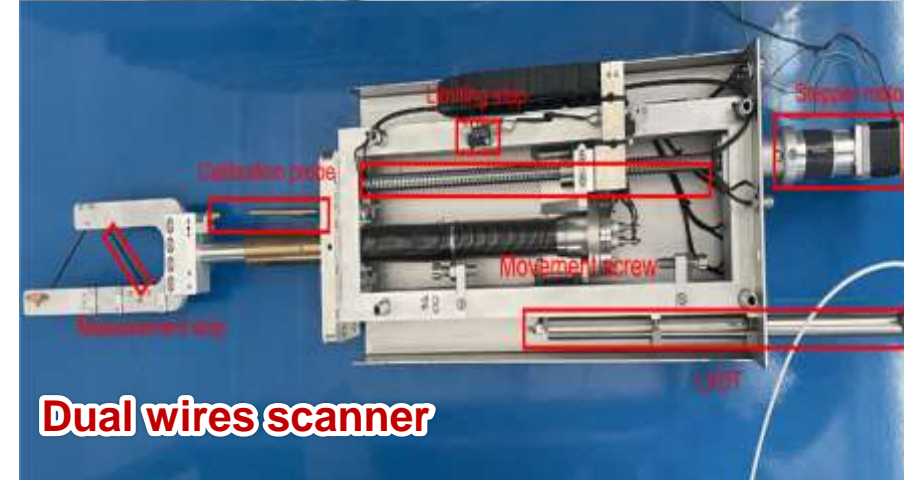
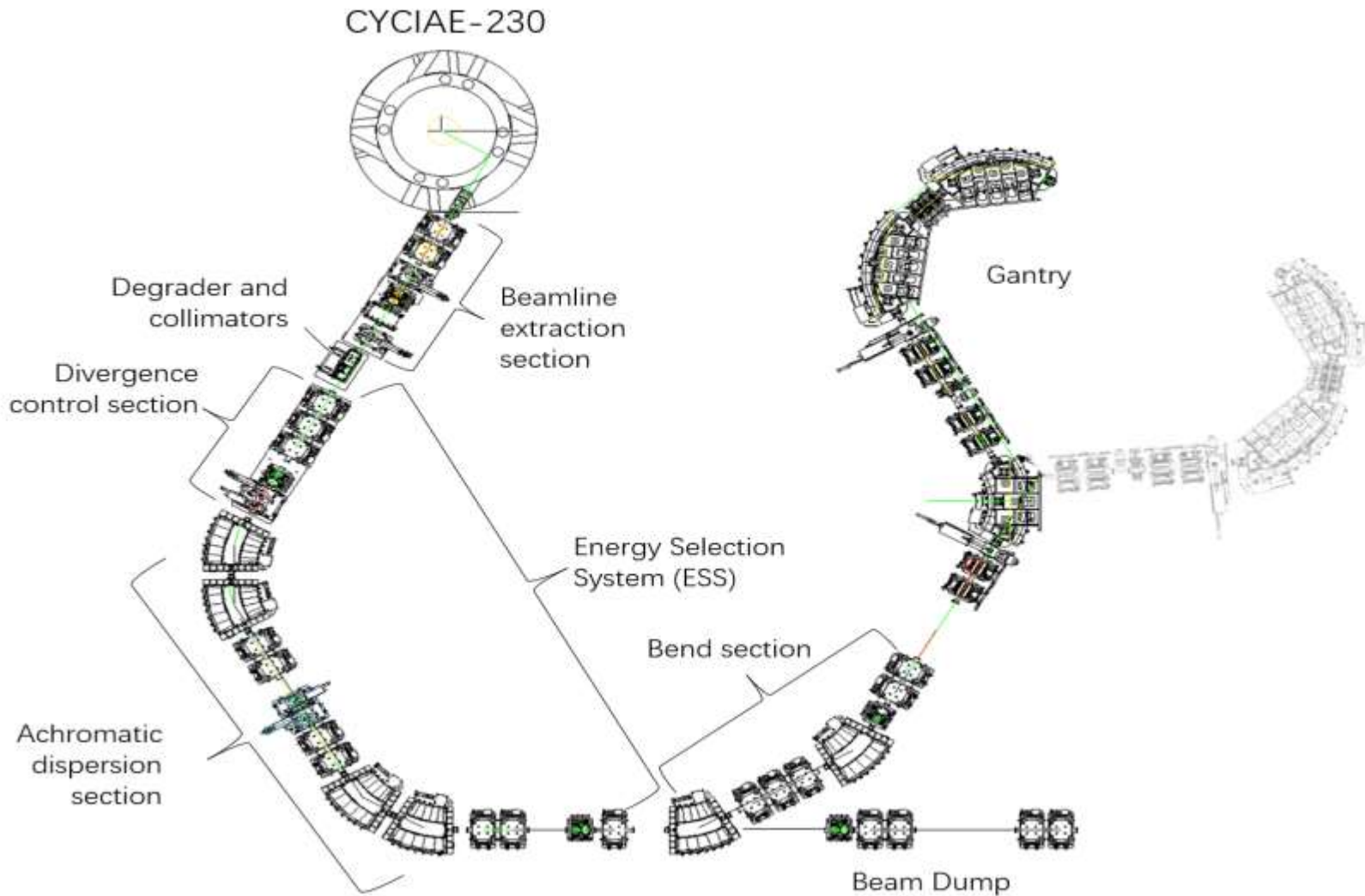


Development and commissioning of the beam diagnostics for CIAE proton therapy system

Yang Wang, Zhiguo Yin[†], Tianjue Zhang, Bohan Zhao, Chuan Wang, Tianyi Jiang, Qiankun Guo, Chuanye Liu, Peng Zhu, China Institute of Atomic Energy, Beijing 102413, P. R. China

#187



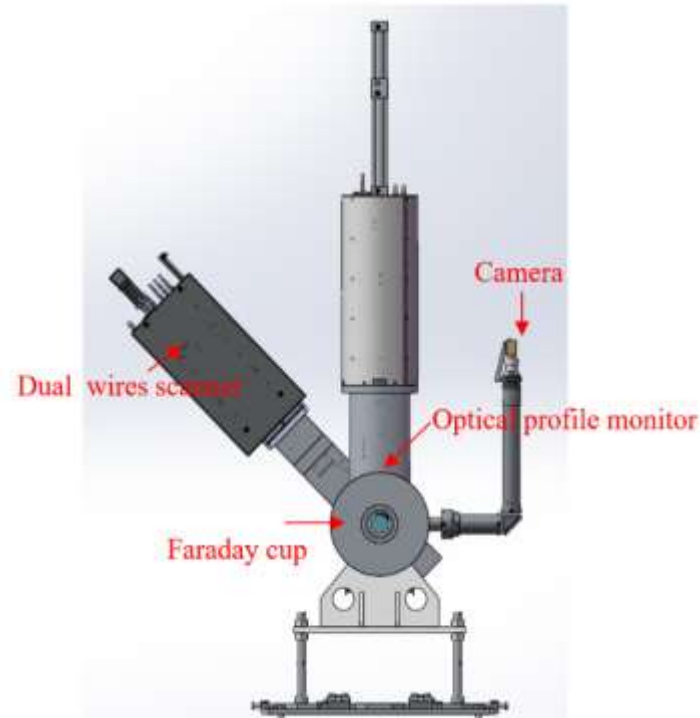
CYCIAE-230 superconducting cyclotron and the Faraday cup, optical beam profile monitor and dual wires scanner

Development and commissioning of the beam diagnostics for CIAE proton therapy system

Yang Wang, Zhiguo Yin^{*}, Tianjue Zhang, Bohan Zhao, Chuan Wang, Tianyi Jiang, Qiankun Guo, Chuanye Liu, Peng Zhu, China Institute of Atomic Energy, Beijing 102413, P. R. China

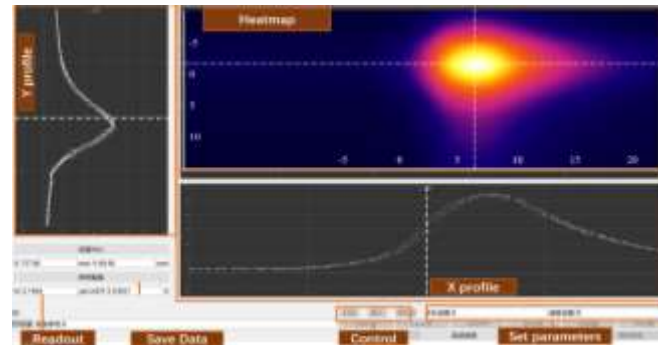
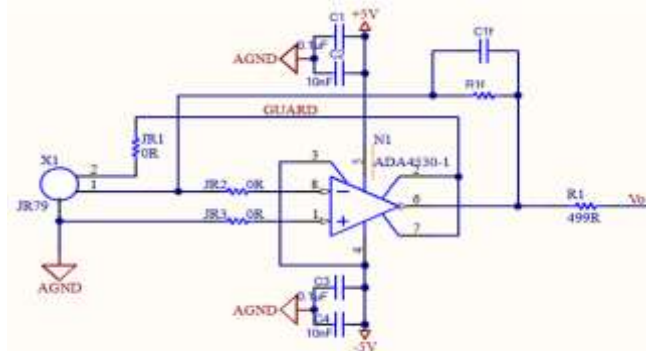
#187

Compact Structure



The comprehensive diagnostic cavity consist of Faraday cup, profile monitor and dual wires scanner

High Gain and Resolution



The gain of electronic can reach **1mV/pA** and the resolution is **0.1mm**

Development and commissioning of the beam diagnostics for CIAE proton therapy system

#187

Yang Wang, Zhiguo Yin^{*}, Tianjue Zhang, Bohan Zhao, Chuan Wang, Tianyi Jiang, Qiankun Guo, Chuanye Liu, Peng Zhu, China Institute of Atomic Energy, Beijing, 102413, P.R. China

ABSTRACT

A superconducting cyclotron based on proton therapy system has been developed at the China Institute of Atomic Energy(CIAE). The system has technical advantages such as high dose rate, fast energy varying, compact structure, and low energy consumption. From the cyclotron to the woods, the beamline employed 51 magnets, including six 36°, one 60°, and two 75° dipoles. Its strict symmetry ensures better beam optics, such as achromatic aberration for a wide energy range beam. The beam diagnostics system has been developed in-house to meet the beam commissioning needs of such high-quality beamline. Along the beamline, the system includes: 1) 7 standardized comprehensive diagnostic units; 2) a pair of X-Y slit for energy selection and emittance reduction; 3) several square circular collimators, fast beam cutoff devices, and online monitoring accessories (chambers for beam position, as well as Faraday cup for measuring beam intensity) in the air section for flexible use. This paper will consider the design of the diagnostic system, the specialized electronics, and the EMC consideration. The dual wire structure for the pA-level weak beam will be introduced. The Ca doped yttrium aluminum garnet (Ca:YAG), which is an excellent scintillation material for proton beam profile measurement will also be presented in detail.

Structure of Dual Wires Scanner

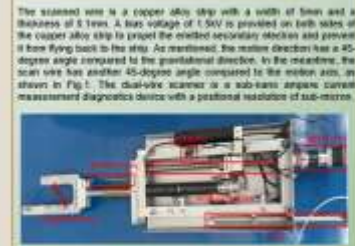


Figure 1. The structure of dual wire scanner

Readout Electronics For pA Level Weak Beam

The dual wire scanner readout electronics chose the ADA4350-1 as the operational amplifier of the IV conversion circuit. Its good properties are suitable for pA scale weak beam signal readout electronics. The scanning efficiency of the dual wire scanner is about 5%. Assume that the extracted beam intensity is 1 nA, the signal intensity detected by the dual wire scanner is about 20pA, therefore, the value of the feedback resistance is 10G ohms. The sensitive of the IV convert is 1mV/pA. It can meet the resolution requirement of the dual wire scanner readout electronics for CIAE-23W superconducting cyclotron. The IV convert circuit is shown in Fig.2.

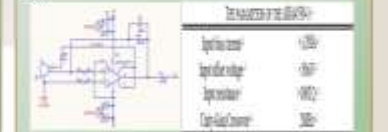


Figure 2. The IV converter electronics circuit and parameters of ADA4350-1

Electromagnetic Compatibility Design

The signal cable adopts tri-coaxial cable, the inner core conductor of the tri-coaxial cable connects the signal source, the inner shield is driven to a protective circuit and the outer shield is grounded.

All the tri-coaxial cables are wrapped in a double-layer shielding sheath to prevent transmission signal leakage and external interference signal intrusion. The structure of the tri-coaxial and the shielding sheath is shown in Fig.3.

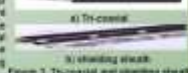


Figure 3. Tri-coaxial and shielding sheath

Beam Commissioning & Time structure

The beam profile monitor can provide position and size of the extraction beam to the physicist. (Fig.4)The software analyzes a digital signal processing technique that discovers the free structure of the beam. The sampling rate is set to 100 MHz, utilizing a Faraday cup to collect the original beam information and detect the edges of the macro-pulses. By calculating the pulse frequency, the number of sampling points per cycle is determined, and the number of samples per macro-pulse is calculated by duty cycle.



Figure 4. The measurement of the BPM

Future Work

The extracted beam intensity of the CIAE-23W superconducting cyclotron is several nA range, the brightness of the beamline for the beam profile monitor is related to the intensity of the extraction beam. CIAE has investigated a material(Ca:YAG) that is particularly suitable for beam profile detection in proton therapy. It has a very low intensity threshold for proton beam profile measurement. This not only prevents radiation damage caused by strong beam intensity to image capture equipment but also shortens the maintenance and replacement cycle of the beam diagnostic system. We will replace the old material(SiC) with this new material(Ca:YAG). This material is shown in Fig.5.



Figure 5. Ca:YAG for beam profile monitor