The T2K experiment

Chiraz Ferchichi

irfu

cea saclay

(France)

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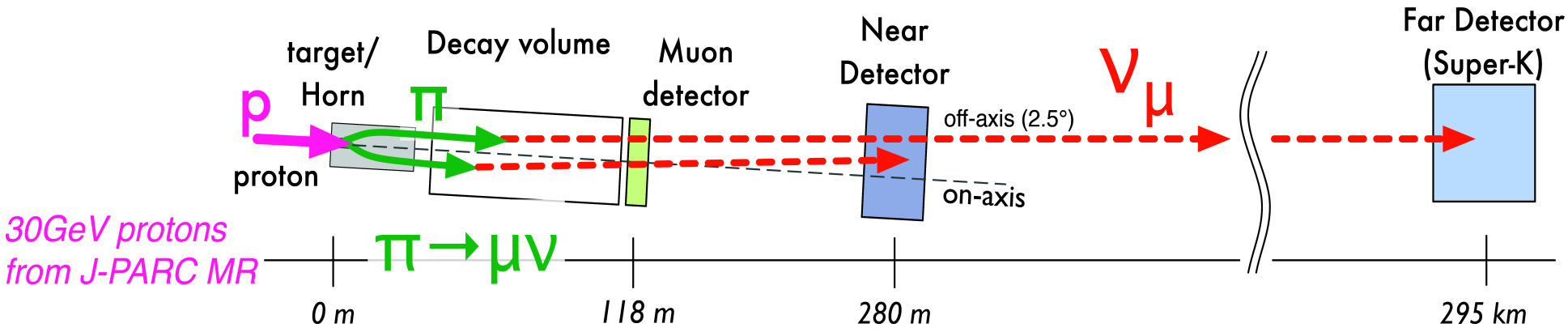
T2K is a long-baseline neutrino oscillation experiment that uses a ν_μ beam peaked at 600 MeV

produced at J-PARC and directed to Super-Kamiokande



Main goals of T2K:

The search for θ_{13} by discovering ν_e appearance

$$P(\nu_\mu \to \nu_\mu) = 1 - \sin^2 2\theta_{23} \sin^2\left(\frac{\Delta m^2_{23} L}{4E}\right)$$

The precise measurement of θ_{23} and Δm^2_{23} by ν_μ disappearance

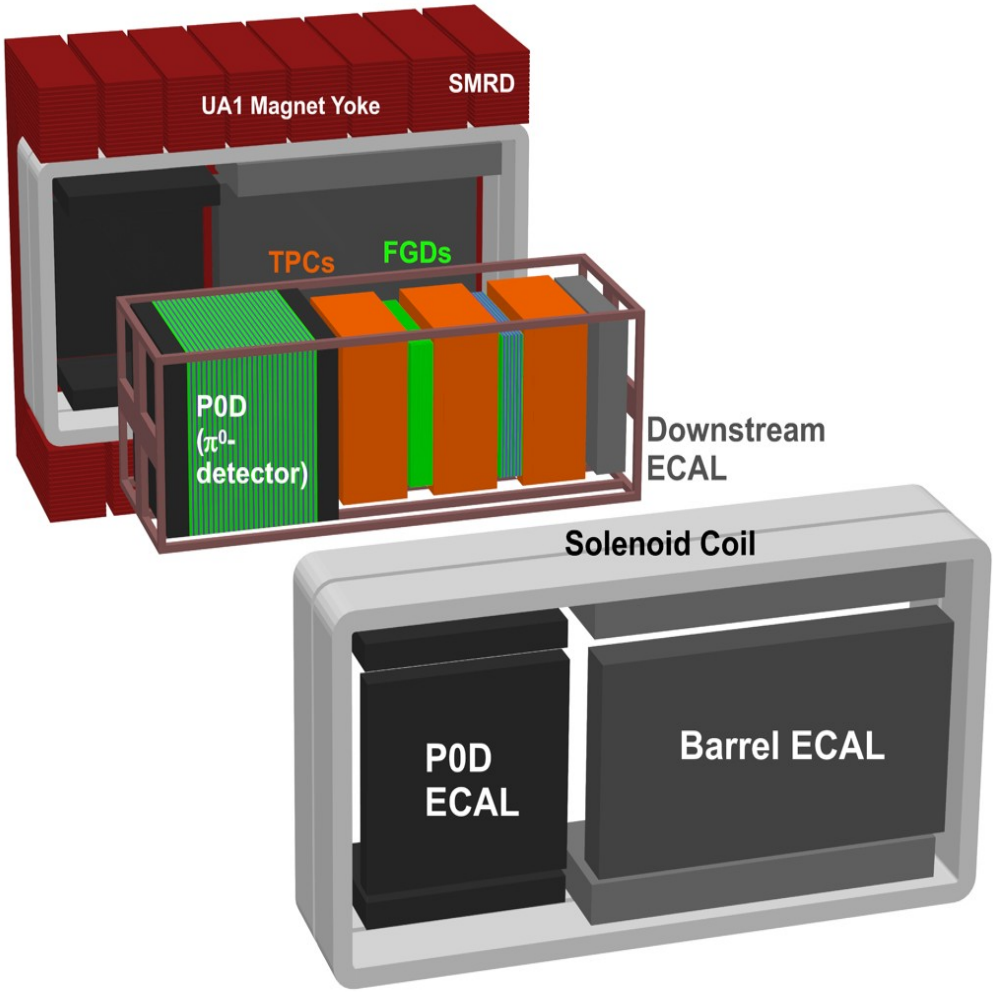
$$P(\nu_\mu \to \nu_e) = \sin^2 2\theta_{13} \sin^2 \theta_{23} \sin^2\left(\frac{\Delta m^2_{31} L}{4E}\right)$$

Off-axis Near Detector (ND280)

Located at 280m from the proton target, off-axis angle of 2.5°.

Different detector types:

- **P0D** (π0 detector) ;
- **Tracker**: 3 Time Projection Chambers (**TPCs**) + 2 Fine Grained Detectors (**FGDs**) ;
- **Ecal** (Electromagnetic calorimeter) ;
- **SMRD** (Side Muon Range Detector) embedded in the magnet yoke.

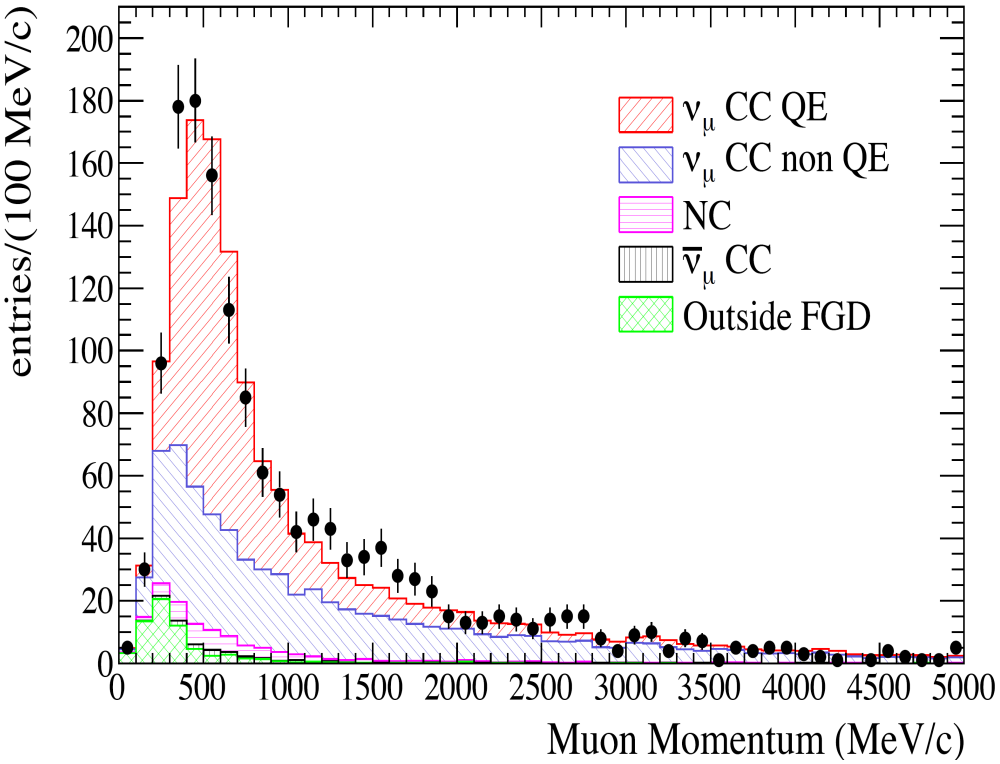


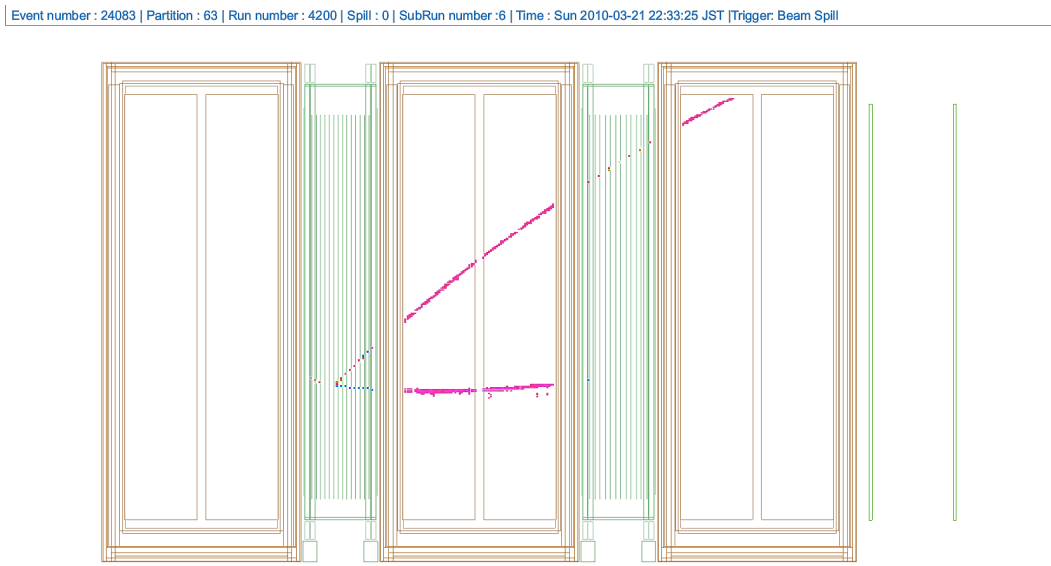
Goals:

- To predict event rate at the far detector without oscillation
- To measure the neutrino flux and spectrum
- To characterize the beam composition

Off-axis Near Detector (ND280)

An inclusive ν_μ charged-current (CC) measurement





Basic CC neutrino candidate

Measured data/MC ratio is:

$$R_{ND}^{\mu,Data}/R_{ND}^{\mu,MC} = 1.036 \pm 0.028(\text{stat.})^{+0.044}_{-0.037}(\text{det.syst.}) \pm 0.038(\text{phys.syst.})$$

Super-Kamiokande (SK)

50 kton Cherenkov
water detector

Criteria of selection ν_e event in SK

Fully-contained fiducial volume event

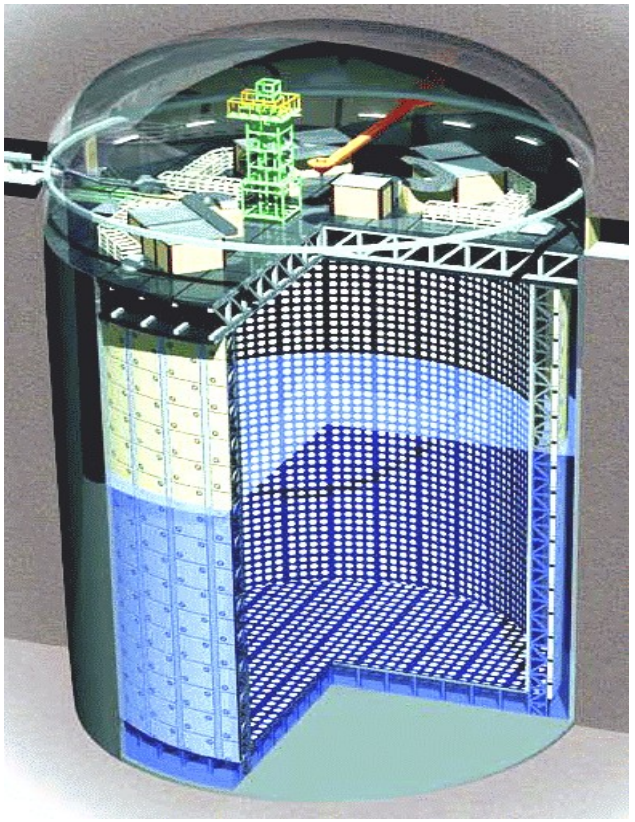
Single ring e-like

Visible energy > 100 MeV

No decay electron

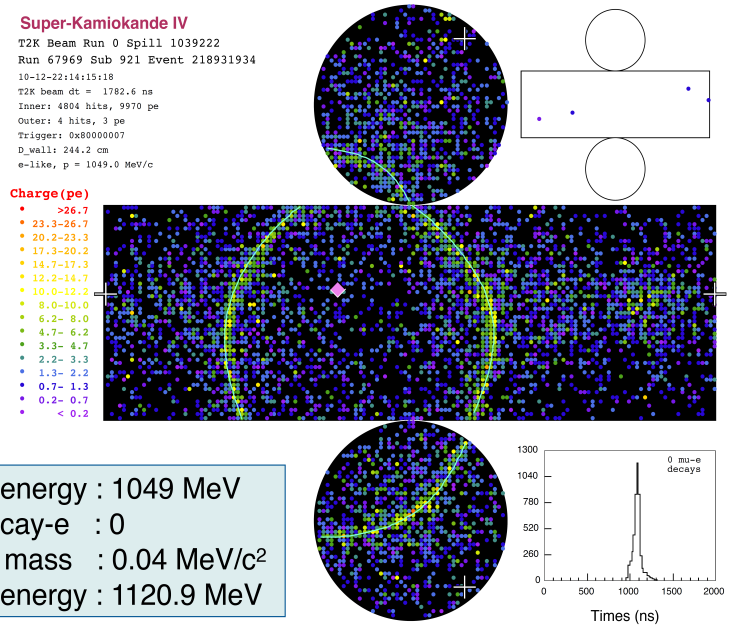
Reconstructed invariant mass < 105 MeV

Neutrino energy reconstructed < 1250 MeV



Super-Kamiokande (SK)

ν_e candidate event



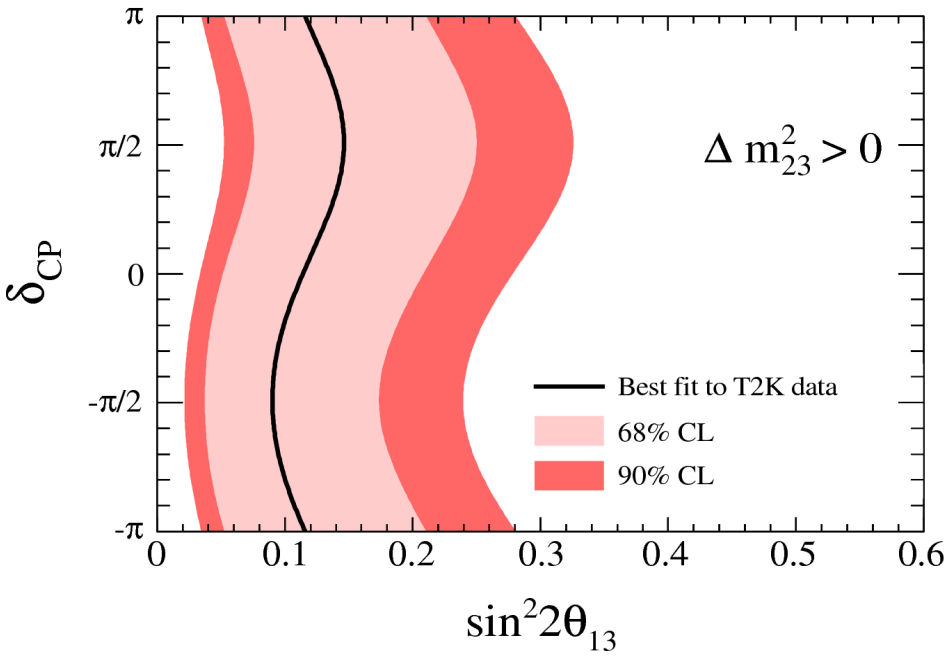
visible energy : 1049 MeV
# of decay-e : 0
2γ Inv. mass : 0.04 MeV/c²
recon. energy : 1120.9 MeV

- With $1.43*10^{20}$ protons on target → 6 observed ν_e events remain after all cuts

- Assuming $|\Delta m^2_{23}| = 2.4*10^{-3}$ eV², $\sin^2 2\theta_{23} = 1$ and at $\sin^2 2\theta_{13} = 0$ → The expected number of ν_e events is 1.5 ± 0.3(syst.):
  - * 0.03 ν_μ + ν_μ CC
  - * 0.8 intrinsic ν_e CC
  - * 0.1 $\nu_\mu \rightarrow \nu_e$ oscillation events
  - * 0.6 NC event

First ν_e appearance result

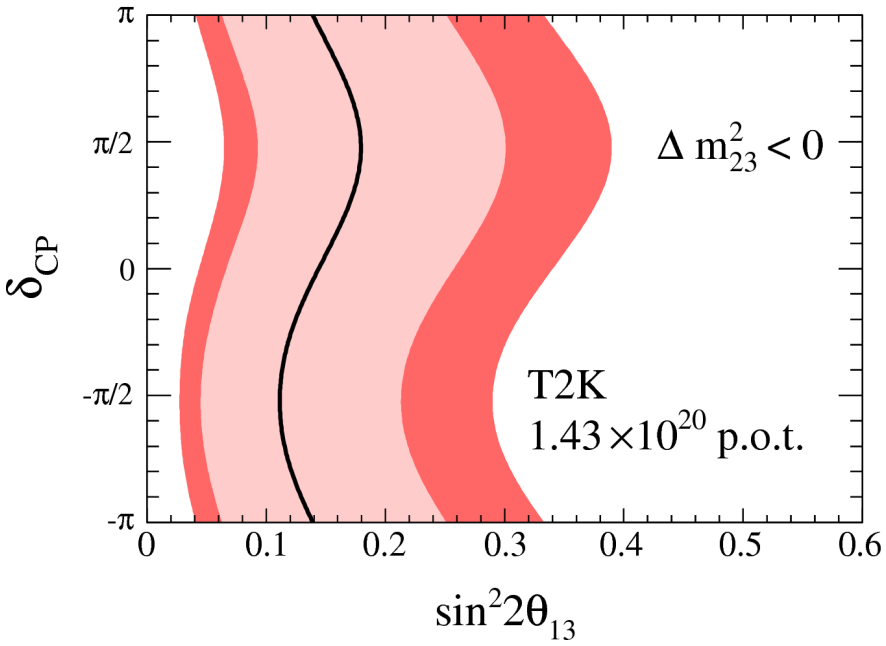
Reference: Indication of Electron Neutrino Appearance, accepted for publication by PRL, arXiv:1106.2822



Normal hierarchy

$0.03 < \sin^2 2\theta_{13} < 0.28$

$\sin^2 2\theta_{13} = 0.11$ at $\delta_{CP} = 0$ and 90% C.L.



Inverted hierarchy

$0.04 < \sin^2 2\theta_{13} < 0.34$

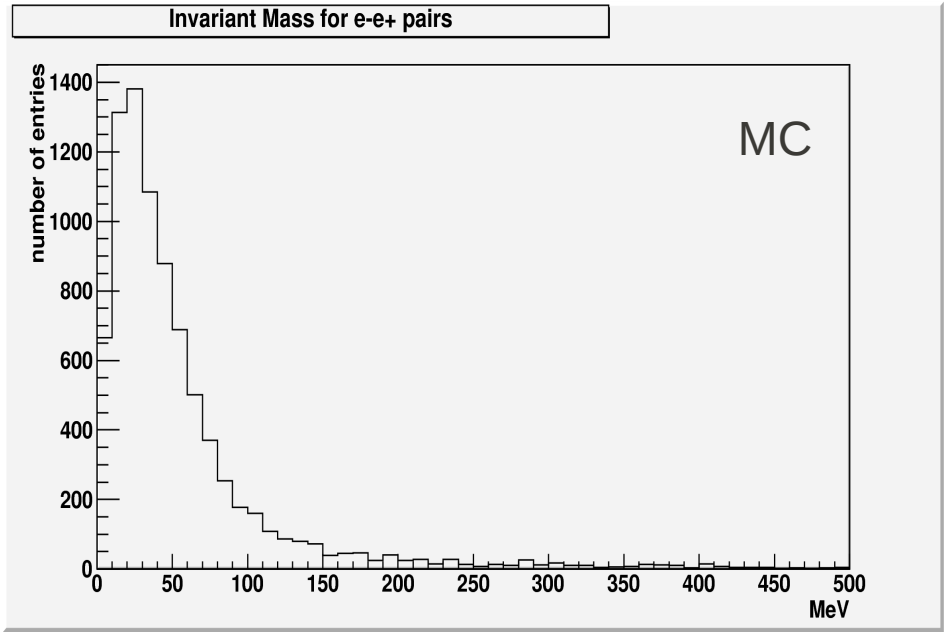
$\sin^2 2\theta_{13} = 0.14$ at $\delta_{CP} = 0$ and 90% C.L.

Under the $\theta_{13} = 0$ hypothesis, the probability to observe 6 or more candidate events is $7*10^{-3}$

(equivalent to 2.5σ significance)

My current thesis work

- The intrinsic ν_e component in the beam is measured before oscillation.
- In ND280, most of the electrons do not come from ν_e CC interactions.
- One important background in the ν_e flux measurement is due to NC interactions producing a π^0 in the final state.
- In order to find π^0s produced in the FGD, we search for an e^+e^- pair in the TPC coming from a gamma conversion in the Ecal.



Invariant mass of the e^+e^- coming from a gamma conversion

Thank you for your attention!