Precision Measurement of the Reactor Flux and Spectrum at Daya Bay

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The Daya Bay Collaboration

Daya Bay collects reactor antineutrino data at a tremendous rate which enables a precision measurement of the reactor antineutrino spectra in the near site detectors. The Daya Bay experimental configuration allows spectral and flux measurements as close as 360m from the reactor cores at the Daya Bay site and 480m at the Ling Ao site. At these detector locations the measured reactor antineutrino flux from the nearest reactor cores remains largely non-oscillated in the standard 3-neutrino oscillation framework. The contribution from the more distant reactors at ~900m is approximately 20% (7.5%) of the total event rate at Daya Bay (Ling Ao). The oscillation effects from the far reactor can be corrected for in any spectral analysis assuming a 3-neutrino framework. With this detector configuration Daya Bay will be able to report the following measurements and physics analyses:

1. **Highest-precision measurement of the reactor antineutrino spectrum** in a reactor antineutrino experiment. An <1% statistical uncertainty is achievable in a 2-year run over a large range of energies at the near sites.
2. **Test of the reactor antineutrino spectrum and search for new antineutrino interactions:** Using known reactor data such as thermal power output and fission fraction evolution from reactor core simulations Daya Bay can predict the expected non-oscillated spectral shape of reactor antineutrinos emitted from each reactor. A precise comparison of the spectral prediction with the Daya Bay measurement will test our understanding of reactor antineutrino spectrum calculations and reveal potential shape effects. *Shape discrepancies may point to (a) missing nuclear physics in the reactor spectrum predictions or (b) new physics beyond the 3-neutrino framework including non-standard interaction (NSI) effects.* Daya Bay can search for new antineutrino interactions through comparison of the measured and expected reactor spectra. Understanding the shape of the measured and predicted reactor spectrum is a pre-requisite to any absolute reactor flux measurement. Due to the high statistics of the Daya Bay measurement, the statistical uncertainty in the 2011–2012 Daya Bay data set is already below the flux conversion uncertainty on the spectrum.
3. **Absolute reactor flux measurement:** In addition to a shape analysis, an absolute flux measurement tests our understanding of reactor flux predictions and can, in principle, shed light on the issue whether there is an apparent deficit in the measured reactor neutrino flux at short baselines, also known as the "reactor anomaly". An analysis of past measurements and reactor flux predictions has revealed a discrepancy of about 5.7%. While Daya Bay has demonstrated superb relative detector uncertainties, an absolute measurement will be systematics limited. A statistical precision of 0.1% will be achievable. Improvements in the analysis may eventually reduce absolute detector uncertainties to <1%. An absolute flux measurement will be limited by our knowledge of the reactor flux normalization: this includes a theoretical uncertainty of 2.7% in the reactor flux predictions. One can compare Daya Bay data to previous reactor flux measurements by "anchoring" it to the absolute Bugey-4 measurement with an uncertainty of 1.4%. Daya Bay's measured flux and spectrum will provide important input to test the reactor anomaly.
4. **Study of the time-evolution of the reactor antineutrino flux**: The large reactor antineutrino event rate measured at Daya Bay allows a detailed study of the time variation of the reactor antineutrino flux. This contains information on the operation of the reactors as well as the evolution and isotopic composition of the core fuel. Correlating the measured antineutrino flux with reactor operations is of interest to reactor monitoring, the safeguard community, and applied neutrino science. With six reactors and 4 near-site detectors Daya Bay will provide the largest data set on reactor flux variations as a function of time.