Atmospheric Monitoring of Ultrafine Particles

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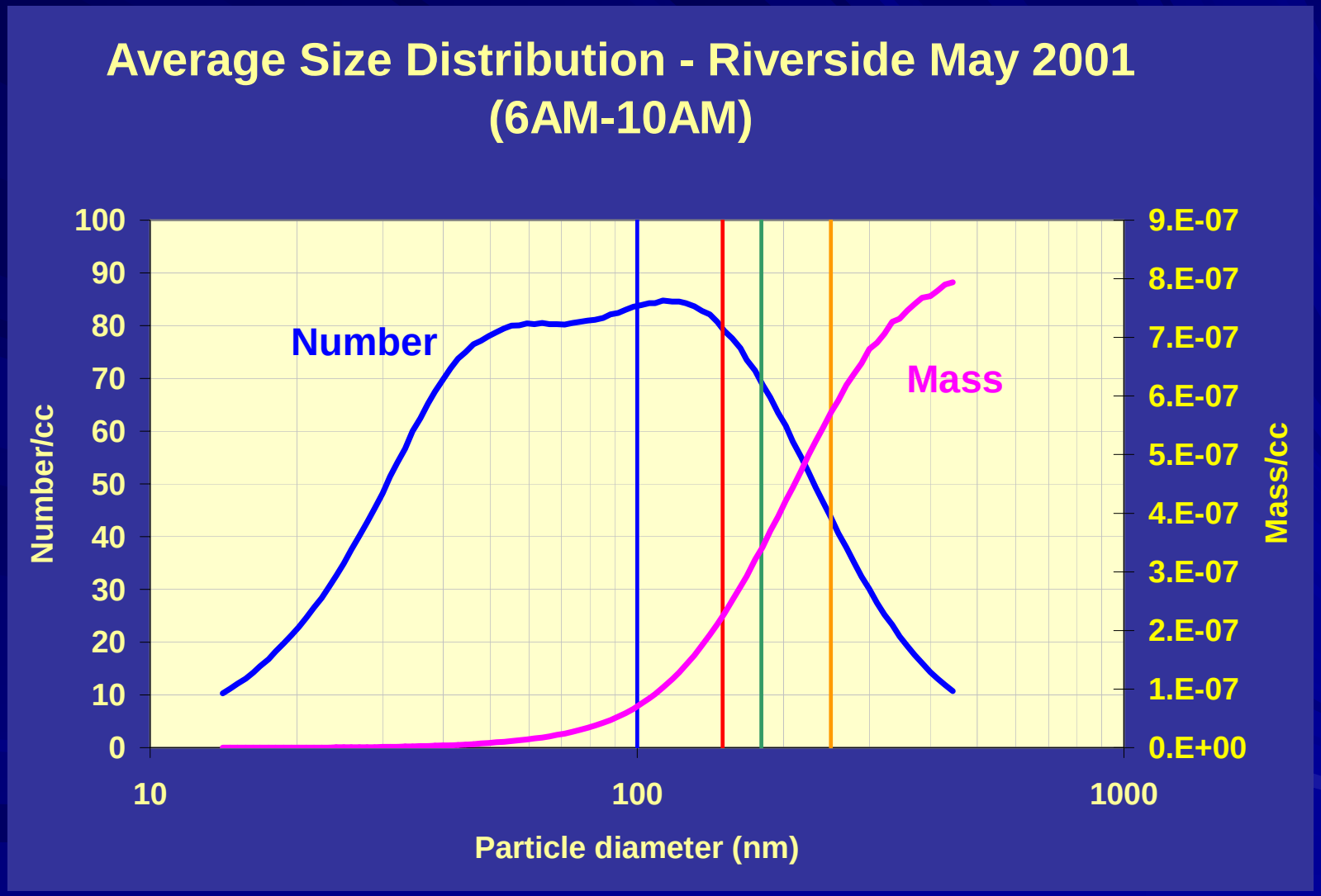
Outline

- What do we monitor?
  - Mass, upper size cut, total number, non-volatile number
- Where do we monitor for Ultrafines?
  - Siting criteria
  - Local or regional influences
  - Number of locations
- How do we monitor for Ultrafines?
  - Instrumentation
  - Averaging times/maxima – daily/annual
- Does a monitoring network for Ultrafines even make sense?
  - Criteria pollutant vs. air toxic

What Characteristics of Ultrafines Do We Measure?

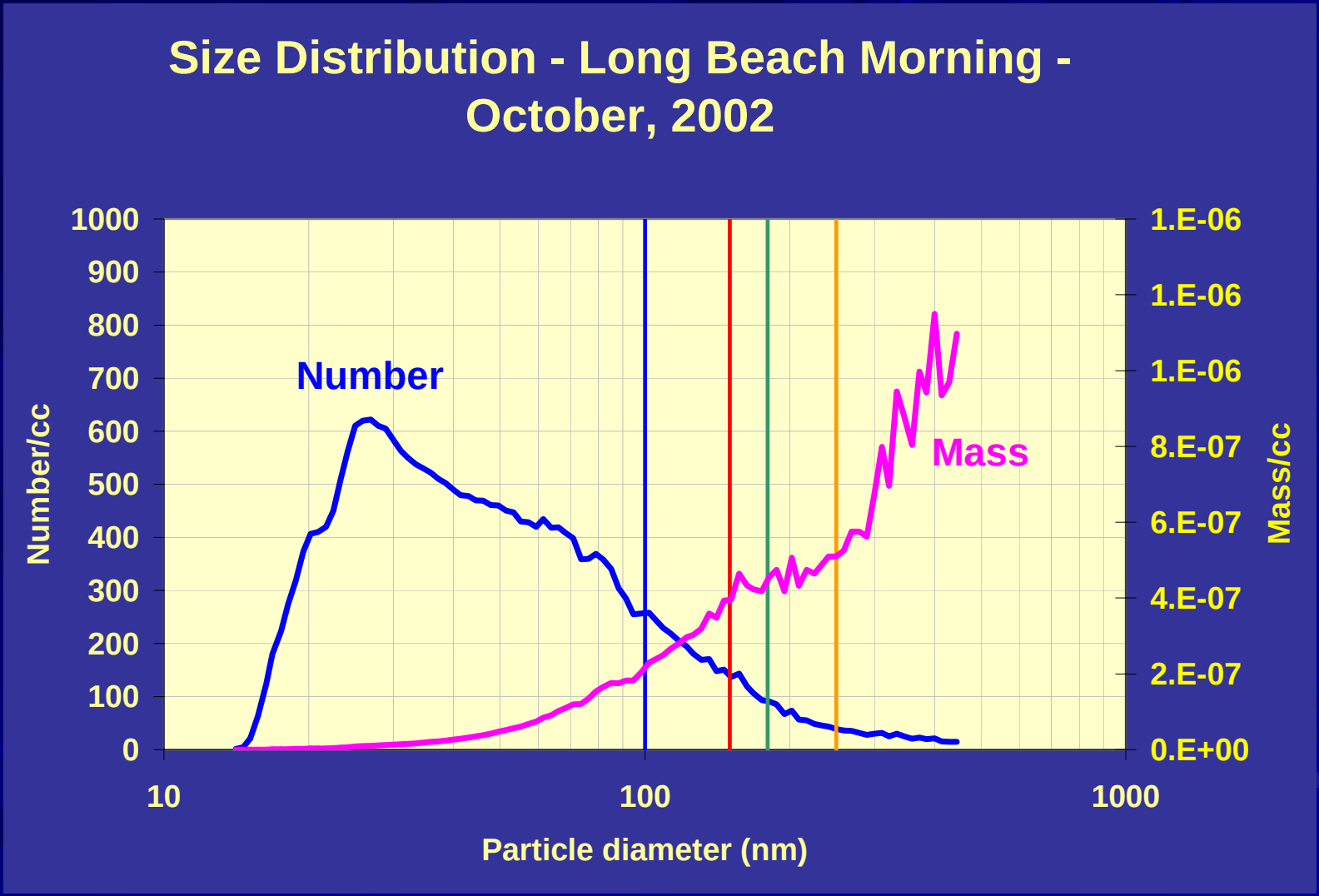
- Mass
  - PM mass measurements similar to PM10 or PM2.5 methods
    - Time-integrated filter-based methods
    - Continuous methods (TEOM, BAM)
  - Size-selective inlet to remove larger particles
    - Ultrafine size-cut leads to higher pressure drops across inlet device
      - Still feasible down to 150-180 nm
        - Demonstrated for 150 nm inlet on BAM (Chakrabarti et al., AS&T 38(S1), 2004)
      - What is the upper size cut?
        - 50 nm, 100 nm, 150 nm, 180 nm, 250 nm

Size Cut (Aged Aerosol)



100 nm 150 nm 180 nm 250 nm

Size Cut (Source Aerosol)



100 nm 150 nm 180 nm 250 nm

Size Cut

For the previous size distributions and upper size cuts, **80% of the measured particle mass** would be found in the following size ranges, thus biasing measurements towards the upper end of the measured ranges

Riverside

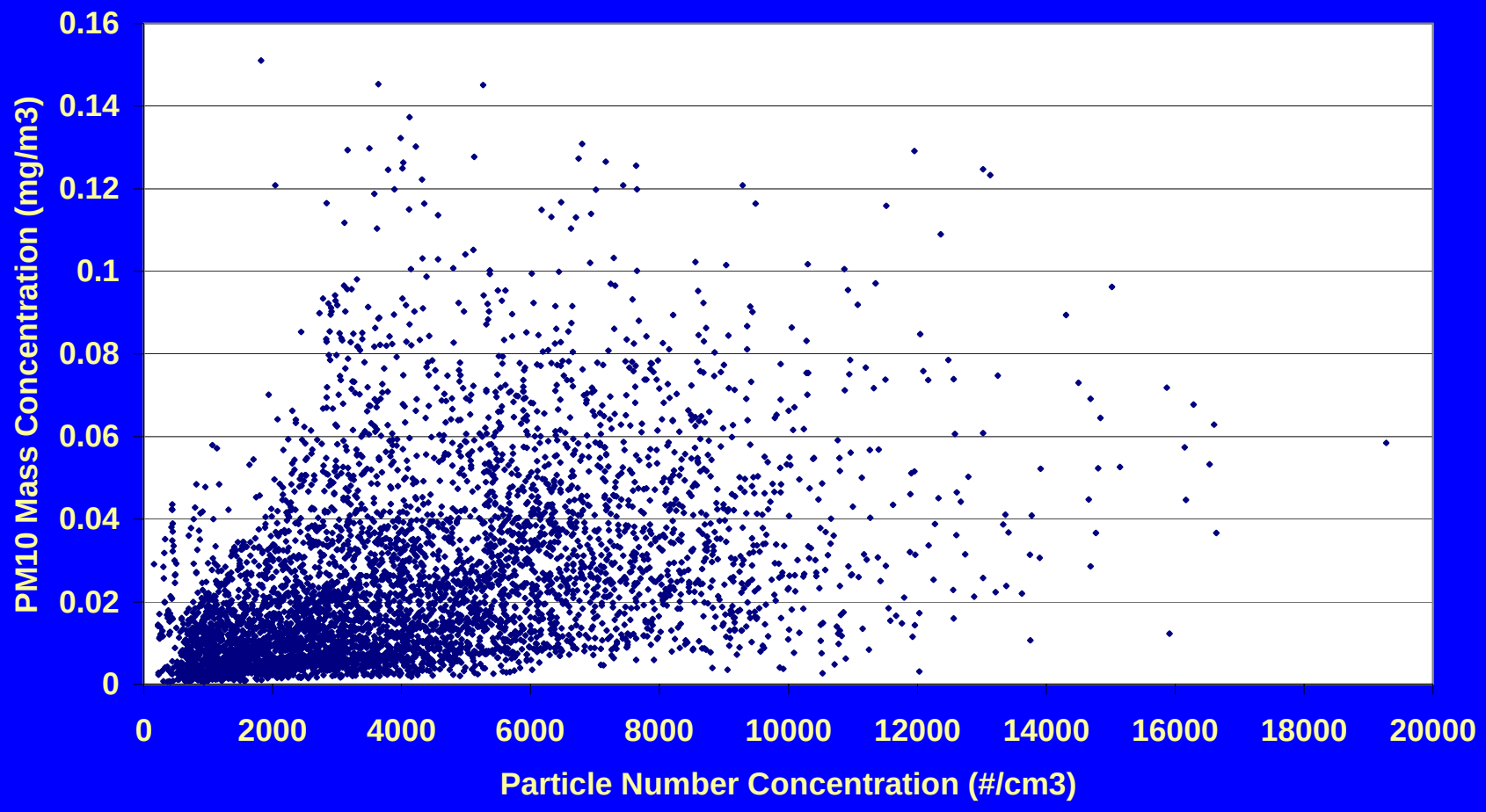
Upper Size Cut	80% of Mass Is Within
100 nm	61-100 nm
150 nm	94-150 nm
180 nm	109-180 nm
250 nm	141-250 nm

Long Beach

Upper Size Cut	80% of Mass Is Within
100 nm	55-100 nm
150 nm	73-150 nm
180 nm	82-180 nm
250 nm	98-250 nm

Number vs. Mass

Little or no correlation between PM number and mass



Riverside, Rubidoux, and Claremont, California. (Feburary 2001 - March 2002)
(Fine et al, AS&T, 38 (S1), 2004

What Characteristics of Ultrafines Do We Measure?

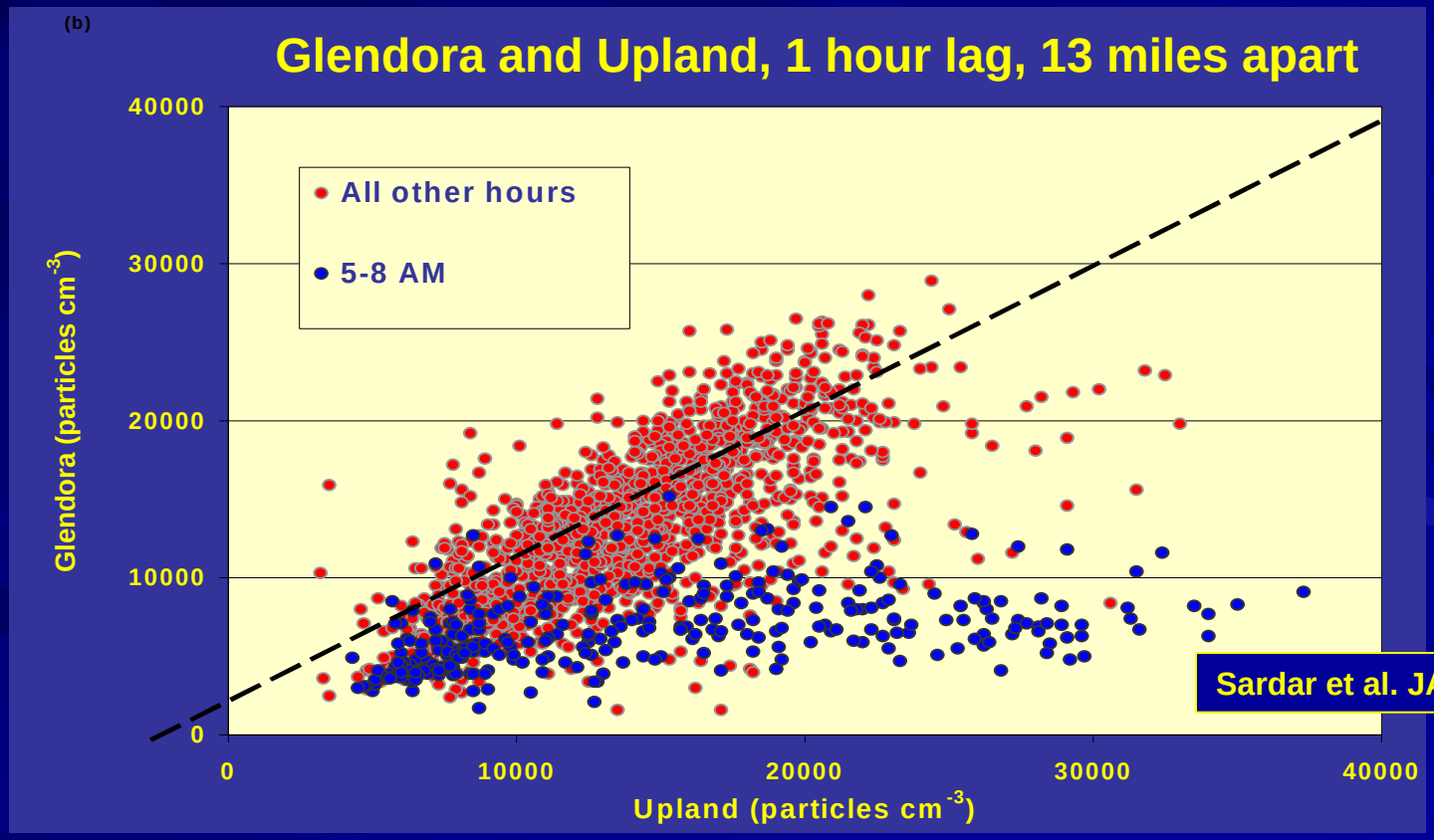
- Particle Number
  - Relatively easy continuous measurements with CPCs
  - Total Particles
    - Total or upper size cut?
      - Aged aerosol can have a mode at 100 nm or larger
    - Lower size cut of the type and model of CPC
      - Ranges from 5 nm to 20 nm
      - Potential composition effects
    - Accuracy of single counting vs. photometric modes
  - Non-Volatile Particles Only
    - Adapt PMP Protocol to ambient measurements
      - Thermal denuder or heater upstream
      - Possibly more consistent measurements

What Characteristics of Ultrafines Do We Measure?

- The Ultrafine characteristics measured by any ambient monitoring program should reflect the latest health effects data
  - More Volatile vs. Solid Particles
  - Mass vs. Number
  - Primary vs. Secondary
- Evidence exists for adverse health effects for all of the above.

Where do we monitor for Ultrafines?

- More challenging than more spatially homogeneous pollutants such as ozone and $PM_{2.5}$
  - Local sources (traffic) can dominate Ultrafine Number concentrations at any given location



Sardar et al. JAWMA 54, 2004

Where do we monitor for Ultrafines?

- Siting criteria
  - Distances from roadways and local sources
- Local vs. more regional influences
- Number of locations
  - Only 13 miles apart can give very different results
  - Good spatial coverage needed
  - Representative of human exposure
    - Most of daily exposure occurs during driving, not at home
  - Can particle number levels be interpolated or modeled, and what data do the models need?

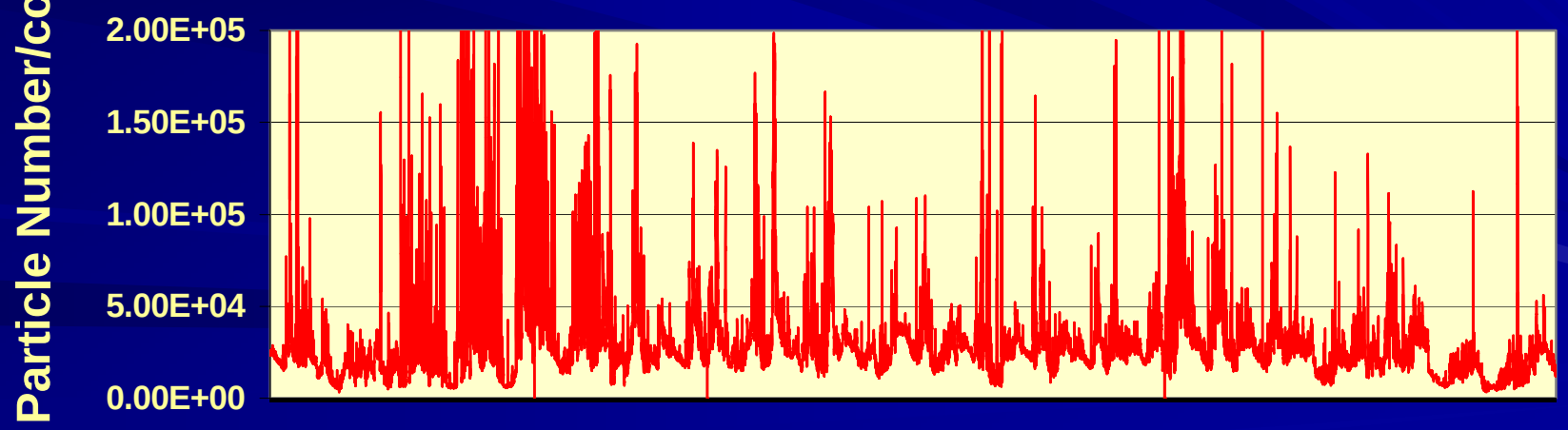
How do we monitor for Ultrafines?

- Instrumentation
  - Condensation Particle Counters ($12K-$25K)
    - Particle number only
  - Scanning Mobility Particle Sizers (up to $70K)
    - Full size distributions
    - Number and mass (with assumptions)
  - Filter-based techniques with inlet ($5K-$25K)
    - Mass only, speciation possible
    - Time-integrated or continuous
  - New, cheaper, smaller techniques are being developed
    - Number, size and mass

How do we monitor for Ultrafines?

- Averaging Times
  - An ambient standard could be based on:
    - Hourly, daily or annual averages
    - Maximum or percentile ranks of any of the above
  - Choice should be based on emerging health effects data
    - Acute effects: short-term events
    - Chronic effects: long-term exposure

December 2005, Van Nuys



Time, 1-minute data for one full month

Does a monitoring network for Ultrafines make sense?

- Criteria Pollutants
  - National Ambient Air Quality Standards
  - Regulation driven by ambient levels measured at Air Monitoring Stations
  - Source controls implemented to meet the Standards
- Hazardous Air Pollutants (Air Toxics)
  - Regulation at source only
    - No Net Increase
    - Best Available Control Technologies
  - Monitoring only for special studies or assessment programs

Does a monitoring network for Ultrafines make sense?

- Which approach should regulation of UF take?
- Criteria Pollutant Approach
  - Criteria Pollutants are generally regional or urban scale, while Ultrafines are more localized (exception: CO)
  - Monitoring issues more complex for Ultrafines than current criteria pollutants
    - more sites, more expensive equipment, complex atmospheric behavior (unlike CO)
- HAPs approach
  - Many HAPS are dominated by local industrial emissions
  - Most ultrafines are also local, but mostly from mobile sources
  - Control of mobile source emissions would not account for particle formation in the atmosphere

Conclusions

- If a decision is made to regulate Ultrafine Particles, the next step is to decide whether to regulate sources alone or also ambient levels
- If ambient monitoring is desired, the UF metric should be based on emerging health effects data
- The design of a monitoring network for Ultrafine particles needs to consider
    - Representation of population exposure
    - Local, regional and secondary particle sources
    - Cost
- Modeling estimates (i.e. distance to roadways, traffic density) should also be considered