Reducing the Environmental Impact of Accelerator Operations using Fixed Fields and Permanent Magnets

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Particle accelerators are used for a wide variety of applications, from ion implantation to cancer treatment. In all there are over 50,000 accelerators globally [1], and their combined lifetime emissions are not insignificant. In recent years there has been an increasing push for 'green accelerators' [2, 3], addressing factors such as the fossil fuel burning to provide power for electromagnets. For Project TURBO, a new beamline is being designed and constructed for the University of Melbourne Pelletron to demonstrate a method for improving charged particle cancer therapy, utilising a 'large momentum acceptance' arc to simultaneously transport many different beam energies without magnet adjustments. Permanent magnets will be used for beam steering and focusing, which will reduce the power consumption during operations and showcase how other accelerator facilities could reduce their emissions. Instead of requiring custom-designed magnet wedges, which could not be re-used for other projects, the TURBO beamline will utilise commercially available magnet blocks inserted into custom mounts such that the magnets can be used for other future projects. Here we present the essential details of the TURBO project, including the design of this novel arc and the beam shaping systems that are required to integrate it with the Melbourne Pelletron. We also discuss how the TURBO magnets will be modelled, measured, and made. Finally, the application of these ideas to other facilities is considered, such that the contribution of accelerator scientists to anthropogenic climate change can be minimised.

1. Doyle, B. L., et al. ‘The Future of Industrial Accelerators and Applications’. *Reviews of Accelerator Science and Technology* 10 (2019): 93--116.
2. *For example*, see the recent 'Sustainable High Energy Physics (HEP) workshop', https://indico.cern.ch/event/1355767/overview
3. Shepherd, B. et al. ‘Sustainability for Particle Accelerators: RUEDI - A Case Study’, 2024