A Letter of Intent to Extend T2K with a Detector 2km away from the JPARC Neutrino Source

T2K collaboration

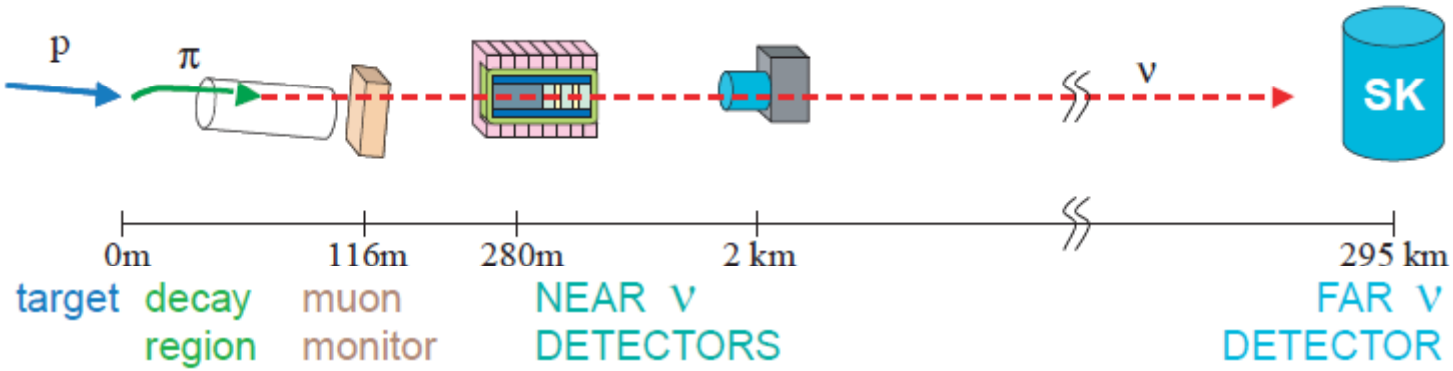
Third J-PARC PAC meeting, July 6-7, 2007

(presented by Takaaki Kajita)

Motivation for 2KM detector at T2K

◆T2K will be a high-intensity neutrino experiment.
◆It will be very important to control systematic errors in the high-intensity period of the running of the T2K experiment.
◆We express our interest in constructing the 2KM intermediate detector facility.
◆This facility will be a important element of T2K in the high intensity period of running where careful control of the systematic errors are required.

Motivation for 2KM detector at T2K
- Strategy -



◆ND280 detector together with the NA61 (hadron production experiment) data predicts the un-oscillated flux at Super-K.

◆However, the flux observed at Super-K is oscillated.

◆Therefore, the most convincing case to be made by the T2K experiment will be a comparison of the predictions at Super-K of the energy spectrum and the backgrounds to the ν_e search by both the 280m and 2KM detectors.

Motivation for 2KM detector at T2K
- Basic idea -

2KM detector;

1) Has the same target material as Super-K

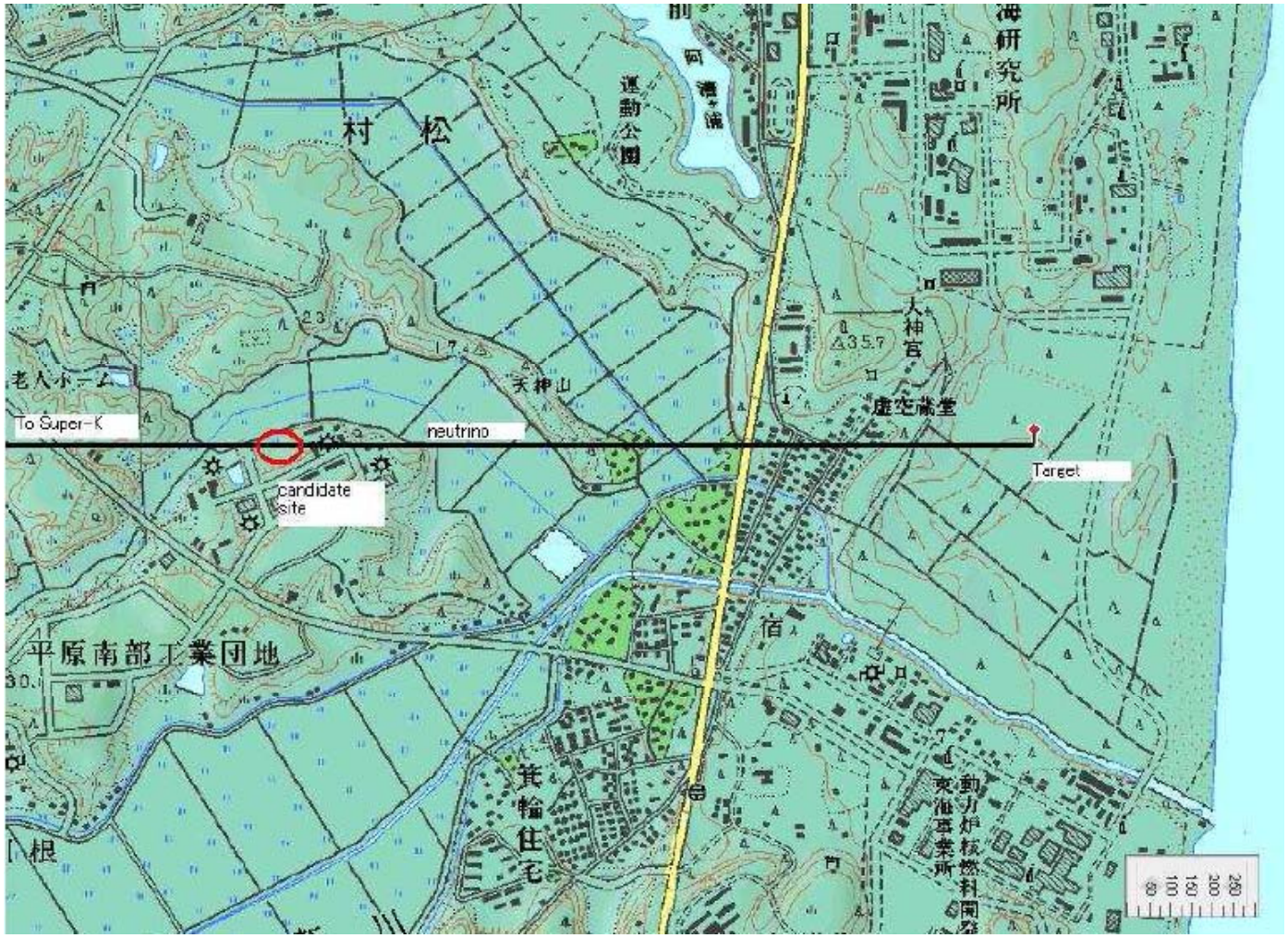
2) Uses the same detector technology as Super-K

3) Uses almost the same reconstruction algorithms as Super-K

4) Sees almost the same un-oscillated neutrino spectrum as Super-K

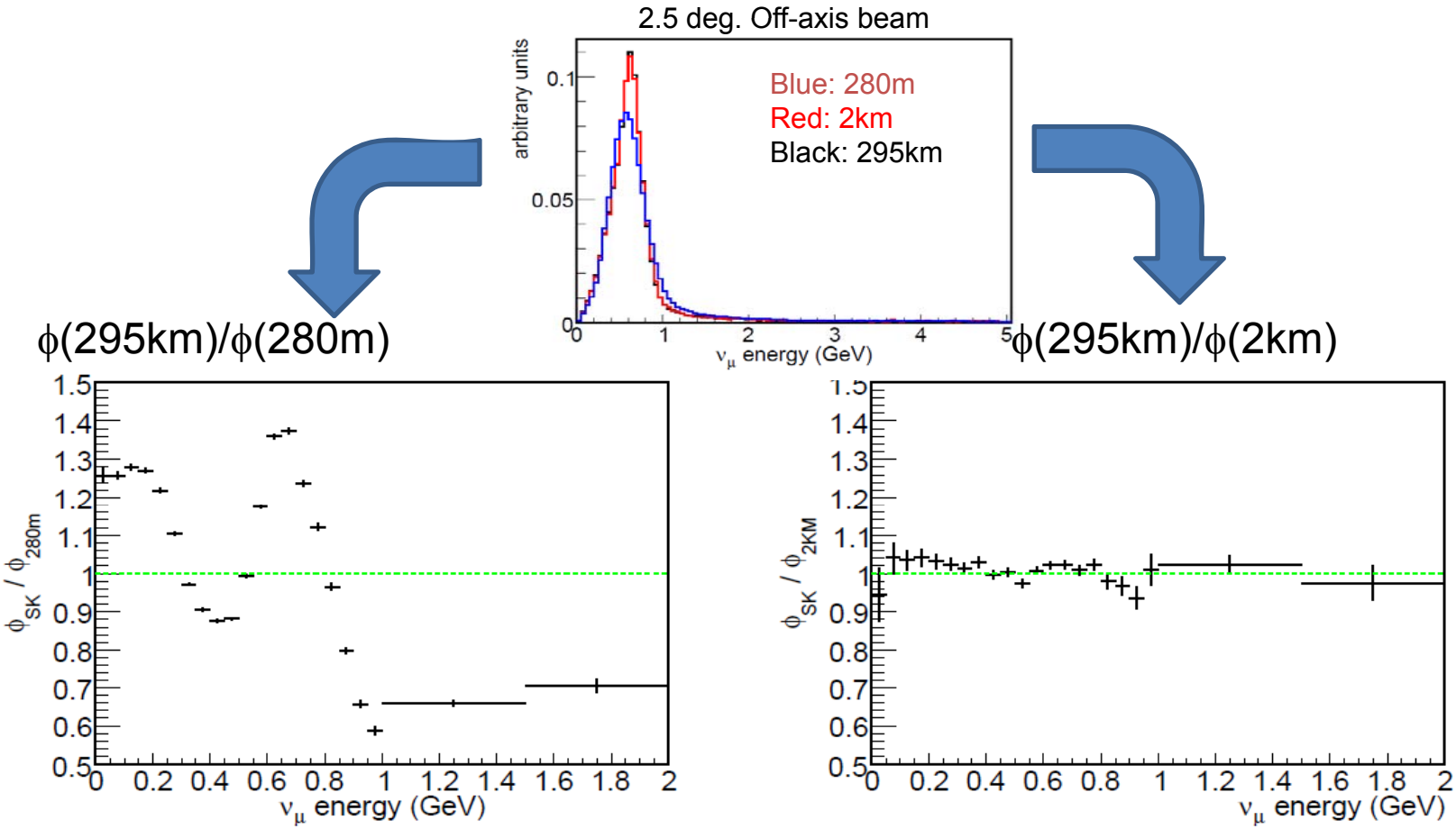
Final goal: getting the most believable oscillation data from T2K.

Candidate cite for the 2KM detector



1.84 km down stream from the target. (However, in a left-right symmetric position.) Owned by the Tokai-village. Tokai-village agreed to use this location without any cost for this detector in 2003. The detector will be located 56m underground.

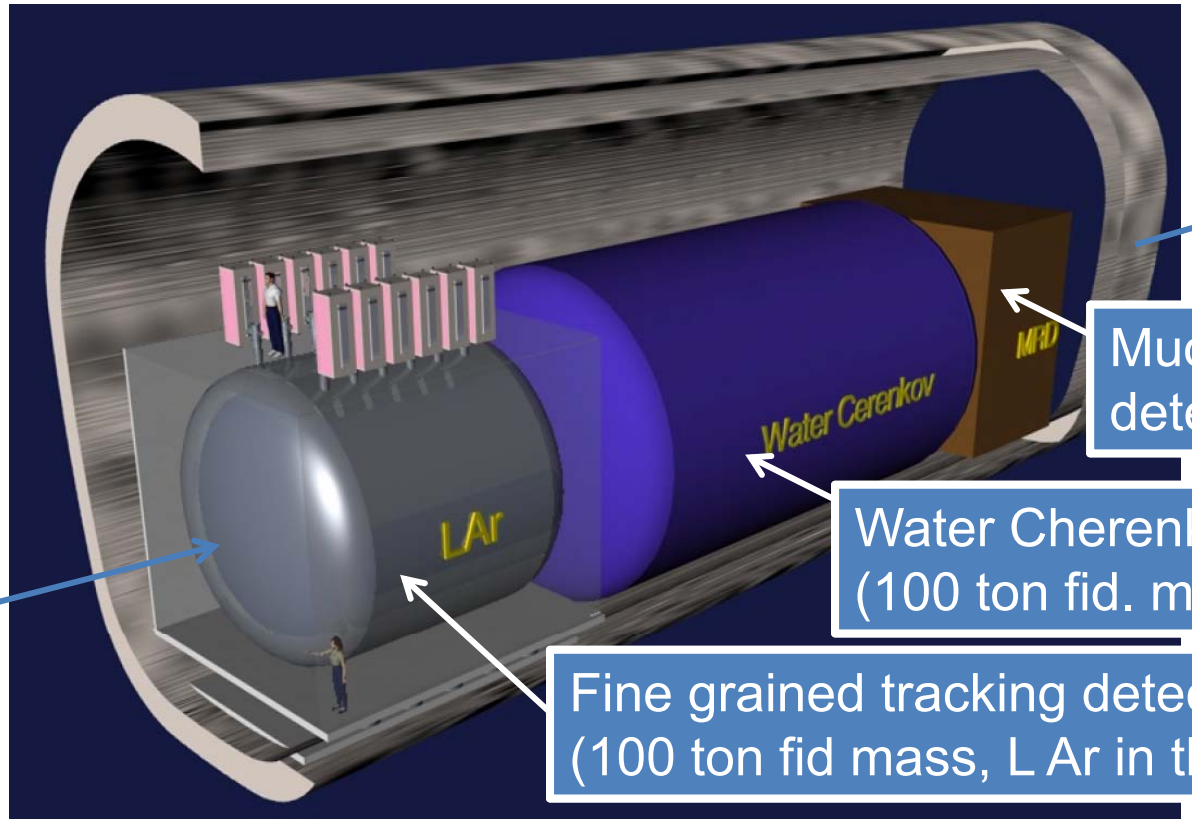
Flux at the 2KM position



- ND280+NA61 prediction on the neutrino spectrum at SK can be directly checked by the 2KM detector. ➔ More robust prediction with (ND280+NA61) and 2KM.
- Extrapolation from 280m to 2km guarantees the further understanding of 295km/2km.

The 2KM intermediate detector

-baseline design-



To Super-K

Muon Range detector

Water Cherenkov detector (100 ton fid. mass)

Fine grained tracking detector (100 ton fid mass, L Ar in this figure)

ν beam

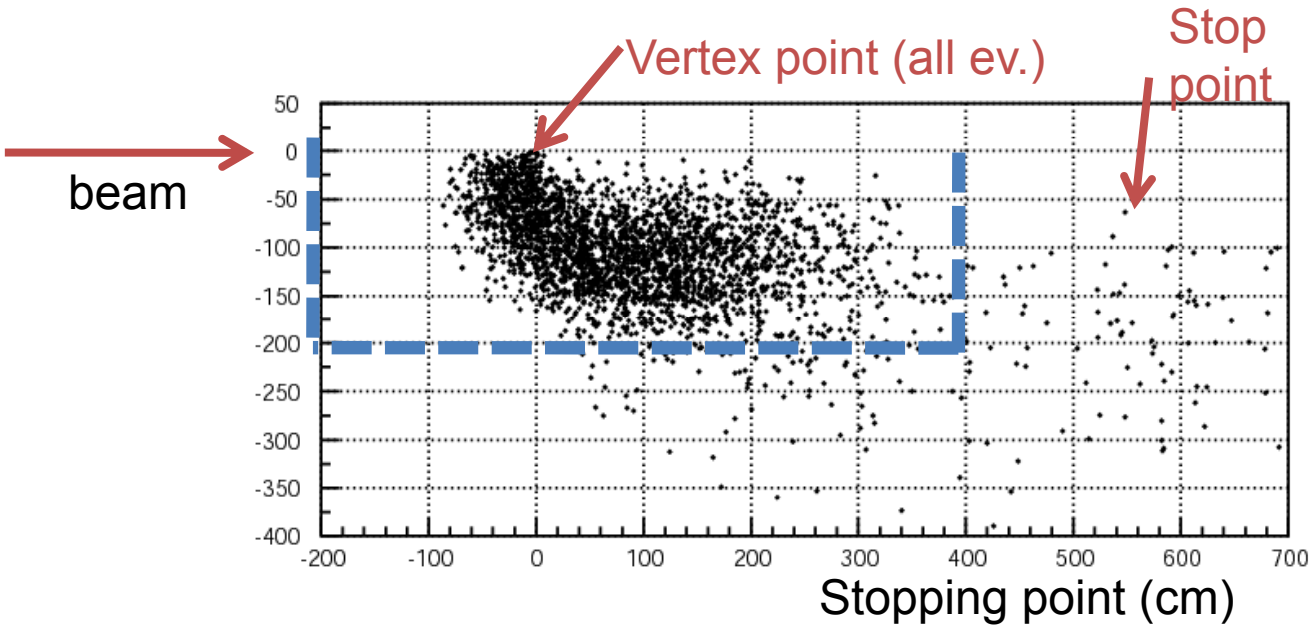
1) Has the same target material as Super-K

2) Uses the same detector technology as Super-K

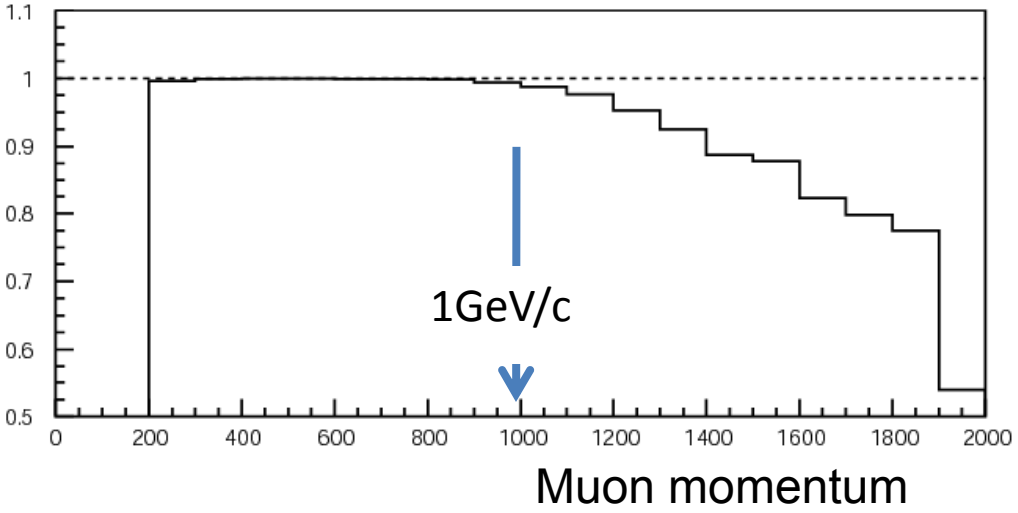
3) Uses almost the same reconstruction algorithms as Super-K

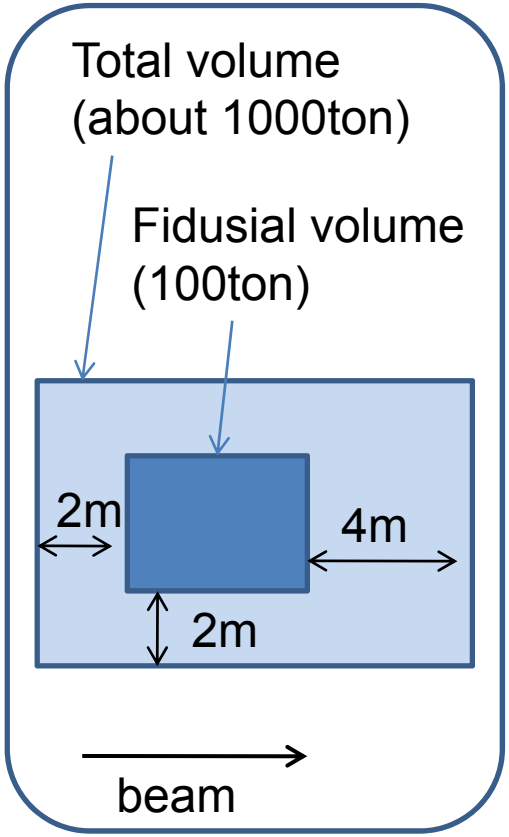
We mostly discuss water Cherenkov detector in this LoI.

Basic design requirement for the 2KM water Ch. (1): Very high efficiency below about 1GeV



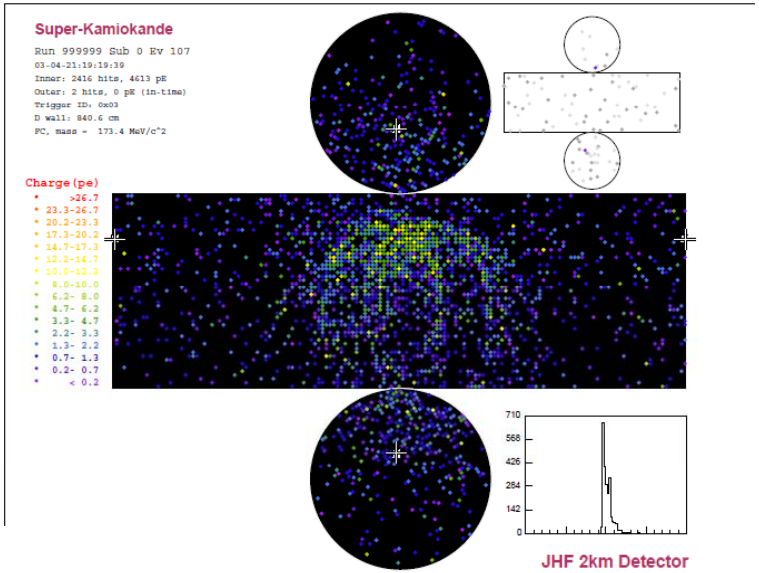
Efficiency (events contained in the fiducial volume)





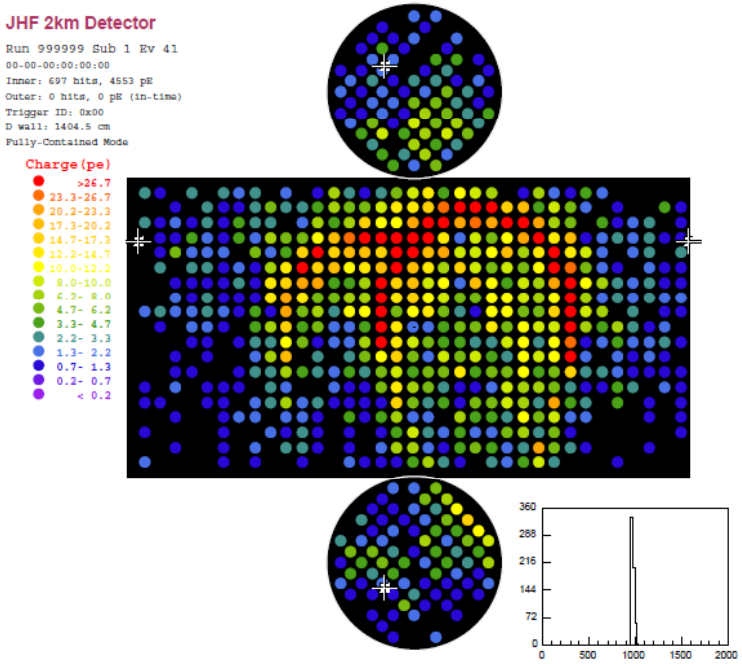
Basic design requirement for the 2KM water Ch. (2): - 2KM should be similar to Super-K -

Super-K π^0 event

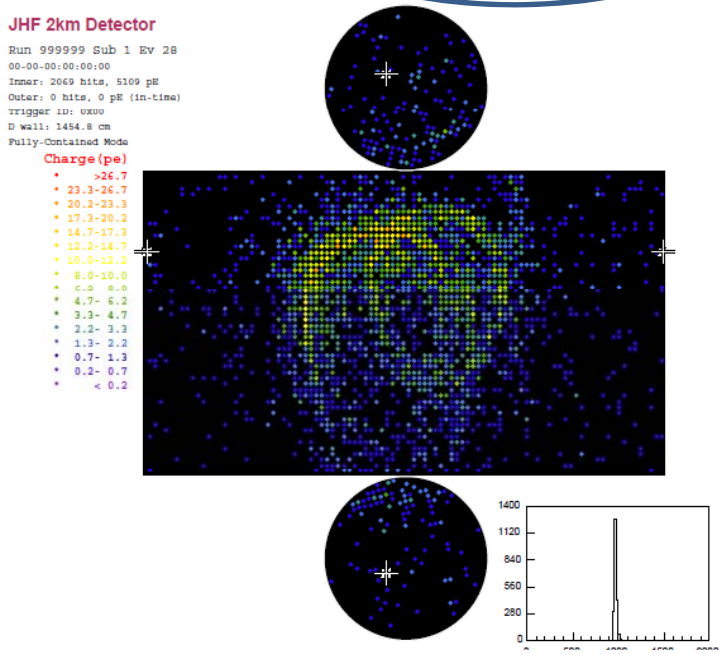


Our baseline design

2KM π^0 event (20 inch PMT option)

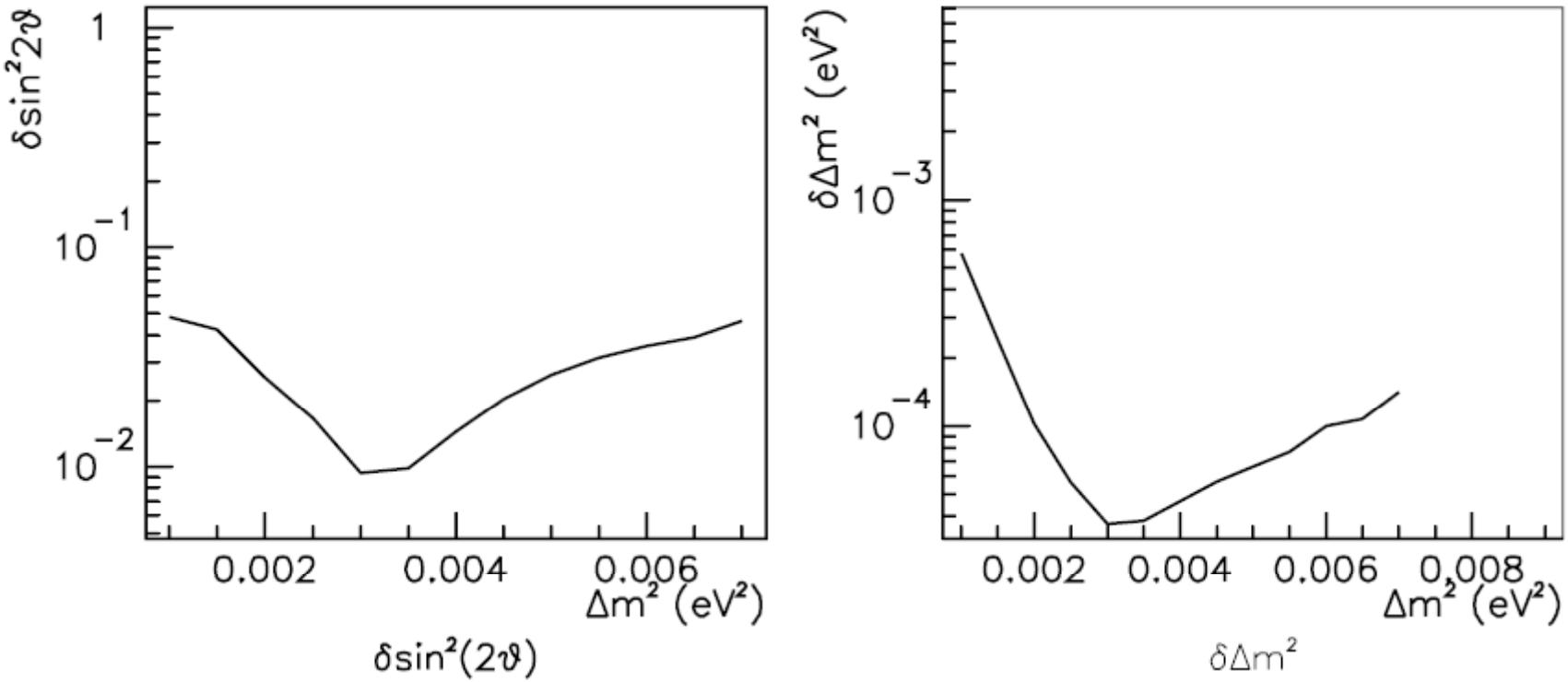


2KM π^0 event (8 inch PMT option)



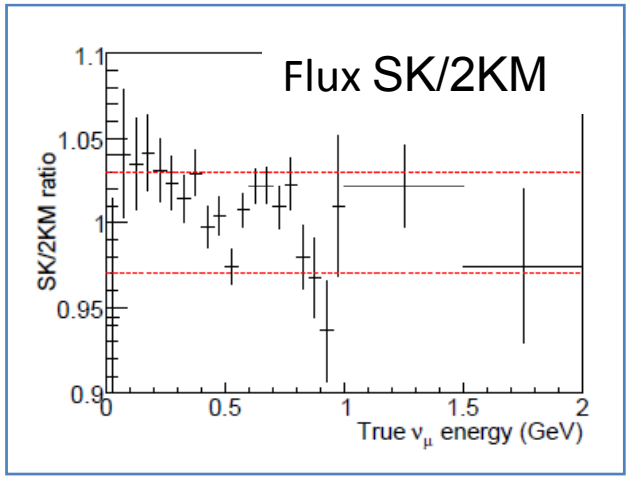
ν_μ spectrum measurement and (Δm_{23}^2, $\sin^2 2\theta_{23}$)

Sensitivity of T2K from the original T2K LoI

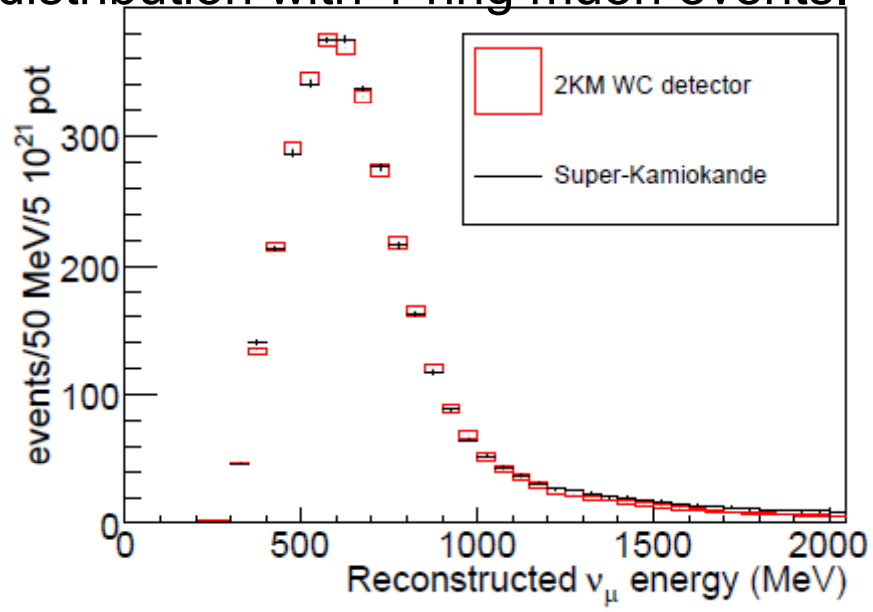


Requirement: Experimental sensitivity should not be limited by systematic errors even in the high intensity period of the running

ν_μ spectrum measurement with 2KM water Ch.

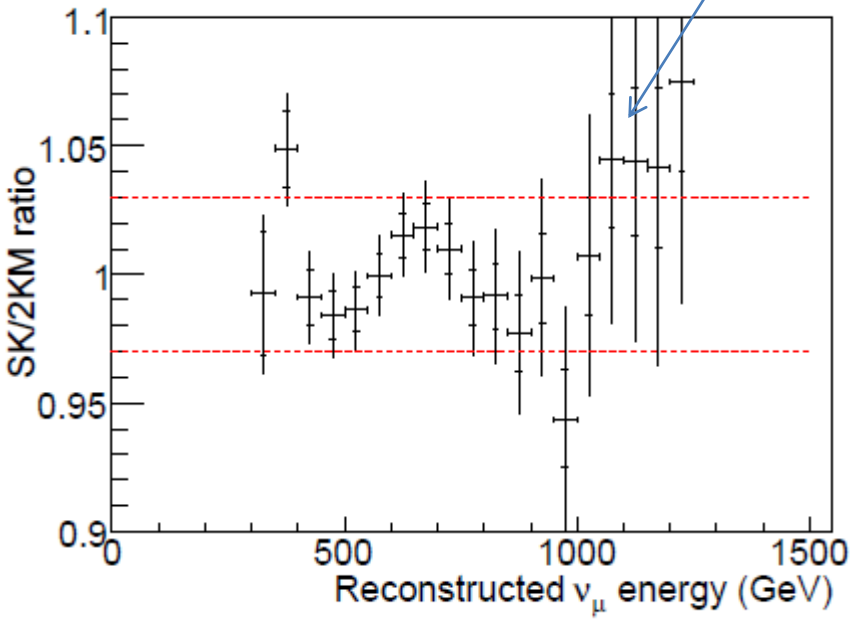


Reconstructed neutrino energy distribution with 1-ring muon events.



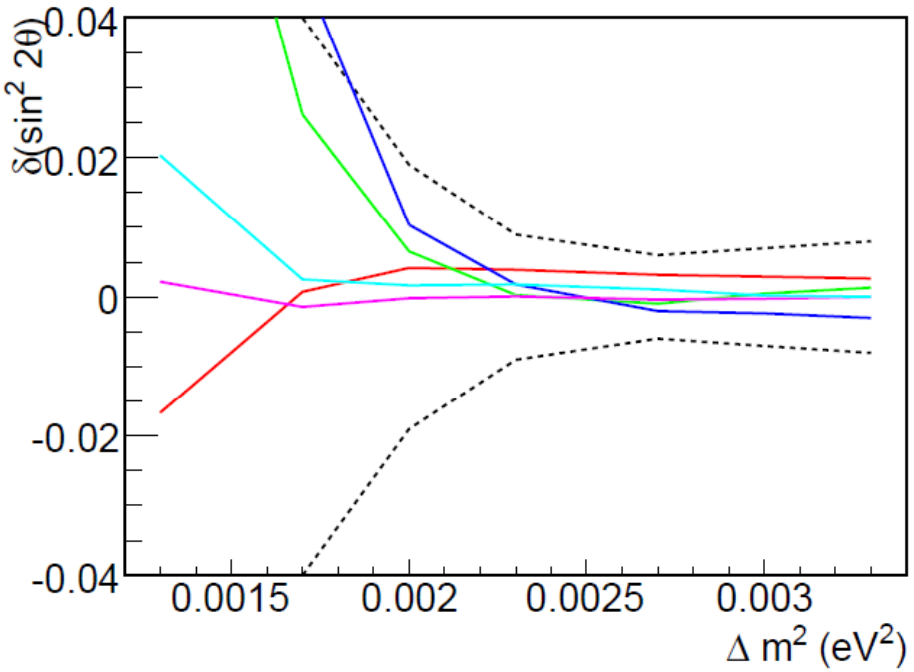
Reconstructed neutrino energy:
SK/2KM (w/o flux far/near correction)

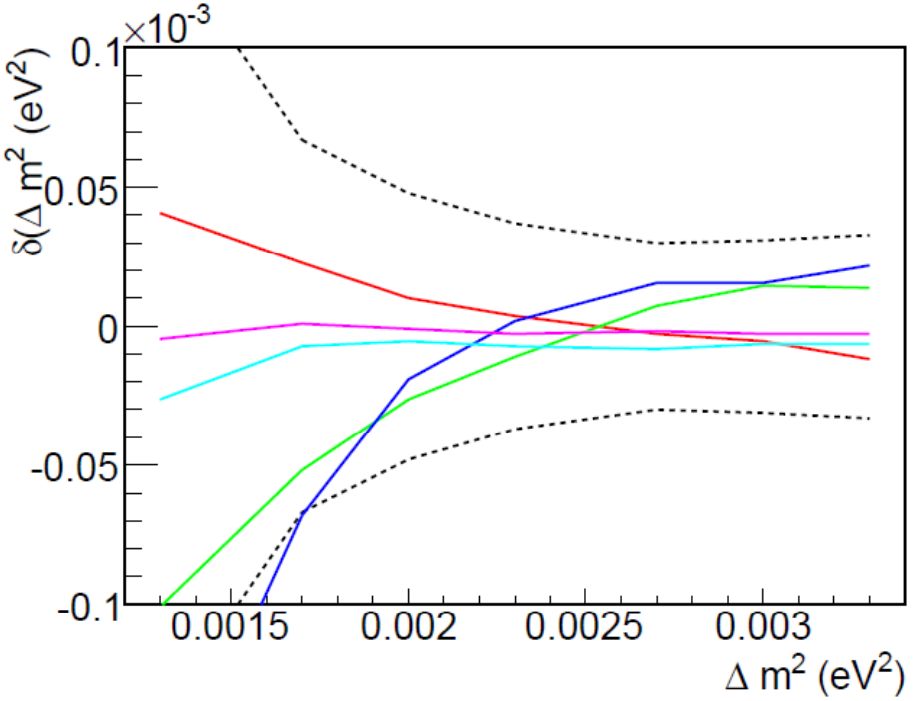
This needs to be corrected by MRD



Inner error bars: Interaction
MC stat only
Outer error bars: (beam+int.)
MC stat. error
Syst. Error: not included in this fig.

(Δm_{23}^2, $\sin^2 2\theta_{23}$) measurement with ν_μ disappearance (5 J-PARC years)

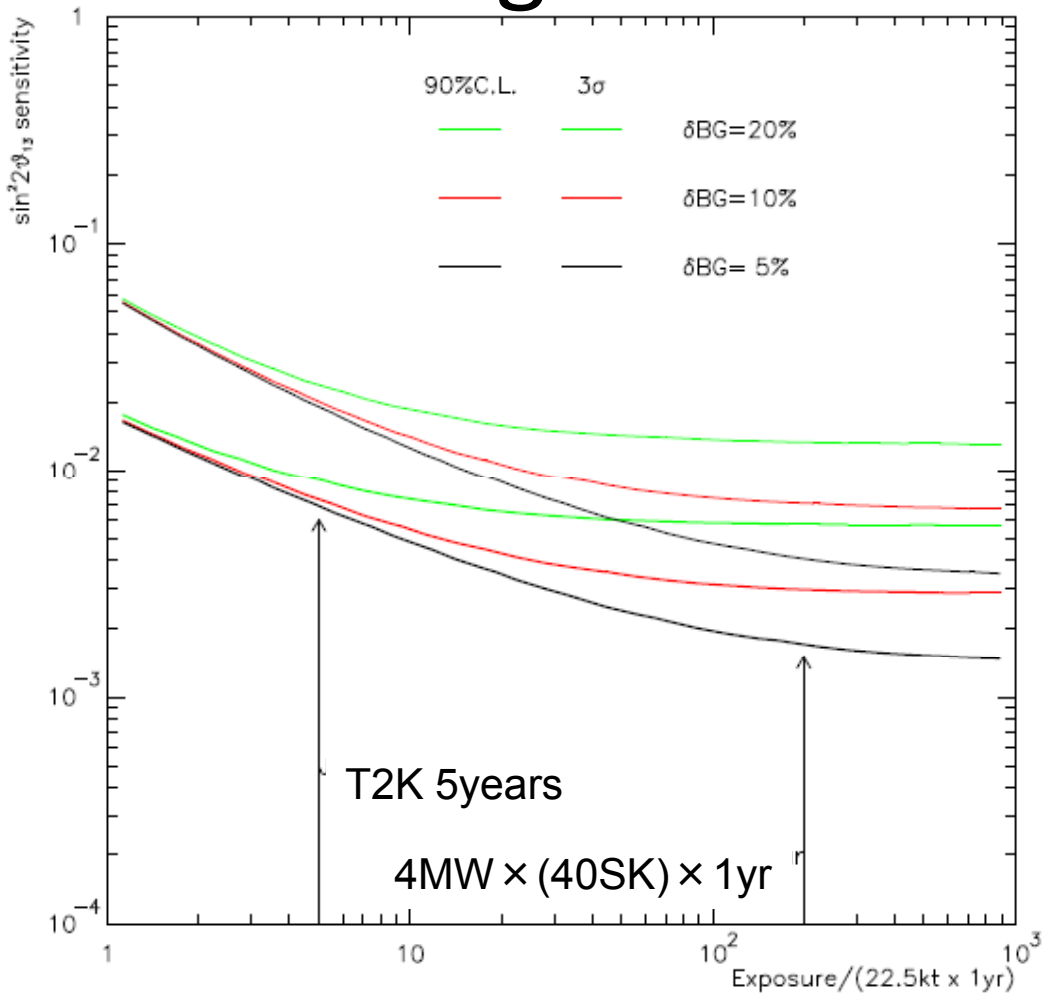




ND280+2KM
systematic errors

- Event normalization (2.9%)
- non-QE/QE (5%)
- Energy scale (2.3%)
- Spectrum linear uncertainty (1%)
- Spectrum width (0.3%)

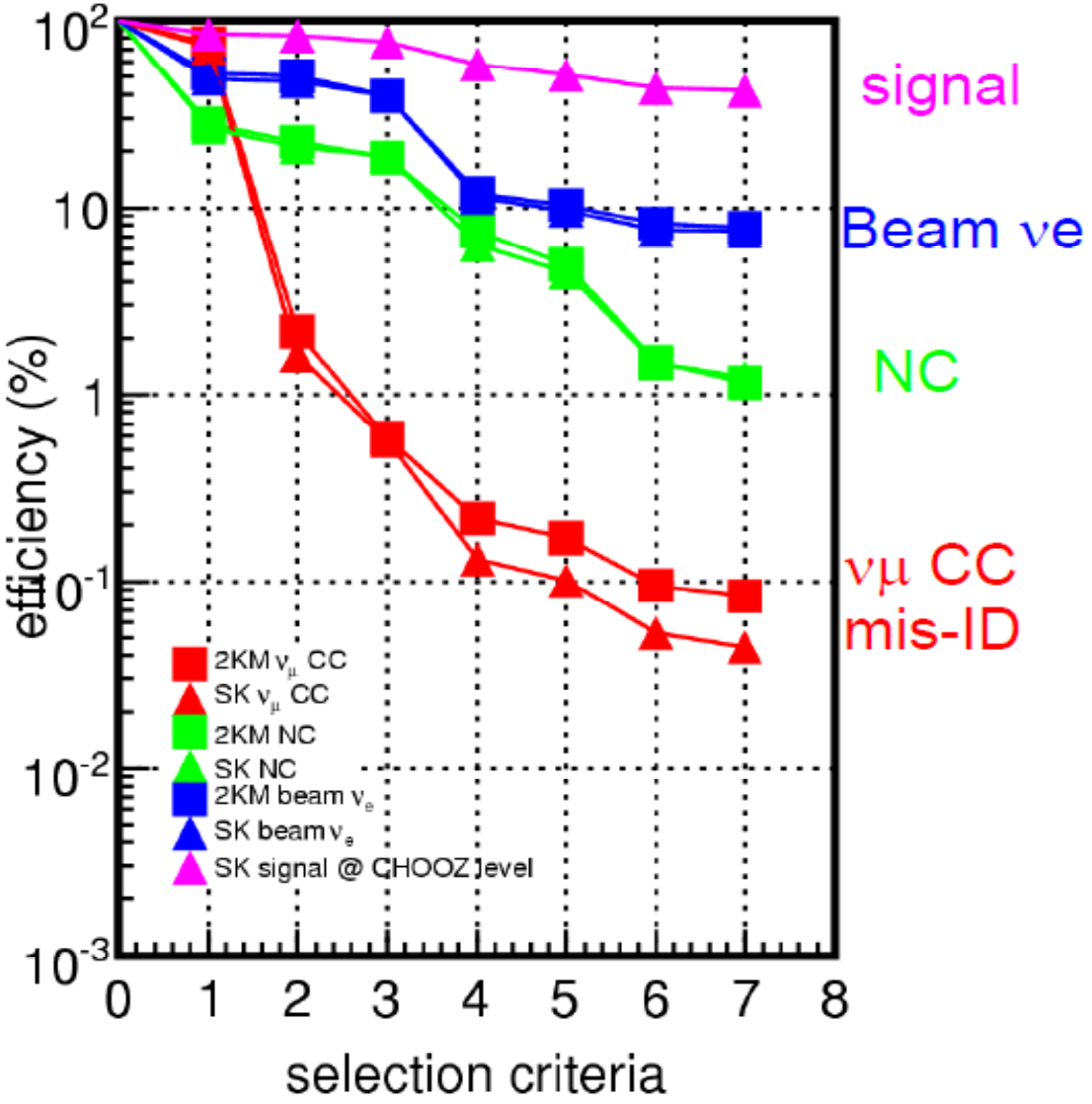
Measurement for the ν_e appearance background



Requirement: Experimental sensitivity should not be limited by systematic errors even in the high intensity period of the running

Predicting the ν_e appearance BG

-Rejection of BG events at each selection criteria -



0) Evis >100MeV

1) 1-ring

2) e-like

3) No μ-decay

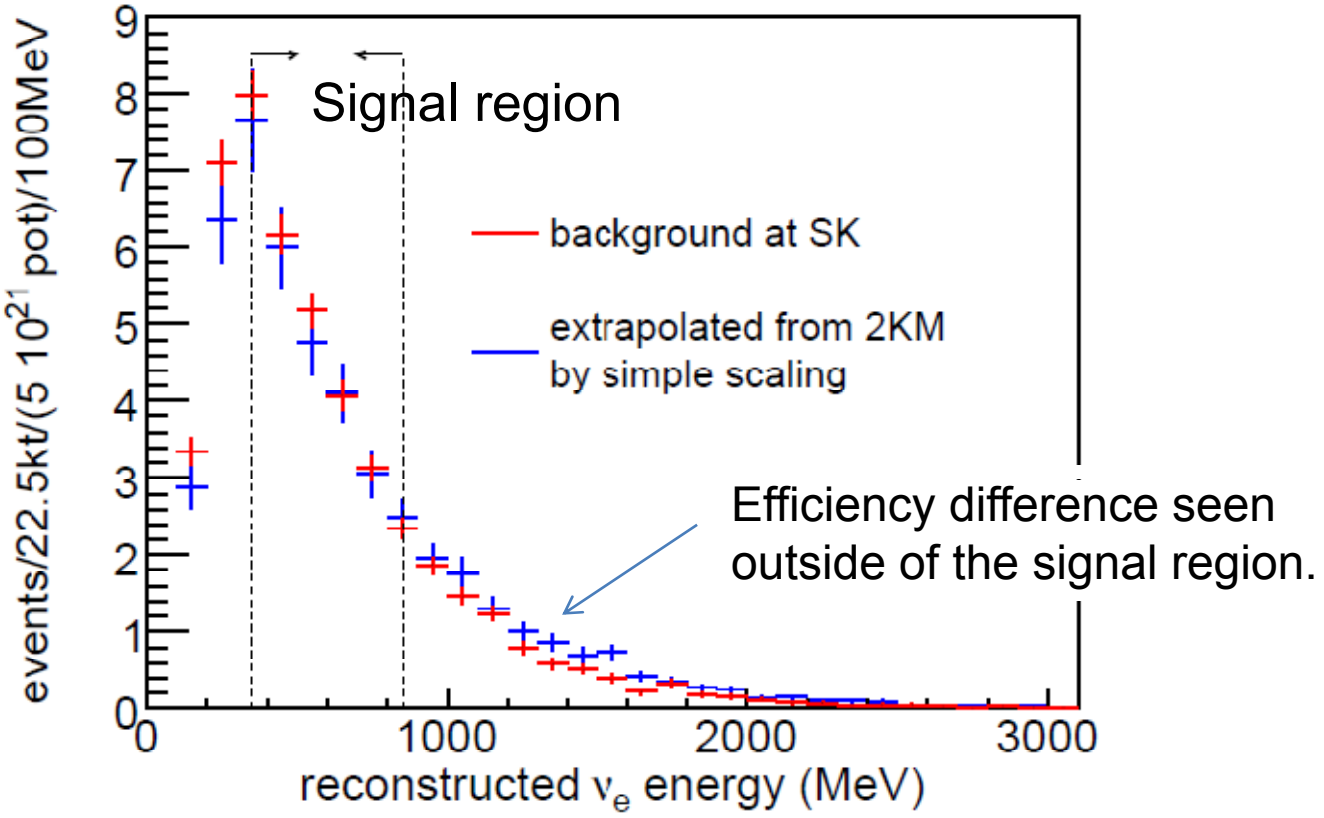
4) $E_{\nu\text{-reconstructed}}$ = (0.35 – 0.85 GeV/c^2)

5) $\cos\theta_{\nu e} < 0.9$

6) Polfit $M\gamma\gamma$ < 100MeV

7) Δlog-likelihood(Polfit) < 80

ν_e appearance background measurement
(after 5 J-PARC years)

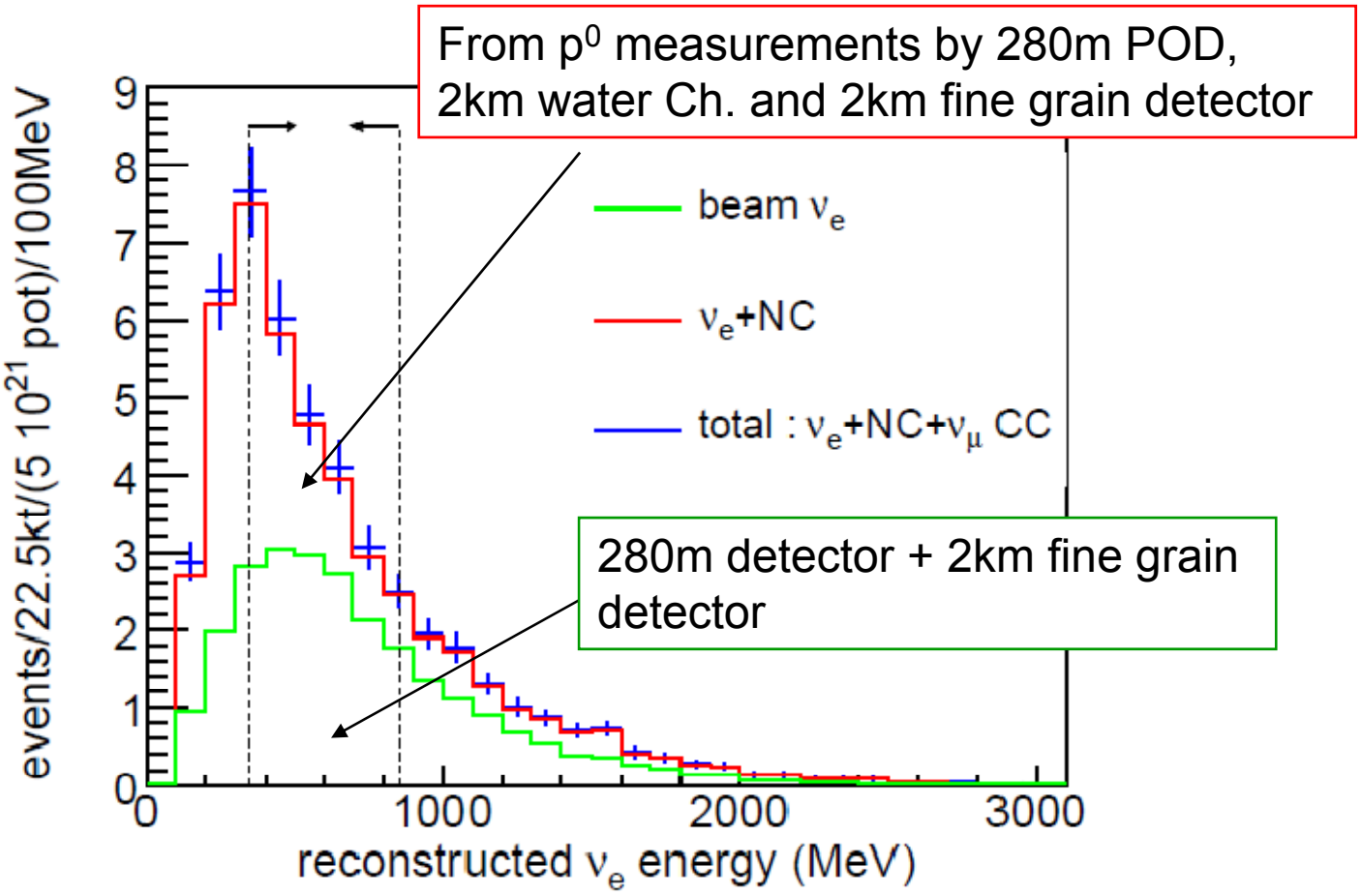


	NC	Beam ν_e	ν_μ CC	Total
Super-K	10.2	13.2	0.35	23.8
Extrapolation from 2KM	9.4	13.0	0.67	23.0±0.4(stat)

(Systematic error: under investigation)

ν_e appearance: after 5 years(2)

- Understanding the each electron background component-



Summary

- We express our interest in constructing an intermediate detector at about 2km away from the target for the high-intensity period of the running.
- The 2KM detector;
  1) has the same target material as Super-K
  2) uses the same detector technology as Super-K
  3) uses almost the same reconstruction algorithms as Super-K
  4) sees almost the same un-oscillated neutrino spectrum as Super-K
- The 2KM detector, in combination with measurements from the ND280 detector, will allow for the best constraint on the prediction of the un-oscillated neutrino spectrum and ν_e appearance background at the Super-K detector. Furthermore, the extrapolation from 280m to 2km guarantees the further understanding of the Super-K signal.