Environmental Air Quality

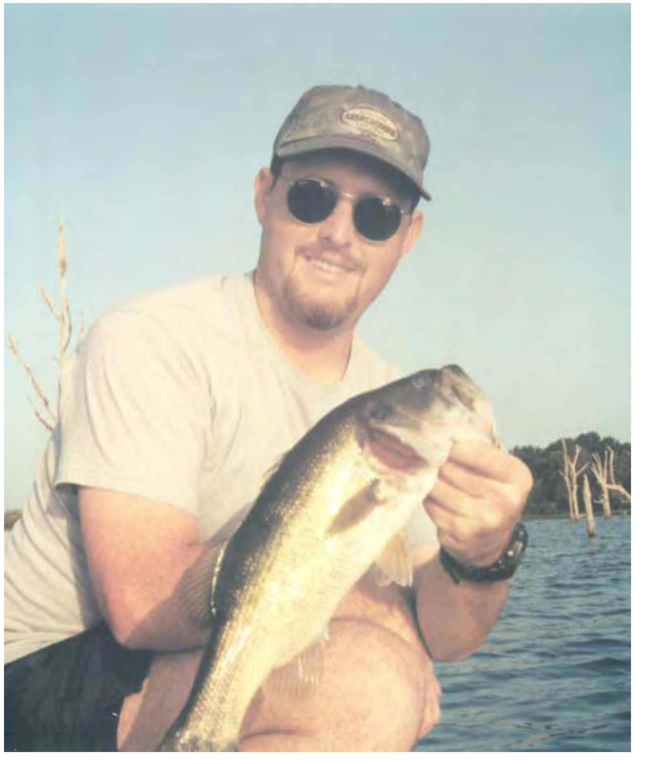
Monitoring Methods in Agricultural Settings

The Posse

Acknowledgments

Kevin Heflin, M. S.

- Water quality
- Manure combustion
- Carcass composting
- *Micropterus salmoides*



Gary Marek, (soon-to-be) M. S.

- Feedyard evaporation
- Instrumentation
- *Odocoileus virginianus*

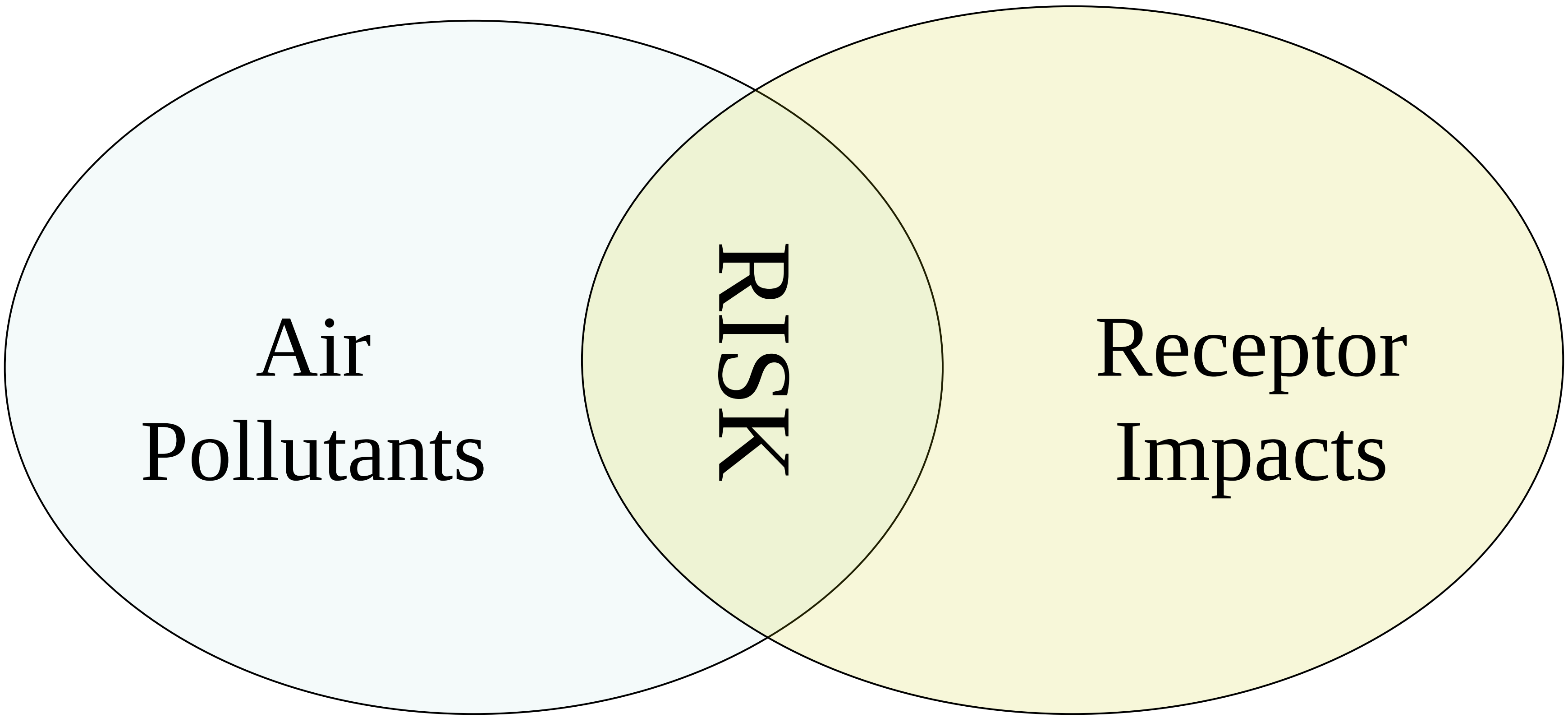
Jack Bush, M. S.

- Feedyard dust control
- Ambient $PM_{2.5}$ monitoring
- *Ursus arctos horribilis*

Billy Chaffin, B. S.

- Mechanical engineering
- Biomass energy
- Mechanics of dust emissions
- Ongoing study of the aerodynamics of the common *Horseshoe*

Risk Factors vs. CAFO Emissions



	Nuisance-Neighbor	Nuisance-Community	Current Regs	Anticipated Regs
PM	☑	☑	☑	⊗
Odor	☑	☑	⊗	☑
NH_3	⊗	⊗	⊗	☑
H_2S	⊗	⊗	⊗	☑
VOCs	⊗	⊗	⊗	☑
GHGs	⊗	⊗	⊗	☑

	First Impressions	Environmental Justice	Nutrient Efficiency
PM	☑	☑	☑
Odor	☑	☑	☑
NH_3	⊗	☑	☑
H_2S	⊗	☑	⊗
VOCs	⊗	☑	⊗
GHGs	⊗	⊗	☑

This PM factor is intended to include viable bioaerosols, endotoxin etc.

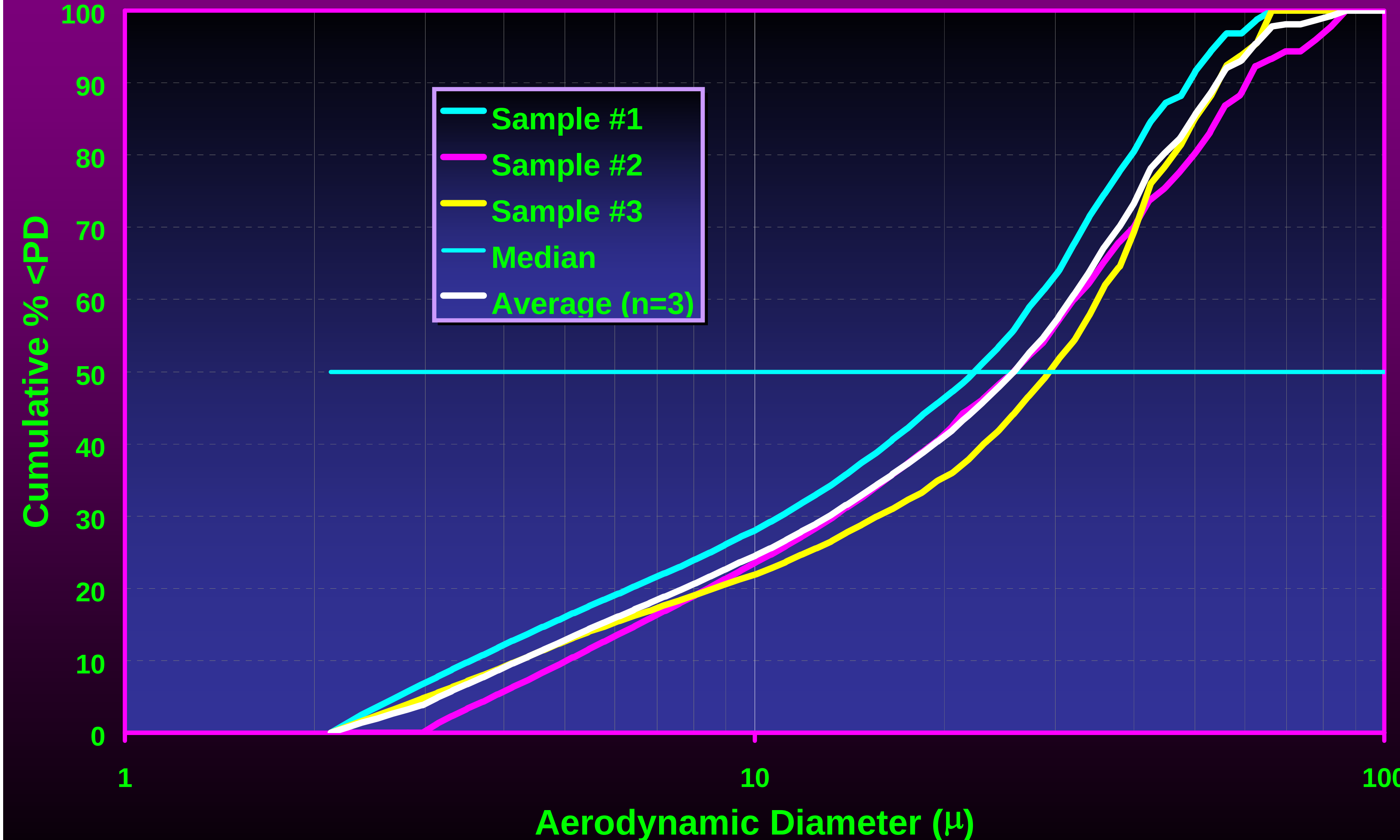
	Health-Human	Health-Occupational	Health-Animal	Visibility/ Liability
PM	☑	☑	☑	☑
Odor	☑	⊗	⊗	⊗
NH_3	☑	☑	☑	⊗
H_2S	☑	☑	☑	⊗
VOCs	☑	☑	⊗	⊗
GHGs	⊗	⊗	⊗	⊗

Regulatory Environment

- Federal Clean Air Act
  - Title V (major source emissions fees)
  - National Ambient Air Quality Standards (NAAQS) for “criteria pollutants,” including PM, CO, Pb, NO_x, SO_x, O_3
    - ☞PM includes 2 fractions: PM_{10} and $PM_{2.5}$
    - ☞Chronic and acute standards
- State-specific air-quality regulations
- Nuisance litigation & case law
- Local ordinances

Particle Size Distributions

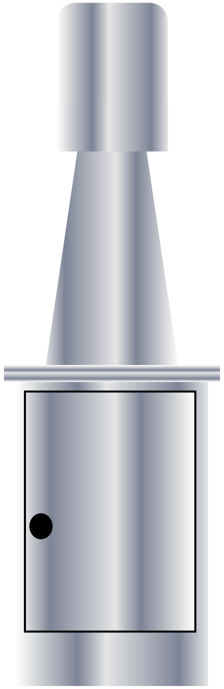
Manufactured Dust, Bushland, TX



PM_{10} and $PM_{2.5}$

- Refer to "aerodynamic equivalent diameter," not physical dimension
- PM_{10} – generally, "inhalable" PM
- $PM_{2.5}$ – "respirable" PM

Anatomy of an FRM Sampler for PM_{10}



Principles of Operation

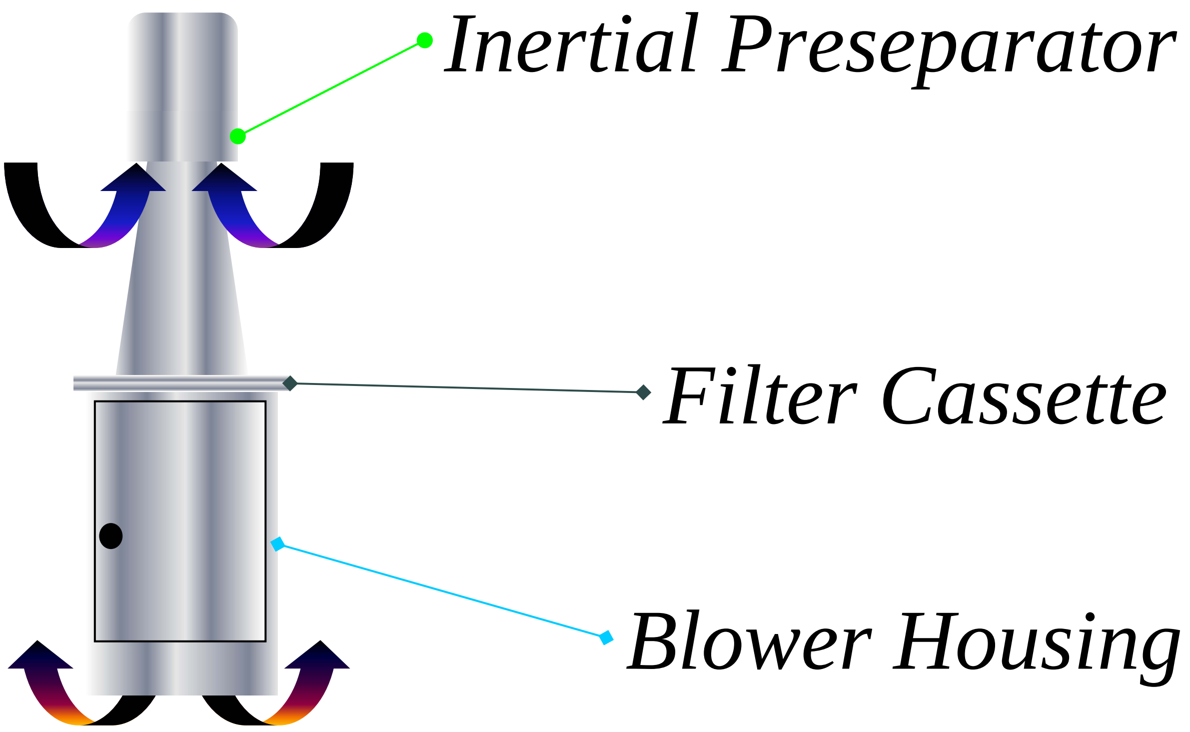
1. Move air at a specified rate

2. Remove the “boulders”

3. Capture what’s left and weigh it

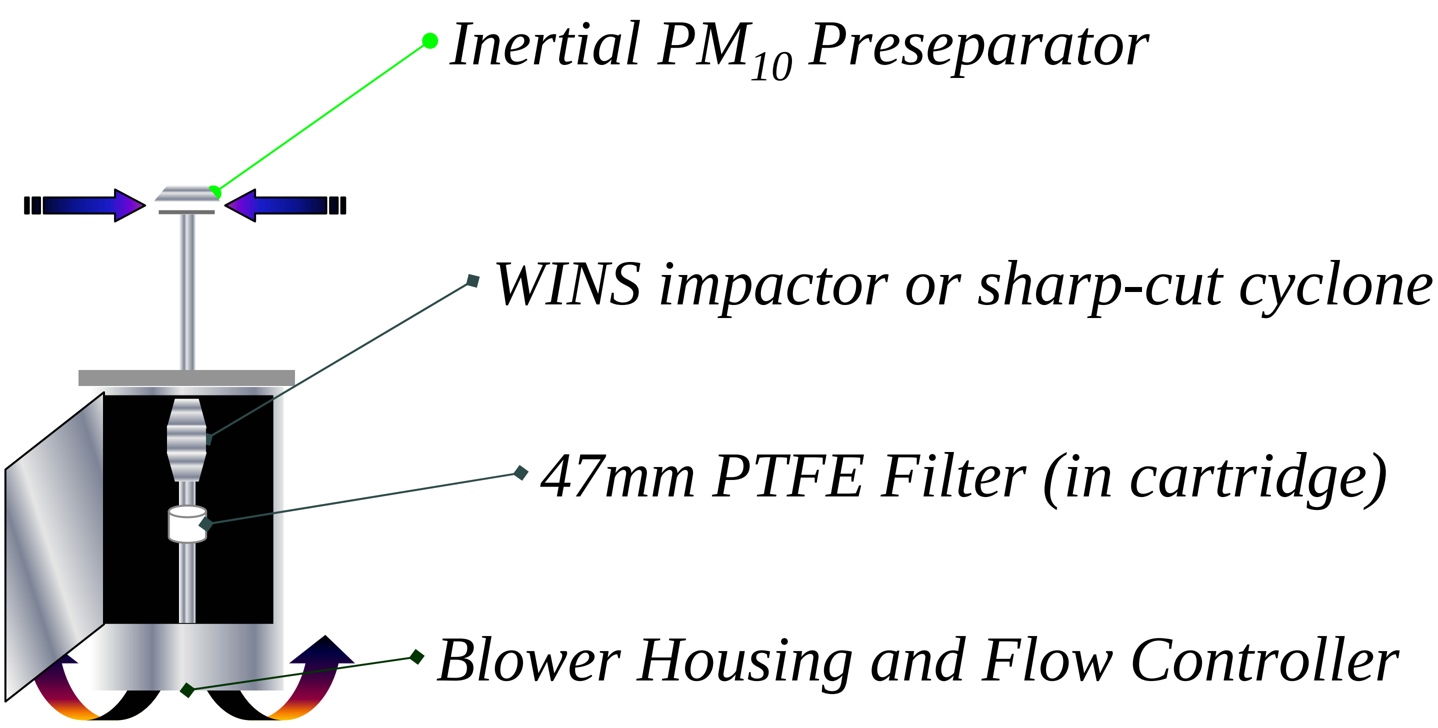
4. FRM standard: *performance*

Anatomy of an FRM Sampler for PM_{10}



Microbalance Requirement: 0.1 mg accuracy

Anatomy of an FRM Sampler for $PM_{2.5}$



Microbalance Requirement: 0.1 µg accuracy

Federal $PM_{2.5}$ Air Monitoring

Amarillo, Texas

$PM_{2.5}$ FRM Air Sampler

- Rupprecht & Patashnick Partisol-Plus Model 2025 Sequential Air Sampler
- U.S. EPA Reference Method Designation

  RFPS-0498-118

A Closer Look

- A filter-based, gravimetric sampling method
- 24-hr samples every three days
- System is automated with some moderate maintenance and programming

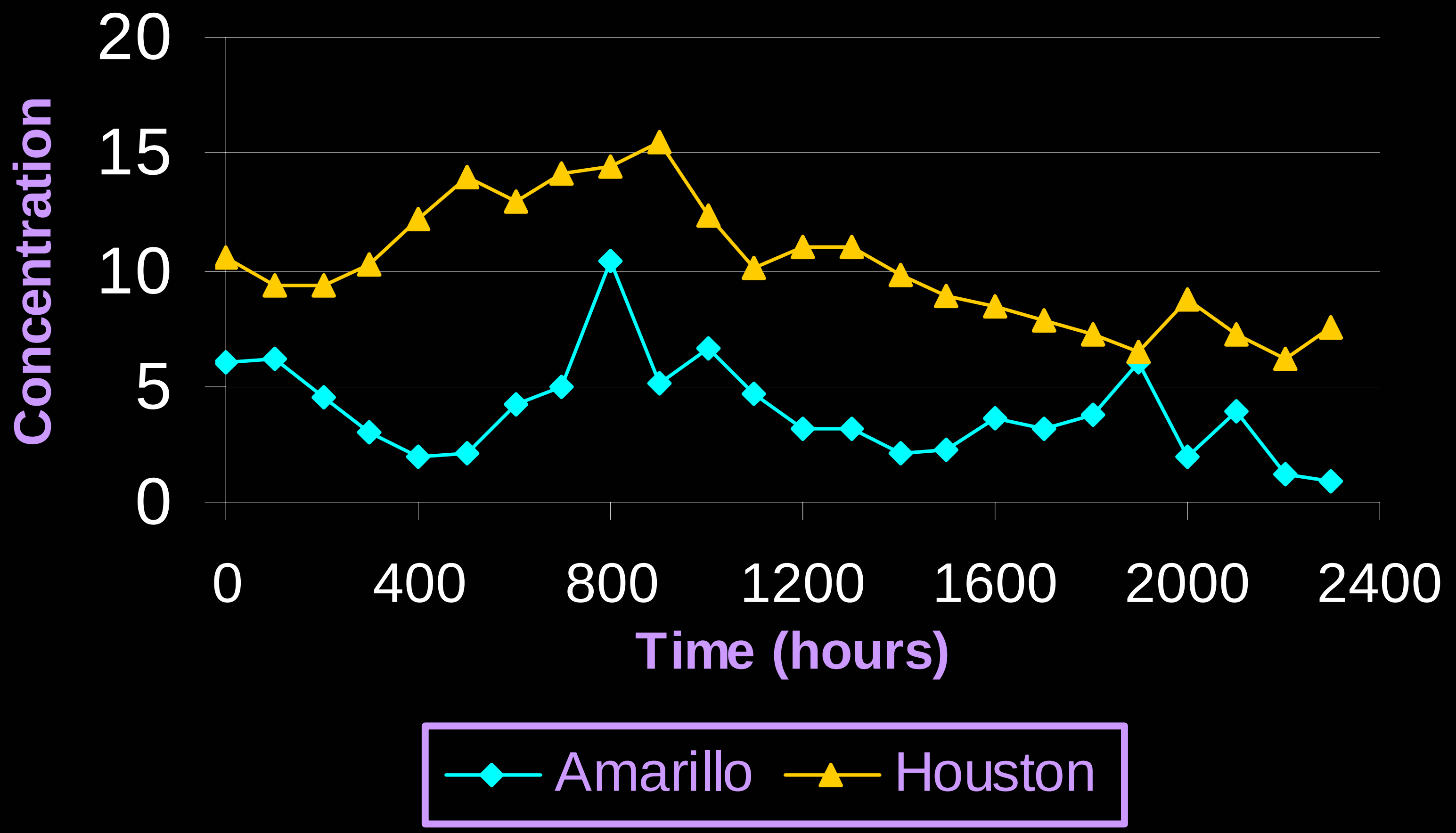
$PM_{2.5}$ Continuous Air Monitor

- TEOM Series 1400 Ambient Particulate Monitor
- Converts the change in oscillation frequency of a tapered element into a measure of increased PM mass on the end of the element

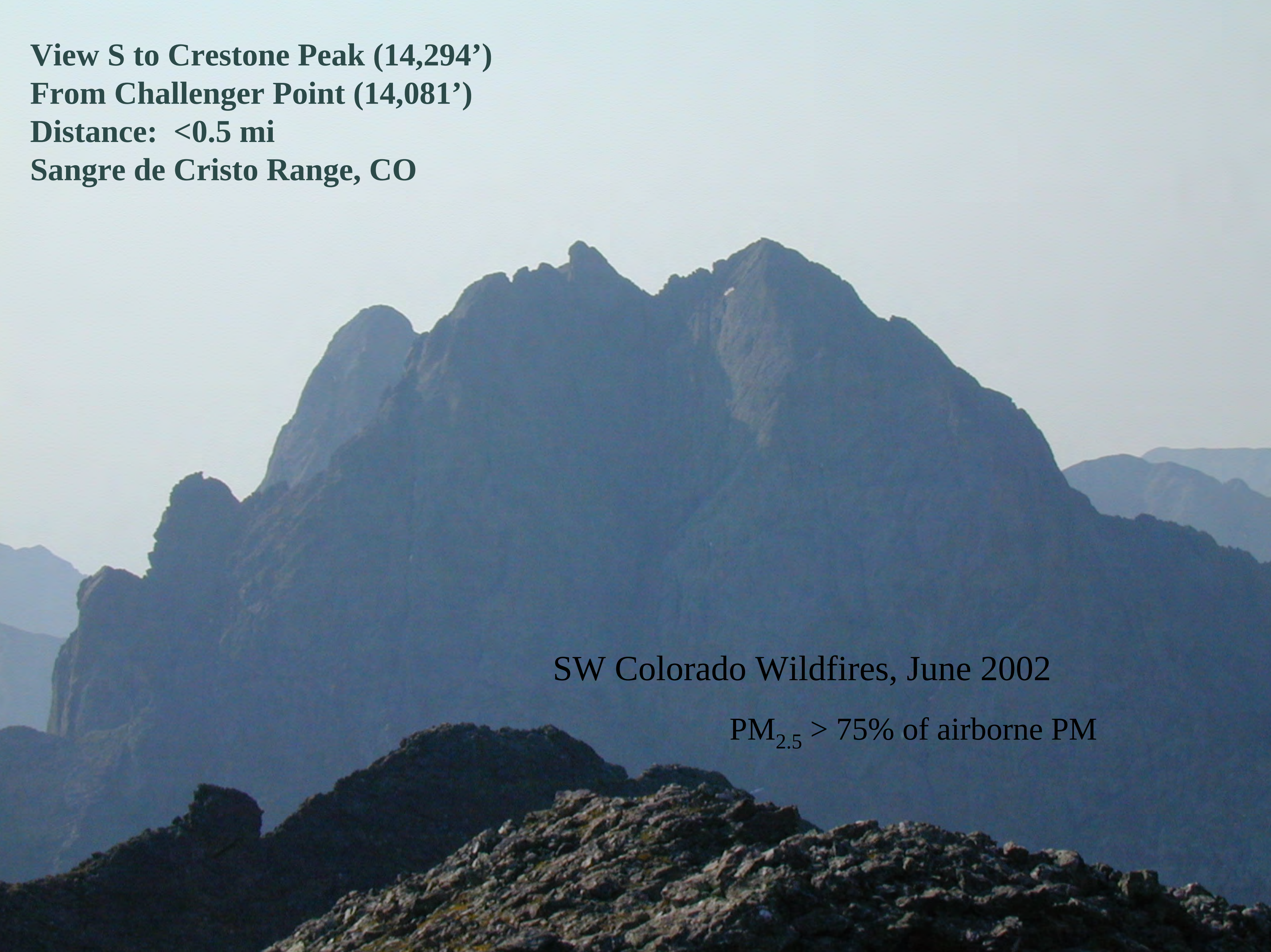
A Closer Look

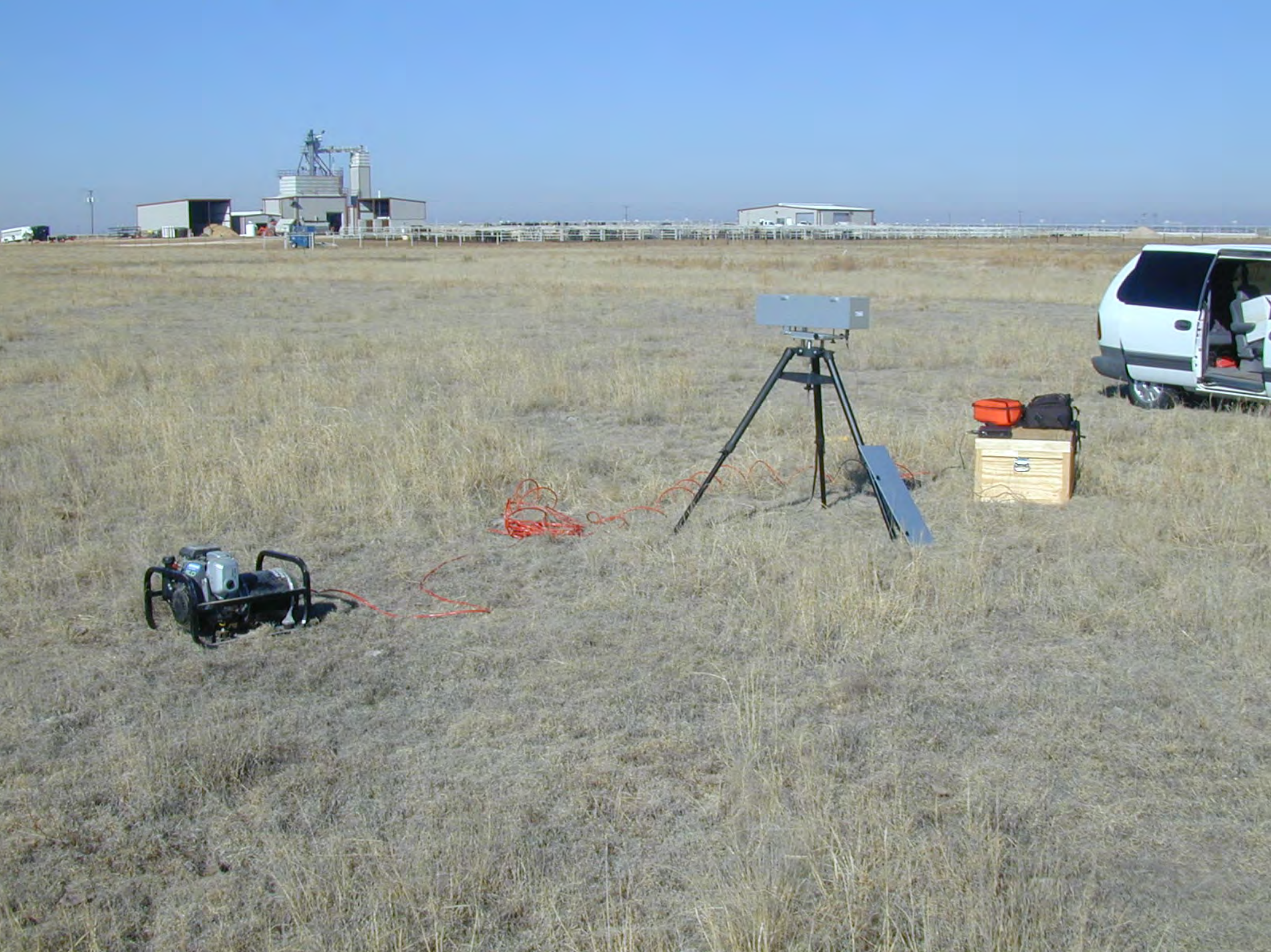
- Inline filter method of sampling
- Fully automated with little maintenance
- Uploads hourly averages via the internet

Hourly $PM_{2.5}$ Concentrations ($\mu g/m^3$)
April 23, 2003




Selved Manure Dust
EHT=15.00 kV
WD= 10 mm
Mag= 150 X
10µm
Detector= SE1


View S to Crestone Peak (14,294’)
From Challenger Point (14,081’)
Distance: <0.5 mi
Sangre de Cristo Range, CO
SW Colorado Wildfires, June 2002
$PM_{2.5}$ > 75% of airborne PM



Nuisance Condition

Any condition that interferes with the reasonable use or enjoyment of property

The FIDO(H) Factors in Odor Assessment

Frequency

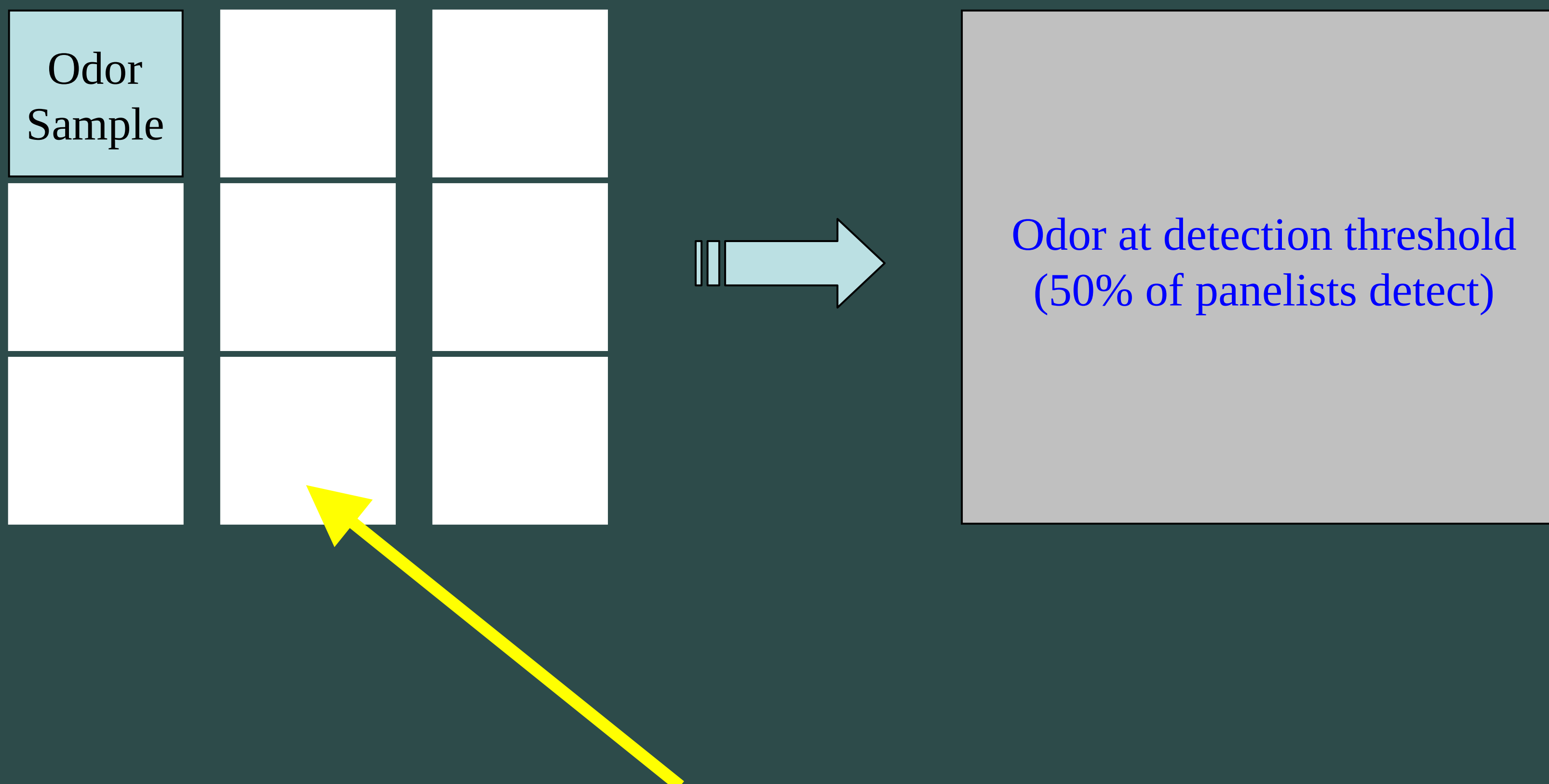
Intensity (DT)

Duration

Offensiveness

Hedonic tone (what does it smell *like*?)

Dilutions to Threshold



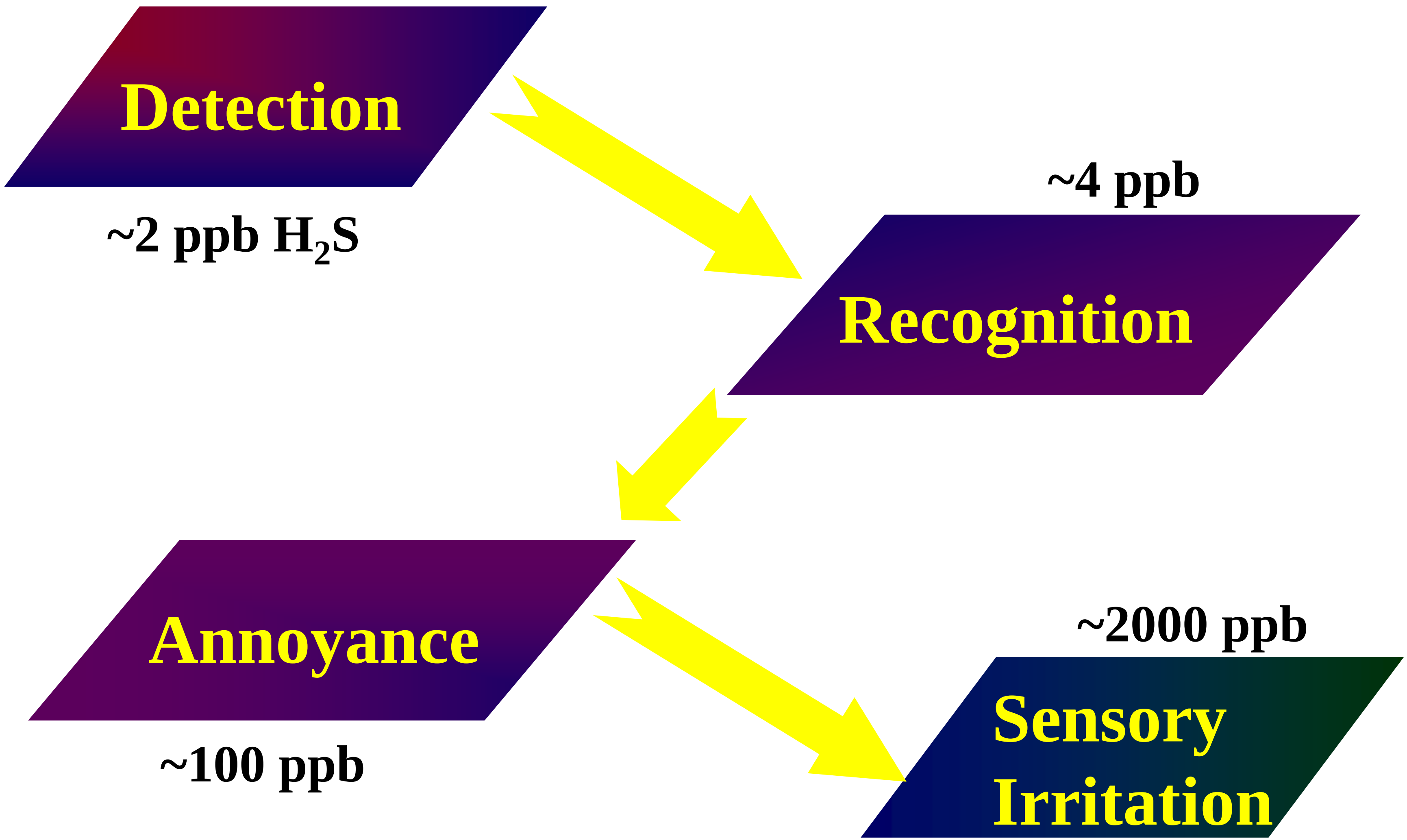
Dilution (odor-free) air: How much is needed?

Odorant Classifications

- S compounds (“rotten”)
  - Mercaptans
  - H_2S
  - Organic sulfides
- N compounds (“fishy or pungent”)
  - NH_3
  - Amines
  - Indole, skatole
- Phenolic compounds (“medicinal”)
  - Phenol, cresol

Odorant Classifications

- Alcohols, aldehydes, ketones (“sweet”)
  - Methanol
  - Acetaldehyde
  - Methyl ethyl ketone
- Organic acids (“sour”)
  - Acetic acid
  - Butyric acid
  - Isovaleric acid


Detection
~2 ppb H2S
~4 ppb
Recognition
Annoyance
~100 ppb
~2000 ppb
Sensory
Irritation

Introduction to Open-Path Transmissometry as a Surrogate Measure of Ambient PM at Cattle Feedyards


621

Difficulties Posed by Ambient PM_x Monitoring

1. Labor-intensive, esp. in research mode
2. Time resolution amplifies labor issue
3. Size-selective inlets not aerodynamically robust
4. PM_x not an intuitive concept to the masses
5. Not well suited to spatially chaotic plumes

What We Want

1. Reduce labor requirements;
2. Permit time-resolved measurements;
3. Avoid biases of inertial, size-selective inlets;
4. Deliver an intuitive and reliable surrogate for PM_x as a dust measure; and
5. Integrate measurement along a line transverse to plume drift

Where Doth Transmissometry Fit?

- Potentially:
  - ✓ Reduces labor requirements;
  - ✓ Permits time-resolved measurements;
  - ✓ Avoids biases of inertial, size-selective inlets *(sort of);*
  - ? Delivers an intuitive and reliable surrogate for PM_x as a dust measure; and
  - ✓ Integrates measurement along a line transverse to plume drift

Caveat

Like substitutes for dynamic, forced-choice olfactometry, visibility data have little regulatory meaning *without being anchored to the accepted methods*:

Odor: Human panelists

PM_x: Federal Reference Methods

Principles of Visibility

- Image strength can be attenuated by reflection, refraction, absorption
- Contrast is modified by wavelength dependence of attenuating processes
- Instruments can differentiate among scattering processes, but…
- …our eyes and brains respond to the *integration* of those processes

Components of Total Atmospheric Extinction

Scattering

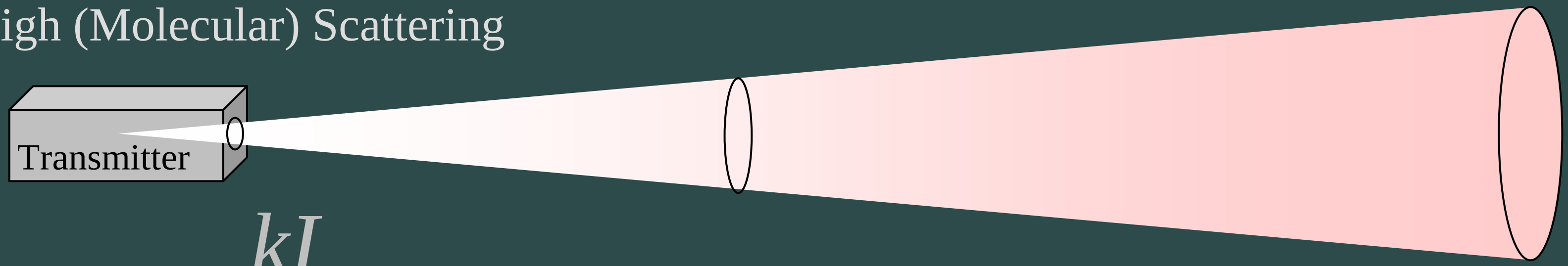
Absorption

Particles

Total Extinction

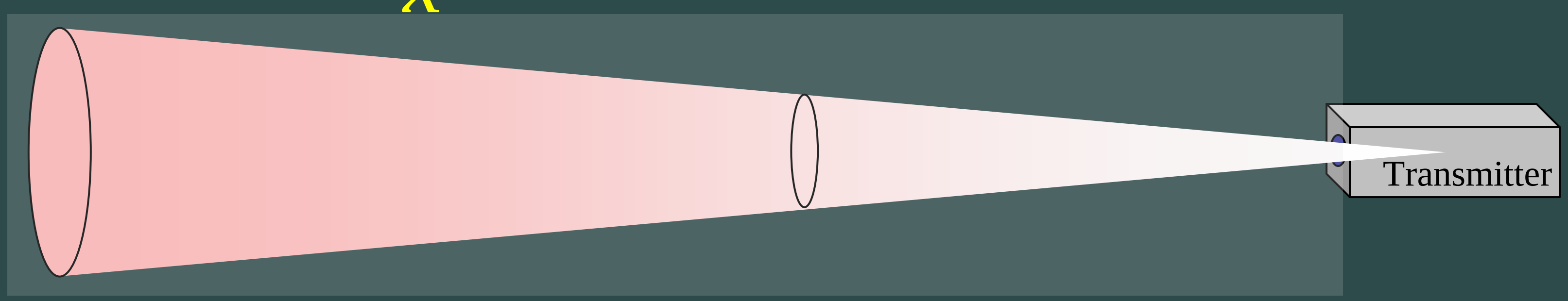
Gases

Rayleigh (Molecular) Scattering



$$I_R(x) = \frac{kI_o}{x^2} e^{-\alpha_R x}; \lim_{P \to 0} \alpha_R = 0$$

$$I_T(x) = \frac{kI_o}{x^2} e^{-\alpha_T x}; \alpha_T = f(C_{PM}, C_{gas} \ldots)$$



Molecular and Particle Scattering

Transmissometry Equation

$$f = \left\{ \frac{k_j}{r^2} \frac{I_{o,j}}{I_j(r)} \right\}^{1/r} = e^{-\alpha_j}$$

Koschmieder Equation

$$VR = \frac{3.912}{\alpha}$$

.: Home .: Air Quality Info .: Links .: Contact Us

Wyoming Visibility Monitoring Network

Wyoming

Department of Environmental Quality

Live Sites

Campbell County
Cloud Peak
Thunder Basin
All Sites

Image Gallery

Bridger Wilderness
Cloud Peak Wilderness
Teton Wilderness
Yellowstone National Park

Campbell County
Cloud Peak
Green River Basin
Thunder Basin

Cloud Peak

Web Cam | Save Image | Landmarks | Map It | 2wk Image Archive

Image Updated Every 15 Minutes

Meteorology

Temperature	71°F	Humidity	54%
Wind Speed	8 mph	Wind Direction	ESE

Air Quality Information

Visual Range ~ 94 miles

Wyoming

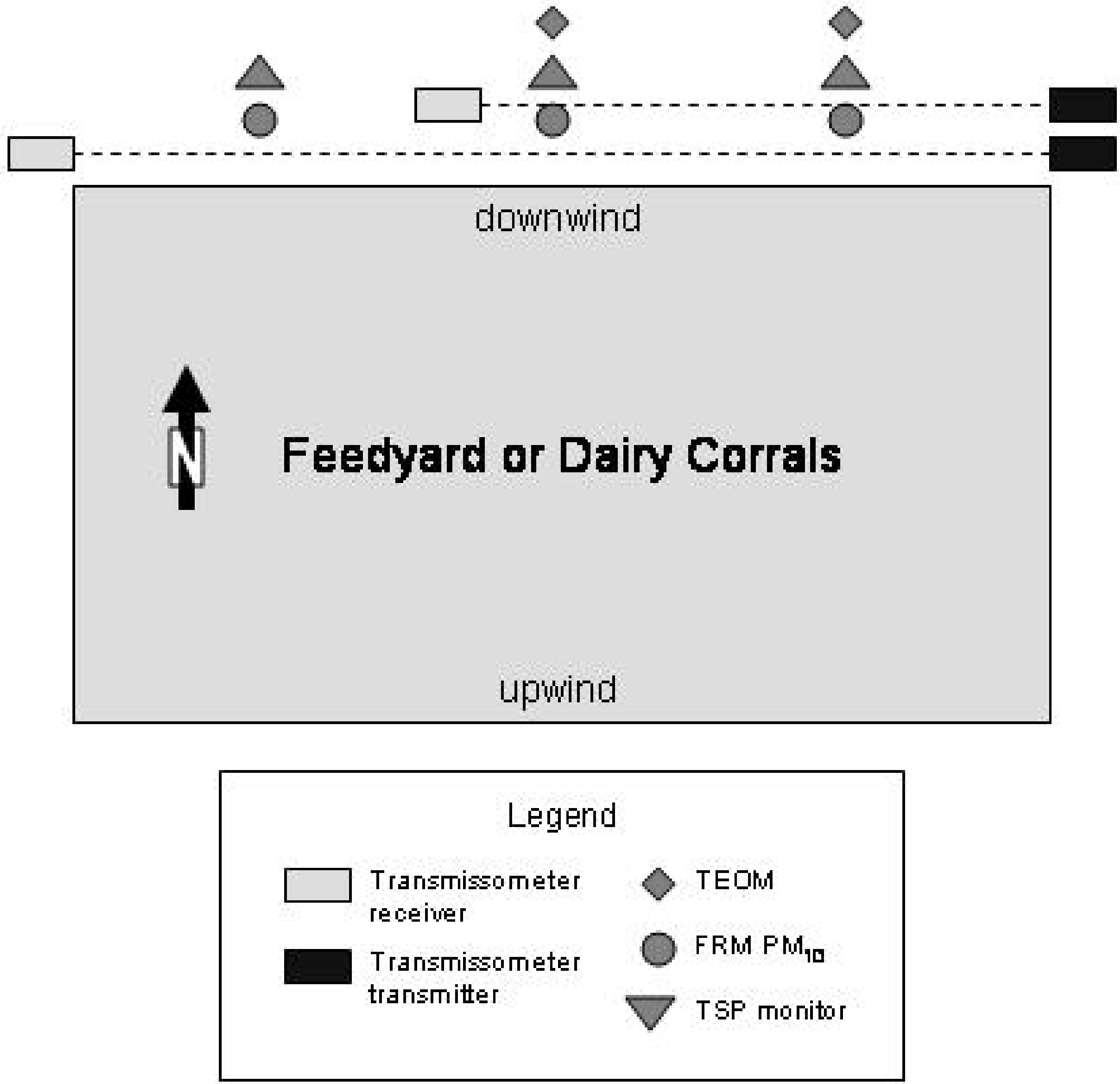
Extinction Efficiency of Air Pollutants

$$\beta_i = \frac{\partial \alpha_T}{\partial C_i}$$

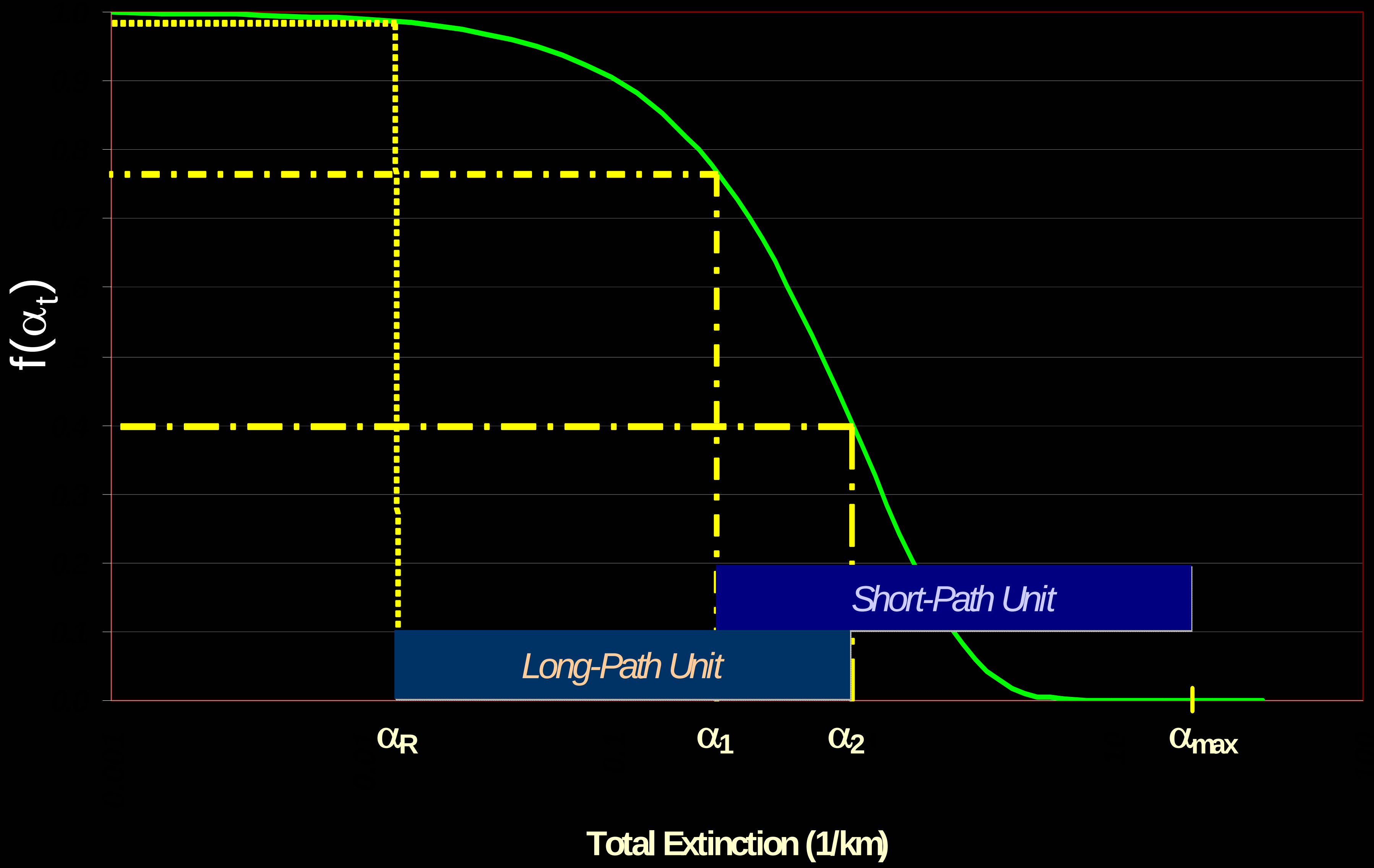
Units: $L^{-1}\ L^{3}\ M^{-1} = L^{2}\ M^{-1}$

Extinction efficiencies by particle type (Malm, 1999)

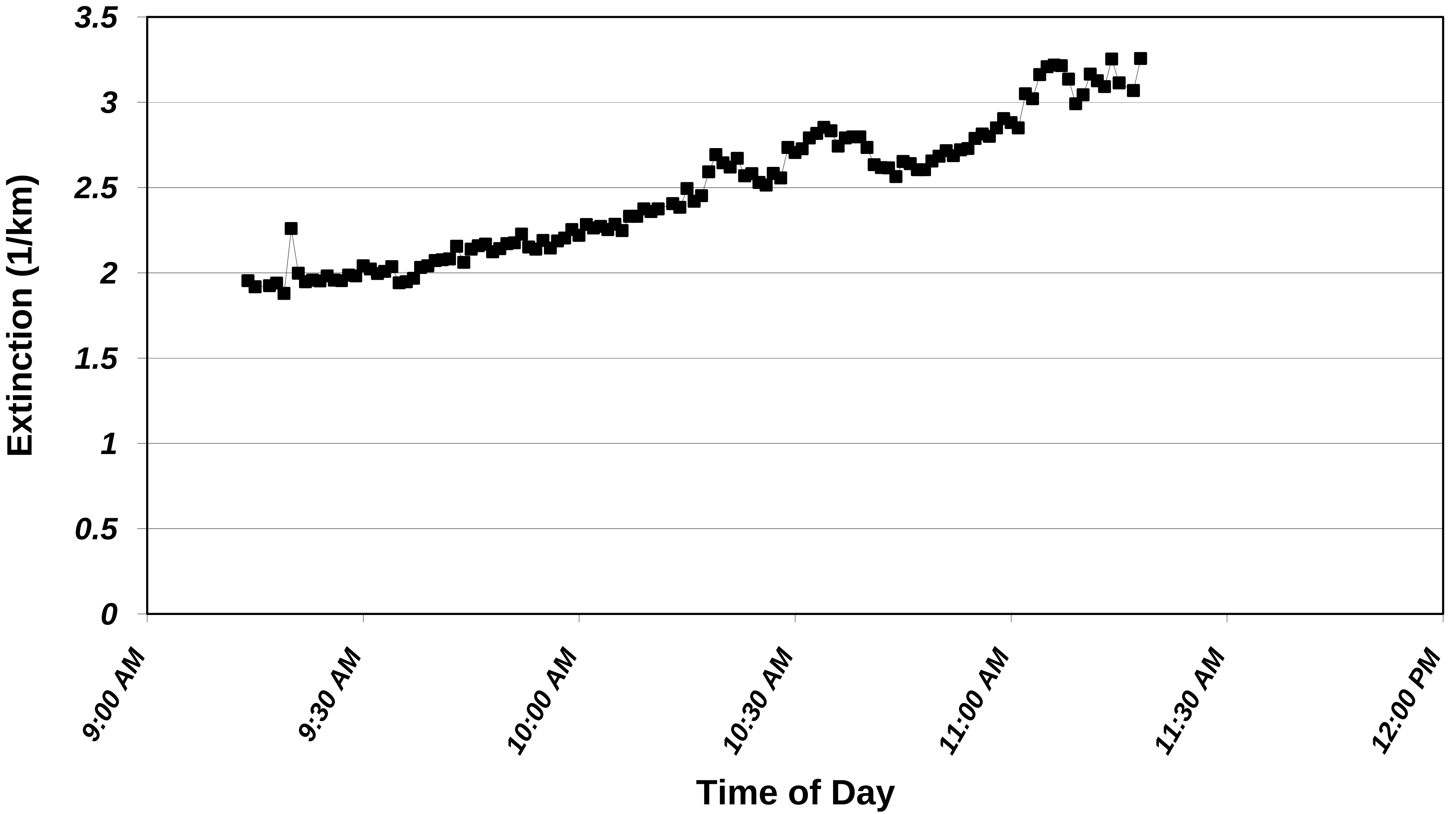
Particle Type	*Dry Extinction Efficiency (m^2/g)*
Sulfates	3.0
Organics	3.0
Elemental Carbon	10.0
Nitrates	3.0
Soil Dust	1.25
Coarse Particles	0.6
Feedyard Dust	***????***


downwind
N
Feedyard or Dairy Corrals
upwind
Legend
Transmissometer receiver
Transmissometer transmitter
TEOM
FRM PM_{10}
TSP monitor

Two-Transmissometer Concept



Downwind Extinction Coefficient, Feedyard C
April 23, 2004

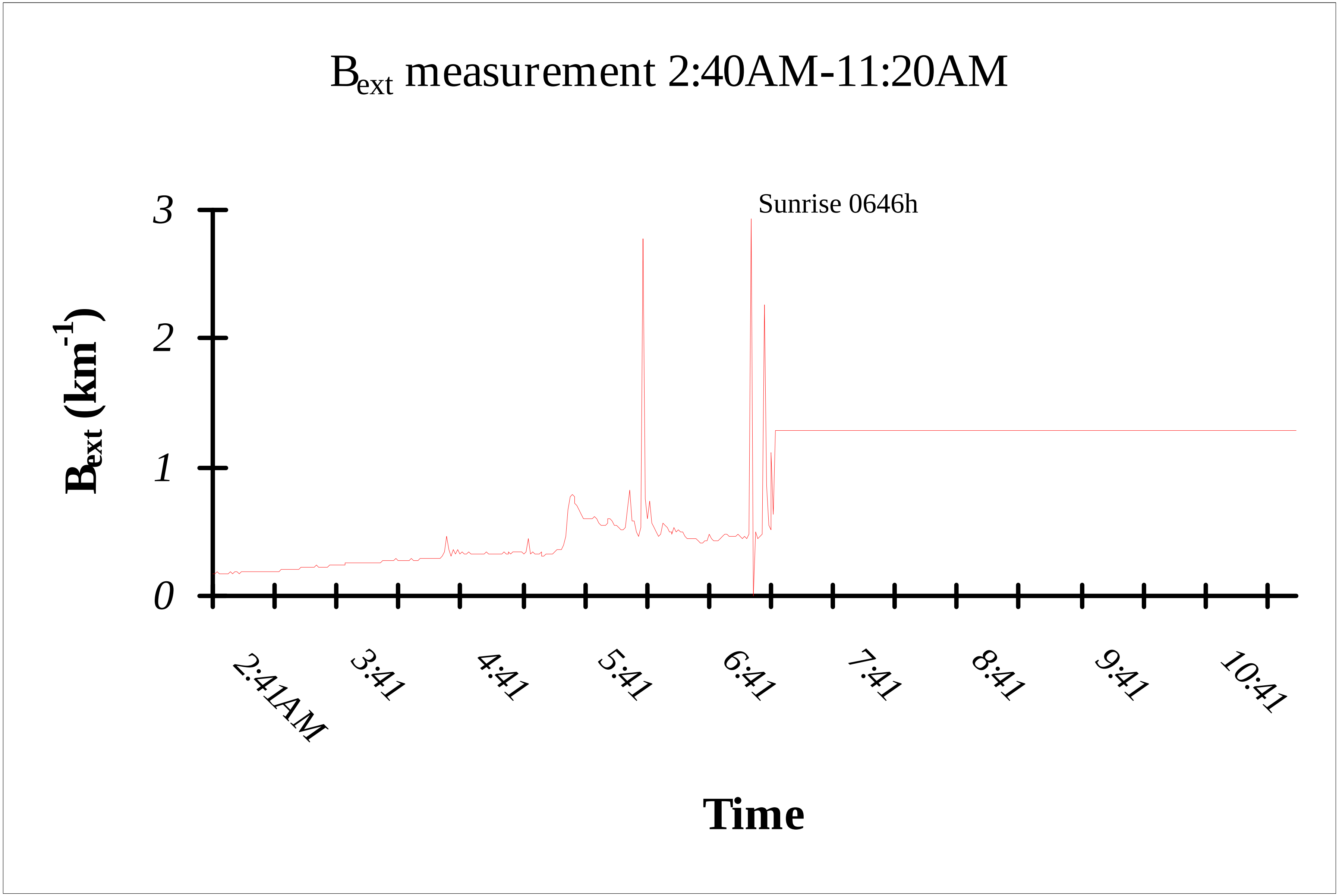


Elevations of transmitter and receiver must sum to 30’ per km of path length

Depth of dust plume (50’) limits us to about 3.0-3.6 km path length

Physical dimensions of feedyards limit us to 1.5-2.0 km path length

Legend
Transmissometer receiver
Transmissometer transmitter
TEOM
120VAC electrical drop



B_ext measurement 2:40AM-11:20AM
Sunrise 0646h
3
2
1
0
B_ext (km^-1)
2:41AM
3:41
4:41
5:41
6:41
7:41
8:41
9:41
10:41
Time