TPS Design Status

An intermediate energy synchrotron light source has been proposed. The goal is to construct a high performance light source in complementary to the existing 1.5 GeV ring in Taiwan to boost the research capabilities. A 3 GeV machine with 518.4 m and 24-cell DBA lattice structure is considered and other options are also investigated. We report the 24-cell design considerations and its performances.

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Almost two years ago, NSRRC Board of Trustee suggested that we propose another synchrotron light source with energy around 3 GeV to increase the research capacity, especially in the X-ray range. To fit into the existing site and to satisfy the user requirements, some configurations of the accelerator systems as well as the size of the storage ring have been discussed. One of the attractive configurations is a 24-cell ring with its circumference around 500 m. If we choose the booster synchrotron as the injector, we could have it either in the independent building or sharing the same tunnel as a concentric booster ring.

A 24-cell Double Bend Achromate (DBA) structure is presented. By allowing slight positive dispersion in the long straights, the natural emittance of 1.7 nm-rad can be achieved. With a 6-fold symmetry configuration, the ring provides 6 long straights for injection, long IDs, and SRF modules. The lattice optical functions are depicted in Fig. 1, and some of the major lattice parameters are listed in Table 1. With different kind of insertion devices, the calculated brilliance with 1% emittance coupling is plotted in Fig. 2.

To correct chromaticity and to reduce the nonlinear effects we employ a sextuple scheme of 8 families. A sufficient large dynamic

Table 1: Major parameters of the TPS

Energy [GeV]	3.0
Beam current [mA]	400
Circumference [m]	518.4
Nat. emittance [nm-rad]	1.7
Cell / symmetry / structure	24 / 6 / DBA
$\beta_x / \beta_y / \eta_x$ [m] LS middle	10.59 / 9.39 / 0.11
RF frequency [MHz]	499.654
RF voltage [MV]	3.5
Harmonic number	864
SR loss/turn, dipole [MeV]	0.98733
Straights	11.72m*6+7m*18
Betatron tune ν_x / ν_y	26.22 / 12.28
Synchrotron tune ν_s	5.6×10^{-3}
Bunch length [mm]	2.8
Dipole B/L [Tesla]/[m]	1.3789 / 0.95
Mom. comp. (α_1, α_2)	2.0×10^{-4} , 2.3×10^{-3}
Nat. energy spread σ_E	9.53×10^{-4}
Damping time ($\tau_x/\tau_y/\tau_s$) [ms]	10.5 / 10.5 / 5.25
Damping partition ($J_x / J_y / J_s$)	0.997 / 1.0 / 2.003
Nat. chromaticity ξ_x / ξ_y	-78.2 / -32.5

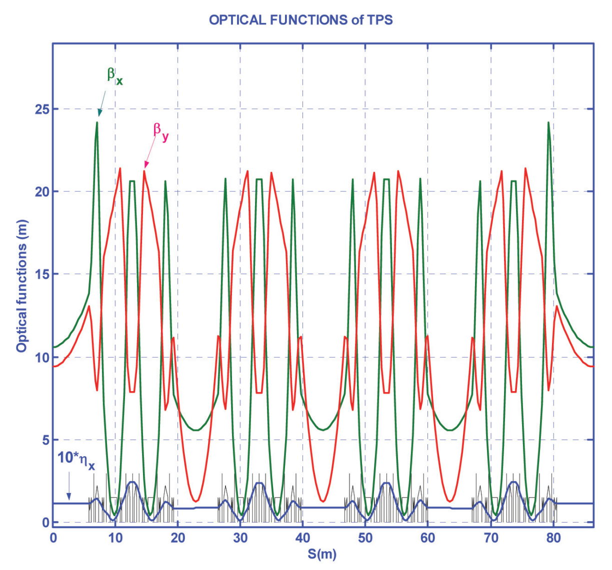

Fig. 1: Optical functions of the TPS lattice.

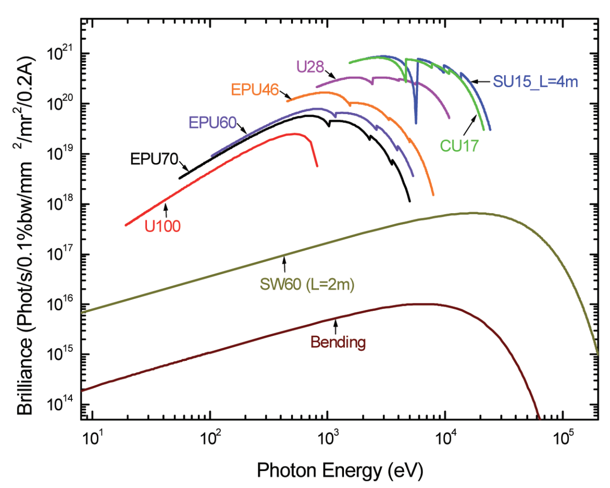

Fig. 2: Brilliance of the TPS, 1% emittance ratio is assumed.

aperture, in both on-energy and off-energy particle cases, is obtained to ensure efficient injection and reasonable lifetime. Figure 3 gives dynamic aperture for on-energy and off-energy (±3%) particles tracked for 1000 turns at the long straight centre.

Other nonlinear driving sources are from the imperfections of the magnetic field in dipole, quadrupole and sextupole magnets, and from insertion devices, etc. We take a set of typical multipole errors and we find that there is some reduction of the dynamic aperture but still good enough.

There will be more than 21 insertion devices in the ring and their effects on the beam dynamics are also investigated. We simulated beam dynamics effects with 21 planned insertion devices in the TPS. The beam dynamics effects such as tune shift, emittance changes, etc. are studied and the tracking results with these IDs show there are significant impacts on the dynamic aperture, but still acceptable.

Closed orbit distortions (COD) due to alignment errors and dipole field errors are analyzed. It is found that the rms amplification factors due to rms quadrupole misalignments are around 50 in both planes. For the designed girder support, the well prealigned supports magnets help to reduce the amplification factors down to around 30 and 10 in the horizontal and vertical plane, respectively. Targeting small alignment errors down to 30 μm with respect to girder is our goal. Taking into simulations with a set of rms errors: quadrupole misalignment w.r.t. girder 0.03 mm; girder misalignment 0.1 mm; dipole roll 0.2 mrad; girder roll 0.1 mrad; dipole relative field error 0.001, we obtain the rms COD of 4.0 mm in x and 1.8 mm in y, respectively. Employing a COD correction scheme, we are able to correct it down to 50 microns rms in both planes.

The small emittance coupling, as low as 1%, is necessary to achieve high brilliance photon beam. We also analyze the contribution factors such as dipole and quadrupole roll errors, the off-center beam in quadrupoles and sextupoles, etc. It is found with the typical roll errors as given above, we need to correct orbit w.r.t. the quadrupole and sextupole center to be less than 0.15 mm rms in order to get less than 1% emittance coupling, both for spurious vertical dispersion and betatron coupling contributions. Skew quadrupoles around the ring will be implemented to control the coupling as well.

Vertical beam size in the low emittance and small coupling ring can be less than 10 microns. Stringent request for small vertical beam orbit fluctuation within sub-micron range is necessary to keep the photon flux stable. Therefore time dependent orbit error sources need to be controlled. One of these sources is the ground vibration. The maximum optics response to the plane ground wave in the vertical plane is less than 5 within 10 Hz and around 10 above 10 Hz with the help of girder supports. Integrated vertical ground motion from the measurements in NSRRC site above 1Hz is around 100 nm and the simulated vertical beam motion above 1 Hz due to ground wave is around 300 nm. Careful ground motion con-

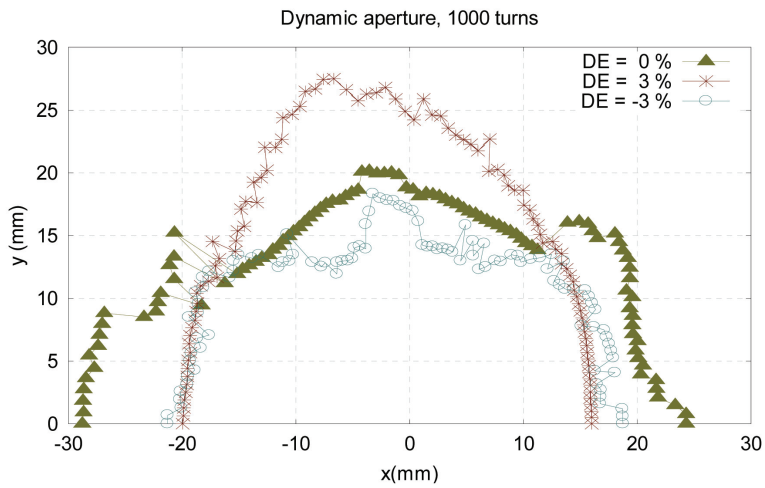

Fig. 3: Dynamic aperture for on-energy and off-energy particles at long straight center.

trol is needed in the facility construction planning. A sophisticated girder design is also necessary.

With the superconducting cavities, no coupled bunch instabilities are anticipated due to higher order modes of cavities. However, the small gap insertion devices can induce transverse instabilities and the impedance budget is also very low to avoid microwave instabilities. Lifetime is estimated to be larger than 10 hours for 5 mm vertical chamber size, 1% coupling, 1 nTorr vacuum, 0.6 mA bunch current and 3.5 MeV rf voltage.

Booster synchrotron combined with a linac will be the injector. We can have concentric booster ring or separated one. Both types can have emittance less than 20 nm-rad. To satisfy civil engineering constraints, we have different configuration options such as 20-cell design or 24-cell but with different straight lengths, etc.

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