

13th ETH Conference on Combustion Generated Nanoparticles
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Zurich, Switzerland

***Regeneration, volatile
nanoparticles, toxicity and
other research questions for
diesel emission controls***

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Research Division

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Mobile Source Control
Division

Collaborators



UCLA

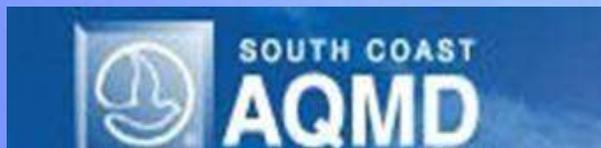
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In-kind Contributors



CALIFORNIA DEPARTMENT OF
TRANSPORTATION



Johnson Matthey

State of Diesel Affairs in CA/US

- CARB has rules in place to retrofit every diesel engine
- New low carbon fuel standard: biodiesel, renewable diesel
- President Obama adopts new national policy on GHG emission for new cars and trucks based on California's program
- US stimulus funding under Diesel Emission Reduction Act
- Black carbon nexus between air quality and climate change
- New emission reduction requirement under Low Vehicle Emissions III (LEVIII)
 - Criteria emissions (gaseous and PM)
 - Particle number standard

Towards HDDE 0.2 g/bhp-hr NO_x

- Urea-SCR technology on track for 2010
 - This technology is large departure from conventional technology
 - Potential for new compounds to form highlights need for research
- Several options for catalyst on the table:
 - Vanadium, Fe & Cu zeolites
- “New” substance may require new methods

Key Observations for this Presentation:

Diesel Retrofits	<ul style="list-style-type: none">– Retrofits work as designed to reduce PM and NO_x– Enhance formation of nucleation mode particles (sulfuric acid)– Reduce other toxic air compounds and indicator of oxidative stress potential
Regeneration Event	<ul style="list-style-type: none">– Emissions of substantial amount of nano-particles–
PMP Nuance	<ul style="list-style-type: none">– Penetration of apparent sub-23nm solid particles.

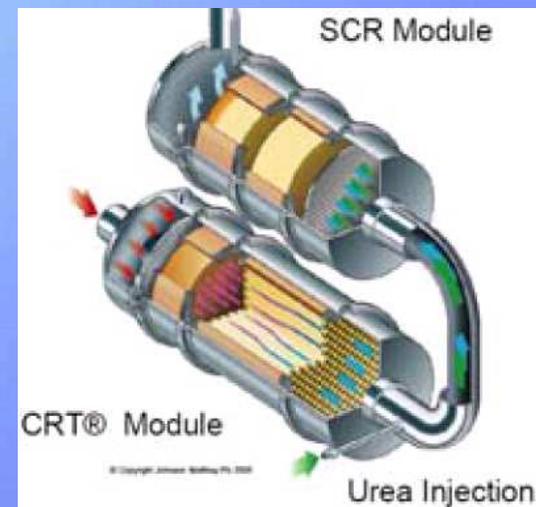
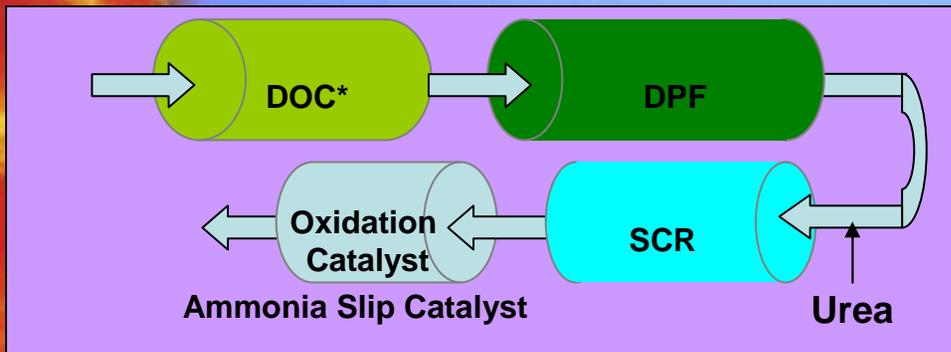
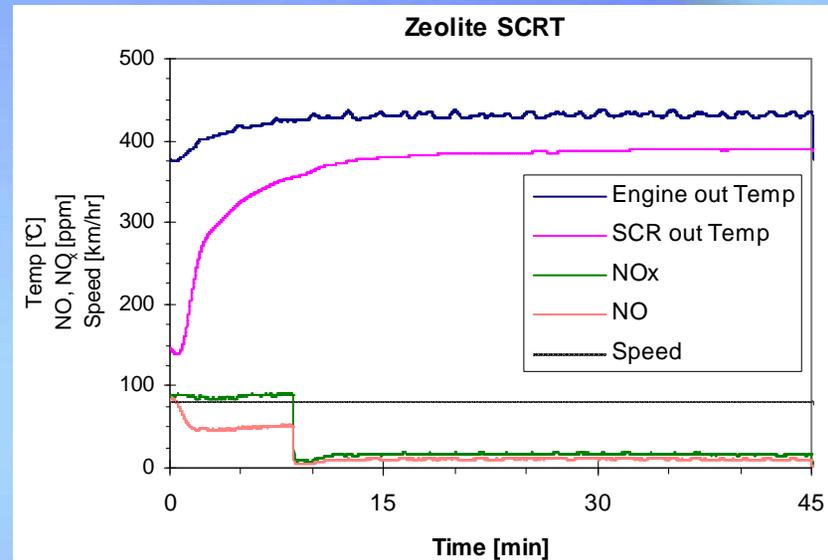
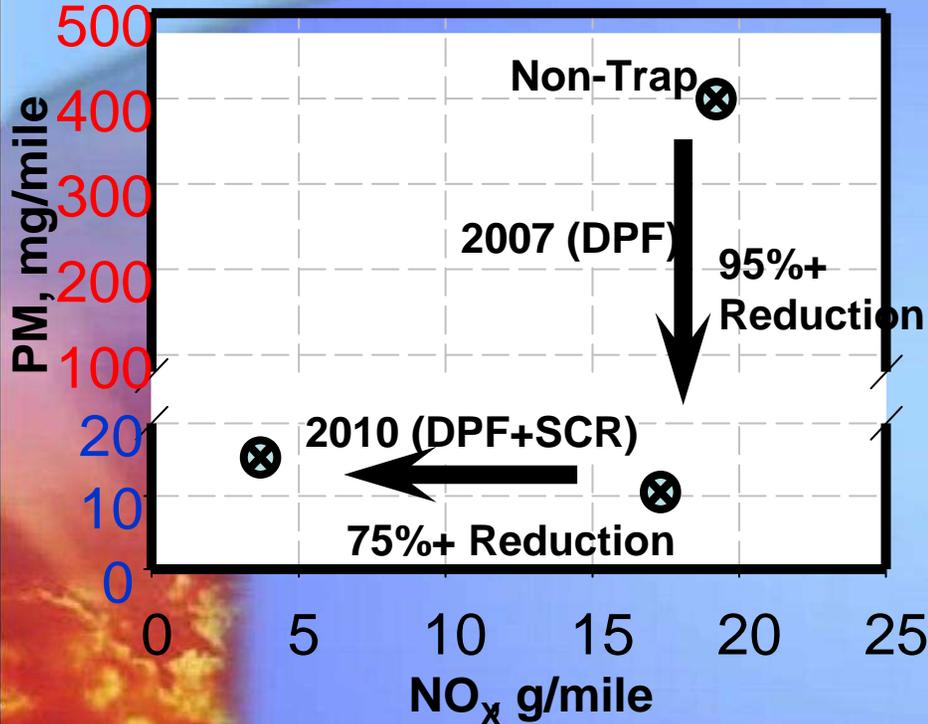
VEHICLE EMISSIONS LABORATORIES



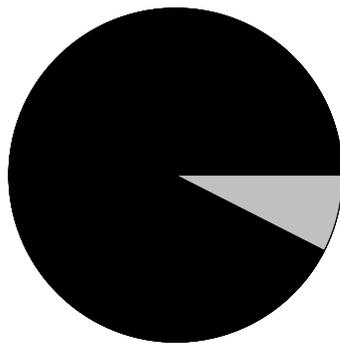
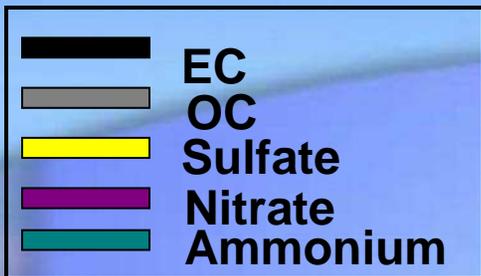
CARB HD STUDY FOCUS = CRT + SCR

SCR retrofits >>> 75+ % NO_x reduction
 DPF retrofits >>> 90+ % PM reduction

Two types of SCR retrofits: CRT + Fe-Zeolite-SCR and CRT + Vanadium-SCR

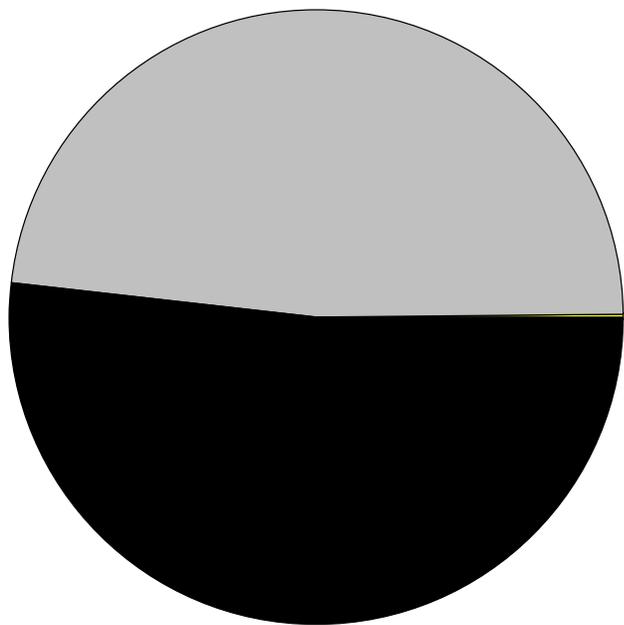


Ammonium sulfate dominates composition of particle emissions from catalyzed HD retrofits

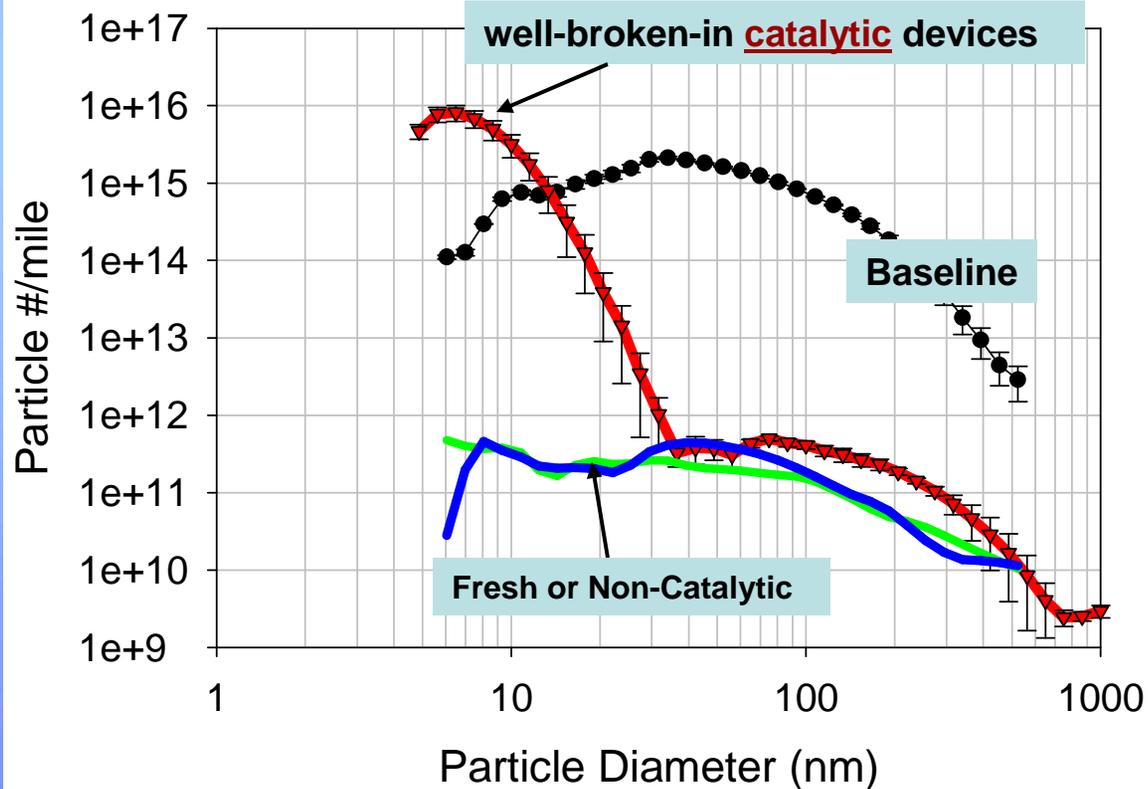


DPF + SCR
PM = 17.4 ± 6 mg/mile

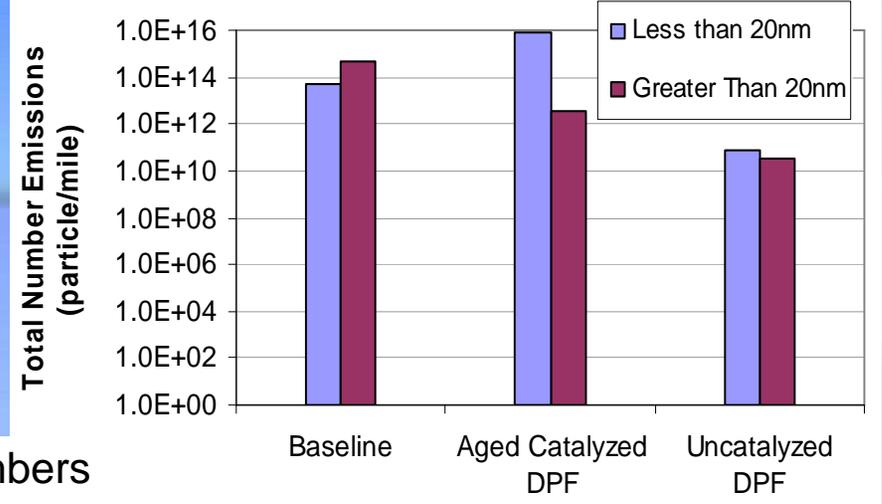
Exhaust temperature promotes substantial formation of nanoparticles for well-broken-in catalytic devices



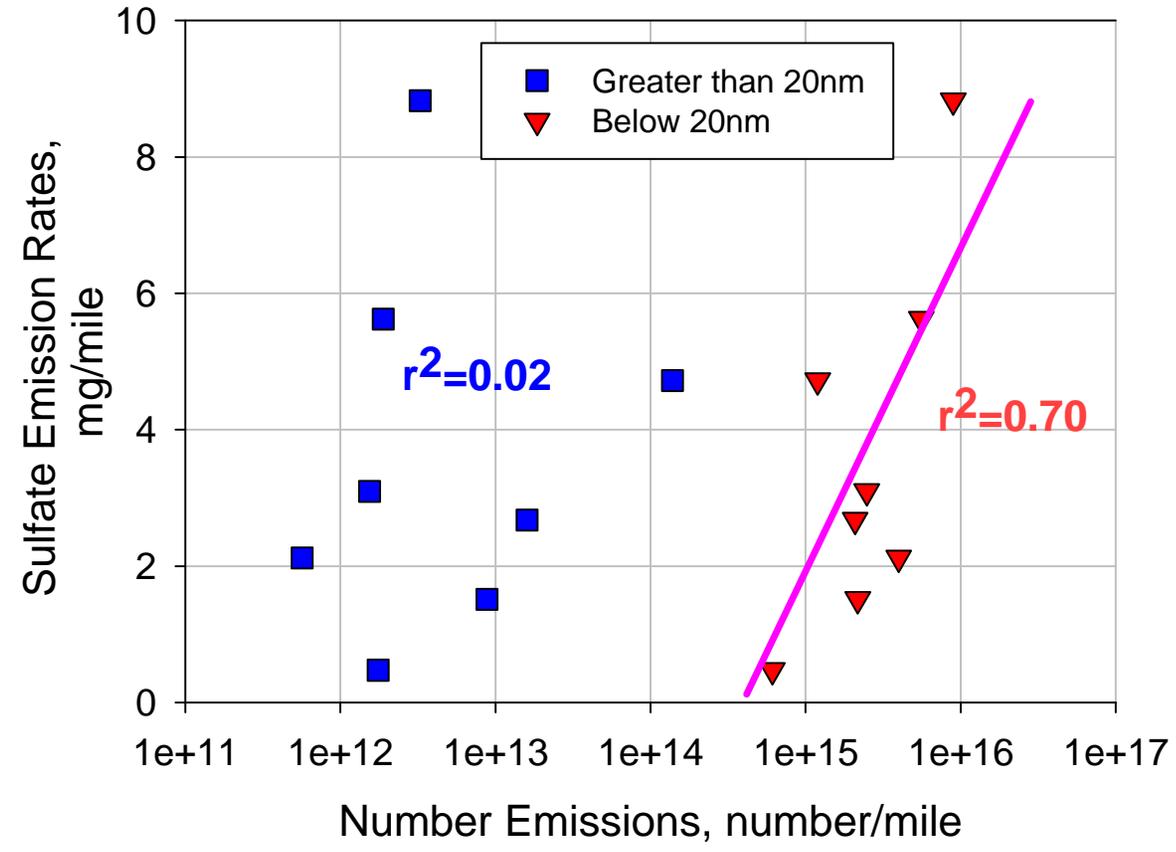
Baseline
PM = 130.3 ± 61 mg/mile



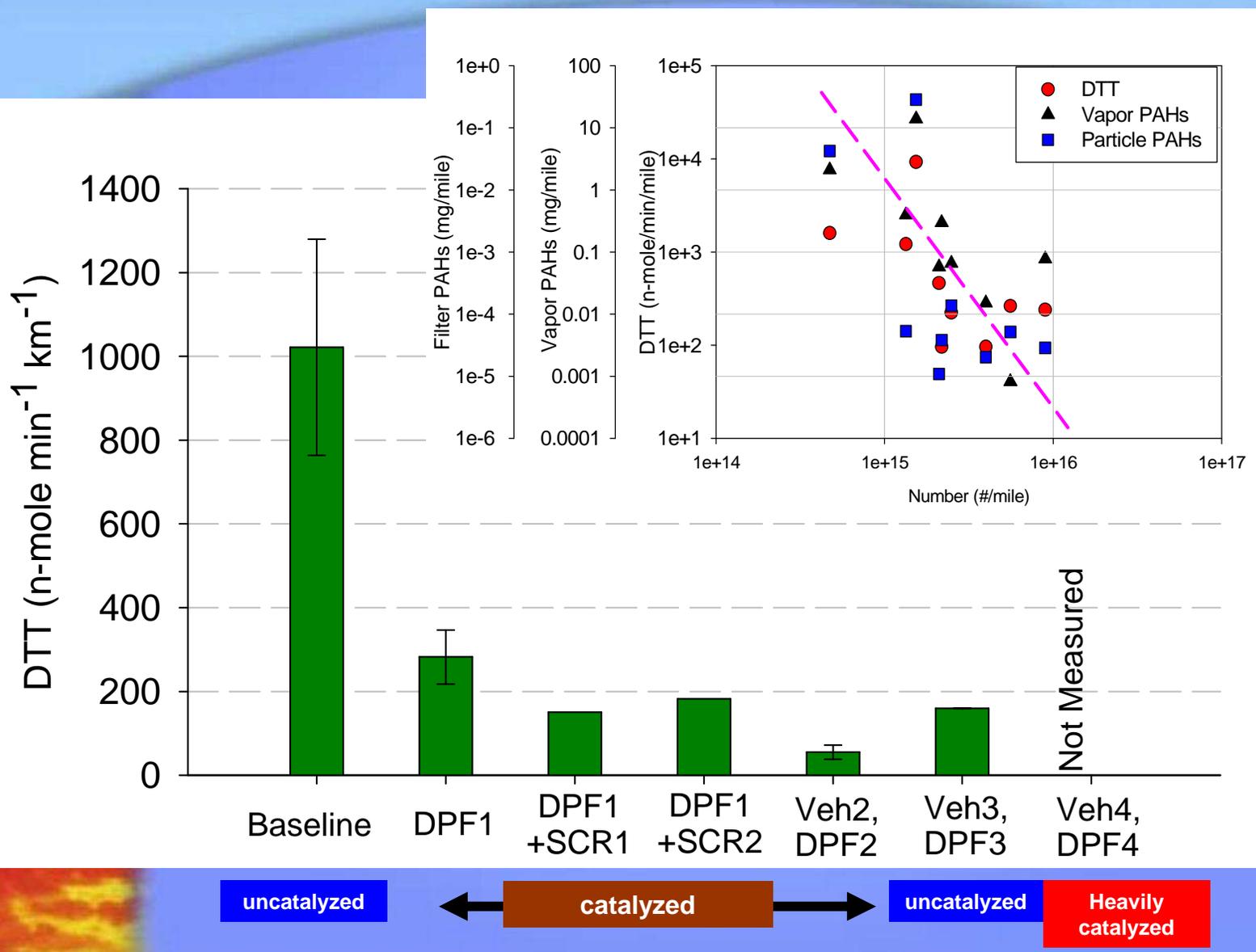
HD Nanoparticles are strongly correlated ($r^2=0.70$) with sulfate. Larger particles are not.



Sulfate as a function of particle numbers



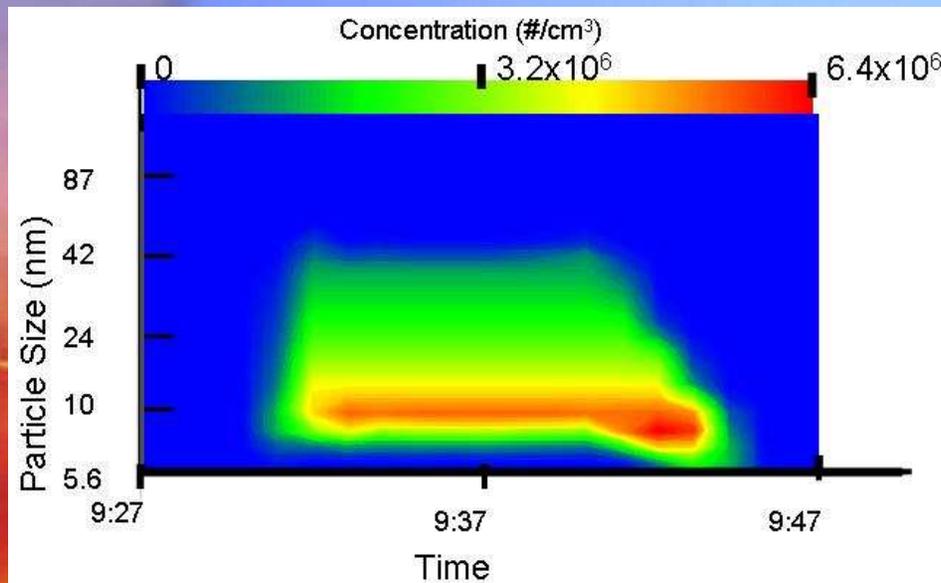
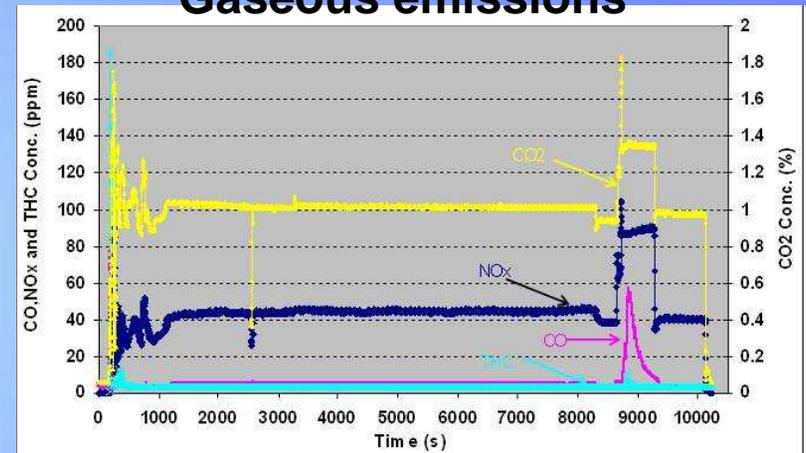
OXIDATIVE STRESS POTENTIAL OF TOTAL PM PER DISTANCE DRIVEN IS REDUCED BY ALL HD RETROFITS



Golden Vehicle DPF Regeneration: During Constant Speed Test

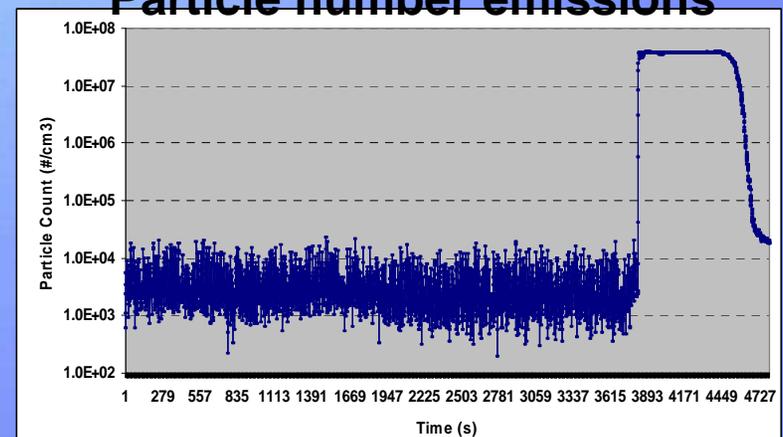


Gaseous emissions



**Particle size and concentration
distributions during DPF
regeneration
Note: Nanoparticle formation!!!**

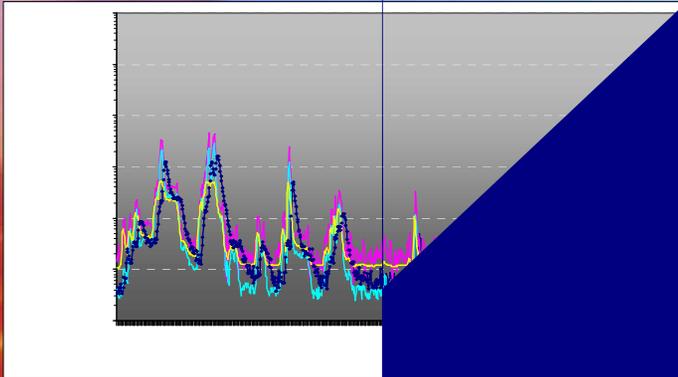
Particle number emissions



Golden Vehicle DPF Regeneration (cont')

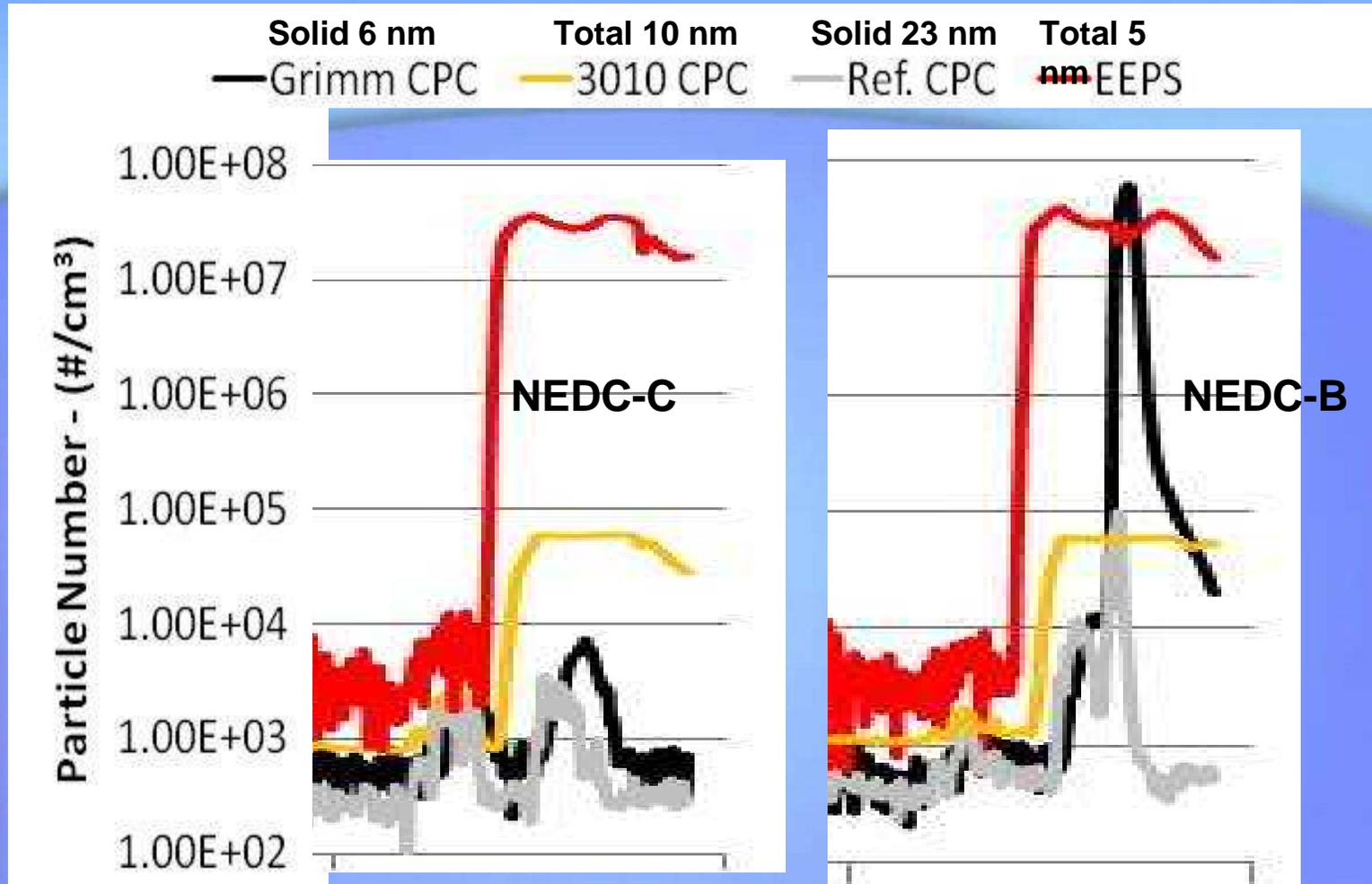
- Particle emissions in three consecutive partial DPF regenerations during three NEDC cycles

Gaseous and PM Emissions:



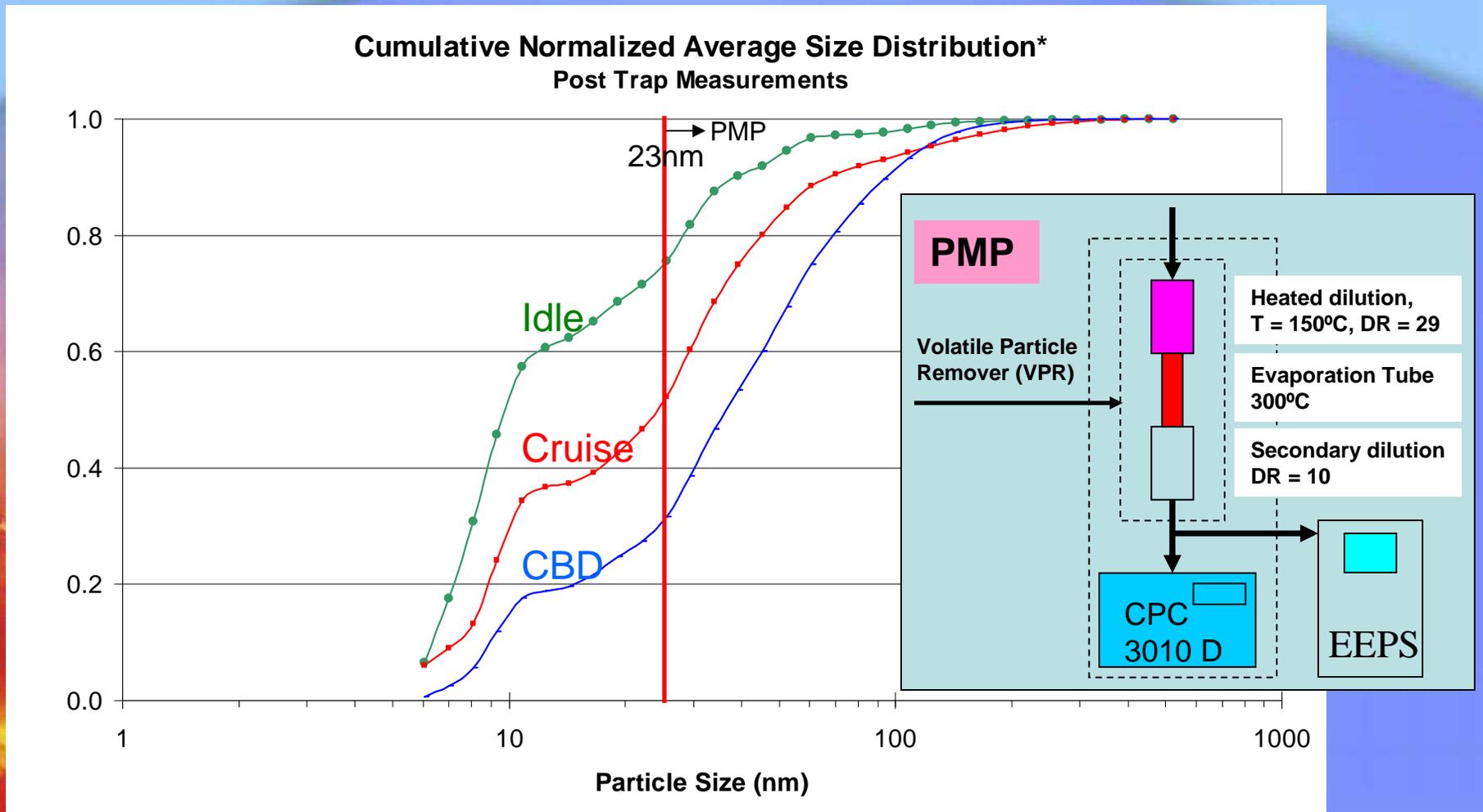
Particle emissions increase sharply during DPF regeneration and were measured by the EEPS and TSI 3010. The PMP systems detected a moderate increase in particle numbers. The Grimm CPC measured higher particle numbers than PMP CPCs. Those particles could be either volatiles that survived the VPR, or sub-20 nm solid particles emitted during DPF regeneration.

Golden Vehicle DPF Regeneration (cont')



1. Detailed comparison of particle number emissions during NEDC B and C during the partial regeneration events
2. The Ref. CPC only show a small increase in particles relative to cold start, and the particle number does not reflect the PM increase measured by filters

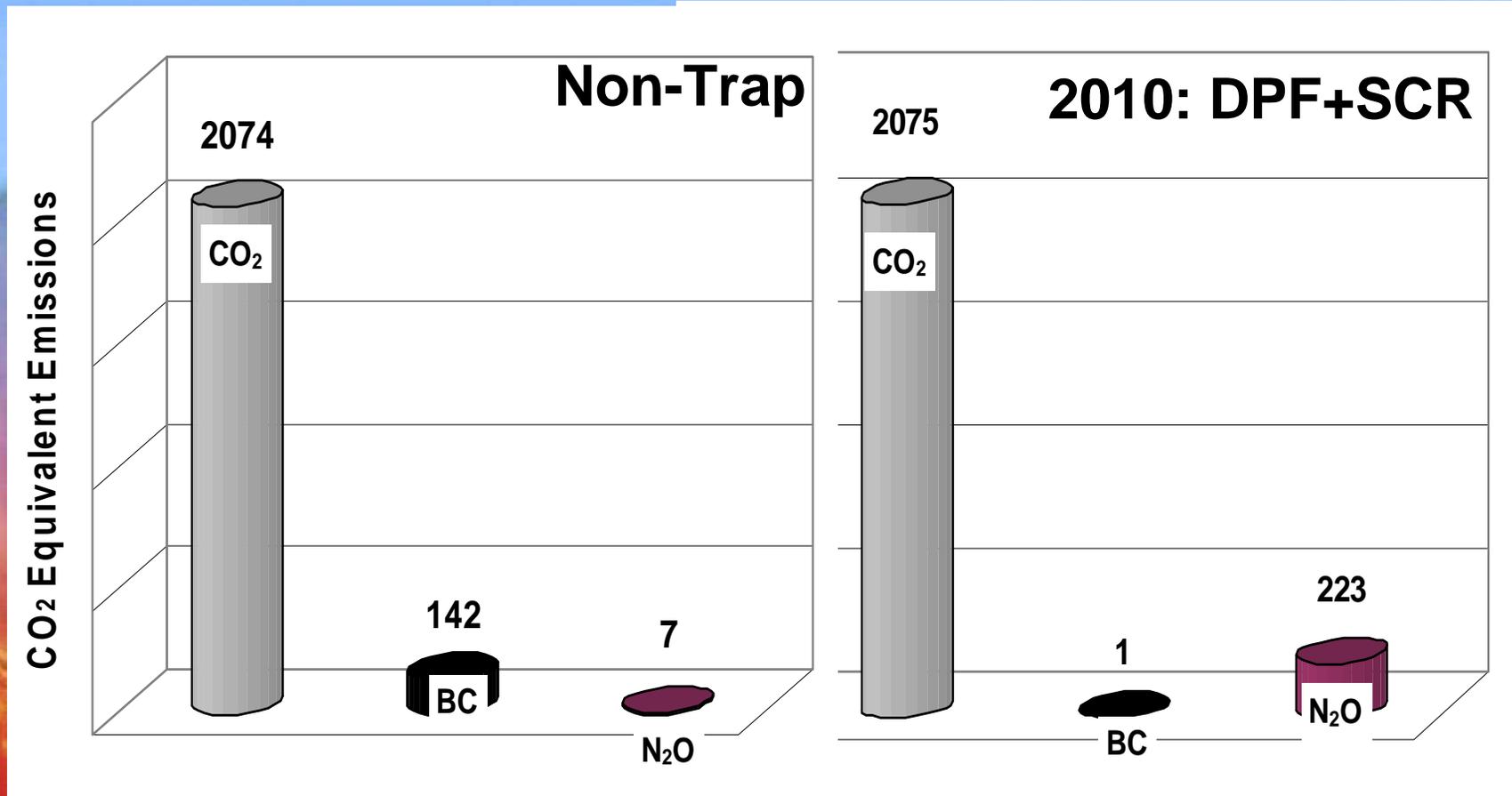
Depending on HD cycle, 25-75% of solid particles appear to be smaller than 23nm.



*Measured with EEPS

Evaporation Tube 300°C

NET GREENHOUSE GAS IMPACT IS MINOR



- Black Carbon Reduced By DPF
- N₂O Increased by Retrofit SCR (Prototype)
- Better Fuel Economy (Reduced CO₂) Anticipated for New OEM Systems

CONCLUSIONS

(To Be Edited)

- **Nanoparticle Number**
 - The traps can and do increase nanoparticle number under some conditions
 - Regeneration event, emissions of nanoparticles
- **Toxicity Indicator (i.e., chemical assay)**
 - Significant reduction