

# International workshop on “Equation of State of Dense Nuclear Matter at RIBF and FRIB”

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The international workshop of “Equation of State of Dense Nuclear Matter at RIBF and FRIB” was held on 23rd and 24th May, 2023. This workshop is primarily focused on physics at RIBF and FRIB that can be probed using high intensity beams like Equation of State (EoS) of neutron stars as well as fission. In this workshop, the following topics are covered

- neutron star
- nuclear symmetry energy and equation of state
- heavy ion collision
- transport model
- nuclear fission

Determination of nuclear EoS is among the most important research topics as it is crucial to understand the internal structure of neutron star, dynamics of neutron star merger (NSM), and  $r$ -process nucleosynthesis in NSM. Recent experiments with heavy-ion and rare isotope beams from low to ultra-relativistic energies, coupled with multi-messenger observations of neutron stars and their mergers, have facilitated significant progresses in understanding various aspects of the nuclear matter EoS. This workshop aimed to review the current understanding of density and isospin asymmetry  $\delta = (\rho_N - \rho_Z)/(\rho_N + \rho_Z)$  dependence of nuclear EoS, and to discuss a strategy for establishing a realistic and reliable nuclear EoS based on accelerator based experiments.

In the workshop, 17 talks comprising 8 theoretical talks and 9 experimental talks were given. In addition, a special session of seminar talk by W. G. Lynch (MSU/FRIB) was allocated on the first day, co-organized with RIBF Nuclear Physics Seminar. In this seminar, the first  $S\pi$ RIT experimental campaign at RIBF was reviewed, and new experimental program measuring collisions at higher incident energies to investigate the open questions were presented.

Nucleus–nucleus collisions are the only means to experimentally probe the nuclear EoS at supra-saturation densities and determine its dependence on density and  $\delta$ . The first  $S\pi$ RIT experimental campaign at RIBF has provided charged pion data,<sup>1)</sup> which constrains the EoS and other transport phenomena at densities of approximately  $\rho = 1.4 - 1.5 \rho_0$ . The possibility of combining  $S\pi$ RIT results with other experimental and astronomical measurements was discussed. A Bayesian analysis shows the constraint on the nuclear EoS at densities of  $0.2 \rho_0 < \rho < 3 \rho_0$ .

The international workshop on the experimental device of Time Projection Chamber (TPC) was held one week before this workshop. TPC was employed by  $S\pi$ RIT experiment, which is typical device for the measurement of multiple charged particles produced in heavy ion collisions. A review of TPC workshop was presented such that a discussion on the next generation experimental program could be triggered.

The number of participants was 47: 21 from Japan, 12 from USA, 6 from China, 3 from Korea, and 1 from Thailand, Italy, Poland, Germany, Romania each. Figure 1 shows the group photograph taken during RIBF tour in front of  $S\pi$ RIT TPC. The details of the symposium program can be found in Ref. 2).

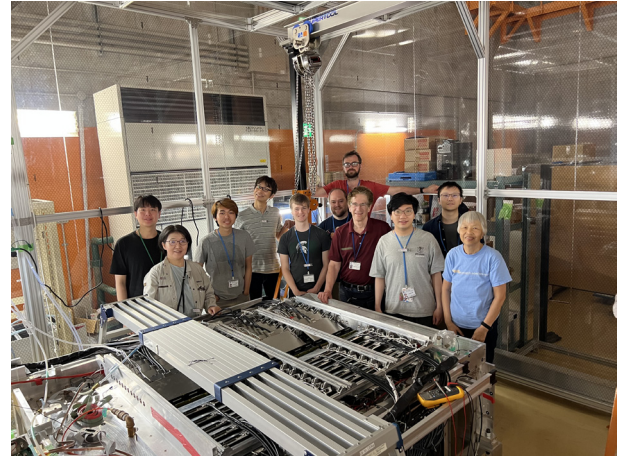


Fig. 1. Group photograph of RIBF tour in front of  $S\pi$ RIT TPC located at RIBF-SAMURAI area.

## References

- 1) J. Estee *et al.*, Phys. Rev. Lett. **126**, 162701 (2021).
- 2) <https://indico2.riken.jp/event/4449/>.

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