Development of the FVTX high multiplicity trigger system for the PHENIX experiment

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Protons and neutrons, which are the components of familiar substances, are composed of quarks and gluons that bind quarks together. Immediately following the big bang, under extremely high-density and high-temperature conditions, quarks and gluons are considered to escape from the boundary of nucleons. This liquid-like state is called Quark Gluon Plasma (QGP).

The PHENIX group investigates the behavior of matter in such a high-density and high-temperature state produced by collision using Relativistic Heavy Ion Collider (RHIC). In particular, in Au+Au and Pb+Pb collisions, the particle angular correlation exhibits a similar azimuthal pattern throughout the wide range of the rapidity region, referred to as "ridge." The ridge correlation is considered as a consequence of the hydrodynamic flow of products, and it is interpreted as a characteristic of QGP. Certain experiments at the LHC have recently reported that the ridge was observed especially in high-multiplicity events in small colliding systems, such as p+p.[1] Similar ridge phenomena were observed in d+Au and He3+Au at RHIC. However, they have not yet been observed in p+p.

Previous experiments demonstrated high-multiplicity events are the key to observe the ridge in p+p collisions. In PHENIX, the Forward Silicon Vertex Detector (FVTX) is suitable to select such high-multiplicity events since it is the tracker closest to the vertex point. The FVTX trigger design is shown in Fig. 1. The trigger signal is generated on FPGAs implemented on FVTX readout electronics,[2] Front End Module (FEM) and FEM Interface Board (FEM-IB). Using the feature that each FEM corresponds to an azimuthal slice of the FVTX sensor, each FEM judges whether there is any track, following which the FEM-IB counts the number of track flag sent from the FEM, and finally the FVTX trigger fires when the number of track is greater than that of our interest.

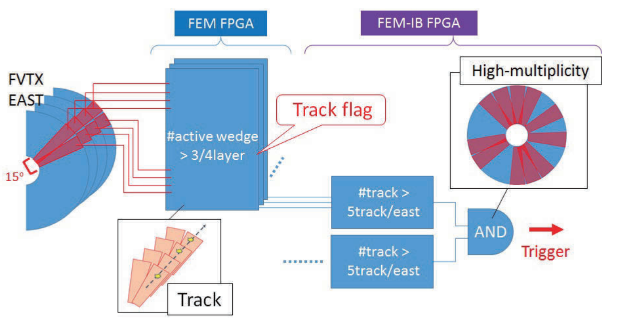

Fig. 1. FVTX trigger design based on the FPGA logic implemented on the readout electronics

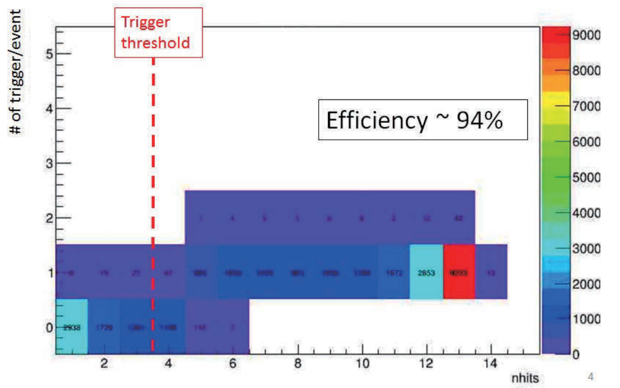

Fig. 2. Correlation between the number of hits and the trigger state

The trigger algorithm in the FEM FPGA was tested through evaluation of the process efficiency depending on the number of hits on the detector. The hits were generated by using a calibration pulse that injects typically 13 strips per detector per event. Fig. 2 shows the correlation between the number of hits per event measured from offline data analysis and the trigger state; the vertical axis shows the trigger flag at an FEM that is supposed to give 1 for the events where the number of hits is greater than the threshold. The efficiency, defined as the number of trigger events divided by the number of events with more hits than the trigger threshold, was 94%, and a few fake triggers were observed.

New serial line cables for FEM - FEM-IB communication were installed in the trigger system, and their signal transmission test was performed. Performance was monitored by scanning the signal rate, and the cables exhibited good performance up to a trigger rate of 4.7 MHz. The timing of the trigger signal was tuned with GL1. It was found that GL1 does not recognize the trigger signal depending on timing. It is adjusted using the BBC trigger signal, which is already used as a trigger.

References
1) V. Khachatryan et al.: CMS Collaboration, JHEP 1009 (2010) 091
2) arXiv:1311.3594v2 [physics.ins-det] 14 Feb. 2014

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