Energy dependence of π^- differential cross section in ^{28}Si + In with beam energies of 400, 600, and 800

M. Sako,[*1*2] T. Murakami,[*2] Y. Ichikawa,[*2] K. Ieki,[*4] Y. Ikeda,[*4] S. Imajo,[*2] T. Isobe,[*1] S. Ebesu,[*2] M. Matsushita,[*6] J. Murata,[*4] Y. Nakai,[*1] S. Nishimura,[*1] M. Nitta,[*4] H. Sakurai,[*1*6] R. Sameshima,[*2] E. Takada,[*3] and K. Yoshinaga[*5]

Information on the nuclear equation of state (EoS) within a broad density range is important for understanding the physics of neutron stars. However, the isospin-dependent term in EoS, i.e., the density dependence of the symmetry energy $E_{sym}(\rho)$ has a large model dependence in the supra-normal density region ($\rho > \rho_0$, the saturation density $\rho_0 \cong 0.16 fm^{-3}$). As a result, the relationship between the radius and the mass of a neutron star cannot be reliably calculated. According to a transport model calculation (IBUU04),[1] detailed studies of the pion yield ratio, $Y(\pi^-)/Y(\pi^+)$, in central nucleus-nucleus collisions at intermediate energies can be conducted to obtain significant constraints on $E_{sym}(\rho)$ in the supra-normal density region.

The IBUU04 predicts that the beam energy dependence of the pion yield ratio is strongly related to the behavior of $E_{sym}(\rho)$ in the supra-normal density region.[1] We performed a series of experiments using 400, 600, and 800 MeV/nucleon ^{28}Si beams accelerated at the Heavy Ion Medical Accelerator in Chiba (HIMAC) and an In target with a compact centrality filter and a pion range counter(RC)[2].

The π^+ events can be clearly identified by the $\pi^+ \rightarrow \mu^+ + \nu_\mu$ decay after they are stopped at the RC.[3] The π^- events were selected using ΔE_i-ΔE_j (energy deposition at each layers of RC) correlations obtained experimentally for π^+ events, because in-flight energy depositions are same between the π^+ and π^- events. However, a pionic atom, which is created by the stopped π^- and surrounding nuclei, decays various particles and some of them hit the next counter. Next we estimated a π^- leak rate to the next counter.

The leak rate α at which the decayed particles hit the next elements was estimated with CsI(^{129}Xe,$\pi^\pm$)X experimental data at 90° for which, the statistics is sufficient and the S/N ratio is large. We obtained a typical value of α, $10.83^{+0.81}_{-0.59}$(SYS) %. For obtaining the production cross section of the π^-, the reduction rate by the decay in flight, nuclear reaction, and multiple Coulomb scattering until the π^- reaches the RC from the production point was estimated using Geant4.

The Lorentz-invariant cross sections of the π^- as a function of the kinematic energy of the π^- in a mid rapidity frame E_{mid} (the CM frame of NN) were shown at Figure 1. Further analysis of the π^- and efforts to fix the systematic uncertainties are in progress.

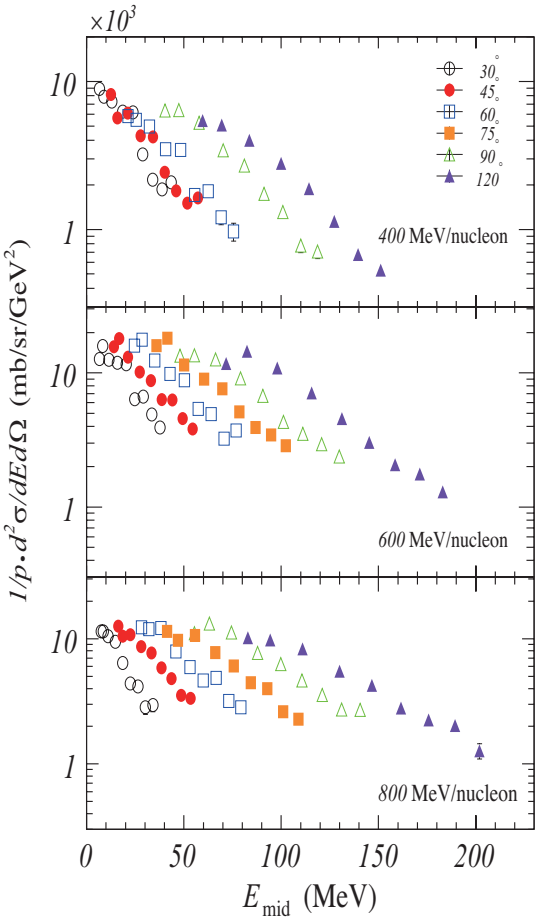

Fig. 1. Lorentz-invariant cross sections of the π^- as a function of kinematic energy in the mid-rapidity frame (E_{mid}) for In(^{28}Si,$\pi^\pm$)X reaction with 400(top part), 600(middle part) and 800(bottom part) MeV/nucleon beam with statistical errors.

*1 RIKEN Nishina Center
*2 Department of Physics, Kyoto University, Kyoto
*3 Department of Accelerator and Medical Physics, NIRS
*4 Department of Physics, Rikkyo University, Tokyo
*5 Department of Physics, Tokyo University of Science
*6 Department of Physics, University of Tokyo

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