The Aerosol Observing System Inlet Characterization Experiment

Chongai Kuang, Robert Bullard, Janek Uin, Scott Smith, Cynthia Salwen, Stephen Springston

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

U.S. DEPARTMENT OF ENERGY | Office of Science

Wednesday, May 4th 2016
Tysons, VA

AOS: Aerosol Observing System

- Primary ARM platform for in-situ aerosol and precursor measurements at the surface
- Deployed in diverse environments

courtesy of S. Springston

courtesy of arm.gov

AOS Inlet

AOS Inlet: From Stack to Instrument

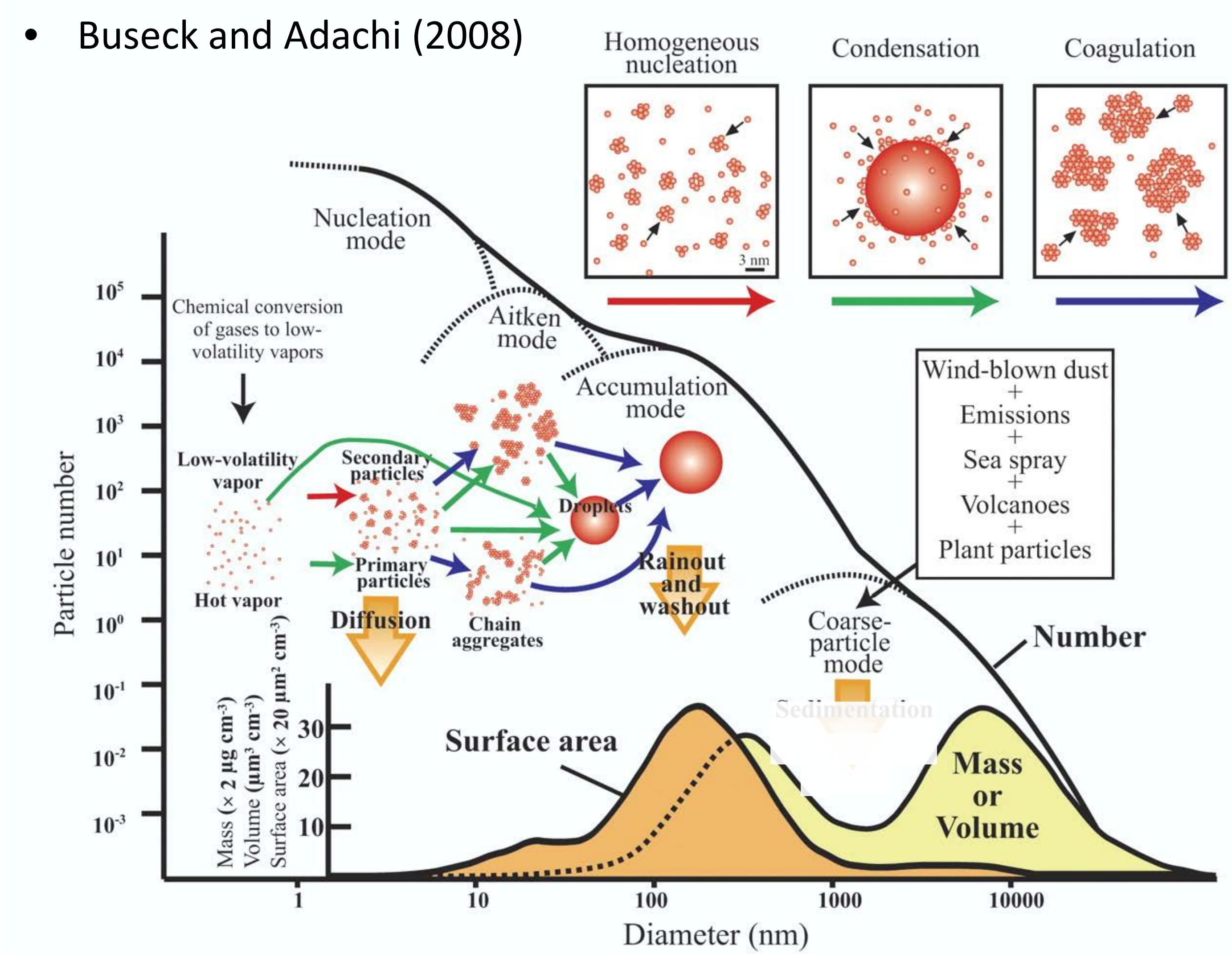
- 7.3 m x 20 cm diameter outer pipe mounted on top of a 2.4 m high SeaTainer
- 1000 LPM flow rate through the outer pipe

- 1.8 m x 5 cm diameter tube sub-samples from outer pipe at a flow of 150 LPM
- Flow is split into 5 lines at 30 LPM each

- Example: Scanning Mobility Particle Sizer (SMPS) sub-samples from this 30 LPM line

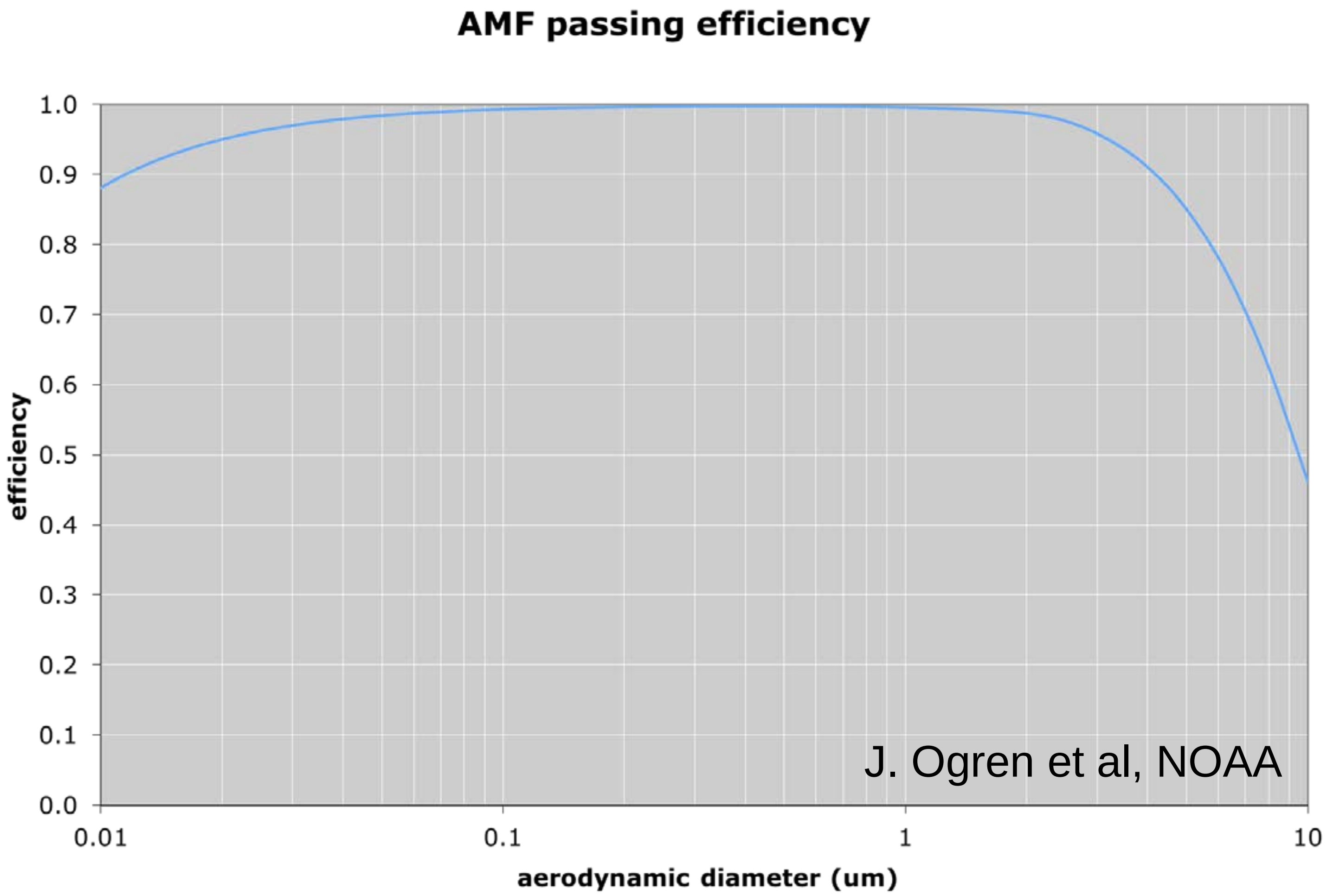
Ambient Aerosol Size Distribution

- Buseck and Adachi (2008)



- Accurate measurements of ambient aerosol **properties** and **processes** depend on accurate characterizations of the aerosol size-dependent transport losses from the entrance of the inlet stack to the inlet of each aerosol instrument.

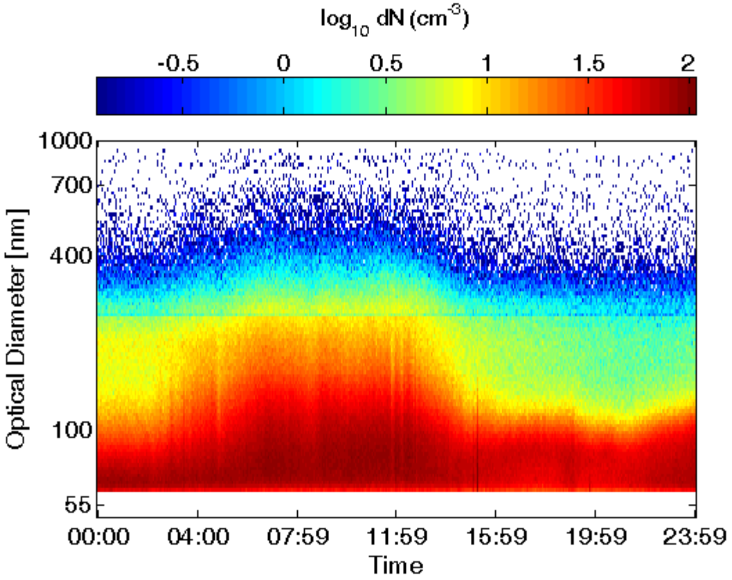
AOS Inlet: Theoretical Transmission Efficiency



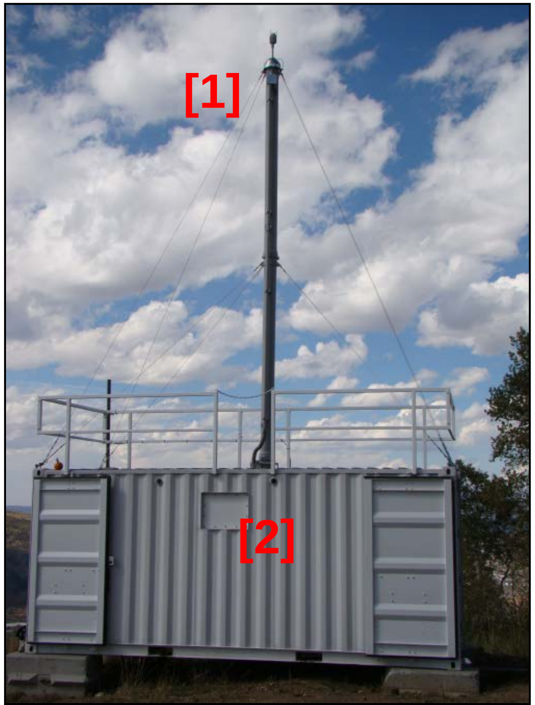
- Inlet designed to optimize transmission of aerosol in the 0.02 – 2 micron diameter size range
- **Goal: Provide a measured characterization of the size-dependent aerosol losses from 10 nm – 10 um through the AOS inlet from the entrance to the exit of the inlet stack.**

Experimental Approach

- Due to the physical dimensions and high sampling flow rate of the inlet stack, the **ambient atmospheric aerosol** was used as the aerosol source.



- The experimental approach for the inlet characterization involved measuring the ambient aerosol size distribution under two scenarios:
  [1] sampling from the ambient
  [2] sampling from the exit of the inlet stack

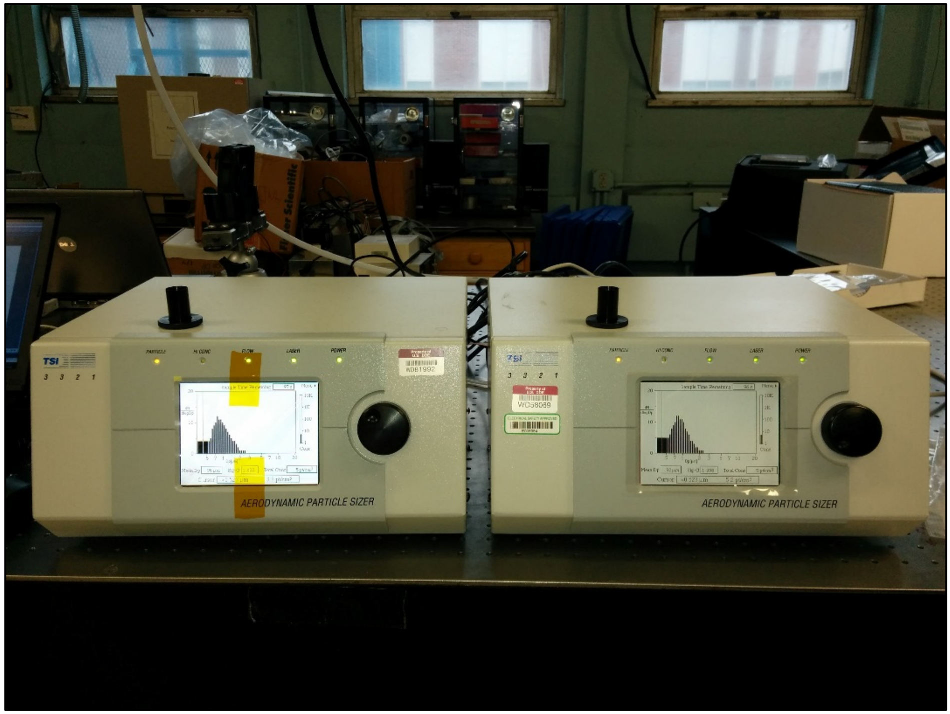


- Simultaneous sampling from 1 and 2
- 3-way valve sampling switching between 1 and 2

Instrument Measurement Ranges

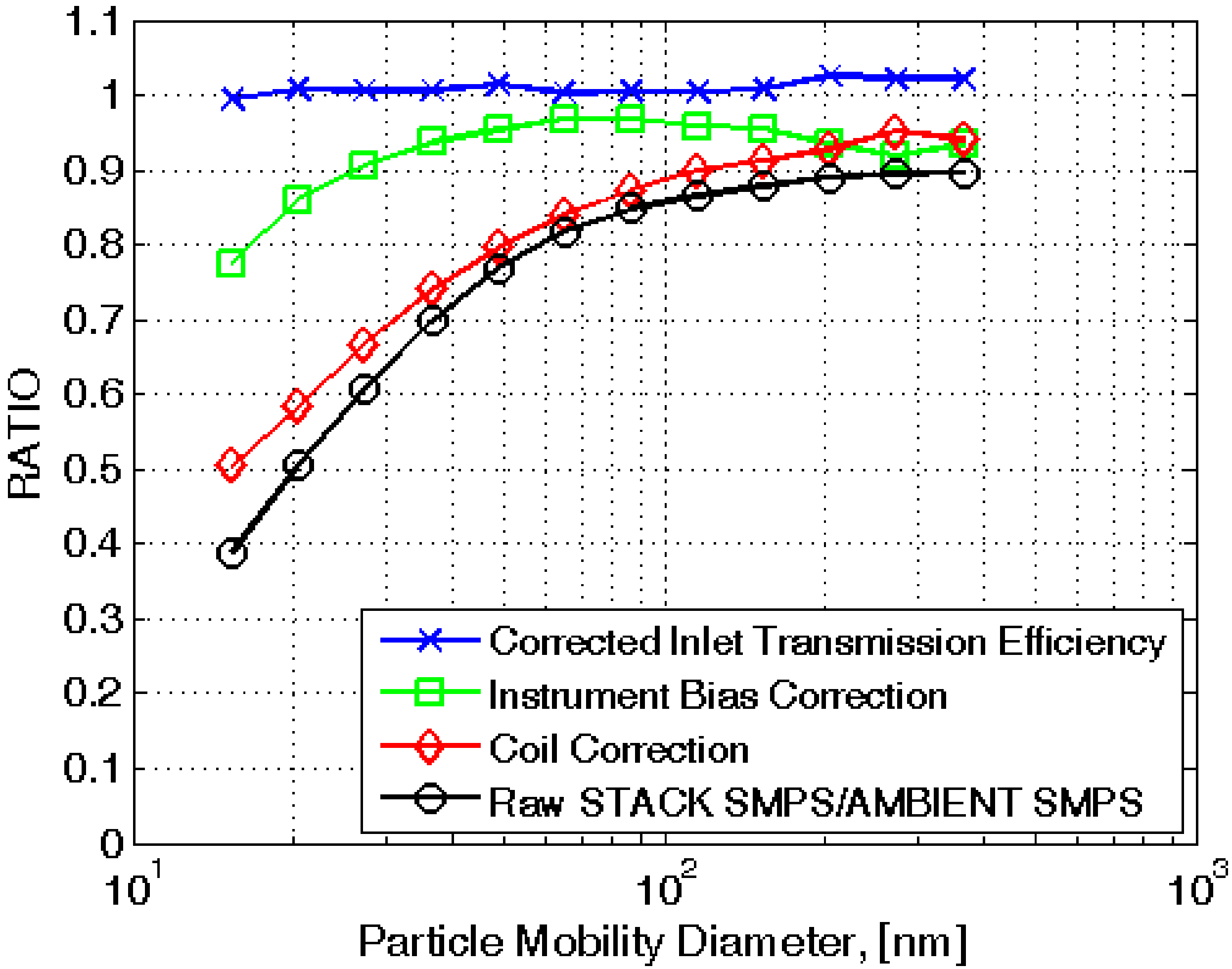
- The instrumentation used to characterize the ambient aerosol size distribution included 2 of each of the following instruments:
  - **SMPS** (scanning mobility particle sizer, 10 – 400 nm)
  - **UHSAS** (ultra-high sensitivity aerosol spectrometer, 60 – 1000 nm)
  - **APS** (aerodynamic particle sizer, 0.5 – 20 microns)

SMPS



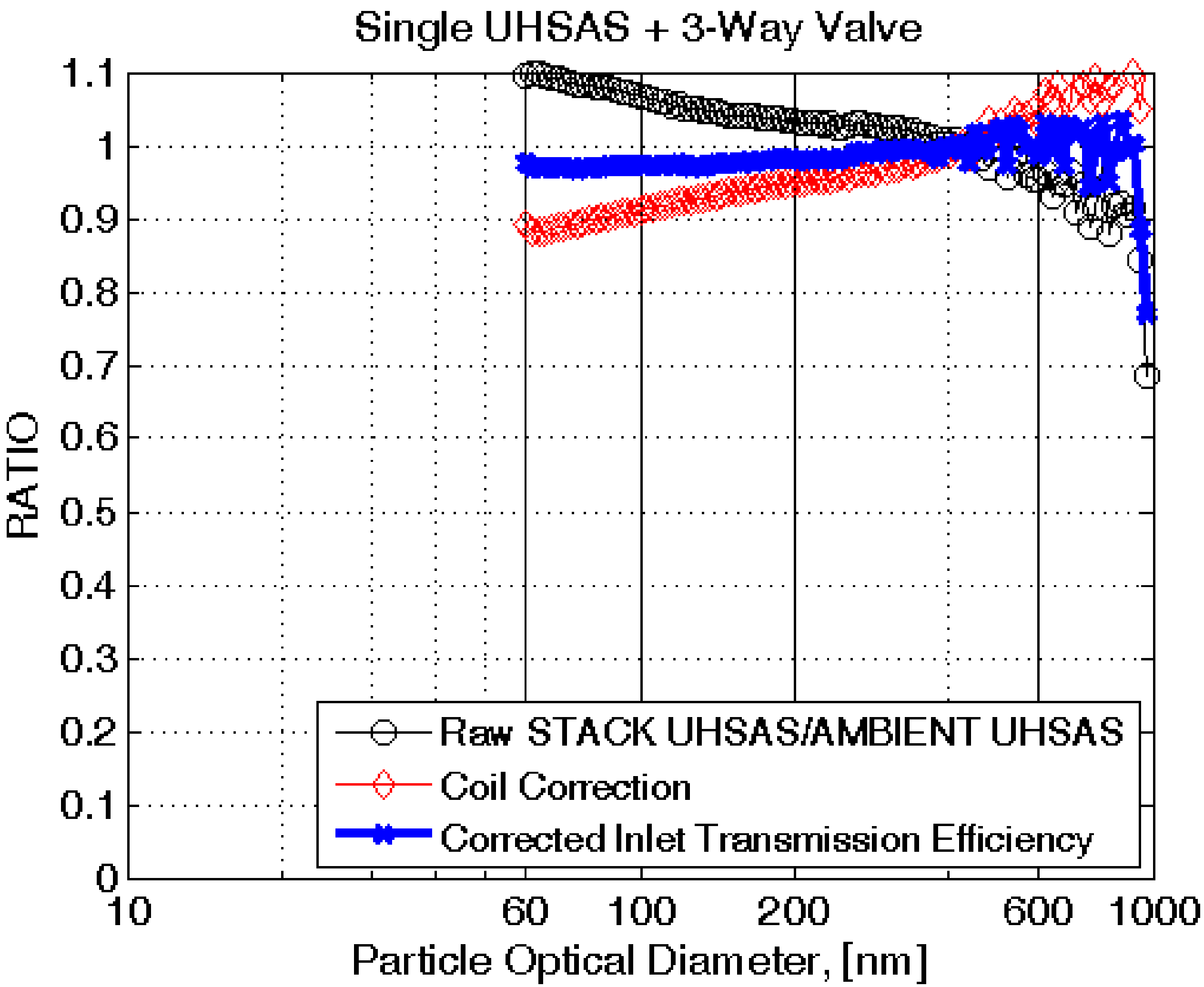
APS

SMPS: 15 – 400 Nanometers



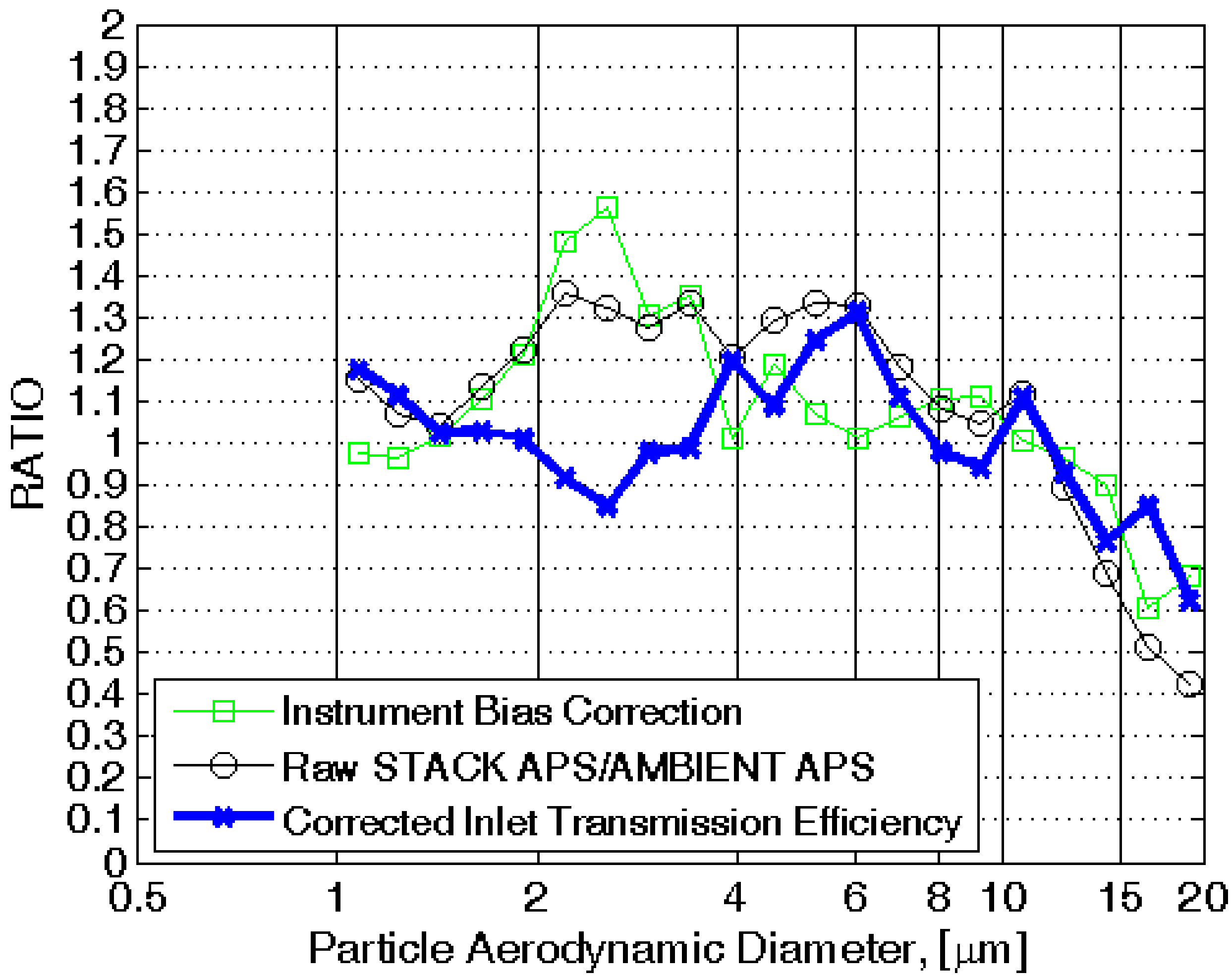
- Near 100% transmission of aerosol from 15 – 400 nm

UHSAS: 60 – 1000 Nanometers



- Near 100% transmission of aerosol from 60 – 900 nm
- Non-smooth transmission efficiency > 900 nm ➔ low counting statistics

APS: 1 – 20 Microns



- Non-monotonic transmission efficiency ➔ low counting statistics
- Transmission efficiency ratio of 0.8 – 1.3 from 1 – 10 microns

Summary

Outcomes:

- AOS inlet transmission efficiency characterized from 15 nm to 20 microns
- Transmission efficiency near 100% from 15 nm to 1 micron

Continuing Work:

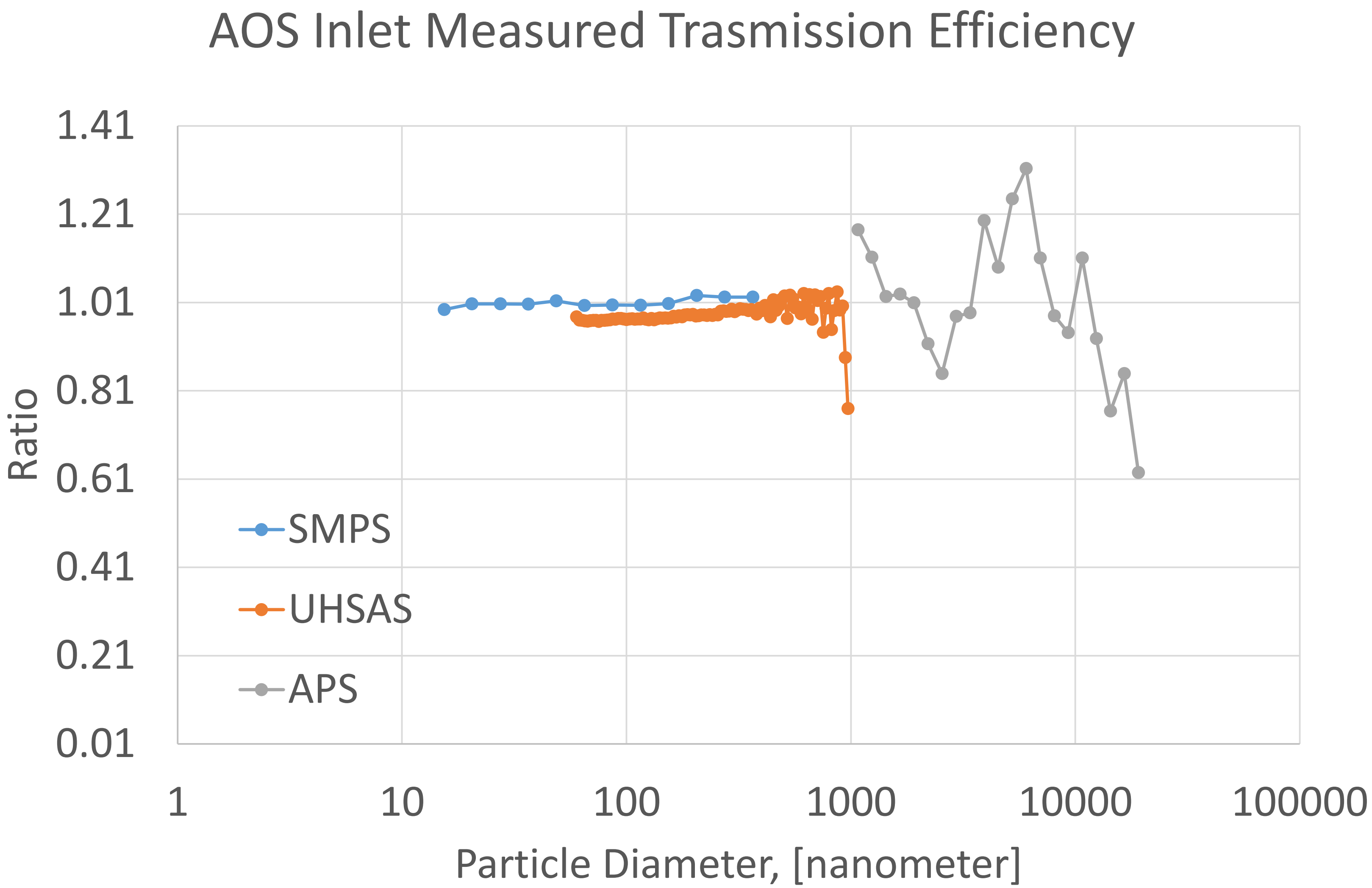
- Improve counting statistics from 1 – 20 microns through bin averaging, longer sampling times
- Determine transmission efficiency from 1 nm to 15 nm

Acknowledgements

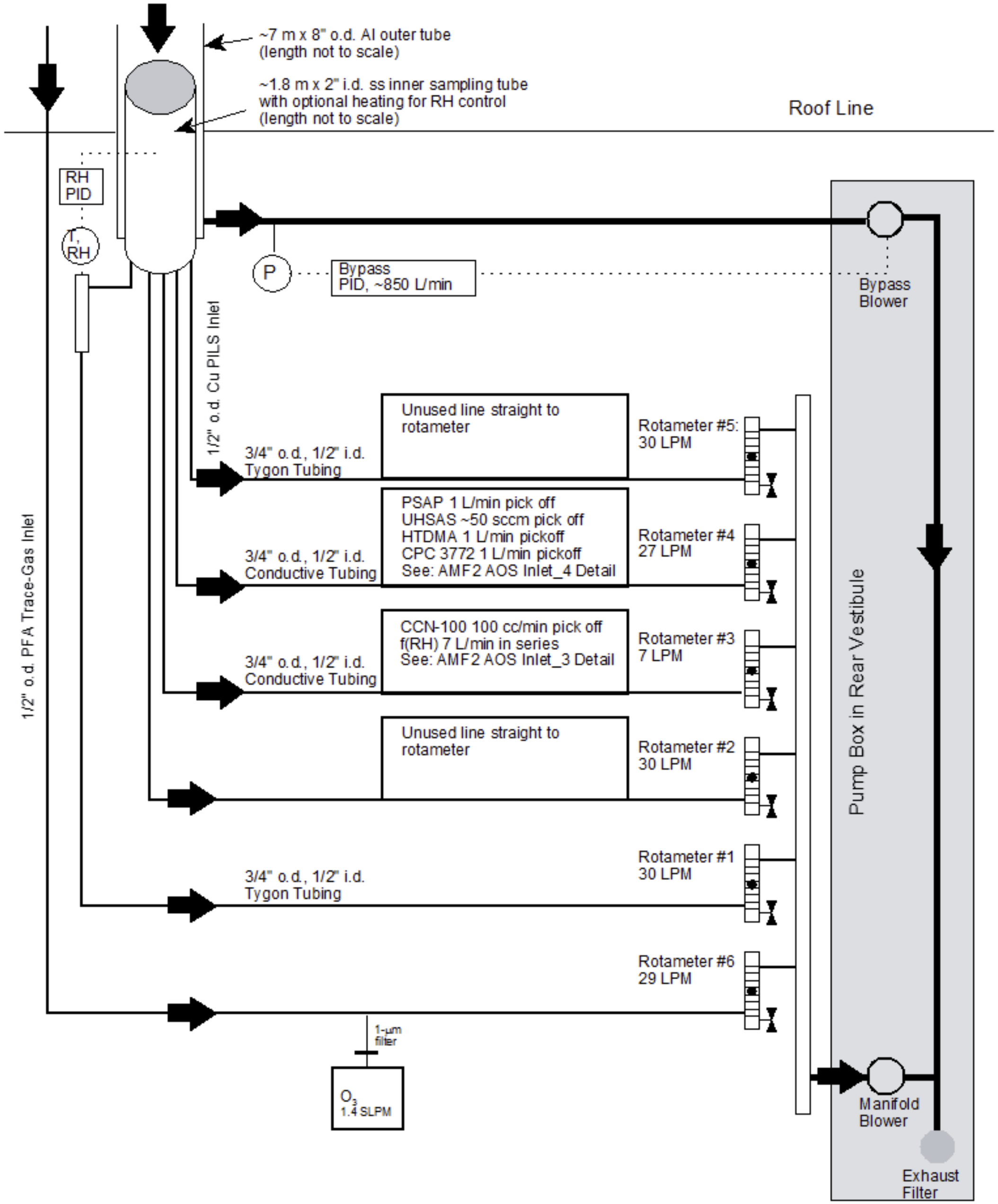
- The DOE ARM Climate Research Facility
- Don Collins, TAMU
- Mikhail Pekour, PNNL

Backup Slides

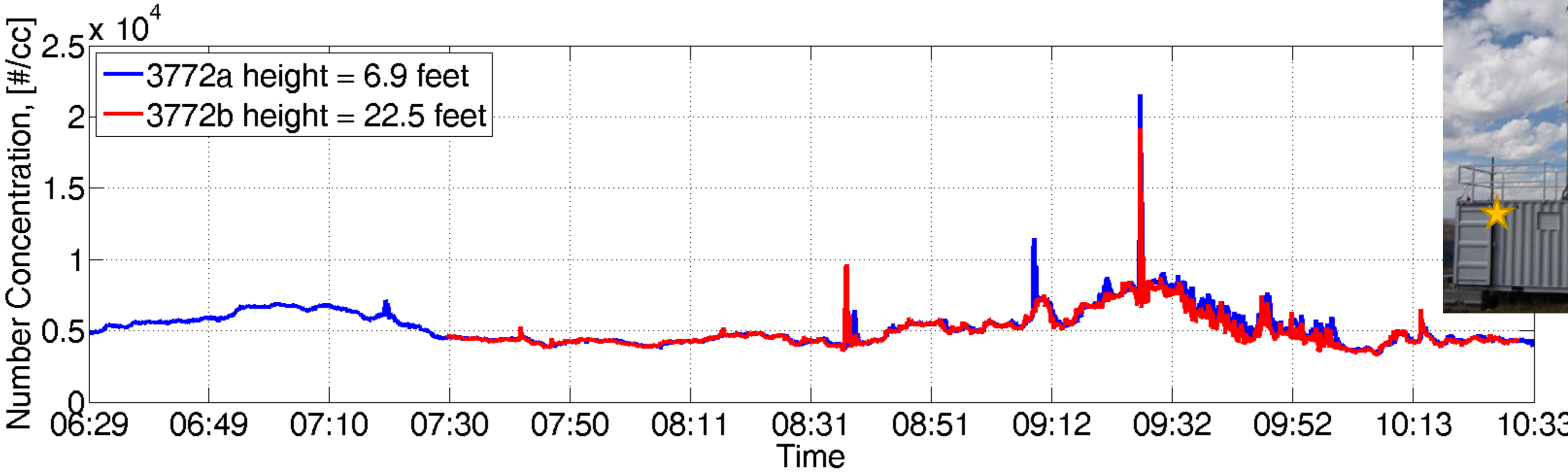
Composite Transmission Efficiency

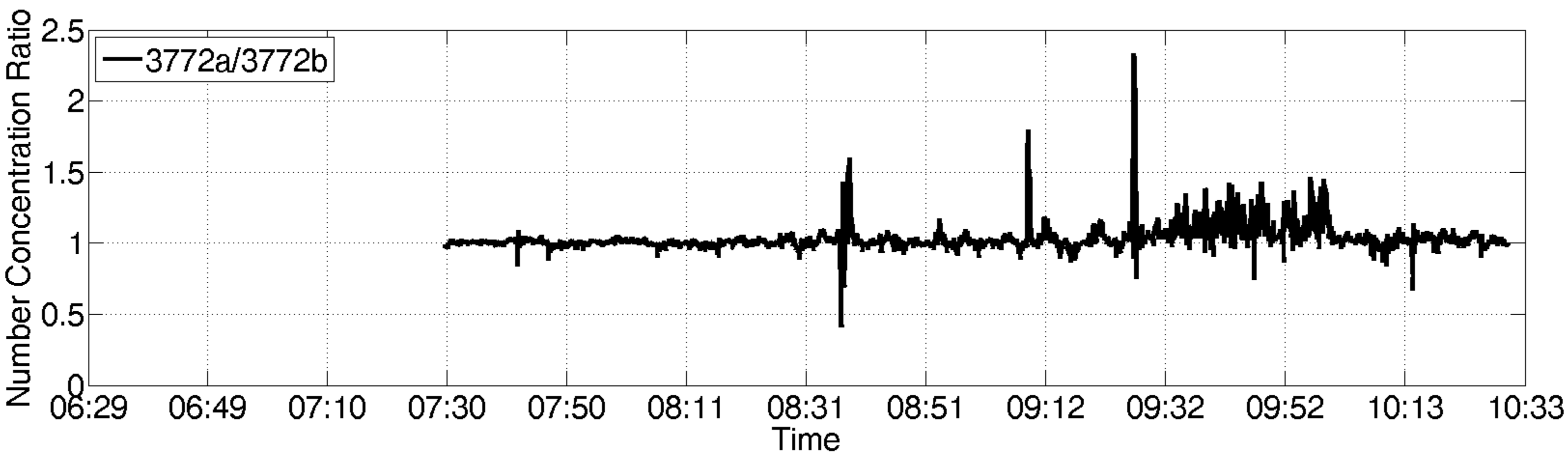


AOS Sampling Schematic



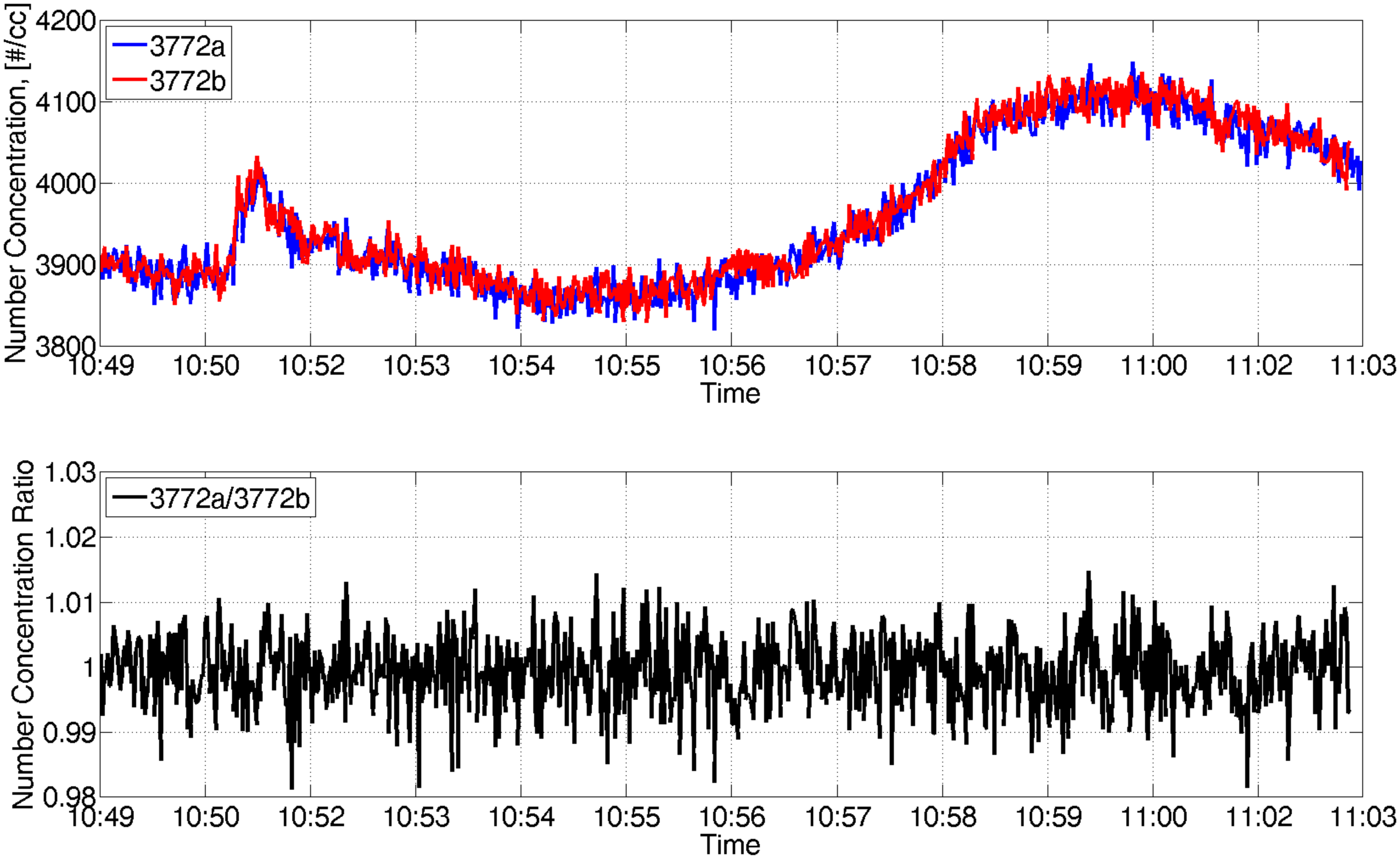
AMF3: Aerosol Spatial Homogeneity





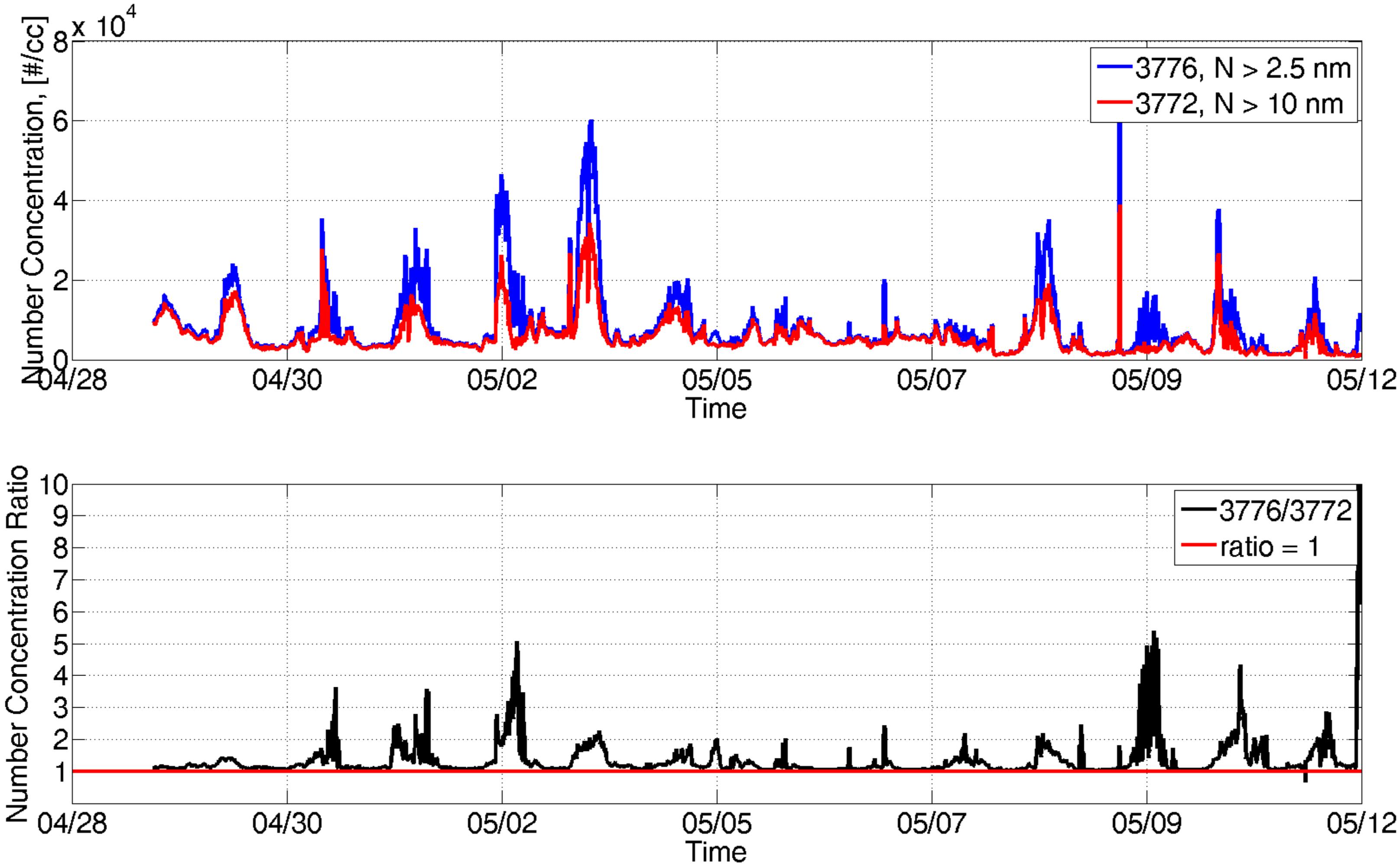
- Reasonable agreement between CPC measurements at the two heights
- Sampling at 6.9 feet should reasonably capture aerosol number concentration at the top of the inlet stack

AMF3: Aerosol Spatial Homogeneity



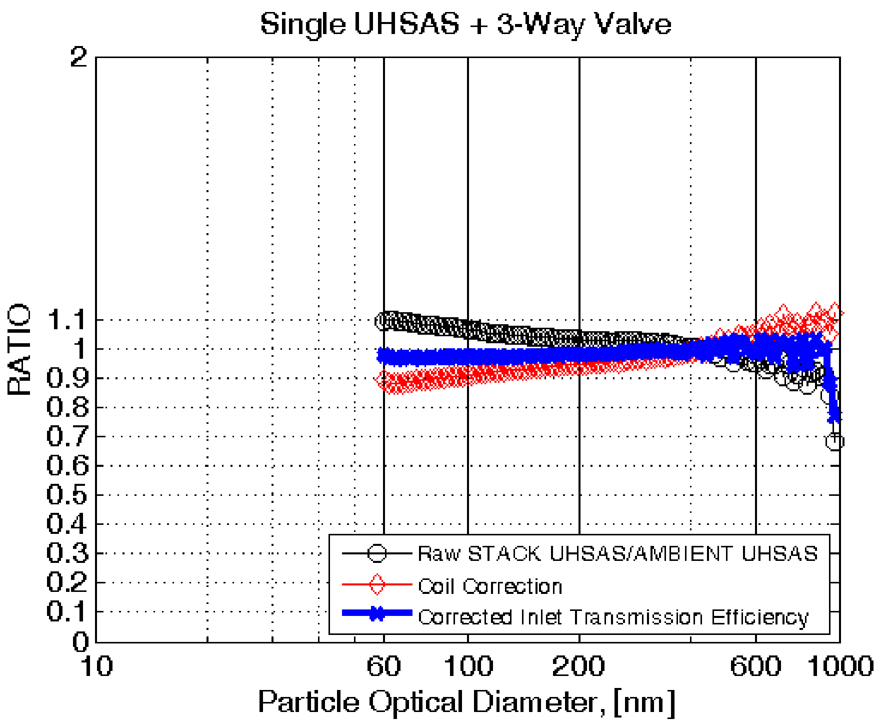
- Two 3772 CPCs sampling through the same inlet in the laboratory

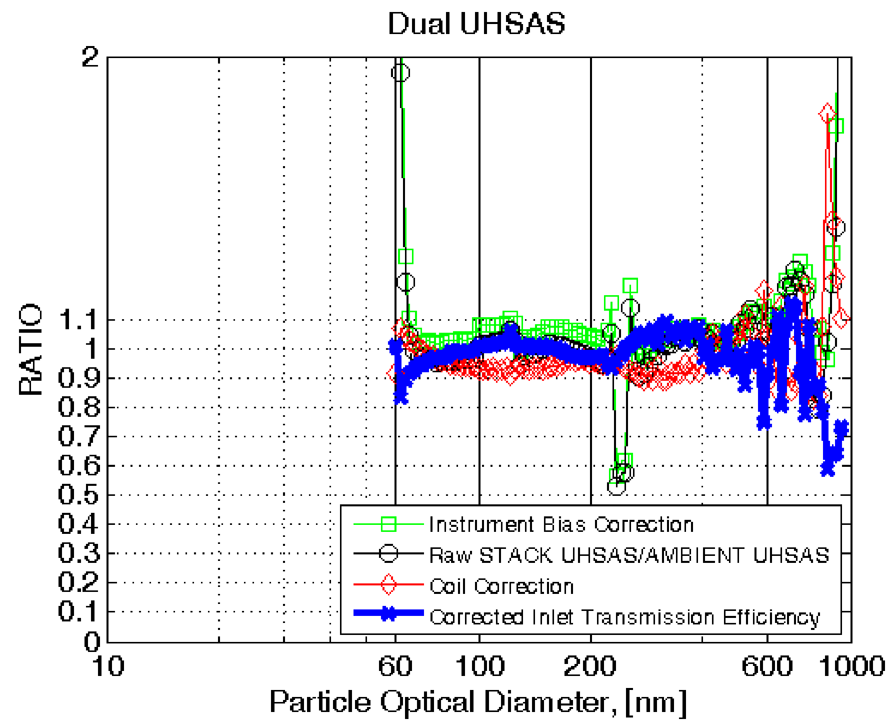
Ambient Observation of sub 10 nm Aerosol



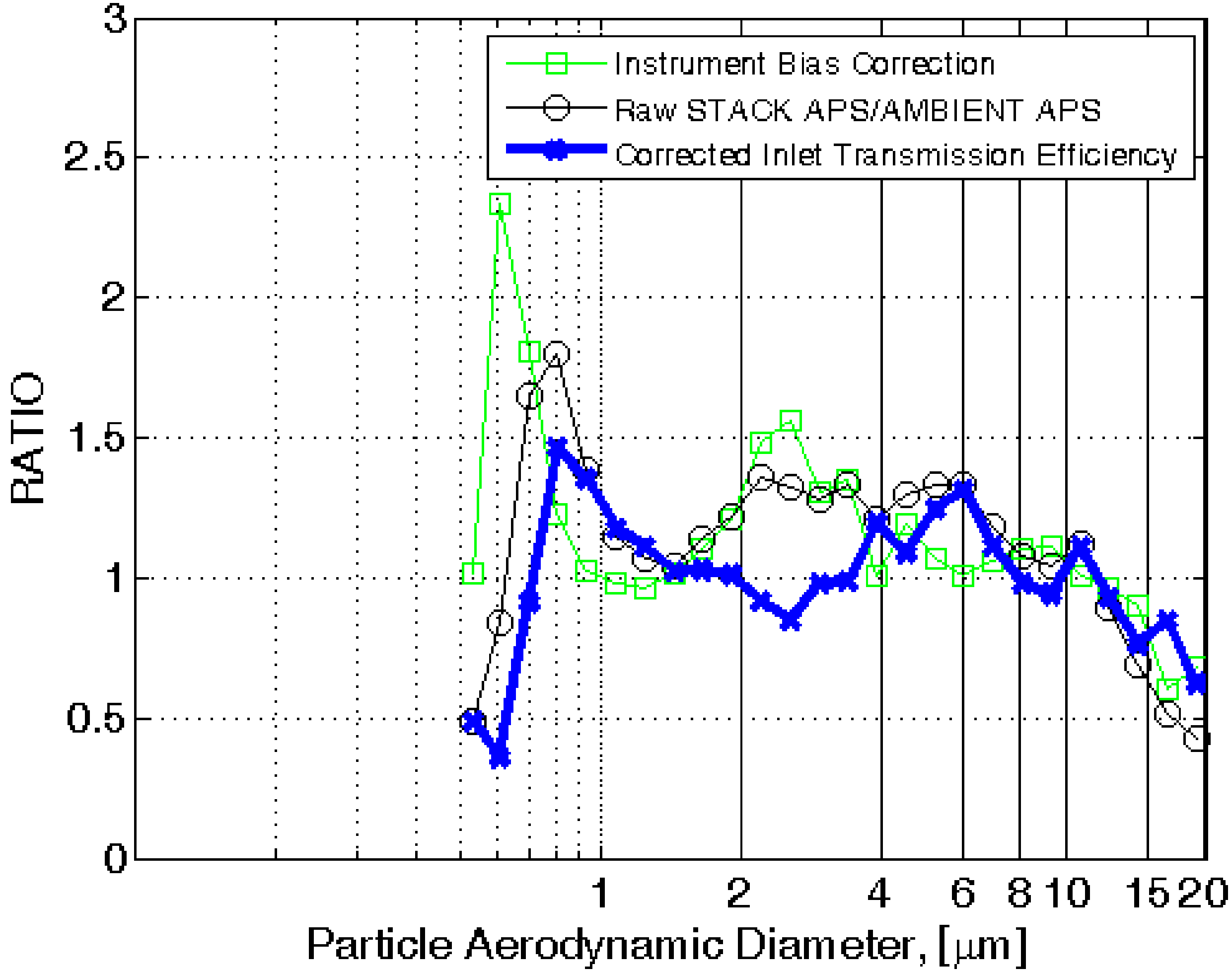
- AMF3 frequently samples sub 10 nm aerosol (and potentially sub 2.5 nm aerosol) at BNL
- Sufficient sub 10 nm aerosol is transmitted through the inlet stack

UHSAS: 60 – 1000 Nanometers



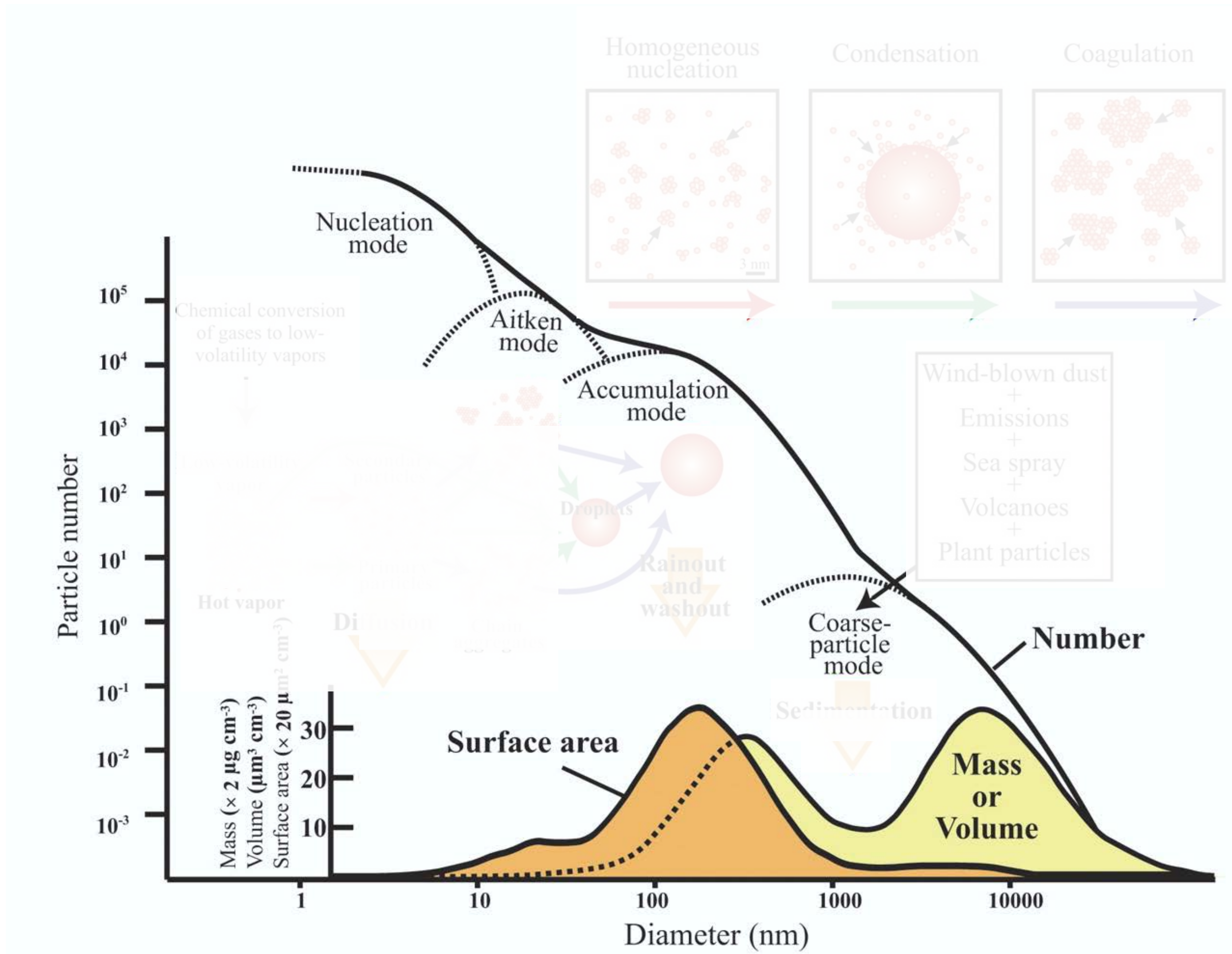


APS: 0.5 – 20 Microns



Experimental Approach

Ambient Aerosol Size Distribution



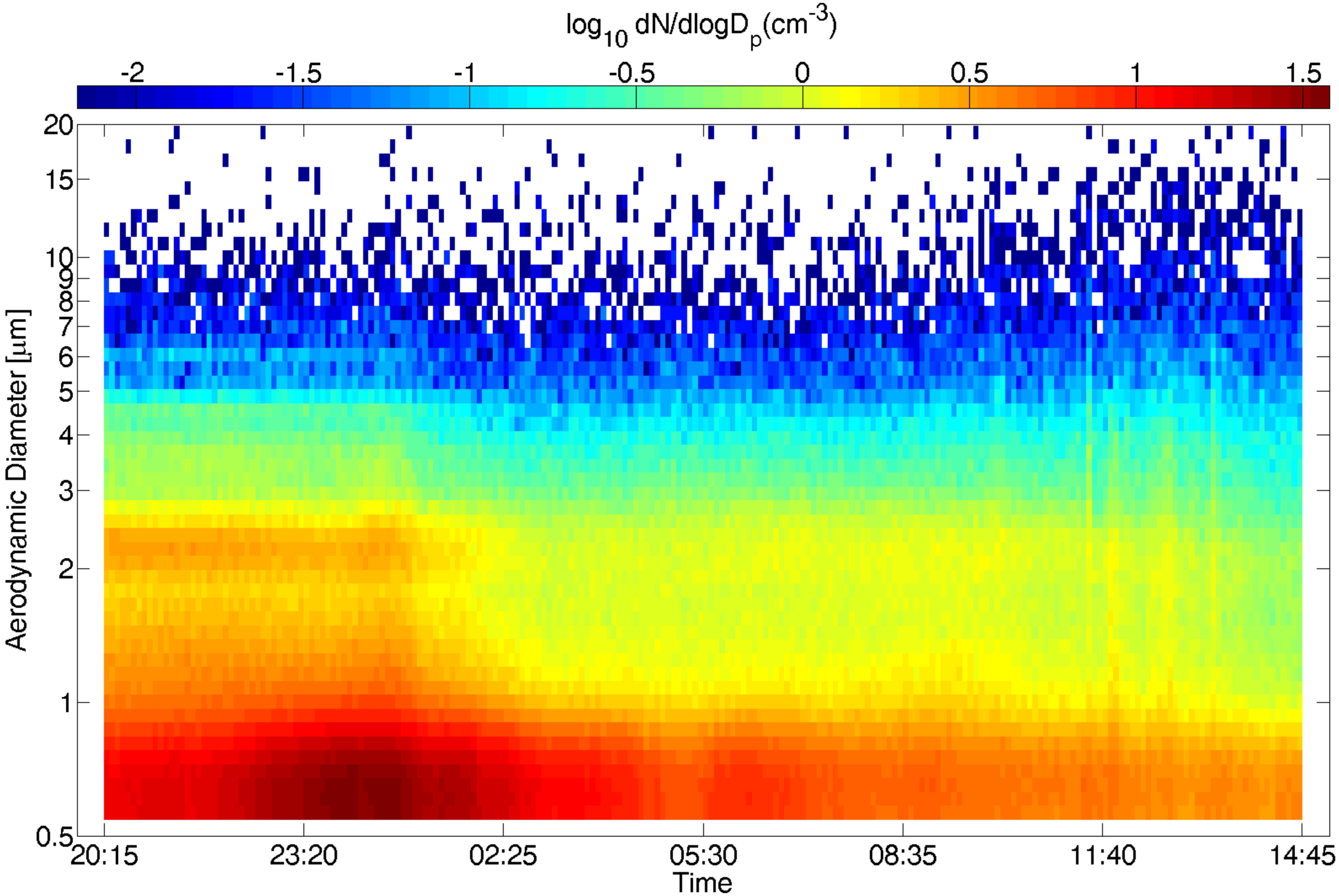
- Buseck and Adachi (2008)

AOS Inlet Sampling Specifications

Inlet system:	
Diameter, main stack, cm	20
Flowrate, main stack, lpm	1000
Flow velocity, main stack, m/s	0.53
Reynolds number, main stack	7070
Particle stopping distance, main stack (cm)	0.02
Diameter, heated inlet tube, cm	4.76
Flowrate, heated inlet tube, lpm	150
Flow velocity, analytical sample line, m/s	1.4
Reynolds number, heated inlet tube	4440
Particle stopping distance, heated inlet tube (cm)	0.04
Diameter, analytical sample line, cm	1.59
Flowrate, analytical sample line, lpm	30
Flow velocity, analytical sample line, m/s	2.5
Reynolds number, analytical sample line	2670
Particle stopping distance, analytical sample line (cm)	0.07

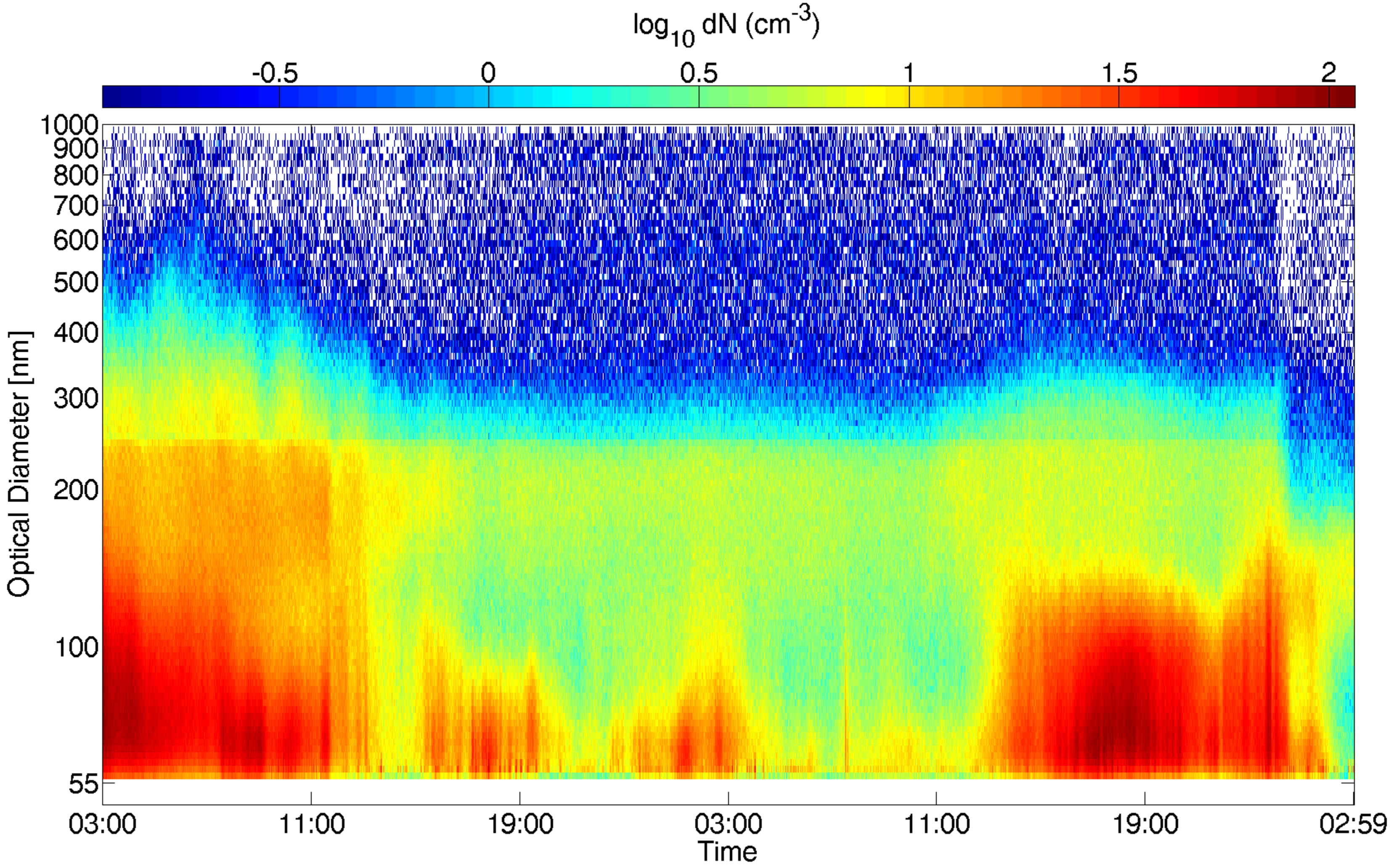
From J. Ogren

Aerodynamic Particle Sizer (APS): 0.5 – 20 µm



- Sampling through AMF3 inlet
- Verified transmission of aerosol up to 10 µm with 5 min. sampling interval

Ultra High Sensitivity Aerosol Spectrometer (UHSAS): 55 – 1000 nm



- Sampling through AMF3 inlet
- Verified transmission of aerosol up to 1000 nm with 10 min. sampling interval