Recommendations of the 83rd Physics Research Committee

April 2017

Outline

General remarks

As **date for the next PRC meeting (PRC84)**, the time slot 19/20 October 2017 has been chosen, 18 October being reserved for the various pre-meetings. The meeting will take place in Hamburg.

LHC Experiments

ATLAS

The DESY ATLAS group, consisting of 18 scientific and 9 support staff members, 21 postdocs, 26 Ph.D. students as well as 2 Master's students, continues to make important and highly visible contributions to the experiment. The DESY ATLAS group contributed to 8 publications since the last PRC, with more to come as the Moriond conference cycle comes to a close. The influx of new staff members has helped to further consolidate the analysis portfolio with a range from Standard Model physics, Higgs and top physics to BSM searches (Exotics). The group also supports a number of operational tasks that may require a prolonged presence of some individuals at CERN. Another highly visible effort revolves around the phase 2 ITk upgrade where the group holds a central role in integration, module testing and thermal and mechanical studies.

The PRC welcomes that a staffing plan for the phase 2 upgrade has been worked out that appears to be commensurate with the tasks at hand, albeit with little contingency.

The PRC congratulates the DESY ATLAS group for their significant accomplishments. We encourage the DESY ATLAS group to continue efforts to attract young talent for a second YIG to be established, preferably in Zeuthen, in 2017/18.

Recommendations for ATLAS:

- Continue to cluster physics analysis channels with good interplay between YIG and senior staff
- Remain vigilant about personpower demands for the phase 2 Upgrade.

CMS
The DESY CMS group continues to make very significant contributions in all areas of CMS, and the PRC congratulates the group on their accomplishments in this period.

- The phase 1 pixel upgrade detector was installed and is being commissioned.
- The new Beam Condition Monitor & Luminometer (BCM1F) was constructed and installed on a demanding schedule.
- The HO calorimeter trigger project is nearing operations, which will improve L1 muon triggering by adding calorimeter information.
- Phase 2 tracker upgrades are progressing and as requested at the last PRC, a staffing plan was developed.
- R&D is progressing towards a TDR for the phase 2 tracker.

Recommendations for CMS:
No specific recommendations were issued.

DAF
The detector assembly facility (DAF) is a unique common infrastructure located at DESY Hamburg (bldg. 25c, bldg. 26) that will be shared by the DESY ATLAS and CMS groups. Since the last PRC, excellent progress has been made such that a start of pre-production for both projects should be possible in early 2018, despite the significant delays previously encountered.
Recommendations for the DAF:
None.

Computing / IT and data preservation
We commend DESY IT on completing the storage migration, the Open Science Cloud award and progress on the HTCondor deployment.
Recommendations for computing / IT and data preservation:
No specific recommendations were issued.

e+e- experiments

Belle / Belle II
The DESY group in Belle is involved in several important and demanding aspects of the detector upgrade: the vertex detector VXD, in particular the PXD part of it and the BEAST II system for beam commissioning, the remote vacuum connections RVC, and the Belle II magnetic field mapping. Furthermore the group participates in important physics analyses of Belle data and studies for Belle II. It contributes to tracking and alignment, and to the simulation of synchrotron radiation backgrounds as well as to Monte Carlo tuning. DESY contributes significantly to the Belle GRID computing and it now hosts the collaborative tools of the Belle collaboration. This is

an impressive program of work given the size of the group. The Belle group continues to make very good progress.
The last missing ASIC (DHP) for the PXD modules is now available and tested ok. PXD module construction (outside DESY) is supposed to start end of March 2017 and remains on the critical path for PXD half-shell commissioning at DESY in Q4/2017 and delivery of the PXD to KEK in January 2018. It is important that a strong team is built up at DESY to perform the PXD commissioning.
The vacuum-insulated coaxial CO_2 pipes produced at DESY have been delivered to KEK and installed in Belle II in December 2016. The RVC hardware is ready, but delivery to KEK will be delayed from June to October 2017 because it cannot be used before due to delays in the installation of the final focus quadrupoles at KEK. Likewise, the delivery of the BEAST II system will be delayed from June to September 2017 when the cleanroom to receive this system will be ready at KEK.
Despite these and other delays, the Belle schedule retains closing of Belle II in January 2018 and the phase 2 running from February to July 2018 with the BEAST II system installed in place of the VXD. VXD installation into Belle II is supposed to follow on a very tight schedule of 3 months in Q4/2018 so that phase 3 data taking could start in January 2019. This planning seems to be rather optimistic. However, it has to be stressed that all DESY contributions have been, or are on track to be, delivered as planned.
The PRC congratulates the DESY Belle group for the very good progress and is looking forward to see, at its October meeting, the second B field measurement completed, the beam test analysis results available, the RVC and BEAST II systems delivered to KEK, the PXD half-shells ready, and PXD commissioning at DESY just starting.

Findings and recommendations for Belle / Belle II:

- It is important that a strong team is built up at DESY to perform the PXD commissioning.

International Linear Collider Activities and Preparations for Future Experiments

The PRC recognizes the DESY ILC group for its valuable and critical contribution to the common worldwide international effort to develop a future project for accelerator based particle physics. In particular, the group is one of the major players in the Linear Collider Collaboration and has leading roles in its structure.
This time the PRC discussion has focused on the overall ongoing activities and strategic future planning of the group. Activities reported cover:

- detector development (time projection chamber, hadron calorimetry, vertex detector R&D);
- software developments;
- physics studies;
- ILC and ILD site-specific studies.

The PRC is pleased to see the excellent progress in those areas in which the group participates.
The effort and on-going cooperation with CLIC in the areas of software development, physics studies and calorimetry are very much acknowledged.
The leadership and high implication of the group in the AIDA-2020 European project is welcome and encouraged. This project (AIDA-2020) and its future evolution is considered as the European flagship for the detector R&D in view of future lepton and hadron colliders as well as for neutrinos experiments.
The PRC heard about the future plans of the group:

- to continue the activities under the linear collider project and their involvement in the preparation of its physics case in view of the next update of European Strategy for particle physics;
- explore the implementation of the TPC and hadron calorimetry technologies, developed under the Linear Collider project, to be used in LHC (CMS), neutrino experiments and hadron experiments at RHIC;
- cooperate to export the LC common software framework to other initiatives for future experiments as members of the HEP software foundation;
- generic detector development (e.g. pixel detectors).

The PRC acknowledges and strongly supports the strategic plans of the group.

Recommendations:

- In order to guarantee the correct development of the planned activities there is need to keep the technical and engineering support. Specific scientific support in terms of new post-doc positions focused on detector and software R&D developments should be considered by the lab in its future calls.

Particle Astrophysics

DESY continues to play significant roles in four operating gamma-ray observatories with strong results and is involved in two planned gamma-ray instruments, TAIGA and CTA. A recent paper on searches with Fermi, VERITAS and others for a gamma-ray counterpart to a neutrino triplet detected by IceCube is one example for the wide multi-messenger efforts of DESY. The completion of the four upgraded cameras of H.E.S.S., handed over in March 2017, is a significant achievement. MAGIC presented results on the variability in a 2015 flare of quasar PKS 1510-08 that constrain the emission region and plausible external Compton models. VERITAS completed an analysis of the Cygnus region, covering 300 h and spanning many years, thereby providing the deepest survey of the region at E>100 GeV.
The involvement by DESY in CTA is major, including the development of the medium-size telescopes (MSTs), the array control and data acquisition, the science analysis and simulation, and involvement in the project office and as a shareholder of the CTA GmbH. DESY now has leadership roles in science analysis with G. Maier

heading the newly formed Analysis and Simulations working group and S. Ohm leading the Cosmic Rays science working group. Plans are being developed for the CTA Science Data Management Center to be hosted at DESY-Zeuthen. The center will carry out data management tasks and make CTA‘s data available to the worldwide community. The DESY participation in TAIGA, which will perform TeV/PeV astronomy using wide-field non-imaging Cherenkov detectors, is limited to one person. To-date, 28 detectors are installed in Siberia, and one imaging telescope is in development at DESY.

DESY has a strong group on IceCube with investigations in many of the key scientific topics and a strong involvement in planning the future Gen2 detector. Ongoing scientific activities include understanding the flavour content of astrophysical neutrinos, using an improved reconstruction technique for tau neutrino interactions, continuing to exploit the real-time system that alerts the community on neutrino events of interest, doing high-energy neutrino follow-up of the LIGO/VIRGO GW150914 event, and searching for sterile neutrinos using several years of DeepCore data. The major technical activity is associated with the Gen2 upgrade. As part of the initial phase 1 of the upgrade, IceCube plans to prototype new photon detectors and new calibration devices. Ideas for the new detectors include multi-PMT modules to provide directional information and a wavelength-shifting design to reduce the cost of drilling and the dark rate. Among other things, DESY is contributing to the UV calibration of the ice transmission and detector response.

Findings for particle astrophysics:

- We congratulate DESY on the excellent scientific results from all operating experiments. The two new junior investigators further strengthen the already excellent astroparticle physics effort. Joint professorships with Potsdam and Humboldt have been a success, and another hiring will hopefully be successful.
- While we appreciate the presentation on first ideas on the long-range planning of the astroparticle effort at Zeuthen, we would like to hear a complete account of the planning of the efforts in terms of manpower, facility and scientific focus at the next PRC meeting. With regard to gamma astronomy, this presentation should include the planning for the CTA SDMC in terms of its impact on Zeuthen and the local CTA group as well as the future of DESY’s contribution to TAIGA. With regard to the neutrino activities, we ask for a presentation of a top-level roadmap for the IceCube activities over the next several years. Specifically it would be helpful to learn about the tasks that DESY would be immediately responsible for should the phase 1 proposal be funded, when decisions will be made on the future path of Gen2, and how long it takes to establish a production facility at Zeuthen. If the phase 1 proposal is not funded, we would appreciate to learn about DESY’s plans to move forward.

Other experiments

ALPS-II

The group continues to maintain a high profile in the axion-like-particle and axion community. Over the last year, ALPS-II scientists have given key talks on ALPS and ALPS physics. ALPS-II is 1 of 3 worldwide axion flagship projects (along with laser and RF-cavity experiments), and ALPS is identified with DESY.

The state of ALPS physics is largely unchanged from the last PRC. There has been a bit more activity and variety of models in the theory in connection with the relaxion mechanism and photophilic axion-like-particles.

We are very impressed by the technical progress, and we are gratified to see ALPS II being integrated into DESY project planning and schedules.

The delays connected with preparing the tunnel area and straightening the magnets are slowing down progress a bit.

The delays may push the ALPS-IIa hidden-photon search to 2018 or beyond; this is unfortunate. The ALPS-II group is continuing to explore the possibility of a vacuum birefringence measurement; this is attractive science.

Findings and recommendations for ALPS:

1. In the trade-off between photon counting versus a heterodyne receiver, the group wants both with a “fast switch” capability between the two. This complicates the optics systems.
2. The optics line responsibility is held by postdocs, which may cause a knowledge-continuity problem during data taking.
3. The ADR is dead, and bids are solicited for a dilution refrigerator replacement for the ADR.

Bullets 1, 2 and 3 are coupled: It may make sense to have the baseline be the heterodyne receiver, even though engineering details are yet to be worked out. This simplifies the optics, thereby reducing the load on the optics personnel (the University of Florida would then have line responsibility for their heterodyne receiver), and simultaneously eliminating the need for a dilution refrigerator.

4. It may be the case that more aggressive vibration and motion control is needed. This should be in cost and schedule contingency until the technical requirements are validated in situ.

OLYMPUS

The main physics goal of Olympus was to measure with high precision the ratio of the electron-proton and positron-proton elastic scattering cross section. This ratio is very sensitive to the difference in internal radiative corrections for these two cross sections, driven by the two-photon exchange process. It is believed that the discrepancy between the results for the form factor ratio G_E/G_M as function of Q^2 measured through the recoil polarisation method or the Rosenbluth technique can be explained by the non-ability of the commonly used internal radiative correction calculations to account correctly for the two-photon exchange (TPE) effects. These TPEs cannot be calculated from first principles in QED as they involve model-dependent hadronic corrections, which can only be determined from data.

The Olympus experiment has access to the TPEs, because they are arising from the interference between one- and two-photon exchange amplitudes, have opposite signs for electrons and positrons, whereas most of the other radiative corrections cancel to first order in the ratio. The challenge in measuring TPEs directly is that they are most prominent at high momentum transfer and backward scattering angles, where the cross section is suppressed. There have been three competing experiments to measure the TPEs: CLAS at JLab, VEPP-3 at Novosibirisk and Olympus at Doris at DESY.

The biggest challenge for the Olympus experiment was the extremely compressed and tight time schedule to set up and commission the experiment and take the high precision data (November 2012 to January 2013). Despite a preceding engineering run, several critical issues were only discovered during the “main” data taking. Examples are

- that the magnetic field could not be flipped → no cancellation of systematic,
- that the Moeller/Bhabha calorimeter did not give the advertised performance,
- and that the GEMs in the 12^{o} lumi calorimeters had an efficiency issue.

The major reasons for these issues have been:

- the software, MC and tracking were lagging significantly behind the hardware, which hampered the understanding of the data from the engineering run, as well as the monitoring of the main data taking;
- the engagement of several collaborative institutions was not as large as originally predicted. i.e. a high fraction of senior manpower was involved only with a small FTE fraction, i.e. 0.1 FTE.

For the future, there are a couple of things to be kept in mind if such a project should be repeated at DESY:

- **Collaboration structure:** It would be advantageous to have binding MoUs between collaborators and DESY as a host laboratory. Several collaborative institutions where not successful to secure funding, and this should have been mitigated by identifying additional funding sources.
- **Execution of the experiment:** Over the entire lifetime of Olympus, from proposal to execution, the PRC made recommendations how to improve things, but there was unfortunately only limited follow-up by the collaboration. It is suggested to use some of the management tools as detailed in DOE project management guidelines.

Despite these challenges, Olympus had several major achievements:

Olympus is the experiment to show that TPEs are smaller then originally proposed by theory. The other two experiments alone, VEPP-3 and CLAS, would not be precise enough to allow drawing this conclusion.

The verdict if missing/overestimated TPEs in radiative corrections can explain the discrepancy between the two different ways to measure form factors is still open. But this is purely due to the fact that parallel to the running of Olympus more refined theory calculations reduced the size of TPE effects to 1% equal to the Olympus statistical precision. Therefore, to resolve the G_E/G_M form factor puzzle data at higher Q^2 (where TPE effects are larger) are required, as are more precision calculations on radiative corrections and the investigation of alternative explanations.
Olympus is currently finalising several more awaited publications. In summary Olympus has overcome most of its hurdles with very creative alternative solutions and achieved its projected goals.