CRYOGENIC SYSTEM DESIGN FOR SPIRAL 2 PRJECT AT GANIL

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Abstract

The future superconducting Linear accelerator of the SPIRAL2 project at GANIL (France) will require a complete helium cryogenic system. Air Liquide DTA has been selected to provide around 1300W equivalent refrigeration power at 4.5K with mainly refrigeration load but also helium liquefaction rate and 60K thermal shields feed. The Helium cold box designed and manufactured by Air Liquide DTA will be derived from the standard HELIAL LF product to match the need for the SPIRAL2 project.

The cryogenic system also includes a liquid Dewar, cryogenic lines and recovery system for liquefaction rate. Cryogenic distribution line and valves boxes for LINAC Cryomodules are designed and installed by GANIL.

WHAT IS SPIRAL 2 PROJECT ?

Tomorrow's physics is under preparation at GANIL CAEN (France). The future SPIRAL2 linear accelerator will produce light and heavy exotic nuclei at extremely high intensities. These entirely new particle beams will make it possible to explore the boundaries of matter. SPIRAL2 (Second Generation System On-Line Production of Radioactive Ions) is a linear particle accelerator project for the study of fundamental nuclear physics and multidisciplinary research.

The heart of the future machine features a superconductor linear accelerator, delivering some of the most intense beams in the world, which are then used to bombard a matter target. The resulting reactions, such as fission, transfer, fusion, ... will generate billions of new nuclei.

Figure 1: SPIRAL II Installation at GANIL.

The LINAC comprises two types of accelerator cavities : 12 RF cavities of type A having their Cryomodules each, followed by 14 RF cavities of type B arranged in pairs in a Cryomodule. The so-called type A cavity has a low-energy acceleration area, whereas B cavities comprise two high-energy acceleration areas. Each cavity is placed inside a cryomodule at a temperature as low as 4.5 K (~ -269°C), to prevent any increase in temperature of the equipment, and allows the use of a very strong electric field.

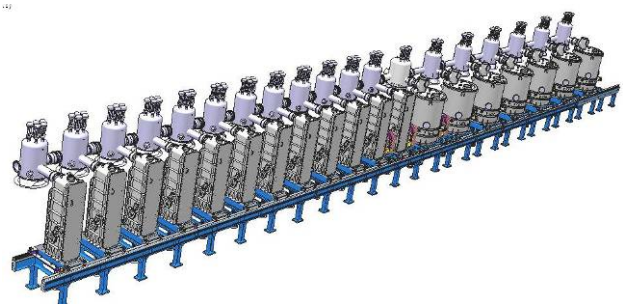

Figure 2: Cryomodule and cavity assembly.

CRYOGENIC SYSTEM FOR SPIRAL2 LINAC

Air Liquide DTA has been selected to provide around 1300 W equivalent refrigeration power at 4.5 K with mainly refrigeration load but also helium liquefaction rate and 60 K thermal shields feed.

Table 1: Margin Specifications

Heat Load Type	Temperature level	Value
Refrigeration	4.5K	1100 W
Refrigeration (Thermal shields)	Between 60 K & 80 K	3000 W
Liquefaction	4.5K	10 L/hr

The helium cold box designed and manufactured by Air Liquide DTA will be derived from the standard HELIAL LF product to match the need forthe SPIRAL2 project.

Specific requirement for this project

Three main functions have to be addressed by the system :

- Provide refrigeration load to cryomodules with fine pressure stability on LP helium side during nominal operation
- Provide refrigeration load to thermal shields within the main cold box

• Cool-down of cryomodules by group with the respect of the cool-down time between 150 K and 50 K to avoid the 100 K effect on RF cavities

Air Liquide dedicated solution

In order to satisfy customer requirements, the technical solution includes customised components :

• HELIAL LF cold box is equipped with 3 gas bearing turbo-expanders (see Figure 3 and 4)

• Specific return valves are implemented in cold box for cool-down of cryomodules

• Two different sizes of cycle compressors with specific oil removal system are considered for flexibility and stand-by mode with cold gas recovery

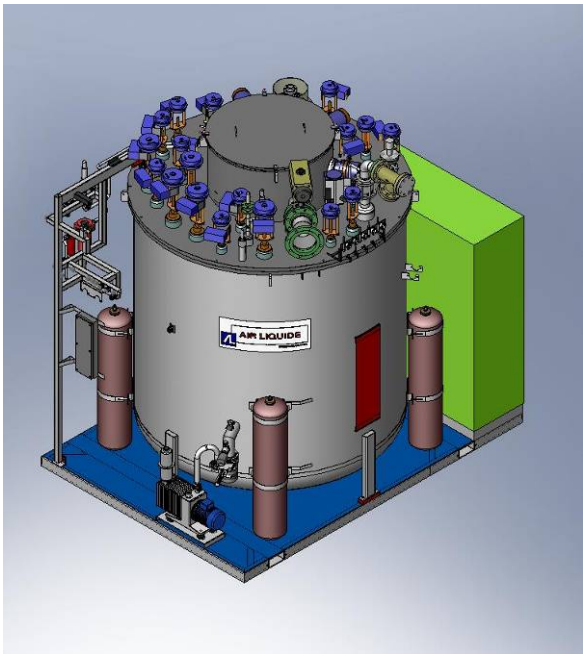

Figure 3: Cold Box assembly for Spiral 2 Project.

Main Schedule for cryogenic system

The main steps of the project are :

• Project launch: January 2010
• Cold box test at DTA facility: May 2011
• System available Ex-works: July 2011
• GANIL building ready for installation: Oct 2011
• Start-up at GANIL: ~ middle 2012

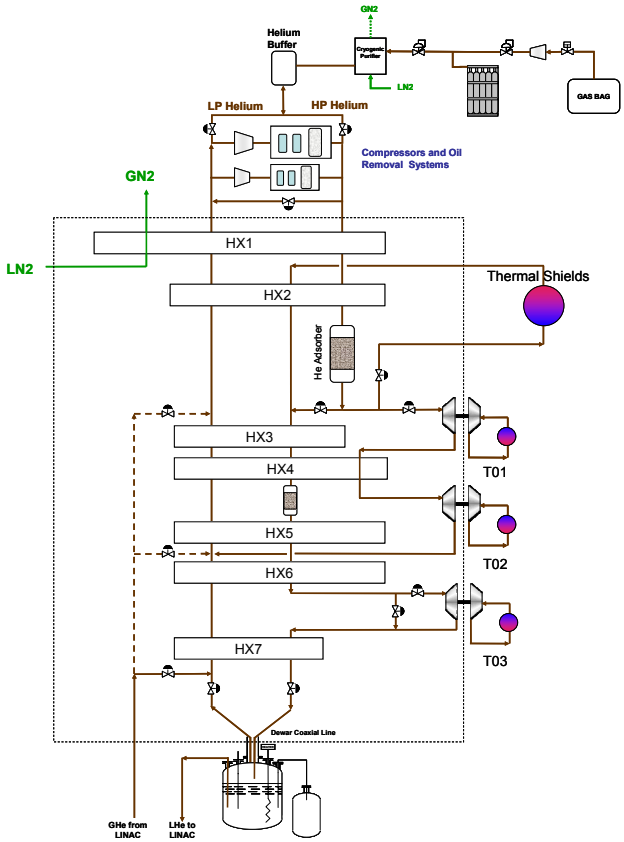

Figure 4: Cryogenic system Process Flow diagram.

TECHNICAL HIGHLIGHTS : HIGH PERFORMANCE GAS BEARING TURBO-EXPANDERS

Based on gas bearing technology, Air Liquide has industrialized for more than 30 years turbo-expanders optimized for each customer application. These components can process gas with high enthalpy drop and however high efficiency. This proven technology is used in industrial or scientific environment (magnetic fields, neutron beam, …). Each stage from design to manufacturing including in-house test and commissioning is fully controlled. This critical component for the refrigerator owns the following kes characteristics :

• Machine designed for zero maintenance

• Easy operation (stop & go and capacity change without any precaution thanks to static gas bearing technology)

• Up to 82% efficiency

• From 30 000 RPM to 300 000 RPM

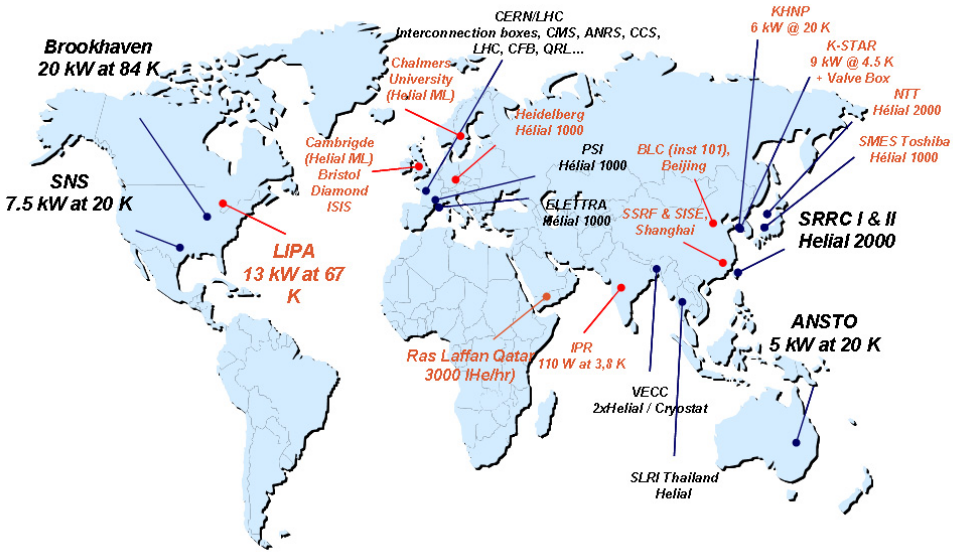

Figure 5: References.

REFERENCES AND PROJECTS IN PROGRESS

On figure 5, are presented major recent references of Helium Refrigeration systems of AIR LIQUIDE DTA.

The recent references for superconducting cavities are :

- **NSRRC and NSRRC II(Taïwan)**
- **DIAMOND (U.K.)**
- **SOLEIL (France)**
- **SSRF (China)**

At present, other projects are in progress to propose customised solutions. In several cases, these systems will be fully tested at DTA.

- **UCNS Garching :** Ultra Cold Neutron Source for Reactor FRMII (TU Munich) ⇨ 2 x 650 W@4.5K & 1 supercritical helium loop
- **HMFL:** Helium Refrigerator for Hybrid Magnet for CAS (Hefei, China) ⇨ 360W@4,5K
- **Neurospin :** Helium Refrigerator for 1.8K RMN experimental installation for CEA (Saclay, France) ⇨ 40W@4,5K & 900W@50K & 70 L/hr
- **PAL** : Helium Refrigerator and Transfer lines for Synchrotron at Pohang Accelerator Laboratory (Korea) ⇨ 700 W@4.5K & 28 l/hr