PROCEEDINGS OF SCIENCE

Overview of the Electromagnetic Calorimeter Trigger system at the Belle II Experiment

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We have been developing the trigger system using the Electromagnetic Calorimeter(ECL) which is one of sub-detectors in the Belle II experiment. The ECL trigger system is based on Trigger Cell(TC), and each TC consists of 16 crystals. To make a decision of physics events at an online trigger level, energy deposit in the TC and the event timing are required. Therefore, we have performed the TC energy calibration by a method of comparing the ECL trigger data with the ECL data, and the TC time offset calibration by using a least χ^2 algorithm. We report the calibration method and performance using cosmic ray data.

ICHEP 2018, International Conference on High Energy Physics
4-11 July 2018
Seoul, Korea

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PoS(ICHEP2018)804

1. Introduction

8736 CsI(Tl) scintillating crystals have been used for the Electromagnetic Calorimeter(ECL) in the Belle II experiment. The signal of energy deposition in scintillator is sent to ShaperDSP, then 16 fast-shaping signals from neighboring 4 $\times$ 4 crystals are analog summed. This unit of analog summed signal is called a trigger cell(TC). The TC is a basic unit of ECL trigger system and there are 576 TCs in total. TC signal is processed in FADC Analysis Module(FAM). FAM receives the analog TC signal and digitizes it. Then, By performing a wave form analysis on FPGA, FAM measures TC energy and timing. All FAMs send the TC energy and timing data to ECL Trigger Master (ETM), then ETM generates physics and Bhabha trigger signals.

2. Trigger Cell Calibration

Both TC time offset calibration and energy calibration were performed using cosmic ray data. First, the TC time offset calibration was performed by solving a spontaneous equation $\sum_n \sum_{i\neq j} \frac{t_i'-t_j'}{(\sigma_{i,j}^n)^2} = \sum_n \sum_{i\neq j} \frac{t_i-t_j-TOF_{ij}}{(\sigma_{i,j}^n)^2}$, which is minimizing χ^2. Where, i and j are TC index, n is an event index, σ is time resolution which is a function of TC energy deposition, t$'$ is a time offset which would be obtained, t is a TC timing data and TOF_{ij} is time of flight between two TCs. To prevent high energetic cosmic shower events, which disrupt time offset calibration, only events with energy less than 1 GeV and number of TC hits less than 8 were used. Second, the TC energy calibration was performed by comparing TC amplitude and ECL energy sum. A TC signal amplitude is obtained by a wave form in the FAM, and an ECL energy is sum of offline calibrated crystal energy. When turning on TC threshold in unit of ADC, a fired TC efficiency is a function of ECL energy sum. Efficiency data was fitted to $\frac{1}{2}$(1+erf((x-p_0)/p_1)). Where p_0 is estimated energy corresponding to the TC threshold and p_1 is a parameter related to energy resolution. By iterating this process with different TC threshold, TC energy conversion factor was obtained.

3. Conclusion

TC time offset and TC energy calibrations were performed by using cosmic ray data. The results were used for TC threshold and time offset adjustment during the Phase II run. Now, TC calibration using beam data is under study.

References

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