DAQ performances of the RHICf operation in 2017

H. Menjo[*1,*2] and K. Sato[*2,*3] for the RHICf collaboration

The RHIC forward (RHICf) experiment,[1] measuring very forward neutral particles, photons, neutrons, and π^0 s, produced in 510 GeV proton-proton collisions at RHIC, has successfully completed a 4-day operation in June 2017. The data acquisition (DAQ) system of the RHICf experiment was developed based on the system of the LHCf experiment[2] as well as the detector. The RHICf detector consists of two sampling and imaging calorimeters. Each calorimeter is composed of tungsten plates, 16 layers of GSO scintillators and 4 X-Y hodoscopes of GSO bar bundles. Trigger signals are generated by a logic based on the energy deposit on the scintillator layers, which is implemented on a system with discriminator modules and a field programmable gate array (FPGA) board.[3] In the logic, three trigger modes were implemented as follows;

- **Shower trigger** is implemented for detecting any electromagnetic (EM) showers and hadronic showers induced by photons and neutrons. This trigger is issued when each of any three successive layers has an energy deposit greater than 45 MeV.
- **π^0 trigger** is specialized to detect photon pairs from π^0 decays. This trigger is issued when EM showers are detected in both the calorimeters simultaneously.
- **High-EM trigger** is newly introduced for the RHICf experiment to increase the statistics of high-energy photon events ($>$ 100 GeV). The trigger is issued when the 4th layer in either calorimeter has an energy deposit greater than 500 MeV.

These trigger signals were mixed after being pre-scaled down by factors of 8–30 for shower triggers and 1–4 for high-EM triggers. The rate of π^0 triggers is the lowest among the three trigger modes and its pre-scaling factor was always set to 1 (no pre-scaling). The event rates of these triggers strongly depend on the operation conditions such as the detector position with respect to the beam axis. The raw rate of shower triggers was 6–30 kHz, and it was scaled down to approximately 1 kHz after the pre-scaling. These pre-scaling factors were optimized occasionally during the operation to keep the final trigger rate to approximately 1 kHz, which corresponds to the DAQ condition with approximately 50% of the DAQ live fraction. Figure 1 shows the total trigger rate and rates of the three triggers. The rates decreased during an operation period because of the decrease of beam intensity, while the rate suddenly increased in some moments owing to re-optimizations of the pre-scaling factors.

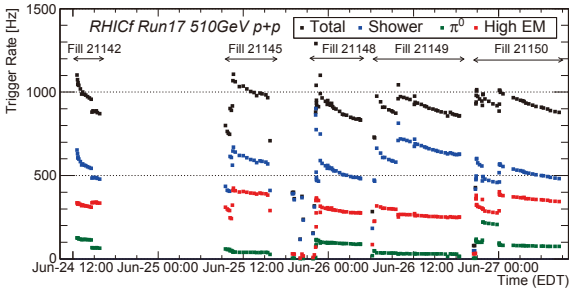

Fig. 1. Trigger rates of the RHICf operation in 2017. The upper arrows indicate the physics operation periods.

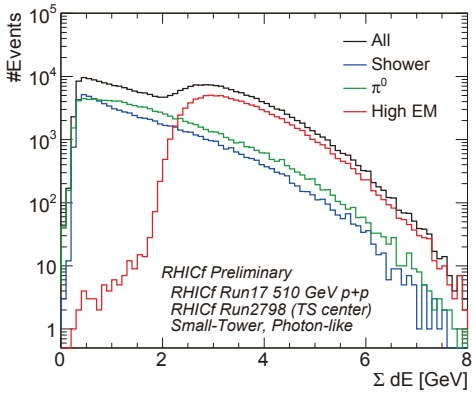

Fig. 2. Spectrum of total visible energy measured by the RHICf calorimeter. Colored lines correspond to spectra obtained from the events triggered by the three modes.

Figure 2 shows the raw spectra of measured total visible energy ΣdE obtained in the EM-shower events. The number of EM showers in the π^0 trigger events is mostly comparable with that in the shower trigger events. The high-EM trigger successfully worked to enrich high-energy EM shower events in the recoded data. The number of photon events in the high-EM-triggered events is larger than that in the shower triggered events by a factor of approximately 10 in the region of ΣdE $>$3 GeV, corresponding to photon energies greater than approximately 100 GeV.

*1 Graduate School of Science, Nagoya University
*2 RIKEN Nishina Center
*3 Institute for Space-Earth Environmental Research, Nagoya University

References
1) RHICf Collaboration: Letter of Intent, arXiv:1401.1004; RHICf proposal: arXiv:1409.4860.
2) LHCf Collaboration: TDR, CERN-LHCC-2006-004.
3) H. Menjo *et al.*, RIKEN Accel. Prog. Rep. **50**, 109 (2017).