CERN-RRB-2009-020
3rd April 2009

ATLAS Progress Report for the April 2009 RRB

1. Introduction and Collaboration Composition

In anticipation of LHC colliding beams data taking later in 2009, ATLAS activities are focused on readiness to record quality data and to process and analyze the data. To this end, the current LHC shutdown period is being used for routine repairs and maintenance of the detector and trigger and data acquisition and to continue commissioning of the detectors and of ATLAS as a whole. During this period, work is ongoing to exercise and optimize the software, computing, and grid infrastructure both through processing and analysis of cosmic ray commissioning data and through rigorous, dedicated testing.

The ATLAS detector ás builtôand its basic performance have been documented in a comprehensive publication in 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 initial staged detector configuration, now operational, corresponds to the financial framework which was defined in the Completion Plan as presented and approved at the October 2002 RRB (CERN-RRB-2002-114rev1) and updated at the October 2006 RRB (CERN-RRB-2006-069).

The Collaboration has been active preparing for physics. These efforts led at the end of 2008 to the release of an extensive report (*Expected Performance of the ATLAS Experiment - Detector, Trigger and Physics*, CERN-OPEN-2008-020, arXiv:0901.0512v3), which summarizes most recent evaluations of the detector performance and of the experimentôs physics potential.

The ATLAS Collaboration consists today of 169 Institutions from 37 countries with roughly 2800 scientific authors (including 800 students). No new institutions have joined the Collaboration since the last RRB. The University of Granada, Spain, University Politehnica Bucharest, Romania, and University of São Paulo, Brazil, have joined the Collaboration via so-called clusters with existing ATLAS Institutions, which does not change the composition of the Collaboration Board or voting upon collaboration matters.

After many years of successful leadership by Peter Jenni, which brought ATLAS to readiness for data taking and into the maintenance and operations phase, ATLAS management has rotated on 1st March 2009. Fabiola Gianotti (CERN) is now ATLAS Spokesperson. Andy Lankford (University of California, Irvine) is a Deputy Spokesperson. Dave Charlton (University of Birmingham) will become the second Deputy Spokesperson on 1st July 2009, when his term as Physics Coordinator ends. Marzio Nessi (CERN) and Markus Nordberg (CERN) have begun new terms as ATLAS Technical Coordinator and ATLAS Resources Coordinator, respectively. Kerstin Jon-

And (Stockholm University) continues her term as ATLAS Collaboration Board Chair, and Gregor Herten (Albert-Ludwigs-Universität Freiburg) replaced Chris Oram (TRIUMF), former Collaboration Board Chair, as Deputy Collaboration Board Chair on 1st January 2009. The Collaboration has expressed its deepest appreciation for the leadership of past Spokesperson Peter Jenni and Deputy Spokesperson Steinar Stapnes.

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: Following operation of the full magnet system for many weeks during cosmic ray commissioning data taking in fall 2008, many improvements are being made to the magnet services systems during the shutdown in order to enhance robustness, reliability, and ease of operation. Improvements include: vacuum system upgrades; upgrades to instrumentation controls software and panels; and new ECT seismic brackets. Investment in a second, back-up compressor for the main cryogenic refrigerator is being studied, in order to avoid the risk of a 9-month downtime.
Changes: Improvements to magnet services systems.
Concerns: None.
Plans: Prepare for magnet testing when detector closes in mid-June and for subsequent ATLAS cosmic ray commissioning data taking. Determine whether to invest in a back-up compressor for main refrigerator.

3. Commissioning of the Inner Detector

The Inner Detector (ID) combines three concentric sub-system layers, from inside out the Pixel detectors, the Silicon strip detectors (SCT), and the Transition Radiation Straw Tracker (TRT).

Status: Last October and November, the Inner Detector systems were taking data with cosmic rays. Very good progress was made in understanding the detector alignment, and transition radiation was observed in the TRT for the highest momentum muons. The evaporative cooling plant for the Pixels and SCT operated with generally high efficiency on 199 of the 204 cooling loops. Problems in controlling certain circuits were resolved by using different temperature sensors further from the heaters. One SCT loop and 3 Pixel loops were off due to leaks, and an additional SCT loop could not be operated because of a problem with the heater. The major cause of down time was due to a number of cracks, which opened up on the pipes around the compressors in the USA15 plant room. These cracks were found to be due to metal fatigue provoked by the vibrations. The pipe work around the compressors has been redesigned. All compressors have been sent back to the manufacturer for the pipe work to be modified. One compressor has already been returned to CERN, and further measurements of the vibrations have been made to validate the new design. An additional compressor has been ordered to bring the total number of compressors to 7, where 4-5 are needed for normal operation and the remainder is available during maintenance or repairs on 1-2 units. The distribution racks for the evaporative cooling are also being upgraded during the shutdown. New valves are being added so that individual circuits can be isolated, and pressures sensors are being added to improve diagnostics. The heater problem on an SCT circuit was found to be due to a damaged cable, and this has been repaired. Measurement of pressure loss from closed cooling loops (leak down tests) have been repeated on all circuits, with the worrying result that one more pixel end-cap circuit, and some barrel layer 2 circuits, have developed small leaks inside the detector volume. The upgrade to the distribu-

tion rack will allow more routine leak down measurements, in order that the evolution of the leak rates can be tracked much more easily in future. There is strong evidence that the failure of the off-detector opto-transmitter plug-ins, used in both the Pixels and SCT, is due to damage from electro-static discharge (ESD) during manufacture. Intensive study has revealed several improvements to be made in the production process, and the full scale production of replacement plug-ins has just begun.
Changes: Repair of compressors and improvements in the distribution racks of the evaporative cooling system.
Concerns: The compressors and surrounding pipe work may need further rework or replacement with an alternative. Leaks exist in pixel cooling circuits. Production of replacement opto-transmitter plug-ins has taken time to begin.
Plans: Resume operation of the evaporative cooling plant at the start of May with four compressors. Then reintegrate the ID with the other ATLAS detectors, and subsequently install the remaining compressors and opto plug-ins during summer. Closely monitor leaking pixel cooling circuits, and study effects of C_3F_8 on the detector.

4. Commissioning of the Calorimeters

The calorimeter systems include a liquid argon (LAr) electromagnetic calorimeter, a barrel and two extended barrel Tile hadronic Calorimeters, end-cap liquid argon hadronic calorimeters, and liquid argon forward calorimeters.

Status: All calorimeter systems performed well in cosmic muon and first beam running in 2008. In particular, the refurbishment of the Tile Calorimeter electronics has proven successful. A wealth of cosmic ray data is being used for the tuning of the calorimeters. Failure of 1 out of 8 low voltage (LV) power supplies for the cold preamplifiers of the LAr hadronic end-cap (HEC) calorimeters in August 2008 was traced to faulty soldering in an internal component; consequently, all HEC LV supplies were sent to the manufacturer for inspection during the shutdown. No further supplies needed repair. One of 58 LAr LV supplies powering the Front-End Boards failed in 2008, and two more suffered partial failures. Consequently, all LAr LV supplies have been sent for repair during the shutdown. As there are remaining doubts about the medium- and long-term reliability of these retro-fitted supplies, development of backup solutions for possible future installation is in development at two vendors. Careful survey of the stability of Tile Calorimeter LV supplies over time is being carried out. During the shutdown two malfunctioning LV supplies out of 256 were replaced. Previously reported LAr Front-End Board (FEB) failures were traced to the light emitting component (VCSEL) on 11 of 1524 optical transmitters from the detector, and repaired. The cause of failure is being investigated, and a backup solution for possible future installation is in development. Failures of some Receivers, electronics boards that receive signals for the level 1 trigger, were linked to corrosion; consequently, all Receivers are being inspected and repaired during the shutdown. The goal of maintenance during the shutdown is to reduce the number of inoperable LAr channels to the 0.02% that are known to be irreparable. The Tile Calorimeter goal is to reduce the number of inoperable channels to less than 1%, in which case the number of bad cells in the Tile Calorimeter will be negligible because each cell is instrumented with two readout channels. Progress of all calorimeter repairs is proceeding on schedule.
Changes: None
Concerns: Medium- and long-term reliability of the LAr LV power supplies and of Tile Calorimeter LV supplies; long-term reliability of LAr optical transmitters.
Plans: Complete maintenance and repairs of electronics and LV power supplies during shutdown, reintegrate with ATLAS for combined cosmic running in summer and beam running in autumn. Continue development of long-term backup solutions in areas of concern.

5. 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: The complete muon chamber instrumentation for the initial detector configuration was available for the LHC start-up in 2008. Installation of additional chambers in the region between barrel and endcaps is being started during the current shutdown and will be completed during subsequent shutdowns. Five large sectors will be installed this year, bringing the total to 7 installed out of a total of 16 large sectors. The mechanical supports for the small sectors will also be installed this year. Cosmic ray muon data recorded in 2008 is being used for commissioning and alignment. Delivery of power supplies, with which problems were previously reported, is now complete. The shutdown is being used to repair problematic chambers, where very few residual problems now exist. For 2009/2010 running, MDTs and TGCs will be greater than 99.5% active and CSCs and RPCs will be greater than 98% active. Radiation hard read-out fibres have been installed on the 6 Big Wheelô end-cap MDT chambers Side C and will be installed in Side A in May. Repair of the unexpected read-out limitation with the Read-Out Drivers (RODs) of the CSCs is progressing well and will be complete for 2009 running. All four component systems of the Muon Spectrometer will be available for the first beam in 2009.

Changes: Power supply delivery complete. Additional MDT EEL chambers and radiation-hard read-out fibres installed. Large improvements on the barrel trigger coverage have been achieved.
Concerns: Fragility of RPC gas inlets; observed cracking on a few gas jumpers of the EO MDT chambers
Plans: Complete repairs of problematic chambers (HV, gas) as far as possible during shutdown. Complete installation of new EEL chambers (max 5 large sectors) and radiation-hard read-out fibers. Re-integrate with other ATLAS detectors for combined cosmic running, and continue commissioning work, particularly on the RPCs and CSCs. Establish final trigger timing in the barrel region using first beams.

6. Forward Detectors

The forward detectors for the first phase of ATLAS consist of a Luminosity Cerenkov Integrating Detector (LUCID) placed around the beam pipe inside the forward shielding at 17 m from the Interaction Point (IP), of a Zero Degree Calorimeter (ZDC) placed in the absorber structure TAN where the beams join separate beam pipes at 140 m away from the IP, and of an Absolute Luminosity for ATLAS (ALFA) detector in Roman Pots at 240 m from the IP. A proposal for an ATLAS Forward Protons project (AFP) is being considered by an ongoing review.

Status: LUCID is in an advanced stage of commissioning. The ZDC is installed and commissioning is in progress. ALFA detectors are in development.
Concerns: None.
Plans: Install ALFA mechanics, and complete preliminary commissioning of LUCID and ZDC during shutdown. Complete development of ALFA detectors for installation in next shutdown period.

7. Commissioning of the Trigger and DAQ System

Status: The major sub-systems of the Trigger and Data Acquisition System, including components of the 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), have been operational at Point-1 for many months, 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 full chain is working well and continues to be tested and tuned both in real data taking conditions of the combined cosmic ray runs and in special technical runs pushing the performance beyond its design limits. At this stage about 35% of the final HLT CPU capacity is installed and operational.
Changes: None.
Concerns: None for the initial system. However, the initial performance 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: Continue to optimize the full Trigger, DAQ and DCS system.

8. Shutdown Activities and Global Commissioning of the Detector

Status: The ATLAS detector was operated until mid-December collecting cosmic ray data. Several hundred million cosmic ray triggers have been collected with the full detector. These events are very valuable for improving procedures for data quality monitoring, alignment, and calibration. They are being used to tune detector performance in order that ATLAS is as ready as possible in advance of beam running next autumn.

As already detailed in the previous sections, ATLAS has adopted a plan of activities at Point-1 matched with the anticipated LHC schedule, including colliding beams near end October 2009, and with the expectation of an extended data run extending until late 2010. The planning of activities is shown in Figure 1. Routine repairs and maintenance of the magnets, detectors, and trigger and data acquisition are being performed, concentrated during the first portion of the accelerator shutdown. Many of these activities are nearing completion and are described elsewhere in this report. Closing of the detector commences in April and will complete in mid-June. Commissioning of individual detector systems has resumed. The summer months will be used for global commissioning of the experiment with cosmic rays.

Based upon the experience gained during commissioning running in 2008, estimates of the effort needed for the so-called "Operation Tasks" (OTs) are in the process of being refined. During the last part of 2008, ATLAS operated at the equivalent of 600 FTE, covering from operation at Point-1 to the computing and data preparation tasks, which can be partially executed remotely. First estimates for 2009 are slightly higher but will depend upon the final period of data taking. The shared obligations of operation tasks among the Institutions will be proportional to their number of ATLAS authors. The dedicated Web tool used for OT planning is being enhanced according to the experience that has been gained.
Changes: None.
Concerns: Operation (in the broad sense as specified above) will require significant resources for which Funding Agencies need to plan ahead.
Plans: Prepare in a timely fashion for 2009 beam running, including an ample schedule of global commissioning.

9. Commissioning of the 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. 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: The whole ATLAS and wLCG computing and software chain has been operational with real data since ATLAS combined cosmic ray data taking prior to LHC start-up in September 2008. At the beginning of this year, the computing and software infrastructure has been successfully exercised to reprocess approximately 280 million cosmic ray events collected in 2008, exercising a primary function of the Tier-1 centers worldwide. The experience gained during 2008 has been used to identify issues to be addressed in optimizing capabilities. Although several data challenges with simulated data have been made in the past years, the computing and software have not yet been exposed to real physics data or the demands of timely processing of large quantities of new data. Large-scale testing programs of distributed data analysis at Tier-2ôs using simulated data are starting in order to prepare optimally for the analysis of real physics data. A common testing period with other LHC experiments to exercise Tier-1 operations at full scale has been discussed and agreed with the wLCG partners for end May ï early June this year. Some software performance issues related to database access and memory utilization are being addressed. Adequate manpower to fully address ongoing software developments in several technical areas is not available, and progress to address this issue has been slow despite efforts. The core computing infrastructure and services tasks, defined as M&O category A, play a crucial role for the smooth operation of the full software and computing chain. They enable ATLAS to exploit the large investments of computing resources made worldwide by the wLCG collaboration partners.
Changes: None.
Concerns: Manpower in some technical software and operation areas. The Collaboration remains somewhat concerned about the slower than pledged build-up of computing resources at some sites in order to meet the anticipated 2009 requirements.
Plans: Consolidate and commission further the software and computing infrastructure for the collaboration-wide, distributed approach, in full coherence with the wLCG infrastructure backbone.

10. 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 November 2008 RRB. The following section recalls the framework, and updates the situation, in which the detector construction and installation have 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 fit 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 under-

stood 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 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 calculated 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 5 MCHF at the end of 2008, mainly due to late payments of baseline Common Fund contributions, as discussed in the corresponding budget document CERN-RRB-2009-023.

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 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.

11. Planning towards Full Design Luminosity Detector and Beyond

The 2002 Completion Plan reduced the scope of the Full Design Luminosity (FDL) detector as a temporary measure. The staged items included common elements, such as shielding and processors, as well as components of the Inner Detector, Calorimeter systems, and Muon systems. Some of these items have meanwhile been restored; whereas, the fate of other items depends upon the measured performance of the ATLAS detector. It is clear however that the common infrastructure, *e.g.* shielding, environmental monitoring, configuration control, access, and cooling/gas/cryogenic systems, will require improvements. A replacement of the Inner Detector pixel b-layer was envisaged as a part of the FDL detector. A status report *Towards ATLAS Full Design Luminosity Detector and Beyond* is provided in CERN-RRB-2009-066.

An Insertable B-Layer (IBL) has been chosen to replace the existing b-layer when the performance of the existing b-layer becomes degraded due to radiation damage. The IBL, along with a new beam pipe, will insert inside the inner radius of the existing b-layer. IBL design is advancing, and an IBL project, with dedicated project leader, has recently been established in order to complete the technical design and eventual implementation.

In accordance with the CERN plans for the Super-LHC (sLHC), ATLAS has established an R&D program to study the detector improvements required to operate at the higher luminosities of the sLHC. An Upgrade Steering Group coordinates the R&D. To date, 16 R&D proposals have been endorsed by the ATLAS Executive Board. In addition to R&D directed towards the extreme requirements of the Phase 2 LHC upgrade (earliest 2018), the Upgrade Steering Group is presently surveying the upgrades required to address Phase 1 luminosity upgrades (earliest 2014). The IBL should be complete on the timescale of the Phase 1 upgrade. A centralized Project Office has also been established. ATLAS plans to proceed by drafting a Letter of Intent, possibly for 2010, followed by Technical Proposal(s) and Memorandum of Understanding.

2nd April 2009

Cost to Completion Funding Planning (all in kCHF)
(revised 2nd April 2009)

CERN-RRB-2009-020

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	**118**	304	
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	**66839**	411	**4400**

(1) The remaining 3 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

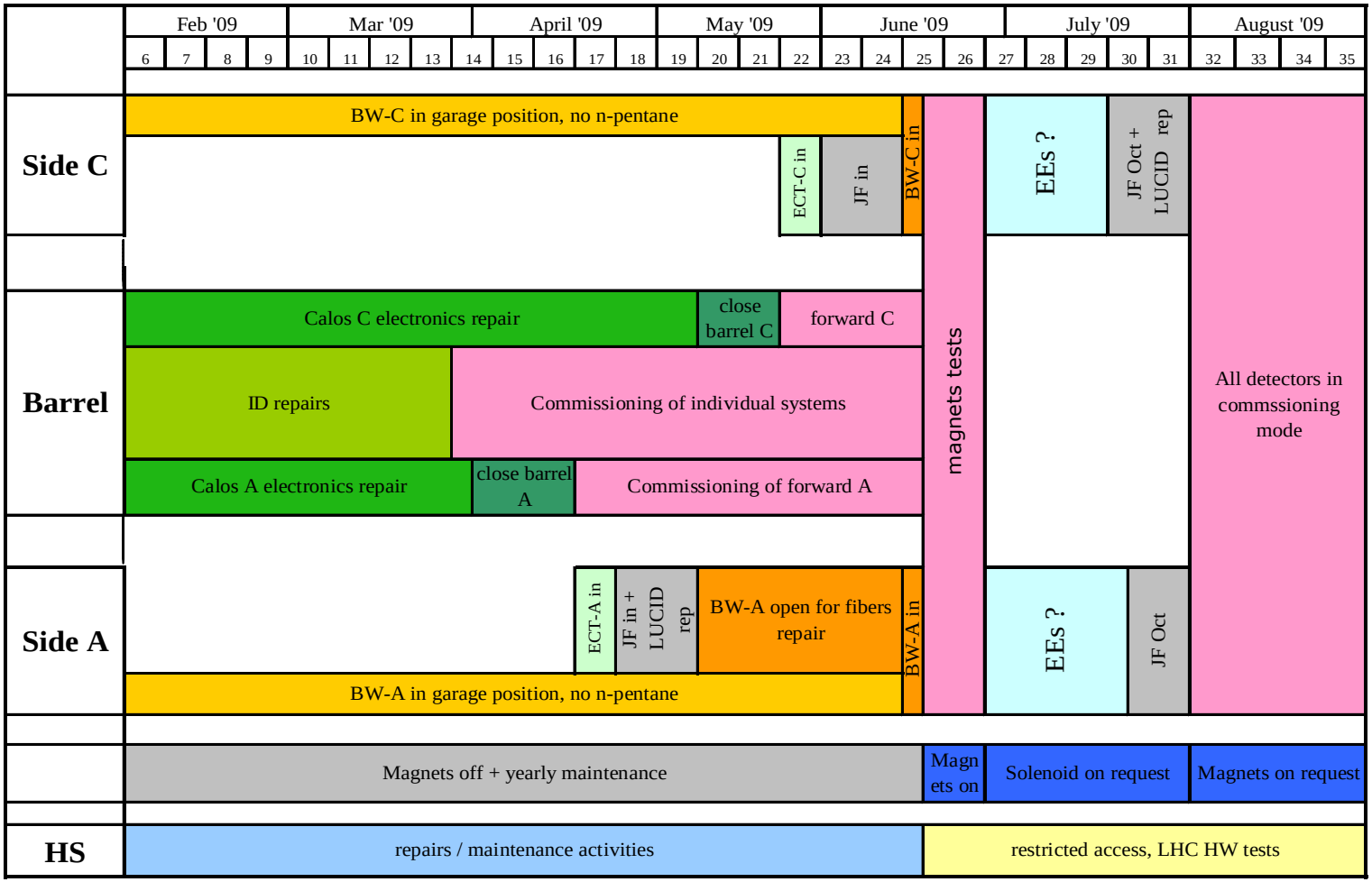

Figure 1 ATLAS shutdown planning Feb. ï Aug. 2009 (Schedule Version 10.5)