

BEAM HALO MEASUREMENTS USING VIBRATING WIRE AT THE KOMAC*

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Abstract

In high-intensity particle accelerators, due to the fact that preventing beam loss plays a crucial role in conducting any experiments, it is important to measure and control the beam halo. Fortunately, it is feasible nowadays to measure the beam halo region thanks to the development of several sensitive beam scanning methods, including the vibrating wire technique. Since the vibrating wire is exceptionally sensitive to the heat deposition by the beam particles, it can be used to scanning the beam profile. This study will be concentrated on the precise beam profile measurement using the vibrating wire at the Korea Multi-Purpose Accelerator Complex (KOMAC) facility. First, we describe the best condition to construct beam profile measurement experiment. Finally, we present the results of the beam halo measurements performed with 20 MeV proton beam at the KOMAC facility.

INTRODUCTION

There are many types of scanning methods of beam profile which is fundamental in high-intensity beams to meet the demand of increasing beam-driven experiments at the moment. By developing unprecedented high-intensity and good quality of the beams, it makes us possible to investigate a diverse of scientific realm such as finding new particles, cutting-edge cancer therapy, mine detection, ion-cutting and defence applications, etc. Under the support from Korean government, user program is underway for 100 MeV and 20 MeV high current proton linear accelerator. One of the main tasks that has to be developed is that diagnosis of the beam to provide beam in a better quality. To realize this, Vibrating Wire Monitor (VWM) technique is being used to scan the beam to decide whether the beam is provided properly. It is based on the wire's natural frequency which is dependent upon on its Vibrating wire's tension and temperature. Once the particle penetrates the wire which leads to change its tension, its resonant frequency is also changed compared to initial frequency. Also, the Vibrating wire must be tightened in accordance with their own initial frequency of its wire by the analogy of each experiments. With characteristic property of VWM, high sensitivity of the frequency to colliding particles has been achieved to facilitate the experiment. In this experiment, VWM was installed on the 20 MeV proton beam and diagnose the beam with high sensitivity.

Experiment Set-ups

On the table, experiment to identify the influence of convection was conducted in advance to the experiment at the KOMAC, and 80 mm-large aperture with 0.1 mm-diameter Stainless-steel wire is used to test circumstance with convection and without convection. As you see in Fig. 1, it is identified that there's a big difference about frequency shift after blocking convection like Fig. 2. Approximately 25 Hz of frequency shift was occurred before blocking which give us a result of nearly 1 Hz of frequency shift with its initial frequency [1].

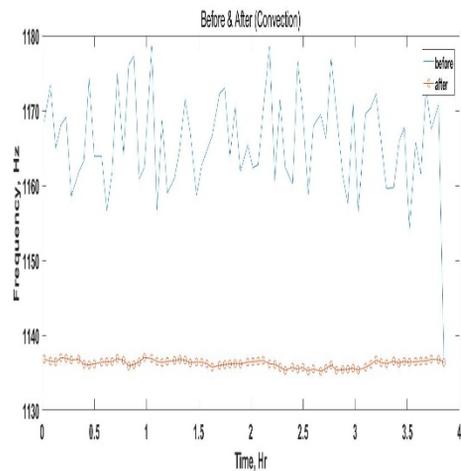


Figure 1: Comparison figure before blocking the convection and after.

COMPARISON FIGURE



Figure 2: Before box is installed to block the convection vs after it is blocked.

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KOMAC Experiment

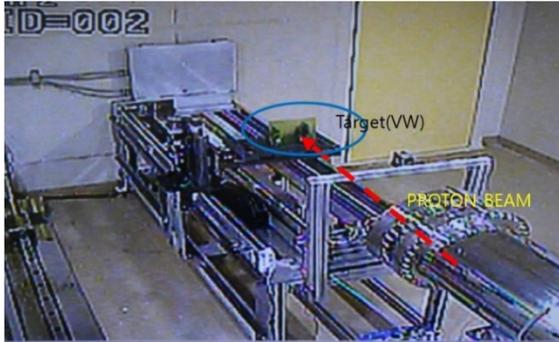


Figure 3. Inside the room of proton beam targeting the Vibrating wire.



Figure 4. The Vibrating wire with convection protection with a collimator (Collimator D=30 mm).

Table 1: VWM Experiment Condition at the KOMAC

Parameters	Value
Energy(MeV)	20
Mean current(nA)	100
Repetition rate(Hz)	1
Energy spread(%)	<1%
Wire length(mm)	80
Wire type	Tungsten

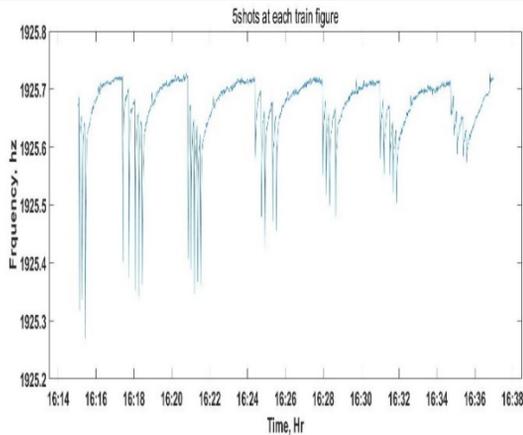


Figure 5: 5 shots in 60seconds at same position with 4mm-step/2mins.

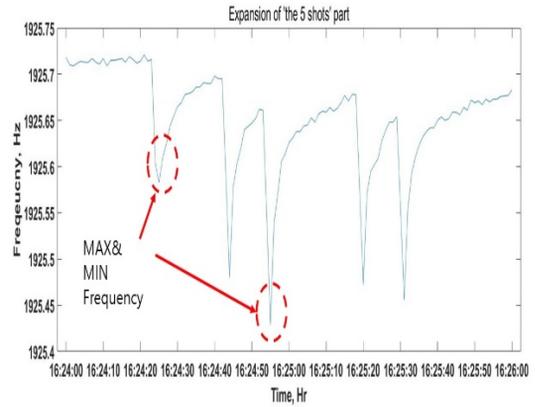


Figure 6: 2 irregular value shots compared with 3 relatively regular shots.

The experiment of 5 proton shots in 60 seconds with 4mm-step/120 seconds with result is shown in Fig. 5 and it is done by under the condition of 20MeV energy with Tungsten wire (Table 1) like Fig. 3. In addition, collimator was used like Fig. 4 to make the beam more aligned. However, it was very rare to get the result in the way that we pursue; each single shot of protons in a regular magnitude. Therefore, to plot the beam profile with respect to the position that the protons were shot, maximum and minimum magnitude of shots were deduced among 5 shots like Fig.6. As a result, the plotting Fig. 7 was done by this data and the slightly tilted beam was detected from our measurement [2]. Also, it is identified that the result since it corresponds to frequency shift calculation result (Table 2).

Film scanning the beam right nearly at the point of Vibrating wire is shown in Fig. 8, and to compare with the beam profile construction plot in Fig. 7, Fig. 9 has been made by using one of each colour intensity. It can be easily observed that the plot from Fig. 7 and 9 has a similar look and which can be lead to the truth that the experiment result from Vibrating wire monitor is correlated with the result from the film as slightly tilted figure is also shown in the Fig. 9 as well.

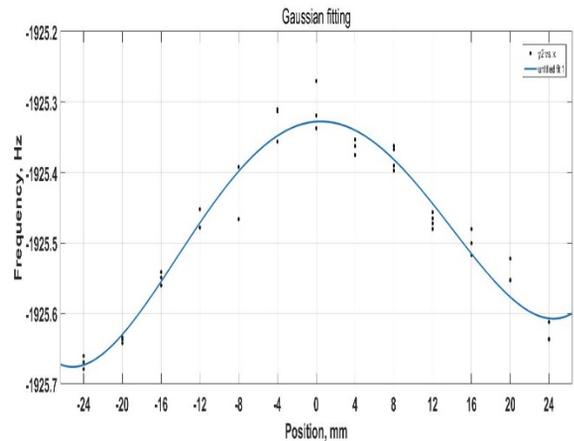


Figure 7: Beam profile construction.

It is shown that the beam is somewhat moved from the centre position from the Fig. 9. Furthermore, since the Figs. 9 and 7 is correspond to each other, it is possible that the problem of beam diagnosis can be solved by VWM.

Besides of frequency, owing to the fact that the temperature is another important factor, Fig. 10 shows the temperature inside the target room and detected as very stable [3].

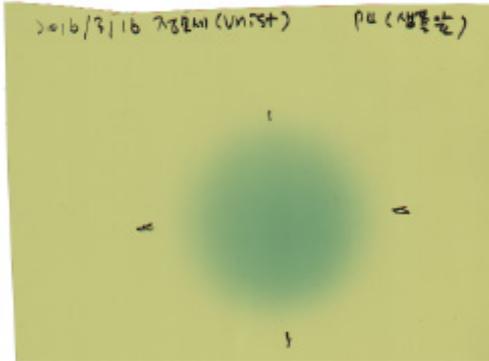


Figure 8: GAFCHROMIC Type HD-V2 film attached right in front of Vibrating Wire.

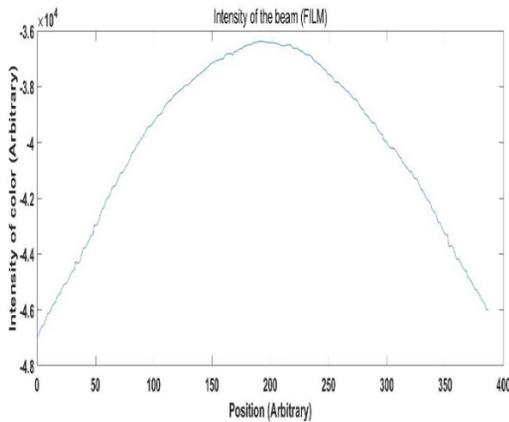


Figure 9: The procedure mentioned above was used to fit a Gaussian curve

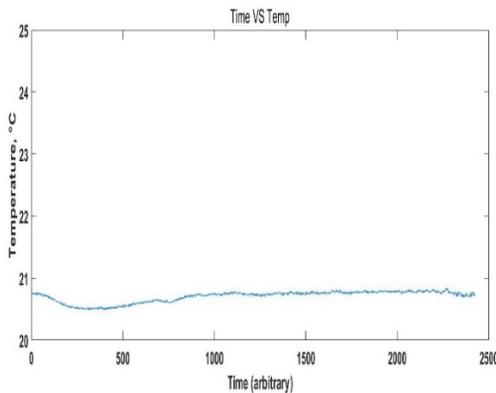


Figure 10: Time vs Temperature inside the proton target room.

Table 2: Theoretical Calculation Results

Parameters	Value
Beam average current	100 nA
I_{TOTAL}	
Part of losses converted into the heat ϵ_{HEAT}	0.37, air
Initial frequency F_0	2000 Hz
Frequency shift ΔF	0.35 Hz
Wire deposited current in center of beam I_p	$2.175E-10$ A,

CONCLUSION

From this experiment, firstly, stabilization of wire frequency has to be achieved by blocking convection from the air and the light as it shows relatively big difference in its frequency.

In addition, it is observed that the beam from source to the target isn't straight as it has to be. Furthermore by the comparison of frequency shift calculation derived from the loss rate, VWM can play a role as a diagnostic tool for very sensitive beam profile.

This application is planned to use in the future project such as study of LASER beam profile and neutron beam measurement by using Gd-coating based wire.

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