Performance of the SπRIT Time Projection Chamber

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The goal of the SAMURAI Pion-Reconstruction and Ion-Tracker Time-Projection Chamber (SπRIT-TPC)[1)] project is to constrain the symmetry energy term in the nuclear-matter equation of state (EOS) at super-saturation density. We propose the comparison of π^-/π^+ production ratio among various isospin asymmetry systems through several combinations of unstable Sn beams and stable Sn targets inside the SAMURAI magnet. A commissioning run using a ^{132}Sn beam impinging on a natural tin target was performed in April 2016, immediately before the pion ratio experimental campaign of May 2016. This included four beams (^{132,124,112,108}Sn) on two different targets (^{124,112}Sn) and a cocktail beam consisting of p, d, t, ^{3}He, ^{4}He, and ^{6}Li particles used to calibrate the gain of the detector. For the commissioning experiment, the SπRIT-TPC was placed inside the SAMURAI magnet and lined up at 0° with respect to the beamline. The secondary ^{132}Sn beam impinged on a 0.5 mm natural tin foil target mounted on a ladder in front of the TPC field cage window. The complete version of the SπRITROOT analysis framework was officially deployed and tested for the first time. The three plots on the right side of Fig. 1 show the pad-plane view (with 12096 pixels) of examples of collision on target (top and middle) and active-target (bottom) events. Two spiral trajectories can be observed in the first two panels and are identifiable as rare low-energy π^- particles, which curve in the opposite direction from the positively charged ions. In the bottom panel, an active-target collision event between the ^{132}Sn beam and the gas molecules filling the volume of the TPC is shown, where the reaction vertex can be visually identified inside the TPC. In all of them, the saturation effects of the electronics caused by high-Z particles and the beam passing through the target can be observed in the center region of the pad plane (red pads). The left plot of Fig. 1 shows the particle identification spectra of particles emitted from the ^{132}Sn+^{nat}Sn collisions and detected in the TPC. The reaction vertex was extrapolated from reconstructed tracks event by event. About 30% of the events have one reconstructed vertex inside the TPC volume in active-target-like collision events. Of the remaining events, 85% have a reconstructed vertex within 5 mm from the target position along the beam axis. The average track multiplicity per event is 45 with the distribution shape affected by the multiplicity selection criteria in the multiplicity trigger arrays. Preliminary reconstruction efficiencies due to the geometry of the TPC have been estimated from Monte Carlo simulation to be above 90% for charged particles of momenta up to 2000 MeV/c in the range $[-60, 60]$ and $[-70, 70]$ degrees for polar and azimuthal angles, respectively. The expected momentum resolution is estimated to be a few percent by using GEANT4 simulation to model the TPC. The lower limit in the reconstructed pion momenta is about 30 MeV/c. With the ongoing improvement of the tracking and fitting algorithms of the SπRITROOT analysis package the final efficiencies will be determined at a later stage. The success of the first commissioning of SπRIT-TPC inside the SAMURAI magnet and the pion ratio experiments performed in May 2016 are the basis of future proposals for the physics program of constraining the symmetry energy term in the nuclear-matter equation of state (EOS) at super-saturation density.

This work is supported by the U.S. DOE under Grant Nos. DE-SC0004835, DE-SC0014530, DE-NA0002923, US NSF Grant No. PHY-1565546, the Japanese MEXT KAKENHI grant No. 24105004, and by the Polish NSC Grants UMO-2013/09/B/ST2/04064 and UMO-2013/10/M/ST2/00624.

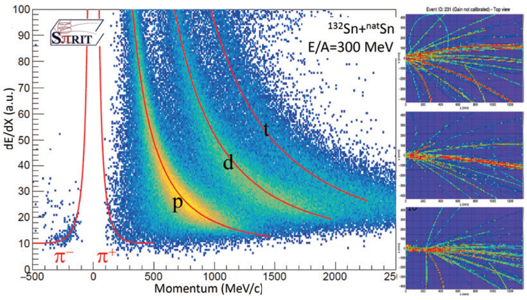

Fig. 1. Commissioning of the TPC with the ^{132}Sn radioactive beam: particle identification map (left) and pad-plane track projections for three sample events (right).

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Reference

1) R. Shane et al., Nucl. Instr. Meth. A **784**, 513 (2015).