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Development of front end electronics for PHENIX RICH

T. Sakaguchi[a], Y. Akiba[b], K. Ebisu[c], S. Frank[d], H. Hamagaki[a], H. Hara[c], R.S. Hayano[e], M. Hibino[f], J.P. Jones[d], S. Kametani[f], J. Kikuchi[f], T. Matsumoto[f], C.G. Moscone[d], S. Nishimura[a], K. Oyama[a,*], K. Shigaki[b], Y. Tanaka[c], T. Ushiroda[c], J.W. Walker[d], A.L. Wintenberg[d], G.R. Young[d]

[a]*Center for Nuclear Study, Graduate School of Science, University of Tokyo, 7-3-1 Hongo, Bunkyou-ku, Tokyo 113-0033, Japan*

[b]*High Energy Accelerator Research Organization, 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan*

[c]*Nagasaki Institute of Applied Science, 536 Amiba-cho, Nagasaki-shi, Nagasaki 851-0193, Japan*

[d]*Oak Ridge National Laboratory, Oak Ridge, TN 37831-6006, USA*

[e]*Department of Physics, Graduate School of Science, University of Tokyo, 7-3-1 Hongou, Bunkyou-ku, Tokyo 113-0033, Japan*

[f]*Advanced Research Institute of Science and Engineering, Waseda University, 17 Kikui-cho, Shinjuku-ku, Tokyo 169-8555, Japan*

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Abstract

A new front-end electronics (FEE) for PHENIX Ring Imaging Cherenkov Detector (RICH) has been developed. It consists of custom-made Backplane, Controller module, Readout module and AMU/ADC module, which are capable of processing signals from 5120 Photo-Multiplier Tubes (PMTs). Several tests have been carried out, and RICH FEE was proved to satisfy the requirement of PHENIX experiment. The charge spectrum due to single photo-electron was successfully observed as well.

1. Introduction

The Ring Imaging Cherenkov detector (RICH) of PHENIX experiment is the primary device for electron identification [1]. It will employ C_2H_6 gas to identify electrons with the momentum up to 3.5 GeV/c or CO_2 gas to identify up to 4.9 GeV/c. The frequency of beam collision is 9.6 MHz, and thus very fast operation is required of the Front-End Electronics (FEE) [2]. The FEE must preserve events occurring in every Beam Crossing (BC) until the decision is made by Level-1 (LVL-1) trigger within 40 BC whether or not to take the event. The LVL-1 trigger reduces events to the average rate of 25 KHz. The specifications required for the FEE of PHENIX RICH are very special, and therefore a new development was needed. This paper comprehensively describes the composition and concept of new FEE for RICH as well as the results using FEE test bench and the charge spectrum of photo-electrons that were recently obtained.

2. Development of FEE for PHENIX RICH

Table 1 shows the specification required for RICH FEE. RICH FEE must handle signals from 5120 Photo-Multiplier Tubes (PMTs) with the

* Corresponding author.

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Table 1
Required specification of RICH FEE

Beam crossing (BC) rate	9.6 MHz
Expected event rate	~ 1 KHz (Au + Au at 100 GeV/n) ~ 1 MHz (p + p at 250 GeV/n)
Maximum LVL-1 rate	25 kHz
Number of channels	5120
Input charge	0–10 photo-electrons (0–160 pC)
Charge resolution	~ 1/20 photo-electron
Time range	0–110 ns (corresponds to 1 BC)
Time resolution	~ 200 ps
Level-1 trigger generation	within 40 BC
Data transferring speed to DCM	~ 1 Gbps

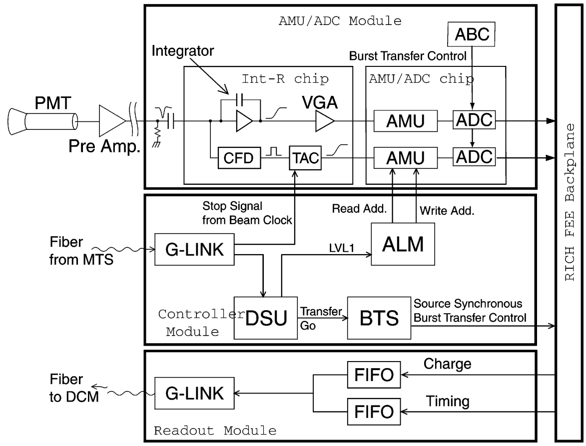

Fig. 1. Block diagram of RICH FEE.

frequency of 9.6 MHz. The acceptable charge range is from 0 to 10 photo-electrons, which corresponds to the input charge from 0 to 160 pC preceded by pre-amplifier. Charge resolution is required to be ~ 1/20 photo-electron and TAC resolution to be ~ 200 ps. In addition, RICH FEE has to be capable of queuing five events that are validated by LVL-1 trigger. To transfer the data to Data Collection Module (DCM) with an average frequency of 25 kHz, the G-link transmitting speed of 1 Gbps from FEE to DCM is needed.

The block diagram of RICH FEE is shown in Fig. 1. The Controller module controls all the function concerning serial setup, burst transfer and Analog Memory Unit (AMU) list manager. AMU/ADC module accepts analog signals from

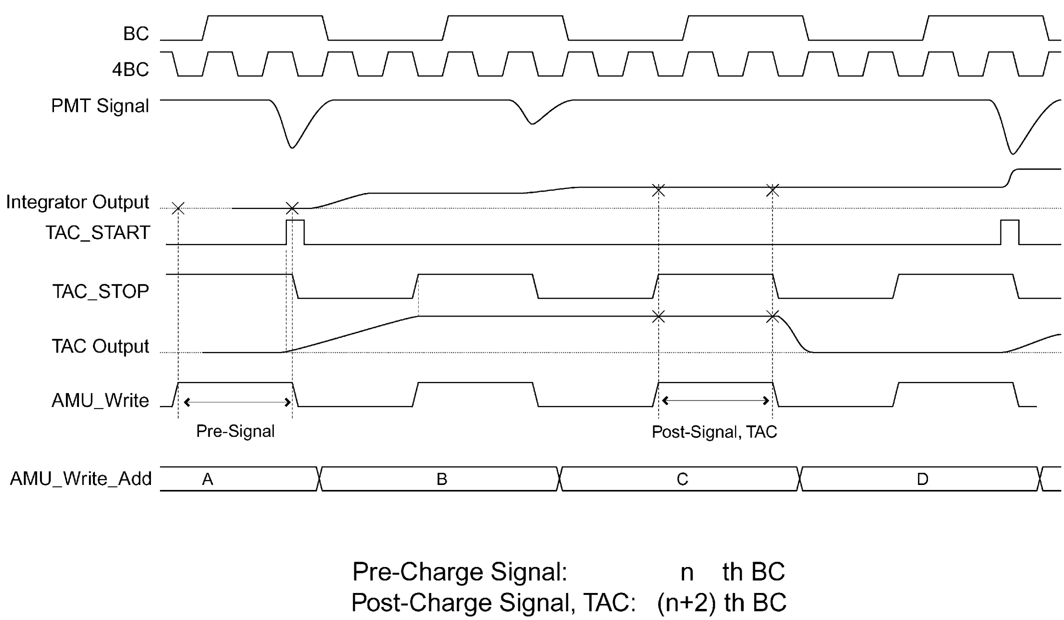

Fig. 2. Data acquisition timing of RICH FEE. The pre- and post-Charge signals are taken with an interval of 1 BC, while TAC signal is taken at the same timing as post-Charge signal.

64 PMTs. It consists of eight Int-R chips [3] that include integrators, Variable Gain Amplifiers (VGAs), discriminators and TACs, and four AMU/ADC chips [4] that include AMUs and ADCs. An Int-R Chip accepts eight inputs from PMTs, and outputs TAC and Charge signals for each channel and charge sum signals for each of the four channels that are used for Local LVL-1. An AMU/ADC Chip handles 32 inputs preceded by four Int-R Chips and preserves them till "LVL-1 accept" is issued by a Controller module. The validated data are then digitized and transferred to the Readout module by AMU/ADC Burst transfer Control (ABC). Readout module receives the digitized data from AMU/ADC module and transfers the data to DCM via G-link. The clock used for transferring data from FIFOs to DCM via G-Link is asyncronous to the one used for other modules.

Fig. 2 shows the data acquisition timing chart of RICH FEE. The pre- and post-samples are taken for Charge measurement to subtract pre-sample from post-sample. This subtraction results in a good reduction of low-frequency baseline noise. The pre-sample is taken prior to the validated event, and post-sample and the TAC sample are taken at the second BC from the pre-sample. It is shown later that subtracting pre-sample from post-sample enabled us to observe the charge spectrum due to a single photo-electron, very precisely.

3. Results of performance tests of RICH FEE

3.1. Basic characteristic test results

Test Bench for testing RICH FEE was developed. It consists of Mini-DAQ developed at Oak Ridge National Laboratory (ORNL), AMU/ADC Test Master (ATM), variable pulse generator, and PC. The test bench is operated with LabView. The ATM simulates all the control signals issued by Master Timing System (MTS) of PHENIX electronics system as well as a trigger to drive the pulse generator. After the generator pulses, the ATM issues a LVL-1 trigger to Controller module via G-Link. The Mini-DAQ receives data processed in RICH FEE, and sends them to a PC. Fig. 3 shows

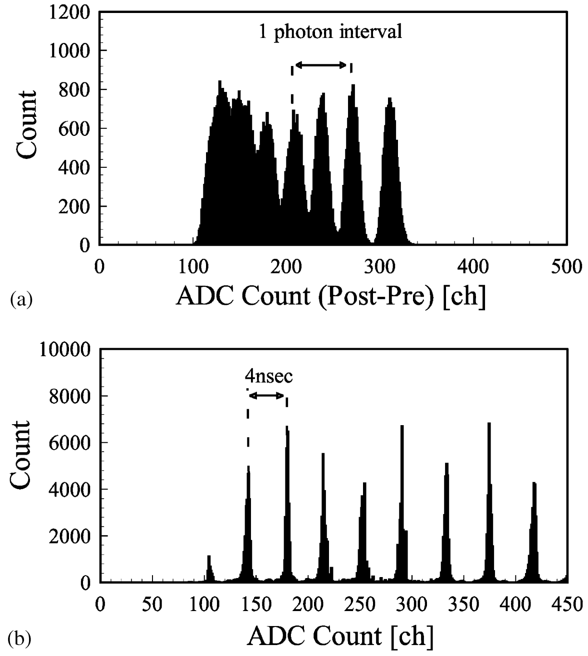

Fig. 3. Test results of RICH FEE by feeding the test pulses with various amplitudes and delay time. Good linearity and resolution are seen.

the results obtained by RICH FEE using the test bench. Both Fig. 3(a) for Charge and Fig. 3(b) for TAC show the good resolutions compared to the interval of each peaks. The resolution of 240 ps for TAC and that of 1/10 photo-electron for Charge are derived, respectively.

3.2. Observation of charge spectrum of photo-electrons

The charge spectrum from a PMT is acquired by RICH FEE as shown in Fig. 4 using the photon emitted from a blue-light LED. The pre- and post-samples of charge have the broad distributions as seen in Figs. 4(a) and (b), respectively. Subtracting pre-sample from post-sample results in very good noise reduction, and thus enables the measurement of the charge spectrum of photo-electron as shown in Fig. 4(c). The spectrum has the peak at around ADC count of 100 ch. It is proved that RICH FEE has enough capability to measure the charge signal of photo-electrons from a PMT.

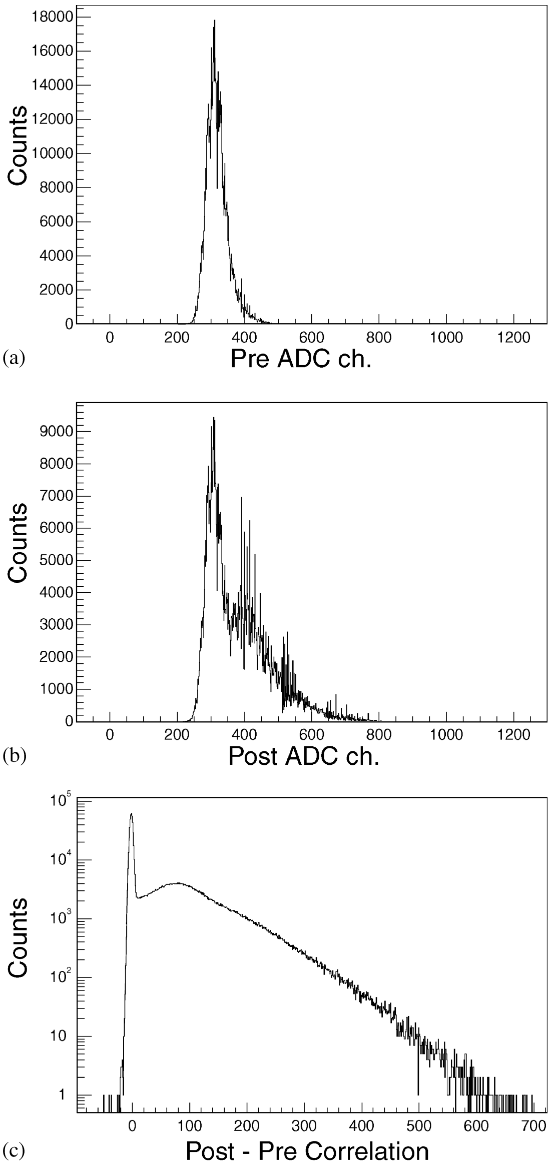

Fig. 4. Charge spectrum derived by RICH FEE. The photon emitted from blue-light LED is detected with a PMT.

4. Conclusion

The RICH FEE has been developed and proved to satisfy the requirements of PHENIX experiment. Timing resolution of 240 ps and charge resolution of 1/10 photo-electron were obtained. The charge spectrum of photo-electrons was successfully observed as well. Mass production of RICH FEE is now in progress, and will be finished by the end of January 2000.

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