STATUS OF BPMS IN THE FIRST STAGE OF COMMISSIONING AT CADS INJECTOR I*

H.Z. Ma#, J.S. Cao, Y.F. Sui, Q. Ye, IHEP, 100049, China
Key Laboratory of Particle Acceleration Physics and Technology,
IHEP, Chinese Academy of Science

Abstract

The paper will introduce the status for BPMs in the first stage of commissioning at CADS (China Accelerator Driven Subcritical System) Injector I. The measurement principles and results of BPM at injector I are presented. The measurement of BPM is rigorous in the first medium energy beam transport line of CADS Injector I. To ensure the safety of test cryomodule, beam orbit should be corrected to the minimized region. The third order fitting way is used to calculate the position of beam for BPM non-linearity. And the average of data in the single pass window should improve the resolution. Then BBA of BPM can help tracking beam position accurately. Finally the interlock circuit of BPM is tested with the beam.

INTRODUCTION

China Accelerator Driven Subcritical system (CADS) is a strategic plan to solve the nuclear waste problem and the resource problem for nuclear power plants in China[1]. CADS has two injector linacs named Injector I and II to ensure its high reliability, which are respectively built by Institute of High Energy of Physics (IHEP) and the Institute of Modern Physics (IMP).

With the energy of about 3.4MeV in the first stage of commissioning, the injector I in IHEP is composed of ECR ion source, Low Energy Beam Transport line (LEBT), Radio Frequency Quadrupole (RFQ), Test Cryomodule (TCM), Medium Energy Beam Transport line (MEBT) and beam dump. The layout of BPMs for the ADS Injector I at the first stage of commissioning is illustrated in Figure. 1.

The injector I linac at the test stage includes total 10 BPM detectors of three types, which are strip line, capacitive and button. Two of BPMs are cryogenic mechanical structure. The rest of them are designed to work in the normal temperature environment. Here are the parameters of BPMs and beam characteristics as Table 1.

Table 1: The Parameters of BPM and Beam Characteristics of 3.4 MeV C-ADS Injector I

Parameter	Value
Electrode type	Strip Line /Capacitive/Button
Beam pipe diameter	30/50/35 mm
Beam max displacement (with ref. to beam pipe)	50%
Position accuracy	±100um
Position resolution	30um
Beam energy	3.4MeV
Bunch repetition rate	325MHz
Beam pulse length	30us-CW
Pulse repetition rate	5Hz/10Hz
Peak current	10mA

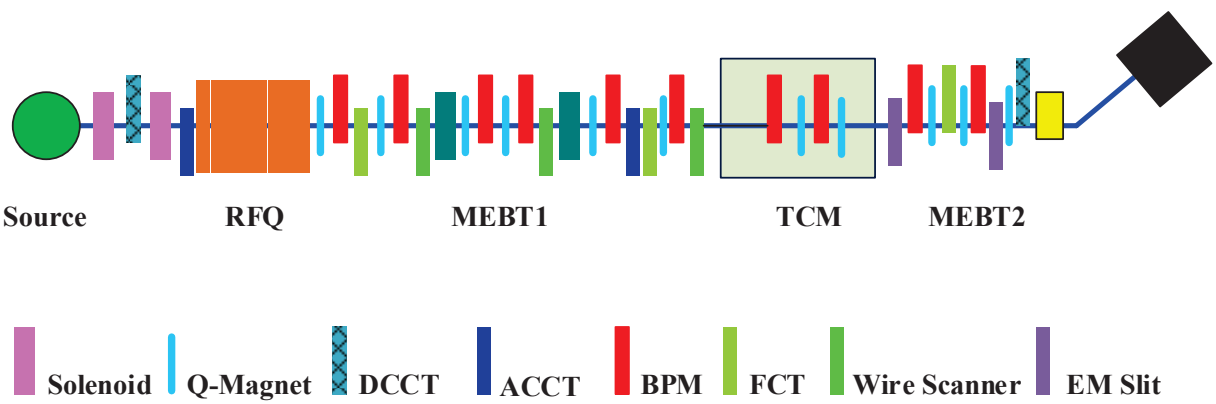

Figure 1:The layout of BPMs of the ADS Injector I.

*Work supported by China ADS Project (XDA03020000)
#mahz@ihep.ac.cn

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BEAM POSITION MONITOR MAPPING

First, the BPM should be calibrated on the test stand before installed on the injector. The standard signal generator is used to do the mapping test. The figure 2 shows the result of mapping for BPM. Then in order to improve the accuracy of BPM, the third fitting way is adopted to decrease measuring error due to the non-linearity effect. The formula 1 for calculating the beam position can be described to be the third order of function. U and V in the formula 1 stand for the normalized data of 4 digitized electrode signal for BPM. The fitting coefficients A and B can be estimated according to the database of mapping. The RMS for fitting error is about 0.2-0.3mm. Finally, the data of measurement for calculating beam position by the formula 1should be more accurate.

$$x = \sum_{i=0}^{3}\sum_{j=0}^{i} A_{i-j,j} U^{i-j} V^{j}$$
$$y = \sum_{i=0}^{3}\sum_{j=0}^{i} B_{i-j,j} U^{i-j} V^{j} \quad (1)$$

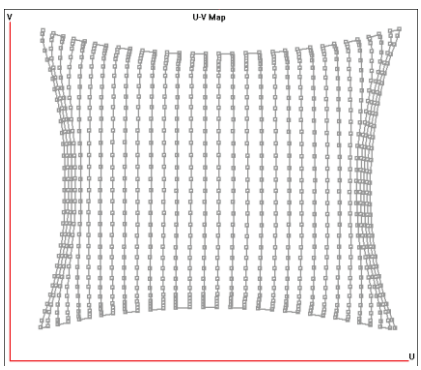

Figure 2: Sensitivity mapping of 4 electrodes for BPM.

THE MEASUREMENT OF BAEM POSITION MONITOR

Signal Processing Electronics

Libera Single Pass H (LSPH) is an instrument intended for position and phase monitoring in hadron and heavy ion linacs [2]. Starting from the four BPM signals, beam position is calculated by delta-over-sum formula. With a stable 325 MHz sine signal using as a reference, the four phases measured by each input are then averaged. Figure 3 shows the status of LSPH equipped with BPM label.

Figure.3 Libera Single Pass H.

DAQ

The data acquisition system of BPM is based on EPICS. The position data obtained by BPM IOC is only linear fitting. Therefore, the new third order fitting way for calculating position. The average of the position and phase data in the single pass window is realized by the soft IOC in the DB level.

Beam Measurement

At the first stage of commissioning for injector I, the Beam Based Alignment (BBA) of BPM on the first MEPT should be carried out. Table 2 gives the deviation of BPM detector from beam centre, which are within 0.5mm.

Table2 : BBA Measurement for BPM on First MEPT

OFFSET	X(mm)	Y(mm)
BPM2	-0.28	0.05
BPM3	0.3	0.08
BPM4	0.055	-0.5

Orbit correction on the first MEPT can be completed according to the BBA test. Stability of the beam orbit should be kept in the range of ± 0.15 mm [3], especially for the safety of spoke cavity in TCM.

INTERLOCK TEST FOR BPM

In the case of injector I, the Interlock of BPM electronics is an optoisolated open collector output [4]. The circuitry outside should be externally connected as shown in Figure 4. Depending on applied 24 V power supply, R should be calculated to not exceed 8 mA over resistor. Finally it is chosen to be 2K ohm.

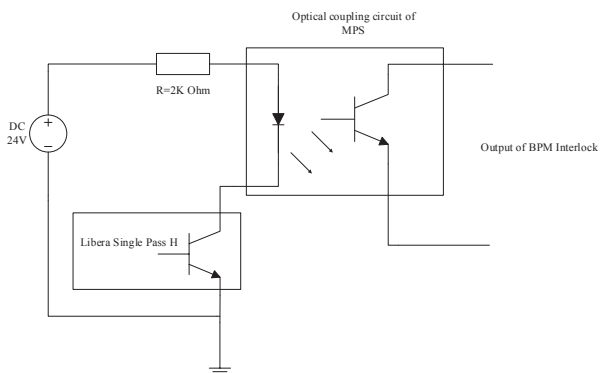

Figure 4: The BPM Interlock Circuit.

The circuitry test with BPM electronics. The output signal is DC high level or negative pulse 5V, which can be checked in Figure 5.

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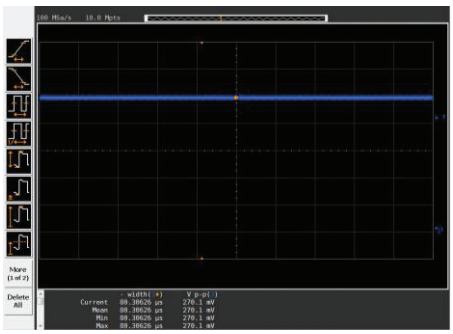
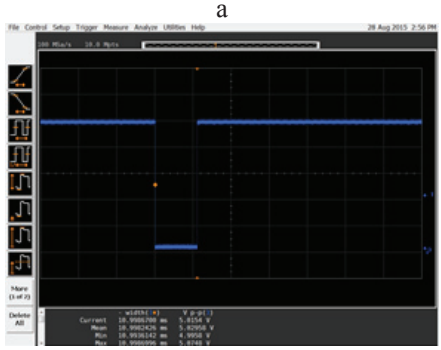


a



b

Figure 5: Output of BPM Interlock. a) Interlock enabled b) Interlock disabled.

CONCLUSION

All type of BPM detectors are installed on injector I linac for the 3.4MeV beam testing. BPM mapping, position data reconstruction by SOFT IOC and BBA improve the accuracy of beam measurement. Preliminary research of BPM interlock guarantees stable operation of the superconducting cavity in TCM. Although the BPMs work well during the operation of Injector I, there is detailed research to be done to optimize the whole system.

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