

M. Gautam  
West Virginia University  
Morgantown  
US

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**Nanoparticle emissions from catalyzed trap equipped heavy-duty vehicles operating on ultra-low-sulfur Diesel fuel**

# **Nanoparticle Emissions from Catalyzed Trap Equipped Heavy-Duty Vehicles Operating on Ultra-Low Sulfur Diesel Fuel**

**Sandeep Mehta, Mridul Gautam, Wesley Riddle,  
Dan Carder, Nigel Clark, Don Lyons**

**West Virginia University  
Department of Mechanical & Aerospace Engineering  
College of Engineering & Mineral Resources  
PO Box 6106  
Morgantown, WV 26506-6106**



## **GLOBAL OBJECTIVE**

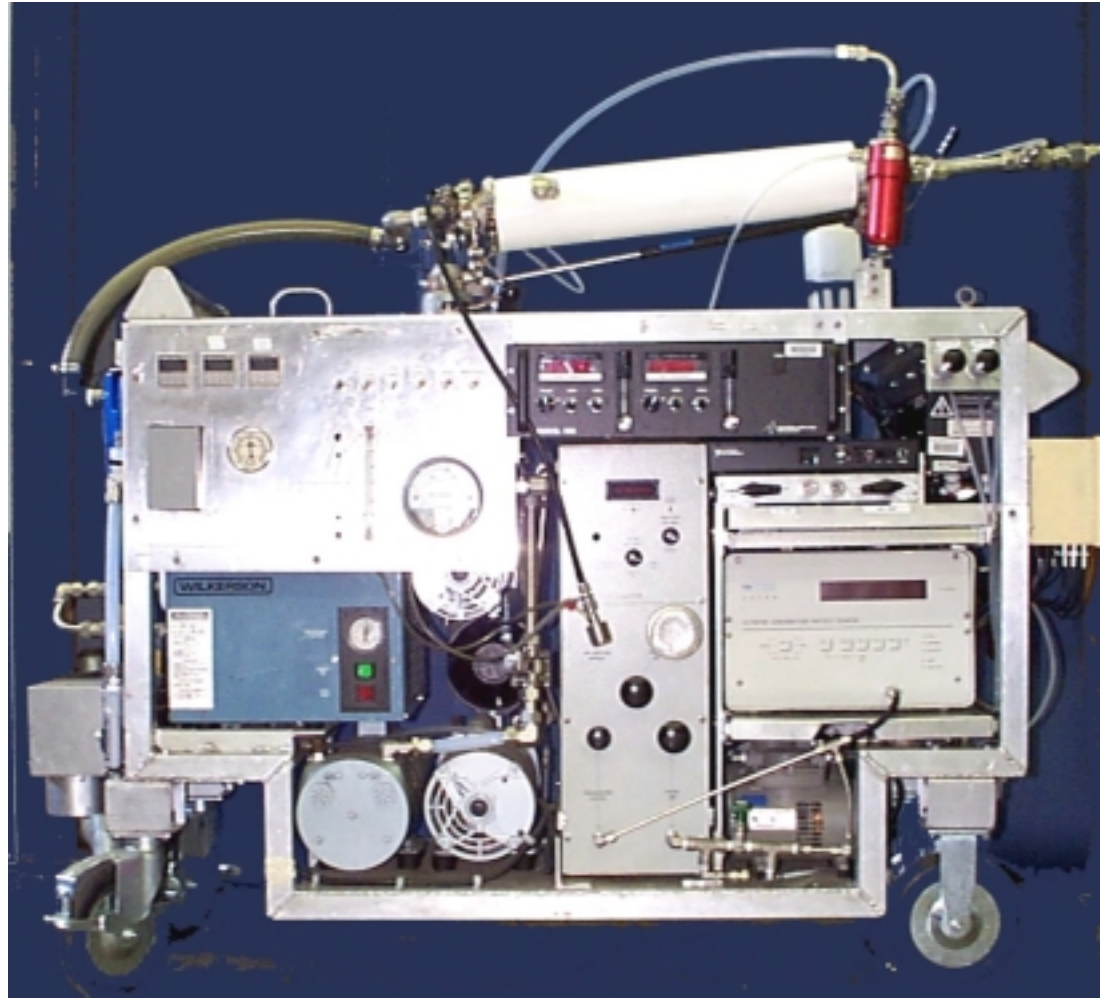
- **TO DETERMINE THE TOXICITY OF PM EMISSIONS FROM VEHICLES EQUIPPED WITH CATALYZED PARTICULATE MATTER TRAPS AND OPERATING ON ULTRA-LOW SULFUR FUEL**

## **SPECIFIC OBJECTIVE**

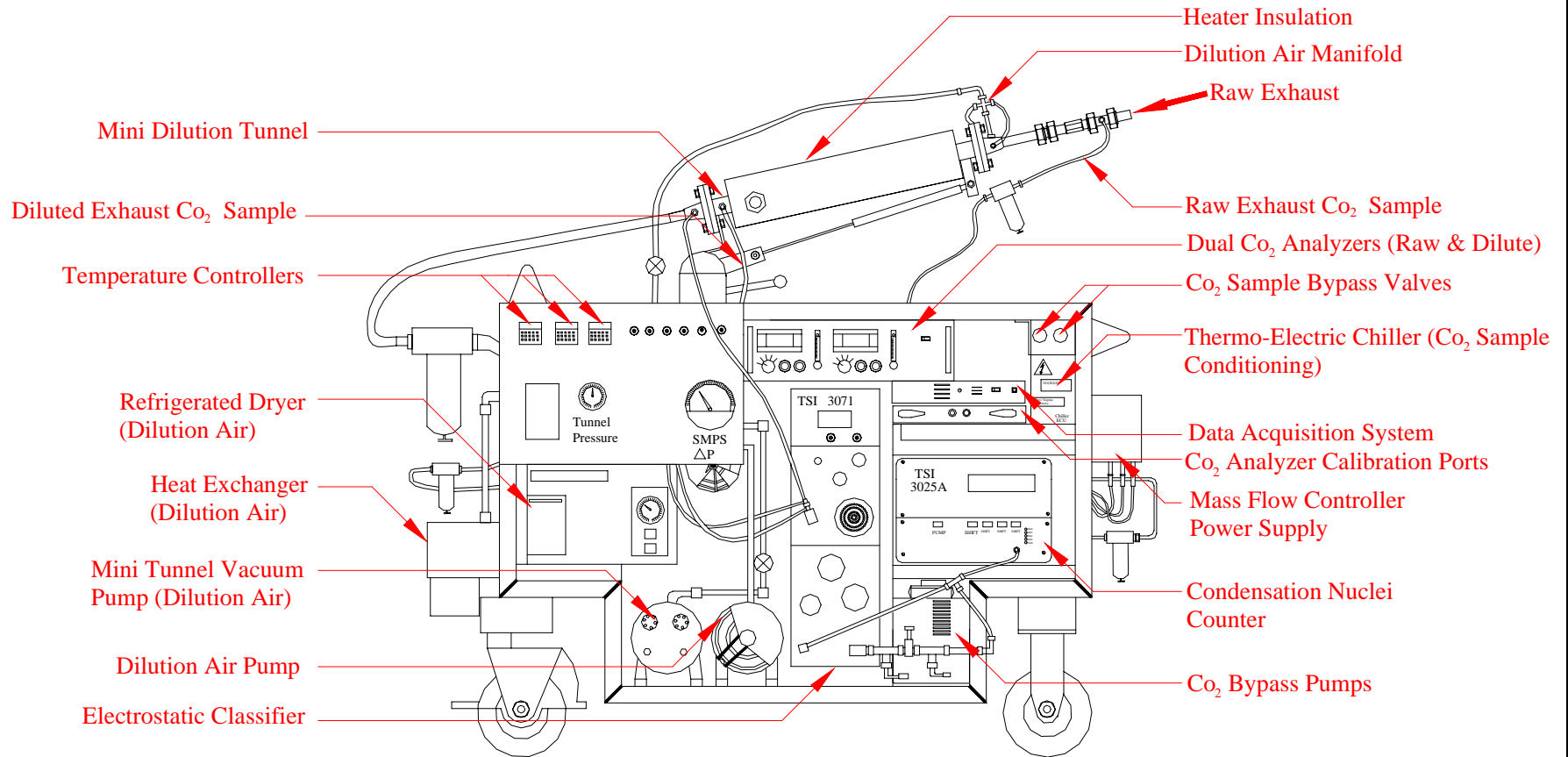
- **TO EXAMINE PARTICLE SIZE DISTRIBUTIONS AND CONCENTRATIONS FROM VEHICLES OPERATING ON ULTRA-LOW SULFUR FUELS AND EQUIPPED WITH CATALYZED PARTICULATE MATTER TRAP SYSTEMS**



# PARTICLE SIZING CART



# PARTICLE SIZING CART



# EXPERIMENTAL TEST MATRIX

VEHICLE ID	VEHICLE TYPE	FUELS	EXHUAUST AFTER-TREATMENT	VEHICLE ID	VEHICLE TYPE	FUELS	EXHUAUST AFTER-TREATMENT
SDUDSB-8439	SCHOOL BUS	ECD	ENGELHARD DPX	LACMTA-3005	TRANSIT BUS	ECD	JOHNSON-MATTHEY CRT
		ECD1				ECD1	
		CARB				CARB	
		FT					
		ECD	NONE			ECD	NONE
		ECD1				ECD1	
		CARB				ECD1	
		FT				CARB	

## **EXPERIMENTAL TEST MATRIX**

<b>VEHICLE ID</b>	<b>VEHICLE TYPE &amp; ENGINE</b>	<b>FUELS</b>	<b>EXHUAUST AFTER-TREATMENT</b>
<b>LACMTA-3005</b>	<b>TRANSIT BUS</b> <b>37,920 lb GVW</b> <b>29,900 lb Test Weight</b> <b>5-speed Auto.</b>	<b>ECD</b>	<b>JOHNSON-MATTHEY CRT</b>
		<b>ECD1</b>	
		<b>CARB</b>	
	<b>-----</b> <b>DDC Series 60</b> <b>4-Cylinder;</b> <b>8.5 liter;</b> <b>275 hp</b>	<b>ECD</b>	<b>NONE</b>
		<b>ECD1</b>	
		<b>CARB</b>	

## FUEL ANALYSIS RESULTS

<u>Property</u>	<u>CARB</u>	<u>ECD</u>	<u>ECD-1</u>
<b>Cetane Number</b>	<b>54.1</b>	<b>64.7</b>	<b>51.3</b>
<b>Sulfur, ppm</b>	<b>121</b>	<b>7.4</b>	<b>13.1</b>
<b>SFC Aromatics</b>			
<b>Total, vol%</b>	<b>22.5</b>	<b>10.9</b>	<b>23.8</b>
<b>PNA, wt%</b>	<b>4.1</b>	<b>0.9</b>	<b>2.8</b>



# ARCO Tanker Trucks

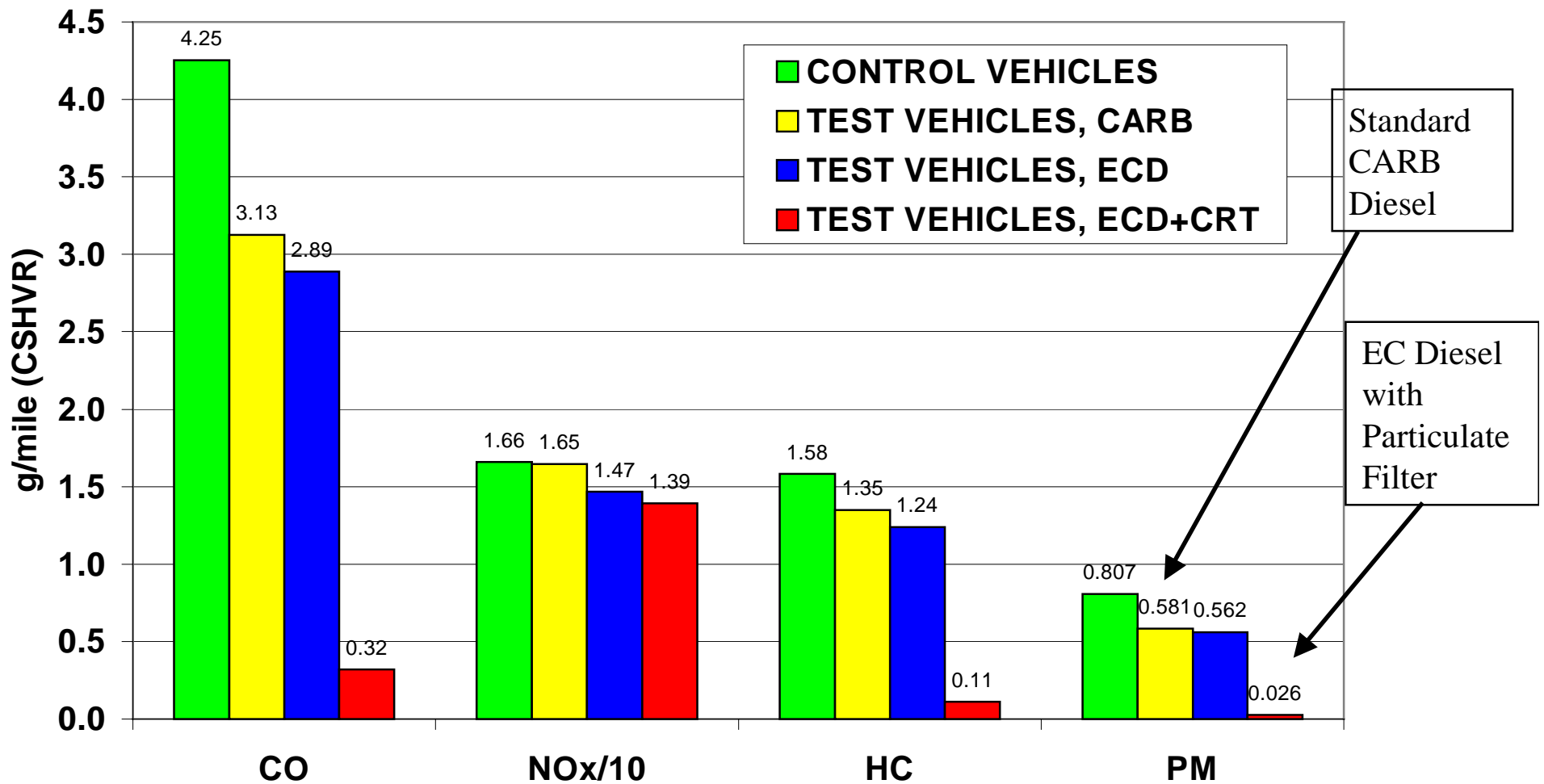
- Kenworth chassis
- 1995 & 96 Cummins M11 10.8 litre turbocharged diesel, 330hp
- 10 spd. manual transmission
- Johnson Matthey CRT  
(continuously regenerative  
technology)
- 32,200 lb  
test weight

# Average Tanker Truck Emissions

Each bar is average of 2 vehicles, 3 runs per vehicle

(LeTavec, C., ARICE Workshop, California Energy Commission, July 10, 2001, Sacramento, Ca.)

## Average Tanker Truck Emissions

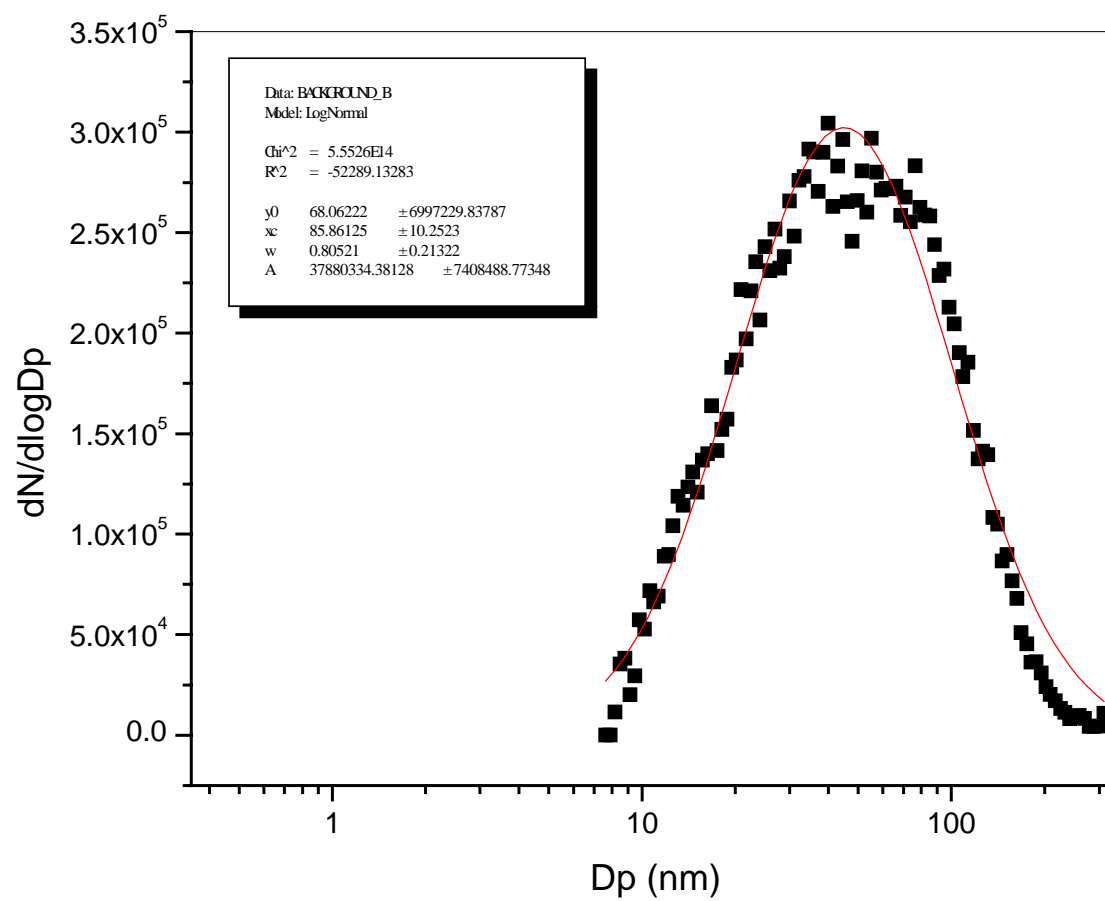


## **APPROACH**

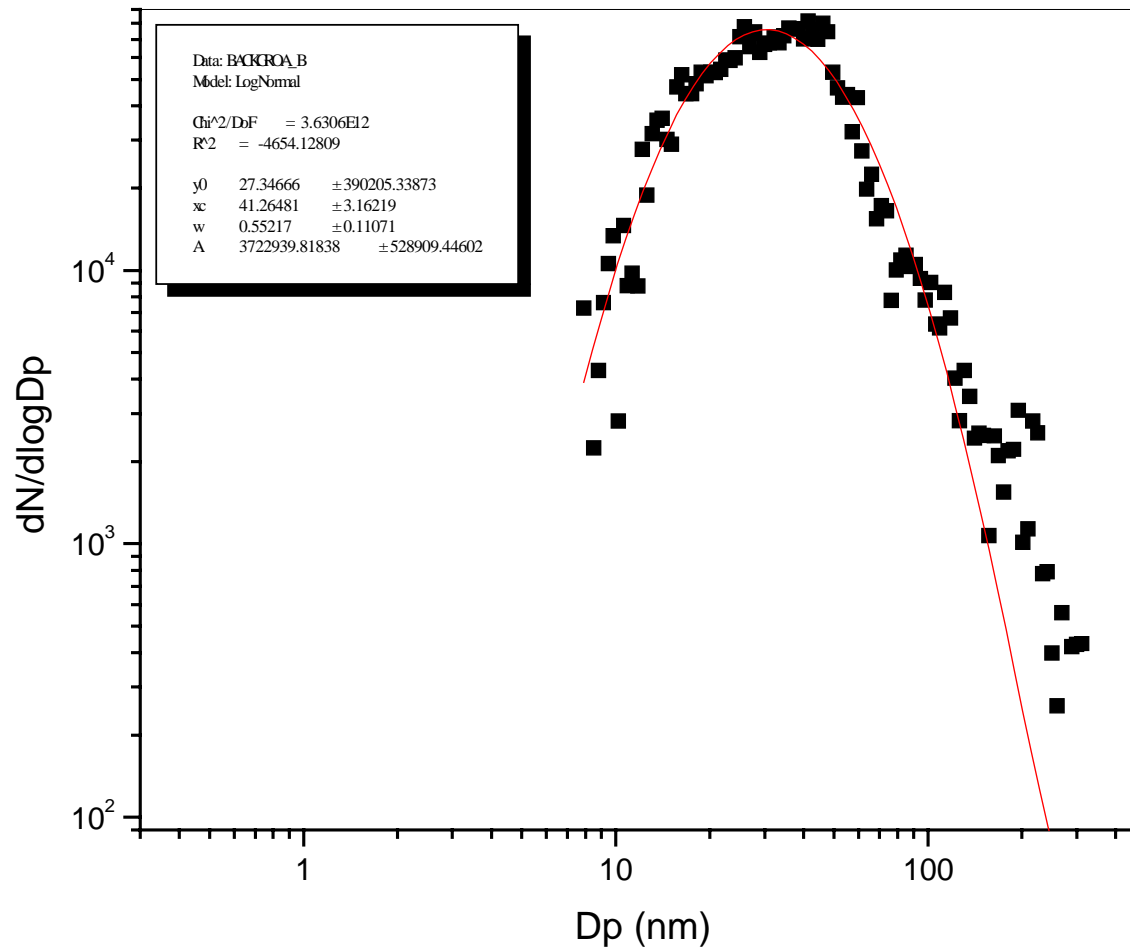
- **SINGLE STAGE DILUTION OF RAW EXHAUST WITH A MASS FLOW CONTROLLER-BASED DILUTION SYSTEM**
- **MEASURE CONCENTRATIONS AND PARTICLE SIZE DISTRIBUTIONS ON STEADY-STATE OPERATION**
- **COLLECT DATA DURING WARM-UP TO OBSERVE THE EFFECT OF CATALYST LIGHT-OFF ON PARTICLE SIZE DISTRIBUTIONS**
- **BASED UPON THE STEADY-STATE PARTICLE SIZE DISTRIBUTIONS, SELECT A FEW KEY PARTICLE SIZES FOR TRACKED DURING THE TRANSIENT OPERATION**



# MINI-TUNNEL BACKGROUND

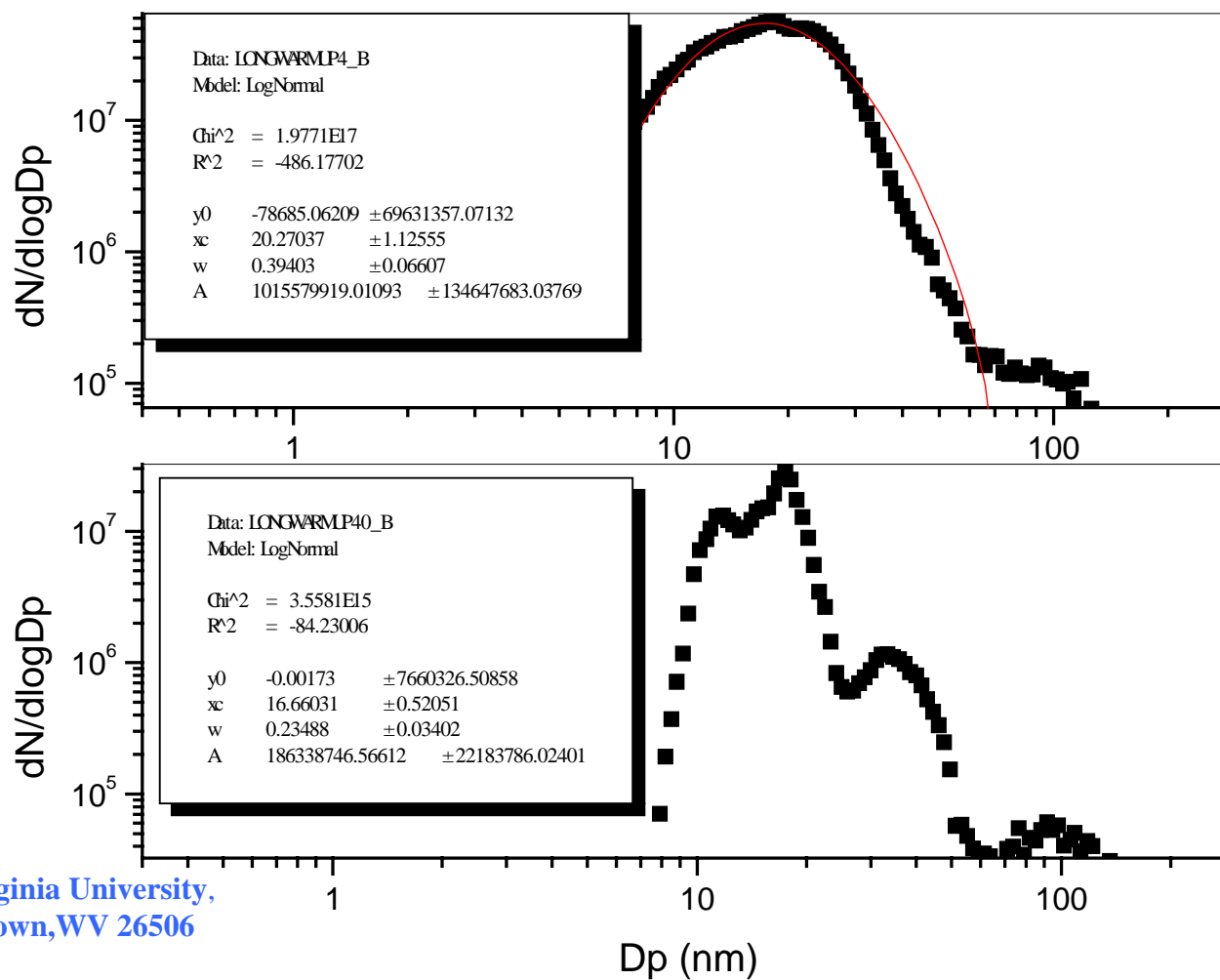


# TUNNEL BACKGROUND

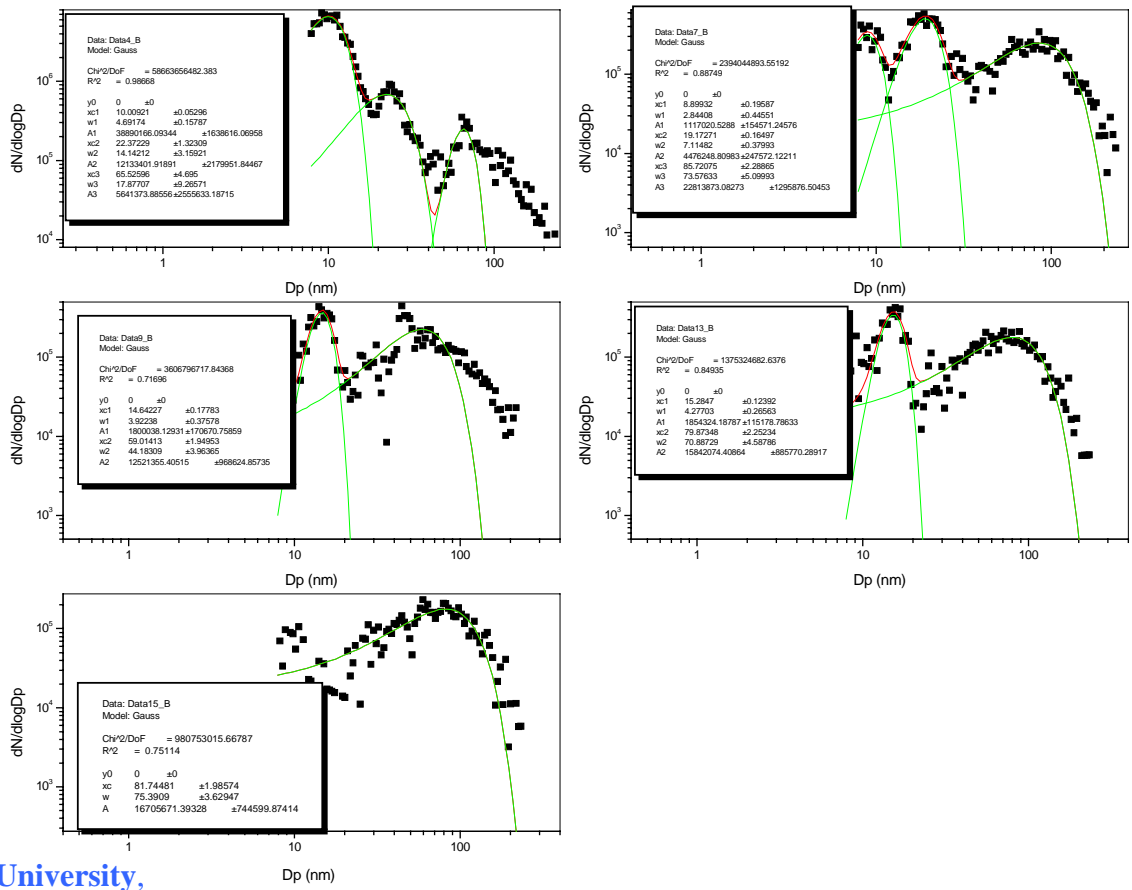


# COLD START AT 40 MPH; DR=13:1 TRANSIT BUS FUEL: ECD

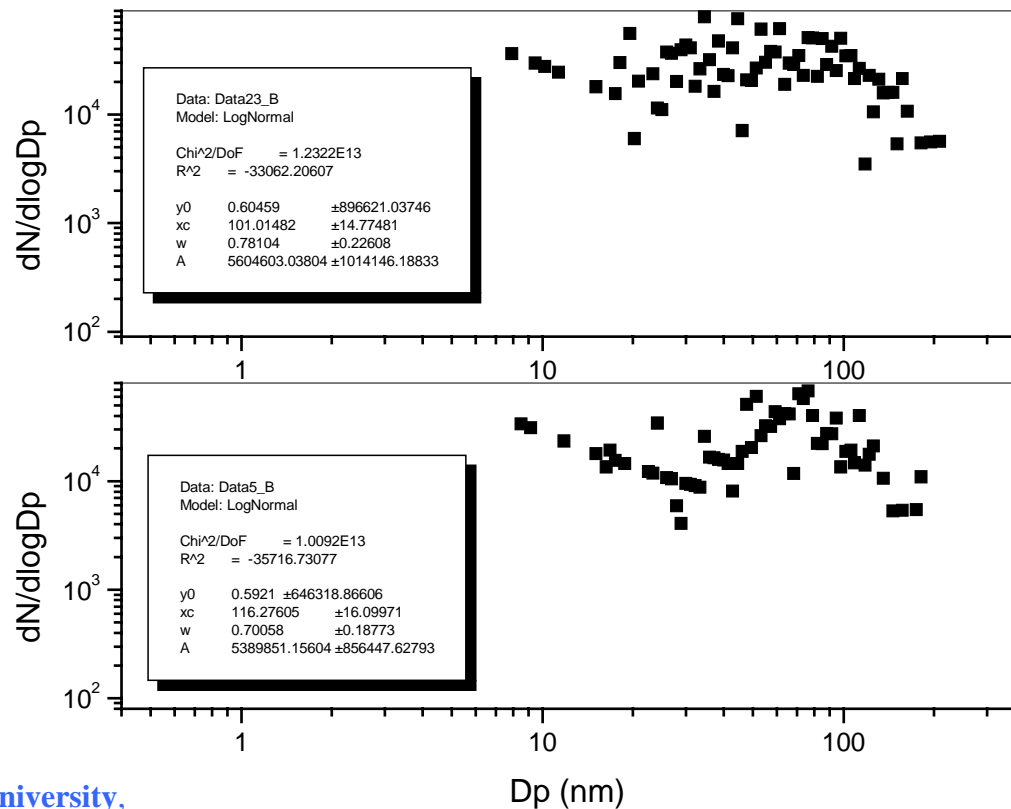
## EXHAUST AFTER-TREATMENT: JOHNSON-MATTHEY



# COLD START AT 40 MPH; DR=25:1 TRANSIT BUS FUEL: ECD EXHAUST AFTER-TREATMENT: JOHNSON-MATTHEY

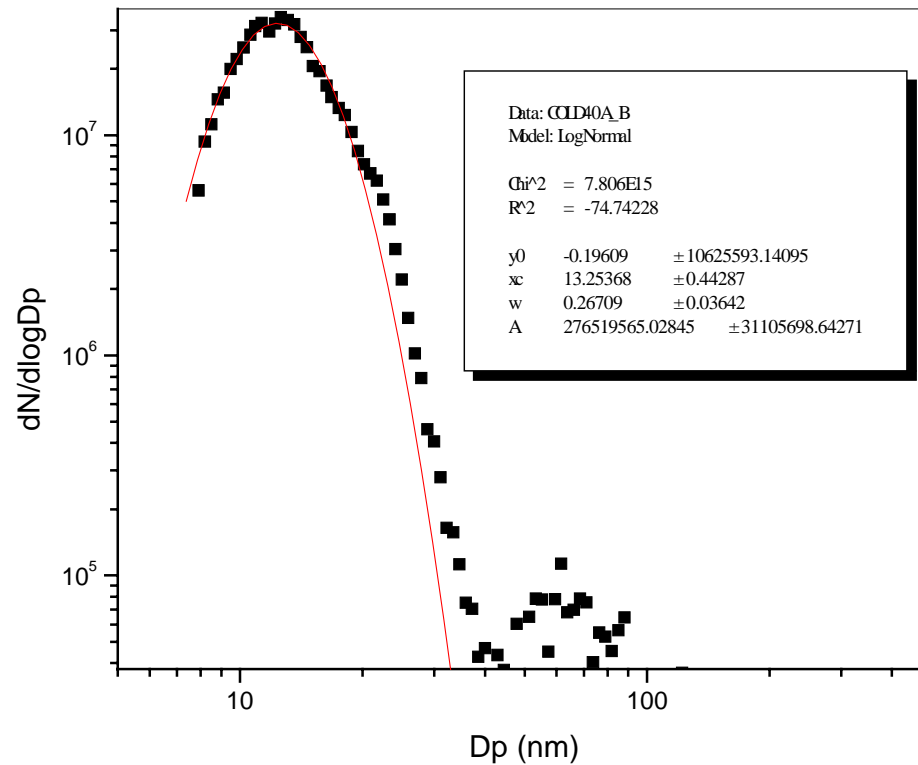


**AFTER WARM-UP AT 20 MPH; DR=25:1  
TRANSIT BUS  
FUEL: ECD  
EXHAUST AFTER-TREATMENT: JOHNSON-MATTHEY**

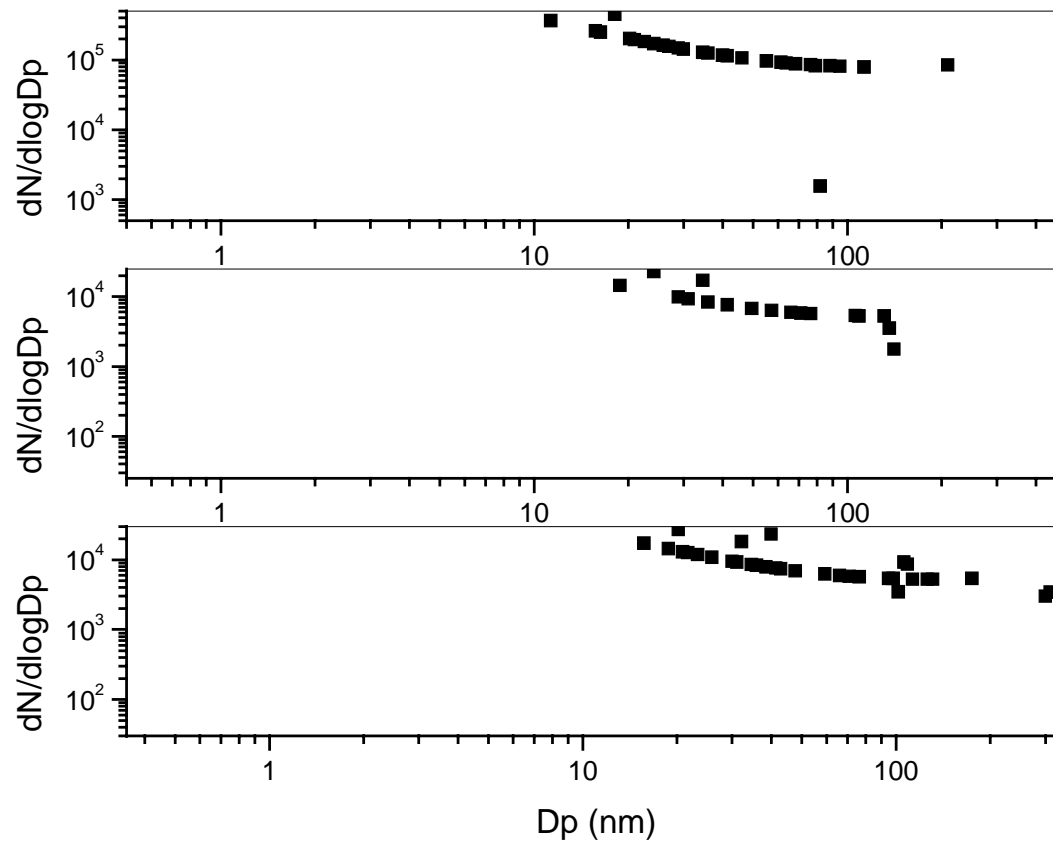




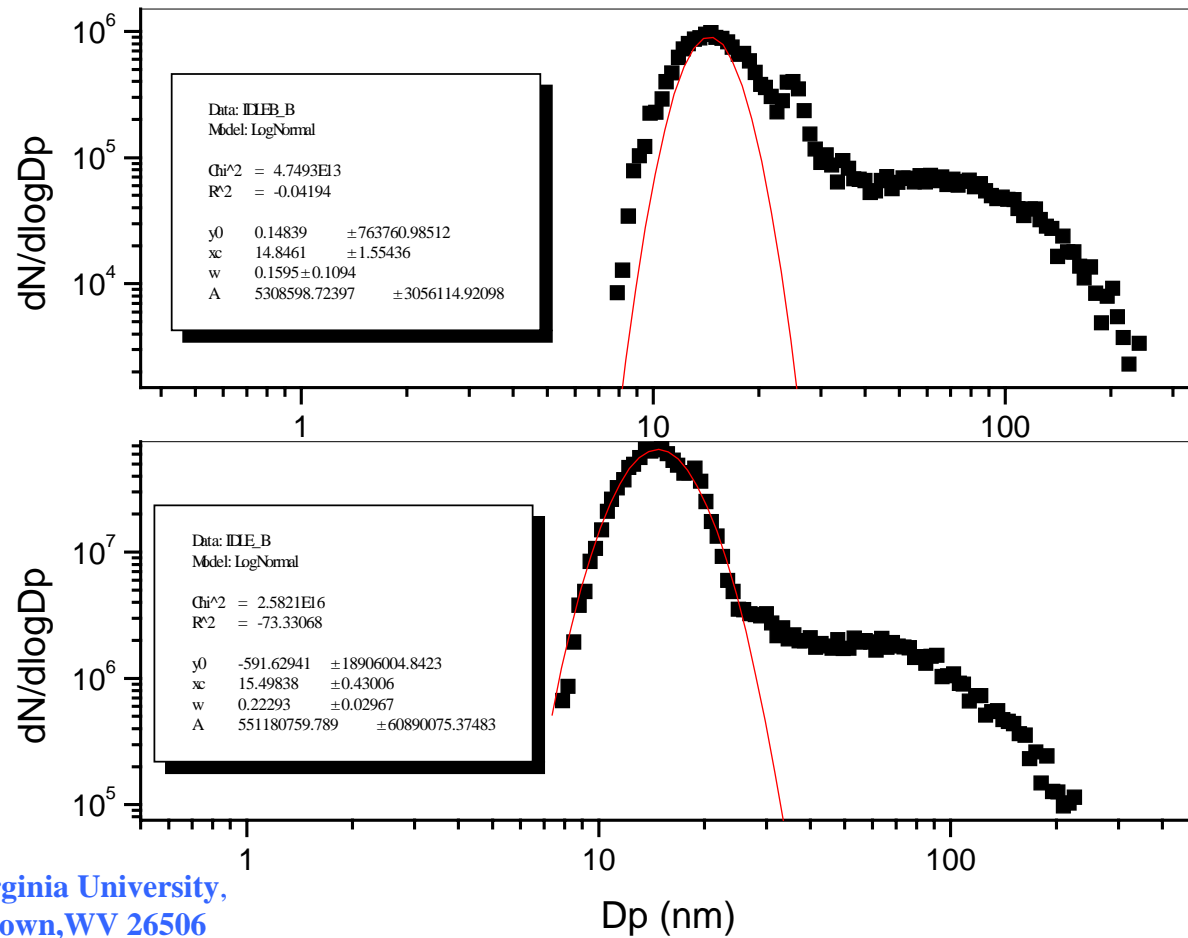
**COLD START AT 40 MPH  
TRANSIT BUS  
FUEL: ECD 1  
EXHAUST AFTER-TREATMENT: JOHNSON-MATTHEY**



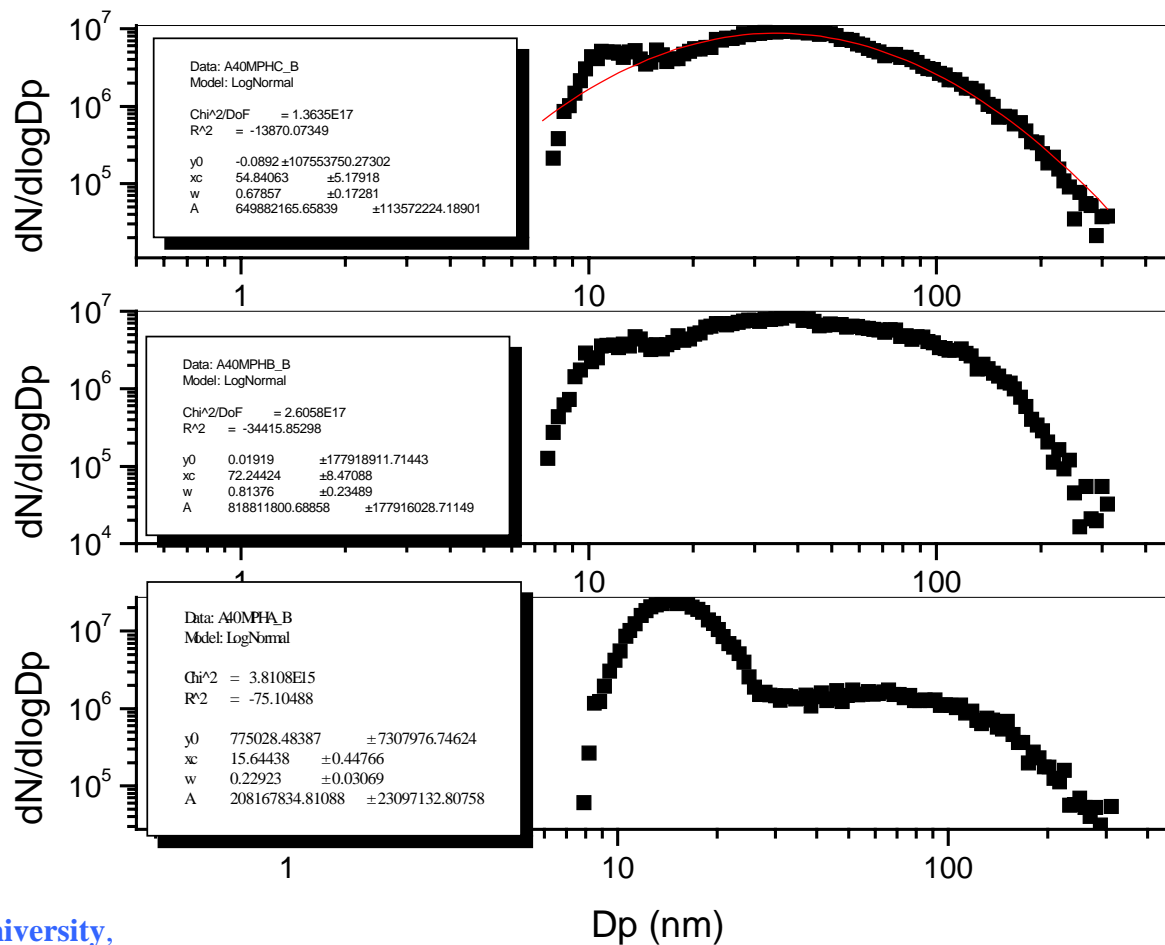
**AFTERWARM-UP AT 40 MPH  
TRANSIT BUS  
FUEL: ECD1  
EXHAUST AFTER-TREATMENT: JOHNSON-MATTHEY**



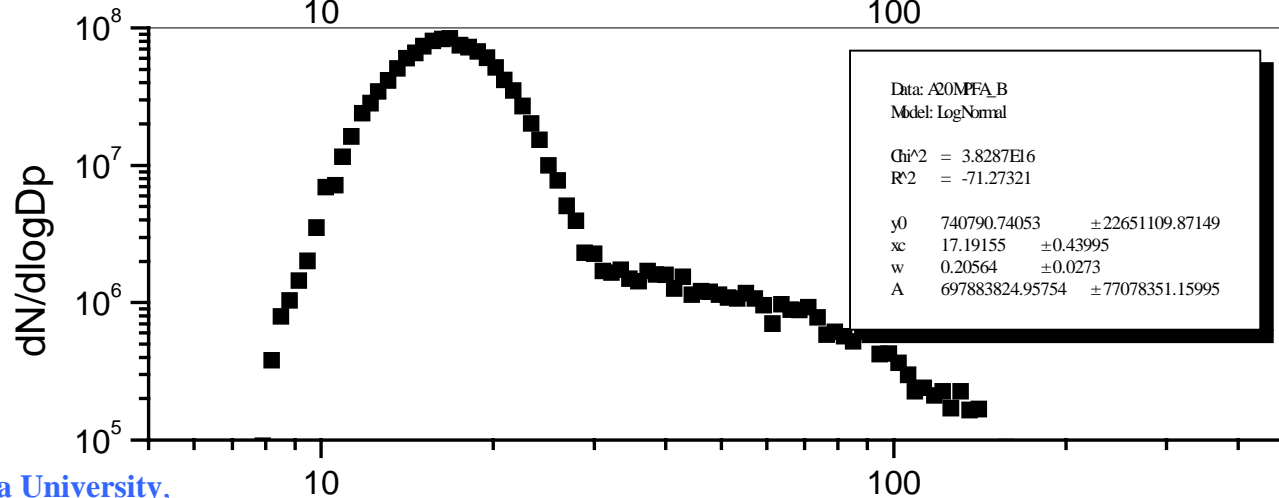
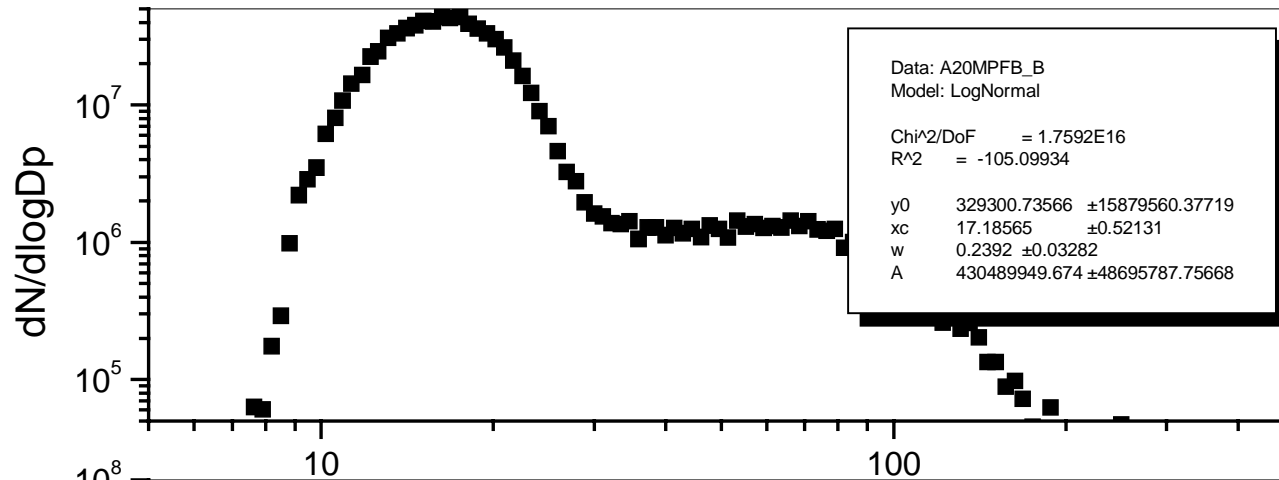
# AFTERWARM-UP IDLE TRANSIT BUS FUEL: ECD1 EXHAUST AFTER-TREATMENT: NONE



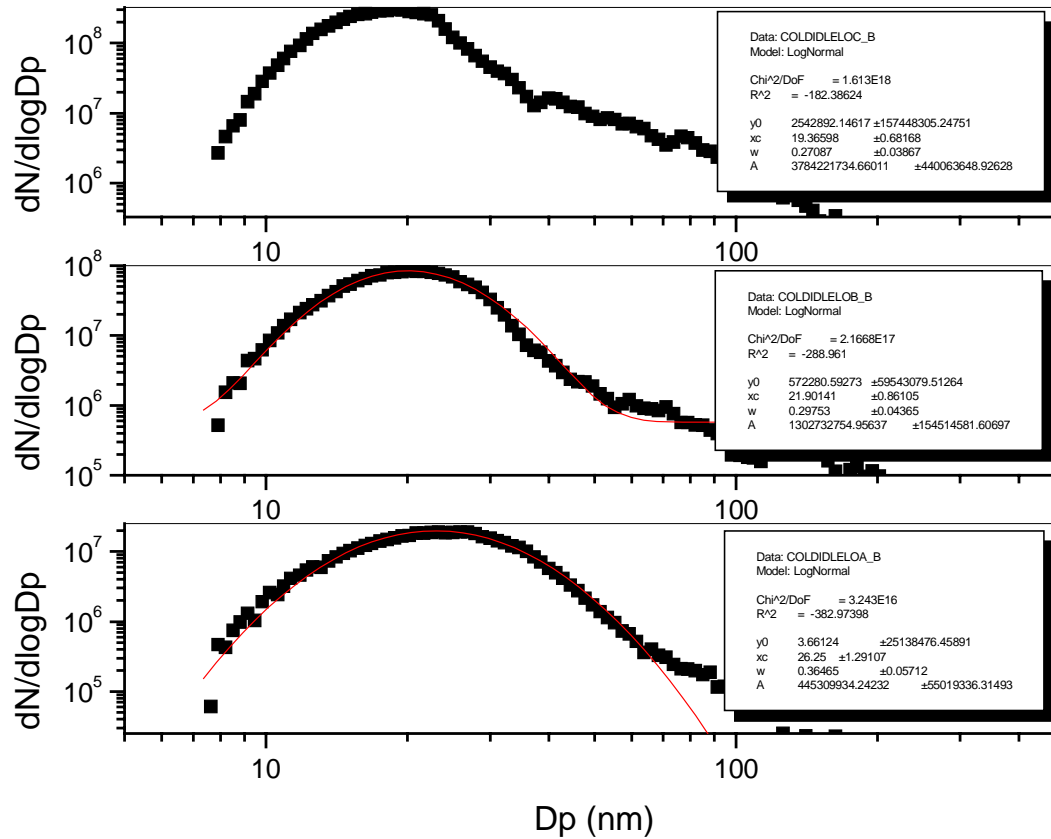
# AFTERWARM-UP AT 40MPH TRANSIT BUS FUEL: ECD1 EXHAUST AFTER-TREATMENT: NONE



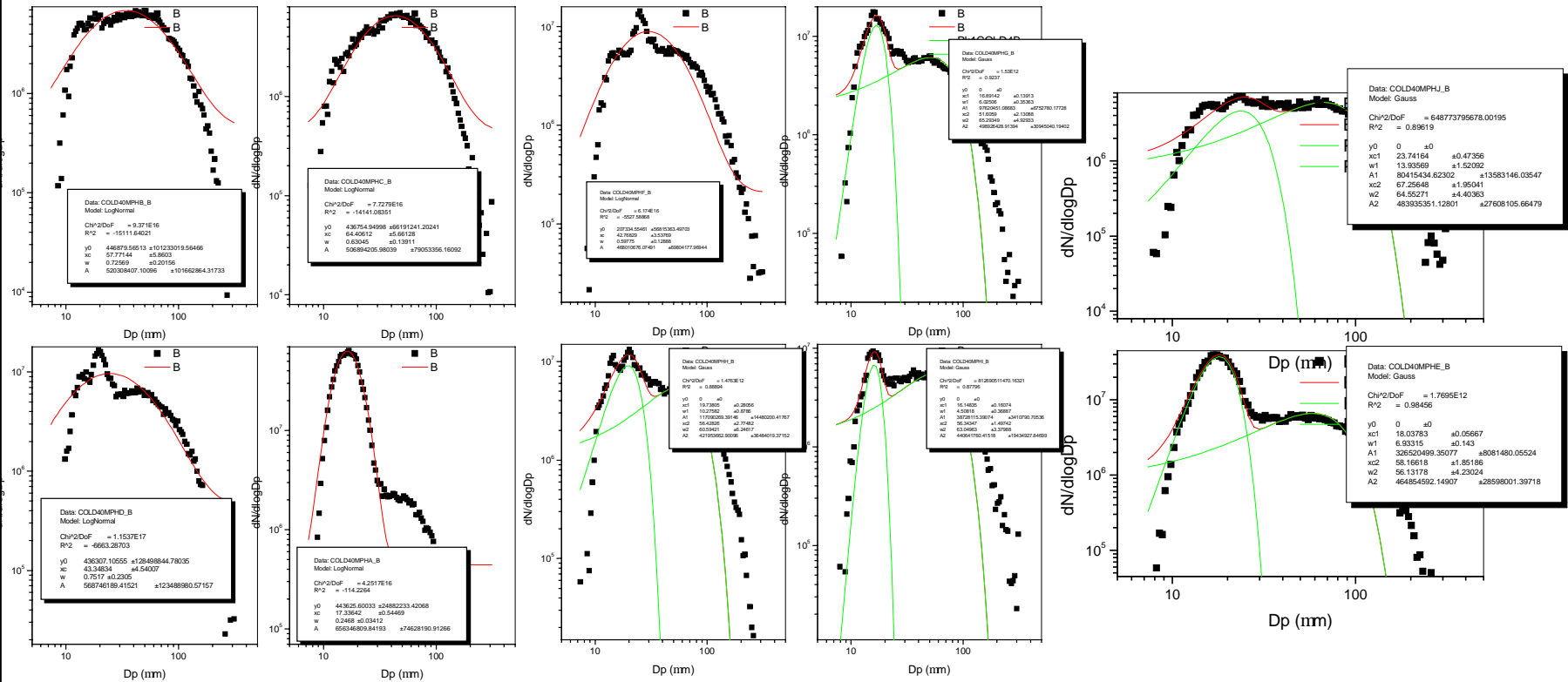
**AFTERWARM-UP AT 20MPH  
TRANSIT BUS  
FUEL: ECD1  
EXHAUST AFTER-TREATMENT: NONE**



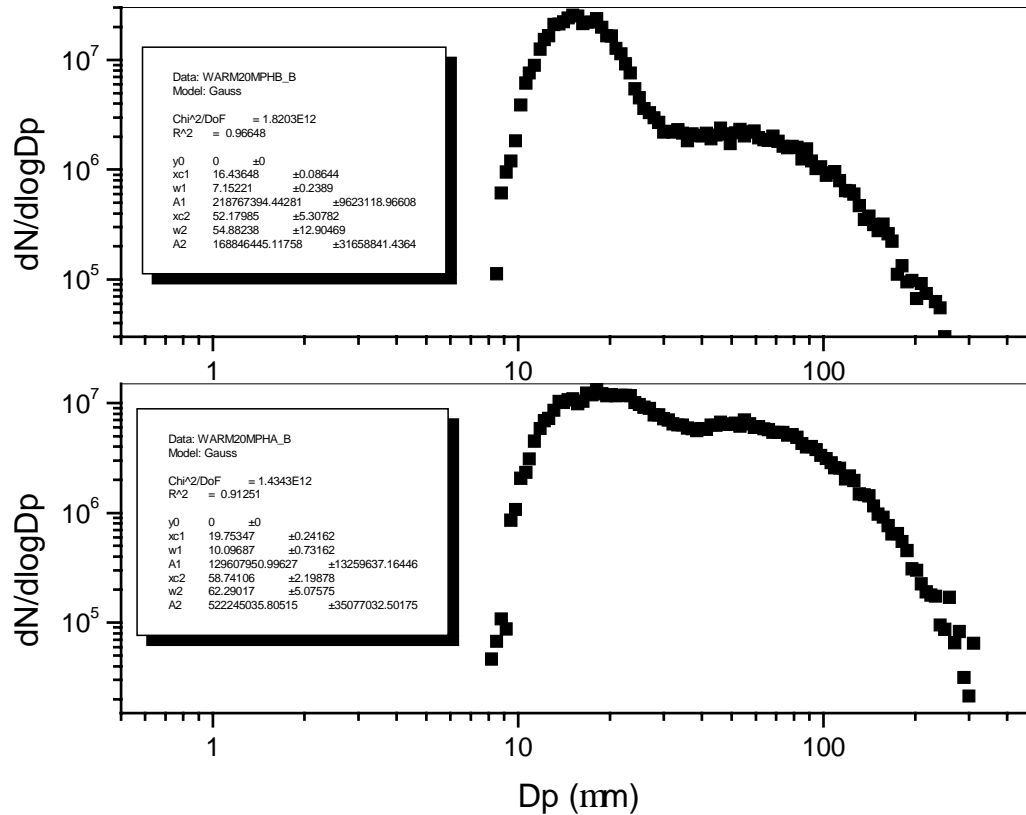
# COLD START IDLE TRANSIT BUS FUEL: CARB EXHAUST AFTER-TREATMENT: NONE



# DURING WARM-UP AT 40MPH TRANSIT BUS FUEL: CARB EXHAUST AFTER-TREATMENT: NONE



# DURING WARM-UP AT 20MPH TRANSIT BUS FUEL: CARB EXHAUST AFTER-TREATMENT: NONE





## **CONCLUSIONS**

- **ENGINES EQUIPPED WITH CATALYZED PM TRAPS AND OPERATING LOW SULFUR FUELS CAN DRAMATICALLY REDUCE THE PM EMISSIONS, AFTER THE CATALYST LIGHT-OFF TEMPERATURE BEEN ACHIEVED.**
- **HIGH CONCENTRATIONS OF NANO-PARTICLE WERE OBSERVED DURING THE COLD START OPERATION OF VEHICLES.**
- **BI-MODAL DISTRIBUTIONS WERE OBSERVED FOR FEW OF THE TEST RUNS, BUT THEY WERE NOT THE NORM.**