Into the Wilds of Alpha Spectroscopy

Surprising treasures in the details

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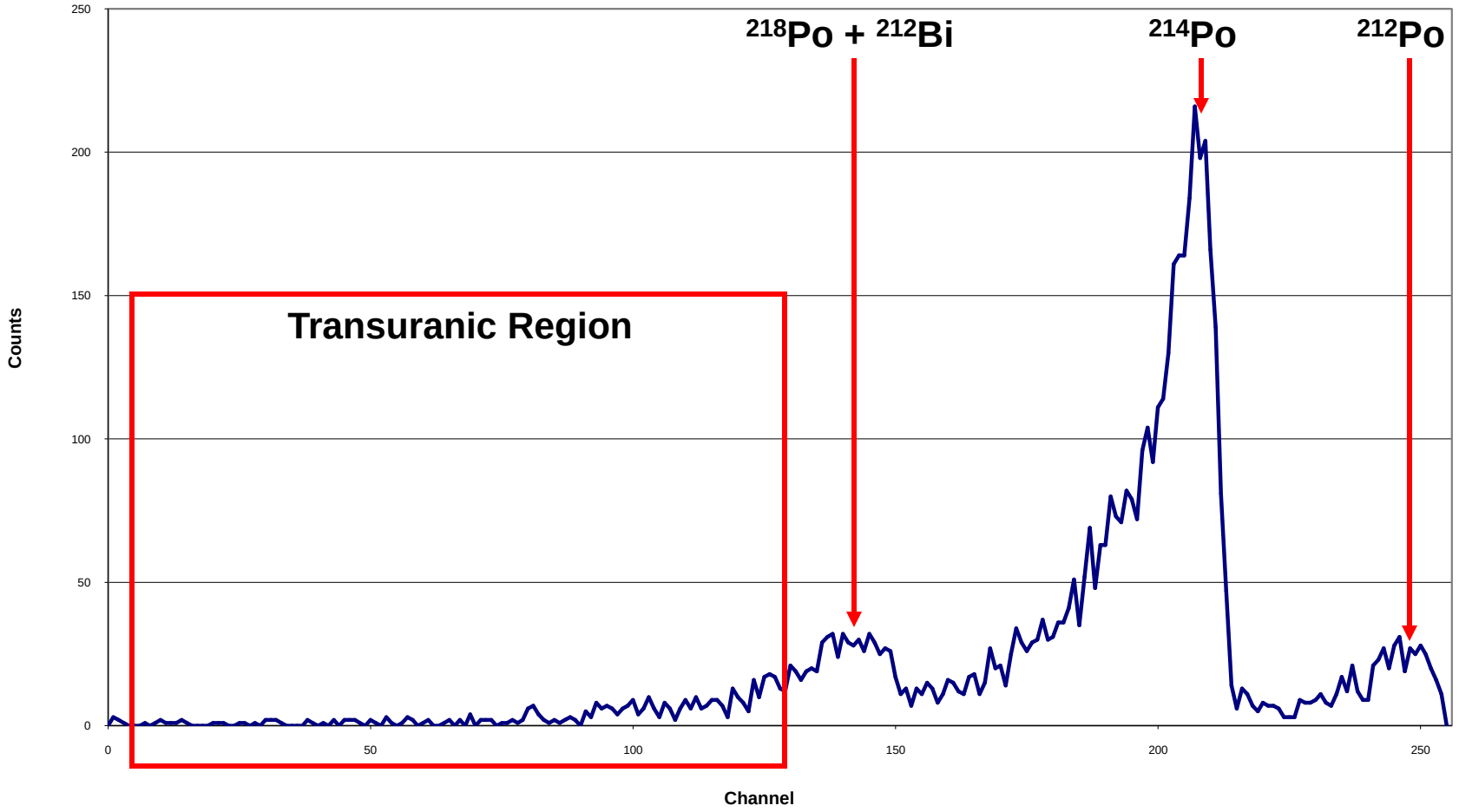
More than an annoyance

Alpha-emitting radon decay products can be a nuisance when monitoring for transuranics, but there are some surprising benefits to the most common of background interferents. We will cover a few of them here and delve into the details of some of the most promising.

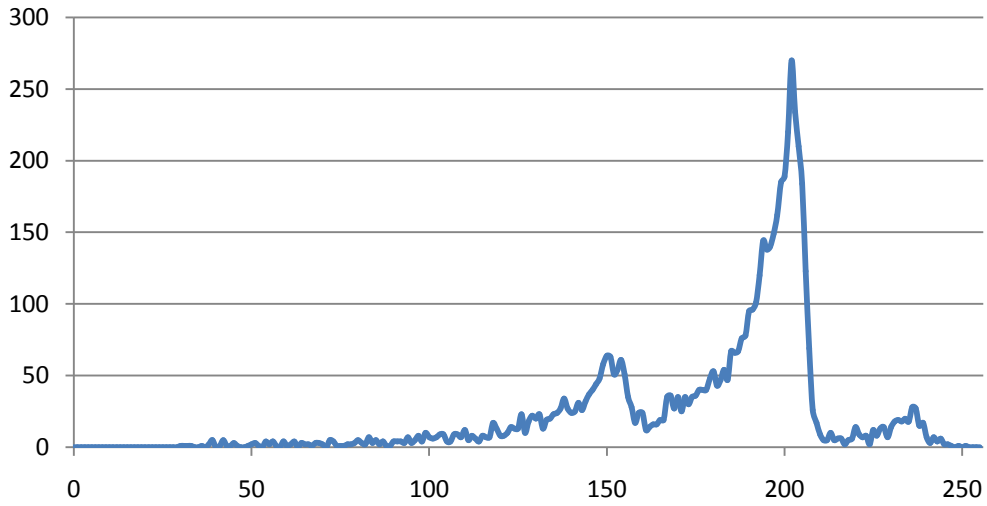
Radon/Thoron Background Spectrum



Benefits of RDP Background?

Admittedly, we will never be able to eliminate RDP background, but when we are looking for a few DPM from transuranics against a background of 200 to 2000 DPM of RDP, what benefits could there possibly be?

Benefit #1: A calibration reference

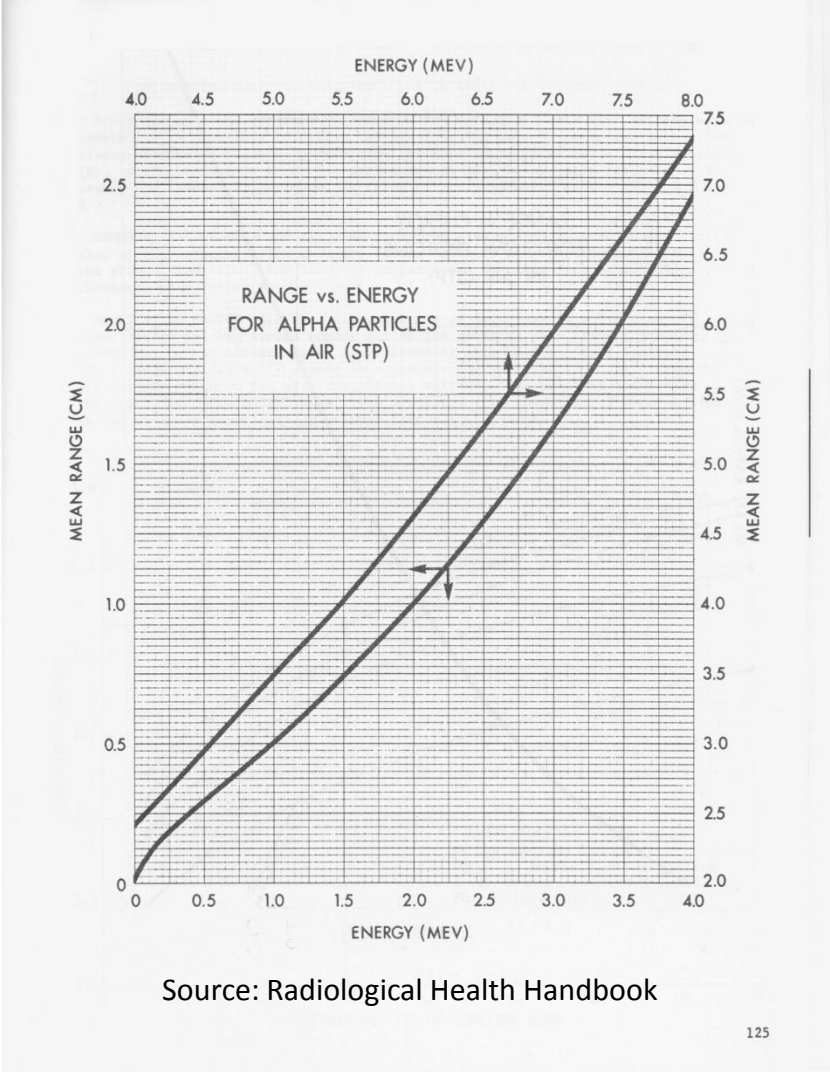


- Radon progeny provide two/three energy reference points.
- If the peaks move, so will the isotope-of-interest.

What can be done with this?

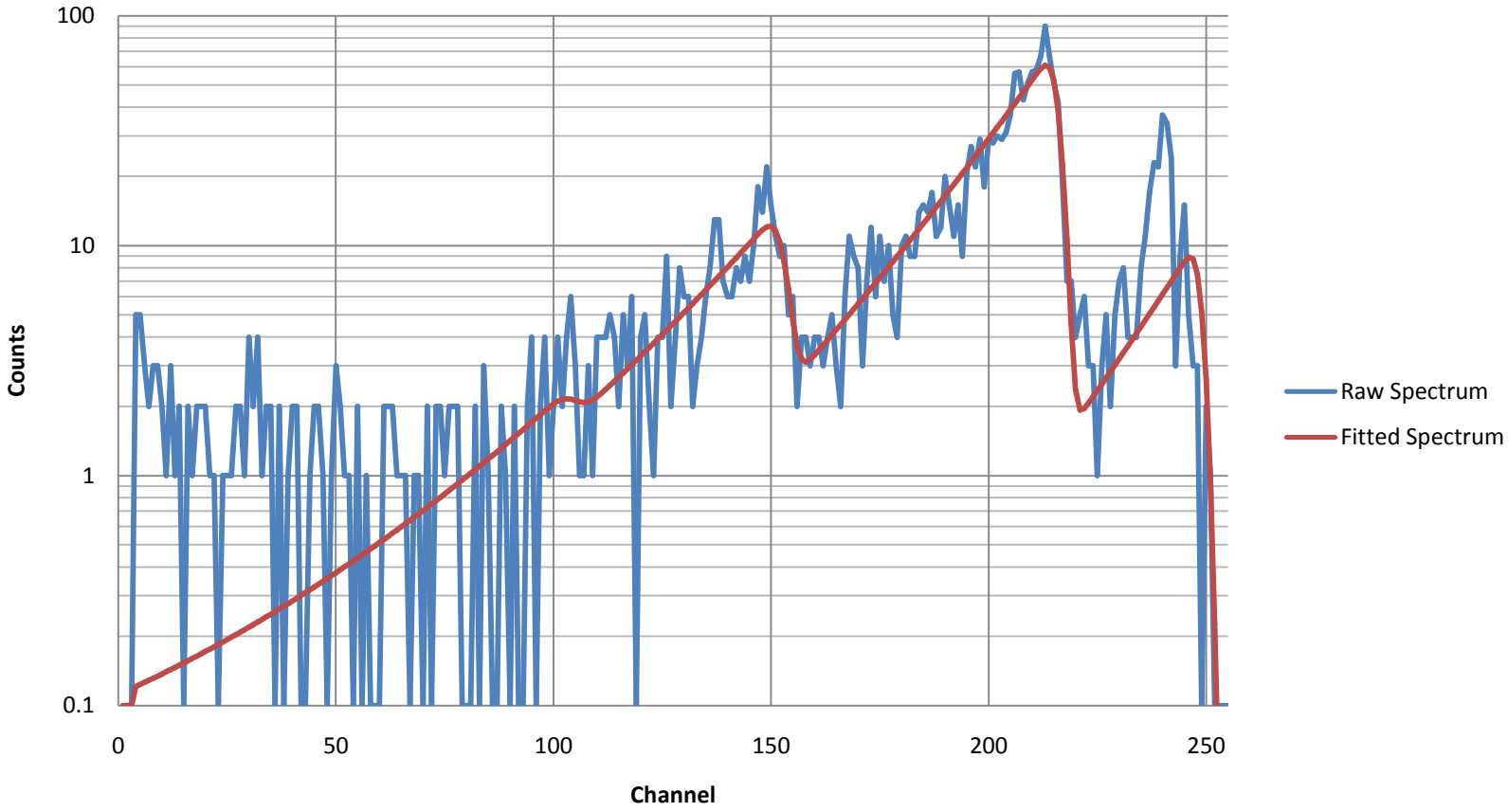
- Energy calibration without sources
- Automatic energy offset adjustments for temperature/pressure
- Automatic compensation for changes in altitude

Benefit #2: Energy Compensation



Source: Radiological Health Handbook

- Apart from electronic nonlinearity, alpha particle energy loss in air is nonlinear.
- Less energetic alphas have more attenuation per millimeter than more energetic alphas.
- The shape of the ^{218}Po tail gives us information about this attenuation so we can better predict where the peak of a specific radionuclide will fall.



- Adjustment of ^{218}Po tail yields an energy non-linearity correction factor which reduces bias in isotope-of-interest fit.

Benefit #3: Beta compensation

Accurate compensation of a gross beta channel for beta-emitting RDPs (^{214}Pb, ^{214}Bi, ^{212}Bi, ^{208}Tl)

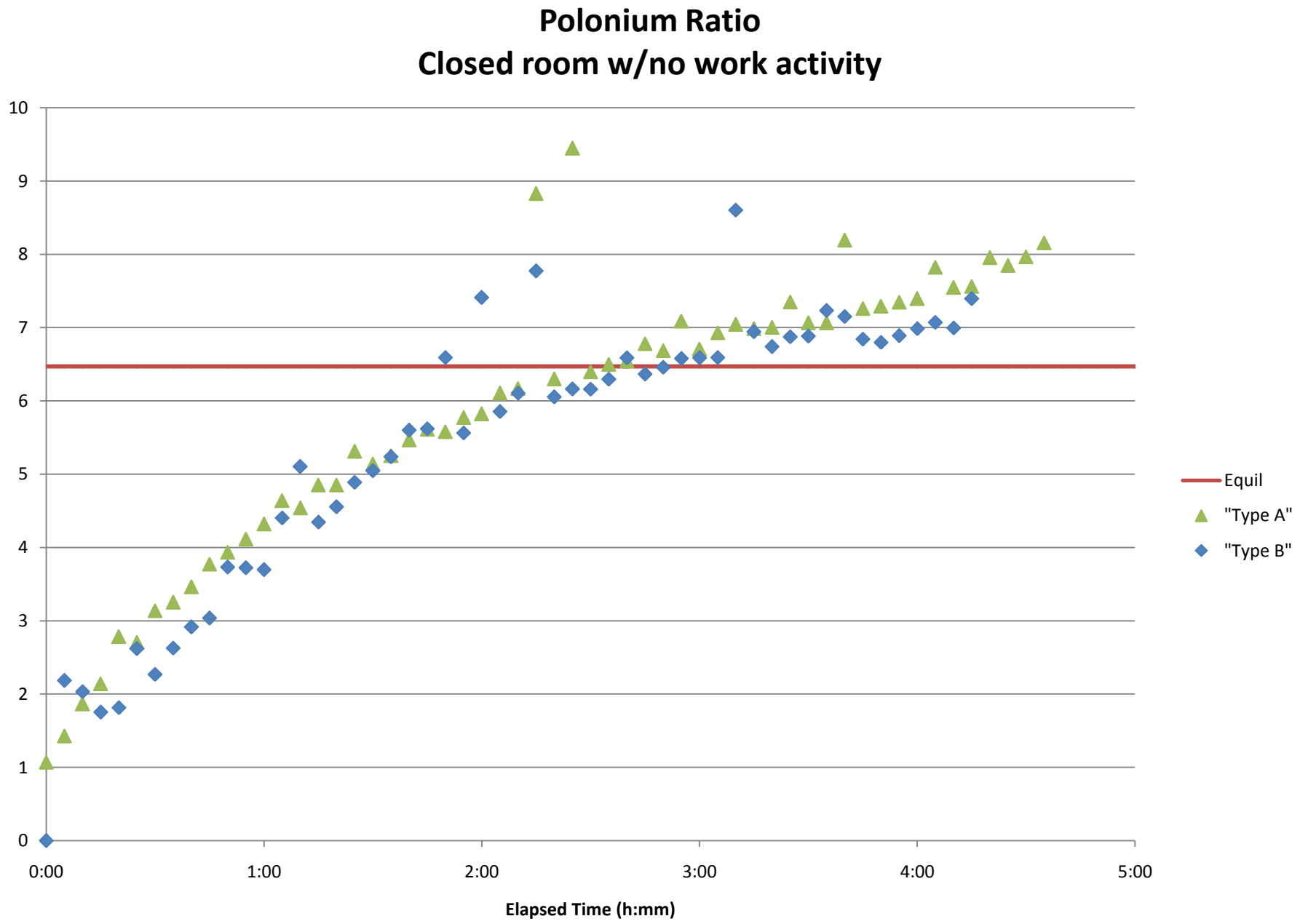
- ^{214}Pb counts can be estimated by ^{218}Po and ^{214}Po concentrations and equilibrium level
- ^{214}Bi = ^{214}Po
- ^{212}Bi = ^{212}Po x 1/0.64 x 0.35
- ^{208}Tl = ^{212}Po x 0.36/0.64 (with 3.05 min $T_{½}$)

Benefit #4: Equilibrium information

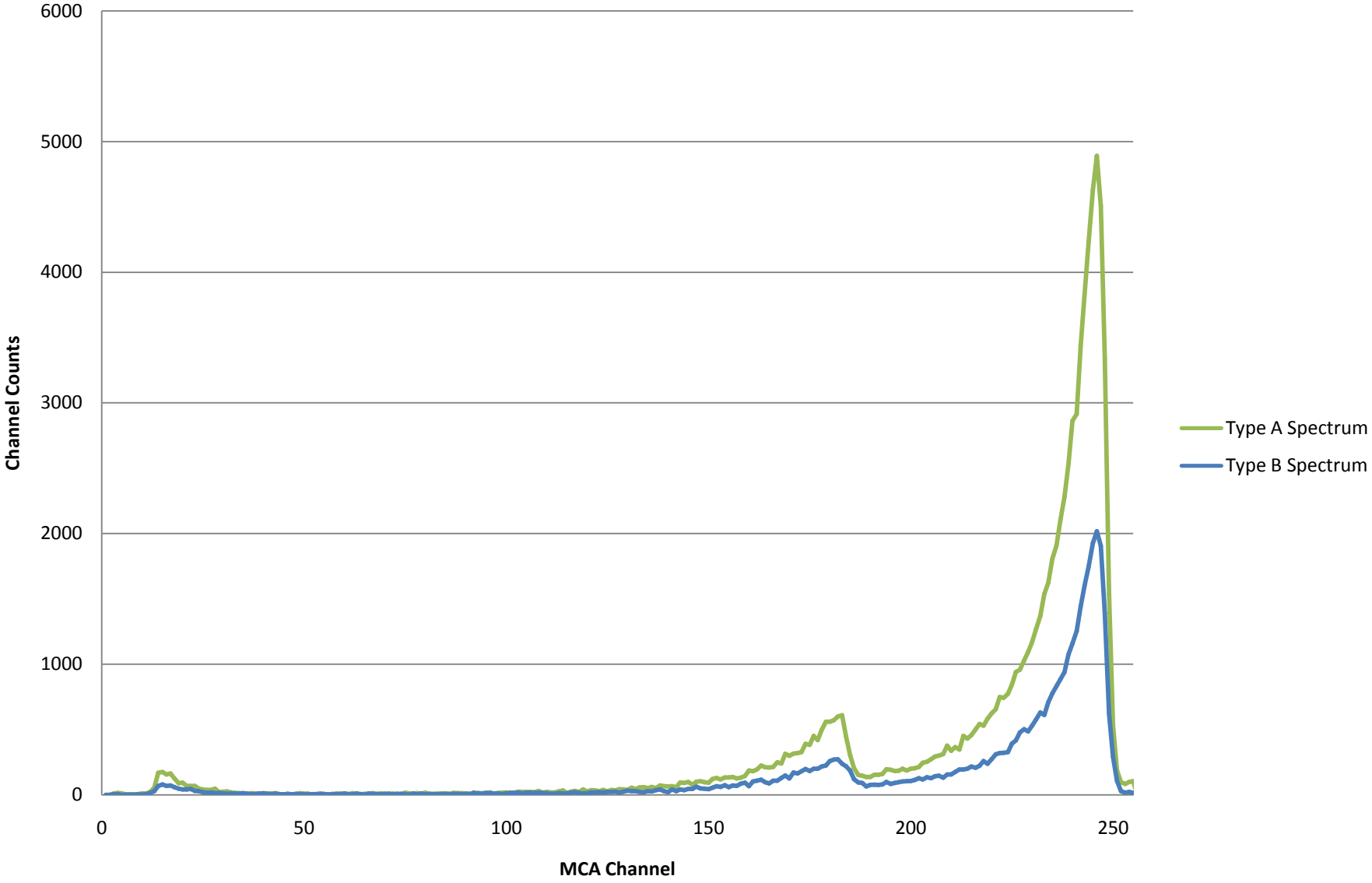
- The ratios of the ^{218}Po, ^{214}Po, and ^{212}Po peaks can give us an indication of the concentration equilibrium.
- Full equilibrium yields a $^{214}Po/^{218}Po$ ratio of 6.47 (must be adjusted for ^{212}Bi)
- Lesser ratios indicate partial equilibrium
- In HEPA-filtered air, equilibrium level can be accurately estimated.

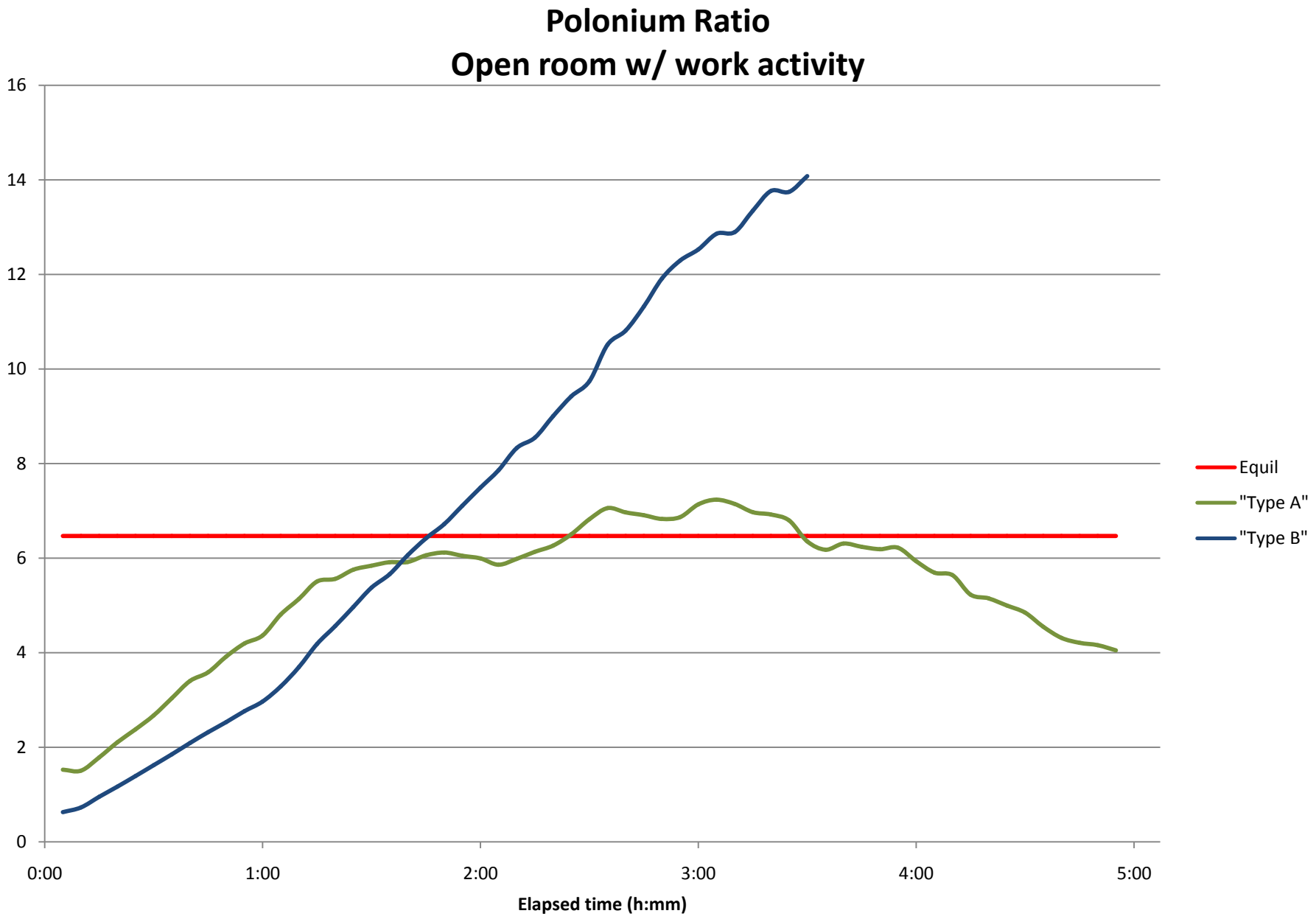
Benefit #5: Particulate size information

- When the concentration equilibrium is known and a filter media with significant sub-micron penetration is used, the $^{218}Po/^{214}Po$ ratio can provide sizing clues about the particulates to which the RDP are attaching.
- Comparison with ‘full collection’ filter media can add to the picture.

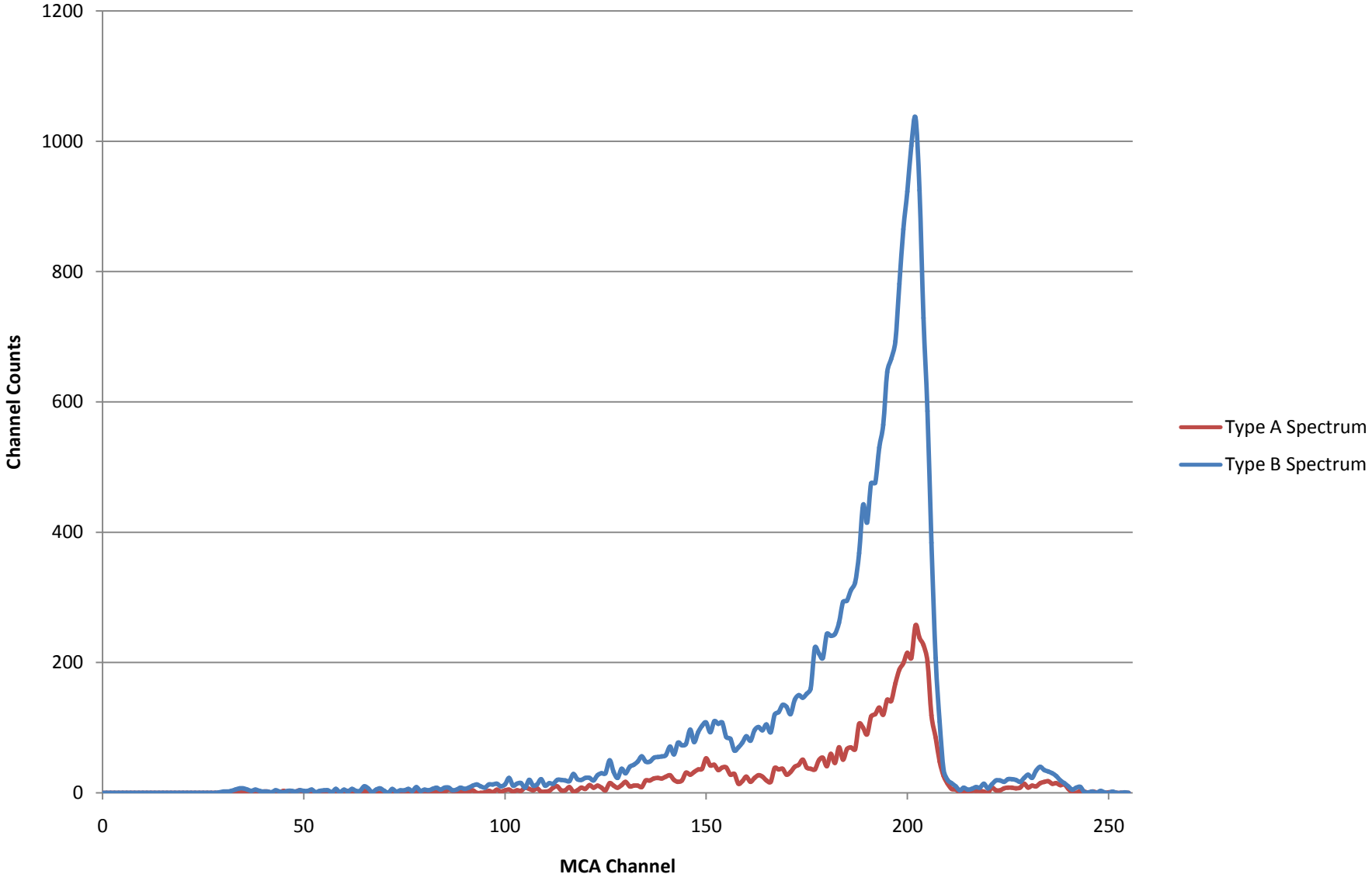

Polonium Ratio
Closed room w/no work activity
10
9
8
7
6
5
4
3
2
1
0
0:00
1:00
2:00
3:00
4:00
5:00
Elapsed Time (h:mm)
Equil
"Type A"
"Type B"

Spectrum Comparison
Closed room w/no work activity




Polonium Ratio
Open room w/ work activity
16
14
12
10
8
6
4
2
0
0:00
1:00
2:00
3:00
4:00
5:00
Elapsed time (h:mm)
Equil
"Type A"
"Type B"

Spectrum Comparison
Open room w/ work activity



Discussion

- Is source-less energy calibration useful?
- For Radon background subtraction of a beta channel to be truly practical, a two point beta efficiency should be done. Is it worth the effort?
- What is more useful to the HP, knowing the equilibrium, or knowing the particulate sizing?