Status of the resonant Schottky pick-up for the Rare RI Ring project

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Precise mass measurements of rare RI make a substantial contribution to the study of nucleosynthesis and nuclear structure. Rare RI Ring is an isochronous storage ring for precision mass measurements of rare RI [1,2]. The Rare RI Ring allows us to determine masses with a precision of 10^{-6}. For such high precision measurement, it is essential to maintain the isochronous condition at 10^{-6}. We are interested in neutron-rich nuclei that have short lifetimes and low production rates. To measure such nuclei, we adopted the individual injection technique, in which a single particle is injected to the ring and stored.

Resonant Schottky pick-up is a beam diagnostic device which can detect non-destructively the signal from a particle passing through the resonant cavity at the resonance frequency, $f_{\rm res}$. With the resonant Schottky pick-up we acquire revolution frequencies of nuclei circulating in the ring. The distribution of the revolution frequency corresponds to the distribution of the momentum of nuclei. We adopted the resonant Schottky pick-up as a monitor for tuning the isochronous field in the ring. Similar resonant Schottky pick-ups have been used for the same purpose at GSI[3] in Germany and IMP[4] in China.

We performed the offline performance test of the resonant cavity with a network analyzer[5]. From the measurements, $f_{\rm res}$ = 171.43 MHz, shunt impedance $R_{\rm sh}$ = 161 kΩ, unloaded quality factor Q_0 = 1880, and $R_{\rm sh}/Q_0$ = 86 Ω were obtained. With results of the offline test, the output signal power corresponding to a single ion with charge q at resonance[3] is estimated to be $P = q^2 \times 2.7 \times 10^{-21}$ W and the power of thermal noise $P_{\rm noise}$ is estimated to be 7.1×10^{-19} W. For $q \geq 17$, the signal from a single particle could be detected by the present Schottky pick-up.

We have started new offline test to investigate the sensitivity of the resonant Schottky pick-up. We developed a test system using the electron beam generated by an electron gun. Figure 1 shows the schematic view of the setup. We used a Ta filament cathode. A grid is connected to a function generator. With the output coupler, we detect the induced electromagnetic wave inside the resonant cavity at the resonance frequency. Usually, we obtain a DC electron beam when thermal electrons are accelerated. However, the DC electron beam does not induce the alternative electromagnetic field in the resonant cavity. Therefore, we add a frequency modulation at the desired frequency and amplitude into the grid. The modulated frequency is set to the resonance frequency. This simulates the ion circulation in the storage ring at the frequency. Changing the amplitude of the modulation controls the ion beam current. Therefore, we quantitatively evaluate the sensitivity of the resonant Schottky pick-up. The results of the test will be reported in coming publications.

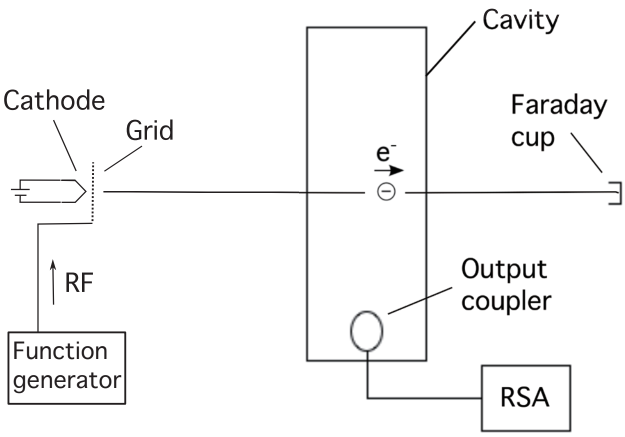

Fig. 1. Schematic view of the offline test using an electron beam. To induce an alternative electromagnetic field inside the resonant cavity, we use the grid to modulate the DC electron beam at the resonance frequency. Therefore alternative electromagnetic fields are induced by electrons passing through the resonant cavity. We detect the induced signals with a real time spectrum analyzer (RSA).

References
1) Y. Yamaguchi et al.: Nucl. Instrum. Methods. Phys. Res. B 317 (2013) 629.
2) A. Ozawa et al.: Prog. Theor. Exp. Phys. 2012 Issue 1 (2012) 03C009.
3) F. Nolden et al.: Nucl. Instrum. Methods. Phys. Res. A 659 (2011) 69.
4) J. X. Wu et al.: Nucl. Instrum. Methods. Phys. Res. B 317 (2013) 623.
5) F. Suzaki et al.: JPS. Conf. Proc. (ARIS2014) *in press.*

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