

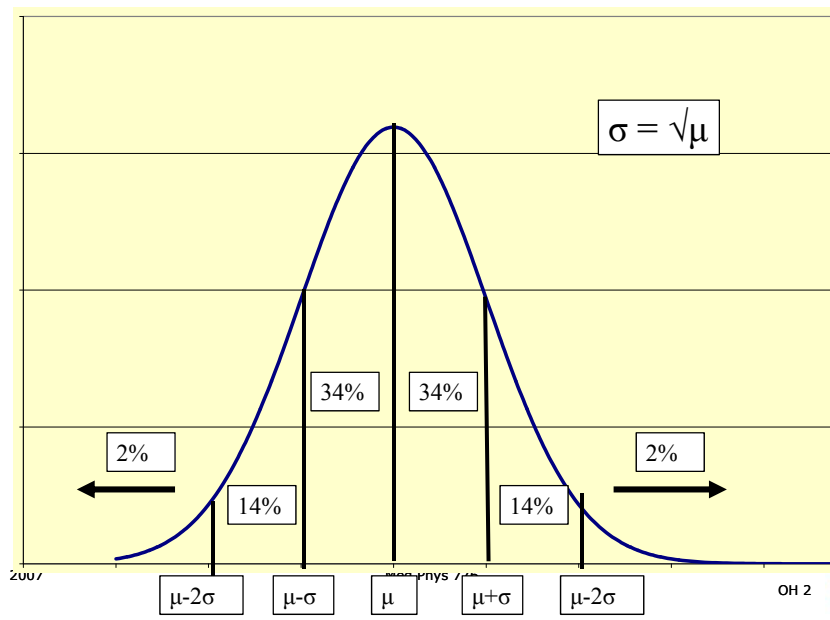
Notes on Counting Statistics

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Dave Tucker



Normal Distribution



Characteristics

- Value at x is $p(x)$ – the probability of getting result x
- Area under the curve represents cumulative probability.
- The area under the curve from $-\infty$ to $+\infty$ is 1
- The probability of getting a result between two values in the integral (i.e. the area under the curve) between this two values.

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Confidence Intervals for the Normal Distribution From Cember

Confidence Interval %	No. of Standard Deviations
50	0.6745
68	1
90	1.645
95	1.96
96	2
99	2.58

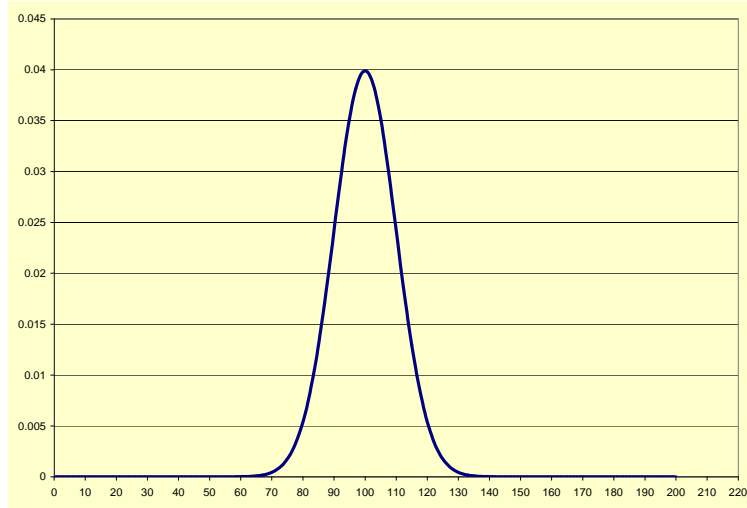
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Distribution of 1 minute measurement of Background if the True Mean of background is 100 counts



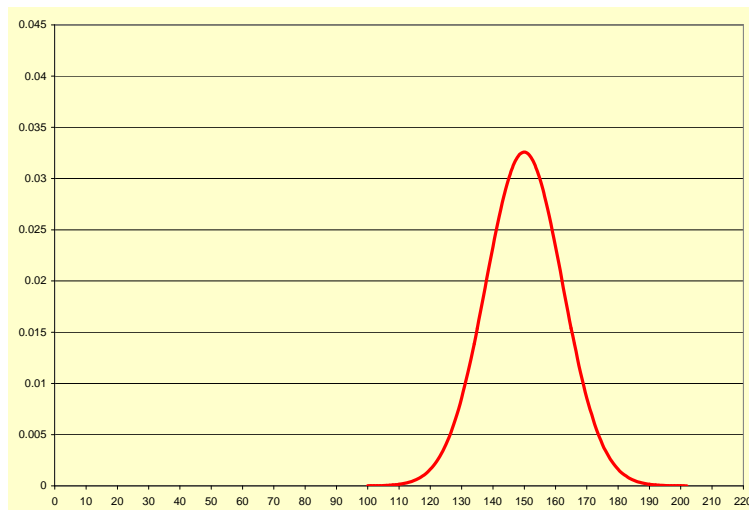
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Distribution of 1 minute measurement of Sample if the True Mean of Sample plus background is 150 counts



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Making Decisions

- If you get a measurement of 120 counts, what does it mean

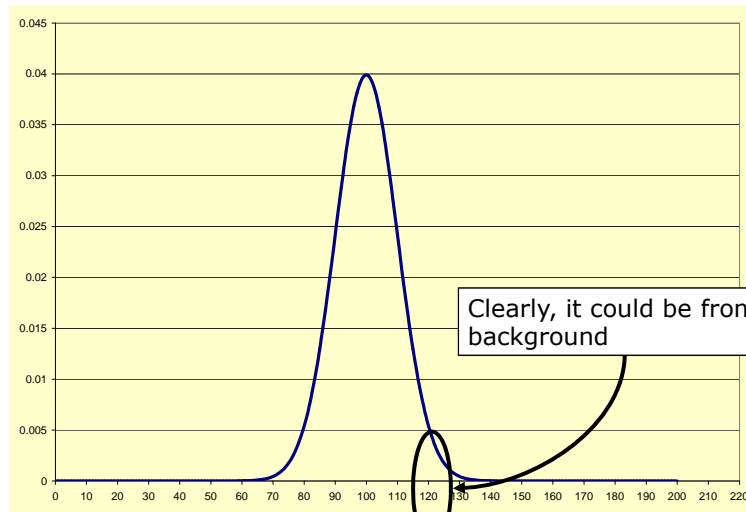
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Distribution of 1 minute measurement of Background if the True Mean of background is 100 counts



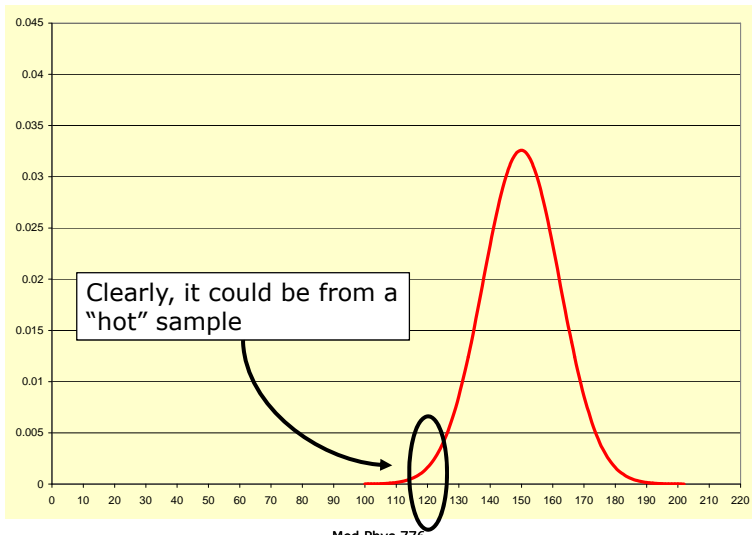
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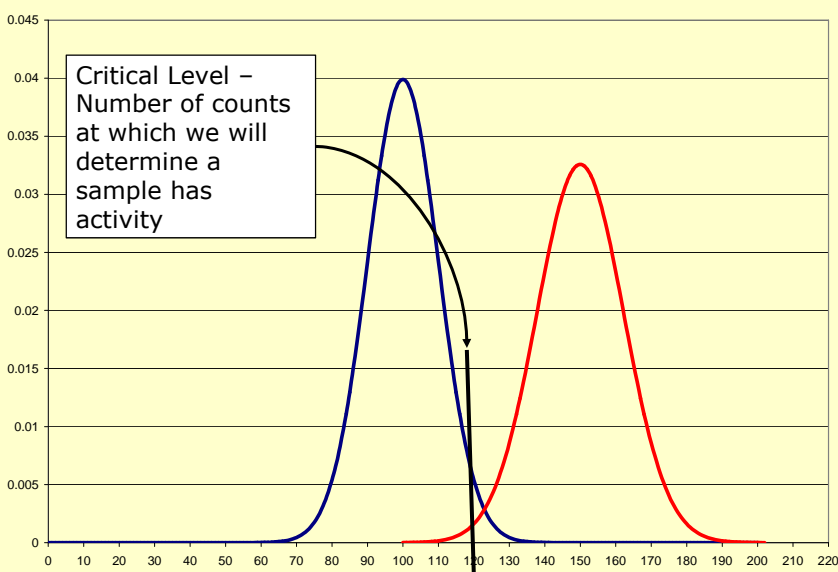
Distribution of 1 minute measurement of Sample if the True Mean of Sample plus background is 150 counts



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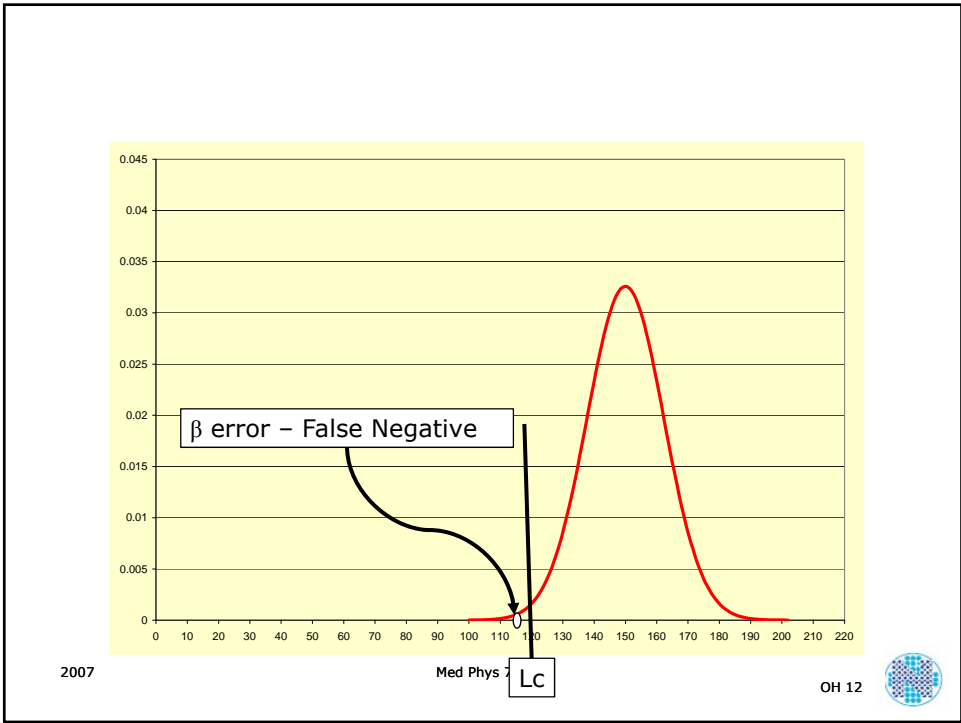
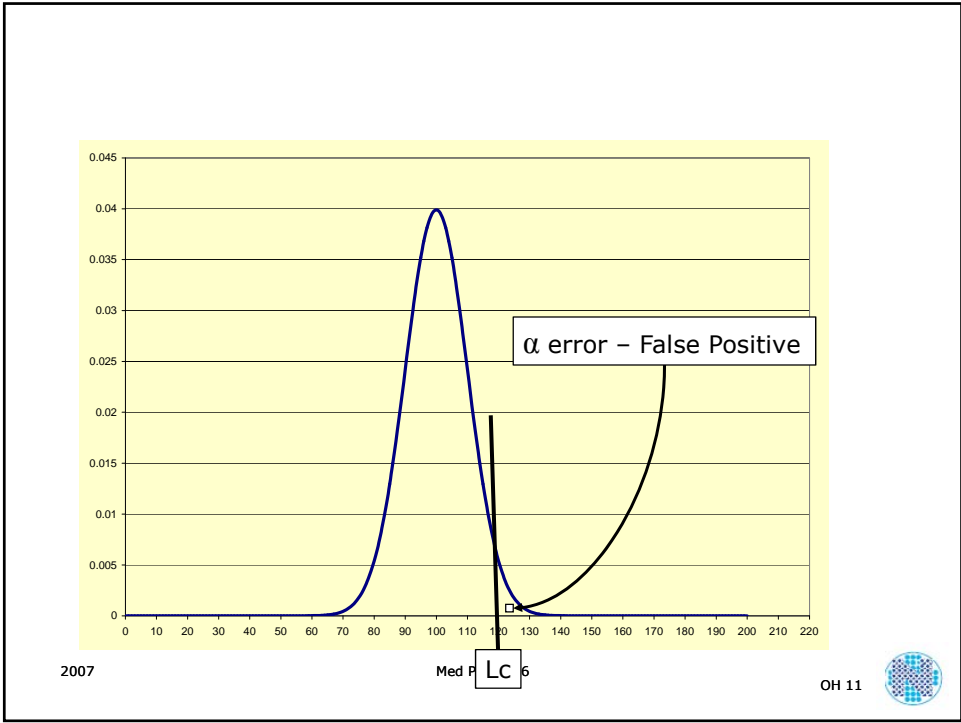
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Choosing the Critical Level

- We could choose the critical level anywhere we want – depending on our tolerance for false positive errors
 - Choose at μ_{bkg} – false positive error rate is 50%
 - Choose at $\mu_{\text{bkg}} + \sigma_{\text{bkg}}$ – false positive error rate is 16%
 - Choose at $\mu_{\text{bkg}} + 1.645 \sigma_{\text{bkg}}$ – false positive error rate is 5%
 - Generally, we choose L_c for $\alpha = 5\%$

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What Sample count rate can we reliably detect?

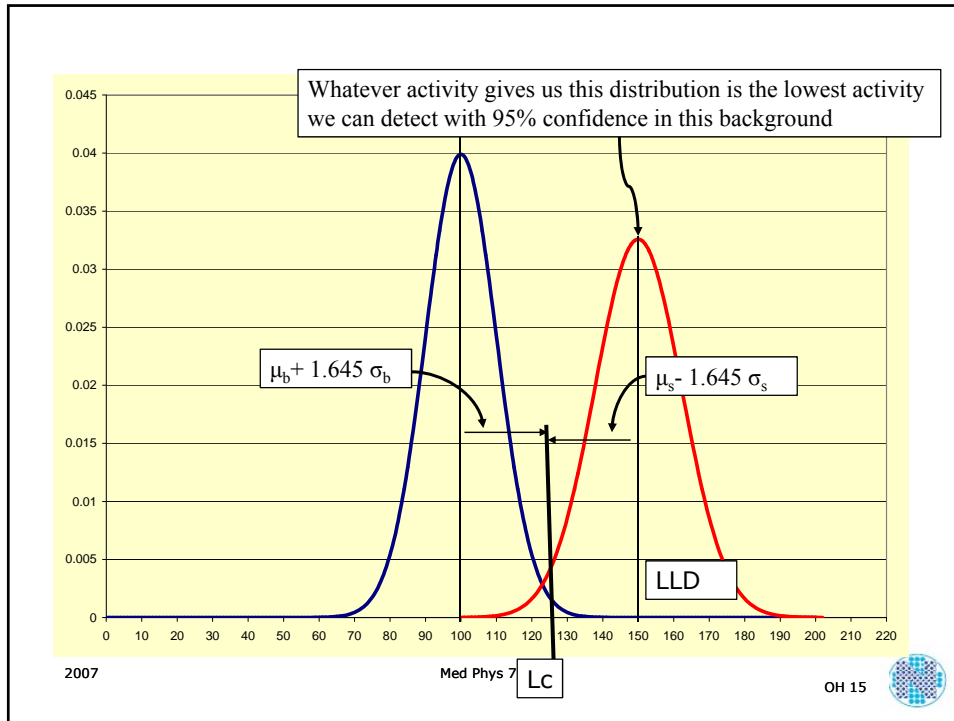
- It depends on what you mean by reliable.
- We can detect a sample that produces an average count rate equal to L_c 50% of the time.
- We can detect a sample that produces an average count rate equal to $L_c + \sigma_s$ 84% of the time.
- We can detect a sample that produces an average count rate equal to $L_c + 1.645 \sigma_s$ 95% of the time.
- Generally, we mean 95% confidence as “reliable” ($\beta = 5\%$)

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Guidelines for Radiological Monitoring of the Environment

Table 8.2
Expressions for Critical Level and Lower Limit of Detection (LLD)
for 95% Confidence in Cases Where Precision Is Determined
by Statistical Fluctuations in Count Rate*

	Critical level	LLD
Paired observations	$2.33 \mu_B^{1/2} C \dagger$	$(2.71 + 4.65 \mu_B^{1/2}) C$
"Well-known" blank	$1.64 \mu_B^{1/2} C$	$(2.71 + 3.29 \mu_B^{1/2}) C$
Zero blank	0	$2.71 C$

* See Appendix C, Item (2).
 $\dagger \mu_B$ = mean number of background counts during the specified count interval.
C = the product of all those factors required to convert an observed number of counts to a physically meaningful quantity, such as a radionuclide concentration or a dose equivalent rate.

Notes:
 (1) For paired observations a single measurement of the background is taken for each measurement of the sample.
 (2) For the "well known" blank, the background is assumed to be precisely known from a large number, eg, 12 of previous measurements under identical conditions.

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Example

- Mean bkg count rate is 100 counts in one minute
- THEN
- $\sigma_{\text{bkg}} = 10$ counts
- $L_c = 2.33 \sigma_{\text{bkg}} = 23.3$ counts
- SO
- We decide that any sample with a count rate over 123 counts in one minute has activity in it.

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Example – Cont.

- What activity are we detecting with 95% confidence?
- $LLD = (2.71 + 4.65 \sigma_{\text{bkg}}) = 49.2$
- SO
- The activity we are detecting with 95% confidence is that which would produce a net count rate of 49.2 counts in one minute.
- Lets assume a system efficiency of 20%
- THEN
- The MDA = $49.2 \text{ cpm} / 20\% = 246.1 \text{ dpm}$

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Example 2

- You are setting up an environmental monitoring program for I-125. You have a counting system that is 6% efficient and which has a well known background of 1000 counts in the nominal 10 minute counting time. If your sampling pump draws at 30 lpm, what is the MDA for monthly samples? Neglect decay during sample collection.

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