Data analysis to evaluate the CPPF system in CMS trigger phase-I upgrade

CMS collaboration

Abstract

The CMS Level-1 trigger upgrade system consists of several layers of electronics with a large number of homogeneous cards based on the Micro-TCA(uTCA) standard. The CPPF(Concentration Pre-Processing and Fan-out) system belongs to one of the electronic layers, covering the Muon RPC (Resistive plate chambers) Overlap and Endcap region, and provides preprocessing algorithm for track finding. It includes, in hardware, eight specially designed CPPF cards, one generic CMS card called AMC13, one commercial MCH card, and a Micro-TCA Shelf. Its functionality is realized with five firmware modules: TTC module, optical input module, optical output module, readout module, and a CORE module for cluster finding and transformation. In addition to the firmware functionality, online software is needed for controlling and monitoring each individual CPPF module and the whole CPPF system. This presentation will discuss the data analysis to evaluate the system.
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Abstract

The CMS Level-1 trigger upgrade system consists of several layers of electronics with a large number of homogeneous cards based on the Micro-TCA(uTCA) standard. The CPPF(Concentration Pre-Processing and Fan-out) system belongs to one of the electronic layers, covering the Muon RPC (Resistive plate chambers) Overlap and Endcap region, and provides preprocessing algorithm for track finding. It includes, in hardware, eight specially designed CPPF cards, one generic CMS card called AMC13, one commercial MCH card, and a Micro-TCA Shelf. Its functionality is realized with five firmware modules: TTC module, optical input module, optical output module, readout module, and a CORE module for cluster finding and transformation. In addition to the firmware functionality, online software is needed for controlling and monitoring each individual CPPF module and the whole CPPF system. This presentation will discuss the data analysis to evaluate the system.
Muon trigger system

CPPF system is one of the upgraded Level-1 Muon trigger subsystems, which is response for RPC data in endcap region preprocessing, concentration and fan-out.

The structure of Muon detectors. It includes four layers in z axis, which also be called 'station'. Besides, each station includes 2 or 3 rings in radium.
Data Analysis

- Two offline software routines were developed:
  1. CPPF Unpacker: Converting raw data from CMS Event record into digis. It includes two parts:
     • RPCDigi: For CPPF input data.
     • CPPFDigi: For CPPF output data.
  2. CPPF Emulator: Simulating CPPF algorithm function which includes cluster finding and angle conversion.

Two analyses for CPPF verification have been done:

1. Comparison of CPPF recorded RPC data (input data) with CMS parallel running Legacy system (The Muon part of old trigger system) recorded RPC data in corresponding region, and part of the results are shown in Figure (a), a total agreement of more than 99%.

2. Comparison of CPPF recorded output data (cluster) with CPPF Emulator Digi output, and part of the results are shown in Figure (b) and (c). The total agreement is about 99%.

- Both analysis results are as good as expected, which demonstrates good performance of the CPPF system.
(a) Hits timing agreement between CPPF and Legacy in Station 1/ Ring 2 (the legacy system fails to read out < 1% of real hits, while the CPPF does read them out)
Cluster agreement in percentage in Station 1/Ring 2

(b) Cluster agreement in percentage in Station 1/Ring 2
Cluster agreement statistics (number) in Station 1/Ring 2

(c) Cluster agreement in number in Station 1/Ring 2