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COOLING AND VENTILATION FOR THE LHC
STATUS REPORT

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Abstract

For the LHC project, investments for cooling and ventilation will exceed 100 MCHF over a period of six years. This report contains an outline of the group's mandate within the project, as well as a summary of the main design parameters. Furthermore, the author will explain the present status of the cooling and ventilation schedule, with some milestones already achieved and others soon ahead. In fact, two important construction projects prior to the civil engineering building sites were already successfully completed before the end of 1997. As the service infrastructure for the LHC needs to match recovered structures from the LEP project, the author will also discuss and compare the technical content in the light of optimized expenses, design parameters and constraints, as well as new and adaptable technologies and methods.

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1 INTRODUCTION

The LHC, now under construction at CERN, is an accelerator which will provide protons–proton to collision with a centre-of-mass energy of 14 TeV, scheduled for commissioning in the year 2005.

In the shadow of the development of state-of-the-art superconducting magnets and gigantic new detectors, the study for services, such as cooling and ventilation, have made a lot of progress since the project was approved. The material and the technology is of industrial standard type, hence the applications, which combine several unusual constraints such as humidity and temperature stability in deep underground areas, represent a non-trivial engineering challenge. The dense stacking of equipment and networks in precious underground space also adds to the complexity of the task.

The cooling and ventilation group have presented preliminary studies and estimates for the investment cost for the supply and installation of cooling and ventilation equipment to the Project Leader. Appendix 1 contains a summary of the latest up-date cost estimate. The present situation is also shown below as the first construction sites for some preparatory work have already been completed and several parts of other projects have advanced beyond the drawing office.

2 OUTLINE OF THE CV SYSTEMS [1–3]

2.1 Cooling towers with attached pumping stations

The cooling towers are the primary source for cooling, the entire thermal power of the accelerator and the experiments are rejected into the atmosphere via them. The design of a typical cooling tower is shown in Appendix 1, Fig. 1.

The primary cooling water — directly from the cooling tower — is used for cryogenic compressors and liquid chillers. All other heat-dissipating objects are connected indirectly to the primary cooling system through various types of heat exchangers. A schematic layout of the primary cooling systems is shown in Appendix 1, Fig. 2.

New cooling towers with a total capacity of 60 MW are being built on the new experimental sites. Existing cooling towers at the LEP even points will be reused mainly for power converters, transfer lines, RF systems, beam dump, and transformed experiments at points 2 and 8.

2.2 Liquid chillers (or refrigeration machines)

When the temperature of the water from the atmospheric cooling towers is not low enough, liquid chillers are needed to provide water at a temperature of 6°C. This water is used mainly for air-conditioning and electronics for the physics experiments. In the latter case, the chilled water is mixed to a slightly higher temperature to avoid condensation. New chilled water plants at points 1 and 5 will be built for a total power capacity of 5MW.

2.3 Demineralized water (cooling) stations and networks

Demineralized water will be used mainly for power converters, beam dumps and some physics instruments. The important use of demineralized water, as the primary coolant for dipole magnets in LEP will obviously disappear. The demineralized water is produced and distributed from one single central plant, and maintained at low conductivity by locally fitted ion-exchanger cartridges. The LEP demineralized water pipeline in the tunnel will stay, although re-positioned for 2/3 of its total length, due to space constraints. The production capacity will be maintained at 25 m^3/h.

2.4 Other fluid networks

Other fluid networks under study in the underground and on the surface are:

- Raw water as drinking water and make-up water in the cooling towers.
- Fire fighting water.
- Seepage and waste water.

The current infrastructure for these fluid networks will, to a large extent, be recovered, but re-routed and modified at several places due to civil engineering construction work.

2.5 Ventilation systems for underground tunnels

The main concept for the ventilation of the LHC tunnels is almost the same as for the LEP tunnel. In fact, an important part of the equipment which is used for LEP today will be recovered.

The tunnel itself is used as a duct for the ventilation air, with air inlet at points 2, 4, 6, and 8 and outlet at points 1, 3, 5, and 7. The ventilation of the new transfer tunnels will follow the same concept. TI 2 will be supplied with fresh air from point 2, with extraction in building 296 on the Meyrin site, and TI 8 will be supplied from point 8, with extraction at point 4 of the SPS. Where heat, must be dissipated into the air locally, as is the case with the so-called alveoles, specific closed circuit air-cooling units are provided.

2.6 Ventilation systems for underground caverns

Whereas the technical concept of the tunnels is the same as for LEP, the ventilation of the new experimental caverns at point 1 and 5 uses a different layout. The operation principle for the ATLAS cavern can be found in Appendix 2, Fig. 1. During the periods when the accelerator is in operation, the main air volume stream is recycled. Only a fraction of fresh air is provided through the technical cavern. In comparison, the LEP caverns work with 100% fresh air. The change of concept is justified by:

- A more economic solution from the point of view of energy consumption.
- A concept which limits the risk of the release of radioactive air.

In addition, a more modern air distribution system will be implemented based on a very low air velocity at the inlet; this has been analysed and found to be beneficial to the thermal charge of the experiments. The air distribution system for the ATLAS cavern is shown in Appendix 2, Fig. 2.

Moreover, the ventilation system has been carefully matched to various emergency scenarios, for example gas leaks, smoke, etc.

The ventilation of surface buildings and technical areas (racks, etc.) has been omitted (though not forgotten) in this report.

3 COST ASPECTS [4–5]

A summary of the last updated cost estimate is shown in Appendix 3. The schedule is also shown over the project's construction time, and the investment situation at the end of 1998 is indicated for committed amounts as well as paid amounts. This could be considered a huge amount of money for the cooling and ventilation systems for a machine like the LHC. However, taking a closer look at all the sub-systems, all costs can be justified, most importantly by the design parameters of all these systems, some of which are mentioned in Section 2. During the preliminary design and planning phase of the project, important efforts were made to optimize the investment schedule and to aim for the most cost effective solutions. The following examples can be mentioned:

- A continued request to users to use, as far as possible, equipment that is principally cooled by water, so that the heat dissipated into the air is kept to a minimum. This effort has helped to keep duct systems relatively small.
- An analysis, so that a maximum of the systems used by the LEP machine can be recovered for the LHC.
- An analysis of the contract content for the calls for tender, so that the contract values are of interest to important consortia in many member states, at the same time aiming for technological coherence.

4 PROGRESS SITUATION IN THE LHC-CV PROJECTS

Table 1 shows a non-exhaustive list of LHC sub-projects related to cooling and ventilation.

5 CONCLUSION

This paper shows that progress in the cooling and ventilation area of the LHC project is in a satisfactory state. So far, estimates and time schedules have been respected. The whole of the CV project represents a major challenge to the new breed of engineers joining the group. With the implementation of a project-oriented structure within the group, and with people who possess the necessary qualifications, I am convinced that the project will be successful. The need to find important sources of cost savings expressed by the Project Leader has unfortunately not been possible. However, efforts are continuously being invested to find optimal solutions in all aspects of the project, including those from a cost point of view, but not to the detriment of reliability or maintainability. The first results from the preparatory work have been promising, but a more concrete confirmation of success should be witnessed in about one year.

Table 1

List of LHC sub-projects related to cooling and ventilation

Project	Progress remarks
Primary cooling systems	The cooling towers have been ordered. The contract for the pumping stations is being negotiated. The design of the hydraulic connections in the galleries and the shafts is in progress.
HVAC for LHC buildings	Call for tender for 24 surface buildings issued in January 99.
Ventilation and air-conditioning of underground areas	A Market survey is to be issued during the first half of 1999. Design in progress.
Demineralized water systems	Market surveys to be issued during 1999; Work starts end 2000.
Fluid services for cryogenics and air-conditioning	Construction work in 2001–2003.
Fluid services for experiments	Specification and design during 1999; construction work should start by October 2000.
Fire Fighting and raw water systems	Construction work in 2001–2003.
Waste water systems	Construction work in 2001–2003.
Compressed air for the LHC	The user specification is in progress.

References

[1] TENDER DOCUMENT IT-2428/ST/LHC: Cooling Towers, B. Pirollet.

[2] Draft ATLAS TDR Infrastructure, J. Inigo-Golfin et. al.

[3] LHC – Experience ATLAS Conception des Installation Aeraulique, 1st CERN ST Workshop Chamonix 1998, J. Roche.

[4] Estimation LHC ST/CV, ST/CV/98.102/MW/KF, K. Foraz, M. Wilhelmsson.

[5] ESTIMATIONS & PLANNING LHC ST/CV, avril 1998, K. Foraz.

APPENDIX 1

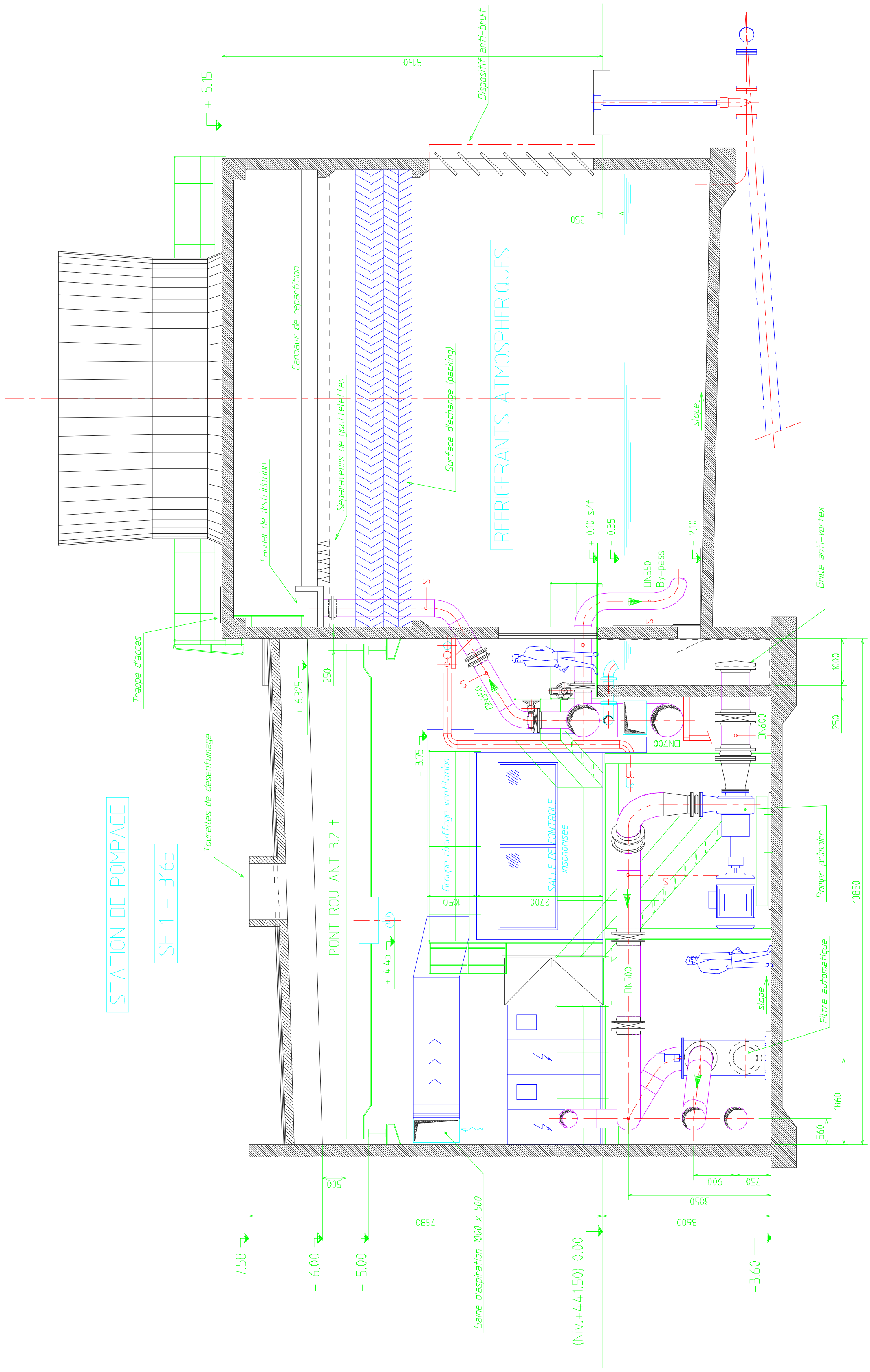

Figure 1: A Cooling tower for the LHC.

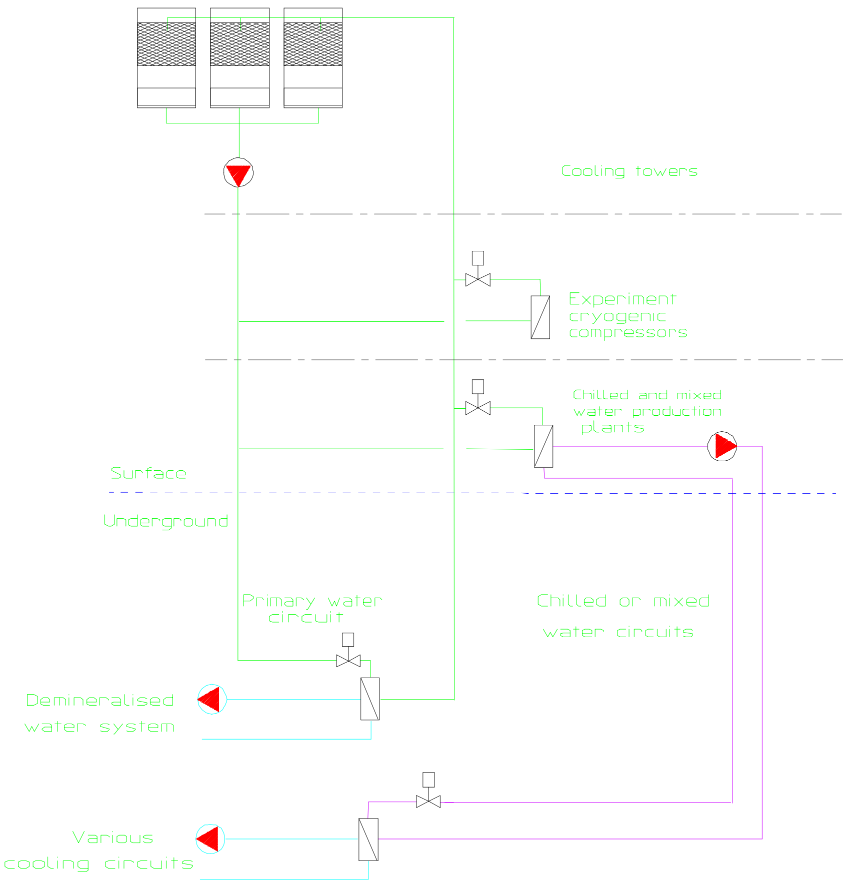

Figure 2: Schematic layout of the primary cooling system.

APPENDIX 2

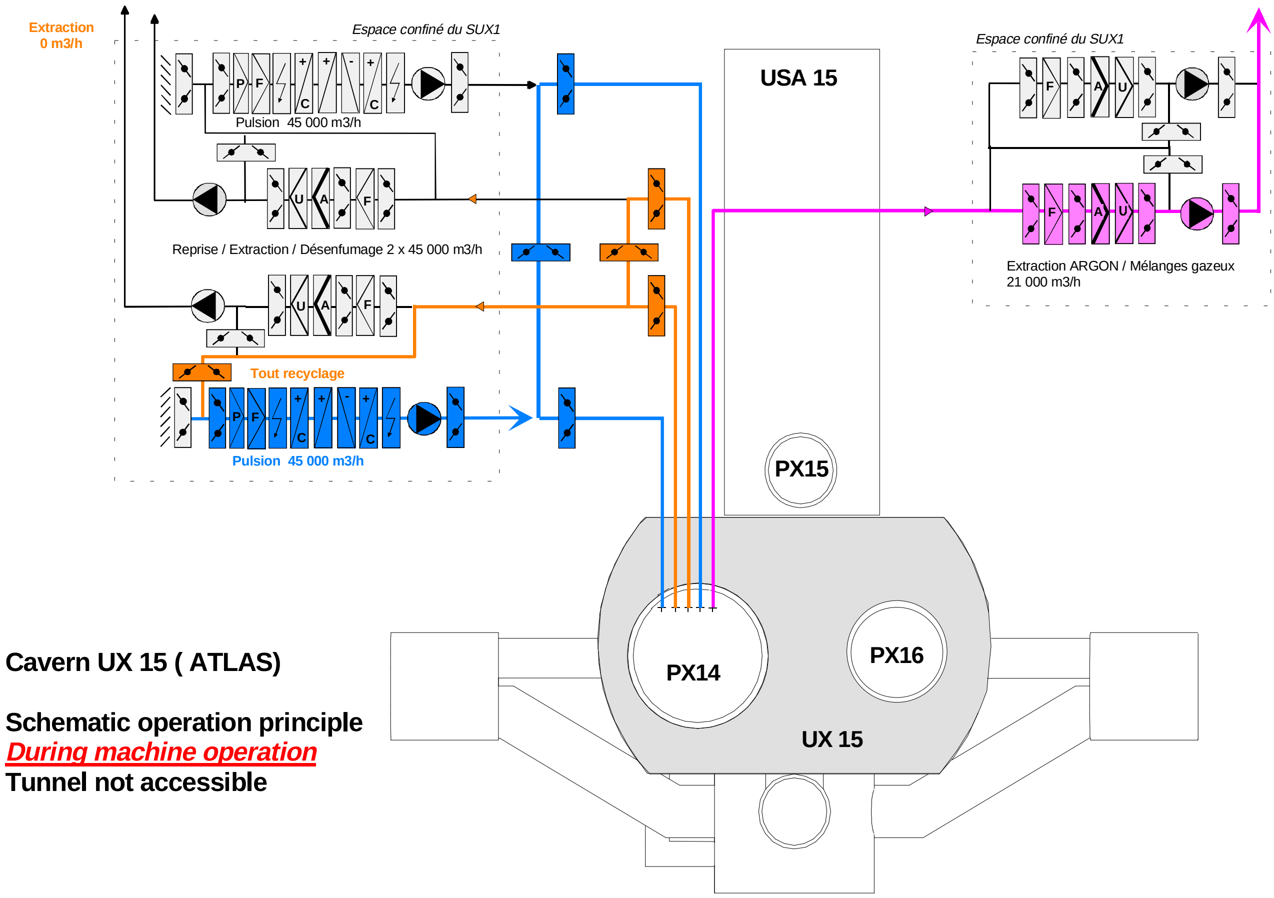

Figure 1: Air Operation principle for an LHC experimental cavern.

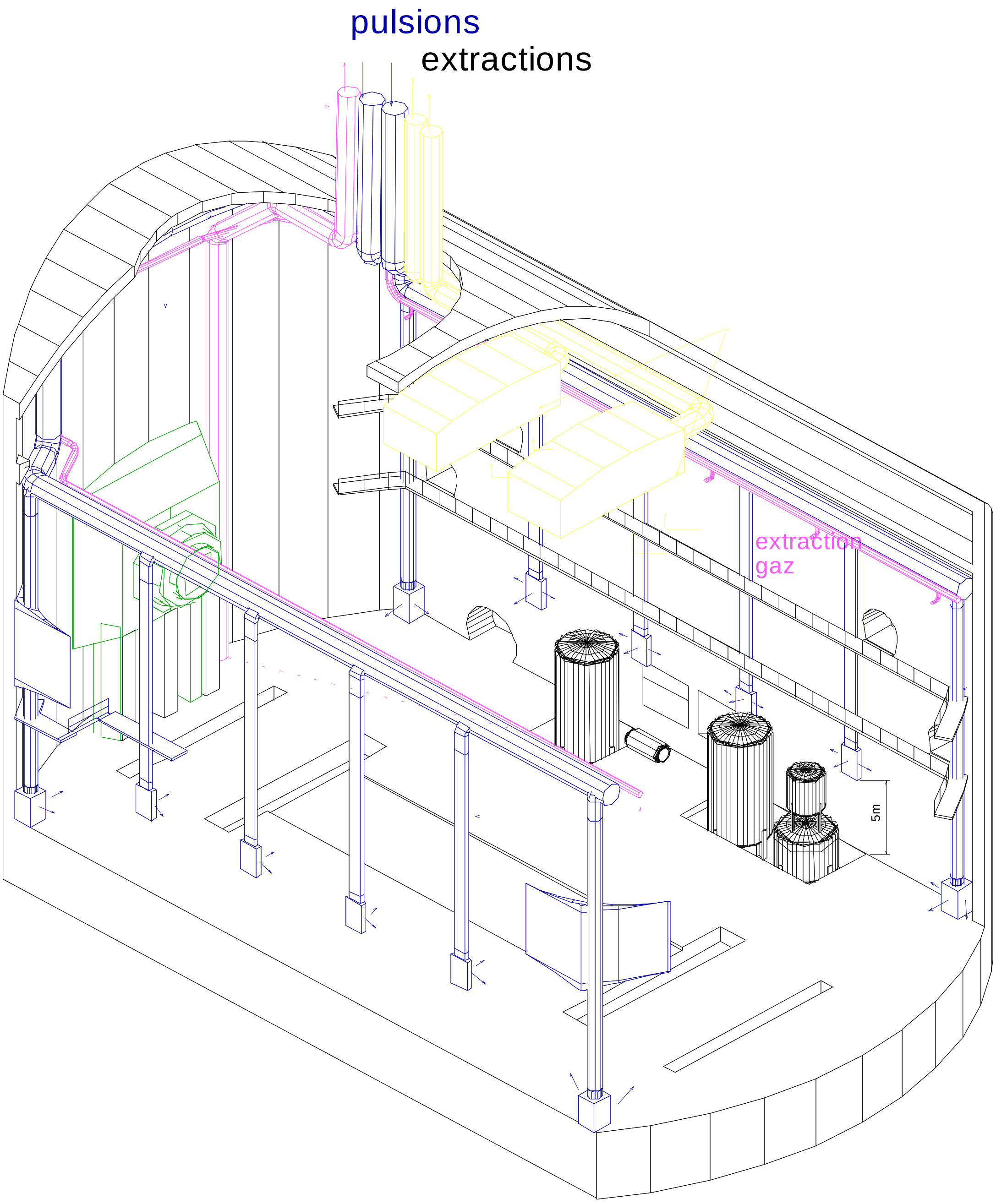

Figure 2: Air distribution system for ATLAS cavern.

APPENDIX 3: COST ESTIMATES

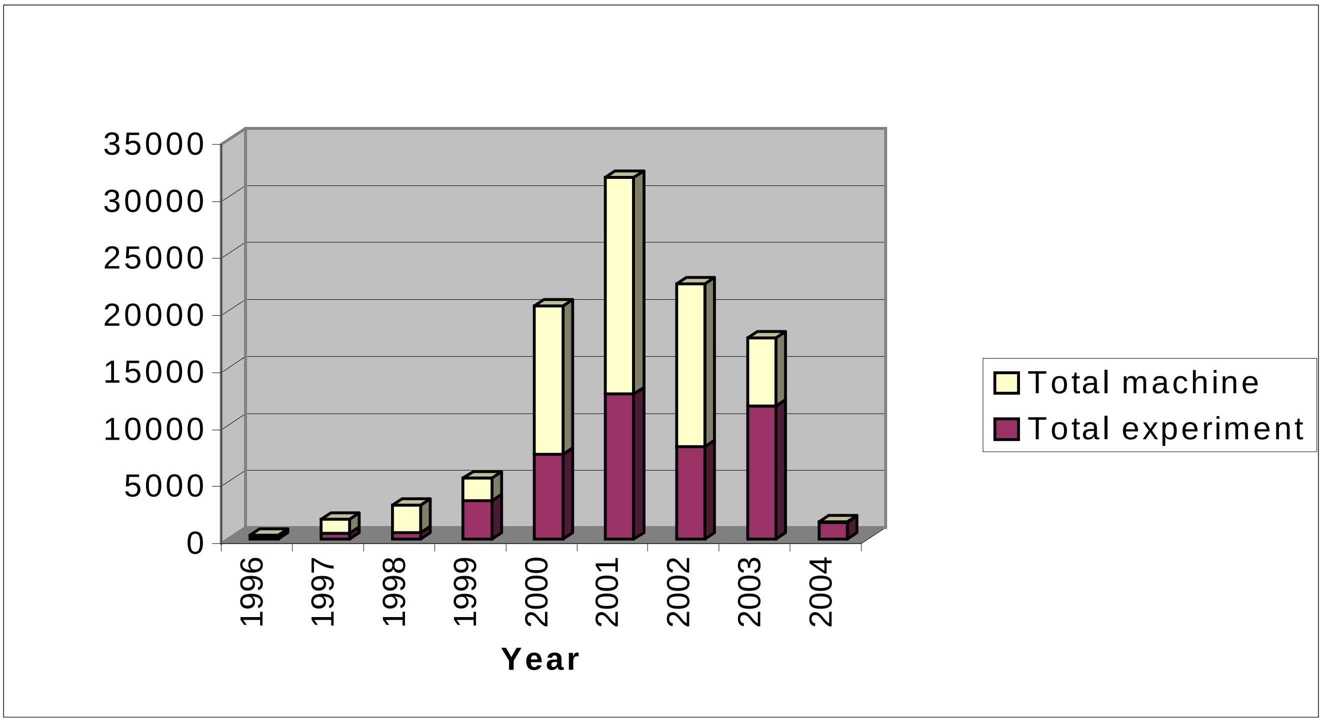

Figure 1: Expense profile for Cooling and Ventilation.

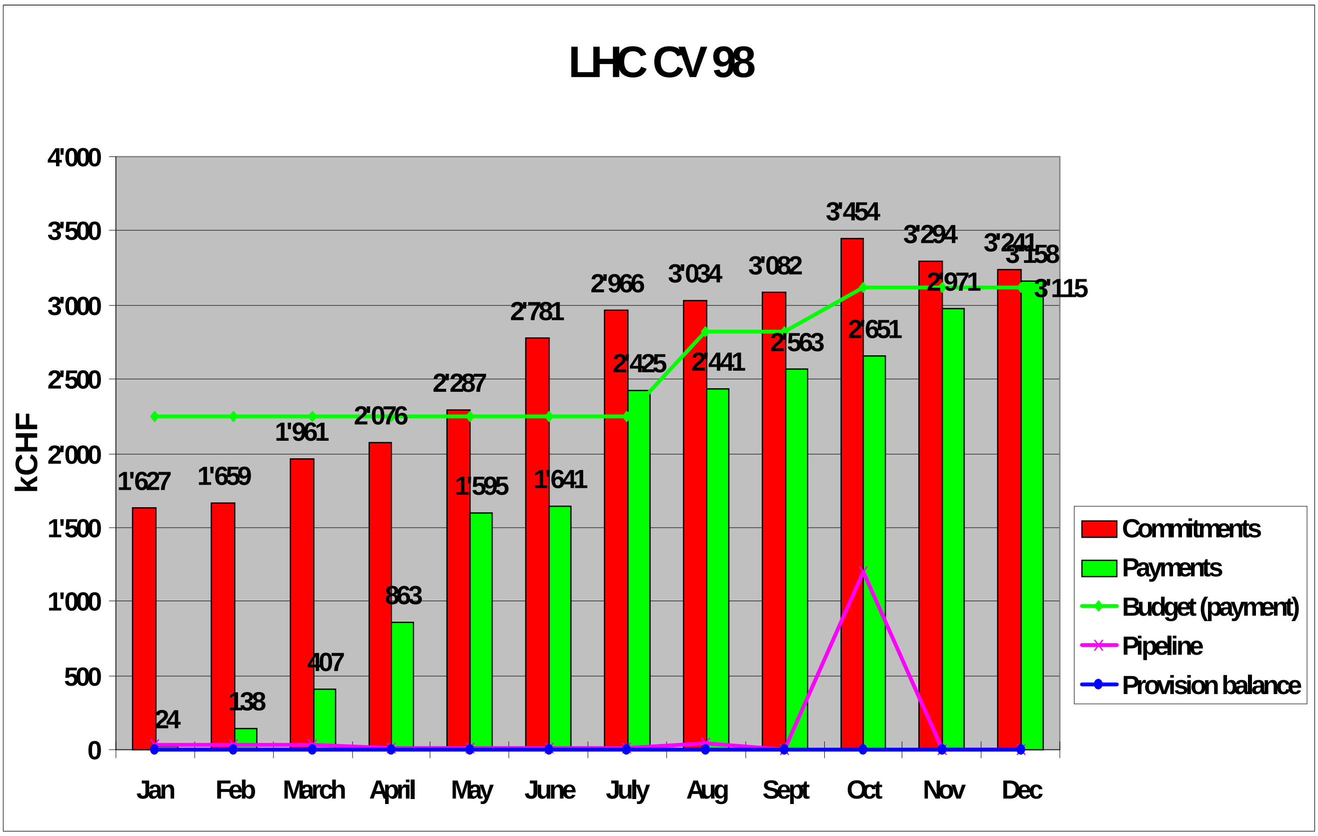

Figure 2: Financial situation, end 1998.

Table 1

Cooling and Ventilation total cost estimates for the LHC

Summary point by point

Point	**kCHF**
1	28’989
2	8’727
3	2’349
4	9’127
5	24’351
6	9’352
7	1’393
8	8’929
Zone 18	2’340
Zone TI 2	2’868
Zone TI 8	3’794
Misc.	1’781
TOTAL	**104’000**