



PROSPECT A reactor oscillation and spectrum experiment at HFIR

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Neutrinos for Nuclear Physics



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Predicting Neutrino Flux/Spectra



Two main approaches:

- · Ab-initio
 - Calculate individual beta-decay spectra for 1000s of isotopes from database info
 - Sum according to cumulative yields
 - Problem: databases have huge uncertainties
- · Beta-conversion
 - Measure cumulative beta spectra from fission parents
 - Use virtual beta-branches to convert into neutrino spectra
 - Problem: can virtual branches capture all relevant physics?

General agreement between experiment and theory until...



Reactor Anti-Neutrino Anomalies

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The PROSPECT Experiment



Physics Goals:

Search for short baseline $\overline{\nu_e}$ oscillations using detector segmentation

- · Distortions in energy spectrum that vary with baseline
- Independent of reactor model predictions
- Measure ²³⁵U antineutrino spectrum to resolve the spectral anomaly



Experimental Strategy:

- Phase 1:
 - Sterile neutrino search, cover best fit region at 4σ in 1 year
 - World-leading ²³⁵U spectrum with ~100k events/year
- Phase 2: Detailed investigation of oscillation if evidence for steriles
 Challenges:
- Minimal overburden, cosmogenic backgrounds
- Reactor-related backgrounds
 - High energy (≲10MeV) gammas

HFIR Research Reactor





- High Flux Isotope Reactor at Oak Ridge National Lab
- ORNL also active in TAGS measurements of key isotopes
- 85MW HEU compact-core reactor, 42% uptime
- PROSPECT activity for past 3 yrs
- Backgrounds fully characterized NIMA 806 (2016)











BG Rejection via Detector Design prespect



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Short Baseline Oscillation Search



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²³⁵U Spectrum Measurement





- Only existing measurement of ²³⁵U is from ILL in 1981 (5k events total)
- PROSPECT: ~700 inverse beta decays detected per day, 100k/year
- Best energy resolution of any reactor neutrino experiment (4.5%@1MeV)
- Phase-1 precision will surpass spectral model uncertainties
 - Directly test reactor neutrino models
 - Produce a benchmark spectrum for future reactor experiments

Probing the Spectral Anomaly



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Summary and Outlook



- The reactor flux and shape anomalies remain unresolved after precision θ_{13} experiments
- These may offer a window to new physics beyond the SM
- ORNL is a unique location for neutrino physics, providing complementary work between nuclear and reactor physics
- PROSPECT will measure the ²³⁵U spectrum with the highest precision to-date
- PROSPECT will make a model-independent search for sterile neutrinos and test best fit point at 4σ within its first year
- HEU and LEU spectra can be compared to probe root cause of the spectral anomaly



Publications: arXiv: 1309.7647, 1506.03547, 1508.06575, 1512.02202

http://prospect.yale.edu