Development of Advanced Fire Detection Algorithms using the "Dunes II" Data

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Purpose

Develop “Advanced” Fire Detection Algorithm that provide:

- Immunity to Nuisance Sources
- Early Detection of Real Fire Sources

What is a "Nuisance" Source?

- Anything that causes unwanted alarming of the smoke detector
  - Examples: Cooking, Smoking, Shower Steam
- Nuisance alarms cause people to disable their smoke detectors
  - 105 deaths/year where detectors disabled due to nuisance alarms

Available Nuisance Sources

- Mhn06 – Toasting bread until black
- Mhn09 – Frying Bacon
- Mhn12 – Boiling spaghetti
- Mhn14 – Frying butter until heavy smoking
- Mhn15 – Cigarette
- Mhn16 – Broiling hamburgers until well-done

Available Nuisance Sources (cont.)

- Mhn19 – Frying hamburgers until well-done
- Mhn20 – Toasting bagel until black
- Mhn32 – Baking frozen pizza
- Mhn35 – Tea candles
- Mhn36 – Frying bacon until crisp, but eatable

Design Level of Nuisance Immunity

- Alarm to Mhn06, 14, 20.
  - Conventional detectors alarmed to all three
- Do not alarm to Mhn09, 12, 15, 16, 19, 32, 35, 36
  - Conventional detectors alarmed to four of above

What is a “Real” Fire Source?

- Fire that threatens life safety of occupants
  - Flaming Fires
  - Smoldering Fires
  - “Aggressive” Nuisance Sources

Available “Real” Fire Sources

- 14 tests total
  - 2 smoldering furniture
  - 4 smoldering mattress
  - 2 flaming furniture
  - 4 flaming mattress
  - 2 flaming grease

What is "Sufficient" Detection Time?

$$(t_{Detection} + t_{Evacuation}) < t_{Hazard}$$

Response times of standard ion and photo detectors chosen as design criteria for development of alarm algorithms.

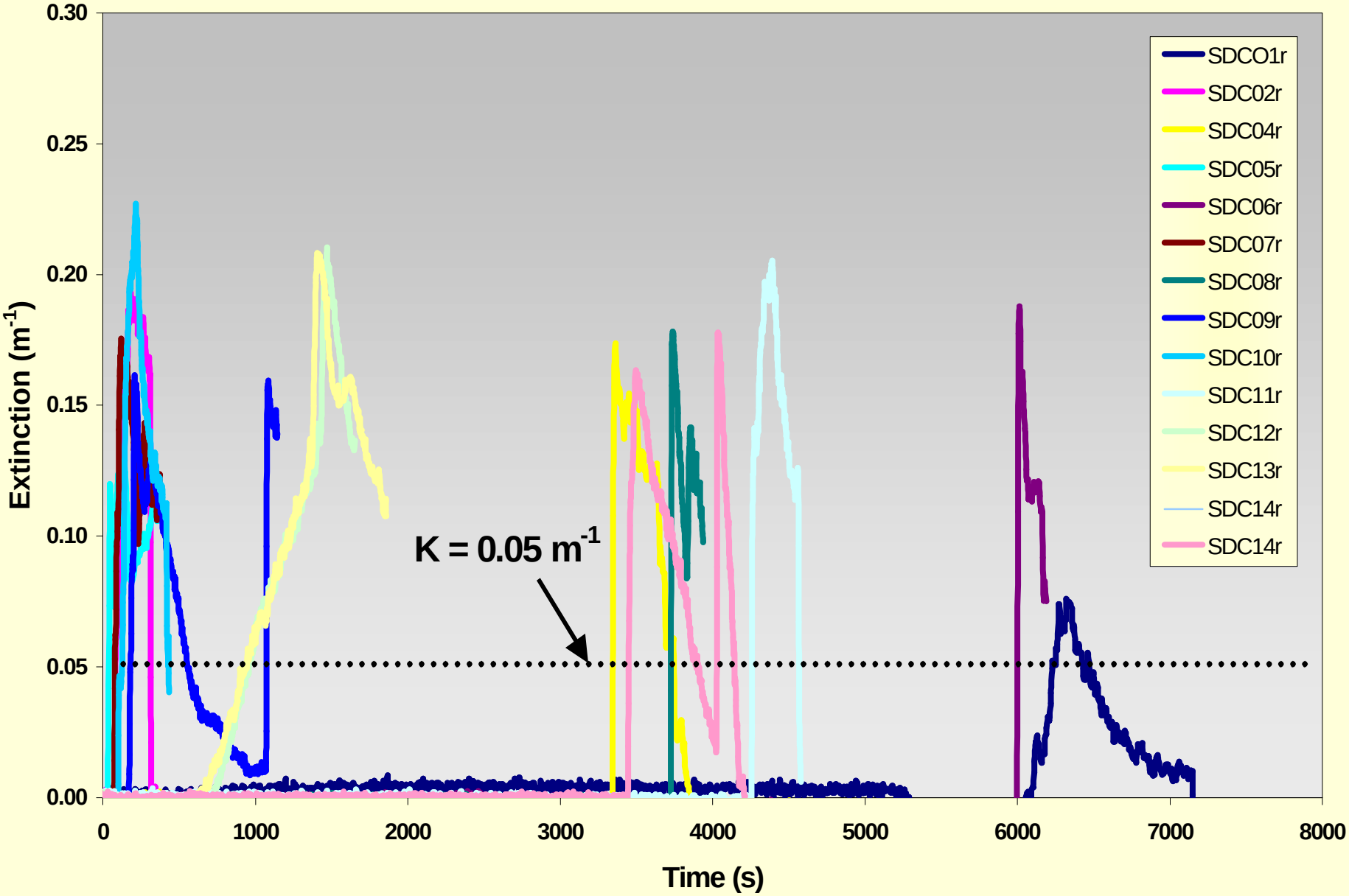
Algorithm Development

- Performance of Individual Sensors
- Multiple Sensor Algorithms
- Principle Component Analysis (PCA)

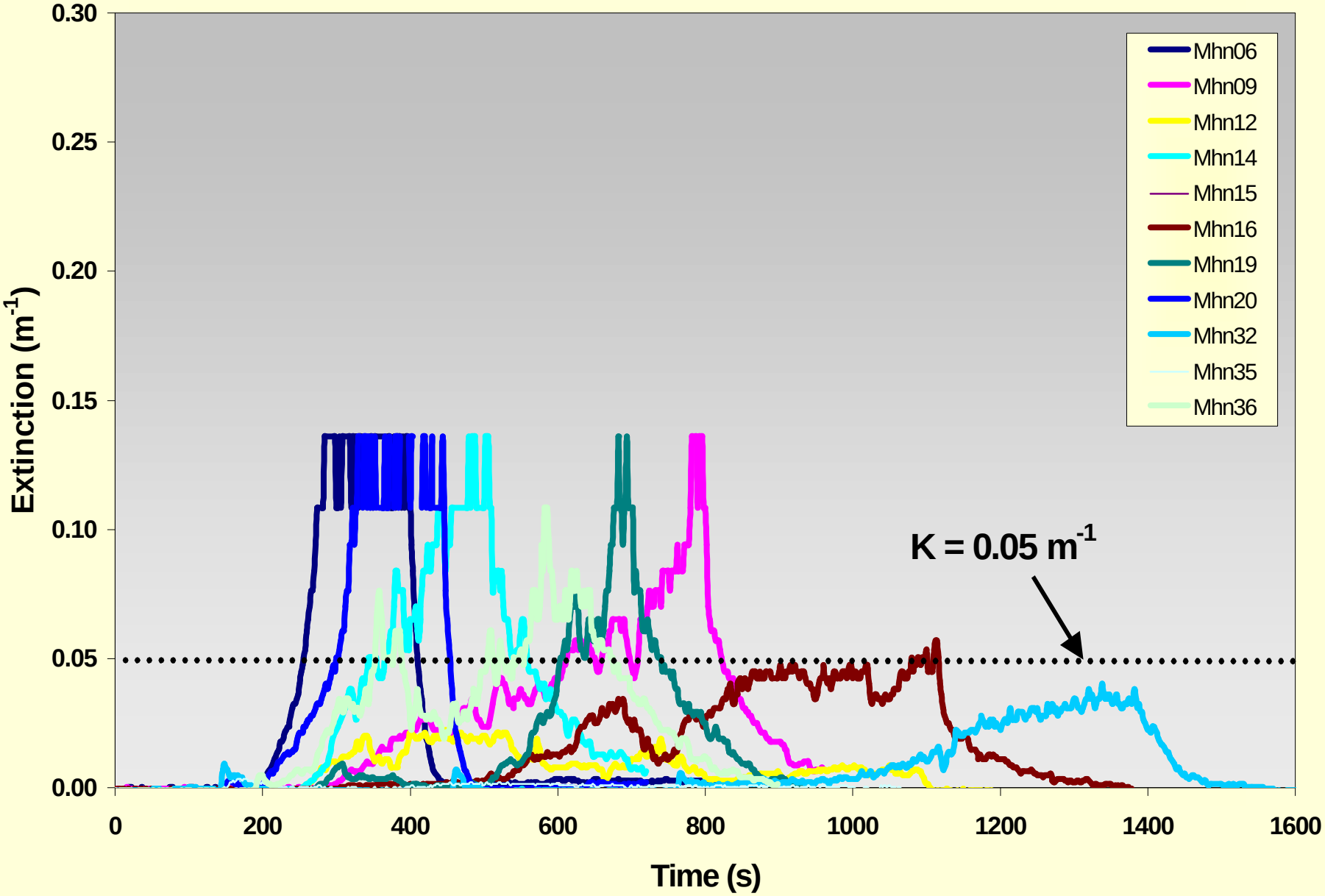
Available Measurements

- Ion
- Photo
- CO Detector
- Temperature

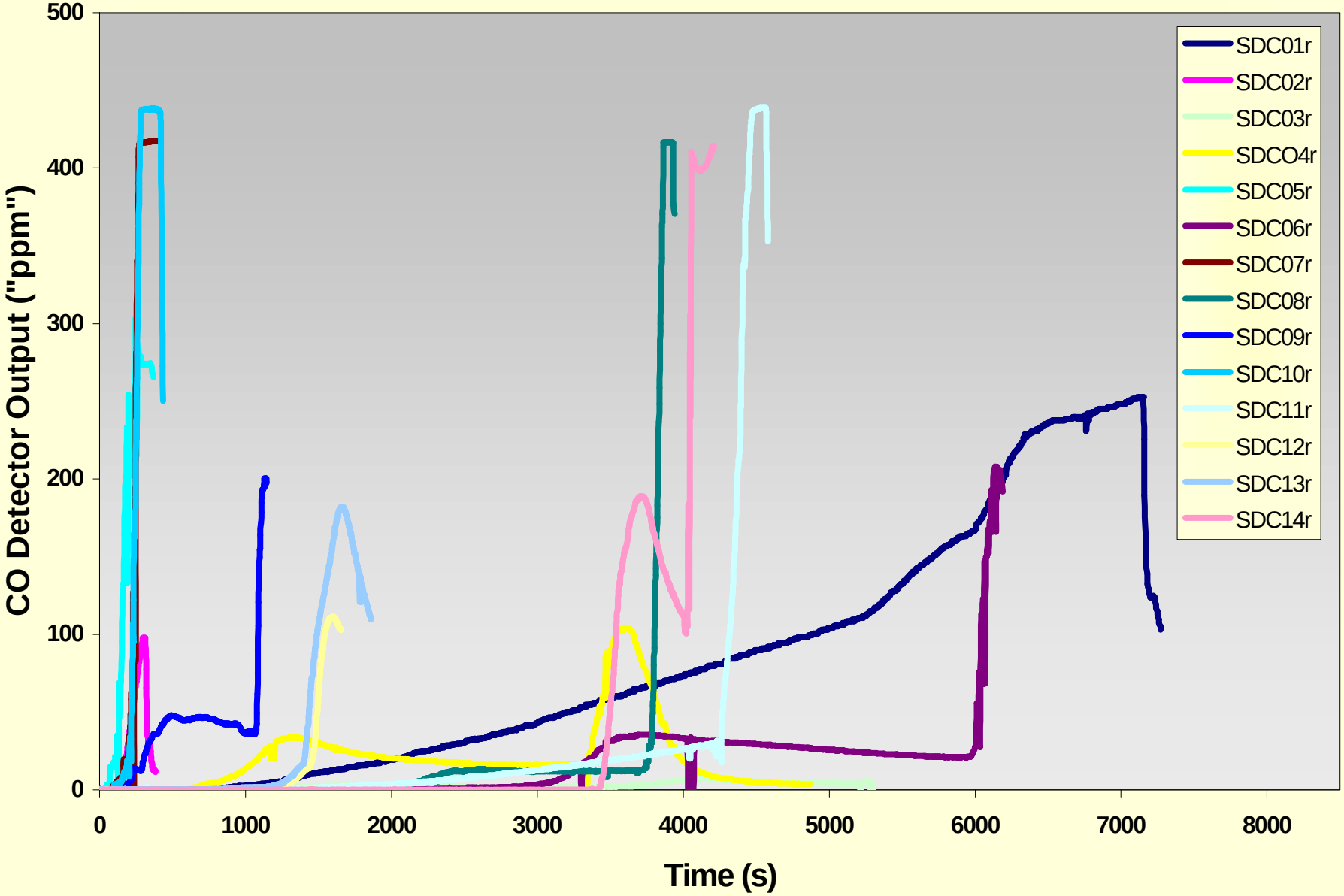
Ion vs. Time - "Real" Fire Sources



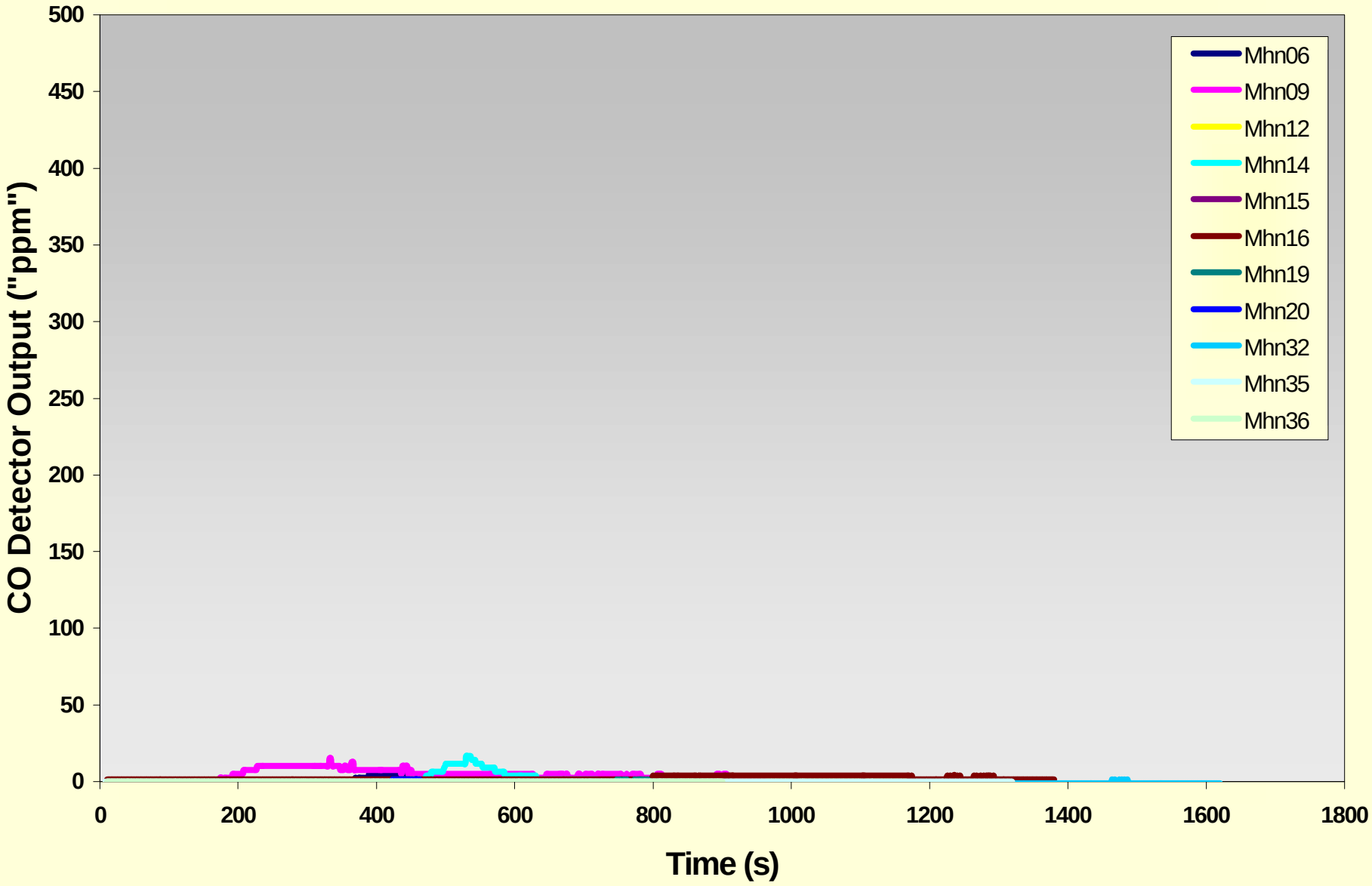
Ion vs. Time - Nuisance Sources



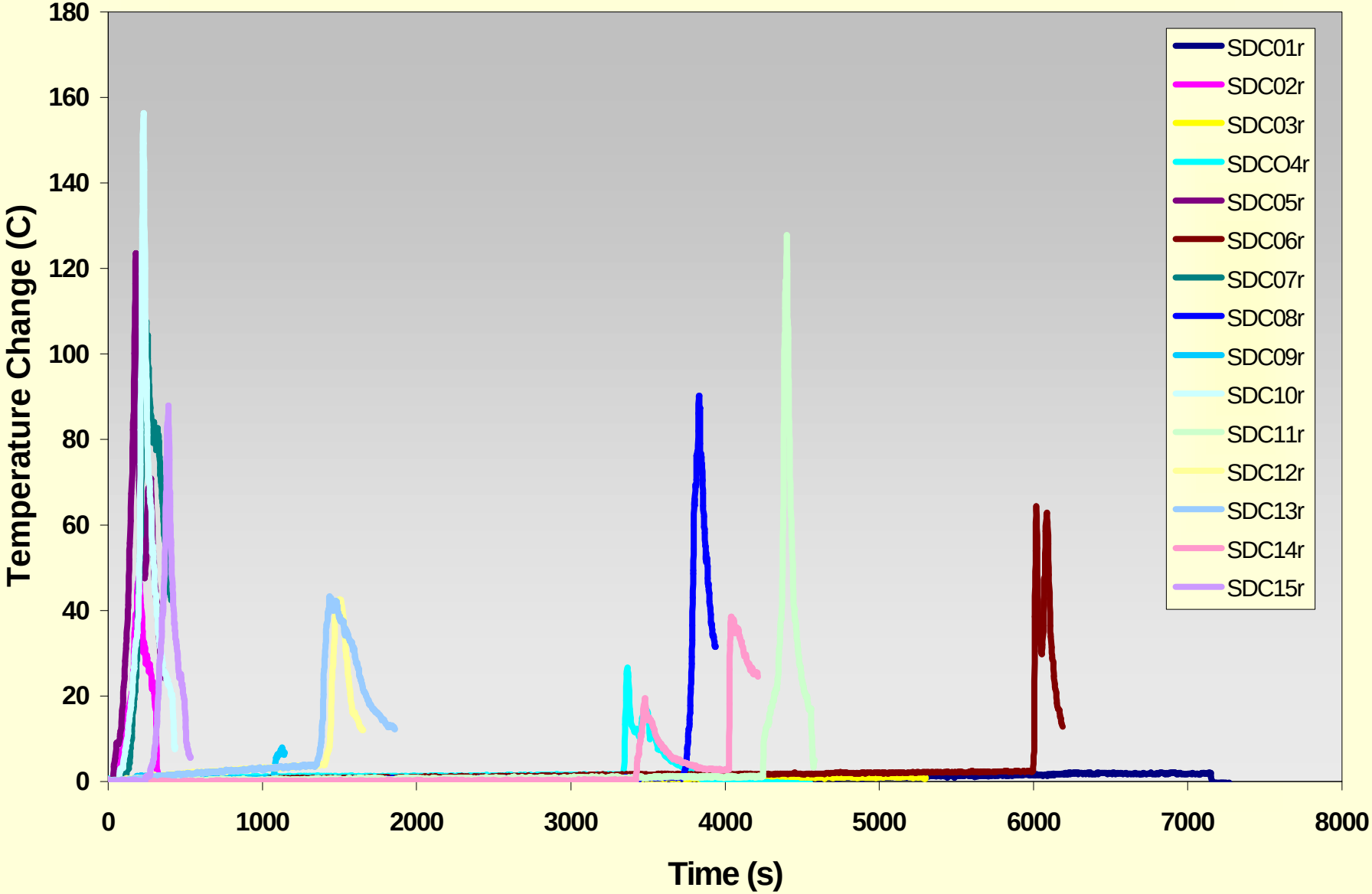
CO Detector Output vs. Time - "Real" Fire Sources



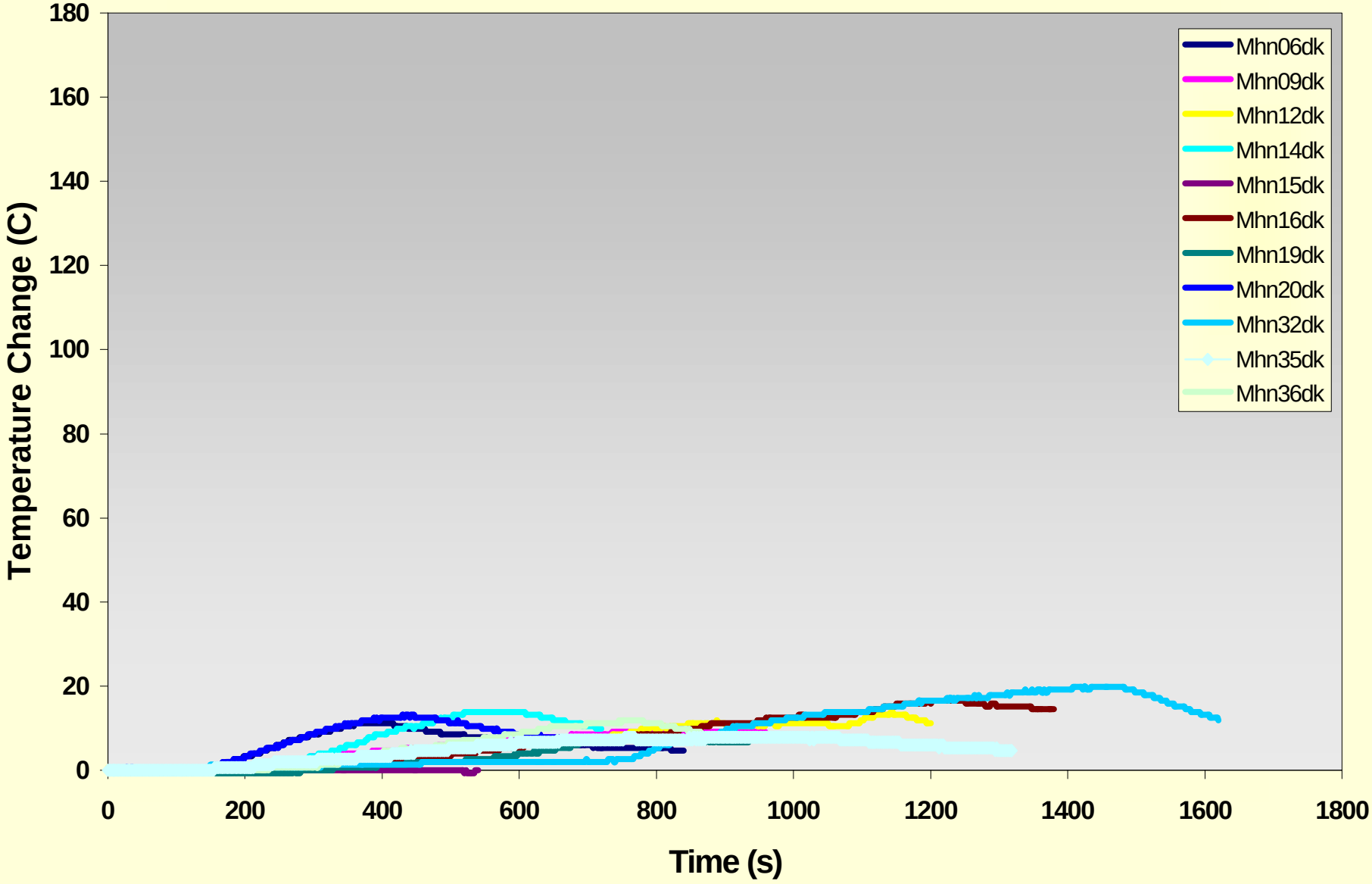
CO Detector Output vs. Time - Nuisance Sources



Temperature Change vs. Time - "Real" Fire Sources



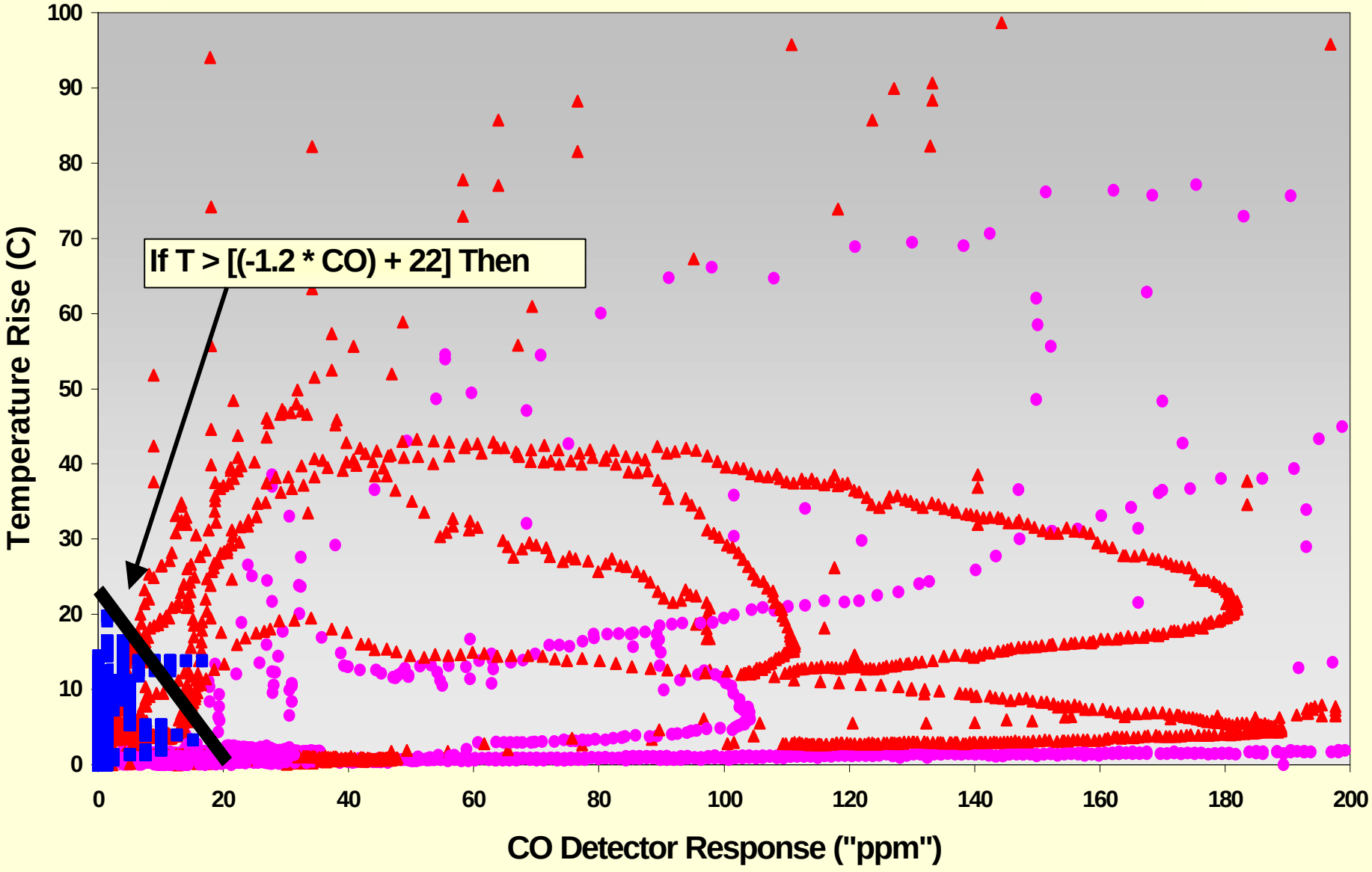
Temperature Change vs. Time - Nuisance



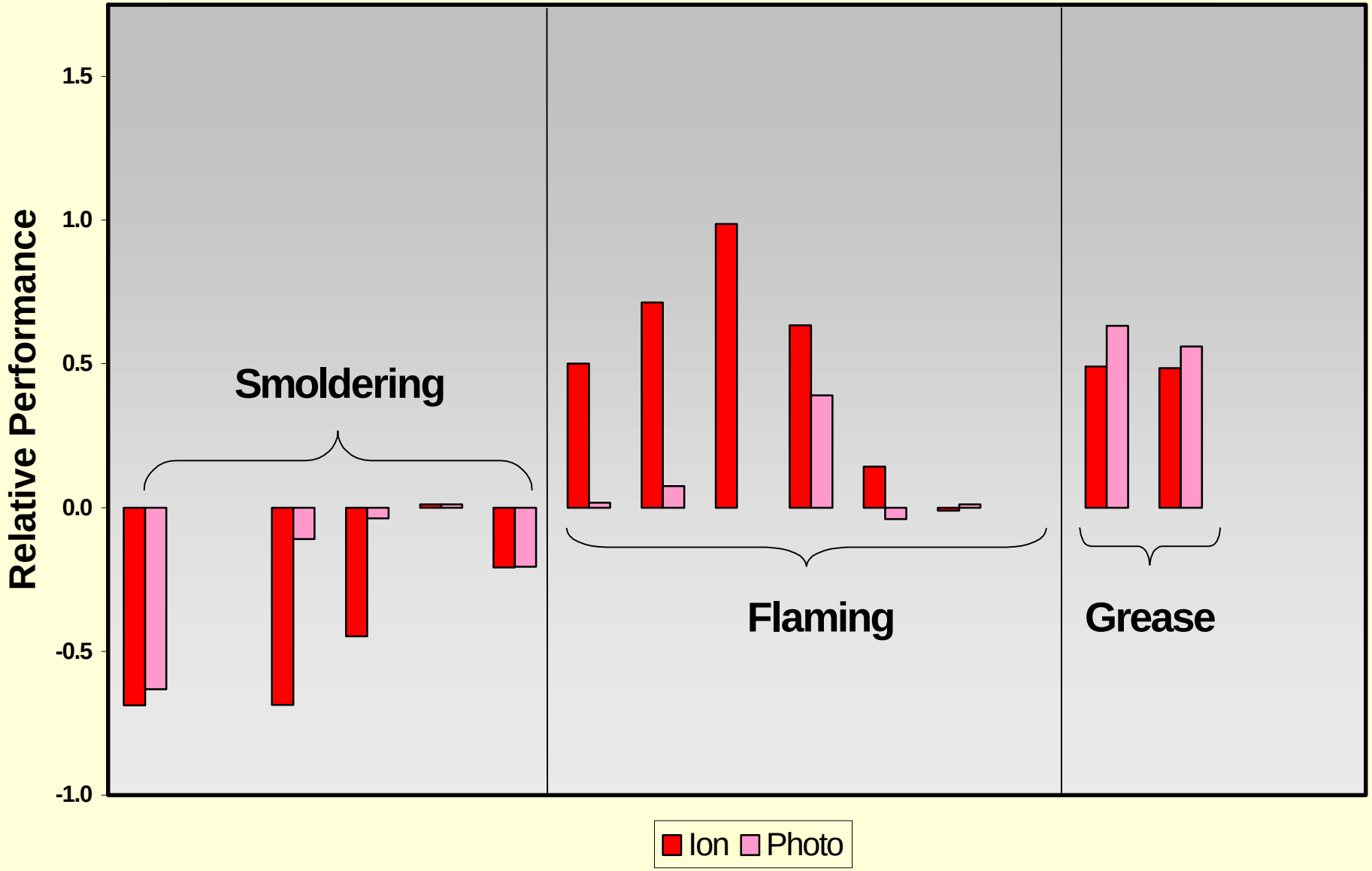
Individual Sensor Performance

- Smoke Obscuration is common to both nuisance sources and real sources.
- CO and Temperature are unique to real sources.

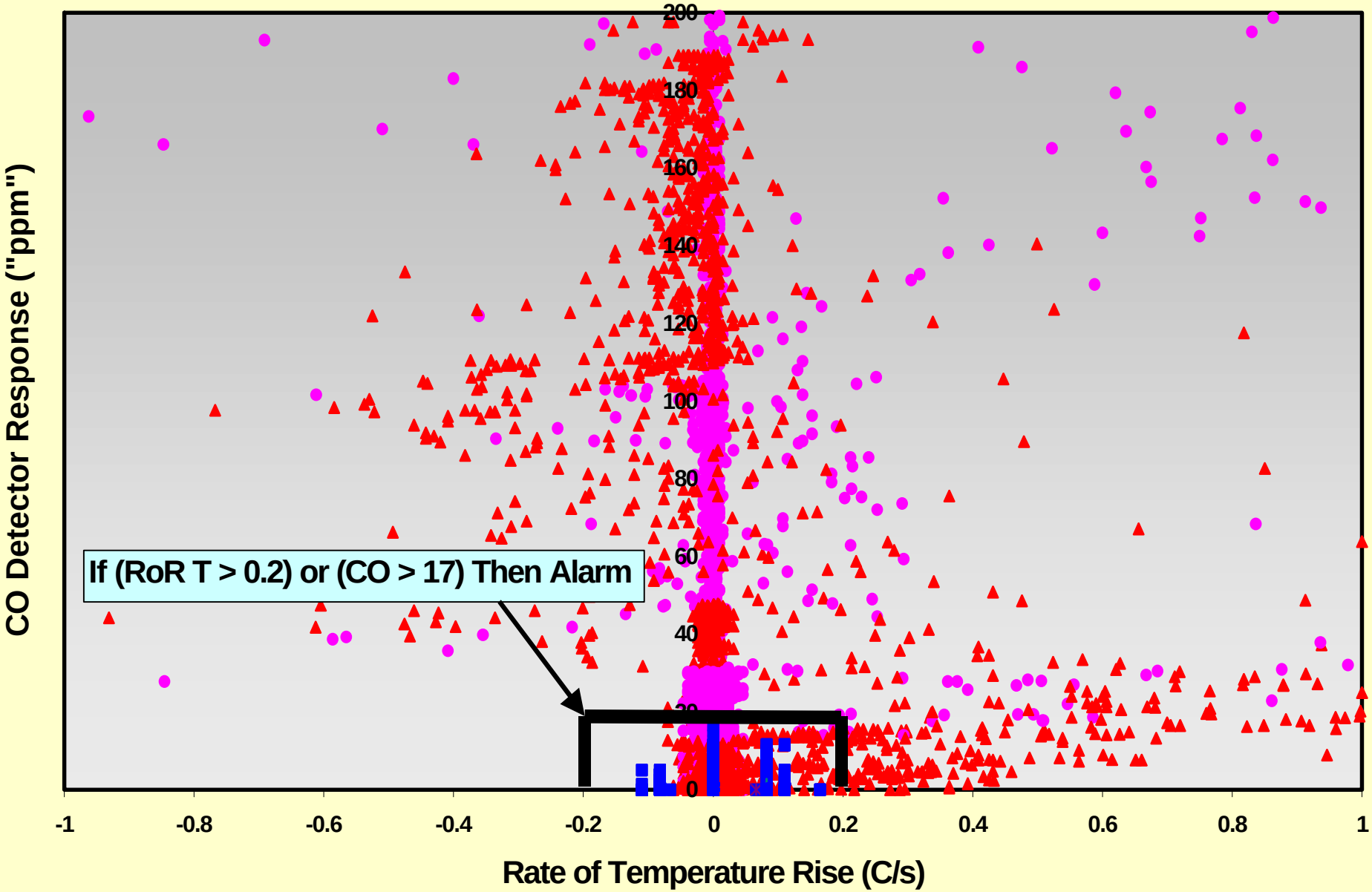
Temperature Rise vs. CO Detector Response



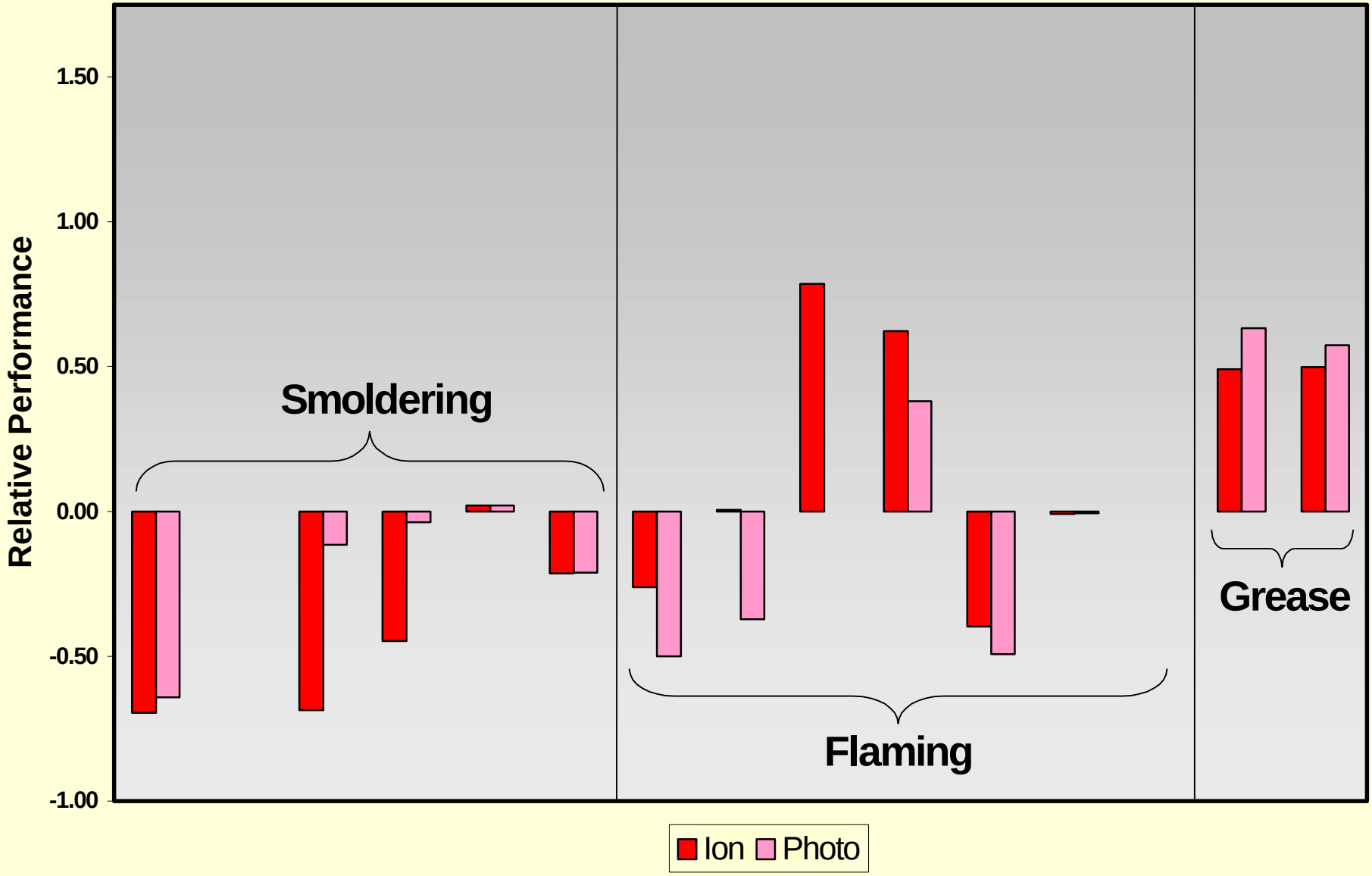
T > [(-1.2 * CO) + 22]
Algorithm Performance



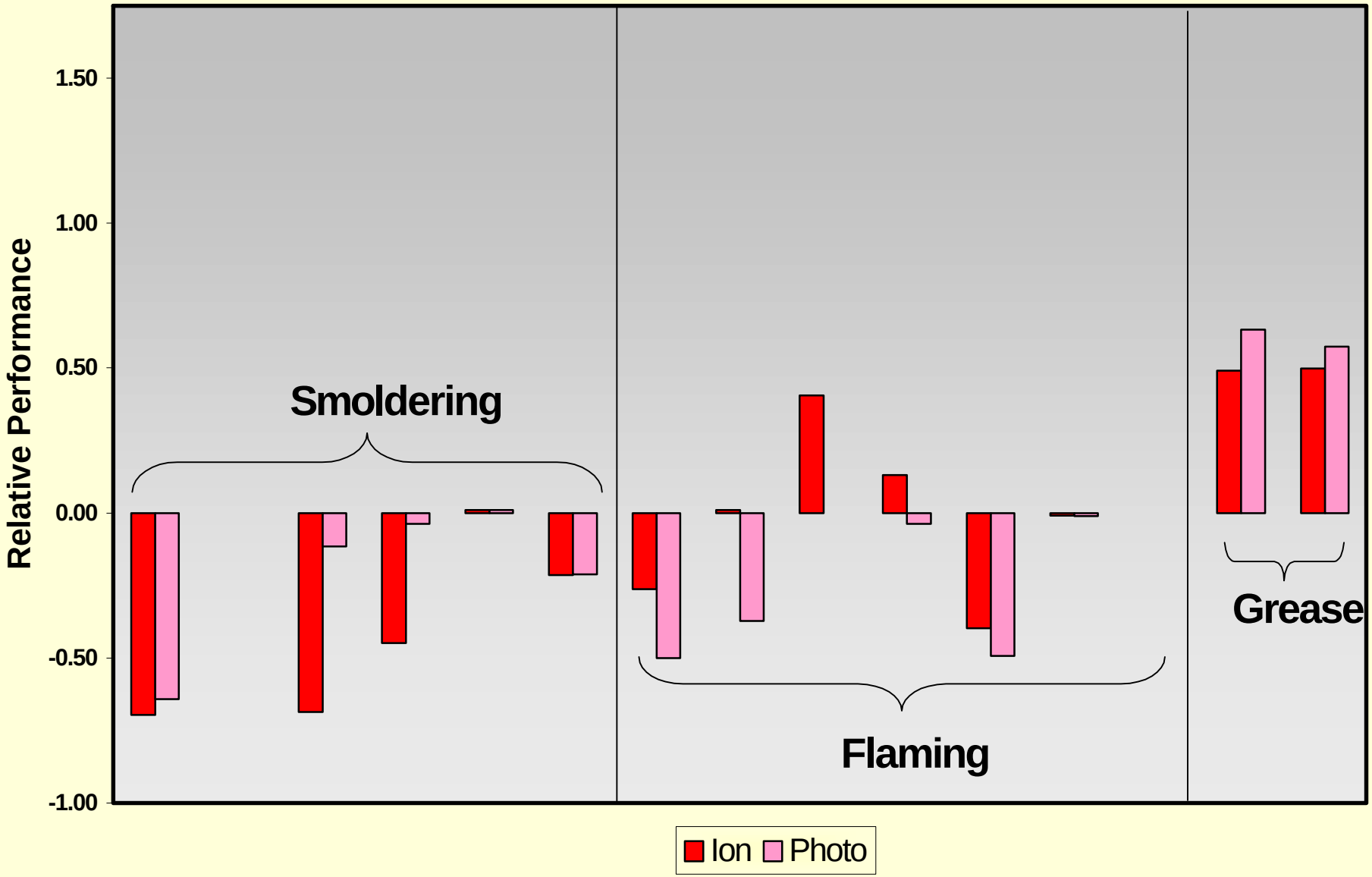
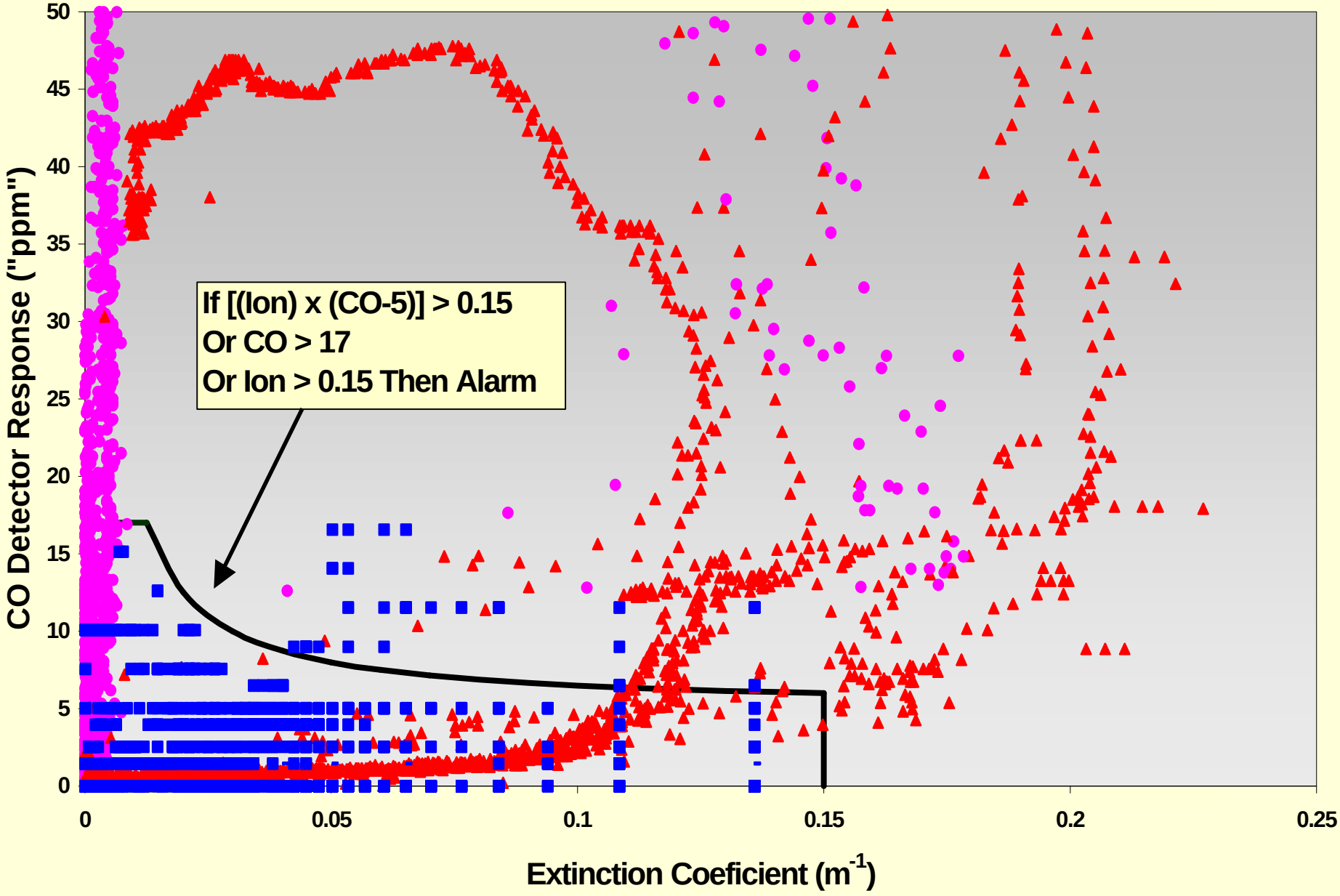
Rate of Temperature Rise vs. CO Detector Response



(dT/dt > 0.20) OR (CO > 17)
Algorithm Performance



(dT/dt > 0.20) OR (CO > 17) OR (Ion > 0.15) Algorithm Performance



Ion vs. CO Detector Response