Status of ALICE: Report to the October 2011 RRB CERN-RRB-2011-081

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 enhancing 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.

In 2011 ALICE has so far taken data with proton beams, mostly at 7 TeV, but with a very important short run at 2.76 TeV used to constrain the extrapolations of data taken in pp at 7 TeV to the energy of the Heavy Ion collisions. The pp run has been characterized by a new mode of operation for ALICE, which has been taking data at relatively high rate applying selective triggers based on the muon detectors and on the Electromagnetic Calorimeter. One month of data taking with PbPb nuclei at 2.76 TeV per nucleon at a luminosity substantially higher than in 2011 is planned starting Nov 14^{th}. The experiment has performed well throughout the year, and so did the data analysis. Exciting scientific results have been produced, bringing the number of ALICE presentations at International Conferences to well over 300 this year (70 at the two main Heavy Ion conferences, Quark Matter and SQM), while the number of publications in refereed journals has reached 18 (including the three latest submissions). Many more papers are currently in preparation. The papers published by the ALICE Collaborations continue to raise considerable interest in the scientific community, as visible from the high number of citations received.

Since the last RRB meeting of April 2011, the following institutes have applied to join the Collaboration: Talca University (Chile) and Suranaree University of Technology (Thailand), both as associate members. 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 Turkey.

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 2011 proton data taking period. The SPD cooling problem is still having a significant impact on the detector efficiency. At this moment up to 25% of the SPD 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 filters will be the first long shutdown (2013-2014).
The TPC is running very well, close to design specifications. The problem of frontend card damage due to chamber trips is clearly related to the discharge of the large capacitors (4.7nF) connected to the wire groups of the readout chambers for reasons of crosstalk reduction. It was verified that in absence of these capacitors the rate of broken channels is dramatically reduced (maybe even eliminated) and the additional crosstalk will be acceptable. This modification will be performed in the winter shutdown. To limit damage during the rest of the 2011 data taking period the operating voltage of the inner readout chambers is slightly reduced – compatible with the needed dE/dx performance.

Particle Identification Detectors (TOF, HMPID, TRD):
TOF is performing very well with time resolution well below 90ps. 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 track reconstruction mismatch between HMPID and ITS/TPC/TRD was understood and HMPID is now working to design specifications.
The 10/18 TDR supermodules are operating routinely. Production of the remaining 8 modules is continuing with the goal of installing the available modules during the 2011/2012 Christmas break.

Calorimeters (PHOS,EMCAL,ZDC):
The EMCAL system is fully operational and one of the main contributors to the trigger. The construction of modules and support structures for the EMCAL extension (DCAL) is ongoing and installation is foreseen in the long 2013 shutdown.
The PHOS (3/5) modules are operating stably and contributing routinely to the trigger.
The issue of collimator shadowing of the ZDC calorimeter will be addressed during the 2011/2012 Christmas break.

Muon Spectrometer:
The muon system was operating at proton collision rates up to several hundred kHz in 2011. Readout issues that are impacting on the data taking efficiency are under investigation and are possibly traced to single event upsets. The inclusion of the GMS alignment system into the data analysis in order to arrive at the nominal spectrometer resolution is still being developed. The trigger chambers showed stable performance in accordance with specifications.

Other detectors (PMD, FMD, V0, ACORDE, T0):
The PMD is in good shape after the consolidation work during the 2011 Christmas break. Frontend channel loss due to occasional discharges is still an issue.
FMD is fully included in the regular data taking.
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 2011, the ALICE online systems have so far delivered more than 1000 hours of stable physics data taking with stable beam, collecting $2.0\ 10^9$ events for a total of 2.1 PB of data. The technical, cosmic, and calibration runs together make a total of 5300 hours of stable data taking service, $1.7\ 10^{10}$ events and 3.5 PB of data.
During this year all the online systems have been revised to increase their performance and improve their reliability.
The Central Trigger now includes online luminosity monitoring using the interaction records and the timing system can automatically adapt itself to the seasonal LHC clock drift.

The maximum throughput for the Data Acquisition System (DAQ) system has been increased from 2.5 to 4 GB/s in view of the heavy ion run.
The High Level Trigger (HLT) upgraded its mass storage system and its Infiniband network, further increasing the operational stability of the system to more than 95% after commissioning of the upgrades. The computing power has been increased by doubling the numbers of GPUs in the cluster, resulting in an increase of the possible event rate to ~200Hz central Pb+Pb events. The bandwidth to DAQ was increased from 10 to 28 DDLs to keep up with this rate.
In view of the Heavy Ion run, the HLT has been extensively tested in a new mode of operation, in which the data of the TPC are first processed by the HLT and only the parameters of the found clusters relative to reconstructed tracks are stored. This procedure applied to the TPC data allows for an overall compression factor of about 3 for the entire ALICE data.
The Detector Control System (DCS) has been operational throughout the whole year (24x7). It has significantly improved its operational stability through amended procedures and improved training of operators. The reliability has also been improved thanks to a large scale precautionary replacement of the most fragile hardware elements.
The Experiment Control System (ECS) has been instrumented in order to monitor and improve the experiment operation efficiency. The results are made available to the whole collaboration through the ALICE eLogBook.

Offline and Computing:

Raw data registration and replication
ALICE has been continuously taking data: 0.604 PB of physics and detector calibration data has been recorded since May, for a total of 1.511 PB of good quality data since the beginning of the year. The data taking condition has switched to a new trigger scheme reducing the fraction of minimum bias events and enhancing calorimeters and muons triggered data. Only PHYSICS raw data, which have passed the online quality assurance tests, are replicated to Tier1s in a fraction according to the tape storage capacity pledged by each site.

Processing strategy
An update strategy for detector calibration and first pass reconstruction has been validated. This strategy introduces a pre-pass reconstruction for which a fraction of the raw data, randomly sampled on a run basis, is reconstructed essentially to calibrate the central tracking detectors. The pre-pass reconstructed data are processed with a QA train, which assesses the quality of the data and the validity of the calibration parameters. After each LHC period, the pass 1 reconstruction is processed over the entire set of runs in that period and applying the previously computed calibration parameters. This procedure does not consume more computing power and provides a faster turn over.
End user data analysis on the Grid and Monte-Carlo simulations continue to be performed routinely
Tests are ongoing with the G4 MonteCarlo. A complete switch to Geant4 cannot be however envisaged because it is four times slower than Geant3, and therefore it will be used only for specialized studies.

Issues
The memory consumption of the organized tasks (RAW data reconstruction, Monte-Carlo production and analysis), which has been a main concern in the past months, has now been significantly reduced and meets the sites requirements. However, the memory consumption of users data analysis remains a concern and is under constant scrutiny by the central Offline team. The reasons for the low job efficiency are understood. The efficiency for central productions, including ordered analysis is presently about 80% and we expect to reach 90% or more. The efficiency for end-user analyses, which are mostly IO bound, vary widely from one task to the other and does not yet exceed 60%.

Operation & Data taking:

Following the very successful data taking during the proton–proton run at 2.76 TeV, at the end of March, ALICE resumed data taking with minimum bias trigger at 7 TeV, while commissioning several rare triggers. By beginning of June the minimum bias program was successfully completed and more than 600 millions events recorded. The experiment switched then to rare triggers data taking based on the EMCAL, PHOS, SPD and MUON detectors. With LHC reaching the maximum number of bunches allowed by the 50ns operation and with the increase in bunch intensity, the background observed in ALICE increased substantially, becoming the major limiting factor of the experiment efficiency. The increase of the background is clearly correlated to the degradation of the vacuum conditions in sections of the machine. A new online luminosity measurement, based on the T0 detector, more reliable as less sensitive to background, was put into operation together with a more accurate online estimation of the background itself. Both measurements have been made available in TIMBER in

collaboration with the machine operation group. In the meantime the vacuum group is actively investigating the origin of the deterioration of the vacuum conditions and the possible mitigation measures. In preparation for the heavy ions run several tests were performed both on the detectors and the trigger while the High Level Trigger was put into operation in test mode in order to validate its performance and configuration. The level 1 trigger based on the EMCAL and TRD detectors is also at present under validation.
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 analysis activity in the spring of 2011 was concentrated on the study of the Pb–Pb data taken during the very successful first LHC heavy-ion run in the autumn of 2010. Considerable effort was devoted to ensure the successful completion of the second reconstruction pass production and of the corresponding simulation production in time for the main conference in this field – Quark Matter – held at the end of May. The ALICE collaboration has presented 37 contributions at the conference, covering practically all signals and observables considered to be promising in the new energy domain. The topics included: the first measurement of particle densities produced in Pb–Pb interactions at the LHC and the suppression of particle production at high-transverse momenta (both signaling the matter density achieved in the collisions), the particle composition and transverse-momentum spectra of the final state (providing information on the temperature and radial flow at the time of decoupling) and the analysis of azimuthal anisotropies and azimuthal correlations, including, for the first time, higher harmonics (that provide information on the shear viscosity of the medium created in ultra-high-energy heavy-ion collisions at LHC). The models describing the bulk particle production processes are further constrained by the results of the study of Bose-Einstein identical particle correlations. The first results on the production of heavy-flavour particles also received large interest: the transverse-momentum dependence of the open-charm-meson suppression was measured using fully reconstructed charmed meson decays and single-lepton spectra, and J/y suppression was measured down to zero transverse momenta at central and forward rapidity. In the history of this high-profile conference series, this was an unprecedented display of results from a single heavy-ion experiment. During the summer this effort continued with the preparation of the publications of Quark Matter results and the production of new results: the first measurement of multi-strange particle enhancements, the enlargement of charm production studies to other charmed particles and the first estimates of J/y polarization at LHC. All these results provide evidence that matter formed in heavy-ion collisions at the LHC is denser and hotter than that at lower energies and expands to a significantly larger volume, while still retaining properties close to those of an ideal liquid. The physics analysis is ongoing together with the preparation of the next heavy-ion run at the end of this year, and continues to provide us with new insights into the behaviour of QCD matter in this new energy domain.