Cryogenic systems maintenance and development in 2013

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INTRODUCTION

In 2014 the cryogenic plants have been running from March to the end of July, in compliance with the energy saving plan approved by INFN-LNL. Before the restart and during the operation there have been some serious failures which however did not cause delays or stops of the plants. This was possible due to the competence of all cryogenic staff.

CRYOSTATS

CR04 After the maintenance in 2013, the cryostat was placed in line in March. Unfortunately, after being cooled, there was evidence of serious problems to RF system [1]. It has been planned a new maintenance for the next year.

CR03 In 2013 a leak from the 4K circuit into vacuum was detected. The cryostat has been removed from the line in March 2014 and taken to the laboratory for maintenance. Only after exhaustive testing has been detected a leak on a CF16 flange. Its geometry was not standard and so the copper seal could not be tightened properly, leaving a very little leak, very difficult to detect.

Moreover, taking advantage that the cryostat has been opened for maintenance, the CR03 has been improved with all the changes adopted on the other low beta cryostats i.e. upgraded with the new coupler cooled with LN2. The CR03, in fact, was the first prototype of the project "upgrade low beta ALPI" realized.

CRB2 The cryostat has been removed from the line in 2013, planning to add two more cavities and to upgrade the buncher CRB2 Cryostat into high beta CR21 cryostat. Furthermore, in order to prepare all the documentation necessary to build the new cryostat CR22 (SPES Project), the CRB2 has been used to check and update all technical drawings available. As far as possible, all the dimensions shown in the drawings have been compared and verified with the respective components installed in the cryostat. During 2014, new technical and economic evaluations have been done, so the original plan of the upgrade (CRB2 into CR21) has been changed. The ALPI refrigerator, thanks to the third turbine is able to keep cold also the buncher CRB2 and other 4 cryostats more, so it was no longer necessary to design and build a new warm buncher and modify the CRB2.

CR06 In 2014 anomalies have been detected on the RF system, able to preclude the correct operation of the resonators, but not clearly detectable. In fact, after repeating the tests at the end of beam schedule, at room temperature, everything has been looked working properly.

More analyses will be done asap.

ALPI Cold Box– The cryogenic plant has been restarted in March 2014, but during the start-up procedures, several problems have been detected and readily solved: a leakage on safety valves of the low pressure line, a leakage on a ball valve of the high pressure line. Some pressure transducers have been replaced. Also all the old positioners of all the control valves have been replaced with new electronic ones.

At the end of the beam schedule, a short period has been taken to test the refrigerator with the III turbine in operation. The results have been very satisfactory. The power of the refrigerator had already been tested on several occasions, confirming an increased power of 300 W cryogenic @ 4K. However, until now, it had never been possible to test the behavior of the cryogenic transfer lines increasing the cryogenic load up to the maximum value in the configuration of 24 cryostats in operation, including 3 buncher. Applying the RF power on the cavities, coupled with additional power fed with the resistors connected to the cavity surface, has been applied in a total a load of about 750W @ 4K

The test allowed to identify some critical situations: first of all the necessity to communicate with the RF system that put power into the cavities and then into the cryogenic system. It is very important for the stability of the machine the control of the power applied on the plant: this is always true but it is critical when is running the third turbine. On one side the turbine offer a best performance offering additionally 300 W @ 4K, on the other side the turbine requires a necessary stability on the load applied to the system. Strong fluctuations of the power on the 4 K cause many strong pressure variations that interrupt the operation of the turbine and cause the temporary shutdown. From the cryogenic point of view, the transfer lines for the Liquid Helium (in and return) have supported the high flow rate. However, although it has been possible to reach the cryogenic maximum load, the working conditions are extremely critical since this working point is the maximum limit to what can operate the cryogenic plant (refrigerator and transfer lines)

ALPI Cryomodules –control system upgrade toward UNICOS - CERN In 2013 has been completed the preliminary design and the final design [2]. In 2014 has definitively take place the working plan [3]. The first group of cryostats implemented with the new control has been the CR04, CR05, CR06 and CR07, which brought together the two different types of cryostat, housing the
two different types of resonant cavities. The new control system has been completed and positively tested in operation for a few months. The work has been continued by extending the new control system to all remaining cryostats of ALPI.

![Fig. 1. New architecture of ALPI – LINAC control system](image)

ALPI Helium Transfer Lines Valve Boxes – Doing the routine checks, after the stop of the cryogenic plant, serious damages have been detected on the 4K control valves, which regulate the level of liquid helium into the LHe vessels, inside the cryostats. The intensive regulation activity caused probably by an abnormality in the PID control loop has damaged some of the sealing bellows, which isolate the 4K circuit from the external environment. Checking all the other cryogenic valves, a lot of signs of intensive wear have been detected. Therefore, it has been necessary to completely overhaul all the inserts of the 4K control valves, in order to avoid future failures that could compromise the entire operation of the accelerator LINAC-ALPI.

ALPI - compressor Units – The compressors C and D have suffered some sudden stops caused by different faults. One has affected the oil drain system of the compressor primary filter. After a careful investigation several concatenated causes have been found: the capacitive probe that control the oil discharge level, was too short and not able to detect the presence of oil over the maximum limit. So, the oil were not discharge by the control system and, every approx. 700 working hours, the compressor has been stopped by "oil" fault.

A second fault, much more serious, was the breaking of both the oil pumps. Fortunately this occurred only at the end of beam schedule, and when it was not more necessary to use both the compressors C and D. bending of the support plate where was fixed the assembly motor-pump. The pump shaft has worked under strong mechanical stress until its breakage. The pumps have been replaced.

PIAVE Cold Box – The cryogenic plant PIAVE, as ALPI, has been started in March 2014 until July. The cryogenic plant has been affected by some problems caused by force majeure (power breakdown, water cooling and compressed air stop). The troubles has concerned the RF system on the SRFQ cryostat, in particular the operation of the cavity SRFQ 2 cavity and the malfunction of the heater/baking system, also on SRFQ 2 cavity. The operation with the SRFQ has not more been possible to and it has been necessary to plan the extraordinary maintenance in 2015.

PIAVE Compressor and Gas Management Panel – The compression unit has been up-graded with a third oil coalescer, as spare filter, in order to compensate any malfunction of one of the first two coalescers. The circuit has been modified and tested. The system has been worked properly.

PIAVE SRFQ Cryostat – during the operation has been necessary to warm up and open the SRFQ cryostat to replace a component of the RF system. This operation has requested the break of the vacuum with nitrogen gas. Unfortunately, the baking phase, necessary to clean the cavity surface, was not available. All the resistors of the cavity SRFQ 2 appeared damaged and there was no way to heat this cavity. Under these conditions it was not more possible to operate with the SRFQ's.

HELIUM GAS RECOVERY SYSTEM

In 2013 an important work has been done [4]: thanks to the possibility to monitor continuously the quality and the quality of the impure helium gas in 2014 it has been possible to reap the benefits of this work: the losses have been reduced significantly with a significant cost savings for the LNL, while these funds have been invested to improve the old cryogenic plants.

REFERENCES

[1] A. M. Porcellato et al., this Annual Report