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Smaller Bump Amplitudes in Even Pits for Trains with Only Two Bunches

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Abstract

The arguments leading to the choice of the amplitudes of the electrostatic separator bumps which separate the two beams at the parasitic collision points are reviewed for the specific case of trains with only two bunches a and c. In the even pits, the separation is largest at the collision points where these two bunches meet, and therefore it is possible to reduce the bump amplitude in the even pits to about 50% of the earlier design value. At the same time, a few calculations done earlier for Version 3 of the LP configuration are repeated for Version 6.

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1 Introduction

In this note, a proposal is discussed to reduce the amplitude of the electrostatic separator bumps to 50% of their nominal values when LEP is operated with only the two bunches a and c in each train. At the same time, computations which were done for Version 3 of the LP configuration are repeated for Version 6.

2 Smaller Bump Amplitudes in Even Pits

2.1 Arguments for Choosing Bump Amplitudes

For trains with only two bunches, a and c, it is possible to reconsider the amplitudes of the bunch train bumps. The "design" amplitudes in odd and even pits were arrived at for trains with four bunches. The criteria for choosing a relatively large amplitude are due to the beam-beam kicks y', the vertical crossing angle, and the beam-beam tune shifts ξ. They are relatively soft. The criteria for the offsets y and the vertical dispersion D_y are harder, since they are related to the luminosity drop caused by the offsets and by the enlarged vertical beam size due to the dispersion D_y. The beam-beam kicks y' at the parasitic collision points and the offsets y at the even pits are related. It is quite possible that we arrived at the bump amplitudes chosen by making sure that the hard criteria were met, and noticing that the beam-beam tune shifts were small.

2.2 Results of Perturbation Theory

Tabs. 1, 2, 3 and 4 show the vertical offsets y and beam-beam kicks y', and the horizontal and vertical beam-beam tune shifts, ξ_x and ξ_y, respectively, for the nominal amplitudes of the electrostatic bumps at all seven collision points in the neighbourhood of the pits for trains with up to four bunches with a bunch spacing $s = 87\lambda_{\mathrm{RF}}$. I label the collision points from 1 to 7, starting to the left of the pits. The head-on collisions in the even pits occur at the fourth collision point.

Table 1: Vertical offsets y in mm at the collision points CP near the pits for a bunch current $I = 0.3$ mA at 45.6 GeV for positrons in the pmpppmpp case, using the data file `jun01b`

CP	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8
1	7.3949	-3.2419	-9.2525	2.4564	7.1688	-3.2441	-9.2561	2.5305
2	-7.1994	-10.4194	9.0318	6.8054	-6.1018	-10.4435	9.0324	5.9429
3	-5.5729	-3.4768	6.9767	3.5228	-5.2627	-3.5235	6.9789	2.7788
4	-7.2025	.0001	8.9962	.0002	-7.1970	-.0001	8.9996	.0001
5	-5.5849	-3.4756	6.9664	3.5191	-5.2747	-3.5218	6.9662	2.7819
6	-7.2259	-10.4420	9.0088	6.7870	-6.1285	-10.4695	9.0039	5.9263
7	7.4078	-3.2563	-9.2414	2.4333	7.1818	-3.2596	-9.2424	2.5057

Tab. 1 shows that the vertical offsets y at the first, third, fifth and secenth collision points near the even pits are small, while those at the second and sixth collision points near

Table 4: Vertical beam-beam tune shifts ξ_y in units of 10^{-3} at the collision points CP near the pits for a bunch current $I = 0.3$ mA at 45.6 GeV, using the data file jun01b

CP	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8
1	-.1458	-.7631	-.0928	-2.8924	-.1550	-.7746	-.0933	-2.7582
2	-.4592	-.2021	-.2922	-.4124	-.6400	-.2069	-.2910	-.2891
3	-.1570	-.1345	-.1000	-.2073	-.1761	-.1212	-.1002	-.2693
4	-.1204	.0000	-.0772	.0000	-.1205	.0000	-.0772	.0000
5	-.1563	-.1345	-.1006	-.2085	-.1754	-.1218	-.1002	-.2693
6	-.4560	-.2017	-.2927	-.4163	-.6341	-.2046	-.2939	-.2898
7	-.1452	-.7551	-.0935	-2.9390	-.1546	-.7710	-.0930	-2.8175

Table 5: Vertical orbit offsets y in μm in the pits due to separated beam-beam collisions for $I = 0.3$ mA at $E = 45.6$ GeV for the k-th bunch in bunch trains consisting of four bunches in the pmpppmpp case, using the data file jun01b

k	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8
1	78.2735	.6524	-95.7184	1.6727	102.4023	.0135	-80.1948	1.0591
2	37.9966	1.3249	-65.0783	1.0117	47.1640	1.2811	-63.0886	-.1686
3	13.6438	-.2904	-34.5237	2.7270	12.8513	-.2542	-33.5418	1.2151
4	-7.3165	-3.1454	25.8038	4.9779	-22.7113	-2.5508	11.8874	3.9620
mx	78.2735	1.3249	25.8038	4.9779	102.4023	1.2811	11.8874	3.9620
mn	-7.3165	-3.1454	-95.7184	1.0117	-22.7113	-2.5508	-80.1948	-.1686
av	30.6493	-.3646	-42.3792	2.5973	34.9266	-.3776	-41.2345	1.5169
df	85.5900	4.4703	121.5222	3.9662	125.1135	3.8319	92.0822	4.1306

Table 6: Vertical orbit slopes in μr in the pits due to separated beam-beam collisions for $I = 0.3$ mA at $E = 45.6$ GeV for the k-th bunch in bunch trains consisting of four bunches in the pmpppmpp case, using the data file jun01b

k	IP1	IP2	IP3	IP4	IP5	IP6	IP7	IP8
1	2.9922	-64.3973	2.2738	-57.6695	2.7584	-61.8040	2.3379	-60.7341
2	.5558	3.9470	-.7970	4.4558	.2073	9.6285	-.9448	2.9756
3	1.2287	7.8895	-.5733	-21.3718	.9240	14.4241	-.7835	-24.2344
4	-2.8942	82.3222	-2.0948	34.4664	-3.0060	85.2582	-2.2759	33.5538
mx	2.9922	82.3222	2.2738	34.4664	2.7584	85.2582	2.3379	33.5538
mn	-2.8942	-64.3973	-2.0948	-57.6695	-3.0060	-61.8040	-2.2759	-60.7341
av	.4706	7.4404	-.2978	-10.0298	.2209	11.8767	-.4166	-12.1098
df	5.8865	146.7195	4.3687	92.1359	5.7644	147.0622	4.6138	94.2880

Pits 4 and 8. The tune splits are small in all these cases.

I conclude from the discussion in this Chapter that reducing the bump amplitudes in the even pits looks very interesting.

Table 7: y/μm and y'/μrad for e^+ bunches a and c of 4 trains with $k = 2$ bunches in the even pits of the L05P46 configuration with 8 bumps +--++--+ at 45.6 GeV with $I = 0.3$ mA, using files `jun01b`, `may30e`, `may30d`, `may30b`, `may27c`.

	IP2		IP4		IP6		IP8	
	y	y'	y	y'	y	y'	y	y'
Nominal Bumps in all Pits								
a	.421	4.442	−.066	−9.386	.058	5.360	−.241	−2.993
c	−1.145	.129	1.900	30.164	−1.321	−5.106	1.392	30.074
6 mm in Odd Pits, 100% in Even Pits								
a	.687	13.496	−.344	−.221	.326	16.292	−.495	7.835
c	−1.317	−11.183	2.262	22.399	−1.517	−17.247	1.722	21.859
6 mm in Odd Pits, 90% in Even Pits								
a	.633	14.672	−.277	−.097	.271	17.338	−.436	7.950
c	−1.381	−13.859	2.344	22.016	−1.536	−20.181	1.791	20.899
6 mm in Odd Pits, 80% in Even Pits								
a	.569	16.294	−.191	.176	.198	18.778	−.363	8.278
c	−1.459	−17.027	2.450	21.668	−1.562	−23.672	1.877	19.898
100% in Odd, 50% in Even Pits								
a	−.005	17.416	.587	−6.506	−.474	16.449	.293	.197
c	−1.682	−20.575	2.671	29.342	−1.543	−28.066	1.990	25.293

Table 8: y/μm and y'/μrad for e^+ bunches a and c of 4 trains with $k = 2$ bunches in the even pits of the L05P46 configuration with 8 bumps +--++--+ at 45.6 GeV with $I = 0.3$ mA, using files `may30d`, `may30f`, `may30g`.

	IP2		IP4		IP6		IP8	
	y	y'	y	y'	y	y'	y	y'
6 mm in Odd Pits, 90% in Even Pits								
a	.633	14.672	−.277	−.097	.271	17.338	−.436	7.950
c	−1.381	−13.859	2.344	22.016	−1.536	−20.181	1.791	20.899
6 mm in Odd Pits, 80% in P2+P6, 100% in P4+P8								
a	.537	5.899	−.364	−9.302	.186	7.936	−.524	−1.894
c	−1.540	−4.466	2.176	32.060	−1.715	−9.321	1.660	32.324
6 mm in Odd Pits, 100% in P2+P6, 80% in P4+P8								
a	.719	23.891	−.170	9.238	.337	27.130	−.334	18.005
c	−1.237	−23.760	2.537	12.014	−1.364	−31.596	1.940	9.433

Table 11: Vertical and horizontal chromaticities, Q'_y and Q'_x, and vertical and horizontal tunes, Q_y and Q_x, for various bunches in 4 trains with $k = 2$ bunches in the L05P46 configuration with bump directions +--++--+ at 45.6 GeV with $I = 0.3$ mA and small vertical offsets in the even pits, using files jun01b, may30e, may30d, may30b, may27c

	Q'_y	Q'_x	Q_y	Q_x
Nominal Bumps in all Pits				
a	.045023	−.157025	76.2572	90.3865
c	.292072	−.144301	76.2528	90.3863
6 mm in Odd Pits, 100% in Even Pits				
a	−.196155	−.158500	76.2551	90.3871
c	.453565	−.134218	76.2491	90.3868
6 mm in Odd Pits, 90% in Even Pits				
a	−.180320	−.156461	76.2549	90.3872
c	.336384	−.135548	76.2484	90.3869
6 mm in Odd, 80% in Even Pits				
a	−.150917	−.153318	76.2547	90.3874
c	.228834	−.135216	76.2475	90.3871
100% in Odd, 50% in Even Pits				
a	.393836	−.129857	76.2535	90.3881
c	.021940	−.109766	76.2456	90.3877

Table 12: Vertical and horizontal chromaticities, Q'_y and Q'_x, and vertical and horizontal tunes, Q_y and Q_x, for various bunches in 4 trains with $k = 2$ bunches in the L05P46 configuration with bump directions +--++--+ at 45.6 GeV with $I = 0.3$ mA and small vertical offsets in the even pits, using files may30d, may30f, may30g

	Q'_y	Q'_x	Q_y	Q_x
6 mm in Odd Pits, 90% in Even Pits				
a	−.180320	−.156461	76.2549	90.3872
c	.336384	−.135548	76.2484	90.3869
6 mm in Odd Pits, 80% in P2+P6, 100% in P4+P8				
a	.039693	−.147763	76.2549	90.3872
c	.458983	−.130602	76.2486	90.3869
6 mm in Odd Pits, 100% in P2+P6, 80% in P4+P8				
a	−.514169	−.169098	76.2549	90.3873
c	.141481	−.142040	76.2479	90.3870