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DESIGN OF AN UPGRADED SCREEN MONITOR SYSTEM FOR THE SIAM PHOTON SOURCE INJECTOR LINAC

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Abstract

The Siam Photon Source (SPS) is a 1.2 GeV synchrotron facility in Thailand, operated by the Synchrotron Light Research Institute (SLRI), providing synchrotron radiation for various applications to the user community. The SPS injector linac generates 40 MeV electron bunches, which are then transported to the booster synchrotron via the Low-Energy Beam Transport line (LBT). To ensure effective beam monitoring along the injector linac and LBT, key beam diagnostics—including beam current, transverse profile, and energy profile monitoring—have been installed in the injector linac. In order to maintain full diagnostic performance, the screen monitor system is planned to be upgraded to enhance transverse beam profile monitoring, improve radiation resistance, and support injector linac optimization for higher machine performance. This paper presents the current status of the screen monitor system for the SPS injector linac and discusses the design and implementation plan for its upgrade.

INTRODUCTION

The Synchrotron Light Research Institute (SLRI) has operated the 1.2 GeV Siam Photon Source (SPS) for over two decades, providing synchrotron radiation to a broad community of academic and industrial users, both domestic and international [1]. As the Siam Photon Source II (SPS-II) project [2] is still in the design and development stage, SPS continues to serve as a key synchrotron facility in Thailand and the ASEAN region, necessitating ongoing machine maintenance and upgrades.

The SPS accelerator complex comprises an injector linac, a booster synchrotron, and a storage ring. The facility was constructed using components transferred from the former SORTEC facility in Japan [3]. The High-Energy Beam Transport line (HBT) and the storage ring were modified during reassembly in Thailand [4]. The linac, capable of generating and accelerating electrons up to 40 MeV, is described in detail in Ref. [5]. Electrons are subsequently transported to the booster synchrotron through the Low-Energy Beam Transport line (LBT). The quality of the beam transported through the LBT strongly influences booster injection efficiency. Therefore, diagnostic devices are installed along the transport line to ensure reliable beam delivery. Earlier diagnostic upgrades included the installation of an AC Current Transformer (ACCT) from Bergoz Instrumentation to replace a wall current monitor (WCM) at the linac exit, as well as modified optics and support for the screen monitors [6].

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The current status of beam instrumentation at the SPS injector linac and LBT, along with recent measurement results, is reported in Ref. [7]. The overall beam transmission efficiency from the injector linac to the end of LBT was measured to be 25.6 %, with significant beam loss observed in the LBT section. To provide more reliable beam diagnostics and support injector linac and LBT optimization, an upgraded screen monitor system is being developed to overcome limitations from radiation damage and maintenance issues, enabling more precise beam measurements.

SPS INJECTOR LINAC AND LBT

A schematic layout of the SPS injector linac and the LBT line together with beam diagnostic devices is shown in Fig. 1. The details of both parts of the SPS accelerator are as follows:

Injector Linac

The injector consists of a triode-type thermionic DC gun with an EIMAC Y646B cathode, operating at 100 kV, with a grid pulser providing 3 µs pulses at 0.3 Hz. The beam is then longitudinally compressed by a bunching system with two single-gap pre-buncher cavities (PB1 and PB2) and a 8.5-cell standing-wave side-coupling structure, operating at 2856 MHz. Final acceleration to 40 MeV is achieved with two S-band (2856 MHz), 2.3 m-long traveling-wave structures operating in the $2\pi/3$ constant-gradient mode. The operational parameters of the injector linac are listed in Ref. [7]. The injector linac was designed to produce beams with a current of about 30 mA and a normalized emittance of 3.8 mm·mrad [5].

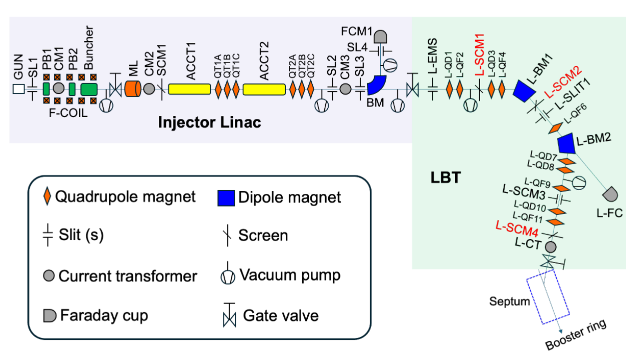

Figure 1: Layout of the SPS injector linac injector and LBT.

Low-Energy Beam Transport Line (LBT)

The LBT line transports the 40 MeV beam from the linac to the booster synchrotron and was originally designed to

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function as an energy analyzer and selector using a slit. It employs two identical C-type dipole magnets (L-BM1 and L-BM2) with a bending angle of 50.5° and a bending radius of 500 mm. Originally, 10 quadrupoles provided beam focusing, but L-QF5 was later replaced by the screen monitor L-SCM2. Five steering magnets were installed for trajectory correction; currently, only three are in use. The magnet parameters listed in Table 1 provide the basis for detailed beam dynamics simulations aimed at assessing transmission efficiency, optimizing settings, and evaluating instrumentation performance.

Table 1: Parameters of the LBT Magnets

Type	Number	Eff. Length	Max. Field
Dipole	2	50.28 cm	0.27 T
Quadrupole (Type 1)			
Focusing	3	13.32 cm	4 T/m
Defocusing	2	13.32 cm	4 T/m
Quadrupole (Type 2)			
Focusing	2	15.19 cm	4 T/m
Defocusing	3	15.14 cm	4 T/m

CURRENT SCREEN MONITOR SYSTEM

Screen monitors (SCMs) are key diagnostics in electron accelerators for measuring the transverse beam profile. They convert incident electron energy into visible light via scintillation or optical transition radiation, which is then imaged by a camera to extract beam parameters such as size, shape, position, and halo. Real-time measurements are essential for diagnosing beam parameters and optimizing the performance of accelerator systems.

Several SCMs are installed along the SPS injector linac and LBT to measure transverse beam profiles. The active monitors are L-SCM1, L-SCM2, and L-SCM4, as indicated in Fig. 1 (highlighted in red). While the control system for L-SCM3 is in place, the mirror, lens and camera are not installed. L-SCM2 is currently inoperable due to a malfunctioning pneumatic actuator responsible for moving the screen. Each monitor employs a movable scintillating screen inserted at a 45° angle, with the resulting light captured by a CCD camera to measure the transverse beam profile.

The original SCM system suffered from radiation-induced camera failures due to its horizontal optical layout. An additional mirror was added to the optical path, directing light vertically and allowing the camera to be positioned farther from the primary radiation plane [6]. However, the screen monitors remain susceptible to radiation damage. The SCMs were modified by relocating the CCD cameras below the radiation level and shielding them with lead sheets as shown in Fig. 2. Example transverse beam profiles measured by L-SCM1 and L-SCM4 are presented in Fig. 3. To address these limitations, an upgraded design is currently being developed to enhance both reliability and measurement accuracy.

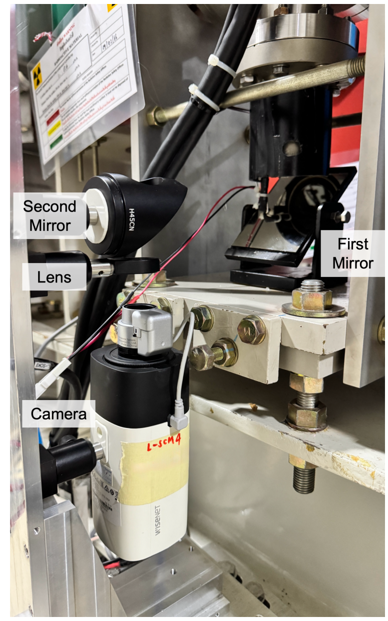

Figure 2: One of the existing SCMs currently in LBT.

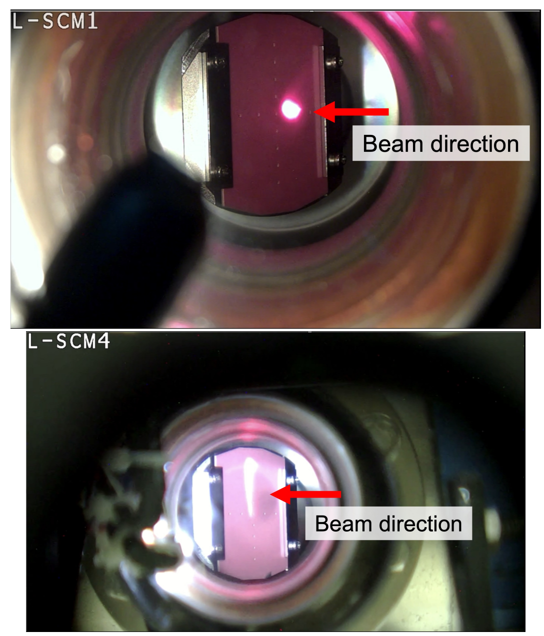

Figure 3: Transverse beam profiles measured with the screen monitor system at L-SCM1 (top) and L-SCM4 (bottom).

PROPOSED SCREEN MONITOR LAYOUT

To improve reliability and reduce radiation damage, a new SCM optical layout is proposed. In the current design, cameras are mounted close to the beamline, where radiation exposure quickly degrades sensors and shortens their operational lifetime. The new layout relocates the camera closer to the floor. As illustrated in Fig. 4, this position reduces direct radiation exposure and simplifies the installation of shielding, all while maintaining measurement performance.

The optical path begins with a retractable 45° scintillating screen, which converts the incident electron beam into

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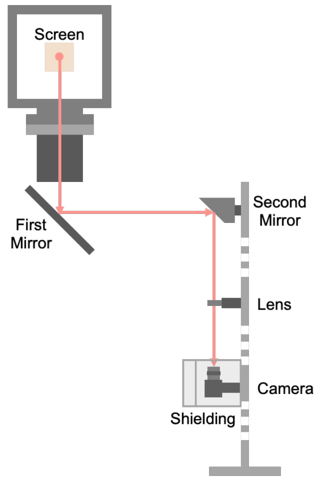

Figure 4: Schematic of the proposed screen monitor optical layout showing the light path from the scintillating screen to the shielded camera.

visible light when inserted. Light from the screen is first deflected horizontally by a mirror below the beam plane and then redirected vertically by a second mirror. A lens then focuses and transports the image to the shielded camera. This periscope-style relay preserves spatial resolution and light collection efficiency while minimizing optical aberrations and stray light, ensuring reliable measurements across different beam intensities.

To further enhance robustness and radiation tolerance, the imaging device will be upgraded to a compact CMOS camera. This device offers a smaller footprint, easier integration with shielding, and sufficient sensitivity and resolution for accurate transverse beam profile measurements.

Radiation dose studies will guide the final camera placement and shielding thickness. This combination of optimized light transport, strategic shielding, and a robust sensor selection is designed to deliver precise beam diagnostics and ensure long-term durability in the high-radiation environment of LBT.

SUMMARY AND OUTLOOK

The SPS injector linac and LBT are critical parts of the SPS facility, providing high-quality electron beams to the booster synchrotron. Existing screen monitor systems allow transverse beam profile measurements but are limited by radiation-induced camera failures and suboptimal optical layouts.

The current status of the SCM system is discussed, with examples of measured transverse beam profiles. A new optical design for the SCMs has been proposed to enhance reliability and measurement accuracy. By employing a periscope-style relay with mirrors and a lens system, light from the scintillating screens is transported to cameras positioned outside high-radiation zones, enabling improved shielding and extended camera lifetime.

Future work includes investigating the radiation dose around the SCM locations, as well as implementing and testing the upgraded SCMs. The design will be verified by assessing key performance indicators, including spatial resolution, light collection efficiency, and overall system durability. Successful deployment will facilitate more precise beam diagnostics and support ongoing optimization of the SPS injector linac and LBT, including beam dynamics simulations based on measured magnet parameters, ultimately guiding future improvements to the overall SPS injector system.

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