Status of the SPES ISOL Front-End: installation and commissioning plan

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INTRODUCTION

Advanced research in nuclear physics and medical applications will benefit from radioactive isotopes produced through the Isotope Separation On-Line (ISOL) method at the SPES facility [1]. The Radioactive Ion Beam (RIB) originates from the extraction of positive ions from the Target Ion Source (TIS) unit within the SPES ISOL1 bunker (S018) [2]. The collision of a 200 µA 40 MeV Primary Proton Beam (PPB) generated by the C70 Cyclotron and a multilayer target consisting of 7 UCx disks is the basis of the process [3]. The isotopes originated from the triggered fission reaction are released from the target material by heating the assembly to the nominal temperature of 2000 °C. At this working point, diffusion and effusion mechanisms allow atoms to flow towards a transfer line terminating in an ion source [4,5]. The atoms are ionized here by removing one of the external electrons. During run preparation, the ion source is selected in accordance with the desired element. The entire TIS unit is kept at a high voltage (40 kV), inducing an electrostatic field that accelerates the ions towards the grounded electrode. The generated RIB will then undergo different mass separation, focusing, and reacceleration stages. The unavoidable efficiency degradation of the target material during irradiation necessitates the periodic replacement of the TIS unit [6]. The radiological conditions of the SPES bunker have been assessed in different studies aimed at simulating the expected environmental dose rate [7] and surface contamination of most critical components [8].

Fig. 1. The SPES Front-End hydraulic and pneumatics control circuits located in the pre-bunker (S017).

Fig. 2. View of the SPES Front-End and the RIB line within the ISOL bunker (S018).

COOLING AND PNEUMATICS

The isotope production process requires a complex integration of service systems. The interior of the bunker will be exposed to radiations, which will have the negative repercussions of both promoting the deterioration of the installed materials and limiting access for maintenance operations. For these reasons, it has been decided to install the most sensitive components in the pre-bunker (S017). This design choice will extend their lifetime and ease maintenance interventions. A closed loop water cooling system is employed to dissipate the external heating of the target and the thermal power generated in the TIS unit and proton channel as a result of the PPB impact on collimators, faraday cups, and target. Water is purged from the cooling circuit using compressed air prior to the TIS unit disconnection. The entire circuit is watertight because the intense neutron field's activation also affects the demineralized water. The pneumatic control system, which consists of specialized electrovalves used to actuate pneumatic motors, vacuum gate valves, and control valves, is likewise housed in the S017 room as shown in Fig. 1. Radiation-tolerant materials that could endure the demanding working conditions were used in the physical realization of the circuits within the ISOL hall. These include copper, stainless steel and peek pipes, together with full metal gaskets. The SPES Front-End and the auxiliary circuits in the ISOL hall are represented in Fig. 2. The active components are operated by a dedicated control system and are linked to the SPES Machine Protection System (MPS).

Fig. 3. The high-voltage platform designed to maintain the TIS unit at 40 kV in order to enable the isotope extraction.

HIGH VOLTAGE

A high-voltage platform is installed on top of ceramic insulators within a dedicated room at the first floor as illustrated in Fig. 3. Thanks to this system, part of the SPES Front-End, including the coupled TIS unit, can be kept at high voltage to allow isotope extraction. A control rack, depicted in Fig. 4, is installed within the HV platform. The system includes the Programmable Logic Controllers (PLCs), electrical circuits and the power supplies used to heat up the target, ion-source, ovens and anode within the TIS unit. A dedicated transformer enables to raise the ground potential of the described systems up to the nominal level of 40 kV. Special fire-resistant cables descend the 4 m thick concrete shielding to enter the ISOL hall running through the "Boris" tube, a tilting tunnel encased in an epoxy resin shell to ensure high voltage. To prevent neutron escape and improve insulating properties, the tube is packed with tiny polyethylene balls. The dedicated cable trays and the HV portion of the SPES Front-End are properly bonded and protected from the grounded environment by specific peek insulators. Thanks to the detailed circuits, the SPES target can be maintained at the nominal working temperature of 2000 °C to optimize isotope release.

Fig. 4. The power supplies used to heat up the SPES target and ion source up to the nominal temperature of 2000 °C.

TESTS AND CONCLUSIONS

Following a first pre-commissioning test campaign focused at validating the SPES Front-End [9], a series of acceptance tests are currently being conducted to validate the entire HV complex under typical operating conditions. The behavior of the whole apparatus has been proven to be stable at 40 kV, and the system is presently being tested to confirm its functionality up to 50 kV. Since sporadic and localized electrical discharges have been observed at this voltage, maintenance interventions have been planned to improve the insulation of most critical regions. Endurance tests will be repeated following this upgrade. The next phase will be to conduct a rigorous text campaign to evaluate the system behavior and the precise influence of water cooling and high vacuum conditions. The testing of the TIS unit heating circuit will be possible once the installation of vacuum, water cooling, and pneumatic services is complete. This will lead to the first stable beam production within the SPES ISOL hall.

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