South Coast Air Quality Management District

Ultrafine Particle Conference

April 30 – May 2, 2006

Understanding the Potential Ultrafine Particle Pollution Problem and its Impact on California's Air Quality

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Chair

California Air Resources Board

California Environmental Protection Agency
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Ultrafine particle toxicology is a research priority

Combustion-generated ultrafine particle emissions is a research priority for CARB as some research evidence suggests that ultrafine particles may be important in the inducement of adverse health effects, but the toxicology of ultrafine particles is remains poorly understood.

Until the science of ultrafine particle toxicology gives better guidance, we will continue to use particle mass as the best indicator of PM related adverse health effects.

Intriguing health-related findings

Ultrafines

- Create greater inflammatory response than fine PM
- Affect heart rate variability
- Are more potent in inducing cellular damage than fine PM
- May be associated with premature death

Why are ultrafine particles harmful?

Little mass, but:

- **Possess large surface area and numbers**
- **Contain toxic components (e.g. metals, organics)**
- **Initiate harmful oxidant injury in lung**
- **Have high deposition rate in the lung**
- **Can access circulatory system and move from lungs to other organs**

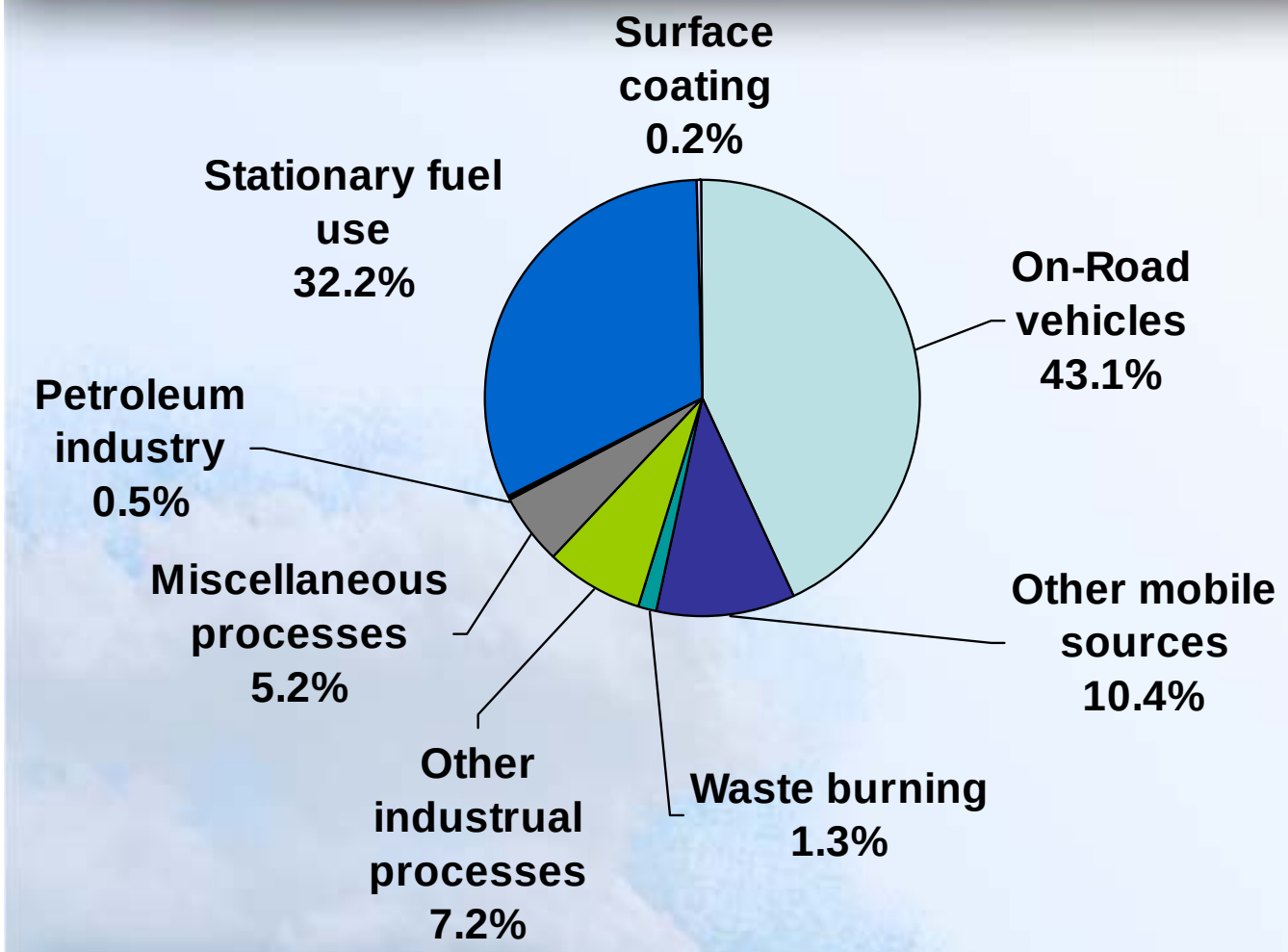
Particle size and composition: relation to toxicity

	Coarse	Fine	Ultrafine
Size	2.5-10 μm	0.15-2.5 μm	<0.15 μm
Organic carbon content	+	++	+++
Elemental carbon content	+	++	+++
Metals as % of total elements	+++	++	+
PAH content	+	+	+++
Redox activity (DTT assay)	+	++	+++
HO-1 induction	+	++	+++
GSH depletion	+	+++	+++
Mitochondrial damage	None	Some	Extensive

Li et al., CI (2003)

Sources of ambient ultrafine particles (<100 nm)

Source contributions to primary ultrafine particle emissions in the South Coast Air Basin (1996)



Primary ultrafine particle originate almost exclusively from combustion sources.

Cass et al., PTRSL (2000)

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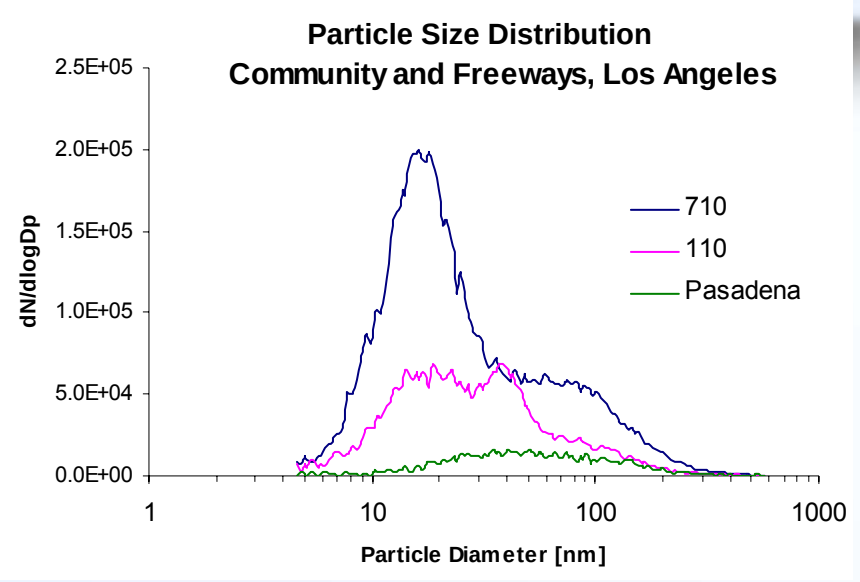
Exposure and diurnal variations

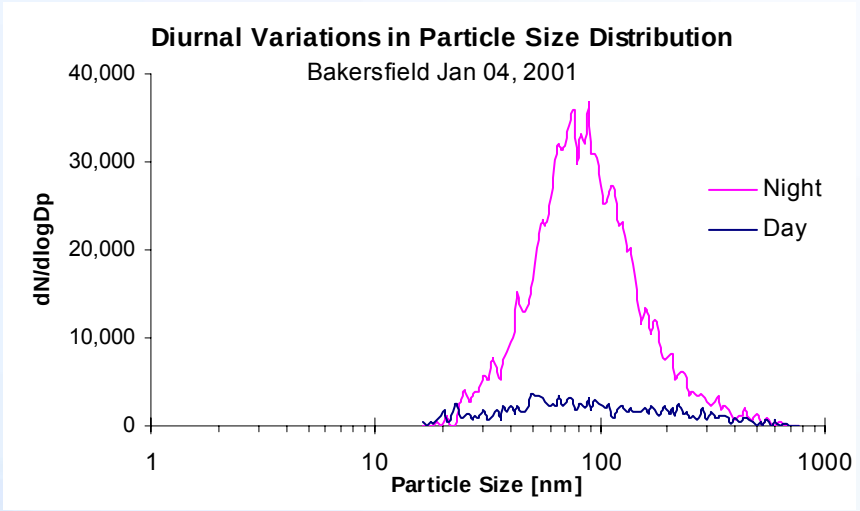
Exposure to ultrafine particles is very different on a freeway dominated by diesel trucks (710), or by light-duty vehicles (110), and in the community.

Westerdahl and Fruin, AE (2005)



Diurnal variations of ultrafine particle concentrations in the community can be significant. In the San Joaquin Valley, emissions from evening wood burning can greatly increase concentrations.

Herner and Kleeman, unpublished



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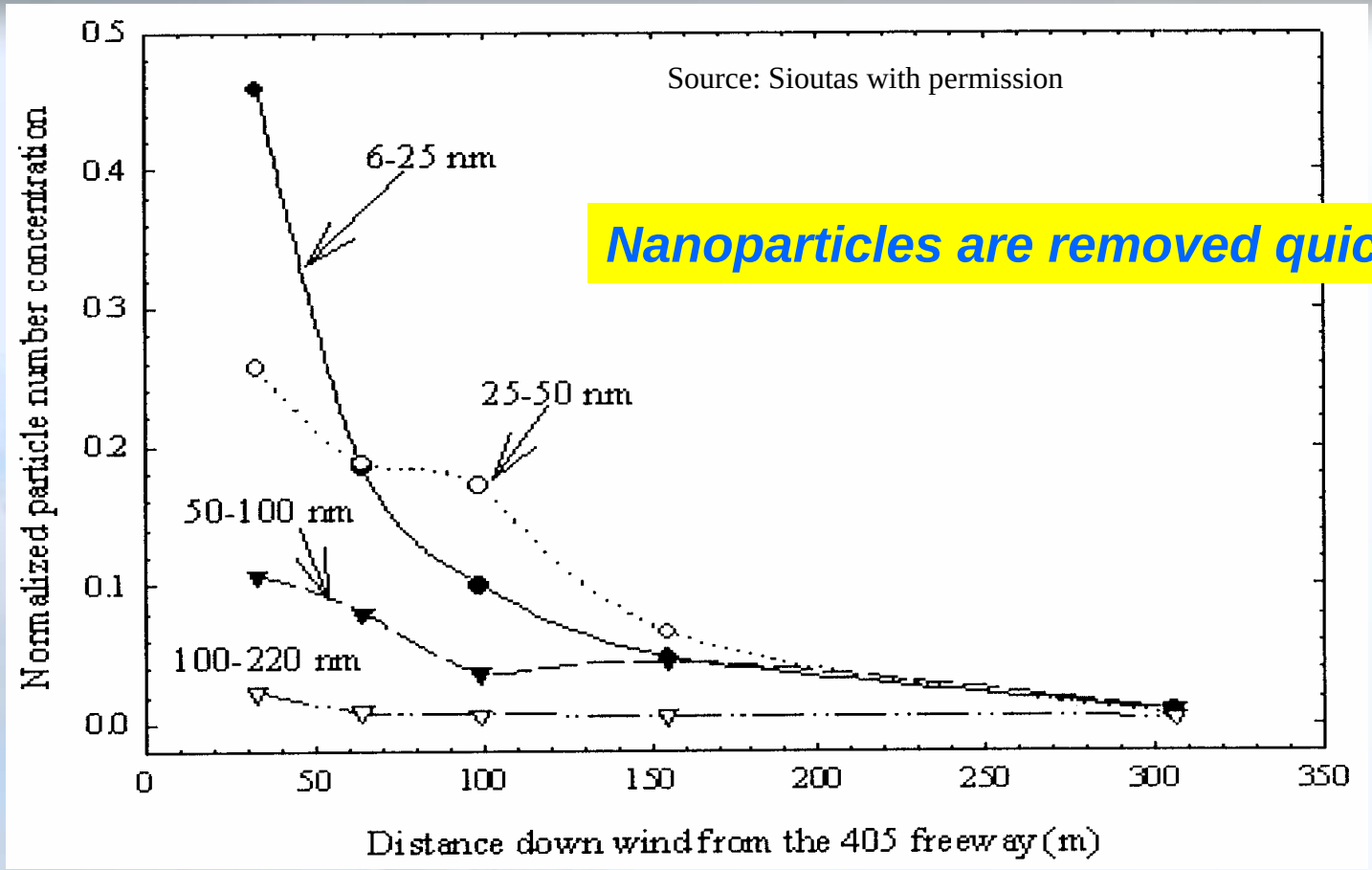
Freeway traffic impacts



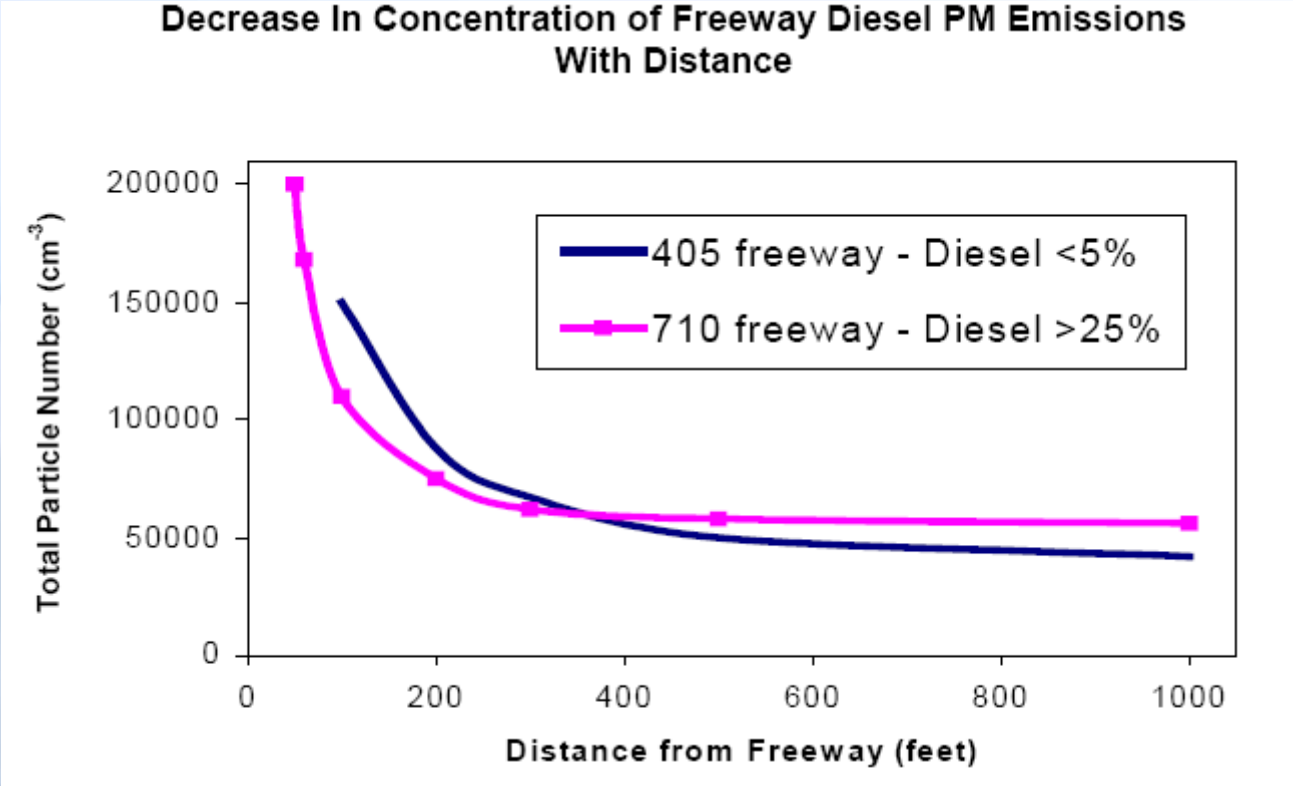
Nanoparticles are removed quickly

"This behavior is best explained by dilution and condensation/evaporation"

Zhang et al., AE (2004)

Application to land-use planning

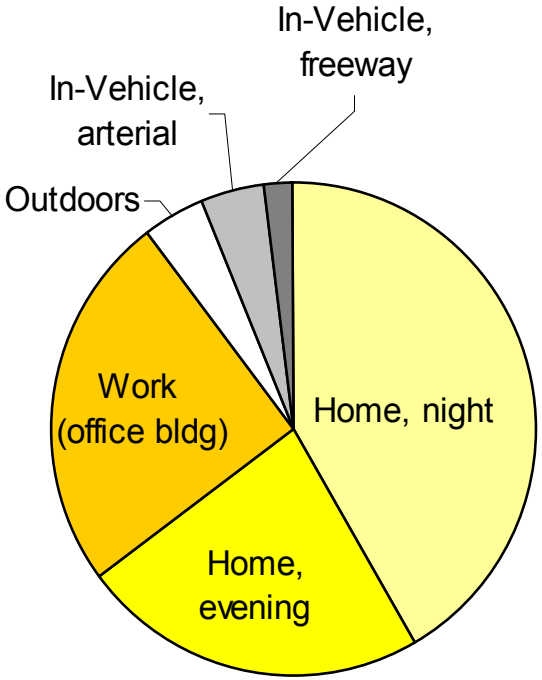
Air Quality and Land Use Handbook: A Community Health Perspective (www.arb.ca.gov/ch/landuse.htm)



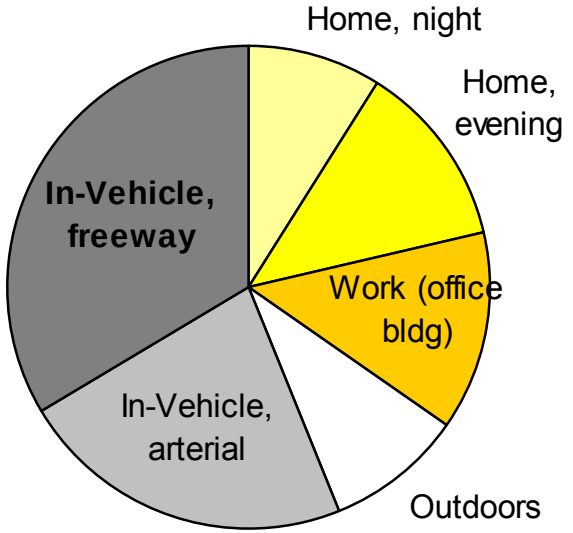
Zhu et al., AE (2002)

In-vehicle fraction of total exposure

6% of day spent driving can represent up to 50% of our exposures



Average Time Spent



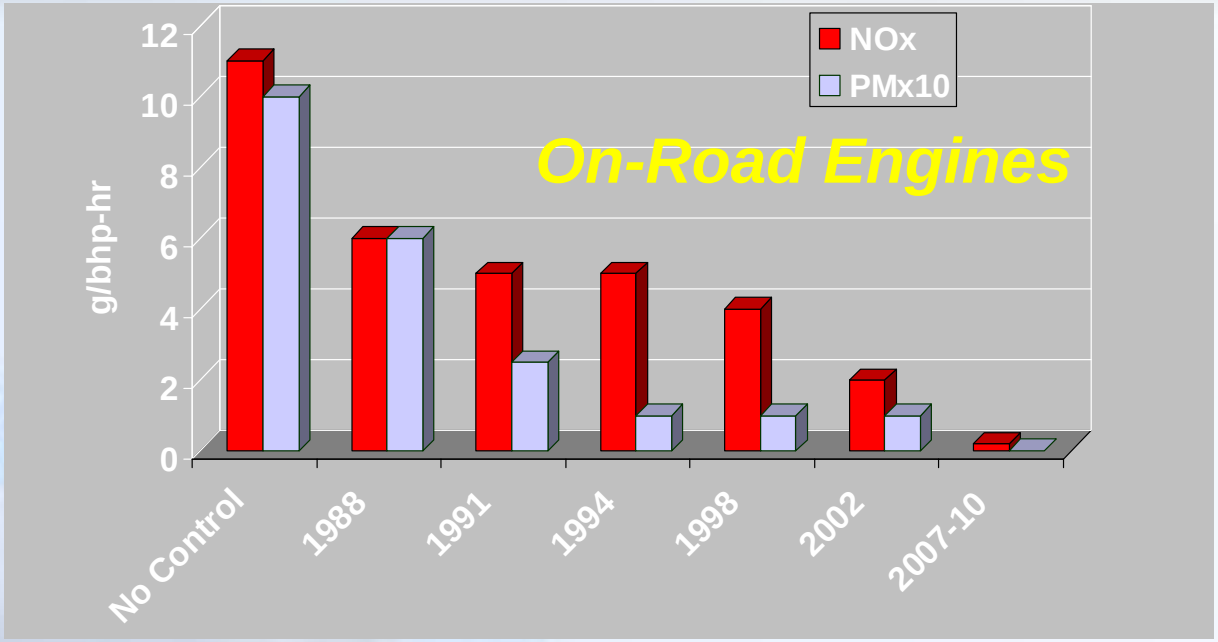
Contribution to Exposure

Fruin, ARB (2004)

Emissions from internal combustion engines

- Ultrafine particle emissions are not a “diesel-only” problem
- More stringent emission standards will lower mass
- Control technology for solid particles
- Agreed-upon measurement protocols for ultrafine particle emissions from vehicles still emerging
- Nucleation events observed driving on road

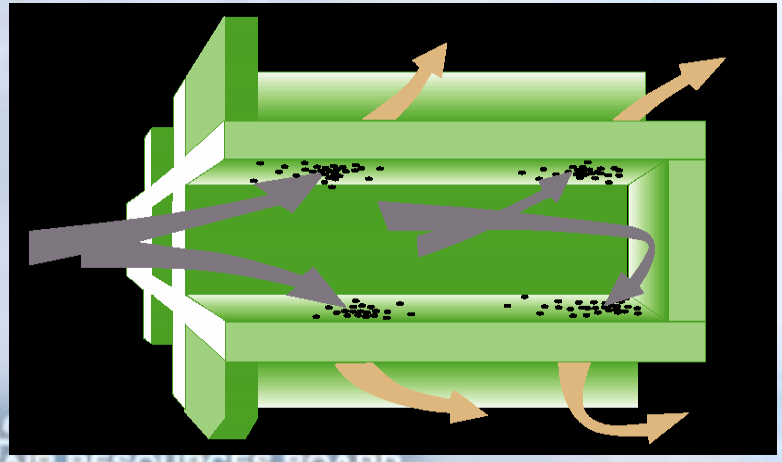
New diesel engine standards will control PM mass emissions

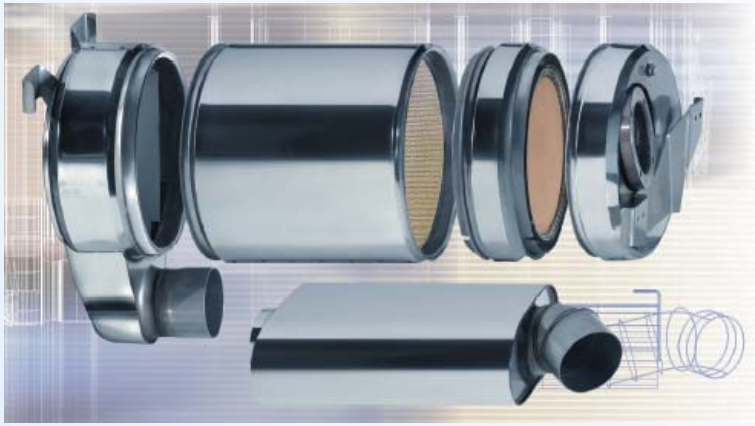


PM mass control does not automatically imply ultrafine particle number control

Diesel particle filter (DPF) is the key enabling technology for Diesel PM emission reduction

Diesel Particulate Filters





Laboratory measurements suggest reduction of diesel ultrafine particle emissions by traps

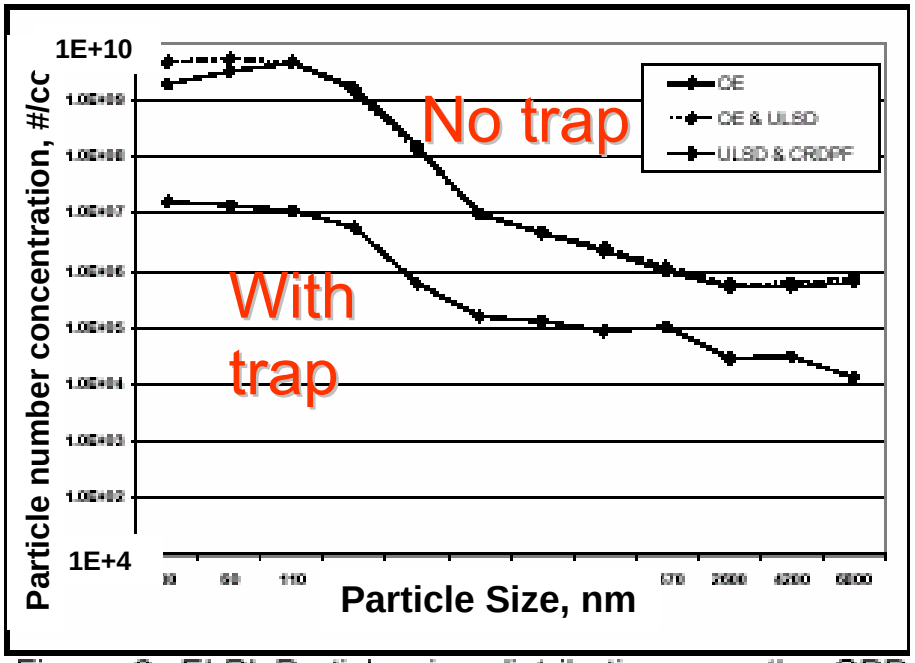
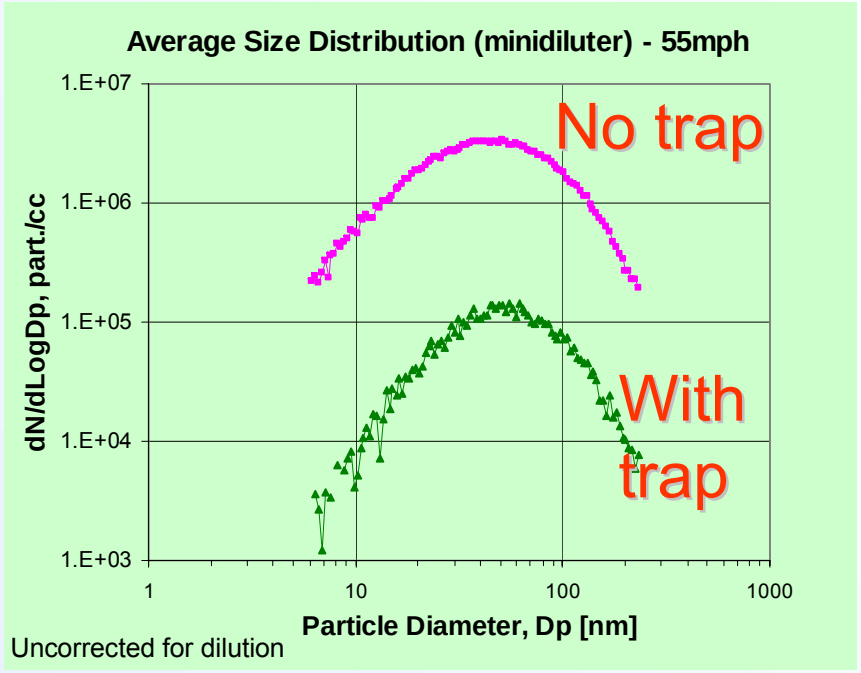


Figure 8: ELPI Particle size distribution over the CBD cycle during phase II emissions tests

Chatterjee et al., SAE (2002)



Holmen and Ayala, ES&T (2002)

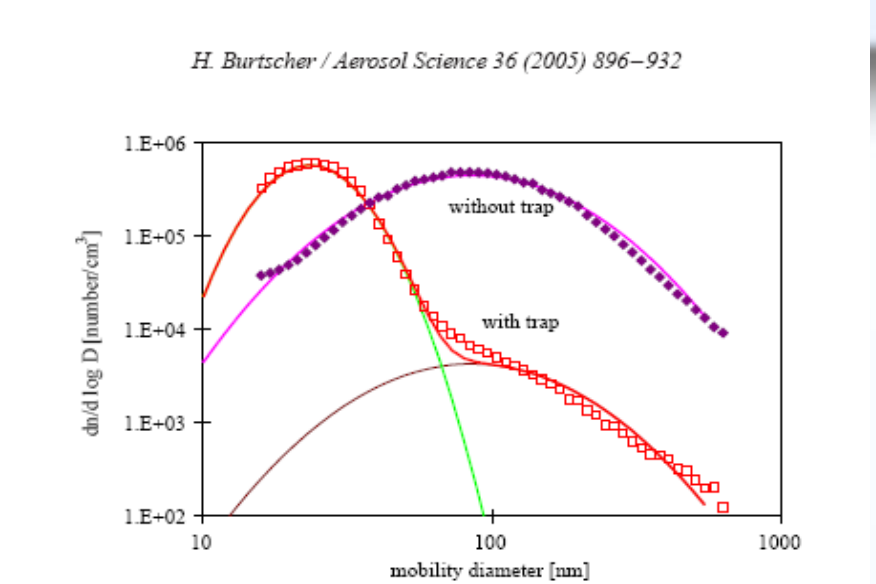
Potential for formation of nuclei mode particles during “real world” driving

There is concern that the use of DPF increases the number of nanoparticles. The contention is that post tail-pipe sulfuric acid and organic vapors are now nucleating rather than condensing onto the removed soot particles.

Burtscher, JAS (2005)

On road measurements behind a CRT-equipped diesel truck had a distinctive nucleation mode. Authors suggests nucleation will happen after degreening of catalyzed traps.

Kittelson et al., JAS (in press)



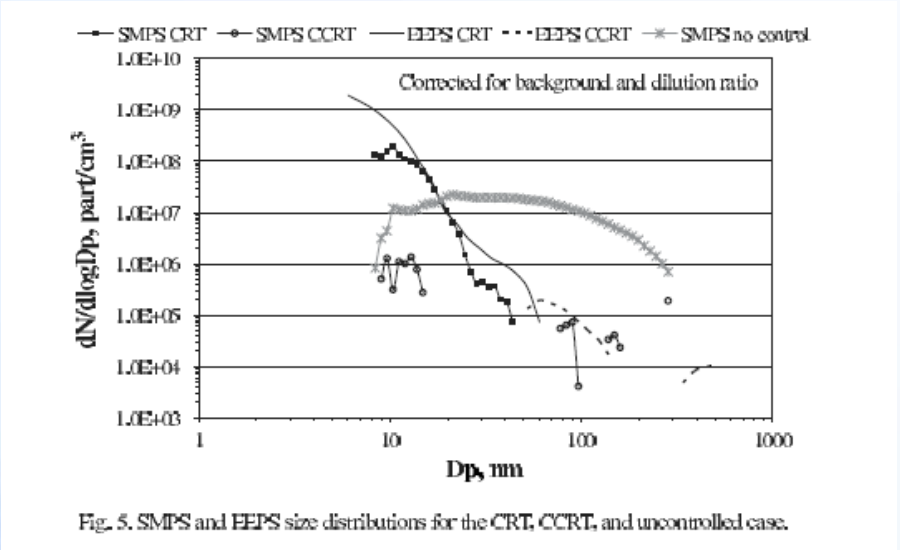


Fig. 5. SMPS and EEPS size distributions for the CRT, CCRT, and uncontrolled case.

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ARB investing heavily in UFP measurement technology to advance our understanding

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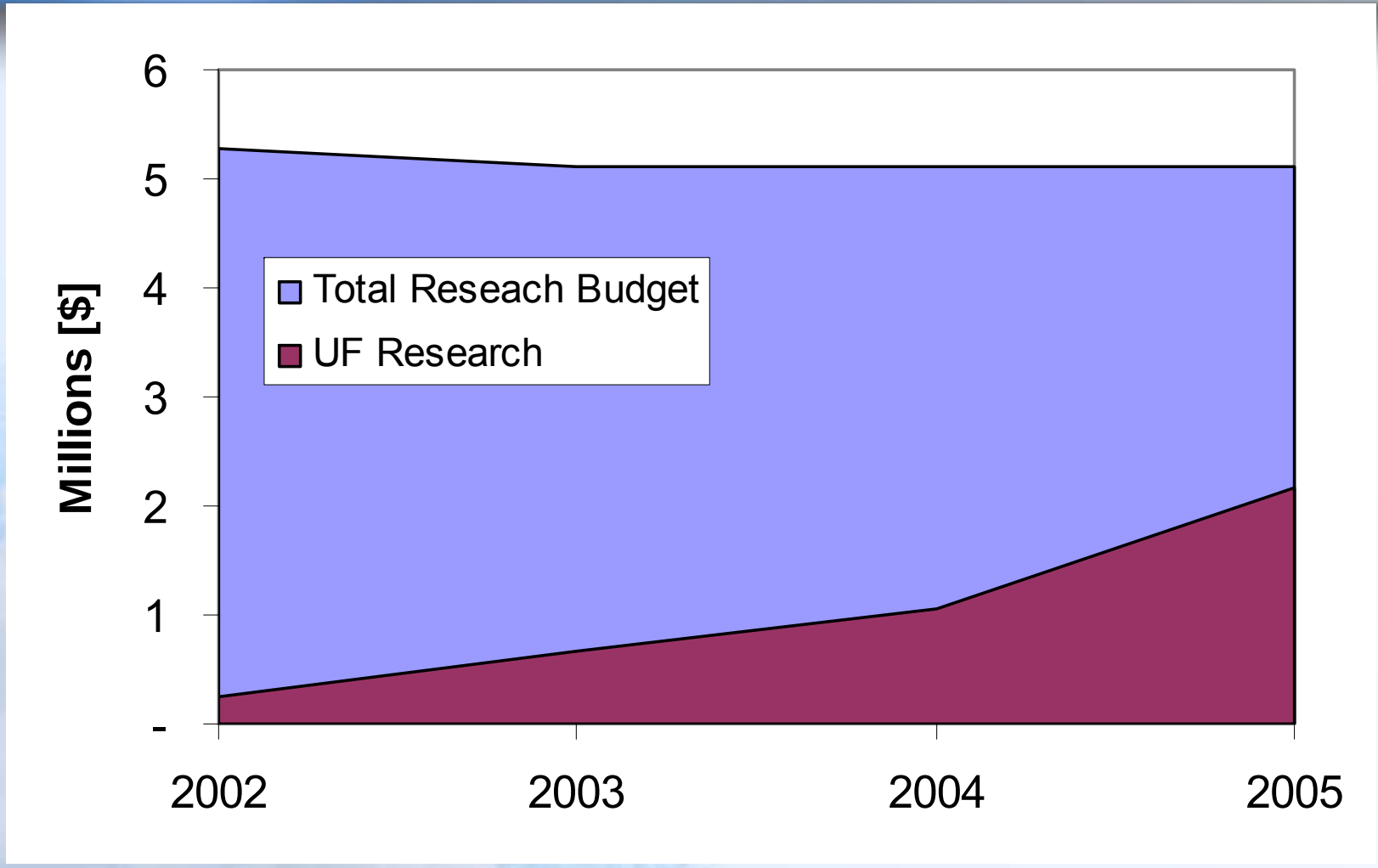
Extramural research portfolio on UF particle studies



On-going CARB-sponsored research

Health and Exposure

- Extension of NIH Cardiovascular Health Study – UCI/USC/UCLA
- Cardiovascular effects of fine and ultrafine particles during freeway travel – UCLA
- Ultrafine particles and black carbon at LAX – UCLA
- Ultrafine particles in schools and homes – UCB
- Spatial distribution of ultrafine particles in community air – USC
- Spatial gradients of pollutants in Wilmington using a mobile monitoring platform – UCLA/CARB staff

Emissions and Control

- Toxicity of emissions from heavy-duty and light-duty vehicles – USC/UCLA/CARB staff
- Evaluation of the European Particle Measurement Program (PMP) protocol for measuring solid particles – UCR/CARB staff

Final remarks

- **Ultrafine particles may be responsible for adverse health effects distinct from $PM_{2.5}$ mass, but mechanisms are poorly understood.**
- **Exposures to ultrafine particles are highest near combustion sources.**
- **It is important to ensure that particle counts are reduced in conjunction with particle mass.**
- **Understanding of these issues is an important research priority for CARB.**
- **The results are important to future air quality standards and regulatory programs.**