# PLS UPGRADE PLAN*

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*Abstract*

Pohang Light Source (PLS) has operated for 14 year successfully. To meet the request of the increasing user community, an upgrade plan of PLS is under consideration. The design goal is to achieve an even lower emittance at an elevated energy of 3 GeV and to install as many insertion devices as possible. To minimize the necessary relocation of existing beamlines, several lattices are under consideration, TBA or DBA. In any case, the existing separated function magnets will be replaced by combined function magnets to reduce the number of quadrupole magnets and to keep more space for more insertion devices. The PLS upgrade plan and the lattice design will be presented in this paper

## INTRODUCTION

Pohang Light Source (PLS) has been and is still the only light source in Korea. PLS is 2.5 GeV TBA machine with 18.9 nm rad emittance. The superperiod is 12 and currently the stored current is 200 mA. Its design goal was to satisfy both VUV and X-ray users. However, as time went, the demand of the X-ray community increased. PLS can not provide high brightness hard X-ray, especially undulator radiation. To meet the need of the X-ray community, we have a plan to upgrade PLS to PLS-II. Goals of the upgrade is as follows:

1. Beam energy upgrade to 3 GeV.
2. As low emittance as possible.
3. As many insertion devices (ID) as possible.
4. 400 mA stored current.

To achieve 1, 2, and 3, we need a new lattice, new vacuum chamber and new magnets. However, we have a restriction of preserving existing beamlines and corresponding. shielding wall. It is practically impossible to relocate the beamlines according to a new lattice. The PLS bending magnet beamlines all come from the central bending magnets. We have two different options to increase the number of IDs and to preserve positions of the existing beamlines at the same time. First option is to use the same TBA lattice as the current lattice but with the bending magnets replaced by combined function magnets. In doing so, it is possible to reduce the number of quadrupole magnets in a cell from 12 to 8. The increased drift space is added to the insertion straight to make it long enough to accommodate two IDs. At most, 20 IDs can be installed. In this way, existing bending magnet beamlines are preserved.

Another option is to build a DBA lattice again with combined function magnets. However, a short insertion straight is reserved at the position of the current central bending magnet, with the existing bending magnet beamline converting to an ID beamline. In both options, a positive dispersion is adopted in the insertion straight.

The reason that PLS stores only 200 mA is that the RF power is not enough. Therefore, to increase the stored current of PLS-II to 400 mA, we need to install powerful RF system. Currently, either a superconducting or a normal conducting system is under consideration. In this paper, the upgrade plan of PLS to PLS-II is explained.

## LATTICE

### *Triple Bend Lattice*

A triple bend (TB) lattice is a natural choice to preserve the existing bending magnet beamlines. A tentative lattice is shown in Fig. 1 and its dispersion function is shown in Fig. 2.

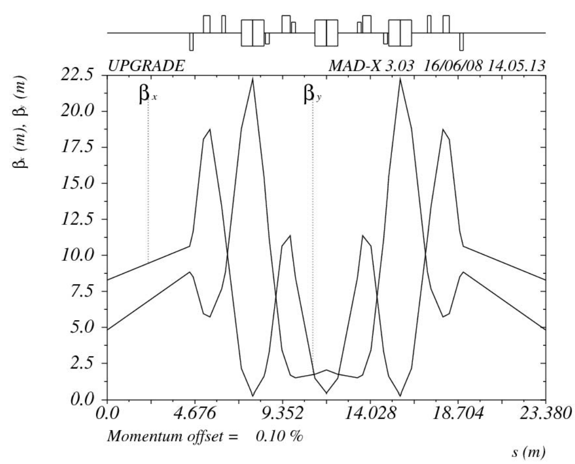


Figure 1: A tentative TB lattice of PLS-II ($\beta$ functions).

Natural emittance of this tentative lattice is around 5 nm rad. As shown in Fig. 2, small positive dispersion is used in the insertion straights to reduce the electron beam emittance. However, the dispersion was chosen to minimize not the natural emittance but rather the effective emittance defined by

$$\frac{\sigma_s^2}{\beta_s} = \epsilon_n + \frac{\eta_s^2}{\beta_s}\delta_E^2, \qquad (1)$$

where $\sigma_s$, $\beta_s$, and $\eta_s$ are the electron beamsize, betatron function, dispersion at the center of the inserion straight

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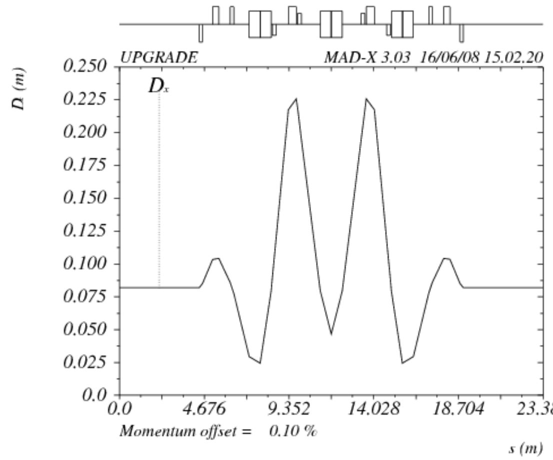


Figure 2: Dispersion of the PLS TB lattice.

respectively and $\epsilon_n$ is the natural emittance. The effctive emittance minimizing conditions are given in [**?**]. The conditions were loosely met in this lattice. Differences between PLS and PLS-II TB lattice are shown in Table 1.

Table 1: Comparison of PLS and PLS-II

| | **PLS** | **PLS-II(TB)** |
|---|---|---|
| Energy | 2.5 GeV | 3 GeV |
| Emittance | 18.9 nm rad | 5 nm rad |
| Superperiod | 12 | 12 |
| Quadrupoles per cell | 12 | 8 |
| ID section length | 6.8 m | 8.8 m |
| Natural chromaticity (H,V) | (-23.36,-18.89) | (-44.1,-25.9) |
| Tunes (H,V) | (13.28,8.18) | (17.38,10.18) |
| Energy loss per turn | 0.55 MeV | 1.03 MeV |

Twelve quadrupoles per call of PLS is reduced to 8 qudrupoles in PLS-II by adopting combined function magnet. As a result, the insertion straight length increases from 6.8 m to 8.8 m. In this long straight section, two IDs will be installed. Three small bending magnets will be used to make a chicane separating the two ID beamlines as in Fig. 3.

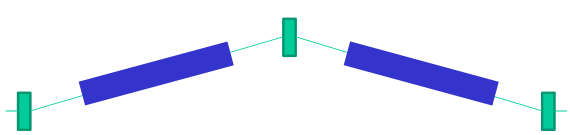

Figure 3: Two IDs in a long insertion straight of PLS-II.

Due to high natural chromaticity, the chromaticity correcting sextupoles get very strong and as a result the dynamic aperture is not very large. Note that there is no space available for the harmonic correction. Therefore, dynamic aperture is the most critical quantity of this lattice. Figure 4 shows the dynamic aperture with no error.

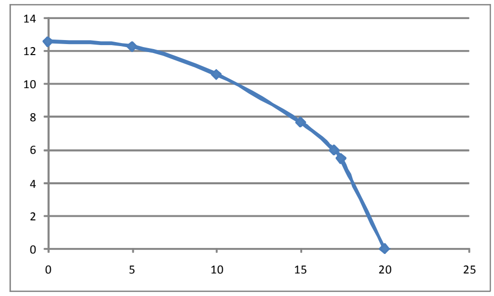


Figure 4: Dynamic aperture of the TB lattice in mm.

### *Double Bend Lattice*

An alternative double bend (DB) lattice is still under study. The point of this lattice is that a short insertion straight section is reserved between the two bending magnets. The total possible number of IDs would be 20. Again, the effective emittance will be optimized by using conditions given in [2]. A tentative lattice that is not optimized yet is shown in Fig. 5.

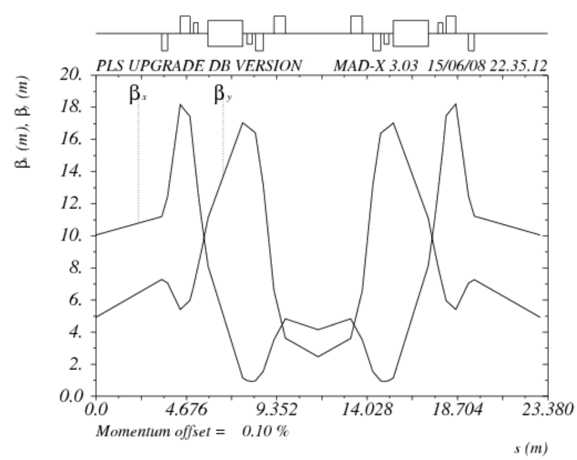


Figure 5: A tentative DB lattice of PLS-II.

## INJECTOR

PLS is using an 2.5 GeV linac as an injector. For PLS-II, we have two options; upgrading the injector linac to 3 GeV or installing a new booster. If we install a booster, the linac will be converted to VUV or soft X-ray SASE FEL. The booster would be installed on the inner wall of the storage ring tunnel. The distance between the storage ring and the booster ring would be around 4 m. A separate linac of energy 100-200 MeV would be prepared for the injection to the booster.

The booster ring circumference would be 250 m and the lattice would be modified FODO with combined function magnets. It would have three fold symmetry with three straight sections reserved for injection, extraction, and RF system, respectively. The natural emittance goal would be around 10 nm rad. A tentative lattice for a cell is shown in Fig. 6.

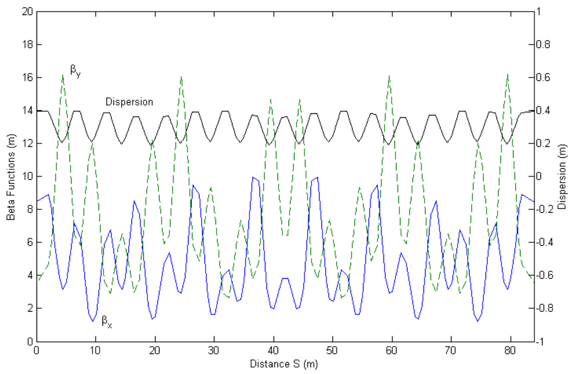


Figure 6: One cell tentative lattice of a booster in PLS-II.

## RF SYSTEM

Currently, PLS stores 200 mA. RF power is not enough to store higher current. In order to store 400 mA in the PLS-II, we have to upgrade the RF system. Again, we have two options; normal conducting (NC) and super-conducting (SC) system. Obviously, each system has its own advantages and disadvantages. But, since they are well known, they won't be discussed here. A simple comparison of the two systems in PLS-II is shown in Table 2.

Table 2: Comparison of NC and SC RF system in PLS-II

| **Parameters** | **SC** | **NC** |
|---|---|---|
| Gap voltage (MV) | 2.53 | 2.53 |
| Radiation loss/turn (kW) | 676 | 676 |
| No. of cavity | 3 | 6 |
| Gap voltage/cavity (kV) | 844 | 422 |
| $P_{beam}$/cavity (kW) | 225.3 | 112.7 |
| $P_{wallloss}$/cavity (kW) | 0 | 20.9 |
| $P_{input}$/coupler (kW) | 225.3 | 133.6 |
| Total RF power (kW) | 676 | 801.6 |

## SUMMARY

PLS-II, an upgrade of PLS is under study. The design goal is a higher energy (3 GeV), lower emittance (5 nm rad), higher current, and more IDs. A big design requirement is to minimize possible relocation of the existing beamlines and modification of the storage ring tunnel structure. For the purpose, a TB and DB lattice are under study and tentative lattices are under investigation. In both cases, at most 20 IDs would be installed. As an injector, an installation of a booster ring on the inner wall of the storage ring tunnel is under consideration, although upgrade of the existing 2.5 GeV linac to 3.0 GeV would also be possible. For the RF system upgrade, both NC and SC system are under study.

## REFERENCES

[1] T.-Y. Lee and J. Choi, Nucl. Instr. and Meth. A 534 (2004) 371.

[2] T.-Y. Lee and J. Choi, Nucl. Instr. and Meth. A 515 (2003) 410.