Measurement and Characterization of Unregulated Emissions from Advanced Technologies

John Storey (PI), Jim Parks (PI), Sam Lewis, Laura Kranendonk, and Teresa Barone

Oak Ridge National Laboratory

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Dr. James Eberhardt
U.S. Department of Energy, VT

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Collaboration

- **Intermediate Blends:**
  - Support through Kevin Stork, OVT and Joan Glickman, OBP
  - FEERC vehicle team: Brian West, Shean Huff, John Thomas, Kevin Norman, Larry Moore
  - NREL Intermediate Blends team
- **PM studies**
  - University of Maryland: Anshuman Lall and Michael Zachariah
  - Advanced Combustion and Efficiency program
  - ORNL-HTML: Jane Howe

Overview

Timeline

- **Project start: October 2006**
- **Project end: September 2009**
- **Percent complete: 91%**

Budget

- FY08: **$475K**
- FY09: **$500 K**

Barriers

- **3.3.5.8 B Lack of emissions data on future fuels and engine technologies**
  - **Identify regulated and unregulated emissions from pre-commercial fuels**

Partners

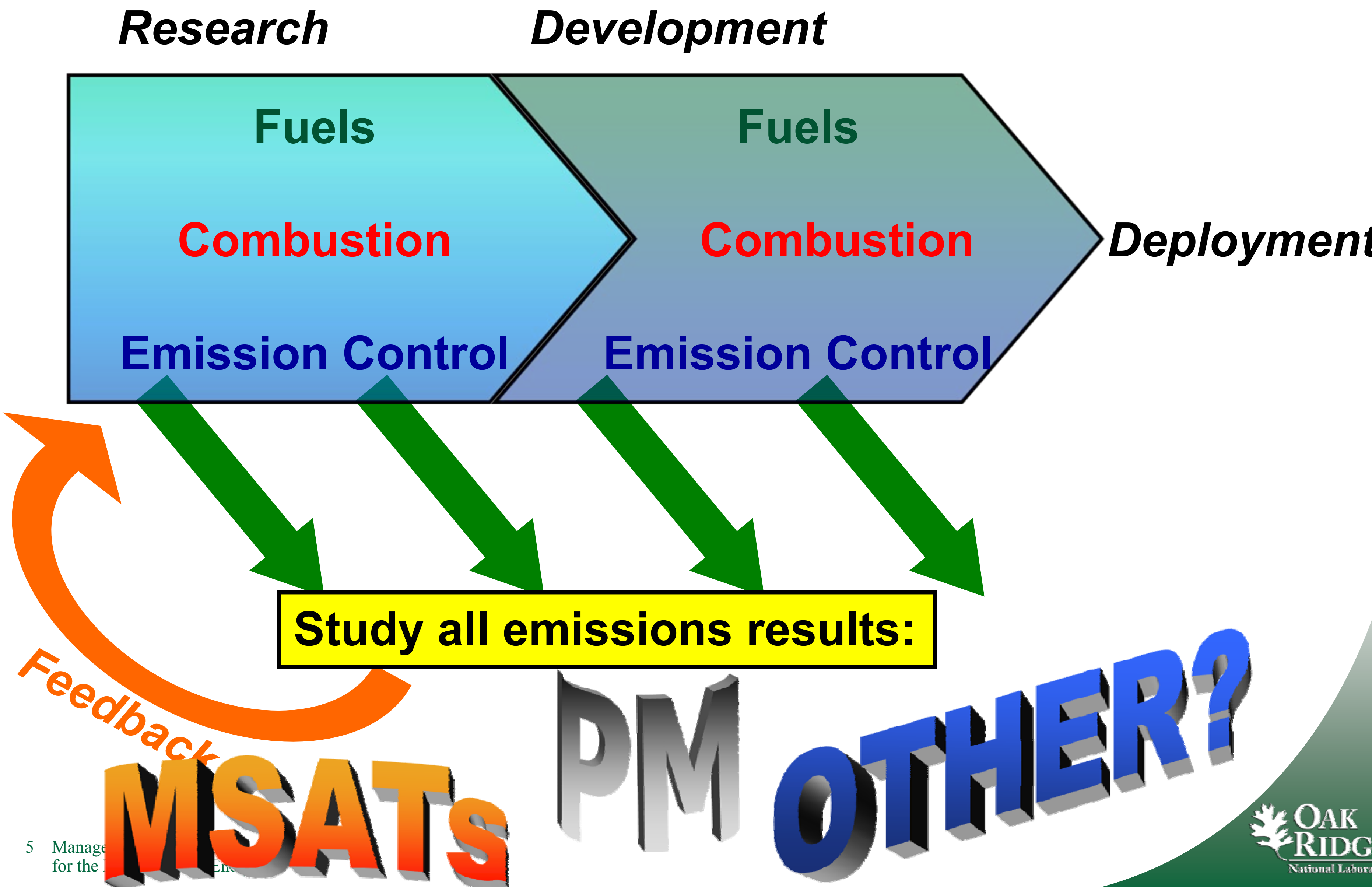
- Input and feed back from **CRC, EPA, CARB, FHWA**
- Working closely with DOE-VT activities on Advanced Combustion Engines and Fuels

Ongoing Need started in FY07: Measurement and Characterization of Unregulated Emissions from Advanced Technologies

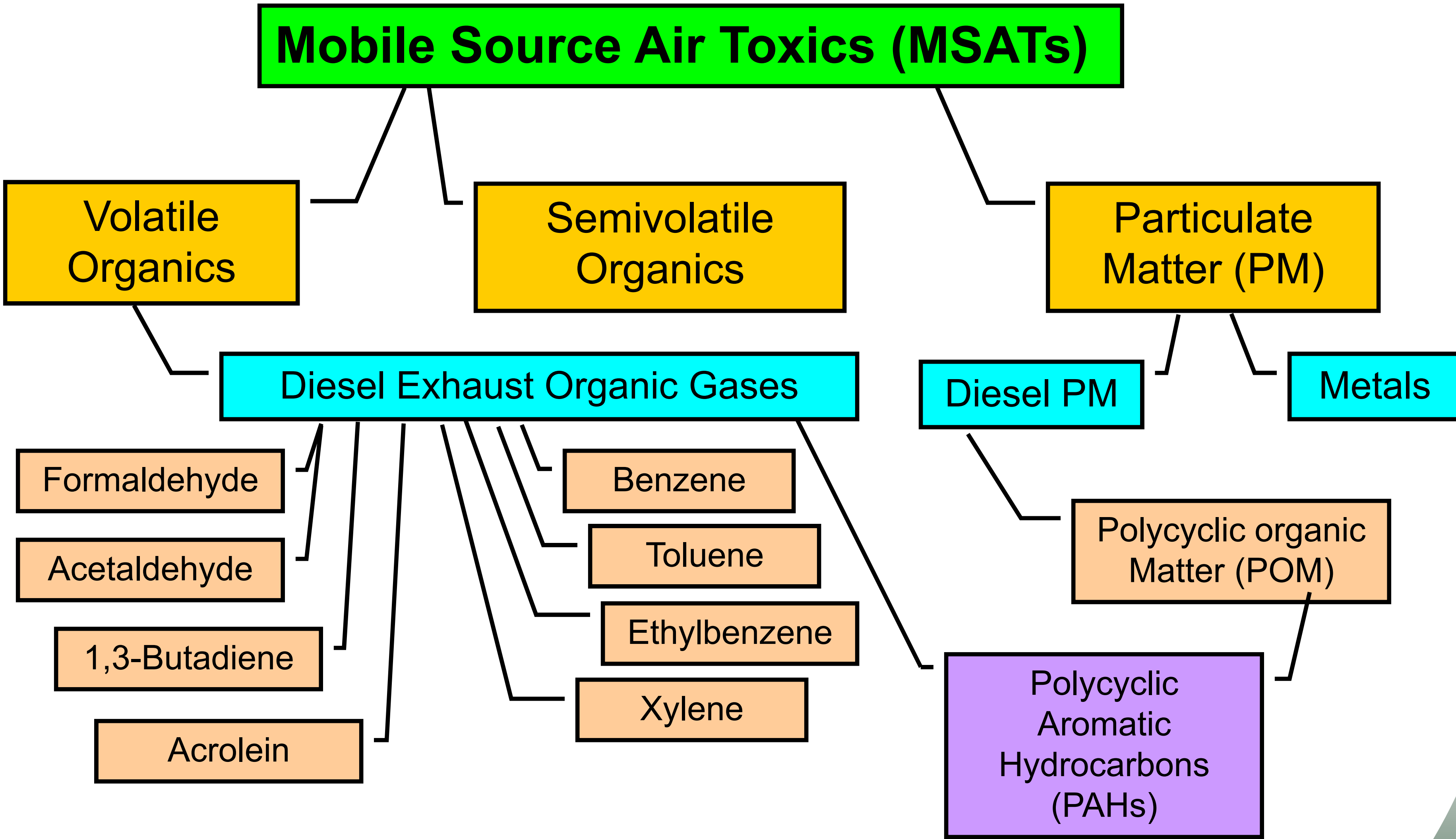
Objective

Ensure that advanced petroleum-saving technologies "do no harm"

Approach designed to address key barriers

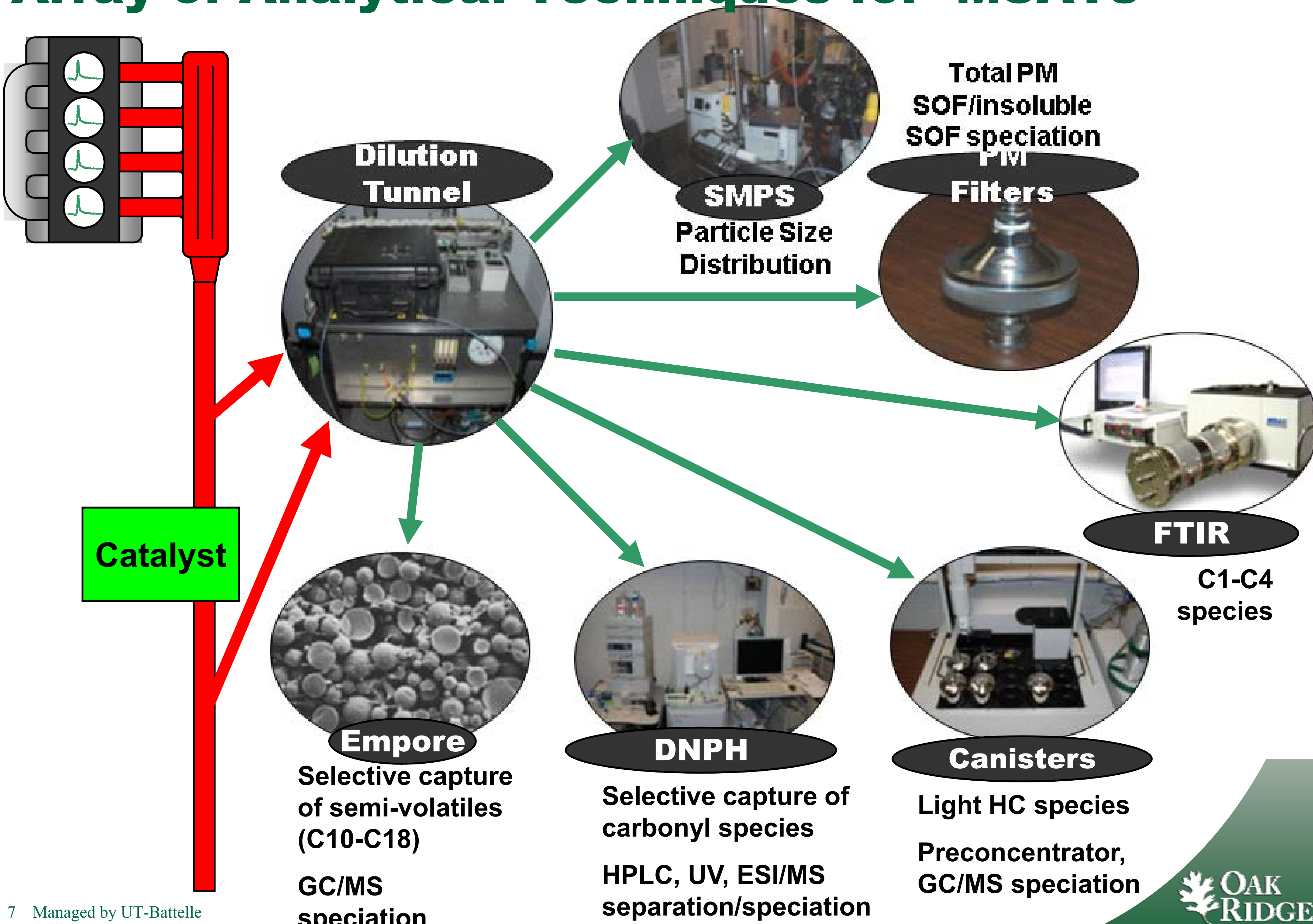


What are Mobile Source Air Toxics (MSATs)?



Note: Specific health risks associated with each compounds are only known to varying degrees, but all MSATs raise concerns.

Array of Analytical Techniques for MSATs



Milestones

- **FY08 Milestones (completed):**
  – Measurement of mobile source air toxics from E85 vehicle
  – Measurement of unregulated emissions from HCCI and PCCI engines equipped with oxidation catalysts
- **FY09 Milestones (planned and in progress):**
  – Characterize mobile source air toxics from vehicles operating on intermediate blends of ethanol and gasoline (September 30, 2009)
  – Identify differences in particle characteristics for PCCI and conventional diesel combustion (September 30, 2009)

FY08 Summary

- MSATs from HCCI and PCCI studied
  - Catalytic control generally reduces to low tailpipe levels, but low load and cold start (low temperature) modes a concern
  - Differences in nature of PM from HECC vs. conventional combustion observed with SMPS
    - Significant interest expressed at Merit Review and DEER
- Results shared at DEER and SAE PF&L and CRC MSAT Workshop

FY09 Plans

- Analysis of MSATs from intermediate blends of ethanol nearing completion ✓
  - Will include E0, E10, E15, E20 for several in-use cars
- Investigate physical characteristics of PM from HECC and conventional combustion ✓
  - Unique centrifugal device used to measure PM density
- Compare idealized aggregate theory with measured PM
  - Transmission Electron Microscopy (TEM) analysis of particles

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Alcohol Blend Effects on MSAT Emissions

2007 Buick in ORNL Vehicle Laboratory

- Intermediate Blends activity large component of OVT and OBP programs
- V1 activities at ORNL, NREL, and contract labs
- Large number of tests gave opportunity to look at MSATs
- Major HC speciation effort underway in V2 activity

  -$8M program

Examine two cars here: 2007 Buick (10K miles) on E0, E20

1999 Honda (81K miles) on E0, E15

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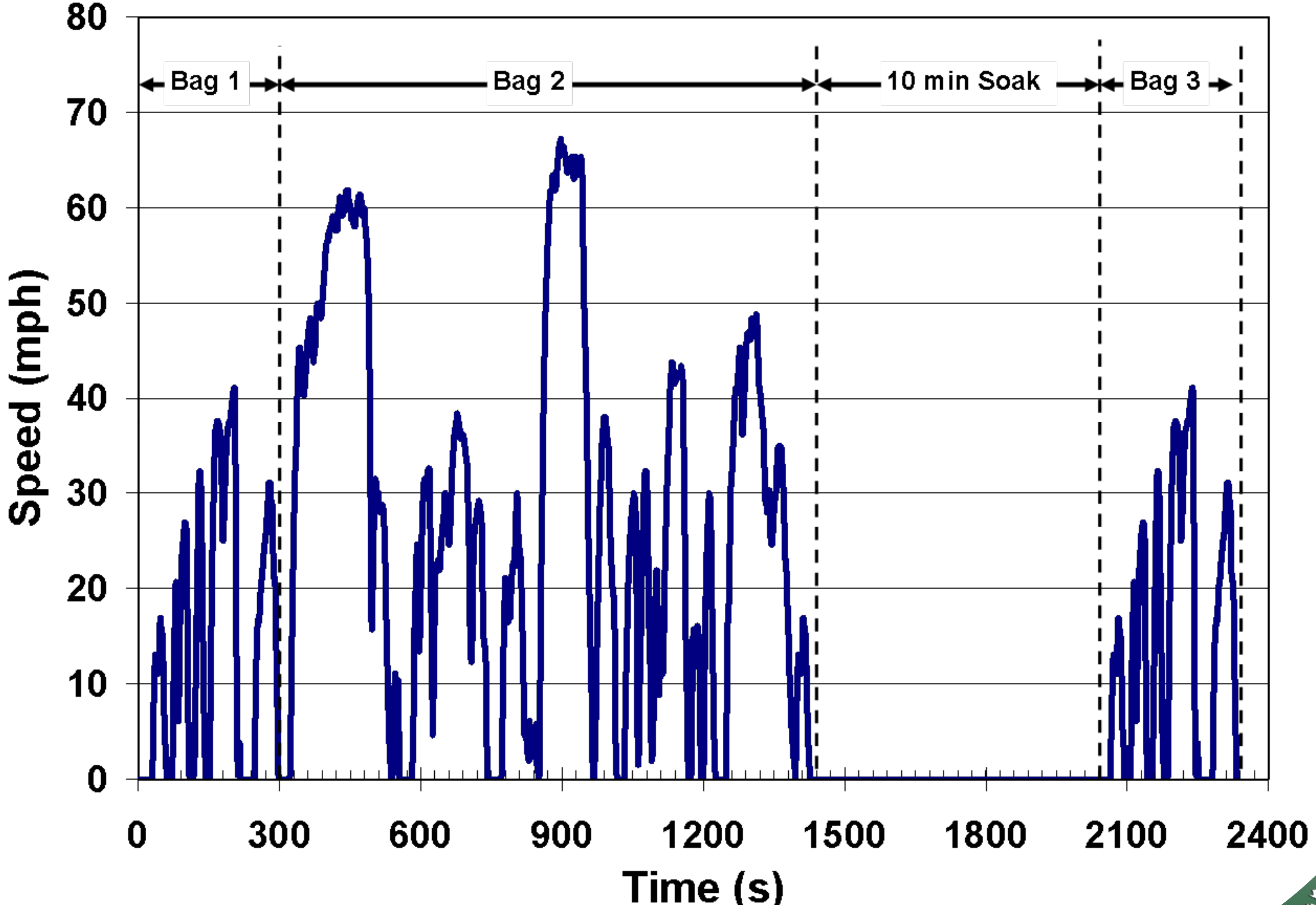
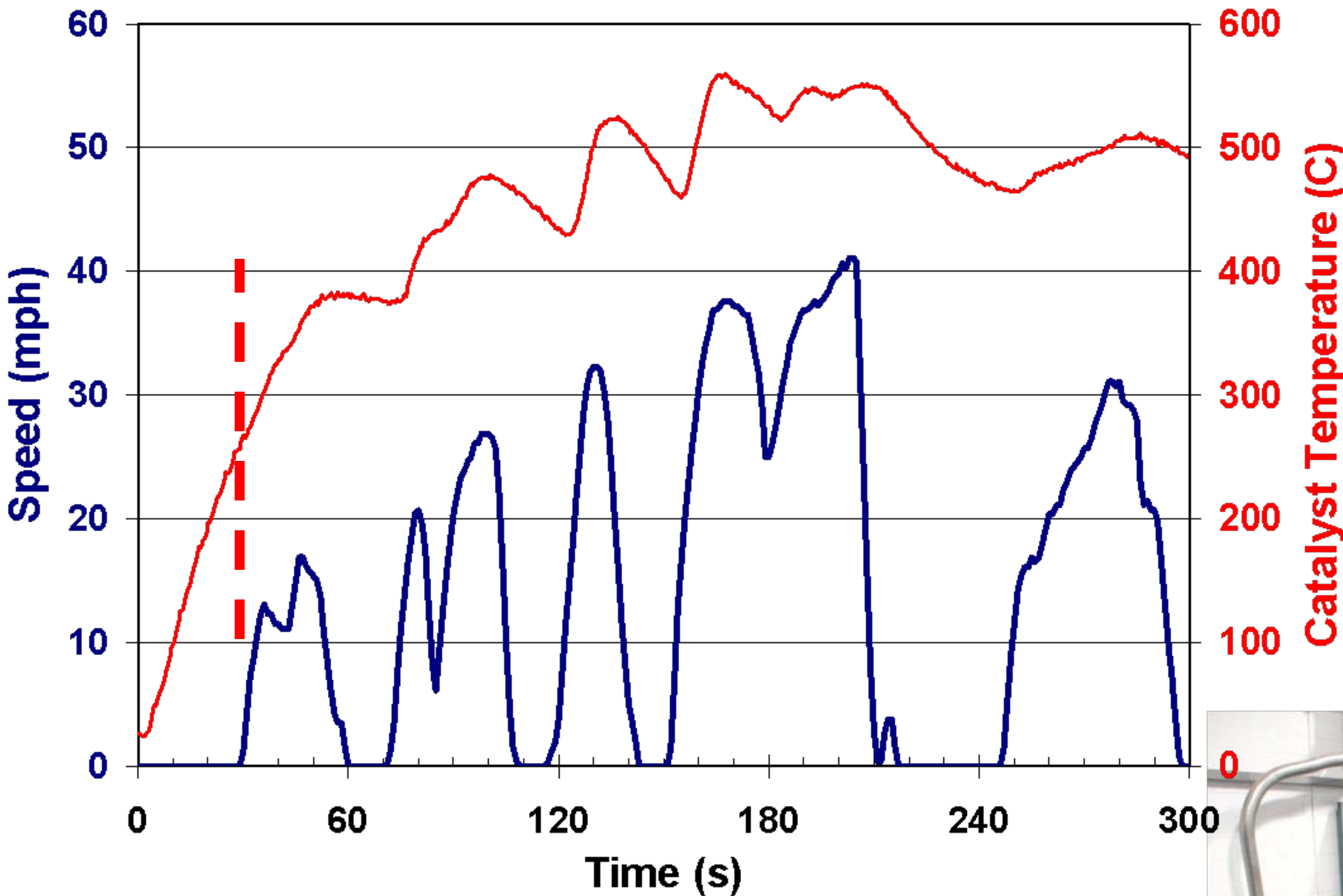
MSATs from in-use vehicles measured on LA92 driving cycle

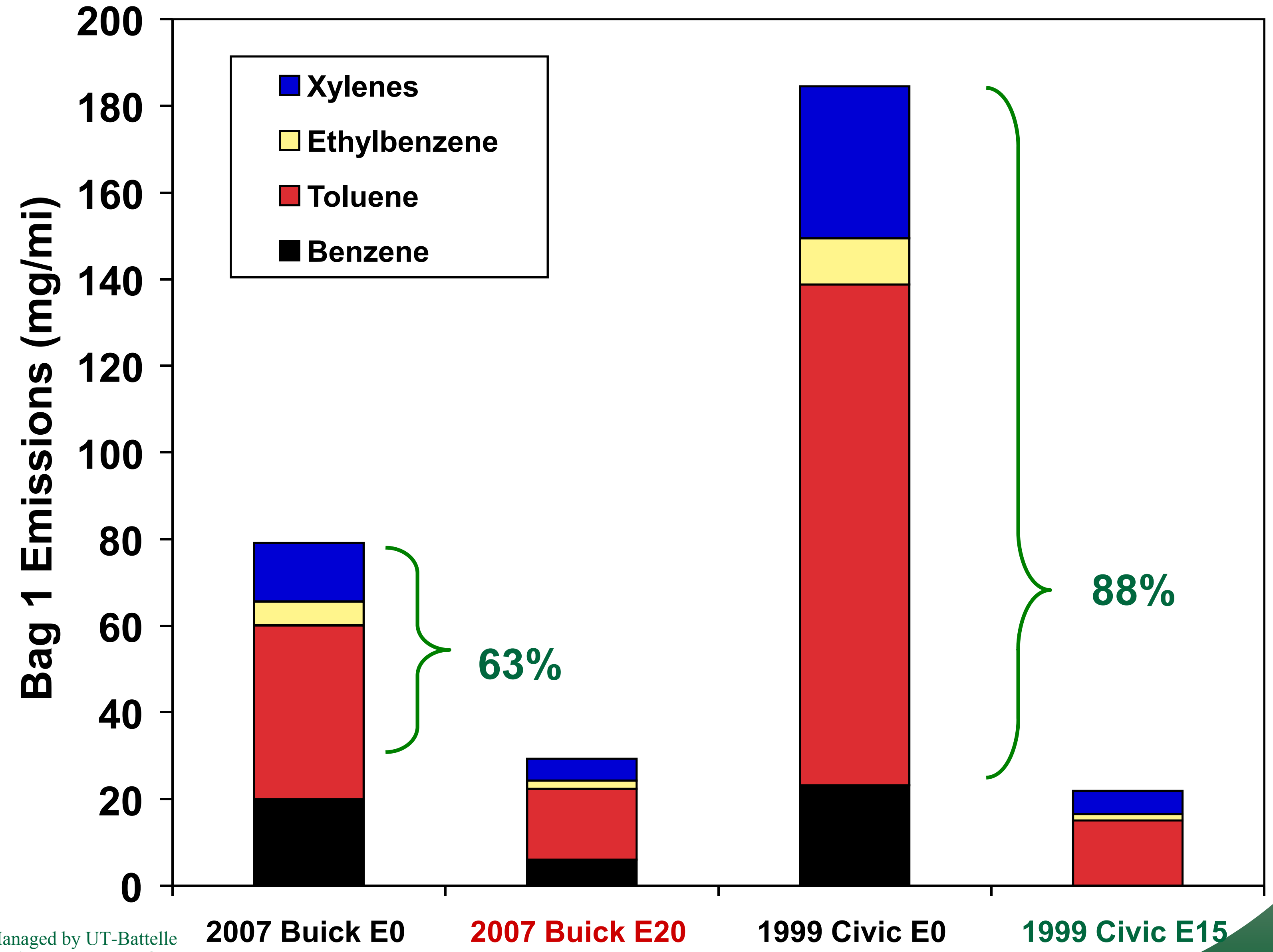


Exhaust catalyst reaches 300C in first 30 seconds of phase 1



- MSAT focus on Bag 1 only
- Quantitation: 500 ppb raw

Intermediate Blends can lower BTEX



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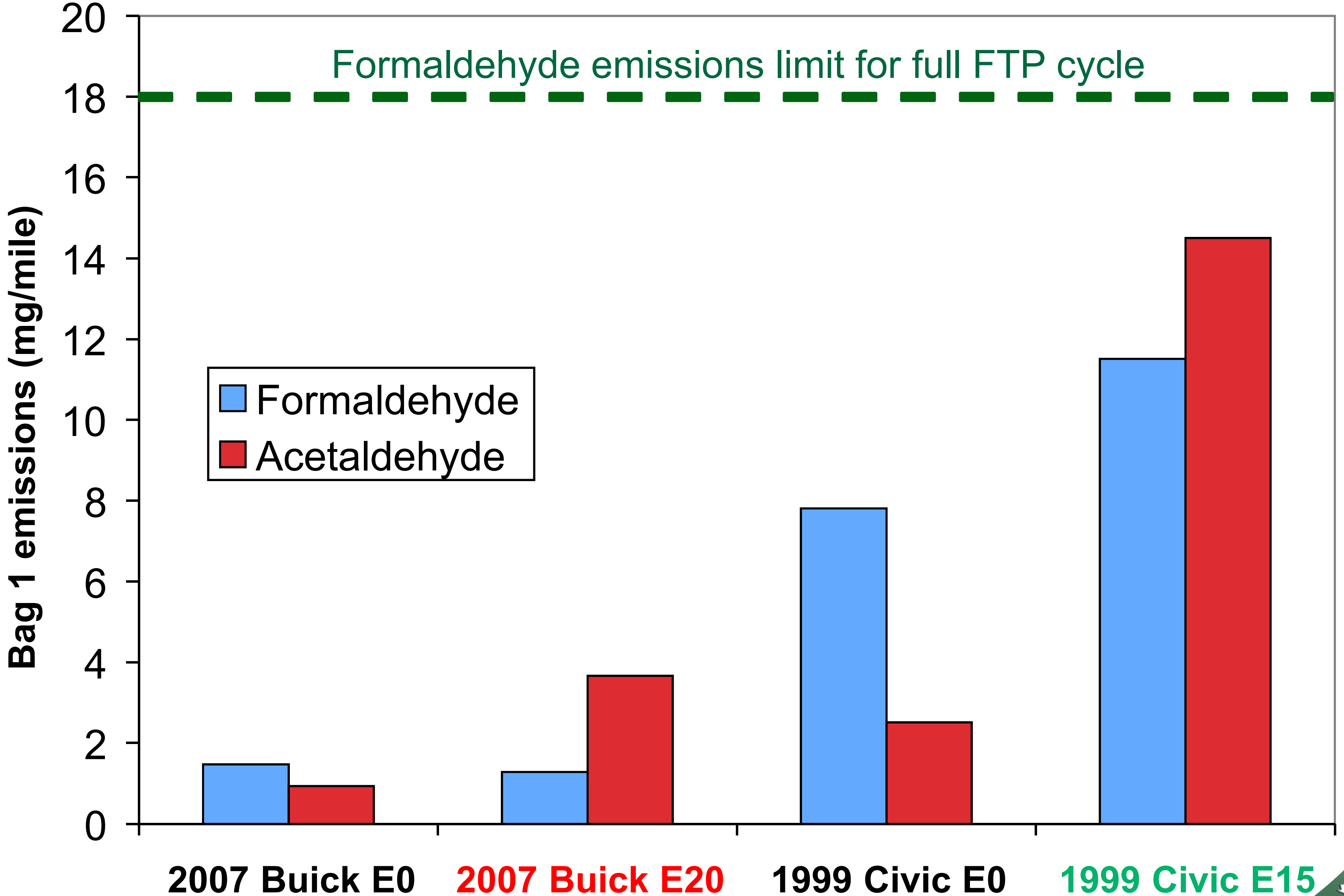
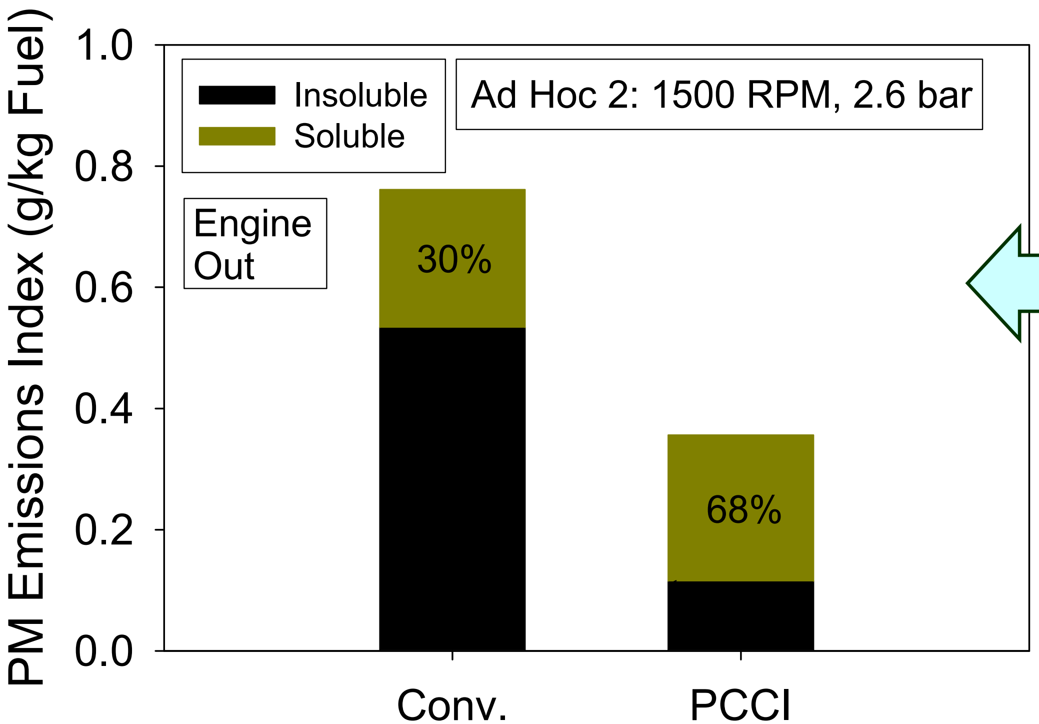
Intermediate blends reverse ratio of formaldehyde to acetaldehyde emissions



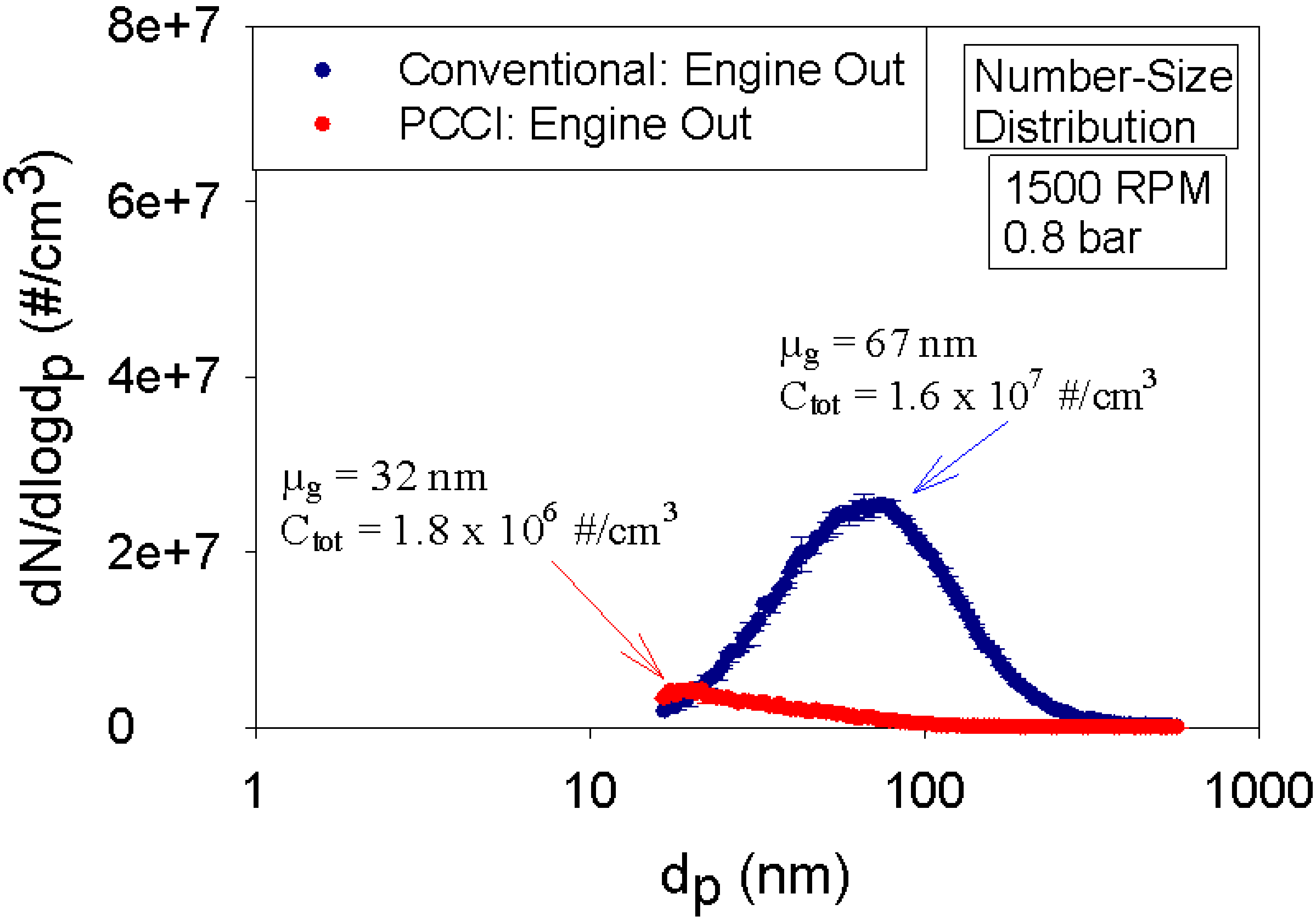
Understanding PM from HECC operation

- **PM studies continue look at HECC PM characteristics**
  - **PM is altered under HECC conditions; high SOF may have health impacts implications**
  - **PM changes can have direct affect on efficiency due to changes in DPF loading and regeneration**



We expect **HECC PM** to have **higher density** due to droplets of heavy organics

PM from HECC(PCCI) smaller than PM from conventional (OEM) combustion



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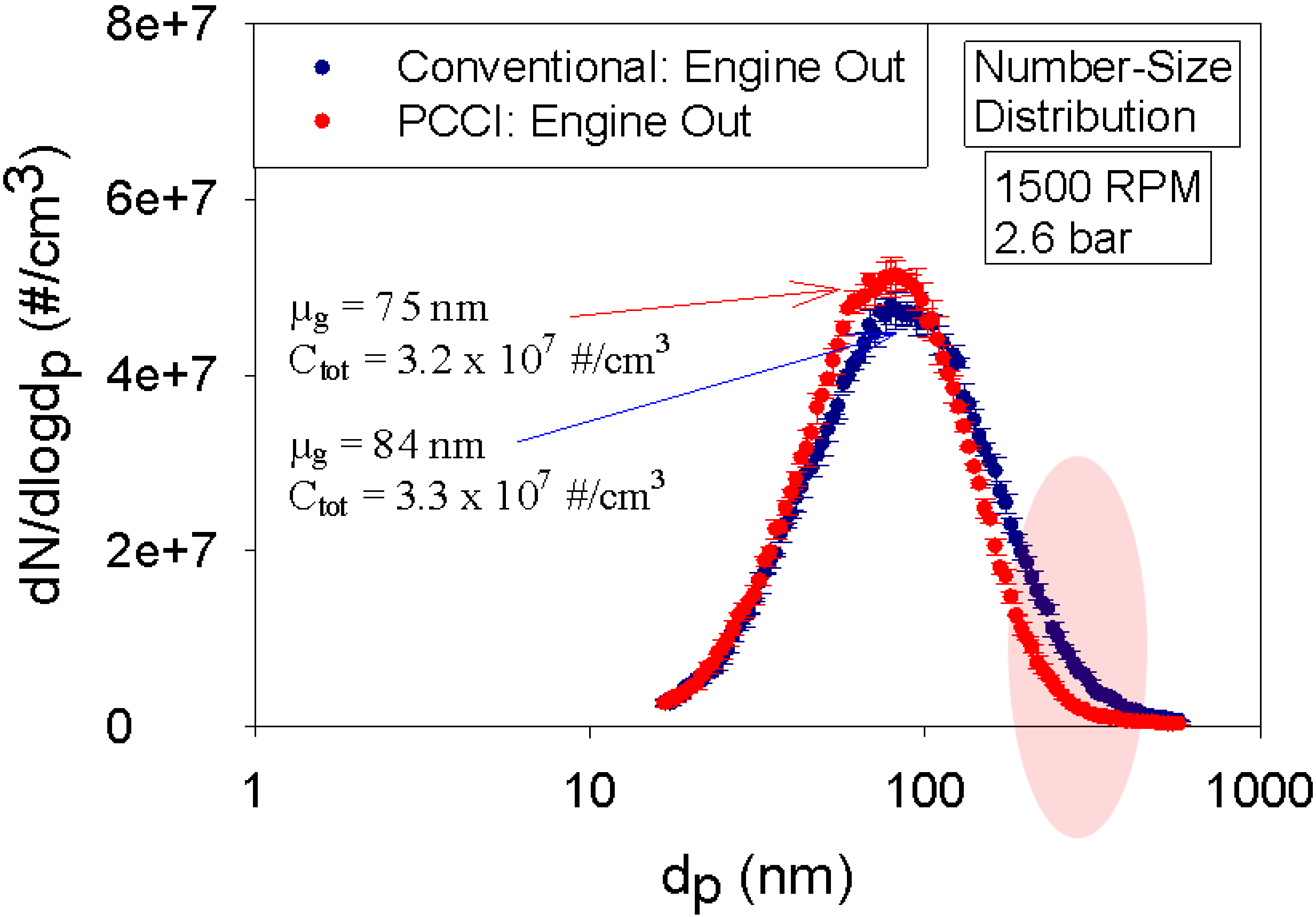

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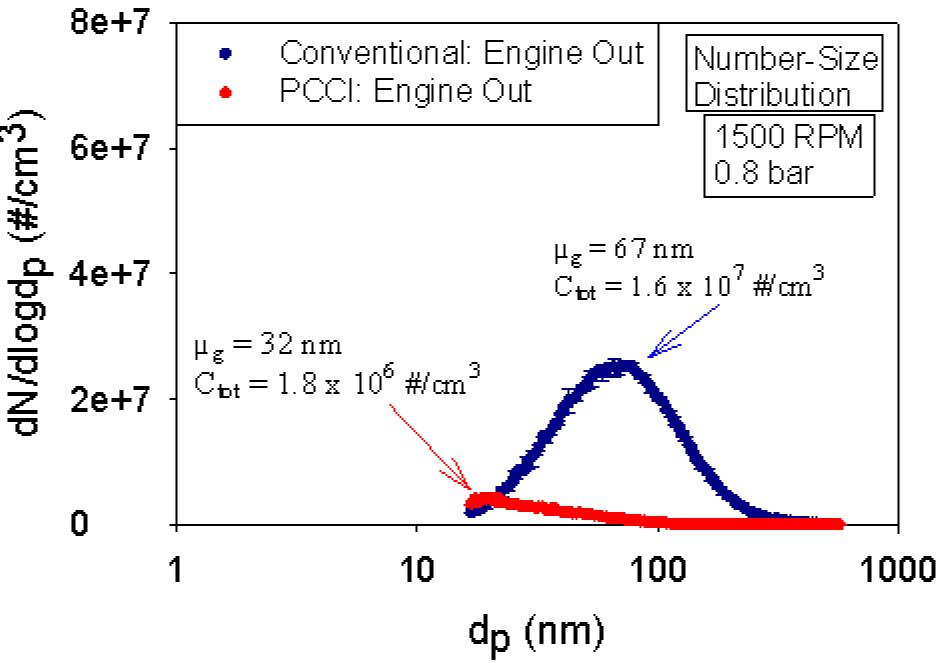
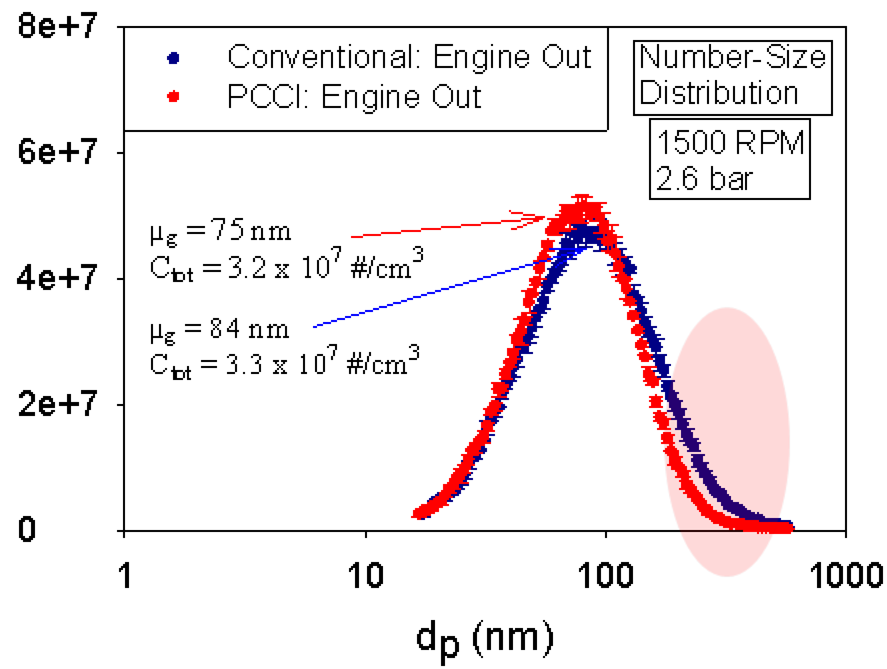
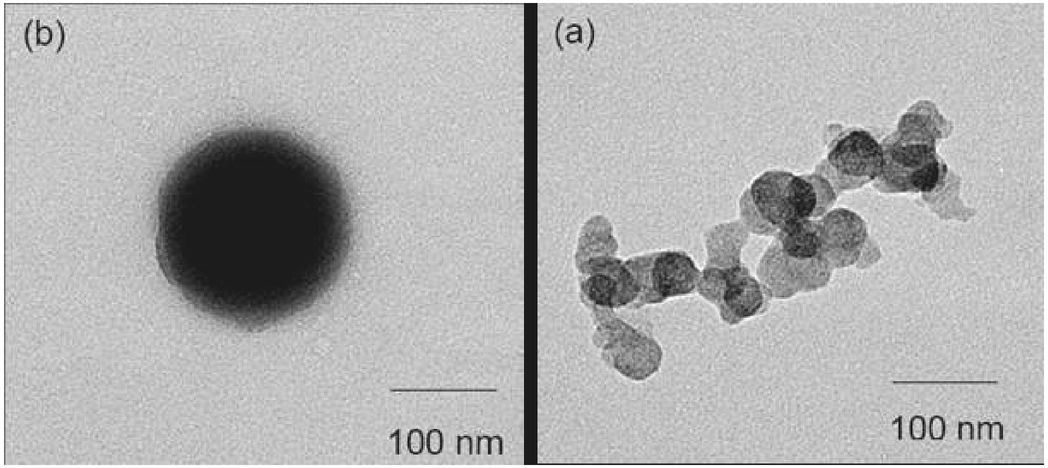
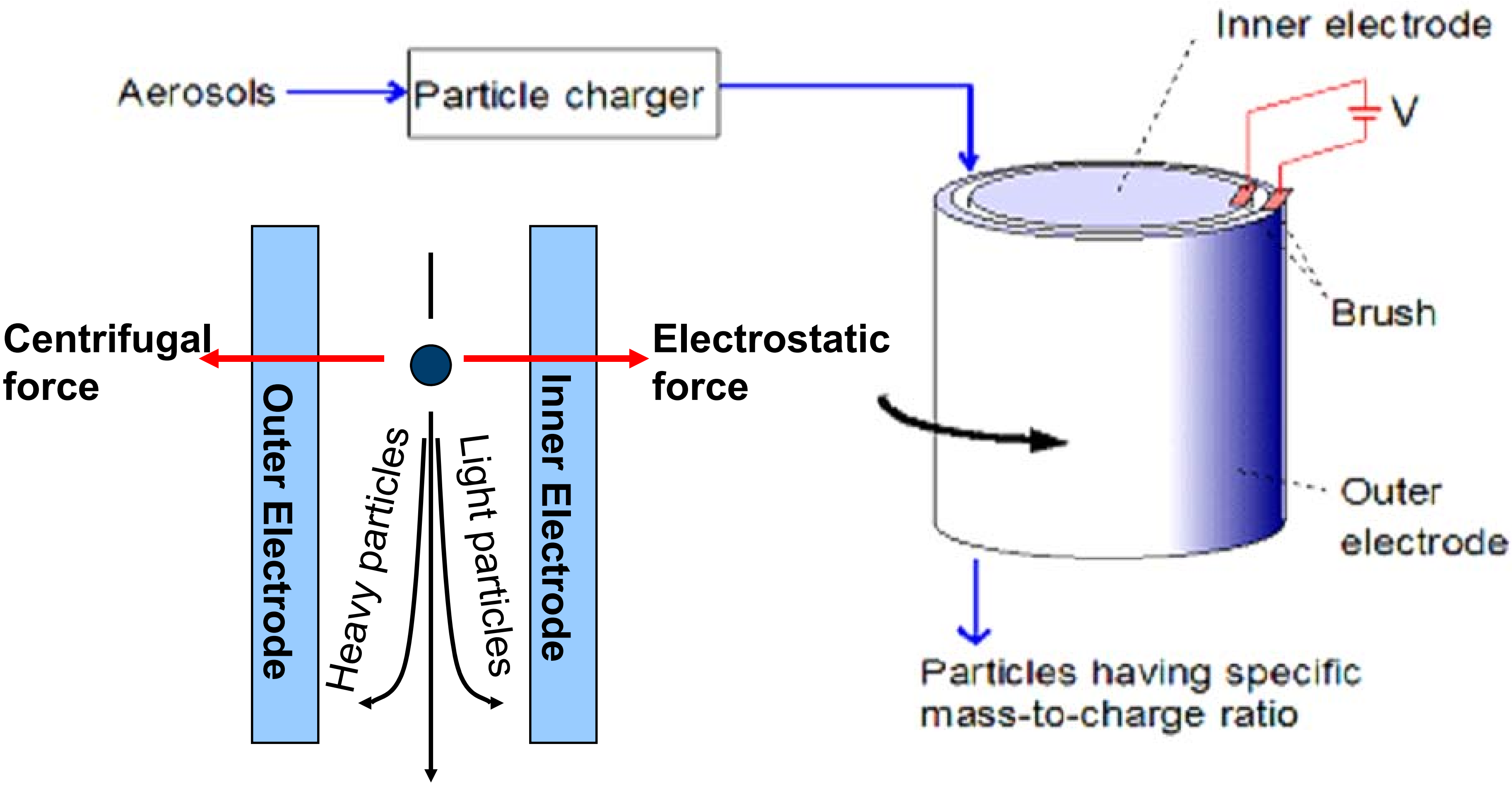






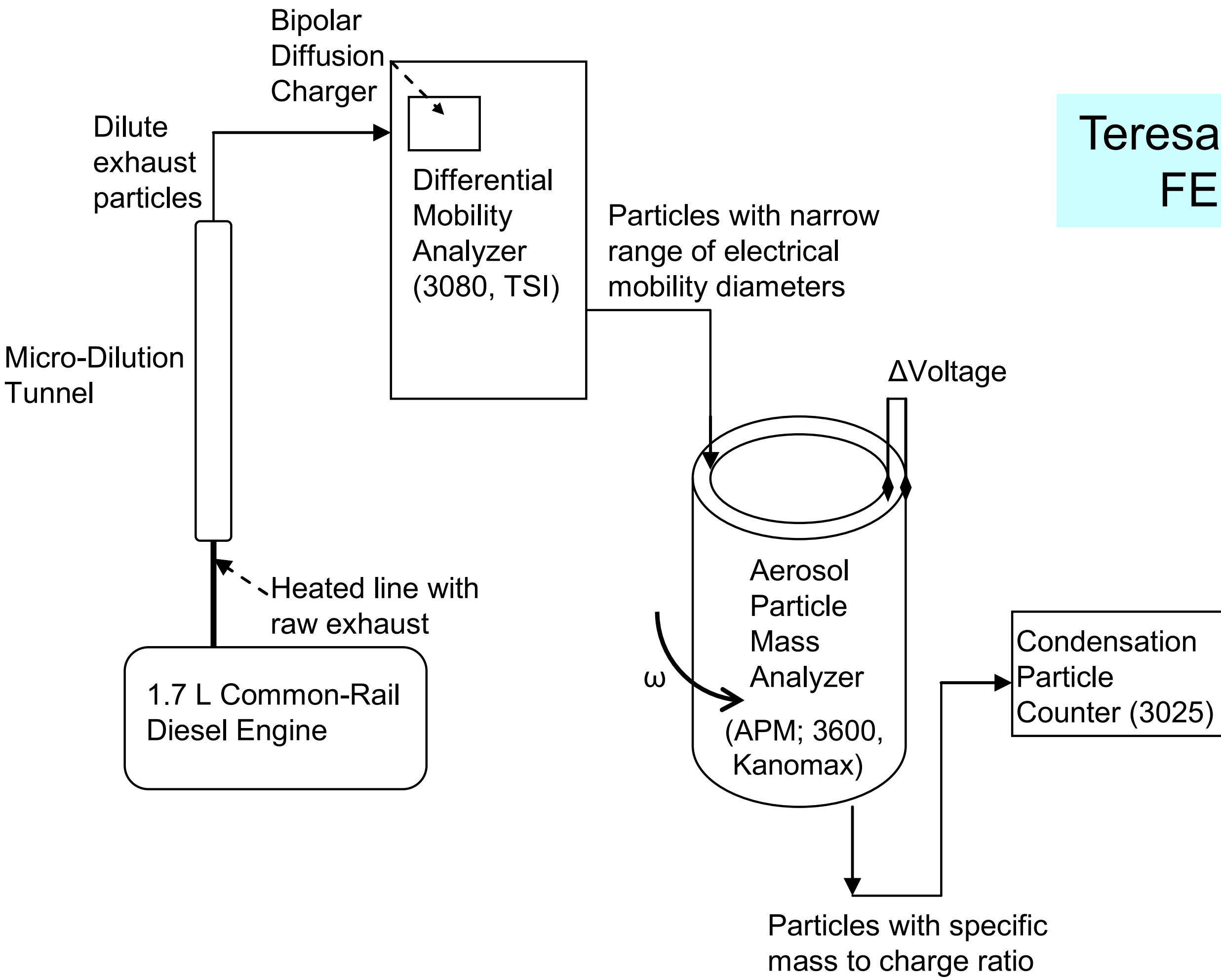
- **SMPS Data:**
  - Conventional PM has larger mean size
  - PCCI Has Smaller Particle Size Range

Unique tool employed to measure PM density Aerosol Particle Mass (APM) analyzer



Conventional and HECC particles measured

- Particles are generated by engine, diluted with clean air
- Sorted by SMPS into single sizes, mass measured by APM
- Density calculated from mobility diameter



Teresa Barone, FEERC

Anshuman Lall, Univ. MD

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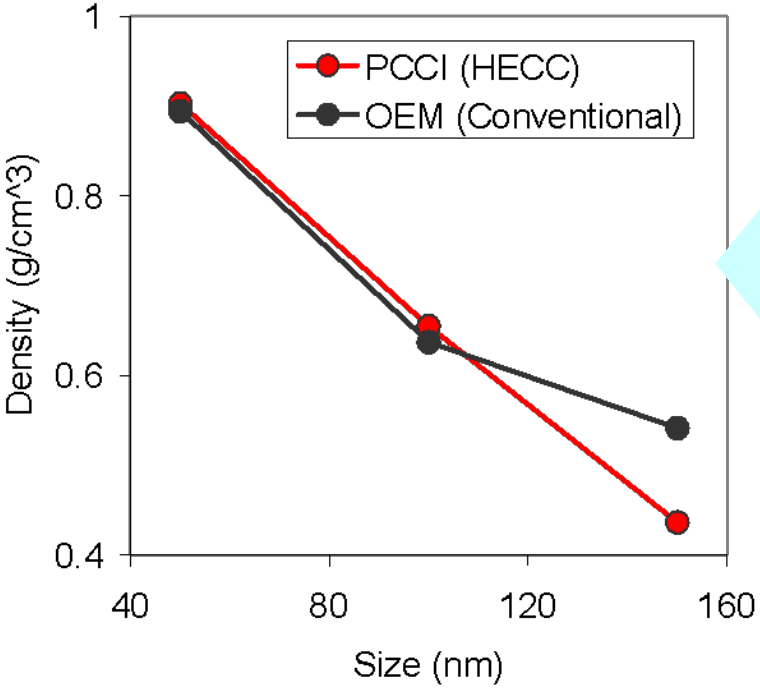
APM shows lower density for largest PCCI particles vs largest OEM particles



APM data:

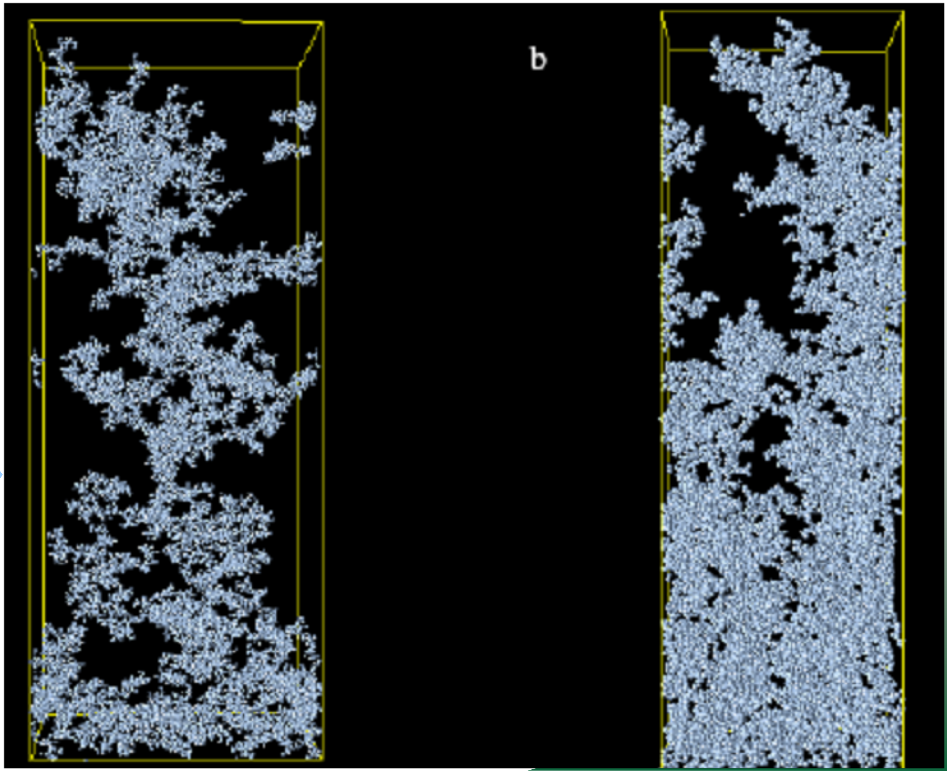
- PCCI and OEM particle densities similar for 50 nm, 100 nm
- PCCI density smaller for 150 nm

Implication:

Smaller primary particles

Lower packing density

Need confirmation from TEM!



Summary

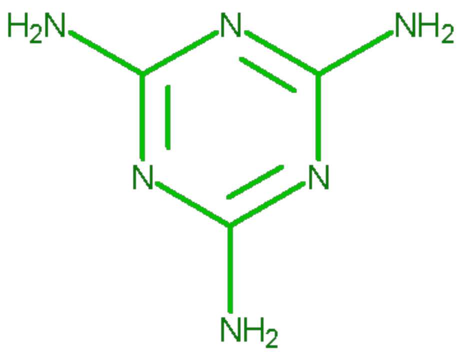
- **MSATs all very low in late model vehicles**
  - Benzene, toluene, ethylbenzene, xylenes (BTEX), and formaldehyde decrease with increasing ethanol
  - Acetaldehyde emissions increase with increasing ethanol; levels still quite low

- **Diesel particle density, morphology different with HECC/PCCI**
  - Health impact: aggregates more efficiently deposited in the lung
  - May affect DPF loading and regeneration; also EGR cooler fouling rates
  - Research can provide actual particle data for DPF models

John Storey
865-946-1232
storeyjm@ornl.gov

Future Work

- **Rest of FY09**
  - **Capture MSAT data from FlexFuel (E85) conversion vehicle: 2008 Dodge Charger**
  - **Use TEM to reconcile PM characterization with soot aggregate theory**
  - **Examine PM and HC emissions during active DPF regeneration**
- **FY10 and beyond**
  - **Continue to look at MSATs from "other" alcohol blends**
    - **Butanol, lean burn ethanol**
  - **SCR health impacts – what is emitted?**
    - **Urea decomposition products**
    - **Other nitrogen species**
    - **PM from DPF-SCR systems**



melamine