



Joint Isotope-Dependent Analysis of the Daya Bay and PROSPECT Reactor Antineutrino Spectra

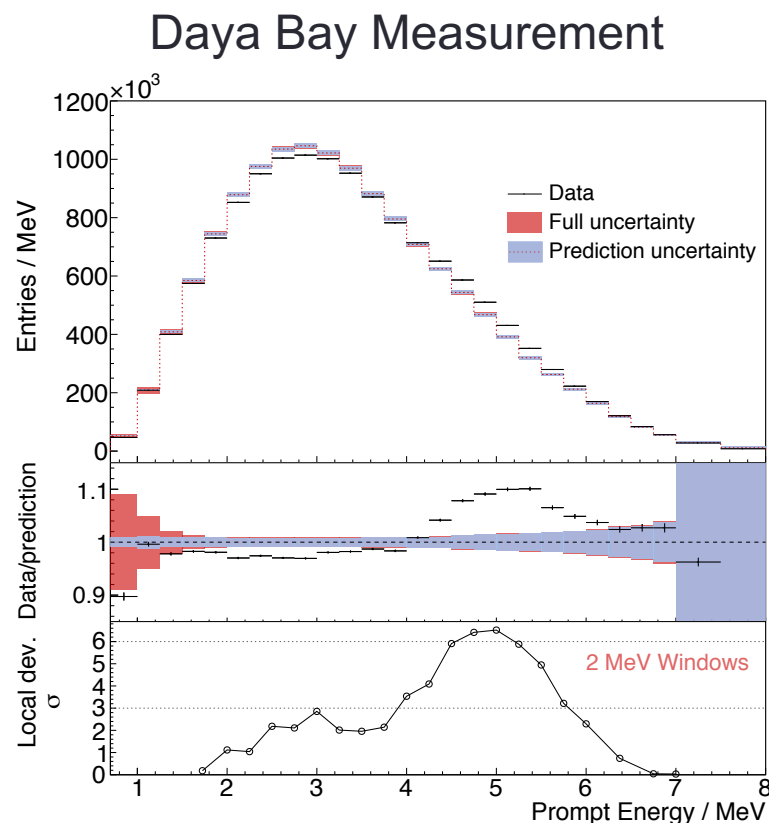
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Model - Measurement Disagreements

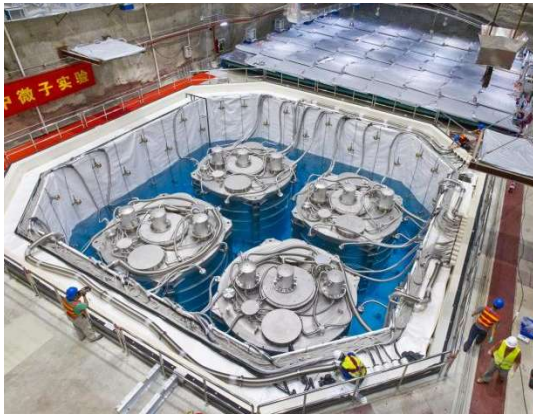
- Recent measurements of the neutrino energy spectrum from nuclear reactors deviates from model predictions
- What are the contributions from each fissile isotope?
- Deficiencies in the model prediction / input databases?
- More precise spectral measurements are needed to help resolve these issues**



Reactor Measurements

- Neutrinos identified via inverse beta decay (IBD)
- Detect positron events in coincidence with neutron events as tagged by neutron capture agent to determine neutrino energies
- Multiple recent experiments have measured ^{235}U neutrino energy spectra

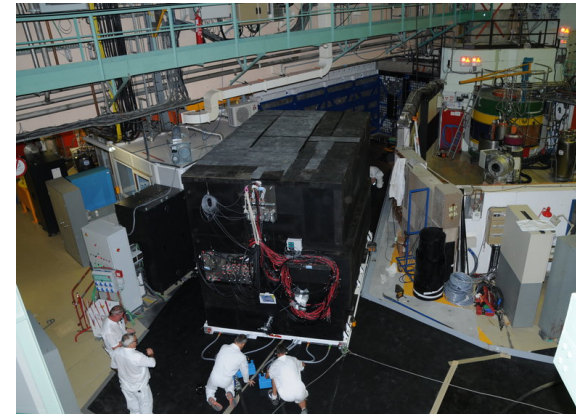
Daya Bay



PROSPECT



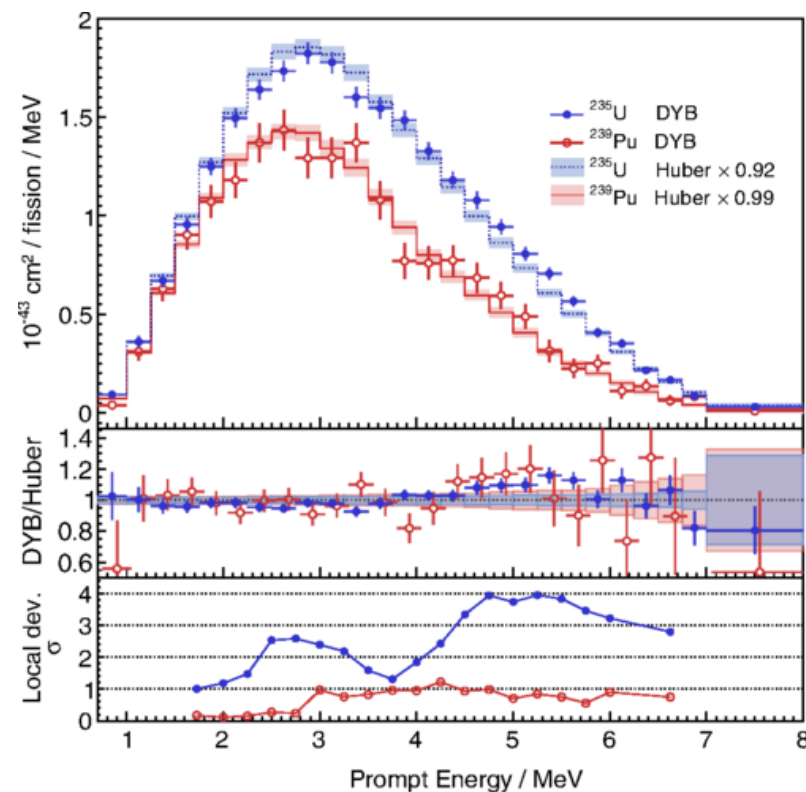
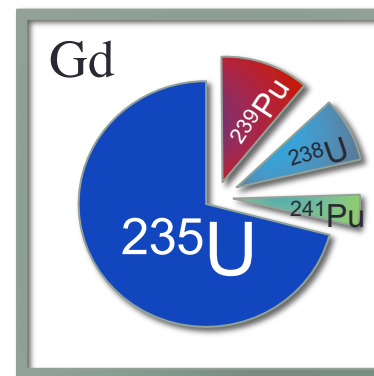
STEREO*



*More information on joint PROSPECT + STEREO analysis in [next talk by B. Foust](#)

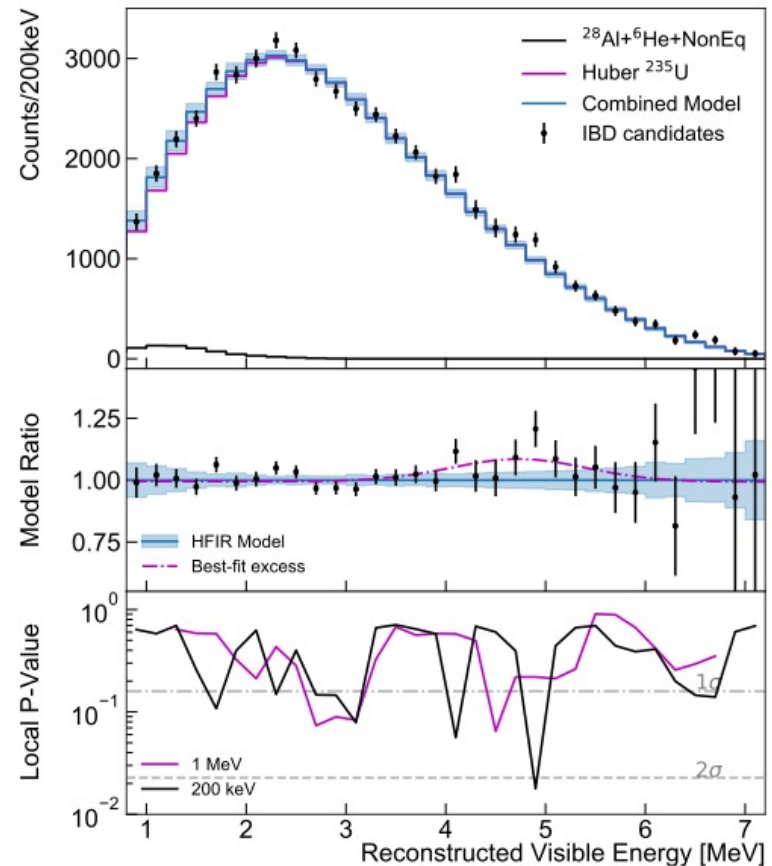
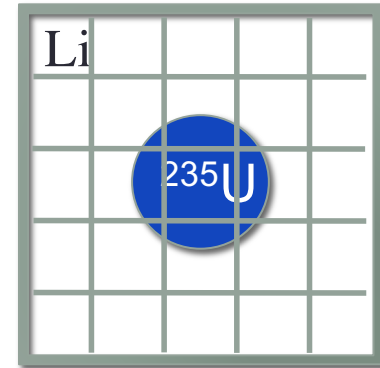
Daya Bay

- Gd-loaded scintillator
- Multiple monolithic detectors
- Hundreds of meters from source
- 3.5 million antineutrinos detected
- Measurement of Low Enriched Uranium (LEU) power reactors with evolving fuel composition
- ^{235}U spectrum extracted from full measured spectrum using isotope fission fraction information and model constraints on ^{238}U and ^{241}Pu



PROSPECT

- Li-loaded liquid scintillator
- Single, segmented detector
- 96 days of reactor-on data taking
- 50,000 antineutrinos
- ~10m from HEU reactor, direct measurement of ^{235}U



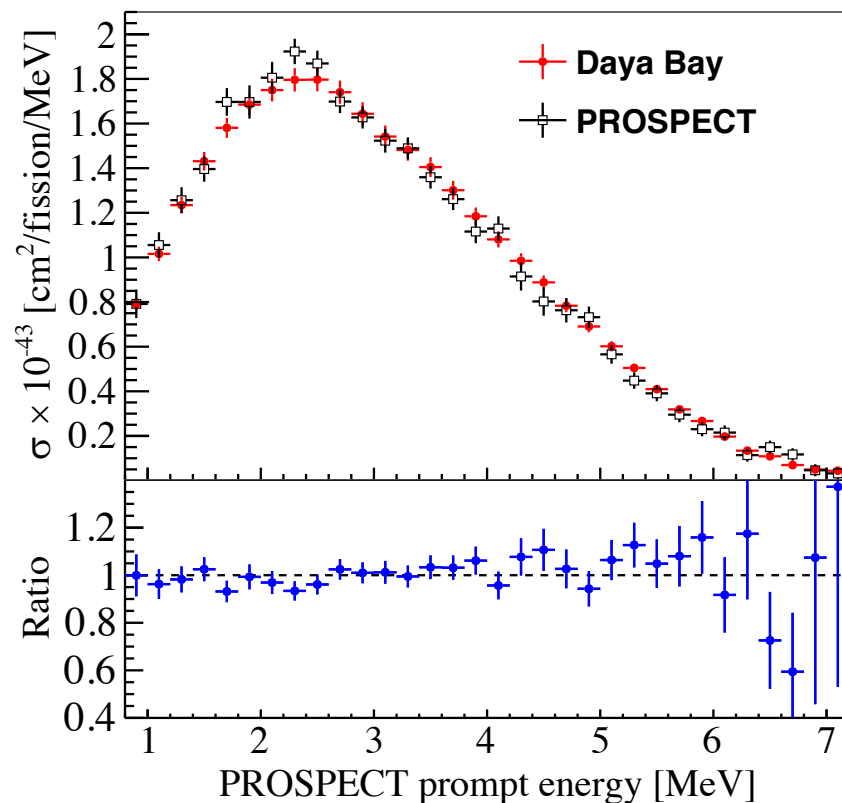
Prompt Energy Definitions

- Published neutrino spectra are in different energy spaces, and must be transformed in order to compare and combine
 - Daya Bay: positron energy
 - PROSPECT: visible energy in detector
- Measurements cannot be directly compared as is, but can be mapped from one energy space into the other through detector response functions

$$\mathbf{R}^{\text{map}} = \mathbf{R}^{\text{PRO}} (\mathbf{R}^{\text{DYB}})^{-1}$$

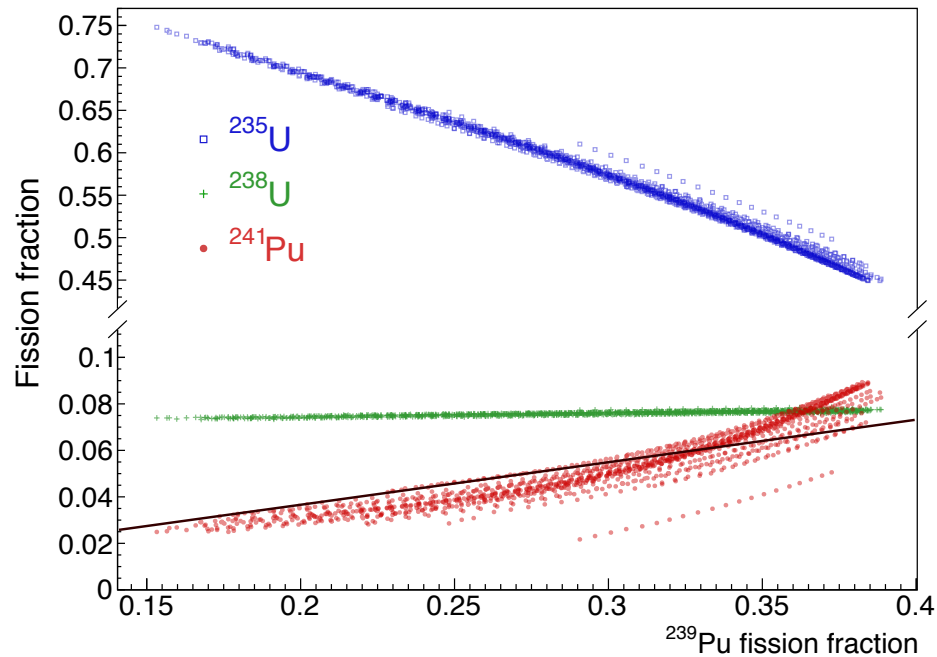
Prompt Shape Compatibility

- PROSPECT rate scaled to match Daya Bay
- $\chi^2/\text{dof} = 25.4/31$
- p-value of 0.75
- **Daya Bay and PROSPECT ^{235}U measurements in good agreement**



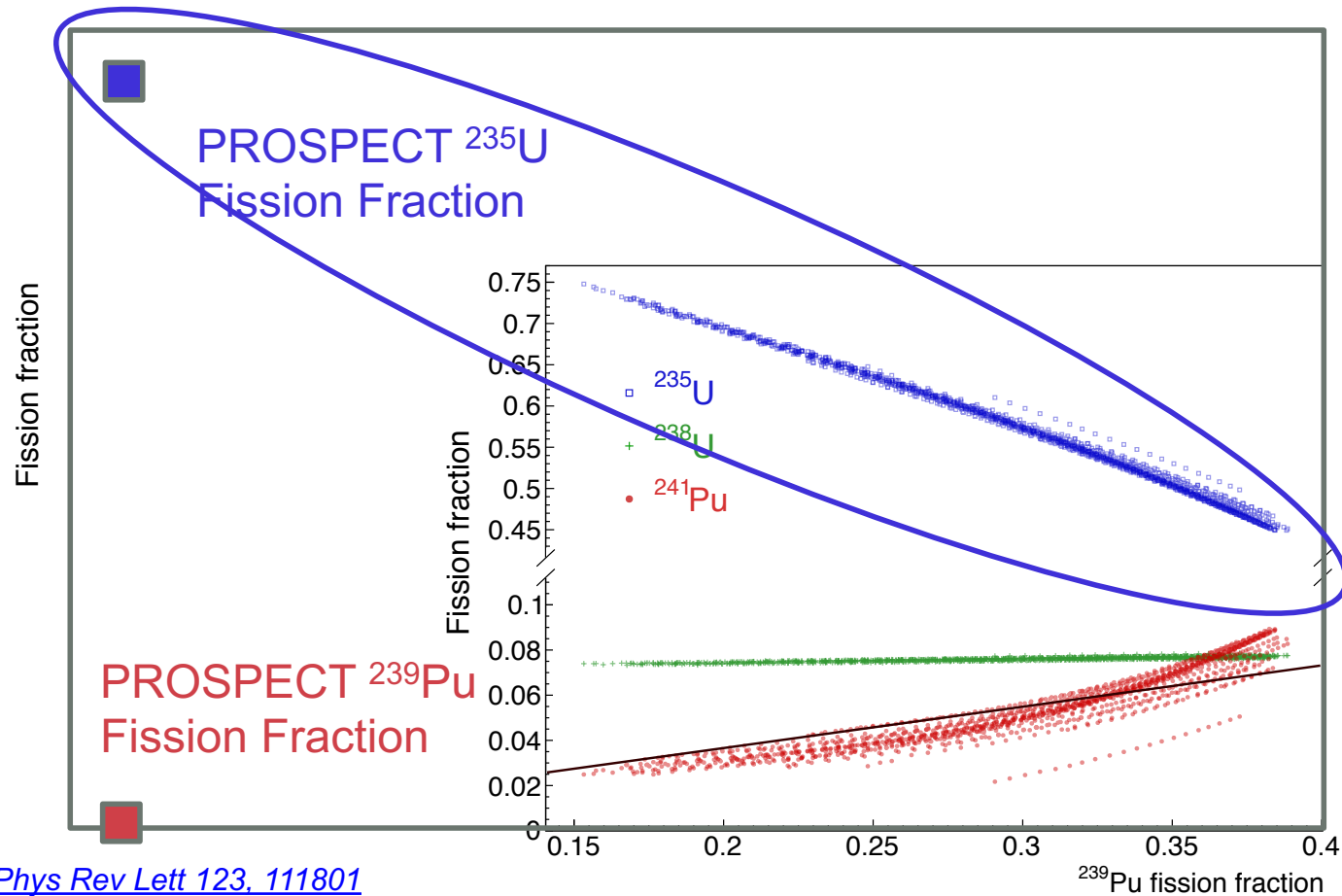
Spectral Deconvolution with Evolving Fission Fractions

- Daya Bay total spectrum grouped by fission fraction and used to deconvolve ^{235}U and ^{239}Pu contributions



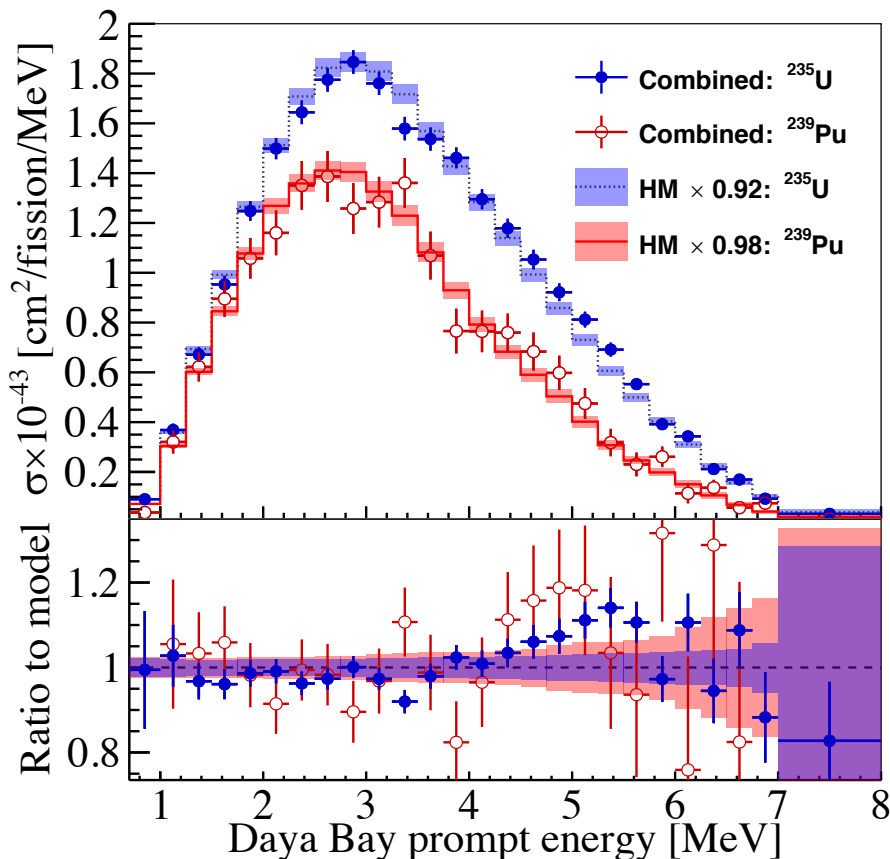
Spectral Deconvolution with Evolving Fission Fractions

- Pure ^{235}U measurement from PROSPECT constrains Daya Bay isotopic deconvolution



Deconvolved Prompt Energy Spectra

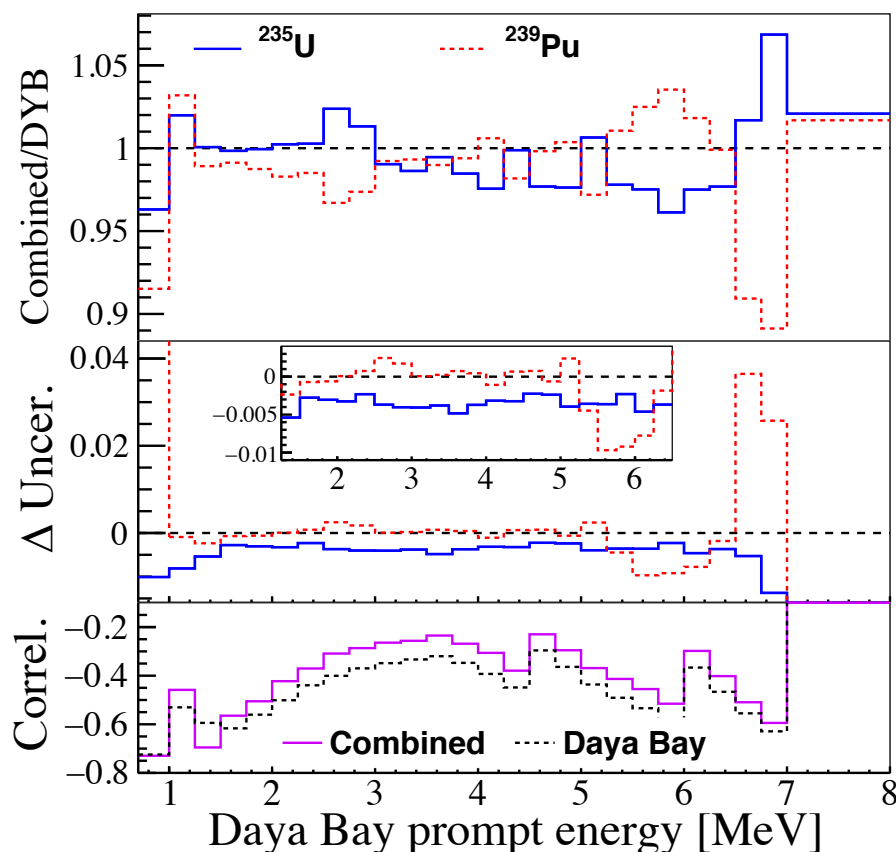
New Results



- New results consistent with previous results
- Local deviations from scaled model (2 MeV wide windows) increase by 0.2-0.5 σ at all energies for ^{235}U
- No significant change for ^{239}Pu

Improvements from Previous Work

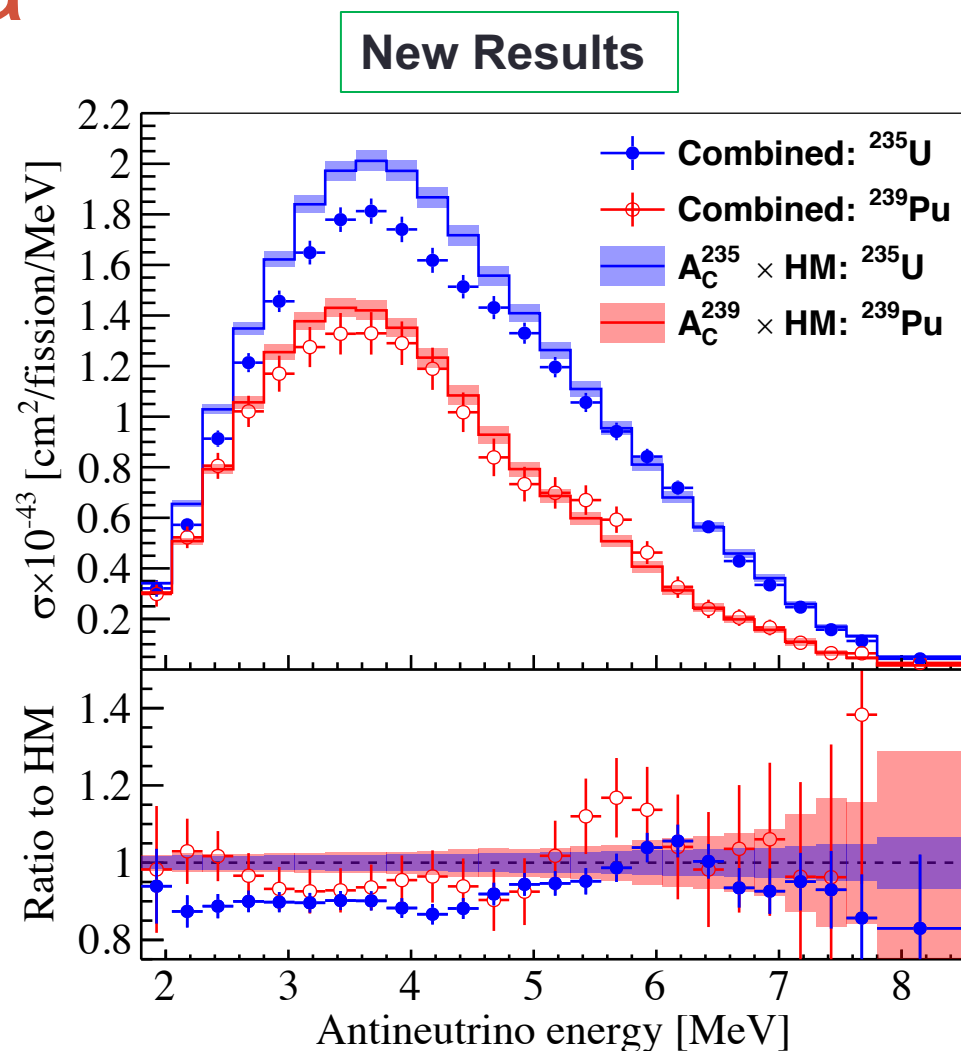
Difference from Previous Results



- Relative shape uncertainty of ^{235}U improves to 3%, no significant change to ^{239}Pu shape uncertainty
- Isotopic degeneracy improved by $\sim 20\%$

Unfolded Spectra

- Deconvolved spectra unfolded and regularized via Wiener-SVD* technique
- A_C smearing matrix encodes effect from unfolding regularization into any model
- Rate constraint from Daya Bay



*[W. Tang et al, JINST 12, P10002 \(2017\)](#)

Conclusions

- Precision measurements needed to resolve tension between current models and measurements of reactor antineutrino spectra.
- Daya Bay and PROSPECT ^{235}U measurements are compatible with each other.
- A jointly deconvolved reactor antineutrino spectrum improves both ^{235}U shape uncertainty to 3% and ^{235}U - ^{239}Pu correlations are reduced by $\sim 20\%$ from Daya Bay-only results.



Thanks!

See Other PROSPECT Talks:

[Latest Reactor Antineutrino Spectrum and Boosted Dark Matter Results: P. Weatherly](#)

[Reactor Position Reconstruction Study: D. C. Venegas-Vargas](#)

[Joint Analysis by PROSPECT and STEREO: B. Foust](#)

[Physics Opportunities with a PROSPECT Upgrade: R. Carr](#)

