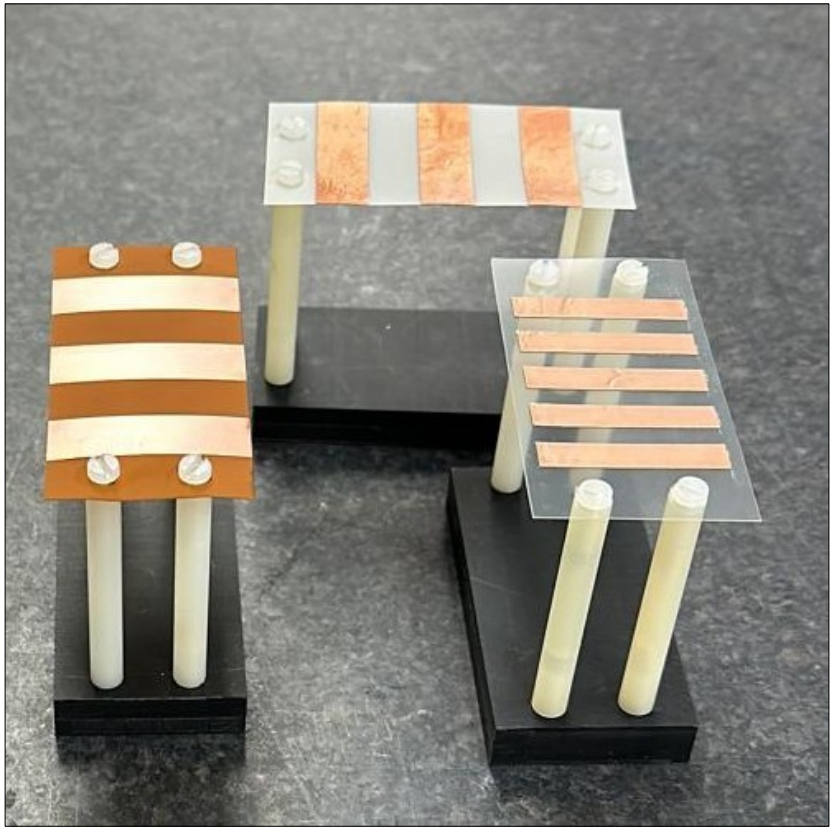
Field Cage Foils measurements

Donatella Tozzi
La Sapienza University – INFN

Cygno Collaboration Meeting 2024

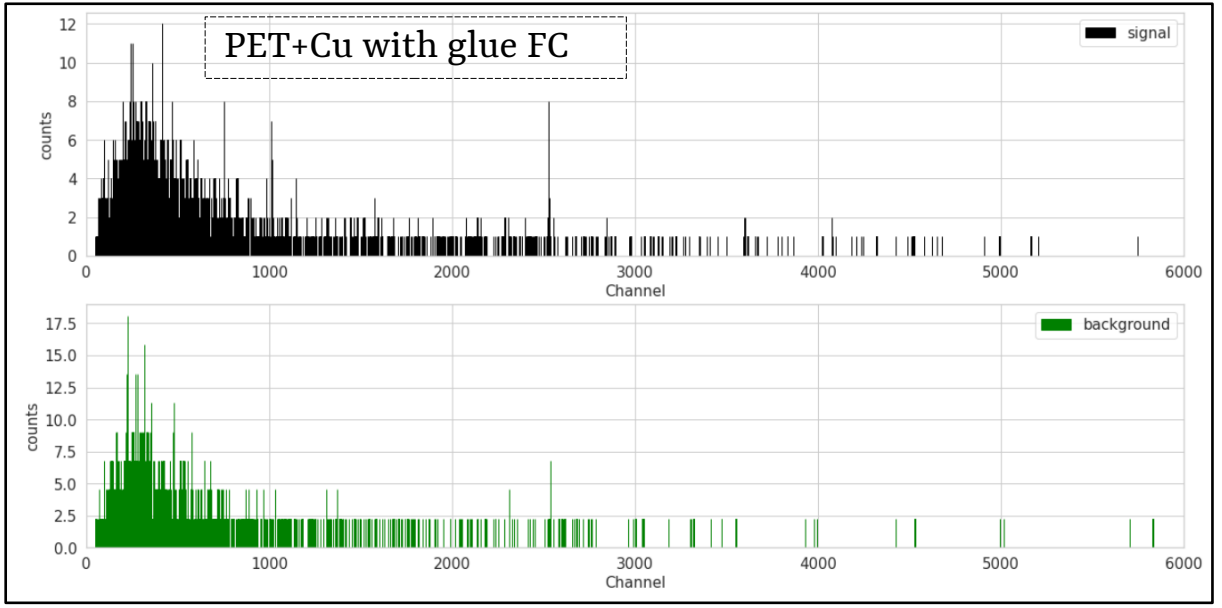
Field Cage Foils

- Three different field cage foils:
  - **PET+Cu with glue**: a polyethylene foil with Cu strips glued by spreading the adhesive over the entire foil
  - **PET+Cu with no glue**: a polyethylene foil with Cu strips glued by applying the adhesive only between the strips and the foil
  - **Kapton+Cu:** a kapton foil with Cu strips
- The foils were measured at LNGS

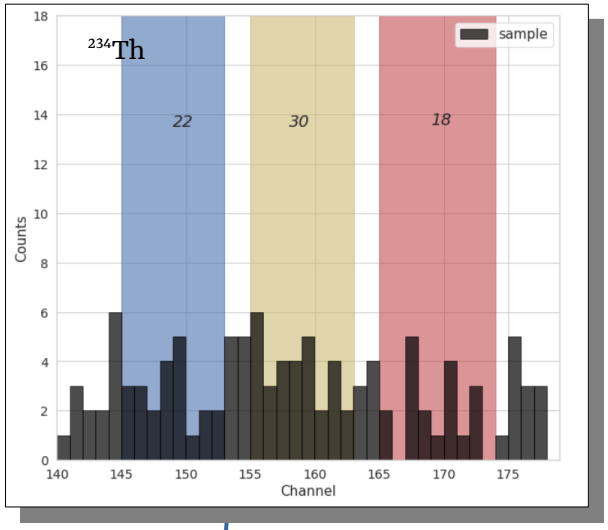


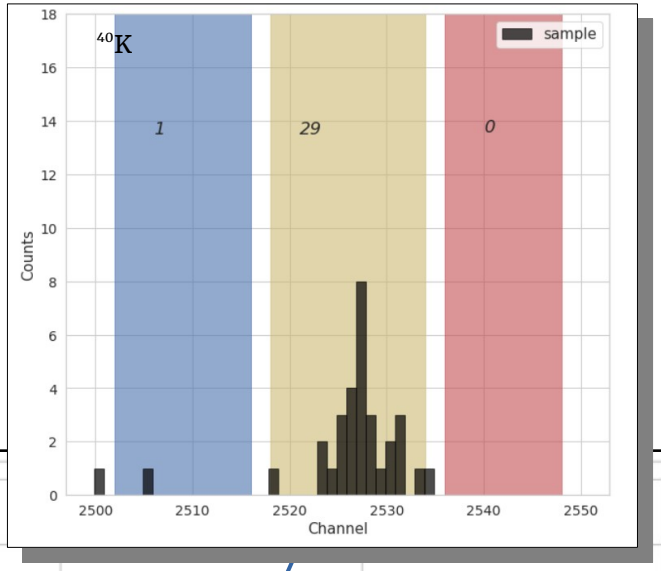
Analysis steps

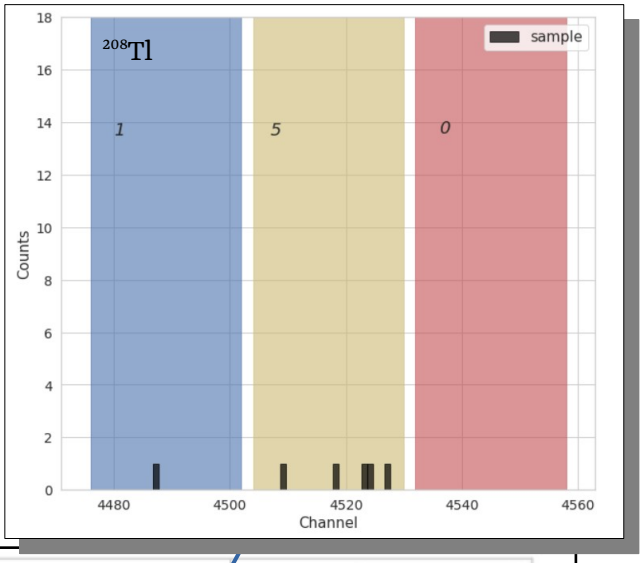
- The FC foils were measured with the same HPGe, $\sigma_E \sim 0.58 \ \ keV$
- The analysis was performed by considering Channels along the x-axis of the spectrum
- Analysis steps:
  - **ROIs selection**
  - **Counting events in each ROI**
  - **Determination of activity of each radionuclide**

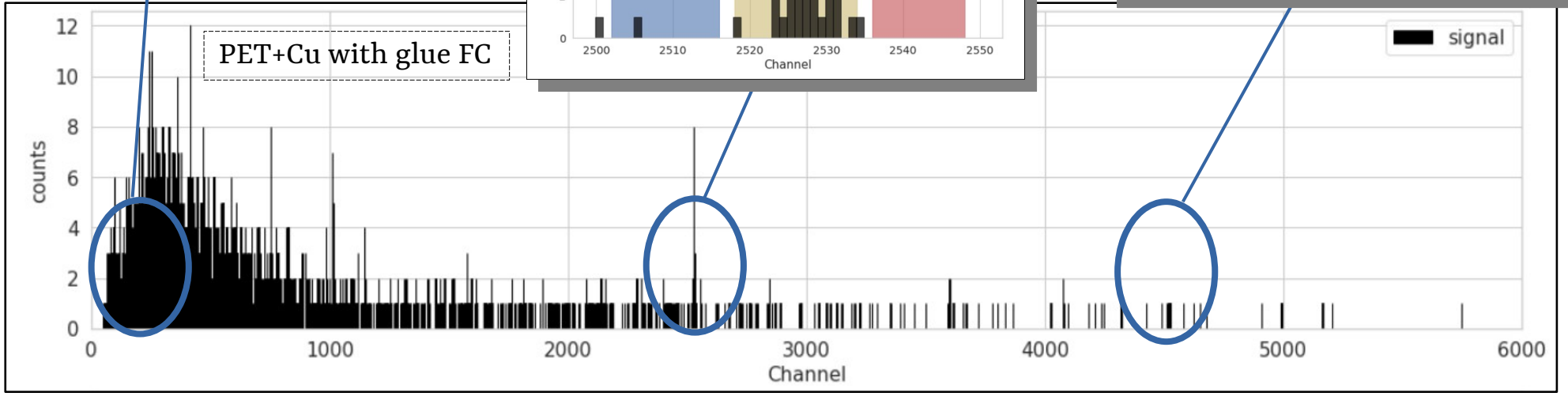


ROIs selection



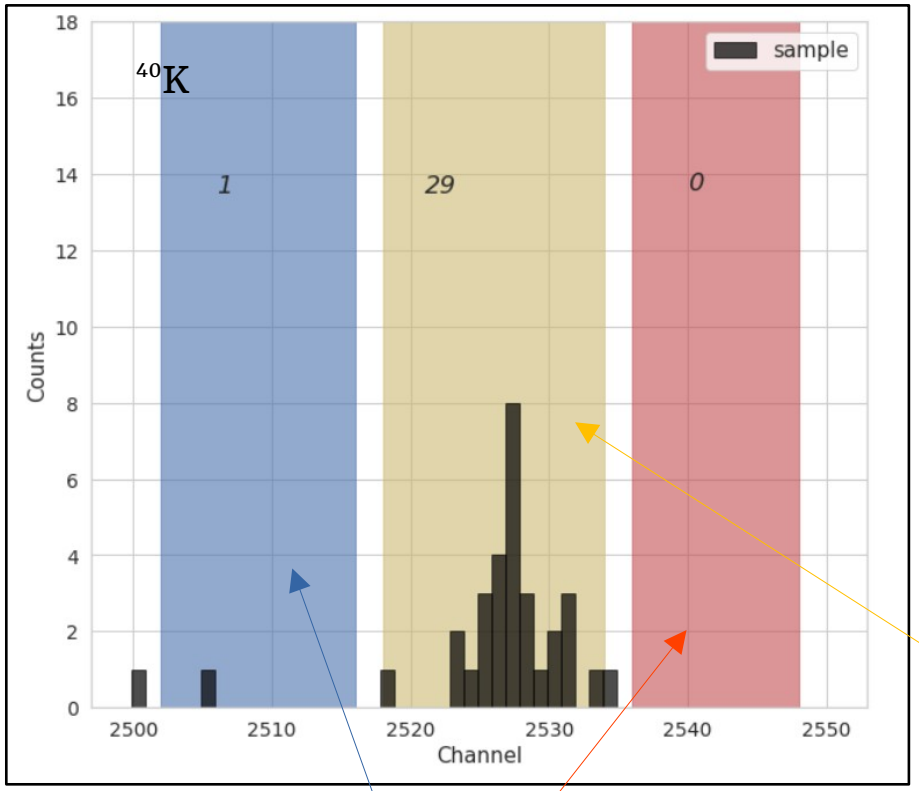


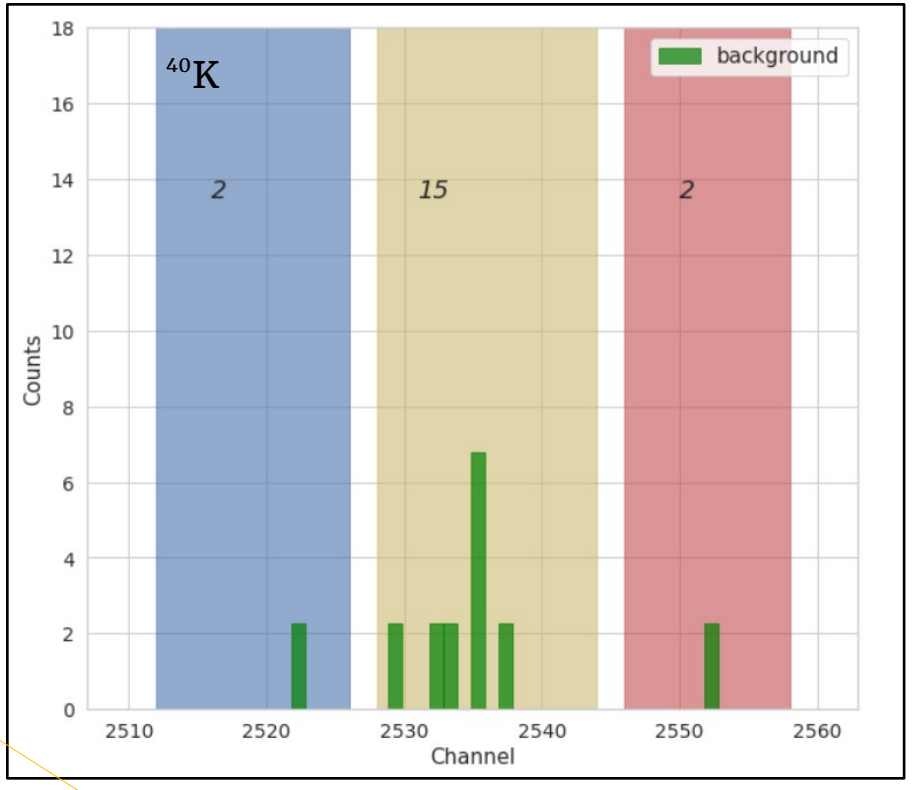




PET+Cu with glue FC

Counting events in each ROI



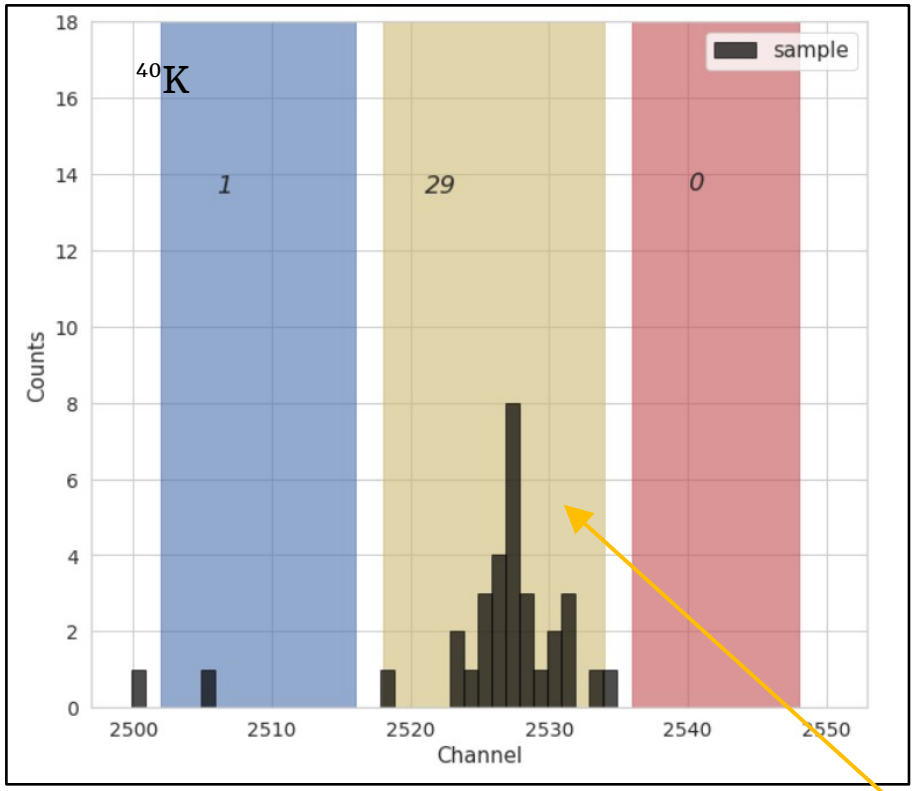


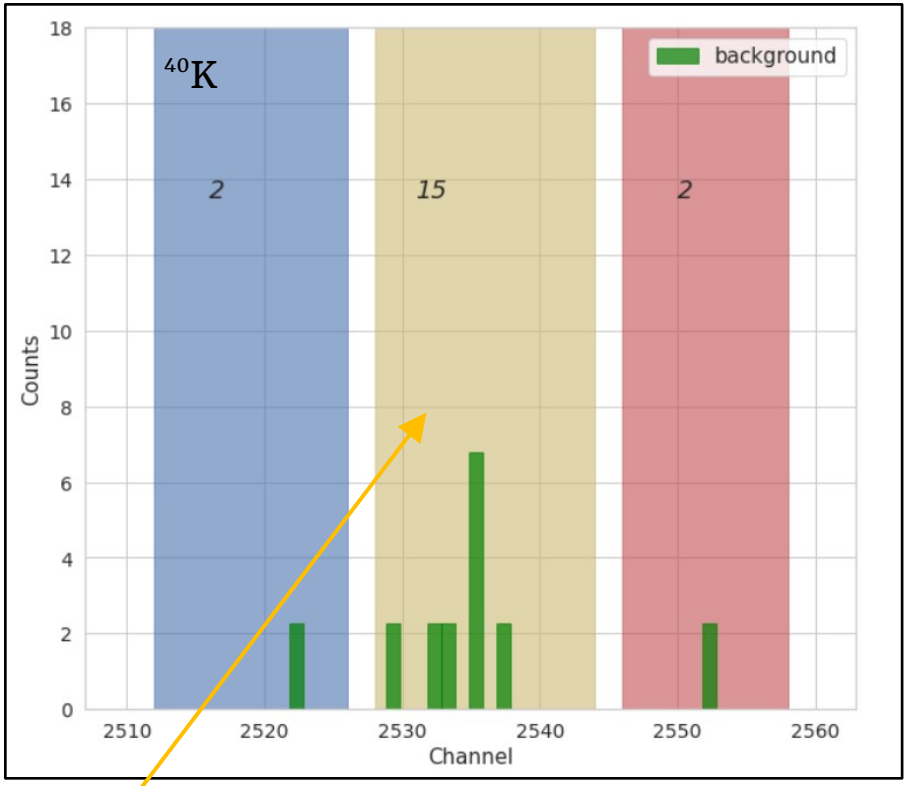
$$\overline{C}_{sideBands} = \frac{C_{left} + C_{right}}{N_{LeftBins} + N_{RightBins}}$$

$$C_{totSignal} = C_{centralPeak} - (\overline{C}_{sideBands} \cdot N_{centralBins})$$

PET+Cu with glue FC

Counting events in each ROI





$$C_{net} = C_{totSignal} - C_{totBkg}$$

Activity Determination

- The activity was estimated by using the following formula

$$A = \frac{C_{net}}{\epsilon \cdot \frac{BR}{100} \cdot t}$$

Branching Ratio

Sample measurament time

Detector efficiency

- When a radionuclide has two or more energy peaks:

$$\overline{A} = \frac{\sum_{i=1}^{N} \frac{A_i}{\sigma_i^2}}{\sum_{i=1}^{N} \frac{1}{\sigma_i^2}}$$

$$\sigma_{\overline{A}} = \left(\sum_{i=1}^{N} \frac{1}{\sigma_i^2}\right)^{-\frac{1}{2}}$$

- If the σ > A/2 a limit is set and the limit is estimated as

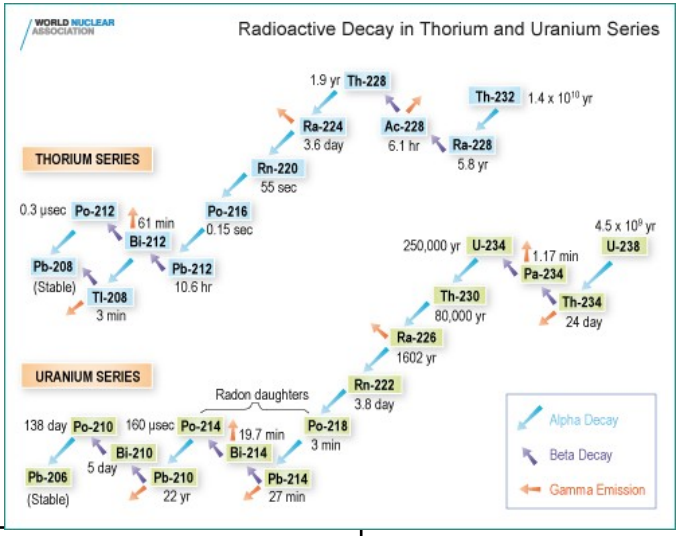
$$L = \overline{A} + k\sigma_{\overline{A}}$$

with k=1.645

The total activity was divided by the sample mass

Results

PET_Cu Field Cage (glued)			
Nuclides	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Th-234	0.09	0.27	0.53
Ra-226	$8.06 \cdot 10^{-3}$	$9.70 \cdot 10^{-3}$	$24.01 \cdot 10^{-3}$
Pb-214	$8.06 \cdot 10^{-3}$	$9.70 \cdot 10^{-3}$	$24.01 \cdot 10^{-3}$
Ac-228	$0.36 \cdot 10^{-3}$	$14.91 \cdot 10^{-3}$	$25.02 \cdot 10^{-3}$
Pb-212	$25.81 \cdot 10^{-3}$	$9.99 \cdot 10^{-3}$	-
Bi-212	$57.03 \cdot 10^{-3}$	$33.94 \cdot 10^{-3}$	0.11
Tl-208	$26.83 \cdot 10^{-3}$	$10.40 \cdot 10^{-3}$	-
U-235	$10.72 \cdot 10^{-3}$	$7.69 \cdot 10^{-3}$	$23.41 \cdot 10^{-3}$
K-40	0.16	0.07	-
Cs-137	$5.96 \cdot 10^{-3}$	$3.65 \cdot 10^{-3}$	$12.01 \cdot 10^{-3}$




```
Sample:         PET foil with Cu, (370 x 250 x 0.1) mm, CYGNO
mass:           23.96 g
live time:      2696425 s
detector:       GeMPI2

radionuclide concentrations:

Th-232:
Ra-228:         < 29 mBq/kg             <==>    < 7.0 E-9 g/g
Th-228:         (30 +- 6) mBq/kg        <==>    (7 +- 2) E-9 g/g

U-238:
Ra-226          < 9.2 mBq/kg            <==>    < 7.4 E-10 g/g
Th-234          < 0.64 Bq/kg            <==>    < 5.2 E-8 g/g
Pa-234m         < 0.45 Bq/kg            <==>    < 3.7 E-8 g/g

U-235:          < 22 mBq/kg             <==>    < 3.9 E-8 g/g

K-40:           (0.21 +- 0.06) Bq/kg    <==>    (7 +- 2) E-6 g/g

Cs-137:         < 12 mBq/kg
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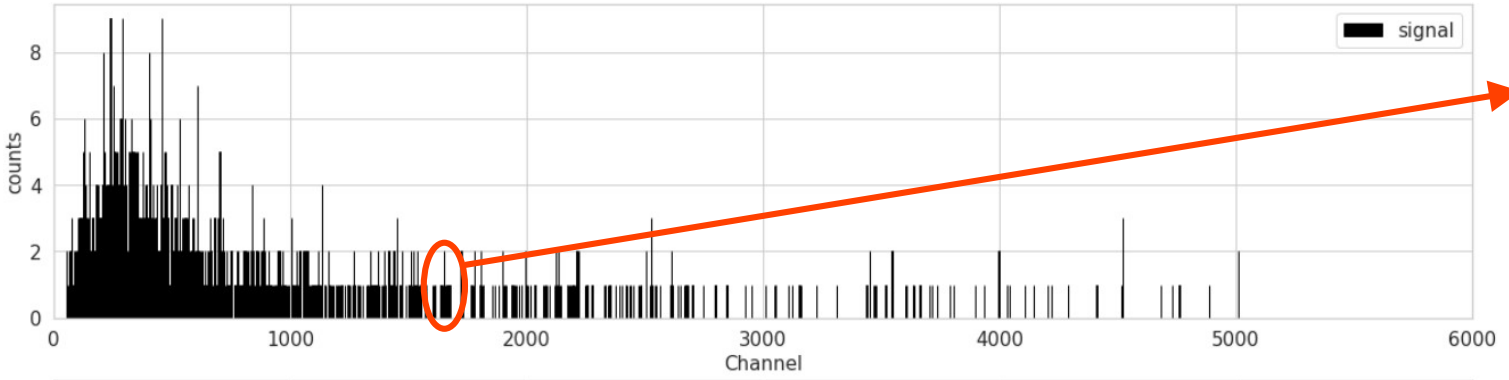
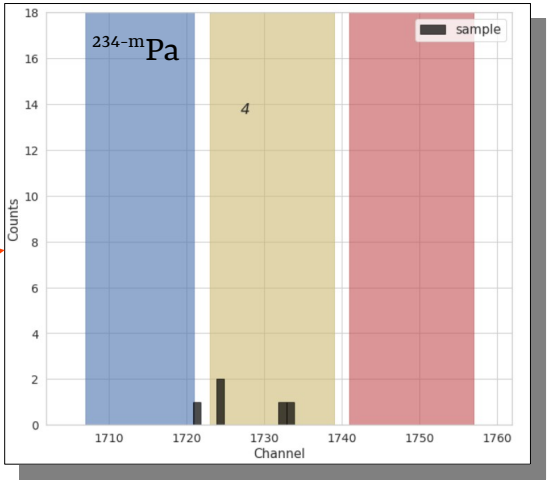
LNGS results

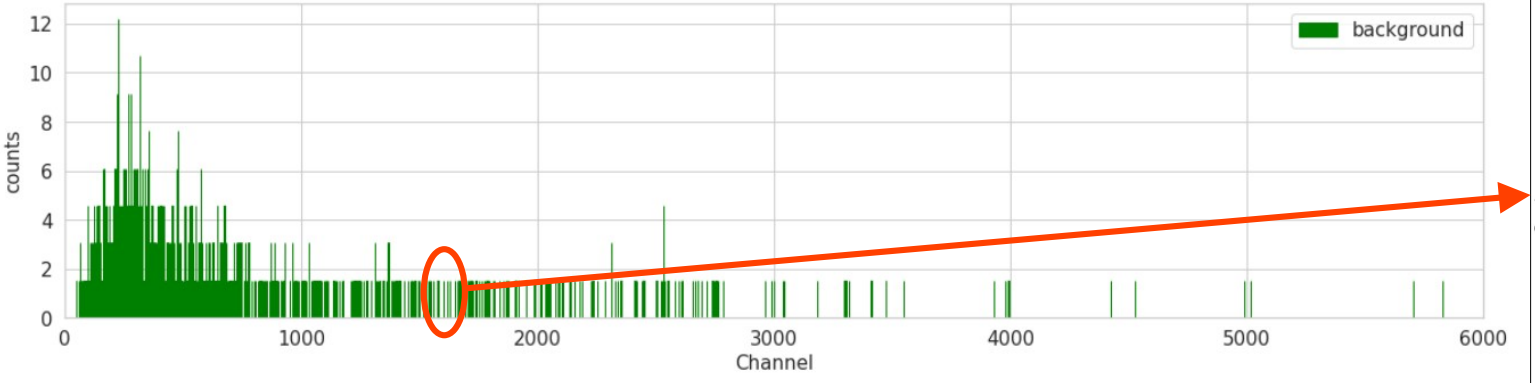
PET_Cu Field Cage (glued)				PET_Cu Field Cage (no glued)			Kapton+Cu Field Cage		
Nuclides	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Th-234	0.09	0.27	0.53	0.08	0.60	1.07	-	-	-
Pa-234m	-	-	-	-	-	-	0.62	0.44	1.34
Ra-226	$8.06 \cdot 10^{-3}$	$9.70 \cdot 10^{-3}$	$24.01 \cdot 10^{-3}$	$35.71 \cdot 10^{-3}$	$23.22 \cdot 10^{-3}$	$73.92 \cdot 10^{-3}$	$6.98 \cdot 10^{-3}$	$4.24 \cdot 10^{-3}$	$14.02 \cdot 10^{-3}$
Pb-214	$8.06 \cdot 10^{-3}$	$9.70 \cdot 10^{-3}$	$24.01 \cdot 10^{-3}$	$28.31 \cdot 10^{-3}$	$44.23 \cdot 10^{-3}$	$101{,}02 \cdot 10^{-3}$	$17.61 \cdot 10^{-3}$	$11.81 \cdot 10^{-3}$	$36.92 \cdot 10^{-3}$
Bi-214	-	-	-	$38.51 \cdot 10^{-3}$	$27.32 \cdot 10^{-3}$	$83.41 \cdot 10^{-3}$	$5.41 \cdot 10^{-3}$	$4.54 \cdot 10^{-3}$	$12.91 \cdot 10^{-3}$
Ac-228	$0.36 \cdot 10^{-3}$	$14.91 \cdot 10^{-3}$	$25.02 \cdot 10^{-3}$	$9.02 \cdot 10^{-3}$	$33.31 \cdot 10^{-3}$	$63.81 \cdot 10^{-3}$	$5.05 \cdot 10^{-3}$	$13.82 \cdot 10^{-3}$	$27.83 \cdot 10^{-3}$
Pb-212	$25.81 \cdot 10^{-3}$	$9.99 \cdot 10^{-3}$	-	-	-	-	-	-	-
Bi-212	$57.03 \cdot 10^{-3}$	$33.94 \cdot 10^{-3}$	0.11	-	-	-	-	-	-
Tl-208	$26.83 \cdot 10^{-3}$	$10.40 \cdot 10^{-3}$	-	$43.32 \cdot 10^{-3}$	$21.20 \cdot 10^{-3}$	-	$21.83 \cdot 10^{-3}$	$11.13 \cdot 10^{-3}$	$40.03 \cdot 10^{-3}$
U-235	$10.72 \cdot 10^{-3}$	$7.69 \cdot 10^{-3}$	$23.41 \cdot 10^{-3}$	$23.92 \cdot 10^{-3}$	$17.33 \cdot 10^{-3}$	$52.43 \cdot 10^{-3}$	$12.54 \cdot 10^{-3}$	$8.37 \cdot 10^{-3}$	$26.31 \cdot 10^{-3}$
K-40	0.16	0.07	-	0.18	0.15	0.43	-	-	-
Cs-137	$5.96 \cdot 10^{-3}$	$3.65 \cdot 10^{-3}$	$12.01 \cdot 10^{-3}$	-	-	-	-	-	-
Co-60	-	-	-	$1.54 \cdot 10^{-3}$	$7.48 \cdot 10^{-3}$	$13.82 \cdot 10^{-3}$	-	-	-

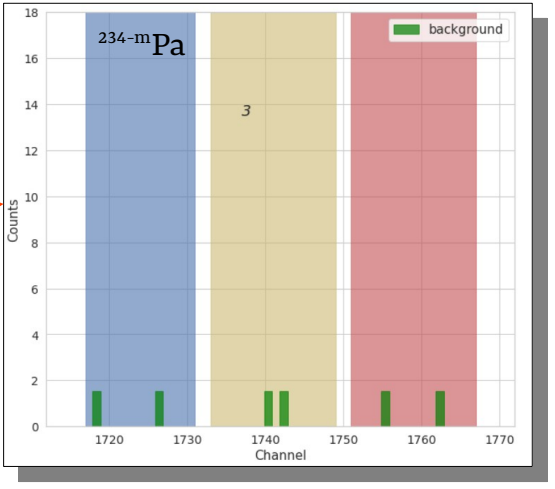
The efficiency values of PET_Cu FC glued were used to determine every activity in tables

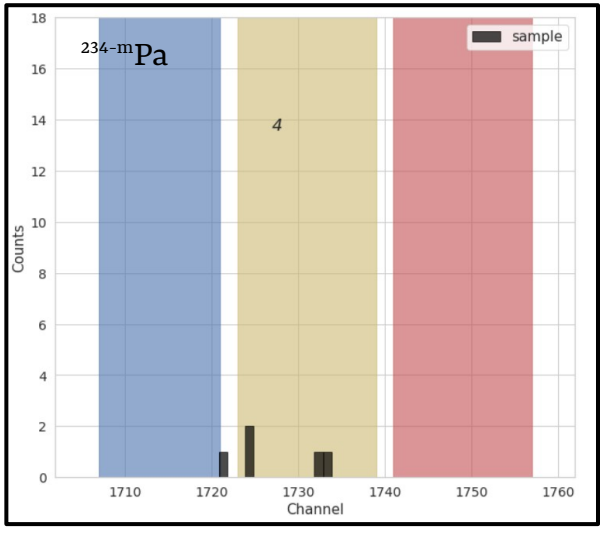
Kapton+Cu FC

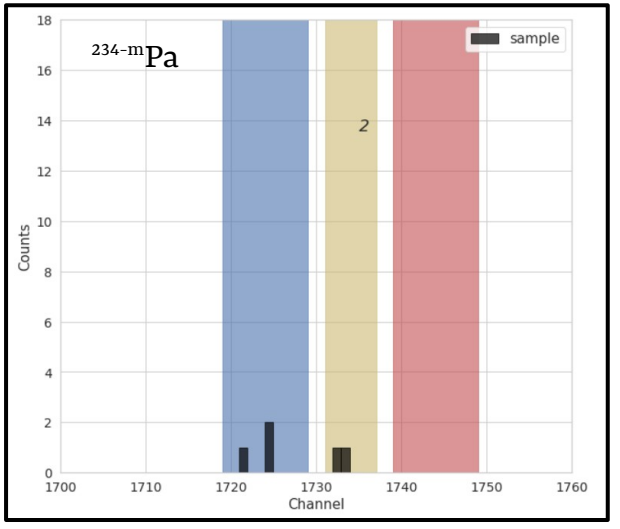

signal
counts
Channel
0
1000
2000
3000
4000
5000
6000

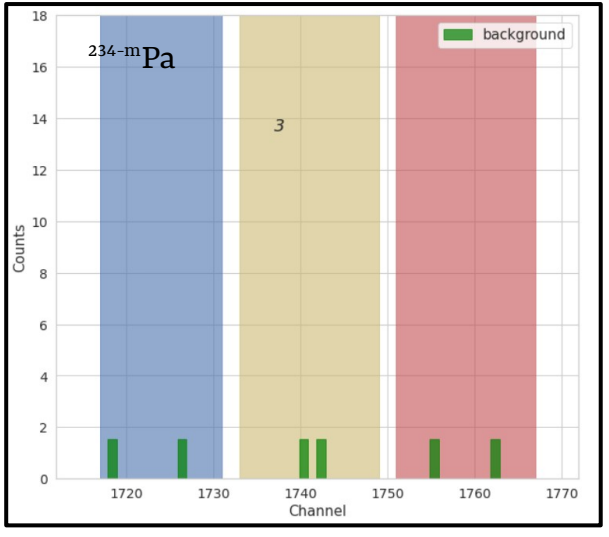

234-mPa
sample
4
Counts
Channel

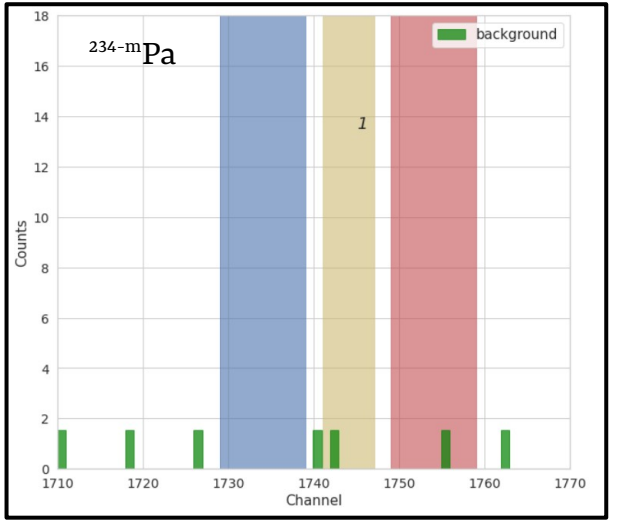

background
counts
Channel
0
1000
2000
3000
4000
5000
6000


234-mPa
background
3
Counts
Channel


234-mPa
sample
4
Counts
Channel


234-mPa
sample
2
Counts
Channel


234-mPa
background
3
Counts
Channel


234-mPa
background
1
Counts
Channel

Kapton+Cu FC

	PET_Cu Field Cage (glued)			PET_Cu Field Cage (no glued)			Kapton+Cu Field Cage		
Nuclides	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Th-234	-	-	-	-	-	-	-	-	-
Pa-234m	-	-	-	-	-	-	$4.42 \cdot 10^{-3}$	0.29	0.48
Ra-226	$3.39 \cdot 10^{-3}$	$2.34 \cdot 10^{-3}$	$7.23 \cdot 10^{-3}$	$2.59 \cdot 10^{-3}$	$1.23 \cdot 10^{-3}$	-	$18.21 \cdot 10^{-3}$	$6.43 \cdot 10^{-3}$	-
Pb-214	$18.51 \cdot 10^{-3}$	$7.45 \cdot 10^{-3}$	-	$8.53 \cdot 10^{-3}$	$4.83 \cdot 10^{-3}$	$16.52 \cdot 10^{-3}$	$25.10 \cdot 10^{-3}$	$9.36 \cdot 10^{-3}$	-
Bi-214	$2.06 \cdot 10^{-3}$	$2.46 \cdot 10^{-3}$	$6.11 \cdot 10^{-3}$	$2.17 \cdot 10^{-3}$	$1.28 \cdot 10^{-3}$	$4.27 \cdot 10^{-3}$	$12.13 \cdot 10^{-3}$	$8.84 \cdot 10^{-3}$	$26.61 \cdot 10^{-3}$
Ac-228	$14.42 \cdot 10^{-3}$	$6.20 \cdot 10^{-3}$	-	$5.72 \cdot 10^{-3}$	$3.62 \cdot 10^{-3}$	$11.72 \cdot 10^{-3}$	$10.12 \cdot 10^{-3}$	$5.86 \cdot 10^{-3}$	$19.74 \cdot 10^{-3}$
Pb-212	$19.52 \cdot 10^{-3}$	$8.87 \cdot 10^{-3}$	-	$33.32 \cdot 10^{-3}$	$26.12 \cdot 10^{-3}$	$76.23 \cdot 10^{-3}$	-	-	-
Bi-212	$9.25 \cdot 10^{-3}$	$22.53 \cdot 10^{-3}$	$46.31 \cdot 10^{-3}$	-	-	-	-	-	-
Tl-208	$12.32 \cdot 10^{-3}$	$6.28 \cdot 10^{-3}$	$22.61 \cdot 10^{-3}$	$21.72 \cdot 10^{-3}$	$81.52 \cdot 10^{-3}$	0.16	$16.92 \cdot 10^{-3}$	$8.61 \cdot 10^{-3}$	$31.20 \cdot 10^{-3}$
U-235	$1.04 \cdot 10^{-3}$	$6.17 \cdot 10^{-3}$	$11.23 \cdot 10^{-3}$	$10.21 \cdot 10^{-3}$	$13.73 \cdot 10^{-3}$	$32.81 \cdot 10^{-3}$	$4.15 \cdot 10^{-3}$	$6.93 \cdot 10^{-3}$	$15.62 \cdot 10^{-3}$
K-40	0.12	0.06	-	0.25	0.13	0.48	$14.31 \cdot 10^{-3}$	$52.71 \cdot 10^{-3}$	0.10
Cs-137	$6.81 \cdot 10^{-3}$	$2.83 \cdot 10^{-3}$	-	-	-	-	$0.30 \cdot 10^{-3}$	$2.27 \cdot 10^{-3}$	$4.03 \cdot 10^{-3}$
Co-60	-	-	-	$0.20 \cdot 10^{-3}$	$0.11 \cdot 10^{-3}$	$0.38 \cdot 10^{-3}$	-	-	-

Larger region of central peak				Smaller region of central peak		
Nuclides	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Th-234	0.09	0.27	0.53	-	-	-
Pa-234m	-	-	-	-	-	-
Ra-226	$8.06 \cdot 10^{-3}$	$9.70 \cdot 10^{-3}$	$24.01 \cdot 10^{-3}$	$3.39 \cdot 10^{-3}$	$2.34 \cdot 10^{-3}$	$7.23 \cdot 10^{-3}$
Pb-214	$8.06 \cdot 10^{-3}$	$9.70 \cdot 10^{-3}$	$24.01 \cdot 10^{-3}$	$18.51 \cdot 10^{-3}$	$7.45 \cdot 10^{-3}$	-
Bi-214	-	-	-	$2.06 \cdot 10^{-3}$	$2.46 \cdot 10^{-3}$	$6.11 \cdot 10^{-3}$
Ac-228	$0.36 \cdot 10^{-3}$	$14.91 \cdot 10^{-3}$	$25.02 \cdot 10^{-3}$	$14.42 \cdot 10^{-3}$	$6.20 \cdot 10^{-3}$	-
Pb-212	$25.81 \cdot 10^{-3}$	$9.99 \cdot 10^{-3}$	-	$19.52 \cdot 10^{-3}$	$8.87 \cdot 10^{-3}$	-
Bi-212	$57.03 \cdot 10^{-3}$	$33.94 \cdot 10^{-3}$	0.11	$9.25 \cdot 10^{-3}$	$22.53 \cdot 10^{-3}$	$46.31 \cdot 10^{-3}$
Tl-208	$26.83 \cdot 10^{-3}$	$10.40 \cdot 10^{-3}$	$43.92 \cdot 10^{-3}$	$12.32 \cdot 10^{-3}$	$6.28 \cdot 10^{-3}$	$22.61 \cdot 10^{-3}$
U-235	$10.72 \cdot 10^{-3}$	$7.69 \cdot 10^{-3}$	$23.41 \cdot 10^{-3}$	$1.04 \cdot 10^{-3}$	$6.17 \cdot 10^{-3}$	$11.23 \cdot 10^{-3}$
K-40	0.16	0.07	-	0.12	0.06	-
Cs-137	$5.96 \cdot 10^{-3}$	$3.65 \cdot 10^{-3}$	$12.01 \cdot 10^{-3}$	$6.81 \cdot 10^{-3}$	$2.83 \cdot 10^{-3}$	-
Co-60	-	-	-	-	-	-

PET+Cu FC with glue

```
Sample:          PET foil with Cu, (370 x 250 x 0.1) mm, CYGNO
mass:            23.96 g
live time:       2696425 s
detector:        GeMPI2

radionuclide concentrations:

Th-232:
Ra-228:          < 29 mBq/kg              <==>    < 7.0 E-9 g/g
Th-228:          (30 +- 6) mBq/kg         <==>    (7 +- 2) E-9 g/g

U-238:
Ra-226           < 9.2 mBq/kg             <==>    < 7.4 E-10 g/g
Th-234           < 0.64 Bq/kg             <==>    < 5.2 E-8 g/g
Pa-234m          < 0.45 Bq/kg             <==>    < 3.7 E-8 g/g

U-235:           < 22 mBq/kg              <==>    < 3.9 E-8 g/g

K-40:            (0.21 +- 0.06) Bq/kg     <==>    (7 +- 2) E-6 g/g

Cs-137:          < 12 mBq/kg
```

PET+Cu FC no glued

Larger region of central peak				Smaller region of central peak		
Nuclides	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Th-234	0.08	0.60	1.07	-	-	-
Pa-234m	-	-	-	-	-	-
Ra-226	$35.71 \cdot 10^{-3}$	$23.22 \cdot 10^{-3}$	$73.92 \cdot 10^{-3}$	$2.59 \cdot 10^{-3}$	$1.23 \cdot 10^{-3}$	-
Pb-214	$28.31 \cdot 10^{-3}$	$44.23 \cdot 10^{-3}$	$101{,}02 \cdot 10^{-3}$	$8.53 \cdot 10^{-3}$	$4.83 \cdot 10^{-3}$	$16.52 \cdot 10^{-3}$
Bi-214	$38.51 \cdot 10^{-3}$	$27.32 \cdot 10^{-3}$	$83.41 \cdot 10-3$	$2.17 \cdot 10^{-3}$	$1.28 \cdot 10^{-3}$	$4.27 \cdot 10-3$
Ac-228	$9.02 \cdot 10^{-3}$	$33.31 \cdot 10^{-3}$	$63.81 \cdot 10-3$	$5.72 \cdot 10^{-3}$	$3.62 \cdot 10^{-3}$	$11.72 \cdot 10-3$
Pb-212	-	-	-	$33.32 \cdot 10^{-3}$	$26.12 \cdot 10^{-3}$	$76.23 \cdot 10-3$
Bi-212	-	-	-	-	-	-
Tl-208	$43.32 \cdot 10-3$	$21.20 \cdot 10^{-3}$	-	$21.72 \cdot 10-3$	$81.52 \cdot 10^{-3}$	0.16
U-235	$23.92 \cdot 10-3$	$17.33 \cdot 10^{-3}$	$52.43 \cdot 10-3$	$10.21 \cdot 10-3$	$13.73 \cdot 10^{-3}$	$32.81 \cdot 10-3$
K-40	0.18	0.15	0.43	0.25	0.13	0.48
Cs-137	-	-	-	-	-	-
Co-60	$1.54 \cdot 10-3$	$7.48 \cdot 10^{-3}$	$13.82 \cdot 10^{-3}$	$0.20 \cdot 10-3$	$0.11 \cdot 10^{-3}$	$0.38 \cdot 10^{-3}$

Kapton+Cu FC

	Larger region of central peak			Smaller region of central peak		
Nuclides	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Th-234	-	-	-	-	-	-
Pa-234m	0.62	0.44	1.34	$4.42 \cdot 10^{-3}$	0.29	0.48
Ra-226	$6.98 \cdot 10^{-3}$	$4.24 \cdot 10^{-3}$	$14.02 \cdot 10^{-3}$	$18.21 \cdot 10^{-3}$	$6.43 \cdot 10^{-3}$	-
Pb-214	$17.61 \cdot 10^{-3}$	$11.81 \cdot 10^{-3}$	$36.92 \cdot 10^{-3}$	$25.10 \cdot 10^{-3}$	$9.36 \cdot 10^{-3}$	-
Bi-214	$5.41 \cdot 10^{-3}$	$4.54 \cdot 10^{-3}$	$12.91 \cdot 10^{-3}$	$12.13 \cdot 10^{-3}$	$8.84 \cdot 10^{-3}$	$26.61 \cdot 10^{-3}$
Ac-228	$5.05 \cdot 10^{-3}$	$13.82 \cdot 10^{-3}$	$27.83 \cdot 10^{-3}$	$10.12 \cdot 10^{-3}$	$5.86 \cdot 10^{-3}$	$19.74 \cdot 10^{-3}$
Pb-212	-	-	-	-	-	-
Bi-212	-	-	-	-	-	-
Tl-208	$21.83 \cdot 10^{-3}$	$11.13 \cdot 10^{-3}$	$40.03 \cdot 10^{-3}$	$16.92 \cdot 10^{-3}$	$8.61 \cdot 10^{-3}$	$31.20 \cdot 10^{-3}$
U-235	$12.54 \cdot 10^{-3}$	$8.37 \cdot 10^{-3}$	$26.31 \cdot 10^{-3}$	$4.15 \cdot 10^{-3}$	$6.93 \cdot 10^{-3}$	$15.62 \cdot 10^{-3}$
K-40	-	-	-	$14.31 \cdot 10^{-3}$	$52.71 \cdot 10^{-3}$	0.10
Cs-137	-	-	-	$0.30 \cdot 10^{-3}$	$2.27 \cdot 10^{-3}$	$4.03 \cdot 10^{-3}$
Co-60	-	-	-	-	-	-

Status of samples measurement

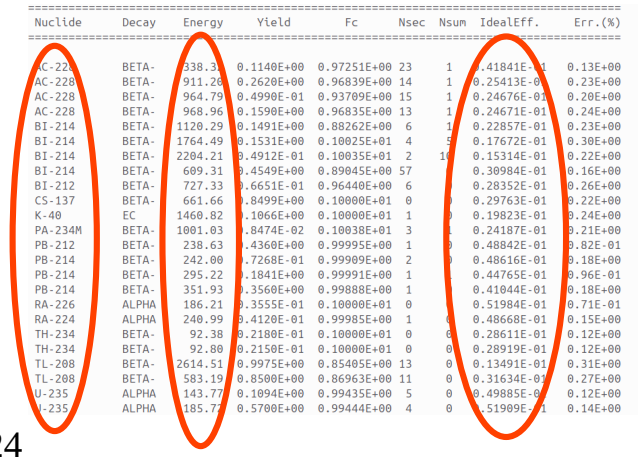
	alias	LNF	LNGS	in measure	measured	analysed
FC-kapton+Cu			x	no	yes	on-going
FC-PET+Cu	PVC		x	no	yes	yes
FC-PET+Cu no glue	PVC no glue		x	no	yes	on-going
FC-PET+Cu+glue	forato	x				
nylon6	PA6		x	no	yes	on-going
Foglio GEM			x	no	no	no
nylon screws			x	no	yes	no
steel screws			x	no	yes	no
SMD resistors			x	no	yes	no
CMOS camera				no	yes	yes

We have results that can be used in simulation

Samples awaiting analysis

Conclusions

- Results depend on the length of the central region:
  - **Which technique do we want to adopt?**
- The analysis is performed taking into account ROIs used by Matthias:
  - **Do we want to add other energy peak regions, such as ^{210}Pb?**
- From the simulation we do not have the efficiency value of all radionuclides:
  - **If we want to add other radionuclides to our list of ROIs, we need to ask to Matthias adding them in the simulation**



Nuclide	Decay	Energy	Yield	Fc	Nsec	Nsum	IdealEff.	Err.(%)
AC-228	BETA-	338.32	0.1140E+00	0.97251E+00	23	1	0.41841E-01	0.13E+00
AC-228	BETA-	911.20	0.2620E+00	0.96839E+00	14	1	0.25413E-01	0.23E+00
AC-228	BETA-	964.79	0.4990E-01	0.93709E+00	15	1	0.24676E-01	0.20E+00
AC-228	BETA-	968.96	0.1590E+00	0.96835E+00	13	1	0.24671E-01	0.24E+00
BI-214	BETA-	1120.29	0.1491E+00	0.88262E+00	6	1	0.22857E-01	0.23E+00
BI-214	BETA-	1764.49	0.1531E+00	0.10025E+01	4	5	0.17672E-01	0.30E+00
BI-214	BETA-	2204.21	0.4912E-01	0.10035E+01	2	10	0.15314E-01	0.22E+00
BI-214	BETA-	609.31	0.4549E+00	0.89045E+00	57	1	0.30984E-01	0.16E+00
BI-212	BETA-	727.33	0.6651E-01	0.96440E+00	6	1	0.28352E-01	0.26E+00
CS-137	BETA-	661.66	0.8499E+00	0.10000E+01	0	0	0.29763E-01	0.22E+00
K-40	EC	1460.82	0.1066E+00	0.10000E+01	1	0	0.19823E-01	0.24E+00
PA-234M	BETA-	1001.03	0.8474E-02	0.10038E+01	3	1	0.24187E-01	0.21E+00
PB-212	BETA-	238.63	0.4360E+00	0.99995E+00	1	0	0.48842E-01	0.82E-01
PB-214	BETA-	242.00	0.7268E-01	0.99909E+00	2	0	0.48616E-01	0.18E+00
PB-214	BETA-	295.22	0.1841E+00	0.99991E+00	1	0	0.44765E-01	0.96E-01
PB-214	BETA-	351.93	0.3560E+00	0.99888E+00	1	0	0.41044E-01	0.18E+00
RA-226	ALPHA	186.21	0.3555E-01	0.10000E+01	0	0	0.51984E-01	0.71E-01
RA-224	ALPHA	240.99	0.4120E-01	0.99985E+00	1	0	0.48668E-01	0.15E+00
TH-234	BETA-	92.38	0.2180E-01	0.10000E+01	0	0	0.28611E-01	0.12E+00
TH-234	BETA-	92.80	0.2150E-01	0.10000E+01	0	0	0.28919E-01	0.12E+00
TL-208	BETA-	2614.51	0.9975E+00	0.85405E+00	13	0	0.13491E-01	0.31E+00
TL-208	BETA-	583.19	0.8500E+00	0.86963E+00	11	0	0.31634E-01	0.27E+00
U-235	ALPHA	143.77	0.1094E+00	0.99435E+00	5	0	0.49885E-01	0.12E+00
U-235	ALPHA	185.71	0.5700E+00	0.99444E+00	4	0	0.51909E-01	0.14E+00