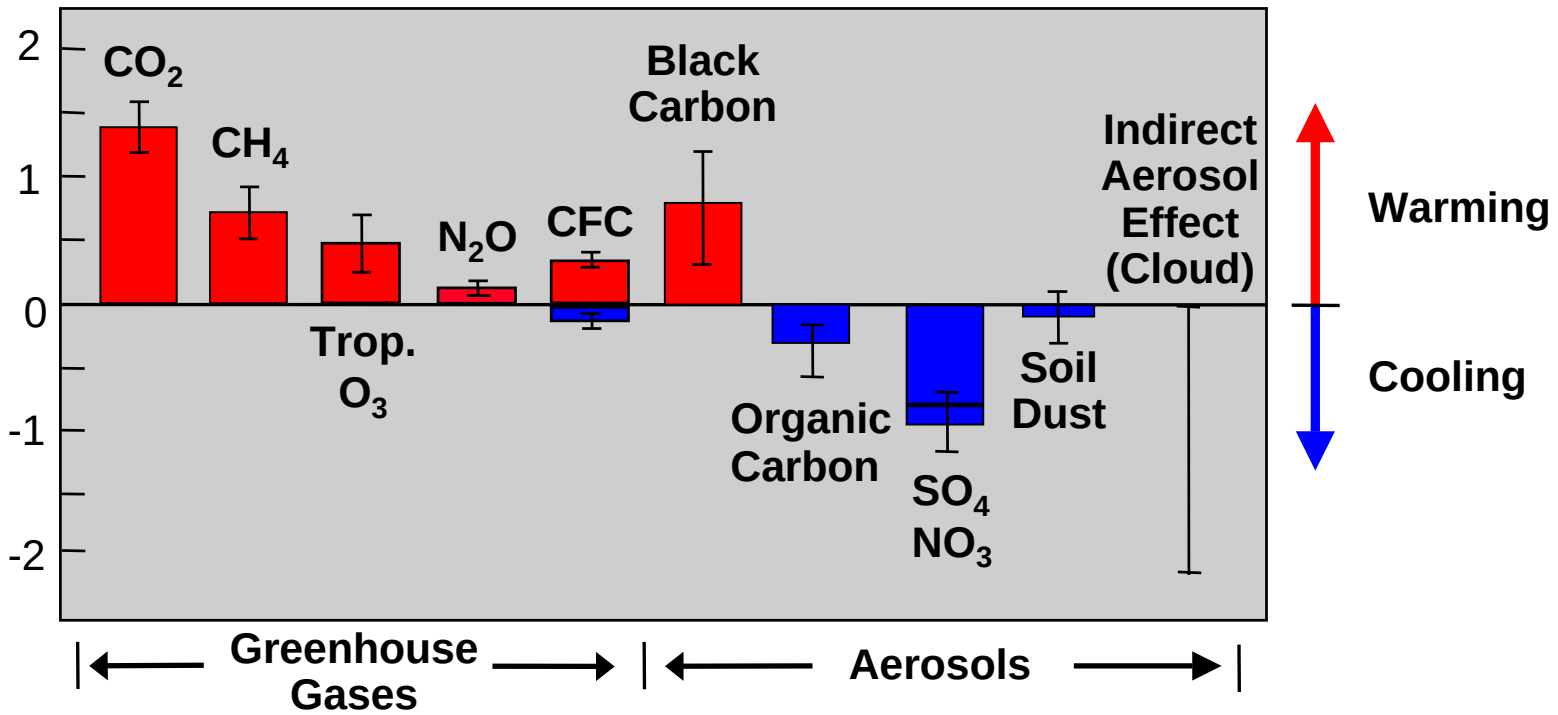
Use of filter based light transmission techniques to measure aerosol light absorption properties

Daniel Hooper
Lawrence Berkeley National Laboratory

Consequences of aerosol light absorption

Global climate change Regional climatic effects Reduced visibility

(Global Average from 1850 - 2000, from Hansen and Sato, IPCC)



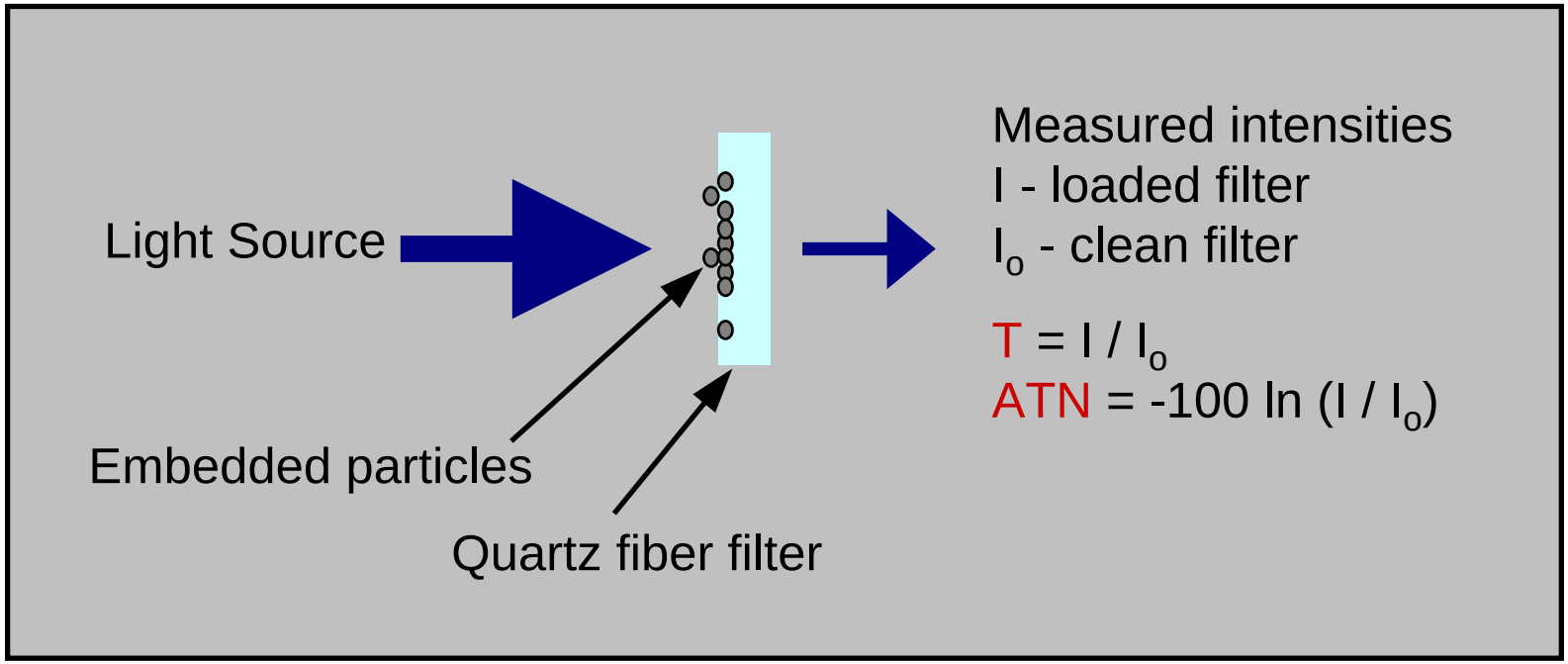
Forcing: + 2.5 ± 0.5 W/m^2 +0.5 to – 4 W/m^2

Research Experience

- Analyze fine particulate matter samples collected on quartz filters
- 2 wavelength Aethalometer (light transmission device)
- Light transmission [370nm (UV)-850 nm (IR)] measured with Multi wavelength Light Transmitter (MWLT)
- Carbon content and light transmission measured simultaneously using a new thermal Evolved Gas Analysis device (EGA)

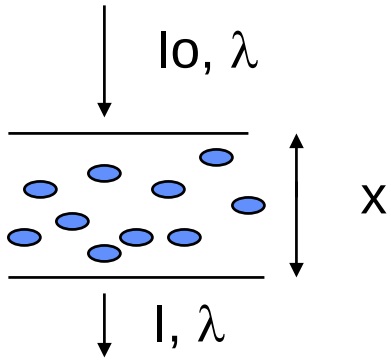
- Samples: controlled wood fires (Redwood and Oak)
  urban air (Berkeley, CA)

Light Transmission Method



- Optical property of quartz filter minimizes influence of particle light scattering, renders method sensitive mainly to particle light absorption

What is Attenuation?



- **The decrease in intensity of a signal, beam, or wave as a result of absorption of energy and scattering over a given distance**

$I\lambda = Io,\lambda \exp(-\beta\lambda x)$

Io, λ = initial light intensity at y wavelength

I, λ = light intensity after passing through the atmosphere containing absorbing particles

bλ = extinction coefficient (m-1)

x = path length of polluted atmosphere (m)

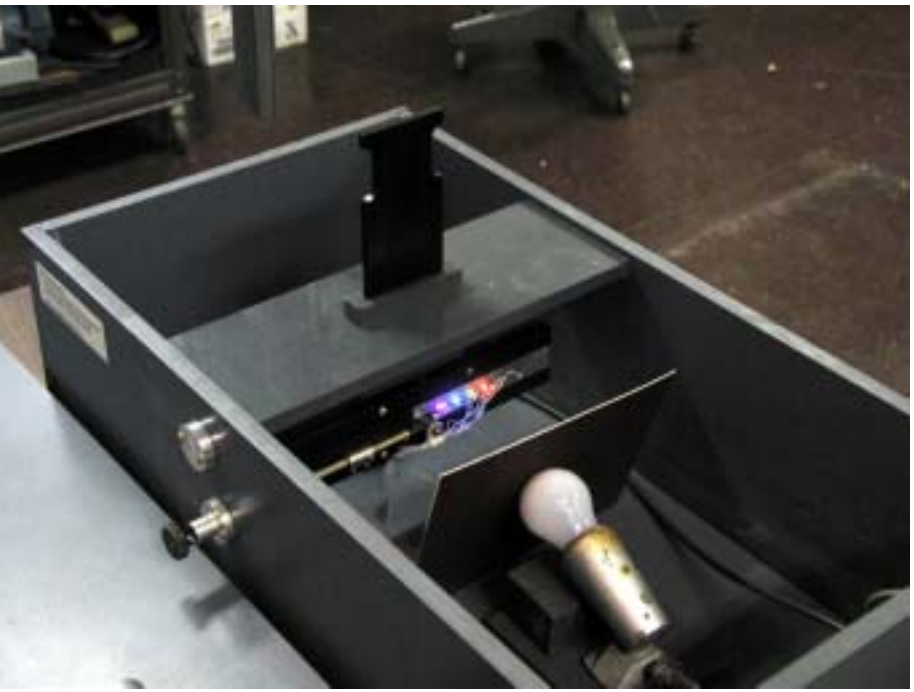
$b\lambda = \sigma\lambda C$

σλ = particle absorption coefficient (m2/g)

C = concentration of absorbing species (g/m3)

ATN = -100ln(I/Io)

Multi Wavelength Light Transmitter (MWLT)

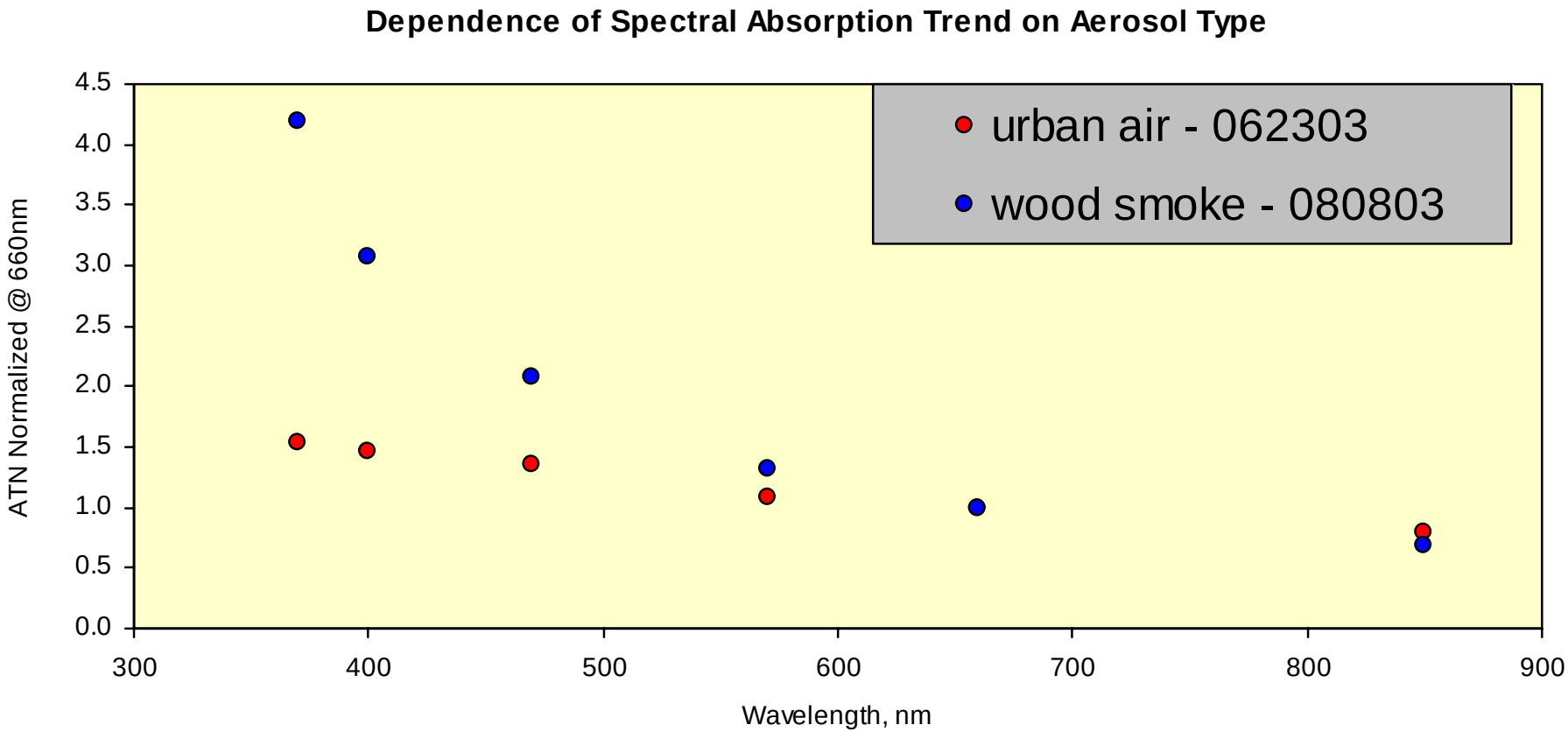


- Light sources in the MWLT:
- 370nm LED
- 400nm LED
- 470nm LED
- 570nm LED
- 660nm LED
- 850nm LED
- 15 W light Bulb

- Equation of ATN:

- -100ln[(I/Io)]

Comparison of Spectral ATN Measurements, 08August03 Wood Smoke Sample

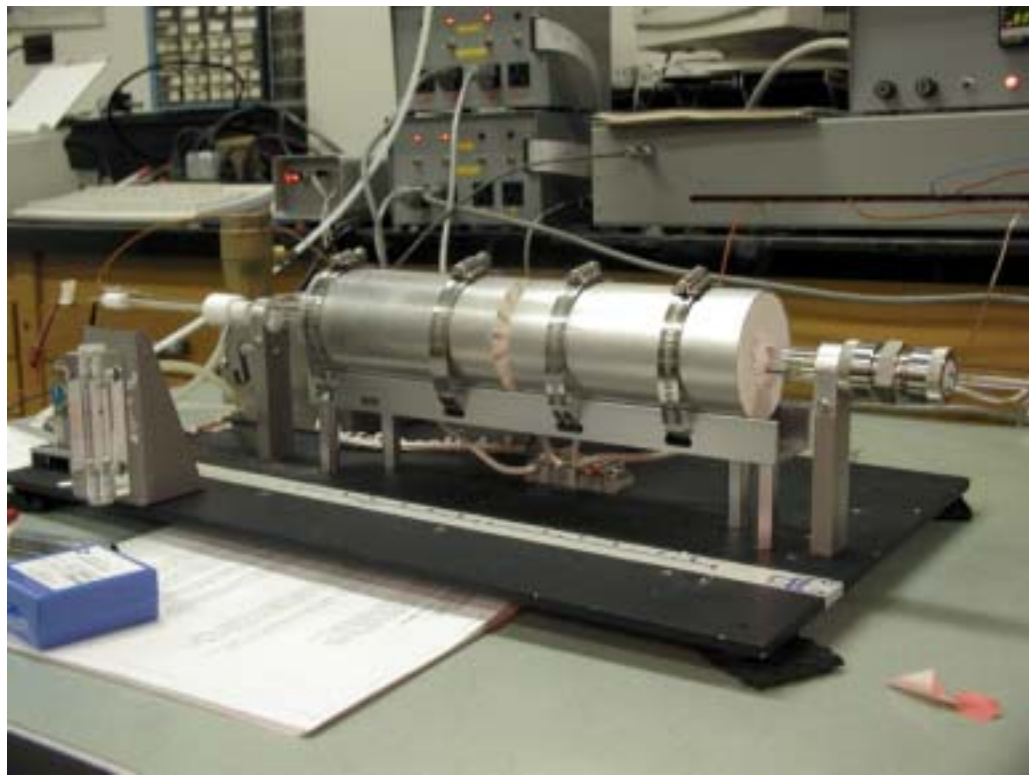


Evolved Gas Analysis Device (EGA)

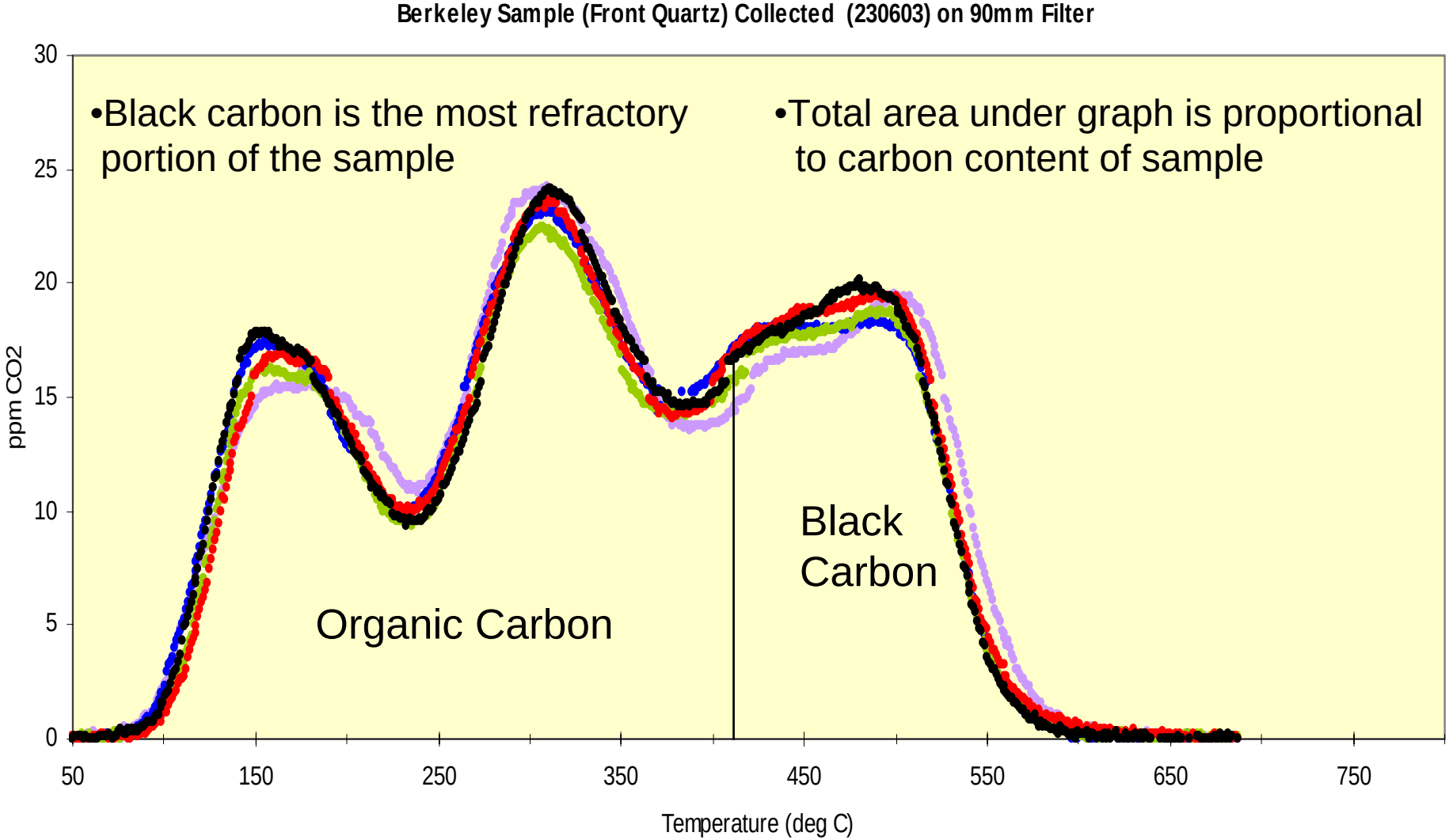
- Carbon content and light transmission measured simultaneously
- Converts gases into CO2 using O2
- Equation of ATN:

  -100ln(I/Io)

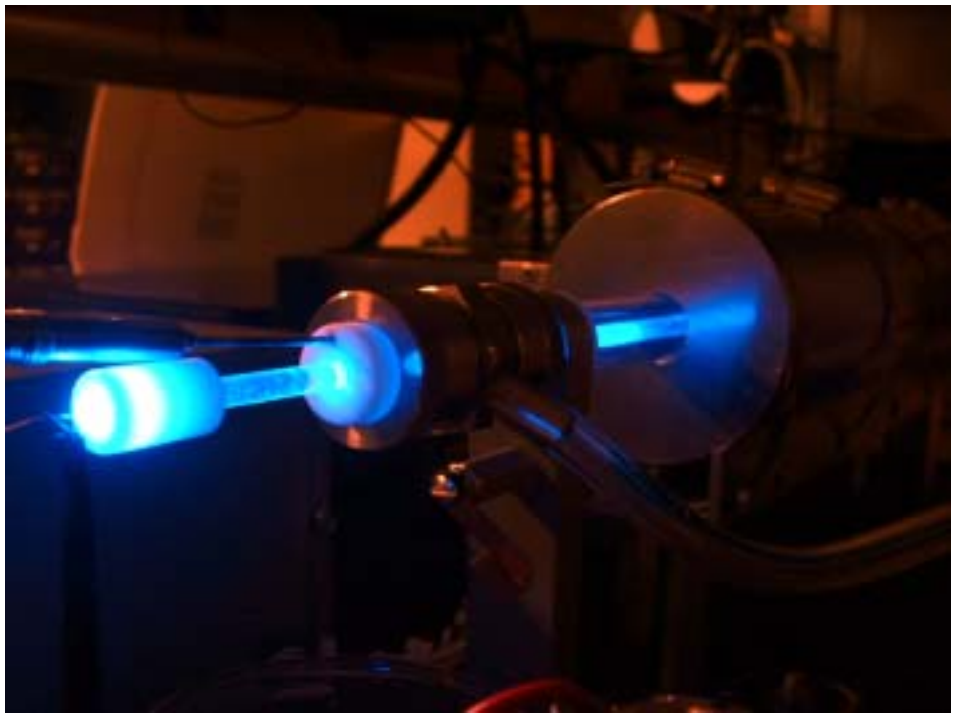
- Two furnaces capable of maintaining different temperatures



Carbon Thermogram

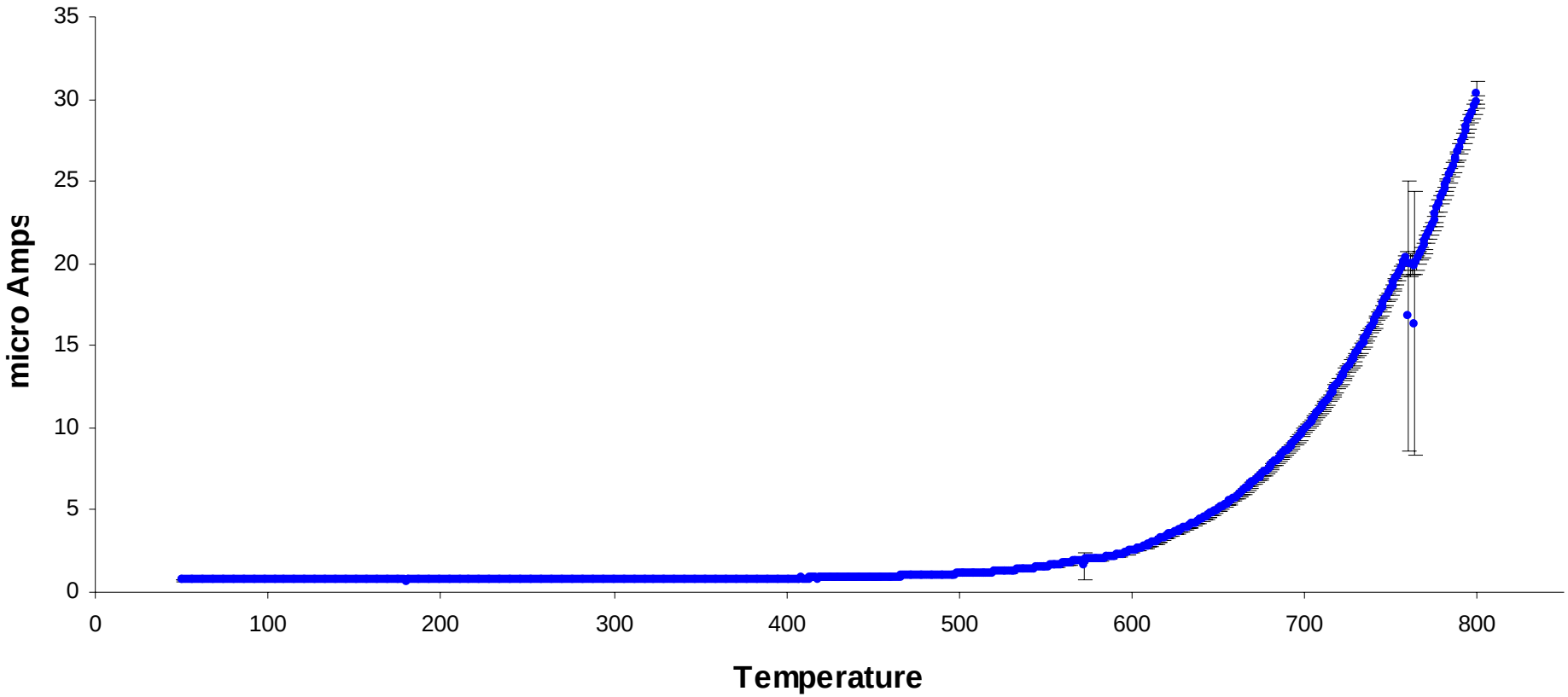


EGA optical readings

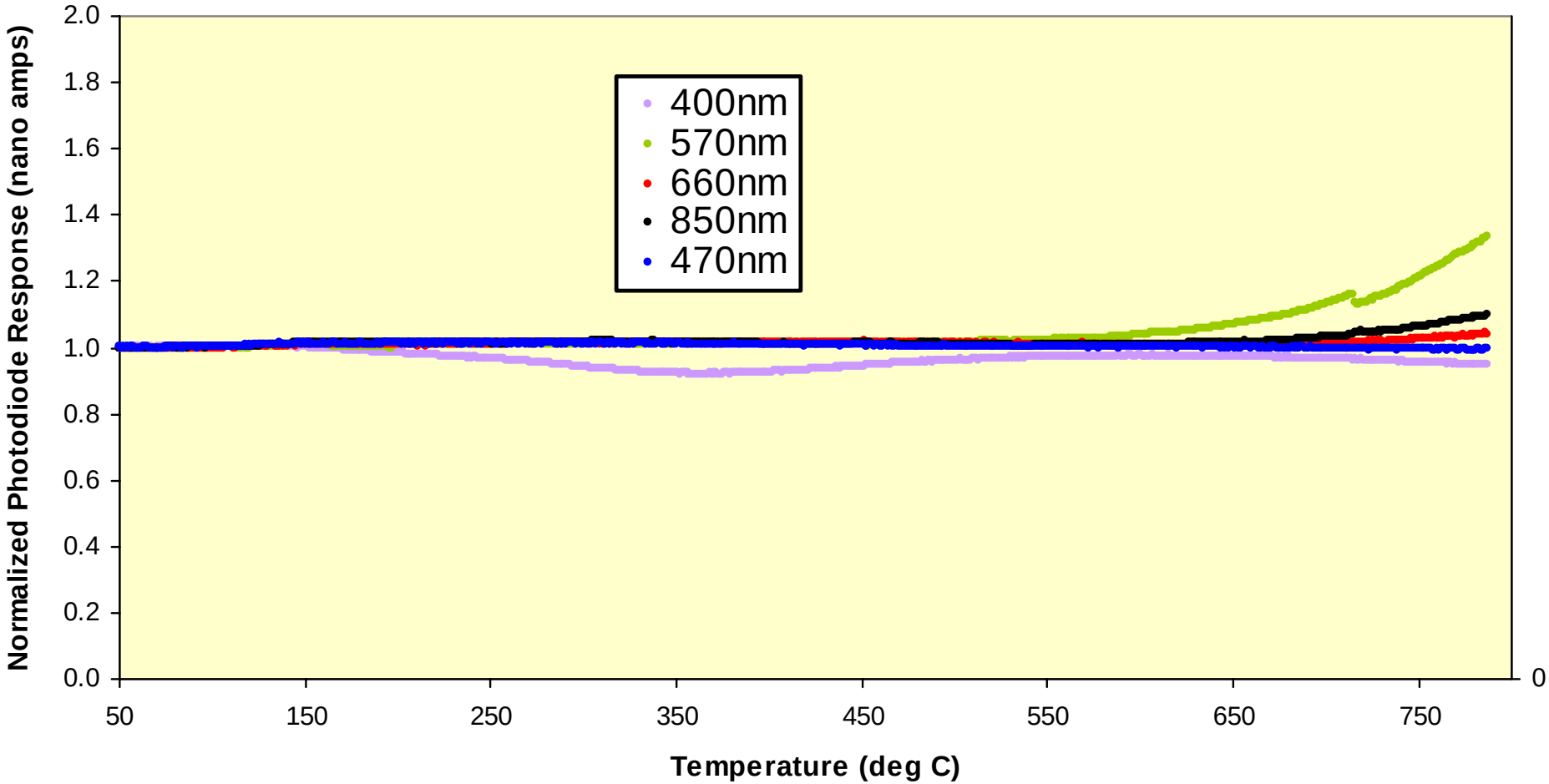


- Two glass rods connect and allow the LED light to transmit through the filter
- Can use multiple LED's at different intensities
- Can use multiple optical filters which attach to the picoammeter

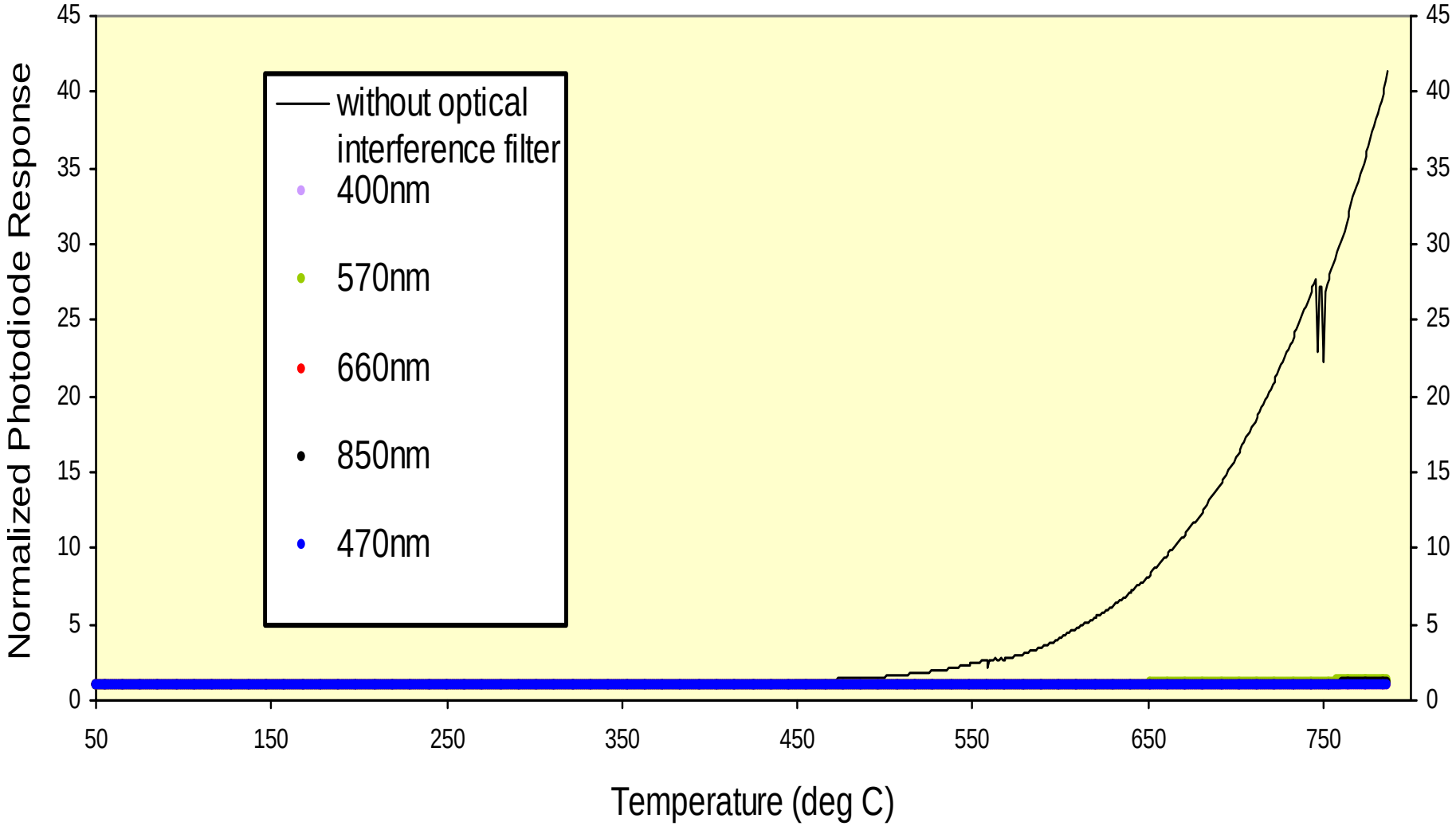
AVERAGE +/- STDEV Photodiode Response to Increasing Sample Furnace Temperature (no optical interference filter)



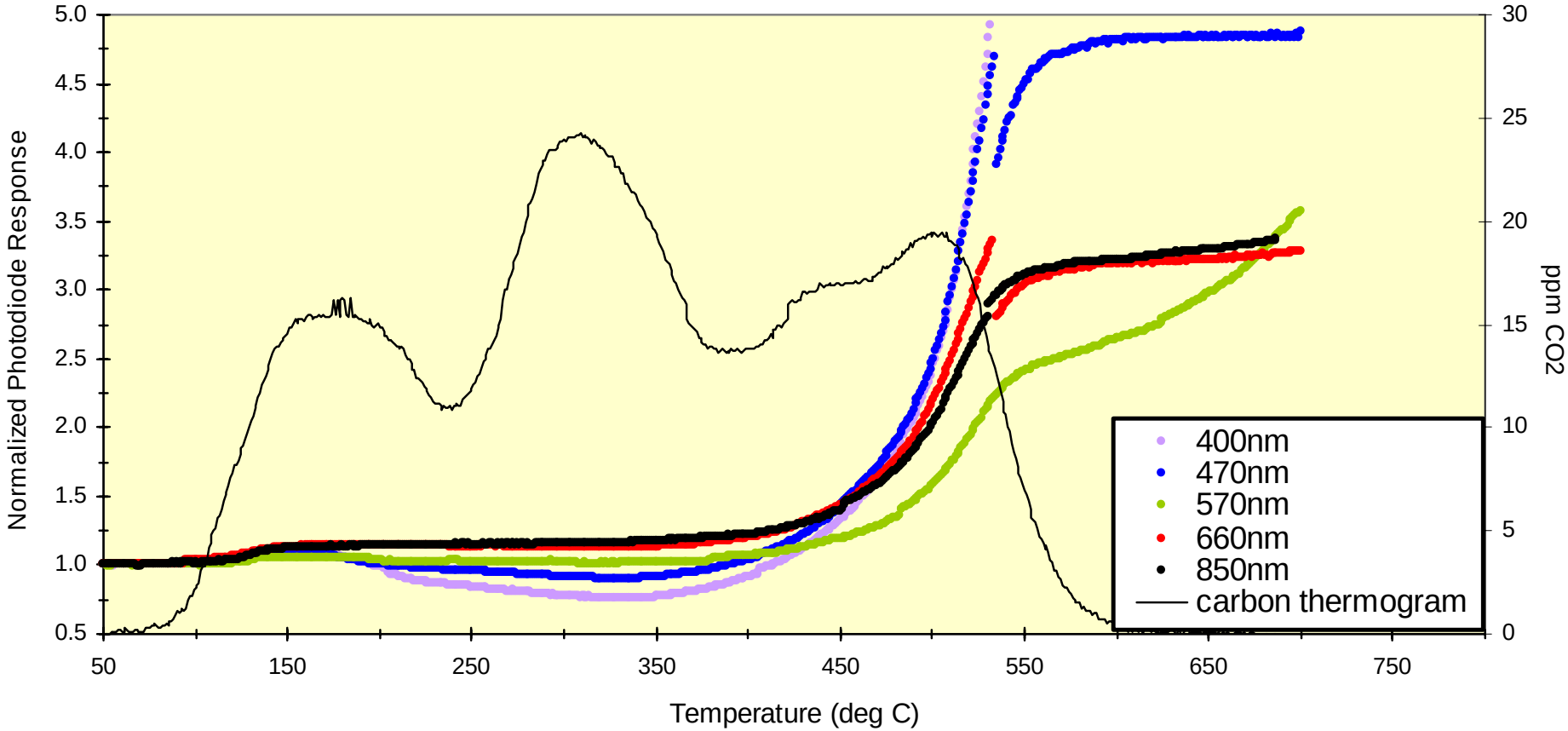
Optical Interference Testing (22-230703)
(LED's and Matching Optical Filters)



Optical Interference Testing (22-230703)



Berkeley Sample (Front Quartz) Collected (230603) on 90mm Filter



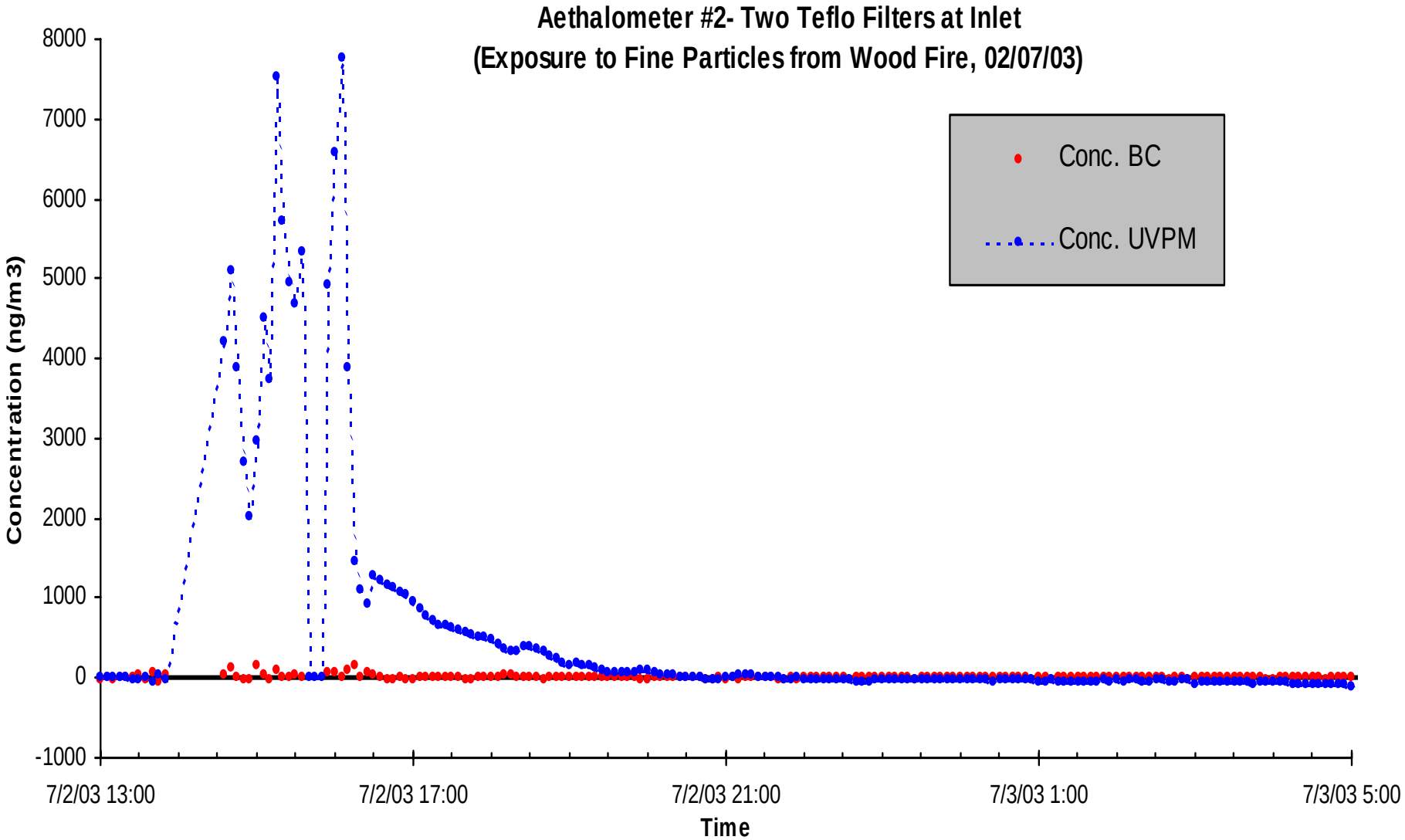
Aethalometer Collection Process

- **Small pump pulls in sample air at 30 L/min**

  Path of the air

- **Enters system through the “hat”**
- **Large particles are extracted by the impactors**
- **Air enters both aethalometers at 3 L/min and the filter sample at 21 L/min**

Fire Sample Data



Summary

- **Light absorption is not constant over the wavelength spectrum**
- **Light absorbance varies with different types/compositions of air pollution**
- **Can use three different machines to distinguish the different absorption properties and composition of multiple air samples**

Shout Outs

Props to Dr. Tom Kirchstetter

Thank you GCEP for keeping it real

HOLLER!