# Ion-Induced Nucleation of Atmospheric Aerosols

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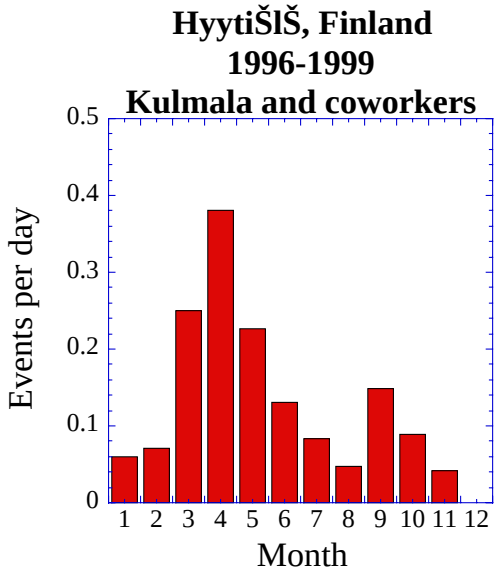
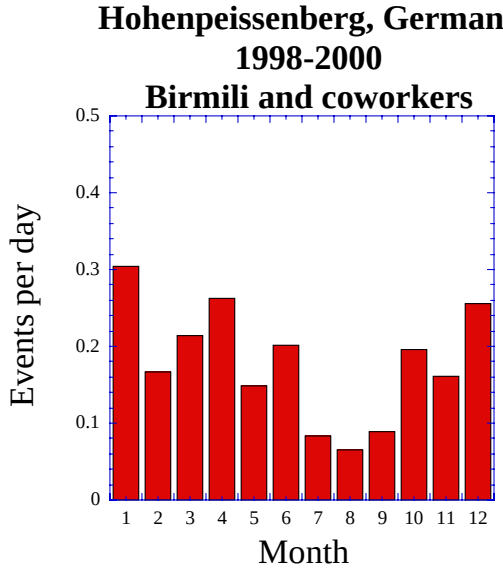
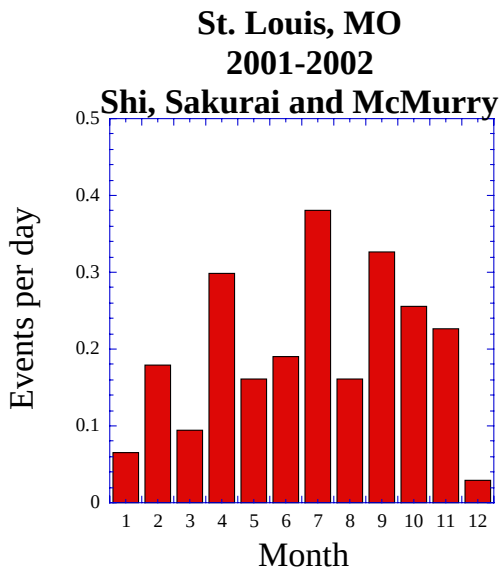
# Frequency of Regional Nucleation Events at Three Locations[1]




Finnish Boreal Forest




Continental Europe



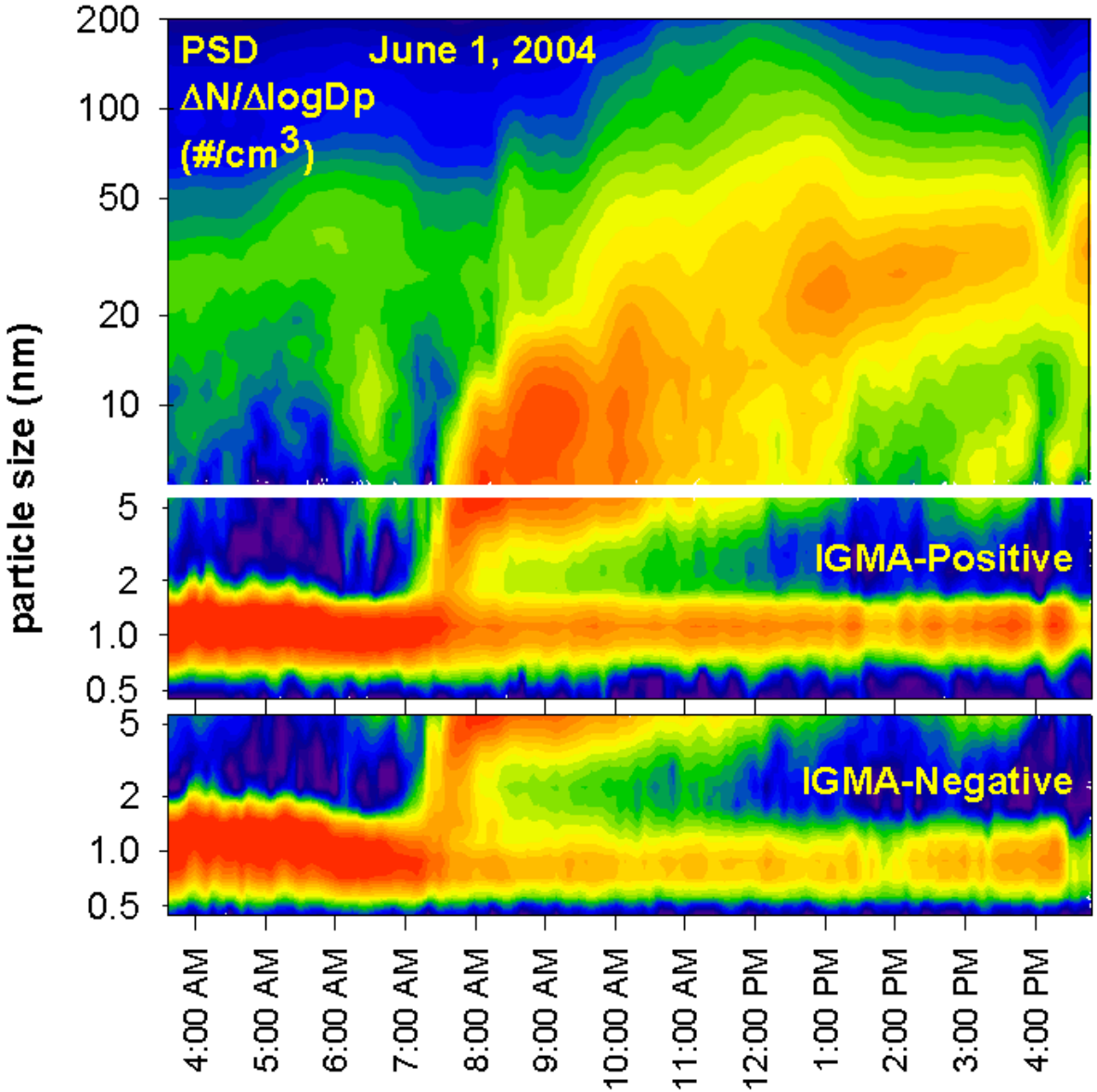

Major U.S. City

[1]Kulmala, M., H. Vehkamäki, T. Tetäjä, M. dal Maso, A. Lauri, V.-M. Kerminen, W. Birmili, P. H. McMurry, 2004, "*Formation and growth of ultrafine atmospheric particles: A review of observations,*" J. Aerosol Sci., **35(2)**:143-176.

# Environmental Importance of Atmospheric Nucleation

- Effects of nucleation on climate
  - Formation of cloud condensation nuclei
  - Effects on aerosol size distribution
    - » Albedo and optical extinction
    - » Dry deposition
- Effects on human health
  - Lung deposition of nanoparticles

# Number Distributions During Nucleation Event in Boulder, CO




Nano-SMPS Data

*Size distribtions of All particles (neutral+positive + negative)*

IGMA Data:

*Size distributions of Positive (top) or Negative (bottom) particles*

# Nucleation Mechanisms

- Neutral molecule
  - Involves clustering of neutral molecules
  - Typically multicomponent, e.g., $H_2O$, $H_2SO_4$ & $NH_3$
- Ion-Induced
  - Involves clustering of various molecules about ions
  - Different Chemistries for +ve and -ve ions

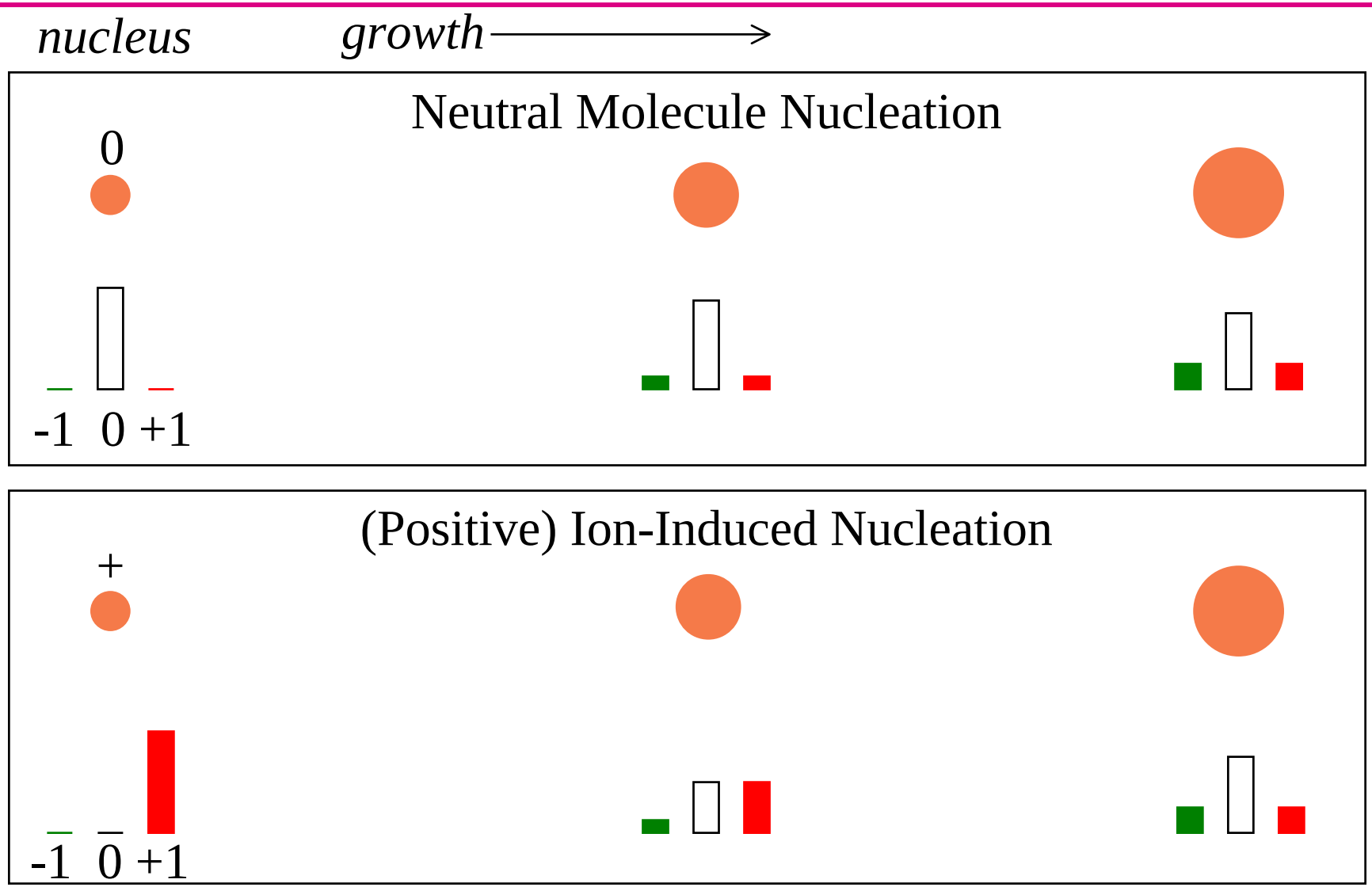
# Project Objectives

- To determine whether or not ion-induced nucleation leads to the formation of significant numbers of particles in the atmosphere
- To learn about the physics and chemistry of ion-induced nucleation in the atmosphere

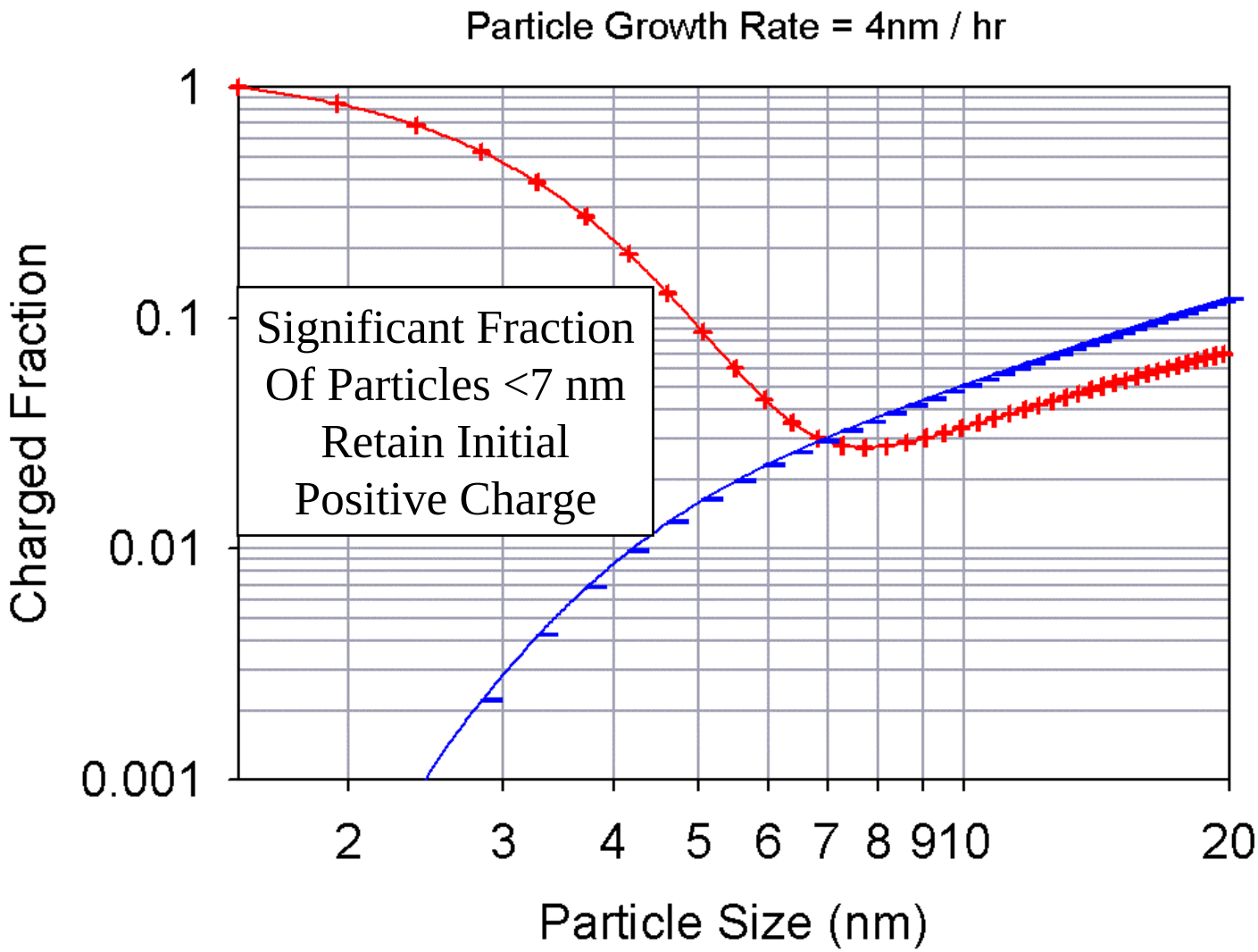
# Atmospheric Measurements

- Measurements supported by EPA Star Grant
  - Composition of +ve and -ve ions during nucleation events
  - Ion mobility distributions (0.5 to 5 nm)
- Complementary measurements supported by DOE
  - [$H_2SO_4$]
  - Aerosol size distributions (3 nm to 2 μm)
  - NanoTDMA: water uptake and volatility of 3 to 1- nm particles
  - Composition of 3-10 nm particles by TDCIMS

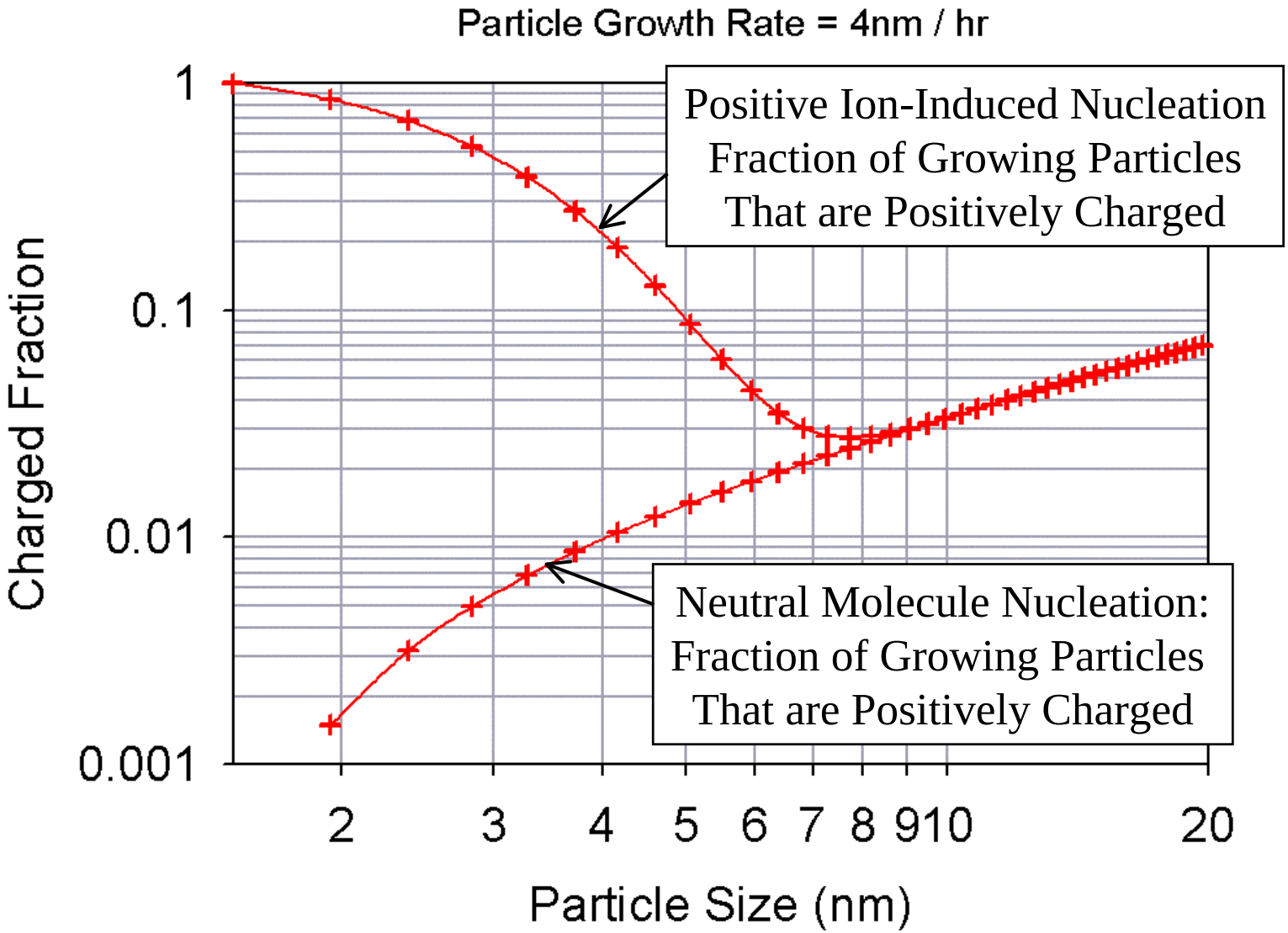
# Charge Distributions of Particles formed by Neutral Molecule and Ion-Induced Nucleation



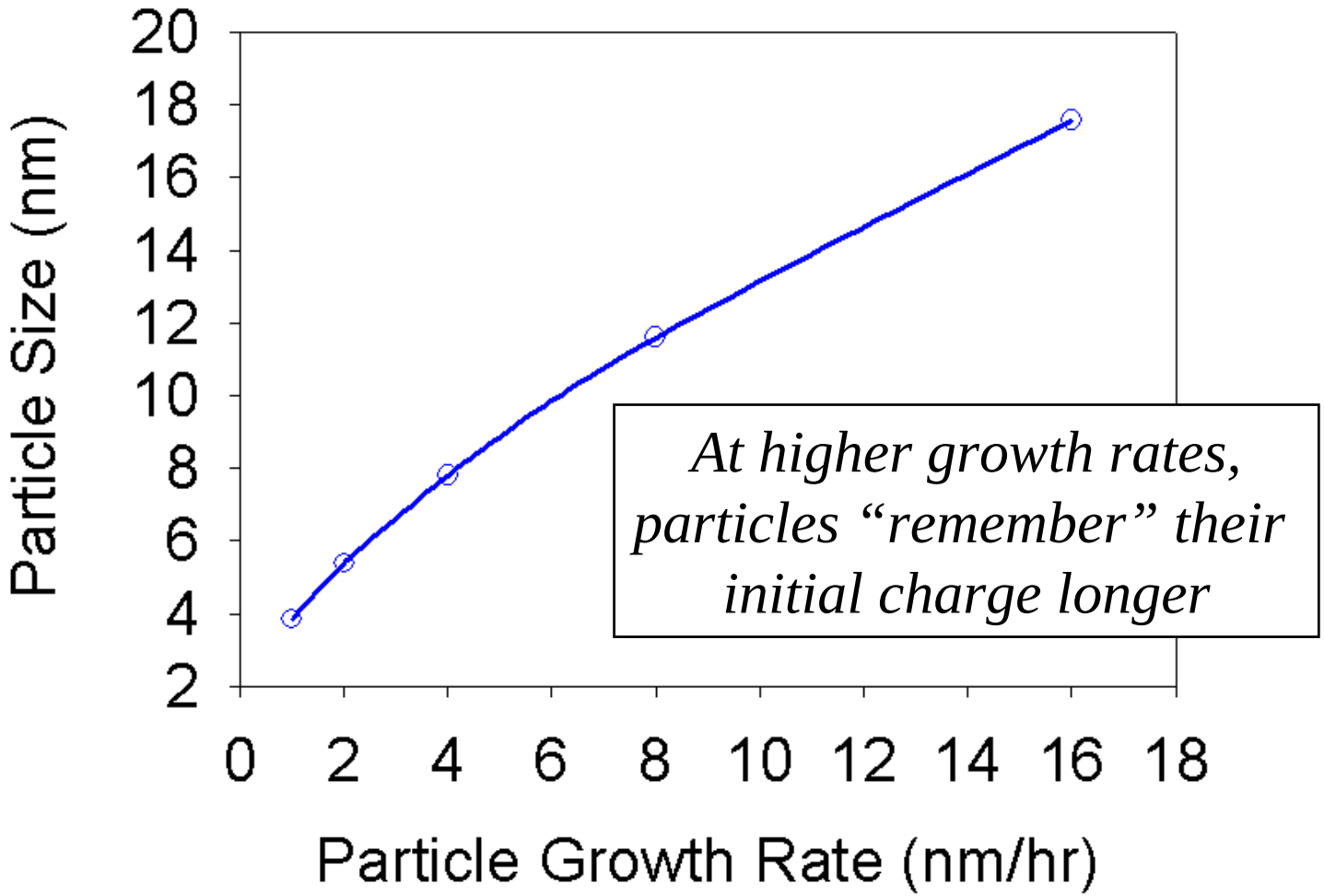
# Positive Ion-Induced Nucleation: Size at which Initial Charge is "Remembered"



# Distinguishing between Positive Ion-Induced and Neutral Molecule Nucleation



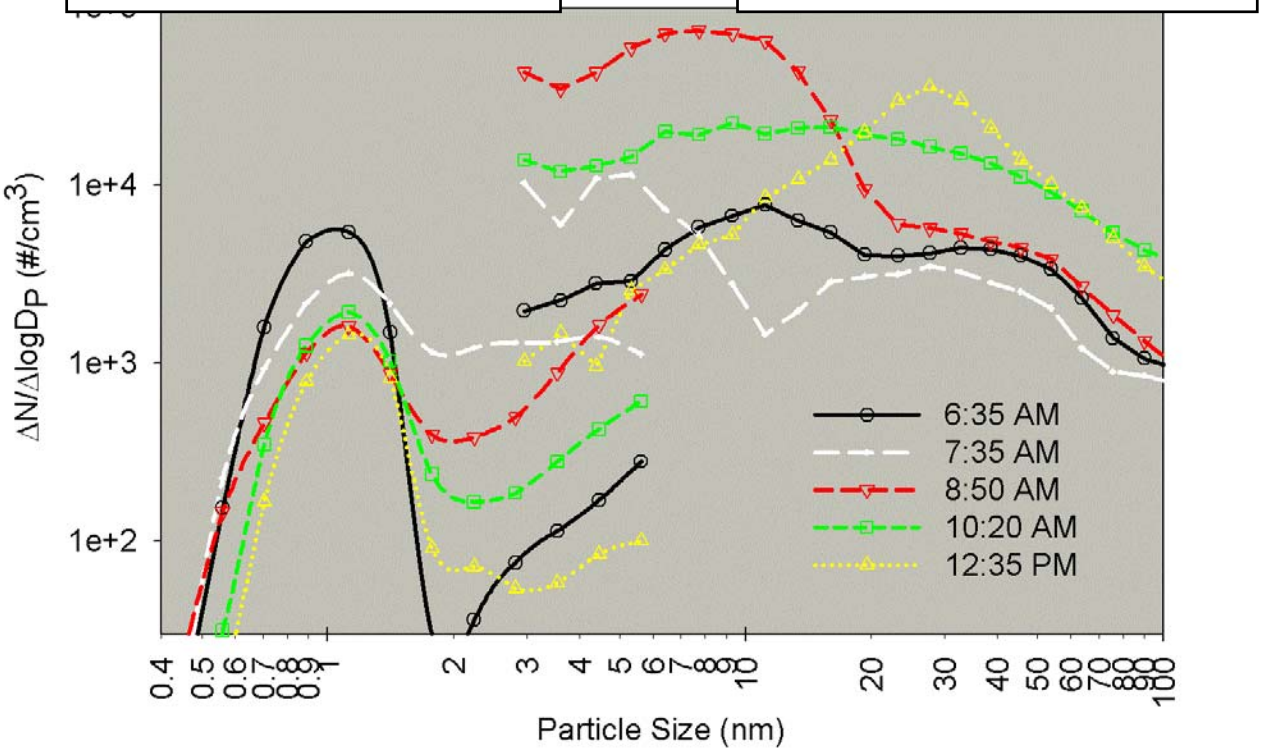
# Size Below Which Charge Distributions Must be Measured to Identify Nucleation Process



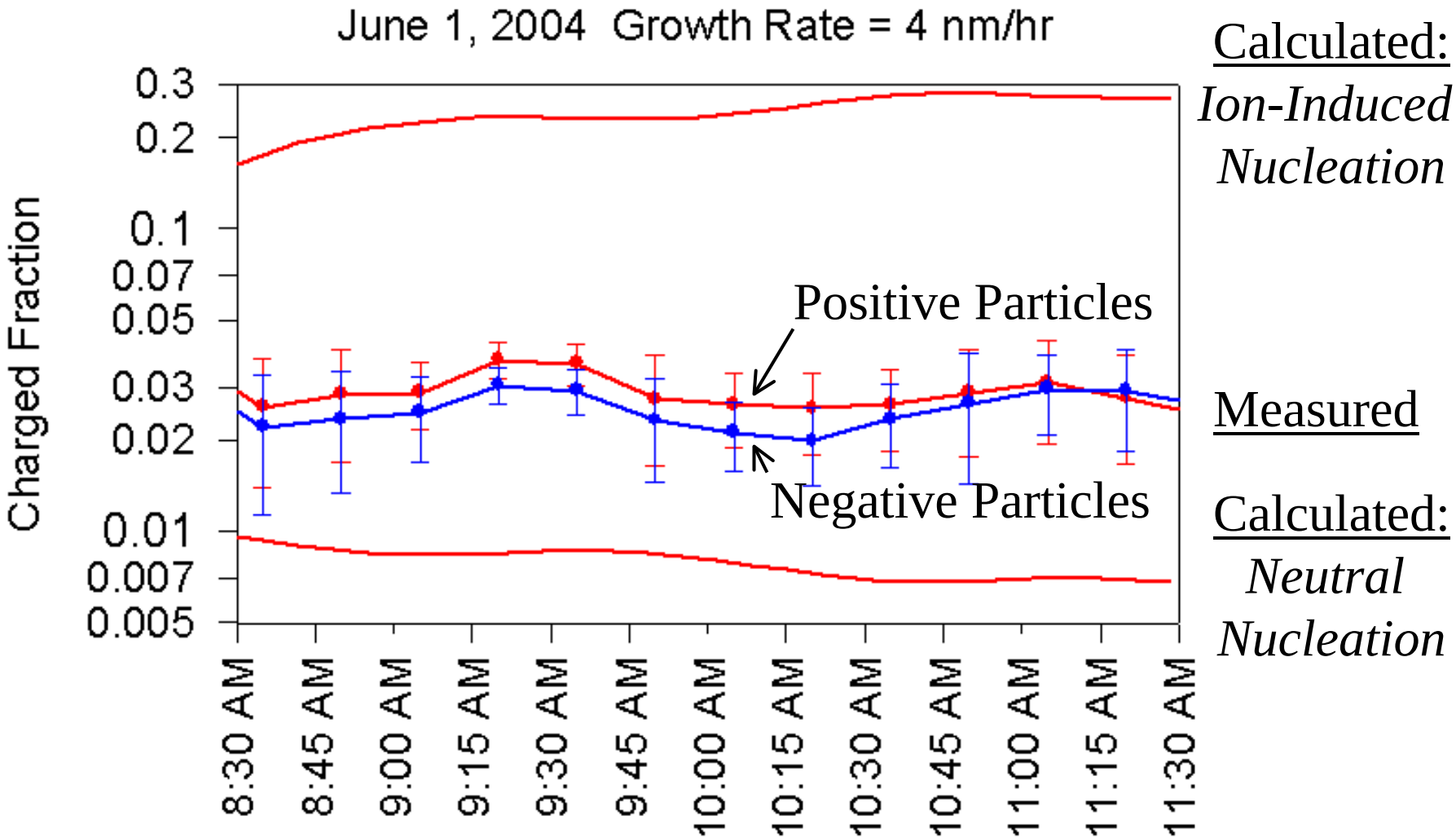
# Selected Size Distributions from June 1, 2004

*IGMA Data:*
*Positive Particles*

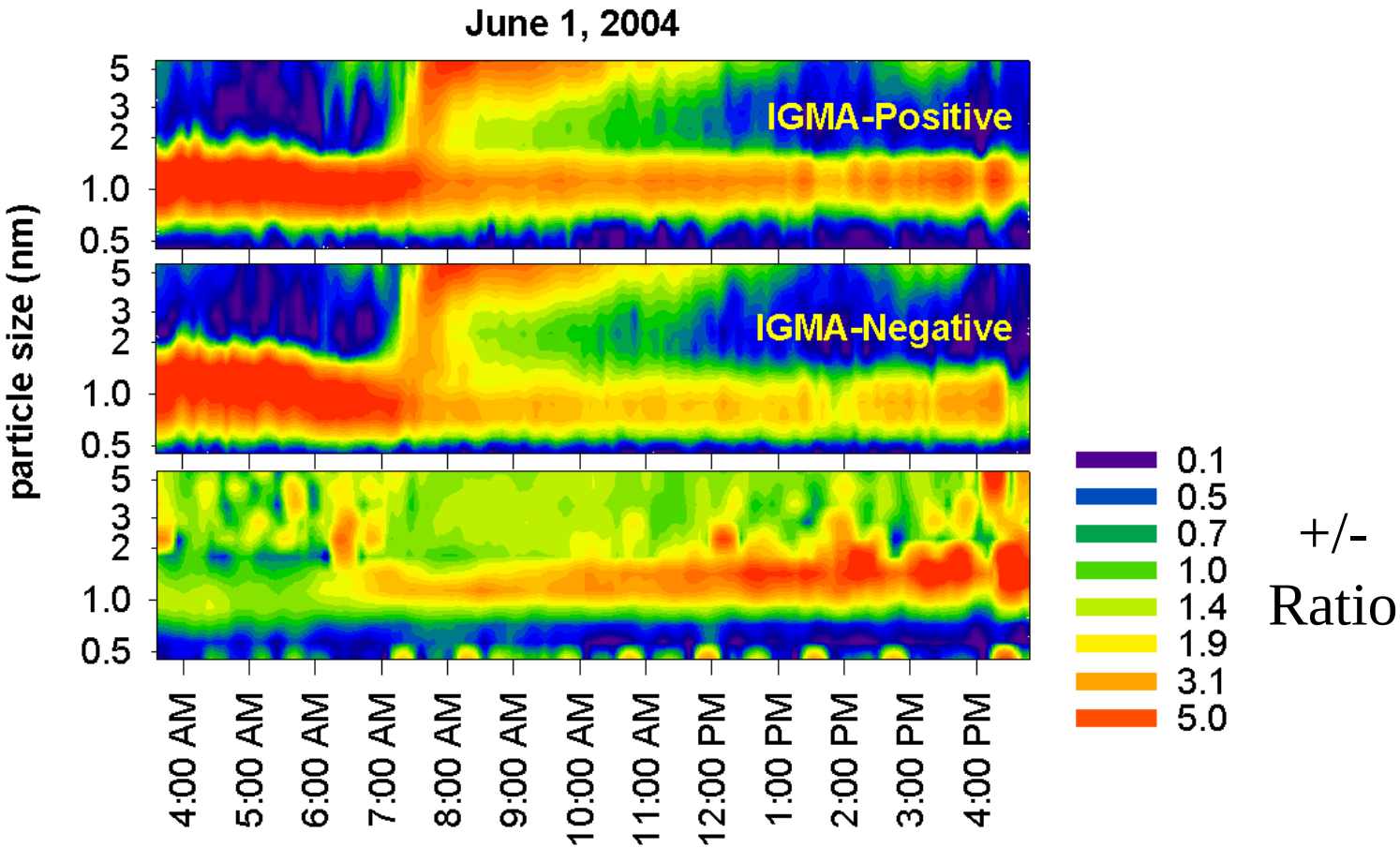
Nano-SMPS Data:
*All Particles*



# Charge Fractions for 3-5 nm Particles



# IGMA Data: Positive and Negative Particle Size Distributions and +/- Ratio



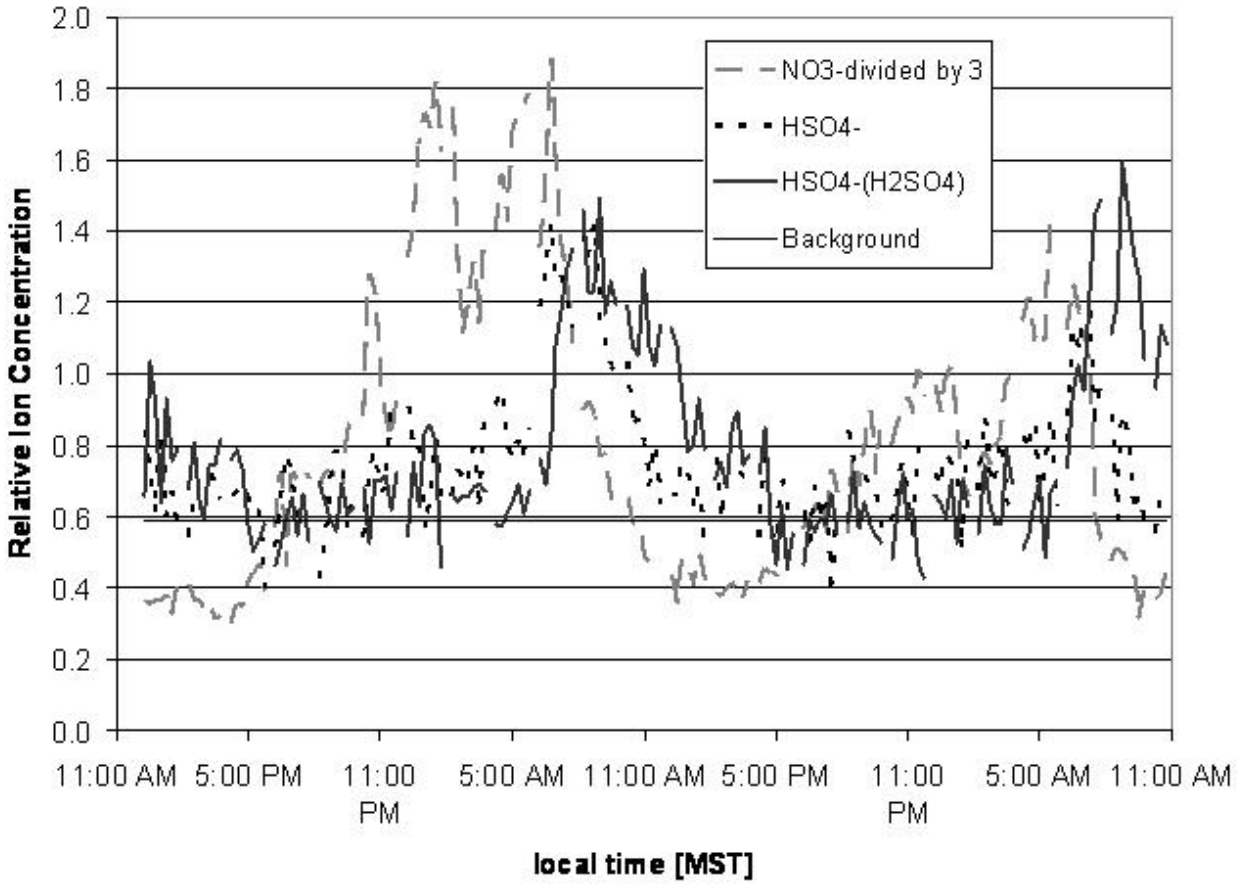
# Conclusions

- IGMA enables measurements on *nucleated particles* as small as 2 nm (~30 molecules)
- Nucleation in Boulder, CO, is dominated by neutral molecules, *not* ions.

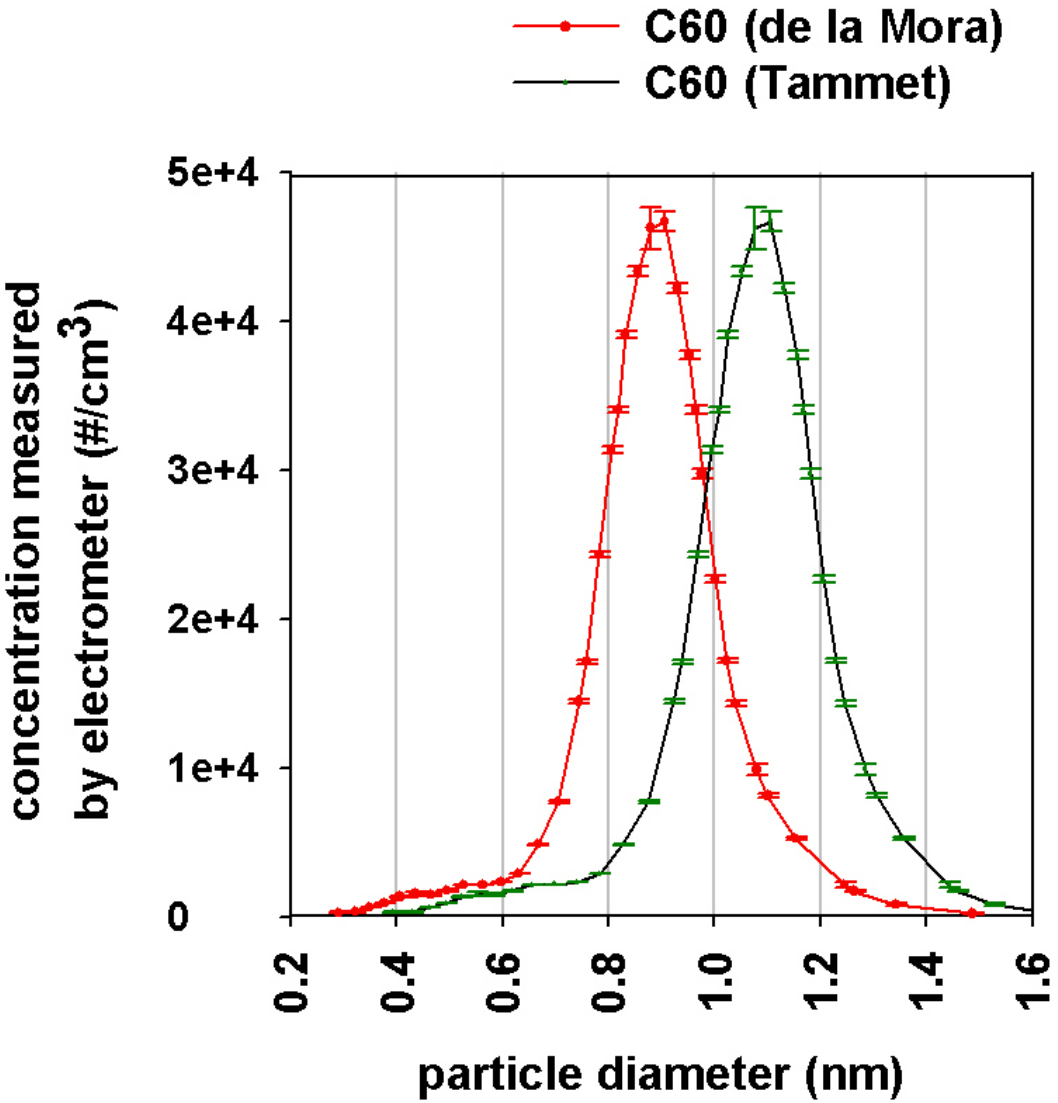
# Other Ongoing Work

- Measurement of Ion Composition During Nucleation Events
- Design of new nano-SMPS for measuring *total size distributions* of particles down to 1 nm

# Mass Spectrometer Measurements of Negative Ion Composition in Boulder, CO , March, 2004

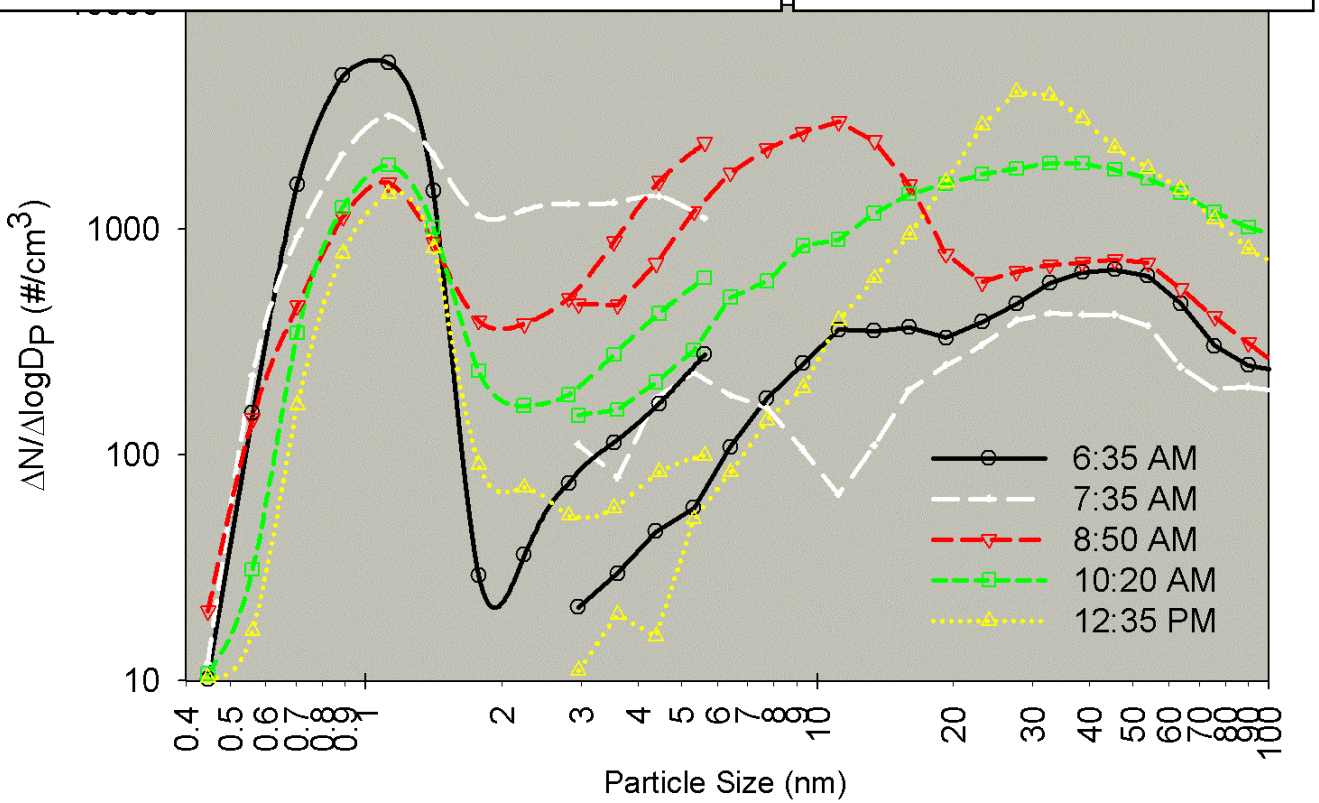


# Improved Nano-SMPS:
# Total (neutral, +, -) Distribution functions down to 1 nm



# Selected Size Distributions from June 1, 2004

| *Calculated From IGMA Data:* *All Particles* | Nano-SMPS Data: *All Particles* |
|---|---|



# Inclined Grid Ion Mobility Analyzer: For 0.5 nm to 5 nm ions: An Improved Instrument

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