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Calorimeter DAQ status

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Abstract

In this memo, the JRA3 calorimeter data acquisition system is presented, summarising the completion of the task's final deliverable, the status as of the 2009 Annual Meeting and the progress made between then and the end of 2009. The system is being integrated by calorimeter groups with debugging ongoing to finalise the system for use.

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1 Introduction

The data acquisition (DAQ) system to be used by the next generation of prototype calorimeters being developed within the CALICE Collaboration and as part of the EUDET JRA3 workpackage is described. As there are several types of calorimeter, all with different technologies and hence different needs such as control data, volume of data to be read out, etc., the DAQ system needs to be necessarily flexible. A modular system has been designed, making use of modern networking capabilities and powerful FPGAs, and using commercial equipment where possible. The system is now in the final stages of mass production needed to provide all calorimeters with a DAQ system and the debugging is ongoing in collaboration with calorimeter groups so as to provide high-speed and efficient data transport. Hence, this memo also outlines completion of the final deliverable in the task, “DAQ system available”.

2 DAQ system overview

An overview of the DAQ system, demonstrating its modular nature is shown in Fig. 1. Data can be passed from the detector units to the final PC or control signals can be sent up the chain from the PC to the detector units. In the following, each layer of the system is described in the case of reading out data from the detector units. The data are taken by the detectors on the detection slabs and digitised by the very front-end on-detector electronics which are embedded in the detector slabs. All output data are then delivered to electronics boards, called a detector interface (DIF) card, at the end of the detector. Data is then sent to a concentrator card, a link-data aggregator (LDA), which collects data from many detector units (in this case ten) via standard HDMI cables before sending off the detector on Gigabit optical fibres to an off-detector receiver (ODR) in a PC the counting room. To interface to the accelerator and e.g. know when a trigger has occurred, a clock and control card (CCC) fans out signals to all LDAs. All of the above is controlled by a PC running the DAQ software which has so far been developed using the DOOCS framework.

During the last year, work has focused around making systems available and having it as debugged as possible and can be summarised as follows :

- final hardware corrections and improvements with production versions of all relevant components;
- evaluation of needs of various calorimeters and hardware orders to have enough systems for tests, both in laboratories and at a test-beam facility, and spares.
- firmware improvements and debugging;
- system tests of full chain;

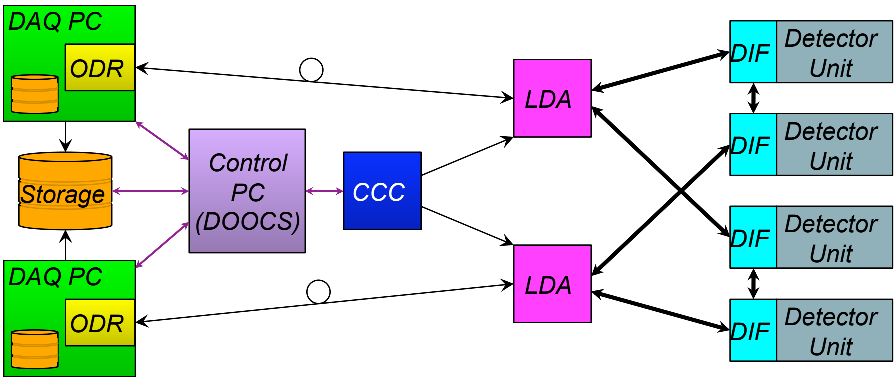

Figure 1: Overview of the DAQ system.

- delivery of full DAQ system to LLR for use and testing.

More details of the above are given in the following sections.

3 Individual component status

3.1 ECAL DIF

The ECAL DIF has been developed by UK groups, with the HCAL DIFs developed by the respective detector groups. Previously, a prototype DIF [1] was produced which conformed to standards set out by a working group of representatives of each of the calorimeters. This was thoroughly tested and is in use at LLR for various tests of the ECAL. A production version was re-designed with some miniaturisation and reduction of the number of components which were surplus to requirements. Ten of the new production DIFs have been produced and tested in-house and several sent to LLR for tests within the ECAL group. Once they have given feedback on the cards, the full complement of 40 DIFs will be made—all components are in-house and production time will be within the requirements of the ECAL detector group. Basic firmware has also been written and tested as part of the tests of the whole DAQ system.

3.2 CCC

The CCC is another custom-made board which incorporates all the needs of the various calorimeters [1] and the flexibility to provide an interface for any given accelerator (or otherwise) timing structure. A full complement of ten cards with power supplies have been produced and tested with basic firmware uploaded. The link to the LDA is being finalised with a small add-on board needed for the LDA. The board has been designed

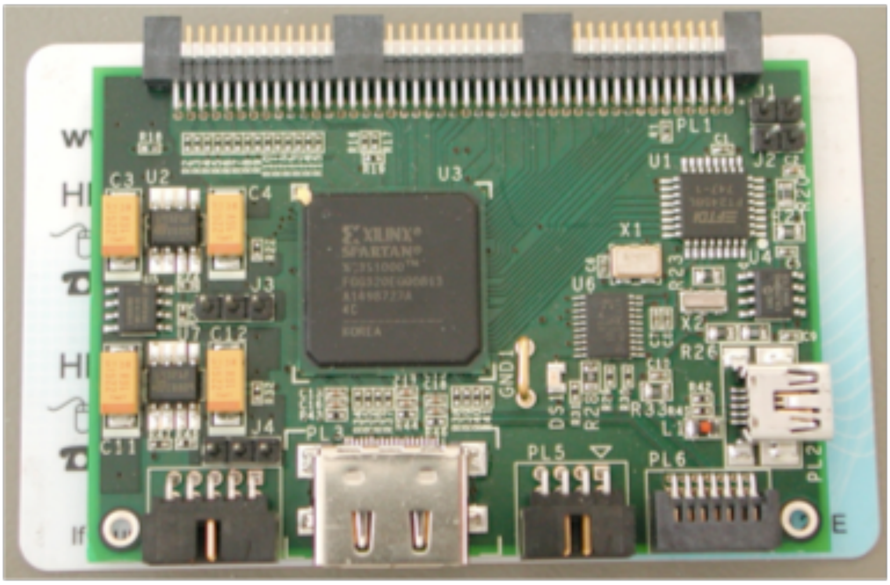

Figure 2: Picture of the detector interface (DIF) card on top of a credit card for size comparison.

and firmware written to test its efficacy. Production of the boards will commence in early 2010.

3.3 LDA

The LDA is a commercially-available concentrator system [2], consisting of a base-board, an add-on HDMI board with ten links to ten DIFs, and an add-on Ethernet board to connect to an ODR. Each of the boards had to go through various modifications when tested for our needs resulting in updated boards or corrections to the design. Production of each of the boards to enable 20 concentrator systems to be built has been done, they have just been delivered and will be tested and put together in early 2010. During the hardware improvements, firmware was constantly improved with the final DIF-to-LDA link being debugged.

3.4 ODR and DAQ PC

The ODR [1] housed in a DAQ PC is a commercially-available product [3] and has been in a stable state during 2009. There are currently eight ODRs, each of which can connect to four LDAs, and six DAQ PCs.

3.5 DAQ software

The DAQ software has been based on the DOOCS framework [4] which is being developed for the European XFEL project in DESY, Hamburg. This offers a flexible framework which can be used in many situations and provides the user with various different user interfaces. Software has been written to interface the ODR and CCC to the DAQ software and the software has also been able to send and receive data from the LDR–ODR link.

Given that the UK will not be able to provide support during a test beam programme over several years, this task has been relinquished and taken over by French groups. This has also prompted to a re-evaluation [5] of the most appropriate software and possible commonality between various detector sub-systems such as tracking and vertexing detectors.

4 System tests

A full system to pass data of a DIF, LDA, ODR and DAQ PC is set-up in the UK to test data transfer along the whole DAQ chain. A system is also set-up in LLR. Using network analysers and oscilloscopes, the system has gone through an extensive debugging phase which has led to a number of firmware improvements. So far, commands have been sent from the ODR to the LDA and data received back from the LDA in the ODR and onto the DAQ PC. Data has also been sent from the ODR, via the LDA, to the DIF and data seen transferring back to the LDA. At the time of writing, the data remains "lost" in the LDA and this link needs more debugging.

5 Hardware needs and procurement

To determine the number of components needed, laboratory tests, test-beam running and spares had to be accounted for with the possibility of a few systems running at any given time. Assuming there are three types of calorimeter to read out, electromagnetic (ECAL), analogue hadronic (AHCAL) and digital hadronic (DHCAL), and that all three may be running concurrently, the number of components needed is summarised in Table 1.

To meet these needs above and have sufficient spares, we have a procurement plan of :

- 40 ECAL DIFs of which 10 have been manufactured and the remaining 30 can be done quickly when needed and feedback received;
- 20 LDAs which have just arrived at the time of writing and so need putting together and testing;

Calorimeter	Layers	DIFs	LDAs	CCCs	ODRs	DAQ PC
ECAL	30	30	3	1	1	1
AHCAL	48	(48)	5	1	2	1
DHCAL	40	(120 + 14 DCCs)	2	1	1	1
Total	–	–	10	3	4	3

Table 1: Number of DAQ components needed for each calorimeter. The numbers in brackets refer to components being built by the resepective detector groups where the DHCAL has an extra concentrator card (DCC) to rationalise the data flow due to the larger number of DIFs.

- 8 ODRs and 6 DAQ PCs are in-house;
- 10 CCCs are in-house.

6 Deliverable, "DAQ system available"

The deliverable was met on time in month 42 by virtue of a complete DAQ system being hosted and under test in another institute, LLR. Other sub-components are also being used by other calorimeter groups.

7 Conclusion

The data acquisition system for the next prototype calorimeters is nearing completion. Systems are available to users and are being debugged and will help in debugging the detectors themselves. Final debugging to provide a complete working version should be finished in early 2010 at which point it will be used in earnest by various calorimeter groups. A supply of components is in-house which should suffice for future laboratory tests, test-beam running and spares for the future R&D programme.

Acknowledgement

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References

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[2] www.enterpoint.co.uk

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[5] D. Decotigny, D. Haas, M. Killenberg, talks in the DAQ session at Linear Collider Testbeam Workshop 2009, Orsay, France.
http://events.lal.in2p3.fr/conferences/LCTW09/