

# B-factory Programme Advisory Committee

## Short report for Focused Review Meeting

8 and 9 November 2021 Remote Meeting

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### Short summary

This focused review meeting of the B-factory Programme Advisory Committee (BPAC) took place, again remotely, with the following questions posed by the director of the Institute of Particle and Nuclear Studies:

- Long Shutdown 1 (LS1) schedule  
Is the proposed schedule for LS1 appropriate? Point out if there are any particular concerns in the preparation and execution of the detector replacement work.
- Yearly Plan  
Are the operation and study plans for machine and detector in coming months reasonable to achieve maximal integrated luminosity?
- Selected items
  - Progress in ageing study of CDC
  - Development plan of entire L1 system towards  $\times 10$  luminosity
  - Improvement plan of data production and processing, especially on the recalibration
  - Solidifying software validation process

– Plan of fail-safe data management in the distributed computation

The following report addresses those questions.

LS1 was originally planned to start in July 2022 to replace the beam pipe for the section around the interaction point, the Pixel Vertex Detector and a part of the photon detectors (conventional PMTs) for the barrel particle identification system (TOP) with an ageing resistant type (life-extended ALD) PMTs. During the meeting, the committee was informed that LS1 would have to be postponed due to the delay in the production of the replacement beam pipe and uncertainties in securing foreign detector experts since the COVID restrictions could still be in place. Two scenarios presented are

1. to start LS1 in January 2023, i.e. a half year delay and
2. to start in July 2023 with one year delay.

Reported progress in the preparation shows that required hardware components, although tight, will be ready for starting the shutdown in January 2023. Expected integrated luminosity for this scenario varies between  $\sim 610 \text{ fb}^{-1}$  and  $\sim 820 \text{ fb}^{-1}$ , depending on whether extrapolating conservatively the SuperKEKB performance or taking aimed machine improvements into account. The second scenario with one year delay is thus motivated by safely securing a data sample before the start of LS1 that would allow physics analysis beyond those by Belle, which collected a dataset of  $\sim 800 \text{ fb}^{-1}$  for the  $\Upsilon(4S)$  and off-resonance. The importance of this ambition is well appreciated by the committee. On the other hand, difficulties in the hardware work for LS1 due to diminishing technical expertise caused by the retirement of key persons is already noticeable. The longer the delay of LS1, the more critical this situation becomes. For the one year delay scenario, the work for replacing PMTs is planned during the regular 2022 summer shutdown starting in July with a two month extension, rather than waiting for LS1, in order to be safe against ageing effect. The recently observed in situ behaviour of TOP PMTs indicates that efficiency drops are developing even for the ALD type PMTs, which were observed as more ageing resistant than the conventional ones in the accelerated laboratory test. Before replacing PMTs, understanding the cause of the observed efficiency loss for the various PMT types, and whether it is related to ageing of the photocathodes, is essential. Starting the replacement work in July 2022 may be too early to prepare an updated plan for the PMT replacement taking this new information into account. An additional incident reported was a cold leak in the final focusing superconducting magnet and an in situ repair might not be possible. In this case, the repair has to wait for LS1. Although this leak currently does not impact the SuperKEKB operation, this might change in the coming months. Considering those facts, **the committee recommends that the Belle II collaboration adopt the half year delay for LS1 as the baseline.** All the LS1 preparation work should be planned and executed according to this baseline. Successful completion of LS1 would be crucial for the long term goal of the Belle II experiment. The committee also supports to assess the situation and to update the plan, if necessary, in May 2022. A detailed report during the next BPAC meeting on

the progress for the LS1 preparation and SuperKEKB luminosity performance will be highly appreciated. It is still the beginning of data taking and the collaboration should make utmost effort to preserve technical expertise.

For the detector and machine planning before the start of LS1, collecting high quality data as much as possible is clearly important. However, maximising the integrated luminosities for this period should not be the highest priority. The stated goal of Belle II is to produce world leading results based on very large and unique data samples. This will require further improvements in the detector operation and data taking, as well as background mitigation and data processing. In parallel, further detailed machine studies and repairs and replacements of ageing components of the accelerator complex are needed to obtain stable machine operation before LS1. Beam currents should be increased while the backgrounds must be kept under control. Therefore, **the committee strongly supports devoting significant effort to machine studies during the ongoing run period.** Lack of personnel in the machine group to perform simultaneously the machine operation and studies remains as a serious concern, although an international task force was established for addressing the luminosity issues. Engaging Belle II physicists to temporarily work on machine issues might significantly enhance the progress.

The committee considers the presented plan for the Central Drift Chamber (CDC) ageing studies adequate and sufficient human resources should be provided for the timely execution of the programme. On the other hand, the behaviour of the CDC in the experiment is worrisome. After the problem of the dark current in the chamber had been mitigated by introducing H<sub>2</sub>O in the gas mixture, CDC has been developing gain losses. Although there is some evidence that this is caused by H<sub>2</sub>O, **further in-depth investigations must be carried out to fully understand the situation before any drastic decision should be made.**

Presented plan for the future activities of the Level 1 trigger is well worked out and covers all the aspects needed for operating at luminosities well above  $10^{35} \text{ cm}^{-2}\text{s}^{-1}$ , i.e.  $\sim 10$  times more than now. On the other hand, **the committee is concerned about the lack of human resources to ensure smooth operation and further implementation of the system.** Efforts to simplify the system and to develop commonalities are highly recommended and should reduce the maintenance effort. New resources could become available by attracting new groups for the trigger upgrade to extend the physics scope such as search for long living particles. However, a careful balance is needed between maintaining the running system and developing an upgrade.

The last three issues for “Selected items” are related to the offline activities. A framework based on the distributed computing for the production of simulated data and processing of raw data is in place and working well. Production centres are all functioning well. A major outstanding issue is the slow production of the run-dependent

simulation samples, which are crucial for the precision of physics analyses. In addition, delays in recalibration of the raw data are occurring due to the need of its validation by expert personnel in the sub-detectors groups. **Careful coordination with the sub-detector groups is required for the planning to ensure speedy recalibration.** A backlog in data processing affects not only physics analysis activities but also the computing resource requirement and should be avoided. Status of the Belle II software is good. **Careful validation of external software such as GEANT4, PYTHIA and EVTGEN, when updated, is essential** before being included in a new major release for production. The committee suggests to introduce software changes in a shorter interval incrementally combined with regression tests and potential intermediate software development releases. The committee strongly supports the collaboration's efforts to further introduce and improve automation to avoid human errors and eventually reduce the need for staff. Although automation has already reduced the needs for human resources, **lack of redundancy in key personnel is a concern.**