SIMULATION OF THE PACMAN EFFECT ON THE SSC

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Here some preliminary results are given for the Pacman effect simulation including long-range beam-beam interactions. The importance of the long range interactions follows from the fact that the tune shift due to long-range interactions for the SSC's about two times bigger, than that due to head-on collisions. Additional to that the long-range interactions cause the orbit distortion and new set of resonances, which do not exist for head-on collisions.

The results were obtained under the following assumptions:

1. Weak-strong interaction.
2. The lattice includes N-groups of clustered interaction regions (IR's). It was assumed that N=2 and there are 2 IR's in each group. The two groups are sited symmetrically along the ring. All IR's are the same. We used Al Garren's IR design: The distance to the low-beta triplets is ± 20 m, the distance to the splitting magnets ± 70 m. The beta function in the middle point of the IR is $\beta_x^* = \beta_y^* = 1$ m. The bunch spacing is 5 m, and the normalized emittance $\epsilon_N = \gamma\sigma^2/\beta^* = 1.E\ -0.6$ m. The Twiss parameters of the IR were calculated with the program Mad and approximated by spline functions at arbitrary location along the IR. We assumed that two beams crossing alternately in the vertical plane. Crossing angle is 50 μrad.
3. At this time the effect of synchrotron modulation of the momentum was not considered. It will be the subject of the following report.

4. The motion between IR's is described by a linear transformation.

5. The motion in an IR is described taking into account long-range interactions. The motion between interactions is given by a linear matrix with a phase advance, which depends on the bunch spacing and location of the interaction along IR. The interaction is described as a kick for round bunches. The rms size of the bunches at the interaction is taken as an average rms size in x, y planes. The linear tune shift was taken as $\xi = 1.826$ E-3. The kick was defined so that the kick is zero for the particle with zero betatron amplitudes. It means, that the orbit distortion due to beam-beam interaction is compensated in some way in the lattice.

6. For estimation of the Pacman effect the tune shift for a regular bunch and that for a bunch which misses the beam-beam interaction at two symmetric IR's might be compared. The bunch which encounter the gap experiences only the force, which is added to compensate the orbit distortion for the normal bunch and which independent on betatron amplitudes.

7. The main results are summarized in Table 1 (for a regular bunch). For the initial tunes Q_x^o, Q_y^o, which are defined for the beam-beam interaction turned off, the tables give the tune Q_x, Q_y vrs initial conditions (one sigma = 1.0E-05 m) and the variation of x and y at the middle point of the IR, where the particle started. To make the conclusion how big is the difference in the results for a regular and "Pacman" bunches the results have to be imposed on the real net of resonances (might be, including the difference resonances).

8. Tables 3, 4 describe the effect of phase advance μ between adjacent IR's on the tune shift (T.3) and modulation of the emittance. The initial tune was chosen close to 1/3 resonance (see T.3). In the case the emittance

distortion displays a dip, if the phase advance μ is close to 3.75, as could be expected. I am grateful to A. Chao, D. Talman and S. Peggs for important and useful discussions. I am thankful to L. Schachinger for her kind assistance.

1454S

table 1

qx= 86.285004 qy= 86.264999

Y_{in} (m) \ Y_{ext} (m)	0.000001	0.000011	0.000021	0.000031	0.000041
0.000001	0.265316	0.265986	0.264667	0.260930	0.265337
	0.308070	0.279711	0.284420	0.288603	0.284747
0.000011	0.268357	0.268464	0.267059	0.262951	0.263039
	0.306038	0.279721	0.283193	0.285969	0.281729
0.000021	0.272236	0.272041	0.271131	0.269142	0.269192
	0.303925	0.278719	0.280454	0.281263	0.278426
0.000031	0.275036	0.275044	0.275125	0.273940	0.271131
	0.322317	0.275553	0.274848	0.273703	0.271004
0.000041	0.277173	0.275074	0.273108	0.271163	0.268704
	0.283789	0.274677	0.273419	0.271165	0.268454

qx= 86.285004 qy= 86.264999 X^*_{max}, V^*_{max}

X_{in} (m) \ Y_{in} (m)	0.000001	0.000011	0.000021	0.000031	0.000041
0.000001	0.000001	0.000001	0.000001	0.000001	0.000002
	-0.000001	-0.000001	-0.000001	-0.000001	-0.000002
0.000011	0.000011	0.000011	0.000012	0.000014	0.000019
	-0.000011	-0.000011	-0.000012	-0.000014	-0.000019
0.000021	0.000021	0.000021	0.000023	0.000028	0.000039
	-0.000021	-0.000021	-0.000024	-0.000028	-0.000039
0.000031	0.000031	0.000033	0.000036	0.000040	0.000040
	-0.000031	-0.000033	-0.000036	-0.000040	-0.000041
0.000041	0.000041	0.000041	0.000041	0.000041	0.000041
	-0.000041	-0.000041	-0.000041	-0.000042	-0.000042

qx= 86.285004 qy= 86.264999 Y^*_{max} V^*_{max}

Y_{in} (m) \ Y_{int} (m)	0.000001	0.000011	0.000021	0.000031	0.000041
0.000001	0.000001	0.000011	0.000021	0.000031	0.000041
	-0.000001	-0.000011	-0.000020	-0.000030	-0.000039
0.000011	0.000001	0.000011	0.000021	0.000031	0.000041
	-0.000001	-0.000011	-0.000021	-0.000030	-0.000040
0.000021	0.000001	0.000011	0.000021	0.000031	0.000042
	-0.000001	-0.000011	-0.000020	-0.000030	-0.000042
0.000031	0.000001	0.000011	0.000020	0.000031	0.000041
	-0.000001	-0.000011	-0.000021	-0.000031	-0.000041
0.000041	0.000004	0.000031	0.000035	0.000041	0.000050
	-0.000004	-0.000030	-0.000034	-0.000041	-0.000051

Table 2

qx^{o}= 86.285004 qy^{o}= 86.264999 average [illegible]

$X_{in}(m)$ \ $Y_{in}(m)$	0.000001	0.000011	0.000021	0.000031	0.000041
0.000001	0.276527	0.276804	0.275904	0.272634	0.270523
	0.364155	0.275092	0.276708	0.278735	0.275903
0.000011	0.278031	0.278059	0.276075	0.275197	0.273688
	0.364155	0.274787	0.275977	0.275596	0.272838
0.000021	0.279993	0.279788	0.275965	0.273816	0.270937
	0.357727	0.273905	0.276824	0.273944	0.270926
0.000031	0.281462	0.281262	0.280256	0.274608	0.272860
	0.348157	0.272952	0.274172	0.272686	0.269638
0.000041	0.282566	0.282416	0.281824	0.280285	0.278998
	0.337141	0.271951	0.272802	0.271651	0.268686

qx^{o}= 86.285004 qy^{o}= 86.264999 X^{*}_{min} Y^{*}_{max}

$X_{in}(m)$ \ $Y_{in}(m)$	0.000001	0.000011	0.000021	0.000031	0.000041
0.000001	0.000001	0.000001	0.000002	0.000002	0.000003
	-0.000001	-0.000001	-0.000002	-0.000002	-0.000003
0.000011	0.000011	0.000011	0.000011	0.000022	0.000029
	-0.000011	-0.000011	-0.000012	-0.000022	-0.000030
0.000021	0.000021	0.000021	0.000021	0.000021	0.000022
	-0.000021	-0.000021	-0.000022	-0.000022	-0.000024
0.000031	0.000031	0.000031	0.000031	0.000031	0.000031
	-0.000031	-0.000031	-0.000031	-0.000032	-0.000032
0.000041	0.000041	0.000041	0.000041	0.000041	0.000043
	-0.000041	-0.000041	-0.000041	-0.000042	-0.000043

qx^{o}= 86.285004 qy^{o}= 86.264999 Y^{*}_{max}, Y^{*}_{min}

Y_{in} \ $Y_{in}(m)$	0.000001	0.000011	0.000021	0.000031	0.000041
0.000001	0.000001	0.000011	0.000021	0.000031	0.000041
	-0.000002	-0.000011	-0.000021	-0.000030	-0.000040
0.000011	0.000001	0.000011	0.000022	0.000031	0.000042
	-0.000002	-0.000011	-0.000022	-0.000030	-0.000042
0.000021	0.000002	0.000012	0.000029	0.000034	0.000042
	-0.000002	-0.000012	-0.000028	-0.000033	-0.000042
0.000031	0.000002	0.000012	0.000026	0.000043	0.000050
	-0.000002	-0.000012	-0.000025	-0.000042	-0.000051
0.000041	0.000002	0.000013	0.000025	0.000039	0.000049
	-0.000002	-0.000013	-0.000025	-0.000039	-0.000050

Table 3

0.100000E-04	0.100000E-04	0.332094E+00	0.334205E+00		
0.10000E-04	0.10000E-04	-.20745E-04	0.21042E-04	-.30170E-04	0.15709E-04
0.100000E-04	0.100000E-04	0.335603E+00	0.329375E+00		
0.10000E-04	0.10000E-04	-.89545E-04	0.87366E-04	-.78162E-04	0.73049E-04
0.100000E-04	0.100000E-04	0.335205E+00	0.329677E+00		
0.10000E-04	0.10000E-04	-.85283E-04	0.85658E-04	-.72656E-04	0.71078E-04
0.100000E-04	0.100000E-04	0.331642E+00	0.333826E+00		
0.10000E-04	0.10000E-04	-.10989E-04	0.21216E-04	-.20027E-04	0.18466E-04
0.100000E-04	0.100000E-04	0.333232E+00	0.333420E+00		
0.10000E-04	0.10000E-04	-.50741E-05	0.98867E-05	-.82643E-05	0.14582E-04
0.100000E-04	0.100000E-04	0.333135E+00	0.333188E+00		
0.10000E-04	0.10000E-04	-.64052E-05	0.99919E-05	-.69385E-05	0.10696E-04
0.100000E-04	0.100000E-04	0.332886E+00	0.333953E+00		
0.10000E-04	0.10000E-04	-.13549E-04	0.12797E-04	-.16030E-04	0.13412E-04
0.100000E-04	0.100000E-04	0.330312E+00	0.333691E+00		
0.10000E-04	0.10000E-04	-.18337E-04	0.24038E-04	-.42550E-04	0.36824E-04
0.100000E-04	0.100000E-04	0.335456E+00	0.329419E+00		
0.10000E-04	0.10000E-04	-.94101E-04	0.90942E-04	-.81019E-04	0.76458E-04
0.100000E-04	0.100000E-04	0.332995E+00	0.332041E+00		
0.10000E-04	0.10000E-04	-.68658E-04	0.66439E-04	-.59958E-04	0.59606E-04
0.100000E-04	0.100000E-04	0.333763E+00	0.333857E+00		
0.10000E-04	0.10000E-04	-.58778E-05	0.97660E-05	-.12607E-04	0.15370E-04
0.100000E-04	0.100000E-04	0.333724E+00	0.333559E+00		
0.10000E-04	0.10000E-04	-.92498E-05	0.99385E-05	-.97562E-05	0.13860E-04

Table 4

	emittance				
0.10000E-04	0.10000E-04	0.88843E-01	0.24597E+00	0.96567E-01	0.30347E+00
0.10000E-04	0.10000E-04	0.75519E-01	0.90195E+00	0.94929E-01	0.80031E+00
0.10000E-04	0.10000E-04	0.57421E-01	0.86699E+00	0.93769E-01	0.75326E+00
0.10000E-04	0.10000E-04	0.35282E-01	0.21221E+00	0.93443E-01	0.22121E+00
0.10000E-04	0.10000E-04	0.41876E-01	0.10179E+00	0.94458E-01	0.14619E+00
0.10000E-04	0.10000E-04	0.90965E-01	0.10231E+00	0.95892E-01	0.10948E+00
0.10000E-04	0.10000E-04	0.96517E-01	0.15388E+00	0.97239E-01	0.16783E+00
0.10000E-04	0.10000E-04	0.84504E-01	0.24283E+00	0.98359E-01	0.45423E+00
0.10000E-04	0.10000E-04	0.67466E-01	0.94101E+00	0.98773E-01	0.82300E+00
0.10000E-04	0.10000E-04	0.43441E-01	0.76398E+00	0.98116E-01	0.67155E+00
0.10000E-04	0.10000E-04	0.42603E-01	0.10000E+00	0.96657E-01	0.16412E+00
0.10000E-04	0.10000E-04	0.89024E-01	0.10907E+00	0.95002E-01	0.14278E+00