Ideas for Future B-Physics at DESY

H. Nesemann, M. Reidenbach, W. Schmidt-Parzefall,
H. D. Schulz, F. Willeke

Deutsches Elektronen-Synchrotron DESY,
Hamburg, Germany

presented by Walter Schmidt-Parzefall

Abstract

At DESY future B-physics experiments are under study. An asymmetric B-factory, colliding e^+e^- with 12 GeV on 2.3 GeV appears most attractive. The machine concept, a detector and computer simulations for experiments on CP-violation, $B_s\overline{B_s}$-mixing and $b \rightarrow u$ transitions are presented.

1 Introduction

At DESY there is interest to continue B-physics beyond the lifetime and experimental capabilities of the ARGUS-detector at the e^+e^--storage ring DORIS II.

Progress in B-physics based on e^+e^--reactions is primarily a challenge for accelerator physics. The construction of an adequate detector, though requiring substantial funds, can be considered a straight forward task. A new B-factory, however, needs new machine concepts to be developed.

There seems to be confidence that DESY is a place where this could be done most successfully.

A decision about a future B-factory at DESY can not be taken before the completion of the construction of HERA. In the meantime a study is being performed in order to consider the options.

2 Design Considerations

Among the various choices considered, an asymmetric scheme appears most attractive [1] e^+ and e^- are collided with energies 12 GeV on 2.3 GeV and thus create an $\Upsilon(4S)$ moving with a Lorentz-boost of $\beta\gamma \approx 1$. It appears clear that this scheme offers a fair chance of observing CP-violation for B-mesons [2].

At present the interest in B-physics is concentrated on the weak interaction of the b-quark. Precise measurements of the fundamental weak interaction parameters can best be performed if the vertices of the weak decays can be recognized and thus the structure of the events can be understood. Some of the most important measurements depend on the observation of the time evolution of the B-meson decays, again needing the detection of vertices.

The mean flight path of a B-meson is $\beta\gamma$ c τ, with $c\tau = 340\ \mu$. For a B-meson originating from an $\Upsilon(4S)$ produced at rest, the boost is $\beta\gamma = 0.07$ leading to mean flight path of 25 μ, a distance too small to be resolved by present experimental techniques. The problem comes from the unavoidable multiple scattering of the particles traversing the beam pipe and the track detector. With a boost of $\beta\gamma = 1$ the mean flight path is 340 μ, a distance which can be measured well.

For any given reaction there exists an optimum boost, where the maximum experimental significance is reached. The position of this optimum depends on details of the reaction. However, we found that this optimum lies always above $\beta\gamma = 0.9$.

For an increased boost the flight path z would increase correspondingly, since

$$z = \beta\gamma c\tau.$$

This leads to an improved vertex measurement precision. However, for forward tracks with a polar angle Θ and a momentum p the vertex resolution Δz would decrease like

$$\Delta z \propto \frac{1}{p \cdot sin^{\frac{5}{2}}\Theta}$$

These two conditions define the achievable vertex resolution and the optimum boost. We have chosen a boost of $\beta\gamma = 0.9$ corresponding to a ratio of beam energies of 5 : 1. To reach the $\Upsilon(4S)$, the beam energies would be tuned to 11.85 GeV and 2.37 GeV.

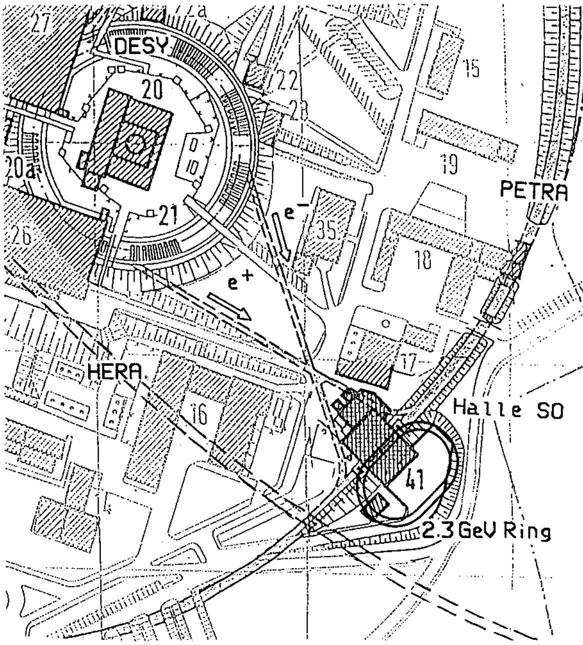

Figure 1: The DESY site. A possible position for a small ring tangential to PETRA

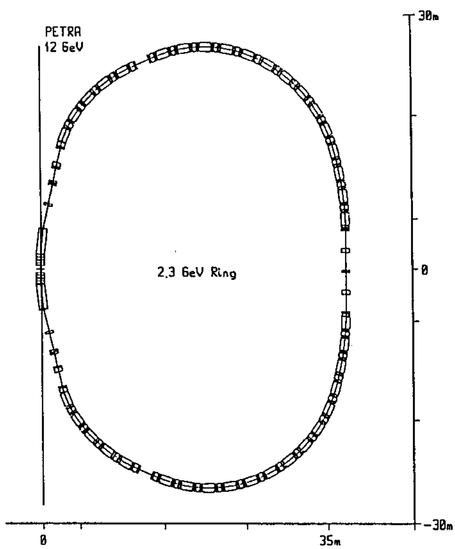

Figure 2: Design example for a 2.3 GeV Ring colliding against a 12 GeV ring.

3 The Machine

PETRA could serve as the 12 GeV machine. If PETRA is not available, nevertheless the PETRA tunnel could be used. The South-East-Hall of PETRA would be the ideal interaction region since the injection transfer channels to PETRA arrive here. The small 2.3 GeV ring tangential to PETRA could then also be filled using one of the existing injection channels.

Fig. 1 shows the DESY site and the possible location of a new small ring for the construction of a Beauty-Factory at DESY.

For an asymmetric machine with two storage rings it is important to study how the luminosity depends on the two beam energies E_1 and E_2.

For small asymmetries below $E_1/E_2 = 2$ both beams must be focussed by a common lens system before they are separated. With such a scheme focussing is never ideal for both beams and leads to a considerable loss in luminosity. If the asymmetry is large enough, a weak lens for focussing the low energy beam can be placed close to the interaction region. The beams are then separated and the strong lens focussing the high energy beam is placed behind. This scheme works well if the asymmetry is large. The asymmetry of $E_1/E_2 = 5$ chosen here, is just large enough to use this scheme without losing luminosity. Actually the strong lens focussing the high energy beam can not be placed quite as close to the interaction point as would be ideally required.

A higher asymmetry, however, would soon lead to unrealistic requirements for the RF-power due to the strong E^4 dependence of the synchrotron radiation produced. Even the apparently generous circumference of PETRA limits the energy of the high energy beam to around 12 GeV since enormous currents are needed to achieve the required luminosity.

Thus it turns out that a ratio of energies $E_1/E_2 = 5$ is close to optimum both for machine and experimental considerations.

Various ideas have been considered to make sure that the solution proposed here is really the best possible choice.

A particularly interesting idea is the replacement of the small ring by a 2 GeV superconducting linear accelerator [3] providing the electrons which are collided with positrons stored in the large ring. The luminosity of such a machine is defined by the following two conditions: How small can the size of the high energy stored positron beam be made in the interaction region, and how large can the current of the colliding low energy electron beam be made before the positron beam blows up? A rough estimate showed that this maximum electron current is around 3.5 mA requiring a still affordable RF-power of 7 MW. But the luminosity achieved would be close to the luminosity of a machine with two rings. Thus no clear advantage was seen which would justify the increased effort and technical risk.

The magnet lattice of PETRA has been found to be adequate and the design of the asymmetric collider has been based on this existing lattice. A new 2.3 GeV ring was designed. It is shown in Fig. 2. A possible set of machine parameters of the two rings are summarized in Table 1.

In order to reach high beam currents, two new developments are required: A feed back system is needed to damp out oscillations of the bunches, and a new type of RF-cavity is needed with very smooth contours in which practically no higher modes are excited.

These developments are already under way at DESY due to requirements of HERA. Thus a luminosity of 10^{33} cm^{-2} s^{-1} is within reach.

Table 1: Possible Machine Parameters

		Ring 1	Ring 2
Beam Energy	Gev	12	2.33
Circumference	m	2304	144
Bending radius	m	192	11.5
RF frequency	MHz	500	500
Bunch separation	MHz	25	25
Number of bunches		192	12
Beam Current	A	0.5	1.3
Particles per bunch	10^{11}	1.25	3.25
Synchrotron radiation power	MW	5	0.5
Beam energy spread		0.001	0.001
Emittance Horiz	π mm mrd	0.18	0.36
Emittance Vert	π mm mrd	0.028	0.055
β^* Horiz	cm	26	13
β^* Vert	cm	4	2
σ Horiz	μ	216	216
σ Vert	μ	33	33
Tuneshift Horiz		0.03	0.03
Tuneshift Vert		0.03	0.03
Luminosity	$cm^{-2}s^{-1}$	$1.1 \cdot 10^{33}$	

4 The Interaction Region

The detailed design of the interaction region has been started. Fig. 3 shows a first straightforward solution. The low energy beam is focussed by a doublet of quadrupoles. They are each divided into two units and are permanent magnets made from cobalt-samarium. These are followed by a dipole magnet which separates the two beams. The synchrotron radiation created by the high energy beam amounts to 10 kW. Absorbers are placed outside the 11 standard deviation beam envelope. No direct synchrotron light and no singly reflected light enters the detector. This scheme allows for a beam pipe radius of 18 mm, making good vertex resolution possible.

Improved solutions are under study. Particularly promising is a scheme where the separator dipole magnet is replaced by a combined function synchrotron magnet. Focussing is then done by a triplet and the deflection angle of the high energy beam is reduced. In this case less synchrotron radiation is produced.

5 The Detector

An example of a detector for an asymmetric B-factory is given in Fig. 4. Due to the Lorentz-boost of $\beta\gamma = 1$ the polar angles of forward tracks are roughly halved. A track emitted at 90° in the e^+e^- centre-of-mass frame is detected at 45° in the lab frame. In order to provide the same acceptance as in a symmetric scheme, the detector for an asymmetric B-factory would have to be about 1 meter longer. The boost is advantageous for the identification of leptons and the energy resolution of photons. The extended momentum

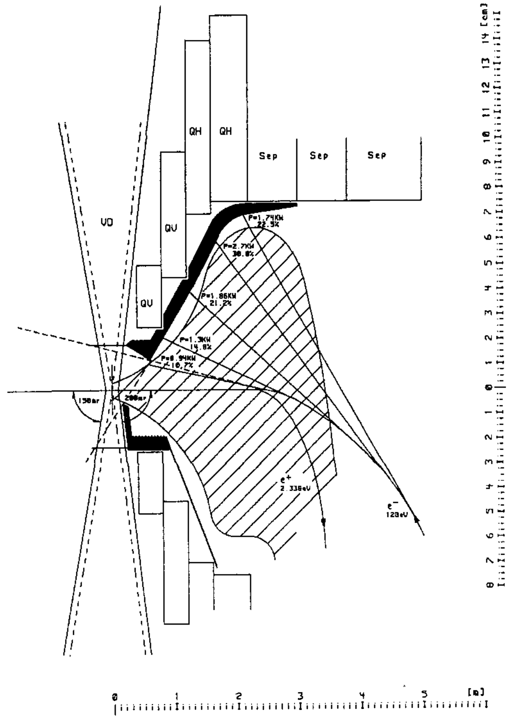

Figure 3: Design example for the interaction region. The low energy beam is focussed by permanent magnet quadrupoles QV and QH then the beams are separated by the dipoles SEP. The hatched area is the 11 σ envelope of the low energy beam. The synchrotron radiation produced by the high energy beam is shielded by collimators indicated in black.

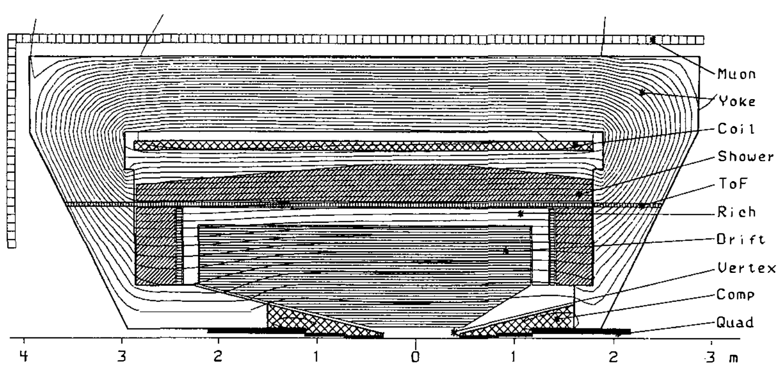

Figure 4: A detector f●r an asymmetric B-factory.

range required for hadron identification can be covered by a dE/dx measurement in the drift chamber and a ring imaging Cerenkov counter.

In addition a detector with a Helmholtz-coil arrangement, where the middle part of the solenoid is omitted, is under study and might have some advantages.

Obviously a detector for an asymmetric B-factory can be built from well proven experimental techniques and does not require special developments.

6 Experiments

Several computer simulations have been performed in order to investigate the physics potential of an asymmetric B-factory. Here we present results for CP-violation, $B_s-\overline{B_s}$-mixing and the $b \rightarrow u$ transition.

The decay $B \rightarrow \psi K_s$ was considered as a typical reaction in which CP violation in B-mesons might be observed. Though other decays like $B \rightarrow \pi^+\pi^-$ might be as useful, the computations investigating the potential of an asymmetric B-factory were based on the ψK_s.

If CP is violated, the B and $\overline{B}$ decay rates into ψK_s will evolve differently with time.

$$\Gamma(B^0 \rightarrow \psi K_s) \propto e^{-t/\tau}(1 + \eta sin\Delta M t)$$

$$\Gamma(\overline{B^0} \rightarrow \psi K_s) \propto e^{-t/\tau}(1 - \eta sin\Delta M t)$$

where τ is the mean B-lifetime and ΔM the $B\overline{B}$ mixing frequency. To measure the size of CP-violation η one observes a neutral B decaying into ψK_s and determines whether it was a B^0 or a $\overline{B^0}$ by tagging the other B in the event.

It is advantageous to use the B-mesons originating from the decay of the Υ(4S) resonance. The measurements are very clean since only a $B\overline{B}$ pair is produced, the beam energy constraint leads to a very high mass resolution and one starts with a well defined CP = - 1 eigenstate. The time evolutions of the two B-mesons from the Υ(4S) are not independent.

The correlated decay rates [4] are as displayed by Fig. 5:

$$\Gamma(B^0\overline{B^0} \rightarrow B^0\psi K_s) \propto e^{-(t+\bar{t})/\tau}[1 + \eta sin\Delta M(t - \bar{t})]$$

$$\Gamma(B^0\overline{B^0} \rightarrow \overline{B^0}\psi K_s) \propto e^{-(t+\bar{t})/\tau}[1 - \eta sin\Delta M(t - \bar{t})]$$

The CP violating effect vanishes if the lifetimes t of the B^0 meson and $\bar{t}$ of the $\overline{B}$-meson are integrated over and not measured. Actually the relevant variable, which must be measured is $t - \bar{t}$. Then η is determined by the expression:

$$\frac{\Gamma(B^0\overline{B^0} \rightarrow B^0\psi K_s) - \Gamma(B^0\overline{B^0} \rightarrow \overline{B^0}\psi K_s)}{\Gamma(B^0\overline{B^0} \rightarrow B^0\psi K_s) + \Gamma(B^0\overline{B^0} \rightarrow \overline{B^0}\psi K_s)} = \eta sin\Delta M(t - \bar{t}),$$

as shown in Fig. 6. Fortunately the variable $t - \bar{t}$ can be measured with an asymmetric Υ(4S) machine. This is illustrated in Fig. 7.

The directly observable distance of the two decay vertices $z - \bar{z}$ translates to a very good approximation

$$t - \bar{t} = \frac{z - \bar{z}}{\beta\gamma c}$$

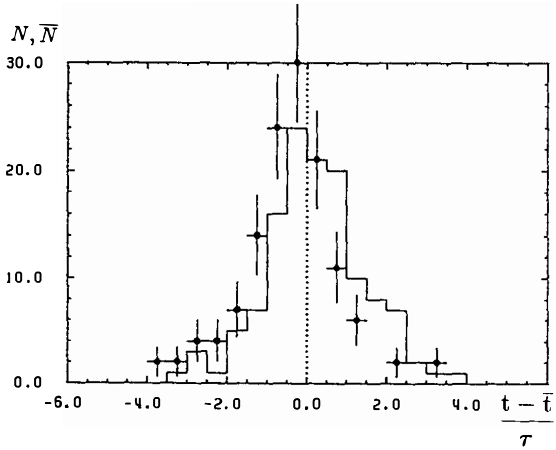

Figure 5: Simulation of a CP-violation experiment with the rates $N(B \to \psi K_s)$, histogram, and $\overline{N}(\overline{B} \to \psi K_s)$, points, as a function of the lifetime difference of the two B-mesons observed from $\Upsilon(4S)$ decay in units of the mean B-lifetime τ.

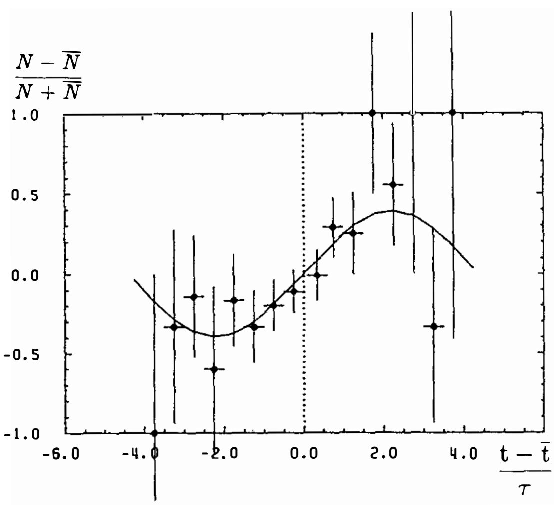

Figure 6: Difference of rates over their sum for B and $\overline{B}$ decays into ψK_s assuming CP-violating effect of $\eta = 0.4$, as it would show up after two years of running at a peak luminosity of $10^{33} cm^{-2} s^{-1}$.

into the difference of lifetimes, since the B-mesons are practically at rest in the $\Upsilon(4S)$ rest frame, and their lab.-velocity is the Lorentz-boost.

After separate summation over positive and negative lifetime differences the following rates are obtained.

$$\frac{N(B^0\psi K_s) - N(\overline{B^0}\psi K_s)}{N(B^0\psi K_s) + N(\overline{B^0}\psi K_s)} = \eta\frac{x_d}{1+x_d^2} = 0.5\eta,$$

where the $B^0 - \overline{B^0}$ mixing rate $x_d = \Delta M\tau = 0.73$ as measured by ARGUS [5] was used.

For the decay $B^0 \to \psi K_s$ the size of the CP violating effect η is directly related to the elements of the Kobayashi Maskawa matrix [6]

$$\eta(\psi K_s) = \frac{2\rho sin\delta(1-\rho cos\delta)}{1+\rho^2-2\rho cos\delta},$$

where

$$\rho e^{i\delta} = \frac{V_{ub}}{V_{us}V_{cb}} \quad .$$

Obviously the CP-violating phase δ of the KM-matrix can be extracted from a measurement of η, once ρ is known. This will be obtained from the observation of the $b \to u$ transition.

$$\rho = \frac{|V_{ub}|}{|V_{us}||V_{cb}|}$$

Assuming that the origin of the CP-violation of the K^0 is the existence of a phase in the KM-matrix, the size of η has been estimated to be

$$0.1 < \eta(\psi K_s) < 0.6$$

The main uncertainty lies in the decay constants f_i and bag-factors B_i of the K- and B-mesons, since it turns out that roughly [7]

$$\eta(\psi K_s) \approx 0.3\frac{f_B^2 B_B}{f_K^2 B_K}$$

With a peak luminosity of $10^{33}cm^{-2}s^{-1}$ and an average running efficiency of $1/\pi$ one will produce $10^7\Upsilon(4S)$ per year. Using the branching ratios

$$BR(B^0 \to \psi K_s) = 5\cdot10^{-4}, BR(\psi \to \ell^+\ell^-) = 0.14, BR(K_s \to \pi^+\pi^-) = 0.69$$

and the efficiencies for reconstruction and for tagging by leptons or kaons

$$\eta_{rec} = 0.52 \quad \eta_{tag} = 0.49,$$

finally 120 fully reconstructed and tagged events are detected per year. Thus for a CP-violation with a magnitude of $\eta(\psi K_s) = 0.4$ an effect would be observed with a significance of 3 standard deviations after two years of running [8].

The running time required to observe a 3 standard deviation effect, rising like the inverse square of the CP-violating effect, is summarized in Table 2.

A running time of 5 years would certainly be acceptable to establish the CP-violation of B-mesons. If $\eta(\psi K_s) < 0.3$ one will have to investigate more decay channels of B-mesons to increase the data rate.

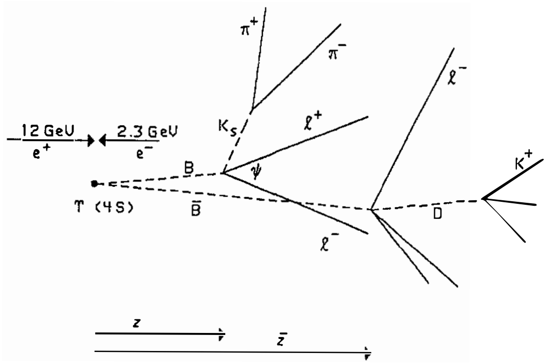

Figure 7: The vertex pattern for a measurement of CP violation in B-decays $B \to \psi K_s$.

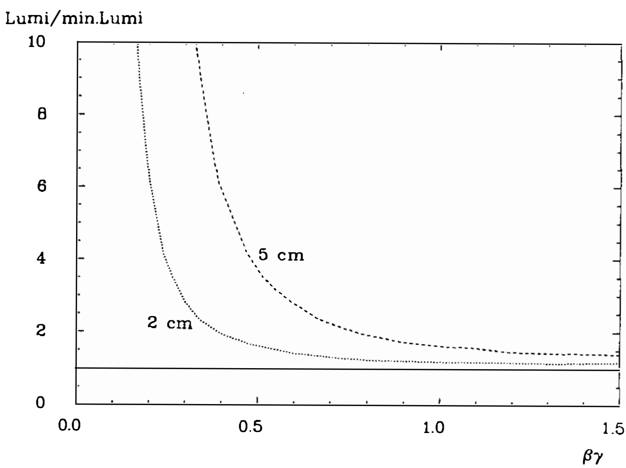

Figure 8: The luminosity required to obtain a given significance for a CP violation experiment with $B \to \psi K_s$ versus the minimal required luminosity as a function of the Lorentz-boost $\beta\gamma$ of the B-factory and the radius of the beam pipe.

Table 2: The running time required to observe a 3σ CP-violation effect for a peak luminosity of $10^{33}cm^{-2}s^{-1}$

$\eta(\psi K_s)$	running time
0.6	9 months
0.3	3.3 years
0.1	30 years

The dependence of the integrated luminosity required for a CP-violation experiment on the Lorentz-boost of the B-factory has also been studied. The significance reached with a given integrated luminosity depends on the ratio of the beam-pipe radius versus the Lorentz-boost. Actually the relevant quantity is the ratio of the vertex resolution versus the Lorentz-boost. But the vertex resolution is dominated by coulomb-scattering in the beam pipe, and its radiation length and radius determine the obtainable vertex resolution. For the simulation a beryllium pipe with a 0.5 mm thickness has been assumed. As a vertex detector 200μ thick silicon measuring two coordinates was used. As Fig. 8 shows, a beam pipe radius of 2 cm is sufficiently small to reach the ideal sensitivity. However, even if the background conditions would require the use of a beam pipe of 5 cm radius, the large boost still allows for a significant CP-violation experiment.

We conclude that an asymmetric B-factory with a luminosity of $10^{33}cm^{-2}s^{-1}$ has the capability to discover CP-violation in B-meson decay.

Another important goal of B-physics is the measurement of the frequency ΔM_s of particle-antiparticle oscillations for B_s-mesons. The parameter

$$x_s = \Delta M_s \tau$$

is 2 π times the number of oscillations per mean B-lifetime τ. To first approximation x_s is related to x_d by

$$\frac{x_s}{x_d} = \frac{|V_{ts}|^2}{|V_{td}|^2}$$

where x_d is the corresponding parameter for B_d-mesons. Thus a measurement of x_s gives very direct information on the structure of the KM-matrix.

Within the Standard Model of 3 generations x_s is bound by the unitarity of the KM-matrix:

$$4 < x_s < 14.$$

These oscillations are too rapid to be measured by a time integrated experiment. They can only be resolved by a measurement of the time evolution of the B_s-mesons.

An asymmetric B-factory offers the possibility of measuring $B_s - \overline{B_s}$ oscillations. The starting point is the Υ(5S) resonance. It has been shown that the largest detectable effect can be expected in the production of $B_s^*\overline{B_s^*}$ pairs [9] from the reaction

$$\Upsilon(5S) \rightarrow B_s^*\overline{B_s^*}.$$

The B_s^*-mesons quickly decay into B_s-mesons which then oscillate into their anti-particles. Finally like-sign lepton pairs from the semileptonic B_s-decays give the experimental signature for $B_s - \overline{B_s}$ mixing. Like-sign lepton pairs from other sources like $B_d - \overline{B_d}$ mixing or random combinations can be easily separated off, since they do not exhibit fast oscillations.

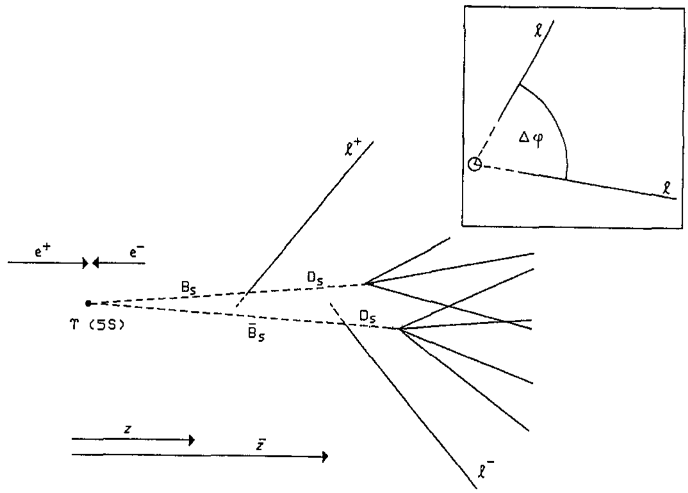

Figure 9: A typical vertex pattern for a measurement of $B_s - \overline{B_s}$ mixing. The signature is derived from the detection of like-sign lepton-pairs. Though semileptonic B_s-decays usually don't from detectable vertices, the insert shows that the intersect of the two lepton tracks projected into the plane perpendicular to the beams gives the vertex coordinates with good precision.

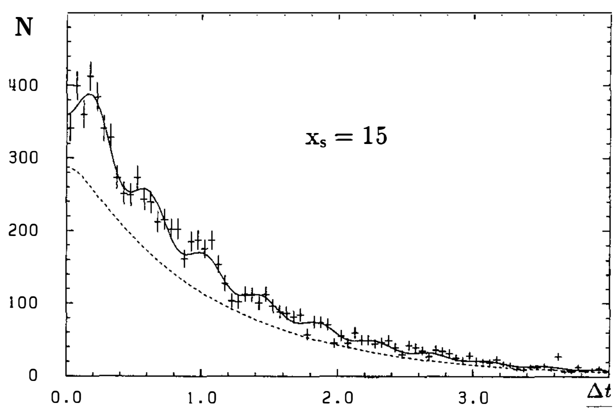

Figure 10: The rate of like-sign lepton-pairs expected from Υ(5S) decays and the underlying continuum. The data points are the total rate and the solid curve is a fit to the data. The dashed curve is the background of like-sign lepton-pairs from sources other than $B_s - \overline{B_s}$ mixing. A mixing rate of $x_s = 15$ was assumed.

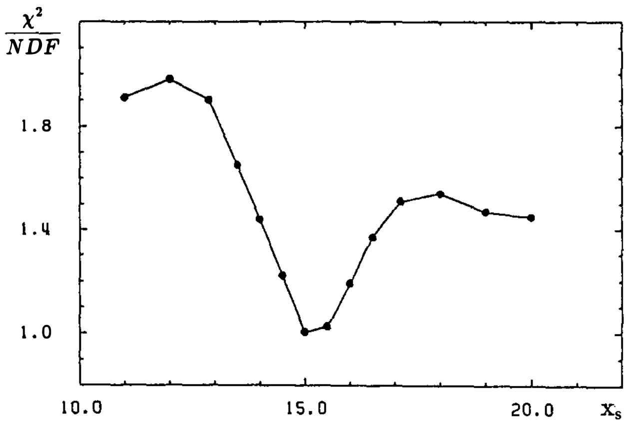

Figure 11: The χ^2 per degree of freedom for the fit ofthe curve to the data of Fig. 8 as a function of the mixing rate x_s, showing a clear minimum for the mixing rate $x_s = 15$ which was originally assumed.

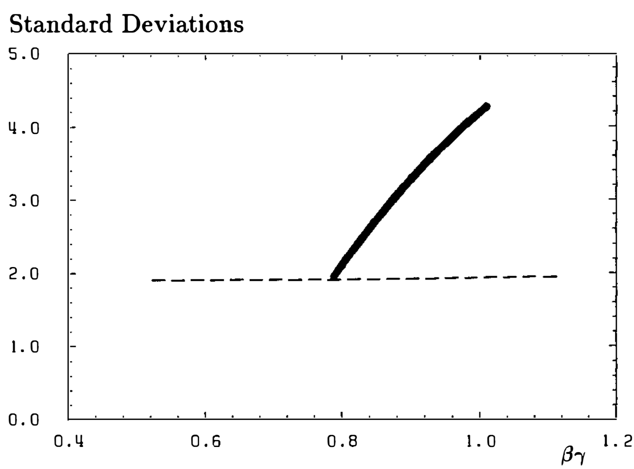

Figure 12: The significance of the measurement of $B_s - \overline{B_s}$ mixing as function of the Lorentz-boost $\beta\gamma$. A large boost is essential for this measurement.

Fig. 9 shows the vertex pattern to be detected. A complication arises, since the semileptonic B_s-decays generally do not produce a detectable vertex. Only the lepton leaves the beam pipe. This difficulty can be overcome by a trick as shown in the insert of Fig. 9. The tracks of the two leptons in the event can be extrapolated and their intersection point projected into the plane perpendicular to the beam can be used as an approximation for the missing vertex coordinates. This approximation works well if the polar angles and relative azimuthal angle of the tracks are not too small. In the simulation

$$30^\circ < \vartheta_1, \vartheta_2 < 150^\circ$$

$$30^\circ < | \varphi_1 - \varphi_2 | < 150^\circ$$

were used. With these cuts 0.4 of the events are accepted. It is important to note that the measurement of the time evolution of the B_s-mesons relies on the fact that they are produced almost at rest in the $\Upsilon(5S)$ rest frame. Therefore the directly measured distance of the two decay vertices of the two B_s-mesons Δz can be converted into the difference of their lifetimes Δt by

$$\Delta t = \frac{\Delta z}{\beta\gamma c}$$

Though only approximately valid, this relation does not introduce any systematic shift in the lifetime difference but only a smearing of the order of 0.02 mean lifetimes.

We found that for a measurement of $B_s - \overline{B_s}$ mixing, silicon strip detectors perform better than a gaseous vertex chamber since only two high momentum leptons have to be detected.

The computer simulation was based on 1.5 years of running on the $\Upsilon(5S)$ resonance with a peak luminosity of $10^{33} cm^{-2} s^{-1}$. Out of these data after all cuts 2500 likesign lepton pairs will be finally detected. Their lifetime difference distribution is shown in Fig. 10. It is superimposed on a large but smooth background. As displayed in Fig. 11 a fit to this time distribution with varying oscillation frequency x_s shows a marked minimum for the χ^2 quality of the fit at $x_s = 15$. This x_s-value was the original input and is well reproduced. For this measurement a large Lorentz-boost is essential to resolve the rapid $B_s - \overline{B_s}$ oscillations, see Fig. 12. For a boost of $\beta\gamma = 1$ an oscillation frequency of $x_s = 15$ is about the maximum frequency, which can be resolved. We conclude that $B_s - \overline{B_s}$ mixing can be very precisely measured with an asymmetric B-factory over the whole range of oscillation frequencies allowed by the Standard Model with three generations.

A precise measurement of the KM-matrix element $| V_{ub} |$ is of extreme importance for a complete picture of the weak interaction. In particular, $| V_{ub} |$ is needed to extract the CP-violating phase from experiments on decay rate asymmetries in B-decays. $| V_{ub} |$ could also provide a determination of the CP-violating phase by exploiting the unitarity relation

$$V_{bu}^* V_{ud} + V_{bc}^* V_{cd} + V_{bt}^* V_{td} = 0$$

The most promising reactions for a precise measurement of $| V_{ub} |$ are semileptonic B-decays like $B^+ \to \rho^\circ \ell^+ \nu$ or $B^\circ \to \pi^+ \ell^- \nu$. Here the theoretical uncertainties for the extraction of the matrix element from the measured decay rate appear to be smallest [10].

We have simulated the reaction $B^+ \to \rho^\circ \ell^+ \nu$ in order to demonstrate the capability of an asymmetric B-factory to isolate and measure rare B-decays. A typical vertex pattern is shown in Fig. 13. A branching ratio of

$$BR(B^+ \to \rho^\circ \ell^+ \nu) = 10^{-4}$$

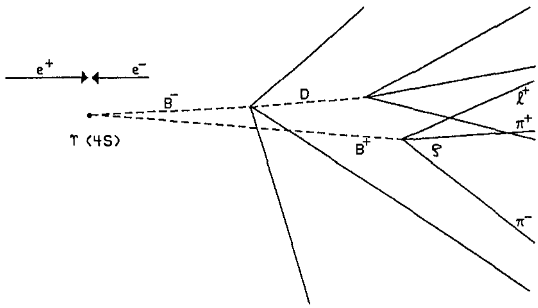

Figure 13: A typical vertex pattern for B-decays $B \to \rho \ell \nu$.

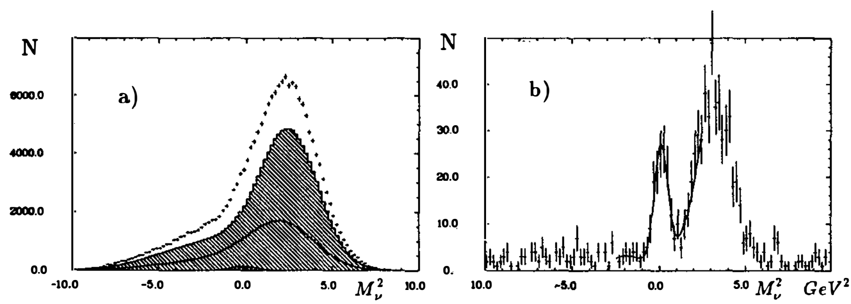

Figure 14: The missing mass squared distribution for the reconstruction of semileptonic B-decays with a missing neutrino. Correctly reconstructed events appear around $M_\nu^2 = 0$. a) Analysis without vertex information. At $M_\nu^2 = 0$: signal from $B \to \rho \ell \nu$. Curve : background from continuum. Hatched : background from $\Upsilon(4S)$ decays. Points : total data rate. The signal cannot be identified in this case. b) Analysis using the vertex information. Points are total data rate. The signal is clearly identified.

was assumed. This value constitutes about the lowest possible value for a consistent picture of a three generation KM-matrix. Consequently it follows that if the reaction can be seen with a branching ratio that small, the whole range allowed by the Standard Model is covered.

The simulation was based on $2 \cdot 10^7 \Upsilon(4S)$ events, corresponding to 2 years of running with a peak luminosity of $10^{33} cm^{-2} s^{-1}$. The $\rho \ell \nu$ final state is reconstructed by actually reconstructing the mass of the missing neutrino M_ν

$$M_\nu^2 = (E_B - E_\rho - E_\ell)^2 - (\vec{p_B} - \vec{p_\rho} - \vec{p_\ell})^2.$$

This method can only be applied for B-mesons originating from the $\Upsilon(4S)$. Here the energy of a B-meson E_B is just one half the $\Upsilon(4S)$-energy and the B-momentum $\vec{p_B}$ can be neglected in the $\Upsilon(4S)$- restframe. The Fig. 14 displays M_ν^2-distributions obtained this way. The correctly reconstructed events are centered around zero, while the background produces a wider distribution. The M_ν^2, Fig. 14 a, contains the $\rho \ell \nu$ events plus background from the $\Upsilon(4S)$ and the continuum, after the application of some event selection cuts. No evidence of a signal can be found. In Fig. 14 b the vertex information has been exploited. As well the tracks from ρ and ℓ should be consistent with forming a common vertex and none of these tracks should be consistent with belonging to another vertex in the event. Clearly a large background suppression is achieved by the vertex information and the signal is now seen as a 5 standard deviation effect. Again a large Lorentz-boost is important for this experiment in oder to achieve a sufficiently large vertex separation.

Also without an explicit simulation it is obvious that an asymmetric B-factory allows a very precise measurement of the mean lifetime of each of the B-meson kinds: B_u, B_d and B_s. Probably also the reconstruction and a lifetime measurement for beauty-baryons will be possible.

In summary, simulations of various experiments have shown that an asymmetric B-factory colliding electrons on positrons with 12 GeV on 2.3 GeV has the physics potential to determine all yet unknown elements of the KM-matrix. These measurements will complete our picture of the Standard Model of the weak interaction. For these measurements the production of the B-mesons through the e^+e^- resonances $\Upsilon(4S)$ and $\Upsilon(5S)$ and a Lorentz-boost $\beta\gamma = 1$ is essential.

We conclude that a luminosity of $10^{33} cm^{-2} s^{-1}$ is sufficient for this task, though it may lead to undesirably long running times, depending on the actual size of the elements of the KM-matrix.

The design of an adequate detector is straightforward though the construction will require substantial funds.

A design example using the PETRA tunnel for an asymmetric collider machine has been worked out and it shows that a luminosity of $10^{33} cm^{-2} s^{-1}$ is within reach. An asymmetric B-factory appears as a very attractive option for future B-physics at DESY.

References

[1] P. Oddone, Proceddings of the UCLA workshop on linear collider B-factory conceptual design, ed. D.H. Stork World Scient. (January 1987).

[2] H. Nesemann, W. Schmidt-Parzefall, F. Willeke, EPAC Rome (1988).

[3] P. Grosse-Wiesmann, unpublished (1988).

[4] I.I. Bigi, A.I. Sanda, Nucl. Phys.B **193** (1981) 85.

[5] H. Albrecht et al. (ARGUS), Phys. Lett.B **129** (1987) 245.

[6] M. Kobayashi and K. Maskawa, Prog. Theor. Phys. **4** (1973) 652;
L. Wolfenstein, Nucl. Phys.B **246** (1984) 45;
N.W. Reay, Proceedings of the SSC Fixed Target Workshop, p. 53, The Woodlands, 1984 (unpublished);
E.A. Paschos, E.A. Paschos, R.A. Zacher, Z. Phys.C - Particles and Fields **28** (1985) 521;
J.W. Cronin et al., Proceedings of the SSC Snowmass Summer Study, p. 161, Snowmass, (1984);
I.I. Bigi, A.I. Sanda, Nucl. Phys. B **281** (1987) 41;
I. Dunietz, J. L. Rosner, Phys. Rev.D **34** (1986) 1404.

[7] I. Dunietz and T. Nakada, Z. Phys.C **36** (1987) 503; Khose and Uraltsev DESY-TH (1988).

[8] R. Aleksan et al., SLAC-PUB, June 1988.

[9] P. Krawczyk et al., DESY 88-163 (1988).

[10] J. M. Cline et al., DESY 88-029 (1988);
I. Hinchliffe and C.H. Llewellyn Smith, Nucl. Phys.B **114** (1976) 45;
G.L. Kane, Phys. Lett.B **70** (1977) 227;
W.J. Wilson, Phys. Rev.D **16** (1977) 742;
V. Barger, T. Gottschalk and R.J.N. Phillips, Phys. Rev.D **16** (1977) 746;
F. Bletzacker, M.T. Nieh and A. Soni, Phys. Rev.D **16** 732;
X.Y. Pham and J.M. Richard, Nucl. Phys.B **128** (1978) 453;
M.B. Gavela, Phys. Lett.B **83** (1979) 367;
A. Ali, J.G. Krörner, G. Kramer and J. Willrodt, Z. Phys.C **1** (1979) 269;
M. Suzuki, Phys. Lett.B **155** (1985), Nucl. Phys.B **258** (1985) 553;
W. Wirbel, B. Stech and M. Bauer, Z. Phys.C **29** (1985) 637;
B. Grinstein, M.B. Wise and N. Isgur, Phys. Rev. Lett. **56** (1986) 298;
F. Schöberl and H. Pietschmann, Europhys. Lett. **2** (1986) 583;
T. Altomari and L. Wolfenstein, Phys. Rev. Lett. **58** (1987) 1563;
S. Nussinov and W. Wetzel, Phys. Rev.D **36** (1987) 130;
J.G. Körner and G.A. Schuler, Z. Phys.C **38** (1988) 511;
M. Bauer and M. Wirbel, preprint HD-THEP 88-22, DO-TH 88-19, to be published in Z. Phys.C.