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Report on NIM paper status for KEK beam test analysis in MICE Collaboration Meeting

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I left for CERN, European Organization for Nuclear Research, near Geneva on February 21th and went back to Japan on February 27th, 2007. I attended in MICE (Muon Ionization Cooling Experiment) Collaboration Meeting, held from 22th to 25th. Many presentations and discussions were held by many foreign researchers including physicists and engineers. The meeting consisted of many sessions, PID session, tracker session, analysis session, magnet session, RF system session and coupling coil system session. Tracker session and magnet session were held on the 1st day, PID and RF system session were on the 2nd day, analysis session and Coupling coil session were on the 3rd day and preparation for phase 1 and summary of several session were on the last day. I gave a presentation in the tracker session on the 1st day with the title of "NIM paper status". Chapter list and list of figures on NIM paper were shown as introduction and the rest is the summary of beam test analysis. The following is the brief explanation of MICE experiment and KEK beam test.

A Neutrino Factory [2], [3] based on a muon storage ring is the ultimate tool for the studies of neutrino oscillations, including possibly the discovery of leptonic CP violation. It is also the first step towards a $\mu^+\mu^-$ collider. Ionization cooling of muons is an important factor both for the performance and for the cost of a Neutrino Factory, however it has never been demonstrated in practice [4]. MICE will be the first experiment to demonstrate the ionization cooling.

The MICE collaboration has designed an experiment in which a section of an ionization cooling channel is exposed to a muon beam. MICE experiment will start from September in 2007 at Rutherford Appleton Laboratory in UK. In MICE, spectrometers are located both upstream and downstream of the cooling section in order to measure the beam transmission and emittance reduction. The particle tracking inside the solenoid, obtained by measuring successive points along the trajectory, allows the position, angle and momentum of each charged particle to be determined. The tracking detectors are required to have low mass, to reduce multiple scattering, and a shorter readout time than typical separation between incoming muons(=100ns). In addition, stable operation under severe background of X-ray from the RF cavities and high solenoidal magnetic field is required for the tracker. To meet these requirements, scintillating-fiber-based tracker will be applied in MICE. MICE SciFi tracker consists of 5 stations and each station has 3 views at the intervals of 120 degrees. Each view is composed of 4480 of 350$\mu$m scintillating fibers. Hit positions at each 5 stations are measured by detecting photons created where charged particles like muons passes. Those photons are transported through optical clear fibers to the photon detector located out side of tracker solenoid. VLPC (Visible Light Photon Counter) will be used as photon detector which has high quantum efficiency over 80% at green light, which is operated at the helium temperature, 9K using a cryocooler. The signals from VLPCs are digitized on the AFE board integrated with cryocooler, and stored in VLSB(VME LVDS SerDes Buffer) memory buffer once and stored in PC. There are 4480 of SciFis

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in one station, which are multiplexed by 7 and connected with optical clear fiber, therefore there are 640 channels in one station, 3200 channels in one tracker, 6400 channels in two trackers. MICE SciFi tracker has been developed in collaboration with UK, US and Japan. The performance had been confirmed as designed by prototype tracker with cosmic-ray at FNAL in 2003.

The beam test had been performed by prototype tracker in the magnetic field with muon at KEK-PS π2 beam line from September 30th to October 7th in 2005. In this test we had checked the performance and capability of the SciFi tracker in the 1 Tesla uniform magnet filed. The prototype of SciFi tracker to be tested consists of 4 stations, named as D, C, A and B from upstream. The tracker installed in the light shielding is embedded in JACEE superconducting solenoid magnet which produces 1 Tesla uniform field. Optical clear fibers attached with SciFis were extracted to downstream of the solenoid and connected with readout system. Several counters are set in the beam line to identify muons. At the most upstream, T1 counter (100mm x 50mm x 20mm plastic scintillator) which generates common start signal is located. At the downstream side of T1 counter, R1 counter (80mm x 5mm x 10mm plastic scintillator) is located. Both counters are read out by two PMTs attached at each side of the counter. Next is the Aerogel counter (100mm x 100mm x 85mm 8 layers aerogel) which can be available to identify muons and pions at low energy around 400 MeV/c from the light yield thanks to the low refraction index, 1.05. Next is the JACEE solenoid, which contains TOF hodoscope, the tracker to be tested, D1 and D2 counter. TOF hodoscope (400mm x 400mm x 40mm 5 by 5 2 layers plastic scintillator) is located 8.5 m far from T1 counter. Time of flight measurement by TOF hodoscope is used to identify muons, pions and electrons. Hit position on TOF hodoscope is also used to confirm the performance of the tracker as reference. D1 and D2 counter (150mm (diam.) x 5mm scintillating fiber sheet) is set at upstream and downstream of the tracker respectively. Beam momentum are applied as 3 GeV/c, 400 MeV/c, 325 MeV/c and 250 MeV/c for negative and 1 GeV/c for positive.

The analyzed items are the following. The VLPC stability on pedestal, gain and noise rate, light yield, hit efficiency on each views and stations and tracking efficiency. There has good stability for all components, which are within 1 ADC-count for mean of pedestal, 2% for width of pedestal, within 2% for gain, 8% for noise rate. Light yield distribution is good agreement with MC simulation calculated from deposit energy for each fiber. Light yield for station D is found to be lower than other stations, which is due to misalignment of connection of internal connector. Hit efficiency on each station other than D is measured by 90%, which are good agreement with MC Simulation. Reconstructed momentum for the longitudinal is measured with the resolution of 8%, as expected by MC Simulation. From the beam test, the performance of SciFi tracker in the magnetic field has been confirmed as designed.

I spent a beneficial time in the MICE Collaboration Meeting at CERN. I would like to appreciate the 21st century COE Program “Towards A New Basic Science: Depth and Synthesis”.

References

[1] Proposal to the Rutherford Appleton Laboratory, An International Muon Ionization Cooling Experiment

