BEAMSTRAHLUNG IN HIGH ENERGY - HIGH LUMINOSITY COLLISIONS

J. Buon,
LAL, Orsay, France.

G. Coignet
LAPP, Annecy-le-Vieux, France

ABSTRACT
This paper gives rough estimates of the beamstrahlung from colliding beams for cases considered by the Workshop, including the quantum corrections to the classical treatment.

The beamstrahlung is the synchrotron radiation emitted when two e^+, e^- bunches collide. It results from the interaction between each particle and the electromagnetic field generated by the opposite bunch.

For a bunch of N particles with transversal area $A = \pi\sigma_x^2$ and longitudinal dimension σ_z, beamstrahlung leads to a beam energy spread $\Delta E/E$ during the collision. In the classical treatment of synchrotron radiation, it is defined$^{1)}$ by the beamstrahlung parameter

$$\delta = \frac{1}{3\sqrt{3}} \frac{r_o^3 N^2 \gamma}{\sigma_x^2 \sigma_z}$$

which increases when energy and luminosity increase.

At high electron energy, that is when the critical energy E_c of the emitted photon is comparable with the beam energy, quantum corrections have to be applied; they tend to reduce the energy spread computed with classical formulae but $\Delta E/E$ has to be estimated for each particular case. Useful formulae and curves have been taken from Refs. 2) and 3). An average value of the magnetic field $B^{av} = B^{max}/2$ has been used.

The following table summarizes rough estimates of beamstrahlung for two cases which have been considered in this workshop.

For a 1 TeV x 1 TeV e^+e^- collider with $L = 10^{32} cm^{-2}s^{-1}$ the breamstrahlung produces an energy spread still relatively small (< 1%).

On the contrary for a 5 x 5 TeV e^+e^- collider with very high luminosity ($10^{34} cm^{-2}s^{-1}$), the critical energy becomes larger than 1 TeV and the beamstrahlung emission leads to a large energy spread, even for moderate values of the disruption factor D. It can be reduced by decreasing the number N of particles per bunch and the beam spot size, at the expense of a higher repetition rate, but keeping the total beam power constant.

1) See for example Report of Group 1 of Proceedings of the Second ICFA Workshop on Possibilities and Limitations of Accelerators and Detectors, Les Diablerets, Switzerland, 4-10 October 1979, p. 3.

2) T. Erber et al., Proceedings of the 12th International Conference on High Energy Accelerators, Fermilab, August 11-16, 1983, p. 372.

3) R. Noble, Talk given at Big Collider Study Group, SLAC, June 26, 1984.

	L.Hand + J.Rees case A	C.Rubbia's case		
E	1	5		TeV
L	10^{32}	10^{34}		$cm^{-2}s^{-1}$
P	1	10		Mw
$f\,A^{eff} = f\,\frac{A}{H(D)} = \frac{P^2}{L^2}$	$4\times(.1)^2$	$64\times(.005)^2$	$16\times(.01)^2$	Khz×μm²
$N = \frac{P}{fE}$	1.5×10^9	2×10^8	8×10^8	
σ_z	3	3	3	mm
$D.H(D) = \frac{\pi r_o N\gamma_z}{2\gamma A^{eff}}$	1×1	2×5	2×5	
$B^{av} = \frac{50\ N(10^{10})}{\sigma_x \ell}$	22	60	118	Tesla
$R = \sqrt{A^{eff}/\pi}\ ;\ \ell = 2\sigma_z$				
$\rho = \frac{10^3\ E}{0.3\ B}$	150	280	140	m
$E_c = \frac{4.44\ E^3}{\rho}$	.029	2	4	TeV
$T = \gamma\ \frac{B^{av}}{4.4\times10^9}$	.01	.135	.27	
$g(T) = \begin{cases} T^2(1-5.953\ T) & T \ll 1 \\ 0.5563\ T^{2/3} & T \gg 1 \end{cases}$	10^{-4}	.01	.03	
$\Delta E^{QM} = 6.4\times10^3\ g(T)\ 2\sigma_z$	4	380	1200	GeV
$\Delta E^{QM}/\Delta E^{clas}$	.94	.35	.40	
$\Delta E/E$	.4	8	23	%

Table 1

Beamstrahlung estimates