

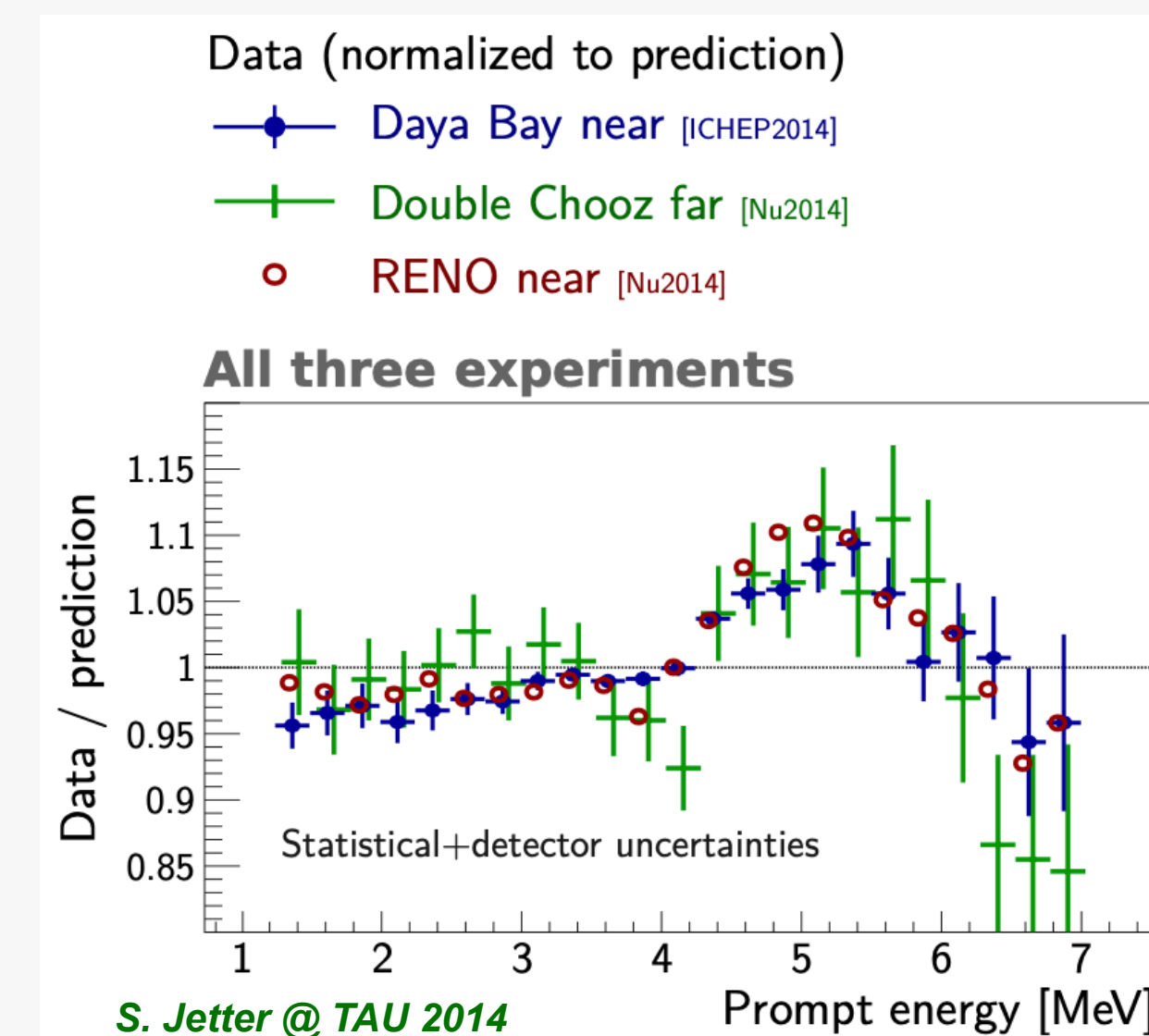
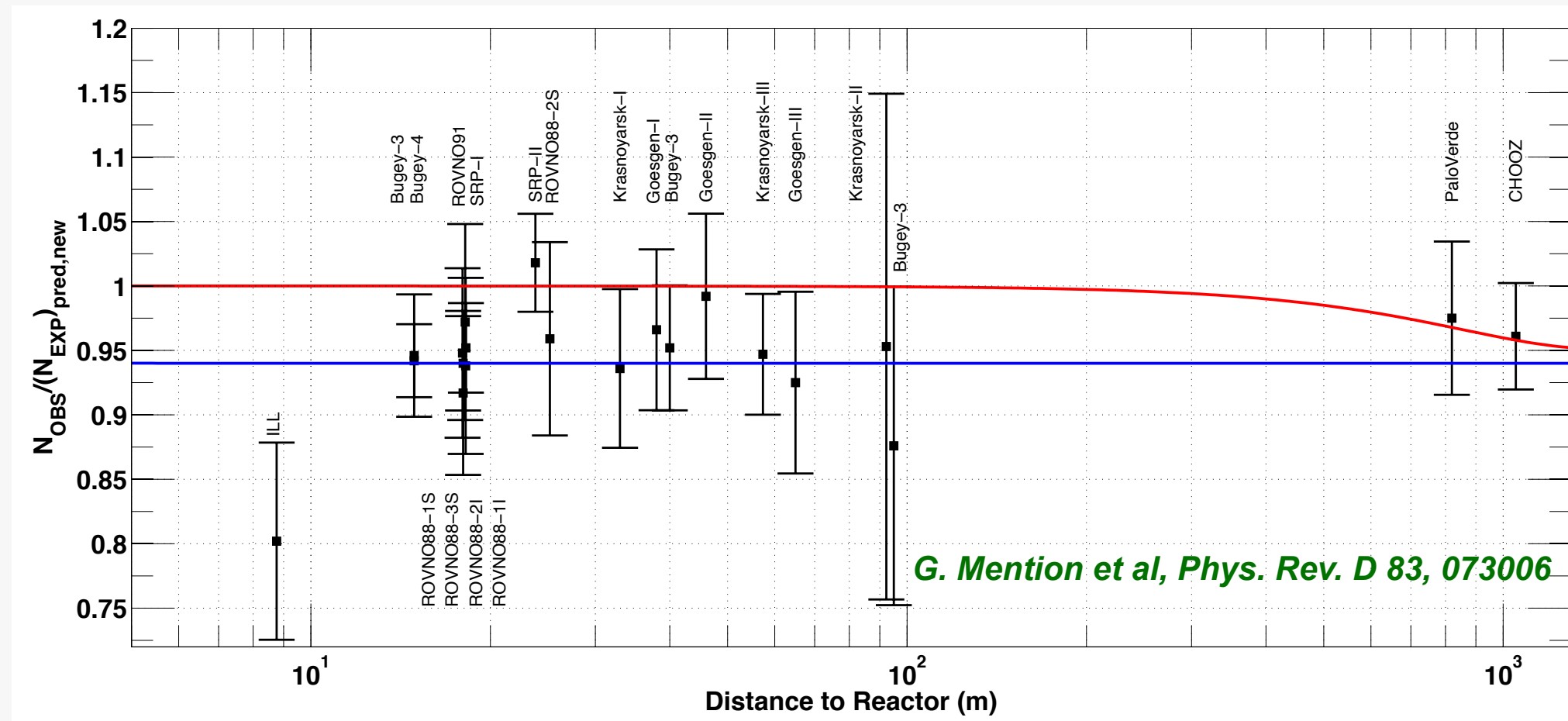
Study of Fuel Evolution & Isotope Contribution Decomposition at Daya Bay

Wei Wang (on behalf of the Daya Bay Collaboration), Sun Yat-sen University



Introduction

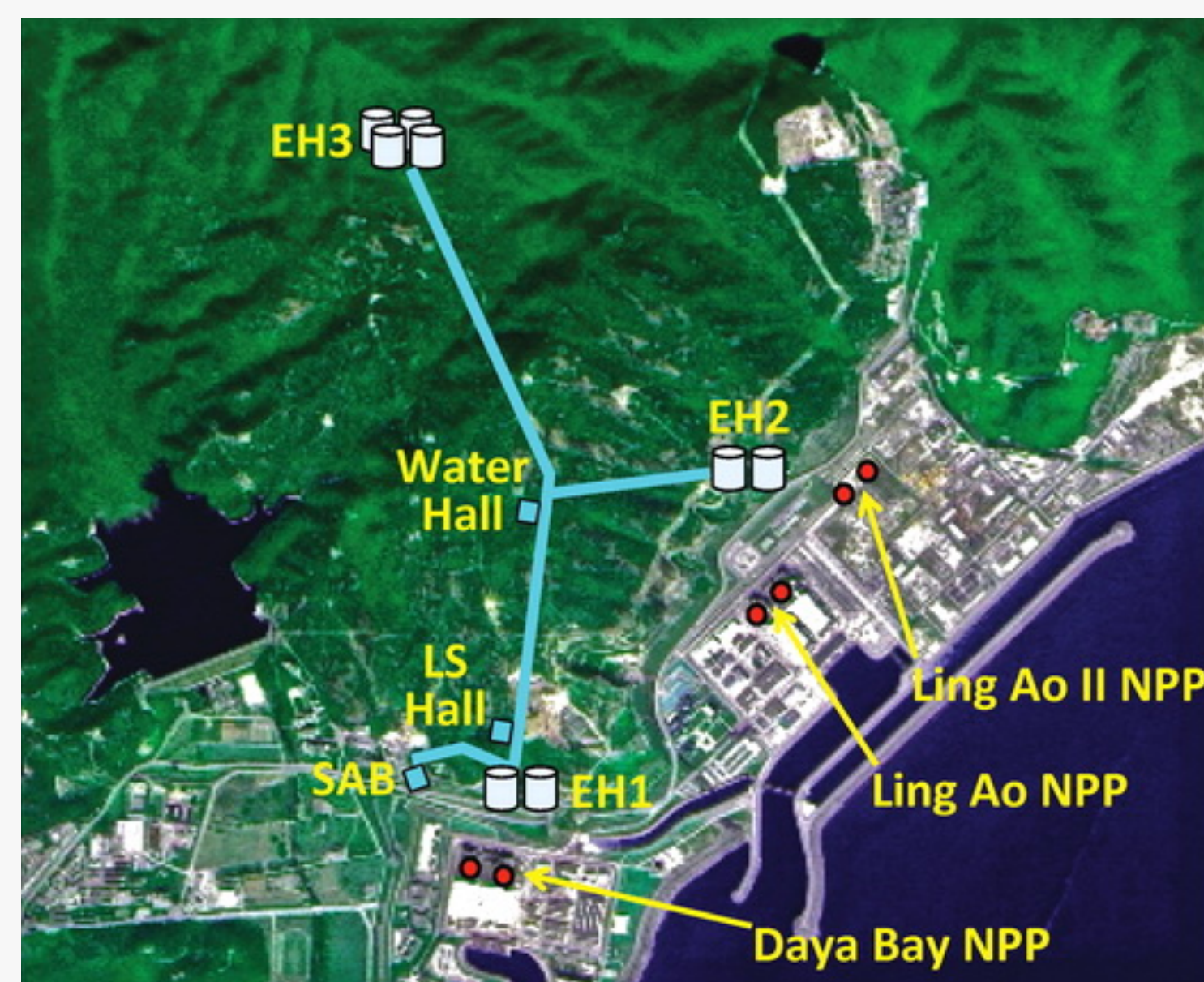
- ❖ Reactor Antineutrino Anomaly (RAA) has been puzzling the community since 2011
- ❖ So has been the energy spectrum discrepancy since 2014



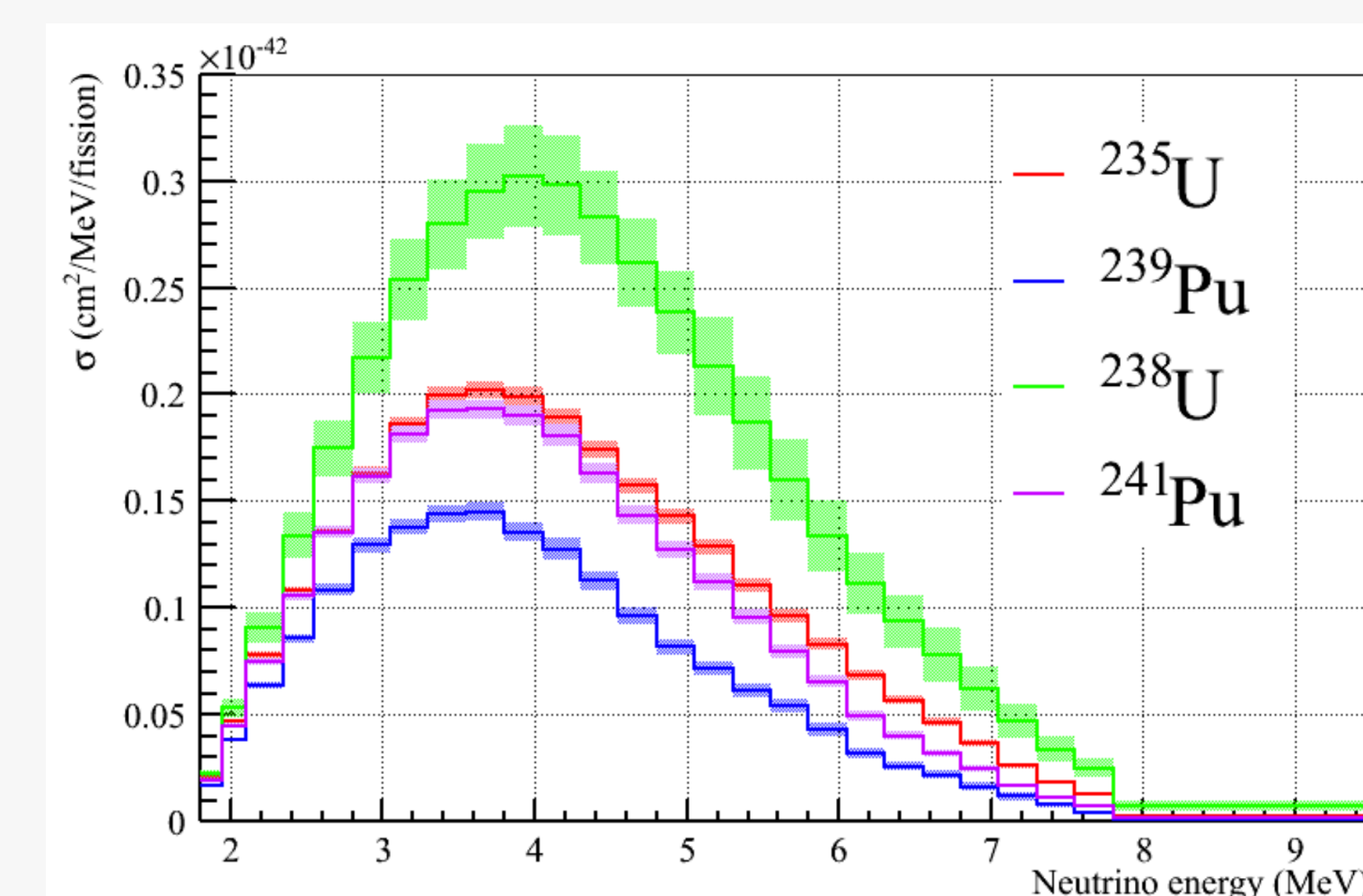
This poster presents the Daya Bay analyses studying the evolution of absolute reactor antineutrino flux and its spectrum with respect to isotope fission fractions, which could provide insights to RAA and the spectrum discrepancy mentioned above.

The Daya Bay Reactor Neutrino Experiment

- ❖ Combined reactor thermal power: 17.4 GW_{th}
- ❖ 8 inverse beta decay (IBD) antineutrino detectors (ADs): totally 160t target mass
- ❖ Multiple fuel cycles since Dec 2011: 1230-day and 1958-day datasets used in this poster



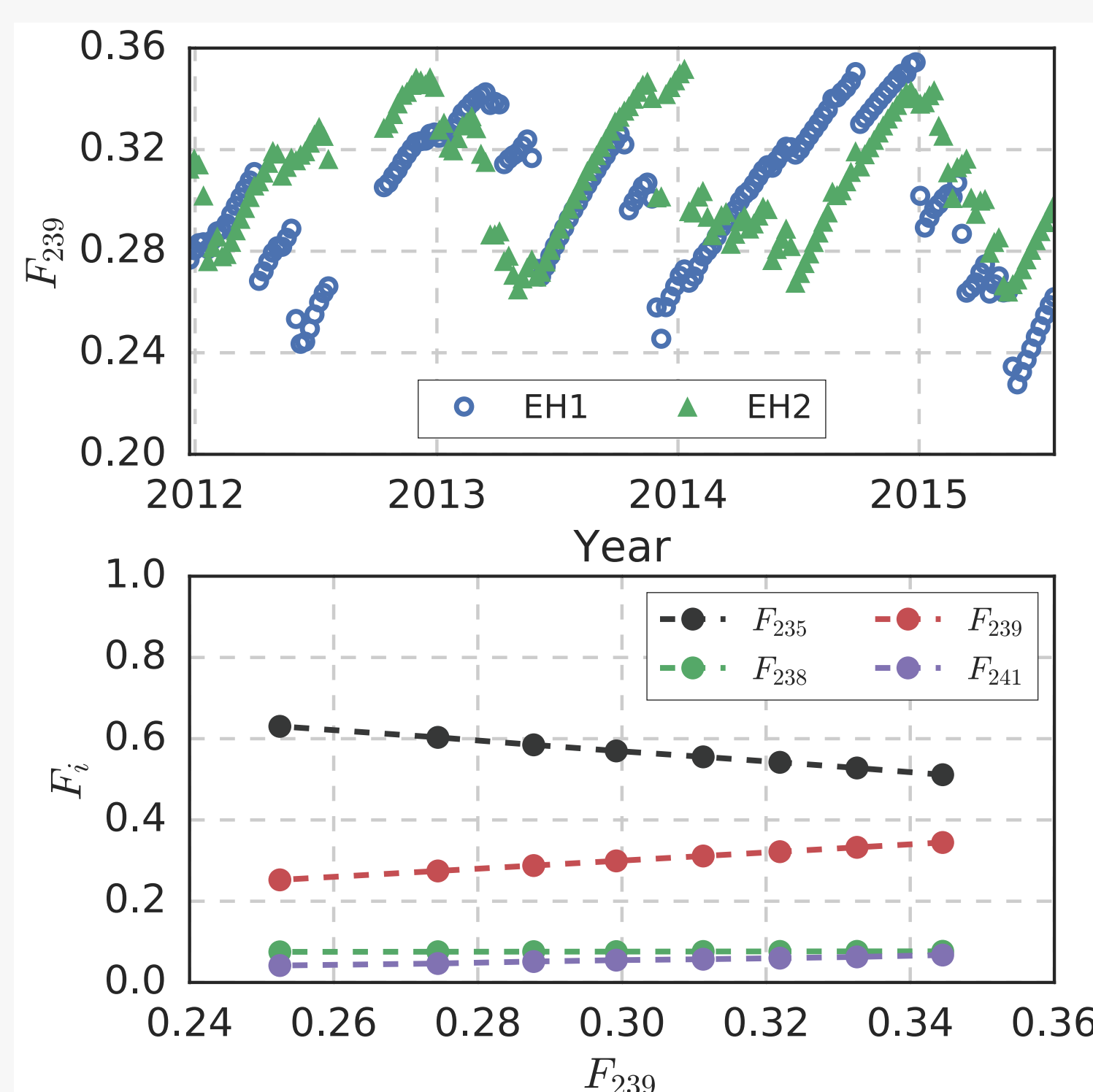
Daya Bay Reactor Fuel Evolution



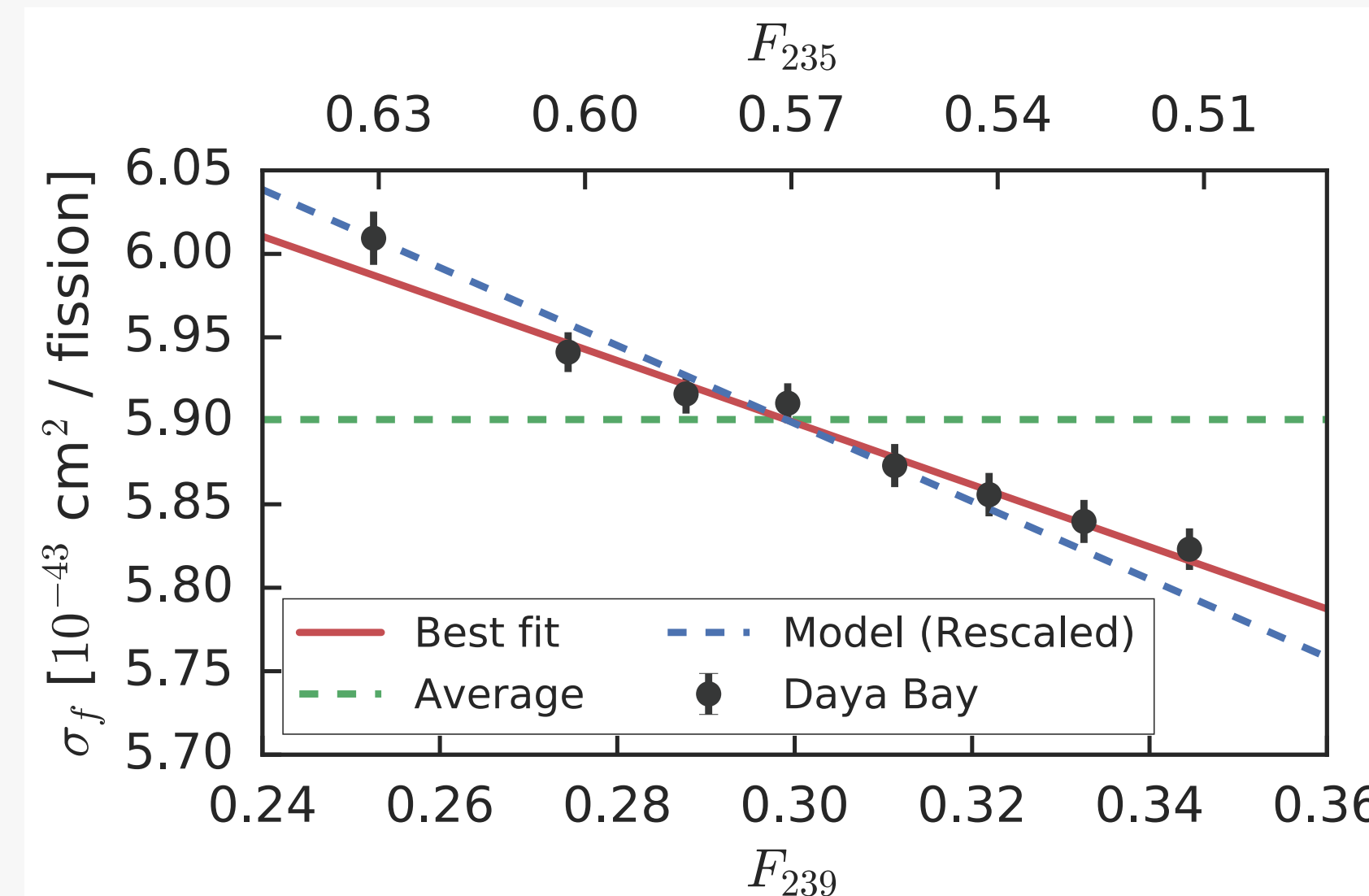
- ❖ Reactor running data, fission fractions and burnups, have been provided by the reactor operation division of the Daya Bay Nuclear Power Plant

Top: Weekly effective ²³⁹Pu fission fractions F_{239} (details in Ref. [3]) based on the reactor operation data provided by the nuclear power plant.

Bottom: Effective fission fractions for the primary fission isotopes versus F_{239} . Each data point represents an average over periods of similar F_{239} from the top panel.



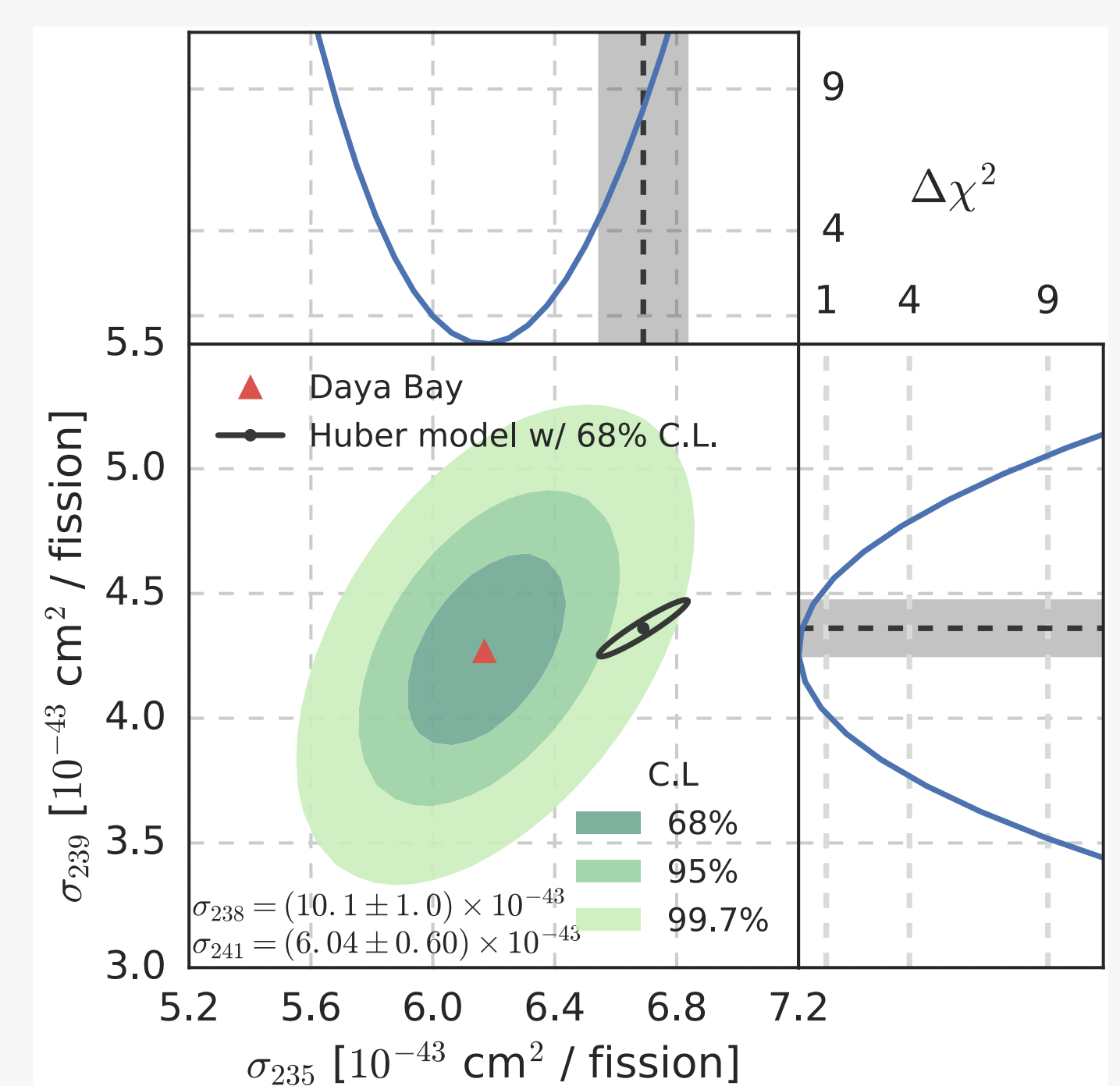
Flux Decomposition



- ➔ IBD yields measured by Daya Bay as a function of F_{239} .
- ➔ As a comparison, predicted yields based on the Huber-Mueller model are overlaid
- ➔ Again, due to differences in spectral shapes and total yields, it is possible to decouple the contributions of different fuel isotopes

Carrying out the correlation analyses: (1230 days of data; constraining the contributions from ²³⁸U and ²⁴¹Pu using the Huber-Mueller model)

- ➔ Compared with Huber's predictions, ²³⁵U has a 7.8% deficit, significantly larger than the 2.7% measurement uncertainty, while ²³⁹Pu is consistent within the uncertainty
- ➔ Disfavor equal contribution by 2.8σ ; or ²³⁹Pu alone by 3.2σ

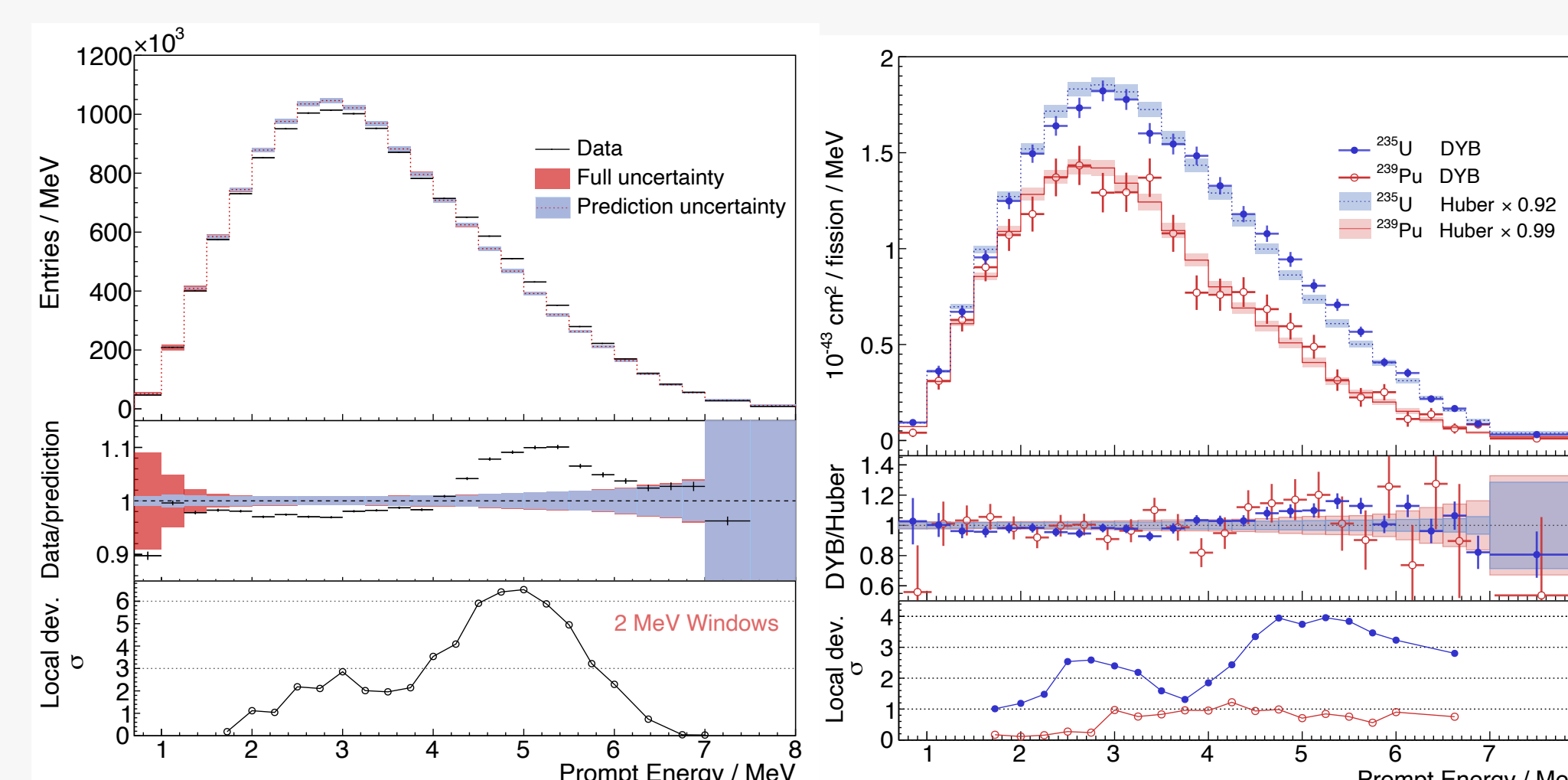
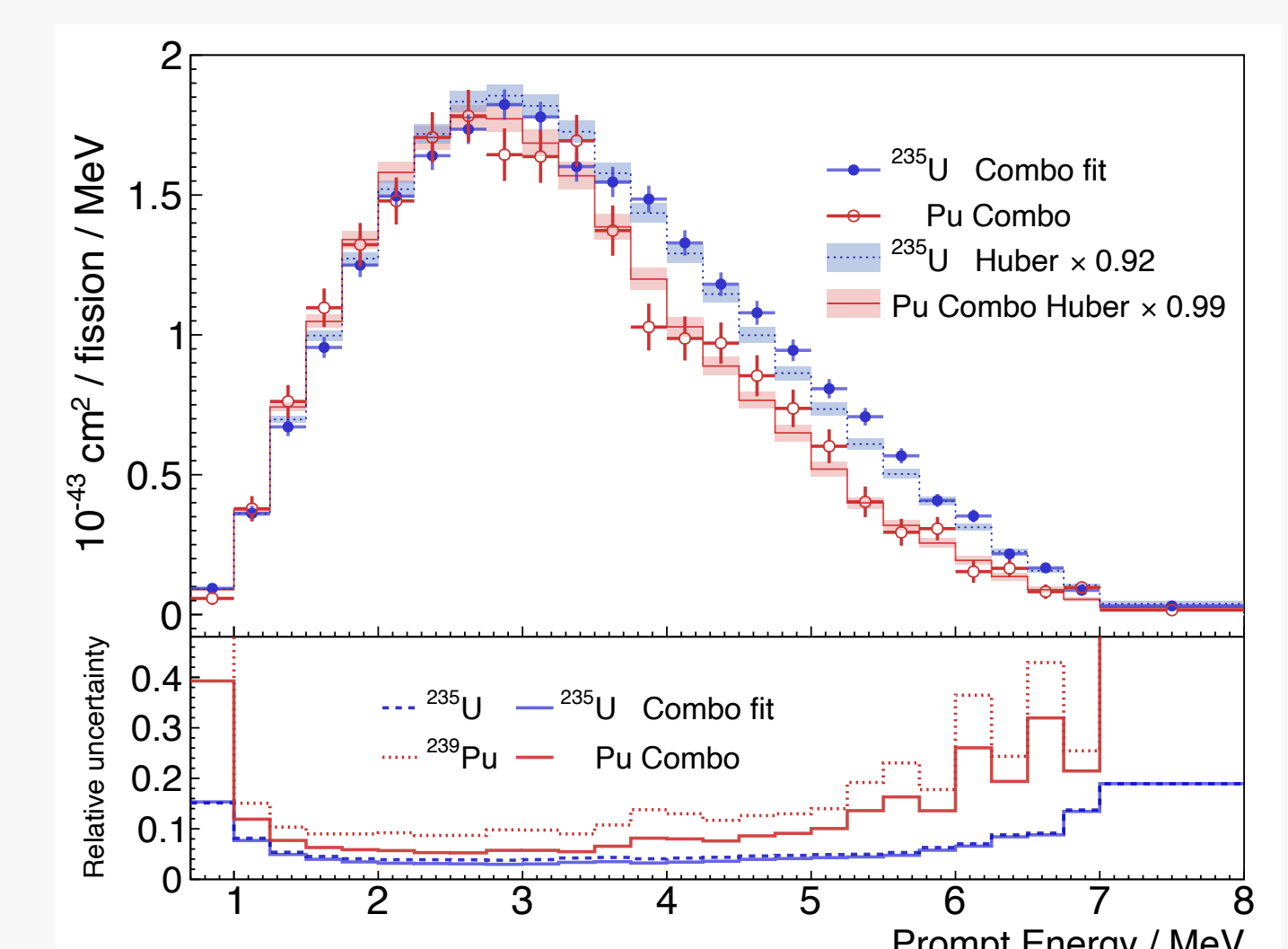


Spectral Decomposition

- ➔ ²³⁵U and ²³⁹Pu fission products' IBD energy spectra are successfully extracted for the first time, by constraining the contributions from ²³⁸U and ²⁴¹Pu using the Huber-Mueller model

- ➔ Uncertainties are ~9%, see below

- ➔ Uncertainty can be improved from 9% to 6% by combining ²³⁹Pu+ ²⁴¹Pu considering their strong correlation



Spectral Discrepancy (compared with the Huber-Mueller model, 1958 days of data)

- ➔ Combined: 6.3σ
- ➔ ²³⁵U spectrum: 4σ
- ➔ ²³⁹Pu spectrum: 1.2σ

Summary and Conclusions

- ❖ The Daya Bay neutrino experiment has collected the largest set of reactor antineutrino IBD events with well understood detectors
- ❖ Fuel evolution analyses indicate that the ²³⁵U IBD yield is more likely to be responsible for RAA, which weakens the sterile neutrino interpretation as that would cause a universal effect for all fuel isotopes
- ❖ Both ²³⁵U and ²³⁹Pu spectra are consistent with the spectrum discrepancy at 4-6 MeV
- ❖ More data are being analyzed

References:

- [1] G. Mention et al, Phys. Rev. D 83, 073006; P. Huber, Phys. Rev. C 84, 024617
- [2] Daya Bay Collaboration, RENO Collaboration, Double Chooz Collaboration, Neutrino/ICHEP 2014
- [3] Daya Bay Collaboration, Phys. Rev. Lett. 118 (2017)251801; Phys. Rev. Lett. 123(2019)111801