The Electron Beam Orbit Sensitivity of the Photon Flux of the Photon Beam Line

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Abstract

The effects of the electron beam position as well as the electron beam orbit slop at the source point on the photon flux of the photon beam lines were studied both by the ray tracing simulation and by the experiments. The experimental result shown that 10 µm beam position change will cause more than 1% of the photon flux change which agreed with the simulation results. However, for some distorted orbit slop (0.2 mrad),10 µm beam position change can cause 8% of the photon flux change.

I. INTRODUCTION

The very high resolution photon beam line is one of the characteristics of a third generation light source. Due to the very high resolution requirement, the optical system of the photon beam line become very sensitive to its photon source position and slop, i.e. the electron beam orbit. Taiwan Light Source(TLS) of Synchrotron Radiation Research Center(SRRC), is one of the several third generation light sources in operation now. The photon flux fluctuation due to the instabilities of the electron beam position and slop is an essential issue of all of these light sources. In this paper, we presented the studies of the sensitivity of the photon flux due to electron beam position change as well as beam angular change (the orbit slop) at the source point of the photon beam line. Because the sensitivity of the vertical beam displacement is much higher than that of the horizontal beam displacement, the studies presented here are all in vertical dimension. The studies include the ray tracing simulations and experiments. The experiments were done by changing the size of the orbit local position bumps as well as local angular bumps and measuring the change of the photon flux of the photon beam line. This study is essential because it will provide the conversion fact of the instabilities between the machine people and the users e.g., photon beam line people. It will also provide information for decoupling the instability sources from machine and those from the photon beam line itself. By the end of the this year, we should reduce the electron beam instabilities such that the photon flux fluctuation is less than 0.5%. The final target of that value should be 0.1%.

II. THE EXPERIMENTS

The experiments were done by changing the size of the orbit local position bumps as well as local angular bumps and measuring the change of the photon flux of the photon beam line. The photon flux was measured by a photon electric detector which was located after the entrance slit. The sensitivity will certainly dependent upon the size of the entrance slit. In all the experiments presented here and in the simulation the slit size was set at 50 µm. The orbit bumps were created by using four correct magnets. Therefore, we can independently control the electron beam position and slop at the source point of the photon beam line. Figure 1 shows two of the typical orbit bumps in our experiments.

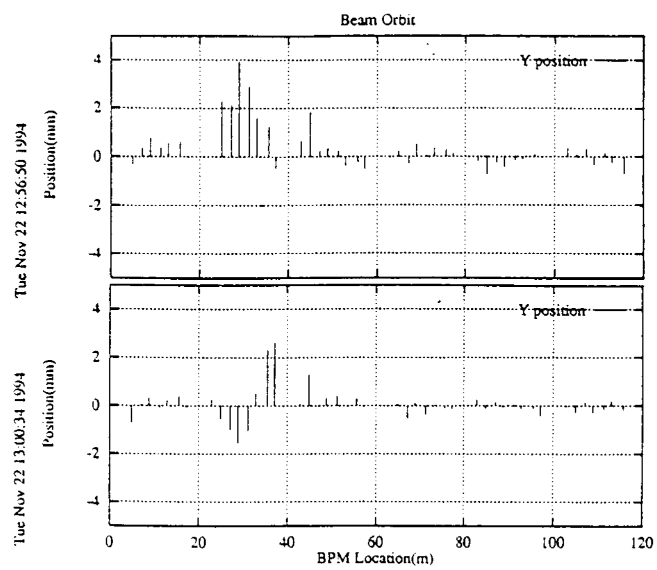

Fig. 1 The position bump and angular bump.

The electron beam position and slop at the source point of the photon beam line were calculated by read two BPMs, one up stream and one down stream of the source point. The resolution of our BPM at the time of doing the experiments was about 50 µm as shown in figure 2. For the case of position bump we moved about 50 to 100 µm in each step and for the case of the angular bump we move about 50 - 100 µrad in each step. We started with a reasonable good orbit e.g., rms. less than 300 µm. We then adjusted the vertical focusing mirror (VFM) until we got the maximum photon flux. After each step of either the position bump change or the angular bump change, we record the photon flux change. We then adjusted the VFM until we got the maximum photon flux. Then the next step of change was proceed. To gain the maximum photon flux by adjusting the VFM is a routine fine tune done by the photon beam line people.

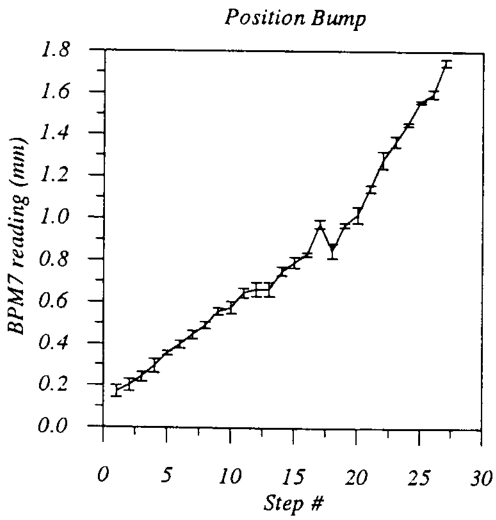

Fig. 2 The raw data of one of the BPM reading. The error bar was the standard deviation of ten measurements

In figure 3, we shown the results when only the position bump was changed. For these changes, the slop should be kept unchanged. Due to the imperfection of the bump, the slop of the beam at the source point does have some change. In the figure we also plot the slop value for each step. From the results we got, we were assured that those small change is ignoble. Therefore, from figure 3 we could conclude that 10 μm vertical beam position displacement will cause 1 to 2 % photon flux change.

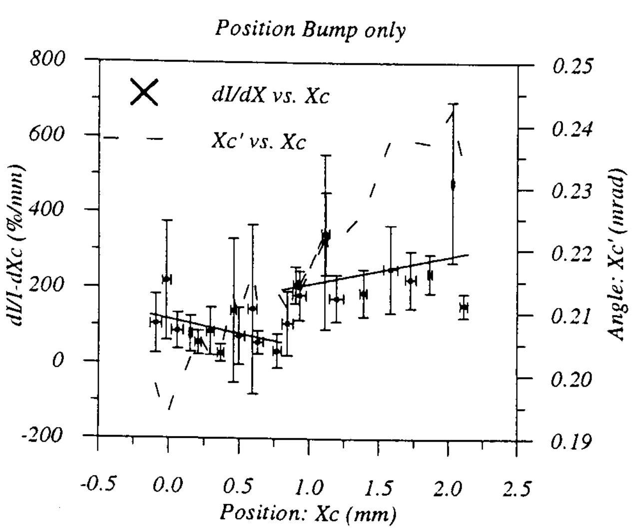

Fig. 3 The results of position bump change

In figure 4, we shown the results when only the angular bump was changed. For these changes, the position should be kept unchanged. Due to the imperfection of the bump, the position of the beam at the source point does have some change. In the figure we also plot the position value for each step. From the results we got, we were assured that those small change is ignoble, too. Therefore, from figure 4 we could conclude that 10 μrad vertical beam slop change will cause 1 to 2 % photon flux change.

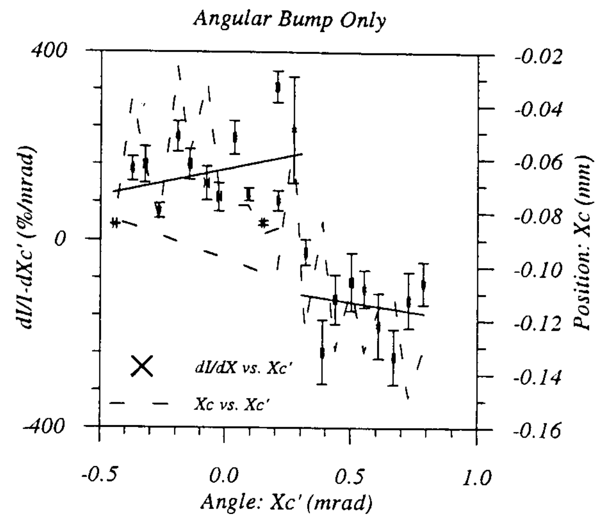

Fig. 4 The results of angular bump change

In figure 5, we shown the results when only the position bump was changed. However, in this case there was a 200 μrad angular bump on top of the position bump. Again, in the figure we also plot the slop value for each step. From figure 5 we could conclude that 10 μm vertical beam position displacement will cause 7 to 8 % photon flux change. This value is much larger than that of the figure 3. There was no extra angular bump in the latter case.

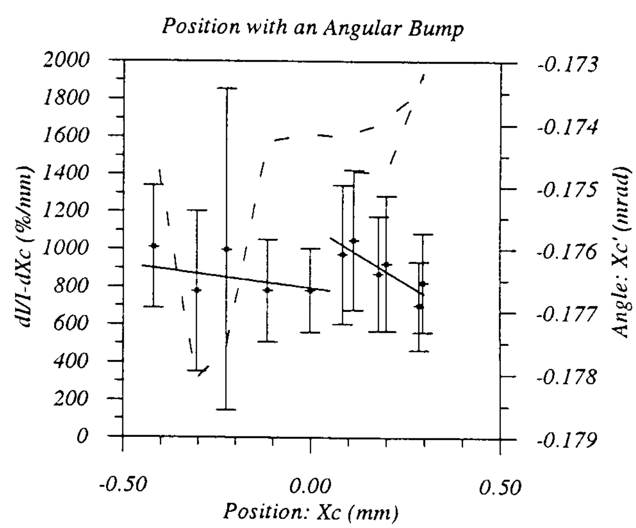

Fig. 5 The results of position bump change with an 200 mrad angular bump.

III. THE SIMULATIONS

Figure 6 is the layout of the 6m-HSGM beam line which is the photon beam line we perform the experiments. According to the optics system of this beam line, we did a ray tracing study for the case of position bump change without angular bump. The results was shown in figure 7. We had shown the results for two different electron beam size, 2σ equals to 100 μm and 50 μm. For the latter case, we got that 10 μm vertical beam position displacement will cause 1.4 % photon flux loss. That agreed with the experiment results.

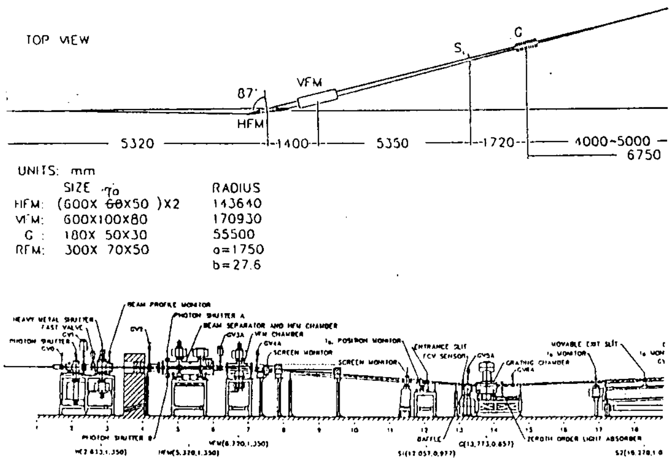

Fig. 6 The 6m-HSGM beam line layout(not complete)

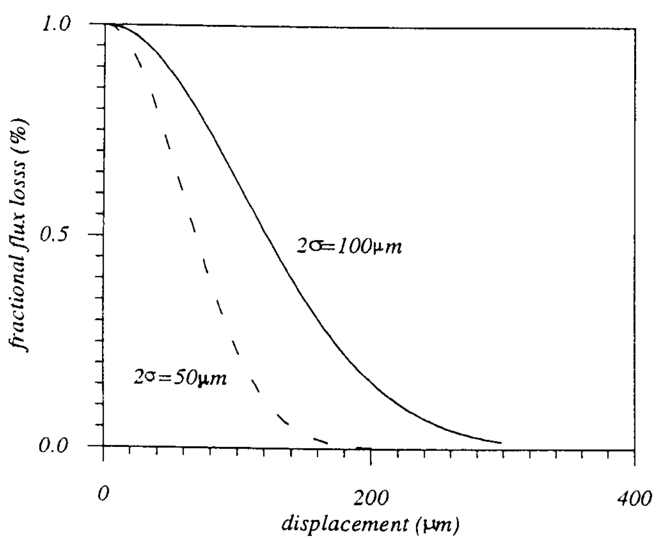

Fig. 7 The photon beam line ray tracing results

IV. RESULTS AND DISCUSSIONS

From the experiment studies and the simulation results, we learned that, for a flat electron beam orbit, 10 μm vertical beam position displacement will cause 1 to 2 % photon flux change. However, if the orbit is not flat the sensitivity could be enhanced by a fact of 10. This fact will strongly dependent on the photon beam line optics.

During the experiments, we also found that when doing the position bump change, in a large range of displacement, the photon flux could be brought back to the original value, e.g., the value before the orbit was changed, by adjusting the VFM. However, when doing the angular bump change, in most of the case, we could not get back the previous maximum value by adjusting the VFM. This was understood by that when the source slop was changed by introducing the angular bump, part of the photon beam was fall outside the VFM, therefore there is no way to bring the photon flux back to previous value by adjusting the VFM. However, for the case of changing source position by introducing the position bump, the photon flux was reduced due to that part of the focused photon beam was fall out side the entrance slit, therefore we could bring the photon flux back to previous value by adjusting the VFM. The origin of this difference is because that the photon beam are incident into the VFM with a very small grazing angle and the distance between the source point and the mirror is large. The above understanding was conformed by the ray tracing studies.

V. ACKNOWLEDGMENT

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