

Fixed Field Accelerators for Particle Therapy

A.F. Steinberg^{a, b, c}, R.B. Appleby^{b, c} and S.L. Sheehy^{a, d}

^a *School of Physics, University of Melbourne, Melbourne, Victoria 3010, Australia.*

^b *Department of Physics and Astronomy, University of Manchester, Manchester, M13 9PL, United Kingdom.*

^c *Cockcroft Institute, Daresbury, WA4 4AD, United Kingdom*

^d *Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Heights, NSW 2234, Australia*

Despite the potential advantages of Fixed Field Accelerator proposals for particle therapy, such as fast energy switching and higher beam currents, none have progressed beyond the design and prototyping phases [1]. Though the case has grown stronger with the emergence of novel therapies, such as high dose rate FLASH, many challenges remain. A key issue is resonance crossing during acceleration, which is inevitable where the magnetic fields are linear: this can be prevented by the addition of nonlinear fields to a baseline linear accelerator, but previous studies have suggested that the result is a significant reduction in long-term beam stability where realistic field errors are included. We present a method for preventing this resonance crossing indirectly, creating a machine where the normalised focusing strength is approximately independent of energy [2]: this removes restrictions on particular fields or geometries, and allows for synchrotron-like insertions that would otherwise be impossible. This design procedure is demonstrated for a Fixed Field Accelerator suitable for ion therapy, where considerations about beam stability and resonances are important for beam extraction. Magnet fringe fields and possible errors are considered, demonstrating that this method can produce robust and achievable Fixed Field Accelerators for cancer treatment.

[1] S. Verdu-Andres, U. Amaldi, & A. Faus-Golfe. (2011). Literature review on LINACs and FFAGs for hadron therapy. *Int J of Mod. Phys. A*, 26, 1659-1689.

[2] A.F. Steinberg, R.B. Appleby & S. L. Sheehy (2022) Tune Control in Fixed Field Accelerators. *Proceedings of the 13th International Particle Accelerator Conference (IPAC'22)*.