CERN-RRB-2011-023
12 April 2011

ATLAS Progress Report for the April 2011 RRB

1. Introduction and Collaboration Composition

The period since the October 2010 RRB meeting witnessed a sequence of successful, exciting events. In Fall 2010 the LHC reached the record peak luminosity of $2x10^{32}$ cm^{-2} s^{-1} and delivered most of the year's integrated luminosity. The proton-proton run was followed by a three-week heavy-ion run. In total, ATLAS recorded an integrated luminosity of 45 pb^{-1} of proton-proton data and about 9 μb^{-1} of lead-lead data. The average data-taking efficiency in 2010 has been stably around 94%, demonstrating the excellent status and performance of all detector components, as well as of the trigger and data-acquisition systems.

Over the last months the experiment has produced a huge wealth of physics results, including increasingly precise measurements of jets, W, Z, top-quark cross-sections and properties, first glimpses of rare processes, such as WW and single-top production, and searches for new physics in a large variety of final states. Search results exceed the Tevatron sensitivity in most cases, and some of the present ATLAS limits are the most stringent today. These results are documents in 31 papers published or accepted for publication, and 150 physics notes submitted at international conferences. These achievements also demonstrate that the Collaboration is able to deliver results very quickly, thanks also to the smooth and effective operation of the computing grid infrastructure based on the WLCG backbone.

The main implication of the LHC run extension into 2012 is a re-profiling of the computing resources as a function of time. Resources previously planned for the year 2013 are now requested to be moved forward to 2012.

ATLAS has a full and well-established programme for the 2013-2014 shutdown, including installation of a new inner-detector cooling plant and a redundant magnet refrigerator compressor, replacement of the liquid-argon and tile calorimeter low voltage power supplies, and a lot of additional consolidation work. Furthermore, the new LHC schedule, and the consequent delay of the first long shutdown to 2013-2014, has encouraged the Collaboration to move forward the installation of the so-called "Insertable B-layer" (IBL) from 2016 to 2014. A lot of progress has also been made on R&D activities and planning for the LHC luminosity upgrade, within the overall CERN schedule. Two dedicated task forces have been put in place a few months ago to finalize the plans for the two following shutdowns (foreseen approximately in 2018 and 2022). The outcome will be summarized in a Letter Of Intent (LoI) by the end of the year.

The ATLAS Collaboration consists today of 174 institutions from 38 countries with approximately 3000 active scientists, of which 1800 with Ph.D. (hence considered for M&O cost-sharing) and about 1000 students.

2. Maintenance and Operation 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: The magnet system has operated with 100% availability for data-taking with stable beams throughout 2009-2010. Some difficulties in operation have been encountered, including power converter unit failures, clogged cold circuit filters, and current lead problems. Failures of power converter units arising from problems in the units' current meter caused a few slow dumps of the toroid magnets in the last year. The power converter manufacturer is expected to provide a reliable solution. A hidden defect in the heat exchanger of the shield refrigerator cold circuit allowed water into the compressor oil, eventually leading to clogging of the filters in the cold box. Installation in the circuit of a dryer in July 2010 eliminated further problems. A permanent dryer will be installed in this circuit and the main refrigeration circuit during the 2013-2014 LHC shutdown. Hot spots in the aluminum-copper bus bars were repaired. Further repairs will be made during the end-of-year technical stop. Additional major consolidation work on the magnet services is planned for the 2013-2014 LHC shutdown. It includes installation of a redundant main refrigerator compressor and adoption of booster compressors, which will preclude a possible year-long ATLAS downtime in case of main compressor failure. Consolidation work is also foreseen for the electrical, vacuum, and controls services.

Changes: Dryer installed in shield refrigerator cold circuit.
Concerns: None.
Plans: Routine maintenance and operation of magnet system and services. Consolidation work during 2013-2014 LHC shutdown, including installation of redundant main refrigerator compressor.

3. Maintenance and Operation of the Inner Detector

The Inner Detector (ID) combines three concentric sub-systems, the Pixel detector, the silicon strip detectors (SCT), and the transition radiation straw tracker (TRT), listed from inside to outside.

Status: For the remaining months in 2010 the entire Inner Detector has continued to operate with very high efficiency. The performance continues to be optimised using high transverse momentum tracks and tracks from known resonances, allowing further refinement of the alignment, especially in the end cap regions. Here the alignment precision is approaching the TDR expectations. The reconstruction efficiency for muon tracks in proton collisions has been shown to be compatible with 100%. Tracking reconstruction was improved in order to allow good efficiency for reconstruction of particles down to 100 MeV transverse momentum. The energy loss measurement in the pixel detector has been calibrated and used in searches for "slow" R-hadrons predicted by Supersymmetric theories.

The Inner Detector successfully took data also during the period of the LHC heavy-ion running. The high particle multiplicities of the ion collisions did not give any problems, neither for the detectors nor for reconstruction of charged particle tracks. The tracking algorithms have proven to be robust, showing only limited degradation of efficiency in the very busy heavy-ion environment. This allowed ATLAS to publish the first LHC paper on J/psi suppression in heavy-ion collisions.

During the shutdown, maintenance work was carried out and the ID was brought back to operation in January without any problems.

The evaporative cooling plant has been operating in 2010 with close to 100% efficiency, and has always been available during collisions. A design for a thermosiphon system to replace the compressors in 2013-2014 is well advanced and the purchase of the large items has started.

There have been no additional failures of the thermal enclosure heater pads since three of eight barrel pads failed during June/July 2009. These pads are large-area copper-kapton heaters that should ensure thermal neutrality of the silicon volumes compared to the TRT, and of the ID volume compared to the outside. Although a thermal configuration that does not lead to over-cooling of the TRT has been established, there are concerns for the longer term, after the SCT modules have been exposed to significant radiation and need to operate at reduced temperature. A risk analysis continues, along with more refined studies of bias voltage and leakage current evolution as a function of radiation dose and temperature. A more effective coolant mixture is also being investigated, and laboratory tests of blends of C_2F_6 and C_3F_8 have started. A new control card for the heater pad power supplies, to reduce the chance of further failures, has been manufactured ready for installation in 2013.

The off-detector optical transmitter plug-ins (TXs) used in both the Pixels and SCT detectors that were replaced in 2009 ran smoothly for a number of months; however, they began to fail in April 2010, with a maximum rate of over twenty per week. Resulting inefficiencies in data-taking have remained small because failed Pixel plug-ins are replaced every few days, while most of SCT modules can be recovered by using built-in redundancy. The cause of the failure has, with some confidence, been identified as humidity around the VCSEL array. A new production of “old style” replacement plug-ins has been launched and deliveries have started to arrive at CERN. The VCSEL arrays (the failing electro-optical component) will be purchased from a different vendor. These arrays have been tested to be more robust against the ingress of humidity. In addition, work has started with a new company to make optical subassemblies that will be part of a new backwards compatible TX plug-in. The Pixel on-detector arrays are of the same type as the off-detector units, although they operate at a lower rate, leading to possible future lifetime concerns. A task force has studied this problem. Aging tests of the on-detector boards are being made, and preparation of replacement parts is underway, in case replacement is necessary during the 2013-2014 LHC shutdown. The SCT on-detector optical transmitters use a different technology, and aging tests already performed during prototyping and production showed that the lifetime of the SCT arrays should not be a concern.

A Pixel task force, convened to study the possibility and implications of on-detector VCSEL failures, has recommended a rebuild of the Pixel services and to move the on-detector transmitters to a more accessible location. This decision is a pragmatic response to the existing situation while investigations of VCSEL failure modes continue. The design and preparation has started and the decision on whether to use these new services will be taken in 2012. A large amount of activity is ongoing in the Pixel community to prepare the integration of the fourth, innermost, layer (IBL) with a re-organization of the resources to match the needs in terms of the consolidation of the existing system and the integration of the IBL.

In 2011 the TRT group is preparing for the anticipated radio-active activation of the Xe gas mixture. To minimize any risks to safety, preparations have been made to monitor the radiation levels. These preparations have been made together with the CERN Radioprotection Group and the ATLAS Central Safety Team. Calculations and simulations indicate that the levels will be below what is considered dangerous. However, a programme is set up to closely monitor the radiation and to study the isotope composition and decay times. These measurements will serve as inputs to the design of the shielding for the TRT active gas system, which will be commissioned once LHC operates at full energy and luminosity. A test program has been started to study possible cleaning procedures for the TRT detector. These procedures might be needed if one observes evidence of performance-limiting phenomena, such as deposits on the straw wires. However, to date no such degradation has been observed, nor is it expected.

Within the Inner Detector community investigations have started on how the operation of the three ID sub-systems might be merged and streamlined, and the number of control room shifters reduced.

Changes: None
Concerns: Maintenance of the compressor plant remains at a high level of attention.
Barrel thermal enclosure heater pad failures may affect long-term thermal management and hence silicon detector lifetime.
Availability of enough spares for the off-detector TX optical transmitters.
Plans: Continue development of alternative technology (a thermo-siphon system) to replace the compressor plant.
Investigate alternative supplies of VCSEL arrays for optical transmitters.
Perform aging tests of on-detector optical transmitters.
Prepare contingency plan for replacement of Pixel on-detector optical transmitters in case needed.
Continue preparations to rebuild the Pixel services allowing to move the on-detector transmitters to a more serviceable place.

4. Maintenance and Operation 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 (HEC), and liquid argon forward calorimeters (FCal).

Status: All calorimeter systems have performed well throughout data-taking. The calibration precisions are nearing the design values. For instance, the LAr energy calibration precision is ~1%. The timing of both Tile and LAr calorimeters have been adjusted and calibrated to the one nanosecond level. The excellent performance of the electromagnetic calorimeter is illustrated by the measured mass resolution for $Z \rightarrow ee$ decays, which is already close to the nominal resolution.

Two detector-mounted components of the LAr calorimeter are of concern, low voltage power supplies and optical transmitters. Five LAr low voltage power supplies (LVPS) have lost redundancy without leading to any data loss (last failure in February 2010). At the end of 2010, 30 (out of 1532) Front End Boards (FEB) were not transmitting digital data because of a failed optical transmitter (OTx) but were still providing the trigger signal. This corresponded to 2% of missing readout channels, leading to a 5% loss of acceptance for electrons and photons. These FEBs were replaced during the winter shutdown, together with 20 other FEBs with OTx susceptible to failure. The width of the optical spectrum has proven to be a reliable indicator for OTx failures. Two months after the replacement, all FEBs are operational (the failure rate in 2010 was at the level of a few per month). The decision whether to build new OTx will be taken at the end of 2011; two backup solutions are being designed and tested.

A new set of LVPS (70 units) has been received at CERN and will be tested on a large scale test bench before installation on the detector during the next long shut-down.The concerns reported in the last report, namely the large rate of HV trips, noise bursts and presampler noise are still present as the LHC restarts. Improvements were implemented on the HV system to reduce the occurrence of HV. Their impact is reduced thanks to fast, automatic ramp-up of the high voltage.

In the Tile calorimeter, 3.8% of cells had failed during the 2009/2010 data-taking period due to three LVPS and five front-end drawer failures (out of 256 units). During the last winter maintenance the failing LVPS have been replaced with refurbished units that are expected to be more robust against trips. The main problem in the drawers was related to bad soldering of power connectors located in digitizer boards. These were glued to the PCB to relieve mechanical stress, and the soldering has been reinforced. In addition, five new LVPS units of the new pre-production were installed, and show a significant improvement in the noise behaviour. At the end of the maintenance campaign the amount of failed Tile cells was successfully reduced to 0.19%. However, three drawers were lost since then, two of them due to LVPS problems and one to a failing connector. Latest results from high rate tests show that Tilecal can run without problems at 75 kHz.

The Tile calorimeter LVPS production readiness review for the new version, initially planned for January 2011, is delayed by few months waiting for complete results of the irradiation tests. The plan is to start the bulk production in summer 2011. All 400 spare photomultipliers have been delivered and have been certified.

Changes: For LAr, 50 FEB replaced, one HEC-LVPS exchanged and the HV system modified during the winter shutdown.
Concerns: Long-term reliability of the LAr and Tile calorimeter low voltage power supplies requires replacement. Long-term reliability of LAr optical transmitters may require future replacement.
Plans: Continue development of long-term backup solutions in the areas of concern. Replacement of LAr and Tile low voltage power supplies in the 2013-2014 LHC shut-down, including an intervention in all the Tilecal drawers to reinforce the power connectors.

5. Maintenance and Operation of the Muon Detectors

The Muon Spectrometer is instrumented with precision chambers for 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: During the whole year 2010 the muon system has been operating with very good efficiency, and the fraction of live channels was 99.7% for MDT, 98.5% for CSC, greater than 97.0% for RPC, and 98.6% for TGC.

The CSC read-out, that was the major concern for the muon system, was active for the full data-taking period and the rate capabilities achieved are close to the requirements.

The RPC top sectors have been operated with a reduced HV (9400 V instead of 9600 V) during the full 2010 run because of the high temperature present in some of those regions. During the winter shutdown a new ventilation system has been implemented reducing the temperature gradients in the detector. In any case the temperature in some small regions of the top sectors remains a concern.

The availability of samples of Z, W and J/psi data allowed the performance of the muon spectrometer, and in particular the reconstruction efficiency and the momentum resolution, to be measured. The measured efficiency is extremely close to that obtained from the simulation. The resolution of the muon spectrometer is not yet fully optimized at high momentum, as the alignment is not yet fully refined. The use of straight tracks (obtained from runs recorded with the toroid magnets off), as well as improved knowledge of the individual tube time offsets thanks to larger data samples, will help improve the alignment and the intrinsic hit resolution, respectively, and therefore reach the nominal momentum resolution.

A small number of maintenance issues continue to be monitored. CAEN high voltage and low voltage power supplies require regular replacement, and Wiener VME power supplies are also showing failures. RPC gas inlets are fragile, and broken inlets are being replaced as needed during maintenance periods. Cracking on a few gas jumpers of some MDT chambers has been observed.

During the winter shutdown a series of maintenance interventions have been accomplished. All the RPC high voltage connectors on the patch panels residing in UX15 have been changed (3700 connectors). Indeed, the old connectors showed fragilities and on average one connector serving 16 gas volumes broke down per week. Since the replacement no new failures were experienced. About 20 RPC gas volumes, which showed leaks due to the breakage of gas inlets, were repaired. Although the repair was successful, during the shutdown period some other gas inlet failures appeared, and the total gas leakage was therefore reduced only marginally. Five TGC chambers that showed HV problems have been exchanged, and other HV failures due to bad HV boards have been repaired by exchanging the boards. As a consequence the amount of operational channels for the TGC increased to 99.2%. For MDTs, standard electronics maintenance has been performed during the shutdown and few front-end electronics boards have been replaced. In the End Cap region, gas leaks due to the cracking of the gas jumpers have been repaired. At the moment only very few gas leaks are still present, and they do not represent a problem for the operation of the system. The temperature monitoring system for the cooling of one of the CSC wheels was recovered during the shutdown.

Changes: Maintenance during the shutdown period: change of RPC HV connectors, repair of chambers with broken gas inlets, change of five TGC showing HV problems, minor repairs on MDT electronics, repairs of end-cap MDT gas leakage, repair of the temperature monitoring system for the CSC.
Concerns: Fragility of RPC gas inlets. High ambient temperature in few regions of the top barrel RPC sectors that may lead to RPC ageing. Final assessment of CSC read-out rate capability.
Plans: Develop methods to lower the amount of lost gas due to leaks in the RPC system. Complete improvements to CSC readout rate. Optimize trigger to sharpen the turn-on of the LVL1 muon trigger and minimize presence of fake triggers. Finalize alignment of the full muon spectrometer to design level (<50 micron), also using no-field runs. Finalize MDT calibration (channel-by-channel timing offsets) with high statistics. Prepare for the installation of a large fraction of the EE chambers during the next technical stop. Prepare for the installation of the trigger electronics to equip the RPC chambers in the feet region.

6. Forward Detectors

The ATLAS forward detectors 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), a Zero Degree Calorimeter (ZDC) placed in the TAN absorber structure where the beams enter separate beam pipes at ±140 m from the IP, and of an Absolute Luminosity for ATLAS (ALFA) system based on fiber detectors located in Roman Pots at ±240 m from the IP. A proposal for an ATLAS Forward Physics project (AFP) is being considered as a possible upgrade project.

Status: Both LUCID and ZDC have been part of ATLAS data-taking throughout 2010. Since the beginning of 2010 data-taking, LUCID is the standard monitor for the luminosity delivered to ATLAS. Following a series of five beam separation scans performed in 2010, the absolute luminosity from LUCID and other luminosity monitor detectors was calibrated with a precision of 3.4%. The ZDC detector, although with not fully optimized performance yet, provided the Level-1 trigger to ATLAS for most of the heavy-ion data-taking, and has shown its capability to select the centrality of the interactions and to detect efficiently the neutrons from Coulomb dissociation events.

The 2010 winter shutdown has marked an important successful milestone for ALFA and ZDC. For the ALFA detector, the remaining three out of four Roman Pot stations were installed, thereby completing its full deployment in the experiment. The commissioning phase started shortly after and data from collisions with the detector in parking position have been already taken and the first tracks reconstructed. For the ZDC detector, the last module (electromagnetic) was installed, and the full detector commissioning phase started with the first collisions delivered by the LHC machine.

Changes: ALFA and ZDC detectors now fully installed
Concerns: None.
Plans: Commissioning with pp interactions of the ALFA and ZDC detectors. ALFA detector to be ready to take data for 90 m β^* beam optics in autumn 2011. ZDC detector ready to provide its luminosity measurement to ATLAS after calibration with the first beam position scans in 2011.

7. Maintenance and Operation of the Trigger and DAQ System

The major sub-systems of the Trigger and Data Acquisition System (TDAQ) are 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).

Status: The complete Trigger and Data Acquisition chain continues to perform very well and has proven to be able to adapt efficiently to the changing data-taking needs of the experiment and to the fast ramp-up of the instantaneous luminosity. Throughout 2010 and during the 2011 startup phase to date, the operational efficiency during collision periods has averaged more than 95%. Towards the end of the 2010 run, the system was operating at a Level-2 input rate of ~20 kHz, a Level-2 output rate of ~3 kHz, and an Event Filter output rate of 200-300 Hz. For some specific runs, the system exceeded its design specification, achieving event building rates of up to ~4.5 kHz. As planned, the HLT computing power was increased during the third quarter of 2010 from 35% of its foreseen capacity to 50%. This increase allowed throughput of the event building system to reach design specification for stable data-taking. The scope and quality of operation procedures and documentation is the subject of continual review and improvement.

The programme of timing optimisation of the Level-1 sub-systems is now largely complete with some remaining work to be done in the calorimeter overlap region. For the Level-1 calorimeter trigger, a timing precision of 2 ns has been achieved. For the RPC and TGC systems, more than 98% of the muon triggers are associated with the correct bunch crossing.

Several trigger selections ("menus") specifically aimed at high-p_T physics were successively deployed in order to cope with the progressive increase over five orders of magnitude in the LHC instantaneous luminosity during the course of 2010. The HLT has been used for the online selection of events since May 2010. The trigger system coped well with the LHC heavy-ion run at the end of 2010, using principally Minimum Bias triggers to select events with some limited use of selection at the Event Filter. The trigger menu for luminosities up to 2 x 10^{33} $cm^{-2}s^{-1}$ has been prepared, tested and successfully deployed during the early 2011 running. Earlier predictions have been found to be largely consistent with the observed trigger rates. The physics performance of the HLT algorithms is being assessed, and they are to date performing robustly in the increasing pile-up environment.

The operational efficiency continues to be improved by closely working with the detector systems to better define and subsequently automate operational procedures. During the course of 2010, additional semi-automatic start and end of run sequences have been defined and implemented. These sequences automatically initiate the procedures (*e.g.* ramping of voltages) that certain detector systems require during machine operations, for instance during the energy ramp of the beams. These procedures contribute significantly to the achieved average data-taking efficiency of 95% stated earlier.

In addition to regular maintenance and optimisations, the following significant activities were completed during the 2010-2011 winter technical stop: a) the mapping of the Pixel detector readout channels to their respective Readout buffers (ROS) was optimized and the associated re-cabling performed in order to minimize data access requests to the Pixel ROSs; b) ROS system parameters were tuned to improve the performance of the data access request mechanism; c) a new trigger based on Missing ET significance (XS), which is much more robust than the traditional Missing ET trigger to increasing pile-up, was integrated and tested in the Level-1 calorimeter trigger firmware. The XS trigger is now undergoing final validation and is expected to be available for event selection shortly.

The plan for procurement of the outstanding HLT capacity will continue to be adapted to the evolution of the LHC schedule and performance, as well as to the evolving needs of the experiment. The plan will be reviewed at the end of the 2011 data-taking period. The rolling replacement of computing hardware that has reached the end of warranty continues during the first half of 2011.

Changes: Missing ET Significance trigger implemented. Physics menu valid up to a luminosity of $2x10^{33}$ $cm^{-2}s^{-1}$ implemented. Continuing improvements to operational efficiency.
Concerns: Manpower to support and run the system to the end of the 2012 run. It is reminded that in accordance with the Cost-to-Completion plans, the initial TDAQ configuration was limited in funds. HLT processors are being added to the initial configuration as deferred funds become available.

Plans: Continue to operate and consolidate the full TDAQ system for data-taking at higher luminosity and increasing pile-up. Continue to optimize the efficiency of trigger selections. Purchase additional HLT capacity during the course of 2011 according to operational needs.

8. Detector Operations

Status: ATLAS operated successfully throughout 2010, despite the rapid evolution of LHC luminosity and beam conditions. In particular, the peak luminosity has increased from approximately 10^{27} $cm^{-2}s^{-1}$ to $2x10^{32}$ $cm^{-2}s^{-1}$, requiring frequent redefinition of operating procedures and trigger selections. Efficient operation has also required continual maintenance of general infrastructure, such as electricity, cooling and ventilation, of individual detector elements, and of control, trigger and data acquisition systems. Constant and careful maintenance and development work has enabled ATLAS to achieve a global data-taking efficiency of 94%.

Consolidation work on the detectors and the deployment of a new TDAQ version made it necessary to re-commission the detector after the end-of-year technical stop. After extensive standalone testing of the sub-detectors, combined data-taking has restarted on 14 February 2011. Since then, ATLAS is performing a long list of tests to assure equally efficient – and in some areas improved – operation of the detector as compared to last year. First collisions in 2011 were recorded mid March.

Over the course of 2010 and the first months of 2011, steps have been taken to streamline Operation Tasks (OTs) in order to reduce the overall effort required and to enable more tasks to be performed at remote sites. A first reduction of the shift crew in the control room has taken place, and planning for further reductions is ongoing. Operation Tasks include all activities essential to the operation of ATLAS, from central shifts and on-call tasks at Point-1 to the computing and data preparation tasks, some of which can be executed remotely. Operation, in this broad sense, requires very substantial effort (600-700 FTE, plus shifts). Responsibility for Operation Tasks is shared among the Institutions in proportion to their number of authors.

Concerns: Operation requires significant resources for which Funding Agencies need to plan.
Plans: Continue to operate ATLAS throughout the extended 2011-2012 LHC data-taking period. Perform minimal urgent repairs during the end-of-year technical stop, and plan for more extensive repair and consolidation work during the 2013-2014 shutdown.

9. 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.

Status: The entire ATLAS and WLCG computing and software chain has performed very well throughout 2010 data-taking. Data is reconstructed by the Tier-0 centre and distributed worldwide within a couple of days of data-taking. The “prompt calibration loop” operates routinely: intensive calibration work is performed at the CAF (Calibration and Alignment Facility) at CERN within a few hours after the data are collected using small specialised samples. Derived calibration outputs are used in the Tier-0 reconstruction of the physics data shortly afterwards. The global Tier-1 computing infrastructure and the reconstruction software have been used several times in the first half of 2010 to reprocess all available detector and simulated data. A reprocessing of the full year's accumulated proton-proton data was completed in November 2010, followed by a complete re-reconstruction of all simulated data in December 2010. Large-scale programmes of distributed data analysis at Tier-2 centres have led to the physics results presented at conferences and in publications. Simulation production continues using available CPU resources at Tier-1 and Tier-2 centres, with an average of approximately fifty thousand jobs running concurrently and with approximately 1.4 billion events simulated in 2010. Computing and software shifts are operated at the Point-1 control room, and worldwide, to support production operations and user analysis.

ATLAS has made efficient use of the computing resources made available at all WLCG sites, including opportunistic use of idle CPU cycles in the Tier-2's and of not-yet-occupied disk space. For instance, additional copies of event summary data ESD have been distributed in order to ease access to the complete information for the events to all members of the Collaboration during detector commissioning. Tools are in place to remove these additional copies when disk space is needed for new and more heavily-used data. Analysis on the WLCG is in full swing, with several hundreds of people routinely submitting jobs. More than a thousand different ATLAS members have performed analysis on the grid.

The present LHC machine schedule, with long data-taking period through 2011 with substantially increased (and, to a large extent, unexpected) pile-up, will require the full computing resources requested for 2011. Timely availability of these resources will be critical to prompt ATLAS physics productivity, and to the ability of everyone in the Collaboration to access the data easily and quickly.
The impact of pile-up is an increase by a factor of 2-2.5 on both the required CPU per event and event size. Therefore, based on our 2010 experience, we have revised our initial data distribution policy. We are now less reliant on the ESD in 2011 than we were in 2010, so we curtail the distribution of ESD and no longer store it permanently for most events. We rely on AOD for the main physics analysis, so multiple copies of AOD are distributed on the grid. Furthermore, substantial progress continues to be made across the broad software development front: for example intensive work has resulted in improved CPU performance of our reconstruction software and in decreased sizes of the derived data (AOD, ESD), essential to be able to cope with the high levels of pile-up now anticipated in 2011-2012. However, several technical software development areas suffer from having insufficient levels of staff. 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 technical software and computing areas. Impact of pile-up on the needed computing resources.
Plans: Continue to operate and consolidate software and computing infrastructure. Expand processing and storage capacity as required by the extended 2011/12 data-taking.

10. Data Collection and Physics Output

In the two months following the last RRB, the LHC reached a peak luminosity of 2×10^{32} $cm^{-2}s^{-1}$, double the goal for the year. The integrated luminosity recorded by ATLAS in pp collisions tripled to 45 pb^{-1} (see Fig. 1). This was complemented by heavy-ion collisions at the end of the year. The data were recorded with a data-taking efficiency of 94%. Data-taking has resumed in 2011, with a total of 25 pb^{-1} already recorded.

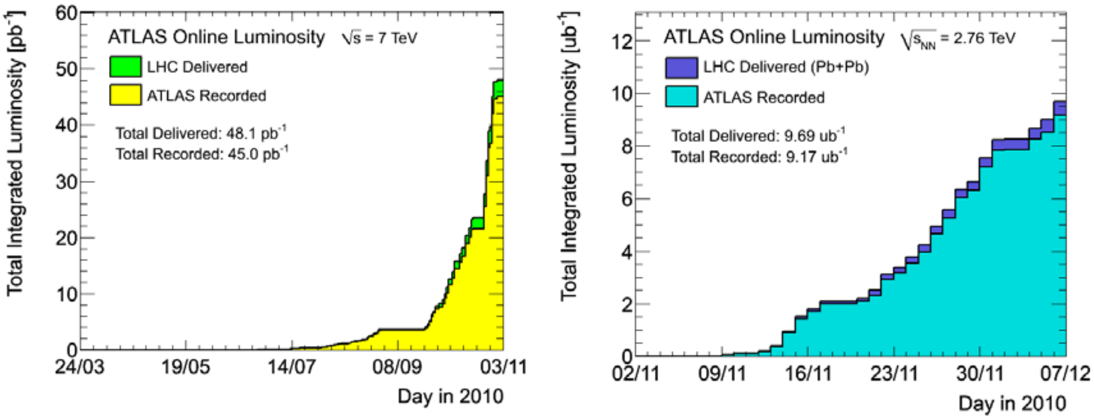
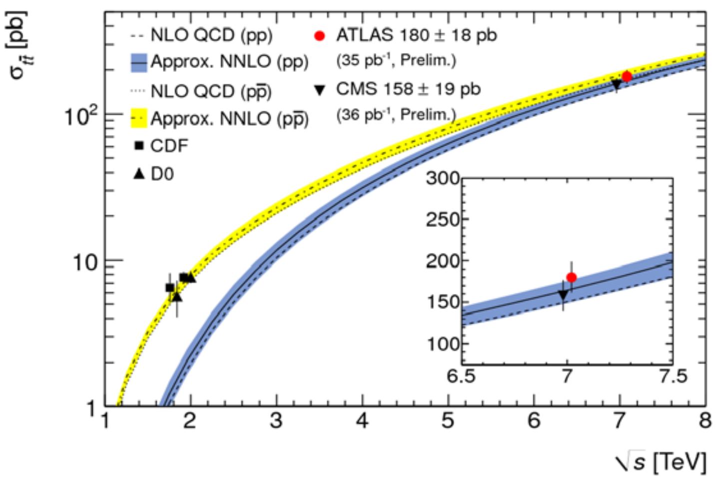


Figure 1: Integrated luminosity vs. time in 2010 data-taking: pp collisions (left) and heavy-ion collisions (right). Cumulative totals indicate the luminosity delivered by the LHC in stable beam conditions, and that recorded by ATLAS.

Understanding of the performance of the detector continues to improve: as an example the jet energy scale is known to 2.5% over a wide range of jet momenta in the central part of the detector. The LHC colliding beam luminosity has been measured in ATLAS to 3.4% using beam separation scans and a range of detector techniques. The cross-sections for production of W and Z bosons have been measured inclusively with an experiment-related precision of better than 2%, and also in association with jets. Diboson pair production WW, Wγ and Zγ have been measured. The cross-section for top pair-production has been measured with 10% precision (see Fig. 2), and single-top production has been constrained. A wealth of measurements of hadronic jet production have been made, including results on the inclusive jet and dijet cross-sections over ten orders of magnitude.

Figure 2: Measurements of the top pair-production cross-section as a function of centre-of-mass energy. The red point indicates the ATLAS measurement using the 2010 data sample.



Having re-established the main Standard Model signatures in this new energy regime, the Collaboration has moved on to search for new physics, and constraints were rapidly placed on a very wide range of models. Already the sensitivity extends beyond the Tevatron reach in most cases. As an example of the sensitivity to new physics, constraints have been placed on production of supersymmetric particles in a wide range of channels – with jets and missing energy and varying numbers of leptons (see Fig. 3). Limits on the gluino mass now extend beyond 750 GeV. Other limits extend beyond 2 TeV. Analyses of Higgs decays to the main search channels have been completed: WW decays are most promising at present, but the H→γγ analysis is also commissioned. This bodes well for the next couple of years, when the Standard Model Higgs question should be settled by the new data.

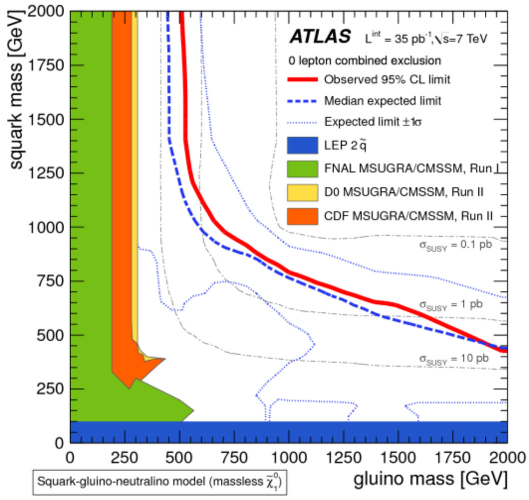


Figure 3: Constraints, at 95% CL, on masses of supersymmetric particles in the CMSSM/MSUGRA model with parameter assumptions as indicated. Comparison with existing limits is illustrative only as some are derived with different assumptions.

At the time of writing, 31 physics papers have been submitted or published, and 53 conference notes already completed in 2011 for the winter conferences, in addition to 102 in 2010. We were pleased that our papers have been the subject of two "Viewpoints" in *Physics*, and also have featured on the covers of *Physical Review Letters* and *European Physical Journal C*.

11. Updates on Due Construction Contributions

ATLAS is grateful to the Funding Agencies for their continuous support over nearly two decades. At present, the Collaboration still faces an income deficit of 3.5 MCHF in the total accepted construction costs (CORE+CtC), including open commitments, mainly due to late payments of baseline Common Fund contributions. Due contributions arriving from Funding Agencies are reported elsewhere (CERN-RRB-2011-026).

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 the full detector and to exploit fully the immense LHC physics potential as early as possible.

12. Status of FDL Activities and Planning for LHC Luminosity Upgrades

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 detector. It is clear that infrastructure, particularly shielding and cooling, gas, cryogenic systems, will require improvement and consolidation during the 2013-2014 LHC shutdown.

An Interim Memorandum of Understanding has been signed by the Institutes and Funding Agencies concerned for the insertable Pixel B-layer (IBL) as a part of the FDL detector. A Technical Design Report (TDR) was submitted to the LHCC (CERN-LHCC-2010-013, ATLAS TDR 19, 15 September 2010). A status report on FDL detector activities is provided in CERN-RRB-2011-026.

As previously reported (CERN-RRB-2009-020, April 2009), in accordance with CERN plans to upgrade the luminosity of the LHC, ATLAS established an R&D programme to study the detector improvements required to operate at higher than design luminosity. Two phases are being planned. The first phase is targeted at the ultimate LHC luminosity of approximately $2x10^{34}$ $cm^{-2}s^{-1}$ following the Phase 1 LHC upgrade, with installation foreseen for 2018. Improvements for this phase will enhance the ATLAS trigger capabilities in order to maintain good physics selectivity in face of higher luminosity and background rates. The second phase of detector improvements is targeted at very high integrated luminosity during the High Luminosity LHC (HL-LHC) era, with installation foreseen for 2022. Improvements for this phase must address the challenges of achieving good physics sensitivity in face of peak luminosity of approximately $5x10^{34}$ $cm^{-2}s^{-1}$, with high radiation and event pile-up levels. This phase will require replacing the full Inner Detector, as well as other detector and trigger upgrades. In preparation for transition from the R&D phase to the construction phase, ATLAS has reorganized its upgrade activity. ATLAS plans to proceed by drafting a Letter of Intent for the upgrades, followed by project-specific Technical Proposals, Technical Design Reports and Addenda to a Memorandum of Understanding of appropriate nature.