Status of ALICE: Report to the April 2012 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 120 institutions in 35 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 measurement has been approved in 2010 and will be installed during the 2013 Long Shutdown. 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 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 calorimeters. At the end of the year one month of data taking with PbPb collisions at 2.76 TeV per nucleon at a luminosity substantially higher than in 2011. The accelerator complex performed remarkably well, delivering an order of magnitude more integrated luminosity in PbPb collisions than in 2010. The experiment has performed well throughout the year, and so did the data analysis. Exciting scientific results have been produced and continue to come at a fast pace. The number of ALICE presentations at International Conferences reached over 500 in 2011 and continues at a similar pace in 2012, (70 at the two main Heavy Ion conferences, Quark Matter and SQM), while the number of publications in refereed journals has reached 32 (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 very high number of citations received.

Since the last RRB meeting of October 2011, the following institutes have joined the Collaboration: STFC Daresbury Laboratory (UK) and IIT, Indore, (India) as full members, Talca University (Chile) and Suranaree University of Technology (Thailand) as associate members. Comsats (Pakistan) and KISTI (Korea) have changed their status from associate to full member. Due to the transfer of the group leader, the U. Frankfurt Institut für Informatik,Fachbereich Informatik und Mathematik has replaced KIP – Heidelberg**.** Discussions to join the Collaboration are ongoing with several institutions in Egypt, Turkey and other countries.

Detector status:

Tracking Detectors (ITS, TPC):

The three ITS systems - silicon pixels (SPD) - silicon drift (SDD) and silicon strip (SSD) have been operating very stably during the Pb-Pb run in Nov. 2011, the SPD detector as previously mentioned, with decreased efficiency due to the filter clogging problem. A major breakthrough was achieved during the 2011/2012 winter stop: The SPD team succeeded in unclogging the filters of three sectors and as a consequence was able to restore the SPD efficiency to >90%. This operation consisted in drilling holes into the filters by using a steel cable with a drilling tip inside the narrow cooling tubes along a distance of 6m. The intervention on more SPD sectors in the next technical stops should then bring the SPD efficiency beyond the 95% level.

Another major consolidation effort during the winter stop was the removal of the 4.7nF capacitors from all TPC wire chambers. This intervention was concluded successfully and is expected to dramatically reduce the rate of broken frontend channels due to wire chamber discharges. The rate of chamber trips should further be reduced by the installation of new HV power supplies during the April 2012 technical stop.

Particle Identification Detectors (TOF, HMPID, TRD):

TOF, HMPID and TRD were working stably during the 2011 PbPb run. During the winter stop, three TRD modules were installed, so currently 13/18 TRD modules are operational.

Calorimeters (PHOS,EMCAL,ZDC):

The EMCAL system showed very stable performance during the 2011 PbPb run. Two more small EMCAL super modules were installed during the 2011/2012 winter stop. The construction of support structures for the DCAL is ongoing, ready for installation in LS1. PHOS and ZDC were also operating very stably during the 2011 PbPb run. A major intervention on the large ZDC vacuum chambers and some collimators during the 2011/2012 winter stop finally eliminated the problem of shadowing of the ZDC by collimators.

Muon Spectrometer:
The muon system operated smoothly during the 2011 PbPb run. Efficient recovery from single event upsets in the muon readout electronics was implemented during the winter stop. A major intervention on the LV connections of the frontend electronics for the tracking chambers was aimed at reducing the number of channels with `noisy`pedestals. The muon trigger chambers showed very stable performance in accordance with specifications.

Other detectors (PMD, FMD, V0, ACORDE, T0):
PMD is also affected by single event upsets and efficiency recovery procedures are being investigated. FMD has fixed some issues concerning faulty slow control reading from the detector and related inefficiencies. The V0 detector showed excellent performance during the PbPb run and was producing the essential centrality triggers. Once new concern is the observed signal loss of the V0 detector during the 2011 data taking period, which is possibly related to ageing issues. Whether these effect of ageing is located on the scintillator, the fibbers, or the photomultipliers, is currently under investigation.
T0 has contributed to the trigger during the 2011 PbPb run by selecting the vertex position in a given range around the nominal IP.

<u>Online Systems (DAQ, CTP, HLT, DCS):</u>

In 2011, the emphasis in the ALICE online systems has been put on increasing the performance and improving the efficiency.
The online systems have delivered their highest performance so far by a large factor thanks to the intensive usage of the HLT during the heavy ion run. During this period, a total of 3.2 PB of data has been readout and compressed by the HLT by a factor 4 reducing them to 860 TB. This has allowed increasing the integrated luminosity collected by ALICE during this period.
The CTP gave reliable performance throughout the year. At the beginning of 2012 there were firmware and software upgrades, and replacements to the infrastructure and hardware, with the servers replaced and increased in number, and a replacement of all the LTU boards for new ones with increased functionality. Additional upgrades are being prepared, both for the CTP firmware and for the L0 board.
The DCS has been extended with new tools and a major effort was put in improving procedures and documentation. This significantly simplified the operation, reduced the risk of operational errors and contributed to excellent overall DCS performance and the experiment efficiency.
The ALICE eLogBook has been improved and generates now several plots showing the data taking efficiency for each LHC fill and the sources of inefficiency.

<u>Offline and Computing:</u>

Raw data registration and replication

The 2011 HI data taking went very well. The HLT system has provided very efficient data compression for TPC, providing a factor 4 data reduction compared to RAW data. Data recording rate has peaked at 4GB/s with an excellent performance of the whole chain, from DAQ to Mass Storage at T0. During this period ALICE has recorded 1.3PB of RAW data for a total of $4.3 \bullet 10^8$ events.

Raw data from “good” runs are replicated to Tier1s with a target rate adjusted to the Tier1 contribution to mass storage resources. The average data transfer was of ~500MB/s during PbPb run and till end February when all the data has been replicated. No incident with data collection, storage and replication 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 collected from the online system or calculated during a pre-reconstruction partial calibration processing dubbed CPass0. The fraction of successful jobs is larger than 98% 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. Two periods out of 6 have already been processed. The fraction of successful jobs is larger than 98%. PbPb data have been reconstructed twice and pass 2 is ready for analysis.

Condition data are calculated with detectors algorithms running on dedicated DAQ workers. The output together with the DCS and LHC 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.. 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. An improved calibration strategy optimizing the available computing resources is being deployed.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 AOD filtering 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 more than 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 (73% available at the time of writing this report) that is quickly shrinking and approaching zero in several sites. We have started a energetic campaign to delete obsolete data.

The storage situation has an adverse effect on job efficiency. Sites with full Storage Elements can still be used, but at the price of writing data remotely, which reduces the efficiency of the jobs. Similarly, the fact of having no room to create more replicas or optimize data location causes some jobs to read the input remotely, again with adverse effects on efficiency. In normal conditions the efficiency for central productions, including ordered analysis is presently larger than 95%. The efficiency for end-user analyses, which are mostly IO bound, vary widely from one task to the other with an average around 60%, close to WLCG standards. Physicists are encouraged to move from ESD to AOD analysis to reduce the I/O load of their tasks. Already 50% of the end user analysis is done exclusively on AODs.

Under suggestion from the reviewers, we have scaled our resource requirements (mainly MonteCarlo and analysis) to fit within the pledges from funding agencies, at the price of introducing “success oriented” strategies reducing contingency and optimizing several procedures.

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 even if it still may exceed some site requirements. However, the memory consumption of user data analysis remains a concern and is under constant scrutiny by the central Offline team.

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 ion 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:

In the last six months, the physics analysis activity was mainly concentrated in three areas:

- completion of the 2011 analyses: a large fraction of the analyses for which preliminary results were presented at conferences in 2011 were brought to completion. In the course of the last six months, final results were published on particle correlations (K^0_S-K^0_S Bose-Einstein correlations, bulk and high transverse momentum anisotropic flow, harmonic decomposition of two particle correlations, jet-like di-hadron correlations), J/ψ suppression, heavy flavour production (nuclear modification factors for fully reconstructed D mesons and for muons from heavy flavour decays) and particle production in pp (identified particles, light vector mesons, J/ψ rapidity and p_T distributions and polarisation, J/ψ from B decays, D meson production at two energies, electrons from heavy flavour decays, underlying event measurements)

- development and preparation of new analyses aimed for first presentation at conferences in 2012 (mainly Hard Probes 2012 and Quark Matter 2012)
- control of the quality of the raw data and reconstruction passes from the 2012 Pb-Pb run: over 140/μb of Pb-Pb collisions were delivered by the LHC in the autumn; the Physics Working Groups were heavily involved in the assessment of the quality of these data while they were being collected, and of the different calibration and reconstruction passes.

In the meantime, the configuration was reorganised, with an increase (from 4 to 8) of the number of Physics Working groups, a rejuvenation of the Physics Board and the initiation of a process of overall consolidation and streamlining of the structure. Special care was taken to ensure a smooth transition between the old and new structures.