FIRST PLASMA OF THE PHOENIX V3 ECR ION SOURCE *

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Abstract

PHOENIX V3 is an upgrade of the PHOENIX V2 ECR ion source granted by the European CRISP project. This new ECRIS features a larger plasma chamber and a reduced vacuum pressure under operation. The V3 source will replace the V2 one on the SPIRAL2 accelerator in 2018. The first plasma of PHOENIX V3 was achieved on May 9th 2016. The early commissioning of the V3 source at low 18 GHz power demonstrates as expected an enhancement of the high charge state production and Ar^{14+} intensity already exceeds the V2 one. Further enhancements are expected the outgassing will be achieved and the full RF power will be injected in the source.

MOTIVATION FOR THE SOURCE UPGRADE

The new SPIRAL2 accelerator at GANIL (Caen, France) includes a nuclear physics program dedicated to heavy ions with the S3 collaboration [1]. The present acceleration scheme of the LINAC imposes the production of ion beams with M/Q=3. High intensity beams are possible with such a M/Q up to M~40. Above this mass, the charge state is so high for a given mass that the achievable intensity collapses rapidly when the mass increases. S3 collaboration is thus interested in the procurement of ion beams with an intensity of several pμA up to the mass M~60. The availability of a European fund (CRISP Project) made an upgrade of the existing PHOENIX V2 source possible. The goal is to enhance the high charge state production to fulfil the need expressed by the S3 collaboration. The strategy of the upgrade is:

- to enhance the plasma chamber volume radially to increase the ion confinement time,
- to reduce the vacuum pressure in the source to decrease the charge exchange process, by adding a pumping system on the injection side of the source.

These two effects are expected to increase by 50 to 100% the M/Q=3 ions up to the mass 60 with respect to the existing V2 source.

V3 DESIGN

The magnetic simulation of V3 and some information on the mechanical design can be found here [2, 3]. For completion, a summary of the information is proposed below. The available funding allowed designing a new hexapole, a new plasma chamber and a vacuum box located on the injection side of the source. An overview of the V3 design is displayed in Fig. 1 (see next page). In order to minimize the impact of the modifications, the axial magnetic structure of the existing V2 source was kept unchanged. The main design difference came from a new hexapole providing a much larger radius at the plasma chamber wall of 45 mm (31 mm for V2). The new chamber volume is 1.4 liter, being ~2.2 time larger than the V2. The radial intensity at wall with the bare hexapole is 1.18T. Later, a special plasma chamber including soft iron slits on its outer part will be installed to reach ~1.25T along the magnetic poles at the aluminium wall. The source can accept new generation ovens up to Ø20 mm. The oven axis is slightly pointing toward the sky to prevent any liquid metal spill toward the plasma chamber. Two WR 62 waveguide ports are available (see Fig. 2). One is currently fed with an 18 GHz 2 kW RF Klystron. The second will be used to inject a 14 GHz power when it will be available for the project. A bias disk with some water cooling is also installed on the injection flange. Two new ovens will be tested in the source. The first, developed at LPSC, is a low temperature oven working up to ~600°C with a design similar to the one used in LBNL and MSU. The new oven will be commissioned in the early 2017 with calcium. The second oven is a new high temperature large capacity oven developed by GANIL. This oven is also expected to be commissioned in 2017 to feed the source.

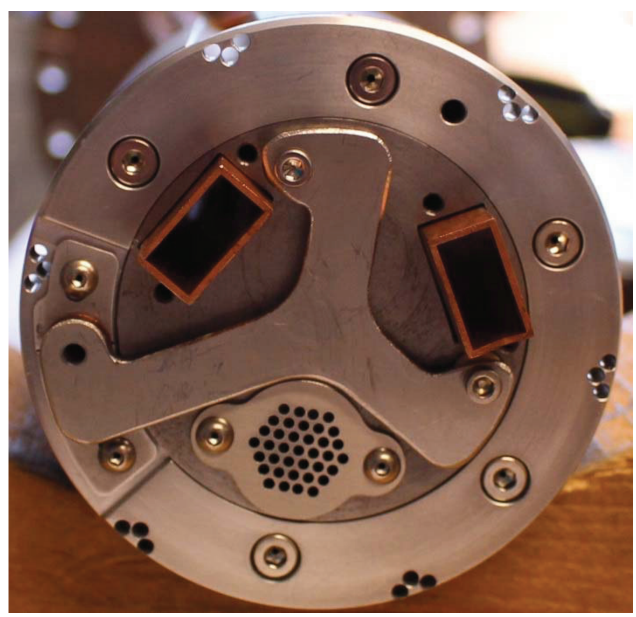

Figure 2: Photograph of the source injection flange.

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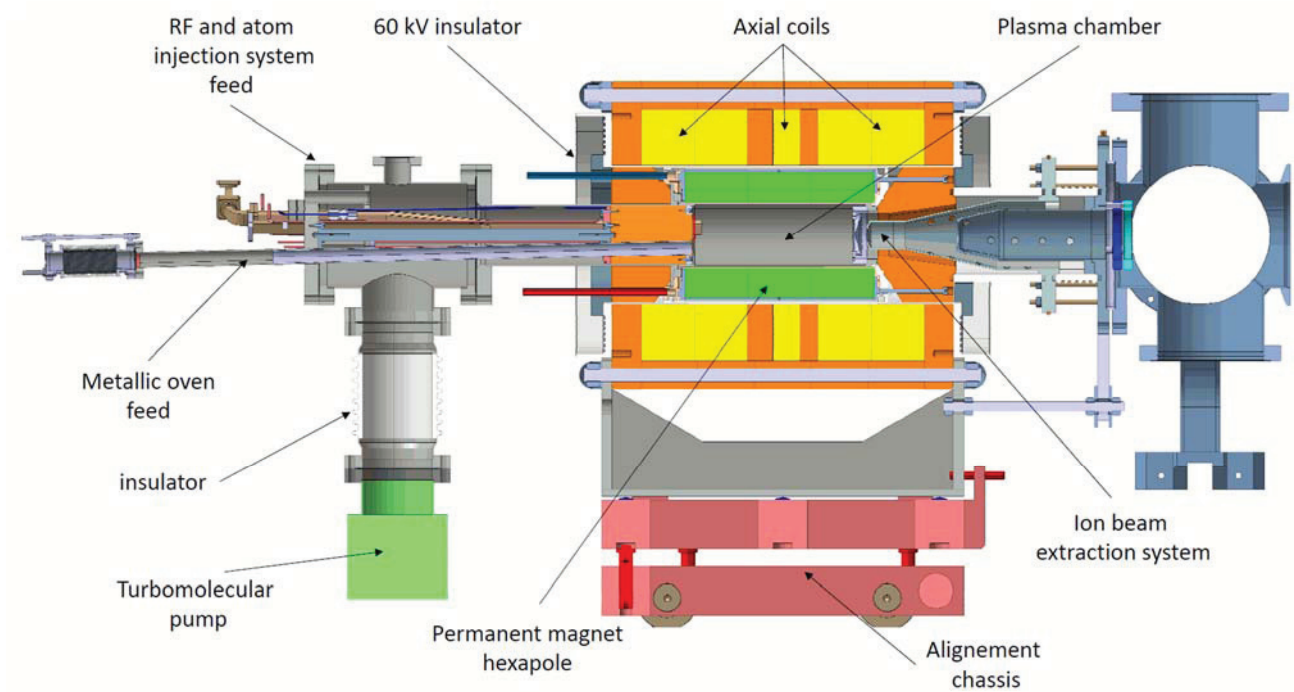

Figure 1: Sectional view of the PHOENIX V3 ion source mechanics.

FIRST PLASMA AND EARLY COMMISSIONING

The first ion source plasma was achieved on May 2016. A water flow measurement of the plasma chamber revealed an insufficient water velocity along the magnetic pole. So the early commissioning was limited to a conservative 50 W of 18 GHz power. Despite this dramatically reduced operation condition, it was possible to produce argon charge state distributions higher than what the V2 source can do. A simulation was performed to find the place where the hot electrons touch the wall (see Figure 3).The water channel geometry was then optimized to grant a turbulent flow along the poles on a sufficiently large surface covering the area of high power density electron deposition. A new plasma chamber was built to correct the flaw and the normal operation could start in August 2016. The first weeks of experiments were used to commission the LEBT which command control system was totally rebuilt in parallel to the source assembly. The residual gas pressure at the injection vacuum box is 2×10^{-8} mbar, provided by a 360 l/s turbomolecular pump. The new source responds normally to pressure and power. So far, the ion currents produced were limited to 500 W and were 100 µA of Ar^{12+}, 60 µA of Ar^{14+}, 450 µA of Ar^{8+}, 400 µA of O^{6+}. It is noticeable that the Ar^{14+} intensity is already higher than the one obtained with V2 (50 µA Ar^{14+}). The outgassing is still not over and better results are expected in a near future with higher RF power and better vacuum pressure. Extensive source operation will be performed in 2017 in collaboration with the GANIL team to study metallic beam production.

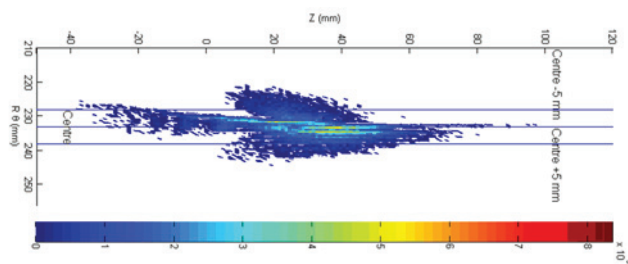

Figure 3: Hot electron impact at the wall and water channel limits (blue lines).

ACKNOLEDGEMENT

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