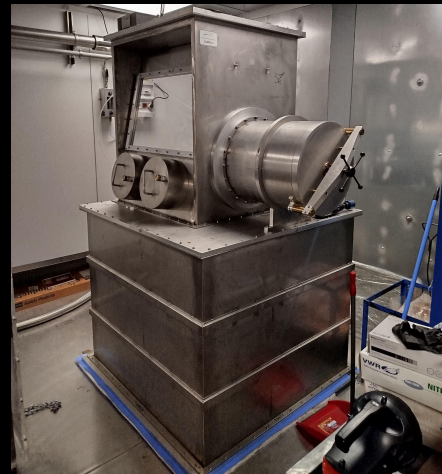


BULLKID-DM Meeting
October 15, 2025



GRAN SASSO BACKGROUND ANALYSIS



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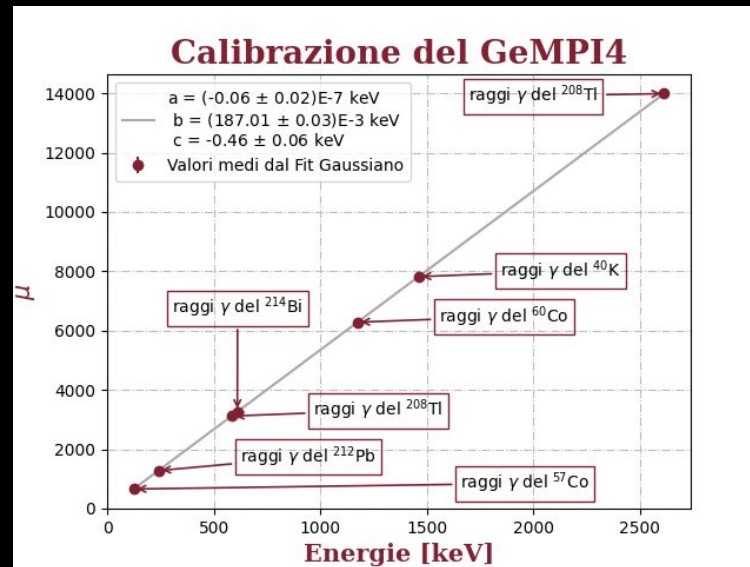
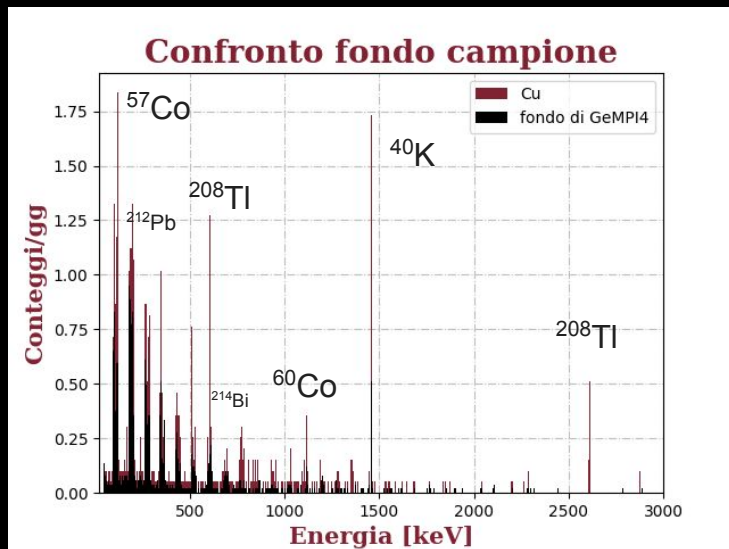
1. CALIBRATION OF DETECTOR

particle & detector → electrical signal

signal => bin

long measurements => histogram

$$\mu = \frac{-b + \sqrt{b^2 - 4a[c - E]}}{2}$$

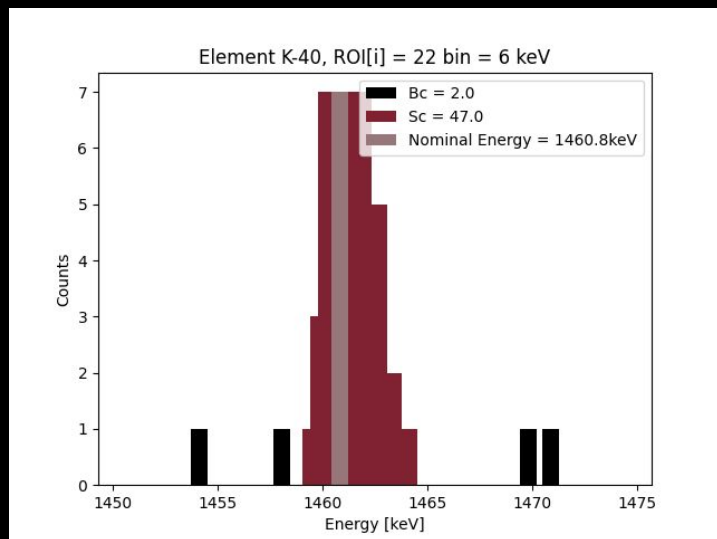


2.1 COUNTS FOR EACH PEAK

$$\text{ROI} = 2.5 \cdot \text{FWHM}$$

$$S := \sum_{i \in \text{ROI}} \text{counts}[i]$$

$$B := \frac{B_{sx} + B_{dx}}{2}$$



only background

$$N = S - B$$

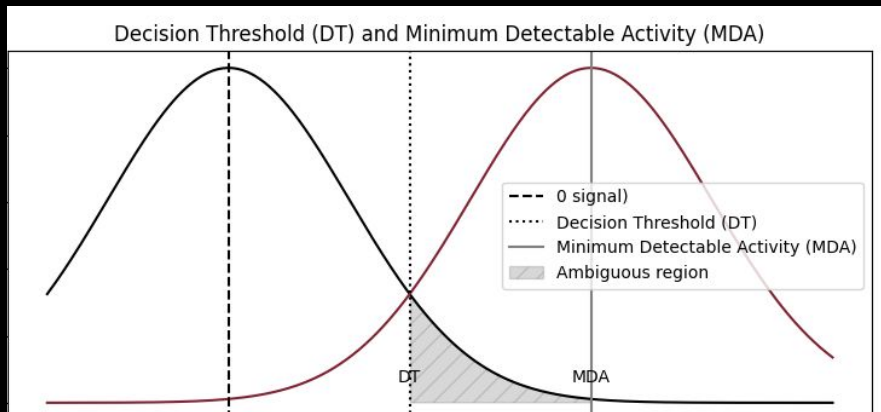
sample + background

$$N_c := S_c - B_c$$

2.2 DECISION THRESHOLD: CRITERIUM

$$DT := 1.43 + 2.39\sqrt{B + 1.36}$$

criterion to decide if the peak is enough
enhanced with respect to noise



$$N > 2DT = MDA$$

SIGNAL

$$A := \frac{\tilde{N}_c}{t_c \varepsilon p BR m_c}$$

2.3 PEAK ACTIVITY DETERMINATION METHOD

background
subtraction

$$n = \frac{N}{t}$$

$$\tilde{N}_c := N_c - nt_c$$

$$A := \frac{\tilde{N}_c}{t_c \varepsilon p BR m_c}$$

sample acquisition time

detector and sample efficiency

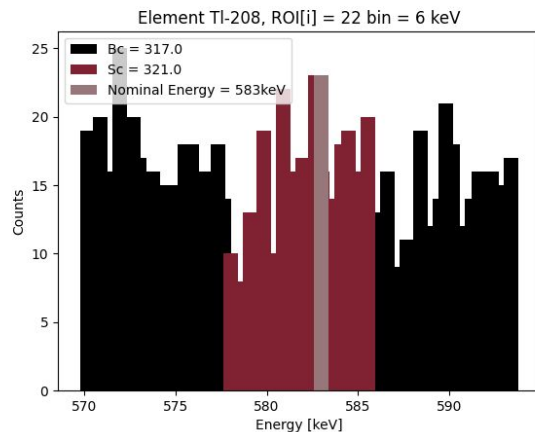
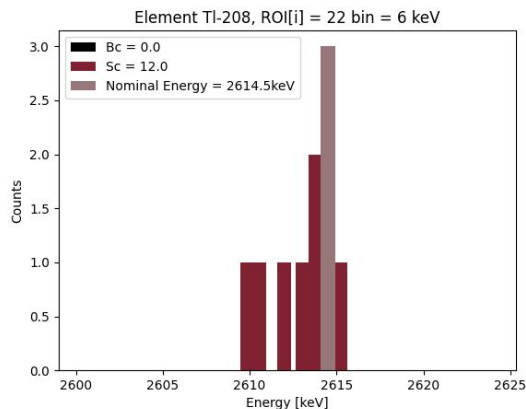
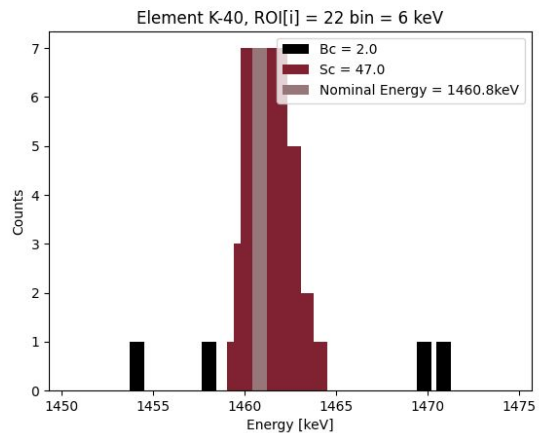
probability that a
decay of the nuclide
produces the radiation
corresponding to the
observed peak

the fraction of total decays of a nuclide
that produces the daughter nuclide

sample mass

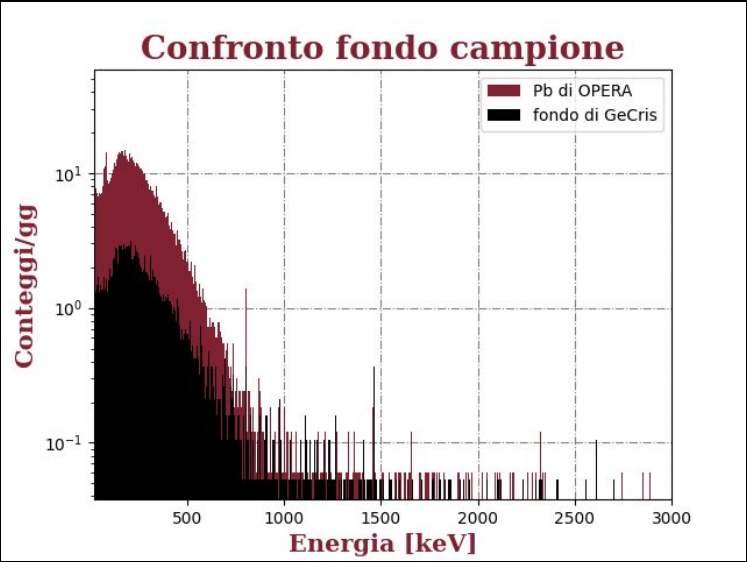


2.4 SOME EXAMPLES



noise

3. ACTIVITY DETERMINATION FOR THE LEAD



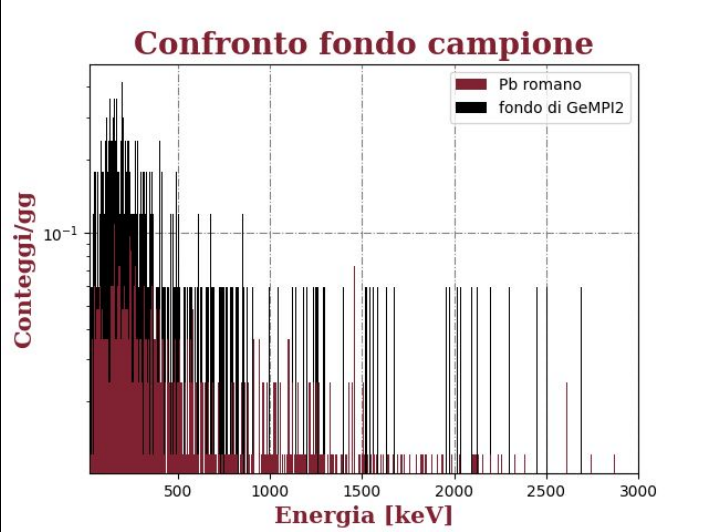
Acquisizione	Massa campione	Tempo di acquisizione
Fondo del rivelatore GeCris	–	18 giorni e 22 ore
Piombo	5,41 kg	16 giorni e 12 ore

Nuclide	Energia [keV]
^{210}Po	803
^{228}Ac	969
^{40}K	1460.8
^{208}Tl	2614.5



Attività [mBq/kg]			Attività [Bq/kg]	
^{228}Ac	^{208}Tl	^{40}K	$^{210}\text{Po}_{\text{fondo}}$	$^{210}\text{Po}_{\text{no fondo}}$
0.4 ± 0.2	0.2 ± 0.1	3.75 ± 0.57	61.2 ± 7.2	44.9 ± 7.9

4. ACTIVITY DETERMINATION FOR THE ROMAN LEAD



Acquisizione	Massa campione	Tempo di acquisizione
Fondo del rivelatore GeMPI2	—	16 giorni e 19 ore
Piombo romano	55.5 kg	82 giorni e 21 ore

Nuclide	Energia [keV]
²¹⁴ Pb	241.9
²¹⁴ Bi	609.3
¹⁰⁸ Ag	614.0
²²⁸ Ac	911.2
⁴⁰ K	1460.8
²⁰⁸ Tl	2614.5

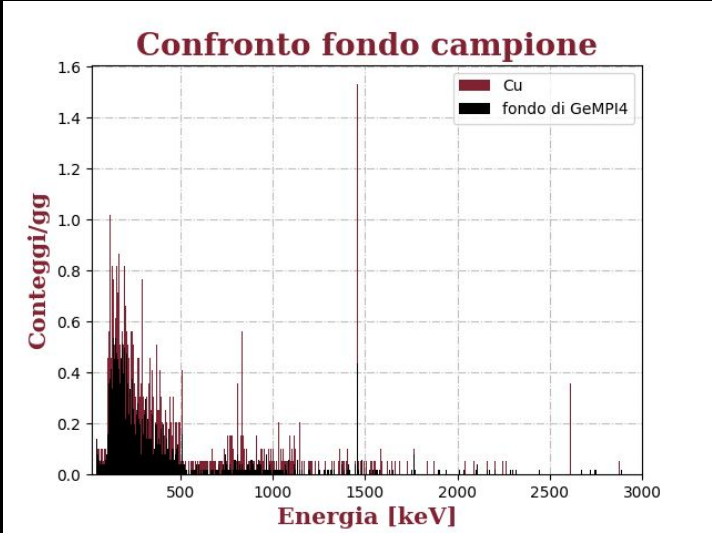
without background

Attività [mBq/kg]		Attività [μBq/kg]	
²¹⁴ Pb	⁴⁰ K	²¹⁴ Bi	
0.78 ± 0.27	90 ± 18	8 ± 5	

with background

Attività [mBq/kg]					
²¹⁴ Pb	²¹⁴ Bi	¹⁰⁸ Ag	²²⁸ Ac	²⁰⁸ Tl	⁴⁰ K
1.98 ± 0.54	0.057 ± 0.017	0.032 ± 0.009	0.054 ± 0.018	0.040 ± 0.011	0.351 ± 0.052

5. ACTIVITY DETERMINATION FOR THE COPPER



Acquisizione	Massa campione	Tempo di acquisizione
Fondo del rivelatore GeMPI4	—	50 giorni e 13 ore
Rame	0.925 kg	19 giorni e 15 ore

Nuclide	Energia [keV]
⁵⁷ Co	122.06
²¹² Pb	238.6
²⁰⁸ Tl	583
²¹⁴ Bi	609.3
⁵⁴ Mn	834.84
⁶⁰ Co	1332.49
⁴⁰ K	1460.8
²⁰⁸ Tl	2614.5

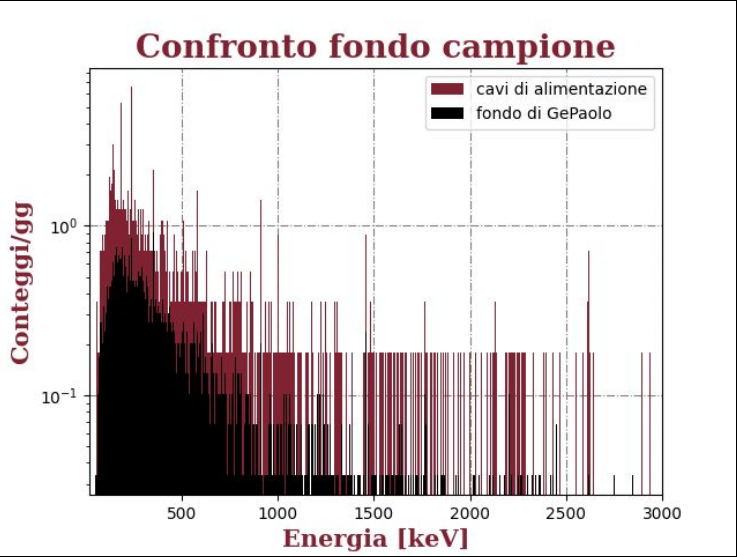
without background

Attività [mBq/kg]
⁴⁰ K _{no fondo}
7.4 ± 2.0

with background

Attività [mBq/kg]						
²¹⁴ Bi	²¹² Pb	²⁰⁸ Tl	⁴⁰ K	⁵⁷ Co	⁶⁰ Co	⁵⁴ Mn
1.29 ± 0.31	0.6 ± 0.2	1.21 ± 0.28	10.4 ± 1.8	0.97 ± 0.22	0.3 ± 0.1	0.3 ± 0.1

6. ACTIVITY DETERMINATION FOR THE POWER CABLES



Acquisizione	Massa campione	Tempo di acquisizione
Fondo del rivelatore GePaolo	—	29 giorni e 16 ore
Cavi	0.366 kg	5 giorni e 15 ore

Nuclide	Energia [keV]
²²⁶ Ra	186.2
²¹² Pb	238.6
²⁰⁸ Tl	583
²²⁸ Ac	911.2
²²⁸ Ac	969
²³⁴ Pa	1001
⁴⁰ K	1460.8
²⁰⁸ Tl	2614.5

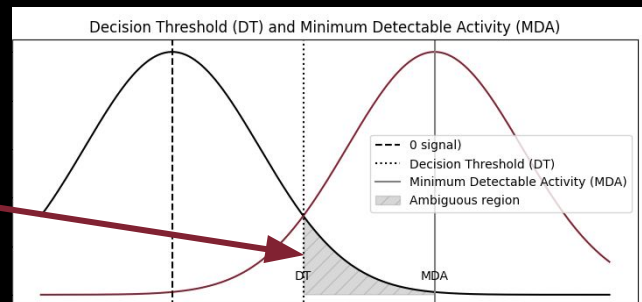
without background

Attività [mBq/kg]	
²²⁸ Ac	⁴⁰ K
25.4 ± 3.8	40 ± 16

with background

Attività [Bq/kg]			Attività [mBq/kg]		
²²⁶ Ra	²¹² Pb	²³⁴ Pa	²²⁸ Ac	²⁰⁸ Tl	⁴⁰ K
0.587 ± 0.066	0.273 ± 0.027	0.66 ± 0.13	28.9 ± 3.8	47.0 ± 5.2	99 ± 15

7. ACTIVITY IN THE AMBIGUOUS REGION



LEAD

Attività [Bq/kg]	Attività [mBq/kg]	
^{235}U	^{137}Cs	^{210}Pb
0.06 ± 0.04	0.2 ± 0.1	0.4 ± 0.3

ROMAN LEAD

Attività [mBq/kg]			Attività $\mu\text{Bq/kg}$				
^{235}U	^{212}Pb	^{212}Bi	^{214}Pb	^{214}Bi	^{228}Ac	^{208}Tl	^{108}Ag
40 ± 10	0.3 ± 0.1	0.13 ± 0.07	90 ± 50	50 ± 40	36 ± 20	40 ± 20	13 ± 5

COPPER

Attività [mBq/kg]	
^{58}Co	^{228}Ac
0.3 ± 0.1	0.9 ± 0.3

POWER CABLES

Attività [mBq/kg]		
^{214}Pb	^{214}Bi	^{212}Bi
18.3 ± 5.2	10.9 ± 5.5	69 ± 17

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THANKS FOR THE ATTENTION

Special thanks are due to Matthias Laubenstein

