Precise Measurement of Reactor Antineutrino Oscillation with full dataset at Daya Bay

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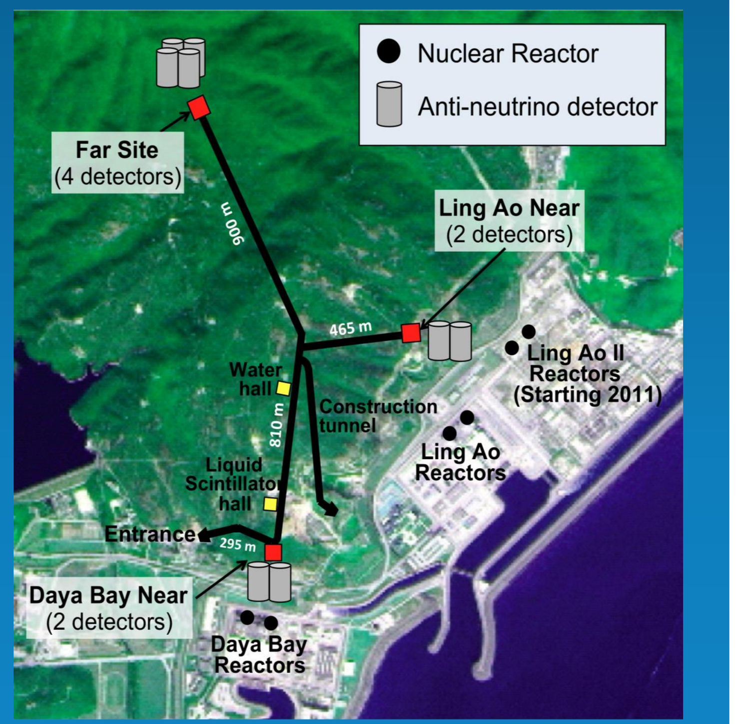
(on behalf of the Daya Bay collaboration)

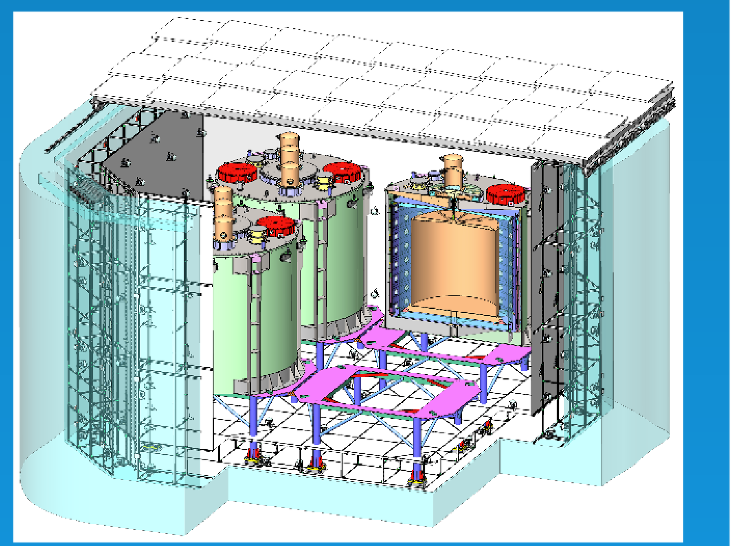
Daya Bay Reactor Neutrino Experiment

Daya Bay Reactor Neutrino Experiment was designed to precisely measure the neutrino mixing angle θ_{13}.

- Nuclear reactors produce a pure sample of electron antineutrinos
  - Six 2.9 GWth reactors in 3 nuclear power plants (NPP)
- 3 underground experimental halls (EHs) which house eight functionally identical antineutrino detectors (ADs)
  - 2 near halls (EH1 and EH2)
  - 1 far hall (EH3)
- Each near hall has two ADs, while the far hall has four.
- Each AD has 3 zones:
  - Gadolinium doped liquid scintillator (GdLS) - 20 tons
    - Target volume
  - Liquid scintillator (LS) - 22 tons
    - catcher and target volume
  - Mineral oil (MO) - 40 tons
    - Buffer hosting PMTs
- 192 8-inch photomultiplier tubes (PMTs)
- The ADs are submerged in a water pool to provide shielding and allows for muon vetoing
- Antineutrino interactions are detected in the ADs via inverse beta decay (IBD) process.



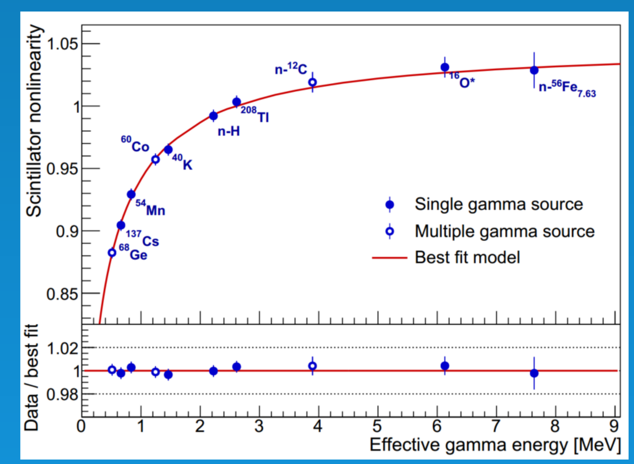
Daya Bay location



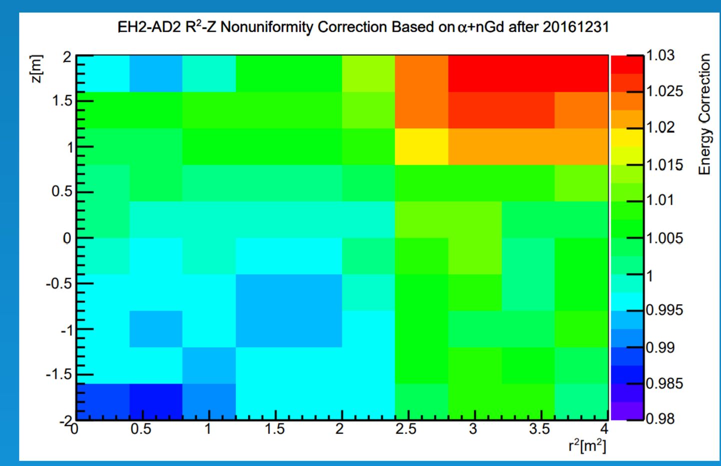
Daya Bay detector

Energy reconstruction

- Energy reconstruction: AdSimpleNL
  - correct electronic nonlinearity channel by channel before IBD selection
- Non-uniformity correction: alpha+nGd
  - Dead PMTs introduce local non-uniformity
  - Residual Earth magnetic field effect
  - Time-dependent non-uniformity correction based on nH overcorrects



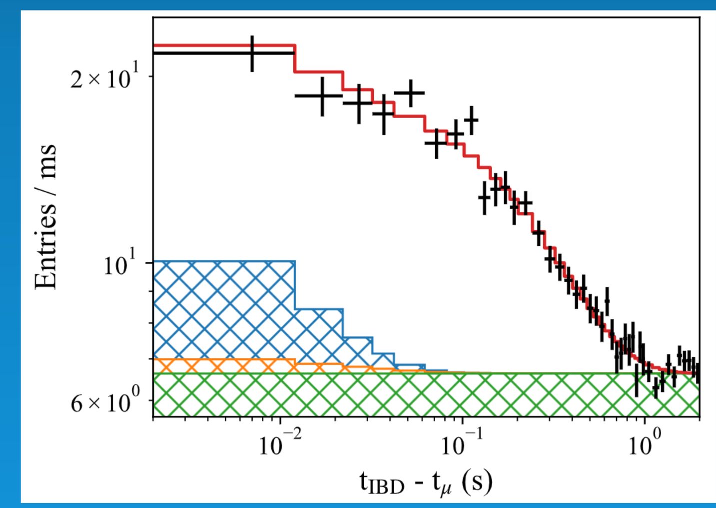
Nonlinearity with gamma source



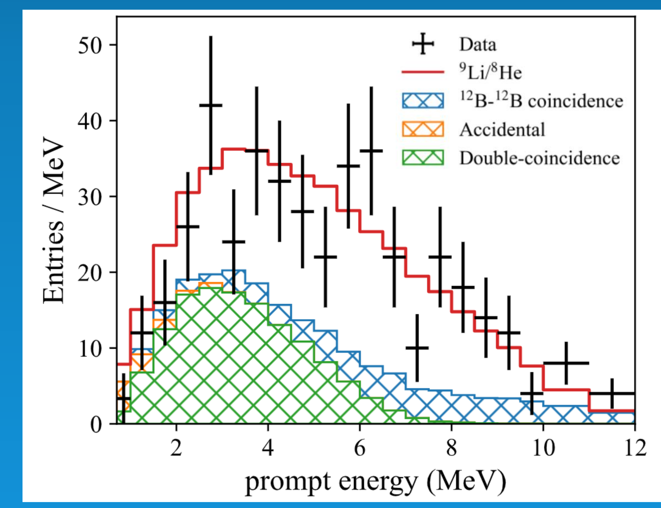
Correction map in EH2-AD2

^{9}Li/^{8}He background

- Modified estimation: three-dimensional time off window method
  - Use information: time gaps from the preceding muons, prompt energy, and distance between prompt and delay signals



Time to last muon



Prompt spectrum of background

Summary of background

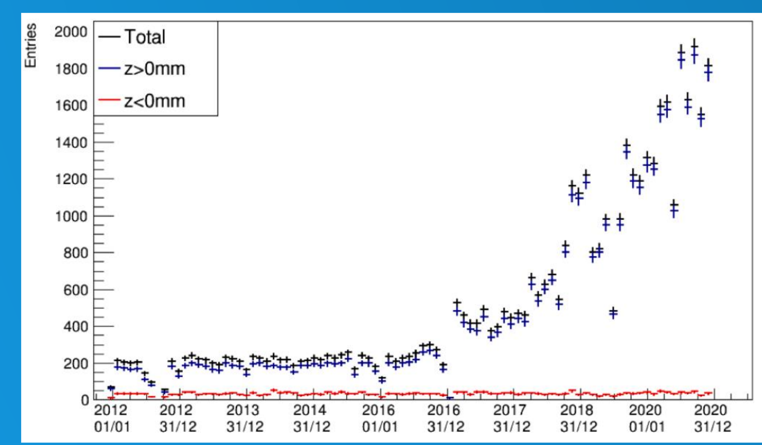
- Accidentals: two uncorrelated signals occasionally satisfied IBD criteria
- Fast neutrons: coincidence of fast neutron scatters and its capture
- ^{9}Li/^{8}He: unstable nuclide from cosmic muons
- ^{241}Am-^{13}C: from the calibration neutron source within ACUs
- ^{13}C(α,n)^{16}O: α from intrinsic radioactivity eject neutrons from nuclei
- New backgrounds after 2018
  - Residual flasher: new PMT flashers escaping from previous cuts
  - Muon-x background: coincidence of muon and Michel electron

Muon-x background

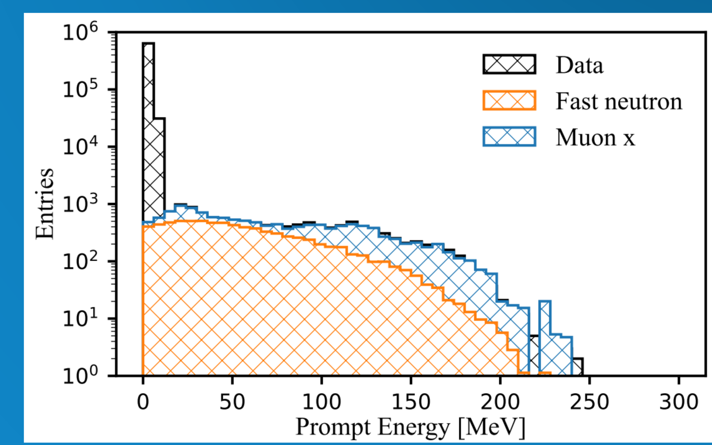
Cause: lower detection efficiency of inner water shield

Rate estimation: scale muon-x spectrum to fit extended IBD sample

Shape estimation: IWS tagging method



IBD rate in EH1-AD2 (IWS nHit > 12)

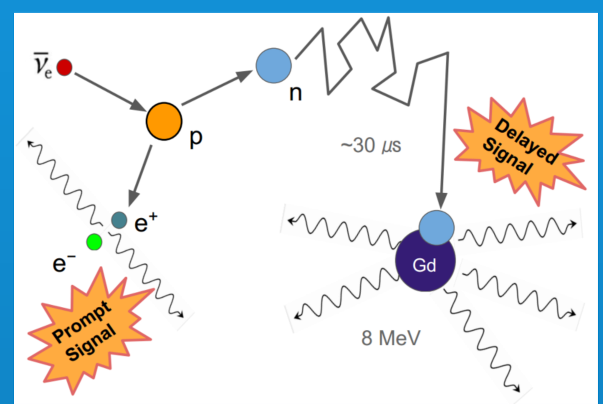


Spectra in EH1-AD2 in 7AD period

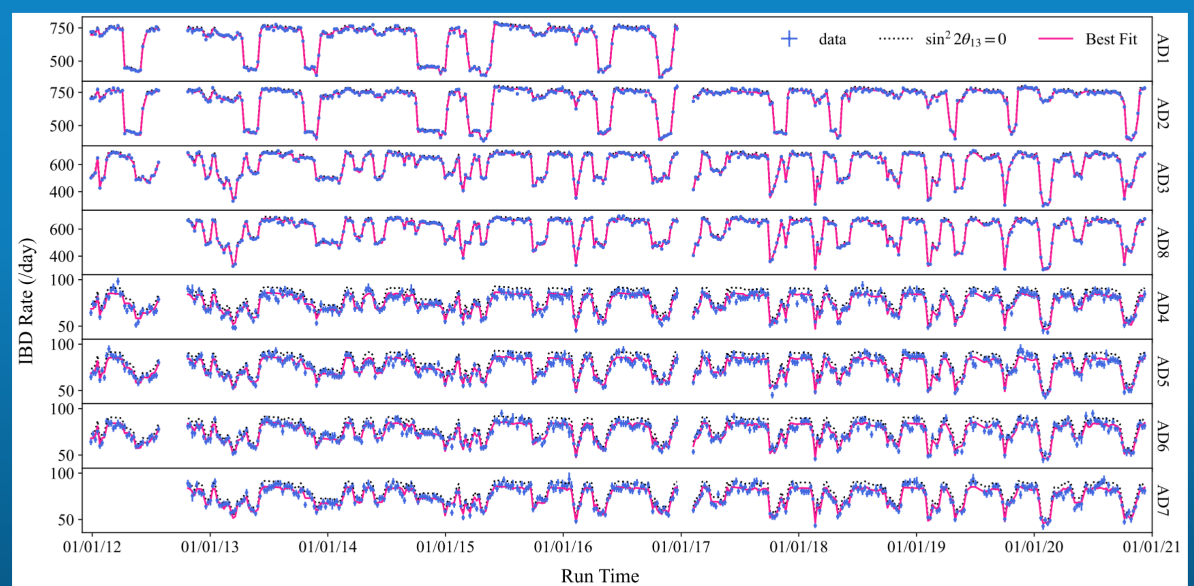
IBD selection and IBD rate

The double coincidence signature of IBDs allow for better selection against background.

- PMT flasher cut
  - New cut to remove residual flashers
- Muon veto cut
- Michel electron cut (IWS nHit > 6)
- Prompt energy cut: (0.7, 12.0) MeV
- Delayed energy cut: (6, 12.0) MeV
- Neutron capture time cut: (1, 200) μs
- Multiplicity veto



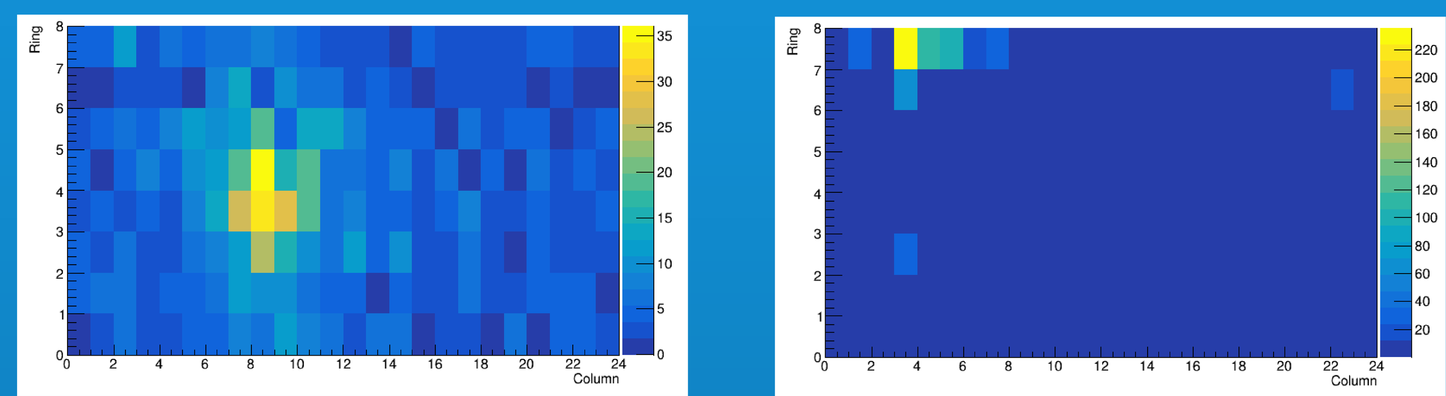
Schematic of IBD interaction



IBD rate with background subtraction in 8 detectors

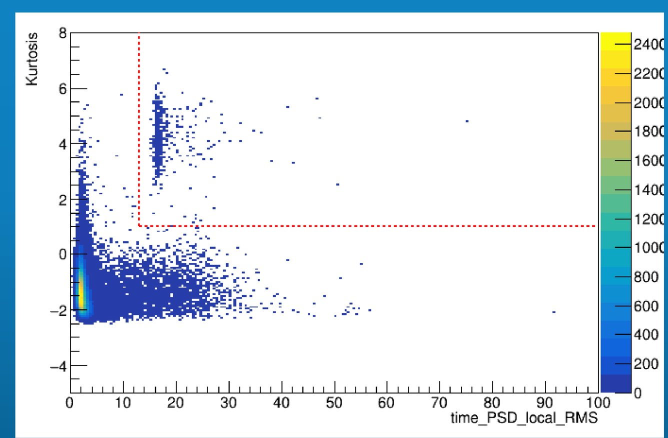
Residual flasher

- Flashers: separated by more than 0.3 s, and can't satisfy IBD coincidence cut
- Impact: overestimate accidentals rate



Charge patterns of physics events (left) and residual flashers (right)

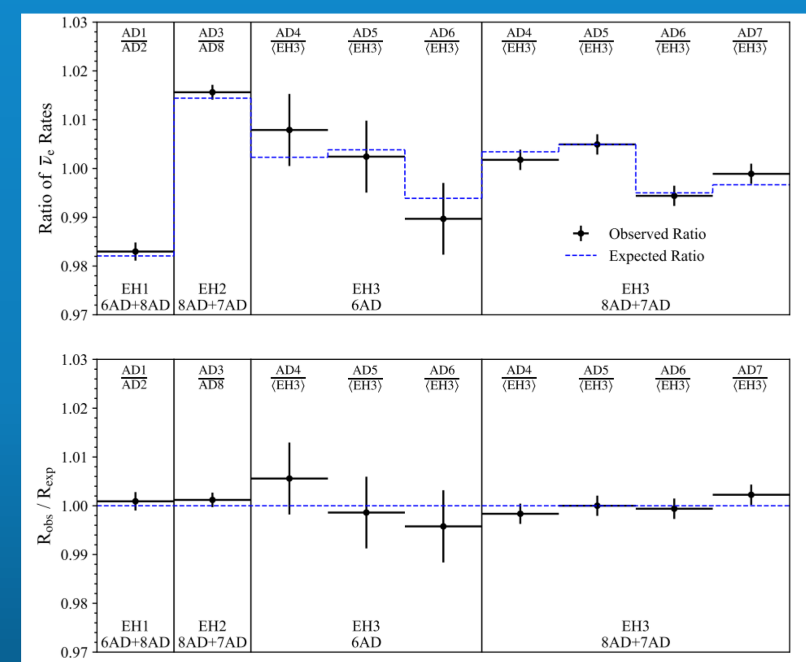
- Features of flashers:
  - Large quantities of charge converges on one specific PMT
  - Located on the top of the detector
- New flasher cut: mentioned in section II
- Inefficiency of the cut for IBD < 0.005%
- Systematic uncertainty is negligible



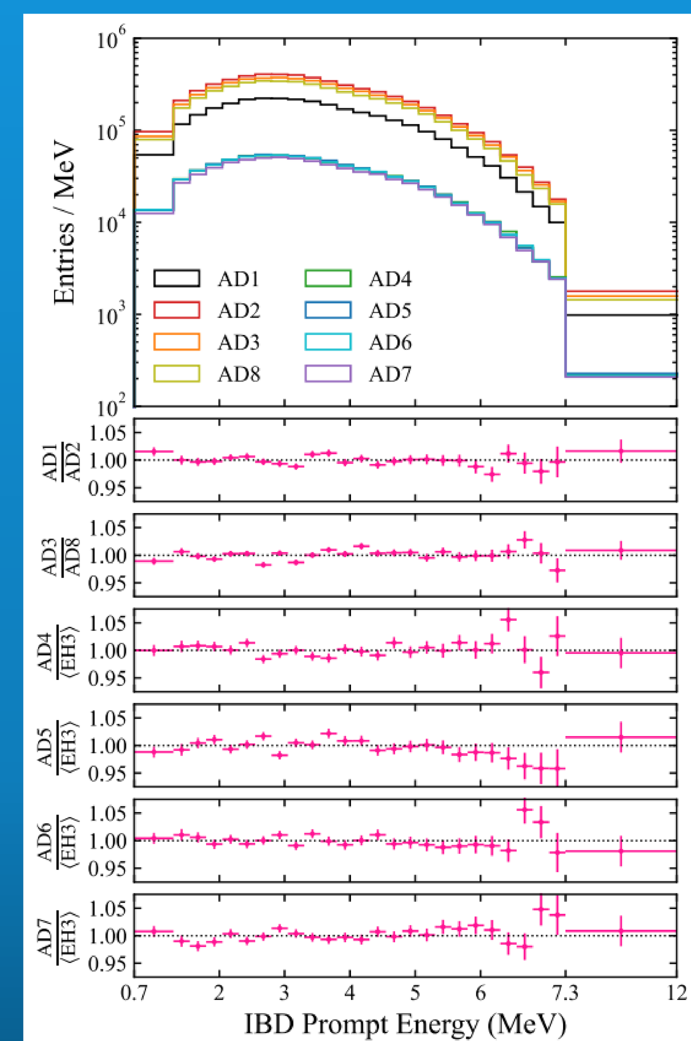
Distribution of time_PSD_local_RMS vs Kurtosis

Side by side comparison

- Both the measured IBD rate and prompt energy spectra are consistent for the side-by-side ADs in the same experimental hall.



Ratios of IBD rates



Prompt energy spectrum

Neutrino2022

The latest oscillation analysis results will be reported in the plenary meeting on June 1st.

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