

# BPAC Nov 2023 Meeting Report

Report Draft dated 31 Dec 2023

Matters related to Chiral Belle

B-factory Programme Advisory Committee  
Full Report for  
Focused Review Meeting on LS1

13-14 November 2023

P. Collins\* (CERN), G. Corti (CERN),  
M. Demarteau (ORNL), R. Forty (CERN), B. Gavela (Madrid),  
S. Gori (UCSC), M. Ishino (Tokyo), V. Luth (SLAC), P. Mato\* (CERN),  
F. Meijers\* (CERN), N. Neufeld (CERN), B. Ratcliff\* (SLAC),  
A. Petrov\* (Univ. South Carolina), M. Sullivan (SLAC),  
H. Tajima (Nagoya), M. Titov\* (Saclay)  
and chaired by T. Nakada (EPFL)

\* Expert member.

## 1 Short summary

31 December 2023

.....

An upgrade project to introduce longitudinal beam polarisation in the Belle II experiment is considered to be a very interesting option by the committee. However, this should be judged together with the other upgrade projects being considered by the collaboration, and weighed against potential disturbance of the approved programme. In order for the BPAC to provide its opinion, an overall comprehensive upgrade plan for the machine and the Belle II detector with well-defined physics objectives would be required. The committee is looking forward to receiving further information in future meetings.

## 8 Upgrade plan with beam polarisation

### 8.1 Status

With Run 2 about to start with an expected running period from 2024 to 2028, reaching a peak instantaneous luminosity of  $2 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ , aiming for a total integrated luminosity up to  $10 \text{ ab}^{-1}$ , the collaboration is considering a major upgrade of the detector in parallel to the upgrade of the accelerator.

At this meeting, no update was provided on the upgrade of various detector components, but the implementation of longitudinal electron polarisation was discussed in more detail. Longitudinal polarisation of the electron beam, where the electron helicity can be flipped bunch-train by bunch-train, combined with the prospect of large integrated luminosity, opens up the possibility for an interesting and unique physics program. Precision electroweak studies via the measurement of  $\sin^2 \vartheta_{\text{W}}$  with a precision similar to that at the Z-pole but at a different centre-of-mass energy of 10 GeV would be possible.

The measurement would be very competitive with, and complementary to, a similar measurement from the MØLLER experiment at JLab and measurements at the EIC. It also opens the possibility of measuring  $g - 2$  for the tau-lepton at the  $10^{-5}$  level to be compared to the current level of precision of  $\mathcal{O}(10^{-2})$ . The physics program with polarisation requires high statistics, with integrated luminosities of 20–50  $\text{ab}^{-1}$  assumed for the quoted goals. The proposal is to run with polarised beams while also accumulating high statistics for the approved Belle II program of flavor physics.

There are three key elements that are required for running with polarised beams: a low-emittance polarised electron source with about 80% polarisation, spin rotators in the High Energy Ring (HER) that do not reduce the luminosity, and a high precision Compton polarimeter that can measure the polarisation to better than 1% precision. When running with a polarised electron beam, transversely polarised electrons would be injected into the HER and rotated to longitudinal right before the interaction point (IP). Tau-decays would be used to get the absolute average polarisation at the IP.

Simulation studies of the proposed spin rotation setup show minimal impact on beam and polarisation lifetime, but these simulations do not take into account collisions. It will be important to cross-check the simulation results with data. To that end, a two-day experiment with a transverse polarised beam in SuperKEKB is proposed to validate the Touschek-polarisation lifetime on the timescale of the end of 2024. The studies will initially be performed without collisions, then the impact of collisions on the lifetimes will be measured. This would require the installation of a source of transversely polarised electrons and a suitably adjusted transfer line for the HER injection, and a polarimeter. A formal proposal is being prepared with a realistic schedule in consultation with KEK source experts and the LINAC team, to be submitted to the Belle II executive board. It was noted that the original machine configuration could be recovered with the spin rotator design that is being considered by turning off various beamline elements and retuning the machine.

## 8.2 Concerns

- The physics goals of running with polarised beams require high statistics, with integrated luminosities of 20–50  $\text{ab}^{-1}$ . This implies that the upgrade would need to be made in a timely manner to profit from the accumulation of such a large dataset. It will be crucial to validate that the complication of adding polarisation does not perturb the achievement of high integrated luminosity, both during the testing and setting up of a polarisation upgrade as well as its final operation.
- Having data with polarised beams is expected to lead to more demands on resources, in particular for the physics analyses, simulation and reconstruction. It will also require a significant amount of effort from the accelerator team.
- The installing of another gun in the injection chain is not trivial and is expected to require significant resources.
- To be ready for the polarisation tests by the end of 2024 without limiting the approved programme of integrating luminosity looks overly optimistic.
- The idea of a polarisation upgrade will be documented in a forthcoming CDR. How this upgrade interfaces with other proposed upgrades to the Belle II detector and SuperKEKB machine upgrades are very important and were not discussed at this review. There is a serious concern that the forthcoming CDR (and possibly multiple CDRs) will not yet be a well thought-out overall package of upgrades, supported by the full collaboration, but rather a collection of possible options, and none of the other machine changes that are being considered will be included there.
- The full scope of the upgrade remains ill-defined. The timeline for LS2, planned for 2028, is very short. There is a serious concern that the timescale and resources required for realising the overall upgrade are underestimated and that the process is not as coordinated across the collaboration and the machine team as should be.

## 8.2 Concerns

- The physics goals of running with polarised beams require high statistics, with integrated luminosities of 20–50  $\text{ab}^{-1}$ . This implies that the upgrade would need to be made in a timely manner to profit from the accumulation of such a large dataset. It will be crucial to validate that the complication of adding polarisation does not perturb the achievement of high integrated luminosity, both during the testing and setting up of a polarisation upgrade as well as its final operation.
- Having data with polarised beams is expected to lead to more demands on resources, in particular for the physics analyses, simulation and reconstruction. It will also require a significant amount of effort from the accelerator team.
- The installing of another gun in the injection chain is not trivial and is expected to require significant resources.
- To be ready for the polarisation tests by the end of 2024 without limiting the approved programme of integrating luminosity looks overly optimistic.
- The idea of a polarisation upgrade will be documented in a forthcoming CDR. How this upgrade interfaces with other proposed upgrades to the Belle II detector and SuperKEKB machine upgrades are very important and were not discussed at this review. There is a serious concern that the forthcoming CDR (and possibly multiple CDRs) will not yet be a well thought-out overall package of upgrades, supported by the full collaboration, but rather a collection of possible options, and none of the other machine changes that are being considered will be included there.
- The full scope of the upgrade remains ill-defined. The timeline for LS2, planned for 2028, is very short. There is a serious concern that the timescale and resources required for realising the overall upgrade are underestimated and that the process is not as coordinated across the collaboration and the machine team as should be.

Requires KEK engagement

### 8.3 Recommendations

- Evaluate the feasibility of installation of another electron gun in the injection chain.
- Initiate a study on the overall resource needs for the polarisation upgrade and its downstream requirements on analysis, simulation and reconstruction.
- Develop a realistic schedule, including cost and resources, for the planned Touschek-polarisation lifetime test for 2024 as quickly as possible.
- Develop a coherent overall upgrade plan, coordinated with other Belle II detector and SuperKEKB machine upgrades being planned, with a well-defined scope as soon as possible.

# Preparation for upcoming BPAC

- Summarize the meeting with KEK Machine Team
  - Include new schedule
- Summarize US-Japan request for R&D



# Preparation for upcoming BPAC

## 8.3 Recommendations

- Evaluate the feasibility of installation of another electron gun in the injection chain.
- Initiate a study on the overall resource needs for the polarisation upgrade and its downstream requirements on analysis, simulation and reconstruction.
- Develop a realistic schedule, including cost and resources, for the planned Touschek-polarisation lifetime test for 2024 as quickly as possible.
- Develop a coherent overall upgrade plan, coordinated with other Belle II detector and SuperKEKB machine upgrades being planned, with a well-defined scope as soon as possible.

Can we report on this now?

# Preparation for upcoming BPAC

## 8.3 Recommendations

- Evaluate the feasibility of installation of another electron gun in the injection chain.
- Initiate a study on the overall resource needs for the polarisation upgrade and its downstream requirements on analysis, simulation and reconstruction.
- Develop a realistic schedule, including cost and resources, for the planned Touschek-polarisation lifetime test for 2024 as quickly as possible.
- Develop a coherent overall upgrade plan, coordinated with other Belle II detector and SuperKEKB machine upgrades being planned, with a well-defined scope as soon as possible.

Downstream requirements are straightforward, need to be explicitly presented – essentially the same impact as any new analysis ideas using BelleII data.

Only the taus are expected to require additional resources. But it is minimal – as already shown with BaBar tau polarimetry experience

# Preparation for upcoming BPAC

## 8.3 Recommendations

- Evaluate the feasibility of installation of another electron gun in the injection chain.
- Initiate a study on the overall resource needs for the polarisation upgrade and its downstream requirements on analysis, simulation and reconstruction.
- Develop a realistic schedule, including cost and resources, for the planned Touschek-polarisation lifetime test for 2024 as quickly as possible.
- Develop a coherent overall upgrade plan, coordinated with other Belle II detector and SuperKEKB machine upgrades being planned, with a well-defined scope as soon as possible.

Determining upstream requirements are focus of this year's US-Japan request,

Can we put this BPAC Recommendation Into the BPAC presentation?

# Preparation for upcoming BPAC

## 8.3 Recommendations

- Evaluate the feasibility of installation of another electron gun in the injection chain.
- Initiate a study on the overall resource needs for the polarisation upgrade and its downstream requirements on analysis, simulation and reconstruction.
- Develop a realistic schedule, including cost and resources, for the planned Touschek-polarisation lifetime test for 2024 as quickly as possible.
- Develop a coherent overall upgrade plan, coordinated with other Belle II detector and SuperKEKB machine upgrades being planned, with a well-defined scope as soon as possible.

Report on this

# Preparation for upcoming BPAC

## 8.3 Recommendations

- Evaluate the feasibility of installation of another electron gun in the injection chain.
- Initiate a study on the overall resource needs for the polarisation upgrade and its downstream requirements on analysis, simulation and reconstruction.
- Develop a realistic schedule, including cost and resources, for the planned Touschek-polarisation lifetime test for 2024 as quickly as possible.
- Develop a coherent overall upgrade plan, coordinated with other Belle II detector and SuperKEKB machine upgrades being planned, with a well-defined scope as soon as possible.

Must take this into account in Chiral Belle CDR

Note that any changes to the HER lattice planned for LS2 must be incorporated into new polarization studies, As these are not known at this time, the plan is to keep up with any changes as they occur in order to stay in sync.