CERN/LHCC-2022-014
LHCC-151
September 2022

LARGE HADRON COLLIDER COMMITTEE

Preliminary Minutes of the one-hundred-and-fifty-first meeting held on

Wednesday and Thursday, 14-15 September 2022

OPEN SESSION – STATUS REPORTS

1. Status of the Accelerator: Andrea Calia
2. ALICE Status Report: Ante Bilandzic
3. ATLAS Status Report: Ten Jian Khoo
4. RD50 Status Report: Gianluigi Casse
5. RD51 Status Report: Maksym Titov
6. LHCb Status Report: Violaine Bellee
7. CMS Status report: Alex Tapper

CLOSED SESSION

Present: C. Biscarat, R. Calabrese, D. Calvo, G. Casini, F. Di Lodovico, I. Efthymiopoulos, C. Hearty, J.J. Hernández-Rey, T. Higuchi*, E.B. Holzer, A. Ianni, M. Krammer, M. Mangano, J. Mnich, F. Moortgat, L. Moneta (Scientific Secretary), J. Nagle*, S. Niccolai*, B. Panzer-Steindel, P. Salabura, F. Simon (Chairperson), B. Petersen, P. Wells.

Invited: A. Boehlein

Excused : A. Weber, E. Worcester

All sessions were held at CERN with some participants (*) connected remotely via Zoom.

1. Procedure

The chairperson welcomed the committee members and discussed general committee matters. The minutes of the previous session were already approved by email.

A proposal on the Forward Physics Facility (FPF), a large underground experimental facility, well shielded in the line of sight of the ATLAS interaction point, is being put forward. First informal discussions about the next steps with this proposal have taken place between the proponents and the LHCC chair.

- Given the scope of the proposed facility and the scientific overlap with projects that fall into the responsibility of other committees, **the LHCC proposes** to discuss the FPF together with other proposals, in an appropriate forum such as the Physics Beyond Colliders study group, prior to moving towards reviews by the scientific committees to ensure a comprehensive and aligned view of the strategy for CERN moving forward. Considering the implications for the long-term

scientific strategy and the future development of the CERN infrastructure, a discussion in the SPC may be appropriate to help define priorities prior to further steps.

2. Report from the LHC Programme Co-ordinator

The LPC reported on the successful start of the Run 3 physics run on July 5, where a media event was held. Since then, the number of bunches has gradually increased to 2461 bunches and the peak luminosity has increased to more than 1.8×10^{34} $cm^{-2}s^{-1}$ in ATLAS and CMS. Beta* leveling in ATLAS and CMS has been successfully deployed and is used to limit the pile-up in ATLAS and CMS to less than 52 events per crossing. The integrated luminosity has increased correspondingly with more than 10/fb delivered to ATLAS and CMS. The bulk of this was delivered during the first three weeks of August when the stable beam time exceeded 40%.

Some performance limitations have been revealed during the initial running in 2022. While operating at 6.8 TeV beam energy, 13 dipoles have undergone training quenches, each causing 8-12 hours of downtime. This is thought to be due to the higher magnet current compared to Run 2 and a small training campaign was carried out in the last weeks to minimize such training quenches in the future. A large number of "UFO"s (falling dust particles) have also occurred, particularly near magnets which were replaced during LS2. This has caused 23 beam dumps and one magnet quench so far, but the UFO rate is rapidly decreasing. Finally, the beam screens of the LHC have not yet been fully conditioned back to 2018 levels, leading to a larger heat load due to the e-cloud effect, particularly in some sectors. This is currently limiting the number of bunches and beam intensity that can be used in the LHC. The beam screens are expected to be a factor limiting the performance in both 2022 and 2023. One consideration is to switch to the "8b4e" filling schemes, where the e-cloud effect is mostly mitigated through the special bunch structure, however, this limits the number of bunches that can be used in the LHC.

On August 23, a PLC failure in the point 4 cryogenic plant led to a loss of cryogenics and a failure of some RF module's rupture disks. To recover from this incident, the RF cavities needed to be heated up to room temperature, purged, cooled down and reconditioned. This process is still ongoing at the time of the meeting and the recovery is expected to take about four weeks before beams can be injected again. In addition, CERN management has decided to reduce the 2022 run by two weeks due to the ongoing energy crisis in Europe. Further reductions of the running time in 2023 and beyond are also under consideration. The LPC has prepared several scenarios for optimal use of the remaining time in 2022 and beyond which are currently under discussion with CERN management and the LHC experiments. In all scenarios, the LHCf run is maintained in 2022 and the high beta* (90m) run has been postponed to 2023.

3. Report from the Director of Research and Computing

The Director of Research and Computing (DRC) reminded of the nice presentation by Andrea Calia in the Open Session, where he reported on the very good performance of LHC and on the incident that stopped the machine for 4 weeks. There is confidence the work is progressing very well and the machine should restart soon.

Major issues of concern are the consequences of the war in Ukraine on the CERN program. An indirect impact is the energy crisis in all of Europe. As a result of this, CERN needs to prepare for energy shortages in the host states this fall and this coming winter, and has to contribute to reducing the consumption of energy. In view of this 2022 running will be reduced by two weeks, with the concrete run plan still under discussion. It is also planned to reduce the running time next year by 4 weeks to reduce electricity consumption. These measures will be proposed to CERN Council at its next session.

A direct consequence of the war in Ukraine is the June Council decision to not automatically renew the International Collaboration Agreements (ICA) with Russia, Belarus and with JINR in 2024/2025. A positive outcome for CERN is that the collaboration with Russia in the LHC collaborations can continue for now, and the experiments can still rely on experts from these countries. However, this leads to prolonged uncertainty on the Phase-II contributions. Discussions with funding agencies and institutes are ongoing with the goal to make the Phase-II upgrade as much as possible independent from Russian and Belarusian contributions.

The definition of the author list for publications submitted after the start of the Russian invasion of Ukraine remains unresolved. Proposals are currently being discussed within the collaborations. The goal remains to reach a common solution for all experiments in the near future.

The start of Run 3 has been successful and the 10-year Higgs anniversary event received a lot of positive media attention in many countries and was also a great success. The inauguration of Science Gateway is now fixed for the 20th of June 2023, which is during the June 2023 Council week.

4. Test Beams

The SPS and PS Physics Coordinator presented the most recent Injector Schedule version 1.2 dated July 12th 2022. The changes with respect to the previous schedule are minimal and have no impact on overall physics time, and only a minor impact on individual test beam users.

The Accelerator Injector Schedule and the User Schedules need to be updated, following the decision to extend the 2022/2023 YETS by stopping the beams two weeks earlier that foreseen.

The PS East Area users have seen very good beam availability and high beam quality during all of the run this year.

The SPS North Area profited from a record performance during August and the first two weeks of September. The combination of a strongly reduced number of parallel activities in the SPS schedule and the absence of extended fault periods lead to a 30-40% higher duty cycle than in the preceding months. At the same time the challenging target beam intensities requested by the experiments were achieved consistently.

Two extended fault periods for the SPS NA occurred since the last LHCC, each stopping the beams for an accumulated period of about one week. The first one related to the electrostatic extraction septum and the second one to a vacuum failure of the beam instrumentation box of the T2 target. The LHC test beam users could compensate for the beam time lost.

A comparatively high number of User Schedule changes continues because of cancellations and additional beam time requests.

A study of the electron beam quality in the H8 beamline of the North Area has been performed beginning of September following a user cancellation. The **LHCC supports** these studies, noting that an improvement of electron beam quality in H8 will be beneficial for a large user community.

5. General Comments

The following comments are applicable to more than one project.

The Russian invasion of Ukraine continues to have a significant impact on all LHC experiments. The June 2022 decision of CERN Council to not automatically renew the ICAs with Russia and Belarus in 2024, and to review the ICA with JINR well in advance of its expiration in 2025 has alleviated the immediate threat of the loss of the technical workforce provided by Russian and Belarusian institutes and JINR for the operation and maintenance of the detectors. Nevertheless, there is a continued threat of a significant decline or complete end of Russian, Belarusian and JINR contributions to the LHC program also well before the expiration dates of the ICAs, depending on the evolution of the situation both geopolitically and at CERN. In view of the current situation, the LHCC reiterates key recommendations made in LHCC 150, with adjustments as appropriate:

- The **LHCC stresses** that a continued reliance on Russian, Belarusian and JINR contributions for the maintenance and operation of the experiments, for computing and for the Phase II upgrades is an unacceptably large risk for the overall scientific program. The **LHCC strongly urges** the funding agencies and institutes to decisively support the efforts of the experiments and CERN to reduce the reliance on Russian Belarusian and JINR contributions in all areas of the program as quickly as possible.
- The **LHCC re-iterates** its previous assessment that swift action, the injection of significant additional resources, and a high degree of flexibility on the part of the funding agencies and institutes is required to avoid an uncontrollably large schedule delay of the Phase II upgrades. Alternative sources for Russian, Belarusian and JINR deliverables, also for those nominally to be delivered prior to the expiration of the ICAs, need to be found without further delay, despite the fact that the ICAs remain in force for the time being.
- The **LHCC supports** the decision of WLCG and the experiments to consider the computing resources offered by Russian sites as opportunistic only going forward. The **LHCC underlines** that a shortfall of resources in Run 3 is an issue that jeopardizes the overall scientific output of the LHC program. Efforts across experiment boundaries are required by funding agencies and institutes to resolve this; the most critical area being the storage of the raw data on tapes.
- The **LHCC commends** CERN management and the experiments for their significant efforts in developing strategies to enable continuing success of the scientific program in these exceedingly difficult circumstances.

Several experiments have reported difficulties in covering on-site shift slots, in particular after the summer break. Reduction in travel budgets, as well as an increased reluctance to travel have been identified as main reason. Often, shortfalls have to be covered by individuals located in the Geneva area, which already had to bear a very high load during the years of the pandemic.

- The **LHCC notes** that adequate coverage of experiment operation shifts is of paramount importance for the safe operation of the experiments and for successful data taking. The **LHCC urges** the institutes to encourage their members to fulfil their shift duties and to prioritize travel for shifts, and **encourages** funding agencies to provide the required resources.
- The **LHCC encourages** the experiments investigate possibilities of increasing the robustness of shift coverage, including the possibility of merging shifter positions and covering more shift duties remotely. The LHCC notes that maintaining a sufficient level of on-site shifts is critical to ensure safety and operational stability, and that it is essential that all collaboration institutes contribute to local shifts at CERN in a fair manner.

Procurement of components and materials for the Phase II upgrades is increasingly challenging. CERN procurement is of central importance, and the collaborations and the LHCC share the impression that it is providing the best possible service, which is important to be maintained. One recent area of concern was the procurement of carbon foam, where a solution now appears probable. A coherent communication with suppliers, and the combination of requests of institutes and collaborations to present a complete picture of the requirements to the suppliers rather than asynchronous piece-meal orders from many different institutes is essential.

- The **LHCC encourages** the collaborations to develop a coherent view of items that are required by both ATLAS and CMS, and, where applicable, across different institutes, to be able to present manufacturers and suppliers with a clear picture of the total volume and of the time profile at which these are required. This coordination should be applied generally to items with difficult procurement and delivery scenarios.
- **The LHCC recommends** that the CERN procurement service is maintained at its present high level to avoid additional delays stemming from the increasingly demanding procurement process.

6. Discussion with ALICE

Scientific output and current activities:

- ALICE continues to have a rich scientific output, with 9 papers submitted since the last session of the LHCC, bringing the total number of publications to 400. Excellent new results have been presented at the ICHEP 2022 conference. Recent results cover a very broad physics output, not only focusing on quark-gluon plasma studies. They include studies of three-body interaction for p-p-p and p-p-Λ, measurement of charm-quark splitting function, studies of neutron emission in

ultraperipheral collisions, and collective flow studies in Pb-Pb collisions.

- ALICE has collected first proton-proton collisions at 13.6 TeV. The integrated delivered luminosity to ALICE is 9.4 pb^{-1}, the running has been stable at a p-p rate of 500KHz, and good quality data have been recorded. The experiment is preparing for the heavy ion run by performing rate scans up to 5 MHz to ensure a stable operation of the detector at the particle densities expected with heavy ions. Some short runs with a higher p-p rate have been already performed, with more to come in the coming weeks. Overall, the ALICE commissioning is on track with respect to the original LHC schedule for 2022, with a heavy ion run later this year. ALICE is then well underway for an exciting physics program in Run 3.
- An in-depth review session focusing on an "after action review" of LS2 and Phase I upgrade activities has taken place. The LS2 activities have been completed successfully with all upgraded detector systems installed on time, representing a great accomplishment of the whole ALICE team. An excellent safety record has been achieved with no work-related injury during LS2. In the area of the detector upgrades, several lessons have been learned following challenges encountered, such as administrative issues with electronics production, expected performance of GEM detectors in the TPC based on measurements made under conditions different from those in actual operations, and production techniques not sufficiently developed in industry for the required large scales and areas. Firmware programming has been recognized as a key issue, suffering from an insufficient number of experts, insufficient continuity of the development teams, and difficult career paths for the required expert profiles. The decision to continue using the legacy readout systems on some detectors rather than upgrading all detectors to new standards may result in increased effort for integration and maintenance. For the O2 system a number of technical challenges were encountered and some lessons learnt, such as the significant effort associated with the switch to a new software framework, and the impact of re-writing software elements from scratch rather than porting existing code with minimal updates into the new framework. Overall, it is noted that the O2 development work placed a high burden on a small number experts since developers with experience in parallel processing and GPU programming are scarce. Having a reference system available for testing early on was essential, but it is recognized that more effort should be made to have it as complete as possible, including also elements such as DCS.

Phase-I upgrades:

- The ITS3 upgrade for Run 4 is making excellent progress, with impressive R&D results achieved and significant progress made on the electro-mechanical integration of the system. The collaboration is planning to submit the TDR in Q4/2023. This submission time is driven by the stitched sensor tests, a key ingredient to demonstrate the technical feasibility of the project.
- The FoCal upgrade for Run 4 had a successful test beam in June at the PS. ALICE presented a clear set of milestones towards the TDR, which is expected in the third quarter of 2023, with a possible preview in March 2023. Funding scenarios are under development and require further work and coordination to achieve satisfactory coverage. Studies of possible extensions of the FoCAL physics

program by including forward jets are underway.

Future upgrade plans:

- ALICE-3 R&D is underway, and the overall scope and necessary resources are being mapped out. Discussions with funding agencies regarding the full cost and scope of ALICE-3 have been initiated, and will continue at the October ALICE Phase-IIB RRB session. A scoping document is in preparation, with submission expected by the end of summer 2023.

- ALICE continues to make excellent progress on its physics program. The **LHCC commends** the collaboration for its continued physics output with 9 new papers submitted since the last meeting. The results are of high impact and demonstrate a very broad physics program.
- The **LHCC congratulates** the ALICE collaboration on the perfect safety record during LS2, with no work-related injuries occurring.
- The **LHCC congratulates** the ALICE collaboration for recording first collisions of p-p at 13.6 TeV.
- The **LHCC notes** the importance of the next SPS test beam for FoCal where results are critical for the TDR preparation.

7. Discussion with ATLAS

Scientific output and current activities:

- ATLAS continues to make excellent progress on its physics programme, with 1081 papers on collision data submitted to date, of which 157 use the full Run 2 data set. 28 new results have been presented at the ICHEP 2022 conference and the Higgs 10-year symposium at CERN. The exciting new results presented include several Higgs measurements, which has been published in Nature, studies of di-Higgs production, a new Higgs mass measurement from the 4 leptons final state, the first observation of simultaneous production of longitudinally polarised W and Z bosons, and the observation of a four-muon excess compatible with a tetraquark decaying to di-charmonium. Overall, there is a large effort to speed up the remaining Run 2 analyses to reduce the backlog in view of upcoming Run 3 analyses.
- Analysis of Run 3 data is under way, and the first Run 3 MC campaign has been completed. This should fulfil the needs for 2022 data, but an updated campaign to prepare for 2023 may be required.
- ATLAS has had a very successful restart of data taking in Run 3, observing the first collisions at 13.6 TeV on July 5th. Overall, 10.4 fb^{-1} have been recorded by the experiment with 11.1 fb^{-1} delivered by LHC. After an initial ramp-up phase, the cumulative recording efficiency as a function of integrated luminosity soon reached that of 2018 with further increases expected as data taking resumes.
- Reduced high voltage stability has been observed in a significant number of RPCs, which could be improved with a dedicated treatment with Argon. Some other detector issues, such as leaks in the TRT front-end electronic cooling system

and problems in the LV distribution of the NSW still need more investigation to evaluate their final impact and to decide on appropriate corrective measures.

- ATLAS experienced some difficulty in filling all the shifts, as discussed further in the general section of these minutes.
- Planning of activities and resources in the area related to the trigger such as trigger menu composition, L1 and HLT trigger commissioning, HLT at Point 1, luminosity and beam spot determination are all instrumental to achieving the Run 3 physics goals.

Phase-I upgrades:

- The different subdetectors and their legacy systems are working properly and the pace at which the new upgraded detectors and systems are being commissioned is remarkable. The goal of having them fully operational between the end of this year and next year is clearly at hand.

Phase-II upgrades:

- Following the Baseline Change Proposal earlier this year, some additional float has been generated in key Phase II projects due to internal schedule optimisation. Nevertheless, the schedule is still very tight and the number of issues that require attention is high. The coming months will be particularly demanding, and are expected to see significant burn of schedule contingency.
- An ATLAS-internal review process for a possible HL-LHC forward physics program and the associated detector systems has been set up, with a decision on the project by the ATLAS EB planned for early October to provide the required input on the machine optics for the October 18 HL-LHC Coordination Group meeting. A convergence on a single system of both ATLAS and CMS is seen as impossible due to the strong involvement of the participating groups in other aspects of the ATLAS experiment, but an exchange on technologies is now under way to exploit synergies between the projects.
- It is observed that the procurement process is becoming increasingly difficult for many components. Concerns have arisen over special materials such as carbon foam, which is also required by CMS. A successful resolution appears possible, with recommendations based on lessons learned discussed in the general section of these minutes.

- The **LHCC congratulates** the ATLAS collaboration on the continuous physics output using Run 2 data and the fast progress towards first Run 3 analysis results. The **LHCC encourages** ATLAS to further speed up Run 2 analyses to avoid clashing with Run 3 needs.
- The **LHCC fully supports** the measures that are being taken by ATLAS to tackle the problems experienced in a few systems, such as the leaks in the RPC gas system, the leak in the TRT cooling system and the problems in the LV distribution of the NSW, whose extent, impact and possible fixes have to be investigated in further detail.

- **LHCC congratulates** ATLAS on the impressive performance of the detector during the start of Run 3 and the good progress with the trigger system and luminosity and beam spot determination.
- **LHCC appreciates** seeing that a clear process to review internally the possibility of a forward detection system for Phase II has been set up and a panel to evaluate the proposal nominated. The **LHCC endorses** the scope of the Initial Design Review, based on which the decisions will be taken. The LHCC **takes note** that a single common forward physics project of ATLAS and CMS appears unlikely to be implemented, and **encourages** continued discussions to exploit physics and technological synergies.

8. Discussion with CMS

Scientific output and current activities:

- CMS continues to make excellent progress on its physics programme, with 1159 papers on collider data submitted to date, including 26 since the last LHCC. Recent results include new Higgs measurements published in Nature, the search for the $H \to cc$ decay using a new charm tagging techniques based on Graph Neural Networks, a new $B_s^0 \to \mu^+\mu^-$ branching-ratio measurement using the full Run 2 data, as well as the most precise measurement of the B_s^0 lifetime. The new results have been presented at the ICHEP conference and the Higgs 10-year symposium. With the top quark pair production cross section at 13.6 TeV, a first preliminary Run 3 result has been released for the recent TOP2022 conference. Significant efforts are under way to make a precise measurement of the W mass with Run 2 data. The detailed discussion of the analysis plans and the challenges associated with this measurement was appreciated by the committee.
- CMS has had a successful start-up of Run 3. LHC has delivered a luminosity of 10.8 fb^{-1} and 9.74 fb^{-1} have been collected by CMS. The overall performance of the detectors has been good with only some minor issues.
- The coverage of shifts has been good in August, but it has been difficult during September and there are significant concerns for the future. Recommendations are discussed in the general section of these minutes.
- The CF4 gas supply has recovered with the identification of new suppliers. There is now enough gas available for 2022 run, but significant price variability is observed. The current supplier is unable to deliver sufficient amounts over the longer term, so the ongoing negotiations between CERN and alternative suppliers are strongly supported.
- The New Forward Shielding has seen delays due to financial-administrative reasons but delivery in time is still expected.

Phase-II upgrades:

- The Phase-II activities are making good progress with some float reductions in the outer and inner tracker, partially driven by external sources, such as the delays in the RD53 ASIC submission noted in the corresponding section of these minutes. The June Council decisions on the international collaboration

agreements has created additional uncertainty and the collaboration is working to develop alternatives.

- To reduce the cost, the proposed Phase II PPS is moving towards re-using existing roman pots. The physics impact has been studied and it has been found to be negligible. The discussions with the machine are ongoing with the goal of finalizing the required modifications and establishing the associated costs. Exchanges with ATLAS have taken place and are continuing, but the convergence on a single project appears to be not possible.
- Significant challenges have been encountered with the procurement of K9 carbon foam, which is also required by ATLAS. A successful resolution appears now likely, with recommendations based on lessons learned discussed in the general section of these minutes.

- The **LHCC congratulates** CMS on the successful start of the run and for the steady outpour of physics results and publications, in particular on the first preliminary Run 3 result.
- The **LHCC notes** that the CF4 issue has been solved for the time being. Given the very large environmental impact of CF4, the **LHCC recommends** completing the investigation to find the minimum amount of gas necessary to run the detector, and to adjust operations accordingly.
- The **LHCC shares** the concerns of CMS regarding the further delays on RD53. See RD53 report for more details.
- The **LHCC acknowledges** the progress of the proposed PPS2 project in the area of performance estimates and the ongoing TREX discussions. The cost-impact on the accelerator still is to be established as part of these discussions. The **LHCC takes note** that a single common forward physics project of ATLAS and CMS appears unlikely to be implemented, and **encourages** continued discussions to exploit physics and technological synergies.

9. Discussion with LHCb

Scientific output and current activities:

- LHCb continues to deliver high quality physics results, with a total of 627 publications to date, including 12 new papers since the last session of the LHCC. New results include the study of direct CP violation in charm, a model independent measurement of charm mixing parameters as well as multi-differential study of charged hadron distributions in Z-tagged jets and preliminary results on doubly charged tetraquarks and pentaquark decaying to $J/\psi\ \Lambda$.
- LHCb has had a successful start of Run-3, taking extremely useful data for detector and software commissioning. All detectors, excluding the Upstream tracker (UT), have been included in the global data taking and have performed a coarse time alignment. LHCb is ready to close the VELO for the first time, which will then enable tracking in the trigger system. The DAQ has been working up to 28MHz, reaching almost its target of 30 MHz. The GPU HLT trigger has shown a lower-than-expected throughput performance, which is not an immediate concern for near-future data taking and investigations are ongoing. An effort will be made to improve the throughput by software measures. The addition of a second GPU per event builder would improve throughput and enable triggers on

more complex final states.

Phase-I upgrades:

- The UT assembly has been completed for the C-side of the detector and the gained experience is beneficial for the future remaining installation in the coming YETS. There are some remaining issues with the installed staves, an electro-mechanical problem with the connectors and an increased error rate in the first installed stave when it is cooled to the operating point. Both issues are under study to understand the cause and possible future risks. At this point they do not represent a relevant degradation of detector efficiency that would require interventions. The goal is to install the remaining staves at a rate of 5/week, finishing in early December. Good progress on preparations for UT installation in the coming YETS. The UT organization has been strengthened in key areas with further personnel added on several management levels, also extending to the UT plans for Upgrade II.

Future upgrade plans:

- A planning group has been formed for Upgrade II to oversee the next steps, including the preparation of TDRs for projects to be installed in LS3.

- The **LHCC congratulates** the LHCb collaboration on the strong progress on commissioning and **notes** that continued stable pp beams are critical for the next steps, including VELO closing.
- The **LHCC congratulates** LHCb on the continued strong physics output and **notes** the widespread recognition of LHCb's leading role in the exploration of exotic states.
- The **LHCC is pleased** to see the completed assembly of the first half of the UT and **looks forward to** continued progress and an updated schedule at the next meeting. The **LHCC appreciates** the strengthening of the UT management structure, which is seen as an important ingredient for the successful completion of the project and for preparations for future upgrades.

10. Discussion with WLCG

The WLCG activities never stopped during the LS2 and the infrastructure kept operating efficiently and has continued doing it by supporting the computing activities of the experiments with the start of Run 3.

The experiments are in data-taking mode. They fully utilise the available resources, including the HLT. The management of the storage space is well taken care of. ATLAS and CMS already provided event samples for early analysis. ALICE and LHCb are still in the commissioning phase.

Russia continues to provide computing resources to the experiments that are efficiently used, but the future availability of these resources remains unpredictable. Such resources are now considered opportunistic.

The hardware costs are now at the pre-COVID, early 2020 level, removing the expected 15% gain/year over the last two years. The delivery time of hardware is still strongly affected by the problem in the supply chain, especially for network equipment, which might require up to 1 year and cause delays in the deployment of already available resources such as CPU and disk. Fortunately, the sites started the procurements early enough to have the 2023 capacity in place. Furthermore, in some countries, the electricity cost increase may add difficulties in purchasing hardware at the requested level in the future. No immediate solution exists for all these problems, but each party concerned is doing their best. The careful use of the resources and adiabatic improvement in their usage is certainly a mitigating factor.

Any reduction in the physics running time of the LHC will impact the computing resource needed.

The common software bodies are very active, and many new developments have been presented. Those have shown to have a direct impact on the improvement of the experiment's software stack, such as new release versions provided by ROOT.

- The **LHCC commends** the WLCG, the experiments and the sites for the success in operating efficiently during LS2 and data taking for Run 3 operations.
- The grid activities such as network transfers and CPU consumption are increasing, though, as expected, not yet at the pace expected during the run-3 data taking years. The **LHCC is confident** that the infrastructure is ready for the full data taking years of run 3.
- The **LHCC supports** the continuous efforts put into the modernisation of the infrastructure, along with the HL-LHC Software and Computing review recommendations, and **is glad** about the continuous improvements obtained by the experiments, such as a 10% gain in the CMS raw size, by using a new compression algorithm provided by the ROOT software.
- The WLCG common software liaisons presented a large panel of activities organised by different communities towards attracting young people and knowledge sharing. Those activities cover training, mentorship or the organisation of dedicated workshops. The **LHCC strongly supports** those initiatives, believing it is an asset to improve skills and trigger collaborative work.
- The war in Ukraine is continuing. The situation regarding the delivery of Russian resources to the experiments did not evolve since the last LHCC meeting and the experiments now consider the resources provided Russian sites as opportunistic. The **LHCC is perfectly in line** with this decision. With the uncertainty of the evolution of the geopolitical situation, the experiments have to be prepared to lose access to these resources at any moment.

11. Report on FASER

FRASER has taken data throughout Run 3, with more than 10 fb^{-1} collected with a data taking efficiency above 99%, and no major issues have been encountered. Trigger rates of particles from IP1 were measured to be ~20% higher than simulation (0.5Hz/cm^2, vs 0.6Hz/cm^2, when scaled to a reference luminosity L_{ref} = $2x10^{34}cm^{-2}s^{-1}$). The overall trigger rate (1.4kHz at L_{ref}, following positioning of the LHC collimators)

is nearly a factor of two higher than pre-collision expectations. This is dominated by beam backgrounds and single scintillator triggers. The higher rate is not a concern for operations with the maximum trigger deadtime at less than 2%. The beam background events can be effectively mitigated in offline analysis using the signal timing and topology.

All aspects of detector performance and operations are satisfactory. Two glitches in the tunnel air temperature have been detected: one due to the rest of the AC system following a power cut, the second is under investigation. The mock data challenge framework, developed in preparation for the run, is now integrating real data, providing also the baseline for automatic data processing, alignment, calibrations, etc. Processing of data collected before the August interruption is ongoing, and first physics results are expected for 2023. CPU and data storage resources are in line with the needs.

The FASERnu box was replaced on June 26, in less than 4 hours, and again on September 14, both as planned, with the detectors exposed to 0.5/fb and 10.5/fb of data respectively. FASER confirms the success of operations at the refurbished emulsion facility, and the cooperation with SND@LHC. The first batch of emulsions was developed and first module was read out. The track density is consistent with FLUKA expectations.

The pre-shower project is progressing well, with a few challenges. Tests of the pre-production ASICs are in progress, with 2 out of the 3 versions of the chips delivered working well.

12. Report on MoEDAL

The MoEDAL installation plan has been approved by LHCb. Final drawings and installation documentation is being completed, for submission to LHCb. The installation schedule has been coordinated with LHCb, covering steps during TS1, TS2 and the YETS. TS1 would cover the mounting of new tilted wall mounts for the nuclear track detectors (NTDs), and the installation of transverse magnetic monopole trapping detectors (MMTs). TS2 will enable the mounting of a temporary VELO-top NTD and of the forward MMTs (pending a decision on the use of rollers for a prompt displacement to give access to LHCb's PLUME detector). All NTDs will be deployed with plastics for the running following TS2. The installation of the permanent structure for the VELO-top and for the TPX detectors is foreseen for the YETS, to achieve a complete detector by the start of the 2023 run. For what concerns the MAPP detector: three crates of scintillator bars, PMT's and cabling have been delivered at CERN, and should allow to complete installation of about 300 bars, out of the total of 400, during TS1. The others should follow during TS2 and the YETS, when also the muon veto detectors would be put in place.

13. Report on SND

SND had a successful start of Run3, with 10.9 fb^{-1} collected with greater than 95% running efficiency. Backgrounds from particle interactions in machine elements have been observed, with the highest rates at the beginning of fills, which however do not have an impact on the physics performance. A first small batch of exposed emulsions,

extracted in July, has been developed and is being analyzed, with first results showing a track density consistent with the measurements of the active tracking detectors.

The operation of the detector has been generally smooth and successful. The concerns at the previous meeting over the delivery of emulsions have been resolved, with a batch of emulsions delivered to CERN from Russia. The remaining emulsions required for 2022 have been delivered by Nagoya University, which can fully cover future requirements, making SND independent of emulsion delivery from Russia. The replacement of emulsions has been carried out successfully, and well within the time budgeted. Smaller detector issues have been encountered, such as a short circuit on one SiPM HV board in the calorimeter, and a water leak in a cooling manifold. These problems have been resolved by repairs and spares installed during brief accesses.

The refurbished emulsion facility is operated in collaboration with FASERnu, and the temporary underground storage space for assembled emulsion bricks near AWAKE has been successfully used.

- The **LHCC congratulates** SND on the successful start of the physics run.
- The **LHCC is pleased** to see the successful resolution of the issues surrounding the emulsion supply for the 2022 run, and commends SND for establishing a long-term solution for Run 3 that does not require a Russian vendor.
- The **LHCC is concerned** by the unexpected failure of a a component on a calorimeter PCB, and encourages SND to study if this may represent a general weakness of the used device which could lead to further failures in the future.
- The **LHCC congratulates** SND, FASERnu and CERN on the excellent progress in the renovation of the Emulsion Facility.

14. Report on LHCf

LHCf confirms its readiness to collect data during a dedicated special run in 2022, and underscores the difficulties it would meet if the run were postponed to 2023.

The **LHCC is pleased to note** that the run remains scheduled as foreseen, to be followed by a calibration run in the North Area.

15. Report on TOTEM

A reduced efficiency with the pixel detectors of two horizontal roman pots has been detected, possibly due to mechanical stresses. The two detector packages have been removed, refurbished, and are now newly installed in the roman pots. The vertical roman pots are ok. The full system integration for T2 has led to a small delay in the commissioning of the firmware, but the detector would be ready for a run after TS2 in 2022. In view of the ongoing rescheduling of special runs, TOTEM requires to complete data taking in 2023, since M&O resources are not planned to be available beyond that.

16. Report on RD50

The RD50 collaboration reported on their progress within their 5-year work plan approved by the CERN Research Board in June 2018 and extending up to the end of 2023. 60% of the milestones of the proposal are now achieved, 20% are currently in progress and 20% are still to be done. All work packages have achieved important new results, many of which were presented to the LHCC.

RD50 is a very active collaboration serving as a central forum for experts from all experiments. The main topics continue to be the study of radiation damage in silicon, extreme timing applications, and more generally new structures for LGADs, 3D and CMOS, which are gaining in importance, and new materials.

The RD50 model of collaboration between institutes and industry works remarkably well even with minimal funding (2kCHF/year per institute). RD50 requests continued support by CERN as in the previous years, with personnel, administrative support and access to CERN and EP-DT facilities.

- The **LHCC congratulates** the RD50 collaboration on the progress made in all work packages and on the new results obtained.
- The **LHCC recommends** continuing the support for RD50, and **notes** that the CERN contribution in terms of both person power and access to facilities is crucial for the collaboration.

17. Report on RD51

The RD51 collaboration is dedicated to the study of micro-pattern gaseous detectors. The collaboration has a wide range of activities, some of which are of central importance for the recently installed LHC detectors. Some activities, such as the R&D on MPGDs are receiving attention also in view of the detector development for the future Elector-Ion Collider. In general, RD51 has a very visible role in training and dissemination, as well as community-building in the area of gaseous detectors.

RD51 operates common facilities at CERN that enables the community to undertake research in this area: the Gaseous Detectors Development (GDD) laboratory and a semi-permanent setup at the SPS H4 test beamline. The collaboration requests continued support by CERN on the current level on these facilities as well as access to CERN facilities such as the Micro-Pattern Technologies workshop and Thin Film and Glass Laboratory, access to computing resources for modelling and simulation tools and general office space and administrative support.

- The **LHCC congratulates** RD51 on the progress made in all areas and on the new results obtained.
- The **LHCC recommends** continuing the support for RD51, and **notes** that the CERN contribution in terms of both person power and access to facilities is crucial for the collaboration.

18. Report on RD53

RD53 collaboration plays a crucial and critical role in the chip design, development and testing for the Phase-II pixel detectors, and in making its production version available on time to ATLAS and CMS. The RD53 developed chip is very complex with more than 500M transistors and extreme radiation hardness requirements. Good progress has been made in the final design, but a significant number of issues that still need to be fixed prior to the submission of the final production ASICs has also been identified.

A key challenge in the current phase is the chip verification and testing. The availability of people with a good knowledge of the chip architecture and experts in running extensive verifications of the chips before the submission is a crucial point. These people are rare to find in our field because they are attracted by industries which offer better conditions.

With respect to the previous schedule discussed in June 2021, the RD53C chips, which represent the final production versions for ATLAS and CMS, are experiencing 9-12 months of delay in submissions, mainly due to the loss of key designers and verification specialists and to some new issues found during verification.

The CERN contribution is crucial to RD53, particularly in the last period, and should be continued. The full support for RD53 by all parties involved all the way through the final submissions remains of paramount importance. Even with the strong additional support provided by CERN, only 80% of the full chip has been verified, creating a non-negligible risk for the first submission of the ATLAS chip for November 2022.

- The **LHCC recalls** that a successful completion of the RD53C ASICs is of utmost importance for the Phase II pixel detectors of ATLAS and CMS.
- The **LHCC is concerned** by the loss of key personnel in RD53 in the critical phase leading up to the final submissions, and **urges** RD53 and its member institutes to make all possible efforts to maintain the full team throughout the entire project duration.
- The **LHCC commends** CERN for the strong support of RD53, noting that essentially all recent departures in the collaboration have been compensated by additional personnel injected by CERN. The **LHCC notes** that it is important to maintain a balance between support for RD53 and other critical ASIC projects that also rely on CERN-ESE support.
- The **LHCC urges** the RD53 collaboration to concentrate all effort on the final submissions of the ATLAS and CMS ASICs. Plans for future developments should be developed outside of RD53, in the framework of the implementation of the ECFA detector R&D roadmap.

19. General Comments on RD Collaborations

A discussion on the implementation of the ECFA Detector R&D Roadmap has been held with RD50 and RD51. While the following comments are primarily in the context of these two collaborations, they are generally relevant for all RD collaborations.

RD50 and RD51 have expressed concerns about the transition process towards new DRD collaborations to be established in the course of the implementation of the ECFA Detector R&D roadmap. The proposed timeline, with new collaborations established by the beginning of 2024 is seen as very ambitious. The expiration of existing MoUs before the new schemes are fully operational is a significant concern, since this may impact the continuity of common funds, running projects and existing contracts. Concerns are also expressed about the size and scope of the new collaborations, which each should cover the full topics of one of the task forces in the roadmap process, and may result in larger administrative overhead inside of the collaboration, and possibly reduced coherence of the research program.

- The **LHCC recognizes** the concerns expressed by RD50 and RD51 on the implementation of the ECFA Detector R&D Roadmap, but also notes that a timely implementation is important for the R&D landscape in Europe leading up to the next update of the European Strategy for Particle Physics.
- The **LHCC identifies** as a key strength of both RD50 and RD51 the scheme of a modest common fund supplied by collaboration contributions of each institute, which supports common R&D activities which in turn leverage own contributions of the institutes and of the funding agencies. The **LHCC recommends** that continuity in this area is maintained in the transition period, to ensure that investments made in common funds and common projects by the current member institutes remain accessible and usable also beyond the transition to the new structure.
- The **LHCC notes** that for the R&D community to be able to deliver proposals on the time scale envisioned, the scope of the proposals will need to be defined and communicated in the near future, before the end of 2022. The level of detail required needs to be appropriate to the level of information on resources available and the level of planning and community building achievable in the time available. In the definition of the scope of the proposals the existing R&D collaborations should be involved, together with the ECFA task force conveners and other stakeholders.
- The **LHCC supports** the transition of the reviewing of R&D activities from the LHCC to a new, dedicated committee, and suggests that the RD review in 2023 is organized as a common review by the LHCC and the new panel. In view of this, the **LHCC does not foresee to request** proposals for a possible extension of the existing RD collaborations beyond 2023.

REFEREES

The LHCC referee teams for this session are as follows:

ALICE: D. Calvo, G. Casini, J. Nagle (Co-ordinator), P. Salabura
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R&D projects:
RD50: D. Calvo
RD51: C. Hearty
RD53: R. Calabrese

The LHCC received the following documents:

CERN/LHCC-2022-011	Minutes of the one hundred and fiftieth meeting of the LHCC held on 1-2 June 2022

DATES FOR LHCC MEETINGS

Dates for 2022
30 November-1 December

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