BEAM PULSE SEPARATION SYSTEM OF INR LINAC

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Abstract

The activity for beam intensity increasing and beam use efficiency improvement is under progress in INR linac. An important stage is the development and implementation of the Beam Pulse Separation System in the accelerator intermediate extraction area (160 MeV). The system is intended for distribution the beam pulses between Isotope Production Facility (up to 160 MeV) and the Experimental Facility located downstream of the accelerator exit. The report describes the upgrade of intermediate extraction area as well as the first results of experiments with the beam.

INTRODUCTION

INR linac is a medium energy high intensity linac [1]. The accelerator includes an intermediate extraction area where the beam with the energy up to 160 MeV is extracted from the main line and is directed to isotope production facility (IPF). To extract the beam a series of two 13° bending magnets are used. The magnets are of DC type so the total beam only can be extracted. Meanwhile the intensity of the beam is sufficient to be used simultaneously for both IPF and experimental facility located downstream of the accelerator exit. Moreover, the activity of doubling the beam intensity by increasing beam pulse repetition rate from 50 Hz to 100 Hz is in progress [1,2]. That is why implementation of the mode of simultaneous operation of the accelerator for IPF and for experimental facility is of importance. A decision to develop and build a beam pulse separation system for beam distribution has been made. The system including a pulse bending magnet and a power supply has been designed and manufactured in NIIEFA [3]. The pulse magnet replaces the first DC magnet. The system can operate with the frequency up to 50 Hz providing distribution of the beam pulses between IPF and experimental facility in different ratios. In case of 100 Hz mode of accelerator operation up to 50% of the beam pulses can be directed to IPF. A DC mode of the magnet is also foreseen thus providing a full beam direction to IPF.

INTERMEDIATE EXTRACTION AREA UPGRADE

The simplified schematic of the intermediate extraction area is shown in Fig. 1. The length of the area along the main beam line is near 14 m. Besides beam extraction the purpose of the area is to match both longitudinally and transversally the beam with the subsequent structure.

In order to implement beam separation the DC bending magnet #1 was replaced by the pulsed one. To avoid distortions of the magnetic field and heating of the vacuum chamber inside the magnet the latter was replaced by the chamber made of electron-tube glass (Fig.2). Vacuum sealing of the chamber is made with the telescopic joints. For mechanical load relief the bellows are used at each of three chamber ports. To have sufficient space for chamber mounting the distance between the magnets was increased: magnet #1 was translated by 50 mm upstream of the beam and magnet #2 - towards IPF target by the same distance. After installation the flanges of the bellows were fixed with special stays to avoid load transfer to the chamber when pumping and venting the system.

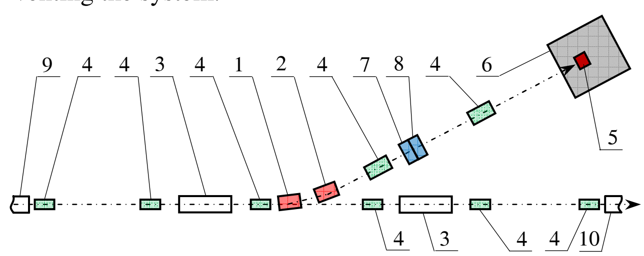

Figure 1: Intermediate extraction area (1 - bending magnet #1, 2 – bending magnet #2, 3 – two-section matching cavity, 4 – quadrupole doublets, 5 – IPF target, 6 – shield, 7 – horizontal beam corrector, 8 – vertical beam corrector, 9 – accelerating cavity #9, 10 - accelerating cavity #10).

Figure 2: Glass vacuum chamber

For beam separation the magnet #1 operates in a pulse mode meanwhile magnet #2 is turned on in DC mode. It was found that the fringe fields of magnet #2 influence the beam moving directly and result in excessive beam loss. The measurements showed that the value of B-field at the beam axis exceeds several hundred gauss and ranges along the beam line for about 40 cm. To eliminate the effect a 60 cm section of stainless steel beam pipe in the vicinity of magnet #2 was replaced by the one made of magnetic steel with the wall thickness of 6 mm. B-field decreased to the level of several gauss thus resulting in no observable influence on the beam. The view of the magnets in the extraction area is given in Fig. 3.

When operating in the beam pulse separation mode the beam matching must be done for both deflected and non deflected beams. For this purpose a separate powering of

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the quads of six doublets is foreseen (two doublets upstream of the magnets, three doublets at a straight line downstream of the magnets and one doublet at the IPF line).

Figure 3: View of the magnets in the extraction area (1 – pulse magnet, 2 – DC magnet, 3 – magnetic screen).

The screen shot of the top of the pulse magnet current is shown in Fig. 4. The pulse represents a portion of a cosine function with the duration at the base of about 13 ms. Stability at the top of the pulse is within ±0.1%. Zero level of the magnetic field between the pulses in the magnet gap is less than 3 G which is smaller than the screened fringe fields of magnet #2.

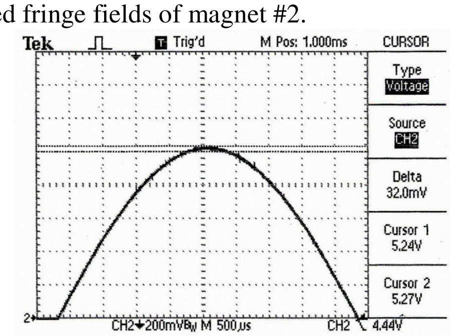

Figure 4: Current of the pulse magnet.

TESTS WITH THE BEAM

To set the beam at the top of the magnetic field pulse the magnet power supply system is triggered ~6.5 ms in advance of the injector. The tests were done with the 158 MeV 1 Hz beam. The beam was deflected to IPF. Beam position was observed with the harp installed in front of the IPF target. No beam position instability was observed. Beam losses in the extraction area and IPF line were observed as well. No increase of beam loss compared with the two magnets DC mode was revealed. The screen copy of information on beam loss is presented in Fig.5.

A smooth shape of the magnet current pulse enables a fine adjustment of deflecting field to be done by changing the delay of triggering within ± several hundred microseconds.

The system was tested for several days with 50 Hz repetition rate and nominal current.

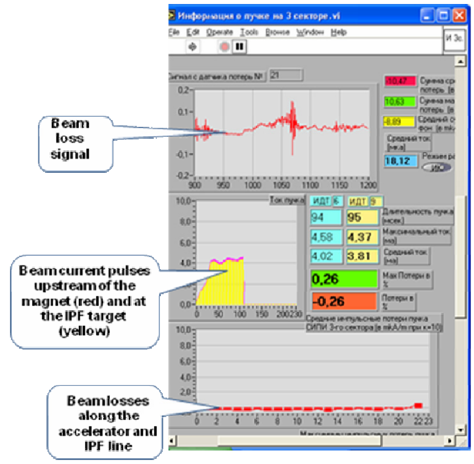

Figure 5: Information on beam loss.

CONCLUSION

Intermediate extraction area of INR linac has been upgraded with implementation of beam pulse separation system. The system has been successfully tested with nominal parameters and the first beam tests have been done.

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