Aerodyne Research, Inc.

Mobile Laboratory Mounted Fast Response Instrument Methods for On-Road Vehicle Emissions Measurements

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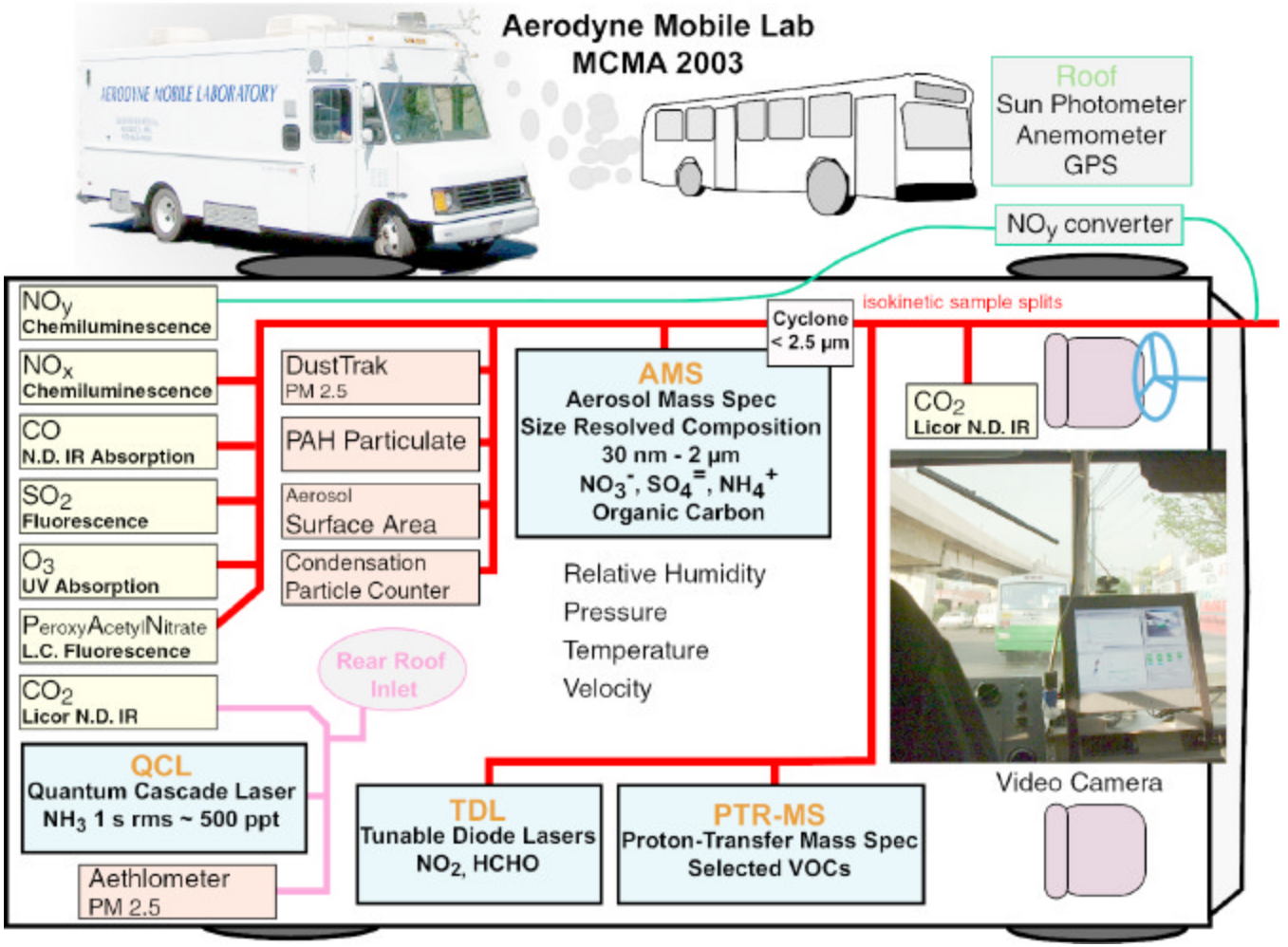
Aerodyne's 2nd Generation Mobile Laboratory

Mobile Lab sampling under stationary conditions at CENICA in Mexico City, April 2003

MIT-CAM-ARI Field Measurement Campaign



Mobile Laboratory Measurement Modes

STATIONARY SAMPLING

High time resolution point sampling
Quality assurance for conventional fixed site air monitors

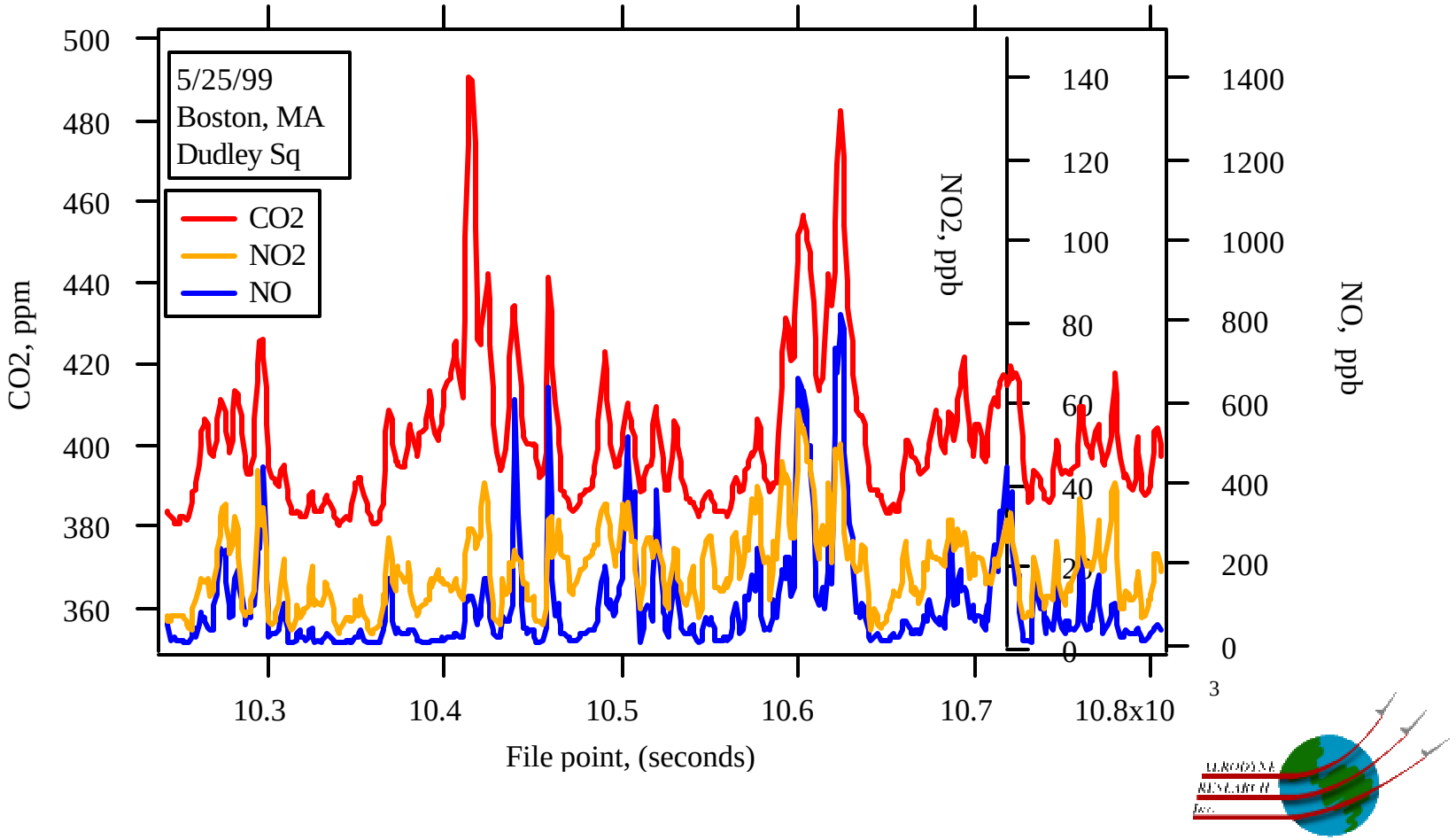
MOBILE SAMPLING/MAPPING

Aggregate (fleet) motor vehicle pollutant emission ratios
High spatial resolution ambient background pollution distributions
Point and area emission plume source location and dispersion measurements
Stationary source plume tracer flux ratio emission measurements

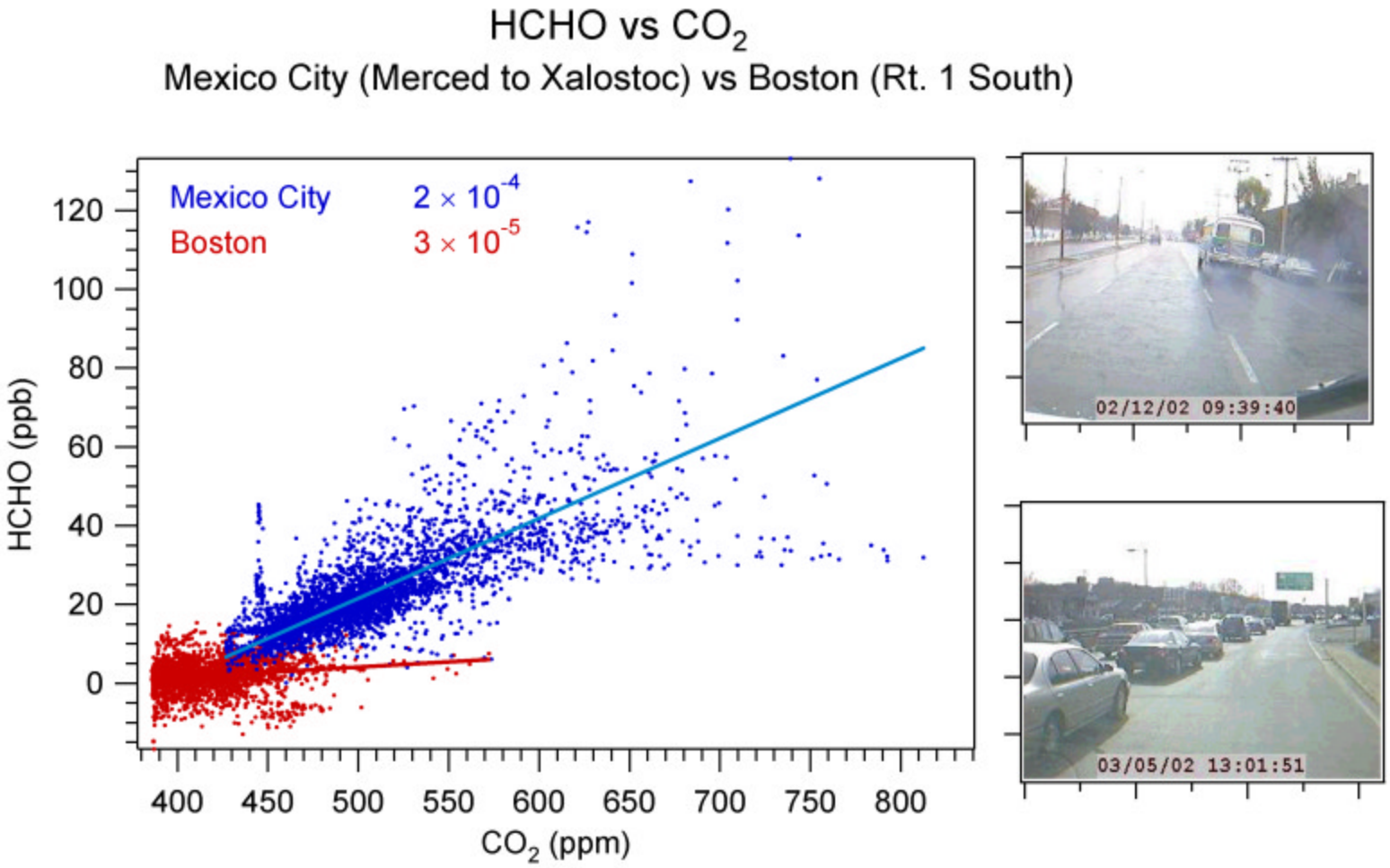
CHASE

On-road vehicle emissions quantification by vehicle and operating condition

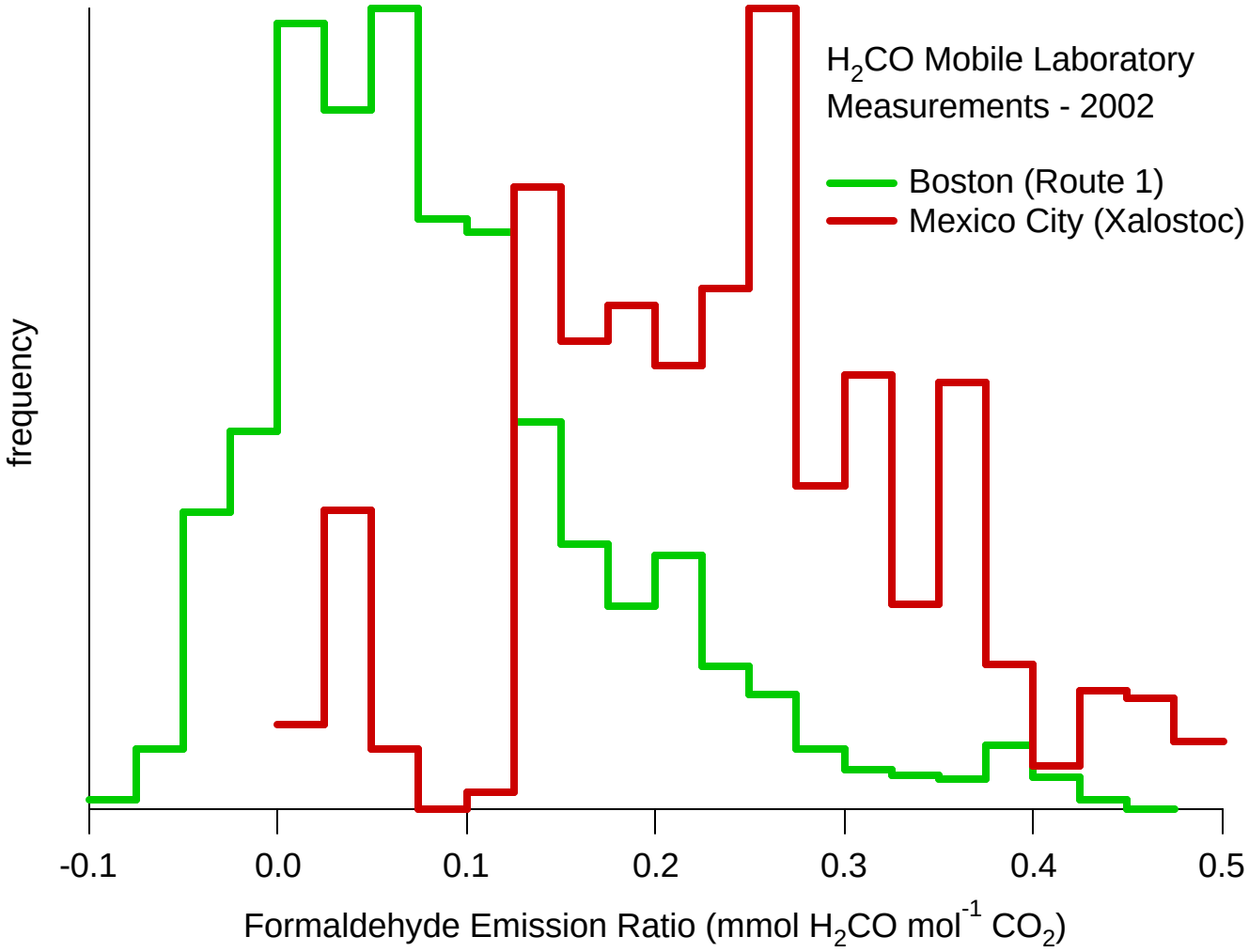
Real-Time Pollutant Correlations



HCHO vs CO_2


HCHO vs CO2
Mexico City (Merced to Xalostoc) vs Boston (Rt. 1 South)
Mexico City 2 × 10-4
Boston 3 × 10-5
HCHO (ppb)
0
20
40
60
80
100
120
400
450
500
550
600
650
700
750
800
CO2 (ppm)
02/12/02 09:39:40
03/05/02 13:01:51

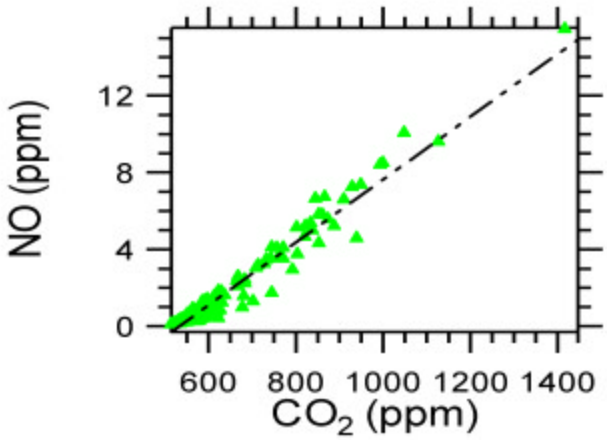
Frequency Distribution of H_2CO Emission Ratios

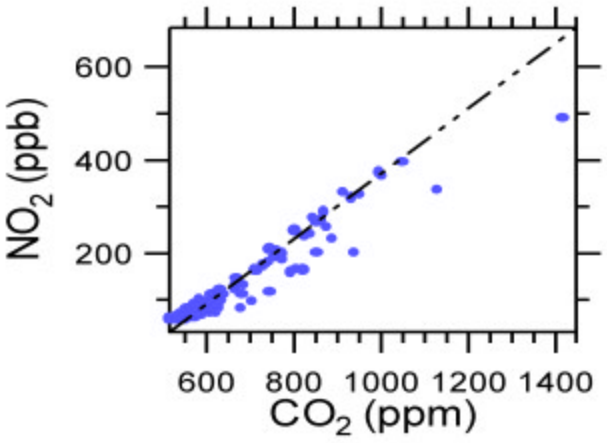


Molar Fleet Emission Ratios for Gaseous Pollutants (Exhaust Pollutant Mixing Ratio/Exhaust CO2 Mixing Ratio) for New England Cities

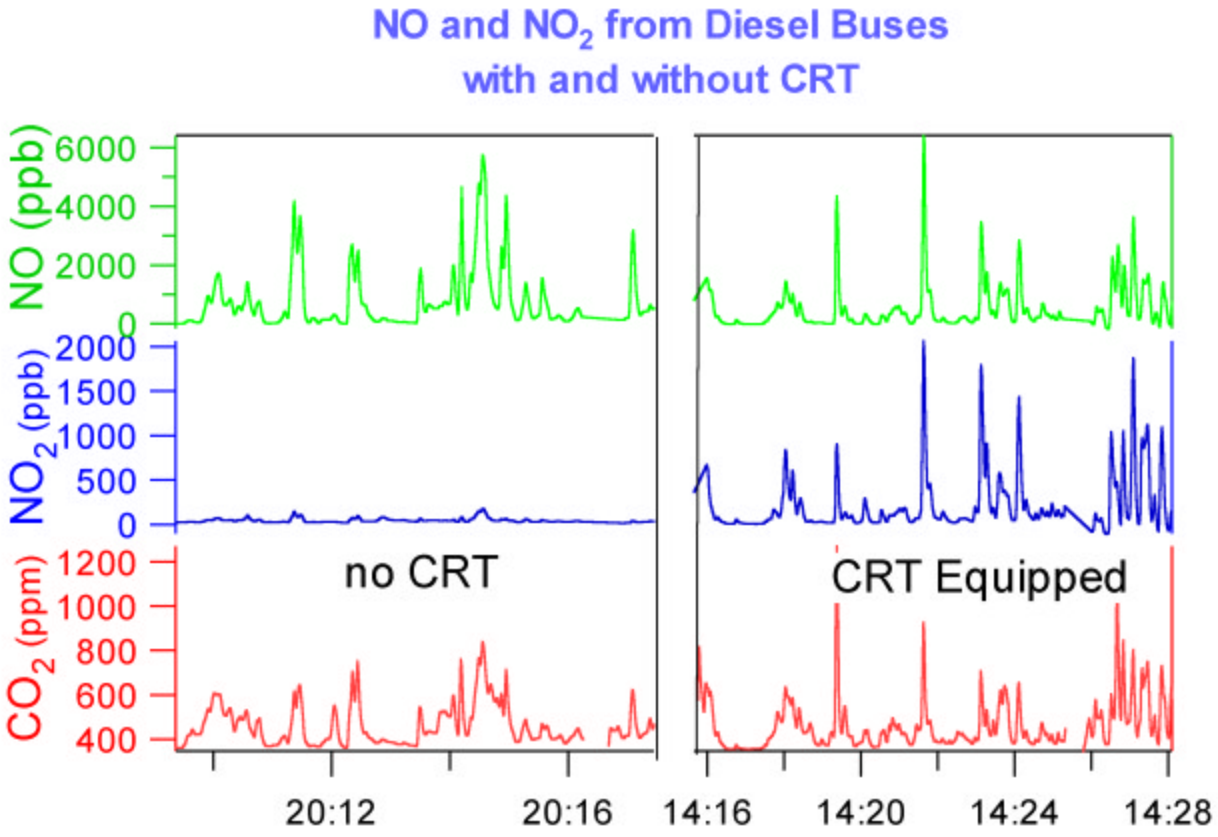
Pollutant	City	Date	Venue	Fleet Emission Ratio
NO	Boston	5/25/99	City Roads	3.7 (± 2.8) x 10^{-3}
			Highway 1	6.2 (± 2.9) x 10^{-3}
			Highway 2	3.6 (± 2.2) x 10^{-3}
N_2O	Manchester	6/18/98	City Roads	1.56 (± .03) x 10^{-4}
			Highway	1.09 (± .03) x 10^{-4}
CO	Manchester	6/18/98	City Roads	3.55 (± .94) x 10^{-2}
			Highway	2.92 (± .66) x 10^{-2}
CH_4	Manchester	6/18/98	City Roads	1.49 (± .09) x 10^{-3}
			Highway	1.51 (± .58) x 10^{-3}

NO and NO_2 Correlation with CO_2 in the Exhaust of an In-Use NYC Diesel Bus



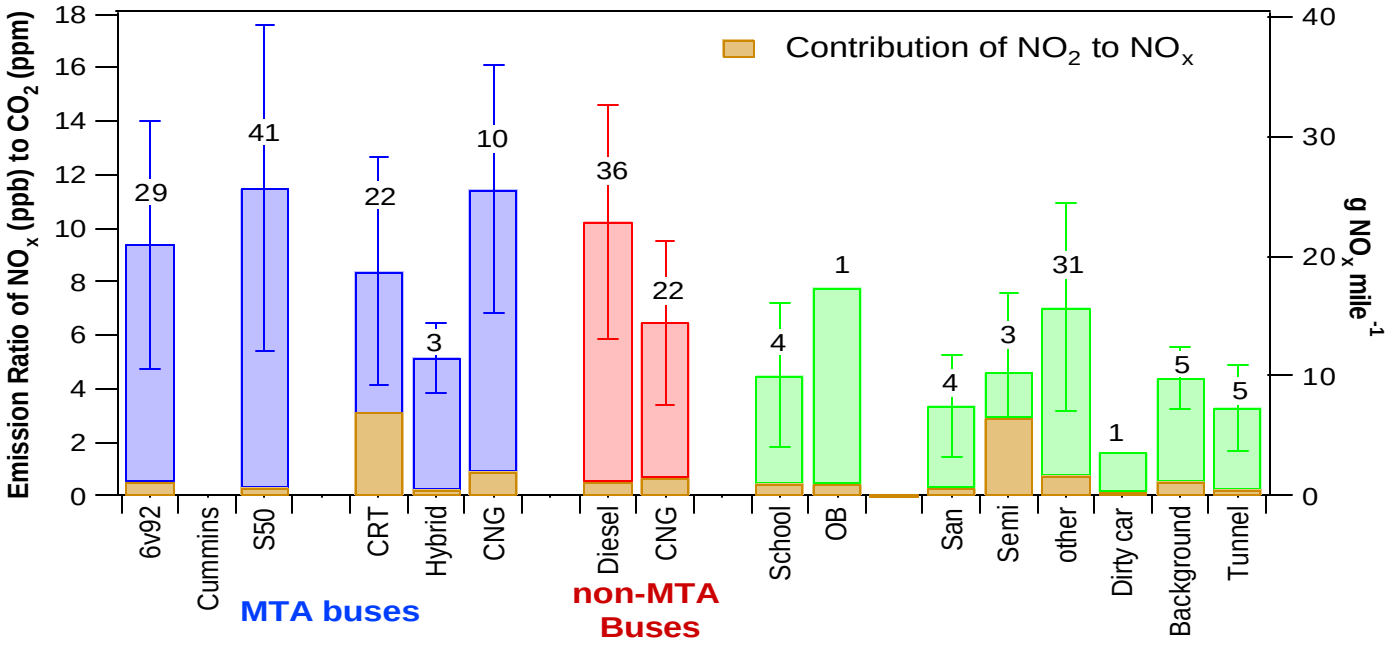


NO and NO_2 from Diesel Buses with/without CRT

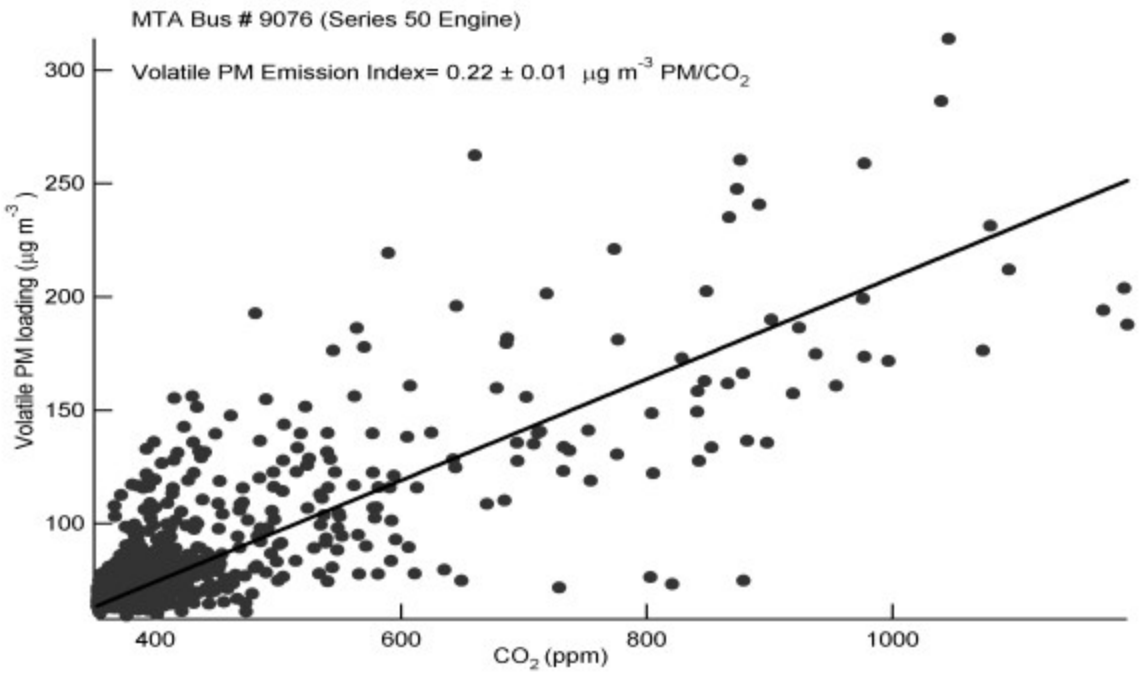


Bus Type	NO_2/NO_x
no CRT	<5%
CRT	30%

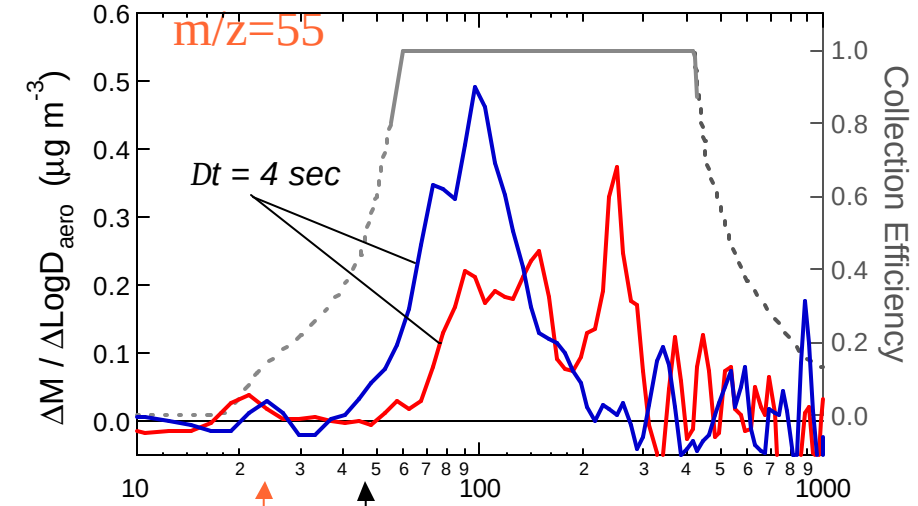
NO_x Emissions From NYC Buses and Other Urban Vehicles



Bus Particle Mass Versus CO_2

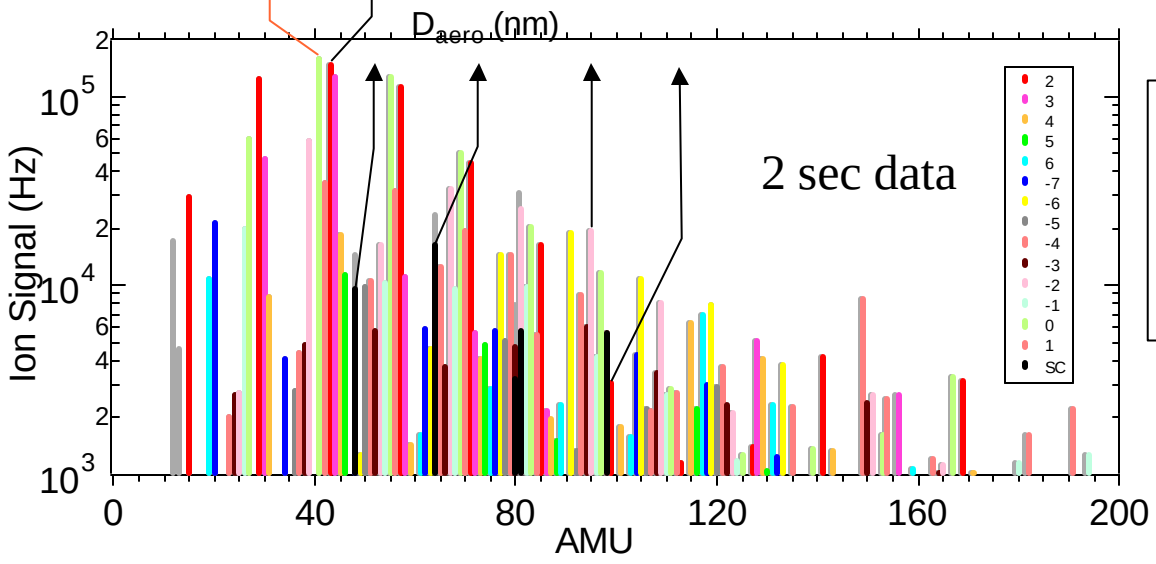


Rapid Real-time Size and Composition



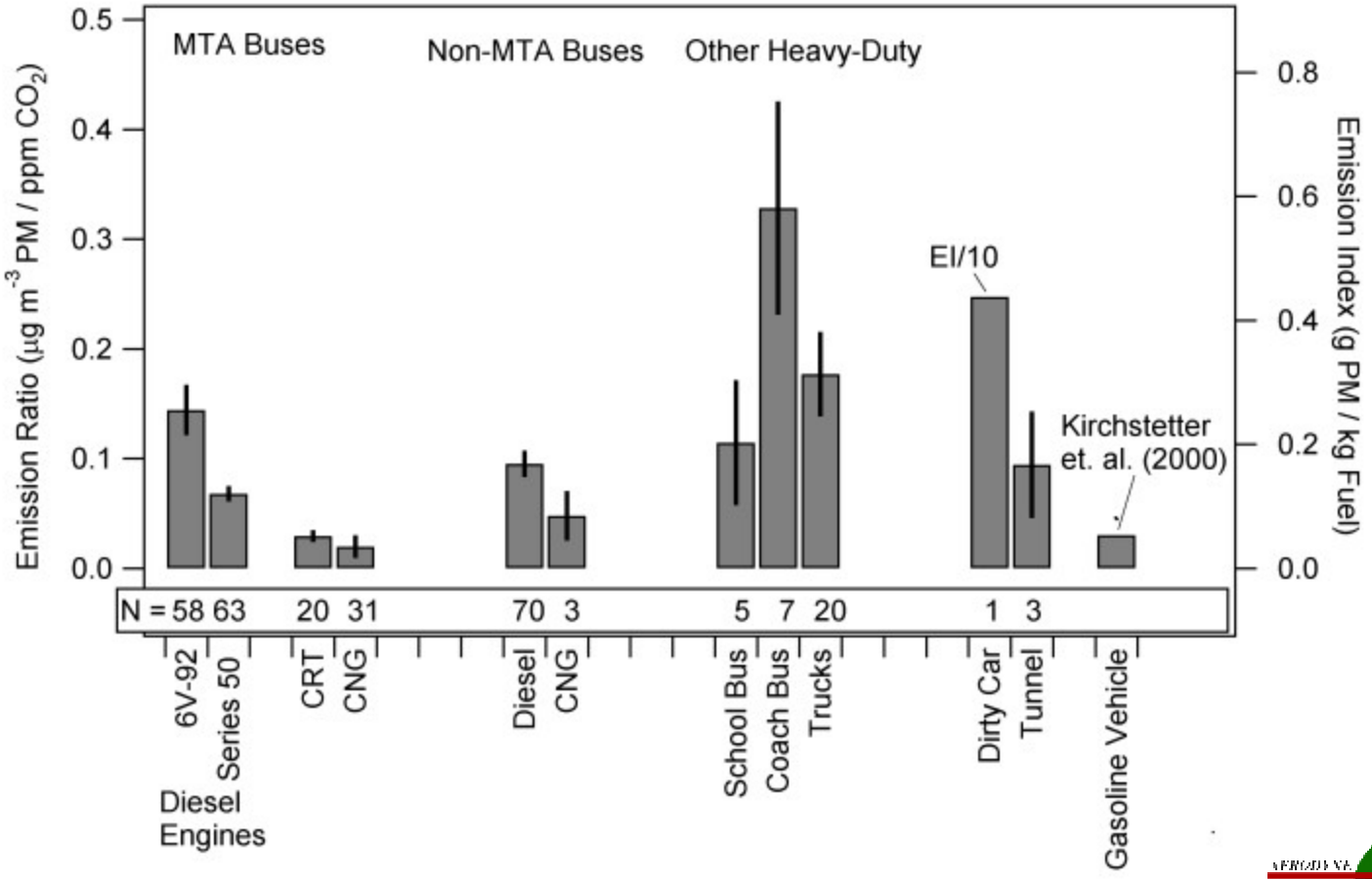
MTA Bus 9076

1996 Series 50 Diesel

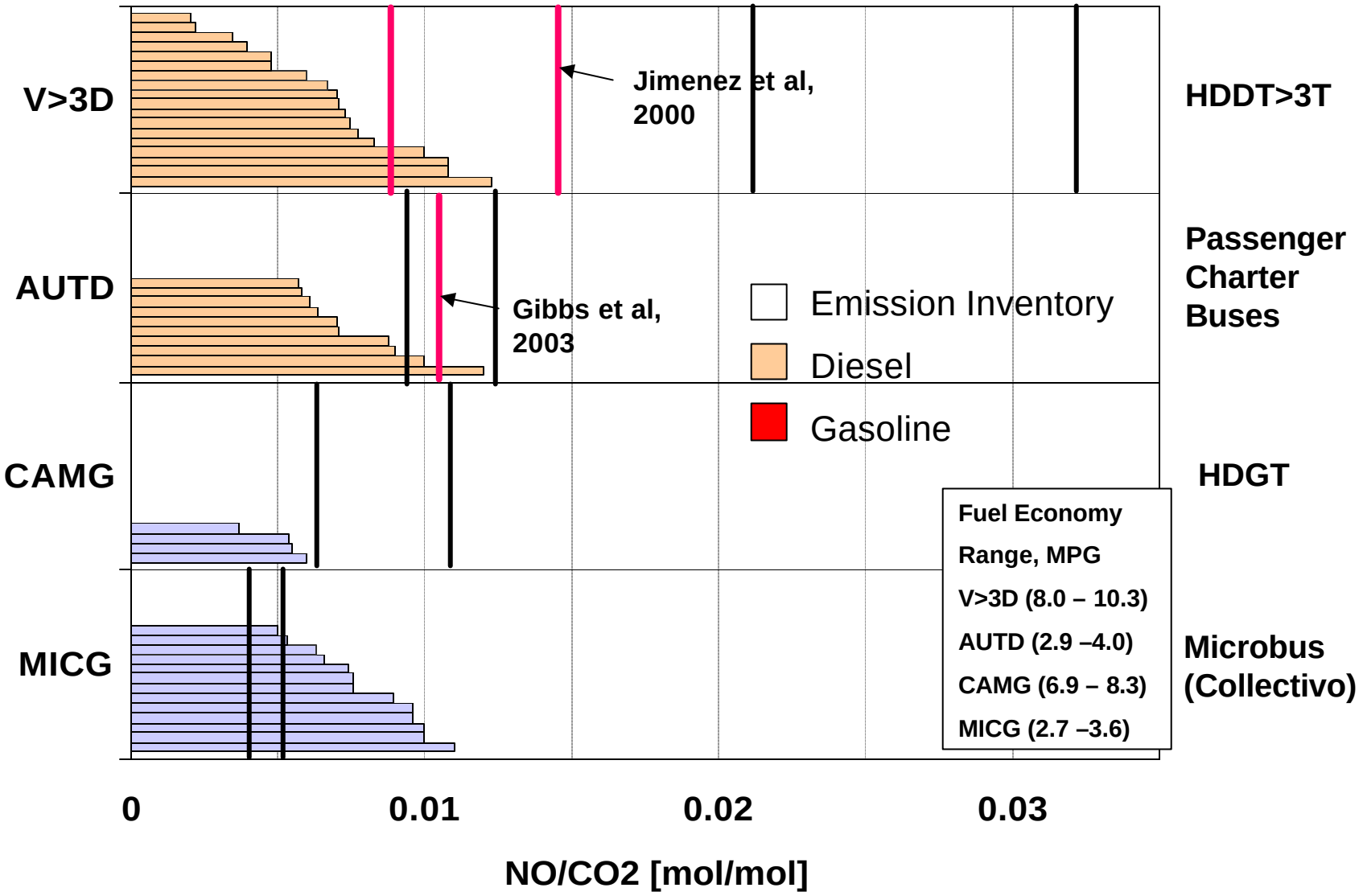


Selected Masses for Size Resolved Measurement
55, 57, 48, 64, 95, 107

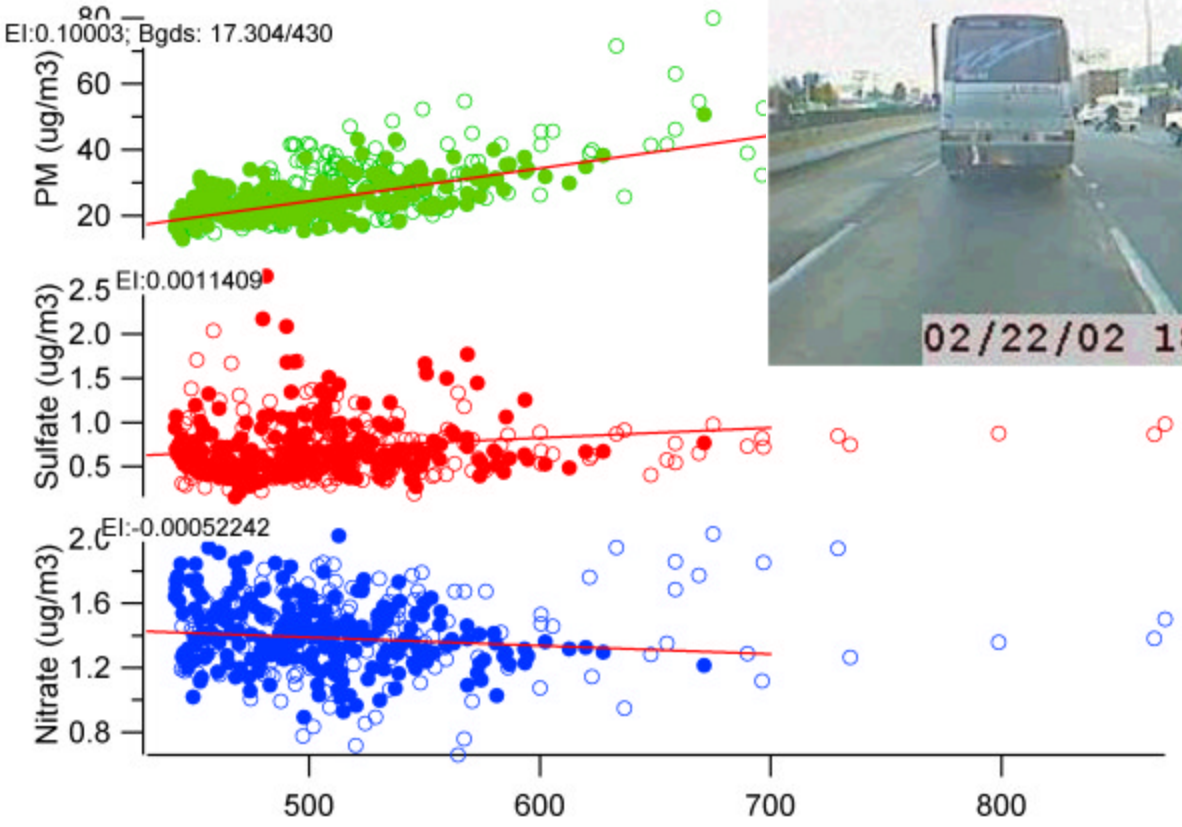
New York City Vehicle Non-Refractory Fine Particulate Emission Ratios



Chasing Experiment vs. Emission Inventory NO/CO_2 Emission Ratio

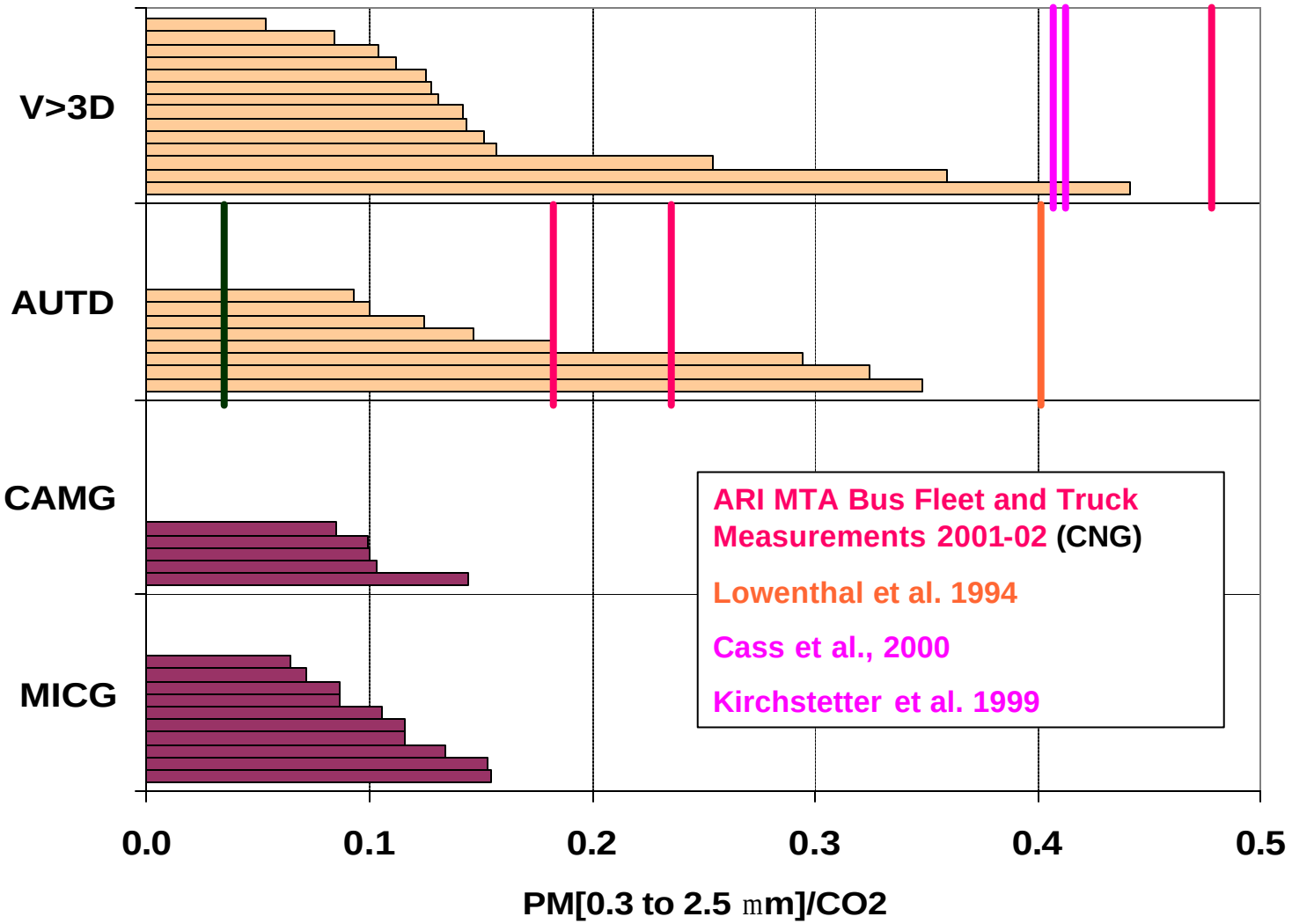


MCMA Passenger Bus PM Emissions

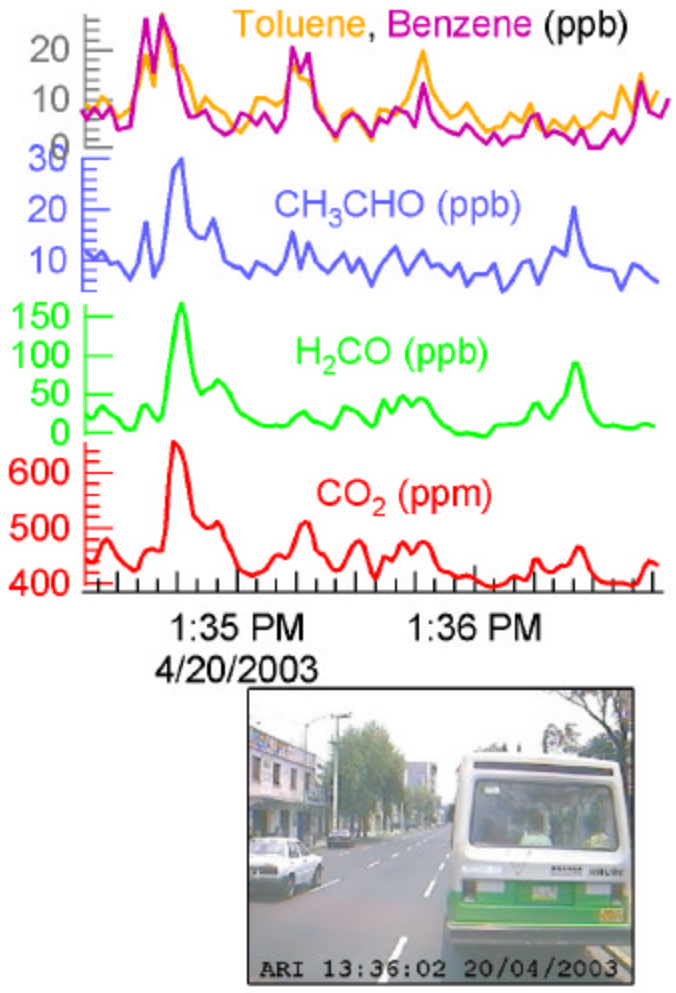


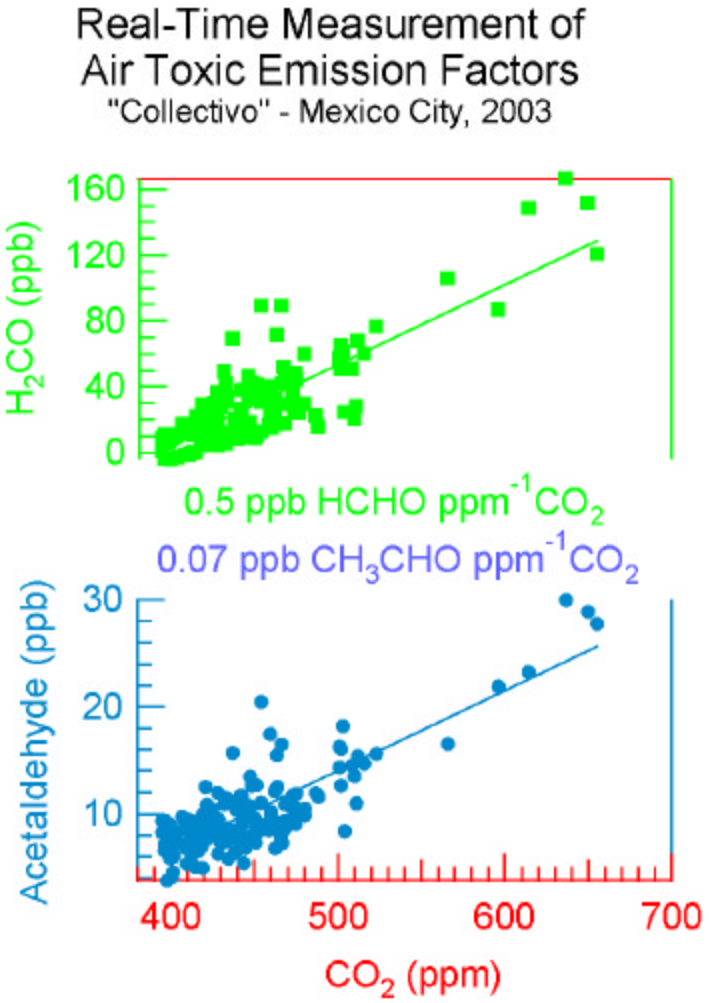
Passenger Charter Buses

Chasing Experiment vs. Emission Inventory PM/CO_2 Emission Ratio



Air Toxics


Toluene, Benzene (ppb)
20
10
0
30
20
10
CH_3CHO (ppb)
150
100
50
0
H_2CO (ppb)
600
500
400
CO_2 (ppm)
1:35 PM
1:36 PM
4/20/2003
ARI 13:36:02 20/04/2003


Real-Time Measurement of
Air Toxic Emission Factors
"Collectivo" - Mexico City, 2003
H_2CO (ppb)
160
120
80
40
0
0.5 ppb HCHO $ppm^{-1}CO_2$
0.07 ppb CH_3CHO $ppm^{-1}CO_2$
Acetaldehyde (ppb)
30
20
10
400
500
600
700
CO_2 (ppm)

H_2CO Loadings by Motor Vehicles

	ppb H_2CO / ppm CO_2 or mmol $mole^{-1}$
Typical Automobiles with functioning Catalytic Converter	<0.1
Gasoline “Tailpipe Out”	0.2-0.4
Diesel Heavy Duty	<0.03-0.1
Compressed Natural Gas	~0.5

At Altitude ~
Diesel and Gasoline emission ratios are greater
Mexico Fleet, Engine Chemistry or Fuel/Air Mixture?

Summary

- **Aerodyne Mobile Laboratory with Fast Response Instruments Can Characterize Urban Pollutant Emissions and High Resolution Ambient Distributions**
- **Mobile Emission Factors Can be Characterized for Urban Fleets as Well as Individual Vehicles Over Real-World Driving Cycles**
- **Mobile Air Toxics (H_2CO, CH_3CHO, C_2H_6) and PM2.5 (including PAHs, total POM, $SO_4^=$, etc.) can be quantified in realtime**
- **Mobile Source Emission Factors in Mexico Can Deviate Substantially from U.S. Values**

Acknowledgments

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