PROCEEDINGS OF SCIENCE

The TPCs of the T2K experiment

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T2K is a long baseline neutrino experiment that will search for $\nu_\mu \rightarrow \nu_e$ oscillation, with an excellent sensitivity to the mixing angle θ_{13}. A near detector complex (ND280) will be installed at 280 meters from the neutrino production point and will be used to measure the neutrino energy spectrum, flavor content and neutrino cross-sections of the unoscillated neutrino beam. ND280 includes three large TPCs based on bulk-MicroMegas technology as readout device. Up to now two of the three T2K TPCs have been completed and have tested in a beam test at TRIUMF. The first results of these beam tests are presented here.
The TPCs will be installed in Fall 2009 in ND280 and will be ready for the first T2K physics run that will start in the Winter 2009.

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1. The T2K experiment

The T2K (Tokai to Kamioka) experiment is a long baseline neutrino oscillation experiment mainly designed to search for $\nu_\mu \to \nu_e$ oscillation (that corresponds to the measurement of the angle θ_{13} of the neutrino mixing matrix) and to improve the knowledge of the ν_μ disappearance parameters (Δm^2_{23} and θ_{23})[1]. It is designed with an off-axis beam configuration providing a narrow band ν_μ beam peaked at 700 MeV/c. The far detector, SuperKamiokande[2], is installed at a distance of 295 *km* from the neutrino production point, distance corresponding to the oscillation maximum. The near detectors, are located along the off-axis direction towards SuperKamiokande, 280 *m* downstream the production target. These detectors are installed in the ex-UA1 magnet that provides a magnetic field of 0.2 T. The purpose of the near detectors is to measure the beam properties before the oscillation.

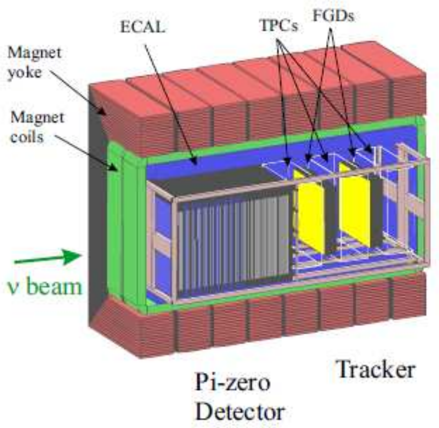

Figure 1: The ND280 off-axis detector

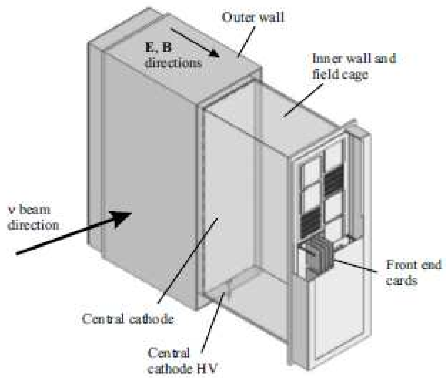

Figure 2: Schematic of one TPC

2. The T2K TPCs

In ND280 three large Time Projection Chambers (TPC) (see figure 2), together with two FGDs (Fine Grained Detectors), will provide a clean sample of charged current quasi elastic (CCQE) events. The momentum of the muons produced in the interactions will be measured in the TPCs and will be used to determine the energy spectrum of the neutrino beam. Moreover in the TPCs it will be possible to distinguish electrons from muons measuring the energy released by the crossing particles in the gas. This will allow to measure the electron neutrino contamination in the beam.

The TPCs will have to measure the muons momentum with a precision better than 10% at 1 GeV/c and given the low magnetic field this requires a good point resolution. Moreover to precisely measure Δm_{23} it is required to measure the overall momentum scale at the 2% level. Finally to reach a 3σ separation of electrons and muons in the T2K energy region, the deposited energy resolution has to be better than 10%.

The TPCs will be installed in the ND280 complex in Fall 2009 and will be ready for the begin of the T2K physics run foreseen in Winter 2009.

3. The TPC design

Each TPC has a rectangular shape and consist of an outer volume with a surface of 2.5*x*2.5 m^2 in the plane perpendicular to the neutrino beam direction, and 0.9 *m* along the beam direction. The active volume, equal to 1.8 *x* 2.2 *x* 0.7 m^3 is defined by the inner box divided into two halves by a central cathode to limit the maximum drift distance to 0.9 *m* and it will be filled with a gas mixture of $Ar/iC_4H_{10}/CF_4$ (95/2/3). A simplified layout of the TPC showing inner and outer boxes is presented in figure 2.

The central cathode is set at 25 *kV* and the ionization electrons are drifted under an electric field of about 200 V/cm. The cathode will be loaded with aluminum strips for the laser calibration system. To amplify the signals and read out the TPCs, micro-pattern gaseous detectors, based on the Bulk-MicroMegas technology are used (see figure 3). This solution, developed by a CERN/TS-DEM and CEA Saclay Collaboration offers a good gas gain uniformity and allows to minimize the dead zones on the edges of the modules. The manufacturing process is described in detail in [3].

Each endplate of the T2K TPCs is equipped with 12 Bulk-MicroMegas modules for a total of 72 modules for the three TPCs. The active area of a Bulk-MicroMegas module is 34×36 cm^2 and the anode is segmented into 1726 active pads of 6.9×9.7 mm^2 arranged in 48 rows and 36 columns. Before the installation each module is validated and characterized in a Test Bench at CERN. In the Test Bench a typical MicroMegas gain of 1500 for an high voltage of 350 *V* has been measured.

Each module is readout by six Front-End Cards (FECs) based on the low noise AFTER chip[4]. This new ASIC has been designed specifically for TPC applications and consists of 72 multiplexed channels. A digital Front-End Mezzanine (FEM) card plugged directly on the six FECs is responsible for slow control, collection of digitized data, pedestals subtraction and zero suppression.

In figure 4 a picture of one T2K TPC, completely equipped it is shown.

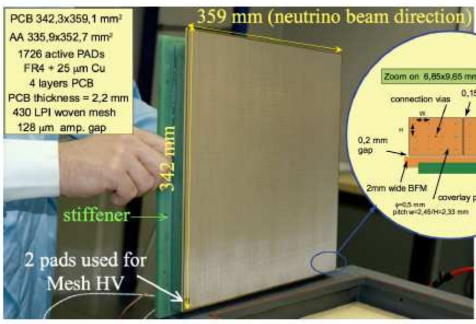

Figure 3: A 34 x 36 cm^2 Bulk-MicroMegas module glued on its stiffener

Figure 4: The first T2K TPC, completely equipped with the MicroMegas modules and the front-end electronic.

4. Test Beam at TRIUMF

After the production and the integration, each TPC undergoes to beam tests in the TRIUMF facility. The beam is composed of electrons, pions and muons. A Time Of Fligth system allows the particle separation. Data have been taken, without magnetic field, for various particle momentum, between 100 and 350 MeV/c.
During the tests, the MicroMegas modules and the electronic ran smoothly, without particular problems and with a measured sparking rate of 0.1 spark per hour per module at 350 V.
The analysis of the data showed an energy resolution, measured with a truncated mean method, better than 8% for muons in all the analyzed momenta and an electron/muon separation better than 5 σ if the momentum is larger than 200 MeV/c.

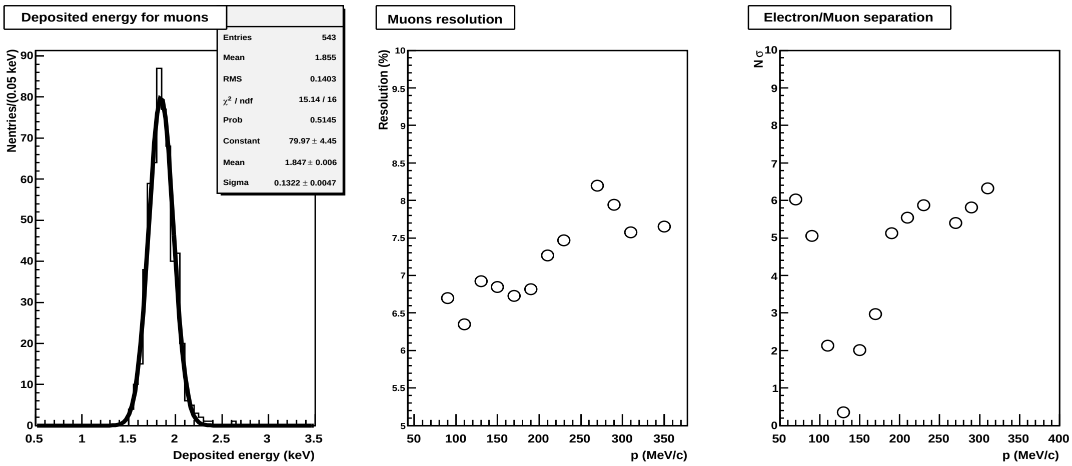

Figure 5: Results of the TRIUMF beam tests: truncated mean distribution for 150 MeV/c muons (left), muons energy resolution (center) and electron/muon separation, measured as number of standard deviation (right) as a function of the momentum.

The spatial resolution was measured to be 650 μm for a drift distance of 75 cm. The results of the beam tests are in agreement with the ones obtained in previous tests of the MicroMegas detectors[5] and will allow to reach the required detector performances.

References

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