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Summary of scientific issues, CERN Council week, Mar 22-26, 2021

By G. Dissertori, 07.04.2021

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This was the 202nd meeting of the CERN Council; because of the still difficult Covid-19 situation, it had to be held again by video-conference.

Members of the CERN management gave reports in the meetings of the Scientific Policy Committee (SPC), the Restricted and Closed Sessions of the Council. Below a summary is provided, closely following the report issued by the SPC. An overview of the main items discussed and decided during this 202nd session of the Council can be found here: <https://council.web.cern.ch/en/content/news>

Report by the Director General (DG, Fabiola Gianotti)

The DG's description of the efforts to control the detrimental effects of the Corona virus emphasised the care with which the situation has been managed. In particular, CERN has made major efforts to mitigate the impact of travel restrictions on all levels. Several institutes have been able to send people to CERN to assist in the preparation of the experiments (especially LHCb).

The DG described the recent ICFA meeting and the evolution of the ILC International Development Team, in which CERN staff participate. The Pre-Lab proposal document is expected to be completed in ~1 month. She mentioned an intent by the ICFA's Chair, Stuart Henderson, to send a letter to Minister Hagiuda "encouraging" MEXT (the Japanese Ministry of Education, Culture, Sports, Science and Technology) to invite foreign government officials to discuss potential commitments to the ILC.

The DG also reported on the signature of an agreement regarding participation by the US Department of Energy in the Future Circular Collider (FCC) Feasibility Study.

In a dedicated presentation, F. Gianotti discussed CERN's main objectives for the period 2021-2025, namely (1) delivering world-class scientific results and knowledge, (2) increasing the return to the Member and Associate Member States, and (3) strengthening CERN's impact on society, with the overarching aim of preserving and expanding the Organization's multi-faceted role in science, technology, training and education, environmental protection and supranational collaboration. Particular attention will be given to CERN's impact on the society – here the SPC and Council noted that this is indeed crucial for ensuring the future of the organization. They also concurred with the vision to strengthen the communication of the scientific knowledge and values and to strengthen and consolidate the student education programmes. The 70th anniversary of CERN and the opening of the Science Gateway will be excellent opportunities to promote science in the member states. Furthermore, reducing the impact of CERN on the environment will be a very high priority, in particular the ambition to reduce emissions by 28% by 2024 and to foster projects that hold promise for improving sustainability for society at large. In the post-COVID era, applied science

directly facing the societal challenges will be a strong competitor in talent attraction. It is mandatory for the future plans of the HEP field, which rely on the participation of thousands of young people, to transmit to the society the importance of curiosity driven science.

Status of LS2 and accelerator upgrades (M. Lamont)

Mike Lamont gave a detailed overview of the status of restart after the Long Shutdown 2 (LS2), presenting an updated schedule with some remaining uncertainties. LS2 has been completed for both the injector chain and the LHC and both are now in the hands of Operations. Linac-4 and PS booster beam commissioning has progressed very well, PS has accelerated a first beam and SPS is preparing for beam commissioning. The LHC Injectors Upgrade (LIU) project, a major task over several years, has been very successfully completed. Major training of LHC dipoles has started and its behavior will determine the possibility of increasing the proton energy to 7 TeV in the next run.

Status of and re-start plans for the LHC experiments (reports by Joachim Mnich and the LHCC chair)

The 145th meeting of the LHCC took place from March 1 - 4, 2021 as a fully remote meeting. All experiments have continued to be very productive in terms of physics analyses. Recently LHCb has presented several remarkable results, such as the discovery of four new tetraquarks states, a new measurement of the Bs mixing frequency with a precision at the level of 3×10^{-4} , and most notably, the new and most precise to date R_K measurement (based on the full run 1 and run 2 data), which deviates from the expected lepton flavor universality by 3.1 standard deviations. Further tests of lepton flavor universality, with much larger samples, will be among the highlights of LHC's run 3. ALICE and ATLAS showed novel results on the transverse gluon distribution and evidence for the Dalitz decay of a Higgs boson, respectively. Searches for new physics are also pursued vigorously particularly in challenging regions with little missing transverse energy, such as in a new search by CMS for scalar partners of the top quark.

LS2 activities and Phase I upgrades continue to make progress, with many infrastructure and consolidation projects completed, and first upgraded systems in commissioning. LHCb remains most critically affected by COVID-19-related travel restrictions and other impact, in particular in the SciFi and Velo projects, which has led to a further shrinking of schedule contingencies. Similarly, ATLAS has seen additional schedule slippage on the New Small Wheels (NSW) project, partially due to the need to investigate noise issues observed during chamber integration. Overall, the current schedules of all experiments remain consistent with the closing of the experimental areas at the beginning of February 2022, and a short pilot run in week 39/40, 2021; however, without schedule contingency for LHCb and ATLAS NSW.

Concerning the Phase-2 upgrades, the SPC expects that a serious discussion about the long-term schedule will take place in fall 2021, or spring 2022, for a full view of the situation and a decision on a further shift of Long Shutdown 3 (LS3). Crucial elements contributing to this discussion will include the input from the MAC (Machine Advisory Committee) cost & schedule review that should be available in November 2021 and a solid understanding of the full impact of COVID on the upgrade schedules of the experiments. The common ASIC projects at CERN, as well as the experiment-specific chips are making progress, but the shortage of wafers and the changing conditions of foundry access due to increased world-wide demand for microelectronics is a significant concern and may negatively impact the schedule. The recently observed failures of VTRx (optical link communication) modules are a major concern that potentially affect all experiments. Investigations are ongoing, and possible mitigation and repair strategies are being developed by the experiments.

The LHCC has reviewed the Technical Proposal of the SND@LHC experiment, an experiment aiming to study collider neutrinos and feebly interacting particles with a combined emulsion and active detector system in the TI-18 transfer tunnel, near the ATLAS interaction point. The physics program is seen as interesting and provides complementarity to the FASERnu experiment due to the difference in rapidity coverage. Following the recommendation by the LHCC, SND@LHC has been approved by the Research Board.

The LHCC has also recommended the approval of the Run 3 program of the baseline MoEDAL experiment, an installation of primarily passive detectors in the LHCb cavern, contingent on reaching an agreement with LHCb that their conditions for installation and operation of MoEDAL are met.

HL-LHC 11 T dipoles: status, plans and implications (reports by Mike Lamont and Norbert Holtkamp, chair of the MAC)

Following the performance problems with the 11T magnets and the decision not to install a 11T unit into the LHC before Run 3, the accelerator team has taken decisive action. A task force has been installed for a detailed investigation of the performance degradation and a 3-phase plan has been laid out towards resolving the issue by autumn 2022. Since there is an alternative solution by using crystal collimators, it is not expected that there will be performance limitations for LHC operation even without 11T magnets being installed in the ring for the proton runs, while some concerns still exist for the ion run.

In January CERN's MAC was informed by Mike Lamont that the 11T magnet program experienced difficulties related to the deterioration of magnet performance driven by thermo-mechanical effects triggered by the combination of powering and thermal cycles, only visible in long magnets. The cause of the deterioration is under detailed investigation. The MAC review had a two-fold goal - first, to comment on the root cause analysis being performed and whether there are any other investigations that the magnet team should perform in parallel. Second, what performance limitations would have to be expected as a result of having the 11T magnets not installed for Run 3, if

any. With regard to the first charge, the committee did not find any other significant investigations that the CERN team is not planning on already. The MAC agrees with the hypothesis on failure modes from the CERN team, but it might not be complete yet. The full results of the ongoing analysis are not expected before later in the summer of 2021. On the second question, no impact is seen on the luminosity performance for Run 3 for protons and likely none for ions, given the availability of the crystal collimation system. This is largely driven by operational experience, understanding of loss and quench mechanisms in the LHC and significant advances in the crystal collimation program. Given the time it will take to finish the 11 T root cause analysis and the additional investigations, as well as the beam experiments to be done as early as possible in Run 3, the MAC recommended no major decisions be taken in the 11T program before the end of 2022, since sufficient information will simply not be available before then.

Lessons learned on the 11 T magnet will be important for the future of the Nb3Sn High Field Magnet program and the understanding of the behavior of Nb3Sn magnets. The SPC joins the MAC in encouraging all Nb3Sn magnet programs, including the MQXF and 15 T dipole program in the US, to exchange the lessons learned among them and to reflect on further possible common programs among the 11T and MQXF teams, CERN, and the US teams.

In this context it is worth mentioning that the SPC organized a dedicated scientific session, continuing the format initiated in December that aims to improve the exchange between the Council scientific delegates and members of the SPC. This time, the session focused on the “high-field magnet development” with an introduction given by A. Yamamoto followed by a lively discussion.

Other scientifically relevant items:

a) Report from the SPS and PS Experiments Committee (SPSC), which held its 140th meeting in January 2021. The committee conducted its annual review of the Antiproton Decelerator programme, and received reports from GBAR, AEGIS, BASE, ALPHA, and ASACUSA. All of these experiments presented plans for their future physics potential once they are connected to the ELENA accelerator. In addition, the SPSC reviewed the two requests for transportable anti-proton traps and recommended that the PUMA experiment be allocated LNE51 and connected to ELENA, and that the BASE-STEP programme be connected to ELENA and located in the area previously occupied by ATRAP. The SPSC also received an addendum from AWAKE describing its Run-2 programme and a letter of Intent to build a large-scale demonstration of the ARIADNE LArTPC, which requires use of the cold box and cryogenics being used by NP02 (Neutrino Platform). Finally, the SPSC received a proposal to measure the production of a low emittance muon beam from a positron beam on a target and an update from the Water Cerenkov Test Beam Experiment.

b) North Area: The fixed target experiments in the North Area plan to resume data taking in summer 2021. The NA62 experiment plans to improve the background rejection by multiple means, and to increase significantly the number of signal events recorded, with the goal to measure the branching ratio of $K \rightarrow \pi \nu \nu$ with an accuracy on the order of 10%.

c) Neutrino Platform: A new organisation of the CERN Neutrino Platform was presented, as well as the investigation of the technical and financial feasibility of the LBNF/DUNE cryostats. An international expert panel will hold a review in May 2021.

d) Quantum Technology Initiative (QTI): J. Mnich reported on the status of CERN's new QTI (see also the summary of the Council week in June 2020). Recently, a Task Force has been put in place, communication channels (website) are being set up, and most members of the Scientific Advisory Board have been nominated. Here it is worth mentioning that **Prof. Klaus Ensslin** (ETHZ, director of the NCCR QSIT) has agreed to represent CH in this board and to coordinate Swiss activities in the context of the QTI. Furthermore, collaborations are being established in the Member States, US (Fermilab, Oak Ridge) and Japan (Tokyo – ICEPP), a roadmap white paper is being worked on, and a workshop on Quantum Technologies for HEP is (tentatively) planned in June 2021 (at this occasion there will be the kick-off of the Advisory Board, the presentation of the draft roadmap and of first projects, activities and results).

e) Organisational structure of the FCC feasibility study: A first proposal by the CERN management on the organizational structure of the FCC feasibility study, as well as an overview on its main work packages and their timelines, was presented both to the SPC and Council for feedback. CERN will host this feasibility study, which will be carried out in collaboration with institutions in the Member and Associated Member States and beyond, under the overall Council authority. The proposed structure aims to ensure: ownership of the study by the Council; effective and timely study oversight; scientific and technical advice integration; participation of other stakeholders to bring contributions to the possible future project; and high level deliverables and timeline towards the delivery of the Feasibility Study Report by end of 2025.

The SPC is of the opinion that the proposal is in line with the recommendations of the updated European Strategy for Particle Physics and emphasizes that the physics part of the proposed study heavily relies on parameters such as the highest achievable energy, luminosity, and precision. Close coordination is recommended with the R&D efforts on technology, in particular on the high field magnets feasibility to be further detailed in the upcoming Accelerator R&D Roadmap (under preparation by the Laboratory Directors Group in the course of this year). The Council invited the Management to update the document taking into account the feedback given by delegations during the extensive discussion, to continue its discussions with the United States and other potential future participants in the feasibility study, and to submit a revised version of the document for the Council's renewed consideration in June 2021.

Elections and appointments

Council approved the following senior staff appointments:

- **Mr Christopher Hartley (UK)** as Head of the Industry, Procurement and Knowledge Transfer department, and
- **Ms Enrica Porcari (IT)**, as Head of the Information Technology department.

The Council took note of the statements by the delegations that had nominated the candidates for the office of Council President as of 1 January 2022, namely:

- **Prof. P. Levai (HU)**,
- **Prof. E. Rabinovici (IL)**,
- **Prof. J. Schieck (AT)**.

The Council agreed to invite the candidates to submit mission statements to the Council Secretariat by 1 May 2021 with a view to interviews at the Closed Council meeting in June 2021 and an election in September 2021.