LOW RADIOACTIVITY ANALYSIS

Status of samples:

	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

Samples analysed:

- PET_Cu Field Cage (glued)
- Kapton_Cu Field Cage
- PET_Cu Field Cage (no glued)
- Nylon-6

→ We only have the results of the field cages

Analysis steps:

- For each energy peak the activity was estimated using the formula

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

- If the radionuclide has two or more energy peak the activity was wstimated by means the weighted average

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

- The limit was estimated as $L = \overline{A} + 2\sigma_{\overline{A}}$

- Then, the activity per unit mass is determined by dividing the total activity by the mass of the sample

PET_Cu Field Cage (glued)			
Nuclides	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Ra-226	$5.59 \cdot 10^{-3}$	$6.60 \cdot 10^{-3}$	$18.80 \cdot 10^{-3}$
U-235	$18.60 \cdot 10^{-3}$	$7.77 \cdot 10^{-3}$	$34.10 \cdot 10^{-3}$
Pb-212	$26.50 \cdot 10^{-3}$	$9.89 \cdot 10^{-3}$	$46.20 \cdot 10^{-3}$
Pb-214	$7.56 \cdot 10^{-3}$	$9.82 \cdot 10^{-3}$	$27.20 \cdot 10^{-3}$
Ac-228	$3.70 \cdot 10^{-3}$	$13.70 \cdot 10^{-3}$	$31.10 \cdot 10^{-3}$
Tl-208	$27.10 \cdot 10^{-3}$	$10.40 \cdot 10^{-3}$	$48.00 \cdot 10^{-3}$
Cs-137	$5.11 \cdot 10^{-3}$	$3.54 \cdot 10^{-3}$	$12.20 \cdot 10^{-3}$
Bi-212	$33.60 \cdot 10^{-3}$	$29.20 \cdot 10^{-3}$	$92.10 \cdot 10^{-3}$
K-40	0.16	0.07	0.31
Bi-214	$3.97 \cdot 10^{-3}$	$8.91 \cdot 10^{-3}$	$21.80 \cdot 10^{-3}$

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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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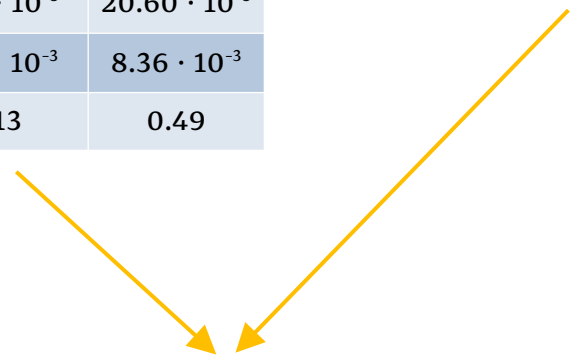
PET_Cu Field Cage (glued) – Testing different ROI			
Nuclide	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Th-234	0.12	0.21	0.54
Ra-226	$12.72 \cdot 10^{-3}$	$5.38 \cdot 10^{-3}$	$23.41 \cdot 10^{-3}$
Pb-214	$17.64 \cdot 10^{-3}$	$7.24 \cdot 10^{-3}$	$32.12 \cdot 10^{-3}$
Bi-214	$6.60 \cdot 10^{-3}$	$8.05 \cdot 10^{-3}$	$22.70 \cdot 10^{-3}$
Ac-228	$11.13 \cdot 10^{-3}$	$5.69 \cdot 10^{-3}$	$22.43 \cdot 10^{-3}$
Pb-212	$27.41 \cdot 10^{-3}$	$9.41 \cdot 10^{-3}$	$46.23 \cdot 10^{-3}$
Bi-212	$13.02 \cdot 10^{-3}$	$22.34 \cdot 10^{-3}$	$57.61 \cdot 10^{-3}$
Tl-208	$16.93 \cdot 10^{-3}$	$7.27 \cdot 10^{-3}$	$31.42 \cdot 10^{-3}$
U-235	$7.96 \cdot 10^{-3}$	$6.38 \cdot 10^{-3}$	$20.73 \cdot 10^{-3}$
Cs-137	$5.96 \cdot 10^{-3}$	$2.69 \cdot 10^{-3}$	$11.33 \cdot 10^{-3}$
K-40	0.13	0.06	0.25
Co-60	$4.61 \cdot 10^{-3}$	$2.67 \cdot 10^{-3}$	$9.94 \cdot 10^{-3}$

PET_Cu Field Cage (no glued) – Testing different ROI			
Nuclide	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Ra-226	$24.61 \cdot 10^{-3}$	$11.73 \cdot 10^{-3}$	$48.02 \cdot 10^{-3}$
Pb-214	$22.81 \cdot 10^{-3}$	$12.10 \cdot 10^{-3}$	$47.01 \cdot 10^{-3}$
Bi-214	$49.60 \cdot 10^{-3}$	$44.70 \cdot 10^{-3}$	0.14
Ac-228	$50.62 \cdot 10^{-3}$	$50.72 \cdot 10^{-3}$	0.15
Tl-208	$6.07 \cdot 10^{-3}$	$7.75 \cdot 10^{-3}$	$21.60 \cdot 10^{-3}$
U-235	$20.03 \cdot 10^{-3}$	$14.42 \cdot 10^{-3}$	$48.71 \cdot 10^{-3}$
Cs-134	$5.31 \cdot 10^{-3}$	$7.65 \cdot 10^{-3}$	$20.60 \cdot 10^{-3}$
Co-60	$3.97 \cdot 10^{-3}$	$2.19 \cdot 10^{-3}$	$8.36 \cdot 10^{-3}$
K-40	0.23	0.13	0.49

Kapton_Cu Field Cage – Testing different ROI			
Nuclide	Activity (Bq/kg)	Uncert. (Bq/kg)	Limit (Bq/kg)
Ra-226	$19.81 \cdot 10^{-3}$	$6.40 \cdot 10^{-3}$	$32.61 \cdot 10^{-3}$
Pb-214	$29.01 \cdot 10^{-3}$	$9.25 \cdot 10^{-3}$	$47.53 \cdot 10^{-3}$
Bi-214	$11.40 \cdot 10^{-3}$	$8.86 \cdot 10^{-3}$	$29.11 \cdot 10^{-3}$
Ac-228	$9.08 \cdot 10^{-3}$	$6.50 \cdot 10^{-3}$	$22.10 \cdot 10^{-3}$
Tl-208	$17.34 \cdot 10^{-3}$	$8.66 \cdot 10^{-3}$	$34.60 \cdot 10^{-3}$
U-235	$3.55 \cdot 10^{-3}$	$6.54 \cdot 10^{-3}$	$16.62 \cdot 10^{-3}$



we don't yet have the efficiency values, so we used the efficiency values of PET_Cu FC glued