§13. Construction of 6 MeV Heavy Ion Beam Probe for LHD

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As for 6 MeV HIBP, FY. 1997 is devoted for the improvement of the negative ion source, the measurement of the transmission rate of the sector magnet and the documentation to get official permission from the Government (ministry of Science and technology)

Development of negative ion source.

The negative ion gold source to be used at a tandem accelerator with the terminal voltage of 3 MeV, is a plasma-sputter-type ion source[1]. We started our work by the ion source supplied from Dr. M. Sasao. We introduced various changes

1). We first changed target material from gold to copper for development work, since the same degree of negative current can be expected and copper is much more inexpensive.

2). Then we tried to reduce the electron current on the extraction electrode. Then we changed into LAB6 electron emitter instead of the tungsten filament to increase the discharge current to about 5 A.

3). We had to changed the cooling system of the target electrode from the heat conduction of thick copper rod to water cooling because of the heat consumption due to larger discharge current and LAB6 emitter.

4). The position of the Einzel lens is very critical for the good focusing of the beam. The sufficient distance should be placed between the lens and the intrinsic focus point of the extraction system. We changed the Einzel lens to reduce the required voltage.

By these changes the maximum negative current measured by a Faraday cup with permanent magnets prepared by Dr. M. Sasao is about 20 μA with the reduced target plate of 15 mm in diameter. We may be able to get the negative ion beam of about 100 μA if we increase the target plate size to 30 mm, which may be sufficient in 6 MeV HIBP for LHD.

Although the sufficient current was obtained in the negative ion source, the life time may be a few tens of hours if we extract 20 μA by a smaller target plate. The main factors for short lifetime are cesium and deterioration of the surface of the target plate. Accordingly we tried pulsed operation of 5 second discharge in 1 minute interval. For the pulsed operation we used the tungsten filament. In this case, the negative current rises to about 5 μA or so in one second, and the fairly stable operation for hours was obtained.

Another problem is weather a small hot cell of ion source plasma is necessary or not. We found that the temperature of the hot cell is about 200 to 300 °C in typical constant discharge. The hot cell may increase the consumption of Cs because it will increase the vapor pressure of Cs because of its high temperature and consequently help Cs to go out of the ion source. So we constructed another negative ion source without a hot cell just like a negative hydrogen ion source. This new ion source also works as good as the old one. Presently it is difficult to say that the ion source without a hot cell really reduces the cesium consumption.

Now utilizing two negative ion sources in the ion teststand and in the LHD accelerator , we are now able to accelerate the development of a 6 MeV heavy ion beam probe.

Official permission of the accelerator

We are now able to get the official permission to use the accelerator in the HIBP laboratory from the Agency of Science and Technology. The present conditions of the permission are the maximum beam current of 10 mA, the ion species of Cu^- and Au^-, the maximum terminal voltage of 3 MV.

Reference

1) Y. Mori et al., R. S. I, **63** (1992) 2361.