QUASI-SINGLE-TURN EXTRACTION FROM THE RCNP AVF CYCLOTRON

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In order to realize ultra-precise experience, single component beam is required. Therefore, single-turn extraction from a cyclotron is desirable, but it is generally difficult because of large phase acceptance of a cyclotron. In the RCNP cyclotron complex, single-turn extraction from the Ring cyclotron is realized. However, single-turn extraction from the AVF cyclotron was not realized for a normal operation. Single component beam at the target point was experimentally obtained by means of cut of extraction beam from the AVF cyclotron by beam slits. Reproducibility and long-term stability are, however, not sufficient.

For single-turn extraction from a cyclotron, well-separated beam at the extract point is necessary. Comparing the Ring cyclotron, the AVF cyclotron has 1) smaller main Rf voltage, 2) less number of Dee electrodes and 3) no flat-topping Rf system. The energy gain for one turn of the AVF cyclotron is roughly 100 keV, which is much smaller than that of the Ring cyclotron(over 1000 keV). No flat-topping Rf system causes an energy width in one bunch wider and the beam energies with different turn numbers are easy to partly overlap.

Even though energy gain for one turn is not sufficient for the AVF cyclotron, a turn separation at the extraction point is estimated more than 1 mm and single turn extraction should be possible if the beam is mono-energetic. Using a phase defining slit located in the central region of the AVF cyclotron, it was already reported that a single or two turns extraction was achieved[1]. For normal operation, however, since finite intensities of beams are required for each experiments, restricted components of the beam can be cut out by the phase defining slit. Therefore, generally speaking, it was very hard to realize a quasi-single turn extraction from the AVF cyclotron for a normal operation.

Another equipment to widen a turn separation at the extraction point is a valley coil system. A revolution center of the beam can be changed by this system. Total magnetic field is also the important parameter for beam orbit. The problem is how to use these equipments in a normal operation.

Recently, practical method to obtain quasi-single-turn-extraction beam with finite intensities have been found out mainly by the operators. Firstly normal beams are accelerated and extracted to check whether the total energy of the beam matches injection of the Ring cyclotron or not. Then the beam probe is inserted to the point of 450-mm radius. This point corresponds to the most inner points to ensure isochronous magnetic field. The beam is reduced typically to one-fourth by using the phase defining slit. Injection-beam-buncher phase and amplitude are also adjusted to improve a turn separation at this point. After that, the beam probe is moved to the point of 970-mm radius, a little bit inside of extraction. At this point main coil current is adjusted by 0.02 A, i.e., the magnetic field is searched on the order of 10^{-5}. Then, the beam probe is again moved to the extraction point(about 1000-mm radius) and amplitude and balance of three valley coils are adjusted to widen a turn separation. Finally, amplitude of the Dee voltage is adjusted.

Figure 1 shows observed herium-3 beam current as a function of a position of the beam probe. Extraction energy from the AVF cyclotron was 93 MeV. The absolute value of the x-axis shown here is (radius – 100) mm. Not well, but separated peaks were observed, which means that quasi-single-turn extraction is realized. The final energy and its resolution after acceleration by the Ring cyclotron was 450 MeV and 187 keV, which is the second best result until then. The reason why not the best energy resolution is that single component beam at the target point had already been experimentally obtained, as mentioned above. However, adjustment time became significantly to decrease and long-term stability seemed to become better than before. More precise beam can be experimentally obtained by using these advantages. In fact, after establishment of this method, two experiments required good-quality 450 MeV herium-3 beams were done in 2002. The energy resolutions were 150 keV (the best value) and 165 keV (the second best value), respectively[2].

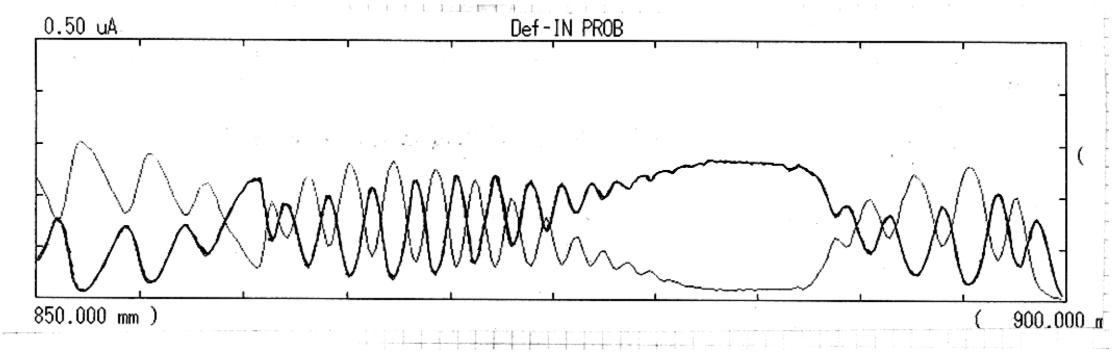

Figure 1 ^{3}He beam current as a function of a position of the beam probe

References

[1] K. Hatanaka et. al., RCNP Annual Report 1982 p.172

[2] S. Ninomiya et. al., elsewhere in this report