ISBN: 978-3-95450-208-0 doi:10.18429/JACoW-IPAC2019-MOPRB028

APPLICATION OF WCM IN BEAM COMMISSIONING OF RCS IN CSNS

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Abstract

Wall Current Monitor (WCM) is the only beam instrument in RCS of CSNS. It is utilized to derive many kinds of physics parameters during beam commissioning. The longitudinal phase distribution of the bunch over the boosting time is deduced for our future analyzation.

INTRODUCTION

China Spallation Neutron Source (CSNS) is a neutron source, with designed beam power of 100 kW. The layout of CSNS is shown in Fig. 1 [1]. The accelerator is mainly composed of an 80 MeV Linac and a Rapid Cycling Synchrotron (RCS). The Linac accelerator accelerates the beam of H^- to 80 MeV, and then injects the beam into the RCS with a repetition rate of 25 Hz. After transferring over the two stripping foils, with two electrons stripped out, H^- Beam turns to proton beam. The RCS boosts the proton beam in 20 ms, and then the beam is kicked out to the target throw the RTBT. During the 20 ms boosting process, the kinetic energy of one proton increases from 80 MeV to 1.6GeV, and the proton beam transfers over the RCS about 19600 rings. At the injection time, the cycling period the beam is about 1.95 μs, while at the extraction time, the cycling period decreases to 0.818 μs.

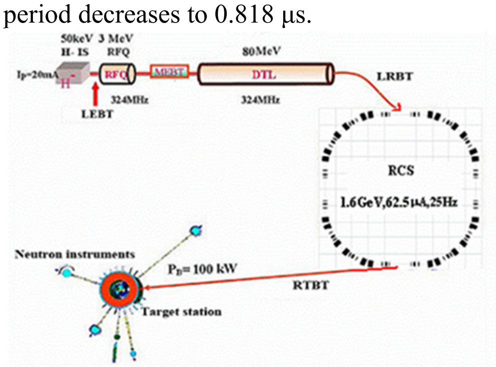

Figure 1: Layout of China Spallation of neutron Source.

A WCM is installed in the RCS. This WCM is running with a sampling rate of 100 MHz over the 20 ms boosting time. The sampling rate has the potential to be increased to 20 MHz. If the wall current over only a small time range, such as 1ms, is concerned, then the sampling rate could be increased to 1 GHz.

APPLICATION OF WCM

The raw data of WCM signal has a length of 2500000. In view of the 20 ms boosting time and the sampling rate of 100 MHz, 2000000 significant figures must be picked out from the 2500000 raw data [2]. These 2000000 significant figures are shown in Fig. 2.

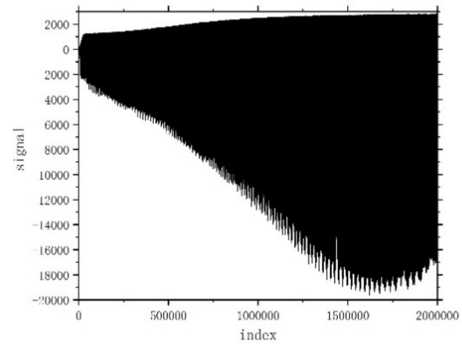

Figure 2: Real wall current data extracted from WCM.

Monitor Beam Current / Beam Charge

After the effective data are extracted, the so-called changing baseline of the wall current is derived in the following step:

(1) Get the positive part of the signal in Fig. 2. The positive part is shown in Fig. 3.

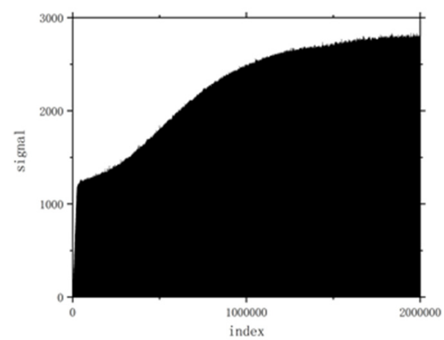

Figure 3: Positive part of the wall current data.

(2) Search the peaks of the signal in the positive signal. The peaks are shown in Fig. 4.Note that here the x axis has been transformed to time in ms unit. Now the curve in this figure indicates the DC part of the wall current. In fact, after multiplying a scale factor, this signal would almost equal to the beam current get from DCCT/SCT.

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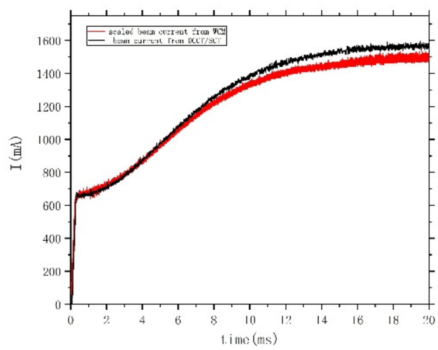

Figure 4: Peaks of the positive part of the wall current data (red) vs. beam current from DCCT/SCT (black).

Figure 4 shows the baseline of the wall current. If this part is subtracted in the real wall current data in Fig. 2, the new signal is shown in Fig. 5.

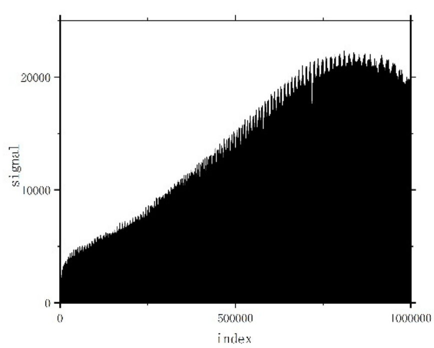

Figure 5: wall current with DC part subtracted. For convenience in data analysing, a factor -1 is multiplied to the signal.

Search the peaks of the signal in Fig. 5, and every peak indicates the bunch in one turn. Then integrating over every peak in Fig. 5, the proton charge changing over the boosting time is derived. Multiplying a factor, the charge changing is compared with the charge data get from the DCCT/SCT in Fig. 6. it is noticed that there is a deviation between the charge data get from WCM and from DCCT/SCT. The problem is the same as that in the Fig. 4. The reason is the nonlinear frequency response of the WCM.

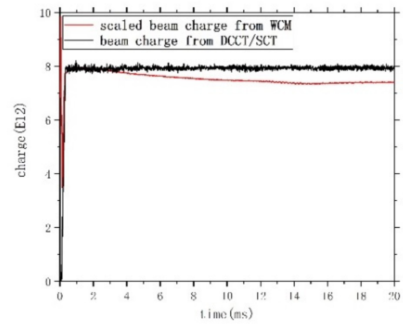

Figure 6: proton charge derived from WCM (red) vs. proton charge from DCCT/SCT over boosting time.

Measure the Bunch Length and Bunching Factor

As every peak of the signal in Fig. 5 has been searched out, then the bunch length and bunching factor could be easily derived. They are shown in Fig. 7:

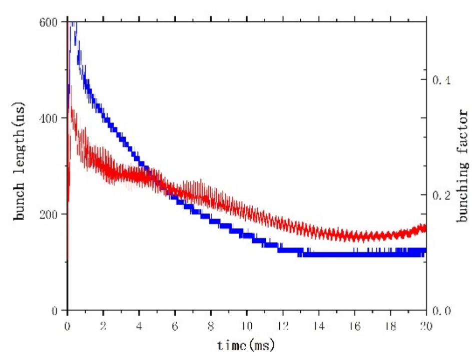

Figure 7: Bunch length (blue) and bunching factor (red).

Measure the Longitudinal Tune

Now search peaks of the peaks of the signal in Fig. 5. Then the synchrotron oscillation period is deduced. The longitudinal tune is shown in Fig. 8. The red squares indicates tune measured from WCM, and the blue curve indicates the tune get from theoretical calculation. The data match well.

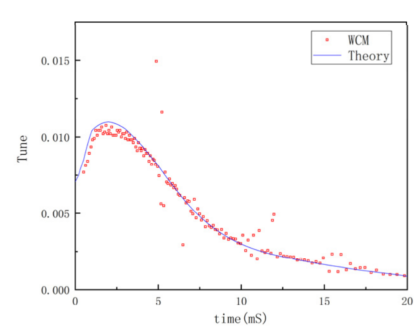

Figure 8: Tune measured from WCM and theoretical calculation.

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Find the Phase Distribution of the Beam over the Boosting Time

The main target of analysing the WCM data is to get the information of the phase distribution of the beam over boosting time.

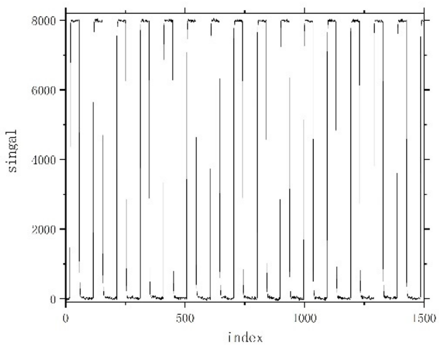

Figure 9: Ring RF gate signal. Take 0~1500 as a sample.

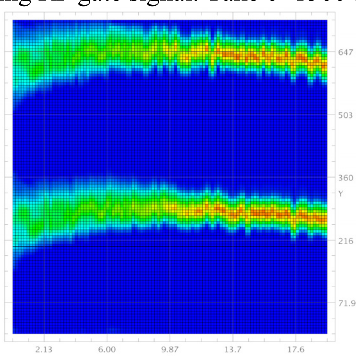

Figure 10: Longitudinal phase distribution of the bunch over the boosting time.

The Ring RF gate signal is used as the reference for analysing the phase distribution of the beam, shown in Fig. 9. The longitudinal phase between two adjacent peaks is defined as 2π.

Compared to the Ring RF signal, the longitudinal phase of the 2000000 WCM data figures could be analysed out. The longitudinal distribution of the bunch is shown in Fig. 10. This is the base for our further analyzation.

CONCLUSION

WCM is a powerful beam instrument in beam commissioning. It is the only instrument for measuring the longitudinal parameters in RCS of CSNS. It has been utilized to deduce many kinds of parameters in beam commissioning, including but not limited to: charge changing, real boosting energy, cycling frequency, bunching factor, bunch length. The main target of analysing the WCM data is to derive the longitudinal phase space distribution, and this is the next work. Fortunately, in this work, the longitudinal phase distribution of the bunch over boosting time has been derived.

REFERENCES

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[2] Wang Shengchang, "The Design of Wall Current Monitor for Proton Accelerator," Master's Degree Thesis, 2012, Institute of High Energy Physics, China.