Observation of charge-stripping of 20 keV/q ions upon injection into gas cell cooler-buncher at KISS

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At the KISS facility, rare isotopes are produced in-flight by multi-nucleon transfer (MNT) reactions. They are then stopped and neutralized in high pressure argon gas and transported by gas flow to an exit nozzle. Atoms of rare isotopes are then re-ionized in an element-selective manner by use of a 2-step laser excitation; the method can only produce singly-charged ions. The gas cell system floats on a 20 kV bias, thereby producing 20 keV/q ions. A magnetic separator with $R_m \approx 900$ ensures only a single isobar chain is transported downstream to the experimental apparatuses.

One of the primary experimental devices at KISS is multi-reflection time-of-flight mass spectrograph (MRTOF). The MRTOF, however, requires very low-energy ions. To make the 20 keV/q KISS beam useable by the MRTOF, a gas cell cooler-bucher (GCCB)[1] has been constructed. This device is similar in construction to a small rf carpet gas cell,[2] but is windowless and pressurized to only 1 mbar. The beam from KISS stops in the GCCB, and is then extracted to vacuum and transferred to the MRTOF. The MRTOF makes rapidly interleaved time-of-flight measurements of analyte (the beam from GCCB) and reference ions.

In the initial test of the GCCB, a 20 keV/q beam of ^{198}Pt$^+$ was delivered from KISS. Figure 1 shows a time-of-flight spectra measured during that study. It was presumed that the peak at $A/q = 99$ was ^{198}Pt^{++} and a high-resolution follow-up measurement confirmed as much.

There are two ion traps between the GCCB and MRTOF. While the first of these has a very broadband response, the second trap (referred to as “flat trap”) is somewhat mass selective. The amplitude of the flat trap was systematically varied to determine the probability of conversion to a doubly-charged state. A time-of-flight spectrum was measured at each amplitude, and the number of singly- and doubly-charged $A = 198$ ions was recorded. The result, shown in Fig. 2, indicates that ≈80% of incoming Pt ions were converted to the doubly-charged state.

From the occurrence of such charge-stripping reactions we presume the GCCB will also be highly effective at breaking molecular contaminants which are a common problem for gas cell based studies. We hope to report on such an effect in the near future.

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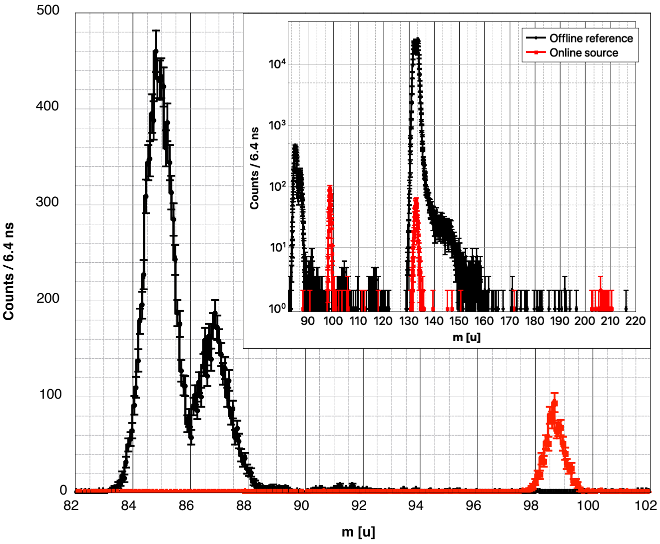

Fig. 1. Time-of-flight spectra from offline test of KISS gas cell cooler-buncher (GCCB) using a 20 keV/q beam of ^{198}Pt$^+$. The black spectrum shows the reference ions, ^{85,87}Rb$^+$ and ^{133}Cs$^+$. The red spectrum shows the ions delivered from the GCCB, dominantly $A/q = 99$.

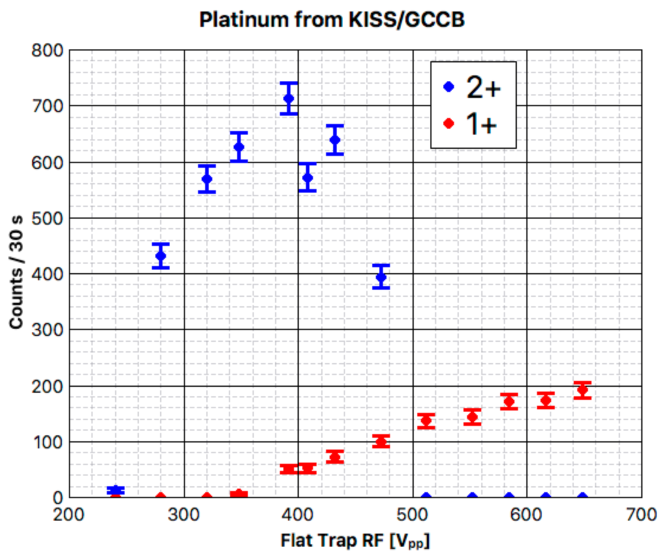

Fig. 2. Effect of varying the RF amplitude of the final preparation trap before the MRTOF, indicating that ≈80% of the incoming beam is converted to a doubly-charged state.

References
1) Y. Ito *et al.*, JPS Conf. Proc. **6**, 030112 (2015).
2) Y. Ito *et al.*, RIKEN Accel. Prog. Rep. **49**, 183 (2016).