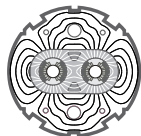


EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
European Laboratory for Particle Physics*Large Hadron Collider Project***LHC Project Report 231****A Microcryostat for Refrigeration at 1.8 K**

A. Bouyaya*, C. Policella, J.-M. Rieubland, G. Vandoni

Abstract

A microcryostat has been developed in the Central Cryogenic Laboratory at CERN with the purpose of cooling a prototype beam loss monitor for the LHC, based on bolometry at 1.8 K. Its characteristics are the very compact volume (some cm³ LHe) ensuring short cooldown-warmup times, and its low heat losses (~ 8 mW). The cryostat can be mounted on top of a small dewar through a rigid straight transfer line for continuous feeding.

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Presented at ICEC 17, 14-17 July 1998, Bournemouth, UK

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Geneva, 25 August 1998

A microcryostat for Refrigeration at 1.8 K

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A microcryostat has been developed in the Central Cryogenic Laboratory at CERN with the purpose of cooling a prototype beam loss monitor for the LHC, based on bolometry at 1.8 K. Its characteristics are the very compact volume (some cm³ LHe) ensuring short cooldown-warmup times, and its low heat losses (~ 8 mW). The cryostat can be mounted on top of a small dewar through a rigid straight transfer line for continuous feeding.

1 INTRODUCTION

Cryogenics at 1.8 K requires effective temperature staging between 300 K and low temperature, as well as a sufficient insulation, and pumping speeds permitting to achieve the necessary refrigeration power. In many laboratory operations, where reduced dimensions can be of great importance, it is useful to dispose of small cryostats, in which 1.8 K refrigeration is obtained in situ, at close distance to room temperature conditions. Applications can encompass calorimetry and optical measurements, vacuum installation and achievement of very high magnetic fields on small distances. An additional advantage of a small size is given by the gain in cooldown and warm-up times. This paper describes a cryostat of very reduced dimensions, developed to provide a heat sink for testing a beam-loss monitor for the LHC, based on calorimetry [1]. The purpose of a beam-loss monitor is to anticipate or detect the quenches induced by particle spillout from the LHC beam in the superconducting magnet windings [2]. The calorimeter itself is constituted by a small block of a material with low specific heat, on which a high sensitivity temperature sensor is mounted: deposition of an amount Q of energy inside the volume of the block results in a sharp increase in temperature, which is monitored by the sensor. The block is mounted on the heat sink loosely enough to experience a quasi-adiabatic reaction over times of the order of some tens of ms. In order to test the beam-loss monitor in working conditions similar to the ones to which it is intended for, it was inserted in an extracted proton beam from the CERN SPS accelerator. The reduced space in the extraction line and the requirement for a long lasting autonomy of the cryostat motivated the development of the microcryostat described here.

2 CRYOSTAT DESIGN AND PERFORMANCE

2.1 Main features

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The cryostat layout is displayed in figure 1. It is enclosed in a sealed vacuum vessel constituted by a stainless steel cylinder, mounted on a NW100 standard flange with a Viton[®] o-ring. Vacuum conditions below 10^{-6} mbar are obtained entirely by active carbon pumping at liquid helium temperature, the pumped volume amounting to 460 cm^3 . The cylinder contains a liquid-vapor helium separator, of a volume of $\sim 50 \text{ cm}^3$ and a helium evaporator, of $\sim 30 \text{ cm}^3$. The separator is connected to a 100 l dewar by a transfer line traversing the bottom flange, and providing the mechanical support to the cryostat on top of the dewar. Vapor is drained from the separator through a capillary, to cool down the thermalization plate of the wires, as well as a thermal screen enclosing the ensemble. The thermalization plate consists in a flat copper plate onto which a thin Kapton foil with copper tracks is soldered; the copper tracks thickness amounts to $20 \mu\text{m}$. Multilayer insulation surrounds the thermal screen, constituted by a thin copper cylinder.

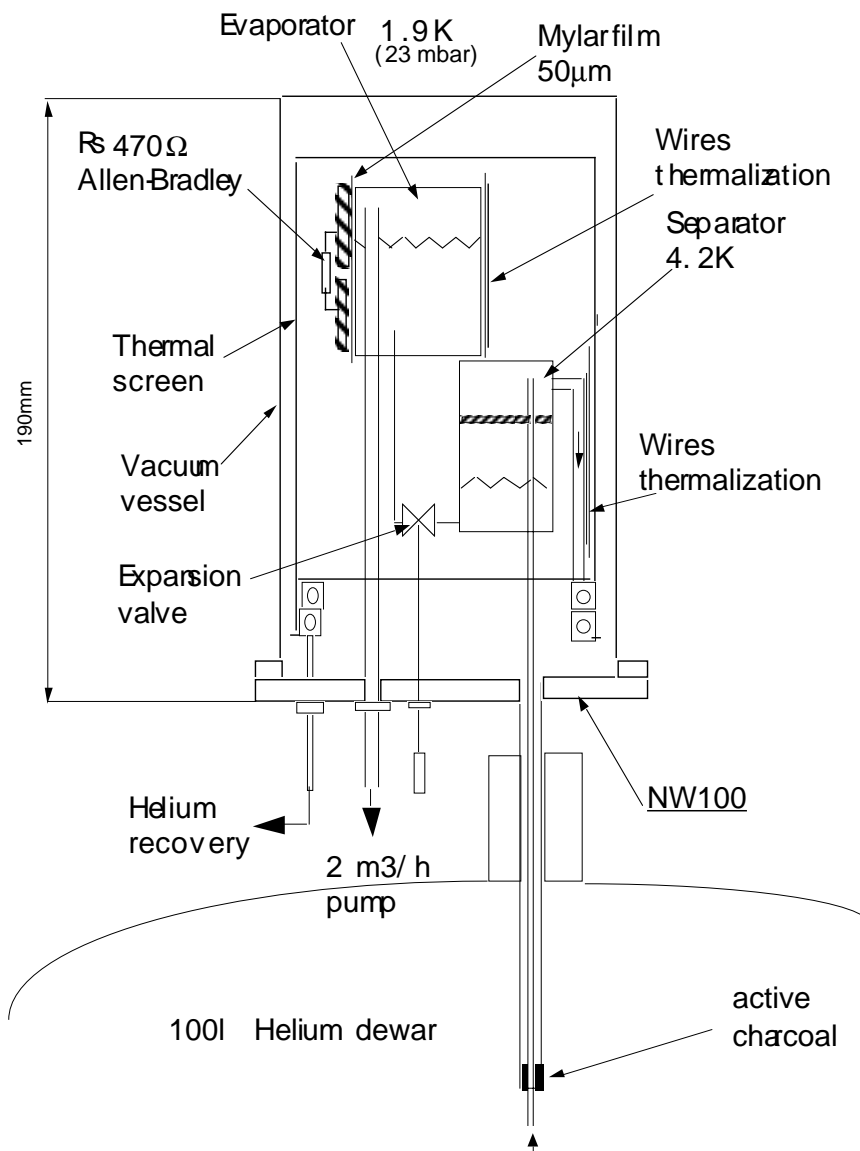


Figure 1: Schematic layout of the microcryostat. The ensemble is mounted on top of a small (100 l) helium dewar via its own transfer line.

At the lower level of the separator, a capillary feeds the evaporator throughout an expansion valve ($\text{Ø} = 0.3 \text{ mm}$), steered from outside the cryostat through a feedthrough in the bottom flange. A tiny tube ($\text{Ø} = 4 \text{ mm}$, pressure drop $\Delta p = 1 \text{ mbar}$) traverses the evaporator and leads through the bottom flange to a small pump ($2 \text{ m}^3 / \text{h}$), at the same time providing the mechanical support for the evaporator vessel.

The evaporator volume is drilled inside a square copper block, which supports the calorimeters. The surface of the evaporator available for the calorimeters amounts to 54 cm^2 , an entire face of the block being reserved to thermalization tracks for the sensor wires of the calorimeters. All tubing connections are obtained by tin-lead soldering.

No particular instrumentation is required to operate the cryostat. Only one Allen-Bradley carbon sensor is mounted on the calorimeter support.

2.2 Operating principle and performances

Due to an overpressure of 50 mbar in the dewar, liquid helium is transferred from the dewar to the separator through the transfer line. At the upper level of the separator, vapor (300 NI / h) is conveyed to the thermalization plate and the thermal screen through a capillary, which are thus cooled down to about 10 K.

From the bottom of the separator, the liquid is drained through the expansion valve into the evaporator. The expansion brings the helium from a pressure of ~ 1000 mbar to 23 mbar, and hence the liquid is cooled down to 1.9 K. Adjusting the opening of the valve permits to control the liquid level in the evaporator. The correct regulation of the valve is found by opening it enough to obtain a pressure at the evaporator pump inlet whose value is twice the pressure obtained when the expansion valve is kept closed. The latter pressure match exactly the heat losses on the evaporator, and the factor 2 accounts approximately for the loss in liquid upon expansion. In case the valve is too widely opened, then the evaporator overflows, whereas if the valve is too much closed, then the evaporator empties itself.

The autonomy of the cryostat, with a 100 l helium dewar, amounts to approximately 7 days. In the current working conditions, the helium flow pumped from the evaporator is of 23 NI / h, yielding a value of the static heat losses of the cryostat at 1.9 K as small as 8 mW. The cooldown and warm-up times from and to 300 K do not exceed 30 minutes.

3 CONCLUSIONS

A cryostat of reduced size and heat loss (~ 8 mW) has been designed and constructed to provide an adaptable and mobile in-situ heat sink for a LHC beam-loss monitor based on calorimetry. Its layout recalls the typical technology of dilution refrigerators, reapplied here to the higher temperature conditions of superfluid helium to achieve a very compact form: the HeII volume amounts to $\sim 30 \text{ cm}^3$, the HeI liquid-vapor separator volume amounts to $\sim 50 \text{ cm}^3$. Peculiar to the cryostat are its reduced heat losses ($\sim 8 \text{ mW}$), the very short cooldown and warm-up times (30 minutes), as well as a remarkable autonomy and flexibility of application.

ACKNOWLEDGMENTS

This paper was written to describe a work initiated with the purpose of providing a microcryostat for testing an idea of J. Bosser (CERN-PS). Useful and encouraging discussion with him are gratefully acknowledged.

4 REFERENCES

[1] Bosser, J., Bouyaya, A., Ferioli, G., Jenninger, B., Policella, C., Rieubland, J.-M., Rijllart, A., Preliminary measurements on Microcalorimeters foreseen to be used as Beam-loss Monitors, LHC-Project-Note 71, 1996

[2] Lebrun, P., Blessing, H., Taylor, T. and Walckiers, L., Cryogenic microcalorimeters for the measurement of energy deposition by beam losses in superconducting accelerator magnets, XVth International Conference on High Energy Accelerators, July 20-24, 1992, Hamburg, Germany