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Beam dynamics design and irradiation experiment of beam loss for a CW 100-mA proton RFQ

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Abstract

For a high-current Radio Frequency Quadrupole (RFQ) accelerator, space charge will strongly affect the stability of beams, which brings challenges and difficulties to the beam dynamics design. For an in-depth study of this space charge effect, a project has been proposed by Peking University and the Institute of Modern Physics of the Chinese Academy of Sciences. This project requires a 162.5 MHz RFQ to accelerate a 100-mA continuous-wave (CW) proton beam to 3 MeV. **The beam dynamics design of this RFQ is based on the four-section procedure with improved radial focusing strength along the RFQ.** We have investigated the relationship between limiting current and beam transmission to analyze the reasons for emittance growth and beam loss. We have also carried out an irradiation experiment based on this beam dynamics design to study the irradiation damage of the electrode surface, as this can be one main reason for reduced transmission or unstable operation that most existing high-current RFQs encounter after long-time operation. The results show that low-energy beam losses need to be kept as low as possible to prolong the life of the RFQ electrodes. **The final simulated transmission efficiency reached 99.8%, as confirmed by the code TOUTATIS.**

Keywords: RFQ; beam dynamics; high current; limiting current; beam loss; irradiation experiment

1 Introduction

The Radio Frequency Quadrupole (RFQ) accelerator was first proposed in 1960s [1]. It has the remarkable capability of simultaneously focusing, bunching and accelerating low-energy ion beams from an ion source, with high transmission and low emittance growth. Today, many scientific institutions put focus on high-current RFQs, as they can be widely used for spallation neutron sources [2], nuclear fusion materials research [3], or stand alone as compact neutron sources for Boron Neutron Capture Therapy (BNCT) [4] among other uses. However, with increasing beam intensity, the space charge effect becomes stronger, significantly reducing beam

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