

17th CRC ON-ROAD VEHICLE EMISSIONS WORKSHOP

San Diego, California

March 26-28, 2007

Session 1: Diesel Vehicle Emissions

**Emissions Measurements from the
Golden Vehicle –
*A Light Duty Diesel Vehicle Used During
Validation of the European PMP
Protocol***

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California Air Resources Board

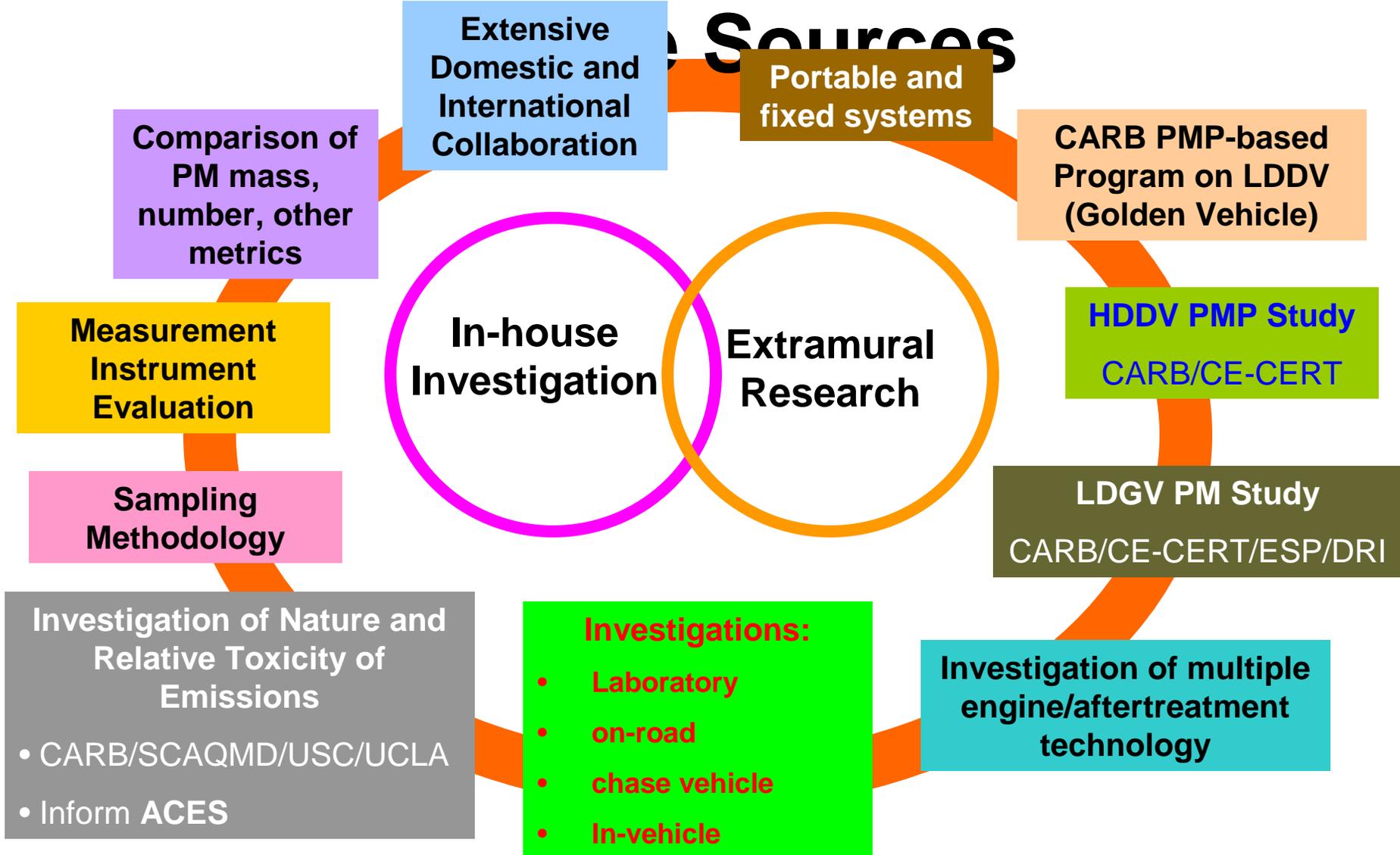
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TSI, Inc.

Qiang Wei

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- Dr. Tom Durbin and others at UCR/CE-CERT
- Dr. Markus Kasper/Matter Engineering AG
- Jon Andersson/Ricardo UK Ltd

CARB's Research Portfolio on Ultrafine Particle Emissions from Sources



CARB PMP-based Program

Study Drivers

- Potential health impacts of ultrafine particles
- CARB and JRC Memorandum of Understanding (MOU) for Research
- Need to understand the potential of the new European proposal for particle # emission standard
 - Assess robustness of PMP Protocol vis a vis gravimetric measurement
 - Evaluate non-specified particle counters, alternative systems, and dilution methods
- CARB is exploring PMP's utility and "*enriching the main programme*" for LDVs and HDVs
- Investigate nature of particles emitted at the tailpipe and their relative toxicity

UNECE-GRPE Particulate Measurement Programme (PMP)

- Initiating governments: France, Germany, Netherlands, Sweden, & UK. Joined by Switzerland, Japan, and Korea
- Key objective: *“Development of type approval test protocols for assessing vehicles fitted with advanced particulate reduction technology that would complement or replace current legislative measurement procedures”*
- Main driver behind PMP is the impact of particles on health
- Key objective is development of new particle measurement technique for very low emission levels
- Inform EU Directives: LDV EURO5 and HDV EURO6

Sources: 1) M. Dunn, UK Depart. Of Transport, ETH Nanoparticles Conference, 2003, Zurich

2) Andersson et al., PMP Light-duty Inter-Laboratory Correlation Exercise Final Report, GRPE-PMP-18-2, Mar.2007

UNECE-GRPE PMP – cont'd

- Phase 1 – instrument comparison (mass, number, surface, chemistry, dilution, sample conditions, cost, ease of use, etc)
- Phase 2 – More rigorous evaluation of best performing systems. Conclusions were,
 - An improved filter-based method based on US07
 - A particle number method based on counting, dilution, and thermal treatment to eliminate volatile particles
- Phase 3 – Inter-Laboratory Correlation Exercises (ILCE)
- 9 international laboratories (Europe, Japan, Korea) + California
- 17 vehicles (Euro 4), including GV (“transfer standard”)
- CARB testing of GV is on-going (Jan 07 – present)

HDV PMP

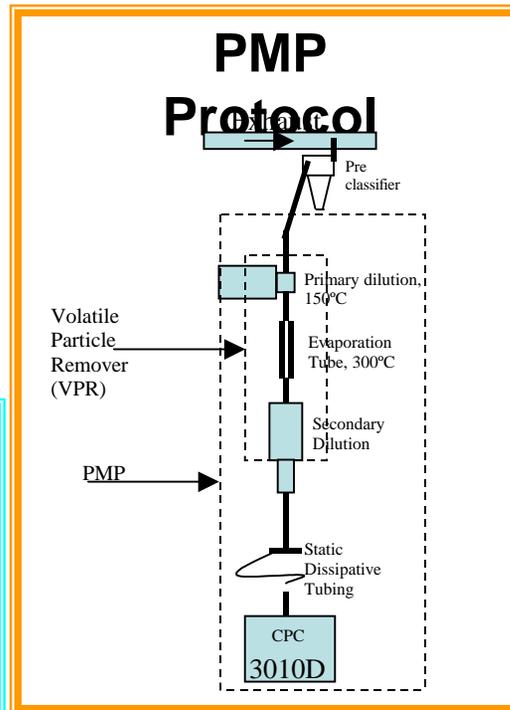
Project

CVS SAMPLING POINT



Heavy-duty Vehicle Testing

- Extensive testing to data (CRC '06)
- Applying PMP protocol for **pre-** and at **CVS** sampling
- California DPF-equipped truck
 - 2000 Isuzu MHD truck (8.3L, 22K lbs)
 - JMI's CRT
- CARB's Heavy-duty Vehicle Emissions Laboratory
- Various US transient duty cycles and steady-state operation
- PMP testing in 2006 and 2007



EMISSION LABORATORY TESTS



CARB Heavy Duty Vehicle Emissions Laboratory, Los Angeles

OVER-THE-ROAD TESTS



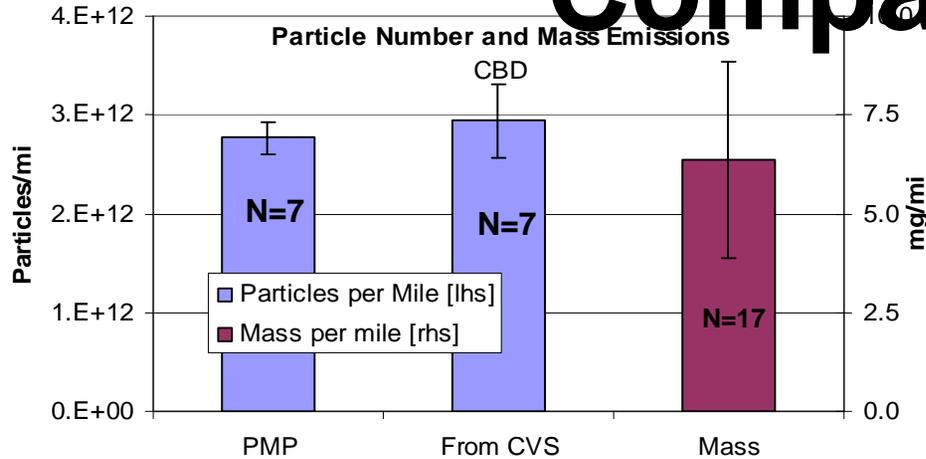
Univ. of Calif. Riverside Mobile Emissions Laboratory



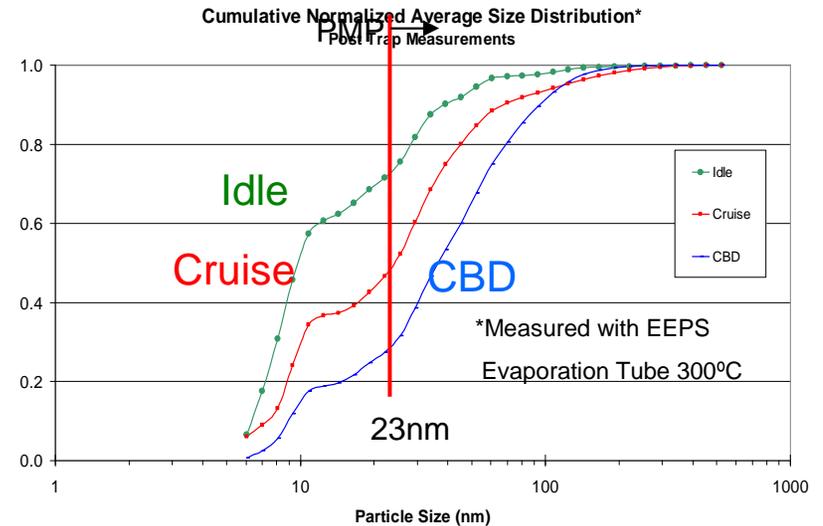
PRE-CVS

SAMPLING POINT

HDV Emission Measurement Comparison



“Solid” particles can be smaller than 23nm (PMP D50 cut)

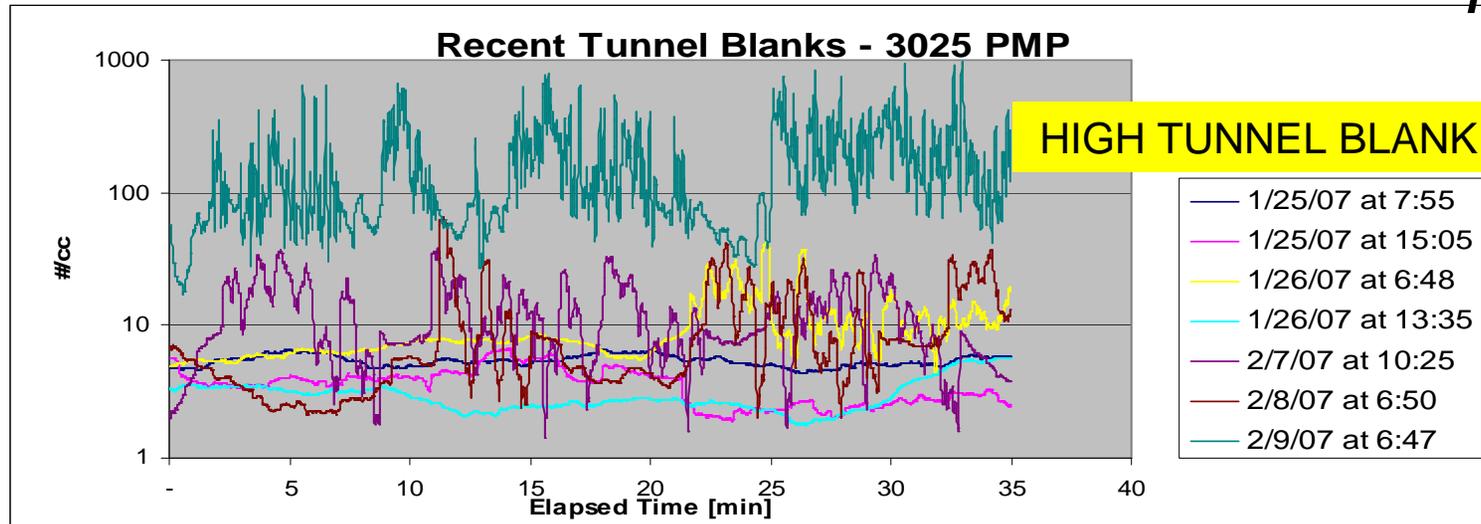


Particle number measurements are considerably more precise than the mass measurement in the current study

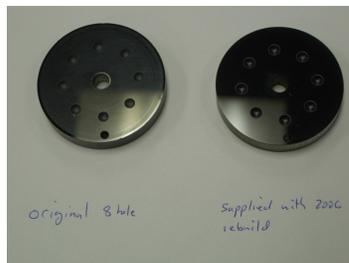
Upcoming improvements in gravimetric measurements at CARB labs are expected to get closer to new US07 1065 Rule

Testing has not been problem-free

One example



- Lubricating coating on rotating disk and diluter head can quickly degrade and wear off
- Once the coating starts to break apart, the instrument appears to generate particles
- It may be preferable to operate the instrument at 80°C or 120°C to avoid wearing off the coating when operating at 150 °C



European Gold descending on Californi



Golden Engineer



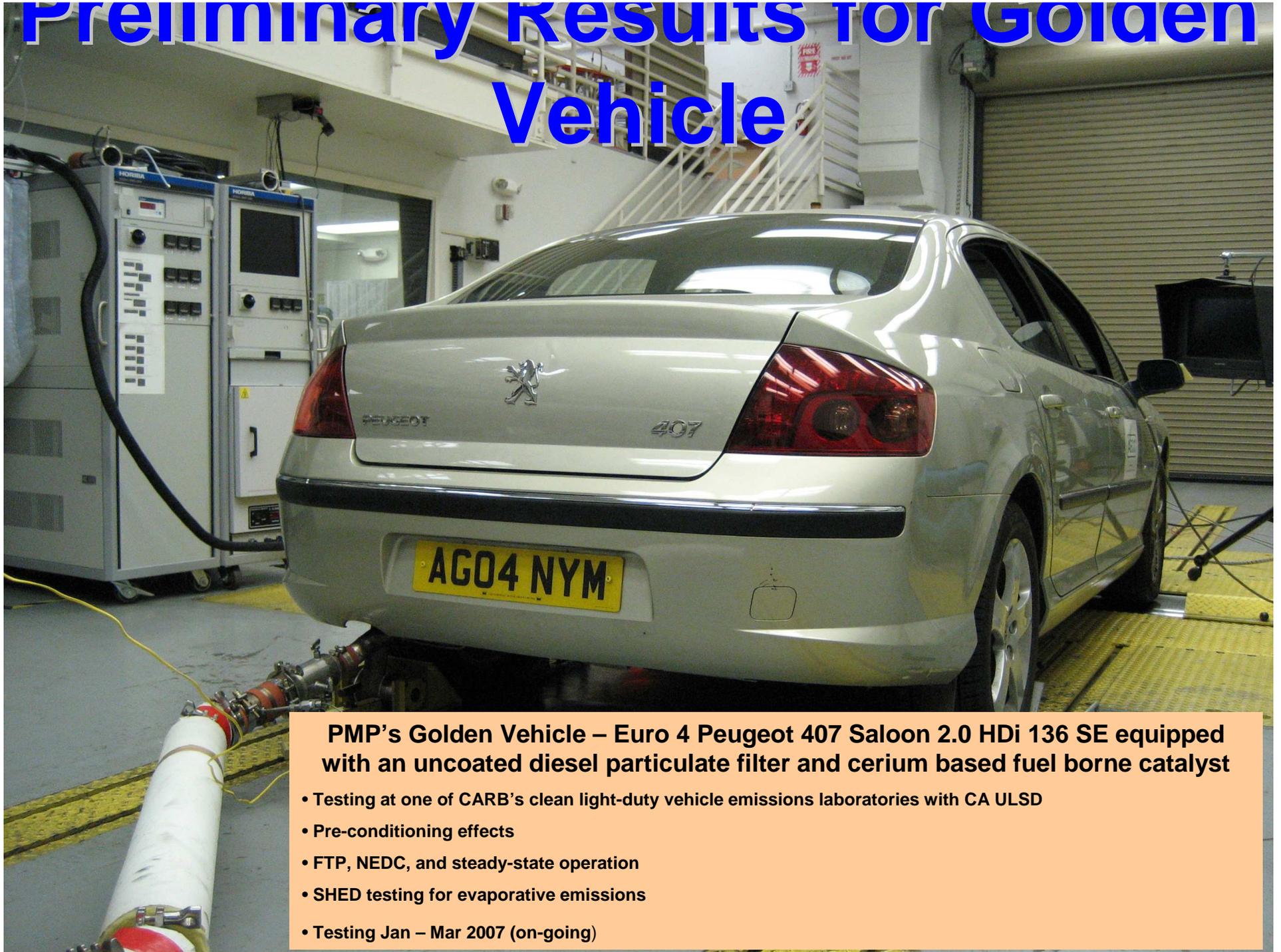
Golden System



Golden Vehicle



Preliminary Results for Golden Vehicle



PMP's Golden Vehicle – Euro 4 Peugeot 407 Saloon 2.0 HDi 136 SE equipped with an uncoated diesel particulate filter and cerium based fuel borne catalyst

- Testing at one of CARB's clean light-duty vehicle emissions laboratories with CA ULSD
- Pre-conditioning effects
- FTP, NEDC, and steady-state operation
- SHED testing for evaporative emissions
- Testing Jan – Mar 2007 (on-going)

Golden Vehicle Testing - Instrumentation

Diluter

Particle Counters



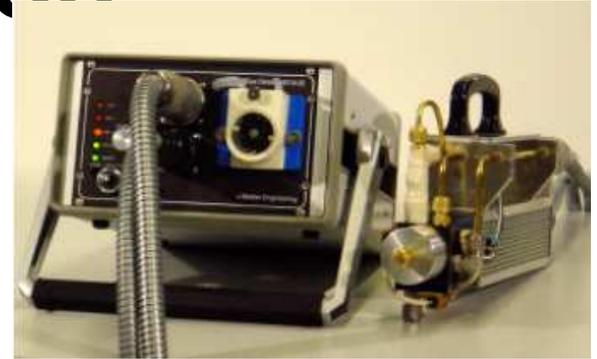
TSI 3790



TSI 3010D



Grimm CPC



Matter Engineering MD-19



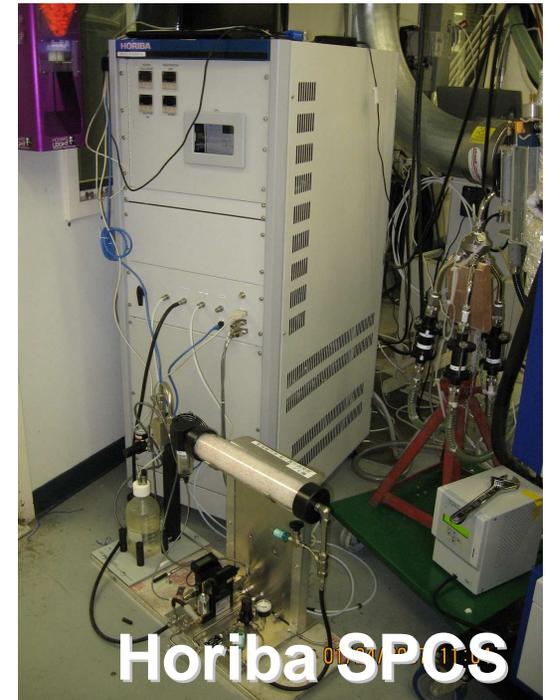
TSI EEPS



EcoChem PAS2000

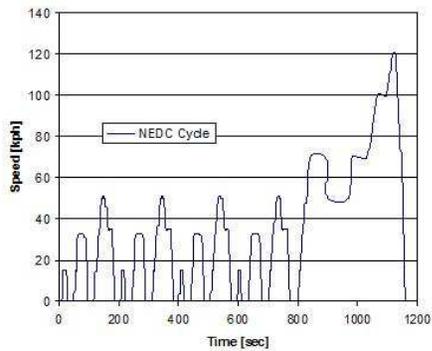


Matter Engineering LQ1-DC

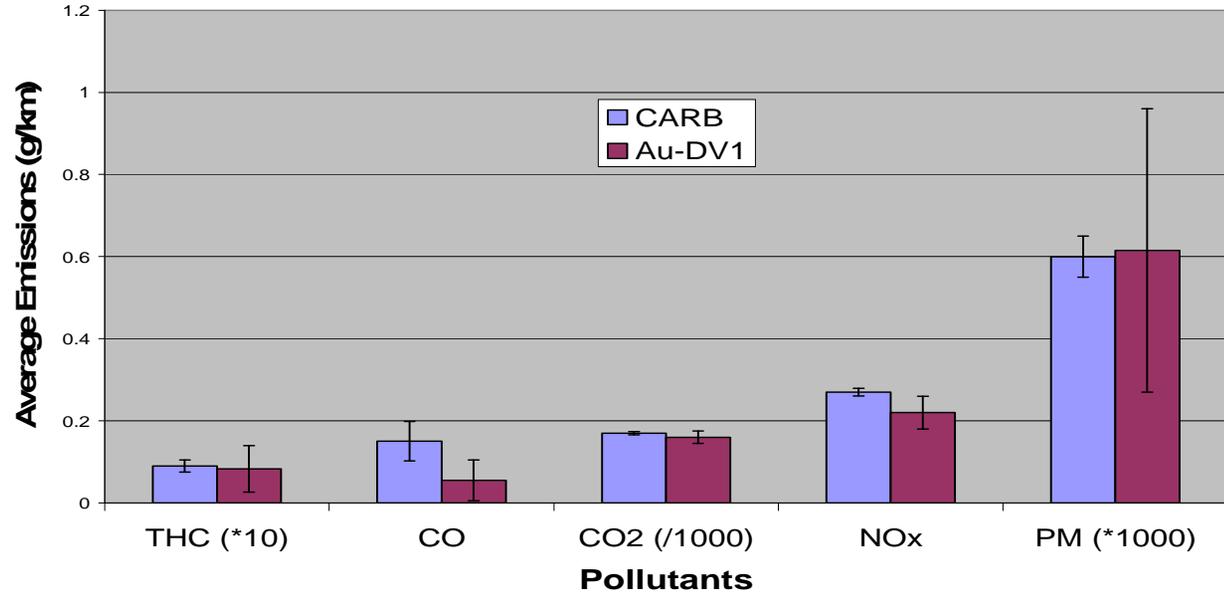


Horiba SPCS

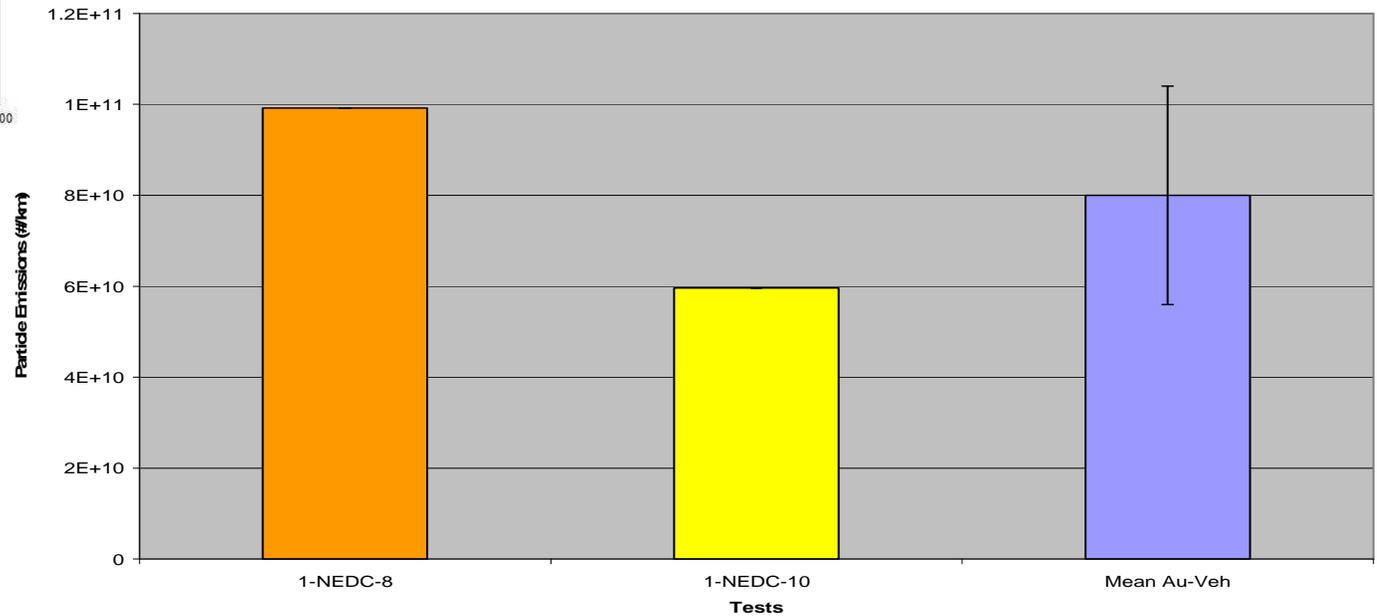
Preliminary



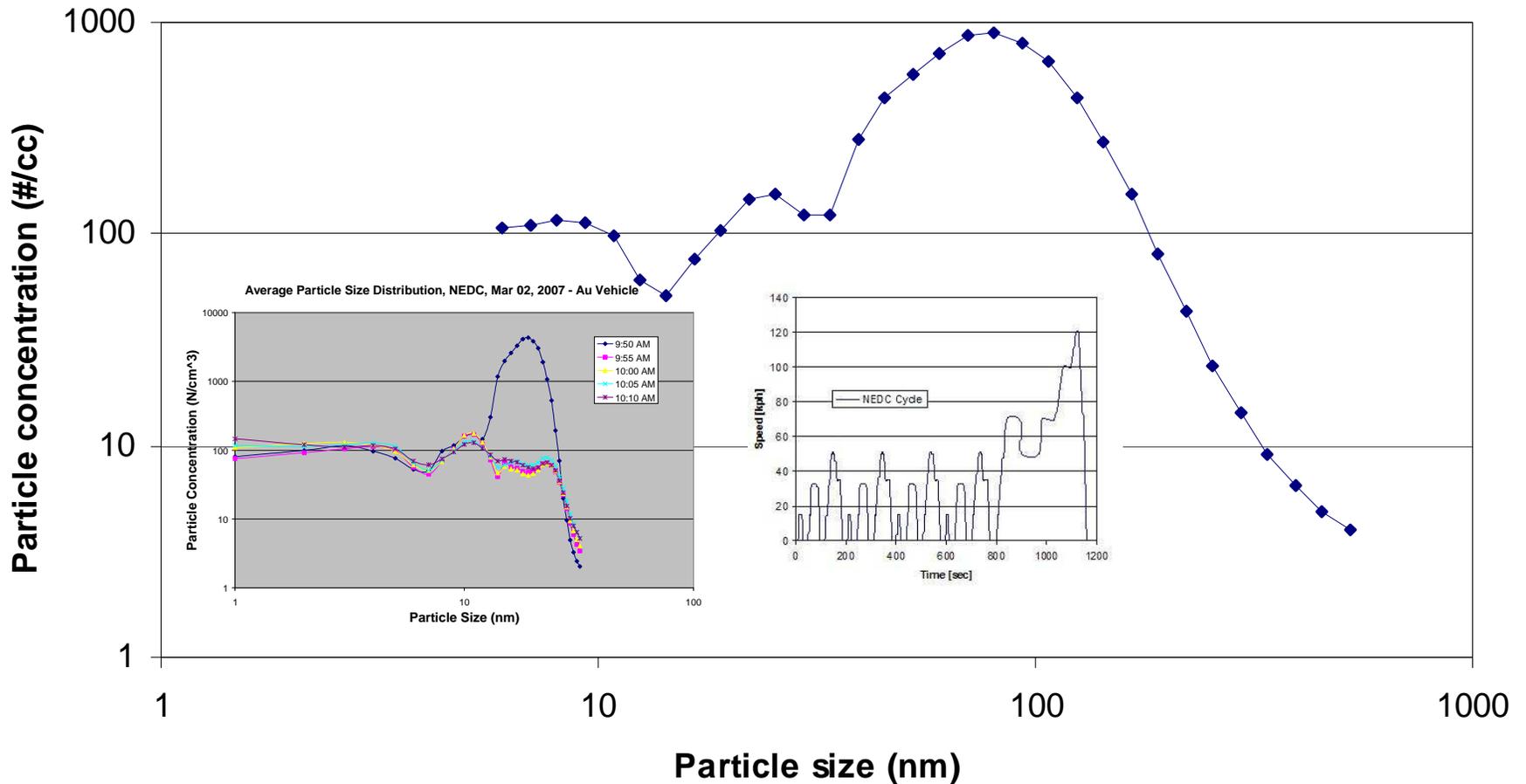
Average Mass Emissions during NEDC for Au Vehicle Preliminary CARB Results



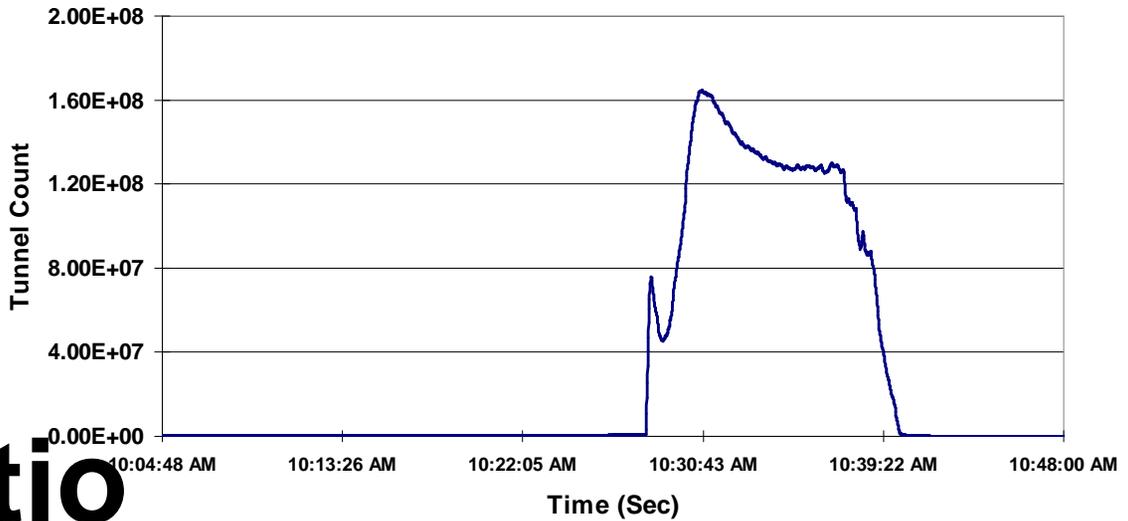
Particle Number Emissions during NEDC Au Vehicle (excluding regeneration) Horiba SPCS



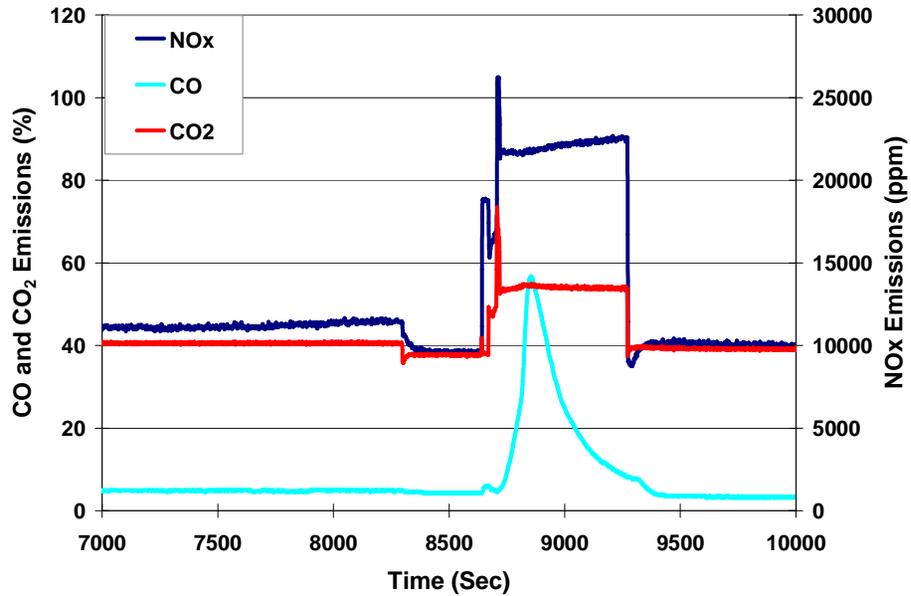
Particle Size Distribution (1-NEDC-10, 02MAR07)* Au Vehicle



*EEPS average over entire NEDC



**Regeneration
achieved
as expected**



Summary

- Study of Au-Veh is on-going, no final interpretations or conclusions yet
- But our findings to date are very encouraging. Preliminary results are consistent with those of 9 other international laboratories
- Gaining important experience with PMP protocol, its potential, and new opportunities for use in California
- Enhancing understanding of nature of ultrafine particle emissions
- PMP project is giving important exposure to light-duty diesel vehicle technology
- From HDV testing:
 - The PMP particle number measurements are more precise than gravimetric measurements
 - There are sub-23nm solid particles post PMP sampling that can be counted with equal accuracy as those >23 nm
- On track to complete study successfully by mid-2007