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California's Efforts for Advancing Combustion-generated Ultrafine Particle Research

Alberto Ayala and Jorn Herner

Research Division

California Environmental Protection Agency

Air Resources Board

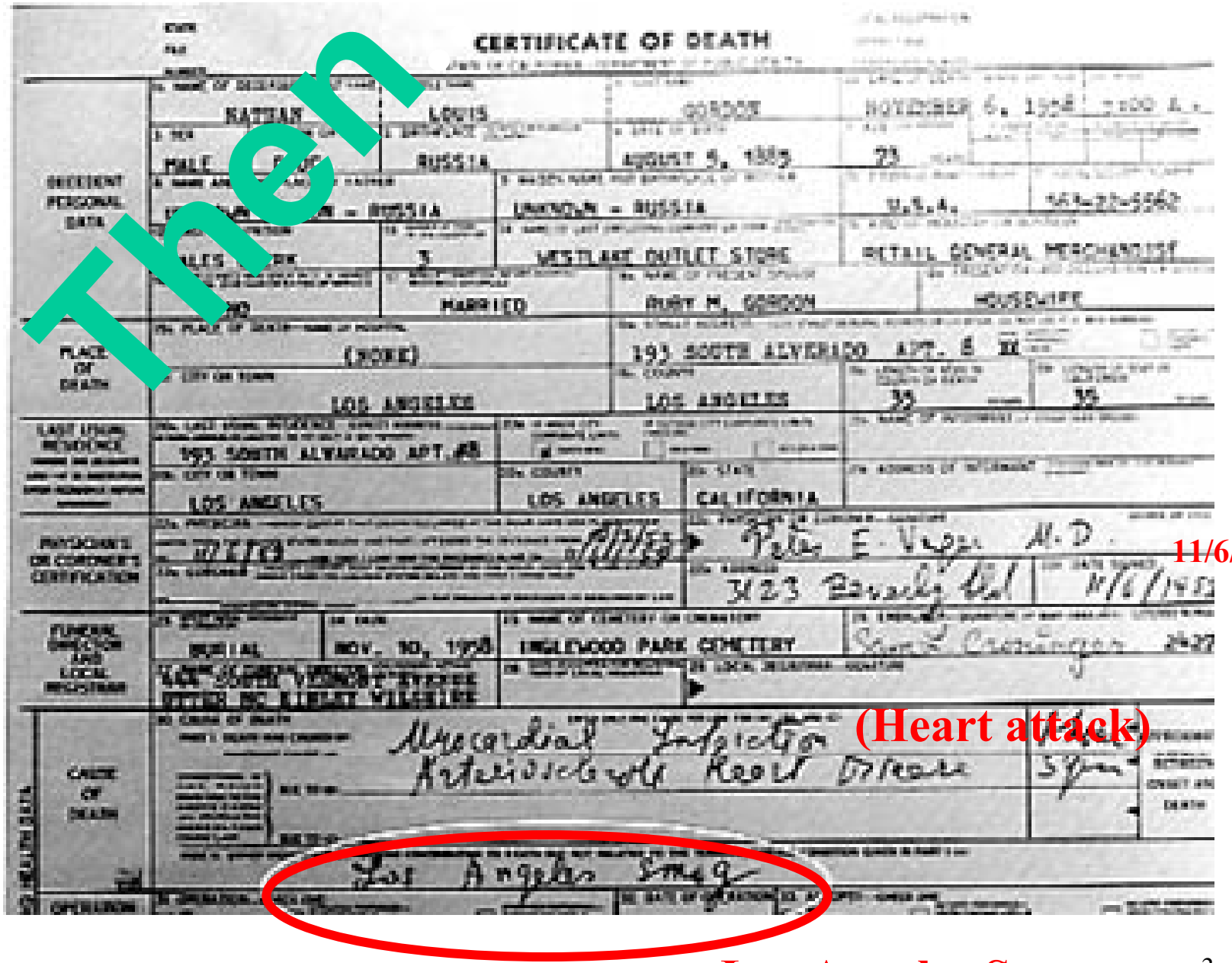
PRESENTATION ABSTRACT

Particulate matter (PM) pollution in California is still a concern and the growth in the emission burden from on-road vehicles continues to outpace the implementation of control strategies and the emergence of lower-emitting vehicles in the in-use fleet. Of special concern are heavy-duty diesel engines, which remain major contributors to the PM and NOx inventories. In addition, interest in combustion-generated ultrafine particle (UFP) emissions is high on the list of research priorities for the California Air Resources Board (CARB) as mounting research evidence suggests that UFPs may be the primary actors in the inducement of adverse health effects via mechanisms that are still poorly understood. Therefore, the need is paramount for robust methodologies to measure accurately and precisely tailpipe emissions of total PM and UFPs includingan on-vehicle PM sampling methodology or a surrogate for determining over-the-road “real world” emissions.

For these reasons, and recognizing the limitations of the gravimetric method for exhaust PM measurements, CARB has developed promising partnerships with European counterparts and CARB staff is following with great interest the progress of important efforts such as the UN-sanctioned Particle Measurement Program (PMP) and the work of the Swiss Agency for the Environment, Forests, and Landscape to limit the number of UFP emitted by diesel-powered vehicles

One objective in CARB’s current research portfolio is to conduct a critical evaluation of newly proposed methods for determination of UFP emissions and their potential in California for compliance testing. The effort may be a two-pronged approach. First, the technical merits of the new protocols such as that proposed by the PMP program would be evaluated critically, giving consideration to all of the technical aspects associated with the correlation of solid particle number emission measurements and measurements of total particle mass under the existing certification guidelines. CARB has obtained the required instrumentation dictated in the PMP method. Thus, some of the necessary assessment work will be carried out in house. The second phase would involve an investigation of the potential for application for in-use compliance testing. This task is not trivial and would entail establishing a universal and statistically significant alternative metric to supplement or replace the established protocol.

The U.S. was absent from global initiatives such as the PMP as the U.S. EPA declined to participate actively. However, we acknowledge that the European efforts have generated leading and state-of-the-science advances in metrology for engine emissions and we attempt to leverage all available lessons in an integrated effort for the benefit of air quality in California.



Courtesy of Dr. N. Steele

Now...

Do Particles Play a Role in Heart Disease?

- Recent study found association with being in traffic and heart attack in following hour[1]
- Study of North Carolina troopers found changes in cardiac rhythm and blood markers of inflammation and coagulation[2]
- Proposed CARB study of ultrafine particles from freeway driving and cardiovascular and blood marker symptoms

Courtesy of Dr. S. Fruin

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[1] *Peters, A., von Klot, S., Heier, M., Trentinaglia, B.S., Hörmann, A., Wichmann, E., Löwel, H. 2004. Exposure to traffic and the onset of myocardial infarction. New England Journal of Medicine 351 (17):1721-1730.*

[2] *Reidiker, M., Cascio, W.E., Griggs, T.R., Herbst, M.C., Bromberg, P.A., Neas, L., Williams, R.W., Devlin, R.B. 2004. Particulate matter exposure in cars is associated with cardiovascular effects in healthy young men. Am J Respir Care Med 169:934-940.*

Current Projects

Emission inventory update

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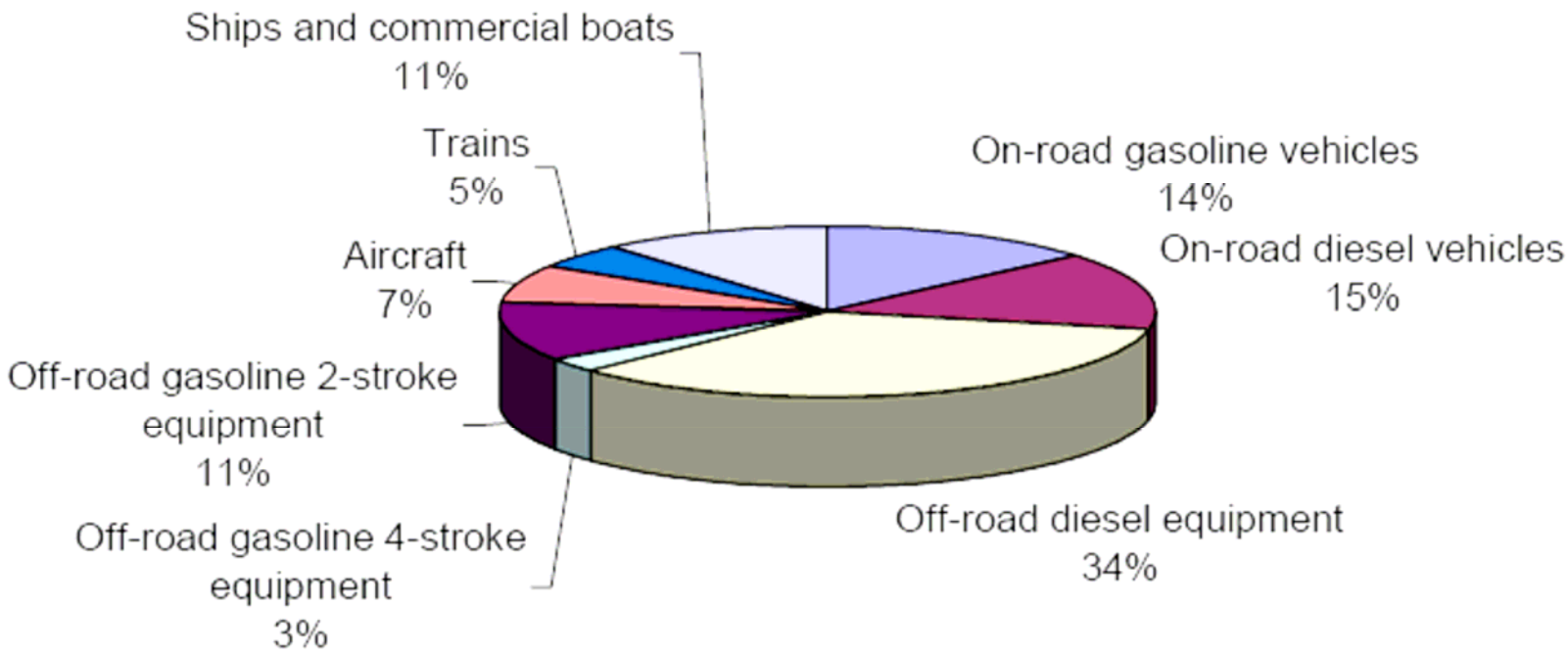
Monitoring ultrafine particles in ambient air, inside passenger cabin in vehicles, and from tailpipe exhaust

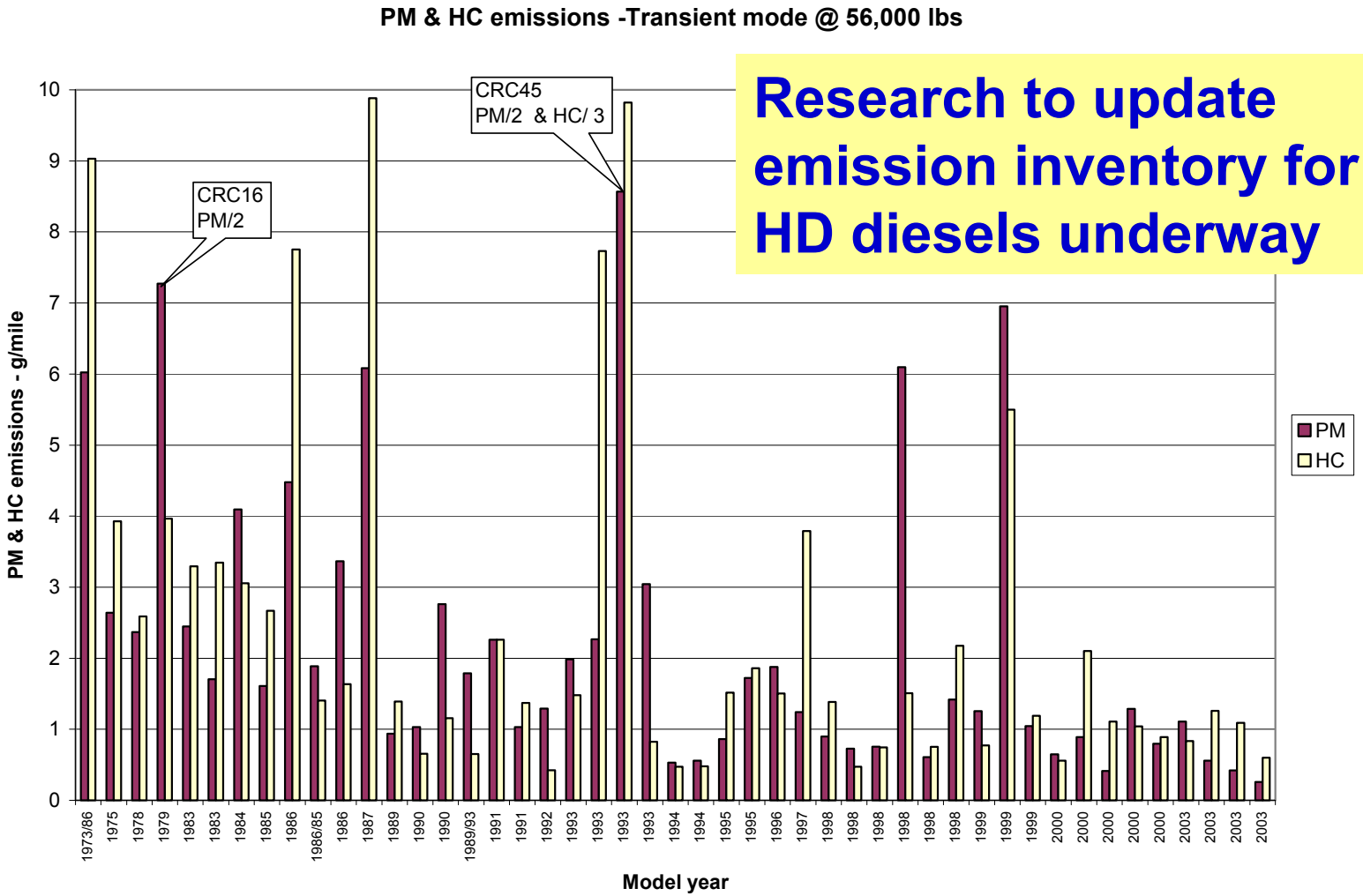
2005 California Emission Inventory for Mobile Sources



Our efforts will continue to be focused on reductions from all key sources:

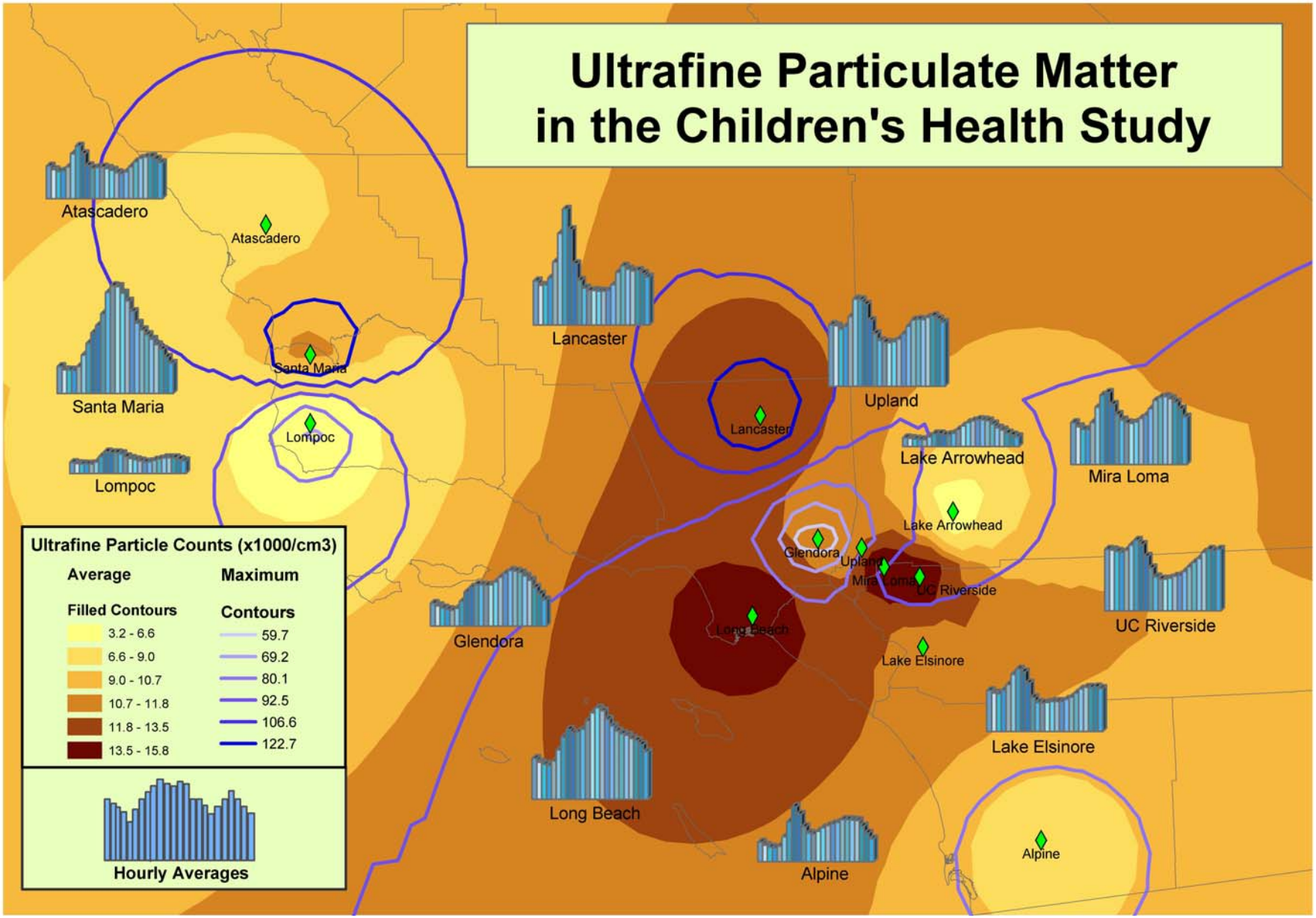
- **–On-road gasoline vehicles because of number of vehicles**
- **–On-road diesel vehicles because of amount of emissions per vehicle**

The growth in the use of the diesel engine and its increasing contribution to the PM and NOx inventories continues to outpace the deployment of control strategies and the introduction of lower-emitting engines



Research to update emission inventory for HD diesels underway

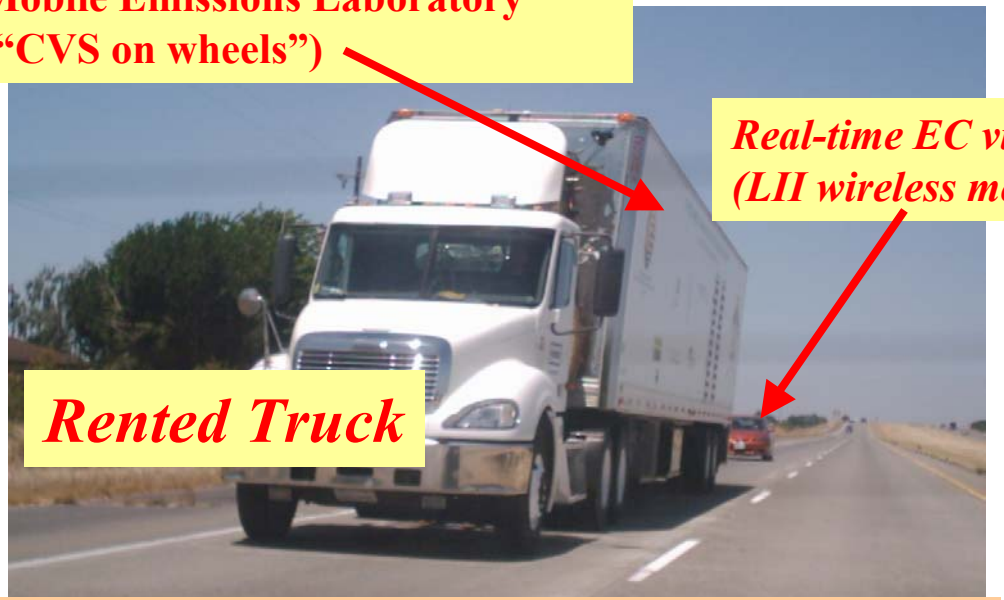
What are the implications of high PM emitters?

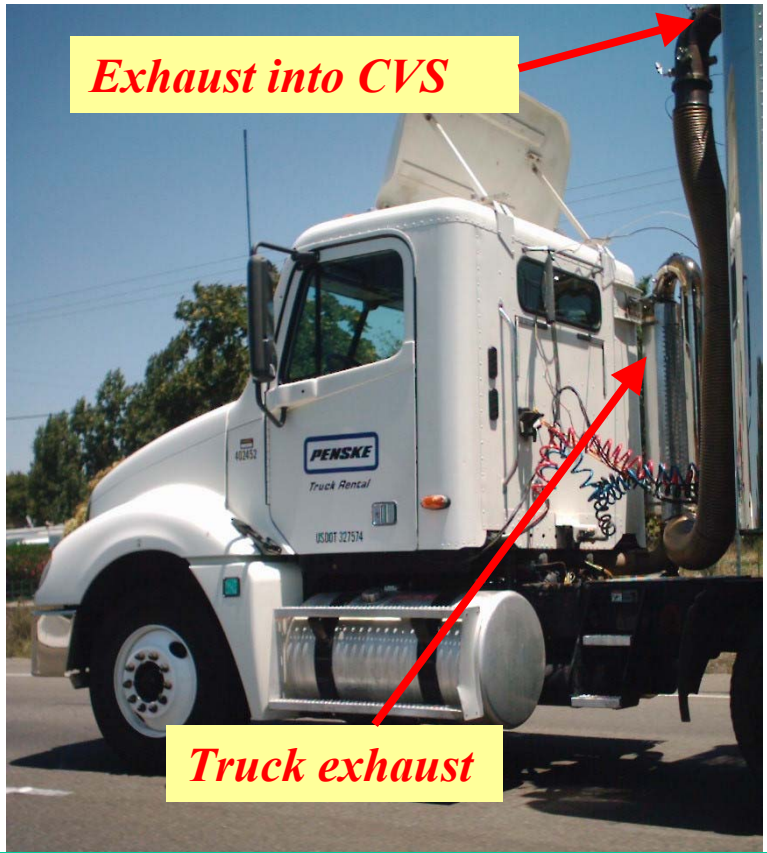


Reference: Singh, M., Phuleria, H., Bowers, K.L., and Sioutas, C., (2004). "Seasonal and Spatial Trends in Particle Number Concentrations and Size Distributions at the Children's Health Study Sites in Southern California." Journal of Exposure Analysis and Environmental Epidemiology, in press.

Real-world On-road Emissions

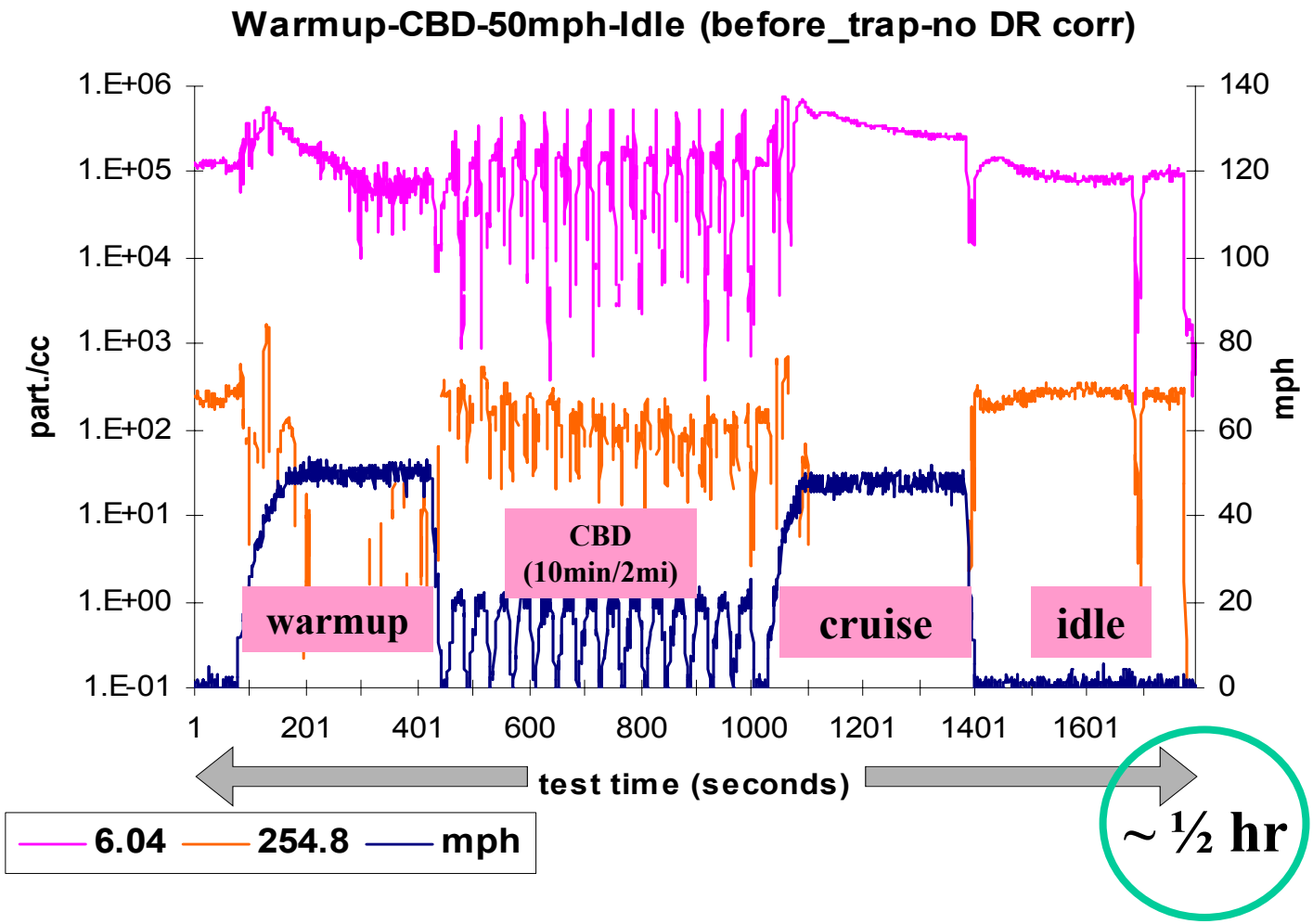
University of California, Riverside
Mobile Emissions Laboratory
("CVS on wheels")





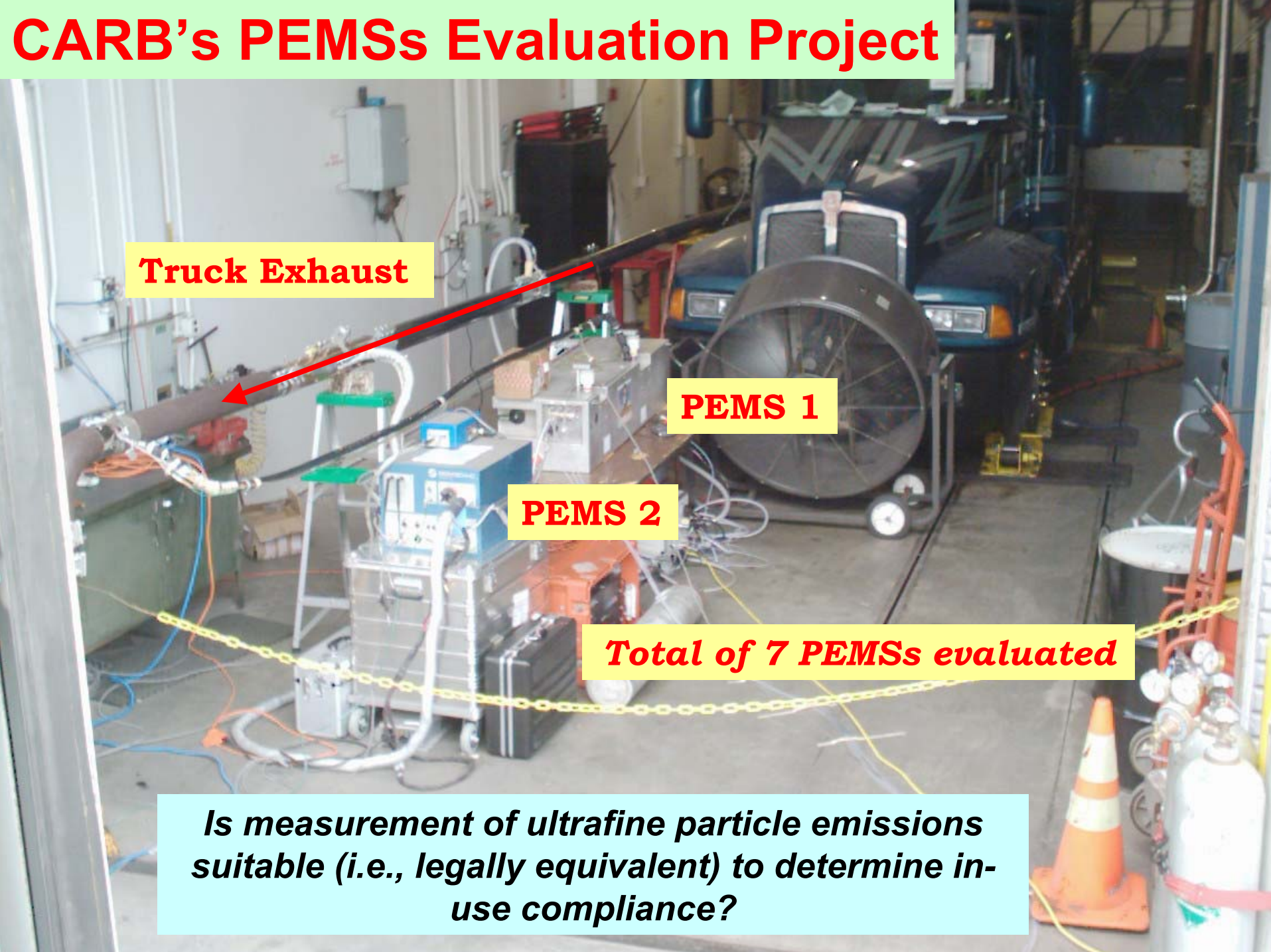
Simultaneous ultrafine particle emission measurements for CVS & over-the-road are possible

New capacity in metrology (real-time particle sizing)



*Source: Ayala, A. and J. Herner, "Transient Ultrafine Particle Emission Measurements with a New Fast Aerosol Sizer for a Trap Equipped Diesel Truck," SAE Tech. Paper, **2005**, Accepted.*

CARB's PEMSs Evaluation Project



Is measurement of ultrafine particle emissions suitable (i.e., legally equivalent) to determine in-use compliance?

CARB/SANDIA/NRC-Canada/Artium Collaborative PM Emissions Research

Comparison of LII and filter-based PM measurements (chassis dynamometer testing)

New Projects

Leveraging significant European progress and contributing to fill data gaps

CARB's Research Portfolio on Combustion-generated Ultrafine Particle Research

- **Project 1: "*Evaluation of the New European Methodology for Determination of Particle Number Emissions and its Potential in California for In-use Screening*"**
  - **In-laboratory assessment of PMP protocol**
  - **Over-the-road testing**
  - **Focus on trap-equipped heavy-duty diesel vehicle (2007 compliant)**
  - **Chassis dynamometer testing**
- **CARB/UCR/European Researchers? Collaboration**

Project 2:

- **Solid particles are "assumed to be better related to health impact" than volatile particles**

- **This assumption is important and requires investigation:**

- **"*Physicochemical and toxicological assessment of the semi-volatile and non-volatile fractions of PM from heavy- and light-duty vehicles operating with and without emissions control aftertreament*"**

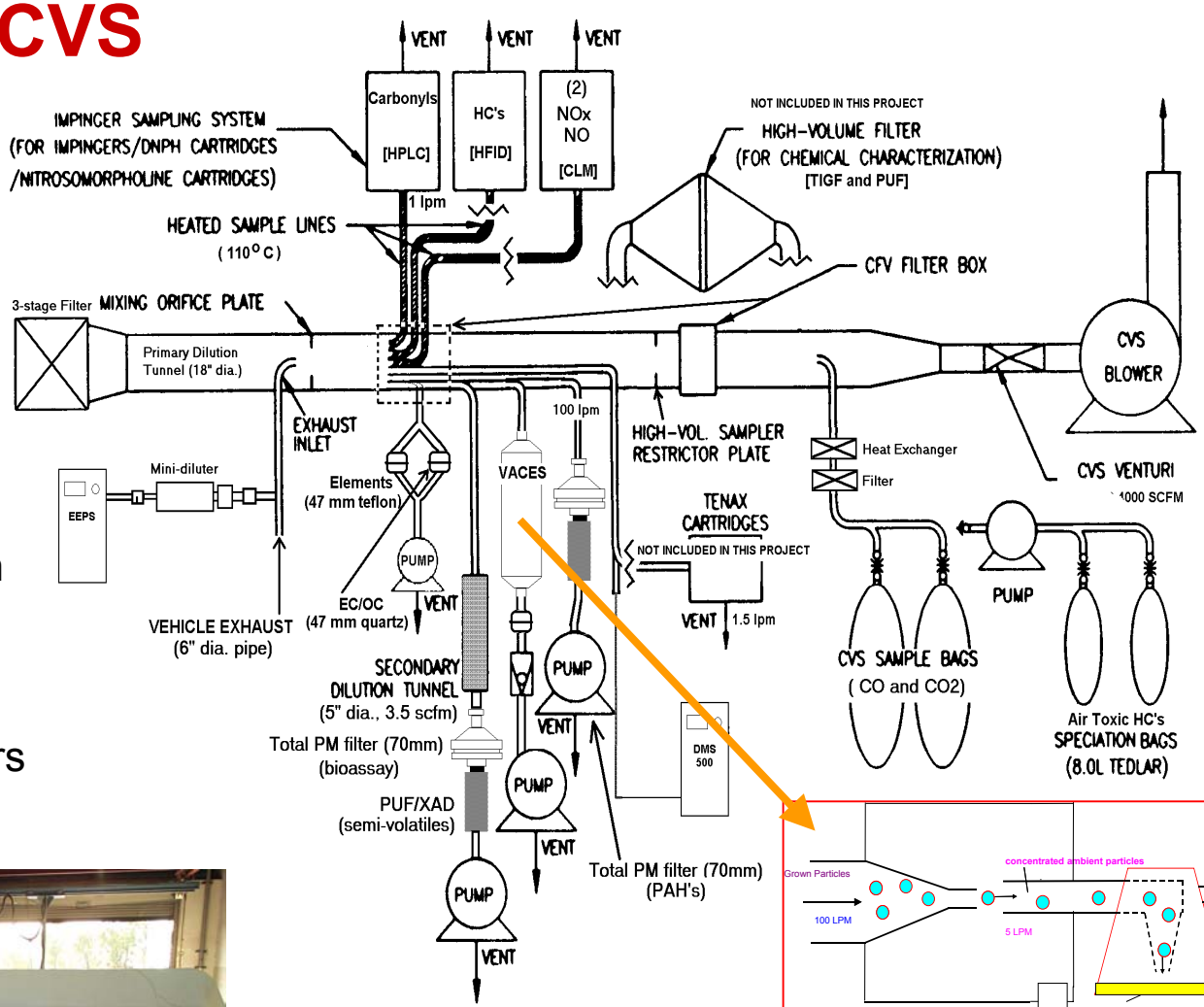
- **CARB/University of Southern California/University of California, Los Angeles Collaboration**

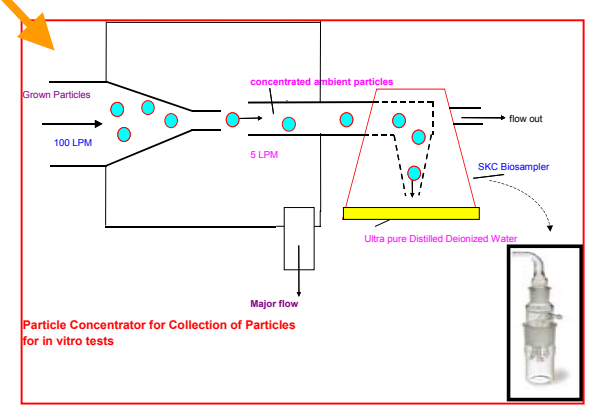
- **Funded by CARB and South Coast Air Quality Management District**

Project plan:

- Regulated + unregulated emissions
- Ames assay
- UCLA - reactive organic species formation and electrophilic chemistry
- Sample collection with USC particle concentrator (VACES)
- Fast particle sizers

CVS





Multiple types of vehicles (HD diesel with DPF, DPF + SCR, CNG + OC, HD gasoline, light-duty gasoline)

MEMORANDUM OF UNDERSTANDING

NO.XXXXXXXXXXXXXXXX

between the

EUROPEAN COMMISSION
DIRECTORATE GENERAL JOINT RESEARCH CENTRE

and the

CALIFORNIA AIR RESOURCES BOARD

on

EMISSIONS AND AIR QUALITY

The European Community, represented by the Commission of the European Communities, hereinafter referred to as "the Commission", represented for the purpose of signing this Memorandum of Understanding by Mr Roland Schenkel, Acting Director General of the DG JRC,

on the one part,

The California Air Resources Board (hereafter referred to as CARB) represented for the purpose of signing this Memorandum of Understanding by Ms. Catherine Witherspoon, Executive Officer, CARB,

on the other part,

Hereafter referred to individually as 'the Party' or collectively as 'the Parties'

PREAMBLE

Whereas the California Air Resources Board is part of the California Environmental Protection Agency whose missions is to promote and protect public health and welfare through effective and efficient reduction of air pollutants. Major goals of the CARB include providing leadership in implementing and enforcing air pollution control

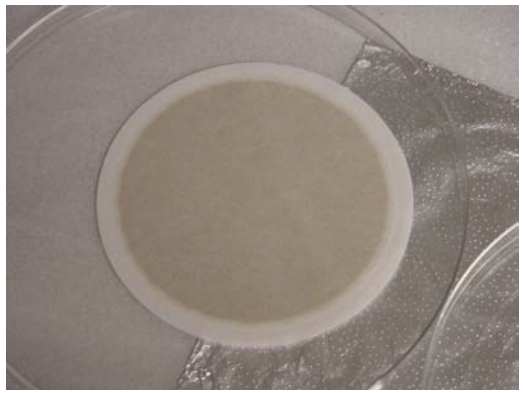
Advancing international cooperation with new JRC & CARB partnership

Focus:

- **Mass emission measurement (in lab and on-vehicle)**
- **Ultrafine particle emissions & PMP**
- **Source apportiontment**

In IC diesel engine mobile emissions world

Will



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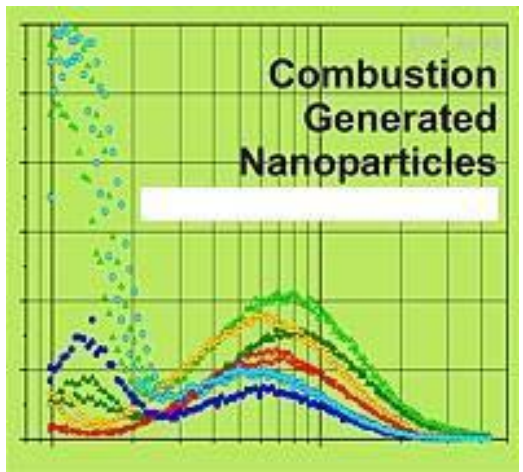

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or should it?