


# Environmental Air Quality Exposure Assessment in a Rural Nigerian Village



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# Background

- Many rural communities in Nigerian use firewood as primary source of fuel
- Firewood combustion is a family-centered activity
- 52% of the world's population cook & heat with solid fuels (>2.4 billion people rely on biomass)
- The population at risk is among the world's poorest



# Problem Definition

- Firewood combustion increases local air pollution and individual vulnerability to indoor air pollutants
- The risks of disease burden have potentially serious public health consequences





# Significance of the Problem

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- In developing countries, indoor air pollution ranks 8th in terms of risk factors contributing to overall diseases and deaths
- 1.1 billion people are exposed to high levels of respirable particles
- Over 3 million excess deaths due to indoor air pollution and 300,000 excess deaths due to urban air pollution



# Significance of the Problem

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- Indoor air pollution from fuel combustion
  - accounts for 1.6 million deaths annually or 2.7% of the global burden of disease DALYs
  - 50% of these deaths occur in children <5 years
  - is the second largest environmental contributor to ill health, behind unsafe water and sanitation
- Over 50% total DALYs lost fall on Africa & highlights an urgent need for intervention

# Risk of Exposure

- Exposure to indoor air pollutants is a function of pollutant levels and individual activity patterns
- Determined by the interactions of sources, sinks, and air movement between rooms, building and the outdoor air
- Women and children are most vulnerable



# Health Impact

- Firewood smoke contains thousands of respirable particles  $<10$  microns ( $PM_{10}$ ) and other pollutants
- Particulate air pollutants penetrate deep into the lungs and may cause acute lower respiratory disease, chronic obstructive pulmonary disease, cancers, etc.





# Environmental Impact

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- Dependency on firewood
  - exacerbates deforestation
  - contributes to greenhouse gasses and
  - enhances global climate change
- Deforestation causes
  - soil erosion and stream pollution
  - loss of biodiversity and
  - increased transmission of vector-borne diseases



# Study Objectives

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The main objectives of the study were:

- To evaluate selected IEQ parameters for a sample of 10 families in rural Nigeria and
- To assess the relationships between various indoor exposure levels for selected parameters and outdoor levels



# Methodology

## Study Homes

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- 10 homes were randomly selected
  - 6 homes used fire woods
  - 4 homes used kerosene or gas stoves
- Measurements were made in summer 2005 during the “rainy season”
- Indoor samples were taken from three locations
  - Bedroom
  - Living room and
  - Kitchen
- Outdoor samples collected for comparison

# Methodology

## Data Collection

Basic IAQ Parameters	Particulate Matter
<ul style="list-style-type: none"><li>■ Carbon Dioxide (ppm)</li><li>■ Relative Humidity (%)</li><li>■ Temperature (°F)</li><li>■ Dew Point (°F)</li><li>■ Carbon Monoxide (ppm)</li></ul>	<ul style="list-style-type: none"><li>■ 0.3-<math>\mu\text{m}</math></li><li>■ 0.5-<math>\mu\text{m}</math></li><li>■ 0.7-<math>\mu\text{m}</math></li><li>■ 1.0-<math>\mu\text{m}</math></li><li>■ 2.0-<math>\mu\text{m}</math></li><li>■ 5.0-<math>\mu\text{m}</math></li></ul>



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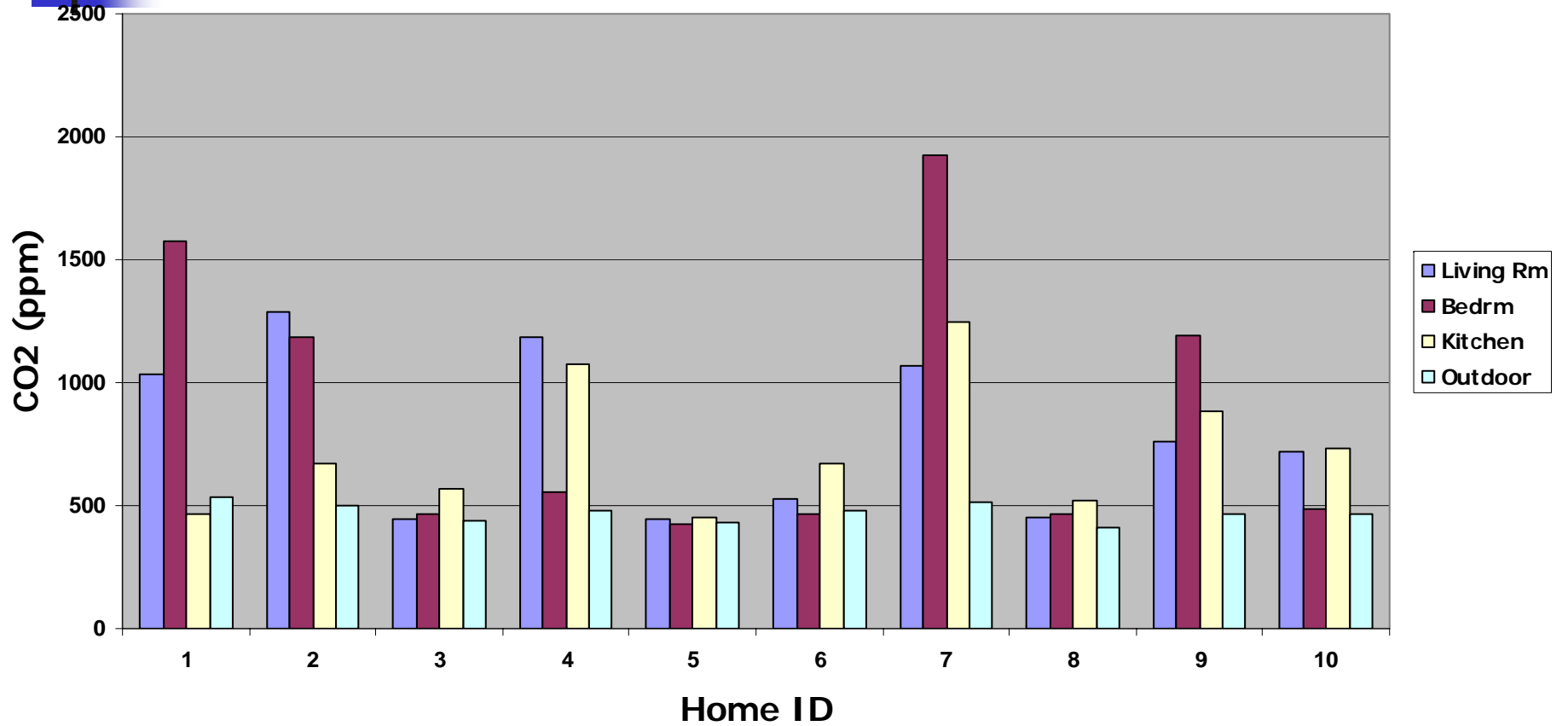


# Results

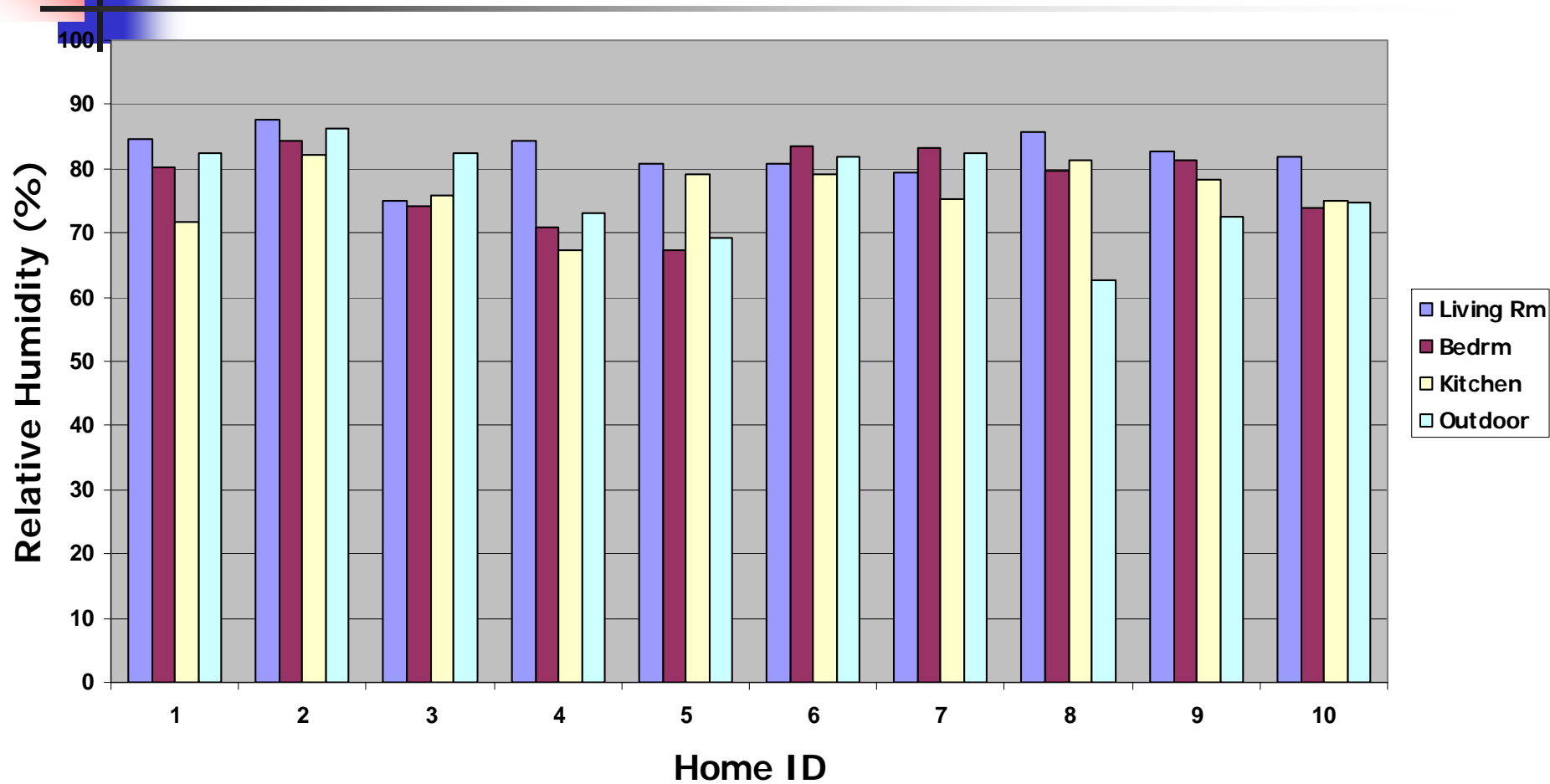
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- Basic Environmental Parameters
  - Carbon Dioxide
  - Relative Humidity
  - Temperature
  - Dew Point
- Carbon Monoxide
- Respirable Particulate Matter
- Correlation between environmental parameters and particulate matter

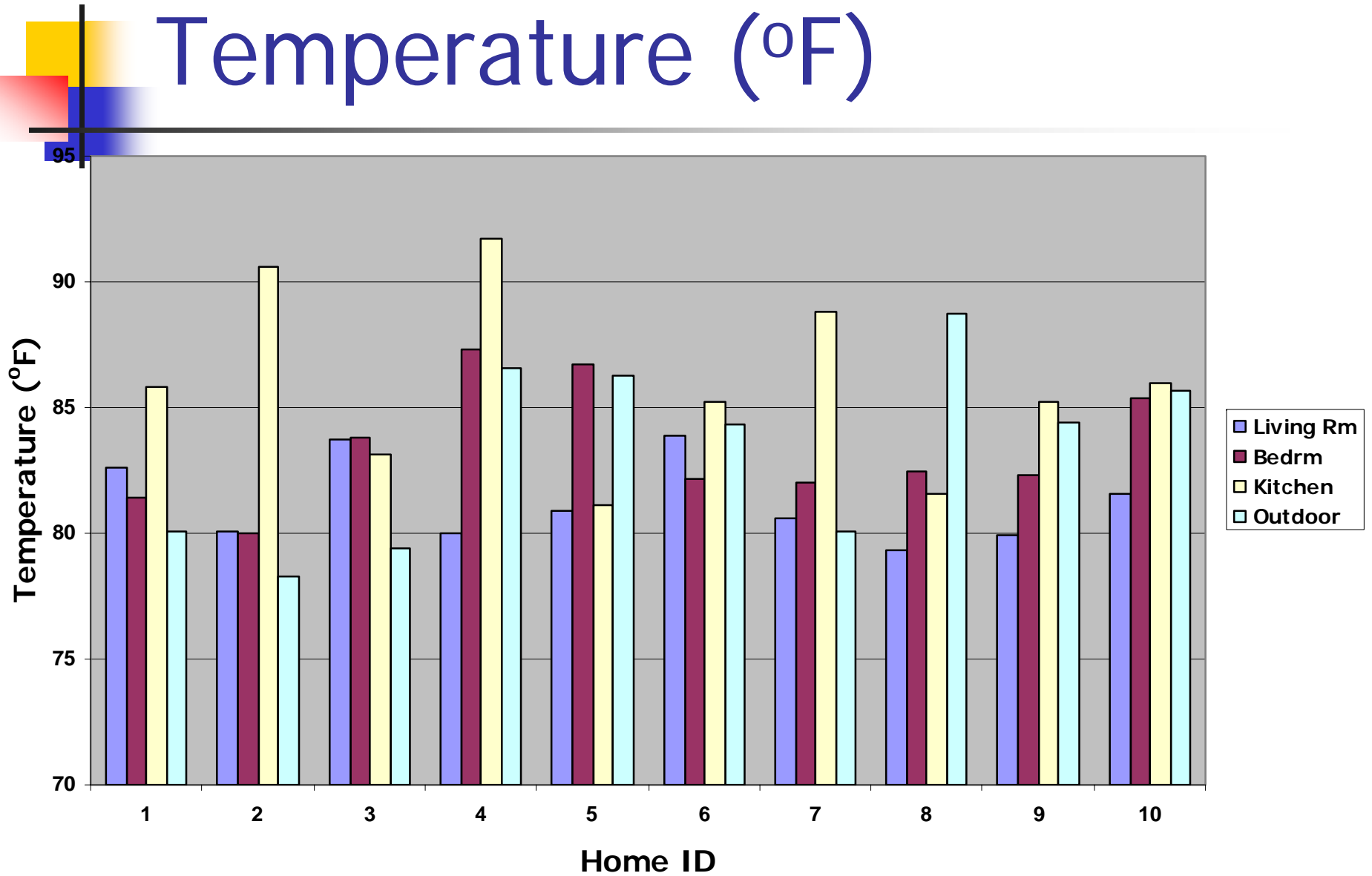
# Carbon Dioxide (ppm)



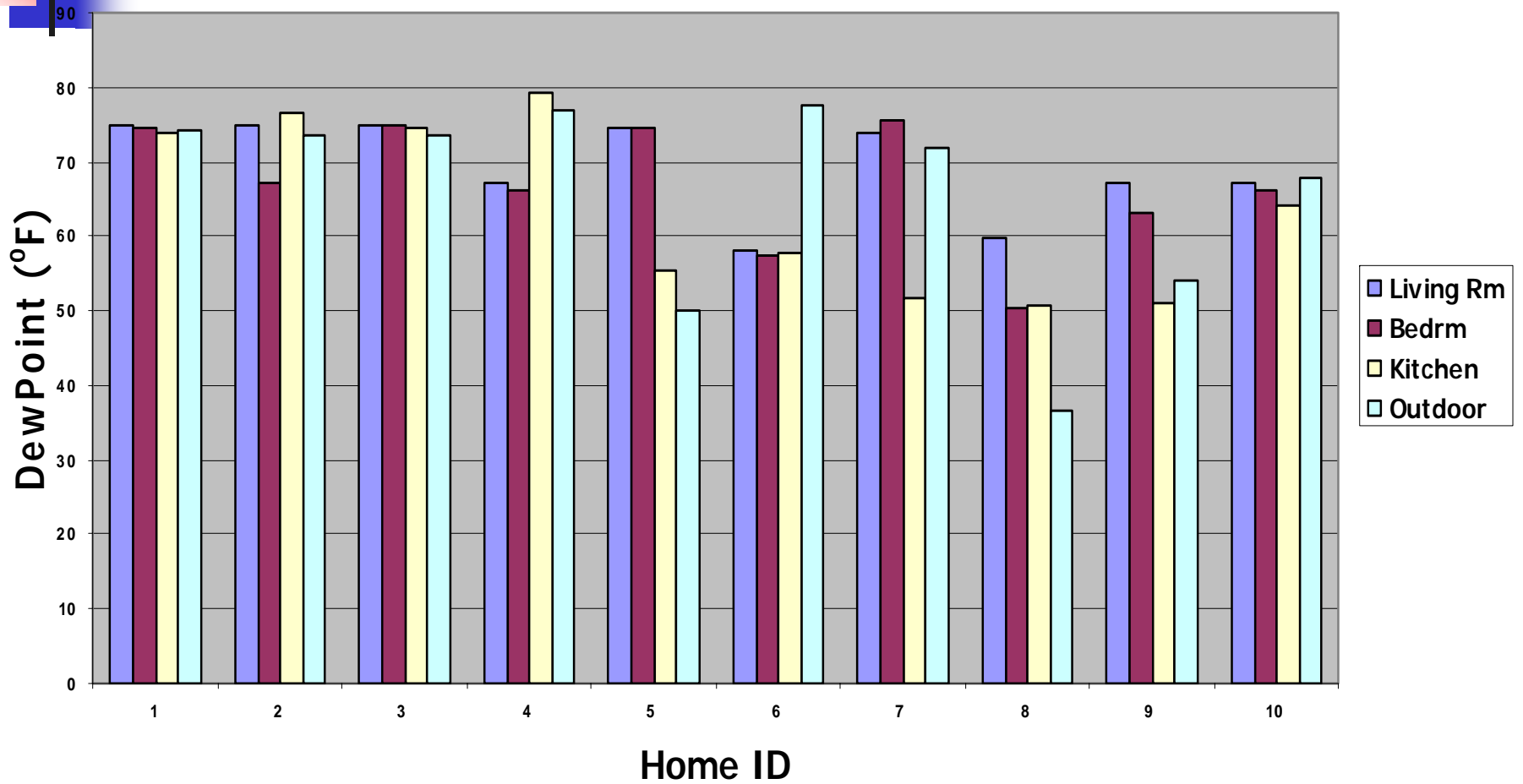
# Relative Humidity (%)



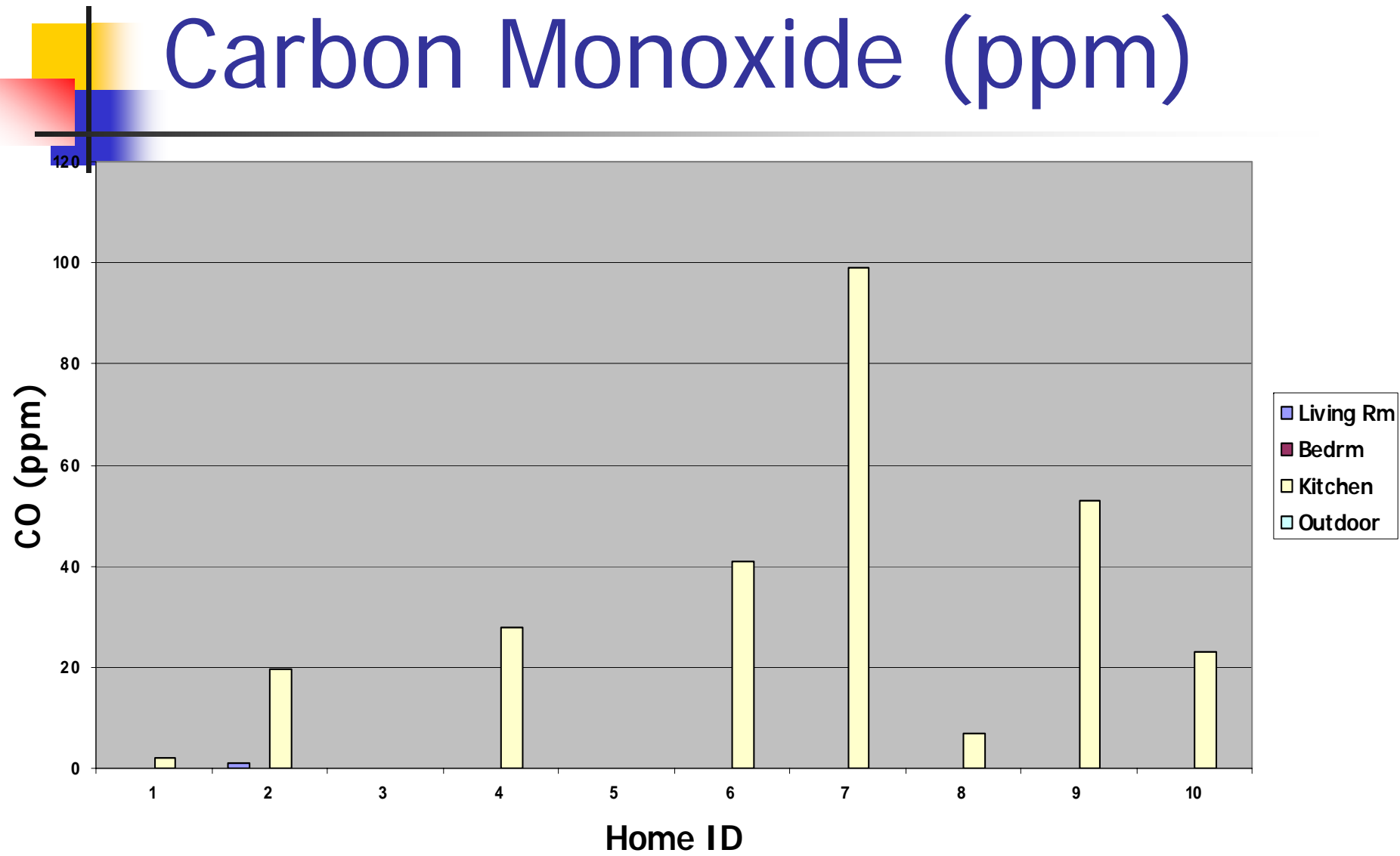
# Temperature (°F)



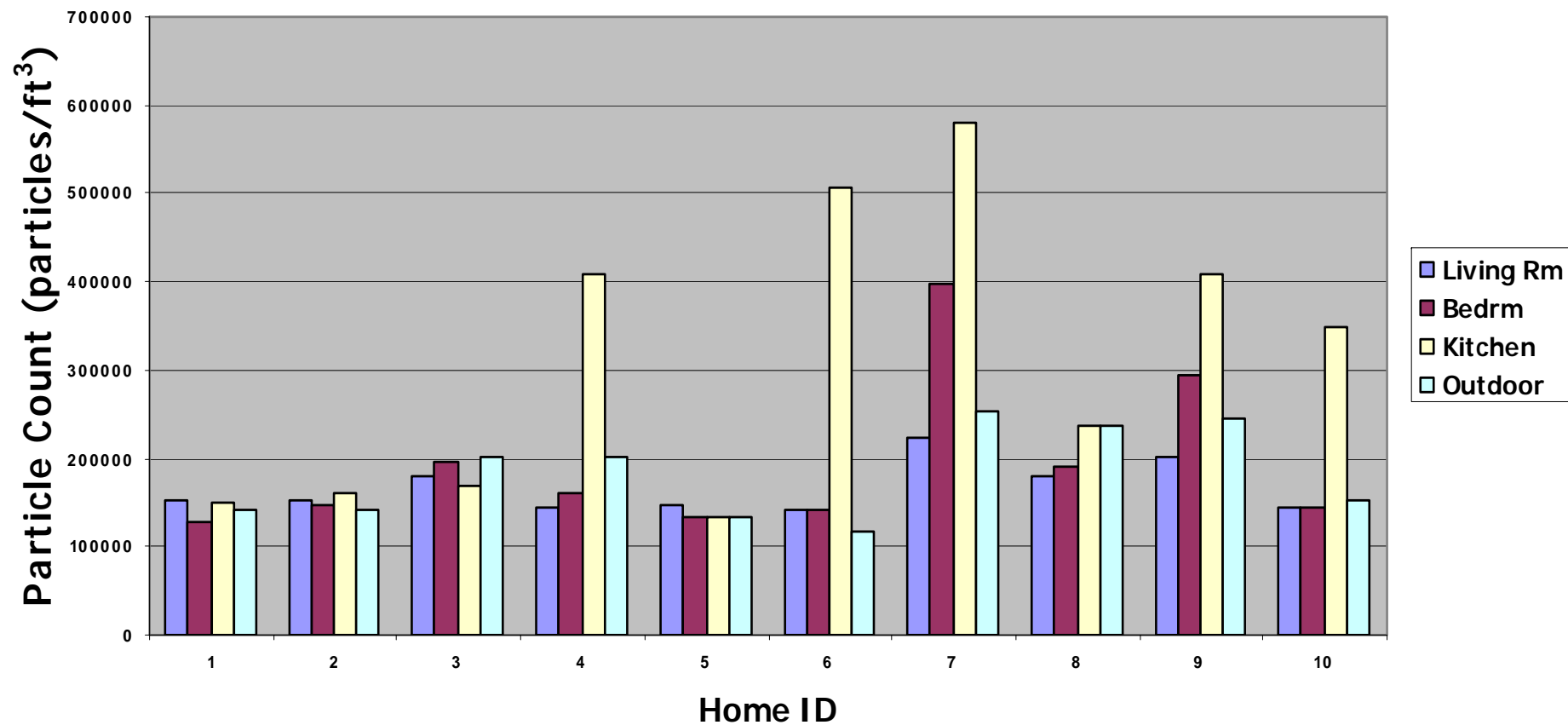
# DewPoint (°F)



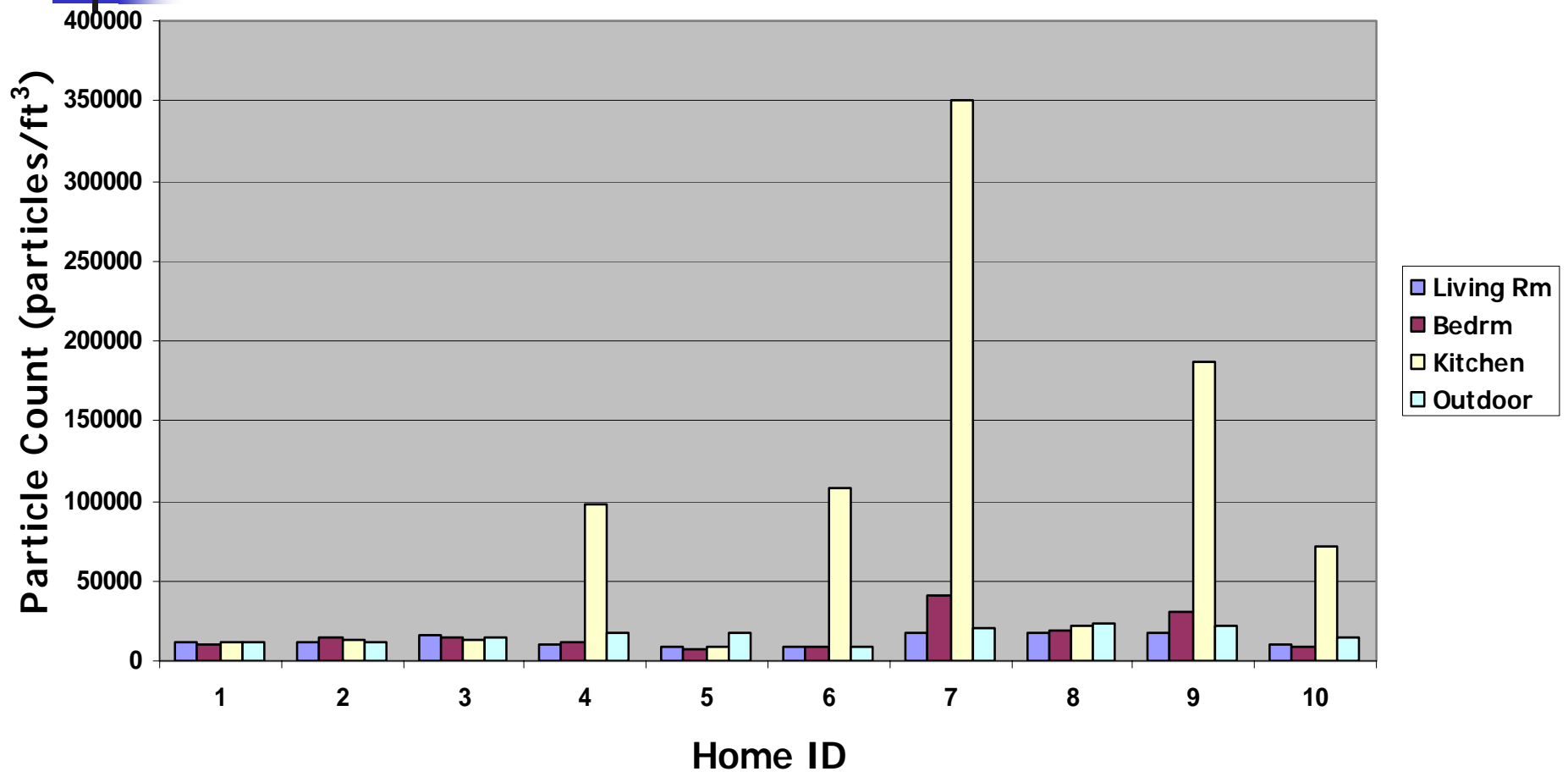
# Carbon Monoxide (ppm)



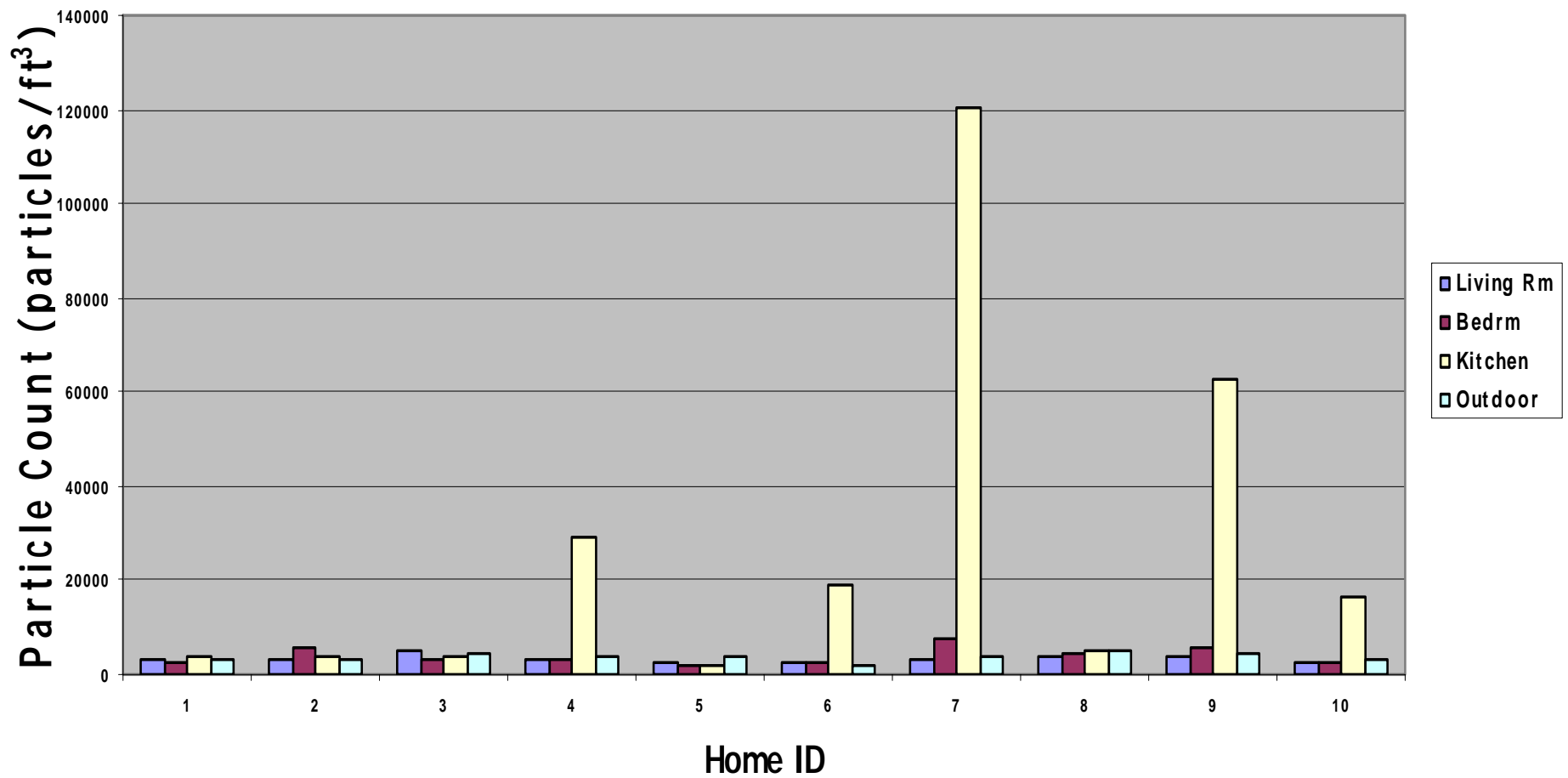
# 0.3- $\mu\text{m}$ Particles



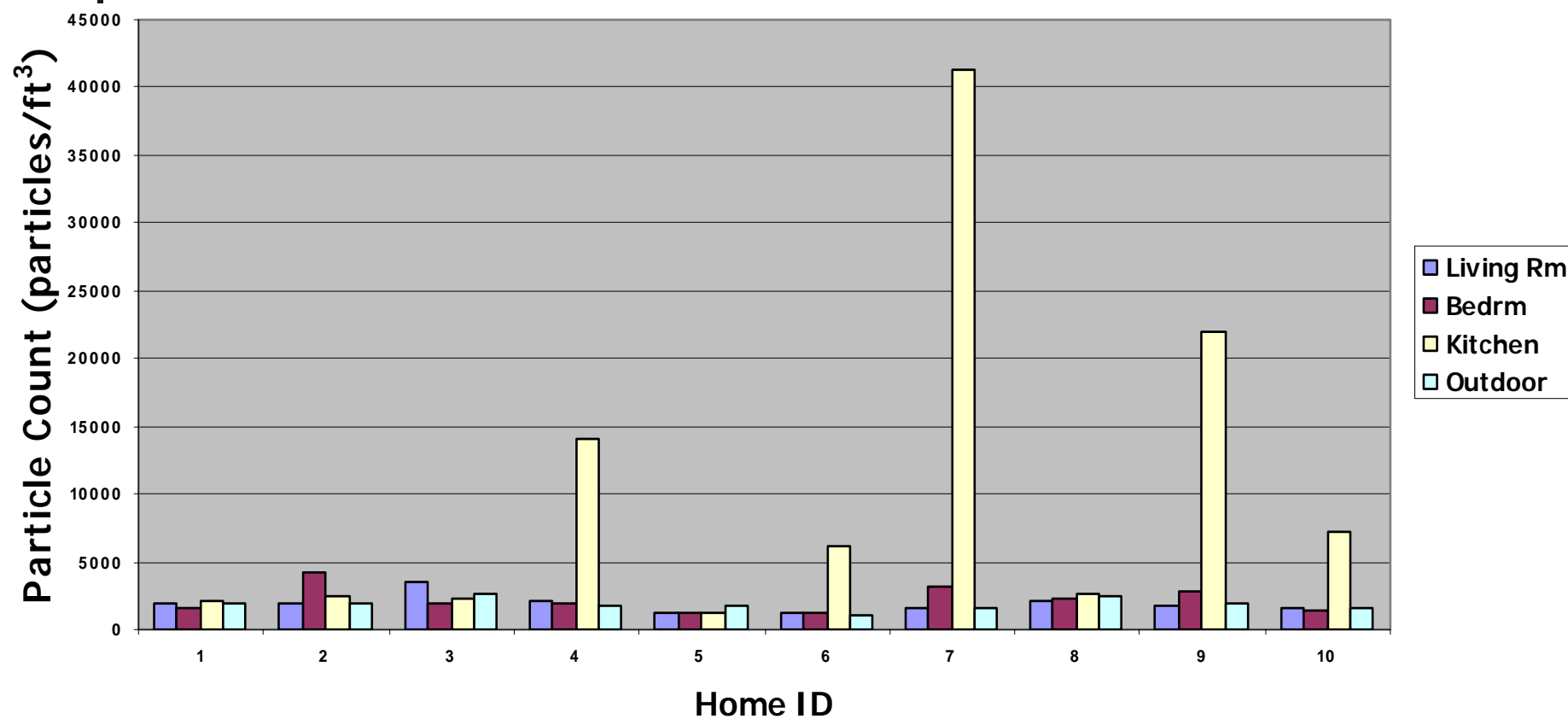
# 0.5- $\mu\text{m}$ Particles



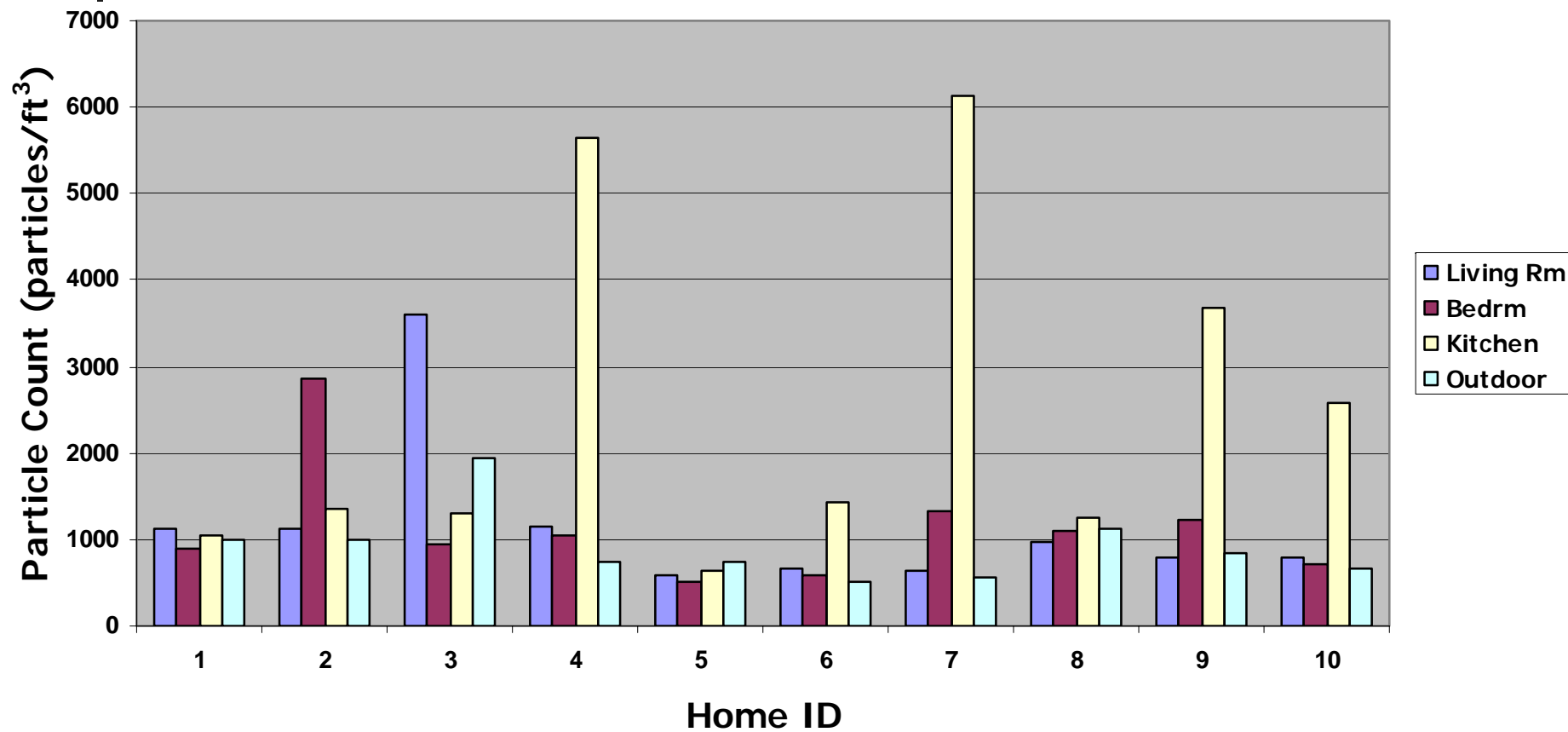
# 0.7- $\mu\text{m}$ Particles



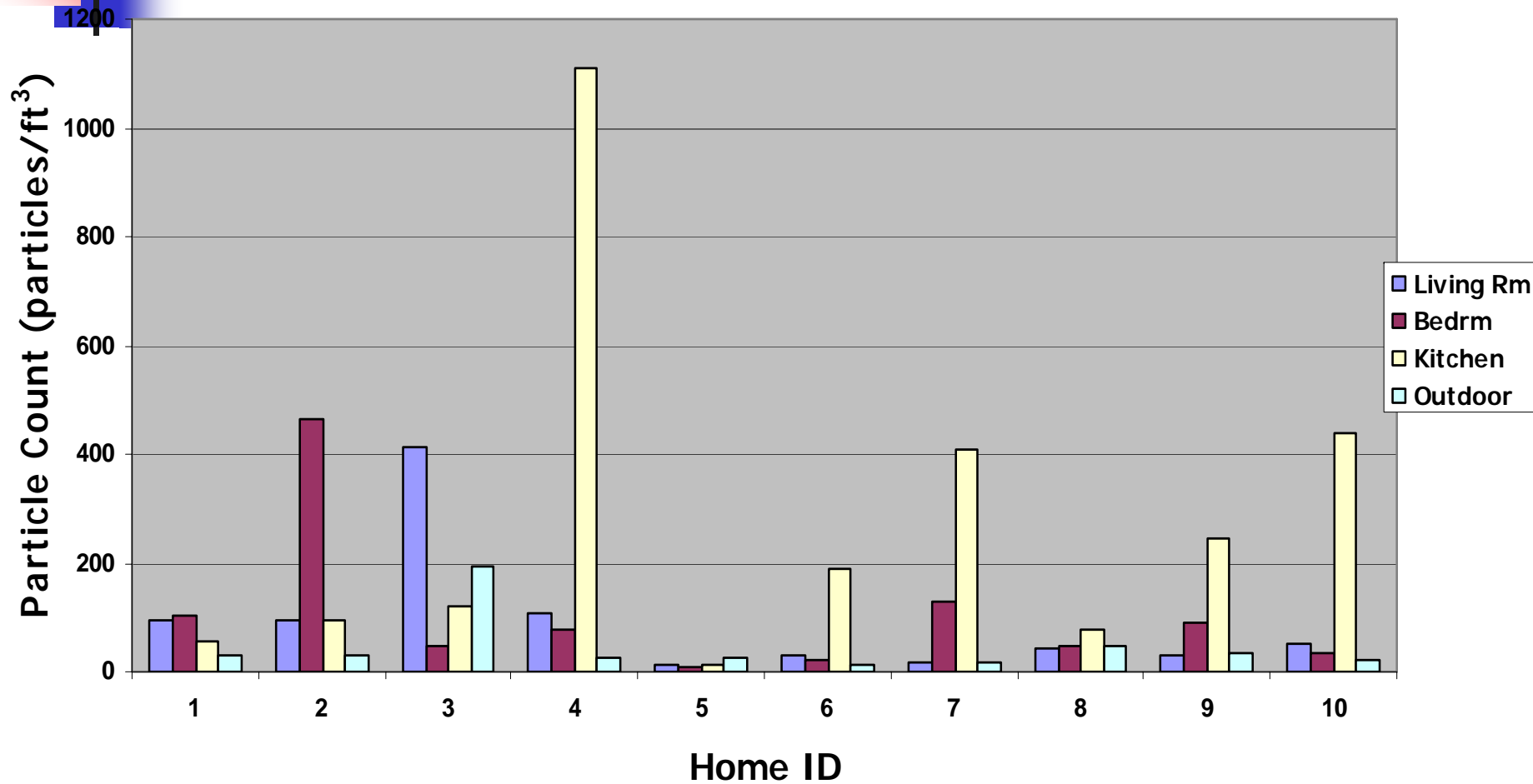
# 1.0- $\mu\text{m}$ Particles



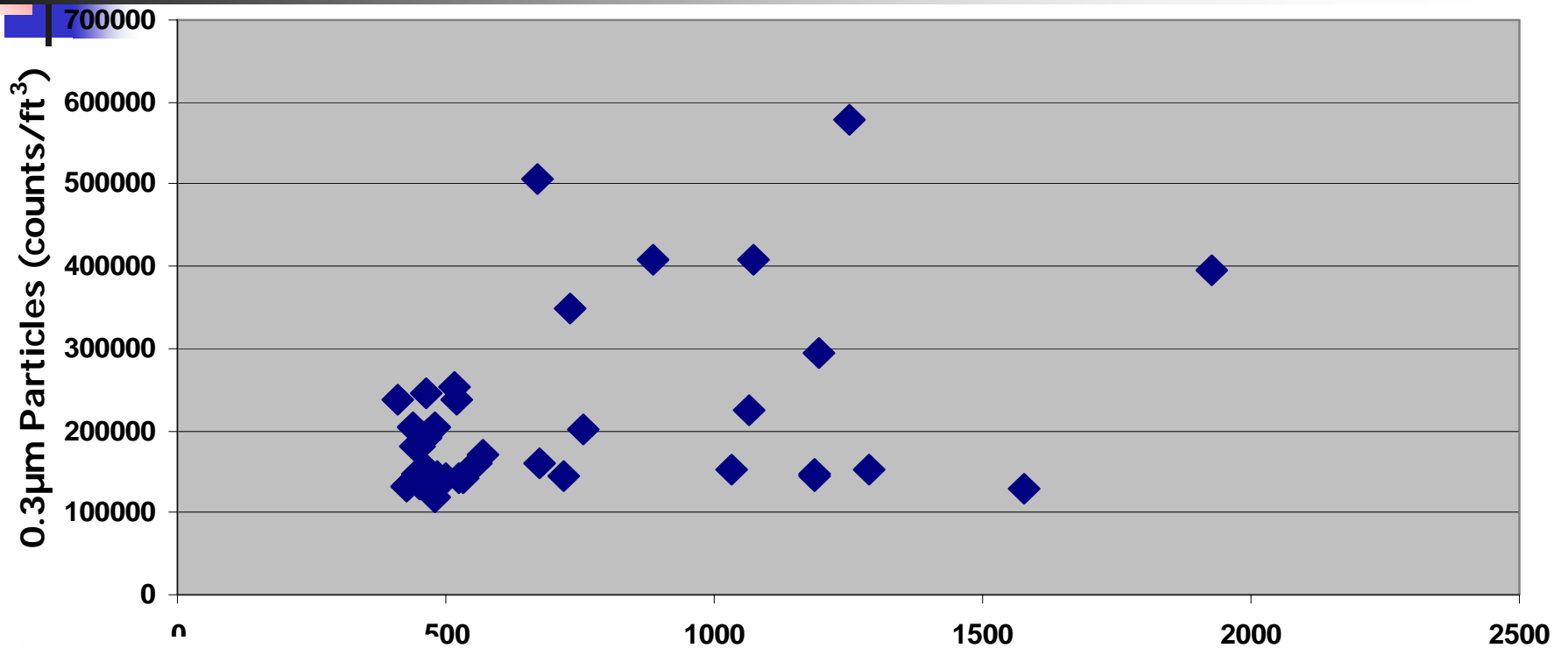
# 2.0- $\mu\text{m}$ Particles



# 5.0- $\mu\text{m}$ Particles



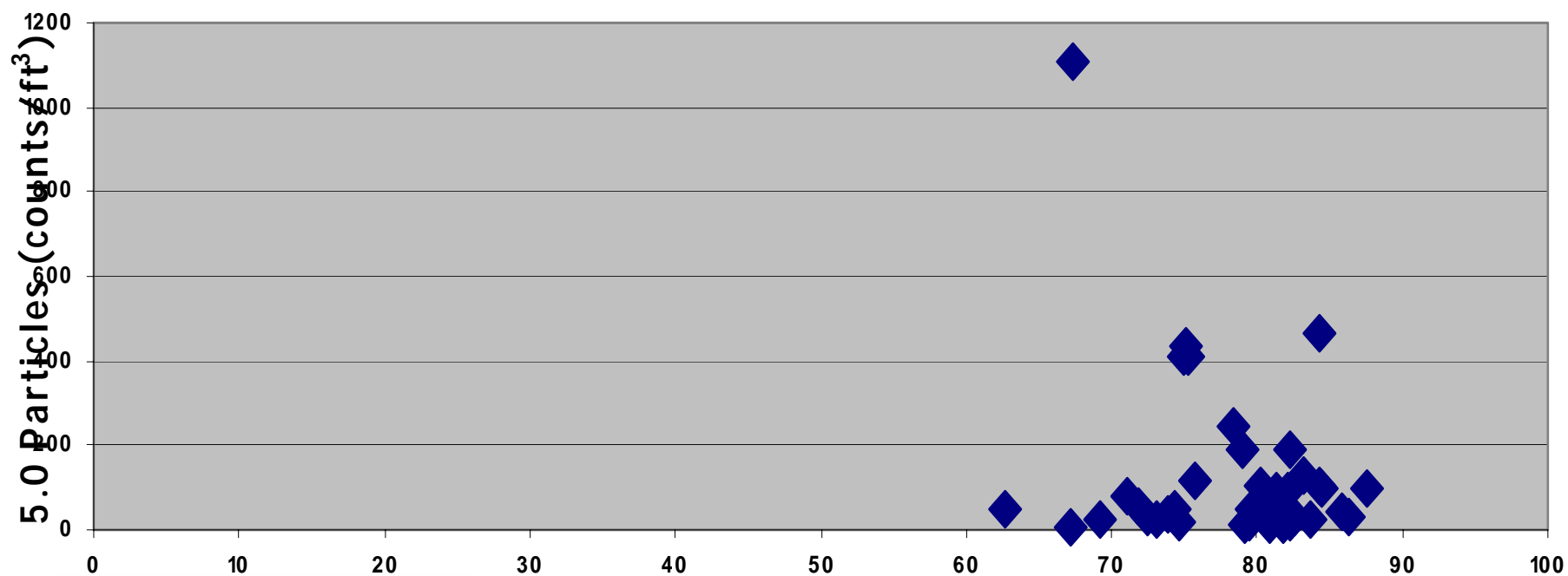
# CO<sub>2</sub> and 0.3-μm Particles



$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

CO<sub>2</sub> (ppm)  
**r = 0.38**

# R.H. and 5.0- $\mu\text{m}$ Particles

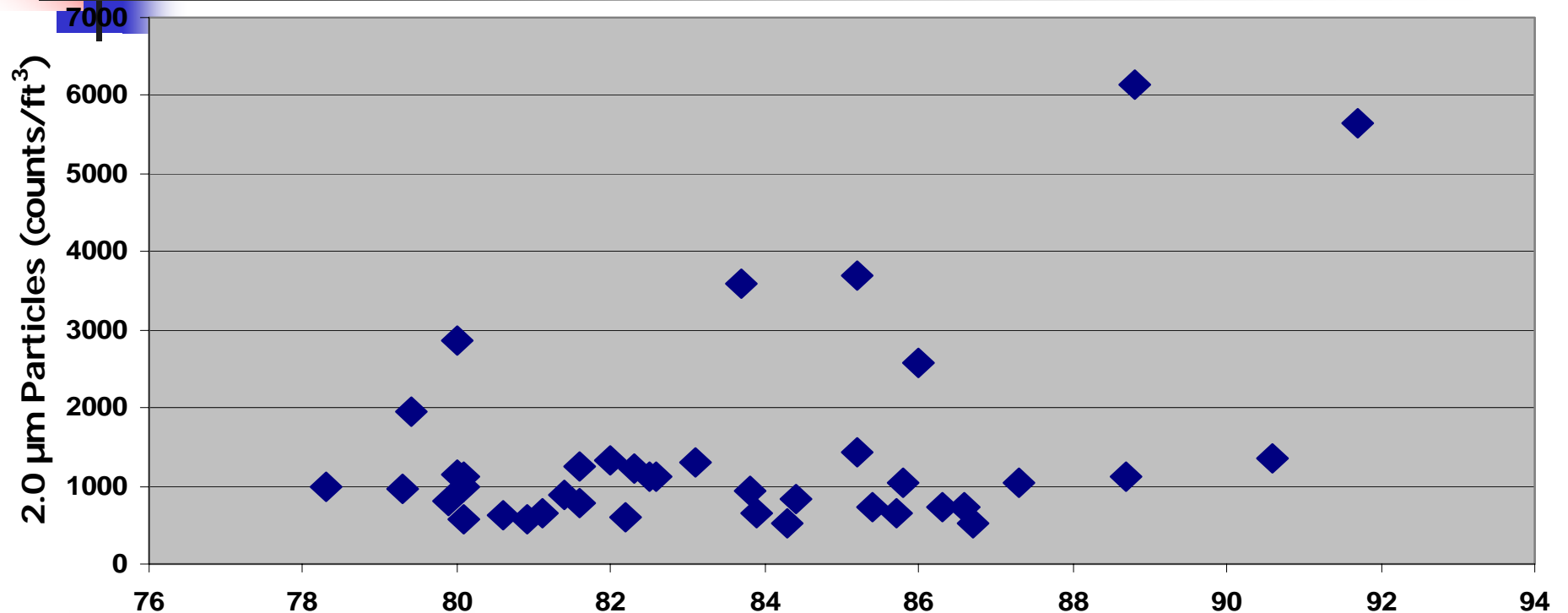


$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

R.H. (%F)

**$r = -0.22$**

# Temperature and 2.0- $\mu\text{m}$ Particles

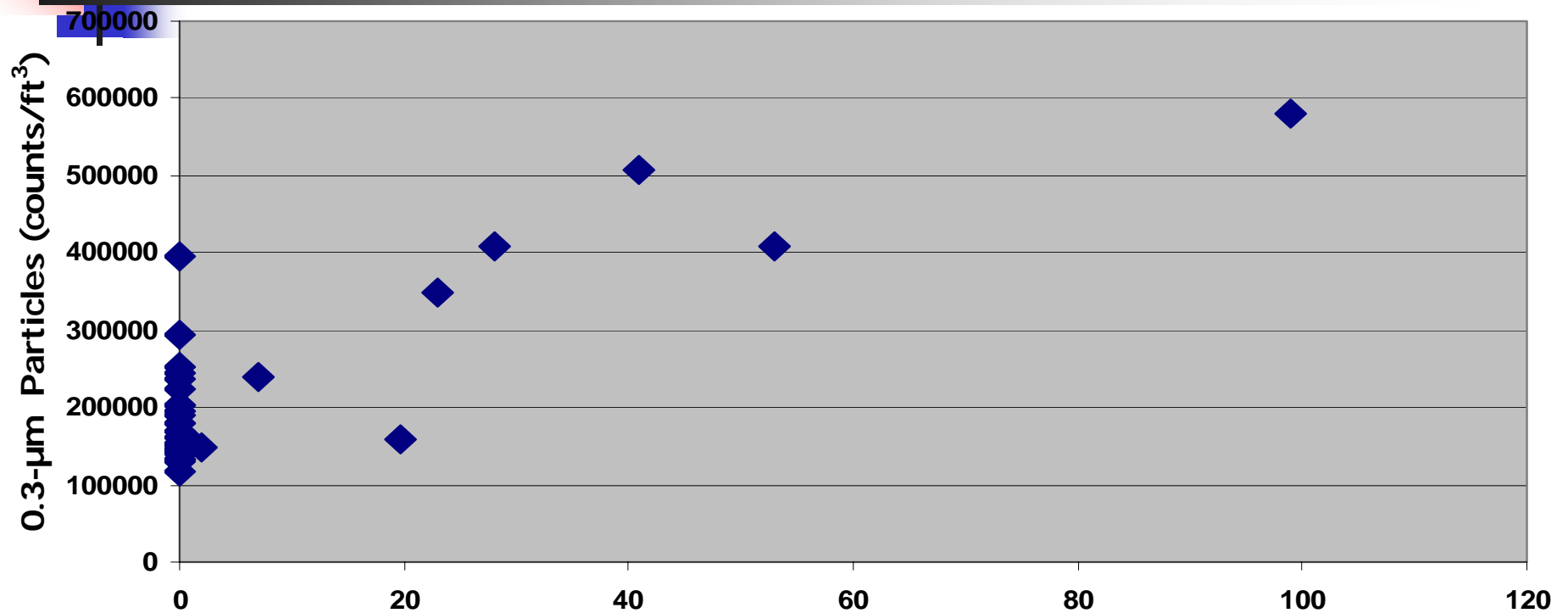


$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

Temperature (oF)

$r = 0.41$

# CO and 0.3-μm Particles

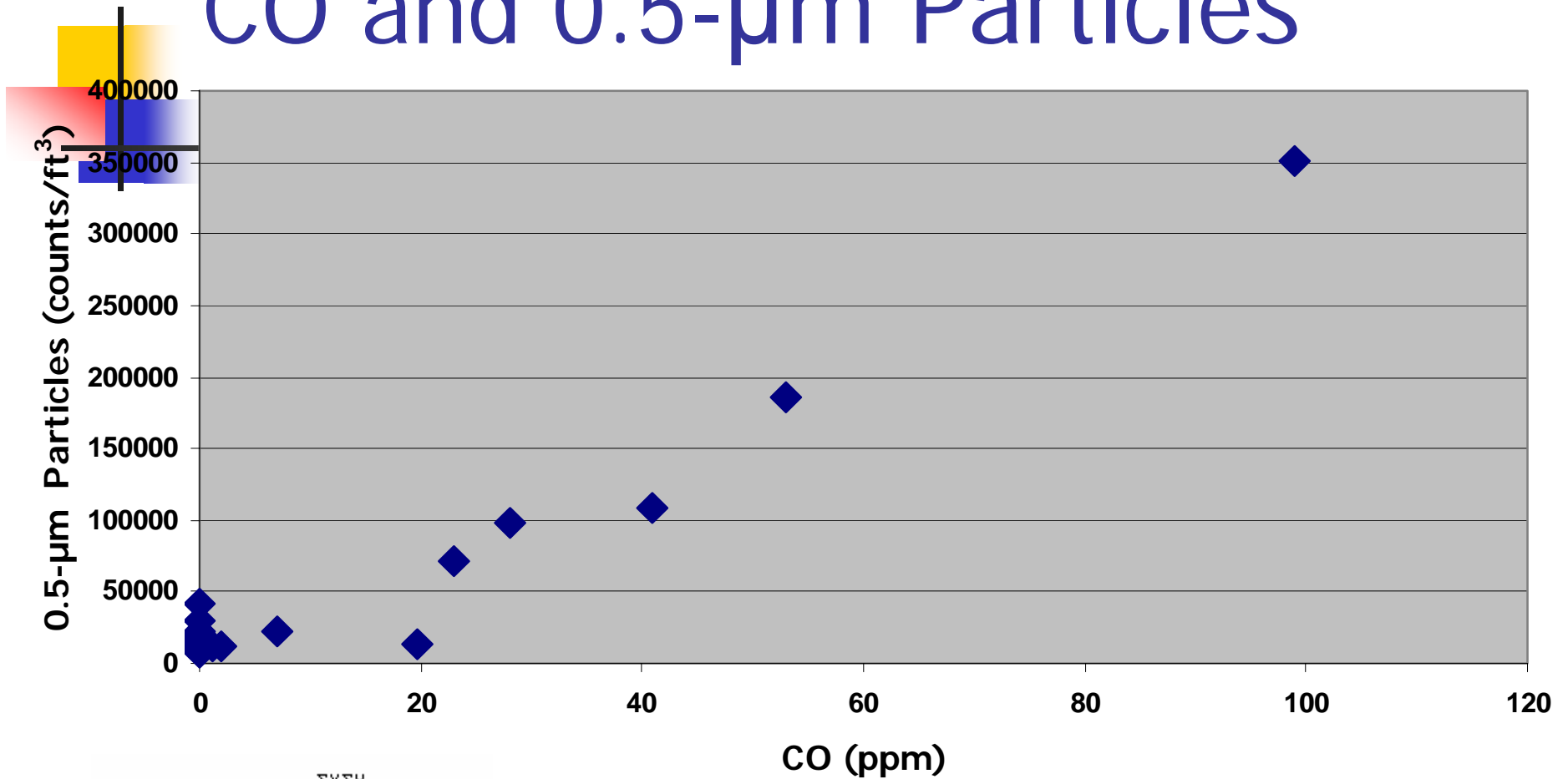


$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

CO (ppm)

**r = 0.81**

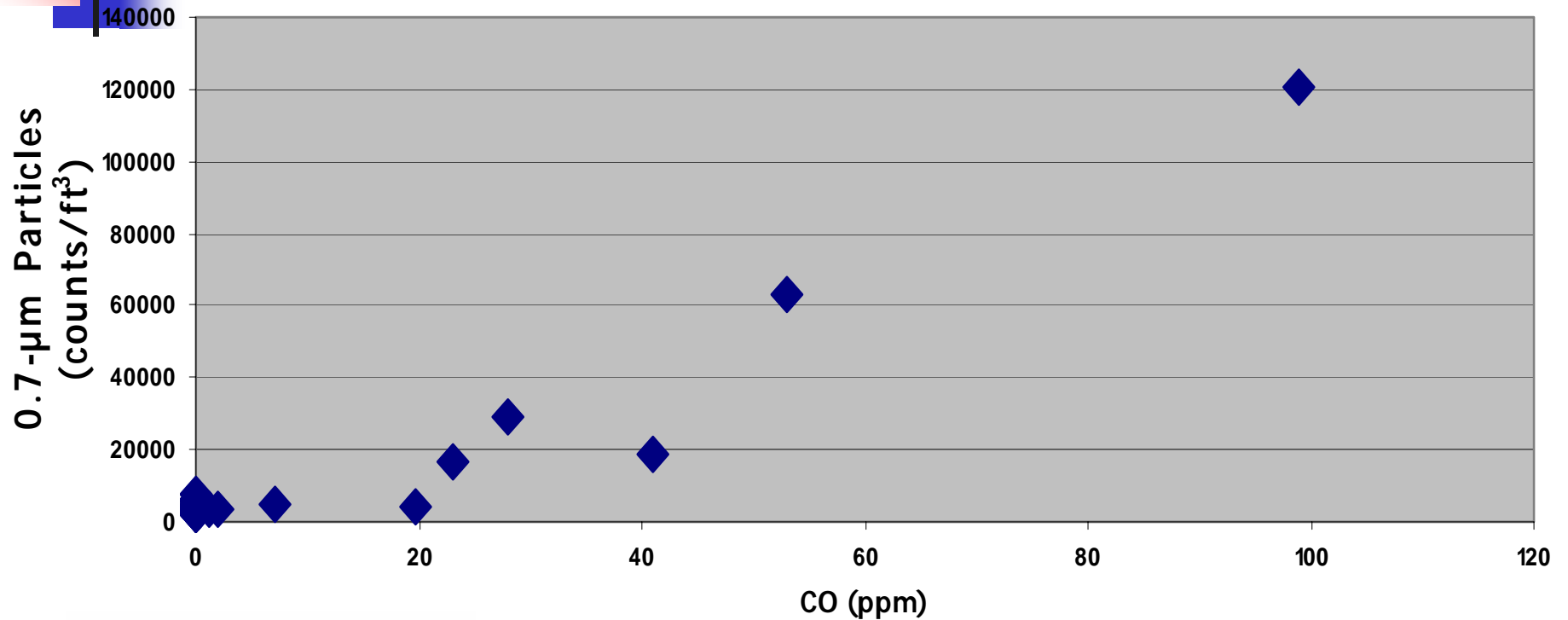
# CO and 0.5- $\mu\text{m}$ Particles



$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

**$r = 0.97$**

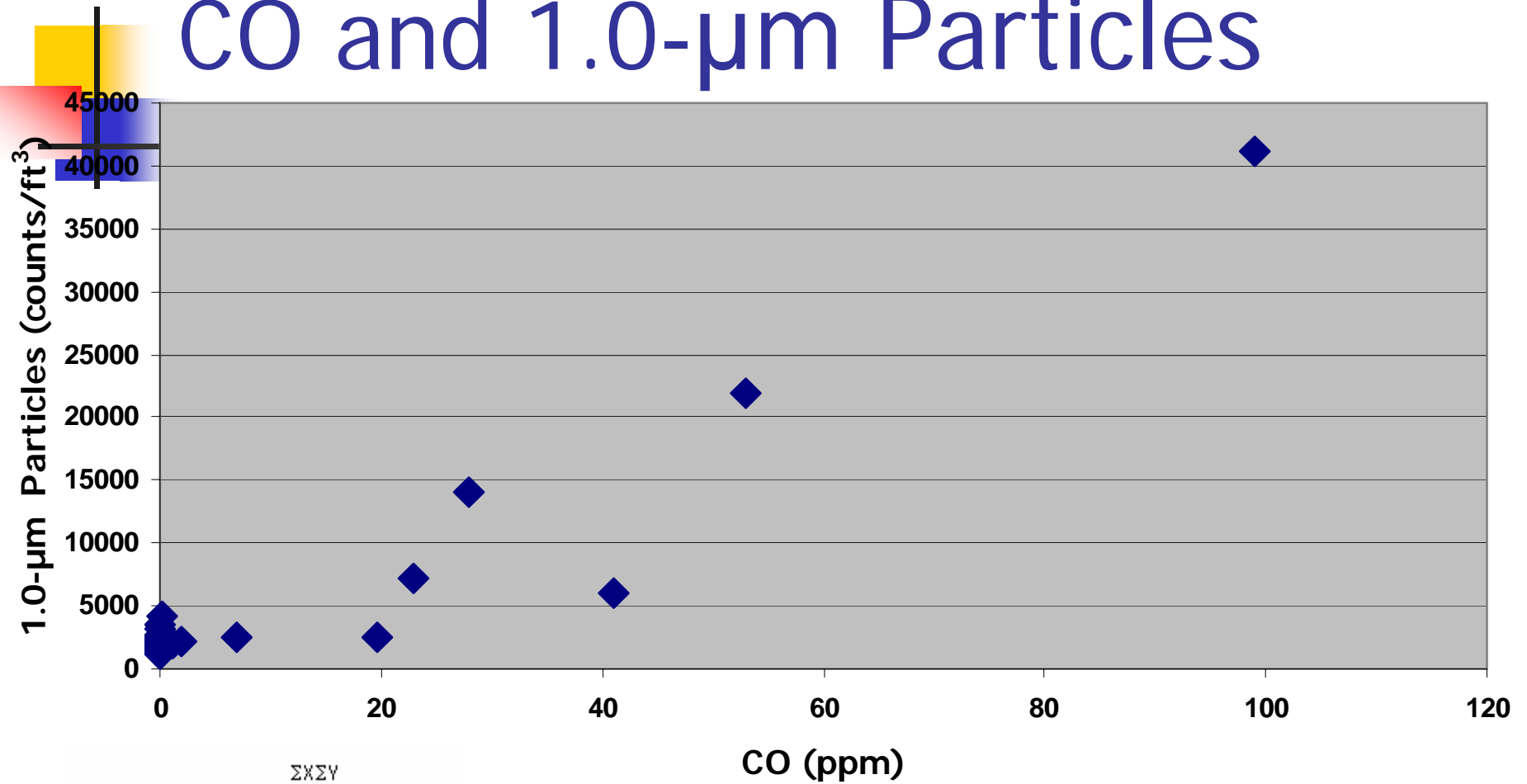
# CO and 0.7- $\mu\text{m}$ Particles



$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

**$r = 0.95$**

# CO and 1.0-μm Particles



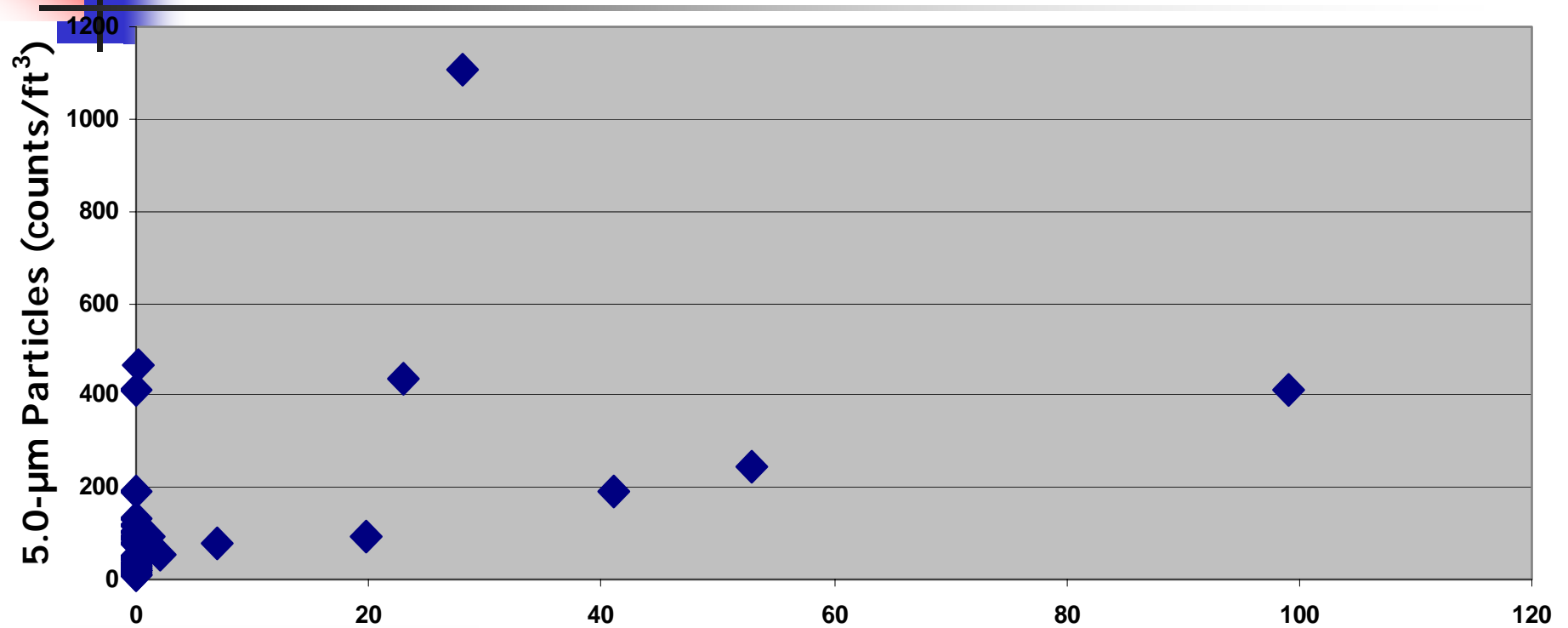
$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

CO (ppm)

**$r = 0.94$**



# CO and 5.0- $\mu\text{m}$ Particles



$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N}) (\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

CO (ppm)

**$r = 0.46$**



# Conclusion

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- Average concentrations of IEQ parameters and airborne particles in houses using firewood were higher than outdoors and levels in houses with kerosene or gas stoves
- Indoor and outdoor airborne levels exceeded standards for ambient air quality standards promulgated by the USEPA & European Union by a factor of 2 to 11



# Recommendations

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- Encourage a shift from firewood to cleaner-burning energy including
  - liquefied petroleum gas
  - biogas
  - solar power generation
- Improved design of stoves and ventilation systems to reduce indoor air pollution in poor communities in developing countries



## Recommendations, cont...

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- Educate the public on potential health risks of indoor air pollution from firewood combustion and ways to reduce their exposures
- Encourage mothers to keep children away from contact with fires and smokes



# Questions

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