Search for Muon Neutrino Disappearance in a Short-Baseline Accelerator Neutrino Beam

Yasuhiro Nakajima (Kyoto Univ.), for the SciBooNE Collaboration

Introduction

Neutrino Oscillation

- Neutrino flavour and mass eigenstates are mixed
- Neutrino change flavor as a function of time (distance traveled)

$$P(\nu_\alpha \to \nu_\beta) = \sin^2 2\theta \sin^2\left(\frac{1.27\Delta m^2[\mathrm{eV}^2]L[\mathrm{km}]}{E[\mathrm{GeV}]}\right)$$

Observed Oscillations

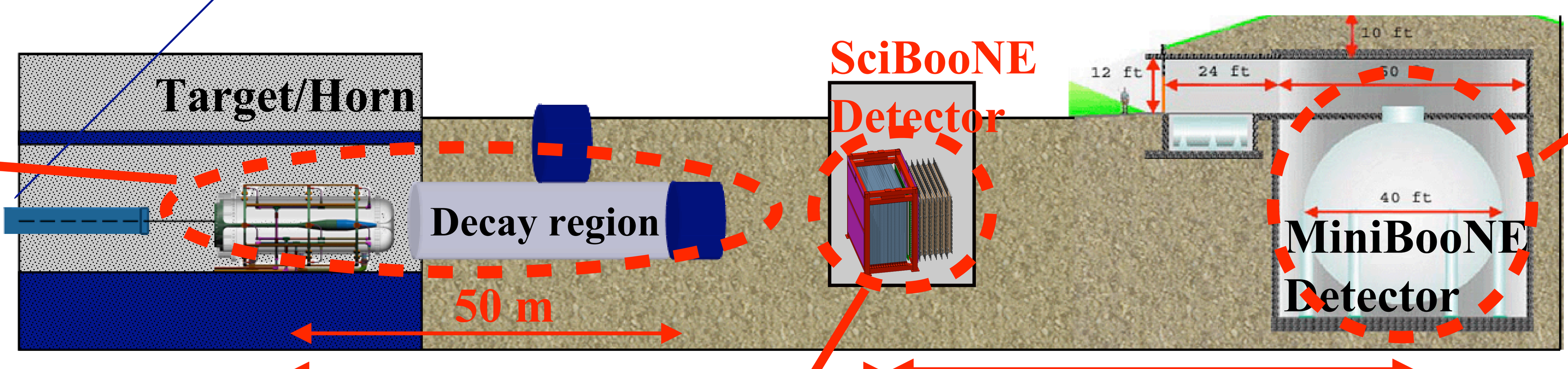
Confirmed in two parameter regions

- Atmospheric region ($\Delta m^2 \sim 10^{-3}\,\mathrm{eV}^2$)
  - Super-K, K2K, MINOS, etc..
- Solar region ($\Delta m^2 \sim 10^{-5}\,\mathrm{eV}^2$)
  - SNO, Super-K, KamLAND, etc..

Oscillations in other parameter regions are prohibited by the current standard model with 3 generations of neutrinos.

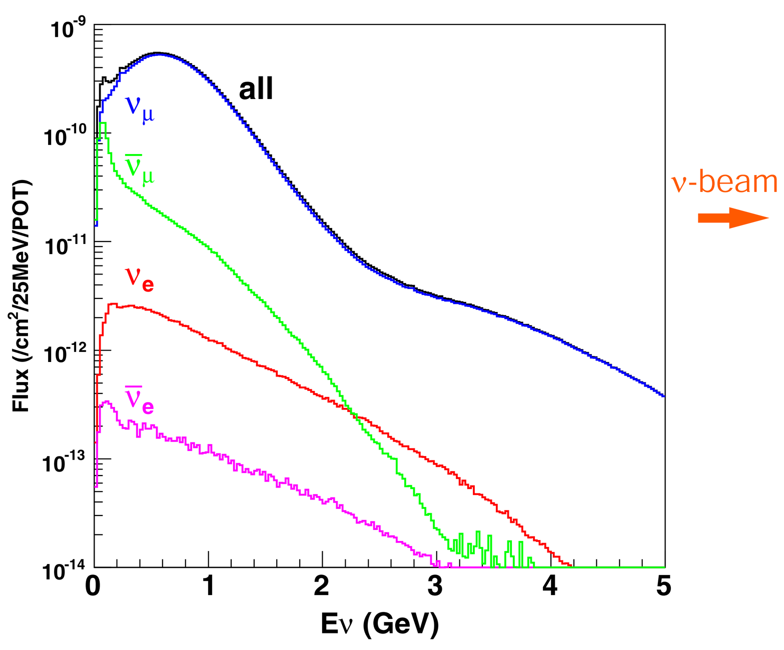
An additional oscillation signal would indicate new physics.
⇒ Sterile neutrino, etc...

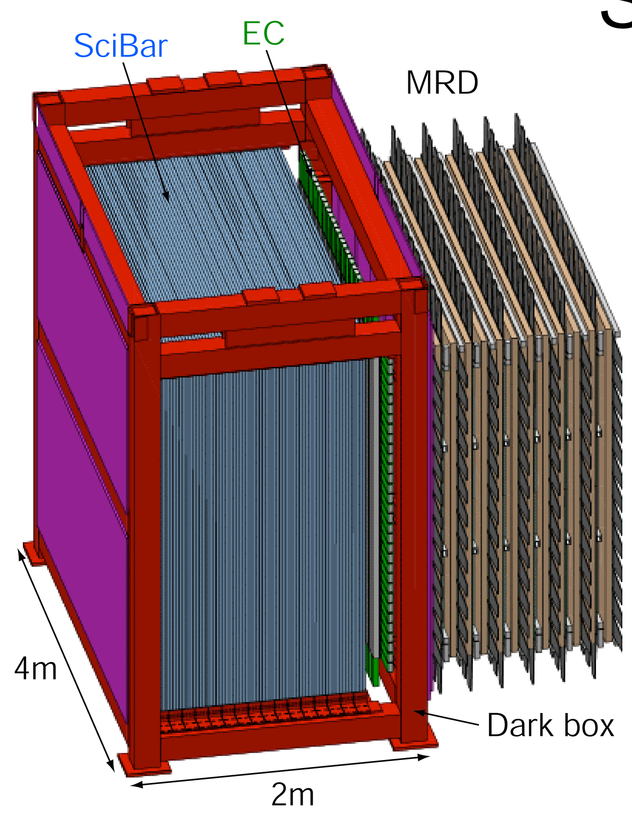
Experimental Setup



Fermilab Booster Neutrino Beam

- High intensity pure muon neutrino beam.
- $\langle E_\nu \rangle \sim 0.7$ GeV





SciBooNE (2007 - 2008)

SciBar:

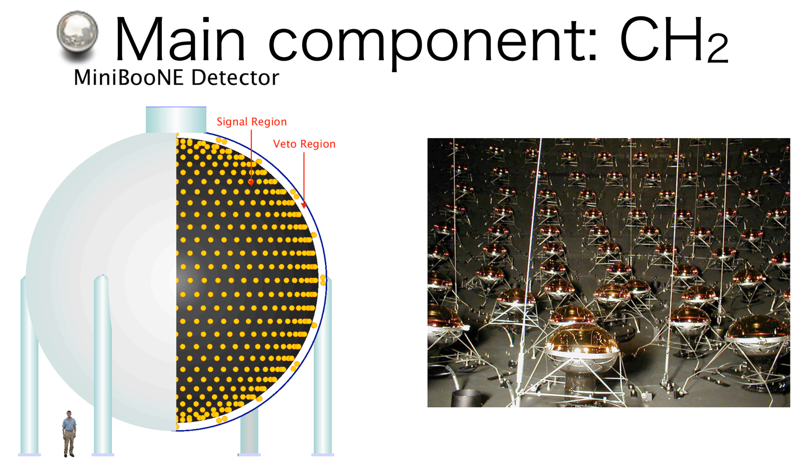
- Fine segmented scintillator tracker (14K strips)
- Neutrino target (CH)
- Fiducial mass: 10 tons

MRD (Muon Range Detector):

- Sandwich of steel and scintillator planes.
- Measure muon momentum

MiniBooNE (2002 -)

- ~ 1 k ton mineral oil Cherenkov detector.
- Main component: CH_2

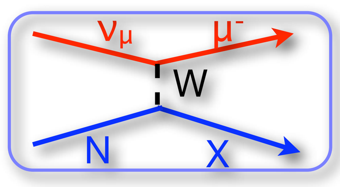


L ~ 500m, E_ν ~ 0.7GeV
⇒ Sensitive to oscillations at ~1 eV^2

Common neutrino target (both carbon) and neutrino beam
⇒ Most of systematic errors cancel

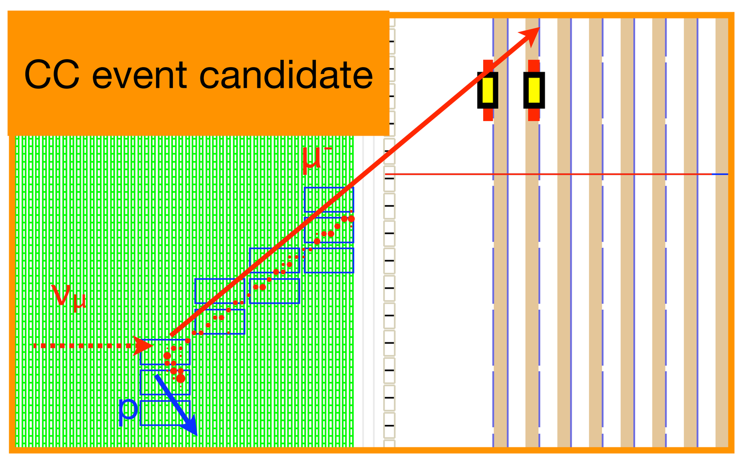
SciBooNE-MiniBooNE Joint ν_μ Disappearance Analysis

1. SciBooNE Charged Current Event Selection



Signature: muon track

- ☑ Long track with MIP-like energy deposit.
- ☑ Originate from SciBar fiducial Volume
- ☑ All SciBar-contained, MRD-stopped and MRD-penetrated muons are used for wide energy coverage.
  - ☑ ~90% pure CC sample
  - ☑ ~40K events

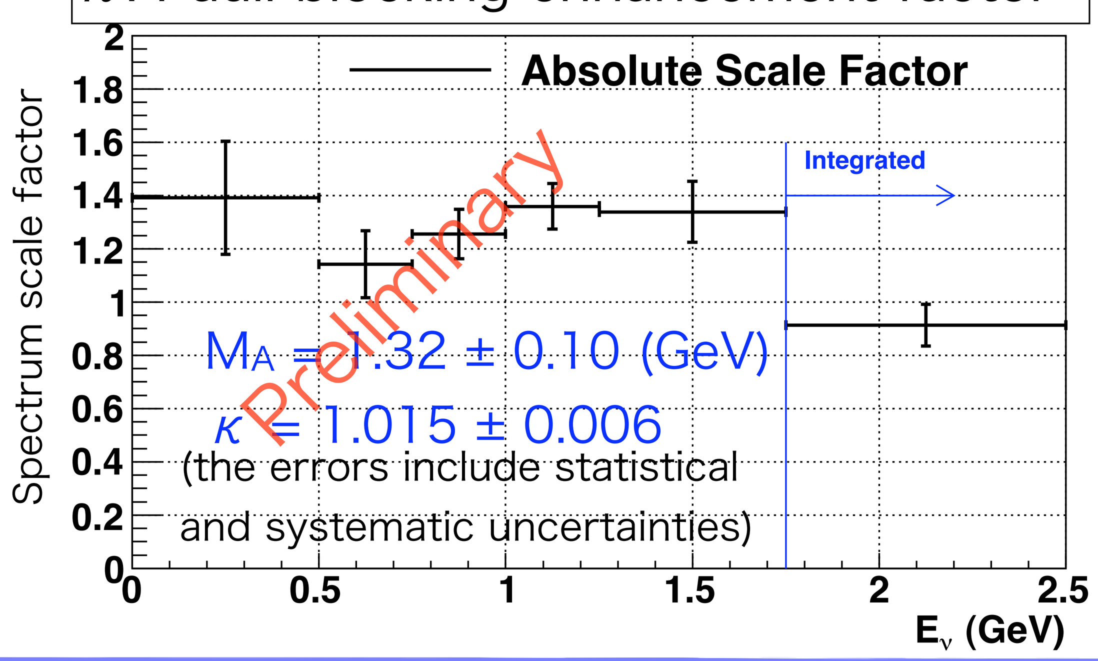


- Muon momentum (P_μ) reconstructed from range
- Muon angle (θ_μ) : reconstructed from SciBar track information

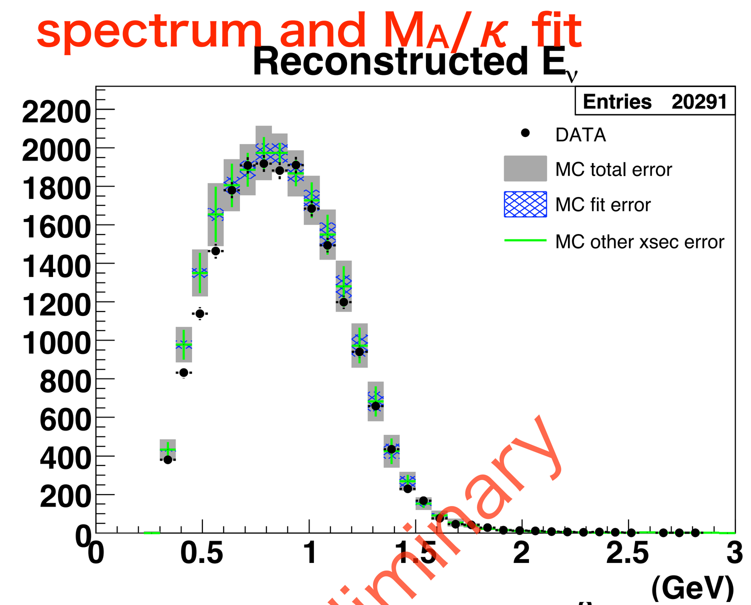
2. SciBooNE Spectrum Fit

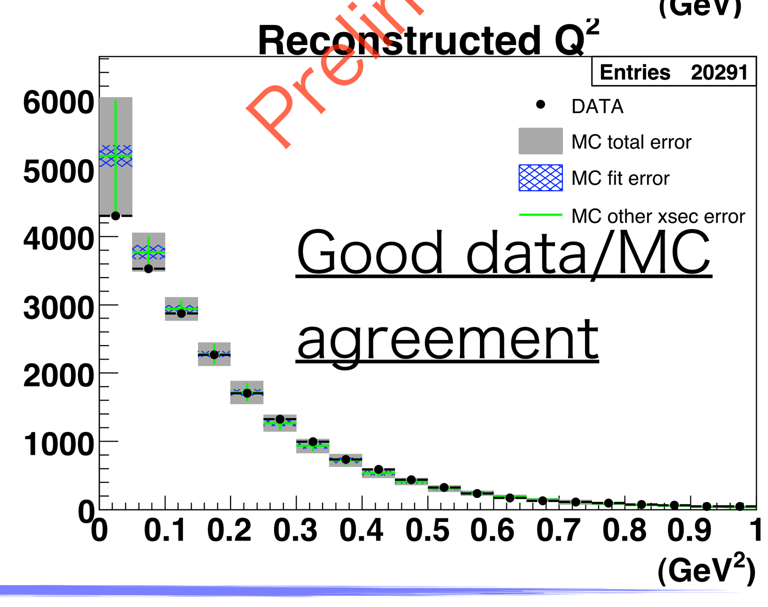
- Fit P_μ vs θ_μ distributions.
- Tune neutrino spectrum and cross-section parameters(M_A, κ)

M_A: Axial-vector mass
κ : Pauli-blocking enhancement factor



Distributions after spectrum and M_A/κ fit

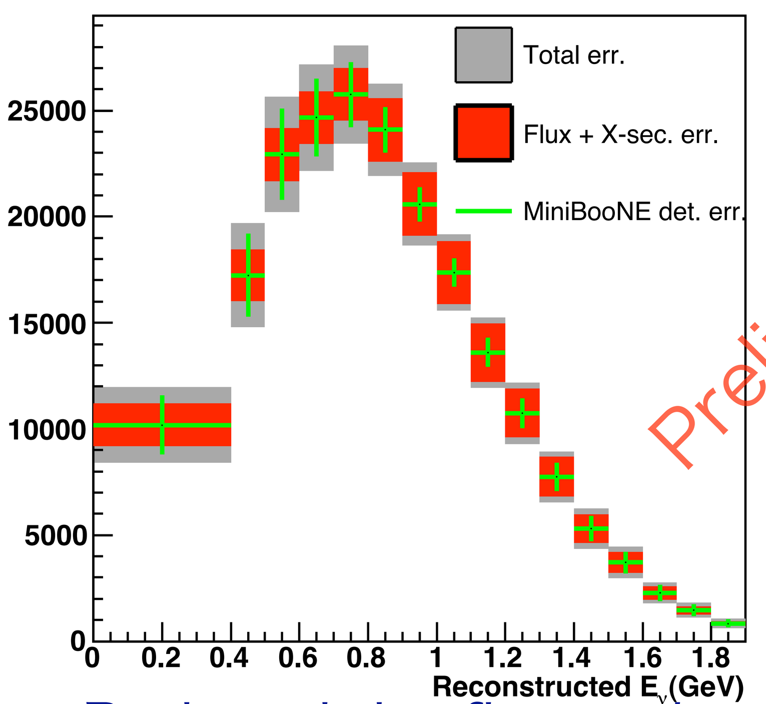


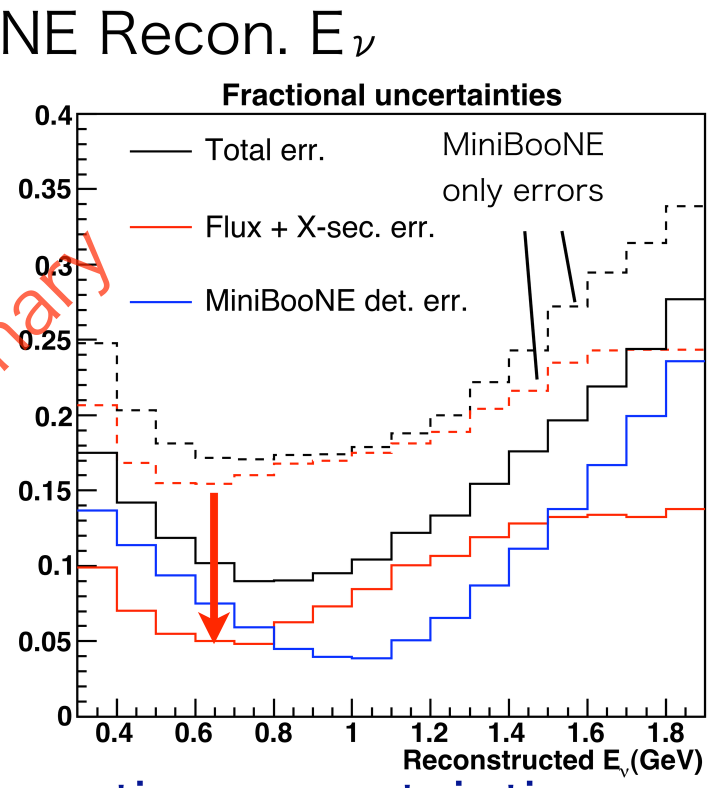


Good data/MC agreement

3. Expected MiniBooNE Distribution

- Extrapolate SciBooNE spectrum to MiniBooNE.
- Propagate errors to MiniBooNE Recon. E_ν



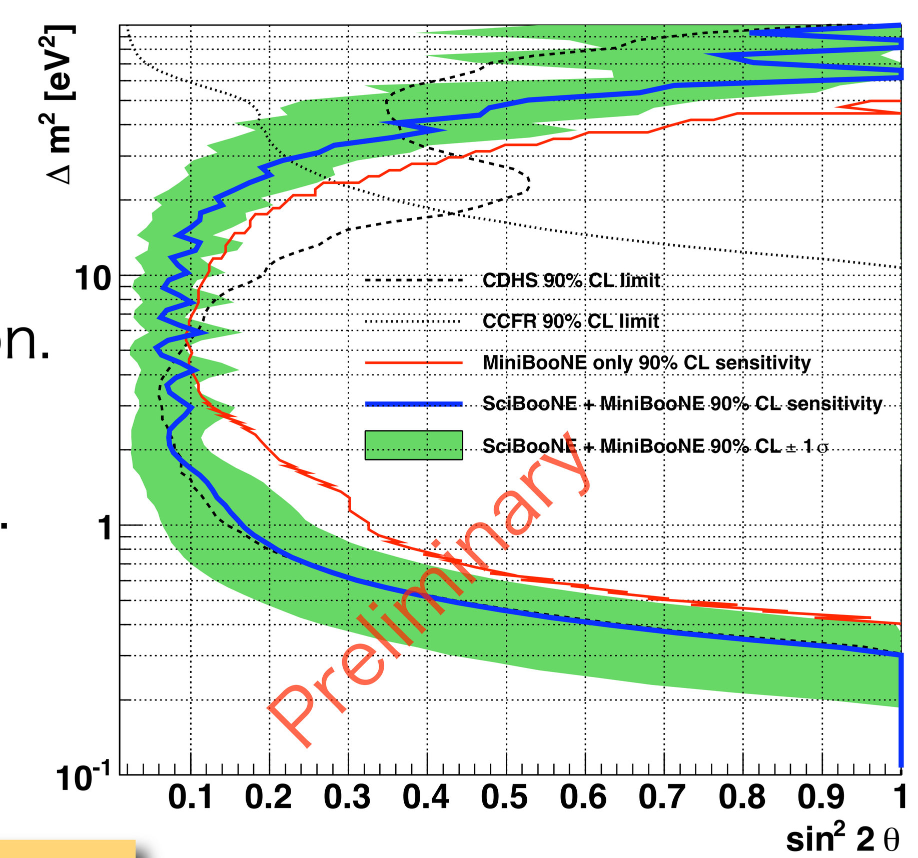


Reduced the flux and cross section uncertainties to the level of MiniBooNE detector uncertainty.

4. Oscillation Sensitivity

- Search for oscillation signal assuming 2-flavor mixing.
- Fit MiniBooNE Rec. E_ν distribution.
  - Evaluate the significance using the Feldman-Cousins's method.

Achieved higher sensitivity than MiniBooNE-only oscillation search.



Final SciBooNE-MiniBooNE joint fit result will be released soon!

\+ Anti-neutrino analysis is also ongoing!