Contribution ID: **717** Contribution code: **THPM075** Type: **Poster Presentation**

Measurements of the Variation of Extracted Beam Current of a Clinical Hitachi Proton and Carbon Synchrotrons and Implications for Particle Therapy

Thursday 11 May 2023 16:30 (2 hours)

Measurements of the extracted beam current (BC) for a Clinical Hitachi carbon therapy synchrotron and a Hitachi compact proton therapy synchrotron are reported for a nominal extracted beam current (BC0) of $\approx$ 10 $\frac{MU}{sec}$ and a sample rate of 5 usec (Carbon) and 8 usec (proton). A noise power spectrum analysis identifies the source of variation to be beam or power supply related. The rise time in the BC has been modelled and estimates of its effect on beam delivery time simulations. Two quantities minMoveT and minMoveMU are defined as the time and dose delivered between spots. Increasing scanning magnet (SCM) speeds of the last decade have implications for these quantities and a model is proposed for the variation in BC from BC0 during the delivery of the spill and compared to measurements. The impact of the variation in BC from BC0 is shown to cause potentially significant dosimetric uncertainties in treatment delivery for modern particle therapy accelerators using fast SCM if plans are not simply beam current moderated or robustly optimized. The variation in beam current is shown to be inconsequential for medical physics quality assurance and commissioning measurements using properly biased ion chambers. Analogous measurements were previously reported for the NIRS/QST synchrotron (1). Comparable results are found for the Hitachi synchrotron when using only the moderated beam current approach instead of the robust optimization approach.

Funding Agency

Footnotes

Inaniwa et al Optimization for fast-scanning irradiation in particle therapy, Med Phys VOL34 pg 3302-3311 (2007)

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Yes

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Session Classification: Thursday Poster Session

Track Classification: MC8: Applications of Accelerators, Technology Transfer and Industrial Relations and Outreach: MC8.U01: Medical Applications