Utilization of trend Data for Reliable delivery of Treatment Beam

Y. Kanto*1 , Y. Iwata*2, , M. Kawashima*1, S. Sato*2, E. Takada*2, H. Uchiyama*1

*1) Accelerator Engineering Corporation, 3-8-5 Konakadai, Inage, Chiba 263-0043, Japan

Email : aechebt@qst.go.jp

*2) National Institute of Radiological Sciences, 4-9-1 Anagawa, Inage, Chiba 263-8555, Japan

Abstract

Most important ingredients of reliability in particle-therapy accelerators like HIMAC are reproducibility of a treatment beam as well as prevention of unexpected down time.

In order to realize reliable operation of medical accelerators, we take trend data of many parameters. For example, water flow of magnets has been re-adjusted during bi-weekly maintenance according to recent trend data, so that we could prevent interlock by flow- meters.

Analyzing trend data in long term may be more important and rewarding. It was known that a treatment beam has faint fluctuation in a beam position, as measured by beam monitors. Due to this fluctuation, correction of a position had to be frequently made by steering magnets. By taking long term trend and analyzing them, we found that this fluctuation would have seasonal characteristic. Thus, we optimized parameters of the steering magnets to minimize the effect of the fluctuation, and hence eliminated frequent re-tuning.

This and other cases will be discussed in the present report, together with future prospects.

Trend in Beam supply operation

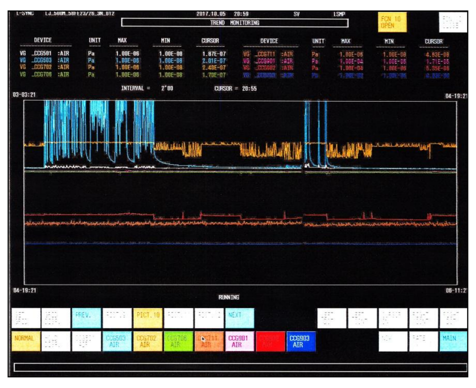

Fig 1 Trend of vacuum in operation room monitor

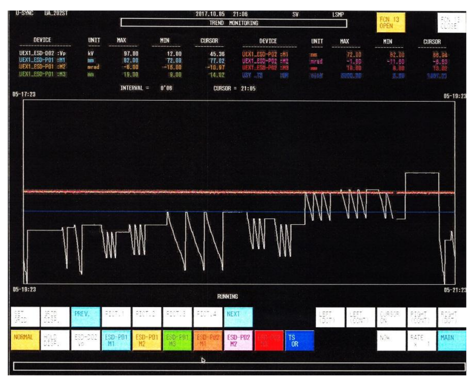

Fig 2 Trend of Electrical current of Magnet

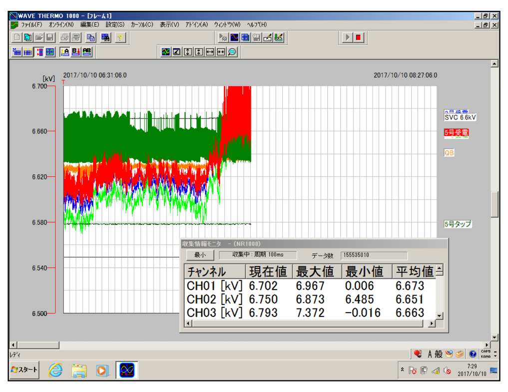

Fig 3 Voltage of facilities

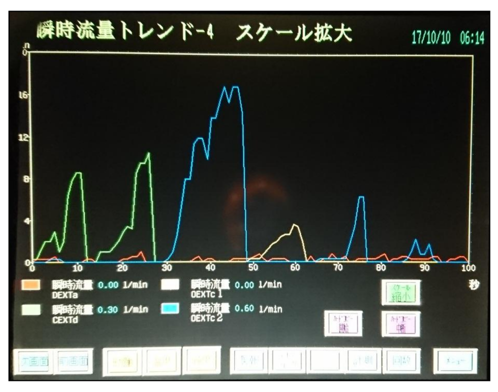

Fig 4 Amount of cooling water supply

In beam supply operation at HIMAC, we use various trends to grasp the equipment status.

However, the trend data used for monitoring is relatively short. These trends range from 2 hours to a few days, which is not suitable for tracking long-term variation.

Therefore, we are trying to grasp long-term variation by using long term trend Graph

OPTIMIZATION OF TREATMENT BEAM PARAMETER

By tracking the fluctuation of the beam center, parameters of the treatment file were optimized.

By determining the appropriate amount of electromagnet excitation, it was possible to reduce the additional adjustment due to becoming out of limitation. This made it possible to use the beam more steadily and promptly.

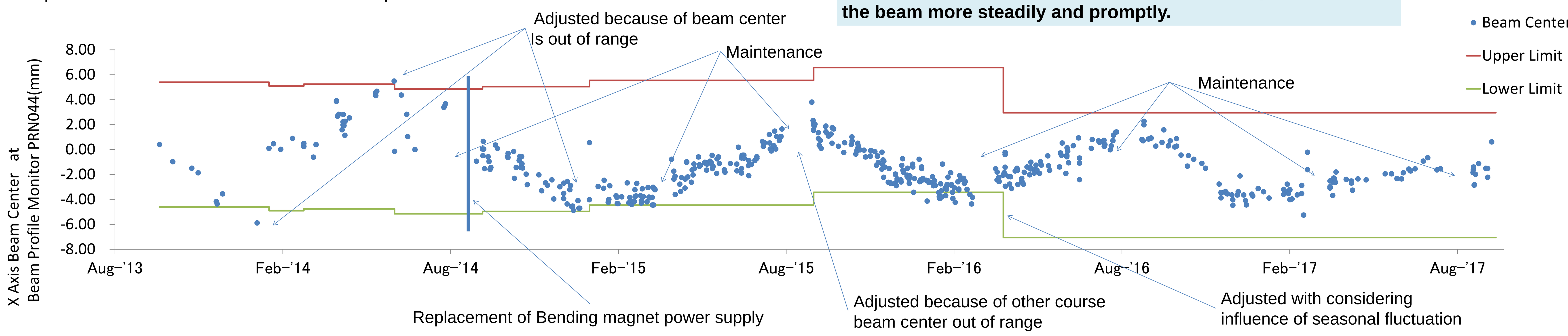

Fig 5 Fluctuation of C350MeV/u beam center at beam profile monitor PRN44

・X axis
Horizontal direction of beam extracted from synchrotron

・Y axis
Vertical direction of beam extracted from synchrotron

・Upper Limit , Lower Limit
Limitation to ensure broad beam flatness for treatment. When this limit is exceeded, the excitation amount of the steering electromagnet is adjusted. Every time the setting file of the therapeutic beam ,which include electromagnet excitation amount and beam profile monitor reference, is updated, ±5 mm on the X axis and ±3 mm on the y axis are set as new limits with reference to the beam center at the semi-nondestructive monitor.

・Beam Center
The beam is measured by a semi-nondestructive beam monitor at up stream of irradiation room. Beam confirmation is performed by using the beam center position in the beam monitor.

Variable factor of beam center

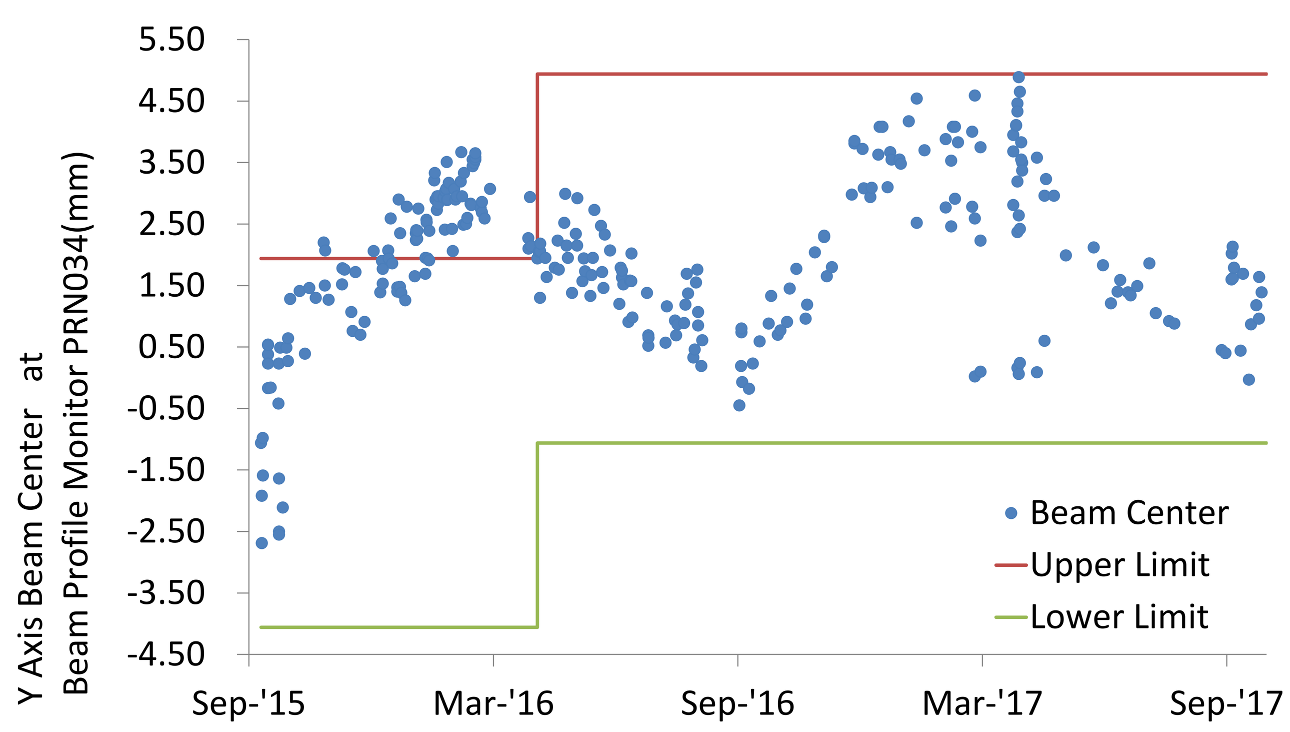

Fig 6 Y axis beam center at beam profile monitor PRN034

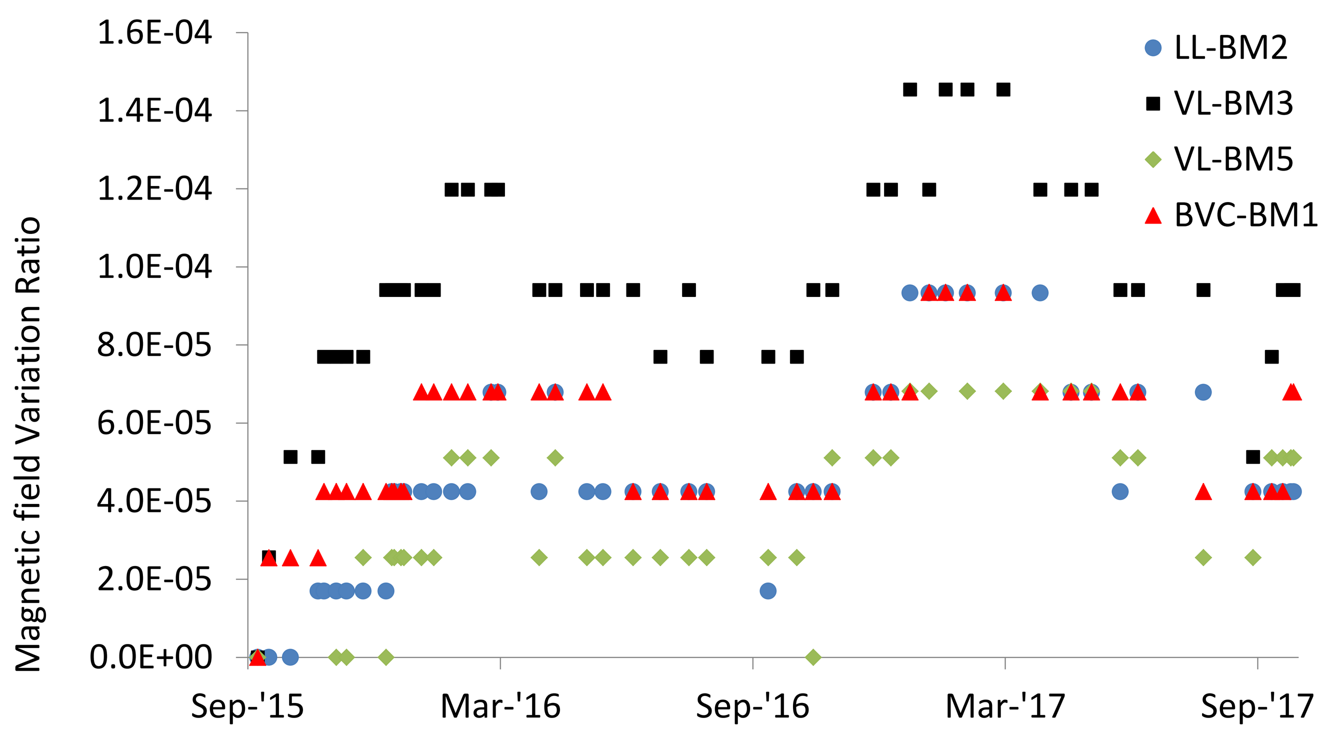

Fig 7 HEBT bending magnet magnetic field variation ratio C350MeV/u

Magnetic field fluctuation is suspected as a factor of these fluctuations. We are currently tracking changes in these fluctuations.

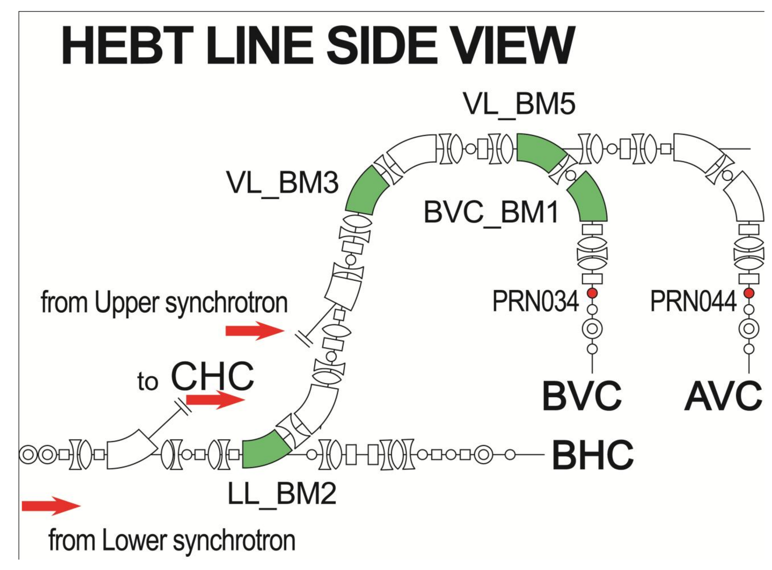

Fig 8 Side view of high energy beam transport line

Evaluation of lifetime of beam shutter

We evaluated the vacuum deterioration accompanying the increase in the number of beam shutter operations, controlled deterioration and controlled beam shutter life time.

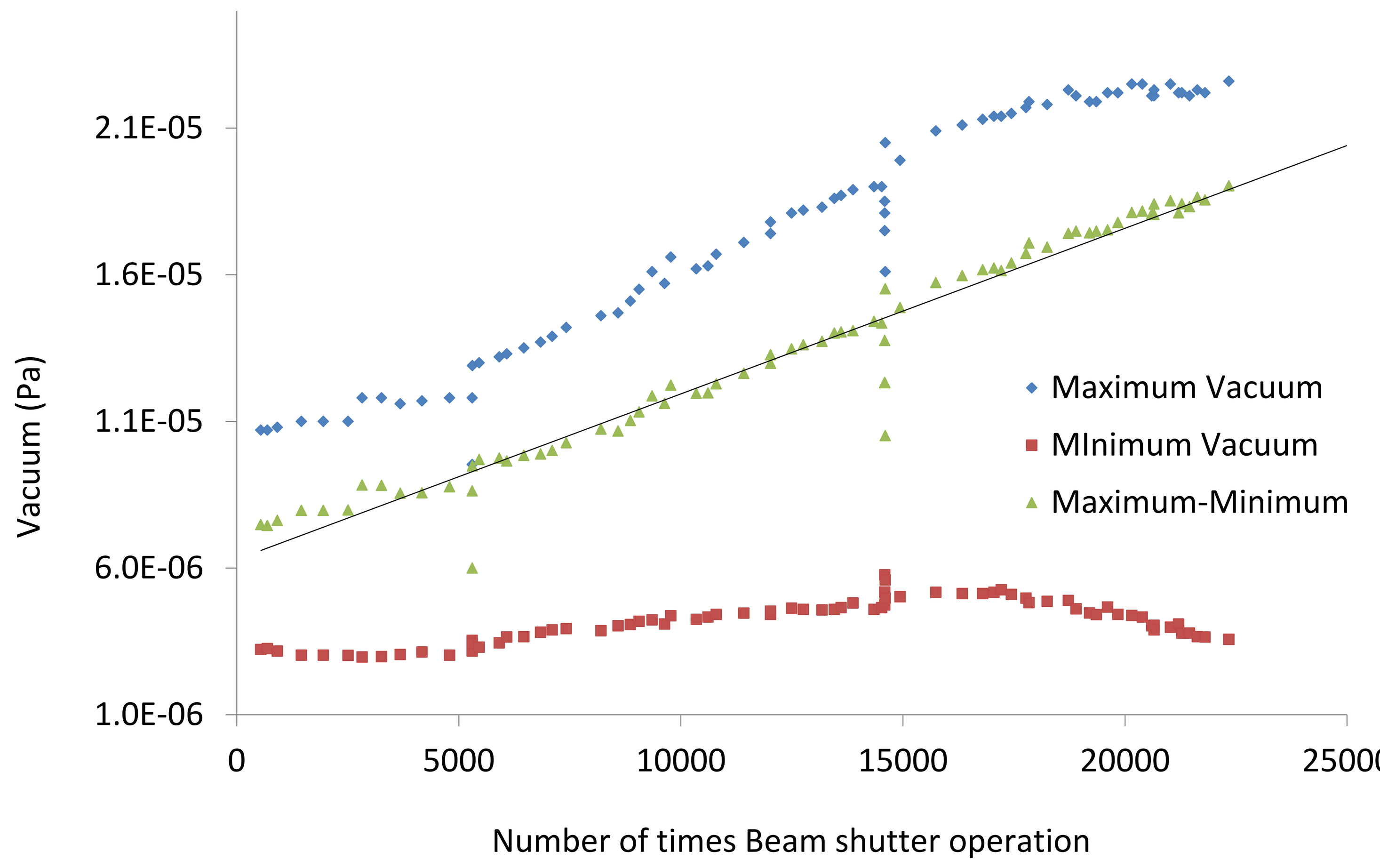

Fig. 9 Vacuum gauge value near the beam shutter and number of beam shutter operations

Although the maximum value of the vacuum tends to increase with the number of operations of the beam shutter ,it dose not necessarily correspond to number of times of operation ,it is difficult to predict beam shutter exact life time.

However, we could predict the lifetime correctly with looking at the difference between maximum and minimum value of the vacuum. Because deterioration of vacuum was turned out that the vacuum worsened at a constant pace with the number of operations.

We controlled deterioration of the vacuum and extended beam shutter life time to completion of beam shutter spare on the basis of the prediction.

・Minmun Vacuum (at Beam shutter close)
Maximum vacuum every 5 days

・Maximun Vacuum (at Beam shutter open)
Maximum vacuum every 5 days

・Number of times Beam shutter operation
Count up started when vacuum leak begun.

Summary

We optimized magnet excitation parameter of treatment beam by using long term trend of beam center. As a result, we succeeded to reduce additional time for adjustment of the parameter.

We evaluated deterioration pace of vacuum. And we predicted beam shutter lifetime and economized on the number of beam shutter operations on the basis of the evaluation. By doing this, we controlled deterioration of the vacuum and beam shutter lifetime.

Problems

Past trend data is divided and saved into files generated every several hours. Thus it is difficult to promptly check long-term trends.

Setting values of various instruments of HIMAC are often changed depending on beam energy and experimental conditions in a day. therefore trend data is needed to edit to get specified situation data. It prevent us from smoothly trend using.

Future tasks

It is a future task to make a system that allows each operators to quickly and easily extract the necessary information from the past trend data to quickly grasp of device change.