早稲田大学大学院理工学研究科

博 士 論 文 概 要

論 文 題 目

Dark Matter Search Experiment with Double Phase Xe Detector

二相型キセノン検出器による暗黒物質探索実験

申 請 者

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There are many interesting physics in deep underground experiment. Actually, **Dark Matter direct search**, **pp/^{7}Be solar neutrino experiment**, **neutrinoless double beta decay experiment** and proton decay are under going or proposed all over the world.
From such a point of view, XMASS experiment is a quite attractive project.
XMASS project has three goals for

- ○ **Xenon detector for weakly interacting MASSive particles**
  (Dark Matter experiment)
- ○ **Xenon MASsive detector for Solar neutrinos**
  (pp, ^{7}Be neutrino experiment)
- ○ **Xenon neutrino MASS detector**
  (Double Beta decay experiment)

We are now going on this project at Kamioka Observatory.
As a part of this project, double phase (gas-liquid) Xe detector was constructed for WIMPs (Weakly Interacting Massive Particles) direct search experiment.
Dark Matter signifies the invisible matter whose presence is only known through its gravitational effects. There is strong evidence from a variety of different observations for a large amount of dark matter in the Universe. Dark Matter problem is very attractive for not only astrophysics but also elementary particle physics.
Because there is possibility that neutralino, which is the lightest superpartner in supersymmetric theory beyond standard model, can be WIMP as Dark Matter.
The direct search, by means of nuclear recoil with low energy, is limited by the radioactive background from detector materials as well as the sensitivity of a detector (low energy threshold).
In this case, identification nuclear recoil from electron recoil due to the background gamma or beta rays is great advantage

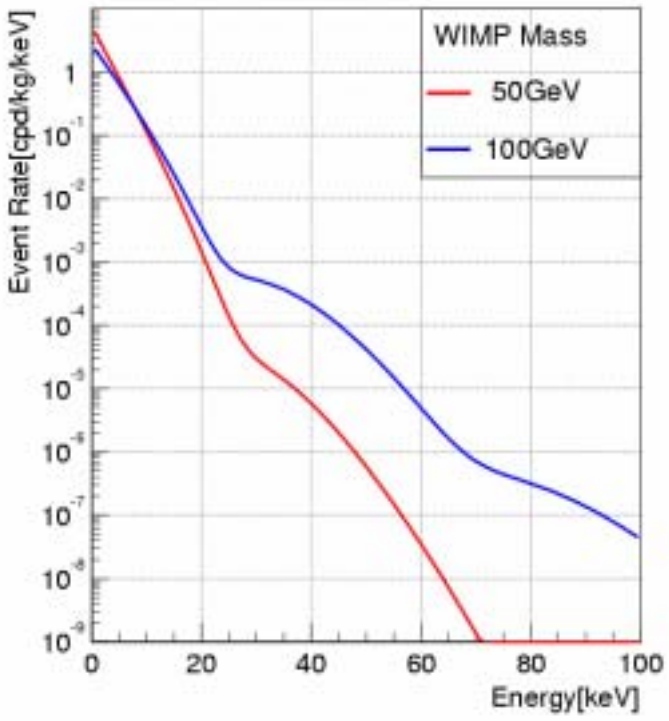

Fig. 1 Expected spectrum from WIMP

for the search. Because it is impossible to avoid the background from the detector itself and the surrounding materials including radiation shields. The expected spectrum of nuclear recoil by WIMP (50GeV and 100GeV case) is shown in Fig.1.

Liquid Xe (LXe) is expected to be an excellent medium for a radiation detector because of its fast response, high scintillation yield (close to that of NaI(Tl) for 1MeV electrons [1]), large atomic number (Z = 54), and high density (3g/cm^3). However, there are some difficulties to detect scintillation light effectively, because the wavelength is in vacuum ultra violet (VUV) region (λ =174nm) and photon detector such as photomultiplier (PMT) should work at low temperature around 170K.

To reduce this deterioration, the most practical and efficient way is to fully surround the scintillator with a good reflector. For this reason, in the framework of the detector R&D for WIMPs by liquid Xe target, the use of PTFE Teflon as the reflector has been proposed [2].

We constructed double phase liquid Xe detector with PTFE Teflon reflector. We got the best results on the energy resolution for several gamma rays using scintillation light [3].

Furthermore, to identify electron recoil from nuclear recoil by WIMP is possible by measuring both direct and proportional scintillation as mentioned above. We showed the performance of detector for WIMPs search [4].

We also constructed the prototype detector for real experiment and investigated the background. Fig.2 shows the detector set up and shields in Kamioka mine.

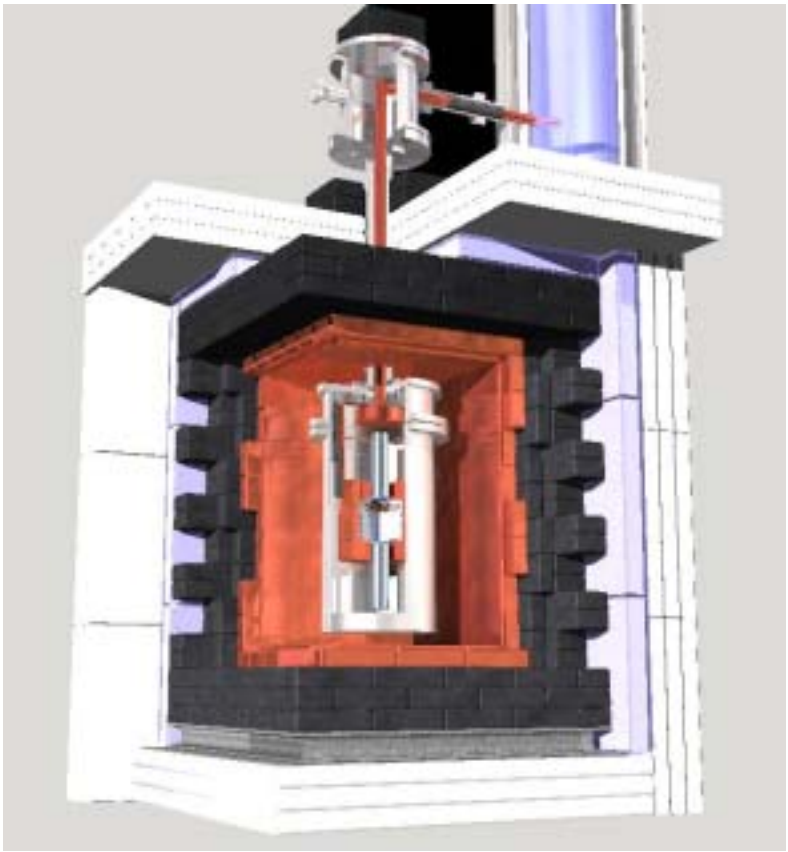

Fig. 2 Double Phase Detector in Kamioka min

In this thesis, the basic performance of the double phase Xe detector and the experiment by prototype detector in Kamioka mine are described.

References

[1] T. Doke et al., Nucl. Instr. And Meth. A291(1990)617.
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[3] M. Yamashita et al., Nucl. Instr. And Meth (to be submit)
[4] M. Yamashita et al., Astroparticle Physics (submitted)