THE KANSAS CITY LIGHT-DUTY VEHICLE EMISSIONS STUDY: ASSESSING PM EMISSIONS FROM GASOLINE POWERED MOTOR VEHICLES

2004 International Emissions Inventory Conference
Mobile Source Session
Clearwater, Florida
June 7-10

Overview

- Why are we concerned about Gasoline PM?
- The Kansas City Study
  - Objectives
  - Participants
  - Recruitment
  - Testing
  - Chemical and Physical Analyses
- Emission Inventory relevant outcomes.

Background

- Issue
  - Emissions from light-duty gasoline vehicles may be significant contributors to ambient PM concentrations
  - EPA inventories indicate diesel PM contributions greater than gasoline PM
- Recent source apportionment studies give conflicting results
  - Denver and Phoenix studies indicate gasoline greater than diesels
  - California studies indicate diesel greater than gasoline

Current State of Knowledge

- Measured emission results vary significantly, indicating the presence of high emitting gasoline vehicles.
- High emitters may have disproportionate contribution to ambient PM.
- Unclear how to relate sampled fleet to national fleet.
- Uncertainties exist on the adequacy of diesel/gasoline profiles.

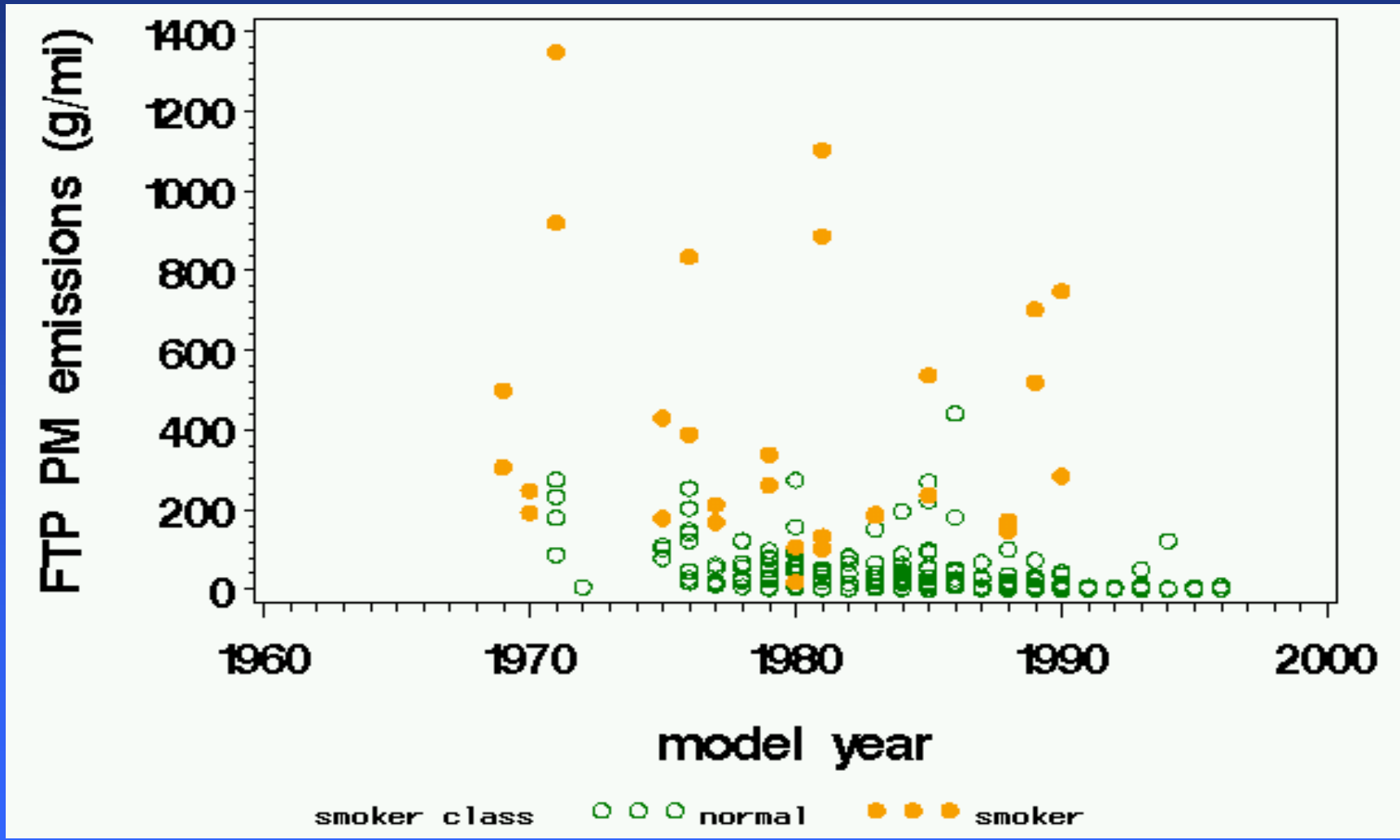
Previous Gasoline PM Studies

- CRC Project E-24-1, Denver, CO, 1998
  - 101 gasoline vehicles tested in the summer and 72 tested in the winter.
  - Gasoline vehicle PM rates ranged over two orders of magnitude depending on vehicle age and smoking condition.
- CRC Project E-24-2, Los Angeles, CA, 1998
  - 129 gasoline vehicles tested, high emitters had 5-10 times the PM emissions of normal emitters.
  - Gasoline vehicle PM rates ranged from 0.01 to 388 mg/mile.
- Representativeness of vehicle fleet uncertain for both studies since vehicle recruitment was not random.

Can We Identify High PM Emitters in Advance?

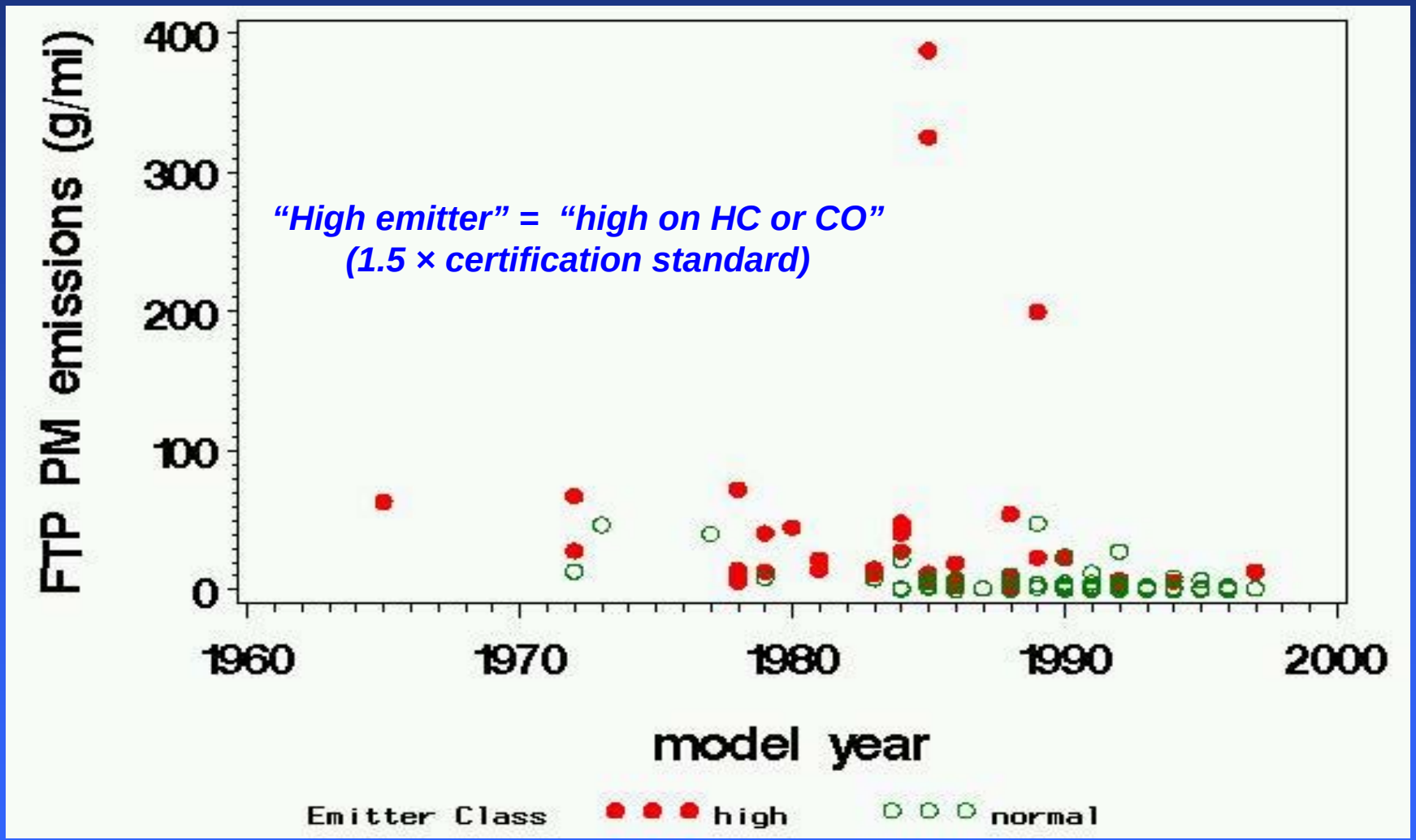
- No technique available to quickly and inexpensively screen PM emissions.
- Other indicators have been used
  - Older vehicles
  - High mileage vehicles
  - High gaseous emitters
  - “Smokers”

FTP PM Emissions vs. Model Year



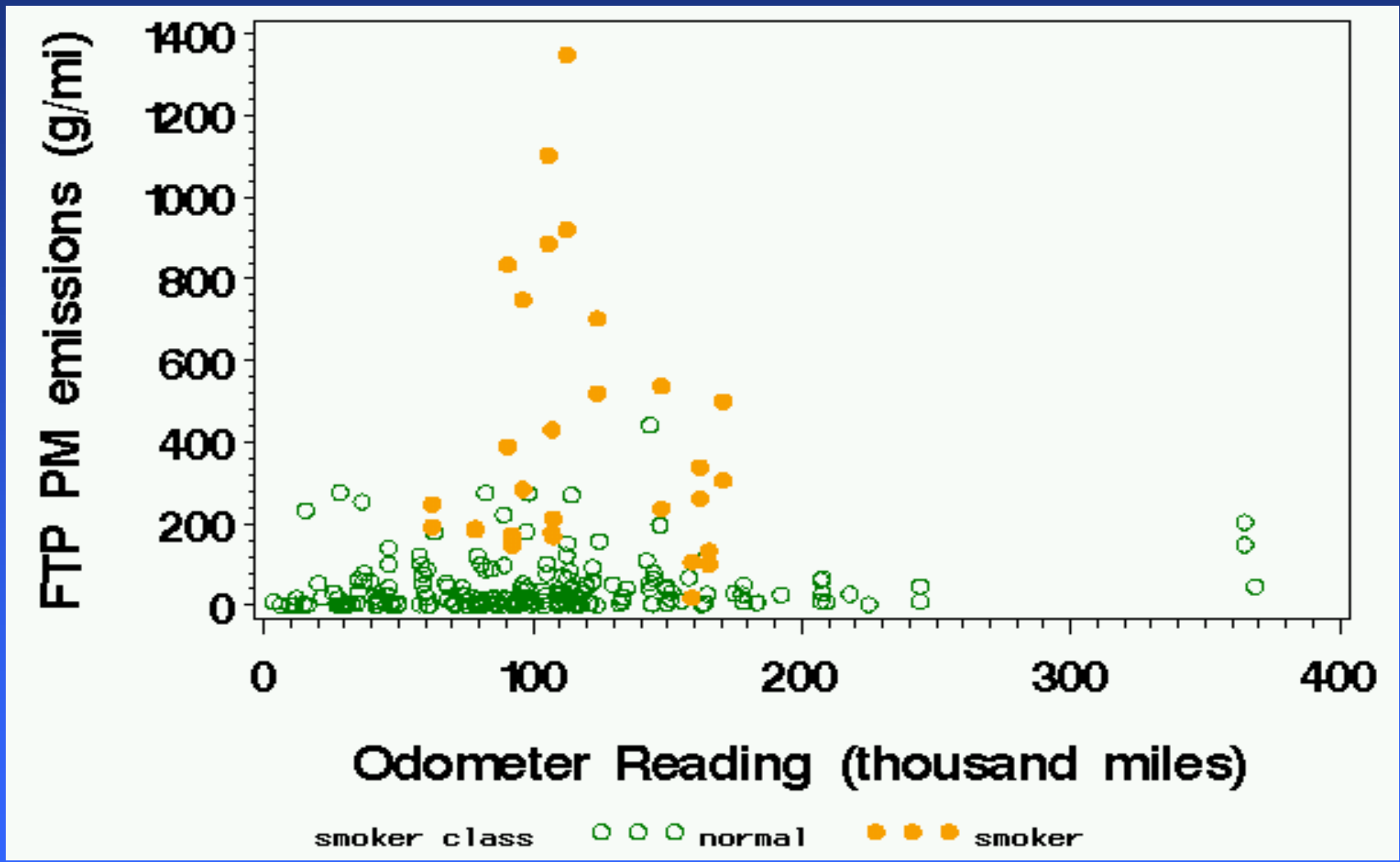
Source: CRC Project E-24-1

FTP PM Emissions vs. Model Year



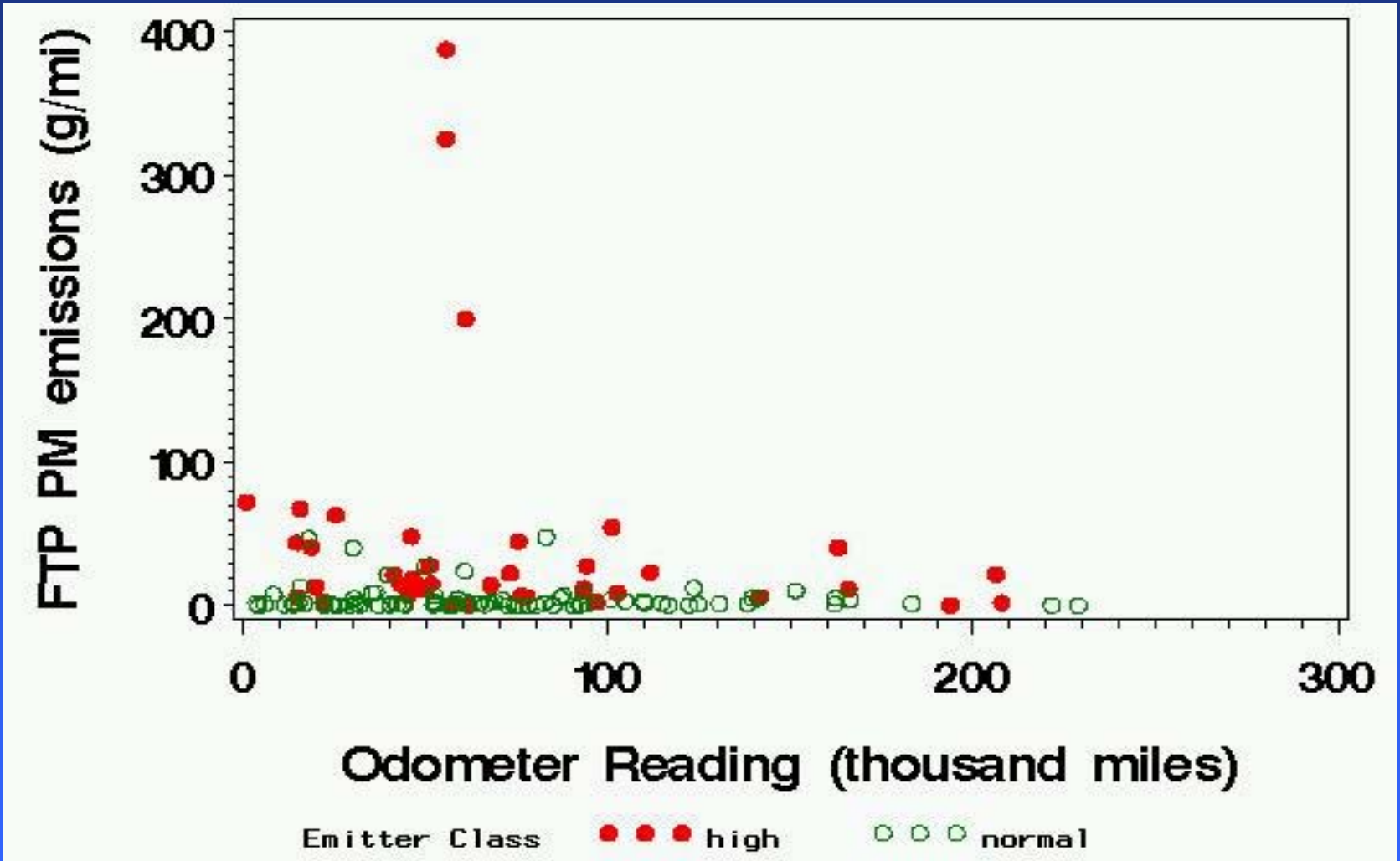
Source: CRC Project E-24-2

FTP PM Emissions vs. Mileage



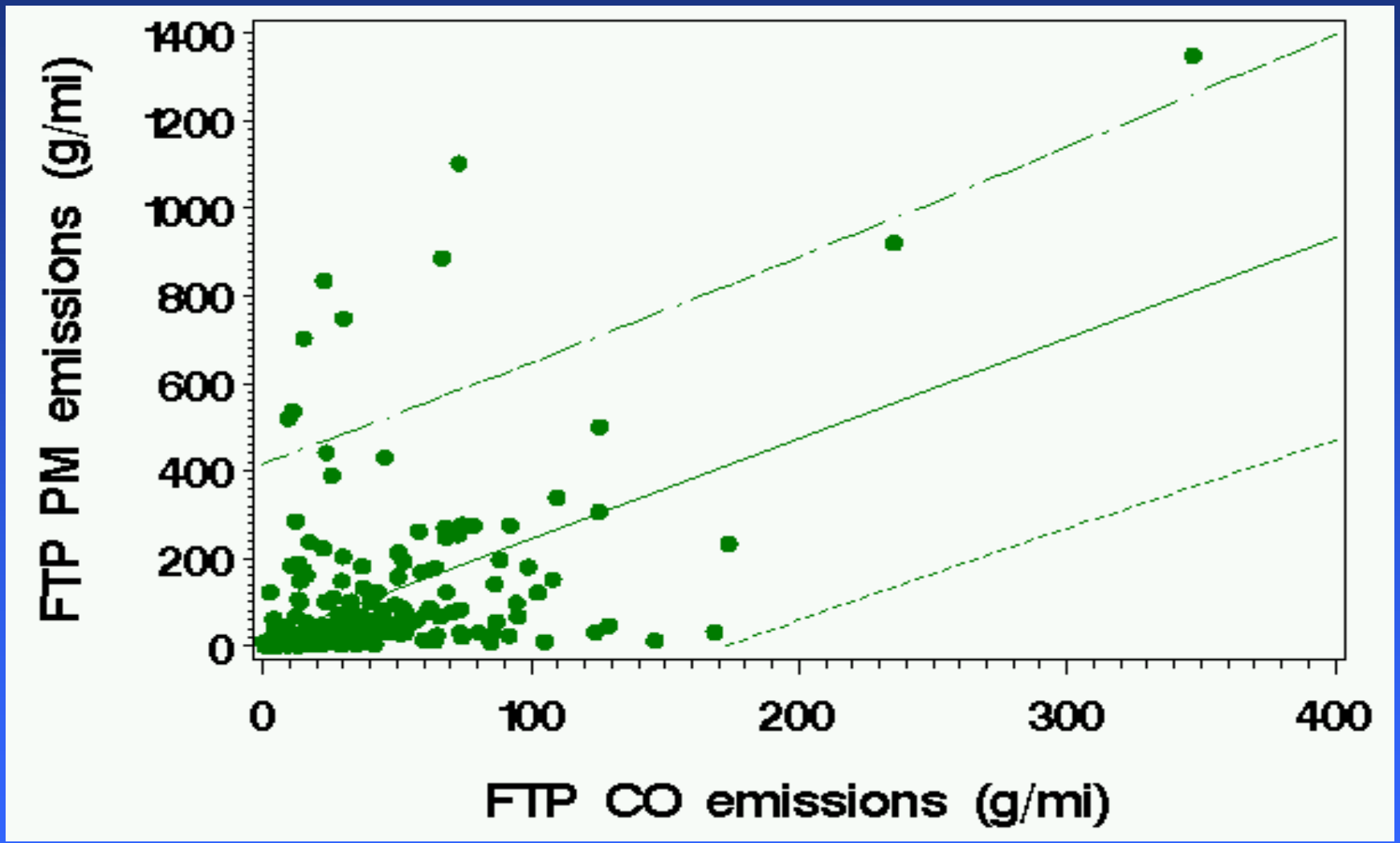
Source: CRC Project E-24-1

FTP PM Emissions vs. Mileage



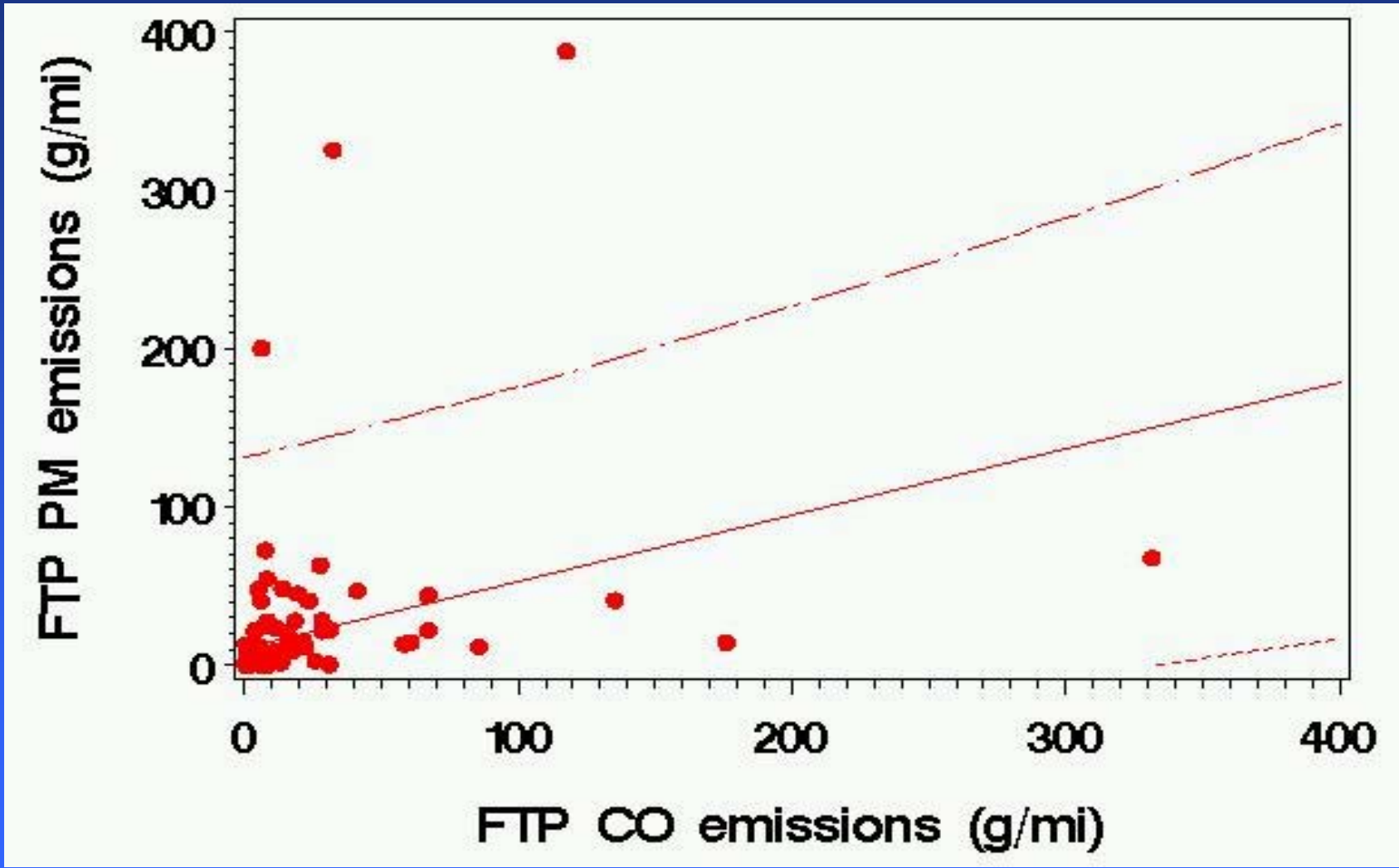
Source: CRC Project E-24-2

PM vs. CO



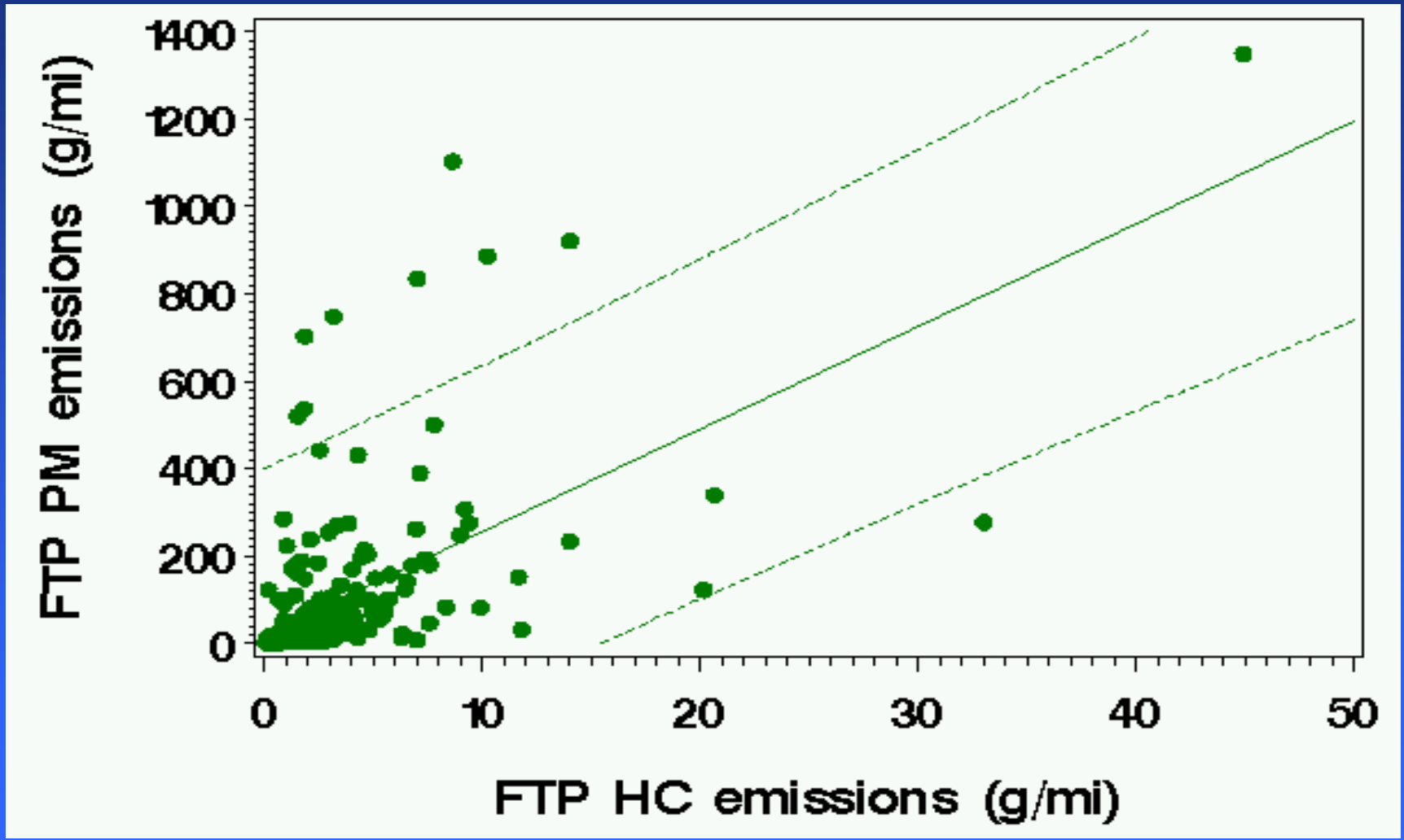
Source: CRC Project E-24-1

PM vs. CO



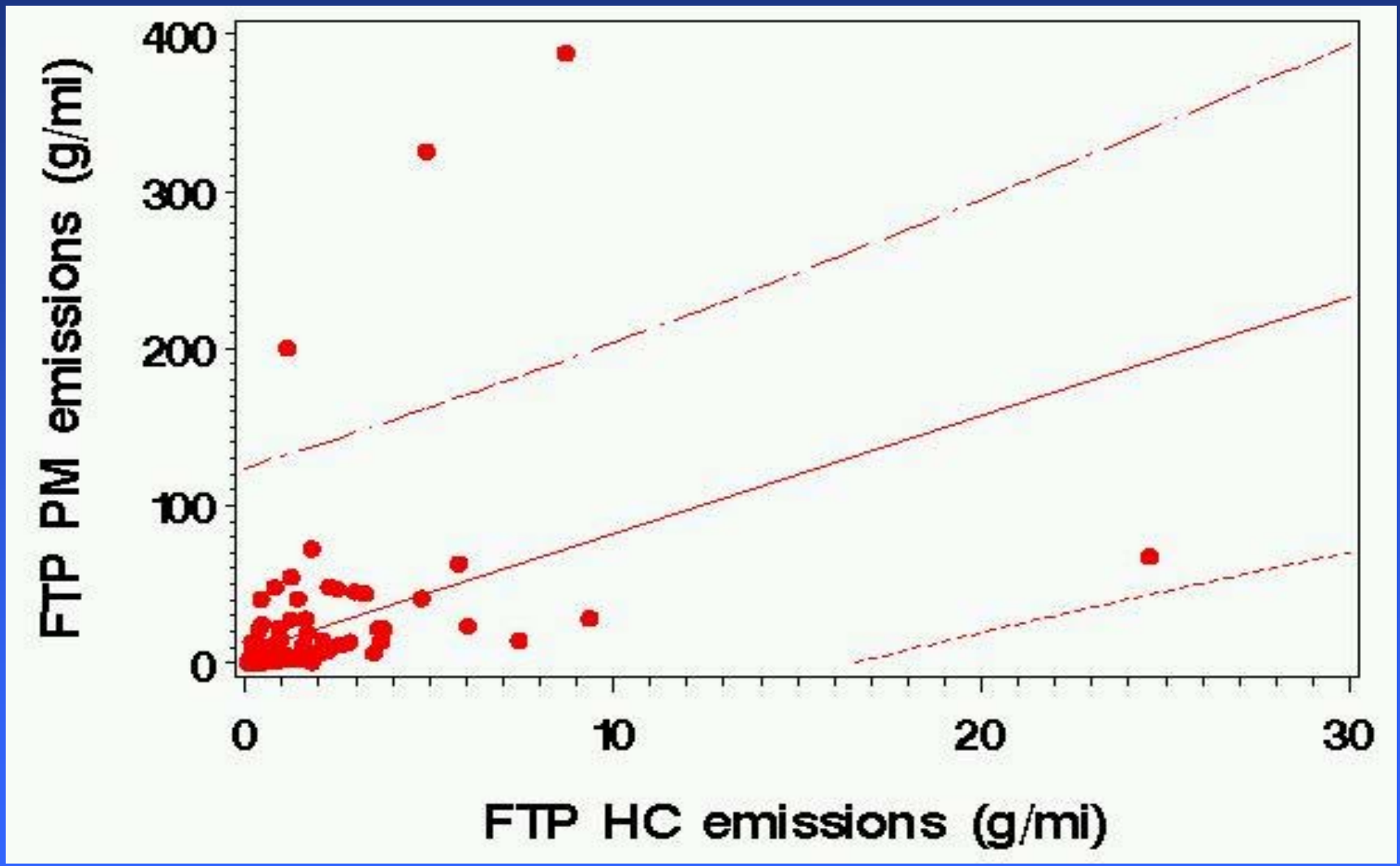
Source: CRC Project E-24-2

PM vs. HC



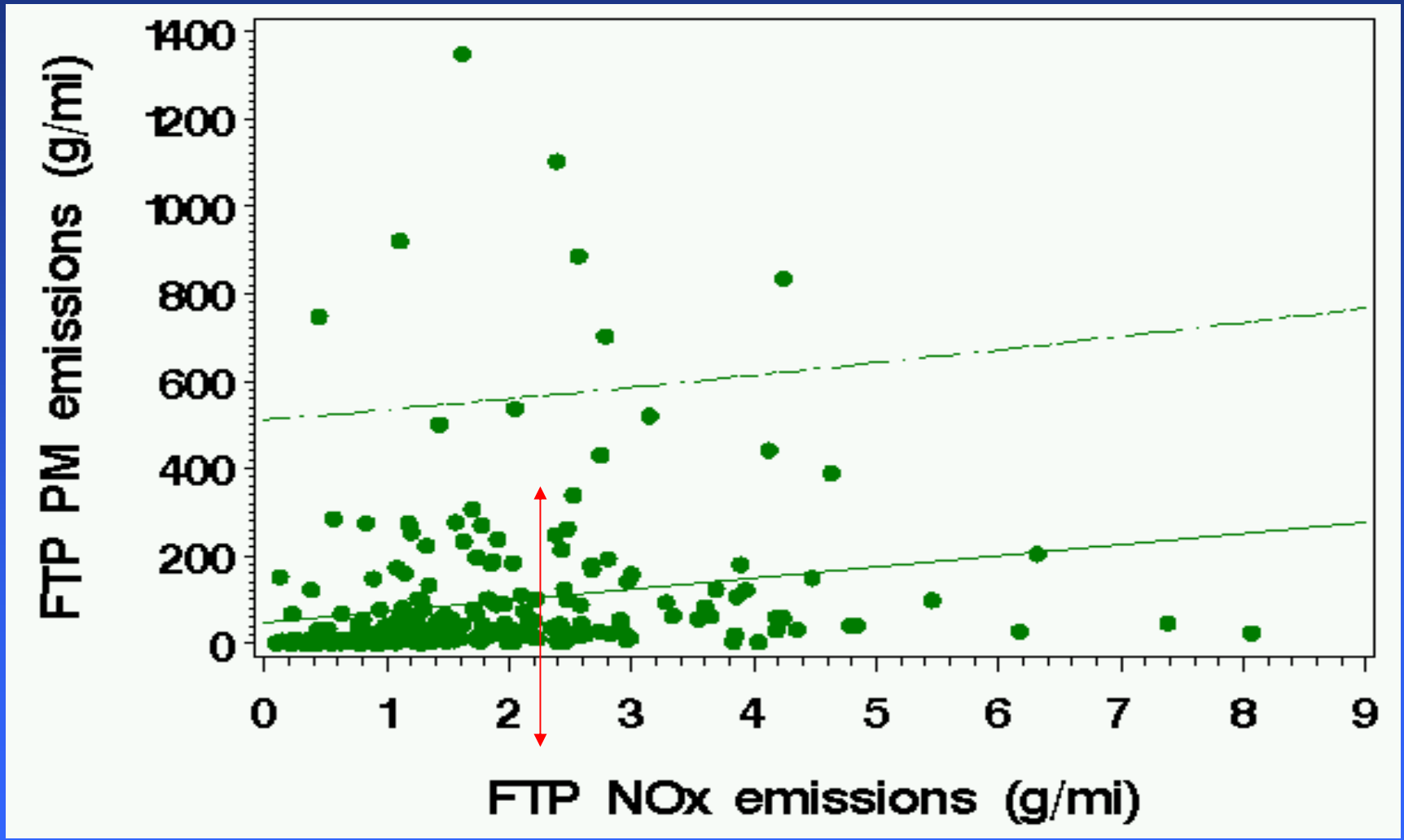
Source: CRC Project E-24-1

PM vs. HC



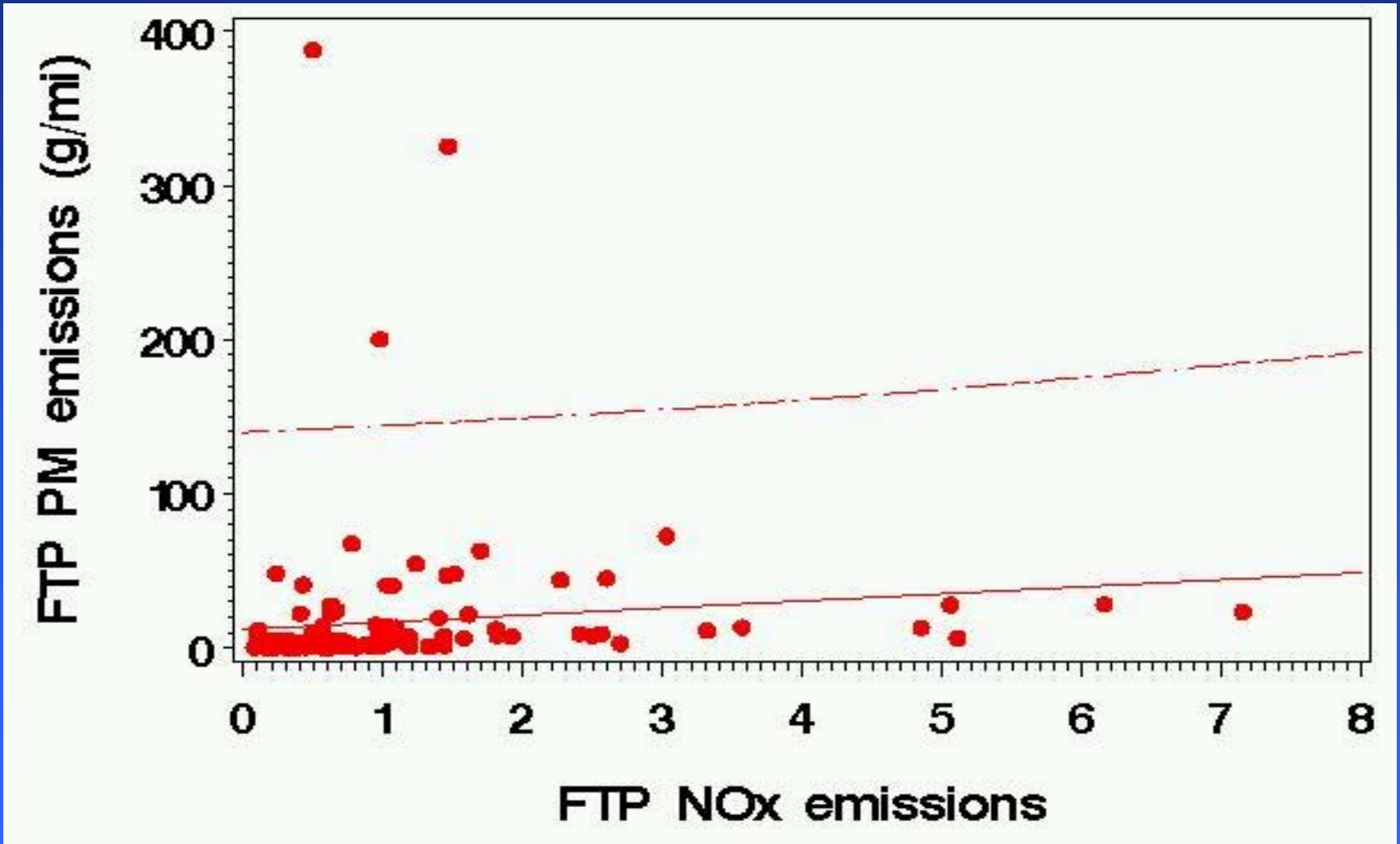
Source: CRC Project E-24-2

PM vs. NO_x



Source: CRC Project E-24-1

PM vs. NO_x



Source: CRC Project E-24-2

What the Data Show

- Some vehicles appear to emit more PM than most.
  - Range of emissions:
    - Denver: (summer and winter) up to 1,400 mg/mi
    - Riverside: (summer) up to 400 mg/mi
- Existing data do not give a basis to assess the importance of high emitters.
  - How many are there?
    - targeted recruiting gives no idea how likely or unlikely it is to find high emitters.
  - How much do they contribute?
    - targeted recruiting gives no idea how much weight to assign high emitters.

Importance of Gasoline PM

- 2020 Mobile Source Direct PM2.5 Inventory
  - Non-road gasoline: 24%
  - Commercial marine diesel: 23%
  - *Highway gasoline vehicles: 16%*
  - Non-road diesel: 16%
  - Aircraft: 9%
  - Highway diesel: 6%
  - Locomotives: 5%

The Kansas City Study: Participants

- EPA OTAQ
- EPA ORD
- EIIP (STAPPA/ALAPCO & EPA OAQPS)
- CRC
- DOE/NREL
- DOT

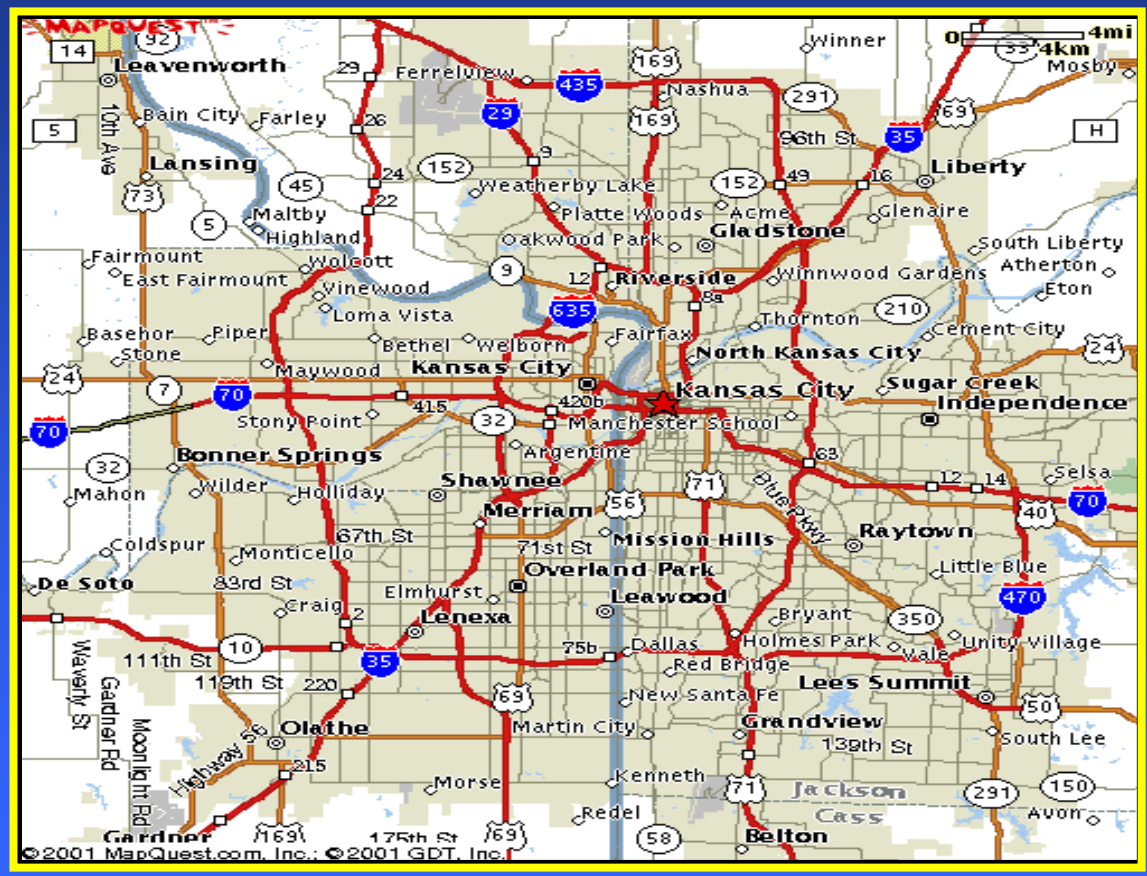
Objectives

- Identify the distribution of PM emissions in the vehicle fleet
- Identify the fraction of PM high emitters in the vehicle fleet
- Evaluate existing mobile source PM and toxics inventories and models
- Improve automobile source profiles.

Project Location

Kansas City

- No I/M Program
- Varying temperatures



Vehicle Recruitment

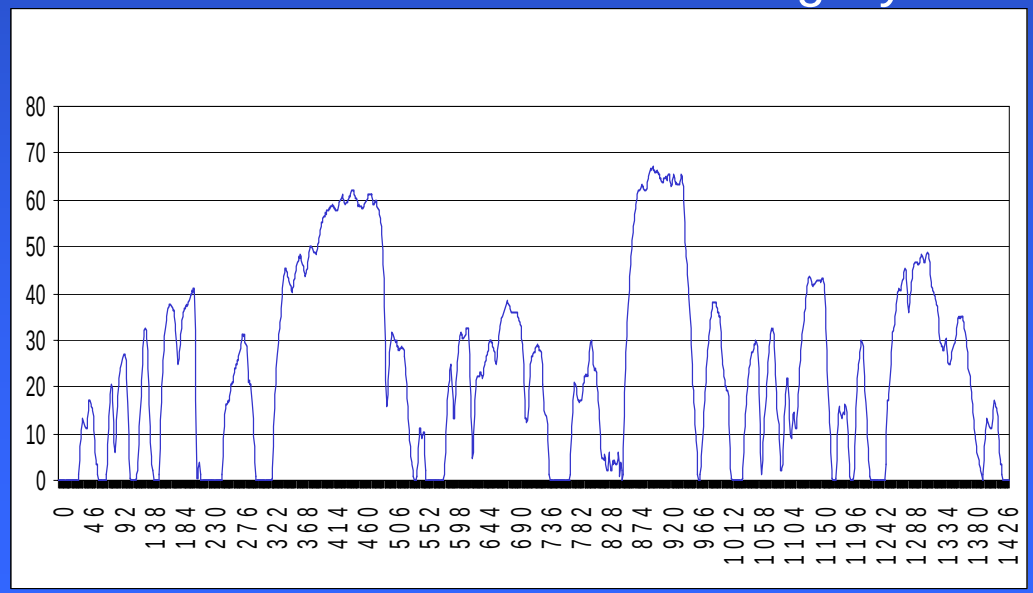
- Up to 480 randomly selected vehicles
  - From random digit dialing, and
  - State DOT records
- Representative of national fleet

Vehicle Class	Age Class	Sample Size
Car	Pre 1980	50
Car	1980-1990	140
Car	1991 and newer	70
Truck	Pre 1980	40
Truck	1980-1990	50
Truck	1991 and newer	130

Testing Procedures

- Equipment
  - EPA ORD Portable Chassis Dynamometer
  - PEMS (HC, NOx, CO, PM and activity)
  - Remote Sensing
- Cycles
  - LA92
  - Real world

LA92 Cold and Warm Start Driving Cycle



Measurements

- Tailpipe Emissions
  - Continuous PM
    - QCM
    - Nephelometer
  - Integrated PM
    - EC/OC
    - Elements
    - SVOCs
    - ions
  - Continuous HC, NOx, CO
  - VOCs and aldehydes
  - Visible Smoke

- Vehicle Fluid Sampling
  - –Fuel and Oil

On-Board Emissions Monitoring

- Subset of vehicles equipped with on-board samplers.
  - Portable Emission Monitoring System (PEMS)
    - Continuous CO, CO_2, HC, NO_x and PM tailpipe measurements.
    - Environmental conditions (temperature, humidity, pressure).
    - Vehicle parameters (engine rpm, vehicle speed, A/C use, OBD codes).
    - GPS locator.

Emission Inventory Relevance

- Improve On-road Automobile Emission Rates
  - PM
    - Distribution of PM emissions for the light-duty fleet.
    - Identification of the percent of high emitters.
    - Improvement of PM mobile source emissions models.
  - Air Toxics
    - Improved emission factors for toxics.
    - Estimate of the association of toxics emissions with criteria gases and PM.
- Improve MOBILE/MOVES emissions models.

Emission Inventory Relevance

- Source Profiles for On-road Automobiles
  - Existing profiles may be inadequate
    - Previous Dynamometer studies - small number of vehicles non-randomly selected.
    - Tunnel studies - only one driving condition (steady-state speeds) and typically newer mix of vehicles.
  - Benefits from Kansas City Study
    - Large number of vehicles representing vehicle fleet mix.
    - Random selection.
    - Test cycle represents typical mix of urban driving.
    - Multiple source profiles will be developed.
      - High emitters
      - Cold start conditions
      - Multiple technologies

Acknowledgements

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