Status of ALICE: Report to the November 2008 RRB CERN-RRB-2008-114

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) will be installed on top of the L3 magnet.

The following institutes have joined ALICE in 2008: The Universities of Purdue (USA), Tennessee (USA), Yonsei (Seoul, South Korea) and Pusan (South Korea); the latter replacing Pohang (South Korea) which had left the Collaboration in 2007. Yildiz Technical University (Istanbul, Turkey) joined as associate member, while the associate members IPE Karlsruhe (Germany) and BARC (Mumbai, India) left after completing their respective technical contributions to the experiment. Discussions are ongoing with the University of Houston (USA) and two institutes in Pakistan (Comsats, Pinstech) who are applying as associate members.

Experiment status

The Technical Design report for the EMCAL has been submitted mid 2008; the first two modules (out of 11) are expected ready for installation early 2009. Construction is also still ongoing for the TRD, which was fully approved and funded only in 2006, and PHOS, where funding for the two remaining modules has been requested in Russia. Installation activities finished by end of spring 2008, with all detectors completely installed with the exception of TRD (4/18 modules installed), PHOS (1/5), and PMD(9/48). DAQ and HLT hardware were installed at 40% of capacity, corresponding to the luminosity requirements expected in 2008.

Detector integration and commissioning was a main activity over the last months, with 2 shorter cosmic runs of several weeks end 2007 and early 2008. Since May and until mid October ALICE has been operated continuously (24/7) for about 6 months, taking cosmic and calibration triggers for global system commissioning, alignment and calibration. As far as could be verified with cosmics, the performance of all subsystems is very close to (or better than) specification.

During LHC commissioning, only a subset of detectors was switched on because of the occasionally very high particle flux during beam tuning. Nevertheless, timing of most trigger detectors was verified and adjusted with beam.

Silicon Pixel Detectors.

Status: The SPD is installed and operational in ALICE including the pixel trigger (FastOR) processor. The detector and trigger commissioning has been completed and the final tuning is well advanced; some difficulties adjusting the cooling flow in a small number of ladders have been encountered. The SPD prompt trigger has been integrated in the Central Trigger Processor; since May 2008 it has been used to collect cosmic data in self-triggering mode as well as to provide the trigger to several other detectors. Alignment data have been collected in the global DAQ partition in conjunction with the rest of the ITS and the TPC. More than 50k muon tracks have been reconstructed in the SPD and used for the preliminary alignment of the detector. The residual misalignment is comparable with the intrinsic detector position resolution. The SPD was fully operational during the beam injection tests since June 2008 and provided relevant information on the background levels in ALICE.

Changes: No major changes.

Concerns: No major concerns.

Plans: Upgrade of the cooling system. Commissioning of the services after removal and repositioning of the mini-frame.

Silicon Drift Detectors

Status Extended data taking with cosmics has allowed a detailed test of all aspects of the detector, and to tune and commission the procedures for calibration and alignment. Calibration, for silicon drift detectors, is a complex procedure since it involves both the calibration of the response of the electronics and the monitoring and calibration of the drift speed, which depends critically on temperature. The drift speed during the runs has been remarkably stable, confirming the good performance of the cooling system. The overall performance is very satisfactory, with noise levels at the design value. The management of the interface to the DAQ has proven to be less flexible than desirable, and a new design for the cards which sit in the counting room, exploiting more powerful FPGAs, is now being designed. Also the routing of services on the so-called miniframe is being redesigned, in order to provide easier access to the TPC chambers and electronics for maintenance. This is a major activity involving all services carried by the miniframe, including redesign of some of the patch panels and detailed optimization of the routing.

Changes: Improved control cards (CARLOS-RX) currently being developed, new routing of services on the miniframe and patch panels being redesigned. The Services will be reinstalled in the present shutdown.

Concerns: No major concerns

Plans: Re-installation of the services. The new Carlos-RX is not specifically tied to the shutdown since the board sit in the counting room.

Silicon Strip Detectors

Status: The SSD is presently fully installed. The new front-end firmware, which performs common mode correction and effective zero suppression, was installed in April. The last power supplies were received end of June and installed during the first decade of July, which allowed stable operation of the full detector. Several weeks of cosmics data were successfully collected and used for calibration and alignment purposes.

Changes: No major changes.

Concerns: Some half-ladders with SINTEF modules show increasing bias current.

Plans: Change of patch-panels position in the miniframe. Re-commissioning of A-side after miniframe reinstallation.

Time Projection Chamber (TPC)

Status: The TPC was brought back into operation in May 2008 after commissioning of the resistor rod cooling system and has been running until Oct. 12, 2008. The complete Kr calibration has been done, with amplitude calibration for all channels. Laser calibration with and without B field has been performed to characterize non-linearities and to calibrate the drift velocity. All active cooling circuits were turned on, and the temperature stability in the TPC after correction is less than 0.1K. Momentum and dE/dx resolutions have been determined from cosmic ray running. All detector parameters are at or better than specifications.

Changes: No major changes.

Concerns: No major concerns.

Plans: Improve accessibility to the electronics, replace some faulty HV capacitors and electronic, and further improve infra-structure and services.

Multigap Resistive Plate Chambers (MRPC) for TOF

Status: The installation of the TOF has been completed with the last SuperModule (SM) installed on April 24 in the ALICE spaceframe. Since then the main activity has been the integration with the DAQ, TRIGGER, DCS and ECS systems which was successfully done during the global commissioning and cosmic runs in spring and summer, starting with a few of the installed SM and increasing progressively their number after passing the gas tightness test; the last three SMs are still under test. An assembly flaw of the LV DC-DC converters was discovered during the first magnet-on period and it was repaired for all but eight of them (i.e. 8 crates), which will require to move eight SMs out by 40 cm. The TOF detector has taken data both in the global DAQ partition with many other subdetectors and in two special partitions, giving a cosmic trigger to the TRD and to the HMPID. Several cosmic-muon tracks, hitting multiple adjacent MRPC strips (up to 18) inside the installed modules, have been observed, proving the full efficiency of the detector. Data taken with the magnetic field on and off have allowed to reconstruct cosmic tracks in the TPC and to test the matching algorithms between TPC and TOF.

Changes: No major changes

Concerns: No major concerns.

Plans: Complete the SM gas tests, repair remaining 8 DC-DC converters and commissioning with cosmics.

High Momentum Particle Identification Detector (HMPID)

Status: The detector**,** together with its auxiliary systems, has been fully commissioned and successfully integrated in the experiment DAQ and DCS systems. Beam induced events have been recorded during the LHC commissioning as well as events with cosmic rays, exploiting the TOF trigger facility.

Offline analysis shows the detector is qualitatively performing as expected although, due to the low statistics available, it is not possible to assess quantitatively its performance in terms of gas gain or photo-cathodes quantum efficiency. The study of the matching between tracks reconstructed in the TPC and entering the HMPID, for which few hundreds tracks are available, shows a distance between the extrapolated and impact points of less than 1 cm, without alignment corrections. The noise level is measured, as expected, less than 1000 electrons on average and HV stability has been recovered after tightening of the connectors.

Changes: No major changes

Concerns: No major concerns.

Plans: During the shutdown the system to monitor online the transparency of the liquid C_6F_{14}, already commissioned in the laboratory, will be integrated in the circulation system at P2.

Transition Radiation Detector (TRD)

Status: With some of the production sites having already finished their share of the readout chamber production the entire production will be finished before the end of the year. During the calibration beam time in November 2007 with an entire super module from the production a leak rate in excess of the financially tolerable rate was discovered. Meanwhile all chambers (but those of the first two installed super modules) have been successfully repaired.

In total 4 super modules were successfully operated during the entire cosmic data taking period of ALICE. Following the repair of readout chambers two previously assembled super modules have been reassembled and one additional super module has been pre-assembled. Readout board production is still slow due to yield issues, which are finally resolved.

The timing of the special TRD pre-trigger has been shown to be properly aligned with the overall timing of the entire experiment in global runs. The Global Tracking Unit (GTU) has been successfully commissioned and a special Level-1 trigger for cosmic rays has been shown to work. The Detector Control System (DCS) has been successfully operated and procedures are in place to monitor the quality of the data during data taking. The gas system has been fully commissioned and is ready now for operation with Xenon.

Changes: New supplier for Multi-Chip-Modules.

Concerns: Tight schedule for the super module production

Plans: Extraction and repair of the first two super modules. Production of at least one additional super module and installation of at least three new super modules.

Photon Spectrometer (PHOS)

Status: The PHOS module #2, as well as the cooling/thermo-stabilization plant of the PHOS spectrometer, have been installed in the experiment in May 2008. In 2008, during the commissioning run, the module was operated at a stabilized temperature of +18^{o}C. The integration with the DAQ, TRIGGER, DCS and ECS systems has been successfully tested during the global commissioning and cosmic runs. Using this module, the PHOS spectrometer has taken data with cosmics.End September, production of the improved and airtight casings for 3 PHOS modules started. The production is expected to be completed between middle December for the first casing and middle February for the third casing. The three PHOS modules will be re-assembled in the new casings and are ready for installation in the experiment by May 2009. Two final modules (4&5) are partially funded (FEE cards by China, APD's and preamplifiers by Japan). The full PHOS with five modules can be completed by the end of 2011 provided that additional funds, requested from Russian in 2009 – 2011 for crystals and mechanics, become available.

Changes: No major changes.

Concerns: No major concerns.

Plans: Three PHOS modules ready for installation in May.

Electromagnetic Calorimeter (EMCal)

Status: Fabrication of all subsystems is now proceeding at maximum capacity. Goal is to complete two super modules for the 2009 run.

Changes: Mass production started

Concerns: Schedule for the completion of the first super modules in time for the 2009 run is very tight with little safety margin

Plans: Continue mass production of detector and electronics.

Muon Tracking Chambers

Status: All the stations are installed. The commissioning is in progress, done for station 1 and station 2 but and ongoing for stations 3/4/5, mostly due to cables and connectors, slowing down the progress and requiring careful handling of the electronics. Fifteen out of twenty four chambers are read out by the global Alice DAQ, the remainder being locally read-out in stand-alone mode for debugging purpose. One component of the noise on slats of stations 3/4/5 has been identified and removed by modifying the low voltage power supplies. Noise still remains high on station 3 inside the dipole, which has to be investigated and solved. The alignment and monitoring system (GMS) for the muon spectrometer is completed. Its final installation and commissioning is in progress in parallel with chamber commissioning.

Changes: No major changes.

Concerns: Delay due to read-out and noise mainly on station 3.

Plans: Continue commissioning, reduce noise in station 3.

Muon Trigger Detectors

Status: The complete set of RPCs, FE electronics, trigger electronics, signal cables (1500 cables in total), service columns and ventilation system are installed since Dec 2007. The installation of cables needed to operate the FE electronics with external (adjustable) thresholds was done in early 2008. Detector alignment was completed in May 2008. The detector, operated in streamer mode, was tested with cosmic rays in December 2007, February and June 2008. During the last test

period, the system was used to trigger on "horizontal" muon events. All along these tests the detector was controlled by the Detector Control System and in the last test the full readout system became operational (two DARC cards). The trigger system was active during the injection tests carried out in summer 2008 and background particles, from interactions with beam screens, were detected. One out of the 72 RPCs has been tested successfully in avalanche mode (different gas mixture, same FEE operated with lower thresholds) in July 2008.

Changes: No major changes.

Concerns: No major concerns**.**

Plans: Complete the installation of the external threshold system by end 2008; further commissioning of the whole trigger system with long cosmic runs.

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

Status: The ZDC detector was fully installed and integrated with trigger and DAQ; first signals were seen during LHC commissioning.
The ACORDE detector is fully is installed, integrated with trigger and DAQ and is in regular use as cosmic trigger for ALICE commissioning.
The PMD detector was partially installed and integrated; the rest of the modules will be installed during the winter shutdown after improving the electronics protection circuit.
The entire FMD consisting of 51200 channels has been installed in ALICE. The full detector system has less than 0.1 percent defective channels. The overall signal to noise of all channels is about 35, i.e. a factor of three better than required. The system including slow control and readout was fully commissioned with injection test beam. First data with circulating beam were acquired. Advanced zero suppression and fast busy signal logic has been implemented successfully. Currently the detector can take data at 2.7 kHz; increased data rate capability is being studied.
Both sides of the T0 detector and its associated electronics have been installed and tested with lasers. The integration with the DAQ, TRIGGER, DCS and ECS systems has been successfully tested during the global commissioning and cosmic runs and the detector was operated during LHC commissioning in September.

The V0-C detector has been installed in June 2007 and commissioned in situ using DAQ, DCS and the ALICE trigger system. The electronics is completed and V0A is installed since June. The detector was operated both as trigger detector and to monitor background rates during the first LHC injections in August/September.

Changes: No major changes.

Concerns: No major concerns.

Plans: Complete PMD installation.

Trigger

Status: The Central Trigger Processor has been operated at Point 2 since the end of last year. During this period it has been used successfully to take cosmic trigger data, and also in runs of increasing levels of complexity in which different operating modes to be used with accelerator data have been simulated using random pulsers. Several significant hardware and firmware modifications have been made. A hardware switch allows the programmable selection of L0 inputs from a total of 50 connected to the switch. Trigger input patterns are now recorded. The LTU now communicates directly with the TTCex, without the need to use the TTCvi interface. The TTCmi machine interface has been upgraded, as for the other LHC experiments, with the new RF2TTC VME board. Numerous software improvements have been made to simplify the control and operation of the trigger. During the beam injection tests at the LHC during the summer, and also during the period of circulating beams in September, the CTP was used to select events for the data acquisition and to perform a preliminary timing of trigger inputs.

Changes: No major changes

Concerns: No major concerns.

Plans: Continue operation with cosmic rays where required. Continue refinement of software. Preparation of configuration files for different modes of operation with beams.

Data Acquisition (DAQ)

Status: The DAQ has been in continuous use (24x7) from March '08. It has provided to the 14 detectors installed the equivalent of 288 days of data taking in standalone mode for a total of 7.9×10^9 events. This has resulted in 1.3 PBytes of data collected out of which 41 TBytes have been recorded. The equivalent of 139 days of global data taking have been performed for the physics partition used in cosmics and during the LHC start-up for a total of 7.1×10^9 events. This has resulted in 443 TBytes of data collected out of which 235 TBytes were recorded. The whole experiment has been operated from the ALICE Control Room and working rooms on the surface. The detectors and the 4 online systems (Trigger, DAQ, HLT, and DCS) have been controlled by the ECS for a total of 34900 standalone runs and 6600 global runs.

Changes: No major changes.

Concerns: No major concerns.

Plans: Address with the detector teams the issues who showed up during the start up period. Increase the performance of the DAQ/ECS by bringing the hardware configuration to its nominal size.

High Level Trigger (HLT)

Status: The HLT infrastructure for the first year running is installed at Point-2 and operational, including the interfaces to other ALICE on-line systems (DAQ/DCS/ECS) and Off-line.

During the global cosmic runs, on-line reconstruction was performed for the DiMuon, PHOS, TRD and TPC detectors. On-line event visualization was also provided. The PHOS detector was using the HLT successfully for reconstruction, calibration and first level data compression during the first injection tests. Raw data compression was performed for the SDD detector. The integration of the FMD on-line reconstruction was successfully done. For the TPC on-line reconstruction, the new tracking algorithm based on the cellular automaton method has been successfully integrated.

The full HLT data path was tested and in use. This includes receiving the raw data in the HLT, on-line reconstruction, data compression, triggering, sending the reconstructed events to DAQ, handling of the HLT trigger decisions by DAQ and use of HLT data in off-line reconstruction.

During the time the HLT is not operated in on-line mode, off-line grid jobs are executed on the HLT cluster.

Changes: No major changes.

Concerns: No major concerns.

Plans: PC cluster upgrade for 2nd year running, finalizing of triggering infrastructure.

Offline

Status: Software: AliRoot was ready in time to process data from the first LHC collisions. Cosmic data reconstruction is routinely performed with a special tuning of the reconstruction parameters. The analysis framework is in production status for on the Grid end-users analysis, for on the Grid organized analysis (analysis train) and for prompt parallel analysis on PROOF clusters at CAF and GSI.

Full Dress Rehearsal: Copy of cosmic data in T1 and subsequent processing at T1 have been suspended to save mass storage space. Selected data sets were exported to some T2s to be analyzed by the local experts. The Detector Algorithms, Preprocessor and SHUTTLE collection condition data in the Condition Data Base operate continuously. The size of raw and reconstructed data is approaching from the top the values quoted in the Computing TDR. The number of GRID users for analysis is steadily increasing reaching presently about 150 users.

Physics Data Challenge: MC production focused on the production of data required for first physics in 0.9 and 10 TeV pp collisions; pp at 14 TeV and AA productions have been postponed.

Grid Services: The deploying of xrootd-enabled SE in T2s is going on at a too low rate (only 50% of the sites have presently a SE installed). Before the LHC stop 40% of the allocated CPU was used and 64% of the usable storage.

Changes: No major changes.

Concerns: Insufficient computing resources remain a concern.

Plans: Code review, Remanufacturing of AliRoot to improve I/O, improve the code management system.

Installation & Assembly activities

Status: In parallel to cosmic data taking, the last 5 TOF modules were installed, completing the entire TOF system, as well as two additional TRD modules, bringing the TRD system to 4/18 modules, and the first of 5 PHOS modules. On the A-side forward region, the compensator magnet, T0-A detector, V0-A detector, FMD1 detector, A-side beampipe and the entire PMD support structure equipped with 25% of the chambers, were installed. In addition the Beam Condition Monitor as well as the Beam Pickup detector electronics were installed and commissioned. The L3 doors were closed in June -- symbolically ending the ALICE detector installation for 2008. The shielding around the Miniframe and the shielding which closes that PX24 shaft were put in place beginning of September prior to first collisions.

Changes: Shutdown activities starting mid October.

Concerns: Planning and resources have to be adapted to the new shutdown planning.

Plans: Rerouting/recabling of miniframe connections & services; installation/exchange of PHOS, TRD, PMD, and EMCAL modules.

Global commissioning

Status: During the February cosmic run all installed detectors collected some calibration and alignment data. At that time up to 14 different detector systems where read out in parallel, with some runs lasting up to several hours. However, the full functionality of different trigger and DAQ configurations was not yet tested, and stability, error diagnosis and recover time needed to be further improved.

In April and May test sessions with individual detectors verified compatibility with the DAQ, DCS and CTP standards and lead to corrections where necessary. At the same time it was decided to continue operating the system 24 hours per day to study the long term stability. During the period June-August the emphasis of testing moved towards full system tests with a large number of detectors being operated together during runs lasting several hours. In addition the tests with simulated triggers were replaced by tests using triggers derived from the silicon pixel detector, the time of flight detector and the muon trigger detector. This has lead to a considerably more stable system able to run many detectors in several clusters with several triggers for extended periods.

In August the "first physics" configuration, consisting of SPD, SSD, TPC, V0, FMD and ZDC was tested extensively using bunch crossing and simulated BPTX (beam pick-up) triggers. It was verified that this system can be operated reliably.

During the LHC injection tests in TI2 and through Alice the SPD, V0 and FMD were used to monitor the radiation produced in the various beam dumps and by the beam halo.

Although not all detectors have been fully integrated, the system as such is operational and ready for first beam. However, during the current shutdown major modifications to the cabling of the central detectors will be made and other detectors will be fully equipped with power supplies etc. In addition the DAQ, DCS and CTP software will be optimized further. This means that the full functionality of the system will have to be verified again after these modifications, before first beam. Assuming the LHC will resume operation in May 2009 the current shutdown plan foresees at least 1 month of commissioning prior to start-up.

The commissioning of ALICE required an extremely large effort in terms of manpower. Extrapolating the experience with 24h/day operation to a nominal year of data taking would require the collaboration to provide about 17000 shifts, as currently each subsystem requires at

least one person on shift in the Alice control room (ACR) in addition to experts being on-call at CERN. However, we expect to significantly reduce the manpower required for operating the detector in the course of next year by automating procedures and recovery operations and by combining shifts for different detector systems.

Changes: No major changes

Concerns: Need to reduce the manpower needed to operate the detector. Readiness for data taking after long shutdown with major hardware intervention in cabling of central detectors and software upgrades.

Plans: At least one month 24/7 operation of the full system with cosmic data and simulated triggers before first beam to ensure that the same level of reliability is reached after the shutdown. Training of personnel to operate the detectors with less people on shift. Upgrades of DAQ and DCS software and tests of individual detectors during the shutdown.