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

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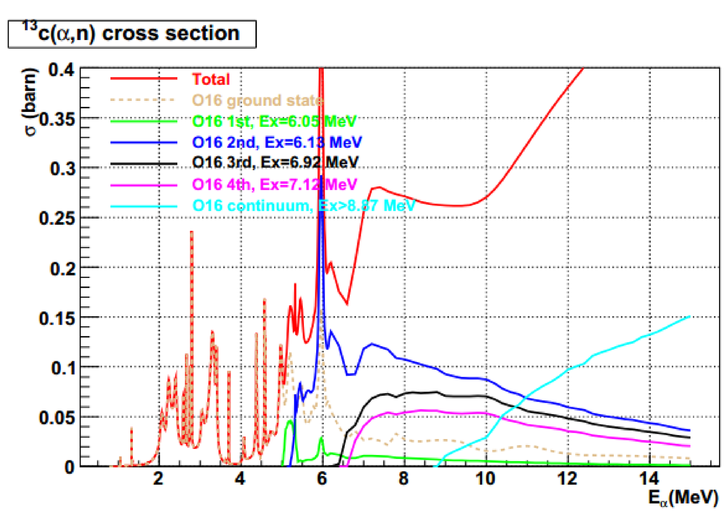
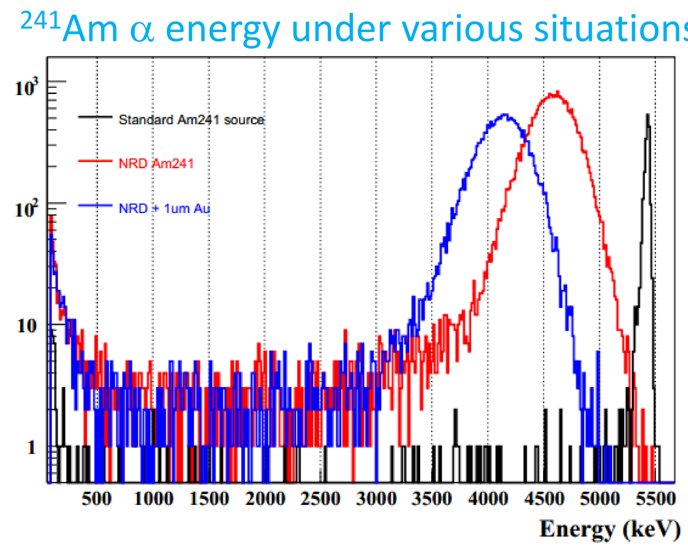
on behalf of the Daya Bay Collaboration

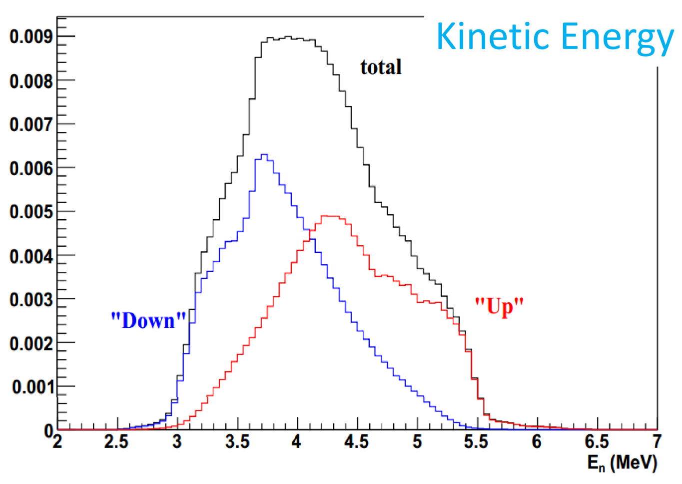
I. The ^{241}Am-^{13}C Neutron Source



^{241}Am α energy under various situations



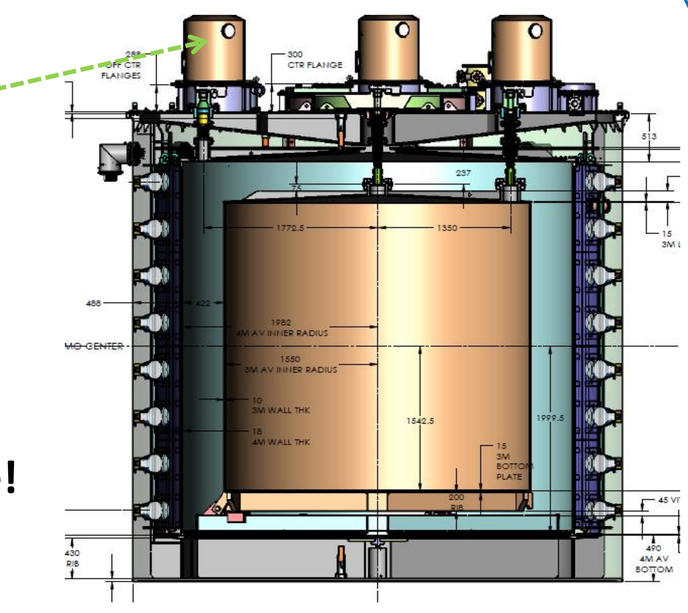
^{241}Am-^{13}C Neutron Kinetic Energy

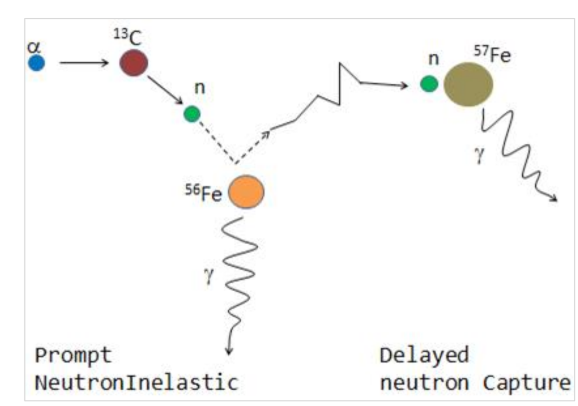


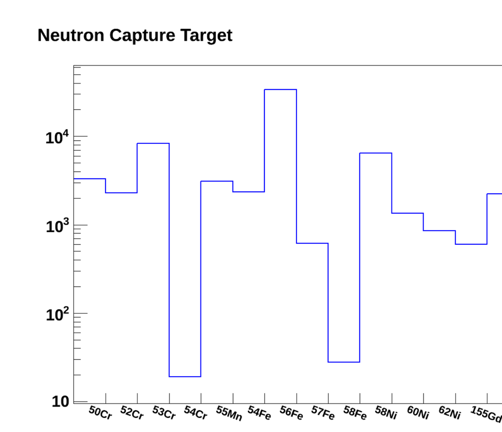
- Low rate (~0.7Hz) neutron calibration source via ^{13}C(α, n)
- Keep accidental background at the far site below 5%
- α energy attenuated to below 5.13MeV with 1um thick Au foil → Ground State (G.S.) neutron emission only (~4MeV kinetic energy on average), completely remove correlated n-γ emission

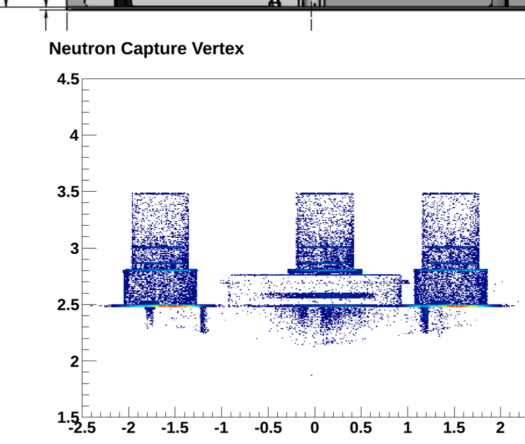
II. Formation of Correlated Background

- 3 Automated Calibration Units (ACU) on top of each Anti-neutrino Detector (AD)
- One ^{241}Am-^{13}C in each ACU
- Neutrons from ^{241}Am-^{13}C inelastic scattering and then being captured mimics the temporally correlated Inverse Beta Decay (IBD) signal
- **Dominant correlated background at the far site!**





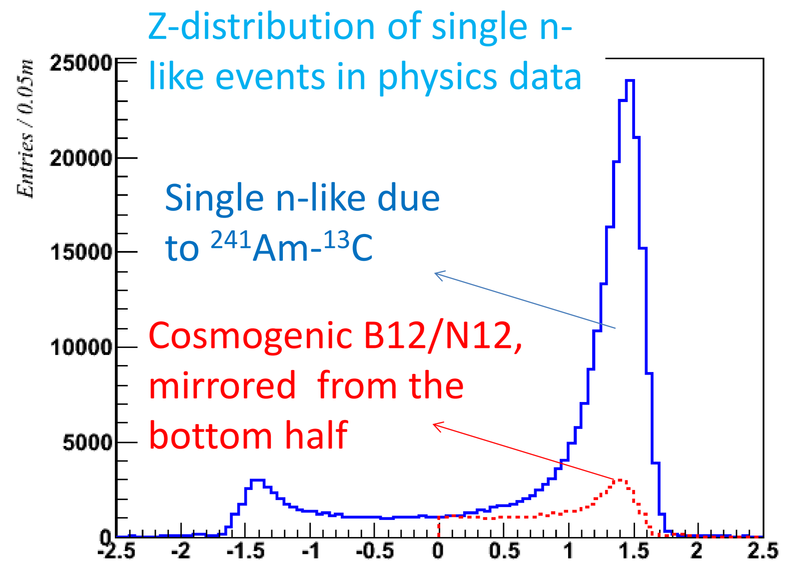




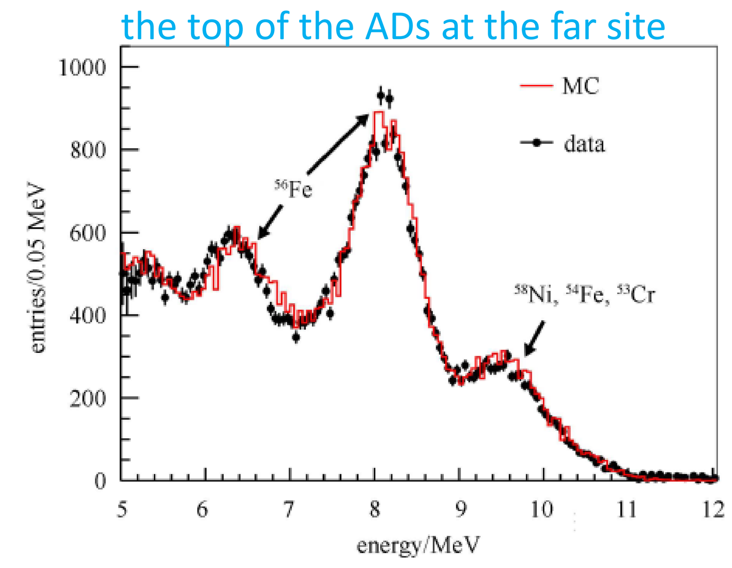
Neutron capture target and vertex from Monte-Carlo (MC) simulation.

III. Method to Determine Correlated Background

Z-distribution of single n-like events in physics data



Single n-like events spectrum near the top of the ADs at the far site

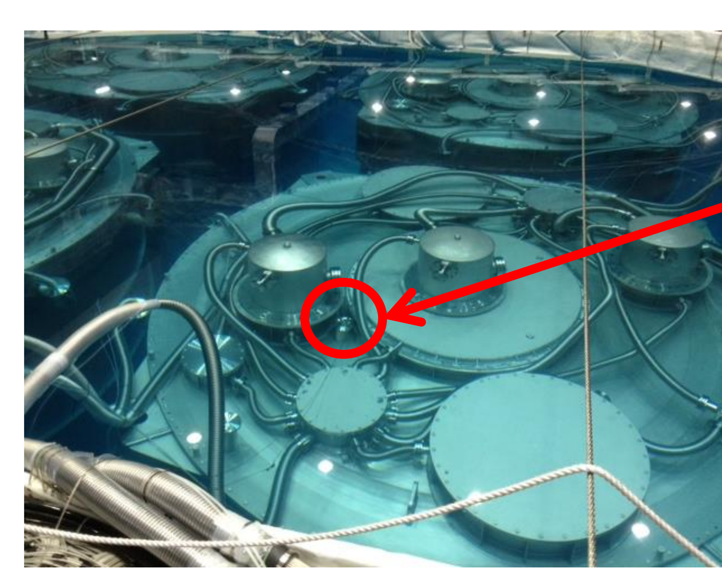


- Measure single neutron like (n-like) rate R_{single} from data
- Predict correlated rate R_{corr} using

$$R_{corr} = Yield \cdot R_{single}$$

Ratio of R_{corr} over R_{single} based on MC, constrained by benchmark measurement.

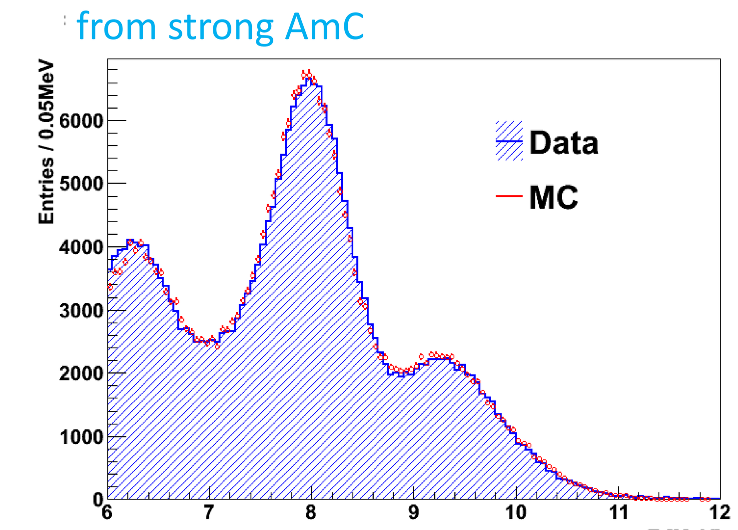
IV. Constrain Systematic Uncertainty with In-situ Benchmark Experiment



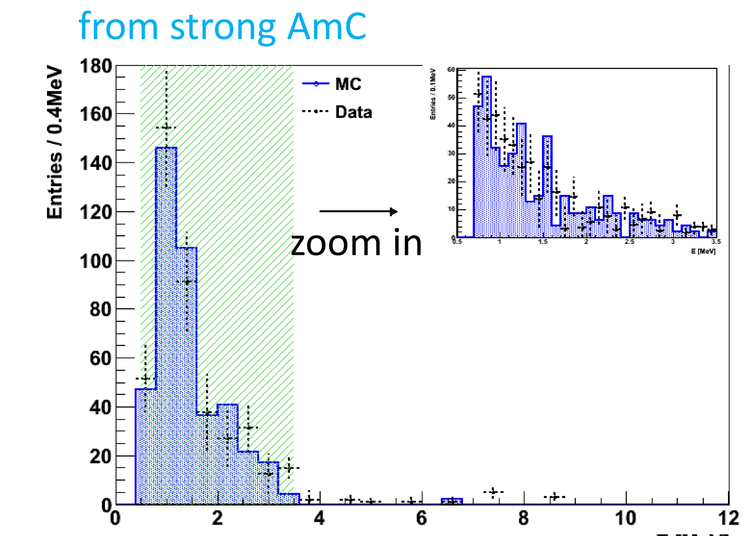
Strong AmC
A ~60Hz ^{241}Am-^{13}C source (80 times stronger than regular ones) with the same design deployed during summer 2012

Direct measurement of correlated background!

Single n-like spectrum from strong AmC



Prompt spectrum of correlated events from strong AmC

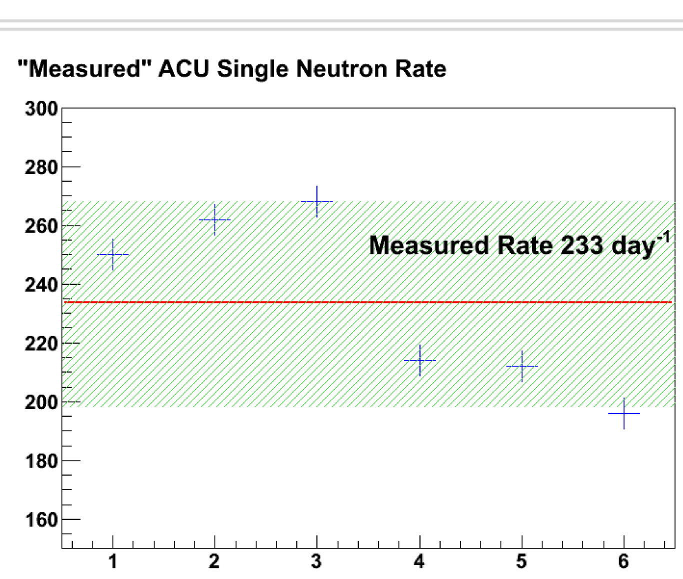


- Direct observation of correlated events!
- Good agreement of both single n-like and prompt spectrum of correlated events between data and MC!

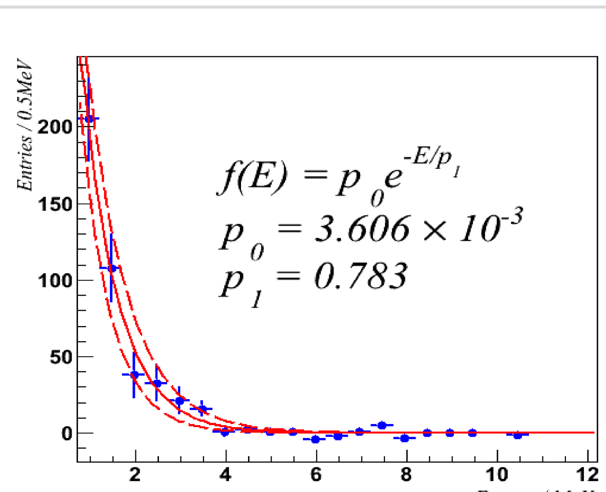
V. Evaluation of Uncertainty

Strong AmC	R_{single} (Hz)	R_{corr} (/day)	Yield
Data	0.48	60	$(1.5 \pm 0.3) \times 10^{-3}$
MC	0.34	35	$(1.2 \pm 0.1) \times 10^{-3}$

30% global uncertainty for *Yield*: 20% syst. + 20% stat.



- R_{single} for each AD is measured by subtracting events at the bottom half of the detector from the top half
- **30% uncertainty for R_{single}** to cover AD by AD variations



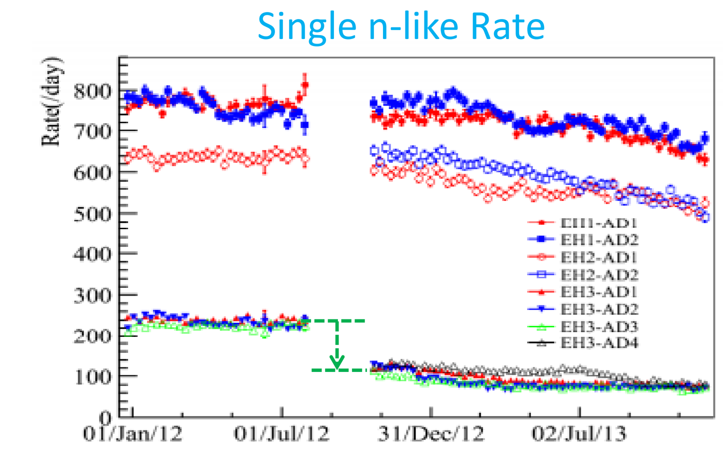
Background shape is based on parameterization of measured strong AmC spectrum by

$$f = p_0 \cdot e^{-\frac{E}{p_1}}$$

- **15% p_1 uncertainty** to encapsulate all possible shape variations
- *Yield*, together with R_{single}, determines **45% global rate uncertainty for p_0**

VI. Far Site Background Reduction

Single n-like Rate



- Removed ^{241}Am-^{13}C from off-center ACUs on all 4 far site ADs in summer 2012
- 80% decrease in ^{241}Am-^{13}C induced single n-like rate after summer 2012 (8AD period)
- Correlated background decreased by the same level accordingly

Far site

AmC background level relative to IBD signal	AD1	AD2	AD3	AD8	AD4	AD5	AD6	AD7
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

VII. Summary

- ^{241}Am-^{13}C background rate and shape at Daya Bay are estimated and constrained based on real data
- ^{241}Am-^{13}C background in 8AD period is largely reduced and is no longer the dominant correlated background at the far site
- Improved precision of oscillation parameter measurement

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