# Ultrafine Particles and Freeways

**Yifang Zhu , Ph.D.**

**Assistant Professor**

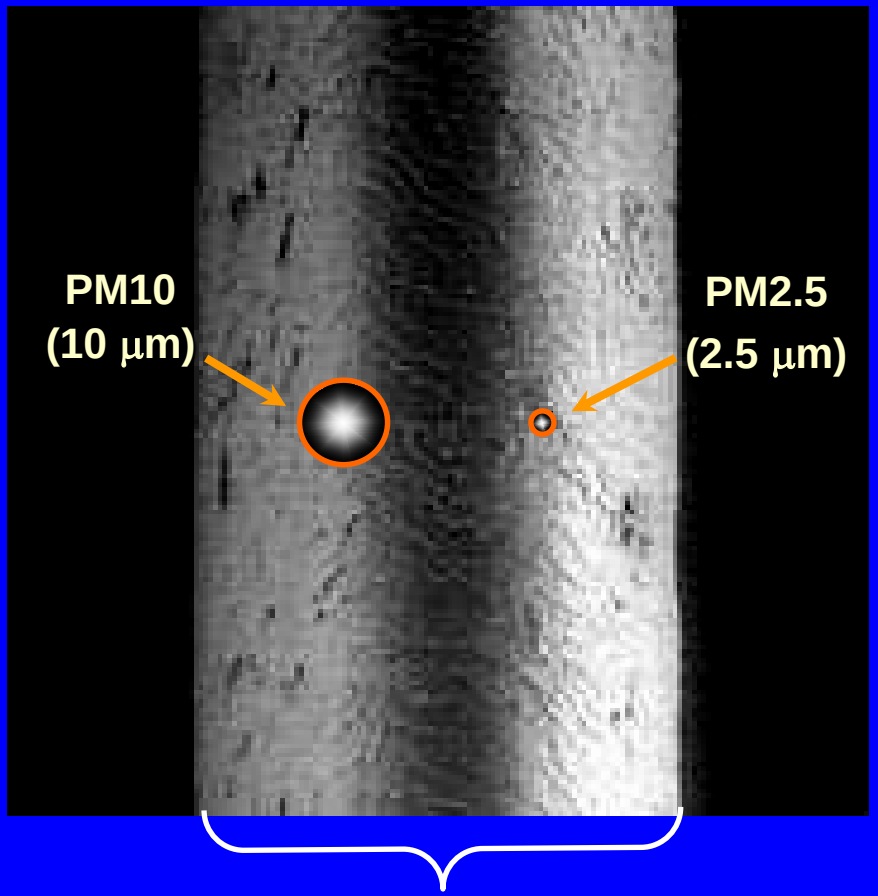
Department of Environmental Engineering

Texas A&M University –Kingsville

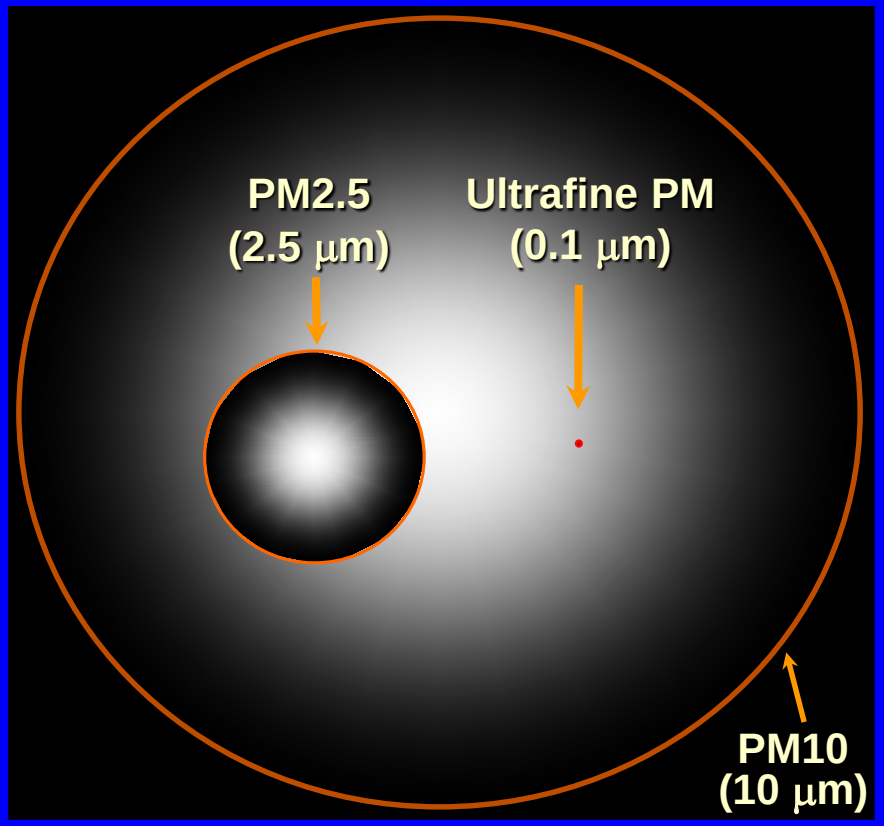
Email: yzhu@even.tamuk.edu

yifang.zhu@tamuk.edu

# Comparison of PM10, PM2.5, and Ultrafine PM

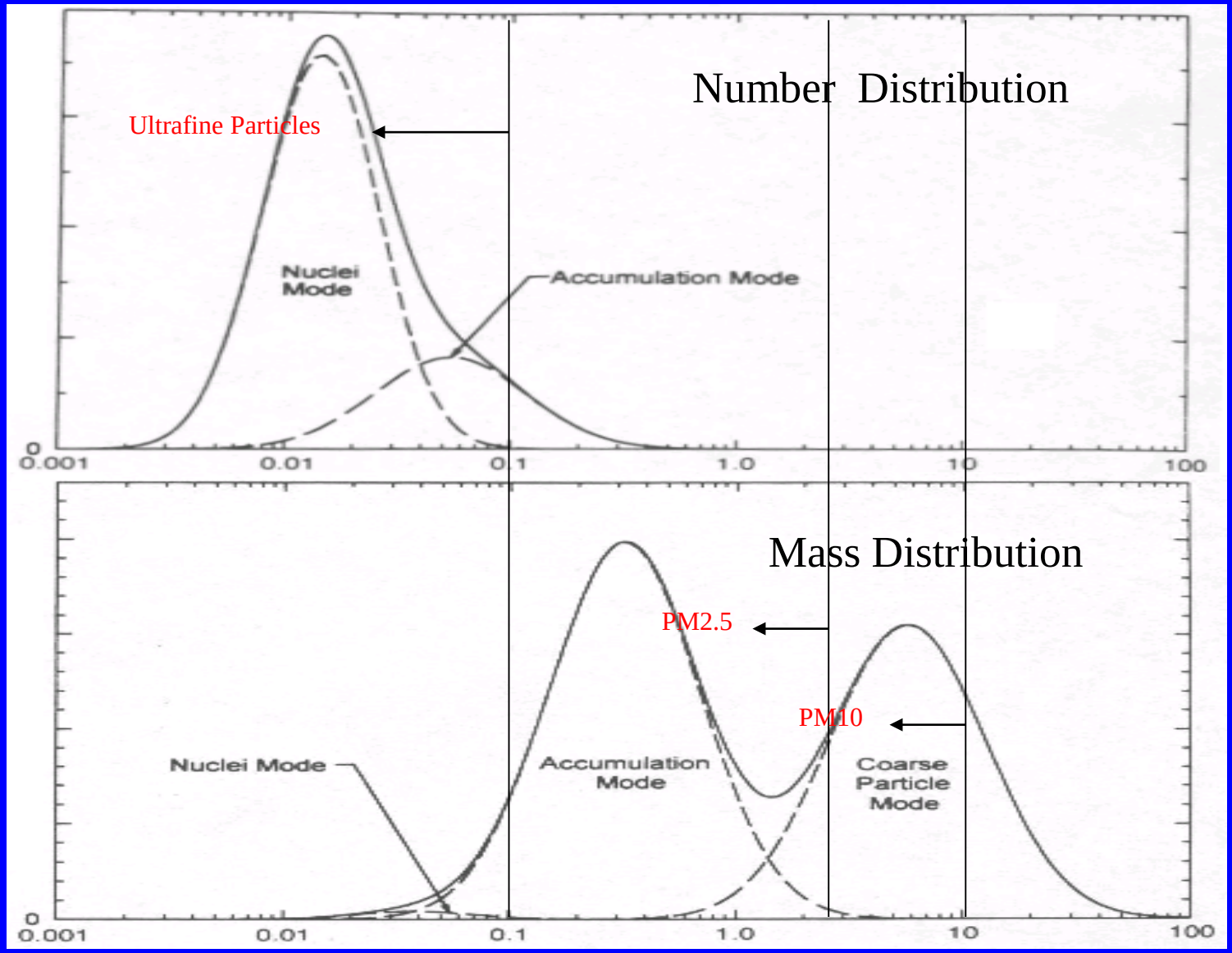



**Human Hair**
**(60 μm diameter)**




**Relative size of particles**

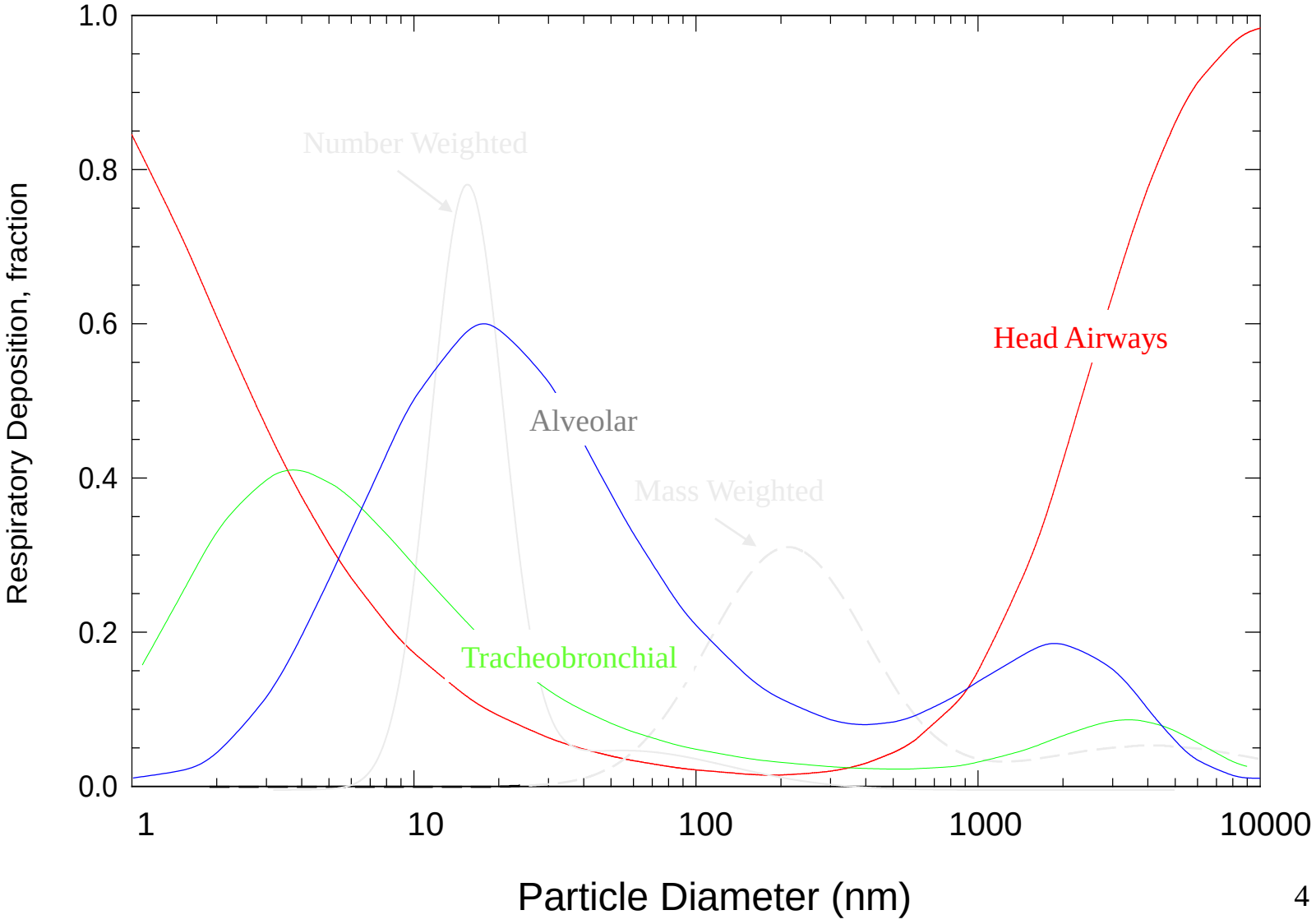
# Atmospheric Aerosols: Particulate Matter (PM) Size Distribution





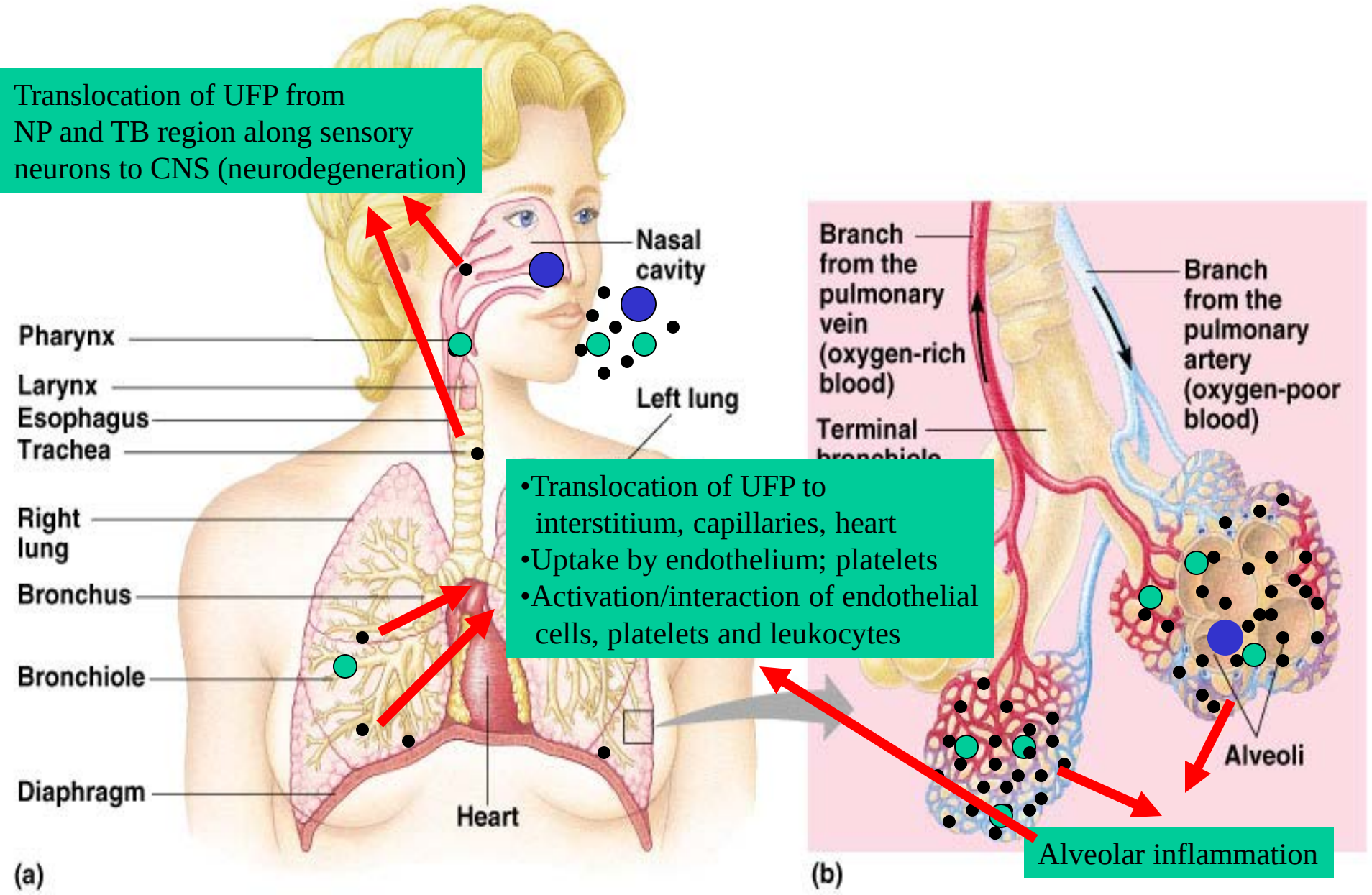

Source: Hinds 1999

# Particle Regional Deposition for Light Exercise



# Pathways of Particle Translocation Within and Outside Respiratory Tract

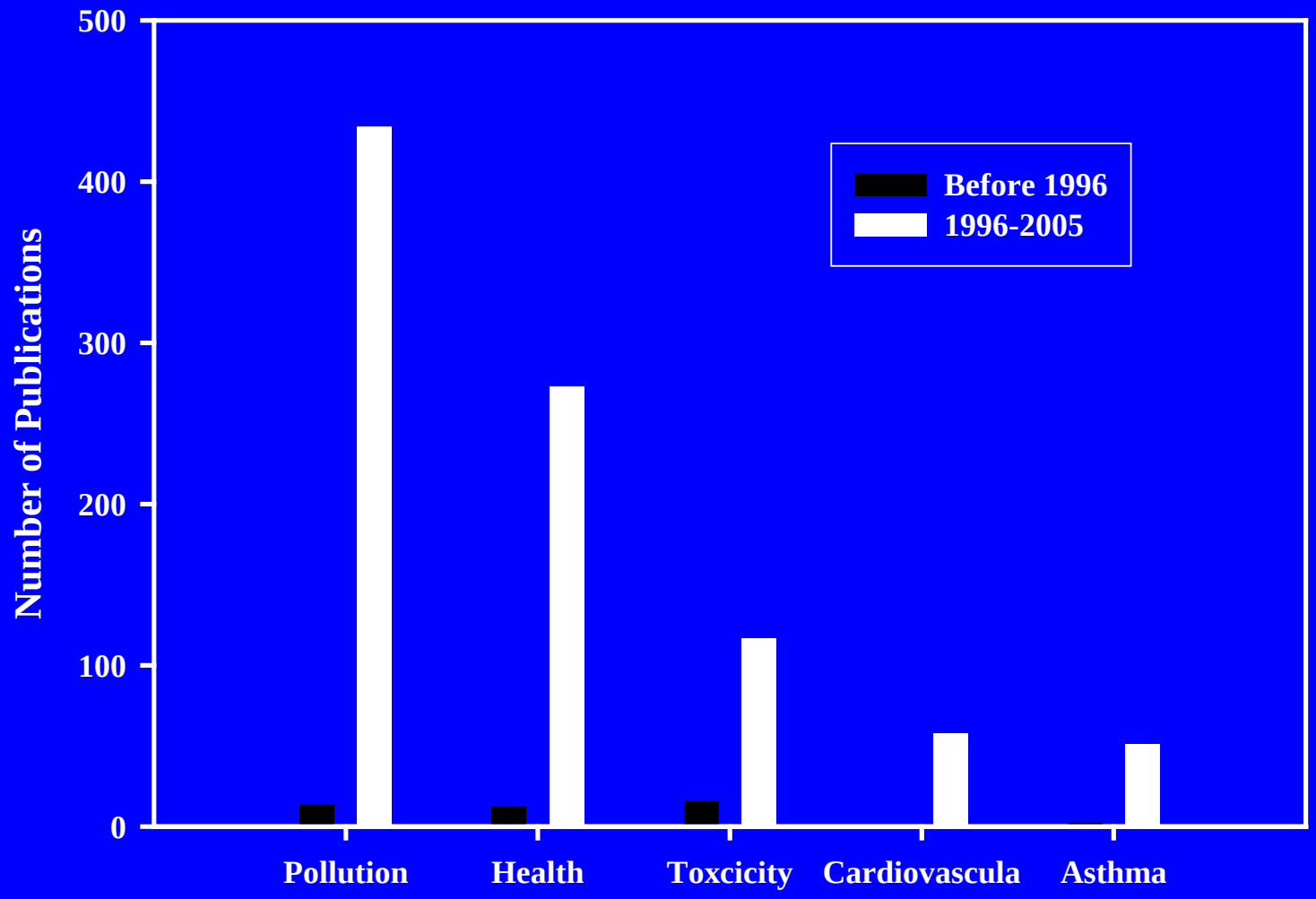
Translocation of UFP from NP and TB region along sensory neurons to CNS (neurodegeneration)

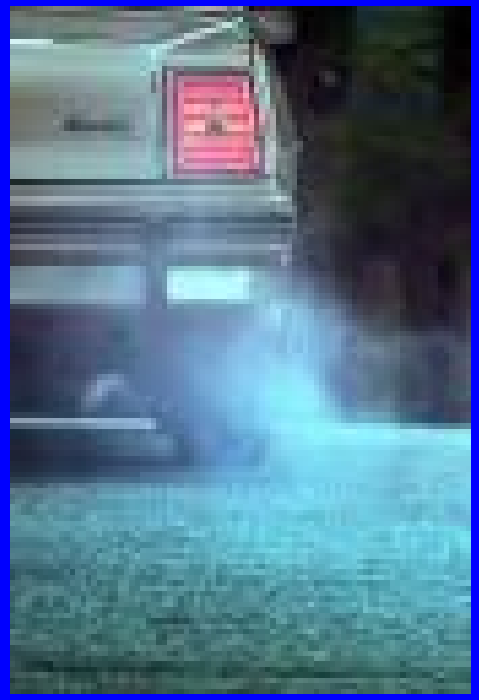



- Translocation of UFP to interstitium, capillaries, heart
- Uptake by endothelium; platelets
- Activation/interaction of endothelial cells, platelets and leukocytes

Alveolar inflammation

# Publications Address Ultrafine Particles

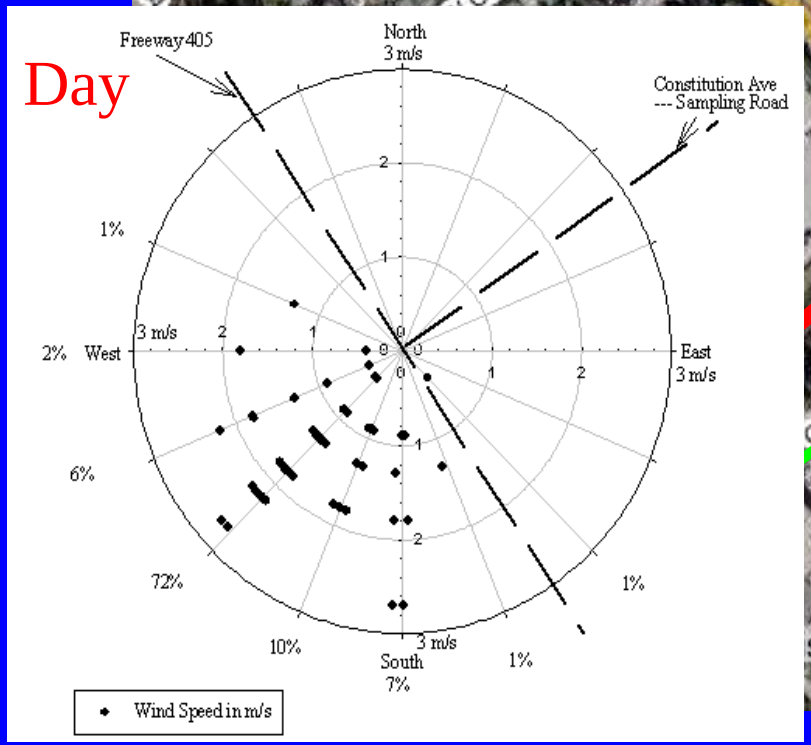


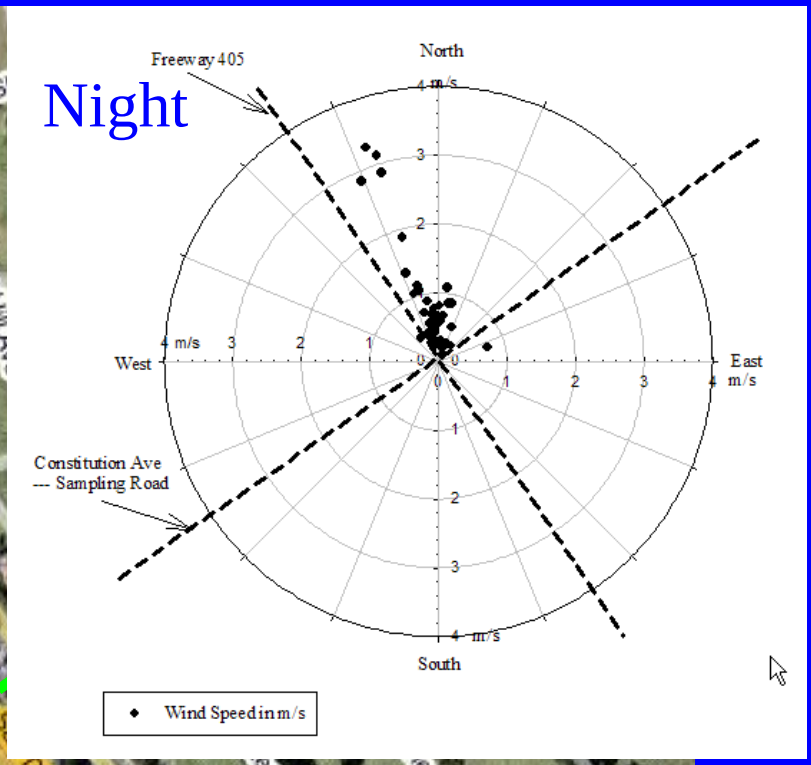


# I-405 Freeway

# Sampling Site





# INSTRUMENTS

Scanning Mobility Particle Sizer (SMPS):
Particle Size Distribution (6-300 nm)

Condensation Particle Counter (CPC):
Total Particle Number Concentration

Weather Wizard III:
Wind speed and direction

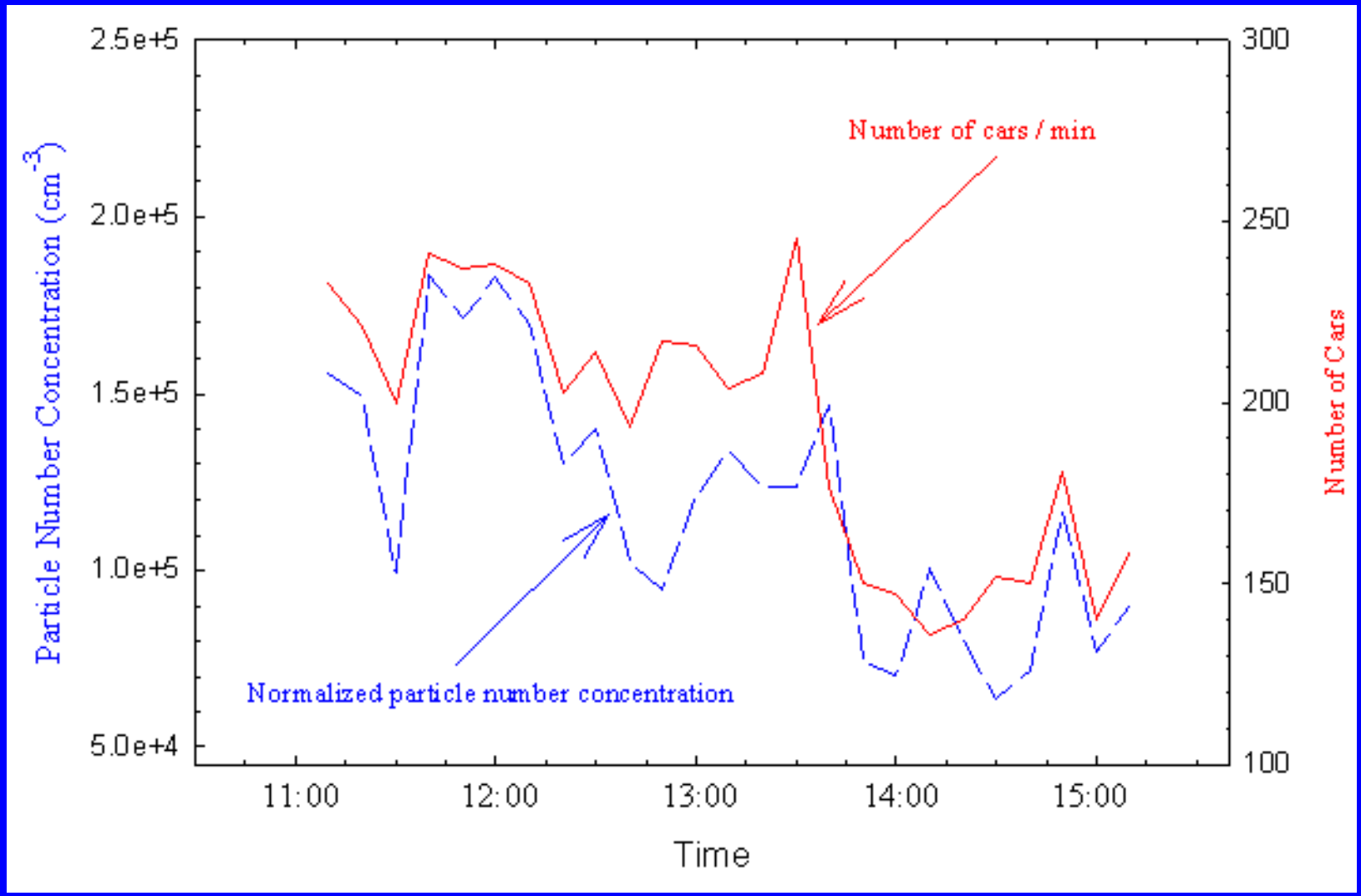
Portable Aethelometer: EC

Dust Trak: Real time
PM10, PM2.5

Q-Trak: CO, CO2, Temp, Rh

# Experimental Setup: 2001 Daytime

# **Traffic Effect:** Total Particle Number Concentration & Traffic Density






Zhu et al., 2002a

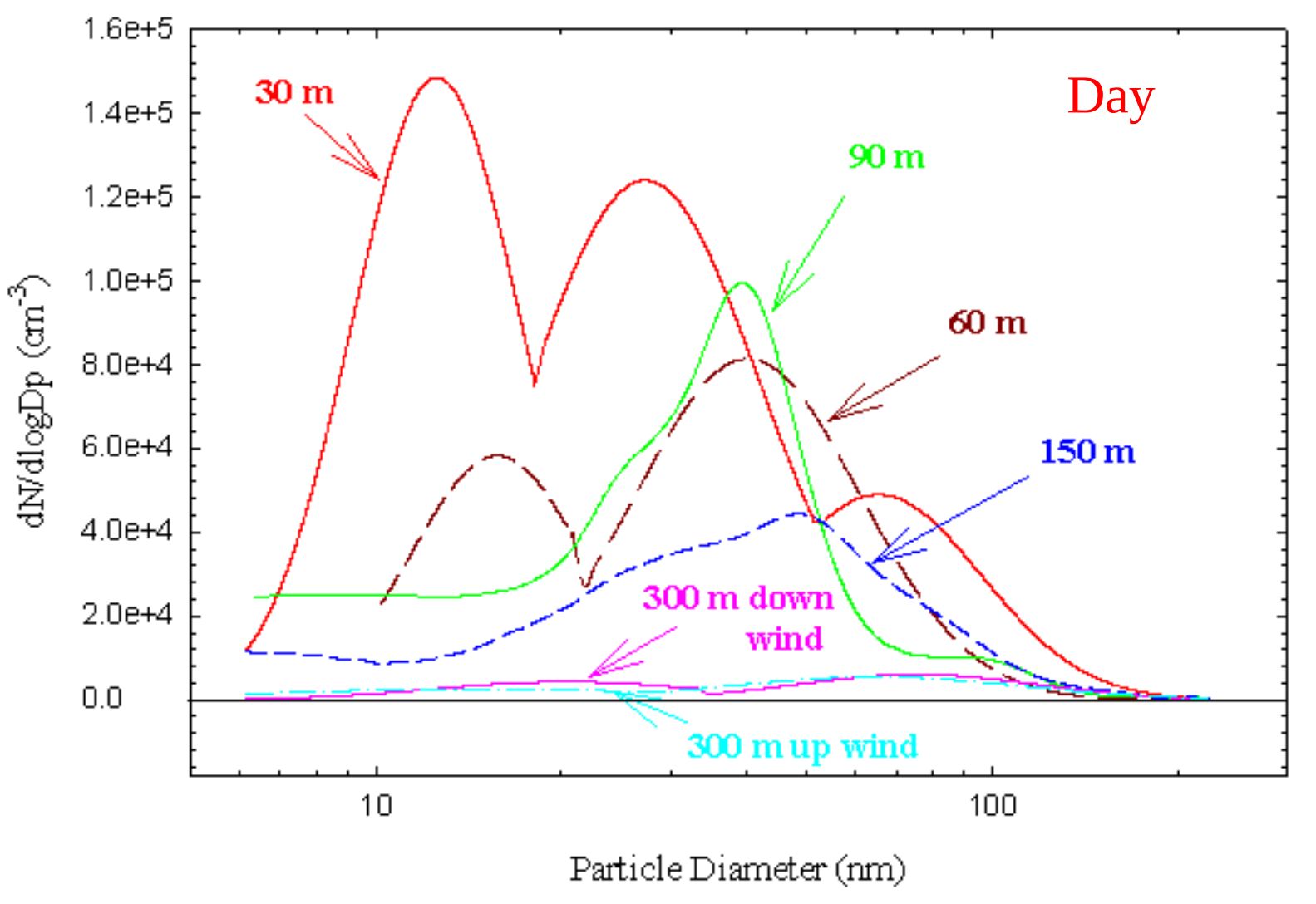

- **Normal Traffic**

- **Traffic Slowdown**



Zhu et al., 2002a

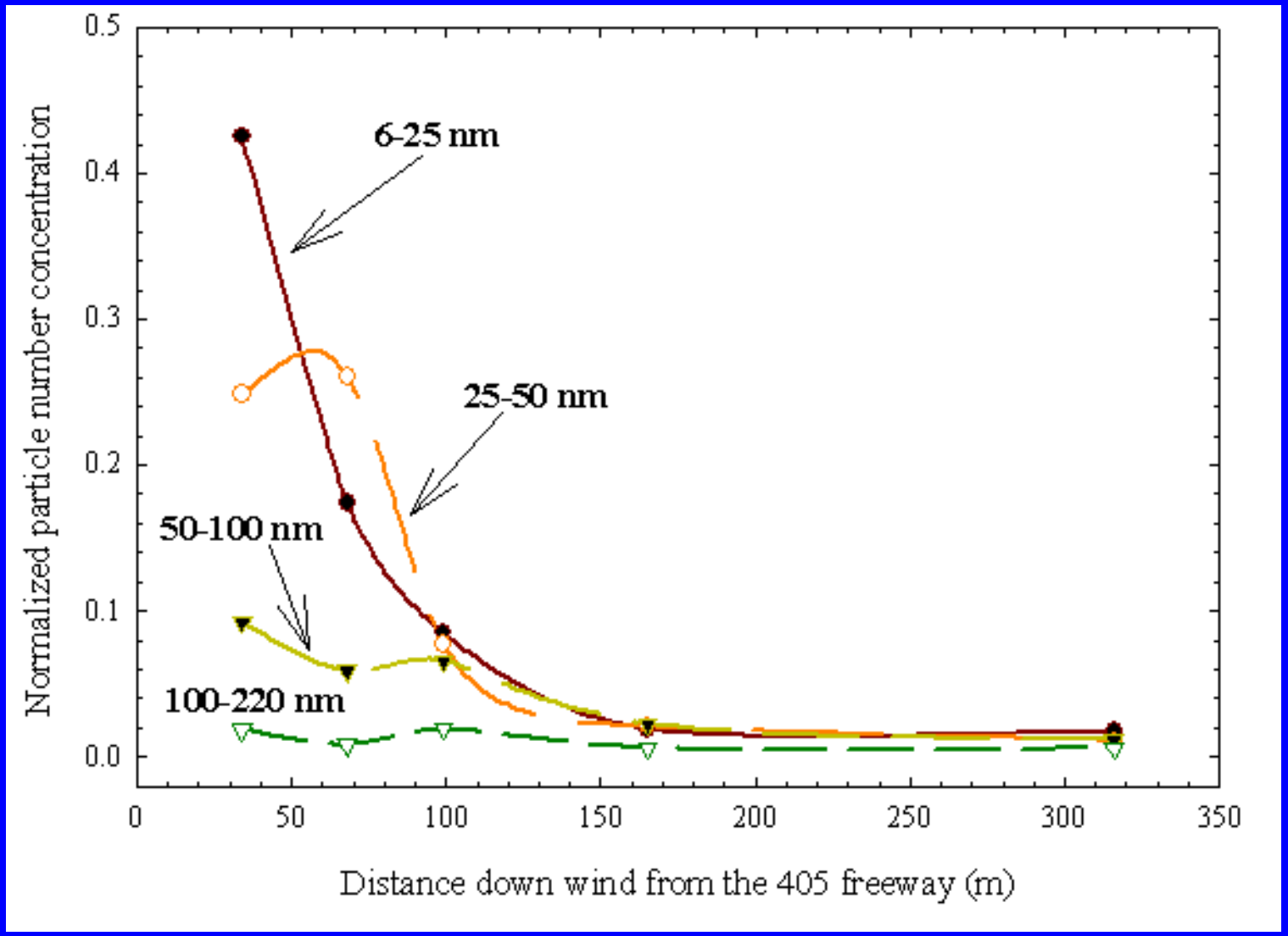
# RESULTS: Change in Ultrafine Particle Size Distribution with Increasing Distance






Zhu et al., 2002a

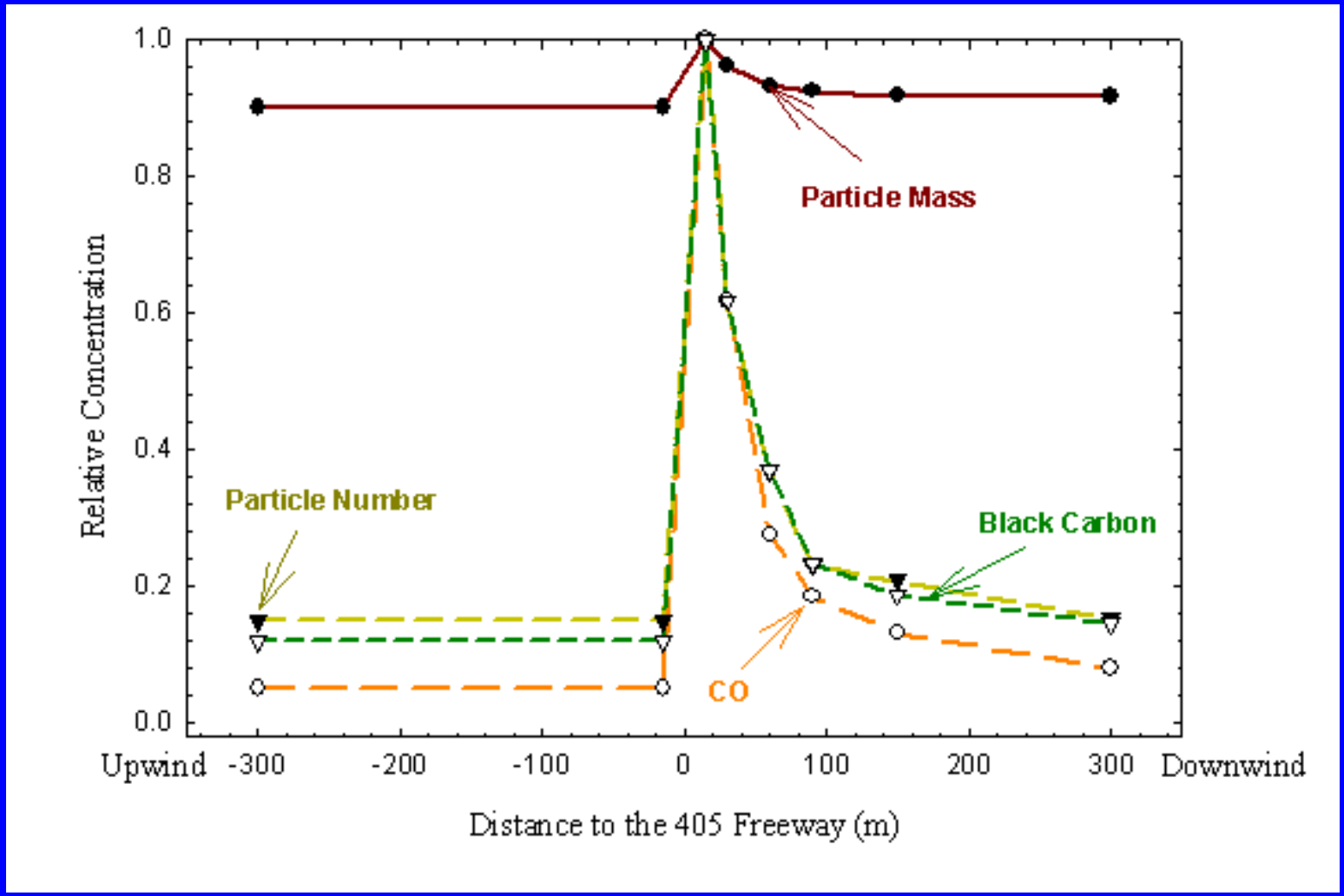
# RESULTS: Number Concentration for Different Size Ranges Vs. Increasing Distance from Freeway 405.






Zhu et al., 2002a

# RESULTS: Relative Particle Number, Mass, Black Carbon, CO Concentration, Vs. Downwind Distance from Freeway 405.






Zhu et al., 2002a

# Los Angeles Times

December 15 2002

## Too freeway close?

**Homes along the Southland's busy highways may be more affordable, but new studies show pe increased pollution.**

By William J. Kelly
Special to The Times

# Daily News

FRIDAY, OCTOBER 18, 2002

## Study: Freeway air filled with unhealthy particles

By Kerry Cavanaugh
*Staff Writer*

People living downwind from freeways or major intersections may be inhaling air that is 30 times more concentrated with unhealthy particles, says a first-of-its-kind health study released Thursday.

Researchers at the University of California, Los Angeles, tested the air along the San Diego and Long Beach freeways and found that areas within 165 feet had particle concentration levels of up to 30 times greater than normal.

"Most people spend an hour a day on the freeway, maybe more," said William Hinds, UCLA professor of environmental health sciences and co- author of the study. "They may be at more risk."

Ultrafine particles — those less than 0.1 micrometers in diameter — one-hundredth

period — can be more toxic than larger particles.

Fine particles are an especially dangerous form of pollution, which can reach into the deepest part of the lungs. Fine particles have been linked to respiratory and pulmonary problems.

The study also found that carbon monoxide and black carbon pollution was concentrated near freeways and busy intersections.

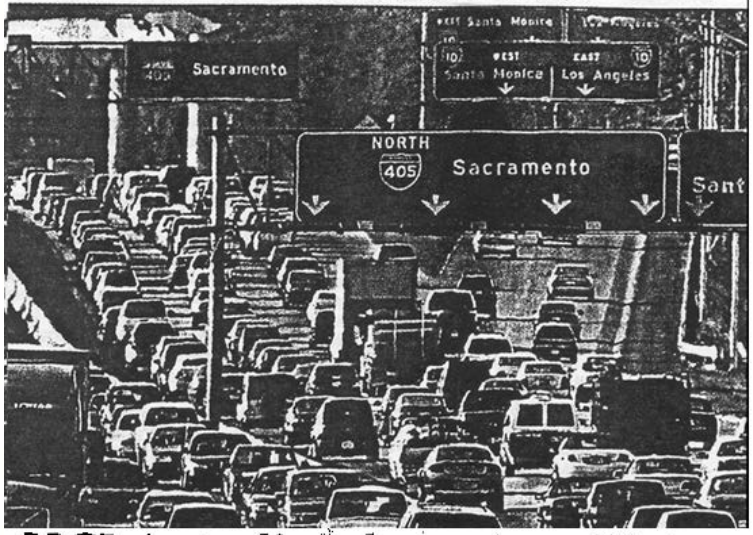
Researchers' findings might seem obvious but the results will play an important role as scientists continue to study the effects of vehicle pollution on health, said Wendy Hunter with UCLA. Next, researchers want to look at human exposure to fine particles while driving on congested routes.

The study was funded by the U.S. Environmental Protection Agency, the California Air Resources Board and the National Institute of Environ-

# Daily Breeze TODAY

MIND & BODY

**"Just think of how many hours people spend on the freeways. The exposure time could be very long."**
— YIFANG ZHU,
researcher with UCLA's Southern California Particle Center and Supersite




## UCLA studies show air pollution worse downwind of freeways

THE UNIVERSITY OF CALIFORNIA, LOS ANGELES

# DAILY BRUIN

Monday, October 28, 2002

## Fine particles may be health threat

UCLA STUDIES REVEAL EMISSIONS MOOT PARTICLE POLLUTION

VOL.23 NO.4 OCTOBER 22, 2002

# UCLA TODAY

CONNECTING STAFF AND FACULTY IN THE UCLA COMMUNITY

### TOO CLOSE FOR COMFORT

People who live, work or travel within 165 feet downwind of a major freeway or busy intersection are exposed to potentially hazardous particle concentrations up to 30 times greater than normal background concentrations found at a greater distance.

# Daily Breeze

Local News

## Residents near freeways get more hazardous pollution

**From staff reports**

Anything 165 feet away or closer.

That's too close when it comes to freeways, say new UCLA studies that found people living or working in the freeway-close zone are subjected to vastly greater concentrations of hazardous particle pollution, from all those tailpipes.

Proximity to freeways or busy intersections particularly boosts exposure to the tiniest or "ultrafine" airborne bits, which are the hardest on human health, said two studies out of the UCLA Southern California Particle Center and Supersite.

One study focused on the San Diego (405) Freeway while the other one looked at the Long Beach (710) Freeway.

The concentration of ultrafine particles downwind was 25 to 30 times greater than upwind of the freeways.

A 1999 study by a North Carolina research institute found that drivers in Los Angeles and Sacramento while in their vehicles were subjected to pollution levels 10 times higher than locations near the road. It's not known how this data fits in with the UCLA

**SENATE BILL** **No. 352**

**Introduced by Senator Escutia**

February 19, 2003

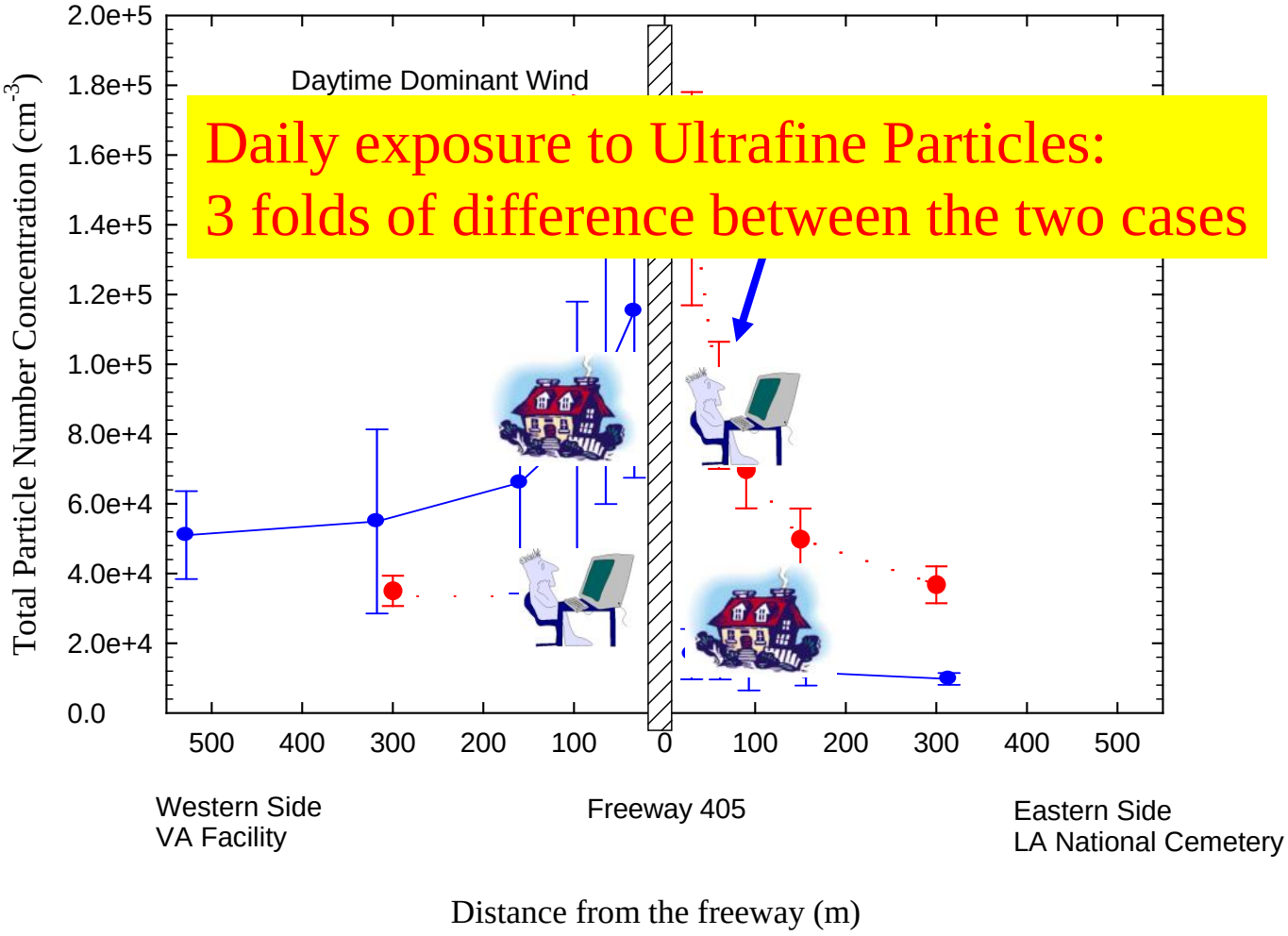


including, but not limited to, a prohibition of the approval by the governing board of a school district of the acquisition of a schoolsite by a school district unless prescribed conditions relating to possible exposure to hazardous substances are satisfied, and a prohibition on the approval of a related environmental impact report or negative declaration.

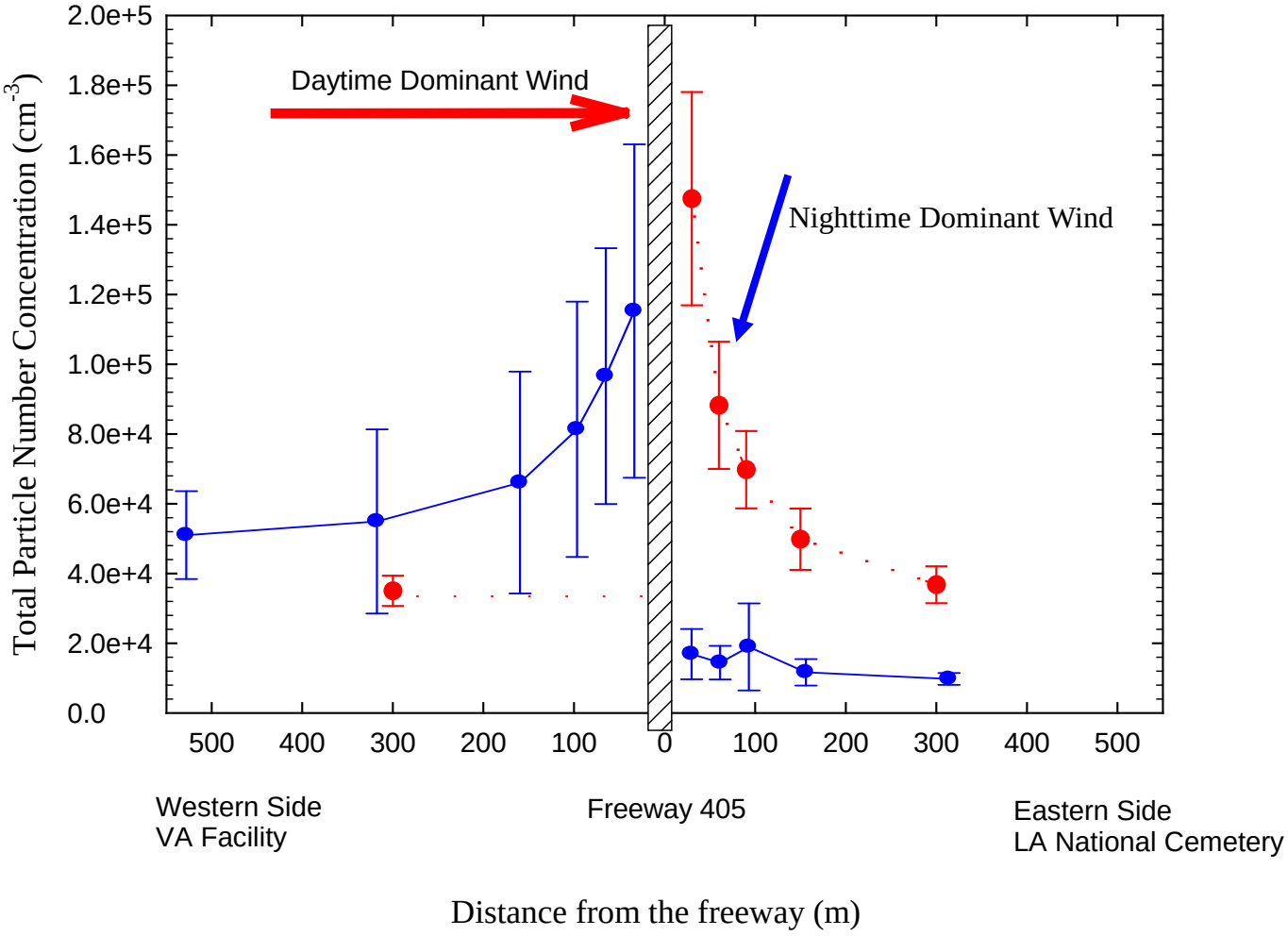
This bill would, in addition, prohibit the approval of a schoolsite within 1,000 feet from a freeway or busy roadway unless prescribed conditions are met and would make conforming changes.

# Experimental Setup: 2004 Nighttime

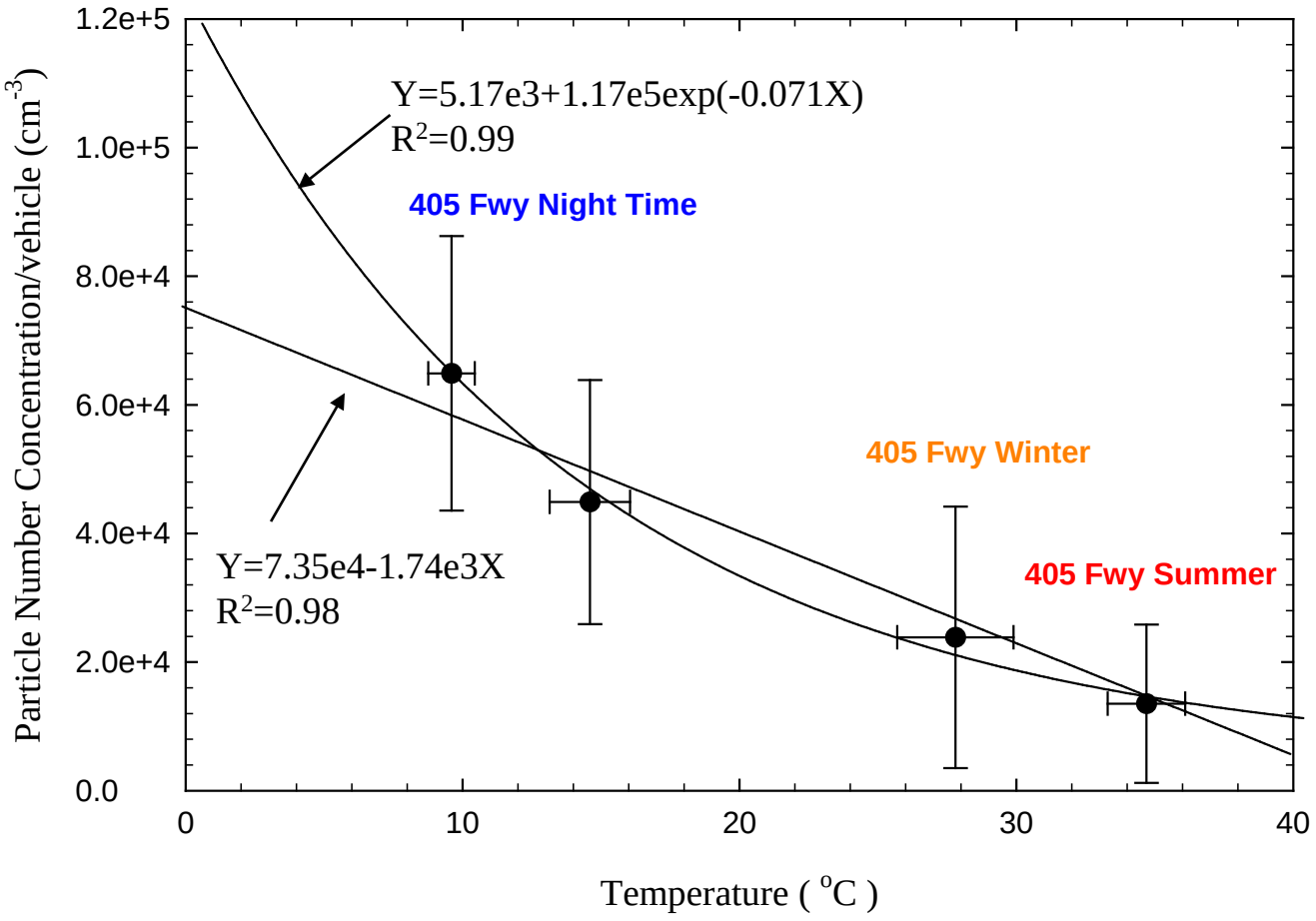
# RESULTS: Decay of Total Particle Number Concentration



# RESULTS: Decay of Total Particle Number Concentration



# RESULTS: Temperature Effect

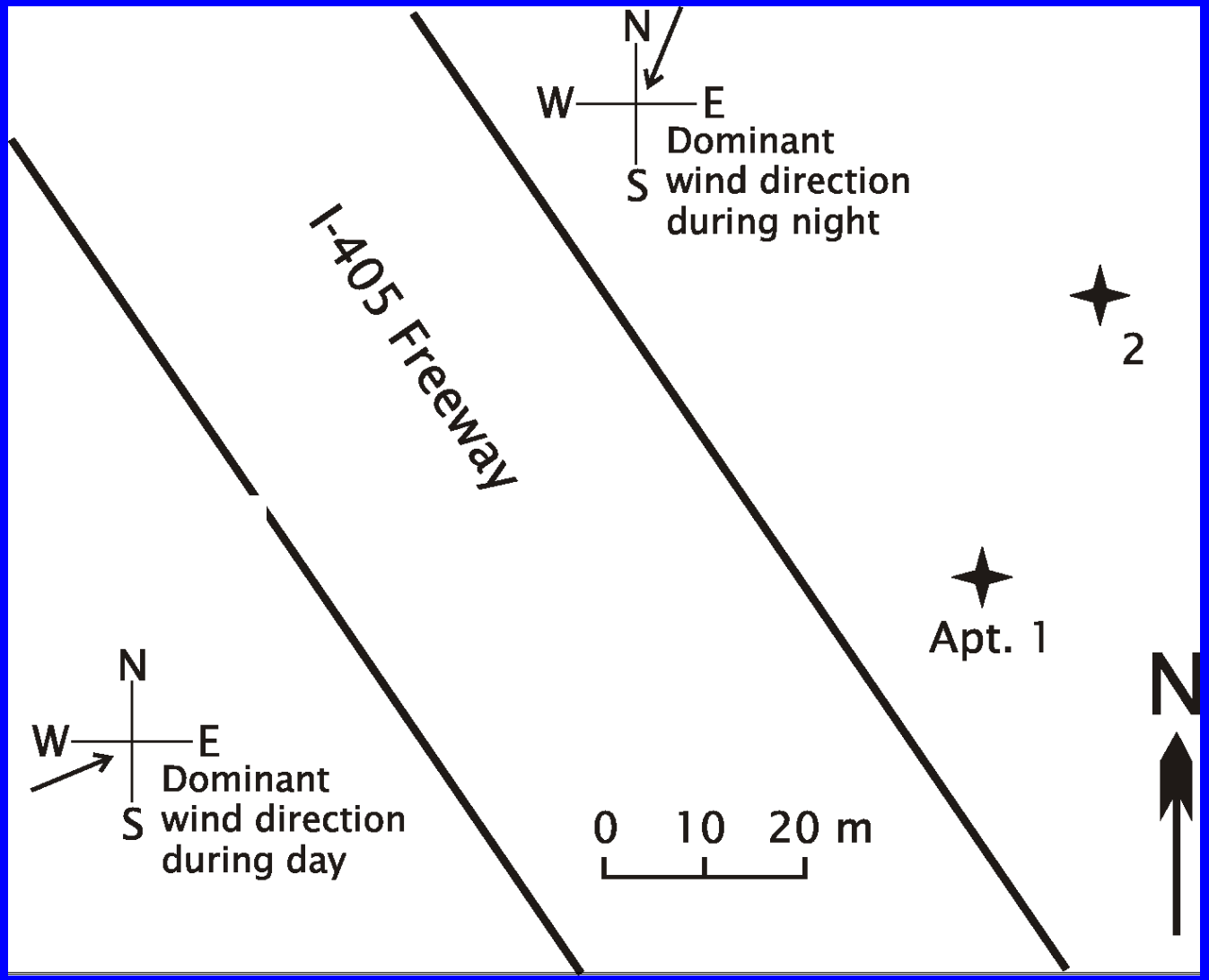





Zhu et al, 2006

# Indoor Study

- Sampling Site and Dominant Wind



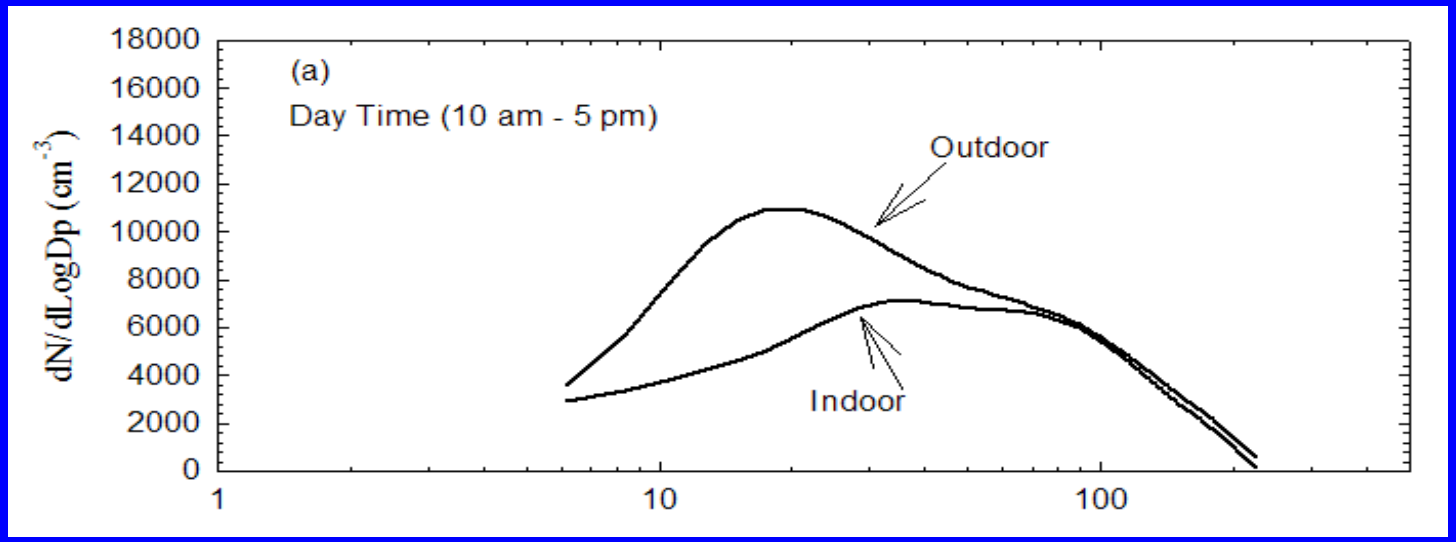



Zhu et al., 2005

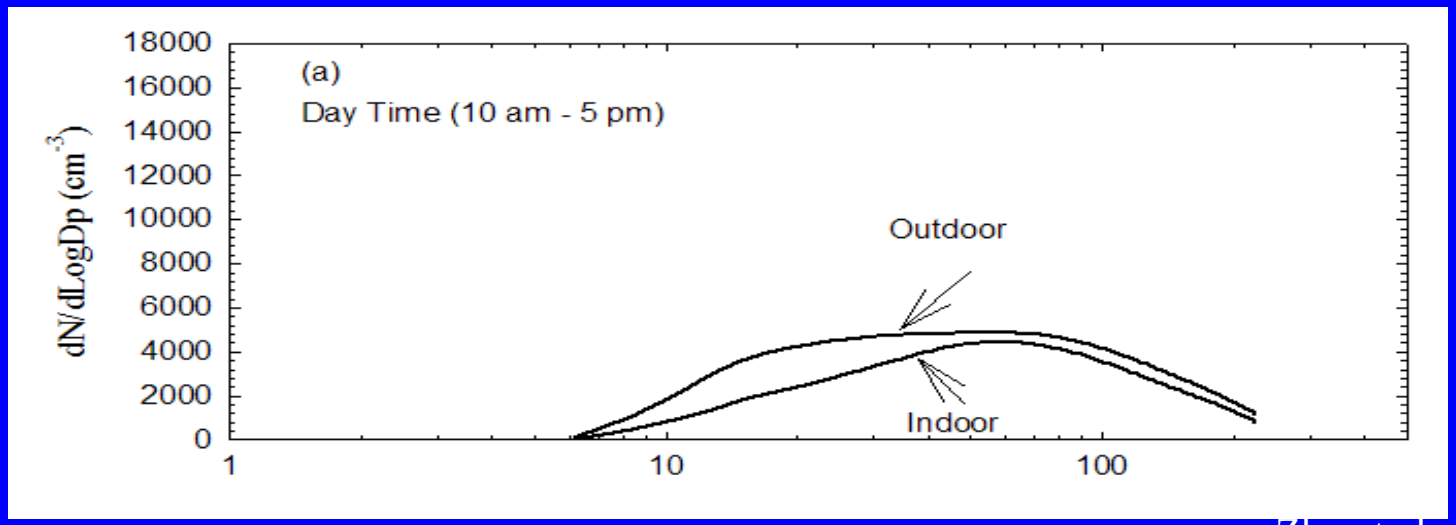
# I-405 Freeway

# RESULTS: Effect of distance from freeways

- **Apartment 1**

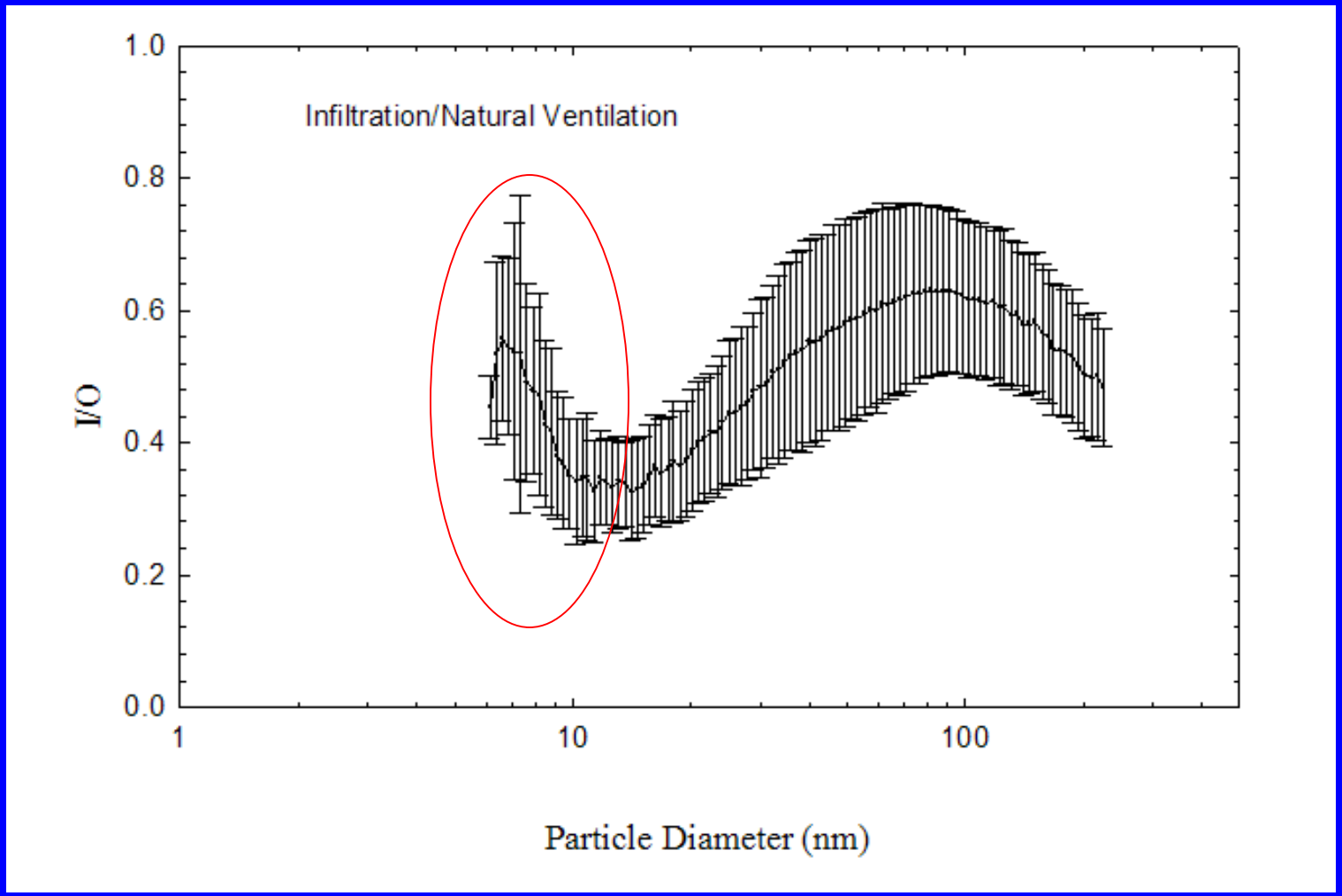



- **Apartment 2**




Zhu et al., 2005

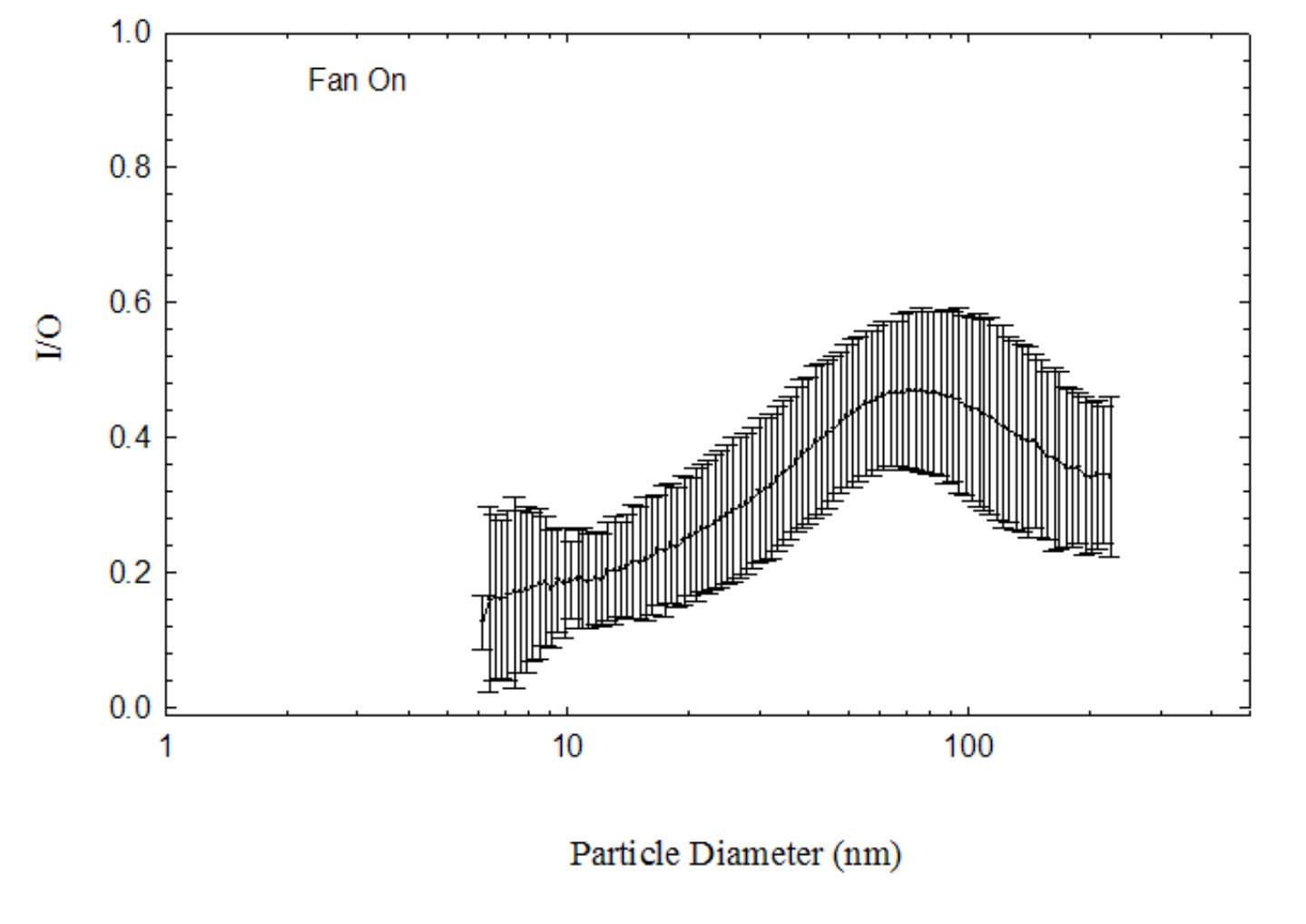
# RESULTS: Effect of Ventilation Conditions on Size Segregated I/O Ratios






Zhu et al., 2005

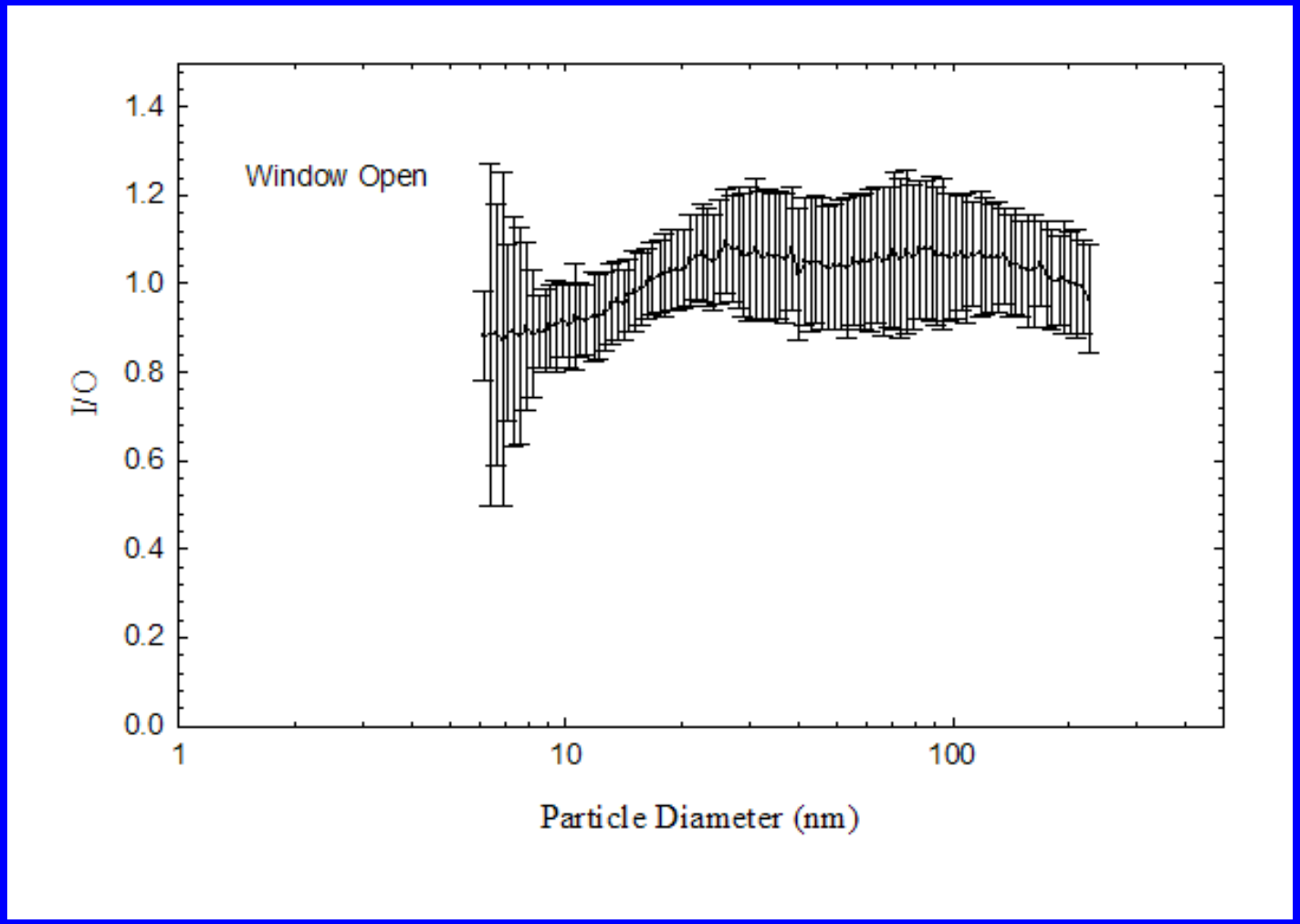
# RESULTS: Effect of Ventilation Conditions on Size Segregated I/O Ratios






Zhu et al., 2005

# RESULTS: Effect of Ventilation Conditions on Size Segregated I/O Ratios

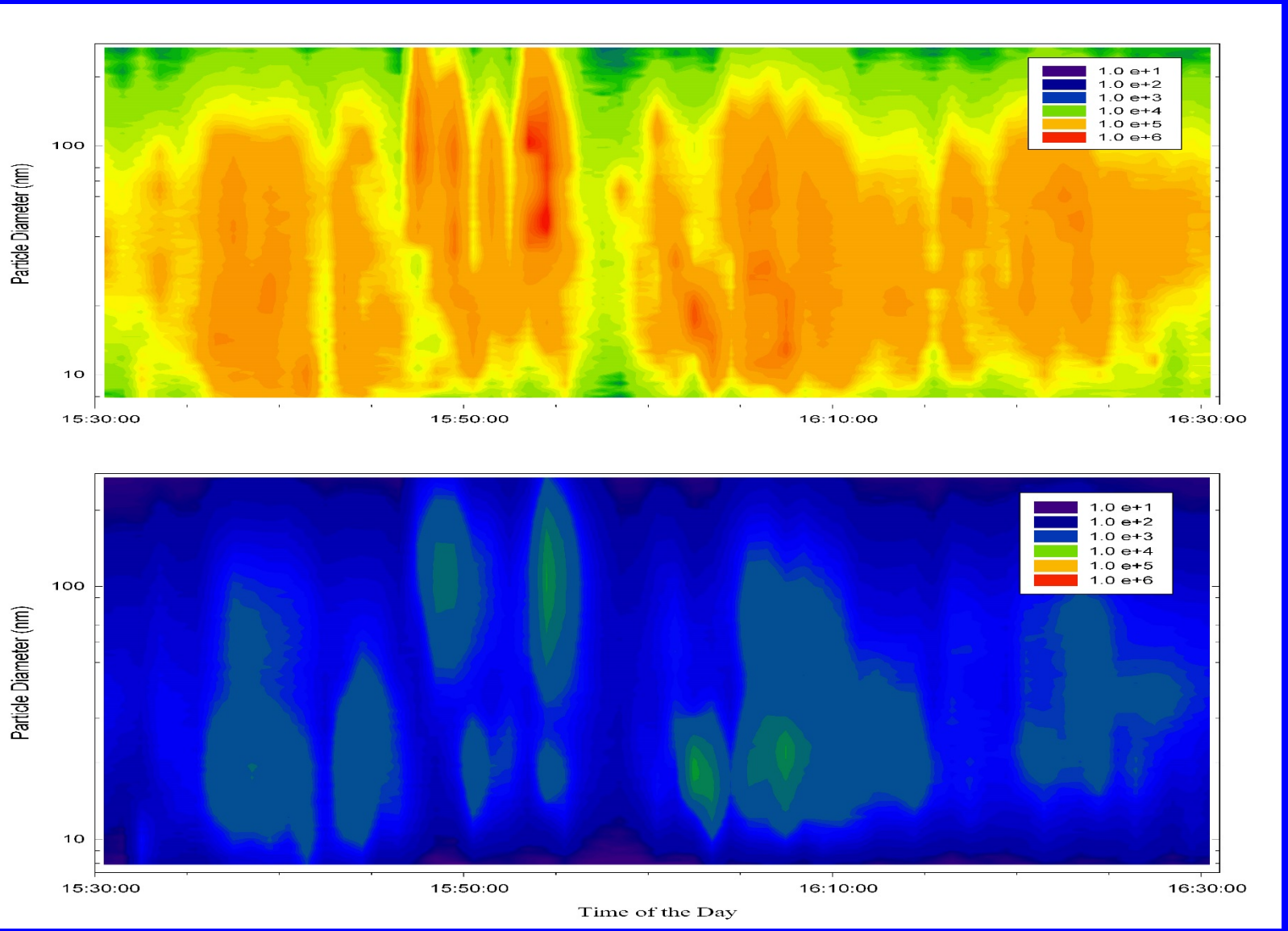





Zhu et al., 2005

# In-Cabin Study

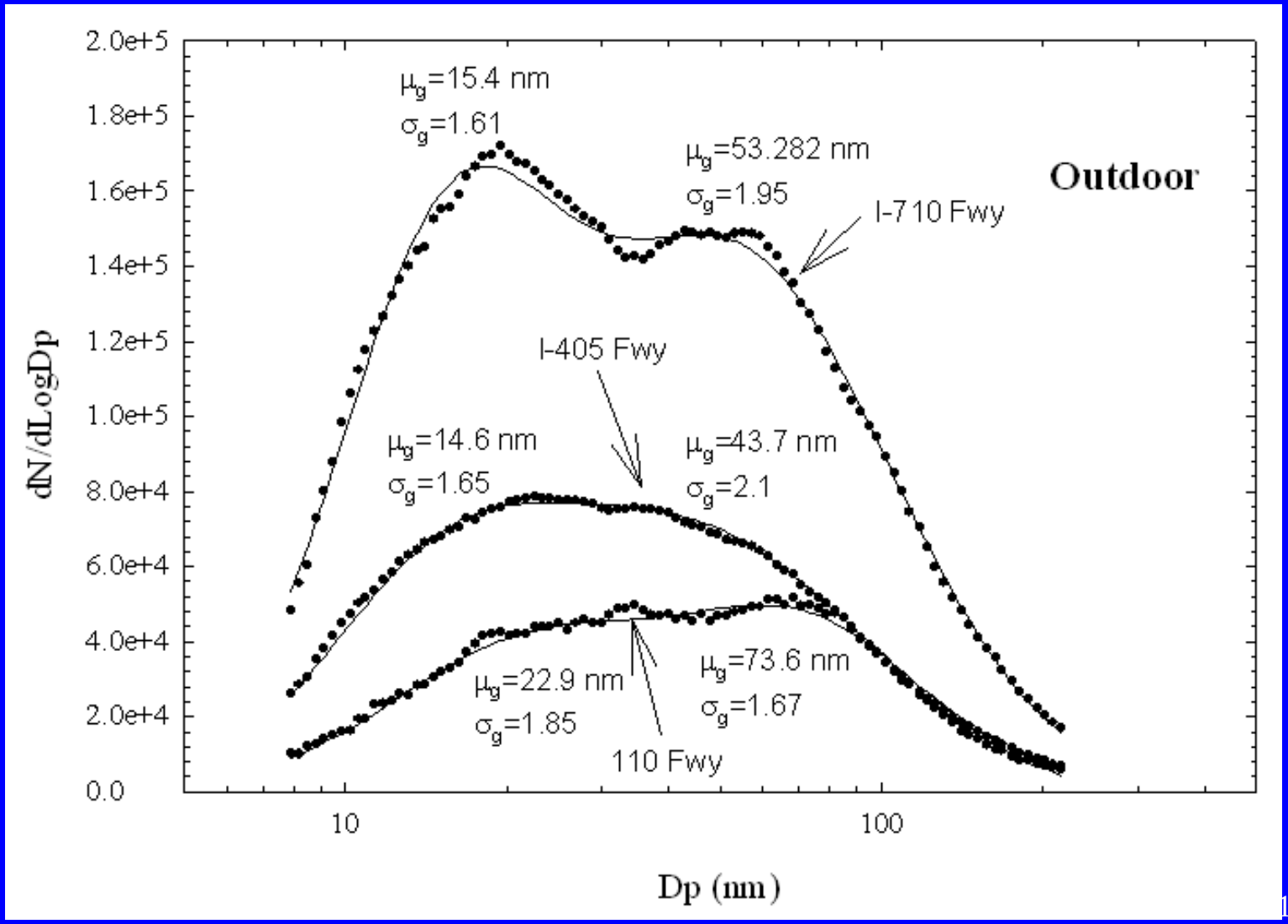
# Outdoor and In-Cabin Size Distribution Time Series





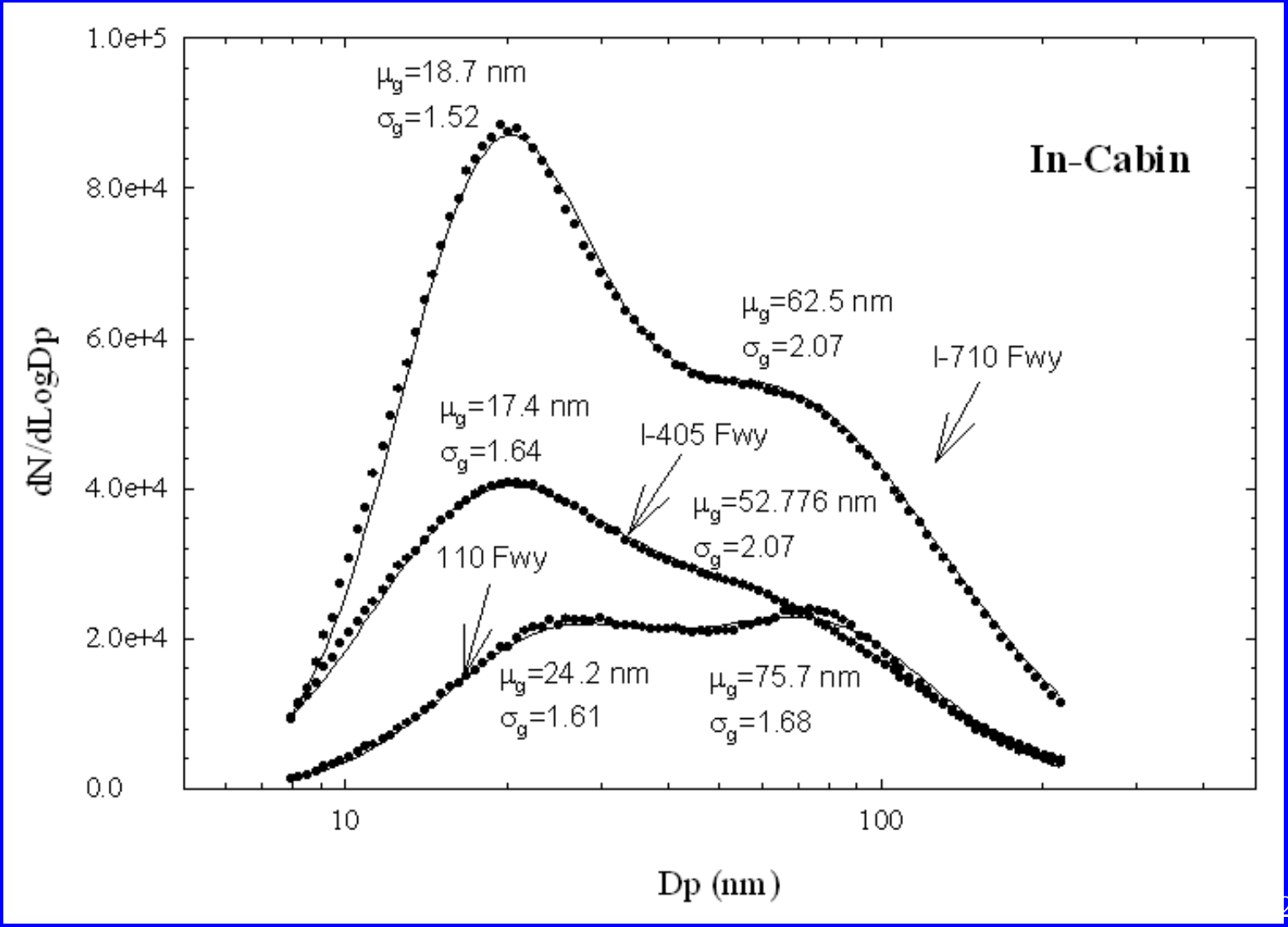

Zhu et al., 2007

# Average Outdoor UFP Distribution on Different Freeways



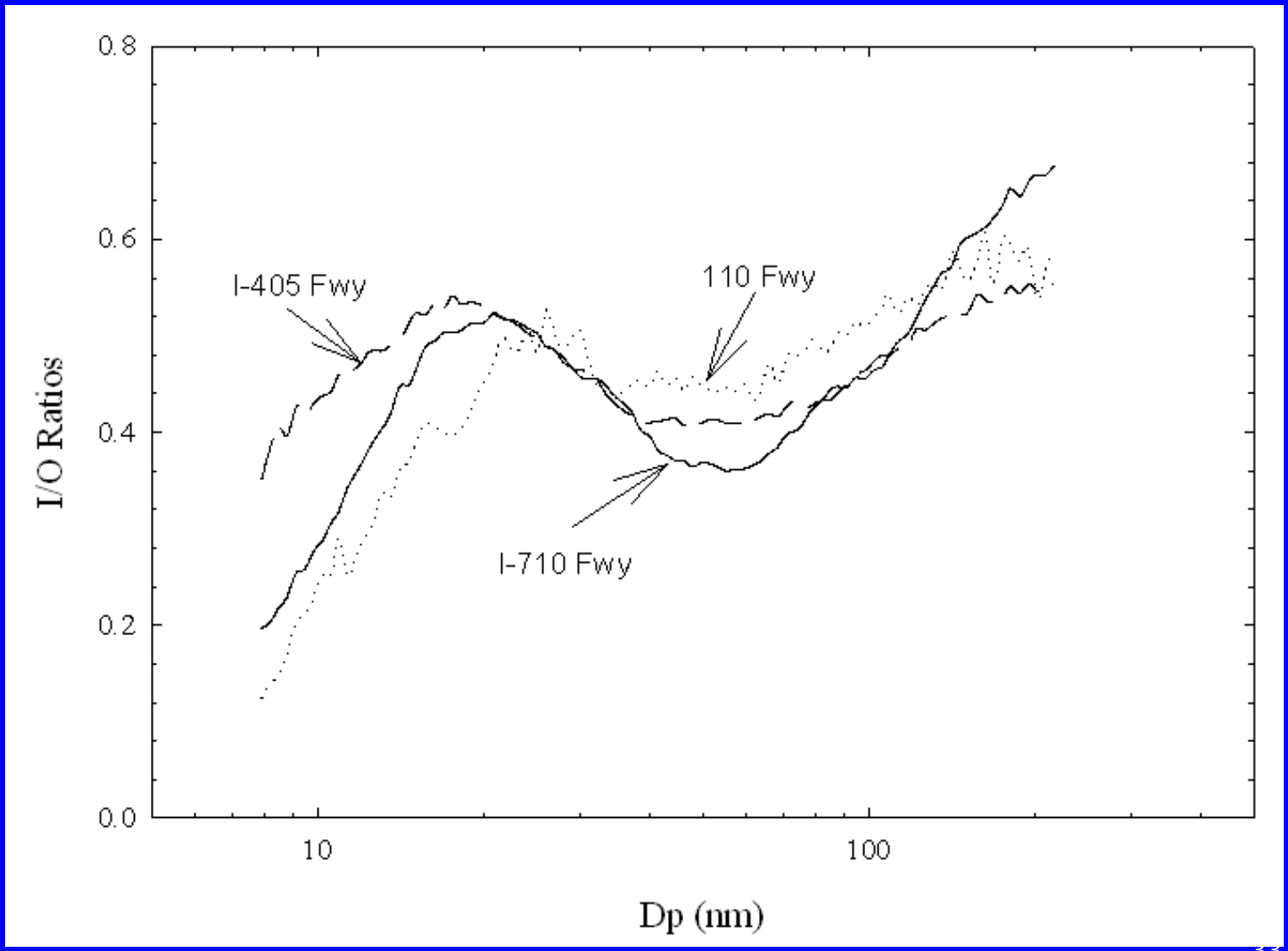

Zhu et al., 2007

# Average In-Cabin UFP Distribution on Different Freeways




Zhu et al., 2007

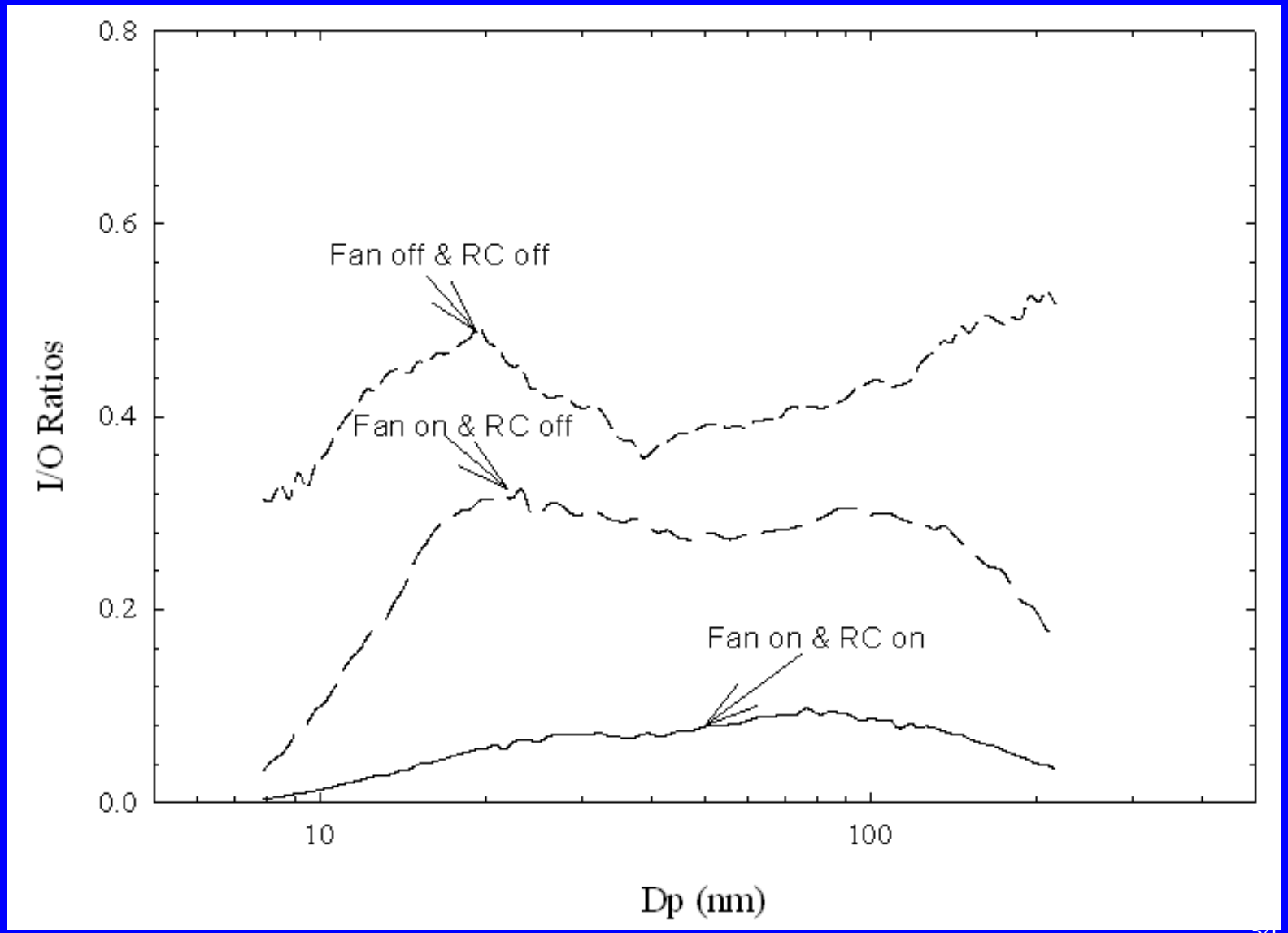
# Similar I/O Ratio Profiles on Different Freeways






Zhu et al., 2007

# Effect of Ventilation Conditions on I/O Profiles






Zhu et al., 2007

# TAKE HOME MESSAGES

- Because of dilution (and coagulation/condensation) ultrafine particles behave like a local source.
- Central station monitoring not useful for estimating dose
- 1 hr on freeway exceeds 23 hrs away from freeway.
- Newer vehicles with recirculation on helps to reduce in-cabin ultrafine particle exposure.

# TAKE HOME MESSAGES

- Most ultrafine particles formed after exhaust leaves the tailpipe

  - Cooling and dilution both occurring
  - Cooling increases nucleation
  - Dilution decreases nucleation
  - Complex physical process
  - Sensitive to environmental conditions

# FUTURE WORD

- **Assessing Children's Exposure to Ultrafine Particles from Vehicular Emissions**

  Objective: To identify hot spots in South Texas where school children are likely to be exposed to high levels of UFPs and develop simple models to estimate children's exposure to UFPs from vehicular emissions.

- **Using In-Situ Observations to Quantify Emissions from Prescribed Fires in two Grassland-Pine Ecosystems**

  Objective: To directly quantify UFP emissions from prescribed fires on DoD managed grassland and grass-shrub type ecosystems with different fuel types and fuel loadings.

# FUTURE WORD

Master and Ph.D. Students will be Financially Supported in Part by National Science Foundation (NSF) sponsored Center for Research Excellence in Science and Technology (CREST)- Research in Environmental Sustainability for Semiarid Coastal Areas (RESSACA) at Environmental Engineering Department at Texas A&M University-Kingsville.