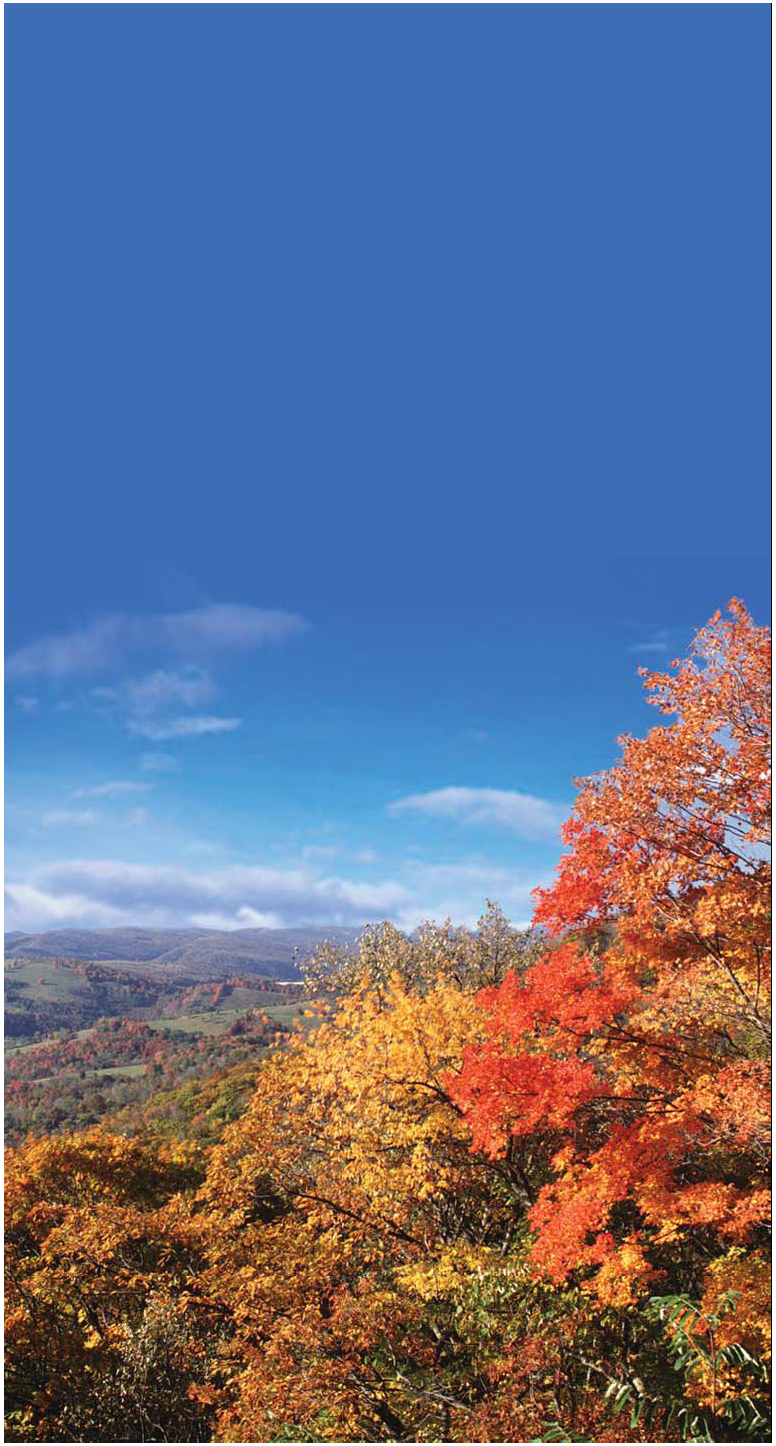

ELECTRIC POWER RESEARCH INSTITUTE

# Health Effects of Coal-Fired Power Plant Emissions

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# Overview

- Background and Key Issues
- What We Know…….
- What We Don't Know……
- EPRI Toxicology Field Studies:
  - TERESA: Toxicological Evaluation of Realistic Emissions of Source Aerosols
  - Tri City CAPS: Tri City Concentrated Ambient Particle Study
- Conclusions

# Background and Key Issues

- $PM_{2.5}$ from power plants:
  - *Primary* particles: emitted directly from plants; very low due to widespread use of PM controls in the US
  - *Secondary* particles: formed through oxidation of $SO_2$ to sulfate downwind of plants

## KEY ISSUES

- What is the relative importance of different PM sources and components in adverse health effects?
- How important are power plant emissions in $PM_{2.5}$-related health effects?

# What We Know……

- Toxicology:
  - Single component studies: little effect of sulfate in animals or human volunteers except at high concentrations
  - Source-focused studies: use of lab-scale combustors or collected coal fly ash – representativeness?
  - Realistic lab emissions studies (e.g., NERC)
  - Concentrated ambient particle (CAP) studies
- Epidemiology:
  - Associations between sulfate and health effects observed

# What We Don't Know……

- No assessment of the toxicity of actual plant emissions
- No information on the toxicity of actual secondary particles formed through $SO_2$ conversion in the atmosphere

# TERESA: Toxicological Evaluation of Realistic Emissions of Source Aerosols

Approach:

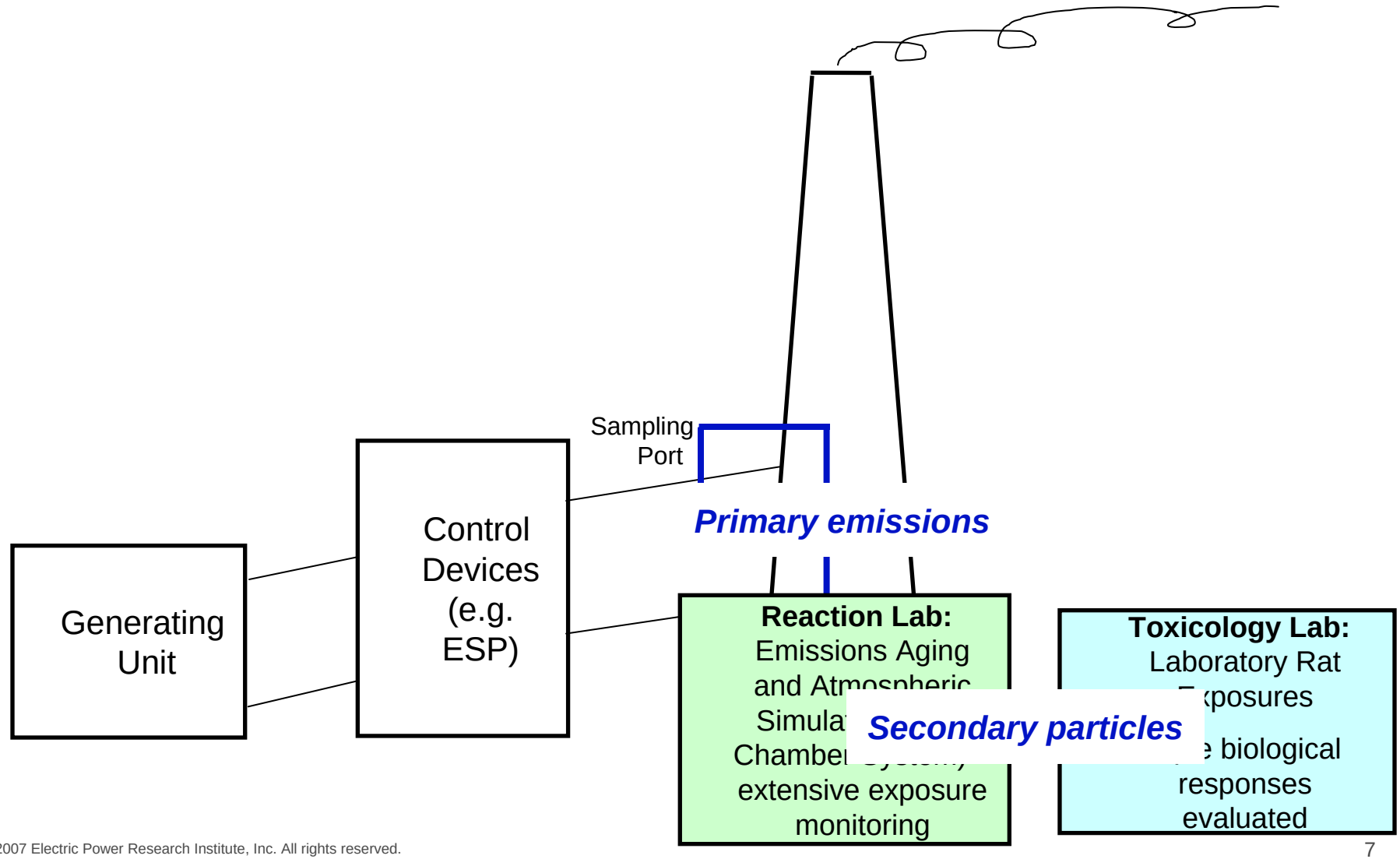
- Evaluate toxicity of *secondary* particles from power plants, at 3 different power plants in the US
- Expose rats to multiple simulated atmospheric conditions
- Examine mobile source emissions using same methods

Project Team:

- EPRI, Harvard School of Public Health

**Supported in part by DOE-NETL (Cooperative Agreement DE-FC26-03NT41902)**

# TERESA Field Setup



# Field Operations at Plant 2

# Exposure Scenarios

| Code | Scenario | Composition | Simulated Atmospheric Condition |
|---|---|---|---|
| P | Primary | Primary (un-aged) emissions, diluted to ~ 1 ppm $SO_2$ | Primary stack emissions |
| PO | Primary + oxidized | Primary emissions + •OH | Aged plume, oxidized stack emissions, sulfate aerosol formation |
| POS | Primary + oxidized + SOA | Primary emissions + •OH + α-pinene/ozone | Aged plume, unneutralized acidity, secondary organic aerosol (SOA) derived from biogenic emissions |
| PONS | Primary + oxidized + neutralized + SOA | Primary emissions + •OH + $NH_3$ + α-pinene/ozone | Aged plume, mixture of neutralized sulfate and SOA |
| O | Oxidized | Primary emissions + •OH, no primary PM | Control scenario |
| S | SOA | α-pinene/ozone only | Control scenario |
| OS | Oxidized + SOA | Primary emissions + •OH + α-pinene/ozone, no primary PM | Control scenario |

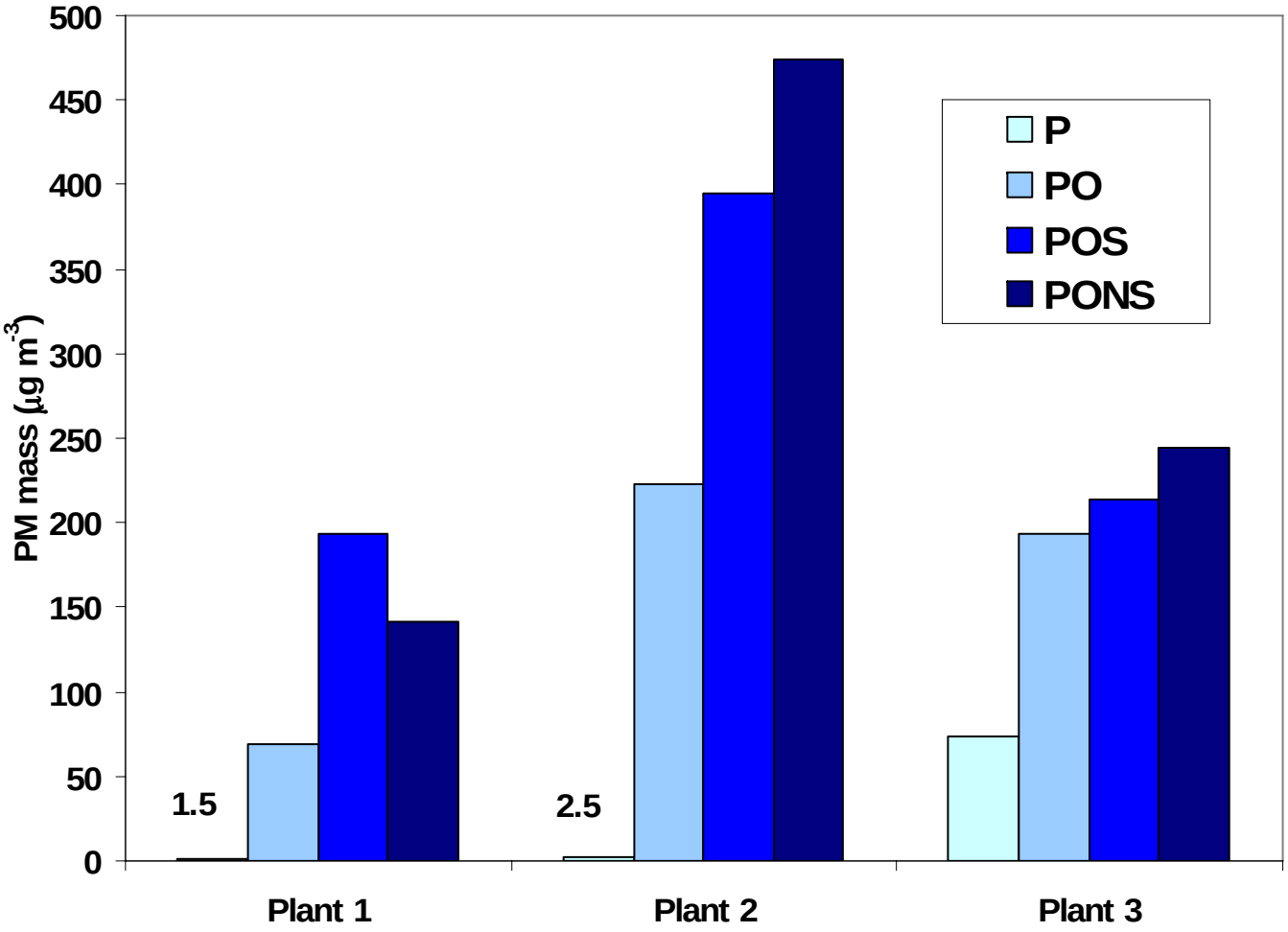
**Plus sham (control animals exposed to air only)**

# Exposures Performed

| Code | Dates (2004)<br>Plant 1 | Dates (2005)<br>Plant 2 | Dates (2006)<br>Plant 3 | Animals<br>Studied |
|---|---|---|---|---|
| **P** | May 10-13 | June 6-9 | August 8-13 | Normal |
| **PO** | November 13-15 | May 9-12 | September 19-22 | Normal |
| **POS** | October 4-7 | March 21-24 (no SCR)<br>May 3-6 (SCR) | July 19-22<br>August 14-15 | Normal |
| **PONS** | June 22-26<br>June 27-30<br>October 11-14 | May 31-June 3 | July 25-28 | Normal |
| **POS** | - | July 8, 13<br>September 8, 9 | August 16-17 | Compromised |
| **OS** | - | - | August 28-31 | Normal |
| **O** | - | - | September 1-4 | Normal |
| **S** | - | - | September 6-9 | Normal |

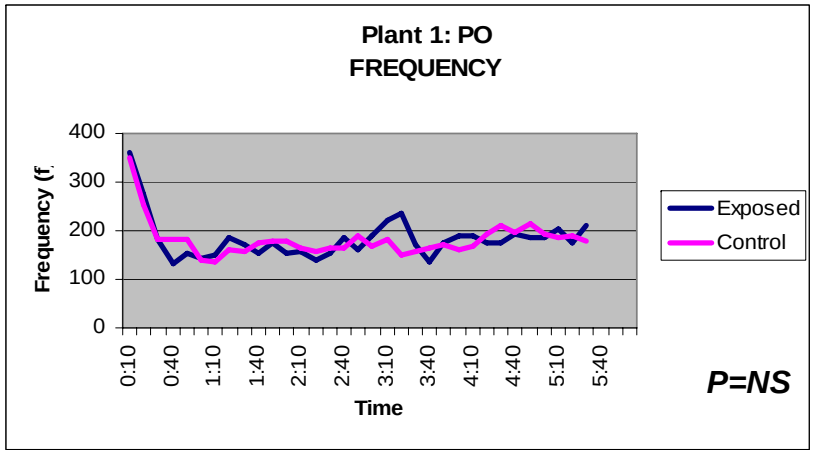
Total: 78 exposure days
12 rats (6 exposed; 6 filtered air control) per exposure

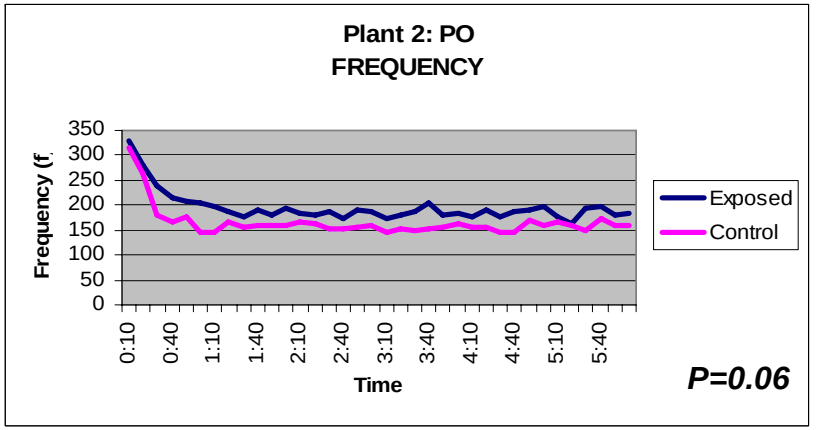
# Summary of Integrated Mass Concentrations

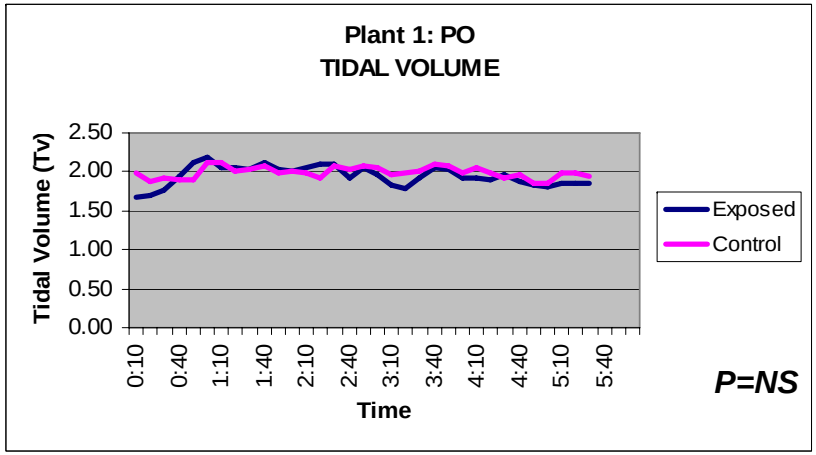


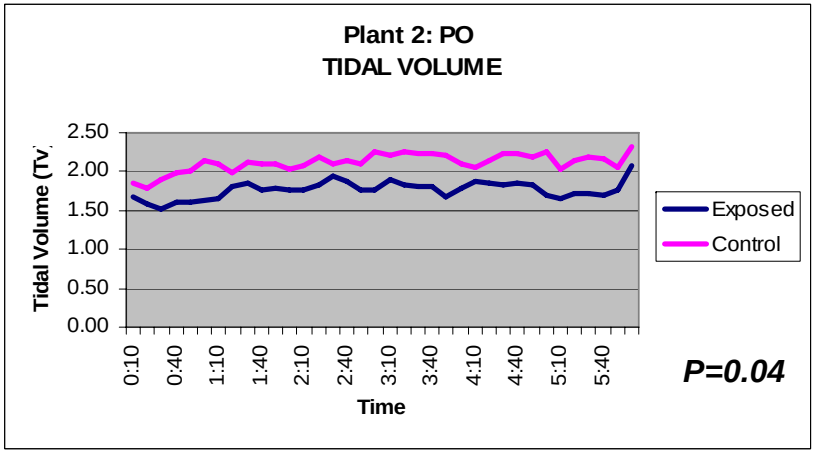
# Breathing Pattern: Plants 1 and 2

Total: 48 exposures



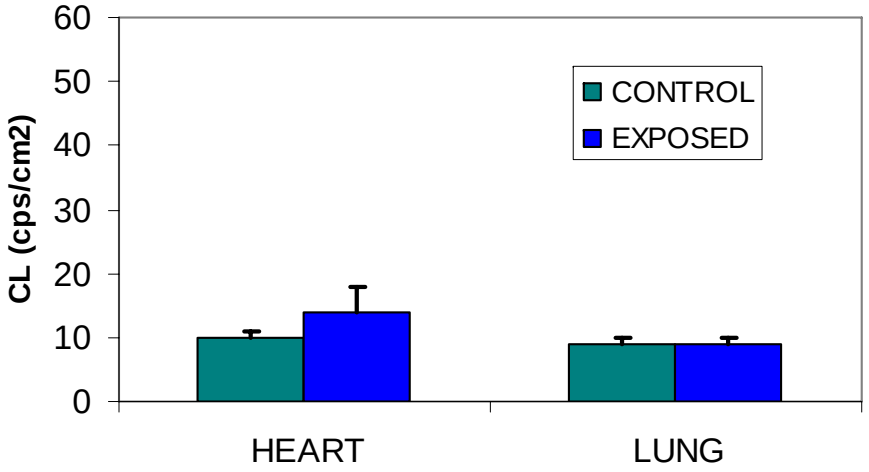



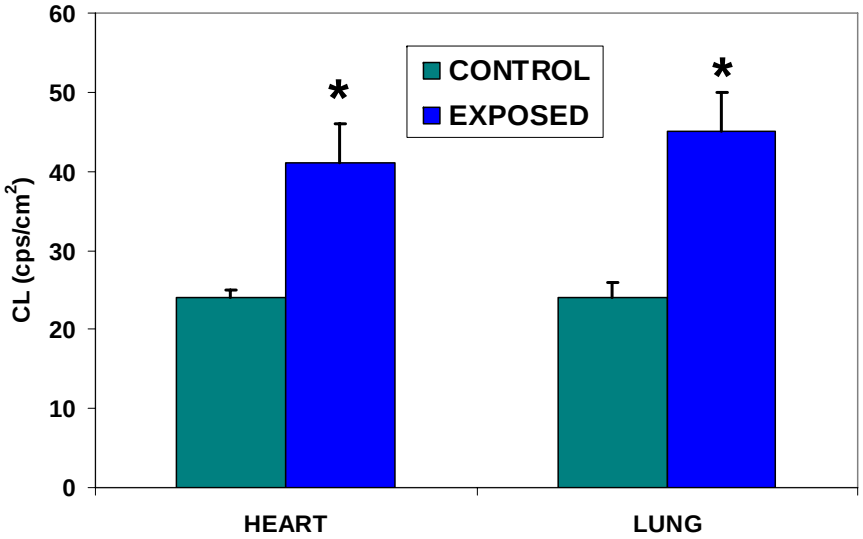



# Plant 1: Oxidative Stress in Heart and Lung Tissue

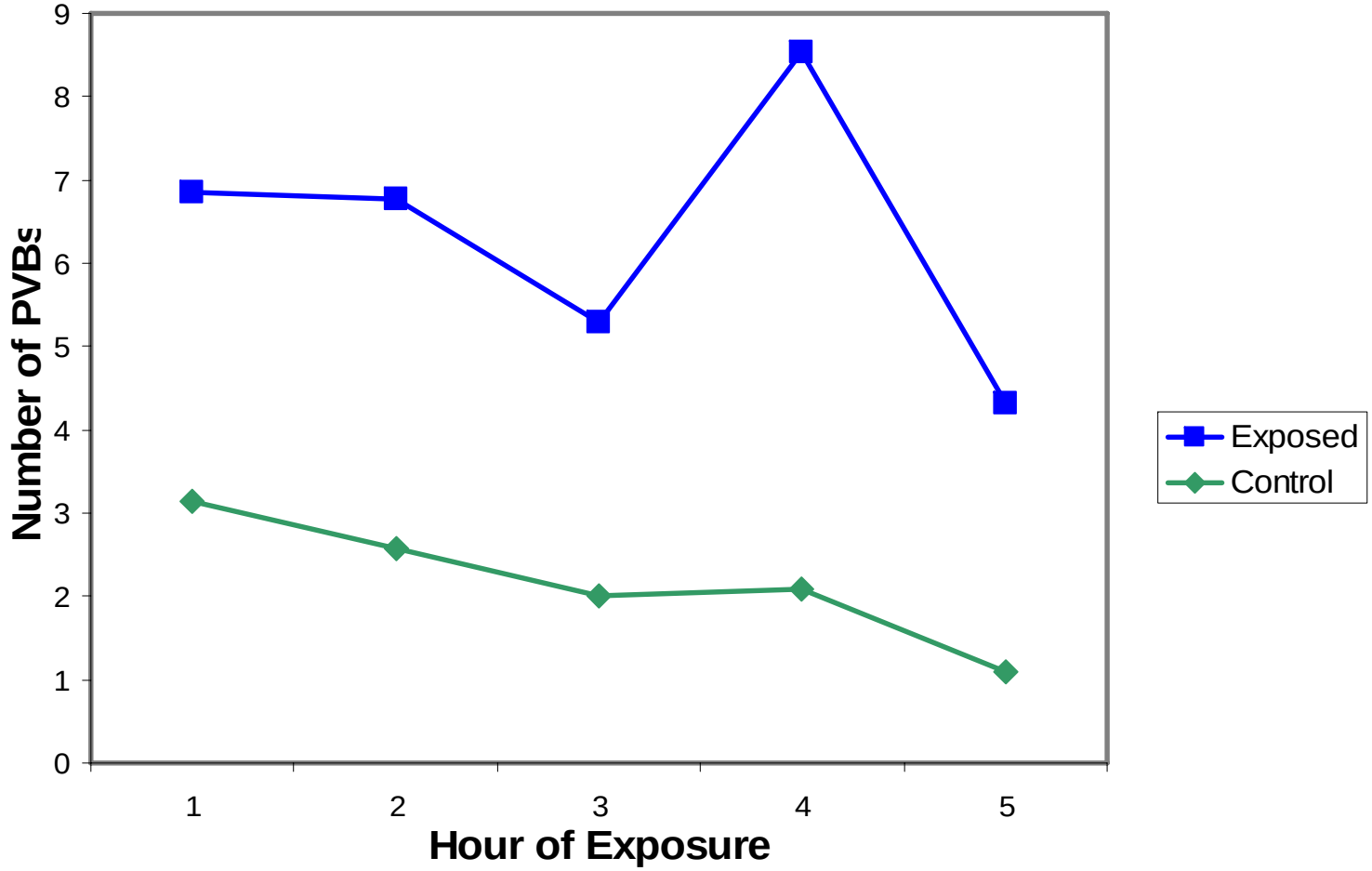
**POS**
**(*n*=8 in each group)**




**Boston Particles**
**(Gurgueira *et al*., 2002)**
**(*n*=4-6 in each group)**



# Plant 2: Effect of Exposure (POS) on Premature Ventricular Beats




Exposed animal PVBs 86.8% > sham; *p*= 0.05

# Summary, Conclusions, and What's Next

- Plant 1: No effects whatsoever
- Plant 2: Some biological effects with some conditions/scenarios
- Plant 3: Very few effects observed
- Primary PM highest at Plant 3; overall mass highest at Plant 2
- Effects do not appear to be correlated with mass
- See majority of effects in scenarios with secondary organics
  - Effect of SOA alone? No.
  - Interaction of SOA with component of mixture?
  - Additive/synergistic effect?
- Analyses ongoing to understand plant/scenario differences
- Mobile source component in 2008 (funded through the Harvard/EPA PM Center)

# Tri City Concentrated Ambient Particle Study (Tri City CAPS)

***Cardiopulmonary Toxicity Induced by Ambient Particulate Matter: Inhalation Toxicology Studies Using a Mobile Particle Concentrator in Regions Dominated by Power Plant and Mobile Source Emissions***

Approach:

- Station ambient particle concentrator/mobile lab at 3 locations for 2 seasons
- Expose rats to CAPs for 8 hrs/day for 13 days
- Link responses to PM sources and components

Project Team:

- EPRI, Michigan State University, University of Michigan

**Supported in part by DOE-NETL (Cooperative Agreement DE-FC26-03NT41902)**

# Location of Study Sites

Downtown Detroit, MI

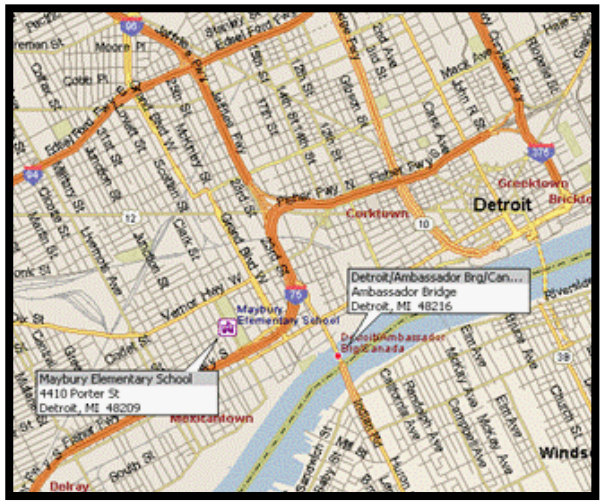
Dominated by diesel and gasoline emission-derived PM

Steubenville, OH

Dominated by power plant and local industrial emissions

State Park in NW PA

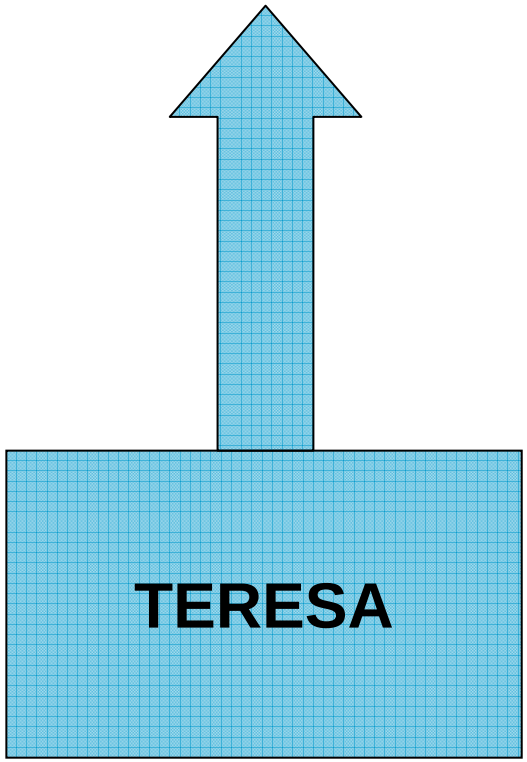
Rural site; dominated by power plant emissions

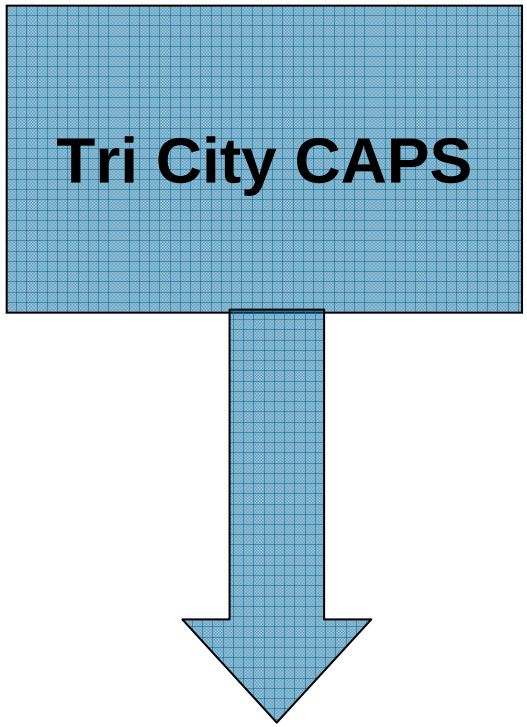




# Complementary Approach to TERESA

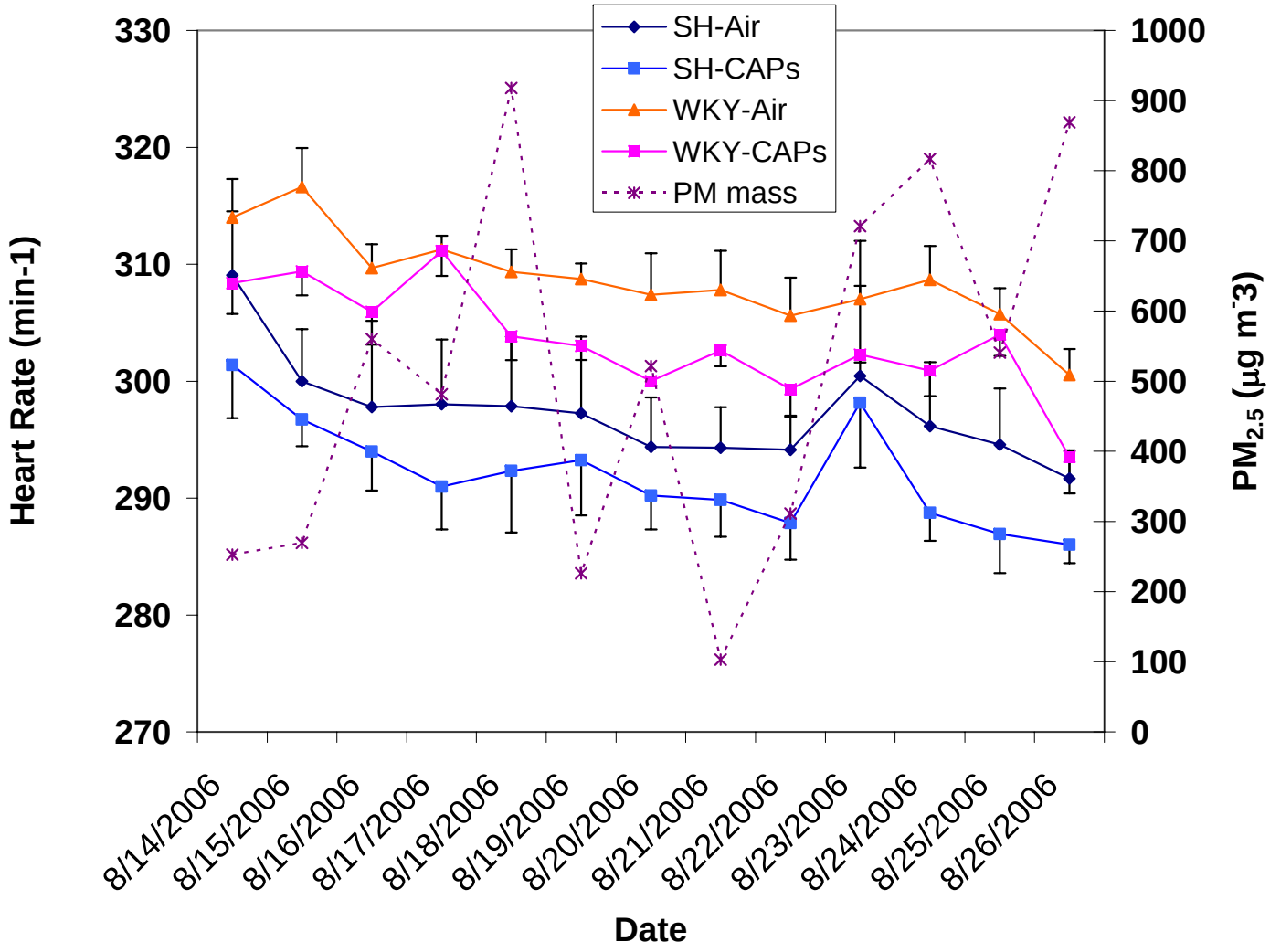
Bottom-up approach (start with controlled sources)




Top-down approach (start with ambient PM, tease out effects of specific sources)

# Detroit CAPs Cause Reduced Heart Rate Summer 2004



# Component Analysis

- Looked at the relationship between specific PM components and heart rate
- Reduced heart rate significantly associated with:
  - Integrated CAPs mass
  - “Unidentified mass” (metals + particle-bound water + some portion of organic carbon)
  - Aluminum
  - Cobalt
  - Phosphorus

# Conclusions

- Innovative approaches are needed to determine the relative importance of different PM sources and components in adverse health effects
- TERESA: showing some biological effects with power plant emissions under certain conditions/scenarios
- Tri City CAPS: showing CAPs-associated alterations in cardiac function