RENO-50:
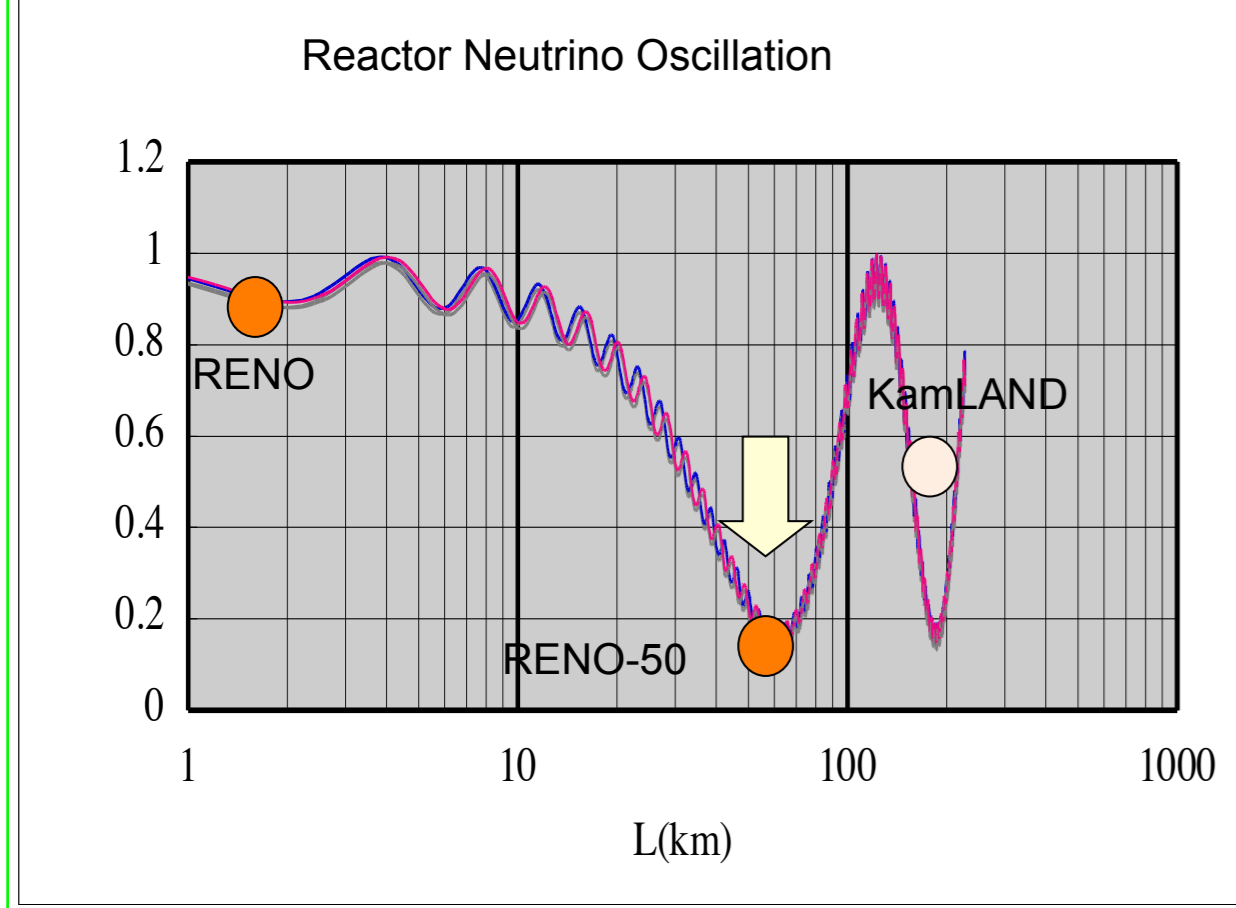# Neutrino Mass Hierarchy and Neutrino Observatory
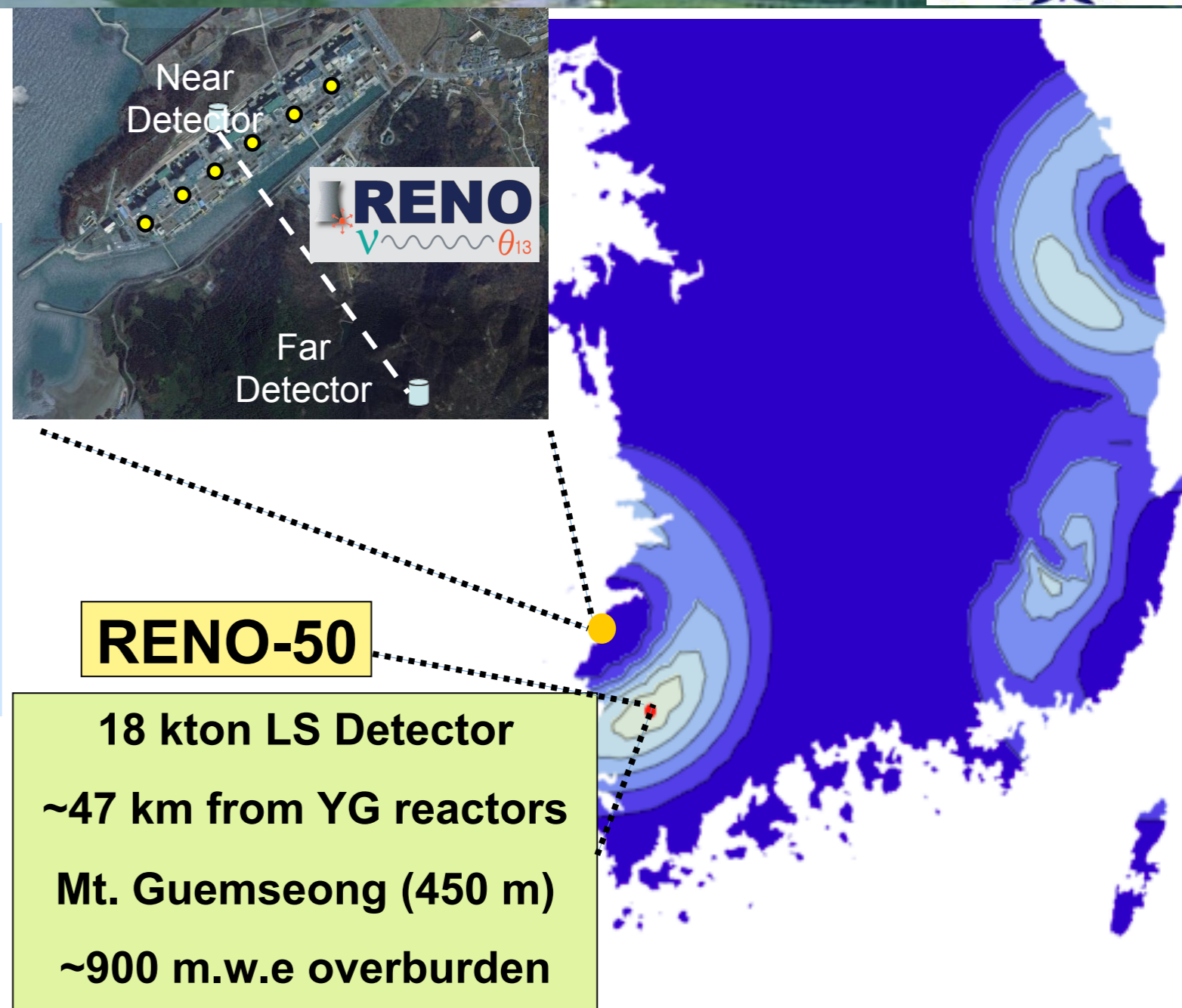
Seon-Hee Seo
Seoul National University, Korea

**KNRC** Korea Neutrino Research Center

Reactor Neutrino Oscillation

RENO
KamLAND
RENO-50
L(km)

$$P_R(\overline{\nu}_e \rightarrow \overline{\nu}_e) = 1 - \left\{ \begin{array}{l} \cos^4\theta_{13}\sin^2 2\theta_{12}\sin^2\Delta_{21} \\ + \sin^2 2\theta_{13}\sin^2\theta_{12}\left(\cos 2\Delta_{31}\sin^2\Delta_{21} - \frac{1}{2}\sin 2\Delta_{31}\sin 2\Delta_{21}\right) \end{array} \right\}$$

◆ Scientific Goals

☐ Determination of neutrino mass hierarchy

☐ High-precision measurement of θ_{12} & Δm^2_{21}

☐ Study neutrinos from reactors, the Sun, the Earth, Supernova, and any possible stellar objects

Near Detector
RENO $\nu \theta_{13}$
Far Detector

RENO-50

18 kton LS Detector
~47 km from YG reactors
Mt. Guemseong (450 m)
~900 m.w.e overburden

◆ Design Concept & Sensitivity

1000 20" OD PMTs   Water
Mineral Oil
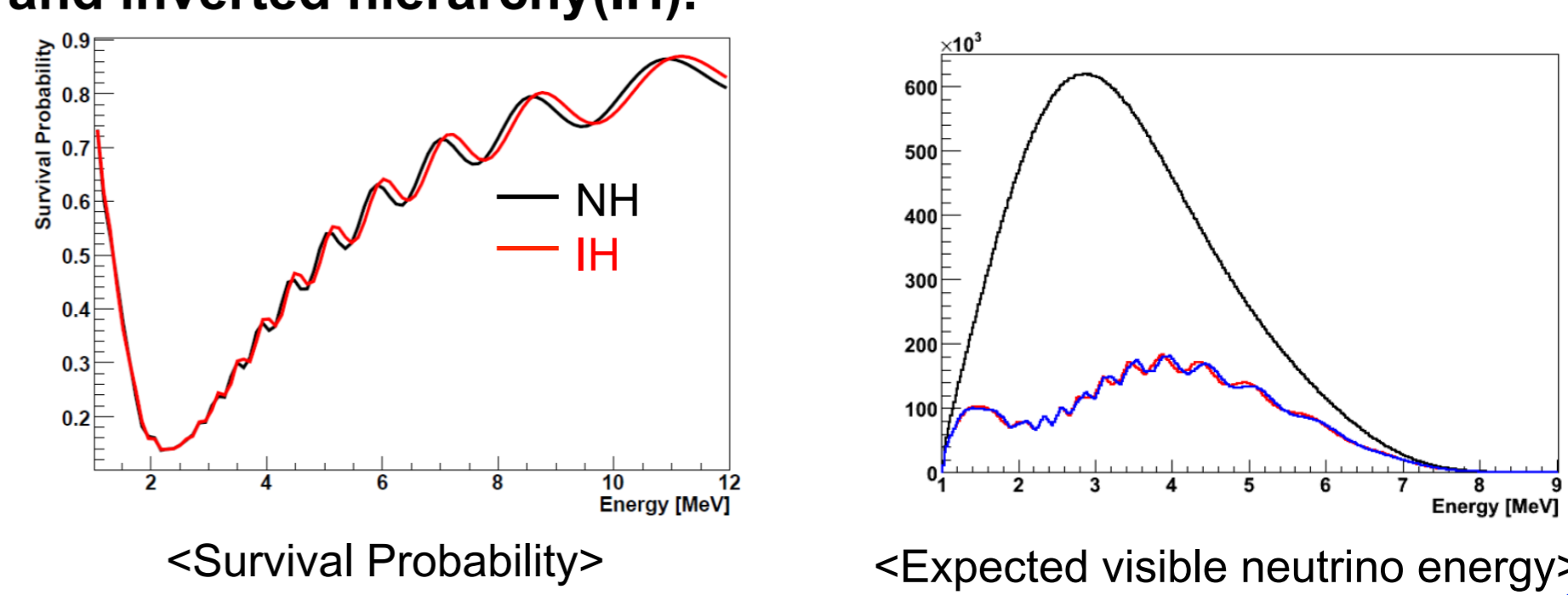LS (18 kton)
15000 20" PMTs (67%)
30 m
32 m
37 m
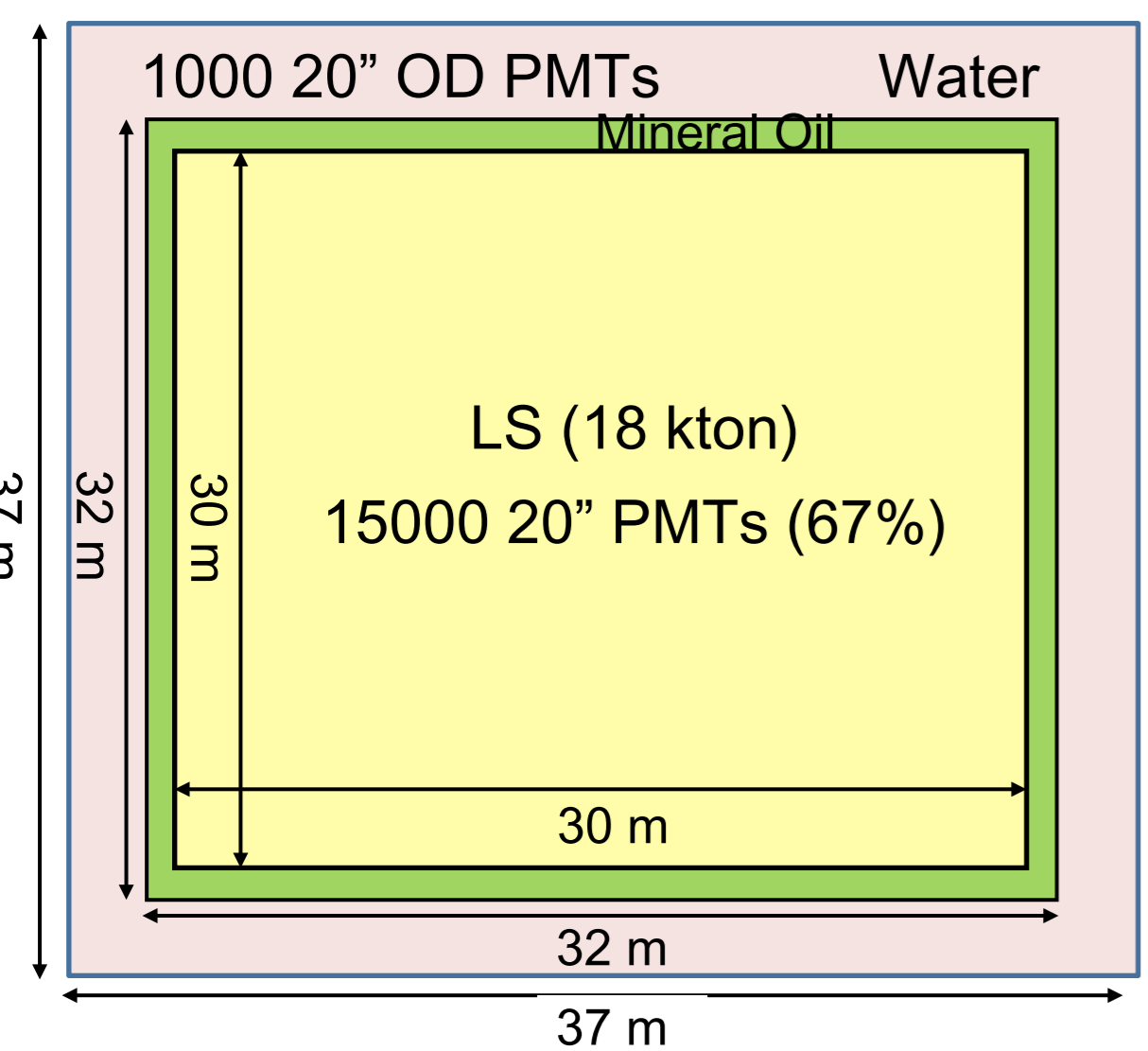
- **Expects ~5400 events / year (w/ oscillation effect & 70% detection efficiency)**

- **Better than 3 % resolution is needed for mass hierarchy.**
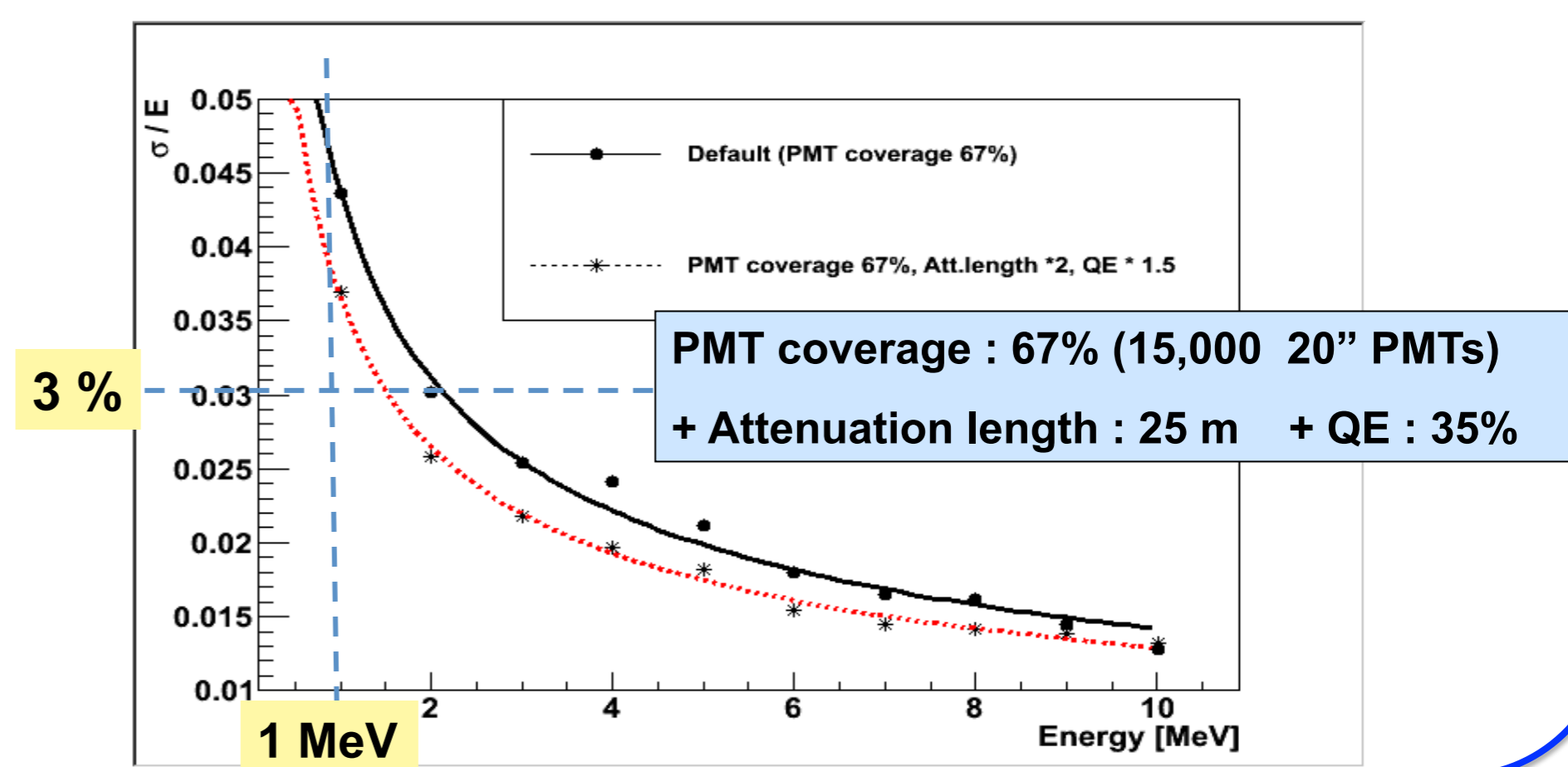
- **10 years of data taking for 3σ determination**

	Osc. reduction	Reactor ν Flux	Detector Size	Sys. Error (Flux)	Error of Mixing param
KamLAND (180 km)	40 %	53 * Φ_0	1 kton	3 %	$\sin^2(2\theta_{12})$: 5.4 %
RENO-50 (47 km)	77 %	6 * Φ_0	18 kton	~0.3 %	< 0.6 %
JUNO (52 km)	85 %	12 * Φ_0	20 kton	5 %	< 0.6 %

◆ Timeline of RENO-50

- **Apr. 2012: Successful measurement of $\sin^2(2\theta_{13})$ in RENO**

- **June 2012: Initial Idea of RENO-50**

- **July 2012~Apr. 2013: RENO-50 Detector conceptual design & MC Study**

- **May 2013: Domestic RENO-50 Workshop @ Seoul**

- **June 2013: International RENO-50 Workshop @ Seoul**

- **July 2013: LOI for RENO-50**

- **Aug. 2013: RENO-50 is recognized as one of the future experiments to determine neutrino hierarchy @ Snowmass meeting, 2013**

- **Nov. 2013: RENO-50 is recommended as future neutrino experiment @ Asian Community Town Meeting by ICFA Neutrino Panel**

- **Current: Waiting for a decision by the Korean funding agency.**

◆ MC Study

◆ Survival Probability @ RENO-50

☐ **Different energy modulation between normal hierarchy (NH) and inverted hierarchy(IH).**

— NH
— IH

Survival Probability
Energy [MeV]

<Survival Probability>

Energy [MeV]

<Expected visible neutrino energy>

◆ Expected Energy Resolution

σ/E

Default (PMT coverage 67%)
PMT coverage 67%, Att.length *2, QE * 1.5

3 %

PMT coverage : 67% (15,000 20" PMTs)
+ Attenuation length : 25 m   + QE : 35%

1 MeV
Energy [MeV]

◆ Mass Hierarchy

* **Bin size effect of determining mass hierarchy.**
* **0.08 MeV per bin for 3% energy resolution @ ~5 MeV : 12 bin/MeV.**
* **At least 3% energy resolution is needed to distinguish NH and IH.**

$\frac{\delta E}{E}$: 6%
NH
IH
(no energy resolution)
50 bin/MeV
Energy [MeV]

$\frac{\delta E}{E}$: 6%
NH
IH
(with resolution)
12 bin/MeV
Energy [MeV]

$\frac{\delta E}{E}$: 3%
12 bin/MeV
Energy [MeV]

$\frac{\delta E}{E}$: 2%
12 bin/MeV
Energy [MeV]