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RESEARCH ON DIGITAL SCANNING POWER SUPPLY TECHNOLOGY FOR PROTON THERAPY SYSTEM

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Abstract

Proton has great advantages in the field of cancer radiotherapy because of its good characteristic of Bragg peak. HUST-PTF is a proton therapy facility under development in Huazhong University of science and technology. It delivers the beam to the patients with a pencil beam scanning nozzle. Scanning power supplies are placed in the nozzle of the proton therapy device and they are required high accuracy, high speed and high stability. In this paper, the structure diagram of HUST-PTF is shown. The parameters of scanning magnets and its power supply are introduced. Finally, some test results of power supply are shown. The next work will debug the control system of the scanning power supply and adjust it with the scanning magnet to see if it meets the design requirements.

INTRODUCTION

The scanning magnet system is the core component of active scanning technology in proton therapy, and contains two pole iron (SMX and SMY) which are vertically placed, and the proton beam is scanned in two directions according to the shape of the tumour [1-4]. According to the treatment requirement, the proton beam is required to form an irradiation area of 30 cm to 30 cm at the isocentre of the Gantry.

The schematic layout of the nozzle in the HUST-PTF is shown in Fig. 1. The proton beam enters in the nozzle through a 30 um kapton window. In front of the window, there is a pixel ionization chamber, it's used to measure the beam profile to verify the beam size and beam position. A chamber filled with 1 ATM Helium gas following the kapton window is used to reduce the scattering effect of the proton beam. Two scanning magnets in X and Y direction are used to control the beam position at isocentre.

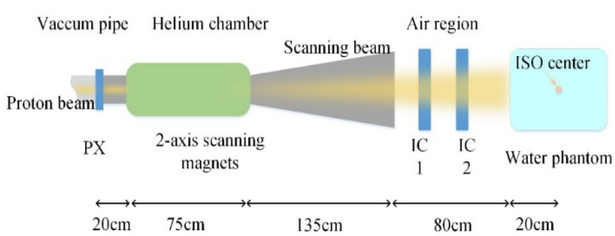

Figure 1: Schematic layout of the nozzle in the HUST-PTF.

PARAMETERS OF SCANNING POWER SUPPLY

The SAD (Source to Axis Distance) in HUST-PTF is designed as 2.45 m, as shown in Fig. 2.

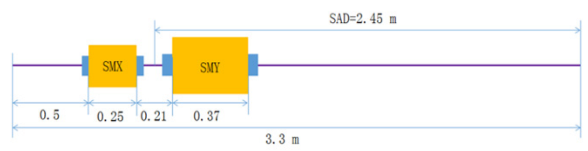

Figure 2: SAD size of HUST-PTF.

The parameters of scanning magnet power supply are specified in Table 1.

Table 1: The Parameters of Scanning Magnet Power Supply

	SMX	SMY
Scanning Field Size@isocenter	30 cm X 30 cm	
Magnet Parameters		
Max. Deflection Angle	58 mrad	70 mrad
Magnet Gap	50 mm	120 mm
Magnet Pole Width	90 mm	160 mm
Max. B	0.55 T	0.4 T
Coil Parameters		
Coil Type	Racetrack	Racetrack
NI (2 coils)	22000 A	40000 A
N	6×6/Φ3 mm	8×8/Φ4 mm
Imax	470 A	420 A
Inductance (2 coils)	6 mH	18 mH
Resistance (2 coils)	40 mOhm	50 mOhm
Power Supply		
Repetition Frequency	100 Hz	10 Hz
Stepping of output current	16 A	15.2 A
Change rate of current	40 kA/s	38 kA/s
Long-term stability	500 ppm	500 ppm

TEST RESULTS OF SCANNING POWER SUPPLY

Under the condition of rated load, the power supply can output current 500 A, as shown in Fig. 3.

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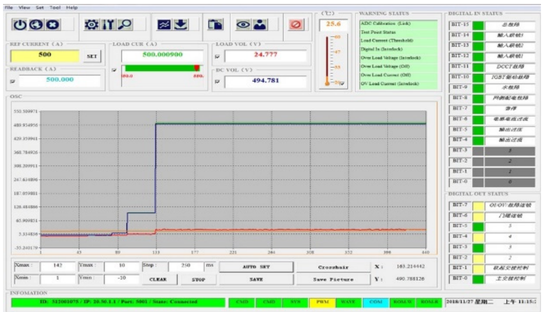

Figure 3: Rated output current test.

The power supply is provided with steps of 500 A to 500 A, and the output current of the power supply is collected by using the oscilloscope TektronicMDO3054. The current rise time is 40000 A/s, as shown in Fig. 4.

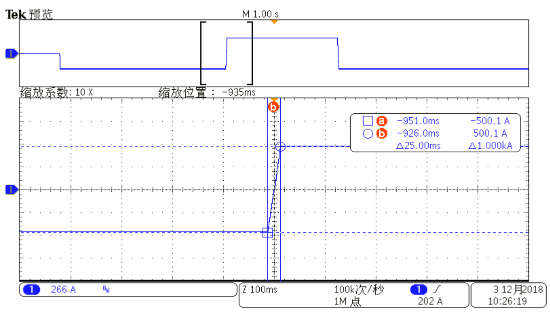

Figure 4: Change rate of current.

The power supply is given 0 A to 96A step 16A a step and the power output current collection is performed using the oscilloscope TektronicMDO3054, as shown in Fig. 5.

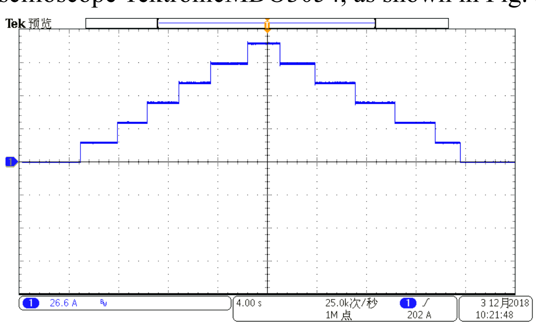

Figure 5: Stepping of output current.

The digital mustimeter uses 20 mS as sampling period, 10 NPLC, high accuracy mode and 10 moving average. The upper computer records the data once a second. Full working current point was selected for testing, and the test time was 8 hours, as shown in Fig. 6.

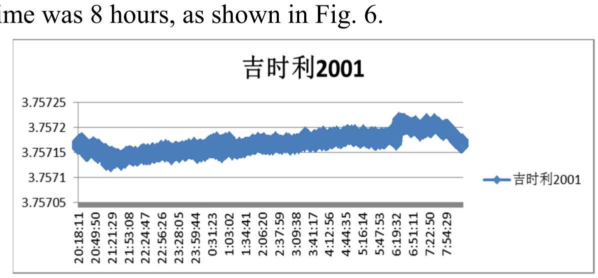

Figure 6: Long-term Stability test.

The Long-term Stability is calculated by the following formula.

$$S = \frac{I\max - I\min}{I_{AV}} = \frac{3.757219 - 3.757123}{3.757168} = 25.5ppm$$

The test result of long-term stability is 25.5 ppm, comply with the design requirement.

CONCLUSION

This paper introduces the basic parameters and some test data of scanning magnet power supply of HUST-PTF. We will debug the control system of the scanning power supply and adjust it with the scanning magnet to see if it meets the design requirements, so as to prepare for the further promotion of the HUST-PTF project.

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