MAFFTRAP and JYFLTRAP Penning Trap Systems

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At the new resesearch reactor FRM-II in Munich the dedicated facility MAFF (Munich Accelerator for Fission Fragments) is foreseen to produce, cool and accelerate high-intensity neutron-rich radioactive beams. The experimental activities at MAFF will focus around nuclear spectroscopy studies and nuclear mass measurements.

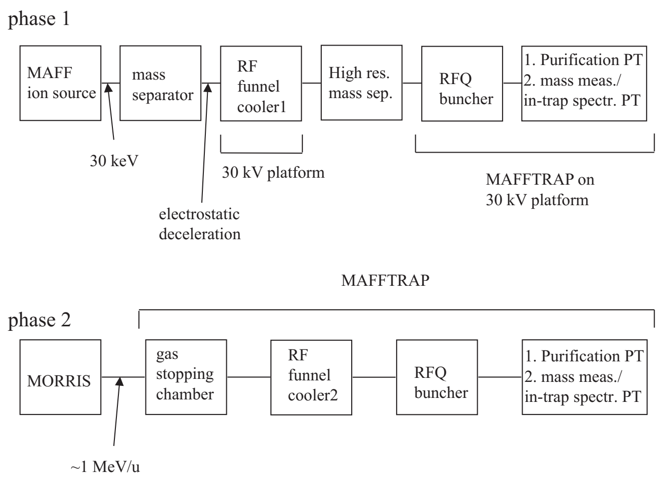

Fig. 1: MAFFTRAP diagram.

One of main experimental devices at the MAFF facility will be the ion trap system MAFFTRAP (Fig. 1). Principal technical tasks of this system are:

1) Decelerate, cool, bunch and purify the radioactive beam. This will allow to obtain a high quality beam and will be done with the use of RF traps and a Penning trap, filled with a buffer gas.

2) Perform high-precision (of the order of 10^{-7} [1]) nuclear mass measurements. They will be performed in the second (precision) Penning trap, operated under high-vacuum conditions. The measurements can be performed on nuclides delivered by both the primary and secondary beam (e.g. fusion reaction products), in MAFF phases 1 and 2, respectively (Fig. 1).

3) Perform so-called in-trap spectroscopy. In this technique, detectors of a needed type are placed directly inside the trap and the radioactive sample is positioned in front of them.

In the first phase of MAFF (phase 1, Fig. 1), when only a primary, low energy (30 keV) radioactive beam will be available, an electrostatic beam deceleration will be applied. This can be done by placing the trap system at the high-voltage (30 kV) platform. Subsequently, decelerated (to about 100 eV) beam will be injected into an RF funnel [2], which is a novel approach for an efficient cooling of high-intensity radioactive beams. The outgoing beam will be re-accelerated to 30 keV and purified with a magnetic high-resolution mass separator ($R = M/\Delta M \approx 10^3 - 10^4$). Then it will be decelerated again in order to undergo bunching, which is necessary for having high efficiency of injection into Penning trap. For bunching, a recently developed technique (see e.g. [3]) of an RFQ cooler/buncher will be used. Finally, the ion bunches will be injected into a cylindrical Penning trap (placed in a superconducting magnet) with buffer gas.

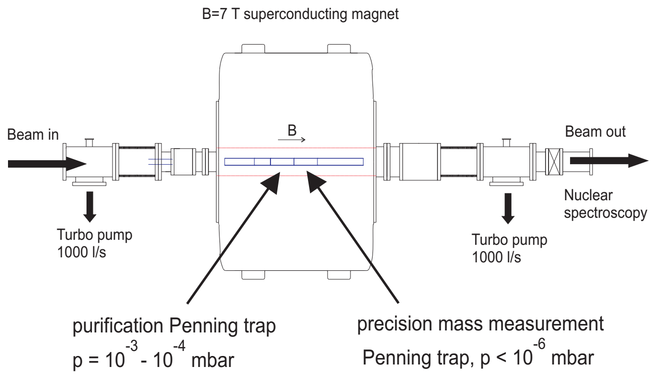

Fig. 2: MAFFTRAP Penning trap system.

There, a very high mass resolving power ($R \leq 10^5$) can be reached [4]. This will allow rejecting even isobaric contaminants (e.g. coming from fission) and ejecting a clean, mono-isotopic beam for further studies. In the final phase of MAFF (phase 2, Fig. 1), a secondary high energy (<6 MeV/u) radioactive beam coming out of the MORRIS recoil separator will be a subject of studies. In this phase, since electrostatic deceleration is impossible at these energies, for the beam deceleration a gas stopping chamber technique will be used [5]. Both purification and mass measurement Penning traps will be positioned in the same superconducting magnet, which facilitates the ion transfer between the traps. The layout of the Penning trap system is shown in Fig. 2.

The mass measurement trap can be interchanged with the in-trap spectroscopy trap where relevant particle detectors will be placed. A superconducting magnet for MAFFTRAP has been ordered in the beginning of 2003. The theoretical simulations done for the purification trap have confirmed a possibility of reaching the expected high resolving power.

One of co-authors (JS) was participating in the construction and testing of a Penning trap system JYFLTRAP [6] at IGISOL (University of Jyväskylä, Finland). In 2002, the goal of this project was to put in operation a cooler Penning trap ($R \leq 10^5$) for isobaric purification of ion beams delivered by IGISOL. The first radioactive ^{58}Cu (3.2 s) ions from was ^{58}Ni(p,n)^{58}Cu reactions were trapped and purified with a mass resolving power ($R = 7 * 10^4$), using a 450 ms trapping cycle. The mass excess of ^{58}Cu could be determined as -51674 (28) keV/c^2, in good agreement with -51660 (15) keV/c^2 from the 1995 Mass Tables.

References

[1] G. Bollen *et al.*, Nucl. Instr. Meth. **A368** (1996) 675
[2] S. Heinz *et al.*, this report p.100
[3] A. Nieminen *et al.*, Nucl. Instr. Meth. **A469** (2001) 244
[4] H. Raimbault-Hartmann *et al.*, Nucl. Instr. Meth. **B126** (1997) 378
[5] J. Neumayr *et al.*, Annual report 2001, p. 83
[6] J. Szerypo *et al.*, Acta Phys. Pol. **B33** (2002) 487