Beam Trip Diagnostics for the TPS

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ABSTRACT

The Taiwan Photon Source (TPS) is available to users since March 2016. A beam trip diagnostic system is used as an important tool to analyze the cause of beam trip events since the beginning of 2017. The main function of the system is to record relevant signals when the stored beam is suddenly lost. In the past few months, some useful features have been added, such as capturing trigger signals for pulsers, power line voltage, and auto generated beam trip reports. A detailed system architecture, implementation and progress will be summarized in this report.

SYSTEM DESCRIPTION

- A trigger signal is generated through the beam trip detector when the stored beam current suddenly drops.
- The data recorders will be updated on receiving a trigger, the server saves all data from the recorders and machine parameters from subsystem through a PV access.
- The probable cause of the event will be analyzed by the program.
- A beam trip report will be generated and saved as a web page. After that, operators can access and analyze the event data from viewer GUI or web browser at any time.

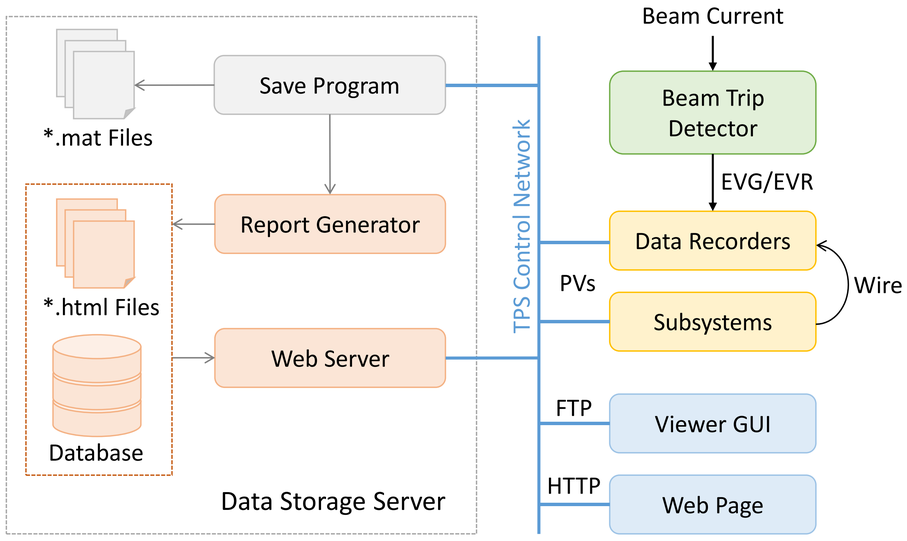

Fig. 1: Schematic layout of the TPS PM system.

PM TRIGGER GENERATION AND TRANSMISSION

- If the stored beam current drops abnormally fast (configurable, for example drop 25 mA within 0.1 ms), a trigger will be generated and transmitted via the timing system.
- Objects that accept this trigger signal include data recorders and beam position monitors (BPMs) which are distributed around the accelerator facility.
- Known possible causes for the stored beam current to drop abnormally include:
  - RF system trips
  - BPM orbit interlock
  - Vacuum interlock
  - Front end interlock
  - Beamline interlock
  - Abnormal firing of pulsers

DATA RECORDER

- The quantity and parameters of the data recorders are shown in Table 1.
- The saved post-mortem data (waveform type post-mortem signals and subsystem parameter set value) are tabulated in Table 2.
- The TPS BPM system provides post-mortem data which plays a significant role in recording turn-by-turn orbit information to analyze beam positions during the trip event.

Table 1: List of data recorder units used

Device	BPM platform	Data recorder (8ch)	
Quantity	173	4	1
Sampling rate (kHz)	~578	100	50,000
Time span (ms)	~17.28	100	6
Data length (point)	10,000	10,000	300,000

Table 2: List of saved post-mortem data

Group	Signals	Description
Beam signals	Ib, Orbit	Stored beam current and turn-by-turn orbit data
RF signals	Pr, Pf, GV, RC	RF system forward power, reflect power, gap voltage, and ready-chain signal
Interlock signals	BPM, Vacuum, Frontend, Beamline, Safety	Subsystem interlocks to shutdown the RF system
Pulser	Kickers	SR injection kicker waveform with trigger signal
Machine parameters	Set value	Subsystem parameters, alarm list
Power line	L1, L2, L3	3-phase voltage
Seismic	X, Y, Z	Up-down, north-south, and west-east acceleration (in planning)

DATA STORAGE SERVER AND VIEWER

Data Storage Server

- The data storage server is used to automatically store post-mortem data, and provides FTP and web services for viewer GUI and web page access.
- The save program also performs a simple timing analysis of the recorded signals in order to give possible event identification.
- The report generator program Generates html file report for the web page access.

Viewer GUI

- The viewer GUI is designed to list and plot beam trip events. The graphic user interface is currently in development with the Matlab guide tool as shown in Fig. 2.
- It can list the beam trip event with a simple note, and a signal list check box can be used to select the desired data for display (as shown in Fig. 3), which can be downloaded from the server using the FTP.

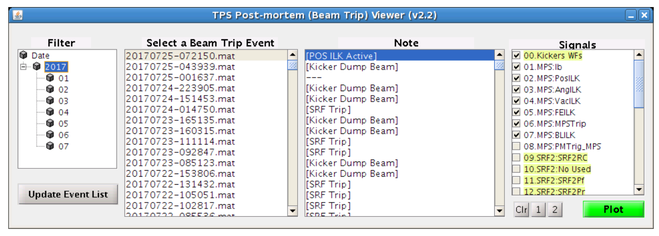

Fig. 2: Main page of viewer graph user interface.

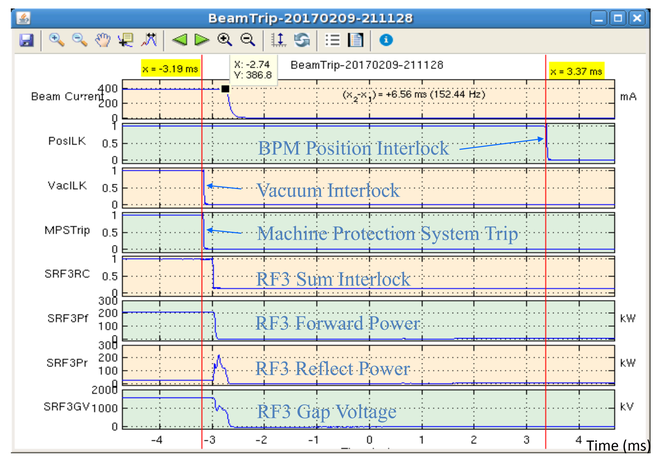

Fig. 3: Plot page of vacuum interlock event.

Website Interface

- The main page is developed with the Python/Django tool as shown in Fig. 4. It can list the beam trip event similar to the viewer GUI.
- The report, as shown in Fig. 5, is generated from report generator at the first moment or from the viewer GUI afterward (regenerate)

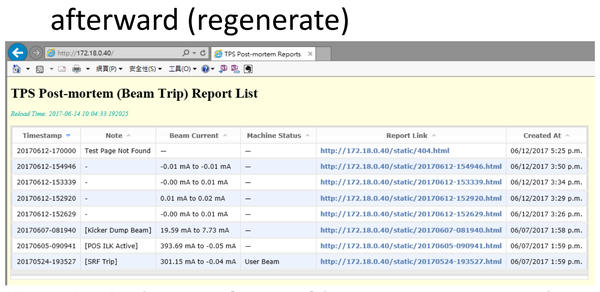

Fig. 4: Web interface of beam trip report list.

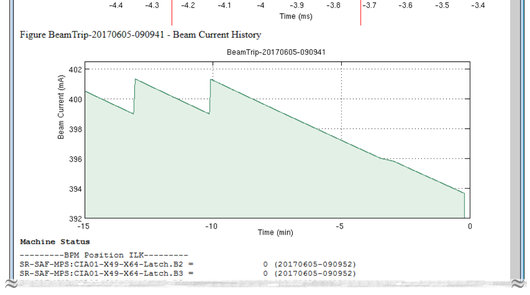

Fig. 5: Web page of beam trip report.

PULSER MISS FIRING

- The current waveforms and the trigger signals of the four kickers should exist at the same time, as shown in Fig. 6.
- Some kickers were unexpectedly triggered without trigger signal, causing an instant loss of the electron beam, as shown in Fig. 7. The K1, K3, K4 spontaneously fires and no trigger signal was observed.
- In order to solve the possible noise interference, the improvement scheme proposed at present is to use the fiber link instead of the copper wire to transmit the trigger signal, hoping to reduce noise pickup.

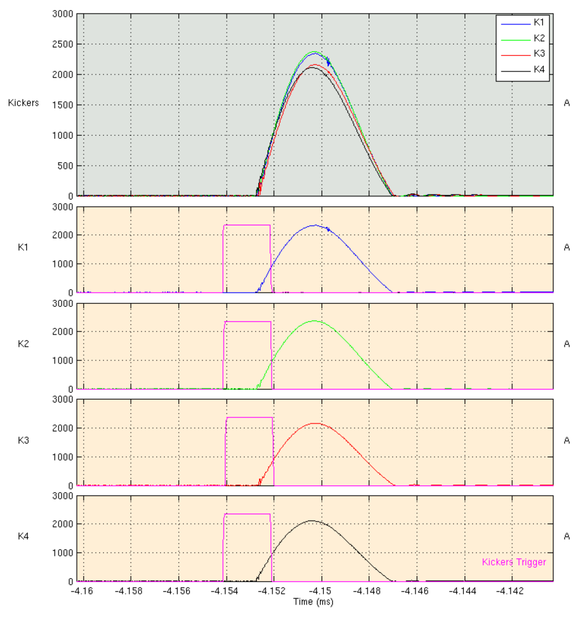

Fig. 6: Kicker waveforms with trigger signals during dump beam process.

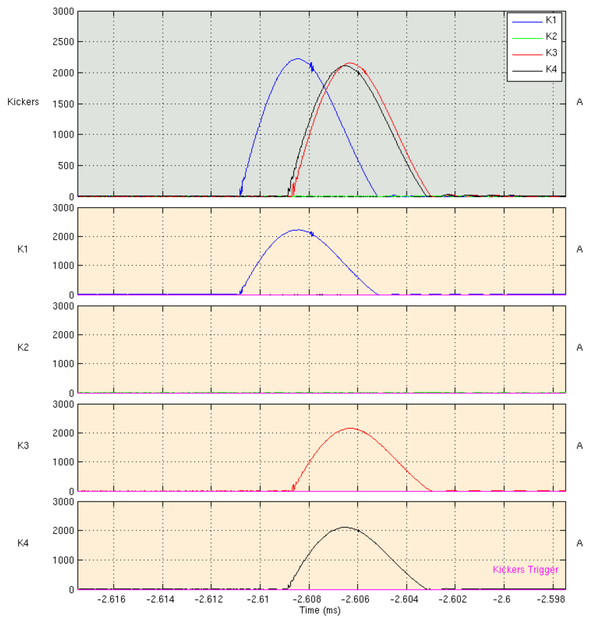

Fig. 7: Kicker waveforms without trigger signals during kicker miss firing trip event.

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