

# **Ultrafine Particles and Cardiac Responses**

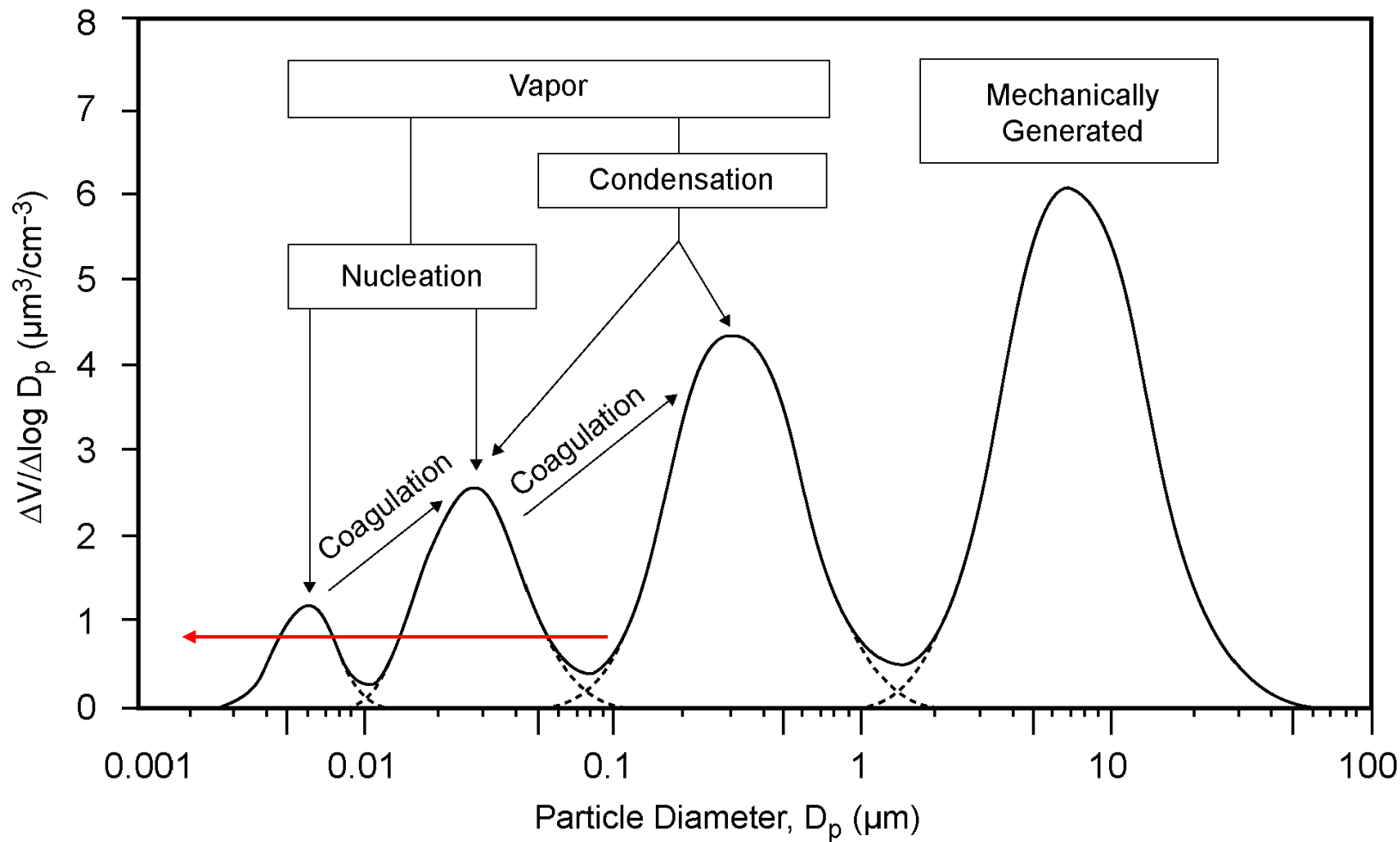
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**NYSERDA EMEP CONFERENCE**

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# Idealized Size Distribution of Particulate Matter (EPA, 2004)



Nucleation Mode

Accumulation Mode

Aitken Mode

Coarse Mode

Fine Particles

Ultrafine Particles

Coarse Particles

# EFFECTS AND FATE OF INHALED ULTRAFINE (NANO)PARTICLES (UFP)

Sources → Exposure → Dose → Response

## Indoors

frying  
broiling  
grilling  
electric motors

## Outdoors

urban air  
internal combustion  
power plants  
forest fires  
airplane jets  
recreation (ski waxing)

## Workplace

metallurgy (fumes)  
welding  
polymer fumes  
nanotechnology  
(biomed. electronics)  
nanotubes

## Concentration

ng/m<sup>3</sup> - mg/m<sup>3</sup>  
10<sup>2</sup> - >10<sup>6</sup> part./cm<sup>3</sup>

## Duration

minutes  
hours  
days  
continuous/peak

## Location

distance from source

## Deposition

nose  
tracheobronchial  
alveolar  
ventilatory parameters

## Disposition

within respiratory tract  
extrapulmonary organs  
disease state

## Physico-chemical Properties

organics  
metals  
crystalline  
amorphous  
surface area  
solubility (water, lipid)

## Epidemiologic Studies

ambient UFP  
susceptibles only?  
mortality/morbidity

## Clinical Studies

lab. generated UFP  
ambient UFP  
healthy/susceptibles  
(respiratory, cardiovascular)

## Animal Studies

lab. generated UFP  
ambient UFP  
compromised animal models  
(respiratory, cardiovascular, CNS)  
mechanisms

## In vitro Studies

mechanisms  
oxidative stress

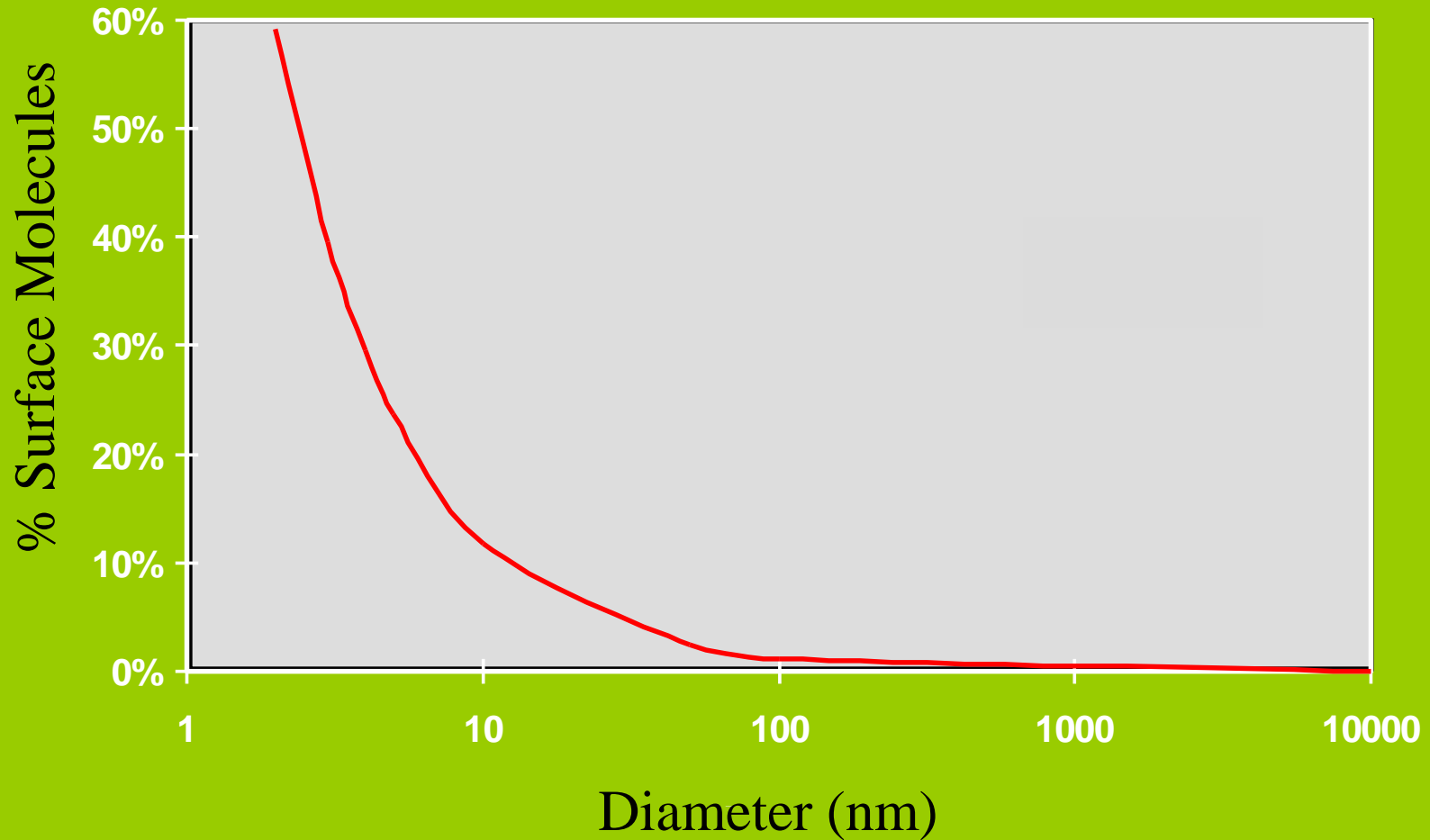
# **Ultrafine Particles: Why the Concern From A Health Perspective?**

# **Numbers and Surface Area of Particles of Unit Density of Different Sizes at a Mass Concentration of $10 \mu\text{g}/\text{m}^3$**

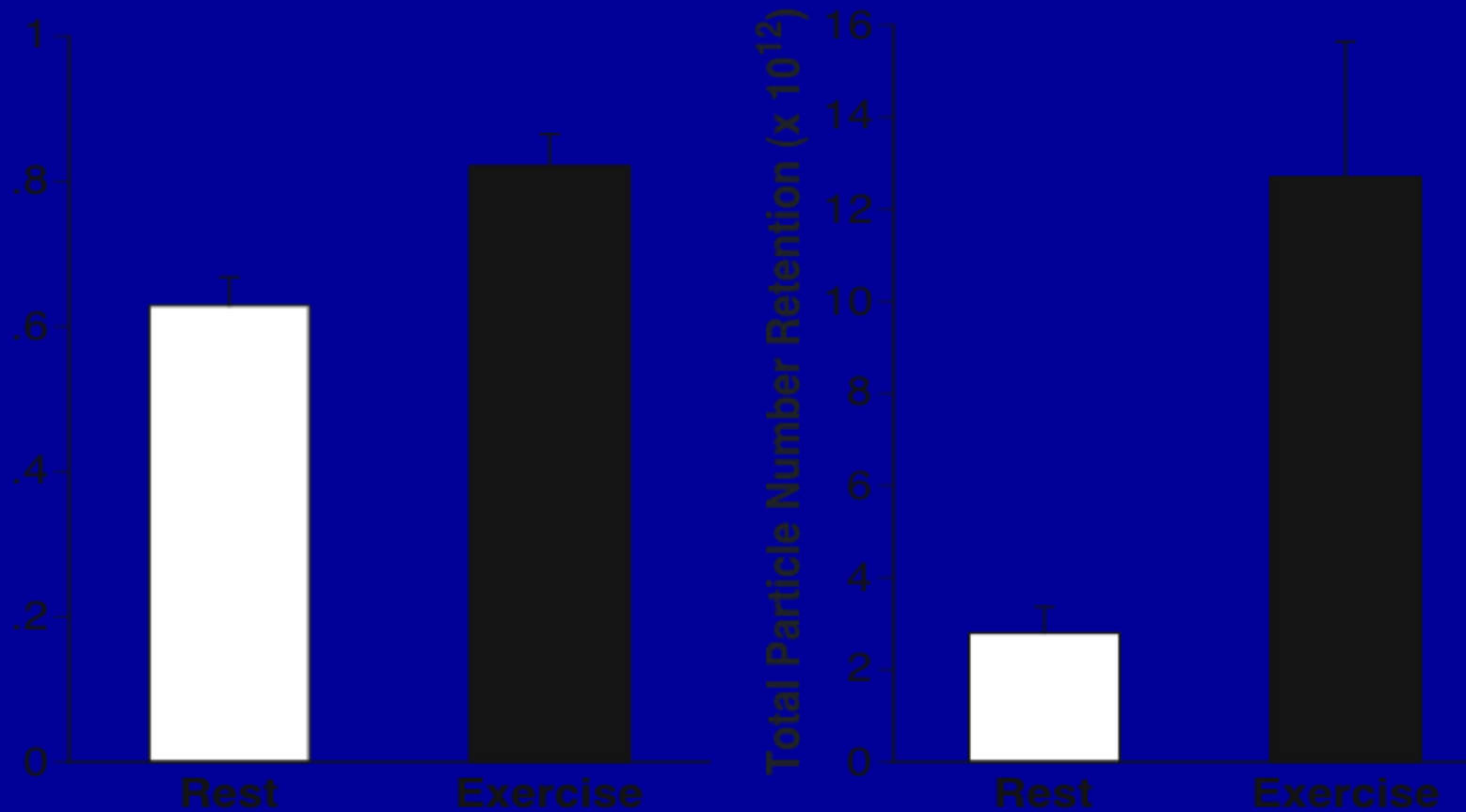
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<b><u>Particle Diameter</u></b> <b><math>\mu\text{m}</math></b>	<b><u>Particle Number</u></b> <b><math>1/\text{cm}^3</math></b>	<b><u>Particle Surface Area</u></b> <b><math>\mu\text{m}^2/\text{cm}^3</math></b>
<b>0.02</b>	<b>2,400,000</b>	<b>3016</b>
<b>0.1</b>	<b>19,100</b>	<b>600</b>
<b>0.5</b>	<b>153</b>	<b>120</b>
<b>1.0</b>	<b>19</b>	<b>60</b>
<b>2.5</b>	<b>1.2</b>	<b>24</b>

# Surface Molecules as Function of Particle Size



# UFP Deposition and Retention During 2 h Exposure



# Fractional Deposition of Inhaled Particles in the Human Respiratory Tract

(ICRP Model, 1994; Nose-breathing)

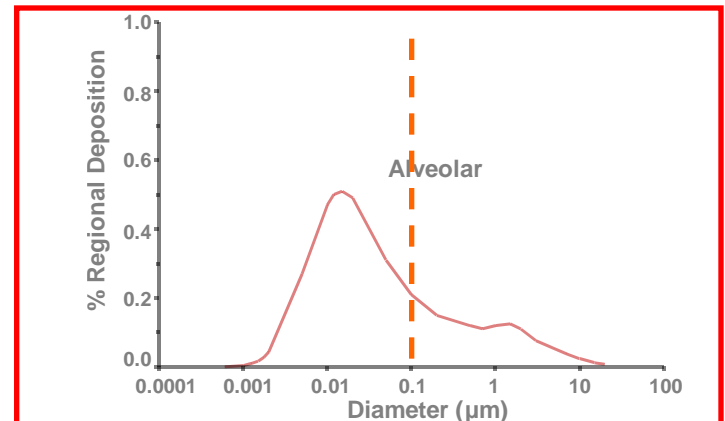
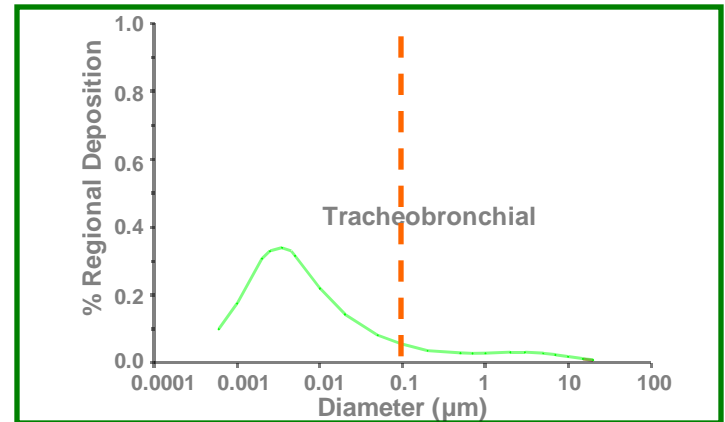
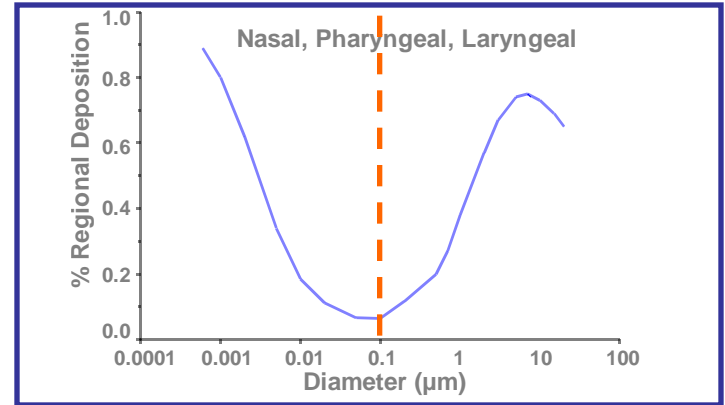
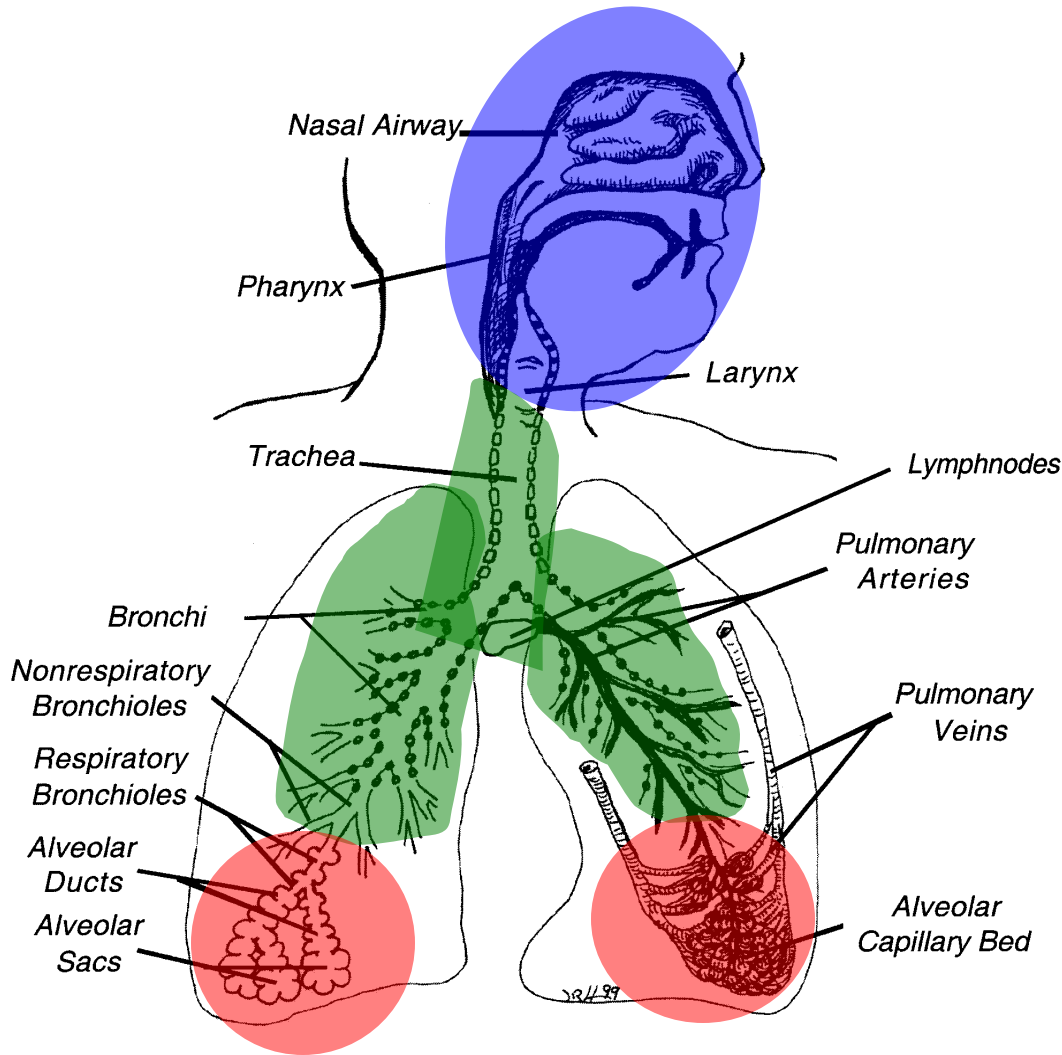


Figure courtesy of J.Harkema



# **Background: Evidence for UFP Health Effects**

- **Animal studies: increased lung inflammation and translocation to blood and distant organs (Oberdorster et al.)**
- **UFP concentrations high at roadside (Sioutas, et al.) and as a result of local sources (Jeong, et al.)**
- **Traffic-related PM effects on mortality/morbidity (Kunzli et al.; Peters et al.)**
- **UFP decreased peak expiratory flow rates in asthmatics (Peters et al.)**
- **UFP caused ST-segment depression during exercise testing in CAD (Pekkanen et al.)**

# **Objectives - NYSEERDA Study: UFP and Cardiac Responses**

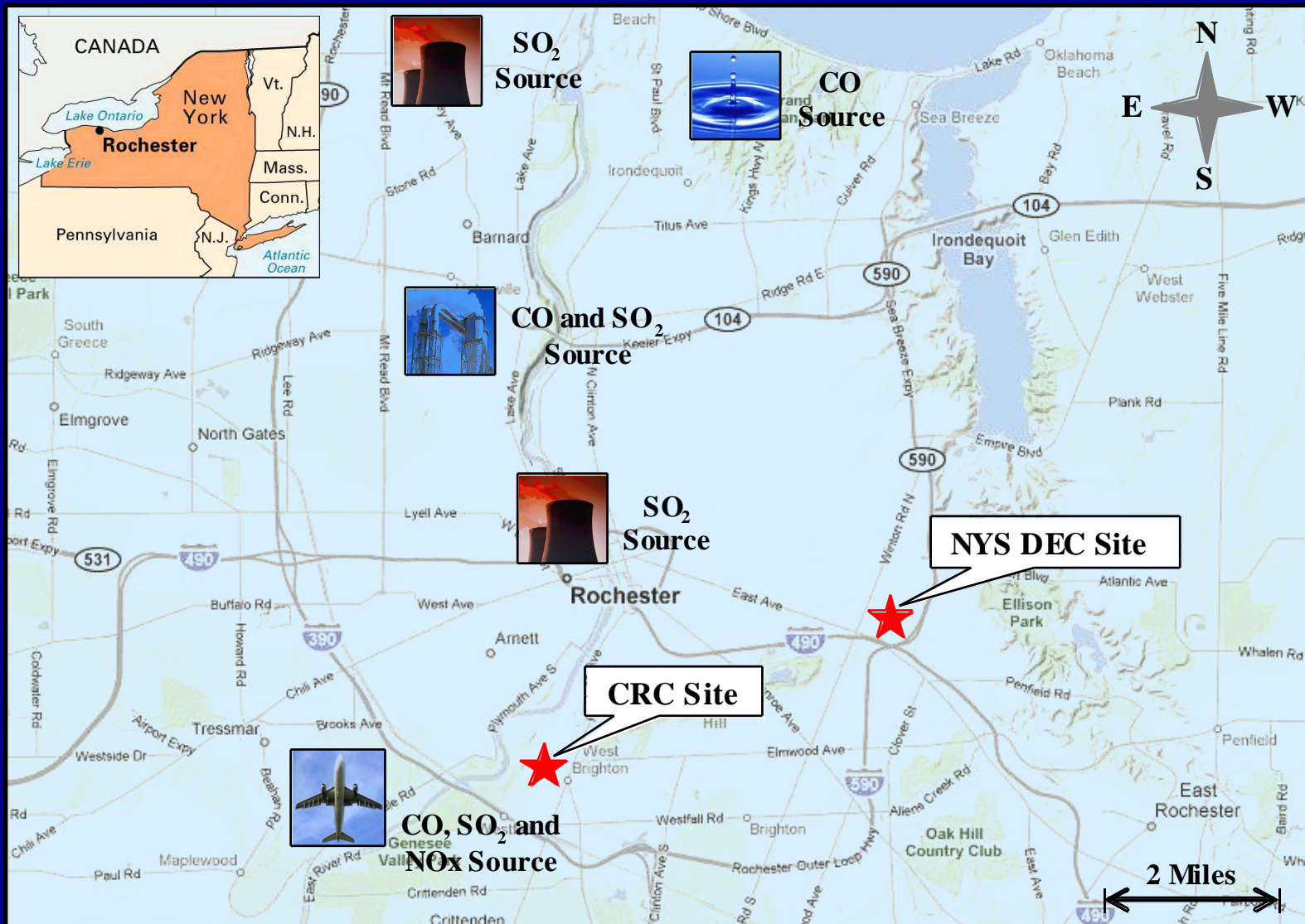
- **Test over 10 weeks whether changes in community ambient ultrafine particle counts are associated with changes in cardiac rehabilitation patients' :**
  - **Symptoms**
  - **Heart rate and blood pressure**
  - **Cardiac electrophysiology, autonomic nervous system control**
  - **Blood markers of inflammation, coagulation**
  - **Rate of cardiac rehabilitation**

# Study Design

- **75 non-smoking patients with recent coronary artery disease exercise for 30 minutes in the cardiac rehabilitation center**
- **Baseline questionnaire**
- **Exercise twice weekly x 10 weeks**
- **Treadmill , cycle, or rowing**
- **Multiple Clinical Assessments each visit**

# Exposure Measures

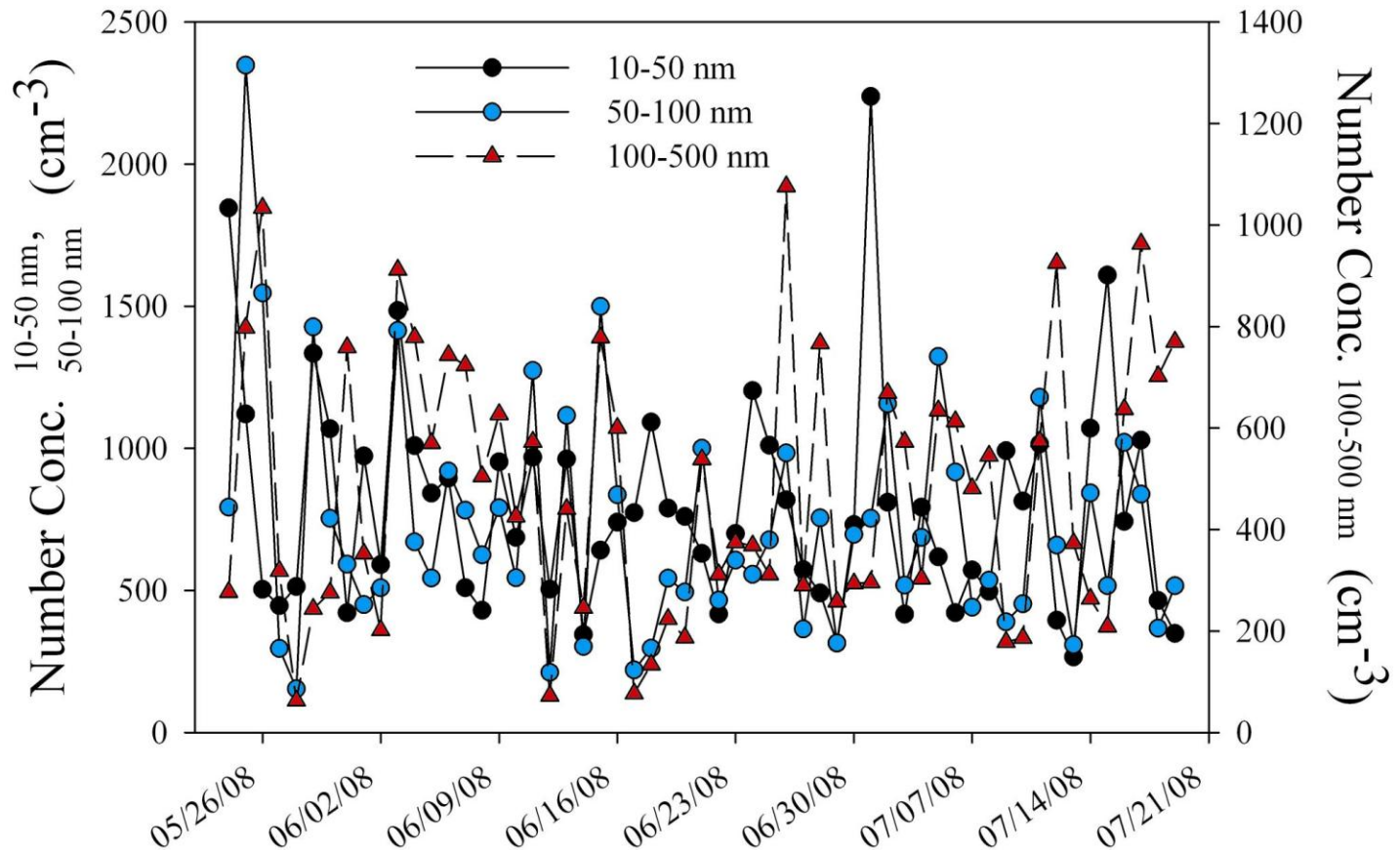
- **Ultrafine particles in two community sites, hourly average**
- **Ultrafine particles in cardiac rehab center, hourly average**
- **Ozone, NO<sub>x</sub>, CO, sulfur dioxide, temperature from same site as ultrafines**
- **Sub-sample: ultrafine particles for 48 hours indoors, subject homes**
- **Sub-sample: ultrafine particles in vehicles driving to/from cardiac rehab center.**



**Map of Rochester area showing measurement sites and major emissions in the study**

# Daily Morning Variability:

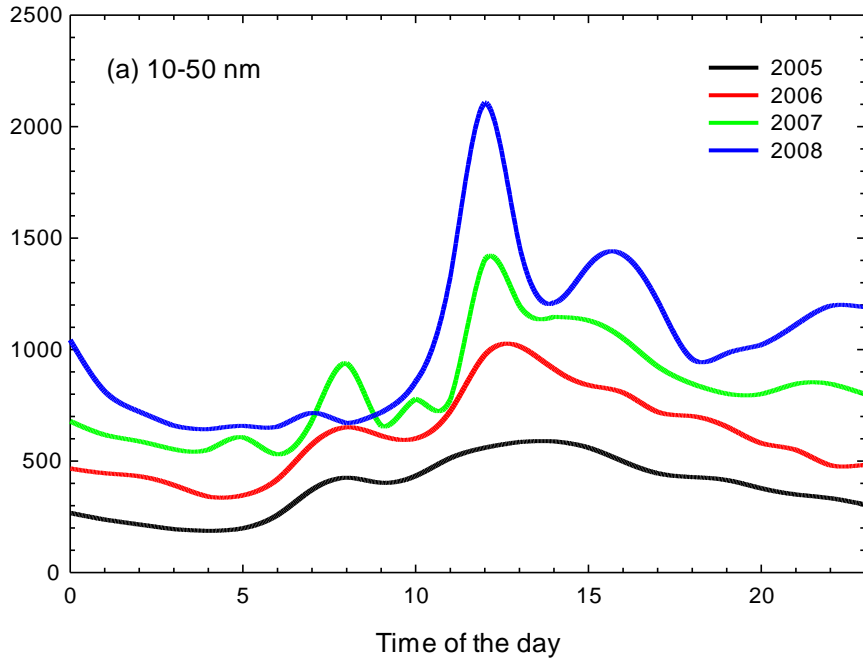
## Indoor Particle Number Concentrations 8-9 AM



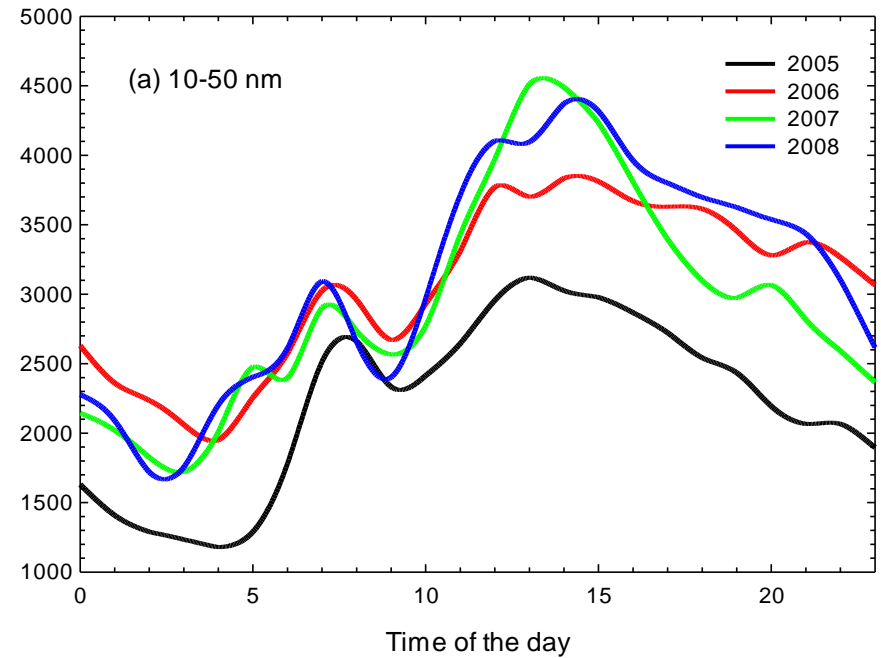
**Mean hourly patterns of the indoor particle number concentration in three size bins  
Cardiac Center**

# Time of Day Variability:

(a) Indoor



(b) Outdoor



**Mean daily patterns of particle number concentration in the 10-50 nm size bin at Cardiac Center**

# Subject Recruitment to Date

**75 subjects recruited and under study**

**68 have completed full protocol**

**Age range : 36-80 years (mean = 60 yrs)**

**Gender: 66% male**

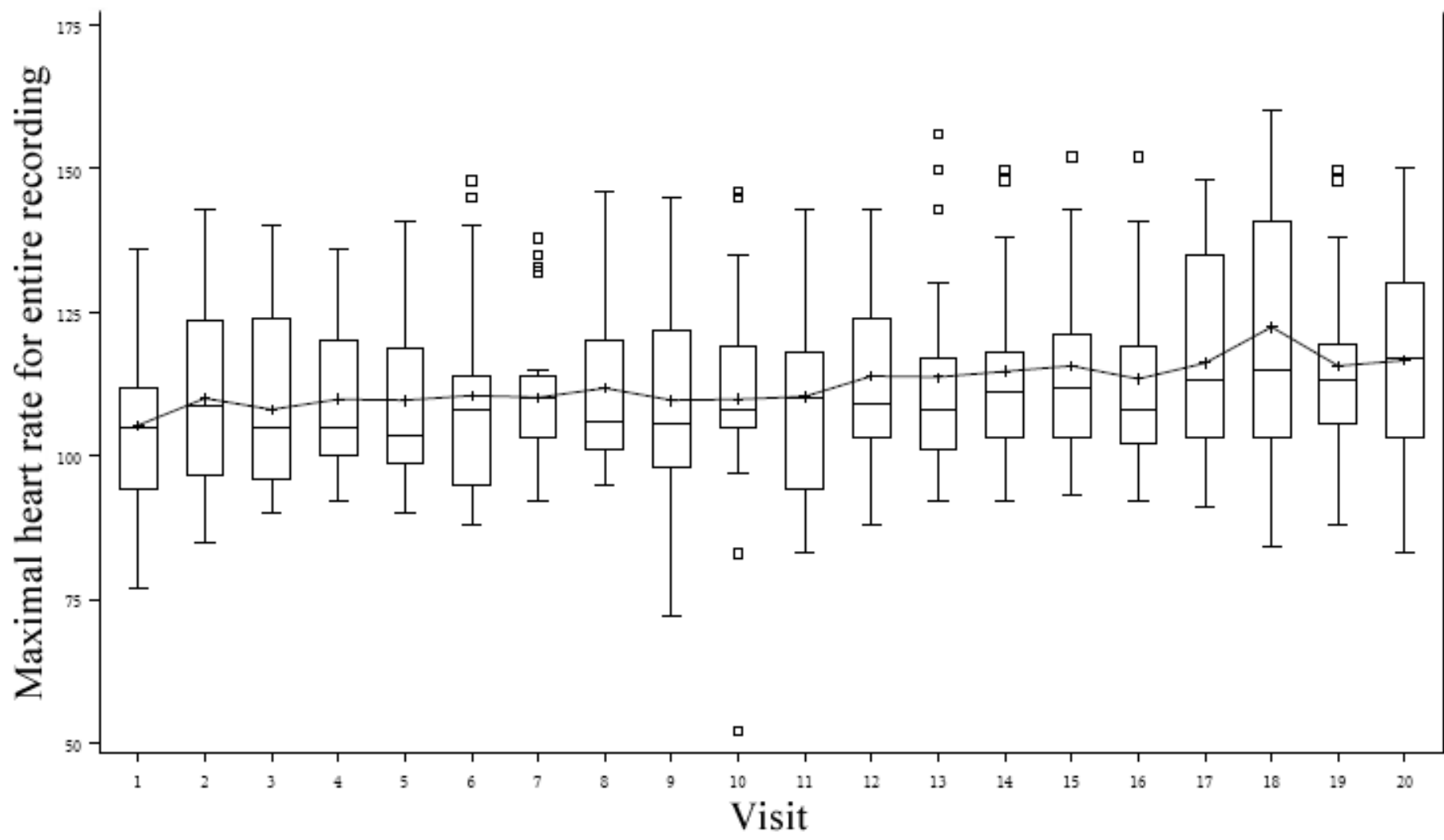
**Subjects live within 10 mile radius of a particle monitors**

**Diagnoses: recent myocardial infarction (60%); unstable angina with coronary stents (35%)**



# Outcome Variables

- Days with angina
- Heart Rate/BP pre, peak, post exercise
- Electrophysiology pre, peak, post exercise (HRV, repolarization, etc)
- Rated perceived exertion at maximal exercise
- Blood counts, C-reactive protein, fibrinogen, weekly (pre-exercise)



# **Analysis Strategy**

- **Biostatistics Group examining UFP number concentrations and outcome variables**
- **Key Features of study design:**
  - **longitudinal measurement on each subject**
  - **highly susceptible group**
  - **indoor and outdoor continuous UFP**

# **Cardiac Rehab Study of Ultrafine Particles**

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- **Wojciech Zareba**
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- **Bill Beckett**
- **Karen Stulpin**
- **David Chalupa**
- **John Kasumba**
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