MINE FIRE DETECTION

AN HISTORICAL PERSPECTIVE and OVERVIEW OF MINE FIRE SENSOR RESEARCH 1969-2007

By

Dave Litton

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OVERVIEW

- What has been done?
- Why have we done what we have done?
- What has worked and what has not?
  - Successes
  - Failures
- Simple Sensors
- Where are we headed?

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BASIC PREMISE FOR SUCCESSFUL FIRE DETECTION

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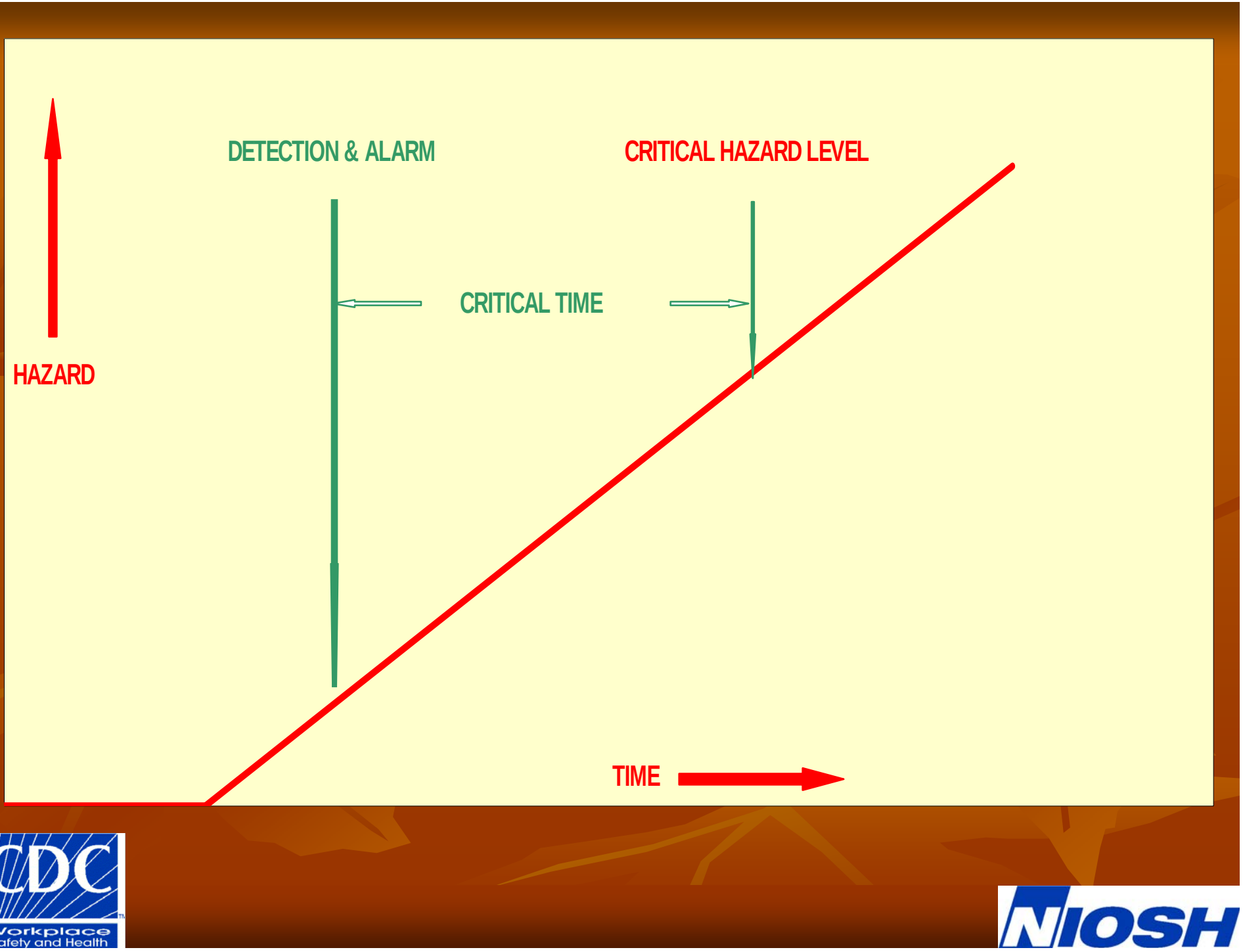
DETECTION & ALARM
CRITICAL HAZARD LEVEL
CRITICAL TIME
HAZARD
TIME

RESEARCH 1969-2007

- Sensors/Systems
- Fires
- Fires and Ventilation
- Modeling

SENSORS/SYSTEMS

CHARACTERISTICS OF SENSORS/SYSTEMS

- Sensitive
- Rapid
- Reliable
- Simple

SENSORS/SYSTEMS RESEARCH 1969-2007

- Heat (Temperature) Sensors
- Optical Flame Sensors
- Gas Sensors
- Pneumatic Sensor Systems
- Smoke Sensors
- Multi-Sensor Arrays

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CHRONOLOGY OF SENSORS/SYSTEMS RESEARCH

- 1969--Point Type Heat Sensors
- 1973-77--Electrochemical CO Sensors
- 1976-79--SMPD Smoke Sensor
- 1976-83--Tube Bundle Detection Systems
- 1981-90--DDD Pyrolysis Sensor
- 1985-93--DDD CO/NO Sensor
- 1993-99--Optical Smoke Sensor
- 1997-2007--Optical/Ionization Sensor
- 1998-2004--Neural Network Multi-Sensor System

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SOME PICTURES

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CO SENSORS

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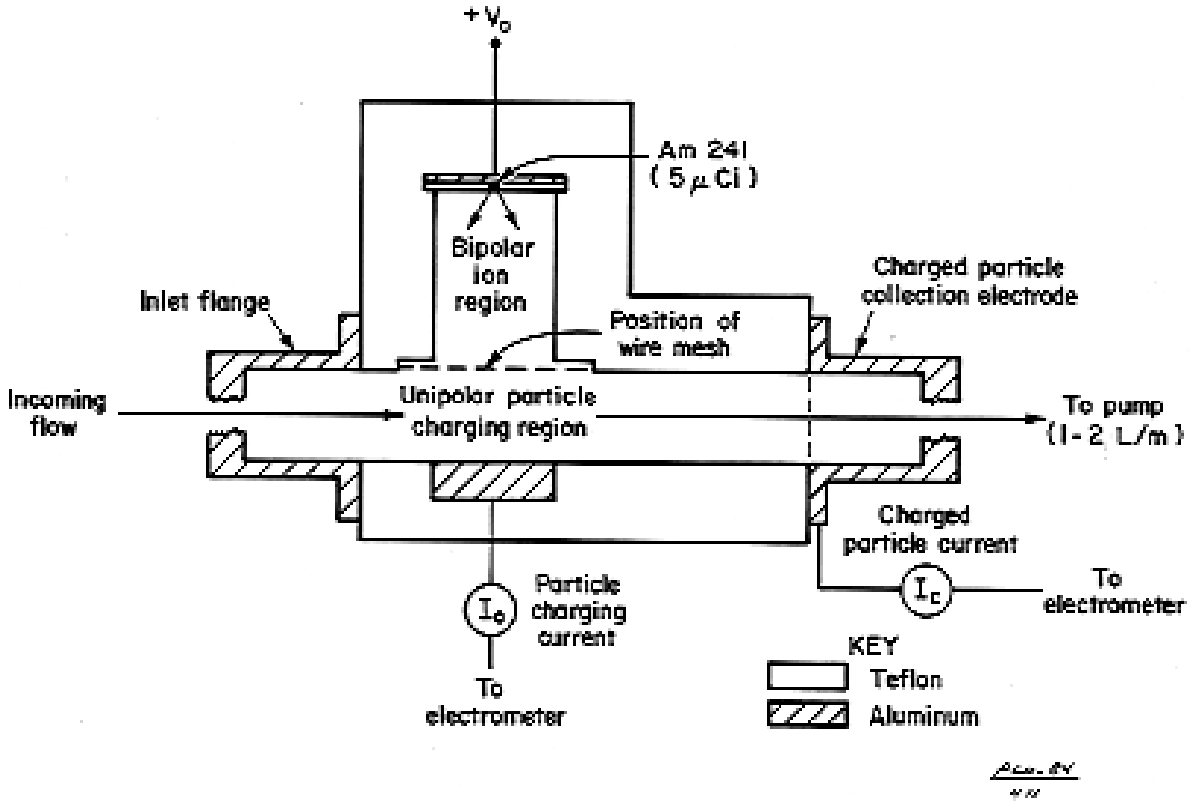
SCHEMATIC OF SMPD



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CO/NO DISCRIMINATOR

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SIMPLE ANGULAR SCATTERING SENSOR

- Measures Angular Intensity at 20°
- Relative Sensitivities at 5.0 mg/m^3
  - Diesel Exhaust Particles—0.027 volts
  - Smoke From Flaming Fires—0.33 volts
  - Smoke From Smoldering Fires—0.72 volts

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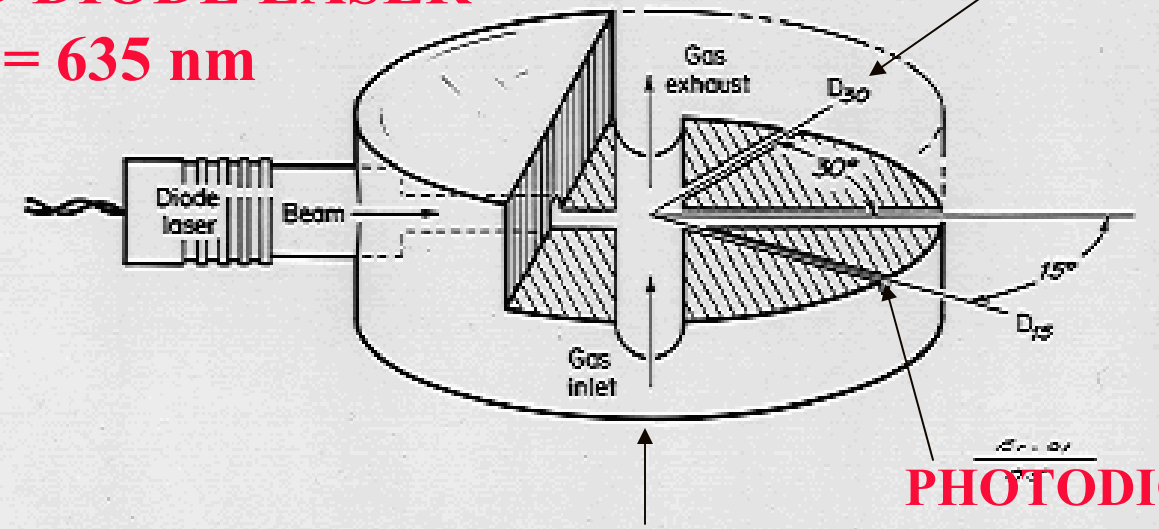
DUAL ANGLE VERSION

PHOTODIODE #1

RED DIODE LASER

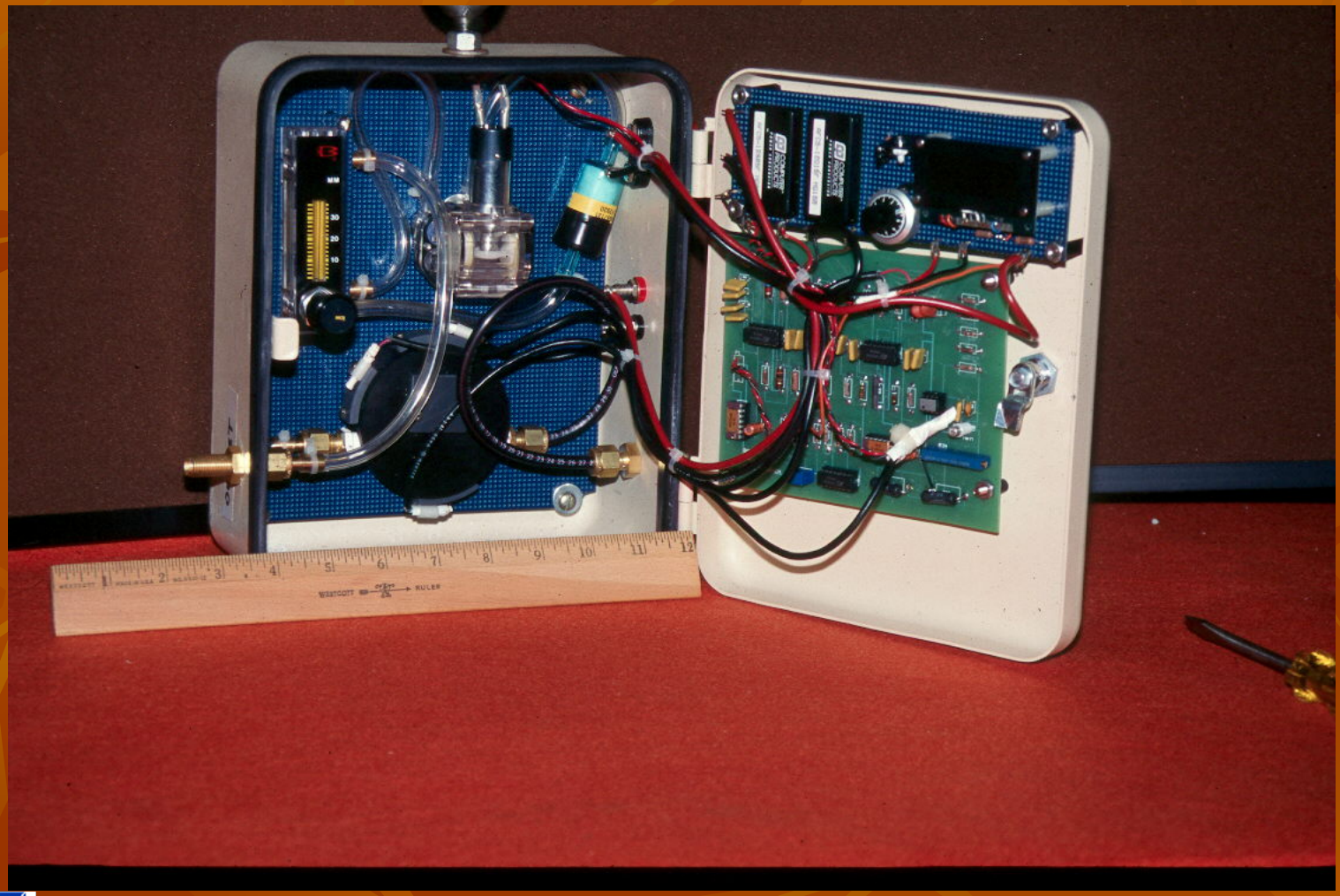
@ λ = 635 nm



PHOTODIODE #2

SMOKE FLOW

OPTICAL PROTOTYPE



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OPTICAL/IONIZATION SENSOR (OPTION)

- Combines Angular Scattering and Ionization Chamber Smoke Measurements
- Uses Ratio of Ionization Chamber Response to Angular Scattering Response to Discriminate Between Smoke from Fires and Particles from Diesels
  - Diesel Particles: R = 17.0
  - Smoke from Flaming Fires: R = 1.0
  - Smoke from Smoldering Fires: R =0.15

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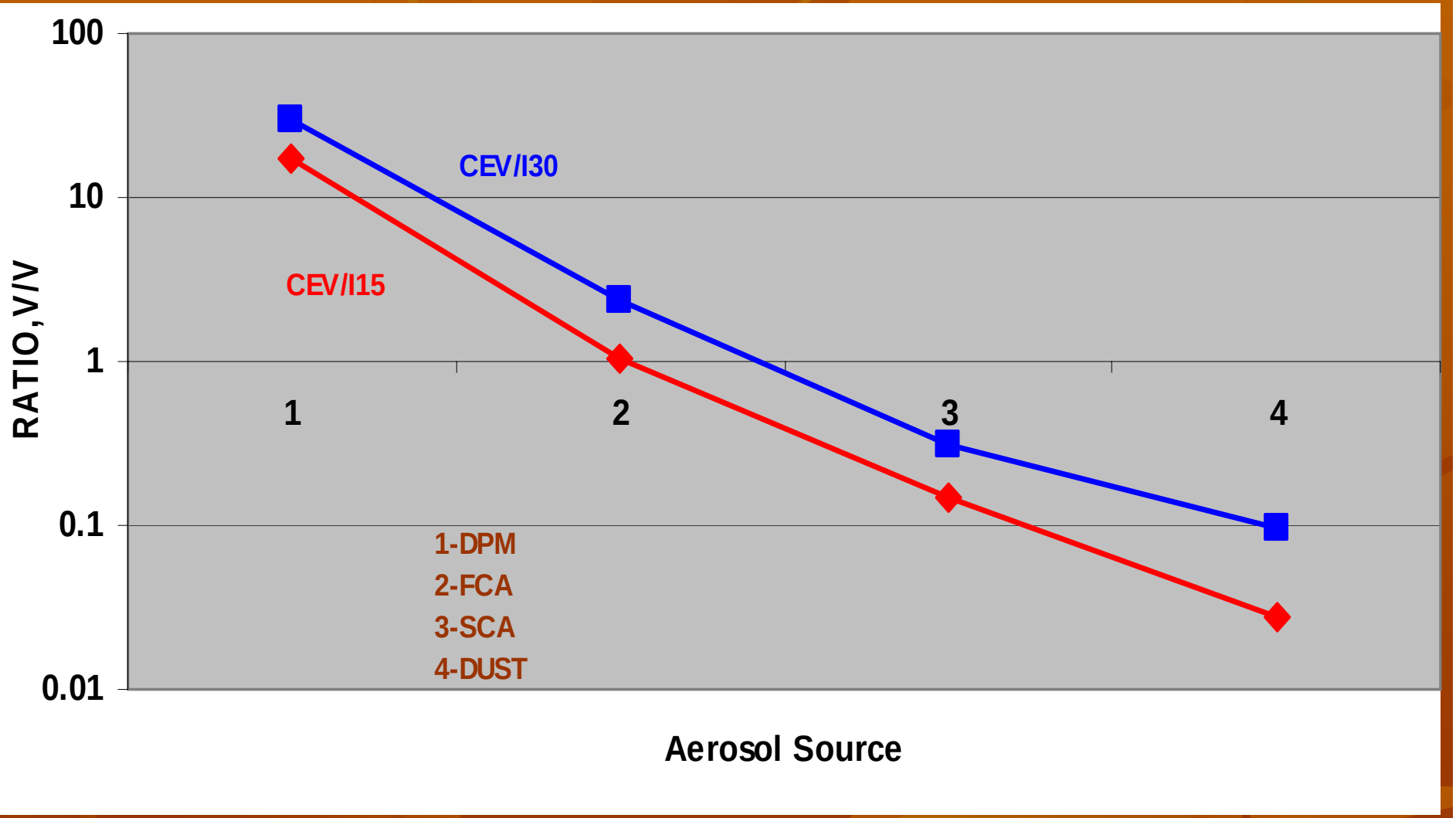
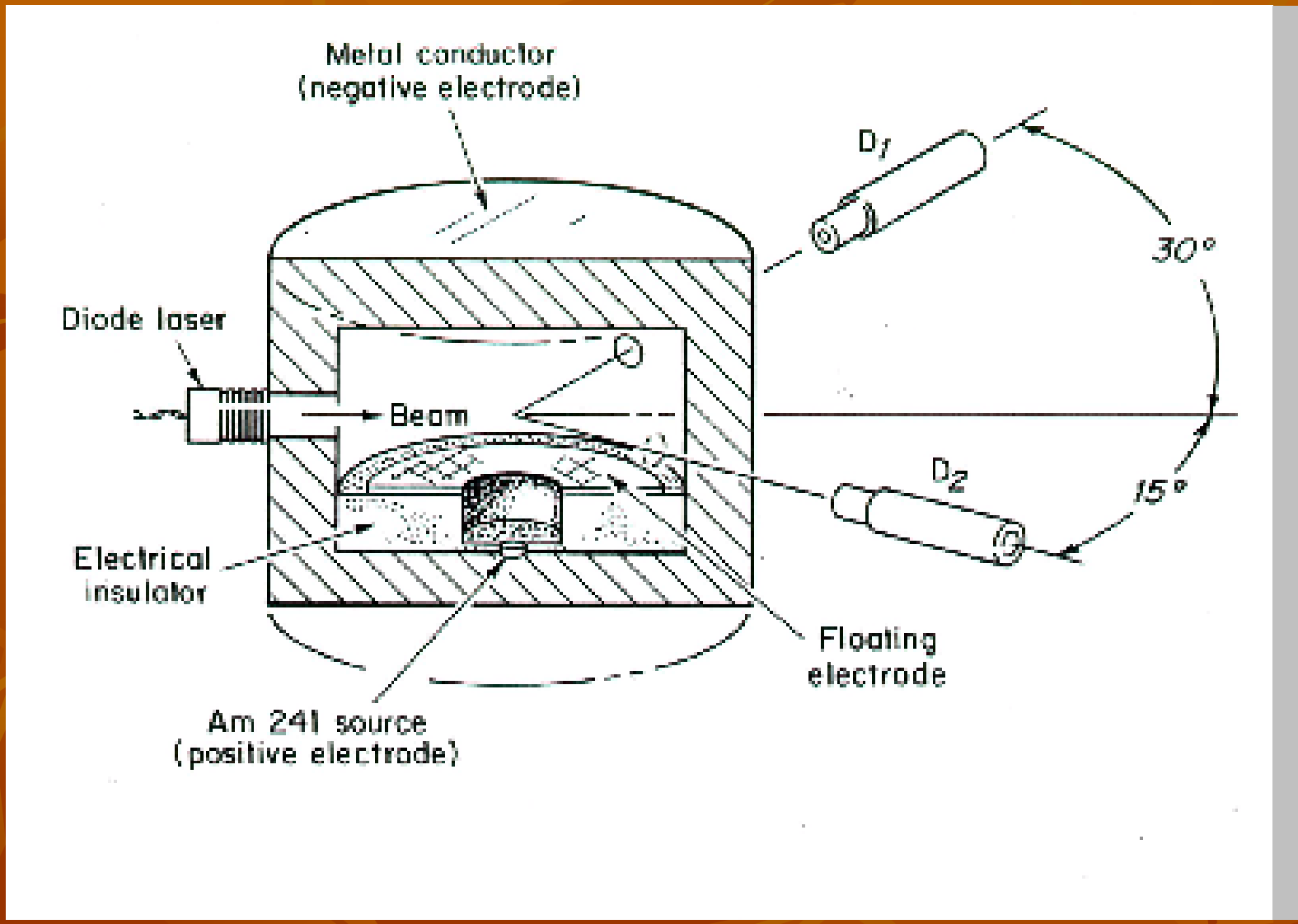

100
10
1
0.1
0.01
RATIO,V/V
CEV/I30
CEV/I15
1
2
3
4
1-DPM
2-FCA
3-SCA
4-DUST
Aerosol Source

SCHEMATIC OF PROTOTYPE SENSOR



STATUS OF OPTION SENSOR

- Ten Prototypes Fabricated for Test and Evaluation
  - Fire Detection
  - Monitoring of Diesel Particulate Matter
- Similar Devices Currently Being Evaluated as Continuous Particle Monitor by UC-Berkeley

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PROTOTYPE OPTION SENSOR

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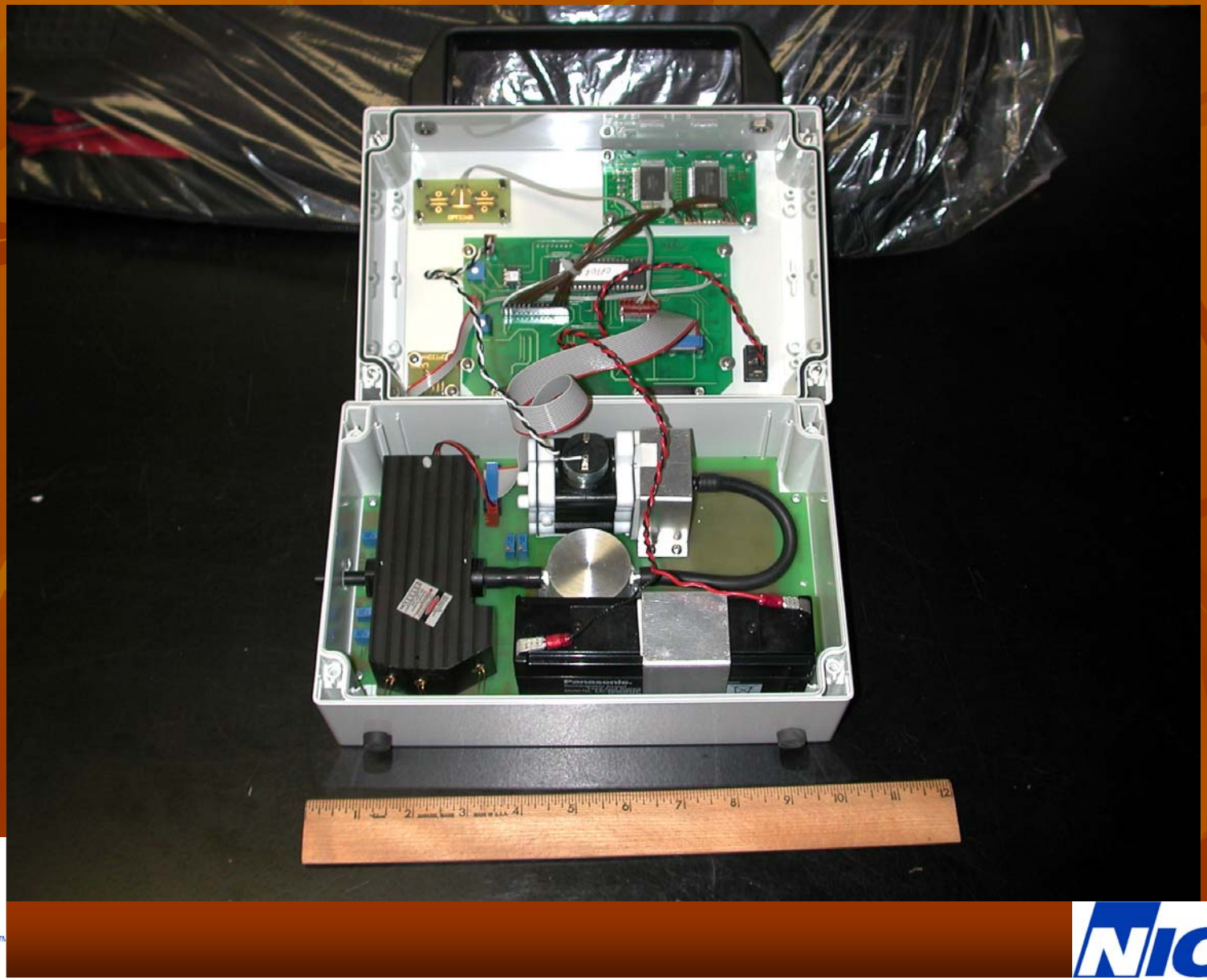
PROTOTYPE OPTION SENSOR



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UC Berkeley Sensor

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ION + Photoelectric

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SMOKE SENSORS

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CURRENTLY AVAILABLE

SmokeBoss

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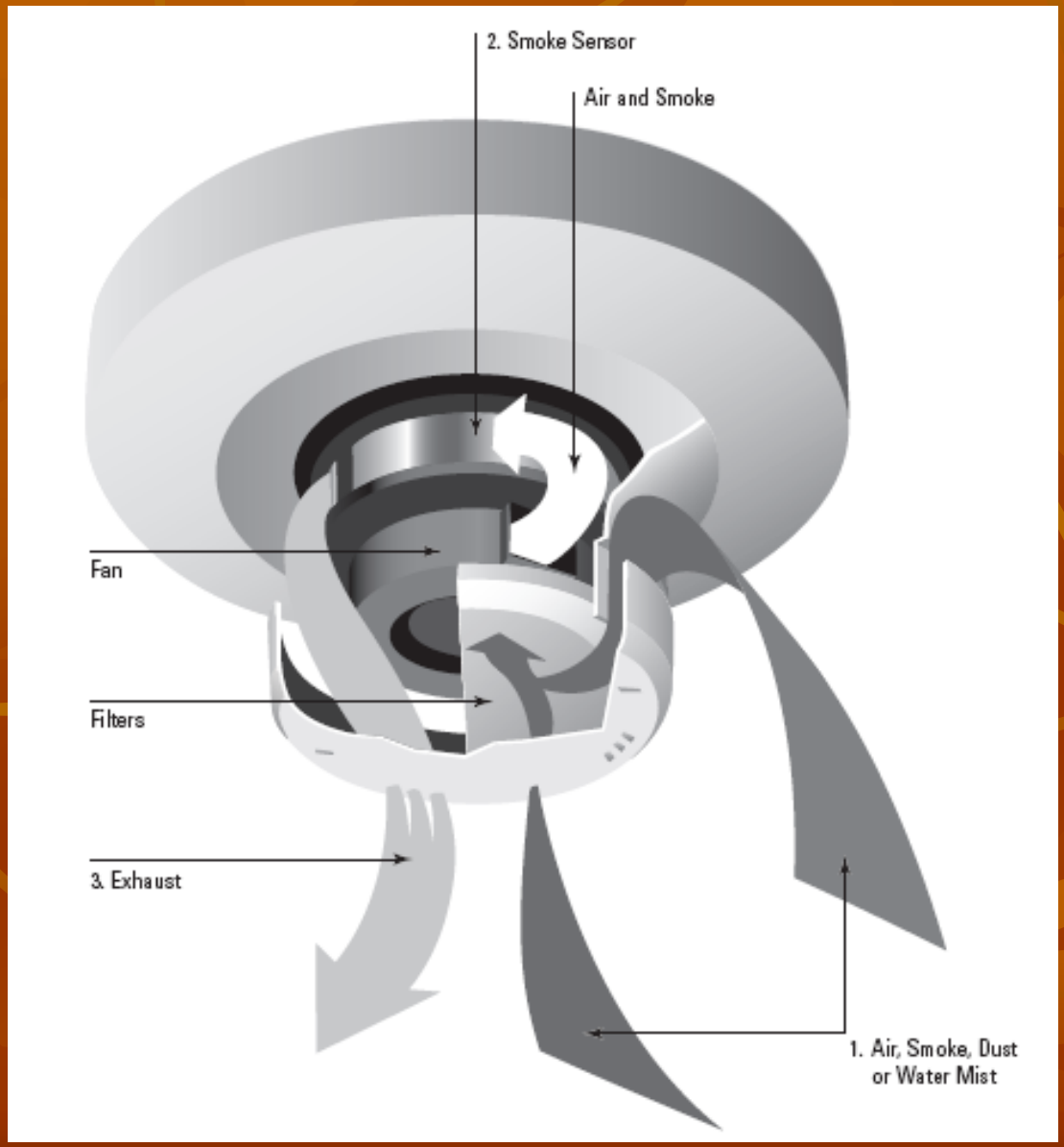
CURRENTLY BEING EVALUATED



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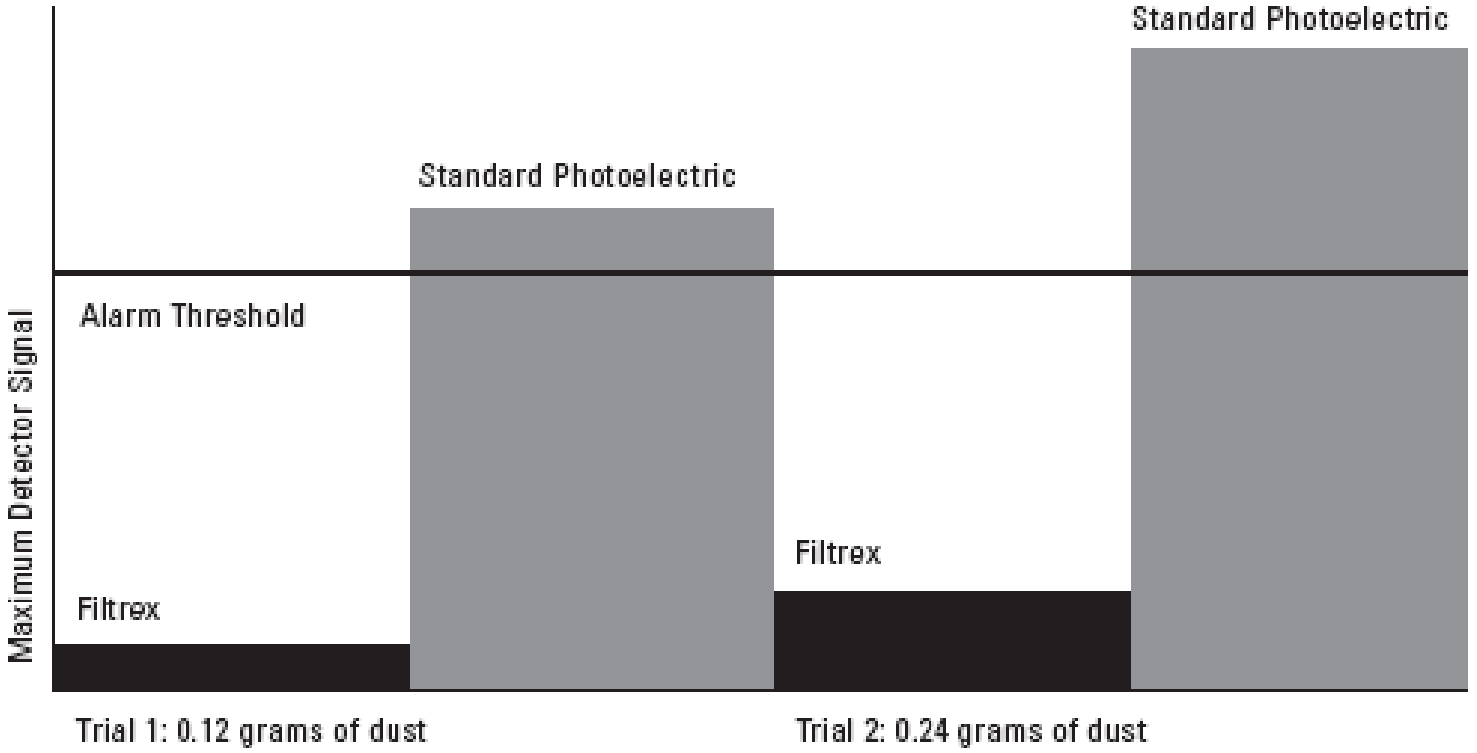
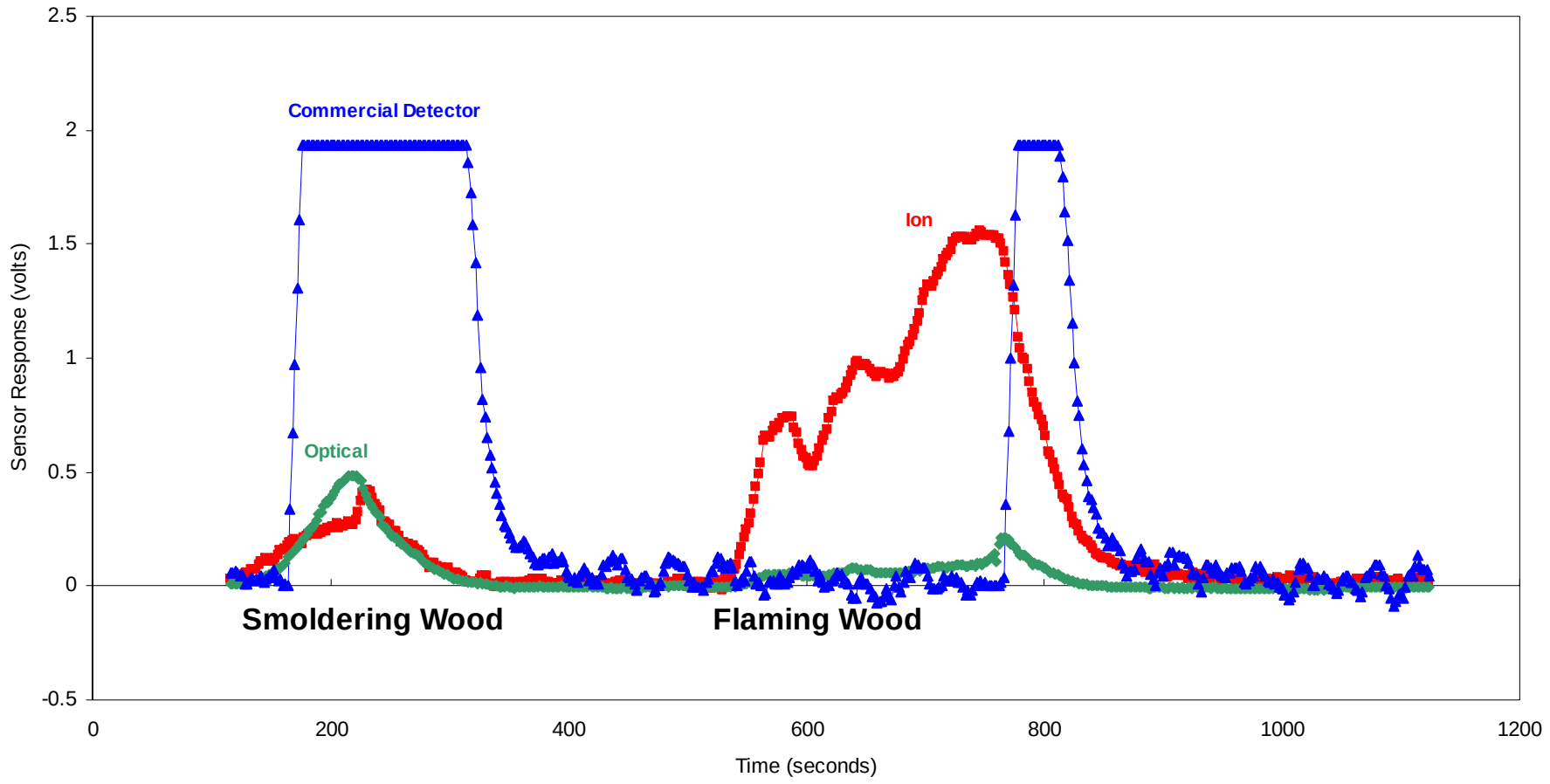
MANUFACTURER DATA



SOME FIRE DATA



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MULTI SENSOR NEURAL NETWORKS

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SUMMARY

THE SENSORS

- Heat (Temperature) Sensors
- Optical (Flame Radiation) Sensors
- Gas Sensors
  - CO
  - Hydrocarbon (Gunk) Sensors
  - Odor
- Smoke Sensors
  - Ionization-Type
  - Optical-Type
  - Other
- Multiple Gas/Smoke Sensors

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U.S. COAL MINES (2004)

- 780 Underground Coal Mines (40,000 UG Workers)
- 85 Use Some Form of Diesel Equipment (11,300 UG Workers)
- 695 Do Not Use Diesels (28,700 UG Workers)

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FIRE DETECTION

- All Mines Need Improved Early-Warning Fire Detection Systems
  - 695 Mines Need Basic, No-Frills Sensors
  - 85 Mines Need Systems That Can Detect a Fire in the Presence of Diesel Exhaust Products

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MINES WITHOUT DIESELS

- CO Sensors Better Than PTHS
- Numerous Incidents of "White-Outs"—Lots of Smoke but No CO
- 17 Smoke Alarms Due to Fires & Frictional Heating, but No CO
  - **(Data from BuMines IC 9311)**

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MINES WITH DIESELS

- Diesels Produce Sufficient CO to Cause Frequent Alarms of Stand-Alone CO Sensors
- In-Mine Alarm Frequencies
  - **CO Sensors @ 10 ppm—22.2 per day**
  - **Ionization-Type Smoke Sensor—1.6 per day**
  - **Optical-Type Smoke Sensor—0.0061 per day**
    - **(Data from BuMines IC 9311)**

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PERSONAL RECOMMENDATIONS

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MINES WITHOUT DIESELS

Simple, Inexpensive, Smoke Detectors

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MINES WITH DIESELS

- Optical Smoke Sensor
- Combination Ionization and Optical Smoke Sensor
- Multi-sensors using Neural Network

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THE END