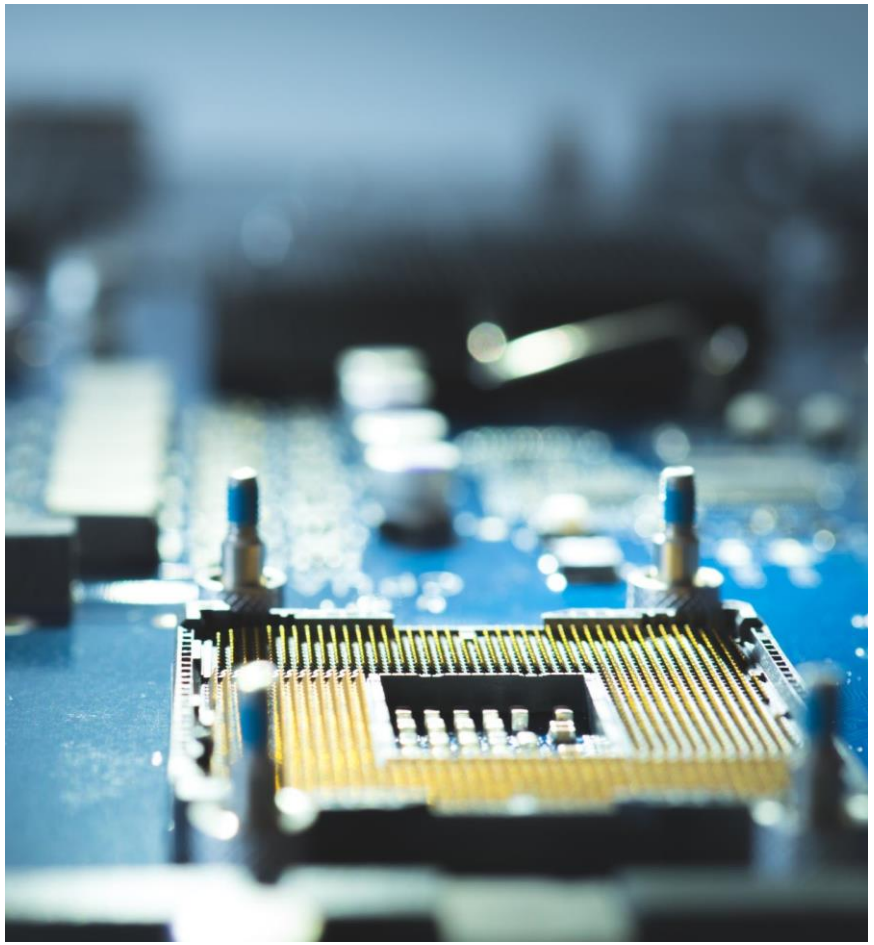


The AirPhoton Nephelometer Product Line

January 2020 Status Update

- Vanderlei Martins – Chief Technical Officer
- Richard Kleidman – Chief Operating Officer
- Lorraine Remer – Vice President Project Development

AirPhoton

Innovative Technology for Earth and Space

AirPhoton was founded in 2012 with the goal of creating and producing high quality instruments for the study of airborne particulates with applications to pollution and human health as well as climate change.

Instruments are required to be sensitive, accurate and robust for global deployment in harsh conditions.

Current offerings

AirPhoton Nephelometer Product Line

MODEL	Forward & Backscatter Measurements	Three Wavelengths	High Speed Fan	Feedback Flow Control System	Multiple Size Cutoffs	Determine Size Distribution	Estimate Particle Mass	Suggested Uses
IN101	✓	✓						Measurement of all particle sizes at ambient conditions
IN101 Turbo	✓	✓	✓					For situations where higher intake pressure is required: high altitudes, clean conditions or long inlet tubes
IN102	✓	✓	✓	✓	PM 2.5 – PM 10			High precision measurements at multiple cutoff sizes under all conditions. For air quality & health and climate studies
IN102Ex	✓	✓	✓	✓	PM 1 – PM 10	✓	✓	For air quality & health and climate studies where size distribution information is required

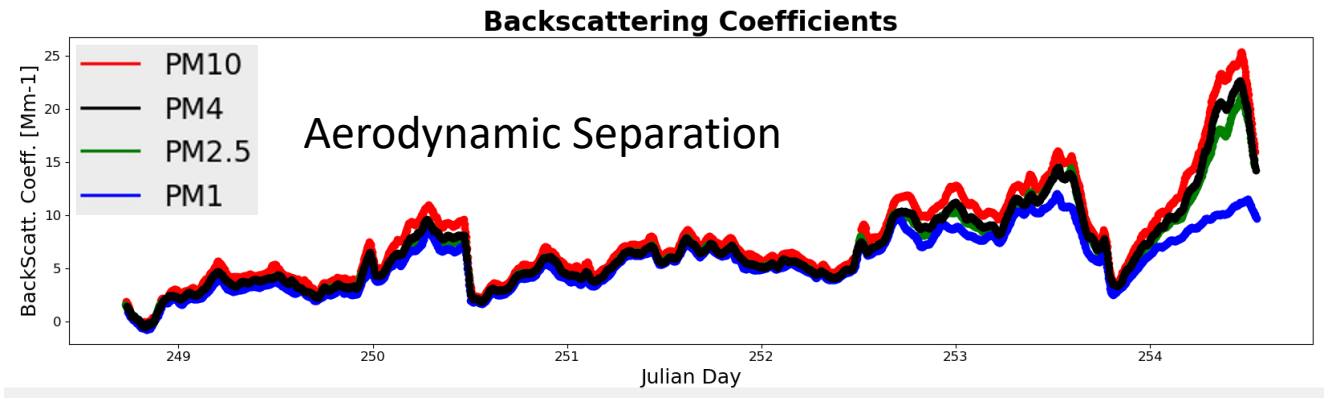
Advantages of AirPhoton Real Time Optical Detection Systems:

- High sensitivity/fast response
- Combination between optical properties and aerodynamic sizing
  - Optical detection is very sensitive
  - Aerodynamic sizing mimics human respiration
  - Better representation for potential health effects

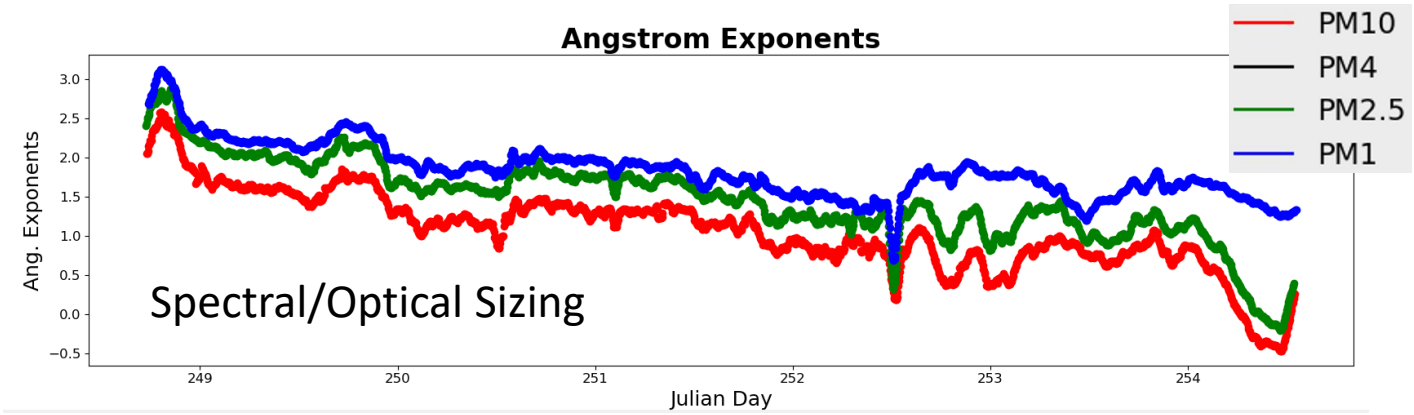
Size-Scanning Nephelometer Allows for Estimates of Size Distribution

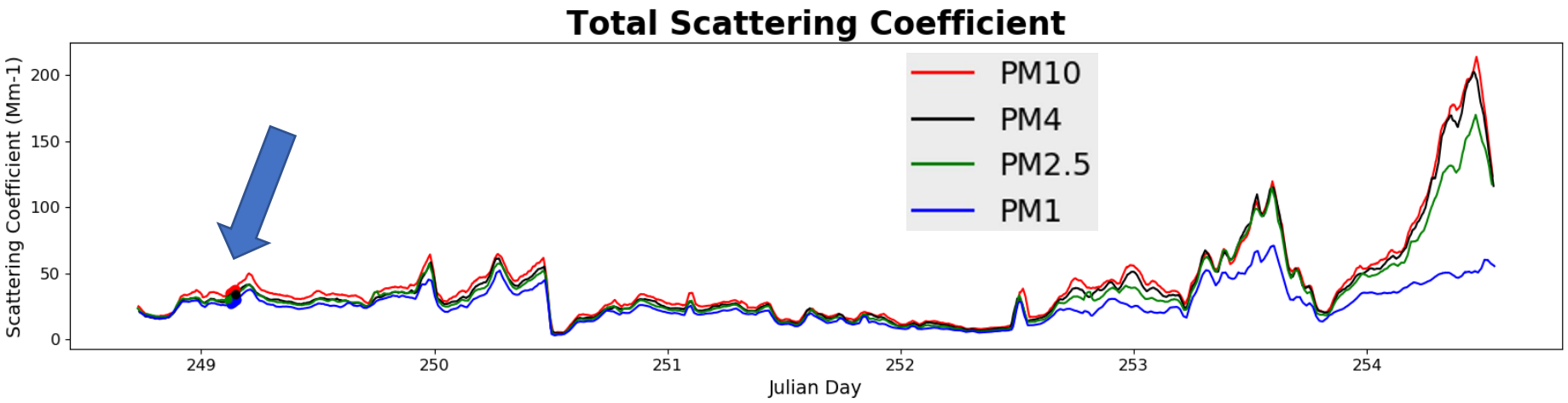
- Provides optimum combination between optical and aerodynamic particle sizing
- Best particle representation to combine in situ and remote sensing measurements
- Ideal size distributions for air pollution and characterization of particle optical properties

AirPhoton Exclusive Size-Scanning Nephelometers

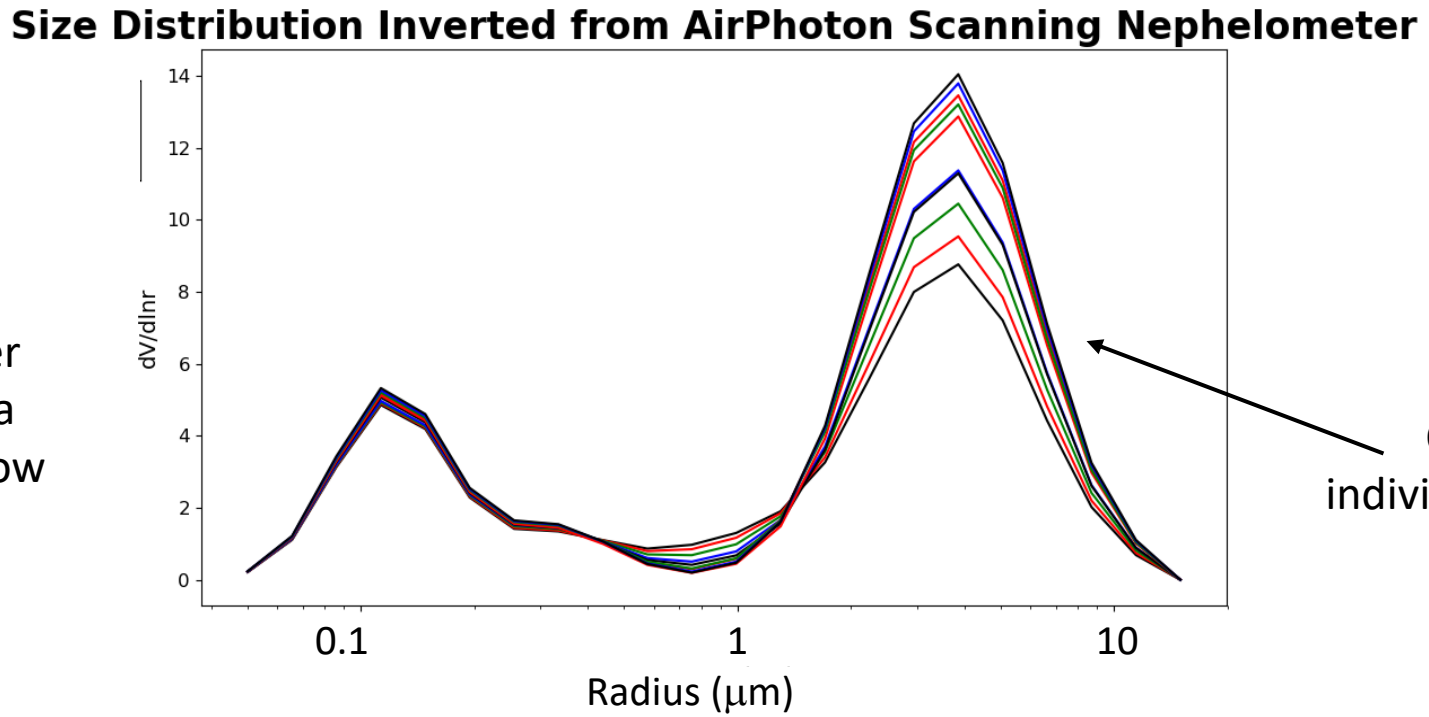


Ratios of spectral response in each cutoff range gives size information



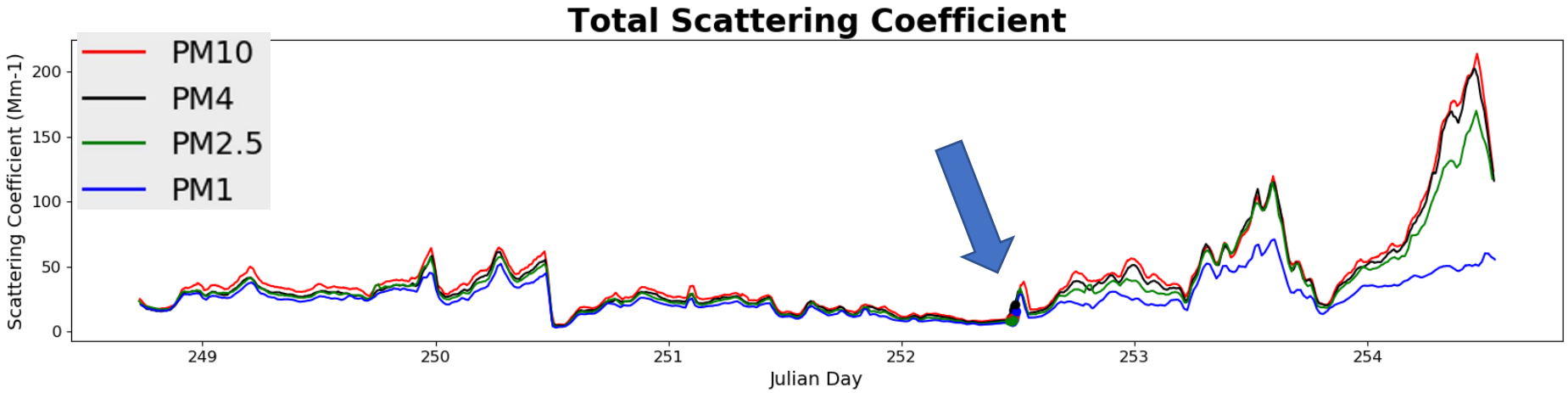


Combination between Aerodynamic and Optical Inversion



Size distributions in lower graph correspond to data collected at the blue arrow in the top graph

Colored lines are individual size distributions



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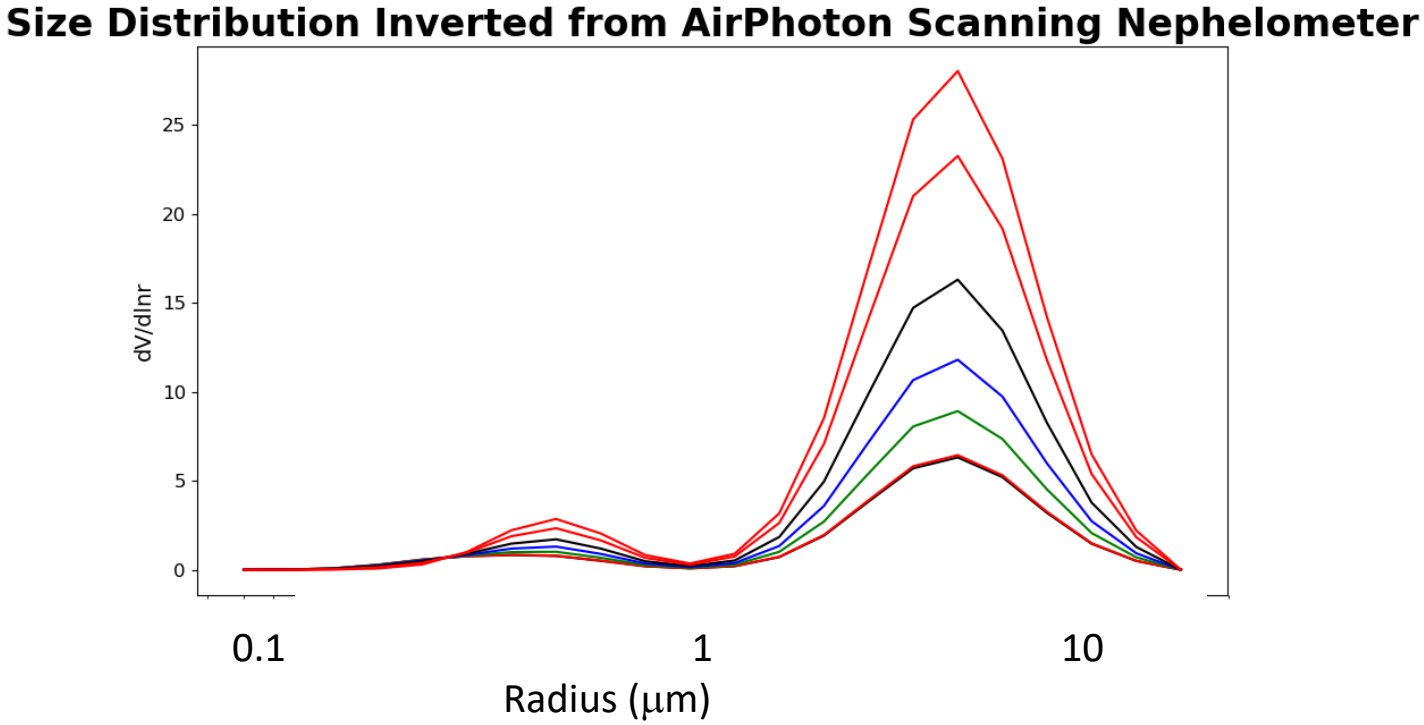

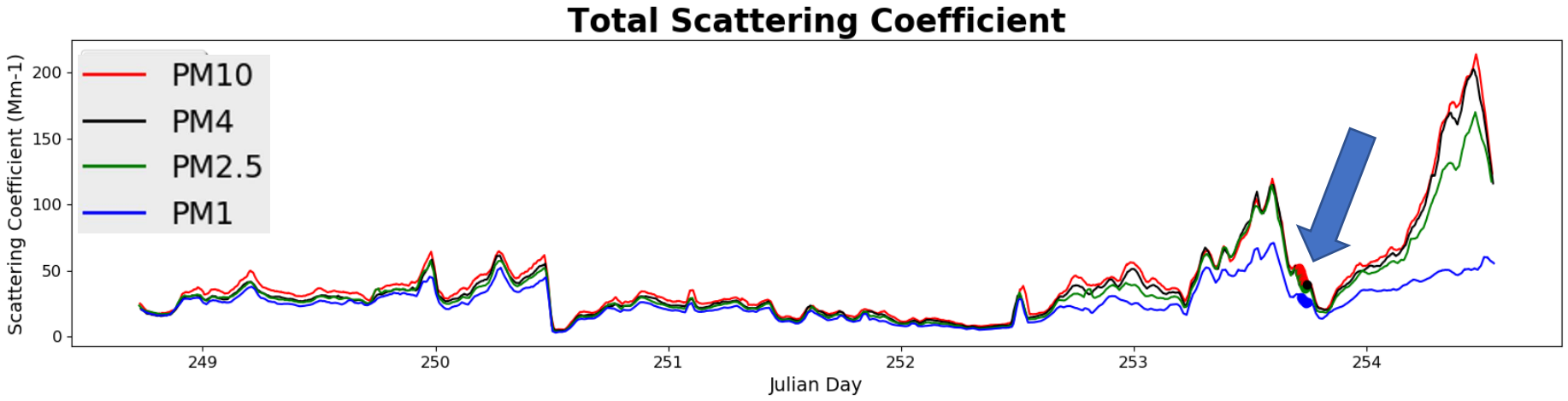

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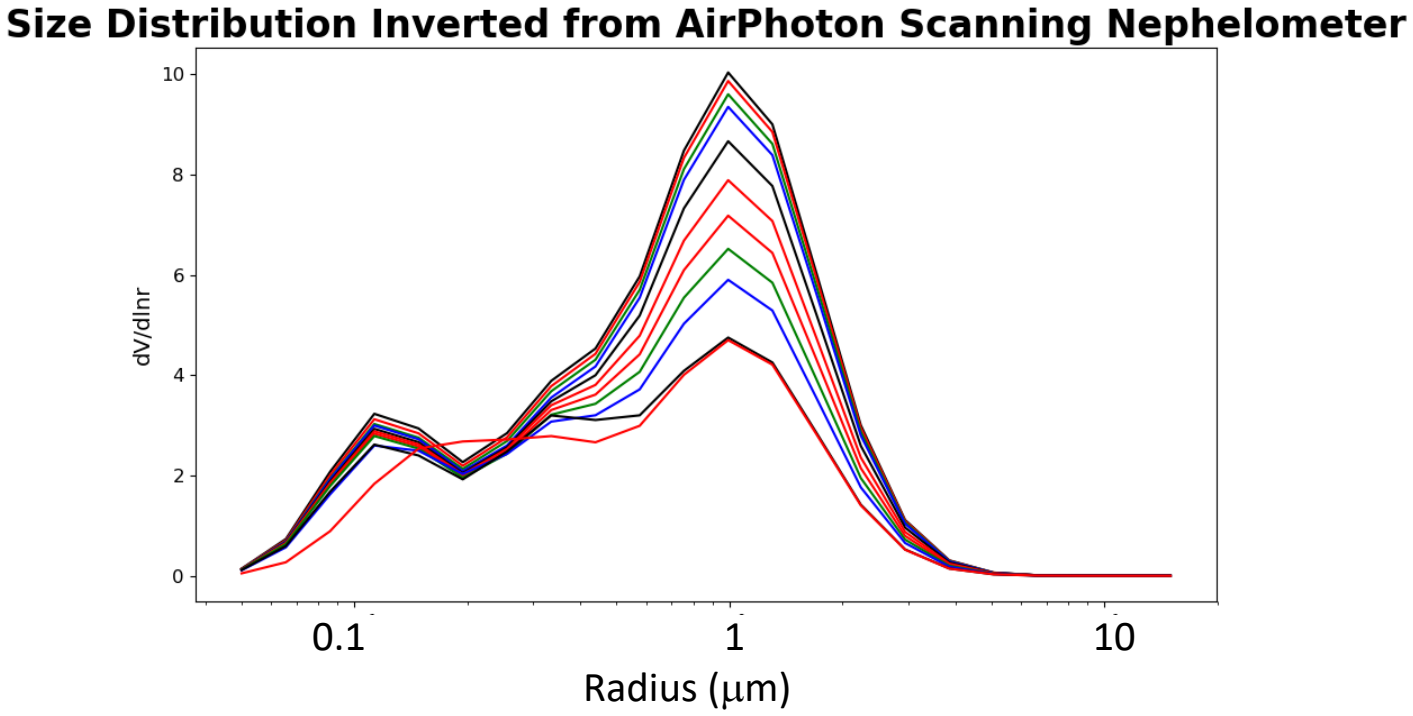
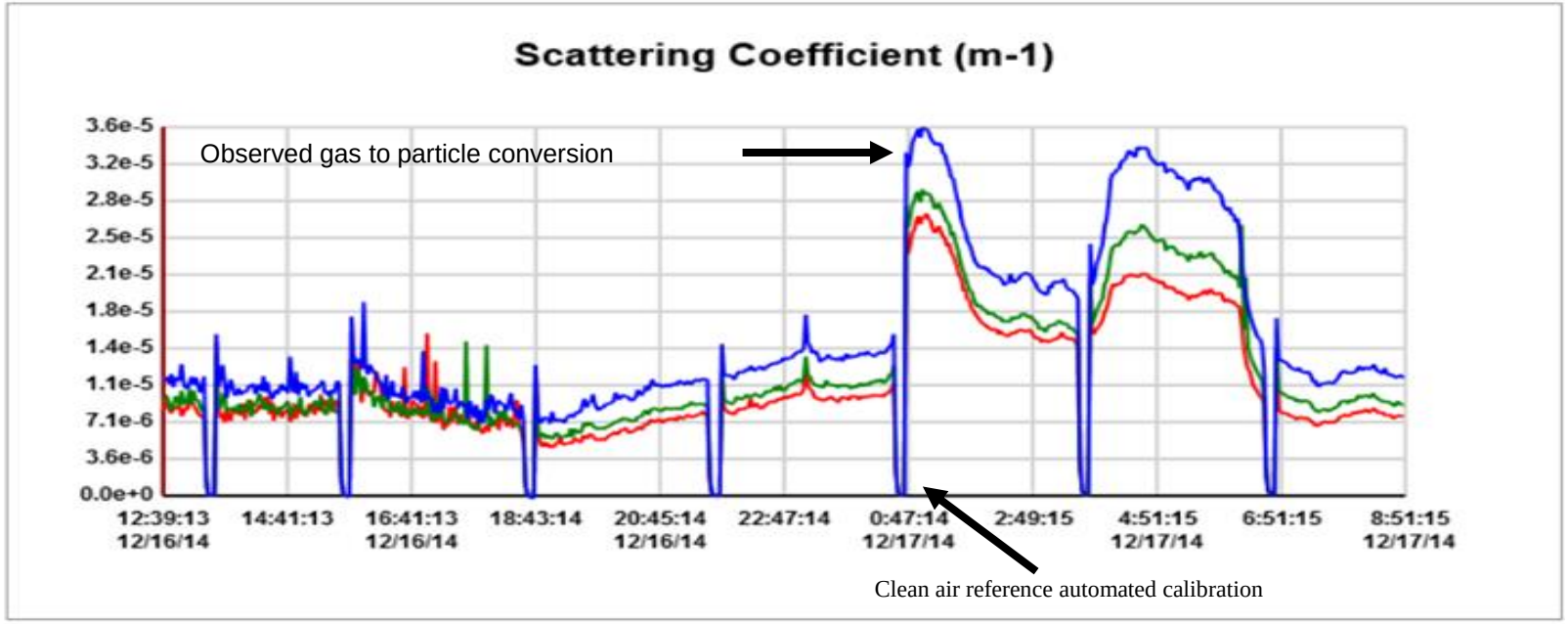


Synergy with GRASP software and calibration:

Size-Scanning Integrating Nephelometer IN102Ex

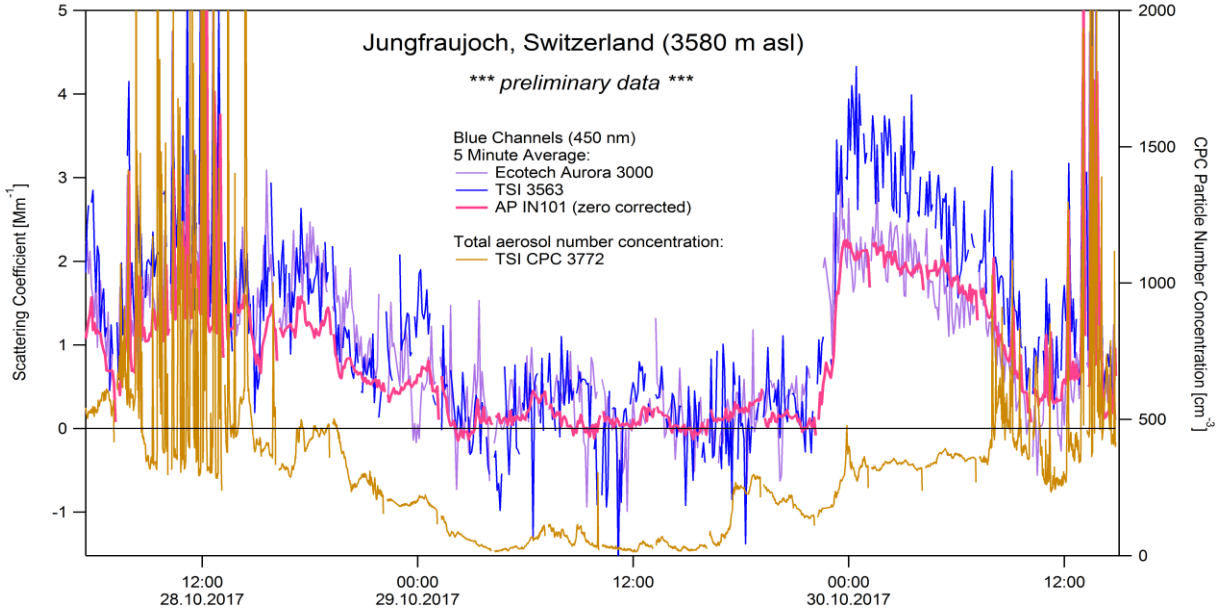
- Utilizes AirPhoton’s proprietary inversion scheme for size distribution
- Calibration is performed with gases including CO2 and clean air
- Clean air System is an attachment sold with the Nephelometer
- Results are compatible with GRASP inversion of remote sensing data from ground (sunphotometer/sky radiometers) and satellite data.

Nephelometer Sensitivity and Response



An AirPhoton IN101 Nephelometer was deployed at the Moscone Center during the AGU conference in December 2014. On successive evenings we observed large spikes in the measured levels of particulates. The large variation in spectral response of the three wavelengths during these spikes indicates very small particles. Further research revealed that we were observing gas to particle conversion from a floor cleaning solvent used elsewhere in the complex. We have observed the same phenomenon other years both at Moscone and other large exhibition halls.

Nephelometer Sensitivity and Response



Researchers from the Paul Scherrer Institute deployed nephelometers from three different manufacturers at Jungfaujoch, their high altitude site in the Swiss Alps. Their response was compared against a TSI particle counter. The response of the AirPhoton IN101 nephelometer (red line) shows its superior stability and sensitivity under very clean conditions. Although a bit difficult to see in the graph under the gold line of the particle counter, the AP IN101 was able to observe and respond to the sudden spikes in particle concentration. This data from the Paul Scherrer Institute is proprietary and confidential and may not be further shared without permission.

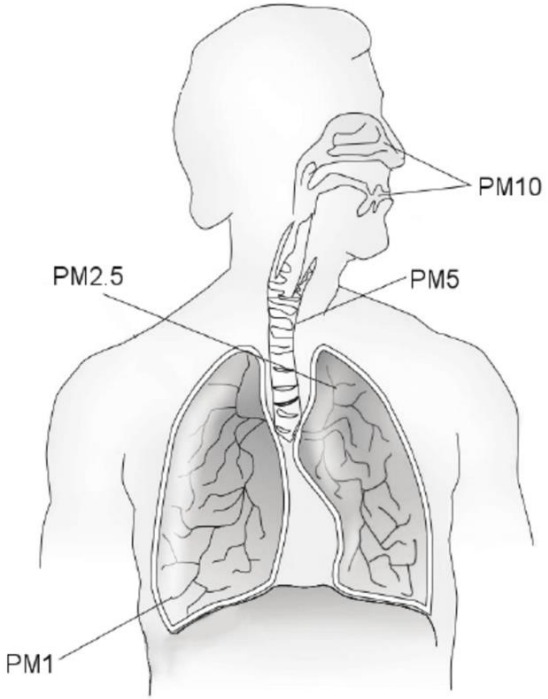
Important Points To Consider

Accuracy of Measurements

- AirPhoton instruments measure based on aerodynamic diameter and full inversion of the optical measurements. They are not optical counters.

"Optical counters measure the optical diameter rather than the aerodynamic diameter. Consequently, these instruments need to be calibrated for each targeted particle type. This makes them poorly adapted for atmospheric pollution as it contains particles of various natures "
- Djoumi et. al. *Sensors* 2017

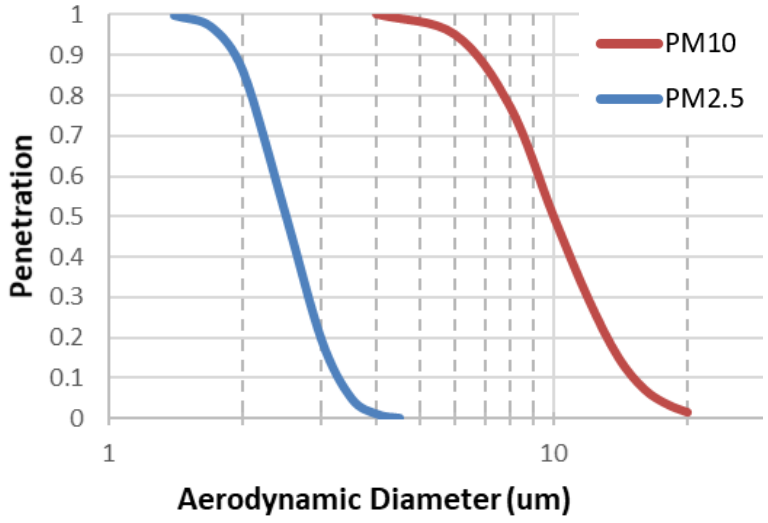
The synergy between aerodynamic sizing and optical measurement



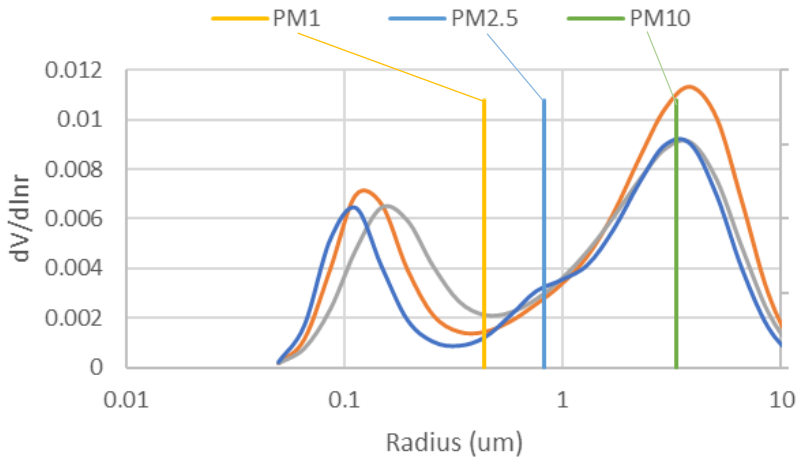
1. Aerodynamic sizing to select particles.

2. Optical measurement of selected particles for high sensitivity & accuracy.

Aerodynamic size cutoff emulating human respiratory system



High sensitivity optical sizing and typing



Important Points To Consider

Health Effects

- AirPhoton instruments measure particles in the complete range of PM1 to PM10
- Several recent articles point to the importance of PM1 in harmful health effects

  - 2017 publication of study in China calls for development of a new health standard for PM1*
  - 2016 publication of study on school children shows PM1 exposure much more important than PM2.5**

*Chen et. al. Lancet Planet Health 2017, **Zwozdziak et. al. Eviron Sci Pollut Res 2016