Beam diagnostics developments for the HIE-ISOLDE linac

Presenter : Francesca Zocca
Instituto de Estructura de la Materia (IEM-CSIC) and CERN-BE/BI/PM section

In the framework of the High Intensity and Energy (HIE)-ISOLDE project for the superconducting upgrade of the REX-ISOLDE linac at CERN, an R&D program has been launched including also beam diagnostics developments. A staged construction of a superconducting linac based on sputtered quarter-wave cavities is foreseen downstream of the present normal conducting linac. The main tasks of the HIE-REX beam instrumentation involve the measurement of beam intensity, position, transverse profile, transverse emittance, energy (both in relative terms for cavity phase up and in absolute terms), longitudinal profile and emittance. For intensity, position and transverse profile a diagnostic box is foreseen in each of the inter-cryomodule regions of the linac, and will contain slits, Faraday cups and current-sensitive devices for the lowest intensity beams, while for the transverse emittance measurement an emittance meter is foreseen at the end of the linac. For longitudinal profile measurements aimed at the cavity phase-up, the prototype of a solid state detector monitor is being developed to be placed downstream of the HIE-REX superconducting modules. The number of cavities used to post-accelerate ions at ISOLDE will increase from 5 to 34 with the HIE upgrade, motivating the development of a quick, and eventually automated, solution for tuning the phases of the superconducting cavities.

In this framework a silicon monitor prototype has been tested in a diagnostic box of the REX linac, downstream of the 9-gap resonator. The purpose of this test was the investigation of the monitor performances in terms of cavity phase scanning and longitudinal beam profile measurements. The prototype monitor consisted of a 50mm^2 300 μm-thick partially-depleted Passivated Implanted Planar Silicon (PIPS) detector. An actuator could place the detector on the beam line to directly stop the beam, so that the particle total energy and time of arrival were measured. Tests were performed with a stable ion beam composed of carbon, oxygen and neon ions accelerated at energies from 300 keV/u to 2.82 MeV/u. The beam intensity had to be strongly attenuated in order to reduce the particle count rate on the silicon detector. The monitor is in fact intended for single-particle detection in order to perform a pulse-height energy spectroscopy of the beam particles. Different attenuation methods were investigated and beam intensities as low as a few pps could be reached by means of perforated copper foils. The energy measurements performed allowed for beam spectroscopy and ion identification with a resolution of 1.4 to 0.5 % rms in the measured energy range. The achieved resolution is suited for a fast phase tuning of the cavities, which was demonstrated with the third REX 7-gap resonator. The time structure of the beam, characterized by a bunch period of 9.87 ns, was measured with a resolution better than 200 ps rms. A Time-of-Flight phase-up procedure has also been demonstrated and is a viable option should a chopper be incorporated in the HIE-REX upgrade and the bunch spacing increased.