TG11 overview

W. Hampel (MPIK Heidelberg) for Task Group 11

Material screening measurements for GERDA

GeMPI measurement of a PEN sample
γ ray screening on a stainless steel sample at Baksan
γ ray screening on stainless steel samples for the cryostat
ICPMS measurements on stainless steel samples → V. Kornoukhov
Intercomparison exercise for Monte Carlo Codes

New low level instruments for GERDA and beyond

Status of the Radon monitor for GERDA
A new Ge spectromenter for γ ray screening at MPIK → W. Maneschg
A new cryogenic detector for Radon → G.Zusel
Ultra low-level γ spectrometry with depleted Ge detectors → S. Belogurov

Thanks to all TG11 members for their contributions, especially to Matthias Laubenstein for the GeMPI measurements !

Table 4 from the report on ICPMS measurements on various samples at LNGS

by Stefano Nisi and Assunta diVacri

SAMPLE	^{40}K	^{210}Pb	^{232}Th	^{238}U
	[mBq/kg]	[µBq/kg]	[mBq/kg]	[mBq/kg]
1	< 12	4.4 ± 0.5	< 0.07	< 0.2
2	14.6 ± 3.3	9.0 ± 0.9	2.1 ± 0.2	46.1 ± 0.5
3	97 ± 5	3.7 ± 0.1	$0.03^{+0.17}_{-0.02}$	$1.66^{+0.04}_{-0.02}$
4	65^{+5}_{-2}	6.9 ± 0.2	$0.66^{+0.17}_{-0.04}$	$9.4^{+0.8}_{-0.6}$
5	$49.9^{+2.9}_{-0.6}$	2.5 ± 0.1	< 0.6	< 1.8
6	$2.6^{+15.2}_{-0.1}$	2.98 ± 0.07	$0.51^{+0.21}_{-0.06}$	$7.5^{+6.4}_{-0.2}$
7	39^{+35}_{-5}	12.6 ± 0.5	< 1.4	< 3.6
8	60^{+35}_{-2}	15.6 ± 0.5	$1.8^{+0.2}_{-0.3}$	47 ± 2
9	135 ± 4	49 ± 1	0.50 ± 0.02	1.43 ± 0.09
10	86 ± 5	142 ± 3	7.2 ± 0.3	23.6 ± 0.9
11	63 ± 1	27 ± 1	1.11 ± 0.05	1.48 ± 0.05

Sample 1: Pure PEN = Polyethylen Naphthalate

(washed by ultrasonic bath adding 1% Detergent 8 from Alconox)

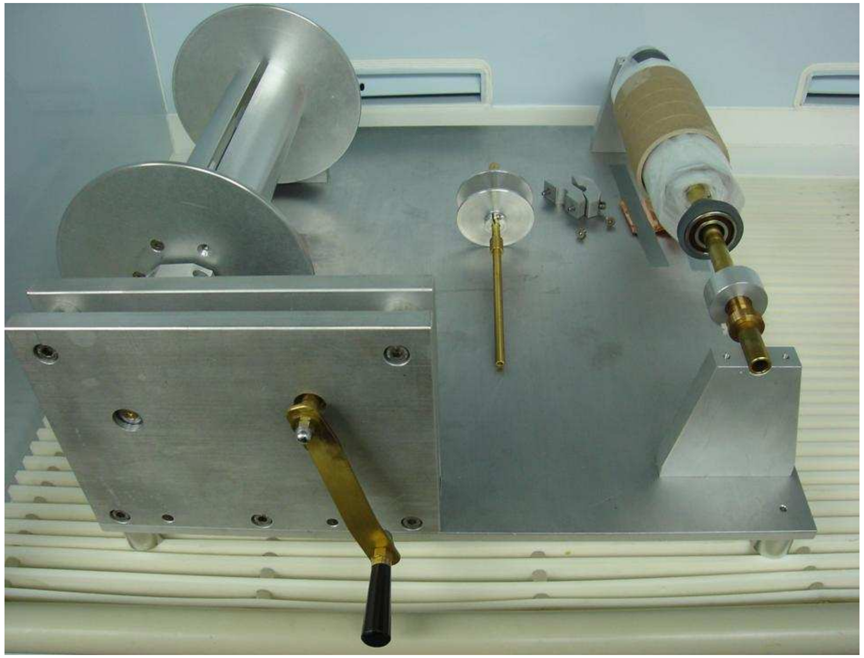
→ compatible with the required radiopurity for the cable material

GeMPI measurement of 4.35 kg PEN

Same company (GTS Flexible Materials)

	^{232}Th	^{238}U	^{40}K
	Activity [mBq/kg]		
ICPMS	< 0.07	< 0.2	< 12
GeMPI		< 590	640 ± 50
^{228}Ra	150 ± 10		
^{228}Th	150 ± 10		
^{235}U		< 590	
^{226}Ra		290 ± 10	

Th and U results: could in principle be explained by an extremely large deviation from radioactive equilibrium. However: K results indicate surface contamination !



Sample treatment before the measurement with GeMPI:

Sample unrolled from 3 original rolls by means of the above apparatus and put to a single roll with inner diameter suited to fit over the GeMPI crystal cap. The whole operation took place in a clean bench. However, there has no special cleaning procedure been applied !

→ Need ICPMS measurements of PEN samples from these 4.35 kg !

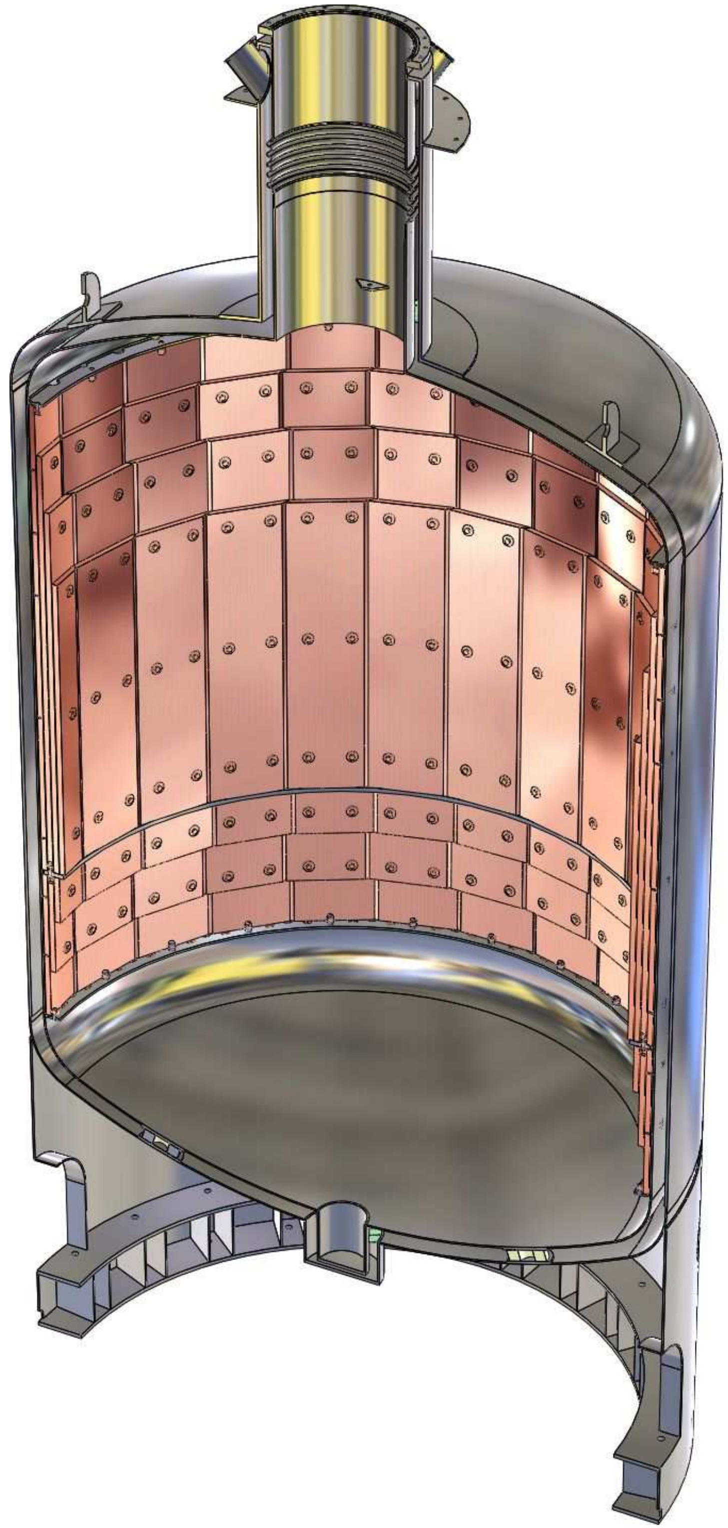
Stainless steel for the GERDA cryostat (~30t)

From the report of Bernhard Schwingenheuer (GSTR-06-011) the limits required for the current design with a double wall steel container, inner Cu shielding and argon as cryogenic liquid and for a background index of 10^{-4} have been estimated:

Cylindric parts:	< 5 mBq/kg ^{228}Th
Top and bottom parts:	< 10 mBq/kg ^{228}Th

Contribution of Igor Barabanov on Monday:

	^{228}Th	Cu amount	Bkg index
Cylindric part	1 mBq/kg	none	$2.2 \cdot 10^{-4}$
Top + bottom part	1 mBq/kg		$0.051 \cdot 10^{-4}$
Total (with Cu)	10 mBq/kg	41 t	$0.74 \cdot 10^{-4}$
	3 mBq/kg	23 t	$0.84 \cdot 10^{-4}$
	1 mBq/kg	8.4 t	$1.17 \cdot 10^{-4}$



Results of radiopurity measurements of a stainless steel sample (SS 1.4300) from Cryogenmash at Baksan Neutrino Observatory

A. Klimenko[1,2], A. Smolnikov[1,2], S. Vasiliev[1,2]

L.Bezrukov[2], A.Gangapshev[2], V. Kazalov[2], V.Kornoukhov[2,3], V.Kuzminov[2]

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2 – Institute for Nuclear Research, Moscow

3 – Institute of Theoretical and Experimental Physics, Moscow

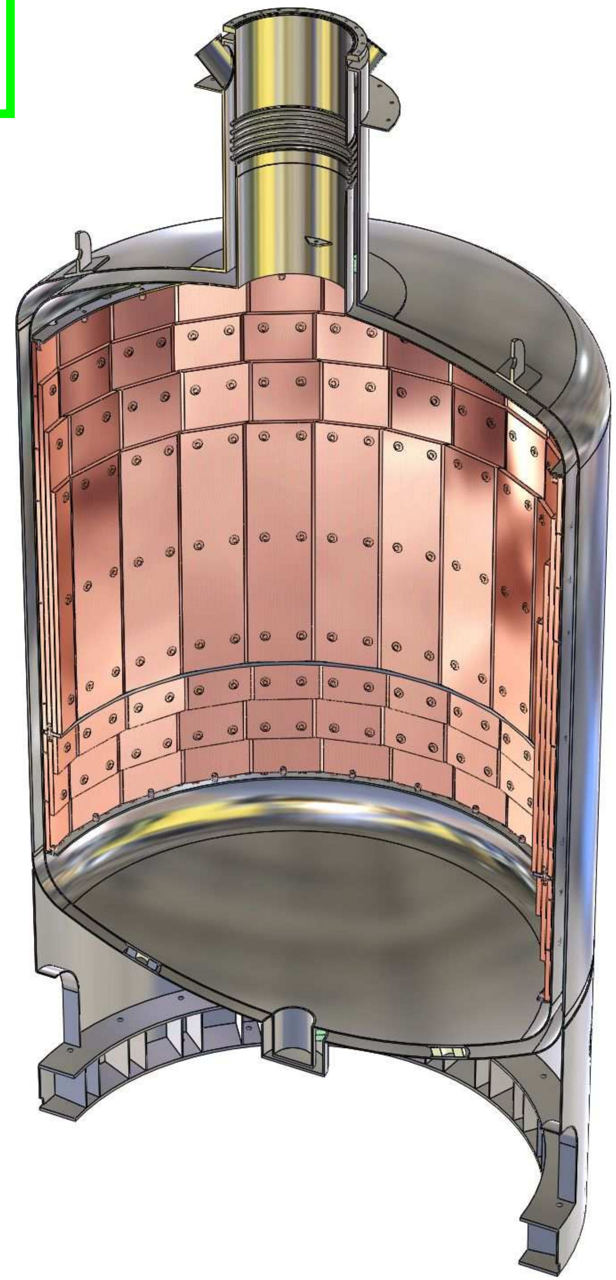
M=2.83 kg t= 8.76 d	^{57}Co	^{60}Co	^{40}K	^{226}Ra	^{228}Th
mBq/kg, 90 % CL	**21.2 ± 5.6**	**13.3 ± 2.5**	**≤ 17.0**	**≤ 6.0**	**≤ 3.3**

Stainless steel from different charges ordered for the cryostat (total 28.7 t)

Samples for top and bottom parts: measured with Dario (D) at MPIK

Samples for cylindric parts: measured with GeMPI (G) at LNGS

Charge #	Supplier	Weight	Used for	Detector/sample #
5991	Industeel	2 x 1.9 t	outer bottom	Dario (D1)
494257	Ilsenburg	2 x 1.1	inner top	Dario (D2)
493553	Ilsenburg	2 x 1.15 t	outer bottom	Dario (D3)
493554	Ilsenburg	1.4 t	inner bottom	Dario (D4)
492217	Ilsenburg	1.4 t	inner bottom	Dario (D5)
495243	Ilsenburg	2.4 t	outer cylinder	GeMPI (G1)
494257	Ilsenburg	3.2 t	outer cylinder	GeMPI (G2)
506015	Ugine	5.0 t 2.5 t	inner cylinder skirt	GeMPI (G3)
255455	Arconi	2.6 t	outer cylinder	GeMPI (G4)
254533	Arconi	1.9 t	outer cylinder	GeMPI (G5)



Samples D2 and G2: from the same charge (494257) !

γ ray screening results of stainless steel samples obtained with Dario and GeMPI

Sample #	Weight [kg]	Counting Time [d]	Specific activity [mBq/kg]							
			^{228}Ra	^{228}Th	^{238}U [a]	^{238}U [b]	^{226}Ra	^{40}K	^{60}Co	^{137}Cs
D 1	54.0	2.939	< 2.9	5.1 ± 1.0			2.9 ± 1.0	< 3.9	6.5±0.5	
D 2	61.3	3.968	< 3.4	< 1.9			< 2.0	< 4.5	14.2±0.6	
D 3	57.3	6.716	< 3.3	1.1±0.4			< 0.84	< 3.3	15.1±0.5	
D 4	39.96	1.462	< 4.5	< 2.6			< 2.2	< 6.2	14.4±1.0	
D 5	40.6	4.221	< 2.6	< 1.1			< 1.2	< 2.8	11.6±0.5	
G 1	54.75	3.194	< 2.6	< 0.20	< 94	< 57	< 1.3	< 2.8	45.5±2.1	0.77 ±0.43
G 2	54.74	19.590	< 0.86	< 0.11	< 12	< 14	< 0.24	< 0.93	14.0±0.1	< 0.16
G 3	74.55	3.106	< 1.0	< 0.41	< 45	< 33	< 0.74	< 1.1	13.8±0.7	< 0.26
G 4	52.86	3.698	< 3.0	5.1±0.5	< 41	< 42	< 1.3	< 1.7	20±1	< 0.36
G 5	53.15	9.598	1.0±0.5	1.5±0.2	54±16	54±33	1.0±0.6	< 0.81	18.3±0.7	< 0.10

[a] **determined from ^{234m}Pa** [b] **determined from ^{235}U**

- Samples from all 9 different charges fulfill the requirement except G4 from charge #255455 (2.6 t to be used for outer cylindric part) → will be replaced by another charge
- Most samples have measured values or upper limits close to or even much lower than 1 mBq/kg ^{228}Th → consequences for the amout of Cu needed
- Sample G5 gives the first clear evidence for equilibrium breaking in the U/Ra chain in a steel sample: ^{226}Ra is depleted by a factor of ~50 against ^{238}U !

Gerd Heusser: Some comments on the measurements of steel for GERDA
Internal GERDA report, November 9, 2006

U/Th

values measured here are (fortunately) lower than stainless steel samples measured earlier for BOREXINO:
^{226}Ra 5-17 mBq/kg, ^{228}Th 5-11 mBq/kg
Systematic studies of steel production: only ~1% of the original U and Th contamination remains in the melt

^{60}Co

is originating from blast furnace shell in steel production;
continously redistributed by scrap recycling, goes mainly into the melt
GERDA steel samples: rather high values (6.5 to 45 mBq/kg)
impact on GERDA background at energies below ~ 1 MeV has to be determined by MC simulations (impact on the amount of Cu needed)

^{7}Be

in steel samples has in principle two components
(a) production by direct spallation reactions on Fe
(b) production by spallation reactions on N and O in the atmosphere;
ash of dust collected from the atmosphere has on the average 400 kBq/kg;
in blast processes contamination scenarios are possible
100mg ash in 1 ton stainless steel results in 40 mBq/kg

Question: are the measured samples (~ 50kg) representative for the whole charge (several tons) ?

- Can in principle only be answered by measuring more than just one sample from the same charge
- Can ICPMS measurements help ? (see contribution by V. Kornoukhov)

Realized only after the measurements that samples Dario #2 (inner vessel head) and GeMPI #2 (outer cylindric part) originate from the same charge (#494257)

Detector	Sample mass [kg]	Counting time [d]	Specific activity [mBq/kg]					
			^{228}Th	^{228}Ra	^{226}Ra	^{40}K	^{60}Co	^{7}Be
GeMPI	54.74	19.590	< 0.11	< 0.86	< 0.24	< 0.93	14.0 ± 0.1	< 3.0
Dario	61.3	3.968	< 1.9	< 3.4	< 2.0	< 4.5	14.2 ± 0.6	34.6 ± 5.3

^{60}Co: very good agreement

^{7}Be: must be surface contamination (or a hot spot)

Cosmogenic radionuclides in stainless steel samples measured with GeMPI

Main production channels: (n,p2n) and (μ^-, ν2n) on Ni, Fe and Cr isotopes

^{7}Be: produced by spallation in the atmosphere

Radioisotope			^{56}Co	^{48}V	^{46}Sc	^7Be
Halflife [d]			77,3	16,0	83,8	53,3
Sample	Charge	Mass [kg]	Specific activity [mBq/kg]			
#1	495243	54,75	< 0,32	0,30 ± 0,11	< 0,35	< 3,9
#2	494257	54,74	0,17 ± 0,06	0,36 ± 0,07	0,24 ± 0,06	< 3,0
#3	T506095	57,60	< 0,62	0,27 ± 0,11	< 0,54	< 5,7
#4	255455	52,86	< 0,71	0,31 ± 0,13	< 0,67	9,6 ± 2,9
#5	254533	53,15	0,28 ± 0,10	0,22 ± 0,09	0,47 ± 0,14	4,8 ± 1,7

→ Measured activities compatible with a sea level exposure for periods of a few weeks to several months

Monte Carlo Code Intercomparison Exercise

- conducted in summer 2006 by the Gamma-Ray Spectrometry Working Group of the International Committee for Radionuclide Metrology (I.C.R.M.)
- comparison of different Monte Carlo codes in order to assess the intrinsic uncertainties due to the different approaches to particle tracking and the nuclear and material data used in the simulation
- the exercise did not involve any reference to experimental data
- participants submitted full energy peak and total detection efficiencies for a precisely defined and very schematic model of a HPGe detector and a sample

Preliminary results

- comparison between participants using similar simulation codes (reference value is the mean result for the given code)
- for GEANT discrepancies are ± 13% (energy dependent)
- largest differences occured in results for low energy gammas (45 and 60 keV) and for high energy gammas (3 MeV)
- smallest differences resulted between participants using the Penelope code (less than 2% in most cases)

Workshop in Paris on November 27 and 28

More information → Dusan Budjas

Radon monitor for GERDA

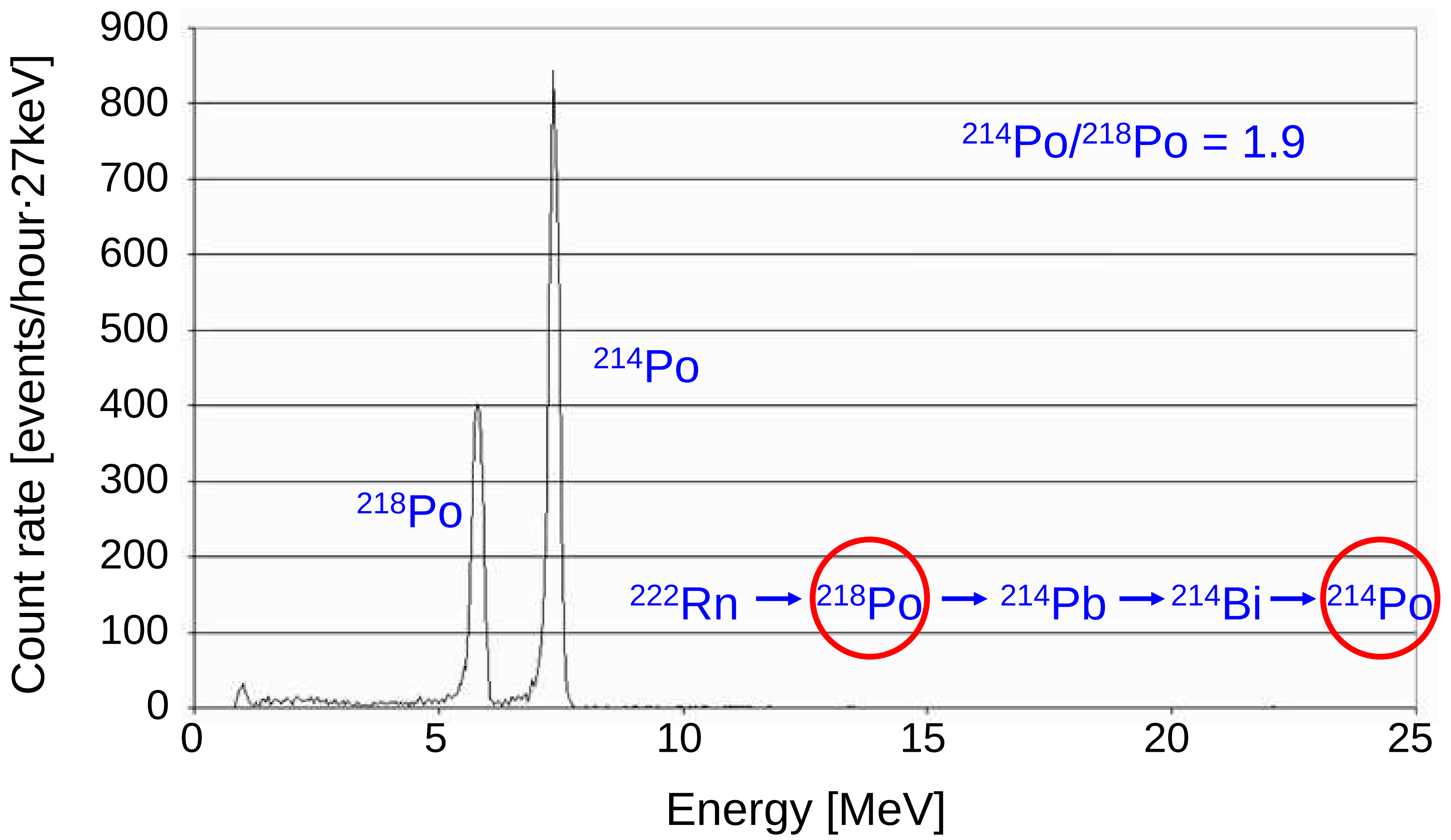
Stainless steel vessel, inner surface electropolished, volume 710 l, HV up to 50 kV

Present status

- Gas inlet system is ready: Manifold with five inlet valves in order to monitor Rn at five different locations
- Detector is working and delivers α spectra, however there are still problems with discharges due to the high field strength at the edges of the nearly quadratic pin diode. Attempts to solve these problems are under way
- Purification and calibration of the detector has to be done after the HV problems have been solved

W. Hampel (MPIK HD) for TG11
GERDA Collaboration Meeting
Milano, Nov. 13-15, 2006

Laboratory air - HV at 50 kV - Cu tube around α detector at 2 kV



More details → Jürgen Kiko