

# Some considerations about MDA and ISO 11929-3(2000)

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# Introduction

- The Minimum Detectable Activity (MDA) – the lowest activity value that can be achieved when a sample is measured with a detection system.
- Gamma-ray spectrometry: MDA depends on the background (statistical nature), counting time, detector and sample properties, measurement geometry, nuclear decay data of the considered radionuclide.
- International norms or standards: no MDA definition, but several counting limits (critical, upper, detection etc.) are defined (the radioactive decay process is of statistical nature – usually Poisson).

# ISO 11929-3 : 2000

- **Determination of the detection limit and decision threshold for ionizing radiation measurements – Part 3: Fundamentals and application to counting measurements by high resolution gamma spectrometry, without the influence of sample treatment**
- **Detection Limit (LD)** – a priori information: smallest expectation value of the counting rate of a net peak area that can be detected with a given measuring system (the probability of wrongly not rejecting the null hypothesis – error type II, is less or equal with a value  $\beta$  fixed before the measurement).
- **Decision Threshold (LC)** – a posteriori information: the critical value of a statistical test for the decision between the null hypothesis and the alternative hypothesis (the probability of wrongly rejecting the null hypothesis – error type I, is equal to a value  $\alpha$ , fixed before the measurement).

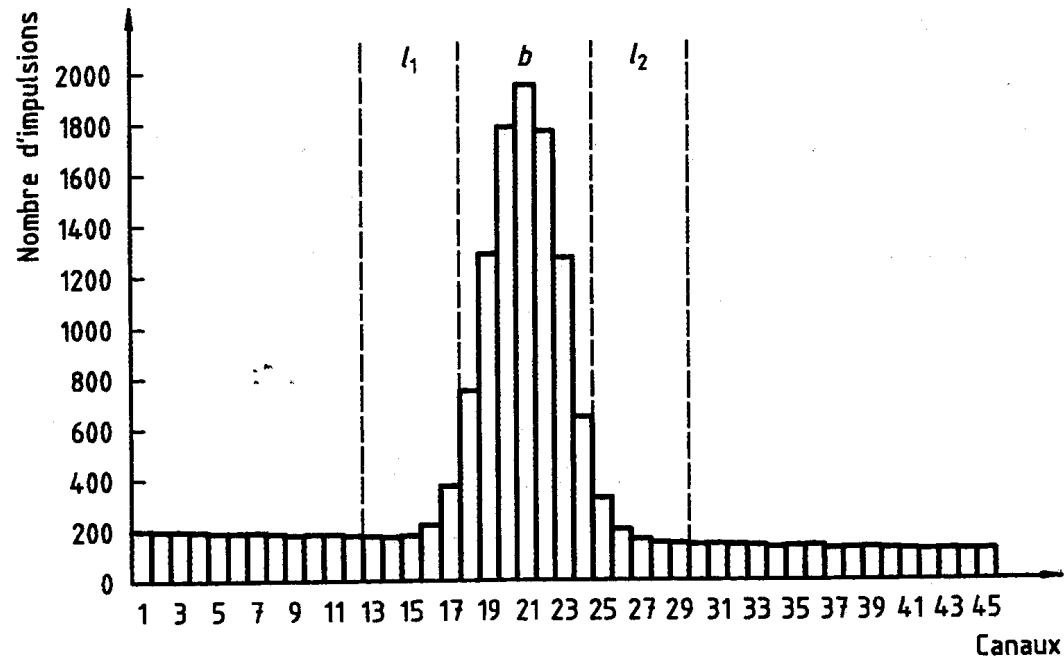
# ISO 11929-3:2000 – Decision Threshold

$$R_n^* = \frac{k_{1-\alpha}^2}{2t} \cdot \frac{b}{2l} \cdot \left[ 1 + \sqrt{\frac{4R_0t}{k_{1-\alpha}} \cdot \frac{2l}{b} \left( 1 + \frac{2l}{b} \right)} \right]$$

$$R_n^* \approx k_{1-\alpha} \cdot \sqrt{\frac{R_0}{t} \left( 1 + \frac{b}{2l} \right)}$$

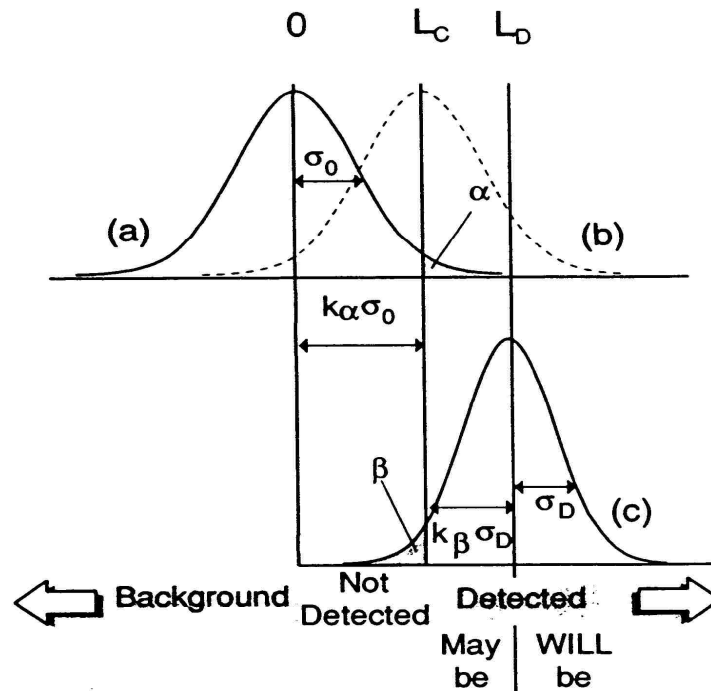
- $R_n$  = net effect counting rate (gross rate – background rate)
- $R_0$  = background effect counting rate
- $\alpha$  = probability of wrongly rejecting the null hypothesis (error type I); [usually  $\alpha = 0.05$ ]
- $k_{1-\alpha}$  = Quantile of normal distribution for error type I [1.645]
- $l_1 = l_2 = l$  (width of regions for background estimation, in channels),  $t$  = measurement time and  $b$  = the width of the region of interest (in channels).

# ISO 11929-3 : 2000 – Regions of the Peak



- $\text{FWHM} \leq b \leq 2.5 \text{ FWHM}$  and  $b \geq 4 \text{ ch.}$
- $b \leq 2l \leq 10b$

# Decision Threshold and Detection Limit



**Figure 5.10** Definition of detection limit (the vertical axis represents the frequency of observing a particular count)

- From “Practical Gamma-Ray spectrometry”, G. Gilmore and John D. Hemingway, Ed. John Wiley & Sons Ltd., 1995, page 122

# ISO 11929-3 : 2000 -Guidelines

- **The measured values: to be compared with the Decision Threshold (LC):**
  - a) **measurement result  $<$  LC  $\Rightarrow$  No net contribution of the sample detected, with the defined confidence level;**
  - b) **LC  $<$  meas. result  $\Rightarrow$  A net contribution of the sample is detected, the result should be reported.**
- **The Detection Limit (LD) defines the performance of the detection system to measure a net signal: must be compared with the guideline value**

# ISO 11929-3 : 2000 – Background for the peak

- The background in ISO 11929-3 is ONLY the continuum component under the net area of the peak; it depends on the few points ( $l_1, l_2$ ) at the left, respectively right side of the peak.
- What about the situations when there is a peaked background contribution in the sample spectrum (like for  $^{40}\text{K}$ ,  $^{214}\text{Bi}$  and other nuclides) ?
  - Probably, ISO 11929-3:2000 must not be applied in these cases ! The new version of this ISO (2009) will solve the problem (according to dr. Gunter Kanisch, vTI, Hamburg, Germany):

$$R_n^* \approx k_{1-\alpha} \cdot \sqrt{\frac{R_T}{t_m} \cdot \left(1 + \frac{b}{2l}\right) + R_{n0} \cdot \left(\frac{1}{t_m} + \frac{1}{t_0}\right) + \frac{R_{T0}}{t_0} \cdot \left(1 + \frac{b_0}{2l_0}\right)}$$

# Examples

- Measurement of the  $^{133}\text{Ba}$  activity in a concrete sample (originating from a decommissioned nuclear reactor, after neutron activation) – in the frame of NPL Environmental Radioactivity Proficiency Test Exercise 2008:
  - Activity result:  $A=0.0059$  (19) Bq/g (simple case, with no peaked background, ISO 11929-3:2000 can be applied); reference result (mean value of the comparison): 0.00704(25) Bq/g.
  - Decision Threshold ( $L_c$ ): 0.00682 s<sup>-1</sup> or 0.0044 Bq/g ( $k_{1-\alpha}=k_{1-\beta}=1.645$ ,  $b=14$ ,  $2l=6$ ,  $t=9000$  s,  $R_0=0.0464$  s<sup>-1</sup>).
  - Detection Limit ( $L_D$ ):  $2 \cdot L_c=0.0088$  Bq/g.

$$L_c < A < L_D$$

## Examples (2)

- For the same concrete sample, for  $^{40}\text{K}$  the net area was 170 counts in 9000 s, while in the background, the net area was 38 counts in 21600 s;

measured value  $A=0.195$  (21) Bq/g; reference value:  
 $0.18$  (8) Bq/g;  $L_C=0.00419$  s $^{-1}$  or equivalent to  $0.048$  Bq/g  
(according to the new ISO);

in this case:  $L_C < L_D=0.096$  Bq/g  $< A$

# Examples (3)

- For a soil sample containing  $^{137}\text{Cs}$  (net area of 916 counts in 61200 s), present also in the background (net area of 709 counts in 61200 s, too), measured with another HP Ge detector, the new ISO was applied again:
- Measured  $A=2.7$  Bq/kg, with relative standard uncertainty of 108 % ! Reference value: 2.50 (5) Bq/kg;
- $L_C=0.00598$  s $^{-1}$  or 4.69 Bq/kg; obviously:

$$A < L_C < L_D$$

- **How should we report such a measured result (as a numerical value or less than  $L_C$ ) ?**

# Discussion

- **The Decision Threshold and the Detection Limit should be reported with all the measured activity results (as requested in PTs or comparisons)**

**OR**

**ONLY if there is no net contribution (peak) from the sample – i.e. no activity value to report ?**

- **What role plays the uncertainty of the measured result when this is compared to the Decision Threshold ?**

**THANK YOU !**