A multiple-orbit time-of-flight mass spectrometer based on a low energy electrostatic storage ring

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A race-track shaped, electrostatic spectrometer capable of storing charged particles has been designed, built and tested using electrons [1] and, more recently, ions. The apparatus, whose circumference is just 65 cm, has stored singly-charged ions with a typical mean kinetic energy of ~10 eV. Careful control of the ion injection pulse allows for the selection of the charge states entering the ring, which can simultaneously store ions of different charge states, as shown in Fig 1.

Using an analytical model of the spectrometer [2], which is based on a matrix description of charged particle optics, we are able to predict zones for long term storage. This enables the system to be an effective multi-pass time-of-flight mass spectrometer. At the present time the mass resolution, ~4000:1, is significantly limited by the source, which is based on electron impact ionization of a neutral gas.

Xenon, krypton and argon ions have been studied, and the adjacent isotopes of Xe can be resolved after ~10 orbits, or travelling ~6.5 m. Path lengths of over 50m have been achieved. Further details and progress will be presented at the meeting.

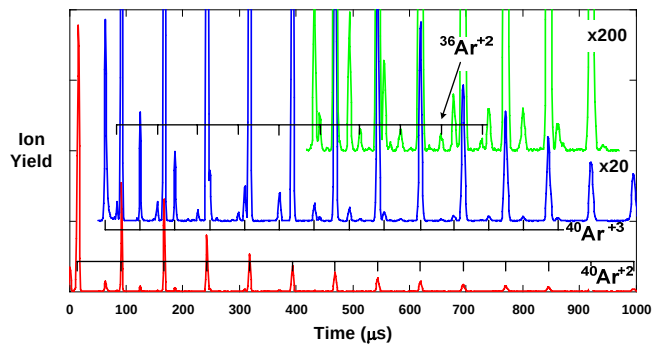

Figure 1. A time-of-flight spectrum for multiple orbits of $^{40}Ar^{+2}$, $^{36}Ar^{+2}$ and $^{40}Ar^{+3}$ ions over a 1 ms time window, with natural abundances of 99.6% for ^{40}Ar and 0.34% for ^{36}Ar. The orbits times are different for each species, whose yield slowly decays in time.

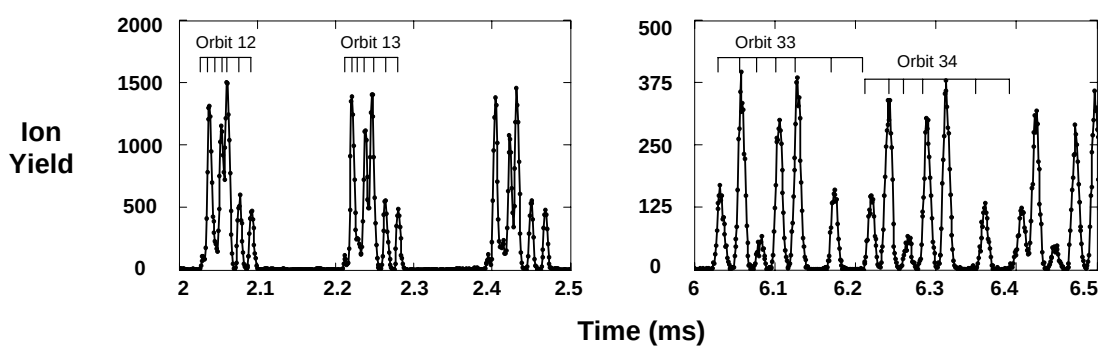

Figure 2. Sections of the ion time-of-flight spectrum for Xe^+ ions showing the improving mass resolution as a function of time / orbit number. The left figure show three distinct groupings of isotopes corresponding to different orbits, while the right figure shows the isotope distributions from adjacent orbit numbers beginning to merge. The existence of the weak ^{124}Xe and ^{126}Xe isotopes (with natural abundances of 0.1% and 0.09% respectively) are discernible above the noise.

References

[1] D. R. Tessier, *et al*., Phys. Rev. Lett. **99,** 253201 (2007).

[2] P. Hammond, *et al*., New J. Phys. **11,** 043033 (2009).

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