

On-Road Measurements of Gasoline and Diesel Vehicle Emissions in the Caldecott Tunnel



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Research Objectives

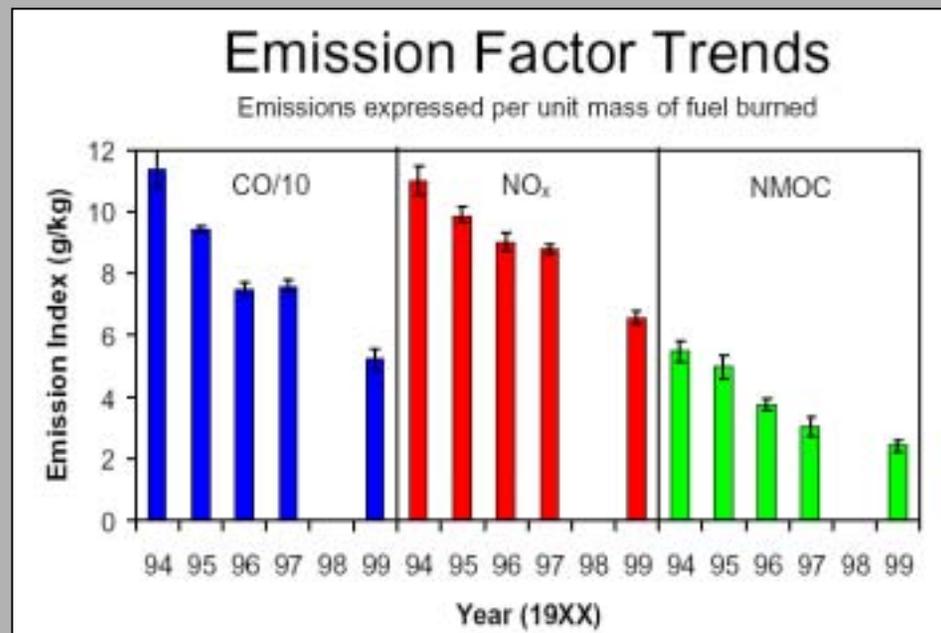


- Investigate fuel reformulation – MTBE removed – Ethanol Added

- Find emissions factors on-road for California fleet - both heavy duty diesel trucks and light duty gasoline vehicles

- Compare different measurement methods for black carbon (BC)

- Add to long term emissions factor data in the Caldecott tunnel

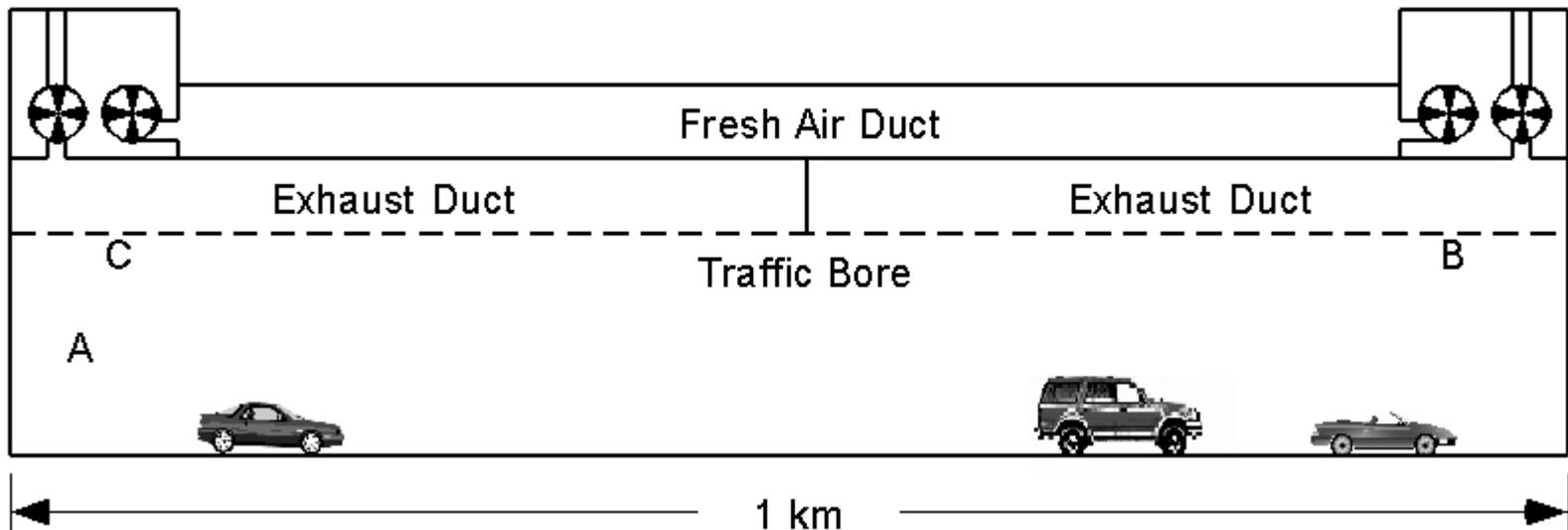


Source: Kirchstetter et al., Kean et al.

Caldecott Tunnel Schematic

West Fan Room

East Fan Room



Bore Outlet



Sampled air at east (outlet) and west (inlet) ends of the tunnel

- Bore 1 carries a mixed fleet of heavy duty (HD) diesel and light duty (LD) gasoline vehicles

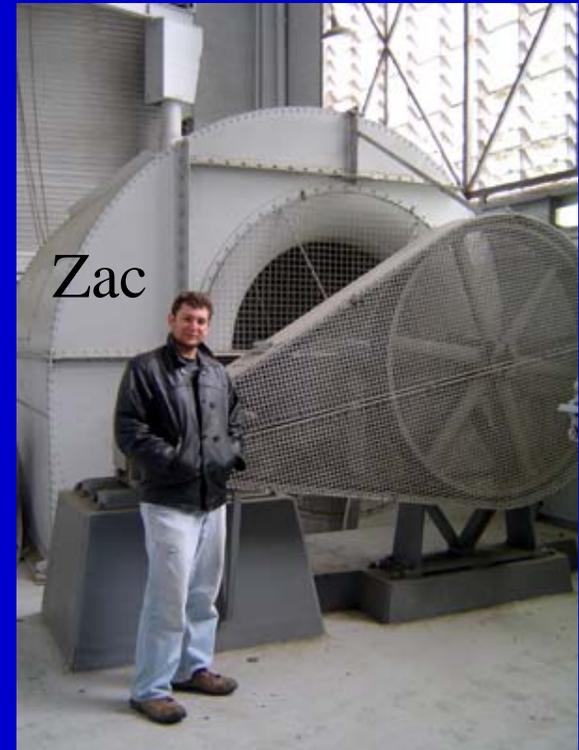
- Bore 2 carries only a LD gasoline fleet

Fan Room

- Four fans per Bore
- Shut off fans while sampling
- While sampling, the “piston” effect from the cars was the only air source
- Allowed for a better concentration of emissions



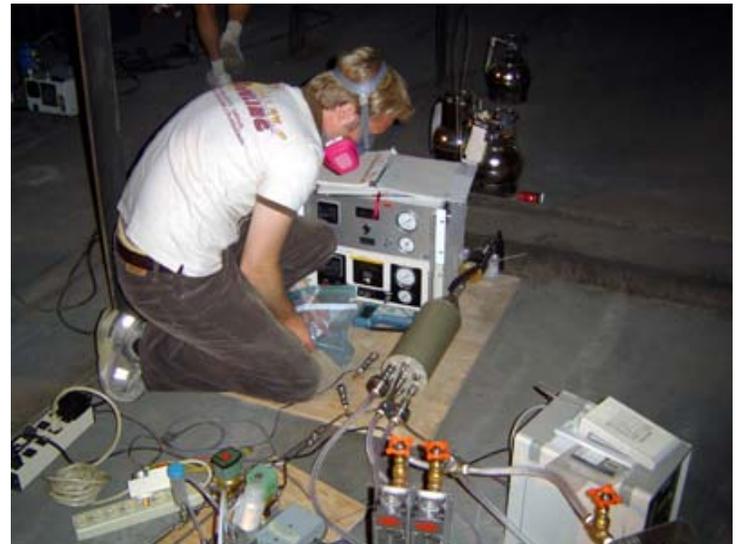
Me



Zac

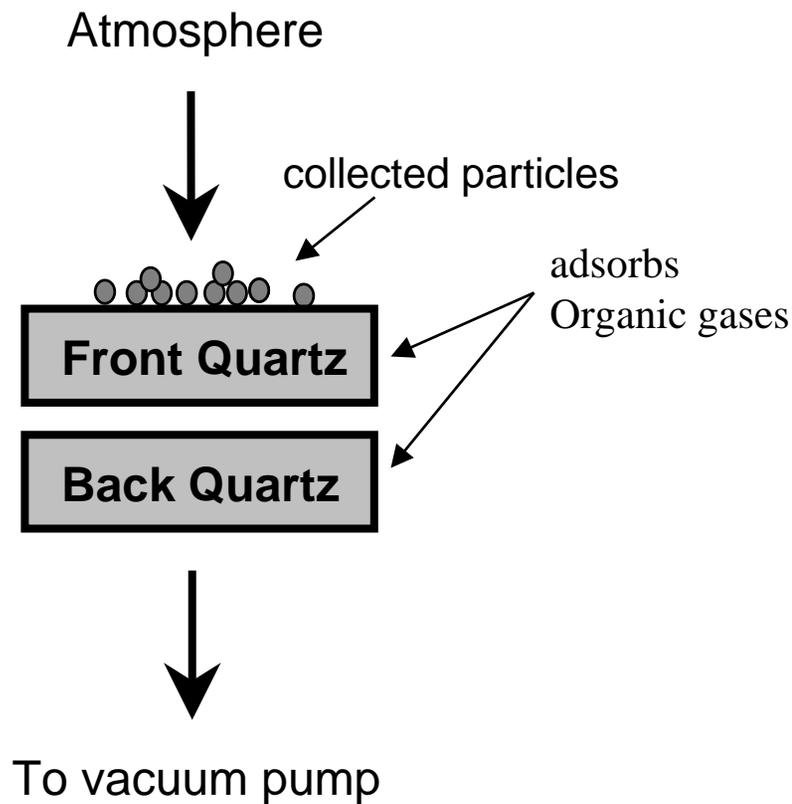
Equipment used:

- **7 λ Aethalometer:** Measured BC
- **Q-Trak:** Measured CO and CO₂ concentrations
- **Filters:** -Quartz filters for particle carbon analysis (OC and BC)
-Teflon filters for PM_{2.5}
- **SMPS:** Measured particle size distributions
- **CW-CRD:** Measured particle light absorption and light scattering (collaboration with NASA Ames research center)
- Collected air samples with stainless steel canisters in conjunction with the Bay Area Air Quality Management District. Analyzed for CO, CO₂, and total and speciated non-methane hydrocarbons (NMHC)



Working hard for the money

Filter Particulate Collection



Evolved Gas Analyses

- Carbon content and light transmission measured simultaneously
- Converts gases into CO₂ using O₂
- Two furnaces capable of maintaining different temperatures

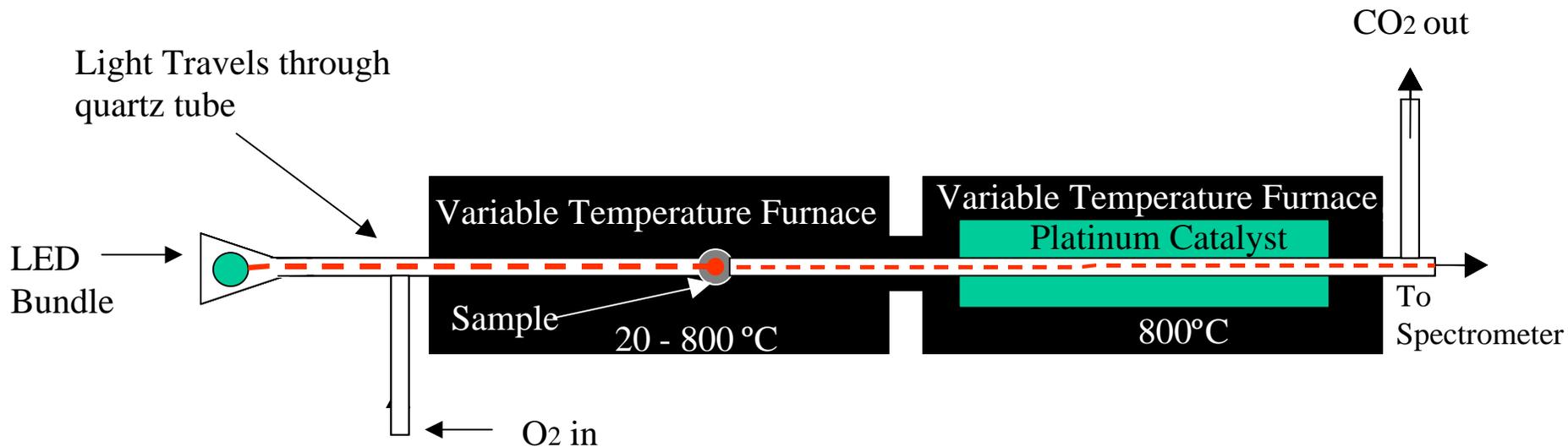
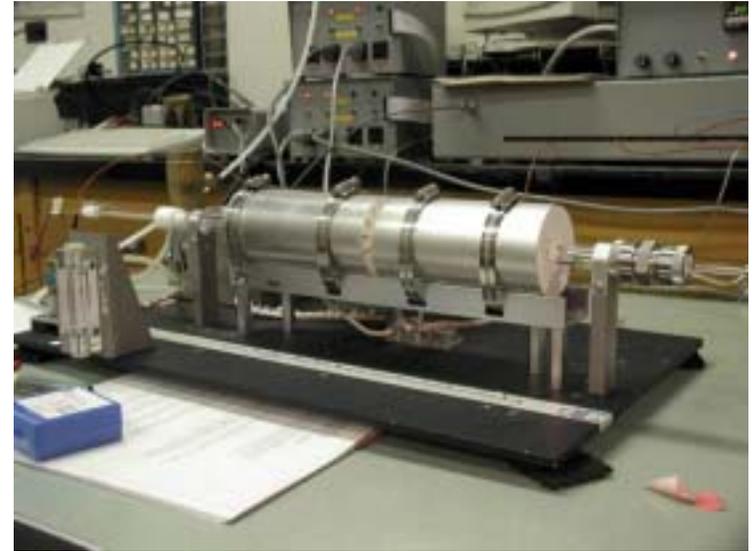
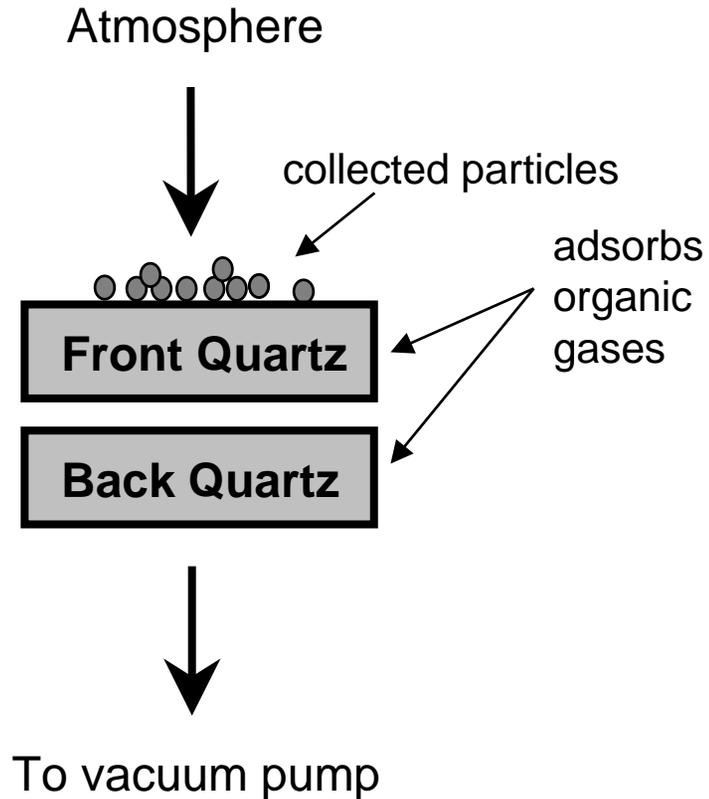
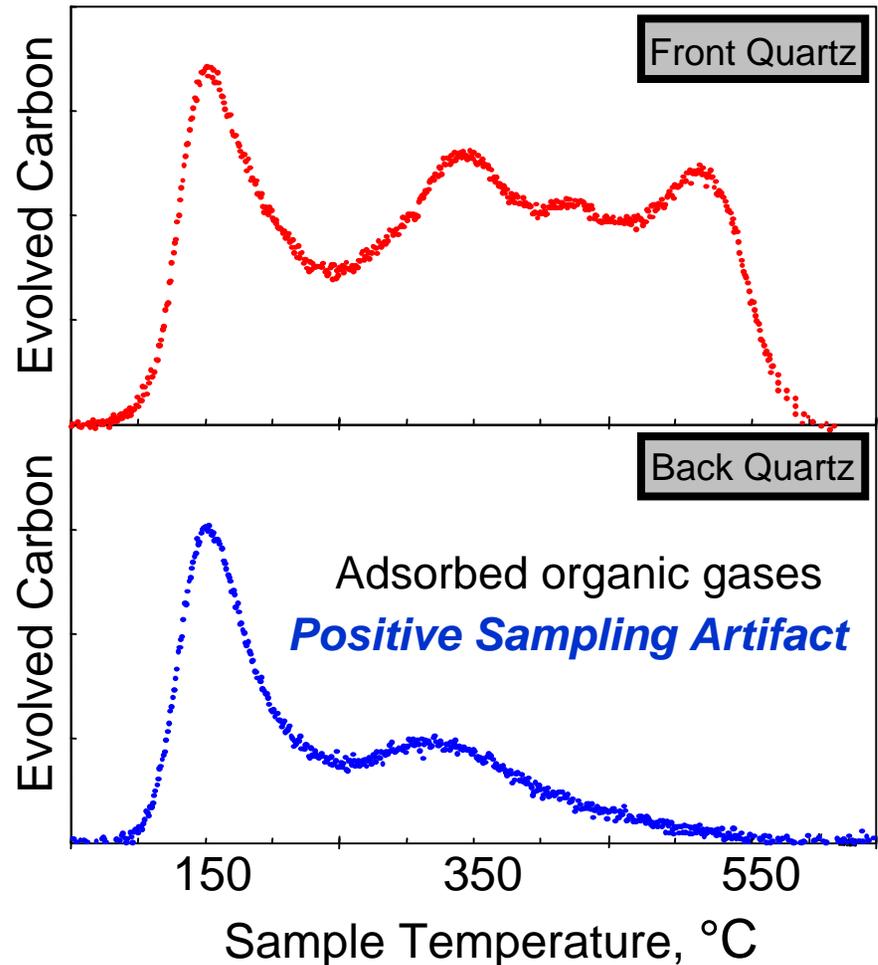


Illustration of Positive Sampling Artifact

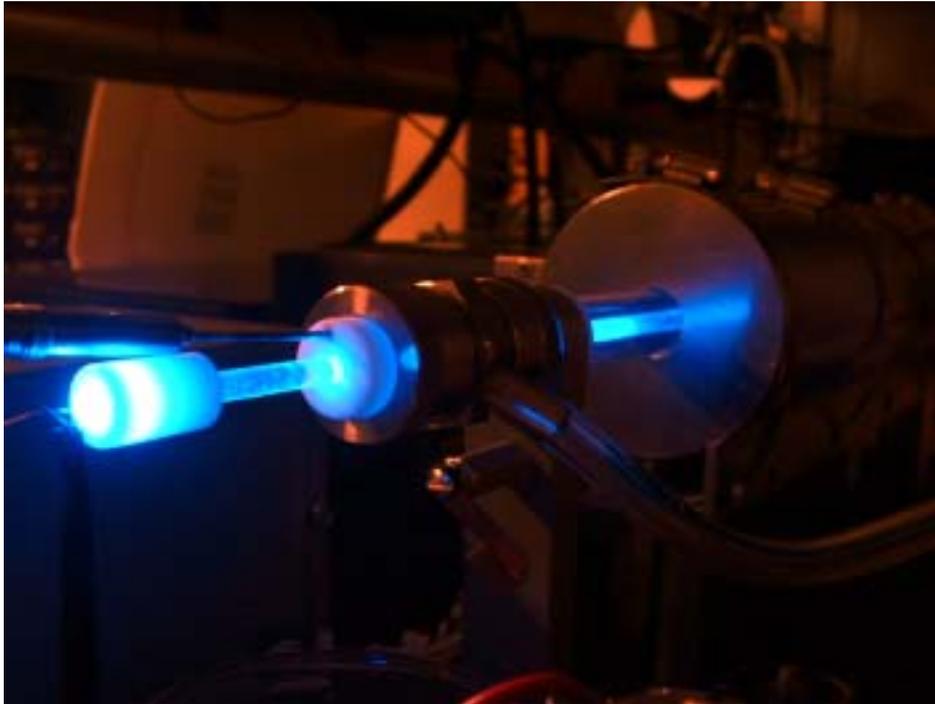


Thermal Analysis of Carbon



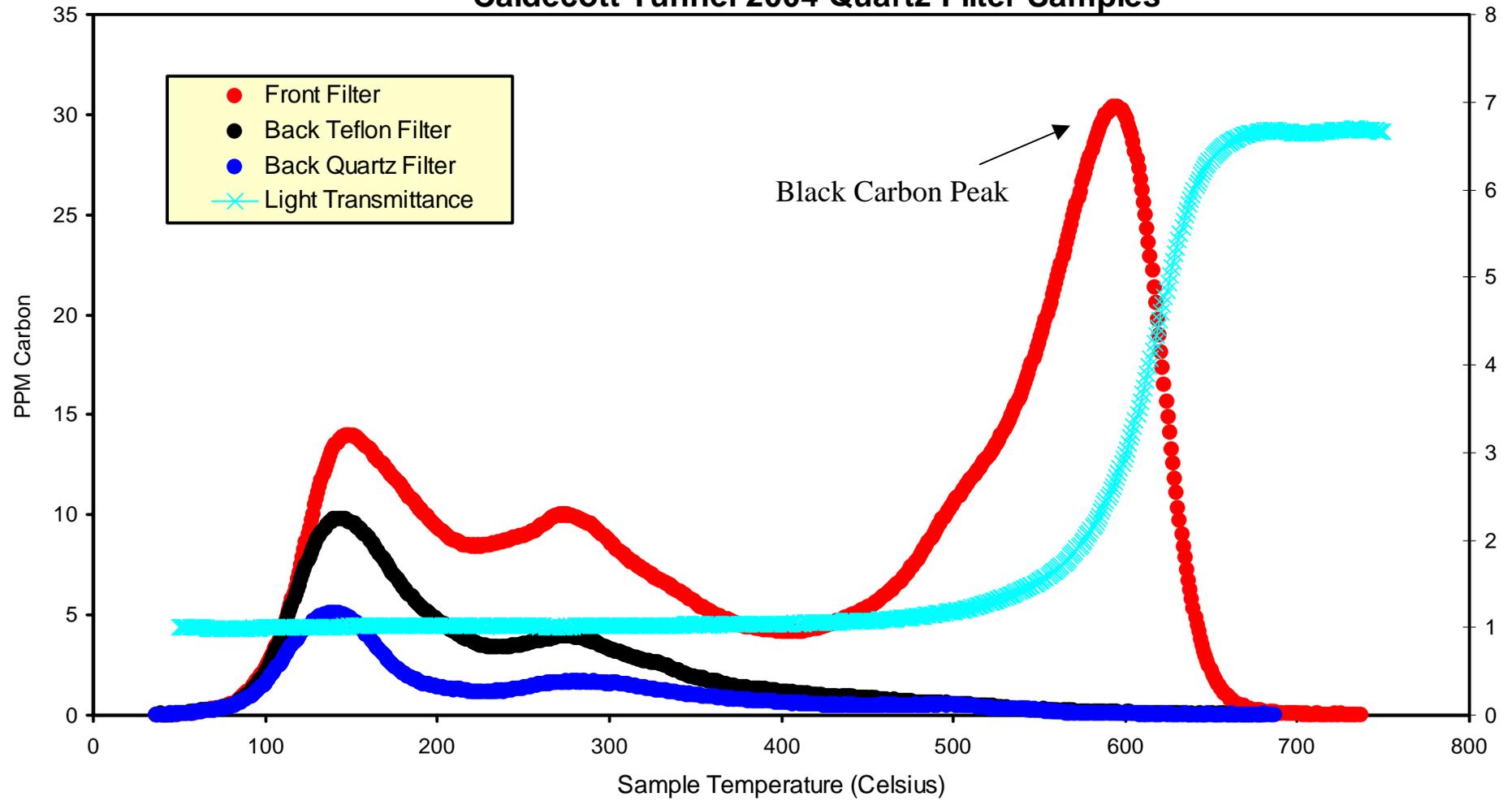
(Kirchstetter et al., 2001)

EGA optical readings

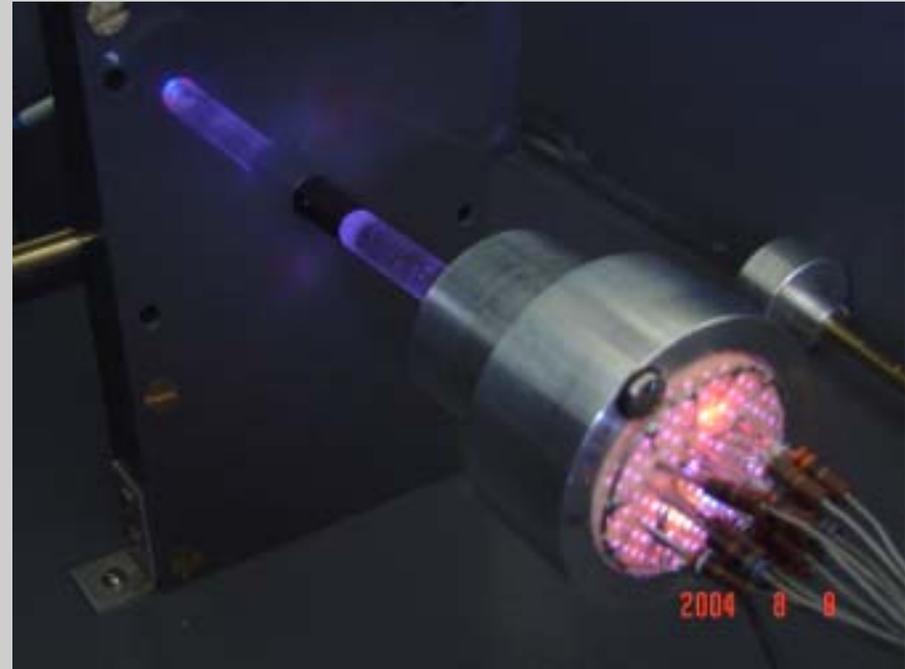
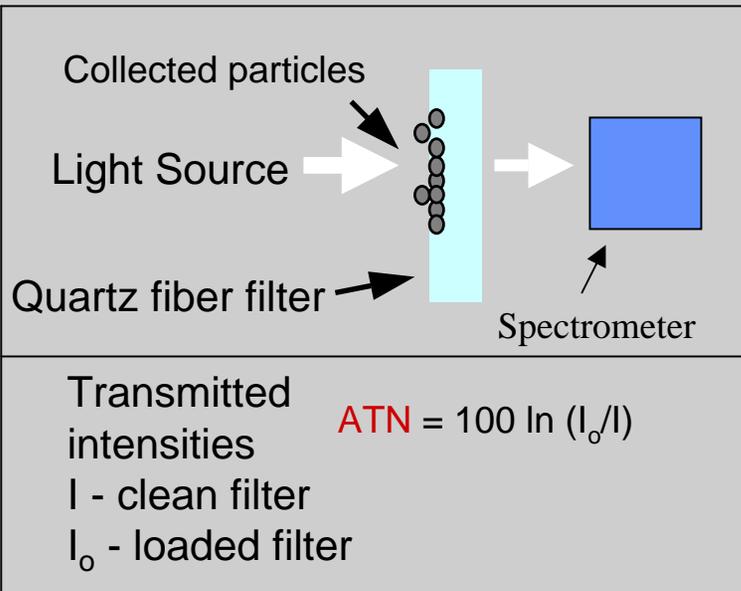


- **Two glass rods connect and allow the LED light to transmit through the filter**
- **Can use multiple LED's at different intensities**
- **Can use multiple optical filters which attach to the picoammeter**

Caldecott Tunnel 2004 Quartz Filter Samples



Light Transmission Method

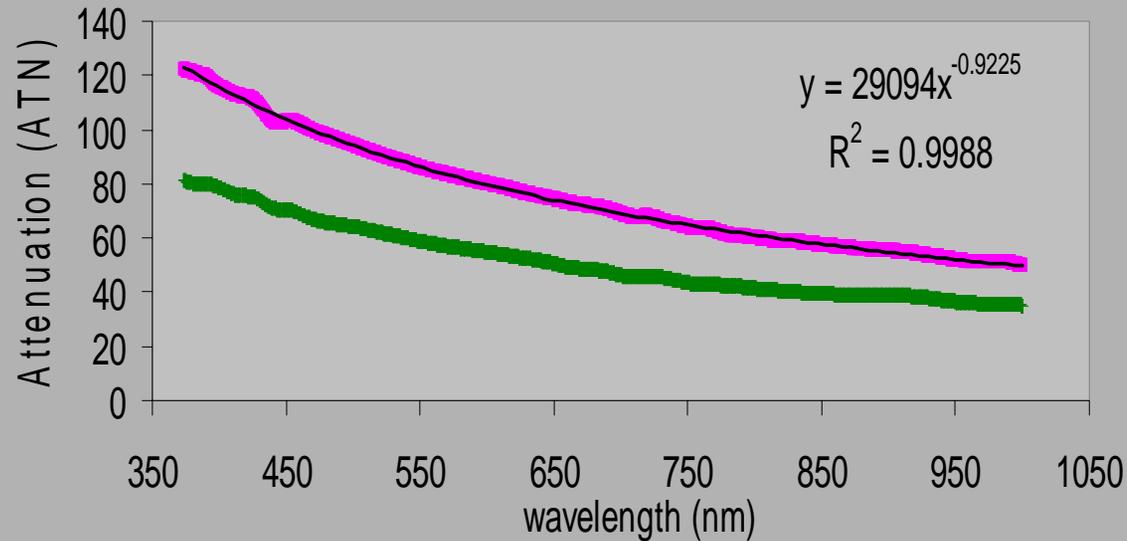


- Measured attenuation is proportional to the absorption coefficient
- The higher the attenuation, the more light the particles absorb

Characterization of Particle Light Absorption



Light Absorption by Particles Emmitted from Diesel Trucks



- Spectral Dependence of approximately λ^{-1} is expected for elemental soot (BC)
- Confirms Spectral Dependence of Calibration coefficient of the Aethalometer
- Particles absorb more light at shorter wavelengths

Emission Factor Equation



Emissions Factors were calculated on a per kg fuel used basis:

$$E_p = 10^3 \left(\frac{\Delta[P]}{\Delta[CO_2] + \Delta[CO]} \right) w_c$$

ΔP is the difference in concentration of pollutant P between the inlet and exit of the tunnel. The denominator represents the vehicle emissions of carbon, and w_c is the carbon weight fraction in fuel.



A particle-loaded quartz filter sample. Note the particles attached to the quartz fiber.

Emissions Factors:

gram pollutant/ kg fuel burned



	PM _{2.5}	BC	OC
Avg. HD	0.79 ± 0.352	0.450 ± 0.148	0.373 ± 0.092
Avg. LD	0.070 ± 0.033	0.026 ± 0.004	0.028 ± 0.013
ratio HD/LD	11.4	17.4	13.1
(%) Change from 1997 LD	-36.3	-25.7	-47.2
(%) Change from 1997 HD	-68.1	-65.4	-26

- HD Diesels Emit **10 to 20 times more** particle mass than LD Gasoline vehicles per kg of fuel burned
- On a per mile basis the disparity is about four times larger because of differences in fuel economy
- The OC/BC ratio for gasoline at approx. **1**, which the Global OC/BC Inventory (Bond et al.) reports as well



Closing Remarks



- Observed significant decrease in particulate emissions since 1997, ongoing investigation will consider reasons why.
- These results will be combined with those of other study participants to characterize particulate emissions from motor vehicles.

Thanks:

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- Zac Apte
- Lawrence Berkeley National Laboratory

Fred the Turkey!

