Dark matter search and measurement of double beta decay by ELEGANT VI

Ogawa,I., R. Hazama, N. Suzuki, T. Nitta, H. Miyawaki,
S. Shiomi, G. Kunitomi, Y. Tanaka, Y. Ishikawa, M. Itamura,
H. Ejiri[a], N. Kudomi[a], K. Kume[a], H. Ohsumi[b], K. Fushimi[c],
K. Matsuoka, S. Ajimura, and T. Kishimoto

Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan
[a]Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan
[b]Faculty of Culture and Education, Saga University, Honjo, Saga 840-8502, Japan
[c]Faculty of Integrated Arts and Science, Tokushima University, Tokushima 770-8502, Japan

We developped a CaF_2 scintillation detector system [1], so called ELEGANT VI, to search for WIMPs (Weakly Interacting Massive Particles) as cold dark matter and search for double beta decay of ^{48}Ca. For the dark matter search, ^{19}F nucleus has the best figure of merit represented by the product of the cross section and natural abundance. For $\beta\beta$ decay study, ^{48}Ca has the largest Q-value of the decay (4.27 MeV) among other potential $\beta\beta$ decay nuclei then good signal-to-noise ratio can be expected. The detector system consists of 25 CaF_2(Eu) crystals surrounded by active and passive shields. CsI(Tl) scintillators and active lightguides which are on both sides of the central CaF_2(Eu) crystals act as 4π active shields. The system achieved effectively 2 keV energy threshold.

A first run was carried out at sea level laboratory (Osaka University) and we schieved similar sensitivity to other experiment carried out at underground laboratory[2]. For further investigations, the whole system was moved to new underground (1200 m water equivalent depth) laboratory "Oto Cosmo Observatory"(OCO) located in Nara[3]. Before starting the full operation at the underground laboratory, we measured neutron flux changing the passive shield consditions of ELEGANT VI both at Osaka and OCO by using boron loaded liquid scintillators[4]. The neutron flux was confirmed to be reduced at OCO at least less than 1/40 (for thermal neutrons), 1/50 (for fast neutrons) of that at Osaka. This measurement shows that LiH+paraffin layer in the passive shield of the ELEGANT VI works remarkably as neutron barrier.

Some improvements on the ELEGANT VI were done. To reduce the internal backgrounds, we changed the material used in the CaF_2 scintillator complex to the one which has lower contaminations[5]. For long term stabilized measurements, thermocouples to mesure the temperature inside the airtight box and flame to support PMTs were introduced. The measurement at the OCO has been carried out from June 1998. The trigger rate is about one third of that of the sea-level measurement.

The obtained energy spectrum at OCO for double beta decay search is shown in figure 1 for a live time of 300 hours, and also shown the one at Osaka. Background events between 3.0 and 4.5 MeV are reduced at OCO by factor 7 of that at Osaka. At present, there is no event in the 0ν window, then we can derive the preliminarly lower limit of the half life as

$$T_{1/2}^{0\nu} > 6.7 \times 10^{20} \text{ year (76\%C.L.)}.$$

For the dark matter search, we used the central 9 CaF_2(Eu) scintillators while the outer 16 scintillators were used as veto counters. The exclusion plot for the Majorana neu-

trino by the present measurement is shown in figure 2 compared with the result of sea level measurement and DAMA collaboration[6].

We expect that the continuous measurement of more than one year will improve the limit both for the dark matter and the double beta decay.

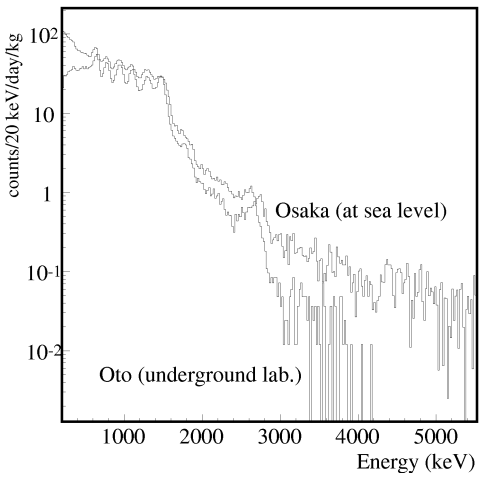

Figure 1: Obtained spectra for double beta decay search at Osaka University (sea level) and Oto Cosmo Observatory (underground). There is still zero event in 0ν window for the spectrum obtained at OCO.

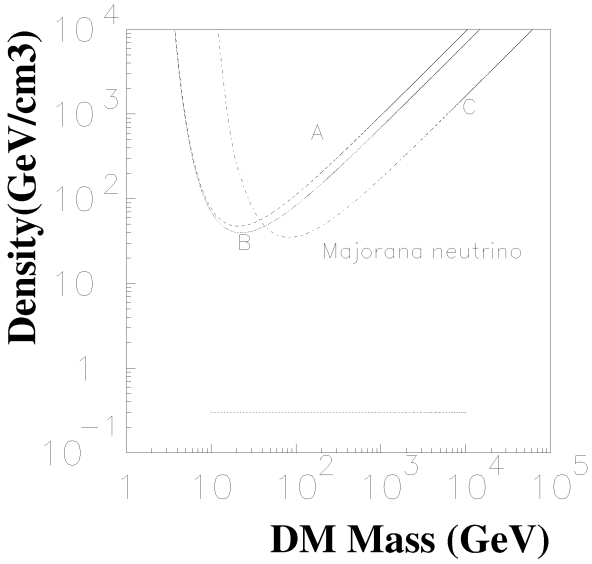

Figure 2: Exclusion plot for the Majorana neutrino (ν_M) dark matter. (A) shows the result of ELEGANT VI at Osaka [2]. (B) shows the present result of ELEGANT VI at Oto. (C) shows the result of DAMA Collaboration at Gran Sasso [7]. The dashed line indicates the critical density of 0.3 GeV/cm^3.

References

[1] T. Kishimoto and R. Hazama Journal of the Physical Society of Japan (in Japanese), **53** (1998) 519; Proc. 2nd Int. Workshop on the Identification of Dark Matter(IDM'98), September 1998, Buxton, UK, World Scientific, in press.
[2] R. Hazama, *et al.*, Doctor thesis, Osaka University 1998.
[3] H. Ohsumi et al., Proc. of FRONTIER'96, Osaka, Japan, 1996, World Scientific, p274
[4] Y. Tanaka, Master thesis, Osaka University 1999.
[5] S. Shiomi, Master thesis, Osaka University 1998.
[6] R. Hazama et al., OULNS Annual Report 1998.
[7] DAMA Collaboration, Astroparticle Phys. **7** (1997) 73.