CERN/INTC 2001-010
INTC/I38
SW 200108

Feasibility study of radioactive beam production by photo-fission

O. Bajeat , F. Clapier, C. Donzaud, M. Ducourtieux , S. Essabaa, S. Galès, D. Guillemaud-Mueller, F. Ibrahim, H. Lefort, A.C. Mueller, J. Obert, N. Pauwels, J.C Potier, J. Proust , F. Pougheon, O. Sorlin, D. Verney
Institut de Physique Nucléaire, Orsay France

P. Jardin, N. Lescene, Y. Macovei, M. G. Saint Laurent , A.C. Villari
GANIL, Caen, France

H. Safa
CEA Saclay, France

U. Koster, C. Lau, A. Joinet, J. Lettry, H. Ravn, M. Santana-Leitner,
CERN, Geneva, Switzerland

As recently accessed by several international expert committees, the availability of intense neutron-rich nuclei opens new opportunities for nuclear-structure studies [1, 2]. Several laboratories are focusing in studies aimed at producing high enough intensities to warrant a new generation of experiments. Facilities are planned to provide these radioactive beams e.g. the EURISOL project.
Fission is a very powerful mechanism to produce such beams. A concept has been proposed by the Argonne National Laboratory to achieve the highest possible luminosities without dissipating too much power in the fissioning target. High energy neutrons in this proposal are produced by breaking up an intense deuteron beam in a dedicated and well cooled converter and induce fission in a thick ^{238}U target.

The R&D program PARRNe (**P**roduction d'**A**tomes **R**adioactifs **R**iches en **Ne**utrons) at IPN Orsay is aimed at studying the parameters to optimize the production of radioactive beams based upon this novel concept. PARRNe0 tested the feasibility of such a program. A 1 mm thick uranium target was bombarded with neutrons produced by breaking up 20 MeV deuterons in a graphite converter. The activity produced in this target is then analyzed off-line by standard nuclear spectroscopy techniques. As a next step we have developed the setup PARRNe1 (Fig.1) which allows to measure the online production of rare gases.The influence of the energy of the deuterons (20 to 200 MeV) along with the nature of the converter (Be, C, U) has been studied within the European RTD program SPIRAL II. These "PARRNe 1" measurements were done at Orsay (20 and 26 MeV) [3], Louvain la Neuve (50 MeV), KVI (80 and 130 MeV) with an UC_x target and at Orsay at 26 MeV with a molten U target [4]. These experiments have demonstrated that fast-neutron induced fission is a highly interesting method for future RNB facilities. However, this method requires the development of very intense primary beam (i.e. deuterons or protons) for the neutron production.

An interesting alternative to this would be to use the Bremsstrahlung - induced fission of uranium. Diamond [5] has calculated that 5 10^{13} fissions / s could be produced in an optimal ^{235}U target or about 60 % of that amount in a natural uranium target using a 100 kW beam of 50 MeV electrons which is about the optimum energy for this production mechanism. Oganessian [6] reports first encouraging off-line results with a low energy (25 MeV) electron beam. Indeed, the significantly lower cost of an electron accelerator compared to any other primary beam accelerator makes this alternative very attractive.

We would like to benefit from the shut-down of the LEP operation to install our PARRNe 0 and 1 devices for a period of about one week after the first 50 MeV injector-linac section. Thus we would be able in about 2 days of measurement time to compare fast-neutron datato Bremsstrahlung data under exactly the same conditions for the observation and extraction of the fission fragments. This direct comparison would allow to have precious input on the assessment of the choice for the driver accelerator for the planned future projects. The installation of our set-up which requires very little space has already be discussed with the PS division. Our method is highly sensitive, several short irradiation pulses of 60s (also suitable for measuring the diffusion times) are sufficient, and, therefore, the total amount of activity produced extracted and collected is small. A technical report on this issue is presently under elaboration in collaboration with the CERN Radiation Safety Group.
We would like to have the following experimental conditions (open to discussions according to the possibilities of the machine) :

energy	50 MeV if possible
intensity	0.5 - 10 μA
beam diameter	≈ 0.5 cm
irradiation time for PARRNe0	a few minutes
irradiation time for PARRNe1	short irradiations over 2 full days

In summary we ask for 2 days of 50 MeV electron beam from the first part of the LEP injector which can be schedule from next spring on.

[1] NuPECC report on radioactive Nucl. Beams Facilities, April 2000 http://www.nupecc.org
[2] OECD Report of the study group on RNB, OECD, Paris 1999 http://www.ganil.fr/eurisol
[3] F.Clapier et al, Phys Rev ST - Accelerators & Beams, 1 (1998) 1
[4] S.Kandri-Rody et al, Nucl Instr and Meth B160 (2000) 1
[5] W.T.Diamond, Nucl Instr and Meth A432 (1999) 471
[6] Y.T.Oganessian, preprint proceedings RNB2000 Divonne les Bains May 2000

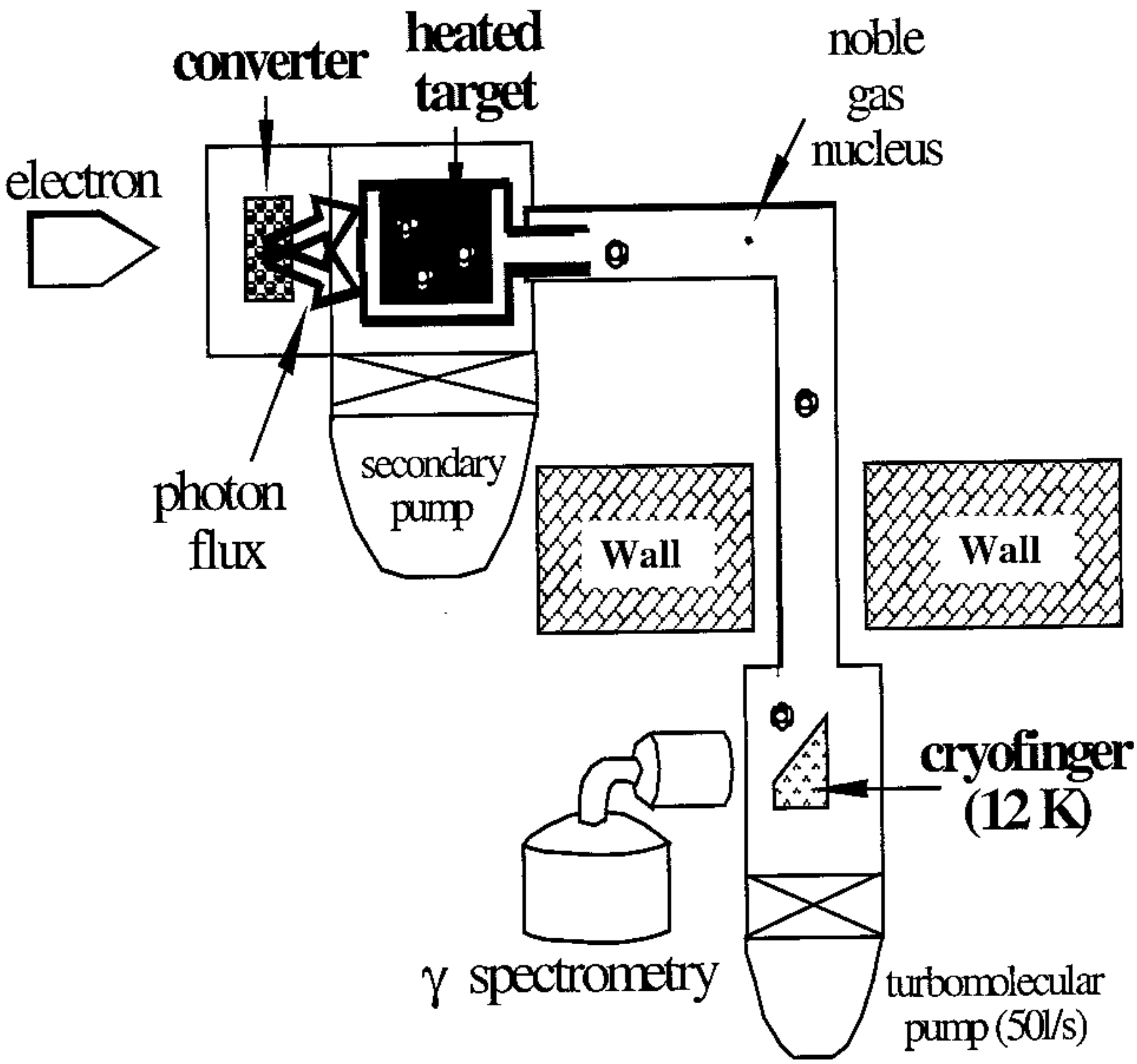

Figure 1 : schematics of the PARRNe1 setup