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核融合駆動用加速器のコンパクト化に関する設計研究

Fundamental design of compact high-energy hadron accelerator for nuclear fusion driver

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The application of GeV-class hadron particles to new energy production by using nuclear fusion reactors has been discussed. The engineering techniques to produce high-energy particles have been rapidly developed recently, and the techniques are also used to the NBI (Neutral Beam Injection) for plasma science research and a new study of muon-catalyzed fusion. On the other hand, the electric power conversion ratio of conventional particle accelerators is very low. LINAC has better electric power conversion characteristics and is capable to apply the resonant cavities with high-gradient electric field of 35 MV/m [1], but the scale of LINAC is large. Cyclotron is the most popular accelerator and is compact, but the large amount of magnetic materials of ten thousand tons is required to produce GeV-class particles. Synchrotron is compact and does not require such huge magnetic materials, but the output beam power is low and it is subtle unstable for AC-magnetic field operation to supply high-energy beam. The FFAG accelerator [2] is attractive for this study because it is compact with small magnetic materials, and is capable to supply stable beam for DC-magnetic field operation, although the electric field of the acceleration rf-devices is low up to 100 kV/m due to the requirements for large aperture and for time-variation of rf frequency to adjust to the non-linear velocity of high-energy particles. We have studied to improve the FFAG accelerator by applying magnetic field configuration to main bending magnets, to satisfy isochronous condition and phase stability. Figure 1 shows the conceptual design of the new accelerator, which is like microtron [3]. An example of the magnetic field configuration (Fig. 2) and the related articles are reported here.

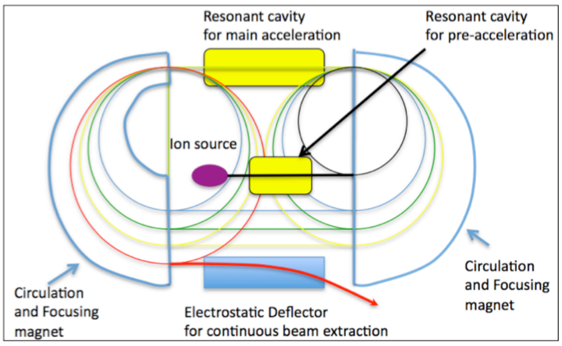

Fig. 1. Conceptual figure of high-energy microtron.

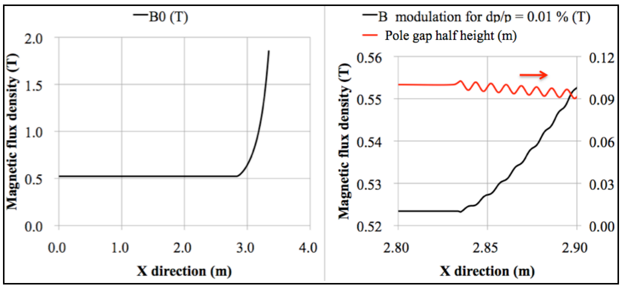

Fig. 2. An example of magnetic field configuration to energize 0.1 GeV proton up to 1.1 GeV. Left: magnetic field configuration to satisfy the isochronous condition. Right: magnetic field configuration to satisfy the isochronous condition with phase stability for dp/p = 0.01%.

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References: [1] ILC Reference Design Report, <http://www.linearcollider.org/ILC/Publications/Reference-Design-Report>. [2] Y. Mori, Nucl. Instr. and Meth. **A 451**, 300 (2000). [3] D. Hasegawa, *et al.*, Proc. of the 8th Annual Meeting of PASJ, Aug. 1-3, 2011, Tsukuba, Japan (2011) pp.872.