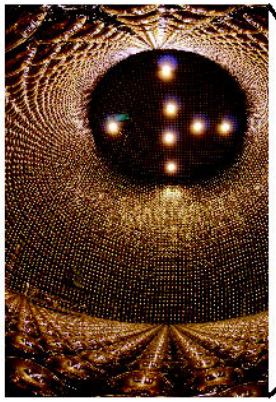
Status of T2K

A. Ferrero

2009 CHIPP Meeting

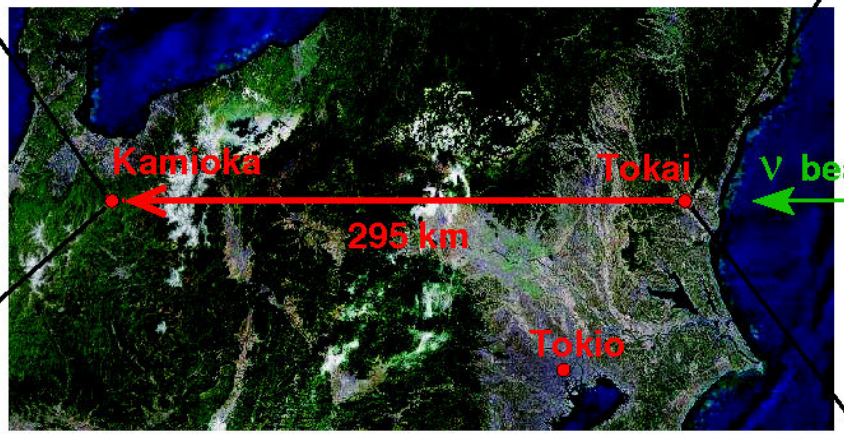
Appenberg, August 24 2009

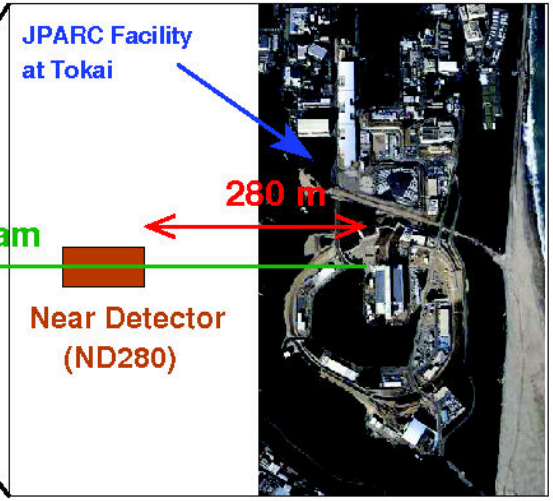
The T2K experiment and ND280 detector



SupeKamiokande

25 kTon Water Cherenkov Detector





Search for ν_e appearence

- better sensitivity on θ_{13} measurement $\rightarrow$ $\sin^2 2\theta_{13} \sim 0.008$ (90% CL)
- presently: $\sin^2 2\theta_{13} < 0.14$ (90% CL)

Measure ν_μ disappearence

- more accurate determination of the "atmospheric" parameters θ_{23} and Δm_{23}:

  $\delta(\sin^2 2\theta_{23}) \simeq 0.01$ $\quad$ $\delta(\Delta m^2_{23}) \simeq 3 \cdot 10^{-5} eV$

- SK, K2K, MINOS:

  $\delta(\sin^2 2\theta_{23}) \simeq 0.04$ $\quad$ $\delta(\Delta m^2_{23}) \simeq 2 - 3 \cdot 10^{-4} eV$

Running time: 5 years @ 750 kW proton beam intensity

Beam (Geneva/ETH/LHEP)

- NA61@CERN: Pion and Kaon production x-sections to characterize the T2K ν beam
- Beam Analysis (MC, flux predictions)

ND280 (Geneva/ETH/LHEP)

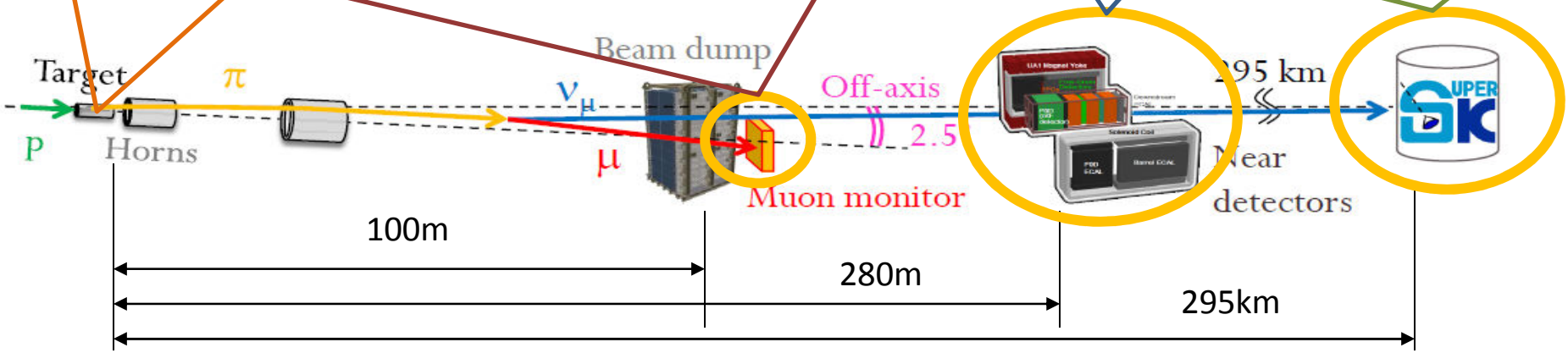
- UA1 magnet installation & Commissioning
- MicroMegas test & calibration
- CC Analysis & MC studies

Emulsion tracker (LHEP)

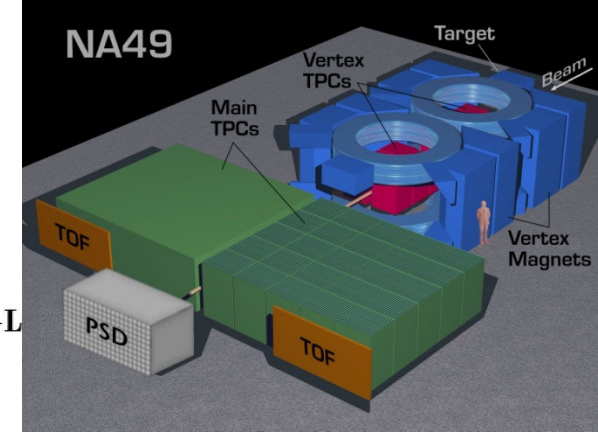
- Absolute number of muons (< 5% accuracy, < 2% electron contamination)
- Angular distributions (few mrad for each muon)
- Cross-check of the beam MC

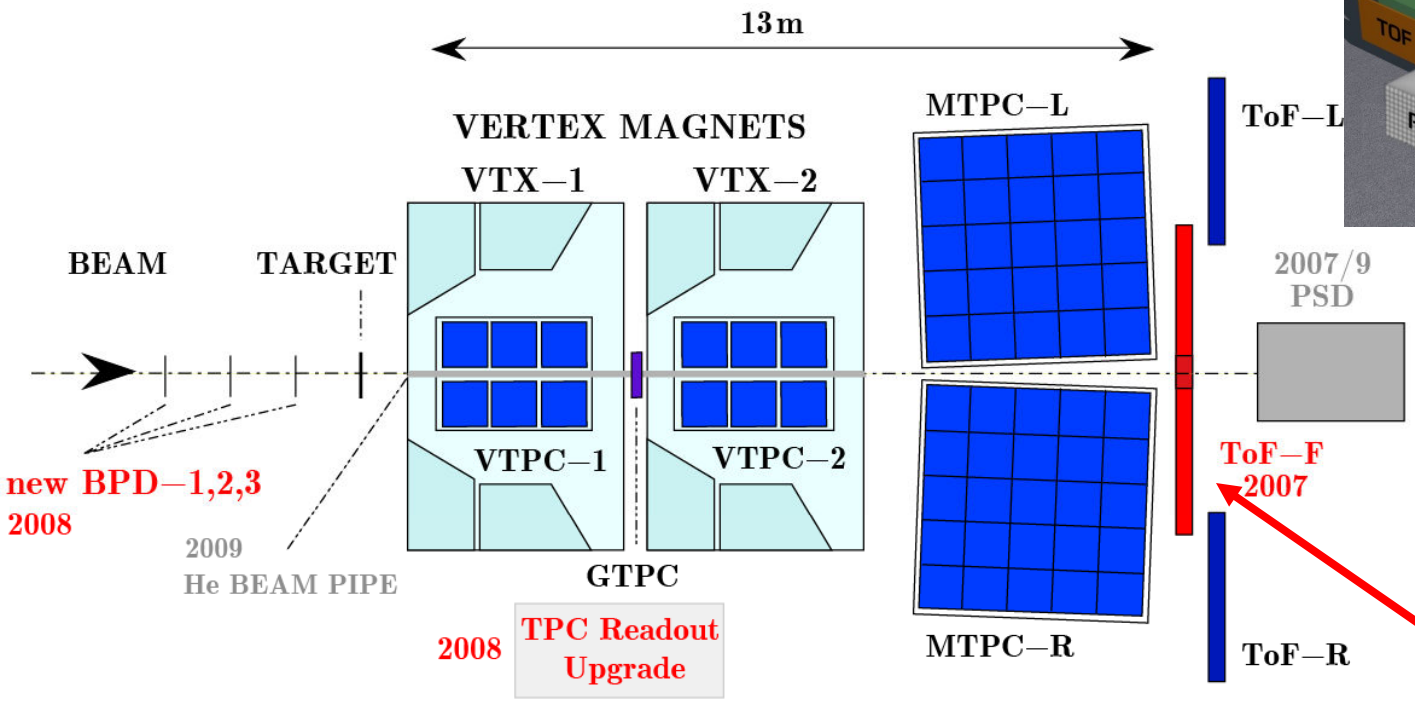
SuperK (Geneva)

Neural network based electron – pi0 separation



The NA61 detector



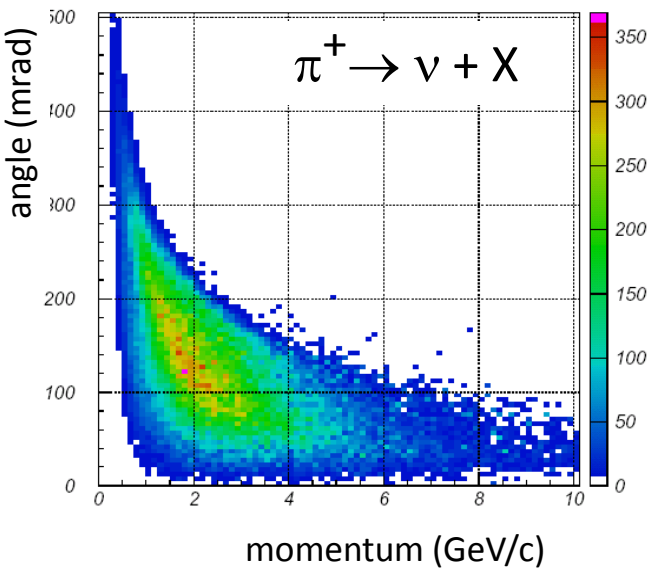


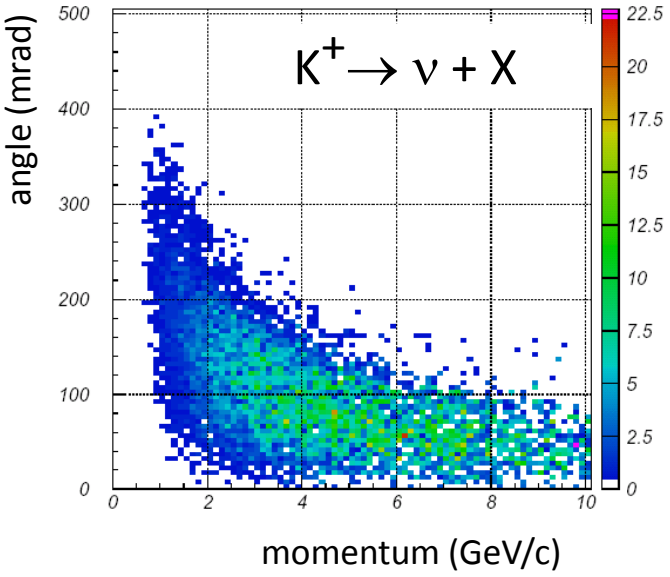
NB Forward-ToF wall used to identify low mom. particles produced at large angles and bent back into the detector acceptance by the vertex magnets

- **large acceptance spectrometer for charged particles**
- **4 large volume TPCs as main tracking devices**
- **2 dipole magnets with bending power of max 9 Tm over 7 m length** (2007-Run: $\int$Bdl ~ 1.14 Tm)
- **high momentum resolution**
- **good particle identification:** σ(ToF-L/R) $\approx$ 100 ps, σ(dE/dx)/<dE/dx> $\approx$ 0.04, $\sigma(m_{inv}) \approx 5$ MeV
- **new ToF-F to entirely cover T2K acceptance** (σ(ToF-F) $\approx$ 120 ps, 1<p <4 GeV/c, θ < 250 mrad)

T2K ν parent hadron phase space

(30 GeV proton beam on the 90 cm long T2K graphite target)

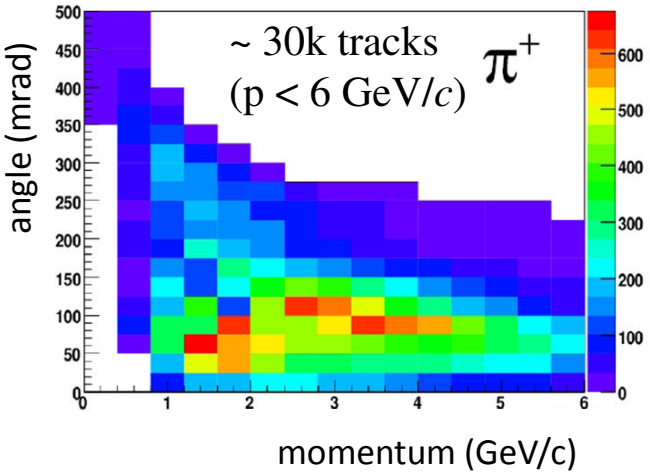


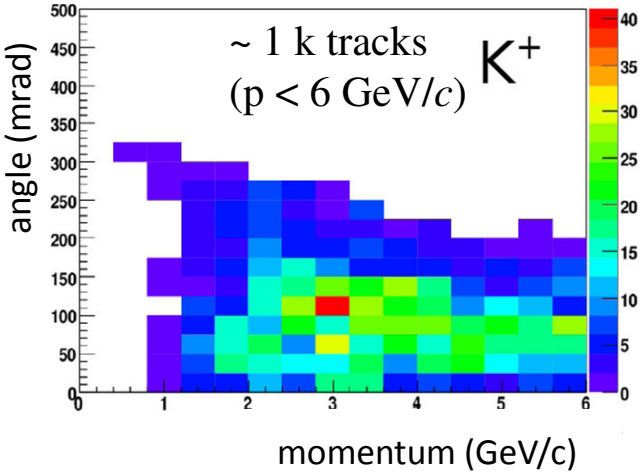


simulated distributions of π and K (*parent* hadron phase space) contributing to the ν flux at SK (these are *acceptance weighted* distributions and not × – sections)

NA61 identified raw particle spectra (not corrected for acceptance, efficiencies, etc.) 2007 data

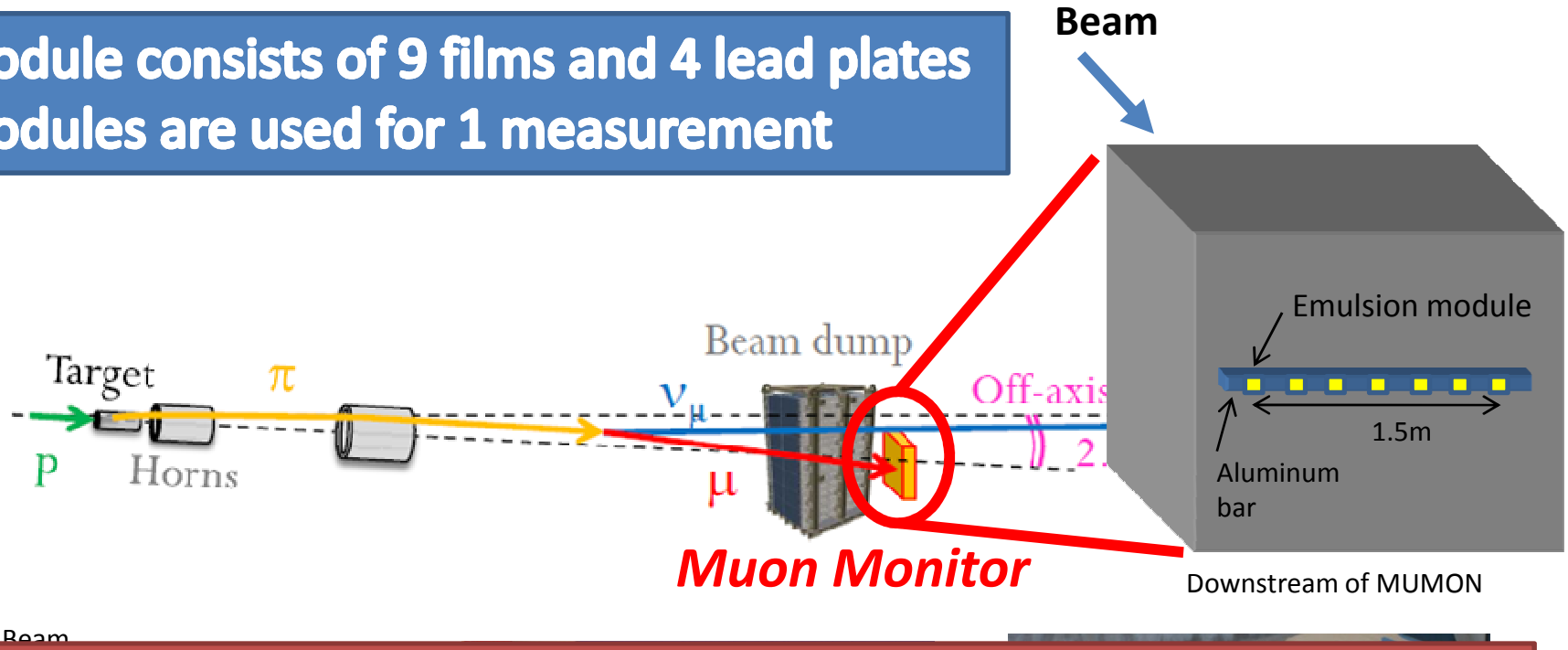
The NA61 detector has the required acceptance and PID capability to fully cover the T2K ν parent beam phase space





Emulsion Detector Setup

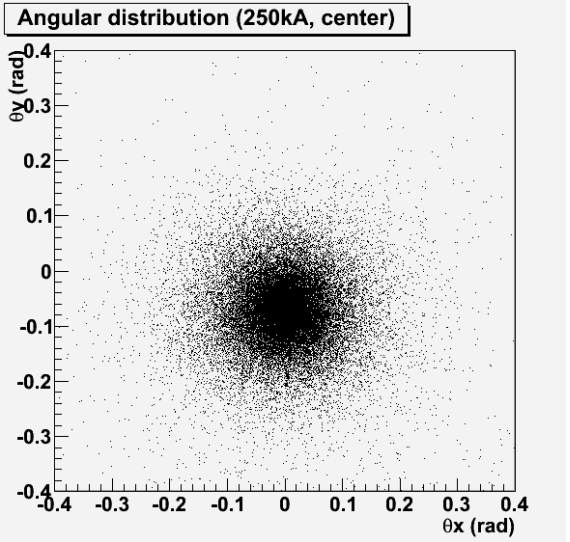
1 module consists of 9 films and 4 lead plates
7 modules are used for 1 measurement

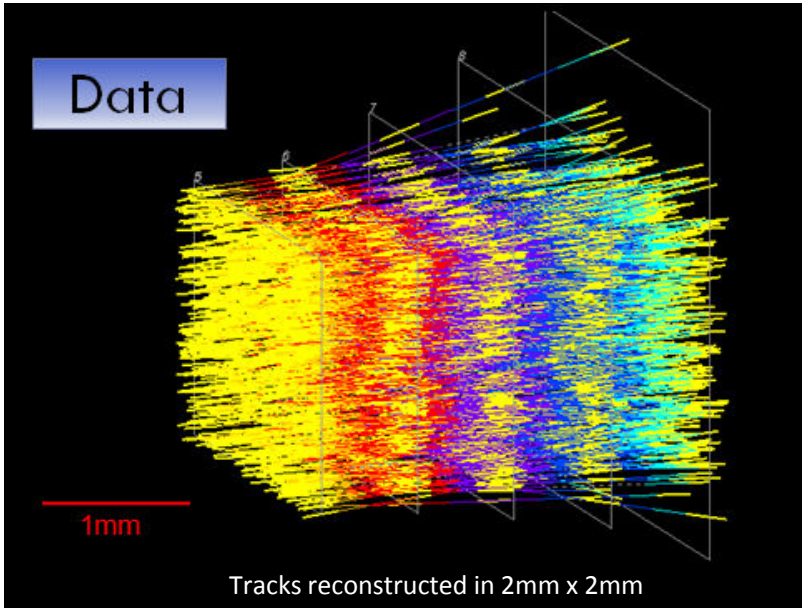


- **Goal: reconstruct muon tracks at very high intensities**
- **Count absolute number of muons**
  (< 5% accuracy, < 2% electron contamination)
- **Angular distributions (few mrad for each muon)**
- **Cross-check of the beam MC**

Emulsion Detector Test Data

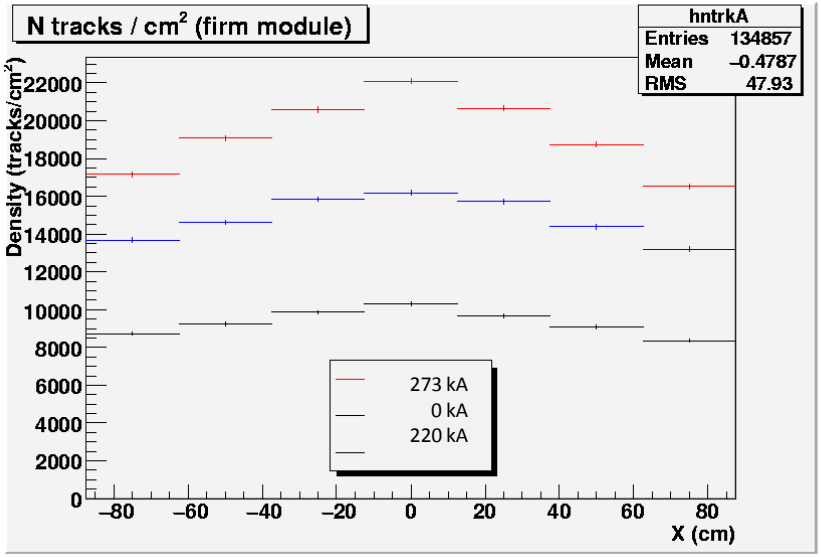
- 1st Exposure on May 27th 2009.
  - Only 1 horn.
  - 3 shots with different horn current (21 modules = 189 films).
- Data taking already finished in June. Net 2weeks of scanning.
- Good correlation with Muon monitor (Si PIN photodiode).
- Cross-check of MC is on going.
- Next exposure is planned in Oct 2009 with full set of horns.





Tracks reconstructed in 2mm x 2mm

Beam profile, depending on Horn current.
(cutoff momentum 50MeV/c)



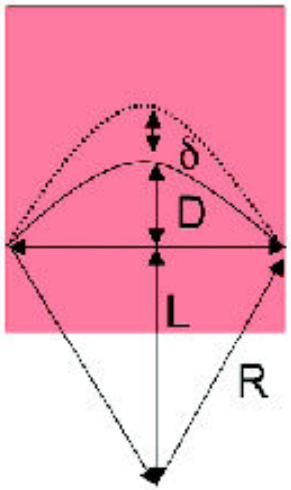
UA1 Magnet Installation (ETH/LHEP)

- Magnet, power supply and water cooling installation completed
- Operation at 1000A (0.07T) successfully achieved on August 15th
- Operation at 3000A still not possible due to KEK facility power limitations – in progress
- Control and safety systems being finalized
- Instrumentation for magnetic field map measurement ready at Jparc (see next slides) – start on August 25th until September 10th

Magnetic Field Measurement

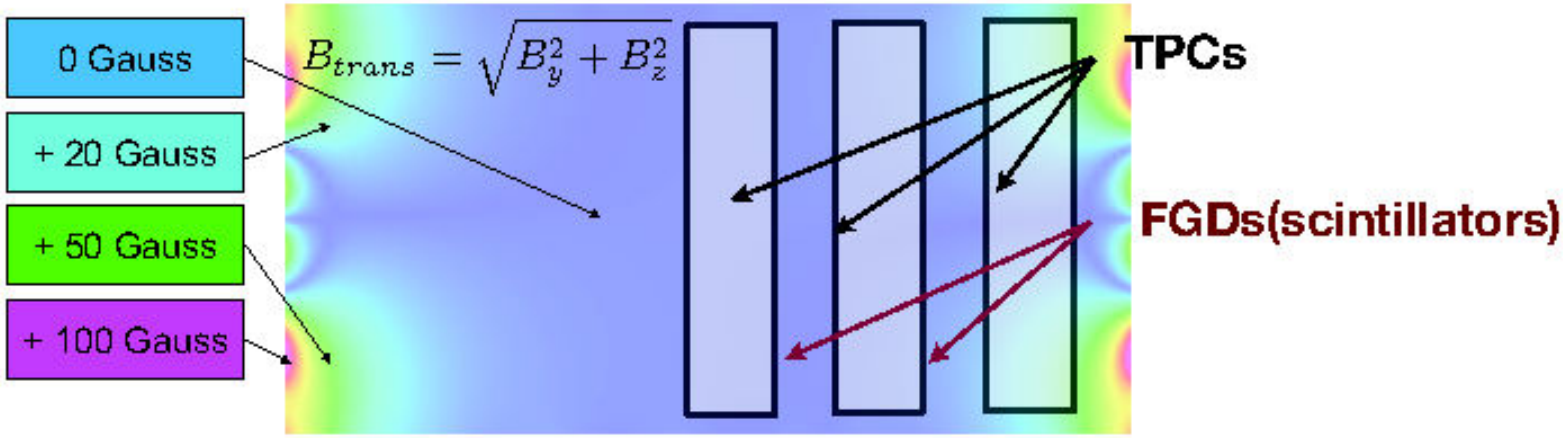
How well we need to measure the field map?
Given a track distortion δ due to a $B_\perp$ the measured momentum is:

$$p = 0.3B\frac{L^2}{8(D+\delta)}$$



For δp~2%, δ~0.08 mm
⇒ δB_{trans}~1-2 %

This implies a required accuracy on the B mapping from 0.6 and 1.6 Gauss



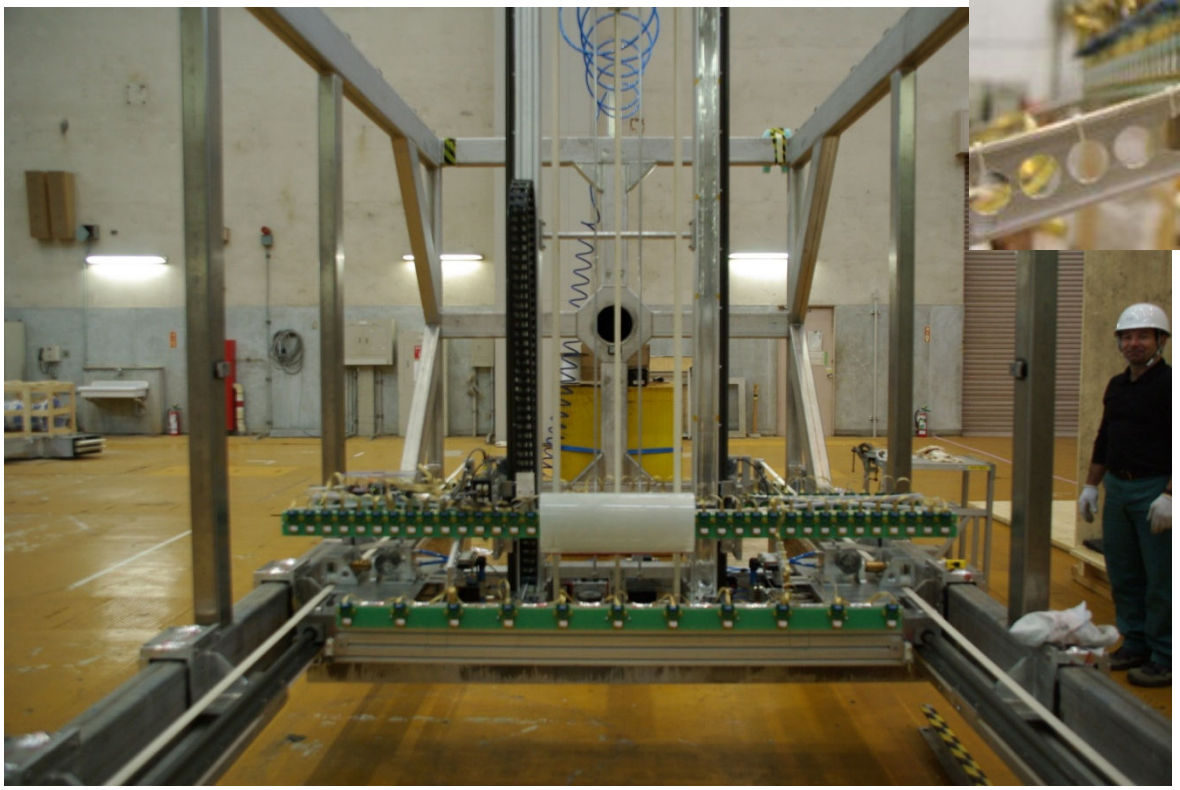
an example: transverse B-Field of ND280 (top view)

Field measurement: current status

B Field instrumentation ready

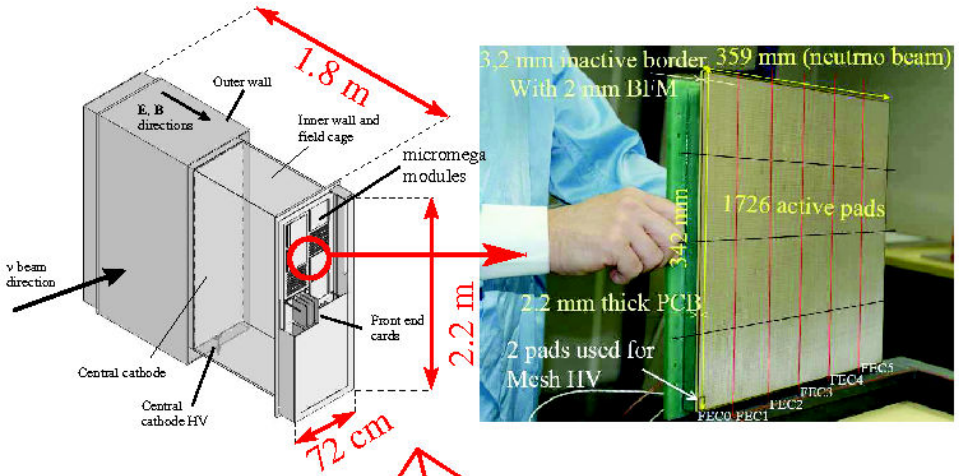
B sensor cards with
3D Hall probes

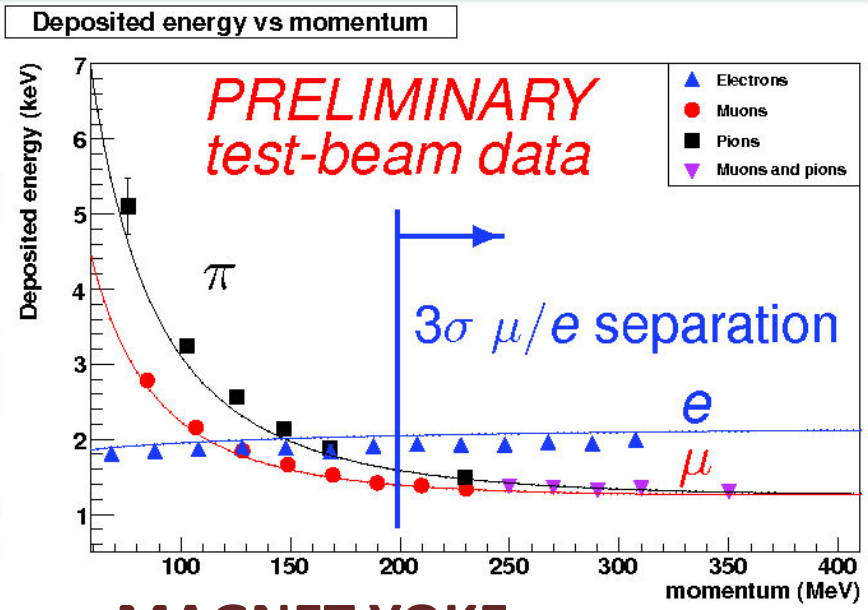
B field mapping device @ JParc

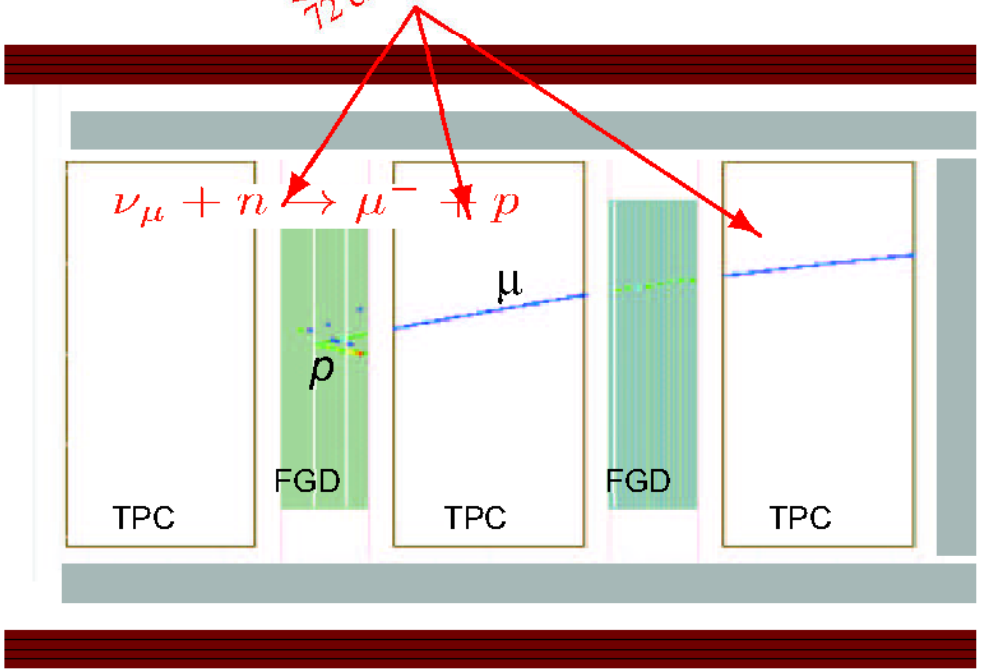


Measurement of Charged Current interactions in ND280

Time Projection Chambers





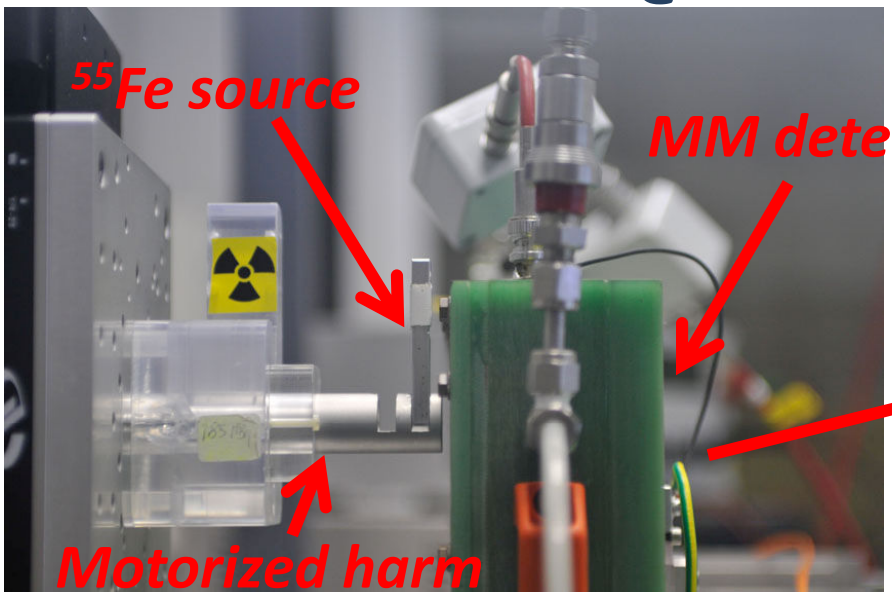


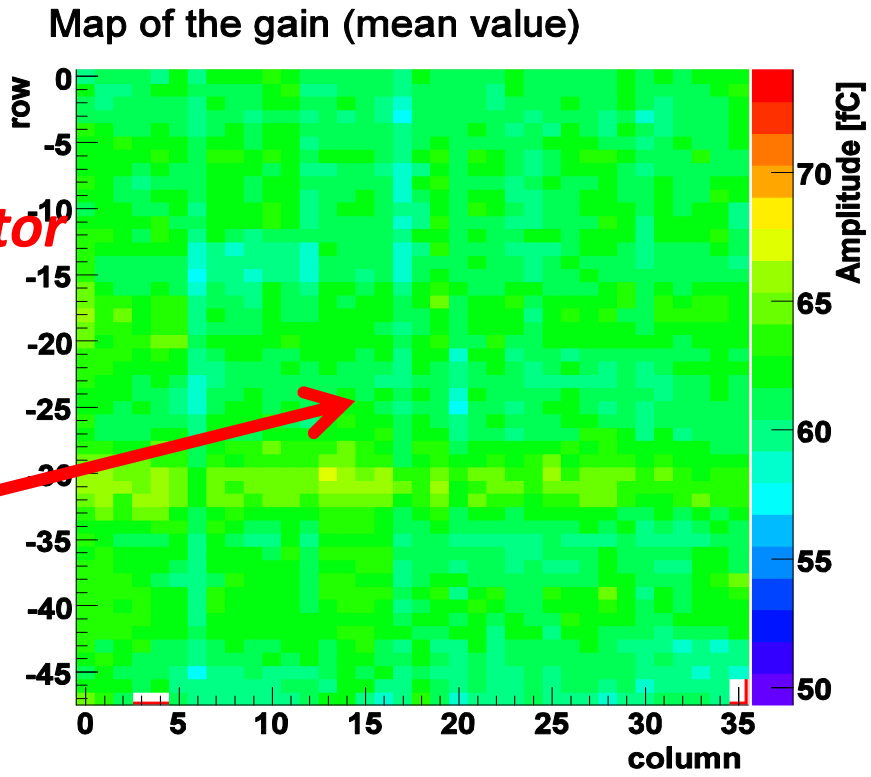
TPC design parameters:

- $\sigma_p/p \sim 10\%$ @ 1 GeV/c
- Momentum bias $< 2\%$
- 3σ μ/e separation in 0.3-1 GeV/c range
- Readout based on BULK-MicroMegas
  - → Spatial resolution ~ 600 μm
  - → dE/dx resol. $< 10\%$ up to 1 GeV/c

MicroMegas calibration (Geneva)

Calibration testbench @ CERN





- BULK-Micromegas modules produced @ CERN
- >90% of the required 82 MM modules have been tested and validated
- Production very reliable: <10% rejected modules, ~10 bad channels remaining
- Individual pad responses (gain/resolution) stored in database for later use
- Two TPCs already equipped with tested MM modules

TPC installation status

- **TPC module 0**
  - All HV filters were upgraded to the nominal configuration (500kΩ-22nF-1Ω)
  - HV test were successfully done
  - All electronics modules were installed, tested and calibrated at JPARC during past week.

First TPC is ready to put into basket !

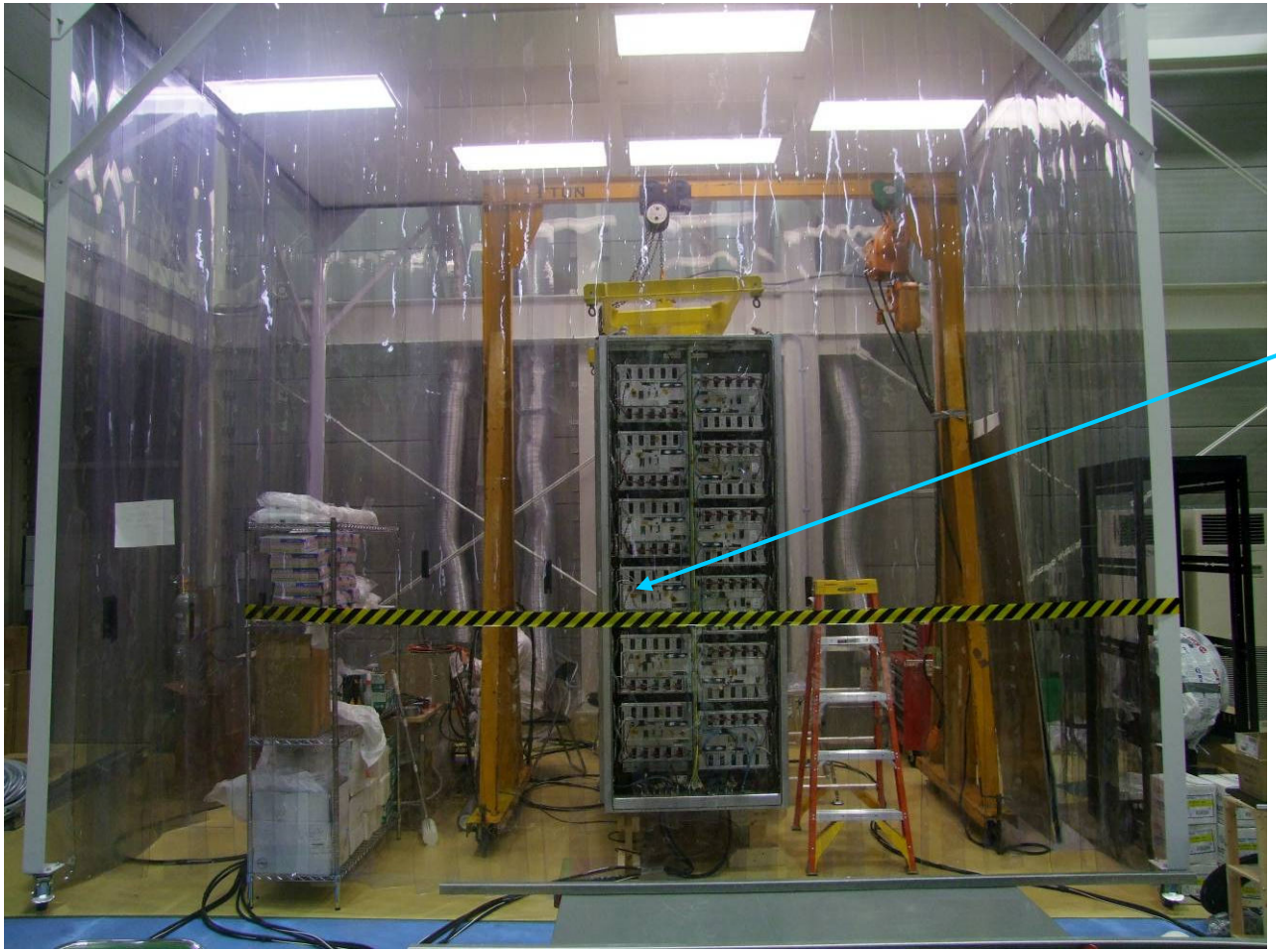
- **TPC module 1**
  - Beam and cosmic test have been performed at TRIUMF during June / July with all electronics.
  - During this test, one short-circuit between MM#10 endplate 1 and last strip of field cage has been found. Investigation will be done at TRIUMF by Eddy on the week of 17th August.

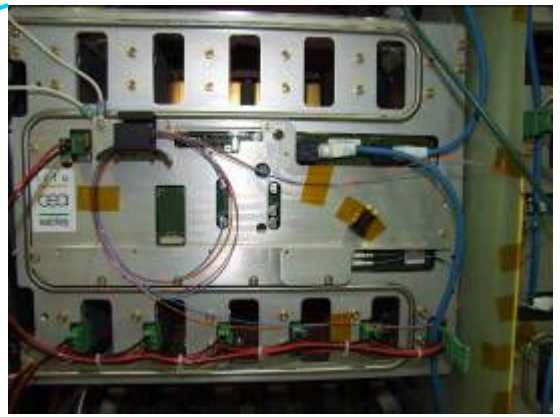
Second TPC will be shipped to JPARC on 28th August

- **TPC module 2**
  - Manufacturing ongoing, installation expected in January 2010

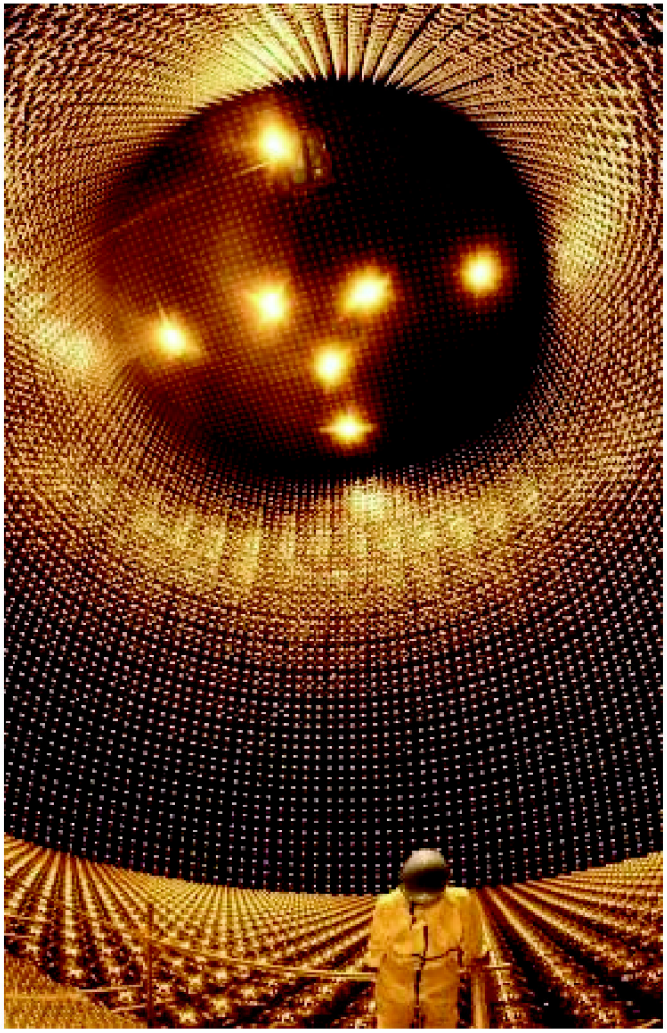
TPC0 at JPARC

- TPC in clean tent of Neutrino assembly building





Superk-Kamiokande analysis

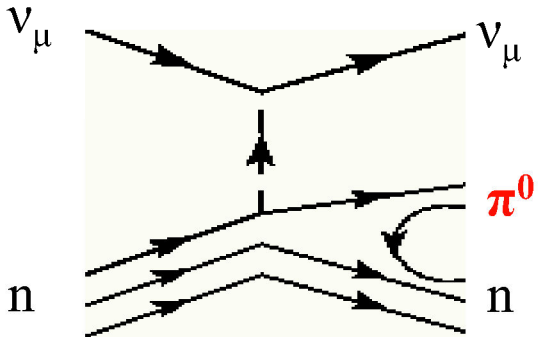


Goals:

- ✦ select muon events for the ν_μ disappearance analysis (measure of Δm^2_{23} and $\sin^2(2\theta_{23})$)
- ✦ select electron events for the ν_e appearance analysis (measure of $\sin^2(2\theta_{13})$)

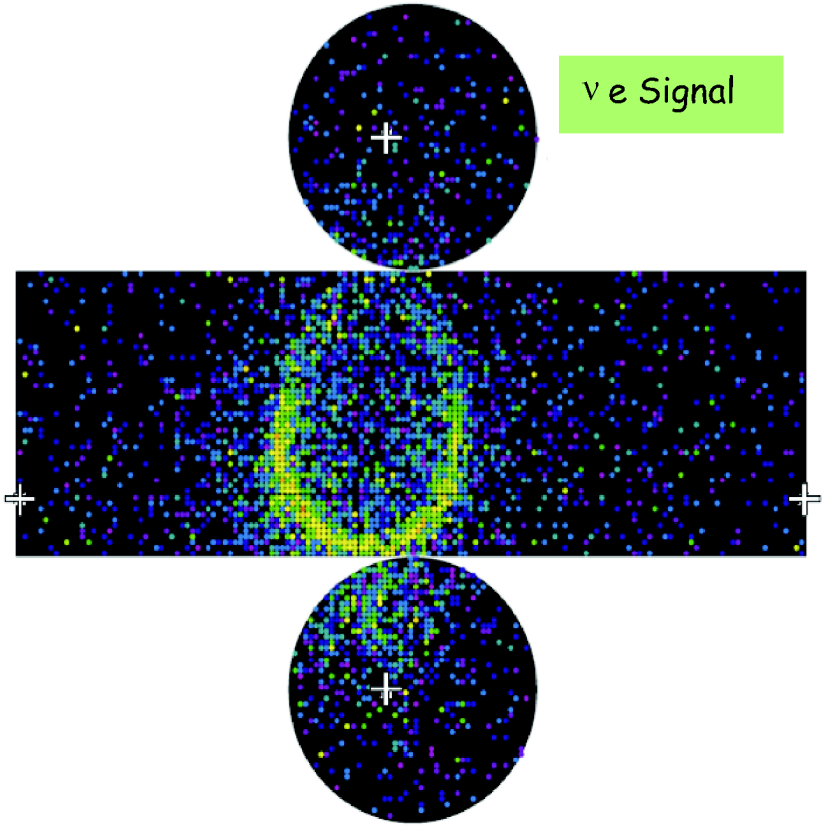
Major background sources for the $\sin^2(2\theta_{13})$ measurement:

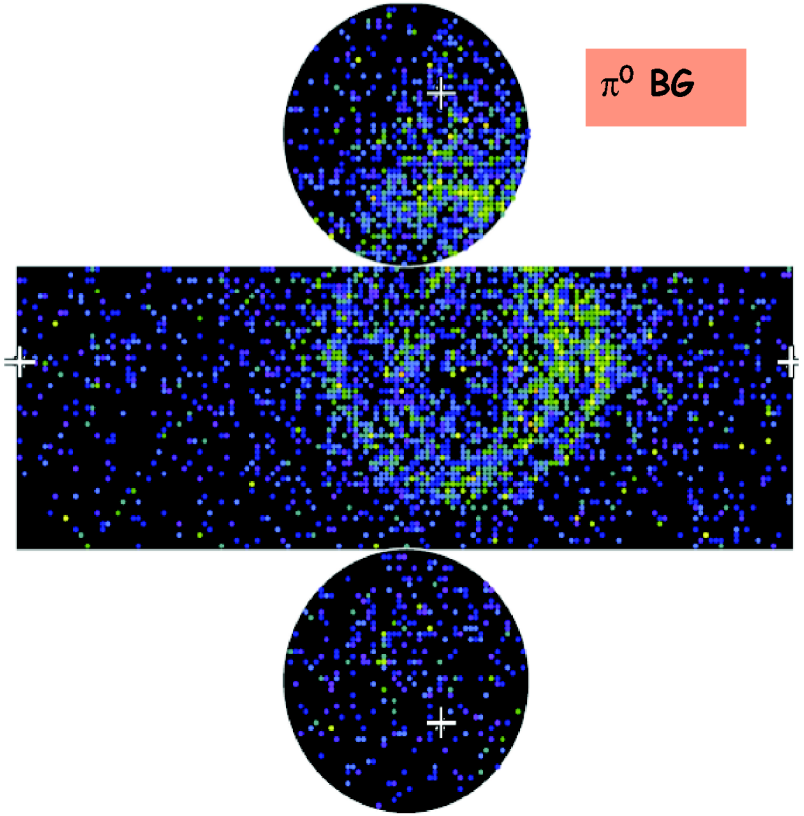
- ✣ μ/e mis-ID (very low ~ 0.7 %)
- ✣ beam ν_e : 0.2-0.3%, known from near detector, nothing can be done in SK
- ✣ **Neutral current creating π^0**



Rejecting π^0 background (Geneva involvement)

- Currently we use a likelihood method to separate electron from π^0.
- Current precuts remove about 90% of π^0 events
- Current likelihood removes 25% of remaining π^0 events
- Upgrade includes moving to a Neural Network, and using the root package TMVA. By using a neural net, we hope to improve background rejection by another few percents.





Conclusions & Outlook

- T2K is well on track
  - Large set of pi/K production data from NA61 by this year
  - Installation of near detectors to be completed by the end of 2009
  - First protons on T2K target successfully sent on April 24th!
- Strong swiss participation in T2K:

  NA61, magnet, TPCs, ND280 CC analysis, SK pid
- 2010 will be an exciting year, hopefully with first oscillation results in summer!

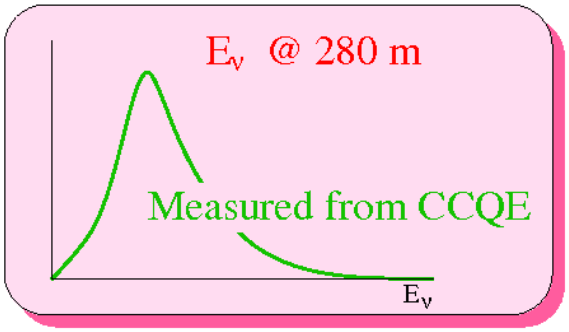
STAY TUNED!!!

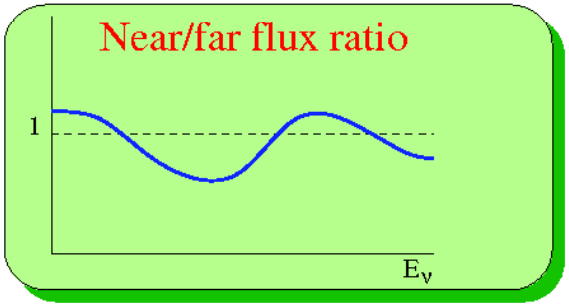
BACKUP SLIDES

Principle of the ν_μ Disappearance Measurement

ν energy spectrum is obtained from C.C. Quasi-Elastic (CCQE) interactions

CCQE @ SuperK are selected as 1 ring μ-like events

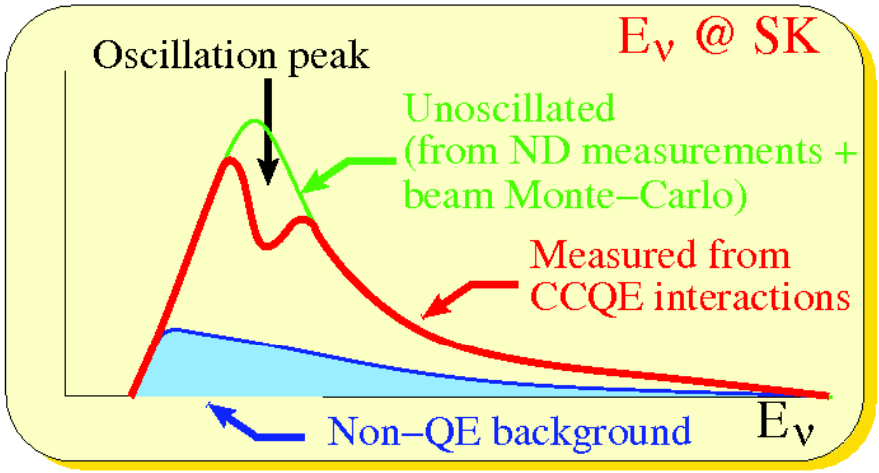


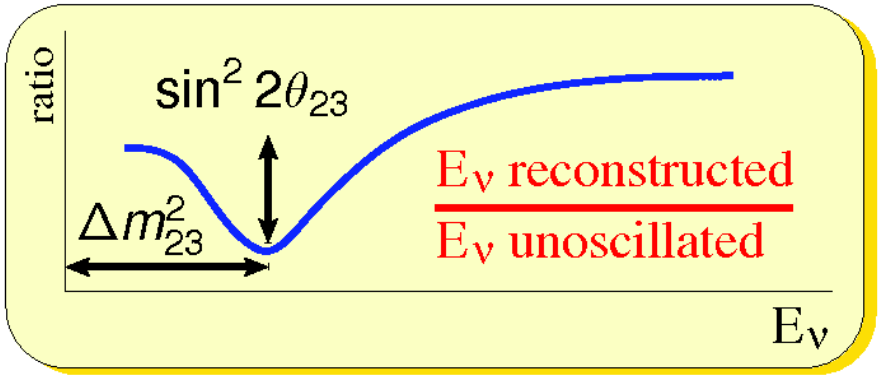


π/K production cross−sections

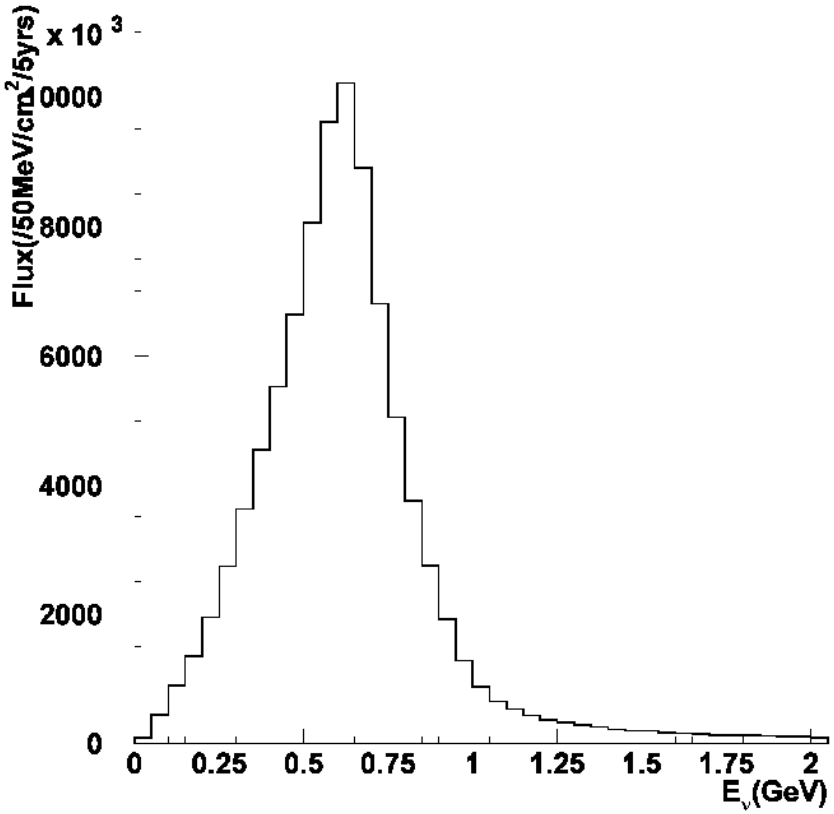
Beam flux and direction

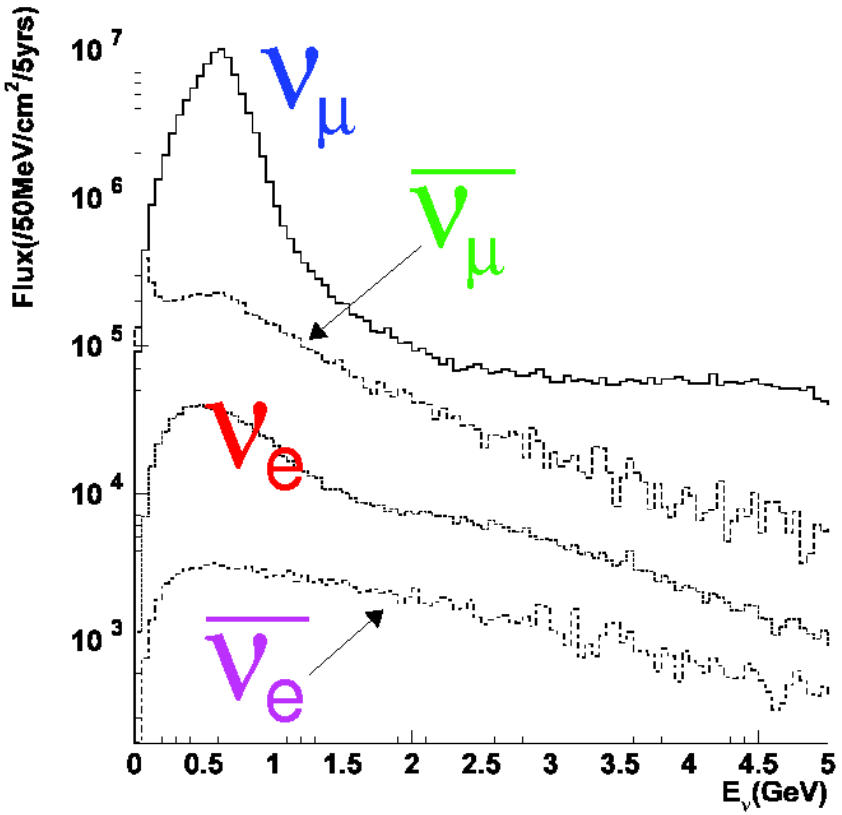
Non−QE/QE interaction rates





Expected Neutrino Flux SK





The ν_e component in the beam is a relevant background source for the electron neutrino appearence studies @ SK

The precise prediction/measurement of the ν_e flux @ SK is essential