

Multiple energy extraction experiments at XiPAF synchrotron

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Multiple energy extraction can deliver multiple energy flattops per accelerator cycle, improving treatment efficiency. In this process, the extraction efficiency of each flattop and the beam loss during non-extraction times are the key parameters. Such beam loss is mainly composed of the spill intensity overshoot, which reduces the number of particles available for treatment and thereby lowers treatment efficiency. So, two new schemes for multiple energy extraction are proposed which can reduce the overshoot while maintain high extraction efficiency. To compare different schemes, a beam loss index is defined and a simple evaluation model established. The model relates such beam loss and the extraction efficiency to the number of tumor layers irradiated per accelerator cycle, allowing for a more intuitive analysis of how beam loss influences treatment efficiency. Then, a comparison experiment between these two schemes and other two schemes is conducted at the Xi'an 200 MeV Proton Application Facility (XiPAF). Results show that the new schemes can indeed reduce the beam loss as expected. However, the beam loss can't be eliminated completely, and the differences among the four schemes are relatively small. Analysis with the established model reveals that the differences among the 4 schemes may have limited influence on the treatment efficiency. Furthermore, through discussion, it is found that the implementation costs vary significantly among different schemes. Therefore, in situations where such beam loss is acceptable, the scheme with the lowest cost may be a better choice actually.

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