SUMMARY OF SESSION 8: LONG SHUTDOWN 2 STRATEGY AND PREPARATION

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Abstract

This paper summarises Session 8 on the Long Shutdown 2 (LS2) Strategy and Preparation. The main messages addressed during the presentations are reviewed and the key elements discussed are detailed.

SESSION PROGRAM

The program of the session included 7 talks addressing general aspects (Organisation & Safety), LHC Experimental areas and the two main projects on Injectors and LHC:

- Scope of LS2 (making best use of the period 2015-2018) by José Miguel Jiménez (TE).
- What has been learnt from LS1 by Katy Foraz (EN-MEF).
- Safety & Radiation Aspects by Doris Forkel-Wirth (HSE-RP).
- LIU Planned Activities by Julie Coupard (EN-MEF).
- HL-LHC Planned Activities – Accelerator by Isabel Bejar Alonso (HL-LHC Project Office).
- LHC Experiments Upgrade and Maintenance by Werner Riegler (on behalf of LHC Experiments).
- LS2 @ LHC by Marzia Bernardini (EN-MEF).

TALKS SUMMARY

Scope of LS2

The project scope covers all activities carried out and resources needed in the context of Long Shutdown 2 over the whole CERN accelerator facilities. It includes the preparation, coordination and follow-up till completion of all LS2 activities done in the frame of the LIU, HL-LHC Projects and other CERN approved projects (Fig.1).

The flexibility to use the end-of-year technical stops before and after the LS2 to decrease the workload during the LS2 is left at the discretion of the LS2 Coordinator and is also part of the scope of the project.

What has been learnt from LS1

The importance of implementing a tool (PLAN.CERN.CH) to collect and prioritize the activities using a unique repository has been underlined. This repository will ease the information exchange between groups since, they will have a clearer picture of the support to be given to other groups. This attenuates bad surprises and eases the prioritization process for the LS2 Coordination Team, allowing focusing only on discordance points. The feedback from LS1 showed that:

- the tool should have come earlier,
- not all activities were announced,
- duplication of resources between APT and PLAN.

To improve the situation in the future, LS2 will use an upgraded version of the PLAN tool to collect future activities. Groups will be given enough time to upload their requests and provide feedback on the requested support. The tool will get improved to better fit with Users and Coordination needs, homogenising the granularity between items and avoiding redundancy with other tools.

The central role of the coordination has been recalled, focusing on the added value to help keeping a very good follow-up on fields, to enhance team spirit & eases information flow and, last but not least, improve safety by reducing as much as possible co-activity

In terms of schedule management, it is proposed to keep a member of coordination team (scheduler) within projects; this would allow a decrease in the impact of delays in component availability or acceptance tests by globally optimising the schedule. Actions need to be taken to optimize the start of an activity w.r.t. radiation cooling period, to avoid shortening too much the available working period.

The documentation will remain a priority, ensuring that the Engineering Change Requests (ECR) get presented on a regular basis in the LS2 Committee (LSC) and then in the LMC or IEFC for LHC and Injectors respectively. This implies proactive actions to have the ECRs edited in due time.

The daily management will be maintained since helping to keep working with the same references. The information exchange will get reinforced to ensure that information flows down to the worksites. One pending difficulty is to rationalise the information provided by Projects since an excess of details, important for the Project follow-up, can create confusion when delivered at a coordination level. This will be compensated by maintaining a web page indicating hyperlinks to the Projects.

In terms of logistics, temporary storage, buffer zones and “bases de chantier” have to be sized and planned sufficiently in advance. Finally, the need to implement and maintain a repository of service unavailability is positively considered.

Safety & Radiation Aspects

The Regulatory Landscape is introducing new constraints which need to be seriously considered during the LS2 preparation. Indeed, it will impact work frames, co-activities, logistics and overall safety. The impact will be evaluated in the coming months and scenarios will be prepared and discussed with concerned Groups.

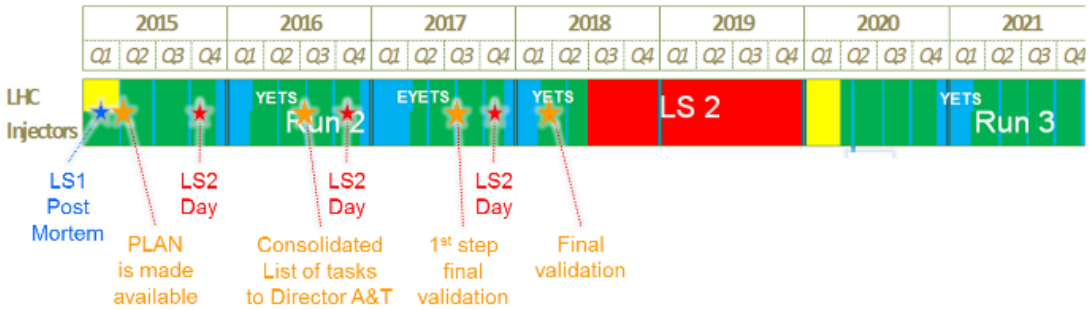

Figure 1: LS2 Period with main milestones.

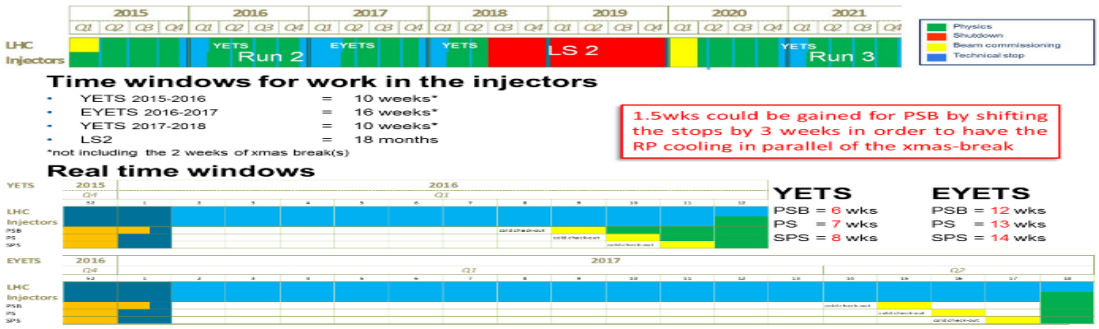

Figure 2: Schedule of LIU.

The training preparation and communication will get high priority. Actions will be taken to have all information and training sessions prepared in due time.

The needs for radioactive storage in surface building and the required handling means will need to be actively evaluated to be better prepared. The case of radioactive waste management (volume & weight) is a major issue. Indeed, all components coming out from the tunnel need to be considered as potential radioactive wastes and follow a severe checking path, requesting lot of resources. In view of LS2, the Group's projections will need to be more accurate.

Some impact must be expected following the decisions to delay the construction of the Bld181 radioactive magnets facility. Thus, the need to share other infrastructures by radioactive and non-radioactive components is a reality and needs to be discussed.

Looking at the dose rates to personnel, the Injectors will dominate the personnel dose rates even though situation in LHC will not improve. CERN individual dose objective of 3 mSv over 12 consecutive months will be more challenging. Some Groups already concerned by this limit during LS1 shall study the situation and give feedback on the opportunity to keep this threshold value. It is important to highlight that during LS1, ALARA procedure has become an essential and natural part of CERN culture. This will help to set the roadmap towards LS2, thanks to the lessons learnt from LS1.

LIU Planned Activities

The LIU activities fit in the LS2 time window defined for the injectors but the schedules are very tight with not much margin and already assuming shift work. This implies that the consolidation prioritization needs to be coherent with LIU activities.

However, at this stage, still additional studies are required:

- Evaluation of the cabling work load as early as possible in order to estimate the EN/EL workload and integration.
- Levelling of the resources of the support/client groups, for example: EN/MME, EN/HE, EN/CV, EN/EL, EN/MEF-SU, GS/CE, TE/VSC. A typical case is the EN-EL cabling for LIU-PSB is already planned in 3 shifts per day.
- Integration studies which need to be completed: 3D models of infrastructures and general services.
- Finalization of the needs for design and production of manufacturing drawings.
- Definition of the works that can be anticipated in YETS and EYETS.

An optimisation of the planning is still possible, as an example, shifting the stop of PSB by 3 weeks could result in a net gain of 1.5 weeks since the radiation cooling time will get in parallel with the Christmas Break (Fig.2). This potential optimisations will be followed in the future in collaboration with the Operation Group.

HL-LHC Planned Activities - Accelerator

Despite the fact that the main interventions in the CERN accelerator complex for HL-LHC will take place during LS3, a substantial amount of work will occur /many work packages have foreseen activities during LS2.The HL-LHC is less advanced in term of shutdown

preparation, many activities are getting defined. However, at this stage, it is important to outline that Groups must identify and prepare the work which can be done in LS2 on the time frame allocated and provided that the technology/solution is mature and cannot bring any risk to the Run 3 start date and machine availability.

The driving concern is obviously the integration of components as early as possible in the 3D integration drawings and in the HL-LHC work planning of LS2 (Fig.3 and 4).

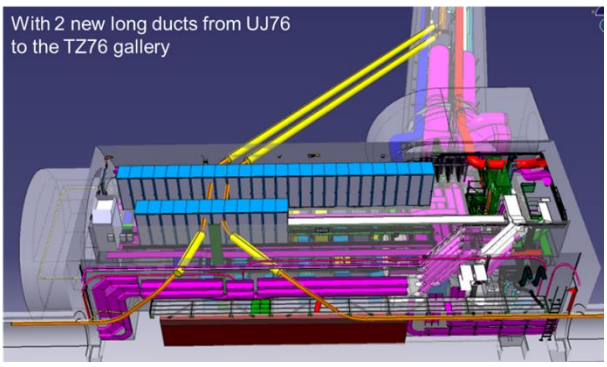

Figure 3: Example of integration of the superconducting links in UJ76.

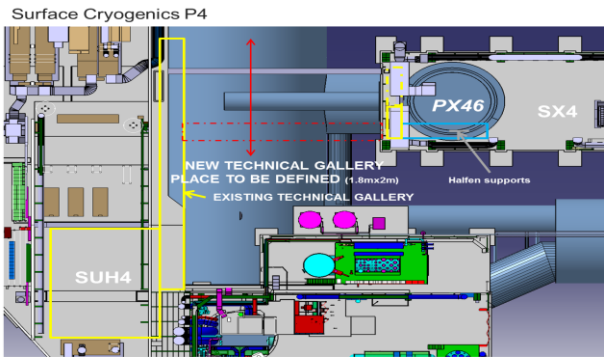

Figure 4: Example of integration of cryogenic components in surface buildings.

Experiments Upgrade and Maintenance

The four LHC Experiments have foreseen major overall during the LS2 period (Fig.5) and already announced that they will need more support from infrastructure Groups of the Accelerators and Technology Sector during that period but also for the preparation **before** LS2. ALICE and LHCb will implement major upgrades with important changes to the entire apparatus, while ATLAS and CMS will perform their major detector upgrades only during LS3. However, the overall scale of the LS2 operations is quite similar for all experiments and especially, the LS2 plans for the IP1 and 5 forward regions (Totem, Alfa, roman pots, movable beam pipes) are being developed.

ATLAS (Fig.6) has implemented many upgrades and medium term consolidation items for Run 2 and Run 3 already during LS1. A new central beam pipe and an additional layer of Pixel detectors, the insertable B-Layer (IBL), were installed during LS1. The experimental beam pipes made from stainless steel were changed to Beryllium and Aluminium for reasons of background and activation. The planned PHASE1 upgrade for ATLAS is detailed in four technical design reports. Beyond the standard maintenance there are at this moment no major foreseen implications on the technical department.

The CMS Phase 1 upgrade was started in LS1 but will continue till LS2, using all opportunities during Run 2 [TS, YETS and EYETS] between 2015 and LS2 (Fig.7) as described in three technical design reports.

The central beam pipe was changed in LS1, the forward experimental beam pipes will be changed to Aluminium in LS2. The UPS system will be upgraded and the electrical infrastructure has to be upgraded as well. An increase of chilled water production and a dry gas system upgrade for Phase2 detectors will also be implemented.

The installation of a second UXC crane with suspended cage for personnel access and replacement of the elevator will also be done during LS2.

Since the detector will be completely opened, the upgrades and detector maintenance efforts are on the same scale as LS1, so transport, rigging, survey & FSU support on the same scale as during LS1 are needed.

The Phase1 upgrade of ALICE (Fig.8) will see major changes to the entire apparatus. This upgrade is detailed in 5 technical design reports referring to the Inner Tracking System (ITS), the readout and trigger system, the Time Projection Chamber (TPC), the Muon Forward Tracker (MFT) and the Online-Offline System. The space and electrical power availability for the computing farm needs to be checked to act consequently.

A new central beam pipe and its mobile bake-out equipment have to be developed. A modification of Miniframe beam pipe, the displacement of the central gauge as well as the implementation of an ion pump made using an Aluminium body are foreseen. Optic fibres have to be installed, the option to use the EYETS 2016/2017 is studied. A new cooling plant is needed for the new ITS detector, and a possible new dry air ventilation system is studied. The change of the elevator to the UX cavern is essential at the earliest possible time.

Vacuum consolidation to achieve the lowest possible level of beam-gas background is essential. To allow maximum Pb-Pb luminosity, collimators in dispersion suppressor region need to be implemented.

The Phase1 (Fig.9) upgrade of LHCb foresees major changes to the detector. All frontends are upgraded to read events at the full 40MHz collision rate into the online farm and several detector systems are exchanged in order to cope with much higher readout frequency. The upgrade is detailed in four technical design reports referring to the Vertex Locator (Velo), the Tracker, the Particle Identification (PID) and the Trigger and Online system.

A large new computing farm will need a surface building or a dedicated container. All beam pipes in the cavern must be removed and then reinstalled during LS2 without changes. Probably a TAN will have to be installed around LHCb. Optical fibres will get pulled from the

experimental hall up to the surface. The EYETS 2016/2017 is an option. The planned changes of elevator and crane have to be properly scheduled to minimise impact.

For integration of cables, cable trays, cooling lines, access platforms as well as supervision of the service installation activities, LHCb relies on the EN-MEF Group.

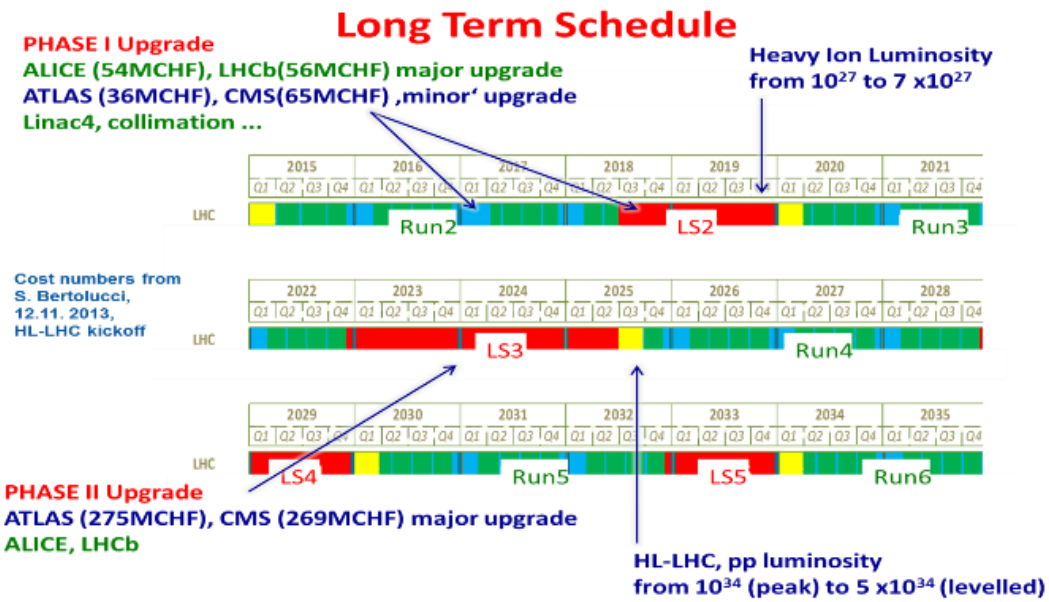

Figure 5: Long Term schedule of the LHC Experiments.

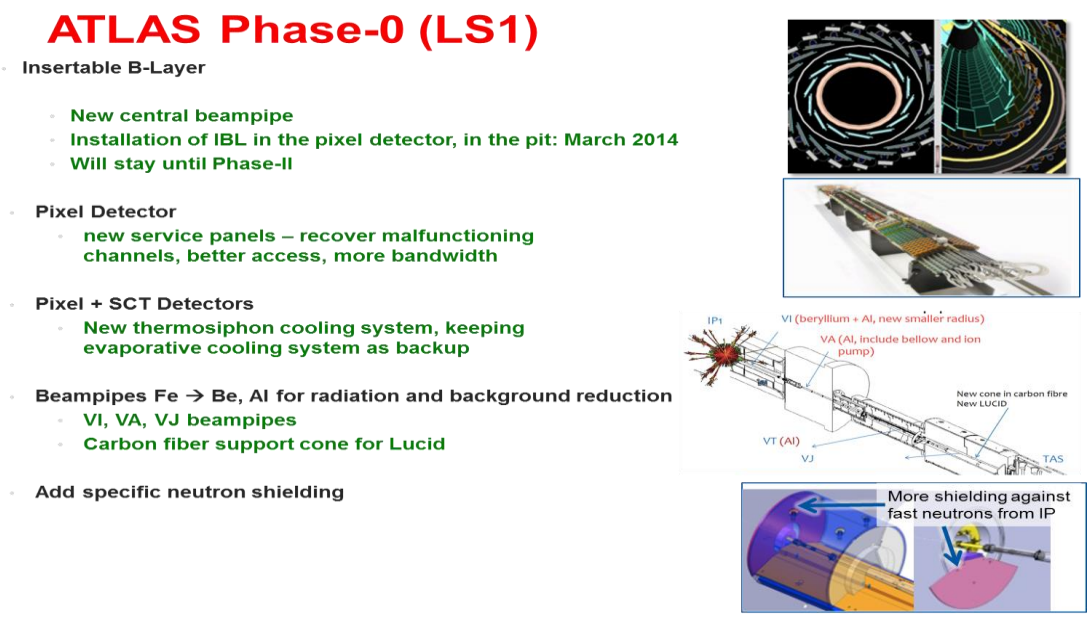

Figure 6: ATLAS upgrades done during LS1.

LHC @ LS2

The LS1 Schedule Coordinator insisted on several key messages: LS2 needs to be prepared NOW! LS2 is mainly dedicated to Injectors and to LHC Detectors. However, it is important not to minimise the maintenance and consolidations in the LHC, which will be of primary importance to preserve the high reliability.

During the preparatory discussions, it became clear that in view of the huge work to be carried on during LS3 and to prevent coactivity incompatibility problems (Fig.10), LS2 has also to be seen as an opportunity to prepare LS3 in the LHC. Whenever possible, one should anticipate as much as possible HL-LHC activities from LS3.

As done for LS1, focusing on Radio Protection issues and ALARA procedures stays a priority and this workload shall be anticipated. Anticipating and/or preparing LS3

activities to LS2 would also be beneficial in terms of radioprotection.

The support activities will be on the critical path and coordination will be challenged, even more than during the LS1 which was following the main streamline of the SMACC (Superconducting Magnets And Circuits Consolidation) project. The LS2 activities should not compromise the LS3 preparation; this shall be constantly discussed with HL-LHC Coordination. The optimisation of resources across the Accelerators and Experiments will be THE key point of the LS2!

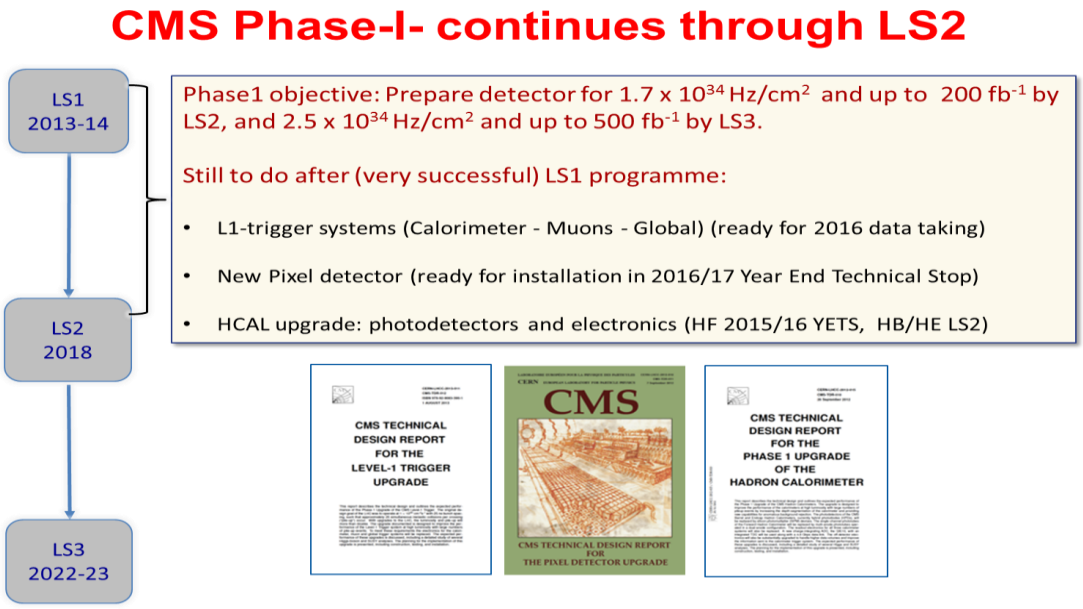

Figure 7: CMS upgrades Phase-I schedule.

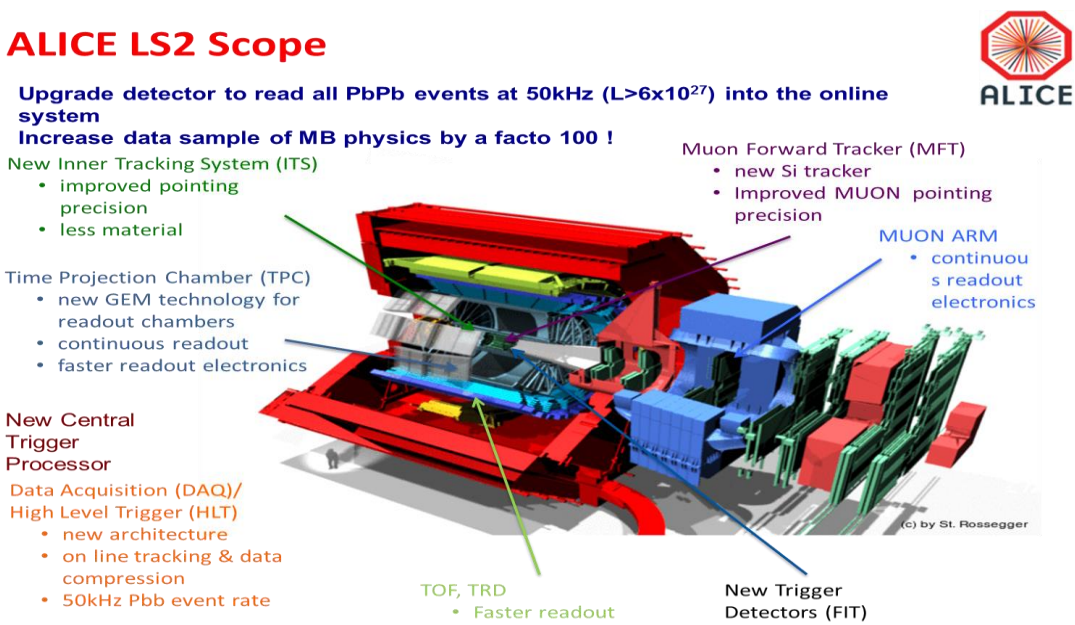

Figure 8: ALICE upgrades planed during LS2.

CLOSING REMARKS

The priorities of the LS2 Coordination will remain first towards Safety & Radiation readiness, with a careful evaluation of applicable rules, training, communication, temporary storages and waste management. The classification levels and dose rates will be of primary criticality as well as the advanced and proper estimation of temporary storages and waste's volume and weight. Draft information should get available by 2016.

The support to the Injectors (LIU) and to the LHC Experiments in order to allow them matching the "compressed" schedule will get followed-up with the corresponding Technical Coordinators.

The skeleton of the LS2 Master Schedule is already available since LIU and maintenances are well defined, using LS1 feedback (Fig.10). However, HL-LHC activities and Consolidations need to be reviewed and tuned. In particular, the prioritisation of Consolidations will need to be assessed in the frame of the available resources during the LS2 period, their impacts on other groups and coherence with LIU project. Even if the LS2 duration is estimated to 18 months, removing the warm-up, cool-down and tests phases, only between 9 and 13 months remain for activities on cryo-elements. (Fig. 10)

As done for the preparation of LS1, the collection and prioritization of activities will rely on an advanced version of "PLAN" tool which will represent the unique repository, useful source of information to exchange between groups. As happened for LS1, it will provide Groups with a clearer picture of the support to be given to other groups, helping to mitigate bad surprises. This will ease the prioritization process and will allow focusing only on discordances.

ACKNOWLEDGMENT

Many thanks to all speakers and to the contributors from all CERN Groups and also to the LHC Experiment Technical Coordinators for their helpful feedback.

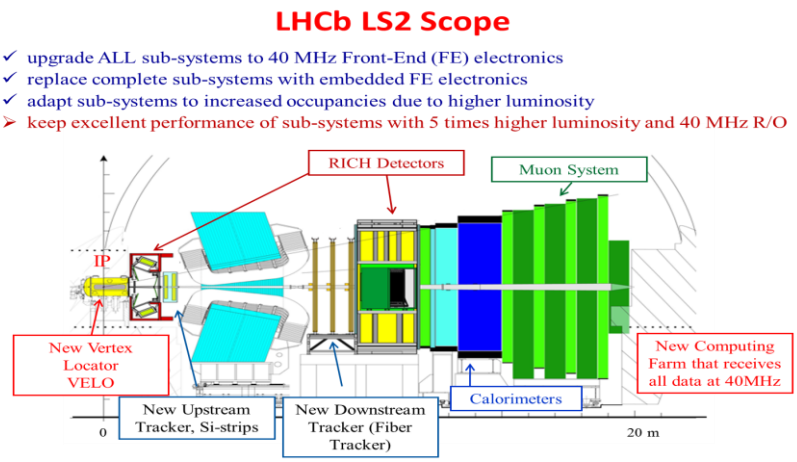

Figure 9: LHCb upgrades planed during LS2.

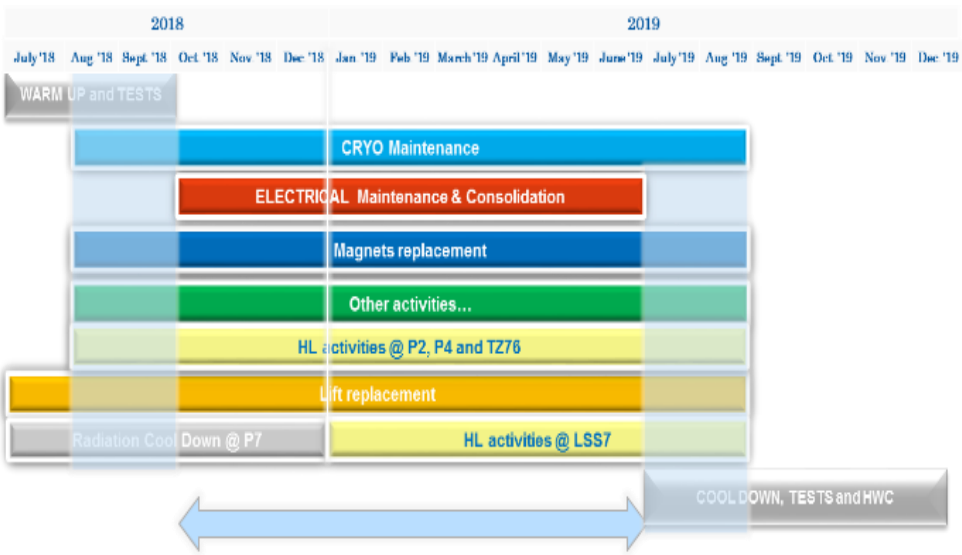

Figure 10: Skeleton of LS2 Master Schedule (indicative)