

# Collection device for the production of $^8\text{Li}$ and $^8\text{B}$ radioactive ions.

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**Abstract.** The goal of the European project EUROnu is the study of different ways to produce the future neutrino beams. One of them, proposed by C. Rubbia, is based on the production of  $^8\text{Li}$  and  $^8\text{B}$  nuclei and their post-acceleration. Within the "beta beams" work package of this project, our task is to study experimentally the production and collection efficiency of these 2 nuclei. Our R&D work is organised in two phases: first - design and construction of a collection device which will be validated with  $^8\text{Li}$ ; second - experimental study of the possible ways to extract  $^8\text{B}$  from the collection device.

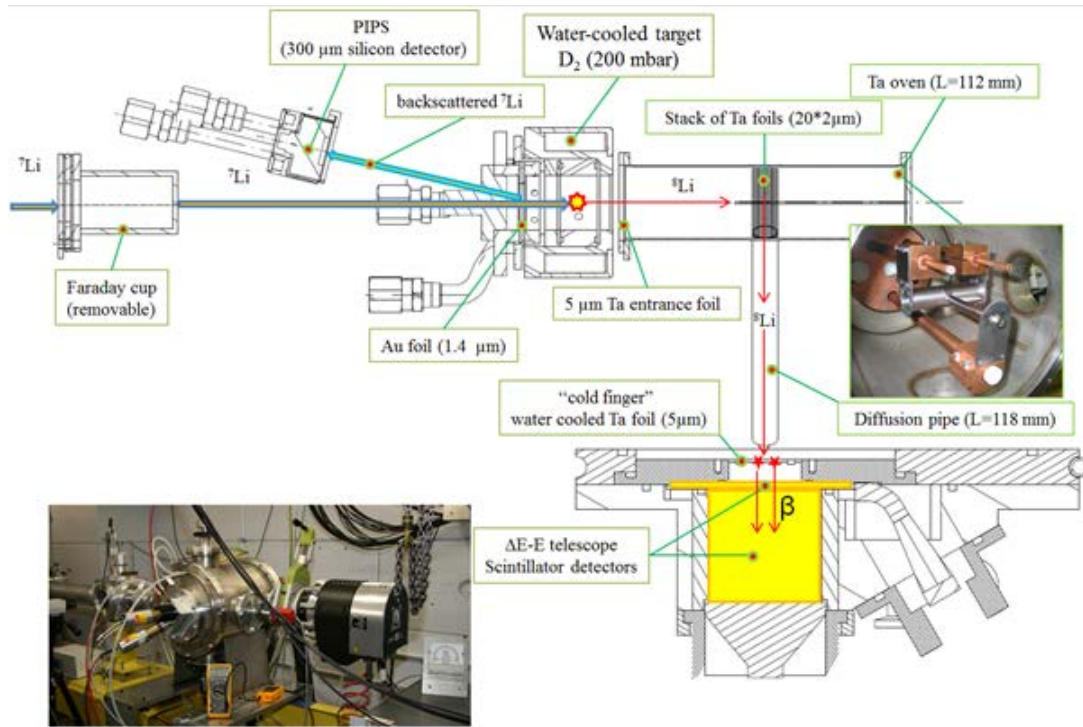
According to ideas described in [1, 2] to produce radioactive isotopes for neutrino beam creation, the collection device is part of the program set up within the EUROnu collaboration. We describe here the progress made during the latest reporting period for EUROnu [3]. The problems initially encountered with the welding of Tantalum, which were at the origin of some delay in the project, have been successfully solved. Mainly, the reported period was dedicated to test on-line our setup with  $^8\text{Li}$  produced by the reaction  $^2\text{H} (^7\text{Li}, ^8\text{Li}) \text{p}$ . For this purpose, a  $^8\text{Li}$  beam accelerated to 30 MeV by the cyclotron is sent on a gas cell filled with  $\text{D}_2$  at about 200 mbar<sup>1</sup>. After the energy loss in the entrance foil of the cell the energy of the  $^7\text{Li}$  beam is 24.9 MeV.

The recoiling  $^8\text{Li}$  are collected in a tantalum tube ( $d = 28$  mm,  $l = 112$  mm) in which they are slowed down by a set of tantalum foils. A diffusion pipe ( $d = 8$  mm,  $l = 118$  mm) brings the  $^8\text{Li}$  atoms to a cold plate in front of a telescope formed by 2 plastic scintillators to detect the beta decay (see Fig. 1). A set of power supplies allows heating this collection device in order to favour the diffusion of the  $^8\text{Li}$ . The beam is pulsed, and  $^8\text{Li}$  is detected during the beam off period. The beam intensity is monitored by the scattering of the beam on a gold foil

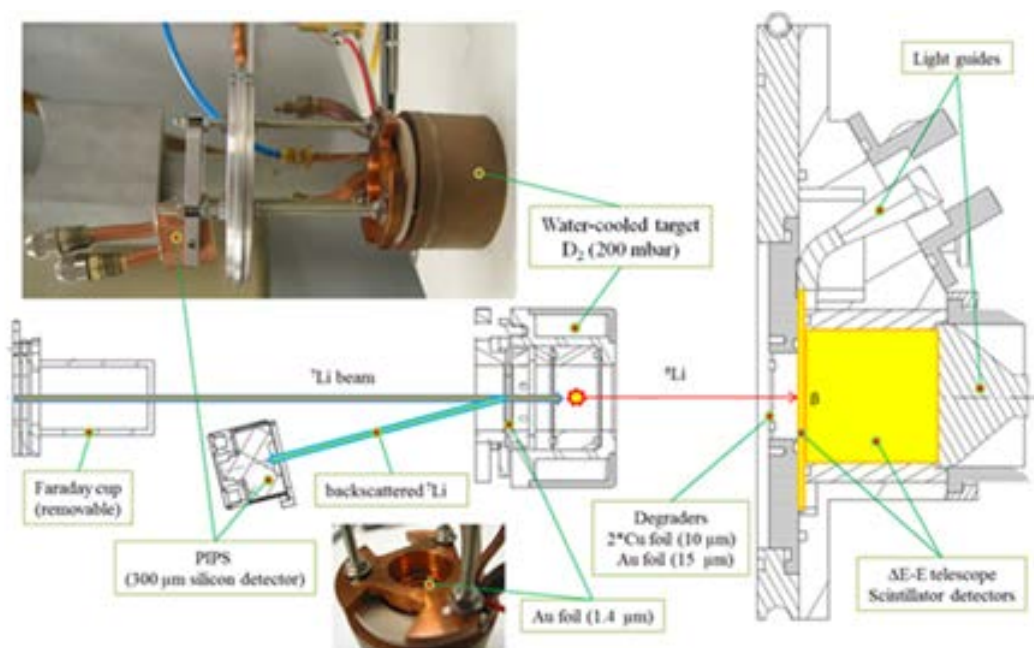
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<sup>1</sup> Initially a gold plated  $\text{CD}_2$  foil ( $\sim 200 \mu\text{g}/\text{cm}^2$ ) was used as a target but after several tests this solution was abandoned, due to the insufficient thermal resistivity strength.

installed just before the gas cell. The backscattered ions are detected by a Silicon detector (PIPS detector from Canberra with 300  $\mu\text{m}$  thickness) which is mounted at an angle of  $166^\circ$ .



**Figure 1.** Experimental setup (sketch).

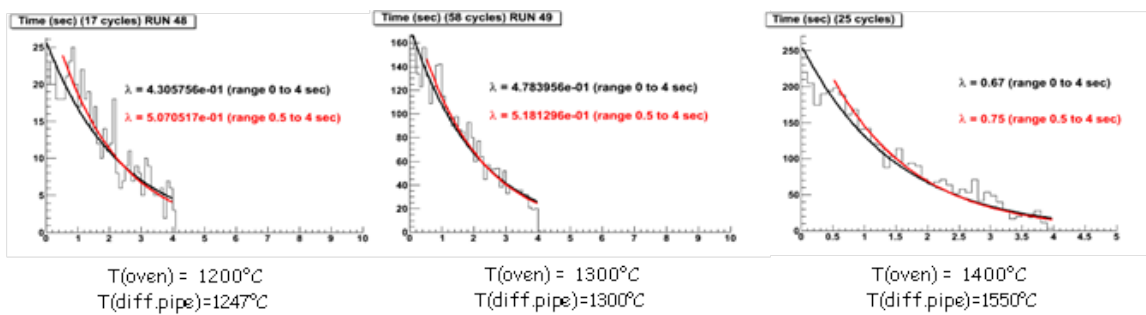


**Figure 2.** Experimental setup without oven (sketch).

In parallel, we made a second setup (without collection device/oven) to measure the overall production of  $^8\text{Li}$  because the first one is giving the efficiency only in arbitrary units (“integral measurement”).

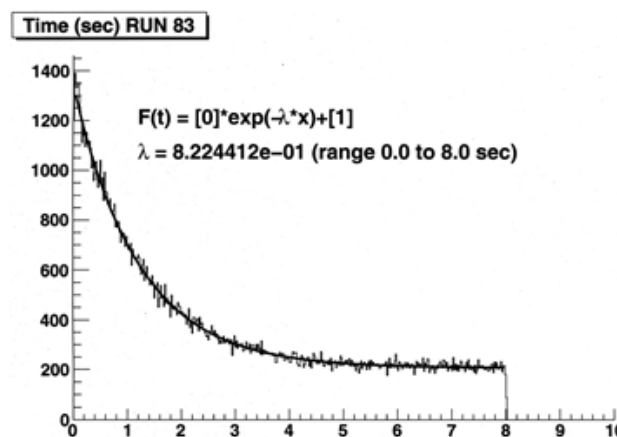
To decrease the production rate of secondary products of  $^7\text{Li}$  interaction before the telescope we use degraders (Cu and Al foils), see Fig. 2. To avoid any normalisation factors and to keep the same geometry (dimensions, distances, angles) we use the same target unit in both cases.

During the 2010-2011 period we had 10 beam runs, two of them in June 2011 were cancelled (due to cyclotron problems). Because of it we had to postpone the final  $^8\text{Li}$  experiments to Fall 2011. Our test runs with the oven during 2010 have shown that the extraction of  $^8\text{Li}$  will still improve if the temperature of the collection device and of the diffusion pipe is increased see test trends on Fig. 3.



**Figure 3.** Decay curves depending on the oven temperature. (Decay constant for  $^8\text{Li}$ :  $\lambda$   $0.83 \text{ s}^{-1}$ ).

We made also on-line tests for the integral measurement (the total amount of  $^8\text{Li}$  produced in the target), the  $^8\text{Li}$  decay constant is obtained (see Fig. 4). From the comparison of these results, it is clearly seen that we need to go higher in temperature; therefore we have ordered new power supplies.



**Figure 4.**  $^8\text{Li}$  decay curve. Integral measurement. Preliminary results.

The next step will be the measurement of the amount of  $^8\text{Li}$  extracted from the target and reaching the end of a heated diffusion pipe of about 120 mm as a function of the temperature up to 2000 °C. This measurement should be finished during Fall 2011. Preliminary schedule of beam runs for the Fall 2011:

1. 2011/09/23 – integral measurement for  $^8\text{Li}$
2. 2011/10/14 - oven measurement for  $^8\text{Li}$
3. 2011/11/11 – technical run. To test  $^7\text{Li}$  beam for  $^8\text{B}$
4. 2011/12/05 – reserved for oven measurement for  $^8\text{Li}$
5. 2011/12/23 – integral measurement for  $^8\text{B}$

The following progress has been made in 2010-2011:

- the preliminary results on the production and release of  $^8\text{Li}$  have been obtained;
- the behaviour of the setup as a function of the temperature, up to about 1400 °C has been tested;
- the problems related to the presence of the detectors in the vicinity of the collection device at 1400°C have been solved.

In parallel, we are preparing the extraction setup for the production of  $^8\text{B}$  ions. In this case, the diffusion of Boron ions will be negligible; hence Boron should be embedded in a molecule. We will slow down and stop the  $^8\text{B}$  ions in  $\text{AlF}_3$  and we expect the production of  $\text{BF}_3$  which can diffuse far enough to reach the detection setup and, in the final project, to reach the ECR source. For the moment we are in the design study of the  $^8\text{B}$  setup. These measurements must be finished in spring 2012.

#### References

- [1] Rubbia C *et al.* 2006 *NIM A* **568** 475–487
- [2] Zucchelli 2002 *Physics Letters B* **532** 166–172
- [3] <http://www.euronu.org/> annual report WP1-001/002/003