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Principle of Isochronous Mass Spectrometry using two time-of-flight detectors

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The Isochronous Mass Spectrometry (IMS) is a storage-ring-based technique suitable for precision mass measurement of short-lived exotic nuclei produced by relativistic beam fragmentation. Several experiments employing the IMS with one time-of-flight (TOF) detector have been successfully conducted at the experimental storage ring CSRe in Lanzhou, China [1]. In these experiments, the typical magnetic rigidity (Bρ) acceptance of the CSRe is around ±2×10-3 and the momentum compaction factor is about 0.51. The experimental results show that the spectral resolving power of the revolution-time spectrum of the stored ions are not constant over the whole spectrum, and only a part of the whole spectrum corresponding to ΔT/T<0.8 ×10-5 are used for further mass determination.

In order to improve the mass resolving power of the current IMS technique so as to make use of the whole measured revolution-time spectrum, one approach is to limit the momentum spread of the ions to the level of Δp/p=5×10-5 before the injection into the ring [2]. The drawback of this method is that the transmission efficiency of the secondary beam is greatly reduced due to smaller transmission acceptance through the fragment separator [2].

In order to bypass this shortage, an additional velocity measurement of the stored ions in the ring was proposed [3]. In this paper we report the realization of this novel idea in CSRe, namely an upgraded isochronous mass spectrometry with two TOF detectors installed in the straight section of the CSRe. A series of simulated data generated from a dedicated program [4] were analysed using the new method. The velocity precision of the two TOF detector system was assumed to be dv/v≈1.6×10−4 in the simulation. With the additional information of velocity, the revolution-time of all injected ions were corrected to the corresponding revolution-time on the reference orbit. The resulting mass resolving power was greatly improved, especially for nuclides with Lorentz factor far away from the transition point of the CSRe.
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