Potential and Prospects for a Super Flavour Factory

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1. Physics Case

The physics case for a Super Flavour Factory (SFF) has been elaborated on in various workshops in preparation for the proposals at SLAC (Stanford, USA), at Tor Vergata (Italy) and at KEK (Tsukuba, Japan). Detailed Studies of the physics reach as well as comparisons between the potential of LHC (in particular LHCb) can be found in the write-ups of the corresponding workshops.[1]

The main conclusions can be summarized as follows

- An SFF has the potential to probe very high mass scales, although only indirectly through precision measurements of flavour physics processes. Key examples for such processes are rare, flavour changing neutral current B decays, in particular the ones involving leptons and photons, but also rare decays of charmed particles and tau leptons. This program requires a large amount of data, which will also serve to reduce systematic uncertainties, including theoretical ones. To obtain a significant improvement beyond the achievements of the flavour factories PEP II and KEKB, which are expected to have accumulated approximately 2 ab^{-1} by the end of 2009, one needs at least an accumulated luminosity of 50 ab^{-1} to establish a solid physics case.
- An $e^+ e^-$ Flavour Factory is complementary with respect to LHC and also to LHCb due to the much cleaner environment with typically low multiplicities. For example, a measurement of inclusive decays, which can be calculated with high precision, is practically impossible at LHC. A study of the B_s-system at an $e^+ e^-$ Flavour Factory would require to run at the Y(5S), which is not the main thrust of an SFF. However, depending on the outcome of LHCb a run at the Y(5S) could provide valuable additional information.

The detailed scenarios of what a SFF could see will be probably correlated to the results of LHC, which will be running already for several years before a significant luminosity can be accumulated at an SFF. Nevertheless, given the time scales for the construbction as well as for the accumulation of sufficient luminosity the efforts towards a Super Flavour Factory have to be started now.

The reach of high mass scales through rare decays provided by an SFF may as well turn out to be the only way to obtain information on scales far above the reach of LHC or an Linear e+e- Collider. In this respect an SFF is an interesting „second road“ to explore the shortest distances.

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[1] T. Browder et al., arXiv:0802.3201 [hep-ph];
J. Hewett, D. Hitlin (eds.), hep-ph/0503261;
M. Bona et al., arXiv:0709.0451 [hep-ex]]

2. Future Projects

SuperB: A Conceptual Design Report has been prepared for this project in 2007, which has been updated in January 2008 in response of the questions posed by a INFN review committee. Currently the proposal is under consideration by the European Committee for Future Accelerators (ECFA) and by the European Strategy Group for Particle Physics at CERN. The ECFA statement has been published and discussed in the last PECFA meeting.[2] From the current perspective, the date for decision on the approval cannot be forseen.

The SuperB project is planned as a completely new facility including all the necessary infrastructure to be constructed at Tor Vergata close to the INFN laboratory at Frascati. The accelerator, an asymmetric e^+ e^- collider, has a planned luminosity of a few times 10^{36} cm^{-2} s^{-1} which pushes the luminosity frontier significantly. As far as the machine design is concerned, the SuperB project needs further R&D to prove that the very low emittance of the beams, the large tune shift, the Crab Waist Crossing as well as the tiny beam cross sections are technically feasible. The advantages of this set-up are low beam-related backgrounds as well as a low total power consumption. From the current perspective, no obvious problems are forseeable, but a substantial R&D effort is still to be made. This is in accordance with the recommendations contained in the ECFA report.

The time line of the SuperB project is quite agressive. After a two year R&D effort the TDR should be written, such that construction could start in 2010. The start of operation is forseen for 2015/16 which would lead to an integrated luminosity of 50 ab^{-1} approximately in 2022.

A full cost estimate of the SuperB project has been performed, the details of which can be found in the CDR. It is planned to re-use components of the PEP II machine as well as of the BaBar detector, leading to a significant cost reduction. The total costs of the project are estimated to be roughly 520 MEuro, not including about 11000 ManMonths of labour. However, out of the 520 MEuro, roughly 180 MEuro can be saved by re-using PEP II and BaBar components, leaving a cost frame of 340 MEuro. How much of these funds can be provided by the Italian government, if other countries want to take a share and if EU resources can be obtained is currently unclear. In particular, funding of the Super B project has to be seen in the framework of an overall European and even more worlwide strategy of HEP machines. However, the plan of funding, including a scheme for cost sharing and operating costs, is to be finalized by the end of 2009.

SuperKEKB: The SuperKEKB project is the sucessor of the existing KEKB project on the KEK site in Tsukuba. It is planned to increase the luminosity of the KEK-B machine to a final value of 8×10^{35} cm^{-2} s^{-1} which would allow one to collect a sufficient amount of integrated luminosity. This increase in luminosity is achieved mainly on the basis of known and tested technologies, by increasing the beam currents. The crab crossing scheme (a less ambitious scheme as the crab waist crossing planned for SuperB), as one major element to increase the luminosity, is still under R&D. However, the planned

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[2] T. Nakada, Report from the Super-b Study Group

design leads to a significant power consumption and to a large beam-related background.

The existing Belle detector has to be substatially upgraded (SuperBelle), which has to operate in the increased backgrounds stemming from the high beam currents. It is planned to take the technological decisions for SuperBelle within the next year, with the upgrade forseen within four years.

The time line of the SuperKEKB project starts after the shut down of KEKB / Belle by the end of 2009; the SuperBelle collaboration will be formed in December 2008. After a three year construction period data taking could start in 2013, which is an ambitious schedule. The goal of 50 ab^{-1} could be reached in 2020; however, this depends on the level of funding. A decision on the approval of this project is expected in spring 2009.

A full cost estimate for the SuperKEKB project has been performed. In a scenario, where the luminosity goal of 50 ab^{-1} is reached as early as possible (in 2020), the full cost is estimated to be 470 MEuro including the cost for the upgraded detector. It has to be kept in mind that this estimate is based on a construction performed completely with industry contracts. Due to the high power consumption of approximately 65 MWatts the project will have significant operation costs, which have been estimated to be 100 MEuro per year at full luminosity. SuperKEKB is planned to be financed solely by the Japanese govenment; the detailed plan of funding and the model of cost sharing of the SuperBelle detector is still under construction.

3. Interests in Germany

The experimental community in Germany in flavour physics has been involved in the BaBar experiment at SLAC and in the HERA-B experiment at DESY and is currently either participating in LHC-b, has moved to other LHC experiments, which are not dedicated to flavour, or has become involved in FAIR and in local projects. The BMBF funding of the current activities is split between the *High Energy Physics* funds and the *Hadrons and Nuclei* funds.

As became clear at the workshop Oct 31 and Nov 1 at the MPI München, there is a sizeable interest in Germany in participating at an SFF. Concrete expressions of interest exist for SuperBelle, actually the MPI München (Kiesling) and KIT (Feindt) have recently joined Belle. Additional strong interests come from Bonn, Heidelberg, Göttingen and Gießen. No such concrete plans exist for a participation in SuperB.

In particular, the development of DEPFET sensors (originally developed in view of the ILC) at the MPI in Munich with contributions from the Universities of Bonn and Heidelberg could provide the key technology for the inner vertex detectors at SuperBelle. In the (probable) case that SuperBelle chooses this technology, this would be an obvious German hardware input. However, the construction of a DEPFET vertex detector still requires a substantial effort which, however, would match the time scales of SuperBelle.

The DEPFET technology could also be used at SuperB, but due to the lower beam currents and hence a lower radiation intensity such a technology would not be mandatory. Since the SuperB vertex detector can be constructed with standard technology, it is unlikely that DEPFET's will be used at SuperB. However, the

technological decisions for the SuperB detector have not been made yet, but are to some extent pre-determined by re-using components of the BaBar detector.

In addition to the six groups (BN, HD GOE, GI, KA, MPI), there have been in total 7 other groups who have expressed in principle an interest in an SFF. These groups are from the *High Energy* as well as from the *Hadrons and Nuclei* community. However, the strong commitments to other projects does not leave resources for a participation in an SFF, at least in the coming funding period. On the other side, this interest shows that, in the long run, a particpation in an SFF project is considered an interesting possibility for a future development in the German community.

4. Some Remarks on a Possible German involvement

In order to participate in the physics harvest of an SFF, which needs and integrated luminosity of about 50 ab^{-1} , the groups joining an SFF project have to make a long-term commitment, reaching well into the 2020ies. Likewise, the funding agencies have to provide the corresponding long term support. Since the funding schemes of both projects have not yet been settled, the cost of a participation is hard to estimate. In particular, due to the high power consumption of the SuperKEKB project, substantial operating costs are expected. However, from the current perspective, neither SuperB nor SuperKEKB expect a participation in the operating costs.

The strong commitment of the MPI in Munich concerning the further development of the DEPFET technology has opened the road for a German participation in SuperBelle. However, the complete project needs the participation of university groups, with an additional funding of approx. 1.5 MEuro, which will be needed in the coming four years.