Wearable Real-Time Direct-Reading Naphthalene and VOC Personal Exposure Monitor

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The contributions of Drs. Hulla, Snawder, and Proctor herein do not reflect the policy of the USACE, NIOSH, USARIEM, or the Department of Defense.

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The VOCDos Sensor

- We are developing a miniature, inherently safe, wearable direct reading personal exposure monitor (PEM) to detect, differentiate, quantify, and log naphthalene and other volatile organic compounds (VOCs) in the breathing zone of the wearer with limits of detection in the low ppb ($\mu g/m^3$) range.

- The VOCDos PEM provides real-time detection and data logging of exposure

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Agenda

- ❑ Overview of the Need & Regulations
- ❑ Overview of Method
- ❑ Sensor Design & Operation
- ❑ Calibration & Linearity
- ❑ Field Trials

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Overview of the Need

In 2003 the National Research Council found that:

- Jet Propellant Type 8 (JP8) jet fuel represents the single largest source of chemical exposure to Department of Defense (DOD) personnel.
- Currently, DOD and its NATO partners use approximately 5 billion gallons of JP8 annually. The commercial equivalent, Jet-A, is the primary jet fuel used by aircraft in the U.S. Worldwide use of kerosene-based jet fuel is over 58 billion gallons per year.
- Other exposure hazards also occur in asphalt paving, sealing, and similar operations

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Overview of the Need

- Naphthalene has been identified as the most hazardous component of JP8 based on Unit Risk compared to other jet fuel components such as BTEX & other components.
- Nevertheless, other VOC components including BTEX and larger ring structure VOCs are also of interest.
- Present methods for field testing are 8-hour time weighted average methods and do no take into account real time exposure as well as location
- Other important needs include real-time risk management triggers at chemical sites or for vapor intrusion into buildings

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Current & Upcoming Regulations for Naphthalene Exposure

- Current OSHA Immediate Danger to Life & Health: 1.31 g/m^3
- Naphthalene vapor pressure at 25C: 800 mg/m^3
- Current NIOSH Short Term Exposure Limit (15 min TWA: 75 mg/m^3)
- Current OSHA Permissible Exposure Level (PEL) (8 hr TWA) : 50 mg/m^3 (10 ppm) for non-cancer end point
- Cal-OSHA PEL : 50 mg/m3 going to 0.5mg/m^3 (100 ppb) based on cancer end point
- ACGIH draft Threshold Limit Value (TLV-TWA) moving from 50 mg/m^3 to 25 mg/m^3.
- Also, ACGIH (American Congress of Government Industrial Hygienists) is changing the carcinogenicity class of naphthalene from A4 (not classified as human carcinogen) to A3 (confirmed animal carcinogen)

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Naphthalene Dosimeter Concept

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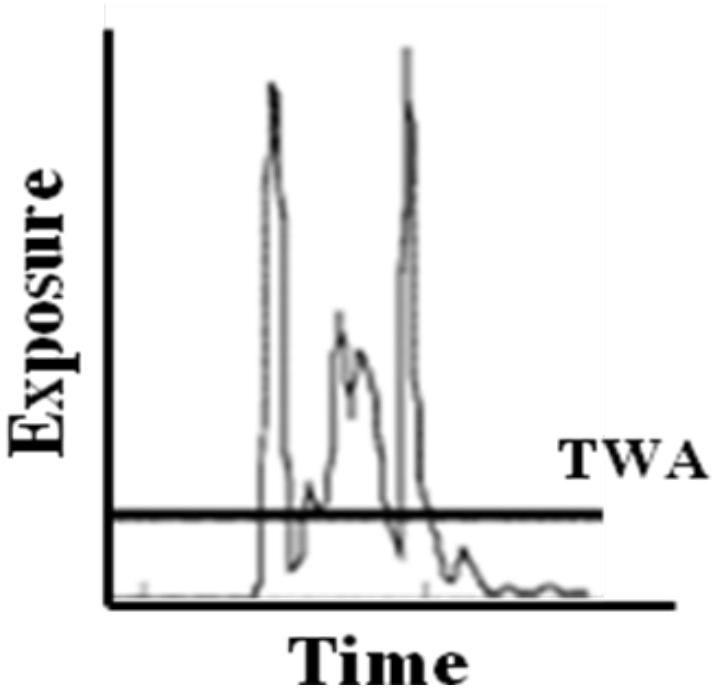
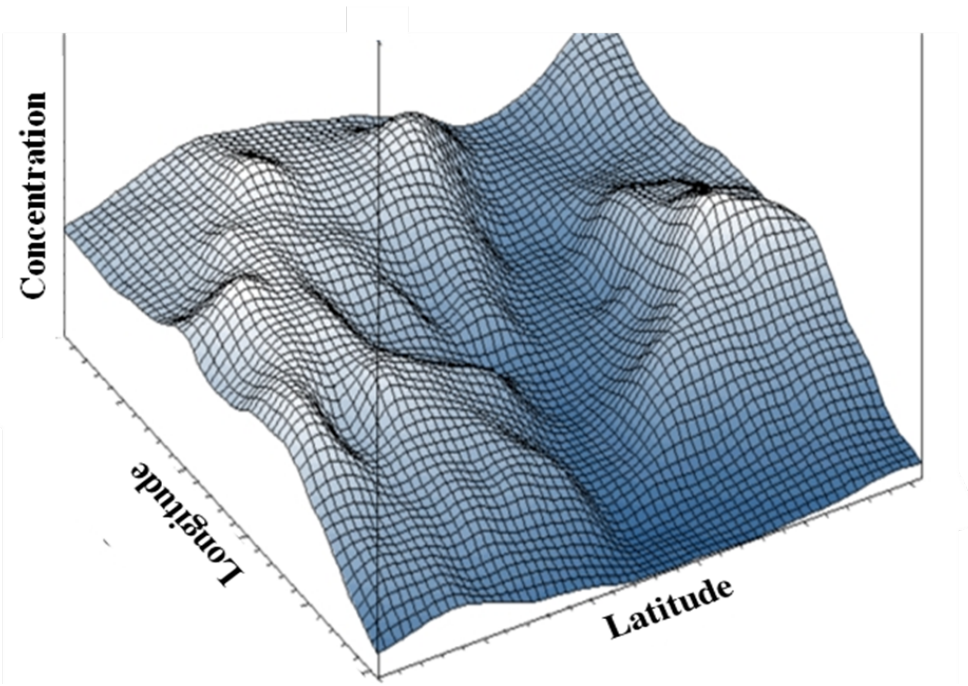
The Goal: Real-Time & In Situ VOC Type & Concentration Logging

VOCDos measures and records real time, in situ, exposures to naphthalene with alarms at PEL, STEL, and IDLH concentration levels





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Source: Poirot P, Subra I, Gérardin F, Baudin V, Grossmann S, Héry M Determination of Short-Term Exposure with a Direct Reading Photoionization Detector. Ann Occup Hyg. Jan; 48(1):75-84, 2004

Overview of Method

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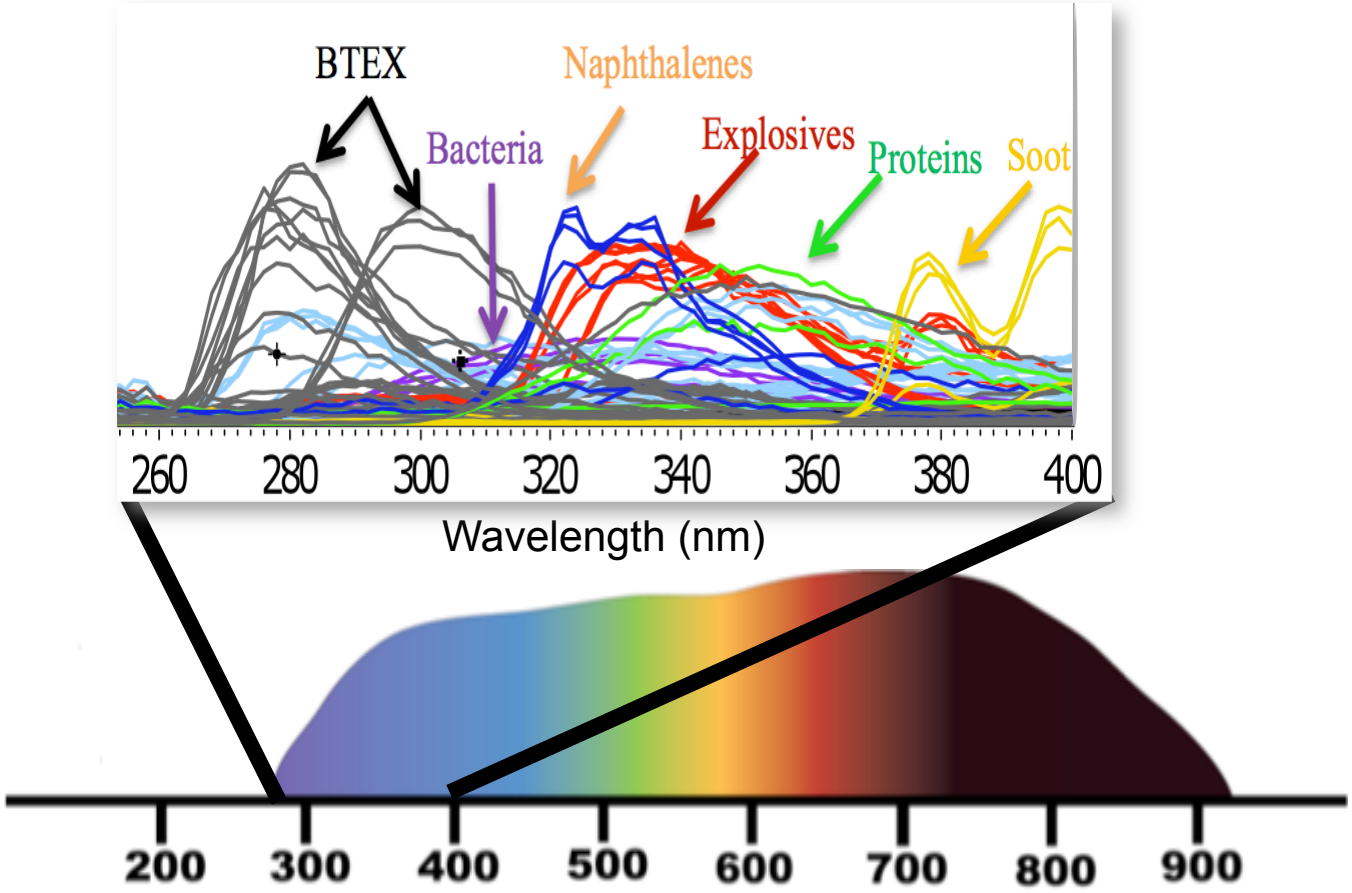
DUV Native Fluorescence of Organics



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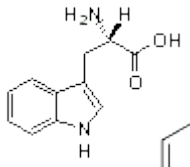
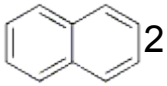
Chemical Differentiability using Deep UV Native Fluorescence Excited at 235 nm

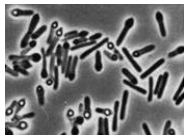


nitrogen based heterocycles **(E)** including tryptophan

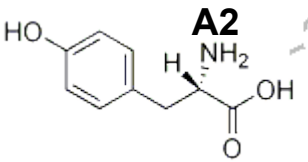


2 ring aromatics **(D)**

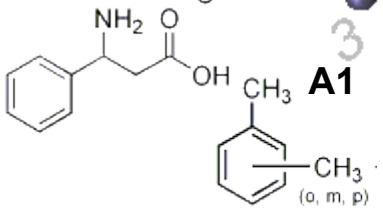
vegetative bacterial cells (Gram + and Gram -) with cellular components **(C),**



bacterial spores **(B)**



A2

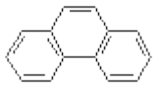


A1

1 ring compounds incl. Tyr & Phe (A1 and A2)

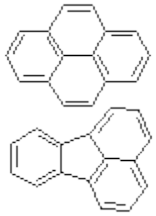
E

3 ring polyaromatic hydrocarbons (PAHs) **(F)**

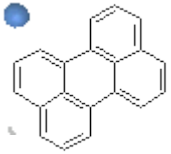


F

4 ring PAHs **(G)**



H



>5 Ring PAHS **(I)**

“background” (H): pollens, dust, minerals, and household materials (sugar, flour, corn starch, etc)

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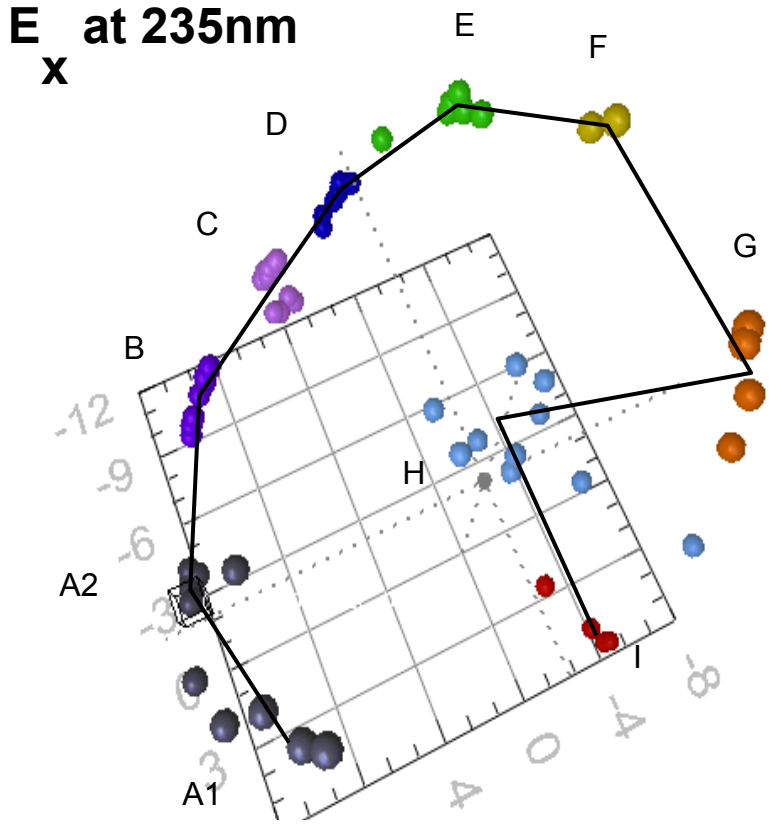
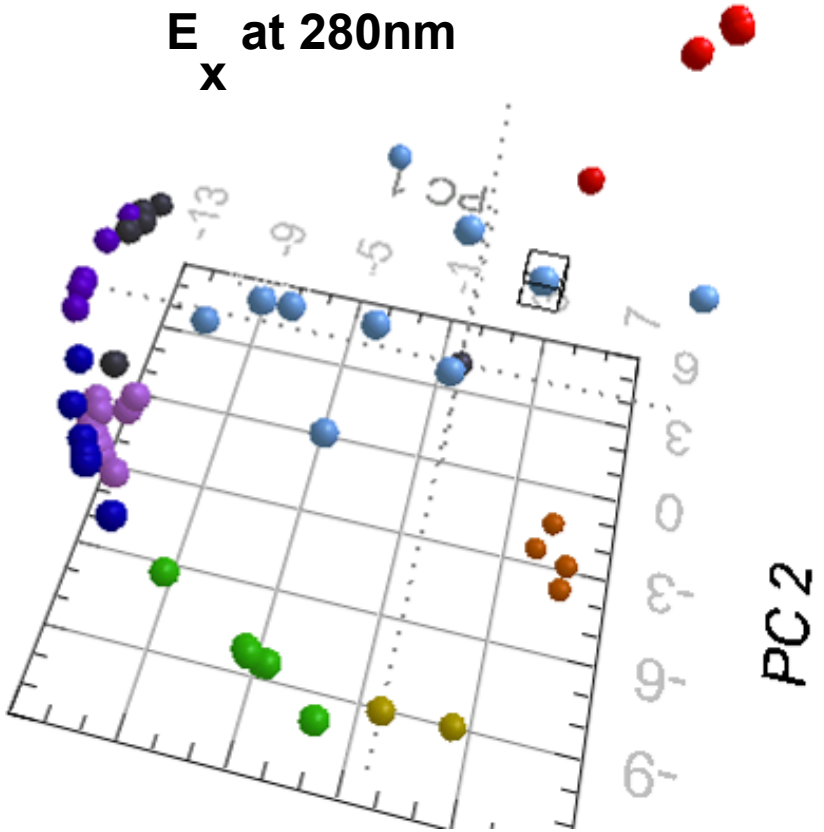
Native Fluorescence Discrimination at 235 nm and 280 nm





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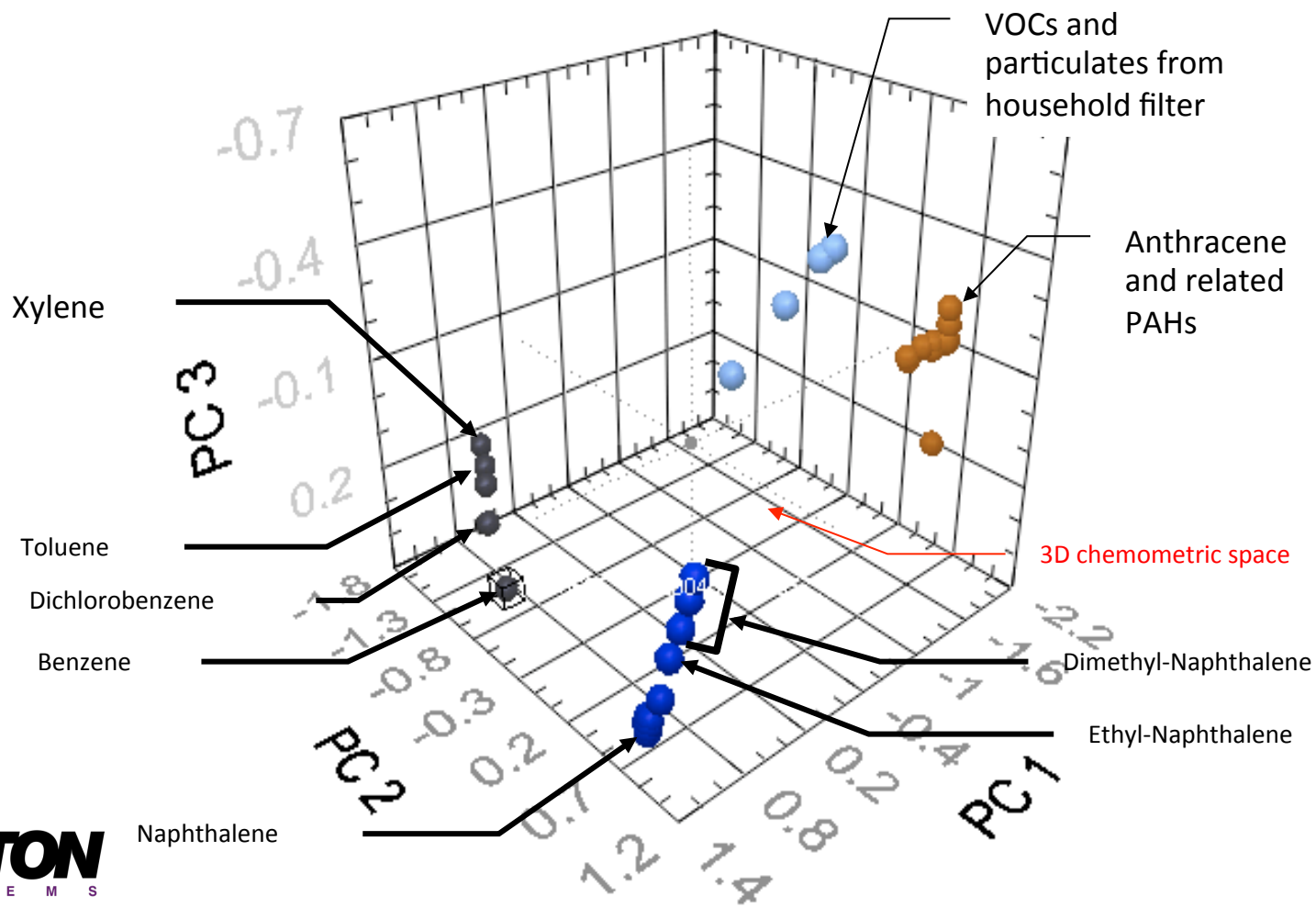
Chemometric Differentiability of Naphthalene in Jet Fuel



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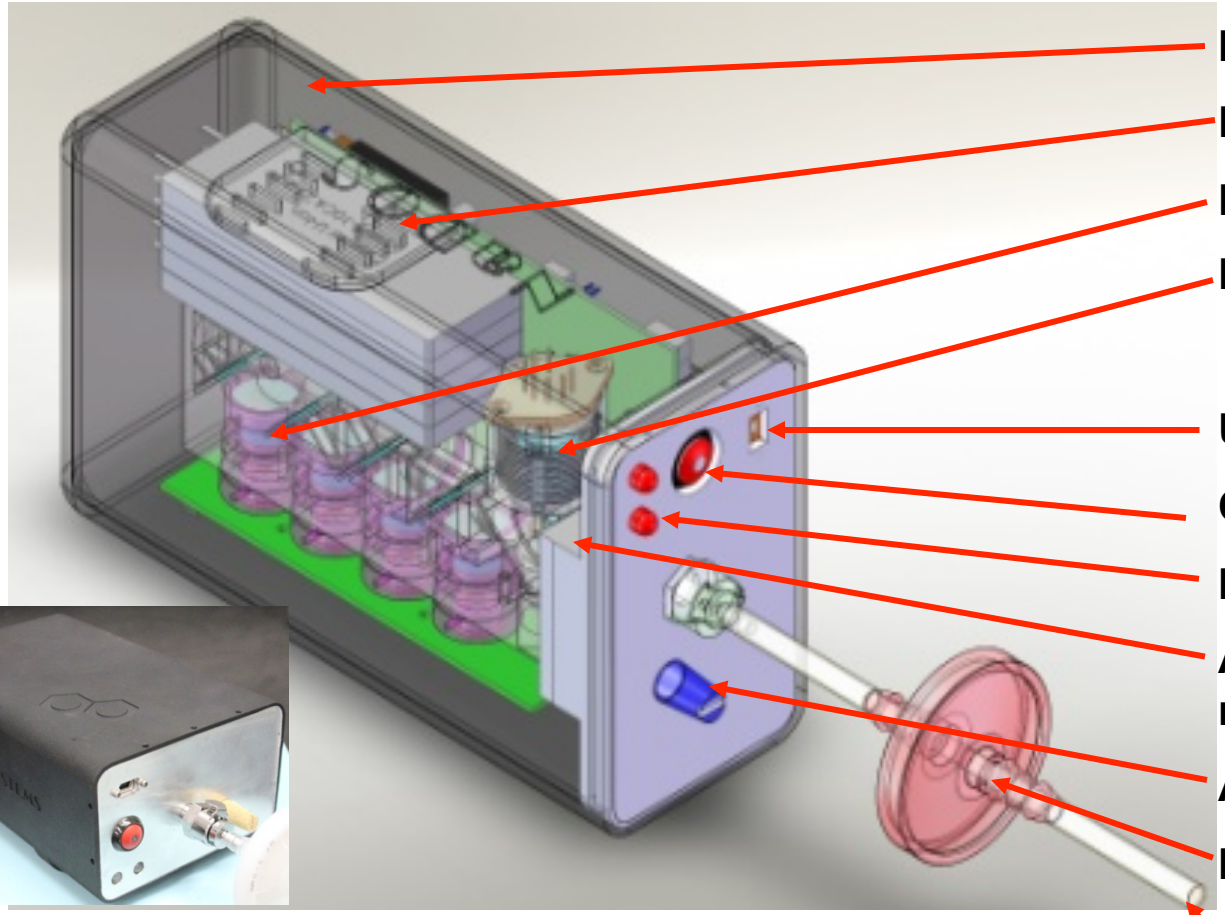
VOCDos 3.0 Sensor Illustration



- Inherently safe housing
- Batteries for 8+ hours
- Deep UV detectors
- Deep UV source
- USB Download & charging
- On/Off switch
- Indicator lights & alarms
- Air Pump with rapidly refreshable concentrator
- Air exhaust
- Intake air filter
- Air intake

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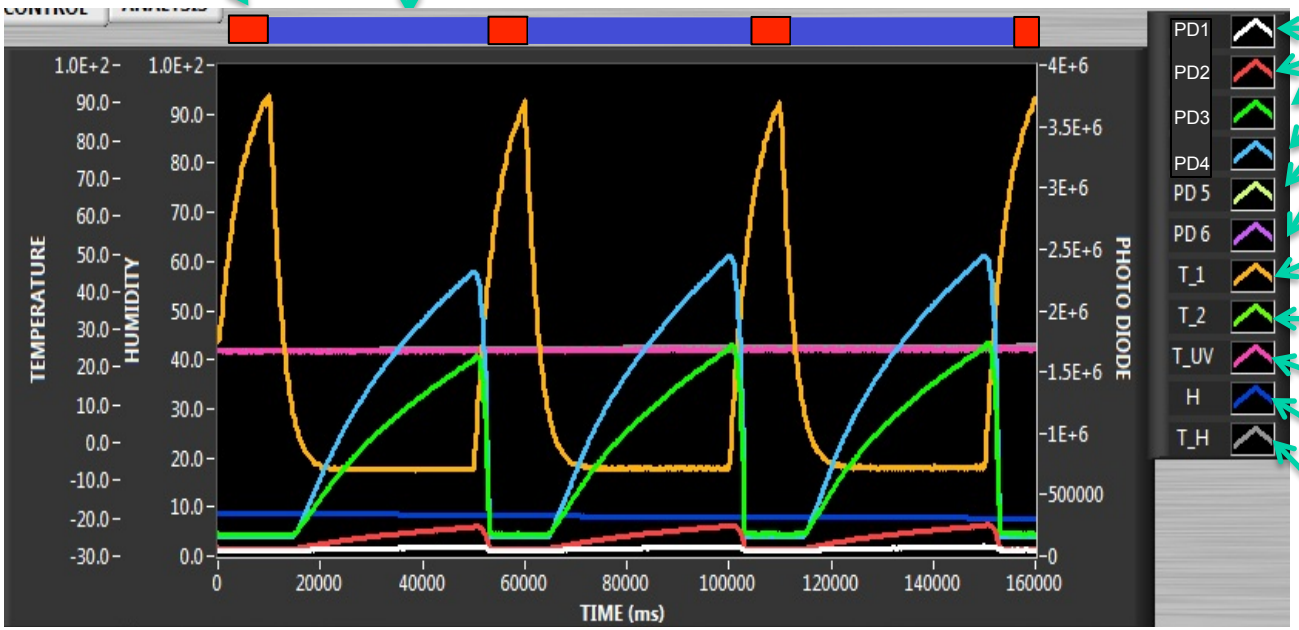
What The VOCDos Sensor Measures

Refresh & Concentrate Cycle: 6 sec refresh, 30 sec stabilize, 20 sec concentrate



Native fluorescence spectra

Refresh/Concentrate

Sensor Temp.

UV source Temp.

%Relative Humidity (0 – 70%)

Ambient Temp. (40F – 130F)

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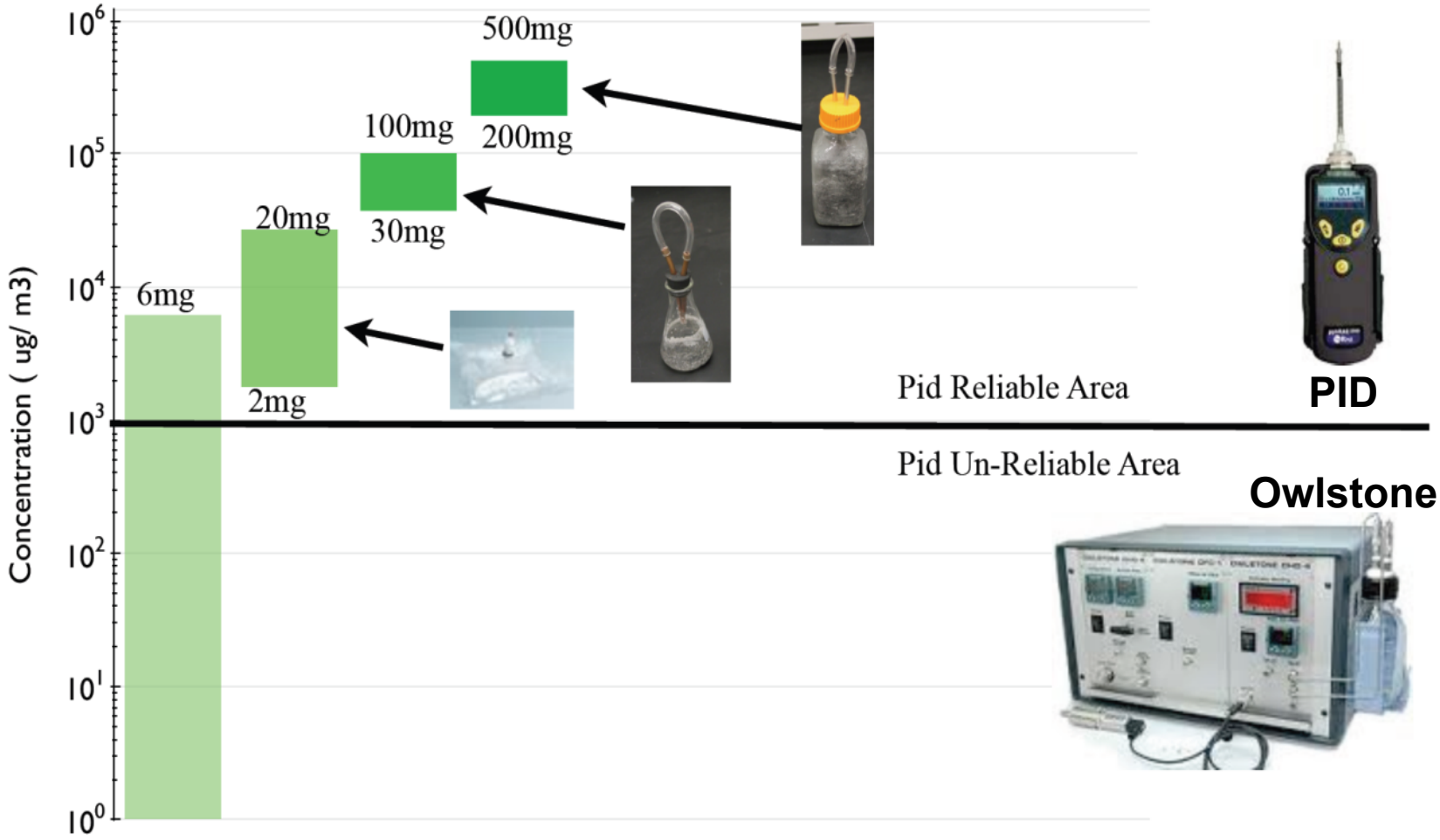
Naphthalene Calibration Methods vs Concentration



PID

Owlstone

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NapDos Sensor Calibration

VOCDos 3.0 PID Owlstone Naphthalene & Water Vapor Generator

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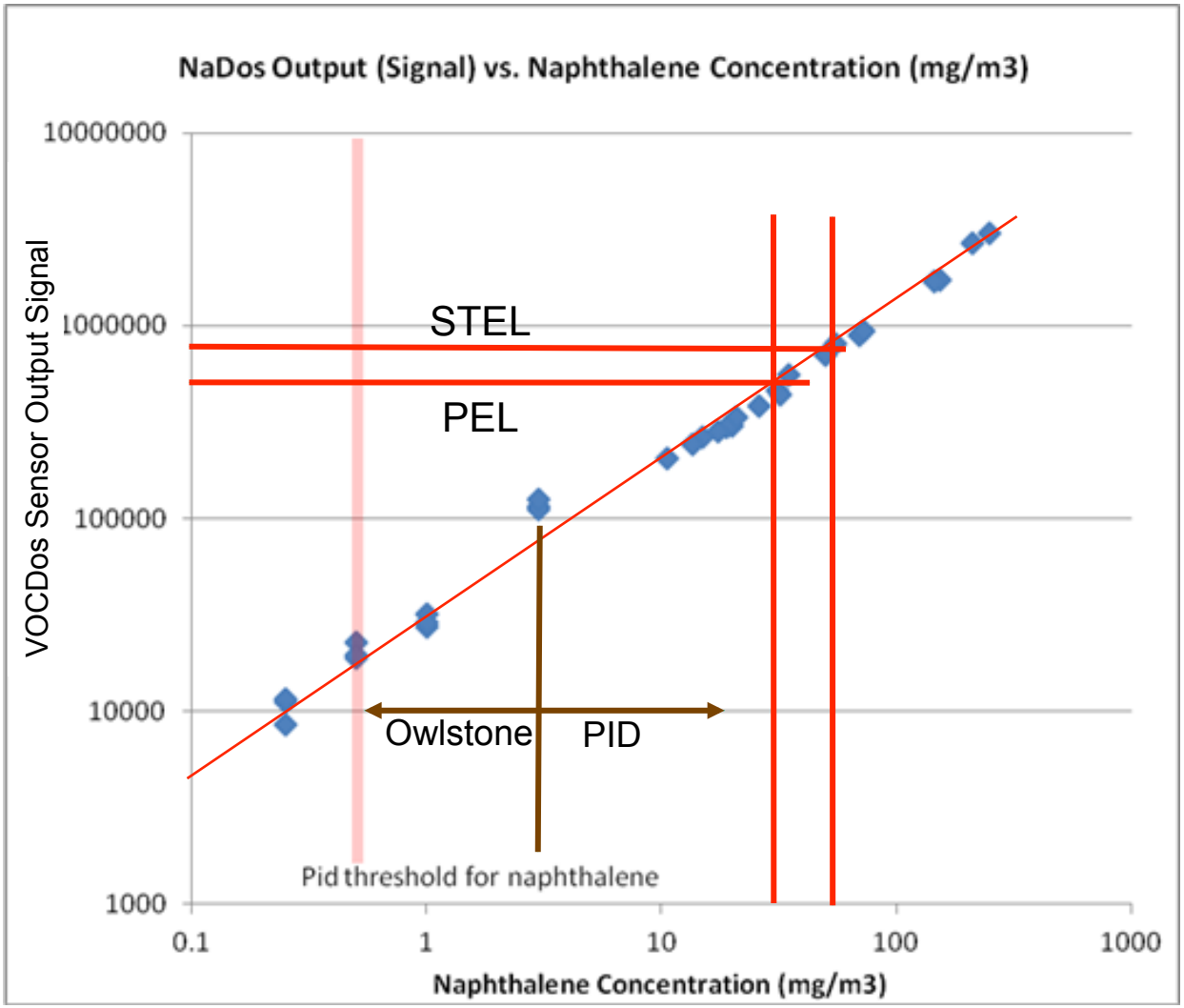
Naphthalene Concentration Linearity Curve

Compensated for Humidity from 0%-70% and Temperature from 40^0F – 110^0F



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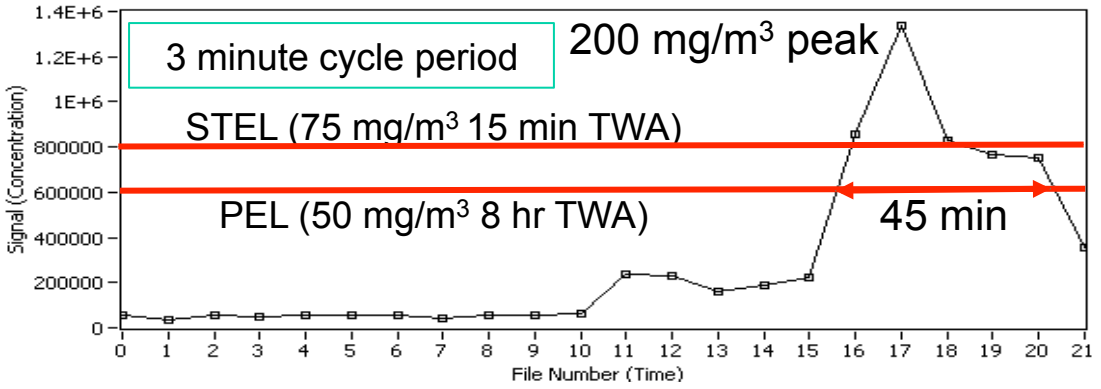
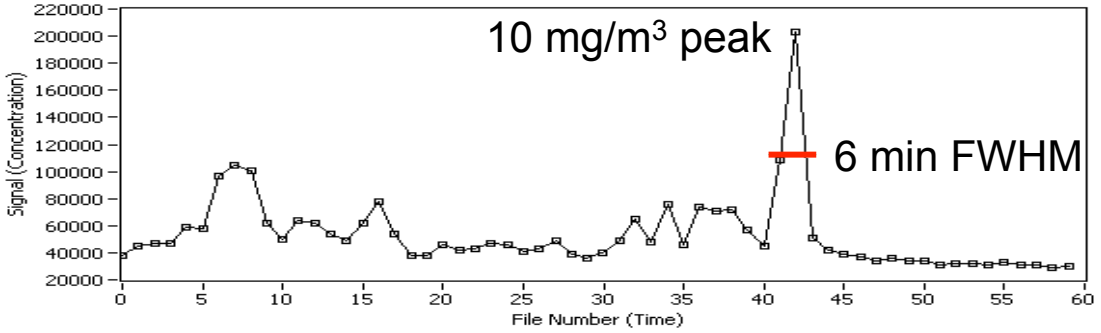
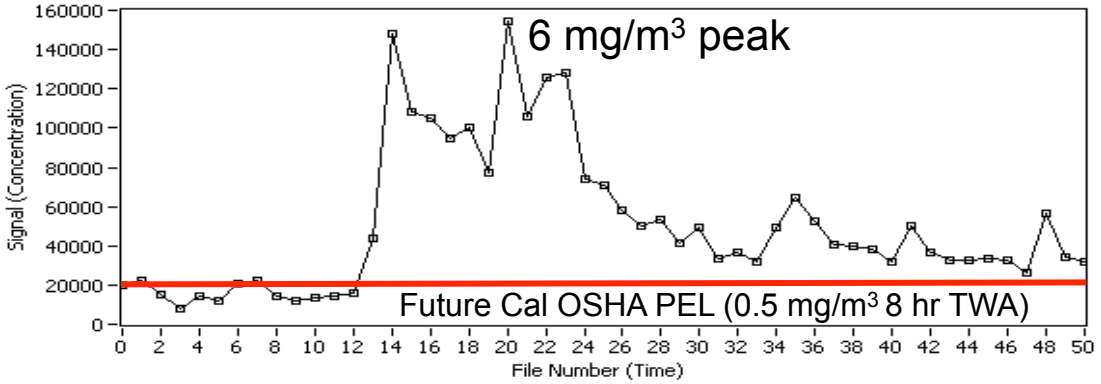
VOCDos 3.0 Preliminary Field Trials Data

(Little Rock AFB, AK. Data not validated)







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Questions

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