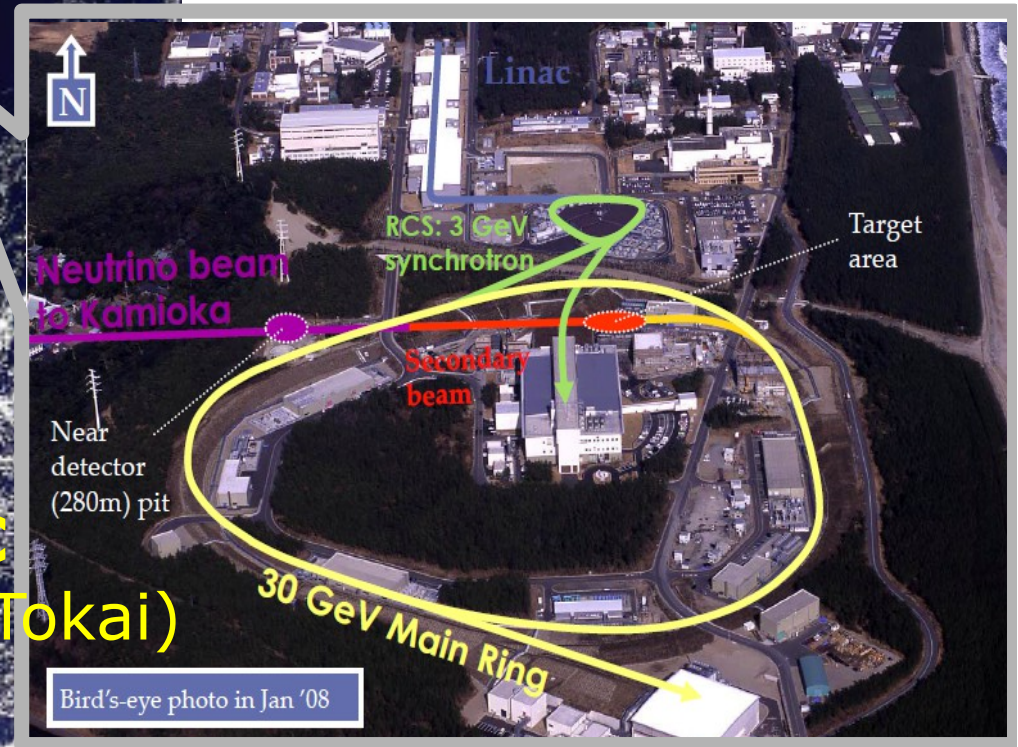


- Collaborazione internazionale
- 450 fisici, 58 istituzioni, 12 paesi
 - 4 sezioni INFN (Pd, Ba, Rm1, Na)
 - Pd: M.Mezzetto, M.Laveder, G.Collazuol



41.4m

40m

long baseline neutrino oscillation experiment

295km

Super-KAMIOKANDE
(ICRR Univ. Tokyo)

J-PARC
(KEK-JAEA - Tokai)



Linac

RCS: 3 GeV synchrotron

Target area

Neutrino beam to Kamioka

Secondary beam

Near detector (280m) pit

30 GeV Main Ring

Bird's-eye photo in Jan '08



Esperimento T2K

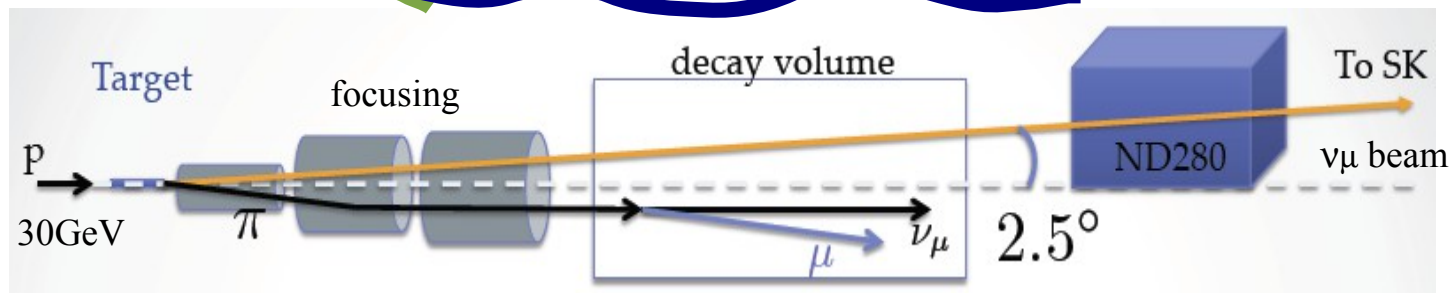
Motivazioni

- Ricerca di θ_{13} in appearance mode
2012 → scoperta $\nu_{\mu} \rightarrow \nu_e$ in
- Misura di precisione θ_{23} e Δm_{23}^2 → in progress
- Misura sezioni d'urto @ 1GeV → in progress
- Indicazione δ_{CP} e gerarchia masse → futuro

Stato attuale

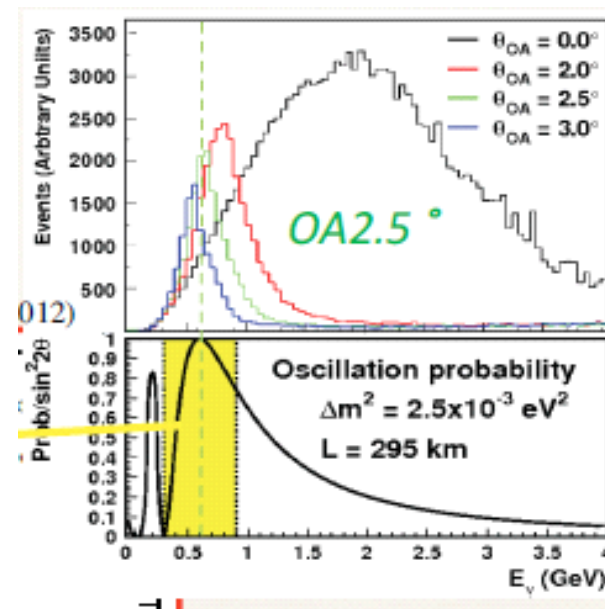
- Statistica finale attesa 7.8×10^{21} pot
→ DATA TAKING APPROVATO @JPARC FINO A 2018
- Fino ad oggi 6.7×10^{20} pot (<10%)
→ graduale upgrade intensita` del fascio → fino 2017
- Risultati scomparsa ν_{μ} e apparizione ν_e con 3×10^{20} pot (estate 2012)
→ nuovi risultati (6×10^{20} pot) a conferenze estive 2013

Fascio off-axis

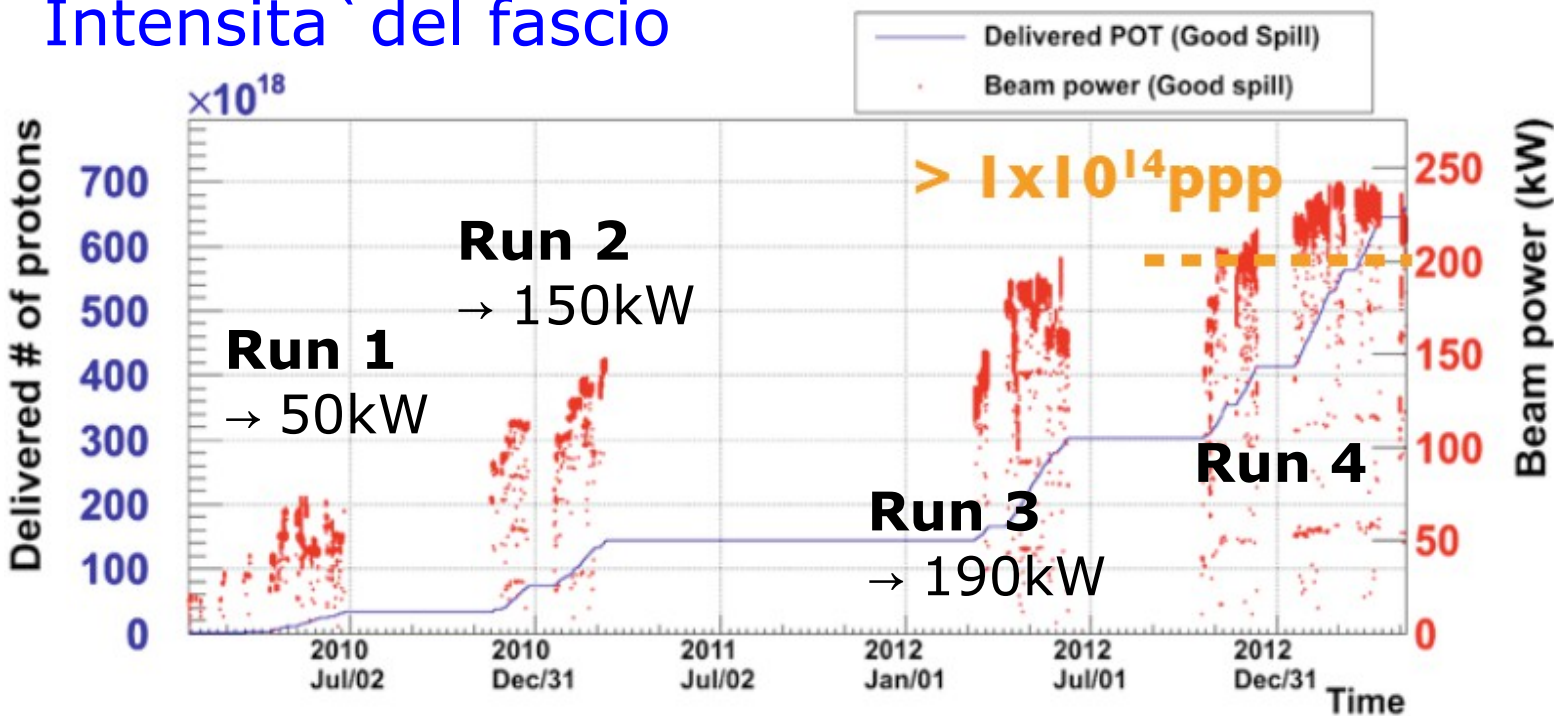


Arricchimento di **neutrini mono-energetici**
(al costo di **riduzione intensita`**)

→ **narrow band beam** aggiustato su **primo massimo oscillazione**



Intensita` del fascio



Run 4
200kW → 240kW
operazione stabile
→ fine luglio 2013..

..fine maggio 2013
stop per incidente
@ Hadron hall

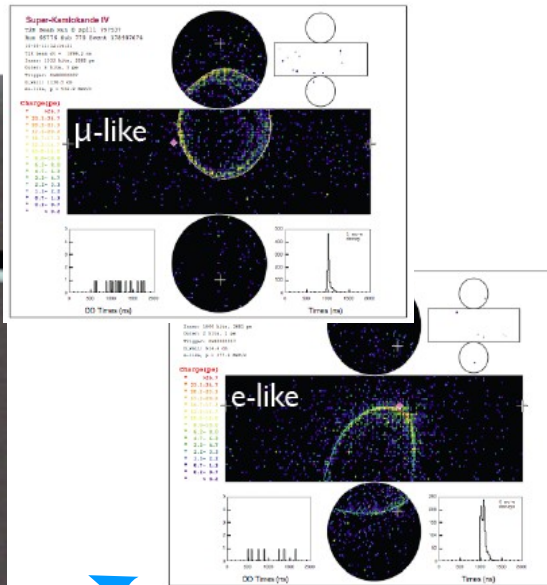
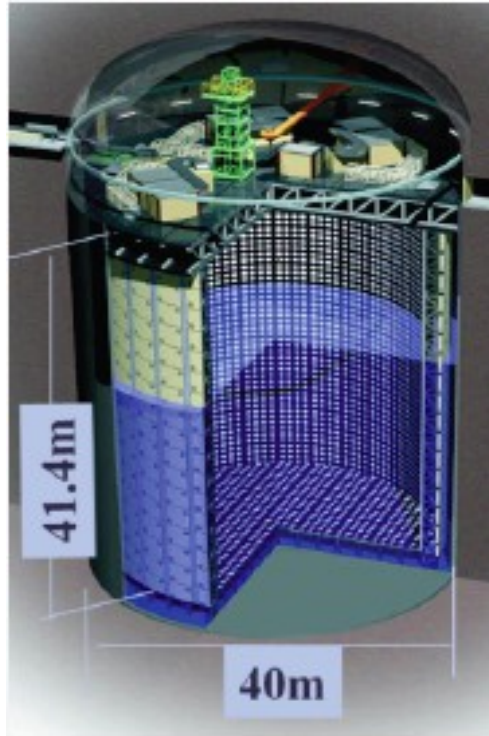
Upgrade fascio

JFY	2011	2012	2013	2014	2015	2016	2017
			Linac Upgrade (180 → 400MeV)				
FX power [kW]	150	200	~ 300	400			750
SX power : User op. (study) [kW]	3 (10)	10 (50)	< 50	50 (100)			100
Cycle time of main magnet PS	3.04 s	2.56–2.48 s	2.48–2.40 s				1.3 s
New magnet PS for high rep.			R&D			Manufacture installation/test	
Present RF system	Install. #7,8	Install. #9					
New high gradient rf system			R&D			Manufacture installation/test	
Ring collimators	Additional shields	Add. shields & collimators (2kW)	Add. shields & collimators (3.5kW)				
Injection system	New injection kicker			Kicker PS improvement, Septum1 manufacture /test			
FX system				LF septum, PS for HF septa manufacture /test			

→ Previsti +4 10^{20} pot in 2014 e +6 10^{20} pot in 2015

I rivelatori

Super-K
(295 km)

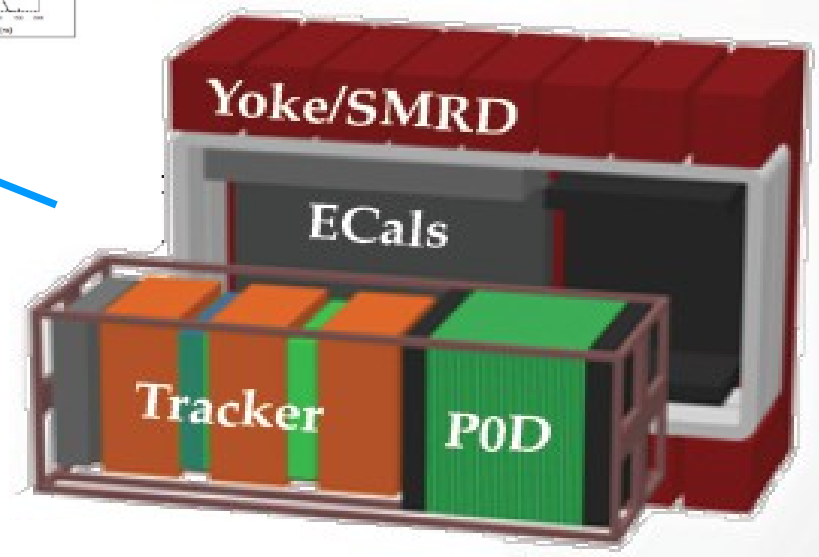


ND280

Near Detector (280m)

- 3 gas TPCs
- 2 fine grained detectors con carbon/water targets
- Dipole magnet 0.2T

→ normalizzazione flusso ν
→ misure sez. urto ν

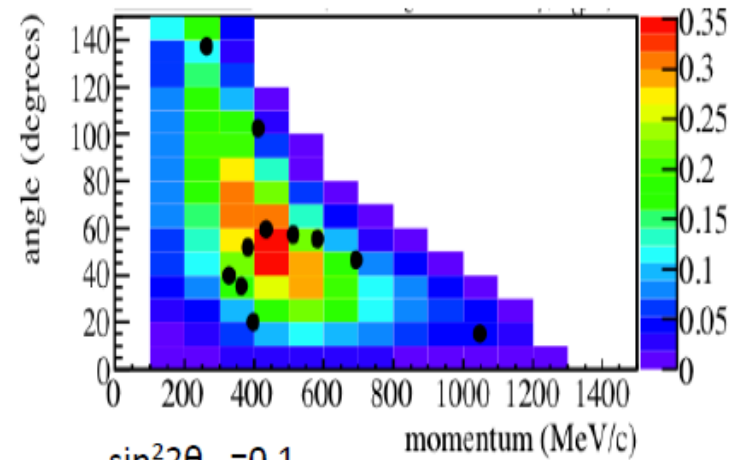
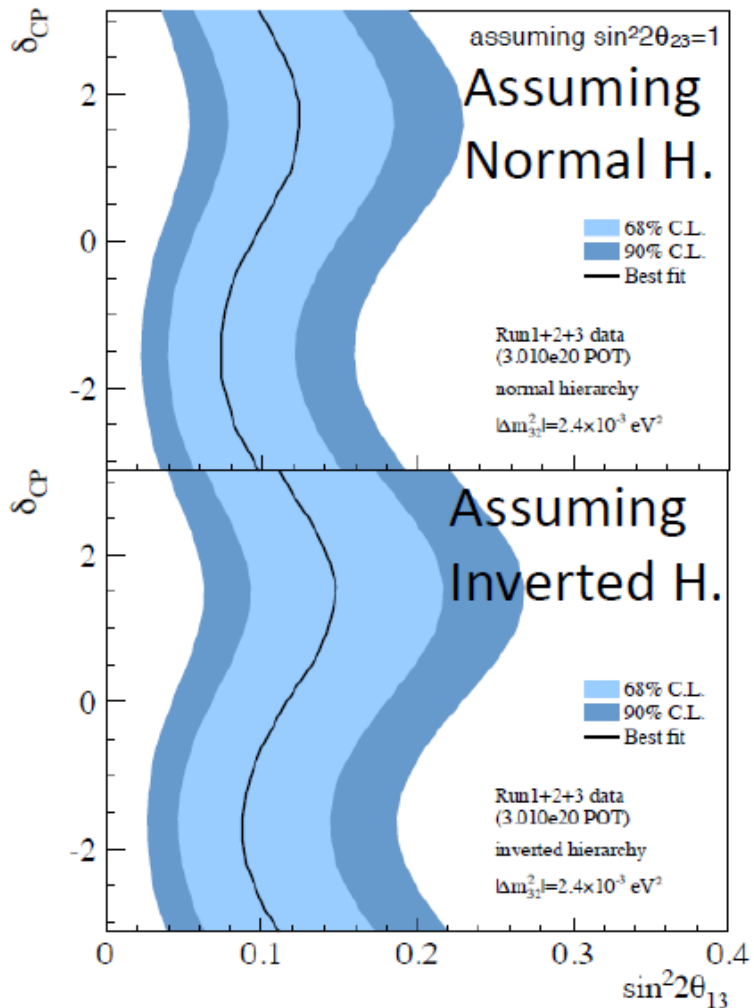


- 1km underground
- 50kt Water Cherenkov
→ 22.5 kt fiducial vol.
- 2m outer detector (veto)

→ ~60% efficiency for ν_e
~95% π^0 rejection

Apparizione ν_e

Risultati 2012 (3 10^{20} pot)



$\sin^2 2\theta_{13} = 0.1$

Error on # of event at SK (%)	w/ ND280	w/o ND280
Flux \times ν cross section	24.4	5.7
Un-correlated ν cross section	7.4	
SK +FSI+SI	3.9	
Total	25.9	10.3

$\theta_{13} = 0$ escluso a 3.2σ

Best fit : $\sin^2 2\theta_{13} = 0.094^{+0.053}_{-0.040}$ ($0.116^{+0.063}_{-0.049}$) for N.H. (I.H)

!!! nuovi risultati ad EPS2013 ($\rightarrow 5\sigma$ sensitivity for appearance)

Scomparsa ν_μ

Risultati 2012
($3 \cdot 10^{20}$ pot)

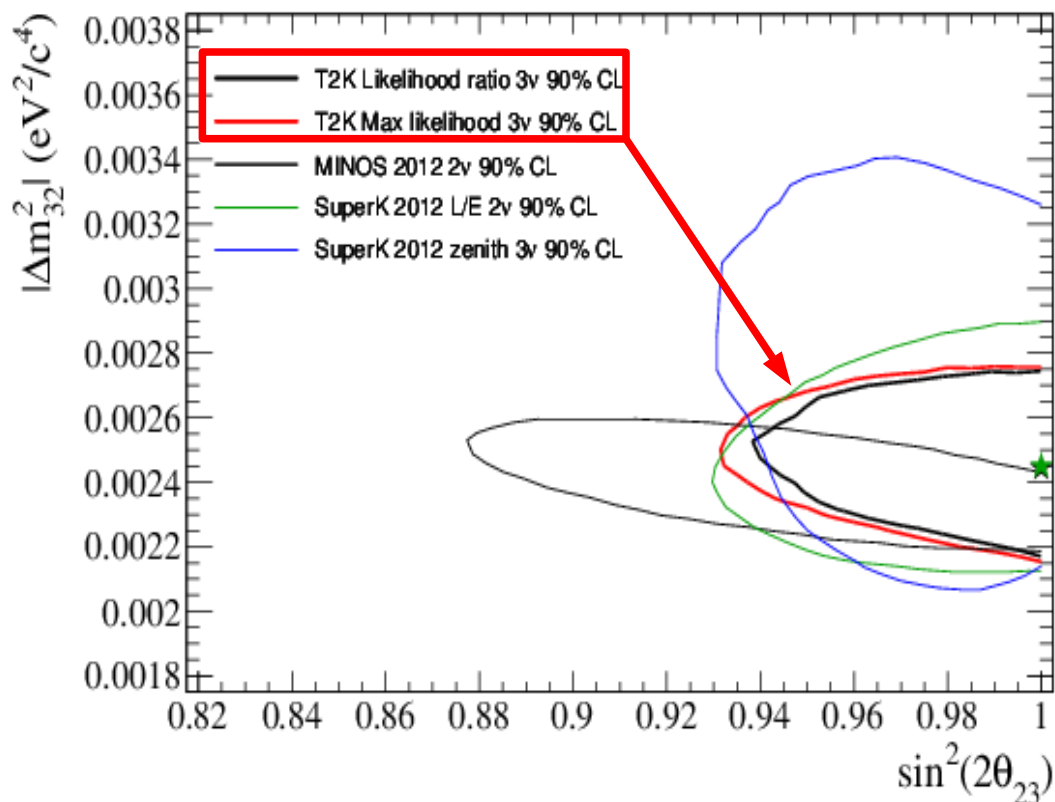
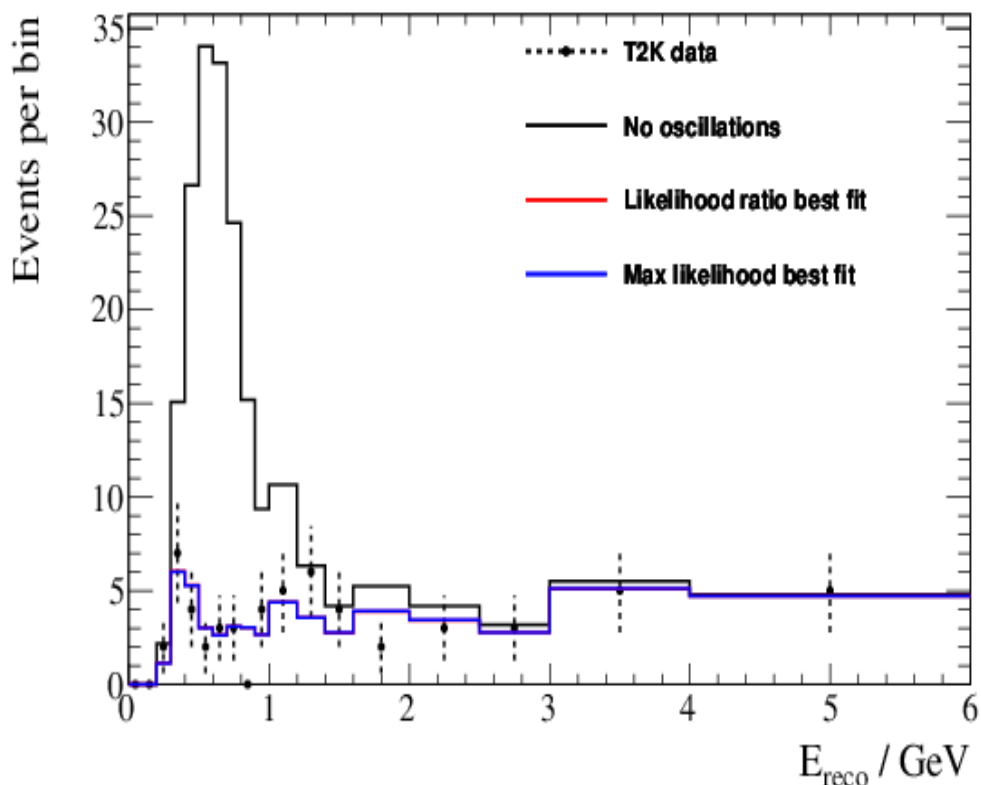
Osservati: 58
Attesi: 207

Best fit parameters:

$$\sin^2 2\theta_{23} = 1_{-0.068}$$

$$\Delta m_{23}^2 = 2.45 \pm 0.30 \cdot 10^{-3} \text{ eV}^2$$

(World record result)



!!! nuovi risultati ad EPS2013

Run 2014 con fascio di anti- ν_μ

Inversione polarita` fascio

→ richiesta PAC di JPARC per run 2014

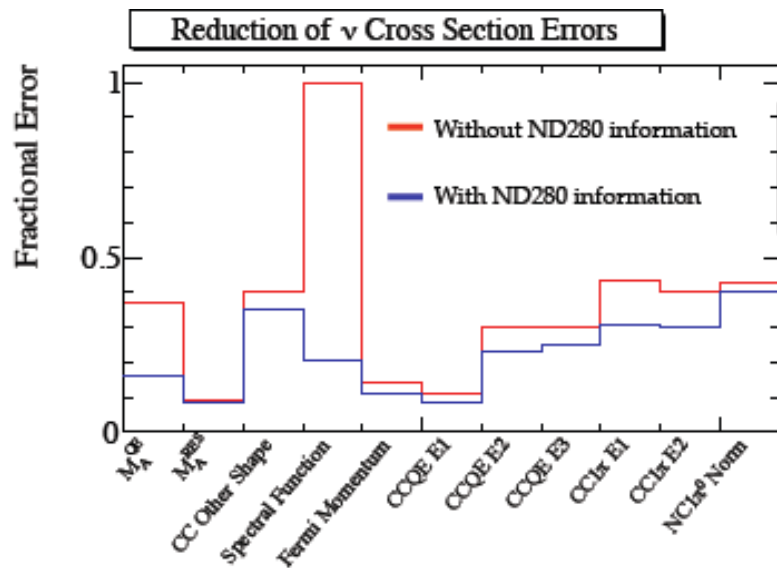
Obbiettivi:

- conferma misura θ_{13} in modalita` anti- ν ...

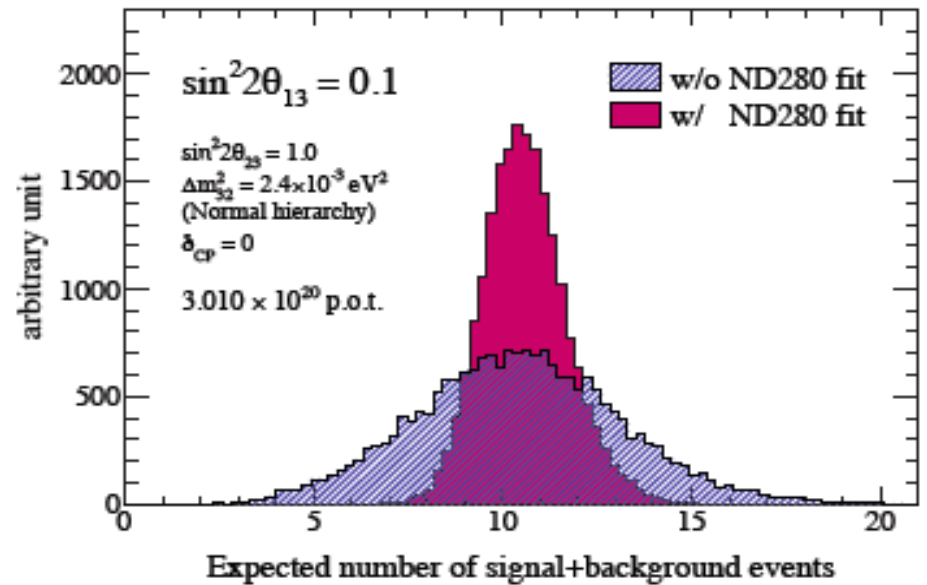
... θ_{13} grande implica possibilita` di **ricerca violazione CP**

→ studi sensibilita` a δ_{CP}

→ discussioni **upgrade ND280** (workshop 2013/09)



Impatto
di near
detector
su attese
 ν a SK

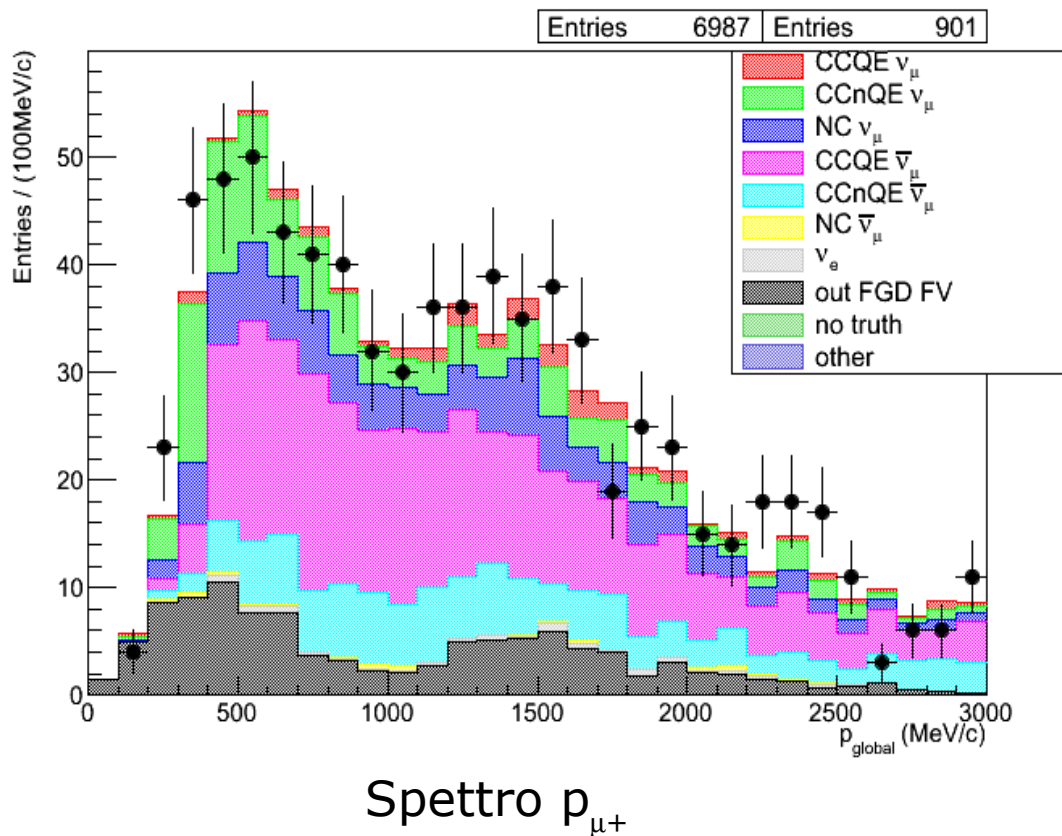


Analisi $\bar{\nu}_\mu$ in near detector

Analisi italiana coordinata da G.Catanesi e gruppo di Bari

Obbiettivi:

- misura **sezione d'urto** (mal conosciuta alle basse energie)
- ridurre sistematico in misure oscillazione
- cruciale per **stime sensitività** a δ_{CP} (inversione polarita` fascio)



numu CCQE	5,2%
numu CCnQE	14,6%
numu NC	11,5%
anti-numu CCQE	37,4%
anti-numu CCnQE	16,6%
OOFV	13,2%

Purezza CC inclusiva $\sim 54\%$



T2K Padova

Gruppo

M.Mezzetto (70%), G.Collazuol (60%), M.Laveder (60%)
→ 1.9FTE

Attività` (presenti e future)

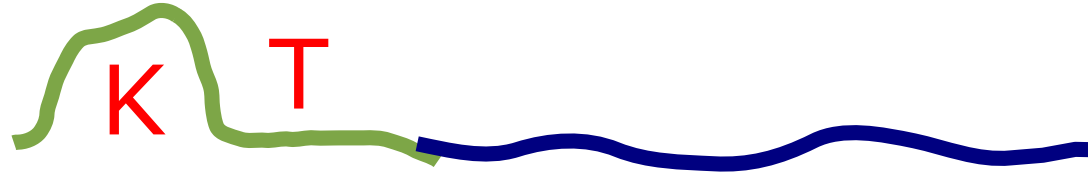
- presa dati a JPARC
- operazioni e shift TPC (JPARC)
- attività` di servizio (tasks): produzioni MC
- analisi anti- ν_{μ} , studi di sensitività` CP, ν sterili

Richieste finanziarie 2014

- si prevedono 7 mesi di Run come in 2013
- common funds approx. come in 2013 (*)
→ [richieste in preparazione, simili a 2013](#)

(*) NOTA: MoU INFN-JPARC in preparazione

Non ci sono richieste per i **servizi di Sezione**



Additional material

Neutrino Mixing

Neutrino flavor states are not mass eigenstates: $|\nu_i\rangle = \sum U_{\alpha i} |\nu_\alpha\rangle$

Matrix U contains 3 angles ($\theta_{12}, \theta_{23}, \theta_{13}$) and one phase (δ)

A useful decomposition:

$$c_{ij} = \cos(\theta_{ij}), s_{ij} = \sin(\theta_{ij})$$

$$U_{\alpha i} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{-i\delta} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Atmospheric: $38^\circ < \theta_{23} < 52^\circ$ Super-K, MINOS

CP sector: $\theta_{13} = (9 \pm 0.9)^\circ$ Daya Bay, Reno, T2K

Solar: $\theta_{12} = (34 \pm 1)^\circ$ SNO, KamLAND

Neutrino Mixing

Mass states interfere during neutrino propagation. Probability of observing flavor ν_β after making ν_α depends on :

- L : The distance the neutrino has traveled (in km)
- E : The energy of the neutrino (in GeV)
- Δm_{ij}^2 : The mass splitting between the i and j mass eigenstates (in eV^2)

NuMu Disappearance:

$$P(\nu_\mu \rightarrow \nu_\mu) \approx 1 - \sin^2 \theta_{23} \sin^2 \left(1.27 \frac{\Delta m_{32}^2 L}{E} \right)$$

$$\approx 2.43 \times 10^{-3} \text{eV}^2 / c^4$$

Nue Appearance:

$$P(\nu_\mu \rightarrow \nu_e) \approx \sin^2 \theta_{23} \sin^2 \theta_{13} \sin^2 \left(1.27 \frac{\Delta m_{31}^2 L}{E} \right)$$

$$\approx 2.43 \times 10^{-3} \text{eV}^2 / c^4$$

