Installation and Commissioning of the New Vacuum System for the ALPI HEBT Line to the III Experimental Hall

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INTRODUCTION

A new beam transport line starting from the high energy end of ALPI was installed in 2014, following its design phase carried out in 2013 [1]. The vacuum is generated by four pumping groups obtained from the decommissioning of the old beam line. Fig. 1, 2 and 3 and Table 1 show the group configuration.

![Diagram of the pipe connections and of instrumentation.](image1)

The turbo-molecular pump (TMP) is pre-pumped by a primary pump (PP). An ion pump (IP) is installed on a second vacuum chamber. The Pirani (PiG) and Penning (PeG) gauges, combined together, set the measurable pressure range from the low vacuum to the ultra-high vacuum regime.

![Picture of the beam line installed in the III Experimental Hall.](image2)

INSTALLATION ACTIVITIES

After the phase of dismantling of the old line, we catalogued and stored all the vacuum hardware, in order to be ready for the next phase of installation. The dismantling operations regarded also the ancillary systems of the vacuum devices, such as the electrical power cables and distribution boards, the control racks, the air compressed distribution panels and the beam supports.

The installation of the beam pipes along with their supports started only after the pre-alignment of the magnet lens and the diagnostic boxes.

![Vacuum hardware layout of the new HEBT Line.](image3)
We installed the vacuum pipes keeping fixed the positions of the pre-aligned elements. The final length of each section was adjusted inserting bellows at both ends. We closed all the flanges with metal gaskets, except for the flanges of the fore-vacuum line and backing line for the TMP (see Fig. 1).

The beam pipe was afterwards helium-leak tested in sections at a leak rate below $10^{-10}$ mbar l/s. Following this result, we installed the control racks near the beam line and we connected them to the vacuum apparatus (pumps, valves, gauges), by assembling new cables and air pipe lines. We reorganized the racks to accommodate the wanted electronic control units for pumps and gauges, and we initially tested them in local mode. Afterwards, the racks were connected with the central control system [2], which was reconfigured to create new GUIs for the new pumping groups (see Fig. 5). The new vacuum line is also equipped with a fast closing valve (intervention time below 10 ms) to protect ALPI from unexpected gas inrush from the experimental apparatus. The location of the valve is near DT1, while the sensor is almost 16 m downstream, near the TMP of C03 in Fig. 3.

**COMMISSIONING PHASE**

The commissioning phase started in November 2014 (see Fig. 4) and initially regarded the functional tests of each pumping group and the reconfiguration of the central control system. The pressure, measured at the pumping groups, were below $10^{-7}$ mbar except for DT5 where it was ten times higher, due to a leak in the bellows installed between the dipoles.

At the beginning of December 2014, a beam of $^{58}$Ni was delivered to GARFIELD to check all the functionalities of the new beam line. The tests showed that the beam losses were too high due to the bad vacuum level, deteriorated by a leak in the junction between the two dipoles. Moreover after the beam test, a new diagnostic box in front of the dipole was required, to make easier the operation of beam steering (see Fig. 6). The line modification started some days after the end of 2014 beam-runs and lasted up the end of January 2015. The reparation of the leak (see Fig. 6 caption) decreased the pressure measured at DT5 to $1.6 \times 10^{-7}$ mbar.

**FUTURE EXTENSIONS**

The present layout permits to create the correct level of vacuum for the GARFIELD experiments. Moreover, the new configuration of the general control system is able to control the pumping groups for the other future, and yet not installed, experiments in the III experimental hall. However, in case delivery of radioactive beams several modifications are mandatory in order to assure that all the exhausted gas are collected to a common storage system.

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