First plasma produced for the FAIR proton linac

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The future compact proton linac will produce proton beams with energy of 70 MeV that will be injected into upgraded Heavy Ion Synchrotron (SIS 18), accelerated to 1 GeV, and further accelerated to 30 GeV in SIS 100 for the production of anti-protons. The first part of the linac includes the high current ion source and Low Energy Beam Transport section (LEBT) designed and built at CEA/Saclay. The proton injector will deliver a pulsed proton beam in the energy range of 95 keV and up to 100 mA ion beam current\textsuperscript{1}. The expected emittance at the entrance of the RFQ (Radio Frequency Quadrupole) is lower than 0.3 $\pi$ mm rad (normalized, rms).

The microwave ion source with a five electrode extraction system operates at a frequency of 2.45 GHz. The RF power is produced by a magnetron microwave generator and is injected into a plasma chamber through rectangular waveguide. The duty cycle of the ion source is 4 Hz with a flat top pulse length of 0.2 ms. Pulsed mode operation of the ion source leads to a longer lifetime and reduces the requirements for the cooling system\textsuperscript{7}.

The LEBT focusing system (shown in the Figure 1) consists of two solenoids with two horizontal and vertical integrated magnetic steerers. A diagnostic chamber with different diagnostic tools is mounted between the solenoids. The current is measured with a current transformer behind the extraction system and the second solenoid. An electrostatic chopper is placed between the second solenoid and the RFQ to cut the beam pulse to 36 $\mu$s.

Figure 1: Proton injector at CEA/Saclay.

The proton injector is almost ready for commissioning at CEA/Saclay. The ion source is mounted on the high voltage platform inside the Faraday cage. The LEBT is installed outside the Faraday cage at ground potential and is connected to the ion source through accelerating column. The mini-control system fabricated at GSI to operate the proton injector remotely is transported and installed at CEA. The first part of control system to operate ion source including magnetron, impedance adapter, gas inlet connection etc. successfully tested. The second part mainly includes connection of the power supplies. The operation will be performed after delivering all necessary power supplies to CEA.

In November 2015 the first plasma was produced at the ion source for the proton linac for FAIR at CEA (Figure 2). The photo of the plasma was taken through the LEBT. A glass window from fused silica has been installed behind a temporally diagnostic chamber after the second solenoid.

Figure 2: First plasma production for proton linac.

As a first step of the commissioning an emittance measurement with an Alnor scanner just after the extraction system will be done. A Wien filter will be also used for the detection of different ion species ($H^+$, $H_2^+$, $H_3^+$). These measurements will be carried out between the solenoids inside the diagnostic chamber, and before RFQ entrance to feature the beam parameters produced from the proton injector.

It is also planned to measure the space charge compensation in the LEBT with a 4-grid analyzer designed at CEA and modernized at GSI. First tests with this analyzer have been successfully performed at the high current test bench at GSI with high current argon beam. The stability of the ion source including beam fluctuation and pulse-to-pulse repetition will be tested during the long time operation. After delivering all power supplies, cabling connections and operation of the mini control system at CEA/Saclay it is planned to start commissioning of the proton injector in Q4 2016.

References
