

CONTROL SYSTEM STUDIO TO MONITOR FRONT END AND BEAM-LINES STATUS AS WELL AS LIGHT SOURCE STABILITY

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Abstract

The primary task during a shift change at the Taiwan Photon Source Accelerator Operations team is to know the exact status of the machine, so that problems can be discovered immediately and solved when the machine behaves abnormal.

To provide a stable beam during top-up operation, it is necessary to monitor closely the stability of the light source, of front end areas and beamlines. Should any abnormality occur, the operator would initiate initial troubleshooting and adjustments, inform users and subsystem staff members and perform subsequent first analyses and system optimizations.

In this article, we describe how to sort through the necessary information with the Control System Studio (CSS) design page.

There are currently seven beamlines in operation at the Taiwan Photon Source (05, 09, 21, 23, 25, 41, 45) and more new beamlines will be added in the future. Compared with other tools, CSS is intuitive and easy to revise. No matter weather adding new parameters or changing settings, the operation team can quickly get familiar with the machine status and perform an interface upgrade.

TPS FRONT END AND BEAMLINE STATUS MONITORING



Figure 1: TPS Front end and beamline status monitoring page.

All real-time information mentioned above is collected on one page (Fig. 1), so that the operator can understand the state of the front end and beamline.

TPS LIGHT SOURCE STABILITY MONITORING

The light source stability is very important for users [1] and we use therefore the CSS to record electron orbit changes upstream and downstream of IDs during user operation (excluding the injection period). Figure 2 shows the corresponding diagram of beamline, ID and upstream/downstream electron BPMs. When a change exceeds the allowable range, the synchrotron radiation will suffer a large offset. When such a problem is discovered, it should be excluded as much as possible at first or it will become the reference basis for further optimization of the system.

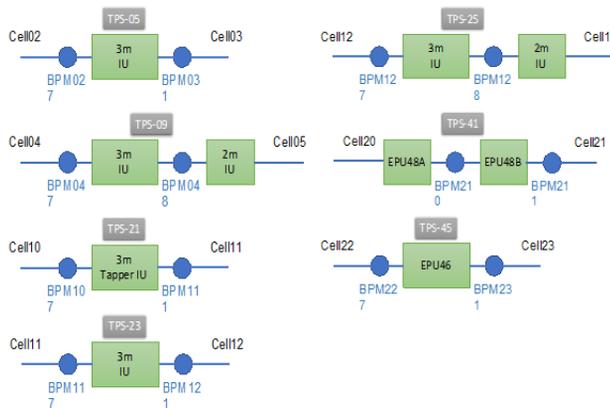


Figure 2: Corresponding diagram of beamline, ID and upstream/downstream electron BPMs.

From the design parameters of the TPS, the tolerable orbit variation is 10% of the electron beam size (design value $\sigma_x = 39.7 \mu\text{m}$; $\sigma_y = 15.8 \mu\text{m}$), which is about $4 \mu\text{m}$ in the X- and $1.5 \mu\text{m}$ in the Y-direction. Figure 4 shows the BPMs located at the up and downstream of TPS-21 and ID gap, the horizontal axis on the graph represents the past 12 hours to the present time, which is the maximum number of hours a particular operator may on duty. The data can also be selected for any other specific time period as shown in Fig. 3.

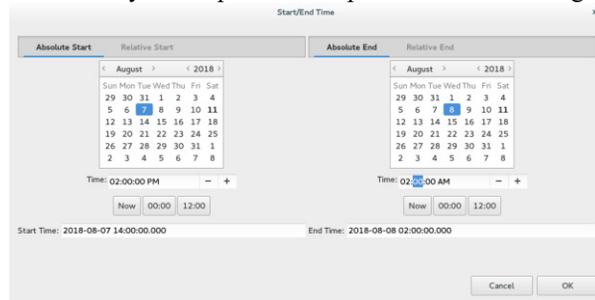


Figure 3: Selection of the temporal display interval for data recording.

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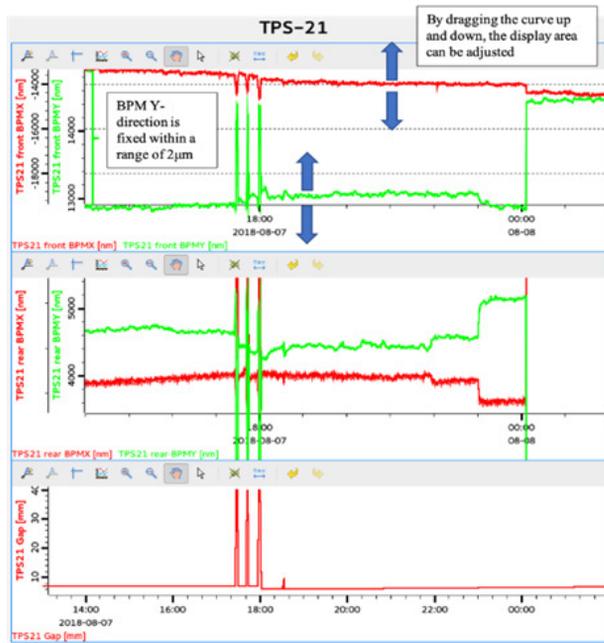


Figure 4: TPS-21 IU22-3m up (BPM107) and downstream (BPM111) electron orbit change and ID gap change record during a typical shift.

The vertical axis in the BPM X-direction is fixed within a range of 6 μm , and the BPM Y-direction within a range of 2 μm . By dragging the curve up and down, the display area can be adjusted. The electron orbit changes as measured by BPM107 - BPM111 and ID gap changes are recorded from 2018/08/07 14:00 to 2018/08/08 02:00.

From Fig. 4, it can be seen that at 2018/08/07 17:30~18:00, the ID gap was changed between 7 and 40 mm three times. BPM107 shows that the electron orbit in the X-direction changed slightly by about 0.8 μm , and in the Y-direction by about 1.5 μm . The electron orbit changes in BPM111 even exceeded the display range. It can be seen that the electron orbit changes exceed 6 μm in the X-direction and exceed 2 μm in the Y-direction. The actual values are 8 μm in the X- and 5 μm in the Y-direction. It can be seen that currently the TPS-21 can cause significant orbit changes for big ID gap changes with the downstream impact being particularly dramatic.

Figure 5 shows the TPS-05 IU22-3m, Fig. 6 the TPS09 IU22-3m, Fig. 7 the TPS-23 IU22-3m, Fig. 8 the TPS-25 IU22-3m, Fig. 9 the TPS-41 EPU48B and Fig. 10 the TPS-45 EPU46 upstream and downstream electron orbit change and ID gap change record. From Figs. 4 to 9 we can observe the changes of the upstream and downstream electron orbits for all IDs in the TPS within 12 hours and the influence of single gap changes on the orbit for individual beamlines.

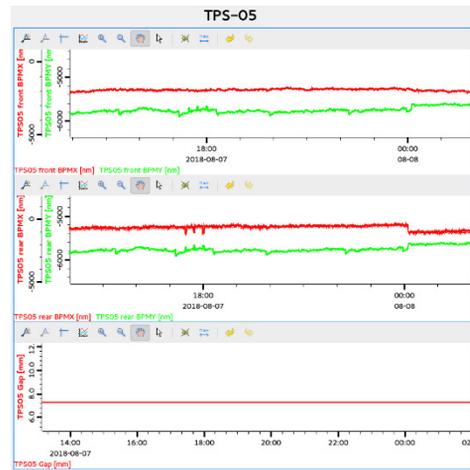


Figure 5: TPS-05 IU22-3m up (BPM027) and downstream (BPM031) orbit and ID gap change record.

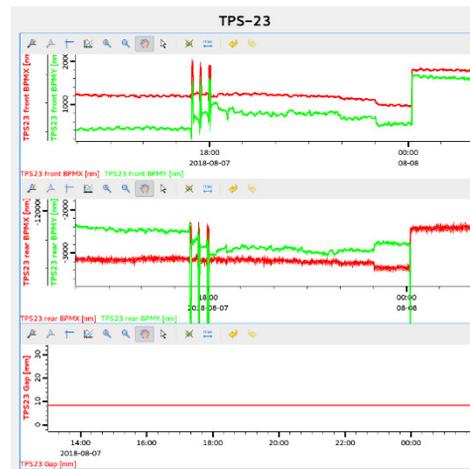


Figure 6: TPS-23 IU22-3m up (BPM117) and downstream (BPM121) orbit and ID gap change record.

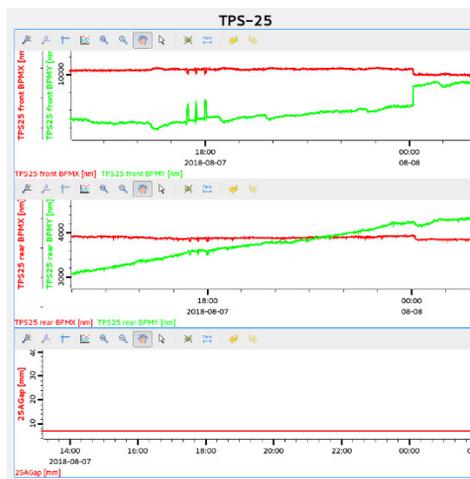


Figure 7: TPS-25 IU22-3m up (BPM127) and downstream (BPM128) orbit and ID gap change record.

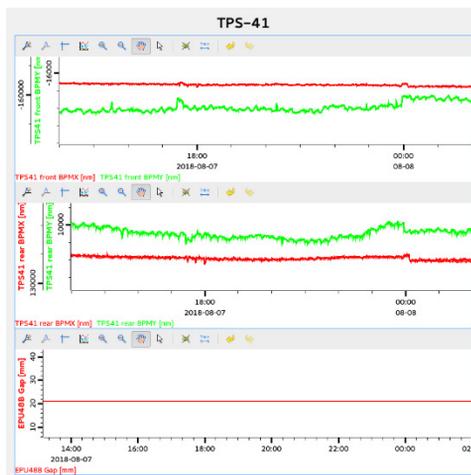


Figure 8: TPS-41 EPU48B up (BPM210) and downstream (BPM211) orbit and ID gap change record.

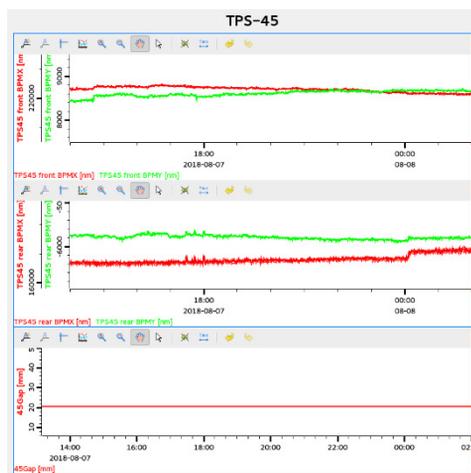


Figure 9: TPS-45 EPU46 up (BPM227) and downstream (BPM231) orbit and ID gap change record.

From Figs. 4 - 9 data we conclude, that the three circulating events of TPS-21 ID gap changes from 7 to 40 mm during the period of 2018/08/07 17:30~18:00 also have a different degree of influence on other beam lines. TPS-05, TPS-25, TPS-41, TPS-45 experience only small changes (less than 1 μm) to the electron orbit and TPS-09 is almost unaffected. The TPS-23 beam line located downstream of the TPS-21 is significantly affected. The amount of electron orbit change upstream of the ID is about 3 μm in the X-direction and about 1.2 μm in Y-direction. The downstream electron orbit change is about 2.5 μm in the X-direction and about 2.5 μm in the Y-direction.

Furthermore, it can be found that on 2018/08/08 00:06, the X-direction electron orbit at the upstream TPS-21 is slightly changed, by about 0.5 μm , and in the Y-direction by about 1.5 μm . The electron orbit changed in the X- and Y-directions downstream of TPS-21 are beyond the display range (the exact value is about 8 μm in the X-direction and about 5 μm in the Y-direction); There is also a significant change in the TPS-23 located downstream of TPS-21. The X-direction electron orbit of the upstream TPS-23 is about 2.5 μm , and the Y-direction is changed by about 1.2

μm . The X-direction electron orbit of the downstream TPS-23 is about 3 μm , and is changed in the Y-direction by about 2.5 μm . At the same time, the TPS-05、TPS-09、TPS-25 TPS-41 and TPS-45 experience also a slight orbit change by less than 1 μm . On 2018/08/08 00:06, it can be found there is no change of the ID gaps in any of the beamlines. Therefore, the electron orbit changes are not caused by ID gap changes but the actual causes are still unknown and need to be clarified.

While the TPS-23 electron orbit is affected by TPS-21 gap changes, it is clear from the above discussions more research must be done to be able to change any beamline without affecting other beamlines. Conversely, if orbit changes do not originate from ID gap changes, we may find the answer from status changes of another subsystem.

Figure 10 is the overall picture on the control computer display, so that the operator can quickly grasp the light source status without having to manually retrieve the data one by one at the start of his/her shift. If the machine shows any abnormality, it can be seen immediately.



Figure 10: Overall computer control display.

SUMMARY

Through the CSS, all information from a beam line is collected into an integrated page, so that the operator can understand the current state of the frontend and beamline immediately.

In addition, the use of the CSS to create a long-term observation record of changes in the electron orbit will help operation team members or subsystems to solve problems and optimize the system and provide users with better light source quality.

Even if there are new beamlines added in the future, with the excellent functions of the CSS, the operations team members can quickly get started and continue to upgrade the interface.

REFERENCES

- [1] Y. C. Liu, "Taiwan Photon Source Towards User Operation", in *Activity Report NSRRC*, 2015, pp. 65-69.