SLAC-PUB-9432
August 2002

BEAM-BEAM SIMULATIONS FOR PEP-II*

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Abstract

The self-consistent beam-beam code described in [1] is used to simulate various parameter sets for PEP-II. The aim is to find better operating tunes and machine parameters such as beta functions and emittances for optimizing luminosity. At the current working point, the simulated luminosity agrees with the measured luminosity within 10 %. New working points in the LER were studied in simulations and measurements. Comparisons between simulations and measurements are shown in this paper.

1 DESCRIPTION OF SIMULATION CODE

The simulations are done using the code described in [1]. It is a self-consistent strong-strong simulation.

About 10^4 macro-particles per beam are used for the simulation. The ring is simulated by a one-turn map taking into account only the tune, i.e. non-linearities like detuning with amplitude or effects from coupling are not included. The code does not include longitudinal dynamics like synchrotron oscillations or effects due to the bunch length. The damping and excitation due to synchrotron radiation are simulated.

After each turn the beam distribution and position at the collision point are calculated and used as input for the beam-beam kick.

This is repeated for several damping times to make sure that an equilibrium state is reached. In the end, luminosity, beam-sizes and beam-beam tune shifts are calculated and written to a file.

One set of parameters for PEP-II usually runs for 6 hours on a workstation or on the SLAC Solaris batch farm.

2 PEP-II PARAMETERS

The simulations are done using typical values for most machine parameters. They are listed in Tab. 1. It is worth noting, that the tunes are almost, but not exactly asymmetric, i.e. $\nu_x^{\mathrm{HER}} \approx \nu_y^{\mathrm{LER}}$ and vice versa.

The simulation uses only one bunch, however all results are scaled by a typical number of bunches to give values that are more easily compared to measurements and typical running conditions as usually only total currents and luminosities get quoted and not the single bunch numbers.

	HER	LER
tunes	.569 .639	.649 .564
β^*	.5 m .0125 m	.5 m .0125 m
emittances	48 nm 1.5 nm	24 nm 1.5 nm
damping times	5014	9740
# of bunches	692	692

Table 1: Typical parameters from the 2000 run of PEP-II as used in the simulations.

3 STANDARD CONDITIONS

Figure 1 shows the dependence of the luminosity on the current in the rings. The simulation was done using a current ratio of 2:1, i.e. the LER current is twice the HER current, which is very typical for standard running in PEP-II.

For high currents the LER vertical beam sizes blows up leading to a reduction in luminosity. Also the horizontal size in LER is increasing throughout, but it is the sudden and strong vertical blow-up that reduces the luminosity.

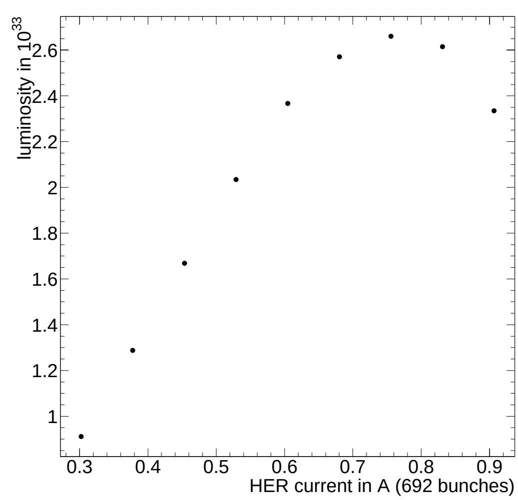

Figure 1: Luminosity as a function of HER current assuming a 2:1 current ratio.

4 NEW WORKING POINTS

The HER worked very well at its current working point but it was assumed that one could gain luminosity by finding a better spot in the tune diagram for the LER. Two working points were studied in detail during the end of the 2000 run. A working point in the vicinity of $\nu_x = 0.7$ and

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Presented at the IEEE Particle Accelerator Conference, Chicago, IL, 6/18/2001 - 6/22/2001

$\nu_y = 0.6$ and the symmetric working point, where the tunes of the two rings are equal.

4.1 $\nu_x = 0.7$ and $\nu_y = 0.6$

This tune was first tried with a single beam only to find a spot with good lifetime. The results of this measurement are shown in Fig. 2. It was decided to study the area below $\nu_x = 0.75$ in more detail, mainly the area in the plot to the right of the resonance going diagonally from top left to center bottom and below $\nu_y = 0.62$.

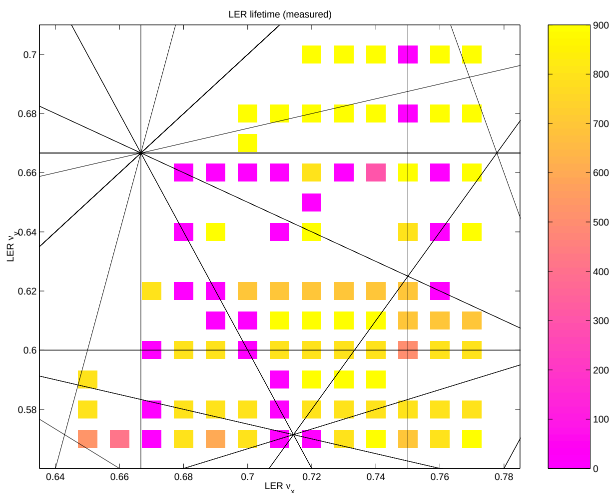

Figure 2: Measured LER single beam lifetime in minutes. Transverse resonances up to fifth order are shown.

Some simulation studies were done to find out, where in the area the highest luminosity could be expected. The results are shown in Fig. 3. As one can see, the highest luminosity should be on the points right on the resonance with an unusable short lifetime and in any case it should be smaller than the one which had been obtained with the standard working point. The significant drop in luminosity when approaching the three quarter resonance is due to the horizontal beam-size in the LER blowing up by a large factor.

The working point was tried in the 2000 run. Measured luminosities are shown in Fig. 4. If the tune was moved beyond the points shown here the lifetime dropped to values below 20 minutes making running at that point impossible. As predicted by the simulation, a very strong horizontal blow-up in the LER was observed on the synchrotron light monitor when approaching the three quarter resonance.

As the luminosity was always significantly lower than the one obtained with the standard working point and it was obvious that this could not be cured by a few days of tuning, this working point was discarded.

4.2 Symmetric Tunes

Simulation results for symmetric tunes looked very promising when compared to the standard working point

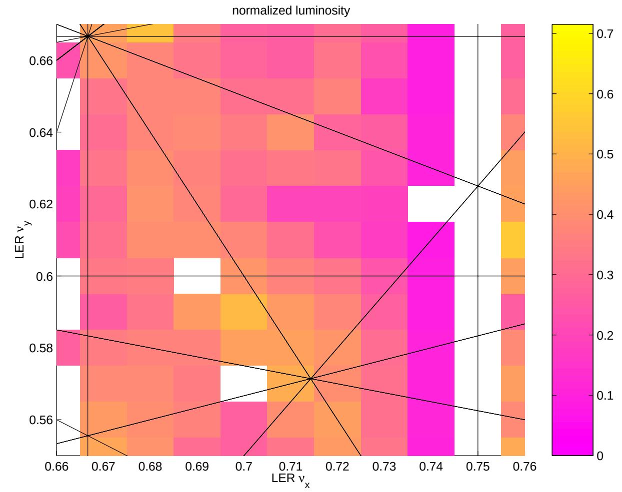

Figure 3: Simulation results for the luminosity. White indicates that too many particles are lost during the simulation.

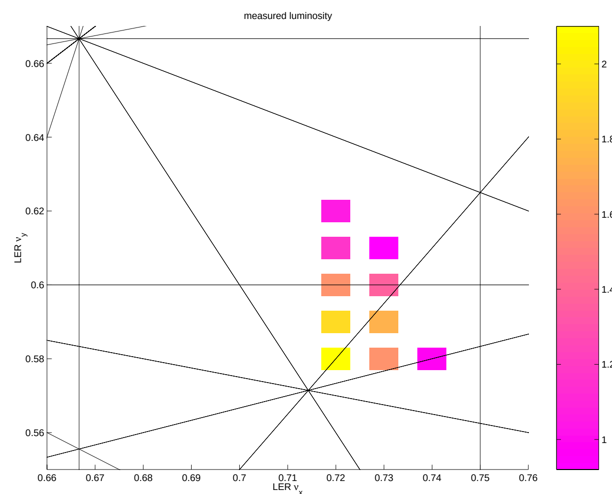

Figure 4: Measured luminosity.

as is shown in Fig. 5. The horizontal beam-size is significantly smaller in the LER for the symmetric case. Also the vertical blow-up is less strong leading to a significantly higher luminosity at high currents.

This working point was tried during the 2000 run. The obtained luminosity was very low, less than half the expected value. The tunes were moved around in the area but no better point was found. When analyzing the data it was found, that the LER has a synchrotron sideband very near that point which was probably responsible for the low luminosity by blowing up the beam. As the HER has a significantly different synchrotron tune, it does not have a side band at that point. As longitudinal dynamics are not yet included in the code, this could not have been predicted.

4.3 Tune Scan in LER

To search for other points which might be worth further study, a tune scan over a larger area was done. The results

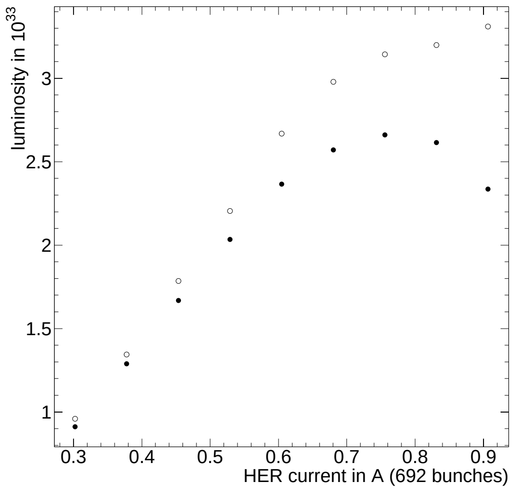

Figure 5: Simulation results comparing the symmetric case (○) to the standard working point (●) for a 2:1 current ratio.

are shown in Fig. 6. As the machine coupling is not simulated, one gets fairly high luminosities right on the coupling resonance which one should not expect to obtain in the real machine.

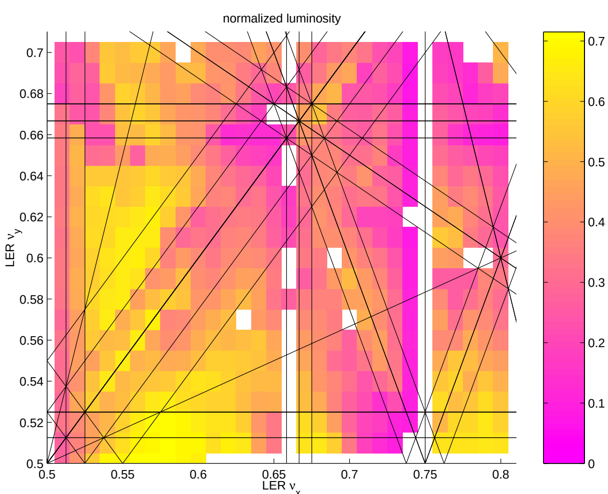

Figure 6: Simulated luminosity (normalized value) for various LER tunes. White indicates that too many particles are lost during the simulation. Resonances up to fifth order are shown including longitudinal ones.

5 CONCLUSION

The code has proven to be a useful tool to explore new sets of running parameters for PEP-II. For typical conditions it predicts the obtained luminosities well. As some things which can lower the luminosity (like longitudinal effects or coupling) are not yet implemented, it can only give an upper limit of the expected luminosity as the real luminosity could be lower due to these effects. The code is currently being expanded to include longitudinal effects [2].

Acknowledgments

I want to thank Yunhai Cai for the help with his code. Many people were helpful in the control room when the different working points were tried, especially Martin Donald and Mike Sullivan. I also want to thank the patient people in the computer center at SLAC for help in getting me started on the batch farm. Without that, I would not have been able to do scans like the one shown in Fig. 6.

6 REFERENCES

[1] Y.Cai et.al., Phys. Rev. ST Accel. Beams 4 (2001)

[2] Yunhai Cai, private communication.