Copper radioactivity

Cleaning Procedure

- The CUPID/COSINUS collaboration uses:
- Ultrasonic bath with 1% acid soap (Elma clean 60, or other soaps acidic.....) for at least 20 minutes.
- Washing with 10% HNO_3 and 1% H_2O_2 solution for 1 hour (takes off about 7/10 um). To shorten the time we can increase H_2O_2
- The use **nitric acid**, because citric acid needs the addition of a lot of H_2O_2 to make it work;
- Washing with 1% citric acid solution and 0.5% H_2O_2 for 15 seconds;
- Bath with demineralized water for 15 seconds.
- Washing under running (demineralized) water to remove the remaining traces of acid.
- Drying with clean room cloth
- Further drying with clean chamber cloth and nitrogen flow under laminar flow hood

Cleaning Procedure

- We asked to the Chemical service of LNGS to apply a new analysis to the Schreiber Copper

Sample list

- Cu piece CSN CARL SCHREIBER

Sample "Cu L"	Weight [g]	Sample treatment	Cu dissolved [g]	Note
Starting	14.10			
After Etching n 1	11.05	6 mL H_2O + 10 mL HNO_3	3.05	Waste
After Etching n 2	8.13	6 mL H_2O + 10 mL HNO_3	2.92	Measured
After Etching n 3	5.20	6 mL H_2O + 10 mL HNO_3	2.93	Measured
After Etching n 4	2.13	6 mL H_2O + 10 mL HNO_3	3.07	Spiked 100 ppt

Tab.1 Sample etching with HNO_3

Rinse and description

Cu sample was rinsed with 5% of acid soap "Decon" in ultra-sonic bath, nitric acid and citric acid, this procedure was performed by Roberto Cerroni together with samples cleaning for gamma-ray spectroscopy.

Copper analysis with ICPMS

- They used the described procedure to clean it and measured the U and Th content

	Etching 2	**Etching 3**
	[pg * g^{-1}]	[pg * g^{-1}]
Th	9 ± 3	7 ± 2
U	5 ± 2	2 ± 1

- These were the Matthias results

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radionuclide concentrations:

Th-232:
Ra-228:         < 0.38 mBq/kg           <==>    < 9.3 E-11 g/g
Th-228:         < 0.20 mBq/kg           <==>    < 4.9 E-11 g/g

U-238:
Ra-226          < 0.44 mBq/kg           <==>    < 3.5 E-11 g/g
Th-234          < 17 mBq/kg             <==>    < 9.3 E-10 g/g
Pa-234m         < 11 mBq/kg             <==>    < 6.5 E-10 g/g

U-235:          < 0.37 mBq/kg           <==>    < 6.5 E-10 g/g

K-40:           < 3.2 mBq/kg            <==>    < 1.0 E-7 g/g

Cs-137:         < 0.14 mBq/kg

Co-60:          < 0.12 mBq/kg           @ start of measurement: 07-OCT-2022

Co-58:          (0.8 +- 0.1) mBq/kg     @ start of measurement: 07-OCT-2022

Mn-54:          (0.12 +- 0.05) mBq/kg   @ start of measurement: 07-OCT-2022
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^{58}Co has an half life of 70 days

^{54}Mn has an half life of 1 year

- Upper limits on U and Th, 10 times larger than actual values

Cleaning Procedure

- These were the Matthias results for the Opera Copper

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Radionuclide concentrations:
Th-232 chain:
Ra-228:          < 73 microBq/kg <==> < 1.8 E-11 g/g
Th-228           < 64 microBq/kg <==> < 1.6 E-11 g/g
U-238 chain:
Ra-226           < 0.10 mBq/kg <==> < 8.4 E-12 g/g
Pa-234m          < 1.9 mBq/kg <==> < 5.7 E-10 g/g
U-235            < 0.51 mBq/kg <==> < 9.0 E-10 g/g
K-40             (0.4 +- 0.2) mBq/kg <==> (1.4 +- 0.7) E-8 g/g
Cs-137           < 28 microBq/kg
Co-60            (31 +- 13) microBq/kg
Ag-108m          (0.25 +- 0.03) mBq/kg
Bi-207           (0.61 +- 0.06) mBq/kg
Pb-210           (7 +- 2) Bq/kg
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- Quite large values, in particular for ^{40}K and ^{210}Pb

- These were the Matthias results

```
radionuclide concentrations:

Th-232:
Ra-228:          < 0.38 mBq/kg          <==>    < 9.3 E-11 g/g
Th-228:          < 0.20 mBq/kg          <==>    < 4.9 E-11 g/g

U-238:
Ra-226           < 0.44 mBq/kg          <==>    < 3.5 E-11 g/g
Th-234           < 17 mBq/kg            <==>    < 9.3 E-10 g/g
Pa-234m          < 11 mBq/kg            <==>    < 6.5 E-10 g/g

U-235:           < 0.37 mBq/kg          <==>    < 6.5 E-10 g/g

K-40:            < 3.2 mBq/kg           <==>    < 1.0 E-7 g/g

Cs-137:          < 0.14 mBq/kg

Co-60:           < 0.12 mBq/kg          @ start of measurement: 07-OCT-2022

Co-58:           (0.8 +- 0.1) mBq/kg    @ start of measurement: 07-OCT-2022

Mn-54:           (0.12 +- 0.05) mBq/kg  @ start of measurement: 07-OCT-2022
```

- Upper limits on U and Th, 10 times larger than actual values

Copper Cathode

- Upper limits on U and Th, 10 times larger than actual values

CYGNO-04 preliminary

	CYGNO-04			
Summary Table	**NR/yr 1-20 keV**	**ER/yr 1-20 keV**	**Reference**	**Comment**
GEM (TREX)	1.10E+03	9.27E+04	T-REX GEM	scaled from CYGNO-1m3
AcrylicBox (SNO)		1.37E+04	SNO acrylic	CYGNO-04 sim
CameraBody		5.19E+04	Laubenstein@LNGS	scaled from CYGNO-1m3
CameraLens		9.35E+04	Laubenstein@LNGS	scaled from CYGNO-1m3
Cathode (Cu)	3.75E+03	3.34E+05	Schrieber Cu (2.5 mm)	scaled from CYGNO-1m3
Field Cage (Flex)	2.56E+02	2.65E+04	Cu+PET	scaled from CYGNO-1m3
Cu Shielding		7.57E+04	4 cm Schrieber + 6 cm OPERA Cu	CYGNO-04 sim
Total (internal)	**1.49E+03**	**3.23E+05**		
External Gamma		1.00E+04	SABRE gamma flux @LNGS	
External Neutrons	7.50E+00	3.41E+00	CUORE n flux @LNGS	
Total (external)	**7.50E+00**	**1.00E+04**		
Tot	**5.11E+03**	**6.22E+05**		

https://docs.google.com/spreadsheets/d/1SKkd1C-zJoFzb0ZRkG0D9_vNOr5A9S34slWkOKHQgxg/edit?usp=sharing

- By using the new values, a copper cathode would produce:
  - Total Rate in [1, 20] keV from all detectors: 11563 ± 302 events per year
  - Total Rate for NR events within the energy interval [1, 20] keV from all detectors: 46 ± 17 events per year

Optical windows

- PMMA seems to have mechanical and radio purity good performance;
- Optical performance quite good except for a possible reflection;
- I’d use it as a default solution