Preparation for very-forward particle measurements in RHICf-II experiment

M. H. Kim*[1] for the RHICf-II Collaboration

In June 2017, the RHIC-forward (RHICf) experiment[1)] measured the very-forward neutral particles in polarized $p + p$ collisions at $\sqrt{s} = 510$ GeV by installing an electromagnetic calorimeter (RHICf detector) 18 m downstream of the STAR experiment. The RHICf experiment has two experimental goals. The first one is the cross-section measurement to constrain the hadronic interaction model, which is necessary to study the origin of ultra high-energy cosmic-rays.[2)] The other one is the transverse single spin asymmetry (A_N)[3)] measurement to understand the spin-involved production mechanism.

The first result[4)] of the RHICf experiment showed non-zero A_N of the very forward π^0, which shows a possibility of the diffractive contribution to the A_N of π^0. To study the underlying interaction of the first result in more detail and also measure various particles, a follow-up experiment, RHICf-II, is being prepared.

Compared to the RHICf experiment, the RHICf-II experiment will be performed at $\sqrt{s} = 200$ GeV. The A_N of the very-forward π^0 at $\sqrt{s} = 200$ GeV and 510 GeV will be compared for testing the x_F scaling at the different energies using the correlation with the STAR detectors. The RHICf-II experiment will possibly include polarized proton-nucleus $(p + A)$ collisions. The ultra peripheral collision and the hadronic contributions to the very-forward neutron A_N in polarized $p + A$ collisions[5)] can be studied in more detail with wider p_T coverage. We will also measure the A_N of the very-forward π^0 in polarized $p+A$ collisions for the first time to study the relation between the very-forward π^0 and neutron A_N.

We are also planning to measure Λ and K^0_S. Cross-section of K^0_S is an important observable to study the atmospheric neutrino flux background of the cosmic neutrino detection. A_Ns of Λ and K^0_S will enable to extend our understanding of the particle production mechanism because the A_N of Λ is a possible origin of that of the very-forward π^0.

Because the acceptance of the RHICf detector was not enough for Λ and K^0_S measurements, a new larger detector (RHICf-II detector) of 8 cm $\times$ 18 cm size is being developed. With the larger detector, we can measure Λ decay into $n + 2\gamma$ and K^0_S decay into 4γ. Because their particle yields in the RHICf-II detector are expected to be one order of magnitude lower than that of π^0, a trigger logic to more effectively measure Λ and K^0_S is being studied.

We are developing the RHICf-II detector by transferring the technology of the ALICE FoCal-E detector.[6)] Figure 1 shows the longitudinal composition of the ALICE FoCal-E. It is a sampling electromagnetic calorimeter which is composed of tungsten and silicon layers. Each layer is made up of high granularity layer (30 μm $\times$ 30 μm) for position measurement and low granularity layer (1 cm $\times$ 1 cm) for energy measurement. To more effectively measure neutron, the interaction length of the RHICf-II detector will be increased compared to that of the RHICf detector.

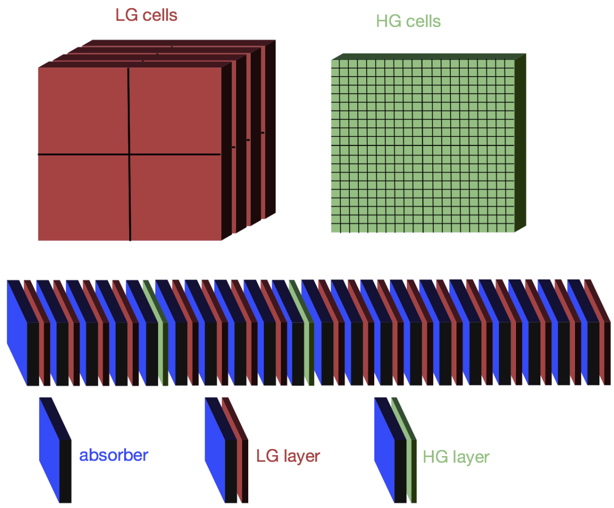

Fig. 1. Longitudinal composition of ALICE FoCal-E detector.[6)]

We are proposing to perform the RHICf-II experiment at STAR in 2024. Currently, we're discussing the detailed plan with the STAR and ALICE FoCal members. Two modules of the ALICE FoCal-E will be used to cover the RHICf-II acceptance. A prototype of the first module is being developed now and its full prototype will be prepared in 2022. The other prototype will be prepared in the next year while the first one is in the commissioning.

References

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*1 RIKEN Nishina Center