

## Paper/Poster-Abstract Form

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**Title:** Cardiopulmonary toxicity of urban source-oriented ultrafine and submicron fine particulate matter from California's San Joaquin Valley

**Abstract:** (min. 300 – max. 500 words)

The abstracts for papers and posters must contain unpublished information on your research subject: background, investigation methods, results and conclusions. Graphs and references are very welcome. Acronyms should be avoided. Abstracts with < 300 words can not be considered. General information on products which are already commercially available can not be accepted as presentations for the conference but are very welcome at the exhibition of particle filter systems and nanoparticle measurement instruments.

**BACKGROUND:** Strong evidence exists for a relationship between exposure to ambient particulate matter (PM) and cardiopulmonary health impacts. Regional, seasonal and temporal variations in PM concentrations and chemical composition can be attributed to a variety of distinct point and mobile sources. However, it is unclear how much each source influences the health of the cardiopulmonary system. Current US national ambient air quality standards (NAAQS) regulate PM according to size and mass concentration, regardless of source or composition. Such PM mass-based regulations do not address how different source composition may differentially contribute to observed health effects. By sampling PM from the atmosphere using a source-oriented approach, subsequent toxicity testing could support an improved understanding of source-specific health effects and concomitant regulation.

**OBJECTIVES:** To determine if pulmonary and systemic inflammatory and cytotoxic responses elicited by source-oriented PM collected in Fresno, California (CA) during the summer and winter seasons differ by source, size, and season.

**METHODS:** A single particle mass spectrometer and 10 ChemVol samplers were used to collect source-oriented and ultrafine (UF) and submicron fine (SMF) PM from Fresno California in Summer 2008 and Winter 2009. Mice were exposed by oropharyngeal aspiration to equivalent mass doses of this UF and SMF source-oriented PM. At 24 hours post-aspiration, mice were examined for indicators of pulmonary inflammation, pulmonary cytotoxicity, and hematological response.

**RESULTS:** Measures of cardiopulmonary inflammation, cytotoxicity and hematology were statistically different for each source-oriented PM sample compared to control values. Significant differences between source-oriented samples for a given size and season were also observed. Source-oriented PM elicited inflammatory responses that were the most significant in the lung compared to the blood at 24 hours following exposure. In general, UF PM was more pro-inflammatory compared to SMF PM.

**CONCLUSIONS AND SIGNIFICANCE:** Toxicity testing of source-oriented PM can detect significant cardiopulmonary inflammatory responses that are dependent on source, season, and particle size. This finding suggests that individual particle sources exhibit different toxicity profiles. Toxicity testing of source-oriented PM can indicate source profiles associated with the greatest potential for

adverse health effects, which is useful for supporting source specific emissions regulations that provide greater protection of human health while minimizing cost.

**Short CV:** Kent Pinkerton is Professor of Pediatrics and Director of the Center for Health and the Environment at the University of California, Davis. He has authored more than 200 articles and book chapters on the health effects of indoor and outdoor air pollution. He is an expert on environmental influences of lung development and the fetal basis of adult-onset respiratory diseases (asthma and chronic obstructive pulmonary disease). Dr. Pinkerton leads an active research program in environmental pulmonary toxicology. His research focuses on ambient air pollutants (ozone and particulates), combustion-generated particles, environmental tobacco smoke and engineered nanomaterials.

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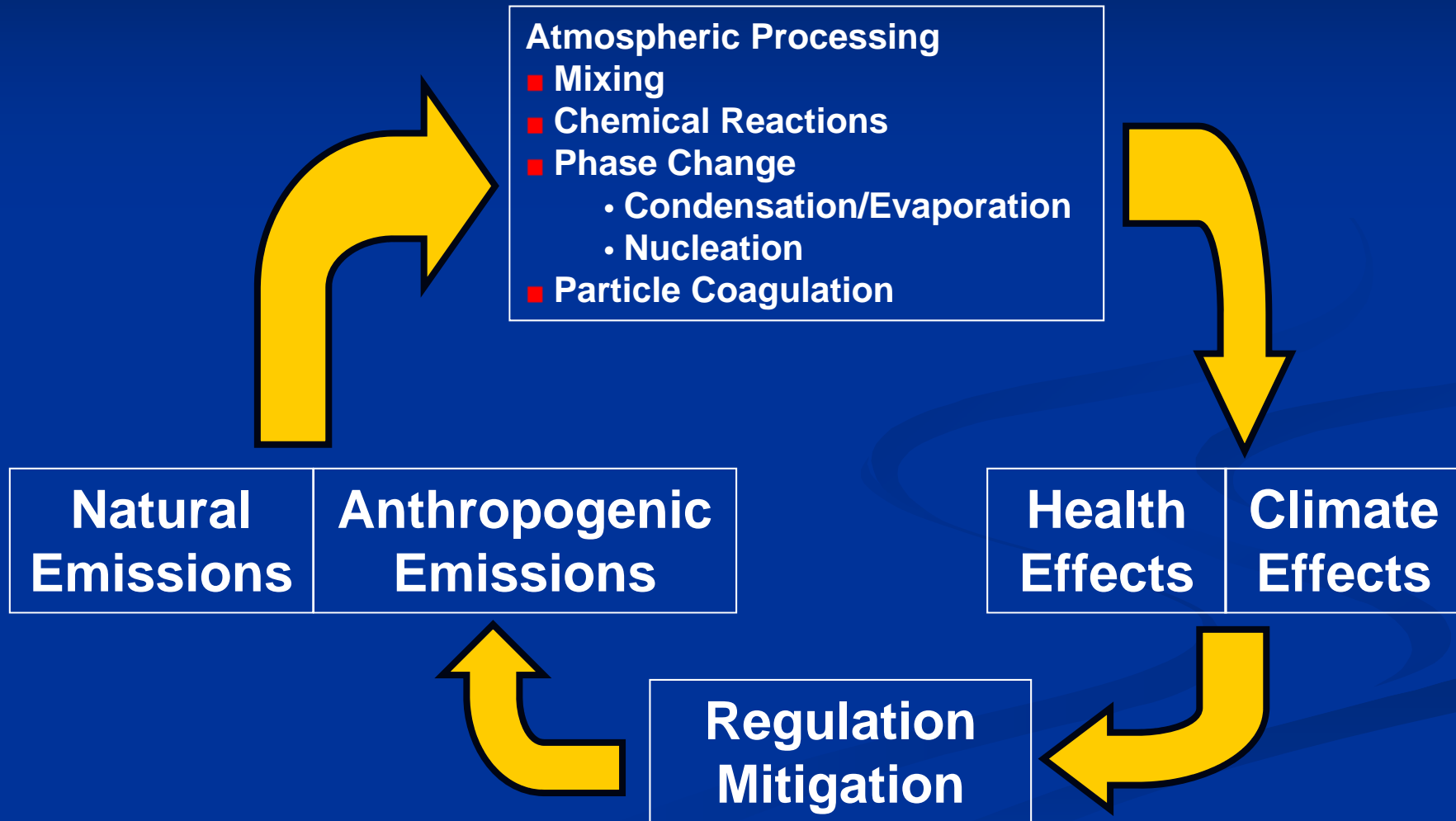
# Cardiopulmonary Toxicity of Urban Source-Oriented Ultrafine and Submicron Particulate Matter from California's San Joaquin Valley

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Keith Bein  
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17<sup>th</sup> ETH-Conference on Combustion Generated  
Nanoparticles  
Zurich, Switzerland  
26 June 2013



# Air Pollution Action/Reaction Cycle



# **Risk-Based Regulatory Imperative: Which Sources are more Toxic?**

- Is all PM created equal?
  - Do sea spray and diesel exhaust pose the same toxicological risk?
  - Current mass-based NAAQS treats each the same
  - Can we differentiate sources by their toxicity?
  - More cost-effective to regulate more toxic sources
- Source- or risk-based regulation may be the future

# Current State of Risk-Based Science

- How do we determine the health effects of different particle sources?
  - Epidemiological-based studies
    - High risk near freeways and downwind of coal-fired power plants (CFPPs)
    - Numerous studies completed under wide-ranging conditions
    - However, most studies are correlative, not causative
  - Toxicological-based studies from direct sources
    - What about secondary atmospheric components?
    - How about the atmosphere changing the toxicity?
    - Can we collect source-oriented PM from the atmosphere?
    - Isn't the atmosphere too well mixed?

# Source-Oriented PM Toxicity: A Multi-Step Approach

- Ambient Source-Oriented Sampling
  - How do we simultaneously characterize, differentiate and collect PM in real-time?
- Filter Extractions
  - How do we remove PM from collection substrates?
- Retrospective Source Attribution
  - Is the collected PM truly source-oriented?
- Toxicological Studies
  - Do different PM samples elicit different toxicity?

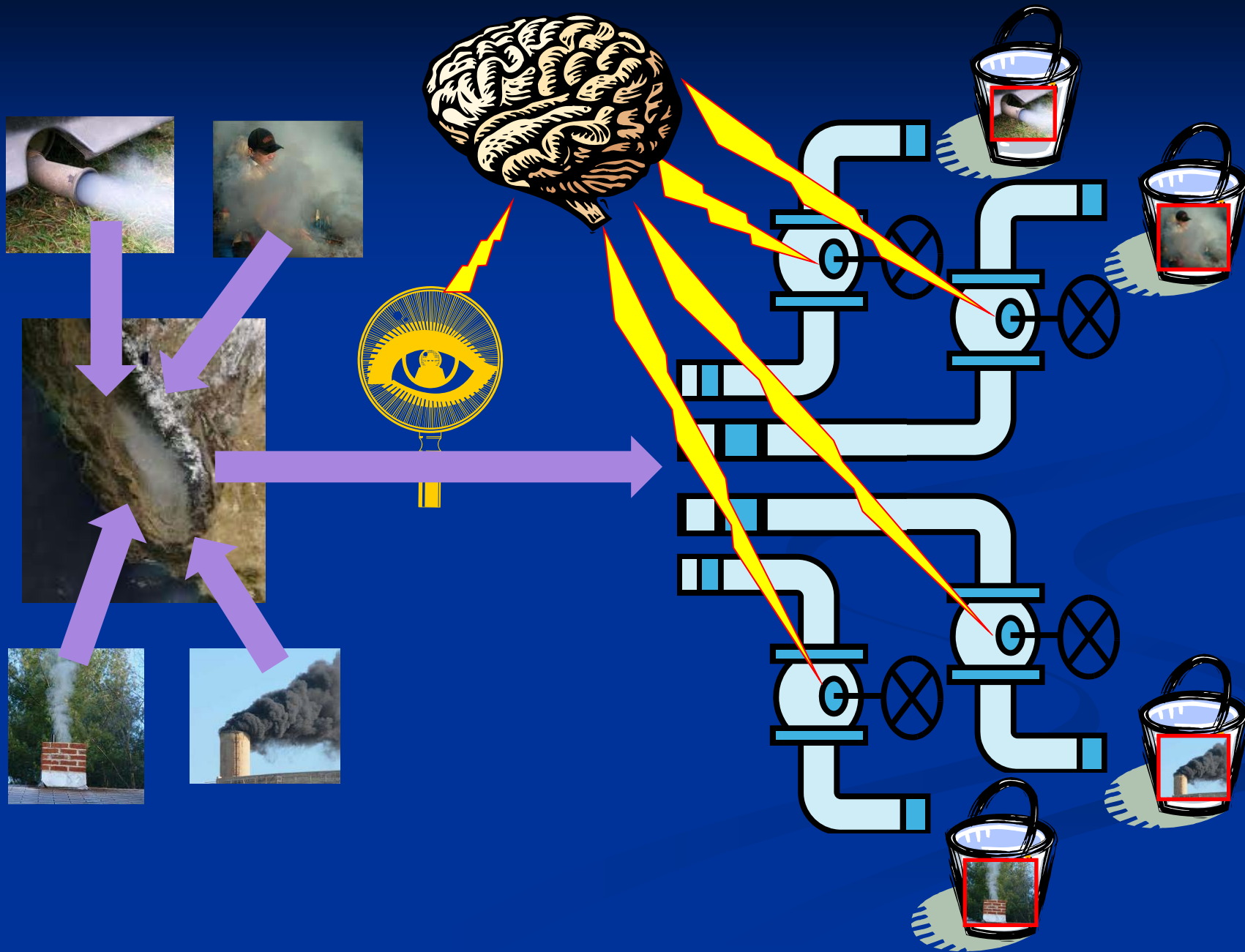
# Ambient Source-Oriented Sampling

## So what's the big idea?

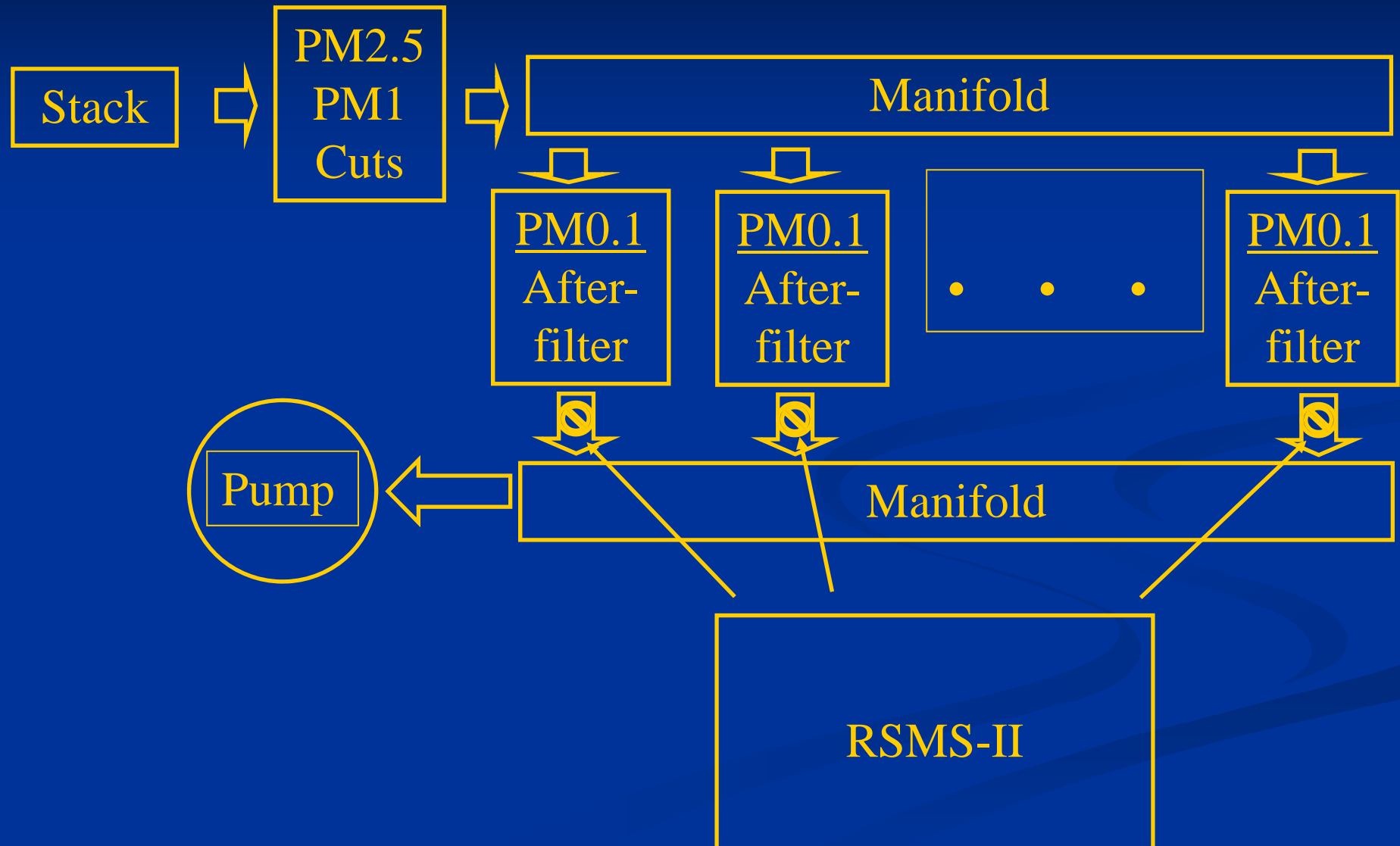
- Run single particle mass spectrometer to characterize the mixing state of the atmosphere
- Assign prevailing sources or source combinations to each of 10 high-volume ChemVol samplers
- Use single particle mass spectrometer to identify and collect each ChemVol sample in real-time
- Collect enough PM for toxicological studies



# Basic Concept of Conditional Sampling



# Sampling Train Schematic



# RSMS-II





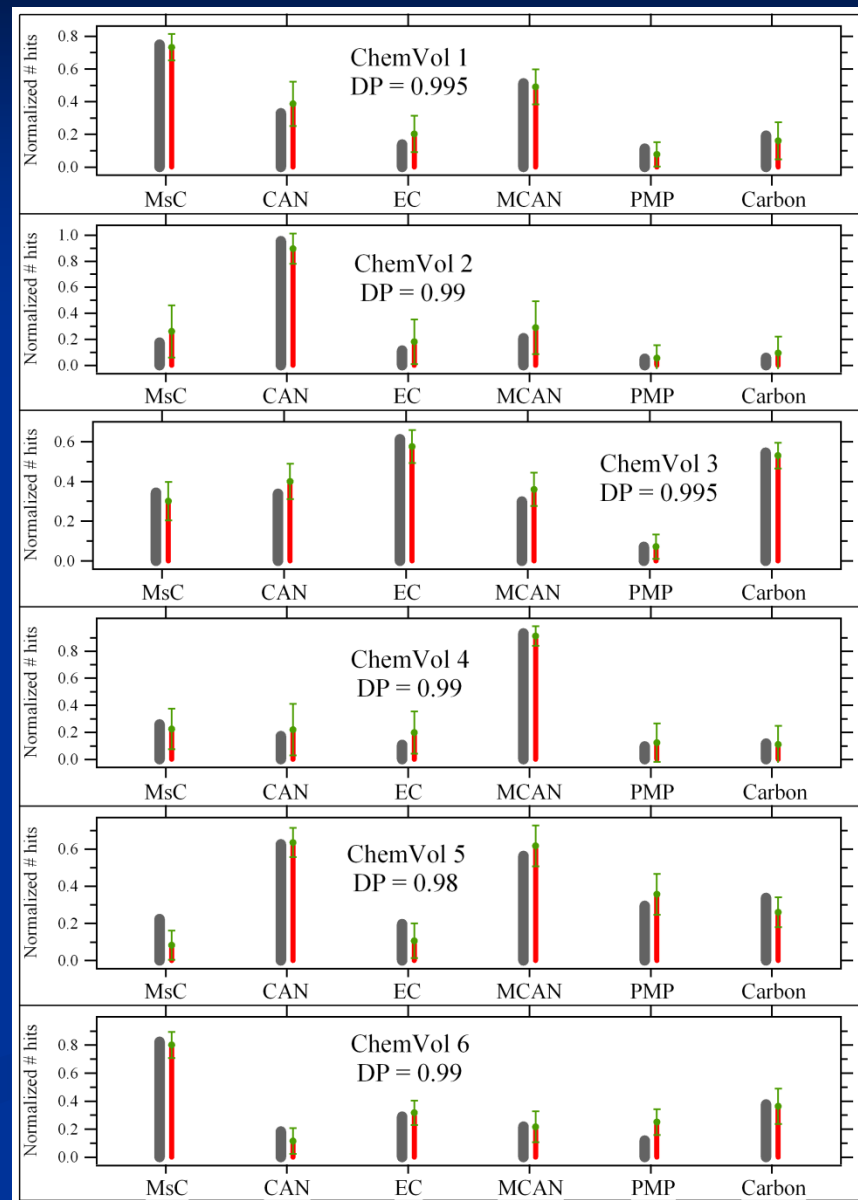
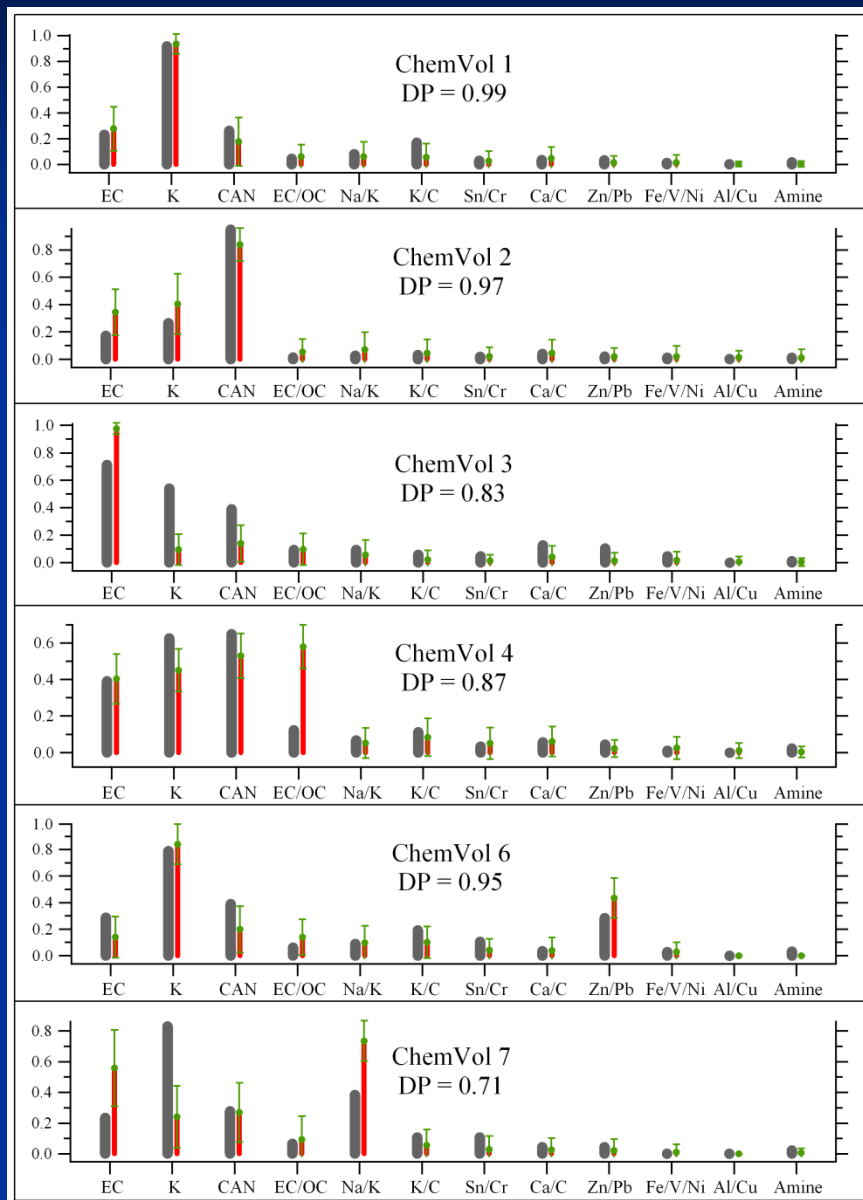
# Sampling Train



# Sampling Fidelity

Summer 2008

Winter 2009

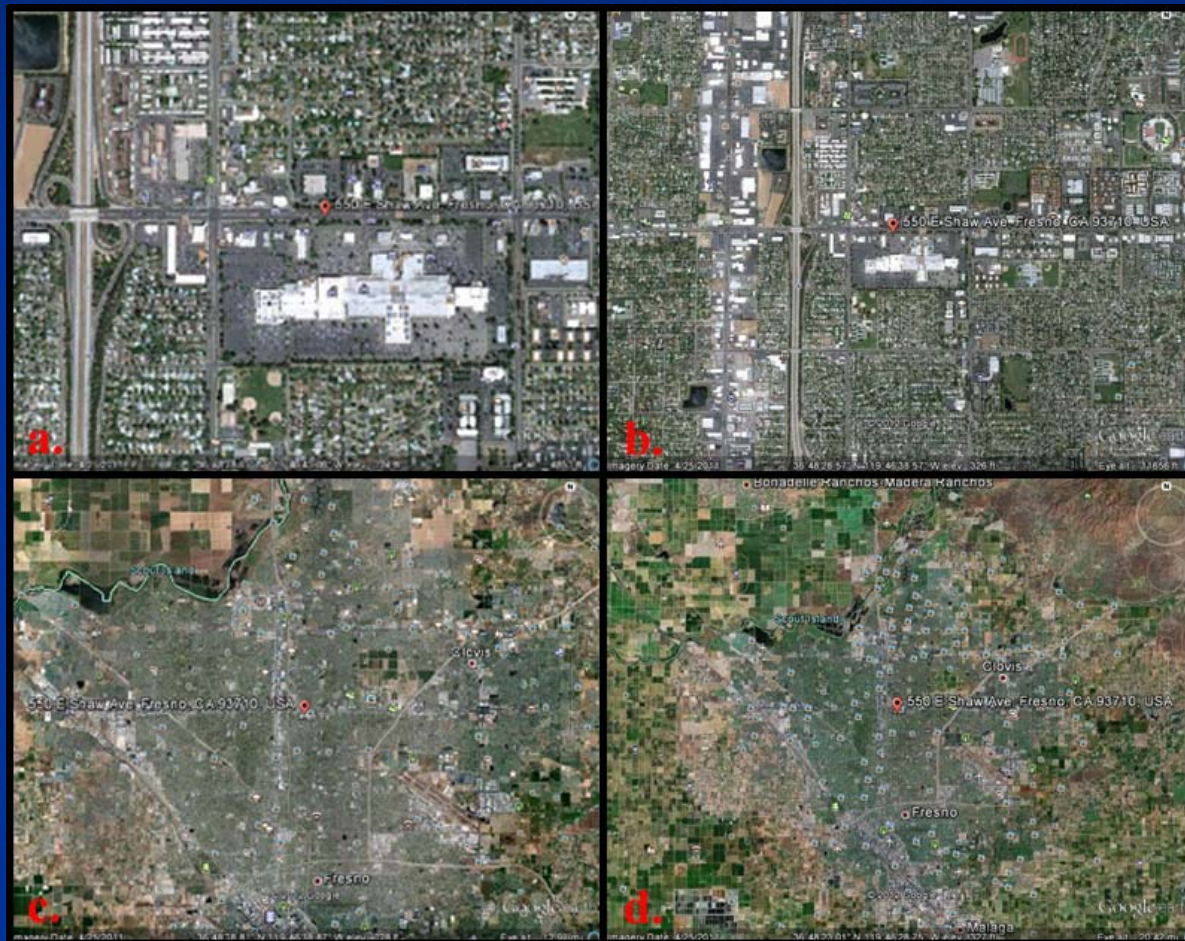




# Retrospective Source Attribution – Site-Source Relation

## Emissions Sources

- Vehicular
  - Gasoline and diesel
  - Highways and residential
- Residential and Commercial
  - Cooking
  - Space heating
  - Construction/landscaping
- Agricultural
  - Ranching
  - Agricultural machinery
  - Waste/debris burning
  - Product transportation
- Regional Processing
  - Ammonium nitrate
  - Secondary Organic Aerosol
- Long-range Transport
  - Wildfires
  - Trans-Pacific transport

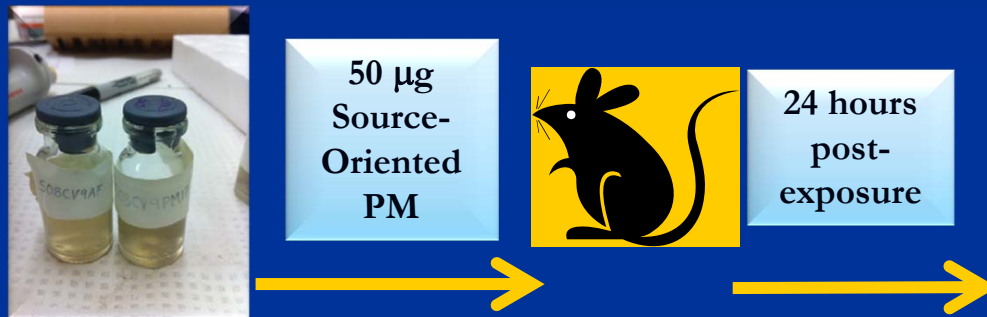


# ChemVol Source Combination Reconciliation

Experiment:	Summer 2008		Winter 2009	
ChemVol	Dominant Particle Type(s)	Dominant Source(s)	Dominant Particle Type(s)	Dominant Source(s)
1	K	Local cooking emissions	K/EC/OC	Local residential heating
2	CAN	Highly processed regional background PM	CAN	Highly processed regional background PM
3	EC	Local vehicular emissions; diesel	EC; EC/OC	Local vehicular emissions; gas + diesel
4	CAN; K; EC/OC	Source Mixture	K/CAN	Highly processed biomass combustion PM
5	EC; EC/OC	Local vehicular emissions; gas + diesel	CAN; K/CAN	Regional source mix; vehicular, biomass + ag
6	Metals	Unknown	K/EC/OC	Local cooking emissions
7	K; Na/K	Local cooking emissions	Timed ChemVol ~ 17:00-20:00	Evening commute and dinnertime cooking
8	N/A	ChemVol not used	Timed ChemVol ~ 09:00-17:00	Morning commute
9	Timed ChemVol ~ 11:00-15:00	Daytime mixed layer	Timed ChemVol ~ 09:00-17:00	Daytime mixed layer
10	Undifferentiated	Nocturnal inversion	Undifferentiated	Nocturnal inversion

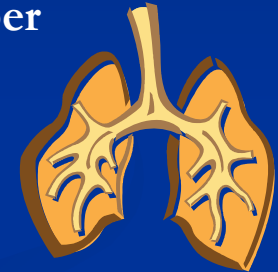
# Source-Oriented Toxicity

## Study Design



### Bronchoalveolar Lavage (BAL)

- Total Cell Number
- Cell Differential
- Cell Viability
- Cytotoxicity
- Cell Damage



### Blood (CBC)

- Total Cell Number
- Cell Differential
- Hematology

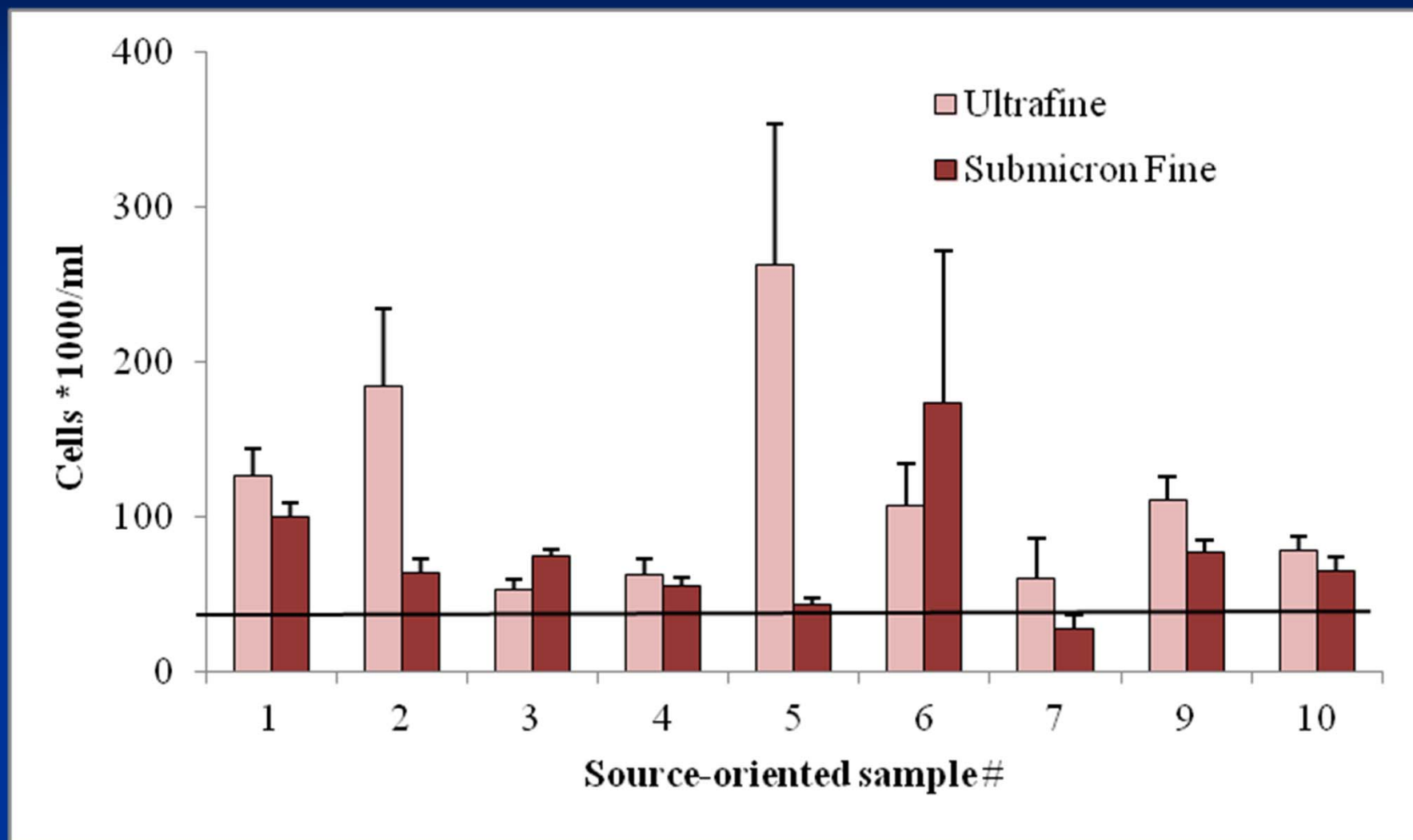


### Reactive Oxygen Species

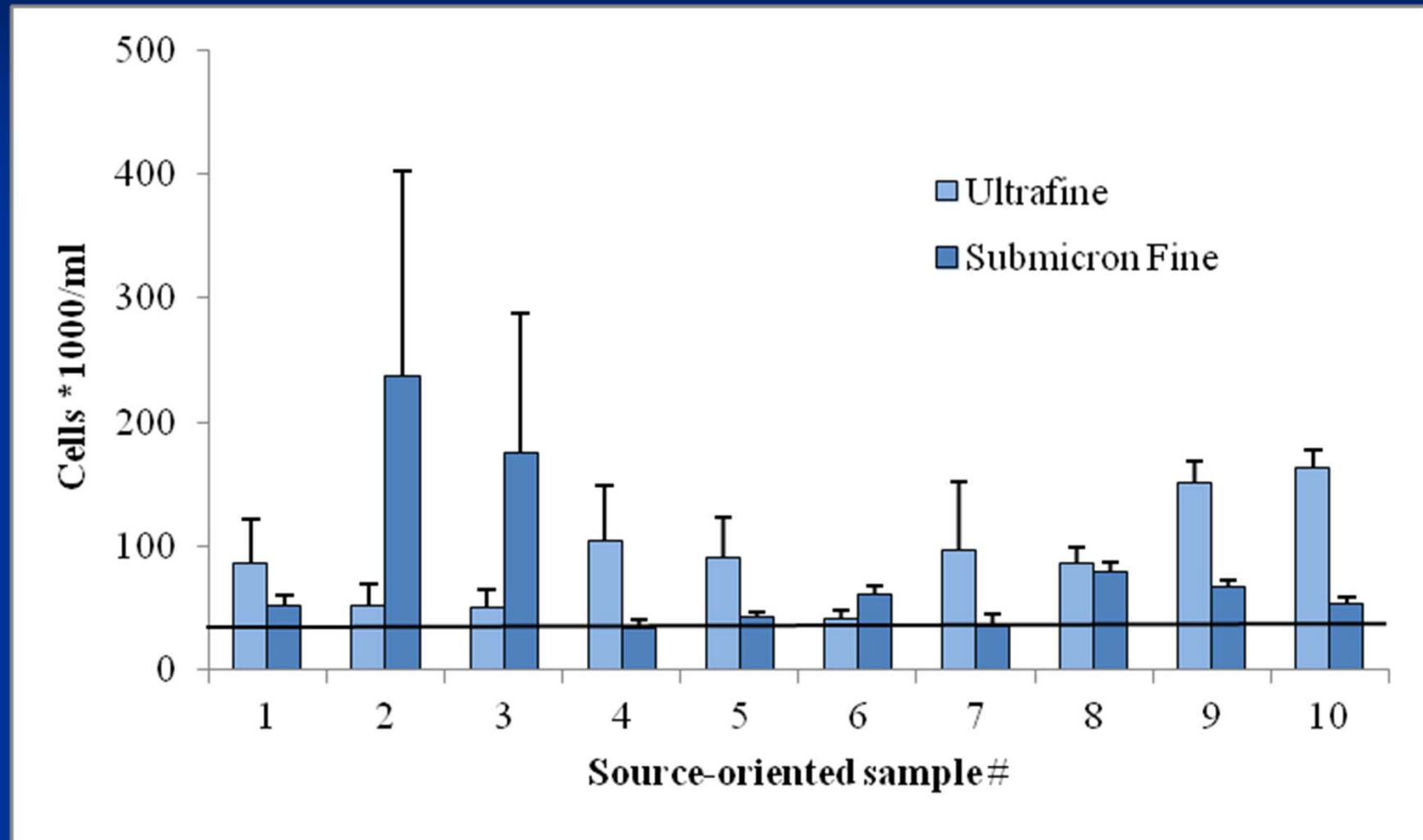
- Hydrogen peroxide
- Hydroxyl radical



# Summer Bronchoalveolar Lavage (BAL)

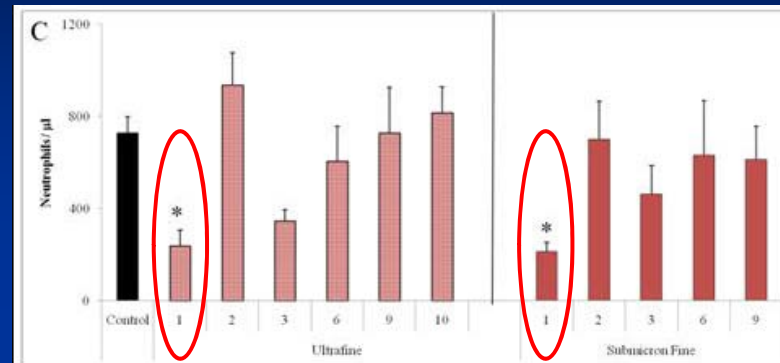


# Winter Bronchoalveolar Lavage (BAL)

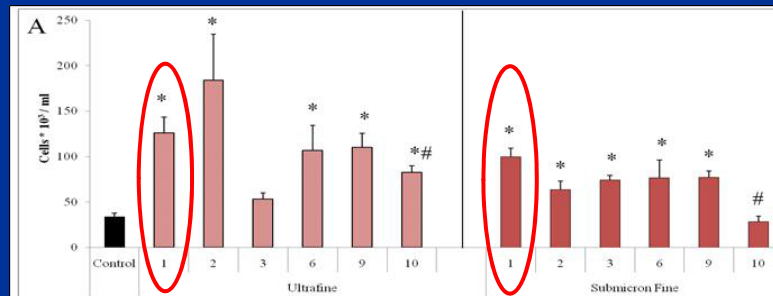


# Summer Residential Cooking

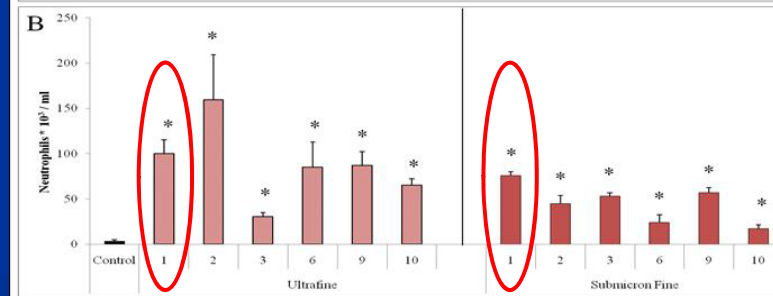
Circulating Neutrophils



Lung BAL:  
Total Cells

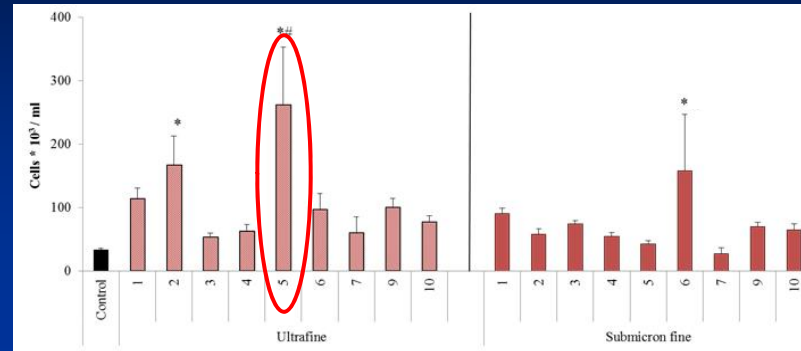


Neutrophils

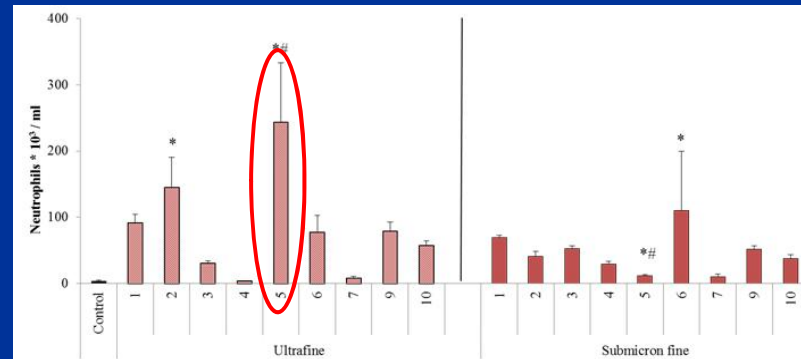


# Summer Vehicular Emissions

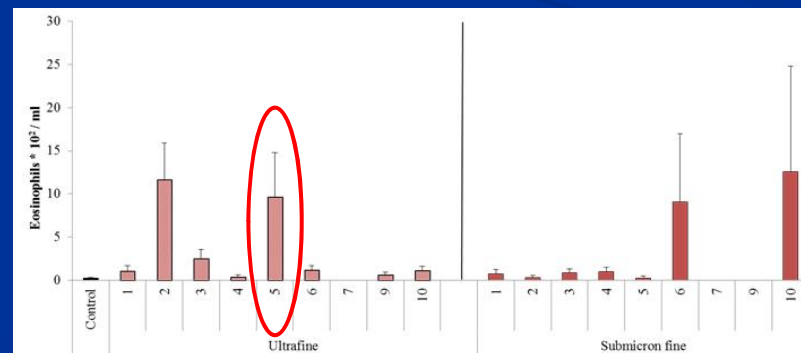
Lung BAL:  
Total Cells



Neutrophils

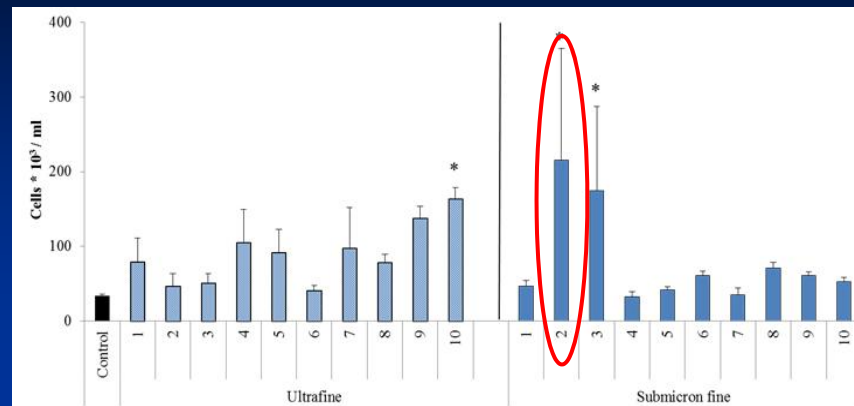


Eosinophils

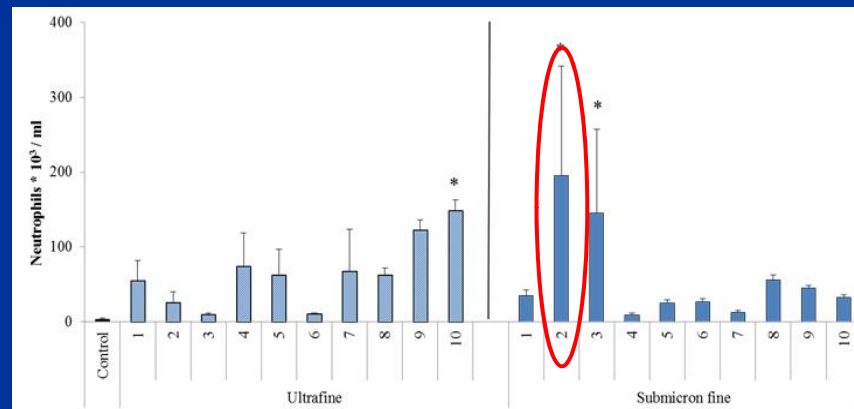


# Winter Processed Regional Background

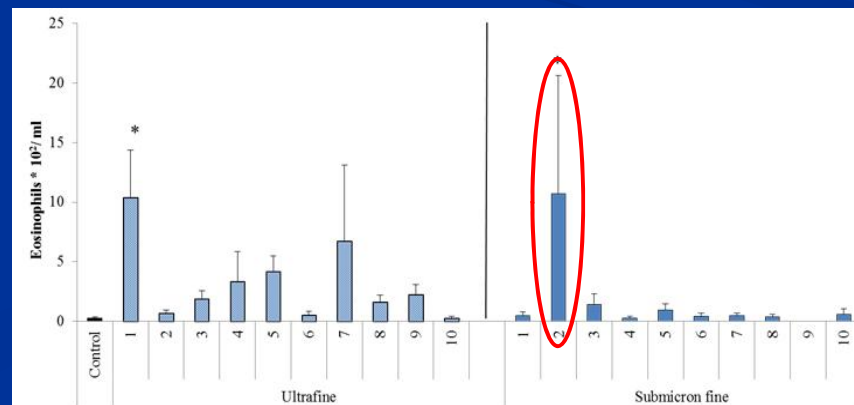
Lung BAL:  
Total Cells



Neutrophils



Eosinophils



# Conclusions

## Source-Oriented Sampling

- Source-oriented sampling is FEASIBLE
  - Novel sampling method implemented successfully
  - Different PM samples attributable to different sources
  - Sufficient PM collected for toxicity studies

# Conclusions

## Source-Oriented Toxicity

- Some particles MORE TOXIC than others
  - Summer PM: metal-containing and vehicular emissions have largest biological response
  - Winter PM: highly processed, vehicular emissions and nighttime mix have largest biological response
  - Ultrafine PM generally elicits greater biological response than submicron fine PM
- Different particles TOXIC in DIFFERENT ways
- Source-oriented regulations are FEASIBLE but further research is necessary