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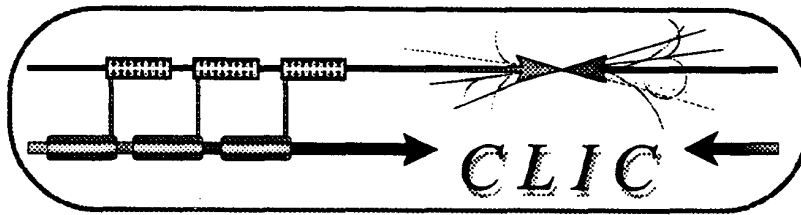
Overview of the Program IRCLIC

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Abstract

A short guide for using the program IRCLIC which calculates the beam envelope disrupted by collisions of bunch trains at a small crossing angle. The effects of parasitic crossing interactions are also included.

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1 General

The program *IRCLIC* is written for the specific purpose of studying the effects of a small crossing angle of the beam trajectories on the emittance increase of a bunch when two trains of bunches (up to 4 bunches in each of them) collide at the *Interaction Region* of CLIC. Two effects contribute to this phenomenon and are included in the program:

(a) *Disruption* of a bunch at the *Interaction Point* due to its electromagnetic interaction with an oncoming bunch, and

(b) *Kicks* which a bunch in a train experiences at the parasitic crossings from the oncoming train of bunches.

In addition, the quadrupole strengths for the outgoing bunches can be rescaled by a factor $(1 + \Delta E/E)$ if one wants to include the effect of the change of energy due to collisions of the bunches.

There is also a companion program *IRCLICAX* which is similar to the program *IRCLIC* and differs only in the geometry of the last quadrupole doublets. Namely, in the program *IRCLIC* the quadrupole axes are assumed to cross at an angle *phix*, while in the program *IRCLICAX* the quadrupole axes are assumed to coincide. Note that the beam trajectories cross with the angle *phix* in both programs. Consequently, in the geometry assumed for *IRCLIC* the incoming beams are situated on the axes of the quadrupoles of the last doublets, which diminishes the effect of the synchrotron radiation on the beam emittance at the collision point.[1]

There is one input file *irclic.inp*, and the program creates two output files *irclicon.res* and *irclicon.top* (for the version with disruption and kicks, or respectively, *irclicof.res* and (*irclicof.top* for the version without disruption and kicks).The first one contains intermediate results and serves mainly as a control for the correctness of the calculations. The second one is the input for the plotting routine *TOPDRAW* which presents the results of calculations in a graphic form.

The geometry of the IR is assumed to be longitudinally symmetric with respect to the plane of the IP $z = 0$.

The calculation starts with defining the input coordinates and angles of the incoming beams at a point $z = -l_{in}$, assuming that the coordinates and angles at the IP is given by: $x_{IP} = 0, x'_{ip} = phix/2, y_{IP} = 0, y'_{ip} = 0$. The distance l_{in} (called *dll* in the program) should be taken beyond the last doublet (counting from the IP), otherwise it is being arbitrary.

The program tracks the trajectory and the beam ellipses using 5 by 5 matrices similar to those used in the program *TRANSPORT*. Hence, it can handle the coupling between the horizontal and the vertical planes as well as crossing in both planes.

At the IP, the horizontal beam ellipse is assumed to be increased by disruptionaccording to formula

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$$\epsilon_x^{disr} = \sqrt{\sigma_x^2 \left(\sigma_{x'}^2 + (\Theta_x^{disr})^2 \right)} \; , \tag{1}$$

where the maximum disruption angle is given by:[2]

$$\Theta_x^{disr} = 0.765 D_x \frac{\sigma_x}{\sigma_z} \; . \tag{2}$$

Here the quantity D_x is the horizontal disruption parameter. See Table 1 for the present CLIC parameters.

The horizontal kicks at each parasitic collision with the oncoming bunches are included to change the bunch trajectory by the following formula:

$$\Delta \theta_x = -\frac{2N r_e}{\gamma \Delta x} \; , \tag{3}$$

where N is the number of electrons per bunch, $r_e \equiv e^2/4\pi \epsilon_0 m c^2$ the electron classical radius, γ is its Lorentz factor, and Δx the horizontal distance between bunch centers at the place of a parasitic collision. Each bunch in a train is marked by one of the letters A (the head bunch in a train), B, C and D (the caboose). The bookkeeping of the collision sequence for each bunch is performed in subroutines STA, STB, STC and STC for the bunch A, B, C, and D, respectively. At present, the maximum number of bunches in a train is 4.

2 Input

Table 1 gives an example of the input parameters for the program *IRCLIC*. The input consists of the title *CLIC512/20* and two namelists. The namelist *BEAM* contains information on the parameters of the beam and flags for a desired options. The namelist *DBLT* contains information on the parameters of the last doublet.

References

[1] K. Oide, Phys. Rev. Letters 61 (1988) p.1713

[2] P. Chen, SLAC PUB-4822 (Dec.1988) and SLAC PUB-4823 (Jan.1989)

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Table 1. Input Parameters

CLIC512/20	Title
&BEAM	the Namelist name
bpop=8.0d09	number of particles/bunch
epsx=6.0d-12	horizontal emittance of incoming beam (m)
epsy=3.0d-13	vertical emittance of incoming beam (m)
btxst=1.0d-02	horizontal beta-function at the IP (m)
btyst=1.8d-04	vertical beta-function at the IP (m)
sgz=0.2d-03	longitudinal rms size of a bunch (m)
gam=0.489d06	the Lorentz factor of an incoming particle
degm=-6.00d-02	relative energy change of the outgoing particle
dsrx=0.286d0	horizontal disruption parameter
nbunch=4	number of bunches in a train (maximum)
nrang=5	matrix size (fixed at 5 for now)
ikick=1	flag for inclusion parasitic kicks
	(ikick=0 means no kicks are included)
ikinck=1	flag for inclusion of disruption
	(ikinck=0 means disruption is not included)
nsig=1	number of sigmas (not used at present)
&END	End of the Namelist
&DBLT	the Namelist name
x0=0.0d0	horizontal position of the trajectory at the IP (m)
phix=0.52d-03	total horizontal crossing angle (rad)
y0=0.0d0	vertical position of the trajectory at the IP (m)
phiy=0.00d-03	total vertical crossing angle (rad)
fsd=0.280d0	the strength of the last quad $[m^{-2}]$
	(defocusing in the horizontal plane)
fsf=0.168d0	strength of the per-ultimate quad $[m^{-2}]$
	(focusing in the horizontal plane)
dqd=2.745d0	length of the last quad (m)
dqf=2.119d0	length of the perultimate quad (m)
appd=12.0d-03	diameter of the bore of the last quad (m)
appf=20.0d-03	diameter of the bore of the per-ultimate quad (m)
dsd=0.35d0	distance between quads of the doublet (m)
dfq=1.25d0	distance from the face of the first quad to the IP (m)
dbc=0.20d0	distance between bunches in a train (m)
dll=90.00d0	distance to the last point of calculations (m)
&end	End of the Namelist