Comparison of Background Compensation Algorithms in Environmental Monitoring

- Data from LANL-WIPP investigations of ECAM performance underground at WIPP

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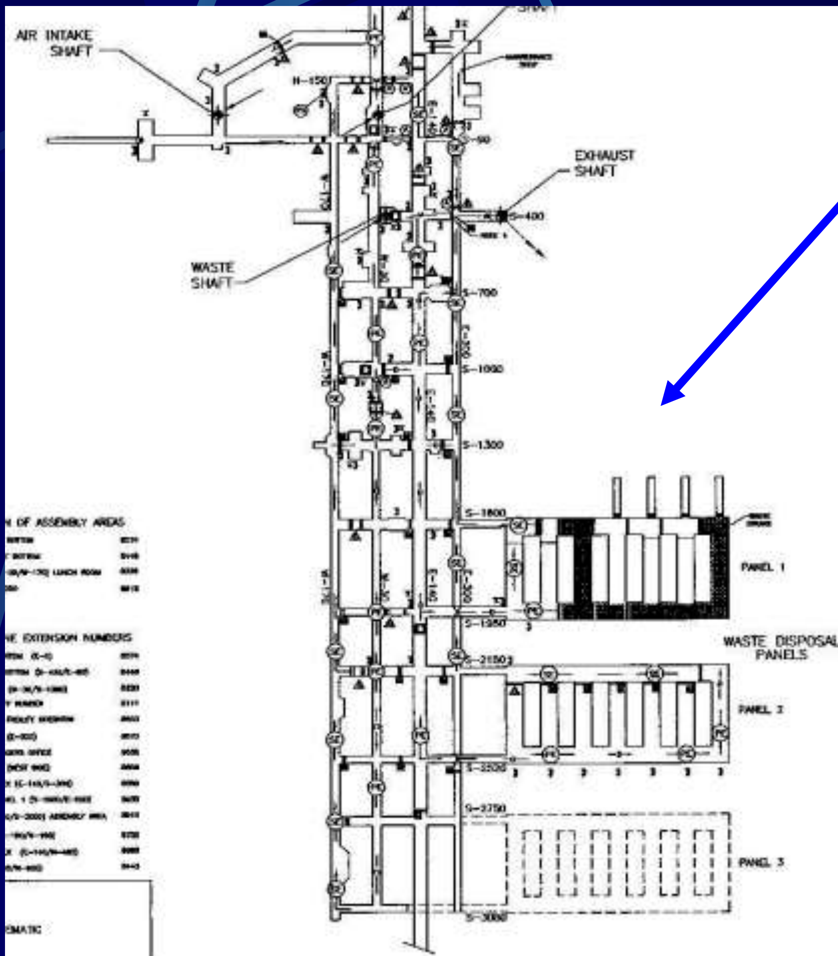
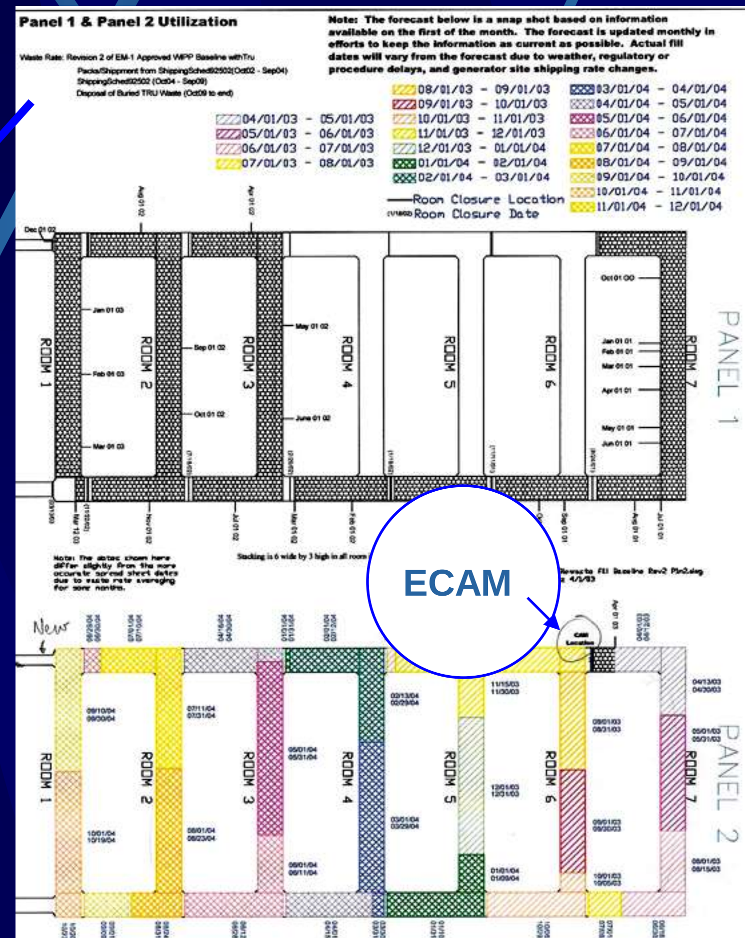
WIPP Underground layout Panel 2

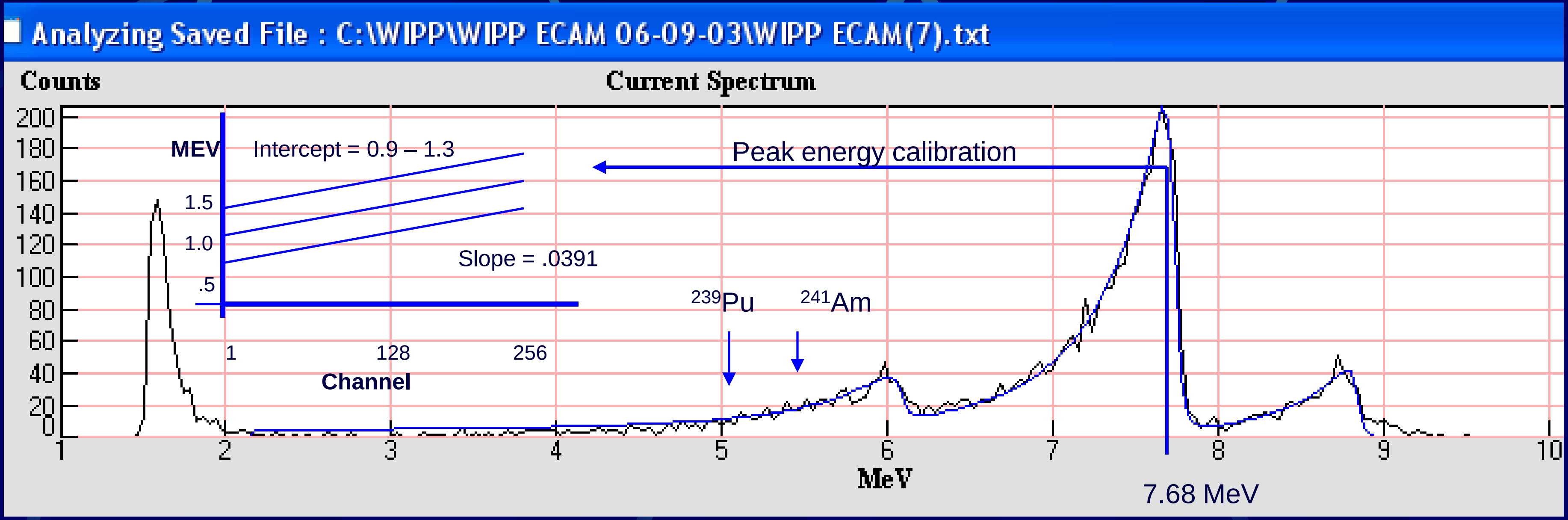




ECAM test setup

Downwind view

The anatomy of radon (progeny) interference in continuous environmental monitoring



β-continuum

TRU α- energy region

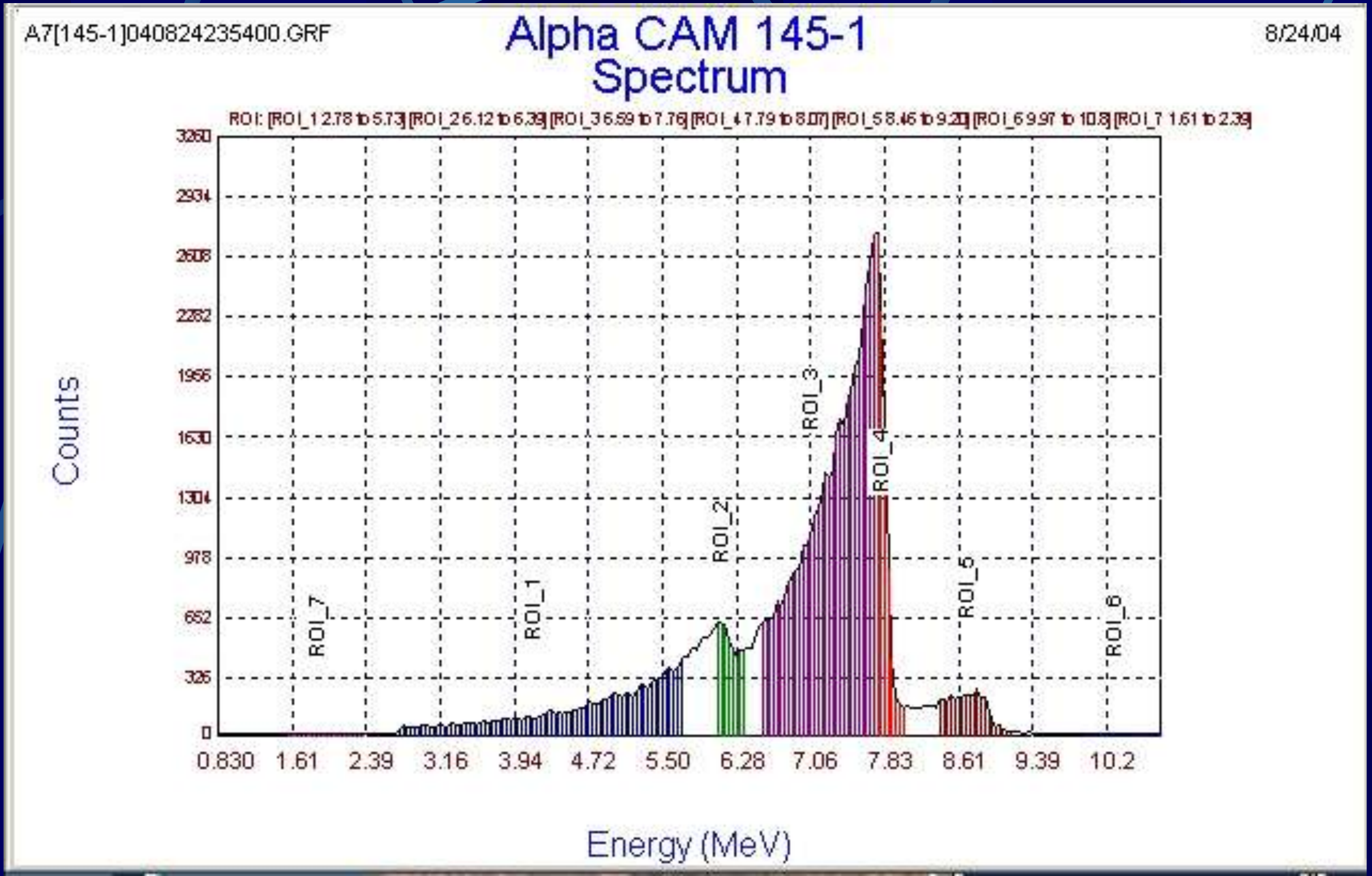
^{218}Po ^{212}Bi

^{214}Po

^{212}Po

Radon progeny α-energy region

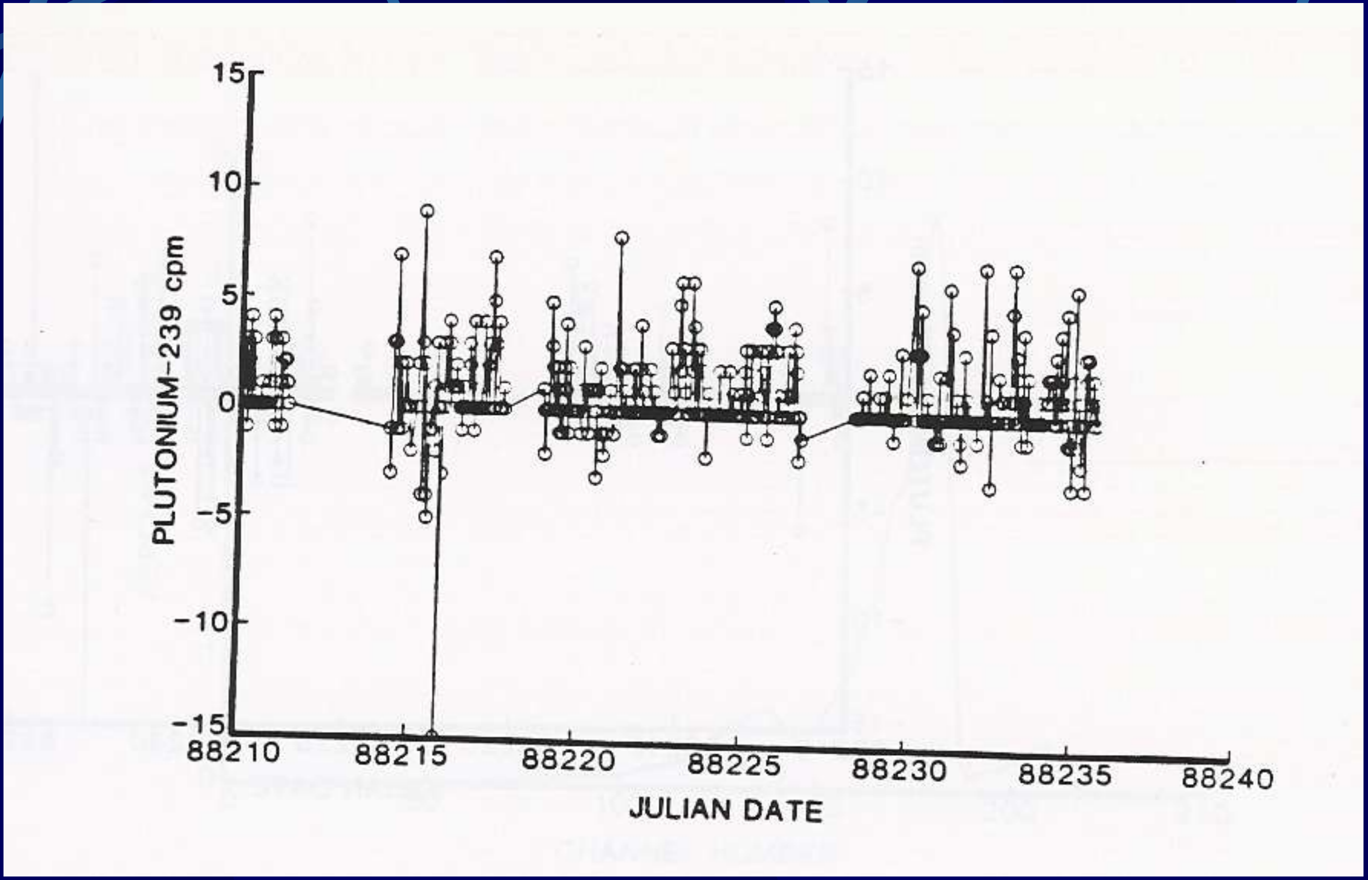
Correction by channel ratios



Pu (ROI-1) = (ROI-2)* K * (ROI-3)/(ROI-4) , K = cal. Const.

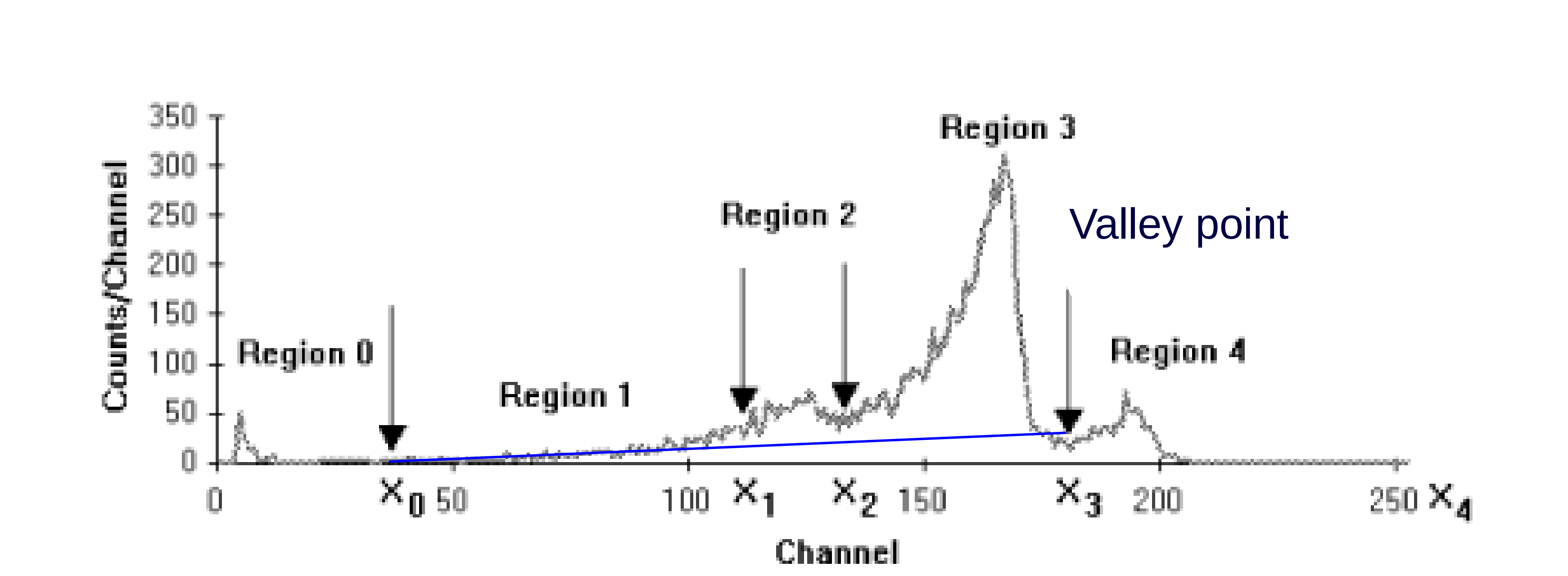
Note: summed spectrum

Over- and under-reporting of net CPM in background conditions (Lovelace study *) using the channel ratios method



* Underground adjacent to exhaust shaft – from Hoover et al, Lovelace, 1990

Exponential fit to low-energy tail valley point regions + stripping



TRU region

6-MeV region

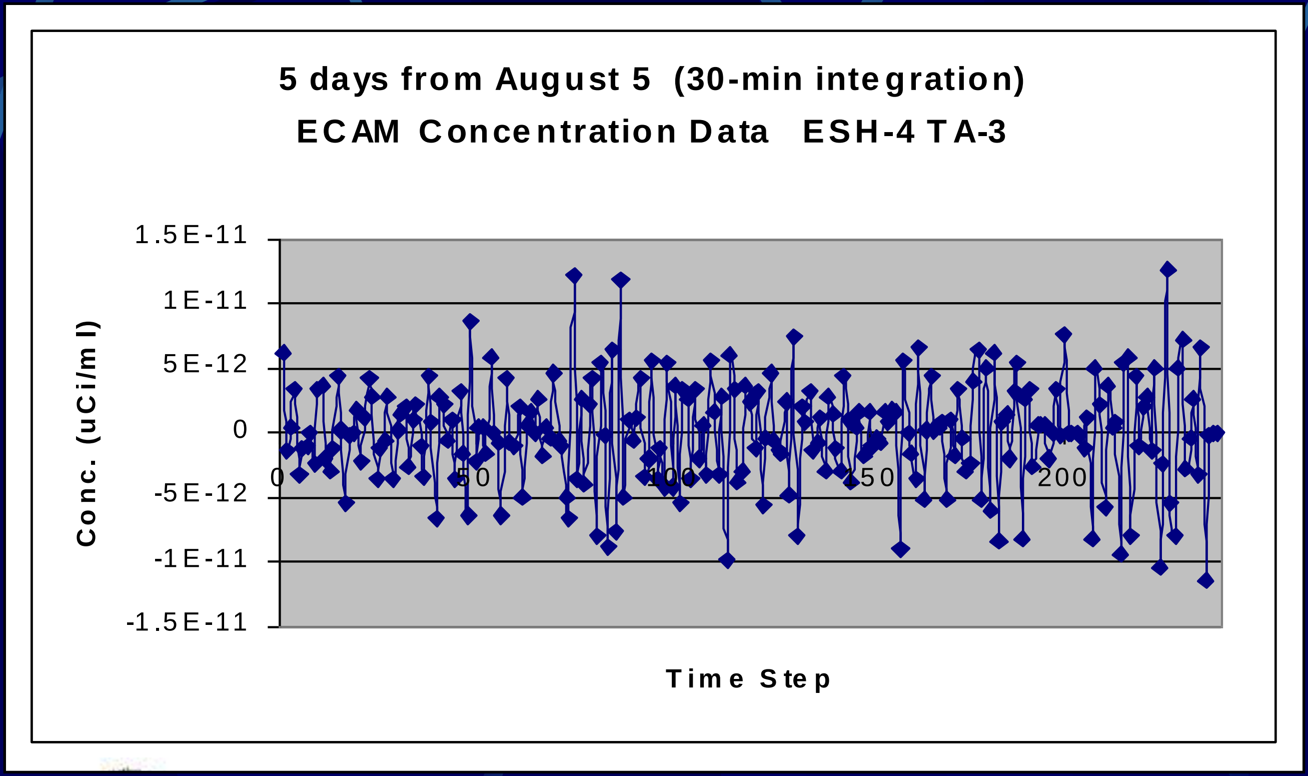
7.68 MeV region

8.78 MeV region

Y_1 = Gross count $X_0 - X_1$

Pu = $\Sigma\, Y_1 - T_{8.78} - T_{7.68} - T_{6.05}$, T_i = exponential tail count from X_0 to valley X_i

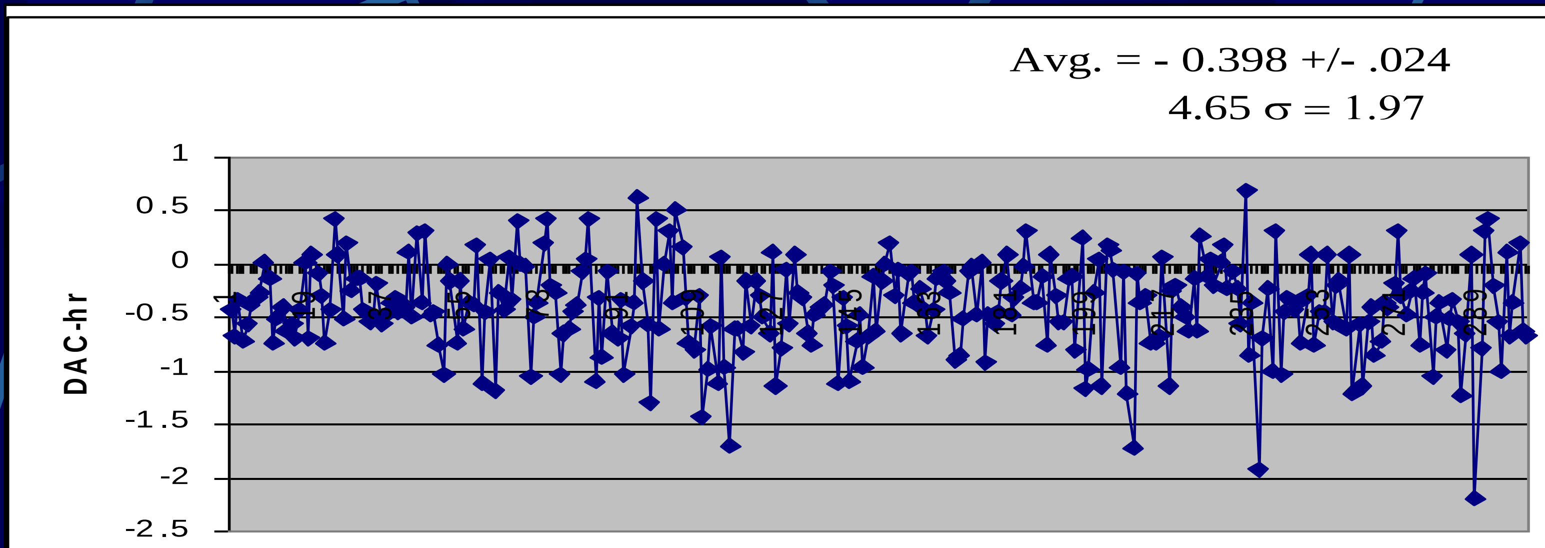
Concentration estimation from consecutive continuous measurements



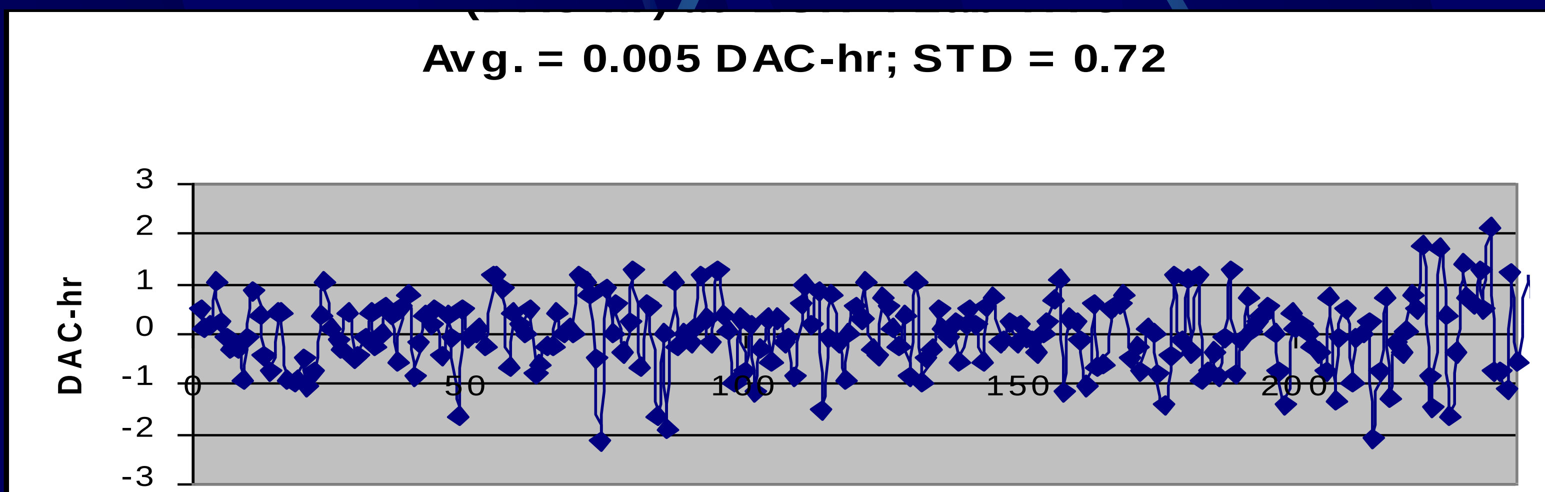
$C_{pu}(T_i) = T_i * [A(T_i) - A(T_{i-1})] / [T^2{}_c * \varepsilon * K * V]$, T_i = time from filter change, T_c = spectrum collect time – assumed same for both counts, K = const., V = total volume of air sampled, ε = detector counting efficiency

Exposure calculation (DAC-hr) from consecutive continuous measurements

10-min.

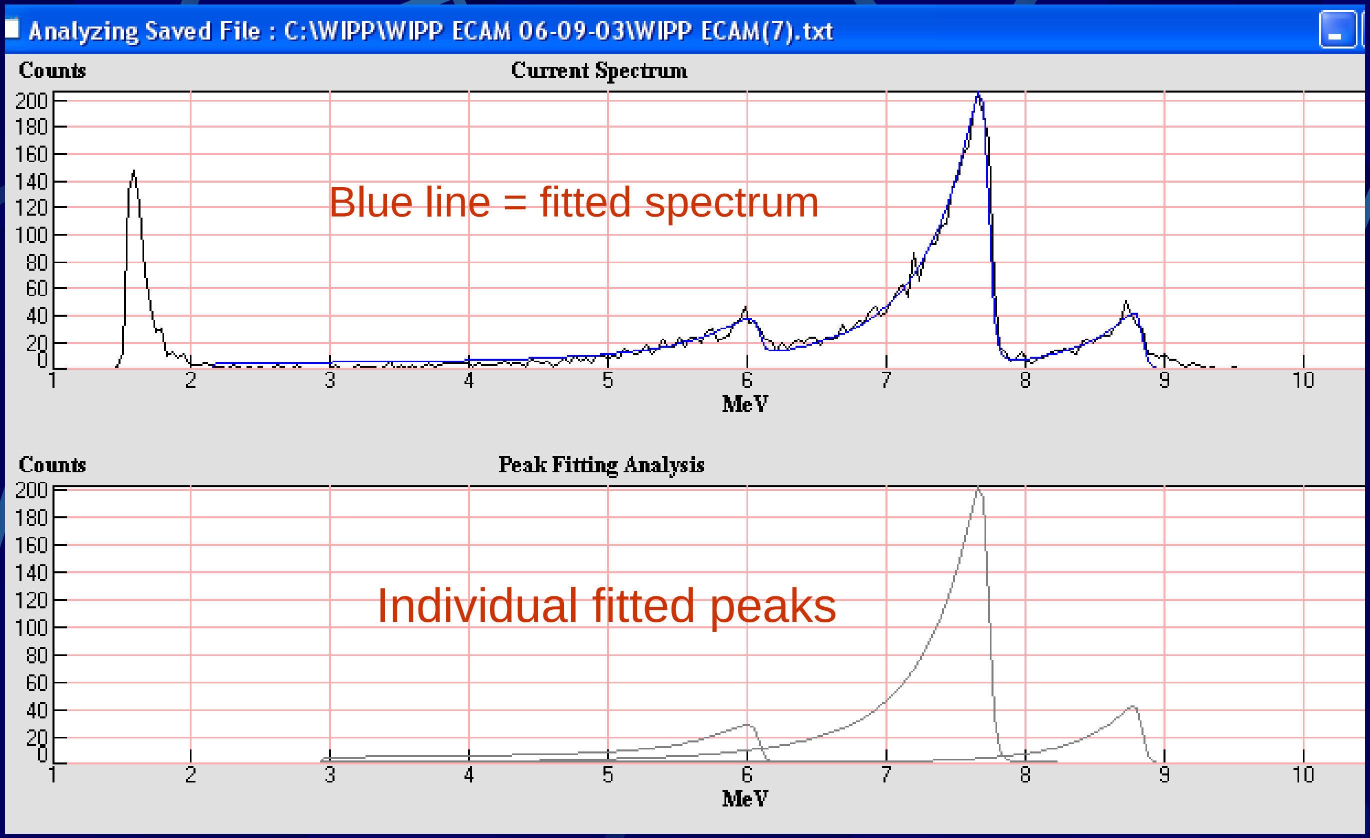


30-min.



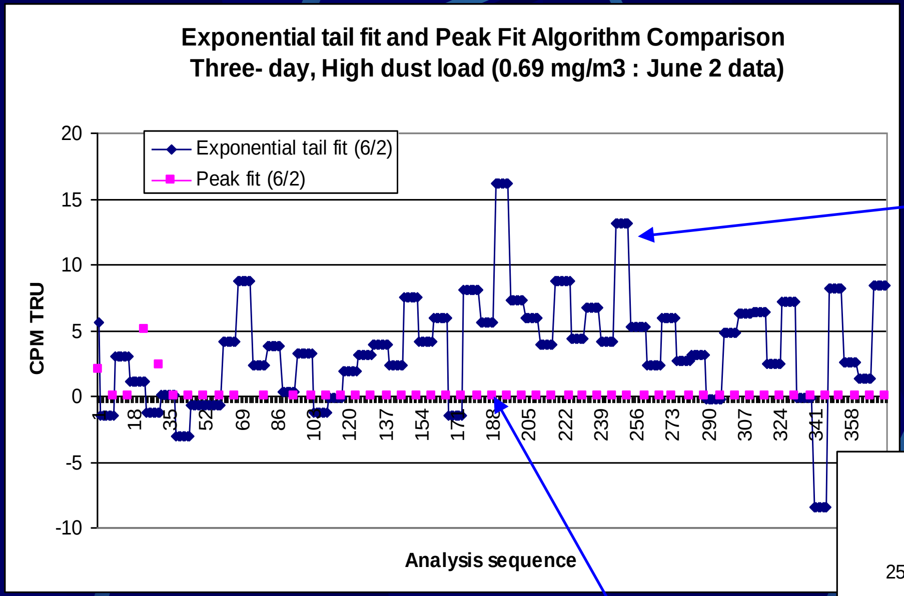
$$\text{DAC-hr} = T_i * A(T_i) / [T_c * K * V * \varepsilon * Z_{DAC}]\ ,\ Z_{DAC} = \text{DAC Pu factor}$$

Background correction by Marquardt-Levenberg non-linear least-square fitting of peak functions

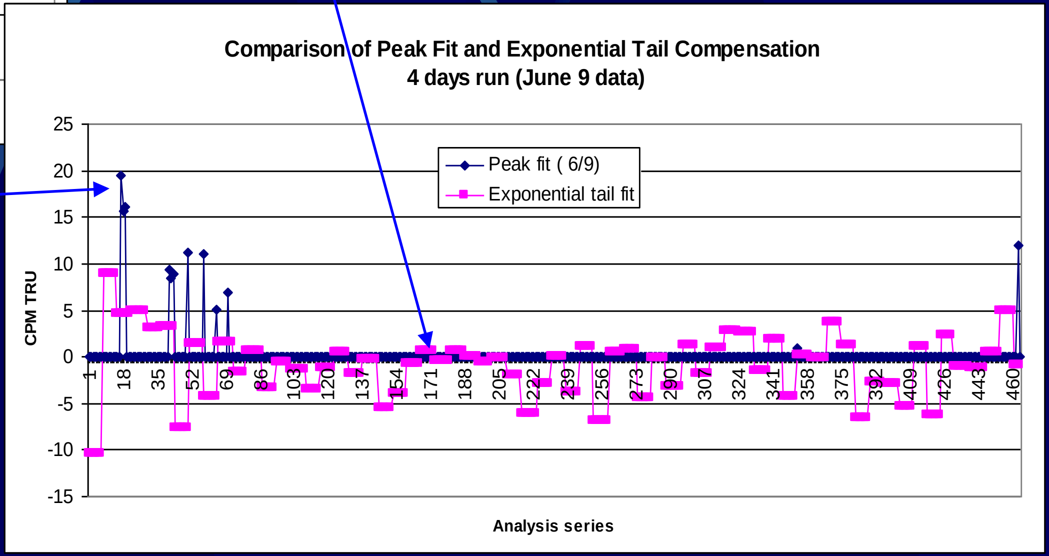


Peak $_k$= A_k* Σ_i t_i*[t'_i ∗exp(f_1)*erfc(f_2)] , f_1= f(x, t''_i, μ, …), f_2 = f(x, t'''_i , μ, …), t, t',t'',t''',… fitting parameters, k = Peak ID- Pu/Am/U, x = chan, μ = centroid, Pu = Σ Counts Peak$_{Pu}$ (fitted), if the Pu peak is present; otherwise, Pu = 0.0 or ?   (Step 1: find, and fit peaks where present)

Comparison of Exponential tail fit vs Non-linear least square Peak fit



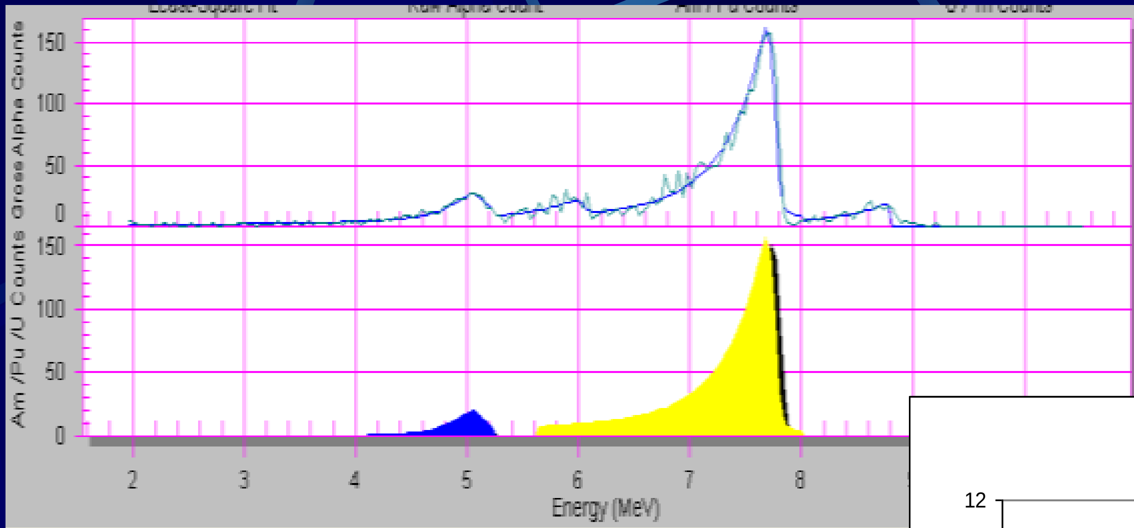
Exponential tail fit integral CPM



Least-square peak function fit integral CPM

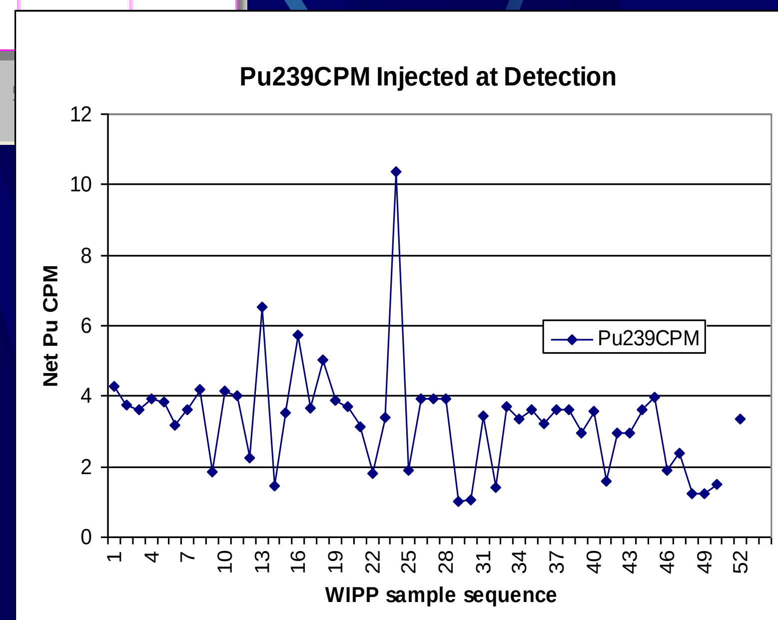
Conclusion: tail fitting sometimes over-, sometimes under-compensates depending on peak shape … how can we estimate the peak fitting approach ?

Pu Peak detection with Rn progeny present



Response Evaluation:

Pu-239 peak injection in WIPP background spectra until detection by peak fitting



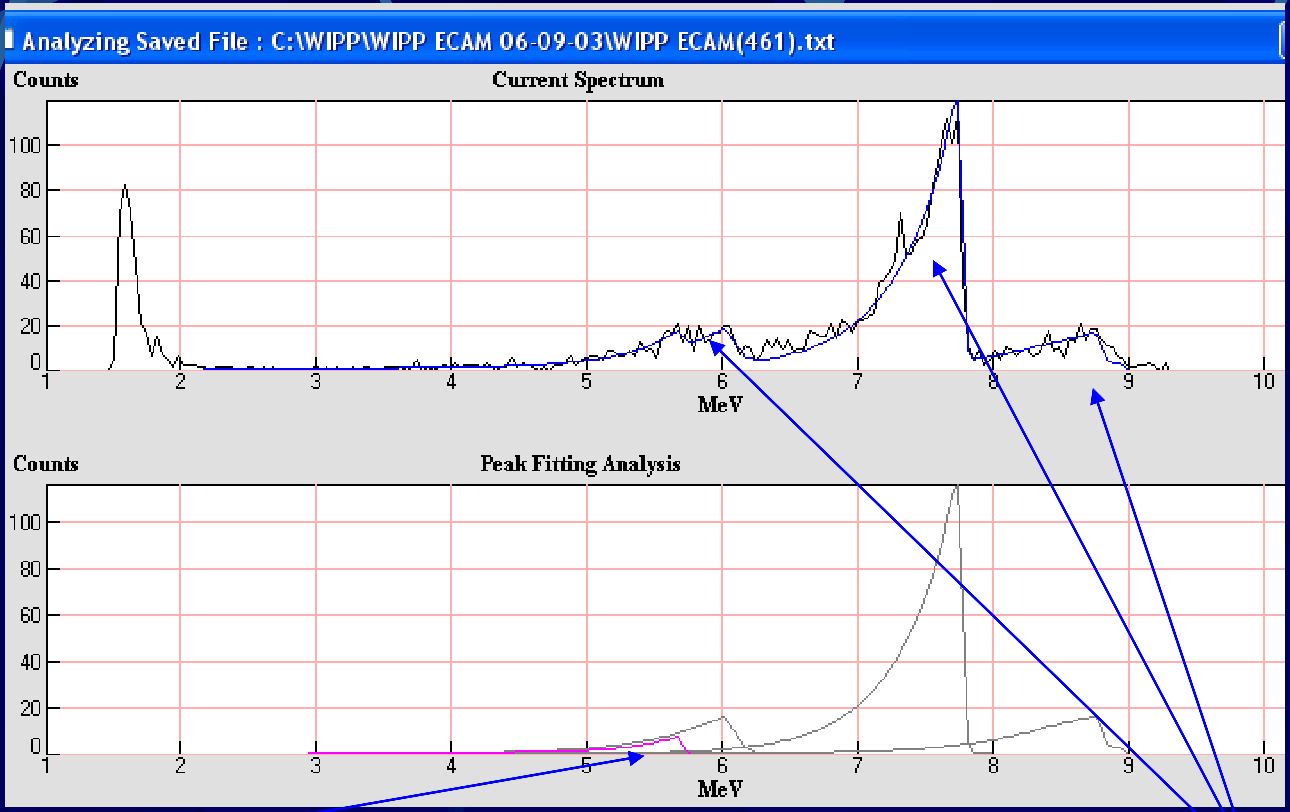
Pu CPM ~ 15.1 +/- 2.5 CPM (2.5 DAC-hr) , 14 min spectrum; Pu source + filter

(Step 2 : determine if count > L_c)

Detection = $A_{Pu} > L_c$, $L_c = k^* \text{ Sigma}$, k = 1.65 – 3.0

Sigma = $[A_{Pu} + 2.0 * (T_6 + T_{7.68} + T_{6.05} + T_{8.78})]^{1/2}$

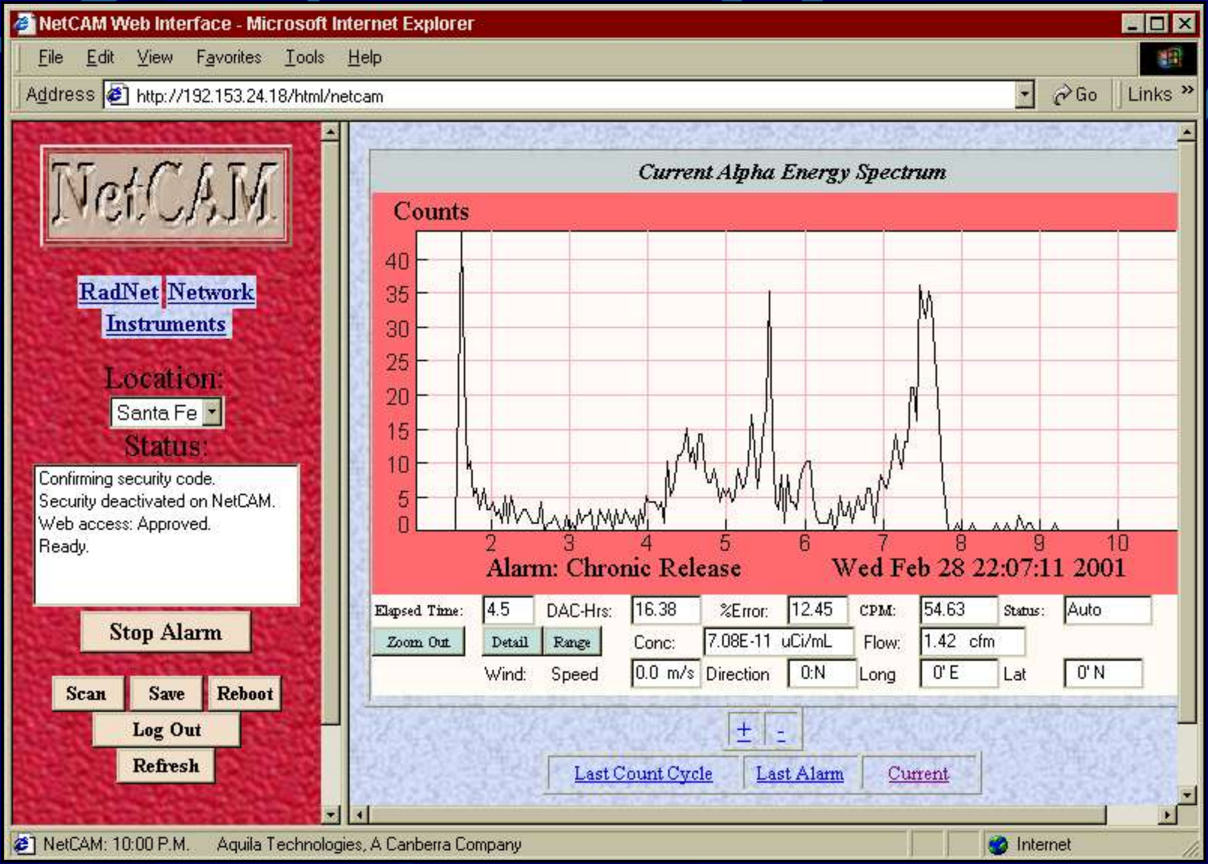
Peak found < L_c due to variable dust + RnD deposition pattern creating multiple peaks



Pu peak found & fitted (5.46 +/- 3.89 cpm), but net CPM < L_c so no detection reported

"Twin peaks"

The alarm condition after detection: Am-241 with RnD & Th-232 Isotope-specific alarm



(Step 3: If CPM > L_c , and DAC-hr > Alarm threshold set alarm “true”; the CPM can be designated to represent the sum of 2 radioisotopes,etc)

Summary observations

- New MCA & embedded PC technologies make more sophisticated real-time analysis feasible
- Real-time, isotope-specific, peak integral measurement provides improved CAM / ECAM performance in a wide variety of monitoring conditions