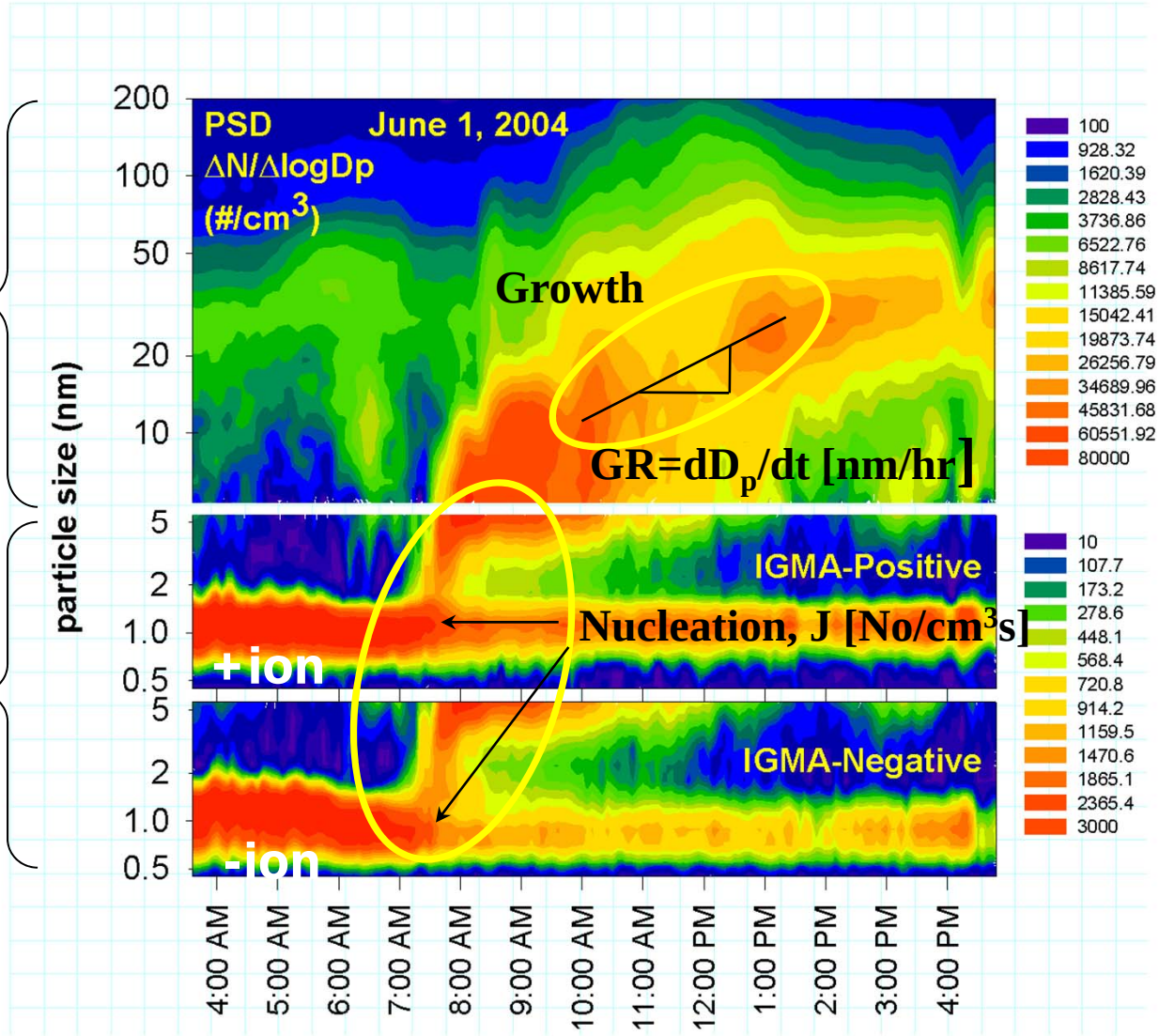
NPF Focus Group White Paper: Objectives

1. Develop models for *Nucleation Rates & Growth Rates*
   -empirical models (short term)
   -first-principles models-link to gas phase precursors
   -climatically important properties
      -hygroscopicity, phase, surface tension
2. Incorporate mechanistic N&G models into regional models
3. Incorporate mechanistic N&G models into GCMs

New Particle Formation (NPF) Event, Boulder: Distinguishing Nucleation from Growth

Size Distribution of all charge states

Size Distribution of Charged Particles (Ions)



Iida et al., *JGR.*, **111**: D23201, 2006

Why is Nucleation an Important Atmospheric Process?

$$J(D_p) = J \exp\left\{-\frac{A_{Fuchs} k}{dD_p/dt}\Psi\right\}$$

NPF Rate

Nucleation Rate $J \simeq J_{1\ nm}$

Survival Probability

Answer: Both J and dD_p/dt are much higher than was originally thought possible. Our research aims at understanding why.

McMurry & Friedlander, *Atmos. Environ.* **13**:1635, 1978
Rodney Weber, *PhD Thesis*, 1995

NPF Focus Group White Paper: Approaches

1. Model Development
    - -Instrumentation
        - -gas & aerosol phase chemistry measurements
    - -Atmospheric observations
        - -vertical measurements
        - -VAPs (value added products): e.g., survival probability
    - -Laboratory studies
2. Model Validation: Incorporation into regional models
3. Global Modeling: Incorporation into global models

NPF Leadership

Peter McMurry (University of Minnesota)
James N. Smith (NCAR)
Chongai Kuang (BNL)

Metrics for Evaluating Progress

-Publish important papers on measurement methods
-Publish experimentally-verified models for J (nucleation rates)
-Publish experimentally-verified models for GR (growth rates)
-Publish papers that compare atmospheric observations with regional models
-Incorporate N&G models into GCMs & evaluate validity
-Publish papers that describe effect of NPF on climate

Highlights

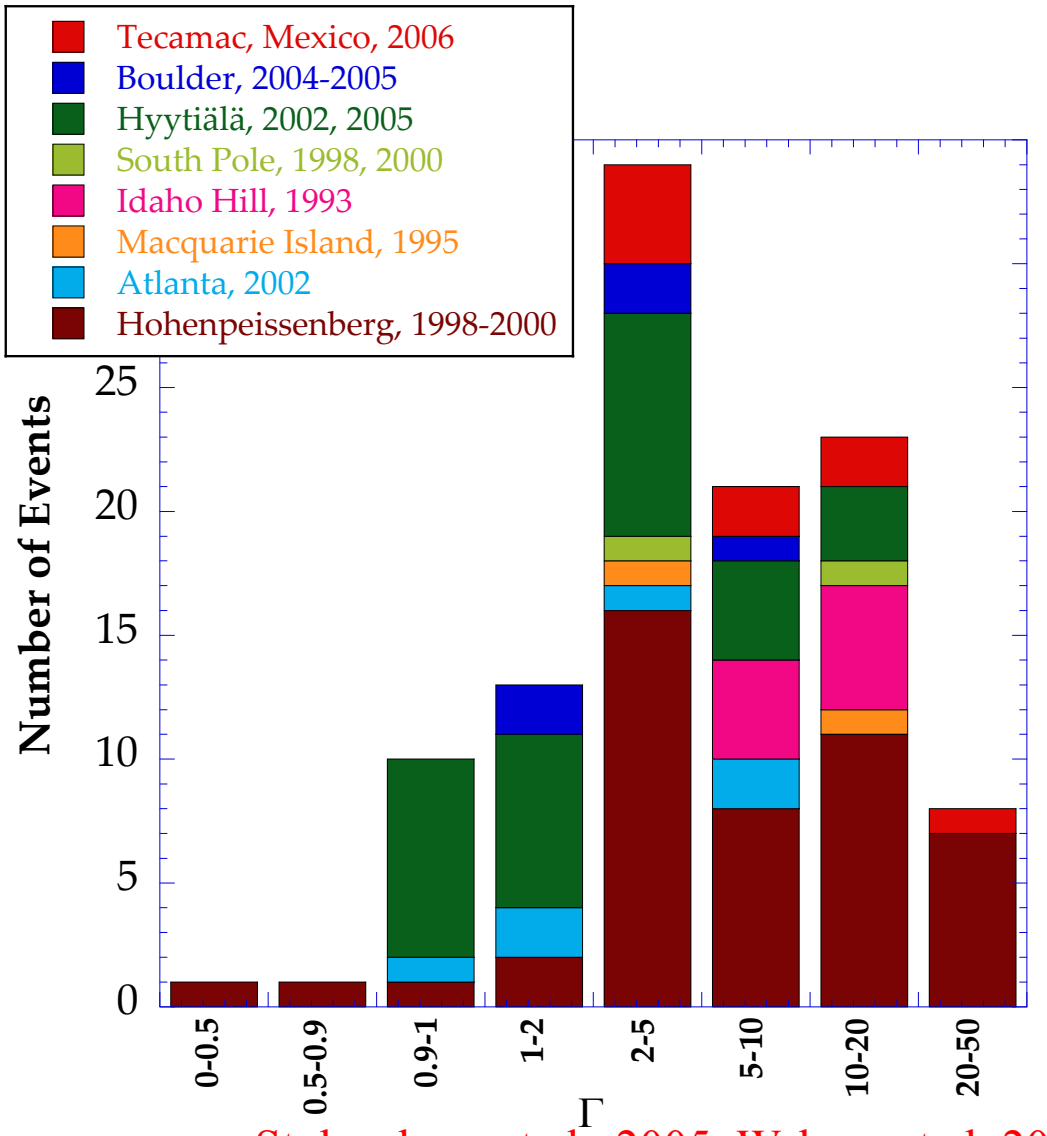
Chongai Kuang (BNL), Modi Chen (UMN), Jun Zhao (NCAR, UMN), Jim Smith (NCAR), Peter McMurry (UMN), Jian Wang (BNL)
(ACP, 2012, in press)
"Size and time-resolved measurements of 1 to 5 nm freshly formed atmospheric nuclei"

$GR_{actual} >> GR_{H2SO4}$

$$\Gamma = \frac{GR_{actual}}{GR_{H_2SO_4}} = \frac{GR_{H_2SO_4} + GR_{other}}{GR_{H_2SO_4}}$$

$$\Gamma >> 1$$

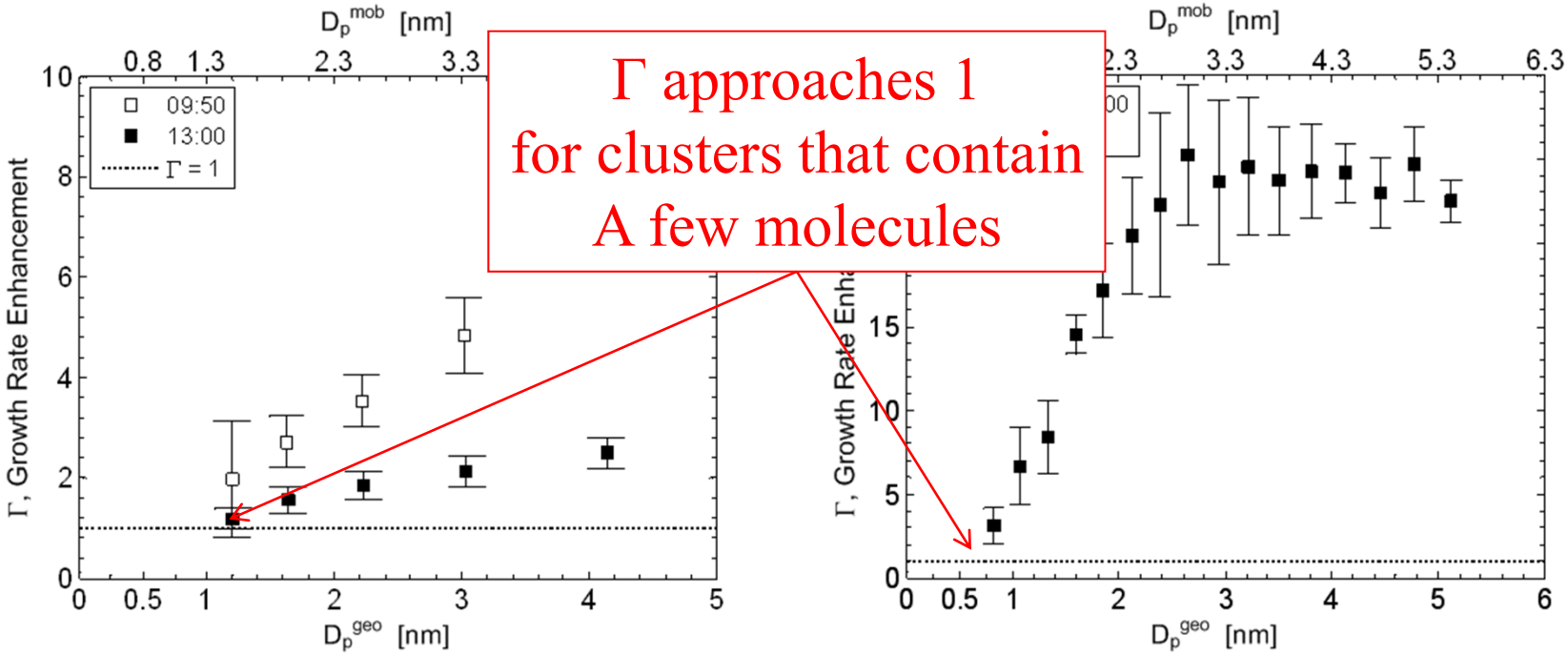
Growth Factors: $\Gamma = GR/GR_{H_2SO_4}$



Stolzenburg et al., 2005; Wehner et al, 2005; Kuang et al, 2010

Γ Values below 5 nm

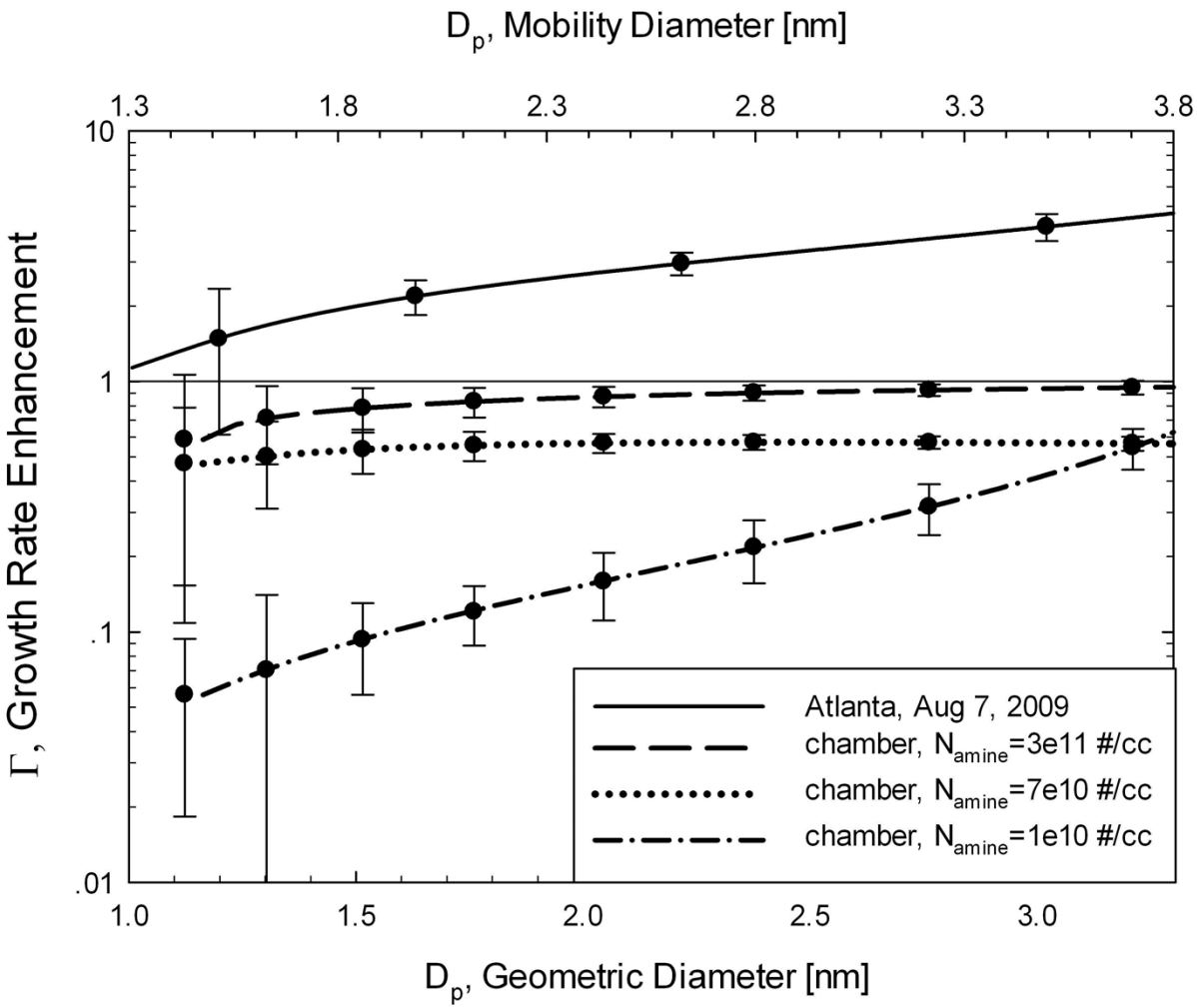
Atlanta, GA: Aug 7, 2009 Boulder, CO: Sept 19, 2010



-H_2SO_4 accounts for majority of growth of cluster containing just a few molecules
-Critical cluster < 1 nm

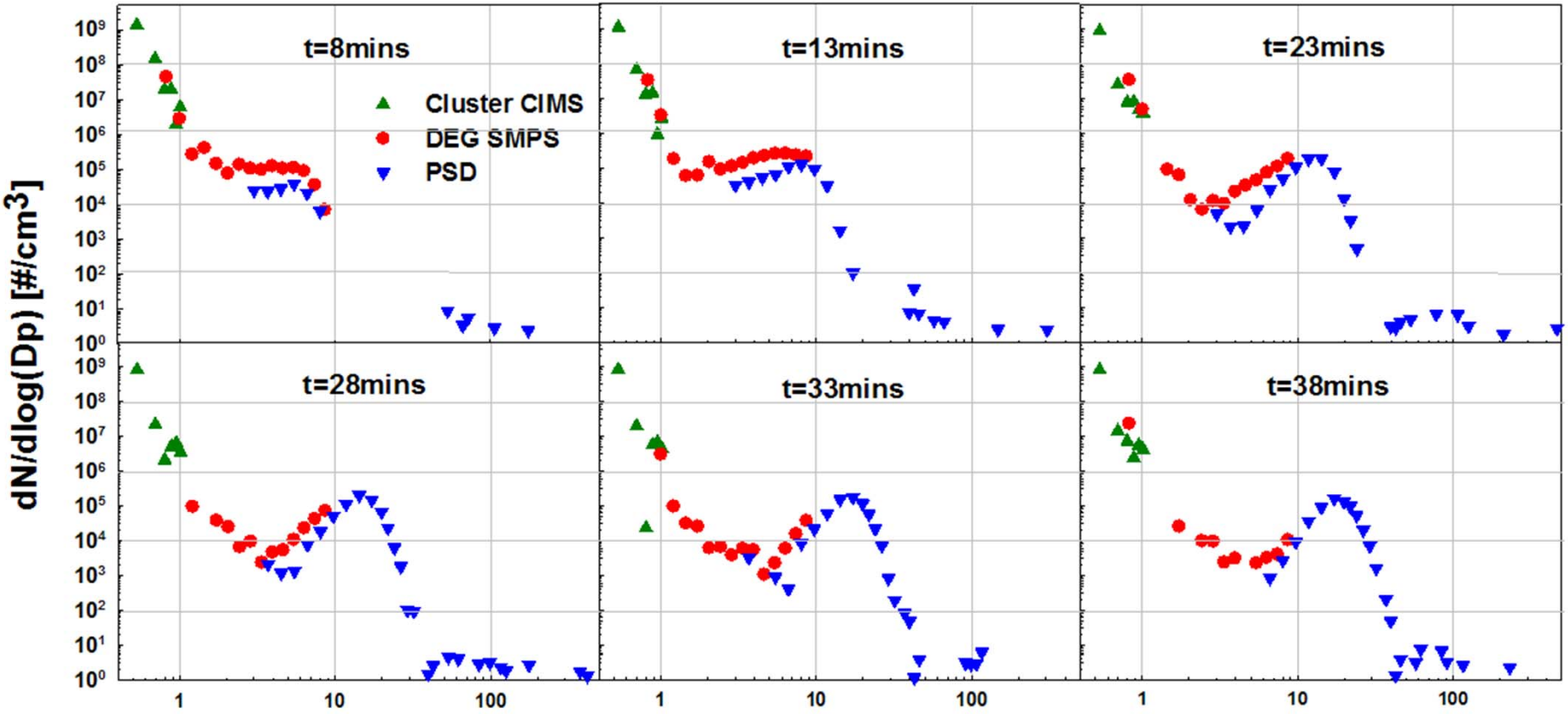
Kuang, et al. (2012), *Atmos. Chem. Phys. In press*

Γ Values below 5 nm



Kuang, et al. (2012), *Atmos. Chem. Phys. In press.*

Number Distributions Measured in a Chamber Experiment July 13, 2010, U. Minnesota [SO_2]=9 ppb; RH=10%; no amines added intentionally



Minnesota-Augsburg-NCAR Research Team, Titcombe, PhD thesis, 2012