MIRION TECHNOLOGIES

Application Note

Application Note for BAYEX

Preface

This application note provides the user a more detailed description of the Bayesian statistical methodology available in Version 8.05 and above, of the Monitor software.

This document is intended to be a useful reference for the customer in setting statistical parameters and decision points for making a clean or contaminated decision during personnel monitoring. The user has a choice in selecting the Traditional or Bayesian methodology.

The purpose of the application note is to highlight the similarities and differences between the two methodologies, with particular attention to their advantages and limitations in radiation measurement.

Introduction

Scope

Effective radiation monitoring systems are essential in radiation protection and security. All radioactivity measurements are subject to uncertainties. The background due to ambient radiation and other factors need to be considered when determining the radioactivity level of a sample/personnel monitoring result.

Statistical false alarms may occur as a result of fluctuations in the number of recorded events. In order to interpret the measured data correctly, and draw valid conclusions, the uncertainty must be indicated and dealt with properly as is described in the JCGM 100:2008 Guide to the Expression of Uncertainty in Measurement (GUM).

Radioactive decay follows a Poisson distribution, which can be approximated by a normal distribution (Gaussian) when the number of counts over a period of time is greater than 20. This approximation breaks down when the number of counts is below this number and Gaussian statistics is not valid in calculating statistical errors. So in comes the Bayesian statistics to the rescue for the determination of statistical uncertainty at low count rates/alarm levels.

The Bayesian methodology is particularly beneficial for low alarm levels and count rates for alpha contamination.

Bayesian methodology vs. Traditional methodology

Similarities and differences between the two methods are summarized in Table 1, below.

Table 1 – Similarities and Differences Traditional and Bayesian Methodology

Traditional Methodology	Bayesian Methodology
Probability is measurable frequency of events determined from repeated experiments.	Probability is a direct measure of uncertainty and might or might not represent a long-term frequency.
Parameters are fixed but unknown quantities.	Parameters are random variables with distributions attached to them.
Is objective and relies only on statistical data.	Provides probabilistic interpretations ($1-\gamma$).
Well-developed methodology with no need of prior data.	Uses prior knowledge.
Poisson distribution is approximated by Gaussian.	Poisson distribution is approximated by Gaussian in defining detection limit and decision threshold; however calculation of best estimate and confidence intervals are done through Bayesian approximation.
Only uncertainties due to counting statistics are taken in account.	Combine all uncertainty contributions, Type A and Type B uncertainties as per the JCGM 100:2008 guide.
Permit all values.	Prior distribution of activity, best estimate of activity and confidence interval are always positives.
Lower Limit of Detection (LLD).	Characteristic limits are defined (ISO 11929:2010) in a way that they don't differ significantly from those of traditional statistics.
Clean/contaminated decision is made using net count rate vs. ATP (Alarm Trip Point) derived from user entered Alarm Activity.	Clean/contaminated decision is made using upper limit of confidence interval of activity vs. user entered Alarm Activity.
When the ATP is lower than LLD then the LLD (Lower Limit of Detection) is used instead.	When the Alarm Activity is lower than the Decision Threshold then the unit will go "Out of Service".

The most important input and output parameters of the Monitor software, Ver. 8.05 are displayed in Table 2.

Table 2 – Input and Output Parameters

Traditional Methodology	Bayesian Methodology	
Alarm activity	Alarm activity	INPUT PARAMETERS
Bkg False Alarm (K_α)	False alarm probability (α)	
Extend Confidence ($K_{\beta 1}$)	Detection probability (1-β)	
Alarm Confidence ($K_{\beta 2}$)		
	Confidence interval probability (1-γ)	
Bkg Reset Level (K_Δ)	Bkg Reset Level (K_Δ)	
Background Average Period	Background Average Period	
Target Uncertainty	Measurement Process Uncertainty	
	Certificate Emission Rate Uncertainty	
	Confidence Coverage Factor (k_c)	
Detection Efficiency (Calibration)	Detection Efficiency (Calibration)	OUTPUT
	Detection Efficiency Uncertainty (Calibration)	
Count time	Count time	
Lower Limit of Detection (LLD)	Decision Threshold	
Alarm Level Set Point (ALS)		
Contaminated Trip Point (CTP)		
Alarm Trip Point (ATP)		
Used Trip Point (UTP)		
	Detection Limit	
Net Count Rate	Best Estimate Activity	
	Uncertainty Best Estimate Activity	
	Confidence Interval	

Default Setting

The default settings for the Bayesian methodology were established using empirical data to achieve enhanced performance and balance between the False Alarm Rate (FAR), Detection Probability (DP) and Count Time while keeping the default settings close to the traditional methodology's default settings. The Bayesian methodology provides the confidence interval of activity with the attached probability (1-γ), which is in addition to FAR and DP and it makes difficult the direct comparison of the two methodologies.

Based on industry norms and our test results, Mirion recommends the following default settings to be used (see Table 3) in any type of contamination monitors, in detecting alpha, beta and gamma radiation, for both Traditional and Bayesian methodologies. Note that the alarm levels for your facility, location, or equipment may be dependent upon different guidance/regulations. Please consult your local authority to select levels appropriate for your use.

Table 3 – Default setting for Traditional and Bayesian Methodology
US units in parenthesis

Traditional Methodology	
Bkg False Alarm	$K_\alpha = 3$
Extend Confidence	$K_{\beta 1} = 2$
Alarm Confidence	$K_{\beta 2} = 2$
Bkg Reset Level	$K_\Delta = 4$
Background Average Period	300 s
Alarm Activity (Alpha)	16.67 Bq (1000 dpm)
Alarm Activity (Beta)	83.33 Bq (5000 dpm)
Alarm Activity (Gamma)	2775 Bq (75 nCi Cs-137)

Bayesian Methodology	
False alarm probability (α)	α = 0.135%, ($k_{1-\alpha} = 3$)
Detection probability (1-β)	1-β = 97.725%, ($k_{1-\beta} = 2$)
Confidence interval probability (1-γ)	1-γ = 97.725%
Bkg Reset Level	$K_\Delta = 4$
Background Average Period	300 s
Alarm Activity (Alpha)	16.67 Bq (1000 dpm)
Alarm Activity (Beta)	83.33 Bq (5000 dpm)
Alarm Activity (Gamma)	2775 Bq (75 nCi Cs-137)

Test results Bayesian and Traditional Methodology

The Bayesian methodology is described in details in *"Supplementary Bayesian Methodology User's Manual"*. The measurements were conducted on the Sirius™-5AB contamination monitor. Alpha and beta radiation were measured with a gas flow detector, LFP-579, and gamma radiation was measured with a plastic scintillation detector, TPS-BG-579. All the other detectors and therefore all sum zones were switched off during the measurements. The testing conditions were kept as constant as possible during the tests in order to minimize the number of test variables.

The activities of Am-241 and Tc-99 radioactive sources were attenuated by limiting the effective source area, which it was possible by partially closing the shutter attached to the source until the desired activity was achieved: 16.67 Bq for alpha and 83.33 Bq for beta. The activity of the Co-60 gamma source was not attenuated; this source had an activity of 836 Bq when the test was done.

No radioactive source was used for the FAR test.

The graphical presentation of the measured data can be found in Figure 1, Figure 2, and Figure 3 with the following notations:

AA – alarm activity

ε – detection efficiency

t_b – background count time

R_b – background count rate

indexes "α", "β" and "γ" refer to type of radiation

indexes "T" and "B" refer to Traditional and respective Bayesian methodology

The count time was calculated at the point where the alarm activity (red line) intersects the detection limit curve (see Figure 1).

During the measurement, three different scenarios may happen for the measured activity:

- Activity is smaller than decision threshold (in this case the methodology is not valid for the measurement purpose)
- Activity is between the decision threshold and detection limit ($DP<1-\beta$)
- Activity is bigger than the detection limit ($DP\geq1-\beta$)

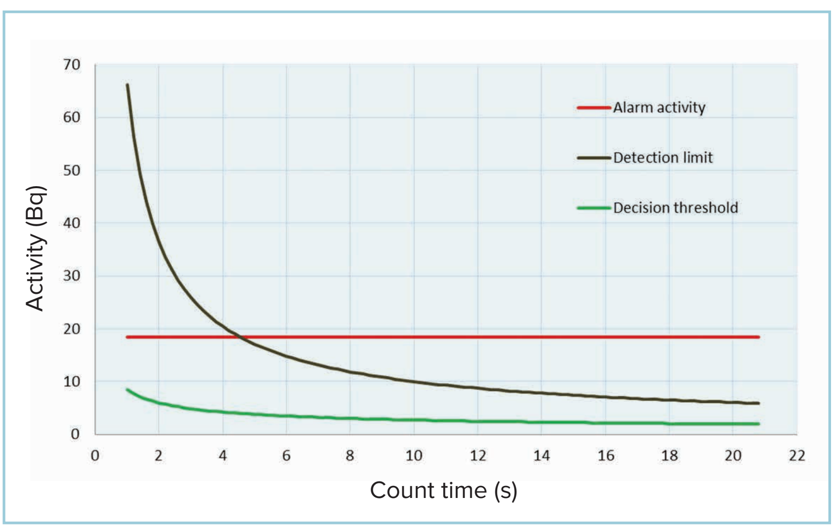

Figure 1 – Detection Limit and Decision Threshold Bayesian Methodology. Alpha alarm set point shown.

Test results

Input Parameters	Traditional methodology	Bayesian methodology
False Alarm Probability	$K_\alpha = 3$	$\alpha = 0.135\%$, $(k_{1-\alpha} = 3)$
Detection Probability	$K_{\beta 1} = K_{\beta 2} = 2$	$1\text{-}\beta = 97.725\%$, $(k_{1-\beta} = 2)$
Confidence Interval Probability		$1\text{-}\gamma = 97.725\%$

AA_α = 16.67 Bq, AA_β = 83.33 Bq, AA_γ = 836 Bq, ε_α = 4.85%, ε_β = 4.95%, ε_γ = 2.5%, t_b = 300 s, $R_{bT\alpha}$ = 0.053 cps, $R_{bB\alpha}$ = 0.04 cps, $R_{bT\beta}$ = 6.08 cps, $R_{bB\beta}$ = 6.08 cps, $R_{bT\gamma}$ = 69.75 cps, $R_{bB\gamma}$ = 69.31 cps

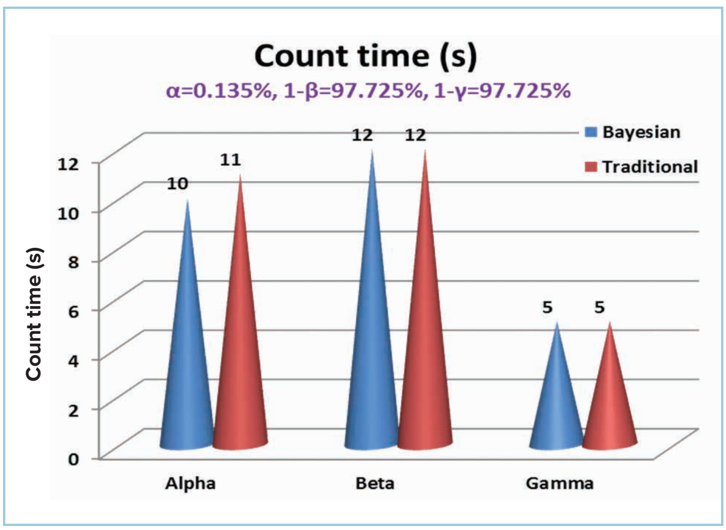

Figure 2 – Count Time for Alpha, Beta and Gamma Radiation for the Traditional and Bayesian Methodology

For the Bayesian methodology, the count time was calculated as described above, and was rounded up to the closest integer.

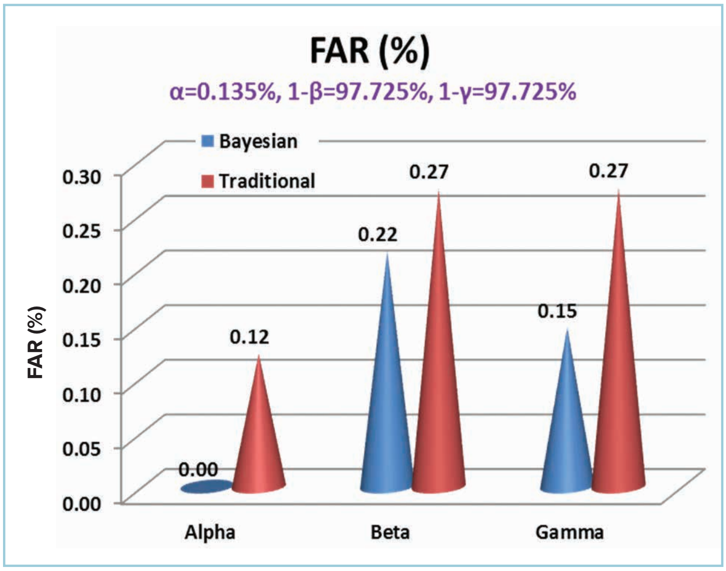

Figure 3 – False Alarm Rate for Alpha, Beta and Gamma Radiation for the Traditional and Bayesian Methodology

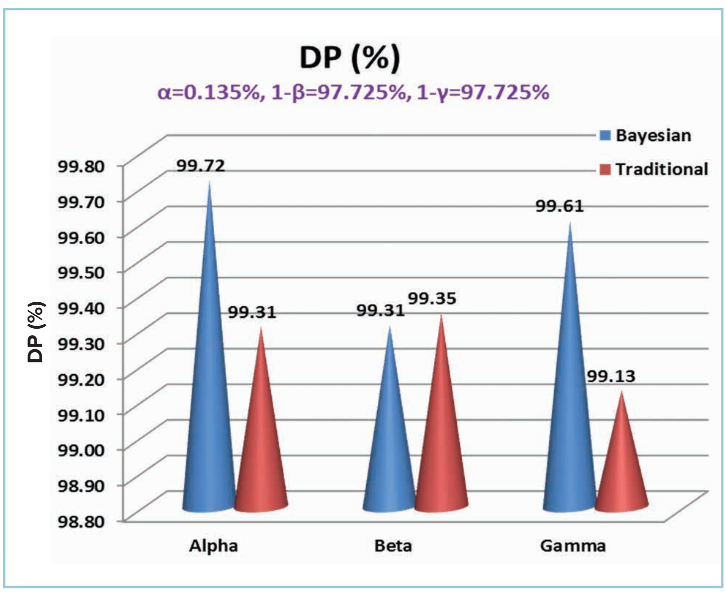

Figure 4 – Detection Probability for Alpha, Beta and Gamma Radiation for the Traditional and Bayesian Methodology

As shown in Figure 2, Figure 3 and Figure 4 respectively, the Bayesian methodology provides better results than the Traditional methodology, with slightly lower count times for the alpha radioactivity, some improvements in detection probability, and lower false alarm rates for low levels of alpha radioactivity.

In order to reduce the count time, the detection and confidence interval probabilities were decreased to 90%, while keeping the false alarm probability at 0.135%, (see table below):

Input Parameters	Traditional methodology	Bayesian methodology
False Alarm Probability	$K_{\alpha} = 3$	$\alpha = 0.135\%$, ($k_{1-\alpha} = 3$)
Detection Probability	$K_{\beta 1} = K_{\beta 2} = 1.28$	$1-\beta = 90\%$, ($k_{1-\beta} = 1.28$)
Confidence Interval Probability		$1-\gamma = 90\%$

AA_{α}=16.67 Bq, AA_{β}=83.33 Bq, AA_{γ}=836 Bq, ε_{α}=4.85%, ε_{β}=4.95%, ε_{γ}=2.5%, t_b=300 s, $R_{bT\alpha}$=0.046 cps, $R_{bB\alpha}$=0.033 cps, $R_{bT\beta}$=6.09 cps, $R_{bB\beta}$=6.08 cps, $R_{bT\gamma}$=67.85 cps, $R_{bB\gamma}$=67.68 cps

The compared test results can be found in Figure 5, Figure 6 and Figure 7, respectively.

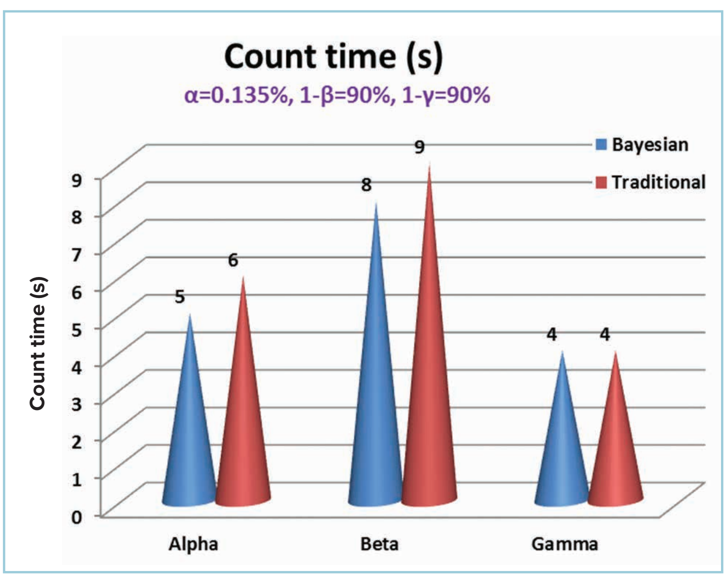

Figure 5 – Count Time for Alpha, Beta and Gamma Radiation for the Traditional and Bayesian Methodology

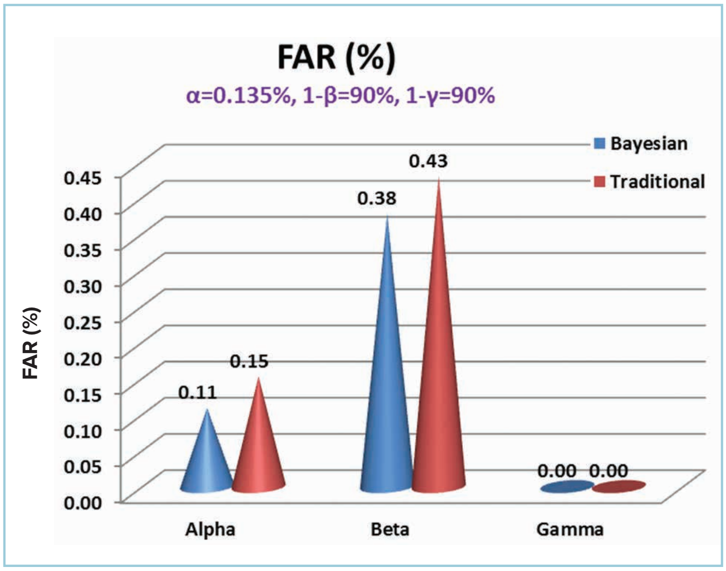

Figure 6 – False Alarm Rate for Alpha, Beta and Gamma Radiation for the Traditional and Bayesian Methodology

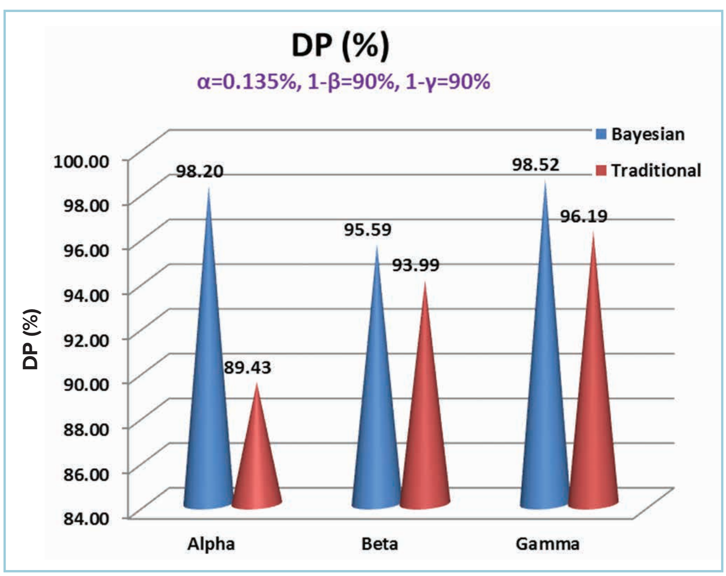

Figure 7 – Detection Probability for Alpha, Beta and Gamma Radiation for the Traditional and Bayesian Methodology

As shown in Figure 2 and Figure 5 the count time for the alpha radiation has been reduced from 10 s to 5 s for the Bayesian methodology and from 11 s to 6 s for the Traditional methodology; less significant count time reduction was observed for higher level of beta and gamma radioactivity. The performance degradation in detection probability was more significant for the Traditional methodology and for low radioactivity (89.4% vs. 98.2%), see Figure 4 and Figure 7.

No significant change in FAR was observed.

Interaction of input parameters and their effect on output results

Interactions of different input parameters and their effect on the measurements were studied, in simulation mode for alpha, beta and gamma radiation on a single detector and by using the Bayesian algorithm as implemented in the Monitor software, Ver. 8.05. The test results are graphically presented in Figure 8 to Figure 25.

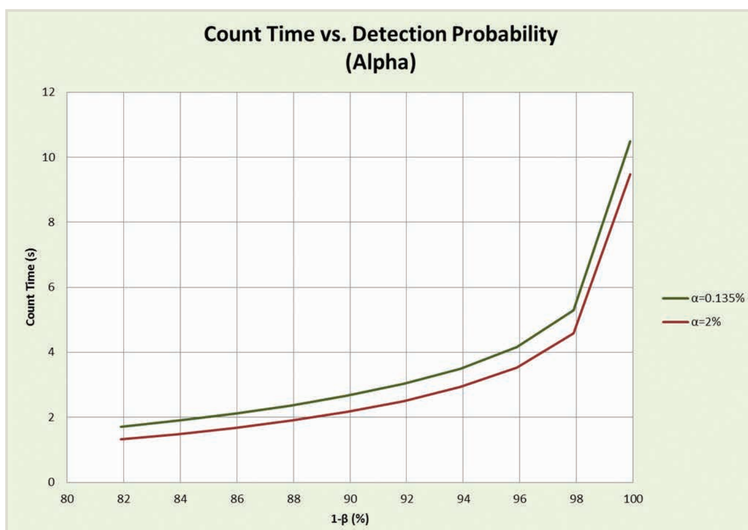

Figure 8 – Variation of Count Time in Function of Detection Probability for Different False Alarm Probabilities (Alpha Radiation)

Input parameters: **Alarm Activity=16.66 Bq**, $\varepsilon = 8\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 0.05$ cps.

Observation: Significant increase in count time is expected for 1-β>97%.

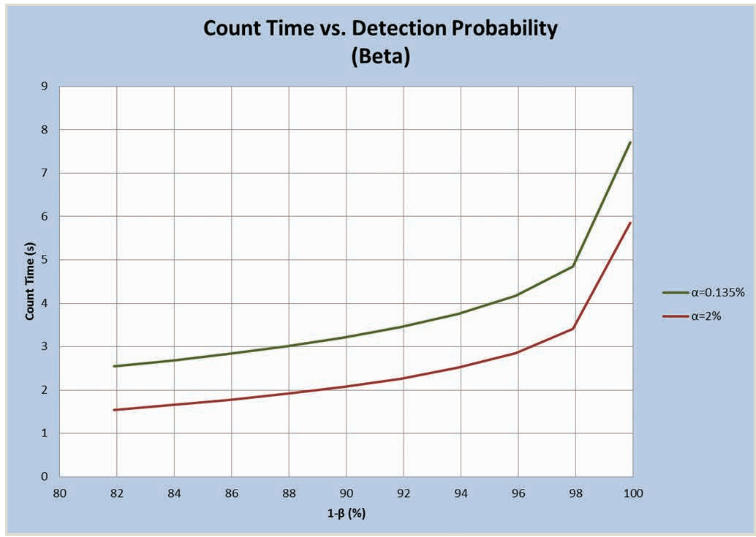

Figure 9 – Variation of Count Time in Function of Detection Probability for Different False Alarm Probabilities (Beta Radiation)

Input parameters: **Alarm Activity=83.33 Bq**, ε=8%, u_{re}=0, S_f=1, t_b=300 s, R_b=6 cps.

Observation: Significant increase in count time is expected for 1-β>97%.

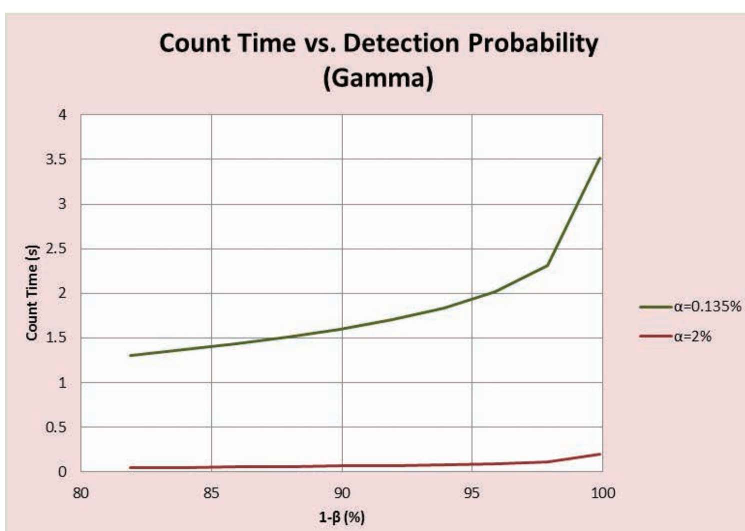

Figure 10 – Variation of Count Time in Function of Detection Probability for Different False Alarm Probabilities (Gamma Radiation)

Input parameters: **Alarm Activity=2775 Bq**, ε=5%, u_{re}=0, S_f=1, t_b=300 s, R_b=70 cps.

Observation: Significant increase in count time is expected for 1-β>98%.

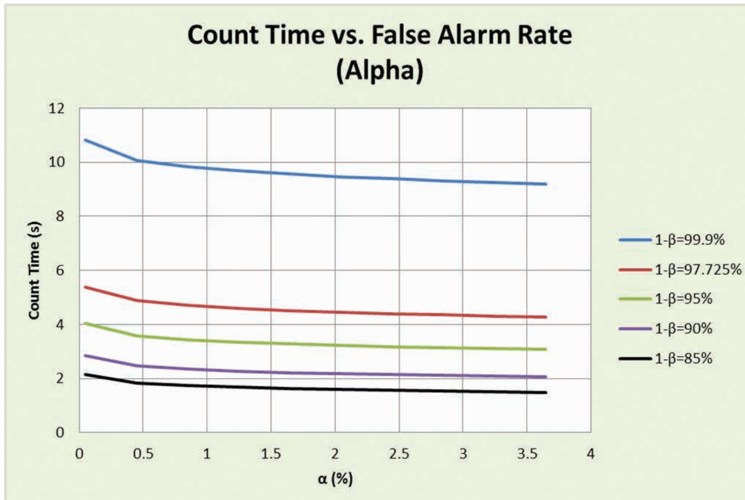

Figure 11 – Variation of Count Time in Function of False Alarm Probability for Different Detection Probabilities (Alpha Radiation)

Input parameters: **Alarm Activity=16.66 Bq**, $\varepsilon=8\%$, $u_{re}=0$, $S_f=1$, $t_b=300$ s, $R_b=0.05$ cps.

Observations: Steeper slope of the curves for $\alpha<0.5$ results in increase of count time.

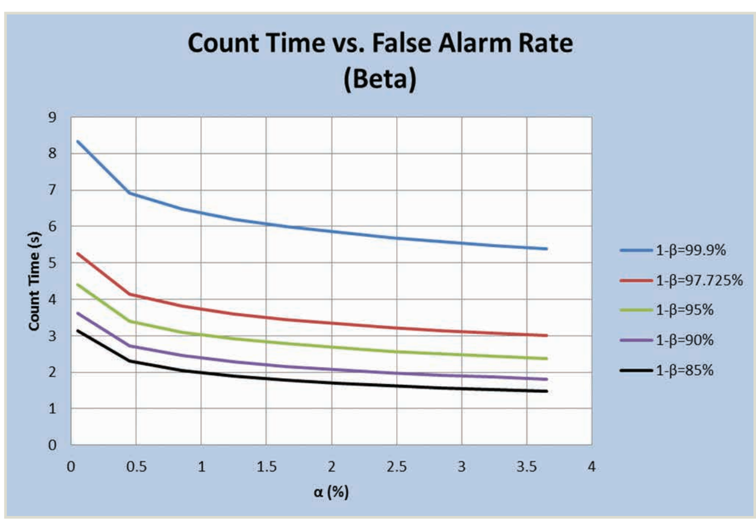

Figure 12 – Variation of Count Time in Function of False Alarm Probability for Different Detection Probabilities (Beta Radiation)

Input parameters: **Alarm Activity=83.33 Bq**, $\varepsilon=8\%$, $u_{re}=0$, $S_f=1$, $t_b=300$ s, $R_b=6$ cps.

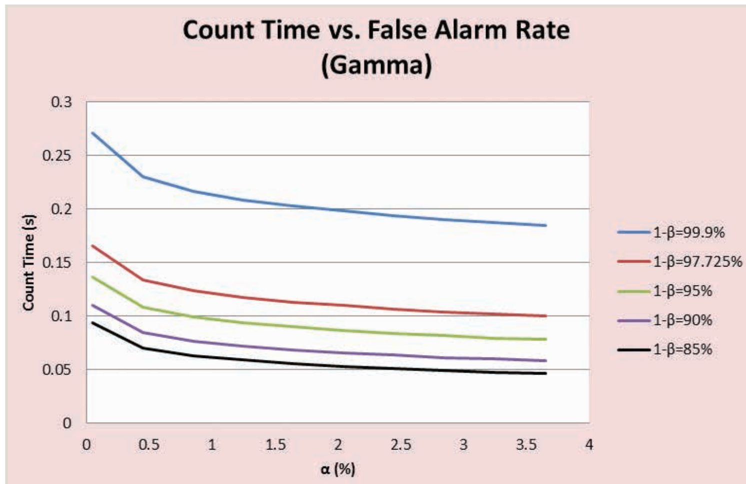

Figure 13 – Variation of Count Time in Function of False Alarm Probability for Different Detection Probabilities (Gamma Radiation)

Input parameters: **Alarm Activity=2775 Bq**, $\varepsilon = 5\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 70$ cps.

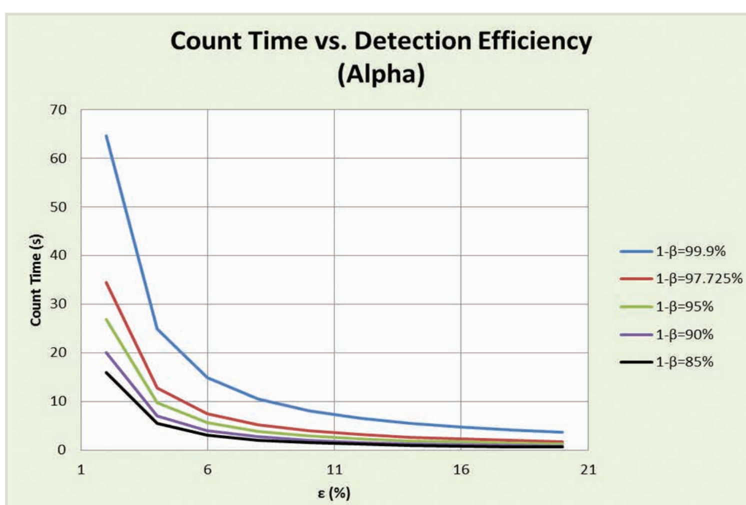

Figure 14 – Variation of Count Time in Function of Detection Efficiency for Different Detection Probabilities (Alpha Radiation)

Input parameters: **Alarm Activity=16.66 Bq**, $\alpha = 0.135\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 0.05$ cps.

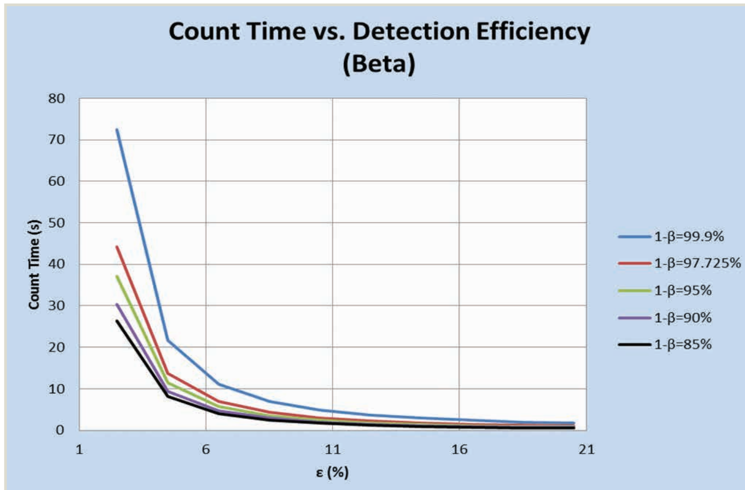

Figure 15 – Variation of Count Time in Function of Detection Efficiency for Different Detection Probabilities (Beta Radiation)

Input parameters: **Alarm Activity=83.33 Bq**, $\alpha = 0.135\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 6$ cps.

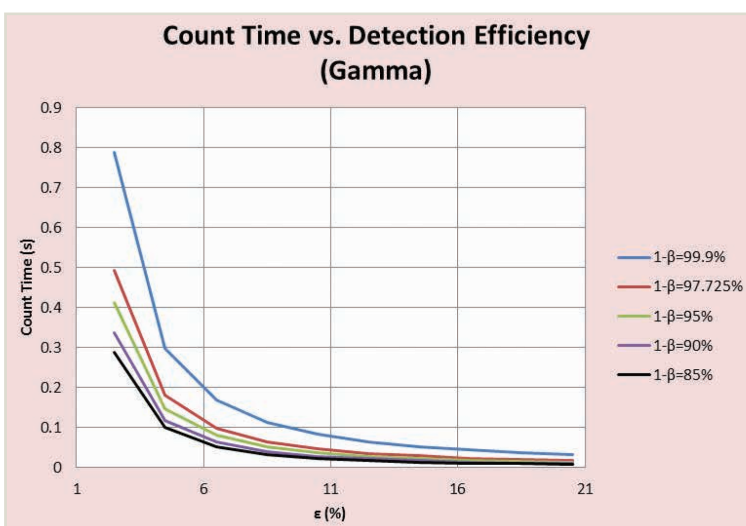

Figure 16 – Variation of Count Time in Function of Detection Efficiency for Different Detection Probabilities (Gamma Radiation)

Input parameters: **Alarm Activity=2775 Bq**, $\alpha = 0.135\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 70$ cps.

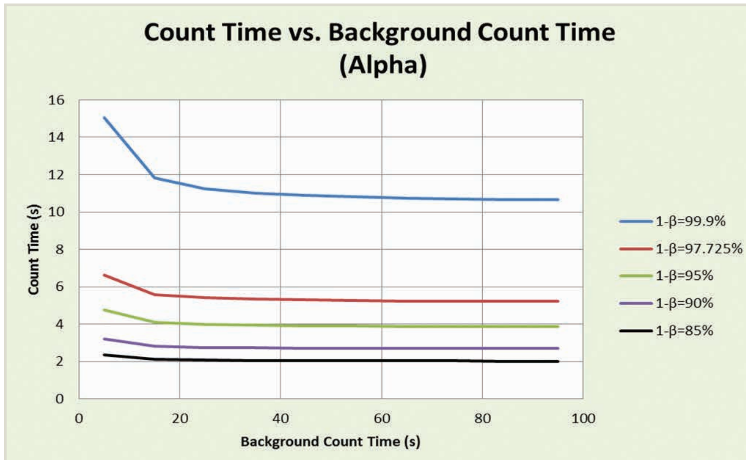

Figure 17 – Variation of Count Time in Function of Background Count Time for Different Detection Probabilities (Alpha Radiation)

Input parameters: **Alarm Activity=16.66 Bq**, $\alpha = 0.135\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 0.05$ cps.

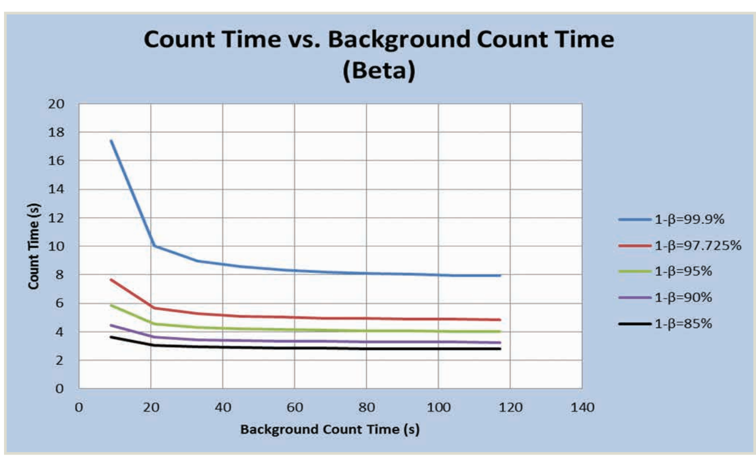

Figure 18 – Variation of Count Time in Function of Background Count Time for Different Detection Probabilities (Beta Radiation)

Input parameters: **Alarm Activity=83.33 Bq**, $\alpha = 0.135\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 6$ cps.

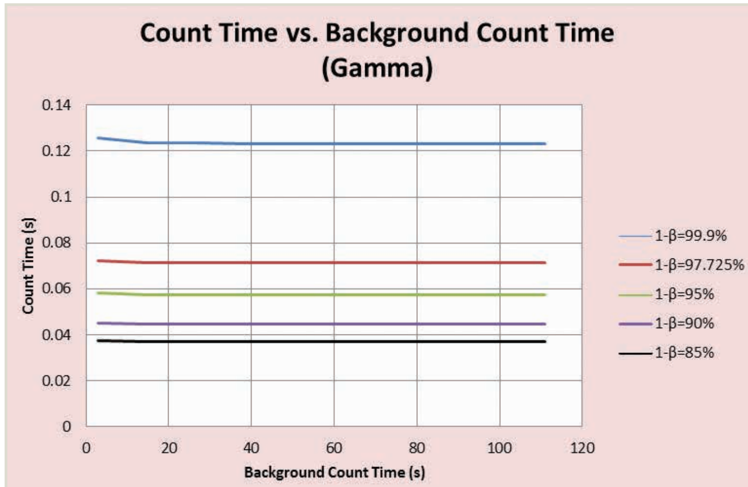

Figure 19 – Variation of Count Time in Function of Background Count Time for Different Detection Probabilities (Beta Radiation)

Input parameters: **Alarm Activity=2775 Bq**, $\alpha = 0.135\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 70$ cps.

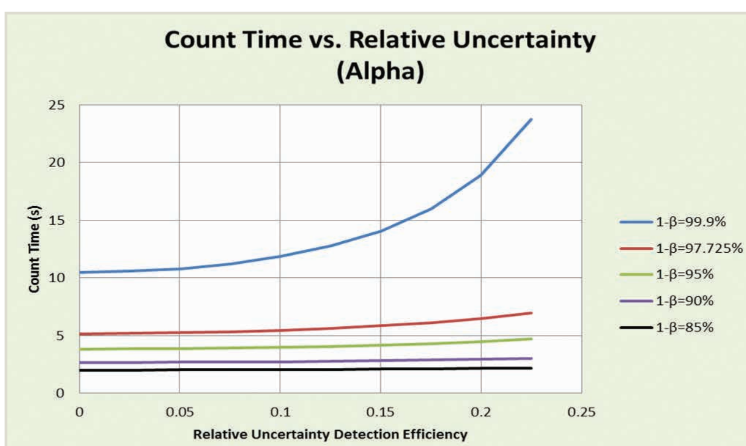

Figure 20 – Variation of Count Time in Function of Relative Uncertainty of Detection Efficiency for Different Detection Probabilities (Alpha Radiation)

Input parameters: **Alarm Activity=16.66 Bq**, $\alpha = 0.135\%$, $\varepsilon = 8\%$, $S_f = 1$, $t_b = 300$ s, $R_b = 0.05$ cps.

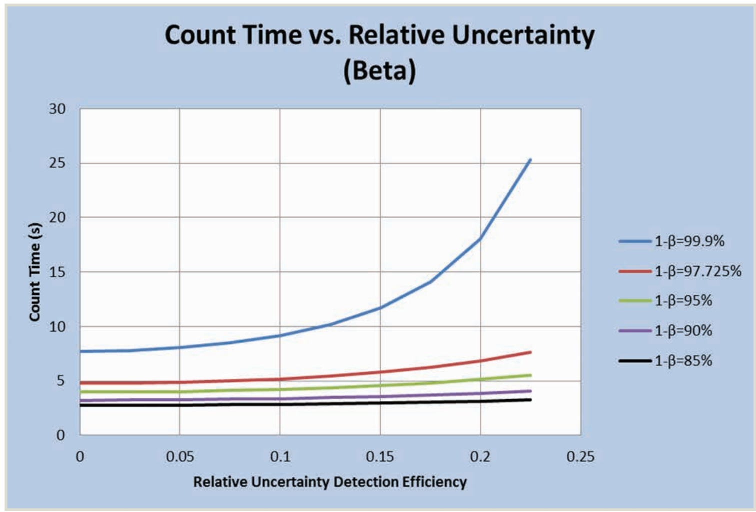

Figure 21 – Variation of Count Time in Function of Relative Uncertainty of Detection Efficiency for Different Detection Probabilities (Beta Radiation)

Input parameters: **Alarm Activity=83.33 Bq**, $\alpha = 0.135\%$, $\varepsilon = 8\%$, $S_f = 1$, $t_b = 300$ s, $R_b = 6$ cps.

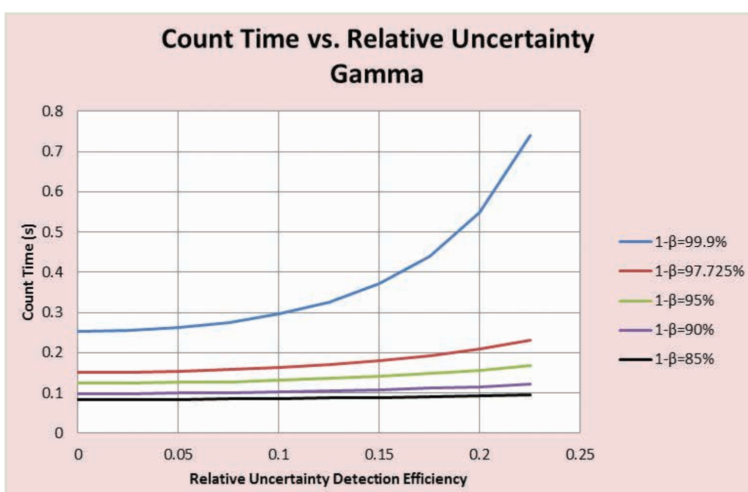

Figure 22 – Variation of Count Time in Function of Relative Uncertainty of Detection Efficiency for Different Detection Probabilities (Gamma Radiation)

Input parameters: **Alarm Activity=2775 Bq**, $\alpha = 0.135\%$, $\varepsilon = 5\%$, $S_f = 1$, $t_b = 300$ s, $R_b = 70$ cps.

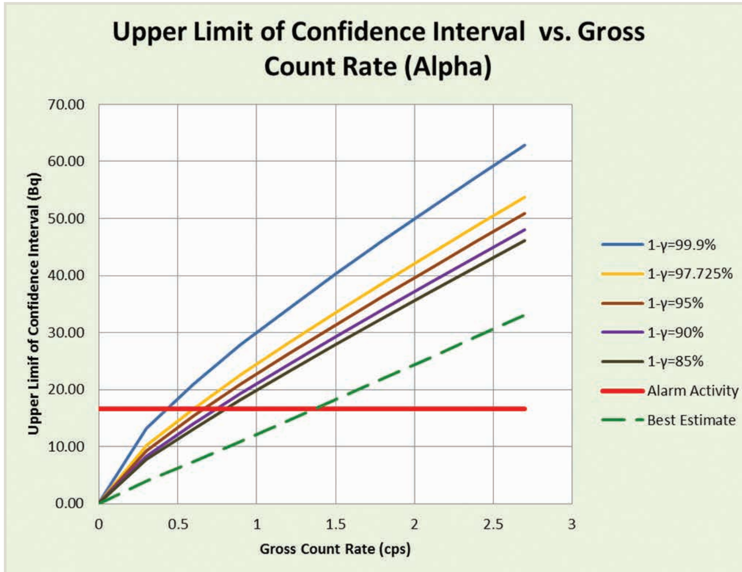

Figure 23 – Variation of Upper Limit of Confidence Interval in Function of Measured Gross Count Rate for Different Detection Probabilities (Alpha Radiation)

Note: The graph also shows the variation of the calculated best estimate of activity (green dashed line) in function of measured gross count rate; the red line on the graph is the alarm activity. When the detected gross count rate is above the alarm activity the contaminated decision will be made; the minimum gross rate at which contaminated decision is made, is at the intersection of alarm activity with the curves (not the best estimate curve) of different 1-γ probabilities; the minimum gross rate is lower for higher 1-γ.

Input parameters: **Alarm Activity=16.66 Bq**, $\alpha = 0.135\%$, $1\text{-}\beta = 97.725\%$, $\varepsilon = 8\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 0.05$ cps.

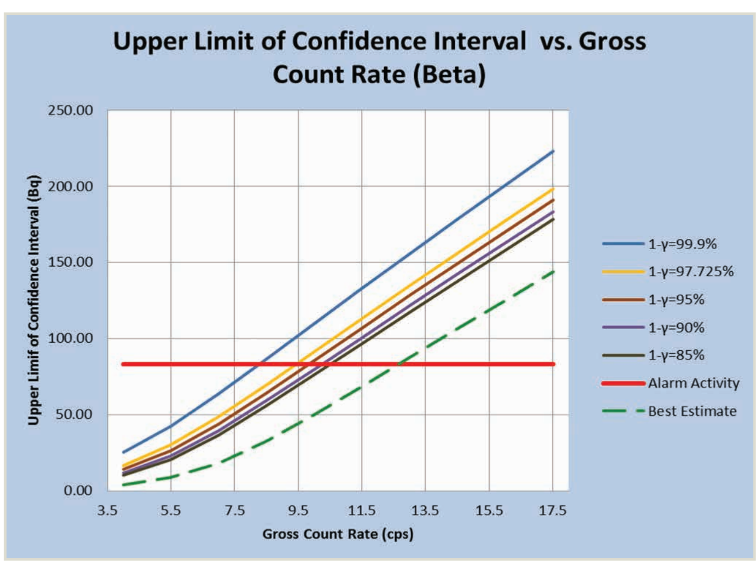

Figure 24 – Variation of Upper Limit of Confidence Interval in Function of Measured Gross Count Rate for Different Detection Probabilities (Beta Radiation)

Input parameters: **Alarm Activity=83.33 Bq**, $\alpha = 0.135\%$, $1\text{-}\beta = 97.725\%$, $\varepsilon = 8\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 6$ cps.

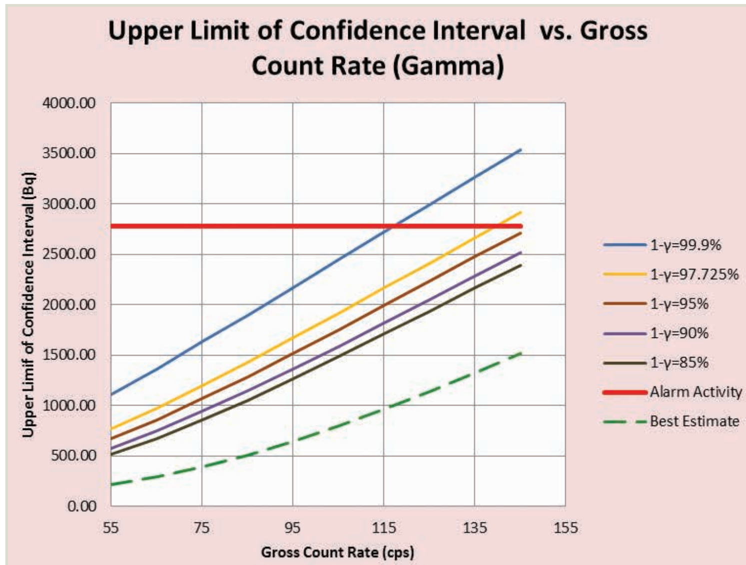

Figure 25 – Variation of Upper Limit of Confidence Interval in Function of Measured Gross Count Rate for Different Detection Probabilities (Gamma Radiation)

Input parameters: **Alarm Activity=2775 Bq**, $\alpha = 0.135\%$, $1\text{-}\beta = 97.725\%$, $\varepsilon = 5\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 70$ cps.

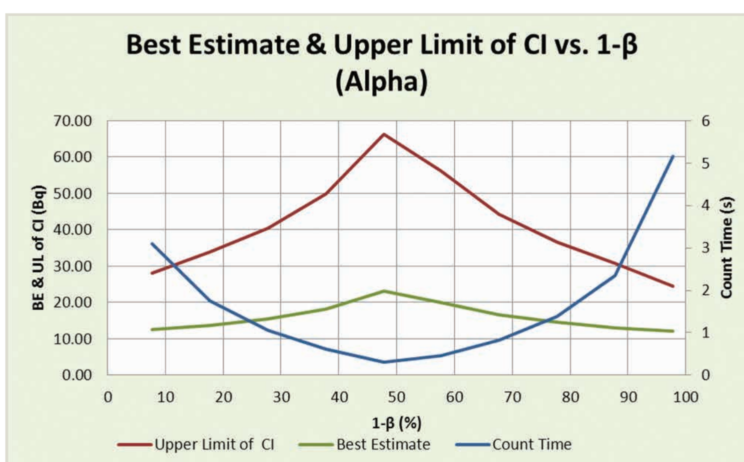

Figure 26 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. 1-β (Alpha Radiation)

Note: For fixed count time, but different 1-β, the Best Estimate and Upper Limit of Confidence Interval are constant.

Input parameters: **Alarm Activity=16.66 Bq**, $\alpha = 0.135\%$, $1\text{-}\gamma = 97.725\%$, $\varepsilon = 8\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 0.05$ cps, $R_g = 1$ cps.

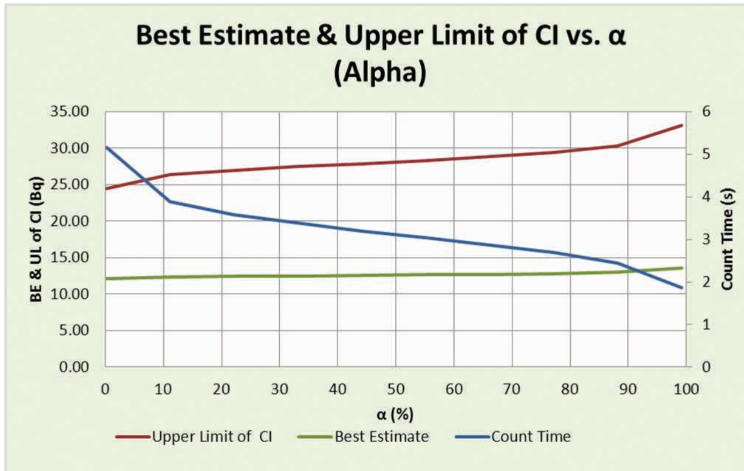

Figure 27 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. α (Alpha Radiation)

Note: For fixed count time, but different α, the Best Estimate and Upper Limit of Confidence Interval are constant.

Input parameters: **Alarm Activity=16.66 Bq**, $1\text{-}\beta=97.725\%$, $1\text{-}\gamma=97.725\%$, $\varepsilon=8\%$, $u_{re}=0$, $S_f=1$, $t_b=300$ s, $R_b=0.05$ cps, $R_g=1$ cps.

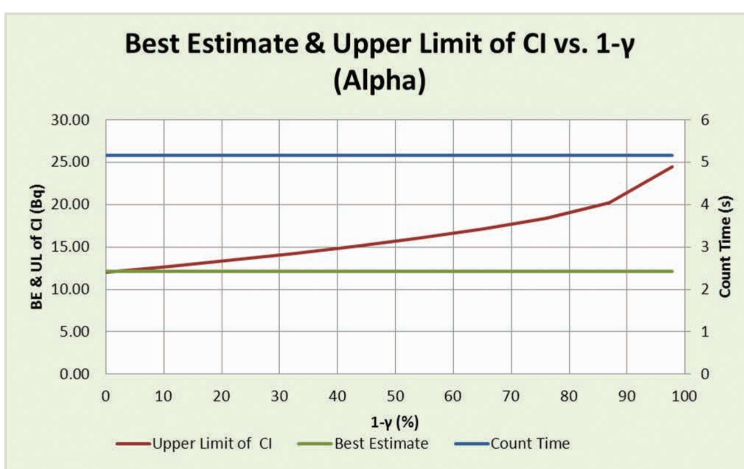

Figure 28 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. $1\text{-}\gamma$ (Alpha Radiation)

Note: The Count Time and Best Estimate don't depend on $1\text{-}\gamma$.

Input parameters: **Alarm Activity=16.66 Bq**, $\alpha=0.135\%$, $1\text{-}\beta=97.725\%$, $\varepsilon=8\%$, $u_{re}=0$, $S_f=1$, $t_b=300$ s, $R_b=0.05$ cps, $R_g=1$ cps.

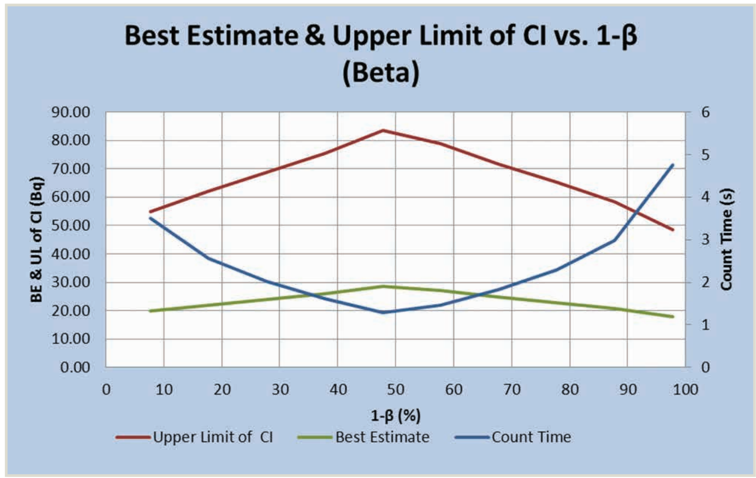

Figure 29 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. 1-β (Beta Radiation)

Note: For fixed count time, but different 1-β, the Best Estimate and Upper Limit of Confidence Interval are constant.

Input parameters: **Alarm Activity=83.33 Bq**, $\alpha = 0.135\%$, $1\text{-}\gamma = 97.725\%$, $\varepsilon = 8\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 6$ cps, $R_g = 7$ cps.

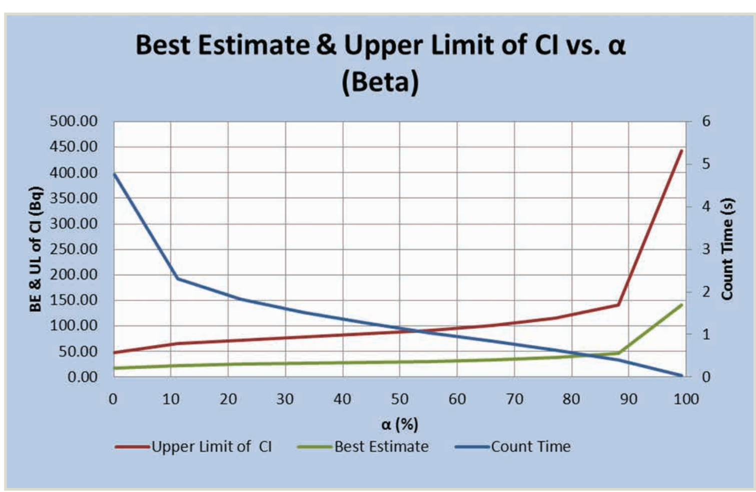

Figure 30 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. α (Beta Radiation)

Note: For fixed count time, but different α, the Best Estimate and Upper Limit of Confidence Interval are constant.

Input parameters: **Alarm Activity=83.33 Bq**, $1\text{-}\beta = 97.725\%$, $1\text{-}\gamma = 97.725\%$, $\varepsilon = 8\%$, $u_{re} = 0$, $S_f = 1$, $t_b = 300$ s, $R_b = 6$ cps, $R_g = 7$ cps.

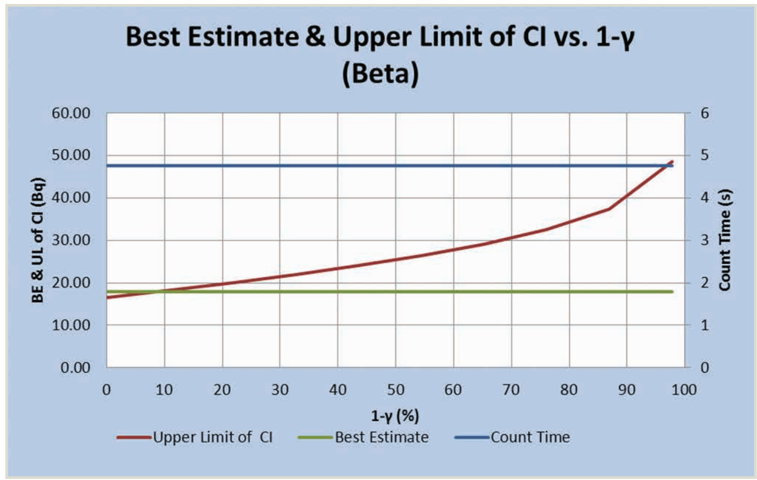

Figure 31 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. 1-γ (Beta Radiation)

Note: The Count Time and Best Estimate don't depend on 1-γ.

Input parameters: **Alarm Activity=83.33 Bq**, α=0.135%, 1-β=97.725%, ε=8%, u_{re}=0, S_f=1, t_b=300 s, R_b=6 cps, R_g=7 cps.

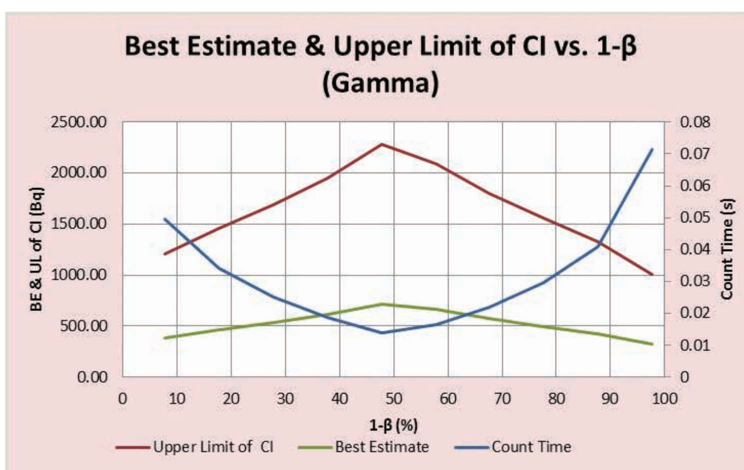

Figure 32 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. 1-β (Gamma Radiation)

Note: For fixed count time, but different 1-β, the Best Estimate and Upper Limit of Confidence Interval are constant.

Input parameters: **Alarm Activity=2775 Bq**, α=0.135%, 1-γ=97.725%, ε=8%, u_{re}=0, S_f=1, t_b=300 s, R_b=70 cps, R_g=71 cps.

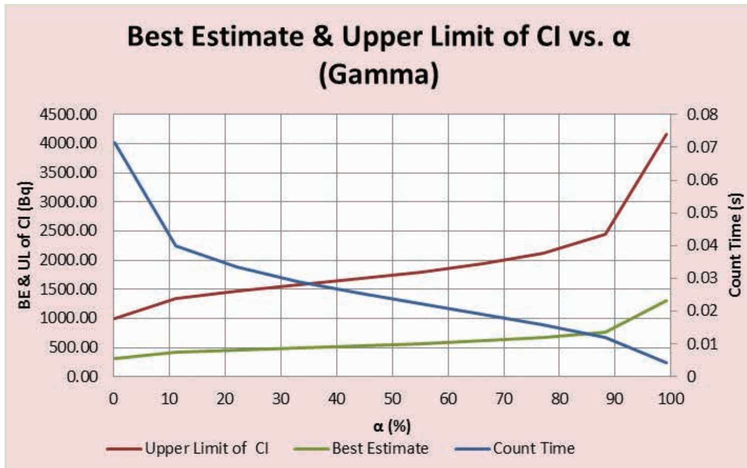

Figure – 33 Variation of Best Estimate and Upper Limit of Confidence Interval vs. α (Gamma Radiation)

Note: For fixed count time, but different α, the Best Estimate and Upper Limit of Confidence Interval are constant.

Input parameters: **Alarm Activity=2775 Bq**, 1-β=97.725%, 1-γ=97.725%, ε=8 %, u_{re}=0, S_f=1, t_b=300 s, R_b=70 cps, R_g=71 cps.

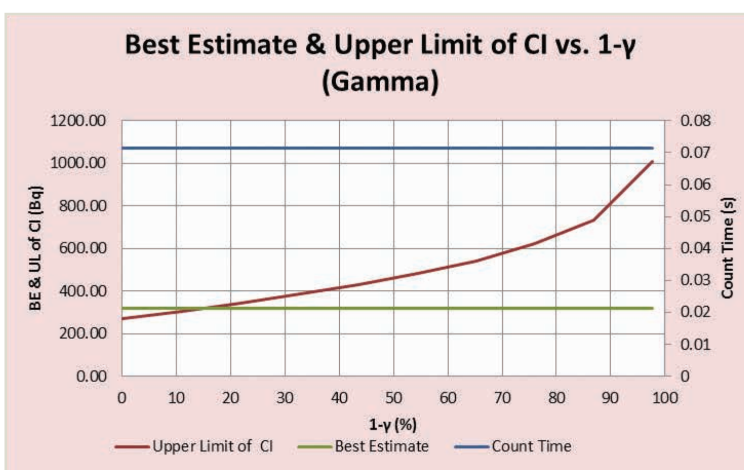

Figure 34 – Variation of Best Estimate and Upper Limit of Confidence Interval vs. 1-γ (Gamma Radiation)

Note: The Count Time and Best Estimate don't depend on 1-γ.

Input parameters: **Alarm Activity=2775 Bq**, α=0.135%, 1-β=97.725%, ε=8 %, u_{re}=0, S_f=1, t_b=300 s, R_b=70 cps, R_g=71 cps.

Table 4 summarizes of how the change of input parmeters will affect the detection probability, false alarm rate and count time for the traditional and Bayesian methodology. For fixed count time variation of α and/or 1-β will not affect the FAR & DP. 1-γ is not used in the calculation of the count time.

Table 4 – Interaction of Input and Output Parameters

Traditional methodology					Bayesian methodology					
$K\alpha$	$K\beta$	FAR	DP	Count time	α	1-β	1-γ	FAR	DP	Count time
↗	→	↗	→	↗	↘	→				↗
↘	→	↘	→	↘	↗	→				↘
→	↗	↗	↗	↗	→	↗				↗
→	↘	↘	↘	↘	→	↘				↘
					→	→	↗	↗	↗	→
					→	→	↘	↘	↘	→

Input parameters: K_α, K_β, α, 1-β, 1-γ
Output parameters: FAR, DP, Count Time
Legend: "↗" – increase, "↘" – decrease, "→" – no change

Summary

The implementation of the Bayesian statistics into analysis of monitoring data has enhanced the detection sensitivity and ability of our contamination monitoring systems, in detecting and confirming the presence of radioactive contamination efficiently and reliably. The Bayesian methodology is better at lower count rates where the Gaussian approximation for the frequency distribution of net count rate breaks down. Since alarm level set-points are lower and the background is lower, the best performance is achieved for alpha.

BAYEX is based on Bayesian statistics and is fully compatible with the ISO11929:2010 standard.

It is applicable to all types of radiation and provides a better approach in the detection of radiation since it takes into account uncertainties that are currently not propagated using the traditional methodology.

The Bayesian methodology implemented in all of the current Canberra™ contamination monitors gives meaningful positive estimates of net rates and more accurate calculation of decision threshold and detection limit.

BAYEX is particularly useful for detecting low activity levels of radioactivity with count rates below background level, where it is hard to distinguish a real signal from noise. It has the potential to reduce the number of false positives without compromising the detection sensitivity.

References

1. ISO 11929-1:2000, *Determination of the detection limit and decision threshold for ionizing radiation measurements*.
2. ISO 11929-1:2010, *Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation*.
3. JCGM 100:2008, *Evaluation of measurement data – Guide to the expression of uncertainty in measurement (GUM)*.

Terms and definitions

Unless otherwise specified, terms and definition used in this document can be found in the *“Supplementary Bayesian Methodology User’s Manual”*.

Quantities and symbols

Unless otherwise specified, quantities and symbols used in this document can be found in the *“Supplementary Bayesian Methodology User’s Manual"*.

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