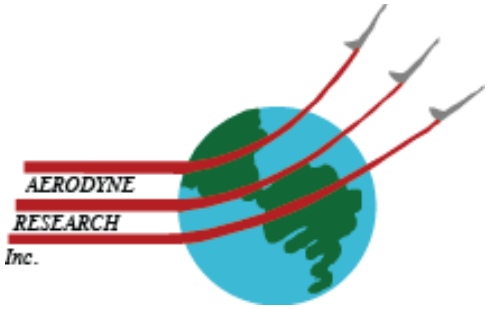

Measuring Aerosol Optical Properties Using CAPS

Timothy B. Onasch, Paola Massoli, Paul L. Kebabian,
Frank B. Hills and **Andrew Freedman**

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Critical Aerosol Optical Parameters for Climate Change Modeling

- Optical Extinction (Visibility^{-1})
  - Total Attenuation of Light
  - Extinction = Scattering + Absorption
- Single Scattering Albedo (**SSA**)
  - Partitioning Between Scattering and Absorption
  - SSA = Scattering/Extinction
- Asymmetry Parameter
  - Directionality of Scattering Component
  - Optics Letters 37:3654 (2012)

Measuring Extinction with CAPS PM_{ex}

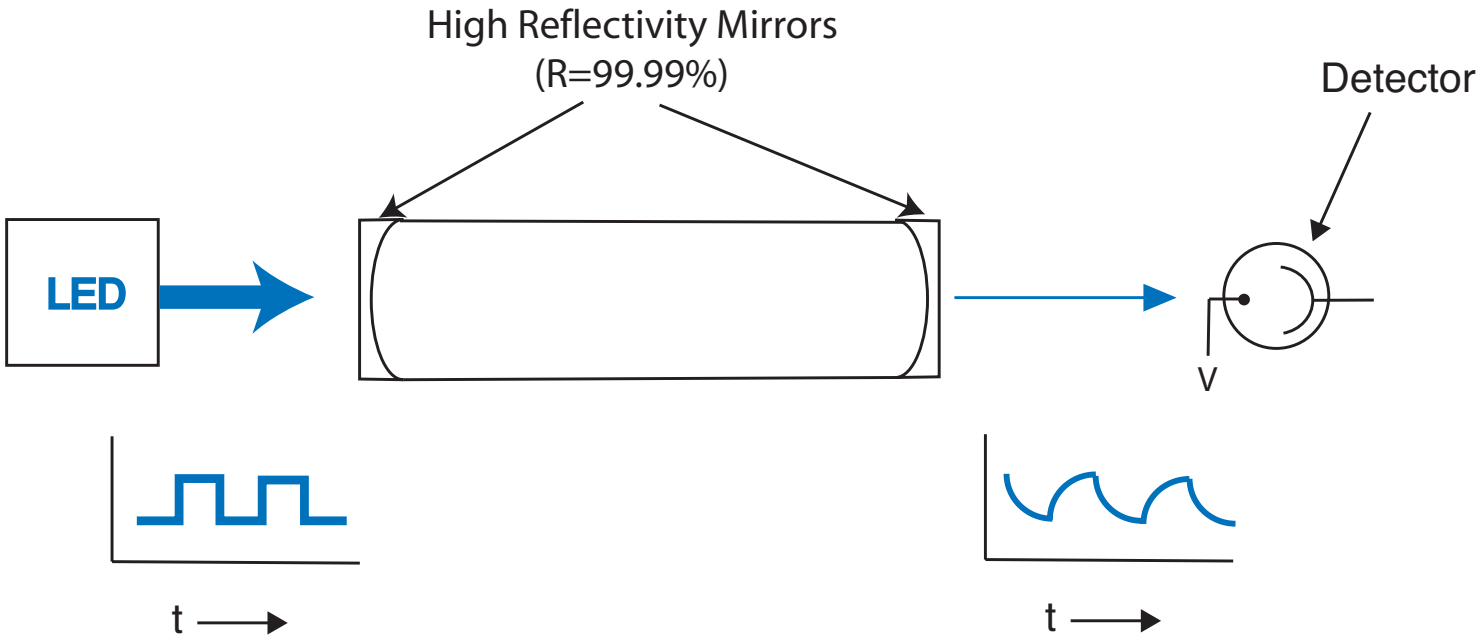
Exactly Like Laser Cavity Ringdown

No Laser

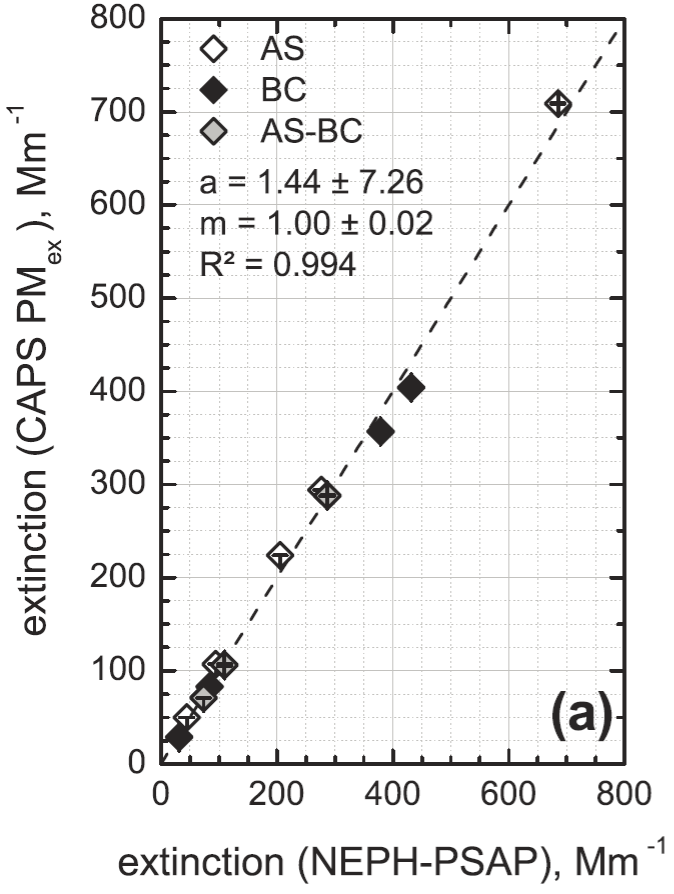
Don't Measure the Ringdown Time

- Cavity Enhanced Technique
- LED Light Source
- Detection of Phase Shift

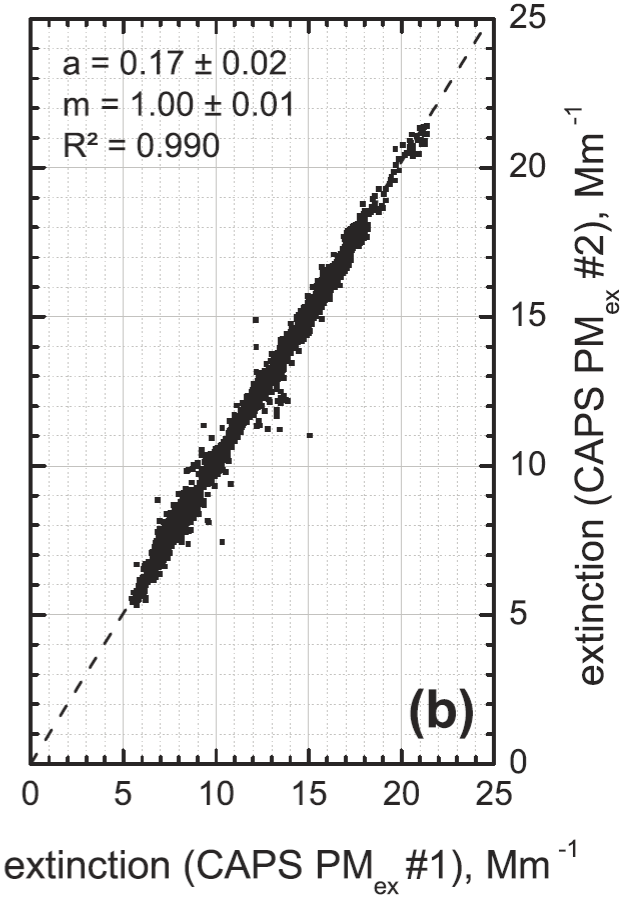
$$\mathbf{Ext = [2\pi f/c][\cot\vartheta - \cot\vartheta_0]}$$



Instrument Comparison



Reproducibility



A. Petzold, T. Onasch, P. Kebabian, and A. Freedman
Atmos. Meas. Tech., 6:1141–1151(2013)

SSA Monitor Approach

Measure Scattering and Extinction on the Same Sample Volume

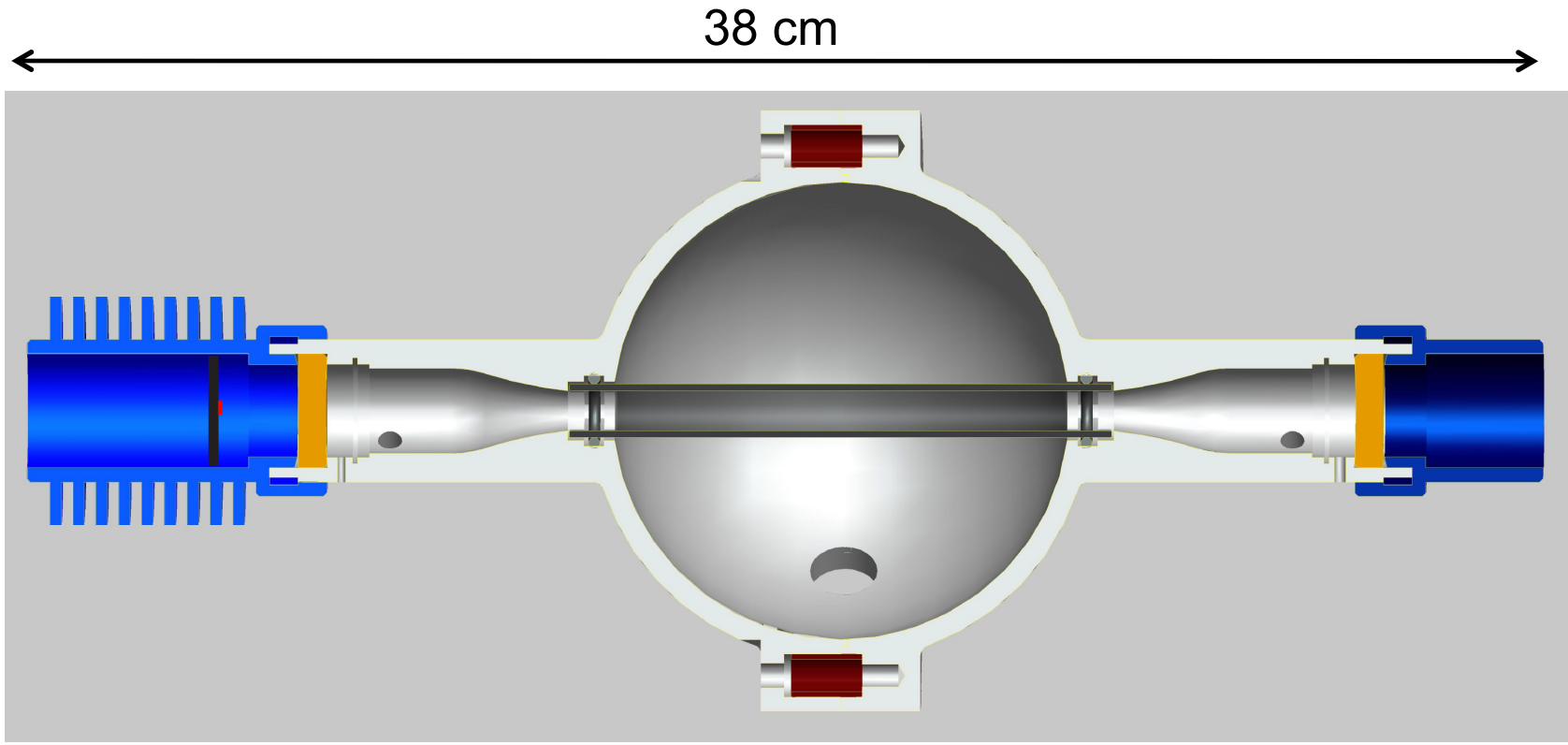
- Scattering Is Self Calibrating
  - Scattering is Ratioed to Extinction
  - Absolute Accuracy is Not an Issue
  - Lack of Suitable Standards for Absorption
- Minimal Sampling Artifacts Compared to 2 Instruments
  - Inlet Issues – Unequal Flow Rates
  - Time Response
- No Wavelength Correction Required

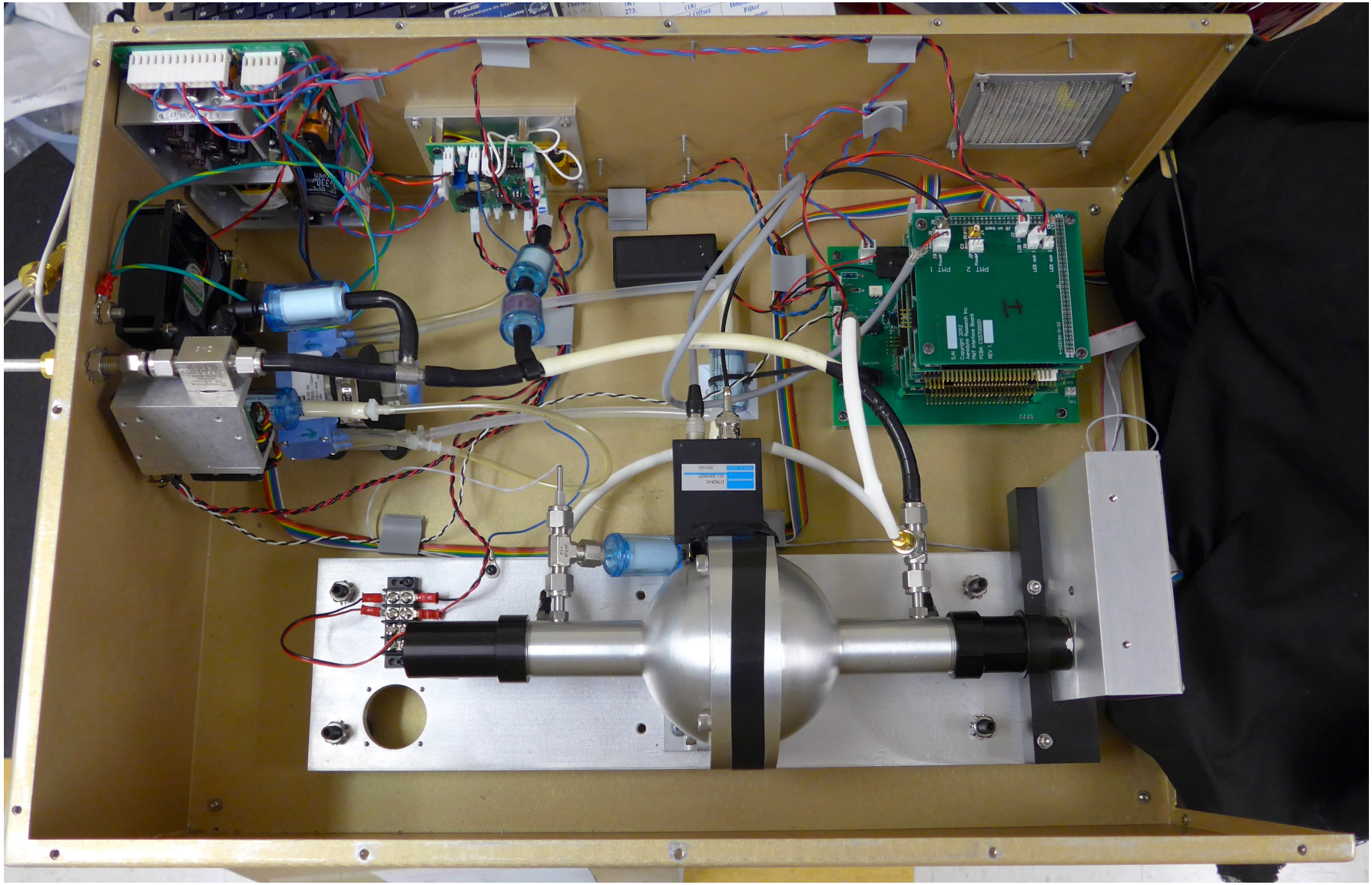
Measuring Scattering Using An Internal Nephelometer

Collimated Light Source

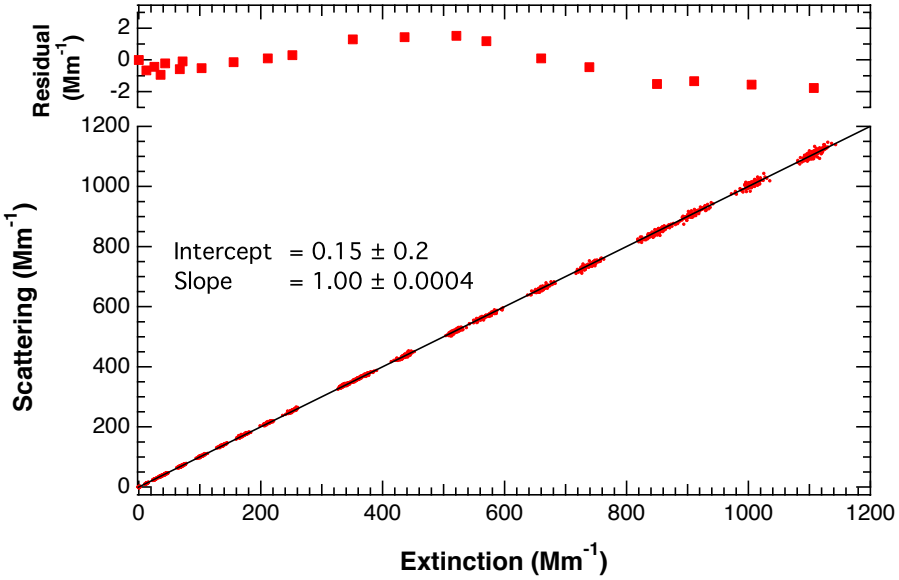
- Integrating Sphere (d = 10 cm) to Collect Scattered Light
- Lambertian Surface
  - Photons Are Randomly Scattered (Cosine Distribution)
  - No Bias with Respect to Initial Scattering Angle
- Photomultiplier Tube Measures Scattered Light
- Scattered Light Calibrated Using White Particles (SSA=1.0)
  - Ratioed to Measured Extinction

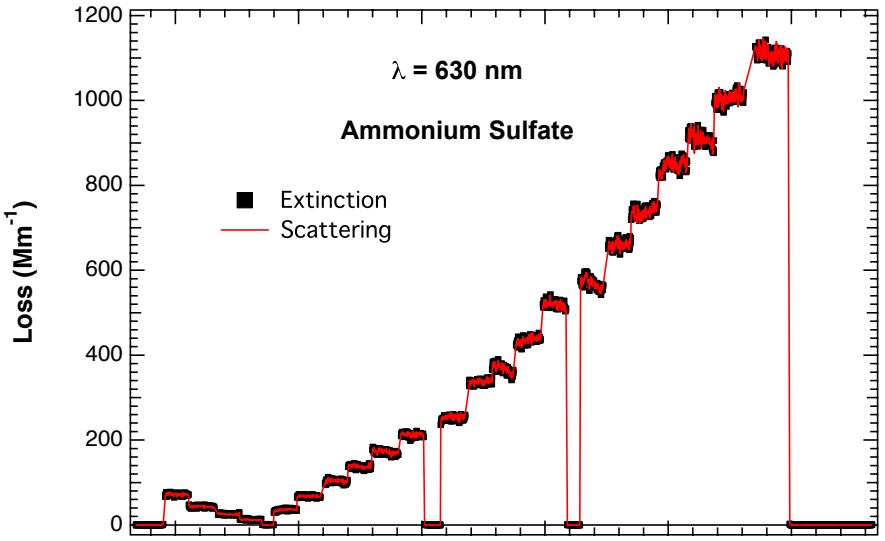
PM_{ssa}



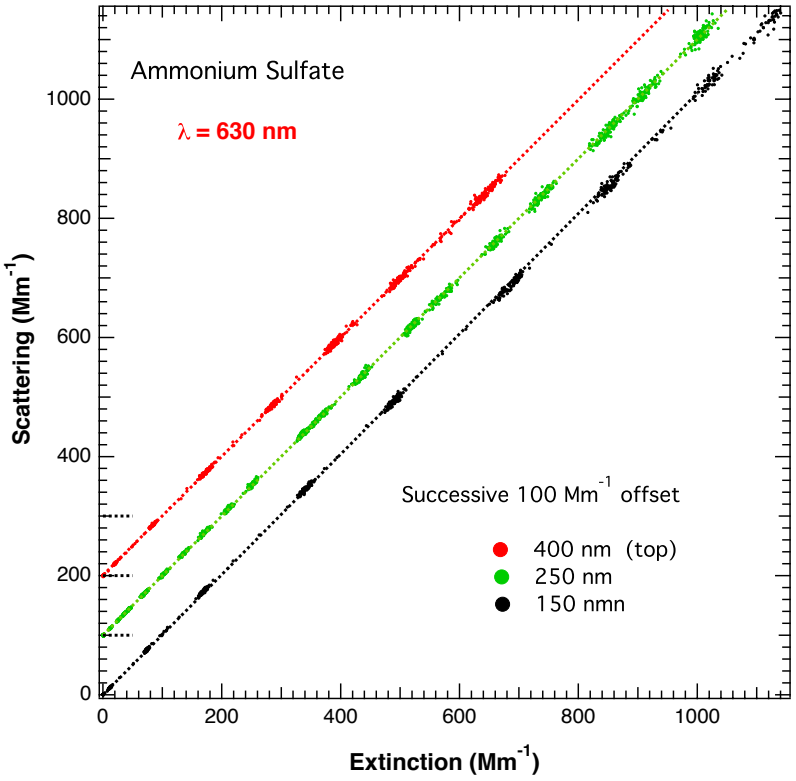


Calibration



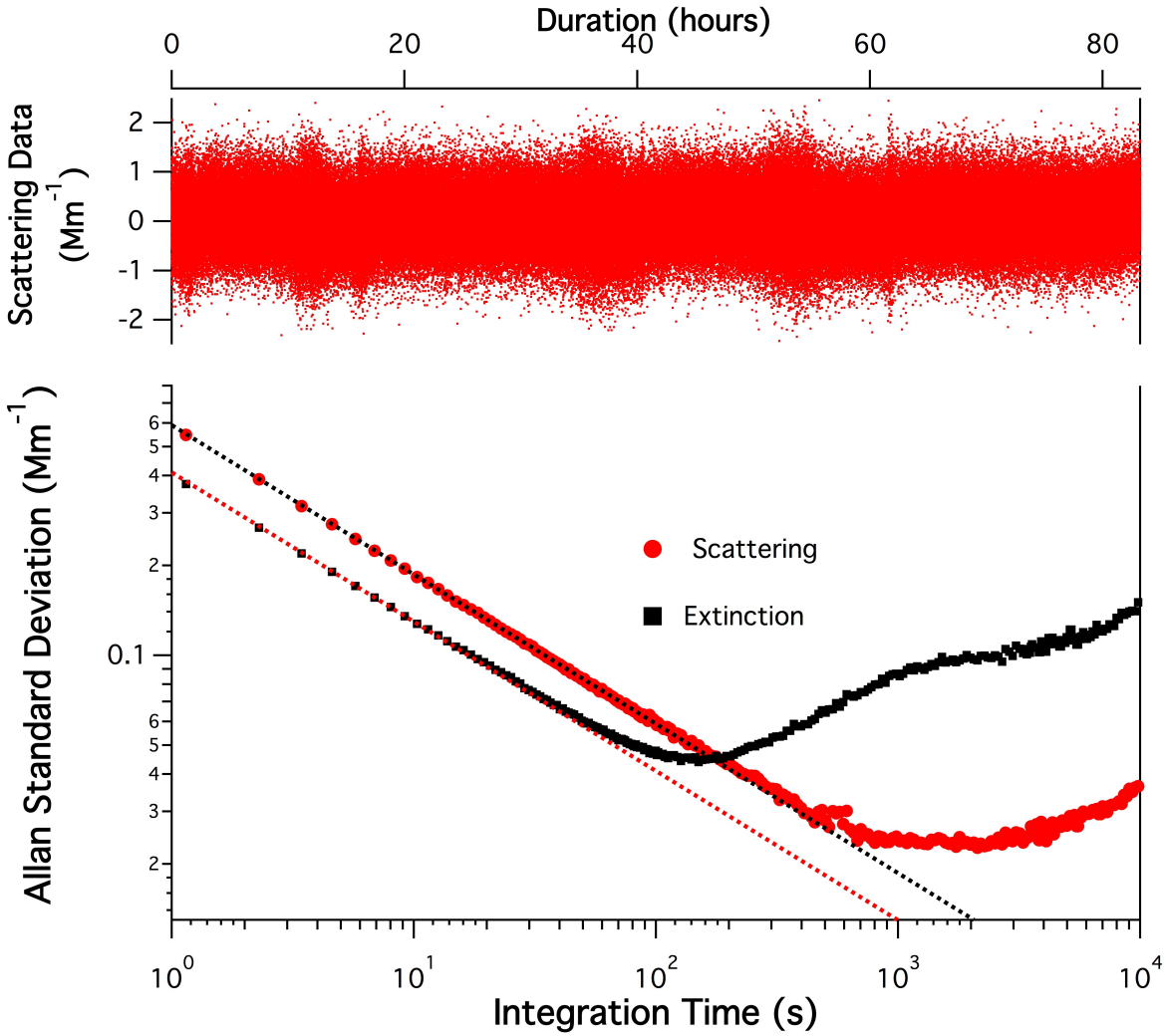


Linearity



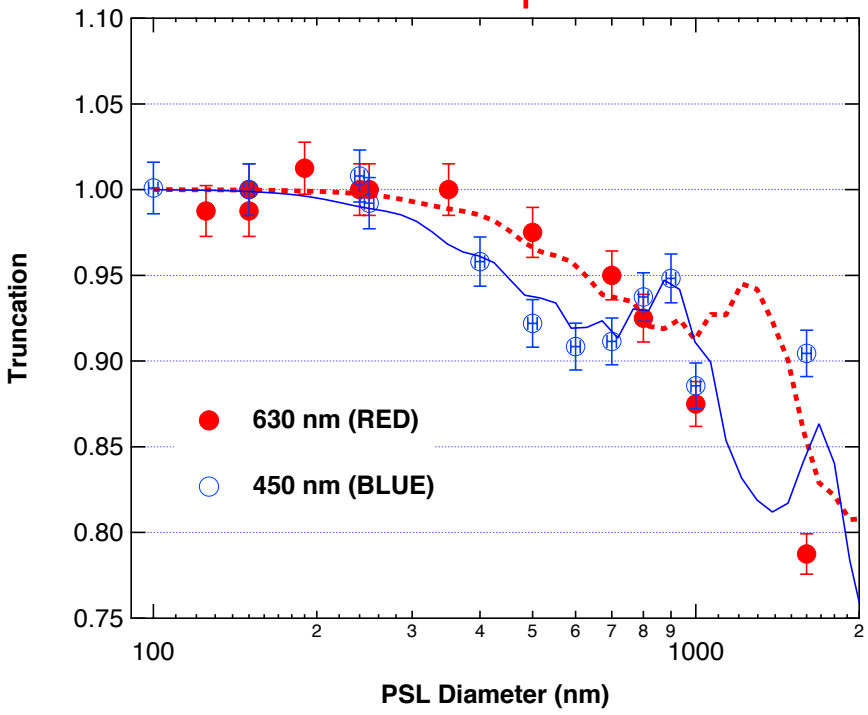
Precision

Allan Analysis (630 nm)

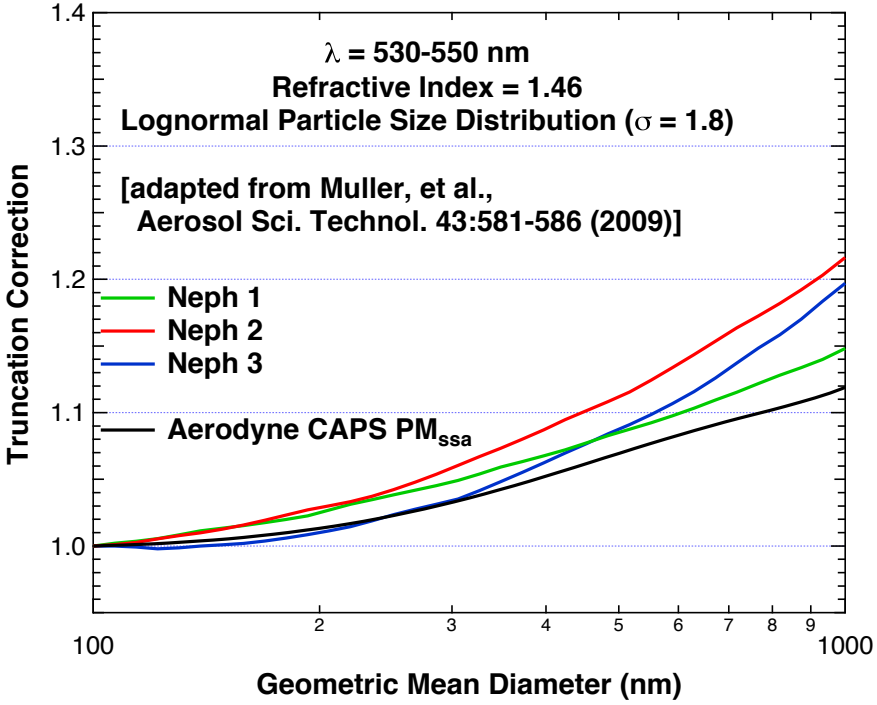


Truncation

Monodisperse



Polydisperse

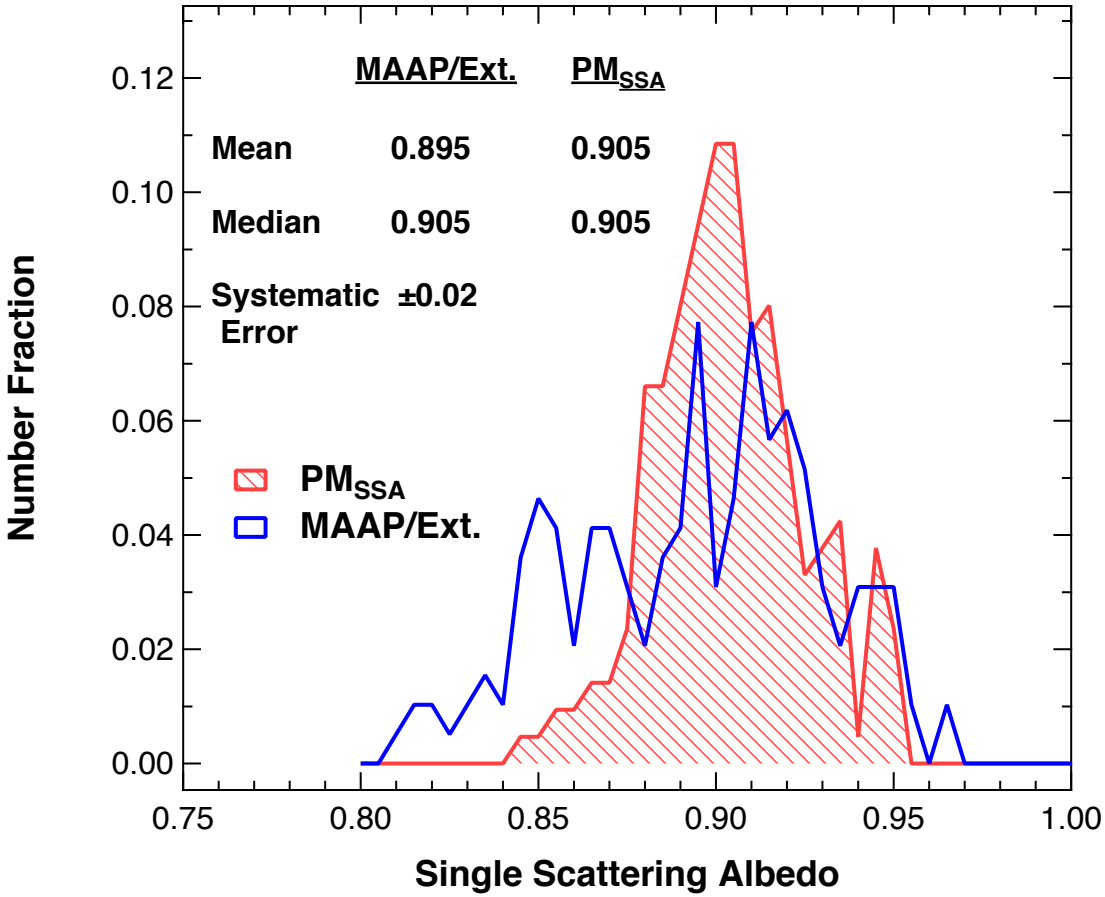


Typical Accumulation Mode Correction 2-6%

Ambient Monitoring

Comparison with MAAP/CAPS

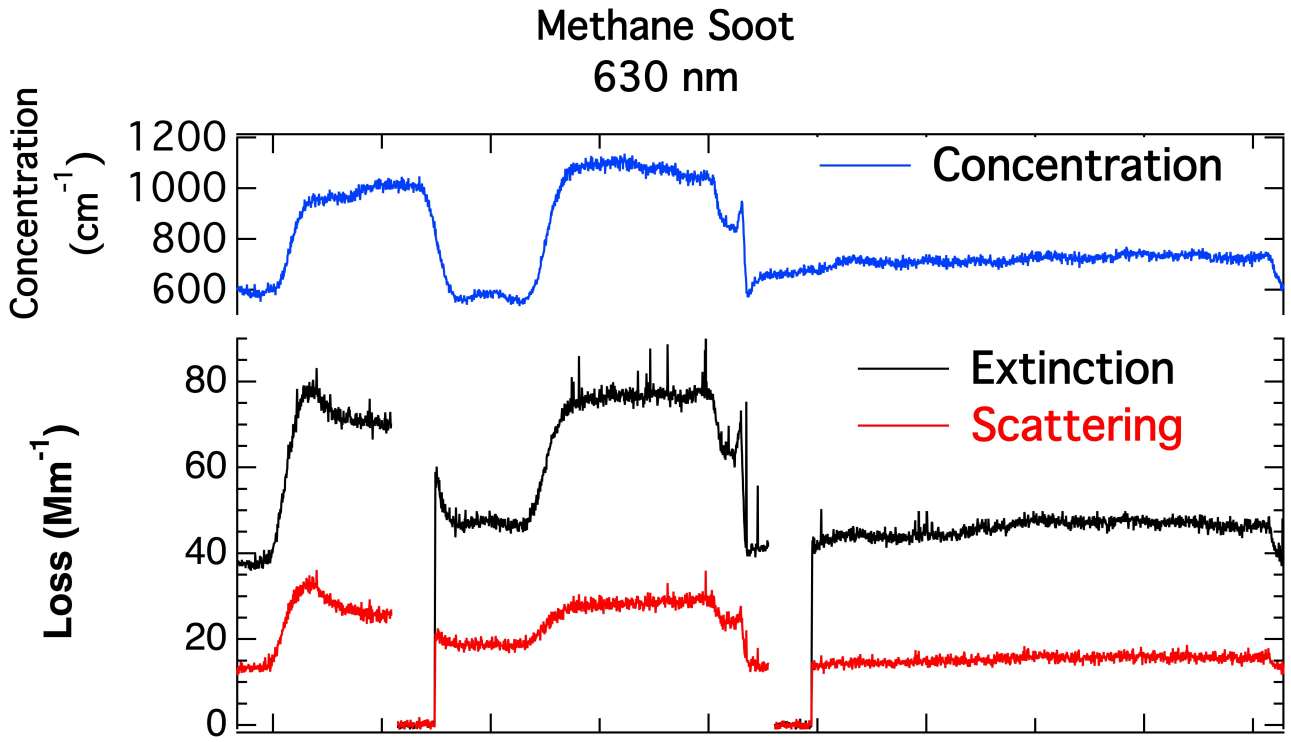
- PM 2.5 Cutoff Located on Roof
- 17 lpm Sample Flow
- PM_{ssa} Sampled Through Isokinetic Probe
- SSA Derived from PM_{ssa} and MAAP/CAPS Combination
- Truncation Correction 1.025



Absorption Measurement

At Low SSA

PM_{ssa} Preferred Way to Measure Absorption



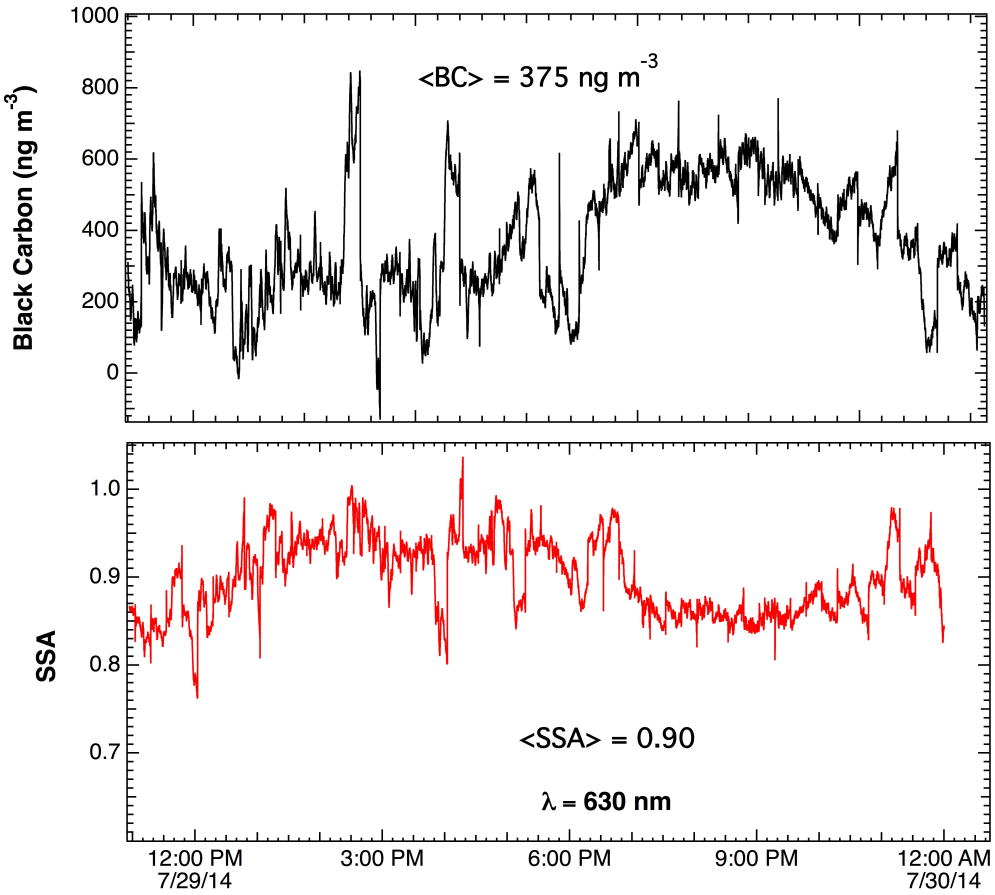
- Extinction is the Most Accurate Optical Measurement
- Error in Scattering Contributes Little to Accuracy of Absorption Determination

Absorption Measurement

At High SSA

Accuracy is the Issue

NCSR- Demokritos, Athens, Greece



Courtesy of Kostas Eleftheriadis

Conclusion

- CAPS PM_{ssa}
  - Autonomous Operation
  - Fast Time Response ~1 second
  - Rugged

- Precision <1 Mm^{-1} (1s) in Both Channels

- Accuracy SSA ±2% (dependent on truncation)
  Extinction ±5% (?)

Tim Onasch
Multi-Wavelength Measurement of Soot Optical Properties:
Influence of Non-Absorbing Coatings
Saturday, 12:15 OP22-3 Room B (104+105)

Andy Freedman
Optical Measurements of Aircraft Engine Soot Emissions
Saturday, 14:45 OP49-2, Room D (109-110)