ECFA EUROPEAN COMMITTEE FOR FUTURE ACCELERATORS

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Dear Minister,

On behalf of the European Committee for Future Accelerators (ECFA), I would like to thank the Norwegian particle physics community for the hospitality extended to Restricted ECFA, which consists of one representative per CERN Member and Associate Member State plus the Director-General of CERN, during our visit to Norway on 28 and 29 April 2023. We encountered a very motivated community and our interactions were extremely fruitful and pleasant.

The visit took place at the University of Oslo. The session on Friday included a welcome address by Professor Svein Stølen, the Rector of the University of Oslo. At the beginning of that session, overview talks were presented on the Norwegian Centre for CERN-related research (NorCC) by Professor Heidi Sandaker, on funding for Norwegian CERN-related research by Dr Liv Furuberg from the Research Council of Norway (RCN) and on the education system in Norway by Professor Ellen Henriksen. In addition, a summary talk was given on industry contacts and technology transfer by Dr Ole Petter Nordahl. The session continued with overview talks on the involvement of Norwegian groups in current experimental particle physics, nuclear physics and astroparticle physics experiments as well as in detector and accelerator research and development (R&D) activities. Additional presentations covered the Norwegian contributions to theory, computing and outreach, and finally the perspectives of early-career researchers were presented.

The Norwegian particle physics community contributes very significantly to today's particle physics research programme, with a strong focus on CERN. Norwegian physicists play a very active and visible role in the Large Hadron Collider (LHC) experiments ATLAS and ALICE. The physics programme is complemented by smaller engagements in other particle and nuclear physics experiments, including AEgIS at the antiproton decelerator and experiments at the ISOLDE facility at CERN. In addition, there are astroparticle physics activities in γ-ray astronomy, although we consider the resources in this area to be insufficient. We stress that experimental astroparticle physics is internationally recognised as a central topic for fundamental physics and strongly complements accelerator-based physics. Theoretical physics has a very strong tradition in Norway, although also in this area we see structural deficits in the provision of resources on which we elaborate below.

Concerning the overall funding situation, we are pleased to see that a long-term plan for research and higher education for the period 2023–2032 is in place. The funding for R&DI is at a level of 2.5% (1% from the public sector) of GDP, somewhat lower than the EC-recommended value. Concerning CERN-related research, we appreciate that NorCC is well established. We consider such a centre to be essential for the successful and efficient physics exploitation of large, long-term high-energy physics

experiments. We also welcome the centre's integrated outreach and education activities as well as its support for the technical student programme at CERN. Continued support for CERN experiments via this centre has been and will be essential in the future, and it fits well with the significant and highly visible Norwegian contributions to these experiments. We would like to stress that, in relation to future detector upgrades, such as ALICE 3, additional funding via dedicated RCN Research Infrastructure programmes is essential and must be maintained. We would also like to encourage our Norwegian colleagues – in both theory and experiment – to make efforts to attract more external funding, e.g. ERCs or other EC-related funding.

CERN as a laboratory is in general well used, with very significant Norwegian participation in the flagship LHC experiments and significant science output. However, the proportion of Norwegians with staff positions at CERN is low (0.9%) compared to the budget contribution (2.1%). It should be noted that the proportion in the student and fellow categories (in the "talent pipeline") is higher than average, which gives hope that the situation can be improved. However, we encourage the community to do still more to advertise the many opportunities at CERN in order to try to mitigate the situation. In this regard, we are pleased to see plans to establish a national CERN-PhD programme to complement the already successful technical student programme. Industrial return is found to be rather stable over the past years, at a level of 0.4–0.5, and improvements in this regard are deemed to be difficult. We note positively the already established technology transfer and cooperation with Norwegian industry.

The funding situation for other, non-CERN-based, experimental activities and theory activities is much less solid. In particular, the resources for astroparticle physics activities are insufficient, which severely threatens the sustainability of ongoing research in this field as well as the expertise that has been built up in Norway. On the theory side, we note the strong increase of professorship positions at some universities over the past years. However, we consider it important that such positions be supported in an appropriate way by the universities: postdoctoral and PhD positions are required in order to provide a solid foundation for a theory group to work efficiently and be productive. Establishing professorships without basic support in the form of postdoctoral positions or PhD students indicates a structural problem. This is exacerbated by the fact that no proper funding programmes for theoretical particle physics seem to exist. The only programme to which theoretical particle physicists can apply is the Research Council's FRIPRO programme. However, this programme is very broad and serves all fields of science and technology on a competitive basis, with a focus that is not restricted to fundamental science but also includes more applied and innovation-focused research. In addition, the programme is modified to fulfil other research ambitions, such as, in recent years, interdisciplinarity, renewable energy and information technology, within the total FRIPRO budget. Given the broad focus of the programme and the large number of applications from all fields, the success rate for theoretical physicists is far too low to provide a solid basis for the continuity of Norway's strategic programme for theoretical particle physics.

On the technology side, we note with satisfaction the significant Norwegian participation in detector R&D activities and the cooperation with industrial partners such as SINTEF. We strongly support the plans of the community to integrate their efforts into the recently established ECFA Detector R&D Roadmap. However, to join the newly forming Detector Research and Development (DRD) collaborations at CERN, corresponding funding support is needed. In addition, the Norwegian community makes a small, but very high-quality, contribution to R&D on accelerators, providing genuine intellectual leadership in some important aspects of plasma acceleration. Although NorCC provides some basic funding in this area, more resources are required to support a strategic approach.

The Norwegian grid computing contributions remain a flagship activity: reliable contributions are made to the present grid computing and essential and original contributions to software and middleware. At present, funding for investment in computing infrastructure relies on the RCN Research Infrastructure programmes. Given the constant and long-term needs in this area, we suggest discussing whether the funding model can be optimised, e.g. via integration of the needs in NorCC or via support by national computing initiatives.

Overall, RECFA appreciates the plans of the particle physics community to establish a "Norwegian Roadmap" for particle physics. We are convinced that such a process, aimed at defining a focused research programme, would be beneficial and would maximise the overall impact of the Norwegian participation in international experiments. In this context, we encourage a discussion of whether and how viably activities in astroparticle physics can be sustained in the future. This also requires the engagement and funding of principal investigators on a full-time basis. Both experimental and theoretical physicists should be involved in such a roadmap process in order to define and foster closer cooperation between experiment and theory on the various research projects. In addition, we strongly recommend that the community get involved in activities on future colliders, such as the Future Circular Collider (FCC) project at CERN and/or the related ECFA study on future e^+e^- colliders.

A serious concern for the future of particle physics in Norway is the age profile of the principal investigators, with many colleagues close to retirement age. Short- and long-term hiring plans are urgently needed in order to secure future participation in and physics exploitation of the large CERN experiments, which have been established with significant Norwegian investment.

Furthermore, we also share universities' concerns that applications to science teacher education and to physics bachelor programmes have been declining in recent years. This is worrisome and, if it persists, the strong needs of a twenty-first century society in science- and technology-related areas may not be covered. We suggest intensifying the efforts to bring more students into STEM subjects, with efforts beginning already in the early school years.

Below we give a brief summary of our assessment of the Norwegian contributions to various research endeavours.

ATLAS: Norwegian participation via the Universities of Bergen and Oslo in the general-purpose experiment ATLAS is very significant, with visible contributions to detector operation, performance studies and physics analyses. In addition, the excellent contributions to software and computing must be stressed. The high visibility in the large ATLAS collaboration is also reflected by the many convener positions held by Norwegian physicists in the computing, physics and performance areas.

The detector, software and computing upgrade programmes are also strongly supported by the Norwegian groups. They are working on well-defined contributions to the ongoing Phase 2 upgrade of the inner tracking system (ITk) and have expressed an interest in participating in a future replacement of the ITk inner pixel system. Based on their excellent expertise in software and computing, they have also taken on significant commitments related to the High-Luminosity LHC (HL-LHC) computing and software.

We would like to stress our strong concerns about the upcoming retirements of senior ATLAS physicists at the Universities of Bergen and Oslo, whose replacements are not planned. If no action is taken and a credible hiring plan is not established, this will seriously threaten the Norwegian involvement in ATLAS, which would be detrimental given the large past and present investments of Norway in this front-line particle physics experiment.

Non-LHC particle physics experiments: The particle physics programme is complemented by contributions to smaller experiments, such as NA61, EuroNuNet and AEgIS. We welcome this diversification but note that the sizes of the participating groups are small, which is largely related to the low level of funding and support of these groups by the funding agencies and universities.

ALICE and non-LHC nuclear physics experiments: The four Norwegian groups involved in the ALICE experiment (Universities of Bergen, Oslo, HVL and USN) make diverse and highly visible contributions to physics analyses, detector upgrades for Long Shutdown 3 (ITS3 and FoCal) and software and computing. They also aim to participate in the ALICE 3 programme if it is approved, or – if it is not approved – in the Electron–Ion Collider (EIC) programme. Norwegian physicists have also held visible leadership positions in the ALICE experiment. Like for ATLAS, a concern is the decreasing number of professor positions at universities and therefore of principal investigators involved in this

large experiment in which major investments have been made. The low number of postdoctoral positions and PhD students is an additional cause for concern.

A diverse non-LHC nuclear physics programme also exists, covering a wide range from basic to applied interdisciplinary research. It is based on both international collaboration (ISOLDE at CERN) and home-based nuclear physics experiments (OSCAR at the Oslo Cyclotron Laboratory). We are pleased to note that the nuclear physics activities are funded through a new national centre (Norwegian Centre for Nuclear Research) and that a new dedicated nuclear science study programme has been established.

Astroparticle physics: The main focus of the Norwegian astroparticle physics participation is on γ-ray astronomy with Cherenkov telescopes (MAGIC and the future CTA experiments). This involvement was supported by significant funding prior to 2015, which allowed R&D and hardware contributions to be made. However, the support has strongly decreased since 2015 and no funding for the MAGIC and CTA participation is secured beyond 2024. This also implies that membership of these experiments – and therefore the Norwegian astroparticle physics participation – is severely threatened. We also note that there are currently no permanent academic staff who are fully dedicated to astroparticle physics, and that the current lack of resources does not allow for a long-term strategy for future involvement.

Theory: Theoretical physics has a very strong tradition in Norway, with substantial research encompassing QCD and heavy-ion physics, phenomenology of physics beyond the Standard Model, general relativity and cosmology. The theory activities are largely organised via the N-PACT network, which is not connected to the experimentally oriented NorCC.

As previously mentioned, at some universities a spectacular increase in permanent faculty hirings has been observed in recent years. However, they do not seem to be supported by appropriate basic funding from the universities in terms of postdoctoral and PhD positions. As discussed above, the opportunities for theorists to apply for RCN grants are limited and – given the focus of the associated programme and the high competition – the success rate for theorists is low.

Given the significant overlap in the experimental and theoretical programmes, we encourage closer cooperation between experiment and theory and suggest that this be addressed in future roadmap or strategy discussions.

R&D on detectors, electronics and accelerators: There is a solid foundation, in terms of equipment, personnel, funding and cooperation with industry (e.g. SINTEF), for participation in the HL-LHC detector construction in the ATLAS and ALICE experiments. The groups also have clear plans for future strategic detector R&D and are interested in getting involved in future R&D collaborations, as defined in the ECFA Roadmap process, in the areas of solid-state detectors, quantum and emerging technologies, and electronics.

On the accelerator R&D side, there is a small but very high-quality contribution with genuine intellectual leadership in some important aspects of plasma research. Appropriate emphasis is put on international collaboration with large laboratories, recently in the context of the European Roadmap for Accelerator R&D.

Overall, we would welcome an enhanced and broader contribution from the established groups in Norway to future detector and accelerator R&D. Routes should be identified to provide the necessary sustained funding to support such initiatives, also bearing in mind the potentially wider applications of the relevant technologies.

Computing and machine learning: The LHC computing needs are currently well covered by two periods of funding through RCN research infrastructure grants covering the periods 2018–2022 and 2023–2027. The Nordic grid decentralised Tier 1 centre in Oslo, Bergen and other places is a successful approach. While fixed-term funding is well suited for detector upgrades, a more continuous funding model would be highly desirable for computing infrastructure.

We consider the R&D network in computing and machine learning within NorCC to be very useful, since it provides an excellent way to develop modern analysis techniques, attract young people and facilitate cooperation among the Norwegian groups as well as efficient knowledge transfer.

We would like to stress again the excellent contributions of Norwegian scientists to software development in ATLAS and their active contributions to benchmarking the eventual new software and computing solutions discussed in the ATLAS HL-LHC computing and software roadmap.

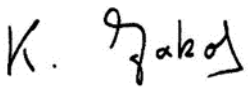
Higher education and outreach: We are very concerned about the declining interest in science, and in physics in particular, at secondary school and university level (declining number of bachelor and teacher programme students). The much lower number of school hours devoted to physics in Norway is striking when compared to international averages and to other Nordic countries.

We appreciate the wide and lively outreach programme, including public events, masterclasses and various online (radio, podcasts) content. Given the declining interest in science, these activities should be intensified.

Perspective of the young generation
Last but not least, we enjoyed an inspiring talk about the perspectives of the young generation. A survey has shown that Norwegian early-career researchers are generally satisfied with their work and would be interested in continuing in the academic field. However, a significant proportion leave to work in industry due to more competitive salaries and to limited career opportunities in the field of high-energy physics.

In conclusion, we wish to stress once again that RECFA is impressed with the high quality of the activities of the Norwegian particle physics community and with their contributions to and achievements in front-line science programmes, in particular at CERN.

Yours sincerely,



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