

# TPS SCREEN MONITOR USER CONTROL INTERFACE

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## Abstract

The Taiwan Photon Source (TPS) is being constructed at the campus of the NSRRC (National Synchrotron Radiation Research Center) and in commissioning. For beam commissioning, the design and implementation of a screen monitor system for beam profile acquisition, analysis and display was done. A CCD camera with Gigabit Ethernet interface (GigE Vision) is a standard device for image acquisition, to be undertaken with an EPICS IOC via a PV channel; display beam profile and analysis properties are made with a Matlab tool. The further instructions for the design and functionality of the GUI were presented in this report.

## INTRODUCTION

Taiwan Photon Source (TPS), a 3 GeV third generation synchrotron light facility, featuring ultra-high photon brightness with extremely low emittance which is being installation at National Synchrotron Radiation Research Center (NSRRC). For beam commissioning and optimize machine operation, the two-dimensional beam-related images were recorded by screen monitor in Linac, LTB, booster, BTS and storage ring, which are widely used in synchrotron light source facility. Due to the most of machine parameters in future TPS [1] will be accessible as EPICS (Experimental Physics and Industrial Control System [2]) process variables (PVs). Thus, an analysis tool use the PVs as inputs with ability to calculate and display results in complex ways is needed. The screen monitor user control interface design and its functionality are present in this report.

## LAYOUT OF SCREEN MONITOR

For the TPS beam diagnostic application distributed in Linac, LTB, BTS, booster (BR), and storage ring (SR), the screen monitor is responsible for the beam profile acquisition from YAG:Ce screen and used to analysis to find the beam characteristic data. The location and quantity of the screen monitor is listed in Table 1. The beam profile image has extensive information on beam parameters, including beam center, sigma, tilt angle and etc. The optical system contains screen, lens, and lighting system. The screen monitor assembly consists of a hollow tube, a YAG:Ce screen with 25 mm in diameter and 0.5 mm in thickness. The YAG:Ce screen is mounted at 45° angle in one side to intercept the beam. A vacuum-sealed window is in the other end of the tube to extract the light. A CCD camera is mounted at a supporting tube with LEDs installed beside the CCD camera for illumination. A pneumatic device is used to move the whole assembly in or out. All of these devices are controlled remotely

including the CCD power control, screen in/out control and LED lighting system. The structure of the screen monitor assembly is shown in Fig. 1. The PoE CCD camera with Gigabit Ethernet interface (GigE Vision) will be a standard image acquisition device. The CCD timing trigger clock is locked with TPS injection system, which is produced from a local timing IOC (EVR).

Table 1: Location and Quantity of the Screen Monitor

Location	Quantity
Linac	5
LTB	5
Booster	6+1*
BTS	5
Storage ring	1+3*

\* Plus additional screen monitor are temporarily installed during the commissioning.

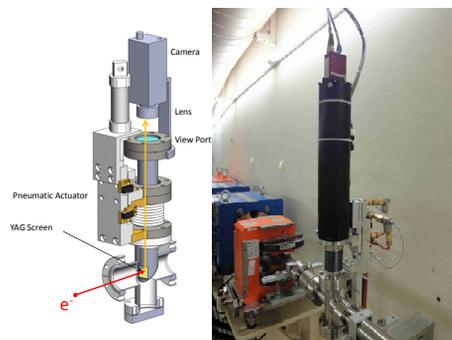


Figure 1: Screen monitor assembly in TPS booster.

## USER INTERFACES DEVELOPMENT

### Camera Parameters and Screen Position Control GUI

Based on the areaDetector module (R1-9-1) [3-4] which provides a general-purpose interface for area (2-D) detectors in EPICS, it is easy to construct a camera control panel by using the EDM tool. The TPS main control panel is shown in Fig. 2, the screen monitor launch page is marked. The screen monitor user interfaces for the TPS Linac, LTB, BR, BTS, and SR are shown in Fig. 3, which can switch in between in one GUI. The camera parameters of exposure time and gain can be configured in this panel, the camera location also shown below. The trigger mode selection include that the Free-Run for simply monitor the image and Sync-In for synchronization of linac injection (3 Hz). This EDM panel only offer lunch the screen, control the CCD parameters and simple monitoring features but do not perform any calculations. The screen position control also can perform in this GUI, the flow state as shown in Fig. 4.

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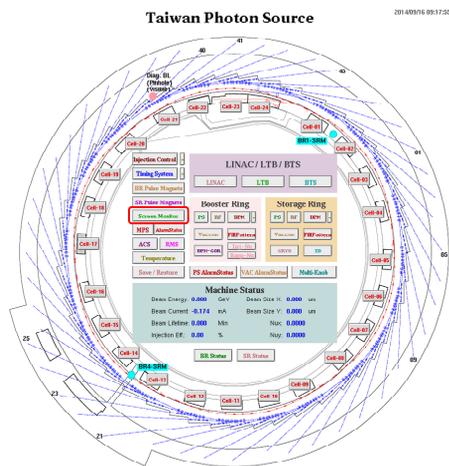


Figure 2: TPS control panel, screen monitor launch page is marked with red rectangular block.

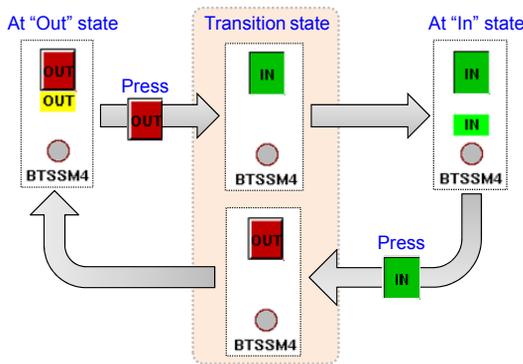


Figure 4: The screen position control flow state.

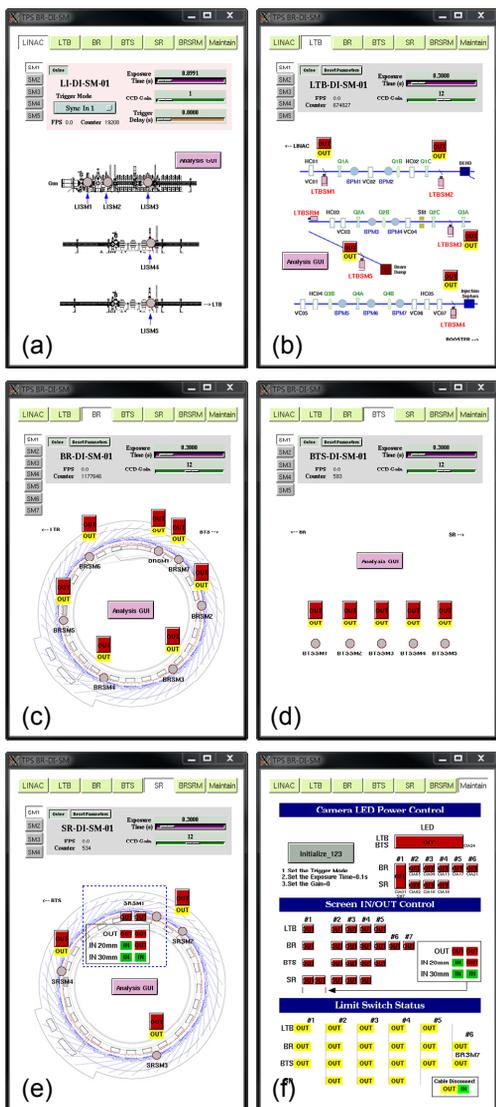


Figure 3: The EDM camera control user interfaces for the screen monitor of (a) Linac, (b) LTB, (c) BR, (d) BTS, (e) SR, and (f) maintain page. The top bar can switch in between the six pages, and the cameras location shows in below.

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Matlab Display GUI

The display GUI was design to simply and quickly to use screen monitor, and it can be launched from the EDM page and display the image of beam profile, as shown in Fig. 5(a). When launch a screen, this action also specify which image will be analyzed by background analysis program. The axes of this figure in pixel unit (Left/Down) and mm unit (Right /Up) had already been calibrated. The status bar at the bottom of the figure is shown current capture date, system counter, and FPS information. The additional statuses, as shown in Fig. 5(b), such as screen out (screen position in out state), image no update (synchronous trigger signal loss) and camera pause will also show.

This display GUI contains right-click functions, the function name and description is shown in Table 2. It can be used to: control the camera update on/off, reset the GUI, save date to file, adjust the image contrast or colormap, image line profile analysis and distance measurement, and shown some information (PV name, resolution, size of image).

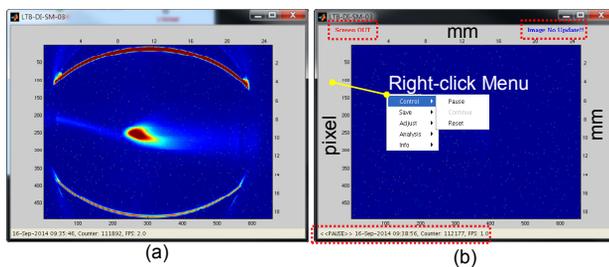


Figure 5: Screen monitor display GUI, (a) normal operation, (b) some information such as screen out, image no update, and camera pause will shown.

Table 2: Right-click Functions of Display GUI

Function	Sub-function Name	Description
Control	Pause	Pause capture image
	Continue	Continue capture image
	Reset	Reset this Program
Save	*.mat	Save as MAT file
	*.png	Save image as PNG file
Adjust	Contrast	Adjust image contrast
	Colormap - Gray	Change image to gray
	- Pesudo	Change image to pseudo (default)
Analysis	Line Profile	Analysis line profile on image
	Line Distance	Measure the line distance on image
Info	Image PV: LTB-DI-SM-03:image:ArrayData	Image array PV name
	1 pixel = 0.038 um	Image resolution
	Size: W656 x H492	Image size
	Ver.20140826	Current version

*Matlab Analysis GUI*

The image analysis work is mainly performed by using background Matlab program and display results via the Matlab GUI [5-6], the layout as shown in Fig. 6. The GUI can run in multiple clients simultaneously and read the analysis results from EPICS IOC and display them in the window. The GUI contains six parts: menu, toolbar, control panel, fitting results, projected profile, and raw image. The menu and toolbar provide save data, colormap change, ROI specify, simulation, reset and close program, and zoom in/out functions. In the control panel it contains active the program, 3D viewing, multi-exposure, and background subtract functions. The fitting results area contains sigma and center in the units of pixel and mm, and beam tilt angle. Two directions, horizontal and vertical, of beam projected profiles of raw data and fitting curve are predrilled in two axes. The camera raw image with the colorbar is integrated into the display GUI. The function of export the raw image data and analysis results can be done. It also can create a simulated beam image for the purpose of evaluating the fitting correctness.

The Matlab analysis program runs in IOC's PC as a background task which can do a complex analytical work to analyze the beam parameters, including the beam center, sigma, and tilt angle. It can specify the region-of-interest (ROI) for clipping the image of each individual camera, and do an optional background subtraction and software multiple exposures. All the analyzed data will store into the EPICS IOC as PVs.

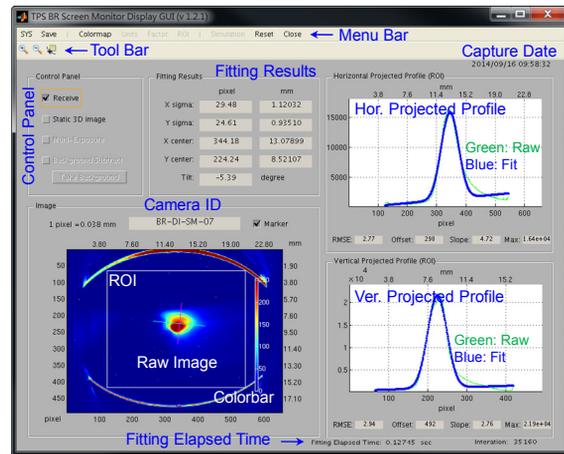


Figure 6: Layout of the Matlab analysis GUI for screen monitor.

**SUMMARY**

The Taiwan Photon Source (TPS) is currently in the commissioning phase, the screen monitor is one of the important diagnostic devices for beam commissioning. The user interface of screen monitor for display beam profile and analysis properties are made and online operation. Prolonged use and user feedback information will help the system reliability and integrity. More useful or desirable function will continue to grow up in this system.

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