Aerodyne Research, Inc.

Utilization of Tunable Infrared Laser Sensors for Cross-Road Mobile Source Emissions Characterization and Qualifications

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Prepared for:
NARSTO Emission Inventory Workshop on
Innovative Methods for Emission Inventory Development and Evaluation
University of Texas
Austin, TX

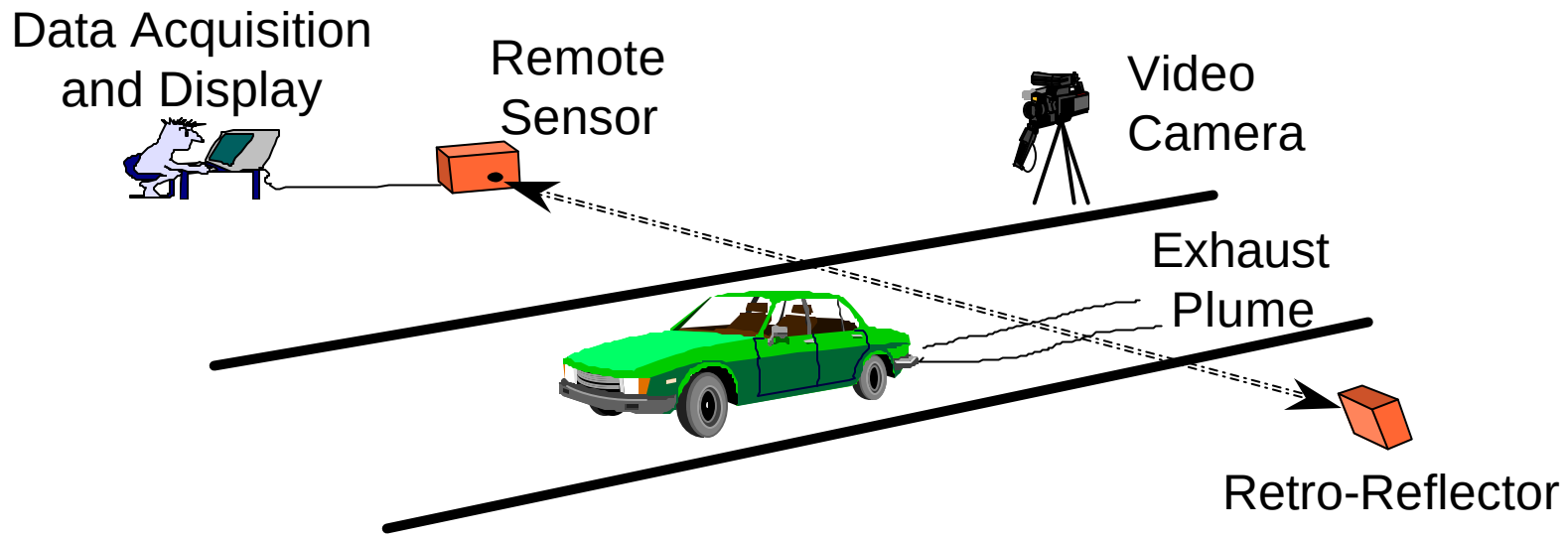
October 15, 2003

ARI-VGR-116

Outline

- Motivation
- Traditional Automotive Remote Sensing
- TILDAS Remote Sensing
- NO and N_2O Emissions from Automobiles
- NO Emissions from Heavy Duty Diesel Trucks
- Quantum Cascade Implementation
- Summary

Traditional Remote Sensing



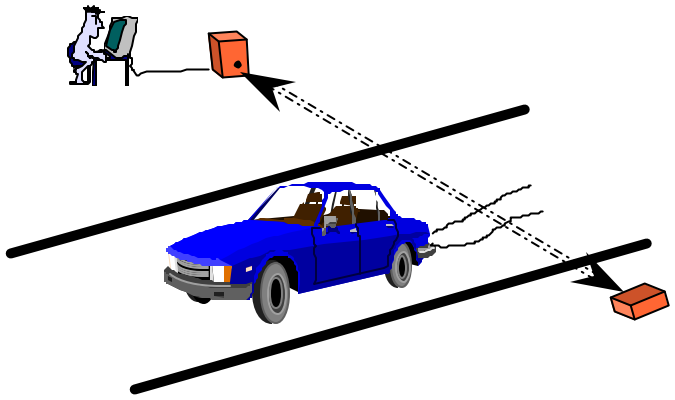
Advantages:

- Thousands of cars per day
- Split second inspection
- Real world emissions
- Faster & cheaper

Limitations:

- Species coverage is limited - works best for CO monitoring
- Range is severely limited
- Site selection constrained

TILDAS Remote Sensing



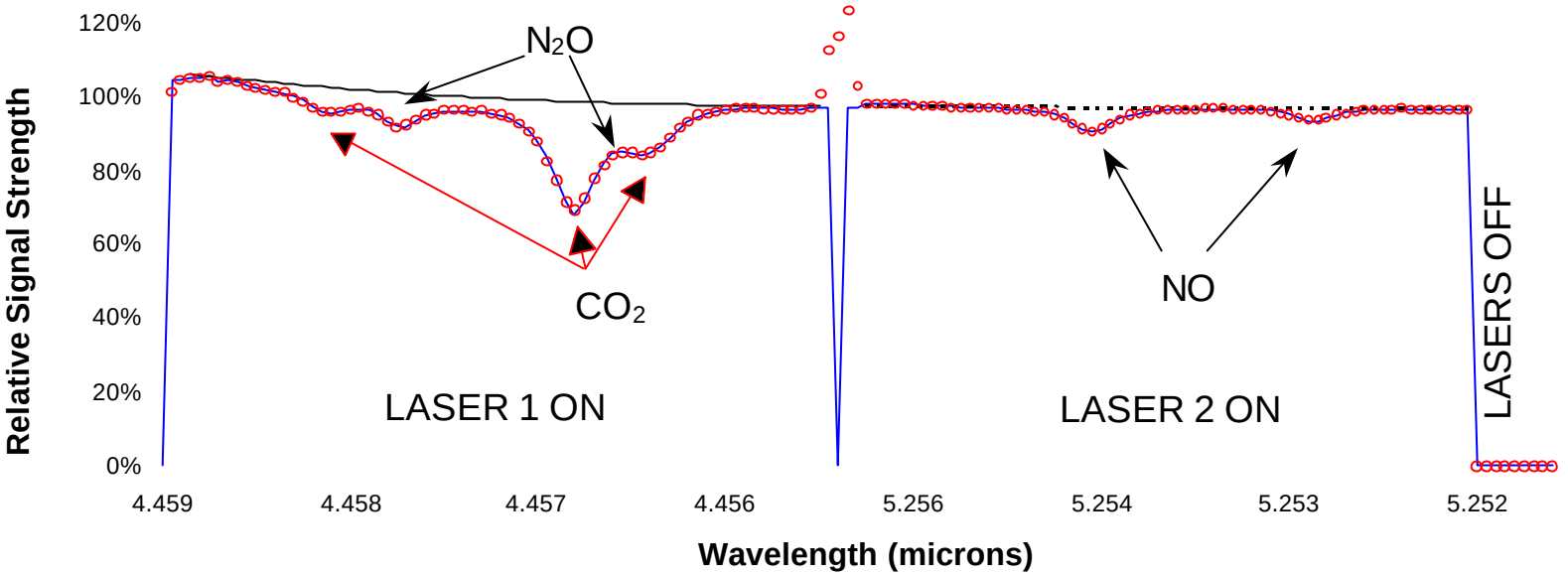
$$\frac{\Delta I}{I_0} = \exp(-\sigma(\upsilon)NL))$$

Frequency

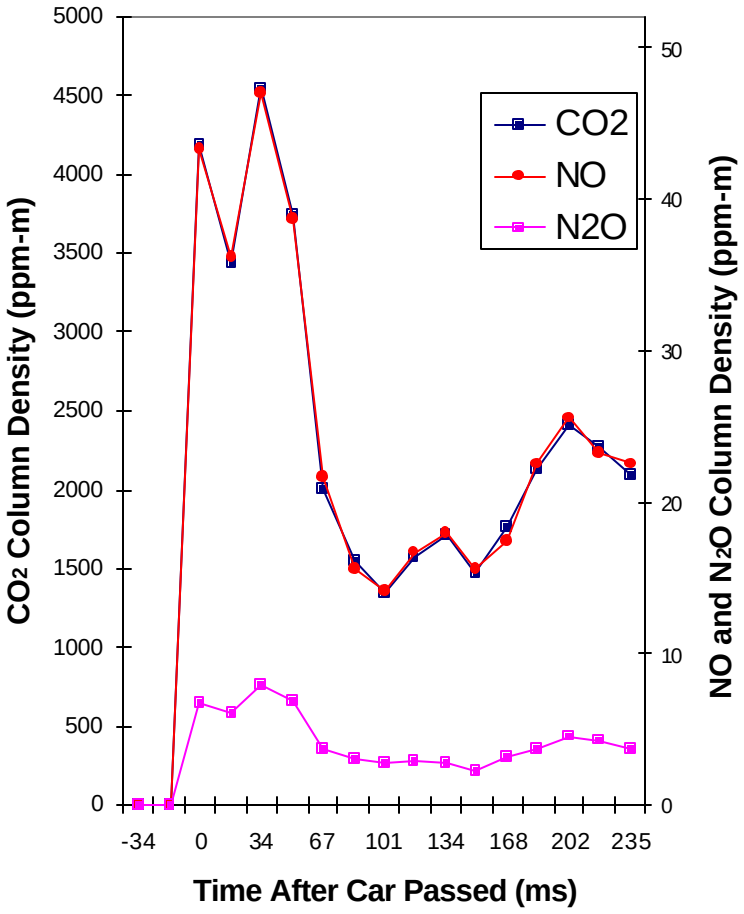
Path Length

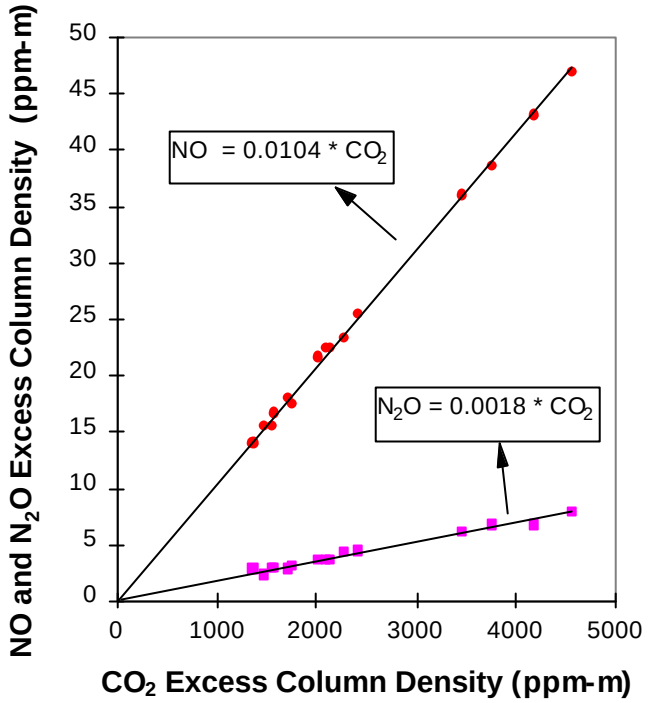
Absorption Cross-Section

Molecular Density



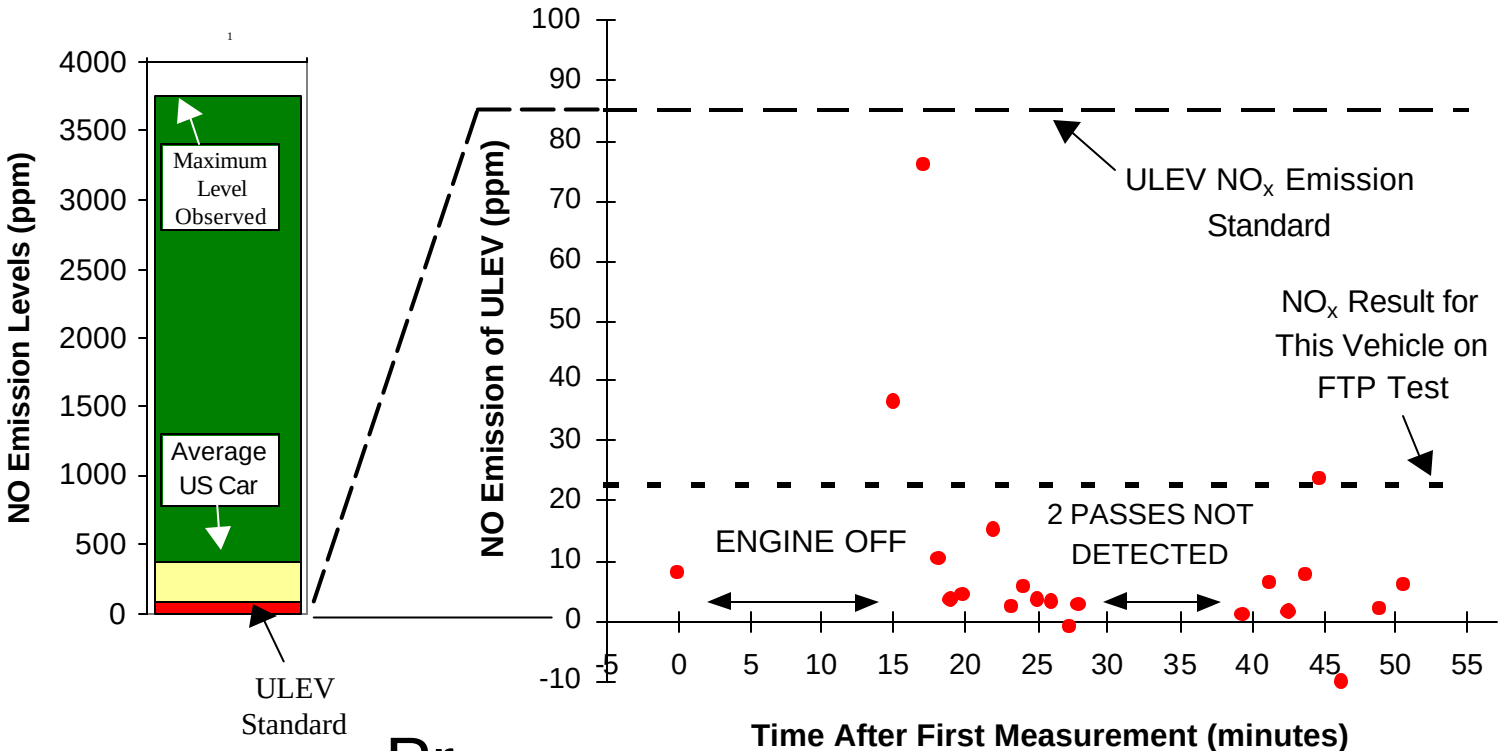
TILDAS Data Processing



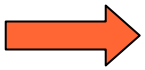


$$\text{ppm NO} = \frac{\text{NO}}{\text{CO}_2} * \text{CO}_2^{\text{stoichiometric}}$$

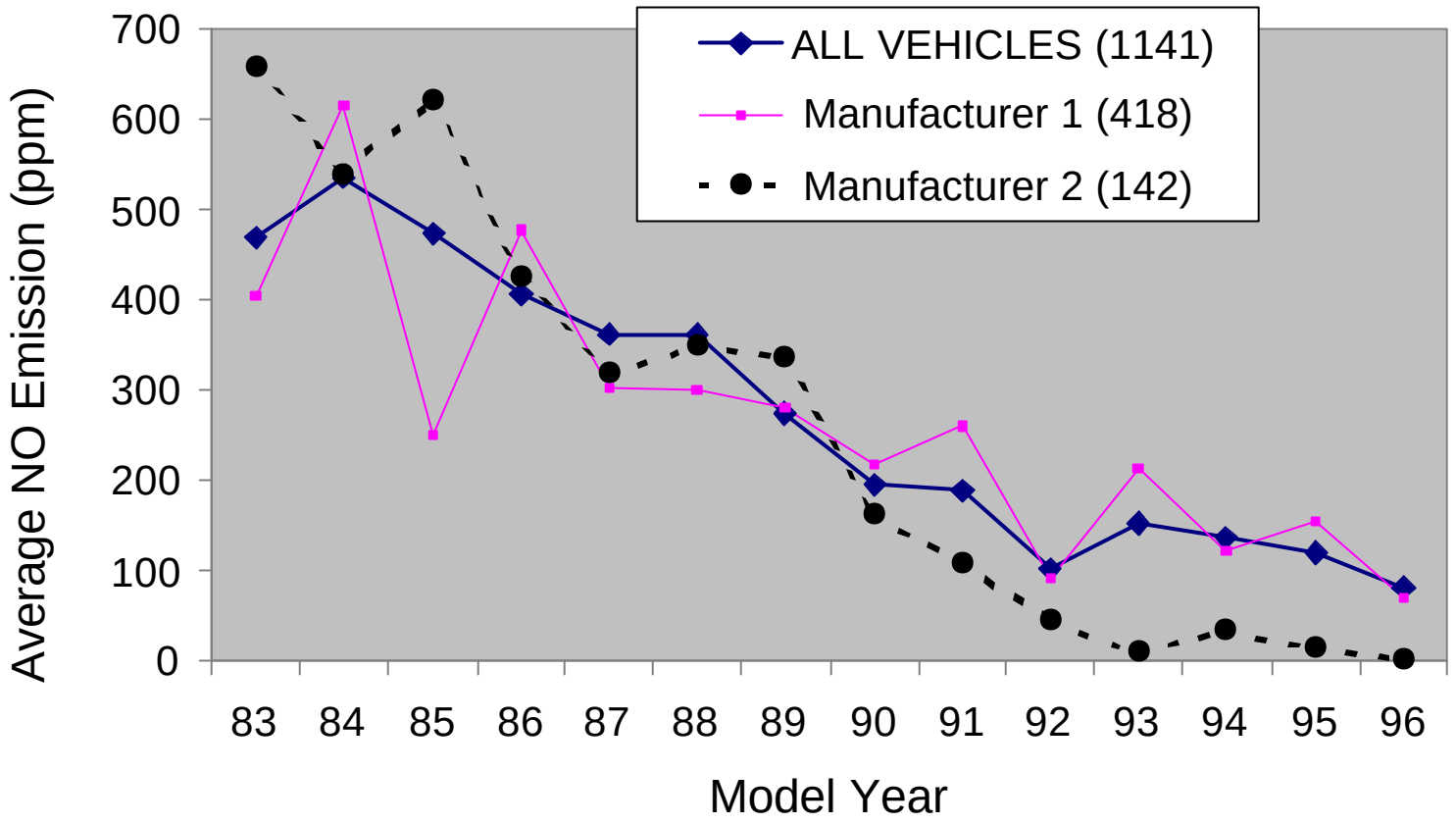
High Sensitivity



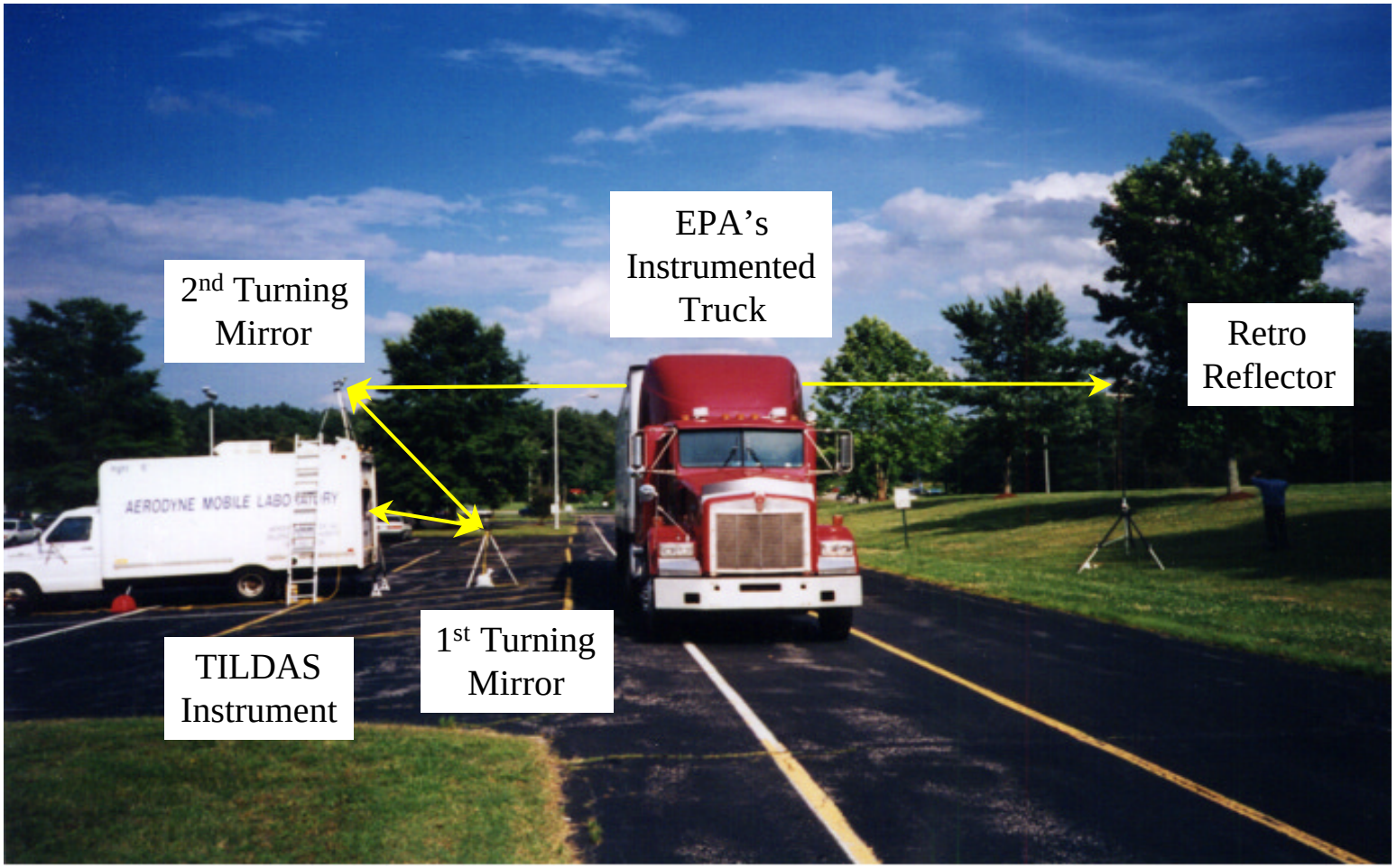
Pr[illegible] ppm of the exhaust



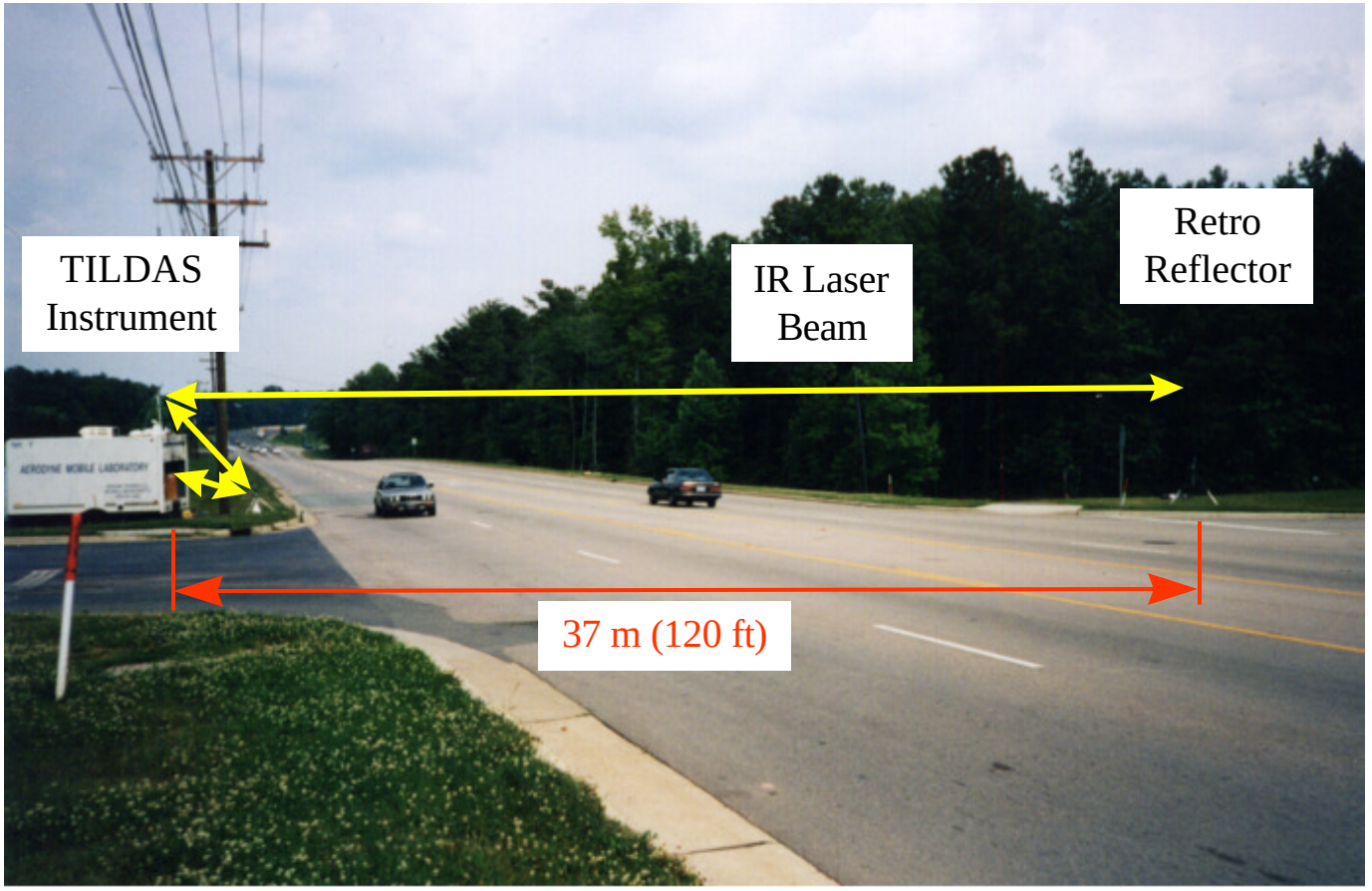
NO vs. Manufacturer



TDL Setup / EPA Parking Lot



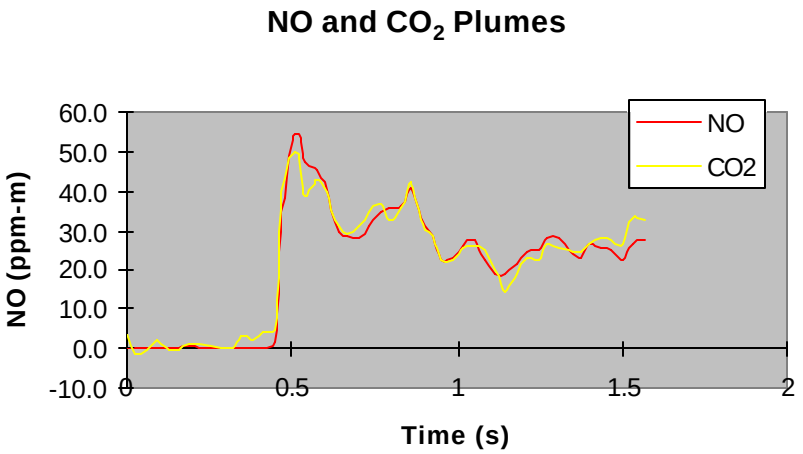
Long Range Remote Sensing Using TILDAS

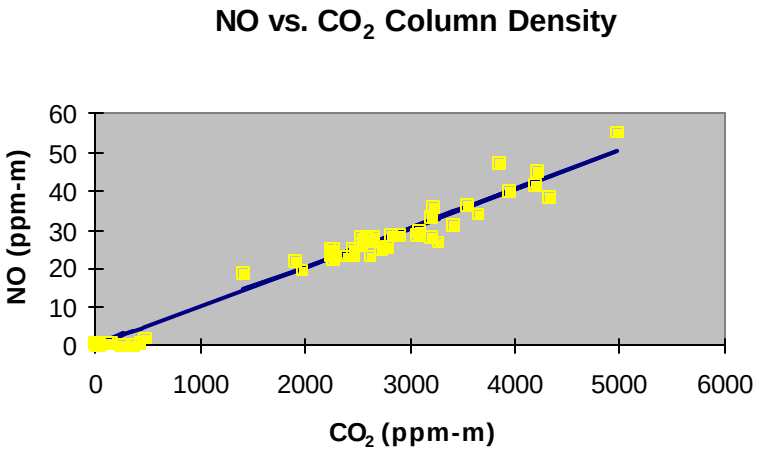


- Remote sensing of heavy duty diesel NO emissions across five lanes of traffic on NC-54 in North Carolina

NO and CO_2 Plumes from Heavy Duty Diesel on NC-54

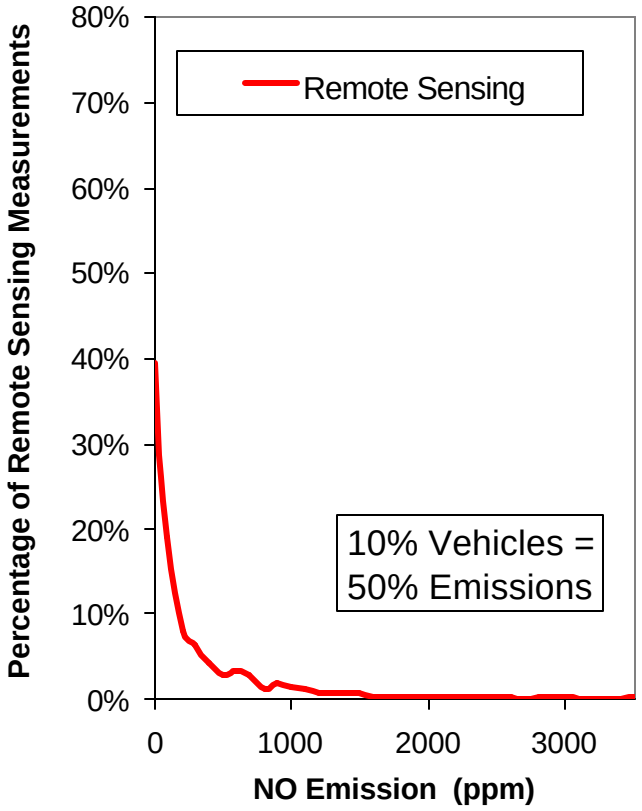
- NO and CO_2 plumes measured at 32 Hz on Route 54 in NC
- Optical pathlength of approximately 280 ft
- NO emission index is NO/CO_2 = 0.0101(5)



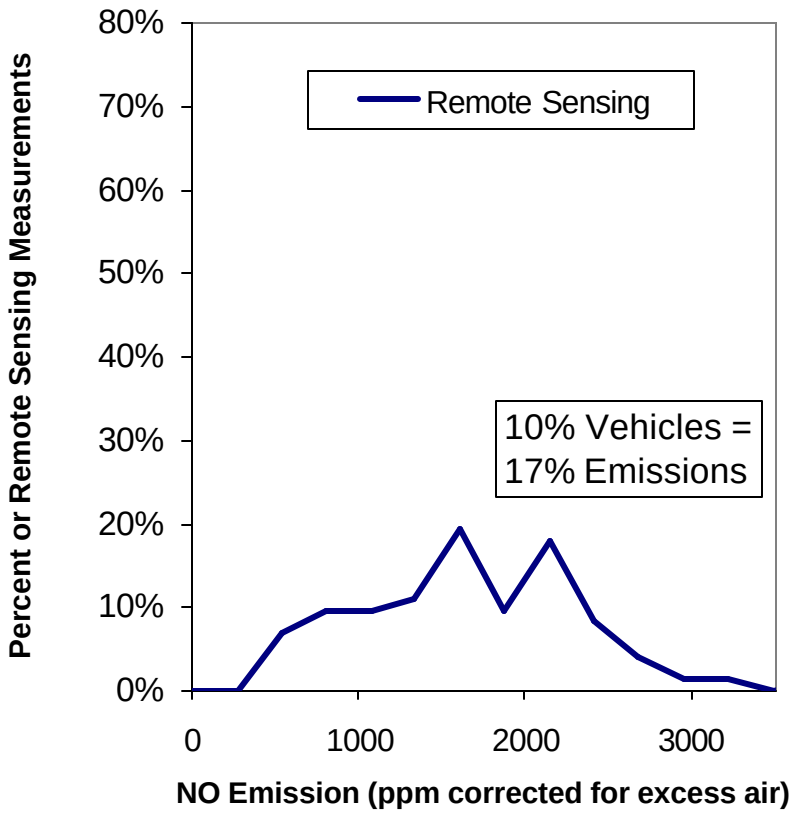


NO_x Emission Distributions

Light-Duty Gasoline

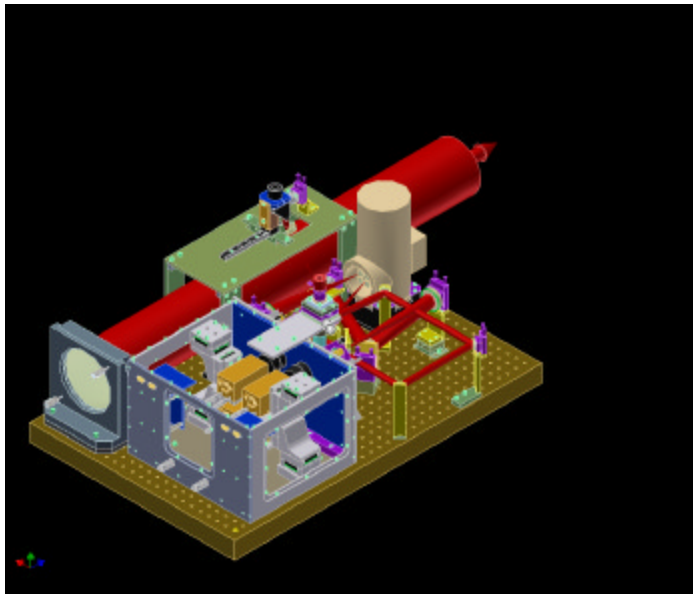


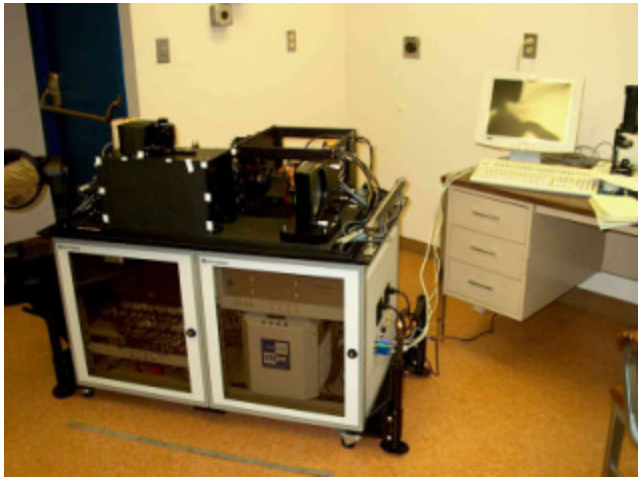
Heavy-Duty Diesel



QUAD-QC Open Path TILDAS

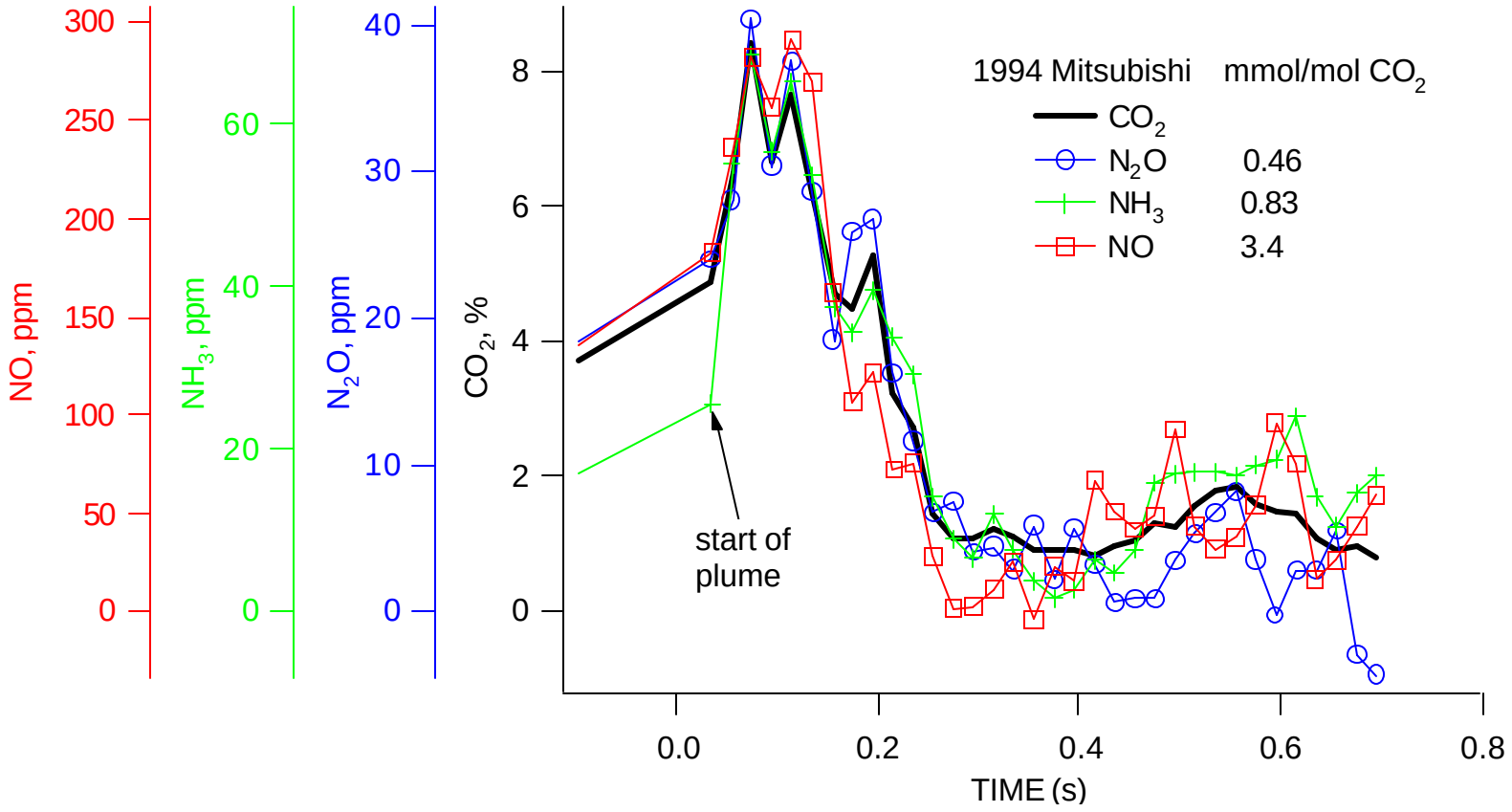
- Four QC Lasers with time-multiplexing
- NO, NO_2, N_2O, NH_3,CO
- CO_2 reference
- Cross-road retro-reflector
- Range 100 meters



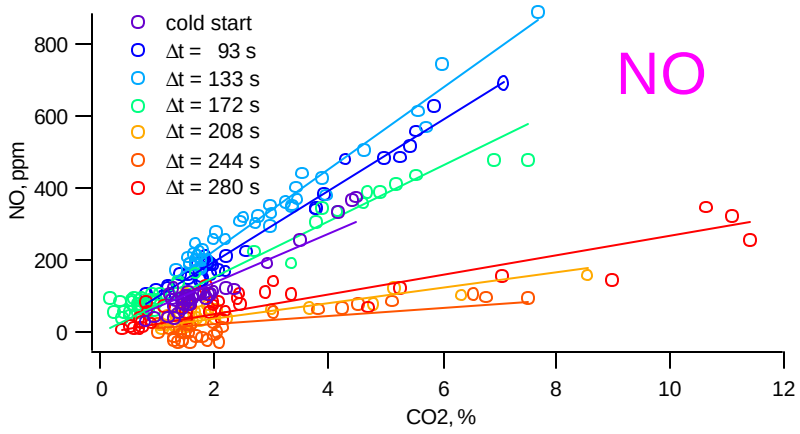


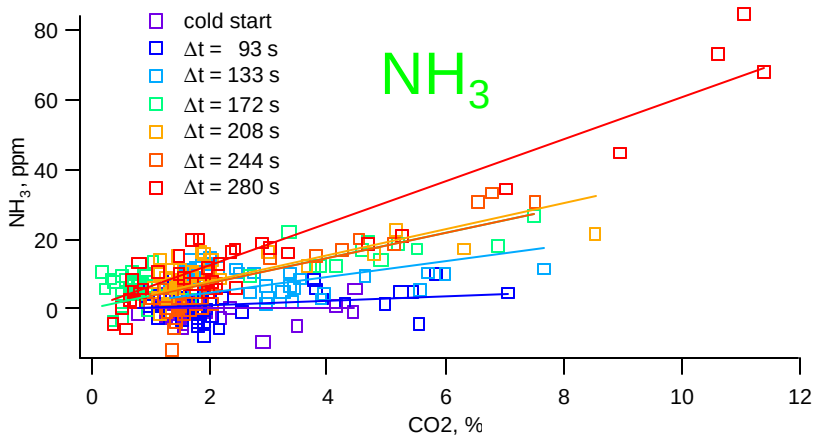
Automobile Exhaust Plume Spectra

Automobile Exhaust Plume



Catalytic Converter Warm-up



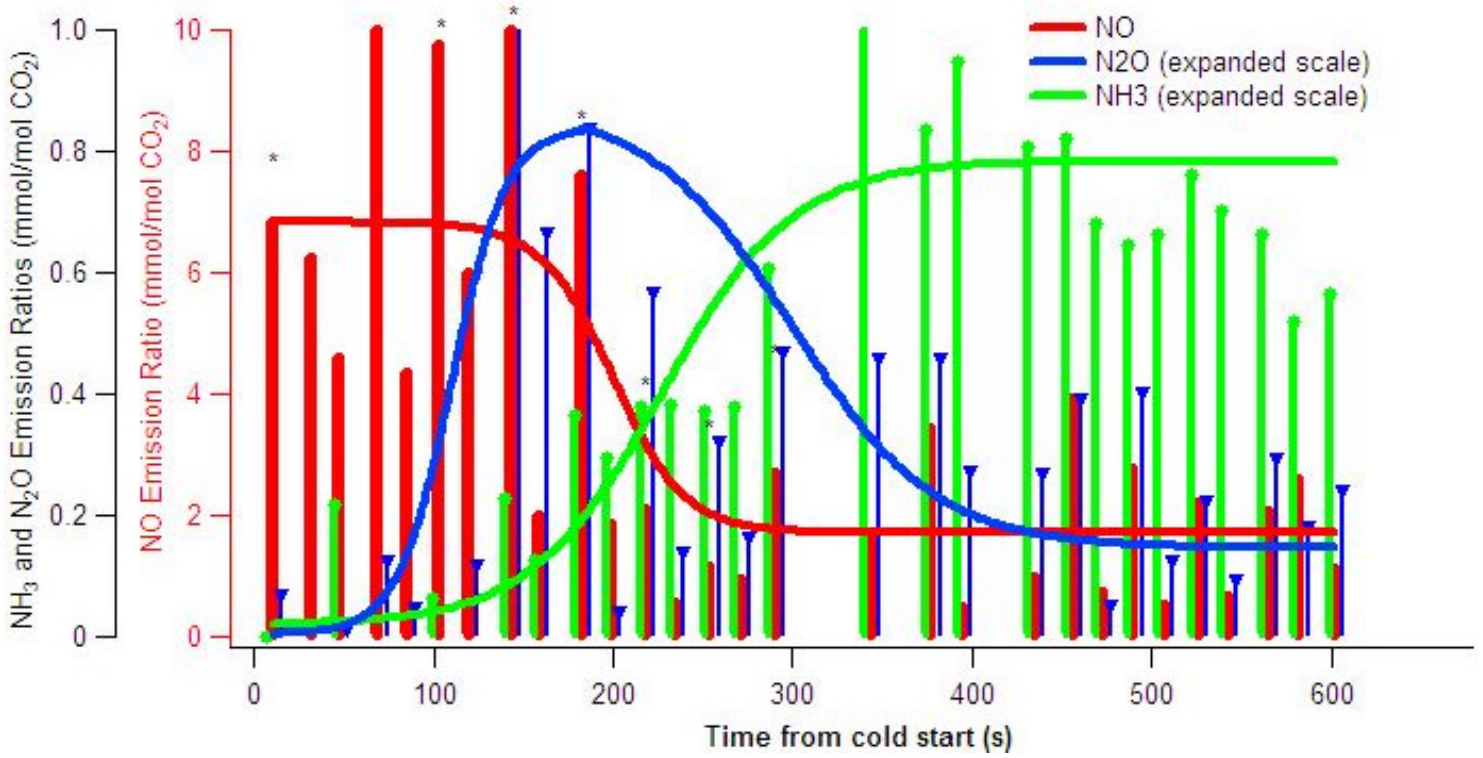


NO emissions decrease

NH3 emissions increase

Emission Ratios to CO_2

Multiple passes with same automobile



1994 Mitsubishi “Expo”
160,000 km odometer

Summary

Tunable IR Laser

Remote Sensing Advantages

- Increased sensitivity (10 – 1000 over NDIR)
- Increased specificity (e.g. NH_3, N_2O, NO_2, individual VOCs)
- Self calibrating (no cal gases required)
- Increased range (up to 100 meters)
- Easier adjustment for exhaust emission heights (for HDD measurements)
- Automated/Remote instrument operation

Acknowledgments

- **Aerodyne Colleagues**
  - David Nelson
  - Mark Zahniser
  - Barry McManus
  - Joda Wormhoudt
  - Patrick Kirwin
- **MIT Collaborators**
  - Jose Jimenez
  - Greg McCrae
- **ADL Collaborator**
  - Stephan Schmidt
- **EMDOT Collaborator**
  - Mike Koplow
- **WPI Collaborator**
  - Babara Wyslouzil

Funding Sources

- NSF, NASA and DOE SBIR Programs
- NASA HSCT Program
- South Coast Air Quality Management District
- EPA-ORD
- Environmental Systems Products