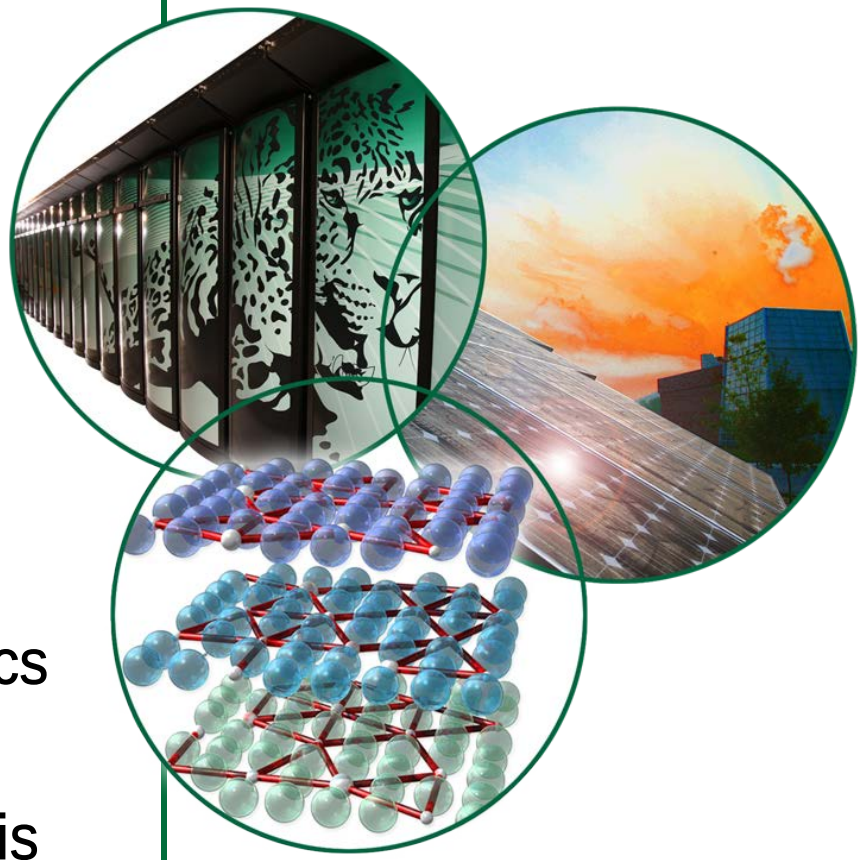
Smart Smoke Alarm



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U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

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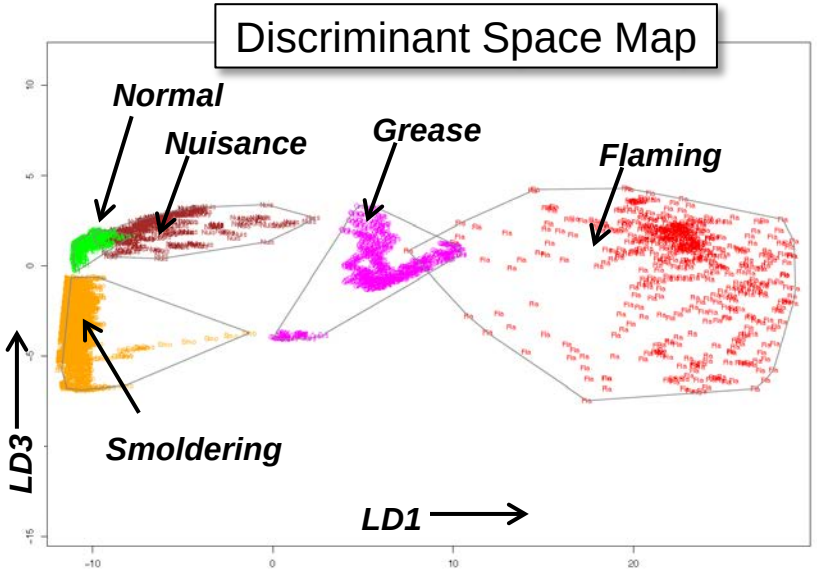
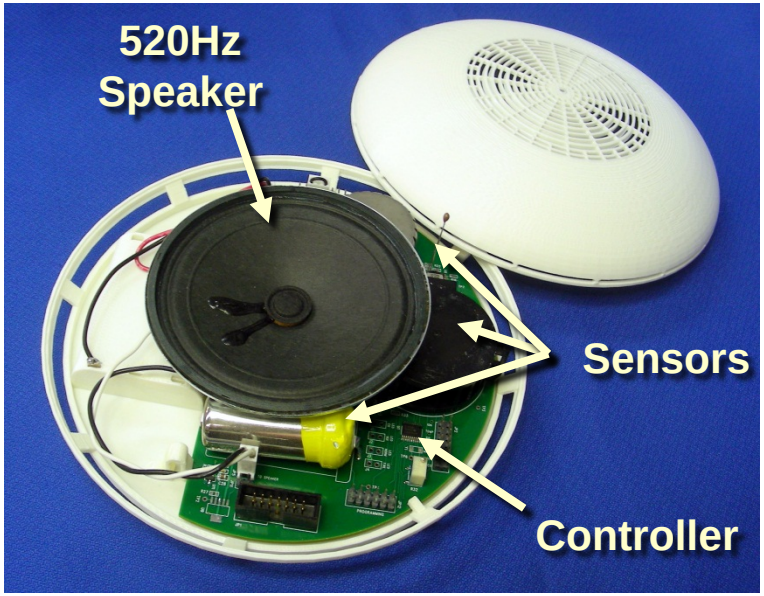
Technology Description



- Smart Smoke Alarm detects fires sooner and with fewer false alarms than present home smoke alarms at comparable unit costs.
- Intelligently combines one or more sensors using an advanced mathematical algorithm to more accurately and rapidly recognize fire conditions.
- Linear discriminant analysis (LDA) is used to distill data from hundreds of residential fire and nuisance tests to allow these inexpensive microcontrollers to recognize and distinguish actual fire hazards from ordinary conditions.

Technology Opportunity



- Smart Smoke Alarm prototype
  - Uses conventional sensors
  - Looks conventional
  - Alerts more quickly for real hazards while suppressing or eliminating false alarms
- TRL-6 prototypes have been built using custom PC board and 3D printer
- Algorithms must be developed to provide optimal discrimination for various sets of commercial sensors
- Development risks are low and depend upon the calibration of fire data and sensors
- Modeling has shown the technology to be effective in recognizing smoldered fires as much as 20-30 minutes sooner while suppressing most nuisance sources.

Technology Leadership

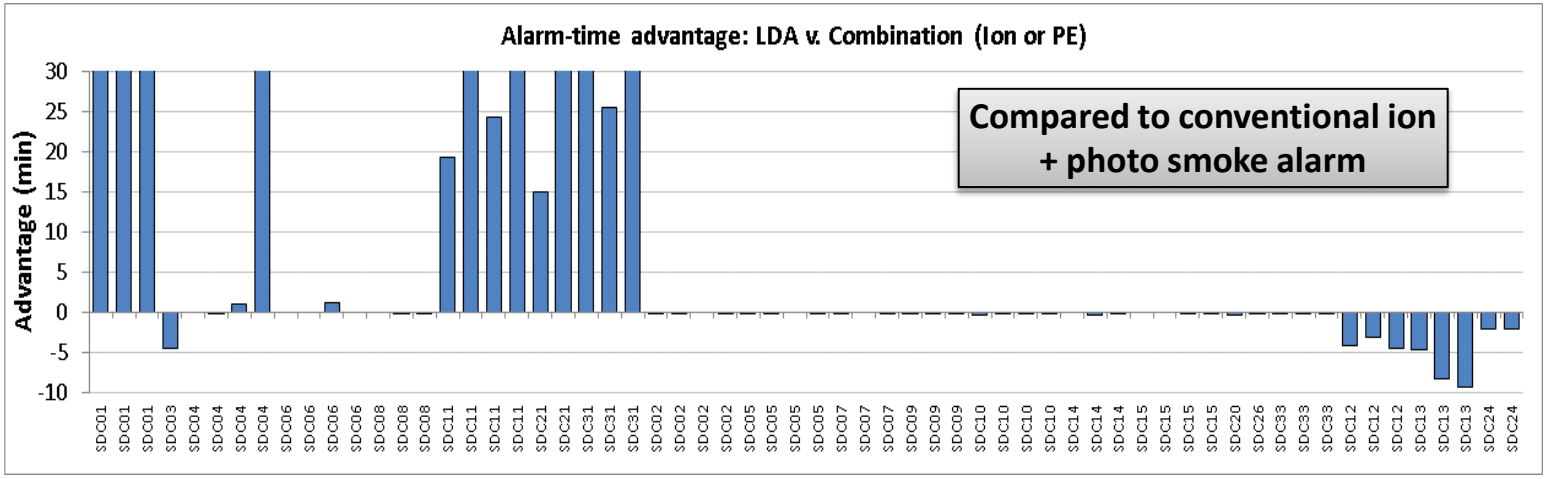
- Smart Smoke Alarm exploits ORNL leadership in advanced discrimination techniques
- Commercial smoke alarms still use threshold levels for alarming – Most alarms are *false* alarms
- Faster detection and <u>complete elimination</u> of false alarms in more than half of cases

Block II CBMS

DHS SNIFFER

Chemring JUNO™

Smoldering ⟷ Flaming ⟷ Grease →



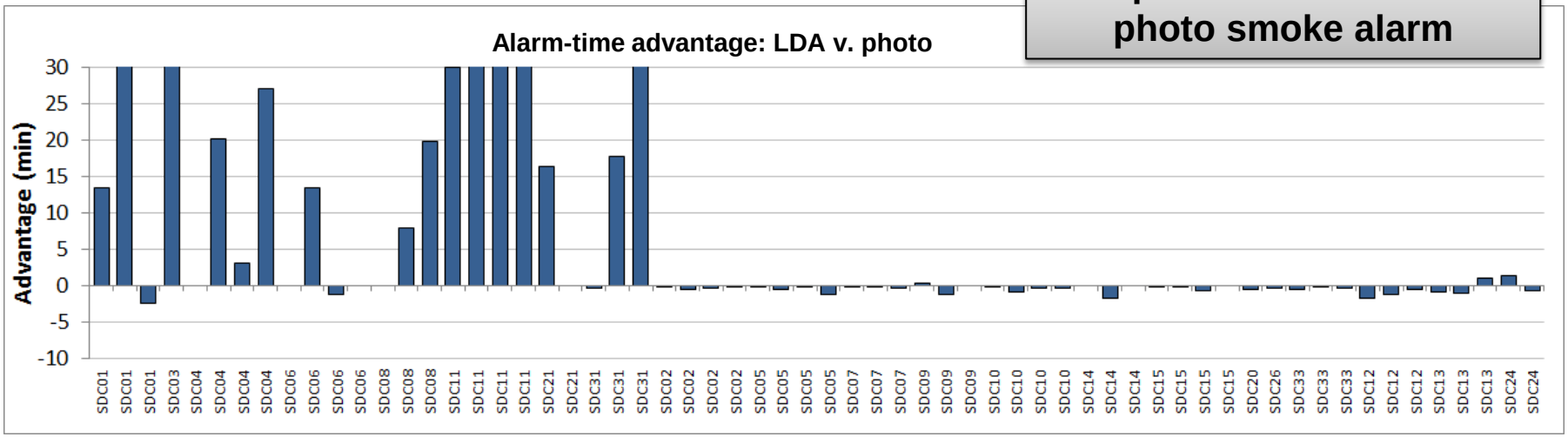
Photoelectric Only

- **LDA with only photoelectric sensor**
  - **Better than conventional photoelectric for smoldering alarms**
  - **Similar performance to conventional for other fires and nuisances**

	Median	Mean	
Smoldering	16.4	20.4	min
Flaming	-0.2	-0.4	min
Grease	-0.8	-0.5	min
Nuisance	0.0	1.4	min
Nuisance	0%	suppressed	

— Processing alone improves alarm —

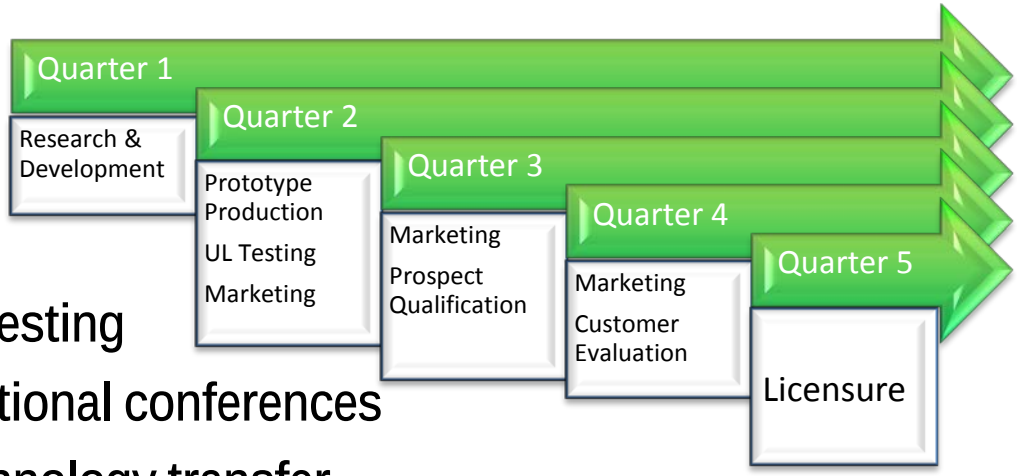
Compared to conventional photo smoke alarm



Research and Development Plan

- Optimize classification to recognize hazardous and non-hazardous situations for various sets of sensors — Dec 2013
- Implement optimized LDAs in real systems — Dec 2013
- Produce a suite of fully functional demonstration units — Jan 2014
- Validation testing at UL — Feb 2014
- Key challenge is to ensure that systems alarm as fast or faster to all fires as conventional alarms and that nuisance alarms are reduced or eliminated completely

Commercialization Plan



- Plan:
  - Validate compliance with UL217 testing
  - Present and publish results at national conferences
  - Develop technical tutorial for technology transfer
  - Produce demonstration units for manufacturer testing
  - Qualification & Licensure
- Prospective partners:
  - Kidde (United Technologies Corp.)
  - First Alert (BRK Brands, Inc.)
  - Universal Security Instruments, Inc.
  - Others … newcomers (?)
  - Possible additional market in the commercial sector with Tyco International Ltd., Honeywell Life Safety, and Siemens Fire Safety

Applications – Target Customers – Current Practice

	Application Description	Target Customers	Current Practice
Basic	Single sensor with smart control	Entry level consumer, Contractors	Single sensor with threshold
Enhanced	Dual sensor with smart control	Cost conscious but safety minded consumer	Dual sensor with thresholds
Enhanced /CO	Smoke sensor with toxic protection and discrimination	Safety minded consumer	Combination smoke/CO alarm (limited connection between each)
Superior	Full suite of sensors	Homeowners wanting the highest performance and protection	None for homeowners

Competitive Differentiation

Technology Feature	ORNL Technology	Kidde	Kidde Intelligent	First Alert	Universal Iophic
Smoke detection	✓	✓	✓	✓	✓
Toxic gas protection	✓	✓	✓	✓	✗
Enhanced fire detection	✓	✗	✓	✗	✓
Nuisance rejection	✓	✗	✗	✗	✗
Enhanced alerting	✓	✗	✗	✗	✗

Market Opportunity

- Market is estimated at 20 million units annually or roughly $500 million
- Since the technology is adaptable for even single-sensor units at little incremental cost, none of the market is excluded
- Introduction of higher performance models are likely in the first year, followed by a progression of lower priced units to replace outdated designs
- Single-sensor alarms are unlikely to pass future standards
- Awareness of CO risks will help drive models that have high performance for fires and toxic hazards

Motivation

- Since 1975, the number of deaths due to home fires has been cut in half.
- Nevertheless, in 2012*
  - Residential Fires: 381,000
  - Lost lives: 2,405
  - Injuries: 12,875
  - Property Loss: $7.2B

Capt. Gary Watlington
ORNL Firefighter

- Residential construction methods and home furnishings have decreased safe egress times from an average of 17 minutes in 1975 to about 3 minutes in 2008
- Alerting occupants sometimes can be problematic

* M.J. Karter, Jr. *"Fire Loss in the U.S. During 2012"* Nat. Fire Protection Assoc., NFPA FLX10-01, September 2013.

Contact Information

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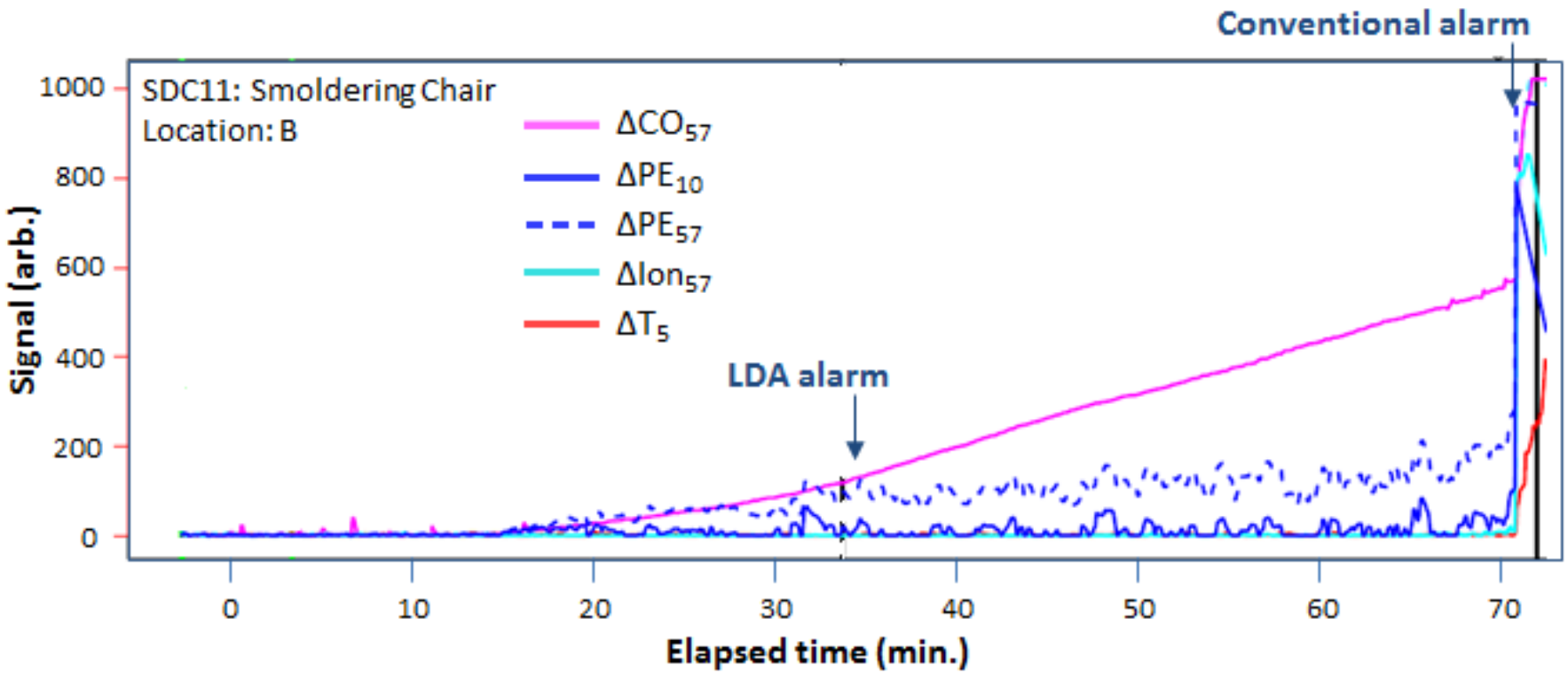
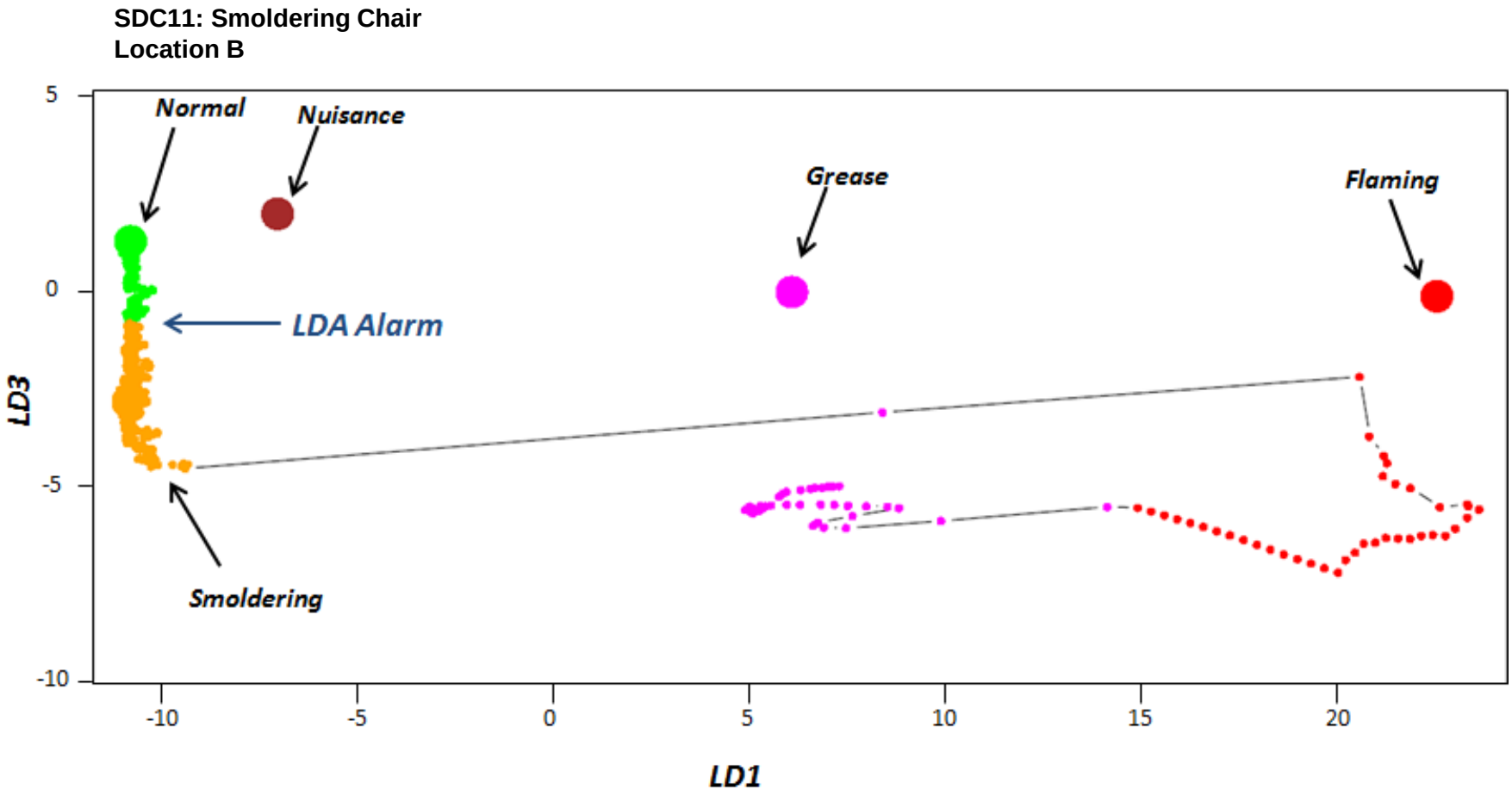
Sensor Response Example

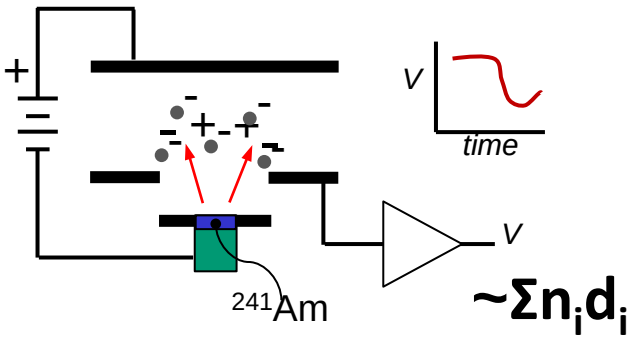


The LDA alarm triggered at 33.9 min., while the conventional smoke alarm (ion + photoelectric), alarmed at 70.5 min.

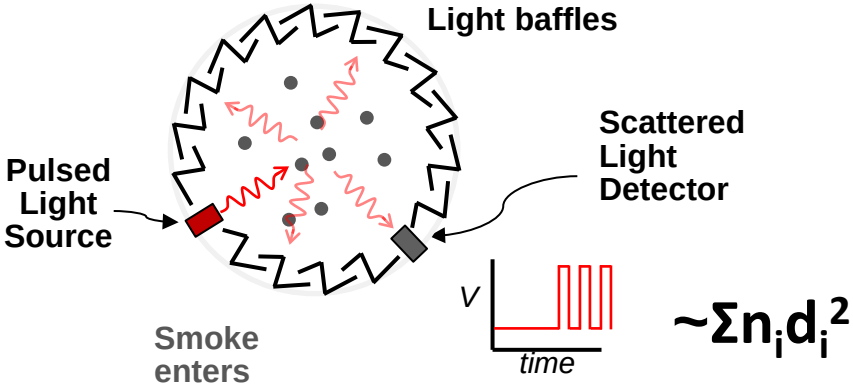
Discriminant Space Example



Smoke Detectors



ION



Photoelectric

- **Ion detectors are sensitive to smaller aerosols generally associated with fast flaming fires**
- **Photoelectric detectors are sensitive to larger aerosols generally associated with slow smoldering**
  - **Larger particles (> λ/3) scatter light – visible**
  - **Smaller particles (< λ/3) – invisible**