Calculation of Low-Energy Electron Antineutrino Spectra Emitted from Nuclear Reactors with Consideration of Fuel Burn-up

*Eka Sapta Riyana[1], Shoya Suda, Kenji Ishibashi[1], Hideaki Matsuuraa, Jun-ichi Katakura[2],

[1]Dept. Applied Quantum Physics and Nuclear Engineering, Kyushu University, Japan,

[2]Dept. Nuclear System Safety Engineering, Nagaoka University of Technology, Japan,

We are interested in neutrinos emitted from reactor in a region of keV, since they may have information on fuel burn-up and may be detected in future with advanced measurement technology. In this work we present neutrino spectra from various reactors such as typical PWR reactor and others types of reactors for comparison in the low energy region. Our result shows the electron antineutrino flux in the low energy region increases with burn-up of nuclear fuel by accumulated nuclides with low Q values in beta decay.

Keywords: PWR type reactor, Low energy electron antineutrino spectra

1. Introduction

Low-energy electron antineutrino flux in a keV region is expected to largely depend on fuel burn-up. The dependence maybe different from that of prompt antineutrino flux by fission fragments. The characteristics, however, have not been clarified so far. Therefore, we attempt to compute emission of low energy electron antineutrinos taking fuel burn-up into consideration.

2. Reactor Electron Antineutrino Spectra

2-1. Pressurized Water Reactor (PWR)

We calculate electron antineutrino spectra from typical 4-loop Pressurized Water Reactor (PWR). The PWR input is assumed to take three fuel compositions of 2.0, 3.5 and 4.1 wt% 235U contents. We divide the reactor operation period into 12-month steps; each step has one-month duration in a steady thermal power (3.4 GWth).

2-2. Other Reactors for Comparison

We also compute spectra from several type reactors such as heavy water reflected research reactor HANARO [1], advanced thermal reactor FUGEN [2] and the High Flux Isotope Reactor (HFIR) [3].

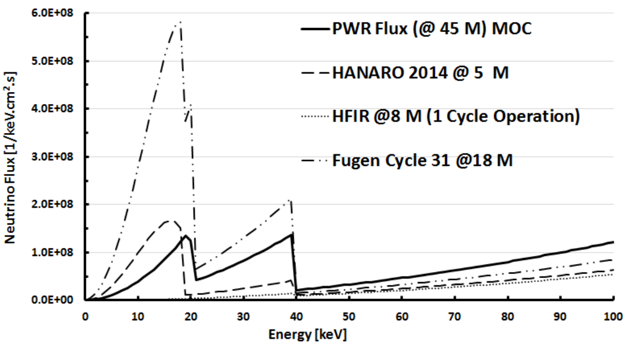

Figure 1. The thermal power calculated electron antineutrino spectra as a flux fo PWR, HANARO, FUGEN and HFIR

3. Conclusion

We confirm that the electron antineutrino spectra in the low energy region are directly influenced by transuranium beta emitter nuclides with low Q value in beta decay (e.g. ^{241}Pu) which are determined by burp-up level. The calculated electron antineutrino spectra for various reactors are shown in Figure 1 as electron antineutrino flux.

References

[1] Kook D, Cho D, Choi H, and Kim Y. Radiation Safety Evaluation of the HANARO Research Reactor. J.Nucl.Technology & Rad. Prot. 2011; 26.1:50-57. [2] Ohtani T, Iijima T and Shiratori Y. Analysis of Mixed Oxide Fuel Loaded Cores in the Heavy Water Reactor FUGEN. J. Nucl. Science and Tech. 2003 Nov; 40.11:959–969. [3] Xoubi N, Primm III R. T. Modeling Of The High Flux Isotope Reactor Cycle 400. USA: Oak Ridge National Laboratory; 2005 August, Report no. ORNL/TM-2004/251.