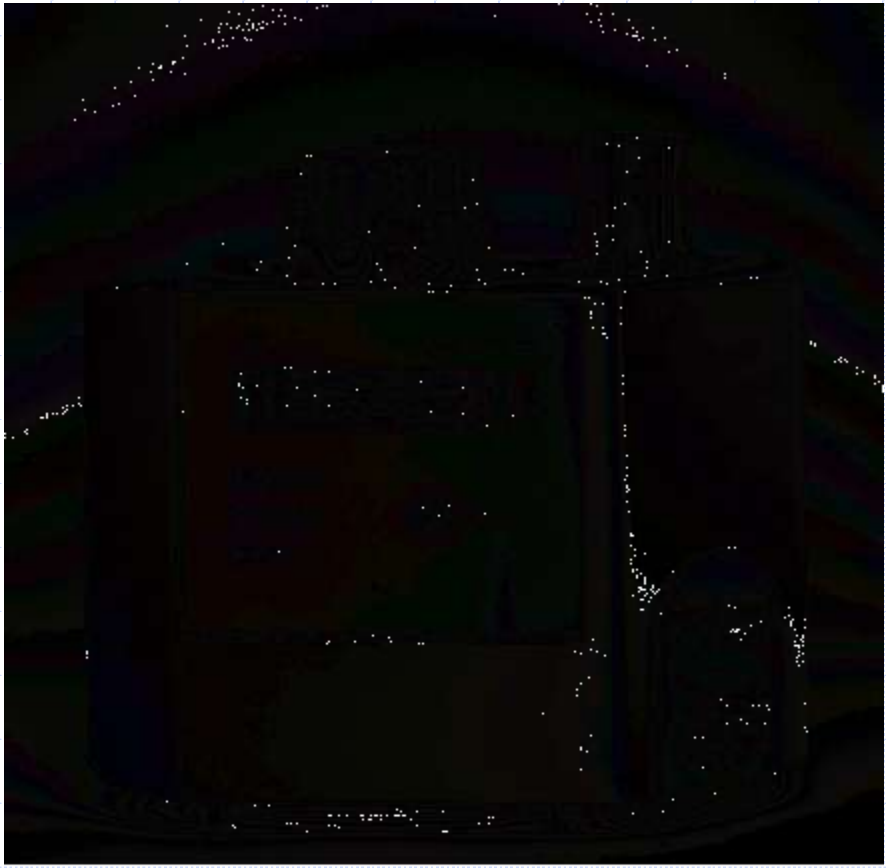
Alpha-7A with Remote Head

Standard In-Line Alpha-7

- In-line Detector
- Flexible, Use:
  - For Stacks
  - For Room Air



The Issues

- Algorithms
  - How well does the Alpha-7 work?
- Response Times
  - How fast does the Alpha-7 alarm?
- Reliability
  - Can a PC-Based System be reliable?

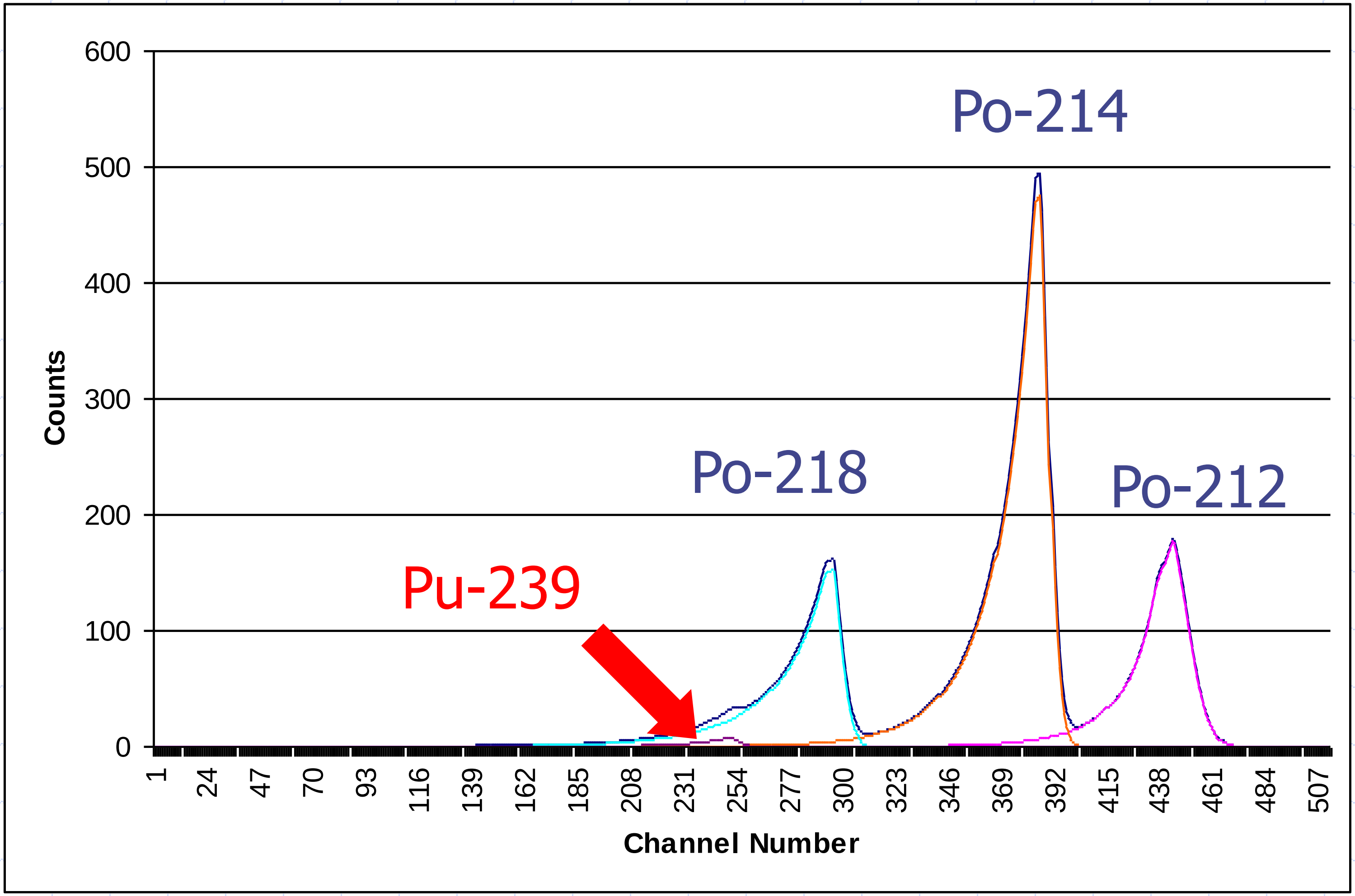
Background Compensation

- ROI's - Alpha-6 series and others
  - 4 or 5 ROI's, mathematical relationships
  - Slight problems with varying conditions, age of filter, and unexpected isotopes
- Peak shape analysis – Alpha-7
  - Non-linear least squares analysis
  - Less dependent on the age of the filter
  - Not affected by noise in the spectrum
  - Analyzes for multiple isotopes

The Alpha-7 Algorithm

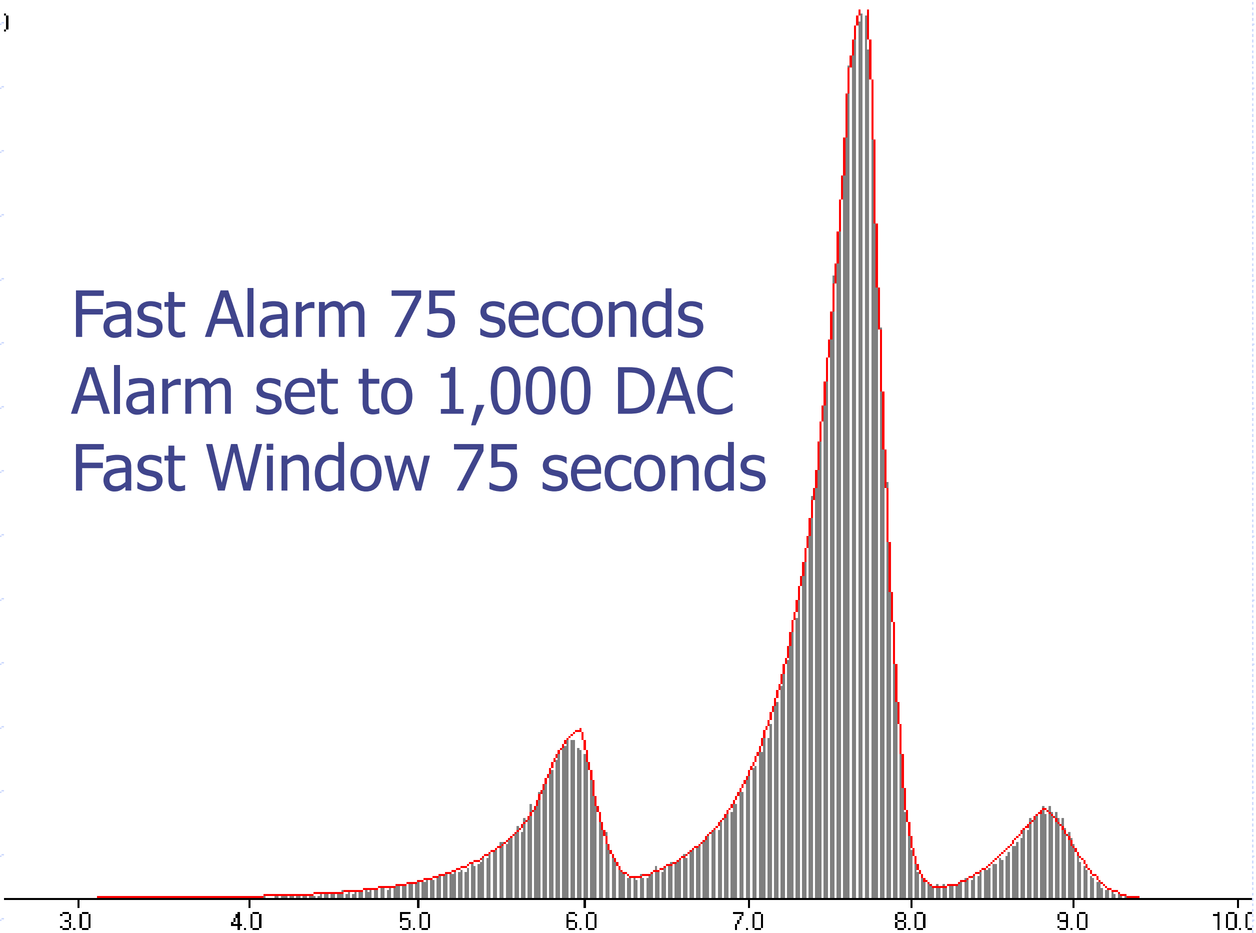
- Library directed peak analysis
- Measures 8 isotopes simultaneously
  - 3 or 4 usually allocated for radon progeny
- Simultaneous fast and slow analysis
  - Independent analysis times for each isotope
- Calculations performed once each second
  - Uses variance of the area under the peak for the calculation of the MDC

Peak Fit Example (Real Data)



Pu-238 with Radon

1,000 DAC on ~330,000 Counts of Radon

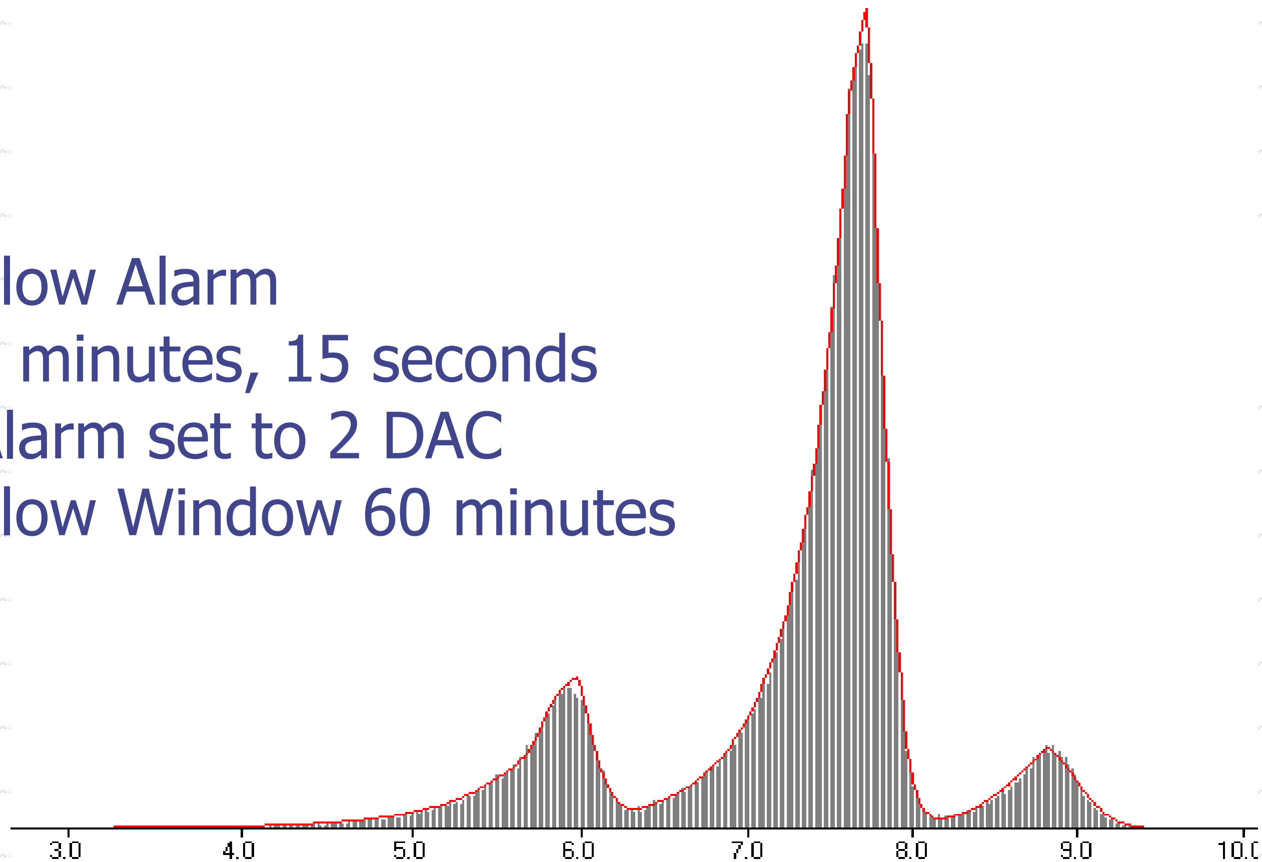


Fast Alarm 75 seconds
Alarm set to 1,000 DAC
Fast Window 75 seconds

Pu-238 with Radon

1,000 DAC on ~330,000 Counts of Radon

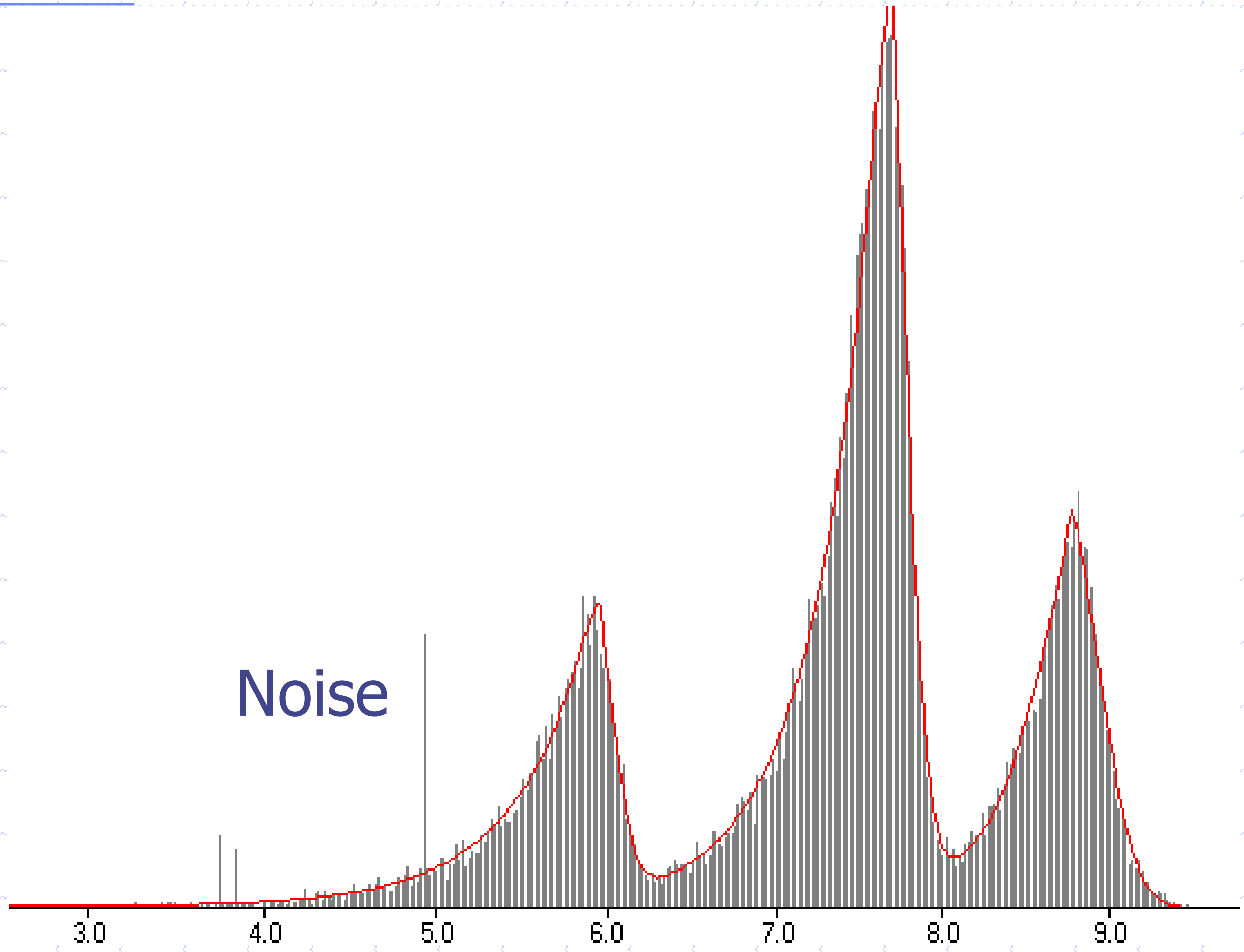
Slow Alarm
3 minutes, 15 seconds
Alarm set to 2 DAC
Slow Window 60 minutes



Peak Shape Analysis

- Works extremely well for radon/thoron in disequilibria
- Works extremely well for longer filter collection times
- MULTIPLE ISOTOPES
- More sensitive – as proven by the comparison with the Alpha-6 series
- More noise resistant – the algorithm indicates problems with the peak shape and is not affected by single channel noise

Spectrum Noise



FIFP15 Filter Benefits

- Better resolution – provides lower MDC
- Lower pressure drop
- Less frequent filter changes
- Very rugged – i.e. will not crack
- Black back reduces improper filter orientation/placement

On-line Energy Compensation

- Alpha-6 and Canberra Alpha Sentry track the 7.68 MeV peak
- Alpha-7 uses 3 "reference peaks"
  - Performs an analysis for the best fit
  - Much more accurate than tracking a single peak
- Alpha-7 also analyses the peak shape for problems with the spectrum
  - Noise, other isotopes, improper filter placement

Alpha-6 Series Equation

$$Pu239cpm = ROI1gain - C(3) \times \frac{ROI3gain}{ROI4gain + 1} \times ROI2gain$$

Where:

Pu239cpm = net count rate for Pu-239

ROI1 = plutonium peak, channels 100 to 121

ROI2 = 6 MeV upper part from channels 128 to 139

ROI3 = RaC' 7.68 MeV lower part

ROI4 = RaC' 7.68 MeV upper part

C(3) = Correction factor

Alpha Sentry Equation

$$A_{TRU} = A_{\text{user selected region}} - T_{8.78} - T_{7.68} - T_{6.05}$$

Where:

A_{TRU} = net transuranic area

$A_{\text{user selected region}}$ = gross transuranic area

$T_{8.78}$ = area of the tail from Po-212

$T_{7.68}$ = area of the tail from Po-214

$T_{6.05}$ = area of the tail from Bi-212

Exponential fit is used for the calculation of the area

Alpha Sentry Equation

$$C_{Pu}(T_i) = \frac{T_i[A_{Pu}(T_i) - A_{Pu}(T_{i-1})]}{T_c^{\,2} \varepsilon_D K_{xxx} V}$$

Where: C_{Pu} = current plutonium concentration in air

$A_{Pu}(T_i)$ = plutonium net area at current time T_i

$A_{Pu}(T_{i-1})$ = plutonium net area previous interval T_{i-1}

T_i = time since the filter was last changed (in hours)

T_c = spectrum collect time (in hours)

V = volume of air (in liters) collected

ε_D = detector counting efficiency

K_{xxx} = unit conversion factor

Alpha-7 Equation

$$C = \left(\frac{(R_1 - R_0)}{T_A} + \mathbf{R_0} \times \boldsymbol{\lambda} \right) \times \frac{Y}{V \times K_U \times E_D}$$

Where:

C = activity per unit volume for the specific isotope

R_1 = net count rate from the current interval

R_0 = net count rate from the previous interval

T_A = actual analysis time in seconds

λ = decay constant for the isotope

Y = calculated yield of the isotope

V = air volume collected in the time interval

K_U = calibration constant for unit conversion

E_D = detector efficiency

Alpha-7 Start Up

For $T_i < 2 \times T_A$

$$T_{A(Ti)} = \text{Integer}\left(\frac{T_{Total}}{2}\right)$$

For $T_i \geq 2 \times T_A$, T_A is used in the equations.

Where:

T_i = current time

$T_{A(Ti)}$ = analysis interval used at T_i

T_A =analysis time

State of the Art Hardware

- 512 channel MCA
  - Better peak definition, lower MDC
- Pentium class processor
  - Much faster analysis
  - PC easily upgraded or replaced
- 10/100 Ethernet – simple wireless
  - Many advantages, great capability
  - Updating A7 software across the network

Embedded PC

- Embedded PC
  - Easily replaced – industry standard format
  - New technology, not available 3 year ago
  - Simple memory upgrades
  - Simple change to new operating systems
- No moving parts for enhanced MTBF
  - No Cooling Fan

Response Times

- Analysis EACH second for EACH isotope
- Fast and Slow Concentration Alarms
  - Optimized for Acute and Chronic Exposures
- N of M alarm logic is offered
  - Alpha-7 updates each second, it’s much faster than units using ROI’s with 30 second (or longer) analysis times

Response Times

Pu-239 DAC	CAM Response Time at the Assumed release Duration			
	10 h	1 h	10 min	1 min
1	70 min	75 min	No Alarm	No Alarm
10	24 min	24 min	No Alarm	No Alarm
100	5 min	5 min	5 min	No Alarm
1,000	1.5 min	1.5 min	1.5 min	1.5 min
10,000	15 sec	15 sec	15 sec	15 sec