Energy Estimator Development for KamLAND-Zen

GPPU Research Progress Presentation

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Haruhiko MIYAKE

RCNS, Tohoku University

Neutrinoless Double Beta Decay (0ν2β)

- Neutrino mass is assumed to be zero in standard model.
- Neutrino oscillation experiments show that neutrinos have mass.
- Next our Questions.
  1. Why is neutrino mass overwhelmingly lighter than other quarks or leptons?
  2. Are neutrino and anti-neutrino the same particle?

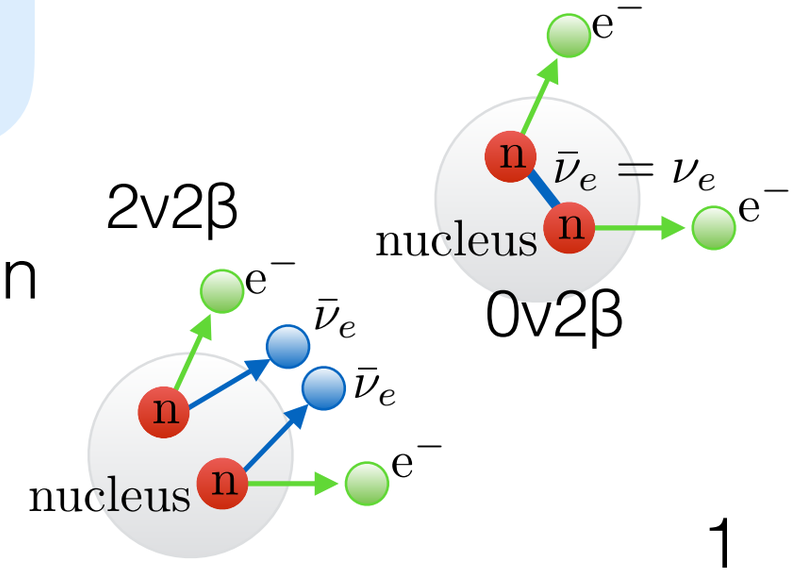
     (Is neutrino Majorana particle?)

If neutrinos are Majorana…,
- Explain small neutrino mass.
- Suggests the existence of ultra-heavy neutrinos.

Heavy neutrinos may have played an important role in the evolution of the universe.

Whether neutrinos are Majorana is important question for both **particle physics** and **cosmology**.

→ **0ν2β is test for Majorana nature of neutrinos.**



KamLAND-Zen

KamLAND-Zen explores 0ν2β of ^{136}Xe and achieved world's best sensitivity of 0ν2β observation.

- 0ν2β and 2ν2β can be distinguished from the difference in energy spectrum of two electrons.(Fig.1)
- Since the detector resolution is finite, the two spectra overlap.(Fig.2)
- We have succeeded in reducing radioactive impurities in the detector.
- **Next dominant background is 2ν2β -> Energy resolution is important.**

Fig.1

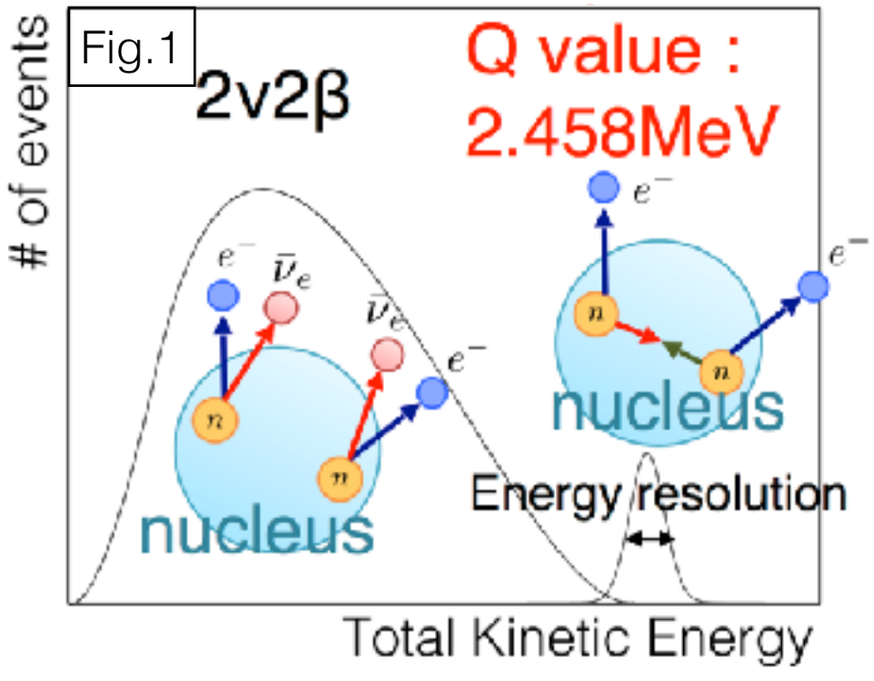
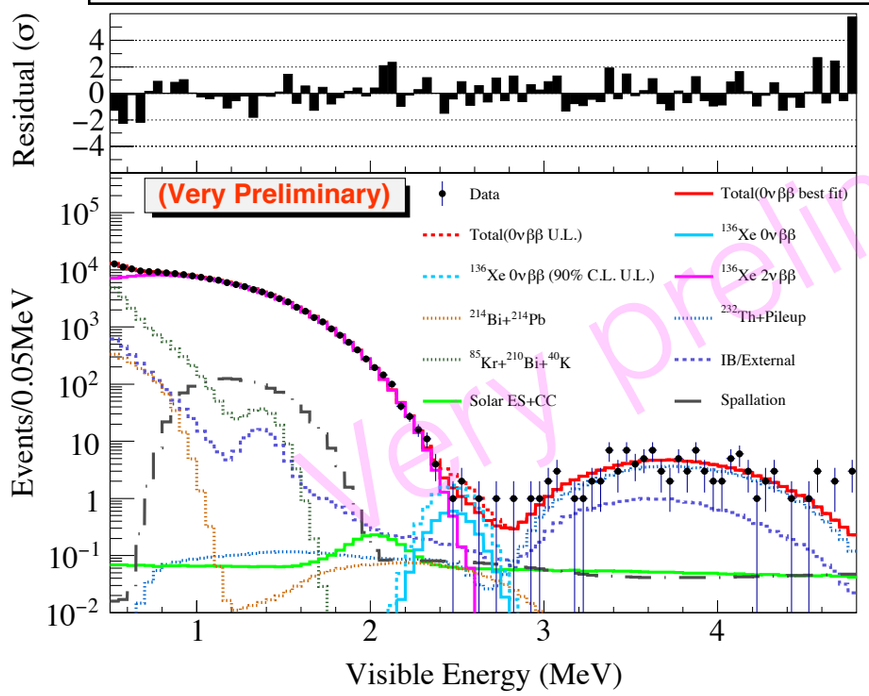
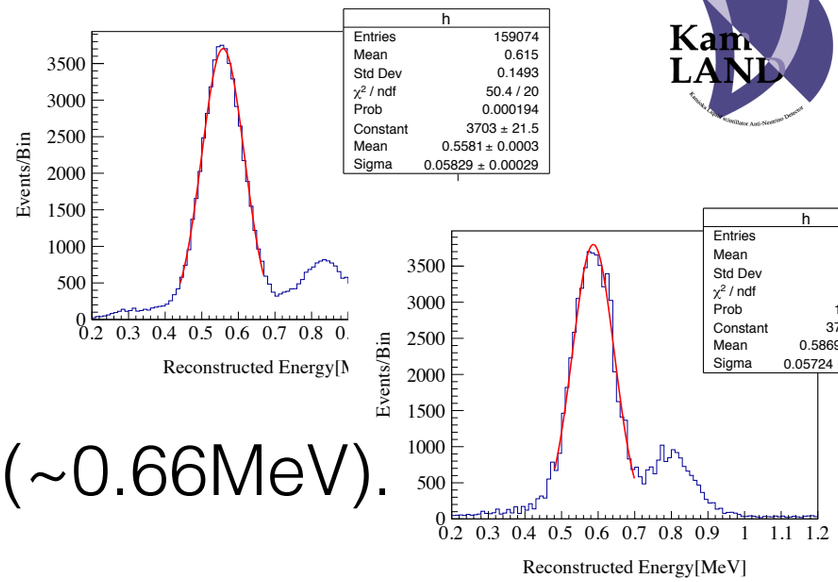


Fig.2 : Very preliminary result of KamLAND-Zen@TAUP, Sep/10/2019



Observed events	8
Best-fit total events	10.7
$0\nu\beta\beta$	2.8
$2\nu\beta\beta$	5.1
^{214}Bi in LS	0.4
^{212}Bi-^{212}Po pile-up	0.4
Film BG (^{214}Bi)	0.9
Spallation (^{10}C)	0.2
Spallation (^{137}Xe)	0.1
Spallation (short-lived)	0.2
Solar ^{8}B ν	0.4

Progress status & Prospect



M2

- **Energy reconstruction tool development**
  - We need higher energy resolution.
  - New tool works well in low energy region(~0.66MeV).
  - ~2.45 MeV (ROI of 0ν2β) is not good.

  -> This is the next target.
  - I want to finalize this work in this academic year.

D1

- **Next year, I want to try new analysis technique.**
  - Machine Learning
  - Bayesian inference

—> We have strong collaborators in data science @ MIT

D2

- **Apply new technique to KamLAND-Zen analysis**

D3

- **KamLAND-Zen analysis??**

I'm not sure my D-thesis theme. I have to compete with my colleagues.

Plan of overseas training

Destination : MIT (Boston)

Pourpose : Develop particle identification tools based on Neural Networks with collaborators at MIT.

Time : May, 2020 -> March, 2021 (11 months)

Current Status

- ☑ Consult with my supervisors and Miwa-san.
- ☑ Send some e-mails to Prof. Lindley Winslow at MIT.

  —> She gave me a positive answer.
- ☐ Prepare application form of overseas training. (海外研修申請書)
- ☐ Visa
- ☐ Housing ⟶ Housing may be main problem because of expensive rent. (>~$800/month)