Short Overview of HPGe detector technology and its calibration

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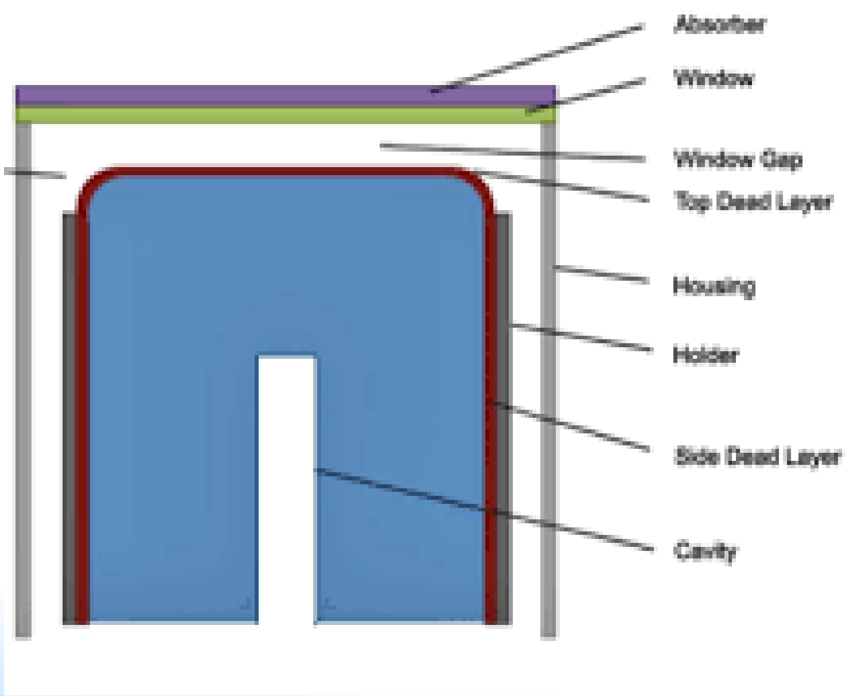
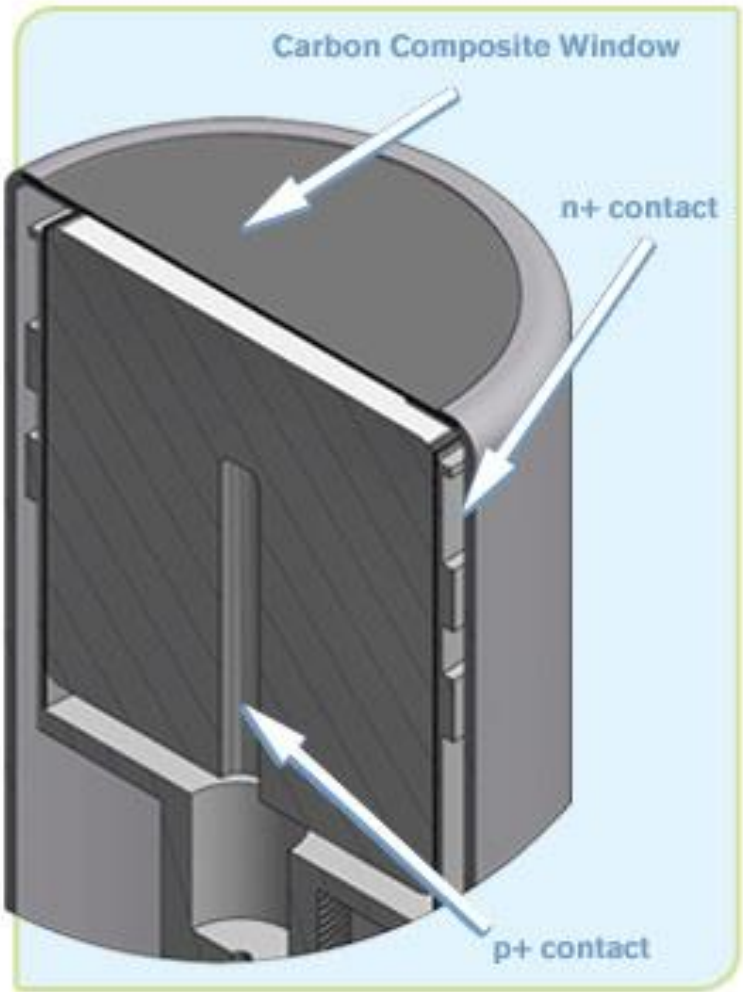
Evolution of HPGe detector models: OLD

Coaxial detectors
(ORTEC GEM and Canberra GC/GX)

Example drawings:





Evolution of HPGe detector models: NEW

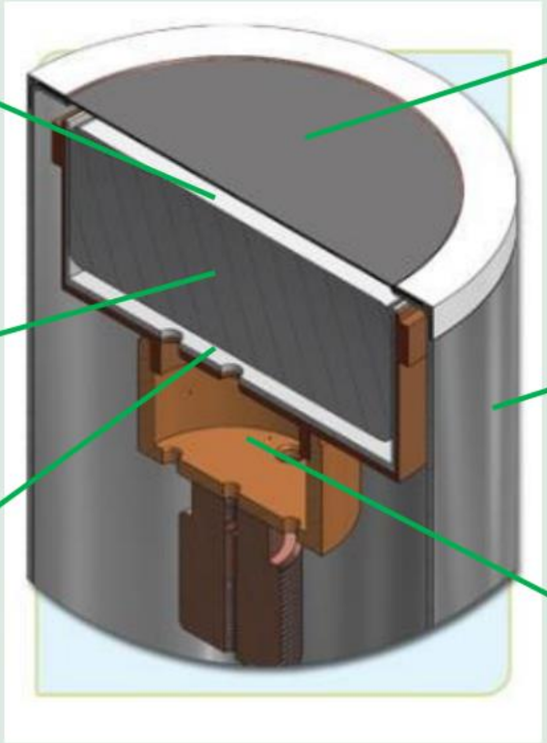
ORTEC : Profile S - HPGe Detectors

CANBERRA : BEGe (Broad Energy) - HPGe Detectors

Thin (0.3µm) and stable entrance window, no growth overtime, even not at room temp.

Optimized detector size and aspect ratio for best absolute efficiency in close-contact geometries over broad energy range.

Spot contact (small-anode) for low electronic noise, yet excellent resolution at higher energies
P-type material, best resolution overall.



Carbon-epoxy cryostat window: robust, yet allowing transmission down to 6 keV.

No observable contribution to background.

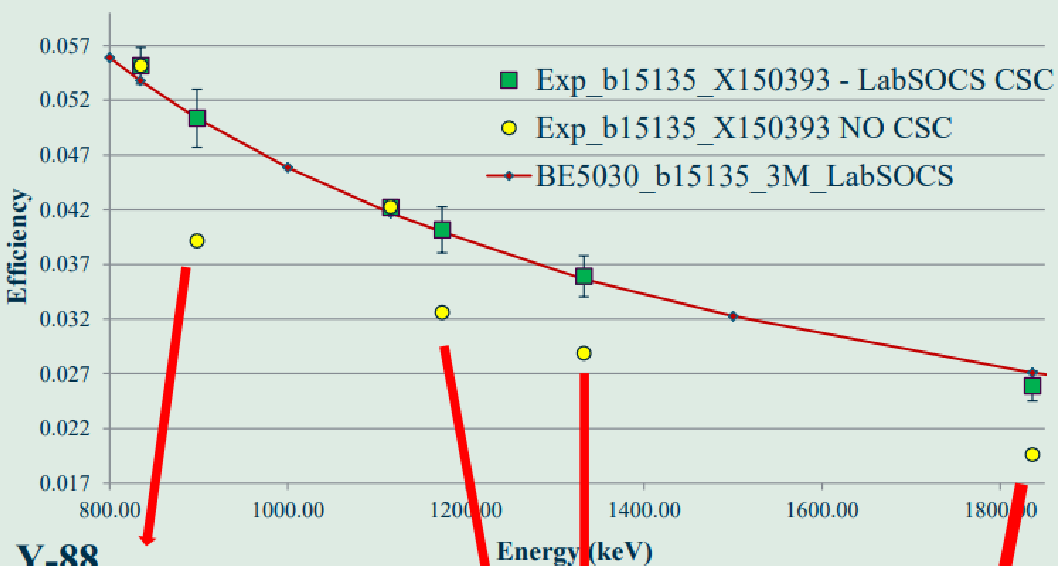
High-purity Al endcap for ULB applications <u>WITH Ruggedized vacuum seal</u>

Low-noise front end electronics, including FET protection diode.

Evolution of HPGe detector models

BEGe/S thinner endcap window (carbon fiber) and thinner dead layer results in increased summing effects!

High energies



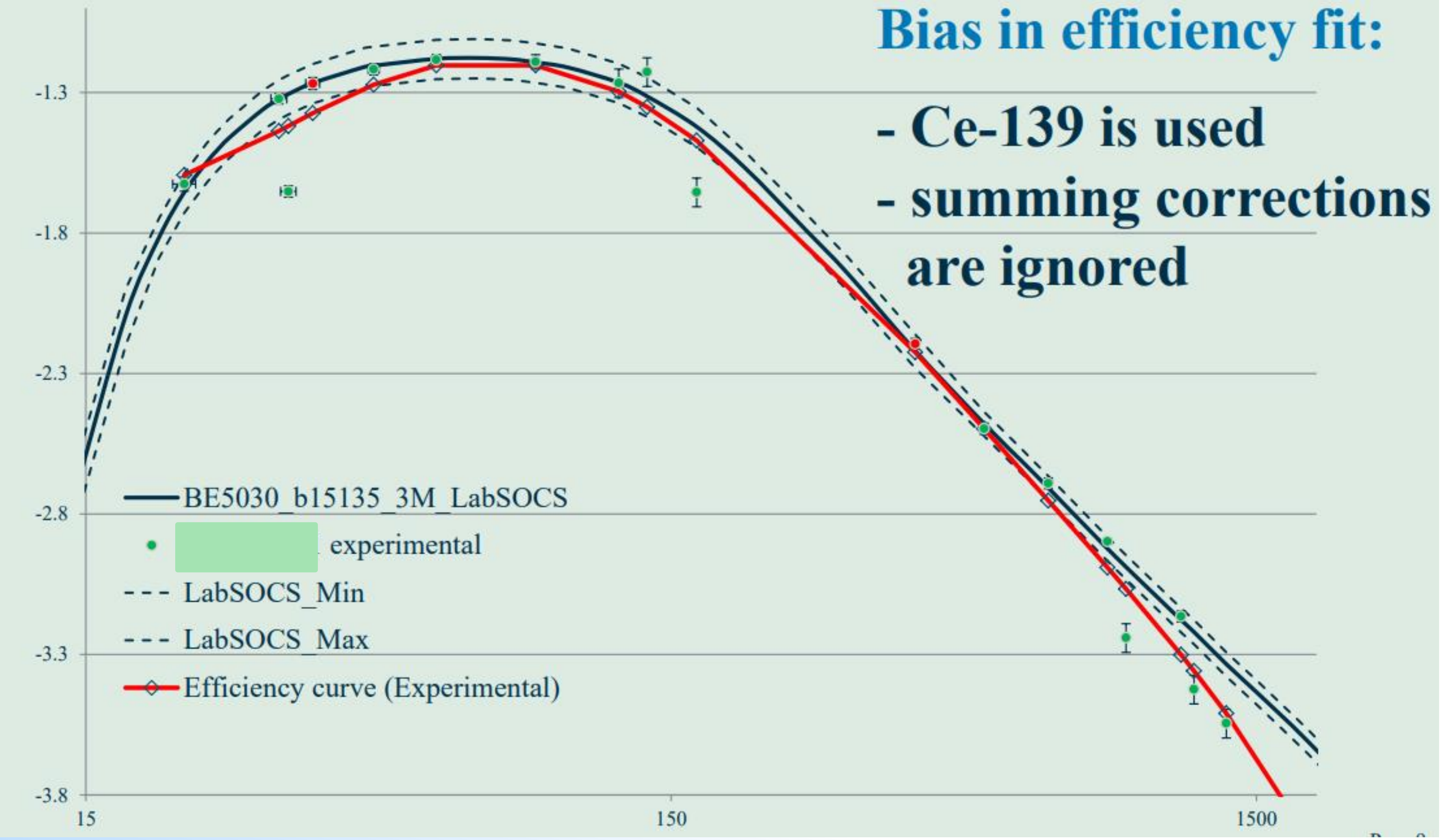
Y-88
Summing Out
(X-γ and γ-γ) - 22%
(X-γ-γ) ignored (~ 0.4%)

Co-60
Summing Out
(γ-γ) - 19%

Y-88
Summing Out
(X-γ and γ-γ) - 24%
(X-γ-γ) ignored (~ 0.4%)

Evolution of HPGe detector models

BEGe/S thinner endcap window (carbon fiber) and thinner dead layer results in increased summing effects!



Bias in efficiency fit:

- **Ce-139 is used**
- **summing corrections are ignored**

Evolution of HPGe detector models

QUESTION:

are HPGe planar (BEGe) detectors suitable for field measurements?

ANSWER:

Yes, BUT “carefully”:

- A minimum distance from detector endcap should be observed, for all measurements, to avoid summing effects
- Aluminium endcap/window is highly recommended, to mitigate summing effects with low energy emissions

FALCON 5000:

BE2830 Ø60 x 30 mm with relative efficiency of approx. 18%

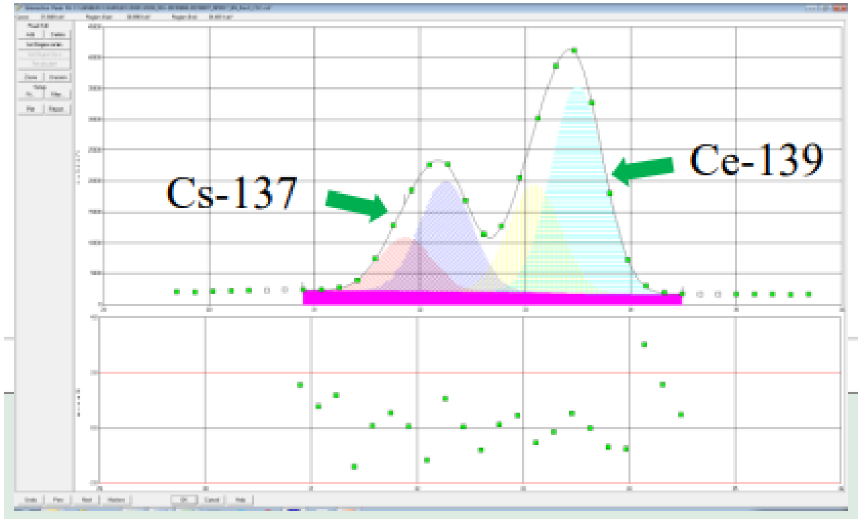
Evolution of HPGe detector models

QUESTION:

WHY using BEGe detectors in the field?

ANSWER(s):

Better resolution? Example:



YES, as long as
the most recent cooling systems are used !

WHY?
Hystorical impact of microphonic effects and mechanical vibrations on detector resolution

Evolution of HPGe detector models

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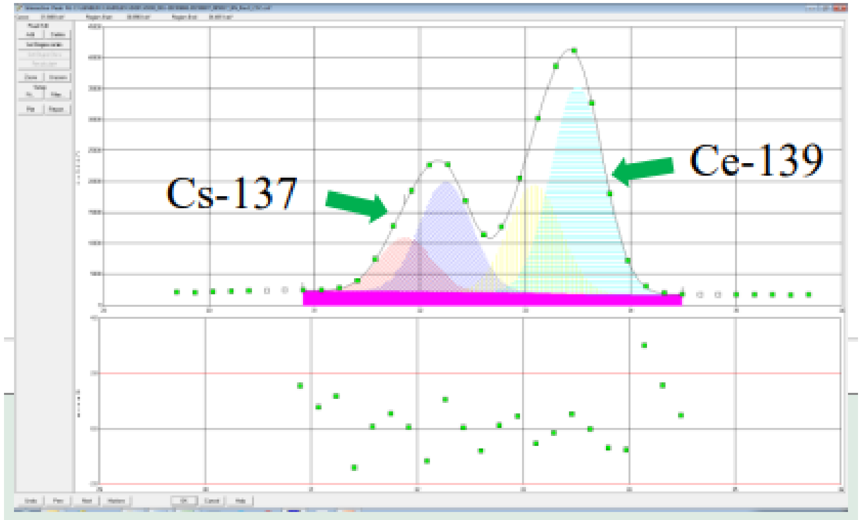

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WHY?
Hystorical impact of microphonic effects and mechanical vibrations on detector resolution

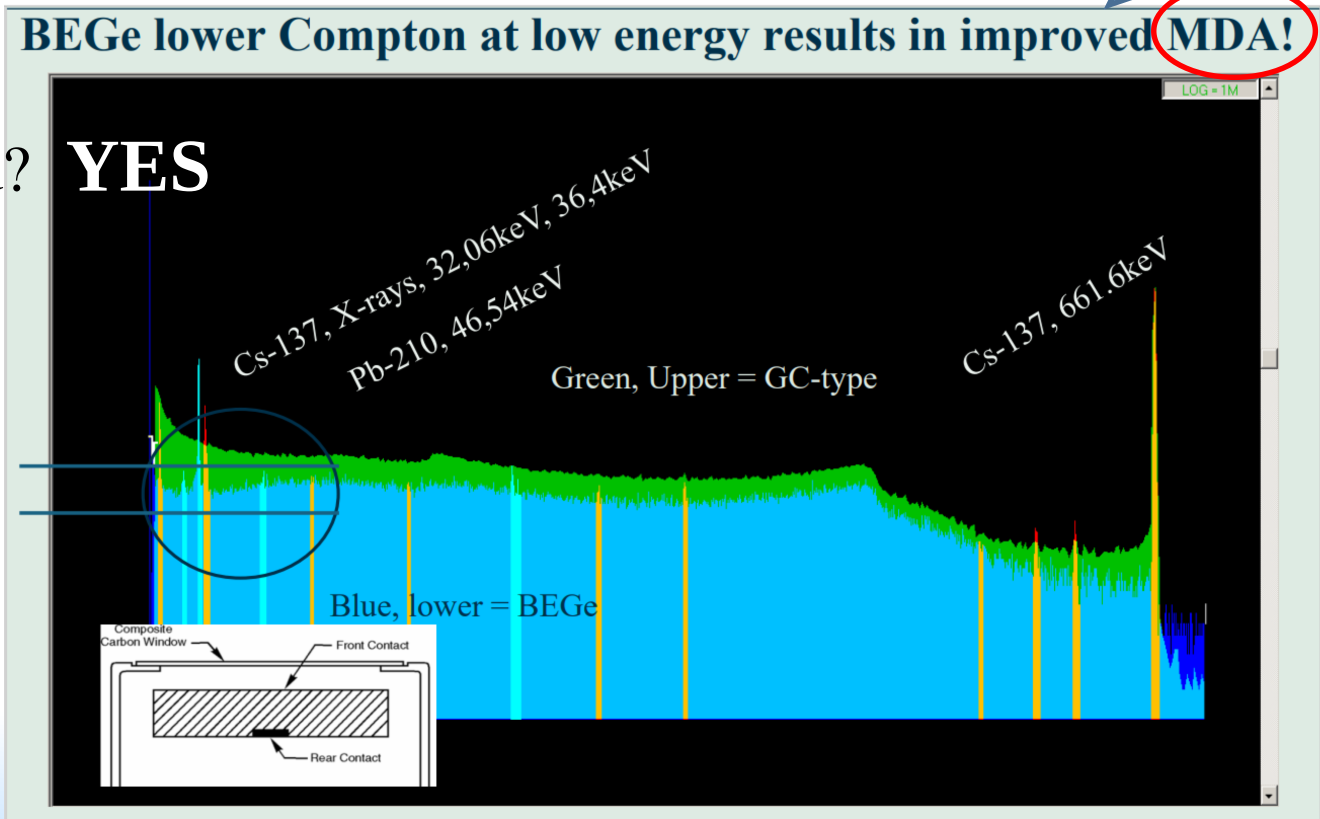
Evolution of HPGe detector models

QUESTION:

WHY using BEGe detectors in the field?

ANSWER(s):

“Better” background? **YES**



Evolution of HPGe detector models

The Minimum Detectable Activity (**MDA**):
”the lowest activity value that can be achieved when a sample is measured with a detection system”.

Gamma-ray spectrometry: MDA depends on the background (statistical nature), counting time, detector and sample properties, measurement geometry, nuclear and sample properties, measurement geometry, nuclear decay data of the considered radionuclide.

$$\mathbf{MDA} \propto \frac{\sqrt{\boldsymbol{FWHM}}}{\boldsymbol{Eff}}$$

Evolution of HPGe detector models

QUESTION:

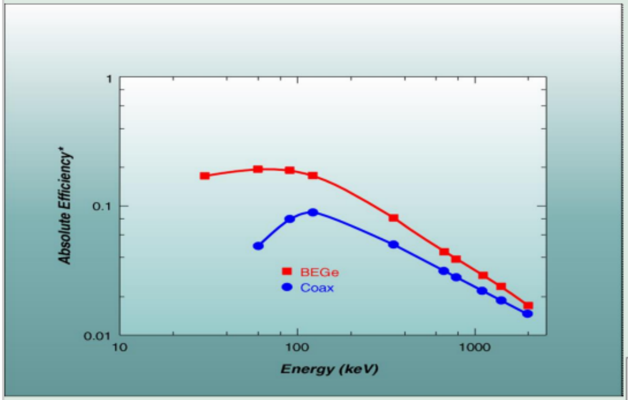
WHY using BEGe detectors in the field?

ANSWER(s):

"Better" efficiency?

YES

BEGe/S high efficiency at low energy results in improved MDA!

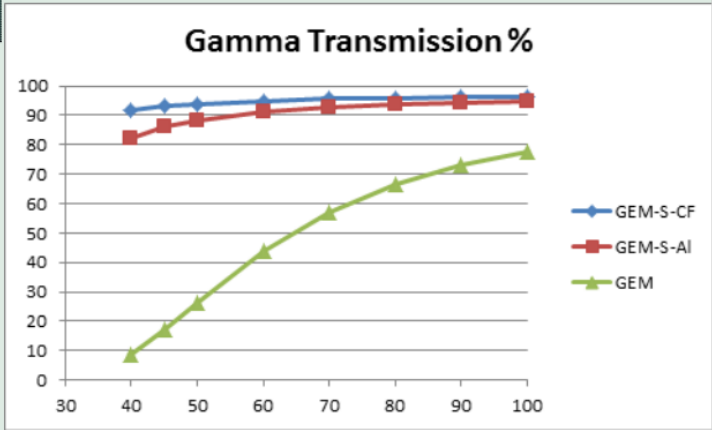


- BE5030
- GC5020 : diameter 60mm, length 80mm, not bulletized
- source : diameter 74mm, length 21mm, on detector's endcap

CANBERRA: BEGe

&

ORTEC: Profile S



Evolution of HPGe detector models

Some detector performance comparison:

Comparison of 3 different detector models with decreasing relative efficiency

Detector model	GC5020	*GC-40%*	BE3830
Rel. Eff. %	63%	***40%***	**37%**
Typical FWHM values (low/mid/high energies) for energy range: 40-2700 keV			
122keV	1.17	**1.2**	0.56
537keV	1.5	1.5	1,2
1332keV	2.01	2.0	1.9
Typical EFFICIENCY values for thin disk close geometry (compressed particulate filter – 50mm disk, 5 mm thickness)			
122keV	0.182	***0.179***	0.282
537keV	0.069	***0.063***	0.077
1332keV	0.028	***0.029***	0.030

Evolution of HPGe detector models

Some detector performance comparison:

Detector model*	GC5020	GC-40%	BE3830	Diff BE3830 - GC40%
Rel. Eff. %	63%	40%	37%	
Typical MDC values (mBq/m^3) for particulate samples with high (≤ 1Bq) Pb-212F content and about 20.000 m^3 sampled volume (Particulate stations, compressed 3M-filters - 50mm disk geometry, 5 mm thick)				
Pb-210 MDC (46.5keV)	748.8	786.9	35	-2148%
Am-241 MDC (60 keV)	25.2	27.4	5.3	-417%
Co-57 MDC (122keV)	3.2	3.5	1.8	-94%
I-131 MDC (364keV)	6.7	7.2	4.8	-50%
Ba-140 MDC (537keV)	18	19.6	15.4	-27%
Cs-137 MDC (661.7keV)	4.5	4.9	4.3	-14%
I-132 MDC (668keV)	4.1	4.6	3.9	-18%
Zr-95 MDC (757keV)	5.8	6.6	5.7	-16%
Nb-95 MDC (766keV)	3.3	3.6	3.2	-13%
C0-60 MDC (1332.5keV)	4.9	5.4	4.9	-10%
Na-24 MDC (1368keV)	44.9	49.5	44.1	-12%
La-140 MDC (1596keV)	14.5	16.1	14.5	-11%

* Detector models and efficiency values reproduced with VGSL

Thank you !

Any questions?