KEK/J-PARC-PAC 2012-18

Test for 250L Liquid Argon TPC

Decmeber 10, 2012

H.Chiba, T.Fujimoto, T.Isoki, S.Narita, Y.Shida, K.Watanabe
Iwate University

T.Hasegawa, K.Kasami, K.Kimura, T.Kobayashi, M.Maki,
T.Maruyama[1], T.Nakadaira, K.Nishikawa, R.Ohta, K.Sakashita,
Y.Yamanoi
High Energy Accelerator Research Organization (KEK)

E.Iwai [2]
Osaka University

Abstract

There are some strong motivations to have a test-beam using well-defined charged particles for liquid argon TPC detectors. We request to use K1.1BR beamline and the beam time for six days during March or May/June (probably the latter) 2013 slow extraction beam as soon as after our 250L LAr TPC is ready to take beam data. We'd like to show the readiness of the hardware of the detector using cosmic ray events before taking K1.1BR beam data, and discuss the beam time schedule with relevant persons in KEK.

[1]contact person
[2]KEK research fellow

1 Introduction

There are some strong motivations to have a test-beam using well-known charged particles for liquid argon TPC detectors for neutrino / nucleon decay / dark matter experiments. Typical motivations are shown as follows;

- To check PID performance; PID is done with dE/dx information in wires (strips) and/or event topology.
- To check energy resolution; Kinetic energy of charged particles is reconstructed in each event using sum of the dE/dx in wires or strips.
- To check hadron transportation; hadron (e.g. pions) always provide difficuty on interaction to nucleus. We have to check if a simulation well reproduces data.
- To check recombination effects; Ionized electrons and ions are recombined. The recombination effect depends on the electric field and dE/dx empirically.

To have these checks, the various kind of particles are necessary, therefore we request to use the K1.1BR beam line, and the beam time for six days. The requested beam time in details are described later.

2 250L liquid argon TPC

The details of the detector setup is discribed elsewhere [1]. Here we write down relevant part of the detector. The cryostat of the 250L LAr TPC consists of the inner cylindrical vessel, size of about 70 cm diamaeter and 100 cm length, and outer vessel to insulate the heat load by vaccum. Inside cryostat, TPC of $40 \times 40 \times 80$ cm^3 is located, and at the bottom of the cryostat, there are two PMTs to have cosmic ray trigger. Fig. 1 shows the overall configuration including the cryostat and the TPC.

Hereafter only upgraded parts from the publication are written, and following hardware are upgraded.

- Gas recirculation system
- Cockcroft-Walton high voltage system
- 2D readout system with 4mm pitch.

Following subsections descibe each hardware upgrde.

2.1 Gas recirculation system upgrade

Fig. 2 shows the schematic view of the upgraded gas recirculation system. The gas argon is extracted using the gas recirculation pump and purified with a commercial

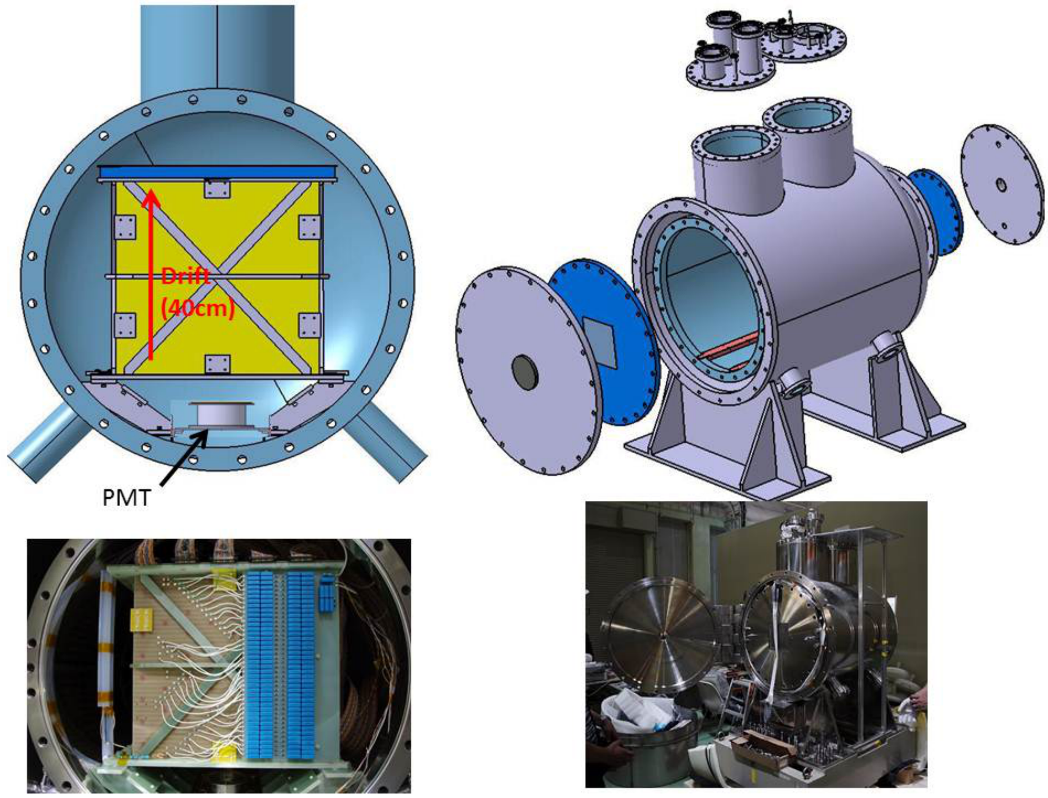

Figure 1: The schematic view of the 250L LAr TPC detector (top-left). Picture of TPC with Cockcroft-Walton high voltage system (bottom-left), 3D drawings of the 250L cryostat (top-right), picture of the cryostat (bottom-right).

filter. Purified gas is liquefied inside condenser and the liquefied argon is returned to the inner vessel.

There are two different features from the old system, which is gas-to-gas purification system.

- The cryo-cooler is stayed out of the inner vesssel in the upgraded system, while the old system has it inside the inner vessel. This upgrade prevents dirty gas to be liquefied around the cryocooler.
- The filtered gas is liquefied in the condenser vessel, and it is returned to the inner vessel. This system provides efficient purificartion of liquid phase argon in the inner vessel.

Due to this upgrade, the liquid argon purity is kept better than 0.3 ppb (parts per billion) for more than a month during the long cosmic ray test [2]. This purity is good enough to make test-beam.

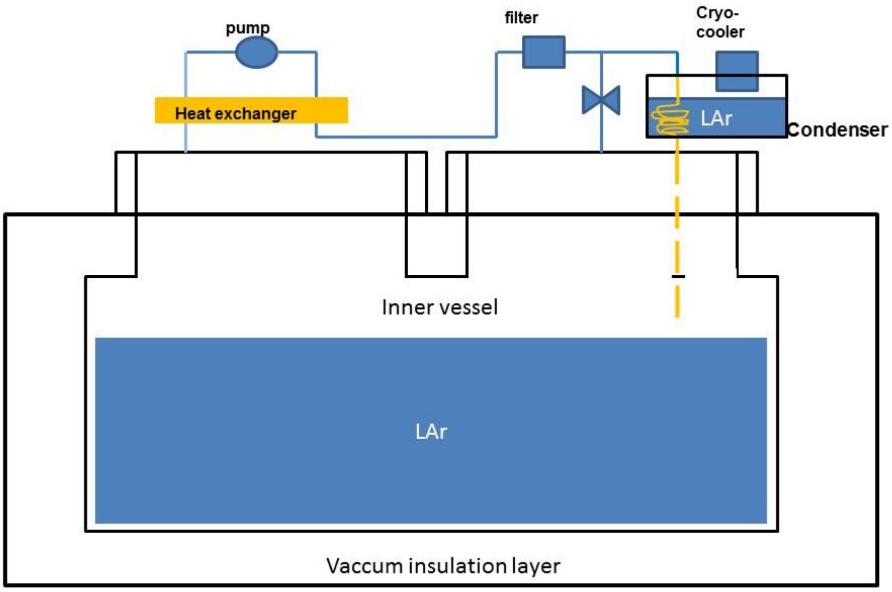

Figure 2: The schematic view of the upgraded gas recirculation system.

2.2 Cockcroft-Walton (CW) High Voltage System

The Cockcroft-Walton (CW) high voltage system creates high DC voltage from low AC voltage current, thus the expensive external DC power supply and the well considered cryostat's feed-through to avoid sparks of gas argon are not issue if we use CW HV.

As shown in the reference [2] and Fig. 1, we successfully implemented CW HV system with 40 stages, and applied HV up to 60 kV in TPC cathode, corresponding to 1.5kV/cm for the electric field. The CW system is also operated for more than a month, therefore the operation of the HV is stable enough and tested well. This makes our recombination study in the test-beam to be easier.

2.3 2D readout with 4mm pitch

The readout anode in the reference [1] is based on 1D strip with 1 cm width consisting of 76 channels, which is far from the best configuration. The 2D readout with 4 mm pitch is planned to be used in the next test-beam to have full liquid argon TPC performance.

At present, the small size of the anode prototype, which have 6.4 cm $\times$ 6.4 cm sensitive area, was tested, and cosmic rays were seen with the anode as 3D tracks successfully (JPS presentation [3]).

Before the next test-beam, we will show the cosmic ray events with 40 cm $\times$ 80 cm readout anode in JPNC meeting to show the hardware feasibility of the detector.

3 Setup in K1.1BR beamline area

Beamline equipments inside K1.1BR area has to be almost identical to that in described in [1], especially, Time-Of-Flight(TOF) counters and Gas Cherenkov counter for external PID are essential. We are going to ask KEK and TREK group to borrow these beam equipments. 250L LAr detector is located at the most downstream of the beamline.

Fig. 3 shows the setup in the K1.1BR area. TOF counters are apart by about 3500mm. The gas Cherenkov counter is located between TOF1 and TOF2. The scintillation counters are located in front of LAr TPC and most upstream part. It is desirable to have Fitch Cherenkov counter to identfy 800MeV/c particles.

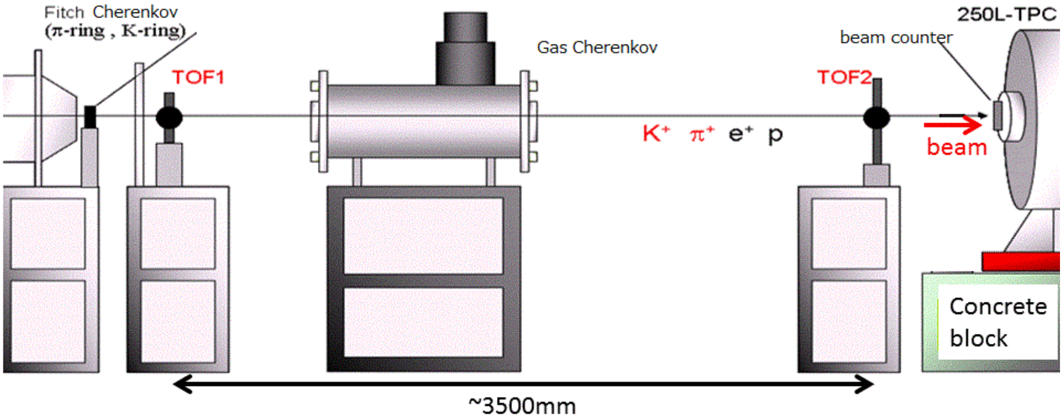

Figure 3: Setup of the test-beam. The most important equipment is TOF counters, which are apart by about 3500mm. The gas Cherenkov counter is located between TOF1 and TOF2. The scintillation counters are located in front of LAr TPC and most upstream part. It is desirable to have Fitch Cherenkov counter to identfy particle of 800MeV/c.

Due to the limitation of the DAQ capability of electronics, the rate of data taking is up to a few particles / spill.

4 Requests

4.1 Experimental Area

Fig. 4 shows the drawing of the location of our detector. The size of the detector is about 3m×3m×3m.

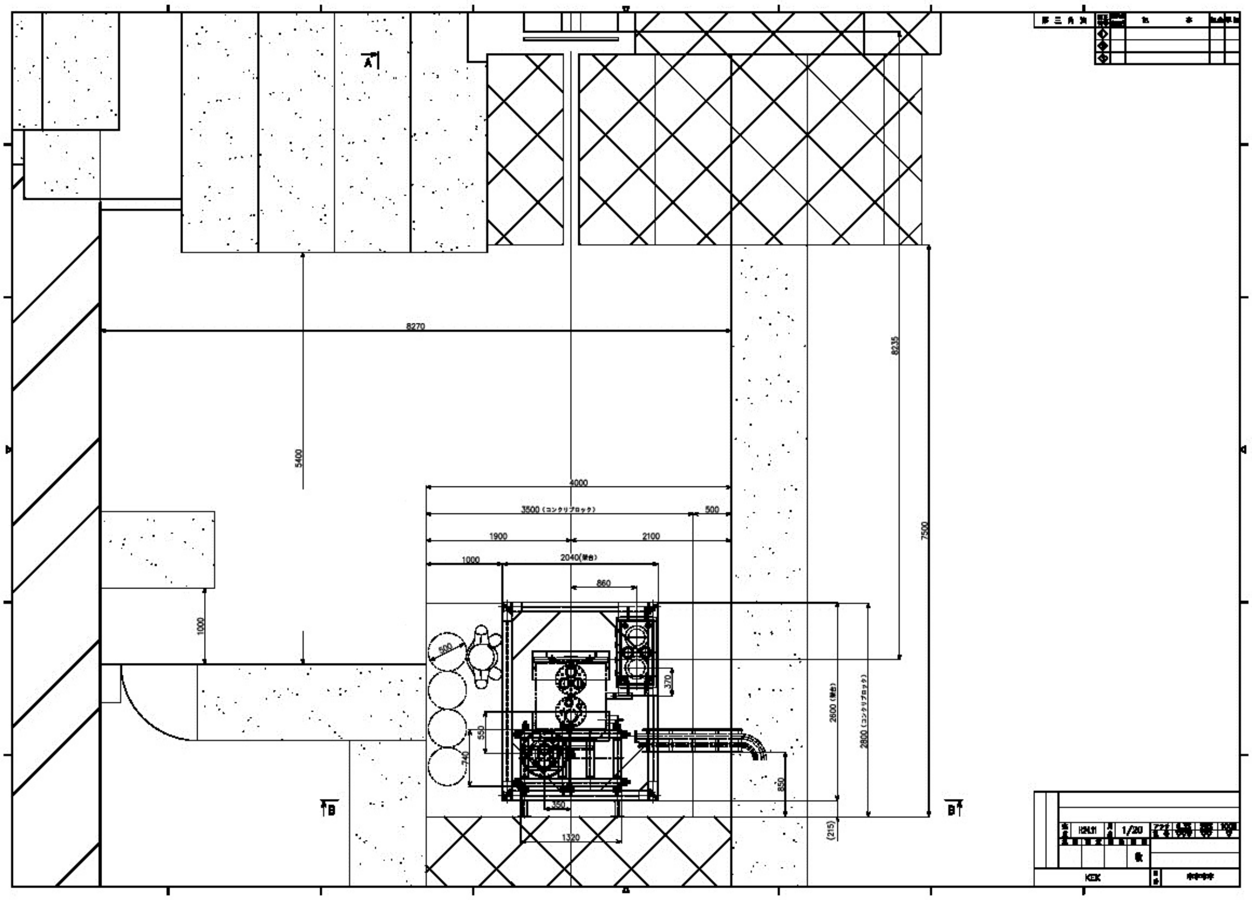

Figure 4: Location of our detector (top view). The size of the detector is about 3m×3m×3m.

4.2 Electronics Area

Outside the K1.1BR area seperated by the concrete wall, we put electronics and DAQ PC. (we call this area as "Electronics area".) There are two 19" electronics racks and four DAQ PCs, so in total 3m × 5m is requested for these.

4.3 Beamtime requests

Table 1 summarizes the our beam-time requests. 800 MeV/c is optimal momentum of K1.1BR, therefore we use it for π^+ and protons. 800 MeV/c π^+ pass through the TPC as MIP particle. 300 MeV/c π^+ and 600 MeV/c K^+ stops around 50cm from the TPC upstream edge, which provide tracks to be analyzed most efficiently. 150 MeV positron energy is the maximum energy to be contained inside the TPC.

HV is varied in all configurations shown in the table to check recombination factor. Energy resolution and hadron transportation are measured with these particles shown in the table simultaneously.

About four days are needed for physics run, and to change the beam configurations

particle	momentum	time	comments
π^+	800 MeV/c	10 hours	for MIP response meas.
	300 MeV/c	24 hours	for dE/dx PID
			for Michel electron response
protons	800 MeV/c	10 hours	for dE/dx PID
K^+	600 MeV/c	24 hours	for dE/dx PID
			MIP sesponse from 2ndary
positrons	150MeV/c	24 hours	energy resolution meas.

Table 1: BeamTime requests. HV is varied in all configurations to check recombination factor. Energy resolution and hadron transportation are measured with these particles simultaneously.

(e.g. beam momentum) and detector configurations, it takes 1.5 days. In total, we request six days for the test-beam during March or May/June 2013 (probably the latter) slow extraction beam time as soon as after our 250L LAr TPC is ready to take beam data. We'd like to show the readiness of the hardware of the detector using cosmic ray events before taking K1.1BR beam data, and discuss the beam time schedule with relevant persons in KEK.

References

[1] O. Araoka *et al.*,
J. Phys. Conf. Ser. **308**, 012008 (2011), [arXiv:1105.5818 [physics.ins-det]].

[2] $http://rd.kek.jp/slides/20120208/seminar20120208.ppt$

[3] $http://kds.kek.jp/getFile.py/access?contribId = 189\&sessionId = 20\&resId = 0\&materialId = slides\&confId = 10811$