Recent Results on Neutrino Oscillations from Daya Bay

Jim Napolitano
Temple University
Philadelphia PA, USA
for the
Daya Bay Collaboration

Daya Bay Publications and Preprints

Neutrino Oscillation Results

Observation of $\overline{\nu}_e$ disappearance at Daya Bay
Phys.Rev.Lett. 108 (2012) 171803

Improved Measurement of $\overline{\nu}_e$ Disappearance at Daya Bay
Chin.Phys. C37 (2013) 011001

… plus updates for Summer 2014.

Spectral measurement of $\overline{\nu}_e$ oscillation amplitude and frequency at Daya Bay
Phys.Rev.Lett. 112 (2014) 061801

Independent Measurement of θ_{13} via Neutron Capture on Hydrogen at Daya Bay
arXiv:1406.6468 [hep-ex]

Search for a Light Sterile Neutrino at Daya Bay
arXiv:1407.7259 [hep-ex]

Selected Instrumentation Papers

A side-by-side comparison of Daya Bay antineutrino detectors
Nucl.Instrum.Meth. A685 (2012) 78-97

Automated calibration system for Daya Bay
Nucl.Instrum.Meth. A750(2014) 19-37

The Muon System of the Daya Bay Reactor Antineutrino Experiment
arXiv:1407.0275 [physics.ins-det]

The Water Purification System for the Daya Bay Reactor Neutrino Experiment
arXiv:1408.1302 [physics.ins-det]

Reactor Neutrino Disappearance

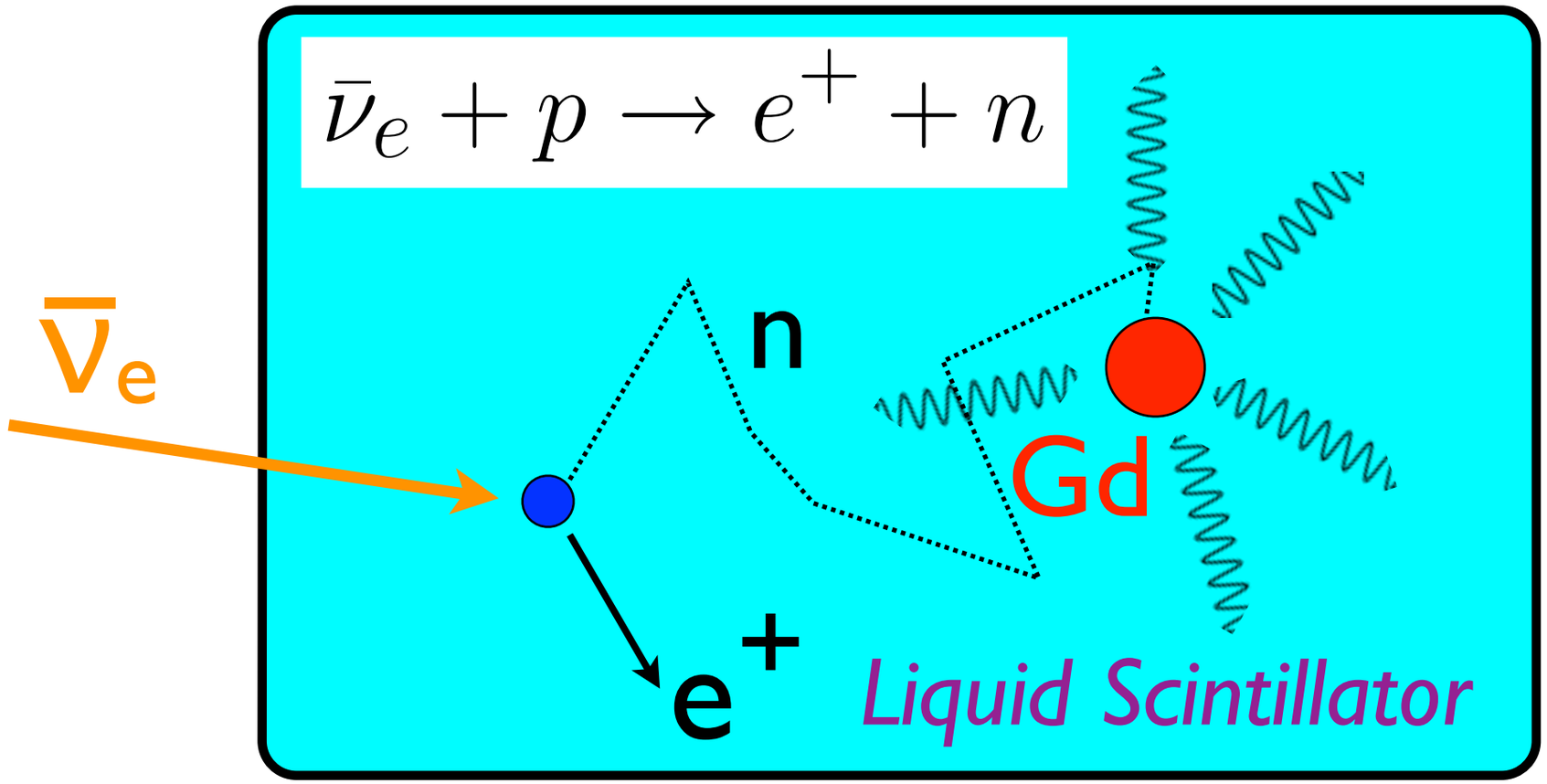
Daya Bay Focus is Precision Measurement of θ_{13}

- Experiments only produce and detect $\overline{\nu}_e$
- Δm^2_{13} sets optimal distance, but we knew Δm^2_{23}
- Complete disappearance probability given by…

$$P_{\bar{\nu}_e \to \bar{\nu}_e} = 1 - \cos^4\theta_{13}\sin^2 2\theta_{12}\sin^2\Delta_{21} - \sin^2 2\theta_{13}\left(\cos^2\theta_{12}\sin^2\Delta_{31} + \sin^2\theta_{12}\sin^2\Delta_{32}\right),$$

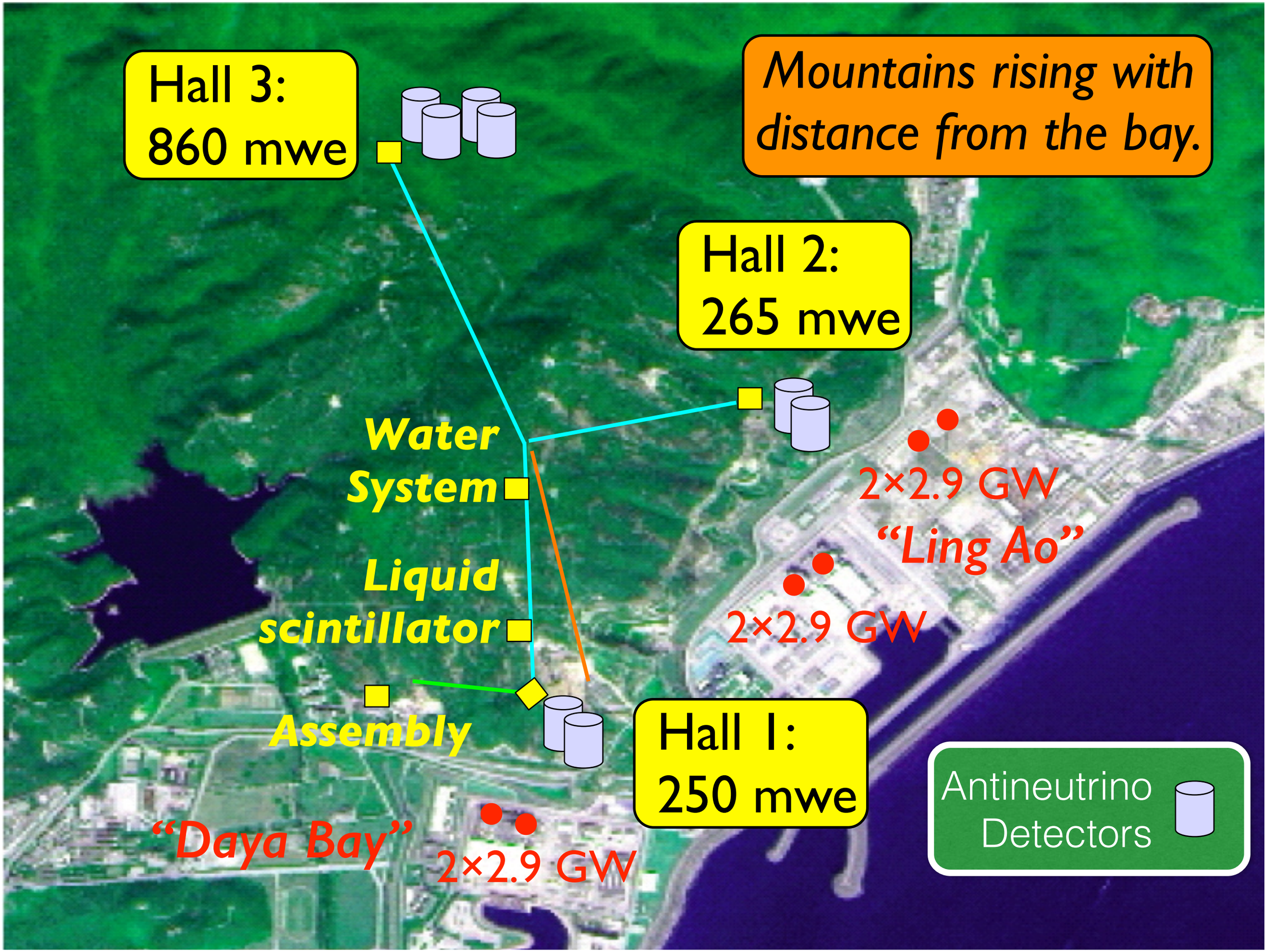
$$\text{where } \Delta_{ji} \equiv 1.267\Delta m^2_{ji}(\text{eV}^2)[L(\text{m})/E(\text{MeV})]$$

Detecting Inverse Beta Decay

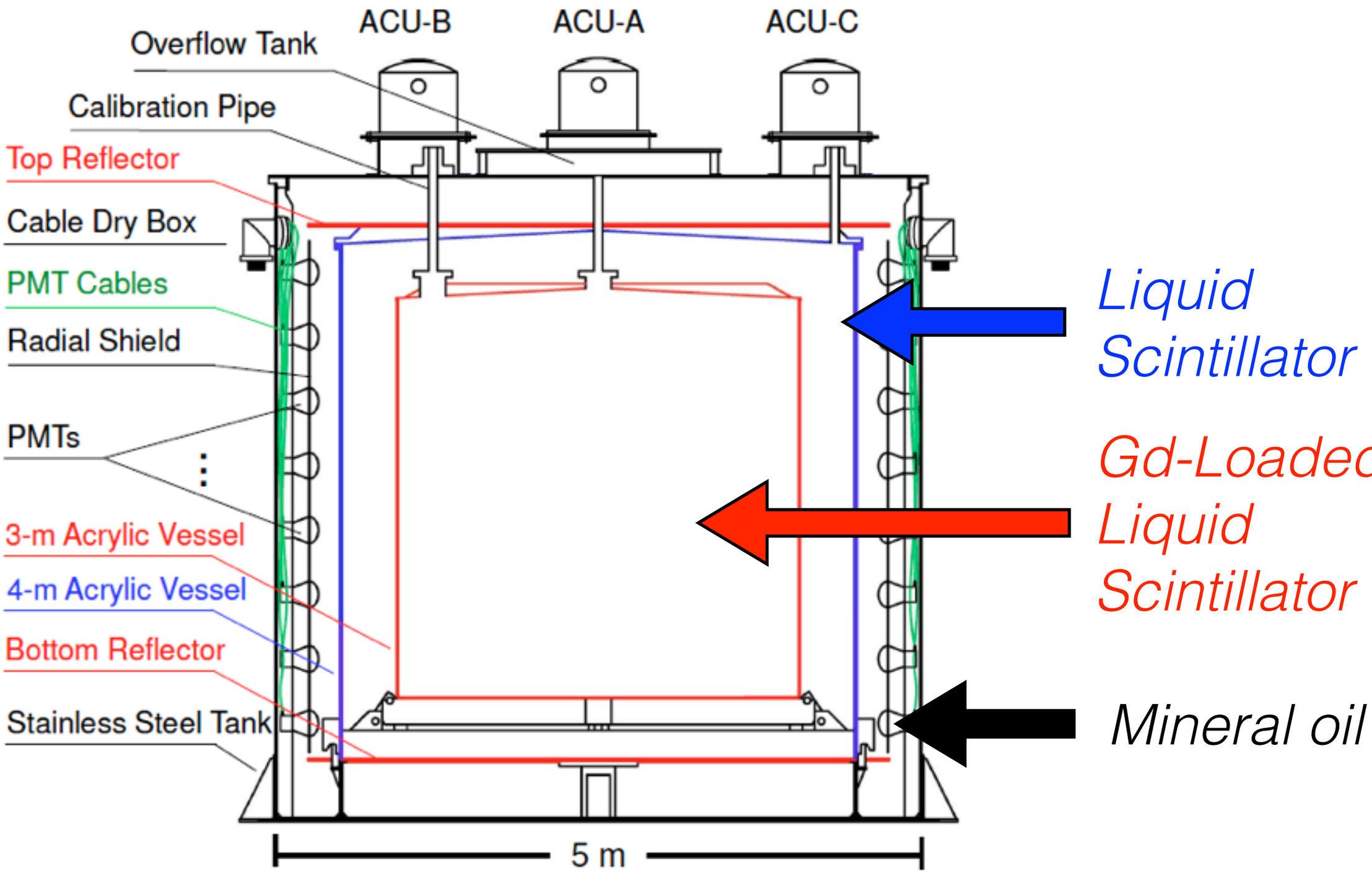


Prompt signal from e^+ gives primary energy signal

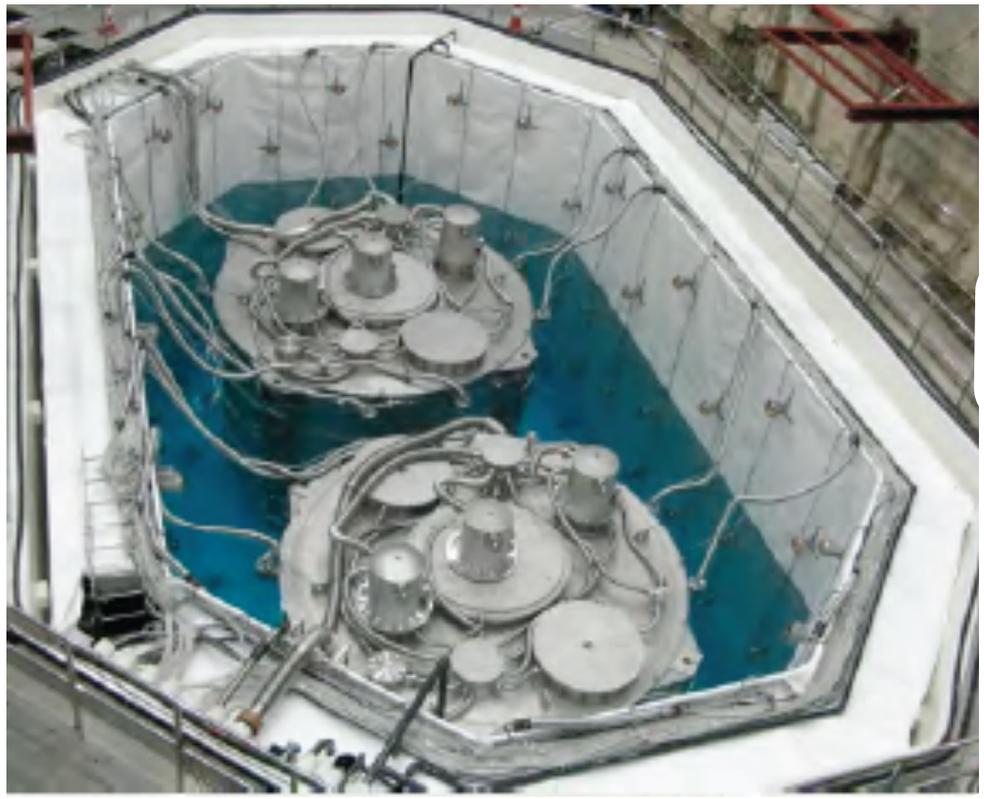
Delayed signal from Gd capture fights background


Hall 3:
860 mwe
Mountains rising with distance from the bay.
Hall 2:
265 mwe
Water
System
Liquid
scintillator
Assembly
2×2.9 GW
"Ling Ao"
2×2.9 GW
"Daya Bay"
2×2.9 GW
Hall 1:
250 mwe
Antineutrino
Detectors

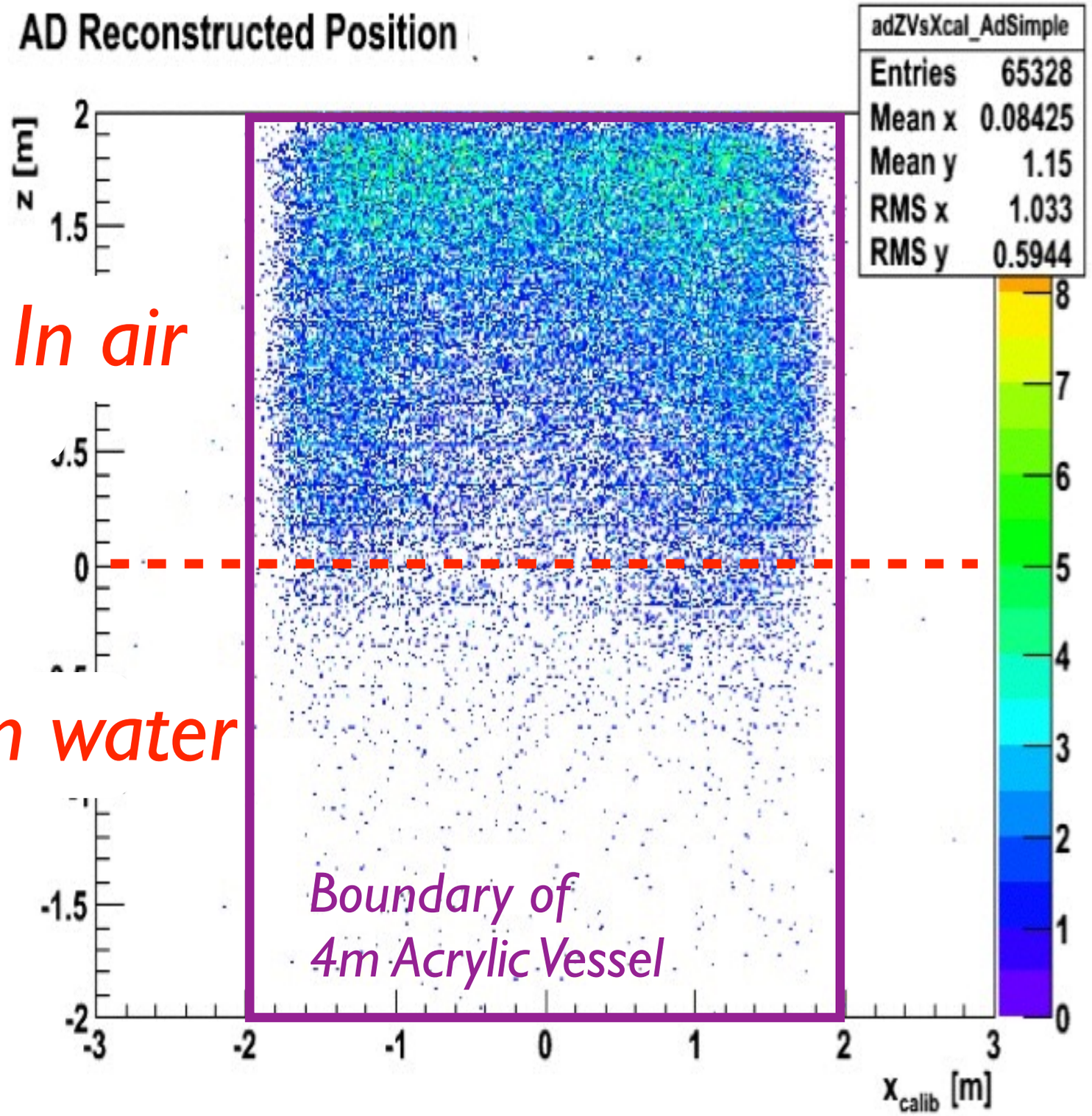
Antineutrino Detectors

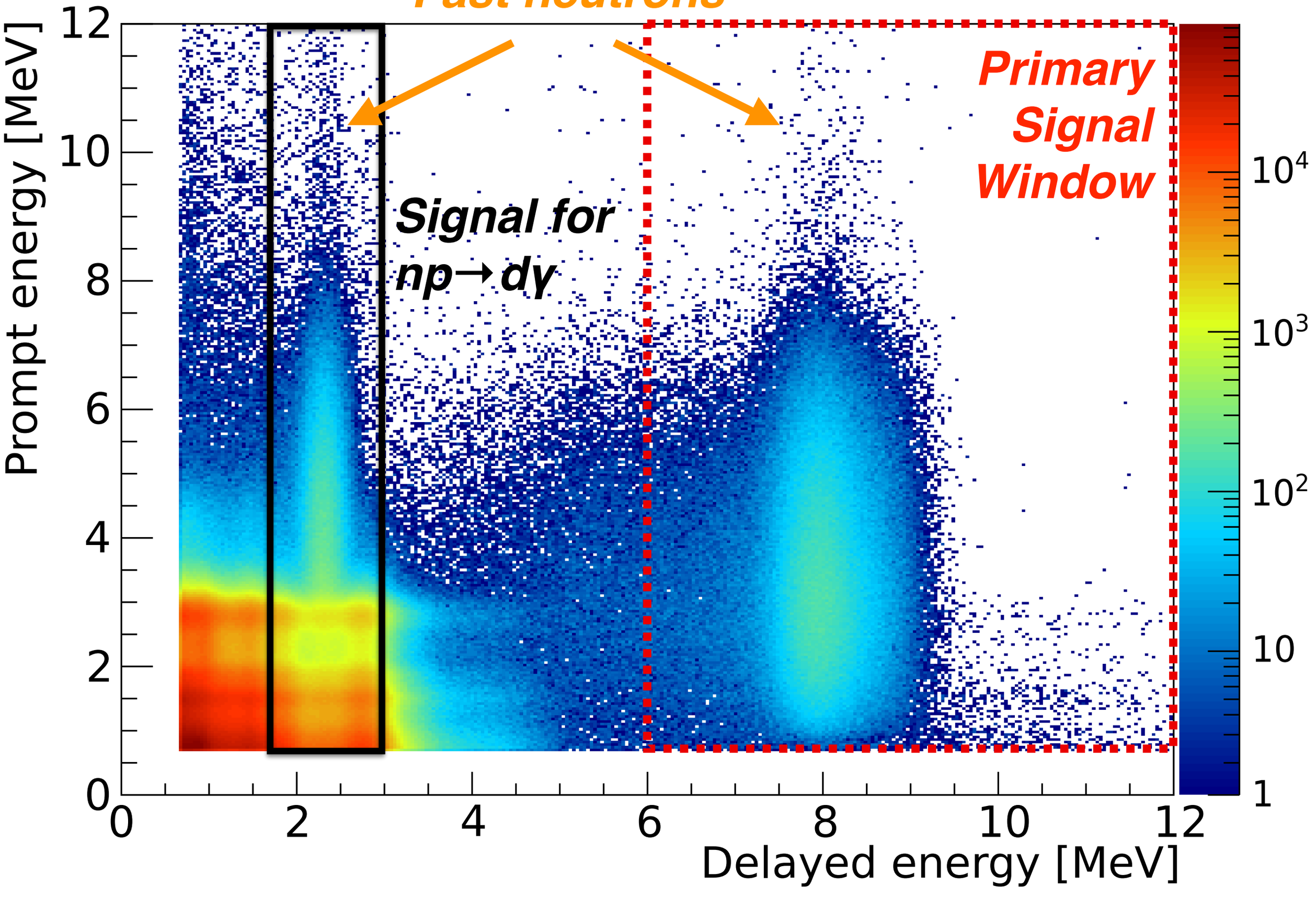


Water Shield

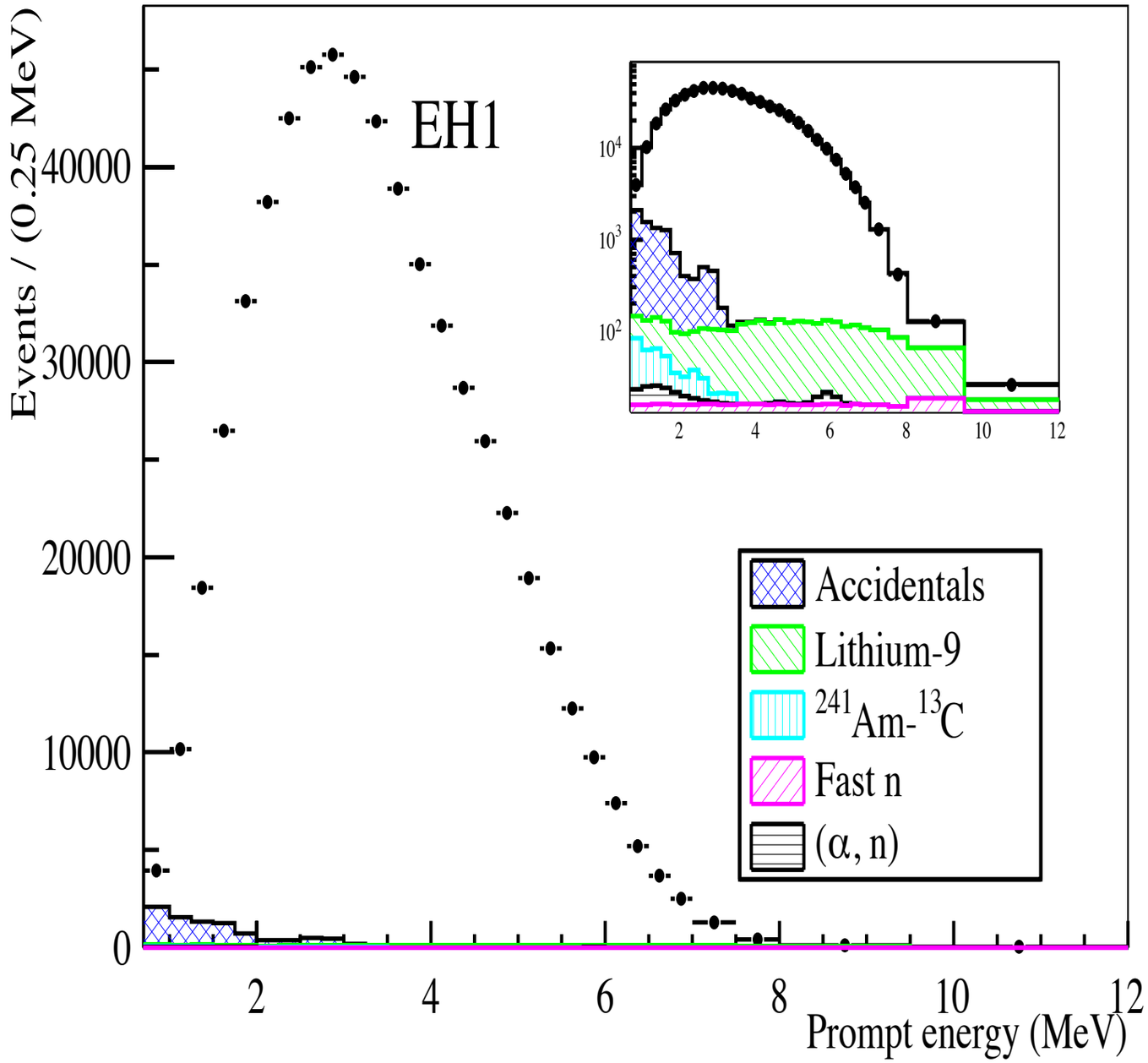


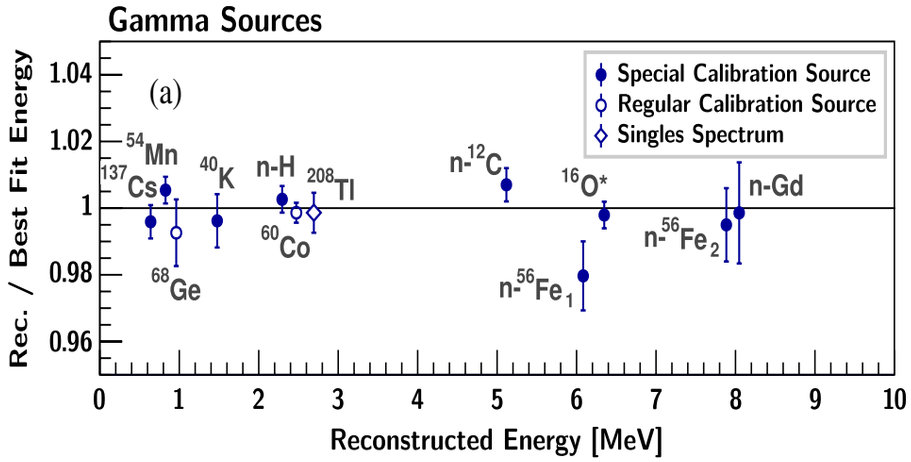
- Passive shielding
- Active shield for cosmic muons

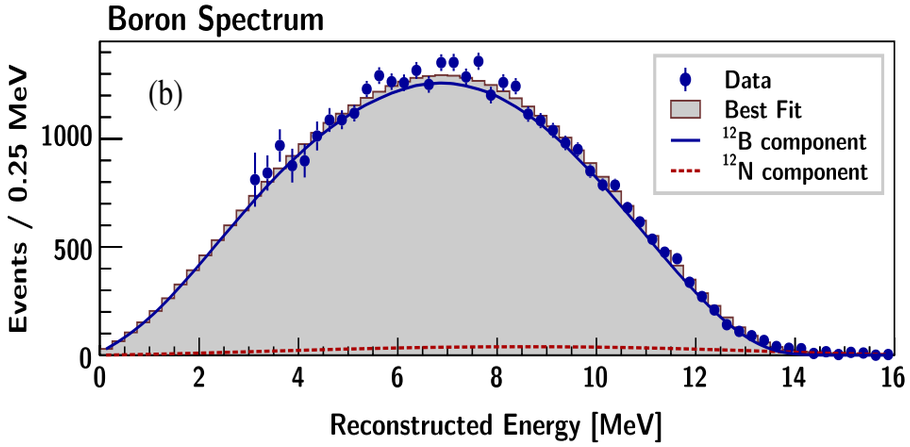


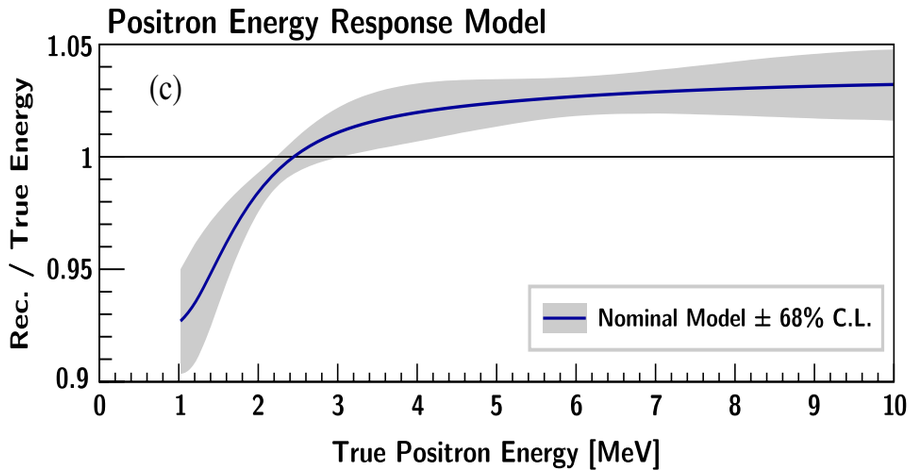

Fast neutrons
Primary Signal Window
Signal for np→dγ
Prompt energy [MeV]
Delayed energy [MeV]
0
2
4
6
8
10
12
1
10
10²
10³
10⁴

Energy Spectrum



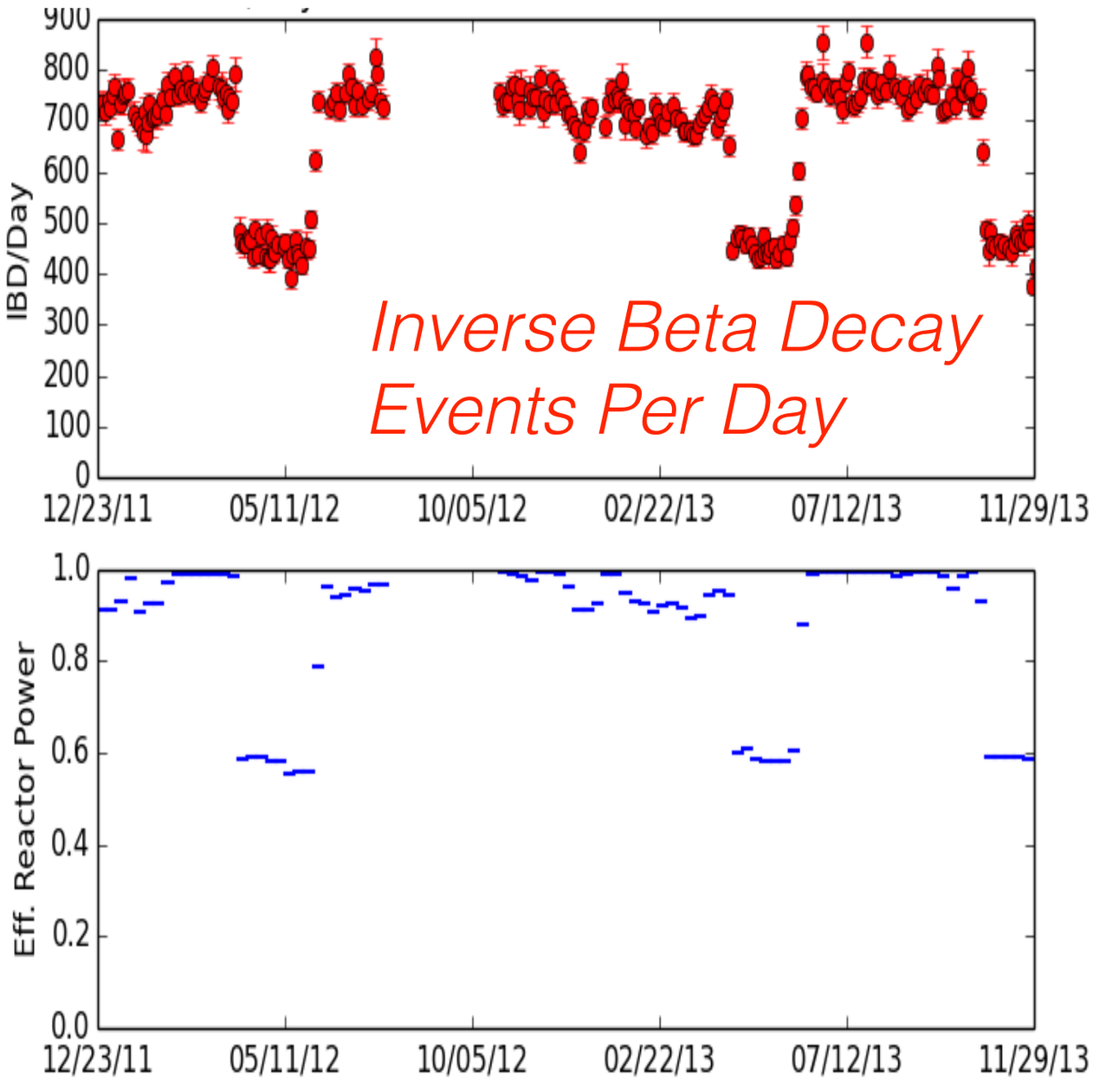




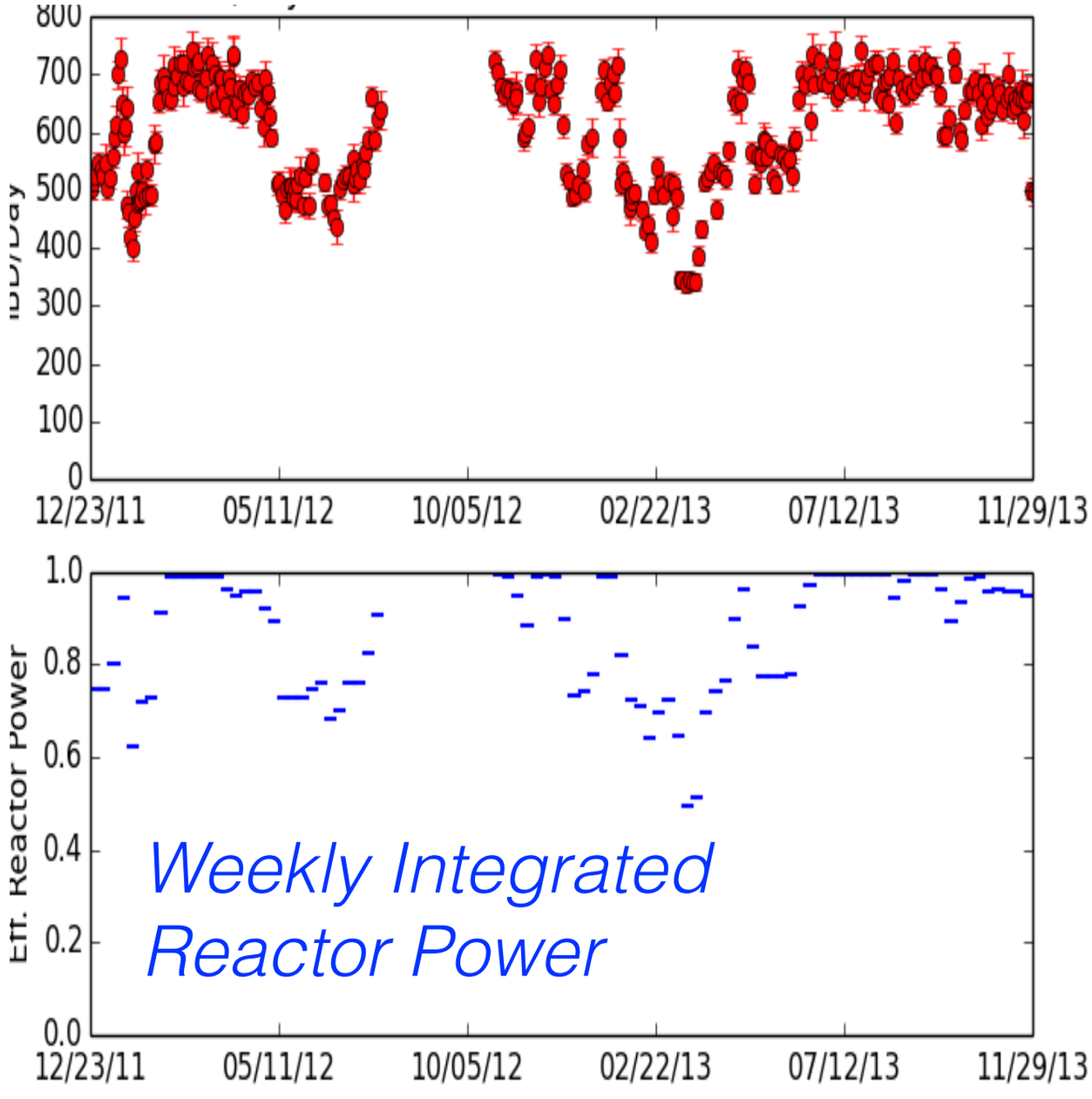


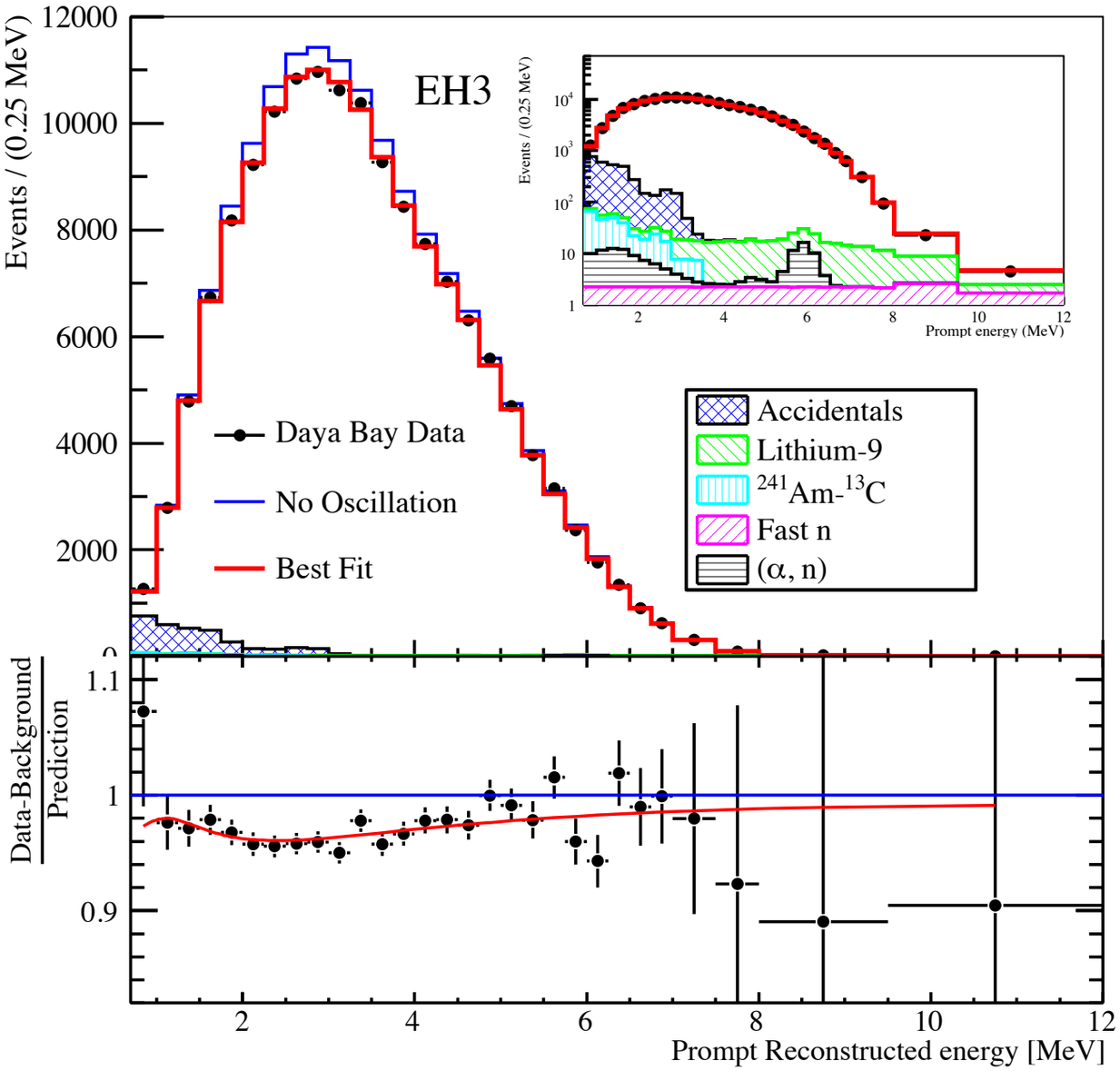
Rates and Reactor Power

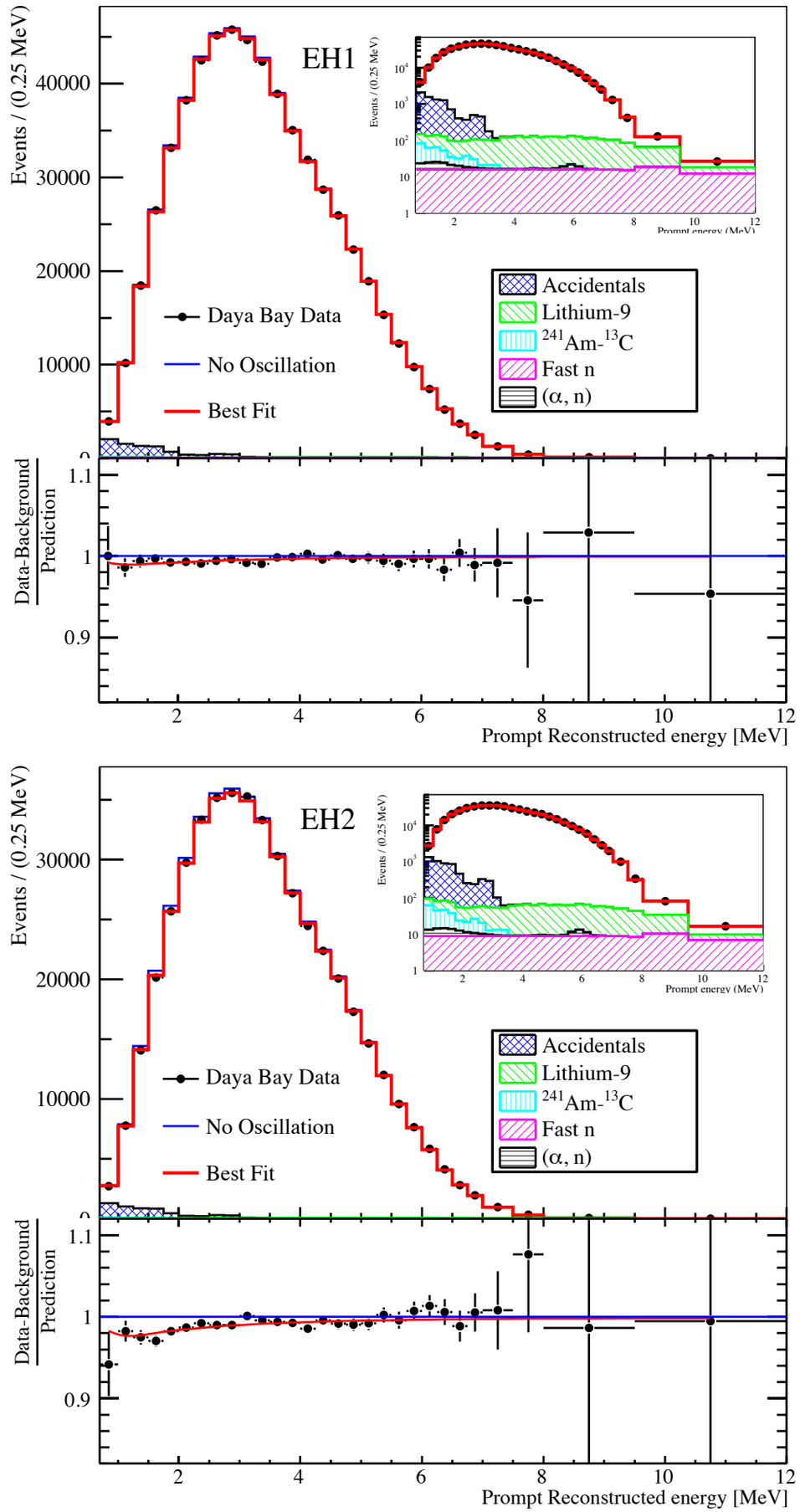
Hall 1 ("Daya Bay")



Hall 2 ("Ling Ao")

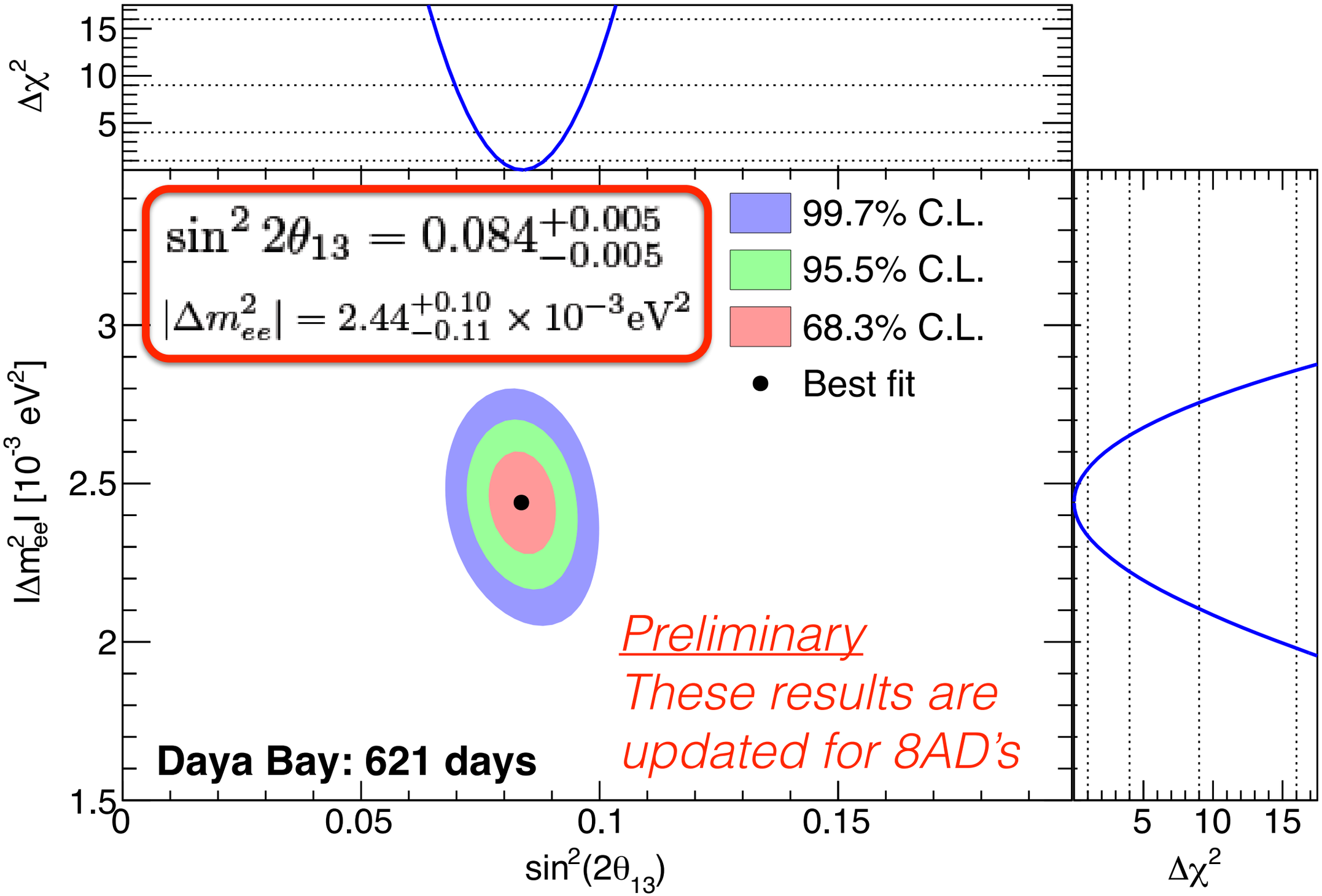




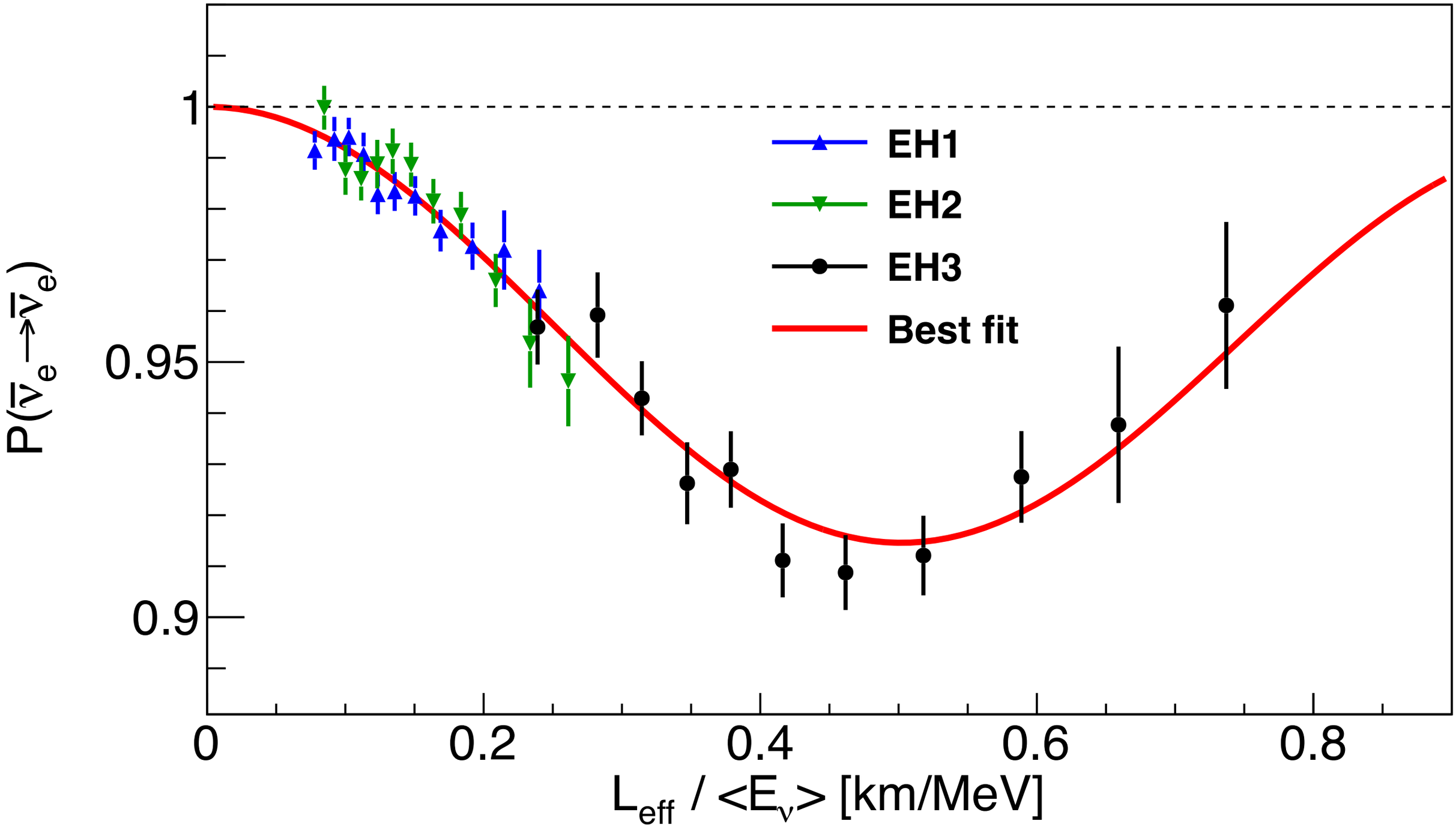


Spectral distortions are consistent with neutrino oscillations.

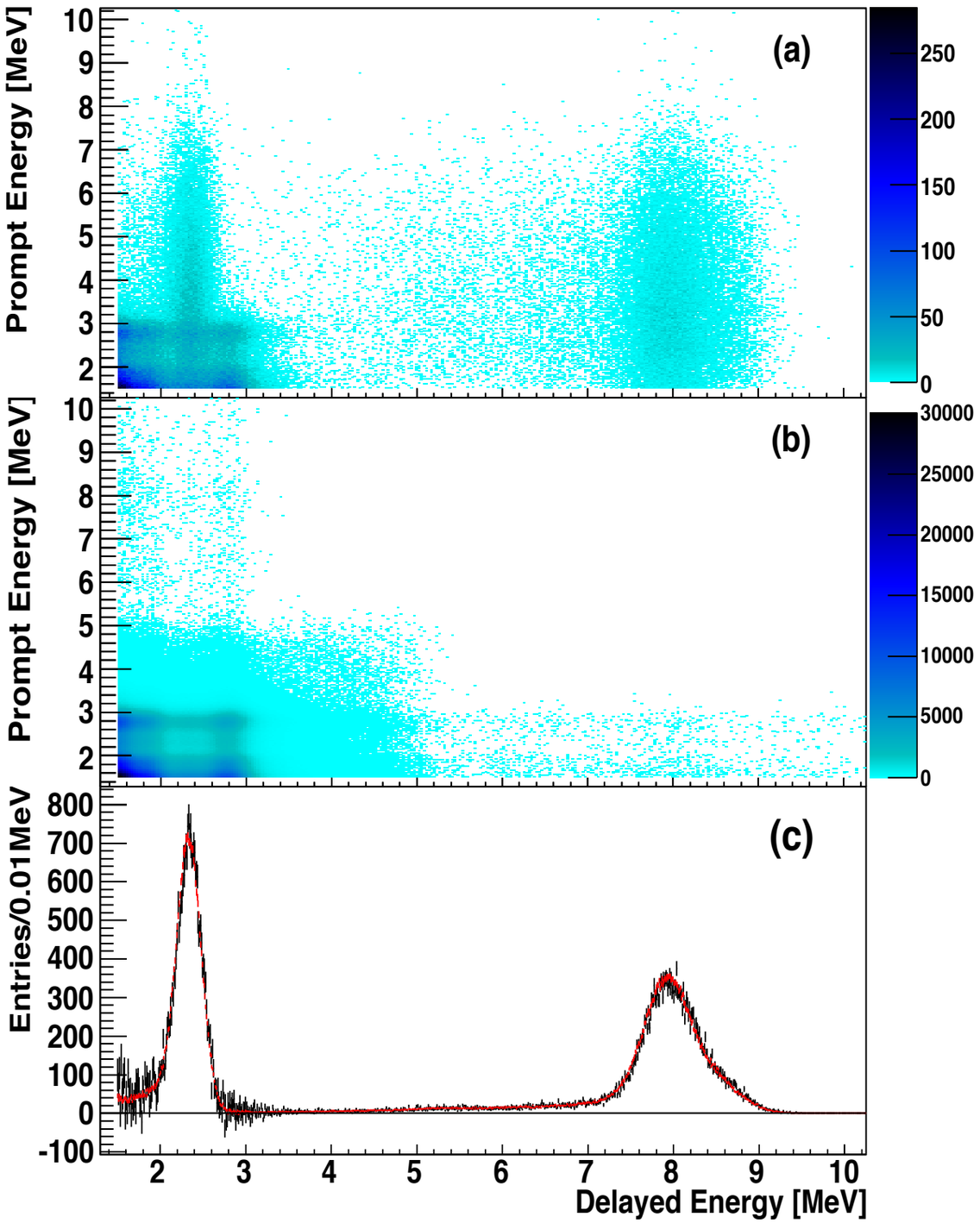
Results: θ_{13} and Δm^2_{ee}

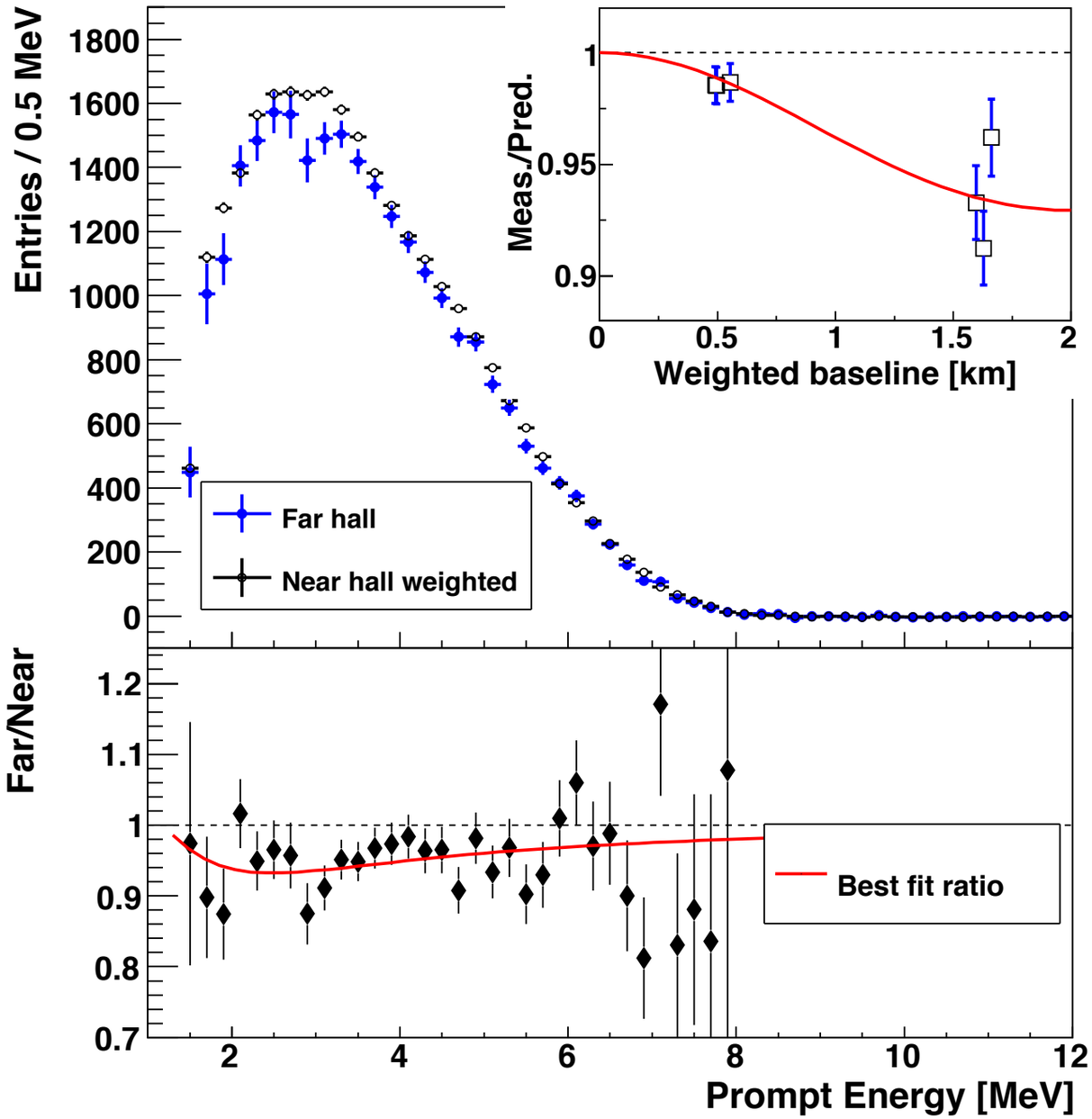


Results: Oscillation Probability



Results: Delayed np Capture

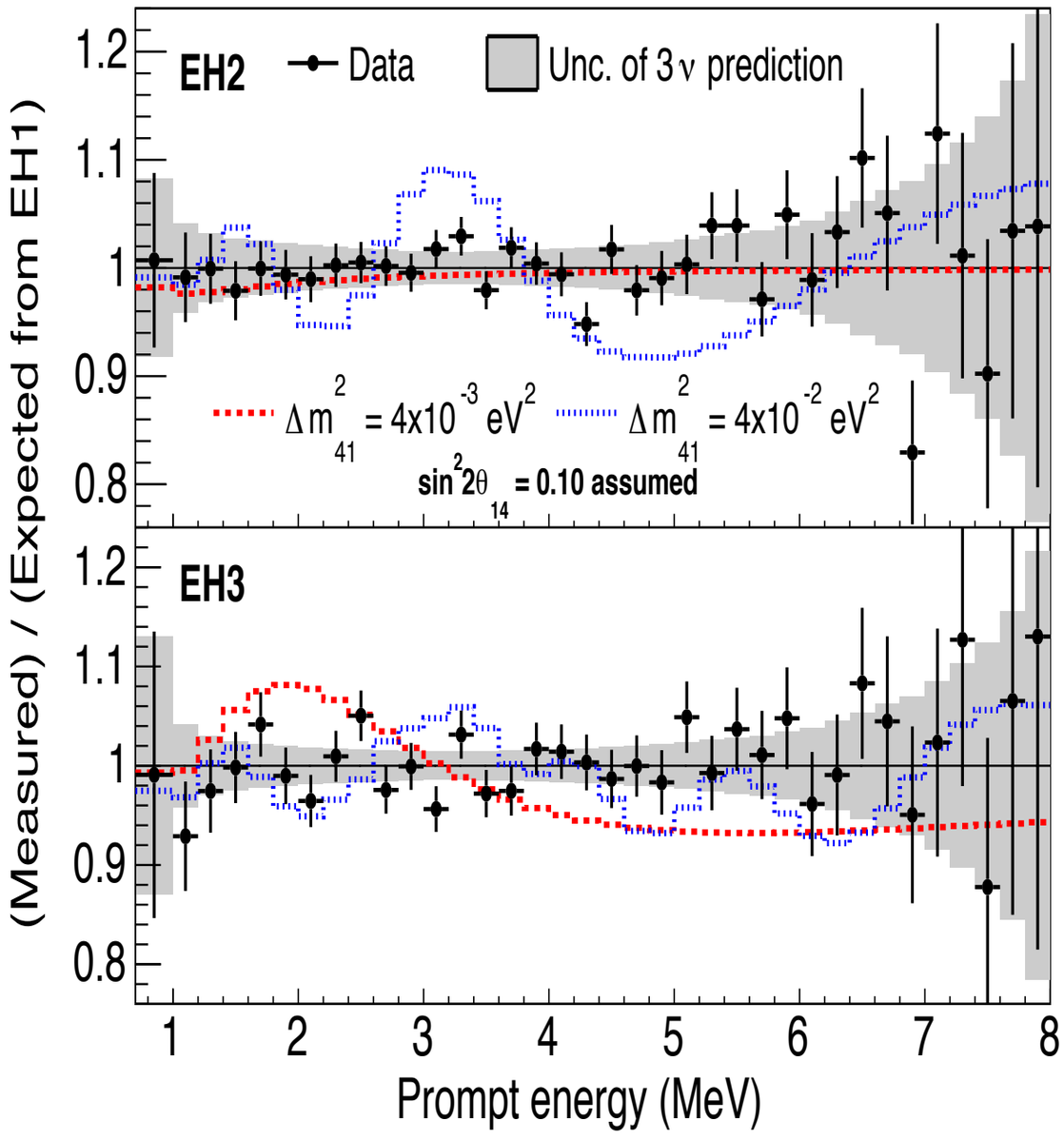


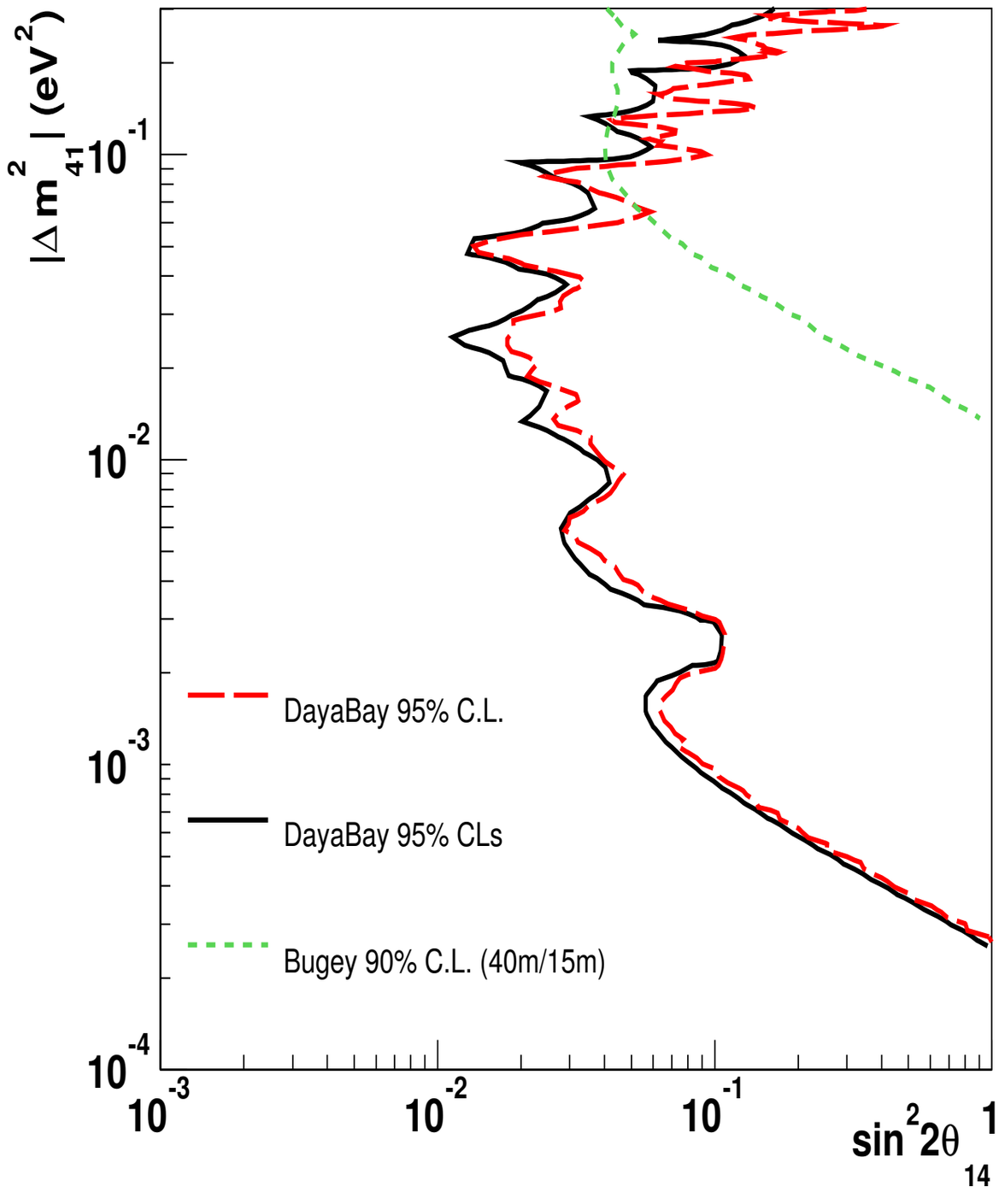


$$\sin^2 2\theta_{13} = 0.083 \pm 0.018$$

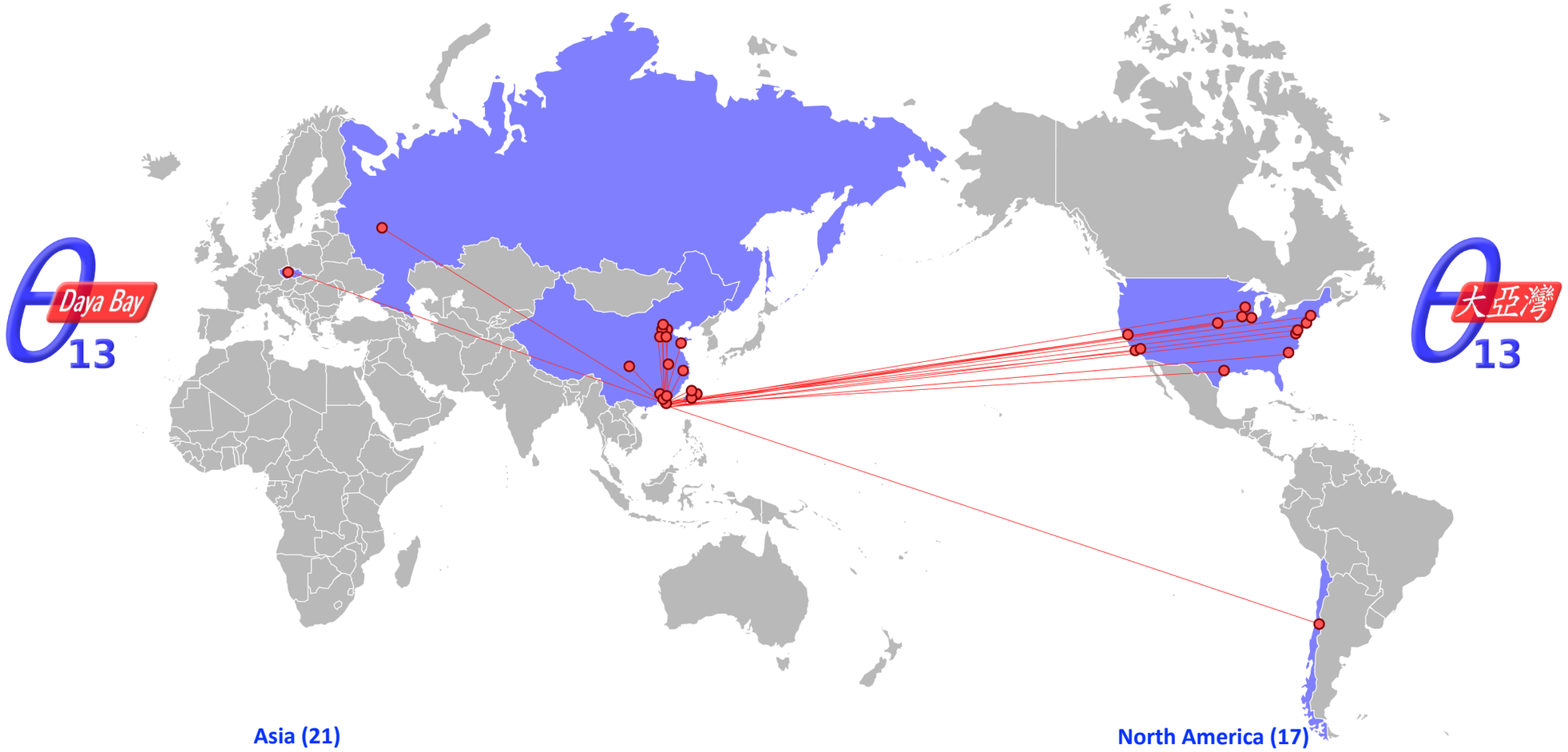
Results: Sterile Neutrinos

Normalize shape to EH1





The Daya Bay Collaboration



Asia (21)
Beijing Normal Univ., CGNPG, CIAE, Dongguan Polytechnic, ECUST, IHEP, Nanjing Univ., Nankai Univ., NCEPU, Shandong Univ., Shanghai Jiao Tong Univ., Shenzhen Univ., Tsinghua Univ., USTC, Xian Jiaotong Univ., Zhongshan Univ., Chinese Univ. of Hong Kong, Univ. of Hong Kong, National Chiao Tung Univ., National Taiwan Univ., National United Univ.

Europe (2)
Charles University, JINR Dubna

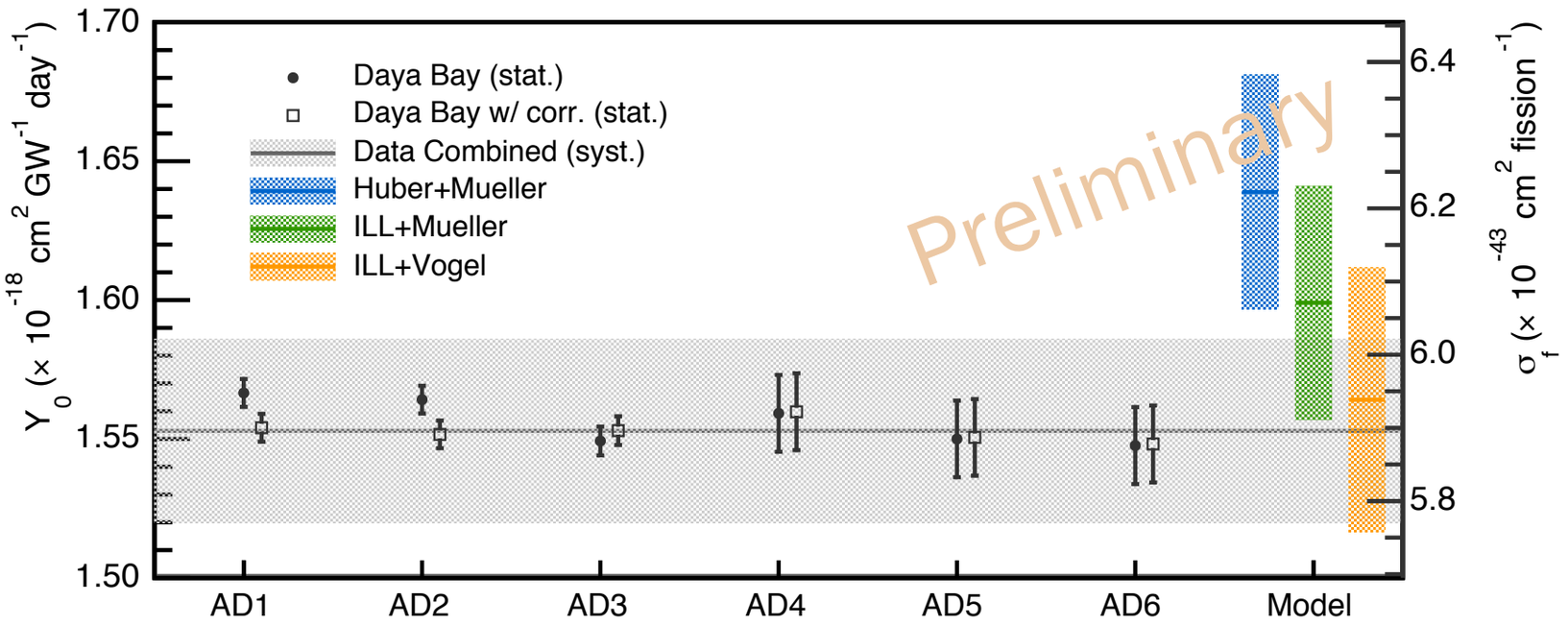
North America (17)
Brookhaven Natl Lab, CalTech, Illinois Institute of Technology, Iowa State, Lawrence Berkeley Natl Lab, Princeton,, Siena College, Temple University, UC Berkeley, UCLA, Univ. of Cincinnati, Univ. of Houston, UIUC, Univ. of Wisconsin, Virginia Tech, William & Mary, Yale

South America (1)
Catholic Univ. of Chile

Thank You!

Additional Slides for Measurements of Reactor Neutrino Flux and Energy Spectrum

Absolute Flux

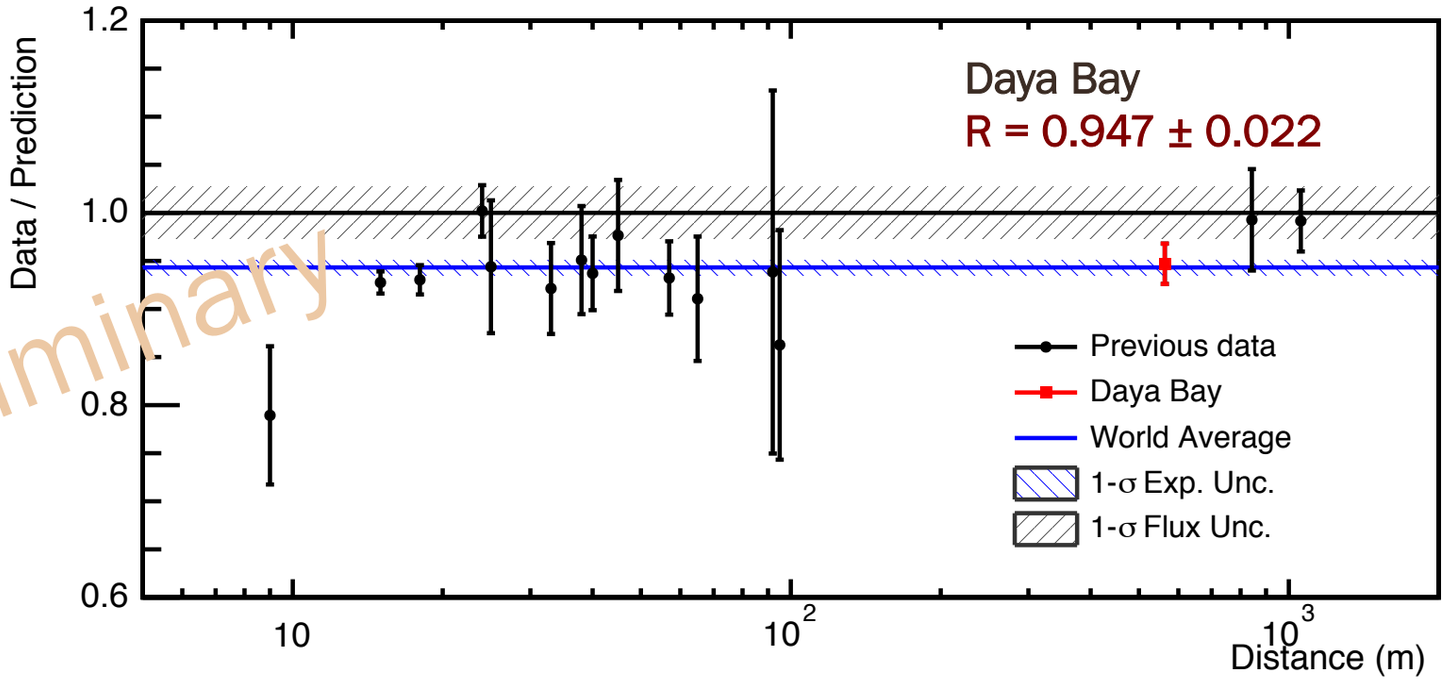


3-AD (near sites) measurement:

$Y_0 = 1.553 \times 10^{-18}$

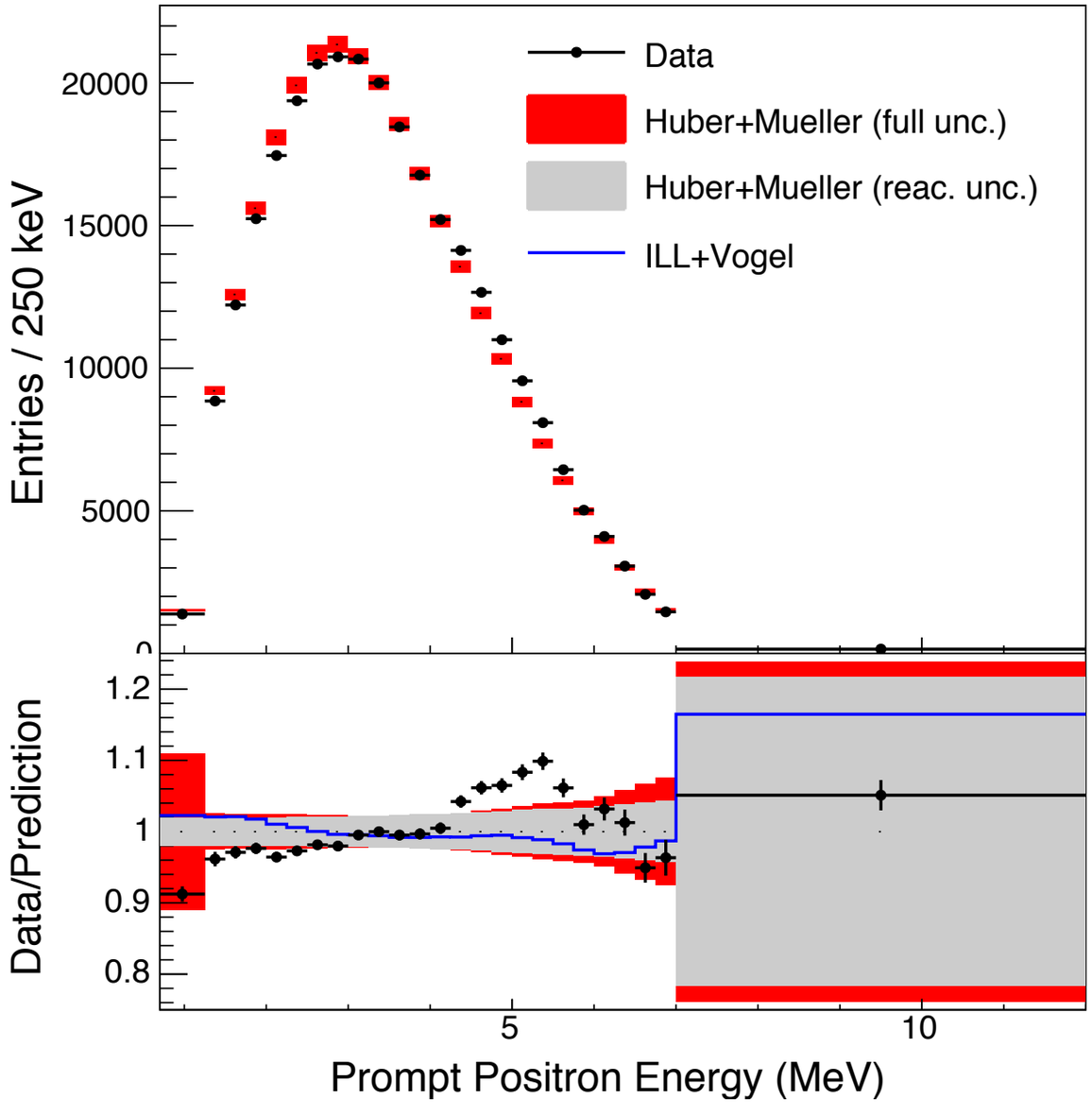
$\sigma_f = 5.934 \times 10^{-43}$

Prediction from Huber+Mueller

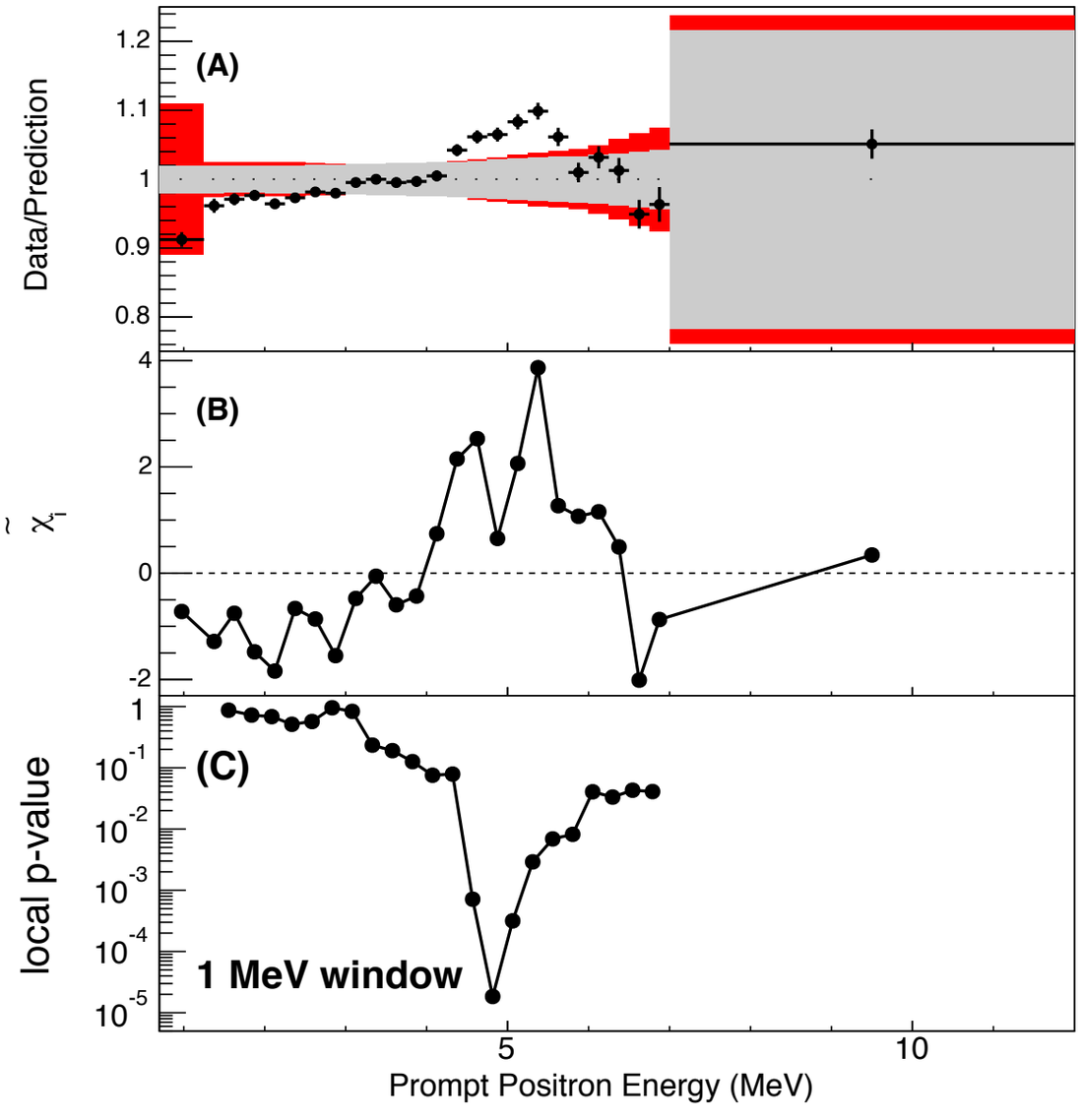


The “Bump” at 5 MeV

Compared to Prediction

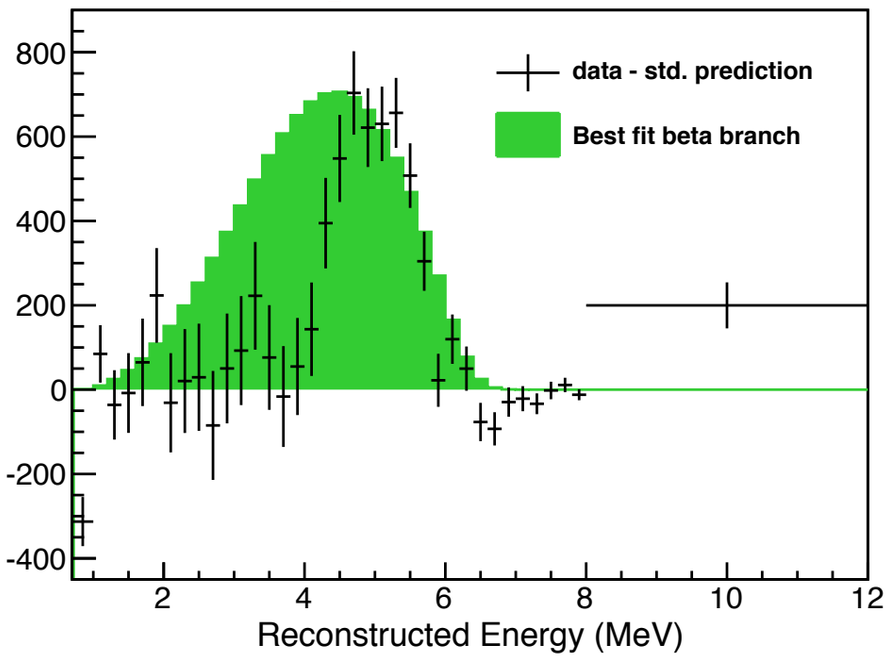


Statistical Significance

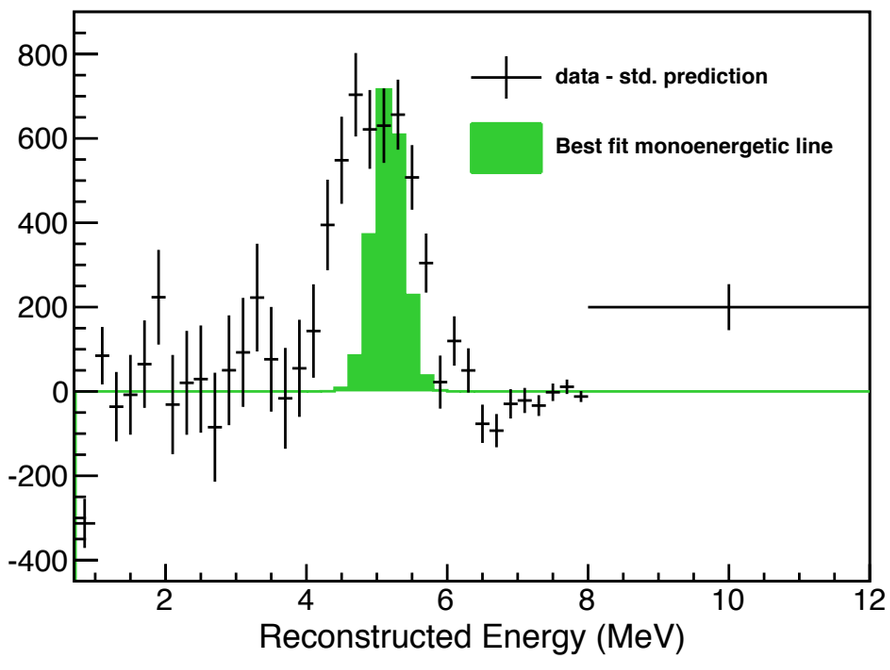


Analysis of "The Bump"

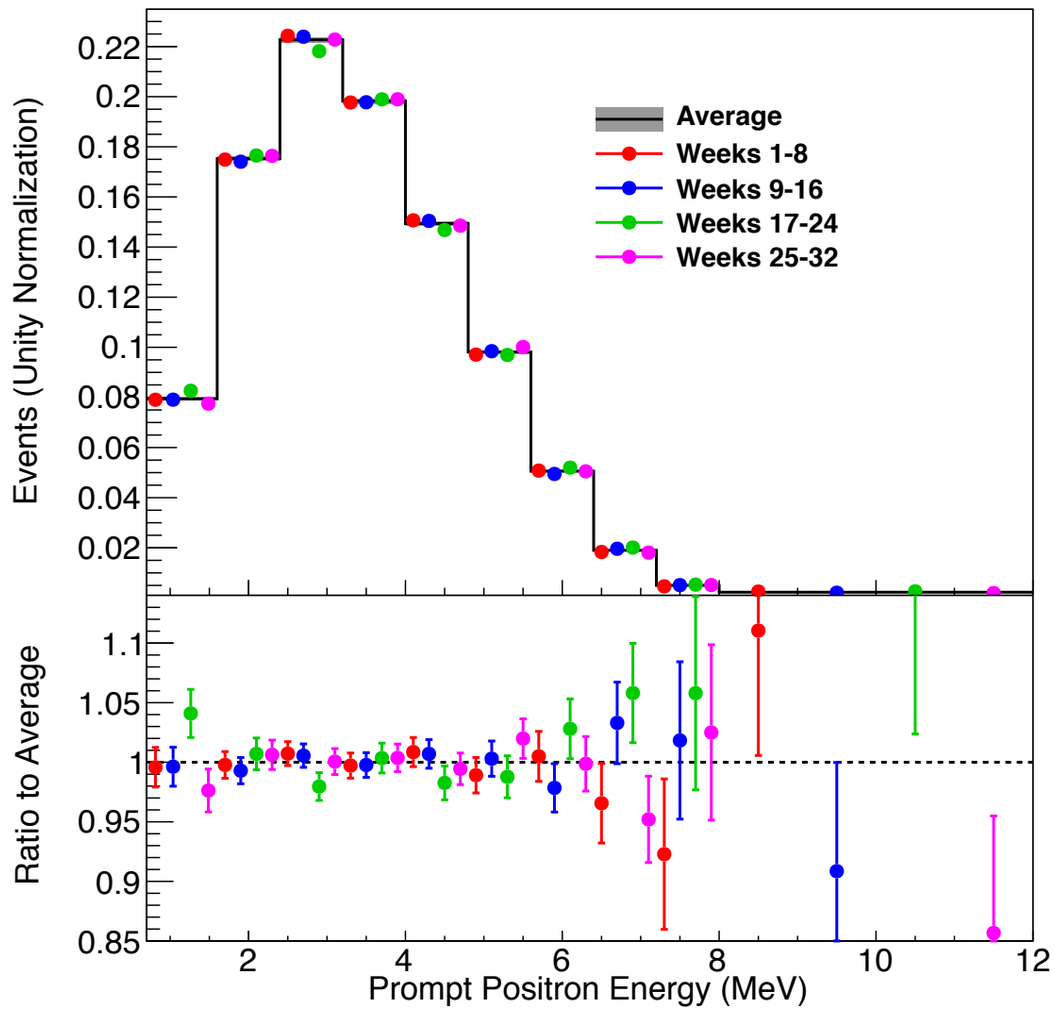
***Not* a β-branch**



***Not* a δ-function**



***Not* time-dependent**



***Also not* in ^{12}B spectrum, so instrumental effects are disfavored.**