

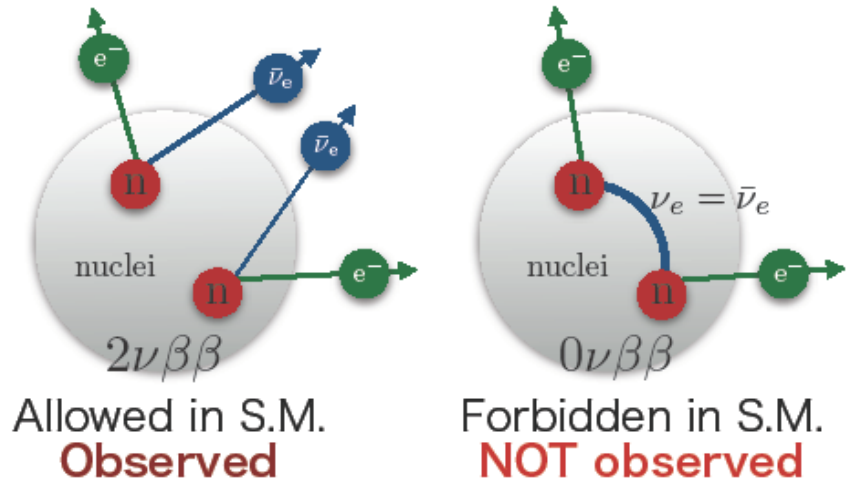
Improvement of Energy Estimation Tools for KamLAND-Zen

GP-PU Progress Status Presentation

Haruhiko Miyake
RCNS, Tohoku Univ.

Neutrinoless double-beta decay search ($0\nu\beta\beta$)

- Double beta decay
 - $2\nu\beta\beta$ mode: emits two neutrinos(observed)
 - $0\nu\beta\beta$ mode: emits no neutrino(NOT observed)
- Direct test of Majorana nature of neutrinos ($\nu = \bar{\nu}$?).
- Lepton number violation
 - > Phenomena beyond the Standard Model
- Access neutrino mass via $0\nu\beta\beta$ decay half life .



Current status of KamLAND-Zen

($0\nu\beta\beta$ decay search of ^{136}Xe with KamLAND)

- Two main background sources :
 - $2\nu\beta\beta$ decay mode
 - > Enhancing the energy resolution is needed.
 - Muon spallation products (Most dominant)
 - > Particle ID(β, γ) method is promising.
- Target sensitivity ($T_{1/2}^{0\nu} > 5 \times 10^{26}$ yr in 5 years)

✓ We can access neutrino mass via half life.

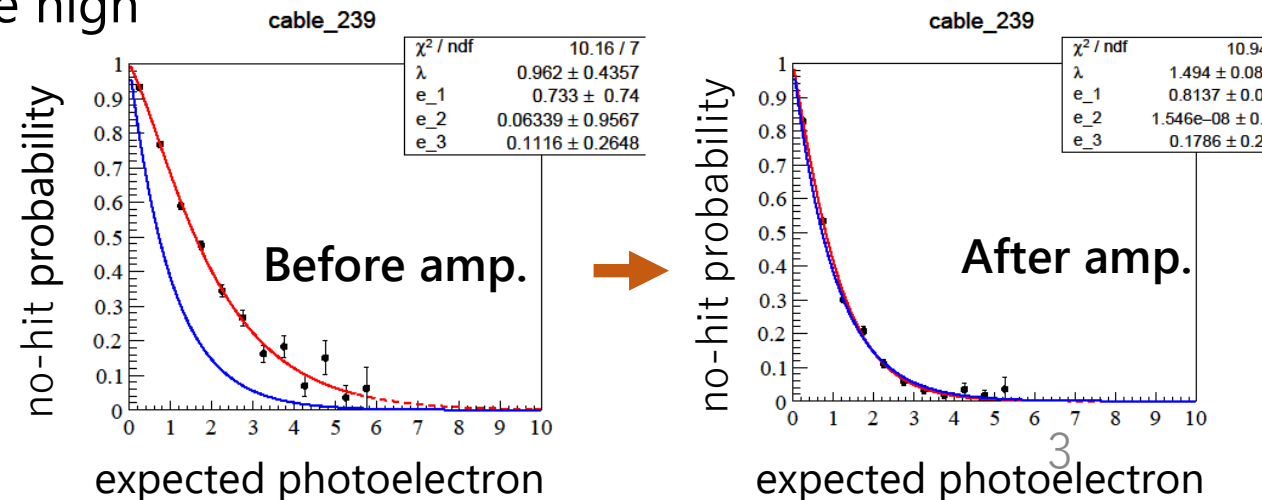
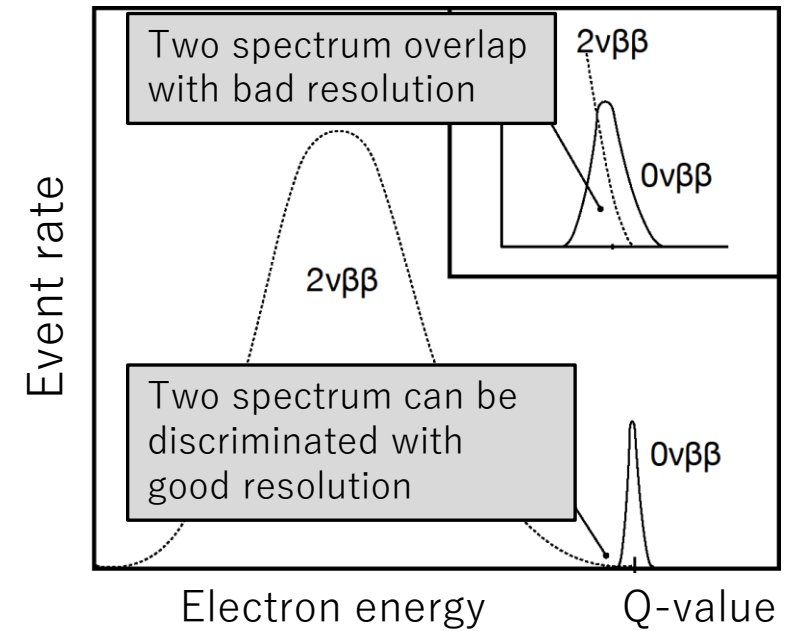
$$\left(T_{1/2}^{0\nu}\right)^{-1} = G^{0\nu} |M^{0\nu}|^2 \langle m_{\beta\beta} \rangle^2$$

↑ Half life
 ↑ Effective Majorana mass

Background reduction(1)

- $2\nu\beta\beta$ (Target : Reduce by $\sim 1/3$)
 - High energy resolution is needed.
 - However, increase of degraded(low-gain) PMTs in KamLAND detector resulted in deterioration of energy resolution.
- > **Reuse of degraded PMTs**
 - 18.3% reduction have been accomplished (QE1 report, this is not sufficient).
- > **Amplifier installation campaign is in progress.**
 - Enhancing hit probability is essential to achieve high energy resolution.
 - 400 degraded channels will be amplified.
 - Amplified channel's response have recovered.

Blue curve : expected curve in good PMTs
The response have recovered by amp.



Background reduction(2)

- **Long-lived muon spallation products**

- Long-lived($T_{1/2} > 10^2 \sim 10^5$ sec) isotopes from ^{136}Xe spallation are dominant.

- Many long-lived isotopes decay are accompanied by γ -rays.

- > Distinguishing β and γ , they can be tagged.

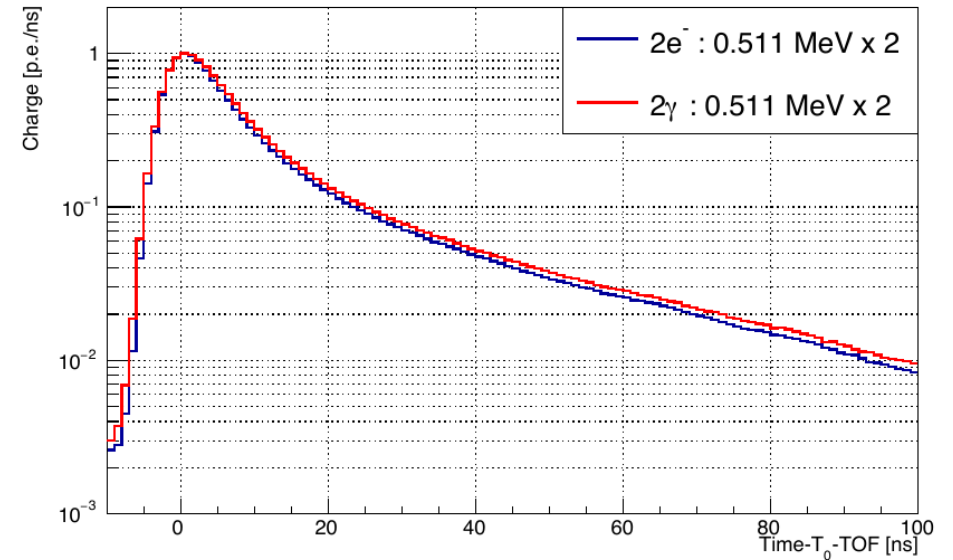
- Neural network technique for PID have been developed (previous study)

- Current problem is its efficiency estimation.

- (Currently it has large errors($\sim 20\%$) due to data driven method.)

- > Accurate Monte Carlo sim tools are needed to estimate neural network efficiency precisely.

- Information of degraded PMTs(Low hit probability, low-gain) should be included.



Difference of timing spectrum
(S. Hayashida D-thesis)

Other topics, Overseas training & D-thesis

- Source calibration campaign is planned in this year.
 - Charge and Timing waveform of source event is necessary to develop Monte Carlo tools.
- Overseas training
 - MIT plan (3 months stay) depends on COVID-19 situation.
 - Alternative plan is remote training .
 - Currently consulting with Prof. Winslow in MIT.
 - Topic will be KamLAND-Zen analysis (not the other experiment).
 - Looking for better solution for me.
 - Weekly online meeting and discussion by e-mail may be compromise.
- D-thesis
 - KamLAND-Zen data analysis.