THE STUDY ON BEAM LOSS CONTROL BASED ON A HIGH INTENSITY RFQ*

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Abstract

A high intensity RFQ has been built with output energy of 3.5 MeV and average current of 3 mA. Based on this RFQ, we plan on performing a number of experimental tests on beam loss control. A series of beam diagnostic devices such as BPM, BLM, WS and so on have thus been developed. Our work can also be easily applied to the CSNS project.

INTRODUCTION

A four-vane RFQ has been built in IHEP. Its output energy is 3.5MeV, and pulse peak current is 46mA. The RFQ cavity that is designed can work in CW mode. Limited by the infrastructure, now the RFQ's maximum duty factor is limited to 20%. The power coupler and end plates of RFQ can't work in CW mode because of its structure. Now the end plate and coupling plate is replaced by water-cooling type.

Based on this RFQ, a plan is carried on beam halo and beam loss controlling research [1]. A new beam line will be built. There are 28 Quadrupole magnets, 14 Wire Scanners (WS) having scraper, 6 Beam Position Monitors (BPM), 6 Steering magnets, 2 Fast Current Transformers (FCT) in the beam line (see Fig. 1).

The total length of the new beam line is about 5.5m. According to the result of beam dynamic, the distance between two Q magnets is 190mm. Thought about the length of magnet itself, it is just left about 63mm for other device. The diameter of the vacuum tube is 36mm.

The first 4 Q magnets are used as matched magnet. The other 24 Q magnets can form FD or FFDD lattice. If the matched magnet working current is adjusted, the beam emittance will be changed.

The beam diagnostics will be discussed in the following sections.

RFQ STATUS

As mentioned above, the end plate and coupling plate can't work on CW mode. The reason is that the stabilized rod is not cooling by water. Just the plate is cooling. When the duty factor of RFQ is increased to 15%, the signal of the RFQ field pickup is little changed. So the RFQ health is cared. The new end plate and coupling plate is manufactured. The plate is made of stainless steel coated by copper and the dipole mode stabilized rod is made of Cr-Cu alloy. And both the plate and rod have the cooling channel.

When the RFQ cavity is opened, what we see exceeded what we imagine (see Fig. 2). There are many little metal flakes around the dipole mode stabilized rod on the inner surface of RFQ. And the copper electroplated coating on the rod is disappeared. So the rod colour is changed from copper colour to stainless steel colour. We think the RF heat evaporation is the main reason.

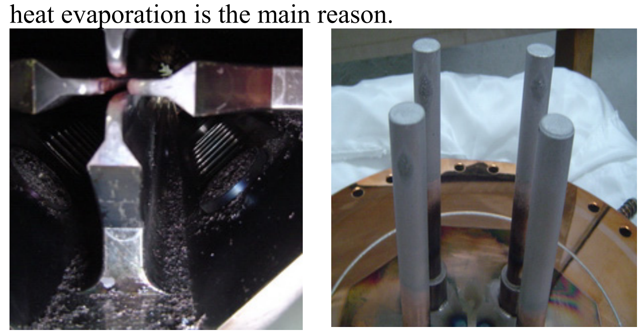

Figure 2: The picture of inner RFQ and end plate.

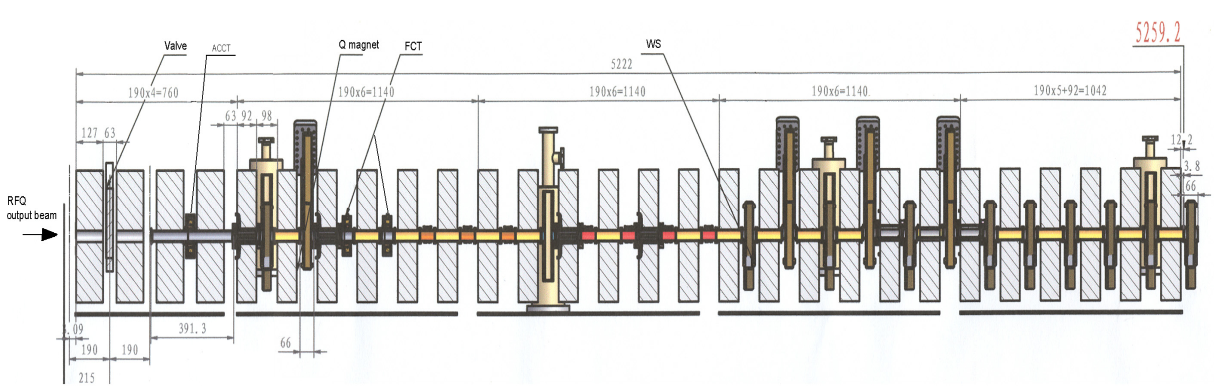

Figure 1: The layout of new beam line after RFQ.

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According to the our situation, it is concluded that for RFQ running in high duty factor larger than 10% mode, it is better to cooling the dipole mode stabilized rod.

Now the new end plate and coupling plate are installed on the RFQ. And we finished low duty factor conditioning of RFQ.

DEVELOPMENT OF BEAM DIAGNOSTICS

As for the beam halo research and beam loss control, many beam diagnostics devices are needed.

BCT

There are two BCT in the beam line. One is located in the beginning of the beam line. the other is located in the end. A whole BCT system that includes the sensor and the electronics is bought from the Bergoz Company. And we will make a set of BCT system by ourselves. Compare the both systems at same situation, we want to find the disparity between the commercial product and self-made product and improve it.

FCT

We bought two FCT sensors from Bergoz Company. Those sensors will be used as beam phase detector. We want to use those two sensors and a BPM to built an online beam energy measurement system by TOF method. The layout of the electronics is referenced to the LEDA method. [2]

BPM

There are six stripline-type BPMs and steering magnets are located in three stations in the beam line. If the halo is formed, the beam size will become larger than the normal. To avoid the beam halo scraped by vacuum tube, the beam orbit should be strictly controlled.

The BPM design is adopted the method of SNS [3]. The dipole mode of BPM is matched to 50 ohm. Because the limited by the beam line space, the BPM is design as Q magnet vacuum tube. So it is naturally formed the separator between the electrodes.

The two prototypes of BPM are made. The mapping of the BPM is measured by using BEPC BPM mapping system. After that, the prototype is installed in the old beam line after the RFQ (see Fig. 3). The Bergoz LR-BPM module is chosen as the electronics of the BPM. We used real beam to pass through the BPM to check the whole system.

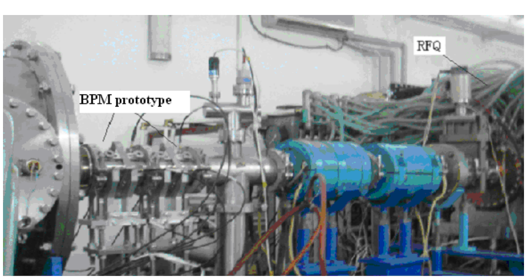

Figure 3: The prototype BPMs installed in the old beam line after RFQ.

The testing result we got is not so good. We got the data is disturbed by the RF system. We will resolve this problem.

The BPM system is also used to observe the LEBT pre-chopper's function. The oscilloscope is directly connected with the BPM electrode feedthrough. Figure 4 is the one of the testing result. The chopped the beam width is about 500ns.

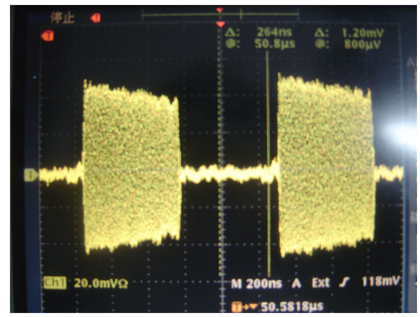

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Figure 4: The BPM signal to observe the pre-chopper's function.

BLM

The BLM design [4] is referenced to SNS design (see Fig. 5) [5].

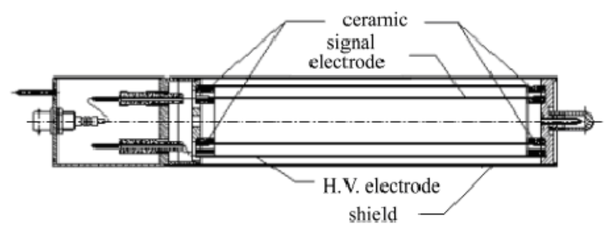

Figure 5: the schematic diagram of the BLM sensor.

The prototype of BLM sensor is tested. The parameters of it are similar with SNS BLM sensor's parameters. The measured BLM sensitivity is about 15pA/rad/h.

After the prototype BLM sensor's research, ten BLM sensors are made. The uniformity of BLM sensor is better than ±7%.(see Fig. 6).

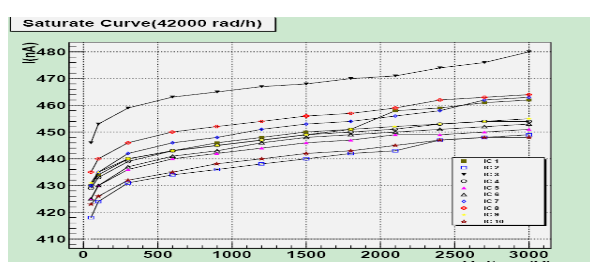

Figure 6: The plateau curve of ten ion chambers at 42000 rad/h.

WS

There are fourteen WS installed in the beam line. The first two WS monitor the parameter of beam from RFQ. Then the last 12 WS divided two groups. The six WS in first group is installed alternately to monitor the X,Y direction beam parameter. The six WS in the second group is installed to monitor just one direction beam parameter. By Used the layout of WS, we can make sure to observe the beam halo.

The structure of WS is similar with the LEDA design. [6] The structure of the WS is show in Figure 7. It has just one signal wire. And at both end it is brazed the scraper to measure the halo beam using integral method.

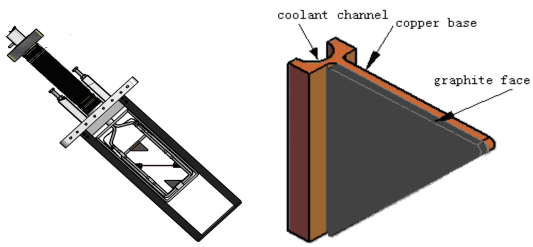

Figure 7: The wire scanner and halo scraper.

We chose the 30μm carbon wire as signal wire. But how to fix the carbon wire to the frame of WS became a problem. Now we plan to solder the carbon wire to the fixture of WS. We adopt the guard ring method to make sure the accuracy of halo beam current measurement.

We will soon test the beam diagnostics device with the 3.5MeV proton beam. Most the work on beam device can easily be changed to CSNS utility. We also own the real situation platform to perform the beam dynamic and the beam tuning research.

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