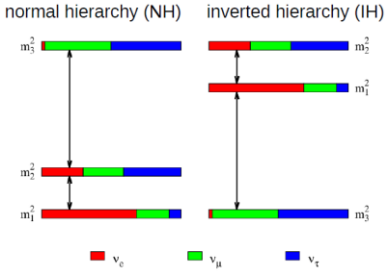
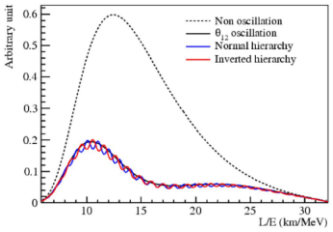
WAVEFORM RECONSTRUCTION OF IBD AND MUON EVENTS IN JUNO

Physics Motivation



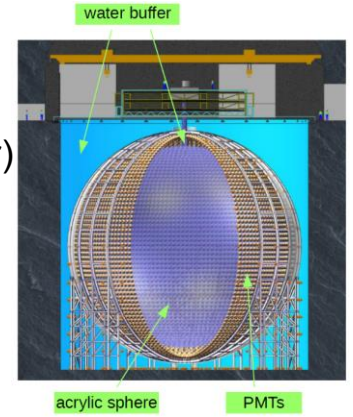


Neutrino reactor spectrum

- Measurement of neutrino mass hierarchy
- Phase of oscillation is different for NH and IH
- Requires good energy resolution (design:3%/$\sqrt{E/MeV}$)

Experiment

- 20 kton liquid scintillator detector
- Acrylic sphere: 35 m diameter
- 18,000 large PMTs (20'' diameter)
- 25,000 small PMTs (3'' diameter)
- 650 m underground
- 52 km baseline
- Location: Jiangmen in China
- Data-taking will start in 2021

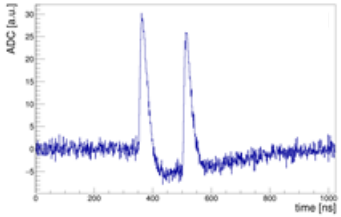


IBD waveforms:

Introduction

- Antineutrinos are detected via the Inverse Beta Decay (IBD):

$$\bar{\nu}_e + p \rightarrow e^+ + n$$
$$e^- + e^+ \rightarrow \gamma + \gamma$$



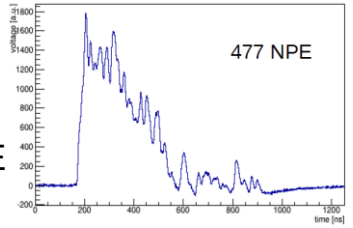
Example of IBD waveform

- PMTs convert photons into photo-electrons (PE)
- Low PMT occupancy rate, typically ≤ 3 PE/PMT
- Waveforms feature PEs as peaks

Muon waveforms:

Introduction

- Waveforms of muon events feature a high number of PE (NPE), typically 500 – 5000 NPE
- First hit time (fht), charge, and rise time are needed to reconstruct muon tracks for muon vetoes

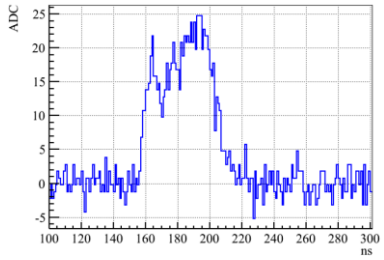


Example of muon waveform

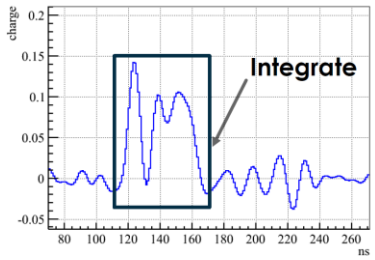
IBD waveforms:

Method

- Deconvolution method reconstructs charge and time of each hit based on Discrete Fourier Transforms (DFT) from the integral of the peak area and peak position



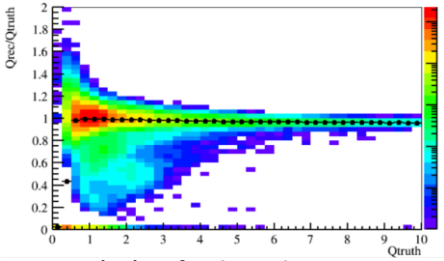
Example of simulated waveform



Waveform after deconvolution

Results

- Residual charge non-linearity of 1 %



Charge resolution for 0 – 10 PEs per waveform

Conclusion & Outlook

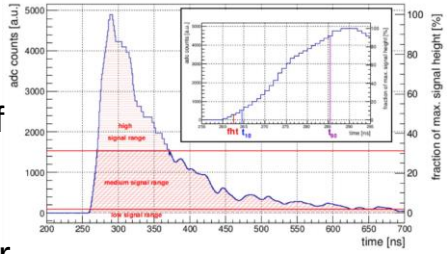
- For IBD waveforms, further studies are conducted on the time reconstruction for each single PE
- Both IBD and muon waveform reconstruction study continued based on deep learning

Muon waveforms:

Method

Time:

- Find fht in typically steeply rising edge of waveform
- Use Constant Fraction Discriminator (CFD) approach



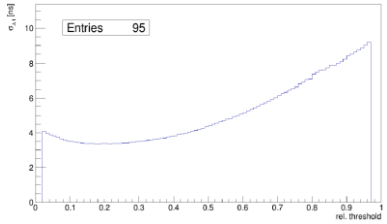
Example of simulated muon waveform

Charge:

- Charge reconstruction done by integrating the entire waveform after baseline correction

Results

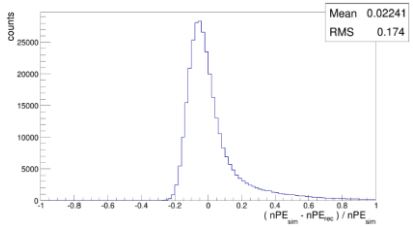
Time:



Fht resolution in dependence on relative threshold height

- Fht resolution 3.4 ns at 4% signal heights

Charge:



Distribution of true – reconstructed charge relative to true charge

- Relative charge resolution RMS ≈ 0.17