

IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

What can you say when there is almost nothing?

Decision thresholds associated with multiple measurements and their application to environmental monitoring results

Alain Vivier- CEA

Guillaume Manificat - IRSN

Jean-Louis Picolo- IRSN

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sample	measurements
A	<1
B	<2
C	<1
D	2,2
E	1,8
F	1
G	4,1
H	7
I	7,5
J	15
K	<1
L	<2
M	<1
N	<1
O	<1

What can you say?

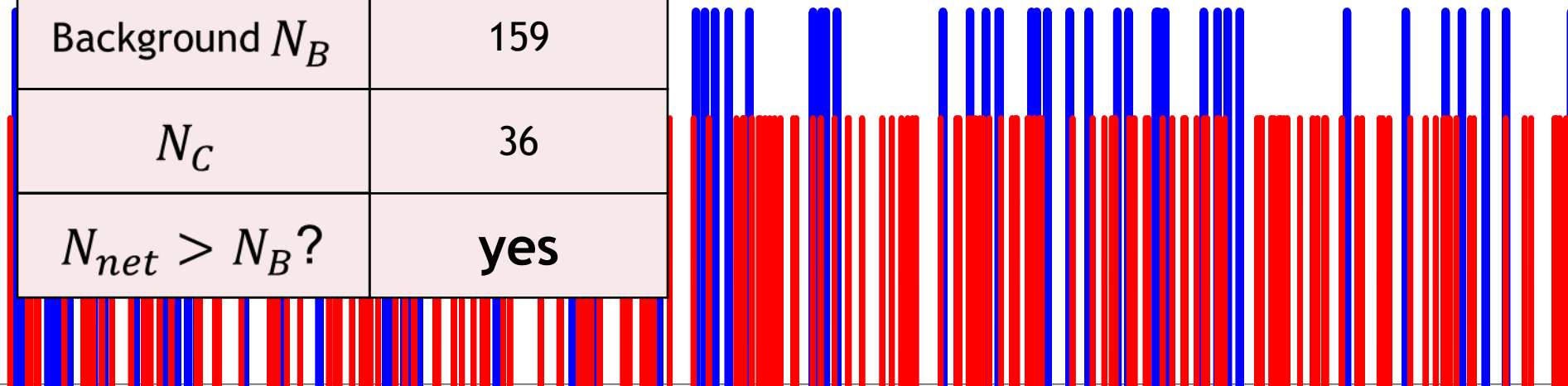
- You can find a rich literature on how to exploit this kind of data (see Helsel-”statistics for censored environmental data”)
- Substitution of <L by L is usually a bad option

- THE DECISION THRESHOLD N_c is the critical value for the statistical test for the decision between the hypothesis that the sample effect is not present and the alternative hypothesis that it is present.
- Because a signal must differ from the variation of the background N_B , it can be demonstrated that:

$$N_c \sim \sqrt{N_B}$$

$Net\ N_{net}$	67
Background N_B	159
N_C	36
$N_{net} > N_B?$	yes

of 20 s

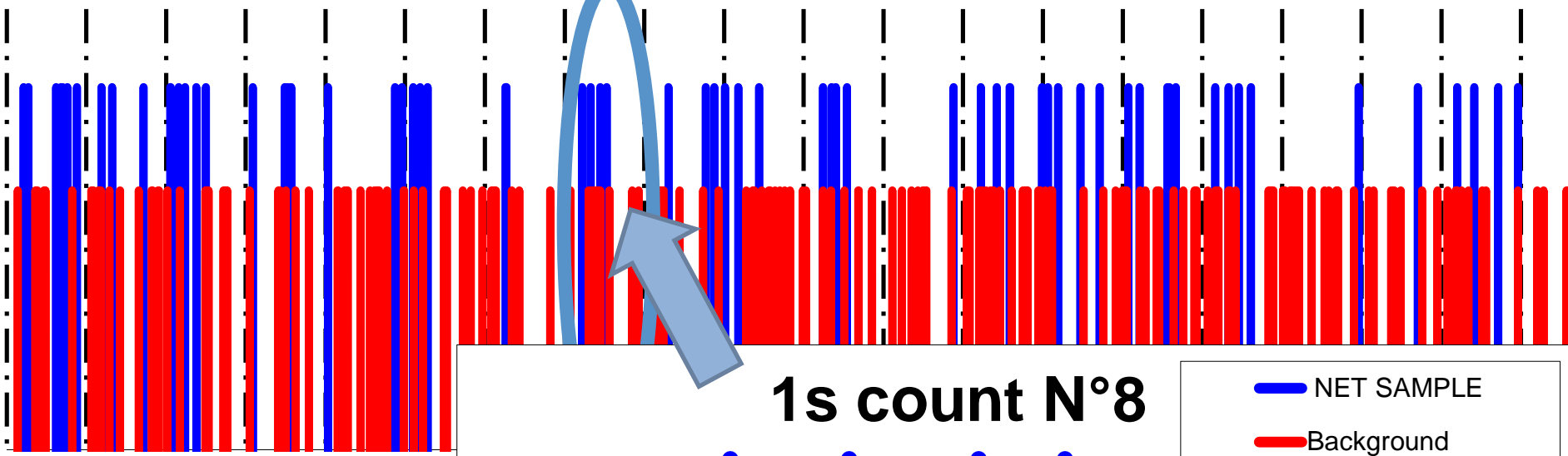


Let us consider a radioactive counting of 20s

We make a background measurement

sum of 20 countings of 1 s

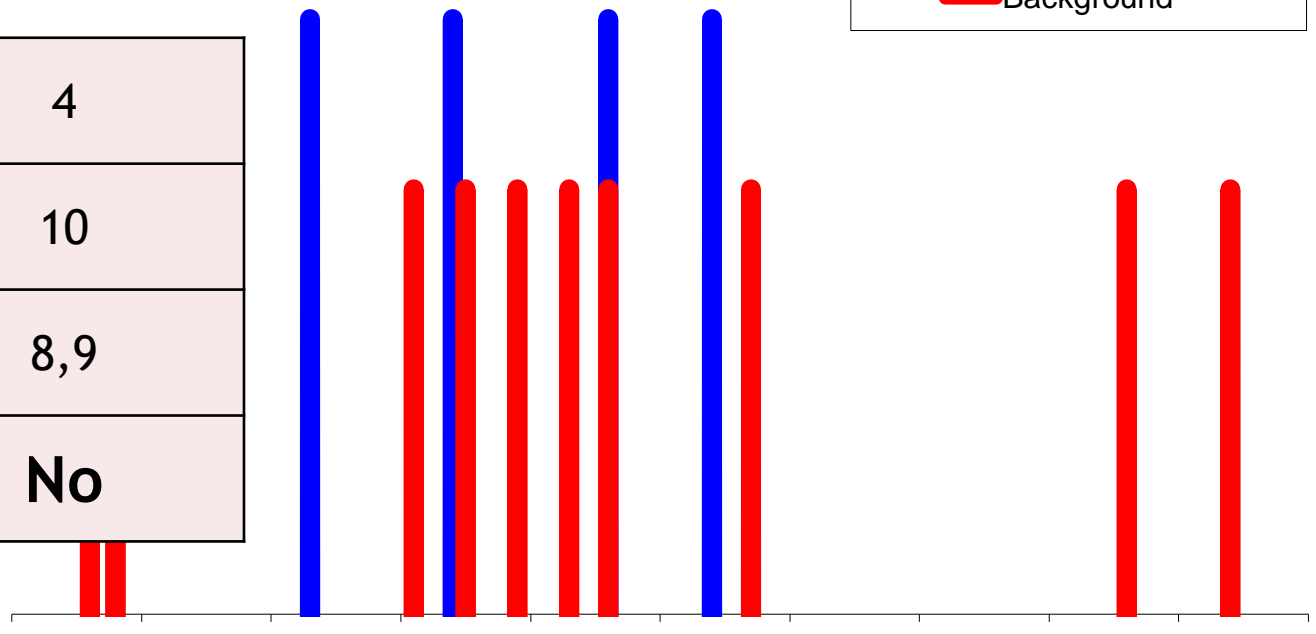
NET SAMPLE BACKGROUND



1s count N°8

NET SAMPLE Background

$Net N_{net}$	4
Background N_B	10
N_C	8,9
$N_{net} > N_B?$	No



Fact:

- ❑ Every radioactive counting (measurement) is an aggregation (sum) of non significant measurements!

This is essentially because the decision threshold vary according to the square root of the background.

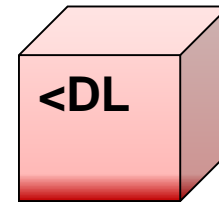
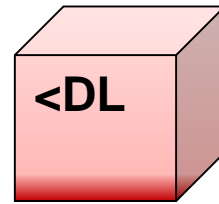
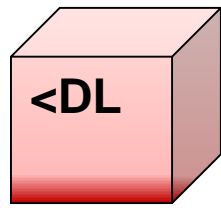
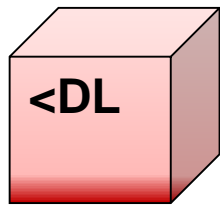
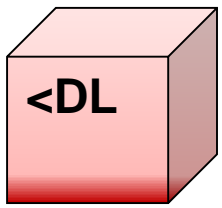
- ❑ Would it be possible then that an aggregation of partially or totally non-significant measurement results could be significant?
- ❑ Is there a way to determine this rigourously?

Real Case

Rainwater samples coming from a single station with monthly sampling and measured for tritium with one single measurement apparatus

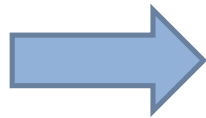
What is the average tritium content of the samples during this period?

Activity (Bq/l)	Decision threshold (Bq/l)	Significant Result?
6,07	3,35	yes
0,93	2,30	no
0,92	2,27	no
3,52	2,39	yes
1,57	2,22	no
1,98	2,43	no
4,30	2,34	yes
6,87	2,25	yes
2,98	2,35	yes
4,51	2,23	yes
3,39	2,28	yes
3,29	2,34	yes
3,58	2,41	yes
3,26	2,48	yes
0,45	2,30	no
5,00	2,28	yes

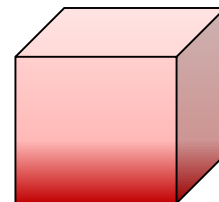
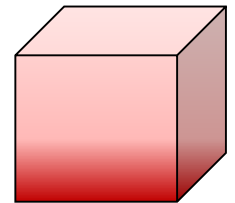
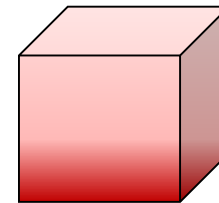
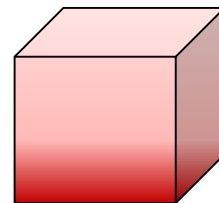
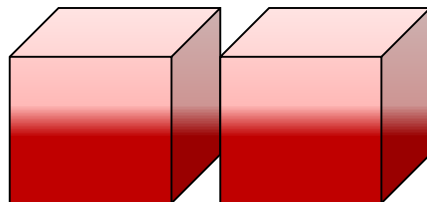
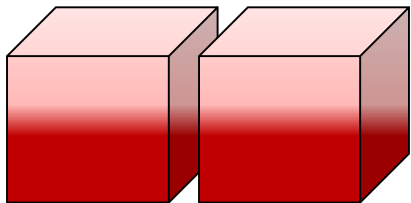
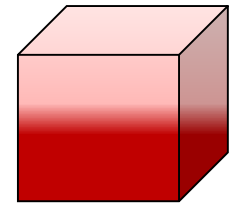
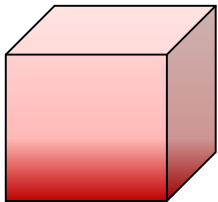


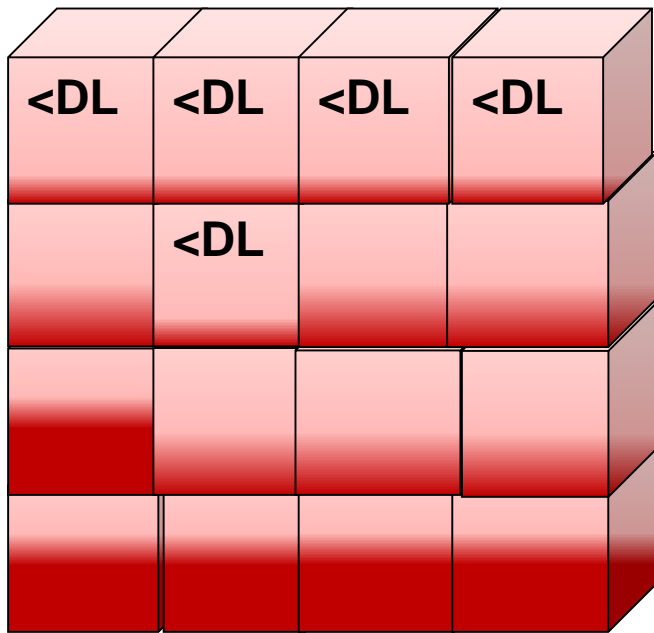
16 samples

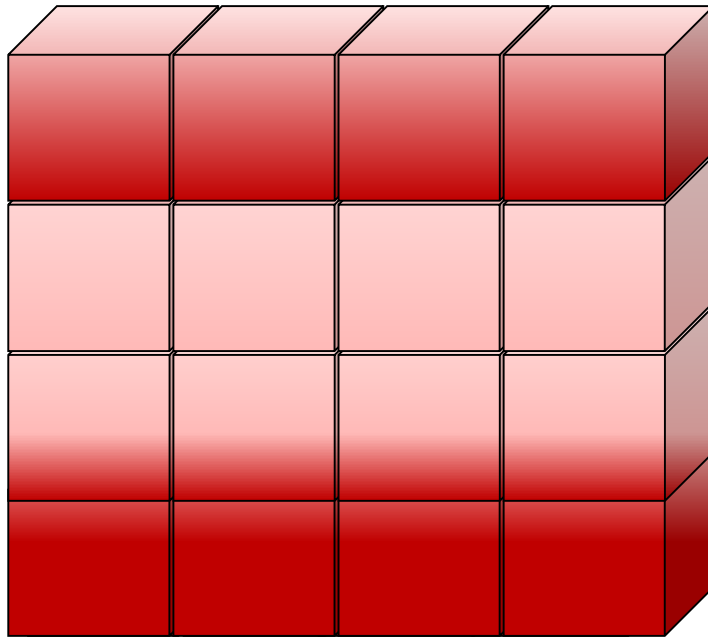
11 are « significant »



We mix them together





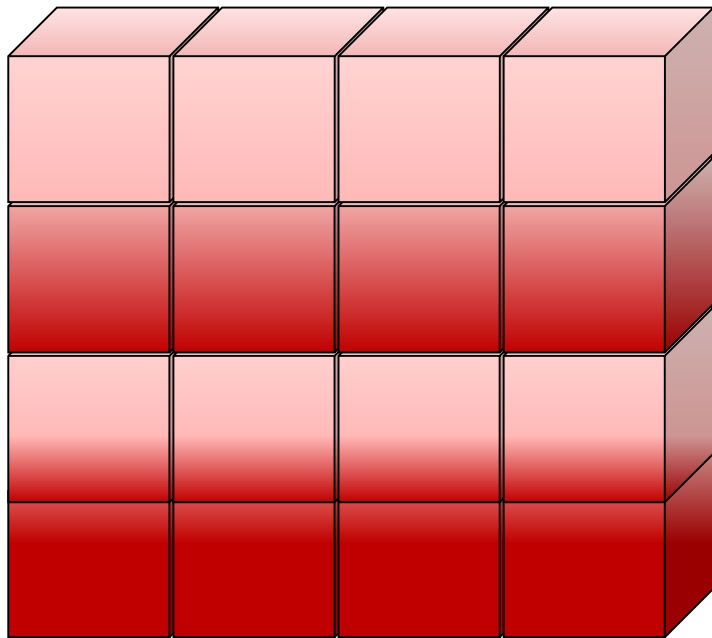


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$$\bar{A} = \frac{1}{n} \sum_{i=1}^n A_i$$



3,29 Bq/l		
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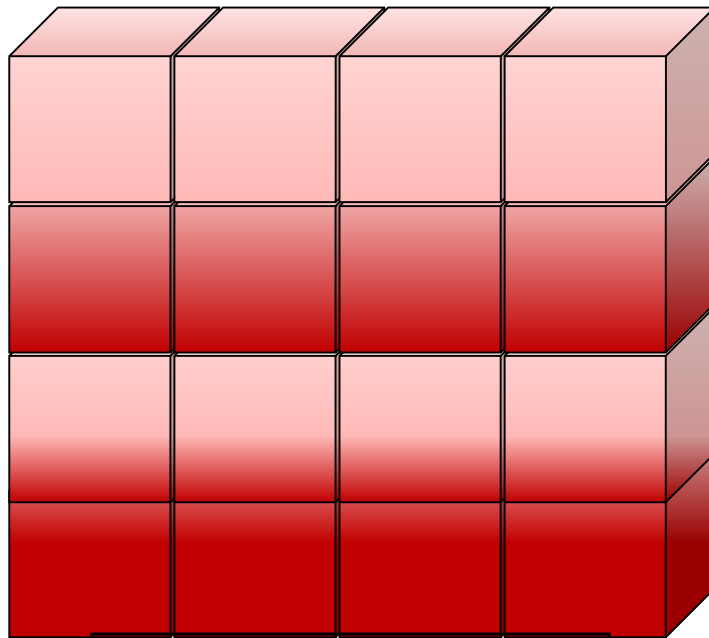
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$$\bar{D}_t = \sum_{i=1}^n D_{ti}$$

NO!

3,29 Bq/l

No!



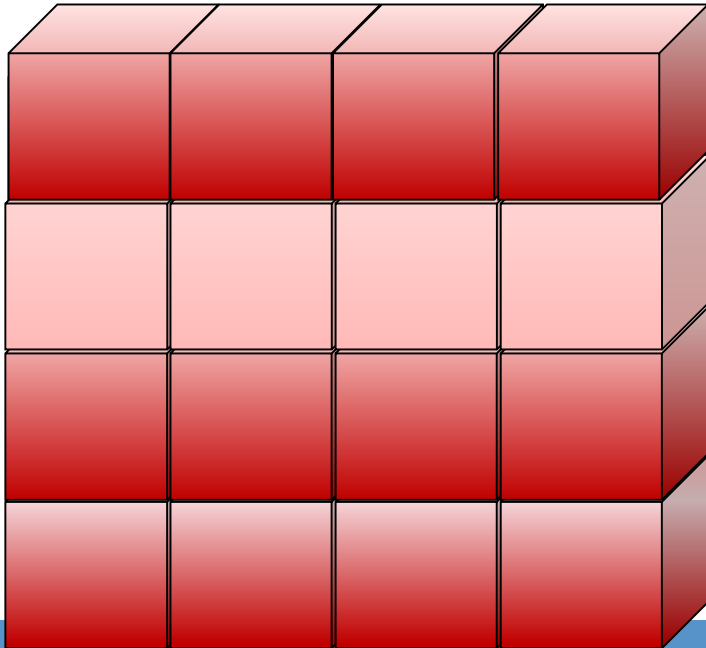
$$\overline{D}_t = \frac{1}{n} \sqrt{\sum_{i=1}^n D_i^2}$$

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0,45	2,30	no
5,00	2,28	yes

3,29 Bq/l	0,6 Bq/l !	YES!
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Conclusions I

- Being careful to average, sum, agregate etc. results that are statistically relevant, one can use non significant results and define a decision threshold associated with this operation.
- A sum of non significant results will or will not be significant but it can be!



Conclusions II

- ❑ In order to do that rigourously, one must get hold of the measurement results even if zero or negative NOT « < MDA »!!!
- ❑ It is not miraculous, it is a rigourous use of the cumulative information in the measurements!
- ❑ Of course you must not aggregate dissimilar or irrelevant results (averaging tritium measurements with gross alpha results is pointless)

I could not agree more...

- “ The laboratory should report each measurement result and its uncertainty as obtained even if the result is less than zero”.

Multi-Agency radiological laboratory Analytical protocols manual (MARLAP), vol III EPA 402-B-04-001C, chapter 20, US Environmental Protection Agency.

Graphical intuition

