Electron Trigger Performance in the PHENIX Run3 Experiment

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1. Introduction

The PHENIX is a unique experiment that can identify individual electrons (the word "electron" represents both of e^+ and e^- in this report) produced in the gold-gold (Au-Au), deuteron-gold (d-Au) and (polarized) proton-proton (p-p) collisions which are provided by the Relativistic Heavy Ion Collider (RHIC) in the Brookhaven National Laboratory (BNL), U.S.A. The measurement of electrons from leptonic decay of heavy flavor quarks (charm and bottom), thermal di-electrons, and electron pairs from decays of light vector mesons are very powerful tools to investigate the properties of hot and dense matter, and to verify the realization of the Quark Gluon Plasma (QGP) in the RHIC-PHENIX Au-Au experiment. Their measurements in p-p and d-Au collisions are crucial to understand the basic production mechanism and nuclear effects. In the polarized p-p experiment, the measurement of electrons from heavy flavored particles is expected to provide the polarized gluon distribution function for the elucidation of spin structure of nucleons.

For the above measurements, the special trigger has been developed in the PHENIX experiment. The Ring-Imaging Čerenkov counter (RICH) and Electro-Magnetic Calorimeter (EMC) are the main devices for electron identification [1] and were used to construct the EMC-RICH Trigger (ERT). The requirement of trigger performance is summarized in Ref. [2]. CNS group has developed the RICH part of the trigger system since 1998. This report presents the performance of the ERT electron trigger in d-Au and p-p collisions at the RHIC Year-3 run (Run3), which were performed from January to May in 2003.

2. The EMC-RICH Trigger (ERT) System

The ERT performs a coincidence between trigger information of the EMC and RICH, which is produced in each Front End Module (FEM) of them. The EMC FEM is capable to trigger an electron when the measured deposit energy is over a threshold in each trigger tile. The non-overlapping tile consists of 36 units of 2×2 = 4 Photomultipliers (PMT) (the trigger tile is called a "super-module", and the unit of 2×2 PMTs is called a "tower" in the PHENIX). The FEM collects signals from a super-module and has six daughter cards (ASIC cards) which hold six MONDO chips [7]. The chip performs energy summation for 4 PMTs of a tower. The total number of super-modules is 172 at present. The programmable threshold can be set at 63 different value (DAC) for each tile separately. If the trigger tile produces noisy signal and the trigger rejection factor becomes low, it is possible to mask off the tile. The RICH FEM is capable to trigger an electron when the measured number of photoelectrons from the Čerenkov ring is over a threshold in each trigger tile. The RICH has 5120 PMTs which form non-overlapping 256 trigger tiles (4×5 = 20 PMTs). The RICH part is described in Refs. [3–6]. The electron trigger is constructed by requiring geometrical coincidences between the EMC and RICH tiles so as to confirm that the tracks penetrate through the same geometrical region.

3. The ERT Operation Status in the Run3

During the Run3, some noisy trigger tiles were found for both of RICH 4×5 and EMC 2×2 by on-line monitoring. They were all masked (RICH; 11.7 %, EMC; 5.20% of each total). The trigger tile status in Run3 is summarized in Ref. [6]. Table 1 gives an overview of the EMC and RICH thresholds used during d-Au and p-p runs. The EMC 2×2 DAC was set to 24 (∼400 MeV), 29 (∼600 MeV) and 34 (∼800 MeV). RICH 4×5 ADC was set to 920 (∼ 3.0 photoelectrons).

Run Number	EMC2×2	RICH4×5
66304 (d-Au)	34(34)	920
67219 (d-Au)	29(29)	920
78312 (d-Au)	34(34)	920
86768 (p-p)	34(34)	920
87618 (p-p)	24(24)	920
89463 (p-p)	34(34)	920

Table 1: The EMC and RICH trigger thresholds in Run3 d-Au and p-p experiment. The DAC for the PbSc (PbGl) and the ADC for RICH threshold are shown.

Two types of triggers were used for electron trigger in the Run3. The first one is named "ERT_Electron&BBCLL1" trigger in which ERT is combined with the PHENIX Minimum Bias (MB) trigger. The MB trigger is constructed by the PHENIX Beam-Beam Counter (BBC) [1]. The second one is called the "ERT_Electron" trigger without the MB trigger coincidence. Table 2 shows the total number of events which were recorded by each trigger in the Run3.

Trigger Name	Run3 d-Au	Run3 p-p
BBCLL1	110,874,637	41,282,805
ERT_Electron&BBCLL1	67,789,443	16,338,345
ERT_Electron	Disabled	16,443,788

Table 2: The number of recorded trigger events in the Run3 d-Au and p-p experiment.

4. The PHENIX Electron Trigger Performance

There are two factors which characterize trigger performances; the rejection factor and trigger efficiency of electrons. The rejection factor is given by the MB raw trigger rate divided by the raw electron trigger rate. Figure 1 shows the run dependence of rejection factor on the ERT_Electron&BBCLL1 in d-Au runs and Figure 2 shows it on the ERT_Electron trigger in p-p runs. Table 3 and 4

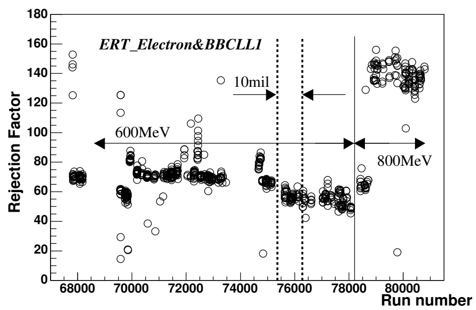

Figure 1: The run dependence of rejection factor in d-Au runs. Only ERT_Electron&BBCLL1 trigger (circle) was used. A 0.25 mm thick photon converter was installed for the indicated runs.

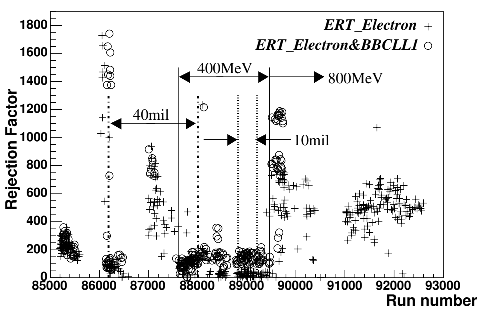

Figure 2: The run dependence of rejection factor in p-p runs. The ERT_Electron&BBCLL1 (circle) and ERT_Electron (squire) trigger were used. 0.25 and 1.00 mm photon converters were installed for the indicated runs.

show the average of rejection factors. The simulation study estimates the ideal rejection factor is ∼700 at the EMC 800 MeV threshold in p-p runs. The actual value got smaller because of appearance of noisy trigger tiles. According to the simulation study [8], the rejection factor is considerably sensitive to changing of the trigger thresholds, especially, the EMC deposit energy threshold. In the Run3, brass photon converters were installed around the Multiplicity Vertex Detector (MVD) [1] (a 0.254 mm thick converter of 1.70% radiation length was installed in d-Au runs. 0.254 mm and 1.00 mm thick converters were installed in p-p runs). Figure 1 and 2 show that the effect of conversion electron enhancement is much smaller than tuning of the EMC threshold. It agrees with the simulation result.

The trigger efficiency is defined by the number of triggered events divided by the number of MB events including electrons. Figure 3 shows the example for the ERT_Electron&BBCLL1 trigger in a particular region (East Sector 2, one-eighth of the PHENIX central detector's acceptance). Each data point in the figure is fitted with the integrated Gaussian function multiplied by a factor which is determined by the fit. The factor can be regarded as the flat efficiency in the high P_T region ($>$1.8 GeV/c). The errors indicated by bars are statistical only. Table 3 includes the factor's average of all the eight sectors at each EMC threshold in d-Au runs. Table 4 shows it for the ERT_Electron trigger in the case of p-p runs. It is found by the off-line analysis that the main source of loss of these efficiencies is attributed to appearance of noisy trigger tiles of the RICH or EMC.

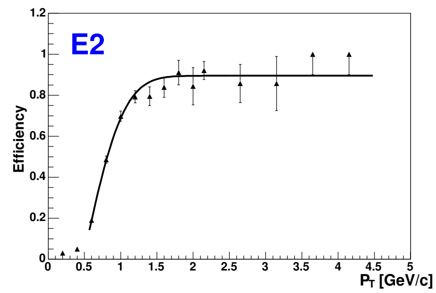

Figure 3: The example of P_T distribution of the ERT_Electron&BBCLL1 trigger efficiency in d-Au runs with the EMC 600 MeV threshold (at the East Sector 2).

Run Type (EMC Threshold)	Rejection	Efficiency
Run3 d-Au (600 MeV)	64.48	73.5 %
Run3 d-Au (800 MeV)	148.1	76.4 %

Table 3: The rejection factor and flat efficiency of the ERT_Electron&BBCLL1 trigger in d-Au runs.

Run Type (EMC Threshold)	Rejection	Efficiency
Run3 p-p (400 MeV)	66.20	73.1 %
Run3 p-p (800 MeV)	504.1	78.5 %

Table 4: The rejection factor and flat efficiency of the ERT_Electron trigger in p-p runs.

References

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[8] https://www.phenix.bnl.gov/WWW/p/draft/xiewei/EMCal-RICH-Trigger/dAu/eff_ana.html (unpublished)