

Recommendations of the 94th Physics Research Committee

November 2022

General remarks

- The various crises hitting the world are also felt in the FH division: the impact of increased energy costs and the general effect of inflation are further intensified by the shortages of materials, electronics components, and also helium. These effects are partly induced by the Russian war on Ukraine that also leads to labour shortage for various projects. The effects of the Covid-19 pandemic are only slowly wearing off. The sanctions on Russia also directly impact the planning for BabyIAXO, LUXE and the HGCAL construction, causing potentially significant delays if no alternatives are found.
- As a consequence of the increased Ph.D. student salaries (2/3 instead of 1/2 E13), the current inflation, and the expected increase in wages, the personnel likely needs to be reduced by about 15% by the end of 2027. All FH groups are therefore making plans for reducing their personnel in order to save cost. This is not an easy exercise, in view of the large commitments DESY has towards the international community. A cut in the number of postdocs and students would significantly reduce the scientific output. The PRC recognises the efforts to mitigate these cuts through 3rd-party funding.
- There are issues with technical personnel (e.g. for HL-LHC upgrades, but also on-site experiments) that require high attention given the large DESY commitments and the national and international visibility of the projects. Mitigation measures must be explored, including hiring of dedicated instrumentation postdocs and technical students, increasing the technical part of the Ph.D. projects, and shifting an increased part of the staff efforts to for example the LHC upgrades for a period. The PRC considers that it should be a priority to establish a replacement plan for the personnel that provides the necessary technical support for experimental construction and support.
- The PRC strongly recommends that care be taken in the planning towards PETRA IV to include a test beam (TB) facility. Test beam are very important for R&D for a large national and international user community in general, and they are vital for the current ECFA Detector R&D Roadmap, which relies on the worldwide unique DESY test beams, in particular when CERN accelerators are in shut-down for another three years in 2026-28 as currently considered. The test beam is also part of the transnational access EU project Eurolabs, and serves as a focal point for detector and instrumentation developments Europe-wide.

ATLAS

In general, the DESY ATLAS group continues to make key contributions to the ATLAS experiment, addressing (and partly coordinating) a wide range of important physics analysis topics, and playing a leading role in the ATLAS silicon strip tracker upgrade. The group is now ready for the detector production phase. The group maintained a good level of leadership positions, including one at the executive level (J. Ferrando, Data Preparation Coordinator).

The group activities were maintained at very high level, connecting hardware, operations, software/performance and analysis projects (including challenging algorithmic work, e.g. for flavour tagging). The group is generating lots of creative ideas (e.g., connecting searches for new physics with standard model measurements in control regions). There are several very successful long-term involvements, e.g. the leadership of the e/gamma efforts. The group is taking care not to spread efforts too thin, and it is phasing out a few activities to maintain focus.

Since the last PRC meeting, these efforts resulted in 10 articles with significant DESY contributions published (including the *Nature* publication for the 10th anniversary of the Higgs boson discovery). In addition, there are 10 public notes from group members. Several papers have been accepted for publication but are on hold due to uncertainty about authorship, due to the war in Ukraine.

In the current **constrained budget situation**, the group articulates a very clear priority of delivering the upgrade (see below), with a commitment not to reduce personnel until ITk is ready (on the order of 5 years). The ratio of staff to postdoctoral to doctoral researchers has changed: collaboration of staff with “shared” early-career researchers is appreciated and strengthens the group’s focus on key area. The group is making an effort to not let delayed appointments of doctoral and postdoctoral researchers create risks for key projects.

Early-career researchers: Postdoctoral researchers within the group work on a broad range of topics, including topics beyond core ATLAS topics, e.g. AI, medical physics. They continue to go on to very good jobs, including fields outside of HEP, and starting companies. Doctoral researchers of the group graduate from several universities, profiting from the strong ties the group developed during the last years. The time scale for publication of LHC data analyses are increasingly longer than the duration of a typical doctorate or postdoctoral contracts. This is a general concern impacting young researchers most, driven by circumstances beyond the control of the group.

A new young investigator group (YIG) started under Lydia Beresford. This will broaden the group’s activities towards “photon collider” physics (gamma-gamma initial states) in LHC Run 3, and it is an opportunity to explore a new forward detector activity for this group.

There has been progress on the **HL-LHC upgrade of the ATLAS ITk** in all areas, including many developments on components, tooling, tests, and collaborations with industry partners. The group is now ready for detector production in early 2023. Tedious site qualification procedures were passed successfully. Planning and testing the final integration of the ITk are ongoing through e.g. a system test with 1/8 of the ITk in 2023, and a dedicated workshop held in 2022.

All in all, the group presented a convincing schedule to deliver the ITk endcap to CERN in 2026, driven by the schedule for module production. The detailed personnel planning is still ongoing. Staffing levels peak in 2023 and will gradually be reduced when component production will be finished. The group intends not to reduce the number of postdoctoral researchers working on upgrade projects.

Generic silicon detector R&D is set up as a cross-group activity, and the intention is to strengthen connections to photon science at DESY and to other Helmholtz centres. This seems well motivated from science, but successful execution will depend on (re)direction of resources towards this activity. It will be important to find the right balance between generic and targeted R&D efforts, while continuing to identify areas where this group can contribute most. The group intends to play an active role in the implementation of the ECFA Detector R&D Roadmap.

Key comments and recommendations for ATLAS

PRC commends the DESY ATLAS group on their broad range of achievements, leadership, and creative input to the experiment.

PRC appreciates that the group is working hard on “doing more with less” – budget constraints will force some prioritization, and the timely delivery of the DESY contribution to the HL-LHC ATLAS upgrade should have very high priority. The PRC recommends to carefully plan delayed appointments in order to not put other key projects of the group at risk.

In general, the PRC recommends that a (resource loaded) plan for detector R&D be developed in the division that considers generic R&D as well as targeted work, that identifies where the different group can have the most/unique impact, and that is well aligned with the ECFA Detector R&D Roadmap.

CMS

The CMS group is continuing to make significant **impact in the collaboration**, and group members are holding important management roles in the collaboration. There is impressive coverage of shifts and operations responsibilities – congratulations on re-establishing these well in the newly started Run 3! The group is also to be congratulated on 11 Ph.D. theses completed since the last PRC, and on the high publication output (six CMS papers with substantial DESY work, including the first Run 3 result (σ_{tt}), three 3 technical papers, 7 phenomenological or review

papers involving group members). PRC is surprised by the high number of phenomenological papers, considering the needs developing elsewhere in the CMS group activity portfolio.

Due to the **budgetary constraints** discussed above, the DESY CMS group has in view the need to shrink the group size by ~20% in the next five years, by a range of measures. One part of the strategy is to work more in collaboration with external teams to allow to maintain range of performance and analysis activity

Concerning the **HL-LHC tracker upgrade**, the DESY CMS group has to build 1120 “PS” modules (strip/pixel stacks) for the tracker endcap. The work on this project is still extremely limited by CMS-wide module & component availability issues. Since the last PRC, one new module (MaPSA) was received thoroughly tested, exercising test procedures. The module quality is found to be within specifications. Pre-production of modules is scheduled to start in the middle of 2023, and two jigs used in the module production under DESY responsibility have been revised based on prototyping experience.

DESY will integrate the produced modules onto 16 Dees, and assemble the Dees into TEDDs. In the process of establishing the integration exercise, the mounting of one functioning module onto a Dee was exercised. This turned out to become a delicate operation in future when many modules are already mounted. It was also found that there is high noise on mounted module, thought to be due to poor grounding. This is being worked on. For the Dee assembly into TEDDs, the procedures are now being developed and shared with other sites. It was agreed that the final assembly of TEDDs into the endcap tube will be done at CERN.

The group shared complete project production plans with the PRC. There exists a success-oriented schedule with unclear contingency at this time, and technical effort profiles were developed. One strong concern is the insufficient number of wire-bonding technicians throughout the production process. In general, loss of expertise is a threat across the entire project, with imminent retirements of key engineers and technicians. In order to mitigate these effects, a significant increase of instrumentation fellows will be required, and an engagement of existing “analysis focussed” staff, fellows and students is foreseen only at 0.2 FTE level.

The HL-LHC upgrade work is a flagship DESY CMS project and must have sufficient technical resources to succeed.

PRC was presented with a summary of the **HGCAL work**, a collaboration of the FTX and CMS groups at DESY. The DESY activities are in the development of tile modules for the outer part of HGCAL (SiPM-on-scintillator tile technology). Concerns were expressed by the group regarding the available effort that will need to be increase. Work is ongoing to engage further German universities in the project. The effort and profiling were not discussed at this meeting since the situation is still developing.

Key comments and recommendations for CMS

PRC congratulates the CMS group on their impressive and broad work across a wide range of CMS activities, including the re-establishing of fair-share operations work despite pressures on travel budgets.

The work on the tracker continues to be delayed with insufficient component availability. The overall CMS tracker production schedule is updated (and challenging), and PRC emphasises the need to ensure continuity of expertise as key engineers and technicians retire (wire-bonding expertise) and to increase the number of instrumentation-oriented fellows. Also an increased commitment from “analysis focussed” staff is strongly recommended, especially given the overall funding situation.

PRC emphasizes that phase-II construction must have priority over Run-3 analysis during the construction period.

FTX

The **DESY FTX** group is key to developing future accelerators, detectors and software, for HL-LHC, local experiments, and future colliders. The group is very visible internationally, and group members are well represented and hold lead positions in EU projects and ECFA studies. The group is actively engaged in discussions about the overall detector R&D strategy at DESY. In

addition to external visibility, the group is doing important work for local research activities, from test beam to plasma accelerator studies and LUXE preparation, all linked to preparation of or R&D for future projects, or for new experimental methods.

The group has a central role in national and international Higgs factory detector and physics activities. Very good progress has been seen in software development for a large number of areas (calorimeter simulations, ML, ...). There are good synergies between detector R&D and computing efforts. Also the efforts in PWA R&D are progressing very well, the FLASHForward facility yielding first results e.g. on beam quality and repetition rates that are essential for future high-energy applications.

However, PRC is aware of **staffing shortages**: The activities in all work areas depend on 1-2 key staff, and almost all engineering resources are shared with other groups. The group supports a multitude of projects and faces challenges due to budget constraints. In particular, the effects of the Russian war on the Ukraine have reduced scientific staff contributions to the DTA sub-group. The **test beam facility** is extremely important for detector R&D, and serves many other uses. The number of users from all over the world is at a record high, amounting to 400 in 2022. The DESY test beams are essential as an international user facility. Detector development depends on it and the long-term availability during the PETRA IV era need to be carefully considered. The test beam facility and team are also engaged in a number of important science outreach and education programmes.

Key comments and recommendations for FTX

PRC acknowledges that there is significant general expertise in the group that is serving e.g. HL-LHC, LUXE etc. and that, with limited resources, makes huge impact also in the field of future colliders. The excellent connections to R&D projects make it a “hub” for development and innovation that strongly benefits future international and local experiments.

PRC strongly recommends to continue any scientific and engineering support for the ongoing efforts, to continue the ongoing integration of detector R&D and computing, and to continue the leadership of future collider studies in alignment with ECFA roadmap processes.

The PWA activities in the FTX group help to keep a focus on HEP applications of this promising technology. PRC recommends to further integrate the PWA efforts with strong outside partners, including those interesting in studying the technology for HEP applications.

PRC urges the necessity to maintain the compatibility of the test beam facility with the PETRA IV injector discussion, and it supports ideas to apply for transnational access EU money from Eurolabs. Care must be taken not to take decisions now that make a test beam at DESY IV impossible. Some person power is needed for the respective orbit calculations / confirmation of the viability of the concept.

Belle

The DESY Belle II group is one of the strongest groups in the collaboration with a broad range of responsibilities and a leading role in many aspects of detector operations, reconstruction and physics analysis.

SuperKEKB has finished its second data-taking period in FY2022 and recorded a dataset corresponding to an **integrated luminosity of 430 fb⁻¹**, about the size of the BaBar Y(4S) dataset. This dataset is being used by the DESY Belle II group for a range of very relevant physics analyses, and a good physics harvest can be expected. The PRC is pleased to see a portfolio of Belle II physics analyses with a clear and **well-chosen scope**, considering the major hardware responsibilities of the group.

Data taking at Belle II has been plagued by high beam backgrounds in the injection time window and sudden beam loss as well as by several detector issues. A broad effort to understand and mitigate these problems is underway in the ongoing long shutdown 1 (LS1).

The **commissioning and installation of the new DEPFET pixel detector (PXD2)** is a key project for DESY. The commissioning at DESY faced several difficulties and revealed a major issue with the mechanical design of PXD2 that led to two bent detector ladders in layer 1. The group has launched several studies to understand the factors leading to this failure mode: Bench-tests such

as mechanical stress tests are complemented by thermal measurements and simulations. Alignment studies in high-luminosity data taking point to the same failure mode. In the process, special operations conditions have been identified that may lead to catastrophic failure of PXD2, if not mitigated by active safety measures. In addition, the new beampipe around the interaction point showed a delamination issue. PRC notes that – under these difficult circumstances – the DESY Belle II group is “doing the right thing” in focusing on a deep understanding of the problems while keeping an eye on the schedule. PXD2 is a flagship project for the German particle physics community and its success is critical to the Belle II physics program. PRC also supports the recommendations given by the B-factory Programme Advisory Committee in its special review of the PXD2 in October 2022. The goal must be to install a well-understood PXD2 and beam pipe in the current long shutdown for safe and efficient data taking thereafter. PRC congratulates DESY on the new Young Investigator Group for Thibault Humair on Belle II, which keeps the person power high and diversifies the group’s portfolio.

Key comments and recommendations for Belle II

The PRC recommends to prioritize hirings of scientists for Belle II with a focus on instrumentation, as a replacement for scientists close to retirement.

PRC encourages DESY to investigate ways of supporting the KEK accelerator group in overcoming the persistent limitations in luminosity and beam background at SuperKEKB.

In view of the PXD2 issues encountered during commissioning, PRC strongly recommends to rethink the safety measures for the system.

The PRC recommends an optimization of the PXD2 installation schedule including careful contingency planning. System-level failure modes should be diligently analyzed and mitigated.

ALPS

ALPS-II has demonstrated that it is very close to data taking; this is a very exciting prospect for this extremely innovative experiment. PRC congratulates the collaboration for completing the magnet string test at full current, including the first cool-down, and for being ready to data taking. Even though the TES detector could not be tested due to the dry dilution issues, the heterodyne method should be more than adequate so that issue is not a critical one. The **helium issues** have been addressed.

PRC is also very excited by the prospects of being able to observe the **vacuum magnetic birefringence** with this long-string magnet system; ALPS II is a unique facility for this purpose. Personnel (postdocs, fellows, positions) is still an issue, and efforts should be made to address them. Data taking should certainly help to resolve this issue, since it might attract new people.

Key comments and recommendations for ALPS II

PRC strongly encourages the collaboration and DESY to continue their efforts to have a physics run within 2022 or at the latest early in 2023.

PRC recommends that DESY should assume that ALPS II will continue taking data for the next two to three years, so the helium issues should be considered carefully.

We recommend that postdoc positions should be allowed to be advertised specifically for ALPS II since this is a unique optics facility in the world. Sufficient scientific personnel should be secured for the physics runs.

BabylAXO

The **BabylAXO collaboration** is continuing its task to develop the experiment in all aspects except, notably, the magnet itself. Progress has been made in acquiring the tracking system, which is now placed in the DESY experimental hall and now needs to be put together. In addition, an additional x-ray focusing system is under development. The low background detectors are in good shape as well. Furthermore, five new collaborating institutes joined the experiment. PRC congratulates the collaboration for reaching critical milestones and for the steady progress!

The **magnet**, which is the main challenge of the experiment, is progressing much slower than hoped for, mostly because of the fact that the originally foreseen cable is not suitable, that a new

cable is not available anymore from industry nor from Novosibirsk/Russia due to the sanctions in place, and because of the lack of engineering personnel at CERN devoted to finalising the conceptual design as outlined in earlier planning. PRC considers significant delays in the project to be a major concern for the BabyIAXO collaboration.

PRC welcomes and encourages the opportunity of being able to do an axion haloscope experiment in the 100-500 MHz, a frequency range that is not targeted by any other experiment and it is of high importance.

Key comments and recommendations for BabyIAXO

We recommend that the DESY leadership, in close coordination with the collaboration, works with the CERN leadership and the international community to secure the timely resolution of the issue of the magnet cable procurement and to come up with a cost estimate and timeline. For this, a viable conceptual magnet design is required and time-critical. The unavailability of the design, and potentially also the cable causes significant delays for the project and a path forward needs to be defined as soon as possible before the collaboration proceeds to performing a “dry run” without magnet.

To keep the collaboration moving forward, PRC encourages to prepare a schedule for the experiment that allows the collaboration to participate as much as possible. PRC considers significant delays in the project to be critical for the BabyIAXO collaboration and thus encourages the collaboration to search for additional expertise and contributors, in particular in the area of magnet design and construction.

Finally, the resource-loaded timeline should be submitted as soon as possible. It will expose all unfunded and required activities where stronger involvement of the collaboration is needed.

LUXE

The LUXE experiment aims to measure the transition between perturbative and non-perturbative QED, by studying collisions between the European XFEL electron beam and a multi-Terawatt optical laser. The LUXE collaboration currently consists of 19 international institutes and about 100 members – five institutions joined recently, and there are discussions ongoing with more. There is interest in collaborating with the CERN beam instrumentation group on issue related to test beam questions and an instrumented beam dump.

Excellent progress has been made since the PRC review in May 2022. In particular, the costing and the related estimated work needed to realize the different components have been closely scrutinized by relevant DESY groups. The required total core investment is estimated to be of the order of 3.5 MEUR, excluding the laser and extraction beamline. The LUXE detector investment of 1.1 MEUR is expected to be financed by 20% from DESY and 80% from external contributions. The total person power required has been estimated to be 18 FTE-years required in FH (including technical contributions from scientific personnel) and 6 FTE-years required in the M division, integrated over a seven-year period after the LUXE project is approved. There are two possible caveats: i) Civil engineering (building) costs are estimated at 1 MEUR, but subject to significant inflation; ii) there is a possible need to update the electrical and cooling power (with estimated costs of < 1.5 MEUR). The building and related infrastructure can potentially be shared with the ASPECT project of the EU.XFEL to reduce cost.

As a consequence of the scrutiny work, the project has just **received CD1 approval** and has thus become an official DESY project. The CD1 status allows the project to attract more collaborators and to apply for external funding sources. A number of third-party funding applications are being made / planned. Work is now focusing on a TDR by the end of 2022 and on obtaining CD2 status. **XFEL has deprioritised the TD20 line** because the second fan will be delayed. That means that the focus on installation during the 2024/25 shutdown can be relaxed and the work on the transfer line can be fully done or staged in a or several regular winter shutdowns.

Key comments and recommendations for LUXE

PRC continues to view LUXE as an exciting opportunity to probe an unexplored domain of physics using the unique facilities available at DESY.

PRC recommends the collaboration to continue their work on funding and funding alternatives. Furthermore, PRC encourages the collaboration to publish their TDR as soon as possible as a compilation of the technical notes that were the basis for the CD1 reviews.

Theory

PRC is disappointed to hear that the hiring of a phenomenologist in the Zeuthen Particle Physics Theory (ZPPT) group was a victim of the difficult financial situation in DESY due to the increased inflation, higher energy prices and increased costs in construction. We reemphasise the need for ZPPT to maintain a critical mass to keep its position as an internationally attractive centre of excellence for quantum field theory applied to particle theory, and we hope that a permanent staff position in this area will be filled as soon as possible.

PRC is very concerned about cuts affecting the construction of the Wolfgang Pauli Centre (WPC) as well as about its possible further downscaling due to rising construction costs. While the committee of course understands the objective reasons for such steps, it nevertheless wants to reiterate the WPC's exceptional importance: The WPC represents an enormous opportunity – it bears the potential of a very significant boost to the international visibility of DESY on the basis of a relatively limited investment. The WPC could become a flagship for fundamental physics research at DESY and Hamburg University, going far beyond its importance for the DESY Theory group.

Possibly unavoidable cuts to postdocs and Ph.D. students in the Theory group are very regrettable, given in particular the world-leading science done there as well as the exceptionally good ratio between financial spending and the resulting visibility in theory research. While applying for 3rd party funding is certainly a valid suggestion, one has to take into consideration the restrictions concerning DFG and BMBF applications which apply to DESY staff scientists. It is crucial to continue providing sufficient travel funding for theory postdocs and graduate students since this is absolutely essential for their career prospects. Especially concerning postdocs, by not providing adequate travel opportunities one would be risking DESY's outstanding reputation as a place where top postdoctoral researchers apply. In this context, we welcome the planned doubling of the travel budget in 2023 with respect to 2022 as well as the freedom that any group has to shift funding between personnel and travel.

PRC congratulates the DESY theory group and of course in particular Elli Pomoni on the successful application for an ERC consolidator grant.

Key comments and recommendations for Theory

The Zeuthen Particle Physics Theory group needs to maintain a critical mass. We hence recommend that, in spite of the financial difficulties, a permanent staff position in particle physics phenomenology is advertised and filled soon. PRC encourages that all efforts are made to realize as much as possible of the original visionary ideas behind the WPC. While we encourage applications for 3rd party funding, any expectations have to take into account DESY-specific restrictions.

IT

The PRC commends DESY IT group on a broad program of activities. The provision of **computing resources to large-scale (HEP) experiments** follows the needs from the experiments, a remarkable achievement in these times of high inflation. IT can achieve this by extending the lifetime of recently-purchased systems. This buys the facility a couple of years, during which energy costs are expected to continue to rise. Funding will need to be secured to guarantee the facilities for 2024 and later. The plans to discontinue university Tier-2s in Germany is part of this discussion; it is natural (and efficient use of funding) to compensate their termination by a commensurate expansion of the DESY Tier-2 centre. There are clear concerns about the **financial restrictions** in particular with respect to personnel and the refilling of vacant positions. This has long-term effects, more than a slip of investments.

PRC recommended last time to assist **Ukrainian science** by provision of resources. This provides additional pressure on the system given the current financial picture including available

funds and rising prices. LHC delays are expected to mostly resolve this problem, as that will reduce the resource requirements for the coming year.

The PRC congratulates DESY and its Helmholtz partners on the very successful evaluation of the **HIFIS platform**, providing extremely important IT infrastructures for Helmholtz and beyond. Concerning astroparticle physics and the new DZA centre to be built up in Lusatia, DESY might consider offering its expertise in big data management for the DZA.

Key comments and recommendations for IT

PRC underlines that the key topics for IT for the next half year are: i) to develop strategies to reduce energy consumption – i.e. to further explore the potential for a reduction of energy consumption and emission footprint of the facilities; ii) to deal with late deliveries; iii) to find a way to productively work under financial restrictions; iv) to manage the data challenge connected to PETRA IV (in general data reduction and compression are important issues to be kept in view); v) to write a proposal for a regional data competence centre together with the local universities.