

Report of the Scientific Advisory Board

Monday 17 and Tuesday 18 August 2020

Remote Zoom-meeting

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Excused: W. Weise (TU Munich)

Due to the exceptional COVID19-situation the SAB met remotely via Zoom on 17 and 18 August 2020. It received a status report from the HIP director followed by progress reports on some selected HIP projects (see attached agenda). Before the meeting SAB had received the following written material: HIP Annual Report 2019, HIP Research Plan 2020, and the draft HIP strategy.

Executive Summary

As reported from previous years, the volume of scientific production of HIP is really very high and generally of high quality. In both the theory and experimental programmes, HIP continues to develop and contribute to research projects with success and at a high level by international standards. HIP also continues to do an excellent job in education and outreach.

Overall the theory programme is working very well with an impressive number of publications and PhD theses. The board was also impressed by the presentations on theoretical cosmology and on topological matter. The SAB finds that having three main projects QCD, phenomenology and cosmology belonging to HIP's core activities together with a small new activity is a good strategy to preserve critical mass and diversity.

The HIP experimental groups in CMS and TOTEM and the close collaboration between CMS and TOTEM offers excellent opportunities for a unique and original programme. The SAB is very impressed by the detector work done in TOTEM and CMS as well as by the analysis work done in both the experiments.

In ALICE the HIP contribution to the analyses is very impressive and the HIP involvement in the ALICE detector hardware is strong and recognized by the collaboration. The SAB is pleased to see the good progress with FIT and congratulates HIP for its contribution.

The non-LHC experiments at ISOLDE and FAIR are progressing very well. The SAB continues to strongly support the participation in this rich and timely field of research, in which HIP gives very valuable scientific and technical contributions.

The HIP Laboratory is indeed very impressive and of great importance for the high quality of the hardware with which HIP contributes to the different experiments.

An issue concerns the technology transfer and industrial activation network. This used to be strong and Finland used to have a relatively large industrial return from CERN. This has unfortunately declined. To improve the situation SAB stresses the need for a well-supported Industrial Liaison Officer.

The SAB would also like to recall the importance of maintaining an administrative presence at CERN, as a national liaison hub, especially to support the education programme.

The main issue for concern is the budget. The funding contribution from the Ministry of Education and Culture was already reduced for the years 2017-2020 and now for the coming years is even further reduced by 24%. The support from the member universities shows a strong commitment from them, which is really appreciated by the SAB. However, the SAB underlines the obvious fact that cuts will inevitably have severe adverse effects on the ability of HIP to execute its current programme and to fulfil the various commitments, as well as reducing the possibility of taking advantage of opportunities to enlarge the current scope with new projects.

General

The director of HIP, Katri Huitu, gave an overview of HIP activities which are based on the utilization of CERN and FAIR, on the infrastructure research roadmap of Finland, and on the strategy plans for HIP member universities, European Particle Physics, NuPECC and APPEC. HIP is also finalizing a strategy plan of its own which was presented. A number of questions were also identified for the SAB to discuss and these discussions will be brought up in connection with the relevant subjects presented in this report.

The numbers of publications, PhD theses and master theses completed since last year were presented together with a report concerning new employments.

The budget presented for the coming years shows that the funding from the ministry has decreased by 24%, but also that the universities have compensated for this loss from their own resources.

In response to a request from the SAB last year Eija Tuominen reported on HIPs work concerning diversity. She presented statistics on the number of women among HIP personal, HIP researchers and HIP management. She showed ongoing work to increase diversity and wellbeing in HIP.

As in every previous year, the SAB finds that HIP is doing extremely well. The number of HIP refereed publications continues to be at a high level and the number of PhD theses has also increased. HIP also continues to do a really excellent job in education and outreach despite some of the events being canceled due to COVID-19.

The SAB is shocked and disappointed by the decreased funding coming from the ministry given HIPs high standard. However, the support from the member universities shows a strong commitment from them, which is really appreciated by the SAB.

Last year the SAB was very pleased to learn that the funding for the upgrade of CMS, ALICE, TOTEM and Computing had been awarded. However, the SAB wants to stress the importance of continuing support for the upgrade projects at LHC.

The SAB finds HIP's strategy plan very good. By focusing on specific areas, it demonstrates that HIP is well aware of its resource limitations as well as its research strengths and the areas where it

has critical mass to make an impact. It is also in line with the European Strategy for Particle Physics and with NuPECCs plans. However, the SAB would have liked to see additional guidelines for future activities. This would also help when deciding which possible new experiments to join, if any, and it would also make it easier to motivate support for new activities. The SAB would like to hear more about the strategy plan next year.

The SAB was asked to give their opinion about HIP taking part in the COSINUS experiment. With the extra information provided after the meeting, the SAB supports such an initiative.

The SAB was very pleased with the presentation on diversity and also with the work put into this very important subject. However, next year the SAB would like to hear more details, such as the particular efforts at the different universities.

Theory Programme

The head of the theory programme Kari Rummukainen gave an overview of the programme and showed the progress done since last year concerning publications and theses. He also presented some highlights from the continuing projects "High-energy phenomenology in the LHC era" and "QCD and strongly interacting gauge theory". The two new projects "Theoretical Cosmology" and "Topological Matter" were presented by their leaders Sami Nurmi and Teemu Ojanen respectively.

1. Theoretical Cosmology

The cosmology project is focusing on frontier topics such as inflation, dark matter and baryon genesis, and gravitational wave signals from the early universe. The presentation identified hotspots of research around quantum origins, non-equilibrium QFT and Dark Matter and Gravitational Waves and Large Scale Structure - each of which had led to a number of publications as well as ongoing collaborations between the cosmology theory groups at the Universities of Jyväskylä and Helsinki. Due to Covid-19 some workshops, meetings and schools had been canceled.

2. Topological matter

The presentation of the topological matter project, showed some highlights on topological states in random systems, on topological superconductivity in magnetic hybrid systems and on Weyl semimetals. The SAB was pleased to see new funding from the Academy of Finland for Designer Topological Matter (2020-2024). New recruitments are ongoing but due to Covid-19 some of them have had to be delayed.

Overall the theory programme is performing very well with an impressive number of publications and PhD theses. The board was also impressed by the presentations on theoretical cosmology and on topological matter.

The SAB finds that having three main projects QCD, phenomenology and cosmology belonging to HIP's core activities together with a small new activity is a good strategy to preserve critical mass and diversity.

The SAB would have liked to see more of the collaboration within HIP for example the number of common publications and more details about the connection with the HIP experiments. The SAB looks forward to obtain this information in a report next year.

The SAB also discussed ERC grants and would also like to hear about the number HIP persons, which have received ERC grants and how many that have applied. HIP could/should be a platform where universities collaborate and support each other in order to better succeed in obtaining funding from outside Finland.

CMS Programme

Kenneth Österberg gave an overview of the CMS activities. He also gave detailed presentations of TOTEM, the CMS Forward Physics and Tier-2. The CMS experiment was presented by Mikko Voutilainen and the CMS upgrade by Panja Luukka, respectively responsible for HIPs CMS operation and analysis project and for HIPs part of the CMS upgrade programme.

1. CMS detector operation and Physics analysis

The HIP group's visibility within CMS with several members acting as co-conveners in different physics groups was shown together HIP's continuing contribution to CMS operations on track alignment, and on Jet Energy Corrections. The use of machine learning for the track finding algorithm and for separating gluon jets from quark jets was highlighted.

Concerning physics analysis, the HIP takes part in precision measurement projects as well as in searches for new particles. Measurements of the inclusive jet cross section and the inclusive gluon jet cross section are part of HIP activities as well as a continuation of precision measurements of the top quark mass. One highlighted activity was a jet energy recalibration, done by the HIP group, of D0 data which shifted its top mass to be in agreement with other measurements. Results of the search for a charged Higgs boson decaying to $t\bar{b}$ and A^0 decaying to 2 leptons and 2 τ were presented. The ongoing work with τ or WH in the final state of charged Higgs Bosons as well as the search for gluino pairs with four top quarks in the final state was reported.

2. CMS upgrades

The CMS pixels in layer 1 have to be refurbished and the modules were flip-chip bonded by a Finnish company and then tested at the HIP detector laboratory. The yield of the models was high with about 90%. With this project finished the main focus will be on reducing the impact of pileup interactions. CMS will add new timing subdetectors for precise time stamping of minimum ionizing particles. Finland will contribute to the endcap precision timing layer, the pixelated Low Gain Avalanche Detector (LGAD). Due to lock-downs in most European countries, HIP was the only institute where testing of the new LGAD prototypes could take place.

HIP is also doing R&D on a new pixel detector which can survive the high luminosity conditions expected during HL-LHC. Atomic Layer Deposition grown thin films, a technology invented in Finland that would allow producing thin p-type pixel sensors with very small pixel sizes, is in the focus of the pixel detector R&D.

The Lappeenranta University of Technology is involved in the CMS Muon System Upgrade. They participated in the construction of the readout electronics and data acquisition system for CMS forward muon station. All the electrical components have been successfully produced and they are now installed and are being commissioned.

3. TOTEM and CMS Forward Physics

The HIP group is responsible for the TOTEM physics coordination and for the analysis of common topics with CMS. The group is taking part in the analysis of soft diffractive and inelastic processes, studies of glue-balls, exclusive $\gamma\gamma$ and low mass SUSY searches. Highlighted in the presentation were analyses that gave evidence for the C-odd three gluon compound state called the Odderon also found in studies in collaboration with D0.

Concerning detectors, HIP will contribute to the new scintillator based detector nT2. The TDR for nT2 was approved by LHCC in September 2019. HIP is also involved in the upgrade of Precision Proton Spectrometer with the diamond based proton time-of-flight detector. This detector is part of CMS and gives a unique possibility to measure high mass exclusive processes.

4. Tier-2

The Tier-2 computing center is performing well with existing resources. HIP Tier2 average availability since last SAB meeting is 91%. A challenge is to fund and meet the increased LHC computing demands.

As the SAB expressed several times in previous reports, it is very impressed by the detector work done in TOTEM and CMS as well as by the analysis work done in both experiments. The SAB finds the plans for the detector work with focus on silicon very good. The CMS experiment priorities with synergies between software developments in tracking alignment and jet energy corrections and physics analysis are very well chosen. The SAB does not suggest any changes. The SAB strongly supports HIP's involvement in building a completely new Precision Proton Spectrometer for HL-LHC.

The SAB was pleased to see that the LHC upgrade projects have been awarded appropriate funding for 2019-2021 but the SAB stresses the importance that the funding continues after 2021 so the projects can be completed.

Concerning computing there is an issue for funding of the increased amount of storage requested in the future which needs to be solved.

Nuclear Matter Programme

A short introduction of the Nuclear Matter Programme was given by Ari Jokinen and the different projects, ALICE, ISOLDE and FAIR, were presented by their respective group leader, Sami Räsänen, Janne Pakarinen and Tuomas Grahn.

1. ALICE

The HIP group is highly visible in the collaboration with contributions to both physics analysis and to hardware.

The main analysis activity is focused on Flow. The convener of the Physics Analysis Group in ALICE is a HIP member. HIP is providing a significant contribution to the Flow chapter in ALICE's review paper in preparation. The group is also involved in studies of the jet transverse structures and of di-jet mass distributions.

HIP has a very large responsibility for the Fast Interacting Trigger, FIT, and the project leader is a HIP member. In the presentation a concern was raised about HIP's funding for hardware versus personnel contributing to the detector work.

The group already last year expressed an interest in taking part in a new detector, a Forward Calorimeter FoCal for Run 4. This project is now approved by ALICE. Funding from some countries has to be secured. HIP wants to contribute to the Technical Design Report with physics performance studies and will apply for funding for that.

As in previous years, the SAB finds the HIP contribution to both the analyses and the hardware very impressive.

The SAB is pleased to see the good progress with FIT and congratulates HIP for its contribution. Concerning the funding of the personnel the SAB needs to be provided with more details to be able to give any advice.

The SAB also supports the planned activities in FoCAL.

2. ISOLDE

The variety of publications and the future plans for HIP-ISOLDE were presented. Highlighted was a measurement at MINIBALL of the Coulomb excitation of $^{224,226}\text{Rn}$ for the determination of the atomic dipole moment. Also highlighted were two particular measurements, one on the first nuclear structure information obtained for the nucleus ^{207}Hg by using the ISOLDE Solenoid Spectrometer and the other on the alpha decay from two-states in the parent nucleus ^{186}Tl for which the use of SPEDE played a key role. For the future, many experiments are planned employing the SPEDE detector which will be installed in the MINIBALL set up.

The SAB is very pleased with the progress made for the projects at ISOLDE and with the obtained results. The SAB is very positive about the on-going plans for experiments exploiting the capabilities of SPEDE. The SAB strongly supports HIP to continue to take part in this rich and productive research.

3. FAIR

The cost and the status of the different in-kind projects were briefly presented. Highlighted was the successful tests of the detector MONSTER at the Jyväskylä ACCLAB.

HIP is involved in two phase-0 experiments at the upgraded GSI accelerators. One experiment concerning searches of nuclei in the region $N=126$ was carried out in 2020 as was another measure of the masses of neutron-deficient nuclides below ^{100}Sn . The phase-0 will continue until phase-1 starts.

The SAB was happy to hear about the progress at FAIR and that the Finnish group is well involved in relevant activities in Phase 0. The SAB is also pleased to hear that some in-kind contributions are getting ready.

The SAB finds that the HIP group has a good balance between experimental activities and the construction work of Super-FRS.

The SAB was asked to express an opinion about the resources needed for the construction work but the SAB needs more details to be able to give any advice.

Technology programme

The technology programme was presented by its director Filip Tuomisto and separate talks were given by Ilja Makkonen and Roel Pieters, the project leaders for “Materials for Big Science Installations” and “Robots and AI for monitoring and intervention”, respectively.

The programme is organized in four different areas, Systems, Materials, Radiation Safety and the Programme director which together contain nine projects. The project “Materials for big science installations” and the following four projects are planned to be finish by the end of 2020. The project “Modules, Structures and Manufacturing” develops high precision industrialized manufacturing and assembly of accelerators components and it has a focus on CLIC. For its continuation the project is depending on funding from Business Finland. The “Gamma project” works on novel gamma ray spectroscopy for testing radioactive materials. This project collaborates with laboratories abroad and has a MoU in preparation with CEA France on the development of an instrument to be installed at CEA Atalante. The project “Materials for Accelerators Technologies” focuses on understanding the evaluation on surfaces under high electric fields. It plans to continue studies of materials for future accelerators at CERN and for acute issues at LINAC for LHC. The “Business Incubation Center” aims to improve commercialization of CERN related technologies and has had some progress during the last years, with some new projects receiving external funding.

Three ongoing projects are dealing with measurements of radioactivity. In one project instruments are developed to measure radiation in medical treatments. In the second one several actions are undertaken to improve the STUKs laboratory detection capabilities by implementing, state-of-the-art techniques and methods typical of experimental nuclear physics research. The third project develops novel instrumentation for nuclear safety and safeguards.

1. Materials for big science installations

The presentation of this project gave examples of new materials which can stand hard radiation and thus could be useful for future accelerators and also for fusion reactors. The plan for the future is to continue to work on Nb-Cu materials together with “Materials for Accelerators Technologies” and to study applications of high-entropy alloys together with the Aalto University and VTT.

2. Robots and AI for monitoring and intervention

The robot project studies the possibility to use robotics and AI in very harsh environment at CERN, specifically at ALICE and in the LHC tunnel.

The SAB was pleased with the presentations which gave a rather clear picture of the technology programme.

The SAB is aware that it does not have the proper expertise for all the projects in this programme and thus cannot give any detailed advice. However, the SAB would like to stress that it is important that the programme is more focused with the clear aim of getting results.

An issue concerns the technology transfer and industrial activation network. This used to be strong and Finland used to have a relatively large industrial return from CERN. It is unfortunate that this

declined. To improve the situation the SAB stresses the need for a well-supported Industrial Liaison Officer.

The Detector Laboratory

The Detector Laboratory was presented by its leader Eija Tuominen. The Laboratory has three missions, to support experimental activities in detector developments and instrumentation, to participate in teaching and social interaction and also in externally funded R&D activities.

The permanent staff has a variety of skills and has since the last SAB meeting expand with one scientist. The Laboratory has excellent premises as well as a variety of technological competences. The Laboratory is involved in CMS, TOTEM upgrade and in the in-kind contributions to FAIR and also in external funded projects connected to HIP. A new activity, introduced by the new staff scientist, is the involvement in the CERN experiment MOeDAL which is searching for monopoles and other exotic particles.

The rich teaching programme contains several master courses, a Nordic research training course and PhD, master and Bachelor theses. The importance of recruiting a permanent member of teaching staff was emphasized. Several examples of outreach activities were also mentioned.

The SAB was pleased with the presentation and is indeed very impressed by the activities at the Laboratory.

The SAB understands the importance of having a teacher in instrumentation and supports the idea but cannot for obvious reasons judge between different priorities at the University of Helsinki.

The SAB supports that HIP formally joins MOeDAL since HIP already has an experienced person involved in the experiment.

The SAB would like to have a presentation from the laboratory also next year and would then appreciate if a schedule and a timeline of the different activities could be presented also.

SAB would like to warmly thank the HIP directorate for the excellent preparation of the meeting. In particular for all the reports and presentations that were suggested in last year's report. The SAB thanks also the speakers for their clear presentations.

For the HIP Scientific Advisory Board

Barbro ÅSMAN (chair of the SAB)