Recommendations of the 86th Physics Research Committee

November 2018

General remarks

The PRC took note that a new Directorate for Astroparticle Physics will be created and that the DESY Foundation Council has formally approved this restructuring. The PRC congratulated C. Stegmann on his appointment as Director for Astroparticle Physics commencing 1 January 2019.
The PRC was not convinced that this added structure will result in an improved degree of scientific cooperation between particle physics and particle astrophysics activities at DESY. The PRC believes that such cooperation is vital for the overall success and future of fundamental physics research at the laboratory.

In moving forward with its review process in light of the new structure, the PRC recommended that it be augmented with additional members to cover astroparticle physics in greater depth. For future PRC meetings it suggested a mode of operation as follows:

- The whole PRC meets with both Directors in closed session at the meeting start.
- The whole PRC attends the open-session presentations so as to be aware of the entirety of the DESY fundamental physics programme.
- The whole PRC discusses PRC-wide matters in the closed-session working lunch.
- The PP and AP 'branches' meet in parallel for the following closed-session discussions with the groups.
- The whole PRC reconvenes for the meeting closeout so as to share major conclusions and discuss relevant issues.

The PRC recommended that the future meeting location could be rotated between Hamburg and Zeuthen according to some sensible pattern.

We congratulate DESY on the award of the Quantum Universe Excellence Strategy cluster for DESY and Hamburg University.

ATLAS

The DESY ATLAS group continues to make strong and visible operational, managerial and technical contributions to the experiment. Group members take several leadership positions (general management, computing, physics working groups, object performance groups, Detector operation, deputy physics coordinator)

Physics analyses portfolio

The group has a balanced portfolio of physics analyses in top/SM, BSM/Dark Matter searches, Higgs, HL-LHC physics studies. It also makes important contributions to physics object reconstruction and performance (e.g. jet calibration, e/gamma, inner tracking, b-tagging, luminosity, MC production, software, simulation). A good integration of YIGs and the ERC group with individual senior staff can be observed.

Since the last PRC, the group has produced or contributed to ten publications and eleven public notes.

Upgrades & Operations
The group provides significant contributions to ATLAS operations (SCT, Alfa, FTK). Also the upgrade project makes very good progress (module building in Hamburg and Zeuthen, petal production, thermal tests, software, test beam ...). The necessary clean room 25c / DAF in Hamburg is operational, the Zeuthen Z-DAF is making good progress.

Personpower & Funding
Several fellows joining the group further increased its size. Furthermore, a YIG group was recently established in Zeuthen, and a new staff member joined in Hamburg. Kerstin Tackmann has be appointed to a joint professorship with Hamburg University as a DESY leading scientist, and the search for a joint W2 professor for detector development with Bonn University are about to conclude.

The PRC congratulates the DESY ATLAS group for their significant accomplishments!

Key comments and recommendations for ATLAS:
PRC takes note that ATLAS plans to outsource petal production to industry in order to free resources at DESY. PRC concurs that thorough quality control and assurance will be essential.
PRC notes that the planned manpower for the upgrade seems adequate at this point in time and is pleased to see that in many cases people successfully contribute both to analysis and upgrade work. PRC recommends that the support of a central technical person for Z-DAF be ensured.

CMS

Since the last PRC, the DESY CMS group has seen four thesis defences, and it has published (or significantly contributed to the publishing of) five publications, include that of the H→bb observation.
DESY's influence on the career paths of Ph.D. students and postdocs remains excellent – while at DESY, young scientists enjoy high visibility and responsibility in their activities and in the experiment. It is thus very attractive for young researchers to get a position at DESY.

Contributions to the experiment
The DESY CMS groups continues to make strong contributions to the experiment: They cover leadership positions and coordination roles across all aspects of the experiment.
The group's contribution to physics papers is above their weight (by number of people). Besides the broad portfolio of physics topics covering SM, top physics, Higgs (key contributions to ttH production in H→bb channel, neutral MSSM-Higgs decays to tau leptons), and SUSY searches, the group is also active in producing phenomenology papers (resulting in five publications since the last PRC). We commend the group's contributions in QCD&SM physics: Improving the understanding of QCD is foundational for the success of the HL-LHC physics programme. Group members are currently top physics and H→bb convenors, among other things.

Data collection and computing
The experiment has so far collected around 50 fb-1 in 2018. The CMS detector is performing at record efficiency.

Detector and detector R&D
The tracker phase II work is well in progress. The DAF construction infrastructure is in place, with occupancy soon, and the necessary ingredients for production are in place or being developed. The design of the disks is novel in construction, and prototyping is well under way for key challenges associated with assembling the modules into half disks. The available effort in terms of staff scientists and fellows is low relative to the staffing plan for the project. **There is a gap in personnel having a strong instrumentation profile, and it will be critical to address this gap in the next year.**
BCM1F is operational and provides CMS with precision luminosity measurements. Planned contributions for BCMF1 for Run 3 seem to maximize potential at low risk.
The HCAL HE SiPM / µTCA is operational – HB is up next for upgrade. The H0 link to the L1 muon trigger is commissioned and studies are ongoing.
Work on the ELAD sensor, which provides higher sensitivity by charge-sharing is ongoing and has already shown promising results. A new 3D material budget tomographic imaging technique using multiple scattering is being developed.

The PRC congratulates the CMS group to a successful data taking in 2018, and it re cognizes the group for their continued significant accomplishments and publication record.

Key comments and recommendations for CMS:
For the next meeting, the PRC would like a 'deep' dive into the project aspects of the tracker upgrade, including updated effort profile.

Belle / Belle II

Belle II phase 2 running took place in April to July 2018. Progress on the focusing of the beams met expectations. 472/pb of physics data has been collected. An unexpected rate of quenches in the final-focus magnets has been observed. The beam currents had to be limited to about 10% of the nominal values due to beam background induced excessive currents in the CDC central drift chamber. In addition, a sudden current increase in the CDC has been observed that, however, seems to be caused outside of the chamber itself and not due to ageing effects.
The DESY deliverables BEAST II, remote vacuum connection (RVC) and the vacuum-insulated CO_2 pipes were operated successfully.
Analysis of the phase 2 data is currently ongoing. Focal points are: alignment, tracking, understanding the material distribution in the new detector, trigger and object reconstruction efficiencies. First "re-discovery" results are available.
The analysis part of the DESY group has grown substantially. It is well integrated in the Belle physics programme and has leading roles in several areas. The analysis plans look very reasonable at this point in time.
A too high failure rate (~40%) during ladder assembly has led to the decision in June 2018 to descope the PXD detector to just the layer 1 plus two ladders in layer 2. This decision was

based on the need to keep a schedule that allows for a start of phase 3 running still in the current fiscal year. It brought the PXD off the critical path.
PXD half shells have been tested at DESY and delivered to KEK on 22 August and 5 September, respectively. By now the PXD has been mounted onto the beampipe and combined with the SVD. VXD commissioning is foreseen until 9 November, then installation into Belle II will take place. First beam of phase 3 is now planned for 11 March 2019.
A strong DESY team of 9 scientists and engineers is active at KEK to commission the detector.

In reaction to the need for descoping the current detector, the collaboration plans to construct another PXD detector (PXD2020), which should be ready for installation in the shutdown July-December 2020. It would use ladders constructed of both existing L2 and new L1 modules. Production of new DEPFET sensors is underway with the aim to finish wafer processing in late autumn 2019. Assembly and test of the half-shells are again foreseen at DESY, in the first half of 2020.
The physics implications of running Belle II with a descoped PXD in 2019 and 2020 strongly depend on the level of background because a main function of the second PXD layer is to establish the link to the SVD and therefore to discard background hits in the first layer. During the phase 2 running the backgrounds have unfortunately been much higher than expected.
PRC notes that DESY's contributions to Belle II continue to be very vital and highly successful: all DESY deliverables were available on schedule and operate as expected. A strong DESY team at KEK was and is essential to commission the Belle II detector. The main goals of the phase 2 running have been achieved and much has been learned about detector operation at the new accelerator. The much higher than expected background rates are a serious concern. The descoping of the PXD detector, caused by severe quality issues in ladder assembly, is unfortunate and will have an impact on the physics performance of Belle II that still needs to be quantified.

Key comments and recommendations for Belle / Belle II:
The PRC agrees that an upgrade to the full two-layer PXD as soon as possible is highly desirable.
The PRC requests a schedule and a resource planning for the construction of a new PXD which document the commitment of all partners.

International Linear Collider Activities and Preparations for Future Experiments

The DESY FLC group is one of the major players in the common worldwide international effort to develop the future projects of accelerator-based particle physics beyond the LHC programme. The groups is very active getting additional external sources, which mainly come from EU funds (AIDA2020, E-JADE, etc.), and gets high-level coordination roles in those projects. The group shows very high leadership and responsibilities in the context of the Linear Collider Collaboration such as the spokespersons of both detector concepts ILD and SiD, physics studies, software development, machine-detector interface. They also provide crucial contributions to EU projects like AIDA2020 or EJADE or to R&D

collaborations like CALICE or LCTPC. There is also good collaboration with the CLIC development.
The DESY FLC group is heavily involved in the process for the next European strategy update (ESU). In fact, its contribution is critical to formulate the ILC case.
The group currently includes 11 FTE scientists; 3,5 technical staff and 13 Ph.D. students. In the near future key people will end their contracts.

The activities of the group cover:

- detector development (time-projection chamber, vertex detector R&D, high-granularity scintillator SiPM-on-tile calorimeter (AHCAL), forward calorimetry),
    - TPC: Test beam results show that the main performance parameters have been reached. Work to improve particle identification (by reducing pad size) is on-going. A new field cage is being constructed in-house.
    - Development of the silicon-strip telescope as a test-beam facility for the TPC and of the associated data acquisition system is ongoing. First tests are expected for early 2019, and together with the TPC mid-2019;
    - Hadronic calorimeter (AHCAL): A prototype (22000 SiPMs) was constructed and successfully tested in a beam test in May-June and October 2018 at CERN). More than 50 million events were recorded, with 0.1% dead channels. Mechanical studies on static and dynamic stability are on-going. Future tests depend on the overall status of LC projects.
    - R&D for the new CMS end-cap (HGCAL) and explorations into neutrino physics (DUNE) have also been pursued. The group delivered important contributions to the HGCAL TDR, and DESY staff hold important coordination roles. The group plans the participation in the EDR for 2021 and a combined testbeam. However, there is no commitment for construction.
- site studies, detector integration and machine-detector interface,
- beam-related studies on backgrounds and positron source
    - Among other things, the muon background for different ILC scenarios was studied for the first time by the group.
    - Studies on the ILC positron source for high-luminosity electron-positron colliders were performed. This work is still in a critical situation as was reported already in the last PRC.
- software developments
    - Software development on core software components, generic implementation of detector geometry (DD4hep), event reconstruction. Large production of events for ILC optimisation completed;
- physics studies (Higgs & BSM)
    - Studies of the physics (Higgs and new physics) for future e+e- colliders considering realistic detector and accelerator conditions are being continued. Recent efforts cover the physics case at 250 GeV and the role of polarization. These are also crucial inputs for ESU.

Overall there is good scientific production on physics detector R&D. The publication record since last PRC comprises 4 Ph.D. theses and 7 publications (papers and preprints).

Key comments and recommendations for the FLC group:

The PRC recognizes the group as one of the major players in the common worldwide international effort to develop the future projects of new accelerators beyond the LHC. In particular we commend the key role the group plays in the next European strategy update, and we encourage the group to keep its leadership. In this context the support of the lab should be continued in both technical and scientific aspects including personnel.
The PRC congratulates the group for the excellent progress and high-quality achievements reached in all areas in which the group participates.
The PRC acknowledges the effort of the group following past recommendations in keeping/creating synergies with other projects of the field (both future and present): CLIC in general, CMS and DUNE in calorimetry, or the development of software tools (future colliders: CLIC, FCC, CepC).
In particular this time, the PRC acknowledges the successful transfer of the SiPM-on-tile technology developed for the ILC to the upgrade of the CMS endcap calorimeter for the high luminosity phase of the LHC. The PRC recognises the mutual benefits of this collaboration and recommends to support it with the needed resources.

Theory

We heard with great pleasure about the new developments and the connections between physics and mathematics in the context of superconformal theories presented in the open session and we congratulate the string theory group for opening novel directions in the application of non-perturbative methods in QFTs.
We moreover congratulate DESY and the DESY theory group on the very good evaluation of the “The Quantum Universe”!
We fully support the plans for the Wolfgang Pauli Centre, both regarding the building of new facilities to promote and boost the interdisciplinary collaboration and communication within the Hamburg theory community and regarding a new organization of the WPC activities. The present relocation of Hamburg University to the Bahrenfeld campus and the success of the Excellence initiative gives DESY a unique chance for strengthening the theory activities in Hamburg, with the perspective of consolidating the present synergies in particle/astroparticle physics and open up the stage for long-term interdisciplinary research.

Key comments and recommendations for theory (partly on questions from PRC84 and before):

The PRC recognises the unique expertise and very visible impact on the field of the DESY Zeuthen collider phenomenology group, and we recommend that DESY develops a strategic plan to maintain a critical mass for this activity within DESY.
It will be a real loss for the community if the unique activity of the Zeuthen group in precision collider phenomenology will be lost (5-loop beta function, PDFs, massive splitting functions, …). This is an outstanding group with activity that is no less world-leading than the rest of the theory group.
We strongly recommend to maintain the collider phenomenology activity at the very least at the level of 2 staff members, and we understand that from informal talks there seem to be positive developments in this direction. We would like to hear more about detailed plans and a clear commitment from the directors.

Particle Astrophysics

The subdivision “Particle Astrophysics” becomes an own division “Astroparticle Physics” being primarly located at Zeuthen. The focal points of the new division are neutrino astronomy, gamma astronomy, a bit astronomical follow-up, theoretical astroparticle physics (sources, accelerators, propagation). These fields work together, pursuing a multi-messenger approach.
Astroparticle phyics at DESY is leading in these fields – the new division is very well positioned in the field with excellent researchers being able to attract excellent people at an international scale
The new division will thus strengthen the role of DESY for astroparticle physics in Germany and Europe even more, but we also see the risk that Hamburg and Zeuthen will drift apart leaving the small particle physics groups at Zeuthen behind. In this context, it is worth remembering that astroparticle physics experiments can and do make measurements relevant to fundamental particle physics. An example are the neutrino oscillation studies carried out by the IceCube collaboration. Conversely, the axion experiments are of interest to astrophysicists, given their connection to stellar cooling.

Key comments and recommendations:
The PRC suggests to keep strong links with the particle physics division at DESY, especially with the growing topic axion and ALP searches there as well as with BSM physics.
The division shall accept its new role also as a responsibility for the astroparticle physics community in Germany/Europe.
The PRC asks DESY to please do not try to find a new definition for “astroparticle physics” different to the one that the funding institutions and the community in Germany are used to.

Neutrino astronomy
The PRC congratulations DESY on its contributions to the discovery of the blazar TX 0506+056 as possibly the first detection of a point source of high-energy astrophysical neutrinos. This result shows that multi-messenger physics indeed becomes reality! We also congratulate for finding the two double-cascade (tau-neutrino candidates) and other interesting events.
The IceCube upgrade has received funding from NSF (pending a technical review in in Februar 2019 The PRC congratulates the whole IceCube Collaboration and especially the DESY group for this breakthrough on the path to IceCube Gen2. DESY will play a leading role in the upgrade, in particular in the string production with mDOMs. For this, the group received special DESY funding (2.85 MEuro). The PRC is happy to hear about the DESY efforts to also include the German universities in this undertaking.
Radio detection of neutrino interactions in ice is being pursued and a proposal to the NSF by US collaborators is due to be submitted by 4 December 2018. The DESY group is planning to take part in the proposed research in Antarctica if the proposal is successful, but is also preparing a backup plan for experiments in Greenland if it is unsuccessful. The PRC agrees that this is a good strategy.

Key comments and recommendations

The PRC encourages DESY to provide continued strong support to its IceCube group to assure the success of the upgrade. Likewise, it should support nascent efforts in radio detectionå.

Gamma astronomy

DESY has strong groups active in all the 'big three' present-generation gamma-ray telescope arrays, HESS, VERITAS, and MAGIC. All three collaborations are planning to extend their observations into the early 2020s in order to maintain scientific output and experimental expertise while the next-generation CTA detector is being built. Support from DESY for operations and personnel will be important during this period. Attrition of people to CTA activities is the main risk.

DESY plays a very important role in CTA; it will host the Scientific Data Management Centre, and preparations for construction of the necessary infrastructure in Zeuthen are underway. Other (in-kind) contributions are foreseen but are not certain. There will soon be a down-select for the small-size telescope (SST) design and it is possible that the DESY-planned CHEC camera will not be chosen. A proposal together with the ASTRI (Italian group proposing a double-mirror SST) to supply a large fraction of the 70 SSTs foreseen for CTA may improve the chances that this design will be chosen. (DESY's position is that it will contribute to construction of SST cameras even if its design is not chosen.)

Smaller efforts, on Fermi LAT data analysis, MeVCube, and TAIGA, contribute to a well-rounded program of gamma-ray astronomy over a broad energy range.

Key comments and recommendations

The PRC appreciates and encourages DESY`s efforts to continue its strong support of the present-generation TeV gamma ray.

Upgrade of the HESS CT5 with flash-cam technology should be carefully considered as it could take financial and personnel resources from the main missions of HESS and CTA. The PRC acknowledges however that there could be positive benefits from this exercise that would be relevant to the CTA project.

Theoretical astroparticle physics

We thank the theory group for a more detailed presentation of the group and its strategy, as was requested after the last (85th) PRC meeting.

The overall impression is that of a healthy group, with strong expertise in particle acceleration, transport, and interactions in astrophysical environments, and close links with experimental community. The theory group has a clear focus on modelling sources of non-thermal neutrinos and photons, and on the interpretation of neutrino, cosmic-ray, and gamma-ray observations. This is appropriate for DESY Zeuthen and its stated mission.

The PRC appreciates that the group has come to a conclusion about the possibilities to investigate astroparticle turbelences with laboratory experiments: The group will not continue to get directly involved in local experimental tests of the Bell instability, although it will maintain an interest and could provide theoretical support for, or profit from, experimental efforts elsewhere.

The group also clarified what they are not interested in doing. The PRC had highlighted during the previous PRC meeting the opportunity to strengthen the links with Hamburg theory

group in the areas of dark matter and cosmology. The Zeuthen-based group has stated that this is not a priority for the group. We recommend to keep the door open to collaborations. We are particularly concerned that astroparticle theory becomes completely decoupled from particle theory once astroparticle physics becomes a separate division at Zeuthen. The committee heard from the future APP division director about possible synergies e.g. in areas such as indirect dark matter searches, neutrino properties, etc. However, this is not reflected in the current interests of the theory group. In fact, they explicitly say they are not active / are not interested in those topics.

Key comments and recommendations

We recommend a strong effort to actively explore possible synergies with particle theory. In particular, it would be good to exploit new opportunities offered by the Wolfgang Pauli Centre in Hamburg to start interdisciplinary projects. In the future, we recommend further strengthening the connection with GW and multi-messenger astrophysics. We suggest exploring the possibility to hire staff with core expertise in numerical relativity / MHD simulations in curved spacetimes.

ALPS-II

The case for ALPS searches is largely unchanged from the last PRC, even if improved limits from astrophysical data came out recently, and still very timely.
The "shining-light-through-walls" ALPS II is one of three flagship axion-search projects worldwide. ALPS is identified with DESY as an on-site experiment.

We are very impressed by the technical progress and pleased to hear that a new cryostat has been installed smoothly and the new SQUID electronics is expected, so that the TES detector will be ready soon. For the heterodyne detection the University of Florida provided a prototype for central breadboard and that seems also on track.
A new mirror coating is being tested at AEI to ensure that the difference in reflecting point for the green and red lasers is within the margins required by the experiment.
The dipoles strengthening has continued at a good rate so that now 13 dipoles are ready, so on this side the project is on a good way to the final goal of 20 straight magnets.

Key comments and recommendations for ALPS:

- Data-taking is scheduled to start 2020 and this is a very optimistic schedule. We would like to ask the collaboration to prepare for the next PRC a more detailed timeline of the project showing the step needed to successfully start data taking as planned.
- Manpower in the optics seems still to be a critical issue. So far this expertise has been covered mostly with DESY fellows and Ph.D. students. This may represent a risk for the final realization of the project and we therefore suggest to find more optics expertise within the collaboration.
- The recent success in bending more dipole magnets has significantly reduced the technical risk of delay, but we recommend to keep up with the momentum in order to meet the schedule.
- We recommend to DESY, if needed, to increase the priority of the experiment in order to avoid delays.

Computing / IT

We commend the continuing success of the DESY Computing Large Scale Facility. The T2 compute and disks systems and the NAF are performing very well with good strong utilization and good uptime. The DESY Zeuthen Computing Facility has good performance and utilization, primarily supporting the Astrophysics program and ATLAS. **The tour of the DESY Zeuthen computer rooms was much appreciated.**

The capacity of the wide area network is being significantly strained by the current LHC load, both on the dedicated LHCone network and on the general-purpose WAN. The general-purpose WAN was increased in capacity from 2 x 5Gb to 2x15Gb. An LHCOne upgrade is an essential longer-term solution to cope with changing LHC Computing Models and the increase in Belle2 network traffic.
DESY IT continues to participate in EU projects, which bring in third party funds. As part of the DESY strategy planning, a proposed "Centre for Data and Computer Science" would extend DESY's portfolio into computational sciences featuring collaboration with Hamburg University and with a potential to obtain third party funding. The organization chart indicates that DESY IT will play a crucial support role. **A graduate program in Data Science and Computer Science has been started, as have common research professorships. This is an important step.** The PRC notes that this is an active time for organizational issues in computing, and would appreciate more information in advance of the closed session.

In the near term, there is a growing need in IT for additional scientific computing expertise required to directly support DESY programs. The requests are for application support (eg. JupyterNotebooks), hardware platforms (eg. GPU), infrastructure support (such with virtualization and containers) and scientific computing expertise (eg. machine learning algorithms).

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

Recommendations for computing / IT:

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