ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-MOPM028

UPGRADES OF BEAM DIAGNOSTICS FOR LINAC OF SIAM PHOTON SOURCE

T. Chanwattana*, S. Boonsuya, S. Bootiew, C. Dhammatong, S. Jummunt, S. Klinkhieo, N. Kumdee, S. Naeosuphap, W. Phacheerak, T. Pulampong, P. Sudmuang, N. Suradet, Synchrotron Light Research Institute, Nakhon Ratchasima, Thailand

Abstract

Siam Photon Source (SPS) is an existing synchrotron light source in Thailand, which has been operated and provided synchrotron radiation for user beam service for more than 10 years. The SPS accelerator system consists of a 40-MeV linac, a 1.2-GeV booster synchrotron and a storage ring with double bend achromat (DBA) lattice. The linac is one of the most critical parts of the SPS machine in which its performance affects beam injection and hence to the beam service. Beam diagnostics of the SPS linac has been upgraded in order to allow better beam monitoring and become a crucial part for linac optimization to achieve higher machine performance. In this paper, upgrades of beam diagnostics of the SPS linac will be discussed.

INTRODUCTION

Siam Photon Source (SPS) successfully operated with the first beam in the storage ring since 2001 [1–3], started user beam service from 2003 [4, 5], has been operated with 1.2 GeV beam from 2005 [6, 7], and insertion devices were fully installed in all four straight sections of the SPS storage ring in 2018 [8–11]. Accelerator complex of SPS consists of a linac, a low energy beam transport line (LBT), a booster synchrotron (SYN), a high energy beam transport line (HBT) and a storage ring (STR). the linac, LBT and booster are in the underground of SPS accelerator building and the storage ring is located on the ground floor of the accelerator building. Layout of the SPS accelerator complex is shown in Figs. 1 and operating parameters of SPS are given in Table 1.

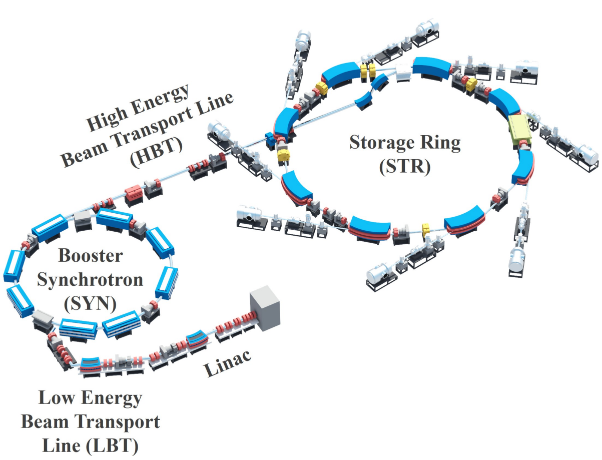

Figure 1: Layout of the SPS accelerator complex.

Table 1: SPS Parameters

Parameter	Value
Storage ring	
Beam energy	1.2 GeV
Maximum beam current	150 mA
Circumference	81.3 m
RF frequency	118 MHz
Emittance	41.0 nm·rad
Natural bunch duration	96.8 ps
Booster	
Injection beam energy	40 MeV
Maximum beam energy	1.2 GeV
Beam current	30 mA
Circumference	43.19 m
RF frequency	118 MHz
Repetition rate	0.3 Hz
Linac	
Maximum beam energy	40 MeV
Repetition rate	0.3 Hz

Main components of the SPS linac are a triode electron gun, two pre-bunchers (PB1-2), a buncher, and two 2.3-m S-band accelerating tubes (ACC1-2). LBT is a transfer line for sending 40-MeV beam from the linac to the booster with two bending magnets with deflecting angle of 50.5°. The linac and LBT are one of the most important parts of SPS and the performance of the linac directly effects beam injection to the booster and then the storage ring. Malfunction of the linac can have huge impact on beam service of SPS. Currently, beam injection efficiency to the booster is 50% or below. To improve overall beam injection efficiency of the SPS accelerator, optimization of linac and also LBT is required. Capability of beam diagnostics can determine performance of the optimization. Therefore, beam diagnostics of linac and LBT should be upgraded. There are three main beam diagnostics of linac and LBT [12]: 1) wall current monitor (CM1-3), 2) screen monitor (SCM1-3) and 3) faraday cup (FC). Layout of linac and LBT with location of the beam diagnostics are shown in Fig. 2.

BEAM DIAGNOSTICS UPGRADES

Beam Current Monitor

A wall current monitor measures beam current from wall current generated on surface of a vacuum chamber when electrons beam traverse through the current monitor. One

* thakonwat@slri.or.th

ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-MOPM028

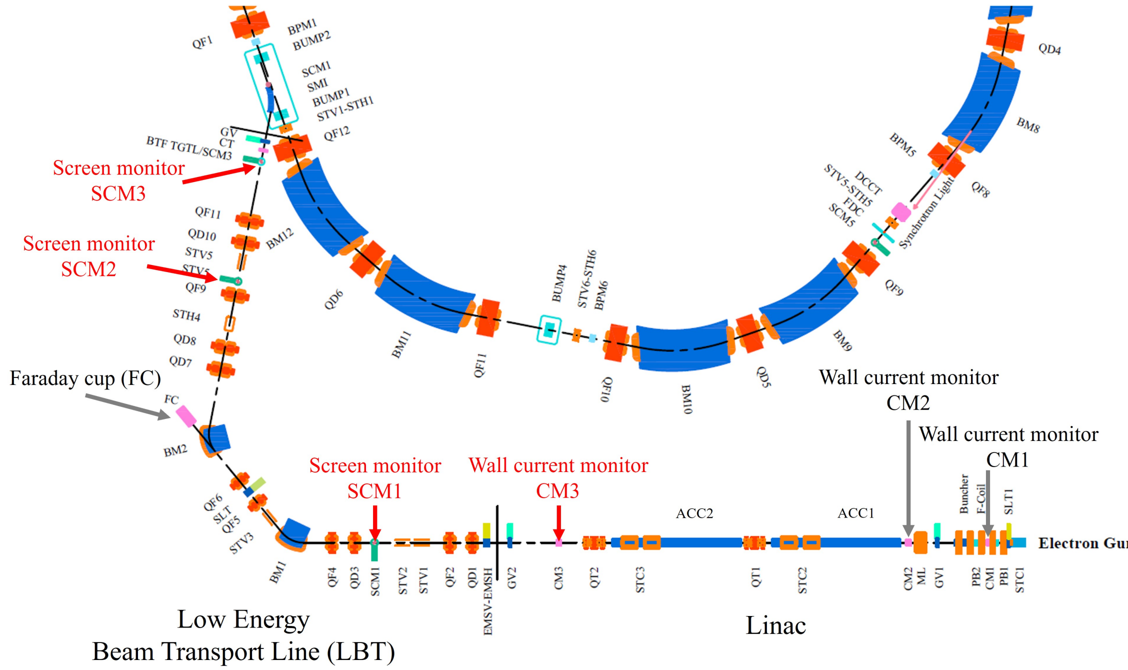

Figure 2: Schematic layouts of linac and LBT with location of all wall current monitors, screen monitors and faraday cup.

main disadvantage of the wall current monitor is that the measured signal of the beam current is correlated with transverse beam position. The wall current is stronger in the side of vacuum chamber which the beam is close to. It is then necessary to remove the effect from off-axis beams by including the signals around the vacuum chamber. Another type of a beam current monitor is a beam current transformer which measures bean current based on the current transformer principle. The beams generate magnetic field in the magnet core of the current transformer and the magnetic field generates electric current in the secondary circuit connected to a resistor. The beam current then can be measured with the current through the resistor. In case of the current transformer, the beam current measurement is independent of transverse beam position.

From three of the beam current monitor of the SPS linac, CM3 is the easiest one to be replaced with a current transformer as the other are covered with solenoid and magnetic lens. An AC current transformer (ACCT) from Bergoz is chosen because the beam pulse duration of the linac is about 4 µs and the ACCT is suitable to measure beam current of the beams with pulse duration in the range between microsecond to millisecond. The ACCT was tested in our laboratory and then installed ACCT at the planned location as shown in Fig. 3. The ACCT was connected to an oscilloscope and tested to measure the beam current as shown in Fig. 4. The measured beam profile shows a few spikes within a beam pulse. Further investigation has to be done in order to verify whether it is the actual beam profile or the measured signal is affected by magnetic fields from adjacent quadrupoles in which the ACCT shielding may be required.

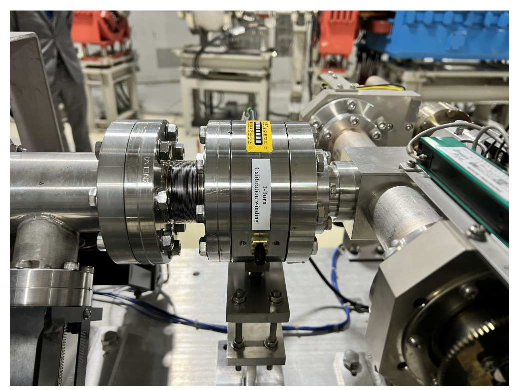

Figure 3: ACCT installed at the end of SPS linac.

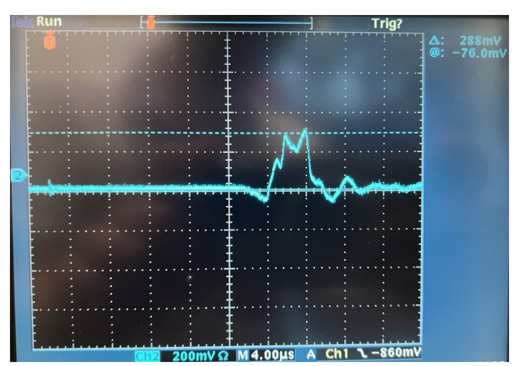

Figure 4: Beam current measurement from the installed ACCT.

Screen Monitors

A screen monitor is a destructive beam diagnostic for monitoring transverse beam profiles. Numeral screen mon-

ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-MOPM028

itors are necessary for an accelerator system, especially a single-pass system like linac and transfer line, to monitor transverse beam distribution and beam position in each section of the accelerator, and hence to allow matching of the beam through different sections of the accelerator. A basic screen monitor consists of a movable scintillating screen which is aligned at an angle of 45° and inserted into the beam pathway, a viewport, some optical components such and lens, and a CCD camera. When a beam hits the scintillating screen, electrons in scintillators of the screen are excited and then emit fluorescence photons which traverse through viewport and optical components and are captured by the CCD camera as an image of the beam.

The screen monitors of SPS linac and LBT have been unusable regularly because a CCD camera was broken. The main problem is that optics of the screen monitor was designed with the camera installed on the horizontal axis, and close to a vacuum chamber.The photons from the screen and other secondary radiation are then damage sensors of the camera. In order to have more reliable screen monitor system, optics and support for the screen monitor will be modified by adding one more mirror making the light direct to the camera on the vertical axis as shown in Fig. 5. One of the installed screen monitor system is shown in Fig. 6. All the screen monitor systems will be installed within 2023.

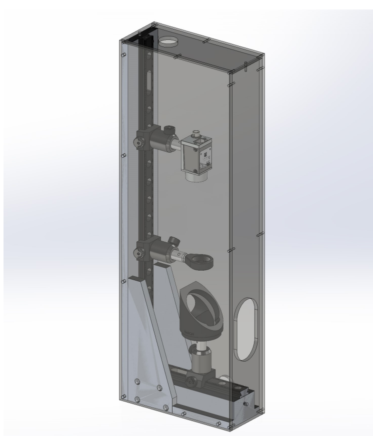

Figure 5: Design of screen monitor system.

CONCLUSION

The beam diagnostics of SPS linac and LBT have been upgraded with installation of the ACCT for measuring beam current and beam profile and the new screen monitor system. The performance of the installed system will be tested during the next beam service. The main goal of the beam diagnostics upgrades is for optimization of the beam injection efficiency from linac to booster and hence the overall injection efficiency of the SPS machine resulting in lower beam injection duration. Parameter adjustment for linac and LBT such as phase and field amplitude of PB1-2 and ACC1-2 will be tested in the next machine shutdown to obtain a full-list of parameters for optimization and various optimization techniques including machine learning will be studied and tested in the later stage. Other major upgrades and improvements of SPS over the past recent years are also reported in [13].

Figure 6: One of the installed screen monitor system.

ACKNOWLEDGEMENTS

This work was supported by Synchrotron Light Research Institute (SLRI), Thailand Science Research and Innovation (TSRI), and National Science, Research and Innovation Fund (NSRF). The authors would like to thanks to SLRI Operation and Maintenance Section for fruitful discussions and wholehearted supports.

REFERENCES

[1] W. Pairsuwan, T. Ishii, "Status of the Siam Photon Laoratory", in *Proc. APAC'01*, Beijing, China, Sep. 2001, paper MOB03, pp. 26–30.

[2] R. Apiwatwaja, P. Songsiriritthigul, W. Pairsuwan, T. Ishii, and G. Isoyama, "The Recent Progress of Siam Photon Laboratory", in *Proc. APAC'04*, Gyeongju, Korea, Mar. 2004, paper WEM104, pp. 468–472.

[3] S. Rujirawat *et al.*, "Progress on the commisioning of the siam photon source", in *Proc. WAO'03*, Tsukuba, Japan, Mar. 2003, paper 10P2-23.

[4] Current events, "Thailand source (Siam photon project) takes off", *J. Synchrotron Radiat.*, vol. 10, p. 103, 2003. `doi:10.1107/S0909049502022835`

[5] P. Songsiriritthigul *et al.*, "The Commissioning Results of the First Beamline at the Siam Photon Laboratory", *AIP Conf. Proc.*, vol. 705, pp. 372–375, 2004. `doi:10.1063/1.1757811`

[6] S. Rugmai *et al.*, "Energy Upgrade of the Siam Photon Source", *AIP Conf. Proc.*, vol. 879, pp. 58–61, 2007. `doi:10.1063/1.2436005`

[7] P.Klysubun *et al.*, "Operation and Recent Developments at the Siam Photon Source", in *Proc. APAC'07*, Indore, India, Jan.-Feb. 2007, paper THC3MA01, pp. 607–609.

ISBN: 978-3-95450-231-8 ISSN: 2673-5490 doi: 10.18429/JACoW-IPAC2023-MOPM028

[8] S. Rugmai *et al.*, "Soft x-ray undulator for the Siam Photon Source", *AIP Conf. Proc.*, vol. 879, pp. 335–338, 2007. doi:10.1063/1.2436068

[9] S. Srichan, Ch. Dhammatong, P. Klysubun, V. Sooksrimuang, K. Takkrathoke, and A. Tong-on, "Operation of SLRI Cryogenic System for a 6.5 T Superconducting Wavelength Shifter", in *Proc. IPAC'14*, Dresden, Germany, Jun. 2014, pp. 2765–2767. doi:10.18429/JACoW-IPAC2014-WEPRI113

[10] P. Sudmuang *et al.*, "Commissioning of the 2.4T Multipole Wiggler and the 6.5T Superconducting Wavelength Shifter at the SIAM Photon Source", in *Proc. IPAC'14*, Dresden, Germany, Jun. 2014, pp. 1192–1194. doi:10.18429/JACoW-IPAC2014-TUPRO068

[11] P. Sunwong *et al.*, "Commissioning and Operation of Superconducting Multipole Wiggler at Siam Photon Source", in *Proc. IPAC'21*, Campinas, Brazil, May 2021, pp. 2398–2400. doi:10.18429/JACoW-IPAC2021-TUPAB375

[12] P. Klysubun *et al.*, "Beam Diagnostics at Siam Photon Source", in *Proc. IBIC'16*, Barcelona, Spain, Sep. 2016, pp. 410–412. doi:10.18429/JACoW-IBIC2016-TUPG33

[13] N. Juntong *et al.*, "Five Years Statistical Analysis of the Siam Photon Source Operation", presented at the IPAC'23, Venice, Italy, May 2023, paper MOPM027, this conference.