LNLS VACUUM SYSTEM

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Abstract

The LNLS synchrotron light source consists of a 1.2 GeV storage ring and a 110 MeV injector. Most of vacuum components have been designed, developed and produced in-house. A summary of the design, commissioning and operational performance of the vacuum system for the linear accelerator, transport line, radio frequency system and storage ring is presented. A brief description of the techniques and procedures adopted in each system is given.

1. INTRODUCTION

All the components and systems were designed with the following requirements:

- Operation pressure 1 x 10^{-7} Pa N_2 equivalent at 1.2 GeV, 100 mA and life time > 10 hours
- Residual gas free of hydrocarbons to avoid carbon contamination of optical surfaces in the beam lines
- A short recovery time after venting of a section
- "Smooth" chambers wall design must minimise electromagnetic fields and losses induced by the beam
- The system must allow modification for new development, i.e. new insertion devices, beam ports or facilities.

The vacuum system of the LNLS synchrotron light source consist of a linear accelerator, radio frequency (RF) system, transport line and the storage ring. We present for each one a description of the final version with specific condition of assembling, operation and performance. The power supply ion pump was developed to control the tension and current for each ion pump and together the gauges, residual gas analysers and valves are controlled from a computer in control room.

2. LINEAR ACCELERATOR

The linear accelerator (linac) is located under ground and consist of a 80 KV gun, four (4) RF linear accelerating structures and a spectrometer (Figure 1). The gun was designed to operate at a pressure better than 10^{-4} Pa to avoid RF breakdown and excessive electron scattering from residual gases [1]. Near the electron gun cathode, the pressure should be even lower to avoid cathode contamination and premature failure. The linear accelerator structures are made of copper and a pressure lower than 10^{-5} Pa range was desired near the RF windows in order to avoid window failure caused by RF power loss on adsorbed molecules [2]. The spectrometer consist of a dipole and a laser cut [3] 316 L stainless steel chamber with two exit in 30° deflection. Many diagnostic devices were included in the design: pneumatic and fixed screen monitors, two types of beam current monitors, inside and outside of vacuum chamber. The system was pumped down with a turbo-molecular pump and a dry backing pump until 10^{-3} Pa then started the ion pump. All the vacuum parts were prepared and cleaned for mounting with no need of baking. The system was assembled together with the RF system and 48 hours later the first beam was run. The average pressure was 2 x 10^{-5} Pa without a beam measured with cold cathode gauge. Now the average pressure with a beam is 2 x 10^{-6} Pa.

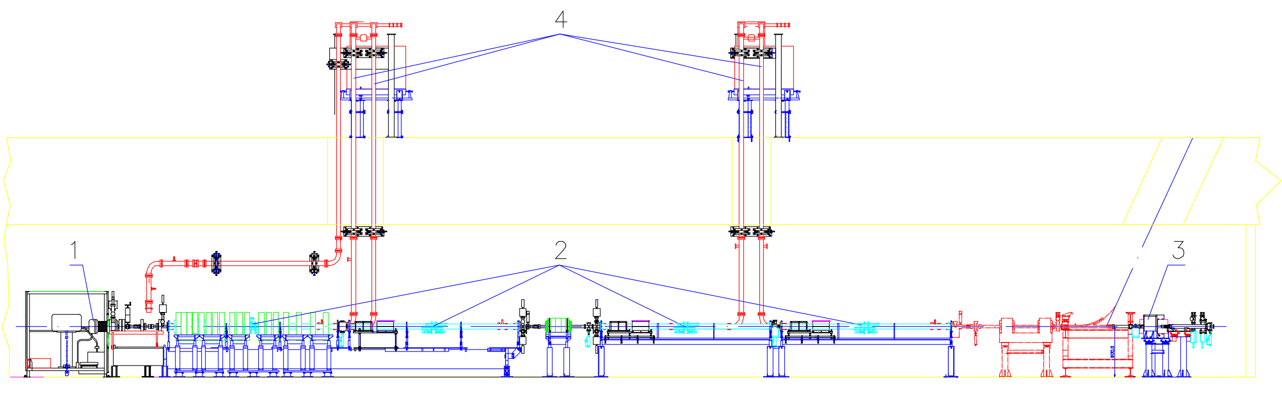

Fig. 1. Linac: CAD drawing of the gun (1), the linear accelerator strutures (2), the spectrometer (3) and the wave guide of RF system (4)

3. RF SYSTEM

The RF system are the wave guides for the RF accelerating structures. It consists of four “arms” (Figure 1), two for each klystron valve. They are a rectangular tube (band S) in OFHC cooper, brazed to 316 L stainless steel flanges. A thin film of Cu and Ni was electroplated over the stainless steel flanges to promote a good contactability of the filler metal on the surfaces. The brazed joints was developed with a Ag/Cu (72% - 82%) euthetic filler metal in vacuum furnace (10^{-3} Pa) or in semi-automatic circular flames, specially developed for the longs assemblies and curves. The mechanical strength of the brazed joints it was verified and approved. All parts were tested under final pressure, i. e., baking for 24 h at 453 K against turbo-molecular pump and cool down with a 20 l/s ion pump. All components get better than 5×10^{-8} Pa and were free of hydrocarbons checked with a residual gas analyser. The system has no gauges, only 20 l/s ion pumps and was baked *in situ* with a turbo-molecular pump and dry backing pump. When started the commissioning, the peak current of ion pumps increased to 1000μA ($\approx 1 \times 10^{-3}$ Pa) with RF power. Today the maximum current is 20μA ($\approx 2 \times 10^{-5}$ Pa) with total RF power.

4. TRANSPORT LINE

The transport line has 19 meters and connects the linear accelerator under ground to the ring in the level of beam lines experiments (Figure 2 and 3).

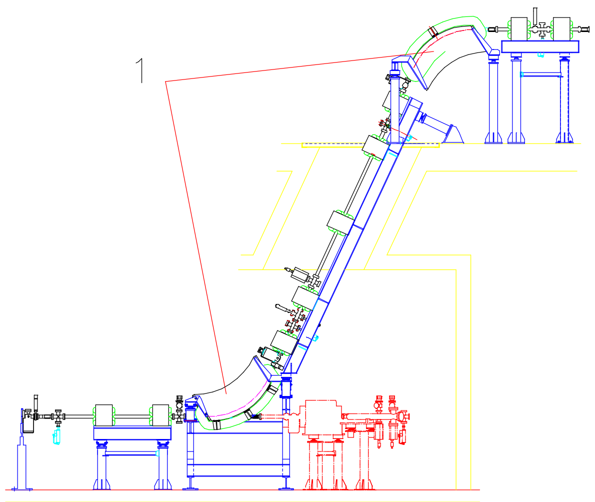

Fig. 2 Transition of under ground level and ring level, with 65° dipole (1) for deflection

The transport line is made of stainless steel 316 L tubes and laser cut dipoles vacuum chambers. Some beam position monitors were included with screen monitors and current monitors to help the first injection and commissioning. The components were prepared like the linear accelerator and no baking was necessary. The pump down was made with a turbo-molecular pump and a dry backing pump until 10^{-3} Pa, then the ion pumps started (20 l/s ion pumps). The average pressure with beam is 2 x10^{-6} Pa.

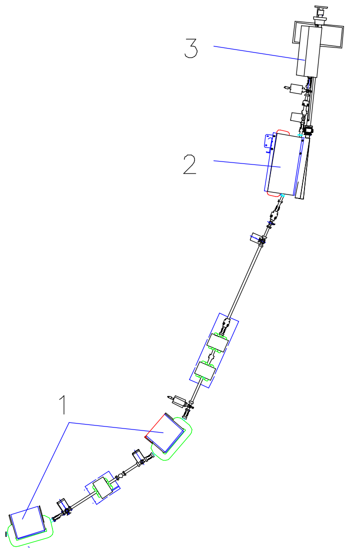

Fig. 3 Top view of transport line in the ring level with 33° dipole (1), the thick septum (2) and thin septum (3)

5. STORAGE RING

The storage ring has 28.6 m diameter and 93.2 m circumference (Figure 4). The vacuum chambers were designed having in mind modularity, easy light extraction, geometric constraints and the above mentioned vacuum guidelines. It comprise straight sections (short and long), bending magnet chambers, a RF cavity, kickers and a septum. Distributed along all the ring are cleaning electrodes: bending magnet chambers, pumping station (PS) and the straight section. The straight sections are tubes of circular cross-section with internal diameter 60.5 mm. The long straight has 2.9 m available for insertion devices. The ring is pumped by PS modules, which also contain vacuum gauges, residual gas analysers head and rough vacuum valves. Each PS has one 230 l/s ion pump and a Ti sublimation pump with 900 l/s. The chamber wall, from the electrical point of view, is not interrupted by these PS since they use the same tube of circular cross-section with small holes connecting to a larger where the pumps and gauges are installed. The connection of PS and the dipole vacuum chambers were made with bellows protected with a copper-beryllium shield. The bending magnet chambers were made of 316 L stainless steel and fabricated with a laser cutting machine, like all the inside magnet vacuum chambers. Most radiation will be colleted by a single water cooled cooper absorber inside the chamber with two exit for beam lines at 4° and 15°. In the inner antechamber it has a non-evaporable-getter (NEG) strip 1.2 m long. A second NEG strip, 1 m long, is located in the outer antechamber.

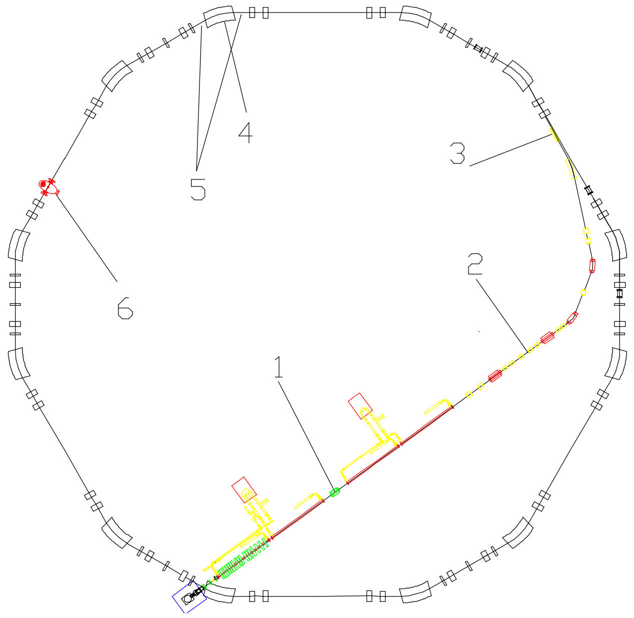

Fig. 4 Top view of the ring with linear accelerator, under ground (1), transport line (2), thin septum (3), dipole magnet (4), PS (5) and RF cavity (6).

The cavity was purchased from Sincrotrone Triste [4]. It is a one cell, bell shaped cavity, similar to those installed in Elettra, specially designed for the LNLS frequency. It has 6 equatorial ports used for the coaxial loop input coupler, vacuum pump, vacuum gauge and pick-up. The ring consist of 11 vacuum sectors and each one has its own pump down valves and sector valves. During assembling each sector was mounted , leak tested and pumped down one by one. The final a average pressure was 10^{-5} Pa range. The first baking *in situ* (423 K, 24 h) was made in half ring against ion pump with all sectors valves opened. Care was taken of bellows and bending magnet chambers. The second half was made in the same way. The final average pressure was 5 x 10^{-7} Pa and the main gases were hydrogen (90%), carbon monoxide (8%). This pressure is enough for come first injection in the ring, commissioning of the RF cavity and of the sub-systems. The RF cavity was baked independently of the ring (423 K, 48 h) with the final pressure of 7 x 10^{-8} Pa. No activation of NEG was done because very soon all the ring will be opened and the beam line front-ends will be added. At this time a new baking will be necessary at 423 K, 48 h and against turbo-molecular pumps and a dry backing pump.

6. CONCLUSION

It was shown that the techniques and procedures adopted in each system was approved. The final average pressure with a beam is 2 x 10^{-6} Pa for linear accelerator, 2 x 10^{-6} Pa for RF cavity, 2 x10^{-6} Pa for transport line and 5 x 10^{-7} Pa for the ring. We will do a new baking with beam line front-ends.

7. REFERENCES

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