

# RHICf experiment to measure cross section and asymmetry in very forward neutral particle production at RHIC

T. Sako\*<sup>1</sup> for the RHICf Collaboration

The origin of cosmic rays is a long-standing mystery in astrophysics. To determine the energy and particle type of the primary cosmic ray from the observed air shower particle distributions, we rely on the Monte Carlo simulation of air showers. However, the lack of knowledge in hadronic interaction modeling results in uncertainty in this interpretation. To understand this process, the Large Hadron Collider forward (LHCf) experiment<sup>1)</sup> measured forward particle production at the LHC up to the particle energy in a fixed target setting of  $9 \times 10^{16}$  eV ( $\sqrt{s}=13$  TeV). LHCf reported a scaling of  $\pi^0$  production spectra at  $\sqrt{s}=2.76$ , and 7 TeV proton-proton collisions<sup>2)</sup>; in addition, it continues analyzing 13 TeV data. To confirm the scaling or its violation in a wider energy range and to extrapolate the knowledge beyond the LHC energy range, the RHICf collaboration was launched.

Another mystery in forward particle production, single transverse-spin asymmetry (SSA), was found in the RHIC experiments<sup>3)</sup>. It is believed that the SSA in neutron production originates from the interference between the amplitudes of spin-flip pion exchange and non spin-flip meson exchange. SSA can shed light on the fundamental process of forward particle production and improve our understanding of air shower development. The excellent position resolution of the RHICf detector improves the measurement accuracy of SSA and enables us to test the proposed mechanism<sup>4)</sup>.

For RHICf, an LHCf detector is installed in front of the zero degree calorimeter of the STAR experiment,

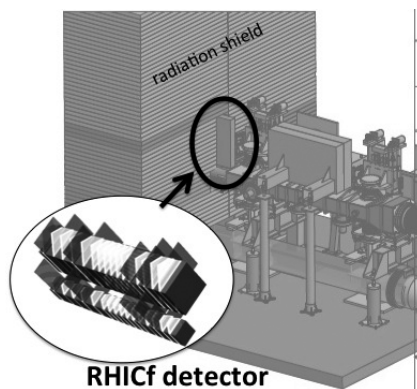


Fig. 1. CAD drawing of the RHICf installation. The RHICf detector can fit in the narrow slot of the radiation shield near the STAR interaction point.

\*<sup>1</sup> Institute for Space-Earth Environmental Research / Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, Nagoya University

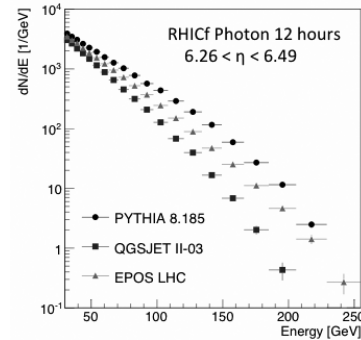


Fig. 2. Expected photon spectra observed in 12h operation for three different hadronic interaction models.

as shown in Fig.1<sup>5)</sup>. The proton-proton collisions with  $\sqrt{s}=510$  GeV at the RHIC enable RHICf to study particle production at the cosmic-ray equivalent energy of  $1.4 \times 10^{14}$  eV. Figure 2 shows the expected photon spectra observed in RHICf operation for 12h. It is found that the statistical errors are negligibly small with respect to the difference between predictions by three major hadronic interaction models. RHICf will also measure spectra, or differential cross sections, of  $\pi^0$ 's and neutrons. In neutron measurement, RHICf has a position determination resolution better than 1 mm<sup>6)</sup>, while the former SSA measurements were performed with 10 mm resolution.

Although the original plan for RHICf was to operate it in the PHENIX site<sup>7)</sup>, according to the long-term plan of RHIC, RHICf was finally approved by PAC in 2015 to be operated in 2017 with STAR. The detailed plan of installation, commissioning, and data collection were intensively discussed with the STAR team in 2015. The STAR and RHICf teams have exchanged an MOU in early 2016.

## References

- 1) LHCf Technical Design Report, CERN-LHCC-2006-004.
- 2) O. Adriani et al.: PRD received, arXiv:1507.08764 [hep-ex].
- 3) Y. Fukao, M. Togawa, et al.: Phys. Lett. B **650**, 325 (2007).; PHENIX Collaboration, Phys. Rev. D **88**, 032006 (2013).
- 4) B. Z. Kopeliovich, I. K. Potashnikova, I. Schmidt, and J. Soffer: Phys. Rev. D **84**, 114012 (2011).
- 5) RHICf Collaboration, LOI, arXiv:1401.1004; proposal, arXiv:1409.4860.
- 6) K. Kawade et al.: JINST, **9** P03016 (2014).
- 7) Y. Goto for the RHICf Collaboration: RIKEN Accel. Prog. Rep. **48**, 107 (2015).