Estimation of the background due to neutrons in the LArGe set-up.

A. Bakalyarov, V. Lebedev, S Zhukov
RRC “Kurchatov Institute”.

The aim of the work is to estimate the background index in the existing Ge-detectors, situated in the LArGe set-up induced by isotropic neutron flux.

We took into account, that neutrons occurred both due to natural radioactivity of surrounding rocks and induced by cosmic muons.

It was important to give a quantitative assessments of most dangerous radionuclides produced by neutrons in Ge-76 and give the estimation of neutron shield efficiency.

Calculations was carried out with GCALOR simulation package
http://www.staff.uni-mainz.de/zeitnitz/Gcalor/gcalor.html

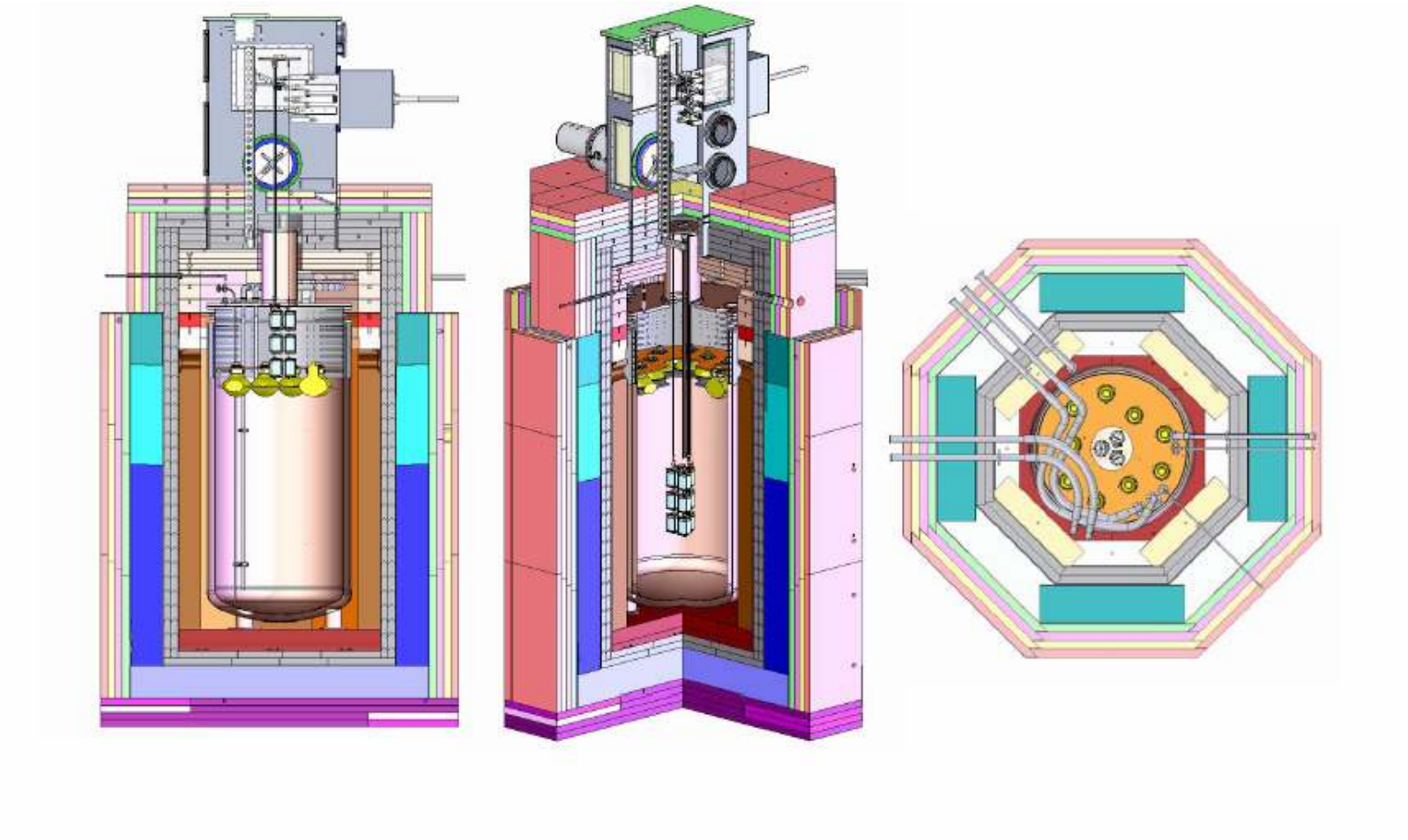
Assumptions:
Isotropic neutron source.
Argon is transparence.

Three regimes of registration:
1) all detectors works independently;
2) Ge-detectors are in anticoincidecies;
3) Ge-detectors are in anticoincidecies and in anticoicidecies with scintillations in argon.

100 mln. events was played for each regime and for each configuration of shield.

The geometry was most close to real one (fig. 1).

fig.1 The geometry of LArGe.



Modeling of background due to neutrons from natural radioactivity

Neutron flux measured and calculated in HallA at the LNGS was taken from works:

P. Belli et al., Deep Underground Neutron Flux Measurement with Large BF3 Counters, Il Nuovo Cimento 101A, N. 6, 959–966, 1989]

and spectrum calculated in H. Wulandari, J. Jochum, W. Rau, F. von Feilitzsch, Neutron Flux at the Gran Sasso Underground Laboratory Revisited, hep-ex/0312050, 2004

Five calculations was carried out for different variants of shield. The background index and quantity of Ge-77 produced in Ge-76 detectors was obtained. The results are presented in table1 and 2.

Table2. Background index in energy region of 2000-2100 keV for different variants of shield (counts/keV·kg·year) . The background induced by neutrons from natural radioactivity.

	All shields	Without borated polyethylene (b/p)	Without b/p and steel	Without b/p steel and lead	No outer shield
Sum spectrum of all Ge-detectors	0	**0.00177**	**0.00258**	**0.00186**	**0.0138**
Ge-detectors are in anticoincidence	0	**0.00118**	**0.00129**	**0.00124**	**0.00965**
Ge-detectors and scintillations in argon are in anticoincidence	0	0	0	0	0

Table 3. Quantity of Ge-77 (1/year) produced in Ge-detectors by neutrons from natural radioactivity and for different variants of outer shield.

All shields	Without borated polyethylene (b/p)	Without b/p and steel	Without b/p steel and lead	No outer shield
0	26.5	56.8	68	295

Modeling of background due to muon induced neutrons

Cosmic muon induced neutron spectra entering Hall A at the LNGS calculated in works:

A. Dementyev, V. Gurentsov, O. Ryazhskaya, N. Sobolevsky,Production and transport of hadrons generated in nuclear cascades initiated by muons in the rock (Exclusive Approach), Nucl. Phys. B (Proc. Suppl.) 70, 486–488, 1999] (solid line)

and H. Wulandari, J. Jochum, W. Rau, F. von Feilitzsch, Neutron Background Studies for the CRESST Dark Matter Experiment, hep-ex/0401032, 2004

The energy spectrum divided into twelve energy intervals (from 0 to 1GeV)
The background index and velocity of production of dangerous isotopes in Ge-detectors was calculated.
Convolution of the results of calculations with the muon induced spectrum in Hall A was done.
The results are in table 3 and 4.

Table 3. Background index in energy region of 2000-2100 keV for different variants of shield (counts/keV·kg·year) . The background stipulated by neutrons from cosmic muons.

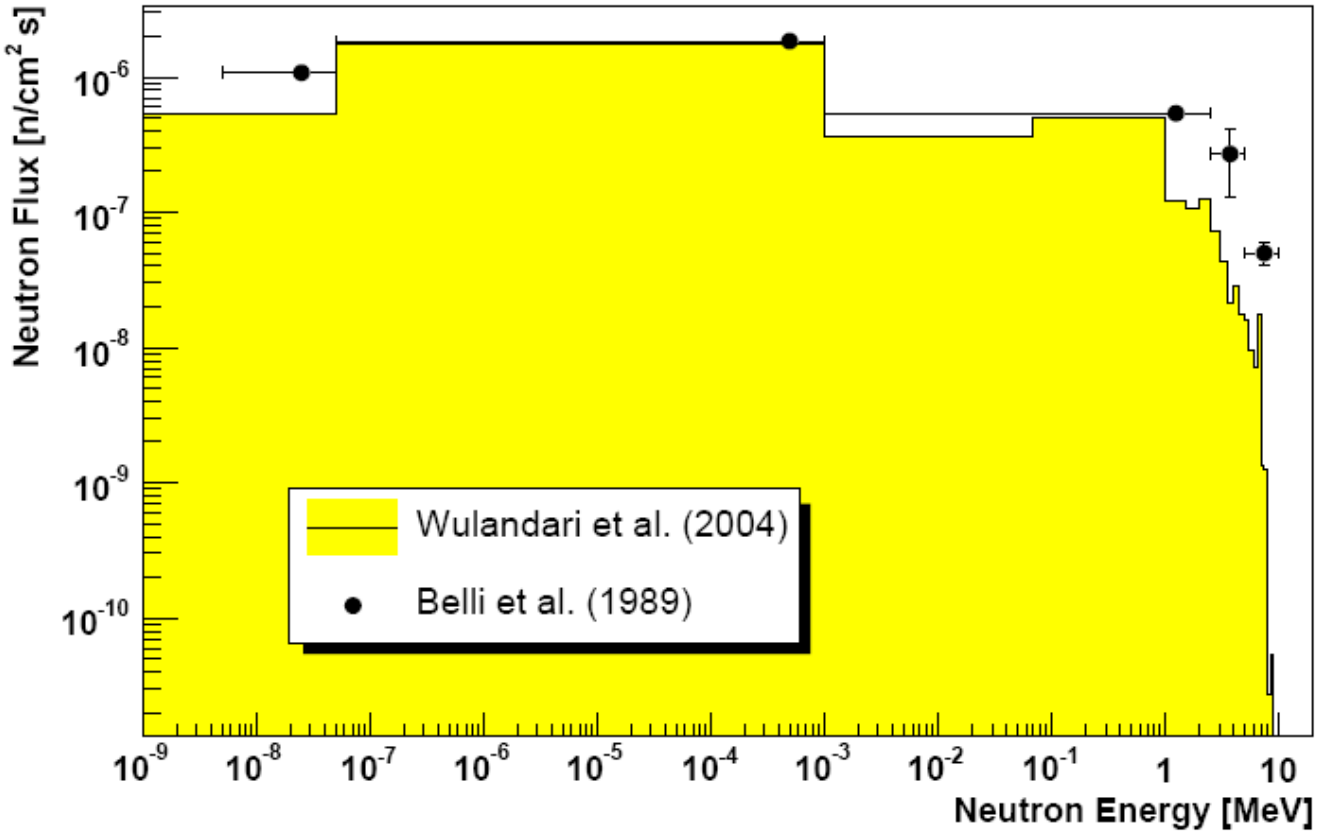
	All shields
Sum spectrum of all Ge-detectors	$4.6 \cdot 10^{-7}$
Ge-detectors are in anticoincidence	$3.0 \cdot 10^{-7}$
Ge-detectors and scintillations in argon are in anticoincidence	0

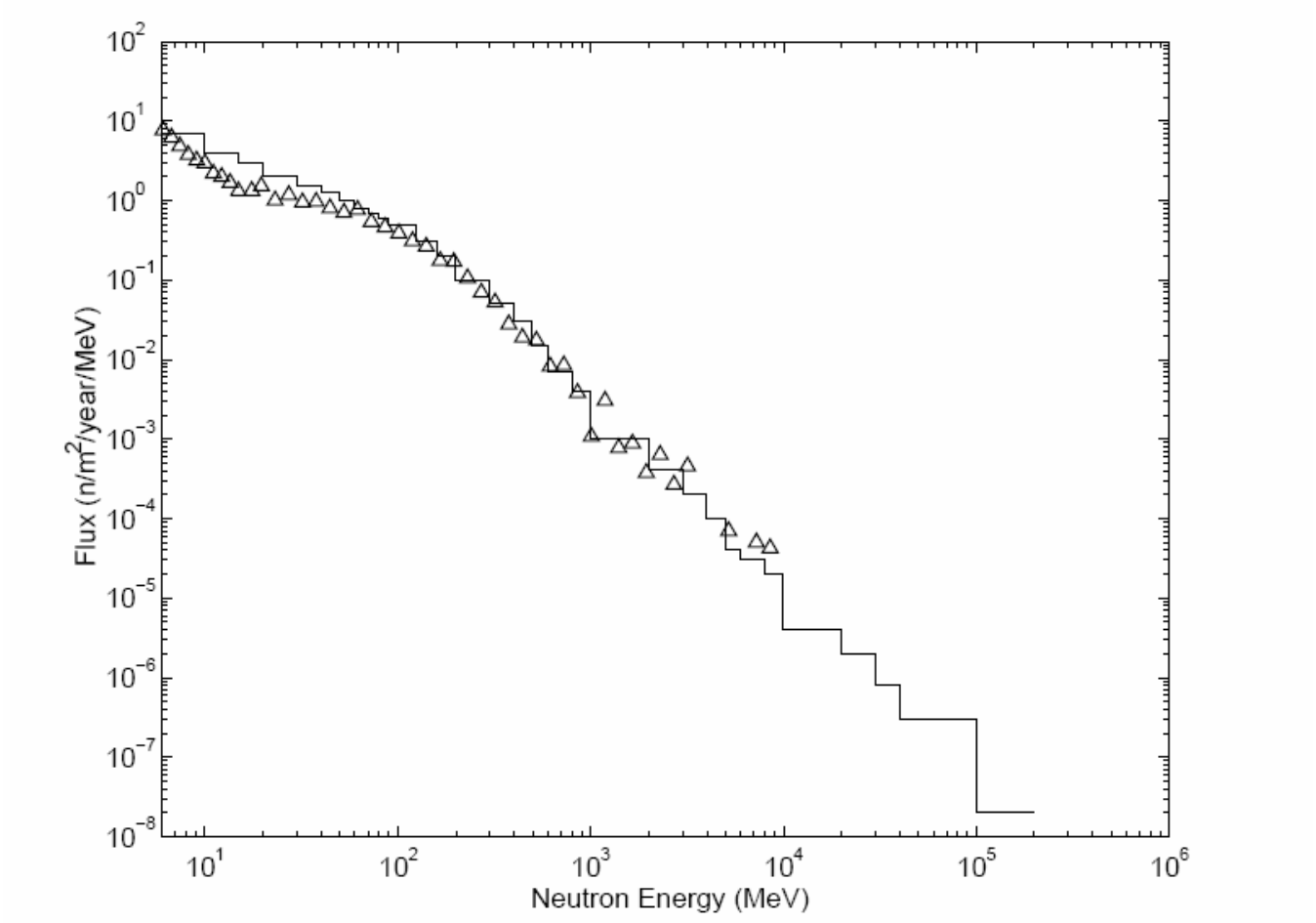
Table 4. Quantity of some dangerous nuclei (1/year) produced in Ge-detectors by neutrons from cosmic muons.

Isotope	Production velosity, nuclei per year
Ge-77	$8.45 \cdot 10^{-2}$
Ga-76	$1.21 \cdot 10^{-3}$
Ga-75	$7.04 \cdot 10^{-3}$
Zn-75	$1.50 \cdot 10^{-4}$
Ga-74	$4.40 \cdot 10^{-3}$
Zn-74	$7.10 \cdot 10^{-4}$
Zn-73	$7.96 \cdot 10^{-4}$
Ga-72	$4.86 \cdot 10^{-3}$
Zn-71	$8.34 \cdot 10^{-4}$
Cu-71	$1.12 \cdot 10^{-4}$
Ge-69	$7.24 \cdot 10^{-4}$
Ga-68	$3.84 \cdot 10^{-4}$
Ga-66	$2.12 \cdot 10^{-4}$

Conclusions

The neutron shield is quite enough to start the measurements in LArGe.


Neutron Flux [n/cm^2 s]
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
Wulandari et al. (2004)
Belli et al. (1989)
10^{-9}
10^{-8}
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
Neutron Energy [MeV]


Flux (n/m^2/year/MeV)
Neutron Energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}

Spectrum of absorbed energy in argon. Full shield with borated polyethylene.