Compensation for Radon Decay Products in Air Monitoring Applications Using Alpha Peak-Shape Fitting

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The Background Challenge

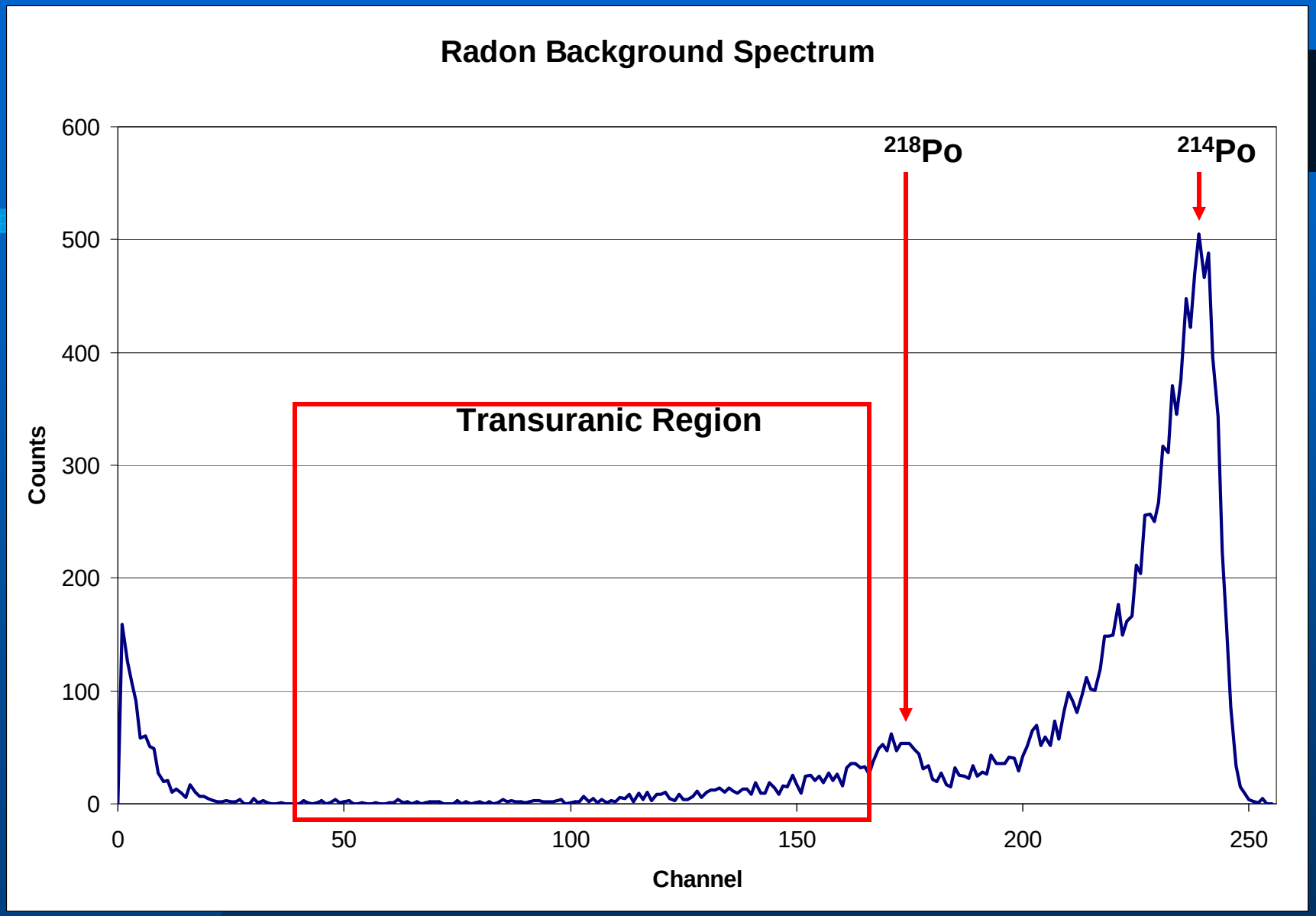
- **While geographically dependent, radon is naturally occurring virtually everywhere**
- **Even in HEPA filtered areas, air sampling with filter papers inevitably results in the accumulation of radon progeny**
- **The resulting alpha count rates are typically many times the level of interest for transuranic regulations**

The Alpha Spectrum Problem

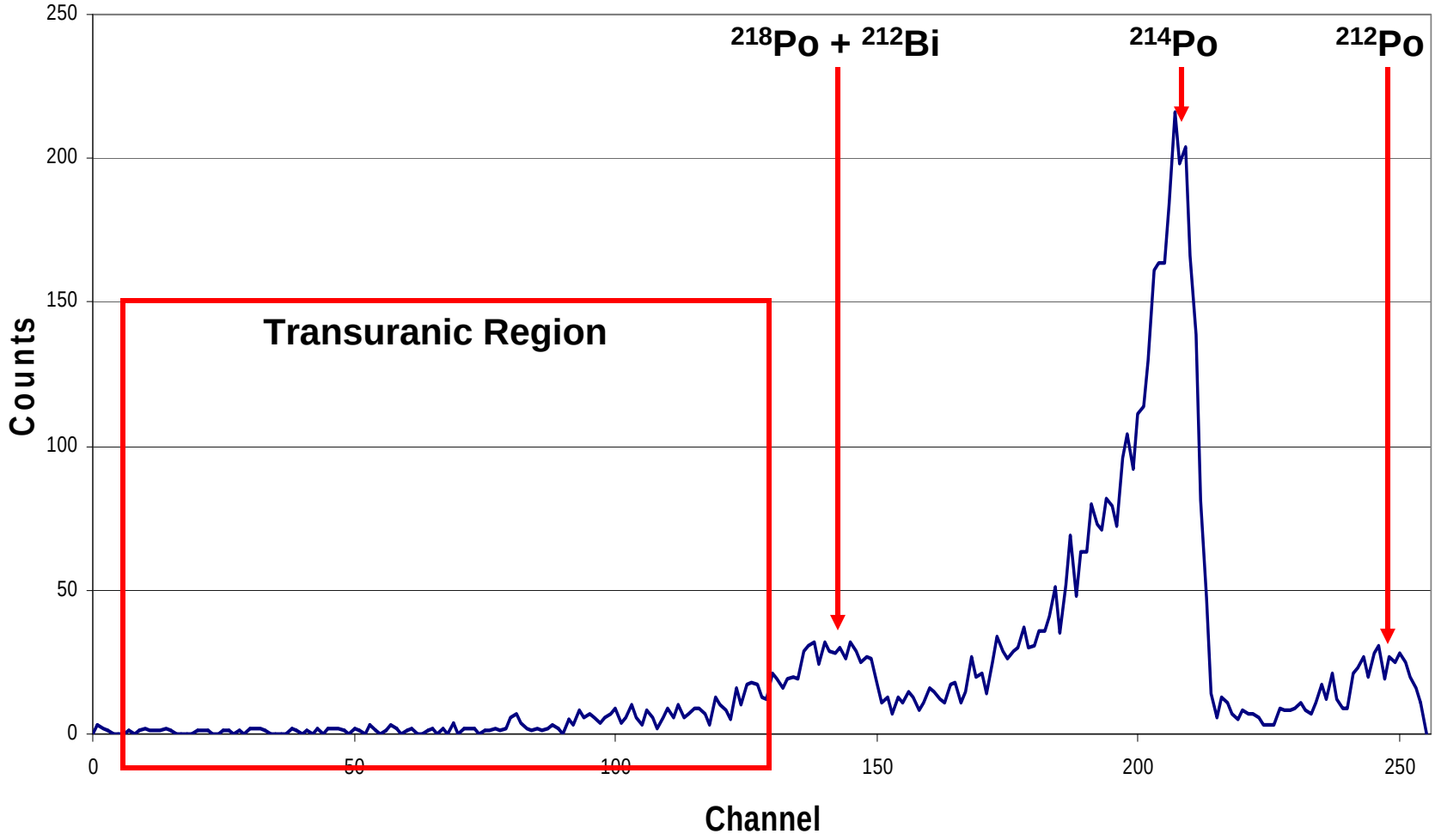
- **Real-time, continuous monitoring of transuranics prohibits the use of vacuum spectroscopy.**
- **Measurement of transuranic radioisotopes under ambient pressure conditions is hampered by interference by higher energy alphas from Radon progeny.**

The Radon/Thoron Interferents

- **Alpha-emitters from ^{222}Rn chain**
  - **^{218}Po @ 6.00 MeV**
  - **^{214}Po @ 7.69 MeV**
  - **^{210}Po @ 5.30 MeV**
- **Alpha-emitters from ^{220}Rn (thoron) chain**
  - **^{212}Bi @ 6.05 MeV (36% yield)**
  - **^{212}Po @ 8.78 MeV (64% yield)**


Radon Background Spectrum
600
500
400
300
200
100
0
Counts
0
50
100
150
200
250
Channel
218Po
214Po
Transuranic Region

Radon/Thoron Background Spectrum



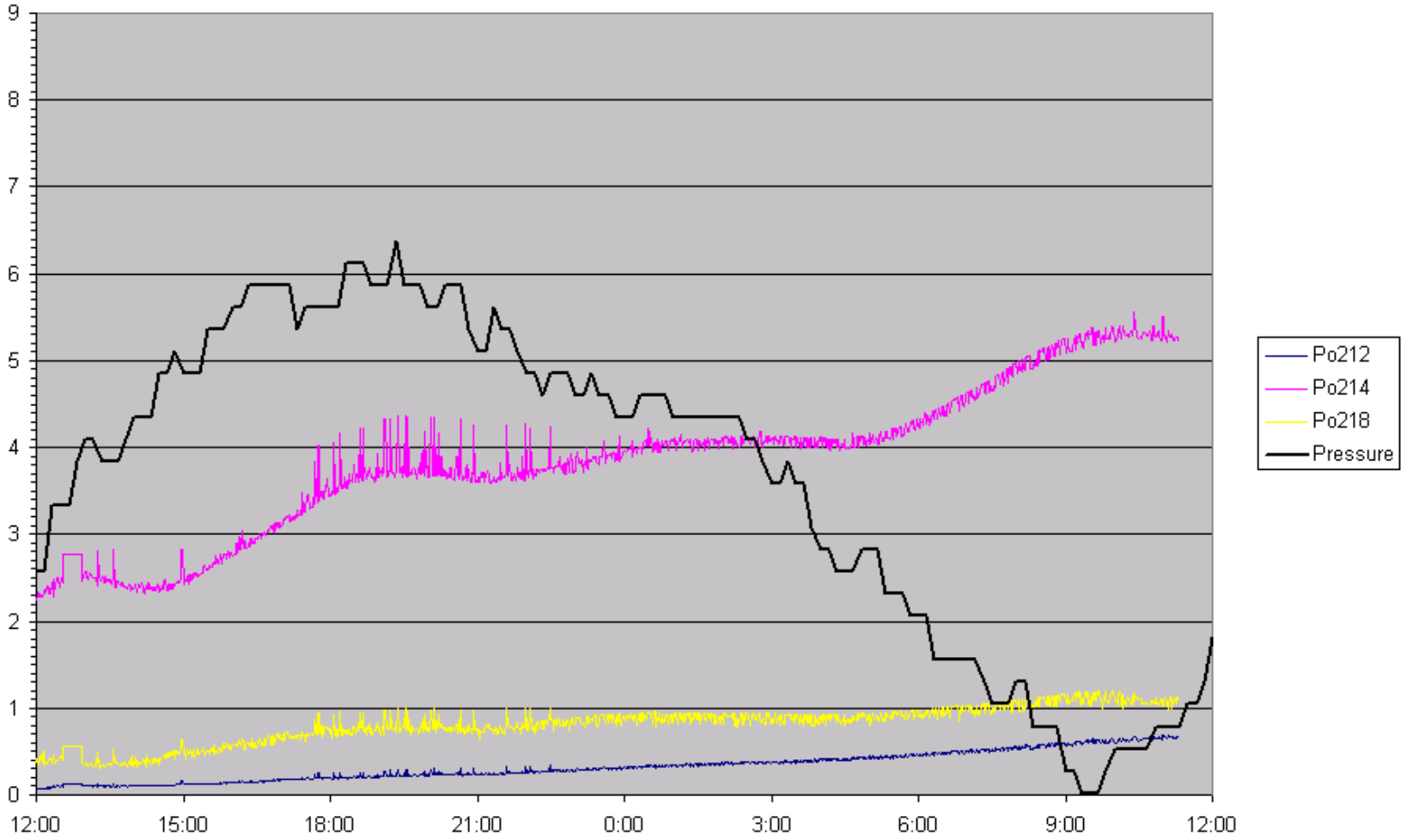
Resolving Isotopes of Interest

- **Counts from the $^{218}Po/^{212}Bi$ and ^{214}Po tails interfere with measurements in the transuranic region.**
- **Several factors affect tail interference**
  - **Air gap**
  - **Filter type**
  - **Dust loading**
  - **Detector resolution**
  - **Pressure/temperature changes**

Radon Concentration Variability

- **Radon levels can vary dramatically with weather conditions**
- **Radon levels can vary dramatically during the day**

Typical Radon Fluctiations



Historical Solutions

Historically, several methods have been employed to compensate for radon interference:

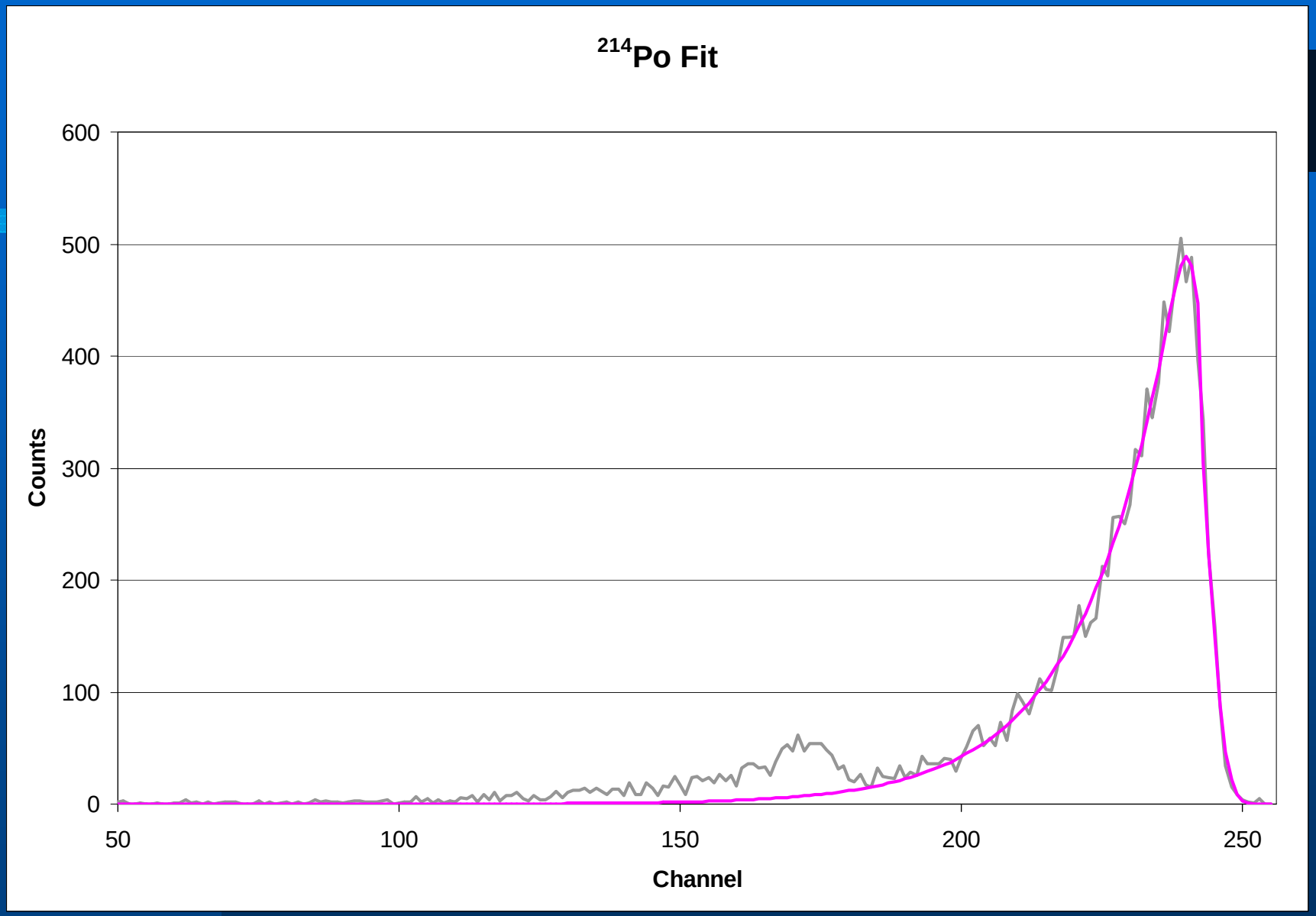
- **Age samples to allow for interferents to decay**
- **Fixed background subtraction**
- **Regions of Interest and fixed ratio subtraction**
- **Exponential tail-fitting**
- **Radon reduction**

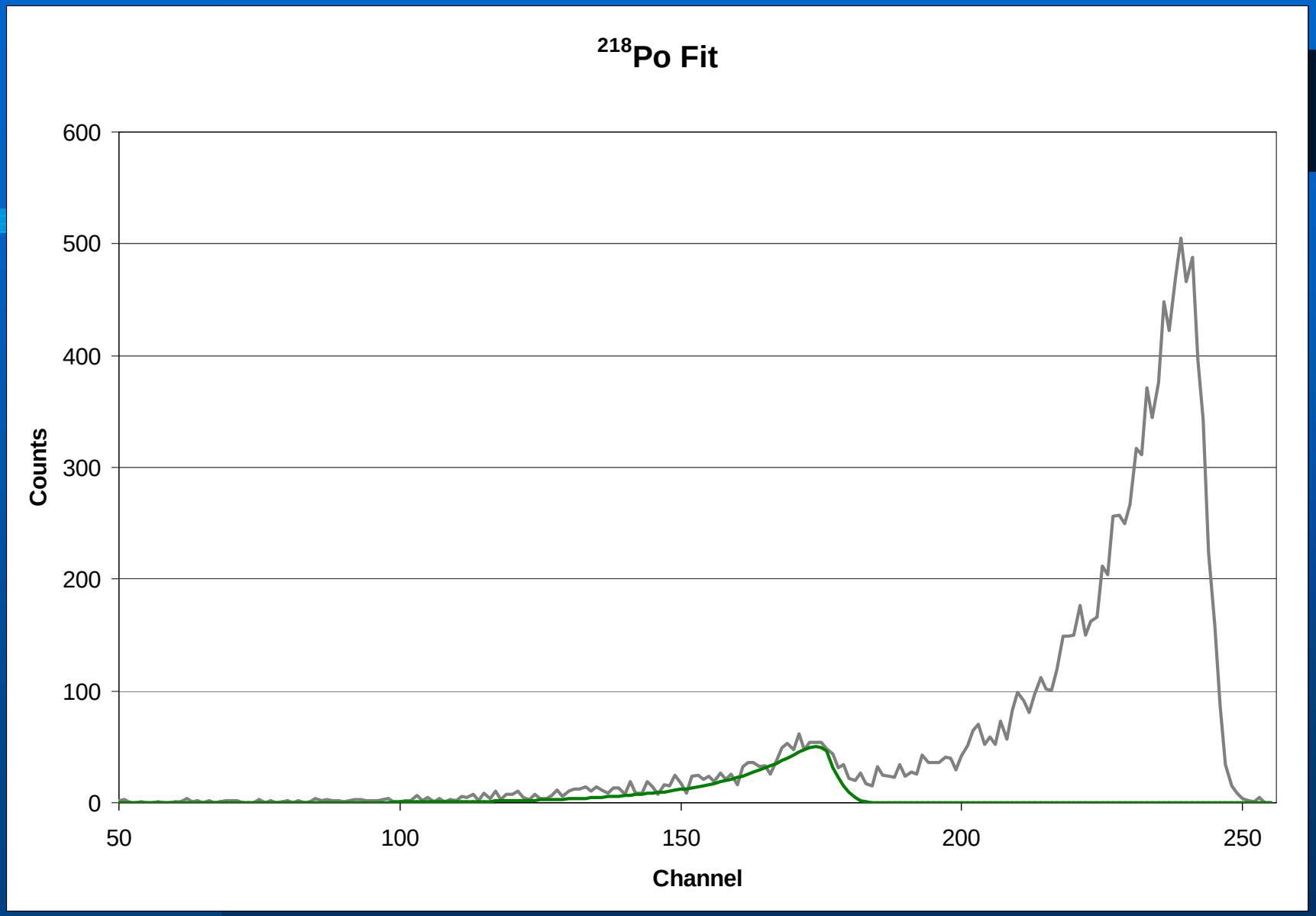
A New Advance In Radon Compensation

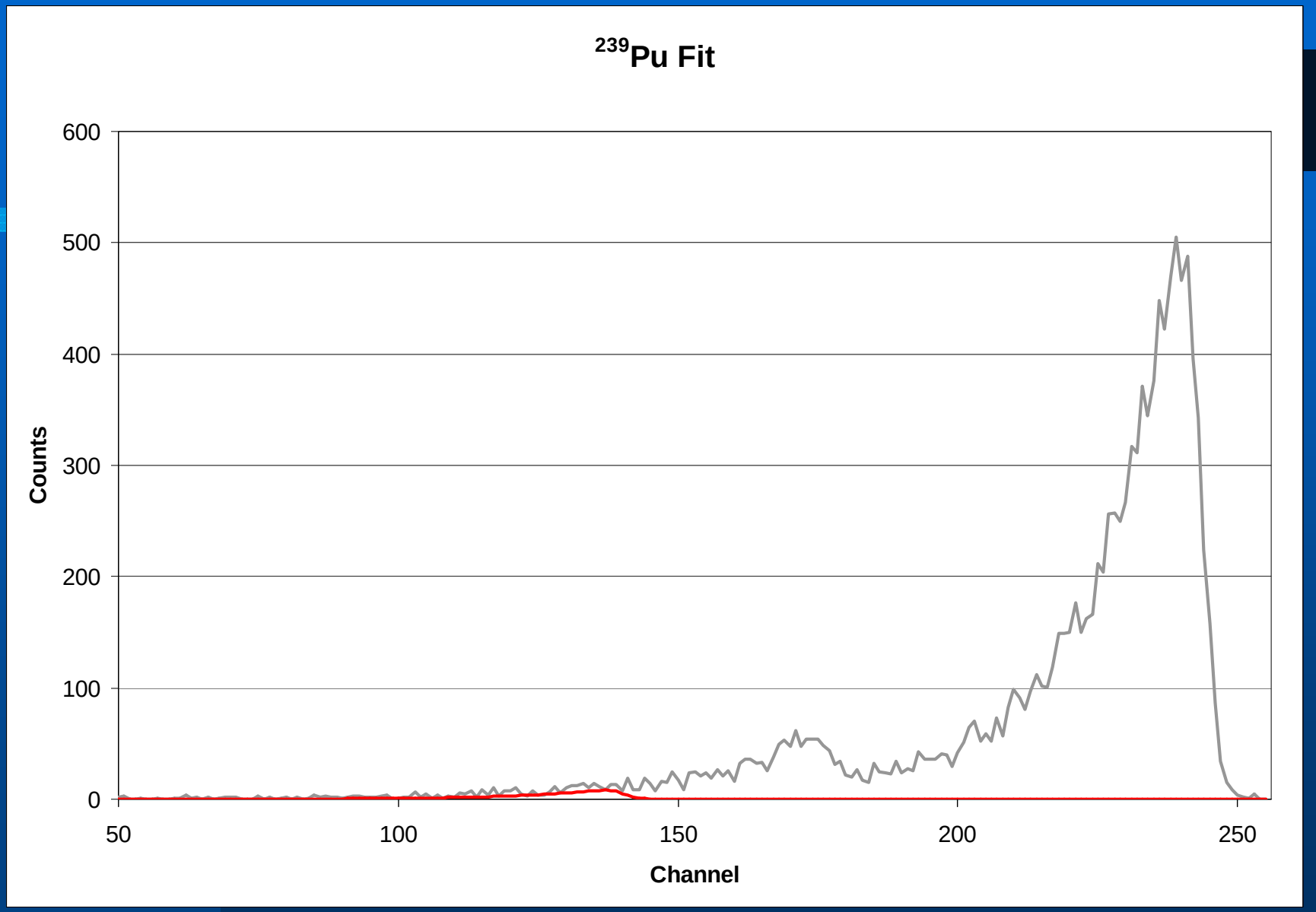
Due to advances in microprocessors and miniaturization, peak-shape fitting—a technique used for years in laboratory alpha spectroscopy instruments—is now practical in portable and real-time instruments.

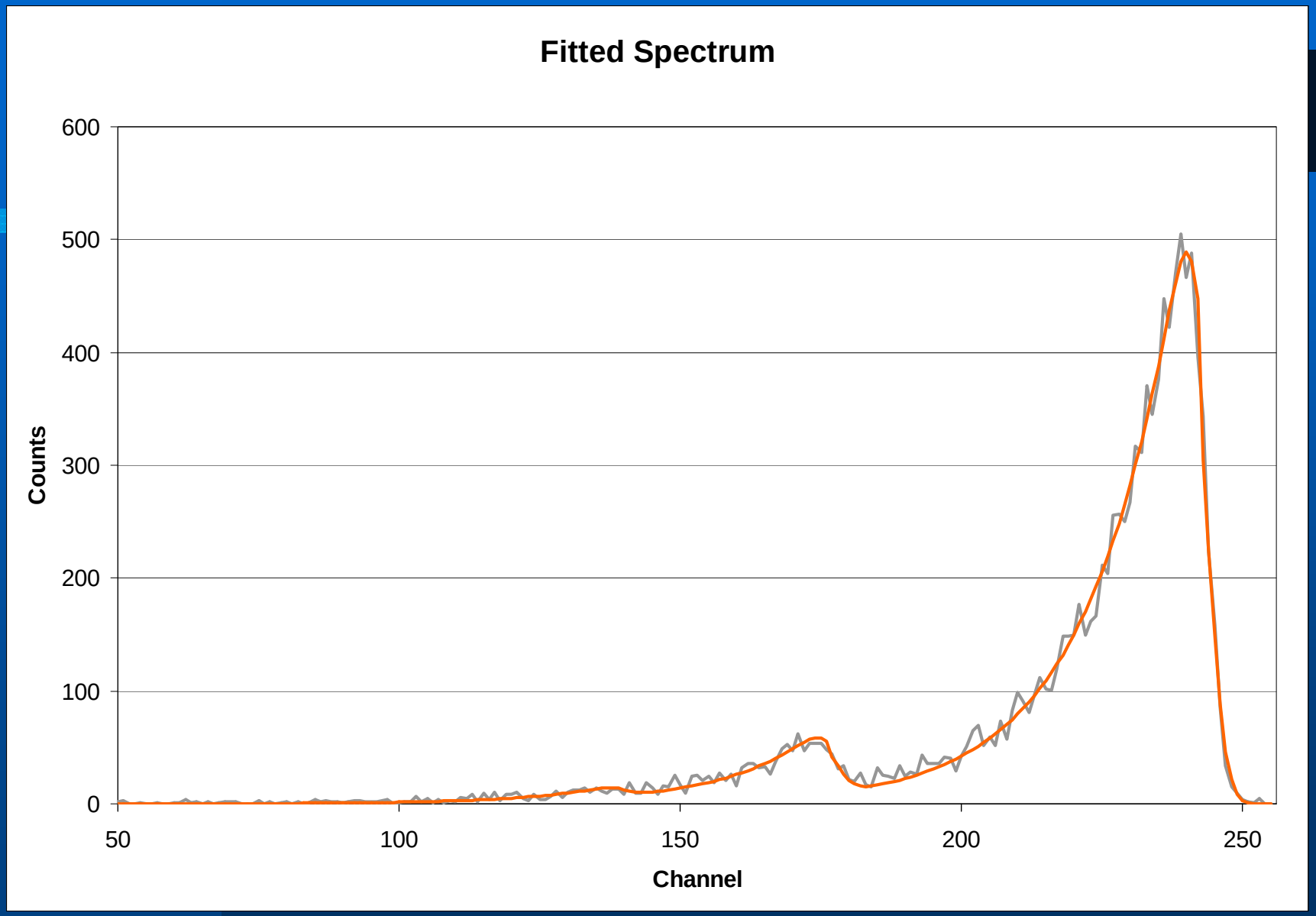
Peak-Shape Fitting Definition

- **Peak-Shape Fitting (PSF) consists of using a mathematical model to represent the spectrum counts for each alpha-emitting isotope so that when the individual models are summed, the result closely approximates the spectrum accumulated from multiple isotopes.**


214Po Fit
600
500
400
300
200
100
0
Counts
50
100
150
200
250
Channel


218Po Fit
600
500
400
300
200
100
0
Counts
50
100
150
200
250
Channel


239Pu Fit
600
500
400
300
200
100
0
Counts
50
100
150
200
250
Channel

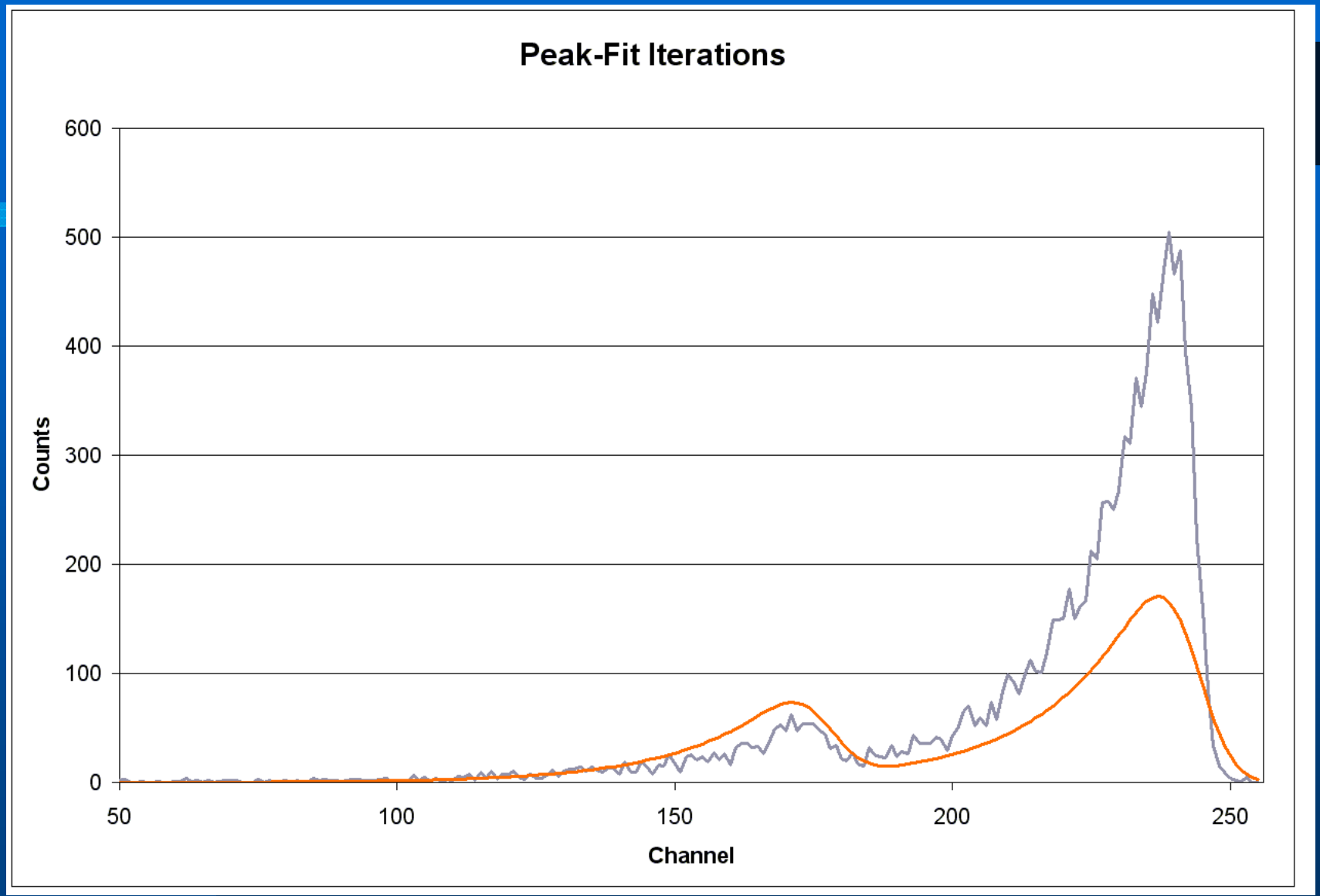

Fitted Spectrum
600
500
400
300
200
100
0
Counts
50
100
150
200
250
Channel

Peak Fit Results

- **After solving for the optimum fit:**
  - **^{214}Po area is 10185 ±216 counts**
  - **^{218}Po area is 1051 ±147 counts**
  - **^{239}Pu area is 169 ±96 counts**

Successive Approximations

- **Begin with initial estimates for peak shape, peak channels and peak areas.**
- **Solve for “best fit” by refining the estimates and comparing the square of individual channel errors.**
- **End when fit error stops improving.**


Peak-Fit Iterations
600
500
400
300
200
100
0
Counts
50
100
150
200
250
Channel

Peak Fit Method Benefits

- **More accurate radon subtraction**
- **Peak area variances include compensation for interfering peaks**
- **Automatically adjusts to spectrum changes due to:**
  - **Peak shifts**
  - **Dust loading**
  - **Disequilibrium conditions**
- **Ignores most counts resulting from RFI noise**
- **Unusual spectrums produce *Poor Fit* warning**

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