Letter of Intent for KEK Super B Factory

Part II: Detector

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Executive Summary

For the upgrade of the Belle detector in the SuperKEKB project, the first consideration is to maintain the current performance in the very harsh background environment due to the high beam current. The performance of the Belle detector is summarized in the next chapter. To evaluate the possible degradation of the performance due to the extremely high background, we extrapolate the observed background to a level 20 times higher taking the nature of the components of background properly into account.

In the view of vertexing, the silicon micro-strip detector with a shaping time 5 times shorter ($1\mu sec$ to $200nsec$) and a strip length 6 times shorter for the inner layers can have 1/30 of the present occupancy. This may imply that the innermost layer can move even closer to the interaction point than the present one ($1.5cm$) without any loss of vertexing performance. To obtain a robust tracking for low momentum particles, the silicon tracker will be extended out to radius of 15 cm. As for tracking, we can easily reduce the hit loss rate due to overlapping of background by making the time constant in the electronics shorter. Further reduction can be accomplished with the drift cells of half the present size. Simulation studies with overlays of real background taken under current beam conditions show that the degradation of the tracking efficiency for high momentum particles would be small (0.91→0.90) even with 10 times more background. Here a factor of two is included to account for the smaller cell size. The degradation of efficiency for low momentum particles is somewhat larger, 0.94→0.85. We believe we can restore this rather significant loss for low momentum particles by the special reconstruction code currently under development.

On the other hand, the present background level observed in the end-cap part (EECL and EKLM) is rather serious and an upgrade to another advanced technology is necessary. Among several candidates pure CsI crystals with photo tetrode readout is the most promising for the EECL. Bars or tiles of plastic scintillator with a silicon photo multipliers (SiPM) are a good candidate for the replacement of the RPC technology used in the EKLM.

For a particle identification device, the upgrade will be undertaken not only for higher tolerance against background but also for much better K/π discrimination in the momentum range up to 4 GeV/c. Reduction of material in front of the calorimeter and allocation of more tracking volume to CDC is also planned. Among several options to be discussed in the later chapter, the DIRC technology with the Time of Propagation (TOP) scheme is a good candidate for the barrel part while RICH technology with aerogel radiator is considered for the end-cap one. For either option, the development of novel photon detectors with timing resolution better than $100psec$, sensitivity as low as a single photon level and an imaging capability are needed. The intense R&D work on these is underway. The current plan for the detector configuration is summarized in Fig. 1.

The trigger and data acquisition systems should also be upgraded to handle the 20 times higher occupancy level due to the higher beam current. The DAQ system will be using a pipelined readout scheme in order to cope with the high trigger rate, more than 10kHz, with

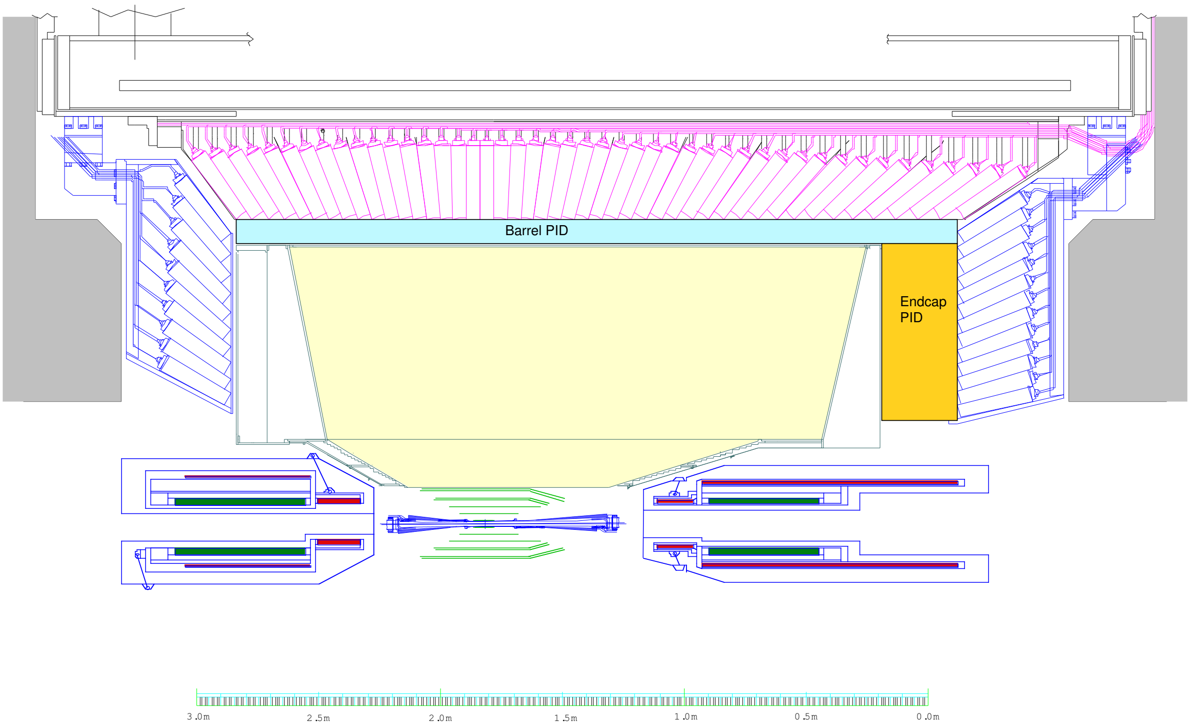

Figure 1: The conceptual illustration of the upgraded Belle.

a low dead time. A readout subsystem consists of a set of modularized common readout platforms called COPPER. They are also modularized and implemented as daughter cards (called as FINNESE) which can be implemented according to various requirements of the detector subsystem. The modules are equipped with a L1 pipeline FIFO so as to record the digitized signal without a readout dead time.

The computing at SuperKEKB is another technological challenge. The online data have to be recorded at a speed of 250 MB/sec after online reconstruction and reduction amounting to the data size of 5 PB/year. Considering the demands from the event skimming and Monte Carlo simulations, we will need a storage system holding 10∼20 PB at the beginning of SuperKEKB, and it should be expandable up to several tens of PB as we take more data. Vast expanding demands are also anticipated in the CPU power and other resources. The GRID technology to be applied in the LHC experiments could be a solution.