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**Determination of Beam Lifetime due to Beam-Beam Effect and Dynamic Aperture of a Circular Collider**

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Beam lifetime in a circular collider is limited by many physical processes, such beam-beam effect, dynamic aperture induced by static nonlinear elements in the lattice, and othe collective effects, such as Toucheck effect. In this note we consider only beam-beam effect and dynamic aperture from lattice.

To answer the question of a given circular collider, such as CEPC, the lattice dynamic aperture should be as large as to at least which value in order to have required beam lifetime with beam-beam each its limit, we could follow the followling steps:

1. Firstly we should know the required beam-beam limited lifetime (at the design luminosity) value for a given collider. In terms of CEPC, if Tau\_bb=60minutes, for Tau\_y=14ms, from the following equation (Eq. 37 in ref. 1)



We know that A\_bb/sigma~4.

1. We assume that the dynamic aperture limited from nonlinear compnents is A\_x,y for a given energy spread (see Fig. 1), then the total dynamic aperture combing the two effects is given below:



1. The beam lifetime for a given energy spread due to beam-beam effect and nonlinear lattice effect could be estimation by using eqs (28 and 37 in ref. 1) with A\_dyna in Eq. 37 replaced by A\_total (see Fig. 2)
2. Calculate the beam-beam lifetime vs energy spread by using the particle density distribution function shown in Fig. 3.
3. Calculate the average beam lifetime by averaging over the whole dP/P.
4. Compare the beam lifetime of w/o lattice DA, if the difference is less than 10%, say, we could say that the DA from nonlinear lattice optimization is acceptable.

***Reference:***

1 ) J. Gao, “Ananlytical estimation of the beam-beam interaction limited dynamic aperture and lifetimes in e+e- circular colliders”, Nucl. Instr. and Methods A463 (2001) 56-61.

dP/P

Alattice

Fig.1: A\_lattice vs dp/P

Fig. 2: Tau\_total vs dP/P

Tau total

dP/P

dP/P

Particle density

Fig. 3: Particle density vs dP/P

Fig. 2: Tau\_total vs dP/P