CERN-RRB-2008-031
31st March 2008

ATLAS Progress Report for the April 2008 RRB

1. Introduction and Collaboration Composition

During the past months the surface integration work at CERN has been completed, and the underground installation of detector components is almost finished. ATLAS is on track for starting to close the detector in April, and to be ready for launching the commissioning with beams end of June. Very directly coupled to this is the strongly developing detector, trigger and data acquisition commissioning activity which will lead into the operation phase of the experiment. In parallel, the distributed computing and physics analysis tools are being exercised and refined, employing fully the Worldwide LHC Computing Grid Project (WLCG) as a backbone.

The ATLAS detector 'as built' and its basic performance have been recently documented in a comprehensive publication submitted to the Open Access journal JINST. It can be briefly recalled that the detector concept 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 3-level 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. This plan takes into account the Cost to Completion (CtC) for the parts which are not fully covered as deliverables, 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 the October 2006 RRB (CERN-RRB-2006-069). A plan was accepted by the RRB to absorb these additional costs within the initial 2002 CtC funding scheme, provided all baseline construction and all requested 2002 CtC would become available. The project completion has progressed within this framework, albeit with still some outstanding contributions.

The ATLAS Collaboration consists today of 167 Institutions from 37 countries with roughly 2200 scientific authors (including 450 PhD students). There were no pending admissions since the last RRB. The Collaboration Board will take at the earliest in July 2008 a decision on three new Expressions of Interest to join from the Julius-Maximilians-University of Würzburg, Germany, from the Palacký University in Olomouc, Czech Republic, and from the University of Texas at Dallas, U.S.A.

2. Commissioning of the Magnet System

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

Status: Both the CS and the BT have been successfully commissioned at full current (plus a small safety margin), and their safety systems have been tested in-situ during August and November 2006, respectively. The cryogenics cooling power

of the plant at Point 1 was increased, based on this first operation, to cope efficiently with the full system. After installation in summer 2007, both ECTs were cooled down and partially exited in a stand-alone mode at the end of 2007. These tests were performed with the ECTs not in their final position, and after an unexpected movement of the ECT during the first test the currents were limited to 75% and 50%, respectively for each side. The complete magnets system will be tested at full current, including some safety margin, in the final closed configuration of the detector, scheduled for May and June, just leading into operation for LHC start-up.
Changes: None.
Concerns: None.
Plans: Full current test of the complete magnet system starting in May and leading into LHC operation start-up in June.

3. Installation and Commissioning of the 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).

Status: The integration work in the clean room facility SR1 at the Point 1 surface has been completed for all sub-systems, and substantial parts of the four integrated large installation components (barrel and two end-cap SCT+TRT, Pixels) have been successfully operated on the surface in cosmic ray tests until early 2007. The installation of the ID services (cables and pipes) has been finished, and the installation and commissioning of the off-detector electronics in the underground control rooms USA15 and US15 have been completed according to plans.

As already reported at previous RRBs, the installation work, the final cabling and as a consequence the commissioning work for the ID were seriously delayed by a problem encountered with the evaporative cooling system used for the SCT and Pixels. In a very major effort over the past year this was overcome with re-fabrication of the failing parts and relocating them into an accessible region in the space between the calorimeter barrel and end-caps. Whereas the commissioning work in-situ of the TRT with cosmic rays progressed according to plans, the crucial steps of electrical and cosmic rays commissioning have only been achieved late with the barrel SCT, showing excellent results, and very recently with the end-cap SCT, again with first very encouraging results. The in-situ Pixel commissioning will only be possible in April, just before the closing of the ATLAS detector.
Changes: Change of the design in the evaporative cooling system (SCT and Pixels) by re-locating the heaters into the gap region between barrel and end-cap calorimeters, change of critical components in the heaters. Both changes are now implemented.
Concerns: The time for the SCT and in particular for the Pixel in-situ commissioning had to be reduced to a bare minimum due to the delays from the cooling system.
Plans: Complete Pixel cabling and services connections, closing the ID volume, and proceed with in-situ commissioning of all components of the ID.

4. Commissioning of the Calorimeters

Status: All three calorimeter cylinders, with the outside rings of Tile Calorimeters around the LAr cryostats, are installed in the cavern. The three cryostats are cold and filled with LAr. During the first ECT test and its unexpected displacement, mentioned in Section 2, the vacuum enclosure of a cryogenic feed-line for one of the end-cap

LAr calorimeters was damaged, and its liquid Argon was emptied as a safety precaution into the storage dewar installed in the cavern. The cryo-line has been repaired successfully in-situ, and the cryostat has been refilled, and commissioning operation is now resuming again after several months of interruption.

The main hardware activities over the past months have concentrated on the electronics and on the system commissioning. More than half of the calorimeter channels are part of the regular read-out chain, and the Back End (BE) electronics in USA15 is operational. Previously reported issues with HV power supplies are all overcome. For the LAr LV power supplies, located on the detector, a retro-fitting campaign for replacing faulty components was launched with a new firm, which completed delivery. As there are remaining doubts about the medium and long term reliability of the retro-fitted LAr LV supplies, development R&D contracts were placed with two vendors. Taking advantage of the available time before start-up, major interventions were launched for both calorimeter systems in order to improve the reliability of the on-detector electronics. For the LAr this consisted in two fixes on the Front End Boards (FEBs), implying that each single FEB had to be removed from the crate for the repair, within the constrained access given the advanced stage of the detector installation. This work is expected to be finished by the end of March. The access conditions were also an issue for the intervention on the Tile Calorimeter electronics ‘drawers’ for which a refurbishing campaign was just recently completed, in order to replace unreliable electrical contacts, observed to develop during the past years of commissioning experience.
Changes: Repair of a damaged cryogenic line to one of the end-cap LAr cryostats.
Concerns: None, but there is a tight schedule for full calorimeter system commissioning.
Plans: Continue full system commissioning, leading gradually into operation mode.

5. Installation and Commissioning of the Muon Detectors

The Muon Spectrometer is instrumented with precision chambers for the momentum measurement (Monitored Drift Tube chambers, MDTs, and for a small high-radiation forward area Cathode Strip Chambers, CSCs) and with fast chambers for triggering (Resistive Plate Chambers, RPCs, in the barrel, and Thin Gap Chambers, TGCs, in the end-caps).

Status: With the exception of about one-third of the end-cap end-wall (EO) chambers, all precision and trigger chambers are now installed. As a last large and spectacular transport and craning operation the two completely preassembled ‘Small Wheels’, integrated with the ‘JD’ shielding disk (10 m diameter, about 140 tons), were brought to Point-1 and lowered into the cavern during February. The remaining EO chambers will be installed end of May and early June so that the complete muon chamber instrumentation for the initial detector configuration is expected to be available for the LHC start-up. The commissioning with cosmic rays is ongoing for both the barrel and end-cap regions, gradually increasing the number of sectors involved. As reported before, the commissioning progress remains seriously affected by the late delivery of power supplies (from a single vendor delivering power supplies to the other LHC experiments). In spite of major efforts involving all partners, and including significant extra resources to speed up production and testing, the complete delivery is not anticipated before the end of May, clearly affecting the efficiency of the commissioning work.
Changes: None.
Concerns: None, however due to the delayed availability of power supplies the full commissioning for the whole system is on the critical path.

Plans: Complete end-cap end-wall installation and continue with commissioning.

6. Trigger and DAQ System

Status: The components of the final Level-1 Trigger (with the sub-systems calorimeter, muon and central trigger processor (CTP)), the High Level Trigger (HLT), the Data Acquisition (DAQ) and the Detector Control System (DCS) are now operational at Point-1, in the underground control room as well as in the surface HLT/DAQ computer room (in reduced configuration for the latter as available for the initial staged detector). The level-1 muon trigger sub-system proceeded along the tight schedule coupled to the muon trigger chamber commissioning which is late mainly because of the power supply components (see also section 5).

The HLT, DAQ and DCS activities advanced well according to plans, and the major emphasis is put on all aspects of the software optimization. Data from combined cosmic ray running were collected regularly through growing final parts of the whole chain. The Read-Out System (ROS) and the Event Builders have been demonstrated in a sequence of technical runs to deliver the required performance and data throughput rates. HLT algorithms have been successfully used with physics events pre-loaded in the ROS, and also with cosmic ray muons. Finally, the DCS is operational and available as an important standard tool to all detector system users in the commissioning runs. Apart from its own commissioning, the Trigger and DAQ system is also heavily and routinely used for the commissioning of the overall ATLAS detector.
Changes: None.
Concerns: None for the initial system. However, the performance of the initial system remains limited by the availability of funds, implying deferrals of processors as foreseen by the Completion Plan, in case not all the Cost to Completion funding becomes available.
Plans: Continued optimization of the full Trigger, DAQ and DCS system, with smooth transition into the LHC running phase.

7. Completion of the Installation and Global Commissioning of the Detector

Status: The installation of the initial detector will be completed following the recently revised Installation Schedule Version 9.3 which is shown in Figure 1. Over the past months the critical path was dominated by the ID as reported in section 3, namely by the delay in the sign-off tests for the SCT which were only possible once the evaporative cooling became fully operational, and as a direct consequence by the late phase for the services connection and testing of the Pixels, which is planned to be completed around mid-April. In parallel the refurbishing of the on-detector calorimeter electronics (see section 5) progressed well and was just completed very recently, but required special actions for access opportunities. As a last major installation milestone for active detectors the ‘Small Wheels’ were put in place in February. Given the fact that all these activities required the detector to be in an open position, the full magnet system test had to be scheduled to come at a rather late stage, namely in May and June.

As shown in details in Figure 1 the closing of the ATLAS detector, installation of the last beam pipe sections, completion of the installation of the end-cap end-wall muon chambers (EO), and installation of the massive forward shielding cones (JF) will take about two months, overlapping with the magnet tests. ATLAS requires therefore a ‘warning signal’ from the LHC two months ahead of the date when the cavern has to be closed. Within the present planning it is expected to launch this final closing phase by mid-April.

The ATLAS Control Room (ACR) is fully operational and heavily used. It has become the centre of many prominent activities over the past months, including periods of global commissioning running with collecting cosmic ray events in the cavern. During these so-called ‘milestone weeks’ gradually all detector components, and increasingly larger fractions of given sub-systems, are integrated into the full chain from the detector to the remote offline analysis. The data flow includes the operation of the trigger system, the DAQ chain, transfer to the Tier-0 and distribution over the WLCG backbone to all 10 ATLAS Tier-1 and most Tier-2 centres. It also means a fully operational safety and DCS infrastructure. Concurrent with the cosmics running, monitoring (online and offline) and data preparation tasks are exercised. The collected data is used for debugging the detector systems as well as for early calibration and alignment studies.

A major aspect of the milestone weeks is also to get first experience with the shift and operation tasks organizations. These periods are fundamental to train an increasing fraction of ATLAS members to become familiar with running the experiment. As already mentioned at previous RRBs, a first estimate of the efforts needed to operate the ATLAS experiment was made. The estimate of the so-called ‘Operation Tasks’ (OTs) amounts to about 600 FTE per year, covering from operation at Point-1 to the computing and data preparation tasks, which can be partially executed remotely (a rough estimate indicates about 40%). Per ATLAS member the projected share of operation task duties is very similar to that of large contemporary experiments running elsewhere. The share of operation tasks among the Institutions will be proportional to their number of ATLAS members. The OT planning is implemented through a new, dedicated Web tool which is still evolving.
Changes: None.
Concerns: Operation (in the broad sense as specified above) will require significant resources for which Funding Agencies have to plan ahead.
Plans: Complete the installation and close the detector for end June, and bring the full detector gradually into data taking operation and functionality.

8. Computing and Software

The Collaboration-wide distributed computing infrastructure is fully embedded into the framework of the WLCG of which ATLAS is a very active partner. However, it must be noted that in addition to this grid infrastructure there is a very sizable experiment-specific effort required to efficiently interface the ATLAS software suite and analysis framework to the WLCG infrastructure.

Status: During the past years ATLAS and WLCG successfully performed large data transfer exercises, from the Tier-0 to all Tier-1s and Tier-2s. For simulations ATLAS is essentially in a continuous operation mode including various large-scale exercises, like Distributed Analysis tests and Calibration Data Challenges. The WLCG is consistently used for running these large simulation productions, needed to develop and refine more and more realistic approaches to the data collection and analysis, including detailed trigger, calibration and alignment aspects. An important further step are the recent Common Computing Readiness Challenges (CCRCs), made concurrently by all four LHC experiments, for which the first phase was operated in February. The core computing infrastructure and services tasks, defined as M&O category A, play a crucial role for the smooth operation, and the (small) increase for

2008 turns indeed out to be crucial, improving on the experience from the past years. It enables ATLAS to more optimally exploit the large investments of computing resources made world-wide by the WLCG collaboration partners.

Many specific tools and procedures, encompassing online and offline aspects of the ATLAS software, were developed and implemented. Specific examples are the data quality monitoring and calibrations. Particular emphasis was put on the usability of the whole analysis suite. The basic functionality was successfully demonstrated in the cosmic ray commissioning runs with large fractions of the detector, as mentioned in the previous section, when the data from Point-1 were distributed over the WLCG grid to the Collaboration.

The preparations for the offline physics data handling is at this stage driven by a detailed planning for the first phase of the LHC operation. The full computing and software chain must be operational from the start, as clearly the main experiment's goal will be to debug the detector and to gain as efficiently and quickly as possible an excellent understanding of the detector performance in order to ensure the quality of the data. As a decisive test for this is a series of so-called 'Full Dress Rehearsal' (FDR) tests that have been launched recently. For the FDRs large samples of simulated LHC data, corresponding to typical LHC fills, are injected from the output of the DAQ system at Point-1 into the offline data flow chain. All stages of processing, distributing, calibrating and compactification of data, according to the ATLAS Computing and Analysis Model, are tested. The first phase of the FDR has been run in February. It has been successful in many aspects, and it showed clearly the areas where improvements are needed, and these are being implemented now for the second phase which will run April-May.
Changes: None.
Concerns: None, even though the Collaboration is aware that it still needs to significantly increase efforts on the computing infrastructure and operation tasks in order to finalize an efficient framework needed to extract the early physics fast. Some crucially needed deliverables from WLCG which are on the critical path will be discussed in the Computing RRB.
Plans: Consolidate and commission the software and computing for a Collaboration-wide, distributed approach, in full coherence with the WLCG infrastructure backbone. Further improve the usability of the software, and implement the ATLAS Computing and Analysis Model, to be demonstrated with the second phase of the FDR.

9. Updates on the Completion Planning

No major updates on the completion planning are to be reported with respect to the situation presented and discussed in the October 2007 RRB. The following section recalls the framework, and updates the situation, in which the detector construction and installation has proceeded.

The framework of ATLAS completion was laid down at the RRB meeting in October 2002, when the 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 were not fully covered as deliverables, including 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. In 2002 the CtC envelope was set at 68.2 MCHF, at that time imposing on ATLAS a scheme to stage and defer components and activities from its initial detector configuration, in order to fit into available resources.

In October 2006 the RRB has accepted a new assessment of the CtC, which resulted in an additional cost increase of 4.4 MCHF (from the magnet system, Big Wheel support structures, LAr cryogenics, and installation efforts, see CERN-RRB-2006-069). The Collaboration stressed that these additional costs could be accommodated within the 2002 Completion Plan *provided* all funding partners contribute their full calculated share to the CtC, thanks to the fact that CERN contributed a larger than calculate share, and *provided* that all Funding Agencies fulfill their baseline Common Fund obligations (Construction MoU).

The ATLAS Collaboration is very grateful to all Funding Agencies that have committed, initially and during all these years, funding towards the full CtC. The current situation is given in Table 1, where an encouraging progress can be seen towards pledges covering the full calculated 2002 CtC, therefore making it not necessary to request additional CtC funding. A total of 71.2 MCHF have been pledged to cover the total needed CtC funds of 72.6 MCHF (68.2 MCHF + 4.4 MCHF), and a number of Funding Agencies have kindly indicated that they may help temporarily with the resulting cash flow issue.

However, it has to be noted that the Collaboration also still faced a deficit of 6 MCHF at the end of 2007, mainly due to late payments of baseline Common Fund contributions, as discussed in the corresponding budget document CERN-RRB-2008-033.

The Collaboration most strongly urges all Funding Agencies that have not yet committed to their full calculated share of CtC funding, or have not yet financed their baseline Common Fund contributions, 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.

Cost to Completion Funding Planning (all in kCHF)
(revised 31st March 2008)

Funding Agency	Cost to Completion 2002 (CtC) calculated share			Member Fee 2004-6 (incl. in CC)	New funding (category 1) incl. Member F	New funding requests (category 2)	CtC 2006 proposed sharing
	Total	CC	C&I		Total	Total	Total
Argentina					75		
Armenia	66	48	18	38	45		
Australia	357	242	115	75	357		
Austria	67	52	15	38	80		
Azerbaijan	43	38	5	38	38		
Belarus	85	75	10	75	75		
Brazil	64	47	17	38	41		
Canada	2090	1528	562	263	2090		
Chile					38		
China NSFC+MSTC	141	99	42	38	141		
Colombia					38		
Czech Republic	316	196	120	113	316		
Denmark	422	290	132	38	58	375	
France IN2P3	5890	4176	1714	225	5890		
France CEA	1940	1379	561	38	1940		
Georgia	42	37	5	38	42		
Germany BMBF	4531	3250	1281	338	4531		
Germany DESY					38		
Germany MPI	1093	761	332	38	1093		
Greece	261	173	88	113	261		
Israel	739	497	242	113	739		
Italy	6638	4650	1988	450	6288		
Japan	4362	3029	1333	563	4362		
Morocco	57	47	10	38	42		
Netherlands	1934	1368	566	75	1934		
Norway	581	391	190	75	581		
Poland	136	94	42	75	136		
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		
Taipei	445	318	127	38	445		
Turkey	85	75	10	75	75		
United Kingdom	4387	3063	1324	450	4387		
US DOE + NSF (1)	12245	8438	3807	1238	12245		
CERN	8452	5770	2682	38	9300		4400
Total	68176	47272	20904	5563	66779	482	4400

(1) The remaining 4.5 MCHF to C&I is provided on a best effort basis
New funding requests as prospects (category 2) are without firm commitment from the Funding Agencies

Table 1

Installation Schedule Version 9.3 (March 2008)

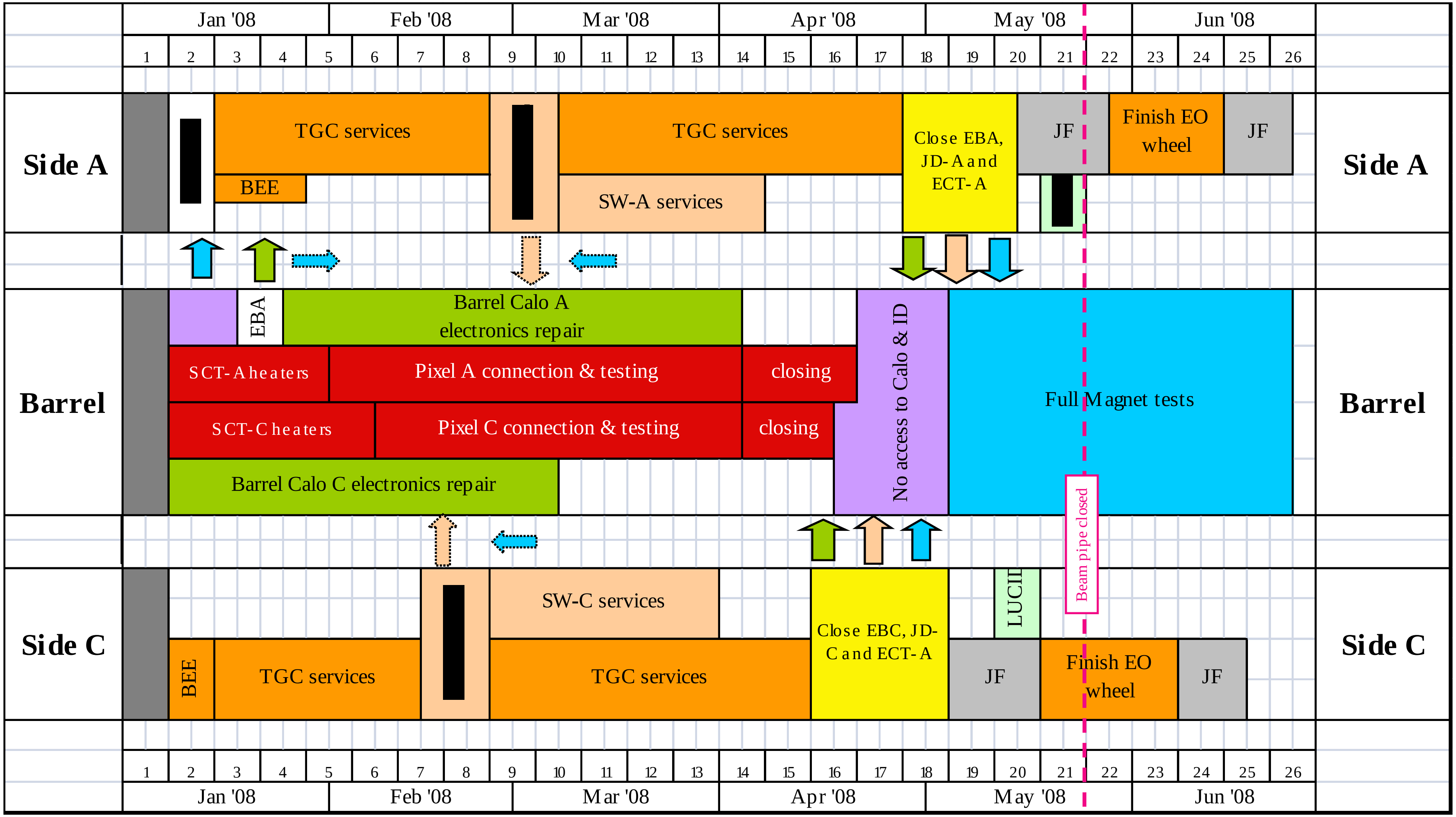

Figure 1