

**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 | $A > 6 \times E$ 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

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

B Pu-239 Counts

$$R - \text{CONST}(3) \times T / U \times S$$

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

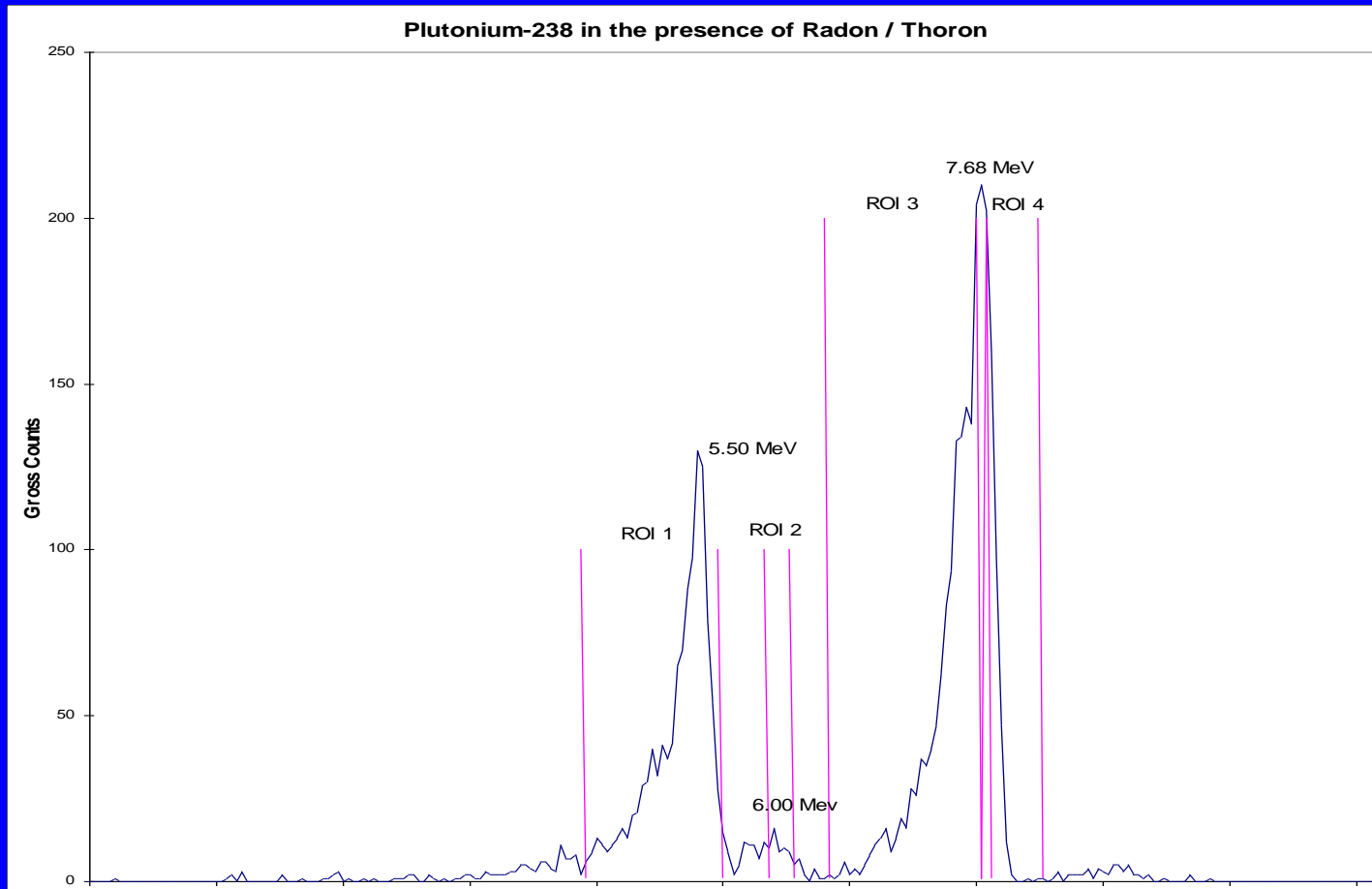
$$(W - W_{59}) + (X - X_{59})$$

Default User Variables

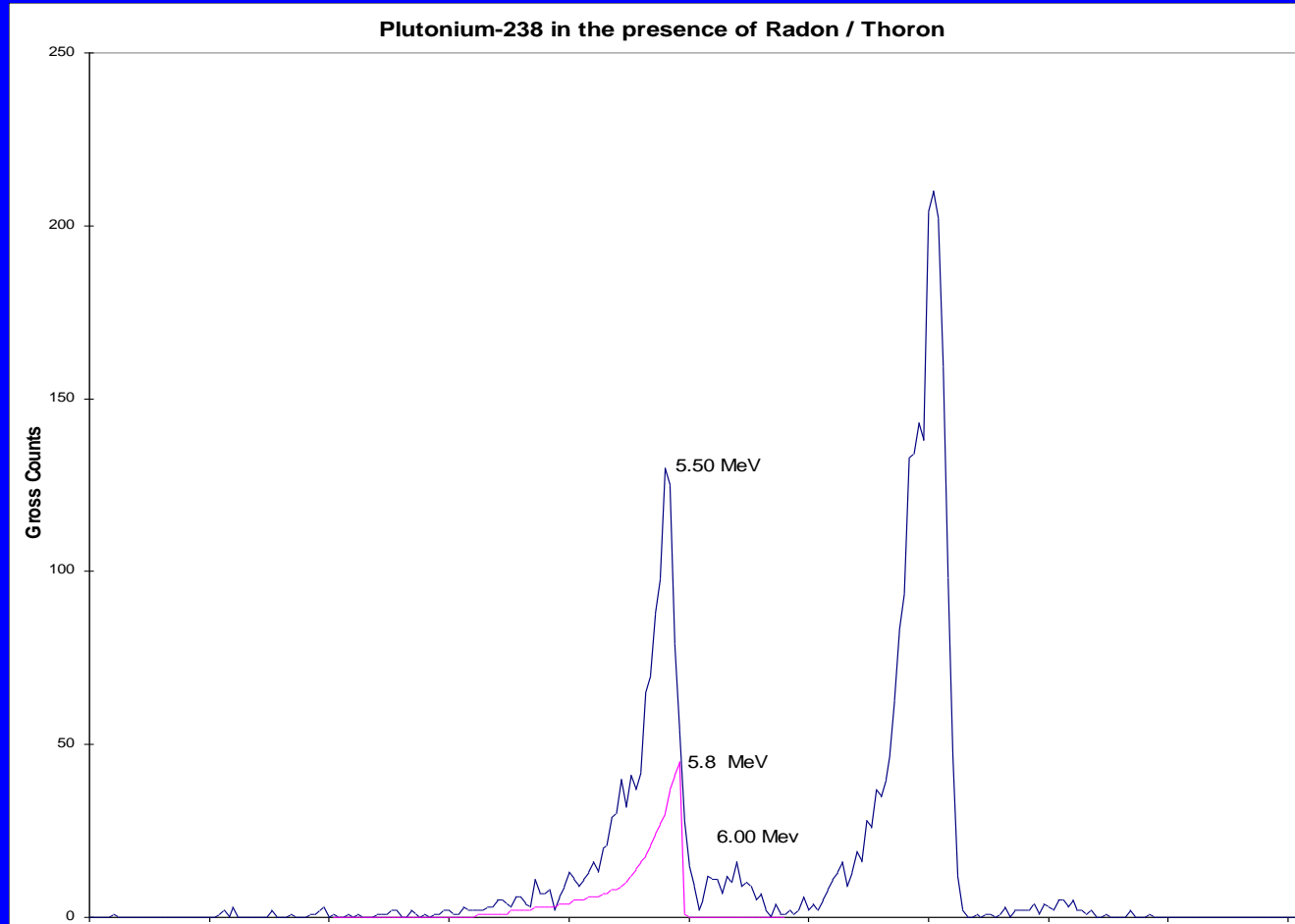
E Sigma CPM

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

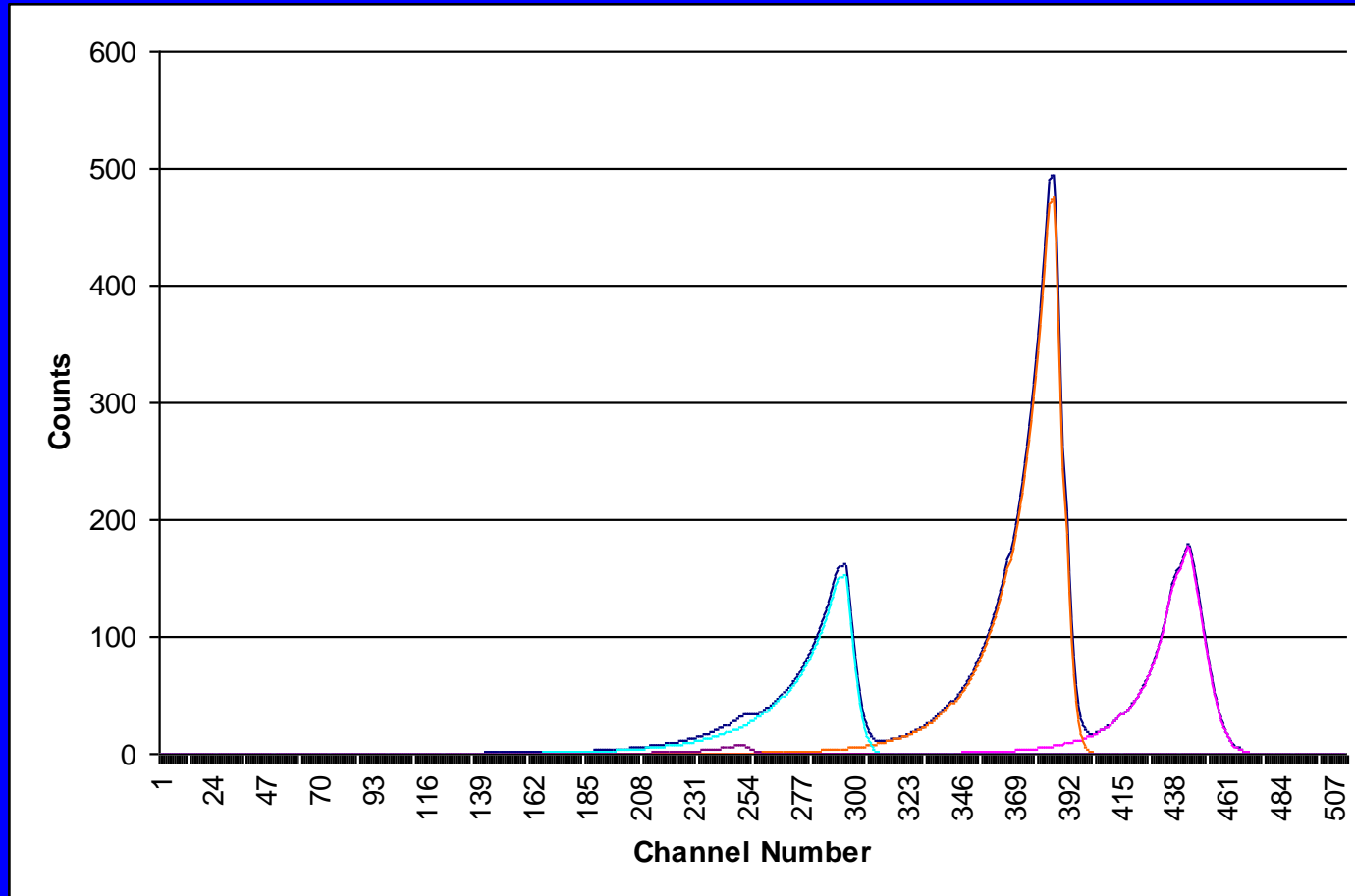
EXAMPLE OF THE "ROI" METHOD OF ANALYSIS



EXAMPLE OF “EXPONENTIAL FIT” OF LOW ENERGY TAIL



EXAMPLE OF "PEAK SHAPE" FITTING METHOD 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