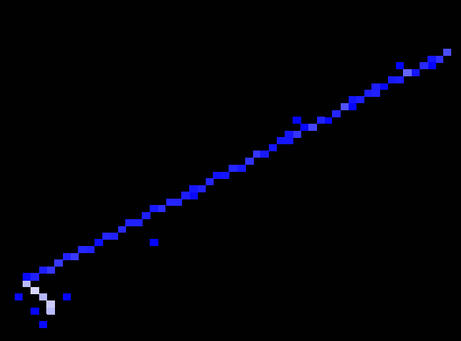
A Brand-new Neutrino Detector “SciBar” (1) Status and prospects



Masaya Hasegawa (Kyoto Univ.)
for the K2K SciBar Group

Hakuba 10th Symposium Feb. 15-18 , 2004

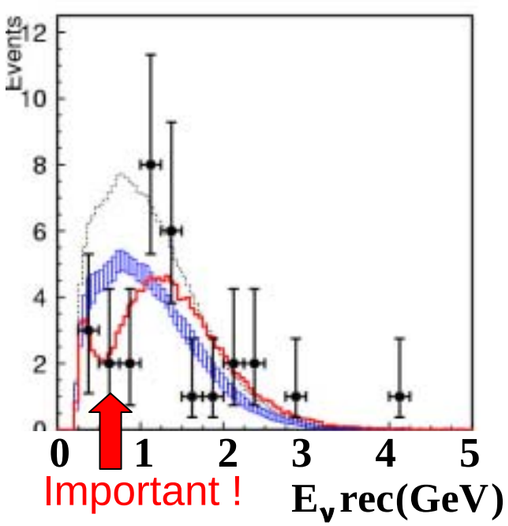
Contents

- K2K NDs status & Motivation for SciBar
- SciBar Detector
- Installation in last summer
- SciBar working status
- Summary

K2K current status

K2K Oscillation analysis

- Null Oscillation probability < 1%
- Δm^2 = 1.5 ~ 3.9 ×10^{-3} eV
  @ $\sin^2 2\theta$ =1(90%CL)



Oscillation max.
Eν ~ 0.6GeV

But !

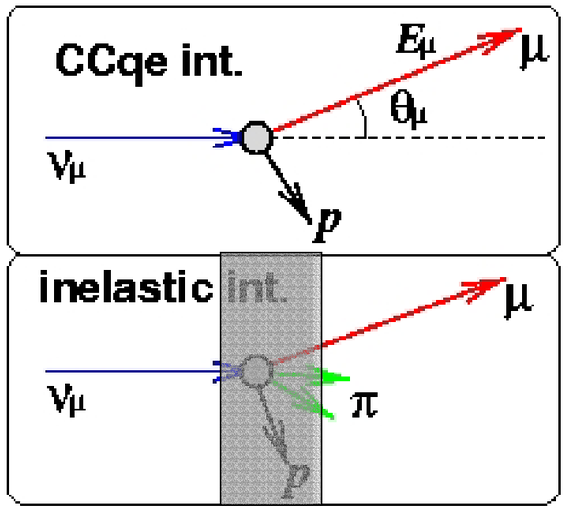
Flux (<1.0GeV) : ~10%
BG @ Super-K : ~20%

Need to study low energy **ν** interactions
(Charged current Quasi-elastic, single **π** production)
to maximize the sensitivity

What's Needed ?

How to identify the CCQE

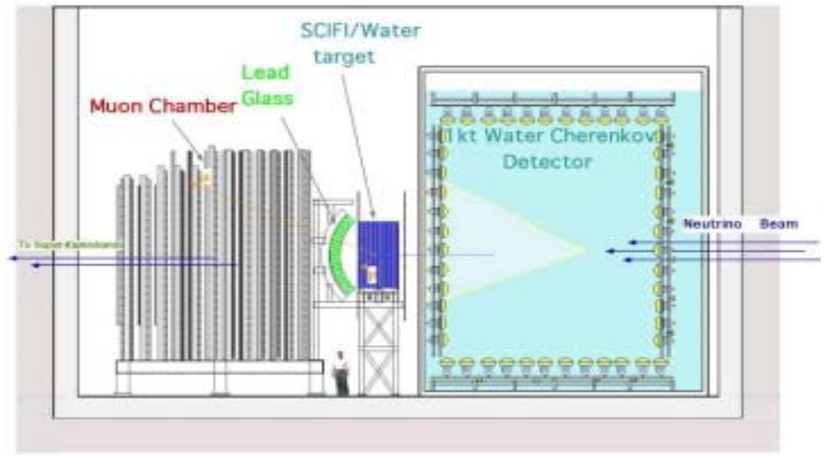
Identify **μ** and *P* (No **π** $^{\pm/0}$)

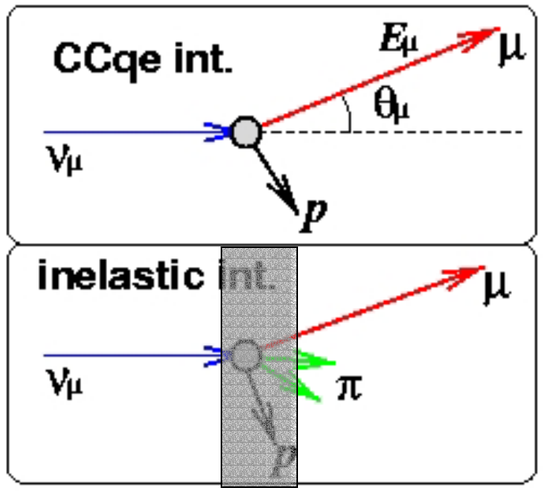


- Observe all particle from **ν** interaction. (Full Active & Tracking)
- Identify the recoil Proton (from low momentum)
- PID (p/**π**)
- Large Volume

Motivation for SciBar

K2K Near Neutrino Detector





- 1kt water cherencov detector (25t fiducial)
  - detect both CCqe and nonQE as 1ring **μ** event (fraction ~ 50%)
- Scintillating fiber tracker (6t fiducial)
  - Low efficiency @ low energy
  - dead space around vertex (fraction ~60%)

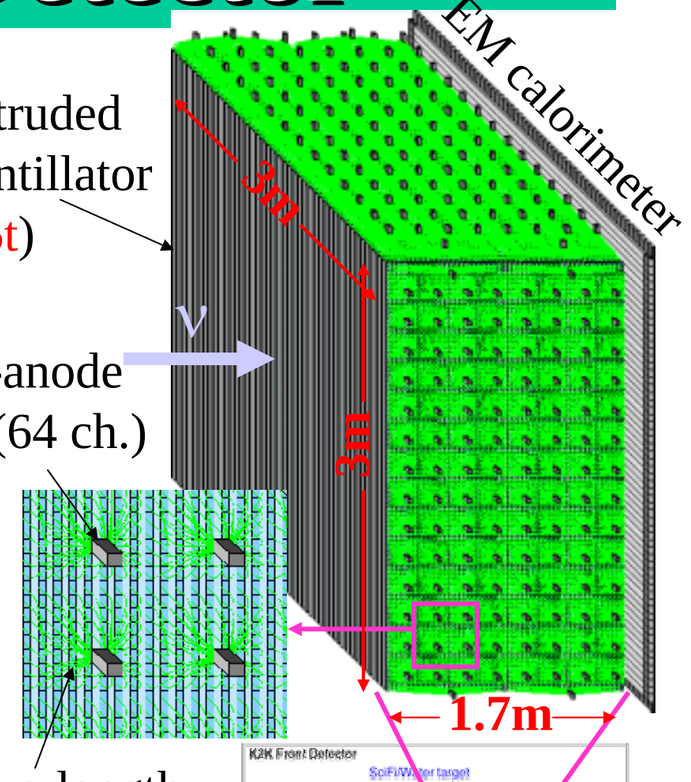
→ Need a new detector !

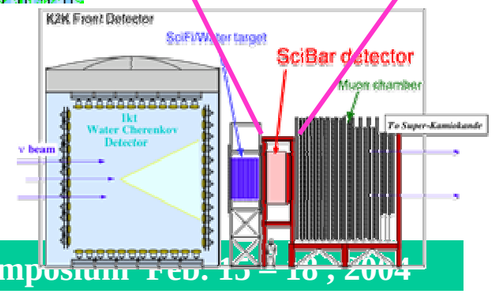
SciBar Detector

- Extruded scintillator with WLS fiber readout
- Neutrino target is scintillator itself
- 2.5 x 1.3 x 300 cm^3 cell
- ~15000 channels
- Detect from less than 10cm track
- Distinguish proton from pion by using dE/dx
- (fairly) large volume

➔High 2-track CC-QE efficiency

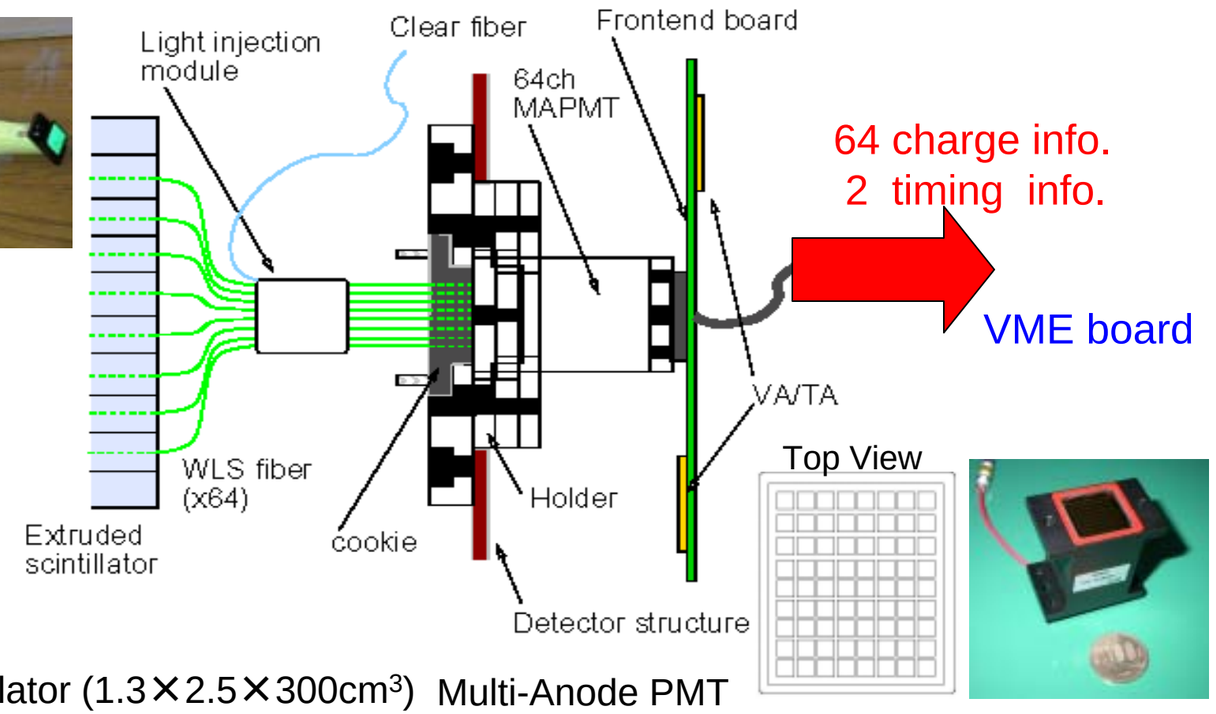
➔Identify ν interaction mode clearly





Just constructed in last summer!

SciBar Component



Extruded Scintillator (1.3×2.5×300cm^3)
- made by FNAL (same as MINOS)

Wave length shifting fiber (1.5mmΦ)
- Long attenuation length (~350cm)

→ Light Yield : 16.5p.e./cm/MIP

Multi-Anode PMT
- 2×2mm^2 pixel (3% cross talk @1.5mmΦ)
- Gain Uniformity (20% RMS)
- Good linearity (~200p.e. @6×10^5)

Readout electronics → Takubo's talk

Expected Performance

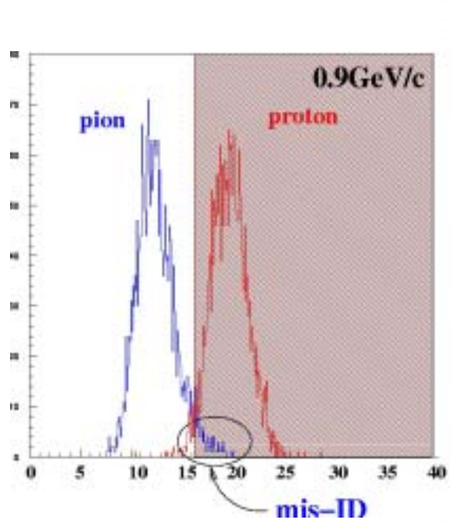
- PID (p/π)
- Momentum reconstruction

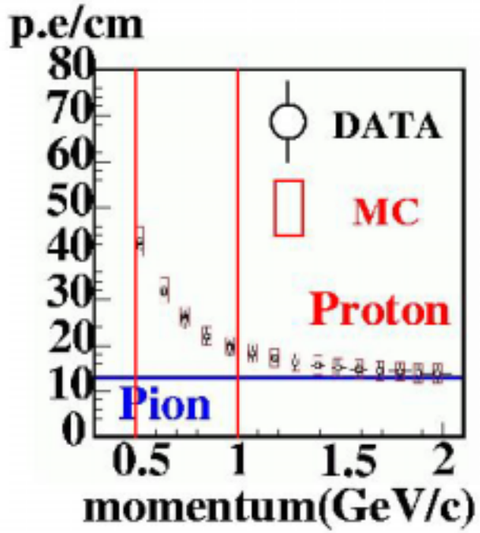
Using dE/dx Info.

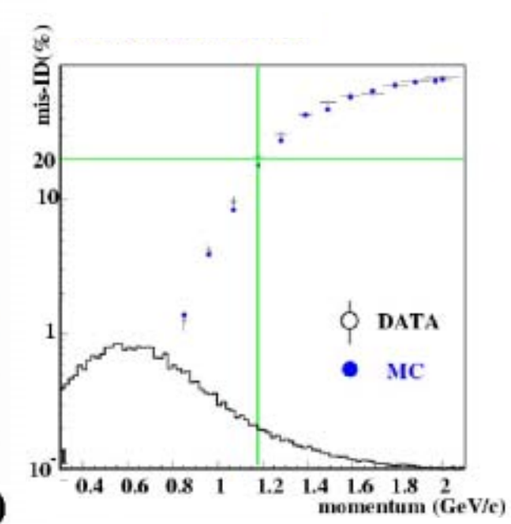
Result from Beamtest 2001 (only using 10cm dE/dx info)

p/π missID probability : ~ 1% (@ 0.8GeV/c) @ P_eff=95%

Momentum (for proton) : less than 10% (below 1.0GeV/c)

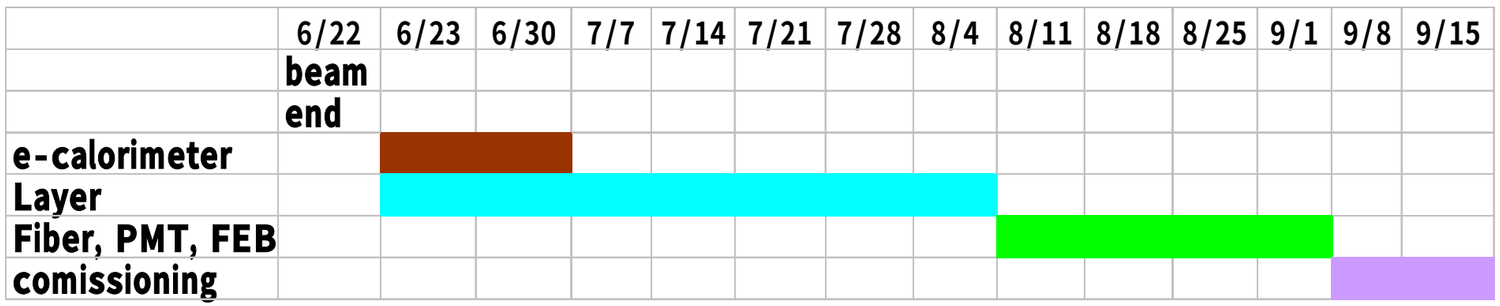






High Efficiency in finding/identifying low energy CCQE events

SciBar Installation



S.Aoki, J.Arygyriades, S.S.Choi, M.Hasegawa, Hiraide, K.Hayashi,

A.K.Ichikawa, Iinuma, Eric J., E.J.Jeon, K.K.Joo, D.Kerr, K.Kobayasi,

A.Kohara, J.Kubota, M.J.Lee, I.T.Lim, H.Maesaka, O.Mineev, T.Morita,

Y.Nakanishi, K.Nishikawa, K.Nitta, P.Rovegno, T.Nakaya, T.Sasaki,

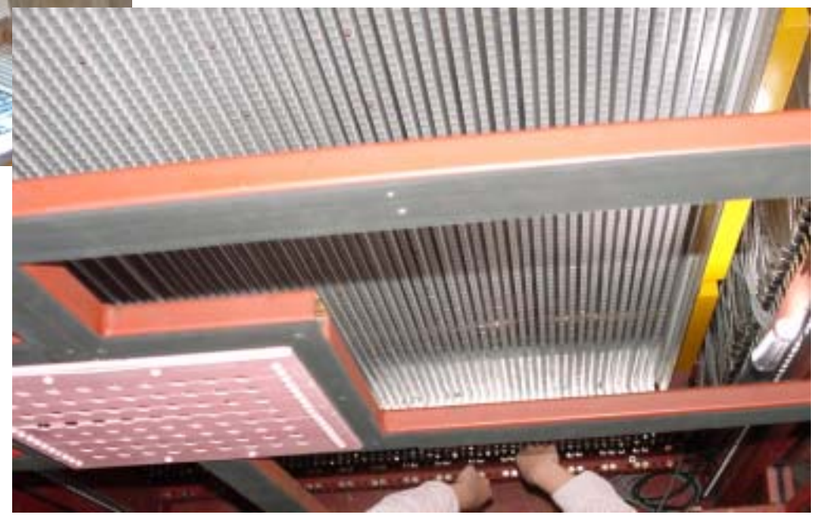
A.Suzuki, K.K.Shiraishi, Y.Takubo, R.Terri, M.Tuchscher, S.Yamamoto,

M.Yokoyama, M.Yoshida, Z.Nawang (and more?)

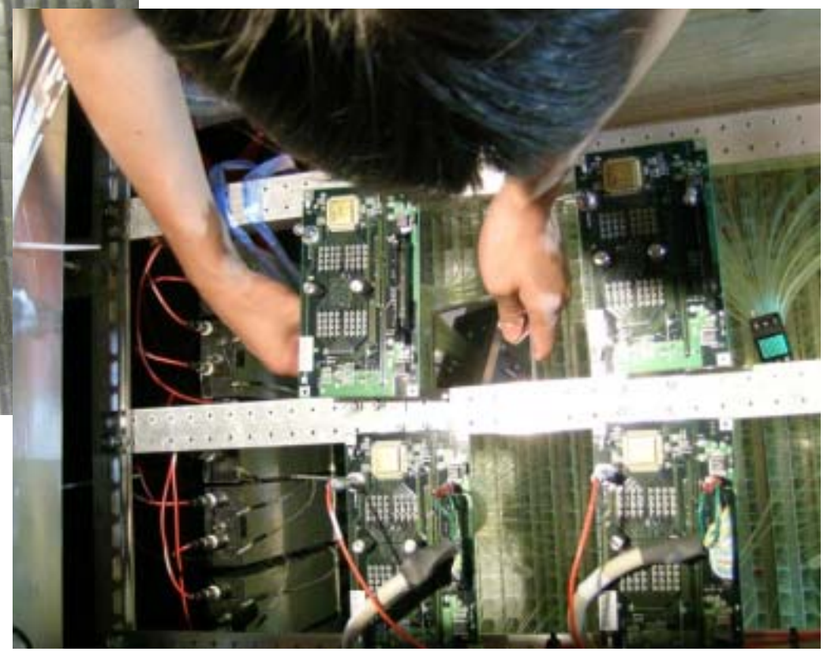
Almost no change from this schedule!

(体育会系的がんばり！)

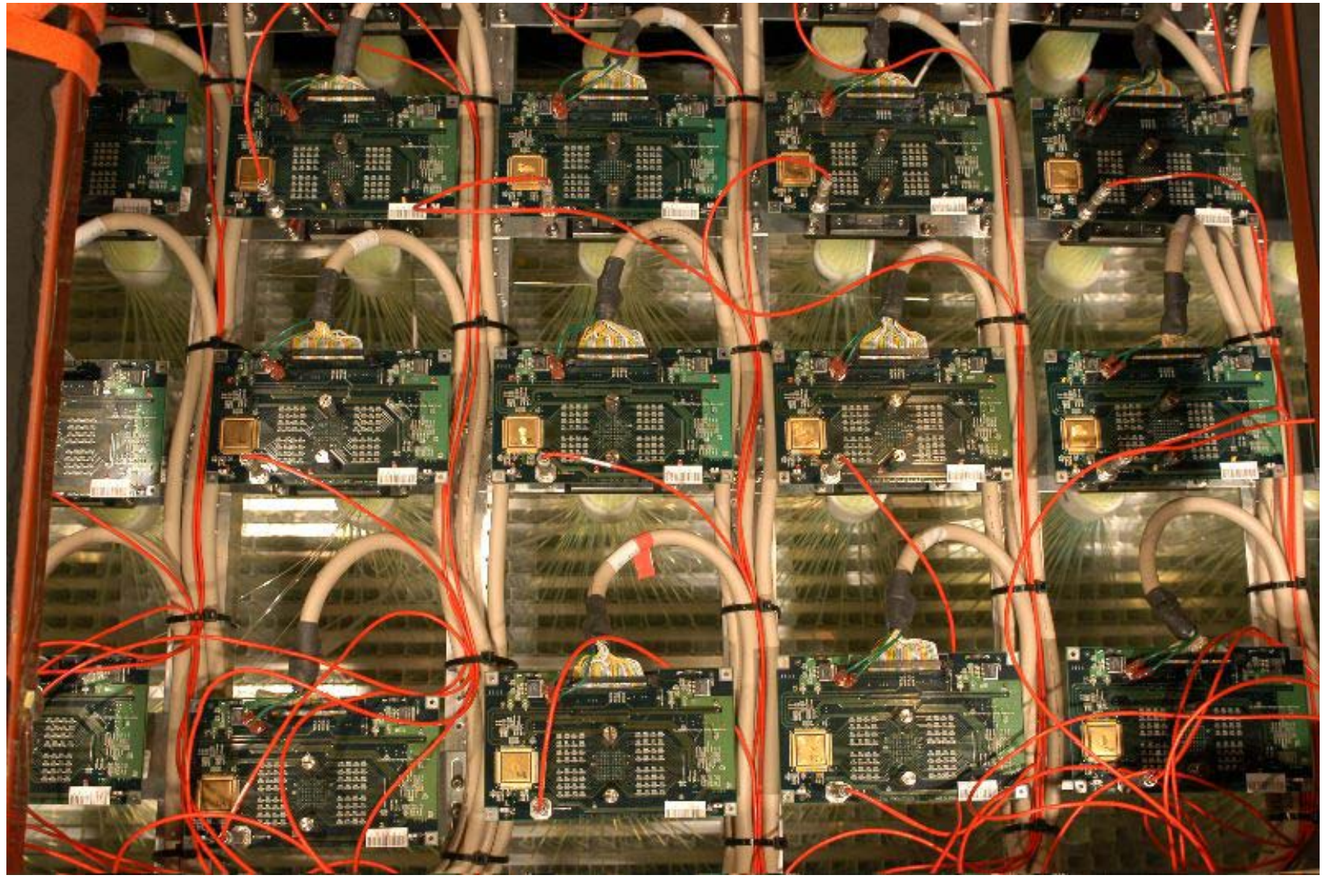
SciBar Installation (1)



SciBar Installation (2)



SciBar Installation – complete !



SciBar in the News


KEK 高エネルギー加速器研究機構
High Energy Accelerator Research Organization

トップ | KEKとは | KEK ツアー | よくある質問 | News@KEK | キッズサイエンティスト | 関連サイト

トップ >> ニュース >> この記事

■ ニュートリノをつかまえろ！ 2003.10.16

～ 新型検出器SciBar ～

KEKの陽子加速器を
れた岐阜県神岡鉱山
で、ニュートリノの振動
も何度かご紹介しまし
ナンス作業のために
ました。今回は、K2K
置についてご説明しま

Nikkei News 2004.01.12

KEK News 2003.10.16

ートリノと物質の反応

観測装置が稼働

高エネ研 精度向上めざす

性子と衝突すると、陽子と負の電荷を持つミュー粒子などが生み出され、高速で飛ぶ。粒子が通り抜けた透明な棒は発光する。

このデータを分析すると、どんな粒子がどの方向にどれほどの速さで飛んだかが分かる。ニュートリノが中性子や陽子と衝突して起きる反応は約十通りあるが、観測装置の能力が不十分で、詳しい様子は解明されていなかった。

高エネ研は加速器を使って生み出したニュートリノビームを岐阜県神岡町にある東京大学の観測施設「スーパーカミオカンデ」に向けて発射、ニュートリノの性質を調べている。SciBarはこのニュートリノビームの通り道に置かれ、一日当たり百―二百例の衝突反応を観測中。この観測データを使って、ビームの受け手側のスーパーカミオカンデのデータを補正すれば、実験精度が向上する。

加速器研究機構（つくば市）

ニュートリノ

して起こる

測する装置

。ニュート

性質解明と

度から茨城

備が始まる

トリノ大型

めの基礎デ

SciBa

）」は、縦

き約二メートル。

い透明な発

き詰めた層

る。棒の総

本。ニュー

構成する中

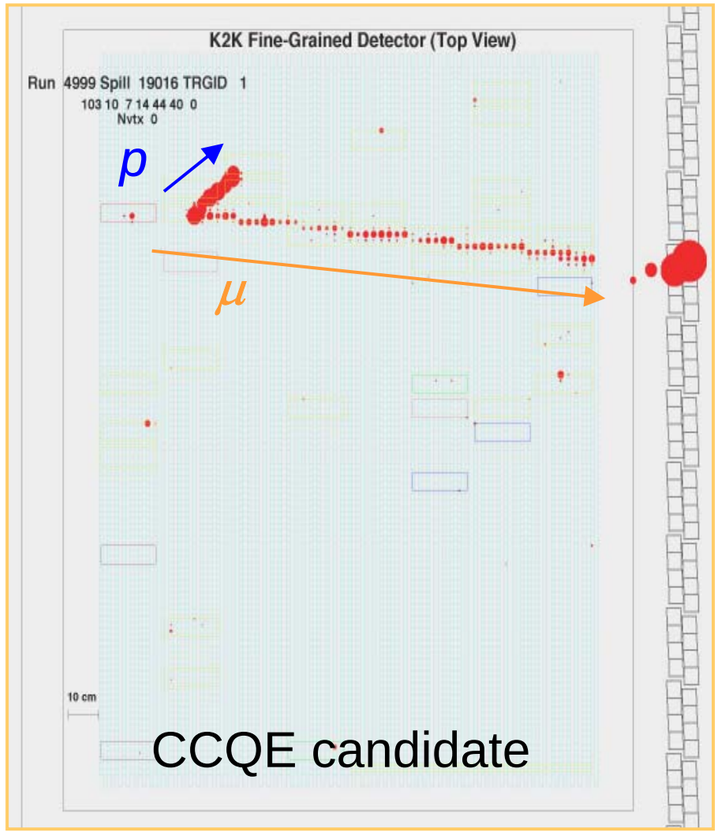
Current Status

- SciBar started **ν** data taking from Oct.10 and working well.
  - few dead channel (6/14336 = 0.04%)
  - collect ~7000 **ν** int./10ton/5E18POT(1month)
  - collect calibration data (cosmic,LED) with beam

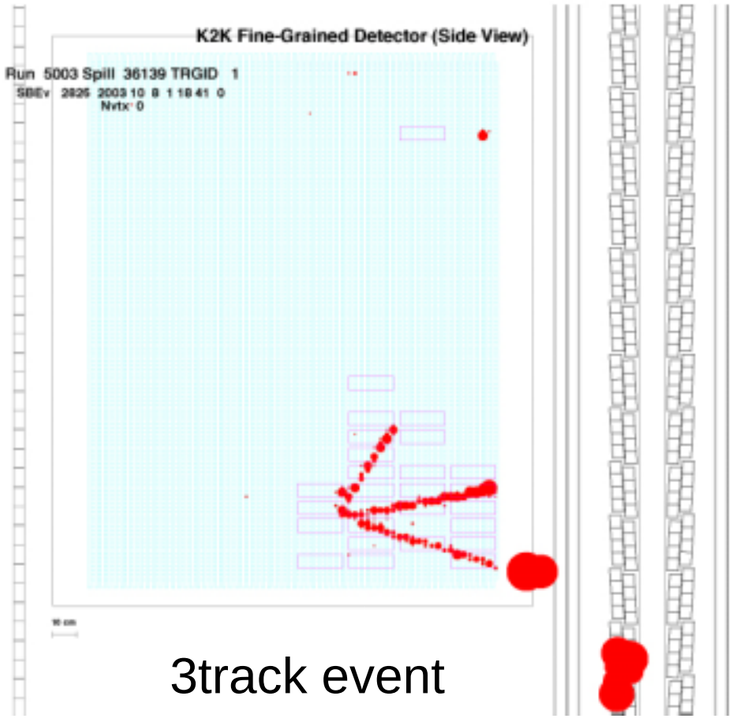
	beam		pedestal		LED		Cosmic ray
0.6s	35μs		100ns, 1take		1μs,1take		Suppression mode

We have already done
- checking the basic hardware performance
- calibration (energy,timing),detector alignment
- comparing with MC and other detectors
  using Muon sample (very preliminary)

SciBar Shot !

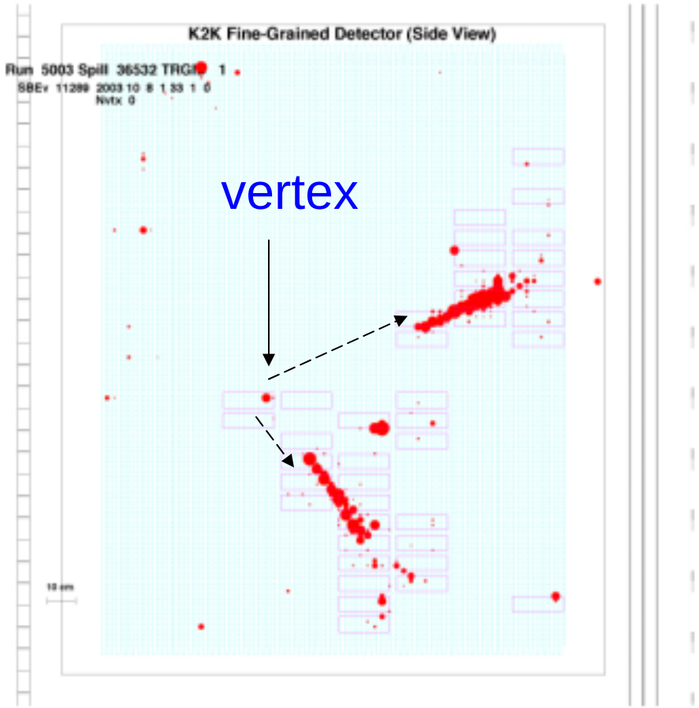


CCQE candidate



3track event

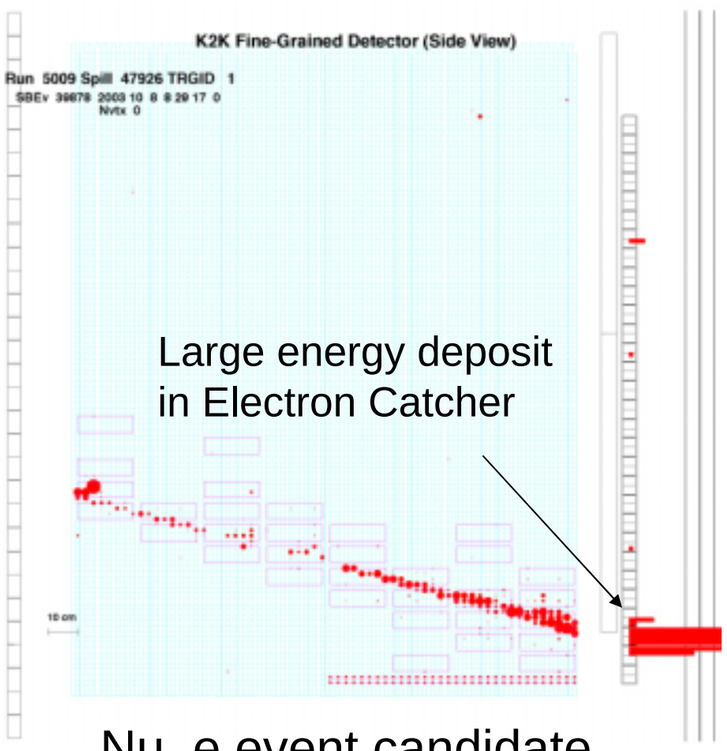
SciBar Shot !



NC pi0 candidate

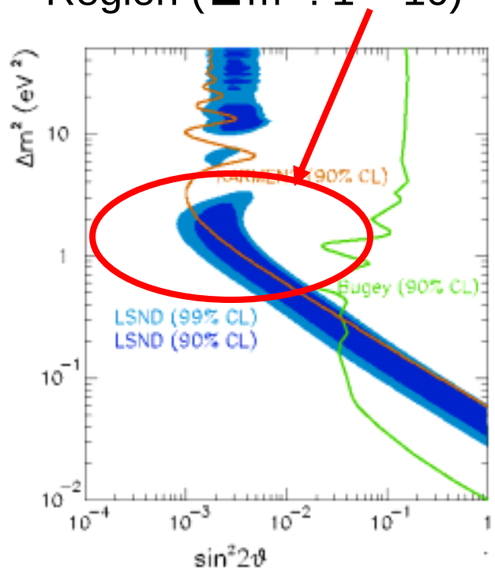
(**ν** + N → **ν** + N + **π**$^{0)}$

SciBar Shot !

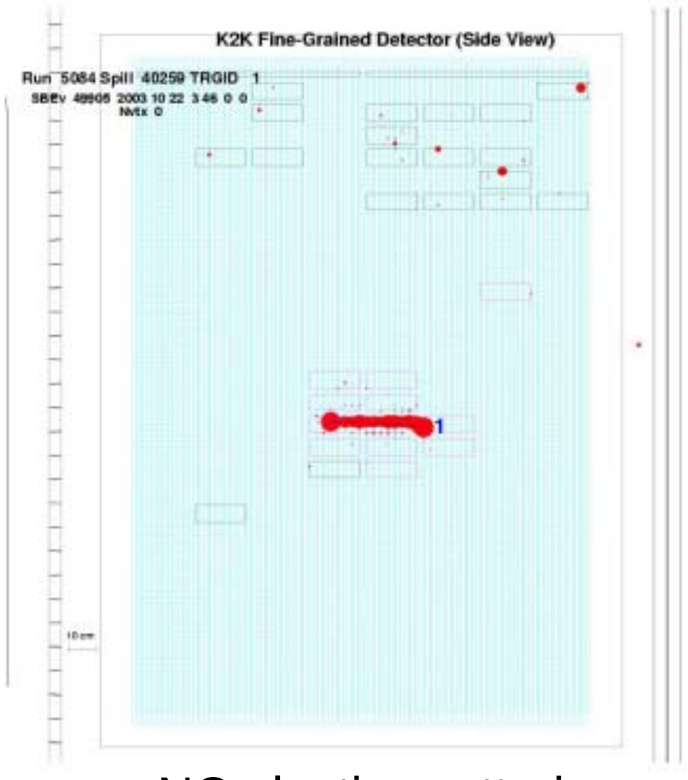


Nu_e event candidate

- ν_e Flux measurement
  → Estimation of Beam BG for ν_e search at Super-K
- Short Baseline Oscillation
  → ν_e appearance for LSND Region (Δm^2 : 1 ~ 10)



SciBar Shot !



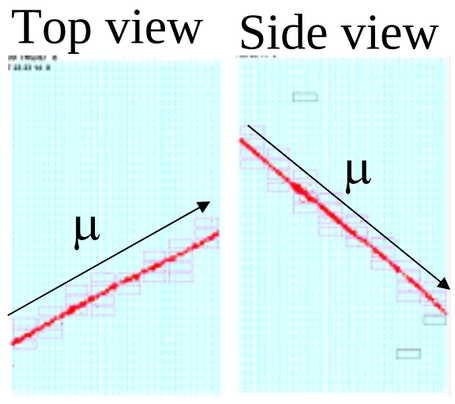
NC elastic scattering
(ν + N → ν + N)

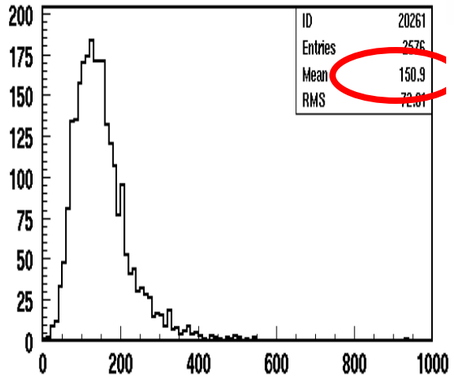
Nucleon spin crisis
What carries the proton spin?
- valence quarks,sea quarks or gluons?

$\sigma(NCE)/\sigma(CCQE)$ ratio probes
Strange sea contribution to nucleon spin
(Nuclear Physics B 105 (2002) 62)

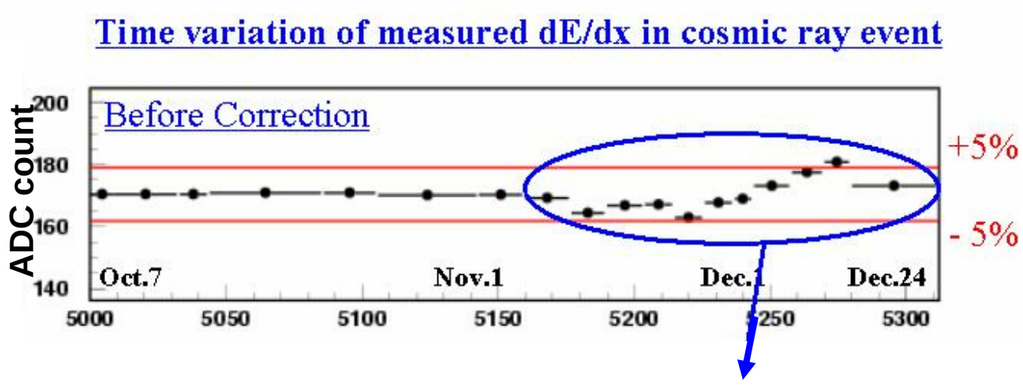
Cosmic Ray Data

- We use penetrating cosmic-ray muon as a (strip to strip) relative energy calibration source.
- Mean ~ 140 count (design value)
- response is very stable





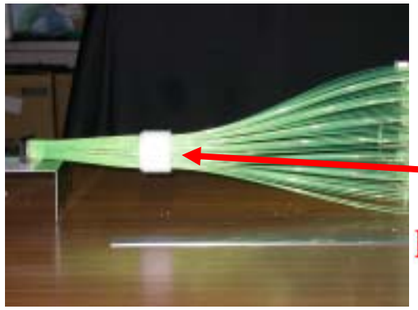
Typical ADC distribution

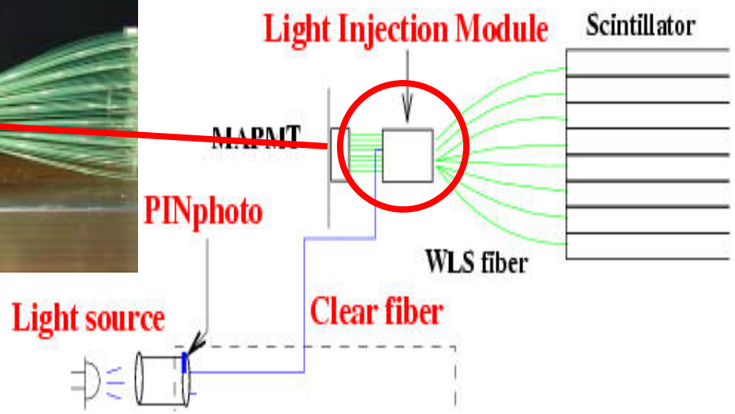


This fluctuation come from PMT Gain variation

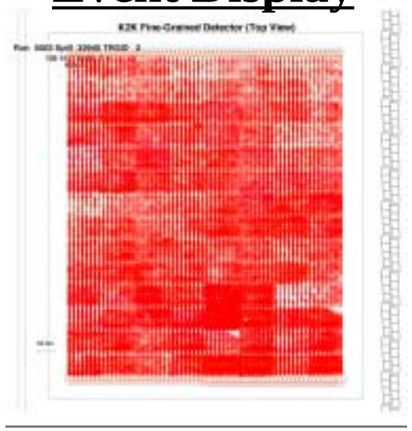
Gain Monitor (1)

High Accuracy gain monitoring SystEm (HASE moni)



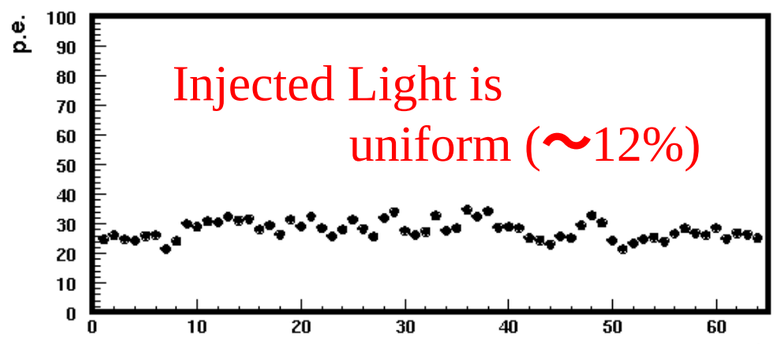


Event Display



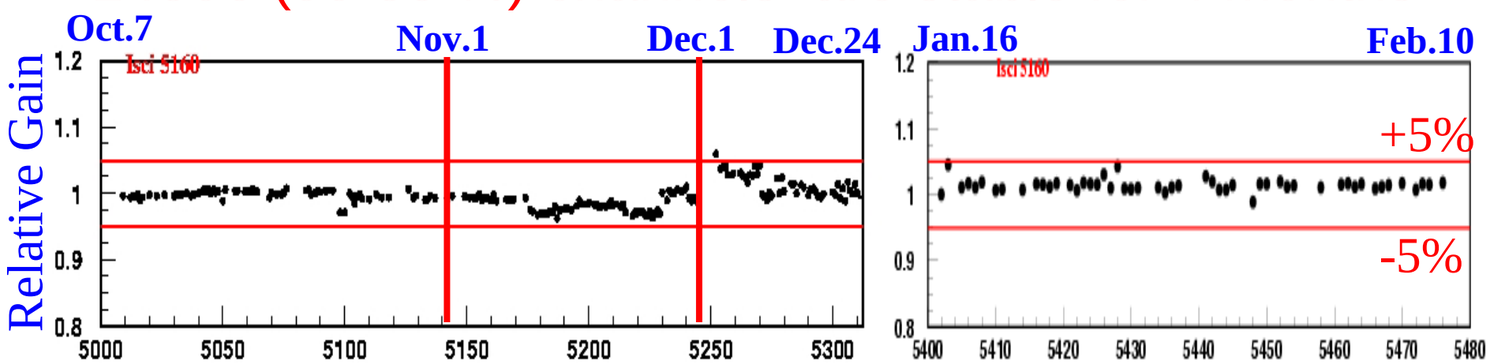
Feature

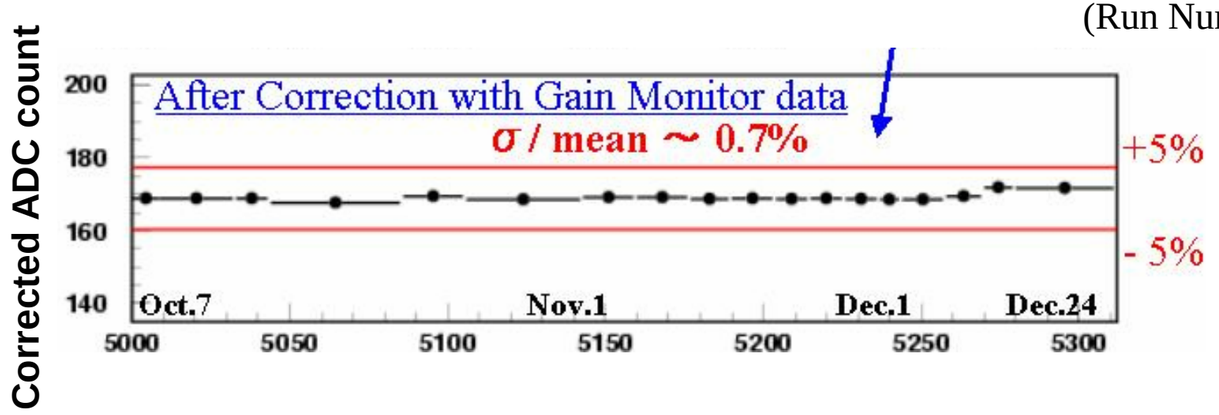
- Monitoring all channels at once with only 4 LEDs.
- Very uniform light (No PMT saturation)



Gain Monitor (2)

14306 (99.85 %) channels are stable for 4 months.





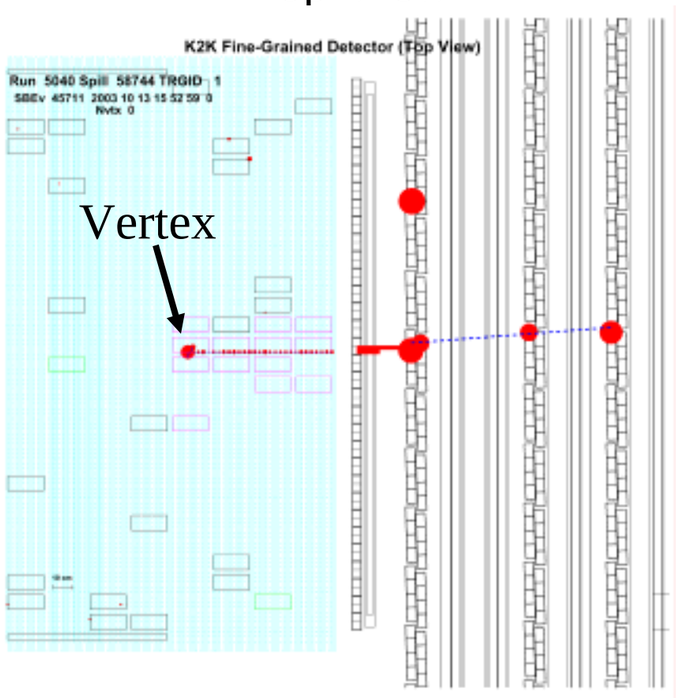
Gain drift can be corrected within 1% level precision !

Muon Track Analysis (1)

■ As a first step , we checked and compared the basic distribution (vertex,momentum) with MC on the clean muon sample.
(p_{μ}>0.5GeV/c, ~35% eff all ν int.)

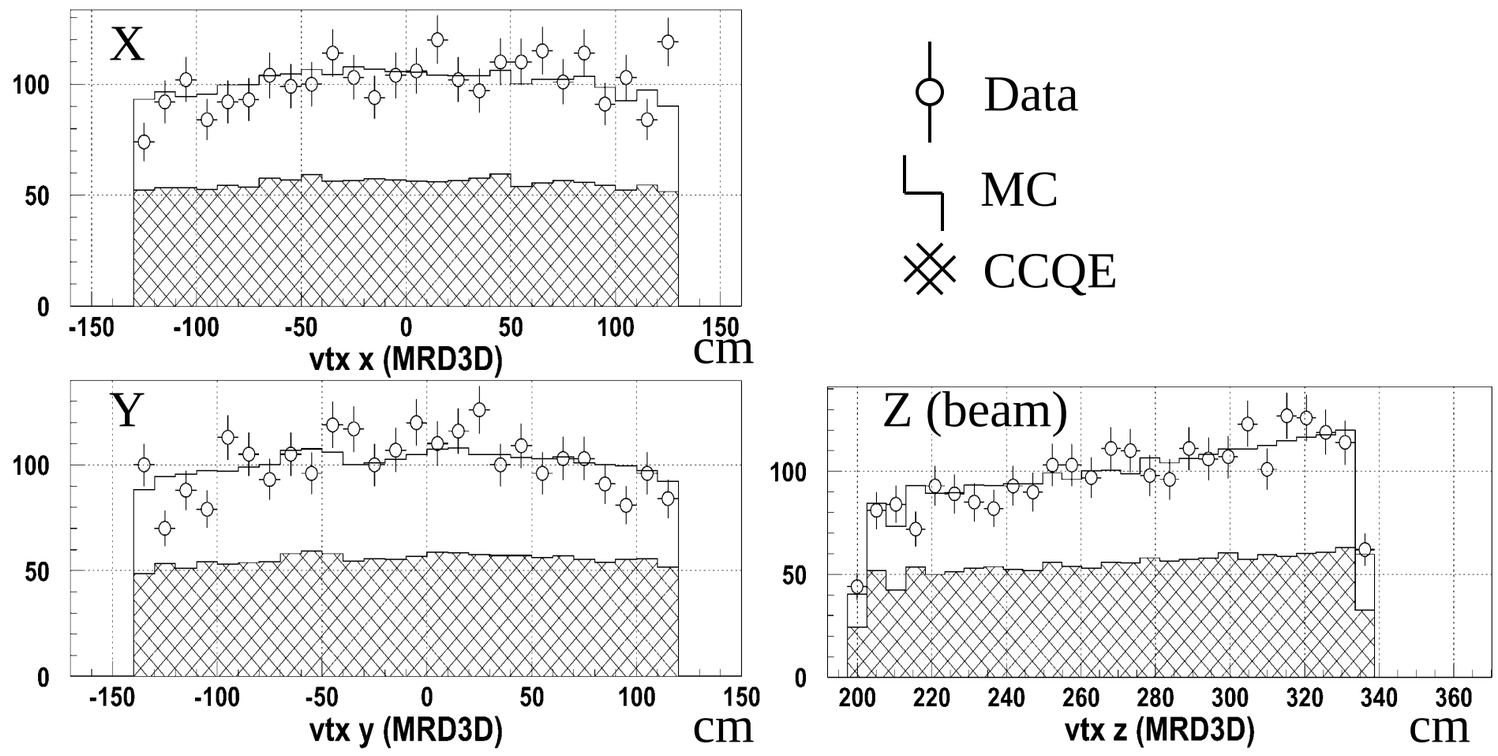
Timing distribution

Top View

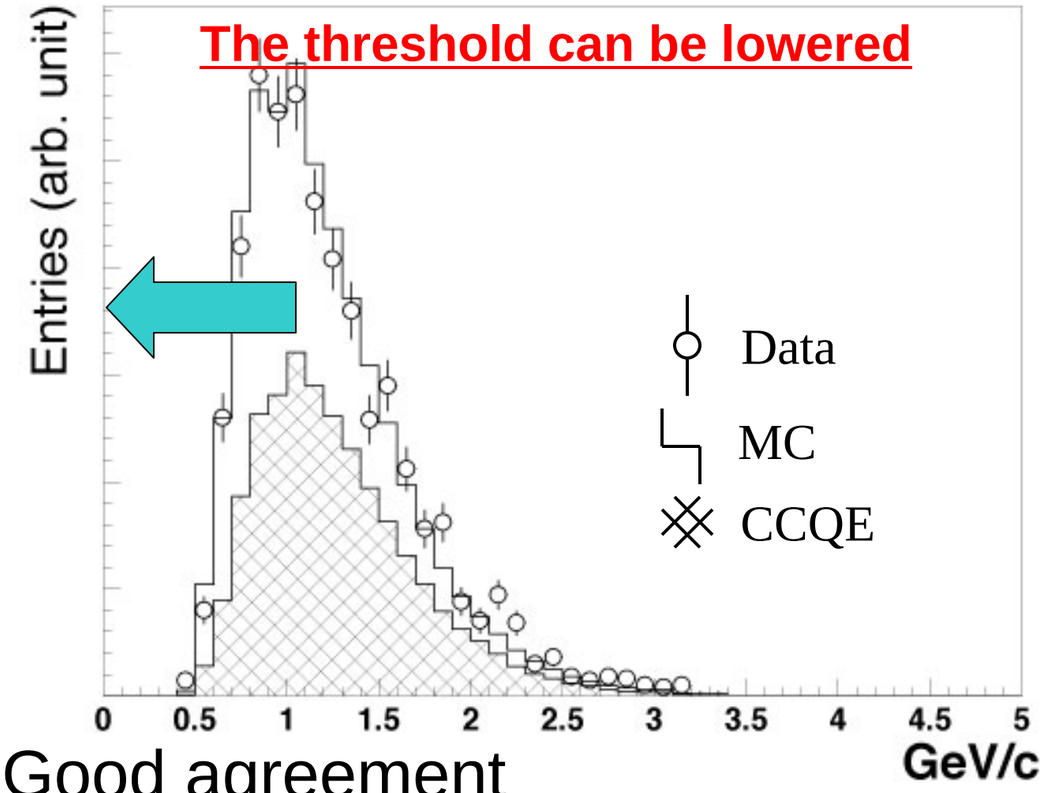


Vertex Distribution

- Data agree with MC well



Momentum Distribution



- Good agreement

→Track Length & Energy scale are OK!

Summary

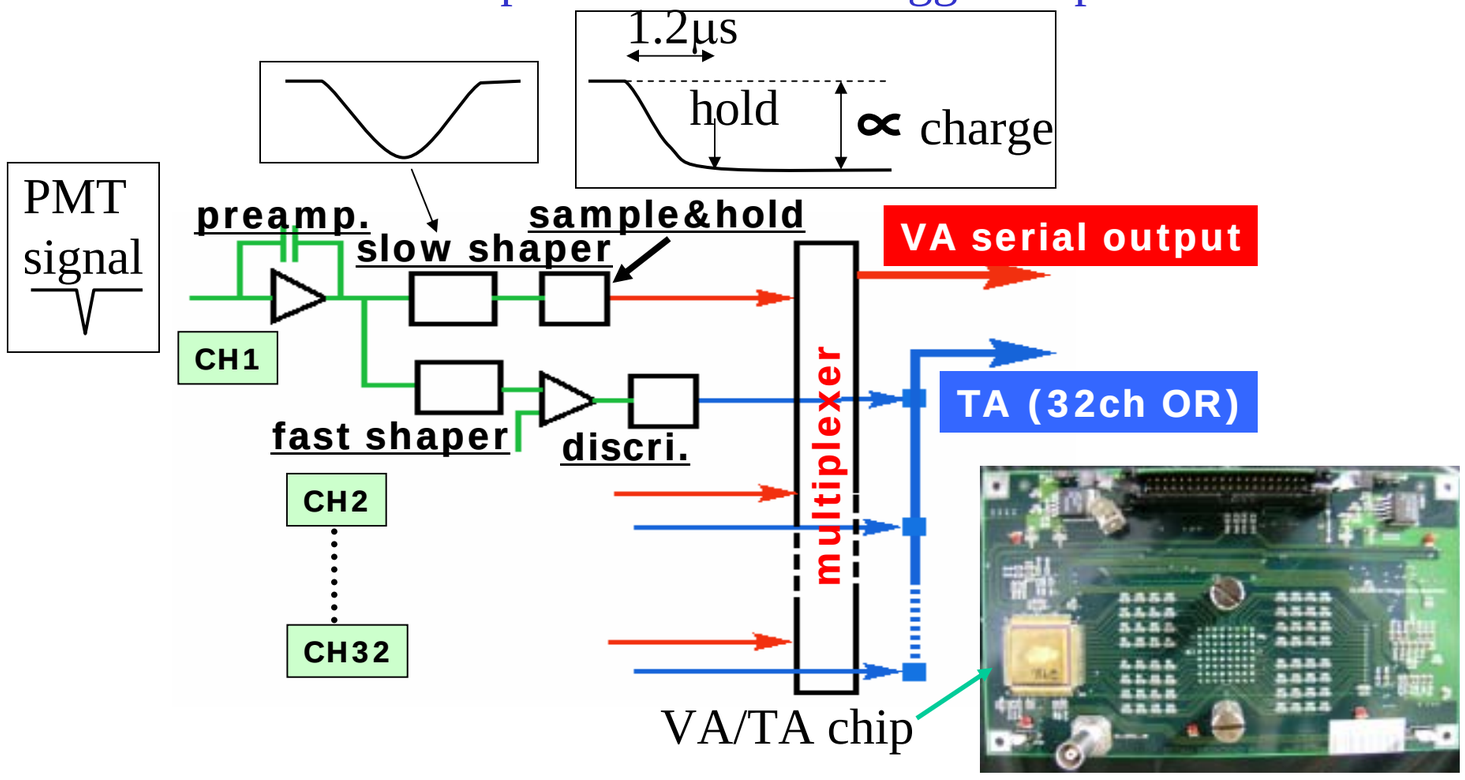
- We installed a brand new neutrino detector "SciBar" to the K2K near detectors.
  - measurement of the ν spectrum precisely
  - studying ν interactions (and more physics)
- SciBar is working very well from Oct. 7 ,2003. And observed many good neutrino events.
- Basic distributions reasonably agree with MC.

More to come !

Supplement

Readout Electronics

- VA/TA chip (Analog ASIC)
  - 32 inputs → shaping → sample & hold → serial analog output → comparator → OR → trigger output



List of shift takers in this summer

S.Aoki, J.Arygyriades, S.S.Choi, M.Hasegawa, Hiraide, K.Hayashi,
A.K.Ichikawa, Iinuma, Eric J., E.J.Jeon, K.K.Joo, D.Kerr, K.Kobayasi,
A.Kohara, J.Kubota, M.J.Lee, I.T.Lim, H.Maesaka, O.Mineev, T.Morita,
Y.Nakanishi, K.Nishikawa, K.Nitta, P.Rovegno, T.Nakaya, T.Sasaki,
A.Suzuki, K.K.Shiraishi, Y.Takubo, R.Terri, M.Tuchscher, S.Yamamoto,
M.Yokoyama, M.Yoshida, Z.Nawang (and more?)

CNU, KEK, Hiroshima, Kobe, Kyoto, Saclay, SNU, StonyBrook, INR, Washington, Osaka, UCI (and more?)

Data Taking modes

	beam		pedestal		LED		Cosmic ray
0.6s	35μs		100ns, 1take		1μs,1take		Suppression mode

Read out : ~100ms/event

Data

ADC for all channels

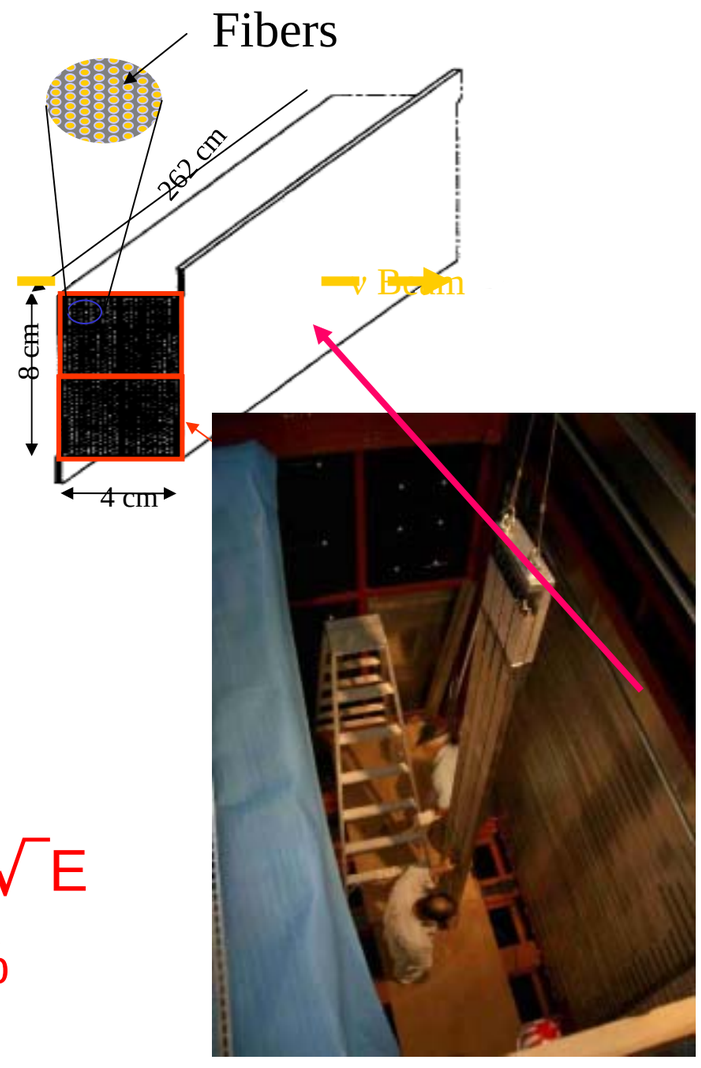
TDC for all TA's -> each 32channel -> 2 TDC for each PMT

Suppression mode : ADC only for TA hit channel

For EC, ADC for all channels, no TDC

Electron Catcher

- “spaghetti” calorimeter re-used from CHORUS
- 1mm diameter fibers in the grooves of lead foils
- 4x4cm^2 cell read out from both ends
- 2 planes ($11X_0$)
  Horizontal: 30 modules
  Vertical : 32 modules
- Expected resolution $14\%\sqrt{E}$
- Linearity: better than 10%



SciBar Detector

Kyoto Univ Masaya Hasegawa

Hakuba 10th Symposium Feb. 15 – 18 , 2004

Event rate & N_{SK}

- For comparing the event rate with other Detector
- 2627 events / 6.216x10^{18}POT / 9.38t

$$N_{SK} = N_{SB}^{obs} \times \frac{\varepsilon_{SK}}{\varepsilon_{SB}} \times \frac{POT_{SK}}{POT_{SB}} \times R_{SK/Near}$$

$$R_{SK/Near} = \frac{\Phi_{SK} \cdot Nt_{SK}}{\Phi_{SB} \cdot Nt_{SB}}$$

Efficiency

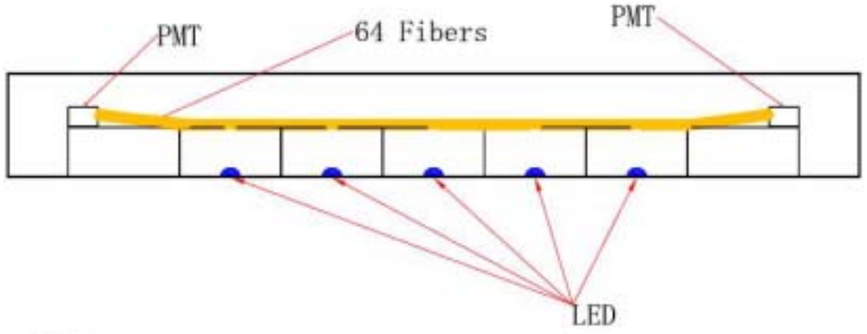
ν flux

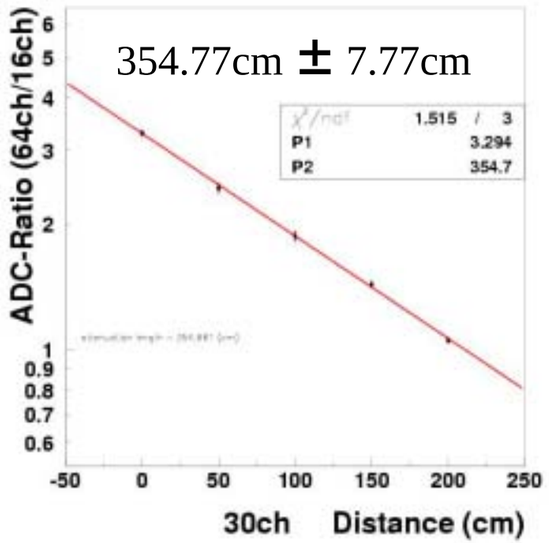
Target volume

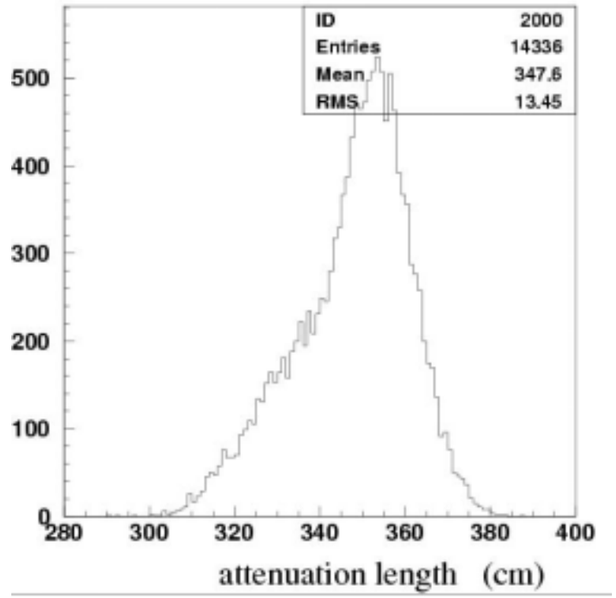
- No official number (not finishing sys. error estimation & near/far calculation yet)
- But Consistent with other detectors

Fiber Attenuation

Semi-Auto Attenuation Measurement System





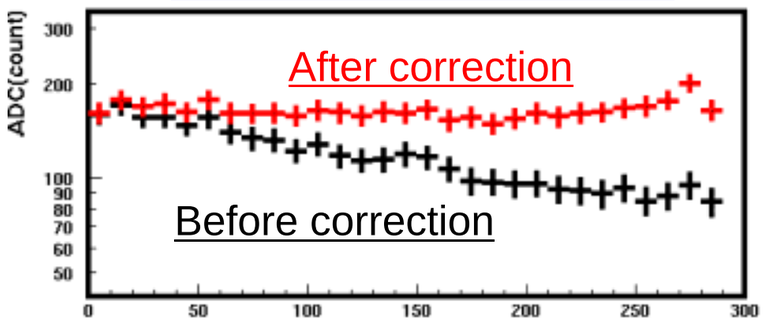


- We measured all(~15,000) Fiber's attenuation length before installation within 2% precision. → We can correct the attenuation effect ~1.4% precision.

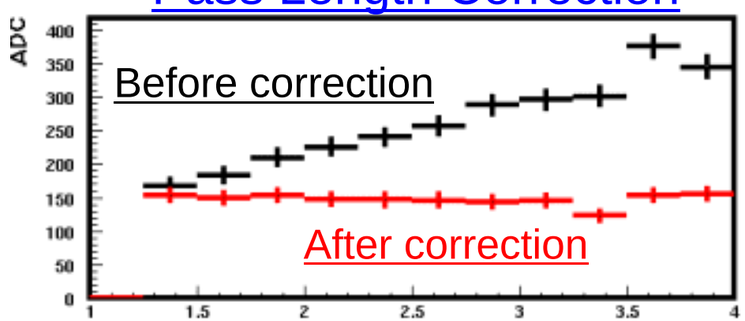
Energy Calibration

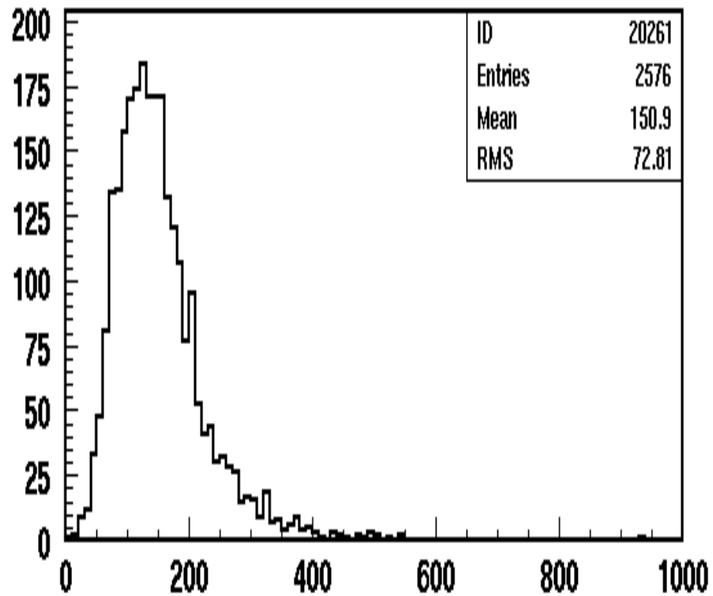
- Use Cosmic Ray Muon for strip to strip relative energy scale calibration
- All samples can be used by correction of Attenuation and Pass length in strip
  (100 Hits/strip/hour → Less than 1% precision can be possible for 5days)

Attenuation Correction

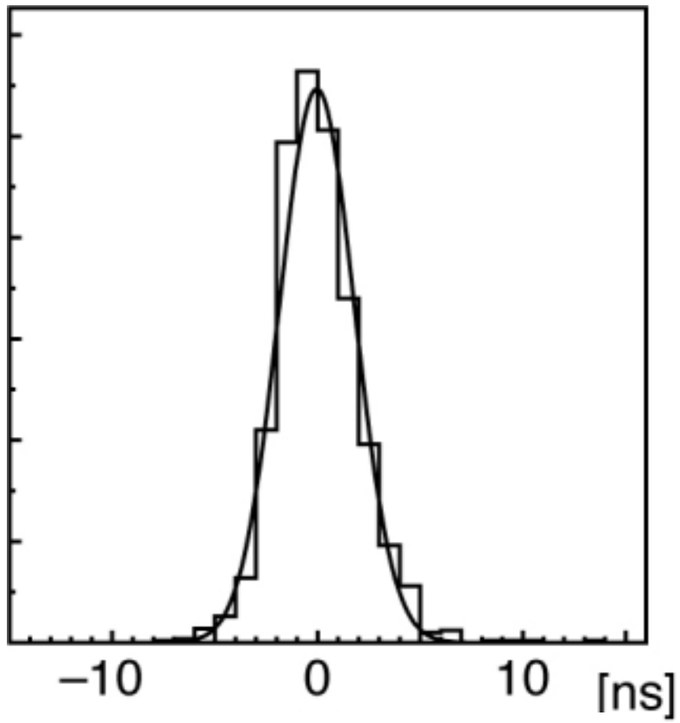


Pass Length Correction



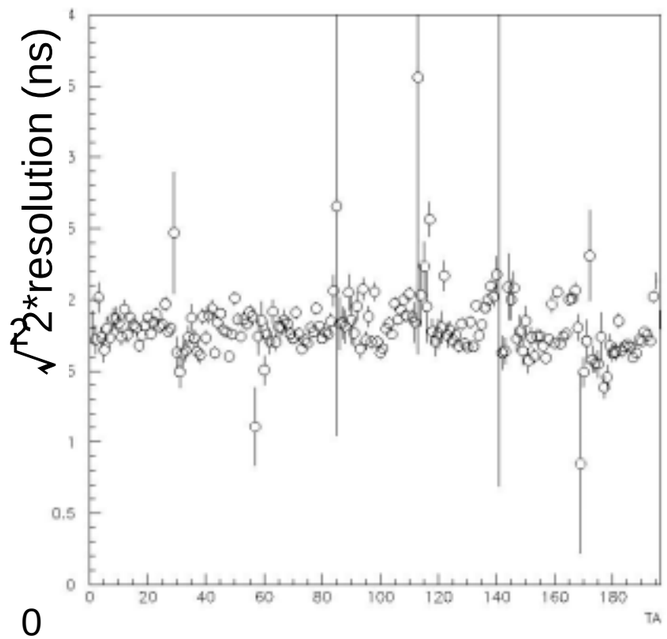


Timing Resolution



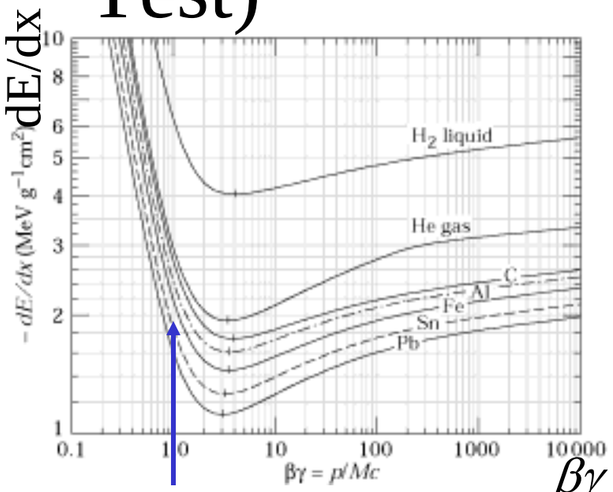
Difference of timing between
two TDC channels
In cosmic ray event

Timing resolution: 1.34ns



TDC channel

Particle ID (Results From Beam Test)



~ 0.1 GeV/c π/μ

~ 1.0 GeV/c proton

- dE/dx

  proton > π/μ

  (~1GeV/c)

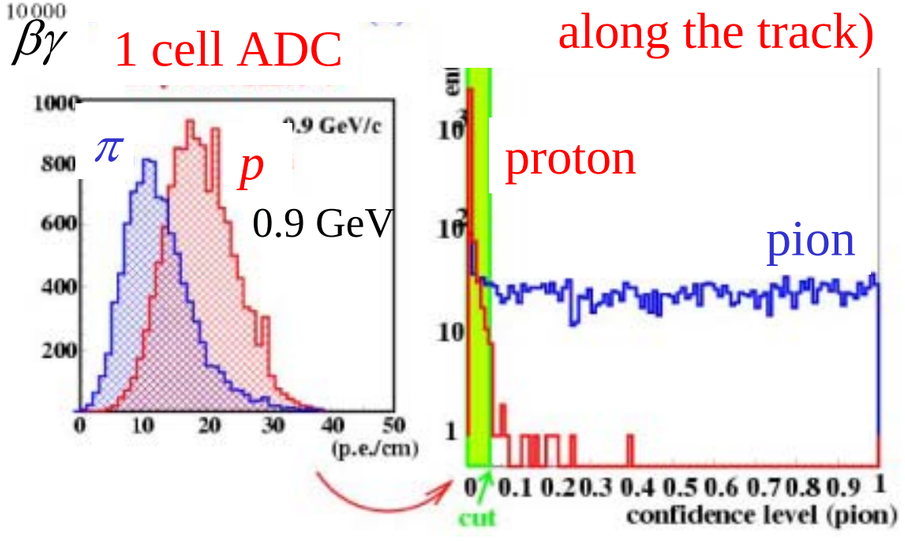
Miss ID probability :

< 20 % (1.2 GeV/c proton)

< 5 % (< 1.0 GeV/c proton)

With 95 % proton efficiency

Pion confidence level (using only 10 hits along the track)



Extruded Scintillator

- Polystylene with PPO 1% and POPOP 0.3%
  - Usual plastic scintillator component
  - Peak of emission spectrum : 420nm
- TiO_2 reflector (white) (0.25mm-thick)
  - Increase light yield
  - Optical isolation
  - Extruded together
- Cheep : ~$20 / kg
- Made by Fermilab