

DEVELOPMENT OF A MACHINE STATUS PROGRAM "HISTORY" AND ITS APPLICATION TO BEAM STABILITY ANALYSIS

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Abstract

In order to monitor SRRC accelerator status and be able to examine correlation among relevant parameters, an application program "history" was developed to acquire archival data from various data servers (VAX, UNIX, WINNT, WIN98). This program can be run in two modes: A) on line : instant display of the chosen parameters of beam properties and machine status. B) off line : detailed study of correlation among parameters related to a particular issue, such as orbit drift, life time change, photon beam stability, vacuum chamber and cavity temperature variation, etc. This report describes the details of the developed program. Typical examples of analyzing beam stability by using correlation plots are presented.

1 INTRODUCTION

In the routine operation of the Synchrotron Radiation Research Center (SRRC) storage ring, monitoring some of the important electron beam parameters is usually required to assure a stable photon beam observed in the beam line end station. Critical monitoring parameters were selected after many interface discussions with the users and experience gained by the operators. It also happened frequently that beam instability issue was raised by the users in the weekly meeting and was too late to respond for a better service. It was realized that a tool providing archival data with correlating capability is required to meet this need. Also, this tool shall be able to provide proper communication protocol that will fit to the various data servers environment in SRRC.

A program "history" was developed for this purpose to acquire archival data from various data servers (VAX, UNIX, WINNT, WIN98). This program can be run in two modes: A) on line : instant display of the chosen parameters of beam properties and machine status. B) off line : detailed study of correlation among parameters related to a particular issue, such as orbit drift, life time change, photon beam stability, vacuum chamber and cavity temperature variation, etc. The details of this program are described in this report.

2 THE PROGRAM OF "HISTORY"

The "history" program provides capability for the user to retrieve data of accelerator status and electron beam parameters from various system servers. Generally, the daily data is stored in the servers with 0.1 Hz data rate. When the user choose to retrieve data more than one day and/or with multi-signals, the program will carry out the assembling process of daily data and stacking the chosen signals for display.

The data retrieval process is based on FTP method, regardless of the server OS environments (UNIX, VAX, WIN98, WINNT). First, the program will check the "present date" in PC which run the program. Then, it connects to the particular system server according to this "present date". If the server does not contain the data in that particular date, the program will check the data log with decreasing date automatically until it finds the data from the server. If the server recorded a lot of data and the running PC has plenty of space to store these data, the program will automatically list all of the data items for retrieving.

3 THE MAIN FUNCTION OF THIS PROGRAM

3.1 Mathematics

Mathematics operation of the raw data is very useful in finding correlation of the parameters related to a particular issue.

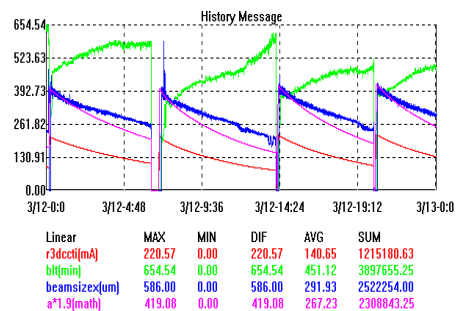


Figure 1: Archived data of σ_x , I , and $I \cdot \tau$.

For example, Figure 1 shows the relationship of the electron beam horizontal beam size (σ_x) with the storage ring beam current (I), and with the product of the storage ring beam current and beam life time ($I \cdot \tau$). Similar archived trend of σ_x and $I \cdot \tau$ is clearly observed. This typical example demonstrates the usefulness of mathematics operation in finding correlation among interested parameters.

3.2 Overlap

The purpose of overlap is to display the selected signals together and be able to find their correlation regardless of their large quantitative difference. The default Y frame range is set to the maximum values and minimum values of all signals. The function is actually zooming in each signal's maximum and minimum to the Y frame range. Example is given in Fig. 2.

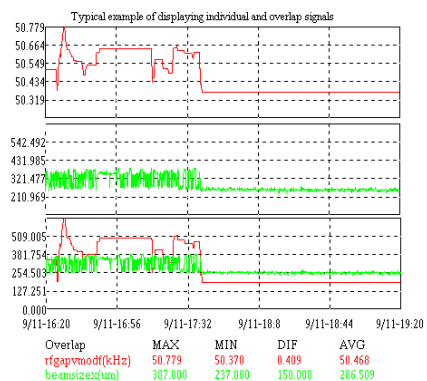


Figure 2: Overlapping of small and large signals.

3.3 Zoom

This function is to enlarge a selected small region or to shrink a large region. User can either select the range of X and Y from the “zoom dialog” or click the mouse to do it. Also, the data can be overlapped first before zooming. Example is given in Fig. 3.

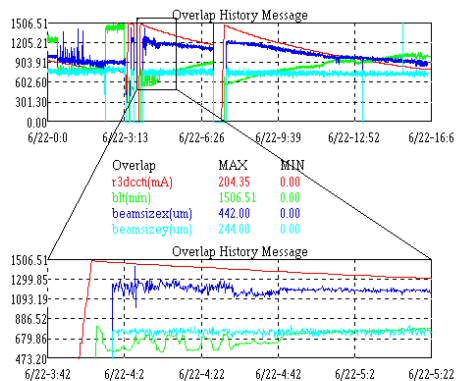


Figure 3: Illustration of the function “ZOOM”.

3.4 Merit

The value of Merit function indicates the overall storage ring operational satisfaction to the users. It was defined based on the users expected to the beam quality and the operational electron beam parameters. The Merit function is defined as follow:

$$Merit = \frac{\int_{user_time} I(t) \frac{A+1}{[A + \sigma_x(t)\sigma_y(t)/\sigma_{x0}\sigma_{y0}]} \frac{B+1}{[B + \Delta I(t)/\Delta I_0]} \frac{C+1}{[C + (\tau_1 t + \tau_0)/\tau(t)]} dt}{\int_{user_time} \frac{I_0 \tau_0^{1/\tau_1}}{\tau_1 t + \tau_0} dt}$$

$I(t)$: storage ring beam current

I_0 : maximum stored beam current during the user's shifts (200 mA)

$\tau(t)$: electron beam lifetime

τ_0 : expected beam lifetime in the user's time (600 minutes).

τ_1 : the slope of beam lifetime during the user's shifts (0.5 hr/hr).

A, B, C: the parameters of beam cross section, beam stability, the weighting factor of beam current and lifetime, respectively.

σ_{x0} , σ_{y0} : the preset value of the beam sizes of horizontal and vertical components (280 μ m, 80 μ m).

$\sigma_x(t)$, $\sigma_y(t)$: the data of the beam sizes of horizontal and vertical components which is recorded in the archived file.

$I(t)$: storage ring beam stability.

I_0 : Preset value of the beam stability (0.3 %).

When the storage ring performance is as expected, the Merit equals to 1. If the performance is better than the preset case, the Merit becomes larger than 1. Usually, the Merit is less than 1 and it indicates user's expectation for beam quality improvement. Since the Merit provides fundamental information on operation statistics, therefore it shall be carefully recorded. For example, the Merit of user's shift and machine study are calculated separately. Typical example of the weekly report of storage ring operation data is given in Fig. 4. The analysis of this weekly data is then performed by Merit function and the result is shown in Fig 5.

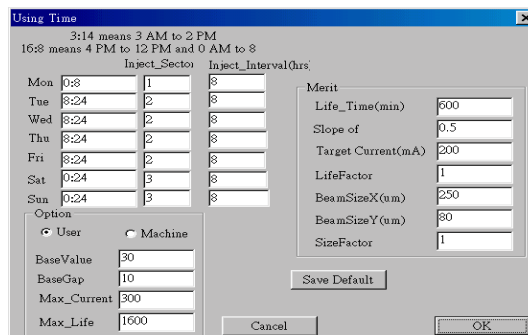


Figure 4: Tuning parameters table of the Merit function.

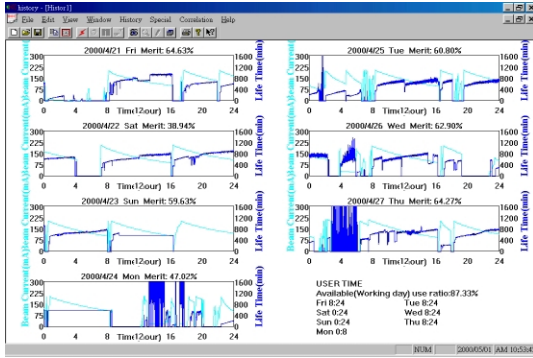


Figure 5: Example of the weekly operation statistics

3.5 Drag and Paste

This function is developed with multi-windows capability, therefore the user can use it to get the data from different servers and put onto the same window. For example, the storage ring beam current, radiation monitoring, and vacuum histories are stored in the different data servers and are retrieved and displayed separately as shown in Fig. 6. By applying the “drag and paste”, these correlated data sets can be displayed on the same window as shown in Fig. 7.

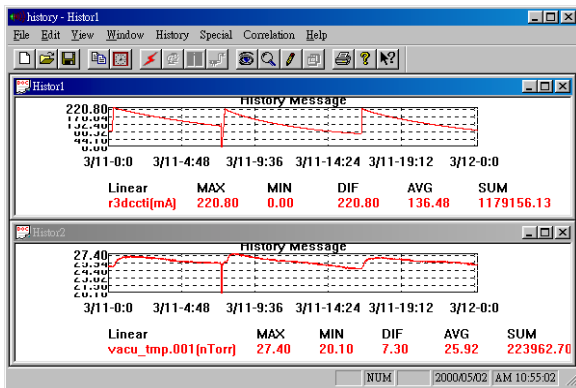


Figure 6: Two sets of archived data from difference servers

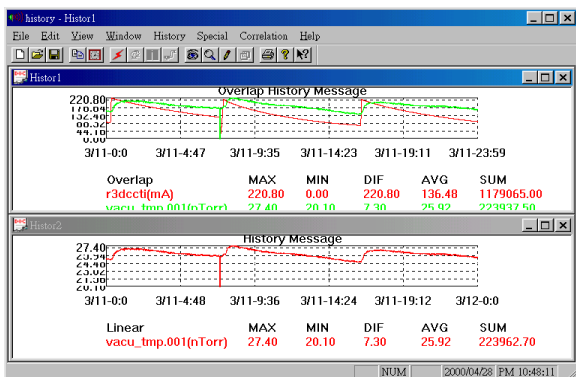


Figure 7: The archived data in the lower half window is “drag and paste” to the upper half window.

4 CORRELATION PLOT FOR BEAM STABILITY STUDY

A typical example to illustrate the application of correlation plot for beam instability analysis is described in the following paragraph.

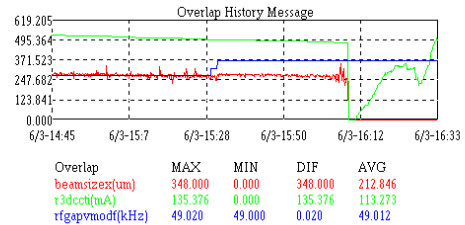


Figure 8: Correlation plot of horizontal beam size, storage ring beam current, and rf gap voltage modulation frequency.

Figure 8 displays the correlation between horizontal beam size (beamsizex) and the rf gap voltage modulation frequency (rfgapvmodf) before the beam was lost at 16:10. Before 15:30, the beamsizex was varied due to the instability occurred in the stored electron beam. At 15:30, the rfgapvmodf was adjusted so that the beam became stable and the beam size stop fluctuating. However, the electron beam became unstable again at 16:05, as shown in term of beam size variation. Since there was no action taken to stabilize the electron, e.g. by tuning the rf modulation frequency, the beam was finally lost at 16:10.

The examples given in both figure 1 and figure 2 also shows similar trick in stabilizing the electron beam. The correlation plot demonstrates the capability of searching wide range of correlated parameters.

5 SUMMARY

In this report, the major properties of the program “history” have been described. It provides the capability of accessing archived data of accelerator monitoring system from different data servers. For comparison and finding correlation purpose, examples shown in this report demonstrate the usefulness and flexibility of this program. Its application to the beam stability study has made contribution in searching sensitive adjustable parameters for a stable electron beam operation.

REFERENCES

[1] G.H. Luo, Glory Lin, K.T. Hsu, C.C. Kuo, I. Hsu, “The Correlation Plot and Phenomena Analysis from Archives Data”, Barcelona, EPAC96.