Development of the MARA-LEB Facility

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Motivation

MARA-LEB (Mass Analysing Recoil Apparatus - Low Energy Branch) [1] is a facility that will be an extension for the MARA separator at JYFL [2]. MARA is an electromagnetic separator with a high mass-resolving power, able to study medium-heavy nuclei.

MARA-LEB will be used to study proton-rich nuclei close to the drip-line. This area is of interest as a fertile ground to test the predictions of the shell model, proton- neutron interaction and shape-coexistence . Knowledge on these nuclei is of paramount importance for undersanding of the astrophysical rapid proton capture process [3]. MARA-LEB will provide the efficiency and selectivity required to study such exotic nuclei.

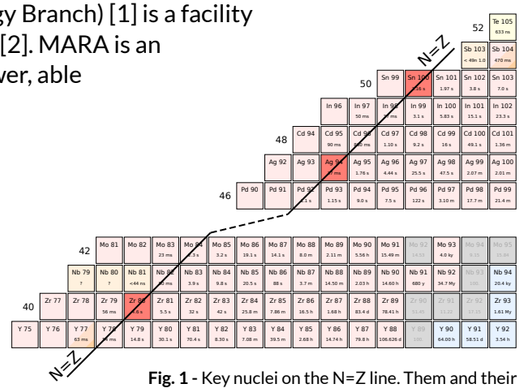

Fig. 1 - Key nuclei on the N=Z line. Them and their surrounding regions are the main regions of interest for MARA-LEB.

Setup

Initially, MARA- LEB will be used for laser ionisation and spectroscopy experiments. Recoils from MARA will be stopped and neutralised in a buffer noble gas cell. They will then be laser-ionised and transported to an acceleration stage by ion guides, where they will be accelerated to 30 keV. A dipole magnet will provide mass separation before the detectors.

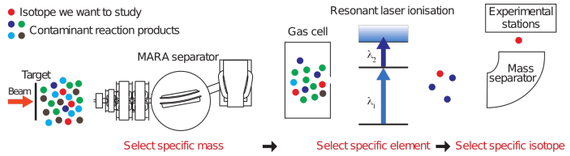

Fig. 2 - Schematic view of MARA-LEB, showing recoil selection stages.

The gas cell is the link between MARA and the LEB.

Its entrance window has to be optimised to maximise recoil acceptance, both in terms of material and size.

MARA experiments using the ions of interest can be used to determine the effect of window size.

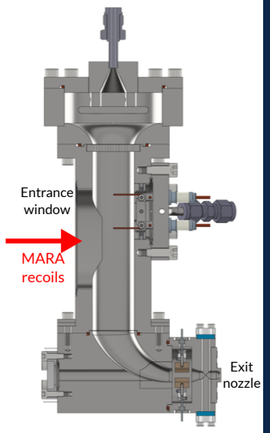

Fig. 3 - MARA-LEB buffer gas cell [1]

Experiment

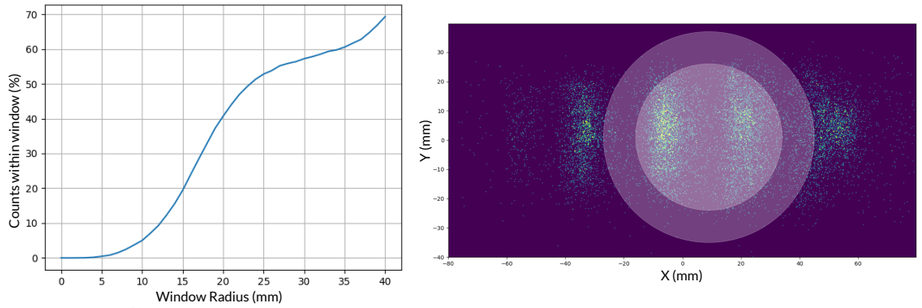

Fig. 4 - ^{96}Pd recoils with 25 mm- and 36 mm-radius windows superimposed (right) and window acceptance as a function of radius (left) centred at charge state 26.5. Two charge states are collected in the cell.

An experiment has been carried out using the MARA separator. A 256 MeV, ^{60}Ni beam was impinged on a ^{40}Ca target. Among the produced recoils, ^{96}Pd is of interest due to it being in the region of ^{94}Ag. The spatial distribution of ^{96}Pd ions at MARA's focal plane, where the gas cell will be intalled, was obtained.

The experimental analysis revealed the effect window size has on recoil acceptance into the gas cell. This helps to make decisions on MARA focus parameters for LEB experiments. The current design features a 31 mm-diameter window.

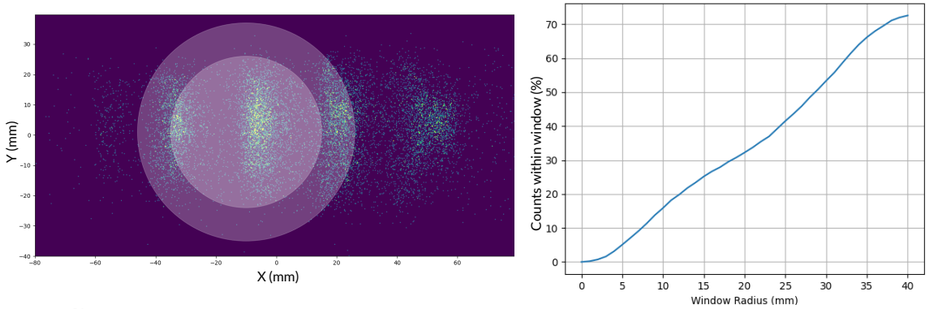

Fig. 5 - ^{96}Pd recoils with 25 mm- and 36 mm-radius windows superimposed (left) and window acceptance as a function of radius (right) centred at charge state 27. One charge state is collected with a small window, and three with a large one.

[1] P. Papadakis et al., AIP Conference Proceedings **2011**, 070013 (2018)
[2] J. Sarén et al., Nucl. Instr. and Meth. B **266**, 4196 (2008)
[3] H. Schatz and W.-J. Ong, The Astrophysical Journal **844**, 139 (2017)