The 2002 harvest of the Penning trap mass spectrometer ISOLTRAP

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The masses of 41 short-lived nuclides have been determined in 2002 with ISOLTRAP [1] with a precision of $1 \cdot 10^{-7}$ and better. ISOLTRAP is a Penning trap mass spectrometer installed at the on-line mass separator facility ISOLDE/CERN. In addition, the performance of ISOLTRAP has been considerably enhanced. The range of accessible nuclei has been increased to those that are produced in quantities of only 100 ions/s and to nuclei with half-lives down to ≈50 ms. The relative uncertainty has been lowered down to $\delta m/m \approx 1 \cdot 10^{-8}$ [2]. In particular, a carbon-cluster ion source was added to the ISOLTRAP spectrometer (Fig. 1) which allowed to explore the previously unknown limit of accuracy and the mass dependent systematic error [3].

ISOLTRAP consists of three functional parts (see Fig. 1): A radiofrequency quadrupole (RFQ) ion trap and two Penning traps. The 60-keV continuous ISOLDE beam is stopped in a linear segmented gas-filled RFQ ion trap. To this end the ISOLDE ions are electrostatically retarded before they enter the RFQ, where they are cooled in helium buffer gas of about 10^{-2} mbar. After a certain accumulation time (typically 10-20 ms) the ions are extracted in a µs short pulse by switching the potential of the last rod segments. The low-energy ion pulse is then transferred to the preparation Penning trap. Here, the ions are stored up to a second and contaminant ions are removed by mass-selective buffer gas cooling. Finally, the ions are transferred to the precision Penning trap for the actual mass measurement. The ions' cyclotron frequency is determined measuring the time of flight from the trap to the detector as a function of the frequency of an azimuthal quadrupolar radiofrequency field. A characteristic cyclotron resonance curve for the $^{24}\mathrm{Ne}^+$ ions is shown in the inset of Fig. 1. A fit of the resonance curve to the measured TOF data yields the ions' cyclotron frequency $\nu_c = 1/(2\pi \cdot q/m \cdot B)$ (for ion mass m and charge q). The magnitude of the magnetic field B is measured by the determination of the cyclotron frequency of reference ions, whose mass is well-known, both before and after the measurement of the cyclotron frequency of the nuclide of interest.

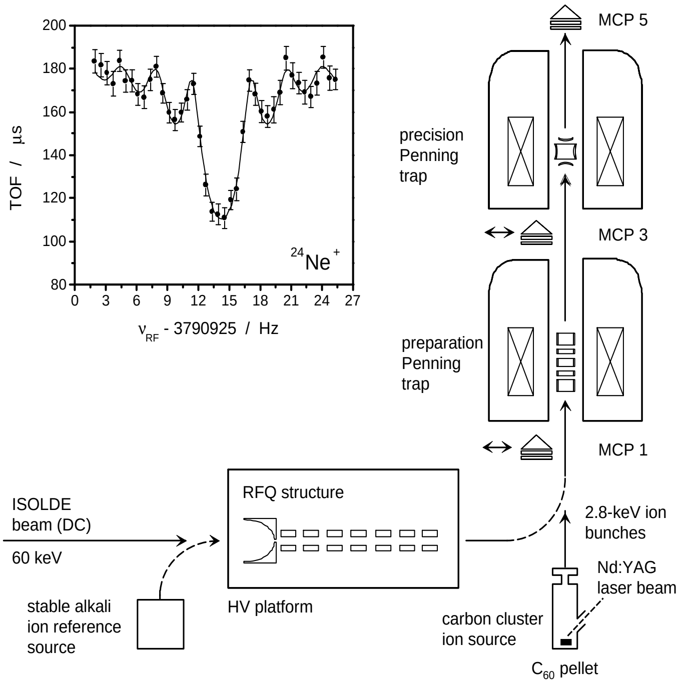

Figure 1: Schematic drawing of the mass spectrometer ISOLTRAP including the RFQ trap, the preparation trap, the precision trap, as well as the carbon cluster ion source. Micro-channel-plate (MCP) detectors are used to monitor the ion transfer as well as for the time-of-flight detection (MCP5) for the determination of the cyclotron frequency. The inset shows a cyclotron resonance of $^{24}\mathrm{Ne}^+$. The solid line is a fit to the data points by the theoretical line shape.

In the first beam time of 2002 a MgO target in conjunction with a plasma ion source with cooled transfer line was used and the masses of $^{18,19,23,24}\mathrm{Ne}$ were measured. These data are important for example to interpret recent collinear laser spectroscopy studies of optical isotope shift at ISOLDE [4].

In the second beam time a ZrO target with a hot-plasma ion source was used. This run was dedicated to the measurement of nuclear binding energies around the rp-process waiting point $^{68}\mathrm{Se}$. In particular, the neutron-deficient Se ($^{70-73}\mathrm{Se}$) and Br ($^{72-74}\mathrm{Br}$) masses have been measured.

In the third beam time about 20 masses in the heavy Pb, Bi, and Tl region were determined using a UC target. Especially in the case of Bi, masses far away from stability ($^{191}\mathrm{Bi}$ and $^{216}\mathrm{Bi}$) could be measured. The determination of binding energies in the vicinity of the doubly magic $^{208}\mathrm{Pb}$ allows, for example, the test of nuclear models and astrophysical calculations. Furthermore, the masses of $^{145,147}\mathrm{Cs}$, $^{226,230}\mathrm{Fr}$, and $^{226,230}\mathrm{Ra}$ were measured during this beam time.

Finally, in one further beam time, the mass of the superallowed β-emitter $^{74}\mathrm{Rb}$ was determined with an uncertainty below 5 keV as a contribution to the test of fundamental relations like the Conserved Vector Current (CVC) hypothesis and the unitary of the Cabibbo-Kobayashi-Maskawa (CKM) matrix.

References

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