Realtime Dust Measurement

UNDERSTANDING, ACCELERATED

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MEASURING METHODOLOGY + INSTRUMENTS

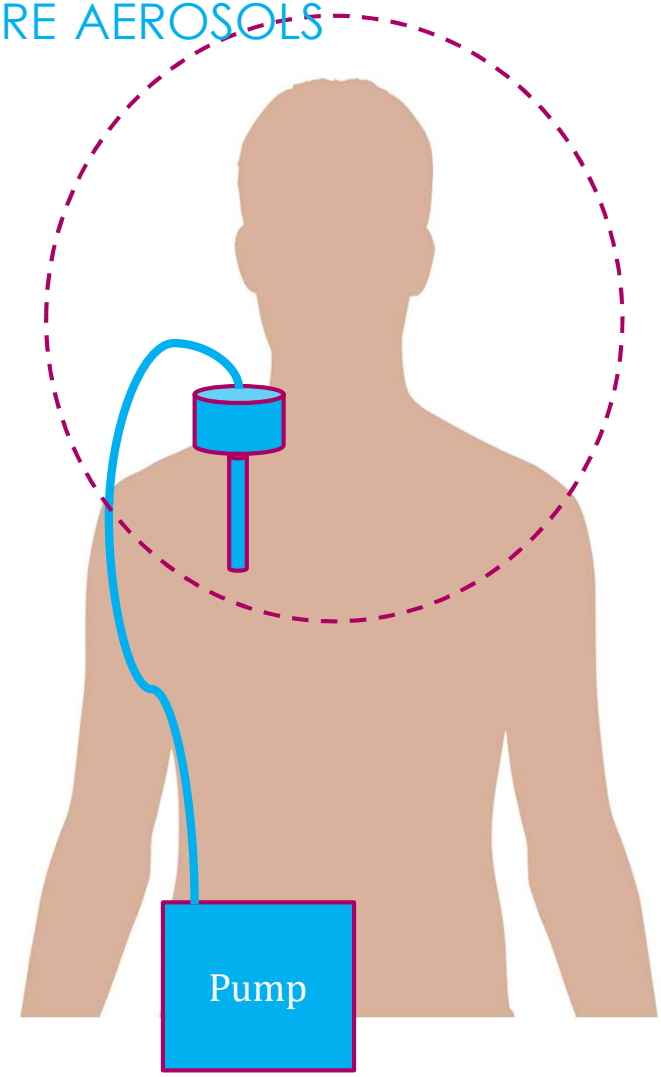
- Gravimetric sampling
- Real-time monitoring / Direct Reading Instruments
- Optical Methods / Photometer
  - Theory of operation
  - Strenghts and values

GRAVIMETRIC SAMPLING

TAKING A GRAVIMETRIC SAMPLE TO MEASURE AEROSOLS

Traditional IH Air Sampling Equipment

- Pump
- Tubing
- Sampling Cassette
- Filter Media
- Cyclone or other sampling heads



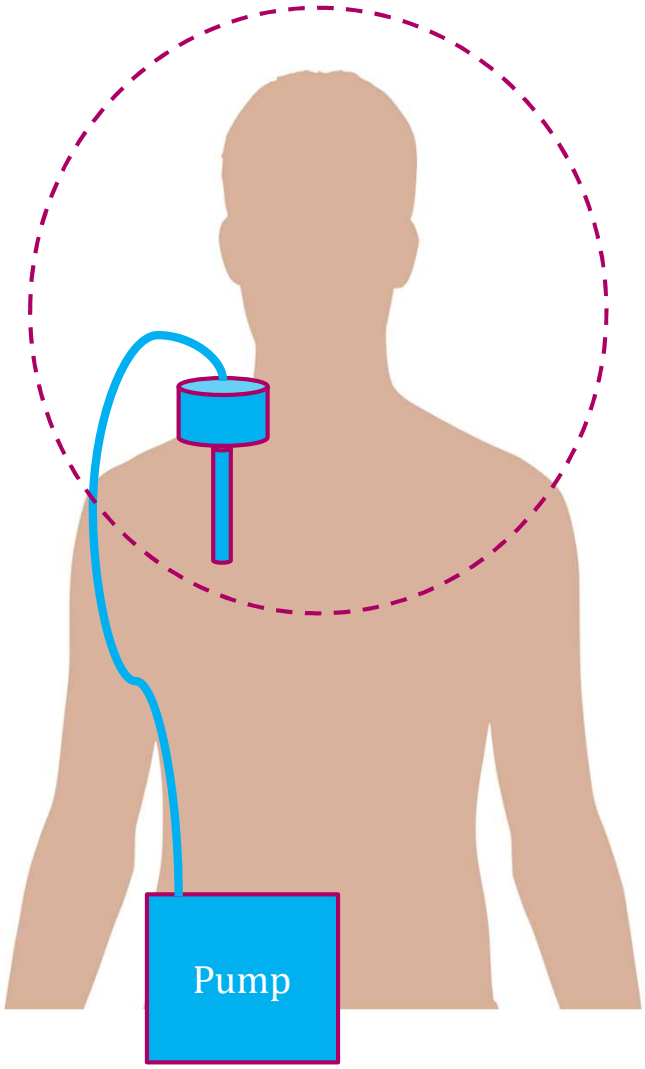
GRAVIMETRIC SAMPLING

PROCESS

Traditional IH Air Sampling Process

- Calibrate pump
- Place on worker, turn on pump
- Record start time

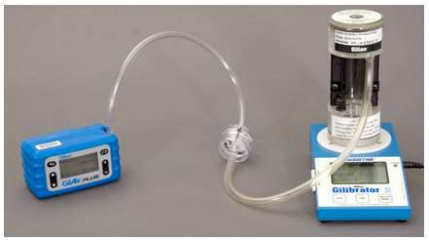
- Turn off pump, cap cassette, document time
- Post-calibrate pump
- Calculate run time
- Document run times, calibrations, sample ID
- Prepare chain of custody form
- Package for shipping
- Complete shipping paper work



GRAVIMETRIC SAMPLING

REFERENCE METHOD: GRAVIMETRIC SAMPLING

- Direct mass measurement
- Laborious and time intensive
- Humidity & dust loading effect measurement
- Potential chemical reactions on filter
- **Poor temporal resolution**
- Costly consumables
- No size information



DIRECT READING/REALTIME METHODS

VARIOUS MEASUREMENT METHODOLOGIES

+ Mass concentration (mg/m^3)
+ Mass concentration with size segregated fractions (mg/m^3)
+ Number concentration (pt/cm^3)
+ Size distributions (pt/m^3 or pt/cm^3)
+ Surface area concentration ($\mu m^2/cm^3$)

Optical Methods

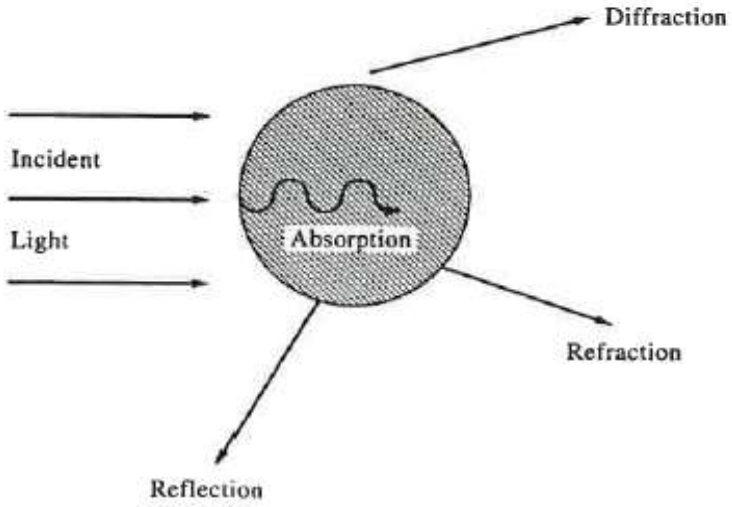
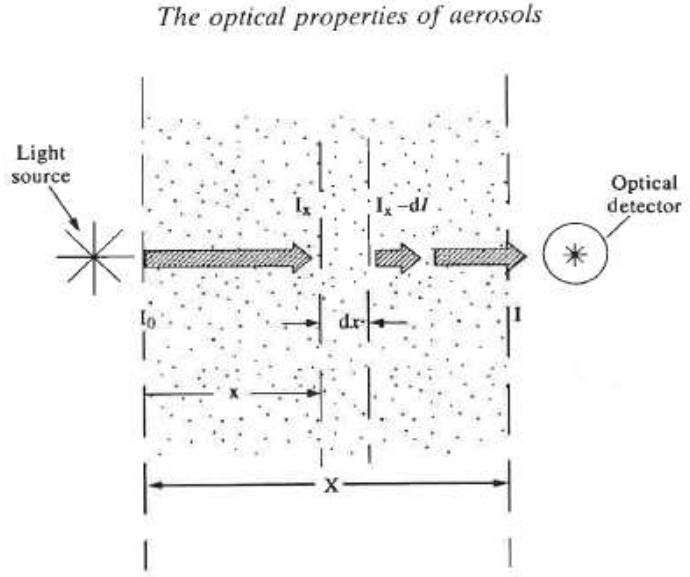


Figure 5.1. Summary of outcomes of the mathematical solution for light interacting with a particle.

Vincent, 1995



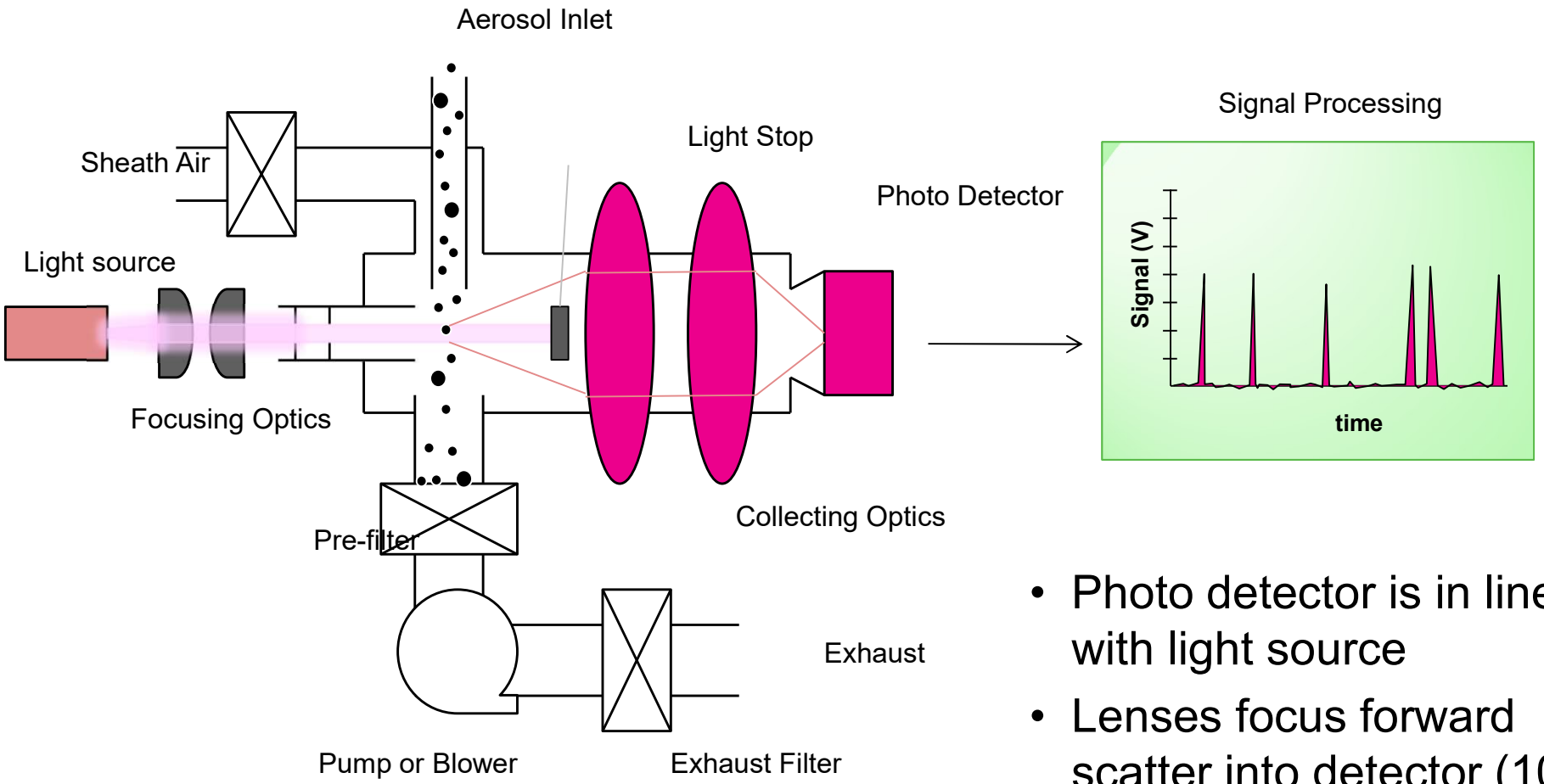
re 5.2. Schematic to describe the phenomenon of light extinction by an ensemble of particles in an aerosol.

Vincent, 1995

- Particle absorb, reflect, refract and diffract light (light scattering)
- Light passing through an aerosol concentration is affected by the properties of the aerosol (ie particle)

Theory of Operation

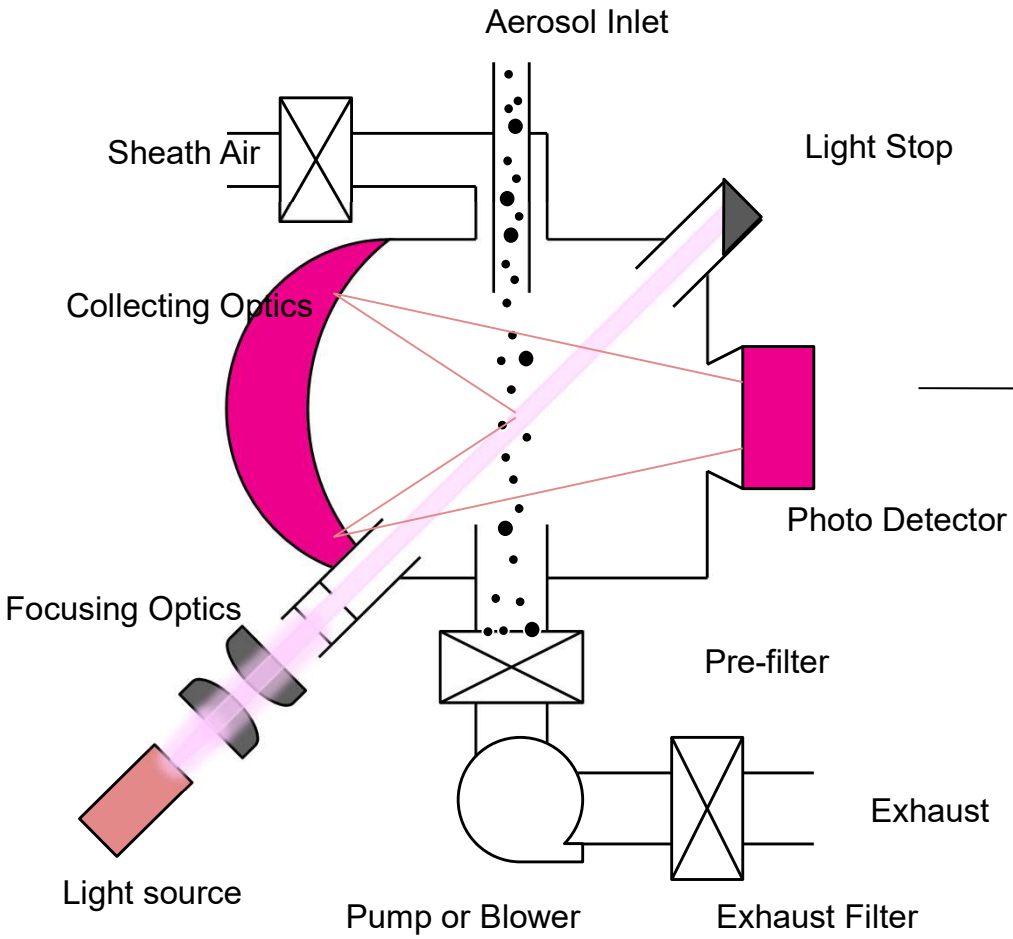
Forward Scatter OPC

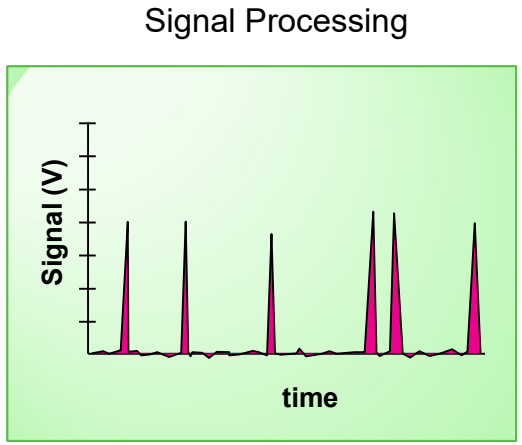


- Photo detector is in line with light source
- Lenses focus forward scatter into detector (10-80 degrees typical)

Theory of Operation

Side Scatter OPC

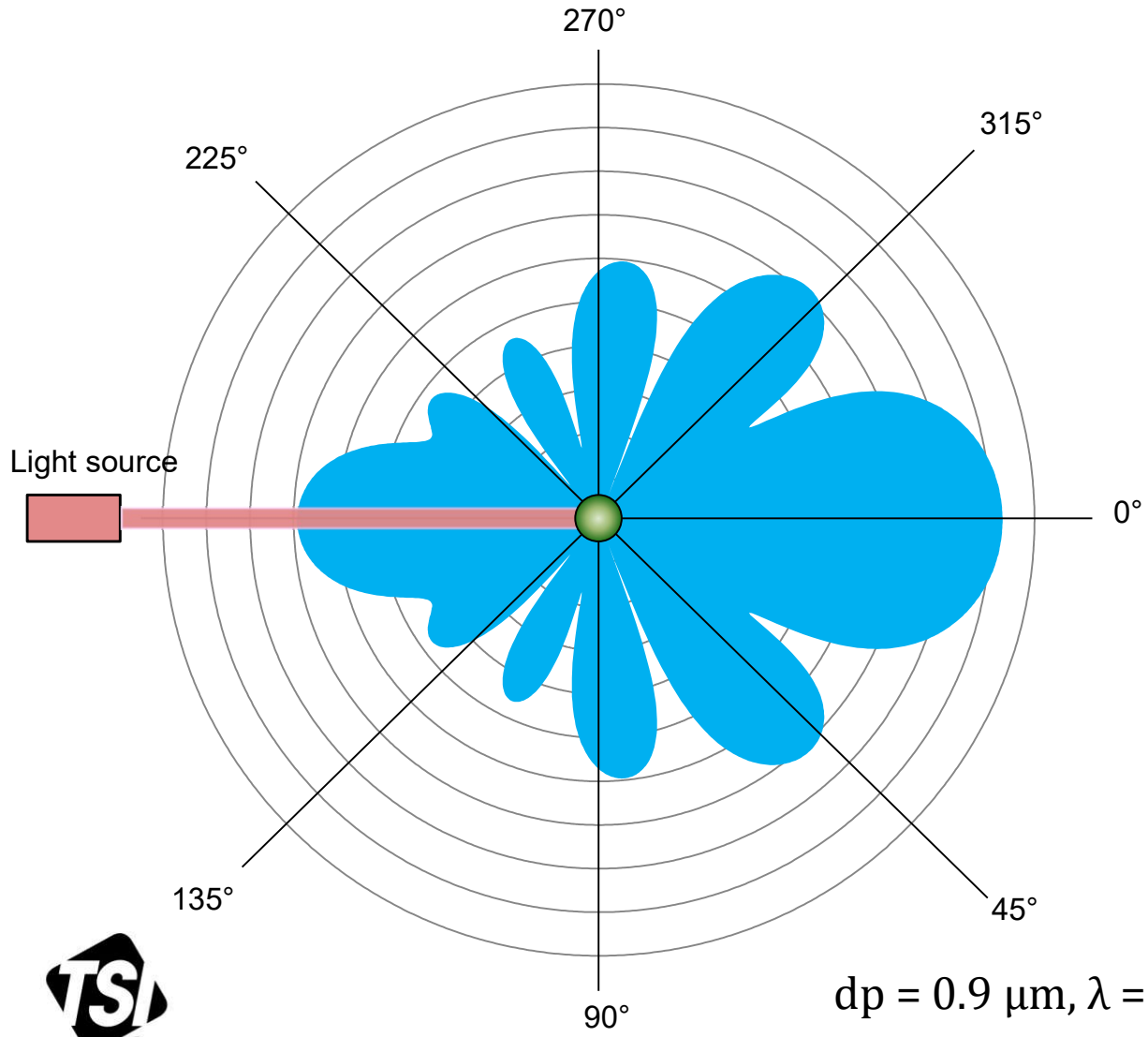




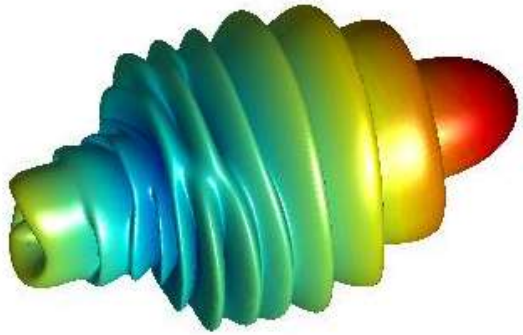
- Photo detector is set at an angle to light source (typically 90 degrees)
- Mirror focuses side scatter into detector (30-120 degrees typical)

Theory of Operation

Mie Scattering



- Intensity depends on scattering angle
- Shape of intensity plot depends on particle size and light wavelength



dp = 0.9 µm, λ = 560 nm

Theory of Operation

Signal vs. particle size d_p

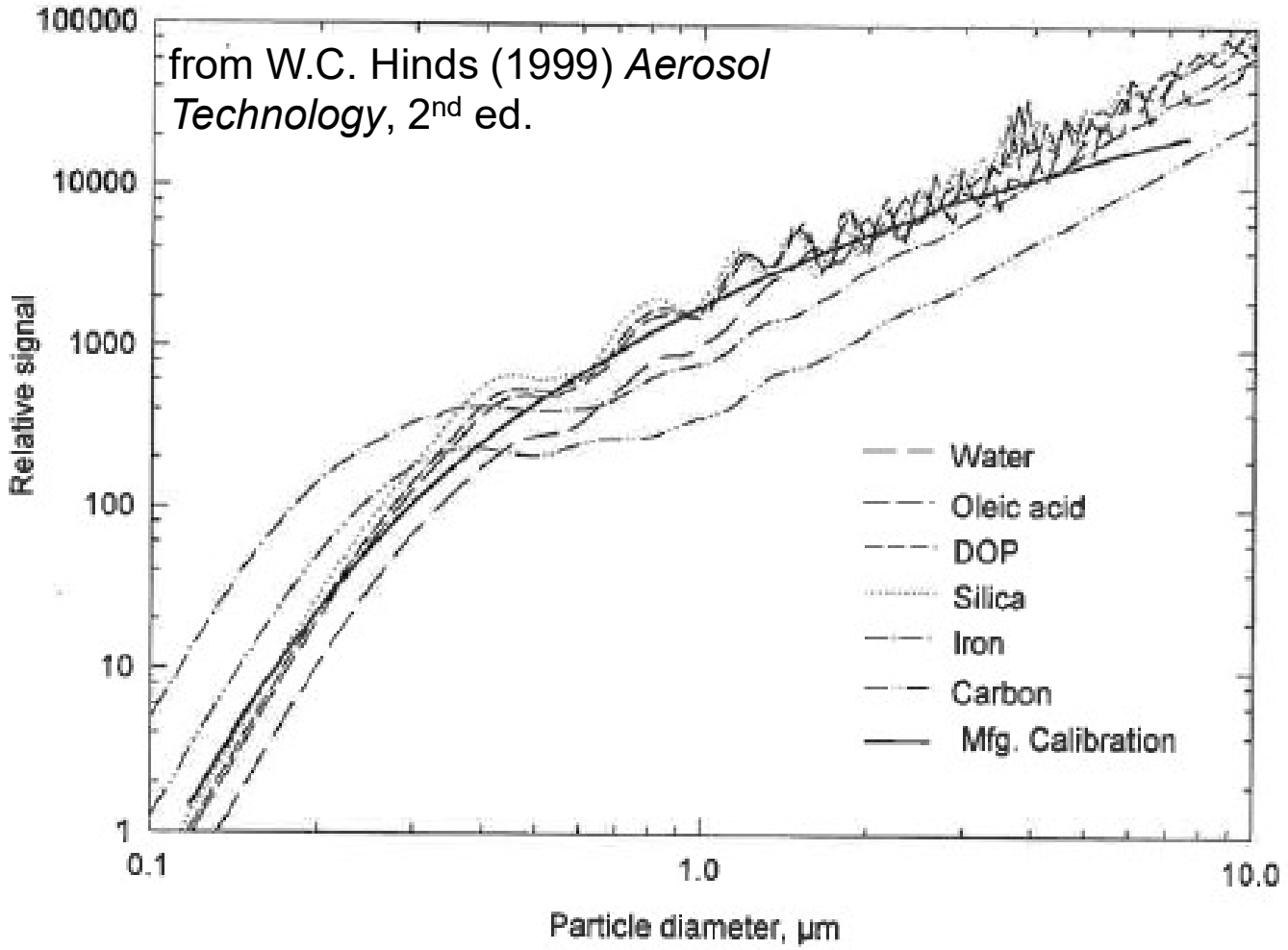
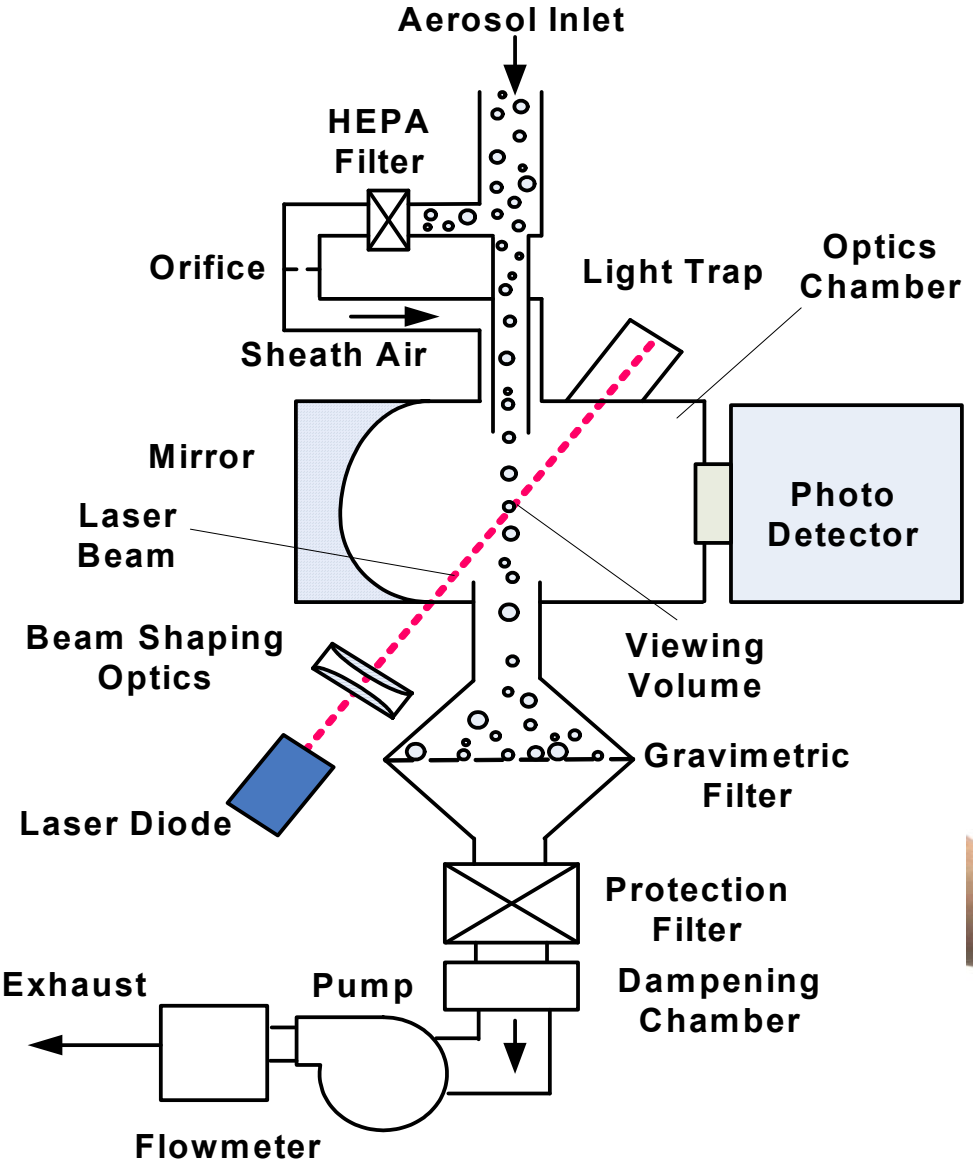


FIGURE 16.16 Calculated response curves for six materials and manufacturer's calibration curve for model LAS-X® (PMS, Inc., Boulder, CO) optical particle counter.

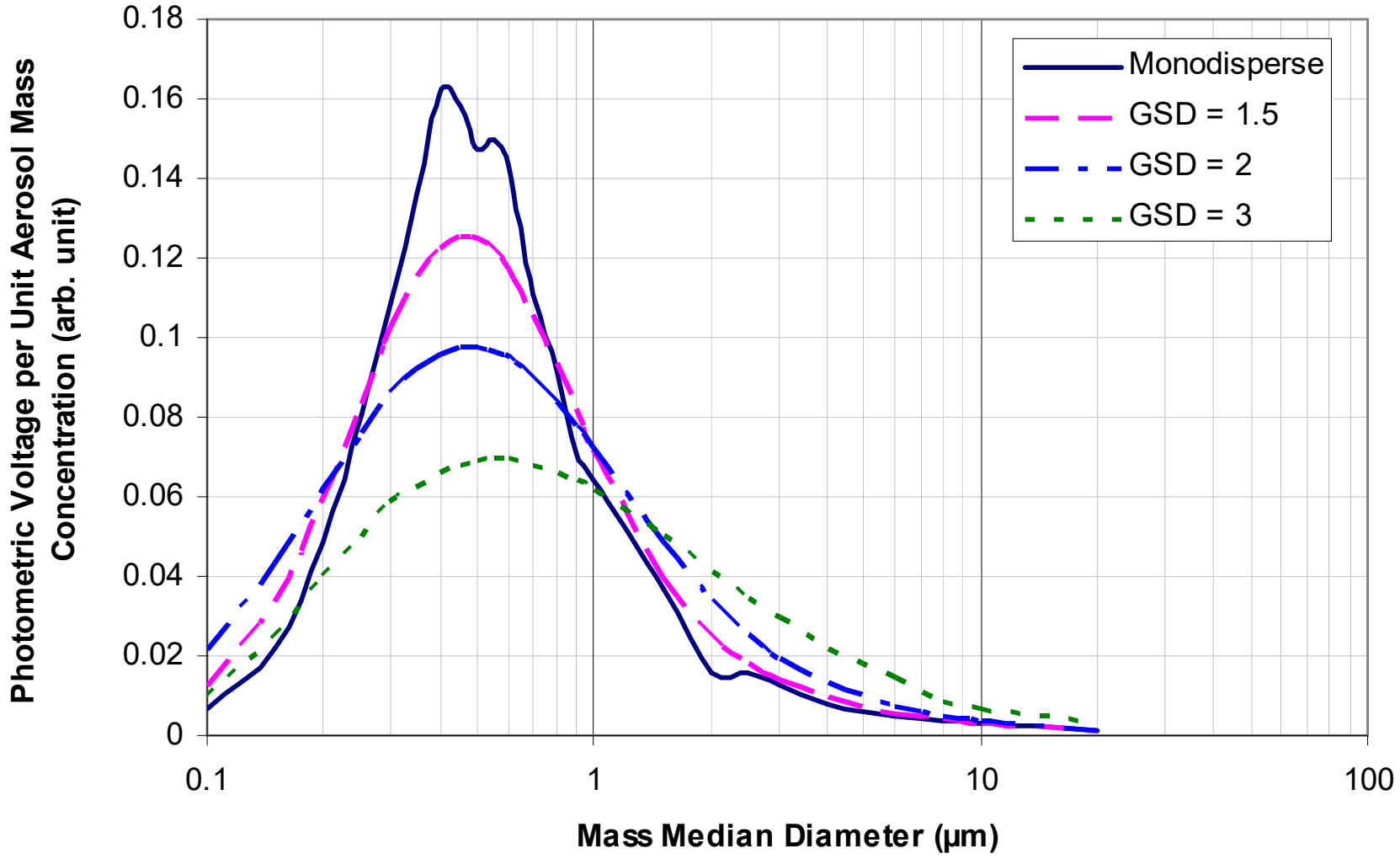
Theory of Operation

DustTrak II (SidePak AM520)



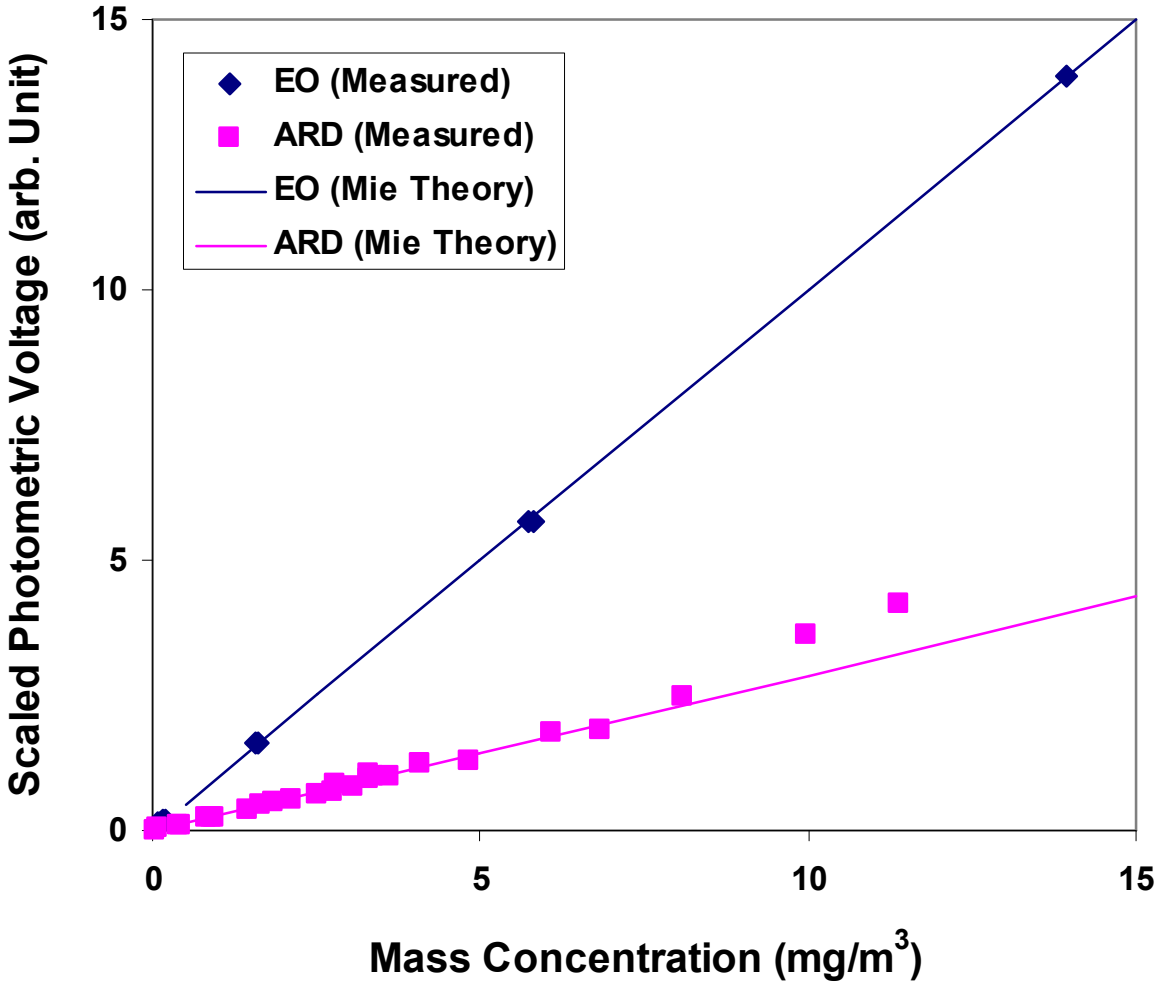
Theory of Operation

Photometer Signal

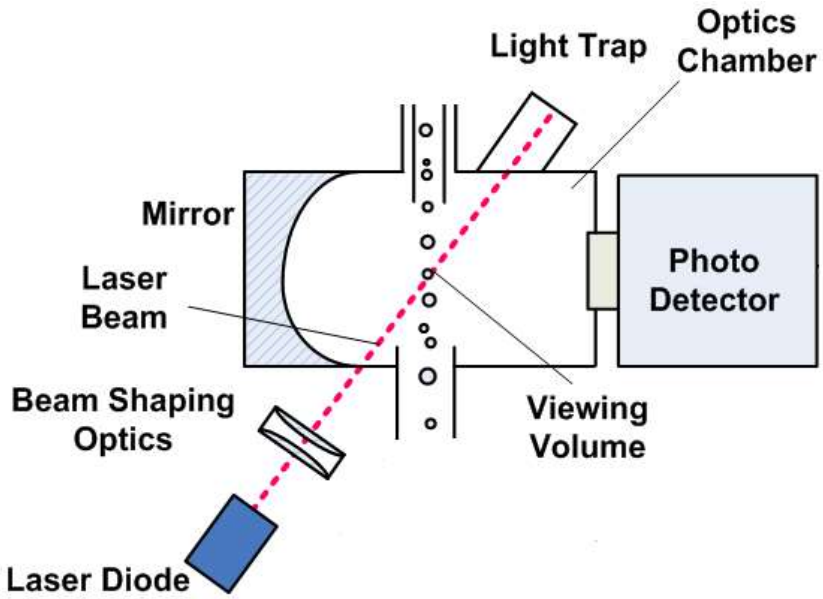


Theory of Operation

Photometer Theory



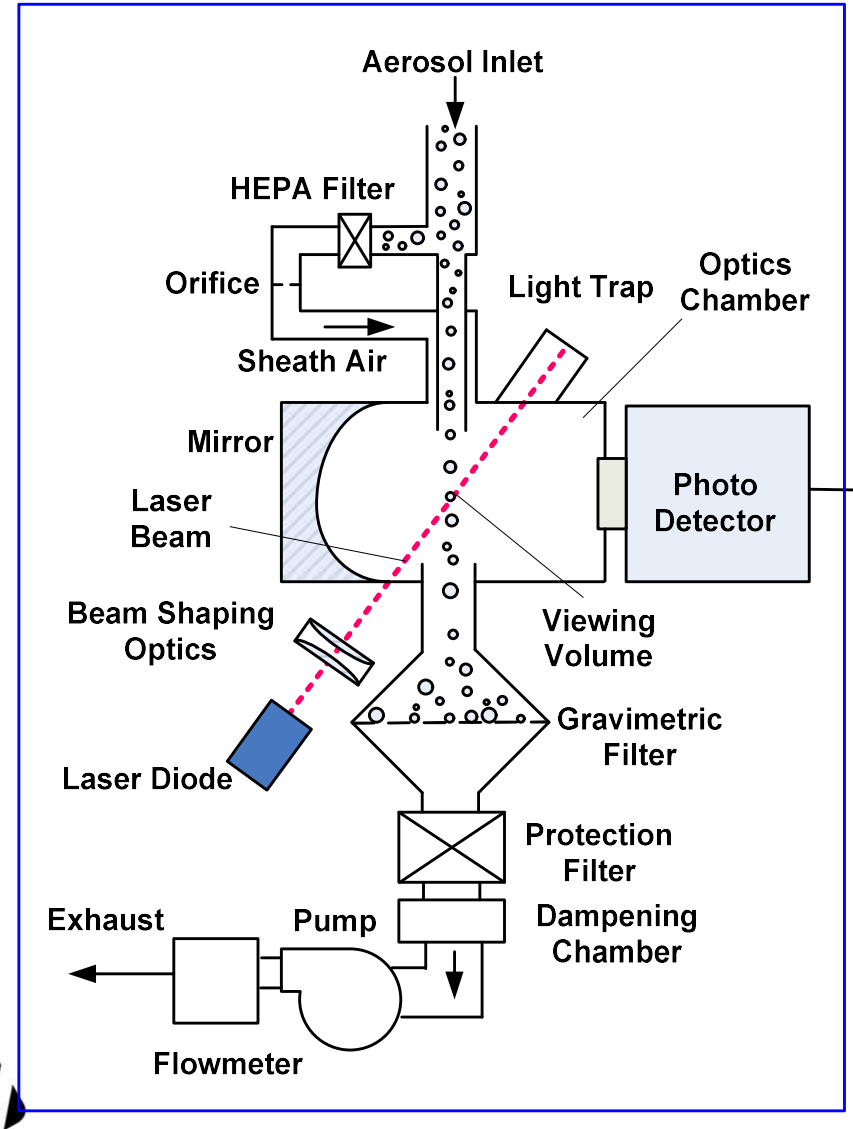
Photometer signal linear with mass concentration



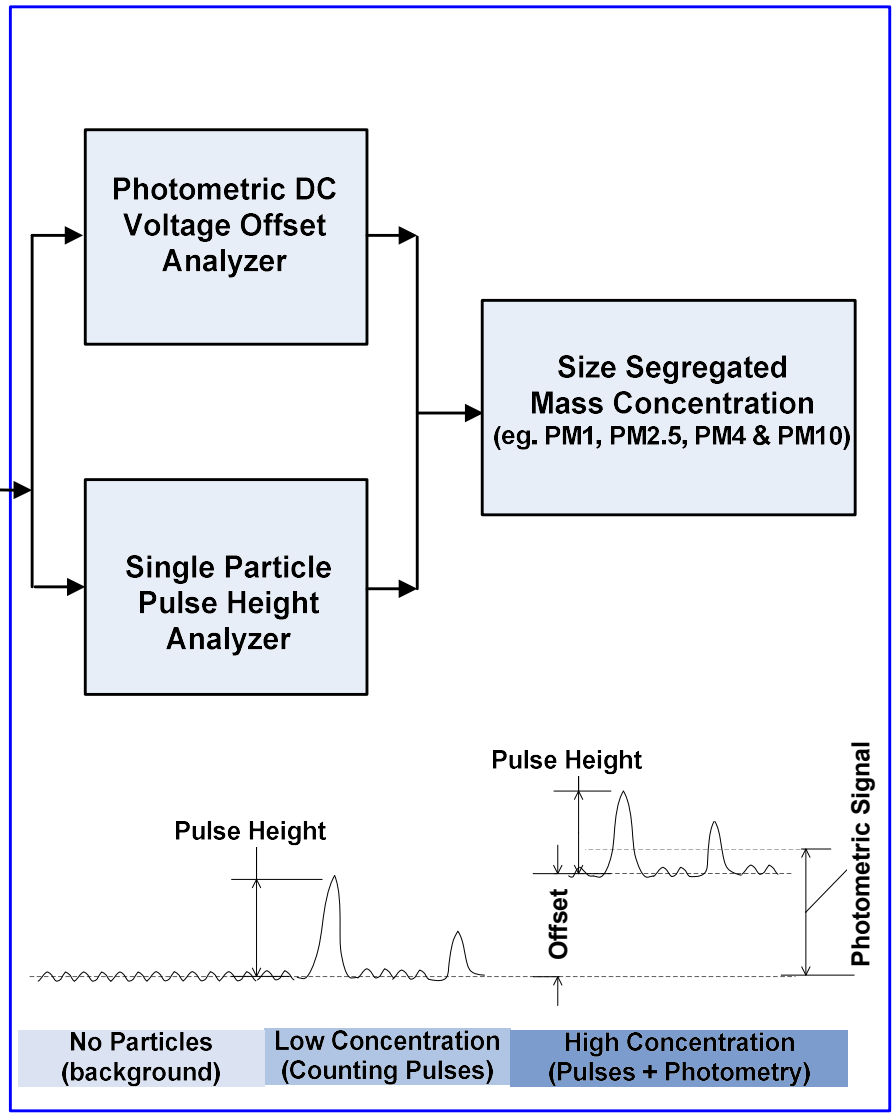
Theory of Operation

DustTrak DRX

Aerosol Measurement



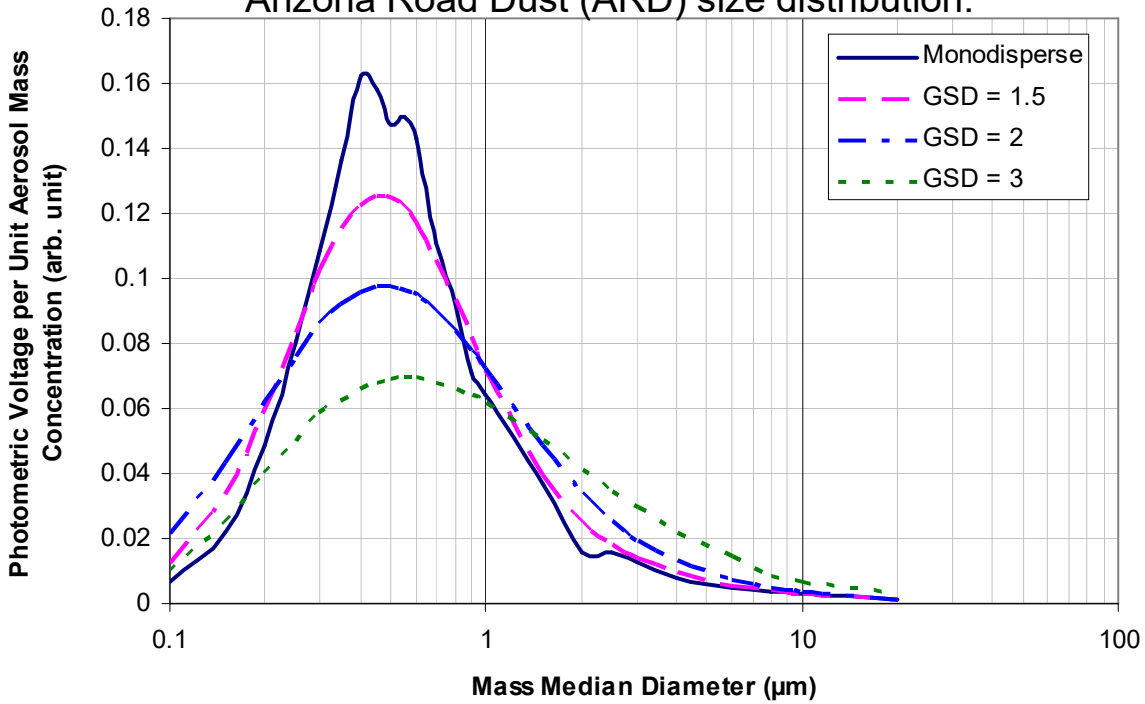
Signal Acquisition and Processing

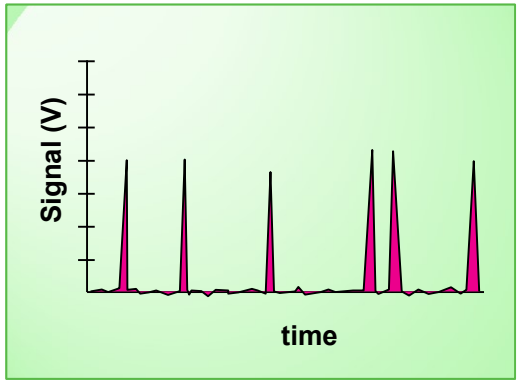


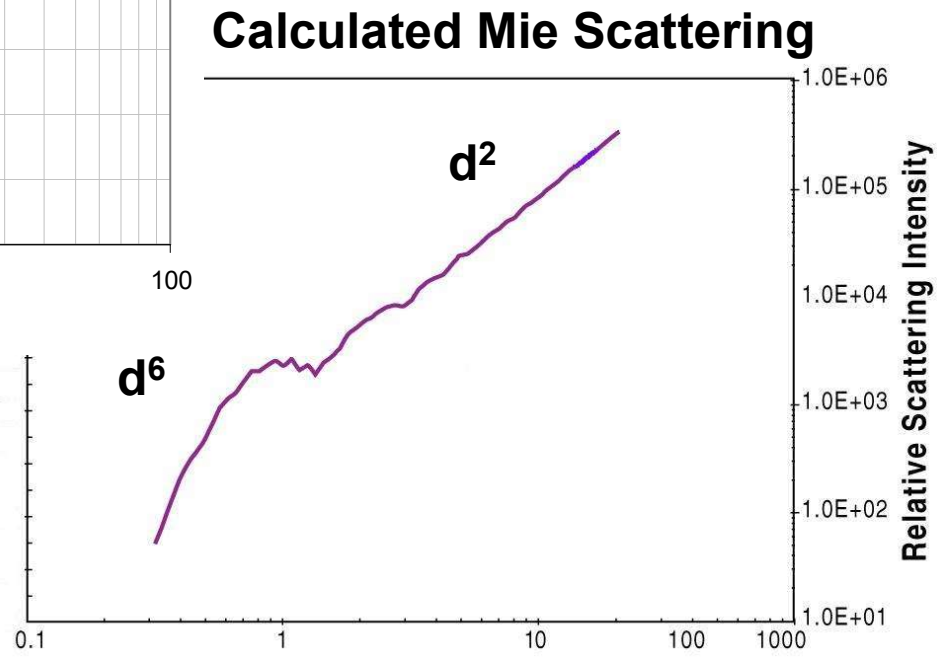
Theory of Operation

DRX Design Considerations

Theoretical photometric response as a function of Arizona Road Dust (ARD) size distribution.







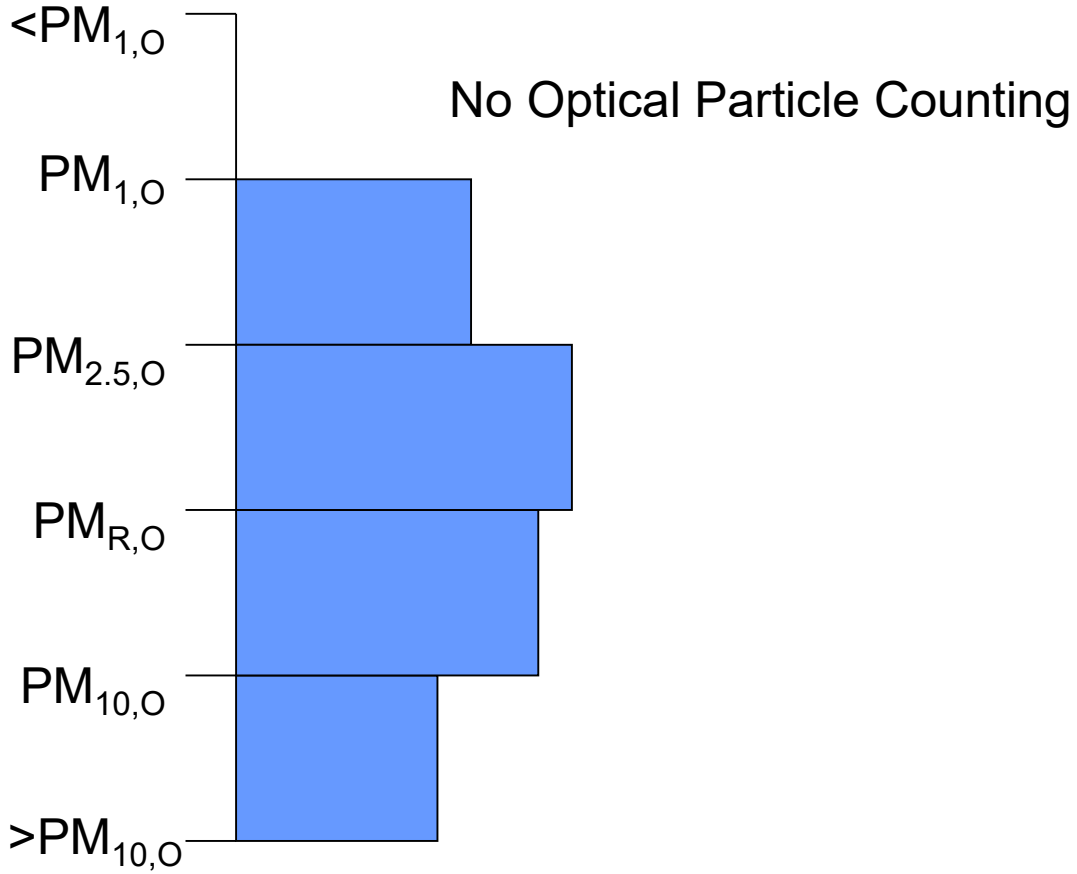
1) Photometric signal *per unit mass* drops sharply for particles larger than PM2.5

2) DRX uses photometric signal to correlate to PM2.5 mass

Theory of Operation

DRX Optical Single Particle Sizing

Only optical sizing larger than 1 μm

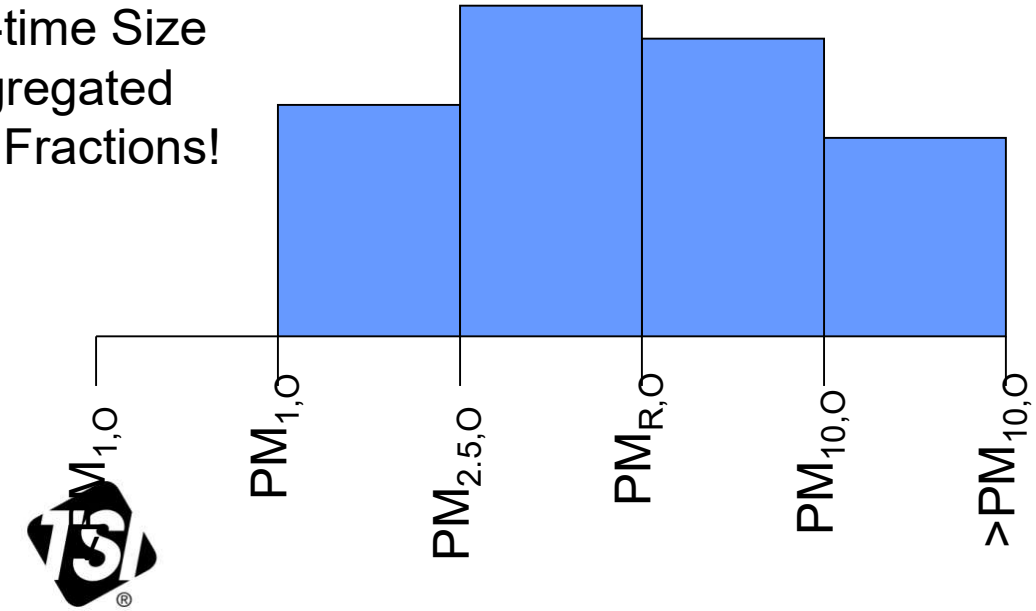


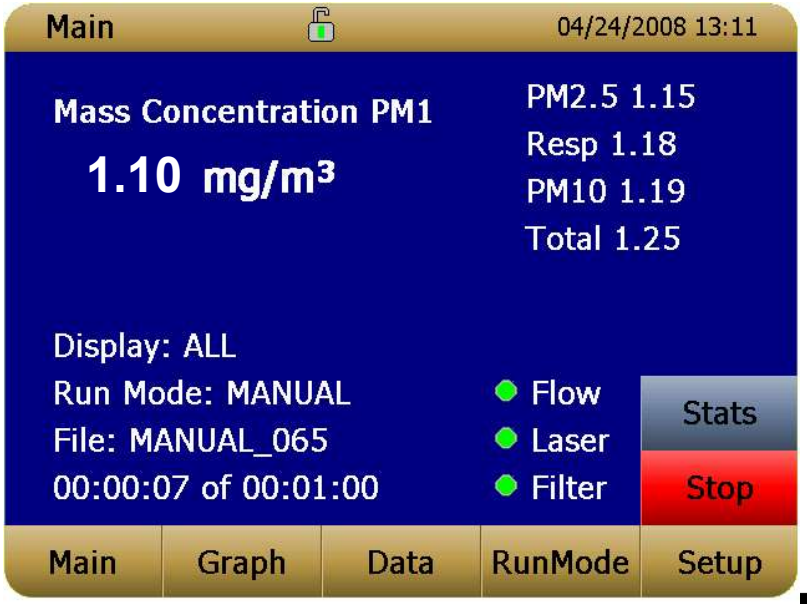
Theory of Operation

Combining Photometry with Single Particle Counting

	$PM_{2.5}$	$PM_{2.5(P)}$
	PM_{1}	$PM_{2.5(P)} - (PM_{2.5,O} - PM_{1,O})$
Respirable	PM_{R}	$PM_{2.5(P)} + (PM_{R,O} - PM_{2.5,O})$
Thoracic	PM_{10}	$PM_{2.5(P)} + (PM_{10,O} - PM_{R,O})$
	TPM	$PM_{10} + >PM_{10,O}$

Real-time Size Segregated Mass Fractions!





Value of Real-Time Monitoring

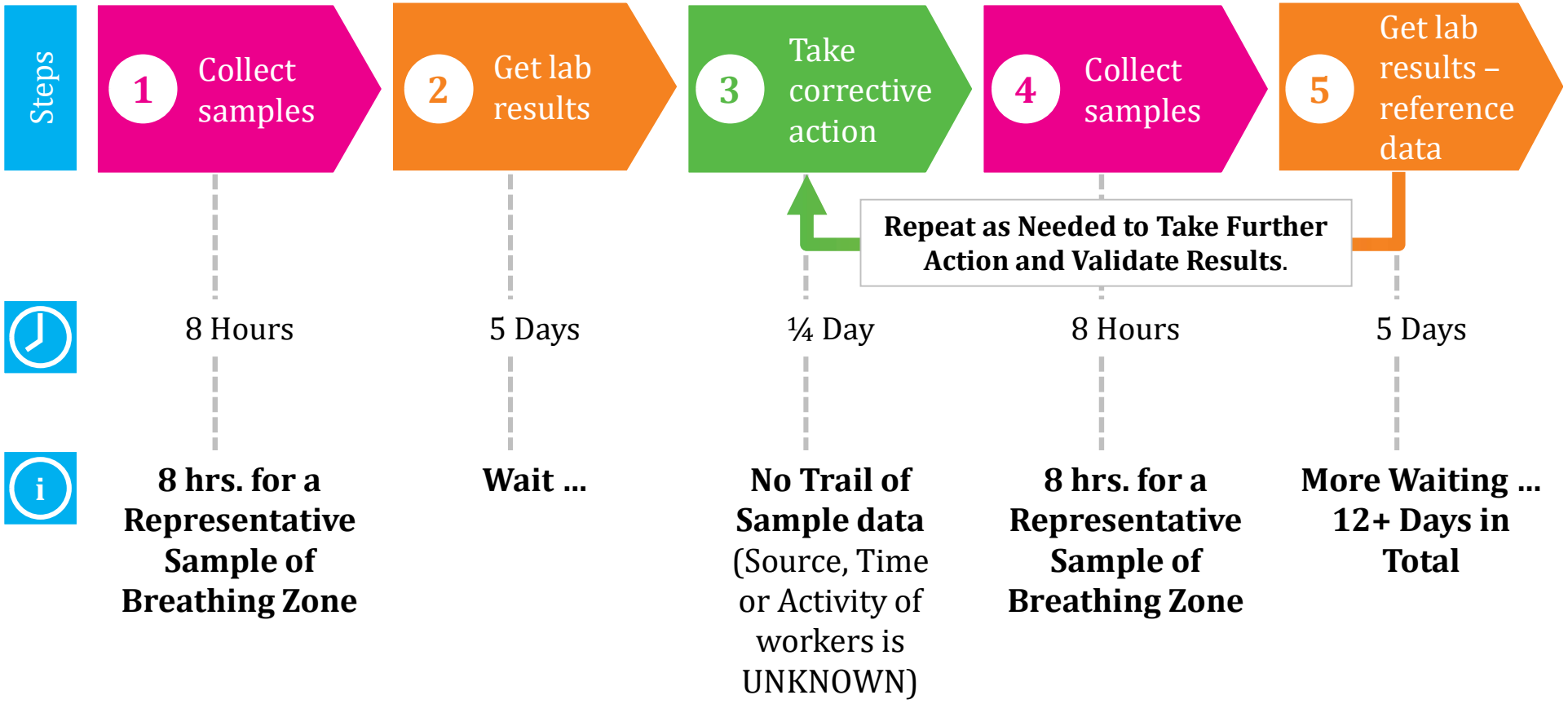
- Gravimetric Samples over 5hrs 27 Min. of work

Sample #	Air Volume L	Respirable Particulates mg/m³	α-Quartz mg/m³
VC 18/17-05	906.44	<0.08	<0.006

Like taking a photo of the daily average of data. Getting the data back in 1-2 weeks

Value of Real-Time Monitoring

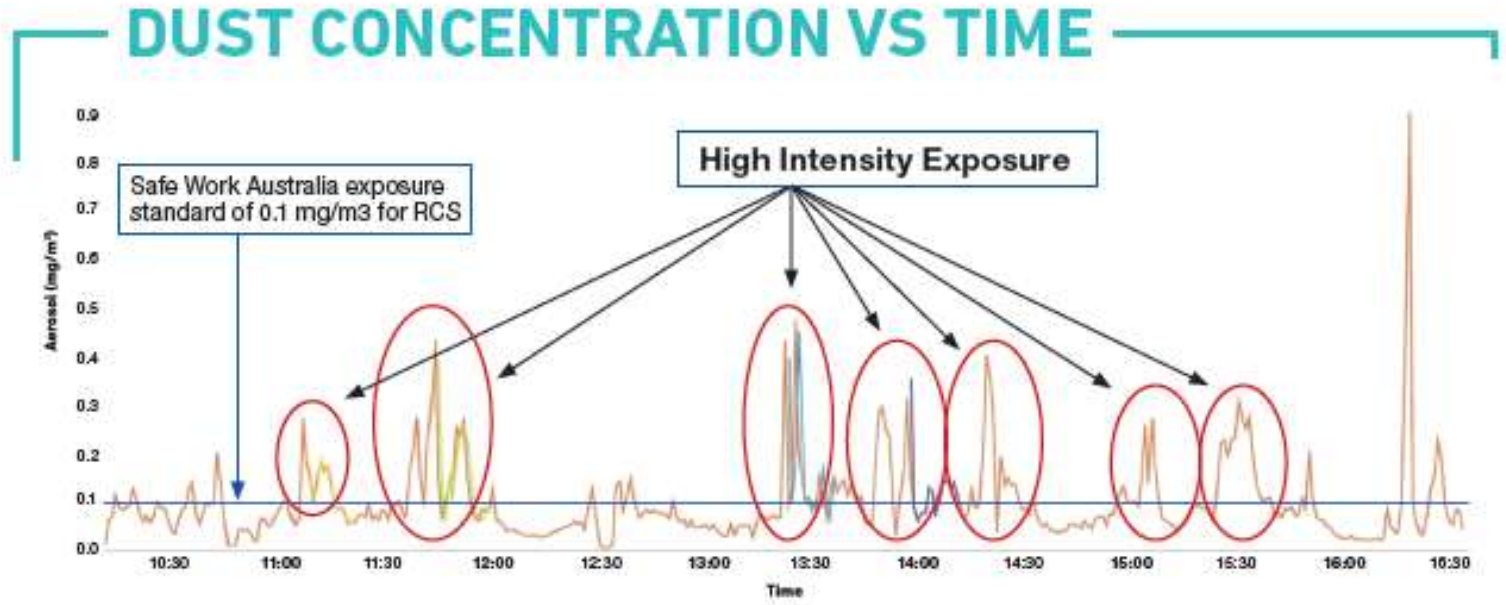
Example: Dust Monitoring Process with Gravimetric Sample Pumps



Do in hours or days what traditionally takes weeks!

Value of Real-Time Monitoring

- Exposure Data over 7 hr. Period



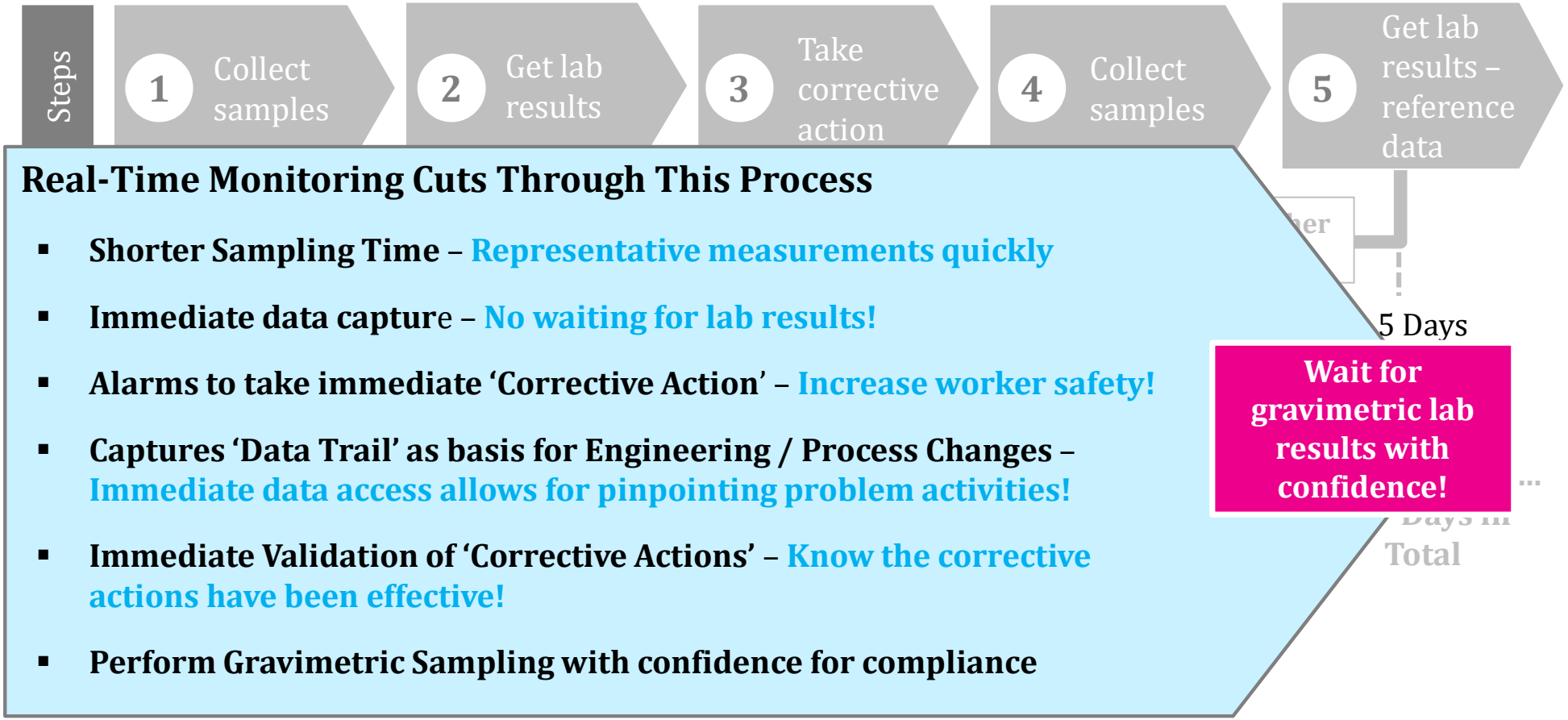
TEST STATISTICS

Channel	Average	Minimum	Maximum	Cal Factor	TWA
Aerosol (mg/m³)	0.101	0 10/08/2018 02:28:05	24.1 10/08/2018 04:23:03	1 factory 06/01/2018	0.08

Similar to taking a Movie of Daily Exposure Data.

Value of Real-Time Monitoring

Example: Dust Monitoring Process with Gravimetric Sample Pumps



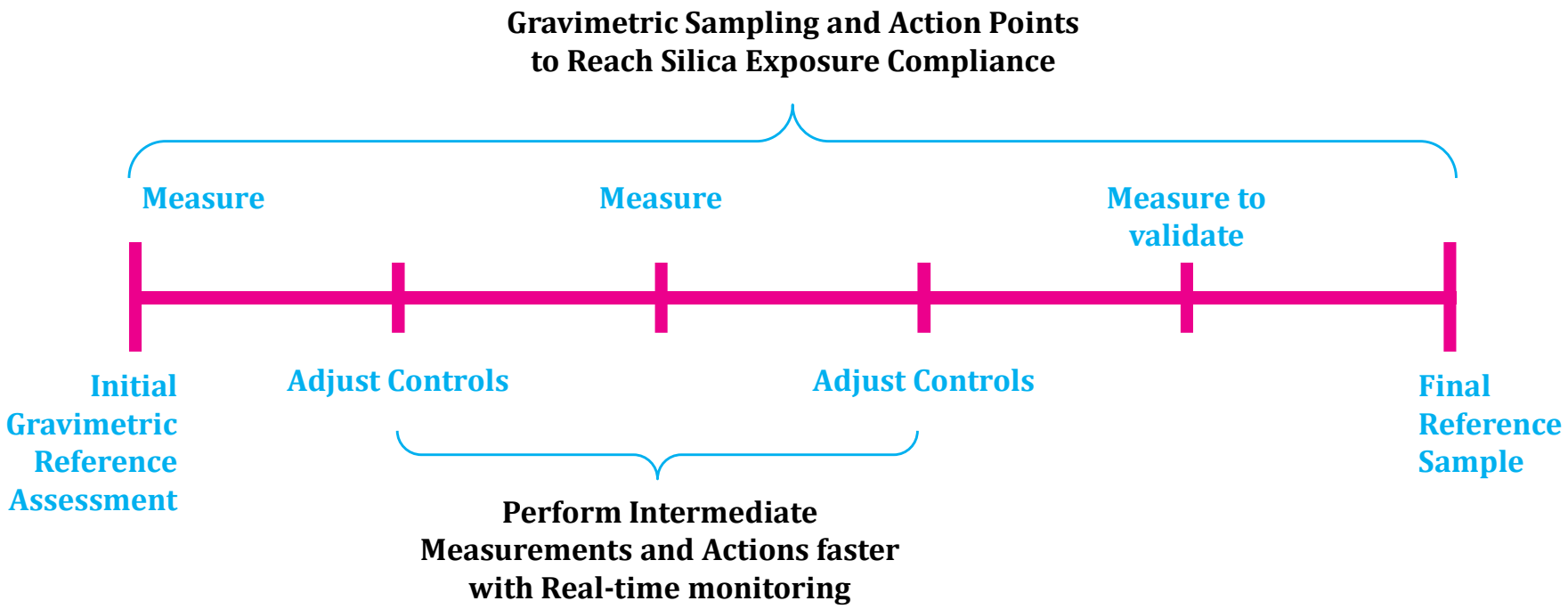
Real-Time Monitoring Cuts Through This Process

- **Shorter Sampling Time** – **Representative measurements quickly**
- **Immediate data capture** – **No waiting for lab results!**
- **Alarms to take immediate 'Corrective Action'** – **Increase worker safety!**
- **Captures 'Data Trail' as basis for Engineering / Process Changes** – **Immediate data access allows for pinpointing problem activities!**
- **Immediate Validation of 'Corrective Actions'** – **Know the corrective actions have been effective!**
- **Perform Gravimetric Sampling with confidence for compliance**

Do in hours or days what traditionally takes weeks!

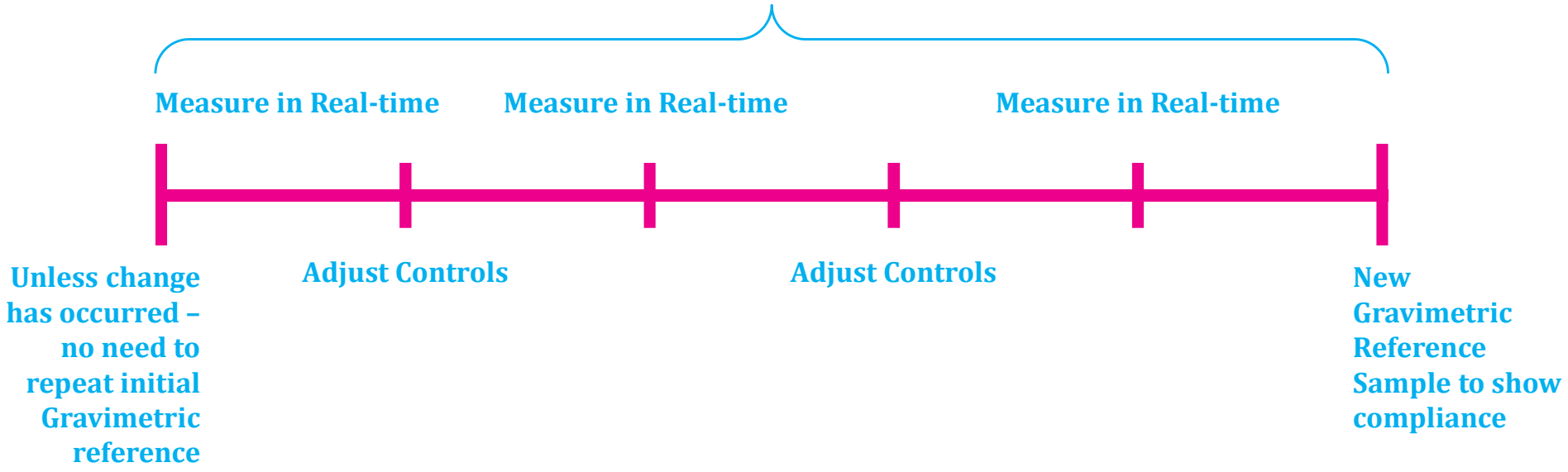
Value of Real-Time Monitoring

Initial Assessment Using Gravimetric Sampling: Significant Time and Money to Capture and Process Lab Samples.



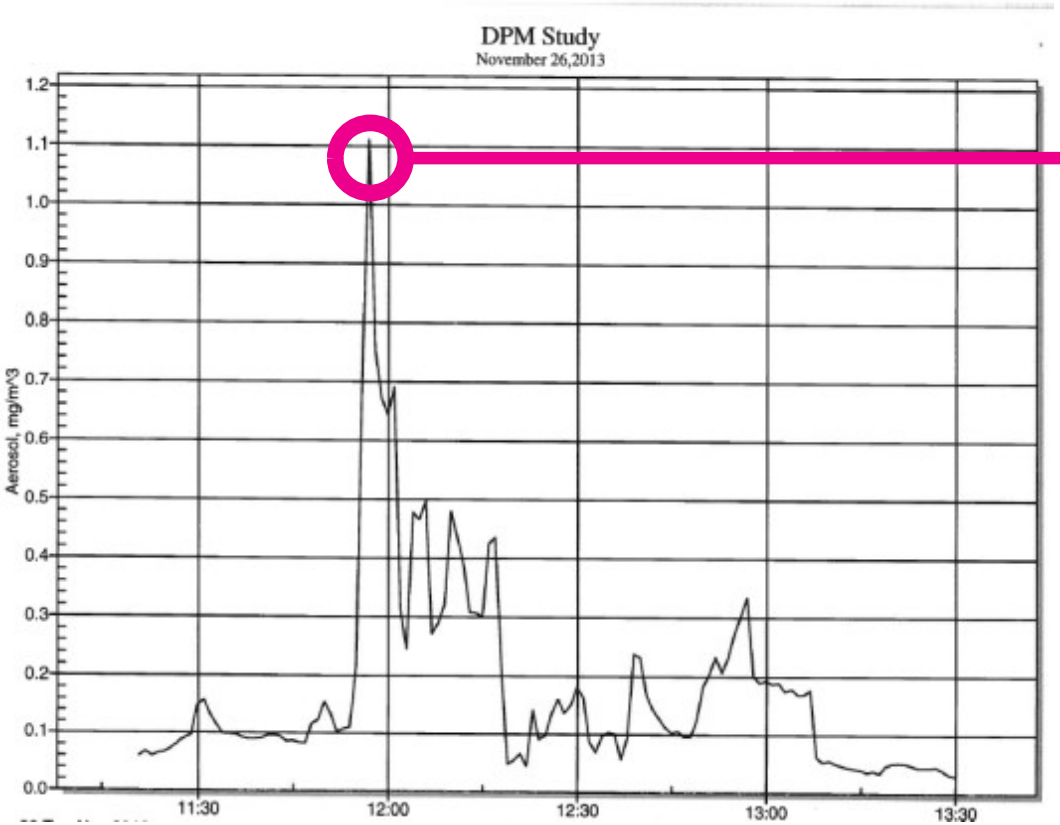
Value of Real-Time Monitoring

+ Re-Assessment of a Task Using Real-Time Monitoring: Significantly compresses the time and costs needed to maintain compliance



Value of Real-Time Monitoring

Peaks



What caused this spike?

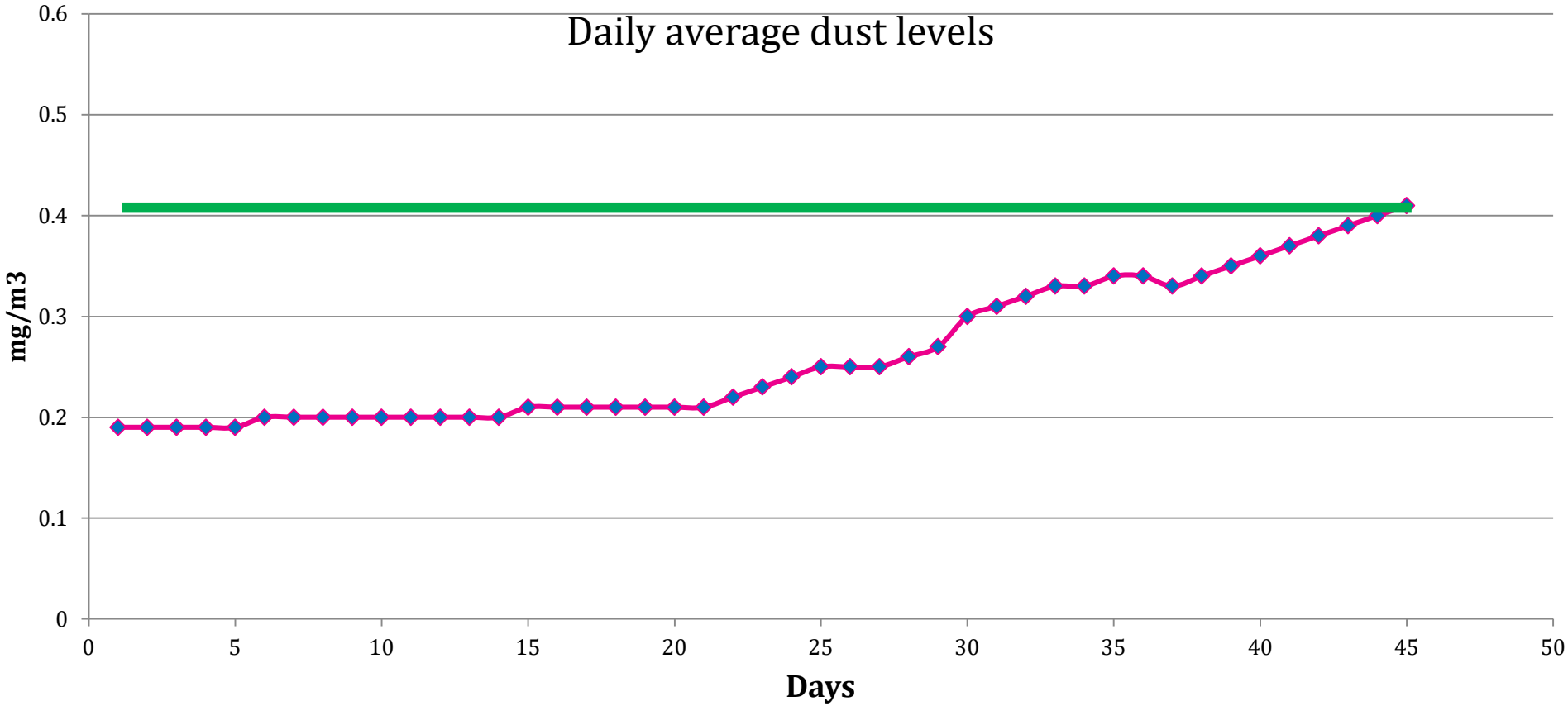
Avg = 0.176 mg/m^3

Max = 1.11 mg/m^3

Customer data

Value of Real-Time Monitoring

HISTORICAL TRENDS



Value of Real-Time Monitoring

Traditional Gravimetric Sampling enables compliance testing, but does not easily support to find the root cause of increased exposure levels > source finding

Real-Time Monitoring

- is quick and easy to setup and deploy
- high time resolution
- visualizes spikes and trends
- is optimal to find sources of pollution
- verifies quickly safe conditions
- Adds an additional sense for the behavier of your process

Real-Time Monitoring enables you to minimize or get rid of the exposure instead of just manage the status quo