First Results from the Borexino Solar Neutrino Experiment

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1. Introduction

The Borexino experiment for the measurement of low-energy neutrinos started data taking on May 15, 2007. After only two months of measuring time, the Borexino collaboration for the first time succeeded to unambiguously identify in real time neutrinos which are released in the electron capture of ^{7}Be in the core of the Sun and thereby to verify independently neutrino oscillations. Besides solar neutrinos, also antineutrinos from the Earths interior and from far distant nuclear reactors generate signals in Borexino, which in the future could also lead to interesting results.

2. Description of the experiment

Main goal of Borexino is the first real time measurement of solar neutrinos below 1 MeV, especially the monoenergetic ^{7}Be neutrinos with an energy of 862 keV. With the measurement of the ^{7}Be neutrino flux with an accuracy of $\pm$ 10 % and including the solar luminosity constraint and the already known oscillation parameters, the primary pp neutrino flux can be determined with an accuracy better than 1 %. As the theoretical error of the standard solar model is also of the order of 1 %, the solar model can be tested with unprecedented precision. Besides the ^{7}Be neutrinos, also pep and CNO neutrinos will be registered and will allow us to constrain the contribution of the CNO cycle to the solar energy production.

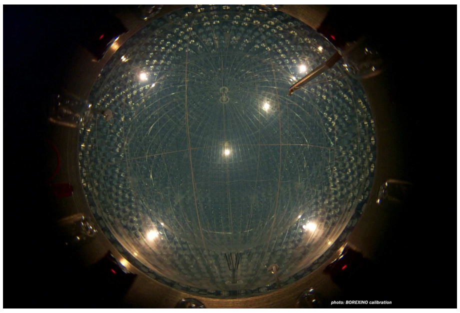

Fig. 1: View inside the Borexino detector.

The Borexino detector is located in the Gran Sasso underground laboratory in Italy at a shielding depth of 3600 mwe. 300 t of liquid scintillator are contained in a spherical nylon vessel of 8.5 m diameter. Only the inner 100 t are used for the detection of solar neutrinos while the outer 200 t provide an active shielding against external background. The target is shielded by 1300 t of pure PC contained in a 13.7 m diameter stainless steel sphere. 2200 photo multipliers mounted on the inside of this sphere detect the scintillation photons. The whole setup is immersed in $\sim$ 2000 t of water contained in a steel dome of 18 m diameter and 18 m height. The water serves as shielding against external radiation, but also as Cerenkov detector to recognize cosmic ray muons crossing the water tank. 208 additional PMTs are mounted in the external water tank and register the Cerenkov light created by the muons in the water.

Solar neutrinos are detected via elastic neutrino electron scattering in the scintillator. As the ^{7}Be neutrinos are monoenergetic (862 keV), the spectrum of the scattered electrons is Compton like, with the edge being at 660 keV. Signals from beta or gamma decays in this energy region are indistinguishable from neutrino events. Therefore the radiopurity of the scintillator itself as well as the shielding against external radiation are crucial for the experiment. The lower detection threshold of 0.25 MeV is set due to the activity of ^{14}C in the organic scintillator.

3. Results

Data collected so far show that the background level in the detector is superior to the design specification. For U and Th we have measured $< 1 \cdot 10^{-17}$ g/g (specification $< 1 \cdot 10^{-16}$ g/g), and the C14/C12- ratio was found to be at the level of $< 1 \cdot 10^{-18}$ (as measured before with the Counting Test Facility). Four ^{85}Kr fast coincidences have been recorded in a 121-day live time period indicating probably a small air leak during filling. The main contamination of the scintillator comes from ^{210}Po with a rate of about 60 counts/day/ton. A fit to the recorded energy spectrum over a total live time of 35.4 days gives the ^{7}Be-neutrino rate of $(47 \pm 7(\text{stat}) \pm 12(\text{sys}))$ counts/day/100 t [1]. This value is in a very good agreement with the Standard Solar Model and neutrino oscillations with LMA-MSW parameters.

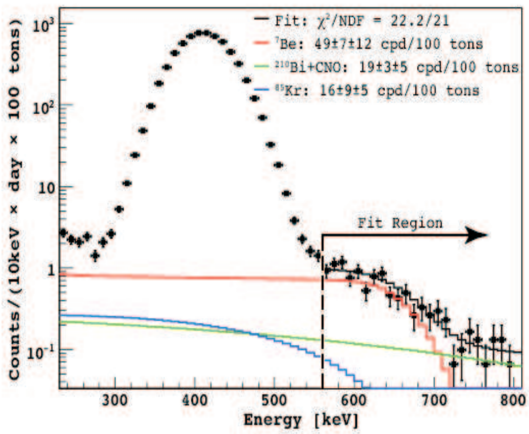

Fig. 2: The recorded energy spectrum by Borexino. The red fit curve corresponds to the ^{7}Be neutrinos. The peak around 420 keV stems from ^{210}Po alpha decays.

References

[1] Borexino collaboration, C. Arpesella *et al.*, "First real time detection of ^{7}Be solar neutrinos by Borexino", Phys. Lett. **B658** (2008) 101

arXiv:0708.2251 [astro-ph]