Measurement of Pion Multiplicities in Asymmetric Sn Reactions Using the SπRIT Time Projection Chamber

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Determination of the nuclear Equation of State (EOS) is of fundamental importance in nuclear physics. To constrain the symmetry energy term of the EOS at supra-saturation density, a series of measurements were proposed with neutron rich and neutron deficient Sn isotopes at about 300 MeV/U. Experimental observables include pion production, n vs. p emission and differential flow, and t and ^{3}He emission. An international collaboration initially started and funded by the groups from Michigan State University, Kyoto University, and RIKEN, which was later joined by collaborators from Korea, Poland, and China, completed the construction of the SπRIT Time Projection Chamber (TPC)[1)], designed to measure pions as well as light charge particles emitted in heavy ion collisions.

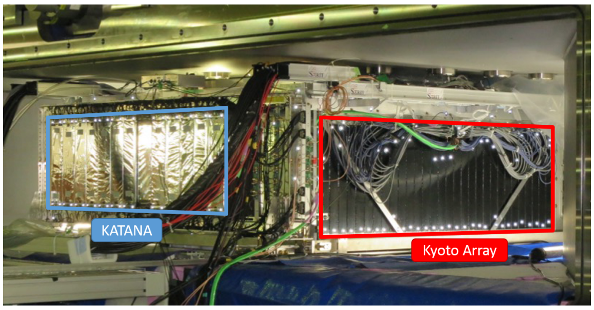

Fig. 1. The SπRIT TPC inside the SAMURAI magnet with ancillary detectors outlined.

Figure 1 shows the experimental set up, including some ancillary devices. The Kyoto Array, consisting of two arrays of 30 scintillators each, are positioned on the beam left and beam right sides of the TPC, while the Krakow Array for Triggering with Amplitude discrimiNAtion (KATANA)[2)], consisting of 12 thick scintillators and three veto paddles, is positioned on the downstream side. Three KATANA beam veto scintillator paddles are used to reject unreacted beam particles. A veto collimator with 2x2 scintillators (not shown) is positioned 22 cm upstream of the target to reject beam particles which do not hit the target. The trigger condition requires a multiplicity of 4 or greater in the Kyoto Array, enhancing central collision events. The NeuLAND neutron detection system (not shown) is used to measure neutrons emitted in the reactions.

The 2016 run of the SπRIT TPC is shown in Tab. 1. A commissioning run was performed in April 2016 with the TPC inside the SAMURAI spectrometer at the 0° configuration, set to 0.5 T. A ^{132}Sn secondary beam was impinged on a 0.5 mm thick natural Sn target. The dedicated commissioning run inside the SAMURAI magnet allowed particle identification with the complete version of the SπRITROOT analysis framework. The first experiment consisted of neutron deficient ^{108}Sn and stable ^{112}Sn secondary beams impinging on 0.836 mm thick ^{112}Sn and 0.828 mm thick ^{124}Sn targets, respectively. The second experiment consisted of neutron rich ^{132}Sn and stable ^{124}Sn secondary beams impinging on 0.828 mm thick ^{124}Sn and 0.836 mm thick ^{112}Sn targets, respectively. Additionally, a cocktail beam of charge $Z = 1-3$ was produced at 100 and 300 MeV/U, providing reference points to calibrate the energy loss measurements with the TPC.

Table 1. Spring Campaign with the SπRIT TPC

Beam	Reaction Target	Triggered Events
^{132}Sn	^{nat}Sn	$\sim 2.0\times10^6$
^{108}Sn	^{112}Sn	$\sim 1.0\times10^7$
^{112}Sn	^{124}Sn	$\sim 5.9\times10^6$
^{124}Sn	^{112}Sn	$\sim 5.3\times10^6$
^{132}Sn	^{124}Sn	$\sim 1.0\times10^7$
Z=1-3 cocktail	No Target	$\sim 6.8\times10^5$

Over 250 TB of data were collected in the 2016 experimental campaign, and analysis of this data is ongoing. The experiment represents a new measurement to constrain the symmetry energy term of the EOS.

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References

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