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LHCC-143
September 2020

LARGE HADRON COLLIDER COMMITTEE

Minutes of the one-hundred-and-forty-third meeting held on

Wednesday and Thursday, 2-3 September 2020

OPEN SESSION – STATUS REPORTS

1. LHC Machine Status Report: Jose Miguel Jimenez
2. ALICE Status Report: Oton Vazquez Doce
3. ATLAS Status Report: Carl Gwilliam
4. CMS Status Report: Kai-Feng Chen
5. LHCb Status Report: Alison Tully
6. RD42 Status Report: William Trischuk
7. RD50 Status Report: Gianluigi Casse
8. RD51 Status Report: Eraldo Olivieri
9. RD53 Status Report: Tomasz Hemperek

CLOSED SESSION:

Present: H. Burkhardt, C. Biscarat, G. Casini, R. Calabrese, F. Di Lodovico, J. Dunlop, E. Elsen, C. Hearty, E. Kajfasz, M. Krammer, K. Krüger, M. Kuze, M. Mangano, F. Moortgat, P. Pakhlov, B. Panzer-Steindel, P. Salabura, C. Sfienti, F. Simon (Chairperson), B. Petersen, S. Smith, D. Waters, A. Weber, T. Wengler (Scientific Secretary), H. Wilkens, W. Wisniewski, E. Worcester

Due to the COVID-19 pandemic, all sessions were held via videoconference.

1. Procedure

The chairperson welcomed the committee members. The minutes of the previous session were already approved by email. The chair welcomed Alfons Weber (Oxford) to the committee as a new member, who will join the CMS referee team. The chair reminded the committee of ongoing activities, including the UCG review of the ATLAS HGTD TDR and the MoEDAL Technical Proposal, as well as discussions of plans for a high energy pp programme in ALICE and the EoI for a forward physics programme during HL-LHC at P5. The chair then updated the committee on the latest developments regarding the proposal for a neutrino/dark sector experiment at TI-18. An updated LoI has been submitted on the Monday of the present LHCC session week by SND, which is now regarded as a dedicated experiment proposal with its own collaboration by the proponents. This collaboration is currently formed primarily by groups from the SHiP collaboration, and also includes members of the XSEN proposal that was suggested for the same position in the tunnel. In the discussion, it was concluded that, given the current

status of the approval process, an installation of the experiment in LS2 and subsequent data taking in Run 3 is seen as unlikely by the committee. The **LHCC asks** the proponents to clarify and document the extent of the required infrastructure and installation work. Given the complex history of this project, the **LHCC requests** that a realistic timeline for the project, in particular for the installation, be established and discussed with the Director of Research and Computing before committing to a review of the proposal.

2. Report from the Director of Research and Computing

The Director of Research and Computing (DRC) reported on issues related to the European Strategy process, the LHC and CERN in general. All experiments have reported a wealth of excellent new physics results in recent months despite the impact of the COVID-19 pandemic, for which they should be congratulated. However, the pandemic and the measures at CERN and elsewhere it made necessary clearly have slowed progress everywhere in the LS2 work. Present indications from discussions with all experiments are that the current LS2 baseline plan with a closing of the experimental areas in February 2022, and a short pilot run in September 2021, is feasible. The ramp-up at CERN is continuing, with now around 2/3 of pre-COVID-19 number of personnel on site every day. The health and safety measures are well respected, as is evident from the low number of infection incidents at CERN, giving confidence that the current ramp-up strategy can be maintained. The DRC also reported that the discussions on the open data policy are now very advanced and will be finalised soon.

3. Report from the LHC Programme Co-ordinator

At the LS2 and Run 3 scheduling meeting on June 8th, it was decided to move the start of Run 3 to February 1st, 2022. This should allow the completion of all Phase-I detector upgrades despite COVID-19 related delays and the training of the LHC magnets to the highest possible energy. A one-week beam test is foreseen for October 2021 in order to perform a basic test of the upgraded machine components before the start of Run 3. The schedule maintains a high number of physics days and is expected to at least double the integrated pp luminosity. The Run 3 schedule will be reassessed on October 23rd when the impact of COVID-19 related delays on the experiments will have been re-evaluated.

Machine experts have updated the luminosity projections for PbPb and pPb running in Run 3. The default bunch spacing for Run 3 is 50 ns which should be feasible after the commissioning of slip-stacking in the SPS during 2021. This will provide improved luminosity to all experiments compared to the 2018 conditions. A total of five one-month PbPb periods and two one-month pPb periods are needed during Run 3+4 to satisfy the luminosity requests from the experiments. Some time will need to be allocated to record matching pp data. Depending on the maximum allowed pile-up, this is foreseen to take up to a week out of each ion period.

The planning of special runs for Run 3 is proceeding. New preliminary high β^* optics have been prepared for a possible 14 TeV elastic pp run and are under study by the TOTEM and ATLAS/ALFA experts. An OO and pO run is currently not included in the MTP, but the resources to conclude the planning for a future injection of oxygen beams into the injector chain are being sought, but not yet fully allocated. These studies need to be concluded by the end of 2022 if an oxygen run were to take place during Run 3. It

was noted that LHCf will not be available after Run 3 which would significantly diminish the scientific value of a pO run for the cosmic ray community.

- The **LHCC takes note** of the updated Run 3 schedule and **recommends** that the preparatory oxygen injector studies be completed as Run 3 would be the optimal time for OO and pO measurements in the LHC.

4. Test Beams

The updated draft of the injector schedule for 2021 was presented. The start of SPS North Area proton physics is now foreseen for July 12th, until November 15th (125 days) and will be followed by four weeks of Pb running. The PS East Area, after a complete renovation, will resume physics with protons on October 18th until the end of operations of the injector complex on December 13th (56 days). The call for beam time requests is foreseen to go out at the end of this year to start the preparation of the user schedule, which should be available in April. The renovation works at the East Area are well on schedule, with the shielding walls in place and the new power supplies installed. In the North Area a new experimental area is being installed in H4 for the NA64 experiment. This will optimise the beam availability to the H4 users as the installation and decommissioning time of the experiment will be significantly reduced. The removal of the ATLAS LAr cryostats from the H6 beam line allows the redesign of experimental areas in H6 and H8, with more space available for the test beam users.

5. General Comments

The following comments are applicable to more than one project.

- The **LHCC notes** that the LHC experiments still have a long-term programme ahead of them, which will need the ongoing continuous commitment from the institutes, but also a strong team of collaboration-funded experts at CERN for integration, installation, commissioning and operation. The **LHCC would like to emphasise** that it is vital that solid structures to guarantee sufficient long-term support for the coming years are set up, taking into account recent changes to the regulations and provisions at CERN that modify the mechanisms used so far to support CERN-based experts from experimental collaborations. A timely resolution of the current uncertainties in this area is of high importance for the experiments. In this context, the **LHCC welcomes** the news that a task force dedicated to these issues has been established and has begun its work.

6. Report on ASIC effort at CERN

The LHCC heard the report on the 'Focus Session on CERN ASICs Efforts' that took place September 1st, 2020, where the status of the development of common ASICs, of the CHIPS initiative, and strategies with respect to design tools were discussed. The activities of EP-ESE-ME, in particular the leading role in the service ASICs (links and power distribution), together with the support for specific experiment ASICs and the Foundry Access Service, were presented. The status of the lpGBT ASIC was reported, together with the one of the various DCDC converters and of the detector-specific ASICs with ESE-ME involvement. The CHIPS service started on January 1st, 2020: resources are used to recruit fresh manpower in order to compensate the support given by the ASIC

experts and correct the lack of verification engineers in the section. The CHIPS project provides support to ATLAS and CMS organized in different work packages. ALICE and LHCb do not have any ASIC on the critical path anymore and are thus at present not targeted by the initiative. Key projects receiving long-term support via CHIPS so far are the CMS Outer Tracker and the ATLAS HGTD ASICs. Beyond this, occasional technical support is given to a number of other ASICs. So far two fellows have been hired, a third fellow is being searched for since May 2020, but seven candidates have declined an offer to date. One verification expert engineer funded by ATLAS is being hired and is expected to start in January 2021. Directly after the LHCC meeting an agreement has been reached with CMS to contribute to the immediate hiring of a second verification engineer.

The tools of the ASIC design platform at CERN are crucial for the community as a whole. A common platform is essential to allow the collaboration across institutes and projects. Design tools and services play a critical role in this area, with EUROPRACTICE being of central importance for academic licenses of various design tools. At present, open source design tools are not yet at a level where they constitute viable alternatives.

The **LHCC observes** that the CERN EP-ESE-ME group has a central strategic role in ASIC development for HEP, as the single largest group in this domain. It has key responsibilities for central ASICs, both for projects common across experiments and contributions to ASICs for individual collaborations.

The **LHCC notes** that the CHIPS initiative is highly valued by the HEP community. It was conceived as a mid- to long-term support framework emphasizing the training of experts in the collaborating institutes. The criticality of many of the developments for Phase-II upgrades however results in requests for immediate support on concrete tasks rather than longer-term build-up of expertise, so the ESE-ME is now 'running in urgent mode', with requests exceeding available person power. The **LHCC also notes** that it is not easy to hire people, as fixed term positions provided by fellowships are not competitive with respect to the positions offered by industry, and the lack of experienced ASIC verification engineers is a threat to the LHC upgrade programme. The **LHCC encourages** CERN to consider making more experienced ASIC engineering effort available in the short term.

The **LHCC also notes** the importance of the design tools for the ASIC design platform at CERN. While the large reliance on a single vendor is a concern, radical short-term changes would jeopardize all ongoing projects. The **LHCC supports** a consolidation of the present arrangement, and a careful development of alternate options as a viable way forward.

7. Discussion with ALICE

Scientific output and current activities:

- ALICE continues to make excellent progress on its physics programme, with three papers submitted since the last session of the LHCC, bringing the total number of publications to 310. Recent results include a measurement of ω meson production in pp collisions at $\sqrt{s}$ = 7 TeV, a measurement of the centrality dependence of J/ψ and $\psi(2S)$ suppression in pPb collisions at $\sqrt{s}$ = 8.16 TeV and results on pion-kaon femtoscopy in PbPb collisions at $\sqrt{s}$ = 2.76 TeV.
- All LS2 and upgrade projects are progressing well and are on time within the

current baseline schedule, with three months contingency until a start date of February 2022 after four months of global commissioning.

Phase-I upgrades:

- An in-depth review of the ALICE Phase-I upgrades took place during the present session of the LHCC.
- After a successful pre-commissioning with 300 hours of irradiation (each side) in the clean room the TPC has been re-installed in the cavern. Connection to the services in the cavern is foreseen for the end of the year.
- Final optimisation on both NVIDIA and AMD GPUs has been performed and based on cost/performance ALICE has decided to purchase AMD GPUs. The PRR has taken place in August. The reviewers approved the architecture and hardware and the tender is now ongoing. Good progress has been reported on the development of the code for asynchronous reconstruction as well. The PRR for the reconstruction is planned for November 2020 and the analysis challenge is ongoing since July.
- Restrictions on travel due to COVID-19 have impacted the completion of the FIT detector. Backup plans for the different components have been prepared but they often involve several logistic issues that need to be worked out.
- The Muon upgrades are proceeding well. MID standalone commissioning is about to start. All MCH components are available and full installation is foreseen for March 2020.
- Surface commissioning of the ITS has resumed at the end of August and will be finished by December 2020. The installation together with the MTF is foreseen for January 2021.
- ALICE has presented an extensive physics programme for high energy pp with data to be collected during the full-energy proton-proton running periods in Runs 3 and 4. The proposed data sample of 200 pb^{-1} with full ALICE magnetic field and 3 pb^{-1} with reduced field enables unique studies of strangeness production in high-multiplicity collisions, light- and hyper-nuclei production, baryon-baryon production, and low-mass di-electrons. Additional measurements of low-pt jets and charmonia, Heavy Flavour and central exclusive production will complement ATLAS, CMS and LHCb. The resources needed by the extended programme appear reasonable.

- The **LHCC congratulates** ALICE on its continuing rich physics output, for the progress made on its upgrade programme and in preparing for Run 3 under the difficult circumstances caused by the COVID-19 crisis.
- The **LHCC encourages** ALICE to perform additional irradiation tests on the TPC chambers in the cavern to consolidate the stability results obtained in the clean-room.
- The **LHCC encourages** ALICE to thoroughly evaluate all backup plans for completing the FIT detector to assure a timely installation of the different parts in the cavern before the start of global commissioning.
- The **LHCC recognises** the unique possibilities in the proposed high energy pp running and **endorses** the running plan of high energy pp for a total integrated luminosity of 203 pb^{-1} (including 3 pb^{-1} at low magnetic field).

8. Discussion with ATLAS

Scientific output and current activities:

- ATLAS continues to have a rich scientific output with 953 papers submitted to date, of which 55 use the full Run 2 data set. An additional 23 papers have been submitted since the last LHCC. Recent new results include the observation of the process $\gamma\gamma \rightarrow WW$, new limits on lepton flavour violation in $Z \rightarrow e\tau/\mu\tau$ and a measurement of the suppression of the charged-particle yield in PbPb collisions compared to pp collisions at $\sqrt{s}$ = 5.02 TeV.
- Work on refurbishment of detectors (electronics, gas leaks) resumed on Liquid Argon, Tile Calorimeter and Muon system (RPC). The COVID-19 delays can be accommodated in the updated CERN schedule.

Phase-I upgrades:

- The Phase-I upgrades have reported good progress. The LAr Phase-I upgrade has acquired some non-critical delays but is now approaching completion. Commissioning tasks never stopped during the COVID-19 shutdown thanks to partial HW in place and a dedicated team working remotely.
- Most of the TDAQ Phase-I deliverables are progressing well towards completion of production. The L1Muon Barrel and Endcap systems are fully installed, with only fibre connections remaining. The L1Calo eFEX system had to go through two pre-production stages, due to quality issues with the manufacturer chosen first. The end of installation is now foreseen for Q2/2021.
- The New Small Wheel has made progress in difficult circumstances. ATLAS expects to be able to install NSW-A in LS2 and aims to further develop the case before October for installation of NSW-C in LS2.

Phase-II upgrades:

- The UCG review of the ATLAS Phase-II High Granularity Timing Detector (HGTD) took place during the present session of the LHCC. The UCG recommends the approval of the TDR at the next session of the CERN Research Board. The reference to the corresponding UCG report is given below.

- The **LHCC congratulates** ATLAS on the wealth of very interesting new physics results produced, as well as the good progress reported on the upgrades and in preparing for Run 3, in particular in keeping the LS2 within the current schedule under COVID-19 conditions. The **LHCC looks forward** to receiving a summary of work still to be done presented as milestones, with related schedule contingency/float by the end of September.
- The **LHCC commends** the NSW team for the progress made under difficult circumstances. The **LHCC continues to see** the schedule for installing NSW-A in LS2 as plausible. The schedule for NSW-C requires more input to reach a similar level of plausibility. The **LHCC notes** that additional resources injected now and through 2021 by all teams involved will substantially increase the likelihood of success**.** The **LHCC acknowledges** the additional contribution of CERN provided already now for the NSW integration. The **LHCC cautions** the NSW Team and ATLAS Management to assure sufficient time for commissioning of the detector and to avoid shortcuts. Caution should also be exercised in making the decision

on irreversible removal of SW-A.

- The **LHCC commends** ATLAS for progress in managing computing resources and in implementing ATHENA MT as well as simulation and trigger improvements for Run 3 and progress in preparing for Run 4.
- Following the review by the LHCC and the UCG, the **LHCC recommends** the approval of the ATLAS High Granularity Timing Detector TDR.

9. Discussion with CMS

Scientific output and current activities:

- CMS continues to deliver high quality physics results, with 992 papers on collider data submitted to date, including 22 since the last LHCC. Recent results include the first 3σ evidence of $H \rightarrow \mu^+\mu^-$, a measurement of the production cross section of polarized WW pairs and a high precision measurement of Z boson production in PbPb collisions at $\sqrt{s}$ = 5.02 TeV.
- CMS has adapted to work in a COVID-19 environment. So far there are limited consequences on LS2 plans. All projects for LS2 are on track and the overall LHC schedule looks achievable with CMS ready for beam by the end of September 2021 and ready for Run 3 by February 2022. The Multiservice Building has been approved and additional manpower has been found for HGCAL tooling which was slowed down by lack of effort previously.

Phase-II upgrades:

- The situation of the Phase-II projects under COVID-19 conditions is being reviewed by CMS every 4-6 week. So far, a delay of about three months has been accumulated.
- CMS does not expect major inefficiencies during the prototyping phase, however a bigger impact of restrictions can be expected when still in place at the start of large scale productions around the second half of 2022.
- Much progress has been reported on the TDR for the Phase-II HLT, however the time margins are thinning and there is a question mark currently on the submission date of Q2/2021.

- The **LHCC congratulates** CMS on its very productive physics programme as well as on managing to keep the impact and delays due to the COVID-19 pandemic on LS2 Run-3 preparation and HL-LHC upgrade work to a minimum.
- The **LHCC is pleased to learn** that the buildings requested by CMS at P5 (New Control Room, Multiservice Building, Engineering Centre) have all been approved by the SIB.
- The **LHCC supports** a detailed and quantitative study of the PPS (Precision Proton Spectrometer) Phase-II project in order to strengthen the physics case of the project. The **LHCC encourages** the project to establish a working group together with the machine coordinators and relevant experts in order to fully assess the feasibility of the installation of detectors at the positions under consideration and the associated cost.

10. Discussion with LHCb

Scientific output and current activities:

- LHCb continues to make excellent progress on its physics programme, with a total of 531 publications to date, including 9 new papers since the last session of the LHCC. New results include the observation of structure in the J/ψ pair mass spectrum, new searches for low-mass dimuon resonances and a model-independent study of resonant structure in $B^+ \to D^+D^-K^+$decays.
- COVID-19 continues to create logistical problems, but there is progress on upgrade infrastructure and on all subsystems.

Phase-I upgrades:

- The new electronics for the muon system should be delivered and completely installed by November. The new front-end electronics for the calorimeter has been significantly delayed by COVID-19, but installation and commissioning will start in October. The RICH upgrade is making good progress, with RICH2 to be installed this autumn, and RICH1 around March 2021.
- The SciFi C-side should be ready in December 2020 for beam pipe installation starting January 2021. The other half will be installed after the beam pipe and is on track to be ready by August 2021.
- For the UT the 8-chip hybrids will be tested shortly. A new version of the SALT ASIC (V3.9) is being tested as well, that should be more robust with respect to single event upsets. The UT has been affected by COVID-19 in several areas, in particular the clean-room required for UT commissioning is delayed due to UK travel restrictions and the commissioning team at CERN is lacking effort due to colleagues not being able to travel to CERN.
- For the VELO the first two modules have been produced with the new gluing method. However also here the schedule is impacted by COVID-19 due to travel restrictions and some critical effort affected by quarantine requirements. The installation schedule is tight should the experimental hall be closed in November 2021. The C side installation goal is May 2021, with the A side foreseen for July 2021.
- The performance of HLT1 on GPUs has improved by 60% since June. The next generation of chips will be evaluated by the end of the year. HLT2 has a path to the required reconstruction performance, but also needs work to speed up the selection algorithms. This benefits from the delay in the start of Run 3.
- Good progress has been reported on the Upgrade 2 framework TDR foreseen for September 2021. Excellent timing resolution is a particular focus.

- The **LHCC congratulates** LHCb on its rich scientific output and commends the collaboration for the progress made on its Phase-I upgrade programme, in particular given the difficult circumstances due to COVID-19. The LHCC notes in particular the production of the first two new VELO modules.
- The **LHCC notes** the difficulty in scheduling under the current circumstances and **hopes** that experience over the next couple of months will enable a reliable update of the master schedule by the next meeting.
- The **LHCC commends** LHCb on its progress on HLT1 and HLT2 and **endorses** the plan to postpone purchases until an appropriate time.
- The **LHCC encourages** LHCb to keep up the effort to produce a draft framework

TDR for the September 2021 LHCC meeting.

11. Discussion with WLCG

The WLCG infrastructure is operating smoothly with no impact from the ongoing COVID-19 situation. The CPU usage is increasing for all four experiments and data transfers are proceeding at variable rates. The CERN tape system migration in preparation for Run 3 is ongoing. Updated run parameters have been agreed with the LPC and are being used for the 2022 resource requests. A gradual ramp-up of resources will be needed already in 2021 in order to reach the 2022 targets but Run 3 looks feasible with a flat spending profile. However, a continuous investment and resource growth will be needed to prepare for HL-LHC.

The committee heard a report from the HSF Physics Generators Working Group on event generator challenges and strategy towards HL-LHC. The production of Monte Carlo simulation samples is a major ingredient for the HL-LHC computing requirements and improvements in efficiency are a key ingredient to stay within a reasonable computing resource request. Following a multi-prong strategy, the group is very active with many activities being pursued in parallel. One difficulty arises from the different mix of skills and expertise required by each of the issues raised and cross domain collaboration is essential. It would be beneficial to attract more theorists to work on generator optimisation as well as for the experiments to dedicate more effort to the working group in order to boost the progress on this important topic. Among other factors the future cost of improved precision needs has to be monitored closely (NNLO when available) and the most expensive samples to ensure the HL-LHC physics programme need to be identified in close collaboration with the experiments.

- The **LHCC congratulates** the WLCG and the experiments on the successful and efficient use of the computing resources, in particular considering the current COVID-19 situation.
- The **LHCC acknowledges** the importance for the funding agencies to plan for a continuous growth in order to prepare for the HL-LHC needs.
- The **LHCC welcomes** the flexibility given to the WLCG sites to put in place their 2021 and 2022 pledged resources with the goal to reach the 2022 needs for the start of the run. This goal (cover the 2022 needs) needs to be clearly communicated to the sites.
- The **LHCC welcomes** in particular the participation of WLCG in the ESNET process of analysing and planning for the operations of the network, and the new collaboration established between CERN, SKA, PRACE and GEANT for HPC integration.
- The **LHCC recommends** pursuing the work on optimising the Monte Carlo generators and **encourages** a close interaction between software experts and physicists to ensure the physics requirements are taken into account in the optimisation process from the beginning.

12. Forward Physics Plans - Machine Perspective

The layout of the interaction regions IR1 and IR5 hosting the ATLAS and CMS experiments will change significantly in the upgrade to the HL-LHC and require more space for machine elements. The maximum β^* reach will be rather limited (no more than 30 m foreseen). Radiation levels will be high, making access more difficult after LS3.

Following requests from CMS-PPS, preliminary discussions with machine experts have started on four possible locations at 196 m, 220 m, 234 m and 420 m from IP5. The 196 m location would require a remotely movable platform and sharing and coordination with the beam-beam wire compensation project also interested in this location. The 220 m position appears currently as the easiest option. The 234 m position would only be possible if a (DQR) cooling station could be moved.

The first three positions would be suitable for roman pot technology and can profit from experience from the current CMS-PPS. A new detector design and launching a study with machine experts would be required to assess the feasibility of forward detectors in the connection cryostat at 420 m.

13. Report on TOTEM

The LS2 activities are well underway, with all the COVID-19 restart work packages in progress. The Roman Pot (RP) Motion Control System will undergo a final movement test this week, the laser calibration of all RPs is scheduled to start on September 14th, and the PPS RP pixel test remains in preparation. The new T2 is making steady progress: the final design of the scintillators is under test, a new approach for the green-to-clear fiber splicing has been found and is being tested and a first final prototype of a tile, produced in Helsinki, is being tested. A full mock-up of the detector exists and was used to simulate the installation and integration procedures. The electronics is in an advanced preparation stage, and the full mezzanine will be finalized following the test beam, currently scheduled at DESY for mid-November.

TOTEM reported two incidents, caused by activities external to TOTEM. In one case, a vacuum loss in a RP's secondary vacuum line led to a pump failure and sudden return to atmospheric pressure, endangering the delicate window separating the inner RP detector from the beampipe vacuum. Inspection showed that a vacuum pipe had been bent during work in the tunnel, presumably accidentally, without being reported. The second incident is the diffusion of dust in the tunnel, near the RP location, following the opening of a new door. Proper steps are being taken by TOTEM to protect the RPs, also in view of the forthcoming movement test.

Two new physics results have been released by TOTEM. The first, jointly with the D0 experiment, reports a comparison of the $|t|$-spectrum in elastic pp and $p\bar{p}$ scattering at 1.96 TeV, providing 3σ evidence for the different interference patterns expected from odderon exchange. The second, based on the CMS-PPS common data taking in 2016, searches for high-mass diphoton pairs. Limits are set on anomalous quartic couplings.

- The **LHCC congratulates** TOTEM for the new physics results and for keeping the LS2 activities on track. The RP and T2 projects are on schedule.
- The **LHCC is worried** about the two reported incidents and **hopes** their origin will be clarified.

14. Report on FASER

The LHCC received a comprehensive status report on the work towards construction and installation of the detector. Civil engineering work in the TI12 tunnel is completed, the base plate has been installed and most service and infrastructure components are in place. Two magnets are complete and tested, showing excellent field quality. Following a slight delay in the delivery of some components, the third magnet is now expected to be ready

for installation by mid-November. Four tracker planes have been signed off, two more will be within a few days. Scintillator layers have been assembled in the respective stations, ready for installation. Eight calorimeter modules are ready for the down-selection to the four best, which will be used for the detector. TDAQ, software and DCS are also in an advanced stage of commissioning, including cosmic ray data taking. All of this was achieved while remaining well within the available budget envelope. The overall detector (except the third magnet) is on-track for the full-system surface test, scheduled to start between end of September and early October. An installation sequence is available, its finalization subject to the definition of the cool-down schedule for sector 81. Both options considered for the cool-down call for a two-stage FASER installation, starting in late October or mid-November, with the second period pushed to January. The optimization of the installation schedule will also account for the need to complete the surface system tests, in view of the necessity to move to TI12 part of the available cables and power supplies. FASER will seek approval to turn on power on the various components upon their individual installation, to speed up their commissioning in situ. A period of 3 or 5 weeks in early 2021 will be required to complete the installation, depending on the sector 81 cool-down scenario.

Construction work on the FASERnu detector and interface detector will start following the FASER installation. The current schedule is consistent with the required completion of the construction and installation by January 2022. Further work on the Monte Carlo estimates of the neutrino flux and its systematics has been carried out, clarifying the issues reported at the previous LHCC review.

- The **LHCC congratulates** FASER for the continued progress and the recovery from the COVID-19 related slow-down. The excellent management, planning and technical coordination shown by FASER provide a valuable reference of good practice for current or future small-scale experiments reviewed by the LHCC.
- The **LHCC notes** that while FASER is on track for a successful completion of the construction phase, no margin is left to fully accomplish the testing and commissioning plans before installation, so additional delays need to be avoided.
- The postponing of the sector 81 cool-down allows FASER to extend surface tests, and possibly have the 3rd magnet ready, before a first period of installation in November/December 2020. The **LHCC recommends** flexibility in the assignment of access periods to FASER, to complete their installation and commissioning in early 2021.
- In view of the limited timeslots and opportunities available to FASER for installation, the **LHCC invites** the experiment to include a thorough risk assessment and risk mitigation analysis in the installation plan.

15. Report on LHCf

The LHCC referees received a progress report on the LHCf preparation towards Run 3. In addition to increasing the statistics at the highest available pp energy, Run 3 offers the unique opportunity for an LHC experiment to study the final states of proton-oxygen collisions in the most forward region that dominates the development of cosmic ray showers in the atmosphere. These data are crucial to improve the MC modeling and the determination of the primary component of the highest energy cosmic rays.

The Arm 1 detector is being reconfigured, following its data taking at RHIC. The production of the new DAQ electronics for the Arm 2 detector is in progress. The replacement of two patch panels near the detector location and at USA15 has been postponed a few times and is now scheduled for early October. This operation is becoming urgent. Test beam requests for 2021 will be filed as soon as possible. The possibility of a common run with the ATLAS hadronic ZDC detector is under discussion. The joint analysis of Run 2 data with ATLAS is ongoing.

- The **LHCC congratulates** LHCf for its continued work in preparation of Run 3 and acknowledges the need of the experiment to replace the patch panels at the scheduled October date.
- The **LHCC acknowledges** the unique knowledge that the LHCf experiment could acquire from collisions with oxygen nuclei. The opportunity to carry out these measurements is only open during Run 3, requiring the timely assessment of the feasibility of oxygen collisions.

16. Report on MoEDAL

The LHCC held a focus session to discuss the Technical Proposal it received from the MoEDAL collaboration. The discussion included feedback from the LHCb Technical Coordinator and Deputy.

The MoEDAL detector is a straightforward continuation of its Run 2 configuration and upgraded analysis facilities are becoming available. The MAPP detector is under advanced construction, no critical elements have been identified. Full detector simulation is in progress for a more robust physics performance assessment. Only minor questions were raised on the detectors concept and implementation. No serious concerns for safety issues have emerged and safety reviews are ongoing. A resource loaded schedule is available, showing that work is in principle on track for readiness by the start of Run 3.

The main concerns arose in three areas: (a) the impact of installation and operations on LHCb resources, (b) the impact on CERN resources and (c) the availability of dedicated MoEDAL personnel resident at CERN on a permanent basis (before/after installation, during data taking, etc). More detailed information must be provided to carry out the assessment of the compatibility of MoEDAL's needs and resources with LHCb and CERN requirements for the installation and operation of equipment at IP8.

- The **LHCC congratulates** MoEDAL for the continued progress towards the construction of the MAPP-mQP detector.
- The **LHCC requests** that MoEDAL documents the impact of their preparation, installation, operation and maintenance plans on LHCb, addressing all items described in the LHCb engineering note EDMS 2135826. This document, as an addendum to the TP, will be reviewed and discussed with the LHCb Technical Board. In particular MoEDAL together with LHCb TC needs to clearly establish the required infrastructure work, including safety installations, to meet the requirements for the installation and operation of the MAPP-mPQ detector in the UCG1 gallery.
- The **LHCC requests** that, in parallel to the documentation requested in the previous point, the TP provides an itemized and costed list of potential resources

required from CERN, together with a description of the team that would supervise and coordinate the various stages of the project at CERN. The **LHCC notes** that, in view of the new scope of the experiment, the MoU with CERN must be renewed, addressing in particular possible new responsibilities arising from the presence of an active detector.

- The **LHCC remains committed** to support MoEDAL's plans for the upgrade and for MAPP **but recommends** decoupling at this stage the approval of the MoEDAL upgrade from the approval of the new MAPP detector, to enable a faster track for the former.

17. Report on R&D Projects

The currently active RD Collaborations have presented their longer-term plans and extension requests at the LHCC meetings in May 2018 (RD42, RD50, RD51) and September 2018 (RD53), and have been granted 3 year (RD42, RD53) and 5 year (RD50, RD51) extensions in the subsequent Research Board meetings as requested. The LHCC heard status reports from the R&D projects:

RD42: Development of Diamond Tracking Detectors for High Luminosity Experiments at the LHC

- The **LHCC commends** the RD42 collaboration for the good progress shown despite the complications and/or delays induced by the COVID-19 pandemic.
- The beam monitors for the HL-LHC are progressing on schedule and will employ both planar and 3D sensors. The 3D sensors are working well and show significantly less loss in charge than planar ones after irradiation.
- The lack of availability of test beams may delay some of the required testing, but this should not prevent providing deliverables to the experiments on time.
- RD42 plays a critical role in diamond sensor and detector developments and testing, and official recognition by CERN is crucial for the collaboration to obtain support from national funding agencies.

- The **LHCC recommends** continuing the RD42 collaboration, including CERN support at the level currently provided (access to CERN facilities, lab and office space, test beams when available).
- The **LHCC encourages** RD42 to keep sustaining close links and commonalities with the LHC and future collider infrastructures and experiments.

RD50: Development of Radiation Hard Semiconductor Devices for Very High Luminosity Colliders

- RD50 is a very active collaboration with a well-structured programme. It functions as the go-to forum for experts from all experiments on this topic. The impact of COVID-19 beyond the lockdown periods has been relatively small.
- Most of the milestones over the last year have been achieved, with good reasons for changes and delays. This includes progress in all areas, such as detector characterisation, investigating new structures and materials and helping experiments in providing full detector systems. The table-top laser for a TPA-TCT system reported on previously has been commercialised.

- The RD50 model of collaboration between institutes and industry works remarkably well even with minimal funding (2kCHF/year per institute). The role of RD50 in understanding radiation damage in silicon detectors and in the development of radiation hard silicon detectors is crucial.

- The **LHCC recommends** continuing the RD50 collaboration, including CERN support at the level currently provided. The **LHCC notes** that the CERN contribution to RD50 (access to facilities, person power) is crucial, and **strongly encourages** CERN to maintain its support of RD50. The **LHCC congratulates** RD50 for the progress made since the last report.

RD51: Development of Micro-Pattern Gas Detectors Technologies

- RD51 is a large and vibrant research collaboration. The collaboration is well organised into seven working groups covering activities from new detector structures and electronics, to modelling, test facility management and industrialisation. Technologies developed within RD51 have been adopted by LHC experiments and elsewhere.
- Recent activities include the investigation of MPGD technologies such as GEM and mRWELL for LHCb and CMS upgrades, new materials for photocathodes used in THGEM based RICH and fast timing micromegas detectors, resistive electrodes based on DLC, optical readout for imaging and TPC.
- The collaboration has coped well with the COVID-19 situation in general, however some collaborators are in difficult situations. Restricted travel and limited access to CERN have slowed progress.
- The success of this endeavour depends critically on CERN providing extensive common facilities such as the gaseous detector development lab, test beam, micro pattern technology workshop and the expertise of the associated personnel.

- The **LHCC commends** RD51 for the progress made since the last report and **recommends** continuing the RD51 collaboration, including CERN support at the level currently provided. The **LHCC notes** that the CERN contribution to RD51 is crucial for the collaboration and should be maintained.
- The **LHCC notes** that RD51 raised the issue of a shortage of support for the facilities themselves, which is funded from other channels than personnel undertaking specific R&D topics.

RD53: Development of Pixel Read-out Integrated Circuits for Extreme Rate and Radiation

- The **LHCC commends** the RD53 collaboration for the excellent progress shown since last year despite the complications and/or delays induced by the COVID-19 pandemic. RD53 plays a crucial and critical role in the RD53B chip design, development and testing, and in making its production version available on time to ATLAS and CMS.
- The 4-bit latch issue found in the latest version of the chip should eventually not have a big impact on schedule. However, it should be ensured that a similar

situation (using part of a non-verified design in a chip submission) cannot happen in the future.
- The current major issue for RD53 is being understaffed regarding the chip verification phases.

- The **LHCC recommends** continuing the RD53 collaboration, including CERN support at the level currently provided (access to CERN facilities, lab and office space, test beams when available), which is crucial.
- The LHCC **strongly recommends** that constructive discussions between RD53, ATLAS, CMS and the CHIPS initiative are continued to find a solution to the pressing need to have one or more chip verification experts join RD53 as soon as possible.

18. REFEREES

The LHCC referee teams for this session are as follows:

ALICE: G. Casini, J. Dunlop, P. Salabura, C. Sfienti (Co-ordinator)

ATLAS: C. Biscarat, R. Calabrese, F. Di Lodovico, W. Wisniewski (Co-ordinator)

CMS: E. Kajfasz (Co-ordinator), A. Kuzmin, P. Pakhlov, D. Waters, A. Weber

LHCb: C. Hearty (Co-ordinator), K. Krüger, M. Kuze, E. Worcester

LHCf, TOTEM: P. Pakhlov, F. Di Lodovico, M. Mangano (Co-ordinator)

MoEDAL: F. Di Lodovico, M. Mangano (Co-ordinator), E. Worcester

WLCG: C. Biscarat (Co-ordinator), J. Dunlop, M. Kuze, D. Waters

FASER: K. Krüger, M. Mangano (Co-ordinator), W. Wisniewski

R&D projects:
RD42: E. Kajfasz
RD50: K. Krüger
RD51: C. Hearty
RD53: R. Calabrese, E. Kajfasz

19. The LHCC received the following documents:

CERN-LHCC-2020-008	Minutes of the one hundred and forty second meeting of the LHCC held on 4-5 June 2020
CERN-LHCC-2020-017/UCG-035	Upgrade Cost Group Review of the ATLAS High-Granularity Timing Detector
CERN-LHCC-2020-018	Future high-energy pp programme with ALICE

DATES FOR LHCC MEETINGS

Dates for 2020
19-20 February
4-5 June
2-3 September
18-19 November

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