NEW DESIGN ISSUES OF THE EXCYT PROJECT

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Abstract

The EXCYT project (EXotics with CYclotron and Tandem) is devoted to the production and the acceleration of secondary beams. The project has been funded by Istituto Nazionale di Fisica Nucleare (INFN) at the end of 1995 over a period of 4 years and most of the design features have been defined. We will present here a brief description of the cyclotron upgrading for the production of intense primary beams, of the target-ion source unit, of the mass separator, designed to obtain a mass resolution of 20,000, and of the other issues of the project.

1 INTRODUCTION

A beam of about 1 pµA of oxygen and carbon at energy up to 100 MeV/amu will produce the radioactive nuclear beams (RNB) in a target-source complex; the secondary ion will be accelerated by the Tandem up to 150 MeV. Intensities up to 10^9 pps are expected.

The project has not required the construction of new buildings, but only minor modifications of the area under the Tandem hall, where the target-ion source unit is located on a high voltage platform (fig. 1,2). New shieldings are limited to 1 m additional walls and roof.

2 CYCLOTRON UPGRADING

The EXCYT facility at nominal performances requires not only a source able to deliver very intense beams of fully stripped ions, but also a special central region which can manage such an intensity and electrostatic deflectors able to operate with a beam power up to 2 kW. From the ECR source SERSE [1,2], under construction, we expect very high currents of fully stripped carbon and oxygen. The construction of the magnetic system of SERSE has been delayed because the company which has built the coils declared to be unable to fulfill the specifications; then we will begin the source tests at magnetic field values 30% lower than the design values, meanwhile a new magnetic system is being made by another company.

The commissioning of the source will begin in September 1996 and in summer 1997 the new magnets will be mounted in the cryostat and the final tests will begin, in order to work with the Cyclotron in May 1998.

Being SERSE insufficient to ensure continuous operation for the EXCYT on-line tests, we have begun the design of a source with conventional magnets.

The study of the extraction process and of the transport of the primary beams to the Cyclotron has been carried out by taking into account the space charge effects [1].

A buncher consisting of two closely spaced grids driving voltage inputs and load resistors in the axial injection line should increase the amount of accelerated ions by a factor 4 with respect to the unbunched beam.

As for the inflector and the central region, our reference point is the axial injection system redesigned for the NSCL K500 Cyclotron. [1,2]. For the LNS Cyclotron, h=2 is the main harmonic number, allowing to accelerate ions from 8 to 100 MeV/amu. All of the simulation runs are being done for the limiting case of E=100 MeV/amu and fully stripped ions.

The inflector will be a 6 mm spiral type one.

The central region will consist of specially shaped electrodes to accelerate the particles from the inflector exit to the main dee region of the machine. We plan to perform the phase selection in the first orbits, in order to have a single turn extraction, which should eliminate beam losses, reducing the activation in the cyclotron.

The electrostatic deflector is another critical component [1,2]. It must operate with a high electrical field of about 140 kV/cm on a 6÷8 mm gap and magnetic field up to 5 Tesla. This system has proven to be very critical because of HV discharges in the gap.

A R&D program, based on a reduced dimensions electrostatic deflector simulator is under development [3], looking for electrode surfaces roughness-free and without superficially adhering microparticles. This can be obtained by finishing treatment at sub-microscopic polishing, final cleaning treatment for removing all traces of superficial debris and thermal treatment producing gas desorption from the electrode materials [2,3]. Moreover surface treatment (nitridation, thick film deposition, ion implantation) will be extensively tested.

Preliminary investigations have shown in the test stand the possibility to work with magnetic field at 140 kV/cm by using titanium and titanium alloys, such as Ti-6Al-4V, for cathode and Mo for liners.

The primary beam line has been designed to deliver vertically the beam onto the production target placed on the HV platform, reducing the radiation shielding. The bending plane of the 90° dipole is designed to coincide with the first section of the separator beam line in order to be able to realign the magnet for a longer ion source.

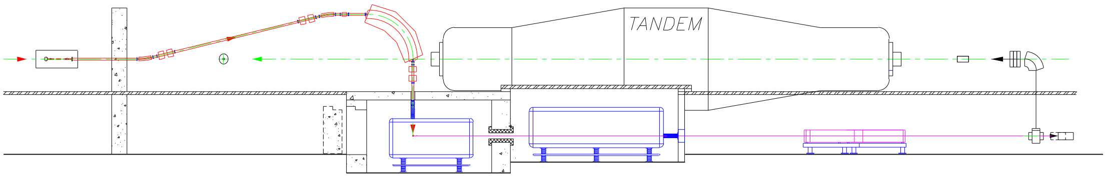

Fig. 1 - A view of the EXCYT area with the HV platforms and the primary beam line.

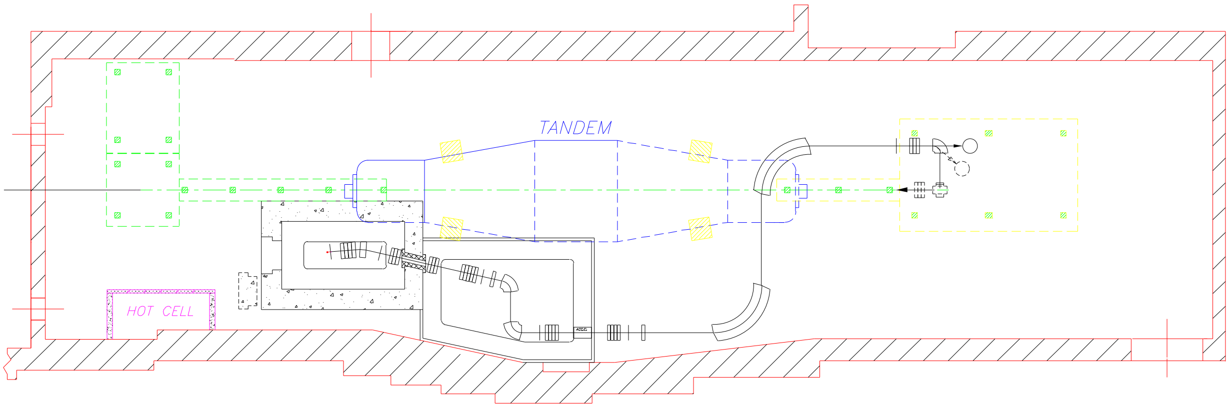

Fig. 2 - A plan of the EXCYT area with the HV platforms, the primary beam line and the mass separator.

3 HIGH VOLTAGE PLATFORMS

Two HV platforms working at the same potential (up to 250 kV) will be built in separated rooms. Most of the radioactivity will be generated and confined in the first platform area, where target-ion source and a preseparator will be placed. Thus all the used materials will be radiation resistant and the platform will be located in a shielded pit. The radioactivity level in the second platform area will be much lower. Thus it will be accessible as soon as the primary beam is switched off and the used materials will not have to be specially radiation resistent.

4 SAFETY AND HANDLING

Fundamental characteristics of systems working with RNB such as reliability, redundancy, safety and easy maintenance, must not change in case of power failure, as well as water, compressed air and vacuum failure.

Materials which could be hit by the beam must be low activation materials. All the parts that, even by accident, could be hit by the beam, must have a suitable cooling system and must be covered with graphite shieldings. The organic materials parts must be easily replaceable, as they can be damaged by the radiation. The operation, controls and replacements of possibly activated sections of the line must be performed remotely and automatically. The parts of key importance in terms of safety will have hardware interlocks. For frequent operations, like the replacement of the target ion source complex, a manipulator will remove the activated target ion source from the platform and move it to the shielded storage area. Conversely it will move a new target ion source from the storage area to the platform. A storage area will be built for new and activated parts. Shielding, air control, environment control and access controls are foreseen. The atmosphere will be controlled and the gases coming from the vacuum pumps treated. A hot cell, accessible also during the facility operation, is going to be built.

5 TARGET - ION SOURCES

In the EXCYT Isol facility, the primary beam interacts and eventually stops in a thick target. The radioactive products diffuse to the surface of the target and are desorbed, then they effuse via a transfer tube and reach the ionization device, where they are produced either as negative 1^- ions or as positive 1^+ ions which will undergo a charge exchange process to 1^- .

The first target material to be used will be carbon (grains). In order to lower the sticking time of the desorbed products to the surfaces, we will try to use rhenium coatings. Power deposition and target temperature distribution will be analysed using a finite element code. We also plan to investigate the use of a conical target, similar to the one used at GANIL [1,2].

For initial use in the Excyt facility we have chosen to use the CERN-ISOLDE electron beam plasma ion source [1,2], which efficiently produces monocharged positive ions of many different species with low emittance (about 2π mm mrad MeV$^{1/2}$) and high reliability. A microwave discharge positive ion source is under development [1,2] and some promising preliminary results have been obtained. A recirculating-type, cesium charge exchange cell, successfully used at ORNL-HRIBF, will be used [2] to get the negative ion for Tandem injection. We plan to develop even a negative surface ionization source.

6 THE MASS SEPARATOR

The ionized short-lived nuclei should be delivered to the post-accelerator purely and efficiently, even in presence of intensities of neighboring isobars that exceed the intensities of the nuclei of interest.

The EXCYT mass separator will consist of two separation stages at two different potentials, in order to accomplish a momentum analysis as well as an energy analysis. The overall system consists of four sections (fig. 1,2): a preseparator on the first high voltage platform located inside a heavily radiation shielded area; the beam guidance system that leads the 50 keV ion beam through a shielding wall to the second high voltage platform and focuses it to the charge-exchange cell, from where it is sent to the first stage; the high resolution second stage that analyzes the ions after they have been accelerated to ground; the beam guidance system to the Tandem.

The preseparator consists of one 18° dipole magnet and 4 electrostatic quadrupoles. The magnet will have a C designe for easy access to the vacuum chamber. The mass resolving power of the preseparator is $m/\Delta m \approx 170$, so that no heavy radioactive shielding is required downstream.

The first stage consists of a beam guidance system that takes the ion beam from the output of the preseparator to the charge exchange cell located between the wall beam guidance system and the first quadrupole quadruplet [1].

The ion beam coming out from the charge-exchange cell is focused to the separator entrance slit by an electrostatic quadrupole quadruplet. The system is aberration free and produces a resolving power $m/\Delta m \approx 2000$ at the exit slit.

The second stage separator will consist of two 90° sector magnets with bending radii of 2.6 m. The achievable mass resolution power of the second stage is 20000.

After the exit slit of the second stage mass separator a guiding system made of three 90° sector magnets deflects the beam to the Tandem axis, ensuring that the beam envelope is well lower than the gap of the magnets.

7 COMPUTER CONTROL

The design of the Computer Control for the EXCYT project [4] we will exploit the experience gained in the last years with the same task performed for the CS [1].

We plan to mantain the computing power distribution but, at the same time, we consider the possibility to improve the hardware, software and network capabilities taking account the new techniques available. Instrumentation interfaces, networking and man-machine interaction are the main subjects that will be investigated. We plan to upgrade the process and supervisor level, orienting our study towards a drastic reconfiguration of the process network, stations as well as the console realizing an improvement of hardware and software but keeping the same design and versatility. We started the first tests using LabVIEW 4.0 (NI) under Windows 95/NT running on powerful PCs based on 586 Pentium as well as RISC processor. Two software tool-kit as Visual C++ and LabVIEW will be explored too.

8 BEAM DIAGNOSTICS

Several types of beam profile monitors (BPM) suitable to detect low intensity beams (10^4-10^8 pps) are under study [1]. Such devices should allow both qualitative and quantitative measurements, in order to perform an efficient beam tuning and transport. Thus a BPM should be robust to withstand beam set-up and accidents (vacuum leaks, power failures, human errors), easy to use, completely accessible to the whole accelerator staff, and rather cheap. Our R&D activity is developing along three main lines: scintillators, in form of screens or fibers; electron/ion detectors, exploiting the gas ionization or the secondary emission effects; very low energy (100-400 keV) beam monitor, that is perhaps the most challenging device.

A number of prototypes have already been developed and tested with interesting results.

9 CONCLUSIONS

The main issues of the EXCYT project have been addressed and some of them have also been solved. With respect to the original proposal [4] the feasibility of the project has been demonstrated. R&D work is necessary to solve the extract such a high currents from the cyclotron and to have an efficient ionization of the recoils. The first on-line tests are planned to be performed in 1999.

REFERENCES

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