B-factory Programme Advisory Committee
Short report for
Focused Review Meeting

27-28 June 2022, Remote Meeting

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Short summary

A half-day remote review meeting of the B-factory Programme Advisory Committee (BPAC) took place on 27th and 28th of June 2022. The meeting was focused on the current performance of SuperKEKB and Belle II, as well as the Long Shutdown (LS1) activities.

The BPAC members were informed that Run 2022c was terminated roughly one week earlier than planned and LS1 has already started. This was caused by a rapid increase of the electricity cost by $\sim 50\%$, that has followed from the war in Ukraine amongst other factors. The electricity cost will remain high and may increase even further in the coming years. Although it was explained that the budget request for the Japanese Fiscal Year (JFY) 2023 is based on a higher electricity cost, it will remain a concern for the future data taking of the Belle II experiment.

Since the start of data taking in 2019, the Belle II experiment collected close to 0.5 ab^{-1} of data before the start of LS1, by steadily increasing the peak luminosity reaching $\sim 5 \times 10^{34}$ $\text{cm}^{-2}\text{s}^{-1}$, twice the record luminosity achieved by KEKB. The committee congratulates the SuperKEKB team and the Belle II collaboration on these achievements. SuperKEKB pushes the boundaries of accelerator operation and enters domains that have not been explored to date. Reaching the final goal of collecting 50 ab^{-1} of data is still a challenge where all components in the long chain from producing electron and positrons to collecting data on tape must work very efficiently. In particular, it will require

1. an increase of the peak luminosity to a level of 5×10^{35} $\mathrm{cm}^{-2}\mathrm{s}^{-1}$, which needs to be maintained during data taking by continuous injections,

2. the machine and detector operating at high efficiencies,

3. sufficient running time.

Further boosts of the SuperKEKB luminosity will require an increase of the bunch current without higher injection background and with much fewer catastrophic beam losses, which could lead to damages of the superconducting final focusing magnets and Belle II detector components. The committee strongly supports the current effort to understand the emittance blow-up in the beam transport and origin of the catastrophic beam losses, as well as further efforts to improve the beam monitoring system and shorter beam abort times. Since the injector chain will be available during LS1, systematic studies of the beam transfer should be continued. The Super-KEKB is a unique accelerator system operating with very small emittance beams, which is a new feature. The BPAC appreciates the broad systematic approach by the accelerator group, including beam simulations, to identify sources of the beam instabilities leading to the beam losses. This should continue in parallel with further analyses of the data from the various beam monitors during catastrophic beam losses. After LS1 all those efforts should lead to an increase of the bunch currents beyond the current empirical limit of 0.7 mA. Installation of further beam monitors during LS1 is highly recommended. The committee notes that some of the ageing components in the injector chain will be replaced during LS1. Once COVID restrictions have been relaxed, more intense and in-person involvement of the worldwide accelerator experts of the international task force can be expected. However, the committee expresses its concern on the lack of human resources given the number of accelerator issues to be addressed, and repeats its recommendation to attract Belle II collaborators for accelerator related work. It might be useful to point out that worldwide demand for accelerator physicists is high.

The Belle II collaboration has been successfully improving the data taking efficiency. The committee notes that the vetoes designed to suppress backgrounds during the beam injection have become a significant fraction of the remaining inefficiency. While efforts are made to reduce the injection background by the machine team, the Belle II collaboration should optimise the veto scheme to minimise this inefficiency.

Rapidly increasing electricity costs resulting from the current unstable state of international affairs may persist for quite some time. It might not be easy to fully cover the rising electricity costs with a corresponding increase of the KEK budget. A KEK-wide strategy needs to be further developed for a sustainable operation of the laboratory. Maintaining annual accelerator operation periods of six months or so would be important. Periodic shutdowns of the accelerator, currently in winter and in summer, will be necessary but should be optimised to maintain efficient data taking.

It is unfortunate that a part of the gold coating for the inner surface of the replacement beam pipe peeled off. This will result in an extension of the LS1 schedule by one and a half to three months, unless the existing vertex detector (VXD) is taken out together with the beam pipe before the new VXD is confirmed to work at KEK. Currently

three approaches are being considered: either to repair the peeled gold coating by adding a copper coating, or applying copper coating for the inner surface and gold coating for the outer surface to the remaining spare beam pipe, or reusing the currently installed beam pipe. The committee strongly encourages the development of a work-plan with well-defined criteria, agreed upon by the machine experts for acceptance in the machine, and evaluate the physics impact of the different options. The recent progress in the replacement pixel detector, PXD2, is very encouraging. It should be ready for transportation to KEK in October, as currently planned. The actual timing for the transport should be decided in view of the overall plan for the detector installation. The committee thinks that it is important to secure more spare ladders by reusing parts from the unqualified ladders, although this may require fabrication of new switcher chips. Concerning the issue of the photon detectors (PMTs) for the barrel particle identification system, the committee concurs with the decision by the Belle II collaboration to decide in January 2023 which PMTs should be replaced during LS1. However, more quantitative criteria than those currently presented should be developed for selecting the PMTs to be replaced. If it is proposed to delay replacement of the majority of the conventional PMTs until after LS1, the risks related to performing that intervention during a subsequent summer shutdown should be evaluated. The committee is very concerned to learn that the loss of efficiencies in some part of the KLM (K-long muon) detector, due to interruption of the gas circulation, was not discovered until recently. A plan to strengthen the real-time monitoring of the system during LS1 will help to detect similar problems early on[1]. In particular, more rigorous monitoring of the gas flow at both inlet and outlet is strongly recommended. Hardware interventions must be decided very carefully. The effect of using a gas mixture with ammonium to recover the damaged chambers must be first studied in a laboratory test. People experienced in operating gas detectors could reinforce the KLM group.

Data processing for the 2022 runs appears to proceed smoothly and the current effort should continue to ensure that the whole data set will be available for physics analysis by the autumn 2022. The committee notes that further effort to move toward using more run-dependent rather than run-independent simulations for the analysis is needed. In conclusion, the committee applauds the overall progress made by the SuperKEKB team and Belle II collaboration. The human resource issues need to be carefully monitored in order to maintain the progress. The future running time remains as one of the largest concerns of the committee.

[1]The committee would like to hear a presentation on the real-time monitoring for the whole Belle II experiment during the next review meeting.