STATUS OF THE SPES PROJECT: A NEUTRON RICH ISOL FACILITY FOR RE-ACCELERATED RIBS

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Abstract

SPES (Selective Production of Exotic Species) is an INFN project with the aim to develop a Radioactive Ion Beam (RIB) facility as an intermediate step toward EURISOL. The SPES Project is under realization at the INFN Legnaro National Laboratories site. The SPES Project main goal is to provide a production and accelerator system of exotic beams to perform forefront research in nuclear physics by studying nuclei far from stability. The SPES Project is concentrating on the production of neutron-rich radioactive nuclei with mass in the range 80-160. The final energy of the radioactive beams on target will range from few MeV/u up to 11 MeV/u for A=130[1]. The SPES facility acceleration system will be presented.

INTRODUCTION

The aim of SPES (Selective Production of Exotic Species) is to provide high intensity and high-quality beams of neutron-rich nuclei to perform forefront research in nuclear structure, reaction dynamics and interdisciplinary fields like medical, biological and material sciences. SPES is a second generation ISOL radioactive ion beam facility, part of the INFN Road Map for the Nuclear Physics and supported by the Italian National Laboratories LNL (Legnaro) and LNS (Catania). It represents an intermediate step toward the future generation European ISOL facility EURISOL. It is based on the ISOL method with an UCx Direct Target able to sustain a power of 10 kW. The primary proton beam will be delivered by a Cyclotron accelerator with energy of more than 40 MeV and a beam current of 200 μA. Neutron-rich radioactive ions will be produced by Uranium fission at an expected fission rate in the target of the order of 10^{13} fissions per second. The exotic isotopes will be re-accelerated by the ALPI superconducting LINAC up to energies of 10-13 AMeV, for masses in the region of A=130 amu, with an expected rate on the secondary target of 10^{8} pps.

FACILITY DESCRIPTION

The proposed facility has two main goals: to provide an accelerator system RIB production facility to study nuclei far from stability and to develop an accelerator based interdisciplinary research centre.

The SPES project is concentrating on the production of neutron-rich radioactive nuclei with mass in the range 80-160 by the Uranium fission at a rate of 10^{13} fission/s. The emphasis to neutron-rich isotopes is justified by the fact that this vast territory has been little explored, at exceptions of some decay and in- beam spectroscopy following fission. Therefore, reactions in inverse kinematics will allow a new class of data to be obtained. The Rear Ion Beam (RIB) will be produced by ISOL technique using the proton-induced fission on a Direct Target of UCx[2]. The proton driver is a Cyclotron with variable energy (30- 70 MeV) and a maximum current of 0.750 mA upgradeable to 1.5 mA and split on two exit ports. The second goal of the facility is achieved by the use of a second high-energy proton beam for applied physics and by developing an accelerator based Neutron and Proton Facility. The Neutron Facility will allow irradiation-processes for material research and cross section measurements. The Proton Facility will allow the production and development of radionuclide of medical interest. The radioactive beams, in selected forms, are also valuable tools for biological and medical research in the field of cancer therapy.

The SPES facility is designed to supply a second generation of exotic beams able to perform a step forward toward EURISOL and to offer a powerful accelerator based system for research in Astrophysics, Medicine, Applied Physics and Material Science.

The most critical element of the SPES project is the Direct Target. Up to day the proposed target represent an innovation in term of capability to sustain the primary beam power. The design is carefully oriented to optimize the radiative cooling taking advantage of the high operating temperature of the target system that is in the order of 2000°C. An extensive simulation of the target behavior has been performed to characterize the thermal properties and the release process. Experimental work to benchmark the simulations was carried out at HRIBF, the Oak Ridge National Laboratory ISOL facility (USA). The production target is designed following the ISOLDE and EXCYT projects and special care will be devoted to the safety and radioprotection of the system. According to the estimated level of activation in the production target area of 10^{13} Bq a special infrastructure will be designed. The use of up-to-date techniques of nuclear engineering will result in a high security level of the installation. The radiation management and the control system will be integrated and redundancies will be adopted in the design. The isotopes will be extracted and ionized at 1+ with a source directly connected with the production target. Laser, surface and plasma sources will be used according to the beam of interest, with the aim to produce a beam as pure as possible. The selection and the transport of the exotic beam at low energy and low intensity is a

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challenging task. Techniques applied to the EXCYT beam will be of reference for the beam diagnostic and an online identification station will be part of the diagnostic system.

A Beam Cooler will be used to both reduce the energy spread of the RIB beam and to optimize the resolution power of the High Resolution Mass Spectrometer (HRMS). To optimize the reacceleration, a Charge Breeder will be developed to increase the charge state to N+ before to inject the exotic beam in a new RFQ that represents the first re-acceleration stage before the injection in ALPI.

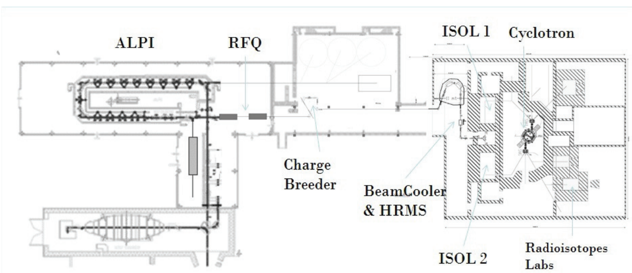

Figure 1: Layout of the SPES ISOL facility. Underground level.

The SPES layout is shown in figure 1. The stripes grey area on the right has to be constructed to house the cyclotron proton driver, the two RIB targets, the proton and neutron facility and the target development laboratory. The plain grey part on the center and of the right is the already existing LNL facility that will be adapted to fit the SPES project requirements.

STATUS OF THE PROJECT

The main milestones of the SPES project during this year are the definition of the final layout for the radioactive beam transfer and the completion of the executive project for building and infrastructures. This year the bid for construction will be performed and the ground breaking is expected at the early beginning of 2013.

A Quality and Safety Management System is under development to follow the different construction phases of the project with the aim to improve the safety from the design to the operation. It is part of the system a general risk analysis and the implementation of safety controls. The authorization to the operation of the Cyclotron is under way as well as the authorization to handle UCx in a dedicated chemical laboratory.

The development of the ISOL target was focused on the study of ion sources and the production and test of UCx materials. The R&D in the production of UCx pellets with controlled characteristics continued during this year and a second in-beam test of the SPES target configuration was performed in collaboration with HRIBF at ORNL.

Both surface ionization and plasma sources were characterized and the study on laser source was continued at INFN-Pavia and LNL with the production of Aluminum beams by laser photoionization and ablation. The test-bench laboratory will be completed with the Wien Filter delivered at the end of the year and on the way to be installed. The Wien Filter will allow the mass selection improving the capability of the test-bench to characterize the ISOL target-ion source system.

The design of the radioactive beam transport was completed up to the injection in the ALPI linac by a pre-acceleration stage based on a RFQ.

In 2010 BEST Theratronics Ltd. won the bid for the furniture of the 70 MeV cyclotron and one beam line. The 70 MeV cyclotron realization is in progress.

CONCLUSION

The SPES project is in the main realization phase after the cyclotron acquisition and the completion of the final building construction project.

Current statuses of several parts of the project are reported in more detail in contributions to the LNL Annual Report, covering cyclotron contruction status, beam transport, evolution of target-ion-source front-end, controls, safety and radiation protection.

REFERENCES

[1] G.Prete et al., “SPES Selective Production of Exotic Species, Technical Design Report,” 2008 INFN-LNL-223 (2008); http://www.lnl.infn.it

[2] A. Andrighetto et al., “The SPES Direct UCx Target” Eur. Phys. J. Special Topics 150, 273–274 (2007) EDP Sciences, Springer-Verlag 2007 DOI: 10.1140/epjst/e2007-00321-6.