XMASS

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The goal of XMASS experiment aims at the direct dark matter, the solar neutrinos from pp and ^{7}Be and neutrino less double beta decay (^{136}Xe) with ton scale fiducial volume of liquid xenon detector. In the current stage, we focus on the the direct detection of dark matter in the form of WIMPs (Weakly Interacting Massive Particles) via their elastic scattering off xenon nuclei with 800 kg detector at Kamioka in Japan. XMASS 800 kg detector will achieve a sensitivity down to 10^{-45} cm^2 of WIMP-nucleus cross section for the spin independent case. The status of experiment will be review and discussed here.

1 Introduction

XMASS is a multi-purpose of ultra pure liquid xenon detector for the underground physics. Its targets are dark matter search, low energy solar neutrinos and neutrinoless double beta decay with ton scale fiducial volume [1]. The project was funded for the 800 kg detector mainly for the dark matter search prior to the final stage. Based on the results and experiences which will be obtained by this 800 kg detector, the final detector will be employed for the study of low energy solar neutrinos and the further investigation of dark matter. WIMPs populating the halo of our galaxy can be detected directly via their interactions with nuclei in terrestrial detectors. XMASS is a dark matter detector, with the aim of observing the small energy (∼10 keV or less) released after a WIMP scatters off a Xe nucleus. Liquid xenon has a large scintillation photon yield of 46,000 photons/MeV, which is as good as NaI(Tl) scintillator. This enables us to achieve the detection of small energy signals. The Key idea of the background reduction in XMASS is self-shielding, to use detector liquid xenon itself as a shield to reduce gamma rays background. Due to its high atomic number (Z=54) and high density of liquid xenon (3g/cm3), the compact detector with relatively small size can be constructed. Using the outer region of liquid xenon as shield for gamma rays, extremely low background environment can be achieved in the detector center region for the purpose of detecting rare events from WIMPs or neutrinos.

2 XMASS 800 kg Detector

The XMASS 800 kg detector was installed in the new experimental hall at Kamioka in Japan. This experimental hall, 15 m wide and 21m deep and 15m height, was completed in August, 2008. Fig.1 shows and the installation of the water tank, ϕ 10 m × 10m, which was completed in March, 2009. The spherical liquid xenon detector was installed in the water tank in fall,

2010. The detector employs a single phase technology and observes only scintillation lights emitted by the interaction of dark matter. The total amount of liquid xenon for active volume is about 850 kg and the total mass of liquid xenon in the detector is 1080 kg. The 642 hexagonal photomultiplier tubes (PMTs), R10789 Hamamatsu, are mounted in an approximately spherical shape with an average radius of 40 cm of xenon as shown in Fig. 1. PMTs photo-cathode give about 64.4% coverage of the inner surface of the detector. The actual shape of the structure holding PMTs is called Pentakis-dodecahedron which consists of 12 pentagonal pyramids and each pyramid is made by 5 triangles. The purification of xenon in gas phase is performed by SAES getter at the 30L/min of flow rate during the filling with two 200W pulse tube refrigerators. The recirculation of xenon in liquid phase is also possible at a few L/min (LXe) of flow rate for the purification ,if necessary.

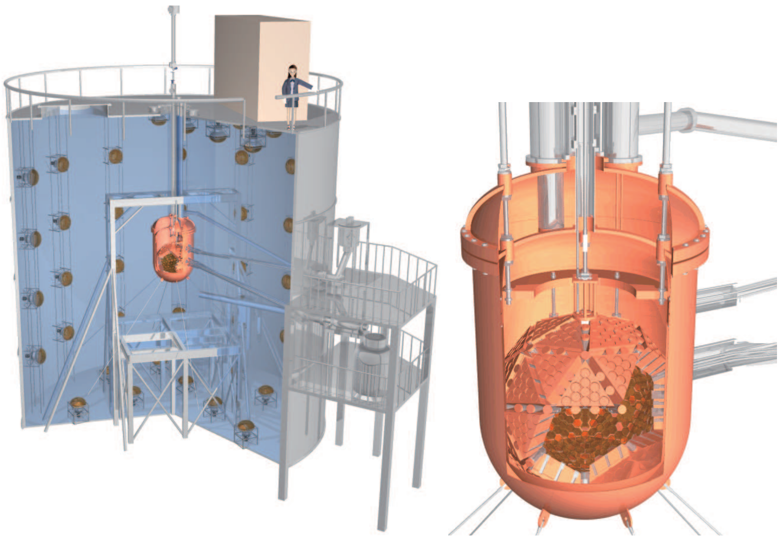

Figure 1: The water tank is used for the radiation shield (Left). The size of the tank is $\phi 10$ mm $\times 10$ m, the detector was installed in the center of it and 20 inch PMTs in the water will be used for the active veto for the cosmic ray events. 850 kg of liquid xenon will be surrounded by 642 ultra low radioactive PMTs. (Right) The double wall detector vessel made of the OFHC is about 1.2 m in inner diameter to hold liquid xenon with the vacuum insulation. The average radius of liquid xenon is about 40 cm.

3 Background and Sensitivity

The key technology to reduce the radioactive background at low energy for XMASS experiment is to use "self-shield" as mentioned above. The clean core of liquid xenon volume will be used as sensitive volume by eliminating the volume near the wall which is suffered from the gamma rays background from the outside. The main component of radioactive background is expected to come from the PMTs. The activity level of PMT is designed to be 1/10 of R8778, giving 0.704 mBq/PMT for uranium-chain, 1.51 mBq/PMT for thorium-chain, <5.1 mBq/PMT for 40K, and 2.92 mBq/PMT for ^{60}Co including the base. The Monte Carlo simulation was performed to estimate the background from PMTs and its rate is about 0.1 count/day/kg/keV in the active volume and less than 10^{-4} count/day/kg/keV will be achieved by 20 cm fiducial volume cut(100 kg sensitive volume) from the PMT windows.

Requirements for the internal background are ^{238}U $< 10^{-14}$g/g, ^{232}Th $< 2\times10^{-14}$g/g and ^{85}Kr $<$ 1 ppt in liquid xenon. ^{238}U and ^{232}Th daughters in liquid xenon are measured using the Bi-Po coincidence method by the prototype detector. Assuming radioactive equilibrium, ^{238}U is $(9\pm6)10^{-14}$g/g and ^{232}Th is less than 23×10^{-14}g/g. As for ^{85}Kr, 3.3±1.1 ppt was achieved by a distillation tower purification system which was developed by XMASS [2]. These radioactive contaminations are near the goal of requirements, within factor 10. The purification system for the 800 kg detector will be installed for removing radon by the filter which is under studying. The distillation tower for Kr was built to achieve $<$ 1ppt with about 4m length of the tower column and about 1.2 ton of xenon gas was processed in September 2010 for 10 days by this tower.

With 10^{-4} count/day/kg/keV background level, the sensitivity of WIMP-nucleon cross section for the spin independent case will be 10^{-45} cm^2 at 100 GeV/c^2 WIMP mass(Fig.2) for 5 years exposure. This sensitivity is more than one order of magnitude higher than the current best limit by CDMSII and XENON10 as shown in Fig. 2.

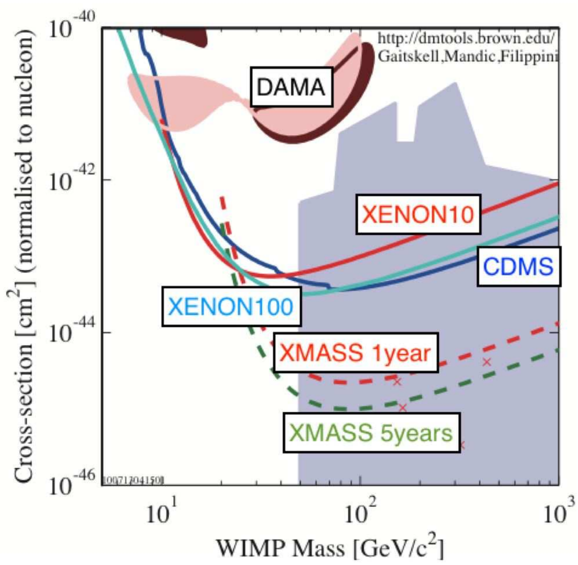

Figure 2: The expected sensitivity of WIMP-nucleus cross section as a function of WIMP mass. For 5 years exposure, the sensitivity will be reach to 10^{-45} cm^2. DAMA/LIBRA [3], CDMSII [4], XENON10 [5] and XENON100 [6] results are also shown here.

4 Conclusion and Summary

The construction of XMASS 800 kg detector was completed in fall, 2010 and the water shield is ready to be used for the active veto for cosmic-rays. After the commissioning run, the data taking will be started in late 2010.

References

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