Background Induced by the ^{241}Am-^{13}C Calibration Source in the Daya Bay Experiment

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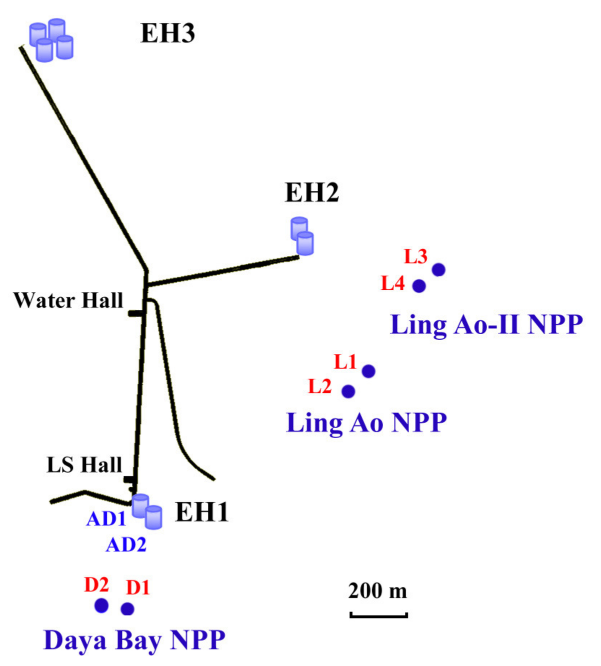
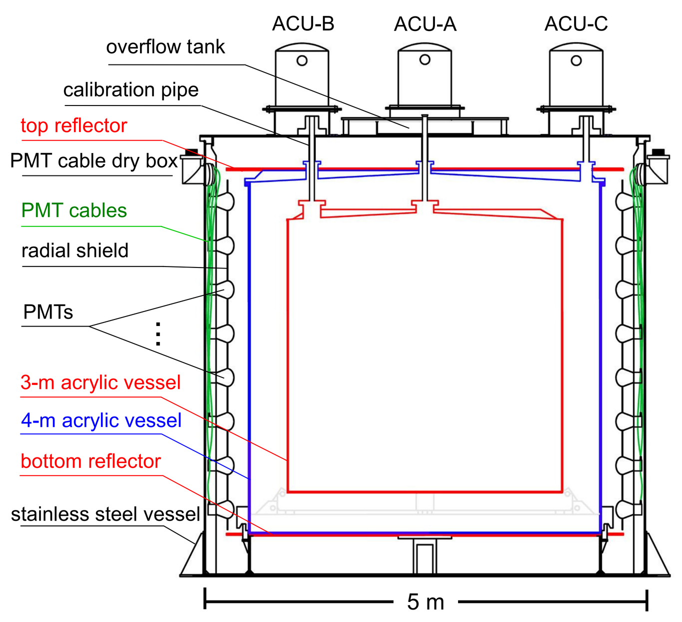
on behalf of the Daya Bay collaboration

Introduction

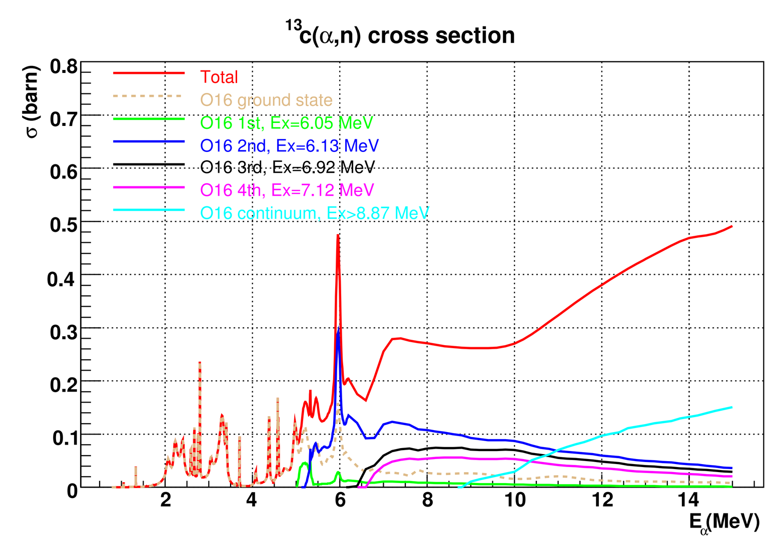
The Daya Bay experiment has made the most precise measurement of the neutrino mixing angle θ_{13} and the first measurement of the effective mass splitting in the electron anti-neutrino disappearance channel based on the measured rate and spectral shape of anti-neutrinos from six nuclear reactors. A thorough understanding of the backgrounds is crucial for the measurement. Among all the backgrounds, one is caused by the AmC calibration source positioned on top of the anti-neutrino detectors, which has a significant impact at the far site. Effort has been made to better evaluate this background and to constrain related systematics, including an in-situ measurement with a much stronger AmC source to directly measure the background spectrum and benchmark our simulation.



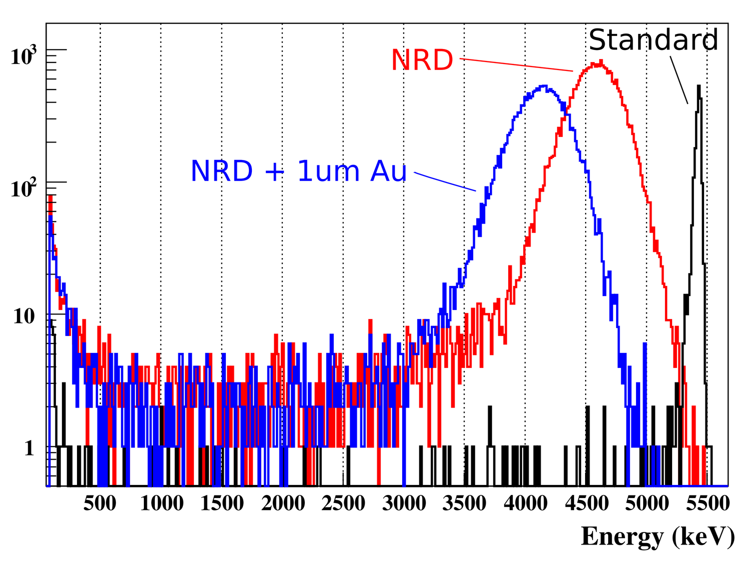


^{241}Am-^{13}C Neutron Source

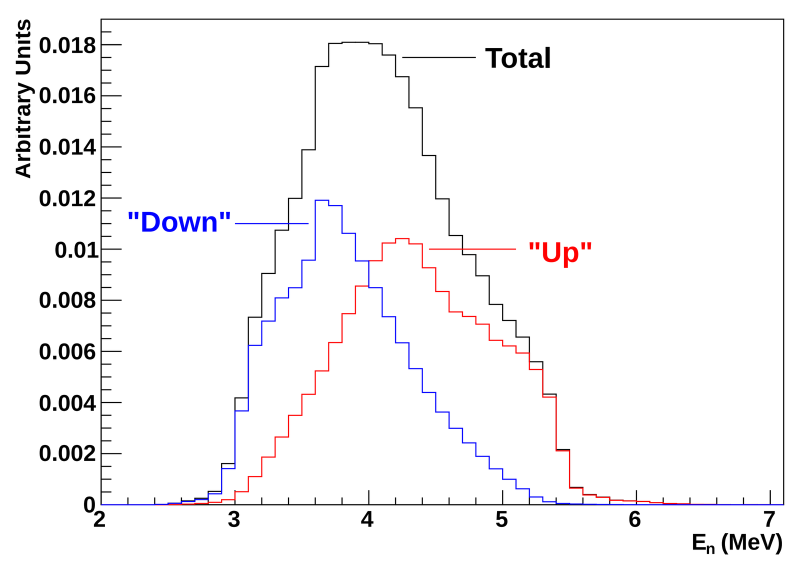
- Low rate($\sim$0.7Hz) neutron source via ^{13}C(α,n)
- Alpha from ^{241}Am is attenuated to yield **ground-state** neutron emission only
  - No correlated neutron-γ emission
- Keep accidental background at the far site below 5%



^{13}C(α,n) cross section



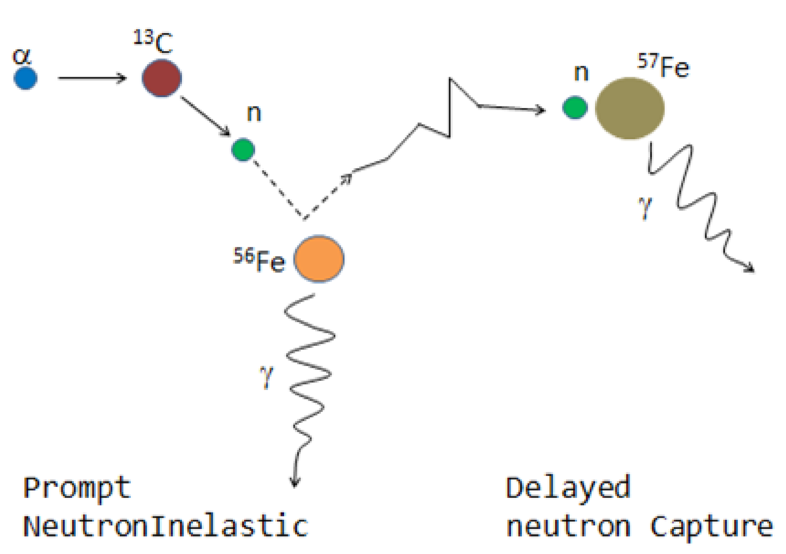
α energy spectra of standard ^{241}Am source and the one from NRD Inc.



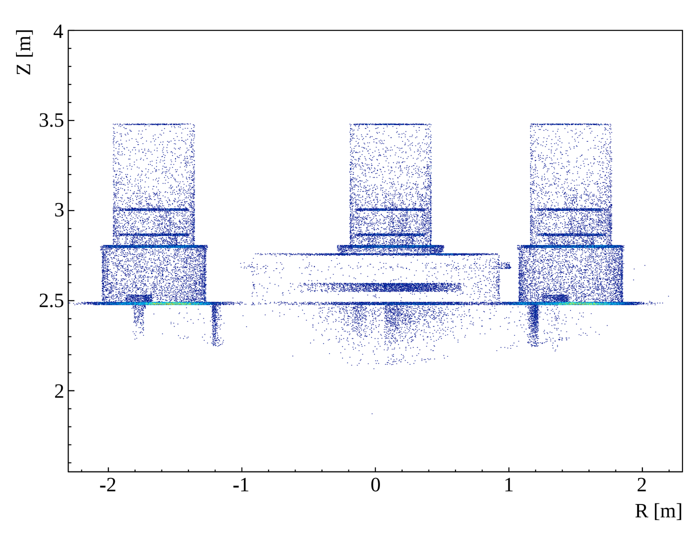
neutron energy spectra of ^{241}Am-^{13}C. Upward and downward neutrons don't share the same spectrum due to the source geometry

Formation of the Correlated Background

- 3 Automated Calibration Units(ACU) on top of each Anti-neutrino Detector(AD) with ^{241}Am-^{13}C source loaded in each ACU
- Neutron inelastic scattering combined with its subsequent capture mimics the temporally correlated Inverse Beta Decay(IBD) signal
- Dominant correlated background at far site



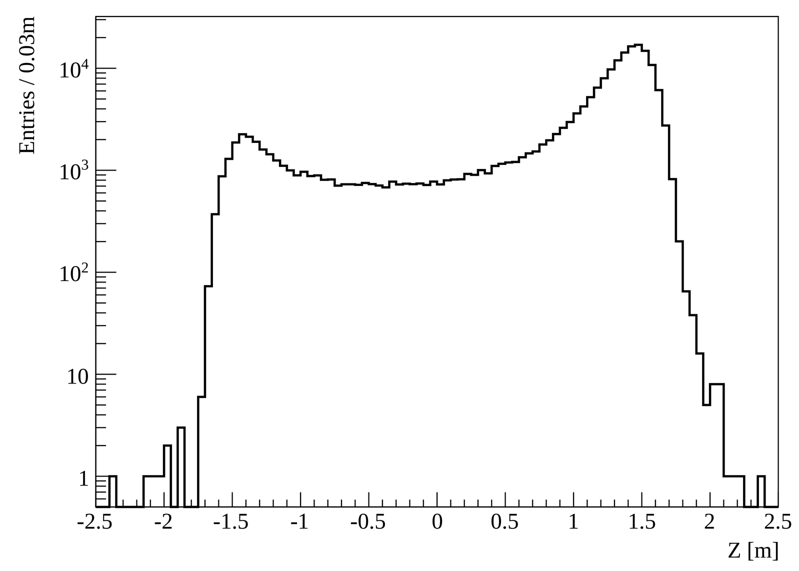
formation of the background



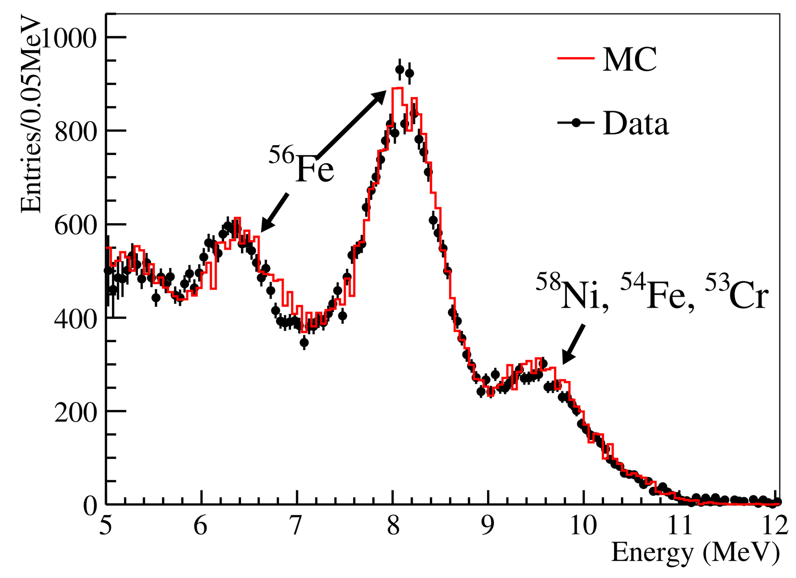
neutron capture vertex obtained by Monte Carlo(MC) simulation. Most of them are in or in the vicinity of the ACUs

Background Evaluation

- Measure the single neutron-like rate $\mathbf{R_{single}}$ from data
  - AmC generates neutron-like events in the top half of the ADs
  - Cosmogenic neutron-like events are uniformly distributed in the ADs

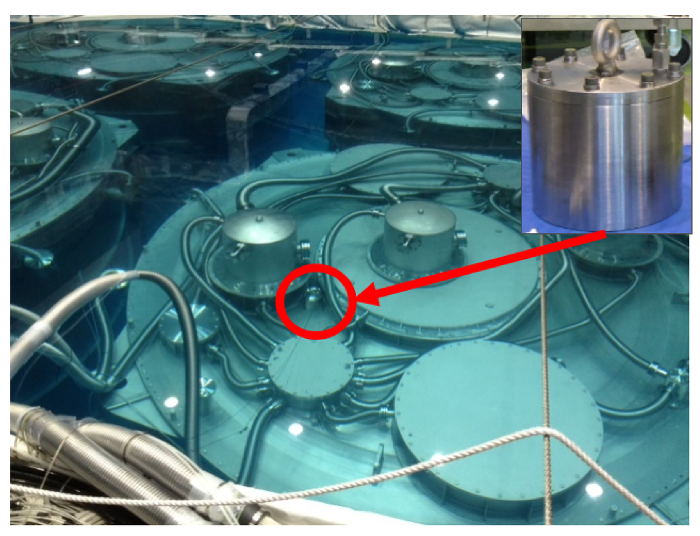


z-distribution of single neutron-like events in physics data

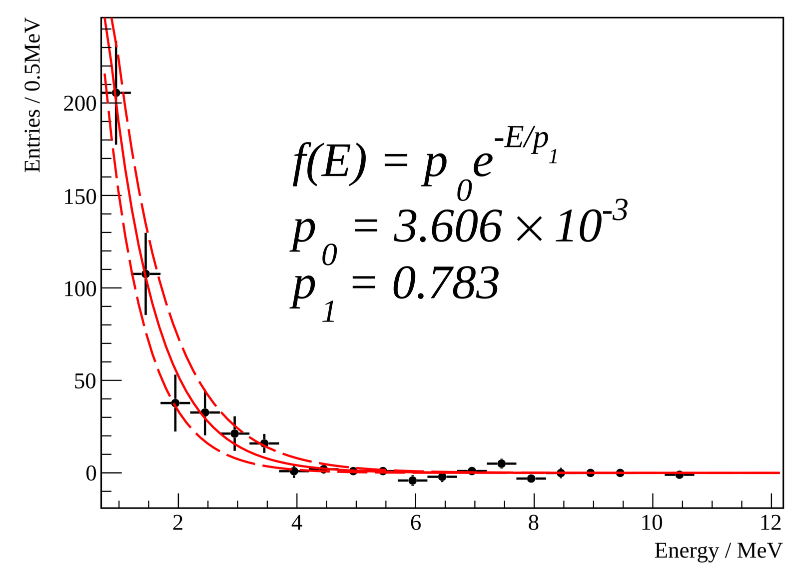


energy spectrum of single neutron-like events near the top of the AD at far site

- Predict correlated background $\mathbf{R_{bkg}} = \mathbf{Yield} \times \mathbf{R_{single}}$
  - **Yield** $\equiv \mathbf{R_{bkg}}/\mathbf{R_{single}}$ based on MC simulation
  - **Yield** is constrained by a special benchmark calibration
- Constrain systematic uncertainty with a special calibration
  - A $\sim$ 60Hz ^{241}Am-^{13}C source with the same design was deployed during summer 2012
  - Direct measurement of the background



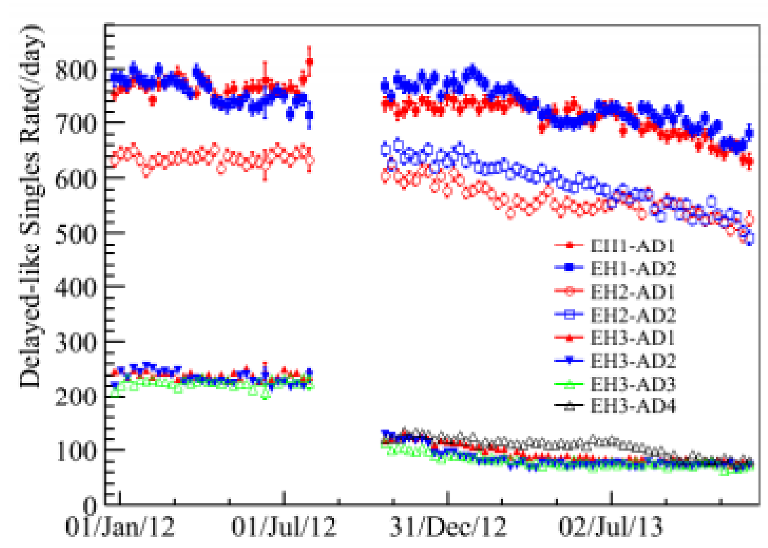
a strong AmC source deployed on the top of AD



background spectrum from the benchmark measurement

Far-site Background Reduction

- single neutron-like rate is significantly reduced at far-site after summer 2012 as neutron sources were removed from **off-center** ACUs for all far-site ADs.
  - a slight decrease of neutron source activity also changes the single neutron-like rate



single neutron-like event rate in ADs

- ^{241}Am-^{13}C background level is reduced correspondingly

	Near-site				Far-site			
AmC background level	AD1	AD2	AD3	AD4	AD5	AD6	AD7	AD8
Before removal(%)	0.04±0.02	0.04±0.02	0.05±0.02	-	0.30±0.14	0.29±0.13	0.29±0.13	-
After removal(%)	0.03±0.01	0.03±0.01	0.03±0.01	0.04±0.02	**0.08±0.04**	**0.05±0.02**	**0.05±0.02**	0.09±0.04

Summary

- ^{241}Am-^{13}C background rate and shape at Daya Bay is evaluated by MC simulation, as well as a special benchmark calibration run
- ^{241}Am-^{13}C background for 8AD period is significantly reduced and no longer the dominant one at far site
- Improved precision in measurement of oscillation parameters

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