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Borexino: Recent Results and Future Plans[1]

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Abstract—Borexino is continuing to take data and presenting the new results. The most recent Borexino results are discussed and plans for the nearest future are presented.

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In 2015 Borexino collaboration obtained new results on geoneutrino flux [1] and established stringent limits on electron lifetime with respect to the decay mode $e \to \nu + \gamma$ [2].

The geoneutrino flux measurement was performed with 2056 days data set, which is twice as large as the statistics used in the previous publication. 77 antineutrino candidates were observed in total, with the expected ratio of geoneutrinos to neutrinos from the European reactors of about 1 : 2 (see Fig. 1). Backgrounds from other sources for antineutrino measurement in Borexino are negligible and do not exceed one event for the measurement time. The observed geoneutrino signal is evaluated by fitting the experimental

[1] The article is published in the original.

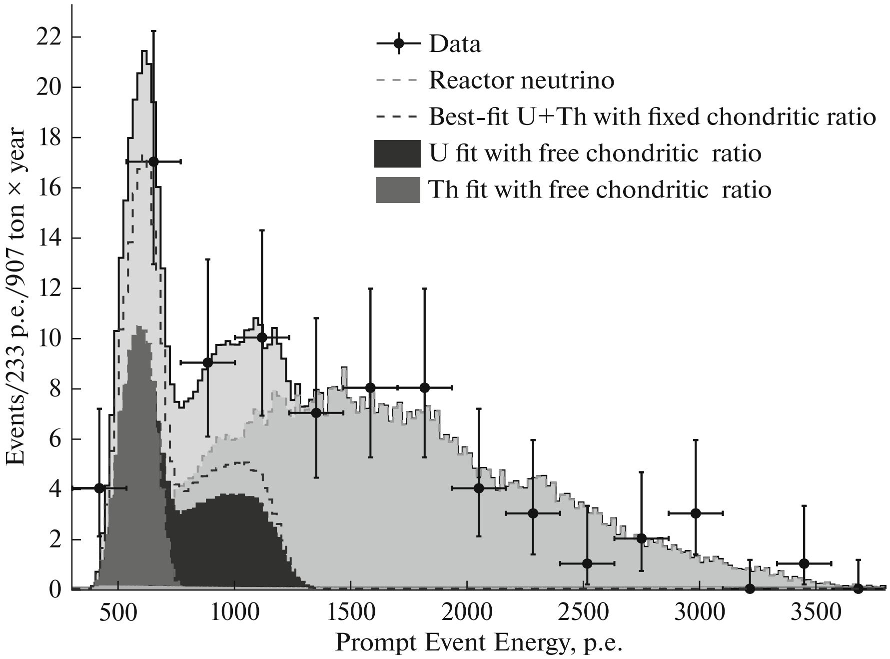

Fig. 1. The Borexino antineutrino data. See text for details.

spectrum with the spectral contributions from geo-neutrino (with chondritic Th/U mass ratio fixed at M(Th)/M(U) = 3.9), reactor neutrino and residual backgrounds. The observed value of $43.5^{+12.1}_{-10.7}$ TNU for the geoneutrino flux is totally consistent with the expected one for most of geophysical models (1 TNU, Terrestrial Neutrino Unit, corresponds to 1 event per year for 10^{32} protons in target). The probability of the absence of geoneutrino signal is negligible, namely, 3.6×10^{-9}. Moreover, for the first time in the history of geoneutrino observations, the non-zero contribution from the mantle is confirmed at 98% confidence level. Estimated crust contribution to the total signal is 23.4 ± 2.8 TNU. The statistical difference between the total observed signal and the crust contribution (i.e. the signal from the mantle) is $20.9^{+15.1}_{-10.3}$ TNU, which corresponds to the non-zero contribution from the mantle with 98% probability. The radiogenic heat contribution calculated for different models is presented in Fig. 2. The radiogenic heat is plotted in the x-axis, and the observed signal is presented in the y-axis. The maximal (red line) and the minimal (blue line) signals correspond to two extreme distributions of the radioactive elements in the mantle: homogeneous (maximal) and all the heating elements at the crust/mantle boundary (minimal). The radiogenic contribution to the total Earth heat, corresponding to the signal observed in Borexino, could be from 11 to 52 TW at 68% C.L. Coloured areas correspond to three classes of the most popular geophysical models, namely, cosmochemical, geochemical and geodynamical ones. Nowadays the discrimination between these models is still impossible due to the limited precision of the measurement.

The second important result obtained by Borexino in 2015 is the best limit for the electron lifetime with respect to the decay mode with the electric charge conservation violation $e \to \nu + \gamma$ [2]. A similar analysis was provided by the collaboration earlier with the

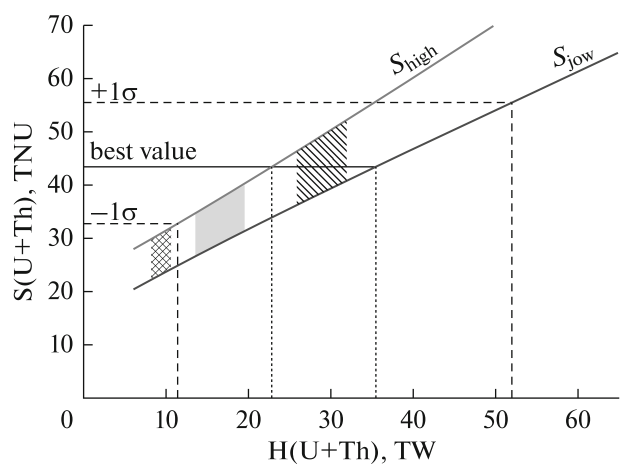

Fig. 2. The radiogenic heat contribution calculated for different geological models. See text for details.

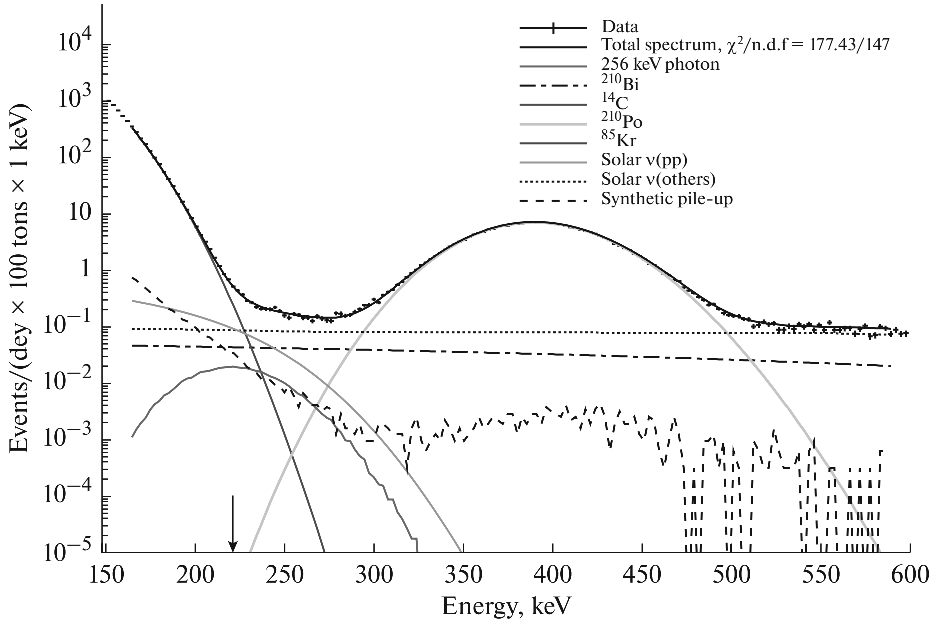

Fig. 3. An example of the spectral fit with superimposed response from 256 keV photon, the event rate of the monoenergetic photon is fixed at the value corresponding to 90% C.L., the arrow points at the position of the 256 keV gamma peak.

data acquired at the 4-tonnes prototype of the Borexino [3]. As Borexino has a much larger mass and a lower residual background level in comparison with its prototype, a significant improvement of the previous result was expected. A monoenergetic photon of energy equal to half of the electron mass (256 keV) was considered as an electron decay signal. The expected signal was modeled with the Monte-Carlo method and included in the total fitting function. Fitting of the experimental spectrum was performed at various event rates of the hypothetical decay. Analysis of the obtained χ^2 profile accounting for possible systematic errors gives a limit on the event rate of 1.33 events per day per 100 tonnes of the scintillator for 90% C.L., which corresponds to the lower limit on the electron lifetime of $\tau \geq 6.6 \times 10^{28}$ years and improves the previous result for this decay mode by two orders of magnitude.

An example of the spectral fit is presented in Fig. 3. Here the event rate of the monoenergetic photon is fixed at the value corresponding to 90% C.L., the arrow points at the position of the 256 keV gamma peak.

The near future plans of the collaboration include an attempt to measure (or constrain) the flux of neutrinos from the CNO cycle in the Sun. This measurement is of the primary interest in modern solar physics in view of the so-called solar metallicity problem (or the problem of solar chemical composition) which can be solved only by measuring the flux of the CNO-neutrino. In view of the measurement, the thermal isolation of the Borexino tank was undertaken this year with a purpose of stopping the transfer of the residual ^{210}Bi into the central core of the detector due to the convection movement, allowing the separation of the fraction of ^{210}Bi rate in secular equilibrium with ^{210}Po. The independent measurement of the ^{210}Bi rate is an essential part of the CNO-neutrino analysis, as the spectral shape of ^{210}Bi is very similar to those expected from the CNO-neutrino.

Combined analysis of the first and the second phases of the experiment is envisaged in order to improve the accuracy of measurement of the most intense neutrino fluxes from the proton-proton chain in the Sun (pp and ^{7}Be). There are also plans for improvement of the limit on the effective neutrino magnetic moment; we expect the improvement by a factor two achieving the sensitivity comparable with GEMMA experiment [4], the most sensitive reactor experiment with germanium detectors. There are good chances to improve also the result on the ^{8}B neutrino flux measurement, with current statistics the precision of the measurement can be improved by at least a factor 2.

In 2016 the measurements with an artificial antineutrino source are planned within the frames of the SOX project [5]. The aim of the measurement is the search for sterile neutrinos actively discussed by physicists in last years. If sterile neutrinos exist they will be detected by searching for a specific oscillation pattern with periodical changes of events density.

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