

# STATUS OF THE EXCYT PROJECT

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## Abstract

The EXCYT facility (EXotics with CYclotron and Tandem) at the INFN-LNS is under completion and its commissioning with  $^8\text{Li}$  as the first radioactive beam is foreseen by the beginning of 2005. In the following, we report the work done with an emphasis on the expected experimental lithium rates deduced from the tests at GANIL-SIRa and at ORNL-HRIBF

## INTRODUCTION

At the EXCYT facility the primary beam coming from an ECR ion source goes into a  $K = 800$  superconducting cyclotron (up to 80 MeV/amu, 1  $\mu\text{A}$ ) and then to the target-ion source assembly (TIS). Here the radioactive nuclides are produced via the ISOL method and, when positive, they pass through the Cs vapours of a charge exchange cell (CEC) to become negative. Then they are mass-separated in two stages, the first with a resolving power of about 2000 and the second up to 20000. Finally they are post-accelerated by a 15 MV Tandem. Besides the post-acceleration there is also a line at 300 keV for low-energy experiments with radioactive positive ion beams. 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 develop radioactive ion beams of  $^8,^9\text{Li}$ .

## THE TARGET-ION SOURCE ASSEMBLY

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  $^{18}\text{F}$ ,  $^7\text{Be}$  and  $^{22,24}\text{Na}$  by shooting  $^{19}\text{F}$  (48 MeV/amu) on a XYCARB UTR146 graphite target [3].

The previous TIS [4] proved to be unreliable and was therefore radically modified in its shape, dimensions and geometry as shown in fig. 1.

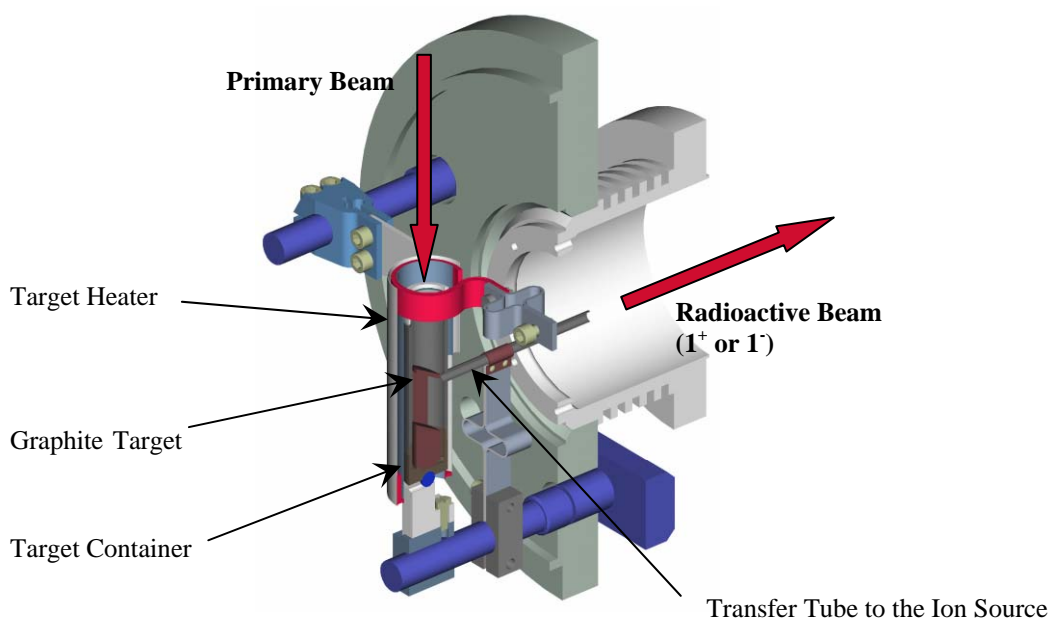


Figure 1: The new TIS. The real target area is mainly constituted by its upper part

In the new TIS the graphite target is standing in a tantalum container, which in turn is inside a tantalum heater. In this geometry, the primary beam impinges on the target from the top and there is no direct contact between heater and container. Heating is achieved by means of direct current while several tantalum layers on the outside of the heater screen 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 ranges of the primary beam and of the produced radioactive species. By a judicious choice, in principle it is possible to obtain that most of the products will be 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. During off-line tests we obtained an efficiency of 75% for  ${}^6\text{Li}^+$ , 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  ${}^{13}\text{C}$  primary beam (60 MeV/amu) on a  ${}^{12}\text{C}$  target under the same operational conditions that will be initially used at EXCYT.

After building an interface between EXCYT and SIRa, making off-line heating tests and running ANSYS thermal simulations at LNS [6], in May 2003 the TIS was mounted and outgassed at SIRa. The TIS withstood three abrupt thermal cycles from about 1700 K to room temperature while outgassing due to failures of the power supplies. Subsequently the on-line experiment started and in a few hours we could detect the first radioactive beams of  ${}^8,{}^9\text{Li}$ . 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).

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

This is mainly due to the increase of the target temperature by the primary beam power and of the heater temperature by Joule effect.

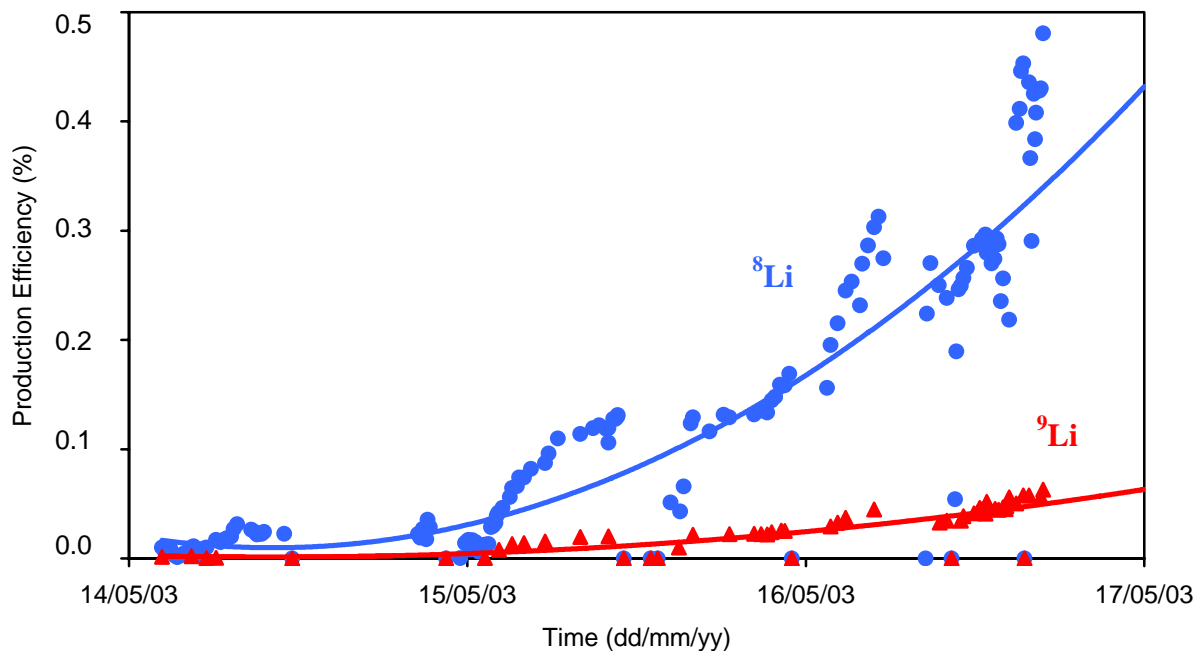


Figure 2: Production efficiencies for  ${}^8,{}^9\text{Li}$  versus time. The production efficiency is the ratio of the extracted radioactive ions to ones theoretically produced into the target (estimation by the EPAX code)

Beam	Projectile	Energy (MeV/amu)	Target	Intensity		
				Pre-accelerated (pps/pμA)	Post-accelerated (pps/pμA)	Post-accelerated, 500W primary beam (pps)
<sup>8</sup> Li	<sup>13</sup> C	60	C	1.4*10 <sup>7</sup>	1.0*10 <sup>5</sup>	6.6*10 <sup>4</sup>
<sup>9</sup> Li	<sup>13</sup> C	60	C	3.2*10 <sup>5</sup>	2.4*10 <sup>3</sup>	1.5*10 <sup>3</sup>

Table 1: Expected beam intensities for <sup>8,9</sup>Li pre and post-accelerated by the Tandem as deduced from the tests at GANIL-SIRa and at ORNL-HRIBF

Currently we are estimating the correlation between these two factors as well as trying to unfold the efficiencies for the three stages of the production process: diffusion, effusion and ionisation, thus getting the efficiencies for each stage.

The yields for <sup>8,9</sup>Li were compatible with the estimation made at the beginning of the project. However, they will 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

## THE CHARGE EXCHANGE CELL

During July-August 2004 CEC efficiency tests for <sup>6,7</sup>Li have been performed at the ORNL-HRIBF facility in collaboration with local staff. In order to reproduce EXCYT's operational conditions, the positive beam intensity was kept within 1 and 100 nA while the extraction energy was varied between 55 and 5 keV. In good agreement with Massey's adiabatic criterion, the efficiency values for <sup>6,7</sup>Li increased from 55 to 5 keV and showed an isotopic effect, thus leading to the conclusion that efficiencies for <sup>8,9</sup>Li at EXCYT will be higher than the corresponding measured ones for the lighter isotopes. The charge exchange efficiency at the EXCYT's minimum extraction energy of 20-25 keV is around 1%, perfectly consistent with the estimation made at the beginning of the project: this figure has also been applied to the expected experimental rates in table 1.

## CONCLUSIONS

The last two years signed three milestones for the EXCYT activity: the radioactive beams <sup>8,9</sup>Li were successfully obtained at GANIL with the EXCYT TIS, a 100 W <sup>12</sup>C primary beam was extracted at LNS [7] and tests at ORNL-HRIBF with the CEC were satisfactorily performed. 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 December 2004, while the start of the nuclear experiments with <sup>8</sup>Li is foreseen by the beginning of 2005.

The experimental programme takes into account the availability of the MAGNEX detector [8, 9], the requests

and the first results obtained by the "Big Bang" collaboration [10] and the RSM experiment [11].

## ACKNOWLEDGEMENTS

The Authors would like to thank Dr. Dan Stracener and Dr. Jean Bilheux (HRIBF-ORNL) for their precious help, support and collaboration in the CEC efficiency tests.

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