Introduction

A method of extracting a model-independent reactor antineutrino spectrum from measured inverse beta decay (IBD) events is developed and examined with Monte Carlo (MC) simulation. Multiple methods are investigated to obtain the antineutrino spectrum from the measured IBD prompt spectra. This antineutrino spectrum could be used to replace current models for predicting fluxes and energy spectra. A method to predict the antineutrino flux and spectrum for experiments of slightly different effective fission fractions is presented.

Spectrum Unfolding

Unfolding is to estimate the true spectrum $T(x)$ from a measured spectrum $M(y)$ and the detector response matrix $A(y,x)$ by correcting spectrum distortion due to detector effects, such as energy resolution.

\[ M(y) = \int A(y,x) T(x) dx. \]


Bias Estimation with Blinding Tests

Toy-MC is used in blinding tests to estimate bias from unfolding. 10,000 “measured” spectra are generated including detector effects and statistical fluctuations and then unfolded with both Bayesian and SVD methods. Mean of bin-by-bin bias is within 1% when using both Bayesian and SVD methods.

Antineutrino Spectrum Study at Daya Bay

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### Spectrum Unfolding

#### Measured IBD prompt energy spectrum: three near site detectors are combined.

#### Detector response matrix: from Geant4 MC (4M events)/Toy-MC (10M events)

#### Covariance matrix includes:
- Systematic, statistical and background subtraction uncertainties
- Detector response matrix includes:
- energy resolution, energy leakage. Nonlinearity and non-uniformity are corrected.

#### Bias of SVD method

Bias of SVD method is within 1% when using both Bayesian and SVD methods.

#### Bias of Bayes method

Bias of Bayes method is within 1% when using both Bayesian and SVD methods.

#### Generic Antineutrino Spectrum

For any reactor experiments that have similar effective fission fractions as those of Daya Bay, the predicted antineutrino spectrum $S_X$ is:

\[ S_X = S_{DYB} + \sum_i (a_k^i - a_{DYB}^i) S_{ILL} \]

Where $S_{DYB}$ is the generic spectrum from Daya Bay; $a_{DYB}^i$ are fission fractions from Daya Bay; $a_k^i$ are fission fractions of experiment $X$; $S_{ILL}$ are isotope spectra from ILL/Huber model.

#### Summary

Different unfolding methods, which are examined with toy MC and tested with measured IBD prompt spectra, yield consistent results. A method of extracting a generic spectrum from measured IBD spectra is developed. This antineutrino spectrum could be used for predicting antineutrino fluxes and spectra for other experiments.

References: