LSUF 2003

Limits of Detection and Determination

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What’s the problem?

Is it above background?

Can it be quantified?

Where we're at

'Currie solution' widely used since 1968

- **Lower backgrounds**
- **More computing power**
- **Customer pressure for lower and lower detection limits**

Definitions

Limit of detection, L_c,defined as level above which a signal differs from background, ie;

$$L_c = k.b$$

Limit of determination, L_d, defined as level above which a signal differs from background and quantified.

$$L_d = L_c + k^{\dagger}. b$$

Where b is the background uncertainty, and k ($k=k^{\dagger}$) is the coverage factor

Distributions

With small (<100) numbers of counts, distribution of data follows a Binomial, rather than a Poisson distribution, so uncertainty on x counts is better evaluated as:

$$\sqrt{(x+1)}$$

(rather than $\sqrt{(x)}$)

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Is it significant?

Test whether the net count rate exceeds zero given that the sample and background count times are equal, is;

$$s_{net} \text{ (or } s - b) > k.\sqrt{(s^2+b^2)}\ ?$$

where the gross sample count is s,

the gross background count is b,

the net sample count is s_{net}, and

the coverage factor (confidence limit) is k

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What's the answer?

If a Binomial distribution of data is assumed, then

$$s_{net} = [k^2 + k\sqrt{(8b + 8 + k^2)}]/2$$

$$s_{net} = 2.86 + 4.78\sqrt{(b + 1.36)} \qquad (k=2)$$

Health Physics Society (1996)	$s_{net} = 3 + 4.65\sqrt{(b)}$	(k=1.96)
CEA (1983)	$s_{net} = 4[1 + \sqrt{(1 + 2b)}]$	(k=2.29)
Gemeinsames Ministerialblatt (1996)	$s_{net} = 5.42 + 4.65\sqrt{(b)}$	(k=1.96)
Sumerling and Darby (1981) -	complex, but similar to original Currie solution	(k=1.96)
Fleming, *et al* (1996)	$s_{net} = 6\sqrt{(b)}$	(k=2.39)
Anonymous, but seems popular;	$s_{net} = 3\sqrt{(b)}$	(k=1.46)

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Try this!

Condition	Report as	Comments
$\mathbf{s_{net} < 0}$	$\mathbf{s_{rep} < 2.86 + 4.78\sqrt{(b + 1.36)}}$	L_c is not exceeded
$\mathbf{0 < s_{net} < 2.86 + 4.78\sqrt{(b + 1.36)}}$	$\mathbf{s_{rep} < [s_{net} + \{2.86 + 4.78\sqrt{(b + 1.36)}\}]}$	L_d is not exceeded, L_c is exceeded
$\mathbf{s_{net} > 2.86 + 4.78\sqrt{(b + 1.36)}}$	$\mathbf{s_{rep} = s_{net} \pm 2\sqrt{[(s+1) + (b+1)]}}$	L_d is exceeded