A SMALL HIGH LUMINOSITY e^+e^- LINEAR COLLIDER AS A TEST COLLIDER AND B FACTORY

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1. Summary

We describe a e^+e^- linear collider that can be used to test the scaling laws for linear colliders and can also serve as a high luminosity B factory. Some B physics goals are described as well.

2. Introduction

The problems of constructing the next generation of linear colliders after SLC are formidable. Not only must the energy be high ($\sqrt{s} > 500\,Gev$) to carry out significant experiments, but the luminosity must be very high to observe very rare processes, such as Higgs Boson production ($\mathcal{L} \geq 10^{33} cm^{-2} sec^{-1}$). The SLC is a very interesting machine but may not test many of the fundamental problems that will be encountered in the construction of a truely high energy collider. Many of us believe that a small linear collider with the ingredients of the high energy machine should be constructed to test the "scaling laws" of linear colliders.

At the same time, such a machine, if it reaches $\mathcal{L} \geq 10^{33} cm^{-1} sec^{-1}$ would be suitable as a B factory, producing greater than $10^8 B\bar{B}$ per year. We will return to the physics goals of the B factory later. Figure 1 shows the expected yields of B's at various places over the next few years. We note that the B production at hadronic colliders is high but the effective yield for many processes is likely to be much less than at e^+e^- colliders.

Recently the interesting B physics has increased due to the observation of B^o mixing in the UA1 experiment† . Although this effect is more or less expected within the standard model, the existence of another system similar to the K^o system can lead to new observations about CP violation and other types of interactions of elementary particles. Thus the search for new rare B processes is one of the important future goals of particle physics.

The possibility of a low energy linear collider that gives a high luminosity B fctory follows from the general principles of linear colliders. The luminosity is given by

$$L = N^2 f / 4\pi\sigma^2$$

where N is the number of e^+ or e^- per bunch, f is the frequency of bunches and σ^2 is related to the size of the beam at the interaction point. High energy linear colliders are being designed with $\mathcal{L} > 10^{33} cm^{-2} sec^{-1}$, it is therefore possible that a low energy collider could be designed to yield a similar luminosity.

Of course we only indicate in a rough manner the parameters of such machines and a more detailed design is in progress.

* Talk given at the SSC Workshop, July 1986
† Talk given at the SSC Snowmass meeting by D. Cline

3. Possible Parameters of a Test Linear Colliderand B Factory

We can work out an approximate set of parameters for this low energy machine as given in Table 1, (using $\mathcal{L} = \frac{N^2 f}{\sigma^2}$). The machine will test the collisions of very small beams ($0.1\mu m$) use of a high frequency collider (f = 5 x 10^3 Hz) and cold electron or positron sources. It will be essential to develop new sources of positrons, since the use of multiple damping rings will be very expensive.

A schematic of such a linear collider is given in Figure 2. We view this collider as a machine to test for new innovative technology that may enhance the development of high energy linear collider as well as a dedicated B factory. One such development would be new sources of intense cold e^+ beams that might become available by breeding e^+ emitters such as ^{64}Cu, i. e. ,

$$N +^{64} Cu \rightarrow^{64} Cu_{\rightarrow e^+} + .$$

It is also necessary to project the collision of submicron beams which will be crucial for very high energy colliders.

4. Physics Potential of a B Factory

As we have reported at this workshop, the UA1 group has strong evidence for $B^o - \bar{B}^o$ mixing. This is the first important physics results from $B\bar{B}$ final states to come from a haldron collider.

The study of B physics is going to be even more important in the future. The b is uniquely coupled to the t quark and thus the loop diagrams test for breakdown of the standard model at very small distances. CP violation can be detected in the decays of B systems. However, the CP violation appears to be largest in the rare B decays ($B^o \rightarrow K\pi$, $B^o \rightarrow \psi\phi$ and so forth.) Finally, the $b \rightarrow \mu$ transition must be determined if we are to understand the K-M matrix further. The most important aspect of the B factory proposed here is the ability to sweep the energy above various $B\bar{B}$ threshhold, for example:

$$B_d^o \;\; \bar{B}_d^o$$

$$B_s^o \;\; \bar{B}_s^o$$

$$B_c^+ \;\; B_c^-,$$

and to observe greater than 10^8 events in each requirement. In Figure 3 we give a list of interesting rare B decays and the expected level of CP violation.

A dedicated, high rate $B\bar{B}$ factory will produce $\sim 10^8 \tau\bar{\tau}$ per year and of course a comparable number of charmed particles since the B decay is dominated by the charm final states.

The small beam size of a linear collider makes it possible to construct novel silicon strip detectors and provide very high resolution in a modest magnitude yield as well as vertex information.

We believe such a test detector and B factory should be built in the USA. The project is "university" sized and need not tie up a large national laboratory.

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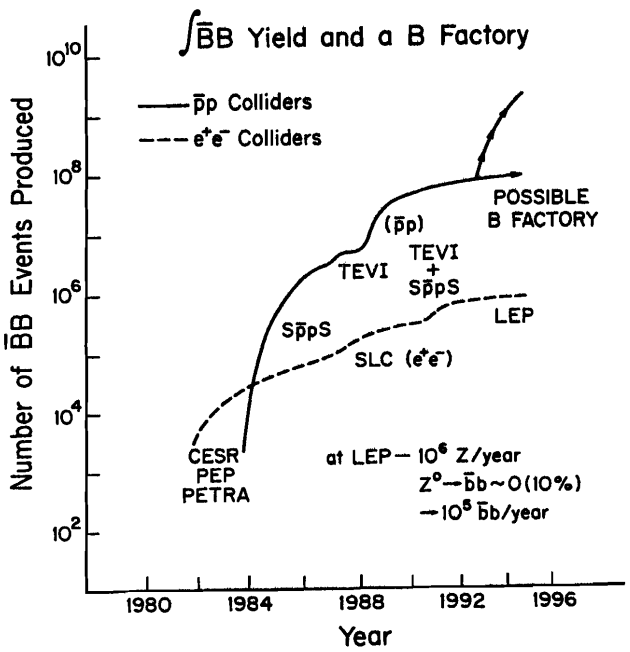

Figure 1

Table I

High Luminosity e^+e^- $B\bar{B}$ Factory

	I		II		SLC
N e^+/sec	7×10^{10}	7×10^{14}	5×10^{10}	5×10^{13}	5×10^{-10}
f	10^4		10^3		180
γ	10^4		10^4		10^5
ϵ	$10^{-5} m - rad$		$10^{-6} m - rad$		$3 \times 10^{-5} m - rad$
β^*	$0.03 cm$		$0.04 cm$		$0.75 cm$
σ_r	$0.3 \mu m$		$0.2 \mu m$		$1.8 \mu m$
σ_z	$0.05 cm$		$0.01 cm$		$0.1 cm$
δ	0.8×10^{-4}		4.8×10^{-3}		3×10^{-4}
P_B	$0.9 mw$		$0.6 mn$		0.07
D	2.8		3.5		0.63
$H(D)$	3		5		1.5
$\mathcal{L}$	$1.3 \times 10^{34} cm^{-2} sec^{-1}$		$3 \times 10^{33} cm^{-2} sec^{-1}$		$2.4 \times 10^{30} cm^{-2} sec$

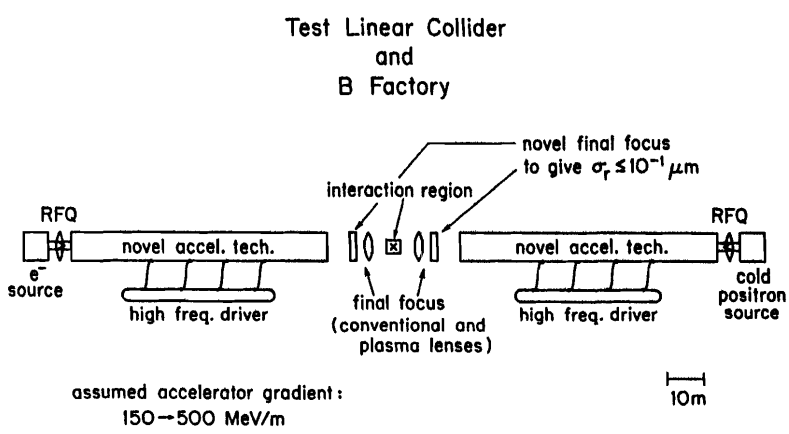

Figure 2

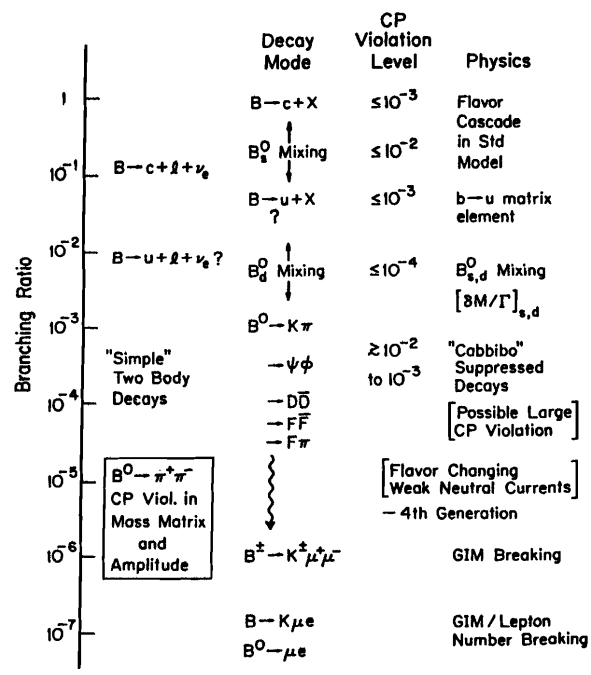

Figure 3