THE ATLAS EXPERIMENT GETTING READY FOR LHC*

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The present status of the ATLAS project is briefly described.

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1. Introduction

The ATLAS project is very broadly known in the community, and will not be described in any details here. It has been amply documented in the literature. All what this write-up can document is briefly the status at the time of this conference, early July 2006. At this stage the ATLAS project has now fully entered the surface integration, underground installation, and commissioning phases. The distributed hardware construction of components which spanned over almost a decade is nearly complete. In parallel, distributed computing and physics analysis are being set up. They are embedded in the Worldwide LHC Computing Grid Project (WLCG) framework as a backbone, and are being exercised with large simulated data samples, and now increasingly also with cosmic ray data from installed components in the cavern. The Collaboration is also evolving its internal working structures to reflect the transition from construction to commissioning, and towards data taking.

Referring to figure 1, it can be briefly recalled that the ATLAS detector uses a superconducting magnet system with a central solenoid around the inner detector and large air-core toroid magnets for the muon spectrometer. Between the two are the liquid Argon (LAr) and Tile Calorimeters. A hierarchical trigger and data acquisition system collects the data for the collaboration-wide computing and physics analysis activities.

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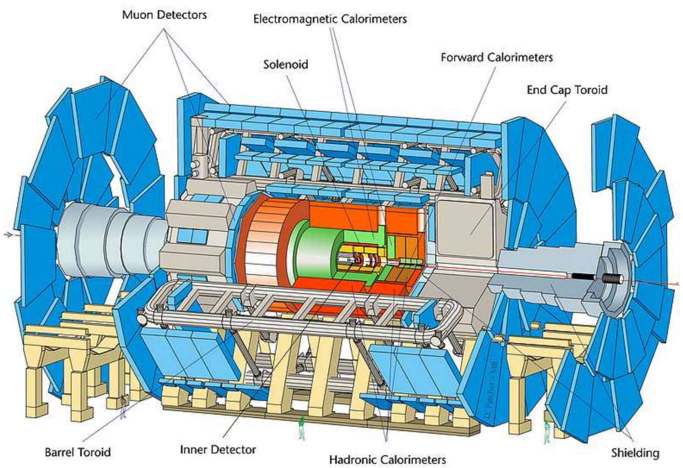

Fig. 1. Three-dimensional view of the ATLAS detector.

The ATLAS Collaboration consists today of 158 institutions from 35 countries with roughly 1650 scientific authors (including about 350 PhD students). It is still growing as new institutions are joining the effort. It is a pleasure to note that both Cracow institutions hosting this conference, the Institute of Nuclear Physics PAN and the AGH University of Science and Technology, are members of the ATLAS Collaboration since its formation.

The status of the detector hardware systems is described in the next sections, followed by the progress of computing and preparation for the very first physics phase of LHC.

2. Magnet system

The ATLAS superconducting magnet system comprises the central solenoid, the barrel toroid, two end-cap toroids, and their common services.

The solenoid, integrated in the LAr barrel calorimeter cryostat, was moved into its final position around the centre of the interaction region in early November 2005. The electrical and cryogenics connections have been completed, and just during the days preceding this conference a first excitation at reduced current was successfully achieved. The plan is to measure accurately the field map during August this year.

The mechanical Barrel Toroid (BT) installation was completed successfully in September 2005 (figure 2) with the release of the external supports, and respects the predicted geometrical envelope for the self-supporting structure. Since then cryogenics and electrical connections have been finalized, notably with the cryo-ring installation and the commissioning of all the external and proximity cryogenics. The first *in-situ* cool down will start in July and take about six weeks, followed by current tests.

Fig. 2. Picture taken of the Barrel Toroid underground installation when the last coil was put into place on 25th August 2005.

The integration of the cold masses for both End-Cap Toroids (ECTs) is in full swing. Due to welding failures and a redesign of support pieces on the thermal shields, the assembly is late by about 2–3 months. The first ECT, side A, will be ready for surface cold tests at liquid nitrogen temperature this summer, and will be transported to the Pit in October. The second ECT will follow about 3–4 months later. In parallel the underground services are being installed on schedule.

3. Inner Detector

The Inner Detector (ID) combines three concentric sub-system layers, from inside out the Pixel detectors, the Silicon detectors (SCT) and the Transition Radiation Straw Tracker (TRT). The series module production is finished for all of them, the work is now concentrating on full pre-assembly and integration of the sub-systems at the surface, prior to installation into the detector in the cavern starting in the second half of 2006.

For the Pixel detector a very major problem was encountered in summer 2005, with corrosion leaks in some barrel cooling tubes. With a huge effort a repair and replacement strategy were developed which include production of new staves for the innermost layer, repair of bare staves with new cooling lines, and a delicate repair operation on already equipped staves with glued modules. All these actions proceed well along a tight schedule which foresees readiness for installation in April 2007. The ATLAS installation schedule was globally optimized to receive the Pixels at this late stage. The end-cap Pixel disk macro-assembly is proceeding on schedule, and the first complete end-cap arrived at CERN in May 2006.

The barrel SCT assembly has been completed and a very major milestone was achieved at the end of February 2006 with the insertion of the complete barrel SCT into the barrel TRT (figure 3). Very recently first cosmic ray events were recorded in the surface clean room, as shown in figure 4. The end-cap assembly is also well advanced. Both sides have been shipped to CERN during the last months. The end-cap integration with the TRT is expected for August and September, respectively. The production of the off-detector read-out electronics and of the power supplies is largely completed.

Fig. 3. Integration of the barrel ID: insertion of the SCT into the TRT (Feb. 2006).

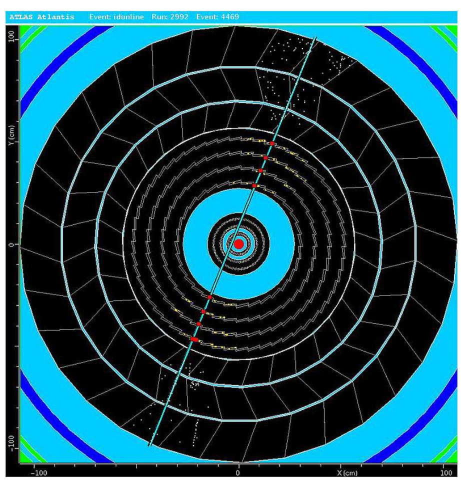

Fig. 4. A cosmic ray event recorded in the barrel TRT and SCT detectors (June 2006).

The barrel TRT has been integrated with the barrel SCT as mentioned above. The integration work for the two end-caps has progressed well, and they are expected to be ready in time for the forthcoming integration with the end-cap SCT.

4. LAr Calorimeter

The LAr cold test activities at the surface were finished at the end of 2005 with the second end-cap cryostat test. The main activities for the LAr calorimeter concentrate on completing the installation and the commissioning in the cavern. The LAr cryogenics infrastructure at Point-1 is ready and functioning.

The barrel calorimeter, comprising the LAr EM cryostat surrounded by the Tile Calorimeter, was moved into its final position centered on the interaction point on 4th November 2005 (figure 5). Just before this conference the cool-down was completed, and first tests in-situ can start. By May 2006 also both LAr end-cap calorimeters were installed and integrated with the Tile Calorimeter, as shown in figure 6 for one of the sides. The underground end-cap commissioning work will follow during the second part of 2006.

Fig. 5. Placement of the integrated barrel LAr and Tile Calorimeter into the detector centre, inside the coils of the Barrel Toroid (4th November 2005).

On the critical path for the LAr calorimeters are both the low- and high-voltage power supplies. For some time both have shown unacceptable failure rates and instabilities, and intense iterations with the two different suppliers have been necessary to master the problems. The previously critical

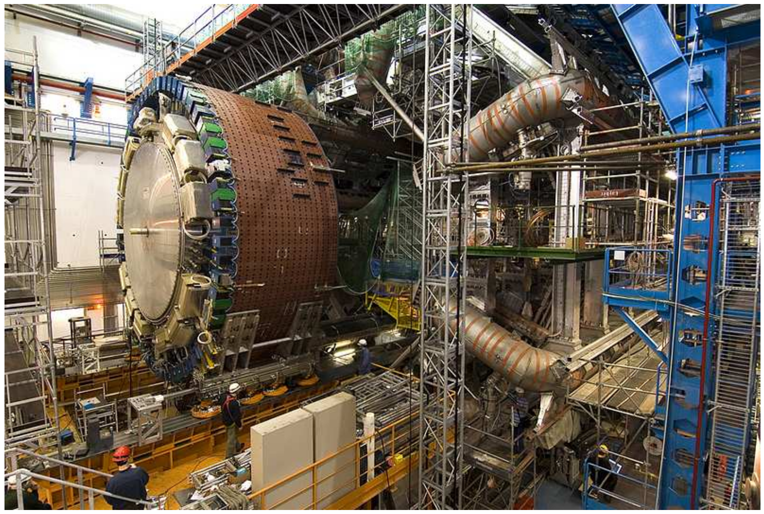

Fig. 6. First completed calorimeter end-cap (LAr and Tiles) being moved towards the detector centre (March 2006).

Front End board production is now essentially finished, and installation on the detector is proceeding. The series production of the other components and of the Back End electronics is on schedule, with their installation and commissioning in the counting room progressing well.

5. Tile Calorimeter

As already noted above, the Barrel Tile Calorimeter cylinder was moved to the interaction region at the end of last year. Both end-caps, called Extended Barrel Tile Calorimeter, were integrated with the LAr end-caps over the past months. Good progress can be reported for the off-detector electronics and its commissioning. The commissioning of the on-detector electronics has been slowed down because of failures in the low-voltage power supplies (a control problem has been understood and will be fixed) and occasional HV trips still under investigation.

6. Muon Spectrometer

The Muon Spectrometer is instrumented with precision chambers for the momentum measurement and with fast chambers for triggering. The series construction of all the chamber sub-systems has been completed. A major effort is underway in the assembly of complete barrel stations (almost finished by now) and end-cap sectors. The barrel installation and commissioning in the cavern is in full swing.

The single barrel chamber production came to an end in February with the completion of the series construction of the Resistive Plate Chambers (RPCs) used for the barrel muon trigger. The series production of the Monitored Drift Tube (MDT) chambers was already completed, and MDTs and RPCs are integrated into barrel muon stations for the middle and outer layers. This activity is almost complete, and includes substantial cosmic ray testing in order to provide certified stations for the underground installation. For about half a year the installation has proceeded including in particular all the stations in the most difficult locations (figure 7), and is now continuing with the standard stations. A major activity is also the installation of the services for the chambers as well as the alignment system. Along with the installation the commissioning has started, and first cosmic ray tracks have been recorded in the feet region of the barrel muon spectrometer.

Fig. 7. Installation of a muon station (integrated MDT and RPC) into the Barrel Toroid.

The series production of end-cap chambers, MDTs and Cathode Strip Chambers (CSCs) for precision measurements and Thin Gap Chambers (TGCs) for triggering, is complete. The main activity now concentrates on the assembly and integration of fully tested complete sectors for the end-cap wheels, including their alignment system. An example is shown in figure 8. The so-called Big Wheels in the middle station consist of a total of 2 MDT wheels and 6 TGC wheels, preassembled in 32 MDT sectors and 72 TGC sectors. The sectors for the first TGC wheel were ready by the end of April 2006, and preparations for the underground installation have started since the completion of the first end-cap calorimeter made the space available. The integration of the Small Wheel chambers for the inner end-cap station is planned to start at the end of 2006 and is expected to meet the schedule.

Fig. 8. Pre-assembled "Big Wheel" MDT sector for the end-caps.

7. Trigger and DAQ system

The Level-1 Trigger, the High Level Trigger (HLT), the Data Acquisition (DAQ) and the Detector Control System (DCS) have all been field-proven in the combined test beam running and large-scale system tests over the past years. Components of the final system are now being installed at Point-1, both in the underground control room as well as in the surface HLT/DAQ computer room, and they are gradually being used in the commissioning of the ATLAS detector as it gets installed.

The level-1 trigger system (with the sub-systems calorimeter, muon and central trigger processor, (CTP)) is in the production and installation phases for both hardware and software. The muon trigger sub-system faces a very tight schedule for the on-chamber components needing several iterations in the ASICs development, but is now proceeding satisfactorily. The calorimeter trigger is being installed following the availability of the corresponding detector signals in the underground counting room. First parts of the CTP sub-system have been already installed, and all components are available.

The HLT, DAQ and DCS activities have continued to proceed according to plan. Large scale system tests, involving up to 800 nodes, have further demonstrated the required system performance and scalability; the latter are particularly important for the staging needs during the initial running of ATLAS. Major emphasis was put on all aspects of the HLT and DAQ software developments. The HLT and DAQ pre-series system hardware, installed and operational at Point-1, was used successfully in a 10% data flow test last year, as well as for early detector commissioning work. An important element for the initial commissioning is the local DAQ capability available to the detector system communities. The operational infrastructure at Point-1 is fully active (central file server and a number of local service machines operational with standard DAQ software, system administration, and networking). Furthermore, about one third of the final Read Out Systems have been mounted and commissioned, a large number of them installed in the control room, and their connection and integration to the LAr and Tile Calorimeters are in an advanced state (figure 9). The DCS is already widely used and was one of the first systems to become operational, at least in part, in the underground installations at Point-1.

Fig. 9. Barrel LAr readout electronics and DAQ system in the underground counting room.

8. Computing, software and physics preparation

The running of Data Challenges (DCs) continues as the major focus of activity for the computing. DC2 earlier in 2005 gave input to the resources estimates for the Computing Model and the Computing Technical Design Report (TDR). The LHCC review process of the TDR was concluded in February with a recommendation for approval. A first very broad computing campaign involving mainly non-expert users was launched to simulate events for the 5th ATLAS Physics Workshop, which took place in Rome in June 2005. About 10 million events were simulated with GEANT4, and the operation was based entirely on POOL persistency and GRID infrastructure. The data were used for large-scale physics studies, with an emphasis on commissioning the detector and early physics during the first years of LHC operation. This large-scale distributed computing activity was fully embedded into the framework of the Worldwide LHC Computing Grid (WLCG) effort of which ATLAS is a very active partner.

More recently, until April 2006, ATLAS and WLCG performed a large data transfer exercise from the Tier-0 to all Tier-1s, known as Service Challenge 3 (SC3). These operations were largely successful and revealed in a constructive manner several areas where improvements needed to be achieved, and which are now being followed up, in order to reach the planned efficient and smooth running of the collaboration-wide computing for LHC turn-on. The SC3 already demonstrated that the anticipated data transfer is becoming within reach, and sustained operation will be demonstrated with SC4 during the second half of 2006. Further large efforts include the simulation and analysis of the data from the 2004 combined test beam deploying real components of the software and computing framework, and developments of GEANT4 and fast simulation frameworks.

Many specific tools and procedures for the whole ATLAS-software are being developed and implemented within Collaboration-wide task forces. Particular emphasis is being put on usability of the whole analysis suite. The computing system commissioning goals are being pursued with the aim to have by mid-2006 a fully working system with all the minimal required functionality, including in particular calibration and alignment procedures, the full trigger chain, Tier-0 reconstruction and data distribution, and last but not least distributed access to the data for analysis. Another important goal is to collect real cosmic ray data from Point-1, which will be used to demonstrate all these steps.

9. ATLAS detector installation and schedule

The installation status and the forthcoming milestones for the detector components have been addressed in the previous sections. It must be noted that in all cases the installation of the services and cables, with their cable trays, patch panels and movable chains, is one of the most personnel-intense activities in the underground cavern, which requires considerable attention and supervision work from Technical Coordination. This massive activity will remain on the critical path until the end of 2006. As an example the ID cabling inside the barrel LAr calorimeter cryostat is shown in figure 10.

Most of the heavy radiation shielding components have been delivered to CERN; still missing is the part inside the end-cap toroid support tubes for which a new fabrication plant had to be found. Recently the first shielding element connecting the cavern with the LHC tunnel (visible in figure 6) has been installed on one side.

Fig. 10. Services (cables and pipes) for the ID installed along the inner wall of the barrel LAr cryostat.

Very roughly summarizing the schedule, the plan is to have around October 2006 the barrel region completely installed (except for the end-cap ID and the Pixels) and operational for common commissioning, both end-cap calorimeters installed and connected, with their electronics commissioning in progress, a substantial part of the muon Big Wheels for one side installed. The first ECT will be lowered into the cavern before the end of 2006. The planning of the activities in the cavern is displayed in figure 11. The installation of the initial detector is scheduled to be completed by August 2007 for the beam pipe closure, and ready for beam by November 2007.

10. Conclusions and outlook

The ATLAS detector construction and installation are proceeding in general very well, in spite of its enormous complexity, thanks to a huge, dedicated and coherent effort from the Collaboration and technical services at CERN. Many technical challenges had to be mastered, as it was mentioned in this progress report.

There are very major software, computing and physics preparation activities under way as well, using the WLCG framework for distributed computing resources. The Collaboration has agreed on a planning for organizing the future data taking and LHC physics exploitation era, which is documented in a so-called Operation Model. Many examples of the ongoing preparations for the first physics data, so eagerly awaited by the Collaboration, will be presented at this Physics at LHC Conference. In short, one can conclude that ATLAS is highly motivated, and on track, for first LHC collisions in 2007.

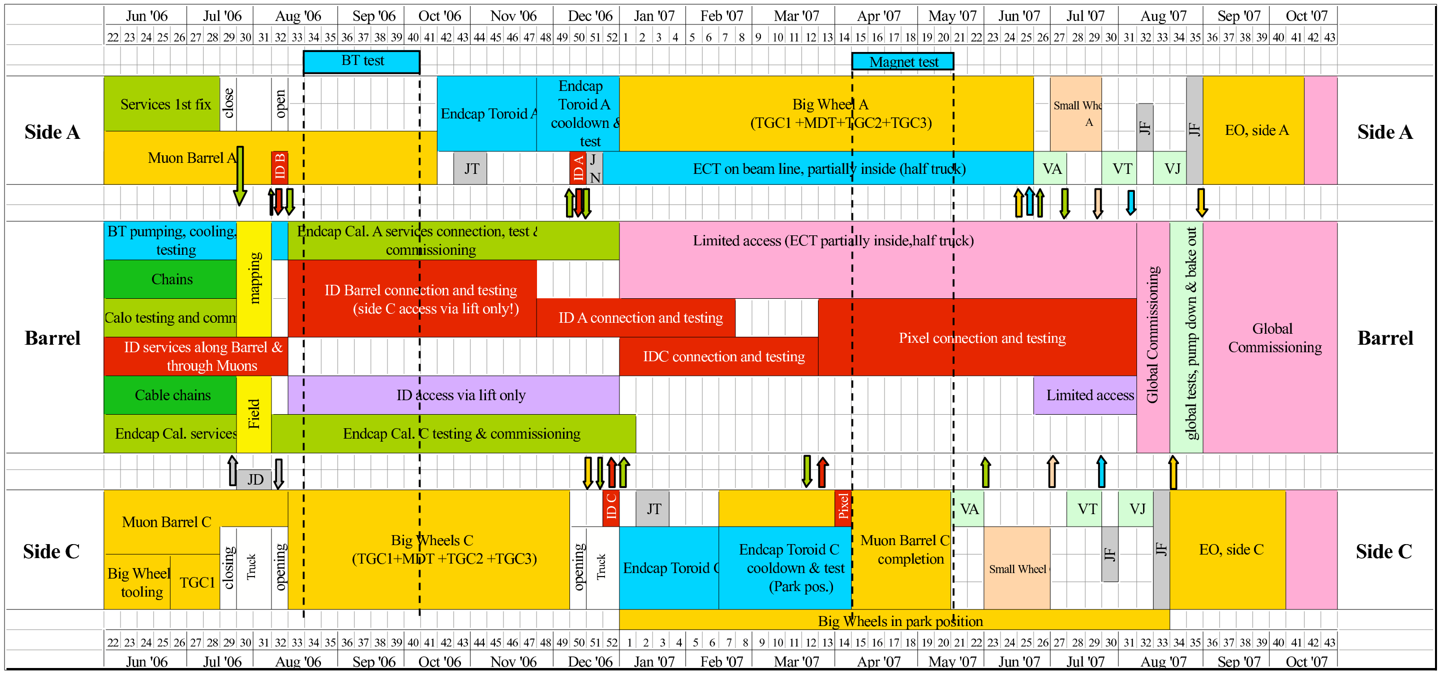

Fig. 11. Planning of installation activities (schedule) in the underground cavern leading to readiness for the start-up of the LHC.

It is with pleasure that I acknowledge the warm and friendly hospitality of Profs. D. Kisielewska and M. Turala, together with all Polish ATLAS colleagues, at this conference. I owe in addition special thanks to Dr. M. Wolter for his efficient help in editing this write-up.