Abstract No.: **PTCOG-AO2025-ABS-0116 (Physics)**

Abstract Title: **Direct Energy Monitoring of Carbon Ion Beam with a Radiation-Hard Detector using Time Of Flight Methodology**

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Background / Aims:

- ❑ Carbon ion radiotherapy (CIRT) utilizes the Bragg peak for precise tumor targeting and healthy-tissue sparing.
- ❑ For reliable treatment verification, a parallel-plate chamber (PPC) with a time of flight (TOF) method was developed to measure carbon-ion beam energy precisely.

Materials and Methods:

❑ Development of the PPC and experimental setup

- Designed and fabricated PPC detectors.
- Two PPCs were assembled for measurements and aligned coaxially (22.5 cm / 46.3 cm).
- Tested with four carbon-ion beam energies (102.6–430 MeV/u), three beam intensity within clinical range (low, middle, high)

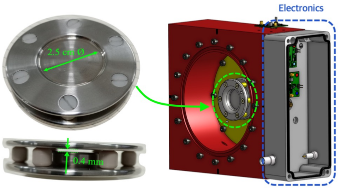


Fig 1. Developed PPC with the detector housing

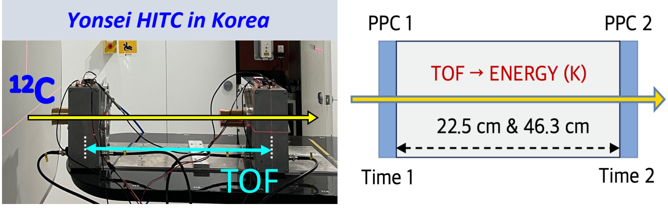


Fig 2. TOF-based carbon-ion beam energy measurement setup

❑ TOF analysis by cross-correlation and range verification

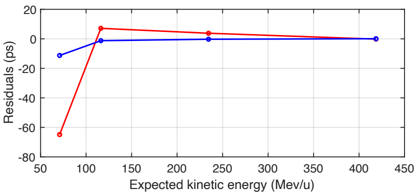
- Cross-correlation was applied to determine time displacement between two PPC waveforms by shifting one signal over another.
- Intensity dependence was corrected, and the final mean TOF ± precision was obtained.
- TOF was converted to energy and then to range.

Results:

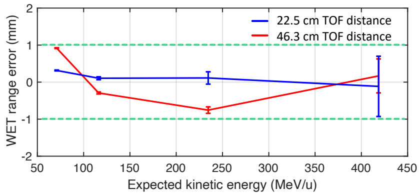
❑ Performance of the PPC-TOF system

- Achieved reliable, spark-free TOF measurements with high stability and consistency.
- TOF precision remained below 1.04 ps, with residual errors < 65 ps (<1.55% of mean TOF).
- Corresponding water-equivalent range errors were within ±1 mm.

TOF difference as function of energy



Range difference as function of energy



✅ **Clinically acceptable**

Conclusion:

Demonstrated the feasibility of independent range verification of carbon-ion beams using a PPC-TOF detector, establishing a foundation for real-time beam monitoring in CIRT.

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