Upgrade of the radiation monitor and beam abort system

Motivation

- *Are the sub-detector limitation/performance degradation and the timescale for it to become important clearly discussed, and supported by studies on MC19?*

  The two most relevant limitations of the current diamond system are:
  1. Limited dynamic range of dose rate measurement. For each sensor it must be determined in advance whether it is to be used for accurately measuring the dose rate (high sensitivity) or for generating beam abort signals (low sensitivity).
  2. Monitor and abort functionalities have to be deactivated during post-mortem readout of buffer memories.

  As an extension, the machine group suggested instrumenting the collimators in the ring and integrating them into the system. This would significantly enhance machine protection capabilities of SuperKEKB.

Upgrade proposal

- *Are the proposed technological solutions sound, and matching the scope*

  From the experience gained in the first two years of SuperKEKB operation the specifications for the new system can be quite reliably derived. In the course of last year a survey of existing beam-loss monitor systems at other facilities has been performed. Based on this survey different technical solutions seem possible and are under investigation.

- *How well is the upgrade supported by physics performance evaluation and background*

  The main task of the system is to protect the sensitive vertex detector and the superconducting final focus magnets from excessive radiation during beam incidents. The second very important function of the system is continuous dose monitoring even during times when the Belle II sub-detectors are switched off or during the trigger veto period. The latter two functions are essential for machine tuning and to estimate total ionizing dose (TID) accumulated in the VXD. Both would largely profit from a synchronization of the dose rate measurement with the timing of bunch injection and with the Belle II trigger system.

- *Robustness studies*

  The scope of the upgrade only affects the electronics of the system, which is foreseen to stay in the E-hut. It is not expected that the performance of the radiation-hard diamond sensors will limit the functionality of the system.

- *Are installation issues clear? Impact on other sub-detectors? In-situ vs roll-out clarified?*

There are currently no plans to change number or location of the diamond sensors in the VXD. Access to the VXD would therefore only be required if also the cables had to be replaced.

- *Length of the required shutdown*

  If the present cables can be kept the replacement can be done in a normal shutdown.

Design development

- *Is the R&D program clear and realistic, with sufficient prototyping and beam tests*

  The basic architecture of the system will remain the same. The major part of the R&D work will have to be invested in the analog front end to achieve the required increase in dynamic range. Since the sensors will be kept, it will in principle be even possible to test prototypes of the electronics during normal operation under real beam conditions.

Human resources

- *Is the potentially interested communities in+outside Belle II strong enough to contribute to the next steps (starting from the CDR)*

  The current level of available human resources of the Trieste group is sufficient to maintain and operate the running system. At present the group has not the capacity to lead the upgrade project since this will require a dedicated physicist and a senior engineer. This is particularly true should the system be extended to instrumenting the collimators. To achieve all the goals of the proposal the machine group should be closely involved. Participation from other Belle II groups is highly desirable to guarantee long-term maintenance of the system.

- *Are the estimated engineering resources sufficient*

  The estimated total time from start of the project until installation of 2.5 to 3 years appears sufficient.
  Amount and kind of expertise of the necessary Belle II person power largely depend on whether or not part of the development can be outsourced to external companies or laboratories.

Cost & Schedule

- *Is the cost estimate realistic? How does the schedule match the rough overall plans of Belle II?*

  A detailed breakdown of the costs is not yet available, but a preliminary offer from CAENels that would cover the core components of a new system sets a scale of about 150 k€, which seems to be the right level of investment required for such a system.

  To minimize the risk of damage to sensitive VXD components from radiation, it would be beneficial to install the upgraded system as early as possible. According to the timeline specified in the EOI, the installation of the new system would be possible

around 2024. This would be before the anticipated RF upgrade of the machine, after which the beam currents are supposed to reach their target values. This means that the new system would still become operational before the start of the probably most threatening phase for VXD operation.

Summary

- *is the proposal justified? Realistic? Well thought out? Possible synergies?*

  At a high luminosity collider like SuperKEKB a high performant radiation monitor and abort system is absolutely vital to protect the detector against damage from beam accidents and to provide an estimate of the integrated dose of the most exposed detectors close to the beam line. The proposed modifications address the short comings of the present systems and are technically feasible.

  Possible synergies with an enhanced instrumentation of machine components like collimators have been proposed and should be further investigated in close collaboration with the machine group.

  Development and construction of a new system offering the full functionality as described in the EOI is estimated to take about 3 years. Until then the present VXD will already have accumulated a significant TID. However estimating the contribution from continuous injection during the trigger veto period presently has large uncertainties. We therefore propose to investigate whether synchronization with the SuperKEKB and GDL timing systems can possibly be achieved within a time frame of less than 3 years without unduly affecting the design and construction of the new system.