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Title: Construction and Testing of an Electron Isolation Algorithm for Data Analysis of the CMS Experiment

Title in Finnish: Elektronien isolaatioalgoritmin toteutus ja testaus CMS koeaseman data-analyysiä varten

Chair: Materials Physics (Tfy-44)

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Abstract:

The Compact Muon Solenoid (CMS) experiment is one of the four major detectors being built for the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland. It is a large general-purpose detector aiming to find the Higgs boson and possible signatures of supersymmetry and new physics. The data rates produced with the detector exceed the capabilities of current computer networks, and on-line cuts on the data rate are needed. The lowest level triggering will be made using dedicated electronics; further selection cuts will be made in the High Level Trigger (HLT) ran on a processor farm. Isolation cuts are vital elements of electron and photon selection, making use of the fact that there rarely are other particles close to the signal electrons and photons.

The purpose of this thesis was to produce and test an algorithm for making a selection cut with electron isolation in the HLT. The implementation of the algorithm makes extensive use of the available tools in Object Oriented Reconstruction for CMS Data Analysis (ORCA) and is now integrated as a part of the HLT in ORCA. Regional track reconstruction was used to limit the CPU resources needed. The algorithm was also extended for use with photon isolation.

To test and optimise the performance of the algorithm, generated events for the signal and background were used. The GEANT-based full detector simulation package CMSIM was used to simulate the detector response. For the background, QCD jets were produced. For the signal, samples of W-bosons decaying into an electron and a neutrino (Wenu), Z-bosons decaying into an electron and a positron (Zee) and a Higgs bosons decaying into two photons (Hgg) were used. All samples were produced at the nominal luminosity of the LHC (10^34 cm^-2 s^-1). To generate consistent results, a simulation of the trigger electronics and the preceding selection cuts in the HLT were used to filter the events.

The regional track reconstruction was shown to be an efficient method for electron isolation. The typical performance for a Wenu sample against single electron jet background was 96.3+-0.4% signal efficiency at 4.0+-0.8 jet rejection. The execution consumed 1.2 s of CPU time with an RMS of 1.1 s per electron track on a 450 MHz Pentium III. The CPU time was shown to have a log-Gaussian distribution, confirming the assumption that the computation times depend exponentially on the number of hits inside the isolation cone, and thus also on the size of the isolation region.

The main alternative method to full track isolation is using only hits from the innermost part of the experiment, the pixel detector, forming so-called pixel lines. With the same 96% signal efficiency as above for track isolation, the pixel-line isolation reaches only 2.2 jet rejection. The CPU consumption per event was tested to be on average 0.53 s with an RMS of 0.23 s.

An extension of the algorithm was tested for photons. A typical result for an Hgg sample was 85.4+-3.2 event efficiency versus 36.6+-11.9 jet rejection in the double-photon stream. The execution time per track is on the same order of magnitude as for electrons, but the usually high number of vertex candidates (10--25) has a price in terms of CPU consumption.

In conclusion, it was shown that track isolation is a powerful method of determining electron isolation at the HLT, to be used either alone or as a complementary method with pixel-line isolation.

Number of pages: 61 Keywords: CERN, LHC, CMS experiment, ORCA, electron isolation, track reconstruction

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Approved: Library code: