Study of the possibility of using 3D printing in low-background experiments

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This study was supported within the State contract of the Ministry of Science and Higher Education of the Russian Federation no. FZZR-2022-0004

Baksan Neutrino Observatory
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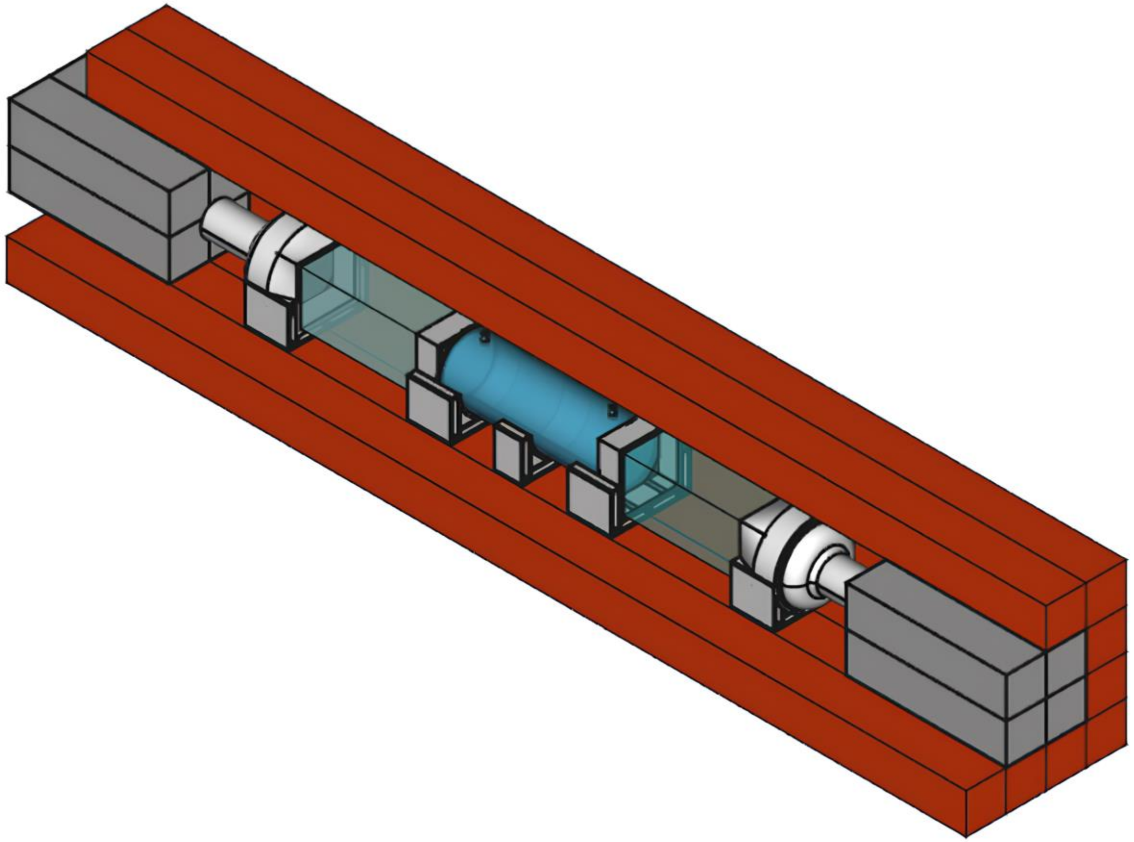
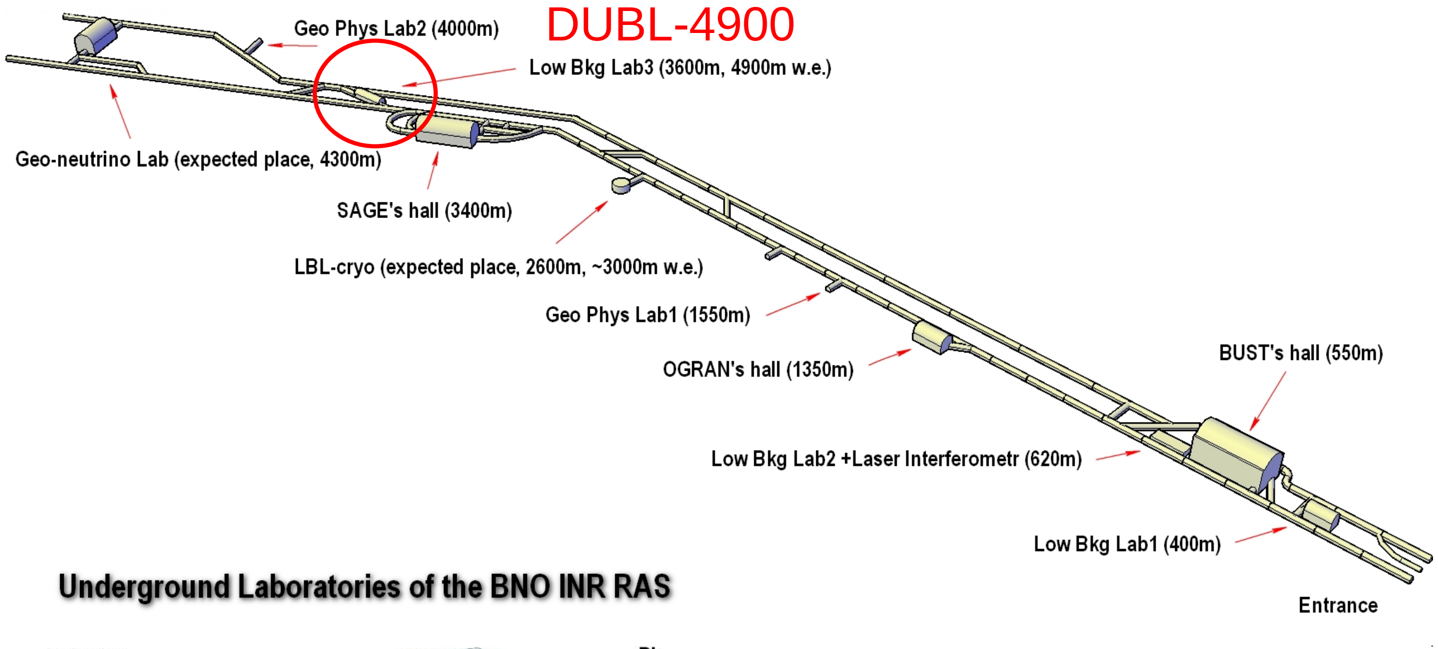
7th International Conference on Particle Physics and Astrophysics, Moscow, MEPhI, 2024

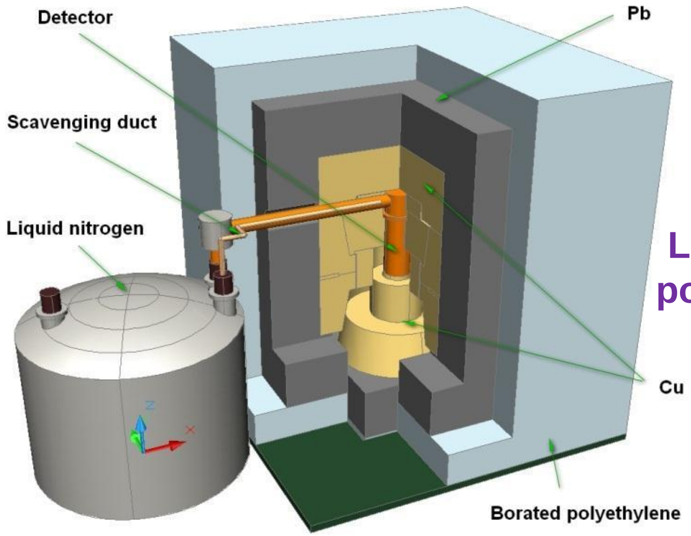
New Projects

As a prototype for a large-scale detector, we are creating a detector within the framework of the "Newmethods for investigating neutrinoless double beta decay" project (**FZZR-2022-0004**). The aim of this project is to create a new scintillation detector to search for neutrinoless double beta decay in ^{150}Nd, ^{96,94}Zr, ^{176}Yb.



Low background gamma spectrometer SNEG





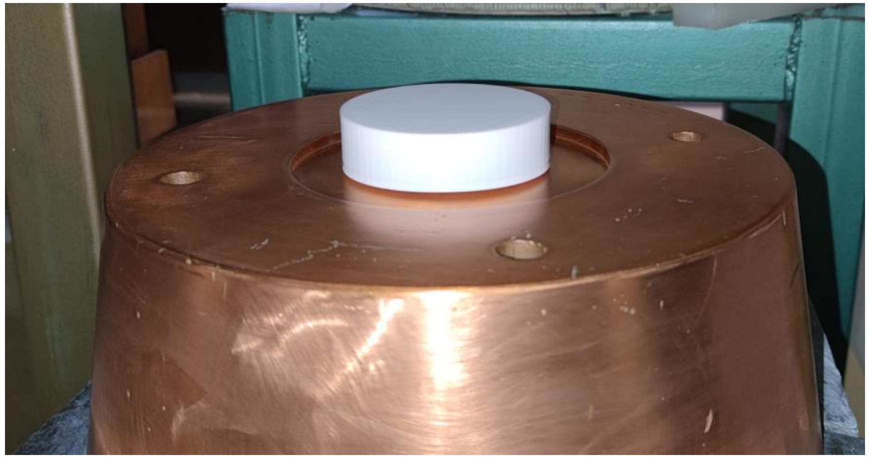
Low-background shield is consists of: 80 mm of borated polyethylene, 1 mm of cadmium (Cd), 150 mm of lead (Pb) and 180 mm of copper (Cu)

Characteristics of HPGe detector “SNEG”

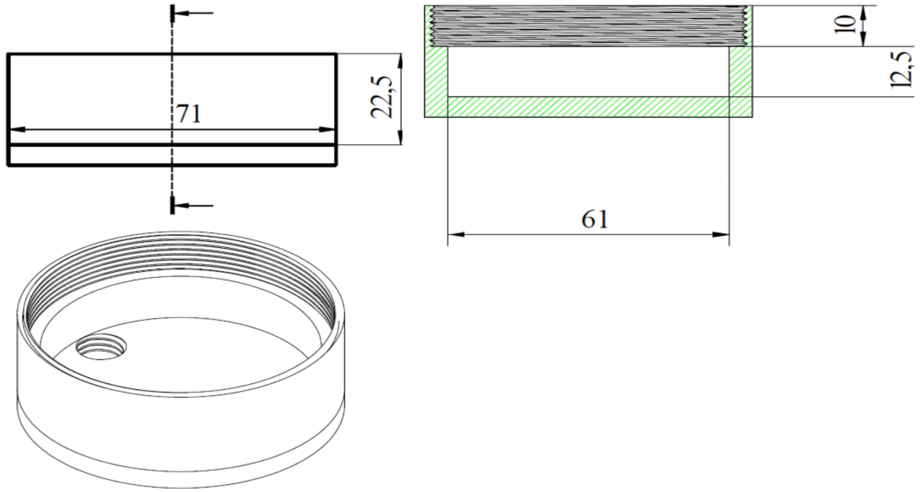
Detector	Ge-Nat
Type of crystal	Coaxial
Type of semiconductor	P-type
Mass, g	1056
External diameter, mm	64
Height, mm	67
The thickness of the dead layer, mm	≈1
The effective mass, g	952
The wall thickness of the cryostat, mm	1
The ratio Peak / Compton (1332 keV)	54.8
The energy resolution, keV (1332 keV) at technical passport	2.32

Material selection

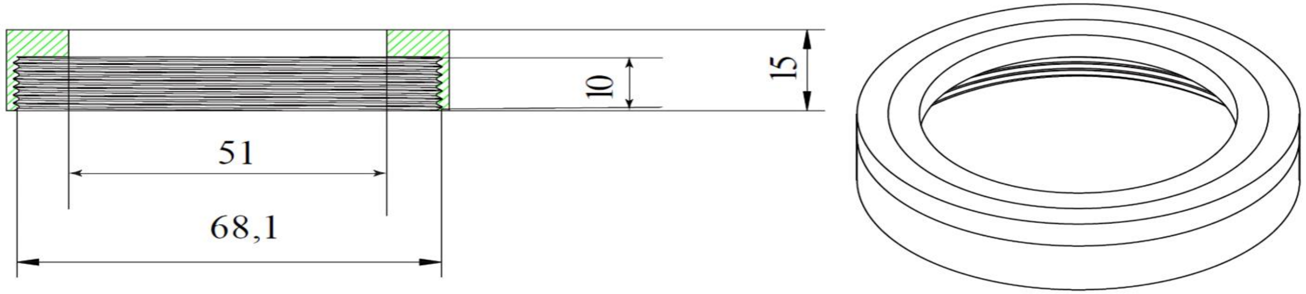
Sample		Isotopes			
		^{226}Ra (^{214}Bi)	^{228}Ac	^{40}K	^{208}Tl
		Activity of radioactive isotopes (mBq/kg)			
1	White plastic (PET-G)	14.2 ± 3.2	15 ± 5	62 ± 20	7 ± 1.5
2	Semi-transparent plastic (PETG)	5.5 ± 2.6	≤ 2.4	110±30	≤ 1.49
3	Quartz	230±10	48.5±8.8	96.7±11.6	8.82±3.11
4	PEEK 343х 6Б	10.9 ± 6.5	23 ± 11	950 ± 100	≤ 12.2
5	Polyphenylene sulfone (294 A (20%) + 295 (80%) +0,4% Taunit-M)	65.41 ± 1.9	≤ 50	2000 ± 200	≤ 24.3
6	Polyethylene terephthalate	≤ 17.5	≤ 10.5	≤ 50	≤ 9
7	Polycarbonate	≤ 17.5	≤ 10.5	≤ 50	≤ 9
8	SLA (photopolymer resin)	≤ 40	≤ 50	≤ 300	≤ 50
9	PPSU Radel	33 ± 12	≤ 26.1	900 ± 200	12.9 ± 6.2



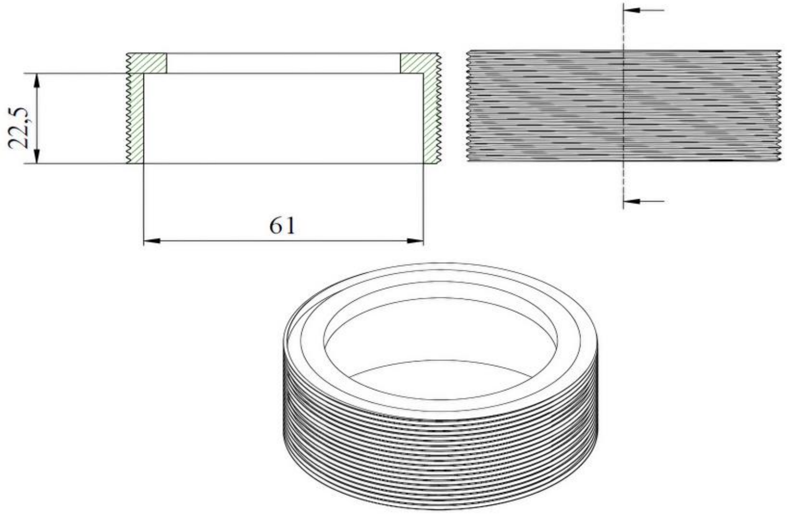
A test iteration of using 3D printing to create a prototype cell



Schematic representation of the base of the scintillation cell

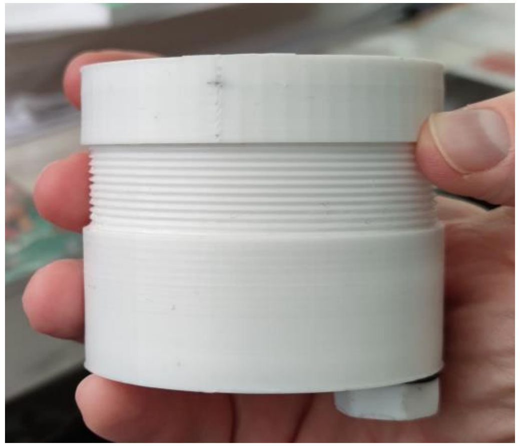


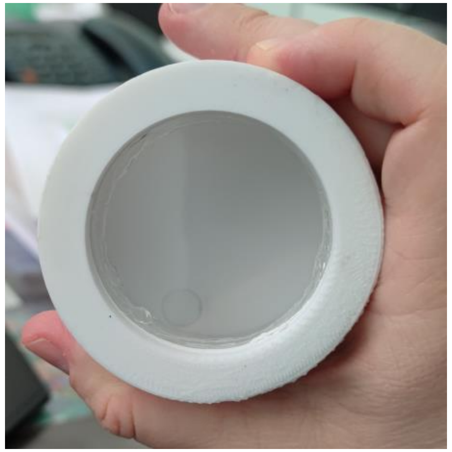
Cover of the scintillation cell, pressing the optical



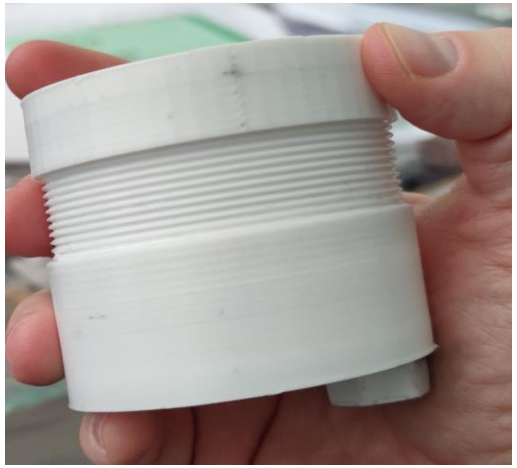
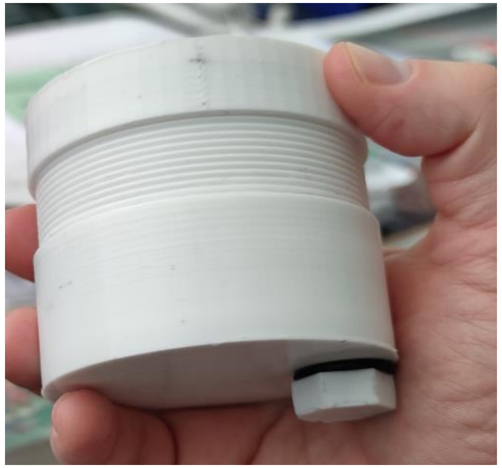
The central part of the scintillation cell

A test iteration of using 3D printing to create a prototype cell



Cell volume :
~ 73 cm^3

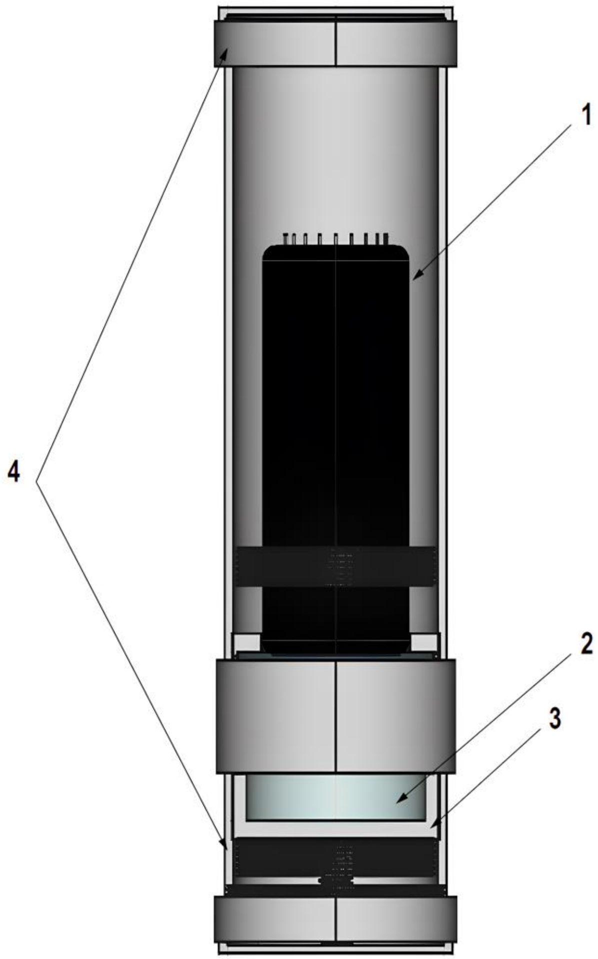




Filled with a scintillator based on:

LAB (Kirishi) PPO 2 g/l
BIS MSB 0.02 g/l

3D model of the cell prototype

The cell filled with scintillator is optically connected to the PMT-97 and placed in an aluminum light-protective housing.



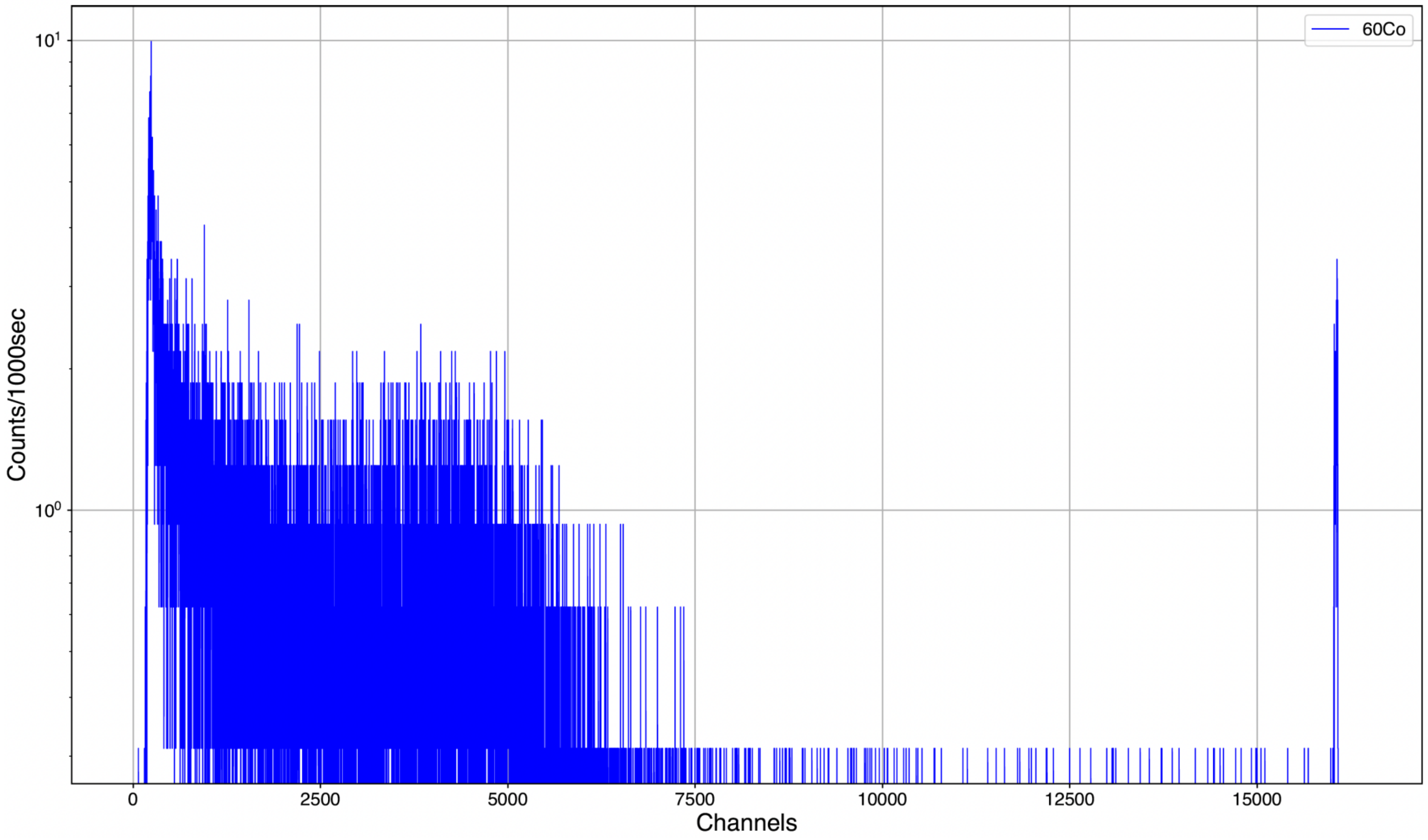
Dimensions of the case :
Height 254 mm
Diameter 73 mm

Assembled experimental stand. Partial cut.

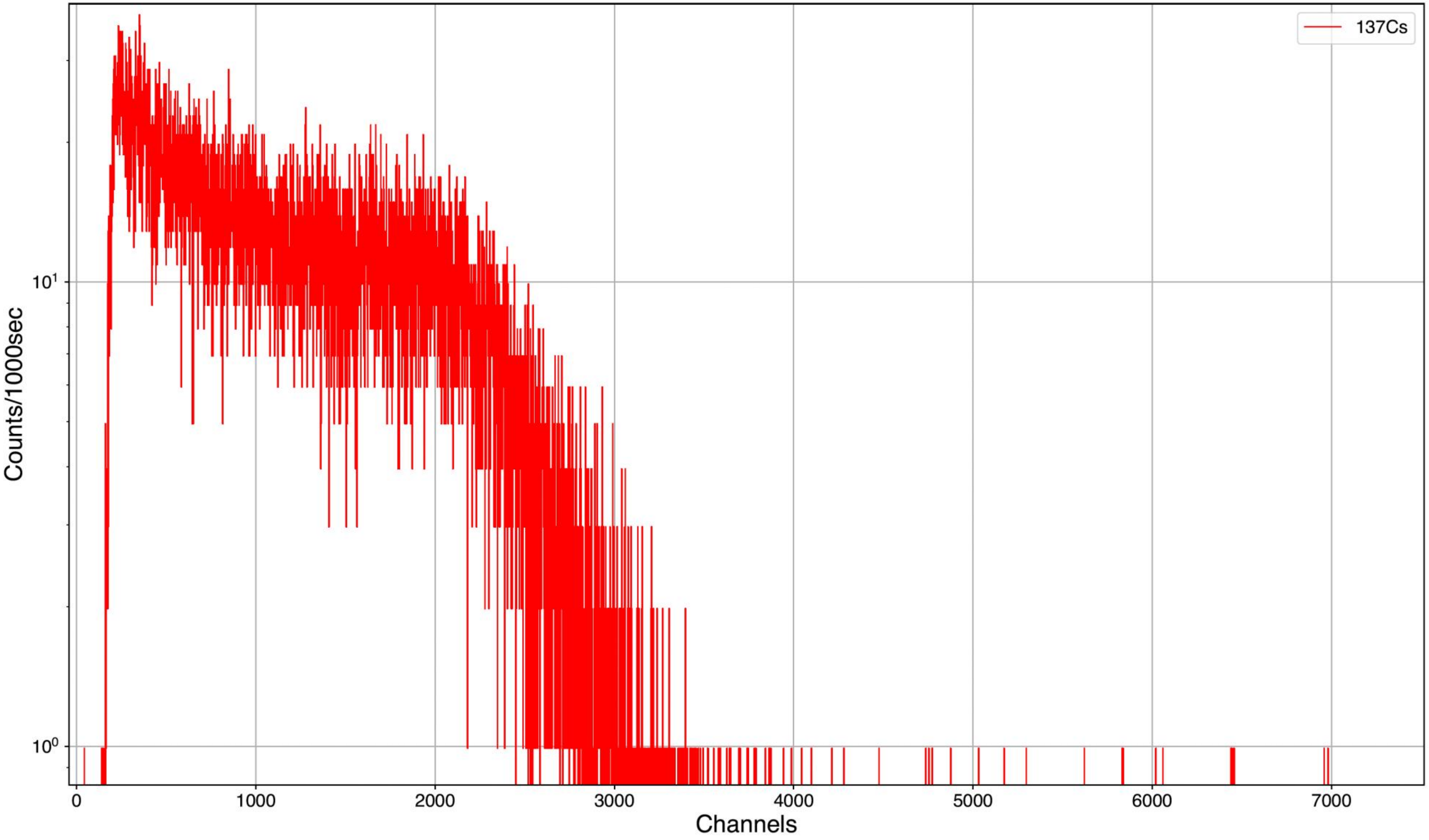
1 – PMT-97
2 – Scintillator
3 – cell made from PETG plastic
4 – light-proof housing

Stand for measurements

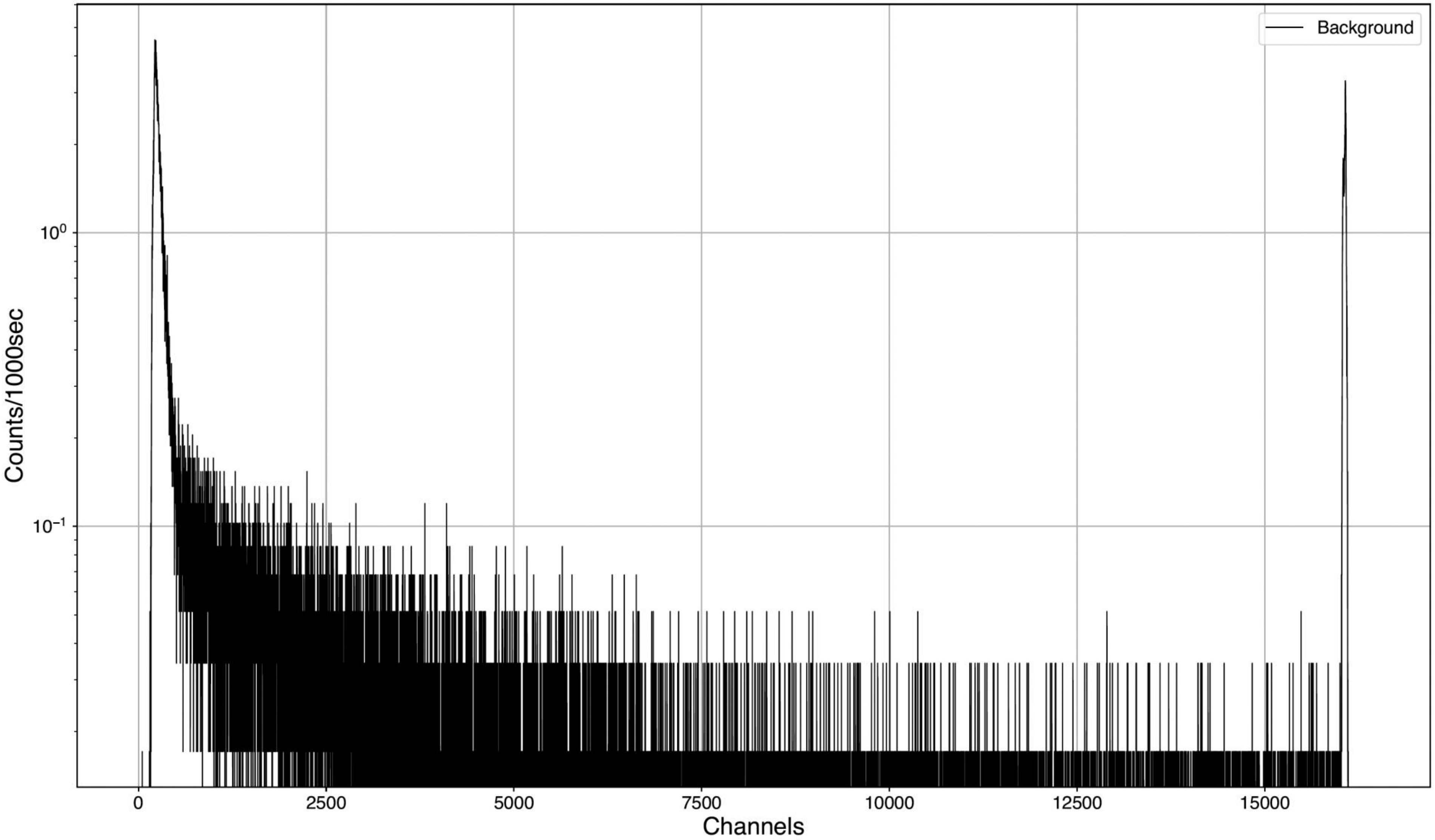
Калибровочный источник ^{60}Co



Калибровочный источник ^{137}Cs



Спектр фона


Background
Counts/1000sec
10^0
10^{-1}
0
2500
5000
7500
10000
12500
15000
Channels

Conclusion

- We obtained a good scintillation response of the detector to radioactive sources
- There are still questions about the reflection coefficient of the material used. Verification measurements are required.
- The next stage is planned to manufacture a detector with a working volume of 3 l, which will be viewed by two photomultipliers on both sides of the case. A scintillator loaded with metal (Nd, Zr, Gd) is planned to be used as a scintillator.
- The possibility of printing a complex-shaped case (for example, a sphere) is being considered.
- 3D printing of optical windows. The question of the possibility of transparent 3D printing

Thank you for your attention!