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Design of Axial Injection Line and Central Region for Ultra-compact Superconducting Cyclotron

Abstract The global demand for medical isotopes is continuously expanding. Currently, ultra-compact cyclotrons built with mature superconducting technology are highly favored due to their high beam intensity, small footprint, and significant commercial advantages. However, their strong magnetic fields, ultra-compact structure, and the high beam intensity required for high production rates bring great challenges for the design of the axial injection line and central region. In the paper, based on the ultra-compact structure of superconducting cyclotron for H_2^+ and α dual beam acceleration, independently developed by the China Institute of Atomic Energy (CIAE), the optics of the axial injection line for H_2^+ and α dual beam injection is matched and designed, under the conditions of strong space charge effects and superconducting leakage fields. The focusing and matching component, buncher and cost etc. are also dedicated, to ultimately determine the axial injection line. The transport matrix for the spiral inflector is calculated by orbit tracking, and beam optics matching from the ion source to the spiral inflector outlet is achieved for such a ultra-compact. The central region is another challenge during the cyclotron design. It is designed to fit the ultra-compact structure, meet the requirements of gap crossing, orbit centering, 50°RF acceptance for high intensity H_2^+ beam and high quality α beam. The matching phase ellipse at the location between the central region and acceleration region, is obtained by multi-particle orbit tracking, enabling full beam matching from injection to acceleration for the dual beams.
The superconducting cyclotron for H_2^+ and α beam with ultra-compact structure developed by CIAE, is expected to advance the development and production of new medical isotope, such as ^{211}At, ^{99m}Tc and so on, as well as the particle irradiation, neutron production for imaging or medical applications.
Key words Axial injection, Beam optics matching, Central region, Ultra-compact Cyclotron

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