Ion source and 4-grid analyzer for the proton injector for FAIR

R. Berezov[1], *A. Adonin*[1], *N. Chauvin*[2], *J. Fils*[1], *V. Ivanova*[1], *and C. Ullmann*[3]
[1]GSI, Darmstadt, Germany; [2]CEA, Saclay, France; [3]IAP, Frankfurt am Main, Germany

The microwave ion source and the low energy beam transport section (LEBT) developed in a joint French-German collaboration (CEA/Saclay – GSI/Darmstadt) will serve as an injector for the compact proton LINAC for FAIR [1]. The microwave ion source is presented in Fig. 1. The ion source will be located on the platform with a potential of 100 kV inside the special cage (Faraday cage). This ion source operates in pulsed mode with a frequency of 2.45 GHz. RF power is provided by a magnetron (microwave generator) and injected into the plasma chamber. The plasma chamber has a length of 10 cm and the diameter of 9 cm.

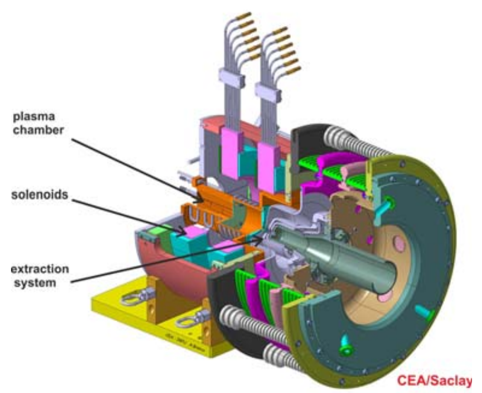

Figure 1: The microwave ion source for the p-LINAC.

The hydrogen gas is injected into the plasma chamber up to the pressure of $2.5{\cdot}10^{-3}$ Pa approximately. In order to increase the proton fraction the chamber is coated with two boron nitride discs. There are two coils with a magnetic field strength of 87.5 mT, which are used to confine the plasma. The “five electrodes” extraction system consists of a plasma electrode, puller electrode (50 kV), screening electrode (- 5 kV) and two ground electrodes [2]. The plasma electrode has an aperture of 8 mm. This extraction system allows the formation of high brightness ion beams with energies up to 100 keV and full beam currents of maximum 130 mA. The duty cycle of the ion source is 4 Hz with a flat top pulse length of 0.2 ms. The requirement for a rise and fall time is in the range of 100 - 200 μs. During the long time operation the ion source has shown its reliability with stable operation conditions and high performance, such as low noise level and small beam fluctuations < 5 % and pulse-to-pulse repetition < 2.5 % based on statistical inquiries. The low energy beam transport section consists of two solenoids and a diagnostic chamber in

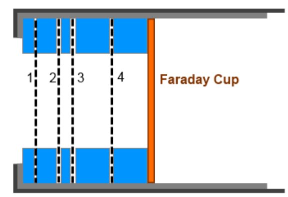

Figure 2: Schematic view of the 4-grid analyzer. 1: First grid on ground potential, 2: Electron repelling grid, 3: Retarding ion filtration grid, 4: Secondary electron suppression grid.

between. The solenoids have a length of 3 cm and maximum magnetic field strength of 500 mT [3]. There are two magnetic steerers, which are integrated into the solenoids for adjusting of the horizontal and vertical beam positions. The diagnostic chamber is equipped with a Wien filter, an iris, an Allison scanner, a SEM profile grid and a beam stopper. The total length of the compact LEBT from the plasma electrode up to the entrance flange of the RFQ is about 2.3 m. The commissioning of the proton injector at CEA/Saclay is planned for the beginning of 2015. During this time the measurements of the emittance, beam current, and determination of the beam fraction and stability of the ion source will be performed. For the measurement of the space charge compensation a modernized 4-grid analyzer will be used. The 4-grid analyzer mainly consists of 4 metal grids as shown in Fig. 2. The first grid on ground potential serves for preventing any disturbance within the probe and the plasma and also for reducing the plasma density. The second grid serves as an electron repelling grid to repel electrons from the plasma. The third grid slows the ions down to the point that only the ions with a higher kinetic energy can pass through the potential on the grid. The fourth grid is needed as a repeller for secondary electrons. For beam current measurements the Faraday cup will be used.

References

[1] R. Hollinger, W. Barth et al., “High current proton beam investigations at the SILHI-LEBT at CEA/Saclay”, Linac06 (2006) 232.

[2] C. Ullmann, R. Berezov et. al., “The proton injector for the accelerator facility of antiproton and ion research (FAIR)”, Rev. Sci. Instrum. 85, 02A952 (2014).

[3] R. Gobin et al., “Status of the Light Ion Source developments at CEA/Saclay”, RSI, Vol.75, No. 5 (2004) 1414.