Test results for the Jet/Energy-sum Processor of the ATLAS Level-1 Calorimeter Trigger

J. Garvey, S. Hillier, G. Mahout, T.H. Moye, R.J. Staley, P.M. Watkins, A. Watson
School of Physics and Astronomy, University of Birmingham, Birmingham B15 2TT, UK

R. Achenbach, P. Hanke, E -E. Kluge, K. Meier, P. Meshkov, O. Nix, K. Penno, K. Schmitt
Kirchhoff-Institut für Physik, University of Heidelberg, D-69120 Heidelberg, Germany

C. Ay, B. Bauss, A. Dahlhoff, K. Jakobs, K. Mahboubi, U. Schäfer, T. Trefzger
Institut für Physik, Universität Mainz, D-55099 Mainz, Germany

E. Eisenhandler, M. Landon, E. Moyse, J. Thomas
Physics Department, Queen Mary, University of London, London E1 4NS, UK

P. Apostologlou, B.M. Barnett, I.P. Brawn, A.O. Davis, J. Edwards, C. N. P. Gee, A.R. Gillman, V.J.O. Perera, W. Qian
Rutherford Appleton Laboratory, Chilton, Oxon OX11 0QX, UK

C. Bohm, S. Hellman, A. Hidvégi, S. Silverstein
Fysikum, University of Stockholm, SE-106 91 Stockholm, Sweden

Abstract:

The Jet/Energy-sum Processor is one of three processing units of the ATLAS Level-1 Calorimeter Trigger. It identifies and finds the location of jets, and sums total and missing transverse energy information from the trigger data. The Jet/Energy Module (JEM) is the main module of the Jet/Energy-sum Processor. The JEM prototype is designed to be functionally identical to the final production module for ATLAS. Three JEM prototypes have been built and successfully tested. Various input test vector patterns were used to check the performance of the jet and energy summation algorithm. Data communication between adjacent Jet/Energy Modules and all relevant modules of the Jet/Energy-sum Processor has been tested. We present a description of the architecture, required functionality, and jet and energy summation algorithm of the Jet/Energy Module. Recent test results using the JEM prototypes are presented and discussed.

Summary:

The Jet/Energy Module (JEM) is the main module within the Jet/Energy-sum Processor of the ATLAS Level-1 Calorimeter Trigger. The JEM processes event information from the PreProcessor system and transmits the results to Common Merger Modules (CMM), as well as information about selected events via Read-Out Drivers (RODs) to the DAQ system. Trigger, timing and slow control are provided by a Timing Control Module, and configuration and control are carried out via a reduced VME bus. The main technology used for the JEMs are field-programmable gate arrays (FPGAs), which offer the required performance together with high flexibility.

Each JEM receives electromagnetic and hadronic energies for each jet element (0.2 x 0.2 in eta-phi) every 25 ns via electrical high speed serial links (LVDS) from the PreProcessor system. The first summation of both parts of the jet elements takes place on 11 FPGAs called InputFPGAs. The jet element sum is multiplexed to 80 MHz and sent to the MainProcessor. Both the main part of the energy summation and the jet algorithm are implemented into a common Xilinx device called MainProcessor. It uses lookup tables to determine the ETmiss components EX and EY from the ET values using the azimuthal angle phi, which is fixed by the calorimeter signal mapping. The jet algorithm identifies positions of potential jet cluster candidates by summing the energies of jet elements in windows of adjustable size and determining local maxima. Board-level energy sum and jet results are transmitted via point-to-point backplane links from each module to a sum- and jet-merging CMM. Detector-wide energy sums and jet multicities are encoded as trigger bits, which are sent to the Central Trigger Processor . The input data and all results of each module are stored in pipelines on each InputFPGA and on the MainProcessor to be read out to the DAQ system, and jet locations (regions of interest) to the level-2 trigger, via a read-out controller and serial links

upon a positive Level-1 trigger decision. For diagnostic purposes, additional playback and spy memories are implemented. The playback memories within the inputFPGAs can be filled with test patterns. Upon receipt of a broadcast command by the Timing, Trigger and Control system, the playback memories start to insert the test data into the processing chain. The energy and jet results of the test patterns are captured in spy memories within the MainProcessor at the end of the complete algorithms. These memories can be read out via VME for analysis.

Three JEM prototypes exist and have been tested in a stand-alone test set-up using test vectors for the energy sum algorithm. Test vectors were generated by the trigger simulation, which provides both input data for the JEM and the energy sum results. Six million random patterns and 60 million top-antitop into 4jets events were produced .

The stand-alone test of JEM used the playback memories or a Data-Sink-Source-Module (DSS) whose source buffers are filled with test patterns and the spy memories. The DSS provides the JEM with a continuous data stream via the serial LVDS links. The received results from the spy memories were compared to the expected values from the trigger simulation. All results are identical to the expected values. Further tests include checking the jet algorithm with test vectors, the read-out facilities at board- level and the data communication between the TCM-, CMM- and ROD modules, as well the data communication between neighbouring JEM modules which is essential for the sliding-window jet algorithm.