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Production of 51Cr neutrino and 144Ce antineutrino sources for SOXand CeLAND experiments (presented by Michel Cribier)

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A number of experimental results (LSND and MiniBooNE, the SAGE и GALLEX calibration experiments with artificial neutrino sources, and "a revision"of the results of former reactor experiments in view of new calculation of reactor neutrino spectrum) that appear anomalous in the context of the standard 3 neutrino scenario, and could be explain by the 4th (a sterile) neutrino.
An unambiguous search for a 4th neutrino by using very intensive (anti)neutrino sources located in close proximity or inside kiloton-scale scintillation detectors like KamLAND or BOREXINO have been proposed recently.
In this report we discuss a possibility for production of about 2⊠200 PBq (50 kCi⊠10 MCi) (anti)neutrino sources for SOX [1] and CeLAND [2] experiments
The project SOX (Short distance neutrino Oscillations with BoreXino) assumes three stages of implementation of scientific program on search of the 4th neutrino: i) experiment with external neutrino source based on 51Cr isotope with activity of 10 MCi, ii) experiment with a 144Ce anti-neutrino source with activity of 75 kCi placed in water shielding, and after iii) a 144Ce anti-neutrino source with activity of 50 kCi placed directly in the center of Borexino detector. The highest priority for the Borexino collaboration is the 51Cr neutrino deployment.
The required activity of the 51Cr source must be 10 MCi at the beginning of data taking at the Gran Sasso Laboratory in Italy. The total activity of the Cr-51 source should be known with a precision of 1%.
51Cr isotope will be produced in 50Cr(n,⊠)51Cr reaction using big quantity of enriched 50Cr isotope as a target and a nuclear reactor with high neutron flux.
In this report we discuss a possibility for production 51Cr source with heavy water reactor LUDMILA at PA "Mayak"(Russia) [3]. Active zone of this reactor permits to accommodate large quantity of starting material (several tens of kilograms of chromium in form of chips) with different level of enrichment. One of the options is to use as a target existing 35 kg of metallic Cr enriched at 38% on 50Cr isotope available from the Gallex experiment done in Gran Sasso in the 90's. There is also the possibility to perform further enrichment of the existing material or to produce a new batch of chromium enriched > 80% at JSC ECP (Russia) [4] in order to increase the total activity needed for the experiment.
Long-lived 144Ce isotope is a fission product of uranium and plutonium from nuclear reactor with high yield of 5,5% and 3,7% respectively. It decays to short-lived 144Pr isotope with Q = 2,996 MeV. Technology and equipment for extraction of individual isotopes - including Cerium isotopes - from spent nuclear fuel exists only in Russia at PA "Mayak". The fission products, including Rare Earths, among which Cerium belongs, are separated from the Purex process raffinate. Technique for recovery of Cerium (144Ce) from Rare Earths is based on displacement complexing chromatography.
To produce 75 kCi antineutrino source it is necessary to reprocess several tons of SNF with burn up about 40 MW⊠day/ton and "cooling time"of about 3 years.
The CeLAND project [7] assumes that antineutrino source based on 144Ce isotope with activity of 75 kCi will be placed in turn i) in water shielding, and after ii) directly in the center of the fiducial volume of KamLAND detector if a hint of signal is being found. The source will be surrounded by a tungsten shielding with weigh about 2 tons to reduce his own dominant ⊠-background. Taking into account small dimensions of active part of such a source (approx. several liters) similar to the vertex reconstruction of antineutrino interaction, it can be considered as practically point-like, providing the necessary conditions for the search for oscillations with the mass term of $\delta m2 \approx eV2$.

1. Bellini G., Brick D., Bonfini G., at al., Short distance neutrino Oscillations with BoreXino. arXiv: 1304.7721v2 [physics.ins-det] 24 May 2013.

2. Cribier M., Fechner M., Lasserre T., Letourneau A., Lhuillier D., Mention G., Franco D., Kornoukhov V., Schonert S. A proposed search for a fourth neutrino with a PBq antineutrino source. - Phys.Rev.Lett., 2011, v.107, p. 201801.

3. Kochurov B.P., Konev V.N., Kornoukhov et al., The possibility to produce 300 PBq 51Cr neutrino source with Russian heavy water reactor-2. Preprint ITEP: ITEP-37-98, Moscow, Oct 1998. (CERN Libararies., Geneva, SCAN 9904041).

4. JSC "Electrochemical plant"http://www.ecp.ru.

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