Real-Time Size-Distributed Measurement of Aerosol Mass Concentration

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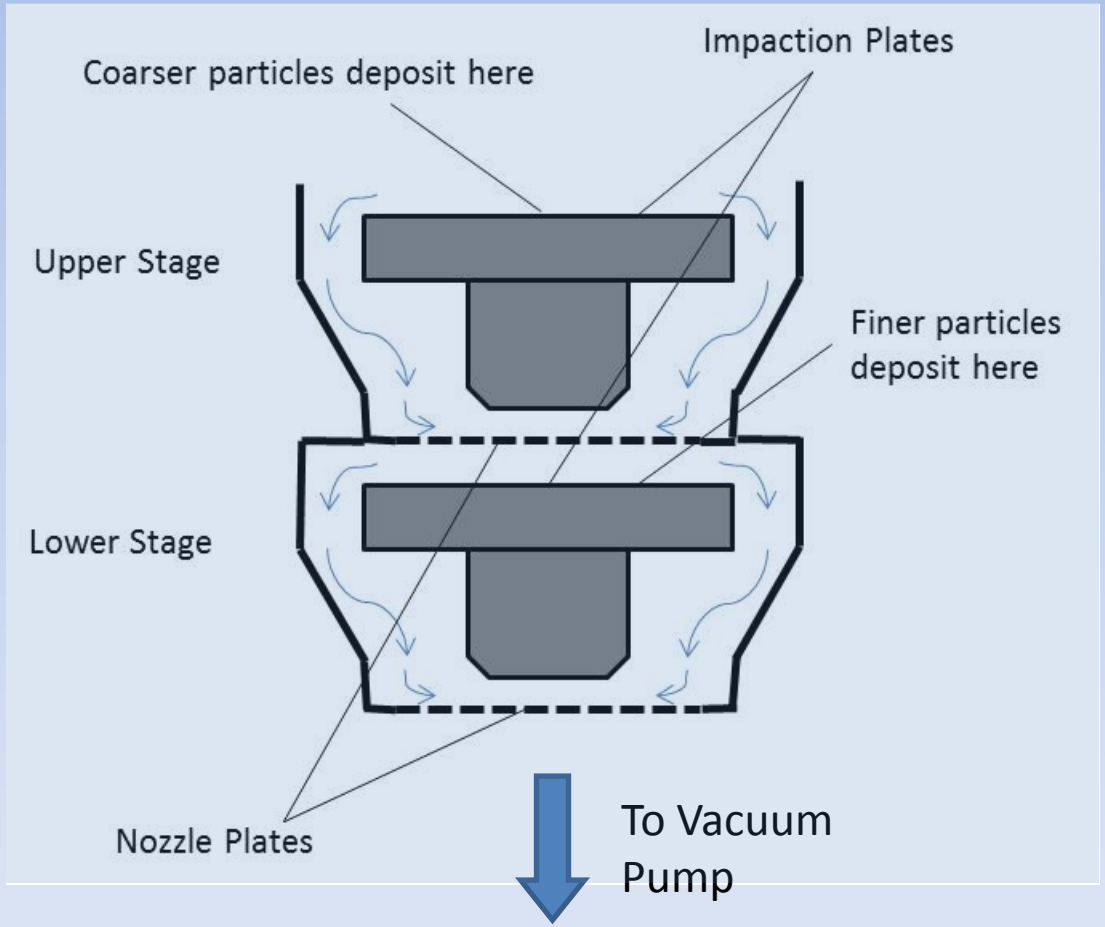
Overview

- DOE Program: Atmospheric Systems Research
  - Subtopic: Atmospheric Aerosols
- Significance:
  - Aerosols affect
    - Cloud formation
    - Penetration of solar radiation into the atmosphere
- MSP's Proposed Technique
  - Sample & classify aerosols down to 10 nm
  - Measure collected mass in each size class in real-time

Base Technology: Cascade Impactor

- **Cascade Impactors** consist of multiple stages—each stage has impaction plate and nozzle plate
- Flow is maintained by a vacuum pump
- Aerosol-containing air is accelerated through the nozzles
  - Particles above a certain size are deposited on the impaction plate
  - Finer particles are carried over to the next stage
- Coarsest particles deposit on the 1st stage; finest on the last



Classical Cascade Impactor

- Advantages
  - Classifies aerosol sample by aerodynamic size, which determines its mobility in a fluid
  - Collects particles in each size class, so they are available for post-analysis
- Disadvantages
  - Provides no information about the aerosol size distribution during sample collection
  - Labor-intensive laboratory analysis is needed for determining aerosol mass deposited on each stage

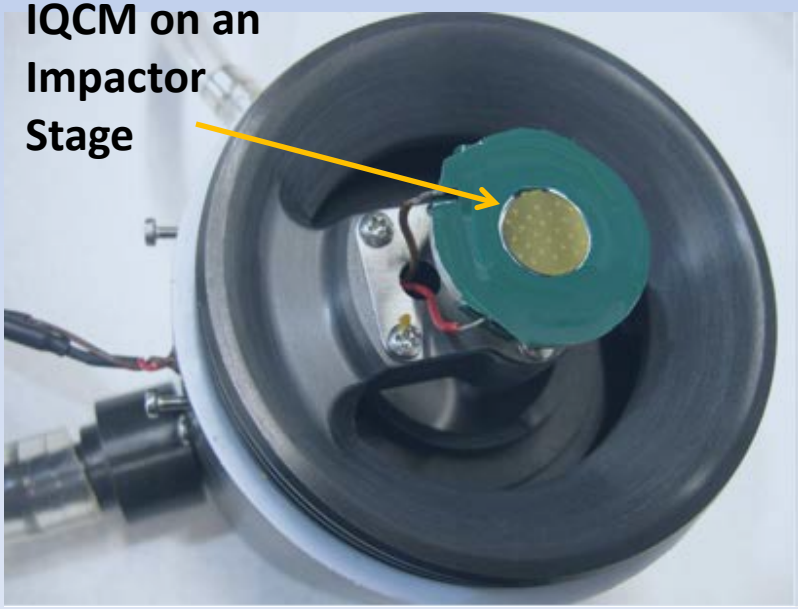
Need of real-time mass measurement on each impactor stage

- A real-time mass sensor flush with the impaction plate of impactors is desirable
- Quartz crystal microbalances (QCM) have been tried for 30+ years for this purpose
- Older Technology
  - Problems with drift and sensitivity to vibration
  - Measurement sensitivity not adequate for atmospheric research

Impedance-based Quartz Crystal Microbalance (IQCM)

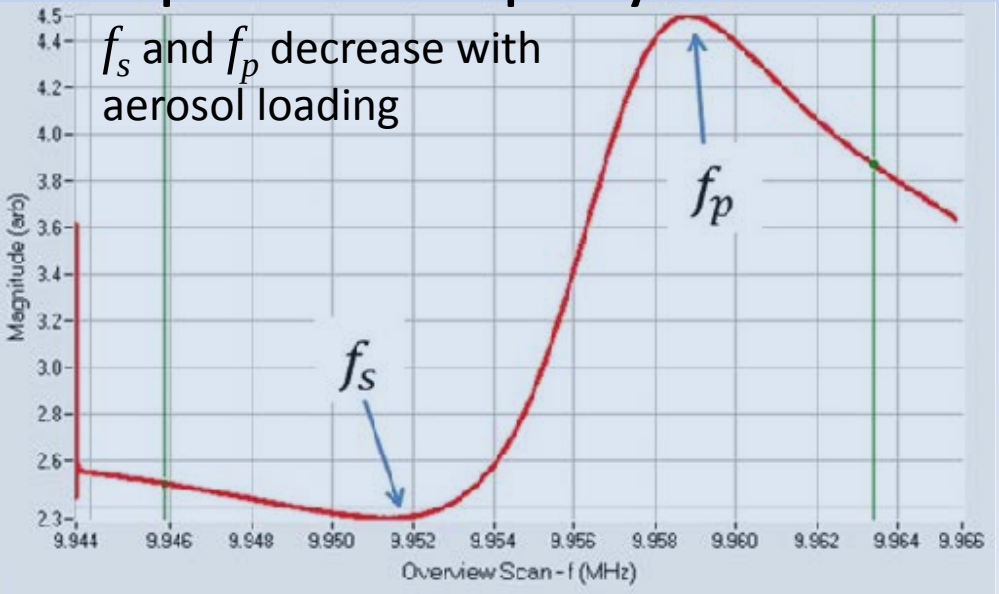
- Overcomes most of the problems with QCM
  - Nanogram resolution
  - Stable output for hours

IQCM on an Impactor Stage

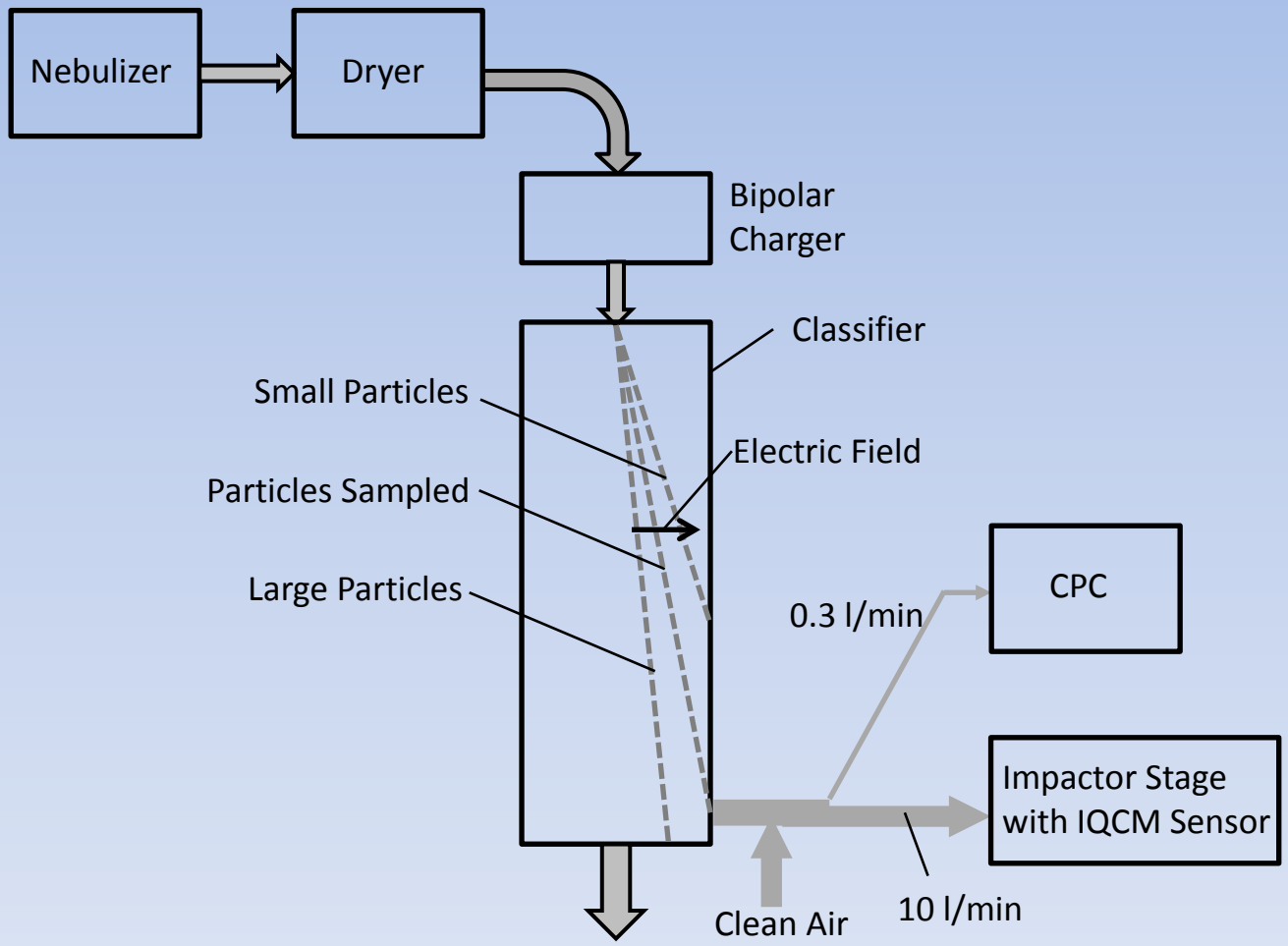


Impedance vs Frequency

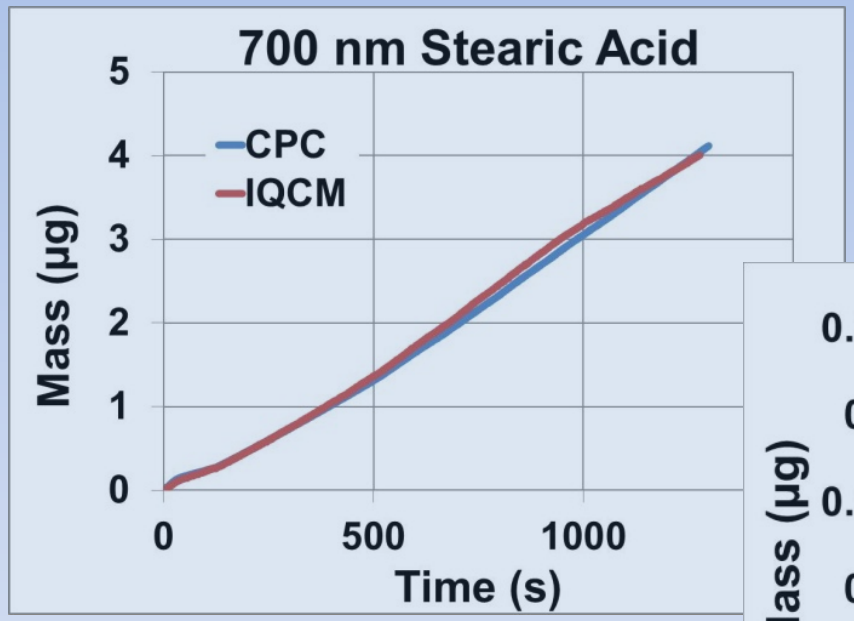
f_s and f_p decrease with aerosol loading

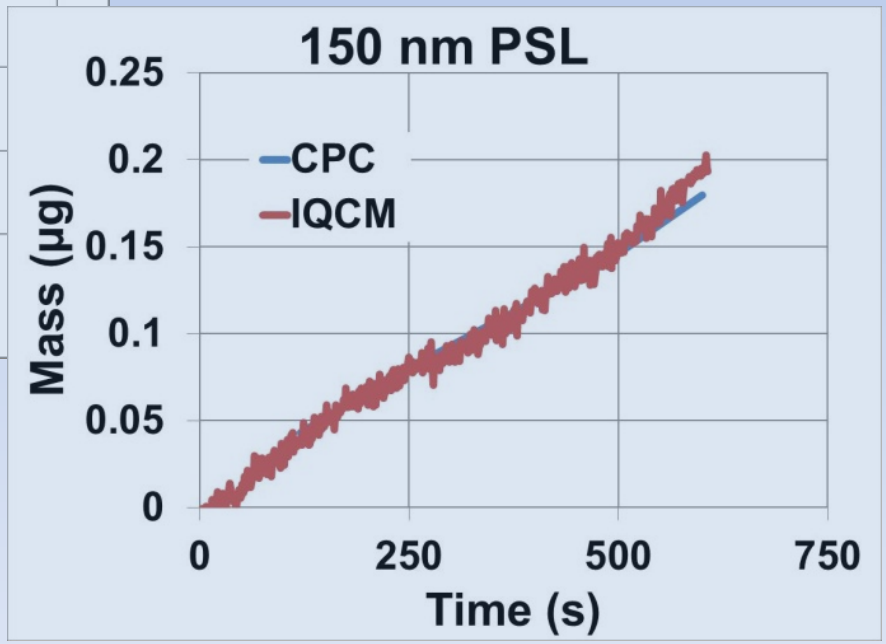


Experimental Setup



Test Results

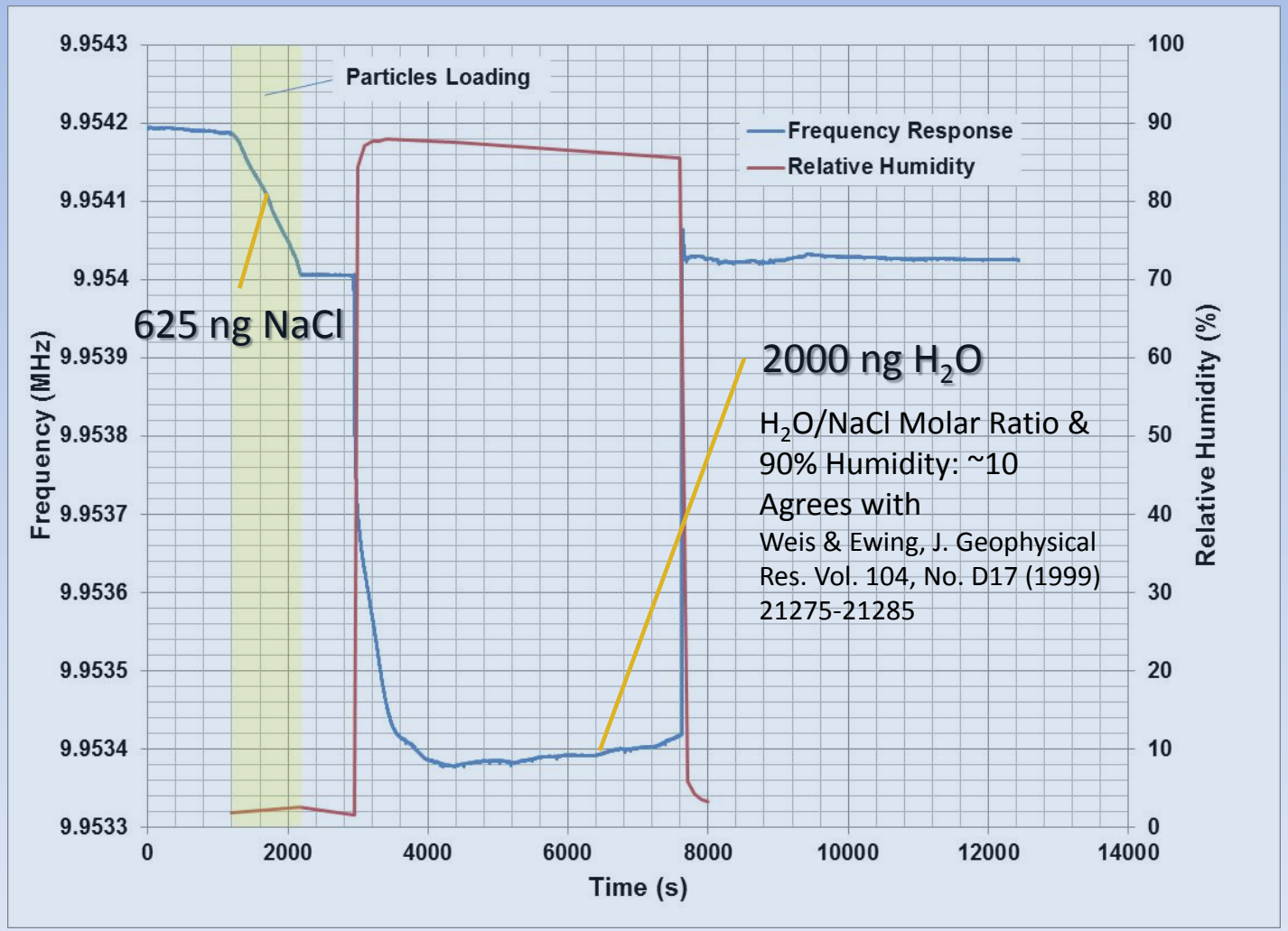




Moisture Uptake Measurement

- IQCM sensor collects particulate matter on a flat surface
  - Suitable for moisture uptake measurement, as well as deliquescence & efflorescence relative humidity
  - Valuable for atmospheric aerosol research
    - Helps understand cloud-formation potential of the particles
    - Helps predict age of aerosols
  - Preliminary Data: absorption and release of moisture from collected NaCl aerosol sample demonstrated (next slide)

Moisture Uptake: Preliminary Results



Future Work

- Build a multi-stage cascade impactor for real-time aerosol mass distribution measurement
- Build accessories to
  - Ensure dry particle mass measurement
  - Enable measurement of relative humidity for deliquescence and efflorescence, as well as moisture uptake ability
- Ruggedize the instrument for flight measurements