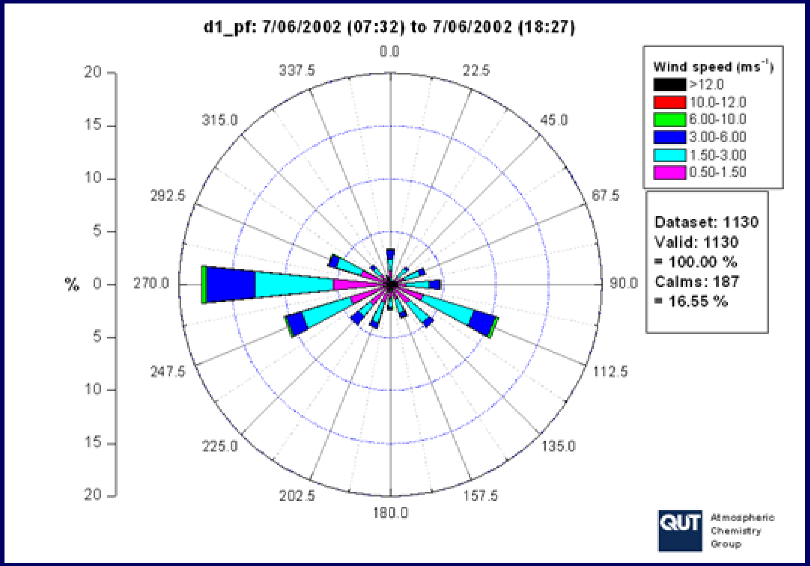
- Risks exist when particles arrive at the vessels system or into the lymph nodes.
- Constant and acute irritation of the lung epithelium.
- Increase cardiovascular damages and carcinogen potential by fine particle exposition.

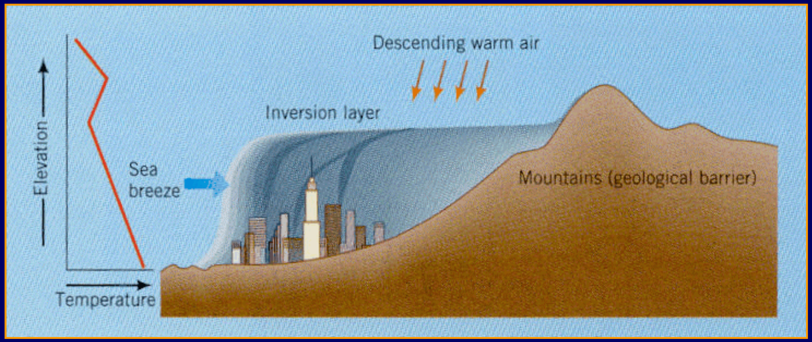
Brisbane - Topography (1/3)

- To the west, north and south,City is surrounded by mountains (1000m.).
- Horseshoe shaped opening to the Pacific.
- These topographical features form the boundary of Brisbane's Air-shed.

Brisbane - Climate (2/3)

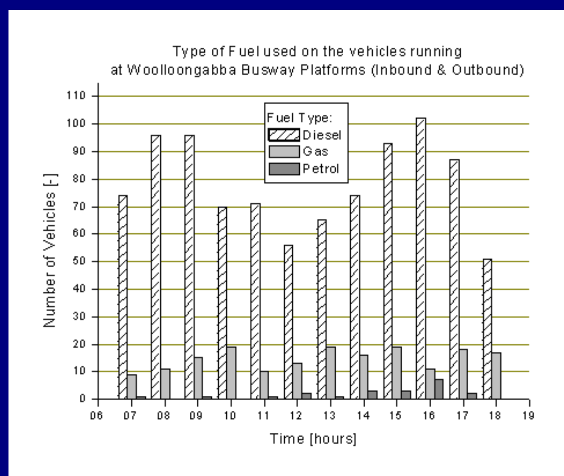
- Prevailing Wind Patterns; early morning out to the sea, late afternoon back landwards.
- During the winter (July-Aug.) the blob of polluted air sits over the CBD.
- It is pushed back and forth without being actually removed.
- Clear and sunny winter days.
- Temperature according to tropical region.

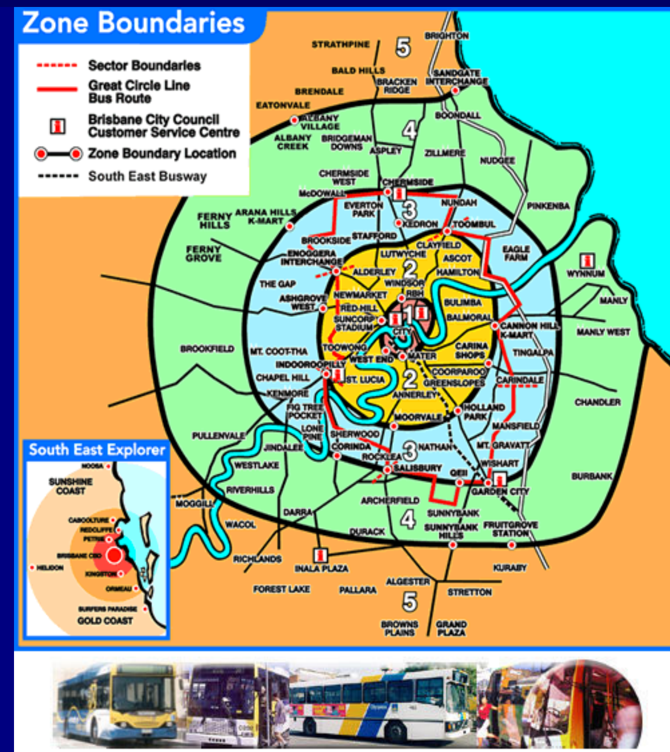




Brisbane – Public Transport (1/3)

- Bus-fleet of QLD transport consists of 85% diesel powered vehicles with the remaining CNG (compressed natural gas)



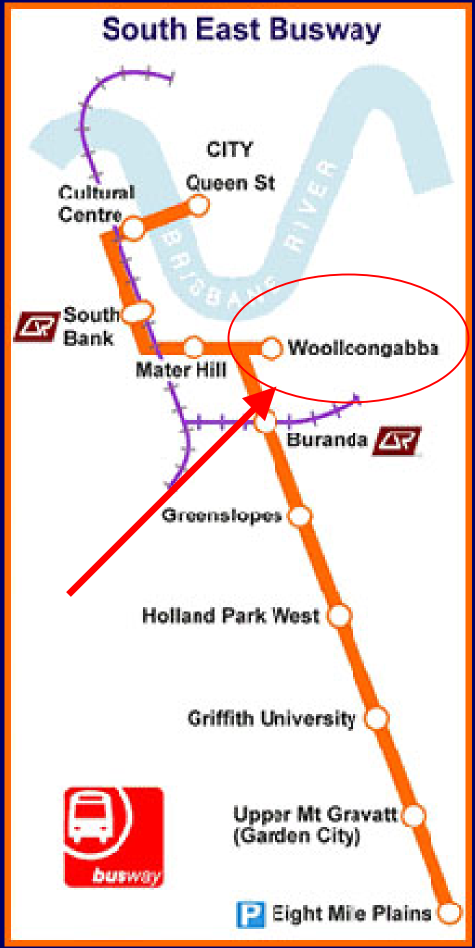


- Bicycle use for commuting is low, but increasing.
- Generally, Brisbane (as all of Australia) is run by DIESEL

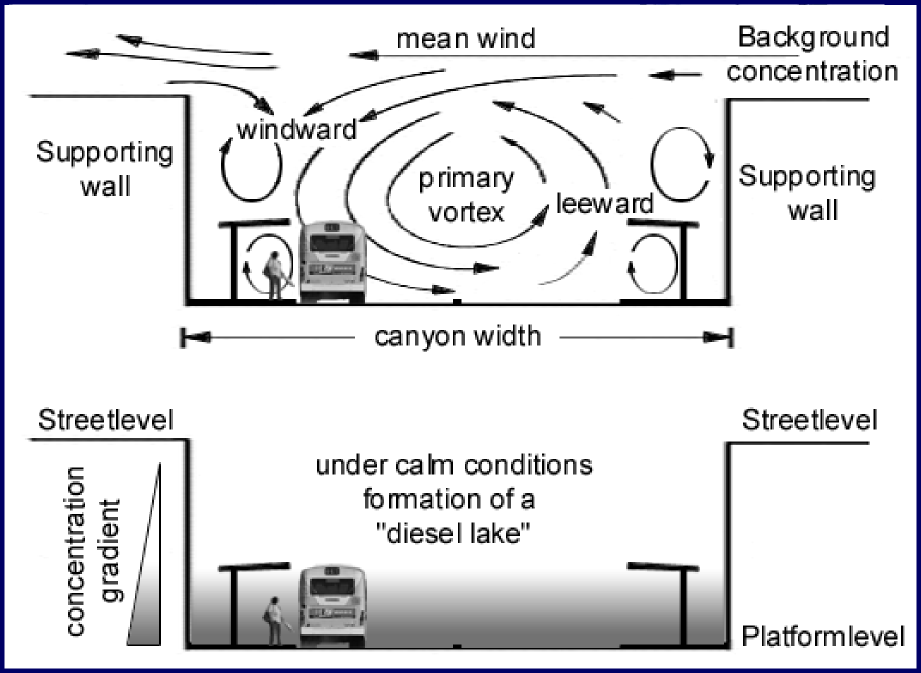
Brisbane - Busway

(2/3)

- In June 1995 a network of five busway corridors was launched.
- The 1st. section of South East Busway between the CBD and Woolloongabba opened in September 2000.
- The 2nd. section between Woolloongabba and Eight Miles Plains opened on April 2001.
- It allows buses to service the low density suburbs, bypassing peak hour congestion on main roads.

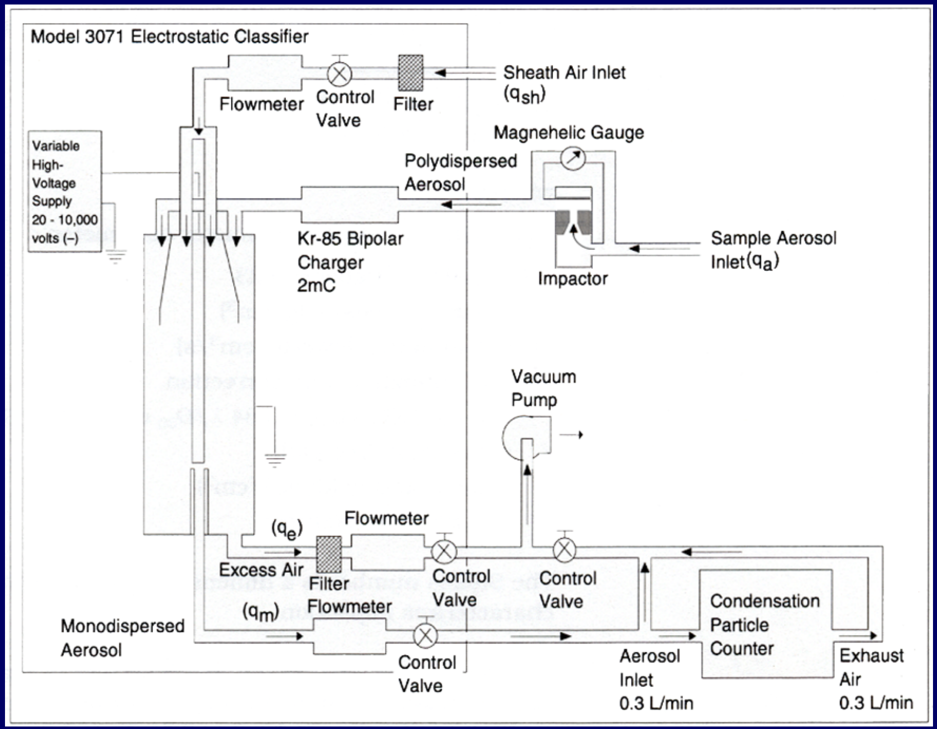


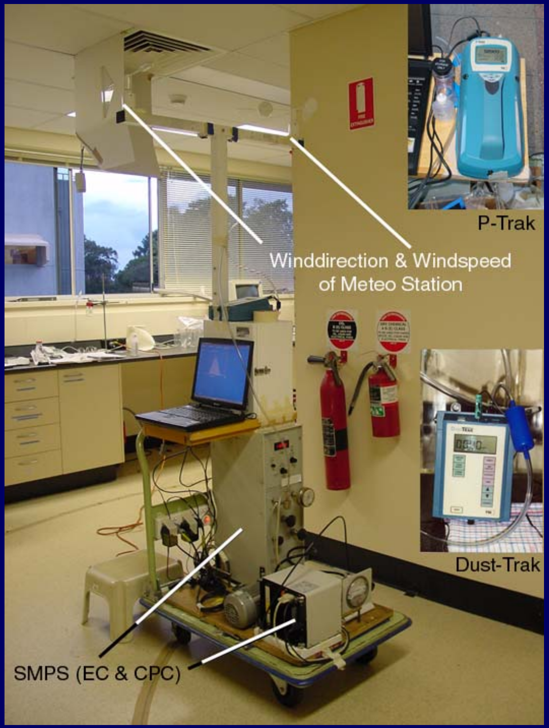
Brisbane – Woolloongabba (3/3)



- About 7-10 m deep underground-similar to a street canyon.
- Traps air pollutants and inhibits wind circulation.

EA Instrumentation - SMPS (1/4)

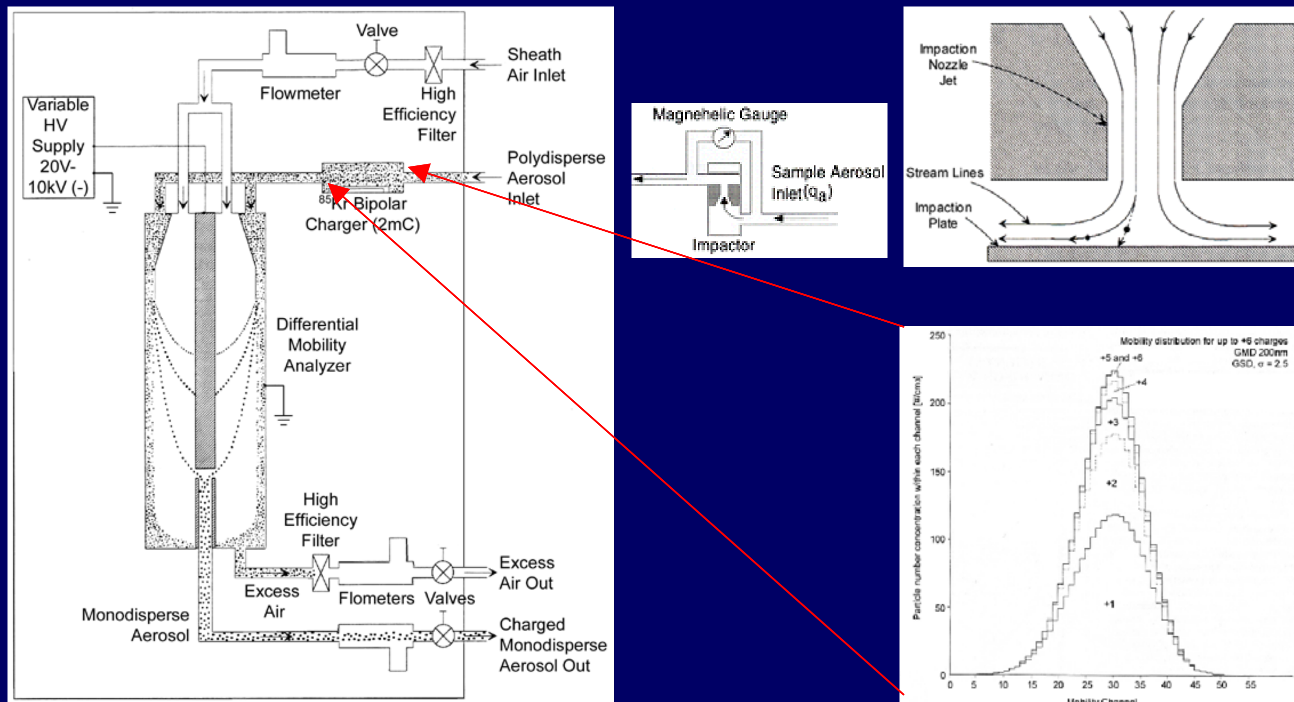




- Scanning Mobility Particle Sizer, is a set of instruments used to measure airborne particles in the size range of 3 to 1000nm; it employs an EC and a CPC.

EA - SMPS/EC

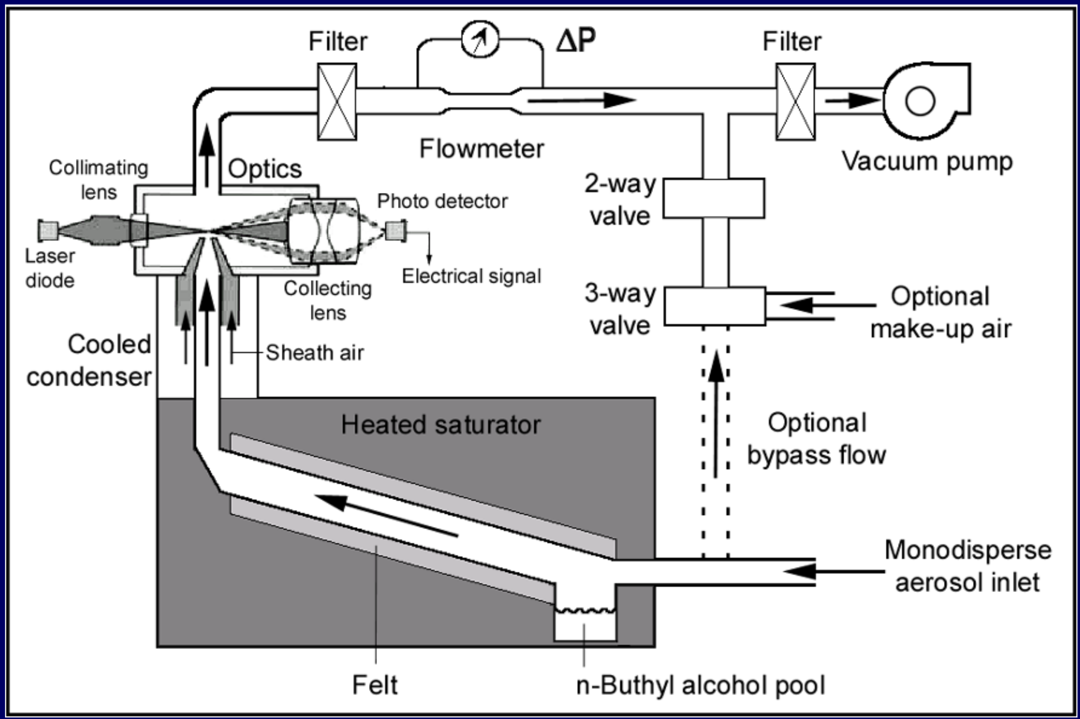
(2/4)



- Electrostatic Classifier, is an instrument to analyze a polydisperse aerosol or to generate monodisperse particles of uniform size from a polydisperse source.

EA - SMPS/CPC

(3/4)



- Condensation Particle Counter, is an instrument that measures the number concentration of small particles with high efficiency.

EA - Programming

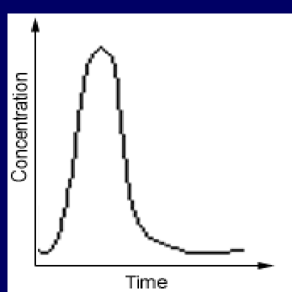
(4/4)

Data Collection:

- Passenger census (number & time spent on platform 447 individuals over 1 day)
- Aerosol sampling (SMPS)

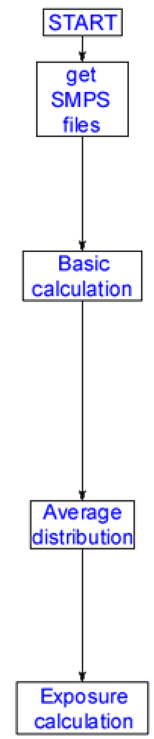
Data Analysis

- Combination of passenger census to measured particle concentrations to estimate individual exposures over 7 days (=1992 cases!)



$E = t \cdot c$

Dr. Aaron Wiegand

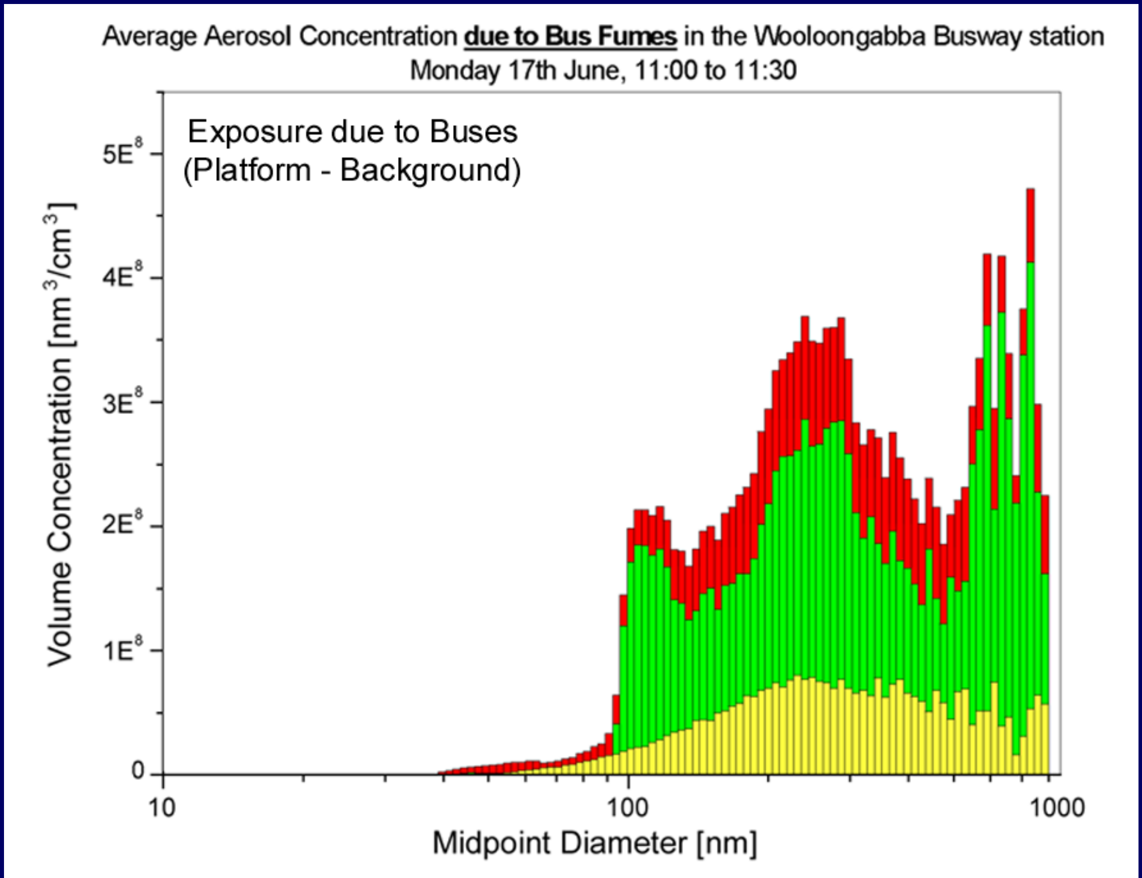


- based on waiting time of passenger, choose appropriate SMPS files
- calculate d_{MP}, d_A, d_V, and statistics of each SMPS file used
- calculate average distribution & stats of used SMPS files
- deduct background data and calculate absolute exposure

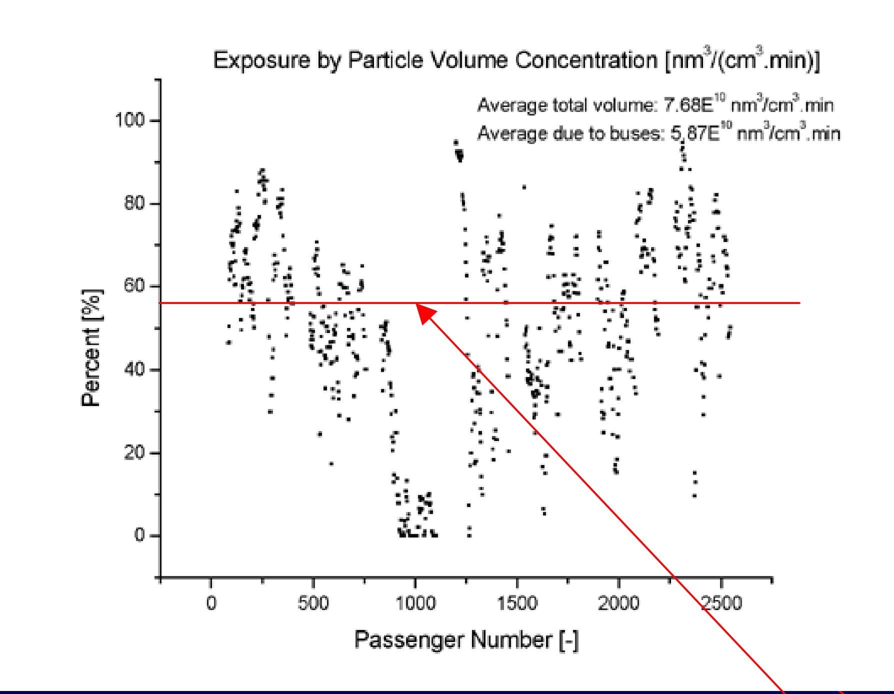
Results & Evaluation (1/3)

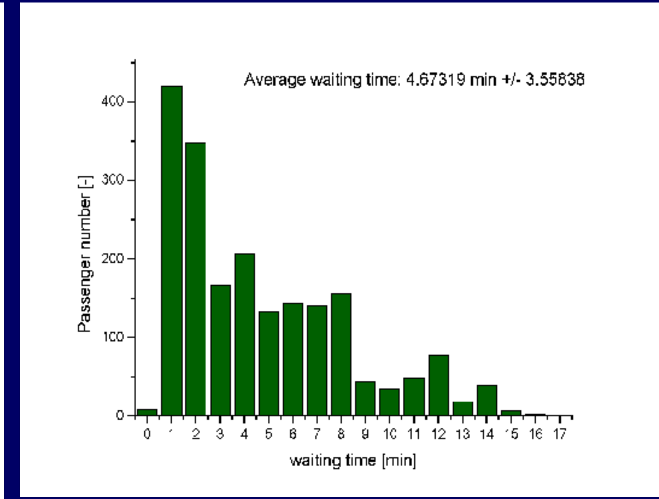
Particle Size Distribution

- Background data (Streetlevel - yellow)
- Platform data (Waiting area - red)
- Due to exposure (green)



Results & Evaluation (2/3)





Average waiting time

- 4.7min (1.2 – 8.2min)

Exposure due to Busses

- Particle load 37%
- Mass load 56%

Results & Evaluation (3/3)

Risks of Soot Inhalation – Health Effects-Dirty Diesel

- t_{AVG} * std breathing rate for a 70kg adult of 11L/min at rest = 51.7L of air inhaled (or 30kg child: 9.4L/min = 44.2L);
- multiplied by the $V_{C\text{-}AVG}$ of $1.64E^{10}$ nm^3/cm^3.min = $848E^{-12}cm^3$ (= $725E^{-12}cm^3$);
- Assigning a unit density of diesel ρ=1g/cm^3 and 100% deposition, yields an inhaled particle mass of 848pg (725pg);
- of which 56% are due to buses, i.e.: 475pg (406pg) in only 4.7mins!
- In one year (260 weekdays) this amounts to 123ng (105ng)
- Or a lifetime exposure (adults only) 3.7μg;

3-nitrobenzanthrone as part of diesel exhaust is the most carcinogenic substance known;

Conclusions & Recommendations

Summary

- A methodology has been developed with which the contribution of bus emissions to particle exposures can be estimated experimentally.

Conclusions

- The mean fraction of ultrafine particles in the W'Gabba bus station due to buses is 37% by number or 56% by volume and mass,
- The mean single exposure of an individual at W'Gabba due to diesel soot particles from buses is 475pg (406pg) in only 4.7mins!

Recommendations

- Methodology: use 2 SMPS to measure background and platform concentrations at the same time (rapid variation in ambient conditions make interpolation of measurements uncertain).
- W'Gabba Busway Station: as buses contribute such a large fraction of the particles to which waiting passengers are exposed, we recommend that buses do not wait at the platform edge for long periods of time with the engine idling (unless CNG- / H_2-powered busses are used or platform architecture is altered to allow better ventilation).

…. and finally ….

Thanks for YOUR attention