First Run of the DAQ System of the COMPASS Experiment

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The apparatus of the COMPASS experiment at CERN [1] will have 250,000 channels which are read out by a fast data acquisition system with minimum deadtime. At a trigger rate of $10 - 100$kHz and an event size around 30 kBytes a data rate of 600 MBytes – 6 GBytes per SPS spill is reached. Our group at TUM is responsible for the development of the data acquisition system (DAQ).

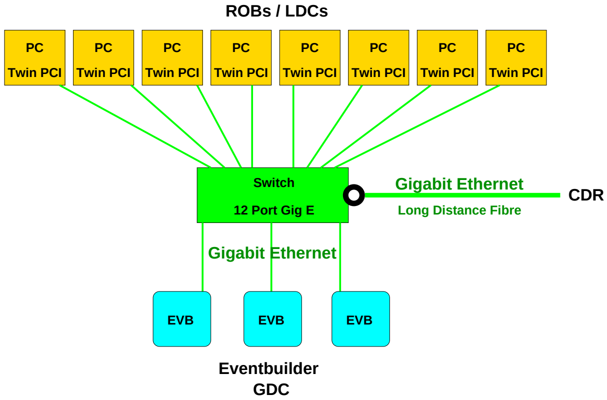

Fig. 1: The COMPASS DAQ system in 2000

Overview. The mostly pipelined detector readout electronics feeds the data in concentrator VME boards called *CATCH*, which are developed at the University of Freiburg. From these boards the data are transferred via optical links to the DAQ computers. These links follow the *S-link* standard [2] developed at CERN. It specifies a protocol and a connector (IEEE 1386, CMC) for a data transfer link. The actual transmission can be accomplished by different types of physical interfaces. In COMPASS we use a FibreChannel version of S-link which achieves up to 100 MBytes/s per link via optical fibers.

The data received via S-link are buffered on PCI cards called *spill buffers* to profit from the accelerator's duty cycle to reduce the sustained data rate. This card was developed in our group at TUM. The computers housing the spill-buffers (readout buffers, ROBs) transmit the data via Gigabit Ethernet to eventbuilder computers, which combine the sub-detector data to a complete event block and transfer it to CERN's central data recording system.

Hardware. In 2000 we used 8 computers as readout buffers with each 1 GB ECC SDRAM as main memory, two 600 MHz PIII CPUs and a 3COM Gigabit Ethernet interface. They have two PCI buses to read the data in on one bus and then transfer it on the second bus via Gigabit Ethernet to the eventbuilder computers. Per readout buffer four spill-buffer cards were mounted. As eventbuilders 3 computers of the same type were used, however with additional 72 GB disk space per machine. All DAQ computers as well as CERN's computer center were connected to a 12-port Gigabit Ethernet switch from 3COM.

Trigger Control System. To insure data integrity in the pipelined readout architecture each trigger has to be labeled by a unique event number. The synchronous transmission of the trigger and its identification to all detectors is done by means of optical signals distributed by the Trigger Control System (*TCS*) developed at TUM.

The TCS controller, a 6U VME board, encodes the trigger input and splits it into a synchronous trigger signal and an asynchronous event data block (event number, type etc.). The encoded pulses are transmitted by a high power laser and distributed via glass fibers and passive optical splitters to the detectors, a system developed at CERN for the LHC experiments [3].

The TCS receiver is a VME P2 transition board, which receives the optical signals and decodes the TCS information. It can be programmed via broadcasts to mask or block specific triggers from the attached CATCH module.

Apart from physical also artificial triggers can be generated and directed to individual detectors by the TCS system. They serve for calibration or noise measurements.

An additional function of the system is to provide separate deadtimes for up to eight independent trigger systems connected to the same readout electronics. This allows the sectioning of the DAQ system to test detectors independently before integration in the full system.

The TCS system provides a stable clock to the entire experiment. This is necessary for precise time measurements of passing particles in drift detectors and scintillators to correctly correlate detector hits at very high beam rate.

The system was operated successfully and at a very low time jitter of about 47 ps RMS between TCS receivers.

Performance. The concept of the COMPASS DAQ system was proven to work properly during the data taking period in 2000. A stable data taking was possible at up to 20,000 triggers per spill, tests were performed until 60,000 triggers per spill and sustained data rates of up to 20 MB/s were reached. A higher performance was not achieved because simple safeguards against overflows in the frontend electronics were not yet implemented. A further problem was the use of low quality lasers in the S-link interfaces which led to frequent failures. These lasers are replaced for the run in 2001.

Plans for 2001. The problems encountered in 2000 will be cured before the start of this year's data taking. Improvements in error handling, overflows, configuration and tests will be implemented. New types of S-link interfaces allowing higher data rates will be employed where needed. On the other hand a card is being developed at TU Munich to multiplex several CATCH modules to one S-link interface in case of low occupancy detectors. In addition new spill-buffer cards with 64-bit PCI buses and more memory will be implemented for better buffering. These measures allow to tailor the bandwidth of each individual detector.

The setup in 2001 will be extended to 16 readout buffer computers and 8 eventbuilder computers, partly of more modern type for improved throughput and performance.

References

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