Towards a Precise Determination of the Reactor Antineutrino Flux at Daya Bay

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on behalf of the Daya Bay Collaboration

Detection of Antineutrinos

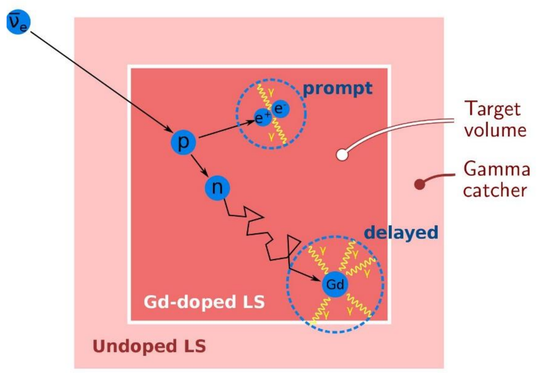
- Antineutrinos are detected via Inverse Beta Decay (IBD)
- Prompt-delayed coincidence between positron and neutron

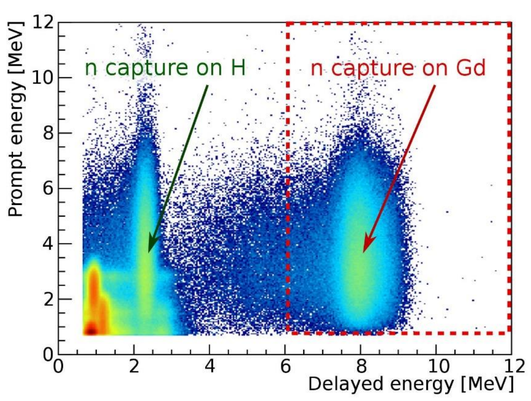
$\bar{\nu}_e + p \rightarrow e^+ + n$

$\tau \approx 30\mu s$

$n + p \rightarrow D + \gamma$ (2.2 MeV)

$n + Gd \rightarrow Gd^* \rightarrow Gd + n\gamma$ (8 MeV)

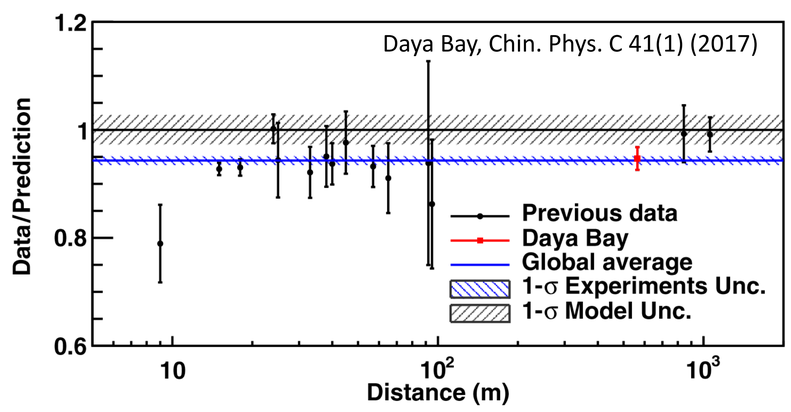




"Reactor Antineutrino Anomaly" (RAA)

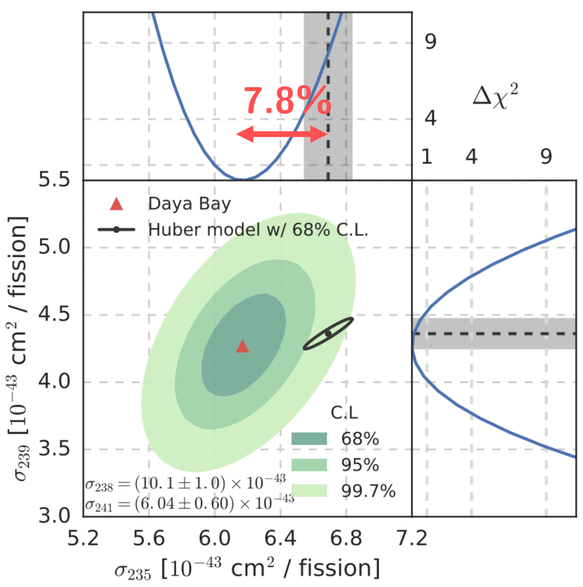
In 2011, improved theoretical treatment of reactor antineutrino flux by Huber and Mueller (HM) *et al*.

- Daya Bay observed a flux deficit in comparison to the HM flux: 5.4% ± 2% (exp.)
- Past global average: 5.8% ± 0.9% (exp.)



- Possible explanation
  - The existence of eV scale sterile neutrinos!
  - Systematic uncertainties in reactor flux calculations

  Daya Bay data implies that HM flux overestimates the antineutrino flux from ^{235}U (Phys. Rev. Lett. **118**, 251801)

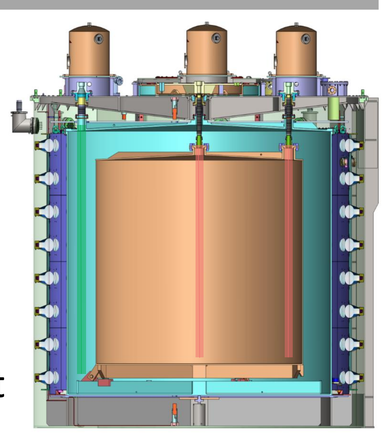


Systematic uncertainties
- detection efficiency (dominant!)
- reactor related
- statistics

Neutron Calibration Campaign

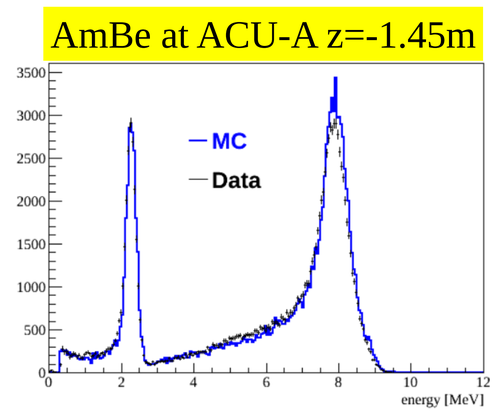
- At the end of 2016
- AmC and AmBe source
- Along three z-axes of the automated calibration units (ACUs)
- Target: improve the IBD detection efficiency (x2)

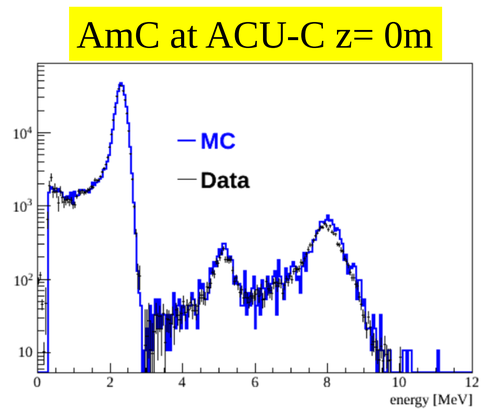
⇒ more precise reactor flux measurement



Data and MC Comparison

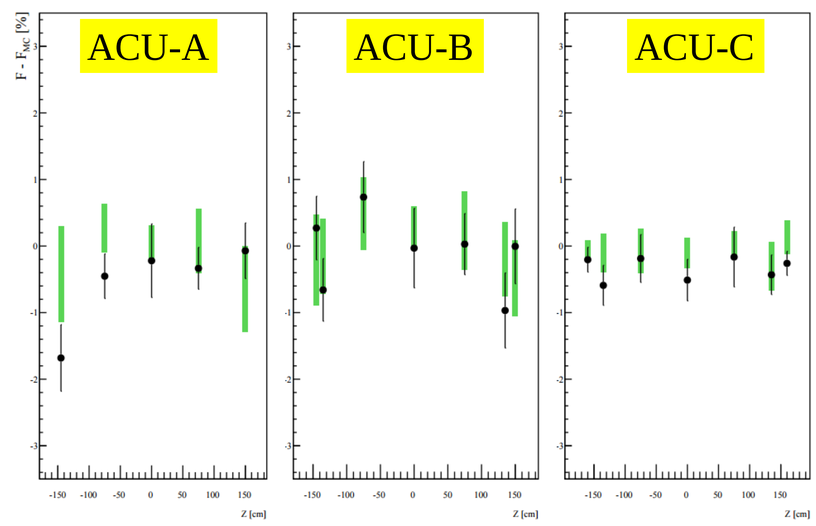
- Delayed energy spectra at two edgy locations





- Efficiency

  F = N([6,12]MeV) / N([1.5,12]MeV)
- Efficiency difference between data and MC along three z-axes. Reasonable agreement with MC

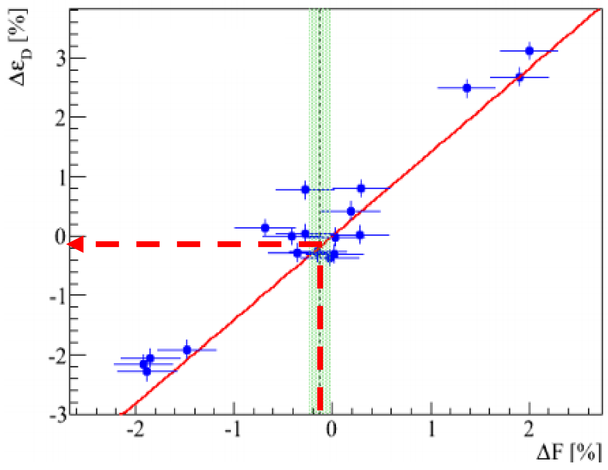


Green bar: systematic uncertainty from model variation in MC

Efficiency Correction for IBD

- The physics models were varied in the simulation
  - neutron transportation
  - n-Gd capture γ spectrum

  common systematics for IBD and neutron sources!



IBD and neutron source efficiency correlated for given model in the MC

- Measured neutron source efficiency ⇒ correction to IBD
- Different subsets of calibration data

  ⇒different correction

  ⇒ systematic uncertainty

Summary

- The RAA is being probed experimentally at Daya Bay
  - The incorrect theoretical prediction for ^{235}U may be responsible for RAA
- An elaborate neutron calibration campaign was performed at Daya Bay in 2016, aiming to further improve the IBD detection efficiency

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