ALPHA SPECTRUM ANALYSIS ALGORITHMS AND ALARM STRATEGIES FOR CAMS (CONTINUOUS AIR MONITORS)

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PURPOSE

This presentation will cover only some of the possibilities in alpha spectrum analysis algorithms and alarm strategies as they apply to alpha Continuous Air Monitors

ALPHA SPECTRUM ANALYSIS ALGORITHMS AND ALARM STRATEGIES FOR CAMS

What are some of the variables we need to consider?

What are some of the analysis algorithms?

Variable	Number of Variations
Air sampling rate	30, 37, 45, 60 LPM (and in both SLPM and ambient LPM)
Sample collection media	SSWP, SMWP, Fluoropore 3 and 5 micron, RW19, GFA
Sample collection diameter	22, 25, 37, 42, 44 mm

Variable	Number of Variations
Detector type	SB, DJ, Ion Implant, Depletion depths from 50 to 1,000 microns; protective coatings with thickness from from 25 to 50 microns (metal and metal + plastic coatings with various metals and plastic coating)

Variable	Number of Variations
Detector diameter	25, 37, 50 mm
Preamplifier	specific by manufacturer

Variable	Number of Variations
MCA	specific by manufacturer
Detector to sample spacing	4, 7, 12 mm
Alpha particle collimator	Most CAMs do not use a collimator; 2 types have been used

Variable	Number of Variations
Analysis algorithm	specific by manufacturer
Alarm strategy	specific by manufacturer

Typically a specific CAM type does not utilize multiple analysis algorithms or alarm strategies.

Just with these possible variations there are several million ways an alpha CAM could collect and quantify the airborne radioactivity!

What are some of the analysis algorithms?

Algorithm	Description
Gross counting	Count all events in the detector above a set threshold; there is NO compensation for radon and thoron progeny
Single window counting	Count all events in the detector between the lower and upper discriminators

Algorithm	Description
Two window counting	Count the events in the detector in a lower and upper alpha energy window and subtract a percentage of the upper window counts from the lower window counts.

Typically the lower window would be set for the alpha particle energies the user wishes to quantify and the upper window would be set for the interfering radon and thoron progeny.

Algorithm	Description
Multiple ROIs (regions of interest)	**3, 4, or 5 ROIs, individual peaks, splitting peaks into low and high energy tails, subtraction K factors**
Peak shape fitting	**Subtraction of the low energy tail of the interfering radon and thoron progeny**
	Self-Adaptable peak shape fitting

Example Pu-239 ROI Algorithm

Defined Program Variables

F	Sample Volume in Cubic Feet since reset
G	Time Stamp
H	Flow Deviation
I	Sample Flow Rate in CFM

Default User Constants

1	1.00	Nominal Flow Rate (1 CFM)
2	5.00	Spectrum Acquisition Interval (5 sec default)
3	0.12	Algorithm ‘K’ Factor
4	0.22	Detector Efficiency

Default Alarm Setpoints

1	I < 0.1 CFM	Flow Fail
2	D > 100,000 CPM	Noise Alarm
3	A > 6 x E net cpm (6 sigma)	Fast Alarm
4	A > 2.5 E net cpm (2.5 sigma)	Slow Alarm
5	H > 0.20 CFM	Flow Out of Limits
6	C > 0.02 pCi/L	Concentration

DEFINING THE ROIs

ROI		Channels	Definition
0	Q	000..255	Entire Spectrum
1	R	100..121	Pu-239 5.15 MeV Peak
2	S	136..143	Po-218/Bi-212
		(6.00/6.05 MeV High Energy Tail)	
3	T	146..178	Po-214
		(7.68 MeV Low Energy Tail)	

DEFINING THE ROIs

ROI		Channels	Definition
4	U	179..185	Po-214
		(7.68 MeV High Energy Tail)	
5	V	190..215	Po-212 (8.78 MeV Peak)
6	W	235..255	Upper Guard ROI
7	X	020..040	Lower Guard ROI

Default User Variables

A Pu-239 CPM

$$(R - R_{59}) - CONST(3) \times \frac{(T - T_{59})}{(U - U_{59} + 1)} \times (S - S_{59})$$

B Pu-239 Counts

R - CONST(3) x T / U x S

Default User Variables

C Concentration (pCi/L)

$$[(B_{64} - B_{94}) - (B_{94} - B_{124})] \times \frac{0.00053}{\text{Const }(4) \times (F_{79} - F_{109})}$$

D Noise CPM

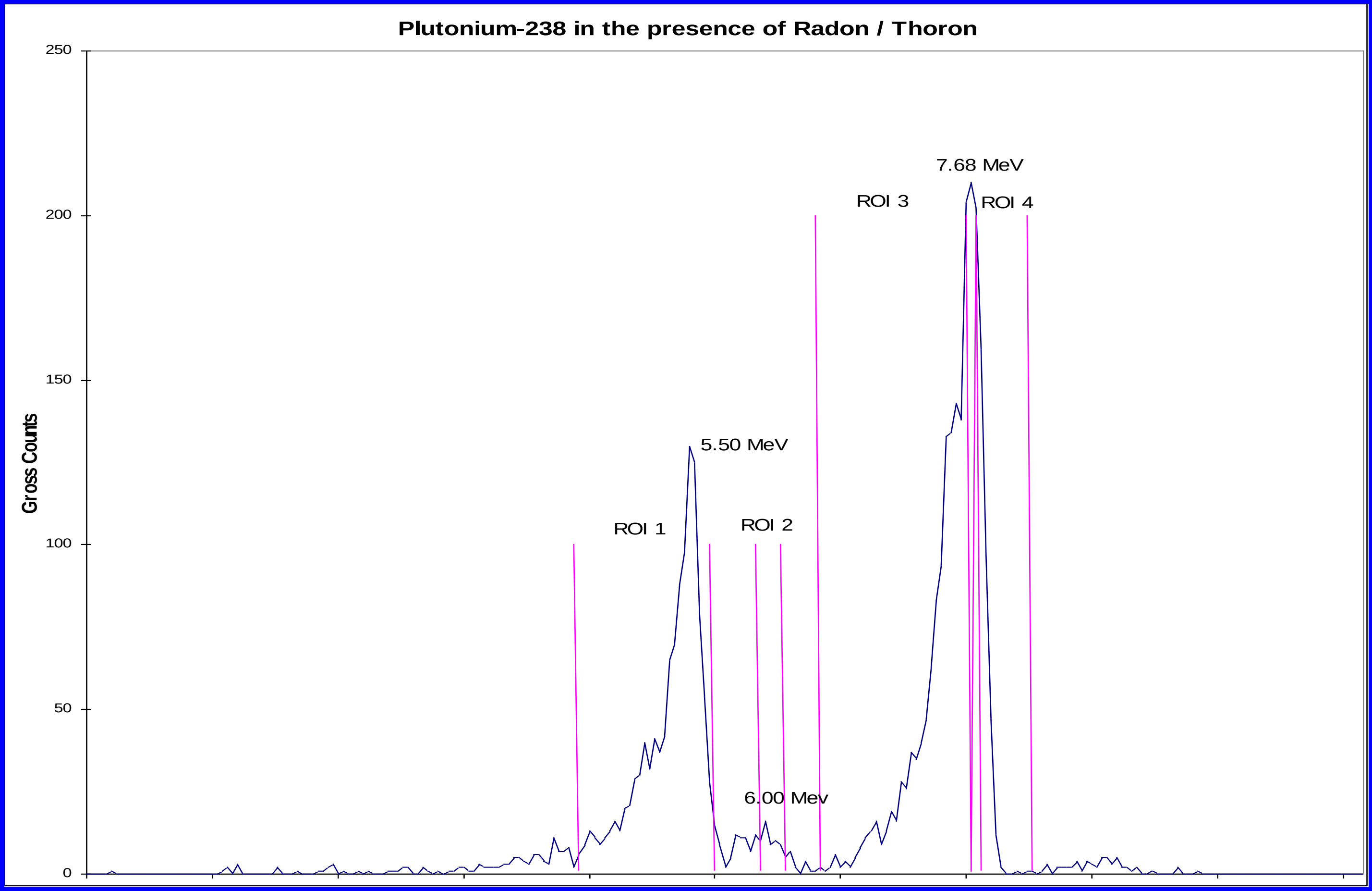
$$(W - W_{59}) + (X - X_{59})$$

Default User Variables

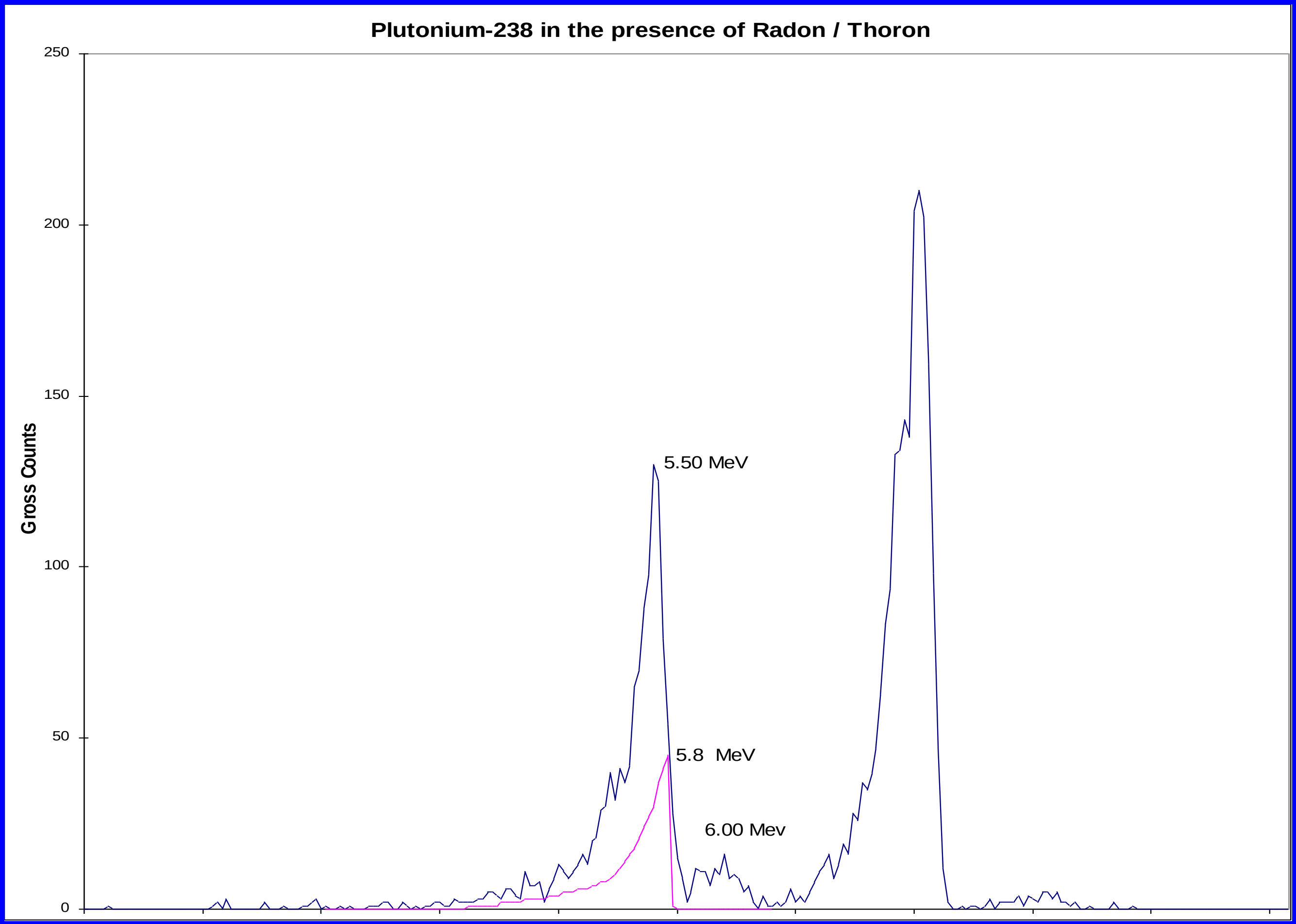
E Sigma CPM

$$\sqrt{(R - R_{59}) + \left[CONST(3) \times \frac{(T - T_{59})}{(U - U_{59})}\right]^2 \times (S - S_{59})}$$

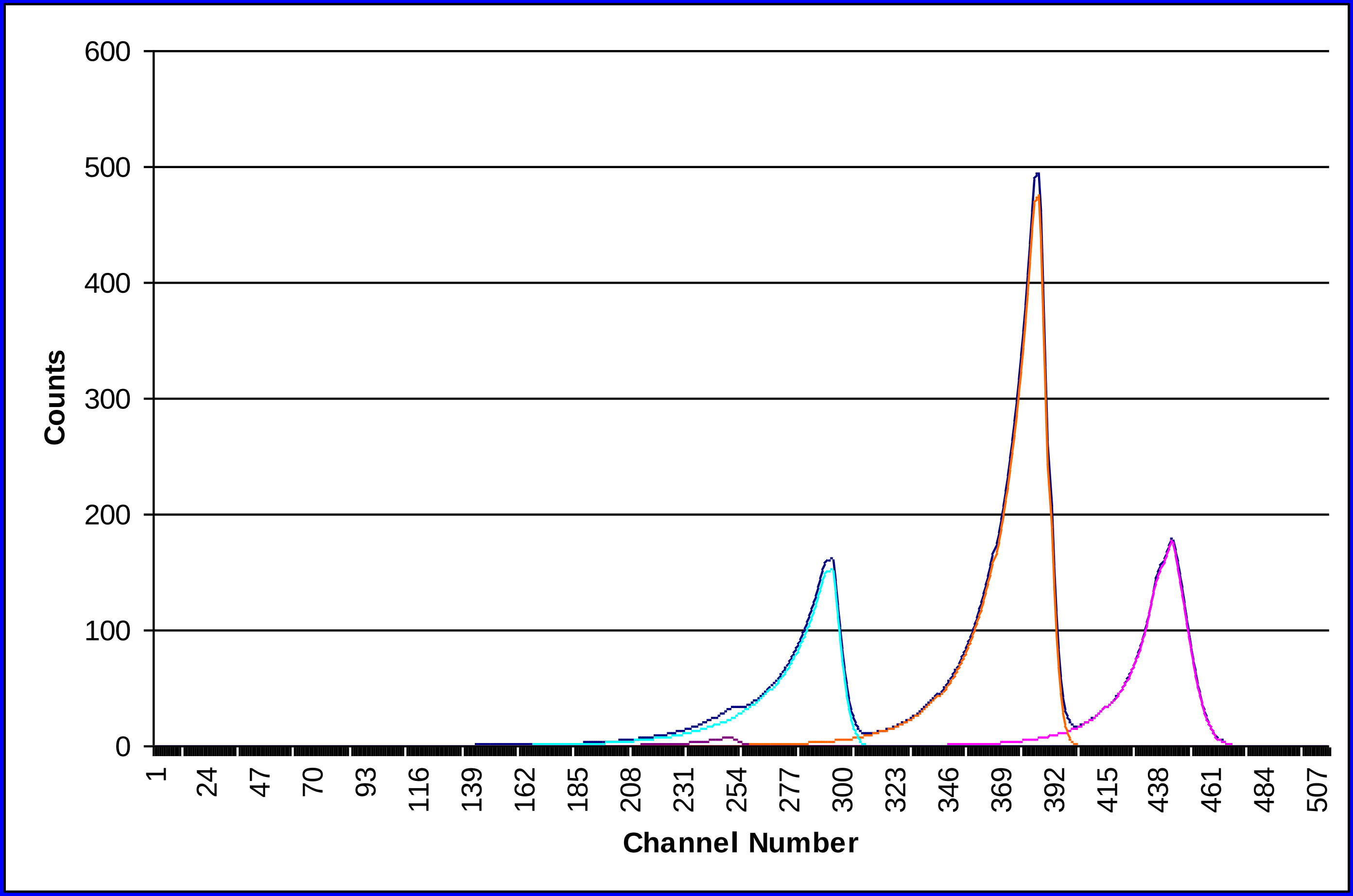
EXAMPLE OF THE “ROI” METHOD OF ANALYSIS



EXAMPLE OF "EXPONENTIAL FIT" OF LOW ENERGY TAIL



EXAMPLE OF "PEAK SHAPE" FITTING MEHOD OF ANALYSIS



CONCLUSIONS

There are many variables to consider.

There are many different ways those variables can be applied.

The user of the equipment needs to be aware of how the equipment will operate.

CONCLUSIONS

A subject matter expert is needed to determine the operational parameters of the equipment.

A subject matter expert is needed to setup the equipment and explain to the user how it will work.

CONCLUSIONS
ALARM STRATEGIES

‘N’ of ‘M’ Logic
‘PEAK SHAPE’ Recognition
‘Timed Coincidence’ Counting
Duplicate Counting
Rate of Rise Comparison Counting
Multiple Analysis Algorithms Running Concurrently
Multiple Alarm Strategies Running Concurrently