THE BEAM COMMISSIONING PLAN OF INJECTOR II IN C-ADS*

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Abstract

The design work of the Injector II, which is 10 MeV proton linac, in C-ADS project is being finished and some key hard wares are being fabricated. Now it is necessary to definite the operation mode of beam commissioning, including the selection of the beam current, pulse length and repetition frequency. Also the beam commissions plan should be specified. The beam commissions procedures is simulated with t-mode code GPT [1]. In this paper, the general beam commissioning plan of Injector II in C-ADS and simulation results of commissions procedures are presented.

INTRODUCTION

Nuclear energy as a kind of clean energy will be widely used in Chinese energy program in the future. But one of the serious problems is how to handle radioactive waste produced by nuclear plants. ADS, which is the effective tool for transmuting the long-lived transuranic radionuclides into shorter-lived radionuclides, is being studied in the Chinese Academy of Sciences. The road map of the project is shown in Fig. 1.

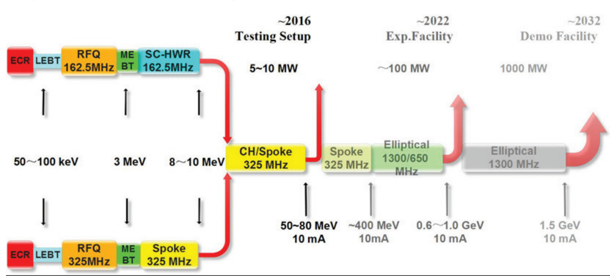

Figure 1: The roadmap of China CAS.

The linac will accelerate the proton with beam current 10mA to about 1.5GeV to produce high flux neutrons for transmutation of nuclear waste.

To ensure technical feasibility in the low energy section, two injectors for the superconduction linac are studded during the first step. One of the injectors, that is Injector II, is been designed and fabricated at Institute of Modern Physics of the Chinese Academy of Sciences.Injector II as part of the ADS is being designed and built at IMP. Injector II is composed of Low Energy Beam transport Line(LEBT), Radio Frequency Quadrupole(RFQ), Medium Energy Beam transport Line(MEBT) and the SC accelerating section. The layout of Injector II is shown in Fig. 2.The LEBT will match the proton beam with 0.035MeV from the ECR source to the RFQ by two solenoids. The RFQ will accelerate and focus the beam from 0.035 MeV to 2.1 MeV simultaneously. The MEBT has two main functions, which are to match the proton beam from the RFQ to the superconducting accelerating section and to place some on line beam diagnostics devices. The superconducting accelerating section will accelerate proton from 2.1 MeV to 10 MeV with 16 superconducting half wave resonator(HWR) cavities. .

The basic parameters of Injector II are listed in Table. 1.

Table 1: The basic parameters of injector II.

Parameters	Value
Particle type	Proton
Operation frequency(MHz)	162.5
Operation mode	CW
Input beam energy(MeV)	0.035
Output beam energy(MeV)	10
Beam current(mA)	10

In this paper, the general beam commissioning plan of Injector II in C-ADS and simulation results of commissions procedures are presented.

THE BEAM DYNAMICS OF INJECTOR II

The MEBT and superconducting section are simulated by TRACK code. The particles distribution out from the RFQ [2] are transported as the initial distribution of the downstream lianc.

The results of the simulation with three-D field map are shown in Fig. 3. The RMS envelopes in both transverse and longitudinal direction are smooth and periodic in the superconducting section. This depicts that there is good matching between MEBT and the superconducting section.

COMMISSIONS BEAMS OF INJECTOR II

The commissions beams will be chopped for the commissioning of RFQ at first stage, then we plan to use unchopped beam for the bulk of the superconducting section commissioning studies. The beam will be consistent with the beam-handing capabilities of the beam diagnostics system in use at the time.

Beam current

The 0.5mA peak current beam will be chosen to be as the initial commissioning study. The reason is we want to reduce the space charge effect as weak as possible to simply the initial commissioning. At the same time the low limitation of measurement dynamics range of the beam diagnostics device should be considered. Also the low current is

* Supported by the National Natural Science Foundation of China (Grant No.11079001)

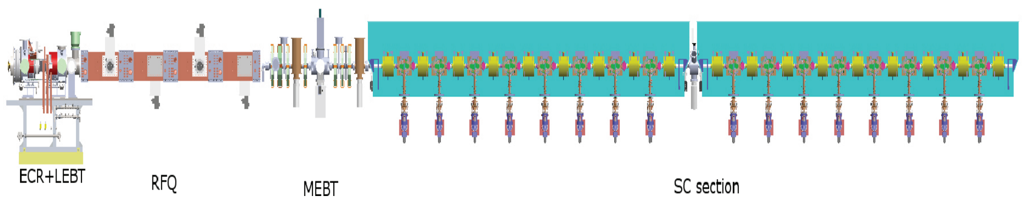

Figure 2: The layout of C-ADS Injector II .

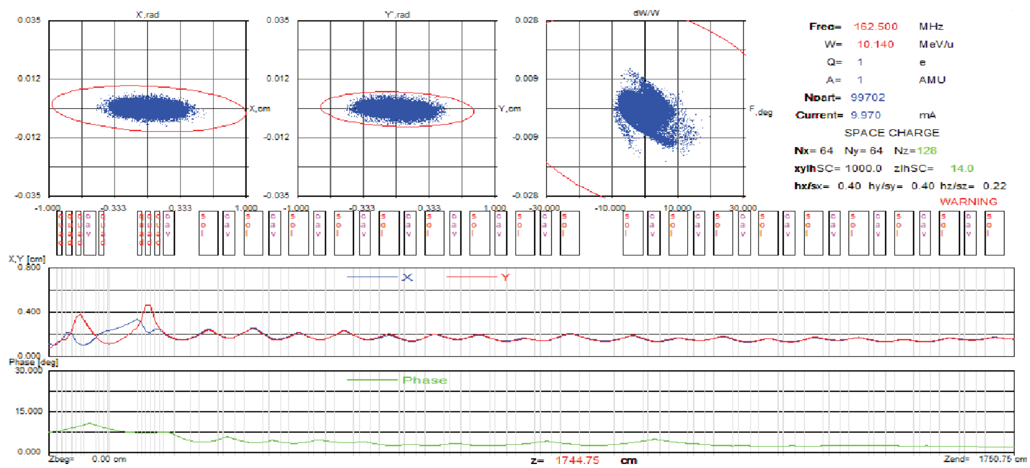

Figure 3: The simulation results of MEBT and the superconducting section.

chosen to minimize dose and activation during initial commissioning. Once the initial linac setup is done, we will increase the current to 1mA, 5mA and finally 10mA.

Pulse length

The pulse length will be set by two factors. One is the limitation of the diagnostics system. The other factor is the machine protect. At the beam commissions stage, the beam will lost on the accelerator element probably. To determine the pulse length, the time dominant code GPT is used to simulated the beam loss in superducting section, which is shown in Fig. 4. . In the Fig.4, the beam loss power distribution is shown supposing the first cavity is broken down. The maximum beam power is 1100W/m. To prevent the quench of superconducting cavity caused by lost beam, the pulse length of commissions at 10mA should be less than 100us.

Repetition rate

The beam commissioning of RFQ will be carried out at repetition rate equal or less that the repetition rate of RFQ RF power supply. Because the energy out from RFQ is 2.1MeV, the radiation activation will be not an issue. For the commissioning of superconducting section, low repetition rate 1Hz will be as initial commissioning beam. "Beam on demand" mode will be used whenever possible and appropriate in order to minimize activation and thermal damage of the hardware by high energy and high power beam.

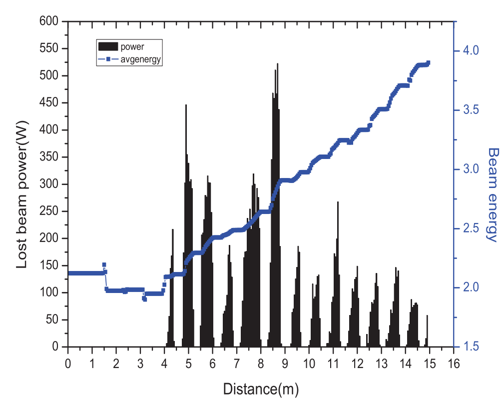

Figure 4: The lost beam power distribution when the first cavity breaks down at 10mA.

THE BEAM COMMISSIONS PLAN OF THE INJECTOR II

In InjectorII, two key sections are RFQ and superducting section. In this paper, the beam commissions plans about this two section are stated. The goal of beam commissions is CW mode at 100KW beam power. An beam dumper will be installed at the end of adjustable HEBT, which will deliver beam with different energy to the beam dumper at different stage.

ISBN 978-3-95450-122-9

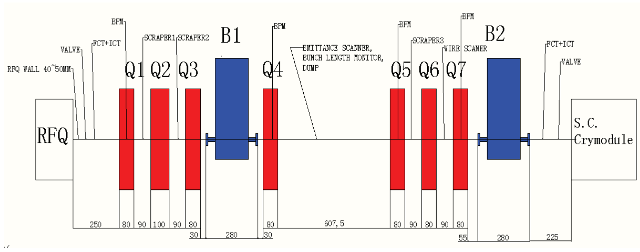

Figure 5: Layout of beam diagnostics in MEBT.

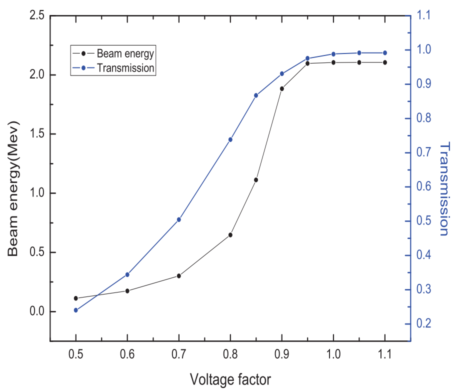

Figure 6: The relation of cavity voltage factor with beam power and transmission.

RFQ and MEBT

The RFQ section will be installed with MEBT at the same time. There are kinds of diagnostics equipments installed at MEBT as shown in Fig. 5. As shown in Fig.5, two sets ICT and FCT are located at the entrance and exit of MEBT to measure the transmission of the RFQ. Also there are other diagnostics equipments to measure the information of beam out from the RFQ, such as emittance, beam halo.

The InjectorII RFQ is designed to accelerated proton beam to 2.1MeV with code PARMTEQ-M [3]. The beam dynamics of RFQ is benchmarked with code TRACK. One of the importance processes of beam commissioning of RFQ is finding the RF operation point by comparing the calculation and experimental results of beam transmission. The simulation results for the beam transmission is given in Fig. 6.

The blue line means the beam transmission rate as a function of the voltage factor, and the black line means output energy evolution with voltage factor. The rehalation can give us an guide in the real beam commissioning experiment.

The superconducting section

For the superconducting section, there are 16 focusing period and one BPM in each period. The BPMs can be used in both transverse orbit correction and RF operation point setting. The RF operation point setting is an main process in beam commissioning. In the tuning of superconducting cavity, first step is to find the synchronous phase. This can be performed by rotating the phase at low accelerating voltage(150-200KV). Two BPMs down stream are used to find the maximum energy increase, which is correspond to zero degree, and then setting the phase to the designed synchronous phase. Second step is to set the amplitude of field, which can be determined by the beam energy out from the cavity. The beam energy variation with the phase is plotted in the Fig. 7. As shown in Fig.7, maximum energy gain correspond to zero degree, the synchronous phase can be find through this way.

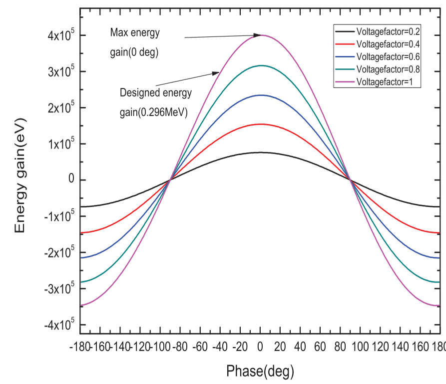

Figure 7: The energy gain of first cavity varying with voltage factor.

SUMMARY

The installation of Injector II of CADS project will start at the beginning of 2013. the commissioning consists of two main stages, RFQ and superconducting section, is scheduled for 2013. The beam commissioning goal is the proton beam power of 100KW for CW 10MeV out from Injector II. The commissioning beam will begin with peak current 0.5mA, pulse length 100us and repetition rate 1Hz.

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