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# #4-240 SiC Timepix3 Detectors: Characterizing Wide Energy Ranges of Various Particle Types Produced in Medical Accelerators

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Silicon carbide (SiC) detectors have become essential in advancing dosimetry for high-energy and high-dose rate radiotherapy. Achieving accurate dose tracking under high-dose-rate and high-energy conditions requires dosimeters that can withstand challenging environments and provide reliable measurements. Conventional silicon detectors, although sensitive, often experience degradation under such conditions due to radiation damage and thermal and dose-rate dependencies, affecting their long-term accuracy and stability. In contrast, SiC detectors demonstrate resilience under radiation, minimal leakage current, and thermal stability due to their wide bandgap, high radiation hardness, and low sensitivity to environmental fluctuations. The Timepix3 with SiC sensors is a high-resolution radiation detection camera capable of real-time beam monitoring and particle tracking. SiC-based detectors are a strong candidate for precise, stable measurements in complex radiation environments, thus supporting the reliable dose delivery essential for modern radiotherapy applications. This study aims to characterize radiation fields in terms of beam structure, particle tracking, and flux using a novel SiC pixelated detector. Moreover, this work provides methodologies for measuring radiation quality in both primary and mixed radiation fields of various beams including protons, carbon ions, electrons and other particles.

The detector is built with an active 65 µm-thick SiC sensor, bump-bonded to a Timepix3 ASIC chip. This combination functions as a pixelated radiation-sensitive volume, enabling spatially resolved measurements and detailed particle tracking. The detector operates under a reverse bias of +200 V and supports per-pixel energy calibration, enabling the measurement of individual particle interactions within its pixel matrix.

Each pixel measures 55 × 55 µm, allowing for high-resolution tracking of particle paths and energy deposition. The full field-of-view ($2\pi$) and advanced per-pixel electronics facilitate the detection of various radiation types, including protons, carbon ions, electrons and even fast neutrons. The detector's compact build and ease of integration with data processing systems make it well-suited for real-time dosimetry and radiation imaging, supporting precise tracking and dose distribution measurements.

An experiment was carried out at MedAustron. It is a medical facility for proton and carbon ion therapy, where high-energy particle beams are used for both treatment and research purposes. The experimental setup at MedAustron allows for precise control over beam parameters, with protons accelerated to energies between 62 and 250 MeV and carbon ions up to 402 MeV/u. The facility supports high particle fluxes, reaching up to 109 particles/$cm^2$/s in clinical mode. A reduced current mode is also available for proton beams, yielding approximately 105 particles/$cm^2$/s for detailed measurements without excessive particle overlap.

In these experiments, the Minipix Timepix3 SiC detector was placed above the beam isocenter, where single-energy pencil beams were directed at the detector to capture particle interactions. This setup enabled the collection of high-quality data with minimal background interference, allowing the evaluation of the detector's response under clinical particle flux conditions for both proton and carbon ion beams.

The Minipix Timepix3 SiC detector was used to provide single particle tracking of carbon and proton beams. The results demonstrate the potential of the Minipix Timepix3 SiC as a new detector sensor material for quality assurance and beam characterization in various accelerators.

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