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Engineering Note

LHCB OUTER TRACKER SYSTEM GAS SYSTEM PROPOSAL

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ABSTARCT

This note describes the gas system for the LHCb Outer Tracker proposed by the Outer Tracker together with the LHC Gas Section TA1/GS. The detector will run with an Ar/CO2/CF4 gas mixture in a closed loop circulation. An inline purifier will keep the impurities at an acceptable level and Water/oxygen meter and monitoring drift tubes will survey changes in the gas mixture.
Standard technical design modules are employed as far as possible, in order to minimise design overheads and long-term support costs.

Keywords: LHCb Outer Tracker, Gas System, Gas distribution

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1.0	2000-08-16	11	Transferred and updated from LHCb note 2001-086-Tracker,6 March 2001 Changes: LHCb light, with three Outer Tracker stations, ST1, ST2, ST3. No gas monitoring system.

Table of Contents

1. INTRODUCTION

The outer tracker consists of three stations with straw tube drift cells, distributed between the magnet and the RICH 2 (Figure 2-1). The active area of the detector covers 200mrad in the non-bending plane and 300mrad in the bending plane. In the inner region of each station the area is covered by the Inner Tracker system.

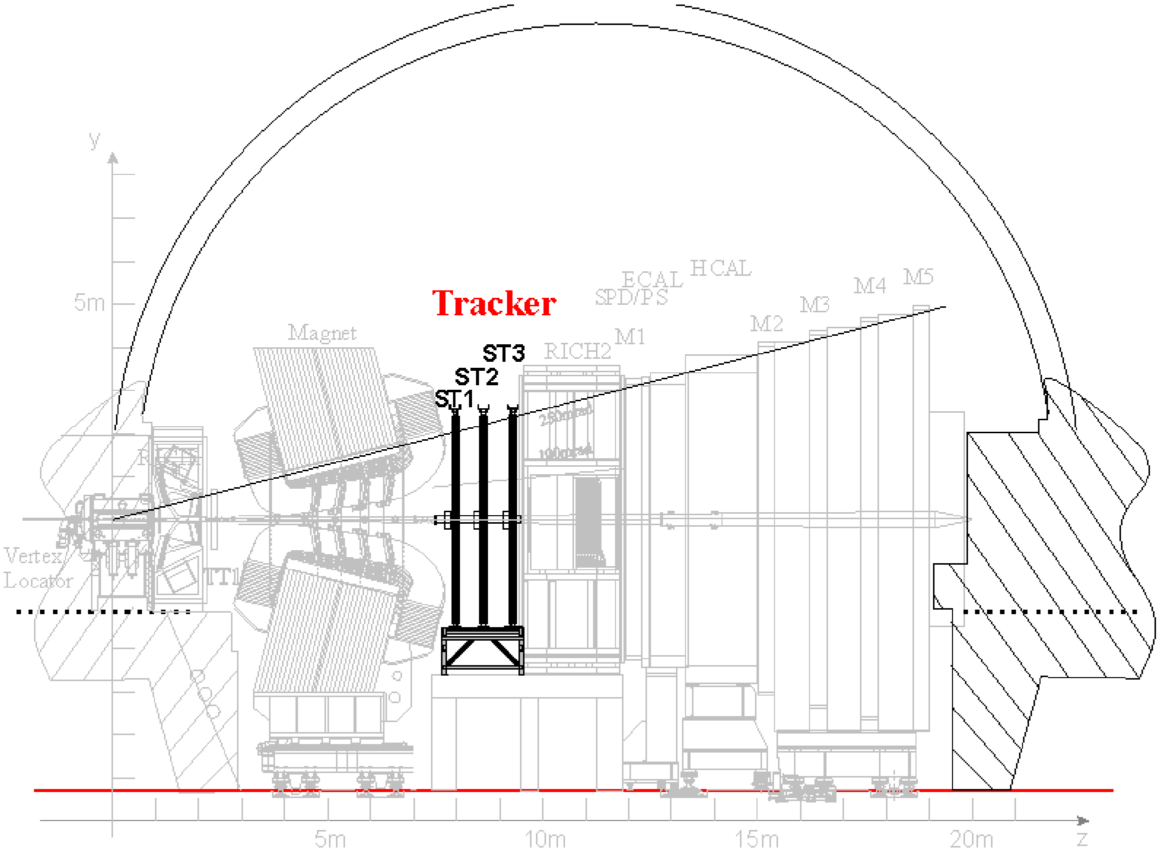

Figure 0-1 *Outer Tracker Station ST1 – ST3 between the magnet and RICH 2.*

2. DESCRIPTION OF THE OUTER TRACKER LAYOUT

2.1 CHAMBER LAYOUT

In the configuration of the tracking stations the emphasis is on tracking precision in the (x,z) magnet bending plane. Therefore all stations have two planes with wires in the vertical direction and two stereo planes, which are tilted by either +5° or -5°. Each plane consists of two staggered layers of drift cells with a diameter of 5mm [1]. A plane is assembled from modules with 64 cells per layer and an identical length of 4800 mm.
The aim is to keep the occupancy for each cell below 10%, which defines the inner acceptance of the Outer tracker, the remaining inner part will be covered by the inner tracker.

2.2 GAS CHOICE

In addition to occupancy, signal latency is a major concern. The delay in signal arrival time at the preamplifier is the sum of drift time and propagation delay along the sense wire. For a fast drift, a gas mixture containing CF4 is advantageously. The drift time resolution clearly deteriorate with rising admixture of CF4 [2] due to the large cross section for electron capture by CF4, but for CF4 admixtures up to 30% it stays in an acceptable level. Another problem resulting from the electron capture by CF4 molecules is the creation of free radicals by CF4 dissociation [3], which can lead i.e. to fluorine or HF production.
Test with outer tracker prototypes have shown that a gas mixture containing Ar/CO2/CF4 with a ratio of 75/10/15 and a gas flow of 2 m3/h are acceptable with respect to maximal drift time for all stations.

3. GAS SYSTEM

The high gas flow rate and the high cost of CF4 in the gas mixture make a closed-loop circulation system compulsory. The system comprises a mixer, and inside the circulation loop the gas distribution, a pressure regulation and a purifier. (Figure 3.1) The mixer and the purifier are located in the gas building at the surface, where the distribution system and the pressure regulator will be placed in the experimental hall, behind the radiation wall.

3.1 MIXER

The gas mixer (Figure 3-1) will be build according to the LHC standard gas module design. It will mix the gas components in appropriate proportions, where mass flow controllers will meter each component. Process-control computers will monitor the flow of the gas, coming from the supply lines, and continuously calculate the correct mixture of the different gas components.

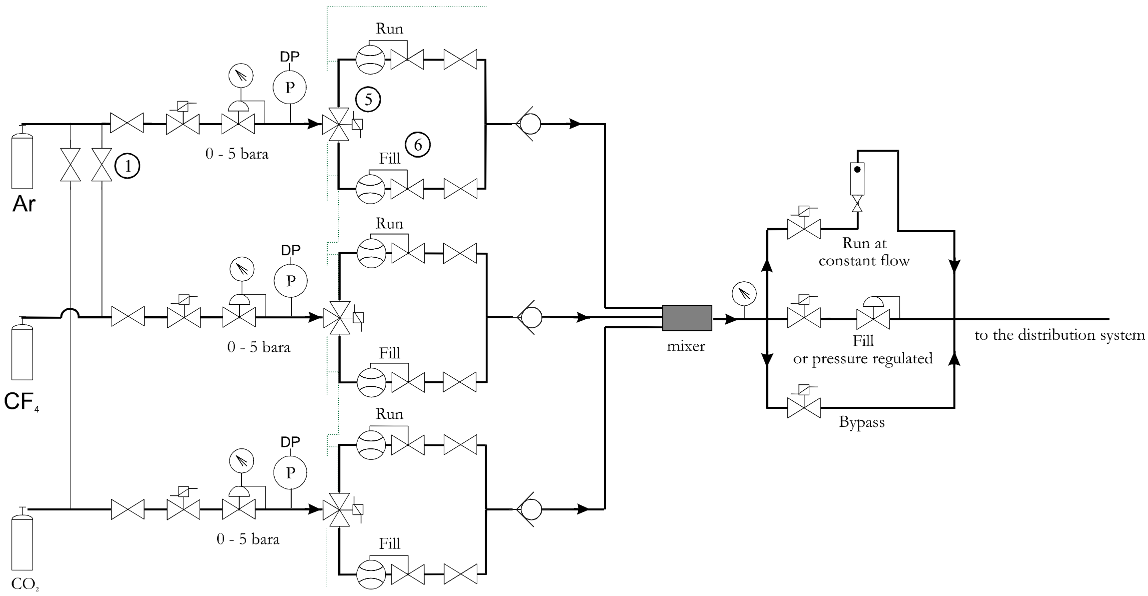

Figure 3-1: The outer Tracker Gas Mixing Unit

3.2 GAS CIRCULATION

The outer tracker gas is circulated in a close loop with an expected regeneration of 90%. The 10%, which will be replaced by the fresh gas, leave the gas system through possible leaks and through the exhaust line.

A gas exchange rate of one volume replacement every 3 hours is foreseen for the complete detector system. With a total gas volume of the outer tracker of 3.0 m^3, the average gas flow amounts to 1.0 m^3/h.

Each outer tracker station is divided in several gas modules, depending on the total volume of the station. The size of each station with the resulting gas volume and the number of modules is given in Table 3-2.

Station	Planes	Size		Volume	Modules	Volume/Module
	#	x[cm]	y[cm]	l	#	l
ST1	4	453	479	918	8	115
ST2	4	480	479	974	8	122
ST3	4	507	479	1029	8	129
S	12			2921	24	mean: 122

Table 3-2: Gas volume of each individual gas module

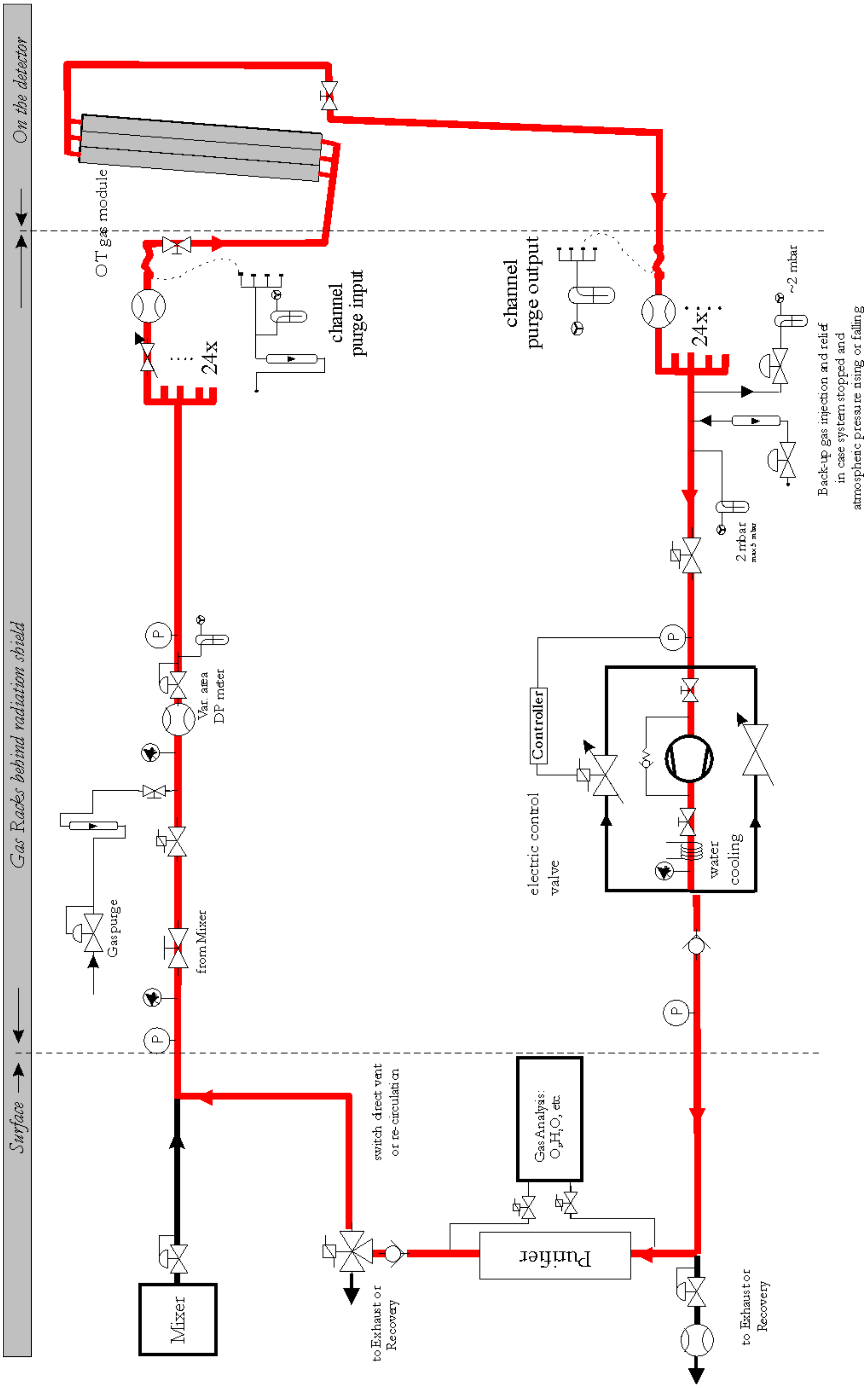

Figure 3-2: Schematic view of the closed loop distribution system

3.2.1 PRESSURE REGULATION AND COMPRESSOR

A pump in the return line allows the gas to be compressed to approximately 300 to 500 mbar overpressure before returning to the gas building at the surface and cleaning through the purifiers. A backpressure regulator in parallel with the pump controls the pressure to 0.5 mbar below atmospheric pressure at the inlet of the pump. Alternatively, a pump driven by a frequency regulator controlled by a pressure sensor on the detector could stabilise the pressure in the outer tracker system.

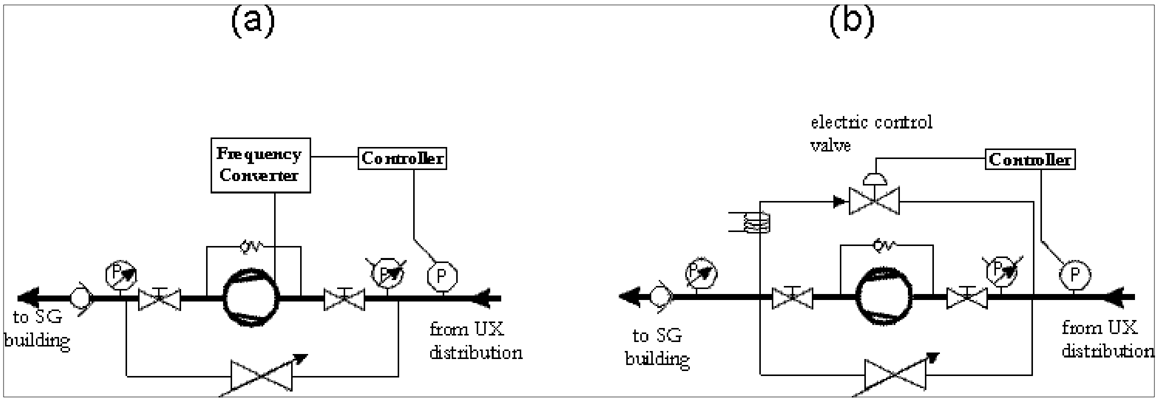

Figure 3-3: Pressure regulation system (a) with frequency regulation (b) with backpressure regulator.

3.2.2 GAS PURIFICATION

Closed loop gas circulation systems require gas purification in the return line from the detectors in order to archive high regeneration rates and low fresh-gas flows. The main impurities of concern, which accumulate in the system, are oxygen and water vapour, entering via joints and the detector sealing as well as at the entrance of the compressor where the pressure is very low.

A set of twin purifier cartridges (Figure 3-4) filled with two cleaning agents: molecular sieve (3Å) to remove the water vapour, and a second part activated copper as reducing agent for oxygen removal. The advantage of having two parallel cylinders in each cleaning stage is to run the gas mixture through on of the while the other one is being regenerated. Both agents in the same cylinder can be regenerated at the same time by heating the columns to 220C in 93% Ar and 7% H2 mixture. The operating cycle to clean the purifiers will be controlled by a process control computer, which allows exactly the same protocol to be followed each time.

The set of twin purifier cartridges will be placed at the surface will be in order to keep the underground as a non-flammable gas zone.

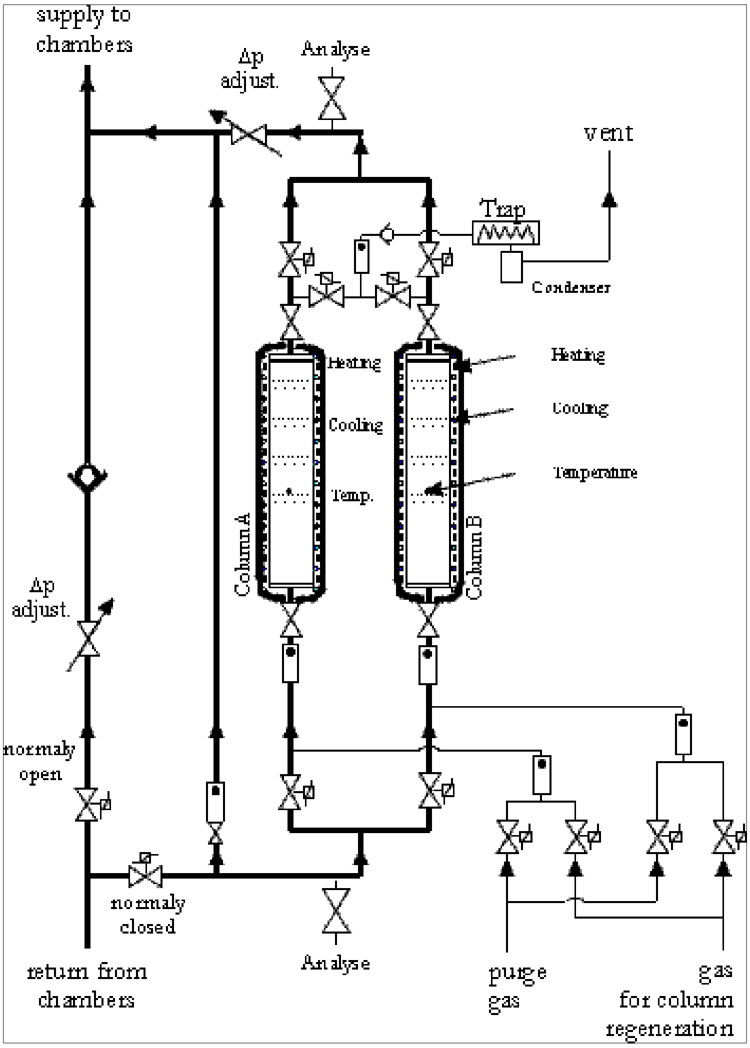

Figure 3-4: Twin Column purifier module with inline regeneration.

4. PIPE DISTRIBUTION

All tubes and fittings will be made of stainless steel or copper; only the connection on the detector module will be flexible plastic pipes. Existing pipes, used by DELPHI at point 8, from the mixer in the gas building at the surface down to the experimental cavern will be reused where possible.

4.1 GAS DISTRIBUTION ON THE DETECTOR

From the distribution system to the detector each gas module will be served by one input and one output gas line. Before the gas will enter the modules, the piping will be split, in order to separate between the straw tubes and the surrounding gas volume (Figure 4.1). At the output of each module, the gas will be collected and routed back to the gas distribution system. This allows a regular gas flow through the straw tubes and possible leaks of the straw tubes will not change the gas composition. The difference in pressure impedance of the surrounding frame and the straw tube has to be equalized by means of orifices at the entrance of each module.

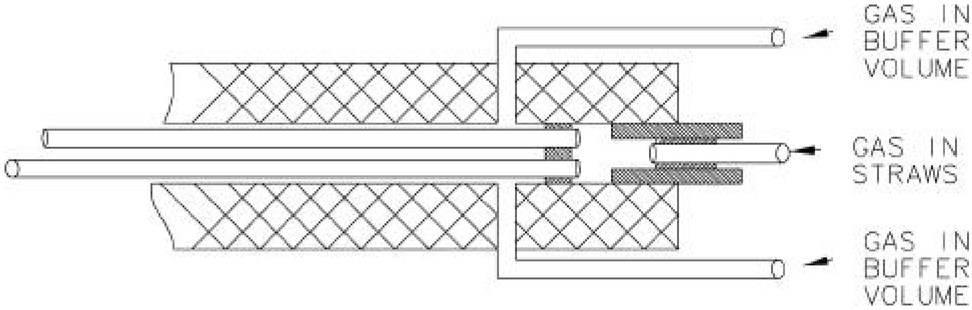

Figure 4-1: Gas flow in each detector module

5. GAS CONTROL

The gas control will follow the general recommendations of the Joint-Control-Project of the four LHC experiments (JCOP). In particular, the production of gas control systems will be prepared using the industrial software development standard PSS05. In the first step of this framework, a User Requirement Document is prepared at the moment, which captures as many details as possible. The hardware architecture of the gas control equipment favours Programmable Logic Controllers (PLC) as front-end computers. This allows secure, standalone solution, which is independent from generally, used computer networks. Signals from sensors and actuators will be transmitted via a fieldbus to the PLCs. On a higher level, users will be able to interact with the gas control system via a Graphical User Interface dedicated for gas. Also here, general recommendations for SCADA systems from JCOP will be followed. This will ensure and facilitate the integration of the gas control system into the general LHCb Detector Control System.

6. REFERENCE

[1] LHCb Collaboration, LHCb Outer Tracker Technical Design Report, CERN-LHCC-2001-024 ; LHCb-TDR-6

[2] I. Gouz, B. Hommels, G.W. van Apeldoorn, LHCb-2001-011 . Beam tests of LHCb outer tracker prototypes in 2000

[3] Bart Hommels， Nuclear Instruments and Methods in Physics Research A 462 (2001)278 .284