1. INTRODUCTION

Measured Earth thermal flux estimated as 30–40 TW [1]. This is approximately 60–80 mW/m² in average. We don’t know exactly all heat sources producing the flux like this. According to Bulk Silicate Earth element abundances in the Earth, the amount of radioactive isotopes can explain only about 20 TW of total thermal flux. It is produced by decays of 238U, 232Th and 40K [2, 3]. They regard some exotic thermal sources like natural nuclear reactor placed in the Earth core [4].

Modern neutrino registration methods can give an answer on amount of radioactivity in the Earth. All radioactive elements and georeactor emit antineutrinos which pass the Earth’s thickness and go away in the Cosmos not delaying in it. Large scintillating detector in vicinity of the surface can detect these antineutrinos and obtain total antineutrino flux which proportional to the total mass of radioactive elements.

Antineutrino can be detected through the inverse beta-decay reaction (IBD), which produce pair events in the detector clearly recognized in backgrounds. However it has relatively high threshold 1.8 MeV, that cuts 40K antineutrinos with maximal energy 1.3 MeV. 40K antineutrinos can be detected only through elastic scattering on electron reaction which cross section is two orders lower than IBD one.

Geoneutrino flux from 238U and 232Th was detected recently by two scintillation detectors of large volume KamLAND (1000 t) [5] and BOREXINO (300 t) [6]. Measured geoneutrino flux doesn’t contradict to minimal abundances of 238U and 232Th followed from Bulk Silicate Earth but doesn’t also cut other theories with larger amounts [7, 8]. Experimental uncertainty is about 25%. Georeactor power is limited by 4.5 TW from these measurements.

In [9] they regard geoneutrino flux produced by 40K. If potassium abundance achieves value of 3.76% (from [8]) the flux becomes comparable to the 7Be flux from the Sun: 7.8×10^8 cm⁻² s⁻¹ contra 4.8×10^9 cm⁻² s⁻¹ of 7Be flux.

Potassium abundance in the Earth varies in a number of works from 0.024% [3] up to 3.76% [8]. We analyzed the influence of potassium abundances in Earth layers on 40K antineutrino flux and estimated upper and lower limits of potassium flux. In differ of [3] we placed most part of potassium in the core and observable abundance in the crust. The calculations we did for the detector volume and scintillator same as for the Borexino one.

2. 40K ANTINEUTRINO FLUX

40K decay scheme is shown at Fig. 1 [10, 11]. Main transition with probability 89.25% goes to base state of 40Ca.
40Ca emitting beta-particle and antineutrino with border energy 1.311 MeV. In 10.55% of events there is K-capture on exiting level of 40Ar with emitting monoenergetic neutrino 44 keV and then emitting gamma when coming to base state of 40Ar with energy 1.46 MeV. In 0.2% K-capture leads to coming in base state of 40Ar with emitting 1.5 MeV monoenergetic neutrino. We calculated 40K antineutrino spectrum corresponding to beta-spectrum shown at Fig. 2 [3, 12]. Our beta-spectrum differs from experimental one but can be used for estimation effect in a detector of antineutrino. At first approximation one does not need to use weak magnetism corrections for antineutrino spectrum that are large enough for beta-particles but small for antineutrinos. That is why we dont use any corrections for antineutrino spectrum, they are shown at Fig. 3.

3. NEUTRINO DETECTOR

We regard as detector target liquid organic scintillator. In BOREXINO detector they use scintillator on base of Pseudocumene (PC), but in KamLAND detector on base of mineral oil. In some modern detectors they propose to use scintillator on base of Linear alkyl benzene (LAB). In Table 1 we show numbers of Carbon, Hydrogen and electrons containing in 1000 t of LAB and PC.

4. EARTH MODELS TESTING

To do calculations we have chosen the Earth model like concentric spheres according to seismic data.

| 1000 t | LAB | PC |
|--------|-----|----|
| Formulae | C_{18}H_{30} | C_{9}H_{12} |
| H | $7.465 \times 10^{31}$ | $6.013 \times 10^{31}$ |
| C | $4.479 \times 10^{31}$ | $4.510 \times 10^{31}$ |
| Electrons | $3.434 \times 10^{32}$ | $3.307 \times 10^{32}$ |
From the surface down to Mohorovicic’s boarder is the crust which is divided on upper, middle and lower parts. We took data on the depth of parts from [13], where data are presented with step 2 degrees on altitude and longitude. Then down to 660 km we accounted there is an upper mantle, which we also accounted as lithosphere. At the depth 2900 km lower mantle is changing on outer core (liquid one) which lasts until 5140 km, then down to the Earth centre continues inner (solid) core.

$^{40}$K we placed in the crust and upper mantle only when calculated lower antineutrino flux limit. We took potassium abundance as 2.1 weight % for the crust and upper mantle according [14] (mean value appeared to be 0.3%). When counting upper limit we add potassium also in solid and liquid cores in amount to achieve 3.7% for the whole Earth according to Hydridic Earth model [7, 8]. Data we used are shown in the Table 2.

In Table 3 one can find calculated antineutrino and neutrino fluxes from $^{40}$K and expected effects for the target of 100 t pseudocumene with threshold 200 keV. Vacuum oscillations were taken in account when on doing calculations but not the MSW effect. Muon and tauon neutrinos appeared in oscillations do the input in the effect of scattering.

Recoil electron spectra for minimal and maximal potassium abundances are shown at Fig. 4 in comparison with single events from solar neutrino fluxes and inner backgrounds of detector BOREXINO [15]. Daily counting rate is shown in round brackets. Counting rate for the flux from $^7$Be solar neutrino flux is 46 per day and $^{40}$K antineutrino flux rate is from 1 to 4 per day.

5. CONCLUSIONS

We present calculations of recoil electron spectra produced by antineutrino flux from isotope $^{40}$K placed in inner parts of the Earth. It is appeared that the $^{40}$K antineutrino flux is comparable with neutrino flux produced by $^7$Be in solar flux measured with BOREXINO. This background never regarded as sufficient for solar neutrino detectors. Calculations show that it can achieve 10% of beryllium neutrinos effect depending on potassium abundance in the Earth.

The result of our estimation doesn’t contradict to the BOREXINO experimental data even in case of maximal abundance according to [7, 8].

Detector of BOREXINO type could register $^{40}$K antineutrino spectrum and establish the upper limit on potassium abundance in the Earth. In nearest plans of Borexino Collaboration is to take efforts in decreasing the existing background level to lower levels. This definitely increases the probability of determining $^{40}$K antineutrino flux. Detection of extra amount of

Table 2. Potassium abundance in Earth’s layers (in weight %). To change on g/g units one needs to use coefficient 10^{-2}

| Layer         | Min. abund. (%) | Max. abund. (Model 1) (%) | Max. abund. (Model 2) (%) |
|---------------|-----------------|---------------------------|---------------------------|
| Crust         | 2.1             | 2.1                       | 2.1                       |
| Upper mantle  | 2.1             | 2.1                       | 3.0                       |
| Lower mantle  | 0.0             | 0.0                       | 3.5                       |
| Outer core    | 0.0             | 10.0                      | 4.5                       |
| Inner core    | 0.0             | 10.0                      | 6.0                       |
| Oceans        | 0.042           | 0.042                     | 0.042                     |
| Sediments     | 0.2             | 0.2                       | 0.2                       |
| Total         | 0.36            | 3.74                      | 3.74                      |

Table 3. Antineutrino and neutrino fluxes and effect in 100 t of pseudocumene

| Flux, cm^{-2} s^{-1} | Neutrino | Antineutrino | Neutrino | Antineutrino |
|----------------------|----------|--------------|----------|--------------|
| 1.70 x 10^6          | 7.58 x 10^8 | 3.05 x 10^5  | 1.36 x 10^8 |
| Rate, d^{-1}         | 0.06     | 4.04 (Mod. 1) | 0.015    | 1.01         |

BOREXINO [15]. The corridor for possible values of $^{40}$K antineutrino flux single events spectrum is shown.
$^{40}$K can find additional heat source for the Earth thermal flux.

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