A Plunger Apparatus for Relativistic Radioactive Beams*

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Nuclear structure investigations with radioactive beams are at present one of the most interesting and active fields in nuclear physics. Absolute transition probabilities are of crucial importance for these studies which can be directly deduced from the lifetimes of excited levels. The aim of this work is to investigate the feasibility of Doppler shift methods to measure level lifetimes of exotic nuclei by using radioactive beams and to provide a first plunger device for such experiments. So far only two RDM experiments with radioactive beams were performed. The first one was done with the RISING spectrometer using secondary fragmentation of a ^{37}Ca beam at 200MeV/u. The second experiment was performed at RIKEN using Coulomb excitation to excite the first 2^+ state in ^{30}Mg. In both experiments set-ups with fixed target and degrader foils were used.

At the NSCL/MSU a RDM experiment was performed with a ^{124}Xe beam at 55 MeV/u in order to test the recoil distance technique under the same conditions as for radioactive beam experiments and with good statistics. The final data analysis where relativistic effects, gamma angular distribution, deorientation and efficiency effects had to be considered, gave a 2^+ lifetime consistent with a recent precise and lifetime measurement Ref. [1]. Details can be found in Ref. [2]. This experiment provided important input for the design of the present plunger device which is shown in Figs. 1 and 2. It is designed to meet the specific requirements of experiments with radioactive beams produced in a production target by fragmentation at relativistic energies resulting from low beam intensities, the large phase space occupied by the radioactive beam causing the need of beam tracking. The plunger device consists of an outer tube, about 1m long and 160mm in diameter (Fig.1) and an inner part (Fig.2) with the frames for the target and the degrader foils, a piezo-motor with an optical device for measuring the target-degrader separation and an additional piezo crystal used in a feedback system for holding adjusted target-degrader distances. In the existing version the target foil can be moved whereas the degrader foil is kept at a fixed position. The target and degrader foils have to be clamped between two rings screwed tightly together and then stretched by screwing the rings to conically shaped support frames. In this way target foils of about 50-70 mg/cm^2 can be stretched.

Some more technical details:

Target/ degrader diameter: 50mm

Target-degrader separation: ≤ 20 mm

Accuracy: ≤ 5µm

For thicker target or degrader foils new target frames and stretching procedures have to be developed.

The plunger will be used first in a measurement for lifetimes in neutron rich Pd nuclei (accepted proposal at NSCL/MSU).

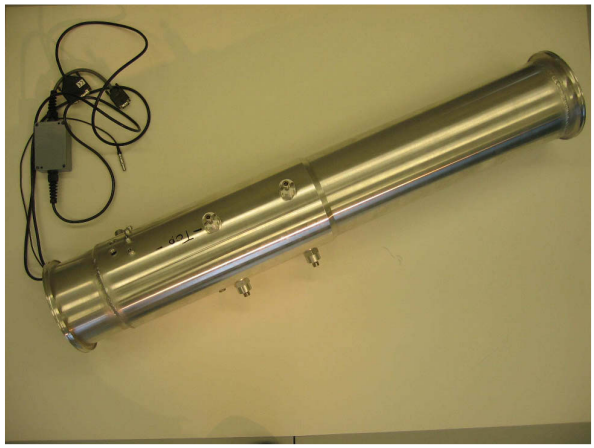

Figure 1: Housing of the inner plunger part shown in Fig. 2.

Figure 2: Plunger removed from the housing shown in Fig.1. At the left side frames and cones for stretching the target and degrader foils can be seen. The black cylinder is the housing of the piezo-motor including an optical device for measuring the target-degrader separation.

References

[1] B. Saha et al., Phys. Rev. C 70 (2004) 034313.

[2] A. Chester et al., submitted to NIM, (2005).

*Work supported by BMBF, contract no.: 06K167 and GSI, F. u. E. contract no. : OK/JOL