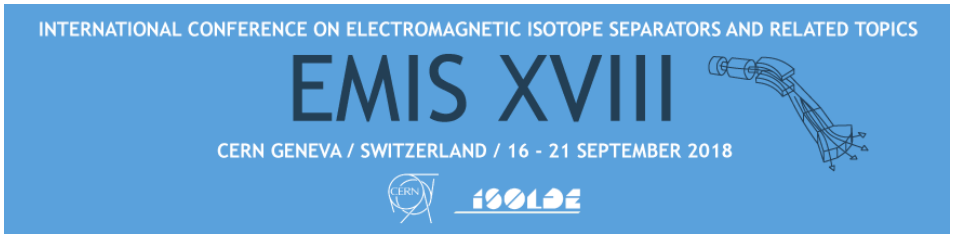

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Application of In-ring Slit on Isochronous Mass Spectrometery

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Nuclear mass measurements provide valuable information on the nuclear binding energy which reflects the summed result of all interactions among its constituent protons and neutrons. The systematic and accurate knowledge of nuclear masses have wide application in many areas of subatomic physics ranging from nuclear structure and astrophysics to the fundamental interactions and symmetries depending on the achieved mass precision [1].

A storage ring coupled with a radioactive beam line has been proven to be a powerful tool for mass measurement of exotic nuclide. This kind of mass spectrometry was inventively pioneered at ESR-GSI in Darmstadt in the 1990s and then successfully established at CSRe-IMP in Lanzhou. For the ions stored in the CSRe, their revolution times T are a function of their mass-over-charge ratios m/q and their momentum p in the first order as follow:

$\frac{\Delta T}{T} \approx \frac{1}{\gamma_t^2}\frac{\Delta(m/q)}{m/q} - (\frac{1}{\gamma^2} - \frac{1}{\gamma_t^2})\frac{\Delta p}{p}$,
where γ_t is the so-called transition point of the ring and γ is the the relativistic Lorentz factor.

Numerous efforts based on this principle have been made to improve the mass resolving power of the storage-ring-based mass spectrometry. According to the equation, the mass resolving power $\frac{m}{\Delta m} \propto \frac{T}{\Delta T}$ for a specific nuclide are inversely proportional to two parameters. One is the phase-slip factor η, defined as $\eta = \frac{1}{\gamma^2} - \frac{1}{\gamma_t^2}$, representing how much the isochronous condition is fulfilled for this nuclide. The other one is the momentum spread $\frac{\Delta p}{p}$, in other words, the magnetic rigidity acceptance of a storage ring, which is almost the same for all nuclides. In this contribution, we will report on the recent development for the Isochronous Mass Spectrometry(IMS) based on the storage ring CSRe.

In the experiment, the transition point γ_t of CSRe was found to be about 1.396 after 12-hours data accumulation. Nuclides with revolution time around 616ns were under the best isochronous condition, while the revolution time of $^{52}Co^{27+}$ is about 614ns. This deviation from the anticipatory setting was mainly caused by the the imperfections of the electromagnetic field. Based on such conditions, the first order isochronicity optimization was made via the modifications of the quadrupole and sextupole magnetic field strengths [2], and thus, the transition point γ_t of CSRe was corrected to be 1.400. In this way the phase-slip factor of $^{52}Co^{27+}$ was significantly reduced. The success of this isochronicity optimization was confirmed via 8-hours data accumulation.

To make a further improvement on separating ^{52}Co from its low-lying isomer ^{52m}Co (excitation energy is about 380 keV inferring its mirror nucleus ^{52}Mn regardless of isospin symmetry breaking, and the corresponding difference of revolution time is about 2.4 ps), the momentum acceptance $\frac{\Delta p}{p}$ was limited via a slit installed at the dispersion section of the straight part of storage ring CSRe. The slit opening was 60 mm corresponding to the momentum acceptance of the CSRe of $\frac{\Delta p}{p} \sim 4 \times 10^{-4}$(sigma), while in previous experiments under the same optical setting but without the slit was $\frac{\Delta p}{p} \sim 8 \times 10^{-4}$(sigma) [2]. With the help of the slit, mass resolving powers for all nuclides were notably improved step by step. Despite of the decrease of statistic, a high resolution revolution time spectrum for ^{52}Co and ^{52m}Co was finally obtained, and the mass resolving power of IMS have touched 4×10^5 (sigma) region for the first time [3].

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