WHAT DO THE EXPERIMENTS HAVE PLANNED?

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Abstract

The shutdown originally planned for 2011-13 is the first opportunity since physics operation started for the experiments to conduct comprehensive maintenance. This long shutdown will also be used to consolidate and upgrade the experimental apparatus so as to fully exploit the expected improvements in LHC performance in subsequent years. This talk will summarize the planned activities in all experiments and attempt to identify areas where resource conflicts may arise .

BASELINE PLANNING

In the current baseline planning [1] around 60 months of p-p running and 8 months of heavy ion running are envisaged before the end of this decade. Maximisation of the physics rewards obtained from the data taken during this period will be the driving factor in deciding how to distribute the remaining time, which is dedicated to technical stops and shutdowns. At present, 3 substantial long shutdowns, LS1 (15 months, 2011-2013), LS2 (15months, 2015-2017) and LS3 (19months, 2019-2021) are foreseen, in addition to year-end technical stops of about 10 weeks duration at the end of years 2013, 2014, 2017, 2018. At this point it is instructive to examine what use the experiments have made of year-end stops like the one just being completed. The evidence suggests that they will be an important ingredient in the overall consolidation and upgrade plan as well as being essential for maintenance and repair.

YEAR-END TECHNICAL STOPS

The experience of 2009-10 and 2010-11 shows that all four experiments can successfully complete complex interventions, requiring partial opening, during a year-end Technical Stop of 10 to 12 weeks, with work spanning the CERN closure if necessary. It is interesting to review some of what the experiments have been able to achieve in the last two year-end stops. During 2010-11:

ALICE [2] partially opened to install 3 TRD modules and 6 EMCAL modules.

ATLAS [3] completed a very substantial programme involving opening both ends of their detector, including work on the electronics of their Liquid Argon Calorimeter and TILECAL, as well as installing the ALPHA detectors in the very forward regions.

LHCb [4] removed and re-installed both RICH1 HPD boxes, having exchanged both electronics and HPD's.

CMS and TOTEM [5] installed the TOTEM T1 tracking system.

To these must be added the full opening of both ends of CMS during the 2009-10 year-end stop to definitively repair a cooling system fault.

These successfully completed programmes demonstrate that besides routine maintenance, emergency repairs, consolidation, new installations and even upgrade are feasible. So far experiment work has been tailored to stay entirely within the shadow of LHC work, but in future stops, this may not always be compatible with the work programme being attempted.

FUTURE SHUTDOWN ACTIVITIES

Detailed objectives for the different technical stop or shutdown periods are interdependent and will evolve progressively, depending at each stage on past achievements and future expectations. Postponing the 2011-13 shutdown (LS 1) to 2012-14, will, in most cases:
-delay the whole LS 1 task-list by one year.
-allow some tasks scheduled for LS 2 to be pre-empted.
-tend to put pressure for more maintenance and repair tasks (and even upgrade tasks) during year-end stop 2011-2012.

Once the schedule is confirmed, further evolution is likely.

LONG SHUTDOWN 1

The provisional plans of the experiments for the first long shutdown are described below. To this list must be added yearly maintenance of the infrastructure and safety systems, infrastructure consolidation and fault repairs, as necessary. Changes to the shielding of the high luminosity experiments to control activation, backgrounds and the dose to maintenance personnel will also be mandatory.

ALICE

ALICE [2] plans a full opening of the detector, moving the TPC to parking position and accessing the Silicon Tracker for repair and consolidation, particularly of the Pixel tracker cooling system. Simultaneously, six more supermodules of the EMCAL upgrade will be installed, along with support structures for the photon spectrometer.

ATLAS

ATLAS [3] plans to replace steel beam pipes, flanges and ion pumps with aluminium ones to reduce activation and induced background

The Pixel Tracker may be brought to the surface for replacement of all services and optical transmitters, a precautionary fix for faults predicted as possible from 2015 onward due to failing optical transmitters inside the detector. The decision to extract or not will be taken during 2012. This is a major operation! Profiting from this and the revised timing of LS1, the Pixel Insertable B Layer (IBL) project, originally targeted for 2016, may be accelerated to be ready to install in 2013. This additional pixel layer will improve vertexing and b-tagging capabilities at nominal luminosity and beyond, but would require a new beryllium central beam pipe with smaller diameter (45 mm) to be ready in early 2012.

Further substantial tasks are:
-The installation of a new C_3F_8 Inner Detector evaporative cooling plant based on a passive syphon concept.
-The replacement of all on-detector DC-DC converters in the Liquid Argon and Tile Calorimeters with a new generation of devices.
-Completion of the installation of the "EE" muon chambers (which better cover the transition region between barrel and toroid end-caps) and instrumentation of existing trigger chambers in the toroid feed region to improve geometrical acceptance

CMS

CMS plans to upgrade its Endcap Muon System, which was de-scoped for the low luminosity detector. This upgrade involves restoring granularity in the inner layer of Cathode Strip Chambers (CSC's), installing an additional (fourth) layer of CSC's and Resistive Plate Chambers in each endcap and constructing a mobile shielding wall which will complete the forward shielding system and protect the newly installed detectors.

The revision of Hadron Calorimetry will start with the replacement of photo-transducers in the outer barrel and in the CASTOR forward calorimeter.

The Forward Shielding and support structures will be revised to give more reproducibility under magnetic cycling and to allow forward detectors to be installed for heavy ion running. Improvements to the beam monitoring system will include the Pixel Luminosity Telescope and the barrel endcap humidity seal will be improved to allow for colder Tracker operation.

Given the prospect of a one or two year delay to LS2, plans are being made to advance to LS1 the preparation and installation of the reduced diameter beampipe needed for the upgrade of the Pixel Tracking detector. This would also result in a newly baked-out pipe for 2014 and open the way for a lower risk logistic sequence with the beampipe removed for much of the shutdown.

The first detailed CMS planning exercise for LS1 has identified in excess of 230 discrete operations, spanning a 15 month period. Beampipe replacement or bakeout would add another 2 months to the time required.

LHCb

As in the ATLAS case, LHCb [4] plans changes to the beampipe and vacuum system to reduce material budget, reducing activation and backgrounds whilst increasing transparency. Exchange of the largest beryllium section (the third, ~6000mm in length), requires moving out the fourth section as well. Machined aluminium bellows between Sections 1 & 2 and between Sections 2 & 3 will be replaced by units with a formed bellows technology**.** Spider-web fixed point supports will also be replaced by a higher transparency design.

One or more detector modules of the Inner Silicon Tracker will be replaced with scintillating fiber technology (as part of the upgrade project) and, depending on the accumulated radiation dose, exchange of both VeLo halves, including the RF boxes, may be considered necessary.

TOTEM

TOTEM [5] is retaining options for servicing of the T1 and T2 telescopes and their test or re-commissioning at beam height, which could have impact on the CMS opening and closing timescales.

Similarly, service requirements, including possible dismount, of Roman pot detectors, may affect local LHC scheduling in the straight sections either side of pt 5.

POINTS TO WATCH

Beampipes:

Change of schedule may lead to more overlap between experiments in both construction and installation of improved beampipes, with the distinct prospect of ATLAS, LHCb and CMS all changing beryllium pipes and other vacuum components in 2013. Whether this transpires or not, the pumping effectiveness of the NEG coatings needs to be regularly monitored so that saturation can be predicted. Bakeout or pipe exchange is complex and the steps must be explicitly included in shutdown scheduling

Survey:

Despite contributing substantially to their own survey efforts, each experiment needs a minimum of one staff surveyor to oversee the survey programme, make sure survey and its documentation is carried out coherently throughout CERN and ultimately to take responsibility for survey work of complex-wide criticality.

Infrastructure:

All experiments require very substantial consolidation of shielding ventilation, cryogenics, cooling, inertion and dry air systems, RP measures, safety systems, and beam diagnostics between now and the end of LS 1, to maintain the good match between experiment and LHC performance and availability obtained during 2010.

LONG SHUTDOWN 2

The existing programme of work for LS 2 is likely to be strongly affected by the knock-on delay resulting from the decision to postpone LS 1, recalling that the baseline date of 2016 was already a compromise between different interests requesting 2015 & 2017.

Presumably the LS 2 start date and duration will be re-considered based on the physics achieved pre-LS 1 and targeted between LS 1 and LS 2, the actual start and duration of LS 1, the capabilities and weaknesses of LHC and the experiments in the period between LS 1 and LS 2, the credible ready for installation dates of various upgrades to the machine and experiments and finally the gains and risks to performance involved in projected LS 2 work.

There are many common features to the plans of the 4 major experiments [2,3,4]. All will execute or complete beampipe and tracking upgrades (although in the case of ATLAS and CMS, part or all of those currently planned may be pre-empted to LS1 and intermediate technical stops) and all have substantial trigger or readout upgrades in mind to cope with anticipated higher luminosities. Upgrades to Calorimetry and in some cases Muon Systems also feature.

CONCLUSION

The LHC experiments plan an intensive programme of maintenance, consolidation & upgrade work for the first Long Shutdown (LS 1) of the LHC. However, this work-plan must be seen as part of an interdependent and coherent set of objectives for all three Long Shutdowns currently foreseen, with proven options to also exploit the intervening year-end technical stops.

Activity overlap and possible resource conflicts have been identified for: beampipe construction and replacement, experiment survey and infrastructure modifications, all of which depend crucially on resources from CERN technical departments.

Delaying LS 1 from 2011-13 to 2012-14 will cause most of the baseline task list to be postponed by 1 year without serious consequence, although urgent exceptions may put more pressure on the 2011-12 year-end stop**.**

The inevitable feed-forward of a one or two year delay to LS 2 (current baseline 2015-17) will likely feedback more tasks to LS 1 and the intervening year-end technical stops. For the experiments to plan correctly, an overall revision of the next 10-15 years including all 3 long shutdowns is needed. In addition to shutdown start times and durations, the capabilities of the LHC after each shutdown are an important input for experiment planning, since the likely boundary conditions for instantaneous and integrated luminosity, bunch pattern and bunch intensity can substantially influence the priority given to different consolidation or upgrade projects.

ACKNOWLEDGEMENTS

I would like to thank the organisers for the opportunity and privilege of providing part of the experiment input to the 2011 Chamonix decision-making process. As usual the workshop was well-organised and well-focussed, confronting the facts head on, and providing an excellent forum for cross-department discussion as well as social activity. I am indebted to my fellow Technical Coordinators: Joachim Baechler, Rolf Lindner, Marzio Nessi and Werner Riegler for the comprehensive material they provided and for their solidarity.

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