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The Identification and Determination of Small Peaks in IDC Radionuclide Particulate Spectra Analysis

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1. *Introduction*

Small peaks identifying and correctly being associated with relevant radionuclides is crucial to radionuclide gamma-ray spectrum analysis in IDC that the goal of the maximum detection sensitivity pursued in CTBT radionuclide verification region. In IDC radionuclide analysis software Saint, the peak detection criteria (*D*) is defined to identify peaks in spectra,

$$D = Max\left\{\frac{SCAC_i - B_i}{LCC_i - B_i}\right\}\ ,\ (i-2, i+2)$$

and,

$$LCC_i = B_i + k\cdot\sqrt{\frac{B_i}{1.25\cdot R_i}}$$

where, B_i is the baseline, $SCAC_i$ is the single channel analyser curve; LCC_i is the critical level curve and R_i is the resolution around peak centre channel *i*. The default risk level of $k=10^{-5}$ and peak energy tolerance of 0.8keV are used in routine spectra analysis.

The peak is identified when D >= 1.

The criteria (*D*) used is of benefit of small peaks standing out. Clearly a complex spectrum baseline *B* and peak structure will significantly impact on the small peaks identification. Thus there are the risks of a nonidentification of a true gamma-ray peak of relevant radionuclide - the false-negative peak, and conversely of an identification of a false gamma-ray peak and subsequent radionuclide association - the false-positive peak (Lars-Erik De Geer 2005, W. Zhang 2008 and J. Burnett 2019).

In this paper, deriving from day to day's spectra analysis, the qualitative data and spectra are used to examine the cases of false-negative peaks and false-positive peaks and CTBT relevant radionuclides detection.

4. *Conclusions*

(1) Small peaks issue is specific to CTBT radionuclide monitoring and its complex will result in the increasing of the false-negative and false-positive peaks.

(2) An advanced interactive algorithm and software is needed to deal with small peaks and complex spectrum baselines. and

(3) necessary laboratory reanalysis to verify the peaks and its possible radionuclide association would promote analysts' knowledge and skill.

2. *False-negative peaks*

The false-negative peak, 661.6keV of Cs-137 was found in one sample spectrum that Cs-137 detected by laboratory reanalysis, but IDC didn't. The peak 661.66keV in station spectrum was unidentified due to D < 1. Some similar cases occurred in station spectra (Fig. 2) that 661.6keV were unidentified and Cs-137 might be missing detection.

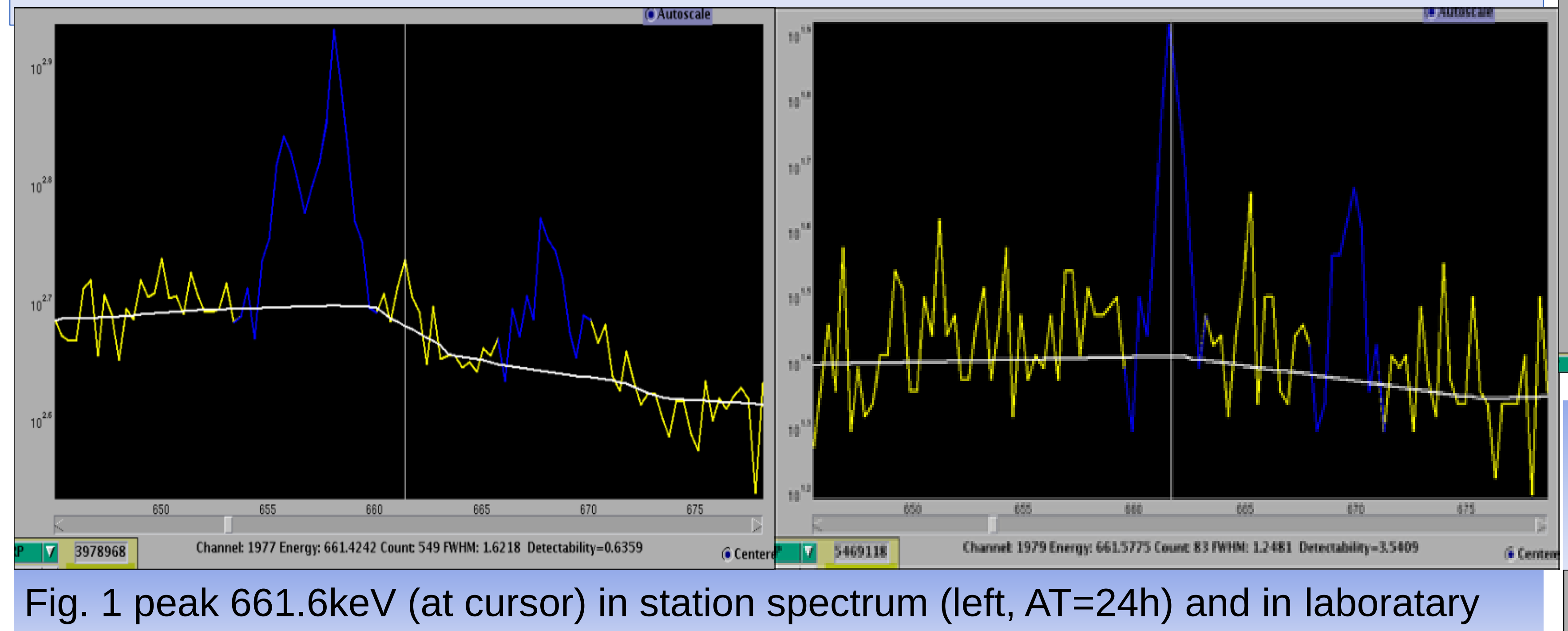


Fig. 1 peak 661.6keV (at cursor) in station spectrum (left, AT=24h) and in laboratory reanalysis spectrum (right, AT=72h) of one sample.

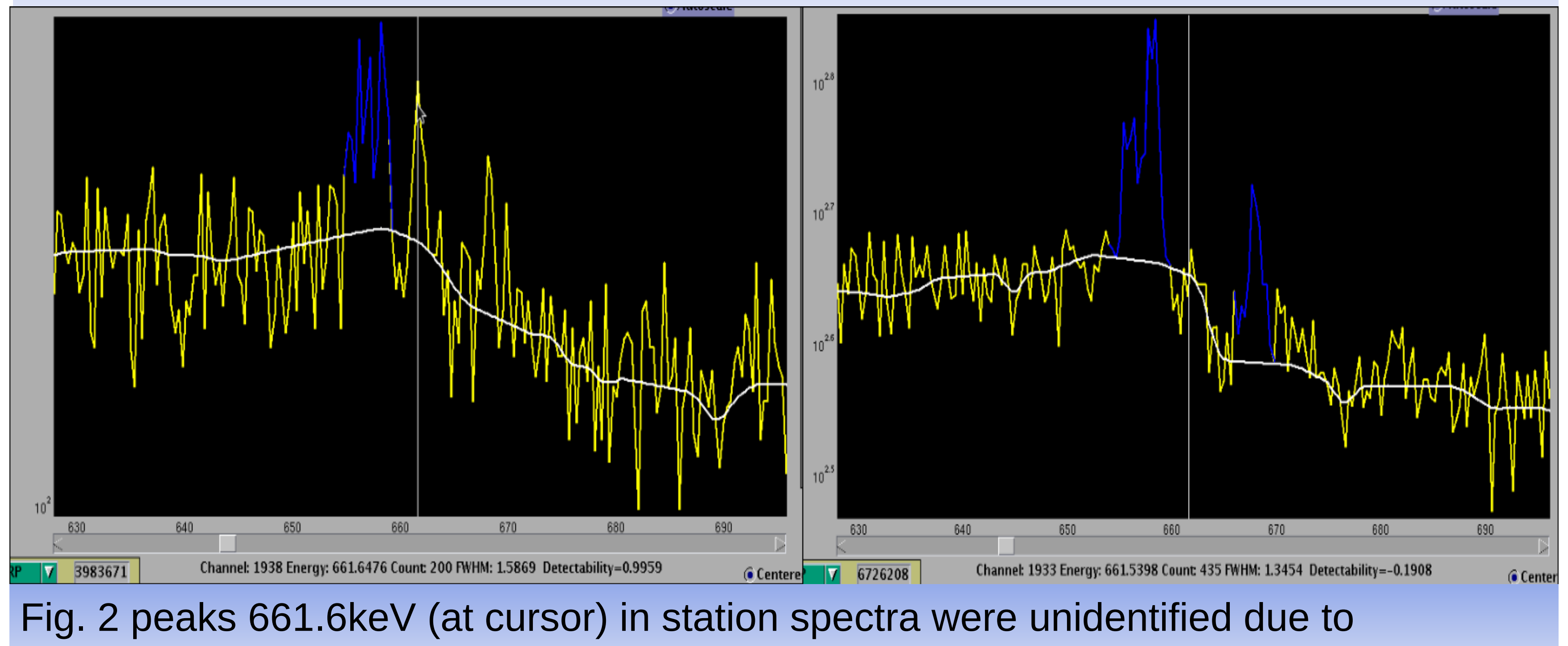


Fig. 2 peaks 661.6keV (at cursor) in station spectra were unidentified due to inappropriate baseline and complicated peak structure.

References

1. Lars-Erik De Geer, 2005. A Decent Currie at the PTS – Detection limit concepts in the PTS rsdionuclide software. CTBT/PTS/TP/2005-1, August 2005.

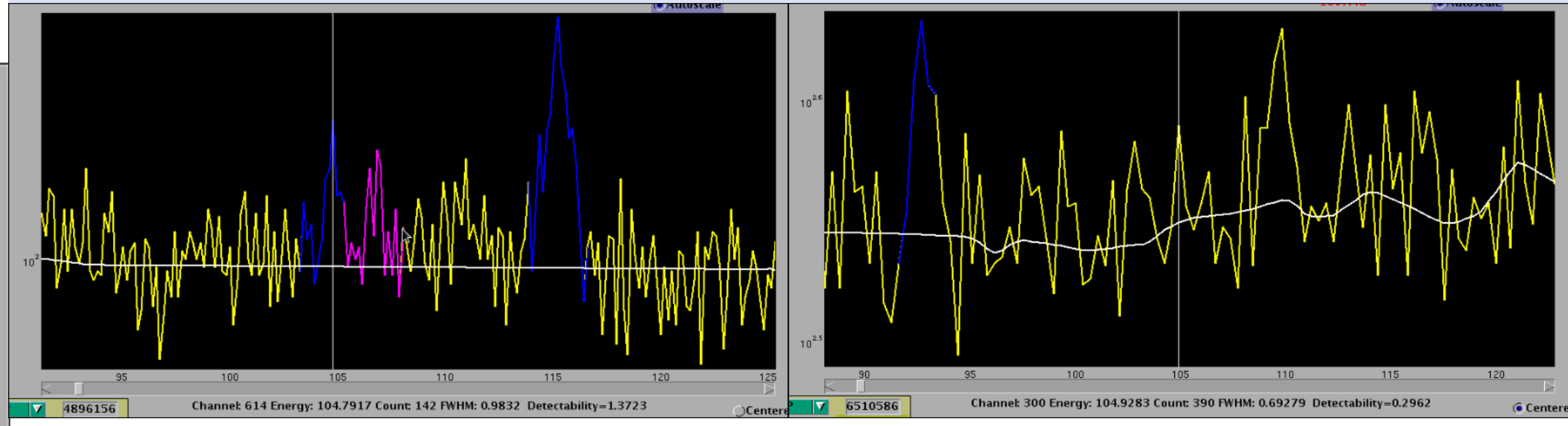
2. Weihua Zhang and et al., 2008. Statistical analysis of uncertainties of gamma-peak identification and area calculation in particulate air-filter environment radionuclide measurements using the results of a CTBTO organized inter-comparison. Applied Radiation and Isotopes 66 (2008) 1695-1702.

3. Jonathan Burnett and et al., 2019. Relevant Radionuclide Detection. Pacific Northwest National Laboratory, Presented at the Radionuclide Expert Group of Working Group B, 25 March – 5 April 2019.

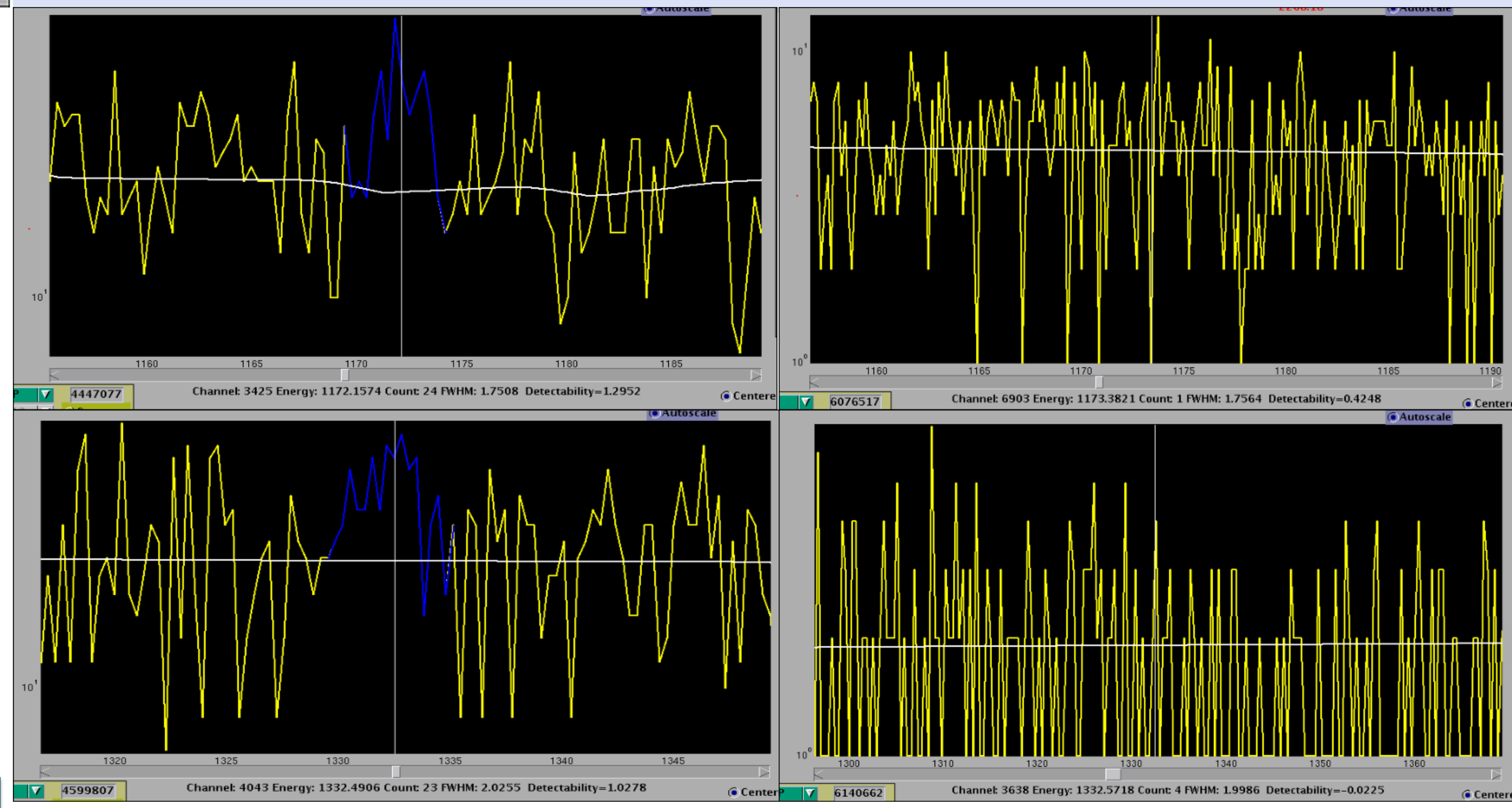
3. *False-positive peaks*

Due to the samples measured near to detectors, the complex small peaks of natural radionuclides in samples make the spectra analysis very difficult. The interference of natural radionuclides will result in false-positive peaks identification and subsequent mis-association.

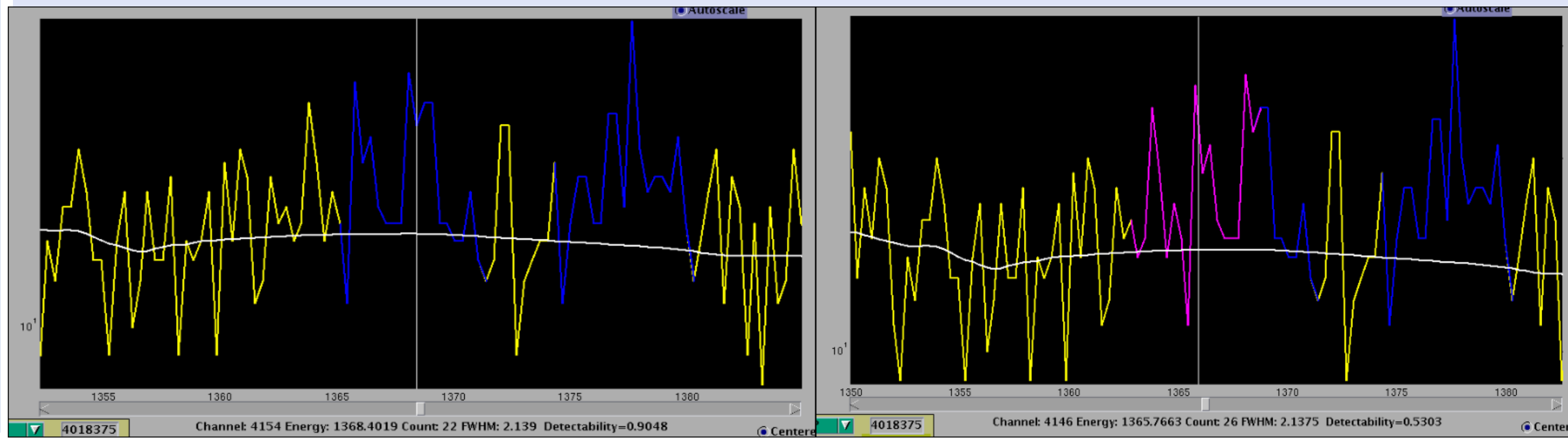
(1) gamma-ray peak 105keV (at cursor) was identified in station spectrum (left) and associated with Eu-155, the lab reanalysis (right) confirmed its association is incorrect .



(2) gamma-ray peaks 1173keV (left/above) or 1332.5keV (left/below) was identified in station spectrum and associated with Co-60, the lab reanalysis (right) confirmed its association is incorrect.



(3) gamma-ray peak 1368.6keV was identified and associated with Na-24 due to inappropriate FWHM value used to determinate the D. Peak 1368.6keV at cursor (left/blue, D=0.90) covered two peaks 1365.7keV (Ac-228) and 1368.6keV (Na-24). The peak boundary is from 1365kev to 1371kev. If peak was manually inserted at energy 1365.7kev, the boundary is 1363kev – 1368kev (right/pink). Obviously the FWHM calibration value 2.1keV@1366and1369keV here is inappropriate for the small peaks 1366kev and 1369keV determination.



PUTTING AN END TO NUCLEAR EXPLOSIONS