Status of ALICE: Report to the April 2011 RRB

Introduction and Organization

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 1300 members from around 116 institutions in 33 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 Time Projection Chamber (TPC), three particle identification arrays of Time-of-Flight (TOF), Cerenkov (HMPID) and Transition Radiation (TRD) counters and two electromagnetic calorimeters (high resolution PHOS and large acceptance EMCAL+DCAL). DCAL, a second arm complementing EMCAL at the opposite azimuth and thus enhance ALICE jet and especially di-jet has been approved in 2010. 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 scintillator array to trigger on cosmic rays (ACORDE) is installed on top of the L3 magnet.

2010 has been the first full year of ALICE operation, and included a long run of data taking with 7 TeV pp and one month with PbPb nuclei at 2.76 TeV per nucleon. The experiment performed remarkably well throughout the year, and so did the data analysis. Exciting scientific results have already been produced, resulting in over 200 ALICE presentations at International Conferences and 12 publications in refereed journals. Many more are currently in preparation.

Since the last RRB meeting of October 2010, the following institutes joined the Collaboration: Bose Institute (Kolkata, India), Gauhati University (Assam, India), Korea Institute of Science and Technology Information (KISTI, Republic of Korea, Associate member) and U. Tuebingen (Germany). Discussions to join the Collaboration are ongoing with PINSTECH High Energy Physics Group, Physics Division, Directorate of Science (Pakistan, Associate member) and institutions in Egypt and Thailand.

Detector status:

Tracking Detectors (ITS, TPC):

The three ITS systems - silicon pixels (SPD) - silicon drift (SDD) and silicon strip (SSD) have been operating stably during the 2010 data taking period and have resumed the 2011 operation with equal performance. The SPD cooling problem is unchanged, i.e. between 10% and 20% of the detector half-staves are not operational because of insufficient cooling flow. The best guess for the location of the problem is the clogging of some components inside the SPD that are inaccessible. Detailed laboratory tests of a reference setup have proven that small contaminations of 10-20 micrometer diameter can clog up the system in a short time, reproducing the reduced flow that is observed in the SPD. The earliest possible time to access these filter will be the long 2013 shutdown, where the TPC will be moved to the parking position. It must be stressed that the operational SPD modules show excellent performance, and the SPD is playing a key role in the physics exploitation. The relative humidity of the ITS has been stabilized to about 20% by means of a specialized ventilation system. Since for the SDD the level of humidity is on the lower limit (danger of charge-up and related discharges, reduced efficiency of calibration injectors) while for the SSD it represents and upper limit (large dark currents leading to bias reduction due the resistor networks and increased noise in ~30 modules), the exact tuning of this humidity value is a crucial issue that must be carefully watched, and another step in improving the stability of the ventilation system is being pursued. The ITS performance in the high occupancy heavy ion collisions was excellent, no different from the low multiplicity proton events.

The TPC is running very well, close to design specifications. Calibration is very advanced. It also performed excellently during the heavy ion collision period. It is at the center of all heavy ion physics exploitation. One central issue is the occurrence of chamber trips, the frequency of which seems to be related to the luminosity. At 10kHz (proton) collision rate or at an ion collision rate giving the same 'track' rate, a trip of an inner readout chamber is observed every few hours. About 1 in 10 of these trips is damaging frontend cards. About 20 cards (out of 4356) broke during 2010, and 16 were replaced during the Christmas technical stop. Operating with reduced gas gain (at slightly degraded performance) the trips disappear. In an attempt to eliminate the problem the nitrogen was removed from the gas mixture during the Christmas break, so the TPC chambers are now operating with a pure Ne/CO_2 mixture. Preliminary 2011 results are positive, the full picture will however only develop in the course of 2011 data taking.

Particle Identification Detectors (TOF, HMPID, TRD):

TOF is performing very well with time resolution well below 90ps. No specific issues during the ion collisions. The frequent problems with DC-DC converters of on-detector LV supplies are being addressed. A small series of upgraded supplies was installed in the Christmas break for tests in view of a full consolidation program. HMPID is operating stably in p-p and heavy ion collision. The current focus of attention is the track reconstruction that matches the ITS/TPC/TRD tracks to the HMPID. Some systematic mismatch in the area is impacting on the HMPID in view of full exploitation for the physics analysis PID. Three TDR supermodules were installed during the Christmas break in record time and after commissioning they are included in the detector readout. Some issues of high resistance LV connections to patchpanels on the TRD were addressed during the Christmas break. Production the remaining 8 modules in continuing with the goal of installing the available modules during the 2011/2012 Christmas break.

Calorimeters (PHOS,EMCAL,ZDC):

The construction of the remaining EMCAL modules was finished in record time and they were all available for installation in the 2010 Christmas break, during which the EMCAL system was completed. 10/10 modules are now operational and commissioning of the entire system has progressed very well. The construction of modules and support structures for the EMCAL extension (DCAL) is ongoing and installation if foreseen in the long 2013 shutdown. The PHOS (3/5) modules were operating very stably during 2010 with signal to noise ratio close to nominal performance. The ZDC calorimeter played a key role during the heavy ion run by measuring the centrality of collisions. Due to the lower than nominal heavy ion luminosity, the shadowing of the so called TCTVB LHC machine collimator could be eliminated by opening the jaws to the maximum and allowing full performance of the ZDC. Negotiations with the LHC to eliminate this problem in the 2013 shutdown by displacing the collimator are ongoing.

Muon Spectrometer:

The muon system was operating well in proton collision rates up to 100kHz and during the entire heavy ion run. Noise performance of the muon chambers is at an acceptable level and alignment of the chambers is well under control. A fraction of the muon chambers has suffered from sudden pedestal jumps during the 2010 run, which resulted in high data volume and necessity of frequent pedestal recalibration. The problem was traced back to quality issues in the on-chamber low voltage connections and a solution was implemented in a large fraction of chambers during the Christmas break. Experience with 2011 running will show whether the problem is cured. The trigger chambers showed stable performance in accordance with specifications.

Other detectors (PMD, FMD, V0, ACORDE, T0):

The PMD detector underwent major consolidation during the Christmas break. The components that were lost due to chamber discharges in 2010 were replaced and both planes are now operating at high efficiencies. A new re-circulating air ventilation system significantly reduced the detector temperature which is now well below 30 degrees in accordance with requirements from TPC temperature uniformity. The FMD is fully included in the regular data taking, materials in front of the detector are finally well understood and corrected for. The V0 runs stably as one of the main ALICE trigger detectors. After-pulsing of the V0 photomultipliers is still existing but understood and under control. Consolidation efforts for this problem for the 2013 shutdown are under way. T0 has been performing well as start counter for TOF, with a resolution well below 50 ps.

Online Systems (DAQ, CTP, HLT, DCS):

In 2010, the ALICE online systems have delivered 1000 hours of stable Physics data taking with stable beam, collecting ~10^9 events for a total of about 1.6 PB of data. All the technical, cosmic, and calibration runs make a total of 11000 hours of stable service, 2.3 1010 events and 4.7 PB of data. The systems have also demonstrated their reliability and performance during the heavy ion run with a sustained data-taking bandwidth of 2.5 GB/s and a demonstrated capacity of up to 4 GB/s.

The High Level Trigger (HLT) has been active during 50% of the pp data taking period to commission and test both hardware and software components, including various physics trigger algorithms. The HLT capacity has then been upgraded for the heavy ion run and has been used for 75% of the physics data taking during this period.

The Detector Control System (DCS) has been operational throughout the whole year (365/365), including during the end of year closure, to ensure monitoring and control of vital systems. The system is evolving with operational experiences as new requirements arise and new features have to be added to the system.

A lot of effort has gone into automation of all online systems; to reduce the probability of user error and the dependence on expert intervention and make the experiment operation as user-friendly and effective as possible.

Extensive and systematic user training has been put in place by the online systems for the shift crew in view of decreasing the manpower required on site during data taking.

Offline and Computing:

Raw data registration and replication

Data are being registered from the DAQ buffer at P2 to CASTOR2 at CERN Tier0 with a rate up to 4 GB/s during the heavy-ion running. No incident has been reported since the beginning of the LHC operation. Since the beginning of LHC operation physics and calibration runs have been recorded for a total of 2.5 PB of raw data in 1.4M of files.

Raw data are replicated using *xrdcp* in Tier1s with a target rate adjusted to the Tier1s contribution to mass storage resources. The maximum transfer rate reached durin the PbPb run was 260 MB/s. No incident has been reported since the beginning of the LHC operation.

Processing strategy

The quasi-online pass 1 reconstruction is performed in the Tier0 using calibration parameters calculated online. The fraction of successful jobs is larger than 97.5% including heavy-ion processing.

Pass 2 reconstruction is performed in Tier1s using improved calibration parameters obtained from the results of the analysis trains processing pass 1 ESDs. Pass 2 is scheduled to run with a unique version of the software over data collected during a single LHC period. Four periods out of 6 have already been processed.

The fraction of successful jobs is larger than 99%. PbPb data have been reconstructed once and pass 2 is being processed now: 15% done so far with an efficiency of 98%.

Condition data are calculated with detectors algorithms running on dedicated DAQ workers. The output together with the DCS data is collected with the offline shuttle system and published on GRID SEs as ROOT files and in the AliEn catalog. Condition data are accessed by the reconstruction jobs. There is no issue with the condition data to signal. Calibration parameters for several detectors computed online do not lead to optimum performances requiring the need for additional processing implemented at the level of reconstruction and analysis. A new calibration strategy optimizing the available computing resources is under preparation.

Analysis of the ESDs is performed on the GRID by two analysis trains: the QA train is started together with pass 1 and pass 2 reconstruction for immediate quality assessment of the raw data, the calibration parameters and the reconstruction algorithms, the analysis train is started after completion of a reconstruction pass to create AODs to be used for the end user analysis. The train operation is routine since the beginning of the LHC operation. End user analysis on the grid is a routine with 25% of all ALICE resources being used for these analyses with peaks before ALICE weeks or conferences reaching 50%.

Issues

The main concerns are the memory usage in PbPb reconstruction, the calibration procedure requiring more CPU resources than anticipated, and the available disk storage (40% available at the time of writing this report) that is quickly shrinking and approaching zero in several sites. In 2011 the resources (storage and CPU) needed to process the proton and heavy ion data are widely under-provisioned (we are missing of the order of 40-50% of the resources).

Installation & shutdown activity:

Activities in this area include planning and organizing short consolidation and maintenance work during the regular short technical stops (~ every 6 weeks) as well as preparing for the longer winter shutdown period. During the 12 week 2010/2011 Christmas shutdown the detector was opened, 3 TRD modules were installed and 6 EMCAL modules were installed. The modules were commissioned and are already taking part in the 2011 data taking. Another major shutdown activity concerned a consolidation of the ventilation system for the central detectors, which will continue in 2011. Among other advantages, the new system will allow proper control of the humidity. Many maintenance activities on the ALICE detector were carried out during this Christmas shutdown.

The construction of the structure for TPC removal and the structure that holds the Miniframe for TRD installation will be concluded early of the year (2011).

The SPD cooling problem is unchanged and located with high probability inside the TPC, and area which will be accessible earliest in 2013.

In the 2011/2012 shutdown we plan again to open the ALCIE detector in order to install more TRD modules, an activity which must be prepared during the year. We also expect the DCAL support structure to arrive at CERN during 2011 and a preassembly, load tests and installation tests are foreseen in the ALCIE surface buildings. The installation of upgraded UPS power has been distributed over the next 3 years and we plan to perform a first part of the installation towards the end of 2011.

Operation & Data taking:

After a very successful data taking during the LHC proton–proton run, the last four weeks of the running period in 2010 were dedicated to Heavy-Ions. After a fast configuration, LHC delivered 10 μb^{-1} to the experiments. ALICE recorded almost 90 million Pb-Pb events, out of which about 30 million are hadronic interactions passing all selection criteria. The experiment's efficiency in data taking improved during this period to levels around 90%.

After the technical stop at the end of 2010, the detector commissioning started at the beginning of 2011, following the completion of the installation of the EMCAL detector and the addition of 3 TRD modules. During the shutdown all damaged FEC cards in the TPC were replaced and nitrogen was removed from the gas mixture used to operate the detector. Two chambers of the muon tracking chambers were also replaced. New releases of the DAQ, ECS and DCS software were installed and validated. The CORDE board to correct for precise correction of the seasonal drift of the clock phase was installed and the timing of all relevant detectors adjusted.

The new LHC handshake procedure was implemented, exercised and validated. In February data taking was resumed with cosmic rays and about 5 millions of events for each polarity of the solenoid were recorded in order to start the calibration of the TPC and check the basic alignment of the detectors. The new EMCAL modules were integrated in the DAQ & DCS systems of the experiment as well as the additional TRD modules. The TRD L1 level was also successfully exercised with cosmic rays. In March the experiment successfully recorded the first collisions at 7.0 TeV and the preparation for the run at 2.76 TeV got full swing. The EMCAL and PHOS L0 trigger were commissioned and integrated in the trigger system while the calibration of the TPC was completed. The stability of the TPC at different interaction rates is under study. The alignment of the ITS and TPC was checked and found unchanged w.r.t. last year. During a fill with both solenoid and dipole switched off data were collected to complete the check of the alignment of the barrel detectors, align the Muon Spectrometer and calibrate the EMCAL calorimeter. The run at 2.78 TeV was successfully completed by early morning of Monday March 28th with the delivery of 35.2 hours of stable beams (ALICE had requested 35). The run was extremely successful, with detector response and trigger rates in agreement with expectations and first analysis of the data demonstrate excellent performance of all detector elements. The average experiment efficiency in data taking during this period was 94%.

Following the quite positive experience during both proton-proton and lead-lead runs, as a consequence of the improved stability and efficiency of the experiment the operations crew will be kept at the reduced level of 5 persons per shift, supported by large number of on-call experts.

Physics & Analysis:

The physics activity in autumn 2010 was concentrated on the preparation for the heavy-ion run and the analysis of the first heavy-ion data. The Pb–Pb run was successful, and the data analysis proceeded very well. Already before the end of the year, five publications from the analysis of heavy-ion collisions were submitted, and are by now published in high-profile scientific journals. Those results provide evidence that matter formed in these collisions is denser, hotter, and larger than that at lower energies, while still having properties close to those of an ideal liquid. Three articles containing results from proton–proton collision have also been submitted for publication during the same period. The physics analysis is ongoing and continues to provide us with new insights into the behaviour of QCD matter in this new energy domain.