Status Report of the Borexino Solar Neutrino Experiment ◇

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In the last few years new data from solar neutrino experiments have confirmed the longstanding solar neutrino deficit. Taken together and independent of solar models, the gallium, chlorine and Kamiokande experiments present a consistent picture, in which the 862 keV ^{7}Be neutrino line must be strongly suppressed. Concurrently, new data from helioseismology experiments are confirming the validity of the standard solar model even in the core, where the neutrino producing nuclear reactions occur. The missing ^{7}Be solar neutrino flux thus presents itself as a fundamental problem, whose solution is apparently not to be found in modifications of the solar model, but possibly in the physics of neutrinos.

A plausible explanation for the neutrino suppression is the process of matter induced neutrino oscillations (MSW effect), as could occur in the dense sun, owing to a finite neutrino mass. The 'small angle' solution in this model provides an excellent fit to all the solar neutrino experiments, explaining in particular the strong suppression of the ^{7}Be neutrinos with less suppression of the higher energy ^{8}B neutrinos.

The goal of the Borexino Solar Neutrino Experiment [1] is to measure for the first time directly in real time the monoenergetic solar ^{7}Be neutrino flux. The neutrino detection relies on the leptonic process of neutrino-electron scattering within an unsegmented, spherical liquid scintillator target with mass of about 300 tons. The neutrino signal of the monoenergetic ^{7}Be neutrino line (862 keV) will cause a "compton like" edge in the electron recoil spectrum around 660 keV. According to the prediction of the Solar Standard Model there will be 50 ^{7}Be neutrino interactions per day in 100 tons of scintillator depositing an energy above 250 keV. In the case of total flavour conversion the rate will be approx. 4 times lower.

The Borexino detector will be located in the underground facilities of the National Laboratory of Gran Sasso (LNGS) in order to shield against cosmic ray induced background. Ultra high radio-purity levels are an imparative requirement for the feasability of the experiment. A small scale prototype detector (Counting Test Facility – CTF) was developed in order to investigate the attainable radiopurity levels [2]. The CTF was built similar to the design of Borexino. An unsegmented 4.8 m^3 liquid scintillator volume confined within a 0.5 mm thick nylon sphere (inner vessel) is viewed by 100 phototubes mounted concentric around the inner vessel in a distance of 3 meters. To shield the scintillator from the γ-rays emitted in the rocks around the detector and in the outer parts of the detector, the inner vessel and the phototubes are located in a tank filled with 1000 tons of ultrapure water.

One of the most important issues was to evaluate the concentration of ^{14}C in the scintillator. ^{14}C is a pure β emitter with an endpoint energy of 156 keV. The energy spectrum at low energies measured in the CTF was normalized to the spectral shape expected from the decay of ^{14}C giving a value of $^{14}\mathrm{C}/^{12}\mathrm{C} = 1.45 \times 10^{-18}$. At this level it will not contribute significantly to the background in the energy range relevant for ^{7}Be neutrino detection.

The concentration of ^{238}U was inferred from its daughters using the delayed β-α coincidence $^{214}\mathrm{Bi} \rightarrow {}^{214}\mathrm{Po} \rightarrow {}^{210}\mathrm{Pb}$. Assuming secular equilibrium in the ^{238}U decay chain a value of $(4.9 \pm 1.5) \times 10^{-16}$g/g could be deduced for ^{238}U. There were, however, strong indications, that the coincidence rate observed was not due to intrinsic scintillator radioactivity, but rather diffusion of radon from the water into the inner vessel.

The concentration of ^{232}Th was measured through the delayed β-α coincidence $^{212}\mathrm{Bi} \rightarrow {}^{212}\mathrm{Po} \rightarrow {}^{208}\mathrm{Pb}$. Provided that the short lived isotope ^{228}Th is not differently removed in chemical treatments than the long lived isotope ^{232}Th, a limit of 3×10^{-16}g/g is obtained for ^{232}Th.

By Rn insertion into the water buffer it could be demonstrated that the external background rate in the CTF was mostly dominated by Rn contamination in the water shielding. A comparison of the radial distribution of CTF events prior to Rn insertion with the radial distribution of the determined external background gives an 1 σ upper limit of 40 counts/day for the internal background rate in the ^{7}Be neutrino energy window (250-800 keV) in 4.5 tons of scintillator. This limit is consistent with a vanishing counting rate due to possible contaminations of the scintillator.

At the moment, an alternative liquid scintillator is tested in the CTF and the tank for the Borexino detector is under construction at the LNGS.

References

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[2] S. Schönert, Proc. of the 2nd Rencontres du Vietnam (1995), Edition Frontieres, to be published.

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