THE PRODUCTION OF RADIOACTIVE ION BEAMS FOR THE EXCYT FACILITY

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Abstract

The EXCYT facility (EXotics with CYclotron and Tandem) at the INFN-LNS is under completion and its commissioning with ^{8}Li as the first radioactive beam is foreseen by the end of 2004. In the following, we report the work done with an emphasis on the measured yields and production efficiencies for ^{8,9}Li

INTRODUCTION

At the EXCYT facility the primary beam coming from the SERSE ECR ion source goes into a K = 800 cyclotron (up to 80 MeV/amu, 1 eμA) and then to the target-ion source assembly. Here the species of interest are produced via the ISOL method and, when positive, they pass through the vapours of a charge exchange cell to become negative. They are mass-separated in two stages, the first with a resolving power of about 2000 and the second up to 20000. It is worth noting that besides the post acceleration there is also an option to supply 300 keV beams for low energy experiments. The facility is described and shown in a number of publications and reports [1]. The following paragraphs contain in some details the work done to obtain radioactive ion beams of ^{8,9}Li.

TARGET MATERIAL AND GEOMETRY

By taking into account the main characteristics of an ideal target, graphite has been chosen as a suitable material. Among the many kinds of commercially available graphite, UTR146 manufactured by XYCARB with a few parts per million of impurities complies also with favourable production and release properties. Experiments with radiotracers in collaboration with CERN-ISOLDE clearly showed a better release from this kind of graphite compared to other materials [2]. As for the production rates, we were less restricted on the choice since at EXCYT the radioactive nuclides are obtained mainly by projectile fragmentation. Nevertheless, we obtained good yields of ^{18}F, ^{7}Be and ^{22,24}Na by shooting ^{19}F (48 MeV/amu) on a XYCARB UTR146 graphite target [3].

The previous Target-Ion Source assembly (TIS) [4] proved to be unreliable and was therefore radically modified in its shape, dimensions and geometry as shown in fig. 1.

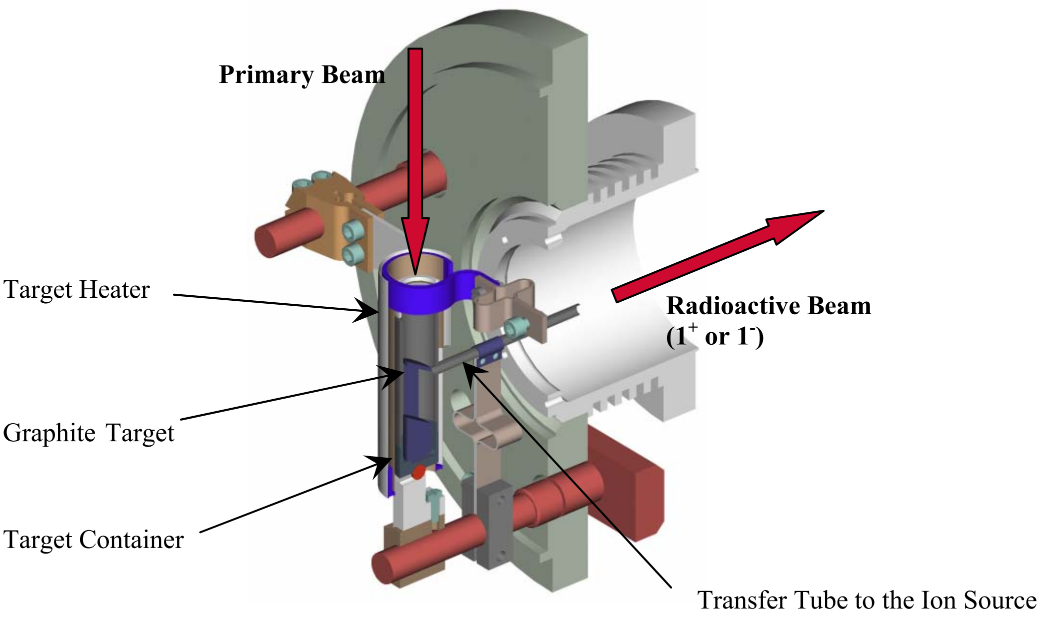

Figure 1: The new TIS. The real target area is mainly constituted by its upper part

In the new TIS the graphite target is standing in a tantalum container, which in turn is inside a tantalum heater. In this configuration, the heater doesn't touch the container and the primary beam impinge on the target from the top. Heating is achieved by means of direct current while several tantalum layers on the outside of the heater shield the aluminium external container (not shown) from high temperature. The target container is heated by irradiation; the target is heated by: irradiation, contact at its bottom, primary beam power. The effective target volume is mainly its upper part, the rest constituting a simple mechanical support. In fact, the thickness of the upper part is chosen according to the range of the primary beam and of the produced radioactive nuclides. By a judicious choice, in principle it is possible to obtain that most of the products are located into the upper part of the target close to the transfer tube.

Lithium can be conveniently ionised by using an ISOLDE-type positive ion source with a hollow W cathode. In off-line tests we obtained an efficiency of 75% for ^{6}Li^{+}, very close both to its theoretical value and to on-line extrapolations [5]

THE EXPERIMENT E435 AT GANIL

Since the TIS had been radically modified, it became necessary to verify off-line its behaviour with respect to the mechanical and thermal stresses at 2300 K as well as to obtain information about the on-line production and the release processes. In order to save time, it was decided to run an experiment at the SIRa test-bench of SPIRAL, GANIL, by shooting a ^{13}C primary beam (60 MeV/amu) on a ^{12}C target under the same operational conditions that will be initially used at EXCYT.

The preliminary work consisted in building an interface between EXCYT and SIRa, making off-line heating tests and running ANSYS thermal simulations. Then, in May 2003 the TIS was mounted and outgassed at SIRa. During the off-line outgassing the TIS withstood three abrupt thermal cycles from about 1700 K to room temperature due to failures of the power supplies.

We started the on-line experiment on May and in a few hours detected the first radioactive beams of $^{8,\,9}$Li. The run lasted three days and the system proved to be robust and reliable: because of radioprotection constraints the maximum primary beam power was limited to 370 W but there was no sign of leaks or breakdown, despite five additional on-line failures of the primary beam (i.e. unwanted thermal cycles).

The graphs in fig. 2 show the production efficiencies for $^{8,\,9}$Li: these are defined as the ratios of the extracted radioactive ions to the atoms produced by nuclear reactions in the target core, as estimated via the EPAX code. It is clear from the plots that the efficiencies increase by passing time.

This is mainly due to three factors: loss of impurities from the target, increase of target temperature by the primary beam power and increase of the heater temperature by ohmic heating.

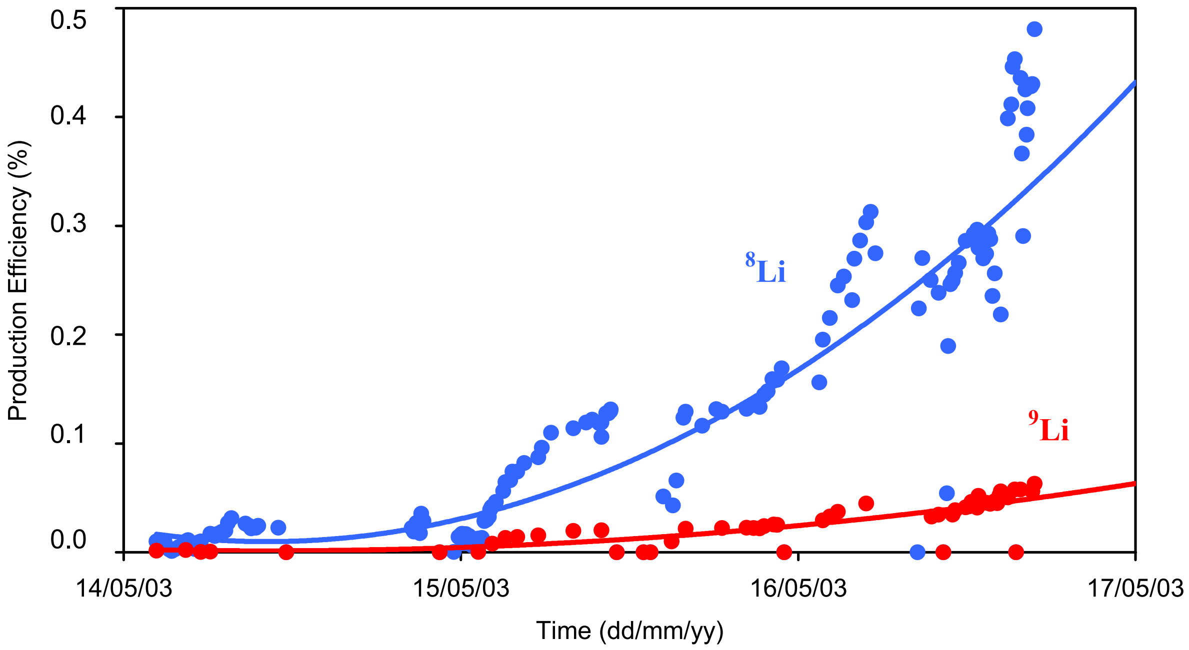

Figure 2: Production efficiencies for $^{8,\,9}$Li versus time. The production efficiency is the ratio of the extracted radioactive ions to ones theoretically produced into the target (estimation by the EPAX code)

Beam	Projectile	Energy (MeV/amu)	Target	Intensity		
				Pre-accelerated (pps/pμA)	Post-accelerated (pps/pμA)	Post-accelerated, 500W primary beam (pps)
^{8}Li	^{15}N	50	C	$6.7*10^{7}$	$2.4*10^{6}$	$1.6*10^{6}$
^{8}Li	^{13}C	60	C	$1.4*10^{7}$	$5.0*10^{5}$	$3.3*10^{5}$
^{9}Li	^{13}C	60	C	$3.2*10^{5}$	$1.2*10^{4}$	$7.4*10^{3}$

Table 1: Beam intensities for $^{8,\,9}$Li pre and post-accelerated by the Tandem. Values in the first row were estimated at the beginning of the project while in the second and third row are reported the expected experimental rates deduced from the experiment at GANIL

Currently we are estimating the influence of the second factor on the third one as well as trying to unfold the three stages of the production process: diffusion, effusion and ionisation, thus getting the efficiencies for each stage.

The yields for $^{8,\,9}$Li were compatible with the estimation made at the beginning of the project (table 1). However, they can be improved by adding a Re liner inside the ioniser and by increasing the target and ion source operational temperatures.

The post-mortem inspection showed that the target unit was intact and reusable after a suitable radioactive cooling period

CONCLUSIONS

This year signed two milestones for the EXCYT activity: the radioactive beams $^{8,\,9}$Li were successfully obtained at GANIL with the EXCYT TIS and a 100 W ^{12}C primary beam was extracted at LNS [6]. In 2004, EXCYT will be completed and authorised to work with a primary beam power of 500 W. The commissioning of the facility with stable beams is planned for September 2004, while the start of the nuclear experiments with ^{8}Li is foreseen by the end of 2004.

The experimental programme takes into account the availability of the MAGNEX detector [7, 8], the requests and the first results obtained by the "Big Bang" collaboration [9] and the RSM experiment [10].

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