Recommendations of the 92nd Physics Research Committee

November 2021

General remarks

The 92nd PRC meeting is the last for four of the committee members – Lutz Feld, Juan Fuster, Laura Covi, and the chair Philip Burrows. Steinar Stapnes will take over the role of chair of the PRC starting in spring 2022. Arthur Hebecker was welcomed as a guest; he will join the PRC starting in spring 2022.

The PRC received with great pleasure the presentation of recent results from the HERA experiments; PRC acknowledged with satisfaction how – even almost 15 years after the end of experiments – numerous important results have been produced by the involved groups without any direct funding. The experiments even managed to attract new collaborators in recent years, not least from the upcoming EIC facility.

All groups have adapted admirably to the difficult working conditions and restrictions imposed by the Covid-19 pandemic, with mostly only minor reductions in productivity. However, the reduction of in-person contacts affects many people, not least students and postdocs who gain less benefit from the traditional collaborative nature of the field.

ATLAS

The DESY ATLAS group continues to make very strong contributions to the ATLAS experiment. Members of the group address a wide range of important physics analysis topics; many analyses are coordinated by DESY scientists. The group also plays a leading role in the ATLAS silicon strip tracker upgrade and is continuously contributing to physics object performance, Monte-Carlo simulation, software tools, and computing. Overall, these efforts resulted in six articles with significant DESY contributions published and one more accepted in peer-reviewed journals since the last PRC meeting. This is supplemented by five conference notes and two non-ATLAS publications from group members.

Personnel and positions: The application for a new Young Investigator Group (YIG) that complements the group's portfolio was successful. The candidate is expected to start in the second half of 2022. The number of incoming postdoctoral researchers is on the low side. Reasons include the tight FH budget, but also ERC and YIG grants ending. One doctoral researcher has finished his PhD theses since the last PRC meeting. The group continues to produce many very relevant results as reported in the open session.

The upgrade of the silicon strip tracker is progressing well, with the first production deliverables produced, but is suffering delays: So far, the strip tracker has accumulated 8 months of delay w.r.t. the current HL-LHC schedule. Extension of availability of the respective resources at DESY are required accordingly. The strip tracker schedule is driven by detector module production, which can be sped up but may suffer from delays in the ASIC supply chain. The HL-schedule, the start of Long Shutdown 3 and its length, will be evaluated and changed in the near future, most likely absorbing the current tracker delay, but the schedule will remain very tight.

The group is working on interesting generic R&D projects that help to attract excellent postdoctoral researchers to the group, for example the Helmholtz innovation pool project on

novel small-pitch CMOS pixel detectors, support of the DESY Test Beam user community with a new and improved analysis tool, or the development of a portable, fast and high-throughput DNA analysis tool.

Key comments and recommendations for ATLAS

- The PRC commends the DESY ATLAS group on their broad range of achievements and their creative input to the experiment, and it congratulates the DESY ATLAS group on winning a new Young Investigator Group.
- The PRC takes note that the ATLAS silicon strip tracker is now 8 months late w.r.t. the current HL-LHC schedule. While this may be absorbed in an overall shift of the HL-LHC schedule which is currently under discussion at CERN, the timely delivery of the DESY contributions should be given the highest priority in the schedule and resource planning for the group.

CMS

The **DESY CMS group** keeps making strong contributions to the experiment, leadership positions and coordination roles and wide range of physics analysis topics: computing (strong contributions to CMS central computing, PUNCH4NFDI, WLCG, quantum computing), tracker alignment (institutional responsibility, cosmics, low pileup collision in October), luminosity measurement(s) (lead role in hardware and software), and data analysis (SMP, TOP, Higgs, SUSY, EXO). There is also a new group from the Helmholtz recruitment initiative with Freya Blekman.

Outer tracker upgrade: DESY will have to produce 1250 out of 13200 silicon detector modules (pre-production at 5%), and it will have to build Dees including module mounting/integration, double disks integration, and full TEDD assembly. There is impressive progress concerning all parts (in general and at DESY), and an EDR for the detector was successfully passed in mid-October, so that green light for pre-production is expected.

There are a **few concerns** or items to be watched: The modules built so-far do not contain the final components; there are uncertainties about module testing (MaPSA) and TEDD cooling manifolds, availability of parts, final sharing of workload, etc. Also the entire timeline with TEDD delivery to CERN in April 2026 is still not considered to be final. Pre-production will be very important.

Key comments and recommendations for CMS

PRC congratulates the CMS DESY team for its excellent performance, results and leadership in many areas of CMS; computing, alignment, luminosity and physics analysis. Work is now well adapted to the new situation induced by COVID-19 but over time represents a strain on the team, the younger/new members in particular.

The CMS tracker Phase II EDR took place mid-October and in general very impressive progress in all parts of DESY's very major role in the tracker upgrade was reported to the PRC. The risks and concerns identified will be addressed in the pre-production phase now starting, and CMS will enter a very critical phase of the tracker upgrade project, where the production rates and production quality of all parts need to be established across the collaboration. The DESY team is well prepared but will need support to solve and deal quickly with known and possibly unexpected challenges in this phase.

Belle II

The Belle II experiment has collected by now about 213 fb^{-1} of data at a luminosity of up to $3.1 \cdot 10^{34}$ $cm^{-2}s^{-1}$. Data taking was efficient and the recorded data are of high quality. Since the last PRC three more papers on Belle II data have been published, including the first B physics results, fully driven by DESY. DESY is a main contributor to the Belle II grid computing and one of six raw data centres. Since 2021 DESY also serves as Belle II re-calibration center. DESY is one of the strongest groups in the Belle II collaboration, with leading contributions and responsibilities in many areas: detector operation (most notably the PXD), tracking and ECL reconstruction, performance studies, computing, and data analysis. DESY is to be congratulated for its Belle II participation, which should be maintained at full strength.

PXD operation is stable, with close to full efficiency in good regions, 90% efficiency over all modules (mainly due to one broken module in layer 1 (covered by layer 2) and damaged regions caused by beam incidents). Impact parameter resolution is excellent, proven by the recent publication of the world's most precise measurement of the D^0 and D^+ lifetimes.

The studies to better understand **the luminosity limitations of the SuperKEKB accelerator** will continue in Run 2021c. More diagnostic systems have been installed around the rings in order to localize the origin of the unexplained beam losses. Belle II has made substantial progress in modelling the beam backgrounds in their detectors.

The long shutdown 1 (LS1), planned to start in July 2022, will be delayed by at least 6 (possibly 12) months so that a luminosity equivalent to the Belle (I) dataset (~800 fb^{-1}) can be collected and used for analysis during LS1. This shift in schedule also covers COVID-19 related delays and the time needed to manufacture a new central beampipe after a failure in the first production. However, PXD expertise has to be kept for longer.

Given the SuperKEKB running experience until now, achieving the luminosity goal of 50 ab^{-1} by 2031 appears uncertain. KEK has formed an international taskforce to develop ideas how to upgrade the accelerator performance so as to be able to reach the original luminosity goal. A report is due in summer 2022. In parallel KEK is defining its Project Implementation Plan with a list of future projects including the SuperKEKB/Belle II LS2 upgrade.

The preparation of the **PXD2 detector** is progressing. There were some delays due to necessary rework of modules and issues discovered in a dummy half shell assembly exercise. Preparations for commissioning at DESY are on track. The 1st half shell is now expected at DESY in December 2021 (6 months later than expected at the last PRC). Shipment of PXD2 to KEK is now planned for September 2022, compatible with the shifted LS1 schedule. Access of the group to the HERA Hall West until end of 2022 is required.

The Belle II collaboration is considering upgrades to the detector during the extended shutdown planned for ≥2026. DESY is closely following these developments but considers it premature to make any commitments.

Key comments and recommendations for Belle II

The PRC commends the DESY Belle II group for their continued strong contributions to the Belle II experiment, from operations through computing, software and calibration to physics analyses.

PRC takes note that the SuperKEKB long shutdown 1 will be moved by at least 6 months and that the installation of the PXD2 detector is now planned for December 2022.

PRC recommends that DESY follows closely the ongoing developments in the SuperKEKB long term planning and adapts its own planning accordingly, including a possible involvement in Belle II upgrades.

Future Linear Collider Activities and Preparations for Future Experiments (FTX)

The FTX group has made excellent progress and has fully arrived in its new form, a considerable achievement under pandemic conditions. A few points are particularly worth mentioning, among them the creation of DESY Future Collider Forum with regular meetings, complementing the Germany-wide FutureCollider Forum.

Group technical activities depend on a small number of key staff, and the postdoc situation remains critical, in particular for the subgroup DTA “Detector Technologies - Calorimeters” (even if a new W2 QU professorship for detector technologies is to come in 2022). The engineering resources are largely shared with ATLAS, BELLE, ALPS, and some of these needs (for example LUXE) are difficult to accommodate (but solutions being found, at least on the short term). The group has a wide range of 3rd party funds and is well represented and has lead positions in EU projects and ECFA studies. LUXE is now ramping up also in FTX, and the test beam is fully operational (new R-Weg beamline ready).

There are a **few points to comment on and monitor**, most prominently the ramp-up of LUXE while maintaining the FTX structure and capabilities (a challenge for staff and engineering effort), the development of the test beam facility in the long term (linked to PETRA IV injector choices), and the personnel situation (postdoc in DTA, technician / engineer in SFT “Software for Future Experiments”).

Key comments and recommendations for the FTX group

PRC continues to express its strong support to the FTX group, which is recognized as one of the key players in the common worldwide activities to develop future accelerators, detectors and software, for HL-LHC, local experiments, and future colliders.

The initiative of the group to create the DESY Forum for Future Collider Activities (theory, experiment and accelerator) is important. The group members also hold leadership positions in EU projects and ECFA studies related to detector R&D and Higgs factories. These activities are very visible internationally. The group is also central in local research activities, from test beam to plasma accelerator studies and LUXE preparation, all linked to preparation of or R&D for future projects.

The DESY test beams are important as an international user facility in the foreseeable future, and their long-term availability during the PETRA IV era needs to be carefully considered.

PRC encourages the group to evaluate strategically the priorities and risks within their wide portfolio of ongoing and potential future projects.

PRC recommends that DESY maintains its strong support for the group in terms of scientific and engineering resources.

Theory

The PRC congratulates the **Particle Cosmology group** for its exceptionally broad, original and ground-breaking program of research, covering all important epochs and phenomena in the early universe and aiming to use the universe as a laboratory to explore physics beyond the Standard Model. The group has obtained many impressive results and has given leading contributions in the prediction of gravitational waves and the study of axion cosmology and its interplay with Higgs physics and phase transitions. The expertise collected in the Cosmology group is unique in the world and has contributed strongly to the development and training of early career researchers, many of whom have continued their career very successfully and have found permanent or long-term positions elsewhere. The group also plays a fundamental role in the Quantum Universe cluster and in binding formal theory and phenomenology together and has been able to keep working very actively during the pandemic.

The PRC is particularly pleased to hear that **two permanent staff positions** in the Theory Group in Zeuthen (one in lattice gauge theory and one in phenomenology) are now in the process of being filled. We also congratulate the Theory Group on their recent fixed term hires in Hamburg.

The PRC is also very pleased to hear that the planning for the **new Wolfgang Pauli Centre** is progressing well and that the cooperation agreement between DESY and Uni Hamburg will soon be signed, so that the technical planning of the building can proceed according to schedule. The reduction in funding leading to the postponement in the construction of the auditorium is understandable but, nonetheless, regrettable. The proposed mitigation of designing the WPC with an auditorium as a second phase is welcome, and we strongly encourage DESY to try to find additional funding to enable the full completion and functionality of the WPC.

The whole DESY Theory group has maintained an enviable stream of high-quality research outputs during the pandemic and the period of working from home. However, it is clear that real face to face interactions are essential for developing new ideas, and starting new projects and new collaborations. Indeed, many of these initial exchanges do not happen during scheduled talks or in the question sessions, which can take place virtually, but during the coffee breaks or the informal conversations “in the corridors” and "in the margins". It is precisely these additional interactions that add value to PRC meetings for example. As we start to recover from the pandemic, it is particularly important for theorists and particularly early career researchers (who are largely unknown in the community and not usually embedded in an established collaboration), to have the opportunity for travel to conferences and to other institutions for training, to gain visibility and to develop personal contacts which cannot be substituted by attending virtual meetings. As a first step, we strongly commend the initiative to define 2G offices which we believe will have a very positive impact on early career researchers in multi-occupancy offices.

Key comments and recommendations for theory

We recommend that the planning towards construction of the new building to host the Wolfgang Pauli Centre continues apace and that DESY tries to find ways to compensate the reduction in funding: the auditorium could become the beating heart of the WPC as the meeting point for the different theoretical communities in Hamburg and as a focus for the

WPC to act as an international centre; we therefore consider it to be a vital element of the WPC.

New ideas and projects in theory arise mostly from personal interactions in informal settings. Therefore we recommend that all efforts are made to restore interactions to pre-Covid levels through increased on-site working, enabling meetings in person (where it is safe to do so) and sustainably resuming travel to conferences and other institutions. As we stated last time, personal contacts and some amount of travel for conferences in person or long-term visits remain vital for the development of new ideas and exchange of knowledge and methods, and are therefore crucial for the long-term health of the Theory group. We recommend that early career researchers are prioritised for travel funds, and that a minimal level of travel is available to each PhD student.

ALPS-II

The **construction of the ALPS-II experiment** in the HERA tunnel has been nearly completed, the cryo-system installed and the optical cavity successfully operated. However, because of troubles with the cryogenic system and the postponed TÜV pressure tests, the physics run has been delayed and, due to the closing down of the cryogenic facility for works at FLASH in December, it may start only in Summer 2022.

We congratulate the collaboration on the steady progress in the construction and the first operation of the cavity. We appreciate also that the ALPS-II group has also taken over the coordination of the refurbishing of the general infrastructure of the HERA North area and that should be finished for Summer 2022.

Open issues are related to the cryogenic system and the clash of schedule with the needs of FLASH that are delaying the physics run; furthermore, while the optics expertise has been now permanently ensured, still the delayed schedule is causing trouble with other contract ends and with external funding.

Key comments and recommendations for ALPS

We congratulate the collaborations for completing the main construction and solving some of the cooling system problems, Covid notwithstanding. The delay of the physics run is unfortunate, but understandable due to the unforeseen problems. We strongly encourage the collaboration and DESY to continue their efforts to have a physics run as soon as possible in 2022.

We recommend that every possibility is explored to keep the personnel and expertise for the experiment, crucial during data-taking until 2024 and perhaps beyond.

BabyIAXO

The BabyIAXO collaboration is a mature and well organised collaboration making impressive progress in many fronts: The MOU with CERN has been signed and will be extended to contain a firm commitment by CERN on the magnet with 1.5M CHF plus a staff/fellow to work on the magnet design. Congratulations! The issues with the location at DESY have also been

cleared, and external (overseas) funding for the x-ray telescope has been obtained and now overall 90% of core construction costs are secured. New collaborators are signing in.

Unfortunately, it has been established that the MELC/INR cable is not appropriate, so the magnet will be based on a new cable based on NbTi with Cu as stabilizer (the new design needs to be followed as the weight of the magnet increases).

On the positive side, there has been also progress with a common software throughout the BabyIAXO systems, as well as with the tracking software. Advancements were reported with the low background MicroMegas detectors as well, to be tested at the Canfranc Underground Laboratory. There is an additional chance to look also at halo axions: RADES at CERN ran a prototype experiment at CAST that could be scaled up with BabyIAXO.

We congratulate the collaboration for reaching these milestones and the steady progress.

Key comments and recommendations for BabyIAXO

We congratulate the collaboration on the progress achieved throughout all important systems.

We recommend that a resource-loaded timeline be shown to enable following more precisely the progress and identifying the critical points.

LUXE

Excellent progress has been made in the short time since the panel that reviewed the case for the realisation of the LUXE experiment in April-May 2021 and since PRC91. The progression to CD0 status is very welcome.

Appropriate actions have been taken by the LUXE collaboration to address their main challenges namely on the beam line extraction layout and design, cooperation and search for synergetic objectives with the EU-XFEL upgrade program (on both the beam extraction and possibly the laser system), organization of the international collaboration and cost sharing, detector development including test-beams and simulation studies, and construction of a fall-back scenario which could guarantee meeting the challenging timescale. In this “bare-bones” experiment, valuable physics measurements could be accessed in the first phase before ultimately leading to the successful completion of the full physics program.

Recommendations for LUXE

PRC continues to express its enthusiasm for the physics motivation for the experiment and recognizes that the main challenge remains the timely readiness for the main installation in 2024. In this sense the magnet procurement for the extraction beam line is urgent and enough technical support is needed to develop the TDR in a timely manner. The new “bare-bones experiment” concept is an excellent measure to mitigate risks and ensure a rich physics program at its early state and which can gradually adapt to the full capability of the experiment later-on.

PRC acknowledges the cooperation and ongoing discussions with EU-XFEL and welcomes the news that the extraction line to be used by LUXE has been identified as an important technical development for the preparation of the EU-XFEL future upgrades. PRC looks forward for a truly synergetic collaboration between EU-XFEL upgrades and LUXE.

PRC welcomes the efforts of the collaboration on organizational matters. New groups are well integrated into the ongoing program of activities. International visibility and participation in conferences is high.
PRC strongly encourages LUXE to continue the efforts of the Collaboration to fully answer all issues raised by the panel review in May 2021 and discussed at PRC91.

Computing / IT

A few general points are to be mentioned in regard to the DESY IT group: Hardware deliveries, especially networking equipment, are currently unpredictable. The Covid-19 pandemic has strong implications for the group: IT members still work largely at home, and meetings and personal interactions remain difficult, reducing the overall efficiency.
In general the experiments are happy with IT provision (e.g. NAF resources added, new user groups). Any schedule slips, e.g. for HL-LHC or Belle II, actually help with managing/planning respective IT resources.
For the purposes of quantum computing, a grant of 15 MEuro of new funding was attracted to DESY-Zeuthen. A digitalisation strategy document was written for the Helmholtz research field 'Matter'.
On the personnel side, it is very difficult to fill (even permanent) posts. Birgit Lewendel (Scientific Computing sub-group) retired, and a successor was appointed. Group leader Volker Guelzov will retire in Sept 2022 – the process has been started to appoint a successor.

Recommendations for computing / IT

The committee is impressed by the scale and diversity of the communities and activities being supported by DESY IT. An outstanding example is the new role as Tier-1 center for the Belle II experiment, in addition to the already successful national and international role as a major LHC Tier-2 center. PRC notes the difficulties imposed by the Covid19 situation, not least the reduced direct contacts among personnel, as well as the global shortage/delays in equipment supply. PRC commends the IT group for coping with these difficulties as well as possible.
DESY IT also leads (in some cases) and participates in a wide range of development activities. In particular the Data Management and Analysis activities have the potential for a large impact on many communities, as the LHC approaches the High-Lumi phase and work proceeds to implement FAIR data practices in research.
We appreciate the initial steps taken to answer the committee's questions about the strategy for the next years. We look forward to seeing the vision for the department emerging from this process. The deployment and support of JupyterHub and Gitlab for the user communities is an excellent strategic choice.
PRC recognises the difficulties in attracting skilled personnel, and encourages DESY to continue its support for the IT group to fill its open positions in a timely manner. DESY IT underpins the mission and scientific productivity of the laboratory. PRC supports and encourages DESY in seeking an outstanding person [to succeed Volker Guelzow] as the next Head of IT.