Impedances in FEL Chicane Region

CEBAF-TN-96-041
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August 8, 1996

Vacuum chambers of optical chicane are constructed with pieces of 2 inch round pipe and 2 inch × 4 inch rectangular beam pipe with tapered transitions at junctions. There are numerous openings of round or rectangular shape on the side wall of chambers for the use of beam diagonistics equipments. Following chamber components and beam diagonistic elements in the region are to be considered in impedance calculations. Even

Component	Quantity
Step(tapered)	4
Bellows	7
Port	8
Flange	22
OTR	2
BPM	2

though bunch length varies between 0.3 mm and 0.4 mm in the chicane region, our estimate of impedances reported in this note is for the bunch length of 0.3 mm for simplicity.

1) Step

Steps found in the region are tapered transitions between 1.88"(I.D.) round pipe and 1.88"×3.74"(inner dimension) rectangular beam pipe with a typical extension of a tapering about 20 cm. Runs with 3-D wakefield code T3, and an extrapolation of results with ABCI for the short bunch length of 0.3mm (not possible to handle with T3 due to the limiation in memory space) produce a following estimate of impedances for a pair of steps (one up and one down):

Bunch Length(mm)	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
0.3	4.8	6.0

2) Bellows

Four Bellows located upstream of wiggler are shielded. Precise drawing of bellows configuration is not available at this time along with a shielded bellows design. Therefore we neglect impedances of a shielded bellows at this time and estimate impedances of an unshielded bellows assumming a generic design. For a 4" long bellows (this length may get changed) we find

Bunch Length(mm)	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
0.3	8.0	11.6

3) Port

A 2.0" diameter hole on the narrow side of previously described rectangular vacuum chamber is expected to contribute a negligible amount of impedances:

Bunch Length(mm)	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
0.3	0.001	0.0001

4) Flange

Two kinds of flanges (8 pairs of 3.375" flange and 14 pairs of 4.625" flanges) are used in the region with both having a 4.32 mm gap. 4.625" flange pairs are used in conjunction with either 2.5" or 3.0" pipes and in this region we assume that they are to be installed on a 2.5" pipe.

Flange Size(inch)	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
3.375	0.8	1.2
4.625	0.65	0.6

5) OTR

An OTR in this region consists of an inner piece of 2.0" pipe with 20 slots (1 mm wide and 36 mm long) and two outer pieces with 32 slots (1 mm wide and 62 mm long) in each. In addition there exists a shallow transition of 2 mm high between the pipe and OTR viewer.

Bunch Length(mm)	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
0.3	2.1	4.0

6) BPM

Beam sees 4 long slots and a narrow gap in the beam pipe while traveling through a stripline BPM designed for IR-FEL.

A smooth 2.0" beampipe is interupted by 4 long rectangular slots of

width = 8 mm

length = 150 mm

and a narrow gap by a BPM.

For 4 slots, taking into account of effective surface filling by the slots, we estimate

Bunch Length(mm)	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
0.3	1.2	1.7

For the impedances of a very narrow gap in the beampipe, we find for two different gap widths presently being considered

Gap	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
0.1 mm(0.004")	0.063	0.105
1.0 mm(0.040")	0.34	0.52

In counting of total impedances we assume that 1.0 mm gap design of BPM will be adopted.

In summary, we expect total impedances in the optical chicane region as follows (excluding wiggler chamber):

Bunch Length(mm)	$k_{\parallel}$(V/pC)	$k_{\perp}$(V/pC/m)
0.3	56.5	77.5

Finally we note that a change of rectangular vacuum chamber dimension from 2 inch $\times$ 6 inch to 2 inch $\times$ 4 inch had a negligible impact on the impedances of chicane region.