Simultaneous Measurement of Particle Optical Extinction and Scattering Using the CAPS PM_{ssa} Monitor

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WHY

Instrumentation for the Measurement of Aerosol Optical Properties

- Simple in Operation
- Rugged
- Inexpensive Components
- Stable
- State-of-the Art Performance

HOW

Extinction

Cavity Attenuation Phase Shift Extinction Spectrometer ($CAPS\ PM_{ex}$)

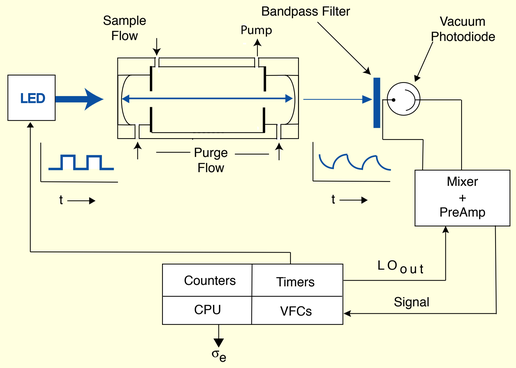
- Use Low-Loss Optical Cavity to Produce km Pathlengths
- Square Wave Modulate Light Souce
- Detect Distorted Waveform Emitted from Cavity
- Phase Shift Provides Information on Particle Extinction

$$\cot\vartheta = \cot\vartheta_0 + (c/2\pi f)\,\sigma_e$$

where ϑ = Measured Phase Shift
ϑ_0 = Phase Shift for Particle-Free Cell
f = Modulation Frequency
σ_e = Extinction

$CAPS\ PM_{ex}$ Particle Extinction Monitor

- Time Response ~1 s (10-90%)
- LOD (3σ, 1s) = 2 Mm^{-1}
- Rack Mount, 12 kg, 50 W, 0.85 l min^{-1} Flow



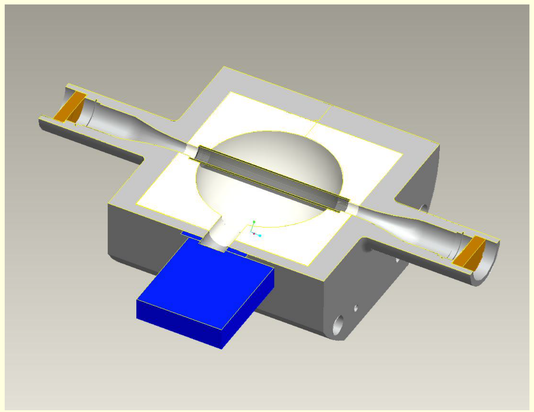
- Near-Confocal Optical Cavity
  26 cm Base Length
- Light Emitting Diode (LED) Light Source
  530 nm

HOW

Scattering

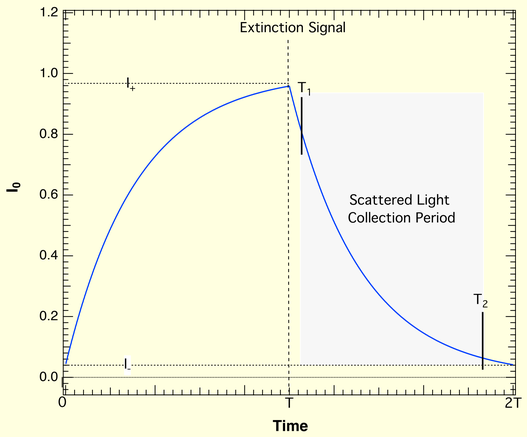
Inverse Nephelometer

- Construct Integrating Sphere Within Optical Cavity
  - Cut Ringdown Cell in Two
  - Install Two Teflon Hemispheres
  - Bolt Cell Back Together
    Cell Stays Aligned
  - Install Single Photon Counting PMT to Observe Scattered Light



- Collect Scattered Light Only During LED-Off Phase
  -Light in Cell Highly Collimated
  - No Scattering from Cell Surfaces
  - Scattering Proportional to DC Light Levels and Cell Loss

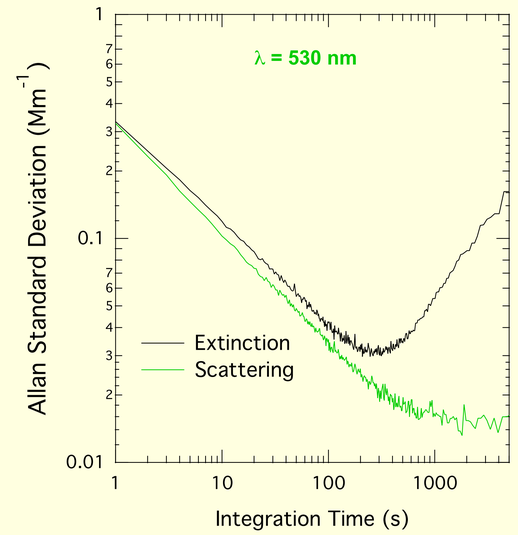
$$\sigma_{sp} \propto \left(\frac{Signal}{I_{ave}}\right)(Loss)$$

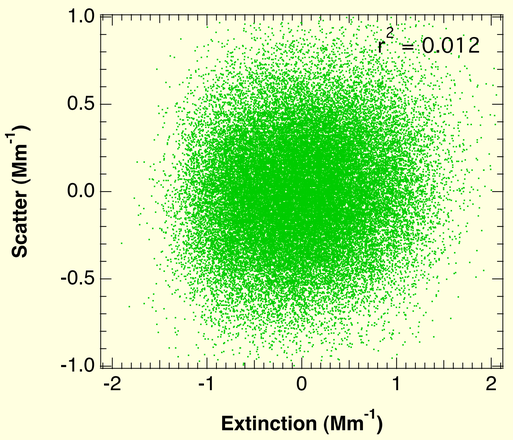


PRELIMINARY RESULTS

Sensitivity
λ=530 nm

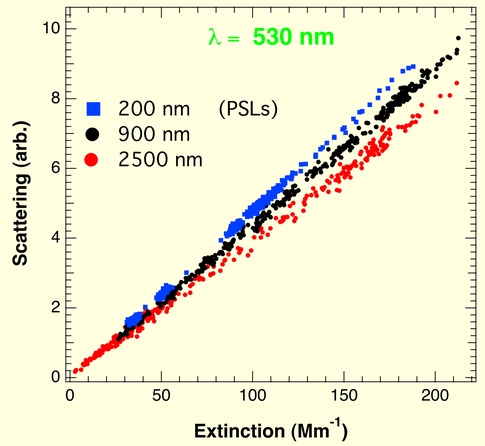
- Allan Analysis
  - Noise as a Function of Integration Period
  - Noise < 0.5 Mm^{-1} in Both Channels
  - Noise in Extinction and Scattering Channels Is Uncorrelated

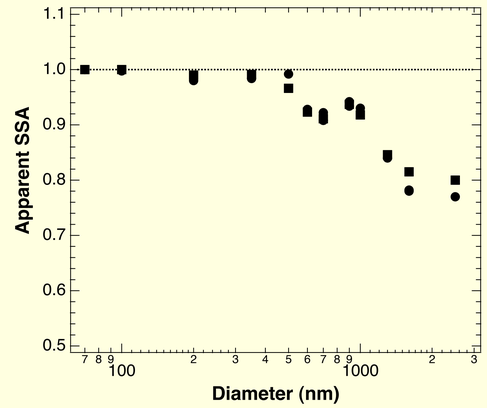




Truncation ?

- All Nephelometers MIss Scattering at Forward and Backward Angles
- Causes Measurement Bias for Larger Particles
- Measured Extinction and Scattering
  - 70-2500 nm PSL
- Minimal Truncation Effects out to 1 micron
- Modest Truncation Effects for Particle Size > 1 micron





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