THE MARA-LEB RFQ GUIDE SYSTEM

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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 [2] at JYFL. MARA is an electromagnetic separator with a high mass-resolving power, ideal 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 to increase the understanidng of the astrophysical rapid proton capture process [3].

MARA-LEB will provide the efficiency and selectivity required to study such exotic nuclei.

[1] P. Papadakis *et al.*, AIP Conf Proc **2011**, 070013 (2018)

[2] J. Sarén *et al.*, Nucl Instrum Meth B **266**, 4196 (2008)

[3] H. Schatz and W.-J. Ong, Astrophys J **844**, 139 (2017)

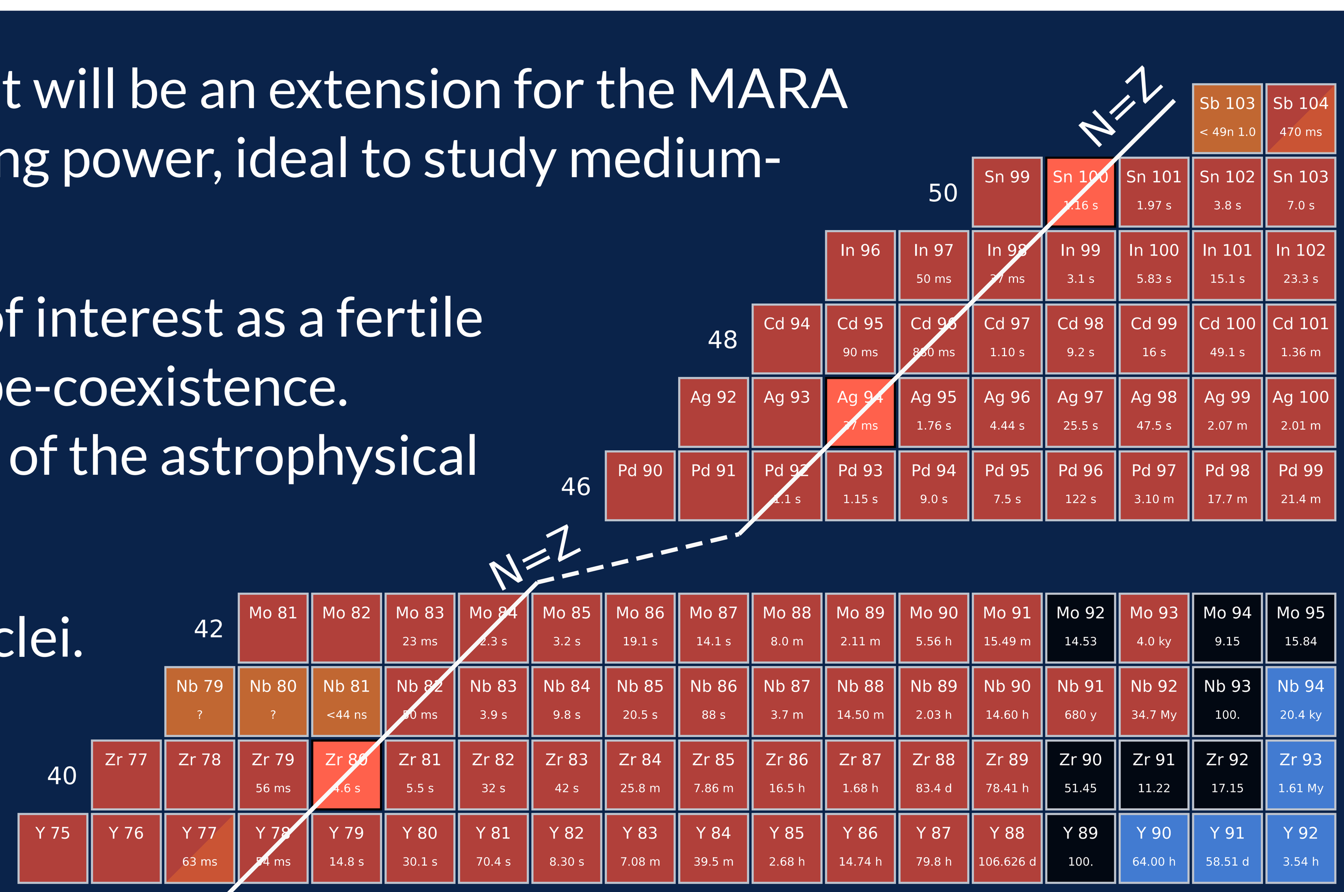

Fig. 1 - ^{80}Zr, ^{94}Ag, ^{100}Sn are key nuclei on the N=Z line. These and surrounding nuclei are of particular interest to MARA-LEB.

Setup

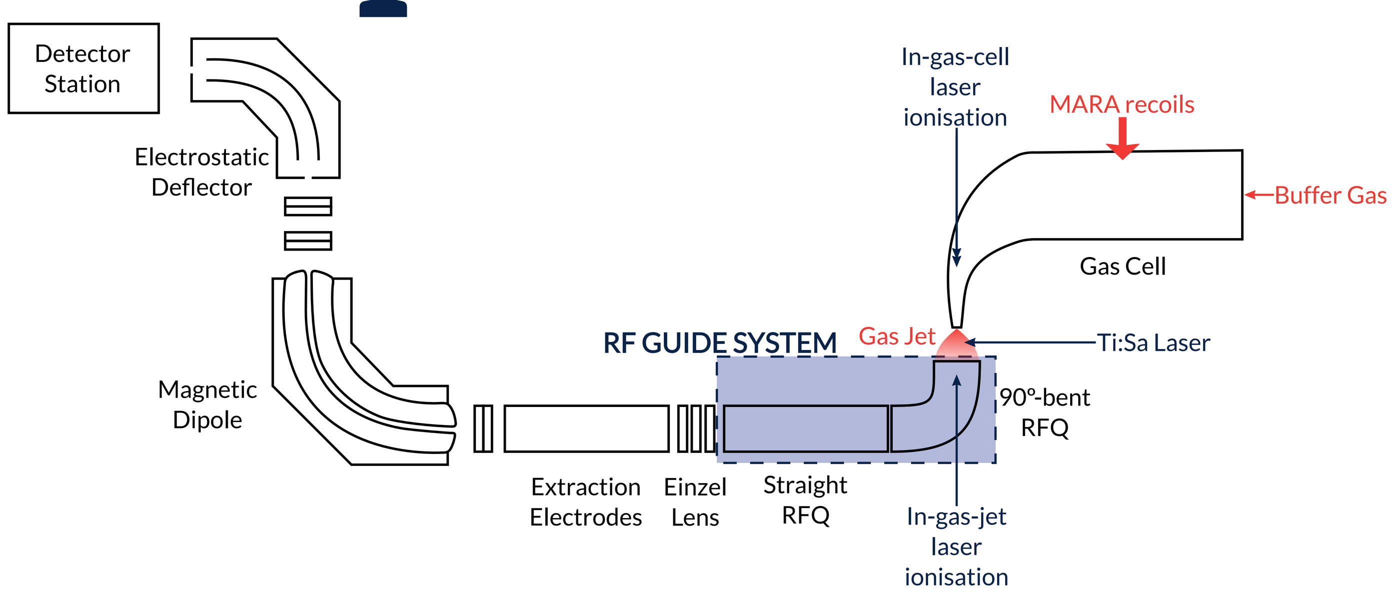

Fig. 2 - Schematic representation of the MARA-LEB beamline. The RF guide system is highlighted. Not to scale.

The Low-Energy Branch will complement the selectivity of the MARA separator with contaminant suppression by using a buffer gas cell in combination with in-gas-jet or in-gas-cell laser ionisation to thermalise, neutralise and re-ionise the recoils of interest coming from MARA. A radio-frequency quadrupole (RFQ) ion guide system then extracts and transports the ions to further acceleration and mass selection before guiding them towards detector stations.

The radio-frequency guides used in the MARA-LEB ion transport system [4] consist of a 90°-bent and a straight RFQ sections which will confine and transport the ions selected by the gas cell through three differential pumping regions which will incrementally reduce the background pressure to ~10^{-6}-10^{-7} mbar, where they can be accelerated to 30 kV.

[4] P. Papadakis *et al.*, Nucl Instrum Meth B 463, **286** (2020)

Simulations

Simulations were carried out using Simion [5] to study the transmission of ions through the RF guides in terms of applied radio-frequency voltages and buffer gas used in the cell. Additionally, new geometries were tested for the electrode connecting the bent and straight RF guides, which will also act as the aperture between two adjacent chambers in the differential pumping system.

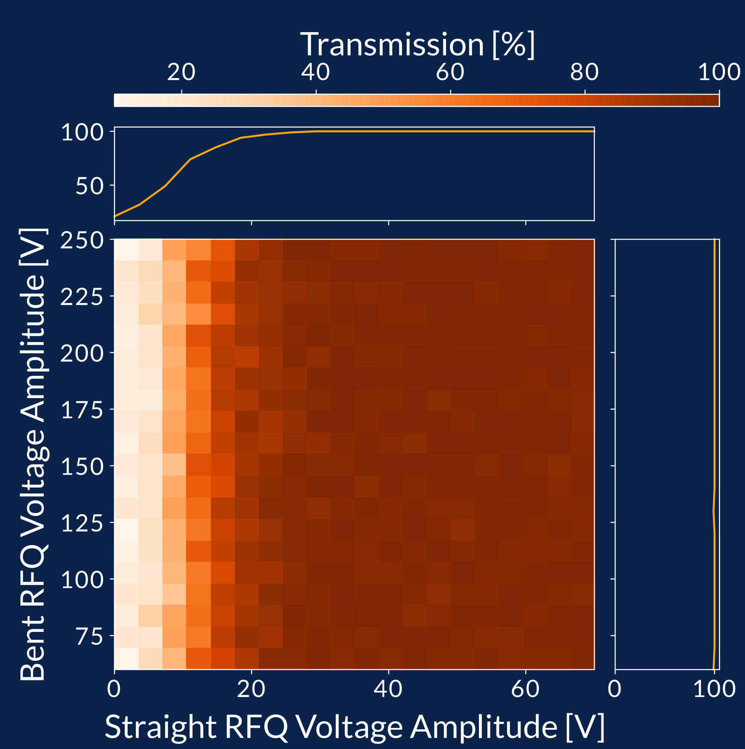

Fig. 4- Transmission through the RF guides for different voltage amplitudes applied on the guides. Helium used as the buffer gas. Projections shown for each axis.

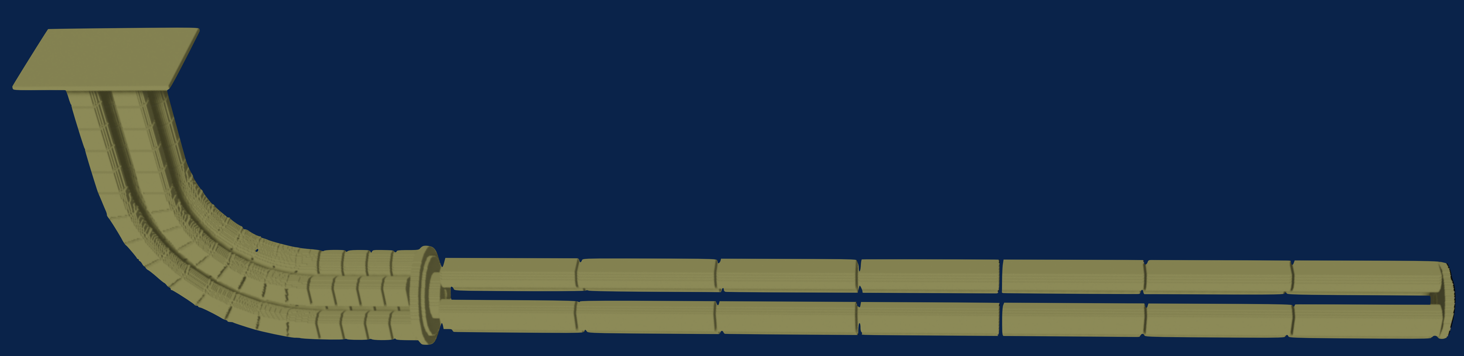

Fig. 3 - 3D render of the 90°-bent and straight RFQ guides.

The results of the simulations will be useful to decide on initial working voltages for the testing and commissioning of the facility. The simulations also informed the final design of the differential pumping chamber aperture geometry.

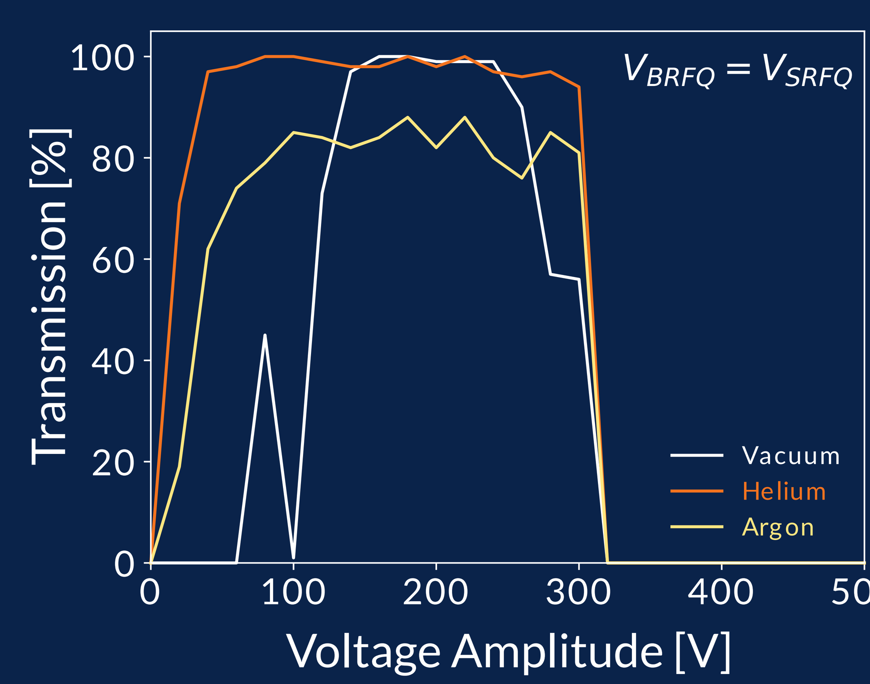

Fig. 5 - Projection of the transmission efficiencies through the RF guides for different buffer gases when the same voltage amplitude is applied for both guides.

[5] Simion 8.1, Adaptas S.I.S., https://www.simion.com/info

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