

FNAL SciBooNE実験

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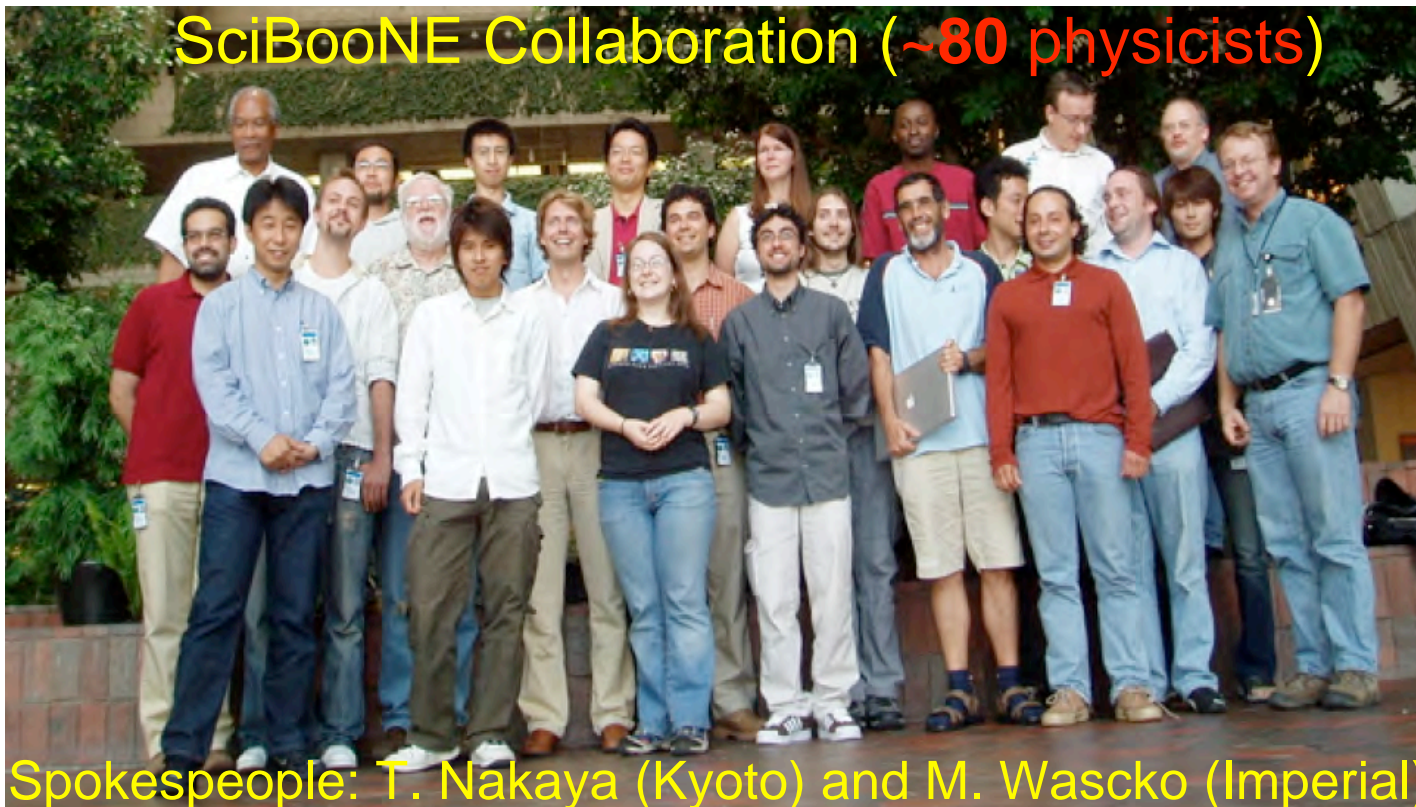
2006年度 特定領域「フレーバー物理」研究会

Outline

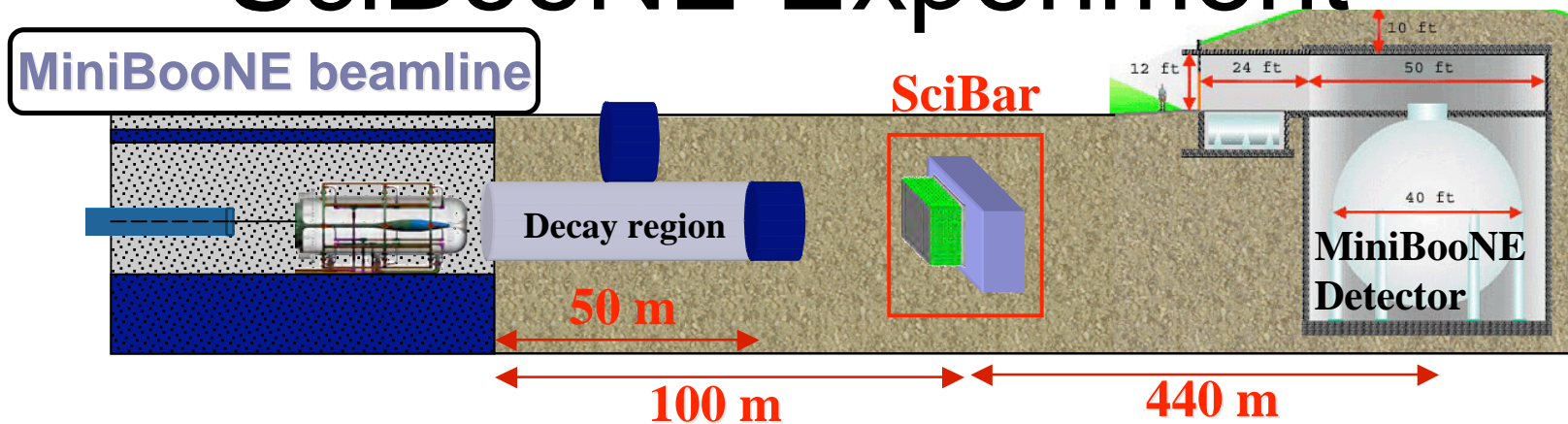
- Introduction to SciBooNE
- SciBooNE Detectors
- SciBooNE Physics
- SciBooNE Status
- Summary

SciBooNE (FNAL E954)

An approved new experiment at FNAL to measure the **neutrino** and **anti-neutrino** cross sections at the Booster Neutrino Beam line



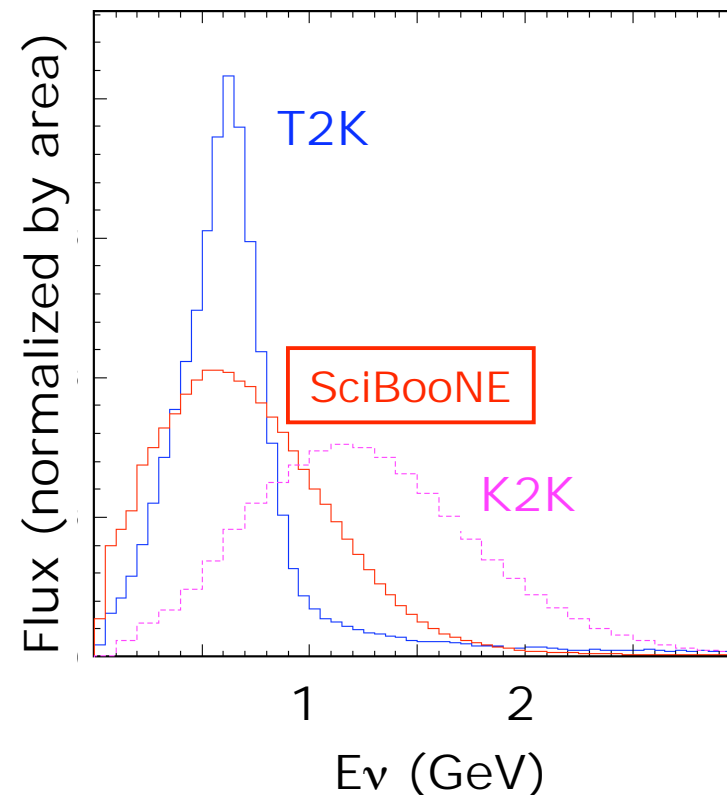
SciBooNE Experiment



- Precision study of neutrino cross sections for T2K.
- Anti-neutrinos
 - Unexplored physics territory and important for CP study in T2K-II.
- MiniBooNE near detector.

K2K-SciBar + FNAL-BNB

- Well developed Detector
- Most intense low energy neutrino beam.



SciBooNE Detector Components

- **SciBar Detector**

- Full active neutrino target
- Tracking
- From KEK, Japan

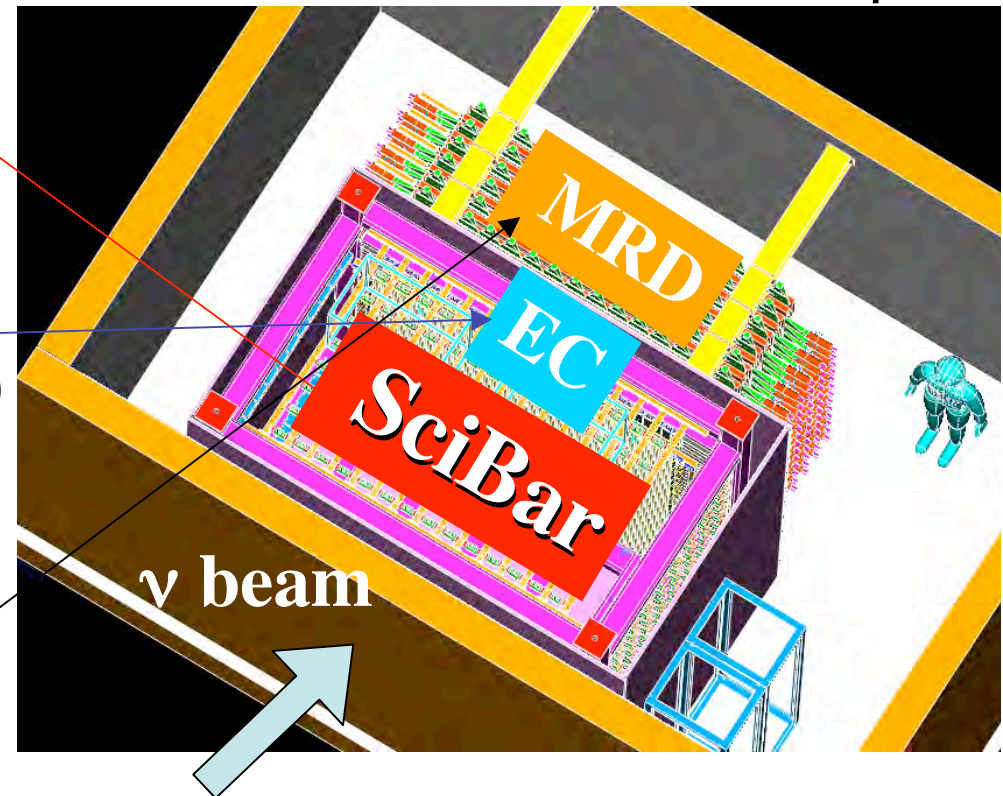
- **EM Calorimeter (EC)**

- Electron identification (for ν_e , π^0)
- From KEK, Japan

- **Muon Range Detector (MRD)**

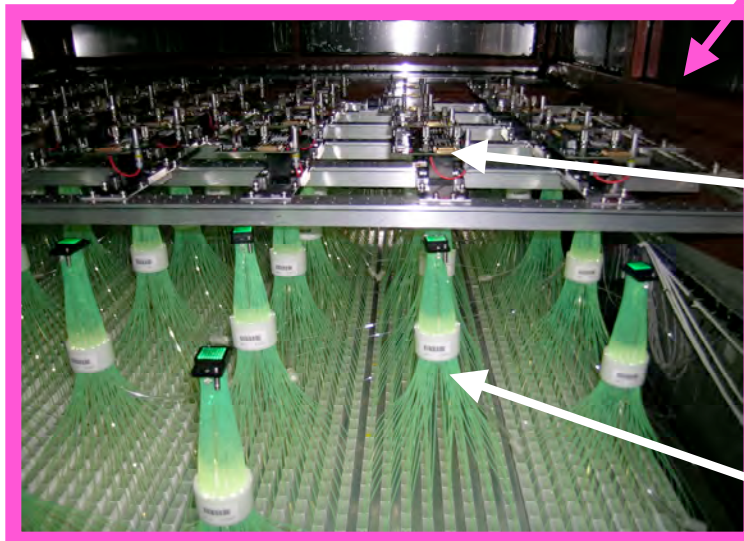
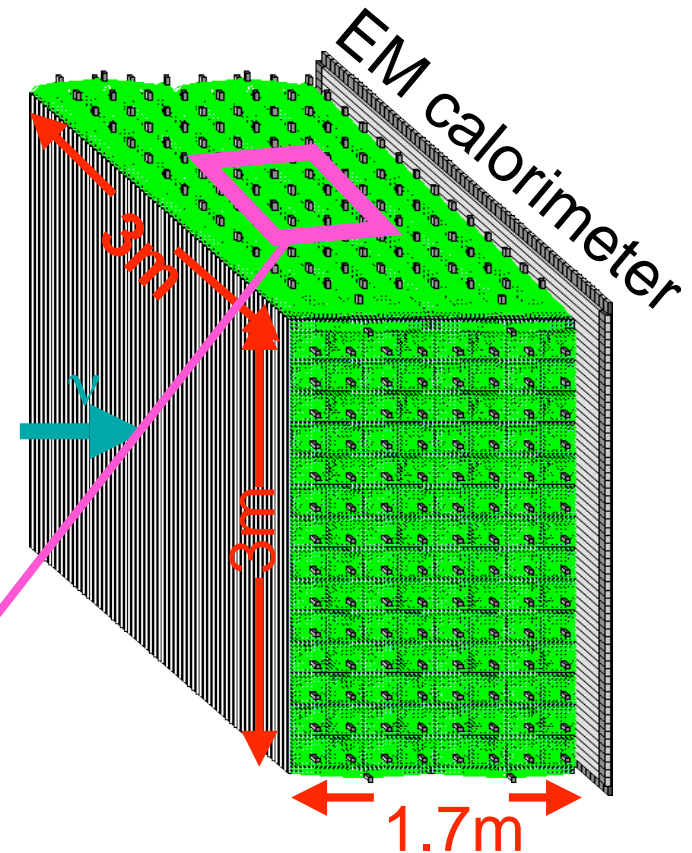
- Muon identification
- Momentum measurement
- Built at FNAL

Detector hall viewed from top



SciBar Detector

- Extruded scintillators with WLS fiber readout
 - $2.5 \times 1.3 \times 300 \text{ cm}^3$ cell
 - ~ 15000 channels
 - Scintillators are the neutrino target
 - Identify short tracks ($>8\text{cm}$)
 - Distinguish a proton from a pion by dE/dx
 - Total 15 tons
- High track finding efficiency ($>99\%$)
- Clear identification of ν interaction process



Multi-Anode PMT
(64 channels)

Wave-Length
Shifting fiber

SciBooNE Physics

- Propose 1 year run (2×10^{20} protons on target)

- Neutrino run ($\sim 1 \times 10^{20}$ POT)

- CC- $1\pi^+$ cross section
- NC- $1\pi^0$ cross section
- Intrinsic ν_e contamination

of interactions
in Fiducial Volume

$$\nu_\mu \sim 156,000$$

$$\nu_e \sim 1400$$

cf. K2K-SciBar (0.2×10^{20} POT) : $\sim 25,000 \nu_\mu$

- Anti-neutrino run ($\sim 1 \times 10^{20}$ POT)

- neutrino BG contamination
- CC-QE cross section
- CC-coherent π cross section

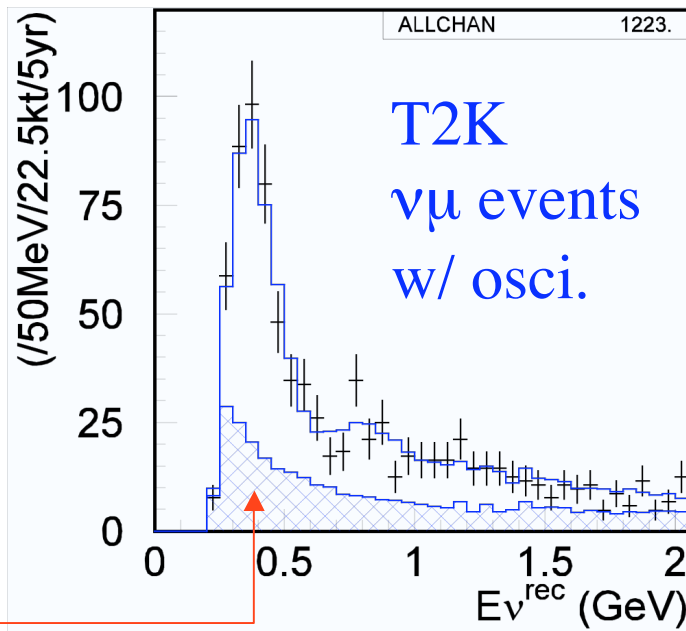
of interactions in FV

$$\bar{\nu}_\mu \sim 26,000$$

$$\nu_\mu \sim 14,000$$

Impact of $\sigma(\text{CC-}1\pi)$ on T2K oscillation measurements

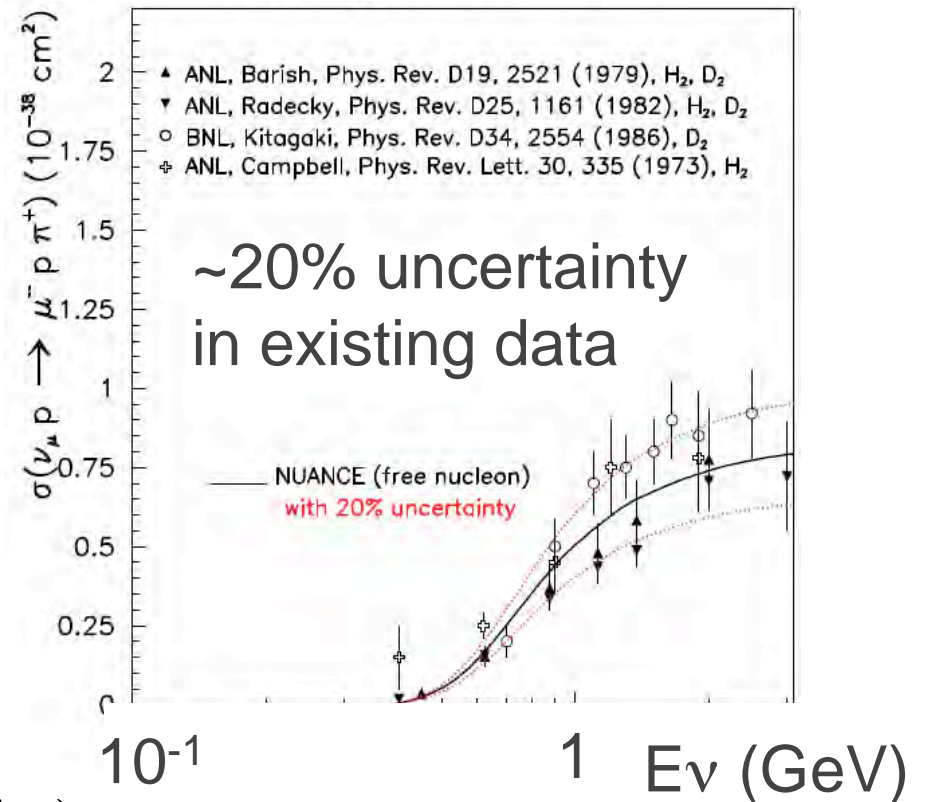
$\nu_\mu \rightarrow \nu_\mu$: precision measurements
(θ_{23} and Δm_{23}^2 measurement)



–Signal: CC-QE ($\nu+n \rightarrow \mu+p$)
(Energy Reconstruction from μ kin.)

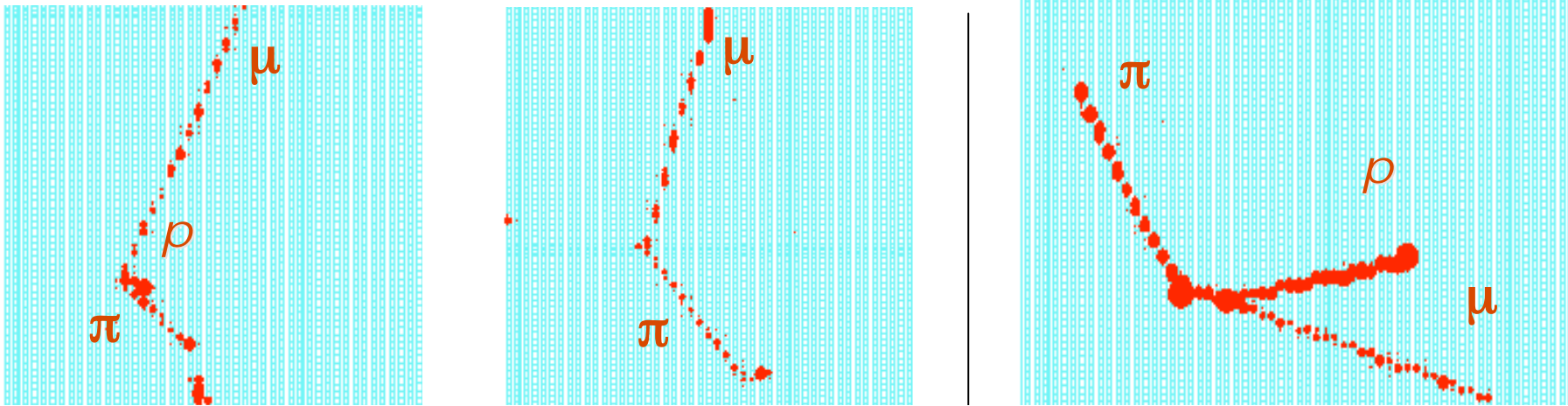
–Background: Mainly CC- $1\pi^\pm$
($\nu+N \rightarrow \mu+\pi+N'$)

CC- $1\pi^+$ cross section (現状)



CC- $1\pi^+$ measurement at SciBooNE

CC- $1\pi^+$ signature: 2 MIP-like tracks



*Clear event-by-event
final-state tagging!*

Vertex activity cuts:

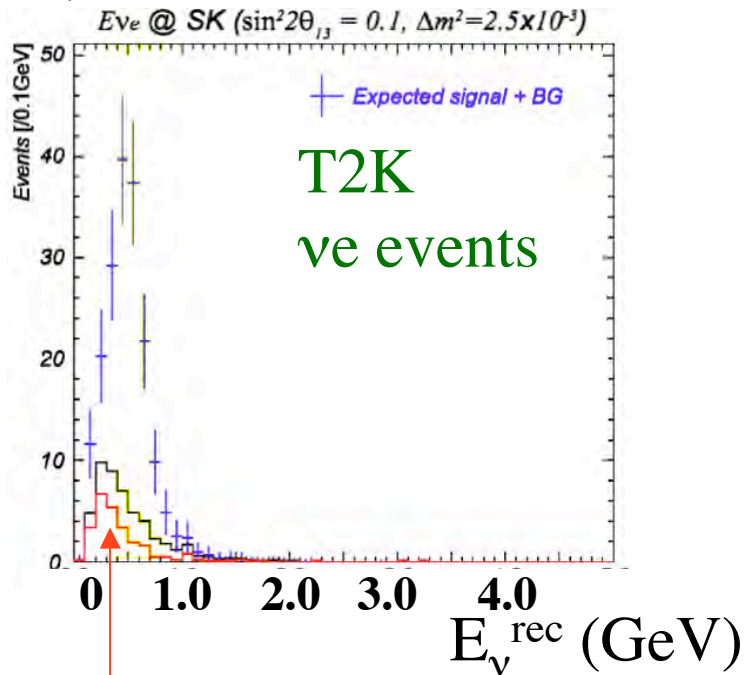
separate $\nu + p \rightarrow \mu^- \rho \pi^+$
from $\nu + n \rightarrow \mu^- n \pi^+$

Expect $\sim 2,800$ CC- $1\pi^+$ events after cuts

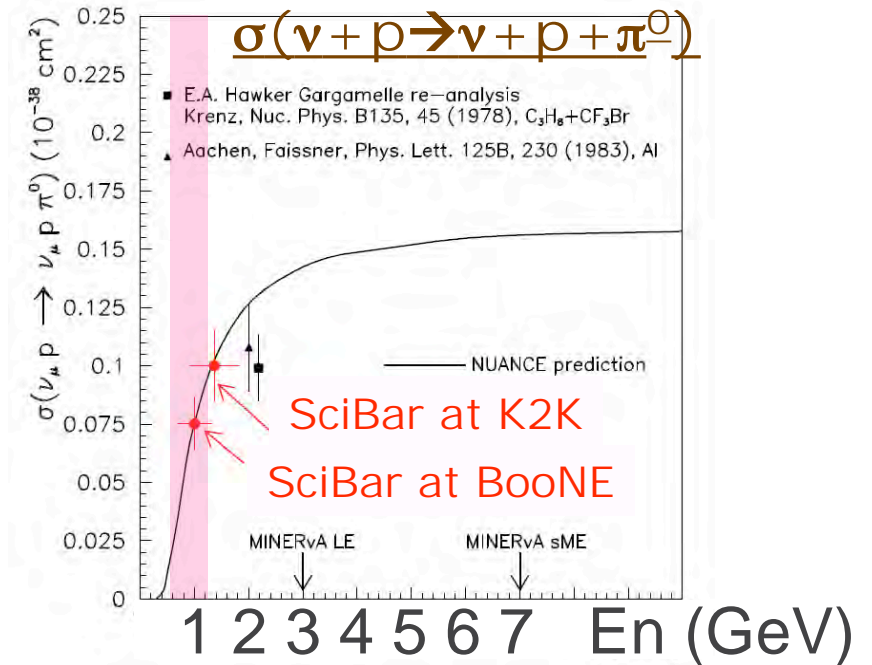
Statistics and systematics
Sufficient for $\sim 5\%$ measurement

Impact of $\sigma(\text{NC-}1\pi^0)$ on T2K oscillation measurements

$\nu_\mu \rightarrow \nu_e$: search for θ_{13}



- Signal: CC-QE ($\nu + n \rightarrow e + p$)
- Background
 - Beam ν_e
 - $\text{NC}\pi^0$ ($\nu + N \rightarrow \nu + N' + \pi^0$)

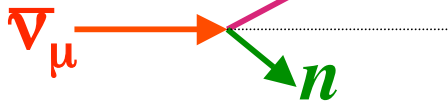


SciBooNE expects to make a
10% measurement

Anti-neutrino CCQE measurement

~BNB Wrong Sign Backgrounds~

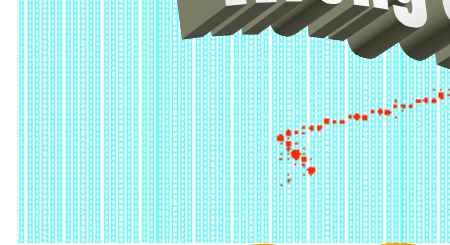
CC-QE:



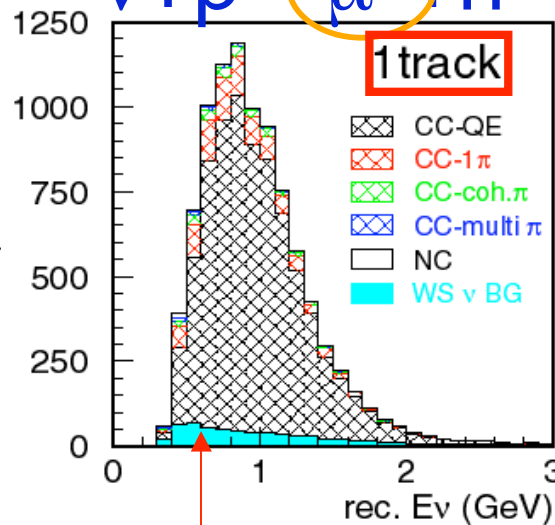
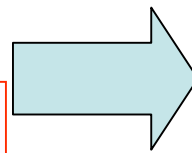
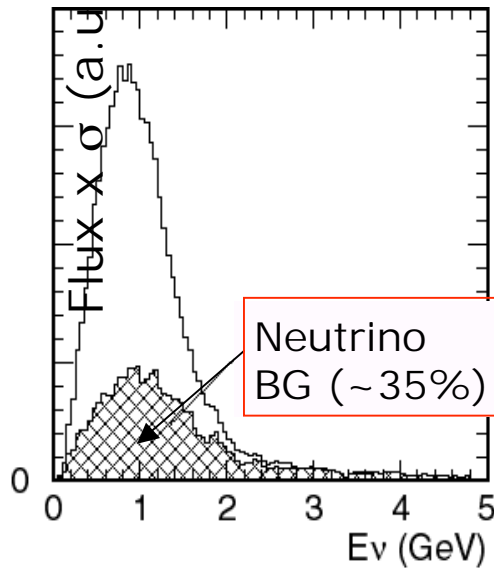
Right Sign



Wrong Sign

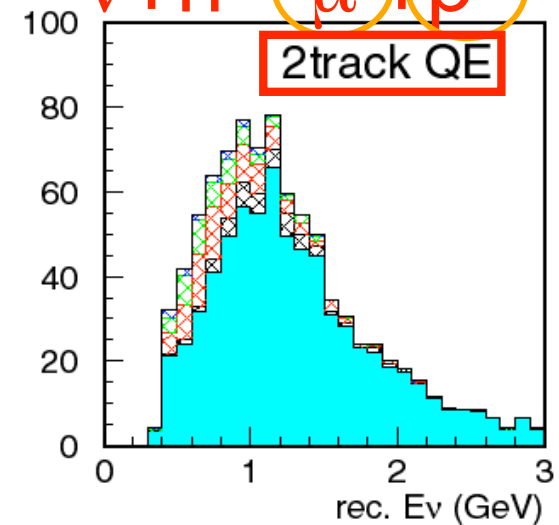


events in FV



$\bar{\nu}$ QE: ~80%

ν BG: ~7%



ν QE: ~80%

$\bar{\nu}_\mu$: ~26,000 int.

ν_μ : ~14,000 int.

SciBooNE can select pure anti- ν events.

SciBooNE実験の現状



Sep. 2006



Experimental Facility



Feb. 2007



Feb. 2007



Oct. 2006



Nov. 2006



Dec. 2006

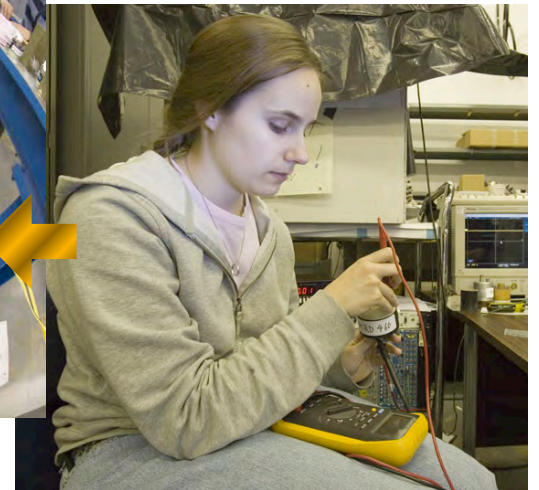


MRD

Muon Range Detector



MRD



Counter install

- Len Bugel

- Joan Catala

- Katsuki Hiraide

- Teppei Katori

- Yoshinori Kurimoto

- Kendall Mahn

- Yasuhiro Nakajima

- Tsuyoshi Nakaya

- Van Nguyen

- Michel Sorel

- Hideyuki Takei

- Makoto Taguchi

- Joe Walding

- Morgan Wascko

- Harman White

- Masashi Yokoyama

MIRD
Counter Assembly Completed
(Mar 5, 2007)



SciBar



SciBar disassembled

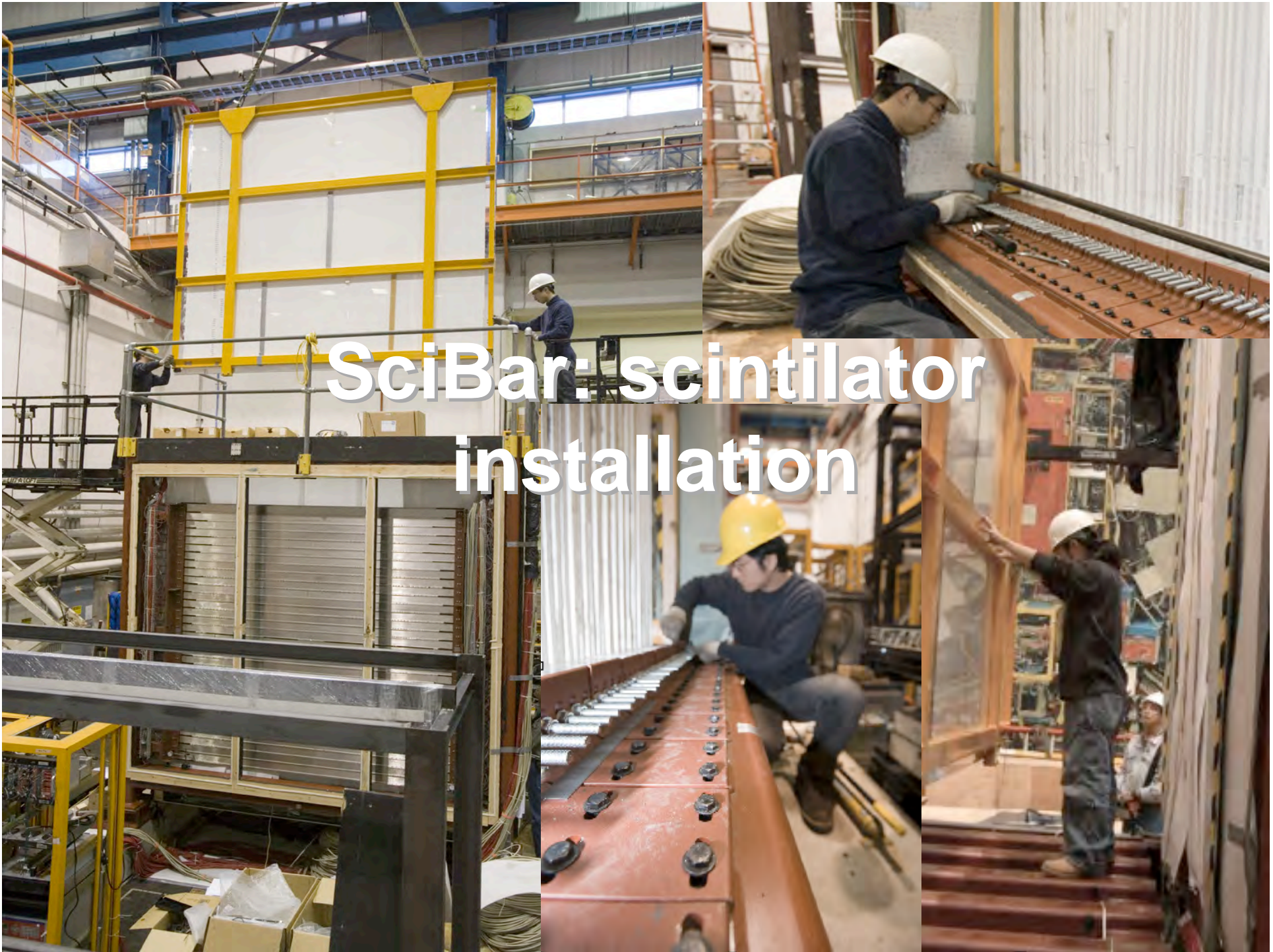


Ship from KEK to FNAL

SciBar
+EC
(shipping編)



Arrived at FNAL
(the CDF hall)



SciBar: scintillator installation

SciBar: scintillator installation completed (Dec. 7, 2006)

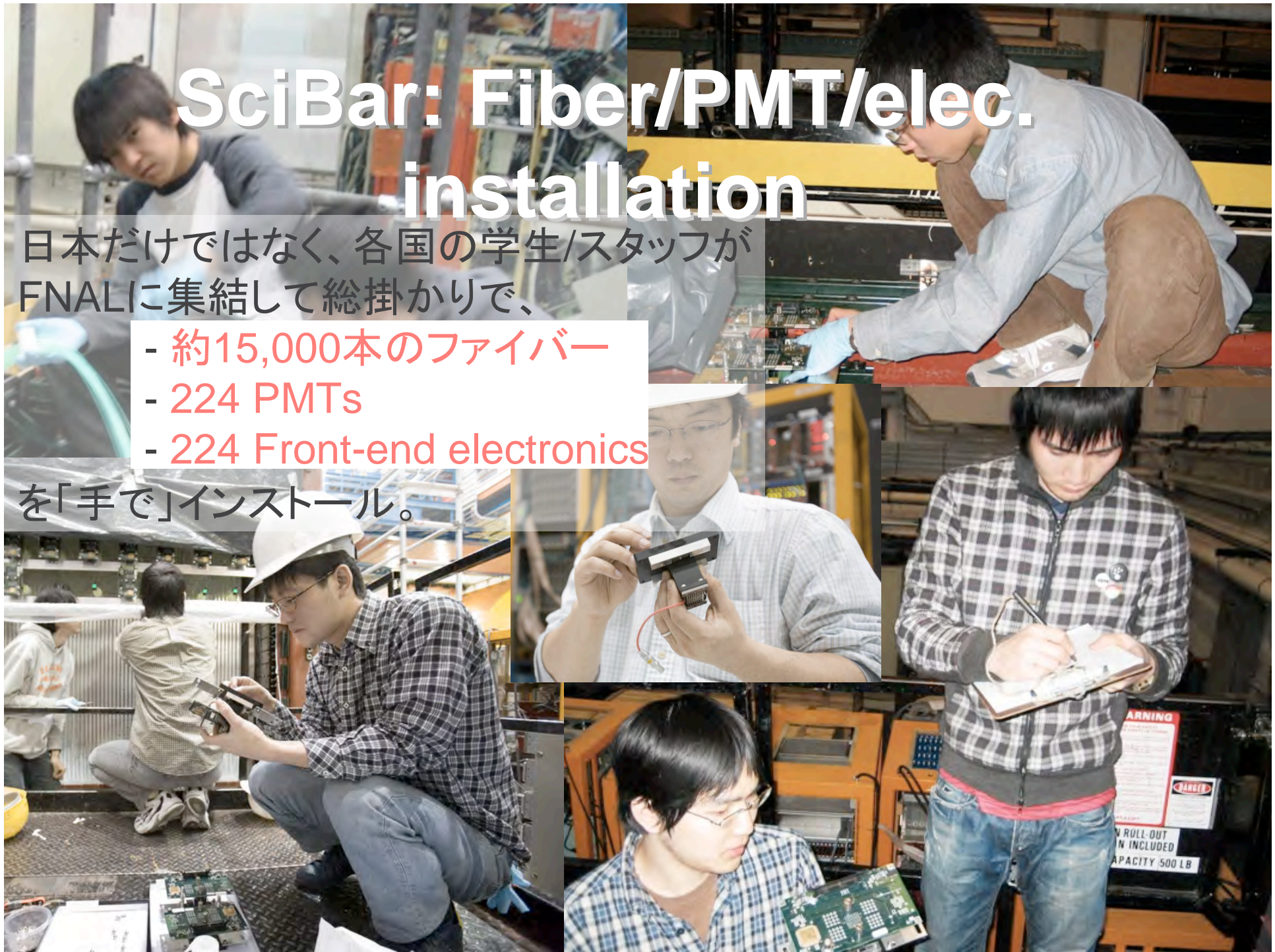


SciBar: Fiber/PMT/elec. installation

日本だけではなく、各国の学生/スタッフが
FNALに集結して総掛かりで、

- 約15,000本のファイバー
- 224 PMTs
- 224 Front-end electronics

を「手で」インストール。



SciBar: fiber/PMT/elec. installation completed (Feb. 9, 2007)

Kyoto U: 10 (Students 7, Staff 3)
Tokyo Tech: 3 (Students 3)
U. Tokyo: 1 (Staff 1)
Seoul National U: 3 (Students 3)
Columbia U: 1 (Student 1)
Indiana U: 1 (Student 1)
Imperial C: 1 (Staff 1)

Total: 22 people



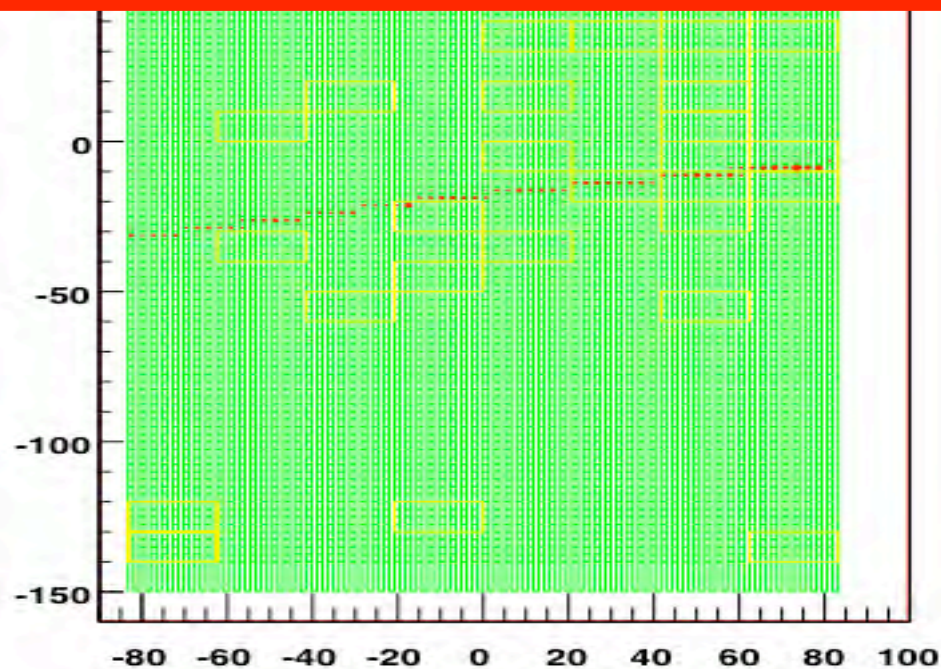


SciBar: DAQ system is ready to take data

SciBooNE-SciBar: first event display

(cosmic ray @CDF hall)

SciBarは太平洋をわたった先でも
ちゃんと動いている。



Summary

- SciBooNE is a new ν experiment at FNAL
 - to study neutrino interactions with nucleus by using both neutrino and anti-neutrino beams.
 - important measurements for T2K
- Detector construction has been completed in **March 2007**
- SciBooNE is now commissioning stage, and is under preparation to start taking data on **May 2007**.