Aluminum Photo-Ionization in SPES Hot Cavity

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INTRODUCTION

The definitive Uranium Carbide (UCx) target that will be used in SPES [1] (Selective Production of Exotic Species) project for n-rich isotope productions, will be preceded by a SiC target, in order to calibrate and validate the functionality of the whole facility. Impinging SiC target with protons, one of the elements coming out from nuclear reaction is Aluminum with its isotopes [2]. In order to provide an Aluminum ion beam, among various type of ionization techniques, the main effectiveness is expected with laser photoionization. Off line tests have been performed on SPES front-end in Legnaro National Laboratories (LNL) of INFN, which it will housed of the SPES facility. In this work will be presented results on laser photoionization and extraction capability of Aluminum using the SPES front end system.

PHOTO-IONIZATION IN LNL HOT CAVITY

In Legnaro we performed Aluminum ionization using the LPX200 excimer laser by Lambda Physik, charged with XeCl gas, lasing around 308 nm wavelength (figure 1). The broadband laser radiation overlaps the absorption line of aluminum and allows ionization.

![Fig. 1. Laser experimental set-up at LNL.](image1)

The LNL set-up involves the SPES front end apparatus. A small tantalum tube (oven) is charged by a calibrated amount of Aluminum and it is directly connected to the hot cavity of SPES system. Once heated the oven to 2000 °C it evaporates atoms of Aluminum which reach the hot cavity and are ready for ionization. Laser radiation, delivered by a focusing telescope 6 meter far away, enters in the 3 mm diameter hot cavity producing ionization. Ionized atoms are extracted by means of the 25 kV high voltage extractor and they are collected by a faraday cup.

![Fig. 2. Layout of the safety control system.](image2)

Activating this button, will immediately turn off the laser with a high level of reliability. The third and final control is carried out by the PLC. It monitors other variables like:
the presence of the protective screens in the laser beam path, the status of the ventilation systems, and the commands given by the user using the HMI. When the laser is active, the access to the laboratory is restricted to a designed and unique door and a well defined procedure has to be performed.

This procedure is also monitored by the PLC. For this, a set of visual and acoustic signal, as well as push button on the access door, are used. Two light towers are placed inside and outside the laboratory. They are used to indicate, in all time and to all the personal nearby, the current status of the laser. The PLC is in charge of controlling this lights. A scheme of the safety control system described is presented in the figure 2.

**FIRST RESULTS AT LNL**

The Faraday Cup (FC) current is the result of the ionization process in the hot cavity. In the normal operation of the front end system, the FC is inserted directly in front of the extractor, collinear to the ion beam after a quadrupole and an electrostatic lenses system. In order to allow laser radiation to reach the hot cavity, it is mandatory to displace the FC from the laser beam propagation axes.

![Fig. 3. Quadrupole lenses setup: the laser beam path points straight to the ion source; the ion beam path goes back towards the faraday cup.](image)

The quadrupole and electrostatic lenses (figure 3) allow to collect anyway a signal. Variations in the laser pulse energy or in the laser repetition rate directly affect the faraday cup current. These variations are proof of laser photoionization (figure 4).

![Fig. 4. Variation of the faraday cup current produced by the sweep in the frequency of the of the laser pulses (a) and variation produced by two energy pulses setting (b).](image)

**CONCLUSION**

Primary target for the SPES project is to validate the front end system with all the available ionization techniques: surface, laser and plasma.

In LNL, first laser photoionization was obtained with excimer XeCl laser, covering a possible ionization path for Aluminum. The results in the measured ion beam current allows to conclude that under laser action a ionization process takes place in the SPES hot cavity. Further investigations using a mass separator will certify the selectivity of laser photoionization on Aluminum despite others atomic species present in the hot cavity, permitting a complete system characterization.

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