Commissioning and initial experience with the ALICE on-line

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Abstract. ALICE (A Large Ion Collider Experiment) is the heavy-ion detector designed to study the physics of strongly interacting matter and the quark-gluon plasma at the CERN Large Hadron Collider (LHC). A large bandwidth and flexible Data Acquisition System (DAQ) has been designed and deployed to collect sufficient statistics in the short running time available per year for heavy ions and to accommodate very different requirements originated from the 18 sub-detectors. This paper will present the large scale tests conducted to assess the standalone DAQ performances, the interfaces with the other online systems and the extensive commissioning performed in order to be fully prepared for physics data taking. It will review the experience accumulated since May 2007 during the standalone commissioning of the main detectors and the global cosmic runs and the lessons learned from this exposure on the “battle field”. It will also discuss the test protocol followed to integrate and validate each sub-detector with the online systems and it will conclude with the first results of the LHC injection tests and startup in September 2008. Several papers of the same conference present in more details some elements of the ALICE DAQ system.

1. Introduction

ALICE (A Large Ion Collider Experiment) is the heavy-ion detector designed to study the physics of strongly interacting matter and the Quark-Gluon Plasma in nucleus-nucleus collisions at the CERN Large Hadron Collider (LHC) [1][2]. It primarily targets heavy-ion lead-lead collisions (Pb-Pb), but it also has a substantial physics program with proton-proton (pp) and proton-ion (pA) collisions. The experiment has been designed to cope with the highest particle multiplicities anticipated for Pb-Pb reactions.

ALICE currently comprises eighteen sub-detectors; the installation of the last one has started in 2009. The detector includes high resolution tracking (silicon detectors, time-projection chamber),

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particle identification, calorimetry, and triggering elements. Ten of the ALICE detectors contribute to the trigger decisions. The sub-detectors are able to take data independently (standalone operation) or in global partitions (set of sub-detectors running together).

1.2. The online systems

ALICE also includes 5 online systems [3]:
- The Central Trigger Processor (CTP) delivers the trigger decisions to readout the sub-detectors based on their busy status and the input from the trigger sub-detectors.
- The High-Level Trigger (HLT) permits a firmware and software filtering mechanism to select interesting events in order to optimize use of the recording bandwidth available.
- The Data Acquisition system (DAQ) handles the data flow from the detector to the permanent data storage in the CERN computing center.
- The Detector Control Systems (DCS) controls the sub-detectors and their services.
- The Experiment Control System (ECS) controls the whole experiment and provides to the shift crew a simplified view of this complex experiment. This function is realized through the control and the synchronization of the other four online systems.

The dataflow of the online systems is shown in figure 1.

![Figure 1. Dataflow inside the ALICE online systems.](image)

1.3. The online software

Some online software instrumental during the commissioning phase of ALICE is detailed hereafter.

1.3.1. The DAQ dataflow: The ALICE dataflow is implemented as a combination of hardware and software. The data are sent by the detectors to the DAQ via the Detector Data Links (DDL). The PCI-X adapters for the DDLs have two channels which can be used either both as inputs or one as input for the data transfer from the detector and the other one as output to transfer the data to the HLT. The dataflow inside the DAQ is organized by a set of dedicated programs. The readout program is running in the Local Data Concentrator (LDC) and is in charge of collecting the data from the different DDLs...
connected to the LDC. The record program transmits these data to one Global Data Collector which will perform the event-building, the data formatting, and the data recording to a Transient Data Storage (TDS). The TDSM (TDS Manager) software is in charge of transferring complete files from the TDS to the Permanent Data Storage (PDS) in the computing centre.

1.3.2. The control Software. In order to reduce as much as possible the duration of the test and commissioning periods, the online systems incorporate a high level of parallelism: all sub-detectors can run standalone and up to 6 global partitions can run in parallel. Each global partition can in addition include several clusters of detectors to allow selective readout of detectors according to the trigger.

The ALICE control software is distributed amongst the five online systems. The global control of the experiment is realized by the ECS which supervises the other four online systems (CTP, DAQ, DCS, HLT). The ALICE control software supports two modes of operations. Figure 2 shows the control flow when a detector is used in standalone mode. A dedicated program of the ECS – the Detector Control Agent or DCA – gets input from the operator and controls the four other online systems. It sends commands to them and monitors their state changes.

![Figure 2. The control flow of the TPC used in standalone mode.](image)

The list of commands sent to the online systems varies according to the type of activity requested by the operator. For each activity, a dedicated control sequence is included in the ECS in order to realize complex operations such as a calibration or pedestal run.

When several detectors are used concurrently for the same type of activity they form a partition. Another program of the ECS – the Partition Control Agent or PCA – is used to control them through their respective DCAs as indicated in figure 3.

1.3.3. The Data Quality Monitoring. The function of Data Quality Monitoring (DQM) is essential in a physics experiment. No detail about the ALICE DQM is given here because a complete paper of the same conference is dedicated to it [4].

1.3.4. The electronic logbook. The electronic logbook is a software tool archiving in a database all the information relevant for every run and providing an access to this database through a web browser for interactive use and through an Application Programming Interface (API) for non-interactive use. It has become an important tool inside ALICE for data-mining tasks [5].
2. The ALICE commissioning

The ALICE detectors have been installed and commissioned during several years. Three periods have been dedicated to the systematic commissioning of every detector with the online systems and the global commissioning experiment: 10\textsuperscript{th} to 21\textsuperscript{st} December 2007, 4\textsuperscript{th} February to 9\textsuperscript{th} March 2008, and 5\textsuperscript{th} May to 20\textsuperscript{th} October 2008. During these periods, the time was shared between the standalone commissioning of each detector and the global cosmic runs.

2.1. The detector standalone commissioning

The commissioning of each ALICE detector was performed following a well established scenario with several milestones to be satisfied by each detector before it could join a global partition.

The basic functioning of a detector is first verified with a standalone trigger generated by the LTU and the readout with the detector LDCs and one GDC allocated to the detector for its standalone tests. Then the behavior of the detector electronics is verified against all types of legal trigger sequences (L0–L1 reject, L0–L1–L2 reject, L0–L1–L2), at different trigger frequencies (up to 40 MHz), and for different types of triggers (pulser, random, or cosmics). The handling of illegal trigger sequences is also verified to ensure a smooth functioning of the experiment even in case of transient errors in one of the systems. A stability test over long periods is the final verification of the good functioning of the detector.

Figure 3. The control flow of a global partition with three detectors: the TPC, the SPD, and the Muon.

Figure 4 shows a plot of the total integrated time that each detector has spent in standalone runs. Some of the detectors were not yet installed for the first or the two first periods, but all detectors

Figure 4. Total time (hours) of standalone run for each ALICE detector.
except one (scheduled to be installed in 2009) were active during the third period. They all have had hundred or hundreds of hours of data taking in standalone mode.

2.2. The global cosmic runs

Once the detector smooth functioning is demonstrated, the detector could join a global partition. Figure 5 shows the total time of the global runs as a function of the number of detectors in the partition. Although some progress can be seen as a function of time for bigger and bigger partitions, one can see that the total time taking data with more than ten concurrent detectors is still limited. This is a direct consequence of the relatively large number of systems (detectors and online systems) in ALICE and the difficulty to get them all ready at the same time to take data. Even if each system has an availability of 97%, the total availability of all systems together is less than 50%.

![Figure 5](image)

**Figure 5.** Total time (hours) of the global runs as a function of the number of detectors in the partition.

There is one figure which has substantially improved from one global commissioning period to the next: the system stability. The large global runs are tough to start but last longer from one period to the next. This is illustrated by figure 6 which shows the fraction of triggers as a function of the minimum run duration. As an example one can see that the number of triggers collected during runs of at least 60 min. was only 17% during the first period and 80% during the third one.

![Figure 6](image)

**Figure 6.** Fraction of the total number of triggers as a function of the minimum run duration.

2.3. The online systems during the commissioning
The main issues that had to be fixed in the online systems during the commissioning concerned: the control scalability, the CPU power needed for the data formatting, and some spurious triggers.

The control scalability was not good at the beginning of the commissioning when all systems were interconnected for the first time. Some systems have been isolated in order to distribute the load amongst several servers and software bridges have been established between servers to allow the desired communication between systems.

The CPU power needed for data formatting was higher than anticipated due to the late decision to format data into reconstruction ready format. This is a good investment because it is the price to pay for allowing a single pass offline analysis. The CPU power dedicated to this function has therefore been increased.

During the commissioning, the experiment suffered from spurious triggers which were fixed during the cosmic run.

The requirements for some parts of the ALICE online are still in evolution. The global sequences of detector control are still in the phase of being defined and are not yet fully automated.

2.4. The plans for 2009 and after
The LHC schedule foresees for 2009 and 2010 the equivalent of a nominal data taking year with ten months of pp beam followed by one month of heavy ion beam. The DAQ system will therefore be fully deployed with a performance increase from 40% to 100% of the nominal performance.

The DAQ software will also be fully enhanced with the DQM entering in production for most detectors.

The ECS software will be extended with the addition of a central system for the configuration of all the trigger detectors and the corresponding trigger processors.

The main operation goal for after 2009 is to reduce the size of shift crews by grouping the operation of detectors, automating the atomic operations (configuration, calibration) and the global planning of the data taking.

3. Conclusion
After almost 15 years of design and installation, the ALICE experiment became reality. This birth happened during the commissioning of detectors and online systems from December 2007 to September 2008. It was a particularly active period leading to a successful commissioning of the whole experiment. The online systems made a major contribution to the detector commissioning, alignment, and calibration and the experiment was ready to start with beam in September 2008. It will again be ready for the next startup in September 2009!

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