Mass measurements of low-energetic fusion-evaporation products at SHIPTRAP

M. Block[1], D. Ackermann[1], K. Blaum[2], A. Chaudhuri[1,3], S. Eliseev[1,4], F. Herfurth[1], F.P. Heßberger[1], S. Hofmann[1], H.-J. Kluge[1], A. Martín[1], G. Marx[3], M. Mukherjee[5], J.B. Neumayr[6], W.R. Plaß[7], S. Rahaman[8], C. Rauth[1], D. Rodríguez[9], C. Scheidenberger[1,7], L. Schweikhard[3], P.G. Thirolf[6], G. Vorobjev[1,4], C. Weber[1,2] and the SHIPTRAP Collaboration

[1] *GSI, Planckstrasse 1, D-64291 Darmstadt, Germany*
[2] *Johannes-Gutenberg-Universität, Staudingerweg 7, 55099 Mainz, Germany*
[3] *Institut für Physik, Ernst-Moritz-Arndt-Universtität, D-17489 Greifswald, Germany*
[4] *St. Petersburg Nuclear Physics Institute, Gatchina 188300, Russia*
[5] *Universität Innsbruck, Technikerstr. 25, 6020 Innsbruck, Austria*
[6] *Ludwig-Maximilians-Universität, Am Coulombwall 1, 85748 Garching, Germany*
[7] *Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Gießen, Germany*
[8] *University of Jyväskylä, P.O. Box 35 (YFL), 40014 Jyväskylä, Finland*
[9] *LPC, ENSICAEN, 6 Bd. Marechal Juin, 14050 Caen Cedex, France*

The ion trap facility SHIPTRAP [1] at GSI Darmstadt allows for studies of different atomic and nuclear properties of radionuclides produced in fusion-evaporation reactions. The physics program comprises in-trap decay studies, ion chemical reaction experiments and laser spectroscopy, but focuses in the first stage on precision mass measurements. The regions of interest cover the transuranium elements, which are uniquely accessible by fusion reactions, the neutron-deficient nuclei near the proton drip-line and the nuclei around the doubly-magic ^{100}Sn. The latter region is not only interesting for nuclear structure investigations but also for nuclear astrophysics.

The fusion products are kinematically separated in-flight at the velocity filter SHIP [2] before they are stopped in a He-filled buffer gas cell. The reaction products enter the gas cell through a thin metal window serving as energy degrader. The thermalized ions are dragged by DC and RF fields towards an exit nozzle, where they are swept out in a supersonic gas jet. A buffer gas-filled RF quadrupole (RFQ) ion beam cooler is utilized to accumulate and bunch the ions. This allows for an efficient injection into the double Penning trap system situated in a 7T superconducting magnet. The first Penning trap is used as isobar purifier, while the actual mass determination is performed in the second trap by a cyclotron frequency measurement.

After the commissioning [1] a first campaign was started in 2005 with mass measurements of neutron-deficient rare-earth elements near the proton drip-line. The masses of 18 radionuclides, produced in the reaction ^{58}Ni + ^{92}Mo, were measured with a relative mass uncertainty between $5 \cdot 10^{-8}$ and $1 \cdot 10^{-7}$. For 9 nuclides the mass was experimentally determined for the first time including the ground state proton emitter ^{147}Tm with a half-live of 580 ms.

In February 2006 mass measurements in the region above ^{100}Sn were performed. The measured nuclides extend to the region where the rp-process endpoint was predicted according to reaction network calculations by Schatz et al. [3]. In two runs the masses of 25 radionuclides of the elements Ag, Cd, In, Sn, Sb, Te, I and Xe were measured with relative uncertainties of $1 \cdot 10^{-7}$ and better.

Presently investigations of the uncertainty limit of the Penning trap mass spectrometer by cross reference measurements with carbon cluster ions are ongoing. In addition, the contribution of magnetic field fluctuations to the mass uncertainty was determined.

Since the production rates for ^{147}Tm are only about a factor of five higher than for ^{254}No, a first direct mass measurement of a transuranium element is in reach.

[1] M.Block et al., EPJA 25, S01 (2005) 65;
[2] S. Hofmann, G. Münzenberg, Rev. Mod. Phys. 72 (2000) 733;
[3] H. Schatz et al., Phys. Rev. Lett. 86, 3471 (2001).