CERN-RRB-2006-027
31st March 2006

ATLAS Progress Report for the April 2006 RRB

1. Introduction

The ATLAS project has now fully entered the surface integration, underground installation, and commissioning phases, with these activities being dominant. 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.

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.

The financial framework for the construction was defined in the Completion Plan for the staged initial configuration of the detector, taking into account the Cost to Completion (CtC) for the parts which are not covered as deliverables, and including the Commissioning & Integration (C&I) pre-operation costs as well as the available resources, as presented and approved at the October 2002 RRB (CERN-RRB-2002-114rev1), and updated at each RRB.

The ATLAS Collaboration consists today of 158 Institutions from 35 countries with roughly 1650 scientific authors (including about 350 PhD students). New Institutions from Argentina (University Buenos Aires, National University of La Plata), Germany (Technical University Dresden, University Giessen), and the U.S. (Oklahoma State University, University Oregon) have been admitted as new ATLAS Institutions at the last Collaboration Board meeting on 24th February 2006, and the RRB is invited to endorse their membership. Further Expressions of Interest to join ATLAS have been submitted, following detailed initial discussions about possible contributions, by DESY and Humboldt University Berlin (both Germany), and by New York University and SLAC (both U.S.). The Collaboration Board will consider these applications following the standard procedures defined in the Construction MoU.

2. Magnet System

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

2.1 Central Solenoid

Status: 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 are ready for cool down starting in April and field mapping in June.
Changes: None.
Concerns: None.
Plans: Cool down starting in April 2006, field mapping in June 2006.

2.2 Barrel Toroid (BT)

Status: The mechanical BT installation was completed successfully in September 2005 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 April and take about six weeks, followed by current tests.
Changes: None.
Concerns: None.
Plans: First in-situ cool down starting in April 2006, followed by excitation tests at the end of May 2006.

2.3 End-Cap Toroids (ECT)

Status: The integration of the cold masses for both 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 in July, and will be transported to the Pit in August. The second ECT will follow about 3-4 months later. In parallel the underground services are being installed on schedule.
Changes: The assembly sequence has been changed to optimize the overall installation schedule, first ECT-A and then ECT-C.
Concerns: Delay accumulated due to welding repairs and modifications.
Plans: Continuation of the assembly, followed by the ECT-A surface cold test (Nitrogen temperature) in July 2006 and the transport to the Pit in August 2006, with ECT-C following after 3-4 months.

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 emphasis has shifted from module construction, finished for SCT and TRT, to the assembly of modules onto the support structures (‘macro-assembly’) and to the integration of the overall ID including the services.

3.1 Pixel Detector

Status: The module production is nearing completion for a complete three-layer system. A very major problem was encountered last summer, as was already reported in the last RRB, with corrosion leaks in some barrel cooling tubes. With a huge effort a repair and replacement strategy was developed which includes

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 so far encouragingly well along a tight schedule which foresees readiness for installation in February 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 all installation tooling is ready.
Changes: Extra effort to recover delays due to corrosion leak problem.
Concerns: Schedule risk for the full system to be ready for LHC start-up.
Plans: Complete module series production and continue with disk assembly, proceed along the repair and replacement strategy for the barrel stave assembly.

3.2 Silicon Detector

Status: The barrel SCT assembly has been completed and a very major milestone was achieved at the end of February with the insertion of the complete barrel SCT into the barrel TRT. It is now being prepared for cosmic ray tests in the surface clean room SR1, before installation in the cavern scheduled for July. The end-cap assembly is also well advanced. One side has been shipped to CERN already, the second one is planned to arrive beginning of May. The integration with the TRT is expected for June and August, respectively. The production of the off-detector read-out electronics and of the power supplies is largely completed.
Changes: None.
Concerns: None.
Plans: Combined cosmic ray tests of the barrel SCT and TRT, followed by the barrel installation in July 2006. Integration and surface tests for the two end-caps.

3.3 Transition Radiation Tracker (TRT)

Status: The barrel TRT has been integrated with the barrel SCT as mentioned above. A repair action is still ongoing to replace leaking manifolds on cooling lines on the end-faces. The integration work for the two end-caps has progressed well, and they are expected to be ready for the forthcoming integration with the end-cap SCT over the coming months.
Changes: None.
Concerns: None.
Plans: Combined cosmic ray tests of the barrel TRT and SCT prior to installation in July 2006. Complete the end-cap integration and tests at SR1.

3.4 Infrastructure and Common ID Items

Status: The clean room facility SR1 is fully exploited with integration and test activities. The underground services installation is in full swing. However it turns out to be a very complex task, and in spite of greatly increased manpower efforts from the system as well as from Technical Coordination it is running somewhat late. After the cooling pipe installation the efforts now concentrate on cabling. The installation of electronics and the planning for commissioning have also started.
Changes: None.
Concerns: Complexity and delays in the services installation.
Plans: Continue electronics and services installation in the cavern.

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 commissioning in the cavern. Major points of attention are faulty low- and high-voltage power supplies which impact the commissioning progress. The LAr cryogenics infrastructure at Point-1 is ready and well advanced in its commissioning phase.

4.1 LAr Barrel Calorimeter

Status: The barrel calorimeter, comprising the LAr EM cryostat integrated with the tile calorimeter, was moved into its final position centered on the interaction point on 4^{th} November 2005. The cryogenics connections and the cabling are being completed, and are needed for the forthcoming cool down scheduled to start in April. In the meantime the on-detector installation of the front-end (FE) electronics is ongoing.
Changes: None.
Concerns: None.
Plans: Continue installation and commissioning of the FE electronics in the cavern. Start cool down in April 2006 and operate the LAr EM calorimeter in-situ for the first time end of May 2006.

4.2 LAr End-Cap Calorimeters

Status: The first LAr end-cap calorimeter was installed and integrated with the tile calorimeter in the pit by the end of January. In February, they were moved together towards the interaction point, thus freeing the floor space below the access shaft. On-detector FE crate and electronics installation is now proceeding. The second end-cap cryostat was moved to Point-1 in January after successful completion of the surface cold tests. Its installation in the cavern is planned for April.
Changes: None.
Concerns: None.
Plans: Completion of the on-detector electronics installation on the first end-cap, followed by its commissioning. Lowering of the second end-cap cryostat into the cavern by the end of April 2006, followed by on-detector infrastructure in the months after completion of the integration with the surrounding tile calorimeter.

4.3 LAr Electronics

Status: On the critical path are both the low- and high-voltage power supplies. For sometime both have shown unacceptable failure rates and instabilities, and intense iterations with the two different suppliers are ongoing. Whereas the situation for the low-voltage supplies is evolving in an encouraging way, alternative suppliers are being investigated for the HV supplies. The previously critical FE 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 (BE) electronics is on schedule, with their installation and commissioning in the counting room progressing well.
Changes: None.
Concerns: Both low- and high-voltage power supply fabrication are on the critical path, with a series of technical problems not yet fully mastered in the case of the HV.
Plans: Continue in-situ installation and commissioning of the on-detector and BE electronics. Follow with highest priority the technical low- and high-voltage power supply issues and their fabrication.

5. Tile Calorimeter

Status: As already noted above, the barrel Tile Calorimeter cylinder was moved to the interaction region at the end of last year. The first extended barrel Tile Calorimeter, integrated with the LAr end-cap, was installed over the past months and moved recently away from the access shaft. The installation of the second extended barrel and its integration with the LAr end-cap is planned for March to May 2006. 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.
Changes: None.
Concerns: HV problems still under investigation.
Plans: Installation of the second extended barrel by May 2006. Proceed with the commissioning work, paying special attention to the HV instabilities.

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 and end-cap sectors. The barrel installation and commissioning in the cavern is in full swing.

6.1 Barrel Chambers

Status: The single 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 now being integrated into barrel muon stations for the middle and outer layers. This activity is in full swing and includes substantial cosmic ray testing in order to provide certified stations for the underground installation. In the course of this effort about 30 stations will be reworked. These stations included RPCs from the very early production and showed tails towards high leakage currents. For about half a year the installation has proceeded with the stations in the most difficult locations (about 100 embedded in the toroid structures), and is now continuing with the ‘standard’ stations, scheduled at a much faster rate to last until summer. 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.
Changes: None.
Concerns: Tight and constrained installation schedule, requiring frequent reconfiguration of access platforms and pre-defined availability of certified chamber stations.
Plans: Continue with station preparation and installation at increased rate until summer 2006, and with their commissioning.

6.2 End-Cap Chambers

Status: The series production of 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. 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. At this stage 18 sectors are completed and 5 others are in different stages of assembly. A corrective action, utilising more manpower, has been implemented to achieve on-time assembly, for complete installation on the first side by the end of 2006 and of the second side by June 2007. The sectors for the first TGC wheel will be ready by the end of April 2006, and preparations for the underground installation have started since the 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. The special stations in the barrel to end-cap transition region are on schedule as well.
Changes: Increased manpower effort in the Big Wheel sector assembly, adding later in the year a further assembly station.
Concerns: Tight schedule for on-time completion of the end-cap wheels.
Plans: Continue sector preparation and commissioning, with the first TGC sector ready for installation at the end of April 2006 and all the wheels installed on the first side by the end of 2006.

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.

7.1 Level-1 Trigger

Status: 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 as reported previously, 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.
Changes: None.
Concerns: Tight schedule for on-detector muon-trigger electronics.
Plans: Proceed with the construction and commissioning phases for all components, continue in-situ installation.

7.2 High Level Trigger, DAQ and Detector Control System

Status: 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 now fully active (central file server and a number of local service machines

operational with standard DAQ software, system administration, and networking). Furthermore, almost 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 is in an advanced state. 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.
Changes: None.
Concerns: The performance of the initial system is limited by the availability of funds, implying deferrals of processors as foreseen by the Completion Plan, in the case that not all the Cost to Completion resources become available.
Plans: Optimization of the HLT/DAQ/DCS system and its software, exploit and expand the pre-series system test at Point-1. Operate online software infrastructure as well as DAQ and DCS tools for detector commissioning.

8. Computing, Software and Physics Preparation

Status: 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 early 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 WLCG of which ATLAS is a very active partner. More recently, until February 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.
Changes: None.
Concerns: None.
Plans: Consolidate and commission the software and computing for a collaboration-wide, distributed approach, in full coherence with the WLCG, and running of SC4 in the second half of 2006. Improve further the usability of the software, and implement all minimally required functionalities.

9. ATLAS Detector Infrastructure

Status: 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 (TX1S), connecting the cavern with the LHC tunnel, has been installed on one side. The installation and commissioning of the electrical power distribution is well advanced and operational in the underground control rooms. An important activity running on the critical path is the installation and commissioning of the back-up power supplies, in particular the Diesel generators needed before the cryogenics activities start. The underground magnet power supplies and the cryogenics plants for the magnet system and the LAr calorimeters are operational and ready for their commissioning. Continued attention is paid to the overall engineering and integration of the detector, including internal access structures. The Technical Coordination is continuously taking active steps for all aspects concerning safety and controls. A major effort is spent in providing safe and protected access for installation work, requiring frequent adaptation of the layout of temporary scaffolding. An expert group has been set in place to gradually develop and implement the surface control room infrastructure.
Changes: Change of supplier for the shielding in the ECTs.
Concerns: Complexity of providing at any time temporary safe access for installation work.
Plans: Completion of the remaining shielding components. Finalize the installation of all the safety systems. Commissioning of the back-up power systems. Continue to equip the underground control rooms, and start-up of the installation of the main surface control room.

10. ATLAS Detector Installation and Schedule

Status: 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 manpower-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. Very roughly summarizing, the plan is to have before the October RRB 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 with their electronics commissioning in progress, a substantial part of the muon 'Big Wheels' for one side installed, as well as the first ECT lowered in the cavern. The planning of the activities in the cavern is displayed in Figure 1. The installation of the initial detector is scheduled to be completed with the forward shielding and end-wall muon chambers by June 2007, ready for beam as of July 2007. The LHCC milestone progress for the remaining construction is shown in an integrated way in Figure 2, by the fraction passed as compared to the baseline planning from the last revision agreed with the LHCC in 2004.
Changes: None, however continuous optimization of detailed installation work planning is necessary to adapt to often rapidly changing technical challenges.
Concerns: Inherent risks by the overall complexity of the installation process, including the cabling and services.
Plans: By the end of summer 2006: completion of the barrel region (except Pixels), completion of the end-cap calorimeter assembly, most of the muon 'Big Wheels' for one side, one ECT lowered. Services and cable installations continue throughout 2006.

11. Updates on the Completion Planning

At the RRB meeting in October 2002, a Completion Plan for the initial ATLAS detector was approved. This plan (CERN-RRB-2002-114rev1) took into account the Cost to Completion (CtC) for the parts that are not covered as deliverables, and included the Commissioning and Integration (C&I) pre-operation costs until 2006. It fitted into the framework of the available resources agreed to at that RRB meeting by the Funding Agencies (called category 1 funding in Annex 2 of the above document). The document also included an indication of further funding prospects, without commitments yet, from the Funding Agencies (called category 2). The detailed implementation of the plan was understood to evolve within the specified overall framework when further financial commitments would become available. The CtC envelope was set at 68.2 MCHF, imposing on ATLAS at that time a scheme to stage and defer components and activities from its initial detector configuration, in order to redirect a total of 21.7 MCHF to cover the difference.

The detector construction has since continued within this framework. Constructive interactions have been pursued with funding partners ever since to improve the situation. The ATLAS Collaboration is very grateful to all Funding Agencies that committed, initially and during these years, funding towards the CtC. Since the last RRB report ATLAS is pleased to acknowledge a new increase in the CtC funding thanks to IN2P3 France, INFN Italy, Poland, Russia and Switzerland. The ATLAS Collaboration also kindly reminds all Funding Agencies that have not yet committed to their proposed share of CtC funding to continue their utmost efforts to secure the missing resources. Only a strong and solid solidarity across all funding partners will allow the Collaboration to complete its powerful detector to fully exploit the great LHC physics opportunities as early as possible.

The updated CtC funding planning is given in Table 1, which at this stage shows a category 1 funding of 62.7 MCHF and a category 2 funding prospect of 2.2 MCHF. It has to be noted that the Collaboration also currently faces a deficit of about 10 MCHF due to late payments of baseline Common Fund contributions, as discussed in the corresponding budget document CERN-RRB-2006-018. This means that the agreed Completion Plan remains valid, within this funding framework, which will force ATLAS to implement a start-up configuration with limited initial performance, in particular having a reduced trigger rate capability.

Cost to Completion Funding Planning (all in kCHF)
(revised 31st March 2006)

CERN-RRB-2006-027

Funding Agency	Cost to Completion proposed sharing Total	Constr. Comp.	C&I	Member fee 2004-6 (included in Constr. Comp.)	New funding (category 1) including member fee Total	New funding requests as prospects (category 2) without commitment from FA Total
Armenia	**66**	48	18	38	**45**	
Australia	**357**	242	115	75	**140**	238
Austria	**67**	52	15	38	**67**	
Azerbaijan	**43**	38	5	38	**38**	
Belarus	**85**	75	10	75	**75**	
Brazil	**64**	47	17	38	**41**	
Canada	**2090**	1528	562	263	**2090**	0
China NSFC+MSTC	**141**	99	42	38	**141**	
Czech Republic	**316**	196	120	113	**316**	
Denmark	**422**	290	132	38	**58**	375
France IN2P3	**5890**	4176	1714	225	**5890**	0
France CEA *)	**1940**	1379	561	38	**1334**	
Georgia	**42**	37	5	38	**38**	
Germany BMBF	**4531**	3250	1281	338	**4531**	0
Germany MPI	**1093**	761	332	38	**1093**	
Greece	**261**	173	88	113	**113**	148
Israel	**739**	497	242	113	**739**	
Italy	**6638**	4650	1988	450	**6288**	
Japan	**4362**	3029	1333	563	**4362**	
Morocco	**57**	47	10	38	**41**	
Netherlands	**1934**	1368	566	75	**1934**	
Norway	**581**	391	190	75	**581**	
Poland	**136**	94	42	75	**102**	34
Portugal	**446**	265	181	38	**339**	107
Romania	**140**	85	55	38	**140**	
Russia	**2991**	1995	996	263	**1759**	
JINR	**1066**	660	406	38	**521**	
Serbia					**300**	
Slovak Republic	**72**	53	19	38	**82**	
Slovenia	**223**	152	71	38	**223**	
Spain	**1706**	1109	597	113	**1706**	
Sweden	**1691**	1121	570	150	**1691**	
Switzerland	**2372**	1701	671	75	**2372**	0
Taipei	**445**	318	127	38	**445**	
Turkey	**85**	75	10	75	**75**	
United Kingdom	**4387**	3063	1324	450	**3133**	1254
US DOE + NSF	**12245**	8438	3807	1238	**6200**	
CERN	**8452**	5770	2682	38	**13700**	
Total	**68176**	47272	20904	5563	**62743**	2156

*) The commitment shown does not include a 1 MCHF additional engineering contribution provided on the initial BT contract (see MoU Annex 8.A)

Table 1

ATLAS Installation Activities in the Cavern

31-03-2006

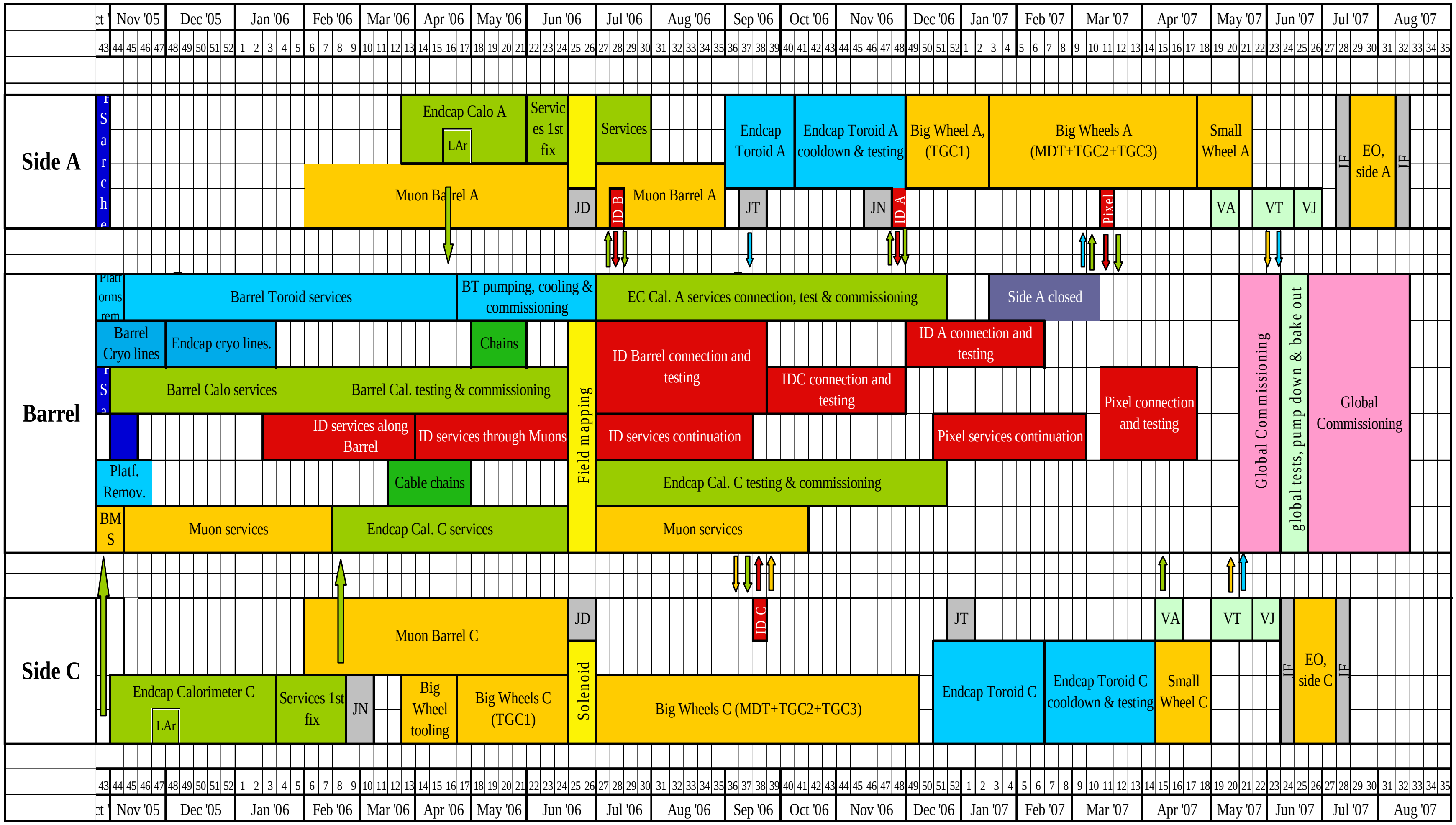

Figure 1

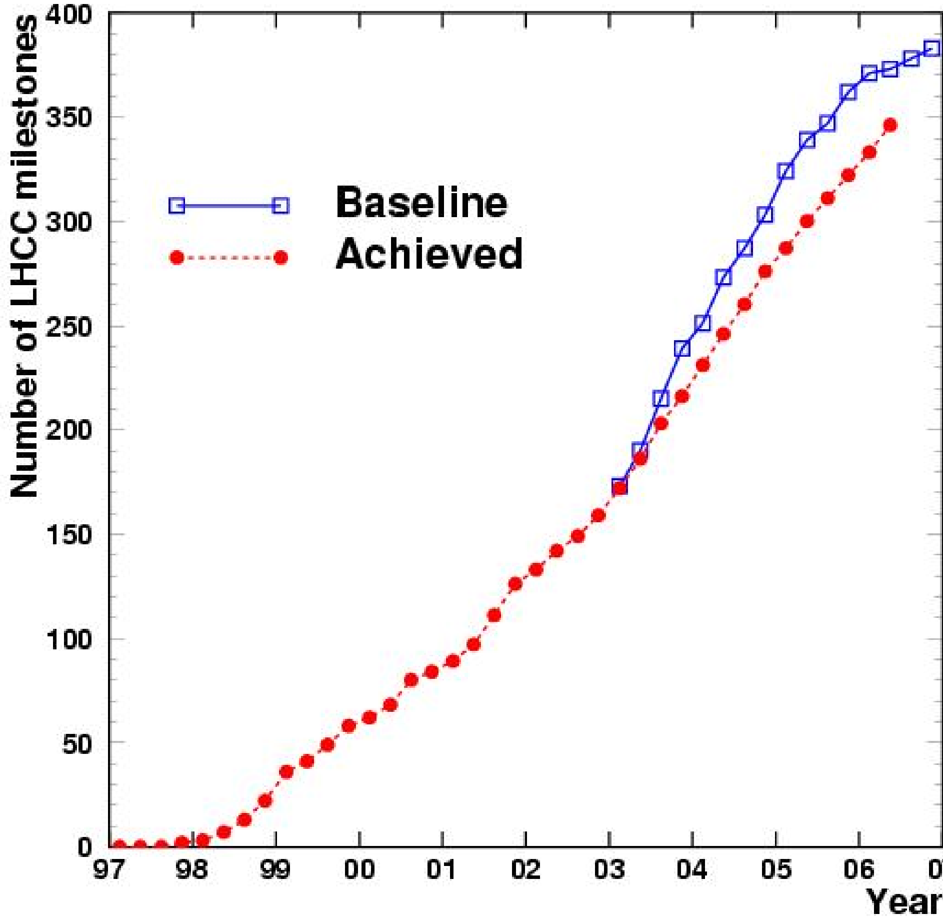

Figure 2: Integrated LHCC Milestone Plot