

Recommendations of the 87th Physics Research Committee

May 2019

General remarks

At the 87th meeting of the PRC, a dedicated review panel evaluated the case for the realisation of the babyIAXO experiment – as a precursor for IAXO – at DESY. The chair of the panel reported to the PRC about the outcome of the review. A written report will follow in due time. The PRC welcomes very much the proposal to host the babyIAXO experiment at DESY. Besides its role as a precursor experiment, babyIAXO will already be able to explore new and very relevant parameter space for axion like particles and has therefore a strong physics case of its own. The installation of babyIAXO at DESY would add significantly to the international visibility of the axion program at DESY. PRC encourages the babyIAXO collaboration to continue their preparations for the realization of this experiment. PRC encourages DESY to take all necessary steps to host babyIAXO and in particular to help in consolidating the collaboration with CERN on the construction of the babyIAXO magnet.

Congratulations to all DESY particle physics on the initiation of the Excellence Cluster *The Quantum Universe* with Hamburg University, and we look forward to hearing about the results from productive collaborations across all involved experiments and theory.

ATLAS

DESY ATLAS group continues to make strong contributions to the experiment. The group holds several **very visible positions** in management, detector operation, upgrade, computing, performance, and physics (e.g. deputy physics coordinator).

It has a well-balanced portfolio of **physics analysis**. Since the last PRC, the group contributed to 18 publications and 15 public notes; in the field of SM physics, these publications cover xFitter-based PDF fits, diboson physics, and light-by-light scattering in heavy ion collisions. In the field of Higgs physics, studies of decays to photons and leptons were published, as were associated ttH production and ttbb production. Also a number of BSM analyses were published with significant DESY contributions (search for electroweakinos, various DM searches, and a number of top-sector analyses).

The group also has very visible contributions to **detector operations**, e.g. to the operation of the silicon tracker, in the software and commissioning of the tracking co-processor (FTK), and in the (soon to be ramped down because of the retirement of key DESY personnel) forward detector ALFA activities. Further impact is achieved through important **software** contributions, e.g. for tracking and object ID (inner detector tracking, electron and photon reconstruction, b tagging), and in performance studies (luminosity from track counting, track selection efficiencies using Z bosons). A particular highlight is the significant reduction of b-tagging uncertainties achieved by group members.

DESY-ATLAS is very visible with its contributions to the **strip tracker upgrade** for the HL-LHC. The new clean room facility in Zeuthen is ready, and the Hamburg facility in bldg. 25c is now fully operational. Various tasks are taken over by the group for modules (assembly in Zeuthen and Hamburg, electrical tests, beam tests, burn-in, thermal cycling), petals (core production, loading with modules, end-of-substructure boards), and the entire end-caps

(petal insertion, infrastructure like large cooling systems, transport frames, etc.). The PRC was presented with a deep “dive-in” on upgrade project planning that showed realistic planning and adequate person power (some details need to be clarified in a follow-up).

On the **personnel** side, there are several new fellows and Ph.D. students; at the time of the PRC meeting, the group had exactly 100 members. There are well-integrated YIGs in Hamburg and Zeuthen. PRC congratulates I. Gregor for accepting a joint W2 professorship on detector development with U Bonn and C. Issever for accepting a joint professorship with HU Berlin.

Key comments and recommendations for ATLAS:

PRC congratulates the DESY ATLAS group for their significant accomplishments in a broad range of ATLAS contributions.

CMS

The DESY CMS group keeps up its **high publication record** – since the last PRC, three Ph.D. thesis were defended (two *summa cum laude*), and five papers were published. The DESY Ph.D.s’ and postdocs’ **career path** continues to be excellent: They obtain high visibility/responsibility in their activities and in the experiment, as is also witnessed by two CMS achievement awards for DESY scientists. It remains very attractive for young researchers worldwide to get a position at DESY.

The DESY CMS group continues to make **strong contributions** to the experiment. DESY scientists take numerous **leadership** positions and coordination roles across all aspects of the experiment. DESY contributes to leadership and physics papers above its weight as number of people.

The DESY group covers a **broad physics portfolio** covering Standard Model, top physics, Higgs and SUSY searches. They make extensive use of machine learning techniques. In SM physics, they contribute to QCD studies, parton density studies, measurements of inclusive jets and of dijet angular correlations, to inclusive B-jet measurements, and to W+c studies. In Higgs physics, they worked heavily on MSSM $H \rightarrow b\bar{b}$ MSSM, $H \rightarrow \tau\tau, b\bar{b}$, and on the search for heavy Higgs bosons, and in top physics on cross sections measurements (inclusive, 1d differential, 2d differential, tt+jets, 3D), on measurements of the top mass, on tt+H(bb) using 2016& 2017 data, on tt+bb and tt+Z, and on boosted and BSM topologies. The programme was complemented by SUSY searches (in the di-tau channel – aligned with the Higgs analysis – and an inclusive gluino search). There were also extensive contributions to physics studies for the HL-LHC and HE-LHC planning exercise.

In **data collection and computing**, DESY clearly contributed to the 92% efficiency of CMS. The DESY T2 is performing extremely well, and all pledges could be satisfied. The LHC1 Network into/out of DESY is now 2x50 Gb/sec, which has relieved the network congestion. DESY is developing deep learning tool to automate workflows. DESY also continues to make significant contributions to pixel alignment (Millipede-II software).

In the field of **CMS detector development and construction**, DESY-CMS has produced 2 C structure prototypes for the phase 2 BCMF1; they are currently undergoing beam tests. The high-granularity calorimeter design chosen for CMS is the DESY SiPM-on-tile design that was co-developed by the DESY-FLC group, to be used in the calorimeter end cap where

the radiation levels permit. DESY contributed engineering to this effort with an EDR to be delivered in 2021.

The **tracker phase 2 “Deep dive”** given to the PRC explored all aspects of DESY responsibilities: The person power and skill mix estimates are now well understood for the duration of project; and the DAF infrastructure is in ‘shake-down’ mode. DESY has to build 1250 4.0 mm PS modules — and detailed plans in place. Four modules per day is feasible, five modules is possible. DESY will also handle the module burn-in for DESY and other modules. The lab’s responsibilities include the assembly of Dees, of Dees to half-disks, and of half-disks to one endcap. The arc frame Dee support structure is a critical component, and the construction of a second prototype is in progress. The overall staffing plan is updated; there is a current understaffing in WP2 (MaPSA).

Key comments and recommendations for CMS:

Congratulations to LHC/CMS for successful data taking in 2018 and the completion of Run 2, and congratulations on the success of the CASTOR project (very forward calorimeter), on many publications and on a public data set. Further congratulations on the awarding of a joint professorship with U Wuppertal for Katerina Lipka, and to Juan Fuster for the Humboldt Award.

PRC recognizes the DESY CMS group for their continued significant accomplishments and publication record. The group provides an excellent choice for the career path of young researchers (Ph.D.s, postdocs).

We commend the level of detail and the clarity of the information presented in the tracker phase 2 “deep dive” as response to the recommendation of PRC 86. There is excellent progress on the preparation/planning for the construction of the phase 2 tracker. DESY is taking a solid and well justified approach to a very challenging project. We look forward to hearing additional progress towards establishing the key roles in the management structure.

Belle / Belle II

The DESY Belle group continues to make very good progress. The schedule presented at the last PRC has been met: the vertex **detector VXD has been installed** into Belle II on 21 November 2018; the phase 3 run was started as planned and **first collisions** have been observed on 24 March 2019. DESY personnel at KEK was essential to accomplish the installation of the VXD and the remote vacuum connections (RVCs) in due time and to commission the PXD.

The (descoped) **PXD is taking data successfully.** The observed efficiency and impact parameter resolution generally fulfill expectations, the latter will still improve with better alignment constants. Radiation effects roughly agree with expectations although there is some discrepancy with the dosimetry based on diamond detectors which is under study.

The KEK accelerator complex has experienced a **3-week shutdown** due to a fire in the LINAC building. The recorded integrated luminosity already passed 1/fb.

A **new luminosity projection** has been shown which reaches 50/ab in 2027, two years later than assumed so far. This is caused by a reduction of the expected running time per year from 9 to 8 months and by a slower ramp-up rate of instantaneous luminosity due to the increased background levels.

Backgrounds in Belle II are still much higher than anticipated. Beam losses are dominated by intra-bunch scattering and beam-gas (as expected) but they lead to unexpected production of secondary particles inside the Belle II detector. It remains to be understood why the collimators are unable to avoid that beam particles hit the beam pipe aperture in Belle II. It is hoped that new collimators will bring a reduction by a factor of 4 which is almost sufficient for the operation of the PXD at design luminosity. However, the CDC and the TOP detectors need a reduction by a factor 50-100. Further background studies are required and ongoing.

The sudden and persistent **current increases in some layers of the CDC** are being further investigated. Mitigation actions have been taken which should allow for a successful operation of the CDC at least for the coming months.

The production of a **new PXD detector** (PXD2020) to replace the currently operated (descope) one is ongoing. The ladder assembly procedure has been revised and ladder production is about to restart. Enough material for assembly of a new layer 2 is in hands. For a new layer 1 more sensors and ASICs are needed. Sensor production is underway at MPP/HLL and progressing well. All but one ASIC types are available. Very recently it became clear that the new batch of Switcher-ASICs cannot be used due to a processing issue. The collaboration needs to decide how best to proceed. One fallback option would be to re-use some of the currently operating layer 1 modules. All groups active in the original production are committed to this new production and the funding is available. However, several key people are leaving the project and an effort is ongoing to replace them. This might also affect the commissioning of the new PXD at DESY and in particular later at KEK for which new people need to be found and trained in the participating institutes.

Belle (I) data are still being analyzed. A new R_{K^*} measurement has recently been published which adds important information to the investigation of lepton flavor universality.

The DESY group takes a leading role in ongoing detector performance studies and first physics analyses with **2018 Belle II data** profiting from its strong engagement in software development in the areas of tracking, alignment, calorimeter calibration and reconstruction as well as physics analysis software.

Key comments and recommendations for Belle / Belle II:

The PRC notes with pleasure that the DESY Belle group continues to make very good progress.

PRC fully supports the ongoing production of a replacement PXD system by the German Belle groups and is pleased that all groups have committed to this new production. PRC notes that the need for a prolonged availability of experts due to the construction and commissioning of the new PXD system presents a challenge to the collaboration and expects that all groups make an effort to secure the required personpower.

International Linear Collider Activities and Preparations for Future Experiments

The DESY PRC reasserts the DESY FLC group as one of the major players to the common worldwide international effort to develop future projects of accelerator-based particle physics beyond the LHC programme: FLC is a core group in the production of the final results and documents submitted to EPPSU, and members of the group have led key

contributions/discussions in recent workshops (LC Community Meeting in Lausanne, European Strategy Open Symposium in Granada), The participation of the group in discussions of the ILC case is essential, as is reflected in the important coordination responsibilities that group members take (e.g. spoke-persons for ILD/SiD etc.). The group's 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 in **attracting additional external resources**, mainly from EU funds (AIDA2020, E-JADE, etc.). There is strong involvement of group members – up to high-level coordination roles – in such projects. E-JADE finished in 2018 and AIDA2020 is preparing a 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. The group currently has 3 Ph.D. students and one master student, four post-docs, finished. No new Ph.D. or fellow started within the past year.

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

The ongoing strategy discussion in the group is based on a strong technological portfolio: **TPC / Si detectors, calorimetry on SiPM technology** – for which the group develops the present CMS cooperation and future applications to the DUNE detector, software including machine learning techniques and their application to broader fields. Important assets in strategic discussions are also the physics studies performed in the group and the contribution to the running of experiments (**like** LUXE effort at DESY/E-XFEL where QED will be tested in very high fields in order to explore the non-perturbative regime).

All in all, there is a good scientific production in terms of physics and detector R&D publications, Ph.D. theses, and contributions to conferences. Since the last PRC, there were 4 Ph.D. theses completed and 7 publications and 8 preprints on physics & detector R&D.

Key comments and recommendations for the FLC group:

The PRC wants to reinforce 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, we commend the group on its outstanding contribution to the document preparation of the ILC case and its participation/discussion in working groups of on-going process of the European Strategy Update.

We acknowledge the internal process to establish a strategy to broaden the group's activities, and we support present lines of exploration. The precise plan and exact direction has to be implemented once the EPPSU is finished, and clearly depends on the priorities of the group and the lab as a whole. Personnel/technical staff needs to be part of the discussion. Concretely, the PRC supports the present efforts beyond ILC: CLIC in general, CMS/DUNE in calorimetry, technology R&D in calorimetry and tracking, and the development of software tools for future colliders.

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

Theory

We congratulate the Particle Cosmology group on their very varied and highly successful studies on cosmological applications of models beyond the Standard Model and on the proposal of new signals, broadening the scope of existing searches and constraints, e.g. exploiting gravitational waves or electron scattering for light Dark Matter, and expanding the interplay with Particle and Astroparticle Physics.

The quality and breadth of research activities in the DESY Cosmology Theory group in Hamburg is outstanding. The Particle Cosmology group is evidently thriving and fostering a substantial number of young scientists (not only the 5-year Junior Staff members) that continue very successful careers and influence and lead the field internationally. We congratulate the group on their successful promotion of Young Scientists and on their important contributions for the future of the field.

We continue to fully support the plans for the Wolfgang Pauli Centre, in particular regarding the building of new facilities to host all the Theory group members, to sustain and possibly even strengthen of the research activities of the Particle Cosmology group and to boost the interdisciplinary collaboration and communication within the Hamburg Theory community.

On the other hand, we are disappointed to hear that the agreement reached at PRC86 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 Raphael 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

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 maintain the collider phenomenology activity in Zeuthen at the very least at the Level of 2 staff members as agreed in the last PRC.

ALPS-II

The case for ALPS searches is still very strong and the experiment very timely. The “shining-light-through-walls” ALPSII is one of three flagship axion-search projects worldwide. ALPS is identified with DESY as an on-site experiment.

We highly appreciate and support the new plan of using 24 HERA magnets instead of 20 magnets giving an increase of the length by 20% and the photon regeneration rate by a factor 2. This improves the sensitivity substantially with a slight delay in the schedule, which seems still manageable.

We are very pleased to hear of the continuous progress since the last PRC, especially the substantial steps forward in the TES and heterodyne detector systems. We are happy to hear that the issue of manpower in the optics is improving. The engineering team has also been strengthened, in order to support the future installation in the HERA tunnel.

Key comments and recommendations for ALPS:

We encourage the collaboration to continue its efforts and keep to the new schedule for data taking to start in 2021.

We would like to ask the collaboration to prepare for the next PRC a revised detailed timeline of the project showing the steps needed to successfully start data taking as planned.

We recommend to DESY to continue in the support to the experiment during the Installation phase.

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 utilisation and good uptime.

We commend the capacity increase to the wide-area network to 2x50Gb/s. This has relieved the bottleneck for the time being. 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.

DESY IT continues to participate in EU projects, which bring in third party funds. There are also multiple initiatives in Germany that focus on data science. As an outcome of the DESY strategy process, the Virtual Scientific Computing Group provides a forum across four DESY divisions for discussing matters related to scientific computing projects. Joint with Hamburg University, the “Centre for Data and Computer Science” (CDCS) is extending DESY’s portfolio into computational sciences featuring collaboration. A graduate program in data and computer science has been started, as have common research professorships. This is an important step. The PRC notes that this is an active time for organizational issues in computing and appreciated a report on digitalization strategy and related projects at DESY. We look forward to hearing more as the initiatives continue to develop during this exciting time.

Staffing is tight considering all of the on-going work, increasing requests for central support and balancing the increasing needs of the XFEL. This situation is intensifying. It is particularly important to be able to meet the needs of CDCS while continuing with excellence in operations of the current program.

Recommendations for computing / IT:

We commend the significant progress with IT 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 virtualisation and containers. GPUs have been deployed on the NAF. There is increased machine learning support, including training sessions.

While DESY IT has been through a number of planning exercises recently, given all of the positive outcomes, we suggest reviewing the proposed increases in scope to refine the staffing plan and work plans for the next five years. These plans would form the basis of negotiation for concrete actions to position DESY IT in this time of opportunity.