Size-dependent Transmission of Aerosols in an ARI Aerosol Mass Spectrometer

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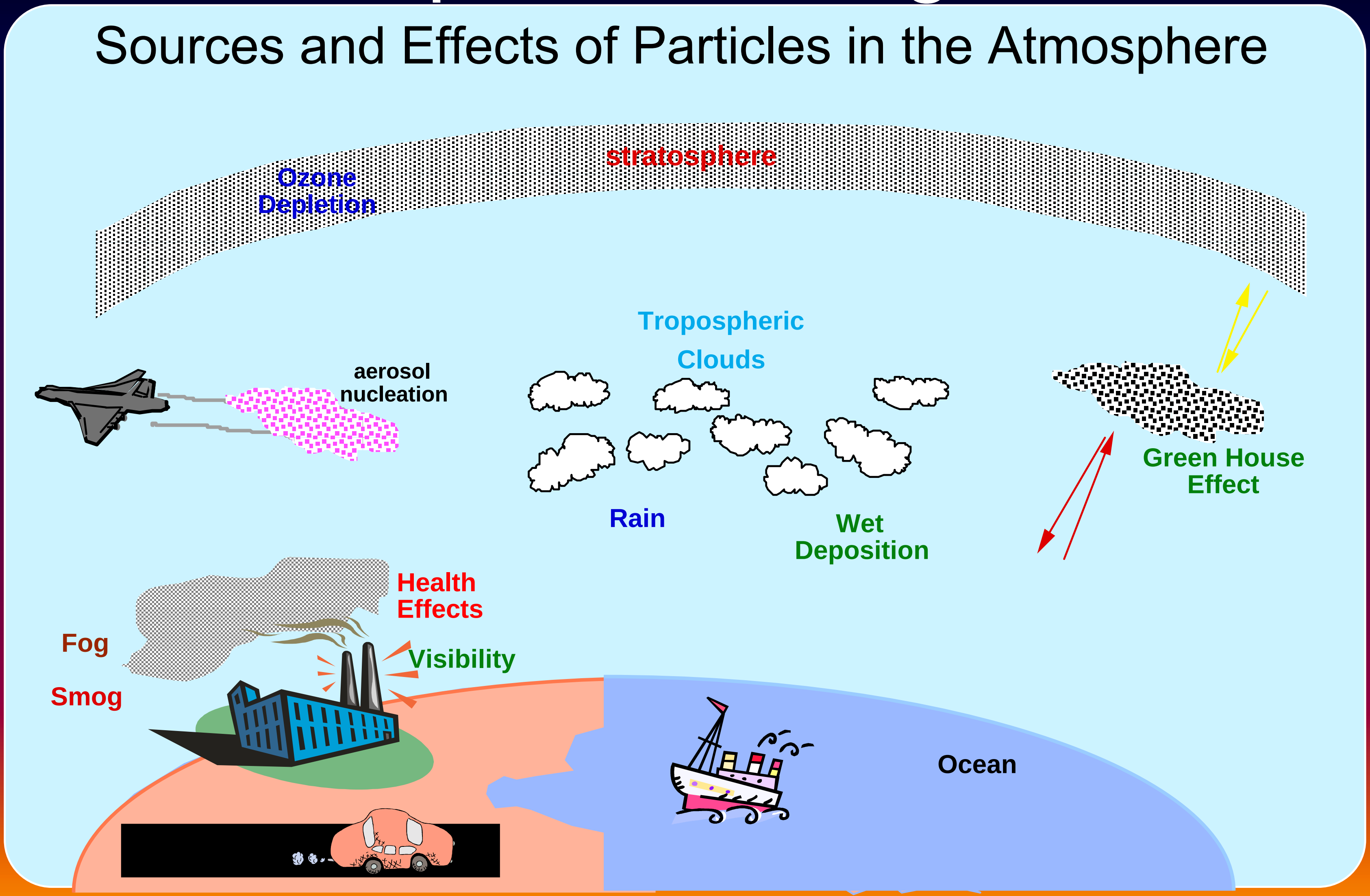
Outline

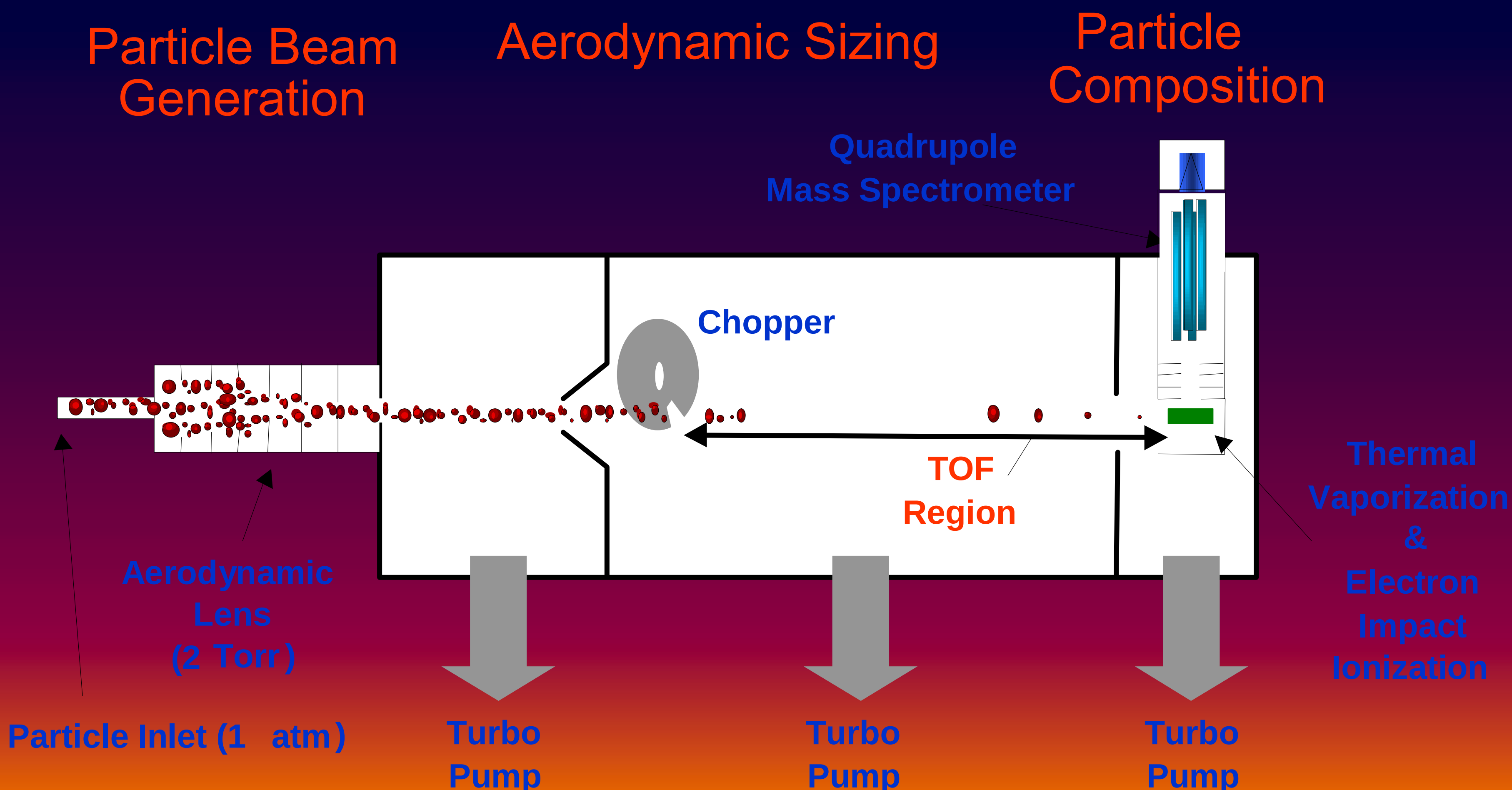
- Aerosols
- ARI Aerosol Mass Spectrometer
- NEAQS-ITCT 2004
- Supermicron Aerosol Project
  - Particle Transmission
  - Preliminary Conclusions and Future Work
- Acknowledgements

Aerosol: solution of particles suspended in a gas



Effects depend critically on size & chemical composition

ARI Aerosol Mass Spectrometer



AMS Schematic

ARI Aerosol Mass Spectrometer

- Definitions
  - Geometric diameter – true diameter, D_p
  - Classical Aerodynamic diameter –

$$D_a = \sqrt{\frac{\rho}{\chi \rho_0}} D_p$$

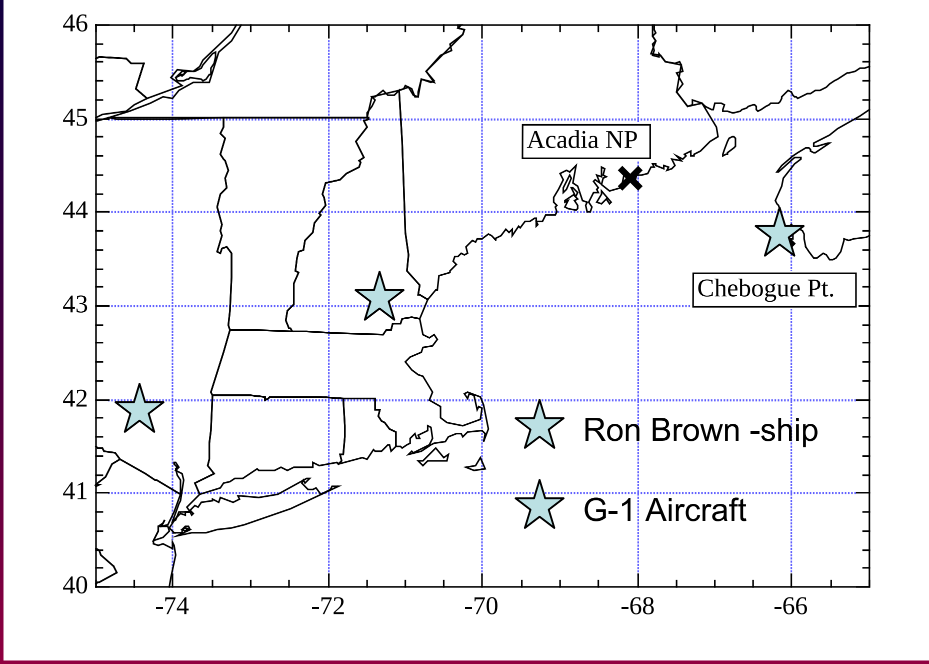
  - Vacuum Aerodynamic diameter –

$$D_{va} = \frac{\rho}{\chi \rho_0} D_p$$

Where ρ is the particle density, ρ_0 is unit density (ρ_0 = 1 g/cm^3), and χ is the particle dynamic shape factor.

NEAQS-ITCT 2004

- New England Air Quality Study - Intercontinental Transport and Chemical Transformation 2004
  - ARI set up an AMS on DOE's G-1 Aircraft
  - ARI manned AMSs in Nova Scotia, Canada and on NOAA's Ron Brown



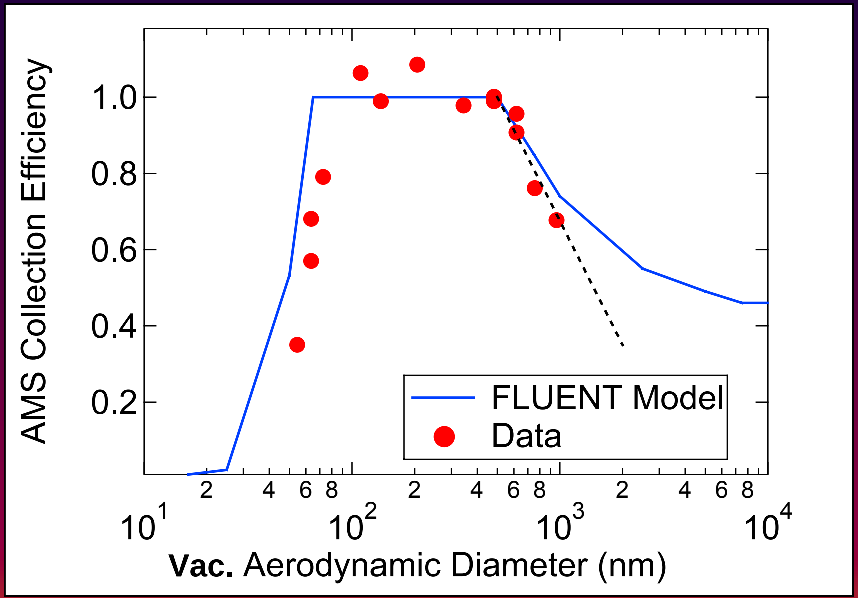
Platform locations w/ AMS

Nova Scotia Site

- Design and install inlet system
- Spatially organize instruments
- Prepare trailer for shipping

Supermicron Aerosol Project

- Goal: Adjust the AMS inlet to pass particles larger than 1 µm
- Particles >~1 µm lost at orifice

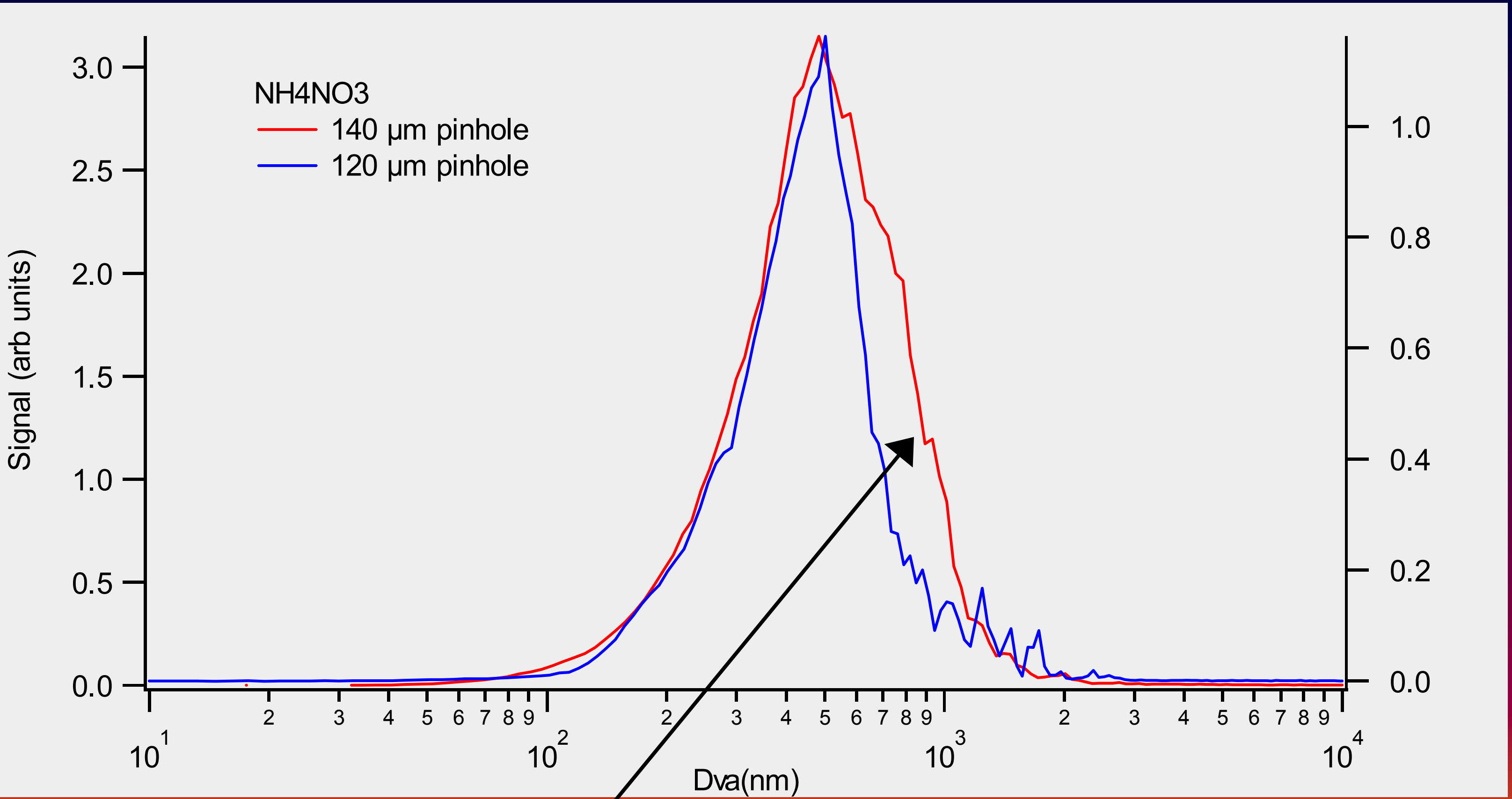


AMS Sampling Efficiency vs. Particle Size

- Objective: Make an orifice that transmits 1-10 µm particles

Particle Transmission

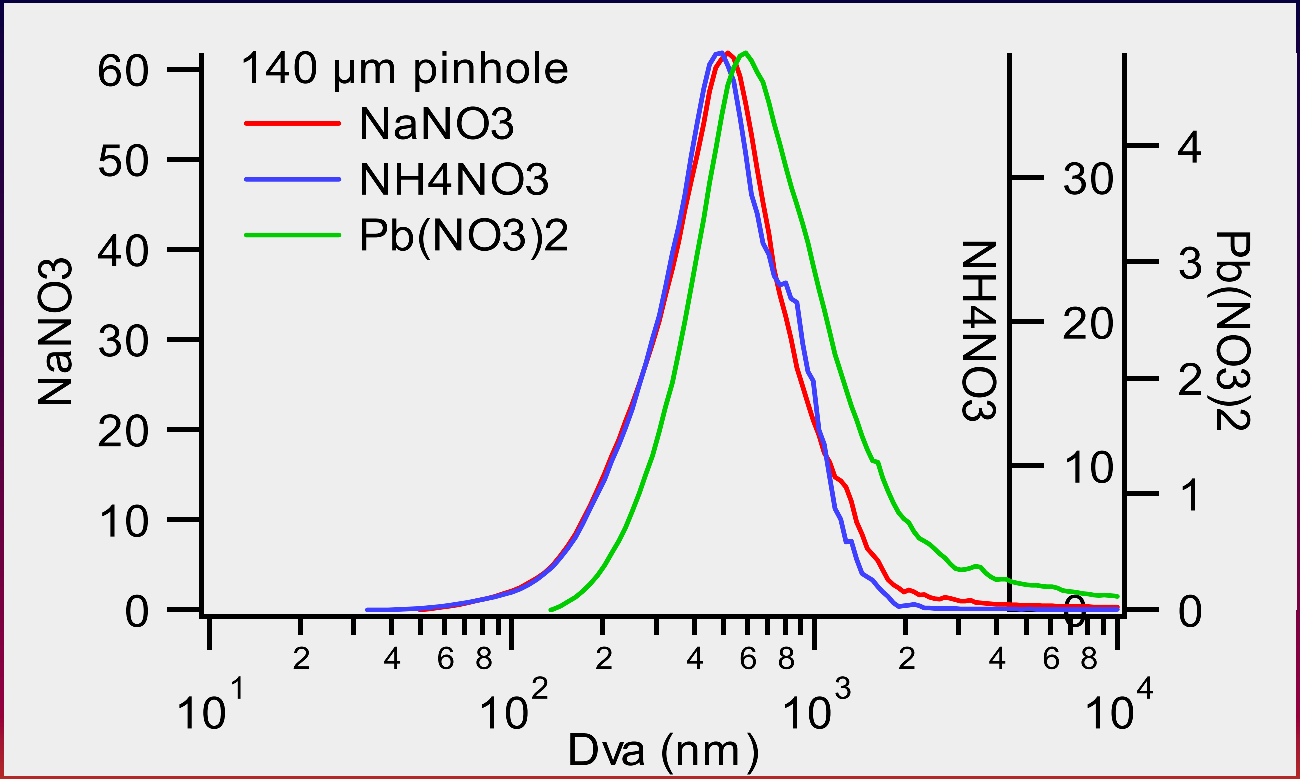
Orifice Size: 140 µm pinhole vs. 120 µm pinhole



More larger particles are able to pass through the 140 µm pinhole than the 120 µm pinhole => step in right direction

Particle Transmission

Compounds w/ different densities



Densities

NH_4NO_3 = 1.72 g/cm^3

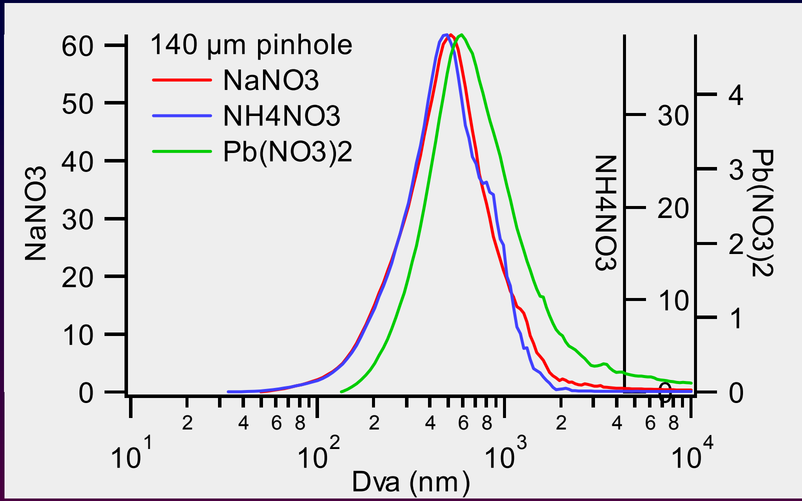
$NaNO_3$ = 2.26 g/cm^3

$Pb(NO_3)_2$ = 4.53 g/cm^3

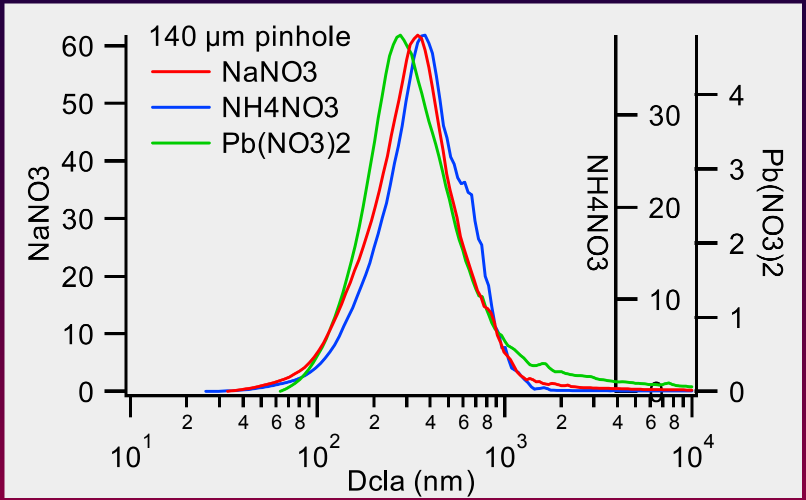
Particles w/ different densities and same diameter have different transmission efficiency => density likely plays a role

Particle Transmission

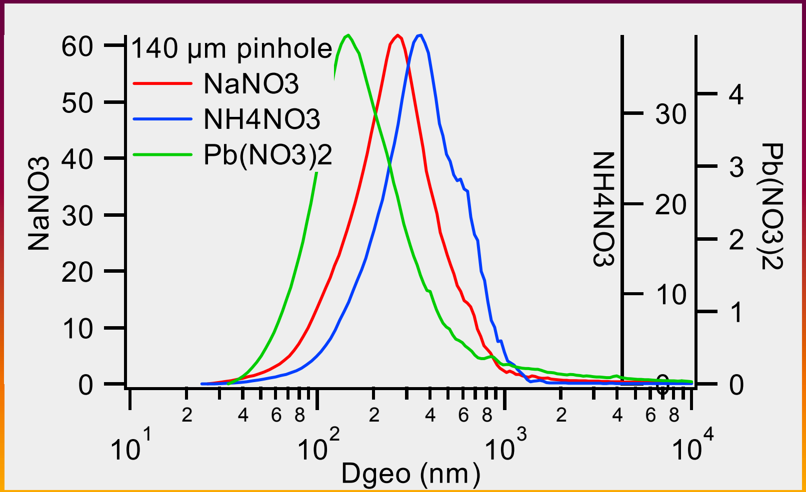
Which diameter determines the cutoff?



Vacuum Aerodynamic diameter – loosely grouped transmission



Classical Aerodynamic diameter - closely grouped transmission



Geometric diameter - wide spread transmission

Preliminary Conclusions

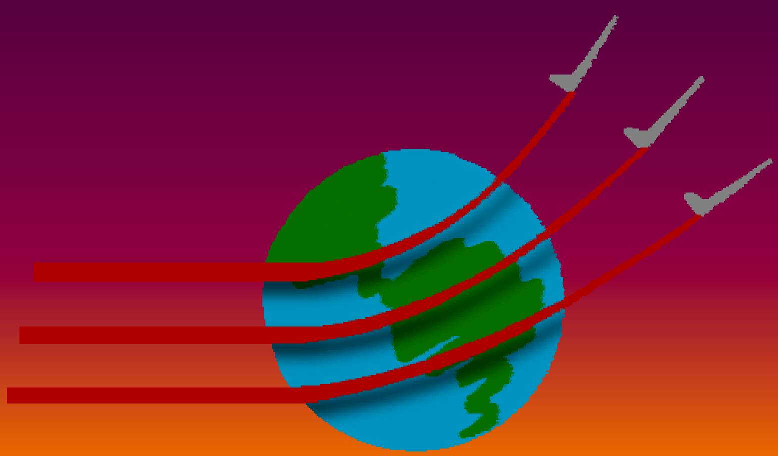
- Larger orifice slightly increases transmission of larger particles
- Particle transmission cutoff determined by classical aerodynamic diameter

Future Experiments

- Larger orifices – 160+ µm
- Laser spectrometry system

Acknowledgements

- GCEP Program
  - Jeff Gaffney, Milton Constantin, Mary Kinney
- Aerodyne Research Inc.
  - Leah Williams, Maragaret Farrar, Doug Worsnop, Phil Mortimer, John Jayne
- Liz



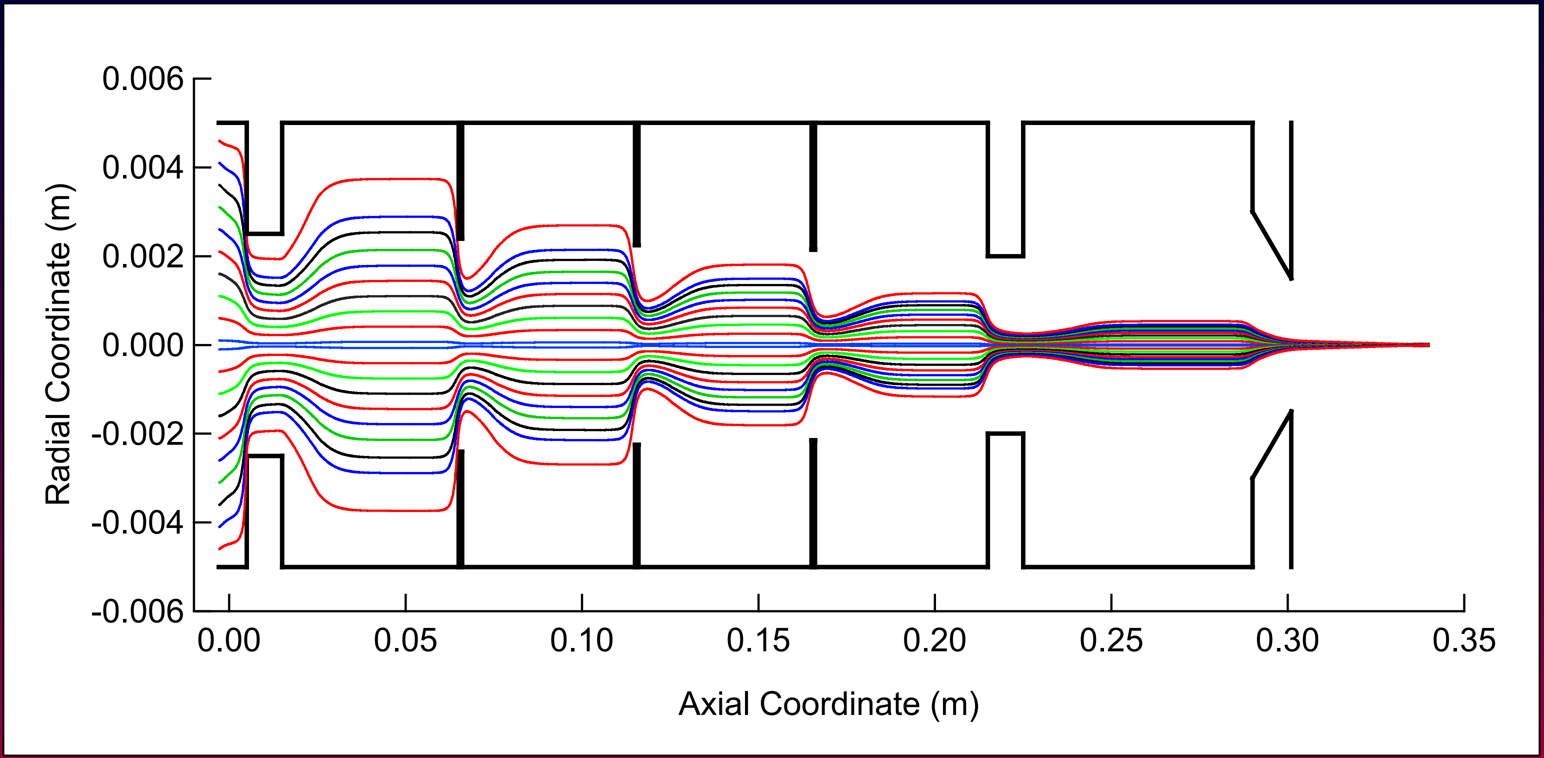
Auxiliary Information

Aerosol Generation System

- Creates particles from 50 nm to >25 μm
- Components
  - Medical Nebulizer
  - Dryer tube
  - $PM_{2.5}$ cyclone

Auxiliary Information

AMS Lens Schematic



Larger particles unable to move out as far with each succeeding plate/pinhole => focusing of particles

Based on work by Liu *et al.*, 1995

References

- Liu, P. Ziemann, P. J., Kittelson, D. B., and McMurry, P. H. (1995). Generating Particle Beams of Controlled Dimensions and Divergence: I. Theory of Particle Motion in Aerodynamic Lenses and Nozzle Expansions, *Aerosol Sci. Tech.* 22:293-313.