AN ON-LINE ISOTOPIC SEPARATOR TEST BENCH AT GANIL

P. Bricault, R. Leroy, M. Lewitowicz, J.Y. Pacquet, M.G St-Laurent, P. Sortais,

GANIL, B.P. 5027, 14021,CAEN, FRANCE,

A.C. Mueller, J. Obert, J.C. Putaux
IPN, 91406, ORSAY, FRANCE,

Liang C.F., P. Paris
CSNSM, 91406, ORSAY, FRANCE

and
J.C. Steckmeyer
LPC-ISMRA, 14050, CAEN, FRANCE.

ABSTRACT

A brief description of an isotopic separator test bench installed at GANIL is given. This test bench is equipped with a very compact ECR ion source made entirely from permanent magnets, operating at 10 GHz. Results obtained during the first run with a ^{20}Ne beam at 95 A*MeV on a MgO thick target are presented.

1. INTRODUCTION

There is over the last years a growing worldwide interest on the possible use of radioactive nuclear beams for a variety of fundamental and applied sciences studies. In our project we use the high energy heavy ion beams provided by the GANIL cyclotrons facility to produce "exotic" beams. For the moment the primary beam intensities are limited to 2 10^{12} pps for light ions. With the new high intensity axial injection system the primary beam intensity will be multiplied by a factor of 10 for light ions from ^{12}C to ^{40}Ar[1].

In order to determine if heavy ions can be competitive compare to high energy protons for the production of "exotic" nuclei we have built an isotopic separator on-line test bench. This test bench is equipped with a very compact ECR ion source made entirely from permanent magnets, operating at 10 GHz. All over the year we will measure the production rate using other heavy ion beams such as ^{24}Mg, ^{86}Kr, ^{12}C, etc. on various target materials.

For future applications of "exotic" nuclei, we plane to post-accelerate them up to a few tenth MeV per nucleon. There are two major solutions under study, the linear accelerator based on super conducting cavities and a compact cyclotron.

In section 2 general layout description of the separator is given. The target assembly and the ECR ion source is described in section 3.2 and 3.3 respectively. In section 4 we will present the first results obtained with this separator.

2.GENERAL LAYOUT OF THE SEPARATOR

A schematic top view of the separator is given in fig. 1. The ion beam from the accelerator makes an angle of 73° to the axis of the separator beam. Reaction products are thermalized in the target and subsequently ionized in the ion source. The reaction products are extracted axially from the ion source. The accelerating voltage is usually 15 kV, but it can go up to 20 kV. The extraction system is the same as the one used on the ECR ion source used at GANIL. The extraction electrode is at the ground potential. In order to compensate the space charge effect observed during the first runs a new extraction system is under studies.

The separator beam travels through the 102° magnet into a collection chamber. The collection chamber is equipped with diagnostic instrumentations, in particular a Faraday cup and a profile monitor mounted on a remote control mechanism.

Low intensity stable beams and radioactive beams can be guided through a narrow slits aperture and after continuing through a quadrupole doublet, comes to a second focus in another collection chamber. This collection chamber is equipped with various instrumentation for final diagnosis and collection, including a tape transport system and detectors for radioactive species identification

The separator beam lies in a horizontal plane, coplanar with the acceleration beam lines. The separator is located in an experimental room, so the second collection chamber is not shielded enough from the accelerator beam lines. This brings some problems during the detection of the radioactive species, so the primary beam must be pulsed to avoid high level of background.

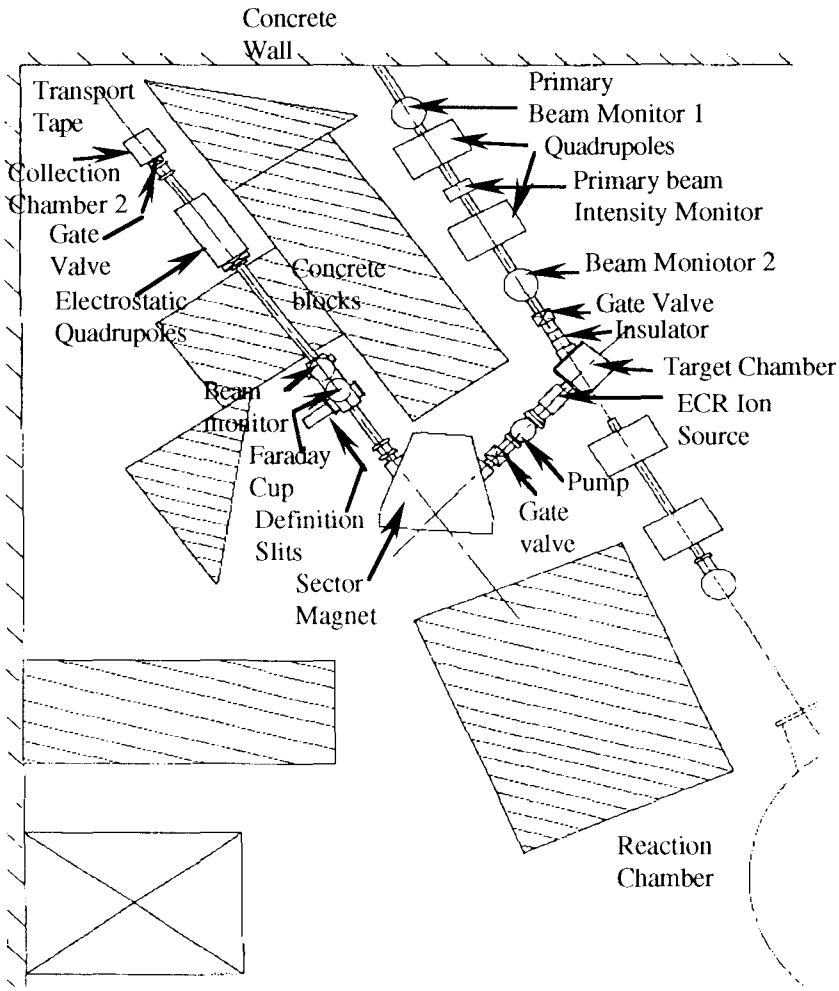

Fig.1 Schematic top view of the separator test bench installed in the experimental room D2 at GANIL.

3. DETAILS OF THE SYSTEM

3.1 The sector magnet

Due to the requested short delay of realization we have chosen for our separator, the same magnet as the one used for the ECR ion source test bench[2]. The magnet was built with an H configuration under the following specifications: radius of curvature r_0= 350 mm, sector angle 102°, the pole face angle are 26°. The resolving power R defined by R=M/δM, where δM is the full width at half maximum of a peak at mass M is about 100 for low masses (A<20).

3.2. The target chamber

In the on line mass separator discussed in this paper the reaction products are always brought to rest before being ionized. We have to separate continuously the product nuclei from a huge amount of target nuclei and transfer them into the gas phase to the ion source. This is done by heating a low vapour pressure target material to a sufficiently high temperature at which the nuclei of interest are released by diffusion and desorption process.

The transfer process is governed entirely by element specific diffusion, desorption and chemical processes.

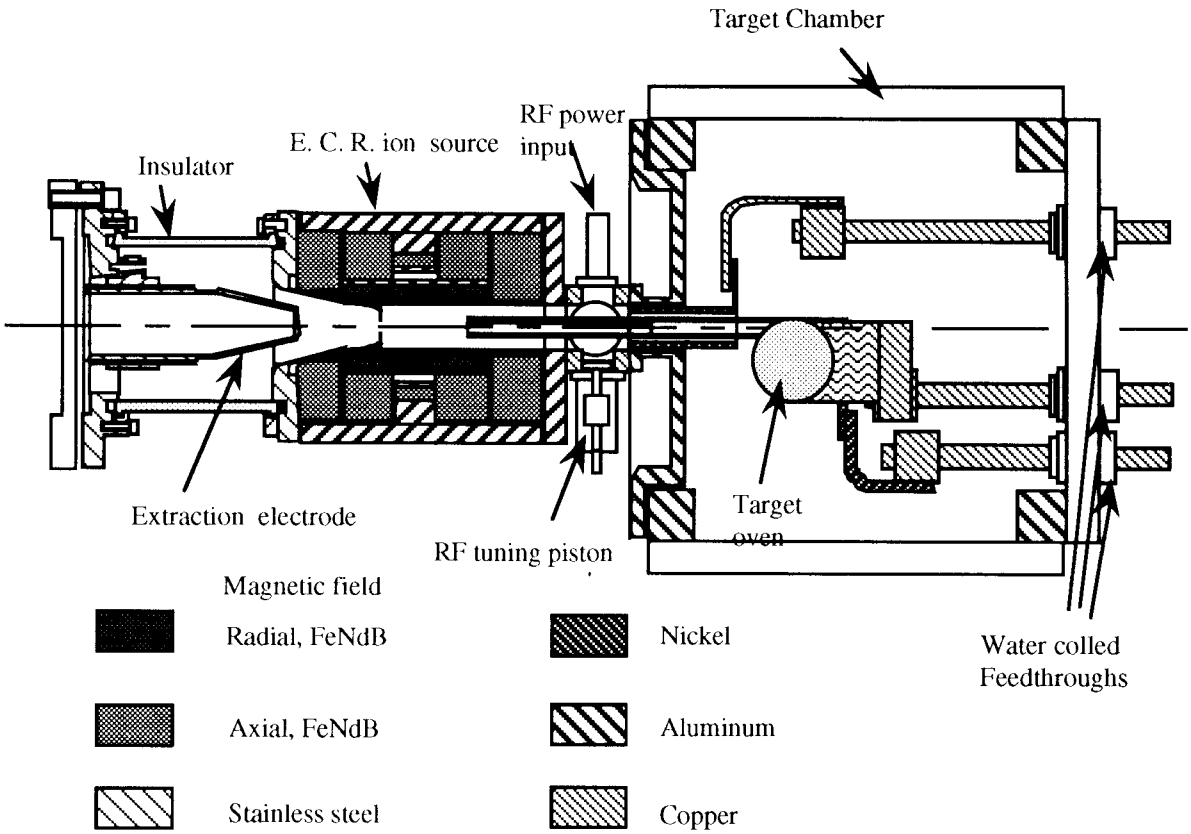

Fig 2 Schematic view of the target and ECR ion source.

We used the same target as the one constructed by the ISOCELE group at Orsay[3]. Fig. 2 shows a schematic view of the target chamber and the coupling to the ECR ion source.

The target is on high voltage (20 kV) mounted on a flange of the vacuum chamber.

The nickel target oven is a 7.5 cm long cylinder heated by resistive heating up to the maximum temperature of about 1200 °C. The current feedthroughs are water cooled copper. Inside the oven is the target crucible supported on boron nitride insulators which holds the target material. The wall of the crucible are made from a very thin grid allowing the gaseous products to escape. The oven is connected to a nickel transfer line.

The transfer line is a 25 cm long, 5 mm diameter nickel tube. This tube can be also heated to several hundred ° C by resistive heating independently of the target oven.

3.3 The ECR ion source

The ion source selected for the on line mass separator is a single stage electron cyclotron resonance ion source (ECRIS). ECRIS showed high efficiencies in ionizing various species and as well demonstrated long running times without any maintenance being necessary. In addition, to post accelerate the radioactive ions up to several tenth MeV per nucleon, a high charge state obtained directly from the ion source will reduce considerably the cost of the planned post accelerator. For this reason it was decided to couple an ECRIS to our test bench.

We have built a completely new ECRIS, the axial field is made using FeNdB permanent magnets. The mirror ratio is 2.9 at the injection and 2.7 at the extraction. This difference is due to the shape of the plasma chamber at the extraction (Fig. 2). An octupole, also made from FeNdB permanent magnets provide the radial electron confinement. The surface field is 0.6 T. Our ion source is 17 cm long and 13 cm of diameter. Such very small ECRIS can only be done by using permanent magnets.

The radio frequency power is brought by a 10 GHz klystron powered amplifier. The rf injection is done using a coaxial line tuned by a small piston. The gas is fed in the ECRIS through the copper tube of the coaxial rf injection. The injection of the vapour directly into the ECR zone seems to lead to very good ionization efficiencies. We plan in a very near future to measure the ionization efficiency using calibrated leak. This can also be done using a similar technic as the one described by

R. Kirchner[4], a stable incoming beam is brought at rest in the target. The ions after neutralization are released to the ion source, ionized and subsequently they are accelerated. Then, we can obtain the release profile I_{out}/I_{in}, where I_{in} is the primary and the secondary beam intensities.

The extraction chamber of the ECRIS is pumped by a 450 l/s turbomolecular pump. Typical pressures achieved in the extraction chamber are of the order of $5x10^{-6}$ mbar or lower.

3.4 Detection system

The collection chamber at the end of the separator beam line is a cube. It is equipped with a Faraday cup and a tape transport system from ISOCELE[3]. The tape transport system is operated in primary vacuum, except for the collection point placed in a secondary vacuum.

The collected beam is moved periodically to one of the two different detector locations. In the first one two NaI detectors are used to detect in coincidence the two gammas produced by the annihilation of the β^+. At the other location we have placed a plastic scintillator and a Ge detectors. We can make single γ detection or coincidence between the plastic and the Ge for delayed γ emitter.

For the both detection systems the informations on particle energies and the characteristic decay time were registered for each studied isotopes.

All information are send to the GANIL acquisition system consisting of VAX computers for further off-line analysis.

Table 1 Summary of the observed isotopes.

Isotope	Half life (s)	Primary beam (nA_p)	Yield (particle/s/μA_p)①
$^{19}Ne^{1+}$	17.2	35	$4,8\ 10^7$
$^{19}Ne^{2+}$	"	35	$8,9\ 10^6$
$^{19}Ne^{3+}$	"	32	$1,6\ 10^6$
$^{18}Ne^{2+}$	1,67	95	$1,9\ 10^6$
$^{18}Ne^{4+}$	"	90	$1,9\ 10^5$
$^{23}Ne^{1+}$	37,5	100	$6,310^5$
$^{24}Ne^{1+}$	$2,0\ 10^2$	110	$1,5\ 10^5$
$^{13}N^{1+}$	$6,0\ 10^2$	40	$3,8\ 10^5$

① This the yield observed on the transport tape, the efficiency of the transport system is not take into account.

4. RESULTS AND DISCUSSIONS

The first run was in march 1992, we have used a 95 A*MeV ^{20}Ne beam impinging a thick target of natural MgO. We succeeded to extract and ionize the $^{18,19}Ne$, $^{23,24}Ne$ and ^{13}N. The results are summarized in Table 1.

The intensity on the target was limited to $1\mu A_e$ for handling and damages cause on the thin window at the entrence of the target.

This results are very promising since this is the very first attempt to produce radioactive species with the on-line isotopic separation method at GANIL.

A new location is under study in order to avoid problems coming from the slow neutrons and background in the experimental room. A new separator is also under consideration, the resolving power should be much greater, of the order of few thousands, in order to separate properly masses in the region of mass 100.

Following the magnet we will place a cylindrical electrostatic deflector in order to separate off neutral components. The new beam line will pass through a concrete wall and the second collection chamber will be well shielded behind 4 m of concrete.

5. REFERENCES

1) C. Ricaud, M. P. Bourgarel. "Commissioning of the New High Intensity Axial Injection System for GANIL", paper presented at this conference.

2) L. Bex, M. Bisch, M.P. Bourgarel, Y. Bourgouin, E. Baron, "First results with the GANIL ECR ion Source", presented at the Workshop in the Sixth Int. ECR ion Source, Lawrence Berkeley Laboratory, Jan, 1985.

3) P. Paris, V. Berg, A. Caruette, J. Obert, J.C. Putaux, J.L. Sarrouy, "Development ot the ORSAY High Current On-Line Separator ISOCELE", NIM 139 (1976) 251-256.

4) R. Kirchner, "On the release and ionization efficiency of catcher-ion-source systems in isotope separation on-line", presented at the conference on Electromagnetic Isotope Separation, Sendai, Japan, Sept 2-6, 1991.