

The T2K Neutrino Oscillation Experiment

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on behalf of the T2K collaboration

Abstract. T2K is a long baseline (295 km) neutrino oscillation experiment planned to start taking data in 2009. A powerful proton beam in the JPARC Laboratory (Tokai, Japan) will produce a neutrino beam aimed at Super-Kamiokande. The goal of T2K is to probe $\nu_\mu \rightarrow \nu_e$ oscillations with a sensitivity an order of magnitude better than current experiments and eventually to measure θ_{13} , the last unknown angle in the PMNS neutrino mixing matrix.

1. Introduction

One of the outstanding questions in today neutrino physics is the measurement of θ_{13} the last unknown angle in the PMNS neutrino mixing matrix. A necessary condition for CP violation in the leptonic sector is that θ_{13} is different from zero. Therefore, this measurement will be an important milestone in the experimental checks of the leptogenesis scenario to explain the baryon-antibaryons asymmetry in the universe. Future projects to measure CP violation in the neutrino sector crucially depend on the value of θ_{13} as this may determine the optimal choice for this kind of neutrino facility.

2. Overview of the T2K project

T2K [1] is a long baseline neutrino oscillation experiment in Japan. A powerful proton beam in the JPARC Laboratory in Tokai will be used to produce a neutrino beam aimed at Super-Kamiokande, with a baseline of 295 km. The main goal of T2K is to probe $\nu_\mu \rightarrow \nu_e$ oscillations with a sensitivity increase by more than one order of magnitude with respect to current experimental limits and eventually to measure θ_{13} . This will be done by studying ν_e appearance at Super-Kamiokande in a dominantly ν_μ beam.

T2K will also provide unprecedented precision to the measurement of the atmospheric oscillation parameters Δm_{32}^2 and θ_{23} . In the following we will briefly present the main components of the T2K project (fig. 1), namely the JPARC accelerator complex including the Neutrino Facility, the near detector at 280 m and Super-Kamiokande. A second detector position at 2km is being considered for a later phase of T2K.

3. JPARC

The Japan Proton Accelerator Research Complex (JPARC) (fig. 2) comprises:

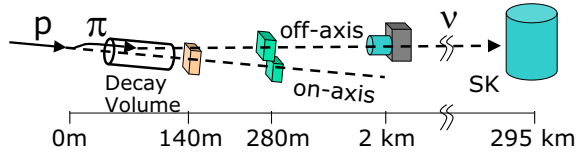


Figure 1. Scheme of the T2K experiment.

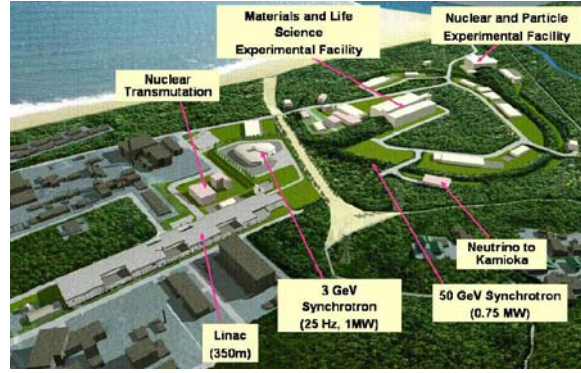


Figure 2. Birdview of the JPARC laboratory at Tokai.

- a 330 m long LINAC with nominal kinetic energy of $400 \text{ MeV}/c^2$, ($181 \text{ MeV}/c^2$ at the first stage of Phase I);
- a 3 GeV Rapid Cycling Synchrotron (RCS) operating at 25 Hz;
- a 50 GeV Main Ring (MR) Synchrotron, with a nominal beam power of 0.75 MW.

The LINAC has been successfully commissioned early this year, accelerating protons to $181 \text{ MeV}/c^2$. The RCS will be commissioned in the fall of 2007, while the first beam in the Main Ring will be in 2008.

After a fast extraction from the MR, the proton beam will be steered by Superconductive Combined Function Magnets (SCFM) onto a 900 mm long graphite target. The pions will be focused by three magnetic systems (horns) and then decay in a 94m long decay tunnel to produce the neutrino beam. 17 out of 24 of the SCFM have been produced at the time of this conference. The first horn has been successfully tested, standing $8.5 \cdot 10^5$ pulses.

The neutrino beam will be directed approximately 2.5° away from Super-Kamiokande. In this way, a narrow off-axis neutrino beam with peak energy around $600 \text{ MeV}/c^2$ (fig. 3) is obtained. The expected ν_e contamination in this ν_μ beam is expected to be at the few per mille level.

4. The near detector at 280m

At 280 m from the proton target, a detector complex (ND280) will characterize the neutrino beam. INGRID, a grid of scintillator/iron slabs, will measure the on axis beam intensity and direction.

A modern multipurpose magnetized detector is located in the off-axis position, inside the former UA1 (and NOMAD) magnet, donated by CERN to the T2K project. Inside the magnet, P0D is an active target formed by scintillator bars and lead foils, optimized to detect neutral currents reactions with a single π^0 production. The tracking part is composed by the Fine Grained Detector (FGD), two active targets formed by scintillator bars interleaved by three large TPC, detecting charged particles and measuring their momenta and ionization loss. ECAL, a lead-scintillator electromagnetic calorimeter, will surround the inner detector. The Side Muon Range Detector (SMRD), composed of scintillator slabs inserted in the magnet return yoke, will detect muons and measure their momenta from the range in iron. The TPC [2] will be instrumented by 72 MicroMegas [3, 4] produced at CERN by an European collaboration. All other detectors will be instrumented with Multi Pixel Photon Counters.

The neutrino beam flux and spectrum will be measured by reconstructing the Charged Current Quasi Elastic (CCQE) events $\nu_\mu n \rightarrow \mu^- p$. The ν_e contamination will be measured using the similar reaction for ν_e and identifying the electrons through their ionization loss in the

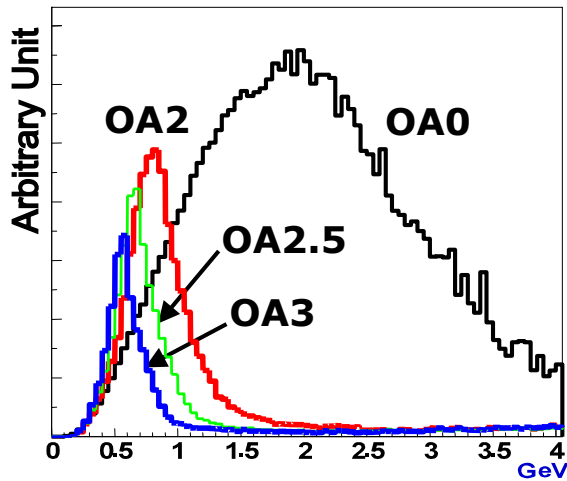


Figure 3. Neutrino energy spectrum for several Off Axis (OA) angles.

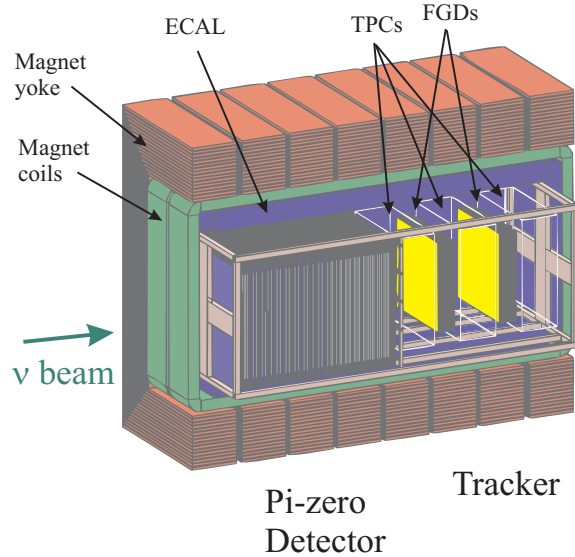


Figure 4. The T2K close detector at 280m from the target.

TPC and the energy deposition in the ECAL. ND280 will also measure other neutrino cross-sections like Charged Current with a single pion production that will contaminate the sample of CCQE selected by Super-Kamiokande.

5. SuperKamiokande

Super-Kamiokande [5] will be used as the far detector of the T2K project. It is a 50 kton water Cherenkov detector, instrumented by 11146 20' PMT. In 2006, Super-Kamiokande has been fully reconstructed recovering a 40 % coverage of the inner volume. It has been taking data since. The main background to the ν_e appearance in the T2K beam are the intrinsic ν_e contamination of the beam and neutral current single π^0 events. Both backgrounds will be studied by the ND280 detector.

6. Conclusions

T2K will start taking data in 2009. The goal of T2K is to have the best sensitivity to $\sin^2(2\theta_{13})$, down to values as low as $8 \cdot 10^{-3}$ (for a value of the CP violating phase δ equal to zero). In the ν_μ disappearance channel, the aim is to have an uncertainty on $\sin^2(2\theta_{23})$ of 10^{-2} and on Δm_{32}^2 of 10^{-4} eV^2 .

Acknowledgments

I wish to thank the organizers for a constructive conference in a pleasant atmosphere.

References

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- [2] See A. Sarrat contribution in these proceedings.
- [3] I. Giomataris et al., Nucl. Instr. and Meth. A560 (2006) 495.
- [4] J. Bouchez et al., Nucl. Instr. and Meth. A574 (2007) 425432.
- [5] See K. Kaneyuki contribution in these proceedings.