

KamLAND-Zen

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KamLAND-ZeN History

(KamLAND Zero Neutrino Experiment)

- Target: 0νββ Xe-136 in LS (*).
- Funded in FY2009
- Debut at Neutrino2010 at Athens
- KamLAND exists (ultra low radio active BG), Liquid scintillator experience.
- R&D: Xe gas handling system, miniBalloon
- Fabrication in 2010-2011
- Installation into KamLAND 2011 Summer
- DAQ start 2011 September
- $2\nu\beta\beta$ results and $0\nu\beta\beta$ limits from KamLAND-Zen (1st, 2nd result)
- New Ονββ limit from KamLAND-Zen (3rd result) PRL 110, 062502 (2013)





KamLAND-Zen

2700 mwe



20m

Calibration access

1200 m³ LS+1800m³ BO 1325 17"PMTs + 554 20"PMTs

 $\sigma_{\text{Energy}} = 6.6 \% / \sqrt{\text{E}}$

 $\sigma_{\text{Position}} = 15 \text{ cm} / \sqrt{\text{E}}$ ²³⁸U: 3.5×10⁻¹⁸ g/g ²³²Th: 5.2×10⁻¹⁷ g/g

136Xe loaded LS in mini-balloon

320 kg (2.4 % by weight) 90 % enriched ²³⁸U: 1.3×10⁻¹⁶ g/g ²³²Th: 1.8×10⁻¹⁵ g/g

Water Cherenkov Outer Detector 225 20" PMTs



mini-Balloon

Fabrication at Sendai in Spring 2011 Installation into KamLAND in Summer 2011

25 µm Nylon6 Class 1 clean room transparency 99.4% @400nm Xe barrier < 220 g/year **Ultrasonic cleaning** Making gores. with pure water. U: 2×10⁻¹² g/g Class 10-100 clean room Th: 3×10⁻¹² g/g Packed and N2 purged. Ready for shipping to Installation into KamLAND Kamioka.

214**PO**

164 µs

210Pb

22 y

214**Bi**

19.9 m

238





Pictures from real installation



Xe-LS facility

Xe distillation (XMASS prototype)





Data sets



2nd(*)

(*) PRC **86**, 021601(R) (2012) (**) PRL **110**, 062502 (2013)



2^{nd} result on $2\nu\beta\beta$



T^{2v}1/2=2.30±0.02(stat)±0.12(syst) ×10²¹ years



Radioactive impurities

Observed ratio of ¹³⁴Cs/¹³⁷Cs is consistent with Fukushima-I reactor fallout (soil sample).







Filtration in February 2012





3^{rd} result on $0\nu\beta\beta$





Filtration of Xe_LS did not help. ^{110m}Ag is preferred.



Comparison with other experiments



(#) Mod.Phys.Lett.A **21**, 1547 (2006) (*) PRL **109**, 032505 (2012)



Strategy for Ag removal





Filling completed @2011 Filtration @2012 Feb. It was confirmed ^{110m}Ag remains in LS. @2012 Summer

We are here @2013 Spring suspended since last autumn

~1/100 Ag ~400 kg ¹³⁶Xe @2013 Summer





We really appreciate a lot of encouragements.



- Power line was fixed temporarily in two weeks.
- DAQ started again in one month.
- Power line was fixed completely last week.
- Measures against (and preventing from) accidents were discussed and taken.
- •We are moving ahead.







Summary

KamLAND-Zen 1st phase

- Data taking start on Sep. 2011
- $2\nu\beta\beta$ decay (precisely measured) T^{2v}_{1/2}=2.30±0.02(stat)±0.12(syst) ×10²¹ years
- Lower limit on 0vββ decay
 T^{0v}_{1/2} > 1.9×10²⁵ years @ 90% C.L.
- Combined result with EXO-200
 (m_{ββ}) < 120-250 meV @ 90% C.L.

It is inconsistent with KKDC claim at more than 97.5 % C.L.

- Solution State Sensitivity (background reduction in 0vββ region.)
 - Purification of Xe and LS is ongoing

R&Ds for future KamLAND2-Zen are going on.



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