

# Development of an Innovative Real-Time Dosimetry Monitoring System for Heavy Ion Radiotherapy

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Cancer is the second leading cause of mortality globally. As a critical technological approach in oncology treatment, radiation therapy is evolving from conventional radiotherapy to ultra-high dose rate radiotherapy (FLASH-RT). With the significant escalation in radiotherapy dose rates, real-time dosimetry monitoring faces the dual challenges of enhancing both response time and measurement precision. This work successfully developed a real-time dosimetry monitoring system for radiotherapy, designed to accommodate a broad range of dose rates. The system consists of a dual-gated integrator architecture front-end circuit and a high-speed data acquisition circuit, providing accurate detection of bipolar current pulse signals spanning from  $-190\ \mu\text{A}$  to  $+200\ \mu\text{A}$ , the minimum current measurement range is from  $-1\ \text{pA}$  to  $1\ \text{pA}$ . Two significant technological advancements were accomplished: first, the elimination of signal processing dead time resulted in a reduction of the single-event readout time to  $5\ \mu\text{s}$ ; second, the nonlinear error from  $-190\ \mu\text{A}$  up to the maximum current is within  $0.67\%$ , with a linear correlation coefficient  $R^2$  is  $0.99992$ . The experiments were conducted using an ionization chamber detector at the Heavy Ion Research Facility in Lanzhou (HIRFL-TR4), this system, combined with a dose detector, achieves real-time dose measurement within the dose rate range of  $65\ \text{Gy/min}$  to  $120\ \text{Gy/min}$ . It demonstrates excellent real-time monitoring performance in the high-dose rate range of radiation therapy and shows potential for further application in dose monitoring for electron and proton beam radiotherapy.

Keywords: Real-time dosimetry monitoring, Heavy Ion Radiotherapy, Data acquisition circuit, Analog front-end circuit

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