In-beam validation of the MINOS device at HIMAC

C. Santamaria,[*1,*2] A. Obertelli,[*1,*2] N. Aoi,[*3] L. Audirac,[*1] H. Baba,[*2] D. Beaumel,[*2,*4] S. Boissinot,[*1] D. Calvet,[*1] F. Château,[*1] A. Corsi,[*1] A. Delbart,[*1] P. Doornenbal,[*2] A. Giganon,[*1] A. Gillibert,[*1] Y. Kondo,[*2,*5] Y. Kubota,[*6] C. Lahonde-Hamdoun,[*1] V. Lapoux,[*1] J. Lee,[*2] C.S. Lee,[*6] M. Matsushita,[*6] J.-Ph. Mols,[*1] T. Motobayashi,[*2] T. Nakamura,[*2,*5] M. Kurata-Nishimura,[*2] S. Ota,[*6] H. Otsu,[*2] A. Peyaud,[*1] E.C. Pollacco,[*1] G. Prono,[*1] H. Sakurai,[*2] M. Sasano,[*2] E. Takada,[*7] H. Tokieda,[*6] T. Uesaka,[*2] K. Yoneda[*2] and J. Zenihiro[*6]

MINOS[1)] is a new device aimed at the in-beam spectroscopy of very exotic nuclei by proton-knockout at the RIBF facility. It is composed of a thick liquid hydrogen target[2)] (10-20cm) to maximize the luminosity surrounded by a cylindrical Time Projection Chamber equipped with a bulk-Micromegas[3)] pad detection plane. The latter allows to track the recoiled protons and thence apply a Doppler correction to the gamma rays measured by a gamma array such as DALI2[4)] at RIBF. As a final phase in the development of MINOS, a full in-beam test of the TPC and of its electronics system was performed at HIMAC in October 2013.

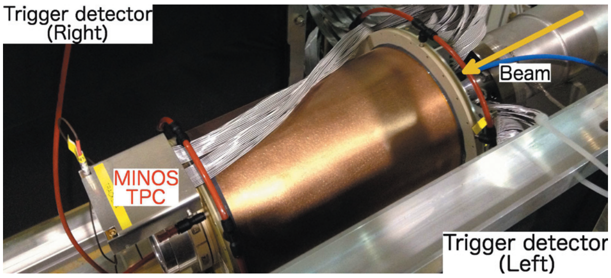

Fig. 1. MINOS experimental setup during the in-beam test using the PH2 course in HIMAC facility.

In this experiment, fragmentation reactions including $(p, 2p)$ were produced using a beam of ^{20}Ne at 350 and 180 MeV/u impinging on 0.5 mm thick CH_2 or C targets placed inside the beam pipe instead of the LH_2 target. Beam detectors were placed upstream and downstream for both tracking and trigger purposes. As no particle identification was provided after the detector, two layers of plastic scintillators were placed on the left and right of the MINOS TPC to select events with charged particles passing through the device. A picture of the experimental setup is shown in Fig. 1.

The MINOS detector composed of about 4864 channels was for the first time read out with the electronics system constituted of front-end cards from the T2K experiment equipped with AFTER chips and of the newly-developed Feminos cards. The MINOS data acquisition was also successfully coupled to the RIBF data acquisition[5)] which handled the triggers and beam detectors information.

The use of two different gas mixtures (Ar+5%C_4H_{10} and Ar+3%C_4H_{10}+15%CF_4), several TPC voltages and two distinct detection pad geometries during this test also enabled a characterization of the TPC with track dispersion, gain as well as drift velocity changes on experiment-like data.

Eventually, this experiment tested the TPC vertex position resolution and its efficiency. The development of a tracking software for MINOS was carried out with the use of Hough filters, first to select the two-particle-like events in the two-dimensional detection plane and then to filter off the noisy signals in the tracks in three dimensions, before fitting the final tracks to obtain the vertex position. A full-width-half-maximum resolution around 5 mm in the beam direction was obtained with the ^{20}Ne beam at 350 MeV/u and the CH_2 targets, as shown on the right side of Fig. 2.

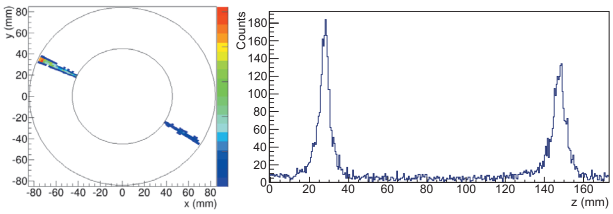

Fig. 2. (Left) Two-proton-like event. (Right) Reconstructed vertex position in the beam direction for a ^{20}Ne beam at 350 MeV/u and two 0.5 mm thick CH_2 targets separated by 124 mm.

Full-scale GEANT4 simulations are also being carried out for comparison to experiment in terms of efficiency as the final step in the validation of MINOS [6)]. This in-beam measurement at HIMAC opens the way to the upcoming physics experiments foreseen in Spring 2014 with the first physics results of the MINOS detector.

*1 CEA Saclay, IRFU/Service de Physique Nucléaire
*2 RIKEN Nishina Center
*3 RCNP, Osaka University
*4 IPN Orsay
*5 Tokyo Institute of Technology, Department of Physics
*6 CNS, The University of Tokyo
*7 NIRS-HIMAC

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