# Status of ALICE: Report to the April 2010 RRB CERN-RRB-2010-018

## Overview

ALICE is a general-purpose heavy-ion detector designed to study the physics of strongly interacting matter and the quark-gluon plasma in nucleus-nucleus collisions at the LHC. It currently includes over 1000 members from around 100 institutions in some 30 countries.

ALICE consists of a central part, which measures hadrons, electrons and photons, and a forward spectrometer to measure muons. The central part, which covers polar angles from $45^0$ to $135^0$ over the full azimuth, is embedded in the large L3 solenoidal magnet. It consists of an inner tracking system (ITS) of high-resolution silicon tracking detectors, a cylindrical TPC, three particle identification arrays of Time-of-Flight (TOF), Cerenkov (HMPID) and Transition Radiation (TRD) counters and two single-arm electromagnetic calorimeters (high resolution PHOS and large acceptance EMCAL). The forward muon arm ($2^0$-$9^0$) consists of a complex arrangement of absorbers, a large dipole magnet, and 14 stations of tracking and triggering chambers. Several smaller specialized detectors (ZDC, PMD, FMD, T0, V0) are located at small angles. A calibration trigger on cosmic rays (ACORDE) is installed on top of the L3 magnet.

## Experiment status

After a long campaign of cosmic data taking, detector commissioning, calibration and alignment, the experiment was fully ready and operational for the first LHC collisions in November 2009. Data taking with first pp collisions at 900 GeV was extremely efficient and smooth and all detectors and systems worked exceedingly well right from the start. The first physics result was accepted for publication by end November. Analysis of the data is ongoing and further physics results are in various advanced stages of preparation.

During the short technical stop of the LHC at the end of 2009, a number of minor modifications, consolidations and service operations were carried out. Recommissioning the detectors and online systems as well as a short cosmic run started in January 2010 and continued until the restart of LHC.

## Silicon Pixel Detectors.

**Status**: In order to improve the performance and the diagnostic of the cooling system, an intensive upgrade work was carried out before the start-up of LHC , with the aim to maximize the number of modules that can be efficiently operated. Unfortunately the number of active modules could be increased only slightly. Currently more than 85% of the detector modules can be steadily operated, the remaining fraction suffering from a reduced local cooling efficiency due to a lack of flow of the cooling liquid (Freon). The investigations showed that the reduced flow most likely is caused by clogging of the filters installed in the feeding lines very close to the detector, which can only be accessed during a long shutdown.

**Changes**: No major changes.

**Concerns**: Unsatisfactory cooling performance.

**Plans**: Test and further investigation of the cooling.

## Silicon Drift Detectors

**Status:** During the winter shutdown additional mechanical protections for optical fibers have been installed and a new routing of services on the miniframe and patch panels has been done. Online calibration and monitoring software have been improved to easy operation of the SDD. Data have been readout using the new software implemented in the CARLOS-RX boards which provides a new coding of the data with significant reduction of the data volume. About 92% of the channels were active during the p-p run. With first p-p data it was possible to calibrate the detector module by module as well as to extract a first estimate of the alignment parameters. Two papers about SDD commissioning, calibration and charge collection efficiency have been accepted for publication in January 2010.

**Changes:** No major changes

**Concerns:** No major concerns

**Plans:** Data taking

**Silicon Strip Detectors**

**Status:** The new ventilation system designed to control the relative humidity (R.H) was installed end 2009. Since then, the ITS barrel was kept at a R.H. around 30% though the system does not provide the quite the stability expected. Throughout the winter shutdown this value was below 20% due to the external conditions. The potential correlation between this low humidity and the bias current as well as the noise (high values of both the bias currents and the noise were observed on SINTEF ladders) was studied extensively. There are indications that both observables demonstrate significant decrease with decreasing R.H. The studies for reducing the common mode signal generated by the low-voltage power supplies are still ongoing. Large-scale deployment of a possible solution will not be feasible until the next long shutdown.

During the 2009 run, 91% of the detector was included in the readout. The data collected in December were used to refine the calibration and alignment constants that were extracted from cosmics data. It was possible to calibrate the detector on a module-by-module basis. In addition, the first particle identification studies were performed.

**Changes:** No major changes

**Concerns:** Some SINTEF half-ladders show high bias current when operated at high R.H.

**Plans:** Improve ventilation system.

**Time Projection Chamber (TPC)**

**Status:** In Fall 2009 the TPC was operated to take first pp data at 900 GeV. The data quality is generally excellent, both concerning momentum resolution and particle identification. Temperature stability of better than 80 mK was achieved. The noise performance was further improved and 'empty' events (after zero suppression) do not exceed 50 kBytes in size. All capacitors in the IROC's are now exchanged. Because of several failures in the gating grid pulser system which required access to fix, the whole pulser system was moved to CR4 so that exchange of a pulser is now a matter of minutes. To provide further improvements in TPC performance, especially for large momenta and at high rates, the calibration program now focuses on electric field distortions and on the possible influence of space charge.

**Changes:** No major changes.

**Concerns:** No major concerns.

**Plans:** Continue calibration with beam and cosmics. Continue data taking with beam with emphasis on high rate operations.

**Multigap Resistive Plate Chambers (MRPC) for TOF**

**Status:** During autumn 2009 the TOF continued the cosmic-ray data taking, providing its cosmic triggers, till the start of the November/December p-p runs. By using the increased statistics of 2009 cosmic runs for a better definition of the calibration parameters, a single-hit time resolution of 110 ps was obtained. Applying stronger cuts on the quality of the TPC reconstructed tracks and on the TOF matching, the resolution reached 89 ps, with still a good margin for improvement expected from channel-by-channel time slewing and from precise time walk corrections for each readout pad. During the p-p data taking the TOF was very stable and efficient.

**Changes**: No major changes.

**Concerns:** No major concerns.

**Plans:** Data taking.

**High Momentum Particle Identification Detector (HMPID)**

**Status:** During the shutdown one detector module was opened in order to exchange one Read-out Control Board (RCB) that showed instabilities during the 2009 data taking. Since then the detector

has been operated stably in the global partition and it is now possible to fully control and operate it, including configuration and calibration, from the ALICE ECS.

In parallel the data collected in 2009 were analyzed and about 5000 rings reconstructed, as expected from Monte Carlo studies. In spite of the low number of tracks available (the HMPID has less than 10% of the TPC acceptance) corrections for misalignment (shifts) were computed and applied to the data. The full alignment, including the corrections for rotations, requires about 3 millions more events, corresponding to a few hours data collection and it will be completed soon after the LHC restart.

**Changes:** No major changes

**Concerns:** No major concerns.

**Plans:** Data taking

**Transition Radiation Detector (TRD)**

**Status:** 7 of the 18 super modules are currently installed and fully commissioned. They have been fully operational during first collisions at the end of last year. Cosmic data have been used for calibration and alignment purposes. With the suitable algorithms in the Global Tracking Unit (GTU), it was possible to produce very high purity cosmic triggers in conjunction with a pre-trigger derived from the time-of-flight system. Radioactive krypton was injected into detector gas to obtain a pulse height calibration for every individual pad. A limited number of chambers (about 10 out of 210) show high voltage instabilities not seen in tests in the laboratory before installation.

Multi-chip module production and readout board production has been resumed with excellent yield after solving a fundamental and longstanding manufacturing problem. Production and testing is now at a level commensurate with the production schedule of the remaining 11 super modules, which will be ready for installation during the planned long shutdown. Special modules omitting the central stack of chambers will be prepared in order to match the requirements of the PHOS spectrometer. With two sites working on the electronics integration on the chambers it is now possible to finish super modules at a rate of one super module every 6 weeks.

Major emphasis is now being put on the development, implementation and test of trigger algorithms to exploit the trigger capabilities of the TRD for jets and high momentum electrons.

Procedures have been put in place that allow for efficient and reliable operation of the TRD by non-expert shift personnel.

**Changes:** None.

**Concerns:** Understand high voltage instabilities.

**Plans:** Production of new super modules at a rate of one every 6 weeks; completion of the remaining 11 super modules for installation during the planned shutdown; trigger development.

**Photon Spectrometer (PHOS)**

**Status:** Three PHOS modules (position 2, 3 and 4) are installed, commissioned and operating. Since last October, PHOS is being operated at the nominal crystal temperature of – 25$^{o}$C. All the modules are included in the global readout during cosmic and pp-runs. Some improvement and repair of the PHOS cooling system and electronics has been done during the winter shutdown.

**Changes:** No major changes.

**Concerns:** No major concerns.

**Plans:** Co-funding of production of the missing crystals for the module #4 are under discussion.

**Electromagnetic Calorimeter (EMCal)**

**Status:** Four EMCal super modules were completed, tested, and pre-calibrated in the laboratory with cosmic rays, and installed into ALICE in 2009. The four super modules were commissioned and participated fully in the ALICE cosmics and p+p datataking periods in 2009. Analysis of the cosmics and p+p data is underway to check and improve the EMCal alignment and calibration. All of the necessary EMCal trigger hardware was installed. Commissioning of the EMCal shower

cluster level-0 trigger has started. The EMCal L0 trigger was confirmed to meet the required low noise performance and the strict timing requirements necessary to participate in the ALICE L0 trigger decision. The assembly, testing, and calibration of the 5th super module in the US and the 6th in Europe is complete. The 7th super module is also assembled and being prepared for shipping to the test calibration site. Fabrication of all subsystems continues at maximum capacity.

**Changes:** No major changes.

**Concerns:** No major concerns

**Plans:** Continue mass production of detector and electronics. Complete commissioning of EMCal L0 and L1 triggers.

**Muon Tracking Chambers**

**Status:** The whole muon tracking system is installed and operational with presently more than 95% of read-out pads fully working with a good noise on the bending planes where the best resolution is required. The GMS system is also fully in place and functional; studies of the GMS monitoring are in progress. All the chambers were already included during the December run where tracks were reconstructed with magnetic field. However the lack of statistics did not allow us to realize detailed studies of the chambers nor to make a significant alignment with particles; this will need collisions with higher luminosities.

**Changes:** No major changes.

**Concerns**: No major concern.

**Plans:** Data taking

**Muon Trigger Detectors**

**Status:** The Muon Trigger was operated successfully as readout and trigger detector of the muon partition during the Dec 2009 first LHC p-p collisions with stable beam conditions. The RPCs, operated in avalanche mode, showed a stable behavior, with low currents and counting rates. Positive indications, although statistics-limited, were provided by the RPC efficiency measurements carried out during data taking. The trigger electronics was successfully delivering trigger signals to the ALICE CTP with an error rate lower than 0,003%. A single muon trigger rate of 0,5% per p-p minimum-bias collision was measured. Offline analysis has shown that data and Monte-Carlo (Pythia) are in good agreement. Some minor maintenance and upgrade operations were carried out during the shutdown of January-February 2010.

**Changes:** No major changes.

**Concerns:** No major concerns**.**

**Plans:** Data taking

**Forward and Trigger Detectors (ZDC, PMD, FMD, T0, V0, ACORDE)**

**Status:** All detectors, including the PMD, are fully installed and operational. Initial problems with the PMD cooling were solved by installing an additional compressor. Additional minor improvements and consolidation has been carried out during the shutdown for some of the detectors. ACORDDE is providing a trigger signal for calibration and alignment.

**Changes:** No major changes.

**Concerns:** No major concerns.

**Plans**: Data taking

**Trigger**

**Status:** The Central Trigger Processor has operated very stably and reliably throughout 2009, both in cosmic and in collision data-taking mode. The trigger configuration was frozen in the summer to ensure stability during last year's data-taking, but in early 2010 several new modifications have been implemented. The most important of these is the deployment of the ALICE Configuration

Tool (ACT) to define the trigger configuration, allowing almost complete automation of the trigger system. In addition there have been developments in software governing triggers for calibration and monitoring of the trigger system.

**Changes:** No major changes.

**Concerns:** Funding in the UK for the trigger group

**Plans:** Operate trigger in 2010 data taking. Continue program of monitoring improvements.

**Data Acquisition (DAQ)**

**Status:** The DAQ has been successfully used to collect the data of the first pp collisions at the LHC: of the order of 800k events for a total of 340 GB of data have been recorded.

According to the plan, two online software packages have been significantly developed, commissioned and deployed during the shutdown. First, the online Data Quality Monitoring (DQM) software includes now the offline Quality Assurance modules of all the detectors, fifteen custom detector agents, and an online reconstruction. The DQM has also been interfaced to the electronic Logbook to provide an automatic archiving of the plots produced and a web access to them. The new software package ACT (ALICE Configuration Tool) has been integrated with most of the detectors and all the online systems. It is now able to automatically configure the whole experiment from a menu of predefined configurations.

**Changes:** No major changes.

**Concerns:** No major concerns.

**Plans:** Continue software improvements.

**Detector Control (DCS)**

**Status:** DCS has been heavily used during the commissioning, startup and data taking in the autumn and has proved that it is reliable and performs very well. During the January –February shutdown a number of improvements and consolidations have been implemented as a result of the first operational experiences with beam. The server cluster has been extended to balance the load of critical systems and to cater for new requirements. Additional redundancy has been added for the Database services and the system monitoring has been improved. The interface to the LHC machine handling the synchronization and data exchange has been further extended and improved. The new detector configuration schema which has been developed during the past year has been integrated with all detectors and the online systems and has been successfully commissioned and used during the first physics runs this year.

**Changes:** No major changes.

**Concerns:** No major concerns.

**Plans:** Optimize, adapt and extend the DCS system to fulfill operational needs and new requirements.

**High Level Trigger (HLT)**

**Status**: In the p-p data taking period at the end of 2009 the HLT has proven to be operational, providing an online display of reconstructed events, vertex information, and to transfer trigger decisions to DAQ.

The necessary infrastructure of the HLT is installed at Point-2 and ready for operation for p-p collisions with a maximum benchmarked and tested rate of 1.5 kHz. All tests have been carried out with simulated p-p events at an energy of 14 TeV and real data from last years runs. The following detectors are integrated in the HLT online reconstruction and analysis : DIMUON, ITS-SPD, ITS-SSD, ITS-SDD, TPC, TRD and PHOS. EMCAL reconstruction and analysis is implemented and currently under testing and benchmarking and will be included as soon as it's considered stable.

For the upcoming HLT upgrade for Pb-Pb collisions the reconstruction and analysis code has been benchmarked with simulated Hijing-4000 events to get an estimate on how many resources are

needed to run at a rate of 300 Hz. These measurements took into account the size of the raw data coming from the detectors, the data volume of the computed results from the reconstruction and analysis code and the performance of the code. For the most compute intensive part, the reconstruction of TPC tracks, two solutions have been realized. The first step of the tracking, the cluster finding, is done in a FPGA based preprocessor in the H-RORCs. The second step, the tracking algorithm has been ported to Graphics Processing Units (GPUs). Both are tested and verified.

In order to cope with the high data volume in Pb-Pb the current Infiniband infrastructure will be extended and installed on all nodes in order to provide the necessary bandwidth. Extensive and detailed tests have been carried out with the already existing infrastructure to analyze and understand the network in detail and correlate the results with the data rates obtained from the Hijing-4000 simulation. All results indicate that the Infiniband network bandwidth will be more than sufficient to handle the data volume.

**Changes:** No major changes.

**Concerns:** No major concerns.

**Plans:** Implementation of various physics triggers, upgrade for Pb-Pb collisions, FPGA-based cluster finding and GPU-based tracking for TPC, Infiniband network infrastructure on all nodes.

**Offline**

**Status:** Software: AliRoot and Offline Calibration Database updates and fixes are discussed, implemented and released on a weekly basis for reconstruction and analysis. Major updates introducing new features appear with new releases, approximately every 6 months.

Operation: Data processing, which proceeded according to what is described in the Computing Model, has been fully exercised during the pp run. Collision data recorded at the end of 2009 (~1 Mio events, 370 GB) have been replicated two times in external Tier1s, and reconstructed on the Grid so far six times with continuously improved algorithms and condition parameters. The reconstructed events are replicated three times in Tier1s and Tier2s for analysis. Analysis is run as centrally organized trains (15 trains as of today) and as end user analysis on the Grid, or as interactive analysis on PROOF-enabled analysis facilities. Almost $10^9$ cosmics events (85TB) have been recorded in 2009 and reconstructed already twice.

Monte Carlo production: 70 MC productions focused on the production of data required for first physics in 0.9, 2.36 and 7 TeV pp collisions.

Grid Services: The available storage has been enabled with xrootd. The deployment of SL5 on WN together with SL5 VO box has been completed at all sites. The deployment of the CREAM CE should be completed by the end of May.

**Changes:** The computing resources requirements for 2010-2012 have been updated taking into account the LHC running scenario during this period.

**Concerns:** Insufficient pledged computing resources remain a concern as well as reduction of pledges announced by a few FAs.

**Plans:** Continuous maintenance and optimisation (memory and CPU) and features enhancements of the AliRoot release, automated large scale distributed reconstruction analysis, and standardization of the PROOF enabled analysis facilities.

**Installation & Assembly activities**

**Status**: In October and November 2009 the PMD cooling was brought to an acceptable level and noise issues in the ALICE detector related to the new PMD ventilation system were resolved. A set of 4 large scintillators was installed in the ALICE forward region behind the muon absorber to improve background diagnostic and event characterization. The major cavern activities during the shutdown Jan-March 2010 consisted in the SPD cooling plant upgrade. Insulation in some low voltage cables was damaged due to the large weight and temporarily fixed; further consolidation will be required in the next long shutdown. Design and construction of installation tooling for the 2012 shutdown has started in January 2010.

**Changes**: No major changes.

**Concerns**: Some services/infrastructure items need improvements (SPD cooling, ITS humidity control, primary electrical power and UPS stability)

**Plans**: Further investigation of SPD cooling problem, fix of ITS ventilation and UPS. Longer term: Preparation of tooling and infrastructure for 2012 shutdown

**Commissioning and operation**

**Status**: After a long cosmic campaign in 2009, ALICE recorded 400k pp events at 900 GeV energy, with stable beams and all detectors operating, and almost 40k collisions at 2.36 TeV, with a subset of the experiment. Data taking and detector operation was very smooth and efficient. A software tool has been developed to allow the experiment to be centrally configured and prepared for running, so as to improve ease of operation. A strong effort is being made in order to reduce the shift crew, by merging operation of different subsystems and by operating more detectors centrally. Preparations for running at higher rates and with more selective triggers are ongoing.

**Changes:** No major changes.

**Concerns**: Need to reduce the manpower needed to operate the detector.

**Plans**: Data taking. Reduce the manpower needed to operate the experiment.