PROCEEDINGS OF SCIENCE

Measurement of θ_{13} using RENO reactor neutrino events with neutron capture on hydrogen

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RENO has been taking data since August, 2011 and successfully measured the smallest neutrino mixing angle, θ_{13}. This measurement was based on observed reactor neutrino events with neutron captures on gadolinium (n-Gd) in the target detector region. RENO also successfully measures the mixing angle from a reactor neutrino sample with neutron captures on hydrogen (n-H) in the gamma-catcher region. Due to a large accidental background in the n-H data sample, the analysis requires additional reduction of backgrounds . This independent measurement provides a valuable systematic cross-check of the θ_{13} measurement using the n-Gd sample. In this paper, we present the results from the n-H analysis using the 500 days of data sample.

38th International Conference on High Energy Physics
3-10 August 2016
Chicago, USA

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1.Introduction

Our experiment goal is measurement neutrino mixing angle (θ_{13}). So, we measured anti-electron neutrino from Hanbit nuclear power plant at South Korea. The neutrinos interact by Inverse Beta Decay (IBD) at our detector. After IBD, positron emit prompt signal using pair annihilation (s1), And neutron is capture by hydrogen or Gadolinium (s2). In this paper, we used hydrogen capture case. This analysis can independent measurement of θ_{13} value, Also consistency and systematic check on reactor neutrinos.

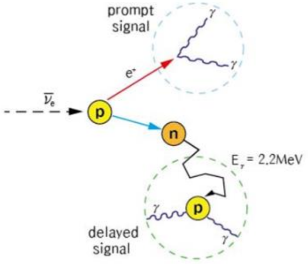

Figure 1. Events pairing with IBD

2.Data selection

In table 1, this is cut criteria for IBD events. Basically, we applied same condition with nGd selection. But, the nH analysis have more background than nGd. So, we changed criteria, and added two dimensional cut. As a result, we have successfully reduced the accidental background. And we need conversion function for number of photoelectron to energy.So, Non-linear response of the scintillation energy is calibrated using γ-ray source. In figure 2, left plot is function of energy conversion, right plot is comparison of boron spectrum between MC and Data. Electron energy spectrum from β-decays from ^{12}B and ^{12}N which are produced by cosmic-muon interaction. We checked conversion function using boron spectrum. As a result, the MC and data is match well.

Table 1. Cut criteria of nH capture.

Muon veto time	1ms
Shower muon veto time	700ms
Qmax/Qtot of prompt signal	0.07
Qmax/Qtot of delayed signal	0.06
Prompt energy	$1.2<E<8.0$MeV
Delayed energy	$1.95<E<2.50$MeV
Time coincidence	$2<\Delta T<400$usec
△R (Distance of s1 and s2	700mm
Additional removal of accidentals	$\Delta R< (-1.5\cdot\Delta T+750)$

3.IBD Candidates and backgrounds

We have analysis using 500days of data sample. In figure3, vertex distribution is dense in gamma catcher. Because, target region include nGd events. The cross section of Gadolinium is more high than hydrogen. The neuron capture time is about 200 usec. In figure 4, Near and Far detector is match very well. The table 2 shown results of number of events. The background fraction of near detector is few percent. But, far detector is ~30%. It is almost accidental background. So, nH analysis have large error of backgrounds. In table 3, it is systematic uncertainties for χ^2 fitting of rate analysis. The isotope fraction and thermal power is same value with nGd analysis. But, detection efficiency and background is bigger than nGd analysis. So, systematics uncertainty of θ_{13} is bigger than nGd analysis.

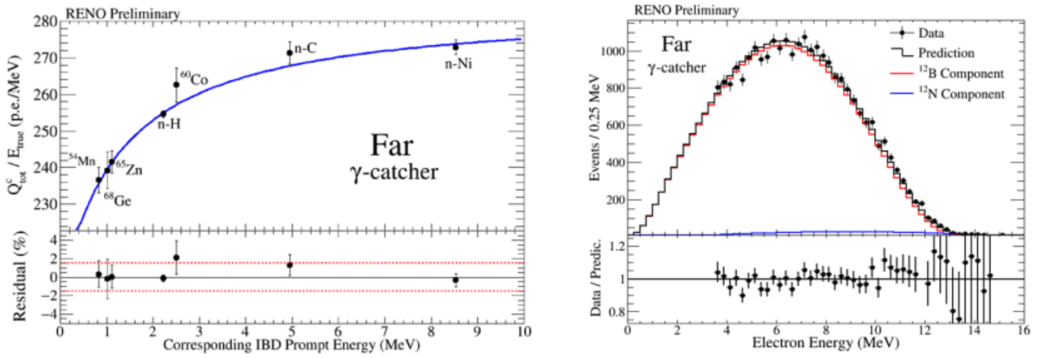

Figure 2. Energy calibration.

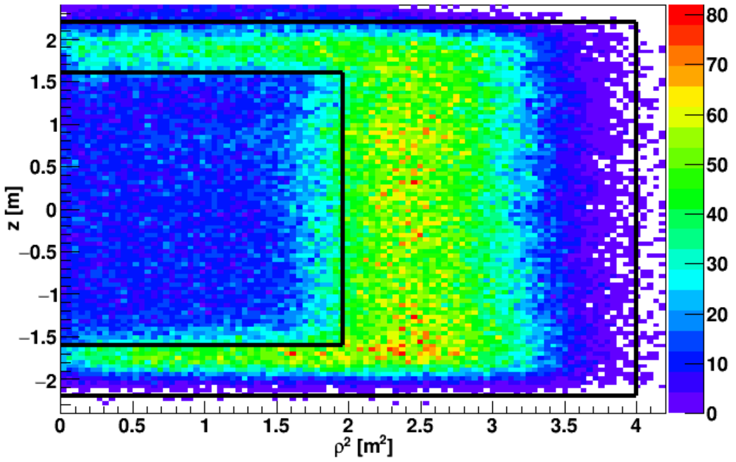

Figure 3. Vertex distribution of IBD candidates.

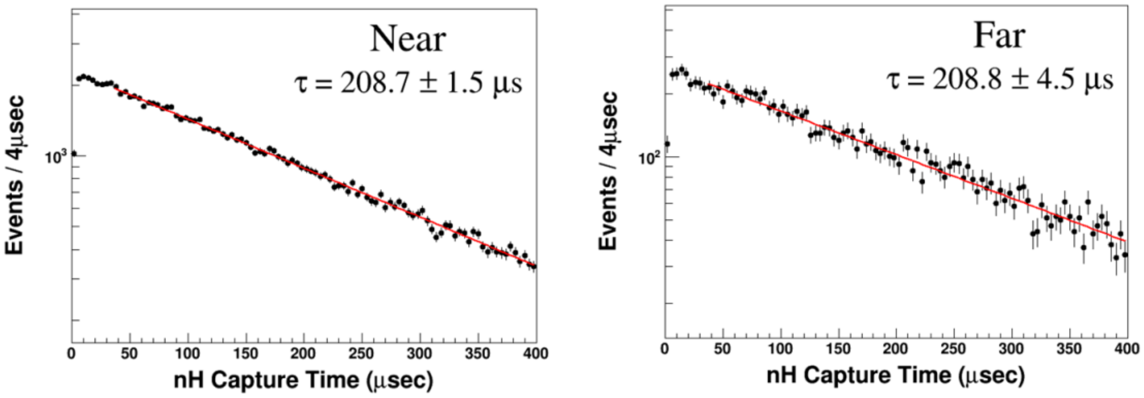

Figure 4. Capture time of neutron capture by hydrogen.

Table 2. Number of IBD and backgrounds

	Near	**Far**
Live time (day)	458.487	489.928
IBD candidate	204,499	31,697
IBD	434.8	44.1
Accidental	2.36±0.13	18.49±0.19
Fast neutron	3.84±0.18	0.91±0.20
Li/He	5.90±0.78	1.17±0.21

Table 3. Systematic uncertainties

Detection efficiency		0.59 %
Thermal power		0.5 %
Isotope fraction		0.7 %
Background	Accidental	Near : 0.02 %, Far : 0.42 %
	Fast neutron	Near : 0.04 %, Far : 0.43 %
	Li/He	Near : 0.17 %, Far : 0.45 %
	Total	Near : 0.20 %, Far : 0.80 %

4.Summary

We have successfully reduced the background with various cut optimizations. The energy distribution of prompt signal is slightly different with high energy in figure 5. And it shown 5MeV excess for MC model. Preliminary rate only analysis results is

$$\sin^2 2\theta_{13} = 0.086 \pm 0.012(\text{stat.}) \pm 0.015(\text{syst.})$$

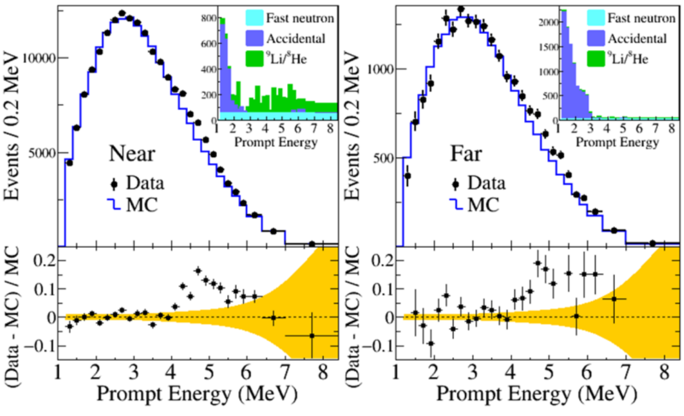

Figure 5. Energy distribution of prompt signal.