BPAC (full report) February 2023

November 13, 2023

1 Accelerator

- Q: A consideration could be made to review the running schedule for the synchrotron light sources to allow for more upgrade time for the linac complex.
- A (H.Ego): By negotiating and adjusting the operation schedule for the synchrotron light sources, we are going to secure both SR user time for more than 3000 hours and the linac upgrade time over 120 consecutive days in the summer of 2023. We will continue to adjust the operation schedule so that we can secure the number of days necessary for the upgrades in the next FY and beyond.

2 MDI

- Q: Further efforts should be made to understand and reduce the LER beam-gas and Touschek backgrounds.
- A (H. Nakayama): The non-linear collimator is expected to further reduce LER storage BGs without being limited by an impedance issue.
- Q: A long-term strategy to refurbish and upgrade the injector complex should be developed to reduce injection backgrounds as well as improve injection stability.
- A (H.Ego): CSR and ISR in the beam transport lines to MRs cause large emittance growth to the injection beams and are supposed to yield a considerable amount of the backgrounds. We are proceeding with beam analysis, and have started RD for the countermeasures such as modifying the equipments of the BT lines and constructing a new BT line in order to suppress the CSR and ISR.

3 PXD

- Q: The Belle II collaboration is strongly encouraged to examine options that could allow machine operation to start at the beginning of 2024 by carefully assessing the risks. For example, the extraction of the VXD could begin already after the initial mechanical and electrical integrity assessments of the PXD2, while further tests of the PXD2 would proceed in parallel.

- A (K. Nakamura): We created the detailed gantt-chart of the LS1 schedule, including the sub-systems driving the LS1 schedule and the IR construction works to start the main-ring beam operation. We found several possible optimizations in the schedule which resulted in the earliest Run2 start on Dec 11, 2023. The optimizations we made were: removed the cosmic ray run during the B4 VXD commissioning which is not critical, reduced unnecessary long contingency in the schedule, and parallelized the VXD system test after the VXD installation and the endcap insertion tests. We also revisited the possibility of an earlier decision on the VXD extraction even before the completion of the PXD2 preparation, but considering the significant risks of further delay in the PXD2 preparation and damaging the detector during the VXD extraction, we concluded that we should follow our original decision protocol and extract the VXD only after the PXD2 readiness is confirmed. As for the current status of the VXD reinstallation as of the end of May, confirming the functionalities of the PXD2 attached to the beam pipe, at mid of Apr we granted the VXD extraction. The extraction was performed at the beginning of May as we planned, and also the detachment of the two SVD halves was done successfully. The reinstallation work is ongoing on schedule, which targets the Run2 start on Dec 11.

- Q: Verify thoroughly the validity of any modifications to the PXD2 detector, evaluate the changes at the system level, and study in-depth the interplay between the changes.

- A (C. Niebuhr): The main changes are the addition of a foil under the washers of the sensor screws, reduced torque on the fwd screws and the fact that the fwd SCB screws are not removed for PXD2. The effect on the thermomechanical behaviour of the ladders was investigated under realistic operating conditions (i.e. CO2 temperature -20°C/-25°C and with beam pipe temperature stabilised at 21°C) in the clean room at B4. At reduced CO2 temperature and increased N2 flow, the sagitta of the three most bent ladders is limited to about 500 um, which is considered acceptable given the bending experienced in PXD1 and the extensive stress tests performed on dummy ladders in the laboratory.

- Q: Establish a safe storage location for the PXD1 to ensure it can be used as a fallback detector for the duration of the experiment.

- A (S. Tanaka): PXD1 (used in Phase3 Run1) will be kept on the beam pipe until confirming the new VXD system is ready. The old VXD has been extracted on 10th May. The radiation level of the VXD is comparable with the BG level, thus the radiation science center agreed to keep PXD1 with BP in the B4 ARICH room, where is safe enough for the storage.

- Q: The PXD2 group should be prepared for some repairs, including the replacement of ladders if necessary at KEK, and spare ladders should be made ready.

- A (C. Niebuhr): All 40 modules on PXD2 are currently operational. In addition to the ladders on the recently extracted PXD1, there are 2 grade A/B ladders left for each of L1 and L2. There are no more modules available to build more ladders.

4 SVD

- Q: The installation schedule of the VXD should be optimised, but the priority is to avoid the injection of additional risks due to time pressure. As far as SVD is concerned, that might be achieved by concentrating the experts on the critical tasks that carry high risks and must not be compressed, and by involving additional manpower to accelerate low-risk tasks like the cabling and the moving of components.

- A (G. Rizzo): A detailed gant schedule of LS1 has been prepared in the last months. In this preparation and optimization we also carefully checked that all the SVD tasks could be covered by the right person power. In particular the critical steps are always covered by the real experts of that area and we ensured that enough time could be allocated to avoid additional risks. We also secured additional person power to help the experts in some of the less critical phases, like some part of the cabling, but still ensuring that they always work with the supervision of an expert, whenever it is necessary.

- Q: The decision of SVD dismounting could be anticipated based on the verification of the integrity of PXD2, so that the SVD commissioning can proceed in parallel with the PXD2 mounting and calibration.

- A (K. Nakamura): There are significant risks in the VXD extraction and SVD dismounting, and also there were still possibilities that the PXD2 is damaged during the attachment on the beam pipe or the failure of the PXD2 gliding functionality on the real beam pipe. Considering these risks and possibilities, we decided that a confirmation of the basic PXD2 electrical functionality and gliding functionality on the beam pipe were required before the VXD extraction decision. We optimized the schedule postponing any further PXD2 commissioning and calibration activities, and the VXD extraction decision was taken on April 21, 2023, well in

advance of what originally planned. The remaining LS1 activities have also been optimized, leading to a project completion date of Dec 11, 2023.

5 CDC

- Q: Water and oxygen monitors have to be re-calibrated on a regular basis to avoid time-dependent drifts. A possibility to install a water filter (silica gel tubes) to reduce water content inside CDC has to be considered, as the water level might be 5-10 times higher than anticipated during physics running.

- A (N. Taniguchi): The default water and oxigen monitors were checked and recalibrated by company. Water monitor is back and has been re-installed in the gas circulation line. We have installed an additional water monitor and confirmed that both monitors show similar value. The default oxygen monitor is still under repair. We have purchased an additional one and it will be delivered in early July. Since regular maintenance of monitors is supposed to be finished in a few months, we will do that every summer shutdown. We have rearranged location of mass flow controller to keep pressure to the monitors within the safety range for stable operation. We have consumed 5 water filters (silica gel tubes) and confirmed that it works to reduce water content. Currently water content is around 3,500ppm.

- Q: Gas condition monitoring for absolute/relative pressure, water/oxygen contents and circulation gas flow rate needs to be included into alarm monitoring system to notify sudden changes.

- A (N. Taniguchi): All variables mentioned there are already included in epics archiver. We will included them into alarm monitoring system.

- Q: LS1 is the right time to consolidate the CDC gas system, i.e. improve gas tubing and filters, better understand flow dynamics inside the chamber, and eventually to modify the system and to install additional gas ports in order to increase the CDC gas flow rate.

- A (N. Taniguchi): We have increased the number of outlet ports from 4 to 8 by installing additional gas tubes. The difference of relative pressure between detector and electronics hut (far from Belle II structure) will be measured soon. We plan to modify layout of gas system on the roof of Ehut, to make bypass line to replace gas filters without affecting main gas flow, to make calibration line for gas monitors, to protect flexible tubes.

- Q: Further studies are required to identify the nature of a slow drift of the gas gain in cosmic ray runs, taking into account that water and oxygen monitors did not work properly.

- A (N. Taniguchi): We will check past data by considering the possiblity that the water content was saturated at some point.
- Q: The trial to reproduce the gain drop with the laboratory test chamber ageing setup should be pursued. On a longer term, this might facilitate development and test of different remediation strategies for gain recovery.
- A (N. Taniguchi): We try to proceed it in Aug. Analog signal readout should be tested, and network in irradiation room and DAQ system should be prepared. Gas mixture without hydrocarbon was studied in Kyoto Sangyo Univ. We may test it for aging test.

6 TOP

- Q: Perform a detailed risk assessment of the PMT replacement program, and ensure that the scheduling maintains contingency to allow for adaptation if any unforeseen problems arise. Extra personnel should be trained if necessary to avoid single points of failure.
- A (K. Inami): We checked possible technical risks and improve the methods and scheduling. We performed the replacement work in 9 weeks with enough contingency due to other works. We finished the work without major issue.
- Q: Efforts to understand and mitigate the effects of temperature on the PMT efficiencies for tubes in the detector should continue.
- A (K. Inami): We will continue to test the PMT samples picked up from the detector. We will check both the conventional and ALD types. Although it looks difficult to reduce the temperature drastically, we will keep trying.

7 ARICH

- Q: It would be helpful to further evaluate the performance both for data collection and for physics as a function of backgrounds.
- A (S. Nishida): ARICH is in general tolerant with high background both in the data aquisition (DAQ) and the performance, so we consider there is no big problem in near future.

  One of the possible effects in the DAQ expected at higher background is more frequent DAQ error caused by SEUs at FPGA in the mergers (SEUs at FPGAs in the Front-End Board are fixed by the scrubber). We plan to develop a scheme to temporarily exclude a merger and reconfigure it on the fly. We also consider to store ASIC parameters redundantly at the mergers so that we can reconfigure the ASICs to cope with the SEUs at ASICs.

As for the performance of ARICH, previous studies show no significant degradation of the performance even with one order higher background hits at ARICH. However, these studies do not include the effect of worse tracking performance at higher background, so more studies should be done.

8 KLM

- Q: As proposed by the KLM team, it is important to check the recovery procedure, such as the addition of Ammonium gas, at the test bench before applying the method to the Belle RPCs.
- A (L. Piilonen): This work is in progress and will be detailed in K.Uno's talk.
- Q: It may be worth to apply a different algorithm to identify muons in the problematic region to mitigate the efficiency loss of 10% but still retaining a good S/N ratio, e.g. by reducing the number of hit layers.
- A (L. Piilonen): up-to-date layer efficiencies are needed for the present algorithm

9 TRG/DAQ

- Q: The PCIe40 upgrade is proceeding well. As stated in previous review, firmware exports of the sub-detector systems where the PCIe40 migration was done just after the end of the 2022ab physics run, should be available at the start of the next physics run, in case unforeseen problems show up.
- A (S. Yamada): In LS1, the replacement of the readout system for SVD, CDC, ECL and TRG subsystems has been done and the commissioning is ongoing. Since we keep the Belle2link protocol used for the old COPPER-based readout system for the communication between FEE and PCIe40 boards, no update is needed for this replacement. Furthermore, according to those sub-detector groups, FEE firmware experts will be available at the start of the next physics run.
- Q: Long-term institutional commitment should be found for the trigger systems at risk of becoming unmaintained.
- A (K. Trabelsi): We are helping our German colleagues to get the necessary financial support from German ministry of education (BMBF) to stay involved in the AI-based track trigger of the Belle II experiment. With the the new appointment of Prof. Ferber, a second institute at KIT has joined the AI-trigger group contributing own resources, and Torben has now taken over the AI trigger coordination of the German group. This

is clearly not sufficient and we need to pursue our efforts to involve other groups (and reboost activities of current groups)

- Q: Effort to understand if the proposed improved injection veto is a viable option should be increased, so that in case an alternative approach is needed, work on this could start as soon as possible.

- A (T. Koga): So far the corresponding study has been done by a student, and the expected detector occupancy and reduction of deadtime are estimated, by using the number of ECLTRG clusters. The remaining task is the estimation of the trigger rate and firmware implementation. From June, a staff (Koga) takes over the work to speed up the analysis with high priority. We are aiming to finish R&D during summer.

- Q: The excellent efforts to improve automatic recovery and increase automation should be continued. They will be very beneficial for increased data-taking efficiency.

- A (S. Yamada/T. Kunigo): We continue improving the automatic recovery system, implementing more recovery actions and enriching the features. For example, during LS1, we have implemented a feature to handle "tolerable" errors. The tolerable errors are defined as the errors which: - are not very critical to data-taking thus we do not need to stop an on-going run immediately, - however they can affect our data quality thus need a recovery procedure. We make a list of tolerable errors during a run, and automatically fix them in a next run stop.

- Q: Although not yet critical, the implementation of sub-event building in the PC will improve throughput. This should be thoroughly tested before deployment in the next physics run.

- A (S. Yamada): With the new sub-event building scheme, sub-event building will be done in a readout PC instead of FPGA of PCIe40. This update improved the throughput of the readout system. The commissioning with the new PCIe40 firmware and readout software has been started in March and we will continue the test until the start of the next physics run.

10 Slow Control

- Q: The systematic consolidation of the HV control and monitoring of multiple subsystems is highly appreciated. Most of the recommendations of the last review remain valid until the programme is completed.

- A (T. Kunigo): During the internal peer review, we will keep them as important recommendations.

- Q: There is considerable momentum in the consolidation effort. The upgrades of the detector control monitoring should continue to be given a

high priority in order to achieve a well-tested new system in advance of the next data-taking period.

- A (T. Kunigo): We will continue this effort beyond LS1.
- Q: The development of common components for the control and alarm handling would benefit from engaging dedicated experts.
- A (T. Kunigo): We agree that DCS and alarm meetings are beneficial for engaging experts.
- Q: A peer review process of the implementation would be beneficial, engaging people from sub-detector groups as well as central experts.
- A (T. Kunigo): We had the DCS review meetings twice; first meeting to summarise the current system, and second meeting to discuss the requirements on the new system. Although all the participants and reviewers are real experts in Belle II, there were much discussion in the meetings. As you recommended, this review procedure is very important to reach agreement among all the sub-systems.
- Q: Documentation and consolidation of DCS and DQM components should continue beyond LS1. Major system revisions and upgrades can be installed during future shutdowns after successful tests.
- A (T. Kunigo): From the view point of DCS, we are trying to establish a common framework among the sub-detectors summarising them in a note. This should be the first step; as you recommended, we should discuss future upgrades based on the note.

11 Detector/Physics performance

- Q: The most recent data were impacted by the large beam injection backgrounds which strongly affected the sub-detector performance. The collimation system should be repaired or upgraded if required, and it is hoped that the machine experts can develop ways to further improve the bunch properties and injection, thereby reducing the detector backgrounds. The future backgrounds affecting the sub-detector performances should be carefully monitored to assess their impact. Re-calibration of the dE/dx performance as a function of time since beam injection should be completed with high priority.
- A (Carlos/K.Nakamura): During LS1, the damaged collimator jaws are replaced with spare jaws. Additionally, reinforcement of the injection point during LS1 through chamber modification and improvements in the septum magnet field should lead to a reduction of the injection oscillation and an overall improvement of injection performance. Concerning dE/dx calibrations, we are giving high priority to it and indeed have in the plan to

validate the new calibration before release-08 deadlines with a dedicated special processing

- Q: The efforts and recent results by the physics performance group to further develop the event reconstruction, and determine the data/Monte Carlo corrections and uncertainties are very promising. Efficiencies and resolutions to distinguish signals from backgrounds will need to be further explored using multivariate criteria. While there is good progress in understanding detector performance and algorithms, data/MC corrections with high precision will be required. The implementation of automation for providing PID and charged particle tracking will require the engagement of experts with an in-depth understanding of the requirements.
- A (A.Di Canto/P.Rados): We agree and we have been making continuous progress towards automation
- Q: Detailed planning and documentation of the complex data processing steps should be implemented, to optimise the data analyses and record variations and problems.
- A (Stefano/Umberto): This is part of the validation and quality control of data and MC production, which should be able to monitor the stability of performances for different productions.

12 Software

- Q: The use of Rivet plugins as references for the tuning with Professor should be investigated. Plugins with Belle II data could be kept private to the collaboration until publication of the relevant results. Their inclusion in the public Rivet repository would provide valuable input to generators authors and the HEP community at large.
- A (F.Meier/G.De Pietro): As soon as the main work on tuning Pythia for Belle II purposes is concluded we are planning to look into Rivet. We fully agree with the benefits of open science and are committed to contributing to it.
- Q: The considerable effort the software group is spending in algorithmic optimisation is to be commended. Nevertheless a complementary effort should be put in the more technical and general aspects of software optimisation.
- A (F.Meier/G.De Pietro): We agree that general software optimisation is just as important as algorithmic optimisations. It has always been part of our work and will continue to be. For example, memcheck is part of our nightly tests and detects memory issues that we try to fix, though many warnings are related to external packages like ROOT. Additionally, we build basf2 with clang and make use of its analyzer. Recently, we

started to investigate whether basf2 is compatible with ARM processors, which so far looks promising. Moreover, we work on taking advantage of parallel processing, which is already implemented in basf2 but needs further vetting.

13 Data processing

- Q: The committee encourages the pursuit of the ongoing developments to automate as much as possible the data processing, the production of skims, and the production of both run-independent and run-dependent MC.
- A (S.Lacaprara/U.Tamponi): Thanks for the comment: this is indeed our plan.

14 Belle physics

- Q: The committee encourages the Belle Collaboration to use their full data set to develop a new analysis that tests the lepton universality in semileptonic B meson decays, i.e. to measure the ratios R(D*) and R(D), comparing the decay rates involving the heavy lepton τ relative to the rate for electrons and muons. These analyses should overcome the modelling issues which impacted an earlier Belle publication. The results could be combined with Belle II results on these measurements.
- A: Thank you for the suggestion. There is one on-going Belle analysis for R(D*) using leptonic tau decays. Since the analysis activity of Belle and Belle II is being merged, further measurements will be done as an updated measurement using combined Belle and Belle II data.
- Q: In analogy to their earlier work on $B^0 \to e^{\mp}\tau^{\pm}$ decays, a measurement of $B_s^0 \to e^{\mp}\mu^{\pm}$ would be of interest. Likewise, a study of radiative decays like $\Upsilon(2S)$ should be considered.
- A: Belle is not competitive to LHCb for the measurement of $B_s \to e\mu$. The current limit is $5 < 10^{-9}$ while Belle Y(5S) dataset includes only 3×10^7 B_s. Radiative LFV decays were studied for $\Upsilon(1S)$ but not for $\Upsilon(2S)$. This looks an interesting topic and can be tried.
- Q: The Belle II Collaboration should extend the use of run-dependent simulations. The same holds for the work on FEI and beam-energy corrections.
- A: Agreed. We had hoped transition of analysts to run-dependent simulation could happen almost spontaneously and be faster, given ample evidence that run-dependent simulation is an improvement over run-independent. But this didn't happen, also due to unavailability of detector-performance

inputs based on run-dependent simulation. Given that these will become available over summer, at the latest general meeting we decided that no result for Moriond 2024 will be approved unless it's based on run-dependent simulation.

- Q: Among the many research projects, the tests of the lepton universality in semileptonic B decays should include not only the $B \to D^* \ell \nu$ decays but also the $B \to D \ell \nu$ decays, which have a smaller branching fraction but potentially higher sensitivity.

- A: Not sure what you allude to: B -¿ D tau nu decays have inferior experimental sensitivity to B -¿ D* tau ell decays, and B-¿ D*tau nu enjoys a richer dynamics owing to the access to angular observables. In any case we are certainly pursuing R(D) as well. But we are building the program from the ground up and since R(D) is experimentally more involved as it lacks the background-rejecting constraint of the D*-D mass difference, it naturally takes more work.

- Q: Joint publications based on Belle and Belle II data have great potential to enhance the precision of important measurements and should be pursued. Up to now, there have been only a few common publications, while the richness of the data call for intense further actions for the benefit of the scientific results.

- A: Agreed. We are improving on that with joint results being prepared now by the EWKP, SL, and Charm WG – and we keep pushing. Certainly the Belle+Belle II physics merger, which is now happening, will help further. In addition, our newly developed flavor tagger, which achieves 37% tagging power (that is, +20% effective sample size), offers very attractive opportunities in pursuing Belle+Belle II anayses also in the time-depenent CP violation program. However, while the general goal is clear, each measurement has its own specificities. In cases where a Belle II-only result already makes significant impact, and extending to Belle implies nontrivial delays, it makes scientific sense to go with the Belle II-only result first and extend to Belle+Belle II later for an updated measurement.

- Q: The Committee recommends that the Belle and Belle II Collaborations merge to benefit from the large Belle data set and the more recent design of the Belle II detector and large effort on data processing, and analysis software and simulation. This will avoid duplication of effort and streamline the completion of many analyses.

- A: The physics merger is happening now. As for a collaborations' merger, this would be the natural and efficient follow up, it has been mentioned but not yet discussed.

- Q: The Belle II Collaboration is encouraged to seek the help of dark-sector experts to optimise the physics reach of the current and future program.

Many dark sector analyses can lead to world-leading results already now; therefore, more manpower is crucially needed in this area.

The Committee is pleased to see the restart of a structured platform for regular exchange with theorists, as was already done in the past. More activities and exchange of ideas with theorists are very encouraged

- A: Agreed on reinforcing our dark-sector critical mass. Informal attempts at trying to attract / recruit colleagues to work on our dark sector program are ongoing inside and outside of the collaboration since a while. For example, DT recently took advantage of a series of seminars in the US to explore the possible interest of groups or individuals into joining us even temporarily (visiting etc) to work on our dark sector analyses. It's not clear whether we'll see any result soon, but attempts continue.

15 Upgrade

- Q: The BPAC therefore has one overarching recommendation for this section: scope, timeline, decision making process and the spatial envelope for the detector upgrade should be decided, preferably before the end of the calendar year.
- A: We will discuss this at coming EB meetings to come up with a plan.
- Q: The committee prompts the Collaboration to further sharpen the physics case, including the case with polarisation. It will be important to have a more defined physics scope beyond the improved $\sin^2\theta_W$ measurement and exploration of $g-2$ of the τ lepton, low-momentum tracking efficiency, and the reconstruction efficiency of neutrals, though these are very important.
- A: We are refocusing the physics performance benchmarking plan, concentrating on the aspects related to the most immediate upgrade paths (tracking, vertexing, KS and KL). We are not trying to expand the physics case beyond what is described in the Belle II Physics Book, but make it more solid and achievable. For Chiral Belle some more detailed physics slides have been prepared and will be presented at the first occasion.
- Q: Explore if parameterised fast simulations would be adequate to provide sufficient support for the choice of detector parameters and geometries.
- A: Currently we do not have a fast simulation system. The space of detector geometries / parameters is relatively small, and we are looking at relatively small effects (say 20-30%) which can be reliably appreciated only with full simulation. The plan is to use existing analysis workflows to evaluate the detector geometries, which requires the full BASF2 infrastructure. Fast simulation can be used to evaluate specific detector performance effects, for instance the KL momentum resolution and ID efficiency for the KLM upgrade.

- Q: A significant effort should be invested in obtaining simulation results as soon as possible for the proposed changes to the IP cryostats as well as for the beam transport lines.
- A: As soon as.the IR improved design proposals are defined they will be simulated to obtain the perfomance parameters.
- Q: Rank the different proposals as to how much expected improvement one should expect, in order to guide the decision process.
- A: Agreed.
- Q: The committee recommends that the Belle II collaboration and the SuperKEKB team setup procedures and deadlines to finalise the LS2 upgrade plan. This is particularly needed for upgrades that affect the machine and detector envelopes.
- A: (see above) We will discuss this at coming EB meetings to come up with a plan.
- Q: Work with the accelerator group and the ITF to define the scope of the accelerator upgrade for LS2, especially the machine-detector interface, and determine the boundary parameters for the detector upgrade as quickly as possible.
- A: We are participating in the ITF-IR group meetings to achieve this goal.
- Q: Delineate what upgrades can be deferred to a shutdown after LS2 and focus on those upgrades for LS2 that have the most impact in physics capability. Defer any effort on actual design of upgraded detector subsystems until the accelerator upgrade plans have been finalised and concentrate in the interim on promising detector technologies and advance them for use at SuperKEKB.
- A: While we want to keep the technology path open, we feel that we have to progress on specific design issues if we want to be ready for LS2. For instance we can proceed to do a detailed detector design for the VXD even if the geometry will require a final adaptation to the IR envelope once defined. We feel it is important to go through the entire design process, since many difficulties will arise along the path, and we would not be ready if we start too late. If other technologies become available or preferred, the basic layout and mechanical design can be reused.
- Q: A decision-taking process for the different upgrade options should be included in the CDR preparation.
- A: It will be included. We already have greatly reduced the number of different options and the CDR will be focused on the LS2 upgrades. Longer term upgrades will be included in a separate section, to allow the R&D effort to continue.

- Q: Evaluation of the need for an upgrade of different subsystems should continue and be sharpened through simulations. In this context, the simulation effort should be strengthened.
- A: The simulation effort must indeed be strengthened. We will continue to try and get more support from the detector and physics groups.
- Q: Work with the accelerator group to understand if the resources are available to carry out a feasibility study of electron polarisation.
- A: Although the resources are scarce, we are pushing for using an existing polarized source to measure the polarization lifetime in SKB, which is basice element to determine the feasability of the polarization upgrade.