

Status of ALICE : Report for October 2002 RRB

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 900 members from 77 institutions in 28 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° to 135° 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 a single-arm electromagnetic calorimeter (PHOS). The forward muon arm (2° - 9°) consists of a complex arrangement of absorbers, a large dipole magnet, and 14 stations of tracking and triggering chambers. Several smaller trigger detectors (ZDC, PMD, FMD, T0, V0) are located at small angles. The CASTOR forward calorimeter is no longer part of ALICE since the withdrawal of Greece from the Collaboration in early 2002.

So far 11 TDR's have been approved (HMPID, ZDC, PHOS, ITS, muon arm, PMD, TPC, TOF, muon arm addendum, TRD, TOF addendum); the last one for the TOF addendum in autumn 2002. Construction of most detectors and large infrastructure items as well as preparation of the experimental area are well under way.

An overview of the financial situation in ALICE and a final estimate of 'Cost-to-Completion' including Commissioning & Integration costs have been presented to the April RRB. The additional funds needed to complete ALICE amount to 6.9 MSF. A contingency plan for the case that not all of these funds will be available will be presented to the October RRB.

Silicon Pixel Detectors

Status: Assemblies of single chips with $200\mu\text{m}$ Si sensors and ladders with $300\mu\text{m}$ Si sensors have been tested in a 350 GeV/c proton beam. The analog PILOT ASIC, submitted in June, has been delivered and testing is under way. A prototype MCM has been developed and is being equipped with components. Thermoplastic adhesives for the stave assembly are being studied.

Changes: No major changes

Concerns: Schedule and manpower resources remain tight .

Plans: Completion of the bump-bonding optimization. Half-stave prototype assembly including choice of adhesives and wire-bonding to the pixel bus.

Silicon Drift Detectors

Status: The layout of the final detector masks produced by Canberra are being checked at INFN-Trieste. One new NTD ingot from TOPSIL is being processed for testing purposes in preparation for the start of detector production in Q3/2002. The prototypes of the full-scale front-end chips (PASCAL-64 and AMBRA-4) have shown major yield problems (no fully-functional chips), likely to be associated to similar problems encountered by other designs in the same technology. A new prototype of PASCAL-64 was submitted in September with corrections for the most likely cause of the problem. Due to this additional prototype iteration, the engineering run for the front-end chips has been postponed to Q2/2003, which brings the FEE on the critical path; in the new planning, the SDD (and the ITS) will be ready for installation at CERN in March 2006. The submission of the next version of the readout-ASIC (CARLOS) in rad-tol technology is planned for Q4/2002. Prototypes of the 5-layer Al-upilex front-end hybrid for the 32-channel version of the FEE are being produced to test the assembly procedures. The design of the liquid and air cooling circuits for the SDD has started. The full-scale ITS-integration mock-up now includes the dummy muon-absorber, the V0 and

T0 detectors and the installation tools to be used on the muon-absorber side. The cabling, tubing and patch panels components have been defined and prototyping on a dedicated cabling mock-up will start by December 2002.

Changes: Engineering run for the FEE has been postponed by six months.

Concerns: NTD silicon availability for SDD production, SDD FEE yield problems, SDD cooling system.

Plans: PASCAL and AMBRA engineering run in Q2/2003. Submission of next prototype of the rad-tol version of CARLOS by November 2002. Detector production should start by Q3/2002. Tests results on final SDD air cooling system by December 2002.

Silicon Strip Detectors

Status: The pre-series of the double-sided silicon detectors were delivered by the three companies according to schedule and the evaluation of the quality is in progress. The HAL25 front-end chip was submitted in August 2002, with some modifications in order to investigate the low (60%) yield experienced in previous runs. Although the chips functions satisfactorily and no design rule violations have been identified a conflict with the IBM process parameters is suspected. Using the available front-end chips and the detectors from the pre-series, the production of a few modules has started in order to validate the complete production process and the production sites.

Changes: No major changes

Concerns: Production of the HAL25 front-end chip.

Plans: Improve yield of front-end chips, completion of assembly lines.

Time Projection Chamber (TPC)

Status: Construction of the TPC is progressing very well. For the Field Cage (FC), the two large composite cylinders (Outer containment vessel and Outer FC vessel) have been assembled and tested. The Inner FC vessel is ready and waiting for the delivery of the inner containment vessel parts (Al conical sections and composite central drum) by the end of this year. The production of the parts for the equipment of the FC has started.

The production of the second half of the small inner readout chamber has started in Bratislava. The prototype of the larger outer readout chambers (OROC), produced as the #0 module of the series production, has performed to expectation; the series production starts in October. The TPC gas system will be completed by the Gas Working Group of CERN this year.

The frontend electronics (PASA and ALTRO chip, FEC and RCU) have had a successful production readiness review; production of the chips and of a first series of FEC's is starting. The prototype 3 of the readout control unit (RCU) has been designed.

Changes: No major changes

Concerns: No major concerns

Plans: FC certification, equipment of FC. IROC production in Bratislava, start of OROC production at HD/GSI. Production and test of FEC's. Tests of the full FEE chain including DDL transfer to the DAQ in a large system (several 1000 channels).

Multigap Resistive Plate Chambers (MRPC) for TOF

Status: Several new prototypes of double-stack MRPC (Multigap Resistive Plate Chamber) strips have been tested at PS during spring and summer 2002 in order to check reproducibility and performance for strips built by different teams. They include a new single PCB ((122 cm) containing a pulser and a HV line, and the new interface cards (0.8 mm). The results in terms of efficiency, time resolution and uniformity are in agreement with those obtained during the October 2001 tests. Two

strips, irradiated at the GIF with a total charge of 2.3 Coulomb/pad (equivalent to about 200 days of Pb-Pb run at LHC with a rate of 50 Hz/cm²), have been remeasured at the PS showing no ageing effect with respect to the October 2001 results. Two new test boards, a master and a slave with four HPTDC (High Performance TDC) v.1.2 chips, have been built in Bologna and tested at PS; their functionality includes almost completely the final TRM (TDC Readout Module) proposed in the TDR Addendum. More tests on these boards are currently performed with the MRPC cosmic-ray stations in Bologna. The first prototype chips of the front-end analogue ASIC showed a layout error that has been identified and fixed; a second MWP run has been submitted in September.

Changes: No major changes

Concerns: No major concerns

Plans: A second "mass" preproduction of MRPC strips will be tested at PS in October 2002. Work is progressing on all components of the detector according to the proposed schedule.

High Momentum Particle Identification Detector (HMPID)

Status: Mechanical elements of the seven modules have been almost completely delivered. Metrology controls are proceeding in parallel. Assembly of module 1 has been accomplished. The entire set of 63 fused silica plates, employed as radiator vessel windows, has been shipped to CERN for the transmission control. The construction of the 21 radiator vessels is underway. The test of almost 15000 Gassiplex chips has been completed showing a yield larger than 95%. The test and classification procedure of the 4000 readout DILOGIC-II ASIC chips has started. Proto-3, equipped with a pre-series (80 cards, 240 Gassiplex chips for a total of 3840 channels) of the final FEE cards, has been successfully tested at the PS thus validating the FEE design. The MCM card housing the DILOGIC chip has been designed and tested in the laboratory together with the related memory card and mother boards. The beam test of Proto-3 fully equipped with a readout segment (3840 channels) will take place in October. The plant for the CsI evaporation has been upgraded with the UV scanner system designed for performing the in-situ measurement of the QE of the photo-cathodes just after the CsI coating. The commissioning of this new facility will start beginning of October. The definitive protocol for the mass production of photo-cathode PCBs has been prepared. A dedicated optical fibers system is being set up for quality check and gain calibration/mapping of the assembled modules in UV lab-tests. The production design of the gas system has been accomplished and the related PRR has been scheduled for October 2002.

Changes: No major changes.

Concerns: No major concerns.

Plans: Finalize the design of the cradle. Complete the construction of the 21 radiators and the production design of cooling and C₆F₁₄ circulation systems.

Transition Radiation Detector (TRD)

Status: The TRD Technical Design Report has been approved early 2002. With the currently available funding, close to 60% of the full detector can be built in a phi-symmetric, but shorter layout. A full size prototype chamber (1200mm x 1600mm) has been constructed and tested to verify the mechanical design. The design of the preamplifier/shaper ASIC is finished and it is now in the final stage of the layout. A first version of the digital chip (based on the 0.18 micron UMC process) has been received back from the foundry and is currently being tested. It contains a newly developed ADC (10 bit 10 MHz) along with a tail cancellation network, the tracklet processor, buffer memory, and a configuration chain. In order to improve z-resolution it was decided to use tilted (by 2 degree) pads in subsequent layers of the TRD.

Changes: Tilted pad geometry to improve resolution.

Concerns: No major concerns

Plans: Beam test of large prototype, test of several planes in parallel, PRR and submission of preamp.

Photon Spectrometer (PHOS)

Status: Pre-production of PbWO₄ crystals continues in the North Crystal Co plant, Apatity, Russia. For the moment, 25 furnaces for the crystal growth are in operation. The crystal growth and annealing technologies have been optimized. The crystal cutting machinery has been adapted for shaping the PbWO₄ crystals. Some 1200 full-size (2.2x2.2x18 cm³) shaped crystals were accepted after tests using the optical and light yield test benches of the Kurchatov Institute and a first batch of 500 crystals have been delivered to CERN. Beam tests of a matrix of 8x8 new crystals as well as matrices of crystals produced by the Bogoroditzk plant (1999 delivery) were performed with electron beams in the energy range of 0.6 – 50 GeV. 64 crystals were equipped with APD's as photo detectors. Preliminary test results show that the crystals from both producers are of the same quality and to specifications and the APD's are of high performance in a broad energy range.

Changes: A decision was taken to use APD's with low-noise preamplifiers as the photo-readout. Participation of Japanese labs is under consideration.

Concerns: No major technical concerns, the funding situation however needs to be reviewed in particular in the light of significant increases in the crystal price.

Plans: Optimization of the crystal mass production technology (growth, annealing and cutting) at the Apatity plant. Production of some 1500 crystals in 2002.

Muon Dipole Magnet

Status: Machining of the majority of the yoke modules (20 out of 28) has been terminated. The factory assembly of the yoke base has been finished successfully and the horizontal assembly of the yoke is progressing. The coil dummy pancake has been successfully shaped and installed in the impregnation mould. The impregnation of the dummy coil will take place in the first week of October 2002. The coil support design has been terminated and a price inquiry is in preparation. New extensive magnetic and mechanical calculations have been conducted to validate the coil support design and to establish the mechanical requirements for the yoke structure.

Changes: Vertical pre-assembly of yoke transferred from factory to CERN.

Concerns: No major concerns.

Plans: Machining of the yoke modules will be finished before end 2002. The transport of the components to CERN is foreseen for early 2003 followed by the pre-assembly in the UX25 cavern.

Muon absorber

The muon absorber is a finely tuned 80 ton device to shield the Muon Spectrometer from the particles produced in the collisions, while disturbing the muons only minimally. The design has been recently optimised with a series of Monte-Carlo studies for performance and cost-effective construction.

Changes: Assembly at CERN.

Concerns: Project delayed because of the redesign necessary to reduce costs.

Plans: At present the components for the device are undergoing a market survey, to be followed by calls for tender toward the end of 2002.

Muon Tracking Chambers

Status: The first final quadrant of the Station 1 has been constructed and tested at the PS in July. This detector was partially equipped with close to final electronics and read-out. Although analysis is ongoing, it appears that the read-out works properly and that the electronics noise is

satisfactory. Some gain variation due do a slight deformation of the chamber is observed. This mechanical aspect is under investigation. Station 2 has been designed in the same technology as Station 1 and a PRR for both stations will be held by autumn prior to production.

For the stations 3,4 and 5, a new medium size slat with all the final PCB configuration has been constructed and tested in July and September at the PS. The FEE and the read-out work also properly in this configuration. The mass production should start by beginning of 2003.

The MANU boards containing close to final FEE have carefully been tested in the lab and will be validated during the next beam period. The PRR will take place after further tests with the final electronics.

Changes: The Global Monitoring System has been changed from using laser beams to the RASNIK system also in use by ATLAS.

Concerns: The validation of the FEE MANAS chip has been delayed and therefore it has not been possible to mount these chips on the MANU boards. The new design of the Global Monitoring System is still in an early phase.

Plans: If the results of the detector in-beam tests are satisfactory, after some adjustments and after the PRR for stations 1 and 2, the mass production will start by the beginning of next year. The validation of the final electronics will be completed with the MANAS tests before launching the pre-production.

Muon Trigger Detectors

Status: Long-term irradiation tests of small prototypes have been continued at the GIF (Gamma Irradiation Facility). A prototype with a thin double-layer of linseed oil is still well alive after an irradiation equivalent to 100 ALICE-periods of 1 month with Pb-Pb. The operation of the detector in p-p strongly depends upon the background from beam-gas interactions, which is being revised. The performances of full-scale RPC prototypes have also been investigated since 2001. The last tests, from August 2002 with a muon beam at the GIF, have demonstrated the satisfactory homogeneity and rate capability of such large prototypes, even if the mechanical design of the RPC stiffener planes was not fully satisfactory.

The final front-end chips (especially designed for the streamer mode) and boards have been successfully operated in various test beams since 2001. The test bench for the mass production is ready. The PRR for the front-end electronics is scheduled in November 2002. The Local trigger electronic prototypes (VME 9U board) are operational. Minor modifications will be done by the end of 2002.

A test of a small scale prototype of the muon trigger, incl. RPC detectors, front-end and Local trigger electronics has been performed in June 2002 at the SPS/GIF. Fully satisfactory performances, especially concerning the robustness to background and the timing aspects, were obtained.

Changes: none

Concerns: Beam-gas background and running scenario in pp. Delivery of the regional trigger prototype delayed (minimum 4 months).

Plans: Aging tests will be continued to further increase the detector lifetime. The construction of one of the large RPC of ALICE, fully equipped with its front-end, has started and the tests are scheduled for 2003.

Forward and Trigger Detectors

Status: The first Zero Degree Calorimeter for neutrons has been assembled in June 2002. A preliminary test with a hadron beam has been performed at the SPS in the summer, in order to check its response as a function of the impact point of particles on the front face of the calorimeter and its linearity and resolution. The analysis is in progress.

A first FMD prototype (employing Si pads) and its associated analogue-digital electronics has been constructed and is being tested. The layout (position, granularity, technology) of the FMD, T0 and V0 arrays has been fixed.

In order to provide triggers for calibration of the TPC and other detectors, we will install an array of (partially) existing scintillator counters on top of the L3 magnet. The conceptual design of this cosmics trigger array has been started.

Changes: PMD re-optimization to avoid excessive background is ongoing. The Castor forward calorimeter is no longer part of the ALICE experiment as the Institutes in charge have withdrawn from the Collaboration.

Concerns: The position and granularity of the PMD is currently being revisited.

Plans: A test of the ZDC with heavy ion beam is foreseen to be done next year, since the lead beam at 160 GeV per nucleon was cancelled this year. A note on the new PMD layout is in preparation.

Trigger

Status: The ALICE trigger system has been re-evaluated. Important changes to the ALICE Central Trigger Processor are being implemented, following suggestions made during the LHCC comprehensive review in Jan01. The number of trigger inputs and in particular the number of trigger classes has been increased substantially, requiring a more complex design. A preliminary design of the Local Trigger Unit (LTU) is being approved. The software framework for the trigger was discussed and agreed at a workshop in Birmingham in May. Both the Birmingham and Ko_ice groups are now preparing for detailed design and construction work.

Changes: No major changes.

Concerns: Resources and schedule remain tight.

Plans: Production of the LTU modules (delivery at the end of 2003), so as to allow detector groups to test their electronics in an ALICE-like environment. Software development is also being prepared so as to allow the modules to be usable as soon as possible after they are produced.

Data Acquisition (DAQ)

Status: After the TPC, the ITS drift detector is the second detector that has successfully integrated its readout controller with the first version of the Detector Data Link (DDL) and its PCI interface. The second generation of DDL, based on the last generation of opto-electronics components at 2.5 Gbit/s, has been designed and is currently being tested. This second generation will deliver more than double the DDL performance at constant cost.

A major version of DATE has been released, including a complete integration with the DDL and its PCI interface. The PCI interface for the DDL has been used for this integration and is reaching the maximum performance of the PCI bus (120 MByte/s). DATE V4 also includes several new key features addressing the issues of larger DAQ configurations. Stability and scalability of these major software DAQ components have been demonstrated as part of the Data Challenge IV (ADC IV) during running periods of several weeks and on a DAQ fabric made of 80 nodes, 20 disk servers and 10 network switches. The package for the online monitoring of the DAQ performances (AFFAIR) has proven to be able to monitor tens of parameters on 100 nodes, to generate the hundreds of corresponding plots and to display them on the web. The two performances milestones of the ADC IV concerning the aggregate bandwidth in the event building network and the data recording to disk have already been exceeded at 1.8 Gbyte/s and 350 Mbyte/s respectively. Systematic testing of different disk storage configuration has been pursued together with the mass storage software (CASTOR).

Simulation of the Trigger/DAQ systems had indicated critical areas for sharing of the DAQ resources between the data streams of different triggers. A possible solution has been identified and its initial simulation has shown satisfactory results. A major new release of the Trigger/DAQ

simulation program is now in development to include more realistic models of the detectors and the trigger system behaviour.

Changes: No major changes.

Concerns: Long-term development and support of the CASTOR mass storage system, reliability of commodity PC's for DAQ applications.

Plans: Irradiation tests of the DD, development of a second generation of PCI interface for the DDL allowing HLT processing. The ALICE Data Challenge IV performance tests to tape are scheduled for the end of this year. The DAQ project is planning to write its TDR during the summer of next year.

High Level Trigger (HLT)

Status: The first HLT PCI-RORC prototypes operating 64-Bit, 66 MHz PCI were successfully tested. A batch of 20 units was submitted for production. The FPGA cluster finder algorithm was improved and is fully running in FPGA. Continued work on the FPGA Hough transform. Efficiencies of the Hough transform were determined. The tracking performance was reevaluated and studied in detail. Started on combined TRD-TPC-ITS tracking. The first implementation of the HLT publish-subscriber communication frame-work (including fault tolerance functionality) was successfully demonstrated. A revised conceptual design report is prepared for October.

Changes: No major changes

Concerns: No major concerns

Plans: Conceptual Design Review end 2002.

Offline

Status: The ALICE offline framework, AliRoot, is now a first version of the complete framework, from simulation to reconstruction and analysis. The Offline group has conducted the simulation and reconstruction of a large number of events for the needs of the Physics Performance Report, running more than 15, 000 jobs world-wide. The GRID system called AliEn providing distributed file and resource management system has been widely used for the mass productions, demonstrating a high level of maturity and stability. The offline group is preparing to participate to the ALICE Data Challenge to test the basic ROOT I/O system for the storage of raw data at very high rates, the target for this year being 200MB/s sustained to mass storage. ALICE has also been very active in testing the prototype software delivered by the DataGRID project. The work to provide a Parallel ROOT Facility (PROOF) is close to completion. This system will allow data processing and analysis to be done in parallel, transparent for the user, on distributed PC clusters making heavy use of the Grid services.

We have completed the design of the Virtual Monte-Carlo interface, which allows the transparent change of simulation Monte-Carlo between GEANT3, GEANT4 and shortly FLUKA without modifying the detector specific code. To prepare for the handling of large numbers of events and files we have designed a flexible I/O system coupled to a new representation of the data in memory.

Changes: No major changes

Concerns: CERN support for some of the main software packages used in ALICE (ROOT, FLUKA).

Plans: The ALICE Data Challenge 4 scheduled for the autumn 2002, analysis of the data produced in the framework of the ALICE Physics Performance Report, implementation of a distributed data analysis framework.

L3 magnet, Installation & Integration

Status: The installation of the Alice detector is proceeding according to the planning. The new door plugs for the L3 magnet has been successfully installed. The tendering for the central support structure inside the L3 magnet, the so-called space-frame, has been completed and an order has been

placed with industry. The construction of the new control room for the Alice experiment has started. The new over-head crane for the experimental area at Point 2 has been installed. Market survey or tendering for major support structures are in progress.

Destructive tests of some welding joints in the L3 cooling circuits by specialized industry have shown conclusively that the cracks observed previously have not progressed since the construction more than 10 years ago; they have been caused by mechanical stresses during welding rather than by corrosion. The repair of the cooling system can therefore be limited to replacing some sections of the outer circuits and auxiliary parts (flow meters, valves etc..).

Changes: The installation planning has been aligned with the new LHC construction schedule. Scope of L3 cooling repairs reduced.

Concerns: No concerns.

Plans: The cooling screens inside the L3 magnet will be removed and modified. The experimental area will be cleaned and painted. Preparations are being made to receive the iron for the magnet yoke of the Muon magnet.

MILESTONES

The milestone list has been revised following the recent delay in LHC commissioning to early 2007. TOF milestones, only recently approved by the LHCC, are not yet included.

