Constraining the EoS with heavy ion collisions and the SπRIT time projection chamber

W. G. Lynch*1 for the Spirit Collaboration

In 2024, the SπRIT time projection chamber was installed within the SAMURAI spectrometer, where it measured ^{124}Xe + ^{112}Sn and ^{136}Xe + ^{124}Sn collisions at $E/A \approx 320$ MeV. The focus of this new SAMUARI63 campaign of the SπRIT collaboration is on improving our current SπRIT constraints on the nuclear symmetry energy at supra-saturation densities. Our current SπRIT constraints are based on analyses of SπRIT pion measurements[1)] and collective flow measurements[2)] that were obtained in the first SπRIT experimental campaign. To extend these SπRIT constraints at $\sim 1.4\rho_0$ to a wide density range, we combined these SπRIT constraints with other existing experimental and astronomical constraints at lower and higher densities to constrain the equation of state (EoS) for neutron stars at densities of $0.3 < \rho/\rho_0 < 3$,[3)] where $\rho_0 = 2.6 \times 10^{14}$ g/cm^3 is the central density of nuclei.

The use of stable beams enabled measurements pion production and flow at higher incident energies. Measurements at higher energies enable us to probe higher densities at RIBF. Higher energies increase the rates for Δ isobar production and decay and increase the precision of our EoS constraints. They also reduce the relative contribution of non-resonant pion production during these heavy ion collisions, reducing the theoretical uncertainties that non-resonant pion production contributes to the theoretical models that we employ.

A total of six million central and mid-central ^{124}Xe + ^{112}Sn collisions were measured in June 2024, and six million central and mid-central ^{136}Xe + ^{124}Sn collisions were measured in November 2024, providing the data we require for our EoS studies of pion production and collective flow. Figure 1 shows a low statistics run of about 10000 events for the latter reaction. This figure shows the measured energy loss for particles as a function of their magnetic rigidity for a normal data taking run. The observed particle lines are consistent with the TPC performance obtained during the first campaign. This consistency means that we are on track to obtain early results within a year.

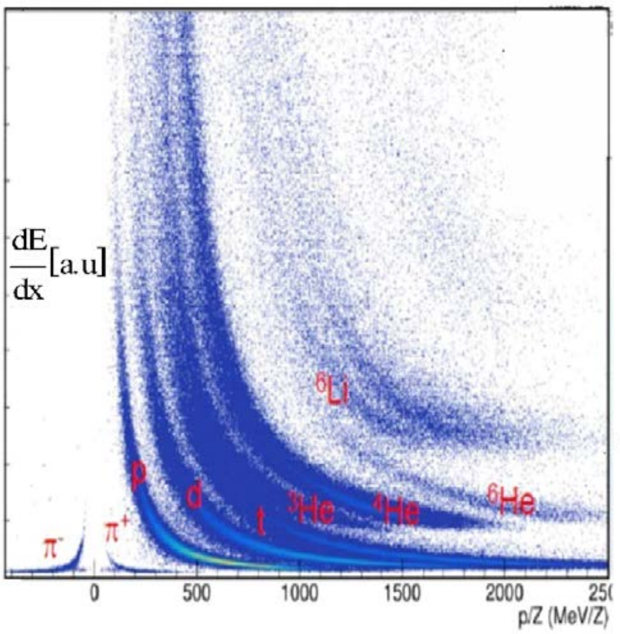

Fig. 1. Particle identification: ^{136}Xe + ^{124}Sn collisions.

References
1) J. Estee *et al.*, Phys. Ref. Lett. **126**, 162701 (2021).
2) C. Y. Tsang *et al.*, Phys. Lett. B **853**, 138661 (2024).
3) C. Y. Tsang *et al.*, Nature Astronomy **8**, 328 (2024).

*1 FRIB & Department of Physics and Astronomy, Michigan State University

DOI:10.34448/RIKEN.APR.58-242