

University of Denver

**Digital Commons @ DU**

---

Fuel Efficiency Automobile Test Publications

Fuel Efficiency Automobile Test Data Repository

---

2014

## RSD Basics (Presentation)

Donald H. Stedman

*University of Denver*

Gary A. Bishop

*University of Denver, gabishop10@yahoo.com*

Follow this and additional works at: [https://digitalcommons.du.edu/feat\\_publications](https://digitalcommons.du.edu/feat_publications)



Part of the [Environmental Chemistry Commons](#)

---

### Recommended Citation

Stedman, D. H.; Bishop, G. A., RSD Basics, presented at the Mexico City Remote Sensing Symposium: Mexico City, 2014.

This Presentation is brought to you for free and open access by the Fuel Efficiency Automobile Test Data Repository at Digital Commons @ DU. It has been accepted for inclusion in Fuel Efficiency Automobile Test Publications by an authorized administrator of Digital Commons @ DU. For more information, please contact [jennifer.cox@du.edu](mailto:jennifer.cox@du.edu), [dig-commons@du.edu](mailto:dig-commons@du.edu).

---

## RSD Basics (Presentation)

**Publication Statement**

Public Domain

**Publication Statement**

Public Domain

First Mexico City Remote Sensing Symposium  
March 27-28, 2014

# RSD BASICS

Donald H. Stedman and Gary A. Bishop  
Department of Chemistry and Biochemistry  
University of Denver, Denver, CO 80208

[www.feat.biochem.du.edu](http://www.feat.biochem.du.edu)

[dstedman@du.edu](mailto:dstedman@du.edu)



# Two Acronyms: FEAT and RSD

- Fuel
- Efficiency
- Automobile
- Test



<http://www.feat.biochem.du.edu/>

- RSD Remote Sensing Detector



<http://www.etest.com/>

# HOW FEAT/RSD WORKS

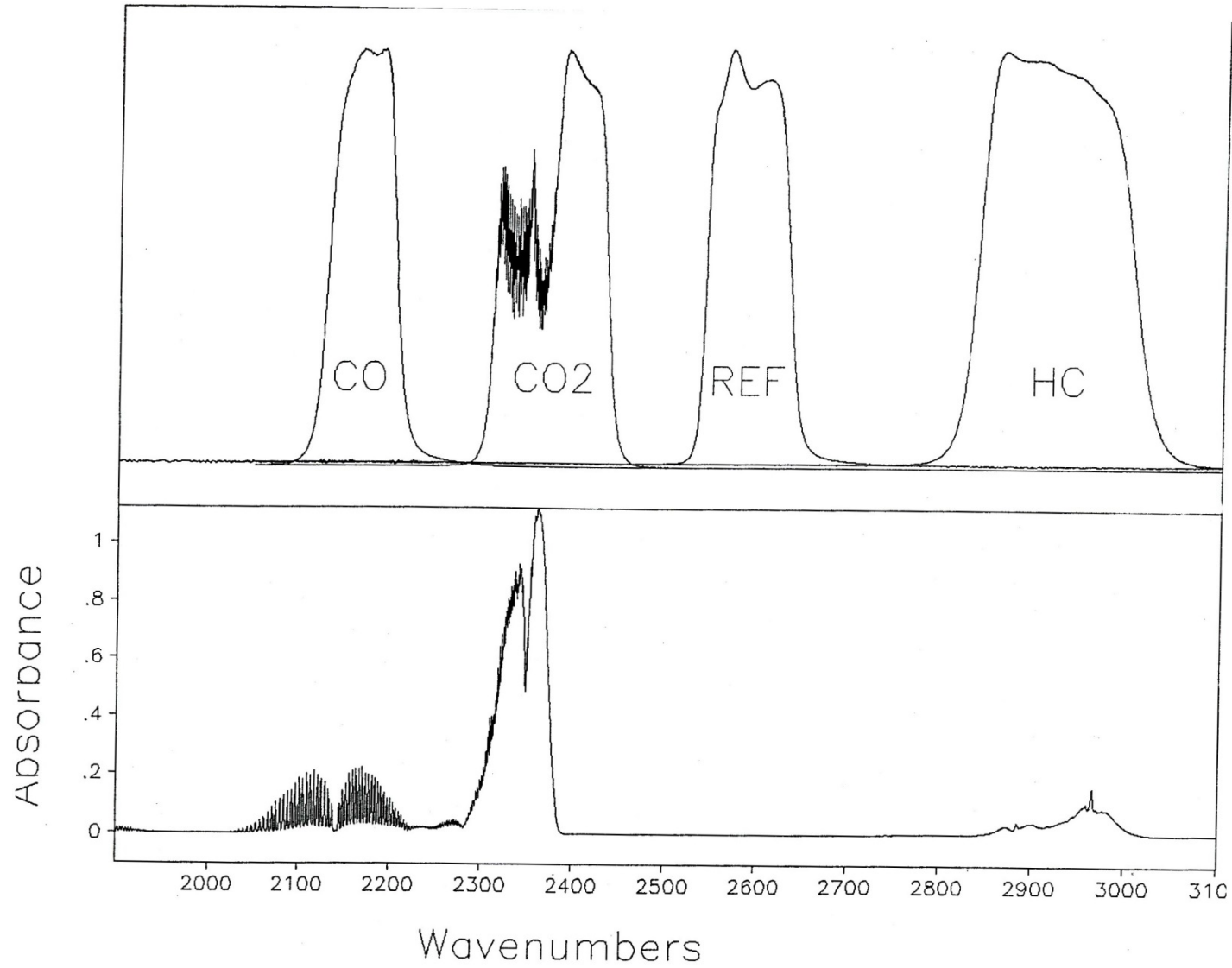
- RSD **COMPARES** things.
- It compares the pollutant ratios (CO/CO<sub>2</sub>, HC/CO<sub>2</sub>, NO/CO<sub>2</sub> etc.) in the vehicle exhaust to the pollutant ratios in a certified cylinder or gas cell.
- RATIOS are what we **MEASURE**; all other results such as fuel specific emissions (grams/gallon or g/kg) are derived from the measured ratios.
- Reported **% and ppm are** corrected for excess air not used in combustion (and for water).

# RSD works by Absorption Spectroscopy

- Light absorption is how our eyes see smoke from diesel vehicles which absorbs sky light.
- At night, no sky light, we can not see smoke.
- RSD uses specific absorption bands, infrared and ultraviolet for pollutant detection.
- Vehicle parts, dust, spray, snow, all absorb light; special software and hardware is needed to discriminate.

# IR

## Non Dispersive

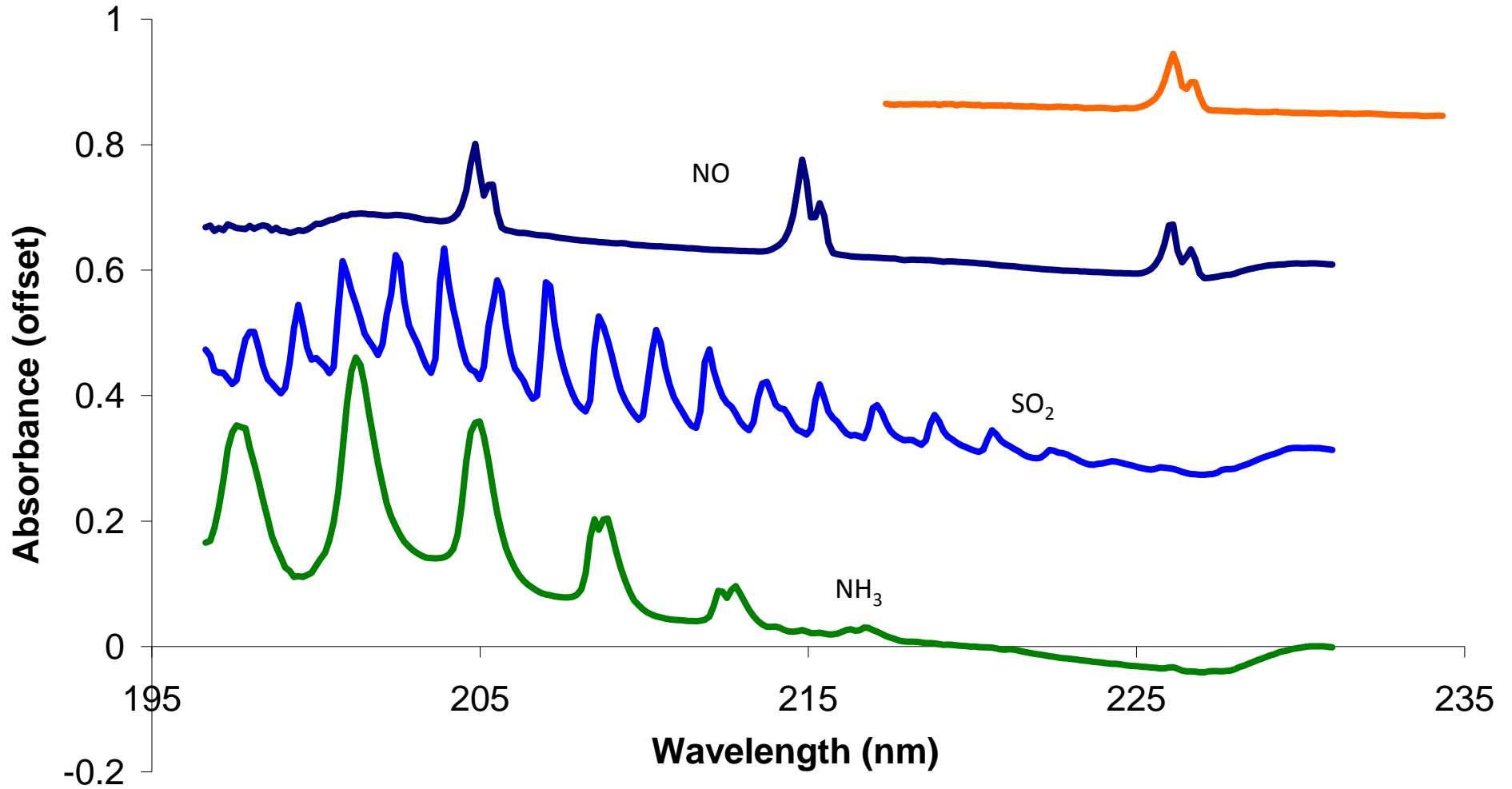


# New Denver FEAT Measures

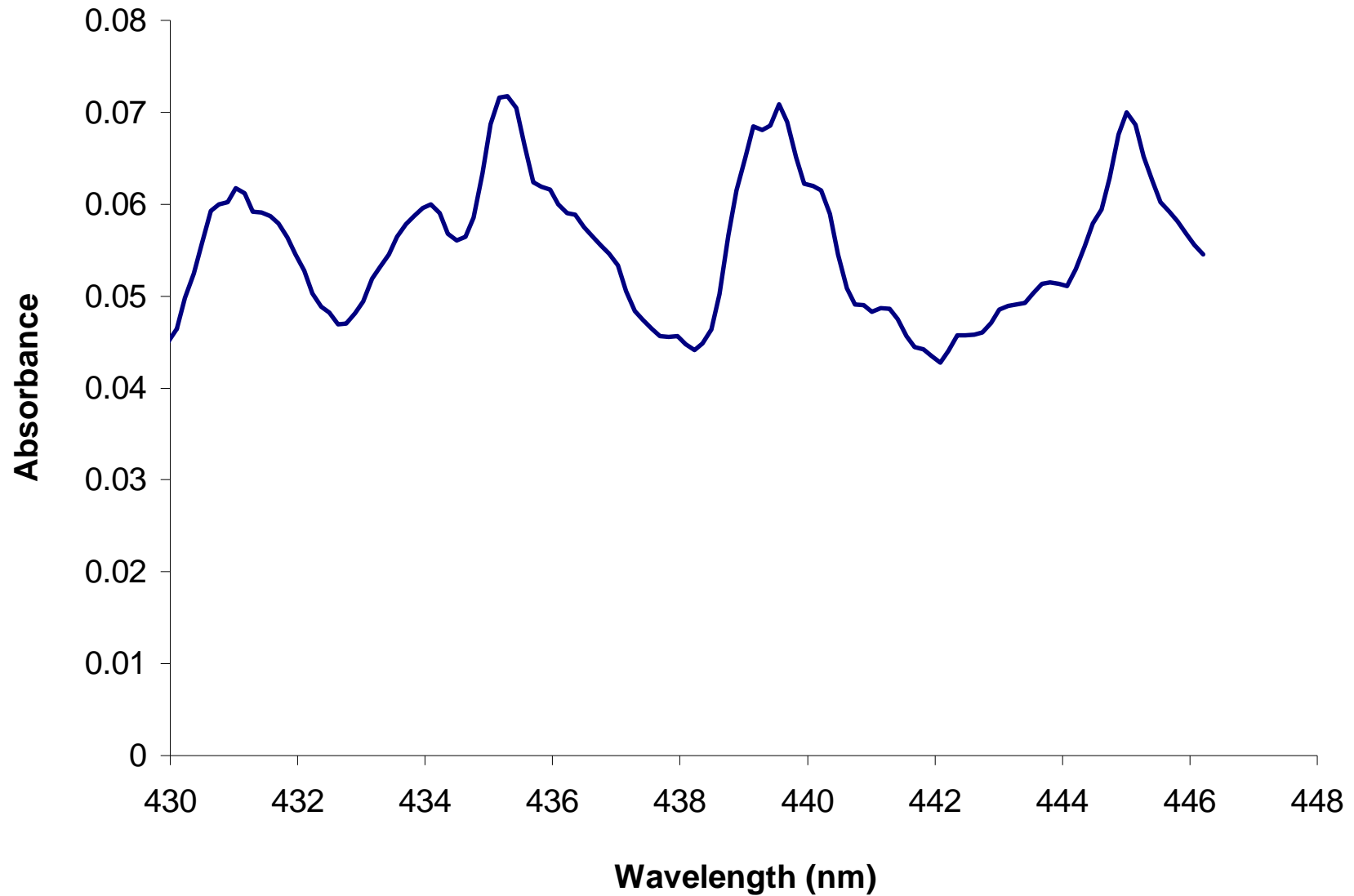
- CO, HC, NO,  **$NO_2$ ,  $SO_2$ ,  $NH_3$** , smoke, speed, acceleration.
- About 5000 vehicles per day.
- Fuel-based mass emissions in gm/kg of fuel.
- Fuel-based emissions are very much less dependent upon driving mode than are emissions per km.



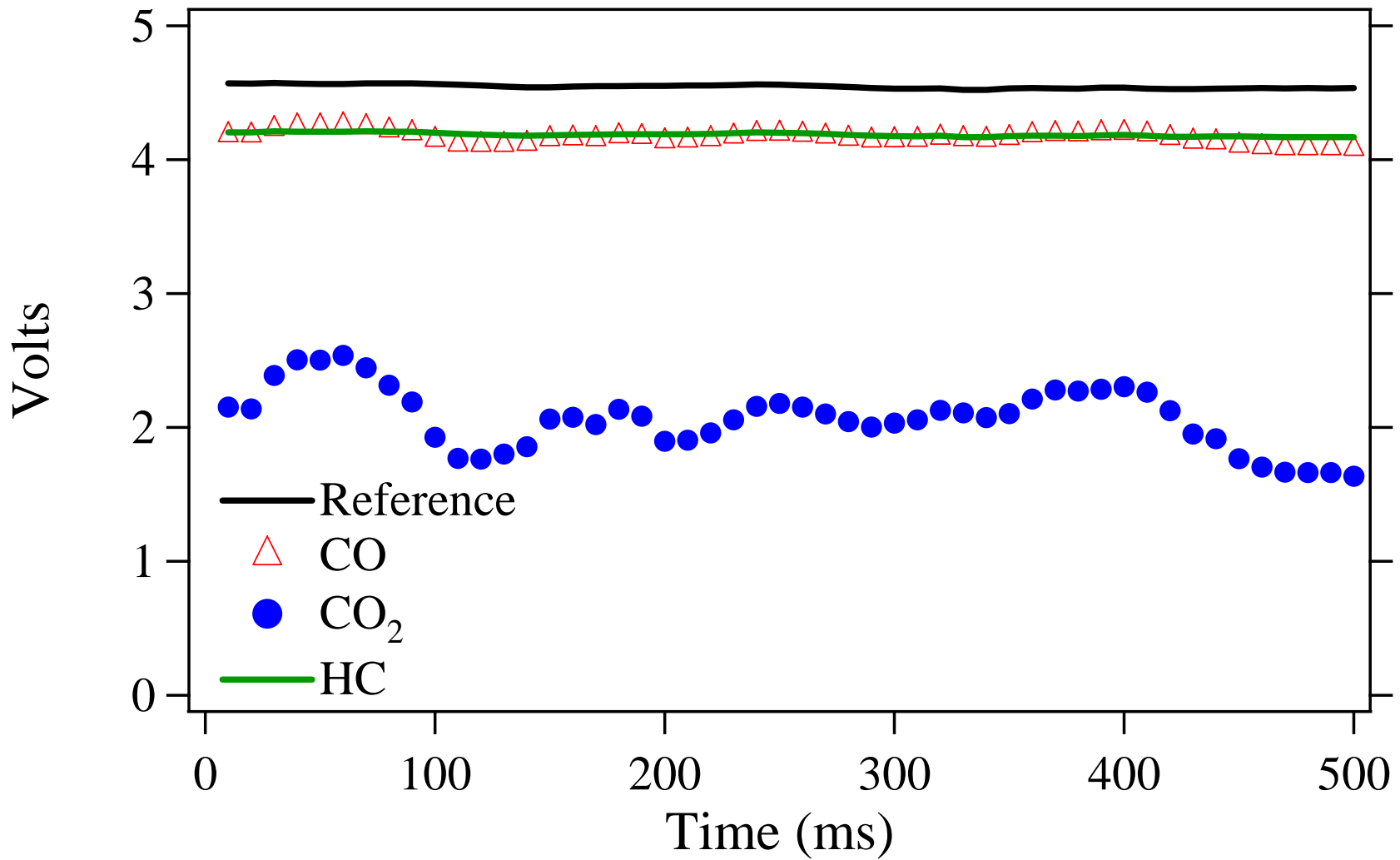
# UV Dispersive Spectroscopy



# NO<sub>2</sub> Spectrum from FEAT Remote Sensor



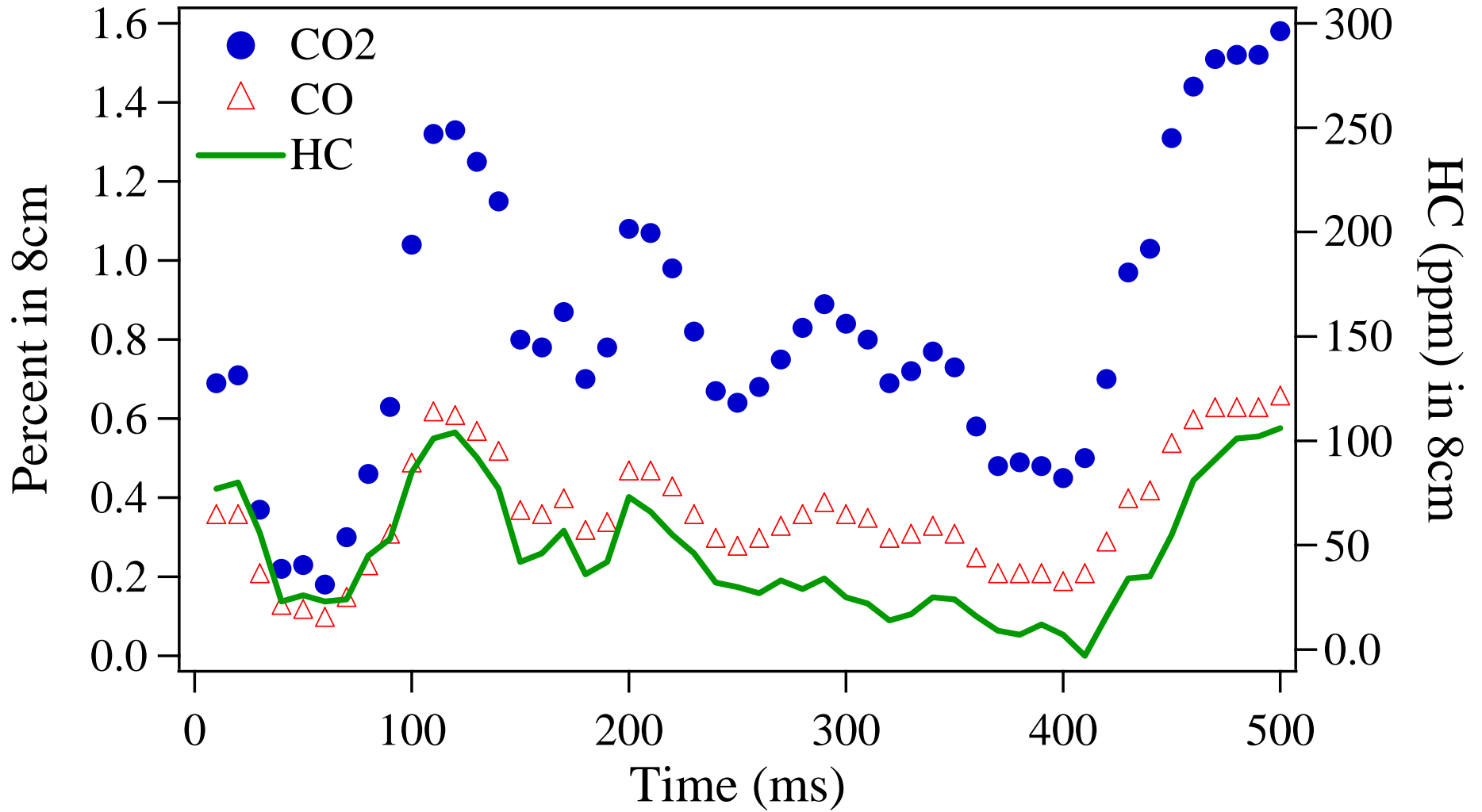
# IR Plume Signal vs. Time



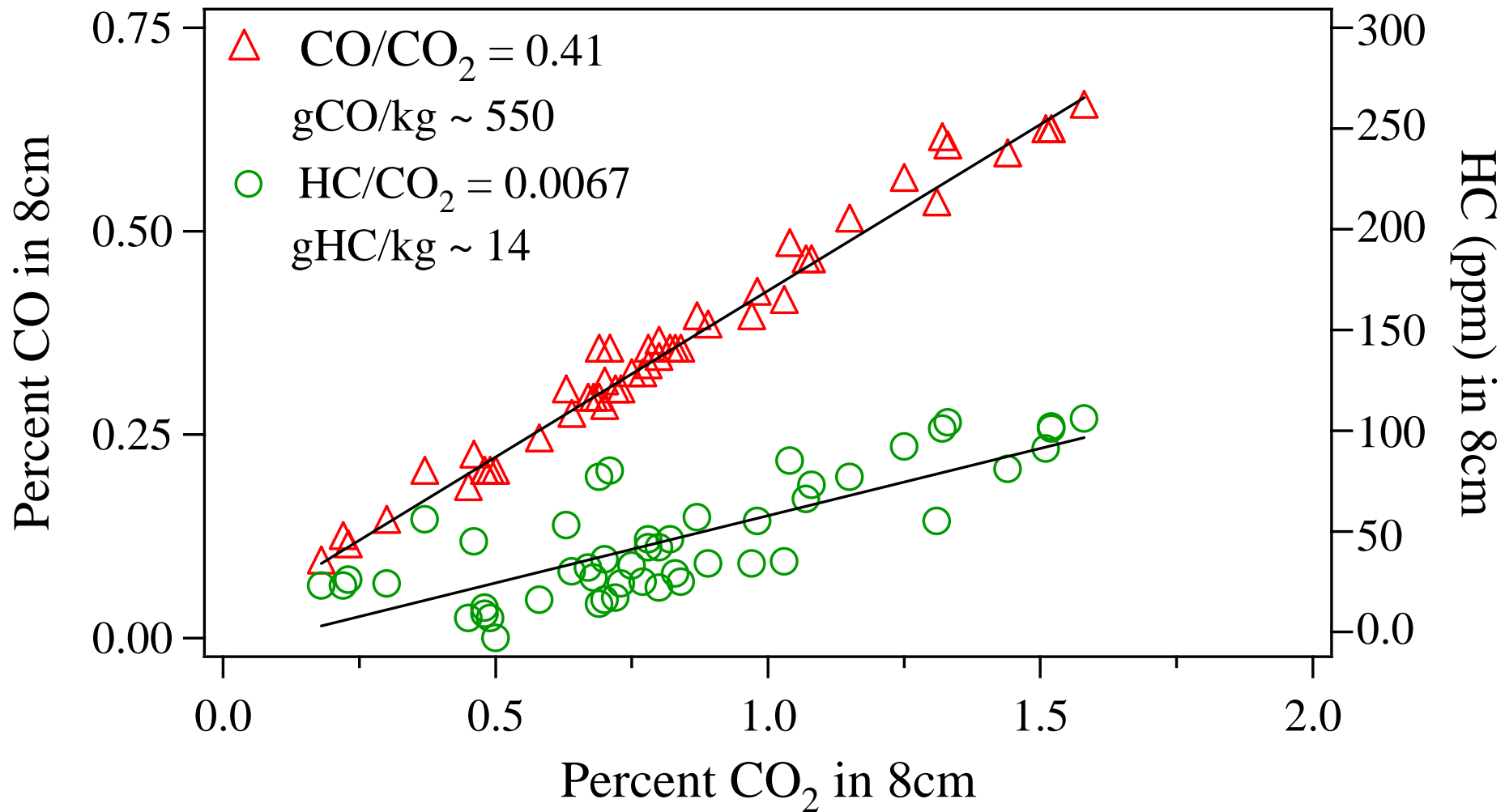
# Convert voltage signals to column amounts

- Notice the already low voltage for CO<sub>2</sub>
- This arises because the vehicle only adds a little CO<sub>2</sub> to the CO<sub>2</sub> already in the air.
- Ratio all signals to a reference signal to remove interferences.
- Use laboratory calibrations to determine pollutant readings versus time.

# Pollutant Readings vs Time



# Pollutant Ratio Plots







# Some Drivers Cheat



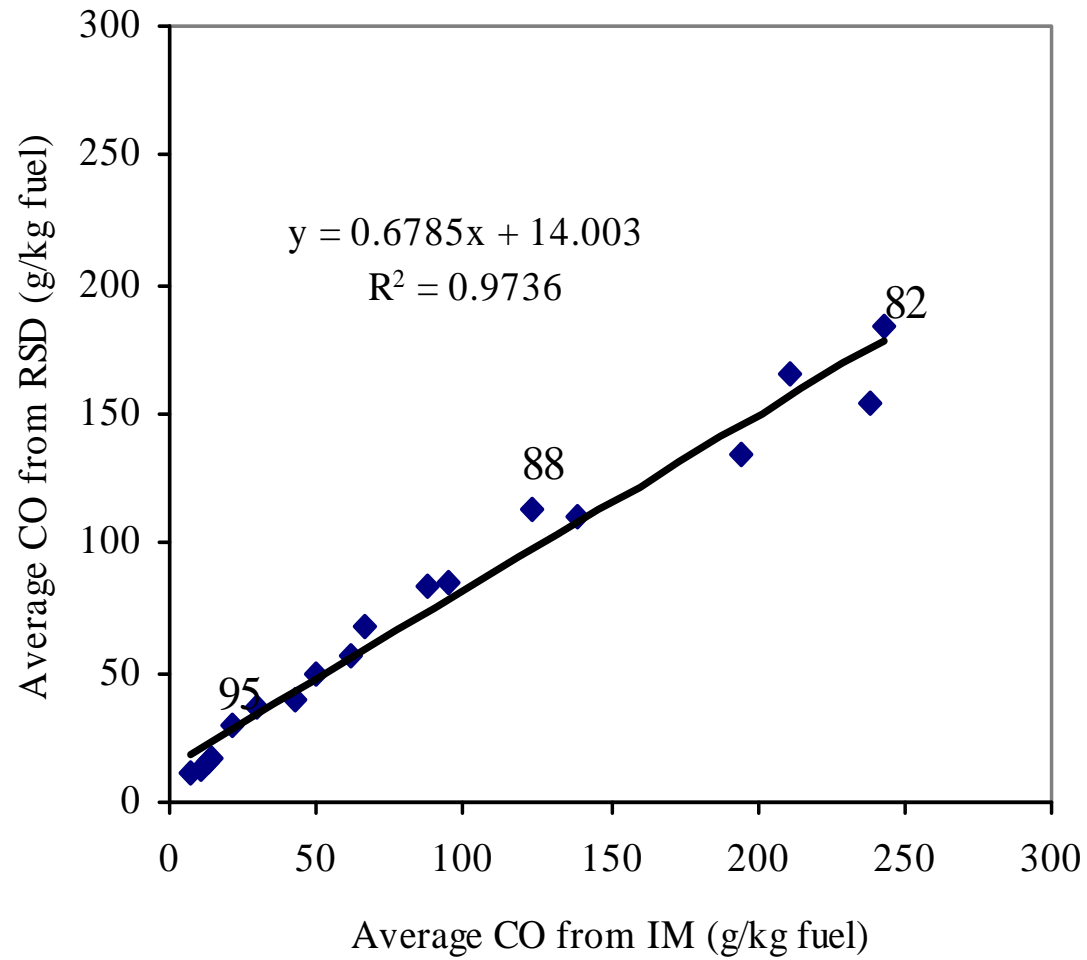
%CO      %HC      %NO      %CO<sub>2</sub>

1% of the Measurements =  
~20% or more of the CO & HC

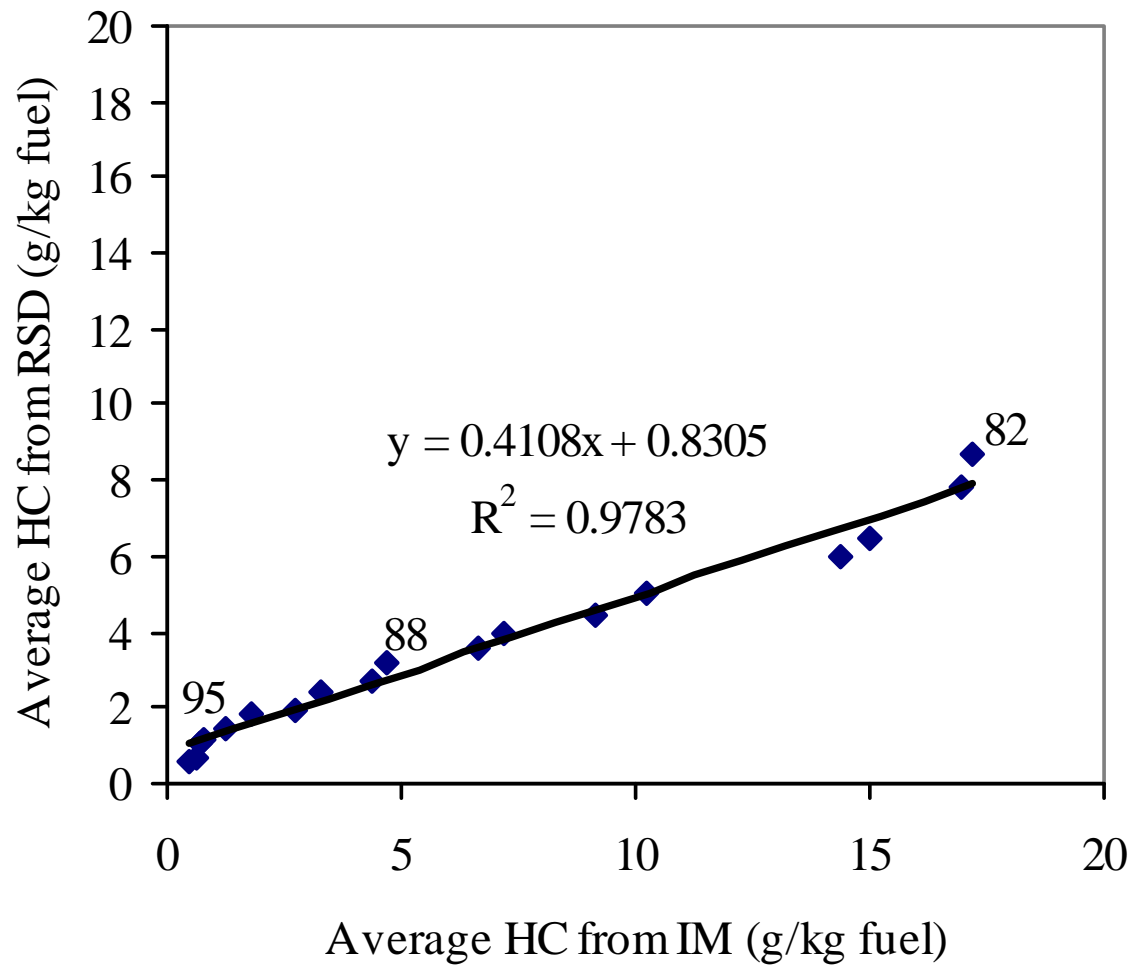




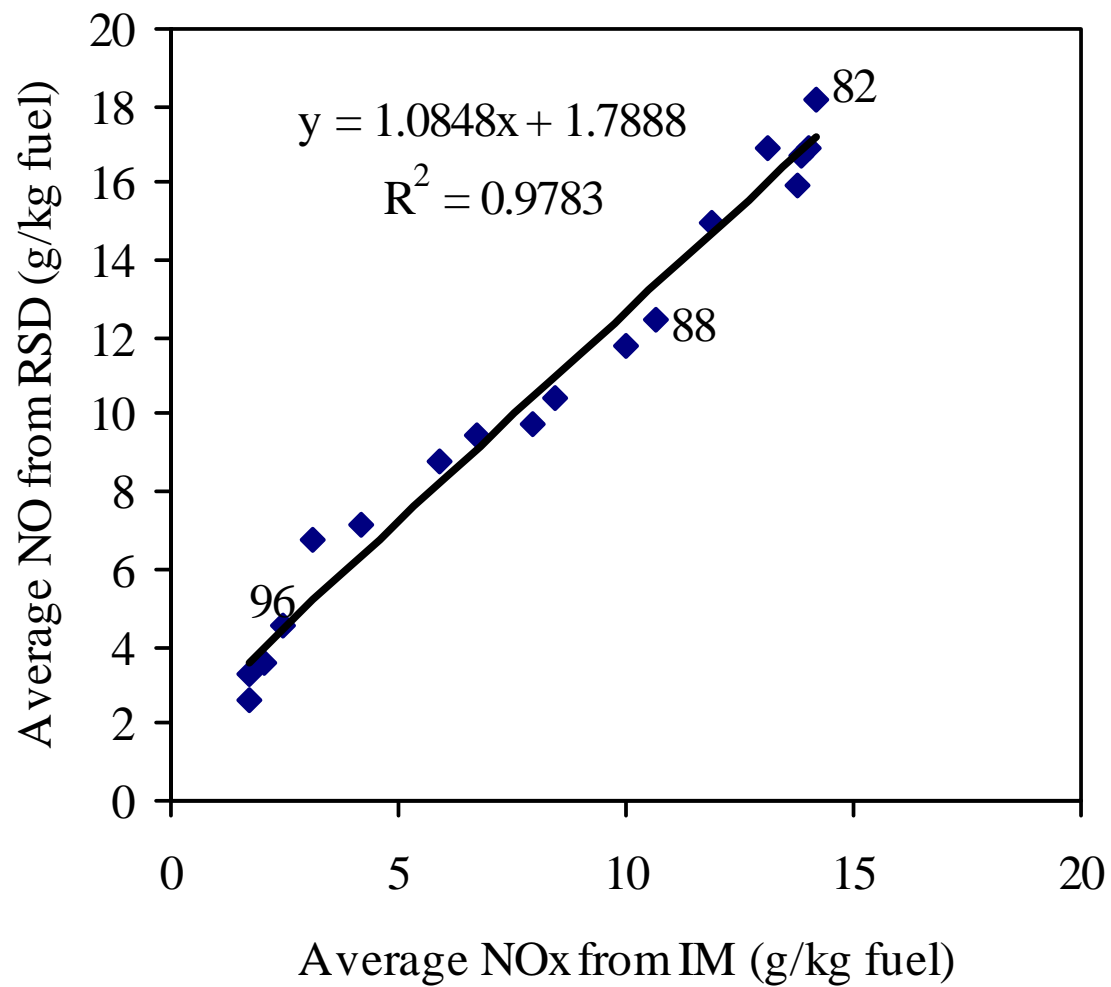
# Denver 1999 CO



# Denver 1999 HC



# Denver 1999 NO

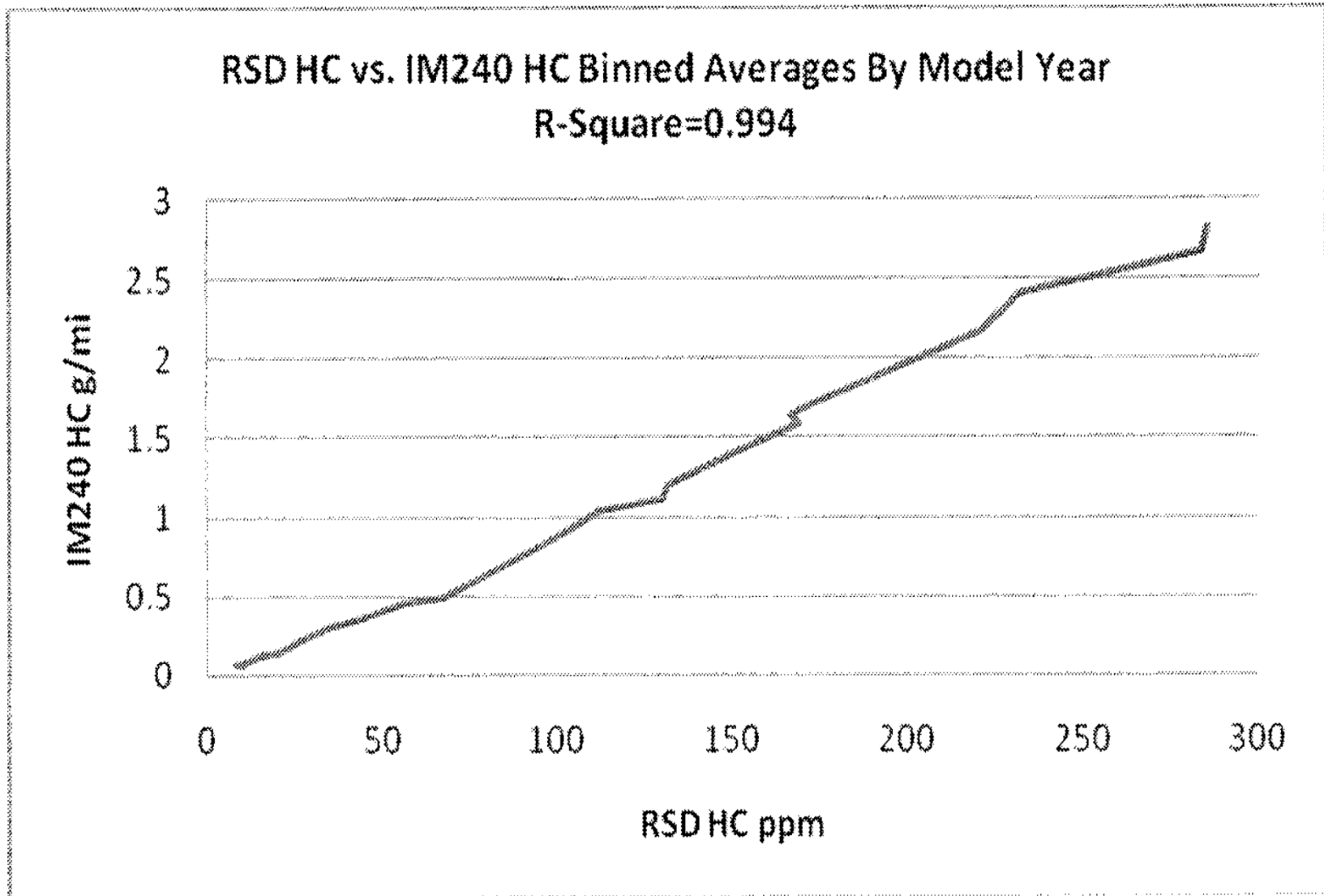


Klausmeier report to Colorado State Auditor 2009:

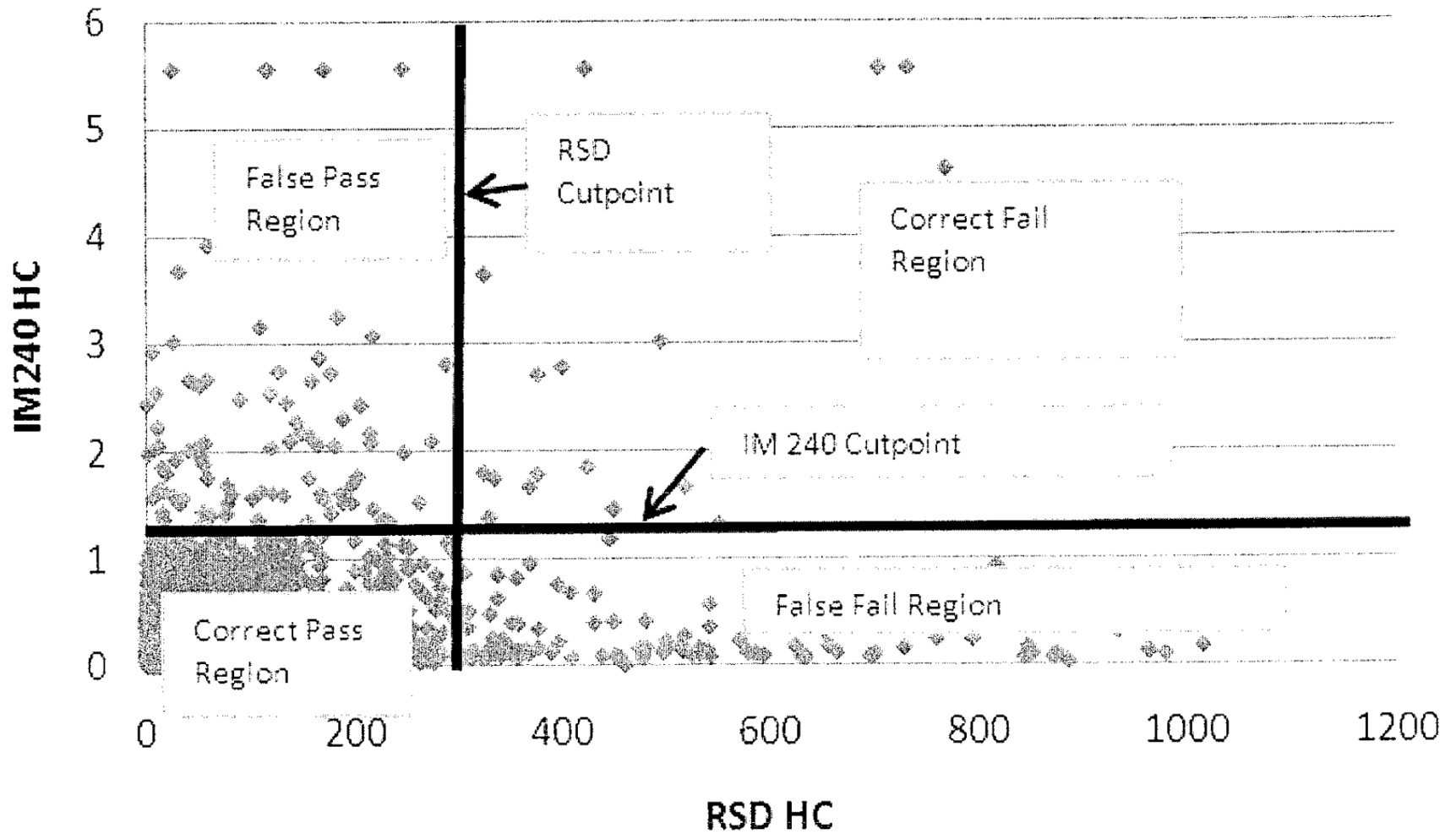
“Many vehicles only operate on surface streets which are not suitable remote sensing sites”.

**The second phrase of the above is not correct.**

**Figure D-10**



**Figure D-9**  
**Colorado Automobile Inspection and Readjustment (AIR) Program**  
**Correlation Between IM240 Test Results and Rapid Screen Results**  
**for 1998 Model-Year Passenger Vehicles**



# CONCLUSIONS

- Remote sensing is worthless because the results sometimes do not correlate to IM240 failures.
- IM240 is worthless because the results do not correlate to the on-road emissions that the I/M program is supposed to be reducing.
- Both conclusions are WRONG.
- Both tests are just fine, the vehicles are the problem.

**TECHNICAL PAPER**

---

ISSN 1047-3289 *J. Air & Waste Manage. Assoc.* **46**: 667-675

Copyright 1996 Air & Waste Management Association

## Motor Vehicle Emissions Variability

**Gary A. Bishop and Donald H. Stedman**

*University of Denver, Denver, Colorado*

**Lowell Ashbaugh**

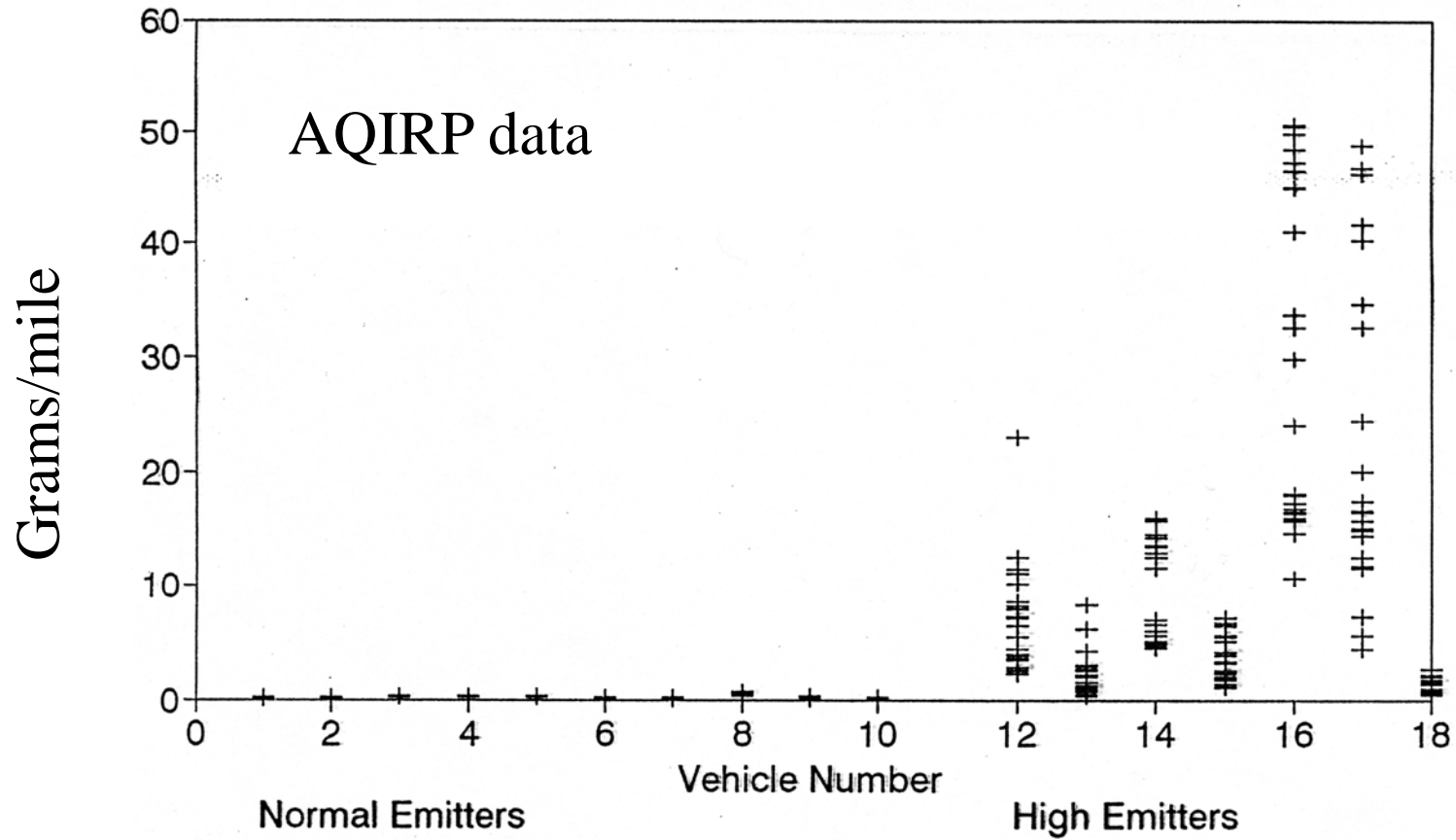
*University of California at Davis, Davis, California*

1996



# Exhaust HC by FTP

## Normal and High Emitters- All Fuels



# To use RSD in an I/M Program

- You must be up front about the variability of emissions. The same test **can** give different numbers on the same car on two different days, especially for broken cars.
- **Advanced system hardware and software can validate the measurements used for screening.**
- There is a well known, well documented and entirely understandable tendency to cheat on scheduled emission testing.
- **Fraud is another well documented issue in I/M tests.**
- See independent California BAR report in 2001. 85-95% of on-road gross emitters failed an IMMEDIATE roadside I/M test. Link on web site.

# Thank You

- Questions