

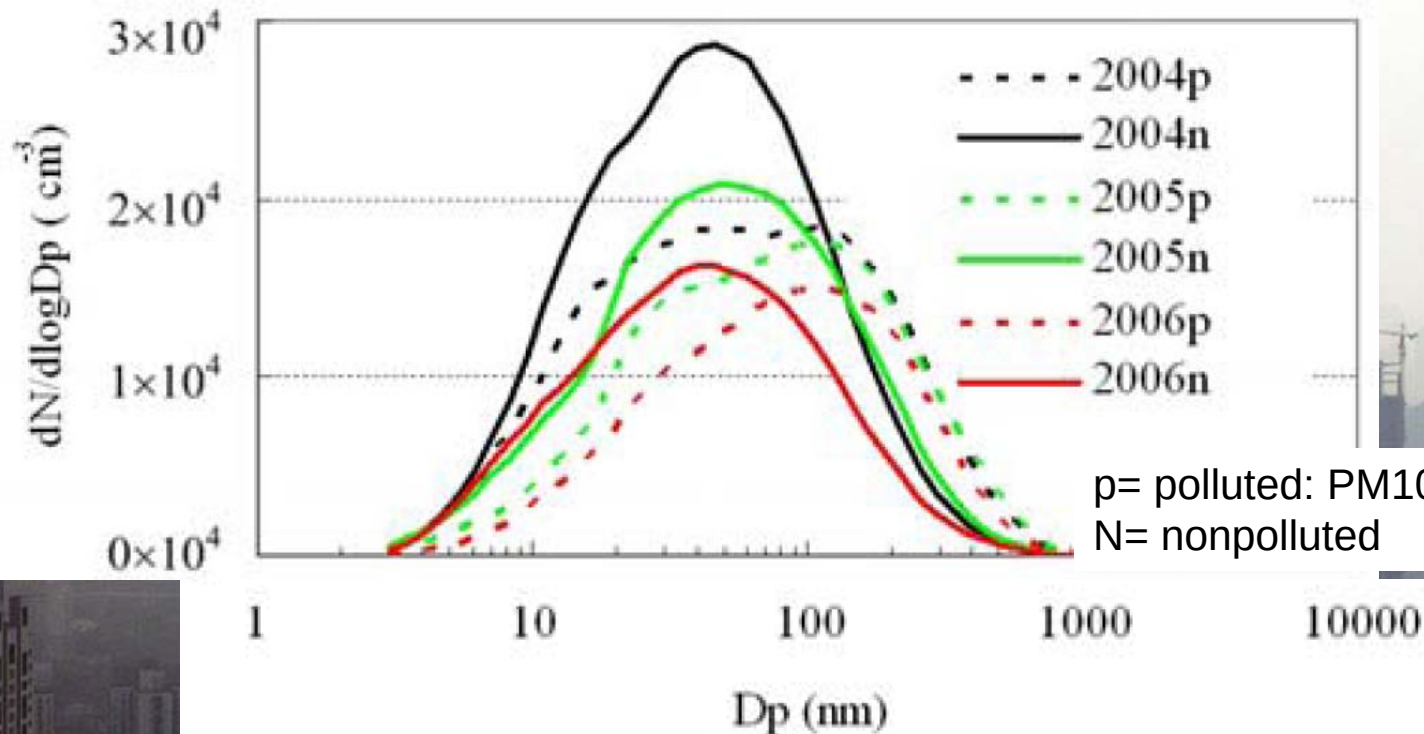
Interdependence of particle number concentration and PM 2.5 in highly polluted urban atmospheres

Martin Seipenbusch,
Markus Kasper, Mingzhou Yu



The Problem:

Number size distributions for polluted and non polluted days in Beijing:



Characteristics of aerosol size distributions and new particle formation in the summer in Beijing

Dingli Yue,¹ Min Hu,¹ Zhijun Wu,¹ Zhibin Wang,¹ Song Guo,¹ Birgit Wehner,² Andreas Nowak,² Peggy Achtert,² Alfred Wiedensohler,² Jinsang Jung,³ Young J. Kim,³ and Shawchen Liu⁴

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, D00G12, doi:10.1029/2008JD010894, 2009

Shanghai 2003 (G. Kasper)

The Problem:

Measurements made with DiSCmini by Andreas Mayer in Beijing:

120.000 p/cm³ at reported PM_{2.5}>300µg/m³

200.000-500.000 p/cm³ at reported PM_{2.5}<50µg/m³

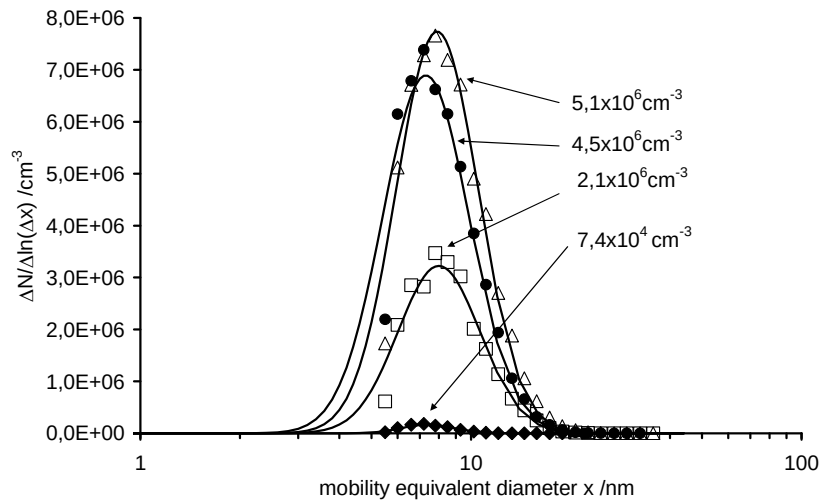
Apparent disconnect between number concentrations and PM concentrations in heavily polluted atmospheres

Shanghai 2003 (G. Kasper)

What is the origin of this disconnect?

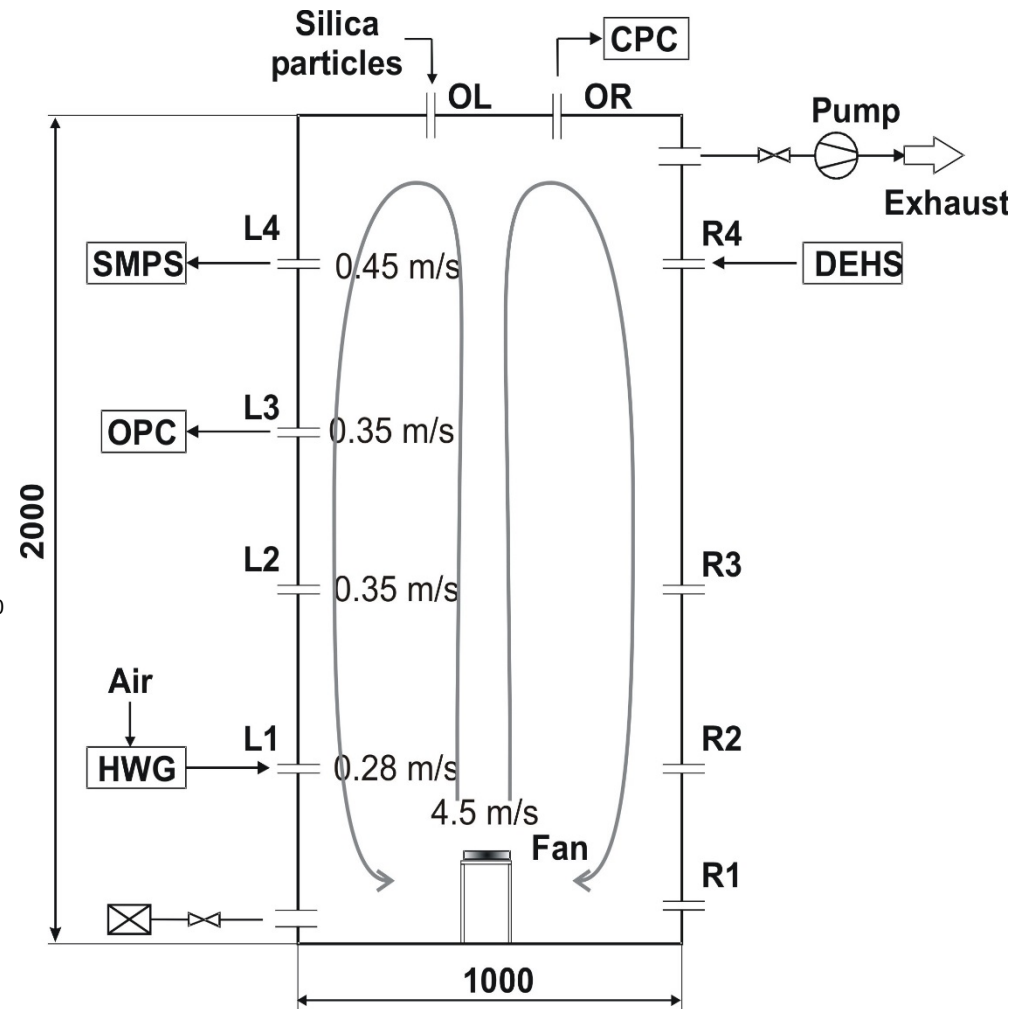
- A aerosol chamber experiment:

Ultrafine particle source:



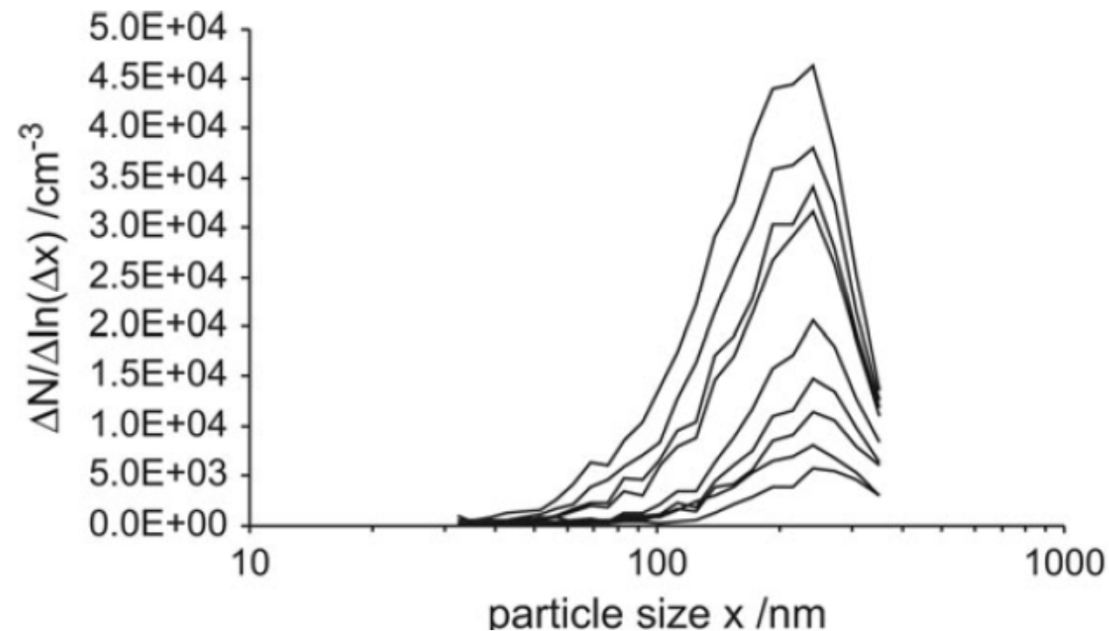
Temporal Evolution of Nanoparticle Aerosols in Workplace Exposure

M. SEIPENBUSCH*, A. BINDER and G. KASPER
Ann. Occup. Hyg., Vol. 52, No. 8, pp. 707–716, 2008

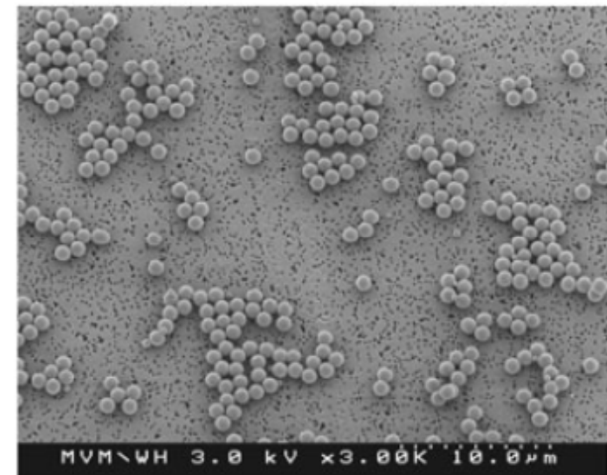


Simulated accumulation and coarse modes

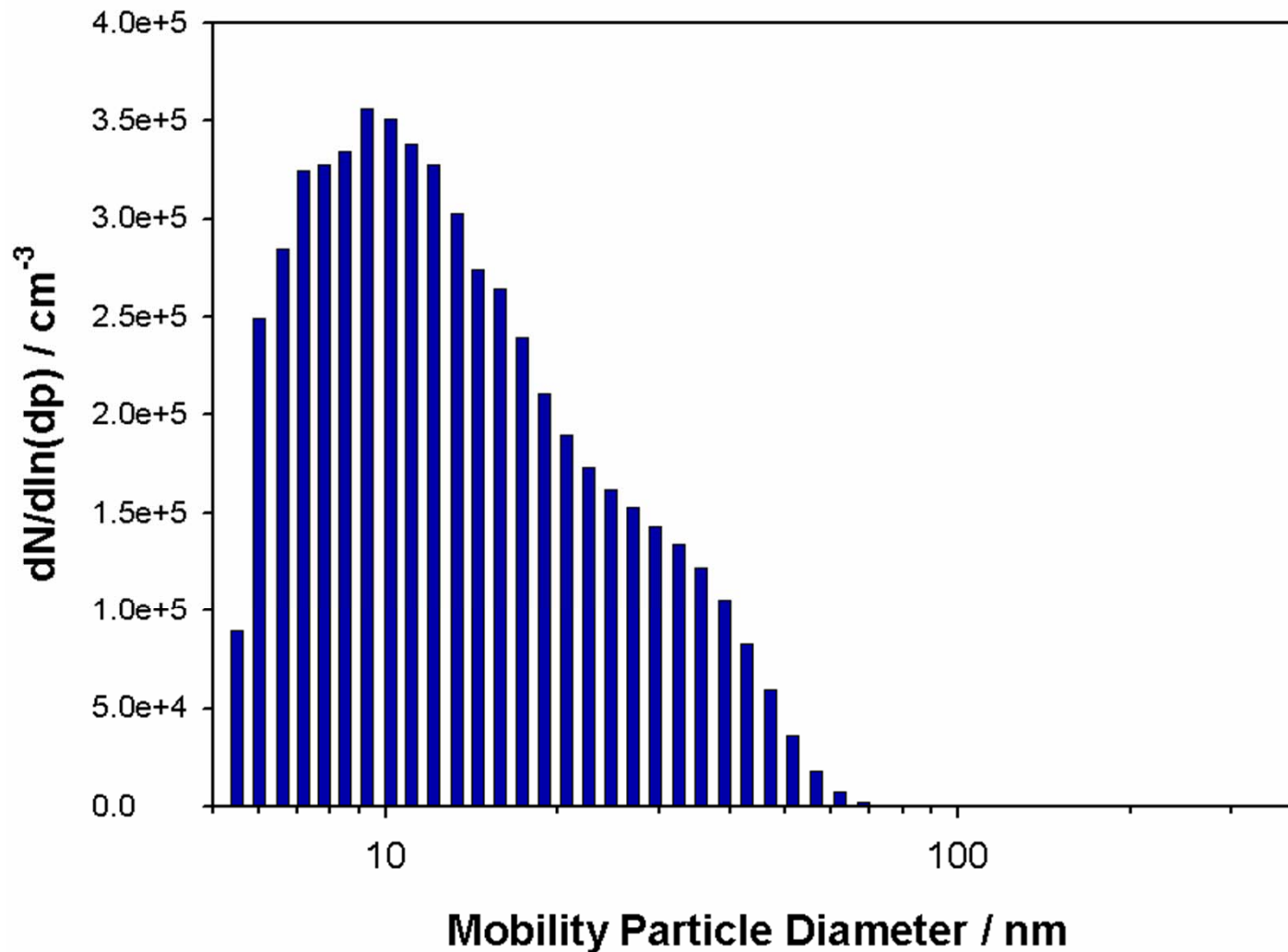
DEHS-droplets from Collison atomizer



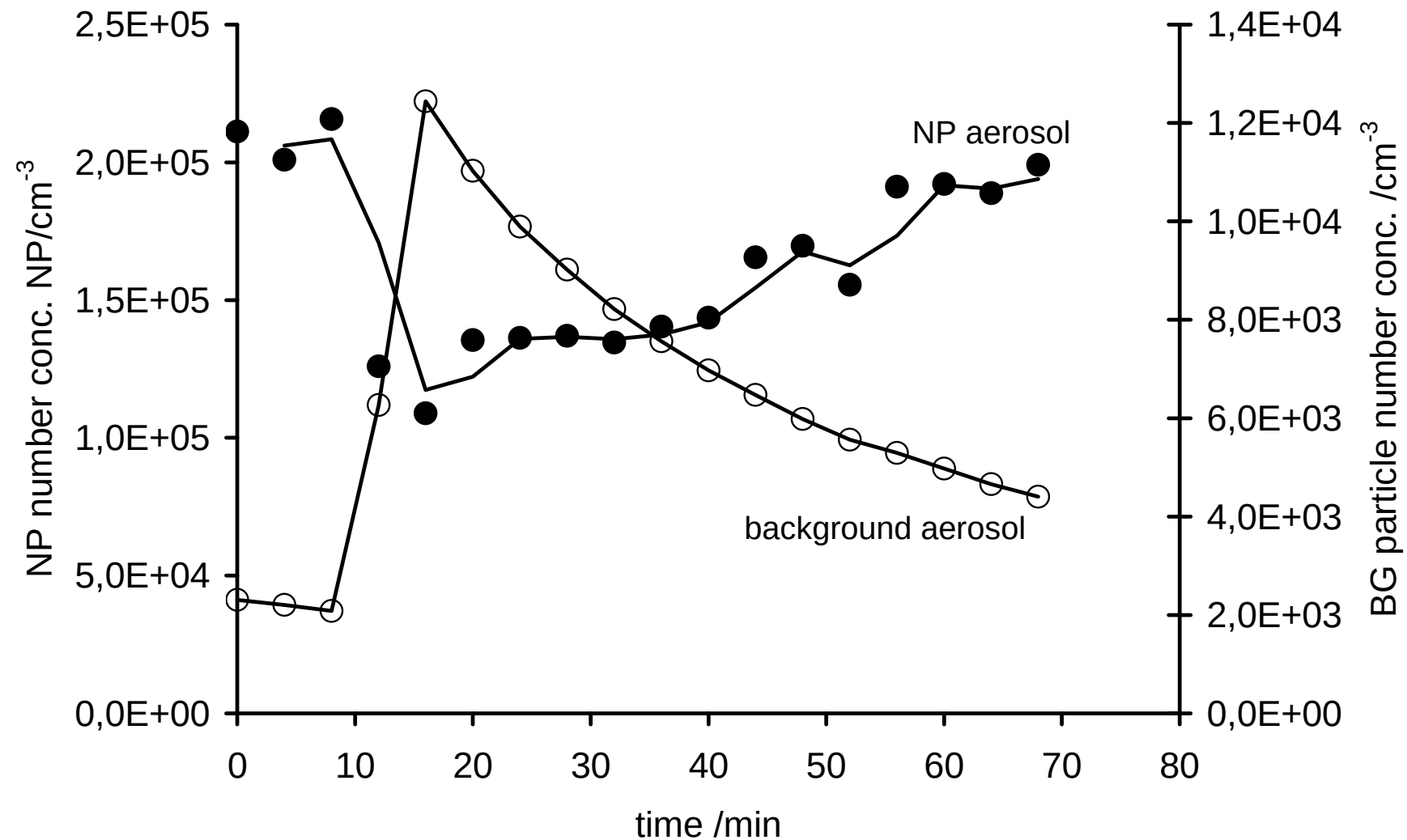
Silica microspheres



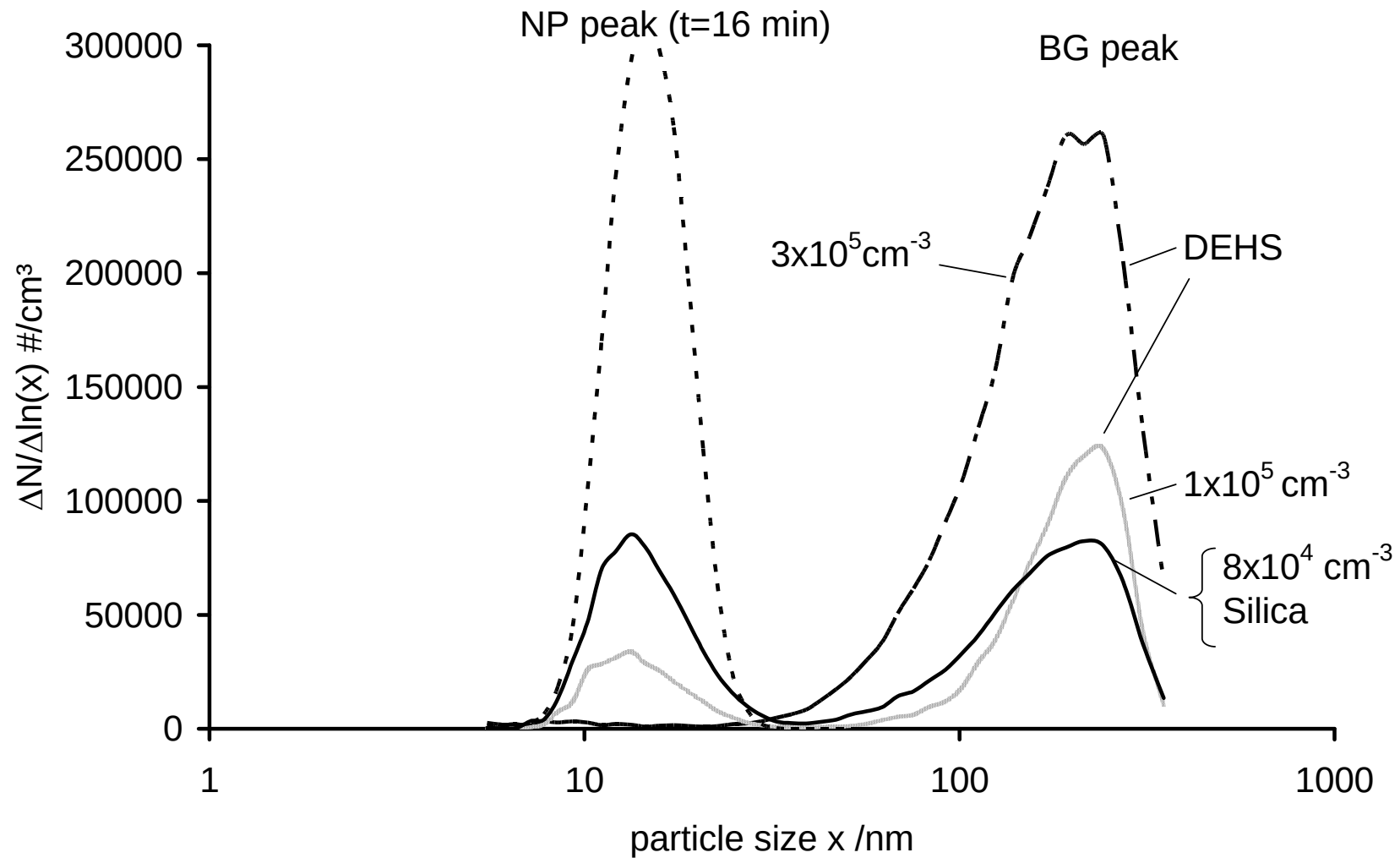
Coagulation of ultrafine aerosol with sudden addition of „accumulation mode“ particles



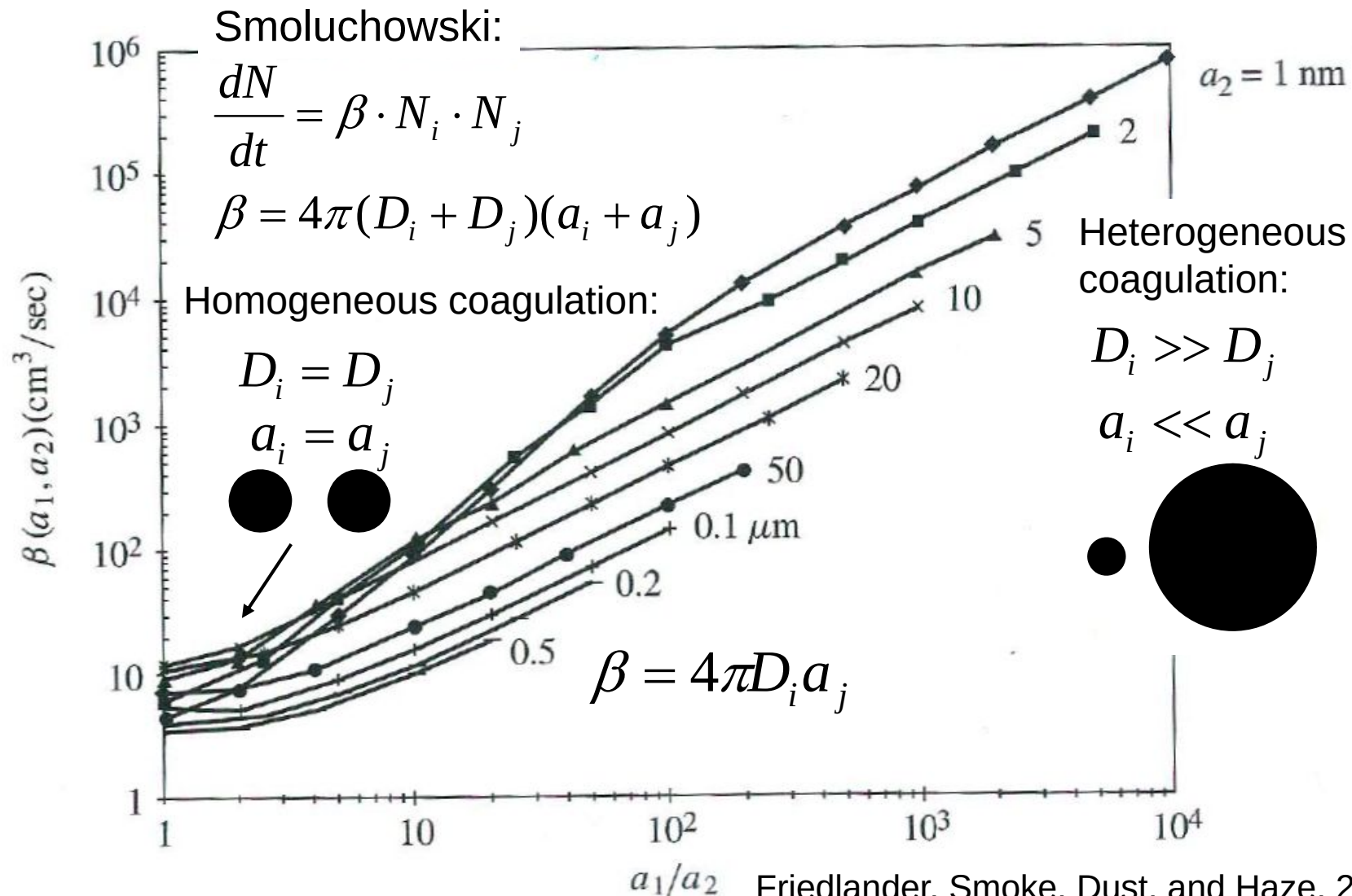
Coagulation of ultrafine aerosol with sudden addition of „accumulation mode“ particles



Number size distributions for various bimodal systems

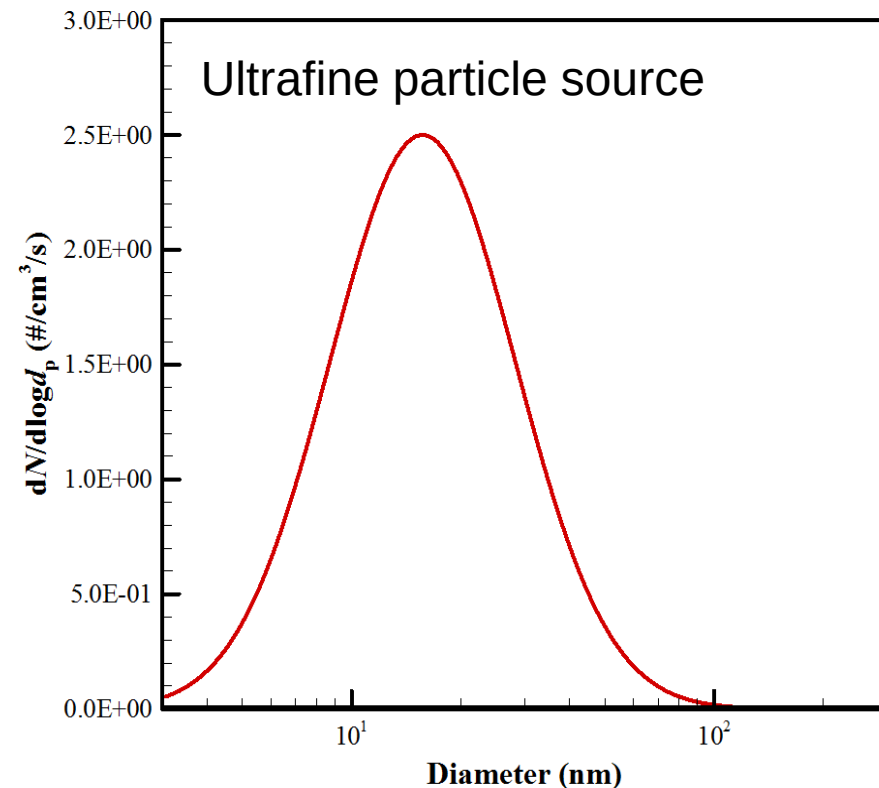
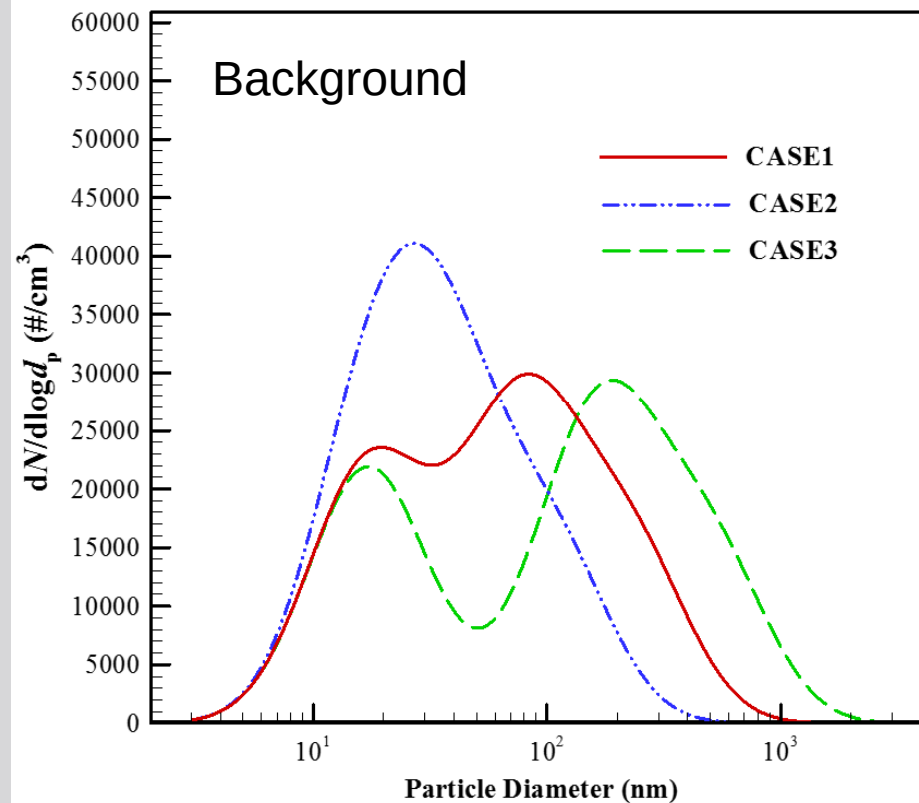


Theory: heterogeneous coagulation



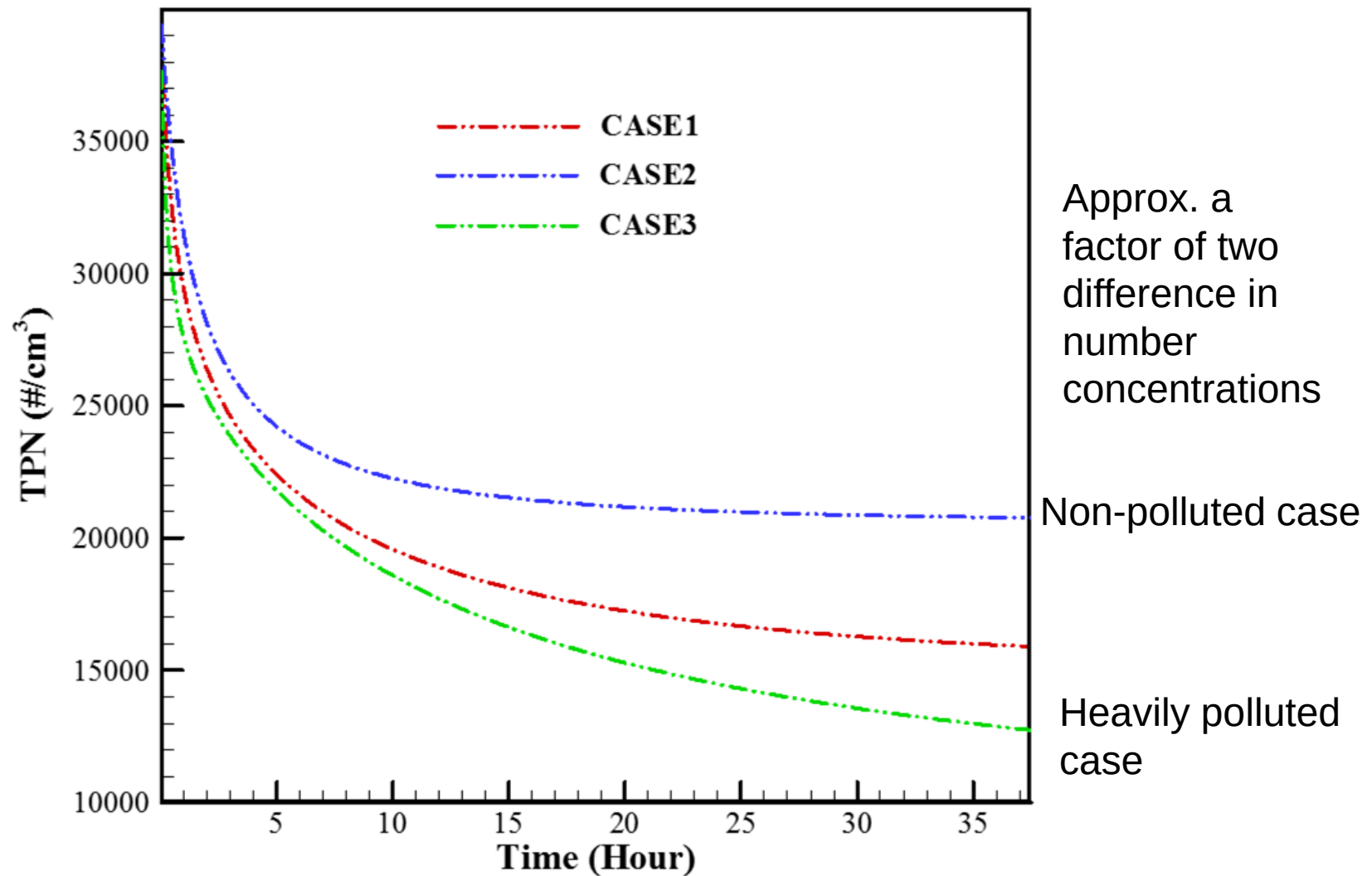
More theory: an aerosol model

- A model was developed to describe the interaction of a background aerosol and a continuous ultrafine particle source



Case 1: size distribution from the polluted case presented in Yue et al..
Cases 2 and 3 are fictional but with identical number concentration as C1

Temporal evolution of the total particle number concentration



Conclusions

- Measured data gives evidence for a disconnect between mass based assessment of fine particles and number concentrations
- Laboratory experiment and modelling results suggest binary coagulation between the ultrafine and coarser modes of the size distribution as likely explanation.
- PM 2.5 does not appear to be a monitoring metric for heavily polluted atmospheres
- Separate limit values needed for PN and PM
 - emissions -> Euro 5B / Euro VI -> in force
 - ambient -> ...?

More theory: an aerosol model

$$\frac{\partial n(v, t)}{\partial t} = \underbrace{\frac{1}{2} \int_0^v \beta(v - v', v') n(v - v', t) n(v', t) dv' - n(v, t) \int_0^\infty \beta(v, v') n(v', t) dv'}_{\text{coagulation within SP mode}}$$

$$\underbrace{-n(v, t) \int_0^\infty \gamma(v, v') p(v', t) dv'}_{\text{SP mode attached to BP mode}} \underbrace{- \frac{F_{\text{out}}}{V} n(v, t)}_{\text{ventilation}} + \underbrace{\frac{f(v, t) F_{\text{in}}}{V}}_{\text{injection}}$$

$$\frac{\partial p(v, t)}{\partial t} = \underbrace{\frac{1}{2} \int_0^v \beta(v - v', v') p(v - v', t) p(v', t) dv' - p(v, t) \int_0^\infty \beta(v, v') p(v', t) dv'}_{\text{coagulation within BP mode}}$$

$$+ \underbrace{\int_0^v \gamma(v - v', v') n(v - v', t) p(v', t) dv' - p(v, t) \int_0^\infty \gamma(v, v') n(v', t) dv'}_{\text{interaction between SP and BP mode}} \underbrace{- \frac{F_{\text{out}}}{V} p(v, t)}_{\text{ventilation}}$$