

## Recommendations of the 96<sup>th</sup> Physics Research Committee

November 2023

### General remarks

- The PRC appreciated the significant progress on all axion experiments. With the portfolio of ALPS II, (Baby)IAXO and MADMAX, DESY has the potential of becoming a world-leading hub for axion research. The further development of this research area at DESY will be an important strategic part of the PoF V preparation.
- The beams at DESY have performances and parameters that offer unique scientific opportunities for on-site world leading experiments and studies. LUXE using an extracted beam for EU-XFEL and HALHF demonstration experiments in FLASHForward are examples, and other possibilities could be considered.
- The uncertainty about the LUXE timescale is of increasing concern to the PRC, as well as to the many collaborators who are investing in preparation of the experiment.
- Building on the good example of the creation of a world-leading on-site axion programme, and in view of the POF5 planning and timeline, it would be interesting to explore systematically the possibilities DESY has that are beneficial for the world-wide HEP programme.
- PRC recommends that personnel planning is strongly focused towards high-priority projects and important hardware construction projects in the division. The priorities and planning should be clearly communicated to and within the groups. With decreasing numbers of students and postdocs, they should be even more encouraged to work on hardware projects and be presented with opportunities and projects including hardware related work.
- PRC welcomes the installation of the two platforms on Scientific Computing and on Detector R&D; they offer potential for synergies and for a strategic planning, also in view of the PoF V process. At the next PRC meeting, the PRC would appreciate a more detailed report on how the silicon R&D projects fit into the DESY Detector R&D Platform and the implementation of the ECFA Detector R&D Roadmap.
- PRC appreciates the careful planning made for the next years, which have significant budgetary challenges caused by large increases in salaries and inflation. PRC is very concerned that the required 10-15% reduction in workforce results in a 30-40% decrease in early career researchers. This will reduce the science output significantly, decrease the DESY's role as educator of the next generation, and reduce DESY's ability to attract outstanding scientists.
- PRC recognises the success in attracting third-party funding. It is, however, noted that such funding often comes with obligations and might deviate effort from high-priority items. It is important to be careful with matching funds to not distract effort from the high priority activities.
- The core cost increase issue for the CMS experiment is now being discussed. For the HGF the potential impact currently discussed is currently estimated to be 2.5-3.4 MCHF. If this funding cannot be secured from outside the regular budget, this would have a severe impact on the science output.

### ATLAS

#### Findings

The DESY ATLAS group remains strong; however, the number of temporary positions at both sites is decreasing. The number of leadership positions remains approximately constant, with an increased number of positions in the ATLAS upgrade. The current level of staffing allows the group to keep its broad portfolio of activities, from detector operations and upgrades, physics objects, software and computing, to data analysis. In data analysis, a wide range of topics is addressed: The group pursues precision measurements of standard model (SM) as well as interpretations of SM measurements in effective field theories and in models beyond

the SM (BSM). Since May 2023, eight ATLAS publications with significant DESY contributions have been submitted, two further publications have been accepted and six conference/public notes have been published.

The group continues its major contributions to the HL-LHC upgrade of the ATLAS detector with a new Inner Tracker (ITk) end-cap as the flagship project. Since the last PRC meeting, very good progress was made on many fronts (petal cores, bus tapes, end-of-substructure cards, module assembly and quality control, beam tests, automated module loading, integration tools), complemented by studies of ITk tracking in dense environments.

The FH division provides a broad portfolio of silicon detector research and development (R&D) projects under the umbrella of the new Detector Development Platform. The silicon R&D effort carried out related to the ATLAS group focuses on 65 nm CMOS sensor technologies (monolithic pixel sensors and silicon photomultipliers with integrated digital logic, strip sensors). The group augmented the beam test environment with a high-voltage CMOS sensor layer and a new LGAD timing layer. In addition, the group addresses technology transfer to medicine with electron-beam computed tomography (eCT) experiments and contributes to training the next generation of detector physicists.

## Comments

The PRC congratulates the DESY ATLAS team on a broad and well-balanced range of excellent contributions to the ATLAS experiment. The overall personnel situation is still viable, but the staffing might become undercritical in some areas. The combination of decreasing staffing levels and increasing upgrade needs make it challenging to fulfil the obligations in the current ATLAS experiment. The PRC commends the group on the inclusive and transparent ways to deal with this situation (e.g., during group retreats) and strongly supports the group's focus to make the upgrade the highest priority. The PRC notes that the ramifications of the reduction of group size on scientific outcome and impact may only become visible later.

The PRC commends the group a very good publication record, including a very high-profile Natur publication on the determination of the strong coupling constant with unprecedented precision. The PRC is pleased to observe the first impact of the new Young Investigator Group on photon fusion processes. Many of the "technology development" projects of the group lead to very visible contributions (e.g. luminosity determination, electron/photon calibration, machine-learning based boosted-jet tagger).

The continuing excellent progress in many projects toward a full ITk end-cap is commended. More than a third of the group members are involved in the ITk end-cap, and all projects are well on track, despite the growing complexity of the upgrade. Many tools and procedures are already qualified for production, with no obvious showstoppers identified. An important milestone was reached: a fully loaded petal was inserted and system-tested.

The silicon detector R&D projects of the FH group cover a broad range of state-of-the-art technologies. The group's progress is commended, in particular its leadership in 65 nm CMOS sensors and the simulation software package Allpix Squared. The PRC encourages the group to continue/expand their training efforts.

## Identification of critical issues

No critical issues identified.

## Specific recommendations for ATLAS

The timely delivery of the DESY contributions to the ATLAS upgrade should continue to have the highest priority. The PRC recommends that the group keeps it high focus and staffing levels. The group shall pay close attention on any critical issues arising in the sub-projects and avoid loss of competence.

## CMS

### Findings

The CMS team has made significant progress across multiple areas since the last PRC. Excellent physics results have been released with DESY involvement, in four papers and three physics analysis notes. Of particular note are a simultaneous analysis of tH and ttH production, and evidence of tWZ production. Eight phenomenology papers, and a ZEUS paper, were also reported by the team. An impressive range of physics analyses are ongoing. CMS team members continue to hold important roles in the international collaboration. Team members have received four CMS awards.

The team complement has fallen by 10% over the last year, distributed across students, postdocs and staff. This has resulted in difficulty filling some operations tasks. The balance of support continues to shift from base funding to third-party sources.

The Remote Operations Centre at DESY is back in use for data-quality shifts, saving on travel and CO<sub>2</sub> emissions. The tracker alignment activity, led and carried by DESY for many years, is losing personnel. The BCM1F detector, reported at the last PRC to be aging, will be replaced at the end of 2024, after identification of sufficient spares. Personnel reductions mean no DESY support at CERN is foreseen for BCM1F from 2024 on. Activity in the computing area continues, including dynamic resource provisioning and leadership within WLCG. The DESY CMS WLCG pledges for 2024 will be met.

Major Phase-II upgrade responsibilities lie in the endcap high-granularity calorimeter (HGCal), and in the outer tracker. The deliverables are unchanged.

The HGCal activity is a close collaboration between FTX and CMS groups. Pre-series production of wrapped tiles and tileboards is underway, exercising production and QC procedures, with beam tests. A production schedule, with resources, using this experience will be brought to the next PRC. After DESY test-beam measurements, CMS is switching to larger 9mm<sup>2</sup> SiPMs across the HGCal tile section. Construction is complemented by detailed software work on detector response, basic reconstruction and calibration.

For the outer tracker, a kick-off production of 5 modules (25 across CMS) was initiated over the summer. Five bare modules were assembled at DESY, and two fitted with hybrids. Difficulties continue with hybrid production, leading to serious schedule slippage. One module works as expected, the second is under investigation. The module assembly pipeline takes the expected four days, plus a day for hybrid attachment, then wire-bonding and testing. The team plans to start four modules each day, so allowing 20 modules per week, beyond the originally planned 12, perhaps increasing to 25 modules per week. Integration of endcap modules onto an endcap "Dee" has been exercised, with staff from five external sites gathering at DESY to mount and test 13 modules. Dee production is delayed by continuing uncertainties on carbon-foam production, reported at the last PRC. A prototype inner rotation tool for disk assemblies has been made and is being tested. A CORE re-costing of the CMS Phase-II tracker upgrade shows a 16% increase. Discussions on sharing currently indicate a 2.5-3.4MCHF cost increase for HGF.

### Comments

The PRC congratulates the CMS team on their achievements, and new CMS results, since the last PRC. A careful focussing of effort onto core work is encouraged during the current period, when upgrade construction is proceeding in parallel with operations.

The 10% reduction in core funding of staff, postdocs and students is having a clear impact on important obligations, especially in the operations area (alignment, BRIL). Such a drop is unsustainable if repeating. A negative impact on physics output will also result. The group is successful in attracting third-party funding, but this brings expectations different from the team's core responsibilities, and may detract from them.

HGCal work proceeds well, with no specific issues flagged this time. As reported at PRC95, the outer tracker continues to be a serious concern, especially with regard to the hybrids, where the number is not at the required level and the quality is unclear; and in the procurement of C-foam, where delays are still unknown. The lack of hybrids means that the kick-off production intended during the summer cannot yet be classed a success. The DESY team's desire to increase module assembly and testing rates, to 20-25 modules per week, in

order to recover time during production, is strongly supported. Reliable access to wire-bonding will be critical during the production – availability of a shared backup bonding machine may be crucial in case of breakdowns. The recruitment of new technical staff, and transfer of expertise to them, is proceeding well. Assembly and testing procedures for modules at DESY, and of modules to Dees, are exercised and well understood.

### Identification of critical items

The drop in personnel numbers now means that there is insufficient effort to maintain key operations responsibilities (tracker alignment, BCM1F).

As flagged at PRC95, the external supply of hybrids remains a major concern for the outer tracker schedule, as does the C-foam needed for endcap assembly. Very little progress in the schedule has been possible in the last six months due to these problems.

### Specific recommendations for CMS

Ensure that there is buy-in across the CMS team to the priorities of the group during the challenging period ahead. As far as possible, redirect effort to ensure that the highest-priority activities, in upgrade construction and in CMS operations, are fulfilled.

## FTX

### Findings

The FTX group serves an important purpose at DESY and beyond, as it seeds future instrumentation, accelerators, experiments, computing, and leads future development for the HEP community at large. Previous R&D investments are bearing fruit for a number of projects (e.g. LUXE, CMS upgrade - HGCAL). In addition, FTX staff provide and maintain research infrastructure such as the test beams and computing frameworks, and work on facilities design and operations, e.g. FLASHForward.

The PRC observed good progress on all fronts. For example, the Science with Lepton Beams continue its leading role in the ECFA study on Higgs/top/EW factories and have been driving the submission of the LUXE TDR. The Advanced Software Group leads the Key4HEP, PODIO/EDM4hep, and iLCSoft efforts and study ML algorithms more generally. The Test Beam group has integrated new telescopes, and user demand remains very high.

The Plasma Wakefield R&D group is making good progress and has been instrumental in developing a new Higgs factory machine concept (HALHF) using plasma acceleration to accelerate electrons to 500 GeV. The HALHF concept is being followed up also on the physics and detector side.

Staffing levels are low across the board, which is especially critical for the future collider study group and the software frameworks group. DESY has an important mandate to provide support to German Universities working in this field. In the present situation departures not replaced will hurt some parts of the activities more than others, and with limiting hiring possibilities imbalances are developing.

Group members have key roles in the recently established SC and DD platforms. These platforms are strategically important for lab wide coordination and knowledge exchange, and also for addressing and exploiting future scientific and funding opportunities.

### Comments

The FTX group's wide expertise and the forward-looking R&D are very important for strategic planning and new initiatives in upcoming experiments, especially planning for a new POF period. The S&C and Detector platforms are important, among others, for the same reasons, and it is important that FTX members have central roles in these platforms.

The test beam facility continues to be a critical community service and is aligned with the core mission of DESY. It is a major asset for detector R&D and serves many groups at DESY and internationally, and it is important that it will also run in parallel to PETRA IV. It is also of importance for science outreach and runs an active education program.

Finally two more general comments:

The beams at DESY has performances and parameters that offer unique scientific opportunities for on-site world-leading experiments and studies in HEP. LUXE using an extracted beam for EU-XFEL and HALHF demonstration experiments in FLASHForward are examples, and other possibilities could be considered. In addition to FLASHForward activities, the FTX group, building on their expertise in physics studies, detector and software developments for future colliders, is very well situated to analyze these opportunities, and possibly propose them.

### Identification of critical issues

No critical issues identified.

### Specific recommendations for FTX

The SC and DD platforms are being started up. It is important that FTX take an active and some cases leading roles, being involved in planning and prioritizing of future scientific opportunities and funding requests. The PRC is looking forward to reports on the progress of these platforms in future meetings.

The PRC recommends to continue the investment in the FTX efforts, strengthening the software group, and maintaining at least a minimal number of scientific and technical staff working on future colliders, since even modest investments have been shown to have a big effect and will be important to support German University activities within future collider studies, including HALHF.

## Belle

### Findings

Since PRC95, the new Belle II pixel detector (PXD2)'s has been installed successfully, as part of the vertex detector (VXD) system. Problems were met closing the beam-pipe due a clash between VXD cables and the Remote Vacuum Connection system, which DESY helped overcome. Risks remain for the operation of PXD2: effectiveness of additional cooling on the beam pipe hot spot, changed grounding and bowing of ladders. Two outer ladders are not sliding properly, and may have to be turned off to avoid damage, but there is redundancy with the inner layer. The DESY team working on the PXD2 is expected to shrink during 2024, including the retirement of Carsten Niebuhr. Some engagement in PXD2 operations and performance monitoring will continue and a test setup at DESY will be revived. The leadership of the PXD2 project is anticipated to pass to another German group. SuperKEKB commissioning is now expected to start in late January 2024 (physics data-taking from last week of February), representing a two-week delay over the previous schedule.

To monitor progress with the B-factory program at KEK, the Japanese ministry MEXT has established benchmarks for the review of SuperKEKB and Belle II, and metrics for success until 2032. KEK has implemented an international task force to identify upgrades towards design luminosity. The plan entails substantial upgrades to the interaction region (IR) to be implemented in Long Shutdown 2 (LS2). The longer-term aspirations of the DESY Belle-II team for the next upgrades of the detector are not yet established. Belle II is putting together an upgrade Conceptual Design Report (CDR) to be followed by a Technical Design Report (TDR) in 2024. Three German institutes (Bonn, Dortmund, Göttingen) are engaged in work towards a major replacement of the current VXD with a five-layer CMOS pixel detector (VTX) – at present DESY is not involved in this work.

One new physics result with DESY leadership was unveiled at the EPS-HEP conference: first evidence of the decay  $B^+ \rightarrow K^+ \nu \bar{\nu}$ , increasing the statistical power with a new inclusive tagging technique. A new Helmholtz Young Investigator Group (YIG) has recently started, with Göttingen. The focus of the group is on time-dependent CP violation.

The DESY role in Belle-II computing is evolving. The current deputy computing coordinator will leave DESY in 2024 but will stay in close contact. The National Analysis Facility (NAF) operated by DESY continues to be heavily used for fast-turnaround workflows in Belle II.

## Comments

The DESY Belle II team continues to be well-positioned in the collaboration: the new YIG strengthens the portfolio, but a substantial loss in PXD2 expertise comes in 2024. The DESY Belle-II team is congratulated on the completion of the PXD2 installation and their swift help with the installation problem. The PRC congratulates the group on establishing first evidence of the decay  $B^+ \rightarrow K^+ \nu \bar{\nu}$ . This was a highly visible and very well received result at this year's summer conferences.

The plans for substantial IR upgrades at SuperKEKB in LS2 are fundamental for achieving the target luminosity. The current proposals presented to the PRC are ambitious, and still somewhat conceptual. The PRC believes that the expertise of DESY in systems engineering, and DESY's national lab infrastructure, will be invaluable for Belle II also on this timescale.

The DESY team should keep a leading involvement in Belle II computing and accompany the further development of fast-turnaround workflows.

## Identification of critical issues

No critical issues identified.

## Specific recommendations for Belle II

DESY should consider the role it can and wants to play in the planned Belle-II upgrade, and play a more active role in shaping the SuperKEKB plans for LS2 and beyond, both the upgrade of the IR and upgrades to the Belle-II detector. If DESY chooses to play a significant role in the Belle-II upgrades, the Belle-II group will need additional detector expertise.

## ALPS

### Findings

ALPS II has started data taking end of May 2023 and successfully operated the experiment for two periods, Run 1 and Run 2, between May and July. During these data taking periods of about  $150 \times 10^3$ s, the collaboration focused on understanding backgrounds and systematics of the experiment.

The collaboration managed to better understand the challenges imposed by stray-light, and developed a mitigation strategy by increasing the duration of future data taking periods to ~1 million seconds such that the stray-light continues to integrate incoherently, thus rapidly increasing our signal to noise ratio. With the initial runs, the collaboration demonstrated that the heterodyne (HET) sensing is working smoothly with its main characteristics being understood from first-principle calculations as well as simulations.

The collaboration managed to implement an automated locking system, which is essential for future runs, increasing the duty cycle and reducing the person power necessary for monitoring and re-calibrating.

Beginning of November next data runs have started with the goal to collect one million seconds of good data with two different laser light polarization to search for scalar and pseudoscalar axion-like particles and axions. These runs will be the basis for a first science publication.

The plans up to end of 2025 are well defined. APLS II plans for the coming years include in winter 2023, with the current optical system two 1-million second runs searching for scalar particles (October - November 2023) and for pseudo-scalar particles (December 2023 - January 2024). These runs will be followed by further stray-light and cavity studies (February - April 2024). It is then planned to include the production cavity during Spring/Summer 2024, and to commission the optical system with the cavity up to Fall 2024. This will be followed by a 1-million second science run searching for scalar particles and another 1-million second run for pseudo-scalar particles.

Currently foreseen is to upgrade the experiment's optics following these runs, to commission the system up to Summer 2025 and the continue with two more science runs of 1-million seconds to search for scalar particles (Fall 2025) and pseudo-scalar particles (Fall 2025).

Since the last PRC, important milestones have been reached by the collaboration for the developments towards a Transition Edge Sensor (TES) detection system. This system represents an alternative for a single-photon detector for the ALPS II experiment. As well, joined activities with other research partners on the development and exploitation of the TES detection systems are expanding, e.g. with the "Physikalisch Technische Bundesanstalt" (PTB) in Berlin, Germany, and the "National Institute of Standards and Technology" (NIST) in Boulder, USA, where cooperation framework agreements are being prepared.

## Comments

The PRC enthusiastically congratulates the ALPS II collaboration and DESY for the successful initial ALPS II science run in May 2023. The committee notes with satisfaction the excellent performance of the experiment and of the infrastructure. The PRC notes with pleasure that the media response to the ALPS II start-up is overwhelming, and that there is a wide range of interest in our science and DESY as laboratory. This success underlines the ambition at DESY to exploit on-site axion experiments as goldmines for fundamental research in particle physics.

The committee also notes with satisfaction that e.g. the ALPS II optical system seems to be more robust than expected, the previous world-record light storage time in the regeneration cavity has been surpassed.

The PRC congratulates all parties involved for their endurance and steady support and progress over more than 11 years to bring the ALPS II experiment to life and is looking forward to a rich physics harvest, which can be expected in the coming years. The committee supports the plans by the ALPS collaboration and DESY to organise an "axion symposium" at DESY in Hamburg in late January 2024 on the occasion of first science results.

ALPS II has successfully demonstrated its large potential, and the experiment should continue to develop its techniques to also search for WISPs with a TES-based detection system, expand the mass range by buffer gas in the magnet tube, use the ALPS II installation to measure the vacuum magnetic birefringence and/or search for high frequency gravitational waves.

The PRC notes the progress achieved by the collaboration towards the developments towards a Transition Edge Sensor (TES) detection system, in particular the possibilities the cryogenic laboratory (DMLAB) at DESY offers for such technologies, which is also beneficial for a wider range of dark matter searches.

## Identification of critical items

There are no major risks identified by the PRC regarding the performance of the ALPS II experiment. However, there are issues, beyond the control of the collaboration, which the committee would like to address:

- The helium transfer-line from the cryo-plant on the DESY campus to the HERA North area (the location of ALPS II) shows a tiny helium leak in a region 150 to 300 m after entering the HERA tunnel from the hall West. To avoid further increase of the leak, a technical solution has been found to warm up only the ALPS II experiment in case of technical interventions, while keeping the transfer-line cold and stable.
- Experience gained in the initial ALPS II runs showed that optics expertise in the collaboration remains a matter of concern.

## Specific recommendations for ALPS

The PRC recommends that DESY continues to give its strongest support to profit from this successful experiment, and appreciates that the Helium supply for ALPS II operation up to

2025 has been secured. The committee suggests that the ALPS II experiment, in close collaboration with DESY at large, starts looking into its longer-term prospects, also in the context of possible schedules of the other Axion experiments BabyIAXO and MADMAX. Concerning the helium leak the committee recommends to prepare scenarios and repair procedures for the case that the leak increases and makes ALPS II operations impossible. The committee recommends to identify mitigation options in the collaboration (attracting new member institutes with optics expertise) and at DESY (hiring of optic expert) to ensure sufficient expertise for the experiment.

## **MADMAX**

### **Findings**

There is significant progress on the experimental setup. The collaboration demonstrated a good understanding of the booster factor of the dielectric disks. Both simulations and measurements show consistent results. There are also strong ongoing R&D activities including first steps towards the physics exploitation. The collaboration had a physics run using the Morpurgo magnet at CERN of 1.5T at room temperature and a 100mm diameter booster. It was able to already surpass CAST in a small frequency range around 20 GHz, already an impressive accomplishment. The planned next steps include a physics runs at cryogenic temperatures that can potentially already improve the sensitivity by an order of magnitude. Boosters with a larger diameter are planned to further improve sensitivity

### **Comments**

MADMAX pursues a unique and leading concept. There is large technical progress noted in the unique detector, and PRC wants to congratulate the collaboration on demonstrating a convincing case of the booster response. Further runs to improve the technical ability of tuning the system also at cryogenic temperatures should be planned.

The collaboration is progressing via well-defined stepping stones, and PRC considers the ongoing work and progress as critical for keeping the collaboration moving forward.

There is a potential for funding for a prototype of a magnet coil. This would a very positive development a very critical area for the collaboration.

### **Identification of critical issues**

A successful future of MADMAX depends critically on the magnet development.

### **Specific recommendations for MADMAX**

- The PRC asks the collaboration to demonstrate frequency tunability of the booster system at cryogenic temperatures.
- The collaboration needs to keep momentum on the magnet issue. The continued work to fund this development is crucial.

## **BabyIAXO**

### **Findings**

There is a lively and active collaboration with more than >125 scientists from 23 full member institutions plus + 5 associate institutions. Progress has been achieved on all aspects of the project, i.e. the mechanical structure and the drive system, the vacuum and gas systems, the magnet system, x-ray telescopes and detectors. The DESY collaborators and DESY support teams continue their vital roles to reach that progress. The funding of the above mentioned system seems sufficiently clear except for the magnet system.

The collaboration is now planning the installation of the experiment assuming that the magnet system will arrive latest, giving a scenario of a "Dry run" installation, where everything except the magnet will be installed. This would allow for an early commissioning, alignment surveys, background measurements and initial physics runs.



On the magnet system, it has to be kept in mind that it is the world largest SC Dipole, and that the system is based on cryo-coolers – a novelty for such size of the superconducting magnet. The magnet design efforts have gained significant momentum (DESY, KEK, CERN, ELYTT,...). As well there is progress towards finding Al-stabilised SC cable. Initial – but not sufficient – funding for the magnet system design and the study of the Al stabilized cable is provided by Zaragossa, Bonn.

## Comments

The PRC notes with pleasure the progress achieved by the IAXO/BabyIAXO collaboration, and that the collaboration remains very active on all fronts, also strengthening and extending the physics programme.

The committee notes with pleasure the developments for the optics, x-ray detectors, including tests at the DESY site, and the support the collaboration receives by DESY to start construction the experiments movable platform and to characterize the experimental facility. The committee congratulates the collaboration for being rewarded with an ERC synergy grant DarkQuantum for I. Irastorza et al.. Also NSF and INAF grants have been obtained supporting the collaboration.

The PRC appreciates the agreement ESA and the BabyIAXO collaboration on the use of an XMM flight spare mirror for the experiment. The committee considers that it is now the time to initiate the process of establishing a formal loan agreement between ESA and IAXO/DESY. The committee takes note of the discussion of the strategy for a “dry run” installation.

The PRC notes the progress on multiple aspects of the magnet system. This concerns both the design effort and the SC cable, where a supplier is currently prototyping a part of it. A review is planned early Spring 2024.

## Identification of critical issues

The PRC still considers the BabyIAXO magnet system driving the projects timeline and remains the main experiment’s risk.

## Specific recommendations for BabyIAXO

The PRC appreciates (external) reviews to establish a realistic cost estimate of the system and a reliable scheduling to build, test, install and commission the magnet system. The timescale for the magnet review, possibly in phases, should be matched to the progress on and results for the magnet conceptual design and the Al-stabilized SC cable.

## LUXE

### Findings

The LUXE collaboration remains attractive for institutes from all over the world, currently more than 100 collaboration members from 20 institutes.

The DESY LUXE team covers specific technical needs as the coordination of the work to install the beam pipe (50% of an experienced physicist, 50% of an engineer) and on software (100% OCPC post-doc for LUXE migration to Key4HEP).

The collaboration completed the TDR <https://arxiv.org/abs/2308.00515>, and the TDR has been submitted to EPJST.

Efforts by the collaboration to secure grants were not successful: an application for an ERC synergy grant (14MEur to fund significant parts of laser and detectors) and an application for an EU-INFRA grant (5MEur, for extraction line with 3.3MEur by DESY to fund technical person power) failed at the final selections. As well, special funding hoped for from the German funding agency BMBF was not granted.

This has impact on the LUXE panning, in particular as a DESY Strategic invest (3 MEur), “earmarked” for LUXE in DESYs mid-term planning in case of the ERC Synergy Grant had succeeded, is not yet released.

At DESY, LUXE had received an approval status "CD1" in November 2022. It was hoped that the next step, approval status "CD2" been granted once outside funding has been secured, in particular via the ERC Synergy Grant application.

An additional approval step - after "CD2" - is imposed by EuXFEL, where the scientific council is required to give an approval for the use of the LUXE beam line, which implies that the LUXE science would become part of the EuXFEL portfolio and strong-field QED could become part of XFEL scientific mission.

In view of the unsuccessful funding applications where mainly the laser components is affected, the LUXE collaboration adapted the spending profile. The first years heavily depend on DESYs strategic investments covering infrastructure and beam-line needs.

With a re-application for ERC and EU-Infrastructure funds it is hoped to cover later spending. Funding from the institutes for detectors seems sufficiently secured.

Since the last PRC, the progress toward preparation of the beam-line for the LUXE experiment (TD20) is limited. The collaboration has planned to prepare the beam-line in two main packages to use the window of opportunity offered by the long shutdown 2025, which allows for a sufficiently long installation time of six to eight weeks.

Package 1, with the goal to be installed in 2025 includes the kicker magnet, the extraction Septa, a short beam-line and a first quadrupole. It requires the dismantling of the XFEL beam-line and an opening of the machine. The PRC identified as critical items of this package the septa and kicker magnets as these require magnet manufacturing at DESY.

Package 2, on the construction of the remaining beam-line up to LUXE, includes preparations of HERA quadrupole and corrector magnets as well as new dipole magnets, which the PRC also considers on the critical path for an installation in 2025. Although here, a delay could be mitigated by a one-year delay and installation in a short shutdown.

On the critical items of package 1, the order for the Septa (~300 kEUR) has been approved by the DESY directorate, but the call for tender has not yet started. The other time-critical preparations for minimal T20 installations in the 2025 shutdown are also still pending.

The collaboration reports on a successful test at DESYs ARES electron LiNAC of the Cherenkov counter. Also since September tests of the instrumented final electron dump are performed at FLASHForward with a backscattering calorimeter prototype. The collaboration also reports of their successful integration of LUXE reconstruction into state-of-the-art HEP software and development of Quantum Algorithms.

## Comments

The PRC notes the progress achieved by the collaboration on the design, prototyping and test of detectors and encourages the collaboration to continue to seek opportunities for beam tests, also to foster the collaboration.

The committee regrets that the efforts by the collaboration to secure grants were not successful.

The PRC is concerned of the delays in the purchase of the beam-line septa which is considered as critical for the preparations for the installation of T20 in 2025 shutdown to proceed with the LUXE beam-line.

Such an unclear situation puts into risk the perception of LUXE in the science community but also among funding agencies as a credible project inside and outside DESY. It also limits chances for success of further 3rd party funding applications, which are vital for the project.

## Identification of critical issues

The PRC is concerned on the funding situation of the experiment.

The PRC notes that several items of the TD20 extraction beamline remain on the critical path towards reaching the shutdown 2025 and encourages orders to be made in a timely way.

## Specific recommendations for LUXE

The PRC encourages the collaboration to re-apply, taking into account any indication which might improve the applications. The committee appreciates the efforts by the collaboration to systematically search for opportunities for 3rd party funds.

(see also general remarks and recommendations concerning on-site accelerator based research for particle physics)

## Theory Findings

We congratulate the DESY Theory Group on its creative, original and successful work in string theory and mathematical physics. The key research directions range from string-theoretic approaches to non-perturbative QFT to integrability, to amplitudes and to AdS/CFT methods. These are very topical and hence competitive directions and it is a great achievement that DESY Theory continues to be a main player in this broader field, with recent breakthrough results concerning, e.g., Gaudin integrable models and high-multiplicity amplitudes. Another research direction in mathematical physics which also has a strong relation to particle physics is that based on supersymmetry, string compactifications and their cosmology. This avenue is pursued, also very successfully, in close collaboration with Hamburg University.

The ensemble of the Theory Group continues to be extremely successful in attracting third party funding. The latest example in a long history of successful applications, after the recent ERC consolidator grant "Broken Symmetries" awarded to Elli Pomoni, is the Emmy Noether group of Johannes Braathen devoted to precision calculations for New Physics.

In addition to bringing in leading young, independent researchers, third party funding at this moment supports about half of the postdocs and PhD students working in the DESY Theory Group. This is an outstanding success, given in particular the fact that permanent DESY staff is not eligible to apply for conventional DFG grants.

A successor to Prof. Bluemlein for the Zeuthen group has still not been hired.

## Comments

DESY Theory enjoys an excellent reputation on a world-wide scale. It contributes significantly to the particle physics research at DESY, to its connections with Hamburg University. It gives the Laboratory as a whole a high international visibility, and for relatively limited funding. Also, the leading role of the DESY Theory Group within the theoretical particle physics community in Germany should not be underestimated.

It appears to be very difficult to continue this success story in view of the expected, very significant, further cuts. While we are certain that the Theory Group will try to do their best, one has to be concerned that further cuts might at some point start to compromise the attractiveness of the DESY Theory Group to young researchers who join with their own funding, bringing in addition funded postdocs and PhD students with them.

It is non-trivial but important to ensure that DESY Theory remains an equal partner to theoretical and mathematical research at the University. Of course, in many DFG grant applications DESY has to be the junior partner by definition. It is then the more important that theorists at DESY have enough base funding to take a leading role in other projects. Also, DESY has an interest in keeping its Theory Group strong enough to resist a possible pull by the University towards more and more formal and mathematical research.

It should be stressed once again that the success in attracting third party funding, especially junior research groups, should not be taken as justification for further cuts.

With respect to DESY Zeuthen, a number of very good reasons for hiring a successor to Bluemlein had already been given already in the last and in previous meetings: such a hire is essential for maintaining a visible phenomenology group at Zeuthen, which would be complementary to the Hamburg activities through its focus on very high order perturbation theory, potentially with a strong connection to gravitational wave physics. It could also play

a key role in linking DESY Zeuthen more strongly to experimental research than it can be realized with a pure lattice group. In addition, a precision phenomenology group provides an ideal contact point to related activities at Humboldt University, e.g. in the groups of Jan Plefka and Peter Uwer. In this perspective, the hiring of a strong successor to Prof. Bluemlein is a strategic decision.

### Specific recommendations for Theory

We reiterate the importance of maintaining a sufficiently high level of base funding. Everything possible should be done to avoid a continuation of the cuts (by two postdocs in 2023 and a planned further cut on postdoc positions in 2024 of 3 or even more -although in any case less than 6). Concerning the planned cut in 2024, it should be up to the Theory group to decide which part of the cuts in FTE is applied to students and which to postdocs. The relative proportion should tend to the simpler options to find alternative sources of positions.

The committee is also concerned about the delays in the renting procedure for the WPC building. The situation should be clarified as much as possible and as soon as possible, and in particular the problems --as well as the prospects-- should be clearly communicated to, and openly discussed with, the DESY Theory group. We can only reiterate the importance of the WPC and a high-quality renovation of the new building, not just for Theory but for DESY as a whole, as well as for the interaction with Hamburg University, including for the successful application for an extension of the Quantum Universe Cluster.

We recall the specific recommendations concerning the renovation of the new WPC building, as the specific needs of theorists should be taken into account: in addition to offices, discussion rooms, blackboards etc., it is necessary to create a large enough and sufficiently high seminar room (for 100+ people), if at all possible with a sloped floor. The plan must also encompass enough space and facilities to host a "research hostel" to attract new talent. Moreover, it would be ideal if the building could accommodate both theorists and experimentalists. This would create an environment where those entirely unprepared and informal encounters can happen which sometimes lead to truly new ideas and breakthrough discoveries.

Furthermore, the committee recommends to proceed with the search of a successor to Prof. Bluemlein for the reasons explained above. Given the present situation with respect to cuts in personnel funding, it may be worth to explore the hiring of a strong expert which comes with associated third party funding, such as Emmy Noether group or other profiles which may attract external extra funding.

Last but not least, in order to maintain DESY's unique position as a centre for axion physics, and to match its increasing experimental success in this quest, it is strongly advised to start early on the search for a young international theoretical leader in that domain of expertise, which would be a successor to Andreas Ringwald, an established world-leader in this field. Now is the time!

## IT Findings

DESY IT consistently provides high-quality computing resources and infrastructure for local, national, and global science, with notable contributions as a Tier-2 provider for LHC experiments and a key player in the Helmholtz data infrastructure. The team focuses on three central themes: 1) scientific computing infrastructure and resources, 2) data management and analysis, and 3) artificial intelligence/machine learning/imaging science. Despite challenges like the change in RedHat licensing and budget constraints, the group successfully addressed issues such as aligning IDAF components and securing funding for the Tier-2. The collaboration with Petra IV scientists has commenced, and the promised computing infrastructure for various experiments is in place for 2023.

## Comments

The PRC commends DESY IT for delivering high-quality results despite challenges. The pledges for 2024 can be realised, however, 2025 poses challenges due to external factors and potential budget limitations. The RedHat licensing model change necessitates a strategic shift, with a negotiated five-year grace period. Local experiments require comparatively more support than the large (LHC) collaborations; DESY's strategic focus on local experiments implies planning for the necessary support effort. IT makes an important, high-impact and high-visibility contribution to the HIFIS platform, for example in ensuring of computing security across the Helmholtz Federation. The PRC appreciates the creation of the FH Computing Platform, emphasizing synergies across the laboratory and its positive contribution to funding proposals to the BMBF. The PRC would like to see more information on how the activities within "AI / Machine Learning / Imaging Science" are providing value to the DESY science program.

## Identification of critical issues

No critical issues identified.

## Specific recommendations for DESY IT

- DESY IT has been extremely successful in attracting external funds; despite their benefits, such external projects can cost effort for the permanent staff and the operation teams. The group is encouraged to also engage in projects that are in line with operational topics to further improve the benefit-to-cost ratio.
- The PRC encourages following through on the collaboration between DESY IT and scientists from Petra IV.
- Regarding the redistribution of Tier-2 resources in Germany, the PRC recommends rapid convergence on a clear division of responsibilities between the various partners - DESY IT cannot afford to brunt the full effort of this redistribution.