SBL Collaboration Meeting@Chonnam NU
2014.11.21

Remarks on Analysis and Systematics?

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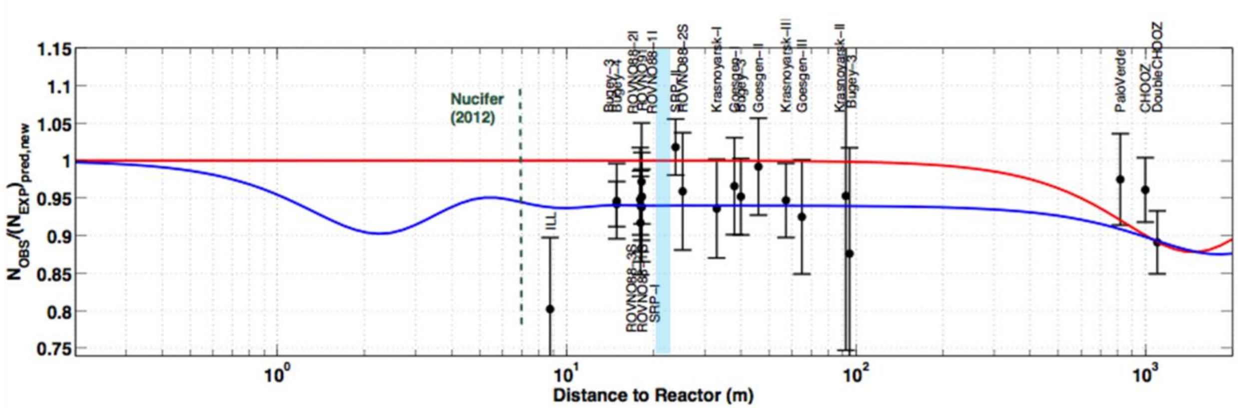
- Because of using a single detector, the uncertainty in the neutrino flux (counts) degrades the sensitivity.

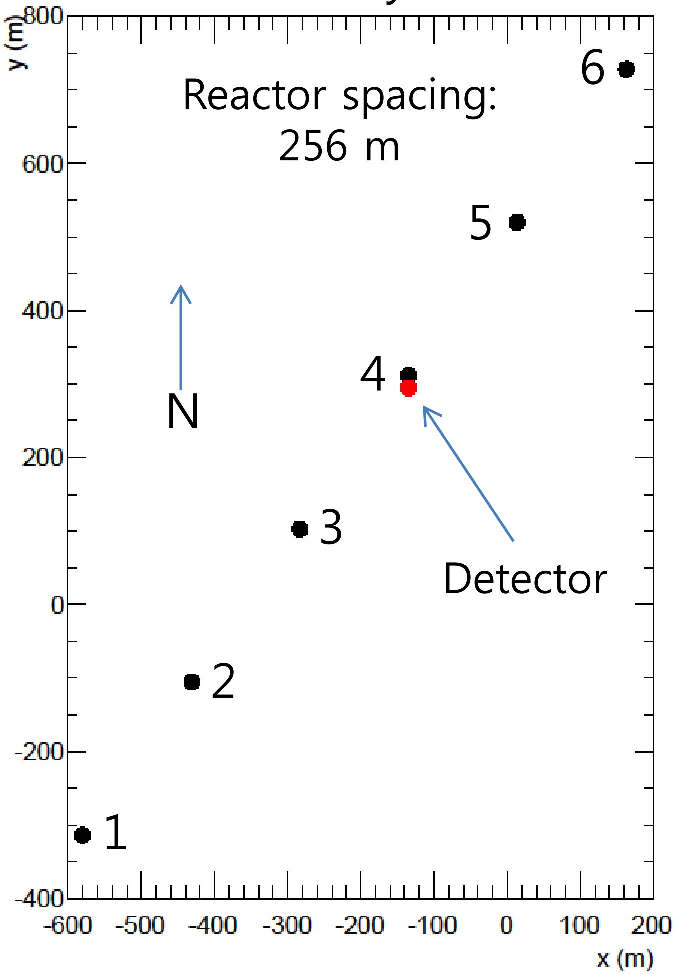
- The shape is of the concern.

$$\mathrm{Prob}(\bar{\nu}_e \rightarrow \bar{\nu}_e) \approx 1 - \sin^2(2\theta_{ee})\sin^2\left(\frac{1.27\,\Delta m_{41}^2\,L}{E_{\bar{\nu}_e}}\right)$$



Calculation Setup

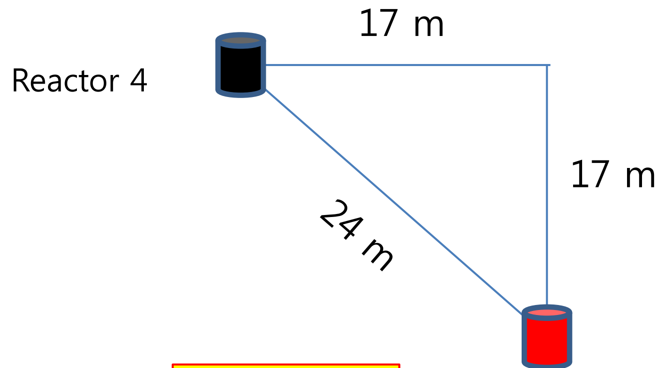
Hanbit NPP layout



Reactor

P_{th}=2.73 GW
^{235}U : 0.6977
^{238}U : 0.0765
^{239}Pu : 0.1912
^{241}Pu : 0.0346

Fuel assembly :
r= 1.56 m, h= 3.18 m



Detector

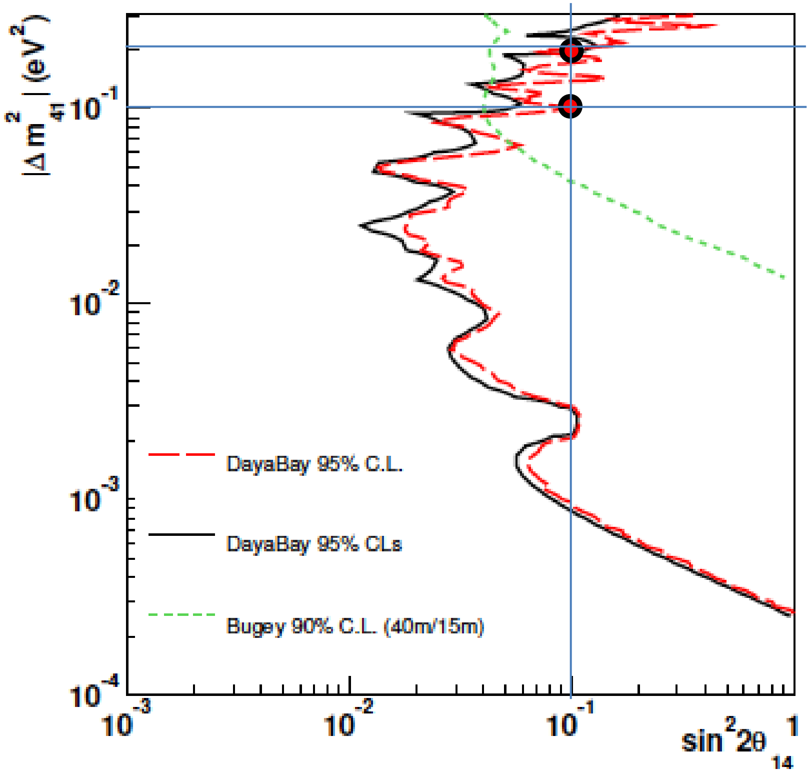
Active volume :
r= 0.5 m, h= 1.2 m

Energy resolution $\frac{\delta E}{E} = \frac{0.06}{\sqrt{E}}$

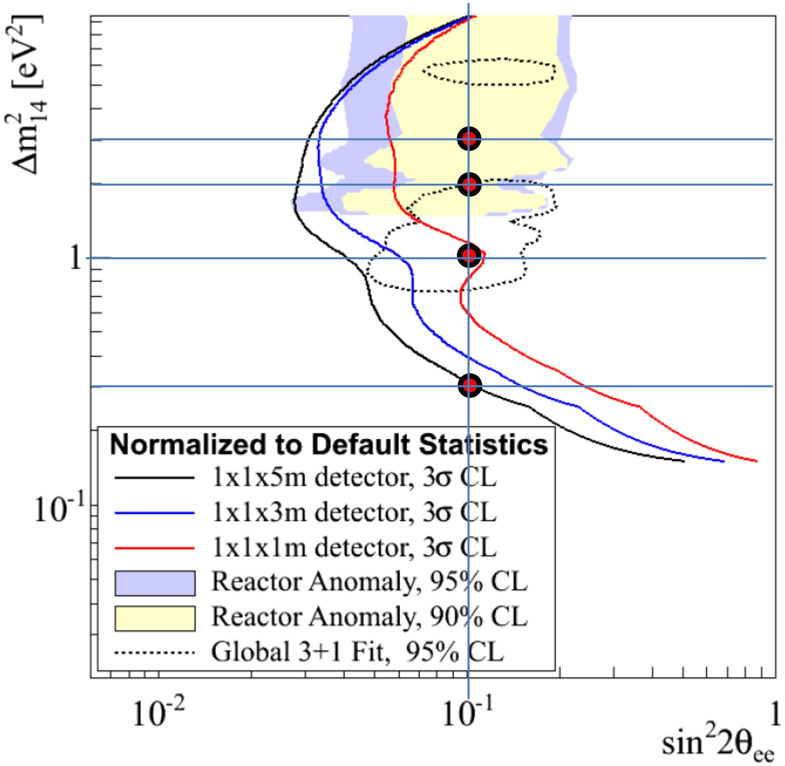
Acceptance: 60%

No boundary effects

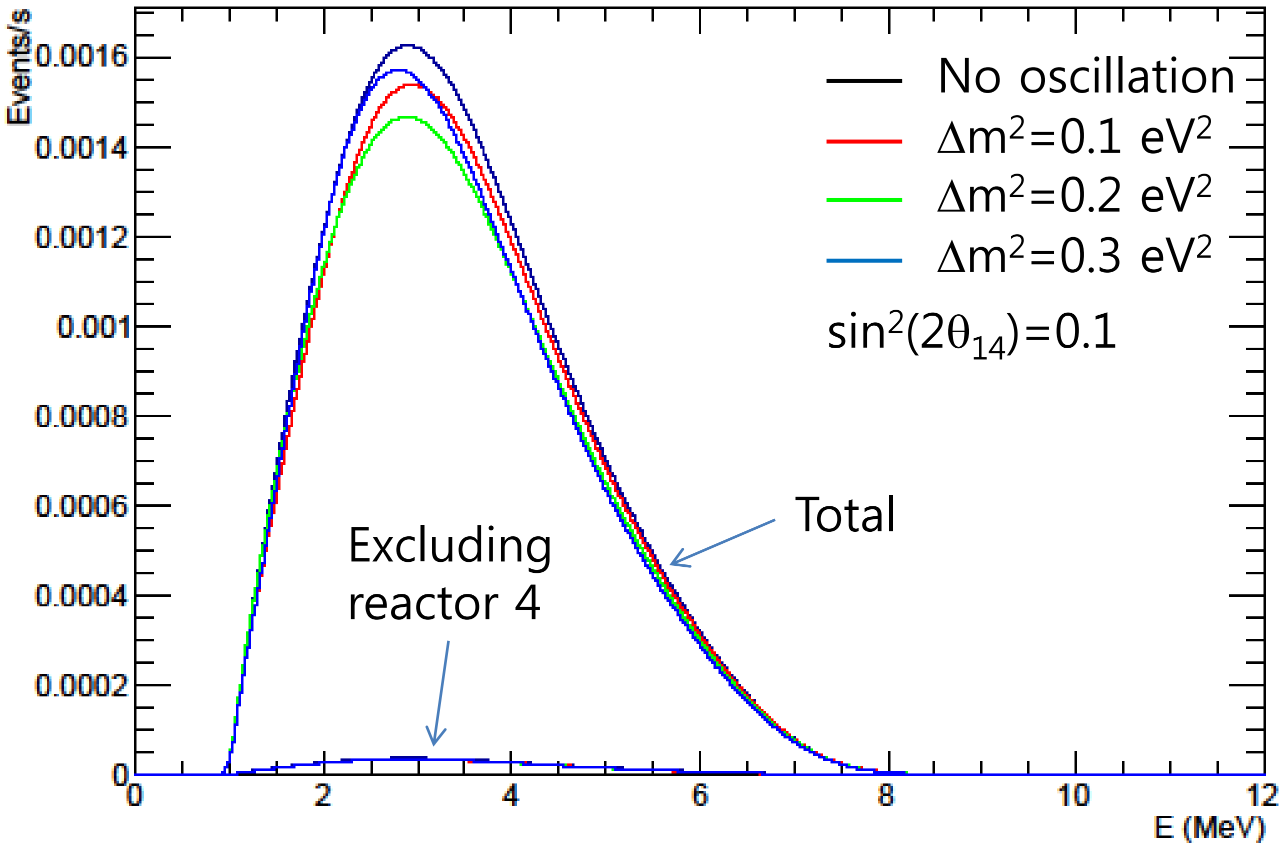
Daya-Bay 95% CL limits



arXiv:1212.2182v1 (feasibility study)

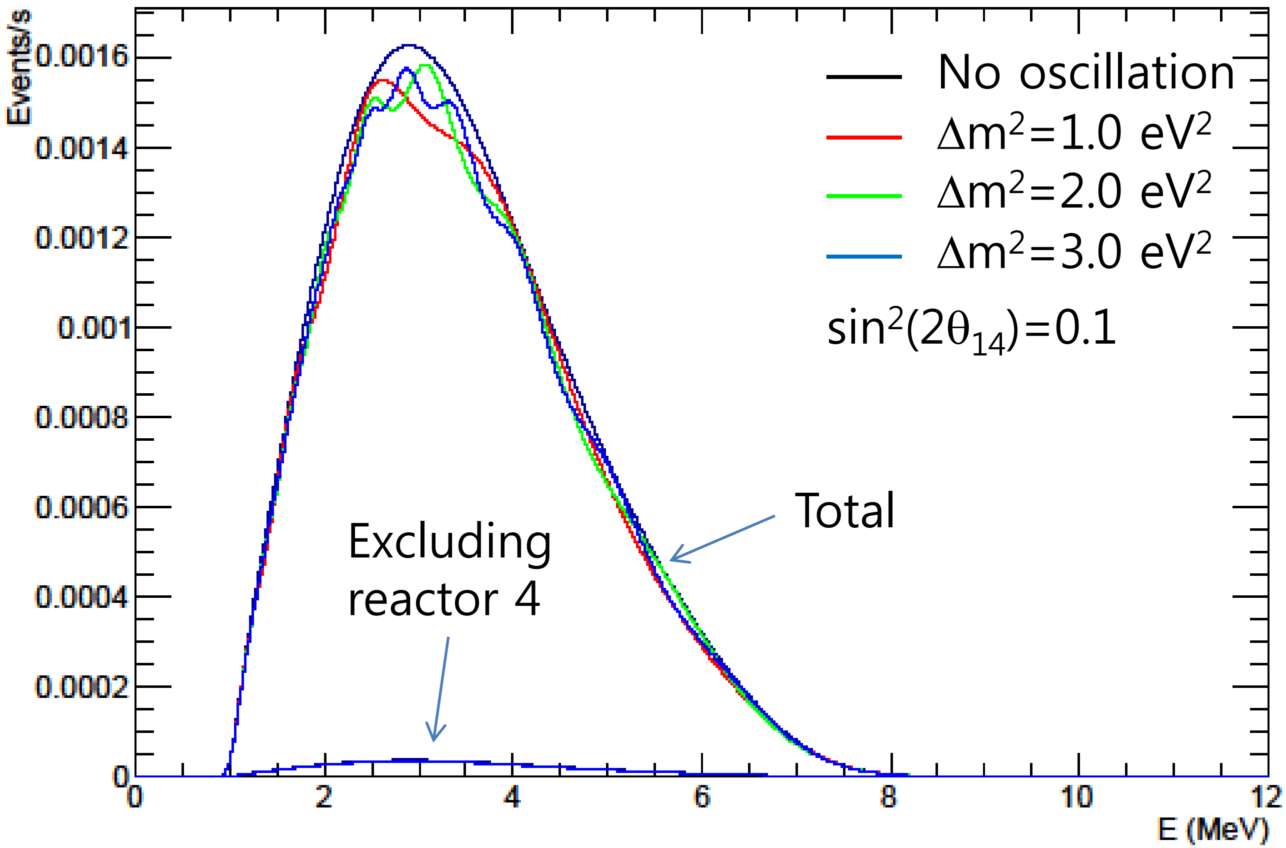


Energy Spectra



Spectra shifted
Low sensitivity if large energy scale uncertainty and large flux uncertinaty.

Energy Spectra



Spectra distorted
Low sensitivity if large energy scale uncertainty and large flux uncertinaty.

χ^2 Fit

From "Experimental Parameters for a Reactor Antineutrino Experiment at Very Short Baselines" (arXiv:1212.2182v1)

Data in the i[th] energy bin

background in the i[th] energy bin

background normalisaton

$$\chi^2 = \sum_{i,j} \frac{\left[M_{ij} - (\alpha + \alpha_e^i + \alpha_r^j)T_{ij} - (1+\alpha_b)B_{ij}\right]^2}{T_{ij} + (\sigma_{b2b}B_{ij})^2} + \frac{\alpha^2}{\sigma^2} + \cancel{\sum_j \left(\frac{\alpha_r^j}{\sigma_r}\right)^2} + \sum_i \left(\frac{\alpha_e^i}{\sigma_e^i}\right)^2 + \frac{\alpha_b^2}{\sigma_b^2}$$

signal in the i[th] energy bin

Absolute normalisaton

Bin-by-bin normalisaton

Minimise with respect to nuisance parameters $\{\alpha, \alpha_e^i, \alpha_b\}$

χ^2 Fit Parameters

$$\chi^2 = \sum_{i,j} \frac{\left[M_{ij} - (\alpha + \alpha_e^i + \alpha_r^j)T_{ij} - (1+\alpha_b)B_{ij}\right]^2}{T_{ij} + (\sigma_{b2b}B_{ij})^2} + \frac{\alpha^2}{\sigma^2} + \sum_j \left(\frac{\alpha_r^j}{\sigma_r}\right)^2 + \sum_i \left(\frac{\alpha_e^i}{\sigma_e^i}\right)^2 + \frac{\alpha_b^2}{\sigma_b^2}$$

$\frac{\alpha^2}{\sigma^2}$ In our case, floating α, i.e. σ=some large number…

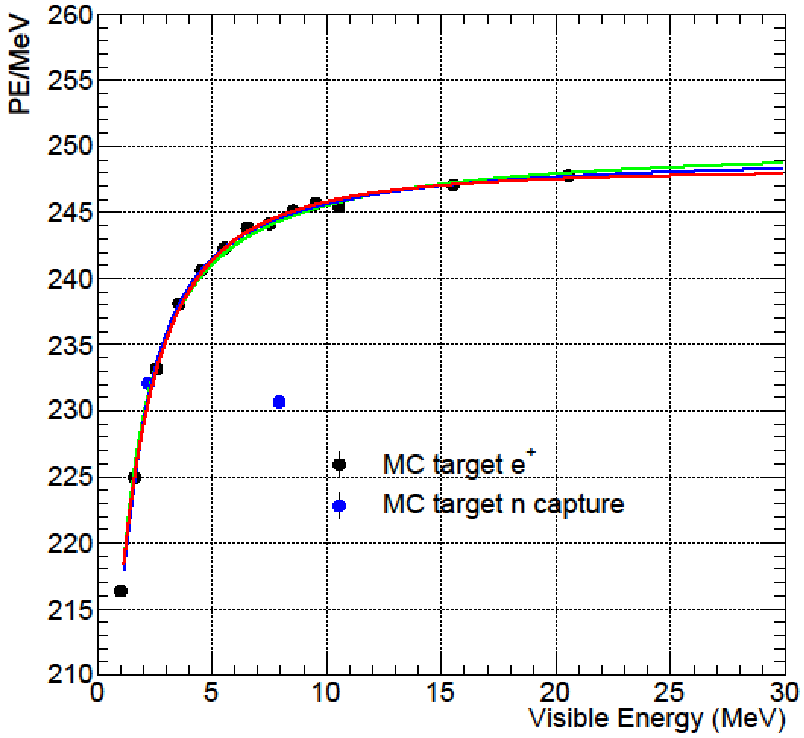
$\left(\frac{\alpha_e^i}{\sigma_e^i}\right)^2$ Bin-by-bin uncertainties: very simple minded. not sure we can account for the correlations between systematics this way.

For example, energy scale uncertainty is correlated and contribution goes in to T_i as $\varepsilon_i \frac{\partial T_i}{\partial \varepsilon_i}\Big|_{\varepsilon_i=0}$ where $E' = (1+\varepsilon)E$

$\frac{\alpha_b^2}{\sigma_b^2}$ Completely bin-by-bin correlated background uncertainty. But not so simple in reality.

Energy Scale

positrons energy deposition: MC (RENO)



Need various calibration sources.
Photon and positron responses are different.

We need to tune the MC as well.

χ^2 Fit Parameters

χ^2 function once used at RENO

Spectral Fit

"current" χ^2 function

$$\chi^2 = \min_{\{\omega\}} \left\{ \sum_{d=N,F} \left[\sum_{i=1}^{N_b} \left(\frac{O_i^d - N_i^d}{U_i^d} \right)^2 + \left(\beta^d\right)^2 + \left(\frac{\delta^d}{\sigma_d^d} \right)^2 + \left(\frac{\epsilon^d}{\sigma_{cal}^d} \right)^2 \right] + \left(\frac{\alpha}{\sigma_a} \right)^2 + \sum_{i=1}^{N_b} \sum_{j=1}^{n_{iso}} \left(\frac{\gamma_{ij}}{\sigma_{shape_{ij}}} \right)^2 + \sum_{r=1}^{N_c} \left(\frac{\xi_r}{\sigma_{cfl}} \right)^2 \right\} + F_i^d$$

5 MeV component

where

$$N_i^d = (1 + a + e^d \quad) \sum_{r=1}^{N_c} (1 + f_r) T_{ir}^d + g^d M_i^d + b^d \cdot \sigma(B_i^d)$$

$$T_i^d \simeq T_i^d(g^d = 0) + g^d M_i^d; \quad M_i^d = \left. \frac{dT_i^d}{dg^d} \right|_{g^d=0} \qquad T_{ir}^d = \sum_{j=1}^{n_{iso}} (1+\gamma_{ij}) T_{irj}^d$$

and

$$U_i^d = \sqrt{O_i^d + B_{ij}^d + (b^d \cdot \sigma(B_i^d))} \; (?)$$

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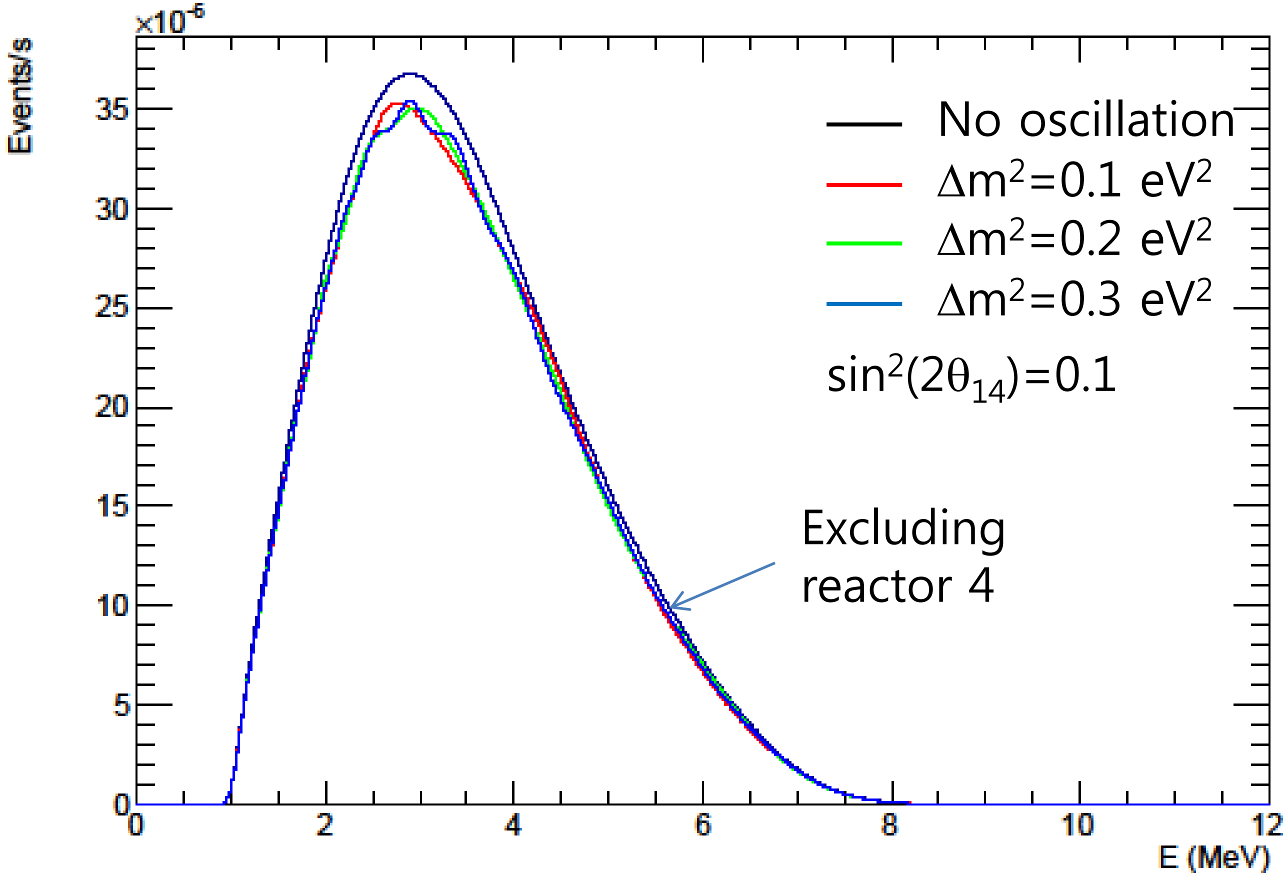
Summary

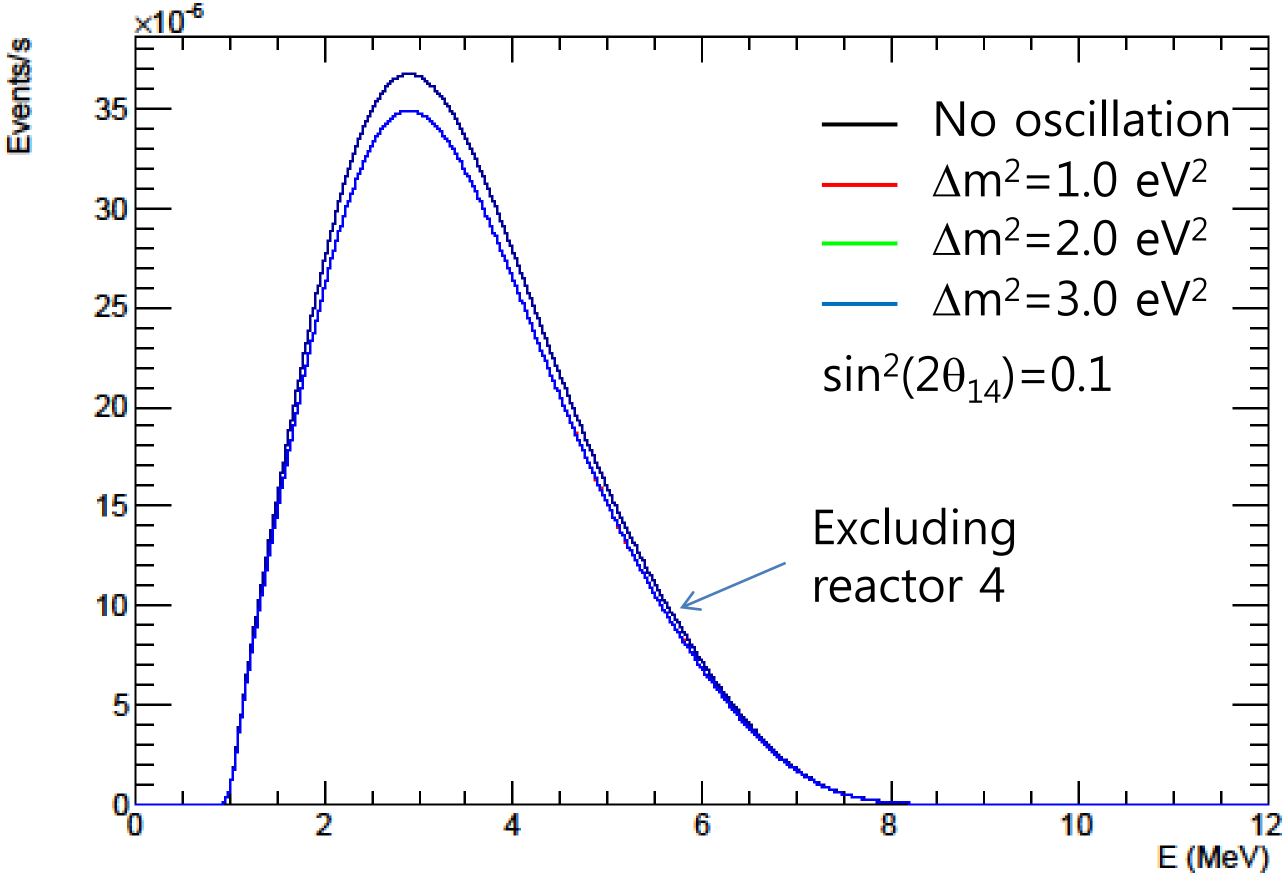
- There's a long and arduous way ahead.

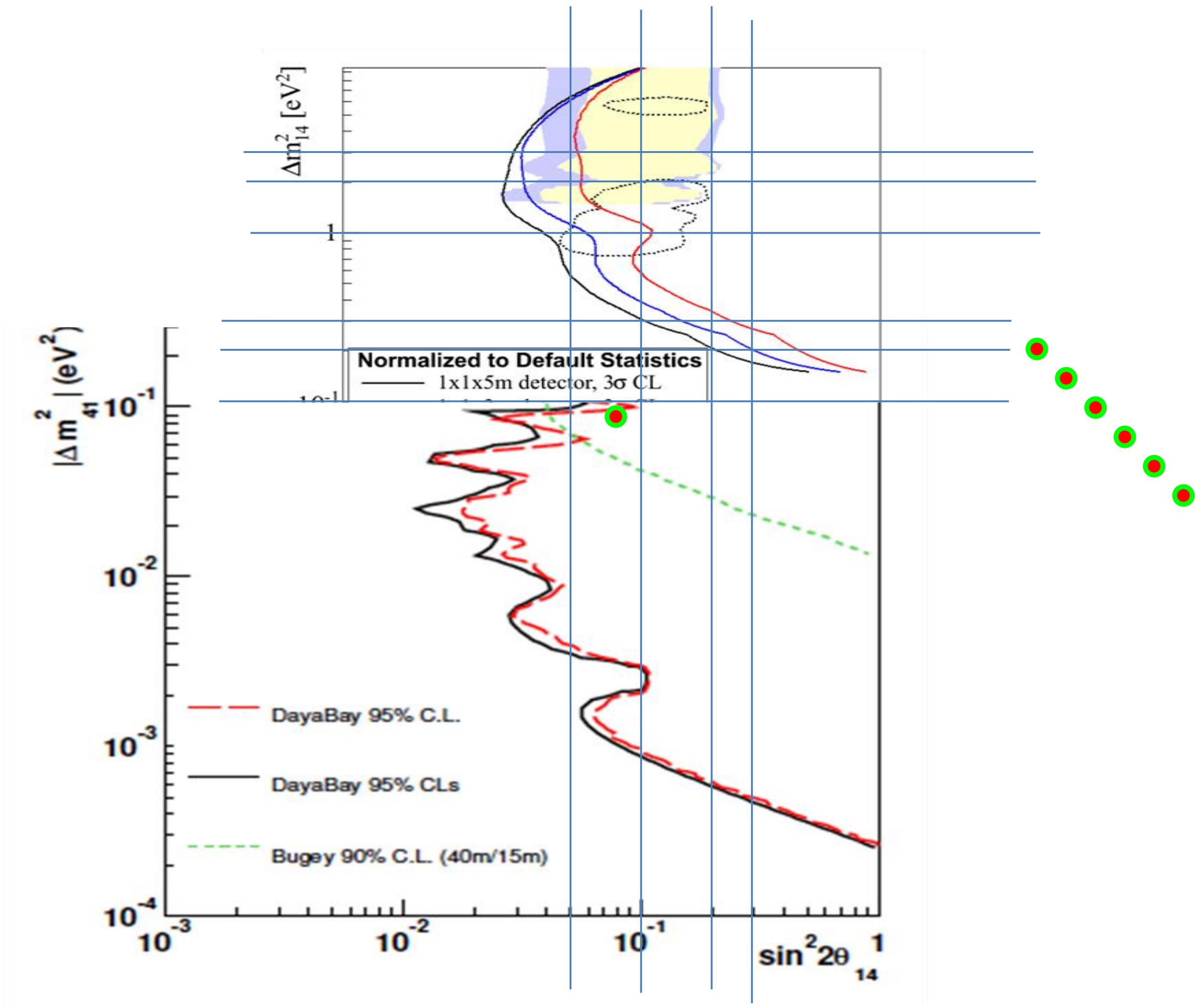
Energy Spectra



Spectra distorted

Energy Spectra





Δm^2_{14} [eV^2]
1
10^{-1}
Normalized to Default Statistics
1x1x5m detector, 3σ CL
$|\Delta m^2_{41}|$ (eV^2)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
DayaBay 95% C.L.
DayaBay 95% CLs
Bugey 90% C.L. (40m/15m)
10^{-3}
10^{-2}
10^{-1}
1
$\sin^2 2\theta_{14}$