

# Recent Results from RENO

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Chonnam National University

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# RENO Collaboration



## Reactor Experiment for Neutrino Oscillation

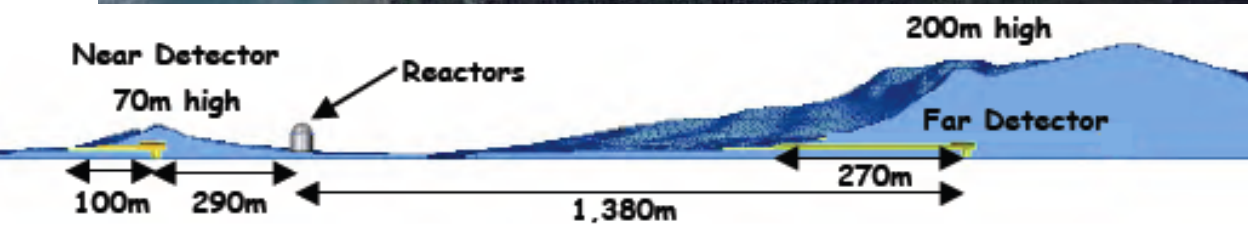
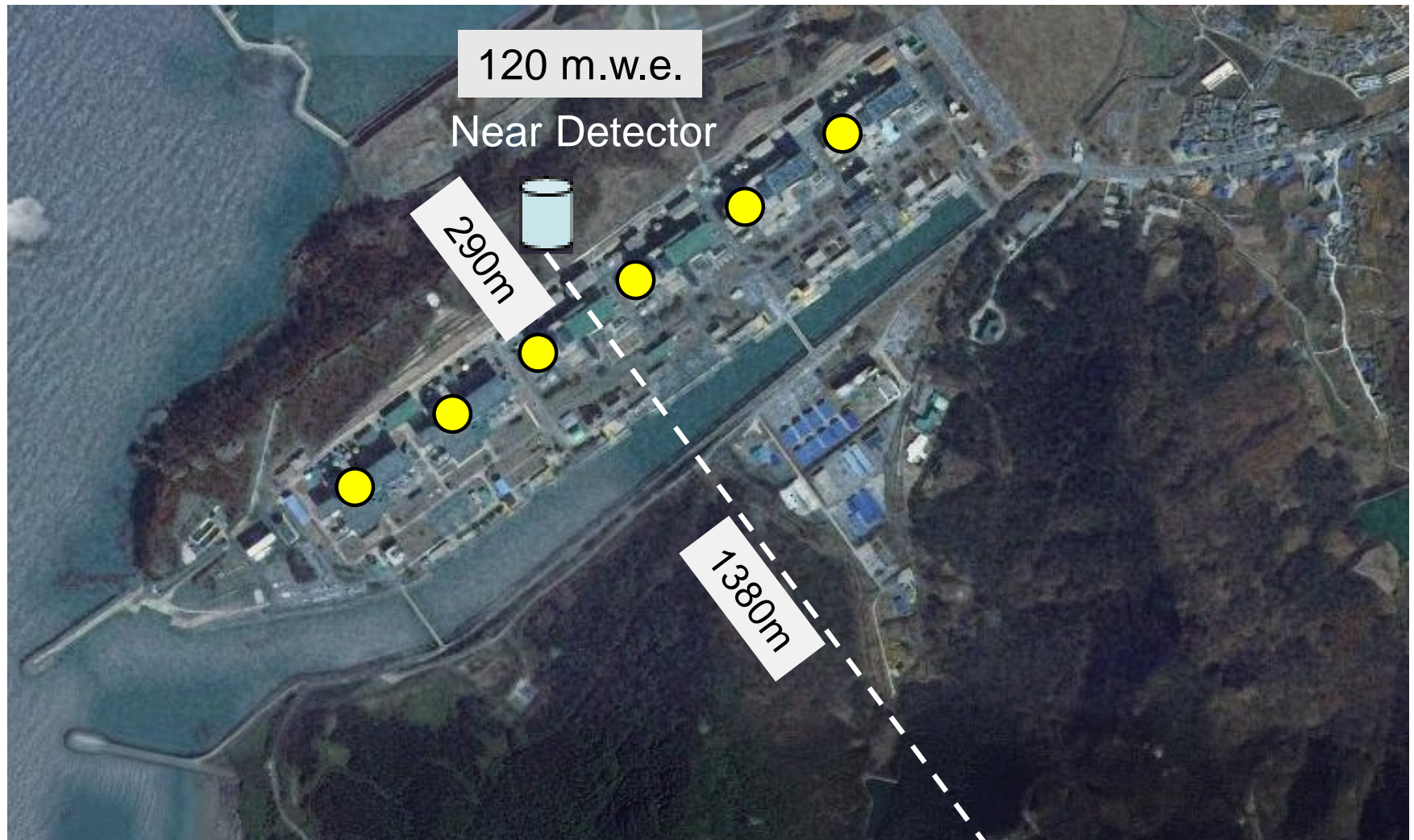
(9 institutions and 40 physicists)

- Chonnam National University
- Dongshin University
- GIST
- Gyeongsang National University
- KAIST
- Kyungpook National University
- Seoul National University
- Seoyeong University
- Sungkyunkwan University

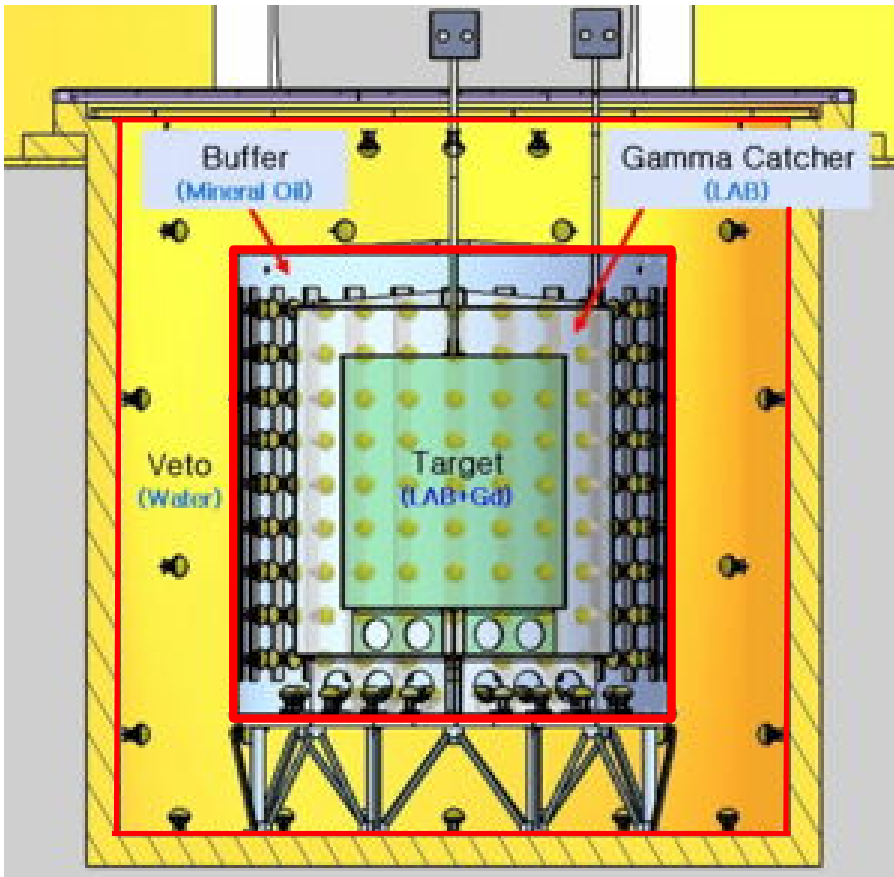
- Total cost : **\$10M**
- Start of project : **2006**
- The first experiment running with both near & far detectors from **Aug. 2011**



# RENO Experimental Set-up



# RENO Detector

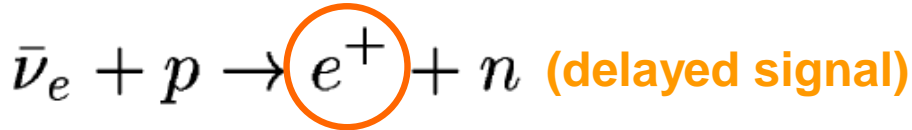


- 354 ID 10" PMTs
- 67 OD 10" PMTs

- Target : **16.5 ton Gd-LS**  
(R=1.4m, H=3.2m)
- Gamma Catcher : 30 ton LS  
(R=2.0m, H=4.4m)
- Buffer : 65 ton mineral oil  
(R=2.7m, H=5.8m)
- Veto : 350 ton water  
(R=4.2m, H=8.8m)

# Coincidence of Prompt and Delayed Signals

(prompt signal)



Prompt signal

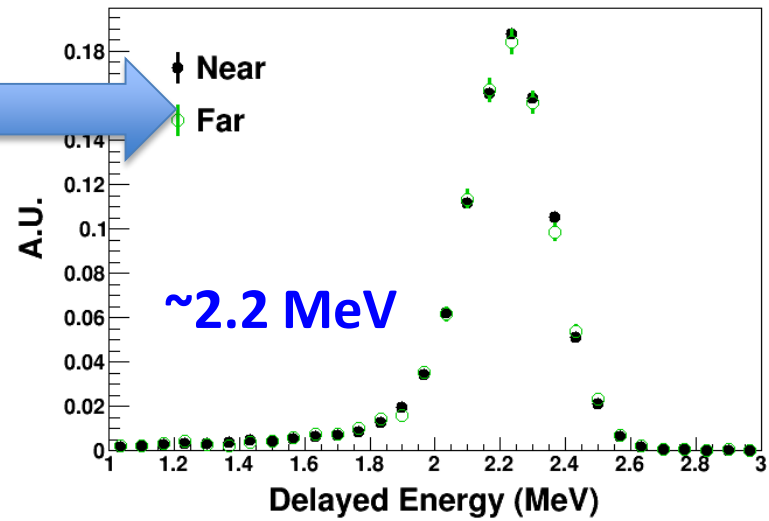
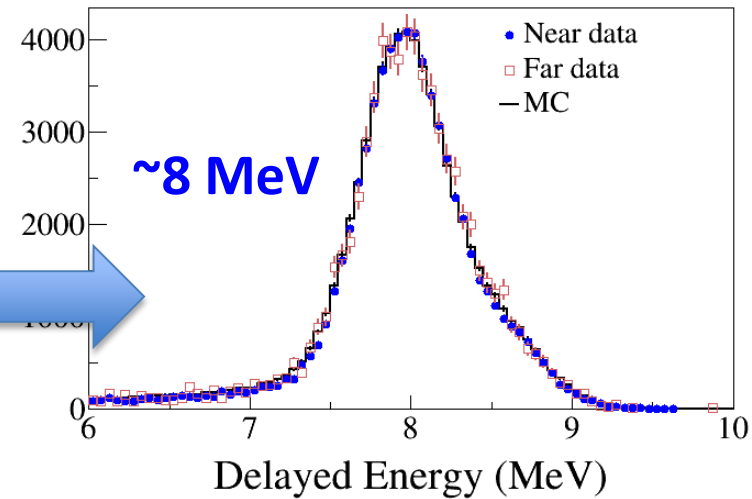
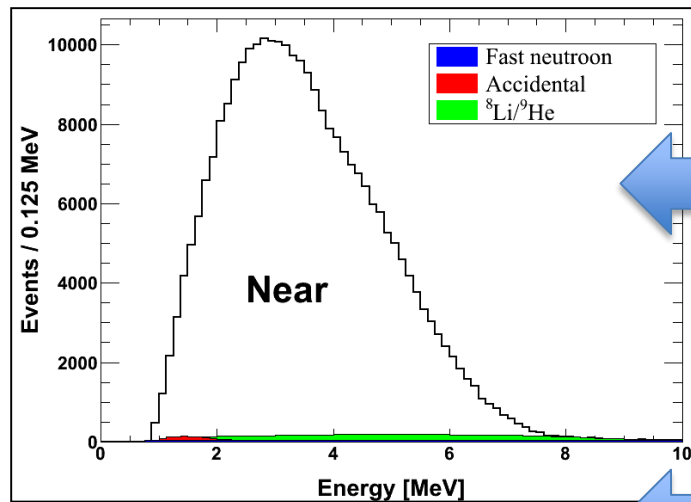
Delayed signal

n-Gd IBD

$\sim 30 \mu\text{s}$

$\sim 200 \mu\text{s}$

n-H IBD



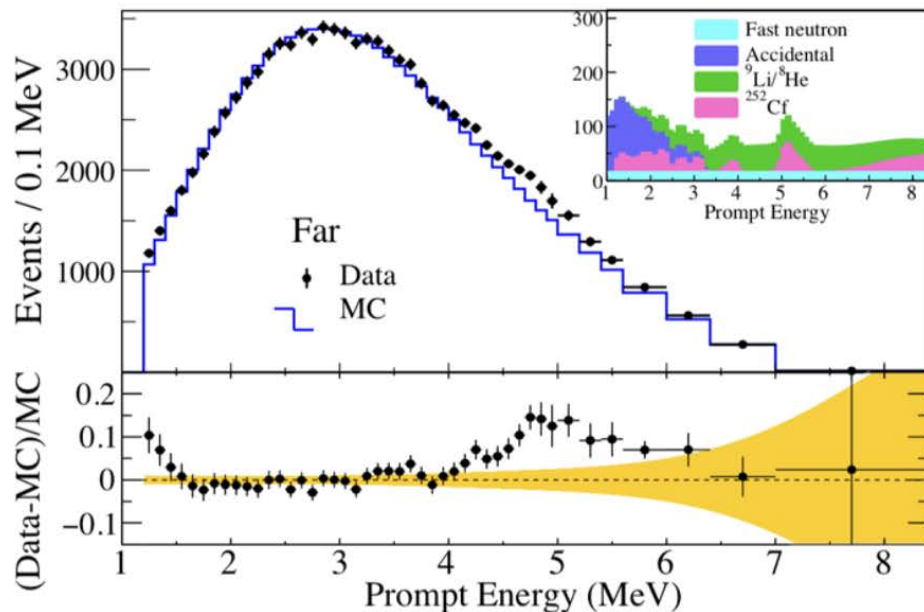
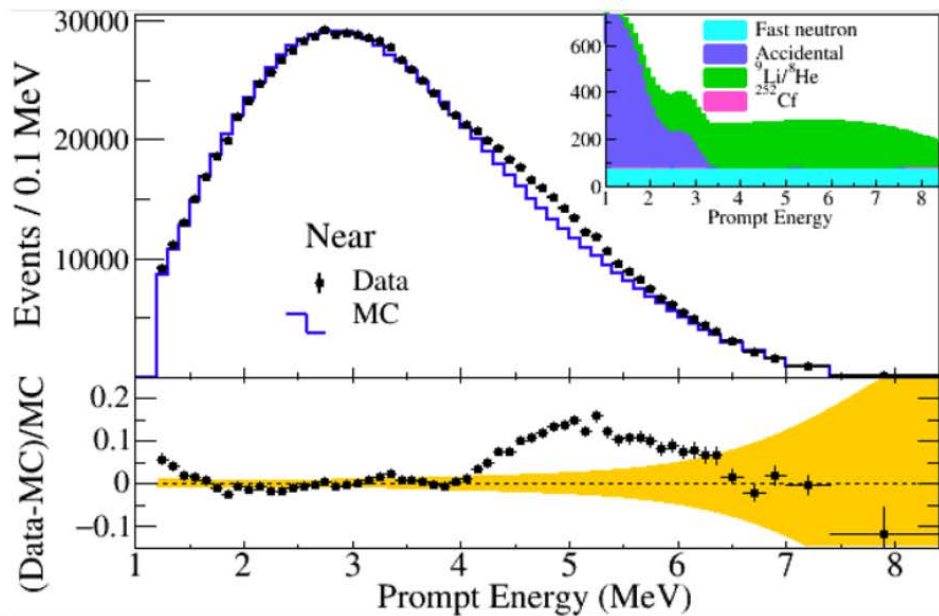
# Recent Results from RENO

- “Fuel-composition dependent reactor antineutrino yield at RENO”  
Phys. Rev. Lett. 122, 232501 (2019)
- “Observation of Reactor Antineutrino Disappearance Using Delayed Neutron Capture on Hydrogen at RENO”  
JHEP04 (2020) 029
- “Search for Sub-eV Sterile Neutrino at RENO”  
arXiv:2006.07782 (2020)
- Updated analysis of 2900 days (Aug. 2011 – Feb. 2020) of RENO data

# Measured Spectra of IBD Prompt Signal

RENO 2900 days : Aug, 2011 – Feb. 2020

**Clear excess at 5 MeV**



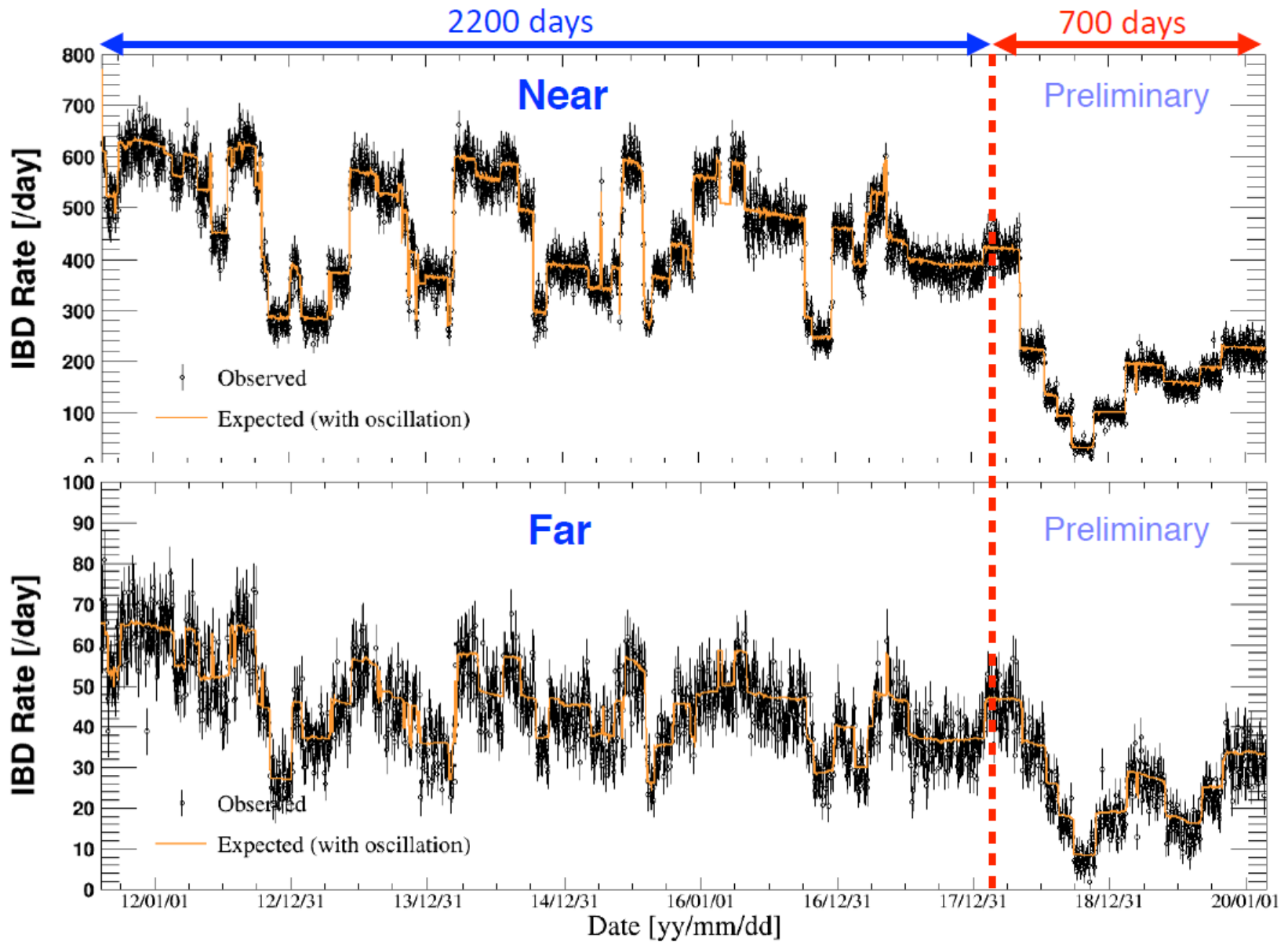
Near

IBD candidates : 989,736  
Background :  $2.26 \pm 0.05\%$   
5 MeV excess :  $2.50 \pm 0.06\%$

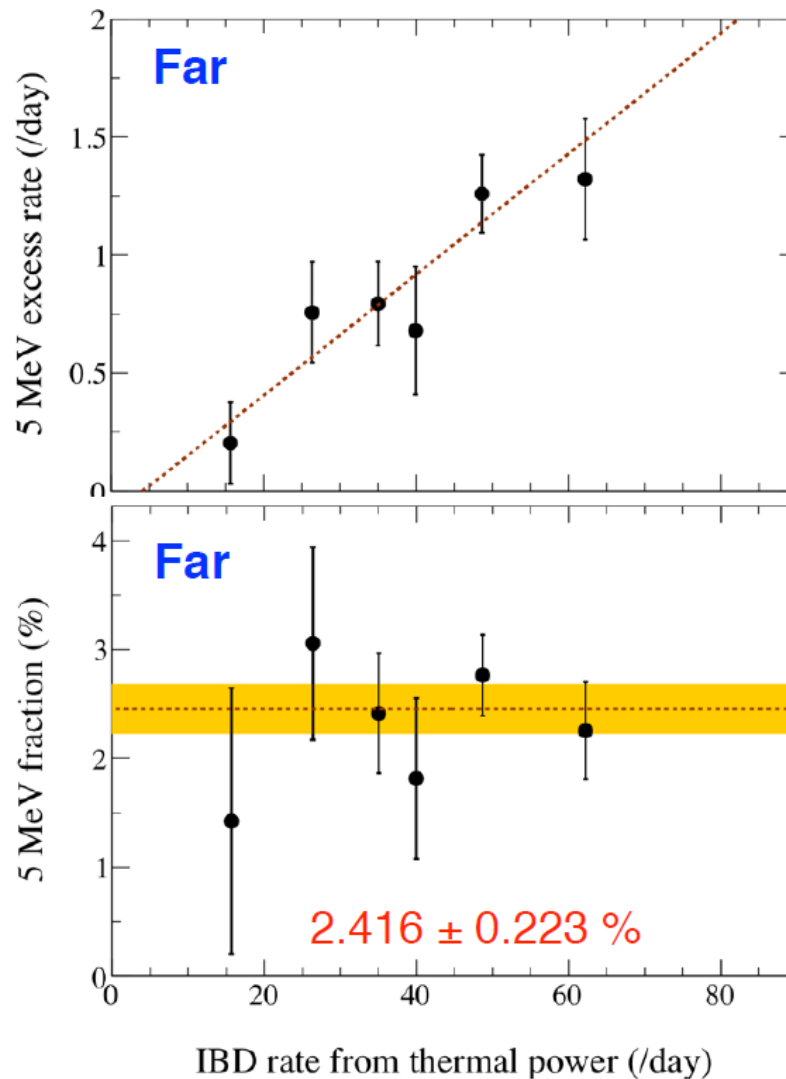
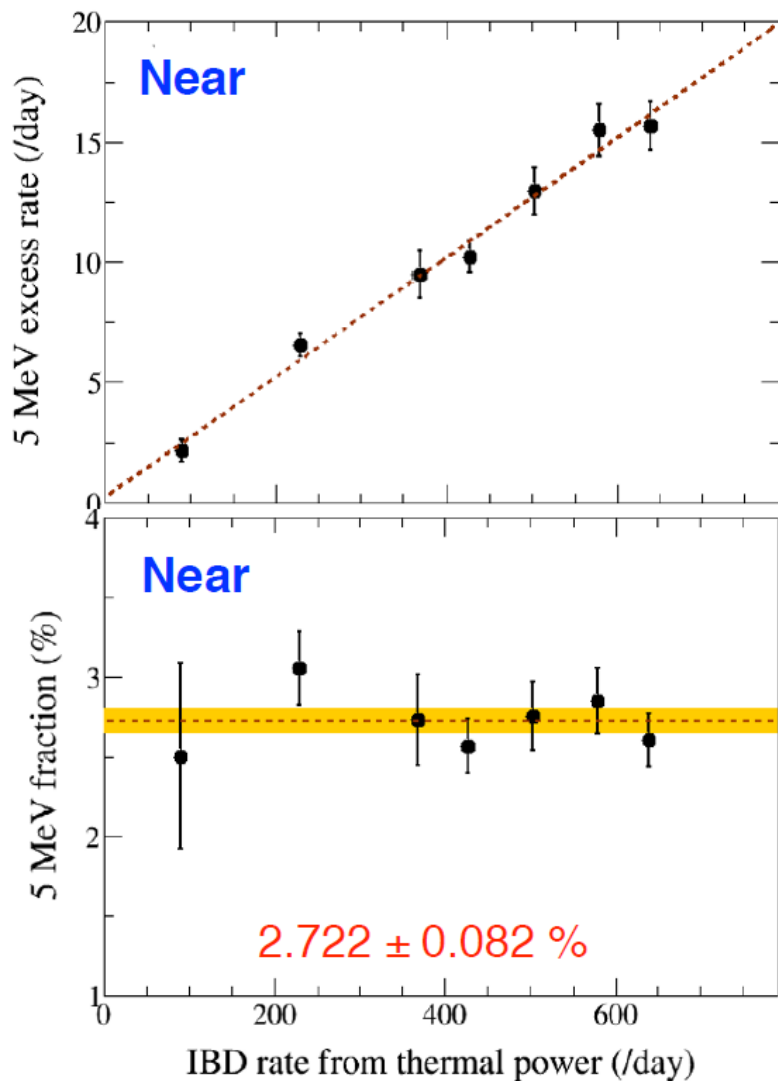
Far

IBD candidates : 120,383  
Background :  $4.77 \pm 0.19\%$   
5 MeV excess :  $2.26 \pm 0.18\%$

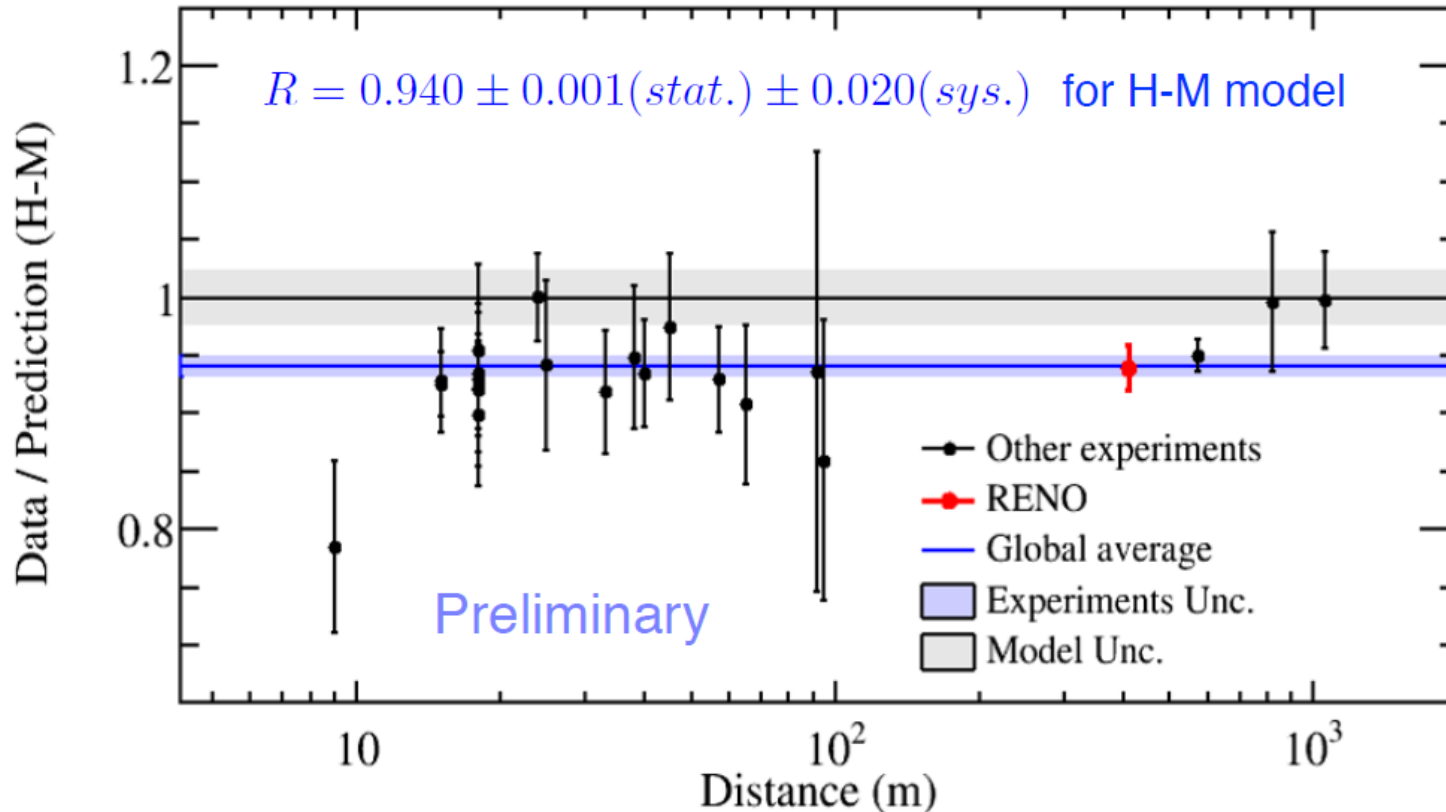
# Observed Daily Averaged IBD Rate



# Correlation of 5 MeV Excess with Reactor Power



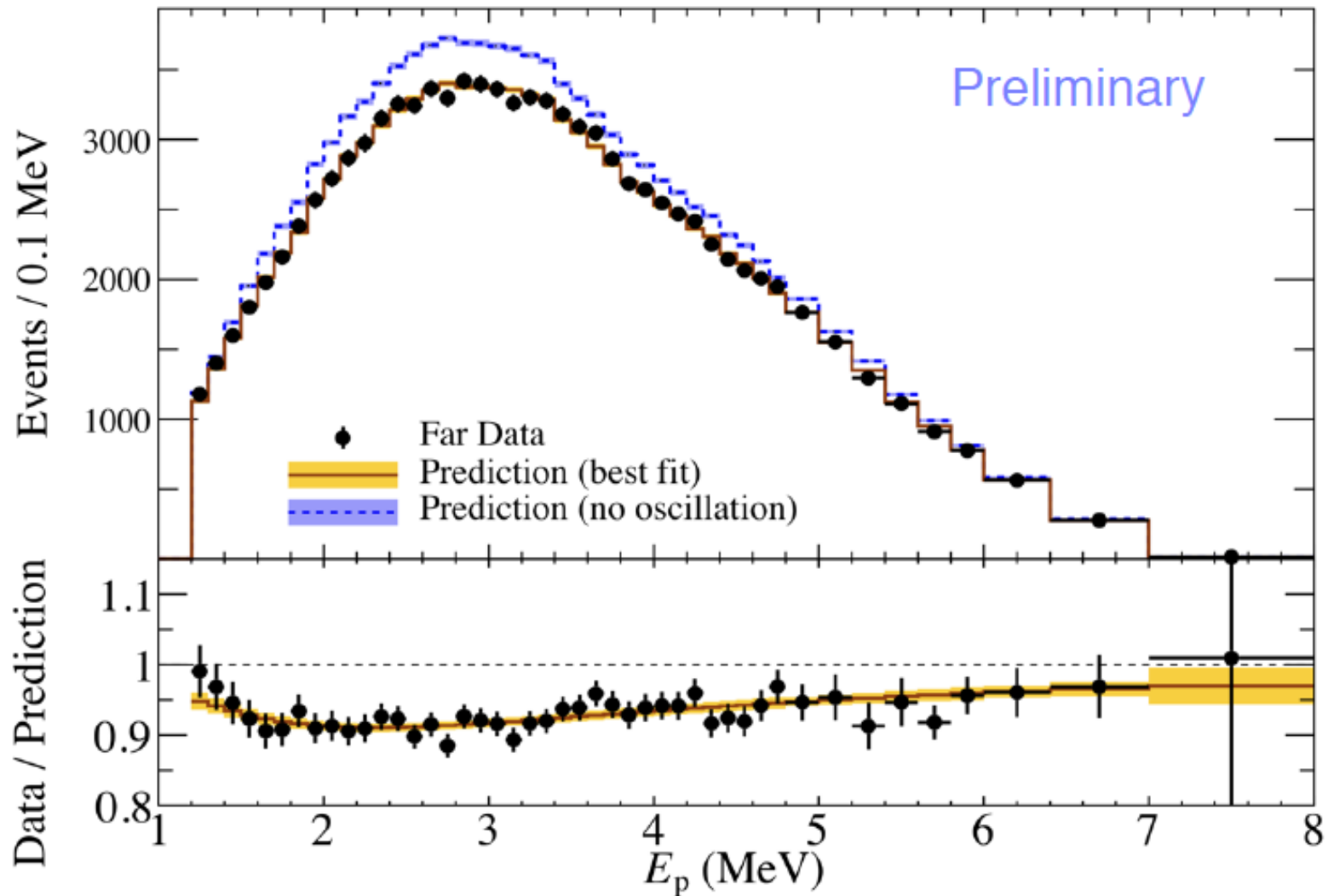
# Measurement of Absolute Reactor Neutrino Flux



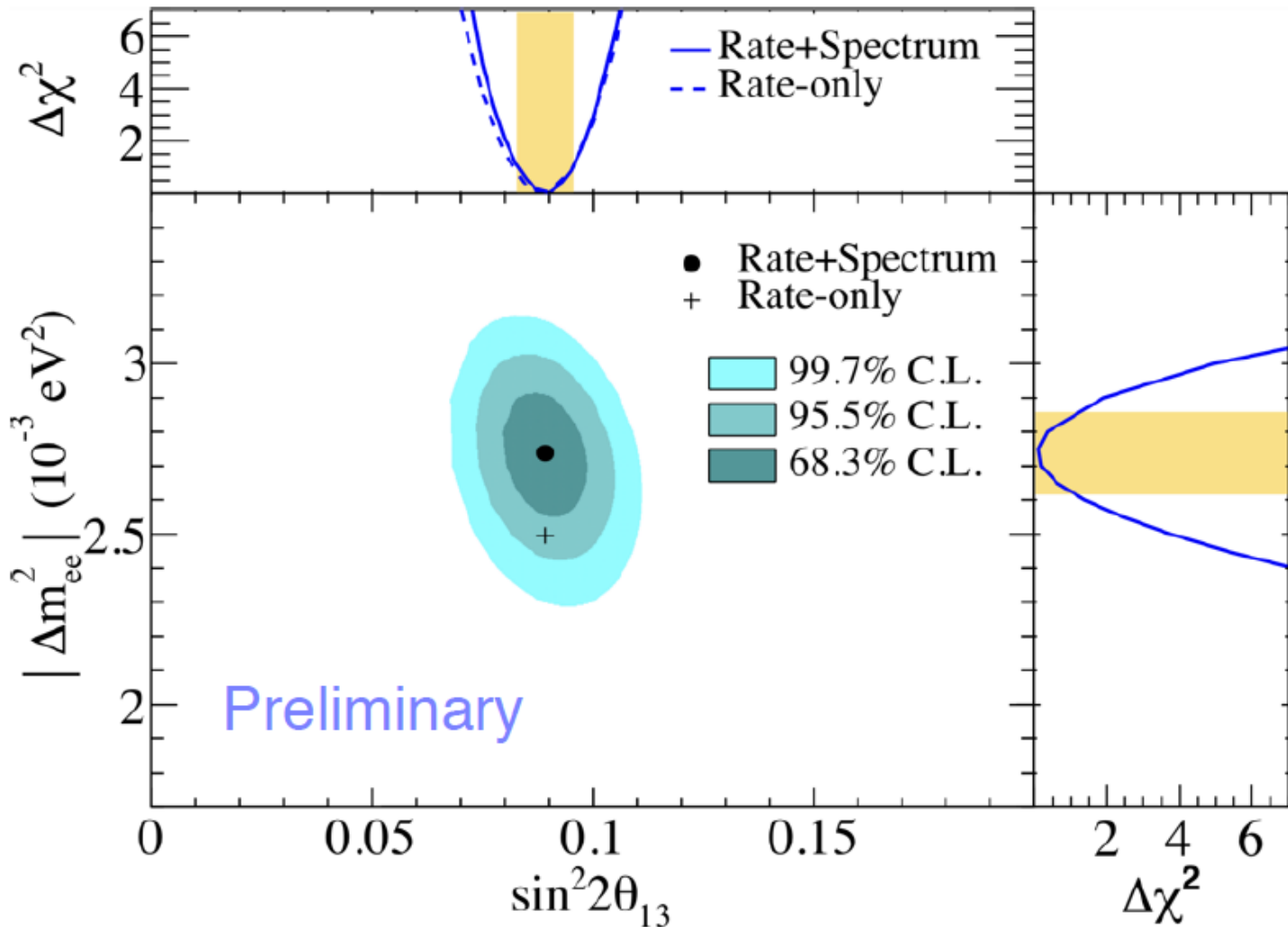
Deficit of observed reactor neutrino fluxes relative to the prediction (Huber + Mueller model) indicates an overestimated flux or possible oscillation to sterile neutrinos

# Results from Spectral Fit

Energy-dependent disappearance of reactor antineutrinos



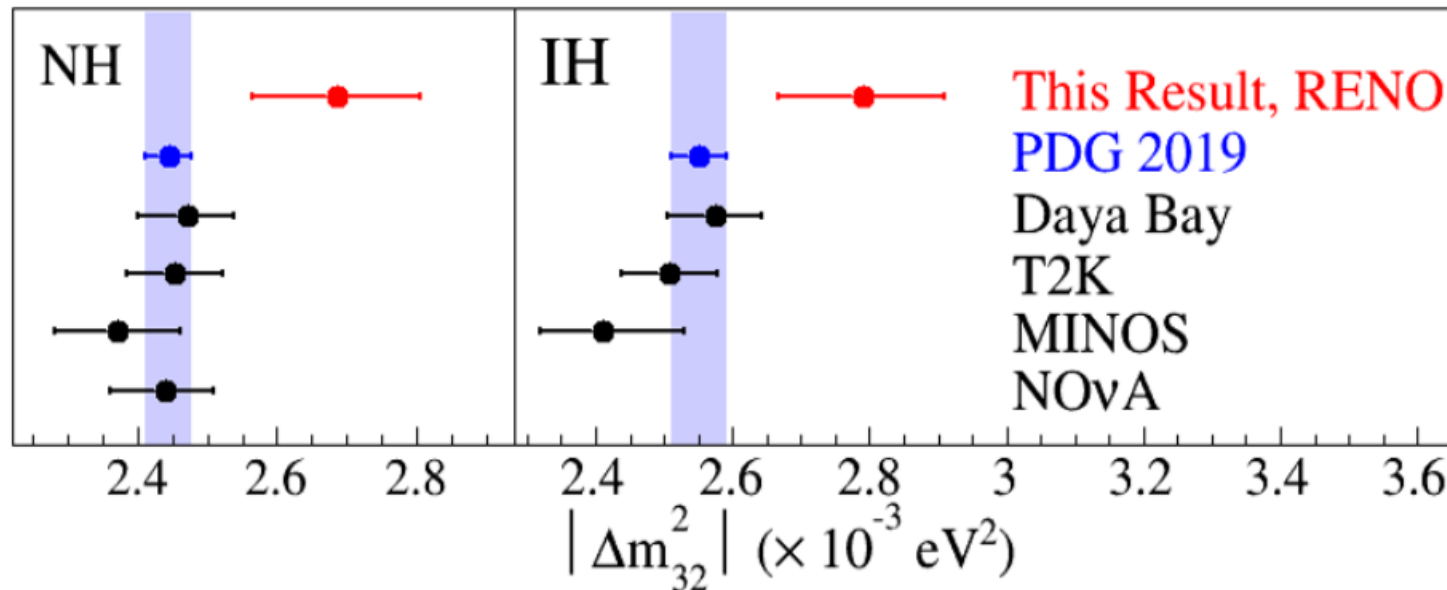
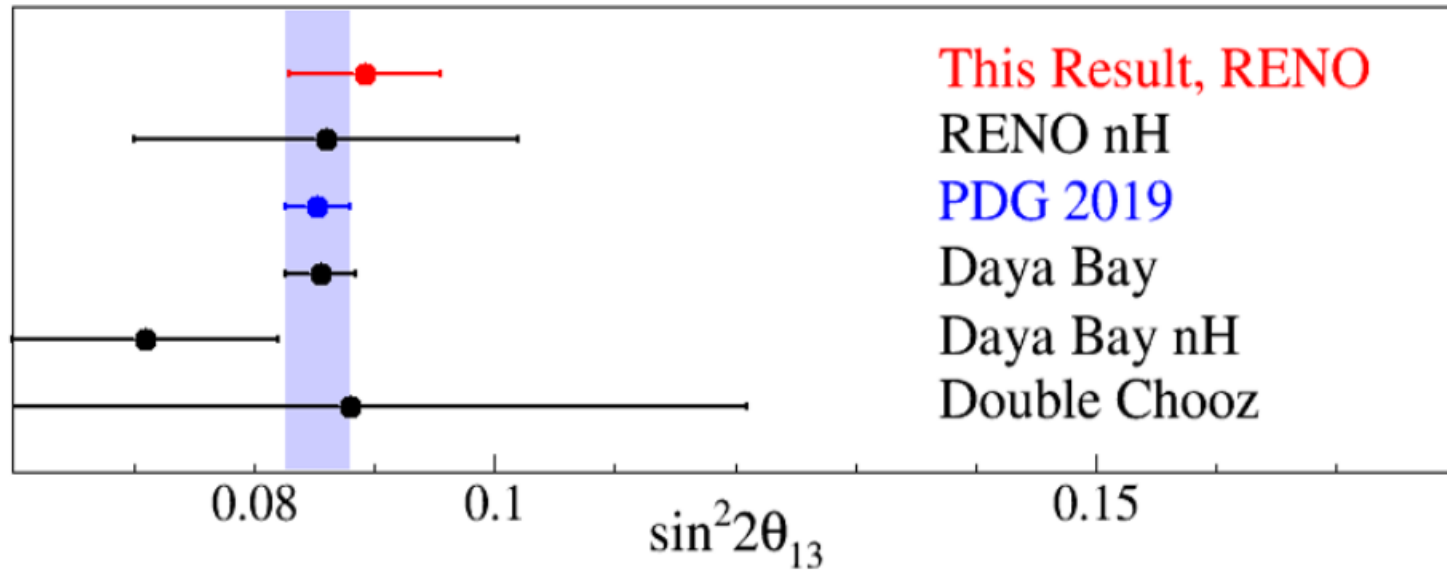
# Allowed Regions in $|\Delta m_{ee}^2|$ and $\sin^2 2\theta_{13}$



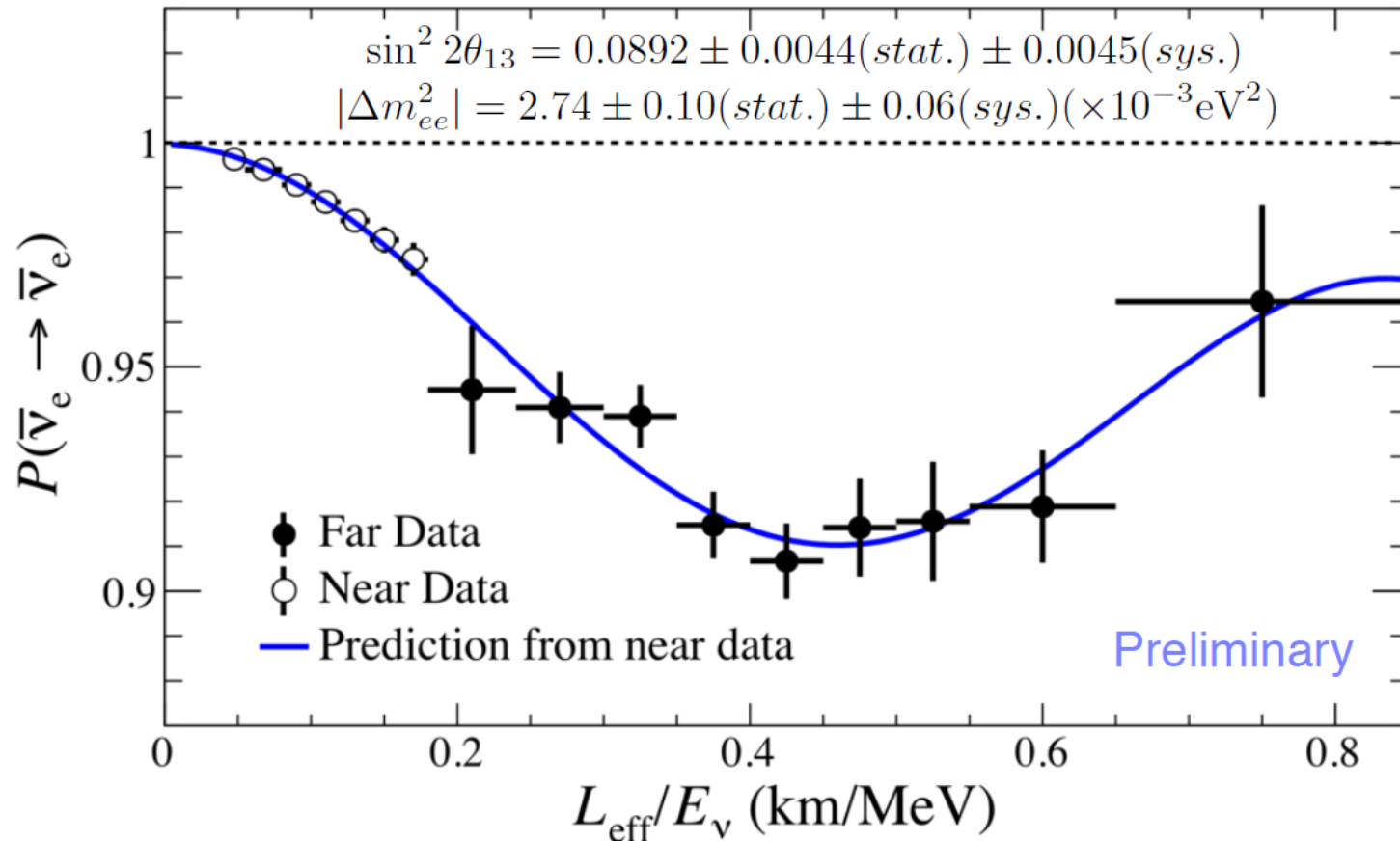
$$\sin^2 2\theta_{13} = 0.0892 \pm 0.0044(\text{stat.}) \pm 0.0045(\text{sys.})$$

$$|\Delta m_{ee}^2| = 2.74 \pm 0.10(\text{stat.}) \pm 0.06(\text{sys.})(\times 10^{-3} \text{ eV}^2)$$

# Global Average of Oscillation Parameters



# Observed L/E Dependent Oscillation

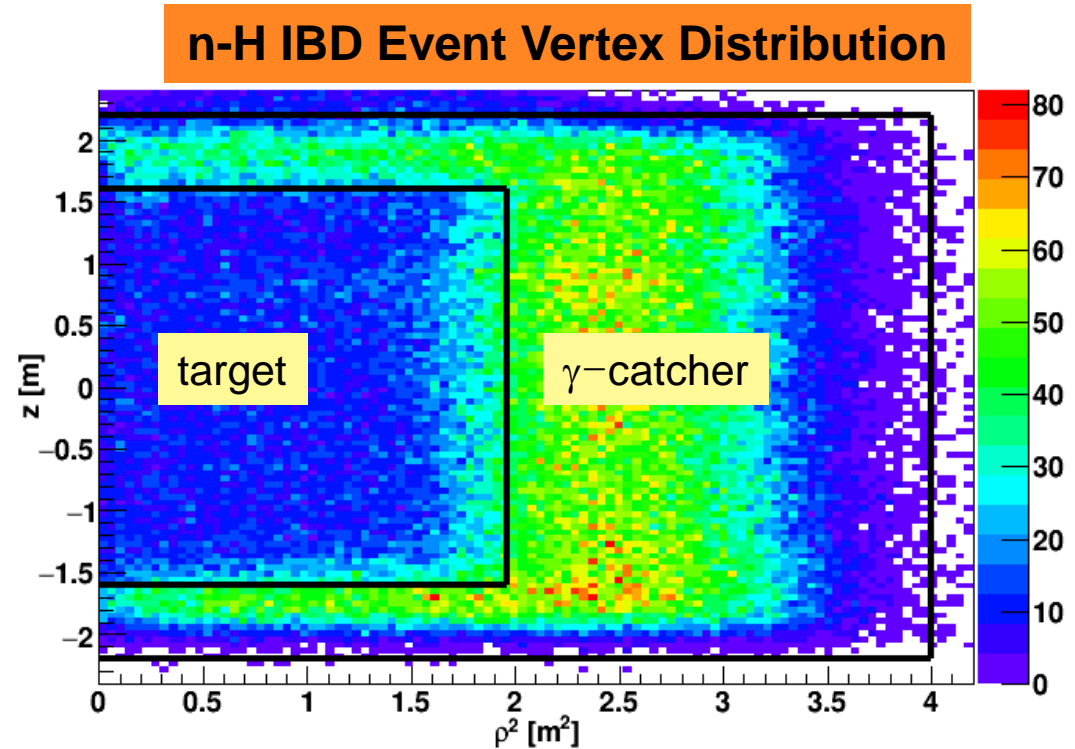
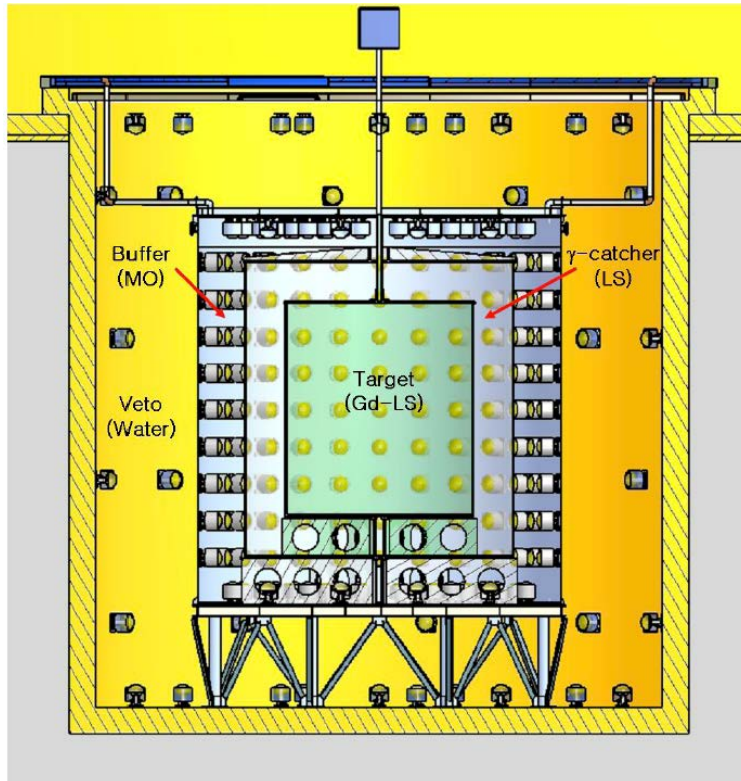


$$P(\bar{\nu}_e \rightarrow \bar{\nu}_e) \approx 1 - \sin^2 2\theta_{13} \sin^2 \left( \Delta m_{ee}^2 \frac{L}{4E_{\nu}} \right)$$

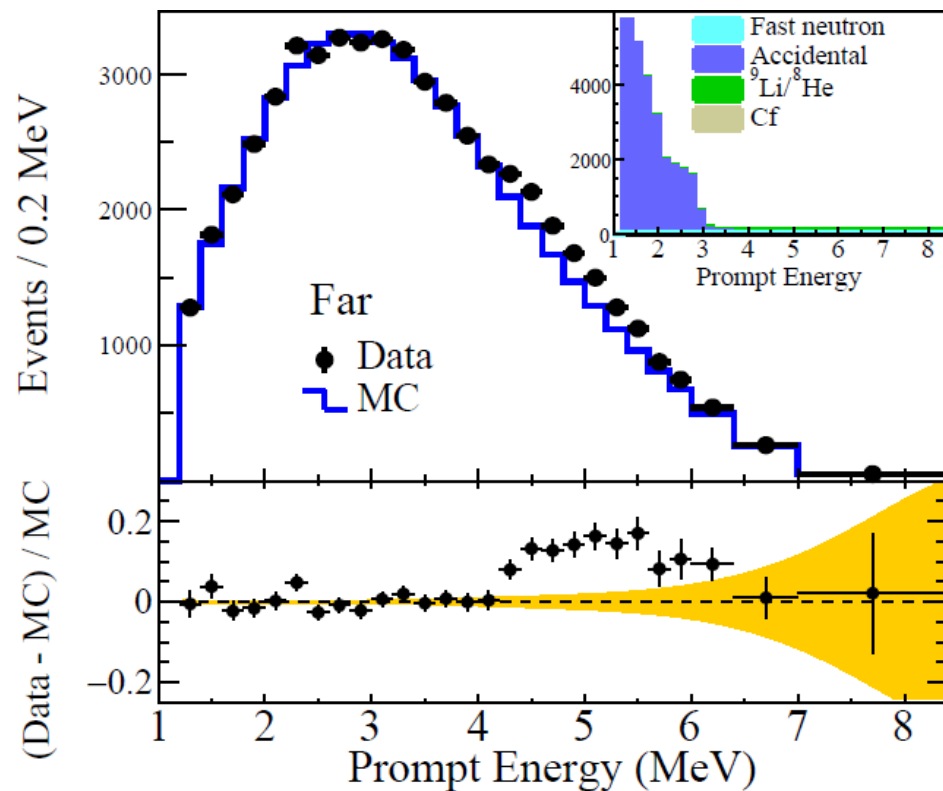
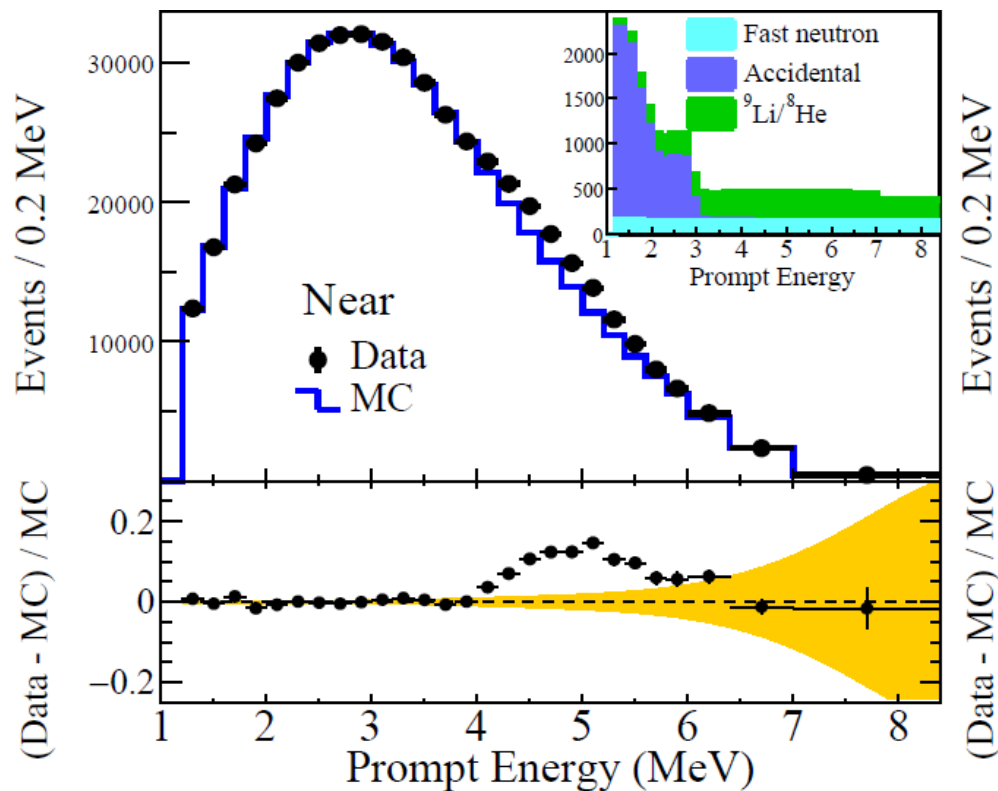
Clear energy-dependent disappearance of reactor antineutrinos

# n-H IBD Analysis

1. Independent measurement of  $\theta_{13}$  value
2. Consistency and systematic check on reactor neutrinos



# Measured Spectra of IBD Prompt Signal (n-H)



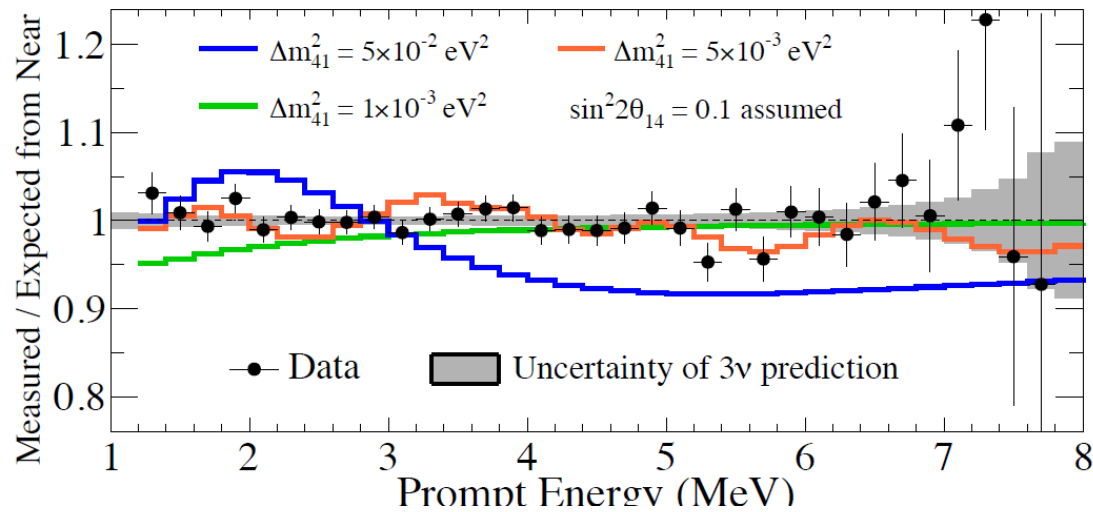
1500 days of data

JHEP04 (2020) 029

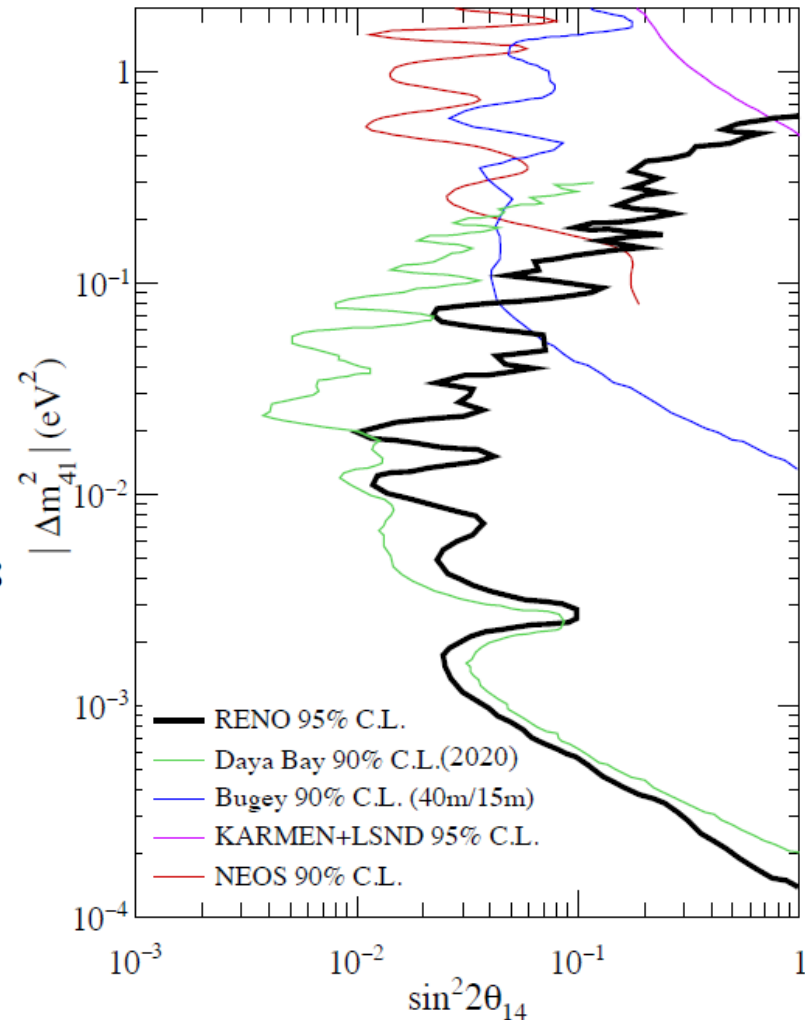
$$\sin^2 2\theta_{13} = 0.086 \pm 0.008(\text{stat.}) \pm 0.014(\text{syst.})$$

# Sterile Neutrino Search

(2200 Days of RENO data, n-Gd)



arXiv:2006.07782 (2020)



# Summary

- Precise measurements of  $\theta_{13}$  and  $\Delta m_{ee}^2$  energy dependent disappearance of reactor neutrinos using 2900 days of data

(Preliminary) 2900days

$$\sin^2 2\theta_{13} = 0.0892 \pm 0.0044(\text{stat.}) \pm 0.0045(\text{syst.}) \quad \pm 7.0 \%$$

$$|\Delta m_{ee}^2| = 2.74 \pm 0.10(\text{stat.}) \pm 0.06(\text{syst.}) (\times 10^{-3} \text{eV}^2) \quad \pm 4.4\%$$

- Measured absolute reactor neutrino flux :  $R = 94.0 \pm 2.0 \%$

- Independent measurement of  $\theta_{13}$  using n-H data

- The first RENO sterile neutrino search results

**Thanks for your attention!**