

Performance of the S π RIT Time Projection Chamber

G. Cerizza,^{1,2} J. W. Lee,³ G. Jhang,^{2,3} J. Barney,^{1,2} J. Estee,^{1,2} T. Isobe,² M. Kaneko,^{2,4}
M. Kurata-Nishimura,² P. Lasko,^{2,5,6} J. Łukasik,⁵ W.G. Lynch,¹ A.B. McIntosh,⁷ T. Murakami,^{2,4}
P. Pawłowski,^{2,5} K. Pelczar,⁶ H. Sakurai,² C. Santamaria,^{1,2} R. Shane,¹ M. B. Tsang,¹ S.J. Yennello,⁷
Y. Zhang,^{2,8} and the S π RIT and NeuLAND collaborations

The goal of the SAMURAI Pion-Reconstruction and Ion-Tracker Time-Projection Chamber (S π RIT-TPC)¹⁾ project is to constrain the symmetry energy term in the nuclear-matter Equation of State (EOS) at super-saturation density. It is proposed to compare π^-/π^+ production ratio among various isospin asymmetry systems through several combinations of unstable Sn beams and stable Sn targets inside the SAMURAI magnet. The commissioning run using a ^{132}Sn beam impinging on a natural tin target was performed in April 2016, right before the pion ratio experimental campaign of May 2016, consisting of four beams ($^{132,124,112,108}\text{Sn}$) on two different targets ($^{124,112}\text{Sn}$), along with a cocktail beam, consisting of p, d, t, ^3He , ^4He , and ^6Li particles, used to calibrate the gain of the detector. For the commissioning experiment the S π RIT-TPC was placed inside the SAMURAI magnet and lined up at 0° with respect to the beamline. The secondary ^{132}Sn beam impinged on the 0.5 mm natural tin foil target, mounted on a ladder in front of the TPC field cage window. The complete version of the S π RITROOT analysis framework was officially deployed and tested for the first time. In this dedicated beam commissioning, the presence of the SAMURAI magnetic field allowed particle identification. The three plots on the right side of Figure 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 a 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 noticed in the center region of the pad plane (red pads). The left plot of Figure 1 shows the particle identification spectra of particles emitted from the $^{132}\text{Sn}+^{nat}\text{Sn}$ 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% of them have a reconstructed vertex found within 5 mm around 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 S π RITROOT analysis package the final efficiencies will be determined at a later stage. The success of the first commissioning of S π RIT-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.

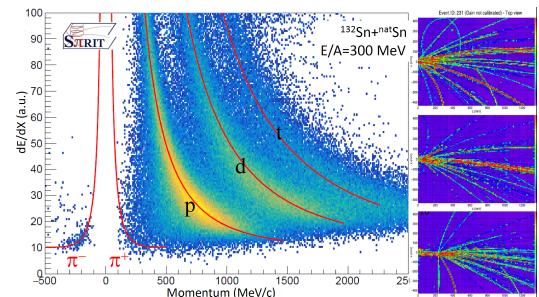


Fig. 1. Commissioning of the TPC with the ^{132}Sn radioactive beam: particle identification map (left) and pad-plane track projections for three sample events (right).

References

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

*1 NSCL and Dept. of Phys. & Ast., Michigan State University
*2 RIKEN Nishina Center
*3 Department of Physics, Korea University
*4 Department of Physics, Kyoto University
*5 IFJ PAN, Kraków
*6 Jagiellonian University, Kraków
*7 Cyclotron Institute, Texas A&M University
*8 Department of Physics, Tsinghua University