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Modified Odd Pits for LEP with Short Bunch Trains

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1 Introduction

In order to separate the short bunch trains [1] of length $l \approx 100$ m vertically near the odd pits a modification of the lattice is needed there. The vertical separator bump near Pit 1 in the standard configuration, based on the sequence lep944.seq and the excitation file k21p20v1.lep in the directory /users/slath/machines/lep94/KPv1 is shown in Fig. 1. The vertical amplitude y drops rapidly beyond the first quadrupole doublet and is halved at about 35 m from the IP. The orbit functions $\sqrt{\beta_x}$ and $\sqrt{\beta_y}$ for this configuration are shown in Fig. 3 for later comparison with the modified lattice. The pit is at the left edge of all figures showing the neighbourhood of a pit.

2 Modified Lattice

I moved all nine elements from ES.QL1A to PU.QL2B on either side of all four odd pits a distance of $s = 25$ m further away from the IP. This is possible in all odd pits without causing overlap of elements. Increasing the distance to $s = 30$ m is not possible near Pit 1. I re-matched the HIBL insertions. In the first step, I try to match to the standard parameters at an odd IP, varying the five quadrupoles in the HIBL insertion, imposing an upper limit $\beta < 250$ m in all quadrupoles except QL1A and QL1B, and giving a weight 0.01 to the constraints on the β-functions. I observe that the constraints on the phase advances μ_x and μ_y are not satisfied, and that β_x at the IP wants to increase because of the limits imposed, as expected. In a second step, I match to the values of β_x and β_y at the IP found in the first step, without constraints on the phase advances through the HIBL. A comparison of the quadrupole excitations is shown in Tab. 1. All excitations are within the quadrupole ratings at 45.6 GeV.

Table 1: Comparison of the quadrupole excitations K in the odd pits in m^{-2}

Configuration	KQL6	KQL5	KQL4	KQL2	KQL1
Standard	-.0233096	.0261185	-.0157254	.0275687	-.0320102
Modified	-.0351757	.0370754	-.0193407	.0299776	-.0209239

A comparison of orbit parameters in the standard and modified configurations is shown in Tab. 2. The horizontal β_x at an odd IP increases by almost a factor of three, while the vertical β_y

Figs. 9 and 10 show the vertical separation $2|y|$ and the horizontal beam radius σ_x in the standard and modified configuration, respectively, near Pit 3. The assumed horizontal emittance is $\epsilon_x = 30$ nm. In the standard configuration, the separation $2|y|$ is comparable to σ_x beyond 30 m from the IP. this is inadequate. In the modified configuration, the separation $2|y|$ is much larger than σ_x up to about 50 m from the IP.

Figs. 11 and 12 show the beam-beam tune shifts ξ_x and ξ_y in the standard and modified configuration, respectively, near Pit 3. In both configurations, $|\xi_x|$ and $|\xi_y|$ remain below 0.001 up to about 55 m from the IP

Figs. 13 and 14 show the beam-beam kicks y' and the normalised beam-beam kicks $n'_y = y'/\sigma'_y$ in the standard and modified configuration, respectively, near Pit 3. In the standard configuration, y' starts rising beyond about 30 m from the IP, while in the modified configuration this happens beyond about 50 m from the IP. The normalised kick n'_y is a indication whether or not the two beams might be vertically separated at the even IP's: If $n'_y \ll 1$, the separation between the two beams is much smaller than σ_y, in the opposite case $n'_y \leq 1$, a separation of about σ_y is only prevented by symmetry [2].

The parasitic collisions in Pits 5 and 7 have the same effects as in Pit 3. In Pit 1, they are slightly different because the vertical separators ES.QL4A are in a slightly different position.

4 Conclusions

I propose to modify the odd pits in LEP in order to separate the two beams vertically over a longer distance from the IP than with the standard configuration, as required by the short bunch trains. According to the information in the LEP database it is possible to shift the elements from ES.QL1A to PU.QL2B by 25 m away from the IP without overlap with other elements. The modified configuration has the advantage that the ratio between the separation $2|y|$ and the horizontal beam radius σ_x stays high up to more than 50 m from the IP. I would appreciate if readers would let me know what is wrong with this proposal.

References

[1] E. Keil, Short Bunch Trains in LEP at the Z^0, to be published in the proceedings of the Fourth LEP Performance Workshop, Chamonix 1994.

[2] E. Keil, CERN SL/93-16 (AP) (1993).

Table 3: Voltages on ZL separators in the odd pits in MV at 20 GeV

Configuration	VZL1A.1	VZL1A.3	VZL1A.5	VZL1A.7
Standard	0.136663	0.141723	0.141725	0.141723
Modified	-0.05453	-0.03154	-0.03154	-0.03154
Configuration	VZL4A.1	VZL4A.3	VZL4A.5	VZL4A.7
Standard	0.055739	0.049061	0.049062	0.049061
Modified	0.133785	0.092853	0.092853	0.092853

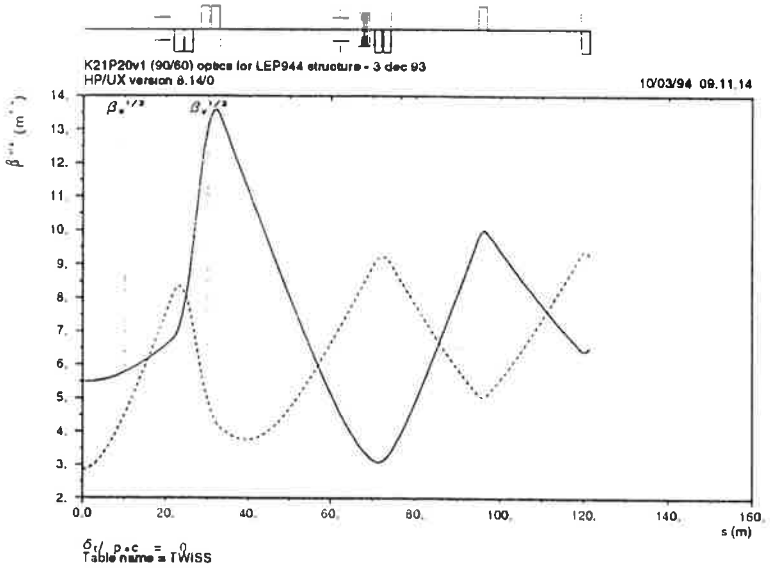

Figure 3: Orbit functions $\sqrt{\beta_x}$ and $\sqrt{\beta_y}$ near Pit 1 in the standard K21P20 configuration.

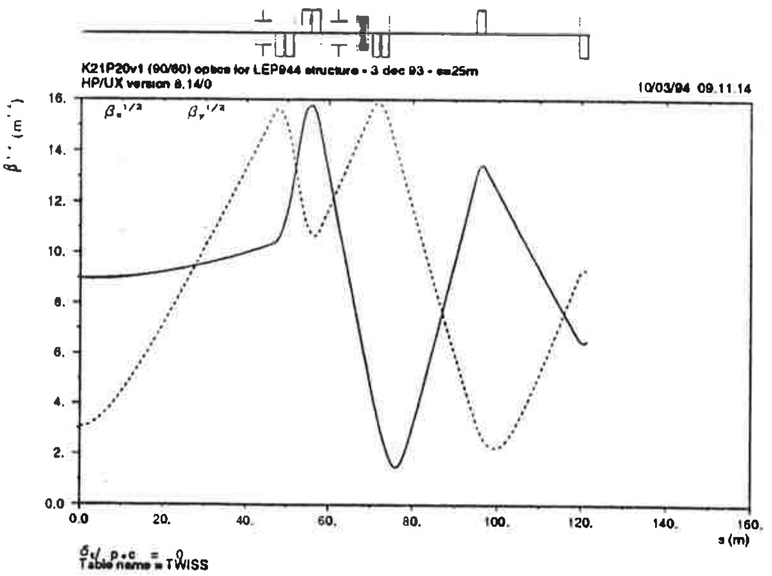

Figure 4: Orbit functions $\sqrt{\beta_x}$ and $\sqrt{\beta_y}$ near Pit 1 in the modified K21P20 configuration.

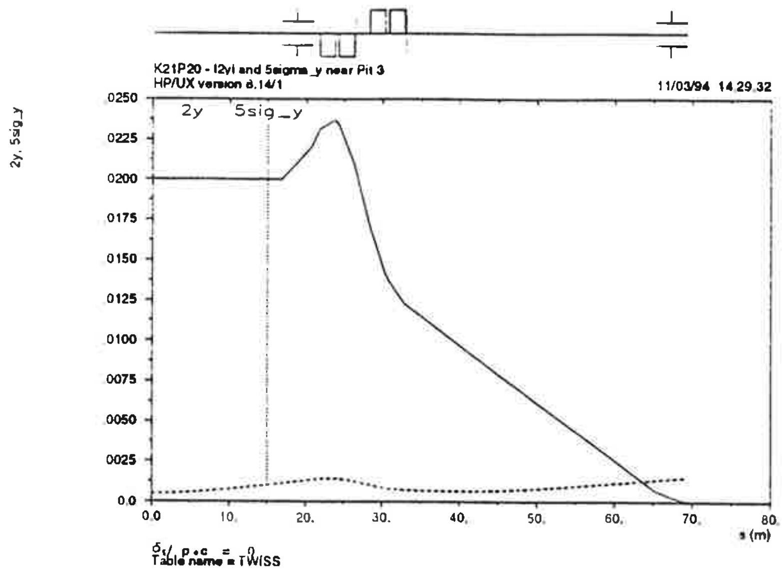

Figure 7: Vertical orbit separation $2|y|$ and beam size $5\sigma_y$ near Pit 3 in the standard K21P20 configuration. The electrostatic separators ZL are excited.

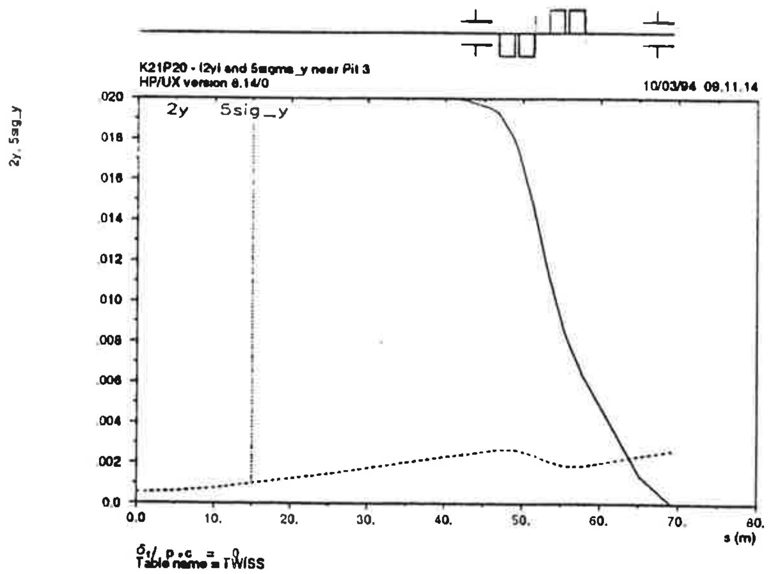

Figure 8: Vertical orbit separation $2|y|$ and beam size $5\sigma_y$ near Pit 3 in the modified K21P20 configuration. The electrostatic separators ZL are excited.

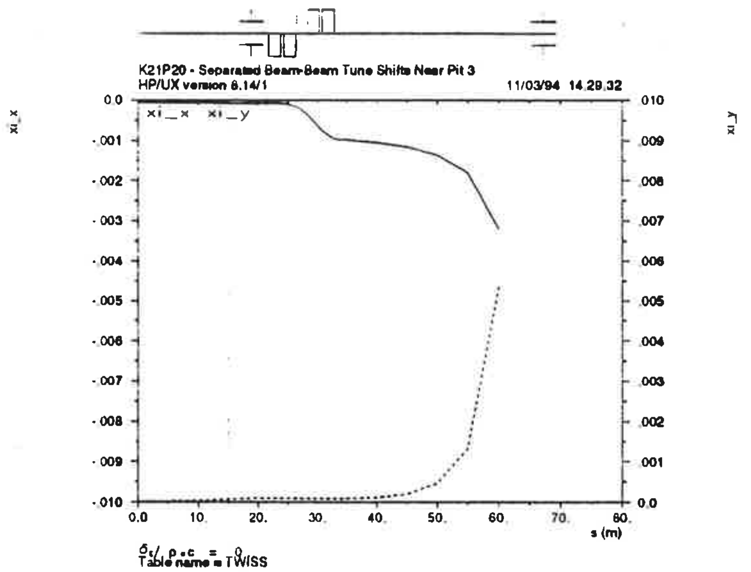

Figure 11: Beam-beam tune shifts ξ_x and ξ_y near Pit 3 in the standard K21P20 configuration. The electrostatic separators ZL are excited.

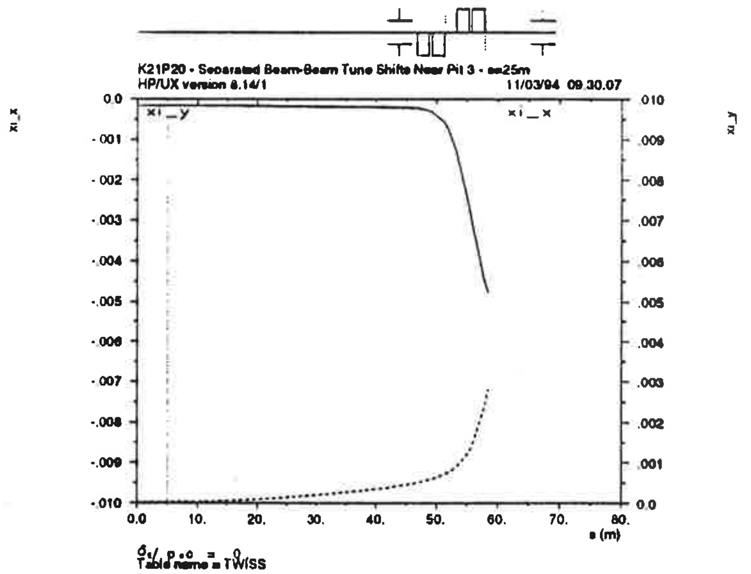

Figure 12: Beam-beam tune shifts ξ_x and ξ_y near Pit 3 in the modified K21P20 configuration. The electrostatic separators ZL are excited.