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The ALTO project at IPN-Orsay

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Abstract The availability of both a tandem deuteron beam and a linac electron beam, the latter converted into Bremsstrahlung, at the new ALTO facility at IPN-Orsay offers a unique opportunity to compare the performance of a laser ion guide under different regimes. The ALTO accelerator has delivered its first electron beam at the end of 2005 and a design for a gas-cell prototype is being studied.

Key words ALTO · IPN-Orsay · Bremsstrahlung

1 The ALTO accelerator

The purpose of the ALTO project at IPN-Orsay is to gather the necessary know-how for the construction of the ISOL-based SPIRAL-2 facility at GANIL. At the same time, it opens a window to study neutron-rich nuclei produced in a thick actinide target by photofission, after conversion of a primary electron beam into Bremsstrahlung [1].

The ALTO accelerator is a 50 MeV electron machine that was recovered from CERN, where it served as the LEP injector linac till the dismantlement of LEP in 2001. The accelerator was moved to IPN-Orsay and reassembled in the main experimental area that also houses the tandem driver and the PARRNE separator. It was put into operation in December 2005 and the first photofission production runs on a uranium carbide target took place in June 2006. For radioprotection issues, the intensity of the accelerated beam was limited to 100 nA instead of its 10 μA nominal current.

The fission fragments were mass separated on-line, deposited on a movable tape and their radiation recorded by a standard germanium detector in close geometry. The dead time-corrected yield of ^{132}Sn from the plasma ion source used so far reached $1.8 \cdot 10^6$/μC [2]. At ISOLDE, this isotope is currently produced with laser ionisation at a rate of $3 \cdot 10^8$/

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μC [3]. The ALTO machine is expected to deliver 10 μA, while ISOLDE runs on an average of 1 to 2 μA.

2 The laser ion source

The purity of the extracted beam at an ISOL facility greatly benefits from the use of an element-selective laser ion source. Such a source is currently under development at IPN-Orsay, based on the experience accumulated by teams at ISOLDE [4], Leuven [5], Jyväskylä [6] and TRIUMF [7]. Ionisation schemes for Sn and Cu were tested off-line with a dye-laser set-up pumped at 30 Hz. Efficiencies of 10^{-6} were obtained for both elements, without auto-ionising state [8, 9].

A new laser set-up will be installed early 2007. It will consist of three FL-3002 Lambda Physik dye lasers pumped by a 532 nm Nd:YAG laser at 20 kHz. Together with the use of ionisation schemes that include auto-ionising states, the higher repetition frequency would lift the efficiency of the source to the percentage range.

3 The laser ion guide

Access to neutron-rich isotopes of chemically refractory elements is often difficult because of their slow release from conventional thick targets. A solution is provided by the ion-guide technique, where thin targets are suspended in a buffer-gas cell. At ALTO, we have undertaken preliminary design studies for the implementation of an ion guide. Simulations were carried out that investigate the influence of various parameters such as the thickness of the converter slab, the radius of the impinging electron beam, the target thickness and spacing, and the gas pressure.

It was found that the highest production yield is achieved for a converter of 3.5 mm thickness in close contact to the target foils. The converter was chosen to be tungsten. As it does not stop the electron beam, the buffer gas is still subject to a considerable charge load. The generation of low-energy secondary electrons and X-rays adds to the creation of a local plasma.

Further calculations show the advantage of a single target along the axis of a well-focused electron beam rather than a wide beam that irradiates a multi-layered set-up with additional off-axis foils. For a given fixed volume the number of fissions evidently increases with the number of perpendicular targets, while the volume in which the particles slow down is inversely reduced. Stopping efficiencies in 500 mbar of argon of 30 and 40% were estimated for distances between 15 mg/cm^2 targets of 10 and 20 mm, respectively. If we take the depth of the gas cell as 40 mm, led by practical considerations, then the two configurations can hold three or one foils, so we opt for the former. While a longitudinal shift by 5 mm allows incorporating a fourth perpendicular target, still more of them would stretch resources. The total number of fissions for the proposed geometry amounts to $6.7 \cdot 10^7$/μC, out of which an estimated $2.4 \cdot 10^7$/μC would be stopped in the buffer gas.

Coupling of the laser ion guide to the existing PARRNE separator will require a study of the necessary adaptations to the front end, for instance the enlargement of the extraction chamber to accommodate differential pumping and the transit of pumping ducts through the concrete shielding walls to high-capacity Roots blowers. In particular, the current design of the laser ion guide does not foresee for any entrance of the laser light other than the extraction axis.

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