CERN-RRB-2012-023
24 April 2012

ATLAS Progress Report for the April 2012 RRB

1. Introduction and Collaboration Composition

The 2011 LHC run finished successfully with an integrated luminosity of 5.2 fb^{-1} recorded by ATLAS during proton-proton collisions and 158 μb^{-1} during heavy ion collisions. These data samples greatly exceeded those accumulated the previous year, by a factor greater than a hundred for proton-proton running and a factor of nearly twenty in the case of heavy ion running. The ATLAS detector continued to perform extremely well. The average data-taking efficiency for 2011 was 93.5%, demonstrating the excellent status and performance of all detector components, as well as of the trigger and data acquisition systems. The fraction of non-operational detector channels ranges from a few per mil to ~5% depending upon sub-detector, and the good-quality data used for analysis is 90-96% of the recorded sample, depending upon the analysis. The full detector, trigger, data acquisition, and computing chain successfully met the challenges of high peak and integrated luminosities and of high numbers of interactions per crossing (average value ~ 12 in the second part of the 2011 run).

The winter 2011-2012 technical stop allowed yearly detector maintenance and consolidation, including a new main compressor for the magnet cryogenics, replacement of various low voltage power supplies, and many small repairs. It also afforded the opportunity to install many of the muon chambers missing in the barrel-endcap transition region. ATLAS finished re-commissioning following the winter technical stop and is now successfully collecting 8 TeV collision data.

The large increase in integrated luminosity in 2011 enables a rich physics program, ranging from detailed precision measurements to searches for new physics beyond the Standard Model. The search for the Standard Model Higgs boson led to tight exclusion limits and the observation of a not-yet-significant excess of event candidates in two decay modes within the mass range not yet excluded. These results were reported first in a joint seminar with CMS during the Council Week at CERN in December 2011, and then were updated to combine twelve different decay modes for the winter 2012 conferences. With the data expected in 2012, ATLAS will have the sensitivity needed to either discover or exclude the existence of the Standard Model Higgs. Altogether a large number of new results were presented at the winter conferences, documented either in public conference notes or journal papers. Approximately sixty papers have been submitted or published since the October 2011 RRB meeting, for a total of about 140 papers based on collision data. These achievements demonstrate that the Collaboration is able to deliver physics results very quickly, thanks also to the smooth and effective operation of the computing grid infrastructure based on the WLCG backbone.

ATLAS has a full and well-established programme for the 2013-2014 long shutdown (LS1), including installation of a new inner-detector cooling plant, replacement of the liquid-argon and tile calorimeter low voltage power supplies, completed installation of staged muon chambers, and much additional consolidation work. Furthermore, the so-called “Insertable B-layer” (IBL) will be installed in the Pixel detector with a new beam pipe and possibly with new pixel services. Substantial progress continued on R&D activities and planning of detector improvements in preparation for LHC luminosity upgrades A Letter of Intent (LoI) describing the detector improvements planned on the timescale of the second long LHC shutdown in 2018 (LS2) was approved by the Collaboration Board and submitted to the LHCC. An LoI for the second phase of upgrades will be presented in approximately one year.

The ATLAS Collaboration consists today of 175 institutions from 38 countries with approximately 3000 active scientists, of which 1800 with Ph.D. (hence considered for M&O cost-sharing) and about 1200 students. At its February 2012 meeting, the ATLAS Collaboration Board admitted Kyushu University, Japan and University of Warwick, UK as new member institutions. An Expression of Interest in membership has been received from the University of Adelaide, Australia.

2. Maintenance and Operation of the Magnet System

The ATLAS superconducting magnet system comprises the Central Solenoid (CS), the Barrel Toroid (BT), two Endcap Toroids (ECT), and their common services.

The magnet system has operated with nearly 100% availability for data-taking with stable beams from 2009 to 2011. Some difficulties in operation have been encountered, including power converter unit failures, clogged cold circuit filters, and bus bar temperature problems. All problems have been solved in an effective way. Hot spots in the aluminum-copper bus bars were repaired. Some of the consolidation work planned for the 2013-2014 long shutdown was accomplished during the winter 2011-2012 technical stop, including installation of a redundant main refrigerator compressor that will avoid a possible long ATLAS downtime in case of main compressor failure. In addition, improvements were made to the vacuum and cooling water systems. Further improvements are being prepared for the 2013-2014 long shutdown, including a new helium gas cleaning system, a new redundant booster compressor, and separation of solenoid and toroid cryogenics to allow continued solenoid operation during quench recovery of the toroid. Additional consolidation work on the magnet services is also planned, including other electrical systems, vacuum systems, controls and magnet safety systems.

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.

The inner detector completed the 2011 data-taking period with very high efficiency. 96.4% of Pixel modules, 99.2% of SCT modules, and 97.5% of TRT channels were operational. The ID tracking performance has proven robust against the increased rate of event pile-up that accompanies the high-luminosity operation of the LHC, in large part because of the continual effort to further optimize the physics and technical performance of the ID reconstruction software.

The ID evaporative cooling plant operated in 2011 at close to 100% efficiency, and has always been available during collisions. The design for the thermo-siphon system to replace the compressors during the 2013-2014 long shutdown is well advanced, and the large components (including the surface chiller) have started to arrive and will be installed ahead of commissioning in 2013-2014.

Both the Pixel detector and SCT are now showing evidence of the effects of radiation. The increase in leakage currents and decrease in depletion voltages are in line with expectations based on previous measurements and calculations that include the influence of integrated luminosity and operational temperature. To mitigate the long-term effects of radiation damage, the evaporative cooling system will now be in constant operation, including shutdown periods.

A new control card design for the heater pad power supplies, to reduce the chance of further failures, has been manufactured and tested. During the winter 2011-2012 technical stop, three (of five) new crates of control cards for the large area heater pads were installed. The remainder will be completed in the 2013-2014 long shutdown.

The off-detector optical transmitter plug-ins (TXs) used in both the Pixel detector and SCT have continued to fail. The cause of the failures has been identified as humidity in the air around the VCSEL. The production and installation of TXs with a new VCSEL that is resistant against the ingress of moisture was completed in the winter technical stop. In addition, work has started with a new company to make optical sub-assemblies that will be part of a new backwards-compatible TX plug-in. These will start to be delivered around the middle of 2012. As an additional precaution, the air that is delivered to the racks where the optical transmitters are housed is actively dried.

A Pixel task force, convened to study the possibility and implications of on-detector VCSEL failures, has recommended a rebuild of the pixel services in order 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 have started, and the decision on whether to install these new services will be taken in mid-2012.

The TRT active gas system is a highly complex recycling system that has been operating for many years without any major problem. In the winter technical stop, additional equipment, mainly more sensitive mass spectrometers for gas analysis, was installed to enable oxygen and CO_2 concentrations to be kept stable at the part-per-mil level and thus ensure a stable gas gain. Double membrane pumps were installed to ensure that, in case one of the pump membranes fails, no air will be drawn into the system. In response to a small leak in one of the TRT barrel modules that increased Xenon gas consumption from 14 litres per day to about 25 litres per day and whose cause is suspected to be damage from high-voltage sparking in an individual straw, a procedure has been established to disconnect discharging straws before any damage could occur. TRT gas consumption has been stable since October 2011, and sufficient Xenon is available for operation in 2012.

Failures of single TRT high voltage power supplies were traced to a power supply card; problematic components were exchanged, and a sufficient number of spare cards were ordered to ensure no problems during 2012 data-taking. A campaign to improve reliability of TRT low voltage power supplies by installing gold-plated connectors has been started, with replacement for ~20% of the power supply crates. The remaining crates will be refurbished during the 2013-2014 long shutdown.

In response to the expectation that the LHC machine will deliver higher-than-design luminosity, with higher-than-design rates of pile-up, the Pixel, SCT and TRT detectors have all started to consider how to upgrade their off-detector readout systems to cope with instantaneous luminosities up to 3 x 10^{34} $cm^{-2}s^{-1}$ after the 2013-2014 long shutdown, at level-1 trigger rates of 100kHz. Various options are available to both Pixel and SCT systems, and a significant part of this year will be spent considering each option in detail for performance, cost and deliverability. TRT effort focuses on developing new data compression schemes.

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, liquid argon endcap hadronic calorimeters (HEC), and liquid argon forward calorimeters (FCal).

All calorimeter systems performed well throughout data-taking in 2011. Measures to further improve the efficiency of recording quality data have been continually refined. The precision of calibration remains near the design values. For instance, the LAr energy calibration precision is ~1% and continues to be improved as more data are analyzed.

The stability of operation and performance of the liquid argon calorimeters continually improved throughout 2011. After the exchange of some faulty or suspect Front End Boards (FEB) in January 2011, no optical transmitters (OTx) have failed. Measurements of the OTx light spectrum show that the width is stable, whereas failed OTx had abnormal spectra. Because OTx operation was reliable in 2011, production of new OTx has not been undertaken. In case of degradation during 2012, production could be launched at the end of 2012 for installation during the 2013-2014 long shutdown. During the winter 2011-2012 technical stop, 10 FEBs were repaired or replaced. The front-end low-voltage power supplies (LVPS) remain a concern. At the end of 2011, seven units out of 58 operated without redundancy on one voltage line, but without any data loss. Twelve LVPS of new design were installed during the winter technical stop, replacing all faulty supplies. The remainder of a full new complement of LVPS will be installed during the 2013-2014 long shutdown. The behavior of the high voltage system stabilized at a low number of trips (typically one or two per fill, with an impact of a few minutes) once the luminosity was no longer increasing from fill to fill. A set of improved HV modules has been ordered for installation in April 2012 for the electromagnetic forward region where most of the trips occur. Currently only 0.06% of LAr channels are non-functional (including 0.02% of dead cells at the detector level).

During the winter technical stop, the Tile calorimeter was brought back to a fully functional state. At the end of this consolidation period, the number of bad cells was only 0.1%, compared to 5.1% at the end of the 2011 data-taking period. Forty new LVPS were installed. The drawers equipped with these new LVPS show a significant reduction of non-Gaussian noise behavior and of correlated noise. The full production of new LVPS (remaining 260 units) has started, and will be installed during the 2013-2014 long shutdown.

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 higher-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 endcaps).

The winter 2011-2012 technical stop provided an opportunity to install and commission EE chambers, which cover the transition region between barrel and end cap, where only two measuring stations were previously available. All the EE chambers on one end of the detector (side C) were installed and commissioned, as planned. Since installation on side C was ahead of schedule, it was also possible to install one large sector on side A, bringing the total of installed sectors to four large sectors out of eight (no small sector is installed yet on side A). These chambers will be particularly useful for signatures that include high momentum muons, since momentum resolution is improved.

Important maintenance work was also accomplished. In the RPC system, all 3500 high voltage connectors were changed because some were cracking and then sparking. The 48-volt primary power system for the RPCs was refurbished with a safer and stronger connection between the primary source and the distribution boards. New impedances in the RPC gas lines were implemented at the input of the chambers to better equalize the gas distribution, and some of the gas inlets that broke during the 2011 running period were repaired. Unfortunately, some other gas inlets were damaged during this work, requiring further intervention during the first technical stop of 2012 at the end of April to bring the fraction of fully functional RPC volumes back to approximately the same value (97%) as in 2011. Nearly all of the ~72 chambers of the TGC system that had been disconnected due to high voltage problems were recovered, leaving only 12 chambers (0.03%) non-operational at the beginning of 2012 data-taking. Gas leaks were repaired in the MDT system, mainly on the EO chambers, where cracking of gas jumpers has been observed. Only 0.03% of the MDTs are not operational.

New muon reconstruction software code has been developed, merging the algorithms used previously. The new code is under commissioning and will be the only muon reconstruction package in the next ATLAS software release, which will be used for reprocessing of the 2012 dataset.

A small number of maintenance issues continue to be monitored. Commercial high voltage and low voltage power supplies require regular replacement, and commercial VME power supplies are also showing failures. RPC gas inlets are fragile, and small gas leaks continue to develop. Broken inlets are being replaced as needed during maintenance periods, but this is a difficult operation. Cracking on a few gas jumpers of some MDT chambers has been observed. Some TGCs showed problems related to HV behaviour at high luminosity, and it must be monitored whether recovered chambers will sustain the increased luminosity foreseen for this year.

6. Maintenance and Operation of the 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 an Absolute Luminosity for ATLAS (ALFA) system based on fiber detectors located in Roman Pots at ±240 m from the IP. All three detectors have successfully been part of the 2011 data-taking.

Since its final installation in January 2011, the ALFA detector has been fully commissioned. Using special β^*=90 m beam optics in late 2011, it successfully collected data for the measurement of the total proton-proton cross-section. A temperature problem, induced by the LHC beam, was found. During the winter 2011-2012 technical stop, its monitoring was improved and some additional solutions were implemented in order to better protect it during normal running conditions. If temperature becomes a problem, the detectors will need to be removed from the Roman Pots and reinstalled for large β^* runs.

As LHC instantaneous luminosity grew during 2011, the number of interactions per bunch crossing exceeded the design limit for LUCID. Consequently, the detector response became sensitive to gain variations from the anode current drawn by its photomultiplier tubes (PMT). These variations affected the luminosity measurement up to ~2%. Furthermore, at high pile-up levels, the event counting algorithms used to determine the luminosity saturate. For these reasons, the Cerenkov radiator gas has been evacuated, such that light is produced only in the quartz windows of the PMTs. In addition, the PMT bases were modified, during the winter technical stop, to reduce the dependence of PMT gain upon current and the backup readout system using quartz fibres was instrumented. These changes have been effective in early 2012 data-taking.

The ZDC readout, which is optimized for heavy ion running, began to suffer radiation damage from high-luminosity proton-proton running. Consequently, the detector was removed during the winter technical stop in order to prevent further damage and to study the damage mechanism. The ZDC will be reinstalled only for the heavy ion run in late 2012. Remediation plans for future proton-proton running are being investigated.

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 – comprising the Level-2 trigger and the Event Filter), the Data Acquisition (DAQ), and the Detector Control System (DCS).

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. Through 2011 the operational efficiency during collision periods has averaged 93.5%, comparable to that achieved in 2010. Near the end of 2011, the system operated at a peak level-1 rate of ~55 kHz, a sustained level-2 output rate of ~5 kHz, and an average event filter physics output rate of 400 Hz. The scope and quality of operational procedures and documentation continue to be the subject of review and improvement.

As previously reported, the rolling replacement of the computers (PCs) used in the Readout Systems (ROS) started in 2011. Despite significant testing over extended periods, both in the laboratory environment and at the ATLAS site, rare intermittent failures were experienced *in situ* that resulted in the halting of the rolling replacement midway through the process. Investigation of the source of the observed issues is ongoing, although identifying the cause is a challenge due to the rarity of the problem and the difficulty in systematically reproducing it outside of the experimental site. During the winter 2011-2012 technical stop, as part of the investigations, a solution has been implemented that works around the issue. During the 2012 start-up and to date, no operational problems with the ROS PCs have been observed. Nevertheless, the rolling replacement remains suspended until the 2013-2014 long shutdown while investigations continue.

Building on the experience gained in 2011, work with the detector systems continues to further automate operational procedures, in particular those that allow ATLAS to recover more efficiently from faults that halt data-taking. For example, procedures are now in place, for all detector systems, to automatically remove faulty channels during data-taking. It is also now possible, for half of the detector systems, to re-insert detector channels during data-taking. These procedures contribute directly to the operational efficiency of ATLAS.

The Level-1 trigger systems are performing efficiently and stably. Additional flexibility has been activated in the Level-1 calorimeter trigger, implementing electromagnetic and hadronic isolation, and eta-dependent thresholds.

Significant improvements have been made to the HLT at Level 2 for 2012 data-taking. An algorithm that accesses level-1 trigger towers from the full calorimeter and then uses sophisticated offline software tools for jet finding has been implemented to improve efficiency for multi-jet signatures. Modifications to both the dataflow system and trigger core software have permitted the implementation of an algorithm allowing triggering on missing transverse energy at Level 2. The algorithm uses energy sum information from the calorimeter readout, rather than having to access the entire calorimeter event data. In addition, trigger robustness against pile-up has been improved across the spectrum of the HLT algorithms.

During the course of 2011, a series of trigger selections (“menus”) specifically aimed at high-p_T physics were successively deployed in order to cope with the progressive increase in the LHC instantaneous luminosity and pile-up, up to a maximum of 3.5 x 10^{33} $cm^{-2}s^{-1}$. For 2012 running, a completely new menu for luminosities up to 8 x 10^{33} $cm^{-2}s^{-1}$ at 8 TeV has been developed and recently deployed. The many (more than 500) items in the online trigger menus are classified to reflect ATLAS physics priorities. Their rates are varied during the course of an LHC fill as luminosity decreases, giving full bandwidth to high priority triggers at the start of the fill and, as their rate decreases, allocating some bandwidth to lower priority triggers. This mechanism allows the mean Event Filter physics output rate to remain at approximately 400 Hz, while respecting the constraints imposed by the available offline computing resources.

The trigger system coped well with the LHC heavy ion run at the end of 2011, using Minimum Bias triggers and extensive selection at the Event Filter to cope with the high luminosity ion beams.

Following detailed measurements of the HLT computing resource usage and trends using the 2011 data, there are currently no plans to increase the HLT capacity for 2012 operations. However the HLT performance will continue to be monitored in face of increased pile-up and its capacity will be increased to meet the needs of the experiment if this becomes necessary. The rolling replacement of computing hardware that has reached the end of warranty continues.

8. General Operation

ATLAS completed 2011 operations successfully, accumulating large data samples with excellent data-taking efficiency and data quality. Efficient operation has 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 93.5%. Data quality requirements depend on the specific analysis, but more than 90% of this sample is used in essentially all analyses.

Consolidation work on the detectors and the deployment of a new trigger and data acquisition software release during the winter 2011-2012 technical stop required re-commissioning the detector after the technical stop. After extensive standalone testing of the sub-detectors, combined data-taking restarted in early March 2012. First collisions in 2012 were recorded on 5 April, and ATLAS has resumed taking data successfully, and with efficiency comparable to that of 2011, even in the challenging new environment of event pile-up (due to operation with more squeezed beams than in 2011), with an average number of interactions per crossing close to 30 at the beginning of a fill.

Over the course of 2010, 2011, and the first months of 2012, 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 further reduction of the shift crew in the control room took place in the autumn of 2011. ATLAS now operates with 9 shifters, compared to 20 initially. OTs 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, many of which can be executed remotely. Operation, in this broad sense, requires very substantial effort, approximately 650 FTE plus shifts. Responsibility for OTs is shared among the Institutions in proportion to their number of authors. Effort on ATLAS-specific WLCG operation, at the level of approximately 180 FTE, is in addition.

9. Computing and Software

The entire ATLAS and WLCG computing and software chain performed very well throughout 2011. Data is reconstructed at the Tier-0 centre and distributed worldwide within a couple of days of data-taking. Prompt calibration operates routinely: intensive calibration work is performed at the CAF (Calibration and Alignment Facility) at CERN within a few hours after the data are recorded using small specialized 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 are used to reprocess real and simulated data. Simulation production uses available CPU and disk resources at Tier-1 and Tier-2 centers, with an average of approximately eighty thousand jobs running concurrently and with approximately 1.5 billion events simulated in 2011. Since the end of 2011, available Tier-0 CPU resources can be used for simulation outside of data-taking periods, and in the second half of 2011 CAF resources could be used to augment the Tier-0 capacity when needed. Collaboration-wide 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. Computing and software shifts are operated at the Point-1 control room and worldwide, to support production operations and user analysis. ATLAS continues to make efficient use of the computing resources made available at all WLCG sites.

The ATLAS data distribution model was changed at the beginning of the 2011 run in order to optimize the usage of our resources, deal with larger than expected pile-up, and accommodate higher trigger rates. Users have been satisfied with this evolution away from analysis with large event-size ESD (event summary data). Physics analysis is being performed using smaller-size AOD (analysis object data) and D3PD (derived physics data; Ntuples). These data types are widely distributed over disks at Tier-1 sites and dynamically to disks at Tier-2 sites. Further changes to the data distribution model are being made in 2012 in order to further exploit dynamic data placement and to further optimize resource usage.

While full simulation continues to be the work horse for most physics analyses, ATLAS fast simulation has now matured to the point that it is used routinely for a significant fraction of simulation (presently ~ 30%, possibly more in the future). A completely reworked simulation framework, allowing better integration between full and fast simulation is being developed to be in production use in 2012.

The sizeable integrated luminosity expected from data-taking in 2012 will produce a considerable dataset, and data analysis, reprocessing, and simulation activities associated with this dataset will continue in full swing through the 2013-2014 LHC shutdown. These activities will require the full computing resources requested for 2012 and beyond.

Although several novices have joined the software project, in some cases as their technical contribution for authorship qualification, the availability of adequate expertise to maintain ATLAS computing and software remains a concern. Indeed, major software upgrades will be planned in 2012 and implemented during the 2013-2014 LHC long shutdown.

The core computing infrastructure and services tasks, defined as M&O Category A, continue to 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.

10. Data Collection and Physics Output

The long proton-proton run in 2011 exceeded expectations with an integrated luminosity of 5.6 fb^{-1} delivered to ATLAS, of which 5.2 fb^{-1} was recorded, with an overall data-taking efficiency of 93.5% (Fig. 1). This was complemented by the lead-lead heavy ion run in late autumn with an integrated luminosity of 166 μb^{-1} delivered to ATLAS, almost 20 times the 2010 Pb-Pb sample. At the time of writing 2012 data collection is just beginning at a centre-of-mass energy of 8 TeV. Instantaneous luminosities close to the 2011 peak have already been obtained just a few days after the year's first stable beams. As expected, the pile-up conditions in 2012 are very challenging right from the start, with the mean number of interactions per crossing above the LHC design value, close to ~30 at the start of fills, and peak values for some bunches approaching 40. An intensive programme of software optimisation has been performed over the last months to ensure that high pile-up can be handled by the reconstruction software within the available computing resources and with only a modest impact on physics.

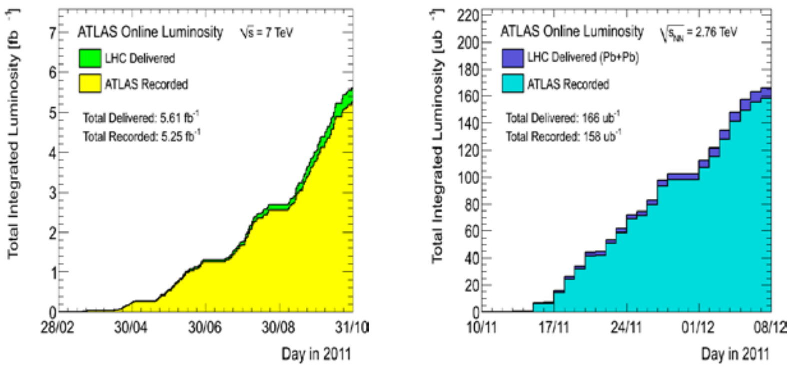

Figure 1: Integrated luminosity vs. time for 2011 proton-proton (left) and lead-lead (right) collisions.

A new reconstruction software release is now being used to reconstruct the 2012 data. This release includes many improvements in physics object reconstruction particularly for high pile-up conditions (the release has been tested on 2011 special high pile-up data with up to 40 interactions per crossing). The improvements are both in the physics performance as well as in terms of CPU and event size. Double the CPU resources will be available at the Tier-0 for prompt reconstruction of the data. A simulation campaign is in progress to match the increase in centre-of-mass energy. A number of further improvements have been brought into the simulation, such as using recent versions of the latest Monte Carlo generator programs.

Physics results based on the full 2011 pp dataset were made public starting already in December 2011, and a wide range were reported at the winter conferences. Major progress has been made in sensitivity to the Standard Model Higgs boson (Fig. 2): the region excluded by ATLAS at 95% confidence level (CL) now extends from the LEP limit to 117.5 GeV, between 118.5 to 122.5 GeV, and all the way from 129 to 539 GeV. Indeed the region 130-486 GeV is now excluded at 99% CL. Furthermore, as has been widely reported, the data show an excess of events consistent with a Higgs boson mass of around 126 GeV, but the significance is only at the level of 2.5σ before including look-elsewhere effects and the global probability to see an excess as significant as this, if there is no Higgs boson in the data, is in the range 10-30%. A substantial quantity of 2012 data will be needed to establish whether this is indeed the first sign of the Higgs boson or not.

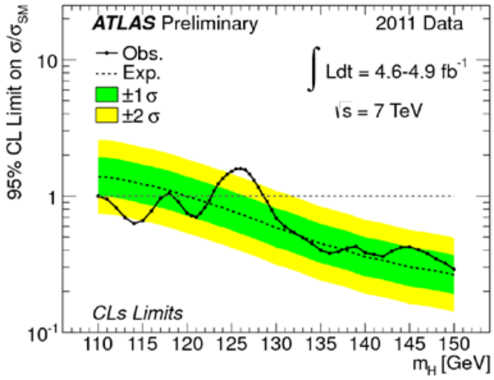

Figure 2: Constraints, at 95% CL, on the cross-section for Standard Model Higgs boson production as a function of its mass in the low-mass region. The solid black line shows the current constraint: cross-sections above the line are excluded at 95% CL or more. The green/yellow bands show the range of expected exclusion in the absence of Higgs production. Only mass regions around 118 GeV and 122.5-129 GeV are not excluded at 95% CL.

Other results with the full 2011 data sample include refined measurements of established processes in the new energy regime, for example of diboson production (*WW* and *ZZ*), and of high-mass dijet event production, also used to place constraints on new physics models (Fig. 3). Searches for new particles made with the full 2011 dataset also include those for excited quarks, massive dilepton pairs, long-lived heavy particles, SUSY signatures in final states with jets and missing transverse momentum. In the B-physics sector, ATLAS observed a new state consistent with being the $\chi_b(3P)$, a bottomonium resonance.

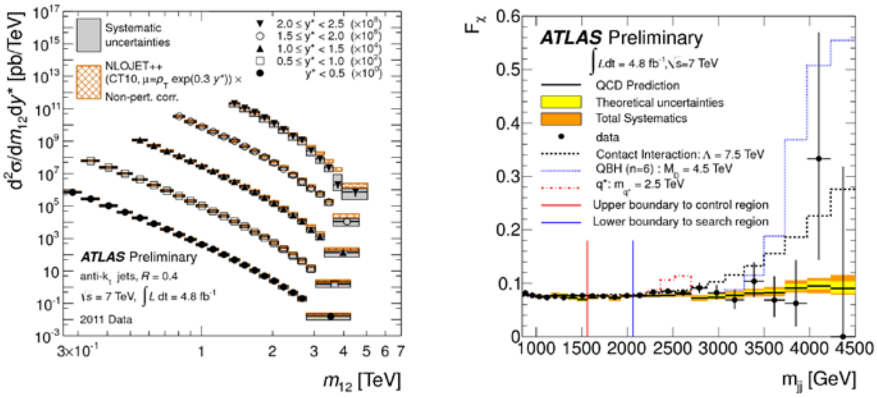

Figure 3: Left: Measurements of dijet differential cross-sections using the full 2011 data sample, extending up to 4.6 TeV invariant mass. Right: Dijet angular variable F_χ sensitive to new physics contributions: a quark contact interaction with compositeness scale Λ>7.6 TeV is excluded at 95% CL.

A host of further results have been submitted for publication or prepared for conferences during the last six months based on the summer 2011 dataset of 1-2 fb^{-1}. They are far too many to list here, but selected highlights were: the first ATLAS limit on $B_s \rightarrow \mu\mu$ decays; limits on 3rd generation squarks and sleptons; limits on many varieties of new heavy quarks; single-top production; and top mass and cross-section measurements. Final results of detailed studies of high cross-section processes in 2010 data provide an interesting complement, making use of the very clean low pile-up conditions in those data. Physics results from heavy ion data continue to be released, recent highlights being comprehensive papers on elliptic flow, and on azimuthal charged particle anisotropies.

At the time of writing, a total of about 140 papers using collision data have been submitted or published – 60 since the last RRB report in October, and more than 300 public conference notes have been released since the beginning of data-taking.

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 1.7 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-2012-012).

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, cooling, gas, and cryogenic systems, will require improvement and consolidation during the 2013-2014 LHC long shutdown (LS1). Improvements to the hermeticity of the muon trigger system are also planned.

The Insertable Pixel B-layer (IBL) is part of the FDL detector activities. The Technical Design Report (TDR) was submitted to the LHCC (CERN-LHCC-2010-013, ATLAS TDR 19) in September 2010, with installation now targeted for the 2013-2014 long shutdown, The project is on track in terms of both major decision milestones and overall delivery schedule. Following the selection of sensor technologies for the IBL, the Memorandum of Understanding has been finalized for signature by the Institutes and Funding Agencies concerned. Along with IBL installation, which includes a beryllium beam pipe, aluminium beam pipes in the forward regions will be installed. An option to replace the pixel services also exists. A status report on FDL detector activities is provided in CERN-RRB-2012-028.

As previously reported (CERN-RRB-2009-020, April 2009), in accordance with CERN plans to increase the luminosity of the LHC, ATLAS established an R&D programme to study the detector improvements required to operate beyond design luminosity conditions. Two phases are being planned. The first phase is targeted at reaching the “ultimate” LHC luminosity of approximately $2x10^{34}$ $cm^{-2}s^{-1}$, with installation foreseen in the second long shutdown (LS2) in 2018. The second phase of detector improvements is targeted at very high instantaneous and integrated luminosity during the High Luminosity LHC (HL-LHC) era, with installation foreseen for the third long shutdown (LS3) in approximately 2022. As previously reported, ATLAS plans to proceed via Letters of Intent (LoI) for each upgrade phase, followed by project-specific Technical Design Reports (TDR) and Construction MoU Addenda.

Detector improvements for Phase 1 target the integration of ~300 fb^{-1} by the start of the next decade, exploiting peak instantaneous luminosities of 2×10^{34} $cm^{-2}s^{-1}$ and above. Improvements focus on enhancing ATLAS trigger capabilities in order to maintain good physics selectivity in face of higher luminosity and background rates. Required changes include replacement of the “small wheels” of the muon spectrometer, because the $|\eta| \geq 1.2$ regions, which dominate the muon level-1 trigger rate, could overload the available level-1 trigger bandwidth beyond design luminosity. New small wheels could also eliminate saturation effects and loss of hit efficiency in the muon drift tubes arising from cavern background. Improvements to the level-1 calorimeter trigger, using finer granularity information and more sophisticated algorithms, are under development in order to cope with pile-up levels well beyond those for which the detector was designed. The goal of these improvements is to keep single lepton and missing E_T thresholds at Level-1 as low as possible, within constraints of the allowable level-1 rate. Phase I plans also include the already approved FTK project, which will provide a hardware track finder at the input to the Level-2 trigger, and associated improvements to the High-Level Trigger and data acquisition systems. Finally, on the timescale of LS2, ATLAS is studying enhancing its very forward detector capability with devices able to operate in high pile-up conditions, in order to study rare processes in γγ scattering (with W^+W^- final state, for example) and extreme diffractive QCD processes. The LoI (CERN-LHCC-2011-012) outlining Phase I plans and their physics motivation was approved by the Collaboration Board in early 2012 and submitted to the LHCC, which encouraged ATLAS to proceed with the related TDRs and MoU Addenda.

Detector improvements in preparation for the HL-LHC era target integrating 250-300 fb^{-1} per year, exploiting peak luminosity of approximately $5x10^{34}$ $cm^{-2}s^{-1}$, with high radiation and event pile-up levels. Such operating conditions will quickly exhaust any remaining radiation budget in the tracker system, requiring replacement of the full inner detector. They also will potentially lead to radiation damage to the cold preamplifier electronics of the HEC, and will probably preclude operation of the present FCal. In addition, such operating conditions will require improvements to much of the currently installed detector readout, trigger, and data acquisition systems. ATLAS is presently conducting a program of urgent R&D on long lead-time improvements. For instance, tracker requirements have received significant attention and prototyping effort, focussing on an all-silicon detector with the very high radiation hardness and granularity suitable for the HL-LHC environment. Programmes to address the extreme radiation requirements for the pixel layers have also been undertaken, and benefitted greatly from the intensive ongoing efforts to qualify technologies for the IBL that will survive until the shutdown for HL-LHC installation. The Letter of Intent describing the detector improvements for this phase is being prepared for early 2013.