【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Mathematical and physical sciences)

# Title of Project： Search for neutrinoless double beta decays with the highest sensitivities with KamLAND-Zen

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Research Area： Particle Physics, Nuclear Physics, Cosmic Rays, Astrophysics
Keyword： Particle physics (experiment), Neutrinos, Double beta decay

## 【Purpose and Background of the Research】

Neutrinos are elementary particles but electrically neutral, so they can be Majorana particles, which means they are themselves the antiparticles. If they really are, the extraordinary small masses can be naturally explained by the well-known "See-saw" mechanism which suggests physics in ultra-high energies far beyond the standard model. Currently neutrinoless double beta decays (0νββ) of nuclei are the only possible way to confirm this problem but there is no accepted evidence to date. The purpose of the study is to improve significantly the sensitivity of the ongoing 0νββ search experiment, KamLAND-Zen.

## 【Research Methods】

The detector is located 1,000m underground in the Kamioka mine. As shown in Fig.1 a mini-balloon made of thin film at the detector center is filled with $^{136}$Xe-loaded liquid scintillator and viewed by photo-multiplier tubes (PMTs).

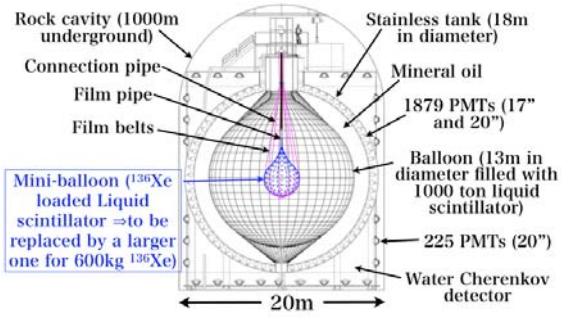


Figure 1　KamLAND-Zen Detector.

The $10^5$ times less cosmic rays than the earth level and the 1,000 ton ultra-pure liquid scintillator enabled the experiment to provide a stringent limit of the $^{136}$Xe 0νββ decay (Fig.2). In this study the sensitivity will highly improved by purification of the Xe-loaded liquid scintillator, the mini-balloon replacement to double the $^{136}$Xe amount and the PMT repair of the outer detector.

## 【Expected Research Achievements and Scientific Significance】

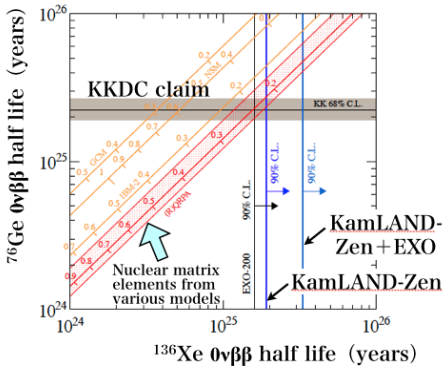


Figure 2　Limits on 0νββ half lives of $^{136}$Xe and $^{76}$Ge. The claim for $^{76}$Ge 0νββ signals (KKDC) was excluded (90%C.L.) by KamLAND-Zen + EXO.

Discovery of the 0νββ decay would show that neutrinos are Majorana particles and make a great impact on the studies of the neutrino masses and suggest physics of ultra-high energies, which may provide a key to clarify the mechanism of the beginning of the Universe and the reason of the matter dominance of the current world. Even if not found, the results may provide important information to determine or severely limit on the absolute values and the hierarchy of the neutrino masses.

## 【Publications Relevant to the Project】

· "Limit of Neutrinoless ββ Decay of $^{136}$Xe from the First Phase of KamLAND-Zen and Comparison with the Positive Claim in $^{76}$Ge", A.Gando et al. (KamLAND-Zen Collaboration), Phys. Rev. Lett. 110, 062502 (2013).
· "Measurement of the Double-Beta Decay Half-life of $^{136}$Xe in KamLAND-Zen", A.Gando et al. (KamLAND-Zen Collaboration), Phys. Rev. C85, 045504 (2012).

## 【Term of Project】 FY2013-2017

## 【Budget Allocation】 131,600 Thousand Yen

## 【Homepage Address and Other Contact Information】

http:// /www.awa.tohoku.ac.jp/kamland/