Recommendations of the 88th Physics Research Committee

November 2019

General remarks

At the 88th meeting of the PRC, a dedicated review committee evaluated the case for the realisation of the MADMAX experiment at DESY. The evaluation led to a separate evaluation report. This report only contains a summary of the main findings of the review.

ATLAS

Since the last PRC meeting, the DESY ATLAS group has yet again made very strong contributions to the ATLAS experiment. The group holds a significant number of leadership positions across all areas of the ATLAS collaboration, most notably the current physics coordinator. The scientific output of the group is excellent, with 16 peer-reviewed journal publications since the last PRC meeting. The PRC is very pleased to observe that the group actively develops its profile and priorities. The group continues to be attractive to early career researchers, who are offered challenging projects that combine detector and data analysis work. A new Young Investigator Group starting in 2020 will further strengthen the group.

The group's physics analysis efforts cover a wide range of timely topics. The group has again made impressive progress, with strong contributions to several analyses that use the full dataset recorded during the LHC Run 2. Among the most visible contributions of the group are measurements of Higgs boson properties, including searches for physics beyond the standard model in the Higgs sector. The PRC is pleased to see several group members publishing short author list papers in addition to ATLAS publications.

The PRC is pleased to see the continuing strong commitment of the group to the development of physics object performance, software tools, and computing.

The PRC is impressed with the progress of the group towards the ATLAS strip tracker upgrade for the HL-LHC. The laboratory equipment as well as detector assembly and qualification tools and procedures are being completed and first detector modules with the final design have been built at both DESY sites.

Key comments and recommendations for ATLAS:

No specific recommendations are issued.

CMS

The DESY CMS group since last PRC has 6 Ph.D. theses defended (1 summa cum laude) and 2 master theses, 6 CMS publications plus 2 phenomenology papers. The career paths for Ph.D.s and Postdocs continue to be excellent; there is high visibility/responsibility in the group's activities and in the experiment. It is therefore very attractive for young researchers worldwide to get a position at DESY.

The DESY CMS group continues to make strong contributions to the experiment:

- leadership positions and coordination roles across all aspects of the experiment; cooperation/collaboration with other groups; the group's contribution to leadership and physics papers is above its weight;
- physics analysis: there is a broad physics portfolio covering Standard Model, top physics, Higgs, SUY and exotic searches. Examples of analyses with key contributions are: ttH production in the H→bb decay channel, single top production, Higgs to t channels, first evidence of the running of the top mass, multi-differential tt cross section, high transverse momentum jets, top polarisation, etc.;
- data collection and computing: precision measurement of integrated luminosity with DESY as main driver and a total uncertainty of 1.1%; significant contributions to pixel alignment;
- detector development and construction / upgrade: There is a recognized effort on the development of ELAD detectors; the PRC encourages the group to explore joining efforts with other R&D groups at DESY. Concerning upgrades, the high-granularity calorimeter is a successful application of the FLC detector group work. For the tracker phase II upgrade, there is excellent progress on the preparation / planning for the construction of the tracker phase II, and the developments are according to schedule – there seem to be no major showstoppers. All in all, DESY is a taking a solid and well justified approach to a very challenging project.

PRC congratulates the CMS DESY team for its excellent performance, results and leadership. PRC recognizes DESY CMS group for their continued significant accomplishments and publication record. We particularly congratulate the group and its members for recent awards (C. Alexandrou, A. Grohsjean, M. van de Klundert).

Key comments and recommendations for CMS:

No specific recommendations are issued.

Belle / Belle II

The DESY Belle group continues to grow, most notably through a W3 group, but also through additional fellows and graduate students. Members of the DESY group hold key positions in the Belle experiment organization.

DESY contributes to or is leading several analyses of Belle II data. The DESY group has a leading role in the ongoing detector performance studies and is strongly engaged in software development in the areas of tracking, vertexing, alignment, calorimeter calibration, and reconstruction as well as physics analysis software.

DESY continues to make strong contributions to the Belle computing and in particular hosts all Belle collaborative tools.

Phase-3 data taking has started in March 2019 with 6.5/fb collected until the summer shutdown. Several problems have been encountered

- two fast beam losses leading to collimator damage, major quenches of the final focus system and beam showers hitting the PXD;
- high beam background by beam-gas scattering in the LER which limits the luminosity that can be achieved;
- beam blow up during luminosity tuning.

These problems need to be understood and cured in order to achieve the luminosity goal of Belle II.

The PXD has suffered from two beam loss incidents which raised the fraction of dead and hot pixels from 5% (=one bad module from the start) to 15%, likely due to single event upsets. During the summer shutdown this fraction could be reduced to 7%. Apart from this set-back the PXD is taking data successfully.

A fast shutdown of the PXD power supplies based on measured radiation doses is being prepared which should reduce further damage in the event of fast beam losses.

Updated extrapolations of the observed beam background to full luminosity running lead to a total PXD occupancy of twice the expected limit of 3% which would still be tolerable (but is untenable for SVD, TOP and particularly CDC).

The PXD collaboration is working on a new PXD detector which will replace the current, de-scoped PXD. Delivery to KEK is currently foreseen for October 2020, well in time for installation into Belle II in spring 2021. The Belle II management is, however, considering to delay this by one year.

Ten L2 ladders for the new PXD have been assembled according to the improved procedures and are fully functional. Therefore, it is concluded that the quality issue in ladder assembly has been overcome. All needed ASICs are in hand. The production of new DEPFET sensors is well on track.

High currents in the CDC limit the beam current and therefore the luminosity. The problem of persistent current increase in the CDC seems to be mitigated by an increase of the H_2O content in the gas and by switching off one layer. There is evidence for cross talk on the CDC front end electronics which can be removed by a filter in the reconstruction code developed by DESY.

Key comments and recommendations for Belle / Belle II:

PRC notes with pleasure that the DESY Belle group continues to make strong contributions to the project and welcomes the initiative of members of the group to help addressing the problems encountered in the operation of the Belle II experiment at the SuperKEKB accelerator.

PRC commends the group for their leading role in physics performance studies and in the preparation of the first two Belle II physics papers.

PRC takes note that the Belle II management considers a possible delay of the installation of the new PXD to 2022. In this case DESY would need to retain the required expertise and person power for longer than currently anticipated.

International Linear Collider Activities and Preparations for Future Experiments

We reassert DESY FLC group as one of the major players to the common worldwide international effort to develop the future projects of accelerator-based particle physics beyond the LHC programme:

- FLC is a core group to obtain the final results and documents submitted to EPPSU;
- members of the group have led key contributions/discussions in recent workshops (LC Community Meeting in Lausanne, European Strategy Symposium in Granada).

The participation of group for the ILC case is essential and is reflected in the important coordination responsibilities (spoke-persons for ILD and SiD). Cooperation with CLIC is positive and continues along the lines/prescriptions that have been recommended by the PRC in previous meetings. The group is very active getting additional external resources which mainly come from EU funds (AIDA2020, E-JADE, etc..). Strong involvement of members of the group and high-level coordination for instance in AIDA2020 new submission.

The group has started an internal strategical process to broaden its scientific activities and to best adapt the knowledge of the group to the possible outcomes of EPPSU. This includes a broader scope of applications on the basis a strong R&D program including detector development (tracking+calorimetry), software tools and physics studies.

The activities of the group cover: detector development (time projection chamber, vertex detector R&D, high granular scintillator SiPM-on-tile calorimeter (AHCAL), forward calorimetry, site studies, detector integration and machine-detector interface, software developments, physics studies in Higgs & BSM.

The strategy discussion is based on a strong technological portfolio: TPC/ Si detectors (activities directed more strongly towards Si tracking R&D); calorimetry on SiPM technology (develop present CMS cooperation and future applications to the DUNE detector); software (apply to broader fields / machine learning techniques); physics studies (create a platform for future facilities on the basis of a Higgs factory).

All aspects above were discussed in detail in the input document to the PRC provided by the FLC group.

The group has an excellent scientific production on physics/detector R&D publications, Ph.D. theses, and contributions to conferences. The publication record since the last PRC comprises 1 bachelor thesis; 3 publications; 4 preprints on physics & detector R&D.

Key comments and recommendations for the FLC group:

PRC reinforces the recognition of the group as one of the key players in the common worldwide international effort to develop the future projects of new accelerators beyond the LHC. In particular PRC acknowledges the group's outstanding contribution to the document preparation of the ILC case and participation/discussion in working groups of on-going process of the European Strategy Update.

PRC supports the internal process of the group to establish the strategy to broaden the scope of application of their activities. We acknowledge the present lines of exploration. Personnel/technical staff needs to be part of the discussion and discussed accordingly.

PRC also supports the present efforts beyond ILC (CLIC, CMS/CALICE/DUNE in calorimetry, technology R&D in calorimetry and tracking, and the development of software tools for future colliders).

PRC encourages the group to explore cooperation with other DESY groups to form a strong R&D DESY team with a broader scope covering future HEP experiments (neutrino physics, Higgs factories)

PRC congratulates the group for the excellent progress and high-quality achievements reached in all areas in which the group participates. In particular the collaboration with the CMS end-cap calorimeter (HGCAL) should be continued and strengthened.

Theory

We congratulate the Lattice Gauge Theory group in Zeuthen for their efforts in improving the Standard Model predictions for the strong gauge coupling and B physics and in computing PDFs from first principles. Although it is a relatively small group, they have the critical mass to have an internationally leading impact. The state-of-the-art evaluation of the strong coupling constant is a particular highlight. More recent work on the computation of first principle PDF's is impressive and we encourage the group to persevere in this promising direction that could lead also to important results and have an impact on future experimental analyses. The potential of applying quantum computing to problems in quantum field theory is exciting, but also a very challenging and should be continued. We congratulate the lattice group on their productive interactions with quantum computing experts in Cyprus. We note that the future of the group relies on developing opportunities for young scientists.

The committee congratulates the theory group on developing a strategy for the Wolfgang Pauli Centre; we continue to strongly support the plans to focus theoretical physics on the DESY site. We strongly believe that the planned new building to host all the Theory group members, will strengthen the research activities of the Theory group and will boost the interdisciplinary collaboration and communication within the Hamburg Theory community. We are convinced of the need for increased space and new facilities for the WPC. We note that the DESY theory group is currently spread across three different locations. The severe shortage in office space restricts the possibility of hosting third-party funded fellows and research groups (for instance Emmy Noether groups). There is no space for master students and this severely limits the number of master thesis carried out. The lack of appropriate communication space and the insufficient level of seminar rooms curtails the scientific exchange within the group. The seminar rooms in the WPC building will also serve the requirements of the 1st Institute of Theoretical Physics of UHH. The fact that this group will move to the Bahrenfeld campus from their current city centre location already in February 2020 will further increase the demand on appropriate seminar room space. It is highly desirable that the new facilities are fully operational by the end of the PoF IV period and will become a positive factor when it comes to apply for an extension to the Quantum Cluster of Excellence.

On the other hand, we are disappointed to hear that the agreement about reopening one position in the phenomenology group in Zeuthen has not been fulfilled and that the future of a critical mass in theoretical particle physics in Zeuthen is still uncertain. While the hiring of Rafael Porto is a positive development and brings in complementary expertise to DESY Hamburg, it does not improve the issue of the phenomenology group in Zeuthen.

Key comments and recommendations for theory

1. We recommend that DESY continues to support the activities of the Lattice Gauge Theory in Zeuthen and generically of the theoretical groups with highly technical expertise. A special role of theory groups at laboratories is given by the fact that reduced teaching and administrative duties allow people to concentrate efforts on research and focus also on very challenging theoretical computations, which are vital for future precision programmes (see e.g. the European strategy!). We are concerned about the age profile of the lattice group, and would like to see a transparent and robust succession strategy for maintaining the very high impact of the group.

2. We recommend that the momentum towards construction of the new building to host the WPC is maintained by assigning this project a high priority.
3. We repeat our previous recommendations:

   "The PRC recognises the unique expertise and very visible impact on the field of the DESY Zeuthen collider phenomenology group, and we recommend that DESY develops a strategic plan to maintain a critical mass for this activity within DESY."

   "It will be a real loss for the community if the unique activity of the Zeuthen group in precision collider phenomenology will be lost (5-loop beta function, PDFs, massive splitting functions, …). This is an outstanding group with activity that is no less world-leading than the rest of the theory group."

   We strongly recommend to support as much as possible the collider phenomenology activity in Zeuthen and to maintain at least the critical mass of 2 staff members.

MADMAX

The review committee enthusiastically endorses the physics goals of the MADMAX proposal, claiming ultimate sensitivity for a very large axion frequency range 10-100 GHz in two phases. In some axion models this frequency range includes the axion mass as a dark matter. The detection of axions will open the field of axion astrophysics and provide insight to the formation of galaxies, but also the strong interactions; it would be a major breakthrough. We recommend approval of the phase II of the project.

The magnet is the highest risk for the experiment, but it can be built and operated safely if it is done properly. We endorse the findings of the separate magnet review panel, but we also strongly recommend the appointment of a magnet Czar. Given the cost of the magnet it would be tempting to cut corners, but this can generate delays at the end of the construction. The coils should be dismountable and enough cable should be purchased all at once; enough at least for one extra coil (largest length).

The booster concept is sound, but mitigation plans should be envisaged in case of breakdowns. The whole prototype concept should be tested under realistic conditions inside the cryostat. The detector concepts are adequate and probably will get better with time. The total noise figure should be estimated and tested by controlling the physical temperatures of the various elements to establish which parts are essential and critical in defining the noise temperature of the system. We believe there are untapped opportunities in that direction which could improve the whole sensitivity, especially in the high axion mass spectrum.

Key comments and recommendations for MADMAX:

Specific recommendations are documented in the dedicated report to the PRC.

BabyIAXO

PRC congratulates the BabyIAXO experiment for the very successful evaluation in the spring PRC meeting, and for their very swift and complete reaction to the recommendations issued there.

ALPS-II

The construction of the ALPS-II Experiment is entering the hot phase. We congratulate the collaboration on the installation of the first magnet(s) in the old HERA tunnel.

We thank the collaboration for the detailed schedule of the experiment for the next years and we are very happy to hear that the delivery of the material and the first installation works are proceeding according to schedule. Also the need of straightening four more magnets is not causing delays as the operation should be completed for January 2020. There are a few open issues:

- longer cavity: mirror coating and length actuation;
- installation of cryogenics should be completed by June 2020;
- person power for the optics, especially TES detector.

Key comments and recommendations for ALPS:

We strongly encourage the collaboration to continue its efforts and keep to the presented schedule to be ready for data-taking in 2021.

We recommend to DESY to continue in the support to the experiment during the installation phase, especially for the infrastructure related to the cryogenics and magnet strings.

Regarding the optics personnel, it should be ensured that in these final stages of the experiment sufficient person power is present for installation of the optics module and later operation. We suggest to explore possible synergies with other experiments in the photon or astroparticle physics to identify people with needed expertise and give them as well a longer-term perspective.

Computing / IT

We commend the continuing success of the DESY computing large-scale facility. The Tier-2 compute and disks systems and the NAF are performing very well with good strong utilization and good uptime.

It was reported in PRC87 that the wide-area network capacity was increased to 2x50Gb/s. While this increase has relieved the bottleneck, still there are short periods in which the network is at capacity. This area will need continued attention as the networking demands are likely to grow with changes to the CMS and ATLAS data organization, management, and access (DOMA) models and as the data traffic for Belle II grows.

IT is increasingly acting as a partner in providing scientific computing expertise required to directly support DESY programs. In the time since PRC86, a JupyterHub has been deployed to support analysis using JupyterNotebooks and have increased the infrastructure support virtualization and containers. GPUs have been deployed on the NAF. There is increased machine learning support, including training sessions. This is very significant progress.

The PRC appreciates receiving the document “Task and Resource allocation of the DESY IT-Group in Hamburg”. This document was quite helpful in understanding how the effort was allocated. In scientific computing, there are two groups, one that

focuses on operations, the second that focuses on externally focused and funded projects.
For the PoF IV period, a new topic 'Data Management and Analysis' was added to the research program *Matter and Technology.* To foster an interdisciplinary approach, the Tier-2 centre will transition to the Interdisciplinary Analysis Facility (IDAF). This will open up NAF resources to PETRA-III/FLASH user and will extend the use of HPC resources for ATLAS and CMS.
Staffing remains tight considering all of the on-going work, increasing requests for central support and balancing the increasing needs of the XFEL.

Recommendations for computing / IT:

The PRC commends IT and DESY for close collaboration between Helmholtz Centres with the Canadian laboratory TRIUMF on machine learning, big data and quantum computing.

The evolution of the Tier-2 Centre to the IDAF represents a new chapter in scientific computing at DESY. Over the past several years, consolidation projects, such as changing to HTCONDOR, have been successful in improving the operational conditions and have facilitated the ability for other consolidation projects and enhanced features. The PRC encourages this nimble approach, which will be extremely helpful in a successful transition to the IDAF.